The Great Grid Upgrade

Grimsby to Walpole

Grimsby to Walpole and North Humber to High Marnham

Strategic Options Report

May 2023

nationalgrid

Contents

Executive summary

Purpose of this report

This report provides an overview of the options that National Grid Electricity Transmission plc ('NGET') identified and subsequently evaluated for the connection of the North Humber to High Marnham project and the Grimsby to Walpole project.

The stages of NGET's process-based approach when transmission system works are identified that would require additional consents and/or permissions are shown below:

Figure A – Approach to consenting process

This report forms part of the initial 'Options identification and selection' stage.

This executive summary provides an overview of the contents of this report and highlights key areas relevant to this consultation including:

- reasons why the transmission system in the Humber/Trent and Lincolnshire regions need to change;
- a summary description of options for providing additional transmission system capability that were identified by NGET as strategic options;
- how NGET identified and evaluated strategic options, and
- the options that NGET intends to take forward to the 'Defined proposal and statutory consultation' stage.

National Grid Electricity Transmission

NGET, who is the owner of the transmission system in England and Wales, holds an electricity transmission licence that permits transmission ownership activities. Our transmission licence requires that we provide an efficient, economic and co-ordinated transmission system in England and Wales.

NGET, as the regulated provider of electricity transmission services in England and Wales, is regulated by the Office of Gas and Electricity Markets ('Ofgem'). Transmission services include maintaining reliable electricity supplies and offering to construct new transmission system assets for new connections to the National Electricity Transmission System ('NETS').

In accordance with transmission licence requirements, we ensure that the transmission system in England and Wales meets the requirements in respect of transmission system security and quality of service at all times. As part of this requirement, we must ensure that sufficient transmission system capability is provided to meet demand and generator customer requirements and wider transmission system needs that exist and/or are expected.

When planning changes to our transmission system, we must be efficient, co-ordinated and economical and have regard to the desirability of preserving amenity, in line with the duties under sections 9 and 38 of the Electricity Act.

The electricity transmission system

The transmission system in England and Wales serves the purpose of transporting large amounts of energy across the country. The system connects large energy generators such as wind farms, nuclear or combined cycle gas turbine (CCGT) facilities, to name but a few, with distribution systems which take energy on to the homes and businesses across England and Wales.

Transmission voltages up to 400,000 volts (400 kV) are used to move bulk energy, because at this voltage level, it is possible to transport the energy whilst also minimising the amount of power lost through electrical properties of the circuits.

The transmission system connects to distribution systems across the country, which in turn transport energy on to homes and businesses across England and Wales, reducing the voltage as the energy progresses through the system. Significant amounts of energy are especially drawn from the transmission system at large demand centres like the M62/M18 corridor, the Midlands, the M4 corridor and the South East. As we decarbonise our economy, demand for electricity is expected to rise across the whole country, as we use electrified transport and heat our homes, and reduce our reliance on fossil fuels.

Originally the transmission system was constructed in the 1960's to move power mainly from the coal fired power stations based near the coal fields of the North and Midlands to 'demand centres'. As we look to the future of energy generation, more low carbon generation such as nuclear and wind is connecting to the system. This low carbon generation is located away from the older fossil fuel power stations. This, alongside growing demand needed to decarbonise our economy, is requiring the transmission system to change and in some cases increased capacity transmission infrastructure is required.

The need case

Consistent with the Government's Net Zero target of connecting up to 50 gigawatts (GW) of offshore wind by 2030, there has been, and continues to be, growth in the volume of renewable and zero carbon generation that is seeking to connect to the electricity transmission system in the Humber/Trent and Lincolnshire regions.

The need for a co-ordinated strategy to meet the 2030 Net Zero target is reflected in the emerging draft National Policy Statement for Electricity Networks Infrastructure (EN-5), which identifies a policy imperative in support of offshore-onshore transmission. This is further reflected in the Holistic Network Design (HND) prepared by National Grid Electricity System Operator (ESO) that then identifies the pathway programme for the transmission infrastructure needed, both onshore and offshore, to support offshore wind developments.

The pathway programme identified in the HND has a direct bearing upon the proposed programme of reinforcement work within the Humber/Trent and Lincolnshire regions. The HND has been developed to identify and recommend a co-ordinated set of onshore and offshore network developments that best meet a range of assessment criteria (economic, environmental, deliverability and community impacts) to enable the connection of new offshore wind generation in line with the government's 2030 target. The offshore wind developments considered are mainly around Scotland and the East Coast of England, with connections at a number of sites along the East Coasts of both Scotland and England. The connections drive the need for local

works in the vicinity of the connections, and the need to accommodate increased power flows from the North and East of Great Britain to the Midlands and South. The HND assessments included existing and future contracted onshore and offshore generation to ensure that any recommended developments account for all of the known requirements. HND includes sites in the Humber/Trent and Lincolnshire regions for the connection of both onshore and offshore generation, and recommends reinforcements to provide network capacity to allow for the increased power flows through the regions. This Strategic Options Report (SOR) describes the future network requirements and the options appraised to meet these requirements.

There are areas within each of the Humber/Trent and Lincolnshire regions where a number of generation projects have contracted with the Electricity System Operator to connect to the electricity transmission system. National Grid has assessed the likely impacts associated with the connection of the total volume of new generation (the 'generation group') for each of the two areas identified within the Humber/Trent and Lincolnshire regions.

The two generation groups identified for the Humber/Trent and Lincolnshire regions are referred to (in this report) as the:

- Creyke Beck area generation group, and
- East Coast (South Humber to North Wash) generation group

Each of these areas need to comply with the generation connection requirements within the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS).

There is also a need to reinforce two "boundaries" within the transmission system, boundaries B8 and B9. A "boundary", in this context, splits the system into two parts, crossing critical circuit paths that carry power between areas and where power flow limitations may be encountered. Boundaries help identify regions where reinforcement is most needed by enabling analysis of power transfers between separated areas. This requirement has been identified within the Economy Planned Transfer assessment as set out in the NETS SQSS. This assessment considers the amount of generation forecast to cross a boundary by 2030.

We also assessed the impacts that the additional contracted generation capacity beyond 2030 would have on volumes of electricity that flow between parts of the transmission system that contain significant amounts of demand and generation. The system boundaries considered as part of our assessment and referred to in this report are:

- North of England to Midlands Boundary 'B8', and
- Midlands to South of England Boundary 'B9'.

Each of the circuits which cross the B8 and B9 boundary has a capacity during the winter Average Cold Spell (ACS) period. This is referred to as the "pre-fault capacity". The "post fault capacity" is defined by the remaining capacity across a boundary following the worst fault "secured event". Following assessment, the Creyke Beck generation group and the East Coast generation group both require additional transmission capacity across the B8 and B9 boundaries to facilitate the connections in both areas.

Figure B – Additional system boundary capability required by 2030

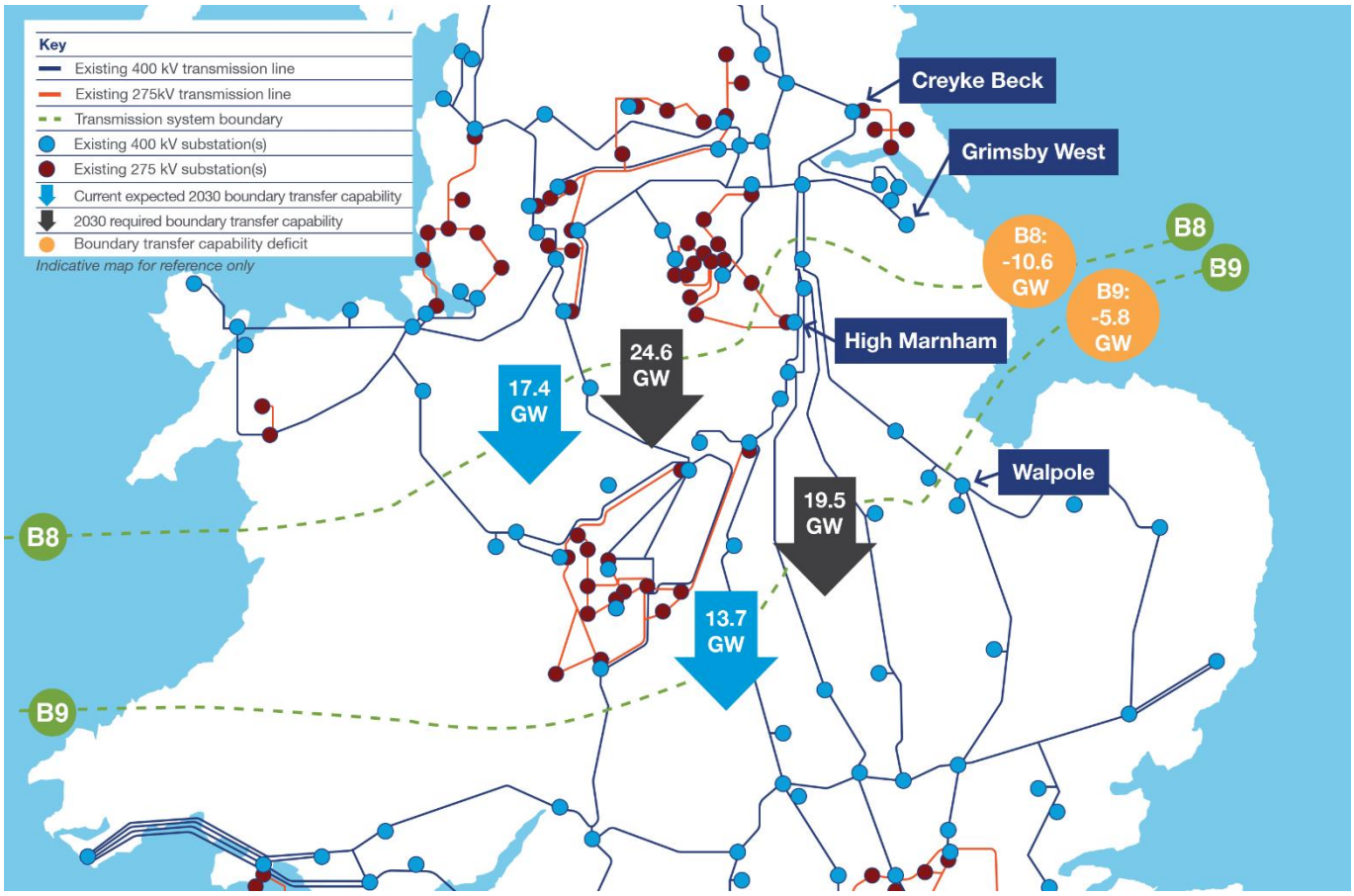


Table A summarises the results from our assessment of the existing transmission system capacity/capability and the volume of additional transmission system capacity/capability needed to meet both the boundary requirements of 2030 and the further contracted generation connection requirements beyond that target date. That additional capability is needed so that all transmission licence obligations can be met. The boundary requirements are based on the Future Energy Scenarios (FES) and the Electricity Ten Year Statement (ETYS), and are an average of the capability needed to meet 90% of network conditions across the three FES that meet the government's net zero ambition.

Table A – Additional transmission system boundary capability required by 2030 and generation group capacity by last contracted date

Areas of transmission system assessed	Additional generation export required from generation group/boundary (MW)	Pre 2030 transmission system capacity/capability (MW)	Additional transmission system capacity/capability deficit (MW)
Creyke Beck generation group - Contracts to 2037	13,026	6,930	-6,096
East Coast (South Humber to North Wash) generation	7,615	0	-7,615

group - Contracts to 2034			
B8 transmission system boundary by 2030	24,632	14,000	-10,632
B9 transmission system boundary by 2030	19,570	13,700	-5,870

Table A shows the additional transmission system capability that would need to be provided to facilitate new generation connections for each of the:

- Creyke Beck generation group.
- East Coast (South Humber to North Wash) generation group. It should be noted that currently there is no existing transmission system capability within this region.
- B8 and B9 transmission system boundaries.

Options considered

In normal circumstances the transmission requirement for the generation groups should be less than the levels set in Table A. This is due to the generation connection criteria in the SQSS requiring the network to be designed based upon typical power station operating regimes within a generating group, which does not assume full output from every generator connected, but a likely output instead.

In this case, both groups contain significant levels of wind powered generation and it is therefore more likely that the group outputs will be close to the levels in Table A on windy days. On this basis, any further calibration of the additional transmission system capability isn't considered necessary in this case.

The additional transmission system capability required, as set out in Table A, needs to address two distinct sets of issues:

- Issue (a) - the need to provide a new AC transmission double circuit or multiple HVDC connections, which would ensure compliance for the Creyke Beck generation group connections, whilst also providing >6 GW of additional boundary capacity across the B8 boundary.
- Issue (b) - the need to provide a new AC transmission double circuit or multiple HVDC connections, which would provide capacity for the East Coast generation group connections, whilst also increasing the boundary capacity across B8 by an additional >6 GW (an increase of >12 GW capacity in total) and providing >6 GW of capacity across the B9 boundary.

The need to provide significant additional boundary capability and to connect several of the generators by 2030, together with the further contracted generation requirements, has resulted in options being assessed to meet all these requirements with the most efficient network improvements. This may mean that some of the connection capacity will be made available ahead of contracted dates.

We also evaluated the interactivity between the options considered in this report with the options that have been identified for the connection of offshore transmission circuits from Scotland, referred to as Eastern Green Link 3 (EGL3) and Eastern Green Link 4 (EGL4). EGL3 and EGL4 each consist of 2 GW voltage source convertor (VSC) high voltage direct current (HVDC) transmission circuits. Together, EGL3 and EGL4 will transfer 4 GW of energy between Scotland and England to meet the requirements of generation connections in Scotland.

Based on current development proposals that inform the latest ETYS requirements, EGL3 and EGL4 are indicated to connect south of the Humber, possibly above the B8 boundary and definitely above the B9 boundary. The links were deemed to be required by 2030 in the Holistic Network Design (HND) and Network Options Assessment (NOA) refresh, published in July 2022.

The EGL3 and EGL4 projects will be subject to their own full review of strategic options. However, the location of the connection points selected for these projects has an impact on the extent of transmission system assets that could be required in the Lincolnshire region. We therefore undertook an interactivity assessment, to investigate how a connection location for EGL3 and EGL4, can impact upon the amount of additional transmission system infrastructure that would be required in the immediate future. Our evaluation included consideration of interactions between EGL3 and EGL4 and options to resolve issue (b) described above.

To meet the 2030 requirements of B9 an additional double circuit from North Lincolnshire to Hertfordshire, referred to as LRN4 in the Electricity System Operator's Network Options Assessment Refresh 2021/22, was recommended. A further new double circuit crossing B9 to Walpole (WWNC) was recommended for development in subsequent years to meet further increases in the B9 requirement. The recommendations were based on the connection circuits for the East Coast generation connecting to the existing transmission system to the North of B9, and therefore not providing any B9 capacity.

In developing and assessing our options we have considered the interaction of EGL3 and EGL4's connection locations, the connection requirements for the East Coast generation group, and the HND/NOA recommendations for two circuits across B9, to determine the overall optimum developments.

The strategic options we considered to resolve issue (a) (Creyke Beck generation group connections and >6 GW capacity across B8) are:

- ECO 1 – New Creyke Beck to new High Marnham **85 km**
- ECO 2 – New Creyke Beck to Cottam **75 km**
- ECO 3 – New Creyke Beck to new Grimsby West, new Grimsby West to new Walpole **225 km**
- ECO 4 – New Creyke Beck to new Grimsby West, new Grimsby West to new Weston Marsh **200 km**
- ECSS 1 – Subsea from new Creyke Beck to new Walpole **195 km**

The strategic options we considered to resolve issue (b) (East Coast generation group connections and the further >6 GW capacity across B8 (>12 GW total) and >6 GW of capacity across B9) are:

- ECO 5 – New Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) to new Walpole **140 km**

- ECO 6 – New Grimsby West to new Lincolnshire Connection substation(s), Lincolnshire Connection substation(s) to new Weston Marsh, new Weston Marsh to new Walpole **140 km**
- ECSS 2 – Subsea new Grimsby West – new Offshore Connection Node – new Walpole **155 km**

Our initial interactivity assessment to determine the best location for the connection of the EGL3 and EGL4 projects to provide an overall, best infrastructure solution considered the following strategic options:

- EGL Option 1 – both connect at new Lincolnshire Connection substation(s)
- EGL Option 2 – both connect at Cottam substation
- EGL Option 3 – both connect at new Walpole substation
- EGL Option 4 – both connect at new Walpole substation, with one project forming a three-ended circuit, connecting to new Lincolnshire Connection substation(s) and new Walpole substation.

The appraisal of strategic options that could address the identified transmission system reinforcement needs considered the likely environmental and socio-economic effects, technical issues and cost that would be associated with each strategic option.

Preferred options

Issue (a)

ECO 1 and ECO 2 options would have a significantly shorter overhead line route than that of ECO 3 and ECO 4. There are expected to have lower environmental and socio-economic effects, as well as lower capital and lifetime costs. ECO 1 and ECO 2 are therefore preferred to ECO 3 and ECO 4 amongst the Creyke Beck generation group onshore options.

ECO 1 has technical advantages when compared to ECO 2. ECO 1 performs better in terms of boundary capacity, while also being less constrained in terms of routeing due to the proposed connection to a new substation at High Marnham rather than Cottam. A comparison of the Cottam and High Marnham sites indicates that High Marnham offers substantial cost savings, as well as reduced constructability risks. Overall, therefore, ECO 1 is the preferred onshore option.

An offshore option, ECSS 1, has also been assessed. Based on the information currently available, technical, environmental and socio-economic factors are not considered to differentiate between offshore and onshore options. However, ECSS 1 was substantially more expensive than any of the onshore options.

We therefore consider that, overall, ECO 1 represents the most advantageous of the Creyke Beck generation group options when balancing cost, technical performance and environmental and socio-economic effects.

Issue (b)

In terms of the East Coast Generation Group onshore options, ECO 5 and ECO 6 offer similar technical performance, and the transmission circuits are similar in length. This means that the levels of environmental and socio-economic effects associated with the transmission circuits would be expected to be similar. However, a key difference between these options is that an additional substation at Weston Marsh would be required for ECO 6. The additional substation

has potential to result in long term landscape and visual effects due to the introduction of new substation infrastructure in a landscape which currently has little major development, as well as incurring additional cost that could be avoided with ECO 5. ECO 5 is therefore the preferred onshore option.

An offshore option, ECSS 2, has also been assessed. Again, based on the information currently available, technical, environmental and socio-economic factors are not considered to differentiate between offshore and onshore options. However, ECSS 2 was substantially more expensive than either of the onshore options. This means that onshore options are preferred.

We therefore consider that, overall, ECO 5 represents the most advantageous of the East Coast generation group options when balancing cost, technical performance and environmental and socio-economic effects.

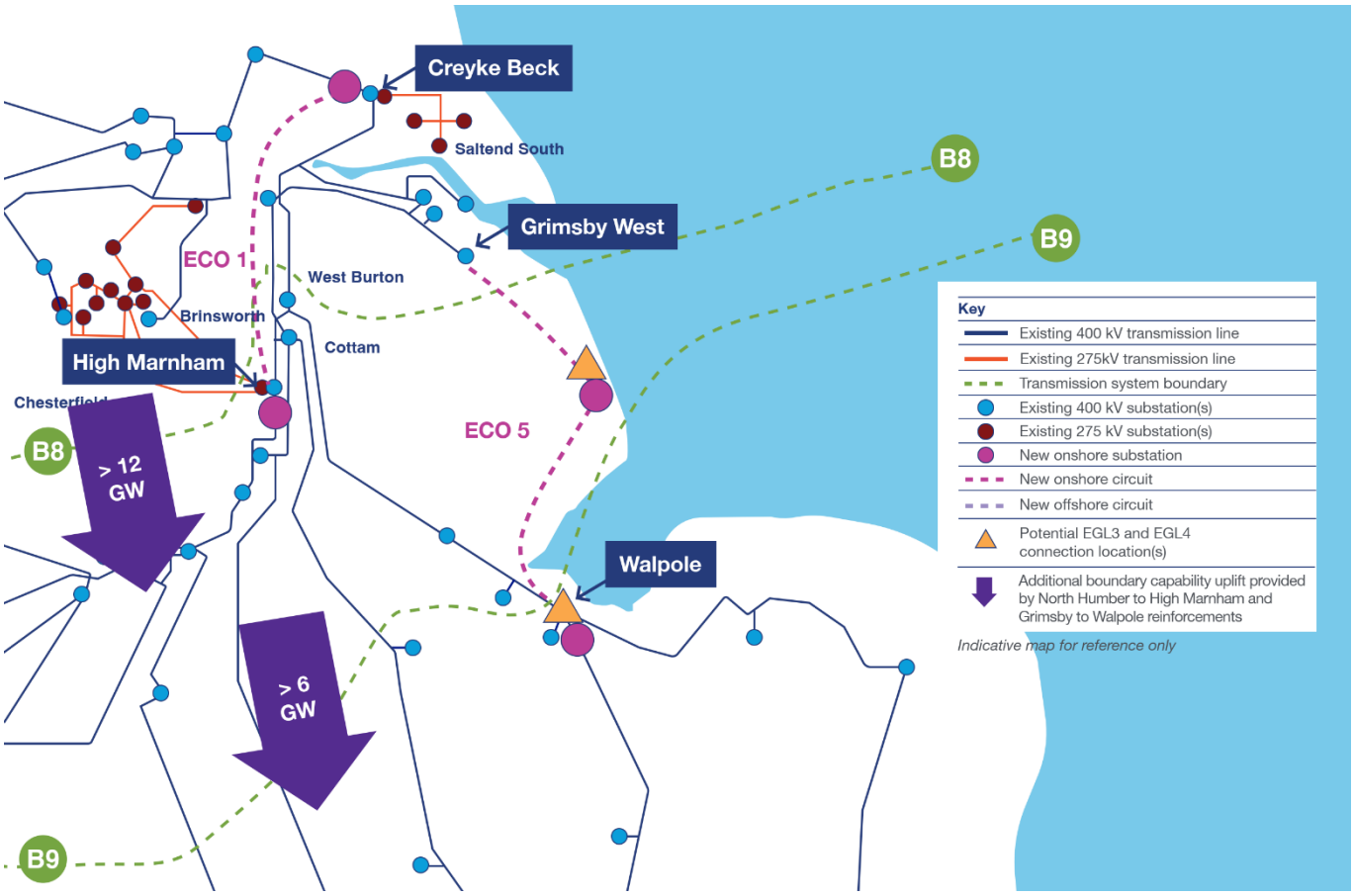
NGET therefore proposes to take forward the following options:

- **To resolve Issue (a)** – ECO 1 a new primarily overhead line connection between new Creyke Beck substation to new High Marnham substation. With a high-level assessment capital cost of **£454m** and lifetime circuit cost of **£582m**. This has been assigned the project title of **"North Humber to High Marnham"**.
- **To resolve Issue (b)** – ECO 5 a new primarily overhead line connection between new Grimsby West substation to new Walpole via Lincolnshire Connection substation(s). With a high-level assessment capital cost of **£1,000.5m** and lifetime circuit cost of **£958m**. This has been assigned the project title of **"Grimsby to Walpole"**.

This report also recommends that EGL3 and EGL4 should be connected south of the B9 boundary to a Main Interconnected Transmission System substation, indicatively identified as a new Walpole substation. This option should have ability to provide a three ended connection to Lincolnshire Connection substation(s) to provide additional capacity.

As indicated above, moving EGL3 and EGL4 south of B9 will provide increased boundary capacity. Also, by providing one of these links as a 3 ended HVDC circuit (EGL Option 4), this would also provide additional future generation capacity to the Lincolnshire Connection substation(s). Provision of this capacity removes the need to construct the 90km Lincolnshire section of LRN4 overhead lines.

Figure C – The preferred options to progress, including EGL3 and EGL4 recommendation



1. Introduction

1.1 This Strategic Options Review (this report) has been prepared by National Grid Electricity Transmission plc (NGET) as part of the decision-making process involved in promoting new transmission projects. It records how NGET has had regard to a range of considerations in developing those projects. This report has been prepared in accordance with NGET's document '*Our Approach to Consenting*'[1].

1.2 This report addresses two projects in particular, the North Humber to High Marnham and Grimsby to Walpole projects ('the Projects'). The Projects are described in greater detail later in this report. This consideration of strategic options is part of an iterative process in response to interaction of a range of emerging energy projects and customer requirements. This report also considers how the Projects interact with other proposals, which would connect power flows from the North and Scotland, with strategic options for the Projects.

1.3 As we continue to develop our plans and as our proposals evolve, we keep strategic options under review, taking account of consultation feedback and any changes that might influence the assessment of technical, environmental, socio-economic and cost considerations.

1.4 As set out in "Our Approach to Consenting" there are 5 stages. This report forms part of the "Options identification and selection stage" and is at the very start of the process, as shown below. This report provides information about scheme development, to support non-statutory consultation.

Figure 1.1 – Approach to consenting process

1.5 The report is structured as follows:

- Background to England and Wales electricity transmission system (Section 2).
- Summary of the need case (Section 3)
- Identification of strategic options (Section 4)
- Options assessment process (Section 5)
- Strategic options overview (Section 6)
- Appraisal of strategic options (Section 7,8,9,10,11,12,13,14)
- Strategic options appraisal conclusions (Section 15)

[1] Our Approach to Consenting, National Grid (April 2022) https://www.nationalgrid.com/electricity-transmission/document/142336/download

- Interaction with other projects (Section 16)
- Conclusion and next steps (Section 17)

1.6 This document is also supported by a detailed set of appendices setting out NGET's obligations, technology assumptions and cost appraisal methodology. The supporting document is called "Strategic options technical appendix 2020/2021 price base".

2. Background to England and Wales electricity transmission system

2.1 Background

2.1.1 In 2019 the Committee on Climate Change (CCC) published its Net Zero report setting out recommendations to the UK Government on long-term emissions targets for the UK. The Government subsequently adopted the Climate Change Act 2008 (2050 Target Amendment) Order 2019[22], which increased its pledge to achieve 100% reduction in emissions by 2050. One of the ways this will be achieved is through decarbonisation, including moving away from fossil fuels providing energy to our homes and businesses. The vision for a transition to clean energy was set out in December 2020 with the publication of the Energy White Paper[33], which added further detail to the Prime Minister's Ten Point Plan for a Green Industrial Revolution. This requires the adoption of alternative sources of energy to power our homes, transport and businesses.

2.1.2 As a result, electricity production is now moving towards reducing greenhouse gas emissions, by increasing renewable and low carbon sources, such as offshore and onshore wind, solar energy and new nuclear generation. The National Infrastructure Commission (NIC) has published a report recommending to the UK Government that renewable generation[44] can be increased to 65% of supply by 2030 at no adverse cost to consumers, enabling the decarbonisation in part of sectors such as transport and heating via electrification.

2.1.3 Following the publication of the NIC report, the UK Government published the British Energy Security Strategy[55] in April 2022 setting out a strategy for secure, clean and affordable British energy for the long term. This strategy sets out energy ambition across a number of sectors such as, including:

- Up to 8 Reactors of Nuclear energy being progressed reaching up to 24GW to be achieved by 2050;
- Up to 50GW of offshore wind connected by 2030 including 5GW of which will be offshore floating wind;
- Up to 10GW of low carbon hydrogen production capacity by 2030, doubling the previous ambition; and

[2] Net Zero the UK's Contribution to stopping global warming, Committee on Climate Change (2019) https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

[3] Energy White Paper: Powering our net zero future, HM Government (December 2020) . https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

[4] Operability of highly renewable electricity systems, National Infrastructure Commission (2021) https://nic.org.uk/studies-reports/operability-highly-renewable-electricity-systems/

[5] Department for Business, Energy & Industrial Strategy. Policy paper: British energy security strategy, HM Government (2022). Available at: https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

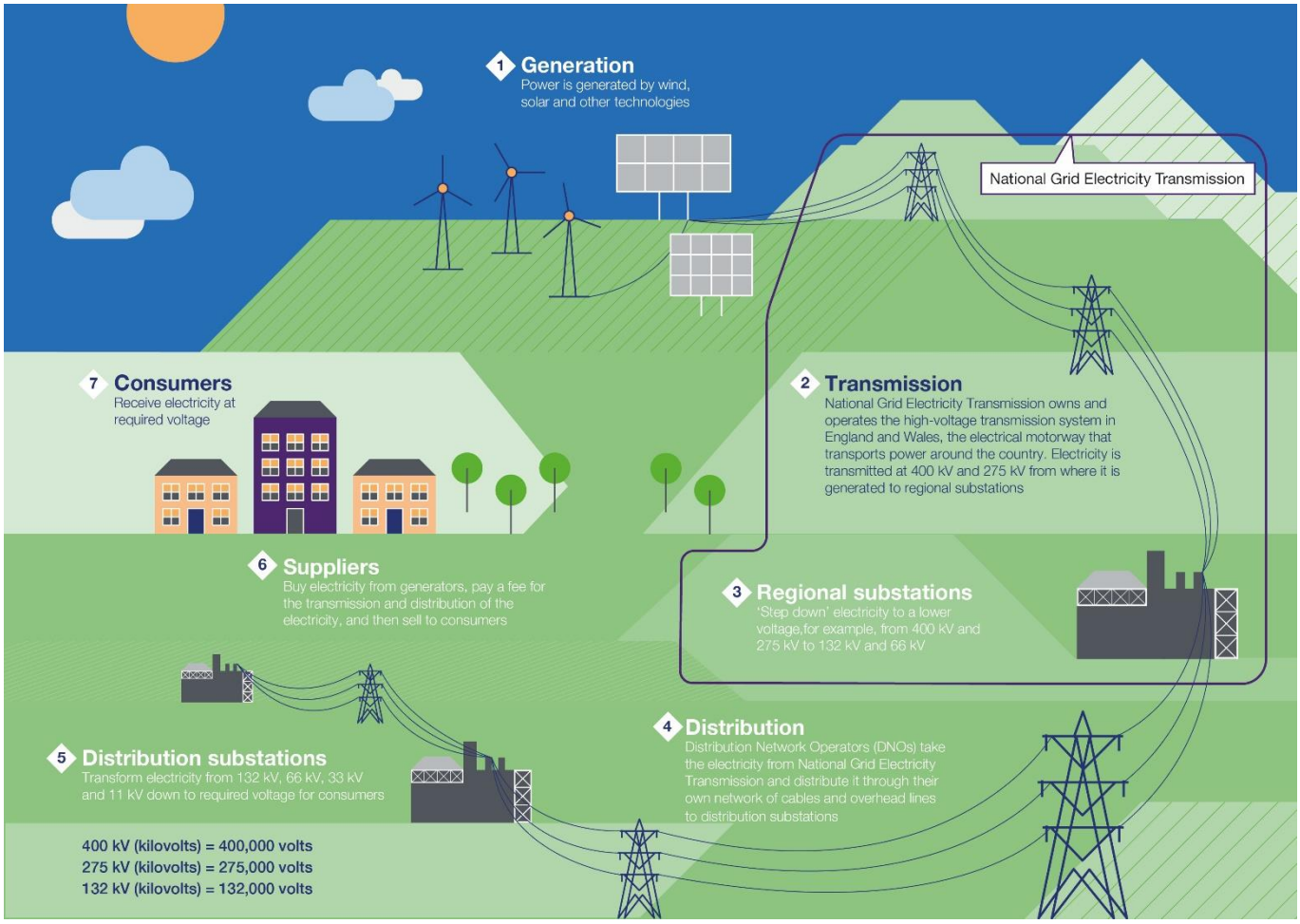
- 600,000 heat pump installations a year by 2028 and improving housing stock insulation.

2.1.4 The Powering Up Britain paper was published in March 2023 by the UK Government. This document provides an update of the strategy for secure, clean and affordable British energy for the long term future, and closely relates to the points raised in Section 3.1.3.

2.1.5 To facilitate these ambitions, electricity network infrastructure is needed to ensure that energy can be transported from where it is generated to where it is used.

2.1.6 The existing transmission system operates at 400 kV and 275 kV and transports bulk supplies of electricity from generating stations to demand centres. Distribution systems operate at 132 kV and below in England and Wales and are mainly used to transport electricity from bulk infeed points (interface points with the transmission system) to the majority of end customers. See Figure 2.1 below**.**

Figure 2.1 – The electricity system from generator to customer



2.1.7 A single electricity market serves the whole of Great Britain. In this competitive wholesale market, generators and suppliers trade electricity on a half hourly basis. Generators produce electricity from a variety of energy sources, including coal, gas, nuclear and wind, and sell energy produced in the wholesale market. Suppliers purchase electricity in the wholesale market and supply to end customers.

2.1.8 Electricity can also be traded on the single market in Great Britain by generators and suppliers in other European countries. Interconnectors with transmission systems in

France, Northern Ireland, Belgium, Denmark and the Netherlands are used to import electricity to and/or export electricity from the transmission system.

2.2 National Grid's role

2.2.1 National Grid Electricity Transmission plc (NGET) is the owner of the high voltage transmission system in England and Wales and is part of the National Grid Group of companies.

2.2.2 Transmission of electricity in Great Britain requires permission by a licence granted under Section 6(1)(b) of the Electricity Act 1989[6] (as amended) (the Electricity Act). NGET has been granted a transmission licence (the Transmission Licence) and is therefore bound by legal obligations, which are primarily set out in the Electricity Act and the Transmission Licence. In its role in providing transmission services in England and Wales, NGET is regulated by the Office of Gas and Electricity Markets ('Ofgem').

2.2.3 NGET's legal obligations include duties under section 9, section 38 and Schedule 9 of the Electricity Act. In summary, these require National Grid to:

- develop and maintain an efficient, co-ordinated and economical system of electricity transmission;
- when formulating proposals for the installation of electric line or the execution of any other works for or in connection with the transmission or supply of electricity, have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and
- when formulating such proposals, do what it reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects.

A fuller consideration of NGET's legal duties is set out in Appendix A.

2.2.4 The Electricity System Operator (ESO) is a separate legal entity to NGET, but as of 2023 is still part of the National Grid Group. The ESO facilitates several roles on behalf of the electricity industry, including making formal offers to connection applicants to the National Electricity Transmission System (NETS).

2.2.5 NGET is obligated to provide the physical connections to the elements of the NETS that NGET own.

2.3 National Grid's existing transmission system

2.3.1 The electricity transmission system is a means of transmitting electricity around the country from where it is generated to where it is needed. The existing transmission system was developed to transport electricity in bulk from power stations to demand centres. Much of NGET's transmission system was originally constructed in the 1960s. Incremental changes to the transmission system have subsequently been made to meet increasing customer demand and to connect new power stations and interconnectors with other transmission systems.

[6] Electricity Act 1989, c. 29., HM Government (1989 as amended) https://www.legislation.gov.uk/ukpga/1989/29/contents

2.3.2 NGET's transmission system consists of approximately 7,200 km of overhead lines and a further 700 km of underground cabling, operating at 400 kV and 275 kV. In general, 400 kV circuits have a higher power carrying capability than 275 kV circuits. These overhead line and underground cable circuits connect around 340 substations forming a highly interconnected transmission system. Further details of the transmission system including geographic and schematic representations are published by the ESO annually as part of its Electricity Ten Year Statement[7] (ETYS).

2.3.3 NGET provides a connection between large generation stations and the connection of demand for homes and businesses in England and Wales. The generation directly connected to the electricity transmission system tends to be of two types: low carbon energy (nuclear, wind farms, solar) and large thermal generation (gas powered generation and older fossil fuel powered generation). This is also supplemented by new storage technologies such as battery storage and hydro storage.

2.3.4 Circuits are those parts of the system used to connect between substations on the transmission system. The system is mostly composed of double-circuits (in the case of overhead lines carried on two sides of a single pylon) and single-circuits. Substations provide points of connection to the transmission system for power stations, distribution networks, transmission connected demand customers (e.g. large industrial customers) and interconnectors.

2.4 How the transmission system operates

2.4.1 A generation group consists of a number of existing generating stations and / or proposed generating stations connecting in a particular geographical area of the transmission system.

2.4.2 Proposed generating stations require a connection agreement with the ESO to authorise their connection to the transmission system. The relevant transmission owner must then assess the generation group to ensure that the transmission system is sufficient in the area to accommodate the existing and proposed generation. Upon completion of the assessment, the ESO will make a formal offer of connection.

2.4.3 The capacity of the transmission system is based on the physical ability of electrical circuits to carry power. Each circuit has a defined capacity and the total capacity of the circuits in a region or across a boundary is the sum of all of the capacity of all the circuits.

2.4.4 The *capability* of the transmission system is the natural flow of energy that can occur in the infrastructure comprising the network. Due to the physical properties of the transmission system, this is often not as great as the theoretical capacity of the infrastructure in question.

2.4.5 Where power flows are constrained by the transmission system across a specific number of circuits, this is termed a "boundary" by the ESO. Such boundaries are used in the ETYS to identify constraints which may require changes to the transmission system in the next 10 years.

2.4.6 Where capacity and capability of the transmission system are not sufficient, either from a generation group or across a boundary, National Grid will be required to reinforce the

[7] Electricity Ten Year Statement, National Grid ESO (2022) https://www.nationalgrideso.com/document/275611/download

network. It does this by either modifying the existing network (if possible) and / or constructing additional transmission infrastructure to resolve the shortfall.

2.5 Requirement for changes to the transmission system

2.5.1 Under the terms of the Transmission Licence, NGET is required to provide an efficient, economic and co-ordinated transmission system in England and Wales. The transmission infrastructure needs to be capable of maintaining a minimum level of security of supply and of transporting electricity from and to customers. NGET is required to ensure that its transmission system remains capable as customer requirements change.

2.5.2 The transmission system needs to cater for demand, generation and interconnector changes. Customers can apply to the independent National Grid ESO for new or modified connections to the transmission system; The ESO is then required to respond to each customer application with an offer for a new or modified connection.

2.5.3 In line with the Government's 2050 targets, a large volume of applications have been made to National Grid ESO for connection at locations that are more remote from the existing transmission system, or which are in the vicinity of parts of the transmission system that do not have sufficient capacity available for the new connection.

2.5.4 NGET has a key role providing a transmission system which serves all consumers in England and Wales. As a monopoly, NGET is regulated by the Office of Gas and Electricity Markets (Ofgem) on behalf of consumers and is required to operate in accordance with the Transmission Licence. This includes maintaining reliable electricity supplies and offering to connect new energy suppliers. Where the network needs to be developed to do that, NGET must be efficient, co-ordinated and economical and have regard to the desirability of preserving amenity, in line with the duties under sections 9 and 38 of the Electricity Act.

2.5.5 In developing new network infrastructure proposals, NGET is therefore guided by the legislative and policy framework set by the UK Government. Including requirements set out in the Planning Act 2008 and associated National Policy Statements as described in detail in Appendix B.

2.6 Electricity System Operator (ESO) role in development of the transmission system

2.6.1 The ESO has annual processes to publish the ETYS, which sets out the network performance and requirements for all transmission in Great Britain over the next 10 years.

2.6.2 The ESO also has annual processes to publish the Future Energy Scenarios[8] (FES) which take a number of energy industry views as part of a consultation process and develop a set of possible energy growth scenarios.

[8] Future Energy Scenarios, National Grid ESO (2022) https://www.nationalgrideso.com/future-energy/future-energy-scenarios

2.6.3 Similarly, it has an annual process to publish the Network Options Assessment[9] (NOA), which considers options for reinforcing the transmission system and makes economic recommendations. This document takes account of the ETYS and FES to establish via a Cost Benefit Analysis (CBA) process when it is right to take forward options proposed by transmission owners to increase network capacity. This considers the capital cost of the proposal, delivery timescales and constraint costs (as explained further below) avoided by delivering the proposal. This establishes when a proposed reinforcement becomes the most economic, efficient and coordinated way to deliver value to Great Britain's energy consumers.

2.6.4 The ESO manages shortfalls in boundary capacity by reducing power flows and constraining generation. This is achieved by paying generators to reduce their outputs, known as 'constraint costs'. Ultimately, constraint costs are passed on to consumers and businesses through electricity bills.

2.6.5 The ESO published the Holistic Network Design[10] (HND) report in summer 2022. It is now engaged in the HND Follow Up Exercise. The HND sets out a single integrated transmission network design that supports the large-scale delivery of electricity generated from offshore wind.

2.6.6 The ESO is also undertaking the Offshore Co-ordination Project, of which the HND is part. This considers how the transmission network is designed and delivered, to ensure that the transmission connections for offshore wind generation are delivered in the most appropriate way considering the increased ambition for offshore wind to achieve net zero. It considers environmental, social and economic costs.

2.6.7 Subsequent to the ESO reinforcements identified in HND and NOA refresh, Ofgem have published the Accelerated Strategic Transmission Investment (ASTI) decision, which aims to facilitate achieving government targets by streamlining the regulatory approval and funding process for ASTI projects.

[9] Network Options Assessment 2021/22 Refresh, National Grid ESO (2022) https://www.nationalgrideso.com/document/262981/download

[10] National Grid ESO. (2022). Pathway to 2030. A holistic network design to support offshore wind deployment for net zero. National Grid ESO (2022) https://www.nationalgrideso.com/future-energy/pathway-2030-holistic-network-design

3. Need case

3.1 Background

3.1.1 The electricity industry in Great Britain is undergoing unprecedented change. Closure of fossil fuel burning generation and end of life nuclear power stations means significant additional investment in new generating and interconnection capacity will be needed to ensure existing minimum standards of security and supply are maintained.

3.1.2 Growth in offshore wind generation and interconnectors to Europe has seen a significant number of connections planned in Scotland, England and significantly in areas of the East Coast of England.

3.1.3 The Climate Change Act 2008 (as amended) now commits the UK Government by law to reducing greenhouse gas emissions by at least 100% from the 1990 baseline by 2050, strengthening the likelihood of most of these connections progressing to delivery. This 2050 target is commonly known as 'Net Zero'.

3.1.4 To achieve Net Zero, there will need to be a substantial shift away from the use of fossil fuel burning generation. This has led to investment in offshore wind generation, which will increase further in the future.

3.1.5 Historically, the transmission system was powered by coal-powered generating stations. The increasing importance of low carbon generation has driven the closure of these generating stations, with more expected to close in the future. This generating capacity is being replaced by low carbon generation which is geographically located away from the coal powered generating stations. The transmission system must be updated to reflect the location of the generating stations.

3.1.6 Electricity demand is especially concentrated in large urban areas, including urban areas in the M62 corridor, the M18 corridor, the Midlands, the M4 corridor and the Southeast. The transmission system carries bulk energy from the generators to points on the network where that power is taken onto the distribution networks for onward transmission to homes and businesses across England and Wales. As the country decarbonises, this demand for energy will increase and replace fossil fuel usage.

3.2 National Electricity Transmission System Security and Quality of Supply Standard

3.2.1 NGET must comply with Section 9 of the Electricity Act and Standard Condition D3 (Transmission system security standard and quality of service) of its Transmission Licence. This means that where the boundary capacity of the Main Interconnected Transmission System (MITS) is exceeded against the standards, NGET must resolve the capacity shortfall under the terms of its Transmission Licence. The standards against which NGET assesses these shortfalls are set out in the "*Design of the Main Interconnected Transmission System*" section of the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS).

3.2.2 The NETS SQSS also sets out in "*Generation Connection Criteria applicable to the onshore transmission system*" that connections to the transmission system must be

secured to meet the identified requirements. Where the NETS SQSS applies, the generator(s) are considered part of a "generation group" for assessment against these criteria.

3.2.3 Generators apply to National Grid ESO for connections to the NETS in Great Britain. If the application is for an onshore generation connection, the applicant will indicate the specific location of the generating station, which will indicate the likely geographical connection to the transmission system. If the application is for an offshore connection or impacts multiple transmission owners, the ESO will co-ordinate the process known as CION[11]/HND to determine the preferred connection option.

3.2.4 The ESO ensures the relevant on-shore or off-shore transmission owner undertakes generation connection process studies via the relevant process and makes a connection offer to the customer for a connection point and identifies the relevant infrastructure work needed to make the connection. Once this offer is signed the connection is recorded on the Transmission Entry Capacity (TEC) Register and forms a contractually binding connection location and timescale with which the transmission owner, such as NGET, is required to connect the generation customer or undertake the works to facilitate their connection.

3.2.5 A connection offer will normally be given in respect of a particular geographical area. Sometimes this leads to a presumption as to the connection point located on the existing transmission network. In other circumstances where there is no or little existing transmission infrastructure, this will require the provision of new infrastructure. The post-connection offer assessment process enables further evaluation of the preferred connection option and refinement of the preferred overall transmission solution. This process continues, informed by evolving circumstances and consultation, until an application is submitted for development consent in relation to a transmission project.

3.2.6 NGET assesses the adequacy of its transmission system in accordance with the method defined in the NETS Security and Quality of Supply Standard (SQSS). We are required to assess power flows between regions of the transmission system (Planned Transfers). The Planned Transfer from the region is calculated by taking the Average Cold Spell (ACS) Peak Demand in the region and generation following the modelling set out in the NETS SQSS. The Planned Transfer is therefore the amount of power which will flow out of the region at ACS peak. Planned Transfer calculations will always consider the power flows for ACS peak demand conditions, as less generation will be entering the market when demand is lower.

3.2.7 Any transmission system is susceptible to faults that interfere with the ability of transmission circuits to carry power. Most faults are temporary, many are related to weather conditions such as lightning or severe weather, and many circuits can be restored to operation automatically in minutes after a fault. Other faults may be of longer duration and would require repair or replacement of failed electrical equipment.

3.2.8 Whilst some of these faults may be more likely than others, faults may occur at any time, and it would not be acceptable to have a significant interruption to supplies as a result of specified fault conditions, including combinations of faults. The principle underlying the NETS SQSS is that the NETS should have sufficient spare capability or "redundancy" such that fault conditions do not result in widespread supply interruptions. The level of security of supply has been determined to ensure that the risk of supply interruptions is managed to a level that maintains a minimum standard of transmission

[11] Connection and Infrastructure Options Note / Holistic Network Design

system performance. The faults we need to design the system to be compliant with are called "Secured Events"

3.2.9 The NETS SQSS defines the performance required of the NETS in terms of Quality and Security of Supply for secured events that at all times:

- Electricity system frequency should be maintained within statutory limits;
- No part of the NETS should be overloaded beyond its capability;
- Voltage performance should be within acceptable statutory limits; and
- The system should remain electrically stable.

3.3 Existing transmission network

3.3.1 The transmission network in the area of the projects was primarily constructed in the 1960s, at the same time as much of the rest of the transmission system. It was designed to connect the in-land large coal fired power stations in the region, with changes occurring in the later parts of the century connecting gas fired power stations in the Humber region in particular. Little or no transmission infrastructure was constructed in some areas, so there is currently limited ability to support connections on the coast.

3.3.2 The existing transmission system in the North of England and the Midlands is shown in Figure 3.1. The geography under consideration for the projects is shown in Figure 3.2.

Figure 3.1 – The National Electricity Transmission System in the North and Midlands

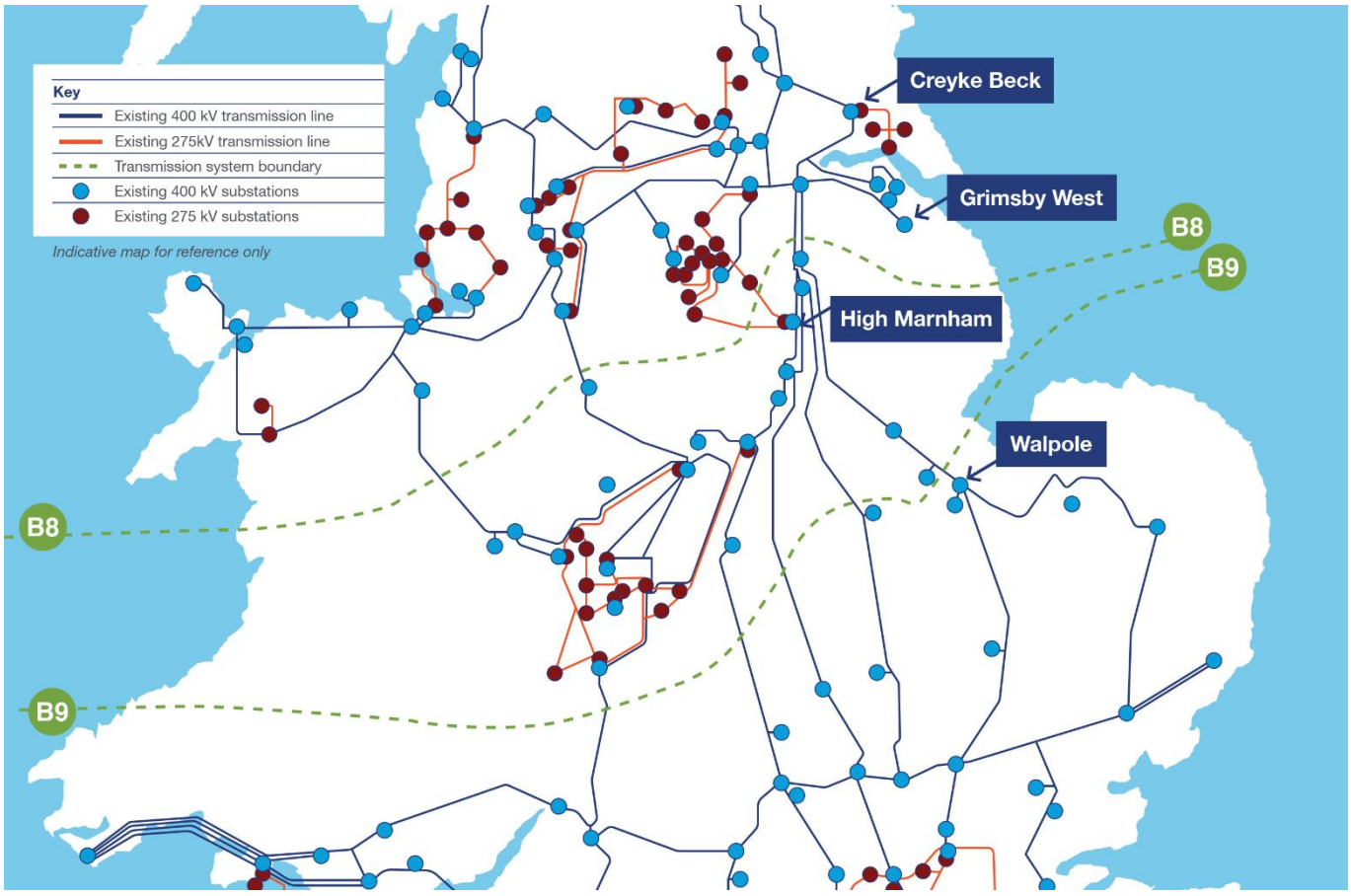
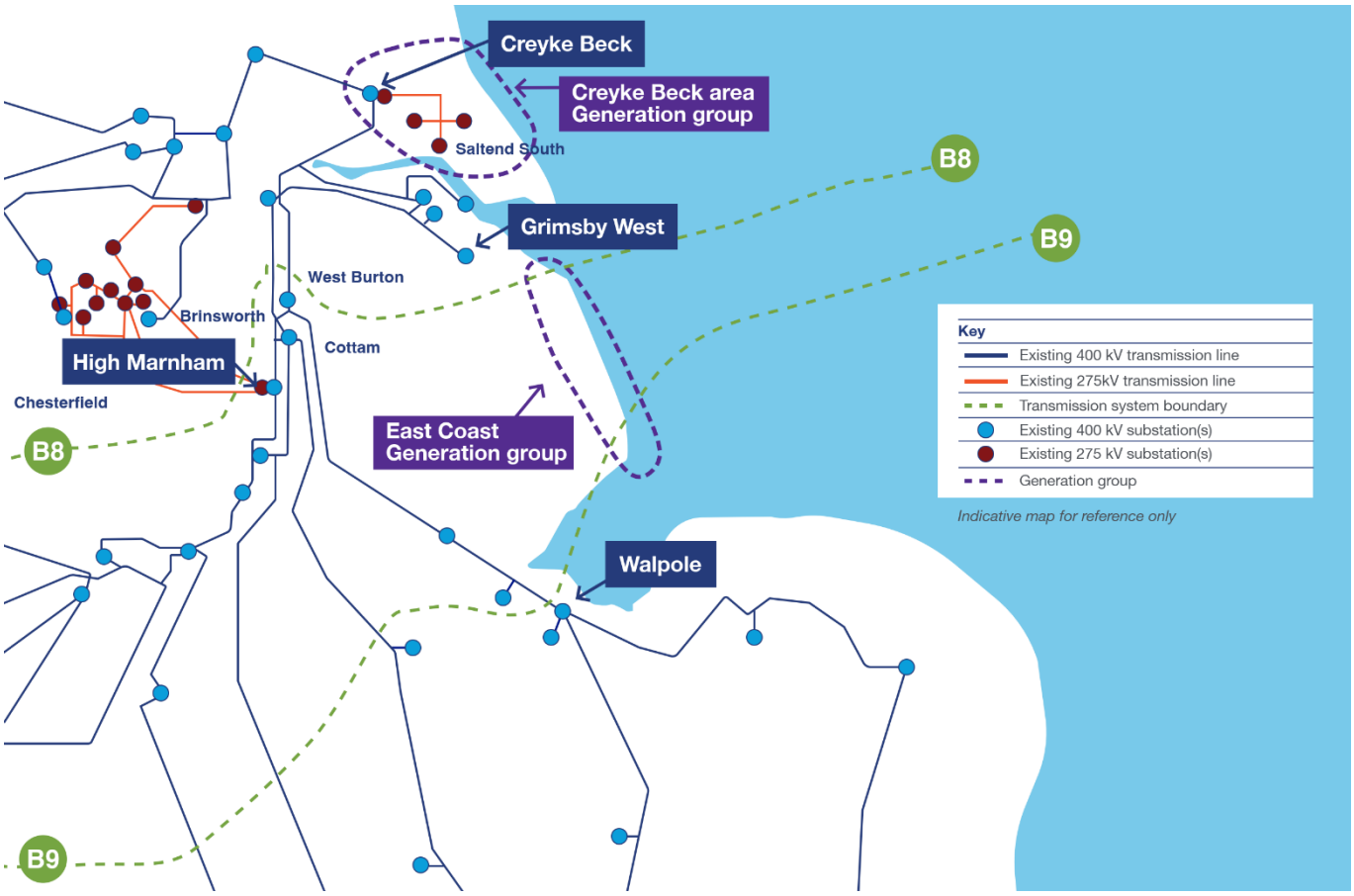


Figure 3.2 – The East Coast (Lincolnshire and Yorkshire) region transmission system



3.4 Generation groups

3.4.1 Figure 3.2 Identifies the two generation group areas under consideration, the first being the Creyke Beck Area generation group and the second being the East Coast Connections generation group (for east coast connections being made from South of the Humber Estuary to North of the Wash).

3.4.2 The Creyke Beck Area generation group consists of existing generation connecting into the current Creyke Beck substation, Hedon substation and the Salt End North and South substations. It also comprises proposed generation contracted to connect in the vicinity of the Creyke Beck substation. This is currently a combination of offshore wind, interconnectors, energy storage and CCGT (combined cycle gas turbine).

3.4.3 The East Coast Connections generation group consists of proposed generation contracted to connect in an area south of the Humber Estuary and north of the Wash. This is currently a combination of offshore wind, interconnectors, energy storage / solar and CCGT.

3.4.4 The generation contracted to connect to the generation group areas specifically are shown in the Table 3.1 and Table 3.2 below. These indicate the contracted generation within each generation group.

Table 3.1 – Connections to Creyke Beck Area (From TEC Registers March 23)

Project Name	Type	Capacity (MW)	Connection Year
Saltend	CCGT	1100.0 MW	Existing
Humber Gateway	Offshore Wind	220.0 MW	Existing
Westermost Rough	Offshore Wind	206.5 MW	Existing
Pillswood BESS Phase 1	Energy Storage	49.9 MW	2022
Pillswood BESS Phase 2	Energy Storage	49.9 MW	2022
Dogger Bank Project A	Offshore Wind	1200.0 MW	2023
Dogger Bank Project 4	Offshore Wind	1200.0 MW	2024
Hornsea Power Station 4 - Stage 1	Offshore Wind	1500.0 MW	2027
Continental Link	Interconnector	1800.0 MW	2027
Atlantic Superconnection	Interconnector	1000.0 MW	2027
Hornsea Power Station 4 - Stage 2	Offshore Wind	1100.0 MW	2028
Clean Air - Creyke Beck	Energy Storage	500.0 MW	2033
North Sea (RWE)	Offshore Wind	1500.0 MW	2033
North Sea B (RWE)	Offshore Wind	1500.0 MW	2033
Saltend North BESS	Energy Storage	100.0 MW	2037
Total		**13026.3 MW**	

Table 3.2 – East Coast Connections between South Humber to North Wash (From TEC Registers March 23)

Project Name	Type	Capacity (MW)	Connection Year
Pivoted Power Norwich	Energy Storage	49.9 MW	2024
Aminth	Interconnector	1400.0 MW	2028
Race Bank Extension	Offshore Wind	565.0 MW	2030
SENECA	Interconnector	1200.0 MW	2031
Norwich Green Energy Centre	Energy Storage/Solar	400.0 MW	2031
Mablethorpe Storage	Storage/CCGT	1500.0 MW	2031
GT R4 Wind Farm	Offshore Wind	1500.0 MW	2033
Carbon Free 2030	Energy Storage/Solar	500.0 MW	2034
Stallingborough PV & BESS	Energy Storage/Solar	500.0 MW	2034
Total		**7614.9 MW**	

3.4.5 Both the Creyke Beck Area and East Coast Connection generation groups have a significant amount of customer generation contracted to connect in each area. Applying the requirements of the NETS SQSS generation criteria, these connection contracts provide the starting locations for reinforcements. To comply with the NETS SQSS, sufficient transmission capacity must be provided to allow the full contracted generation to connect in each generation group. This will impact the B8 and B9 system boundaries along with additional generation from the North and Scotland.

3.5 Boundaries

3.5.1 The transmission system shown in Figure 3.1 and Figure 3.2 also shows two system boundaries, B8 and B9.

3.5.2 A boundary splits the system into two parts, crossing critical circuit paths that carry power between areas and where power flow limitations may be encountered. Boundaries help identify regions where reinforcement is most needed by enabling analysis of power transfers between separated areas. They can be local boundaries, which are small areas of the Transmission System with a high concentration of generation, or wider boundaries, which are large areas containing significant amounts of both generation and demand. Boundary definitions have evolved over many years of planning and operating the transmission system.

3.5.3 Future boundary requirements are assessed using the FES to identify expected future power flows across the boundaries. Power system analysis is conducted by the ESO and NGET to determine the boundary capability, which is the maximum power flow that can be transferred across a boundary while maintaining compliance with technical

standards. Limiting factors on transmission capacity include thermal circuit rating, voltage constraints, and dynamic stability.

3.6 Boundaries B8 and B9

3.6.1 Boundaries B8 and B9 are wider system boundaries containing areas with significant amounts of both generation and demand. Studies have been undertaken to assess the impact of changes in demand and generation on power flows across the boundary and to determine if these impacts require reinforcement to the transmission system.

3.6.2 The boundaries B8 and B9 as described above have been evaluated using the Economy Planned Transfer assessment, which takes prescribed generation contributions from above and below the boundary, alongside demand in each area to determine the expected flow across the boundary. In this case the Economy Planned Transfer condition represents the most onerous boundary condition which must be secured by NGET to the requirements set out in the NETS SQSS.

3.6.3 Each of the circuits which cross the B8 and B9 boundaries has a capacity during the winter ACS period. The summation of the capacity for all of these circuits provides the pre-fault capacity. The post fault capacity is defined by the remaining capacity across a boundary following the worst fault "Secured Event" as described above. Each boundary then will see flows across it based upon the circuit parameters and system conditions, when the natural flow of energy on every circuit will be maximised. This is known as the circuit boundary capability, which is based upon the capability seen following the worst fault "secured event". The following capacities and capabilities are applicable to the boundaries before reinforcement in 2030.

3.6.4 Existing B8 Boundary

- Pre-Fault Capacity 23,531 MW
- Post-Fault Capacity 17,426 MW
- Capability (Post Fault) 14,000 MW

3.6.5 Existing B9 Boundary

- Pre-Fault Capacity 24,411 MW
- Post-Fault Capacity 18,033 MW
- Capability (Post Fault) 13,700 MW

3.6.6 Table 3.3 below shows how the existing generation groups and boundaries perform in 2030 for the expected planned transfer flows.

Table 3.3 – Existing boundary performance by 2030 and generation group capacity to last contract date

Generation Group or Boundary Export		Pre 2030 Post Fault Capability	Pre 2030 Post Fault Capacity	Capability Deficit	Capacity Deficit	Secured Event Fault
Creyke Beck contracts to 2037 (Generation)	13,026 MW	N/A	6,930 MW	**N/A**	**-6,096 MW**	Creyke Beck – Keadby 400kV
East Coast contracts to 2034 (Generation)	7,615 MW	N/A	0 MW	**N/A**	**-7,615 MW**	N/A
B8 – 2030 (Boundary)	24,632 MW	14,000 MW	17,426 MW	**-10,632 MW**	**-7,206 MW**	Keadby – West Burton 400kV double circuit
B9 – 2030 (Boundary)	19,570 MW	13,700 MW	18,033 MW	**-5,870 MW**	**-1,537 MW**	Walpole – Bicker Fen/Spalding 400kV double circuit

3.6.7 Table 3.3 shows that the Creyke Beck generation group requires additional transmission capacity to facilitate the connections in that area. This sets the location where this capacity is required because there is not sufficient transmission capacity in the region to accommodate all the connections in compliance with NETS SQSS. The East Coast generation connection group also requires transmission capacity. There is no existing transmission capacity where the connections are required. The size of transmission required will be in the order of 6GW for Creyke Beck Area and 7GW in East Coast Area.

3.6.8 In normal circumstances the transmission requirement should be less than these levels. This is due to the generation connection criteria in the SQSS requiring the network to be designed based upon typical power station operating regimes within a generating group. This level changes depending on which individual power station is the subject of the assessment. So, for simplicity, the transmission entry capacity for each generator is shown in Table 3.2 and Table 3.3. This shows additional capacity is clearly needed. The total is reflective of all transmission entry capacity of generators within the group.

3.6.9 The boundary assessments completed on the Economy Planned Transfer already accounts for generation contribution. To ensure representative need for reinforcement, NGET has taken the average requirements to cover 90% of operating conditions of the

System Transformation, Consumer Transformation and Leading the Way FES 2022 scenarios. These are the scenarios that meet the government's 2050 net zero ambition. Against this highly likely requirement, clearly there is a shortfall against boundary capability and capacity, for both the B8 and B9 boundaries which will require reinforcement.

3.6.10 The largest capacity AC route we currently accommodate on our network is two circuit transmission circuits of 3465 MW each, on a single set of towers (6930 MW double circuit capacity).

3.6.11 The largest HVDC capacity systems we currently accommodate with HVDC cables is 2000MW.

3.6.12 Therefore, B8 will require more than the capacity of one 400kV AC double circuit or multiple HVDC connections to be provided for the boundary capability deficit need to be addressed. To accommodate for future requirements, B8 needs to be reinforced by two double AC 400 kV transmission routes (four circuits in total) or 6 HVDC connections to address the 10,632 GW boundary capability deficit.

3.6.13 The B9 boundary will require one 400kV AC double circuit or 3 HVDC Connections, to address the boundary capability deficit of 5,870 MW by 2030.

3.6.14 In both cases it is clear even if flows could be maximised across the boundary for fault secured events, the boundary deficits would still require the reinforcements described for B8 and B9 above.

3.6.15 The ESO independently provide their evaluation of boundaries for the ETYS. For the B8 and B9 boundaries the exports in Table 3.3 align with these assessments. The requirements for 90% of conditions across the four scenarios set out in FES/ETYS show boundary export by 2030 in the range of 18,100MW to 28,929 MW for B8 and 13,902 MW to 23,330 MW for B9. However, it should be noted that the "Falling Short" scenario representing the lower end of the 90% range and does not allow for the achievement of the 2030 Net Zero target.

3.6.16 From 2030 further increases in boundary requirements are expected and this is reflected in NGET’s existing contractual commitments. To address these needs additional reinforcements to these boundaries are expected in Central England and Wales which will supplement these boundaries in the future. This will facilitate connections beyond 2030 when further increases in generation are expected in all regions, which will be subject to their own detailed needs case and options assessment. These future requirements would be informed by further SOR and needs case assessments. These emerging requirements do not affect the need case set out within this SOR.

3.6.17 However, through the NOA refresh published in 2022, the ESO signalled the need for additional reinforcements in the Lincolnshire area beyond 2030. NOA recommended development of a new double circuit across B9, referred to as WWNC. This additional requirement is reflected in NGET’s existing contractual commitments and has been included in our assessments to provide the opportunity to optimise the overall reinforcements in the region in response to this foreseeable need.

3.7 EGL3 and EGL4

3.7.1 NGET is currently evaluating the connection of offshore transmission circuits from Scotland known as EGL3 and EGL4. These projects each consist of 2 GW voltage

source convertor (VSC) high voltage direct current (HVDC) transmission circuits. This will transfer 4 GW of energy from Scotland to England and will be subject to their own strategic option assessment. In the required capability assessments used in this document it has been assumed that these links will connect above the B9 boundary in 2030. How these projects will interact with the B8 and B9 boundaries, and options to reinforce them, is considered later in this report.

4. Identification of strategic options

4.1 Introduction

4.1.1 When a need to reinforce the National Electricity Transmission System (NETS) is established, National Grid Electricity Transmission (NGET) brings together a multi-disciplinary scheme team to evaluate a wide range of options. This team produces a list of strategic options which can be further refined through evaluation processes and which are described within this report. The scheme team keeps the options under review as changes to the drivers emerge. Through this review, options can be modified, or deselected and new options can be added. This section provides the chronological history of the projects that have been evaluated.

4.2 Option Development

4.2.1 The growth of offshore wind in the North Sea requires a change in the transmission system from one focused on large fossil fuel generation located away from the coast to a system focused more on connections in coastal regions of England and Wales. NGET alongside the Electricity System Operator (ESO) has examined East Coast strategies as part of long-term planning which ultimately informed the development of strategic options.

4.2.2 In 2019 the Electricity Ten Year Statement (ETYS) identified that system boundary B8 between the North and South of England would have insufficient capability by 2030 to remain compliant with the NETS Security and Quality of Supply Standard (SQSS).

4.2.3 As a consequence, the 2020 Network Options Assessment (NOA) document produced by the ESO recommended that network reinforcements should be developed to resolve the issue identified in the 2019 ETYS. The recommendations included the construction of new circuits, as described in this document, and a number of smaller reinforcements such as power flow controllers to maximise the benefits of new and existing circuits.

4.2.4 Scheme team members were brought together to produce a long list of options, which was subsequently filtered to evaluate the options that met the recommendations of NOA in 2020.

4.2.5 In 2019, the initial project drivers were to facilitate additional transmission capacity for the generation connection groups at Creyke Beck and East Coast, whilst also providing capacity across the B8 boundary.

4.2.6 In 2019/20, the following generation group and boundary exports were identified and used as part of the options assessment process

- 10.8 GW of total connections in the Creyke Beck generation group
- 4.6GW of total connection in the East Coast generation group
- 20.6GW of capability across B8

4.2.7 These requirements are less than those set out in the needs case section of this report (see Chapter 3). This is because more connection applications have been received since 2019/20, along with additional transfers expected from the North of England and

Scotland. These drive higher requirements for the Creyke Beck and East Coast generation groups, and create an increased transfer requirement across B8, and lead to a need also to resolve a capacity shortfall on the B9 boundary, south of B8.

4.2.8 As part of the ESO evaluation process to produce the NOA they require that NGET, as part of its options appraisal, produce a high level scope with an indicative construction delivery date and capital cost for all of the options proposed. The ESO also requires us to explain the impact of each option on boundary capability, which we assess against the relevant study background at the time of assessment. The ESO use this information as part of their Cost Benefit Analysis (CBA) process, which identifies any variance in benefit to consumers across options, based upon estimated constraint costs. The outcome of the CBA is reflected in the regular NOA publication with a proceed signal against recommended investments.

4.2.9 Through this options identification process, we identified the following options, a combination of which satisfied the need as it was defined in 2019/20;

- Creyke Beck to Killingholme South (West)
- Creyke Beck to Killingholme South (East, via New Hedon)
- Killingholme South to Cottam
- Creyke Beck to Grimsby West (West)
- Grimsby West to Cottam
- Creyke Beck to Grimsby West (East via New Hedon)
- Creyke Beck to Thorpe Marsh (Direct)
- Creyke Beck to Thorpe Marsh (Reuse of ZDA route)
- Thorpe Marsh to Cottam
- Thorpe Marsh to High Marnham
- Creyke Beck to Cottam
- Creyke Beck to High Marnham
- Lincolnshire Coastal Node to Grimsby West
- Lincolnshire Coastal Node to Weston Marsh (two double circuits)
- Lincolnshire Coastal Node to Bicker Fen
- Lincolnshire Coastal Node to Bicker Fen (two double circuits)
- Lincolnshire Coastal Node to Weston Marsh

4.2.10 We also appraised each option for environmental and socio-economic impact, considering a 20 km study area around the strategic option identified. This was done to ensure we understood the main consequences of selecting each strategic option. This meant we could identify the likely significant effects and make comparisons between the options.

4.2.11 All the options were appraised for the purposes of identifying an initial preferred option and providing the relevant information for the independent ESO CBA process for evaluation against operational constraints.

4.2.12 It should be noted that projects which have the shortest delivery timescales will have advantages over those that deliver in longer timescales. Provision of capacity at the earliest opportunity can provide benefit by avoiding constraint costs. Constraint cost evaluation is carried out by the ESO and is captured in their independent CBA process and is regularly evaluated in the NOA updates.

4.2.13 By 2023, the needs case had changed, as described in this report. Options have been developed to meet this needs case, which are described in the sections that follow. Any differences between these new options and those identified in 2019/20 are explained in the next section.

5. Options assessment process

5.1 National Grid has published "Our Approach to Consenting" which sets out how we develop our strategic proposal. We apply the following approach to evaluate options we take forward.

5.2 Firstly, we identify if our existing network could be modified or enhanced to deliver the required connection or increase in capacity.

5.3 If we identify there is a need that is beyond the capability of our existing network, as clearly set out in our project need case, we consider strategic options to provide the required increase in capacity.

5.4 We apply a technical filter as part of this assessment to ensure any solution meets the need, either individually or as part of a wider group of reinforcements. There are many ways to achieve increases to our network capability. To allow us to focus on those that best meet our obligations to the environment and consumers we apply a "benefits filter", which ensures any option we present has a comparable benefit over an alternative. The criteria for an option to be considered are any of the following:

- environmental benefit;
- technical system benefit; or
- capital and lifetime cost benefit.

5.5 Where options are very closely aligned across benefits, then options will be included for appraisal to ensure we capture possible solutions that are of very similar capability.

5.6 All options taken forward for appraisal are evaluated in respect of environmental constraints, socio-economic effects, technology alternatives, capital and lifetime costs. Undertaking this appraisal ensures stakeholders can see how we have made our judgments and balanced the relevant factors in accordance with our legal duties.

5.7 The assessment process considers the following areas:

- Environmental assessment topics which consider whether there are environmental constraints or issues of sufficient importance to influence decision-making at a strategic level, having particular regard for internationally or nationally important receptors.
- Socio-economic topics which consider whether there are socio-economic constraints or issues of sufficient importance to influence decision-making at a strategic level, having particular regard for internationally or nationally important receptors.
- Consideration of technical benefits includes, whether the option is providing the required capacity to meet the needs case; whether the option has particular system benefits over alternatives; whether the option introduces any system complexity that would cause system operability issues.
- Capital and lifetime costs considers a range of factors, which are listed below;
  - Capital cost of the substation and wider works

- Capital cost of the circuit costs for each technology appraised
- Circuit lifetime costs, including circuit capital cost, cost of loses over 40 years and cost of operation over 40 years.

5.8 When considering each strategic option, NGET provides circuit cost information for the following technology options for all land-based options:

- 400 kV alternating current (AC) overhead line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV high voltage direct current (HVDC) underground cable and converter stations

5.9 When considering each strategic option, we provide circuit cost information for the following technology options for all subsea based options:

- 400 kV AC subsea cable
- 525 kV HVDC subsea cable and converter stations

5.10 A full evaluation of technologies and costs used in our assessments can be found in "Strategic options technical appendix 2020/2021 price base".

5.11 In this appraisal, all options are considered using information appropriate to this stage of their development on the assumption that they are deliverable in a reasonable timescale. Timescales and deliverability would only be considered further in the assessment process should they become differentiating factors in the selection of the option that best meets our environmental and legal obligations. If these issues of delivery timescales and risk do become differentiating factors in selection of an option, the issue would be set out clearly in the options conclusion. If it is not differentiating the factor will not be considered further for this assessment.

5.12 At the initial appraisal stage, NGET prepares indicative estimates of the capital costs. These indicative estimates are based on the high-level scope of works defined for each strategic option in respect of each technology option that is considered to be feasible. As these estimates are prepared before detailed design work has been carried out, NGET makes equivalent assumptions for each option. Final project costs for any solution taken forward following detailed design, consenting and risk mitigation will be in excess of any high-level appraisal cost. However, all options would incur these increases proportional to initial estimate in the development of a detailed solution. This methodology ensures that all options for appraisal proposes are compared on a like for like basis.

5.13 Strategic options are identified at a very high level as being electrical solutions between geographic points. Therefore, the potential circuit lengths are derived by taking a straight-line distance between the points and adding 20% to accommodate potential route deviations that might be required if the route proceeds forward to more detailed routeing and siting. Where a clear obstacle exists such as an estuary, water course or geographical feature an alternative route length will be derived and explained in the option. Where a subsea alternative is presented, straight lines will be used to a mid-point offshore and 20% added to provide variation in route length.

5.14 These initial option lengths do not define route corridors, and environmental appraisal is provided over a wide study area between points of connection. Any routes for circuit

technologies to take would be subject to detailed routeing and siting for any strategic option taken forward as a preferred option(s).

5.15 As indicated in the strategic options identification chapter (Chapter 7) a number of options were previously evaluated, which no longer meet the criteria for evaluation when considering the benefits filter or the revised needs case set out in this report. These comprised:

- Options through Thorpe Marsh - as all these options required through connections to Cottam or High Marham from Creyke Beck, there is no advantage against the three benefits filters over the direct route appraised with this report.
- Due to the need case changes and requirement to provide additional capacity over B8, options to Killingholme South offer no advantage to Grimsby West alternatives. In both cases, the substations are north of the B8 boundary and require additional transmission south across the B8 boundary. Both options require similar routes with greater ability to do this via Grimsby West.
- The need case now requires that boundary reinforcement extends across the B9 boundary. Bicker Fen has no advantage over options further to the south, as it is north of the B9 boundary. The reinforcement would therefore have to extend south from Bicker Fen and offers no environmental, technical or cost advantage to the alternatives considered.

5.16 As the need case has changed, options that were not previously evaluated but which may offer benefits over those considered need to be captured for comparison. The following options have been introduced.

- Subsea alternative options which may have environmental and socio-economic differences when compared with alternatives and that might be advantageous.
- Options that provide capacity across B9 and connect to an interconnected part of the system, known as the Main Interconnected Transmission System. This is a point on the system where there are more than two circuits south of the connection point such that energy can still flow south if a fault occurs on any two southern circuits.

5.17 The options in the following sections of this report have been taken forward in this document as they meet the need case and have been selected using the methodology set out above.

6. Strategic options overview

6.1 Introduction

6.1.1 Table 6.1 below was described in detail in the needs case section. This table shows the drivers for reinforcement of the transmission system with the capacity deficits for generation groups and capability deficits for boundaries highlighted.

Table 6.1 – Existing boundary performance by 2030 and generation group capacity to last contract date

Generation Group or Boundary Export		Pre 2030 Post Fault Capability	Pre 2030 Post Fault Capacity	Capability Deficit	Capacity Deficit	Secured Event Fault
Creyke Beck (Generation) contracts to 2037	13,026 MW	N/A	6,930 MW	N/A	-6,096 MW	Creyke Beck – Keadby 400kV
East Coast (Generation) contracts to 2034	7,615 MW	N/A	0 MW	N/A	-7,615 MW	N/A
B8 – 2030 (Boundary)	24,632 MW	14,000 MW	17,426 MW	-10,632 MW	-7,206 MW	Keadby – West Burton 400kV double circuit
B9 – 2030 (Boundary)	19,570 MW	13,700 MW	18,033 MW	-5,870 MW	-1,537 MW	Walpole – Bicker Fen/Spalding 400kV double circuit

6.1.2 As described in the need case, the connection of additional generation to the generation groups requires the transmission system to be reinforced. The B8 boundary will require two 400kV AC double circuit or six HVDC Connections of transmission capacity circuits to deliver >10 GW boundary capability, while B9 will require one 400kV AC double circuit or three HVDC Connections transmission capacity to deliver >6 GW of capacity.

6.1.3 Providing no infrastructure for the need case set out would mean the National Electricity Transmission System (NETS) in the area would not be compliant with the NETS Security and Quality of Supply Standard (SQSS) and NGET would not be complying with its transmission licence. Therefore, the provision of infrastructure is a requirement and a key necessity for delivering government "Net Zero" targets.

6.1.4 The need above identifies a requirement for two sets of AC 400kV transmission circuits or multiple HVDC connections to resolve the NETS SQSS compliance and two distinct sets of issues as set out below.

- Issue (a), a circuit is required to ensure compliance from the Creyke Beck generation group whilst also providing >6 GW of boundary capacity across the B8 boundary.
- Issue (b), a circuit is required to provide capacity to the East Coast generation group whilst increasing the boundary capacity across B8 by an additional >6 GW (giving 12 GW capacity) and providing >6 GW of capacity across the B9 boundary.

6.1.5 The following strategic options have been identified as having the potential to resolve these distinct issues while complying with the NETS SQSS.

6.1.6 Figure 6.1 outlines options considered within this report to resolve Issue (a). Options considered to resolve Issue (b) is illustrated by Figure 6.2. The interactions of the EGL3 and EGL4 projects are shown on both Figure 6.1 and 6.2.

Figure 6.1 – Indicative map of strategic options considered to resolve issue (a)

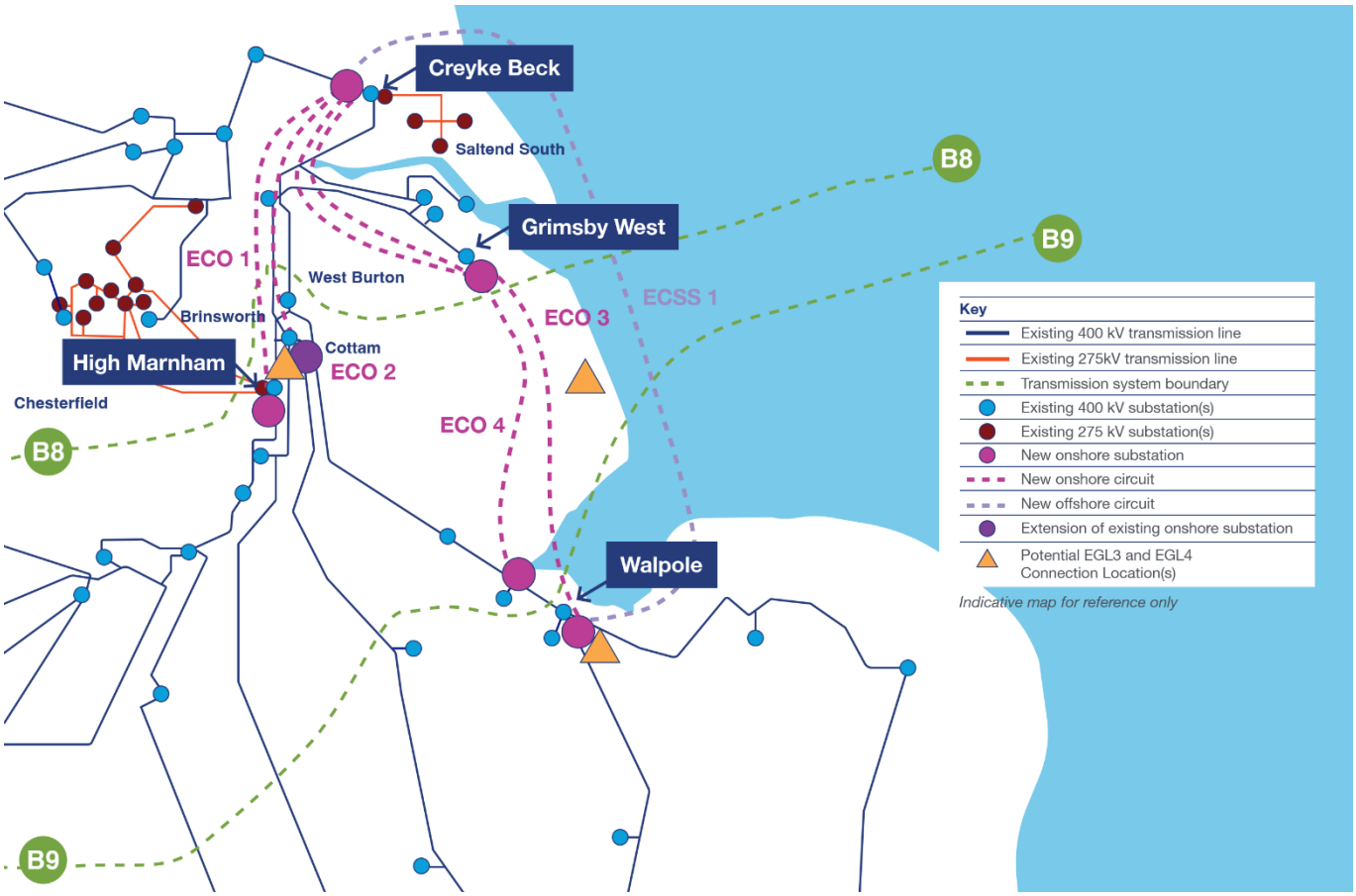
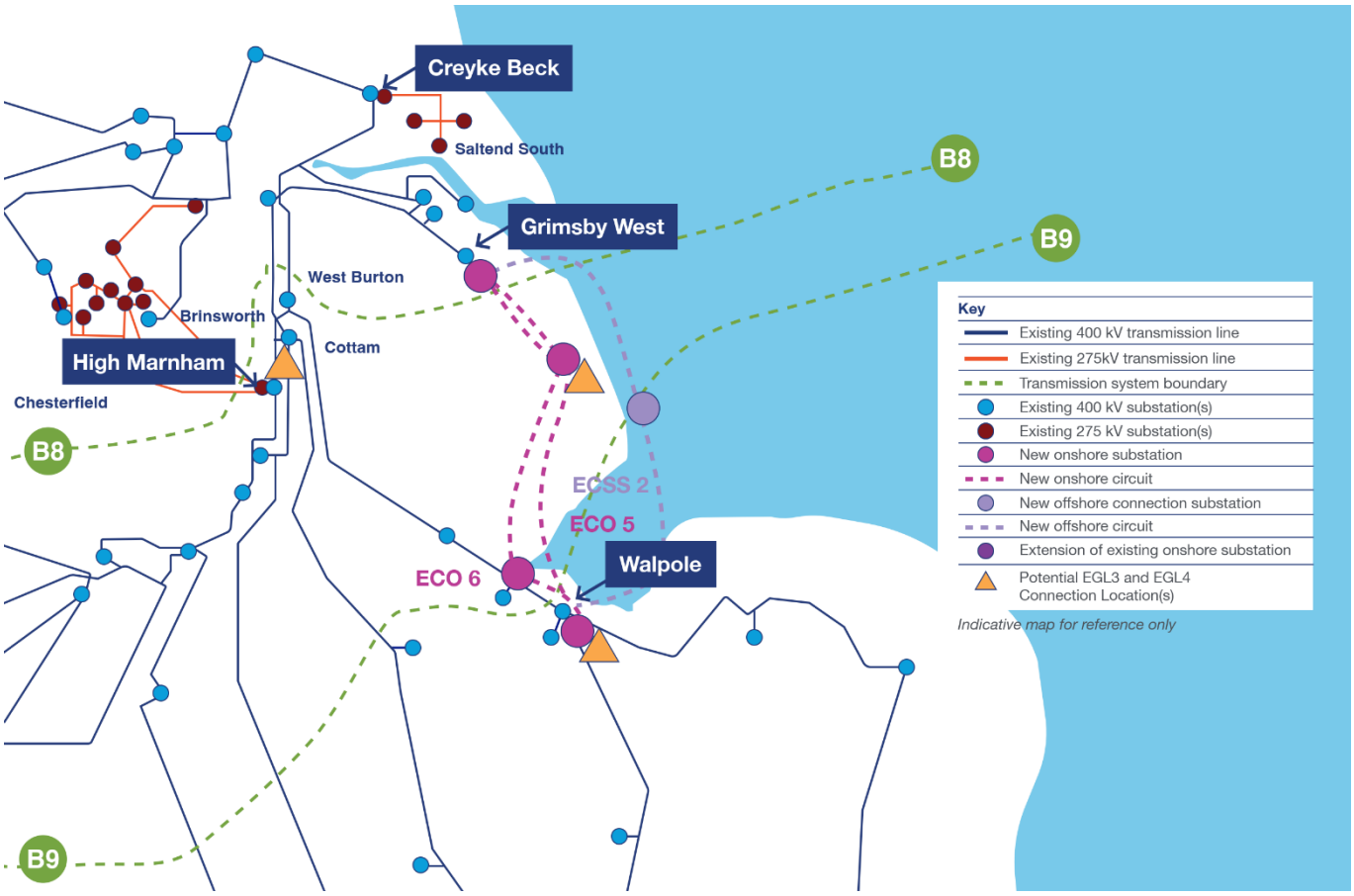


Figure 6.2 – Indicative map of strategic options considered to resolve issue (b)



6.2 Options considered - issue (a)

6.2.1 The options which have been considered with a view to resolving Issue (a) - Creyke Beck generation group and >6 GW capacity across B8 are:

- ECO 1 - New Creyke Beck to new High Marnham **85 km**
- ECO 2 - New Creyke Beck to Cottam **75 km**
- ECO 3 - New Creyke Beck to new Grimsby West, new Grimsby West to new Walpole **225 km**
- ECO 4 - New Creyke Beck to new Grimsby West, new Grimsby West to new Weston Marsh **200 km**
- ECSS 1 - Subsea from new Creyke Beck - new Walpole **195 km**

6.2.2 For those onshore options with a connection at Creyke Beck (ECO 1, ECO 2, ECO 3 and ECO 4), both western and eastern sub-options were considered. The western sub-options (located to the west of Hull) assume an overhead line crossing of the Humber Estuary Special Protection Area (SPA) and Special Area of Conservation (SAC). These options would also need to cross the Yorkshire Wolds, a locally important landscape. The eastern sub-options (located to the east of Hull) assume a requirement for tunnelling for around 6 km beneath the Humber, due to the extent of the estuary in this area. The eastern sub-options would potentially be expected to have lower effects upon the Humber Estuary SPA and SAC due to the use of a tunnel. The eastern sub-options would also avoid the Yorkshire Wolds.

6.2.3 It is noted however that any tunnelling, whilst removing the potential impact of bird strike, could still have negative effects upon the Humber Estuary designations, through disturbance and potential hydrogeological impacts particularly if above-ground infrastructure associated with tunnelling is sited close to the estuary. The potential effects of the western sub-options on the Humber Estuary SPA and SAC site would be dependent on the technologies employed. As such, the project would need to demonstrate that it would not affect the integrity of the Humber Estuary designated site, including the bird populations that form a qualifying feature of the site. It is assumed that a legally and policy-compliant route could be identified at the routeing and siting stage by deploying conventional mitigation. However, if this is not possible then the localised use of undergrounding could help to mitigate or avoid unacceptable effects, where considered necessary.

6.2.4 The capital cost of the eastern (tunnel) sub-options is significantly higher than the western overhead line options for each of ECO 1, ECO 2, ECO 3 and ECO 4. The eastern sub-options would involve additional construction and maintenance risk and would not deliver any greater system benefit. There would also be an impact to the programme in comparison to the western options. Based on the appraisal outcomes, the eastern sub-options for ECO 1, ECO 2, ECO 3 and ECO 4 were not preferred and are not analysed in further detail in this report. However, a summary of the anticipated environmental effects is contained in Appendix G. These eastern options would be reconsidered should detailed assessment of the preferred strategic option identify that it is necessary to do so.

6.3 Options considered - Issue (b)

6.3.1 The options which have been considered with a view to resolving Issue (b) East Coast generation group, further >6 GW capacity across B8 (12 GW total) and >6 GW of capacity across B9) are:

- ECO 5 - New Grimsby West to New Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) to new Walpole **140 km**
- ECO 6 - New Grimsby West to new Lincolnshire Connection substation(s), Lincolnshire Connection substation(s) to new Weston Marsh, new Weston Marsh to new Walpole **140 km**
- ECSS 2 - Subsea new Grimsby West - Offshore Connection Node - new Walpole **155 km**

6.3.2 NGET is currently also evaluating the connection of subsea transmission circuits from Scotland known as EGL3 and EGL4, as described in Figure 6.1 and Figure 6.2 above. These projects will interact with the second set of options for east coast, B8 and B9 boundary considerations. Therefore, this report assesses the interaction of the EGL3 and EGL4 projects with the proposed solution to resolve Issue (b) in section 16, below. This assessment also considers whether that interaction would drive a requirement for additional infrastructure.

6.3.3 The interactivity assessment for the EGL3 and EGL4 projects to determine the best location for these circuits to provide the best infrastructure solution are:

- EGL Option 1 - New Lincolnshire Connection substation(s)
- EGL Option 2 - Cottam substation connection
- EGL Option 3 - New Walpole substation connection

- EGL Option 4 - EGL3 & EGL4 new Walpole substation connection, with one project forming a three ended circuit connecting to New Lincolnshire Connection substation(s) and new Walpole substation.

6.3.4 Where deemed appropriate, a substation designated as "New" has been assigned an optimal closest existing substation for the purposes of identification. These substations will be subject to a detailed siting assessment should an option be selected.

6.3.5 The B9 boundary for instance is defined as cutting the circuits between Spalding North substation and the existing Walpole substation. New Walpole could be sited anywhere along that bisecting circuit, south of the Spalding North circuit tee and west of Walpole, to meet the need of crossing the B9 boundary and providing required boundary capacity.

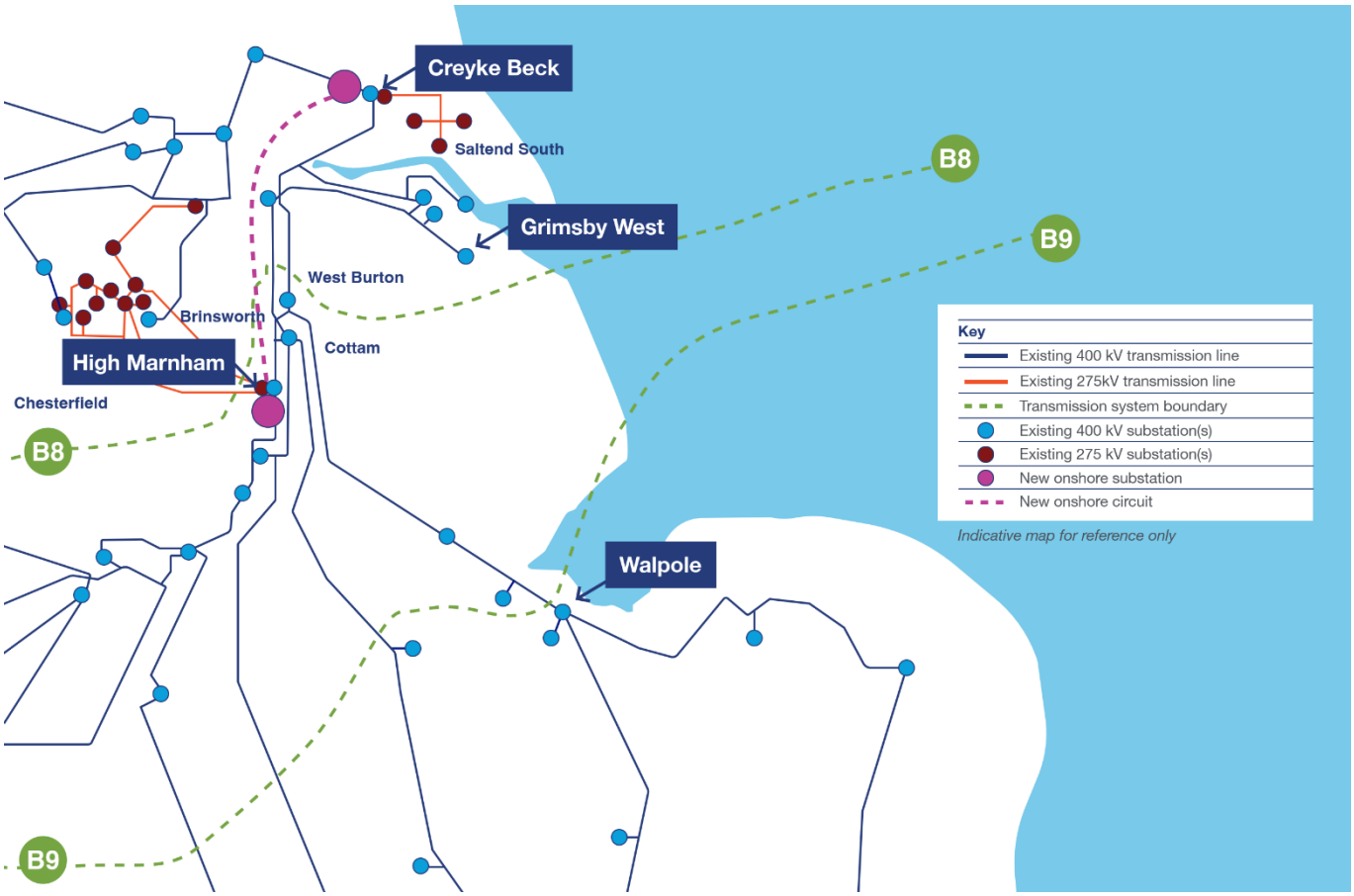
6.3.6 The following sections provide full strategic options evaluation of ECO 1 to 6, ECSS 1 and 2, along with an interactivity assessment of EGL3 and EGL4.

6.3.7 For each option a more detailed account of the environmental and socio-economic appraisal is provided in Appendix G." The technical and cost appraisal detailed information is provided in "Strategic options technical appendix 2020/2021 price base".

7. Appraisal of strategic option ECO 1 – new Creyke Beck to new High Marnham

7.1.1 Option ECO 1, involves the construction of a new transmission circuit connection between a new Creyke Beck substation to new High Marnham substation (constructed as part of other works), following a route to the west of the clear geographical obstacle of the Humber estuary. It has a route length of approximately 85 km, as shown in Figure 7.1 below.

Figure 7.1 – ECO 1 - new Creyke Beck to new High Marnham



7.1.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken. The appraisal is set out in Appendix G. A study area was established in which the project could reasonably be expected to be developed.

7.1.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the impacts of the proposal based upon an assumed use of overhead line technology. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

7.1.4 Overall, the ECO 1 option is relatively constrained in relation to both ecological, landscape and visual considerations. The overhead line would cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst Thorne and Hatfield Moors SPA and Important Bird Area (IBA), Thorne Moor Special Area of Conservation (SAC), Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated, depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The overhead line would cross the Yorkshire Wolds Important Landscape Area (ILA). There would however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

7.1.5 The key factors affecting ECO 1 (West) are similar to ECO 2 (West), however ECO 1 (West) is approximately 10 km greater in length. All Creyke Beck generation group onshore options would need to cross the Humber Estuary SPA, Ramsar and SSSI, with potential for direct effects on breeding, over-wintering and passage bird species (from collision risk). In comparison to ECO 3 (West) and ECO 4 (West), ECO 1 (West) is not located in proximity to The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, or Gibraltar Point Ramsar Site and IBA. All Creyke Beck generation group onshore options would need to cross the Yorkshire Wolds ILA, however ECO 1 (West) would be located further from the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) in comparison to options ECO 3 (West) and ECO 4 (West). The nature of the environmental and socio-economics effects associated with the OHL options (ECO 1, ECO 2, ECO 3 and ECO 4) including the associated substation infrastructure, would be different in nature to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations. There are also potential heritage constraints associated with the subsea options which may result in potential effects on the setting of a number of scheduled monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

7.1.6 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that a transmission connection between Creyke Beck and High Marnham would satisfy the National Electricity Transmission System (NETS) Security and Quality of Supply Standards (SQSS) and resolve the requirement of providing generation group connections at Creyke Beck, whilst providing >6 GW of capacity across the B8 boundary.

7.1.7 This option has been appraised as it meets the technical appraisal requirements of the need case and is compliant with the NETS SQSS.

7.1.8 Technical analysis of this option includes the following:

- advantages from interfacing with upgrades completing ahead of this project, including the upgrade to the Chesterfield to High Marnham circuits to 400 kV. That project has been assigned a Network Options Assessment code of EDEU by the Electricity System Operator and will include a new substation at High Marnham, into which this proposed option would connect.
- High Marnham is situated very close to the demand centres around the conurbations of the east and west Midlands. A connection at this location provides the most effective way for generation to reach the demand and the highest effect on boundary capability in comparison with other options.

7.1.9 As set out in Chapter 5, we undertake a cost evaluation of the following four technologies for onshore options evaluation.

- 400 kV alternating current (AC) overhead line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV high voltage direct current (HVDC) underground cable and converter stations

7.1.10 Option ECO 1 requires the following transmission works to satisfy the requirements of the SQSS.

- New circuit requirements
  - AC options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt ampere (MVA)
  - Or;
  - HVDC options use 525 kV 2 GW voltage source links, which would require a convertor station at each end similar in size to a large warehouse. A 6 GW connection would require three convertor stations at each end, to come close to matching the AC hi-capacity circuits of 6930 MVA.
- Substation Works
  - New 22 bay 400 kV substation near Creyke Beck accommodating 6 circuits and connections for new generation to remain compliant with NETS SQSS.
  - 400 kV 2 bay extension to the substation at new High Marnham.

7.1.11 Table 7.1 below sets out the capital costs for option ECO 1 considering substation works and the new circuit works for each technology option.

Table 7.1 – ECO 1 capital cost for each technology option

Item	Need	Capital cost
Substation works	Facilitate generation	£115.7m

	and connect new circuits				
New circuits		**AC overhead line**	**AC cable**	**AC GIL**	**HVDC**
New circuit 85 km	New circuit across B8	£338.3m	£3,638.2m	£3,677.1m	£2,391.1m
Total capital cost		**£454m**	**£3,753.9m**	**£3,792.8m**	**£2,506.8m**

7.1.12 Table 7.2 below sets out the lifetime cost for the new circuit technology options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "Strategic options technical appendix 2020/2021 price base" Appendix D.

Table 7.2 – ECO 1 lifetime cost for each technology option

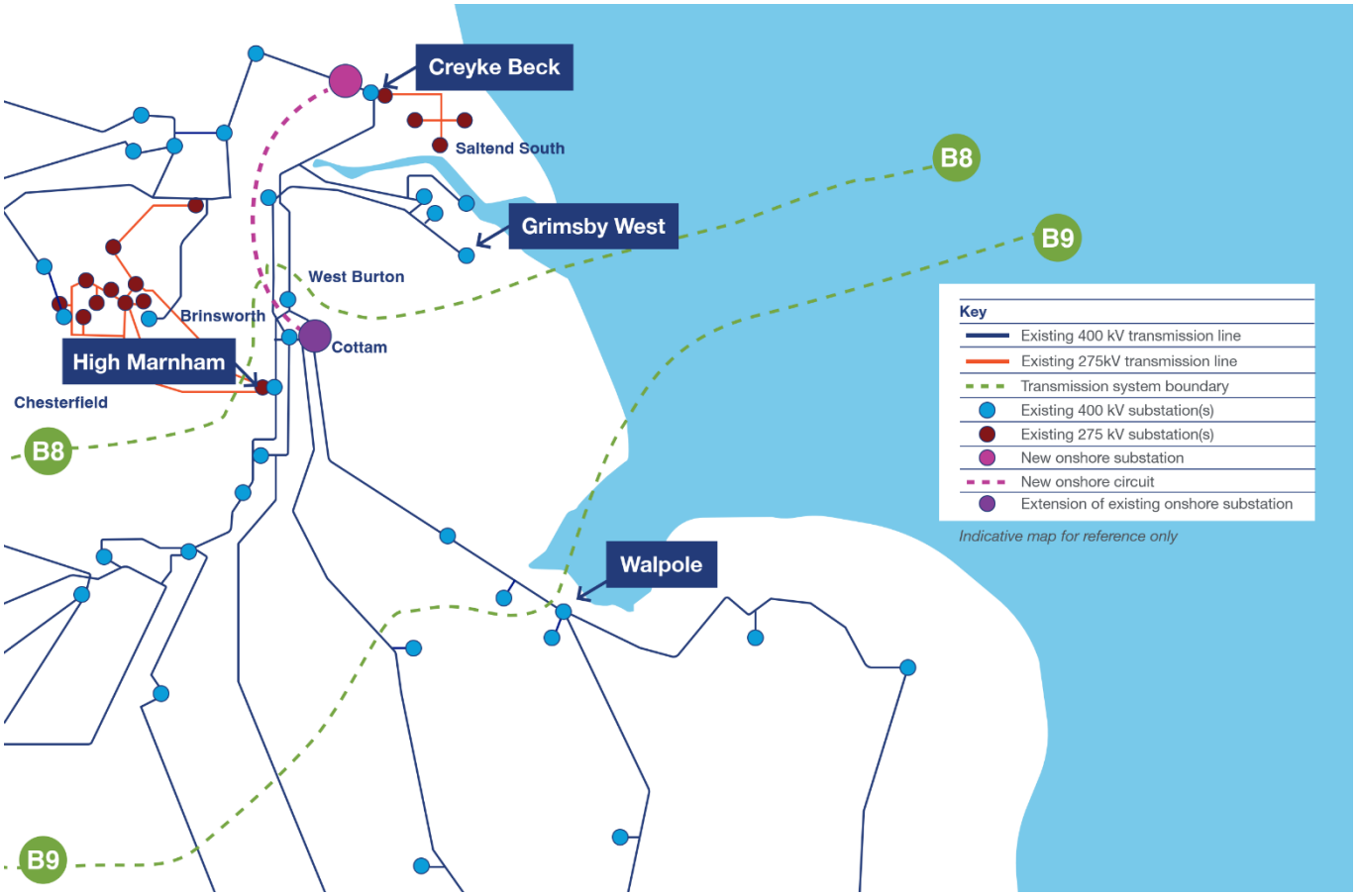
	AC overhead line	**AC cable**	**AC GIL**	**HVDC**
Capital cost of new circuits	£338.3m	£3,638.2m	£3,677.1m	£2,391.1m
NPV of cost of losses over 40 years	£238.4m	£174.9m	£110.7m	£471.2m
NPV of operation & maintenance costs over 40 years	£5.0m	£16.4m	£5.0m	£172.1m
Lifetime cost of new circuits	**£582m**	**£3,829m**	**£3,793m**	**£3,034m**

7.1.13 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred option for ECO 1 is a 85 km connection between a new Creyke Beck substation and new High Marnham substation would be for an AC circuit to the west of Kingston Upon Hull and the Humber Estuary. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection.

8. Appraisal of strategic option ECO 2 – new Creyke Beck to Cottam

8.1 Option ECO 2 involves the construction of a new transmission circuit connection between a new Creyke Beck substation to Cottam substation. There are two broad route options that have been considered, due to the need for any new infrastructure to avoid the major urban centre of Hull following a route to the west of the clear geographical obstacle of the Humber estuary with a route length of approximately 75 km as shown in Figure 8.1 below.

Figure 8.1 – ECO 2 - new Creyke Beck to Cottam



8.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken. The appraisal is set out in Appendix G. A study area was established in which the project could reasonably be expected to be developed.

8.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the impacts of the proposal based upon an assumed use of overhead line technology. This enables the appraisal to

highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

8.4 Overall, the ECO 2 option is relatively constrained in relation to both ecological, landscape and visual considerations. The overhead line would cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species (from collision risk) that are a qualifying feature of these designations. Whilst other ecologically designated sites including Thorne and Hatfield Moors SPA and Important Bird Area (IBA), Thorne Moor Special Area of Conservation (SAC), Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable, there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated, depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The overhead line would also cross the Yorkshire Wolds Important Landscape Area (ILA). There would however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. There is potential for adverse effects on the setting of Scheduled Monuments and listed buildings depending on the proximity of the new sealing end compound infrastructure required at Cottam. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

8.5 The key factors affecting ECO 2 are similar to ECO 1, however ECO 2 is approximately 10km shorter in length and would require sealing end compound infrastructure at Cottam. All Creyke Beck generation group onshore options would need to cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk). In comparison to ECO 3 and ECO 4, ECO 2 is not located in proximity to The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, or Gibraltar Point Ramsar Site and IBA. All Creyke Beck generation group onshore options would need to cross the Yorkshire Wolds ILA, however ECO 2 would be located further from the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) in comparison to options ECO 3 and ECO 4. The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 1, ECO 2, ECO 3 and ECO 4) including the associated substation infrastructure, would be different in nature to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations. There are potential heritage constraints associated with the subsea options which may result in potential effects on the setting of a number of scheduled monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

8.6 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between Creyke Beck and Cottam would satisfy the National Electricity Transmission System (NETS) Security and Quality of Supply Standards (SQSS) and resolve the requirement of providing generation group connections at Creyke Beck, whilst providing >6GW of capacity across the B8 boundary.

8.7 Technical analysis of this option includes the following:

- Construction risks at the site at Cottam are significant due to above and below ground infrastructure sited in the vicinity of the required connection, leading to significant routeing constraints. Alongside power station decommissioning works which could interact with the project.
- Due to Cottam being electrically further from significant demand, the boundary capability improvement at Cottam is lower than other options. It does not, therefore, offer as much system benefit compared to alternatives.

8.8 As set out in the Chapter 5, we undertake a cost evaluation of the following four technologies for onshore options evaluation.

- 400 kV alternating current (AC) overhead line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV high voltage direct current (HVDC) underground cable and converter stations

8.9 Option ECO 2 requires the following transmission works to satisfy the requirements of the SQSS.

- **New circuit requirements**
  - AC connections options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA) or;
  - HVDC using 525 kV 2GW voltage source links, which would require a convertor station at each end similar in size to a large warehouse. A 6 GW connection would require three convertor stations at each end, this is to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation works**
  - New 22 bay 400 kV substation near Creyke Beck accommodating six circuits and connections for new generation to remain compliant with NETS SQSS.
  - A 2 bay extension to the existing Cottam 400 kV substation and cable entries to the site for the new circuits to avoid existing infrastructure

8.10 Table 8.1 below sets out the capital costs for option ECO 2 considering substation works and each technology option.

Table 8.1 – ECO 2 capital cost for each technology option

Item	Need	Capital cost			
Substation works	Facilitate generation and connect new circuits	£167.1m			
New circuits		**AC overhead line**	**AC cable**	**AC GIL**	**HVDC**
New circuit 75 km	New circuit across B8	£298.5m	£3,221.8m	£3,244.5m	£2,298.4m
Total capital cost		**£465.6m**	**£3,388.9m**	**£3,411.6m**	**£2,465.5m**

8.11 Table 8.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "Strategic options technical appendix 2020/2021 price base" Appendix D.

Table 8.2 – ECO 2 lifetime cost for each technology option

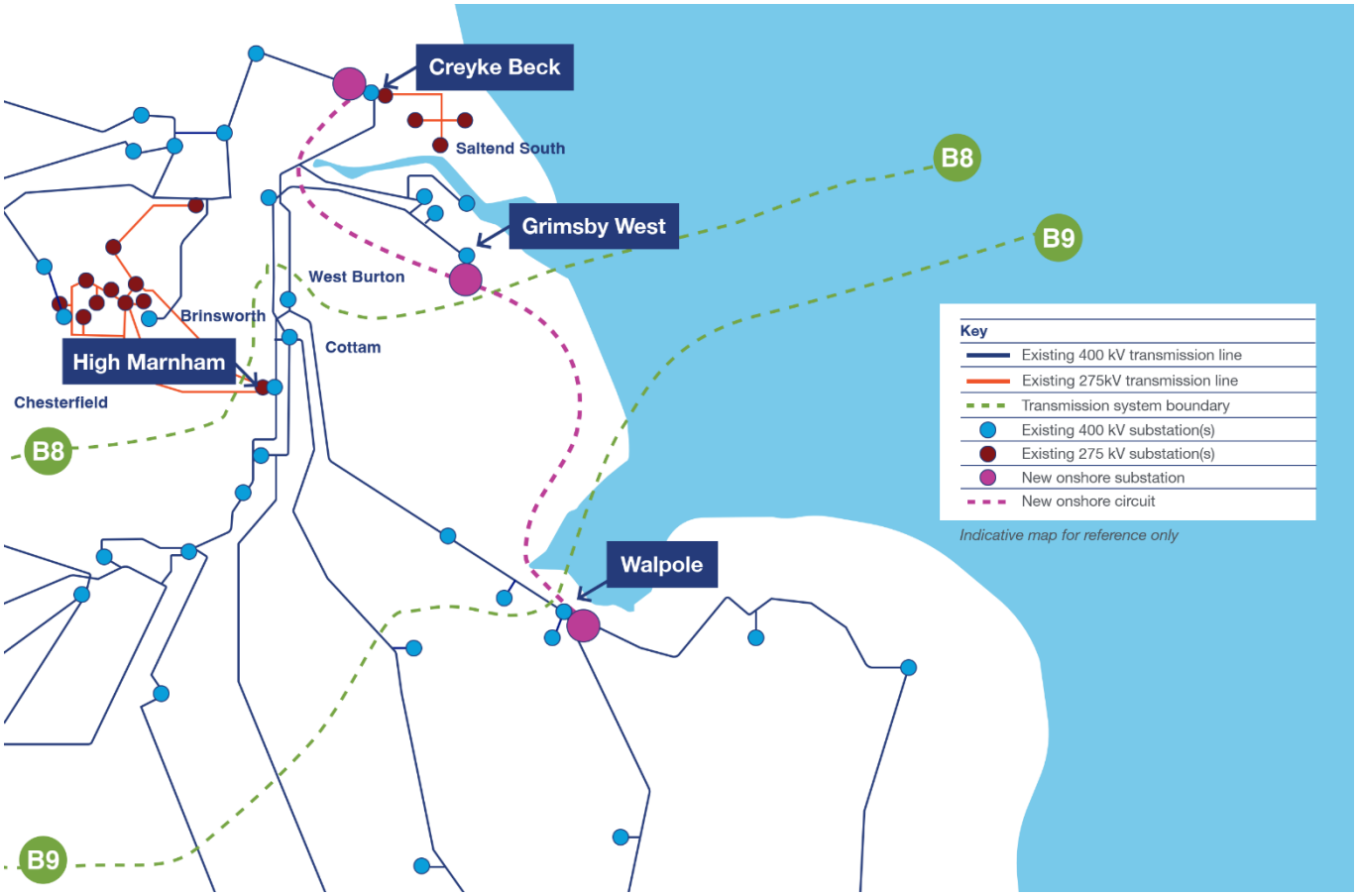
	AC overhead line	AC cable	AC GIL	HVDC
Capital cost of new circuits	£298.5m	£3,221.8m	£3,244.5m	£2,298.4m
NPV of cost of losses over 40 years	£210.4m	£157.0m	£97.7m	£471.2m
NPV of operation & maintenance costs over 40 years	£4.4m	£14.9m	£4.4m	£172.0m
Lifetime cost of new circuits	**£513m**	**£3,394m**	**£3,347m**	**£2,942m**

8.12 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred option for ECO 2 is a 75 km connection between a new Creyke Beck substation and Cottam substation would be for an AC circuit to the west of Kingston Upon Hull and the Humber Estuary. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection.

9. Appraisal of strategic option ECO 3 – new Creyke Beck to new Grimsby West, new Grimsby West to new Walpole

9.1 Option ECO 3 involves the connection of new transmission circuit connections between a new Creyke Beck substation to new Grimsby West substation and new Grimsby West to a new Walpole substation following a route to the west of the clear geographical obstacle of the Humber Estuary, with a route length of approximately 225 km as shown in Figure 9.1 below.

Figure 9.1 – ECO 3 - new Creyke Beck to new Grimsby West, new Grimsby West to new Walpole



9.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken. The appraisal is set out in Appendix G. A study area was established within which the project could reasonably be expected to be developed.

9.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation, the environmental and socio-economic appraisal has sought to establish the impacts of the proposal based

upon an assumed use of overhead line technology. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

9.4 Overall, the ECO 3 option is relatively constrained in relation to both ecological, landscape and visual considerations. The overhead line would cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst The Wash Ramsar Site, SSSI, SPA, Important Bird Area (IBA) and National Nature Reserve, The Wash and North Norfolk Coast IBA and Special Area of Conservation (SAC), and Gibraltar Point Ramsar Site and IBA are avoidable, there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The overhead line would cross the Yorkshire Wolds Important Landscape Area (ILA). Although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) would be avoided by the overhead line, there is potential for long-term effects on views from the AONB from the overhead line. There is potential for adverse effects on the setting of Brocklesby Park Registered Park and Garden as a result of the new overhead line, depending on routeing. There would however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

9.5 The key factors affecting ECO 3 are similar to ECO 4, however ECO 3 is approximately 35 km greater in length. All Creyke Beck generation group onshore options would need to cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (from collision risk). In comparison to ECO 1 and ECO 2, ECO 3 is located in proximity to The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA. All Creyke Beck generation group onshore options would need to cross the Yorkshire Wolds ILA, however ECO 3 would also be located closer to the Lincolnshire Wolds AONB compared with options ECO 1 and ECO 2. The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 1, ECO 2, ECO 3 and ECO 4), including the associated substation infrastructure, would be different in nature to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations.

9.6 There are also potential heritage constraints associated with the subsea options which may result in potential effects on the setting of a number of scheduled monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

9.7 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between New Creyke Beck and new Walpole via new Grimsby West would satisfy the NETS SQSS and resolve the requirement of providing generation group connections at Creyke Beck, whilst providing >6 GW of capacity across the B8 boundary.

9.8 Technical analysis of this option includes the following:

- This is a significantly longer alternative to provide connection capacity from Creyke Beck and would need to connect south from Grimsby West to the existing transmission system to provide the required 6 GW of capacity across B8.

9.9 As set out in Chapter 5, we undertake a cost evaluation of the following four technologies for onshore options evaluation.

- 400 kV alternating current (AC) overhead line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV HVDC underground cable and converter stations

9.10 Option ECO 3 requires the following transmission works to satisfy the requirements of the SQSS.

- **New circuit requirements**
  - AC connection options use hi-capacity double circuits (2 x 400kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA) or;
  - HVDC connection options use 525 kV 2 GW voltage source links, which would require a convertor station at each end, similar in size to a large warehouse. In this case a 6 GW three ended connection would require three convertor stations at each substation (nine in total as there are three connection locations), this is to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation Works**
  - 22 bay new Creyke Beck 400 kV substation accommodating 6 circuits and connections for new generation to remain compliant with NETS SQSS.
  - 14 bay new Grimsby West 400 kV substation replacing the existing substation to accommodate new circuits and existing circuits;
  - 19 bay new Walpole 400 kV substation to accommodate required new circuits.

9.11 Table 9.1 below sets out the capital costs for option ECO 3 considering Substation Works and Each technology Option.

Table 9.1 – ECO 3 capital cost for each technology option

Item	Need	Capital cost
Substation works	Facilitate generation and connect new circuits	£355.2m

New circuits		AC overhead line	AC cable	AC GIL	HVDC
New circuit 225 km	New circuit across B8	£895.5m	£9,718.7m	£9,733.5m	£4,490.5m
Total capital cost		**£1,250.7m**	**£10,073.9m**	**£10,088.7m**	**£4,845.7m**

9.12 Table 9.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "Strategic options technical appendix 2020/2021 price base" Appendix D.

Table 9.2 – ECO 3 lifetime cost for each technology option

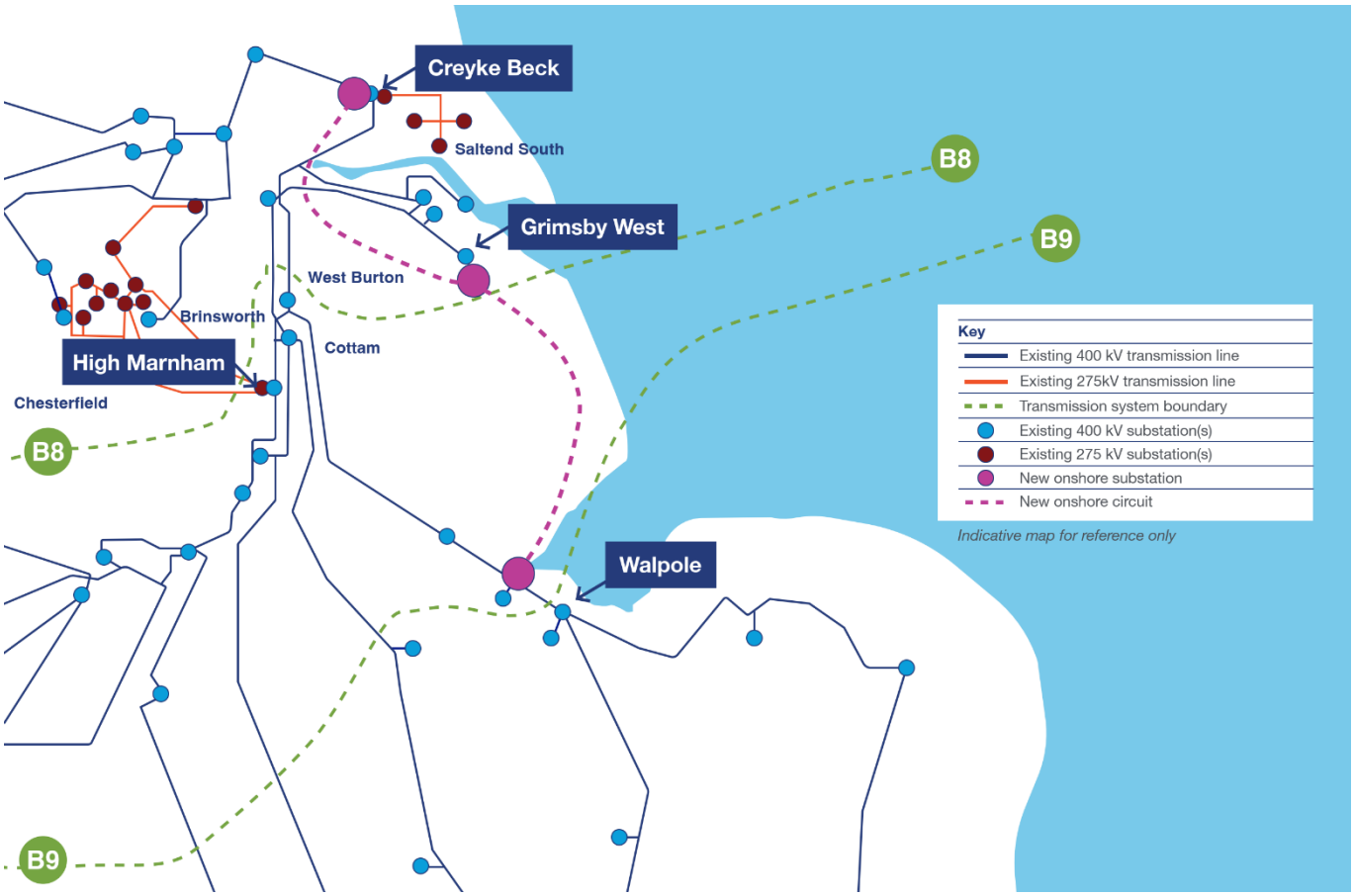
Land based option	AC overhead line	AC cable	AC GIL	HVDC
Capital cost of new circuits	£895.5m	£9,718.7m	£9,733.5m	£4,490.5m
NPV of cost of losses over 40 years	£631.2m	£489.5m	£293.0m	£706.9m
NPV of operation & maintenance costs over 40 years	£13.2m	£46.1m	£13.3m	£259.0m
Lifetime cost of new circuits	**£1,540m**	**£10,254m**	**£10,040m**	**£5,456m**

9.13 From the environmental and technical appraisal considered alongside capital and circuit lifetime costs the preferred option for ECO 3 is a 225 km connection between a new Creyke Beck substation and new Walpole via new Grimsby West, would be for an AC circuit to the West of Kingston Upon Hull and the Humber estuary. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection.

10. Appraisal of strategic option ECO 4 – new Creyke Beck to new Grimsby West, new Grimsby West to new Weston Marsh

10.1 Option ECO 4 involves the connection of new transmission circuit connections between a new Creyke Beck substation to new Grimsby West substation and new Grimsby West to a new Weston Marsh substation, following a route to the west of the clear geographical obstacle of the Humber estuary with a route length of approximately 200 km as shown in Figure 10.1 below.

Figure 10.1 – ECO 4 – new Creyke Beck to new Grimsby West, new Grimsby West to new Weston Marsh



10.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken looking at both the East and West route alternatives for this option. The full appraisal is set out in Appendix G. A study area was established within which the project could reasonably be expected to be developed.

10.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated

development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation, the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the impacts of the proposal based upon an assumed use of overhead line technology. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

10.4 Overall, the ECO 4 option is relatively constrained in relation to both ecological, landscape and visual considerations. The overhead line would cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species (from collision risk) that are a qualifying feature of these designations. Whilst The Wash Ramsar Site, SSSI, SPA, Important Bird Area (IBA) and National Nature Reserve, The Wash and North Norfolk Coast IBA and Special Area of Conservation (SAC), and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated, depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The overhead line would cross the Yorkshire Wolds Important Landscape Area (ILA). Although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) would be avoided by the overhead line, there is potential for long-term effects on views from the AONB from the overhead line. There is potential for adverse effects on the setting of Brocklesby Park Registered Park and Garden as a result of the new overhead line, depending on routeing. There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure at Weston Marsh (assumed to be at a location close to the existing 4ZM route, however exact location subject to routing / siting) in a landscape which currently has little major development. There will however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential, with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

10.5 The key factors affecting ECO 4 are similar to ECO 3, however ECO 4 is approximately 35 km shorter in length. All Creyke Beck generation group onshore options would need to cross the Humber Estuary SPA, Ramsar and SSSI, with potential for direct effects on breeding, over-wintering and passage bird species (collision risk). In comparison to ECO 1 and ECO 2, ECO 4 is located in proximity to The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA. All Creyke Beck generation group onshore options would need to cross the Yorkshire Wolds ILA, however ECO 4 would also be located closer to the Lincolnshire Wolds AONB compared with options ECO 1 and ECO 2. The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 1, ECO 2, ECO 3 and ECO 4) including the associated substation infrastructure, would be different in nature to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations. There are also potential heritage

constraints associated with the subsea options which may result in potential effects on the setting of a number of scheduled monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

10.6 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between Creyke Beck and Weston Marsh via Grimsby West would satisfy the NETS SQSS and resolve the requirement of providing generation group connections at Creyke Beck, whilst providing >6 GW of capacity across the B8 boundary.

10.7 Technical analysis of this option includes the following.

- This is a significantly longer alternative to provide connection capacity from Creyke Beck and would need to connect south from Grimsby West to the existing transmission system to provide the required 6 GW of capacity across B8.

10.8 As set out in Chapter 5, we undertake a cost evaluation of the following four technologies for onshore options evaluation.

- 400 kV alternating current (AC) overhead line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV HVDC underground cable and converter stations

10.9 Option ECO 4 requires the following transmission works to satisfy the requirements of the SQSS.

- **New circuit requirements**
  - AC connection options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA) or;
  - HVDC connections use 525 kV 2 GW voltage source links, which would require a converter station at each end, similar in size to a large warehouse. In this case a 6 GW three ended connection would require three convertor stations at each substation (nine in total as there are three connection locations), to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation works**
  - New 22 bay 400 kV substation near Creyke Beck accommodating six circuits and connections for new generation to remain compliant with NETS SQSS.
  - A new 14 bay 400 kV substation at Grimsby West replacing the existing substation to accommodate new circuits and existing circuits;
  - A new 12 bay substation at Weston Marsh to connect back into the system.

10.10 Table 10.1 below sets out the capital costs for option ECO 4 considering substation works and each technology option.

Table 10.1 – ECO 4 capital cost for each technology option

Item	Need	Capital cost			
Substation works	Facilitate generation and connect new circuits	£298.7m			
New circuits		**AC overhead line**	**AC cable**	**AC GIL**	**HVDC**
New circuit 200 km	New circuit across B8	£796.0m	£8,633.2m	£8,652.0m	£4,258.7m
Total capital cost		**£1,094.7m**	**£8,931.9m**	**£8,950.7m**	**£4,557.4m**

10.11 Table 10.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "Strategic options technical appendix 2020/2021 price base" Appendix D.

Table 10.2 – ECO 4 lifetime cost for each technology option

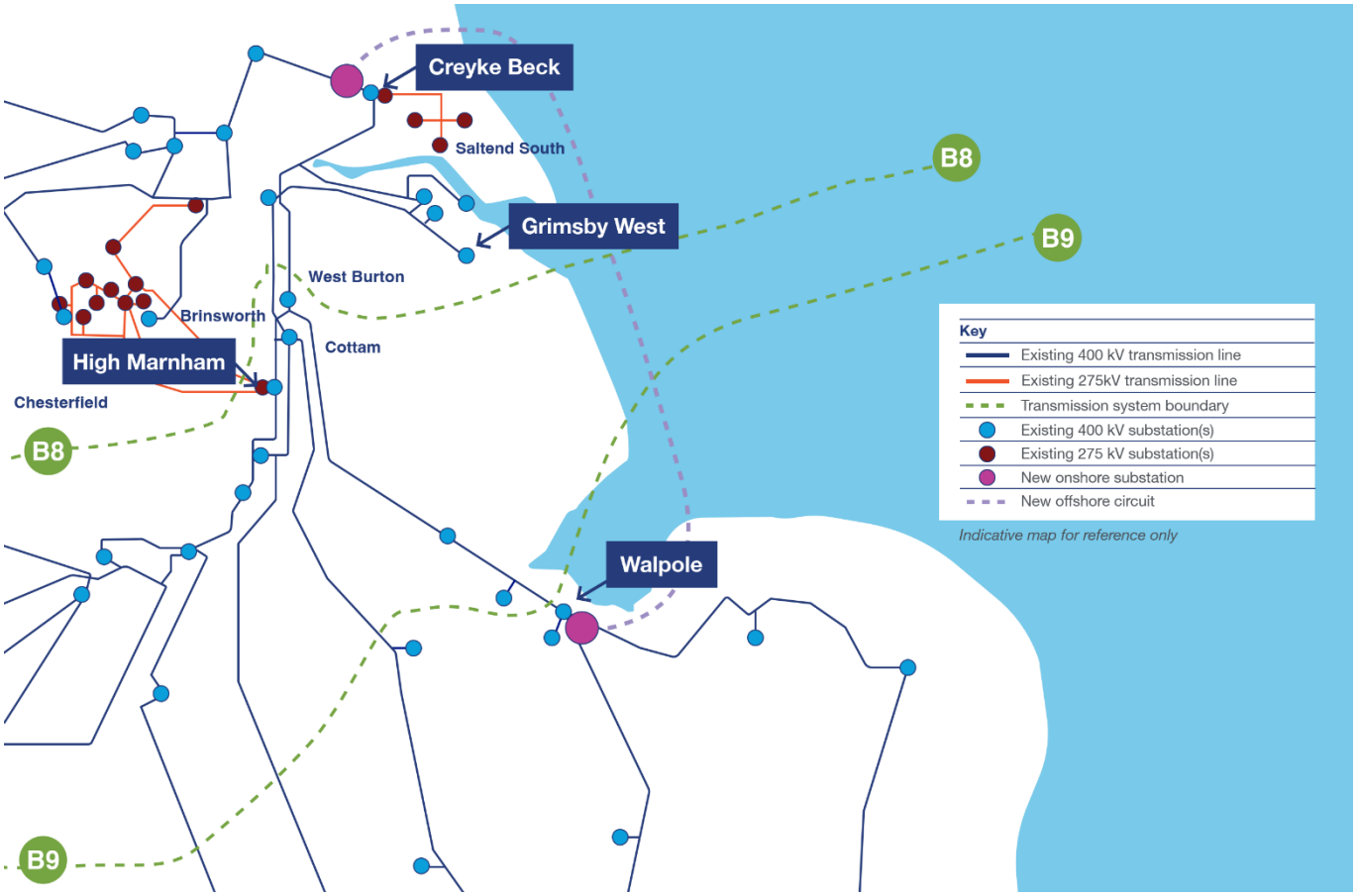
Land Based Option	AC OHL	AC Cable	AC GIL	HVDC
Capital cost of new circuits	£796.0m	£8,633.2m	£8,652.0m	£4,258.7m
NPV of cost of losses over 40 years	£561.0m	£431.0m	£260.5m	£706.9m
NPV of operation & maintenance costs over 40 years	£11.7m	£41.0m	£11.8m	£258.8m
Lifetime Cost of New Circuits	**£1,369m**	**£9,105m**	**£8,924m**	**£5,224m**

10.12 From the environmental and technical appraisal considered alongside capital and circuit lifetime costs the preferred option for ECO 4, 200 km connection between a new Creyke Beck substation and Weston Marsh via Grimsby West, would be for an AC circuit to the west of Kingston Upon Hull and the Humber estuary. In light of this analysis our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection.

11. Appraisal of strategic option ECSS 1 – new Creyke Beck to new Walpole subsea

11.1 Option ECSS 1 involves the construction of new subsea transmission circuit connection between a new Creyke Beck substation to a new Walpole substation. This follows a route to the east coast, offshore along the east coast, to a new onshore Walpole substation, with a length of approximately 195 km, as shown in Figure 11.1 below.

Figure 11.1 – ECSS 1 - new Creyke Beck to new Walpole subsea



11.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken looking at Norfolk landfall and Lincolnshire landfall alternatives for this option. The appraisal is set out in Appendix G.

11.3 For the appraisal of subsea options of significant distance, a HVDC option would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the potential impacts of the proposal based upon high voltage direct current (HVDC) technology in a marine

environment. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

11.4 Overall, the ECSS 1 option with a Norfolk landfall is constrained in relation to ecological considerations. The Holderness Inshore Marine Conservation Zone (MCZ) and The Greater Wash Special Protection Area (SPA) are within the study area. It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ, however this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special Area of Conservation (SAC). Also, due to the number and proximity of designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast Ramsar, Site of Special Scientific Interest (SSSI) and Important Bird Area (IBA), it would not be possible to avoid all of these designated areas. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are also potential heritage constraints which may result in potential effects on the setting of a number of scheduled monuments and listed buildings, dependent on converter station siting, especially in the Creyke Beck area. Other key environmental and socio-economic constraints are considered to be less influential, with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

11.5 Overall, the ECSS 1 option with a Lincolnshire landfall option is less constrained than ECSS 1 with a Norfolk landfall in relation to ecological considerations. The Holderness Inshore MCZ and The Greater Wash SPA are within the study area and would require cable crossings. It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ, however this would extend the overall cable length, and potentially require a crossing of the Holderness Offshore MCZ.

11.6 Designated sites along the Lincolnshire coastline are potentially avoidable, subject to landfall selection and subsea cable installation methods. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are also potential heritage constraints which may result in potential effects on the setting of a number of scheduled monuments and listed buildings, dependent on converter station siting, especially in the Creyke Beck area. Other key environmental and socio-economic constraints are considered to be less influential, with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

11.7 The ECSS 1 option with a Lincolnshire landfall is approximately 60 km shorter in length than ECSS 1 with a Norfolk landfall. Both of the Creyke Beck generation group subsea options, ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk), would result in direct effects on the Greater Wash SPA and Holderness Inshore MCZ which are located within the study area. It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ, however this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC.

11.8 ECSS 1 (Lincolnshire) would avoid direct effects on designated sites along the north Norfolk coast, which would be unavoidable for ECSS 1 (Norfolk). However, ECSS 1 (Lincolnshire) may result in potential for effects on designated sites located along the Lincolnshire coast, including Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleet-by-Theddlethorpe Dunes and Gibraltar Point SAC, and Saltfleet-by-Theddlethorpe Sand Dunes SSSI at the landfall, depending on routeing. Both the

ECSS 1 (Norfolk) and ECSS 1 (Lincolnshire) options would involve sections of undergrounded cable and above-ground infrastructure (converter stations). The nature of the environmental and socio-economic effects associated with the subsea options would be different in nature to the overhead line options (ECO 1, ECO 2, ECO 3 and ECO 4) for a number of environmental and socio-economic topics.

11.9 Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

11.10 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that a subsea transmission connection between a new Creyke Beck substation and a new Walpole substation would satisfy the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), and resolve the requirement of providing generation group connections at Creyke Beck, whilst providing >6 GW of capacity across the B8 boundary.

11.11 Technical analysis of this option includes the following:

- This is a significantly longer alternative to provide connection capacity from Creyke Beck, and seeks to connect to a location south of the B9 boundary in the Walpole area. For the purposes of assessing costs, we have used the Lincolnshire landfall for indicative purposes, as it is the shortest route.
- The offshore options considered for option ECSS 1 offer no technical advantage over options considered for on-shore alternatives. Both onshore and offshore, AC and HVDC alternatives considered offer NETS SQSS compliant solutions that meet the needs case. Each technology considered within an option can be designed to provide the required system performance and capacity albeit with different characteristics. The only delivery advantage offered by offshore cable installation compared to onshore is the ability to carry significant lengths of cable on a large vessel for deployment. Allowing cable laying campaigns of up 100km carried by a single vessel, whereas cables laid on land need to be deployed in drum lengths of circa 1km for delivery to site.

11.12 As set out in Chapter 5, we undertook a cost evaluation of the following two technologies for subsea options evaluation.

- 400 kV alternative current (AC) subsea cable
- 525 kV HVDC subsea cable and converter stations

11.13 Option ECSS 1 requires the following transmission works to satisfy the requirements of the SQSS.

- **New Circuit requirements**
  - AC subsea connections circuit options use hi-capacity double circuits (2 x 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA)
  - or;
  - HVDC subsea options use 525 kV 2 GW voltage source links, which would require a convertor station at each end similar in size to a large warehouse. A 6 GW connection would require three convertor stations at each end, to come close to matching the AC hi-capacity circuits of 6930 MVA.

- **Substation Works**
  - 22 bay new Creyke Beck 400 kV substation accommodating 6 circuits and connections for new generation to remain compliant with NETS SQSS.
  - 19 bay new Walpole 400 kV substation to accommodate required new circuits.

11.14 Table 11.1 below sets out the capital costs for option ECSS 1 considering substation works and each technology option.

Table 11.1 – ECSS 1 capital cost for each technology option

Item	Need	ECSS 1 capital cost	
Substation works	Facilitate generation and connect new circuits	£235.2m	
New circuits		**AC subsea cable**	**Subsea HVDC cable**
New circuit 195 km	New circuit across B8 and B9	£8,433.7m	£3,410.8m
Total capital cost		**£8,668.9m**	**£3,646m**

11.15 Table 11.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "strategic options technical appendix 2020/2021 price base" Appendix D.

Table 11.2 – ECSS 1 lifetime cost for each technology option

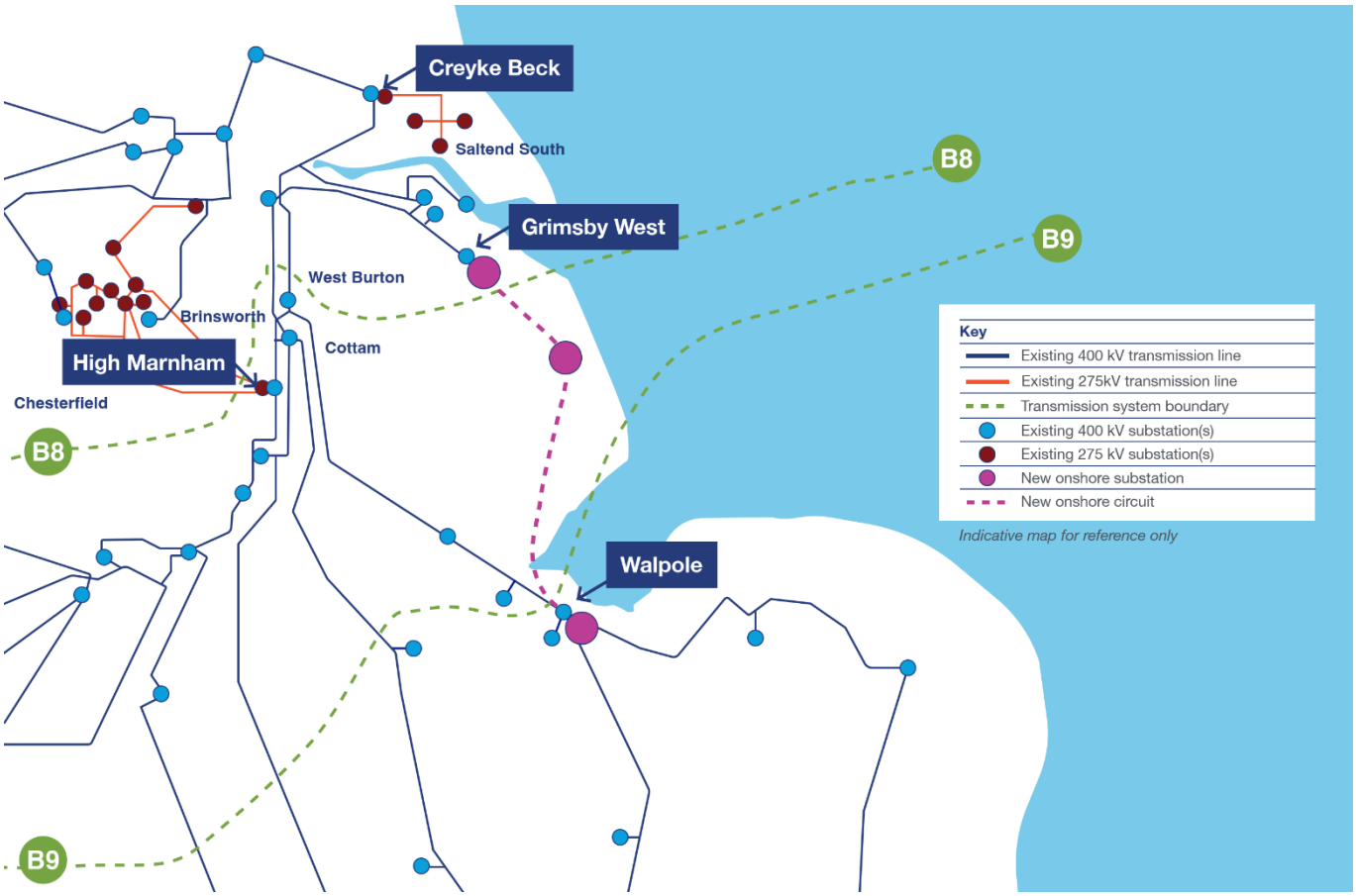
Subsea based option	ECSS 1 AC subsea Cable	ECSS 1 Subsea HVDC Cable
Capital cost of new circuits	£8,433.7m	£3,410.8m
Net present value (NPV) of Cost of Losses over 40 years	£426.7m	£471.2m
NPV of operation & maintenance costs over 40 years	£40.3m	£173.1m
Lifetime cost of new circuits	**£8,901m**	**£4,055m**

11.16 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred option for ECSS 1 is a 195km connection between a new Creyke Beck substation and new Walpole substation, would be for an HVDC subsea circuit to the east of Kingston Upon Hull. In light of this analysis, our starting presumption for further development of this option, should it be selected, would be for a majority HVDC subsea connection.

12. Appraisal of Strategic Option ECO 5 – new Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) to new Walpole

12.1 Option ECO 5 involves the connection of new transmission circuit connections between a new Grimsby West substation to new Lincolnshire Connections substation(s), and Lincolnshire Connections substation(s) to a new Walpole substation following a route through Lincolnshire, with a route length of approximately 140km as shown in Figure 12.1 below.

Figure 12.1 – ECO 5 - new Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) to new Walpole



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12.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken for this option. The appraisal is set out in Appendix G.

12.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation, the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the impacts of the proposal based upon an assumed use of overhead line technology. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

12.4 Overall ECO 5 is relatively constrained in relation to both ecological, and landscape visual considerations. Whilst the Humber Estuary Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site and Site of Special Scientific Interest (SSSI), The Wash Ramsar Site, SSSI, SPA, Important Bird Area (IBA) and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable, there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated, depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). Although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) would be avoided by the overhead line, there is potential for long-term effects on views from the AONB from both the overhead line and substation infrastructure at the Lincolnshire Connection substation(s). There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at the Lincolnshire Connection substation(s) in a landscape which currently has little major development. There would however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

12.5 Compared to the remaining East Coast generation group connections, the key factors affecting ECO 5 are similar to ECO 6, however ECO 6 would require an additional substation at Weston Marsh. The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 5 and ECO 6) including the associated substation infrastructure, would be different in nature to the subsea option (ECSS 2) which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea option ECSS 2 would have challenges relating to the installation of buried cables across marine ecological designations. These would include temporary effects on the Greater Wash SPA which would require a cable crossing, as well as the potential for temporary effects on designated sites along the north Norfolk coast as it would not be possible to avoid all designated areas. There are potential heritage constraints which may result in potential effects on the setting of a number of scheduled monuments and listed buildings depending on converter station siting at Grimsby West. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

12.6 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between new Grimsby West and new Walpole via new Lincolnshire Connection substation(s) would satisfy the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) and resolve the requirement of providing generation group connections for Lincolnshire coastal connections, whilst providing >6 GW of capacity across the B8 and B9 boundaries.

12.7 Technical analysis of this option includes the following:

- This option provides connection locations for all generation connecting between the South of the Humber Estuary and North of the Wash. It also facilities boundary capacity across the B8 and B9 Boundaries.
- This option requires that the configuration of the circuits connecting to existing Walpole and new Walpole allow transfer south of the B9 boundary, even under secured fault conditions.

12.8 As set out in Chapter 5, we undertook a cost evaluation of the following four technologies for onshore options evaluation.

- 400 kV alternating current (AC) overhead Line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV high voltage direct current (HVDC) underground cable

12.9 Option ECO 5 requires the following transmission works to satisfy the requirements of the SQSS.

- **New Circuit requirements**
  - AC connections circuit options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA); or
  - HVDC connection options use 525 kV 2 GW voltage source links, which would require a convertor station at each end, similar in size to a large warehouse. In this case a 6 GW three ended connection would require three convertor stations at each substation (nine in total as there are three connection locations), this is to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation Works**
  - 14 bay new Grimsby West 400 kV substation replacing the existing substation to accommodate new circuits and existing circuits;
  - New Lincolnshire Connection substation(s) (LCN) 1 new 12 bay 400 kV substation & LCN 2 new 19 bay 400 kV substation;
  - 19 bay new Walpole 400 kV substation to accommodate required new circuits.

12.10 Table 12.1 below sets out the capital costs for option ECO 5 considering substation works and each technology option.

Table 12.1 – ECO 5 capital costs for each technology option

Item	Need	ECO 5 capital cost			
Substation Works	Facilitate generation and connect new circuits	£443.3m			
New circuits		**AC OHL**	**AC Cable**	**AC GIL**	**HVDC**
New circuit 140km	New circuit across B8 and B9	£557.2m	£6,027.2m	£6,056.4m	£3,702.5m
Total capital cost		**£1,000.5m**	**£6,470.5m**	**£6,499.7m**	**£4,145.8m**

12.11 Table 12.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "strategic options technical appendix 2020/2021 price base" Appendix D.

Table 12.2 – ECO 5 lifetime cost for each technology option

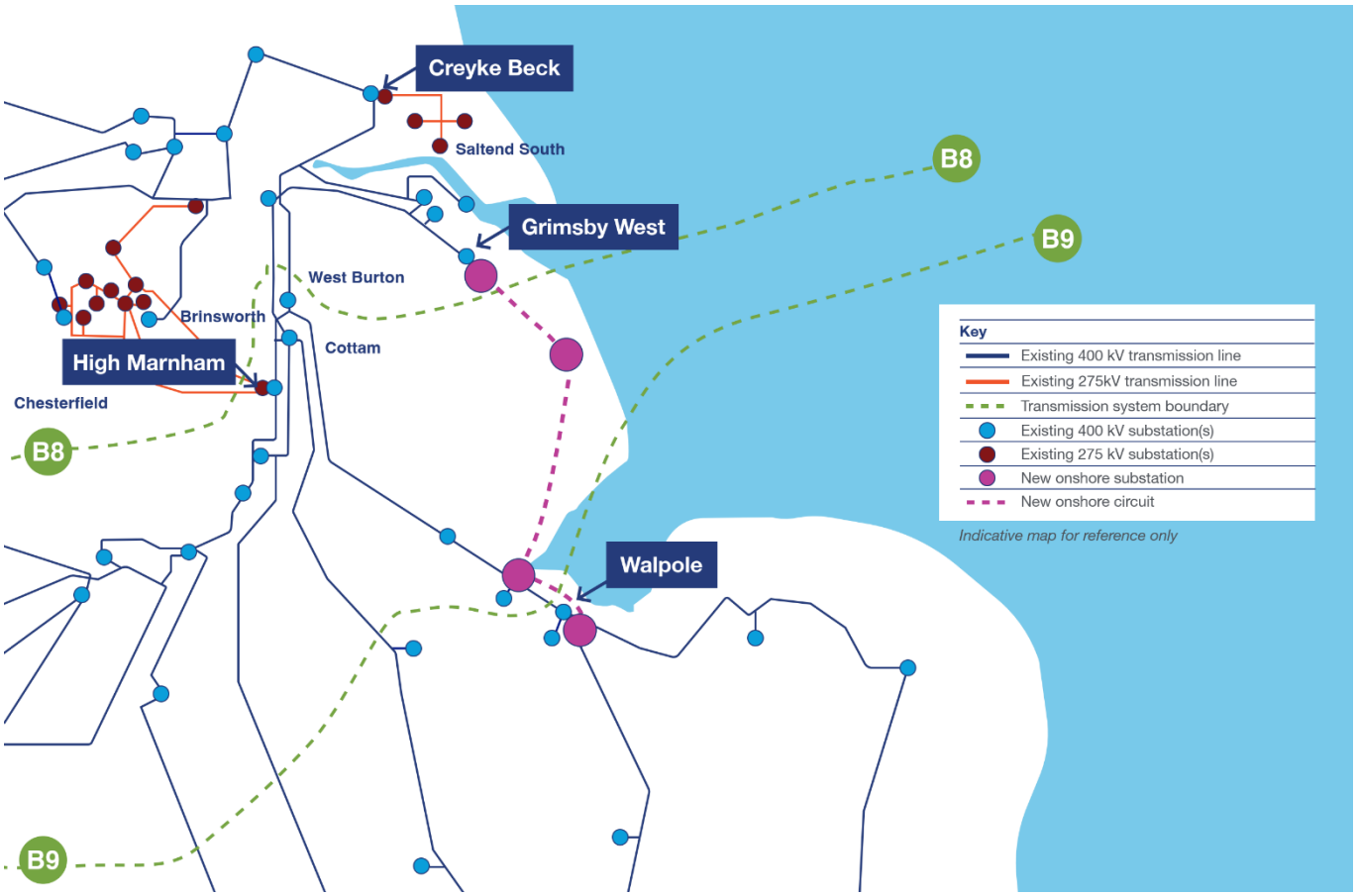
Land Based option	ECO 5 AC OHL	ECO 5 AC Cable	ECO 5 AC GIL	ECO 5 HVDC
Capital cost of new circuits	£557.2m	£6,027.2m	£6,056.4m	£3,702.5m
Net Present Value (NPV) of cost of losses over 40 years	£392.7m	£296.2m	£182.3m	£706.9m
NPV of operation & maintenance costs over 40 years	£8.2m	£28.2m	£8.2m	£258.2m
Lifetime cost of new circuits	**£958m**	**£6,352m**	**£6,247m**	**£4,668m**

12.12 From the environmental and technical appraisal considered alongside capital and circuit lifetime costs the preferred option for ECO 5 is a 140km connection between a New Grimsby West to New Walpole via New Lincolnshire Connection Substation(s), would be for an AC circuit through Lincolnshire. In light of this analysis our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection, with a fully defined proposal being subject to the *Defined proposal and statutory consultation stage* as defined in "Our Approach to Consenting".

13. Appraisal of Strategic Option ECO 6 – new Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) via new Weston Marsh to new Walpole

13.1 Option ECO 6 involves the connection of new transmission circuit connections between a new Grimsby West substation to new Lincolnshire Connection substation(s), and new Lincolnshire Connection substation(s) to a new Walpole substation via a new Weston Marsh substation following a route through Lincolnshire, with a route length of approximately 140km as shown in Figure 13.1 below.

Figure 13.1 – ECO 6 - new Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) via new Weston Marsh to new Walpole



13.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken for this option. The appraisal is set out in Appendix G.

13.3 For the appraisal of onshore options of significant distance, an overhead line would normally be expected to offer the most economic, efficient, and co-ordinated

development and would meet NGET's obligations under section 9 of the Electricity Act. Therefore, prior to consultation on any required mitigation the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has sought to establish the impacts of the proposal based upon overhead line technology. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

13.4 Overall, ECO 6 is relatively constrained in relation to both ecological, landscape and visual considerations. Whilst the Humber Estuary Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site and Site of Special Scientific Interest (SSSI), The Wash Ramsar Site, SSSI, SPA, Important Bird Area (IBA) and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable, there is the potential for adverse effects on the interest features (both habitats and species) for which a number of these sites are designated, depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routeing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). Although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) would be avoided by the overhead line, there is potential for long-term effects on views from the AONB from both the overhead line and substation infrastructure at the Lincolnshire Connection substation(s). There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at the Lincolnshire Connection substation(s) sites and at Weston Marsh in a landscape which currently has little major development. There would however be opportunities through more detailed routeing and design to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

13.5 Compared to the remaining East Coast generation group connections, the key factors affecting ECO 6 are similar to ECO 5, however ECO 6 would include an additional substation at Weston Marsh which would result in a number of additional environmental and socio-economic effects compared with ECO 5. The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 5 and ECO 6) including the associated substation infrastructure, would be different in nature to the subsea option (ECSS 2) which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea option ECSS 2 would have challenges relating to the installation of buried cables across marine ecological designations. These would include temporary effects on the Greater Wash SPA which would require a cable crossing, as well as the potential for temporary effects on designated sites along the north Norfolk coast as it would not be possible to avoid all designated areas. There are potential heritage constraints which may result in potential effects on the setting of a number of scheduled monuments and listed buildings depending on converter station siting at Grimsby West. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

13.6 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between new Grimsby West

and new Walpole via new Lincolnshire Connection Substation(s) and Weston Marsh would satisfy the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), and resolve the requirement of providing generation group connections for Lincolnshire coastal connections, whilst providing >6 GW of capacity across the B8 and B9 boundaries.

13.7 Technical analysis of this option includes the following:

- This option provides connections locations for all generation connecting between the south of the Humber Estuary and north of the Wash. It also facilities boundary capacity across the B8 and B9 Boundaries.
- This option assumes a circuit is constructed from Weston Marsh to Walpole and Walpole remains the Main Interconnected Transmission System (MITS) substation with more than 4 circuits, connecting it to the system to ensure, even under secured faults, transfer south of the B9 boundary continues.

13.8 As set out in Chapter 5, we undertook a cost evaluation of the following four technologies for onshore options evaluation:

- 400 kV alternating current (AC) overhead Line
- 400 kV AC underground cable
- 400 kV AC gas insulated line (GIL)
- 525 kV high voltage direct current (HVDC) underground cable

13.9 Option ECO 6 requires the following transmission works to satisfy the requirements of the SQSS.

- **New Circuit requirements**
  - AC connections circuit options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA); or
  - HVDC connection options use 525 kV 2 GW voltage source links, which would require a convertor station at each end, similar in size to a large warehouse. In this case a 6 GW three ended connection would require three convertor stations at each substation (nine in total as there are three connection locations), this is to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation Works**
  - 14 bay new Grimsby West 400 kV substation replacing the existing substation to accommodate new circuits and existing circuits.
  - New Lincolnshire Connection substation(s) (LCN); LCN 1 new 12 bay 400 kV substation & LCN 2 new 19 bay 400 kV substation.
  - 12 bay new Weston Marsh 400 kV substation to connect back into the system.
  - 19 bay new Walpole 400kV substation to accommodate required new circuits.

13.10 Table 13.1 below sets out the capital costs for option ECO 6 considering substation works and each technology option.

Table 13.1 – ECO 6 capital costs for each technology option

Item	Need	ECO 6 capital cost			
Substation Works	Facilitate generation and connect new circuits	£516.8m			
New circuits		**AC OHL**	**AC Cable**	**AC GIL**	**HVDC**
New circuit 140km	New circuit across B8 and B9	£557.2m	£6,027.2m	£6,056.4m	£3,702.5m
Total capital cost		**£1,074m**	**£6,544m**	**£6,573.2m**	**£4,219.3m**

13.11 Table 13.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "strategic options technical appendix 2020/2021 price base" Appendix D.

Table 13.2 – ECO 6 lifetime cost for each technology option

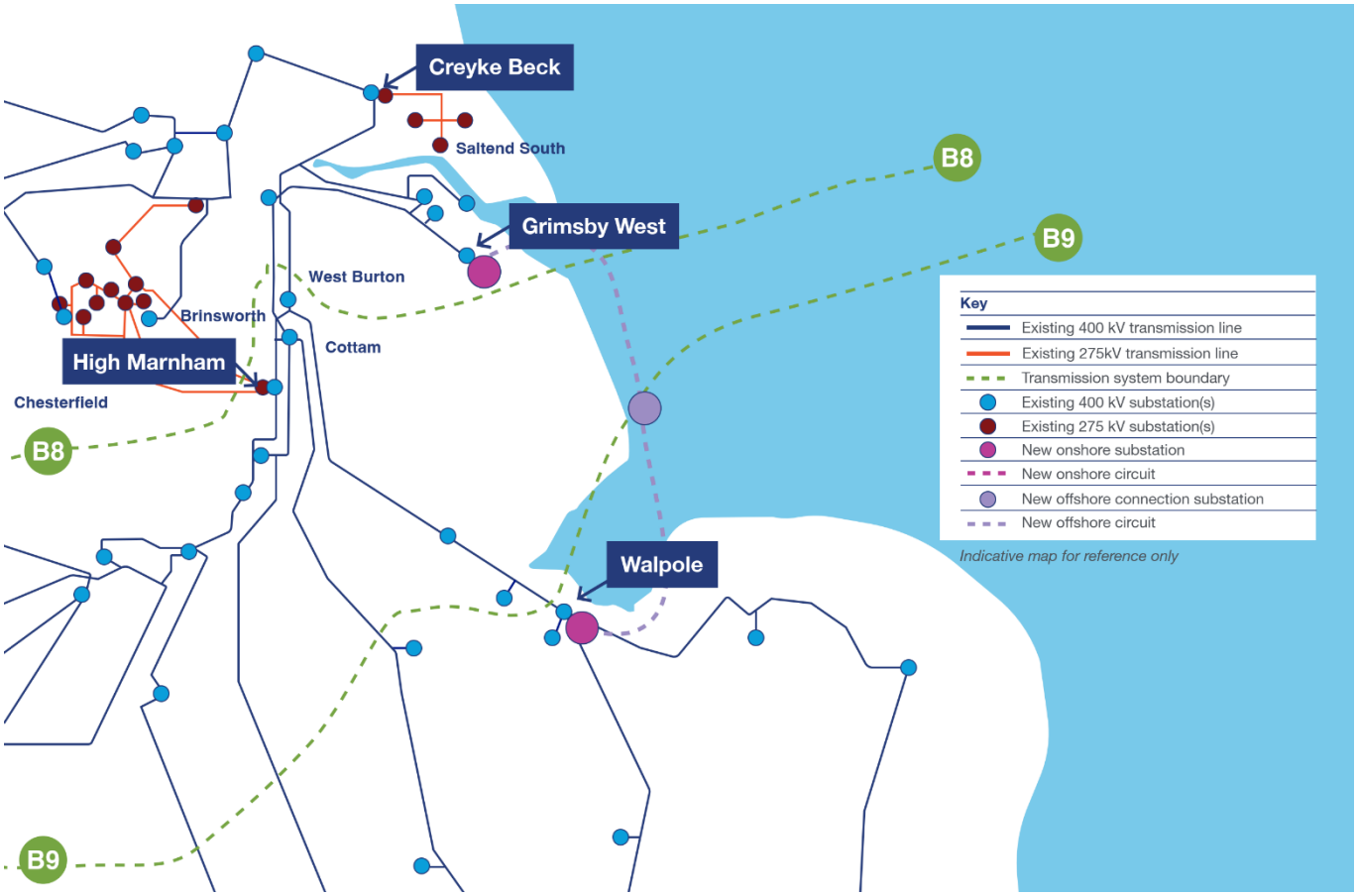
Land Based option	ECO 6 AC OHL	ECO 6 AC Cable	ECO 6 AC GIL	ECO 6 HVDC
Capital cost of new circuits	£557.2m	£6,027.2m	£6,056.4m	£3,702.5m
Net Present Value (NPV) of cost of losses over 40 years	£392.7m	£296.2m	£182.3m	£706.9m
NPV of operation & maintenance costs over 40 years	£8.2m	£28.2m	£8.2m	£258.2m
Lifetime cost of new circuits	**£958m**	**£6,352m**	**£6,247m**	**£4,668m**

13.12 From the environmental and technical appraisal considered alongside capital and circuit lifetime costs the preferred option for ECO 6 is a 140 km connection between a new Grimsby West to new Walpole via new Lincolnshire Connection substation(s) and new Weston Marsh substation, would be for an AC circuit through Lincolnshire. In light of this analysis our starting presumption for further development of this option should it be selected, would be for a majority overhead line connection, with a fully defined proposal being subject to the *Defined proposal and statutory consultation stage* as defined in "Our Approach to Consenting".

14. Appraisal of Strategic Option ECSS 2 – new Grimsby West to new Walpole subsea with off-shore connection point

14.1 Option ECSS 2 involves the connection of new subsea transmission circuit connections between a new Grimsby West substation and a new Walpole Substation, with a new offshore high voltage direct current (HVDC) connection point. This follows a route to the east coast, offshore along the east coast, to a new onshore Walpole substation, with a length of approximately 155km, as shown in Figure 14.1 below.

Figure 14.1 – ECSS 2 – new Grimsby West to new Walpole subsea with off shore connection point



14.2 An environmental and socio-economic appraisal of the circuit connection has been undertaken looking at this option. The appraisal is set out in Appendix G.

14.3 For the appraisal of subsea options of significant distance, a HVDC option would normally be expected to offer the most economic, efficient, and co-ordinated development and would meet NGET's obligations of economy and efficiency under the Electricity Act. Therefore, the environmental and socio-economic appraisal, which takes into consideration NGET's duty to have regard to the environment in Schedule 9, has considered whether the impacts of the proposal based upon HVDC technology in a

marine environment would be likely to be acceptable. This enables the appraisal to highlight areas of highest impact aiding discussions throughout the consultation stage of the project.

14.4 Overall, ECSS 2 is constrained in relation to ecological considerations. The Greater Wash Special Protection Area (SPA) is unavoidable and would require cable crossings. Due to the number and proximity of designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ), The Wash and North Norfolk Coast Special Area of Conservation (SAC), Holkham National Nature Reserve, and North Norfolk Coast Ramsar, Site of Special Scientific Interest (SSSI) and Important Bird Area (IBA), it would not be possible to avoid all of these designated areas. It may be possible to avoid ecologically designated sites associated with the Humber Estuary, Saltfleet-by-Theddlethorpe Dunes and Gibraltar Point along the Lincolnshire coast depending on landfall siting. The Inner Dowsing, Race Bank and North Ridge SAC extends across the majority of the study area; this site could potentially be avoided depending on subsea cable routeing and offshore HVDC connection platform siting. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are potential heritage constraints which may result in potential effects on the setting of a number of scheduled monuments and listed buildings depending on converter station siting at Grimsby West. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.

14.5 ECSS 2 would involve sections of undergrounded cable and above-ground infrastructure (converter stations); the nature of the environmental and socio-economic effects associated with the subsea option ECSS 2 would be different in nature to the overhead line options (ECO 5 and ECO 6) for a number of environmental and socio-economic topics. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

14.6 Alongside the environmental and socio-economic appraisal of the option a technical appraisal has established that a transmission connection between a new Grimsby West substation and a new Walpole substation via new offshore connection platforms would satisfy the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), and resolve the requirement of providing generation group connections for Lincolnshire coastal connections, whilst providing >6 GW of capacity across the B8 and B9 boundaries.

14.7 Technical analysis of this option includes the following:

- This option provides connections locations for all generation connecting between the south of the Humber Estuary and north of the Wash. It also facilities boundary capacity across the B8 and B9 Boundaries.
- The offshore option still requires provision of connection for the generation and is assumed to be connections based offshore on alternating current (AC)/HVDC platforms as part of three ended circuits.
- The offshore options considered for option ECSS 2 offer no technical advantage over options considered for on-shore alternatives. Both onshore and offshore, AC and HVDC alternatives considered offer NETS SQSS compliant solutions that meet the needs case. Each technology considered within an option can be designed to

provide the required system performance and capacity albeit with different characteristics. The only delivery advantage offered by offshore cable installation compared to onshore is the ability to carry significant lengths of cable on a large vessel for deployment. Allowing cable laying campaigns of up 100km carried by a single vessel, whereas cables laid on land need to be deployed in drum lengths of circa 1km for delivery to site.

14.8 As set out in Chapter 5, we undertook a cost evaluation of the following two technologies for subsea options evaluation.

- 400 kV AC subsea cable
- 525 kV HVDC subsea cable

14.9 Option ECSS 2 requires the following transmission works to satisfy the requirements of the SQSS.

- **New Circuit requirements**
  - AC subsea connections circuit options use hi-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6930 mega volt amperes (MVA); or
  - HVDC connection options use 525 kV 2 GW voltage source links, which would require a convertor station at each end, similar in size to a large warehouse. In this case a 6 GW three ended connection would require three convertor stations at each substation (nine in total as there are three connection locations), this is to come close to matching the AC hi-capacity circuits of 6930 MVA.
- **Substation Works**
  - 14 bay new Grimsby West 400 kV substation replacing the existing substation to accommodate new circuits and existing circuits.
  - 19 bay new Walpole 400 kV substation to accommodate required new circuits.
  - A new offshore connection node to facilitate the connection of offshore generation.

14.10 Table 14.1 below sets out the capital costs for option ECSS 2 considering substation works and each technology Option.

Table 14.1 – ECSS 2 capital cost for each technology option

Item	**Need**	**ECSS 2 capital cost**	
Substation works	Facilitate generation and connect new circuits	£550.1m	
New circuits		**AC subsea cable**	**HVDC subsea cable**
New circuit 155 km	New circuit across B8 and B9	£6,696.4m	£3,841.6m
Total capital cost		**£7,246.5m**	**£4,391.7m**

14.11 Table 14.2 below sets out the lifetime cost for the new circuit options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in “strategic options technical appendix 2020/2021 price base” Appendix D.

Table 14.2 – ECSS 2 lifetime cost for each technology option

Subsea based option	**ECSS 2 AC subsea cable**	**ECSS 2 HVDC subsea cable**
Capital cost of new circuits	£6,696.4m	£3,841.6m
Net present value (NPV) of Cost of Losses over 40 years	£336.8m	£706.9m
NPV of operation & maintenance costs over 40 years	£31.9m	£258.4m
Lifetime cost of new circuits	**£7,065m**	**£4,807m**

14.12 From the environmental and technical appraisal considered alongside capital and circuit lifetime costs the preferred option for ECSS 2 is a 155 km connection between a new Grimsby West substation and new Walpole substation, would be for an HVDC subsea circuit paralleling the Lincolnshire coast. In light of this analysis our starting presumption for further development of this option should it be selected, would be for a majority HVDC subsea connection.

15. Strategic options appraisal conclusions

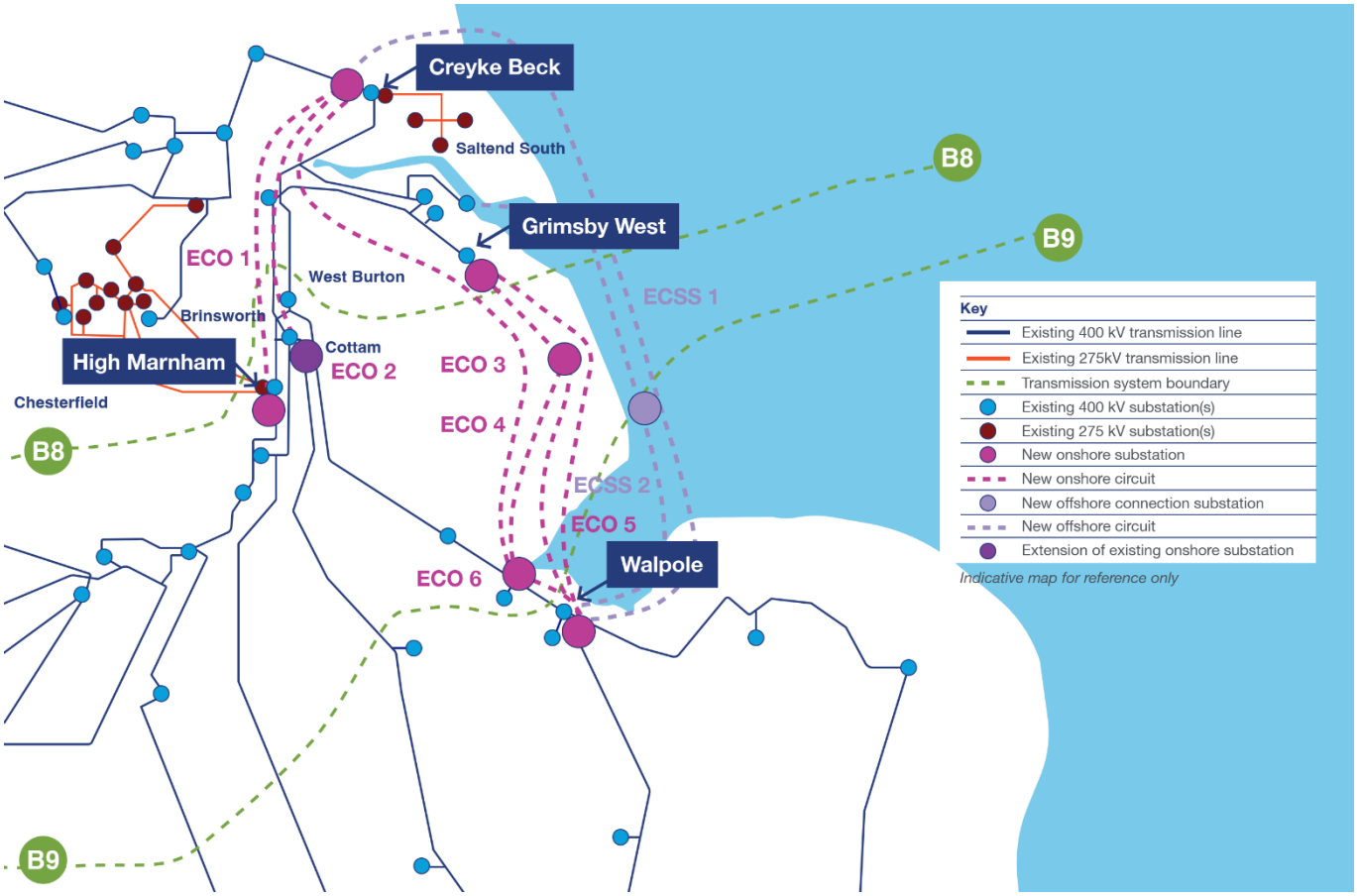
15.1 Introduction

15.1.1 As described in the strategic options overview to resolve the Need Case, two sets of issues need to be resolved:

- Issue (a), a circuit is required to ensure compliance from the Creyke Beck generation group whilst also providing >6 GW of boundary capacity across the B8 boundary.
- Issue (b), a circuit is required to provide capacity to the East Coast generation group whilst increasing the boundary capacity across B8 by an additional >6 GW (giving >12 GW capacity in total) and providing >6 GW of capacity across the B9 boundary.

15.1.2 Figure 15.1 below shows a geographical indication of the 8 options appraised as part of this report

Figure 15.1 – Geographical indication of strategic options appraised



15.1.3 The following options were appraised in the previous sections by reference to environmental and socio-economic impacts, technical analysis, capital and lifetime cost.

15.2 Options resolving Issue (a)

15.2.1 The options considered to resolve Issue (a) – Creyke Beck generation group and >6 GW capacity across B8 are:

- ECO 1 – New Creyke Beck to new High Marnham **85 km**
- ECO 2 – New Creyke Beck to Cottam **75 km**
- ECO 3 – New Creyke Beck to new Grimsby West, New Grimsby West Substation to New Walpole **225 km**
- ECO 4 – New Creyke Beck to new Grimsby West, new Grimsby West Substation to new Weston Marsh **200 km**
- ECSS 1 – Subsea from new Creyke Beck – new Walpole **195 km**

15.3 Options resolving Issue (b)

15.3.1 The options considered to resolve Issue (b) – East Coast generation group, further >6 GW capacity across B8 (>12 GW total) and >6 GW of capacity across B9 are:

- ECO 5 – New Grimsby West to new Lincolnshire Connection substation(s), new Lincolnshire Connection substation(s) to new Walpole **140 km**
- ECO 6 – New Grimsby West to new Lincolnshire Connection substation(s), Lincolnshire Connection substation(S) to new Weston Marsh, new Weston Marsh to new Walpole **140 km**
- ECSS 2 – Subsea new Grimsby West – Offshore Connection Node – new Walpole **155 km**

15.4 Environmental and socio-economic appraisal

15.4.1 The environmental and socio-economic appraisals for each option are fully documented in Appendix G. A comparative analysis is provided in Table 15.1 and 15.2 below. Each of the options appraised have their relative advantages and disadvantages. One of the key differentiators between options relates to overall route length which can impact the extent of environmental and socio-economic effects.

Table 15.1 – Options providing 6 GW increase across the B8 boundary and generation connections to Creyke Beck

Topic		ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
Environmental	Biological	Requires a crossing of the Humber Estuary SPA and SAC.	Requires a crossing of the Humber Estuary SPA and SAC.	Requires a crossing of the Humber Estuary SPA and SAC. Whilst The Wash SPA and The Wash and North Norfolk Coast SAC are avoidable there is the potential for adverse effects depending on routeing.	Requires a crossing of the Humber Estuary SPA and SAC. Whilst The Wash SPA and The Wash and North Norfolk Coast SAC are avoidable there is the potential for adverse effects depending on routeing.	Although the Southern North Sea SAC and Holderness Offshore MCZ could potentially be avoided, the Holderness Inshore MCZ and The Greater Wash SPA are within the study area and would require cable crossings. . It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ however this would extend the overall cable length and potentially require a	Although the Southern North Sea SAC and Holderness Offshore MCZ could potentially be avoided, the Holderness Inshore MCZ and The Greater Wash SPA are within the study area and would require cable crossings. . It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ however this would extend the overall cable length and potentially require a

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
					crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC. Due to the number and proximity of the designated sites along the north Norfolk coast it would not be possible to avoid all designated areas.	crossing of the Holderness Offshore MCZ. The Humber Estuary designated sites are potentially avoidable subject to landfall selection and subsea cable installation methods.
Landscape & Visual	Requires a crossing of the Yorkshire Wolds Important Landscape Area. Potential effects on visual amenity for residents along affected settlement edges and at	Requires a crossing of the Yorkshire Wolds Important Landscape Area. Potential effects on visual amenity for residents along affected settlement edges and at	Requires a crossing of the Yorkshire Wolds Important Landscape Area. The Lincolnshire Wolds AONB itself would be avoided, however there is potential for long-term effects on views	Requires a crossing of the Yorkshire Wolds Important Landscape Area. The Lincolnshire Wolds AONB itself would be avoided, however there is potential for long-term effects on views	Crossing of the Norfolk Coast AONB would be unavoidable. Views from both the AONB and Norfolk Heritage Coast may to be affected for a temporary period during construction. Potential for	The Lincolnshire Wolds AONB itself would be expected to be avoided. Potential for adverse residual permanent effects during the operational phase of the converter stations at

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
	scattered properties.	scattered properties.	from the AONB. Potential for adverse landscape and visual impacts due to the introduction of new substation infrastructure. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	from the AONB. Potential for adverse landscape and visual impacts due to the introduction of new substation infrastructure. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	temporary adverse visual effects on users of the Peddar's Way and Norfolk Coast Path National Trail. Potential for adverse residual permanent effects during the operational phase of the converter stations at Creyke Beck and Walpole.	Creyke Beck and Walpole.
Historic Environment	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of

Topic		ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
		the overhead line.	the overhead line and SEC at Cottam.	the overhead line and substation infrastructure. Routeing to the west of Grimsby would need to avoid the Registered Park and Garden of Brocklesby Park.	the overhead line and substation infrastructure. Routeing to the west of Grimsby would need to avoid the Registered Park and Garden of Brocklesby Park.	the converter station infrastructure.	the converter station infrastructure.
	Physical	Requires crossings of main rivers and Flood Zone 2 and 3.	Requires crossings of main rivers and Flood Zone 2 and 3.	Requires crossings of main rivers and Flood Zone 2 and 3. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Walpole.	Requires crossings of main rivers and Flood Zone 2 and 3. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Weston Marsh.	Requires crossings of main rivers and Flood Zone 2 and 3 as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of converter station infrastructure.	Requires crossings of main rivers and Flood Zone 2 and 3 as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of converter station infrastructure.
Socio-economic	Settlements and Population	Numerous large urban areas within the study	Numerous large urban areas within the study	Numerous large urban areas within the study	Numerous large urban areas within the study	The large urban areas of Kingston-Upon-	The large urban areas of Kingston-Upon-

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
	area including Kingston-Upon-Hull, Scunthorpe and Gainsborough as well as numerous smaller settlements scattered throughout.	area including Kingston-Upon-Hull, Scunthorpe and Gainsborough together with numerous smaller settlements scattered throughout.	area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	Hull and Kings Lynn as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.	Hull and Boston as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.
Tourism and Recreation	The Yorkshire Wolds National Trai and Trans Pennine Trail cross the northern portion	The Yorkshire Wolds National Trai land Trans Pennine Trail cross the northern portion	The Yorkshire Wolds National Trail and Trans Pennine Trail cross the northern portion of the study area. The	The Yorkshire Wolds National Trai land Trans Pennine Trail cross the northern portion of the study area. The	The Trans Pennine Trail extends across cross the northern portion of the study area.	The Trans Pennine Trail extends across cross the northern portion of the study area. The Witham Way

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
	of the study area. The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.	of the study area. The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.	Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.	Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.	The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.	and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
Infrastructure	Multiple road and rail crossings required including M180 and M62/A63.	Multiple road and rail crossings required including M180 and M62/A63.	Multiple road and rail crossings required including M180 and M62/A63.	Multiple road and rail crossings required including M180 and M62/A63.	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of subsea cable routeing. Multiple road	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of subsea cable routeing. Multiple road

Topic	ECO 1	ECO 2	ECO 3	ECO 4	ECSS 1 (Norfolk)	ECSS 1 (Lincs)
					and rail crossings required.	and rail crossings required.

Table 15.2 – Options providing additional 6 GW increase to B8, 6 GW capacity to B9 and generation connections to Lincolnshire Connection substation(s)

	Topic	ECO 5	ECO 6	ECSS 2
Environmental	Biological	Whilst The Wash SPA and The Wash and North Norfolk Coast SAC are avoidable there is the potential for adverse effects depending on routeing.	Whilst The Wash SPA and The Wash and North Norfolk Coast SAC are avoidable there is the potential for adverse effects depending on routeing.	Potential effects on Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI depending on landfall selection. Potential for direct effects on designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast RAMSAR, SSSI and IBA; it would not be possible to avoid all designated areas. The Greater Wash SPA is within the study area and would require cable crossings. The Inner Dowsing, Race Bank and North Ridge SAC extends across the majority of the

Topic	ECO 5	ECO 6	ECSS 2
			study area; this site could potentially be avoided depending on subsea cable routeing. Potential for effects on additional designated ecological sites including River Nar SSSI depending on onshore routeing.
Landscape & Visual	The Lincolnshire Wolds AONB itself would be avoided, however there is potential for long-term effects on views from the AONB. Potential for adverse landscape and visual impacts due to the introduction of new substation infrastructure particularly at a Lincolnshire Connection substation(s) in a landscape which currently has little major development. Potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole. Potential effects on visual amenity for residents along affected settlement edges	The Lincolnshire Wolds AONB itself would be avoided, however there is potential for long-term effects on views from the AONB. Potential for views of new Lincolnshire Connection substation(s) infrastructure from within the Lincolnshire Wolds AONB depending on site selection. Potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at Lincolnshire Connection substation(s) and Weston Marsh in a landscape which currently has little major development. Potential for adverse landscape and	Temporary landscape and visual effects including impacts on the landscape of the Norfolk Coast AONB which could not be avoided. Views within and from both the AONB and North Norfolk Heritage Coast may be temporary period during construction. The Lincolnshire Wolds AONB would be avoided. Potential for temporary adverse visual effects on users of the Peddar's Way and Norfolk Coast Path National Trail. Potential for adverse residual permanent effects during the operational phase of the converter stations at

Topic		ECO 5	ECO 6	ECSS 2
		and at scattered properties.	visual impacts due to the introduction of a new substation at Walpole. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	Grimsby West and Walpole.
	Historic Environment	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of the overhead line and substation infrastructure.	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of the overhead line and substation infrastructure.	Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of the converter station infrastructure at Grimsby West.
	Physical	Requires crossings of main rivers and Flood Zone 2 and 3. Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Walpole.	Requires crossings of main rivers and Flood Zone 2 and 3. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Walpole and Weston Marsh.	The onshore cable would have to cross several unavoidable watercourses including main rivers and associated floodplains, as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable the siting of converter station infrastructure at Walpole.

	Topic	ECO 5	ECO 6	ECSS 2
Socio-economic	Settlements and Population	Numerous large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	Numerous large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	The large urban areas of Grimsby and Kings Lynn as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.
	Tourism and Recreation	The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be	The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be	A number of NCN cross the study area including routes to/from Grimsby and to/from Kings Lynn. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routeing and design.

Topic		ECO 5	ECO 6	ECSS 2
		minimised through careful routeing and design.	minimised through careful routeing and design.	
	Infrastructure	Multiple road and rail crossings required.	Multiple road and rail crossings required.	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of subsea cable routeing. Multiple road and rail crossings required.

15.4.2 For the Creyke Beck generation group connections, all onshore options would need to cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species (collision risk). Paralleling the existing 4ZQ 400 kV overhead route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes. For ECO 1 and ECO 2 whilst sites such as Thorne and Hatfield Moors SPA and Important Bird Area (IBA), Thorne Moor Special Area of Conservation (SAC), Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are designated, depending on routeing. For ECO 3 and ECO 4 whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated.

15.4.3 All onshore options would need to cross the Yorkshire Wolds Important Landscape Area (ILA). For ECO 3 and ECO 4 although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) itself would be avoided, there would be potential for long-term effects on views from the AONB particularly given the low-lying open topography with views from the Wolds to the coast.

15.4.4 The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 1, ECO 2, ECO 3 and ECO 4) including the associated substation infrastructure, would be different to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

15.4.5 Appraisal of the strategic options showed that ECO 1 and ECO 2 options would have a materially shorter overhead line route than that of ECO 3, ECO 4 and would be expected to have lower environmental and socio-economic effects.

15.4.6 For the East Coast generation group connections, appraisal of the strategic options showed that additional transmission circuits within ECO 5 and ECO 6 are comparable in terms of length and also that the levels of environmental and socio-economic effects would be expected to be similar. A key difference between these strategic options is that an additional substation at Weston Marsh would be required for ECO 6. The additional substation at Weston Marsh for ECO 6 has potential to result in long term landscape and visual effects due to the introduction of new substation infrastructure in a landscape which currently has little major development.

15.4.7 The nature of the environmental and socio-economics effects associated with the overhead line options (ECO 5 and ECO 6) including the associated substation infrastructure, would be different to the subsea option (ECSS 2) which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea option ECSS 2 would have challenges relating to the installation of buried cables across marine ecological designations. Overall, on the basis of the information currently available and assuming

that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

15.4.8 All of the options considered in this report met the technical appraisal requirements of the Need Case and were compliant with the NETS SQSS.

15.4.9 Options ECO 1 and ECO 2 (resolving Issue (a)) had a specific technical difference. Option ECO 1 performs better when providing boundary capacity due to the proximity of demand as it is closer to the South Yorkshire conurbation. Option ECO 2 did not provide as much boundary benefit whilst also suffering from highly constrained routeing due to infrastructure in the vicinity of Cottam substation, introducing risks to construction. A comparison of siting between the two sites outlines a significant reduced risk at High Marnham compared to Cottam. The construction of a new substation at High Marnham offers a substantial cost saving compared to the optimum solution at Cottam. Furthermore, constructability risks are controllable by mitigation methods at High Marnham. In contrast, the risk profile is considerably higher at Cottam, risks are less manageable and may lead to abortive works and delays to the programme. This added substantial weight in favour of ECO 1 when balanced with the additional infrastructure cost, environmental impacts and socio-economic impacts.

15.4.10 Table 15.3 below sets out an overview of the capital and lifetime cost impacts of each alternative, noting that an option to resolve Issue (a) and an option to resolve Issue (b) have to be selected in combination to provide the full required connection capacities at Creyke Beck and Lincolnshire Coastal Connections; and the provision of >12GW total capacity across B8 and >6GW Capacity across B9.

Table 15.3 – Capital and lifetime cost impact

Boundary or group	**Onshore options**				**Subsea option**
Issue (a)	**ECO 1**	**ECO 2**	**ECO 3**	**ECO 4**	**ECSS 1**
Creyke Beck connection capacity	New Creyke Beck to new High Marnham	New Creyke Beck to Cottam	New Creyke Beck to New Walpole	New Creyke Beck to Weston Marsh	New Creyke Beck to New Walpole
B8 >6 GW increase			(2 sections)	(2 sections)	
Economic technology (capacity)	overhead line 85 km (6930 MW)	overhead line 75 km (6930 MW)	overhead line 225 km (6930 MW)	overhead line 200 km (6930 MW)	HVDC 195 km (6000 MW)
Total capital cost including non-circuit works	£454m	£465.6m	£1,250.7m	£1,094.7m	£3,646m
Circuit 40 yr lifetime NPV cost	£582m	£513m	£1,540m	£1,369m	£4,055m

Boundary or group	Onshore options		Subsea option
Issue (b)	**ECO 5**	**ECO 6**	**ECSS 2**
Lincolnshire coastal connections capacity	New Grimsby West to new Walpole via new Lincolnshire Connection substation(s)	New Grimsby West to new Walpole via new Lincolnshire Connection substation(s) and Weston Marsh	New Grimsby West to new Walpole with Offshore Connection Node (3 ended HVDC)
B8 >6 GW Increase B9 >6 GW Increase	(3 sections)	(4 sections via Western Marsh)	(Subsea)
Economic technology (capacity)	overhead line 140 km (6930 MW)	overhead line 140 km (6930 MW)	HVDC 155 km (6000 MW)
Capital cost including non-circuit works	£1,000.5m	£1,074m	£4,391.7m
Circuit 40 yr lifetime NPV cost	£958m	£958m	£4,807m

15.4.11 Under the terms of the Transmission Licence, National Grid Electricity Transmission (NGET) is required to provide an efficient, economic and co-ordinated transmission system in England and Wales.

15.5 Conclusion

15.5.1 ECO 1 and ECO 2 options would have a materially shorter overhead line route than that of ECO 3 and ECO 4, and would be expected to have lower environmental and socio-economic effects, as well as lower capital and lifetime costs. ECO 1 and ECO 2 are therefore preferred to ECO 3 and ECO 4 amongst the Creyke Beck generation group onshore options.

15.5.2 ECO 1 has technical advantages when compared to ECO 2. ECO 1 performs better in terms of boundary capacity, while also being less constrained in terms of routeing due to the proposed connection to a new substation at High Marnham rather than Cottam. A comparison of the Cottam and High Marnham sites indicates that High Marnham offers substantial cost savings, as well as reduced constructability risks. Therefore, overall, ECO 1 is the preferred onshore option.

15.5.3 An offshore option, ECSS 1, was also considered. Overall, technical, environmental and socio-economic factors are not considered to differentiate between onshore and

offshore options for the purposes of option selection. However, ECSS 1 was substantially more expensive than any of the onshore options. This means that onshore options are preferred.

15.5.4 Therefore, we consider that, overall, ECO 1 represents the most advantageous of the Creyke Beck generation group options when balancing cost, technical performance and environmental and socio-economic effects.

15.5.5 In terms of the East Coast generation group onshore options, ECO 5 and ECO 6 offer similar technical performance, and the transmission circuits are similar in length. This means that the levels of environmental and socio-economic effects associated with the transmission circuits would be expected to be similar. However a key difference between these options is that an additional substation at Weston Marsh would be required for ECO 6. The additional substation has potential to result in long term landscape and visual effects due to the introduction of new substation infrastructure in a landscape which currently has little major development, as well as incurring additional cost that could be avoided with ECO 5. ECO 5 is therefore the preferred onshore option.

15.5.6 An offshore option, ECSS 2, was also assessed. Overall, technical, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection. However, ECSS 2 was substantially more expensive than either of the onshore options. This means that onshore options are preferred.

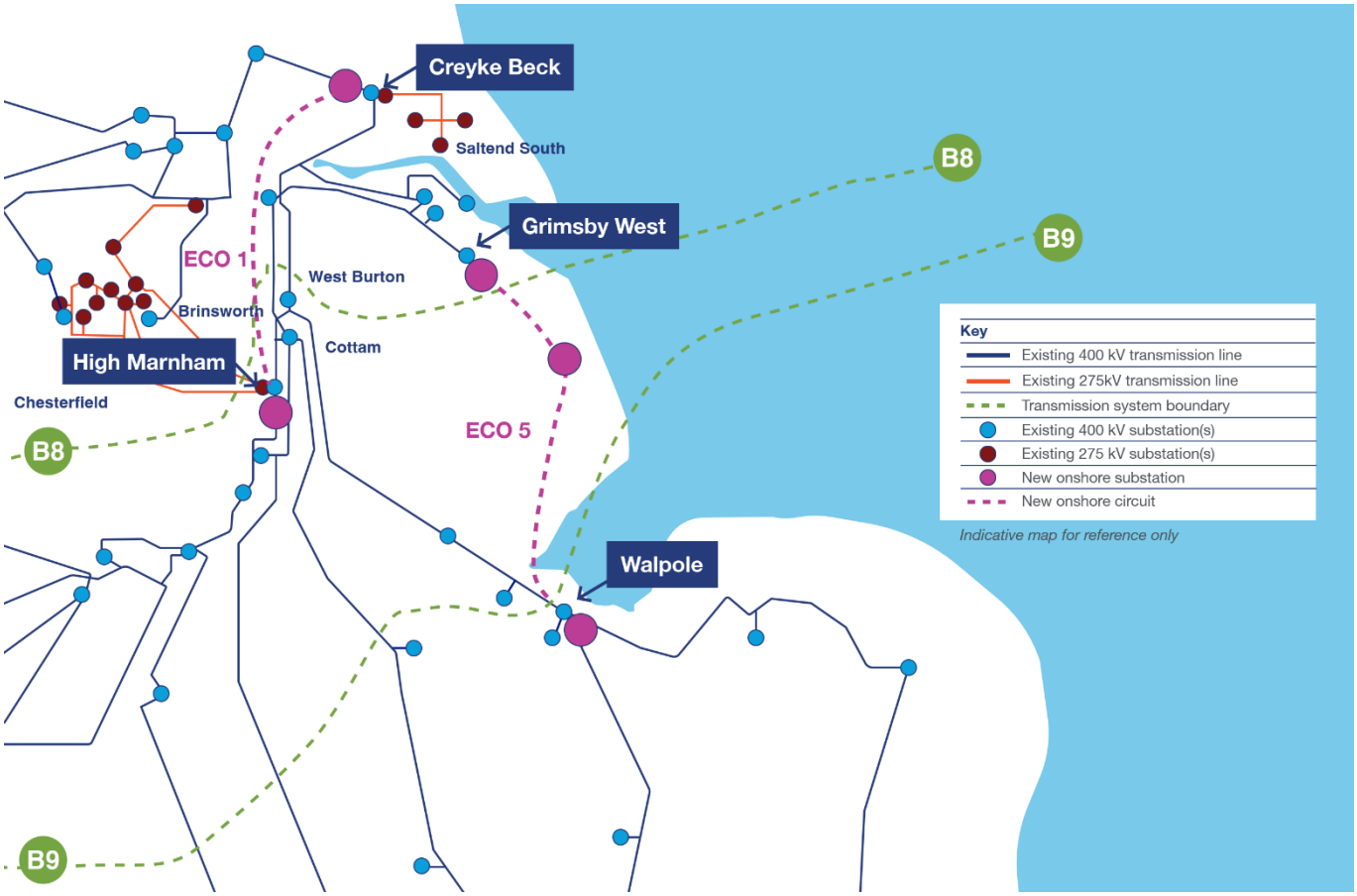
15.5.7 We therefore consider that, overall, ECO 5 represents the most advantageous of the East Coast generation group options when balancing cost, technical performance and environmental and socio-economic effects.

15.5.8 In summary, to satisfy the needs case of resolving both Issue (a) and Issue (b) and considering the above appraisal of environmental, socio-economic and technical differentiators, NGET is proposing to take forward the following options:

- ECO 1 a new primarily overhead line connection between New Creyke Beck substation to new High Marnham Substation. With a high-level assessment capital cost of **£454m** and lifetime circuit cost of **£582m**. This has been assigned the project title of “North Humber to High Marnham”
- ECO 5 a new primarily overhead line connection between new Grimsby West substation to new Walpole via new Lincolnshire Connection substation(s). With a high-level assessment capital cost of **£1,000.5m** and lifetime circuit cost of **£958m**. This has been assigned the project title of “Grimsby to Walpole”
- In conjunction, ECO 1 and ECO 5 have a combined high-level assessment capital cost of **£1,454.5m** and lifetime circuit costs of **£1,540m**

15.5.9 Figure 15.2 below shows the proposed options ECO 1 “North Humber to High Marnham” and ECO 5 “Grimsby to Walpole” projects.

Figure 15.2 – Proposed options ECO 1 “North Humber to High Marnham” and ECO 5 “Grimsby to Walpole” projects



15.6 Electricity System Operator Network Options Assessment (NOA)

15.6.1 As part of an annual process the independent National Grid Electricity System Operator (National Grid ESO) undertake the Network Options Assessment (NOA). This process assesses the capital cost of options provided, delivery timescales, and constraint costs avoided by increasing capacity.

15.6.2 The NOA provides the ESO recommendation relating to which reinforcement projects should receive investment for the next financial year. The NOA reports play an important role in indicating how investments proceeding to the required timescales, prevents constraint costs burden being passed to businesses and domestic consumers.

15.6.3 However, Page 8 of the NOA 2021/22 Refresh report states:

“*While we provide recommendations for the options to meet system needs, the TOs, Ofgem or other relevant parties will ultimately decide on what, where, and when to invest. The specific designs of any option, such as the choice of equipment and route will be developed by the TOs.*”

15.6.4 As stated in the NOA 2021/22 Refresh report, investment proceed signals have been provided in relation to the following onshore options:

- (NOA code CGNC) New 400 kV circuit between Creyke Beck and South Humber;

- (NOA Code GWNC) New 400 kV circuit between South Humber and South Lincolnshire;
- (NOA Code LRN4) New network need between North Lincolnshire and Hertfordshire (see section 16 below);

and a hold signal was provided for:

- (NOA code WWNC) New South Lincolnshire to East Anglia double circuit.

15.6.5 As demonstrated by this report two new double circuits between Creyke Beck and High Marnham, and between Grimsby and the Walpole area, together with changes of scope to the EGL3 and EGL4 projects, best meet the identified B8 and B9 Need Case. In turn, the next iteration of NOA will reflect the optimised set of projects that have been developed by the TOs through detailed assessments following the NOA recommendations.

15.6.6 The projects listed above with a proceed signal have a required in service date of 2030 in the January 2022 NOA report and the NOA 2020/21 Refresh report. WWNC has an optimal delivery date of 2033 in the NOA reports.

16. Interaction with other projects

16.1 As stated in Chapter 5, Strategic options overview, a further consideration NGET is currently evaluating, is the connection of offshore transmission circuits from Scotland, referred to in this report as EGL3 and EGL4. These projects each consist of 2 GW voltage source convertor (VSC) high voltage direct current (HVDC) transmission circuits. Together these will transfer 4 GW of energy between Scotland and England and will be subject to their own strategic option assessment. EGL3 and EGL4 will interact with options considered to resolve issue (b), as set out in Section 6.9 of the report. Therefore, this report will undertake an interactivity assessment of the EGL3 and EGL4 projects, which will in turn provide a proposed connection location to deliver the optimum infrastructure solution for the region and achieve our obligations to consumers and the environment.

16.2 EGL3 and EGL4 will be subject to their own full strategic options appraisal process, however the location of the connection points has a significant impact upon what is required to be built in the Lincolnshire region. For instance, if EGL3 and EGL4 were to connect north of the B9 boundary, then additional transmission infrastructure could be anticipated as has already been suggested in the Electricity System Operator (ESO) Network Options Assessment (NOA) 2021/22 Refresh report and is identified as LRN4. LRN4 is identified as a new 180 km connection between North Lincolnshire and Hertfordshire.

16.3 Due to the interrelation between these projects, this report has undertaken an interactivity assessment to present how the connection location can impact upon the required amount of infrastructure needed in the immediate future.

16.4 The ESO NOA 2021/22 Refresh report indicates that there are further investments interacting with the Lincolnshire area which currently indicate hold or proceed signals. The associated ESO NOA code and descriptions are stated below:

- (NOA code E4L5) Proceed - Eastern Scotland to England 3rd link: Peterhead to the south Humber subsea HVDC Link. Referred to as Eastern Greenlink 3 (EGL3);
- (NOA Code TGDC) Proceed - Eastern subsea HVDC Link from east Scotland to south Humber area. Referred to as Eastern Greenlink 4 (EGL4);
- (NOA Code LRN4) Proceed - New network need from North Lincolnshire to Hertfordshire;
- (NOA Code WWNC) Hold - New South Lincolnshire to East Anglia double circuit.

16.5 The 2021/22 NOA refresh assessments, and the most recent ETYS, assume that EGL3 and EGL4 will connect to the network in England above the B9 boundary, and that any new circuits constructed to connect the East Coast generation will not provide B9 capability (i.e. they will not fully address issue b). The consequence of this, in combination with further generation connections in the area, is that LRN4 (a connection between Lincolnshire and Hertfordshire) and WWNC (a new double circuit crossing B9 between Lincolnshire and East Anglia) have been recommended in NOA to provide additional B9 capability. These recommendations address the boundary capability requirement to 2030 and NGET's further contractual commitments beyond this date.

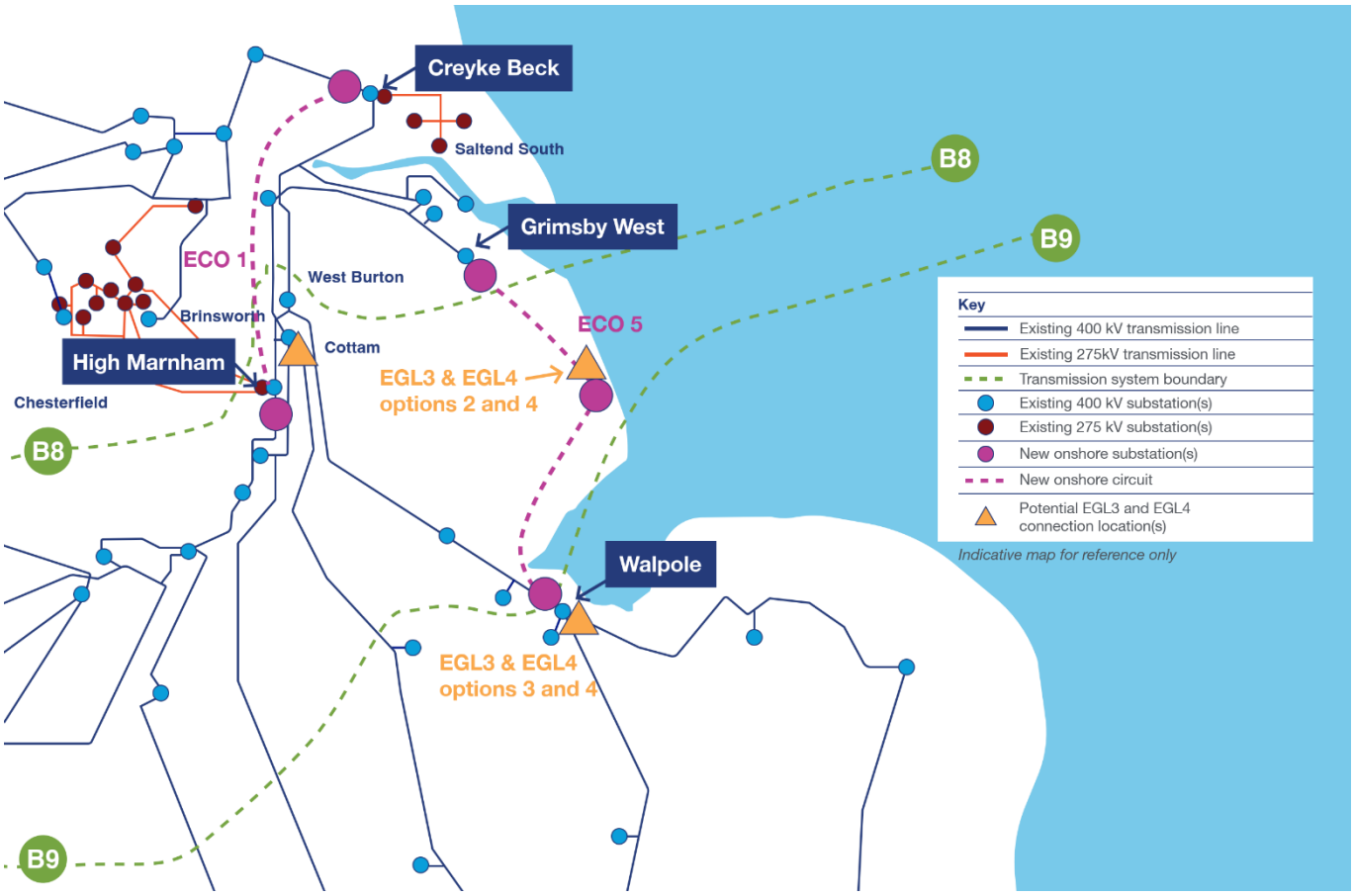
16.6 The options we have assessed to address Issue (b) have included a comparison between connecting the new generation connection circuits above B9, building a separate circuit across the boundary, as per the NOA assessments (ECO6), and connecting the new circuits directly to a MITS substation south of the B9 boundary (ECO5). Our assessments have determined that ECO5 is preferred, removing the need for WWNC.

16.7 We have also undertaken an interactivity assessment of the EGL3 and EGL4 projects and the schemes described in this report. This considered the most appropriate means of connecting those projects in the context of the Grimsby to Walpole proposals having regard to available information and assumptions. In turn, it has looked at the extent to which the interactivity would trigger the need for additional infrastructure such as LRN4. The technology choices and more detailed analysis for EGL3 and EGL4 will be carried out for those projects in due course. The potential strategic electrical solutions for connecting EGL3 and EGL4 are identified below:

- EGL Option 1 – New Lincolnshire Connection substation(s) (representing south of the Humber connection);
- EGL Option 2 – Cottam substation connection (representing moving the connection further inland);
- EGL Option 3 – New Walpole substation connection (representing moving connection south of B8 and B9);
- EGL Option 4 – New Walpole substation connection, with one project forming a three ended circuit connecting to new Lincolnshire Connection substation(s) and new Walpole substation.

16.8 Figure 16.1 below shows how proposed EGL3 and EGL4 projects would interact with our proposals

Figure 16.1 – Proposed EGL3 and EGL4 connection locations



16.9 The connection sites are only indicative for the purposes of comparing the cost of connection and impact upon B8 and B9 boundaries.

16.10 Table 16.1 below shows the capital and lifetime cost variation along with the impact to B8 and B9 boundaries, including infrastructure requirements.

Table 16.1 – Comparison of EGL3 and EGL4 Circuit Cost Options

Boundary or group	EGL3 Option				
	EGL Option 1	EGL Option 2	EGL Option 3	EGL Option 4	
	Lincolnshire Coastal Connection	Cottam Connection	Walpole Connection	Walpole and EGL 3 Coastal Connection Substation turn-in	**Differential between EGL options**
		Baseline + 90km	Baseline + 75km	Baseline + 80km	
	EGL 3 = 565km	EGL 3 = 655km	EGL 3 = 640km	EGL 3 = 645km	
	EGL 4 = 461km	EGL 4 = 551km	EGL 4 = 536km	EGL 4 = 541km	

Impact on B8 boundary capacity	4GW	4GW	4GW	4GW	0GW
Impact on B9 boundary capacity	0	0	4GW	4GW	4GW
B9 Boundary reinforcement required	Y	Y	N	N	EGL Option 3 and 4 don't currently require Lincolnshire section of LRN4 or WWNC
Capital Cost including non-circuit works	£4,239.1m	£4,795.3m	£4,702.6m	£5,000.7m	£761.6m difference between lowest and highest option
(Difference from option 1 Baseline)	(Baseline)	(£556.2m)	(£463.5m)	£761.6m)	
Circuit 40 yr Lifetime NPV Cost	£4,670.4m	£5,227.2m	£5,134.4m	£5,539.6m	£869.2m difference between lowest and highest option
(Difference from option 1 Baseline)	(Baseline)	(£556.8m)	(£464.0m)	(£869.2m)	

16.11 Table 16.1 shows that against identified boundary reinforcement requirements, moving the EGL3 and EGL4 connections to a Main Interconnected Transmission System (MITS) substation south of B9 would remove the need for 90km of overhead line required for LRN4 between North and South Lincolnshire, assuming that ECO5 is also developed.

16.12 Removing the necessity for LRN4 between North and South Lincolnshire means that environmental and socio-economic effects relating to this section of overhead line would not occur.

16.13 Based upon cost evaluation, the circuit only elements for LRN4 would have a capital cost of £358.2m and a lifetime cost of £616m.

16.14 On this basis the option to move EGL3 and EGL4 south of B9 to a new MITS substation on circuits between Spalding North and Walpole would have a net cost of ~£100m (~£460m of additional costs for the links minus ~£360m in savings from the OHL).

16.15 The connection is required at a MITS substation because more than two circuits south of the connection point are required to provide benefit to the B9 boundary. This ensures that under fault conditions energy can flow to the south of the connection location.

16.16 Therefore, the outcome of the interactivity assessment looking at holistic benefits to all projects is a recommendation that EGL3 and EGL4 should be connected south of the B9 boundary to a MITS substation, identified as new Walpole substation.

16.17 As indicated above, moving EGL3 and EGL4 south of B9 will provide increased boundary capacity. Whilst there is no current requirement to provide further capacity for the East Coast generation group, developing one of EGL3 or EGL4 as a three ended link would provide capacity for future connections. Further assessment of this option will be undertaken.

17. Conclusion and next steps

17.1 Overview

17.1.1 This Strategic Options Report (SOR) has considered options to meet the Need Case set out in Chapter 4. A requirement has been identified for two sets of transmission circuits that contribute to National Electricity Transmission System (NETS) Security and Quality of Supply Standard (SQSS) compliance. This requires the resolution of two distinct sets of issues, as follows:

- Issue (a), a circuit is required to ensure compliance from the Creyke Beck generation group whilst also providing >6GW of boundary capacity across the B8 boundary.
- Issue (b), a circuit is required to provide capacity to the East Coast generation group whilst increasing the boundary capacity across B8 by an additional >6 GW (giving >12 GW capacity) and providing >6 GW of capacity across the B9 boundary.

17.1.2 The findings of the options appraisal, which have considered a range of technical, environmental, socio-economic and cost issues, are summarised below.

17.2 Technical appraisal

17.2.1 All of the options considered in this report met the technical appraisal requirements of the Need Case, though some deliver greater benefits over others (for example ECO 1 over ECO 2).

17.2.2 Options ECO 1 and ECO 2 (resolving Issue (a)) had a specific technical difference. Option ECO 1 performs better when providing boundary capacity due to the proximity of demand as it is closer to the South Yorkshire conurbation. Option ECO 2 did not provide as much boundary benefit whilst also suffering from highly constrained routeing due to infrastructure in the vicinity of Cottam substation, introducing risks to construction. A comparison of siting between the two sites outlines a significant reduced risk at High Marnham compared to Cottam. The construction of a new substation at High Marnham offers a substantial cost saving compared to the optimum solution at Cottam. Furthermore, constructability risks are controllable by mitigation methods at High Marnham. In contrast, the risk profile is considerably higher at Cottam, risks are less manageable and may lead to abortive works and delays to the programme. This adds substantial weight in favour of ECO 1 when compared to ECO 2.

17.3 Environmental and socio-economic appraisal

17.3.1 For the Creyke Beck generation group connections, all onshore options would need to cross the Humber Estuary Special Protection Area (SPA), Ramsar and Site of Special Scientific Interest (SSSI) with potential for direct effects on breeding, over-wintering and passage bird species. Paralleling the existing 4ZQ 400 kV overhead route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species. For ECO 1 and ECO 2, whilst sites such as Thorne and Hatfield Moors SPA and Important Bird Area (IBA), Thorne Moor Special Area of Conservation

(SAC), Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable, there is the potential for adverse effects on the interest features for which these sites are designated.

17.3.2 For ECO 3 and ECO 4, whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable, there is the potential for adverse effects on the interest features for which a number of these sites are designated. All onshore options would need to cross the Yorkshire Wolds Important Landscape Area.

17.3.3 For ECO 3 and ECO 4, although the Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB) itself would be avoided, there would be potential for long-term effects on views from the AONB, particularly given the low-lying open topography with views from the Wolds to the coast. The nature of the environmental and socio-economics effects associated with the OHL options (ECO 1, ECO 2, ECO 3 and ECO 4) including the associated substation infrastructure, would be different to the subsea options which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea options ECSS 1 (Lincolnshire) and ECSS 1 (Norfolk) would have challenges relating to the installation of buried cables across marine ecological designations. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

17.3.4 Appraisal of the strategic options showed that ECO 1 and ECO 2 options would have a significantly shorter overhead line route than that of ECO 3, ECO 4, and would be expected to have lower environmental and socio-economic effects.

17.3.5 For the East Coast generation group connections, appraisal of the strategic options showed that additional transmission circuits within ECO 5 and ECO 6 are comparable in terms of length and also that the levels of environmental and socio-economic effects would be expected to be similar. A key difference between these strategic options is that an additional substation at Weston Marsh would be required for ECO 6. The additional substation at Weston Marsh for ECO 6 has potential to result in long term landscape and visual effects due to the introduction of new substation infrastructure in a landscape which currently has little major development.

17.3.6 The nature of the environmental and socio-economics effects associated with the OHL options (ECO 5 and ECO 6) including the associated substation infrastructure, would be different to the subsea option (ECSS 2) which would comprise subsea cables, buried onshore cables and converter stations. With reference to internationally or nationally important sites, subsea option ECSS 2 would have challenges relating to the installation of buried cables across marine ecological designations. Overall, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routing and siting, environmental and socio-economic factors are not considered to differentiate between onshore and offshore options for the purposes of option selection.

17.4 Cost

17.4.1 An overview of the capital and lifetime cost impacts of each option is set out in Table 15.3. These may be summarised as follows:

- ECO 1: capital cost of £454m and lifetime circuit cost of £582m;
- ECO 2: capital cost of £465.6m and lifetime circuit cost of £513m;
- ECO 3: capital cost of £1,250.7m and lifetime circuit cost of £1,540m;
- ECO 4: capital cost of £1,094.7m and lifetime circuit cost of £1,369m;
- ECSS 1: capital cost of £3,646m and lifetime circuit cost of £4,055m;
- ECO 5: capital cost of £1,000.5m and lifetime circuit cost of £958m;
- ECO 6: capital cost of £1,074m and lifetime circuit cost of £958m; and
- ECSS 2: capital cost of £4,391.7m and lifetime circuit cost of £4,807m;

17.5 Preferred Options

17.5.1 ECO 1 and ECO 2 options would have a significantly shorter overhead line route than that of ECO 3 and ECO 4, and would be expected to have lower environmental and socio-economic effects, as well as lower capital and lifetime costs. ECO 1 and ECO 2 are therefore preferred to ECO 3 and ECO 4 amongst the Creyke Beck generation group onshore options.

17.5.2 As set out in paragraph 17.2.2, above, ECO 1 has technical advantages when compared to ECO 2. ECO 1 performs better in terms of boundary capacity, while also being less constrained in terms of routeing due to the proposed connection to a new substation at High Marnham rather than Cottam. A comparison of the Cottam and High Marnham sites indicates that High Marnham offers substantial cost savings, as well as reduced constructability risks. Overall, therefore, ECO 1 is the preferred onshore option.

17.5.3 An offshore option, ECSS 1, has also been assessed. Based on the information currently available, technical, environmental and socio-economic factors are not considered to differentiate between offshore and onshore options. However, ECSS 1 was substantially more expensive than any of the onshore options. This means that onshore options are preferred.

17.5.4 We therefore consider that, overall, ECO 1 represents the most advantageous of the Creyke beck Generation Group options when balancing cost, technical performance and environmental and socio-economic effects.

17.5.5 In terms of the East Coast Generation Group onshore options, ECO 5 and ECO 6 offer similar technical performance, and the transmission circuits are similar in length. This means that the levels of environmental and socio-economic effects associated with the transmission circuits would be expected to be similar. However a key difference between these options is that an additional substation at Weston Marsh would be required for ECO 6. The additional substation has potential to result in long term landscape and visual effects due to the introduction of new substation infrastructure in a landscape which currently has little major development, as well as incurring additional cost that could be avoided with ECO 5. ECO 5 is therefore the preferred onshore option.

17.5.6 An offshore option, ECSS 2, has also been assessed. Again, based on the information currently available, technical, environmental and socio-economic factors are not considered to differentiate between offshore and onshore options. However, ECSS 2 was substantially more expensive than either of the onshore options. This means that onshore options are preferred.

17.5.7 We therefore consider that, overall, ECO 5 represents the most advantageous of the East Coast generation group options when balancing cost, technical performance and environmental and socio-economic effects.

17.5.8 NGET therefore proposes to take forward the following options:

- **To resolve Issue (a)** - ECO 1 a new primarily overhead line connection between new Creyke Beck substation to new High Marnham substation. With a high-level assessment capital cost of **£454m** and lifetime circuit cost of **£582m**. This has been assigned the project title of **"North Humber to High Marnham"**;
- **To resolve Issue (b)** – ECO 5 a new primarily overhead line connection between new Grimsby West substation to new Walpole via Lincolnshire Connection substation(s). With a high-level assessment capital cost of **£1,000.5m** and lifetime circuit cost of **£958m**. This has been assigned the project title of **"Grimsby to Walpole"**

17.5.9 This report also recommends that EGL3 and EGL4 should be connected south of the B9 boundary to a Main Interconnected Transmission System substation, identified as new Walpole substation. This option should have ability to provide a three ended connection to Lincolnshire Connection substation(s) to provide additional capacity.

17.6 Next steps

17.6.1 The North Humber to High Marnham and Grimsby to Walpole projects will now be taken forward to the next stage of development. This involves identification of a preliminary route corridor and graduated swathe, which indicates a more likely location for the development. This will be consulted on at non-statutory consultation to seek feedback from consultees and help shape the further development of the projects.

17.6.2 More detailed analysis for EGL3, EGL4 will be carried out separately for those projects and will come forward in due course.

Appendix

nationalgrid

Appendix A
Summary of National Grid Electricity Transmission Legal Obligations

1.1 Electricity Transmission Licence

1.1.1 The Electricity Act 1989 (the 'Electricity Act') defines transmission of electricity within GB and its offshore waters, as a prohibited activity, which cannot be carried out without permission by a transmission licence granted under Section 6(1)(b) of the Electricity Act (a 'Transmission Licence').

1.1.2 National Grid Electricity Transmission ('National Grid') has been granted a Transmission Licence that permits transmission owner activities in respect of the electricity transmission system National Grid owns, develops and maintains in England and Wales.

1.1.3 Each Transmission Licence includes conditions which define the scope of the permission granted to carry out a prohibited activity in terms of duties, obligations, restrictions and rights. The generic conditions that apply to any holder of a Transmission Owner licence type are set out in Sections A, B and D of the Standard Conditions of the Transmission Licence. Conditions that only apply to a specific licensee are set out as Special Conditions of that Transmission Licence.

1.1.4 National Grid is therefore bound by the legal obligations primarily set out in the Electricity Act and its Transmission Licence. The following list provides a summary overview of requirements that are considered when developing proposals to construct new transmission system infrastructure.

1.2 Electricity Act Duties

1.2.1 In accordance with Section 9 of the Electricity Act, National Grid is required to develop and maintain an efficient, coordinated and economical system of electricity transmission.

1.2.2 Schedule 9 of the Electricity Act requires National Grid, when formulating proposals for new lines and other works, to:

"…have regard to the desirability of preserving natural beauty, of conserving flora, fauna, and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and to do what [it] reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects".

1.2.3 National Grid's Stakeholder, Community and Amenity Policy ('the Policy') sets out how the company will meet this Schedule 9 duty. The commitments within the Policy include:

- only seeking to build new lines and substations where the existing transmission infrastructure cannot be upgraded technically or economically to meet transmission security standards;

- where new infrastructure is required, seeking to avoid areas that are nationally or internationally designated for their landscape, wildlife or cultural significance, and
- minimising the effects of new infrastructure on other sites valued for their amenity.

1.2.4 The Policy also refers to the application of best practice methods to assess the environmental impacts of proposals and identify appropriate mitigation and/or offsetting measures. Effective consultation with stakeholders and the public is also promoted by the Policy.

1.3 National Grid's Transmission Licence Requirements

1.3.1 Condition B12: System Operator – Transmission Owner Code

All Transmission Licensees are required to have the System Operator Transmission Owner Code ('STC') in place that defines the arrangements within the transmission sector and sets out how the transmission system operator can access and use transmission services provided by transmission owners.

The STC structure aligns with key activities within the transmission sector including:

- Planning Co-ordination (of transmission system development works and construction);
- Provision of transmission services within different operational timescales, and
- Payments from transmission system operator to providers of transmission services (after service has been delivered).

1.3.2 Condition B16: Electricity Network Innovation Strategy

All Transmission Licensees are required to have a joined-up approach to innovation and develop an Electricity Network Innovation Strategy that is reviewed every two years.

1.3.3 Condition D2: Obligation to provide transmission services

Each transmission owner is required to provide transmission services to the transmission system operator as defined in the STC. Transmission services provided to the transmission system operator include:

- enabling use to be made of existing transmission owner assets, and
- responding to requests for the construction of additional transmission system capacity (including system extension, disconnections and/or reinforcement).

1.3.4 Condition D3: Transmission system security standard and quality of service

Transmission owners are required to at all times plan, develop the transmission system in accordance with the National Electricity Transmission System Security and Quality of Supply Standard ('NETS SQSS').

A transmission owner with supporting evidence, may ask the Authority to grant derogation from the requirements set out in the NETS SQSS. Any decision in respect of NETS SQSS derogations are subject to the Authority's consideration of all relevant factors.

1.3.5 Condition D17: Whole Electricity System Obligations

Transmission owners are required to coordinate and cooperate with Transmission Licensees and electricity distributors in order to build common understanding of where actions taken by one could have cross-network impacts. A transmission owner should implement actions or processes that are identified that:

- will not have a negative impact on its network, and
- are in the interest of the efficient and economical operation of the total system.

Appendix B
Requirement for Development Consent Order

1.1 Electricity Network Infrastructure Developments

1.1.1 Developing the electricity transmission system in England and Wales subject to the type and scale of the project, may require one or more statutory consents which may include:

- planning permission under the Town and Country Planning Act 1990;
- a marine licence under the Marine and Coastal Access Act 2009;
- a Development Consent Order ("DCO") under the Planning Act 2008, and/or
- a variety of consents under related legislation.

1.1.2 The Planning Act 2008 defines developments of new electricity overhead lines of 132kV and above as Nationally Significant Infrastructure Projects ('NSIPs') requiring a DCO. Such an order may also incorporate Consent for other types of work that is associated with new overhead line infrastructure development, may be incorporated as part of a DCO that is granted.

1.1.3 Six National Policy Statements ("NPS") for energy infrastructure were designated by the Secretary of State for Energy and Climate Change in July 2011. The relevant NPSs for electricity transmission infrastructure developments are the Overarching National Policy Statement for Energy (EN-1) and the National Policy Statement for Electricity Networks Infrastructure (EN-5), which is read in conjunction with EN-1. In September 2021, Government consulted[12] on proposed updates to the NPS suite including EN-1 and EN-5. The proposed updates include clear linkages of EN-1 with policy objectives in respect of net-zero[13].

1.1.4 Section 104(3) of the Planning Act 2008 states that the decision maker must determine an application for a DCO in accordance with any relevant NPS, except in certain specified circumstances (such as where the adverse impact of the proposed development would outweigh its benefits). The energy NPSs therefore provide the primary policy basis for decisions on DCO applications for electricity transmission projects. The NPSs may also be a material consideration for decisions on other types of development consent in England and Wales (including offshore wind generation projects) and for planning applications under the Town and Country Planning Act 1990.

1.2 Demonstrating the Need for a Project

1.2.1 Part 3 of EN-1 sets out Government policy on the need for new nationally significant energy infrastructure projects. Paragraph 3.1 confirms that the UK needs all of the types of energy infrastructure covered by the NPS to achieve energy security and to dramatically reduce greenhouse gas emissions. It states that "substantial weight"

[12] BEIS Consultation, Planning for new infrastructure: review of energy National Policy Statements, September 2021 https://www.gov.uk/government/consultations/planning-for-new-energy-infrastructure-review-of-energy-national-policy-statements

[13] Energy White Paper: Powering our net zero future, December 2020 https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

should be given to the contribution which projects would make towards satisfying each need.

1.2.2 Description of the need for:

- new electricity transmission infrastructure is set out in EN-1 and EN-5
- new offshore/onshore wind generation is set out in EN-1 and EN-3, and
- new nuclear generation is set out in EN-1 and EN-6.

1.2.3 The need for new transmission infrastructure for this project is described in section 3 of this Report.

1.3 Assessment Principles Applied by Decision Maker

1.3.1 Part 4 of EN-1 sets out the general policies that are applied in determining DCO applications relating to new energy infrastructure. Paragraphs 2.3-2.5 of EN-5 set out the general assessment principles in the specific context of electricity networks infrastructure.

1.3.2 Principles of particular importance for transmission infrastructure projects include:

1.3.3 Presumption in Favour of Development

- Section 4.1 of EN-1 requires the Infrastructure Planning Commission ('IPC') to start with a presumption in favour of granting consent for energy NSIPs. This presumption applies unless any more specific and relevant policies set out in the relevant NPS clearly indicate that consent should be refused. The presumption is also subject to the exceptions set out in Section 104(2) of the Planning Act 2008.
- In assessing any application, the IPC should take account of potential:
  - benefits (e.g. the contribution to meeting the need for energy infrastructure, job creation and long term wider benefits), and
  - adverse impacts (e.g. long term and cumulative impacts but taking into account proposed mitigation measures.

1.3.4 Consideration of Alternatives

- Section 4.4 of EN-1 states that, from a planning policy perspective alone, there is no general requirement to consider alternatives or to establish whether the proposed project represents the best option. However, in relation to electricity transmission projects, paragraph 2.8.4 of EN-5 states that, "wherever the nature or proposed route of an overhead line proposal makes it likely that its visual impact will be particularly significant, the applicant should have given appropriate consideration to the potential costs and benefits of other feasible means of connection or reinforcement, including underground and subsea cables where appropriate."
- Section 4.4 of EN-1 also makes clear that there will be circumstances where an applicant is specifically required to include information in their application about the

main alternatives that were considered. These circumstances may include requirements under the Habitats Directive and the Birds Directive[14]

1.3.5 Adverse Impacts and Potential Benefits

- Part 5 of EN-1 covers the impacts that are common across all energy NSIPs and sections 2.6-2.9 of EN-5 consider impact in the specific context of electricity networks infrastructure.
- Those impacts identified in EN-1 include air quality and emissions, biodiversity and geological conservation, civil and military aviation and defence interests, coastal change (to the extent in or proximate to a coastal area), dust, odour, artificial light, smoke, steam and insect infestation, flood risk, historic environment, landscape and visual, land use, noise and vibration, socio-economic effects, traffic and transport, waste management and water quality and resources. The extent to which these impacts are relevant to a particular stage of a project, or are a relevant differentiator at a particular stage of the options appraisal process, will vary. In particular, some of these impacts are scoped out of this stage of the options appraisal process for this project. EN-5 considers specific potential impacts of electricity networks on biodiversity and geological conservation, landscape and visual, noise and vibration, and electric and magnetic fields.
- Potential impacts of particular importance for electricity transmission infrastructure projects include:

1.3.6 Good Design

- Section 4.5 of EN-1 stresses the importance of 'good design' for energy infrastructure, explaining that this goes beyond aesthetic considerations as fitness for purpose and sustainability are equally important. It is acknowledged in EN-1 that the nature of much energy infrastructure development will often limit the extent to which it can contribute to the enhancement of the quality of the area. Section 2.5 of EN-5 identifies a particular need for the applicant to demonstrate the principles of good design were applied in the proposed approach to mitigating the potential adverse impacts which can be associated with overhead lines.

1.3.7 Climate Change

- Section 4.8 of EN-1 explains how the effects of climate change should be taken into account and section 2.4 of EN-5 expands on this in the specific context of electricity networks infrastructure. DCO applications are required to set out the vulnerabilities / resilience of the proposals to flooding, effects of wind on overhead lines, higher average temperatures leading to increased transmission losses and earth movement or subsidence caused by flooding or drought (for underground cables).

1.3.8 Networks DCO Applications Submitted in Isolation

- Section 2.3 of EN-5 confirms that it can be appropriate for DCO applications for new transmission infrastructure to be submitted separately from applications for the generation that this infrastructure will serve. EN-5 explains that the need for the transmission project can be assessed on the basis of both contracted and reasonably anticipated generation.

[14] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; Council Directive 2009/147/EC on the conservation of wild birds.

1.3.9 Electricity Act Duties

- Paragraph 2.3.5 of EN-5 recognises developers' duties pursuant to section 9 of the Electricity Act to bring forward efficient and economical proposals in terms of network design, taking into account current and reasonably anticipated future generation demand, and its duty to facilitate competition and so provide a connection whenever and wherever one is required.

1.3.10 Adverse Impacts and Potential Benefits

- Part 5 of EN-1 covers the impacts that are common across all energy NSIPs and sections 2.6-2.9 of EN-5 consider impact in the specific context of electricity networks infrastructure.
- Those impacts identified in EN-1 include air quality and emissions, biodiversity and geological conservation, civil and military aviation and defence interests, coastal change (to the extent in or proximate to a coastal area), dust, odour, artificial light, smoke, steam and insect infestation, flood risk, historic environment, landscape and visual, land use, noise and vibration, socio-economic effects, traffic and transport, waste management and water quality and resources. The extent to which these impacts are relevant to a particular stage of a project, or are a relevant differentiator at a particular stage of the options appraisal process, will vary. In particular, some of these impacts are scoped out of this stage of the options appraisal process for this project. EN-5 considers specific potential impacts of electricity networks on biodiversity and geological conservation, landscape and visual, noise and vibration, and electric and magnetic fields.
- Potential impacts of particular importance for electricity transmission infrastructure projects include:
  - Landscape and Visual

    Paragraph 2.8.2 of EN-5 states that the Government does not believe that development of overhead lines is generally incompatible in principle with the developer statutory duty under section 9 of the Electricity Act 1989 to have regard to amenity and to mitigate impacts. However, EN-5 recognises that in practice overhead lines can give rise to adverse landscape and visual impacts, dependent upon their scale, siting, degree of screening and the nature of the landscape and local environment through which they are routed.

    In relation to alternative technologies for electricity transmission projects, paragraph 2.8.9 of EN-5 states that, "each project should be assessed individually on the basis of its specific circumstances and taking account of the fact that Government has not laid down any general rule about when an overhead line should be considered unacceptable. The IPC should, however, only refuse consent for overhead line proposals in favour of an underground or subsea line if it is satisfied that the benefits from the non-overhead line alternative will clearly outweigh any extra economic, social and environmental impacts and the technical difficulties are surmountable." Paragraph 2.8.7 of EN-5 endorses the Holford Rules which are a set of "common sense" guidelines for routeing new overhead lines.

Appendix C Technology Overview

1.1.1 This section provides an overview of the technologies available when the strategic options described in this Report were identified. It provides a high-level description of the relevant features of each technology. The costs for each technology are presented in Appendix D.

1.1.2 The majority of electricity systems throughout the world are AC systems. Consumers have their electricity supplied at different voltages depending upon the amount of power they consume e.g. 230V for domestic customers and 11 kV for large factories and hospitals. The voltage level is relatively easy to change when using AC electricity, which means a more economical electricity network can be developed for customer requirement. This has meant that the electrification of whole countries could be and was delivered quickly and efficiently using AC technology.

1.1.3 DC electricity did not develop as the means of transmitting large amounts of power from generating stations to customers because DC is difficult to transform to a higher voltage and bulk transmission by low voltage DC is only effective for transporting power over short distances. However, DC is appropriate in certain applications such as the extension of an existing AC system or when providing a connection to the transmission system.

1.1.4 In terms of voltage, the transmission system in England and Wales operates at both 275 kV and 400 kV. The majority of National Grid's transmission system is now constructed and operated at 400 kV, which facilitates higher power transfers and lower transmission losses.

1.1.5 There are a number of different technologies that can be used to provide transmission connections. These technologies have different features which affect how, when and where they can be used. The main technology options for electricity transmission are:

- Overhead lines
- Underground cables
- Gas Insulated Lines ("GIL"), and
- High Voltage Direct Current (HVDC).

1.1.6 This appendix provides generic information about each of these four technologies. Further information, including a more detailed technical review is available in a series of factsheets that can be found at the project website referenced at the beginning of this Report.

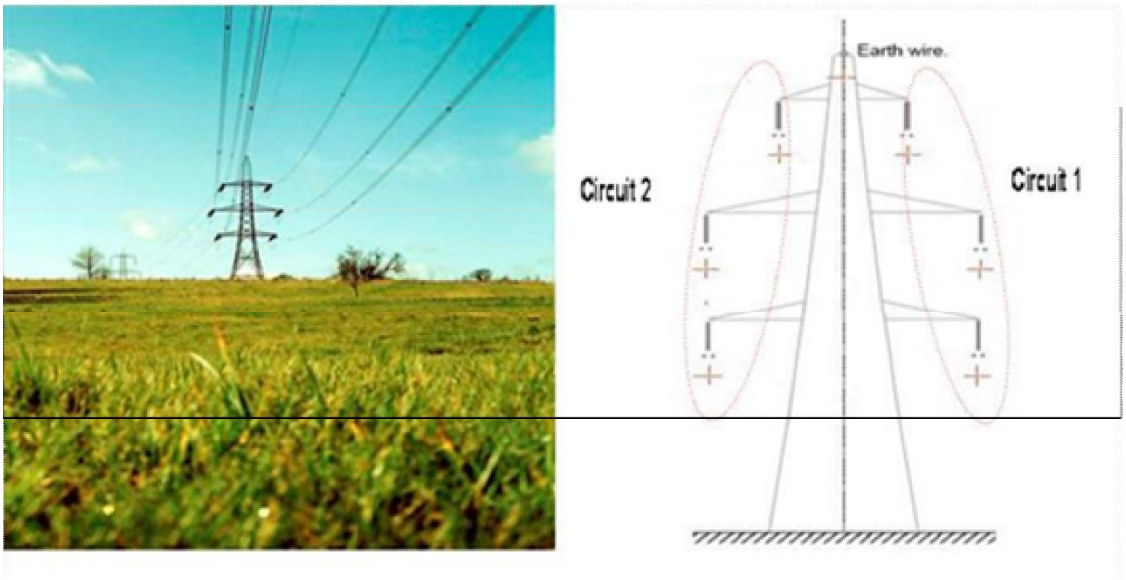
1.2 Overhead lines

1.2.1 Overhead lines form the majority of the existing transmission system circuits in Great Britain and in transmission systems across the world. As such there is established understanding of their construction and use.

1.2.2 Overhead lines are made up of three main component parts which are; conductors (used to transport the power), pylons (used to support the conductors) and insulators (used to safely connect the conductors to pylons).

1.2.3 Figure C.1 shows a typical pylon used to support two 275 kV or 400 kV overhead line circuits. This type of pylon has six arms (three either side), each carrying a set (or bundle) of conductors.

Figure C.1: Example of a 400 kV Double-circuit Tower



1.2.4 The number of conductors supported by each arm depends on the amount of power to be transmitted and will be either two, three or four conductors per arm. Technology developments have increased the capacity that can be carried by a single conductor and therefore, new overhead lines tend to have two or three conductors per arm.

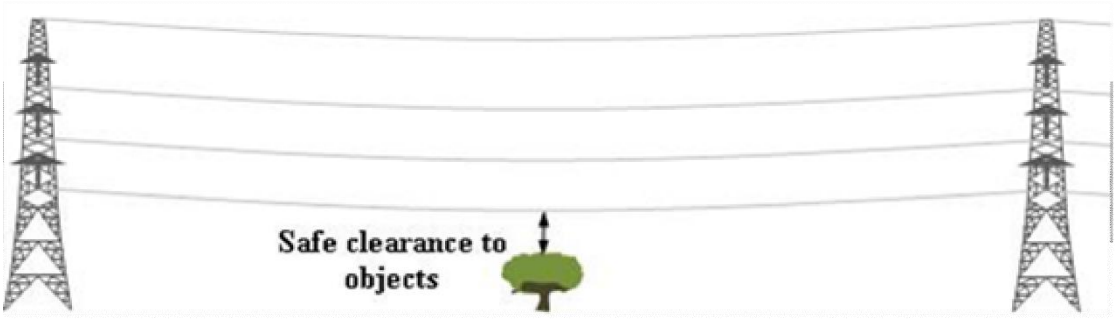
1.2.5 With the conclusion of the Royal Institute of British Architects (RIBA) pylon design competition[15] and other recent work with manufacturers to develop alternative pylon designs, National Grid is now able to consider a broader range of pylon types, including steel lattice and monopole designs. The height and width is different for each pylon type, which may help National Grid to manage the impact on landscape and visual amenity better. Figure C.2, below, shows an image on the monopole design called the T-pylon that was developed by National Grid.

[15] Pylon Design an RIBA competition, https://www.architecture.com/awards-and-competitions-landing-page/competitions-landing-page/pylon

Figure C.2: The T-pylon

1.2.6 Pylons are designed with sufficient height to ensure that the clearances between each conductor and between the lowest conductor and the ground, buildings or structures are adequate to prevent electricity jumping across. The minimum clearance between the lowest conductor and the ground is normally at the mid-point between pylons. There must be sufficient clearance between objects and the lowest point of the conductor as shown in Figure C.3.

Figure C.3: Safe height between lowest point of conductor and other obstacle ("Safe Clearance")



1.2.7 The distance between adjacent pylons is termed the 'span length'. The span length is governed by a number of factors, the principal ones being pylon height, number and size of conductors (i.e. weight), ground contours and changes in route direction. A balance must therefore be struck between the size and physical presence of each tower versus the number of towers; this is a decision based on both visual and economic aspects. The typical 'standard' span length used by National Grid is approximately 360m.

1.2.8 Lower voltages need less clearance and therefore the pylons needed to support 132 kV lines are not as high as traditional 400 kV and 275 kV pylons. However, lower voltage circuits are unable to transport the same levels of power as higher voltage circuits.

1.2.9 National Grid has established operational processes and procedures for the design, construction, operation and maintenance of overhead lines. Circuits must be taken out of service from time to time for repair and maintenance. However, shorter emergency restoration times are achievable on overhead lines as compared, for example, to underground cables. This provides additional operational flexibility if circuits need to be rapidly returned to service to maintain a secure supply of electricity when, for example, another transmission circuit is taken out of service unexpectedly.

1.2.10 In addition, emergency pylons can be erected in relatively short timescales to bypass damaged sections and restore supplies. Overhead line maintenance and repair therefore does not significantly reduce security of supply risks to end consumers.

1.2.11 Each of the three main components that make up an overhead line has a different design life, which are:

- Between 40 and 50 years for overhead line conductors
- 80 years for pylons
- Between 20 and 40 years for insulators.

1.2.12 National Grid expects an initial design life of around 40 years, based on the specified design life of the component parts. However, pylons can be easily refurbished and so substantial pylon replacement works are not normally required at the end of the 40 year design life.

1.3 Underground Cables

1.3.1 Underground cables at 275 kV and 400 kV make up approximately 10% of the existing transmission system in England and Wales, which is typical of the proportion of underground to overhead equipment in transmission systems worldwide. Most of the underground cable is installed in urban areas where achieving an overhead route is not feasible. Examples of other situations where underground cables have been installed, in preference to overhead lines, include crossing rivers, passing close to or through parts of nationally designated landscape areas and preserving important views.

1.3.2 Underground cable systems are made up of two main components – the cable and connectors. Connectors can be cable joints, which connect a cable to another cable, or overhead line connectors in a substation.

1.3.3 Cables consist of an electrical conductor in the centre, which is usually copper or aluminium, surrounded by insulating material and sheaths of protective metal and plastic. The insulating material ensures that although the conductor is operating at a high voltage, the outside of the cable is at zero volts (and therefore safe). Figure C.4 shows a cross section of a transmission cable and a joint that is used to connect two underground cables.

Figure C.4: Cable Cross-Section and Joint

1.3.4 Underground cables can be connected to above-ground electrical equipment at a substation, enclosed within a fenced compound. The connection point is referred to as a cable sealing end. Figure C.5 shows two examples of cable sealing end compounds.

Figure C.5: Cable Sealing End Compounds

1.3.5 An electrical characteristic of a cable system is capacitance between the conductor and earth. Capacitance causes a continuous ‘charging current’ to flow, the magnitude of which is dependent on the length of the cable circuit (the longer the cable, the greater the charging current) and the operating voltage (the higher the voltage the greater the current). Charging currents have the effect of reducing the power transfer through the cable.

1.3.6 High cable capacitance also has the effect of increasing the voltage along the length of the circuit, reaching a peak at the remote end of the cable.

1.3.7 National Grid can reduce cable capacitance problems by connecting reactive compensation equipment to the cable, either at the ends of the cable, or, in the case of longer cables, at regular intervals along the route. Specific operational arrangements and switching facilities at points along the cable circuit may also be needed to manage charging currents.

1.3.8 Identifying faults in underground cable circuits often requires multiple excavations to locate the fault and some repairs require removal and installation of new cables, which can take a number of weeks to complete.

1.3.9 High voltage underground cables must be regularly taken out of service for maintenance and inspection and, should any faults be found and depending on whether cable excavation is required, emergency restoration for security of supply reasons typically takes a lot longer than for overhead lines (days rather than hours).

1.3.10 The installation of underground cables requires significant civil engineering works. These make the construction times for cables longer than overhead lines.

1.3.11 The construction swathe required for two AC circuits comprising two cables per phase will be between 35-50 m wide.

1.3.12 Each of the two main components that make up an underground cable system has a design life of between 40 and 50 years.

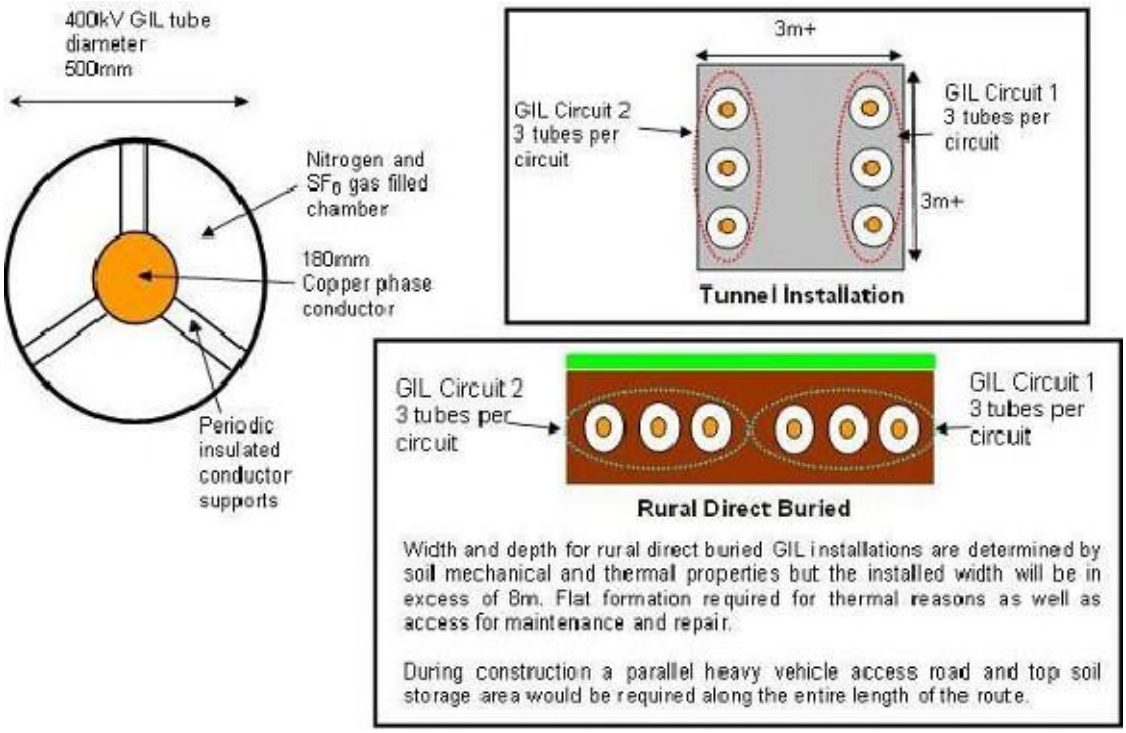
1.3.13 Asset replacement is generally expected at the end of design life. However, National Grid's asset replacement decisions (that are made at the end of design life) will also take account of actual asset condition and may lead to actual life being longer than the design life.

1.4 Gas Insulated Lines ("GIL")

1.4.1 GIL is an alternative to underground cable for high voltage transmission. GIL has been developed from the well-established technology of gas-insulated switchgear, which has been installed on the transmission system since the 1960s.

1.4.2 GIL uses a mixture of nitrogen and sulphur hexafluoride (SF6) gas to provide the electrical insulation. GIL is constructed from welded or flanged metal tubes with an aluminium conductor in the centre. Three tubes are required per circuit, one tube for each phase. Six tubes are therefore required for two circuits, as illustrated in Figure C.6 below.

Figure C.6: Key Components of GIL



1.4.3 GIL tubes are brought to site in 10 – 20 m lengths and they are joined in situ. It is important that no impurities enter the tubes during construction as impurities can cause the gas insulation to fail. GIL installation methods are therefore more onerous than those used in, for example, natural gas pipeline installations.

1.4.4 A major advantage of GIL compared to underground cable is that it does not require reactive compensation.

1.4.5 The installation widths over the land can also be narrower than cable installations, especially where more than one cable per phase is required.

1.4.6 GIL can have a reliability advantage over cable in that it can be re-energised immediately after a fault (similar to overhead lines) whereas a cable requires investigations prior to re-energisation. If the fault was a transient fault it will remain energised and if the fault was permanent the circuit will automatically and safely de-energise again.

1.4.7 There are environmental concerns with GIL as the SF_6[16] gas used in the insulating gas mixture is a potent 'greenhouse gas'. Since SF6 is an essential part of the gas mixture GIL installations are designed to ensure that the risk of gas leakage is minimised.

1.4.8 There are a number of ways in which the risk of gas leakage from GIL can be managed, which include:

- use of high-integrity welded joints to connect sections of tube;
- designing the GIL tube to withstand an internal fault; and

[16] SF_6 is a greenhouse gas with a global warming potential, according to the Intergovernmental Panel on Climate Change, Working Group 1 (Climate Change 2007, Chapter 2.10.2), of 22,800 times that of CO2. www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

- splitting each GIL tube into a number of smaller, discrete gas zones that can be independently monitored and controlled.

1.4.9 At decommissioning the SF_6 can be separated out from the gas mixture and either recycled or disposed of without any environmental damage.

1.4.10 GIL is a relatively new technology and therefore has limited historical data, meaning that its operational performance has not been empirically proven. National Grid has two GIL installations on the transmission system which are 545 m and 150 m long[17]. These are both in electricity substations; one is above ground and the other is in a trough. The longest directly buried transmission voltage GIL in the world is approximately one kilometre long and was recently installed on the German transmission system around Frankfurt Airport.

1.4.11 In the absence of proven design life information, and to promote consistency with assessment of other technology options, National Grid assesses GIL over a design life of up to 40 years.

1.5 High Voltage Direct Current ("HVDC")

1.5.1 HVDC technology can provide efficient solutions for the bulk transmission of electricity between AC electricity systems (or between points on an electricity system).

1.5.2 There are circumstances where HVDC has advantages over AC, generally where transmission takes place over very long distances or between different, electrically-separate systems, such as between Great Britain and countries in Europe such as France, Belgium, The Netherlands, Ireland etc.…

1.5.3 HVDC links may also be used to connect a generating station that is distant from the rest of the electricity system. For example, very remote hydro-electric schemes in China are connected by HVDC technology with overhead lines.

1.5.4 Proposed offshore wind farms to be located over 60 km from the coast of Great Britain are likely to be connected using HVDC technology as an alternative to an AC subsea cable. This is because AC subsea cables over 60 km long have a number of technical limitations, such as high charging currents and the need for mid-point compensation equipment.

1.5.5 The connection point between AC and DC electrical systems has equipment that can convert AC to DC (and vice versa), known as a converter. The DC electricity is transmitted at high voltage between converter stations. Convertor stations can use two types of technology. "Classic" or Current Source Convertors (CSC) were the first type of HVDC technology developed and this design was used for National Grid's Western Link. Voltage Source Convertors (VSC) are a newer design and offer advantages over the previous CSC convertors, as they can better support weaker systems and offer more flexibility in the way they operate, including direction of power flow.

[17] The distances are based on initial manufacturer estimates of tunnel and buried GIL dimensions which would be subject to full technical appraisal by National Grid and manufacturers to achieve required ratings which may increase the separation required. It should be noted that the diagram does not show the swathe of land required during construction. Any GIL tunnel installations would have to meet the detailed design requirements of National Grid for such installations.

Figure C.7: VSC convertor Station

1.5.6 HVDC can offer advantages over AC underground cable, such as:

- a minimum of two cables per circuit is required for HVDC whereas a minimum of three cables per circuit is required for AC.
- reactive compensation mid-route is not required for HVDC.
- cables with smaller cross sectional areas can be used (compared to equivalent AC system rating).
- This allows HVDC cables to be more easily installed for subsea applications than AC cables for a given capacity.

1.5.7 HVDC cables are generally based upon two technology types Mass Impregnated and Extruded technologies. VSC technology may utilise either technology type, whereas CSC technology tends to be limited to Mass Impregnated cables due to the way poles are reversed for change of power flow direction.

Figure C.8: HVDC Cable Laying Barge at transition between shore and sea cables

1.5.8 HVDC systems have a design life of about 40 years. This design life period is on the basis that large parts of the converter stations (valves and control systems) would be replaced after 20 years.

Appendix D Economic Appraisal

1.1.1 As part of the economic appraisal of Strategic Options, National Grid makes comparative assessments of the lifetime costs associated with each technology option that is considered to be feasible.

1.1.2 This section provides an overview of the methods that National Grid uses to estimate lifetime costs as part the economic appraisal of a Strategic Option. It also provides a summary of generic capital cost information for transmission system circuits for each technology option included in Appendix C and an overview of the method that National Grid uses to assess the Net Present Value ("NPV") of costs that are expected to be incurred during the lifetime of new transmission assets.

1.1.3 The IET, PB/CCI Report[18] presents cost information in size of transmission circuit capacity categories for each circuit design that was considered as part of the independent study. To aid comparison between the cost data presented in the IET PB/CCI Report and that used by National Grid for appraisal of Strategic Options, this appendix includes cost estimates using National Grid cost data for circuit designs that are equivalent to those considered as part of the independent study. Examples in this Appendix are presented using the category size labels of "Lo", "Med" and "Hi" used in the IET PB/CCI Report.

1.2 Lifetime Costs for Transmission

1.2.1 For each technology option appraised within a Strategic Option, National Grid estimates total lifetime costs for the new transmission assets. The total lifetime cost estimate consists of the sum of the estimates of the:

- initial capital cost of developing, procuring, installing and commissioning the new transmission assets, and
- net present value ("NPV") of costs that are expected to be incurred during the lifetime of these new transmission assets

1.3 Capital Cost Estimates

1.3.1 At the initial appraisal stage, National Grid prepares indicative estimates of the capital costs. These indicative estimates are based on the high-level scope of works defined for each Strategic Option in respect of each technology option that is considered to be feasible. As these estimates are prepared before detailed design work has been carried out, National Grid takes account of equivalent assumptions for each option. Final project costs for any solution taken forward following detailed design and risk mitigation will be in excess of any high-level appraisal cost. However, all options would incur these increases in the development of a detailed solution.

[18] "Electricity Transmission Costing Study – An Independent Report Endorsed by the Institution of Engineering & Technology" by Parsons Brinckerhoff in association with Cable Consulting International. Page 10 refers to Double circuit capacities. http://www.theiet.org/factfiles/transmission-report.cfm

1.3.2 This section considers the capital costs in two parts, firstly the AC technology costs are discussed, followed by HVDC technologies. Each of these technologies is described in Appendix C in more detail.

1.4 AC Technology Capital Cost Estimates

1.4.1 Table D.1 shows the category sizes that are relevant for AC technology circuit designs:

Table D.1 – AC Technology Circuit Designs

Category	Design	Rating
Lo	Two AC circuits of 1,595 MVA	3,190 MVA
Med	Two AC circuits of 3,190 MVA	6,380 MVA
Hi	Two AC circuits of 3,465 MVA	6,930 MVA

Table D.2 provides a summary of technology configuration and capital cost information (in financial year 2020/21 prices) for each of the AC technology options that National Grid considers as part of an appraisal of Strategic Options.

Table D.2 - AC Technology Configuration and National Grid Capital Costs by Rating

IET, PB/CCI Report short-form label	Circuit Ratings by Voltage		Technology Configuration			Capital Costs		
	275kV AC Technologies	400kV AC Technologies	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)
	Total rating for two Circuits (2 x rating of each circuit)	Total rating for two Circuits (2 x rating of each circuit)	No. of Conductors Sets "bundles" on each arm/circuit of a pylon	No. of Cables per phase	No of direct buried GIL tubes per phase	Cost for a "double" two circuit pylon route (Cost per circuit, of a double circuit pylon route)	Cost for a two circuit AC cable route (Cost per circuit, of a two circuit AC cable route)	Cost for a two circuit GIL route (Cost per circuit, of a two circuit GIL route)
Lo	3190MVA (2 x 1595MVA) [2000MVA 2 x 1000MVA for AC Cable only]	3190MVA (2 x 1595MVA)	2 conductor sets per circuit (6 conductors per circuit)	1 Cable per Phase (3 cables per circuit)	1 tube per phase (3 standard GIL tubes per circuit)	£3.31m/km (£1.66m/km)	£16.35m/km (£8.17m/km)	£26.81m/km (£13.411m/km)
Med	N/A [3190MVA 2 x 1595MVA for AC Cable only]	6380MVA (2 x 3190MVA)	2 conductor sets per circuit (6 conductors per circuit)	2 Cables per Phase (6 cables per circuit)	1 tube per phase (3 "developing" new large GIL tubes per circuit)	£3.64m/km (£1.82m/km)	£28.32m/km (£14.16m/km)	£31.13m/km (£15.56m/km)

Hi	N/A	6930MVA (2 x 3465MVA)	3 conductor sets per circuit (9 conductors per circuit)	3 Cables per Phase (9 cables per circuit)	2 tubes per phase (6 standard GIL tubes per circuit)	£3.98m/km (£1.99m/km)	£39.89m/km (£19.95m/km)	£43.25m/km (£21.63m/km)

Notes: -

1. Capital Costs for all technologies are based upon rural/arable land installation with no major obstacles (examples of major obstacles would be Roads, Rivers, Railways etc…)
2. All underground AC Cable and GIL technology costs are for direct buried installations only. AC cable and GIL Tunnel installations would have a higher capital installation cost than direct buried rural installations. However, AC cable or GIL replacement costs following the end of conductor life would benefit from re-use of the tunnel infrastructure.
3. AC cable installation costs exclude the cost of reactors and mid point switching stations, which are described later in this appendix.
4. 275kV circuits will often require Super-Grid Transformers (SGT) to allow connection into the 400kV system, SGT capital costs are not included above but described later in this appendix.
5. 275kV AC cable installations above 1000MVA, as indicated in the table above, would require 2 cables per phase to be installed to achieve ratings of 1595MVA per circuit at 275kV.

1.4.2 Table D.2 provides a summary of the capital costs associated with the key[19] components of transmission circuits for each technology option. Additional equipment is required for technology configurations that include new:

- AC underground cable circuits
- Connections between 400 kV and 275 kV parts of the National Grid's transmission system.

1.4.3 The following sections provide an overview of the additional requirements associated with each of these technology options and indicative capital costs of additional equipment.

1.5 AC Underground Cable additional equipment

1.5.1 Appendix C of this Report provides a summary of the electrical characteristics of AC underground cable systems and explains that reactive gain occurs on AC underground cables.

1.5.2 Table D.3 provides a summary of the typical reactive gain within AC underground cable circuits forming part of the National Grid's transmission system.

Table D.3 – Reactive Gain Within AC underground cable circuits

Category	Voltage	Design	Reactive Gain per circuit
Lo	275 kV	One 2500 mm^2 cable per phase	5 Mvar/km
Med	275 kV	Two 2500 mm^2 cable per phase	10 Mvar/km
Lo	400 kV	One 2500 mm^2 cable per phase	10 Mvar/km
Med	400 kV	Two 2500 mm^2 cable per phase	20 Mvar/km
Hi	400 kV	Three 2500 mm^2 cable per phase	30 Mvar/km

1.5.3 National Grid is required to ensure that reactive gain on any circuit that forms part of its transmission system does not exceed 225 Mvar. Above this limit, reactive gain would lead to unacceptable voltages (voltage requirements as defined in the NETS SQSS). In order to manage reactive gain and therefore voltages, reactors are installed on AC underground cable circuits to ensure that reactive gain in total is less than 225 Mvar.

1.5.4 For example a 50 km "Med" double circuit would have an overall reactive gain of 1000 Mvar per circuit (2000 Mvar in total for two circuits). The standard shunt reactor size installed at 400 kV on the National Grid transmission system is 200 Mvar. Therefore four 200 Mvar reactors (800 Mvar) need to be installed on each circuit or eight 200 Mvar

[19] Components that are not required for all technology options are presented separately in this Appendix.

reactors (1600 Mvar) reactors for the two circuits. Each of these reactors cost £8.7m adding £69.6m to an overall cable cost for the example double circuit above.

1.5.5 Mid point switching stations may be required as part of a design to meet the reactive compensation requirements for AC underground cable circuit. The need for switching stations is dependent upon cable design, location and requirements which cannot be fully defined without detailed design.

1.5.6 For the purposes of economic appraisal of Strategic Options, National Grid includes a cost allowance that reflects typical requirements for switching stations. These allowances shown in Table D.4 are:

Table D.4 – Reactive Gain Within AC underground cable circuits

Category	Switching Station Requirement
Lo	Reactive Switching Station every 60km between substations
Med	Reactive Switching Station every 30km between substations
Hi	Reactive Switching Station every 20km between substations

1.5.7 It is noted that more detailed design of AC underground cable systems may require a switching station after a shorter or longer distance than the typical values used by National Grid at the initial appraisal stage.

1.5.8 Table D.5 below shows the capital cost associated with AC underground cable additional equipment.

Table D.5 – Additional costs associated with AC underground cables

Category	Cost per mid point switching station	Cost per 200 Mvar reactor
Lo	£15.09m	£8.7m per reactor
Med	£18.44m	
Hi	£18.44m	

1.6 Connections between AC 275 kV and 400 kV circuits additional equipment

1.6.1 Equipment that transform voltages between 275kV and 400kV (a 400/275 kV supergrid transformer or “SGT”) is required for any new 275 kV circuit that connects to a 400 kV part of the National Grid’s transmission system (and vice versa). The number of supergrid transformers needed is dependent on the capacity of the new circuit. National Grid can estimate the number of SGTs required as part of an indicative scope of works that is used for the initial appraisal of Strategic Options.

1.6.2 Table D.6 below shows the capital cost associated with the SGT requirements.

Table D.6 – Additional costs associated with 275kV circuits requiring connection to the 400kV system

275kV Equipment	Capital Cost (SGT - including civil engineering work)
400/275kV SGT 1100MVA (excluding switchgear)	£7.75m per SGT

1.7 High Voltage Direct Current ("HVDC") Capital Cost Estimates

1.7.1 Conventional HVDC technology sizes are not easily translated into the "Lo", "Med" and "Hi" ratings suggested in the IET, PB/CCI report. Whilst National Grid information for HVDC is presented for each of these categories, there are differences in the circuit capacity levels. As part of an initial appraisal, National Grid's assessment is based on a standard 2GW converter size. Higher ratings are achievable using multiple circuits.

1.7.2 The capital costs of HVDC installations can be much higher than for equivalent AC overhead line transmission routes. Each individual HVDC link, between each converter station, requires its own dedicated set of HVDC cables. HVDC may be more economic than equivalent AC overhead lines where the route length is many hundreds of kilometres.

1.7.3 Table D.7 provides a summary of technology configuration and capital cost information (in financial year 2020/21 prices) for each of the HVDC technology options that National Grid considers as part of an appraisal of Strategic Options.

Table D.7 - HVDC Technology Capital Costs for 2GW installations

HVDC Converter Type	2 GW Total HVDC Link Converter Costs (Converter Cost at Each End)	2GW DC Cable Pair Cost
Current Source Technology or "Classic" HVDC	£475m HVDC link cost (£237.5m at each end)	£3.09m/km VDC
Voltage Source Technology HVDC	£534.38m HVDC link cost (£267.19m at each end)	£3.09m/km

Notes:

- Sometimes a different HVDC capacity (different from the required AC capacity) can be utilised for a project due to the different way HVDC technology can control power flow. The capacity requirements for HVDC circuits will be specified in any option considering HVDC. The cost shall be based upon Table C.4 above.
- Where a single HVDC Link is proposed as an option, to maintain compliance with the NETS SQSS, there may be a requirement to install an additional "Earth Return" DC cable. For example a 2GW Link must be capable of operating at ½ its capacity i.e. 1GW during maintenance or following a cable fault. To allow this operation the additional cable known as an "Earth Return" must be installed, this increases cable costs by a further 50% to £4.6m/km.

- Capital Costs for HVDC cable installations are based upon subsea or rural/arable land installation with no major obstacles (examples of major obstacles would be Subsea Pipelines, Roads, Rivers, Railways etc…)

1.7.4 Costs can be adjusted from this table to achieve equivalent circuit ratings where required. For example a "Lo" rating 3190 MW would require two HVDC links of (1.6 GW capacity each), while "Med" and "Hi" rating 6380 MW-6930 MW would require three links with technology stretch of (2.1-2.3 GW each).

1.7.5 Converter costs at each end can also be adjusted, by Linear scaling, from the cost information in Table D.7, to reflect the size of the HVDC link being appraised. HVDC Cable costs are normally left unaltered, as operating at the higher load does not have a large impact the cable costs per km.

1.7.6 The capacity of HVDC circuits assessed for this Report is not always exactly equivalent to capacity of AC circuits assessed. However, Table D.8 below illustrates how comparisons may be drawn using scaling methodology outlined above.

Table D.8 – Illustrative example using scaled 2GW HVDC costs to match equivalent AC ratings (only required where HVDC requirements match AC technology circuit capacity requirements)

IET, PB/CCI Report short-form label	**Converter Requirements (Circuit Rating)**	**Total Cable Costs/km (Cable Cost per link)**	**CSC "Classic" HVDC Total Converter Capital Cost (Total Converter cost per end)**	**VSC HVDC Total Converter Capital Cost (Total Converter cost per end)**
Lo	2 x 1.6 GW HVDC Links (3190MW)	£5.82m/km (2 x £2.91/km)	£704m (4 x £176m [4 converters 2 each end])	(4 x £736m (4 x £184m [4 converters 2 each end])
Med	3 x 2.1* GW HVDC Links (6380MW)	£9.27m/km (3 x £3.09/km)	£1422m (6 x £237m [6 converters 3 each end])	£1602m (6 x £267m [6 converters 3 each end])
Hi	3 x 2.3* GW HVDC Links (6930MW)	£10.32m/km (3 x £3.44/km)	£1818m (6 x £303m [6 converters 3 each end])	£1890m (6 x £315m [6 converter 3 each end])

Notes:

- Costs based on 2GW costs shown in Table C.4 and table shows how HVDC costs are estimated based upon HVDC capacity required for each option.
- Scaling can be used to estimate costs for any size of HVDC link required.
- *Current subsea cable technology for VSC design restricted to 2GW, so above examples illustrative if technology should become available.

1.8 Indication of Technology end of design life replacement impact

1.8.1 It is unusual for a part of National Grid's transmission system to be decommissioned and the site reinstated. In general, assets will be replaced towards the end of the assets design life. Typically, transmission assets will be decommissioned and removed only as part of an upgrade or replacement by different assets.

1.8.2 National Grid does not take account of replacement costs in the lifetime cost assessment.

1.8.3 National Grid's asset replacement decisions take account of actual asset condition. This may lead to actual life of any technology being longer or shorter than the design life, depending on the environment it is installed in, lifetime loading, equipment family failures among other factors for example.

1.8.4 The following provides a high level summary of common replacement requirements applicable to specific technology options:

- OHL - Based on the design life of component parts, National Grid assumes an initial design life of around 40 years for overhead line circuits. After the initial 40 year life of an overhead line circuit, substantial pylon replacement works would not normally be required. The cost of Pylons is reflected in the initial indicative capital costs, but the cost of replacement at 40 years would not include the pylon cost. As pylons have an 80 year life and can be re-used to carry new replacement conductors. The replacement costs for overhead line circuits at the end of their initial design life are assessed by National Grid as being around 50% of the initial capital cost, through the re-use of pylons.
- AC underground Cable - At the end of their initial design life, circa 40 years, replacement costs for underground cables are estimated to be equal or potentially slightly greater than the initial capital cost. This is because of works being required to excavate and remove old cables prior to installing new cables in their place in some instances.
- GIL - At the end of the initial design life, circa 40 years, estimated replacement costs for underground GIL would be equal to or potentially greater than the initial capital cost. This is because of works being required to excavate and remove GIL prior to installing new GIL in their place in some instances.
- HVDC - It should be noted at the end of the initial design life, circa 40 years, replacement costs for HVDC are significant. This due to the large capital costs for the replacement of converter stations and the cost of replacing underground or subsea DC cables when required.

1.9 Net Present Value Cost Estimates

1.9.1 At the initial appraisal stage, National Grid prepares estimates of the costs that are expected to be incurred during the design lifetime of the new assets. National Grid considers costs associated with:

- Operation and maintenance
- Electrical losses

1.9.2 For both categories, Net Present Value ("NPV") calculations are carried out using annual cost estimates and a generic percentage discount rate over the design life period associated with the technology option being considered.

1.9.3 The design life for all technology equipment is outlined in the technology description in Appendix C. The majority of expected design lives are of the order of 40 years, which is used to assess the following NPV cost estimates below.

1.9.4 In general discount rates used in NPV calculations would be expected to reflect the normal rate of return for the investor. National Grid's current rate of return is 6.25%. However, the Treasury Green Book recommends a rate of 3.5% for the reasons set out below[20]

"The discount rate is used to convert all costs and benefits to 'present values', so that they can be compared. The recommended discount rate is 3.5%. Calculating the present value of the differences between the streams of costs and benefits provides the net present value (NPV) of an option. The NPV is the primary criterion for deciding whether government action can be justified."

1.9.5 National Grid considered the impact of using the lower Rate of Return (used by UK Government) on lifetime cost of losses assessments for transmission system investment proposals. Using the rate of 3.5% will discount loss costs, at a lower rate than that of 6.25%. This has the overall effect of increasing the 40 year cost of losses giving a more onerous cost of losses for higher loss technologies.

1.9.6 For the appraisal of Strategic Options, National Grid recognises the value of closer alignment of its NPV calculations with the approach set out by government for critical infrastructure projects.

1.10 Annual Operations and Maintenance Cost

1.10.1 The maintenance costs associated with each technology vary significantly depending upon type. Some electrical equipment is maintained regularly to ensure system performance is maintained. More complex equipment like HVDC converters have a significantly higher cost associated with them, due to their high maintenance requirements for replacement parts. Table D.9 shows the cost of maintenance for each technology, which unlike capital and losses is not dependent on capacity.

[20] http://www.hm-treasury.gov.uk/d/green_book_complete.pdf Paragraph 5.49 on Page 26 recommends a discount rate of 3.5% calculation for NPV is also shown in the foot note of this page.

NPV calculations are carried out using the following equation over the period of consideration.

Dn =1/(1 + r)n

Where Dn = Annual Loss Cost, r = 3.5% and n = 40 years

Table D.9 – Annual maintenance costs by Technology

	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	High Voltage Direct Current (HVDC)
Circuit Annual maintenance cost per two circuit km (AC) (Annual cost per circuit Km [AC])	£2,660/km (£1,330/km)	£5,644.45/km (£2,822.22/km)	£2,687.83/km (£1,343.92/km)	£134/km Subsea Cables
Associated equipment Annual Maintenance cost per item	N/A	£6,719.58 per reactor £41,661 per switching station	N/A	£1,300,911 per converter station
Additional costs for 275 kV circuits requiring connection to the 400kV system				
275/400 kV SGT 1100 MVA Annual maintenance cost per SGT	£6,719.58 per SGT	£6,719.58 per SGT	£6.719.58 per SGT	N/A

1.11 Annual Electrical Losses and Cost

1.11.1 At a system level annual losses on the National Grid electricity system equate to less the 2% of energy transported. This means that over 98% of the energy entering the transmission system from generators/interconnectors reaches the bulk demand substations where the energy transitions to the distribution system. Electricity transmission voltages are used to reduce losses, as more power can be transported with lower currents at transmission level, giving rise to the very efficient loss level achieved of less than 2%. The calculations below are used to show how this translates to a transmission route.

1.11.2 Transmission losses occur in all electrical equipment and are related to the operation and design of the equipment. The main losses within a transmission system come from heating losses associated with the resistance of the electrical circuits, often referred to as I2R losses (the electrical current flowing through the circuit, squared, multiplied by the resistance). As the load (the amount of power each circuit is carrying) increases, the current in the circuit is larger.

1.11.3 The average load of a transmission circuit which is incorporated into the transmission system is estimated to be 34% (known as a circuit average utilisation). This figure is calculated from the analysis of the load on each circuit forming part of National Grid's transmission system over the course of a year. This takes account of varying generation and demand conditions and is an appropriate assumption for the majority of Strategic Options.

1.11.4 This level of circuit utilisation is required because if a fault occurs there needs to be an alternative route to carry power to prevent wide scale loss of electricity for homes, business, towns and cities. Such events would represent a very small part of a circuit's 40 year life, but this availability of alternative routes is an essential requirement at all times to provide secure electricity supplies to the nation.

1.11.5 In all AC technologies the power losses are calculated directly from the electrical resistance and impedance properties of each technology and associated equipment. Table D.10 provides a summary of circuit resistance data for each AC technology and capacity options considered in this Report.

Table D.10 – AC circuit technologies and associated resistance per circuit

IET, PB/CCI Report short-form label	**AC Overhead Line Conductor Type (complete single circuit resistance for conductor set)**	**AC Underground Cable Type (complete single circuit resistance for conductor set)**	**AC Gas Insulated Line (GIL) Type (complete single circuit resistance for conductor set)**
Lo	2 x 570 mm^2 (0.025 Ω/km)	1 x 2500 mm^2 (0.013 Ω/km*)	Single Tube per phase (0.0086 Ω/km)
Med	2 x 850 mm^2 (0.0184 Ω/km)	2 x 2500 mm^2 (0.0065 Ω/km*)	Single Tube per phase (0.0086 Ω/km)
Hi	3 x 700 mm^2 (0.014 Ω/km)	3 x 2500 mm^2 (0.0043 Ω/km*)	Two tubes per phase (0.0065 Ω/km)
Losses per 200Mvar Reactor required for AC underground cables			
Reactor Losses	N/A	0.4MW per reactor	N/A
Additional losses for 275kV circuits requiring connection to the 400 kV system			
275 kV options only 275/400 kV SGT losses	0.2576 Ω (plus 83 kW of iron losses) per SGT	0.2576 Ω (plus 83 kW of iron losses) per SGT	0.2576 Ω (plus 83 kW of iron losses) per SGT

1.11.6 The process of converting AC power to DC is not 100% efficient. Power losses occur in all elements of the converter station: the valves, transformers, reactive compensation/filtering and auxiliary plant. Manufacturers typically represent these losses in the form of an overall percentage. Table D.11 below shows the typical percentage losses encountered in the conversion process, ignoring losses in the DC cable circuits themselves.

Table D.11 – HVDC circuit technologies and associated resistance per circuit

HVDC Converter Type	2 GW Converter Station losses	2GW DC Cable Pair Losses	2GW Total Link loss
Current Source (CSC) Technology or "Classic" HVDC	0.5% per converter	Ignored	1% per HVDC Link
Voltage Source (VSC) Technology HVDC	1.0% per converter	Ignored	2% per HVDC Link

1.11.7 The example calculation explained in detail below is for "Med" category circuits and has been selected to demonstrate the principles of the mathematics set out in this section. This example does not describe specific options set out within this report. A detailed example explanation of the calculations used to calculate AC losses is included in Appendix E.

1.11.8 The circuit category, for options contained within this report, is set out within each option. The example below demonstrates the mathematics and principles, which is equally applicable to "Lo", "Med" and "Hi" category circuits, over any distance.

1.11.9 The example calculations (using calculation methodology described in Appendix E) of instantaneous losses for each technology option for an example circuit of 40 km "Med" capacity 6380 MVA (two x 3190 MVA).

- Overhead Lines = (2 x 3) x 1565.5 A2 x (40 x 0.0184 Ω/km) = 10.8 MW
- Underground Cable = (2 x 3) x1565.5 A^2 x (40 x 0.0065 Ω/km) + (6 x 0.4MW) = 6.2 MW
- Gas Insulated Lines = (2 x 3) x 1565.5 A2 x (40 x 0.0086 Ω/km) = 5.1 MW
- CSC HVDC = 34% x 6380 MW x 1% = 21.7 MW
- VSC HVDC = 34% x 6380 MW x 2% = 43.4 MW

1.11.10 An annual loss figure can be calculated from the instantaneous loss. National Grid multiplies the instantaneous loss figure by the number of hours in a year and also by the cost of energy. National Grid uses £60/MWhr.

1.11.11 The following is a summary of National Grid's example calculations of Annual Losses and Maintenance costs for each technology option for an example circuit of 40 km "Med" capacity 6380 MVA (two x 3190 MVA).

- Overhead Line annual loss = 10.8 MW x 24 x 365 x £60/MWhr = £5.7m.
- U-ground Cable annual loss = 6.2 MW x 24 x 365 x £60/MWhr = £3.3m.
- Gas Insulated lines annual loss = 5.1 MW x 24 x 365 x £60/MWhr = £2.7m
- CSC HVDC annual loss = 21.7 MW x 24 x 365 x £60/MWhr = £11.4m
- VSC HVDC annual loss = 43.4 MW x 24 x 365 x £60/MWhr = £22.8m

1.12 Example Lifetime costs and NPV Cost Estimate

1.12.1 The annual Operation, Maintenance and loss information is assessed against the NPV model at 3.5% over 40 years and added to the capital costs to provide a lifetime cost for each technology.

1.12.2 Table D.12 shows an example for a “Med” capacity route 6380 MVA (2 x 3190 MVA) 400 kV, 40km in length over 40 years.

Table D.12 – Example Lifetime Cost table (rounded to the nearest £m)

Example 400 kV “Med” Capacity over 40km	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	CSC High Voltage Direct Current (HVDC)	VSC High Voltage Direct Current (HVDC)
Capital Cost	£145.6m	£1167.6m	£1,244.8m	£1,795.8m	£1,973.9m
NPV Loss Cost over 40 years at 3.5% discount rate	£125m	£62.6m	£58.4m	£235.6m	£471.2m
NPV Maintenance Cost over 40 years at 3.5% discount rate	£2.33m	£5.5m	£2.4m	£171.7m	£171.7m
Lifetime Cost	£273m	£1,236m	£1,306m	£2,203m	£2,617m

Appendix E Mathematical Principles used for AC Loss Calculation

1.1.1 This Appendix provides a detailed description of the mathematical formulae and principles that National Grid applies when calculating transmission system losses. The calculations use recognised mathematical equations which can be found in power system analysis text books.

1.1.2 The example calculation explained in detail below is for “Med” category circuits and has been selected to demonstrate the principles of the mathematics set out in this section. This example does not describe specific options set out within this report.

1.1.3 The circuit category, for options contained within this report, is set out within each option. The example below demonstrates the mathematics and principles, which is equally applicable to “Lo”, “Med” and “Hi” category circuits, over any distance.

1.2 Example Loss Calculation (1) – 40 km 400 kV “Med” Category Circuits

1.2.1 The following is an example loss calculation for a 40 km 400 kV “Med” category (capacity of 6,380 MVA made up of two 3,190 MVA circuits).

1.2.2 Firstly, the current flowing in each of the two circuits is calculated from the three phase power equation of $P= \sqrt{3}V_{LL}I_{LL} \cos \theta$. Assuming a unity power factor ($\cos \theta= 1$), the current in each circuit can be calculated using a rearranged form of the three phase power equation of:

(In a star (Y) configuration electrical system $I = I_{LL} = I_{LN}$)

$I = P/\sqrt{3}V_{LL}$

Where, P is the circuit utilisation power, which is 34% of circuit rating as set out in D.40 of Appendix D, which for the each of the two circuits in the “Med” category example is calculated as:

P = 34% x 3190 MVA = 1,084.6 MVA

and, V_{LL} is the line to line voltage which for this example is 400 kV.

For this example, the average current flowing in each of the two circuits is:

$I = 1,084.6 \times 106/(\sqrt{3} \times 400 \times 103) = 1,565.5$ Amps

1.2.3 The current calculated above will flow in each of the phases of the three phase circuit. Therefore from this value it is possible to calculate the instantaneous loss which occurs at the 34% utilisation loading factor against circuit rating for any AC technology.

1.2.4 For this “Med” category example, the total resistance for each technology option is calculated (from information in Appendix D, Table D.10) as follows:

Overhead Line = 0.0184Ω/km x 40 km = 0.736 Ω

Cable Circuit[21] = 0.0065Ω/km x 40 km = 0.26 Ω

Gas Insulated Line = 0.0086Ω/km x 40 km = 0.344 Ω

These circuit resistance values are the total resistance seen in each phase of that particular technology taking account the number of conductors needed for each technology option.

1.2.5 The following is a total instantaneous loss calculation for the underground cable technology option for the "Med" category example:

Losses per phase are calculated using $P=I^2R$

1,565.52 x 0.26 = 0.64 MW

Losses per circuit are calculated using $P=3I^2R$

3 x 1,565.52 x 0.26 = 1.91 MW

Losses for "Med" category are calculated by multiplying losses per circuit by number of circuits in the category.

2 x 1.91 MW = 3.8 MW

1.2.6 For underground cable circuits, three reactors per circuit are required (six in total for the two circuits in the "Med" category). Each of these reactors has a loss of 0.4 MW. The total instantaneous losses for this "Med" category example with the underground cable technology option are assessed as:

3.8 + (6 x 0.4) = 6.2 MW

1.2.7 The same methodology is applied for the other AC technology option types for the "Med" category example considered in this Appendix. The following is a summary of the instantaneous total losses that were assessed for each technology option:

Overhead Lines = (2 x 3) x 1,565.52 x 0.736 = 10.8 MW

Cables = (2 x 3) x 1,565.52 x 0.26 + (6 x 0.4) = 6.2 MW

Gas Insulated Lines = (2 x 3) x 1,565.52 x 0.344 = 5.1 MW

1.3 Example Loss Calculation (2) – 40 km 275 kV "Lo" Category Circuits Connecting to a 400 kV part of the National Grid's transmission system

1.3.1 The following is an example loss calculation for a 40 km 275 kV "Lo" category (capacity of 3,190 MVA made up of two 1,595 MVA circuits) and includes details of how losses of the supergrid transformer ("SGT") connections to 400 kV circuits are assessed. This example assesses the losses associated with the GIL technology option up to a connection point to the 400 kV system.

1.3.2 The circuit utilisation power (P) which for the each of the two circuits in the "Lo" category example is calculated as:

[21] A 40 km three phase underground cable circuit will also require three reactors to ensure that reactive gain is managed within required limits.

P = 34% x 1,595 = 542.3 MVA

For this example, the average current flowing in each of the two circuits is:

$I = 542.3x10^6/(\sqrt{3} \times 275x10^3) = 1{,}138.5$ Amps

1.3.3 For this "Lo" category example, the total resistance for the GIL technology option is calculated (from information in Appendix D, Table D.10) as follows:

0.0086Ω/km x 40 km = 0.344 Ω

1.3.4 The following is a total instantaneous loss calculation for the GIL technology option for this "Lo" category example:

Losses per circuit are calculated using $P=3I^2R$

3 x 1138.5 x 0.344 = 1.35 MW

Losses for "Lo" category 275 kV circuits are calculated by multiplying losses per circuit by number of circuits in the category

2 x 1.35 MW = 2.7 MW

1.3.5 SGT losses also need to be included as part of the assessment for this "Lo" category example which includes connection to 400 kV circuits. SGT resistance[22] is calculated (from information in Appendix D, Table D.10) as 0.2576 Ω.

1.3.6 The following is a total instantaneous loss calculation for the SGT connection part of this "Lo" category example:

The average current flowing in each of the two SGT 400 kV winding are calculated as:

$I_{HV} = 542.3 \times 10^6/(\sqrt{3} \times 400x10^3) = 782.7$ Amps

Losses per SGT are calculated using $P=3I^2R$

SGT Loss = 3 x 782.7 x 0.2576 = 0.475 MW

Iron Losses in each SGT = 84kW

Total SGT instantaneous loss (one SGT per GIL circuit) = (2 x 0.475) + (2 x 0.084) = 1.1 MW.

1.3.7 For this example, the total "Lo" category loss is the sum of the calculated GIL and SGT total loss figures:

"Lo" category loss = 2.7 + 1.1 = 3.8 MW

[22] Resistance value referred to the 400 kV side of the transformer.

Appendix F Glossary of Terms and Acronyms

AC		Alternating Current
AC Cable		AC Underground Cable
Conductor		used to transport power
CSC		Current Source Converter
DC		Direct Current
DCO		Development Consent Order issued under the Planning Act 2008
Electricity Act		The Electricity Act 1989
EN-1		Overarching National Policy Statement for Energy
EN-3		National Policy Statement for Renewable Energy Infrastructure
EN-5		National Policy Statement for Electricity Network Infrastructure
EN-6		National Policy Statement for Nuclear Power Generation
GIL		Gas Insulated Lines
HVDC		High Voltage Direct Current
IET, PB/CCI Report		An independent report endorsed by the Institution of Engineering and Technology by Parsons Brinckerhoff in association with Cable Consulting International
Insulators		used to safely connect conductors to pylons
IPC		Infrastructure Planning Commission
National Grid		National Grid Electricity Transmission plc
NPV		Net Present Value
NETS SQSS		National Electricity Transmission System Security and Quality of Supply Standard
NGESO		Operator of National Electricity Transmission System
NPS		National Policy Statements
NSIP		Nationally Significant Infrastructure Project
Ofgem		The Office of Gas and Electricity Markets
OHL		Overhead Line
(the) Policy		National Grid's Stakeholder, Community and Amenity Policy

Pylons		used to support conductors
RIBA		Royal Institute of British Architects
SF_6		Sulphur Hexafluoride (gas used to provide electrical insulation)
Span length		distance between adjacent pylons
STC		System Operator – Transmission Owner Code
SGT		Super-Grid Transformer
The Authority		Gas and Electricity Markets Authority, the governing body of Ofgem
T-pylon		monopole pylon design developed by National Grid
Transmission Licence		Licence granted under Section 6(1)(b) of the Electricity Act
volt (V)		The electrical unit of potential difference 1 kilovolt (kV) = 1,000volts
watt (W)		The SI unit of power 1 kilowatt (kW) = 1,000watts 1 megawatt (MW) = 1,000kW 1 gigawatt (GW) = 1,000MW
XLPE		Cross Linked Polyethylene (solid material used to provide electrical insulation)

Appendix G Strategic Study Area Options Overview: Environmental and Socio-economic Appraisal

1.1 Introduction

1.1.1 Each of the shortlisted strategic options have been appraised in accordance with National Grid's Approach to Consenting. Environmental and socio-economic issues have been informed by desk study information and constraints mapping. For each strategic option, a study area has been established within which the strategic option could reasonably be expected to be developed. Figures illustrating the study areas for each of the options are included within this Appendix.

1.1.2 The high-level options appraisal has had particular regard for internationally or nationally important sites and other features that are of a sufficient scale and importance to inform decision-making at a regional level. Detailed environmental assessments will be undertaken at the design, routeing, siting and development consent stages following the selection, consideration and approval of the final preferred strategic proposal.

1.2 ECO-1 Creyke Beck to High Marnham (Westward Direction)

1.2.1 In order to undertake the environmental and socio-economic appraisal of the ECO-1 (West) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-1 (West), it was identified that a straight line route direct from Creyke Beck to High Marnham would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route west from Creyke Beck around Kingston upon Hull and then southwards to High Marnham. The appraisal assumes that the substation equipment required at Creyke Beck and High Marnham would be delivered by others hence new substation works are excluded from this option. Sites and features that might constrain the development of an OHL for the option are detailed below.

ECO-1 (Westward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.2.2 The nature of the landscape of the study area, with the exception of the Yorkshire Wolds in the north, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief. The Yorkshire Wolds National Trail crosses the Wolds within the northern portion of the study area.

1.2.3 Whilst it should be possible to avoid some potential adverse effects on the landscape and visual amenity, the Yorkshire Wolds (currently identified as an Important Landscape Area in the East Riding Local Plan 2012 - 2029) would need to be crossed by this option.

1.2.4 Consideration would need to be given to the potential benefits of running in close parallel to the existing 4ZQ 400kV OHL to reduce the impacts of introducing a new OHL route into the landscape, although this also has potential to intensify the appearance of wirescape in the landscape.

1.2.5 In summer 2022, Natural England consulted on the Yorkshire Wolds Designation Project to consider the possible designation of a new Yorkshire Wolds Area of Outstanding Natural Beauty (AONB). A Provisional Candidate Area was released as part of a public consultation evaluation stage in June 2022 to obtain feedback on the proposals. The Provisional Candidate Area is located to the north of Market Weighton and is hence outside the Creyke Beck to High Marnham study area. Based on existing information, AONB designation of the area of Yorkshire Wolds within the study area is not anticipated.

1.2.6 West of the Wolds and along the Trent Valley, the generally open intensive agricultural landscape means that there is wide visibility, however the landscape is likely to be able to accommodate an OHL with limited disturbance to landscape character. There is potential to use, or parallel with, the existing ZDA 400kV OHL to avoid introducing a new OHL route, although this has potential to intensify the appearance of wirescape in the landscape. The presence of urban areas and the River Trent adjacent to the east of the ZDA 400kV OHL may limit routeing opportunities.

1.2.7 It is likely some residual permanent effects would occur for residents along affected settlement edges and at scattered properties due to the number present within the study area. There is also potential for some adverse visual effects on users of the National Trail.

1.2.8 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.2.9 There are a number of scheduled monuments scattered throughout the study area including three scheduled monuments (Whimpton Moor medieval village and moated site, Ringwork at Kingshaugh Farm, and Roman Fortress/Camps at Newton on Trent) located approximately 3-5km to the north of the existing High Marnham substation. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.2.10 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area.

1.2.11 There are a limited number of registered parks and gardens within the study area. These include Risby Hall and Thwaite Hall at the northern end of the study area, and Doddington Hall at the southern end of the study area.

1.2.12 It is likely that listed buildings and registered parks and gardens could be avoided by selecting appropriate route corridors and sensitive routeing.

1.2.13 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.2.14 Whilst designated heritage assets are likely to be avoidable there is the potential for significant impacts on the setting of such assets depending on the proximity of the OHL.

1.2.15 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.2.16 The Humber Estuary Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site and Site of Special Scientific Interest (SSSI) between Creyke Beck and High Marnham presents a major constraint for the routeing of the new OHL alignment; these designated sites extend from east to west across the study area. The sites also extend south along the River Trent. There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, and Beckingham Marshes to the west of Gainsborough. There is potential for adverse effects on important habitats and breeding bird populations associated with the Humber Estuary. Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.

1.2.17 The Thorne and Hatfield Moors SPA and Important Bird Area (IBA), Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, Humberhead Peatlands National Nature Reserve and Laughton Forest IBA are located within the central section of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are designated both during construction and operation.

1.2.18 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon Thorne and Hatfield Moors SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). If this is not possible, localised undergrounding could be used to avoid or mitigate unacceptable effects where necessary. Benefits from undergrounding to mitigate bird collision and mortality would need to be considered comparatively with potential adverse impacts that may arise from land and habitat disturbance due to undergrounding within, and in close proximity to, designated sites.

1.2.19 There are a number of additional SSSIs within the study area including Scotton and Laughton Forest Ponds SSSI, Laughton SSSI, Risby Warren SSSI, as well as a number located along linear features such as ditches and canals. There are also several areas of ancient woodland scattered throughout the study area. It is anticipated that direct impacts on these designated assets can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.2.20 Any OHL route between Creyke Beck and High Marnham would have to cross over several unavoidable watercourses and associated floodplains including the River Ouse. There is an opportunity to parallel the existing 4ZQ 400kV OHL which crosses the River Ouse and to parallel the existing ZDA 400kV OHL which crosses the River Don. Any OHL would run parallel to the River Trent which flows to the north through the study area. There could be a need for multiple crossings of this river to avoid other constraints. Areas of Groundwater Source Protection Zones (GSPZ) are present within the study area and are largely concentrated within and around Creyke Beck.

1.2.21 Flood Zones 2 and 3 cover a large section of the study area. Given the extent of Flood Zones 2 and 3 across the study area, it is likely that a significant amount of development would be located within the floodplain.

1.2.22 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 1 (Westward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.2.23 There are a number of large urban areas within the study area including Kingston-Upon-Hull, Scunthorpe and Gainsborough as well as numerous smaller settlements scattered throughout which are a constraint for routeing and siting. There is an opportunity to parallel the existing 4ZQ 400kV OHL and the existing ZDA 400kV OHL to avoid urban areas; however, the presence of existing settlements may limit opportunities for paralleling of these existing 400kV OHLs.

1.2.24 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the new OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.2.25 The study area has a large amount of best and most versatile (BMV) agricultural land considered to be an economic resource. This includes areas of Grade 1 BMV land particularly south of the Humber and along the Trent Valley. Grade 3 BMV agricultural land is the most prominent land type classification within the study area south of Gainsborough. Temporary effects on agricultural land would occur during the construction phase. A small percentage of agricultural land would be permanently lost due to the footprint of the pylons. Standard best practice guidelines should be followed to reinstate agricultural land following construction.

Tourism and Recreation Appraisal

1.2.26 The Yorkshire Wolds National Trail crosses the northern portion of the study area crossing the Wolds. There are a number of National Cycle Networks (NCN) routes located within the northern portion of the study area including the Trans Pennine Trail which extends from east to west across the study area, as well as an NCN in the central portion of the study area in proximity to Scunthorpe.

1.2.27 There is the potential for temporary adverse effects associated with severance should the National Trail and NCN routes need to be temporarily closed during construction, however effects would be temporary. There is the potential for some permanent adverse visual effects on users of the National Trail which are set out in the landscape and visual appraisal.

1.2.28 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notices for users of NCN routes and National Trails should part of these routes be closed during construction.

1.2.29 There are three Country Parks within the study area: Waters Edge and Humber Bridge Country Parks located either side of the Humber Estuary, and Normanby Hall located north of Scunthorpe. These sites are considered to be avoidable.

Infrastructure Appraisal

1.2.30 The road network within the study area comprises major routes including the M62, M18 and M180 which connect the large settlements of Goole, Thorne, Stainforth and Hatfield. Both the M180 and M62/A63 would need to be crossed by the new OHL.

1.2.31 There are also a number of trunk roads within the study area some of which would need to be crossed where they extend across the study area from east to west.

1.2.32 There are also several railway lines running within the study area including a number that would be unavoidable and would need to be crossed.

1.2.33 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new OHL.

1.2.34 There are numerous airfields within the study area. The airfields are considered to be avoidable.

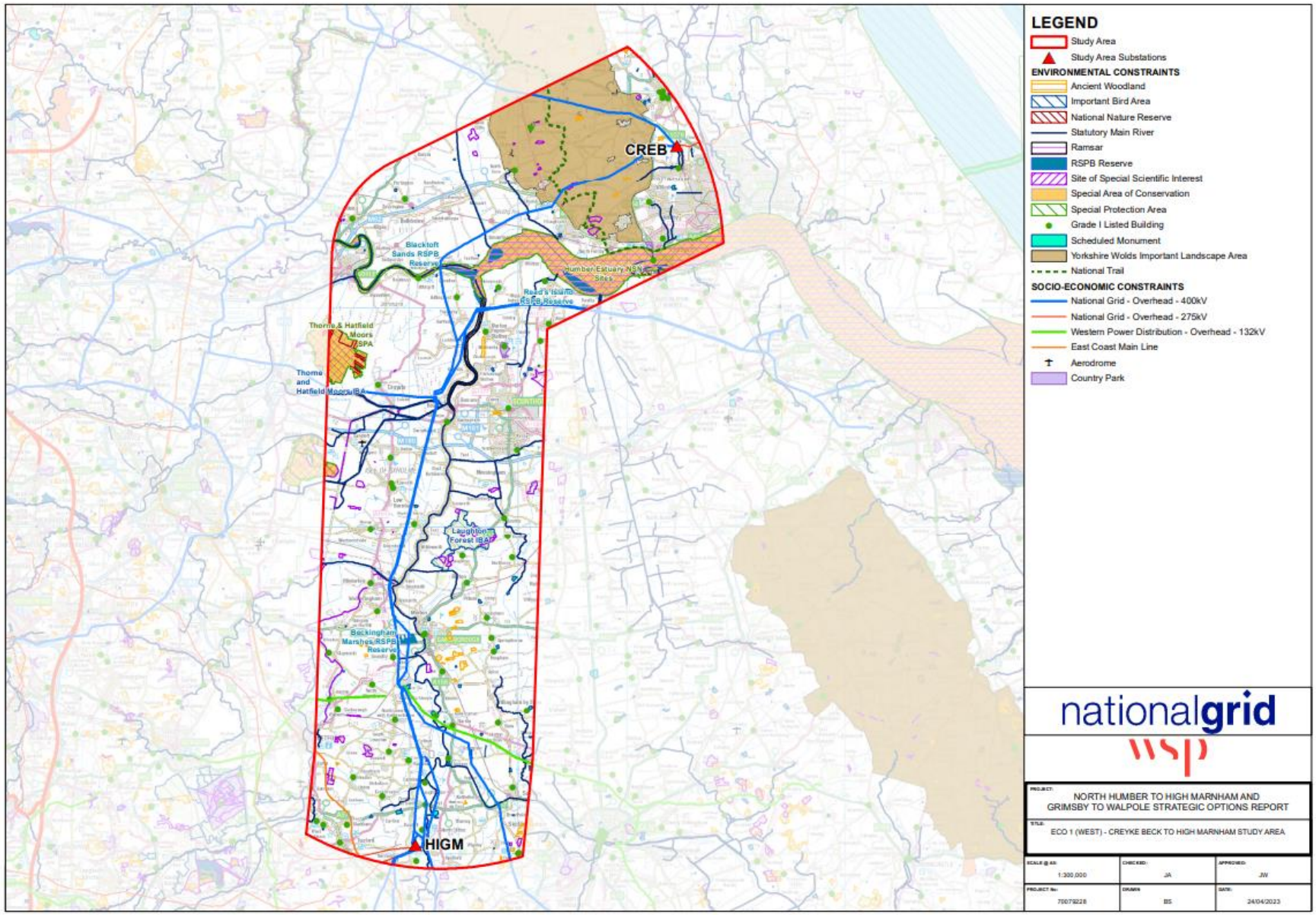
1.2.35 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the 30km Civil Aviation Authority (CAA) suggested safeguarding zone for Doncaster Sheffield Airport and the 17km safeguarding zone for Retford Gamston Airport. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority but also including an area of high priority. Part of the southern portion of the study area is within a Met Radar Zone.

1.2.36 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-1 (Westward Direction) Summary

1.2.37 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. The OHL would cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst Thorne and Hatfield Moors SPA and IBA, Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the

information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The OHL would also cross the Yorkshire Wolds Important Landscape Area. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
HIGM
Blacktoft Sands RSPB Reserve
Humber Estuary SPA, Ramsar Site
Reed's Island RSPB Reserve
Thorne & Hatfield Moors SPA
Thorne and Hatfield Moors IBA
Laughton Forest IBA
Beckingham Marshes RSPB Reserve
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Scheduled Monument
Yorkshire Wolds Important Landscape Area
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
East Coast Main Line
Aerodrome
Country Park
nationalgrid
wsp
PROJECT:
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
TITLE:
ECO 1 (WEST) - CREYKE BECK TO HIGH MARNHAM STUDY AREA
SCALE @ A3:
1:300,000
CHECKED:
JA
APPROVED:
JW
PROJECT No:
70079228
DRAWN
BS
DATE:
24/04/2023

1.3 ECO-1 Creyke Beck to High Marnham (Eastward Direction)

1.3.1 In order to undertake the environmental and socio-economic appraisal of the ECO-1 (East) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-1 (East), it was identified that a straight line route direct from Creyke Beck to High Marnham would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck around Kingston upon Hull and then south-west to High Marnham. The appraisal assumes that the substation equipment required at Creyke Beck and High Marnham would be delivered by others hence new substation works are excluded from this option. Sites and features that might constrain the development of an OHL for the option are detailed below.

ECO-1 (Eastward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.3.2 The nature of the landscape of the study area is predominantly open expansive landscapes under intensive agriculture, with simple landscape patterns. There is little major development outside the main settlements, particularly in the wider area east of Kingston-Upon-Hull and through the centre of the area south of the Humber. The Lincolnshire Wolds AONB encroaches into the eastern edge of the study area but would be avoided.

1.3.3 The generally low-lying open character with long views increases the risk of wide visibility, however the same open character can allow tall structures to be absorbed. The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from high ground) as far as possible. It is assumed that this option would require a 6km cable in a tunnel beneath the Humber.

1.3.4 Visibility of the new 400kV OHL is likely to be extensive due to the low-lying open character of the landscape. However, it is considered that the existing landscape patterns are unlikely to be disturbed by the introduction of a new 400kV OHL.

1.3.5 There is an opportunity to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to reduce the impacts of introducing a new OHL route into the landscape. Similarly, there is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.3.6 Further south, the density of existing overhead lines may lead to the creation of a wirescape in the Trent valley.

1.3.7 It is likely some residual permanent effects would occur for residents along affected settlement edges and at scattered properties due to the number present within the study area.

Historic Environment Appraisal

1.3.8 There are a number of scheduled monuments scattered throughout the study area including three scheduled monuments (Whimpton Moor medieval village and moated site, Ringwork at Kingshaugh Farm, and Roman Fortress/Camps at Newton on Trent)

located approximately 3-5km to the north of the existing High Marnham substation. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.3.9 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area.

1.3.10 There are a limited number of registered parks and gardens within the study area. These include Burton Constable north of the Humber, Brocklesby Park south of the Humber, and Fillingham Castle, Hackthorn Hall and Doddington Hall in the southern portion of the study area.

1.3.11 It is likely that listed buildings and registered parks and gardens could be avoided by selecting appropriate route corridors and sensitive routeing.

1.3.12 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL.

1.3.13 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.3.14 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.3.15 The Humber Estuary SAC, SPA, Ramsar site and SSSI between Creyke Beck and High Marnham presents a major constraint for the routeing of the new OHL alignment; these designated sites extend from east to west across the study area. It is assumed that this option would require a 6km cable in a tunnel beneath the Humber. Any tunnelling, whilst removing the impact of bird strike, could still have negative effects upon the Humber Estuary through disturbance and potential hydrogeological impacts particularly if above-ground infrastructure associated with tunnelling is sited close to the Humber.

1.3.16 There would be a need to follow the Habitats Regulations Assessment process to consider the effects on qualifying species. Any project would need to demonstrate that it would not affect the integrity of the Humber Estuary designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.3.17 The opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull should be considered to reduce the impacts of introducing a new OHL route. Similarly, there is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.3.18 There are a number of additional SSSIs within the study area including Lea Marsh SSSI, Kingerby Beck Meadows SSSI and Normanby Meadow SSSI. There are several areas of ancient woodland scattered throughout the study area, particularly to the east

of Gainsborough. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.3.19 Any OHL route between Creyke Beck and High Marnham would have to cross over several unavoidable watercourses and associated floodplains including the River Trent near High Marnham and rivers around Creyke Beck.

1.3.20 Areas of GSPZ are present throughout the study area.

1.3.21 Areas of Flood Zones 2 and 3 extend across the study area mainly associated with the Humber, the River Trent and the River Ancholme.

1.3.22 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 1 (Eastward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.3.23 The large urban area of Kingston-Upon-Hull presents a constraint for routeing of a new OHL south between Creyke Beck and the Humber. There is an opportunity for the new 400kV OHL to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to allow avoidance of this urban area. However, urban sprawl and future major allocations should be a consideration to the north and east of Kingston-Upon-Hull given the limited space between the YYW 275kV OHL and the outskirts of the urban area. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.3.24 The area to the south of the Humber is not as densely populated and urban areas would be less of a constraint for routeing in this area. The area around the Port of Hull and Port of Immingham is congested with existing infrastructure and may be a constraint for routeing and siting.

1.3.25 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.3.26 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land south of the Humber. Grade 3 BMV agricultural land is the most prominent land type classification within the southern section of the study area. Temporary effects on agricultural land would occur during the construction phase. A small percentage of agricultural land would be permanently lost due to the footprint of the pylons. Standard best practice guidelines should be followed to reinstate agricultural land following construction.

Tourism and Recreation Appraisal

1.3.27 There are a number of NCN routes located within the northern portion of the study area in the vicinity of Kingston-Upon-Hull, as well as an NCN which crosses from east to west across the extent of the study area south of the Humber.

1.3.28 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.3.29 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes be closed during construction.

1.3.30 There is one Country Park within the study area: Burton Constable. This site is considered to be avoidable.

Infrastructure Appraisal

1.3.31 The road network within the study area includes the M180, however this could potentially be avoided depending on routeing. There are also trunk roads within the study area, a number of which would need to be crossed where they extend across the study area from east to west.

1.3.32 There are several railway lines running within the study area mainly in and around the Port of Hull and Port of Immingham. A number of these would be unavoidable and would need to be crossed.

1.3.33 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new OHL.

1.3.34 The Port of Hull and the Port of Immingham are located in the northern section of the study area and would present a constraint to routeing.

1.3.35 Humberside Airport and Aerodrome and RAF Kirton and RAF Scampton are located within the study area. There are also numerous additional airfields within the study area. The Airport/Aerodrome, RAF bases and airfields would be considered to be avoidable.

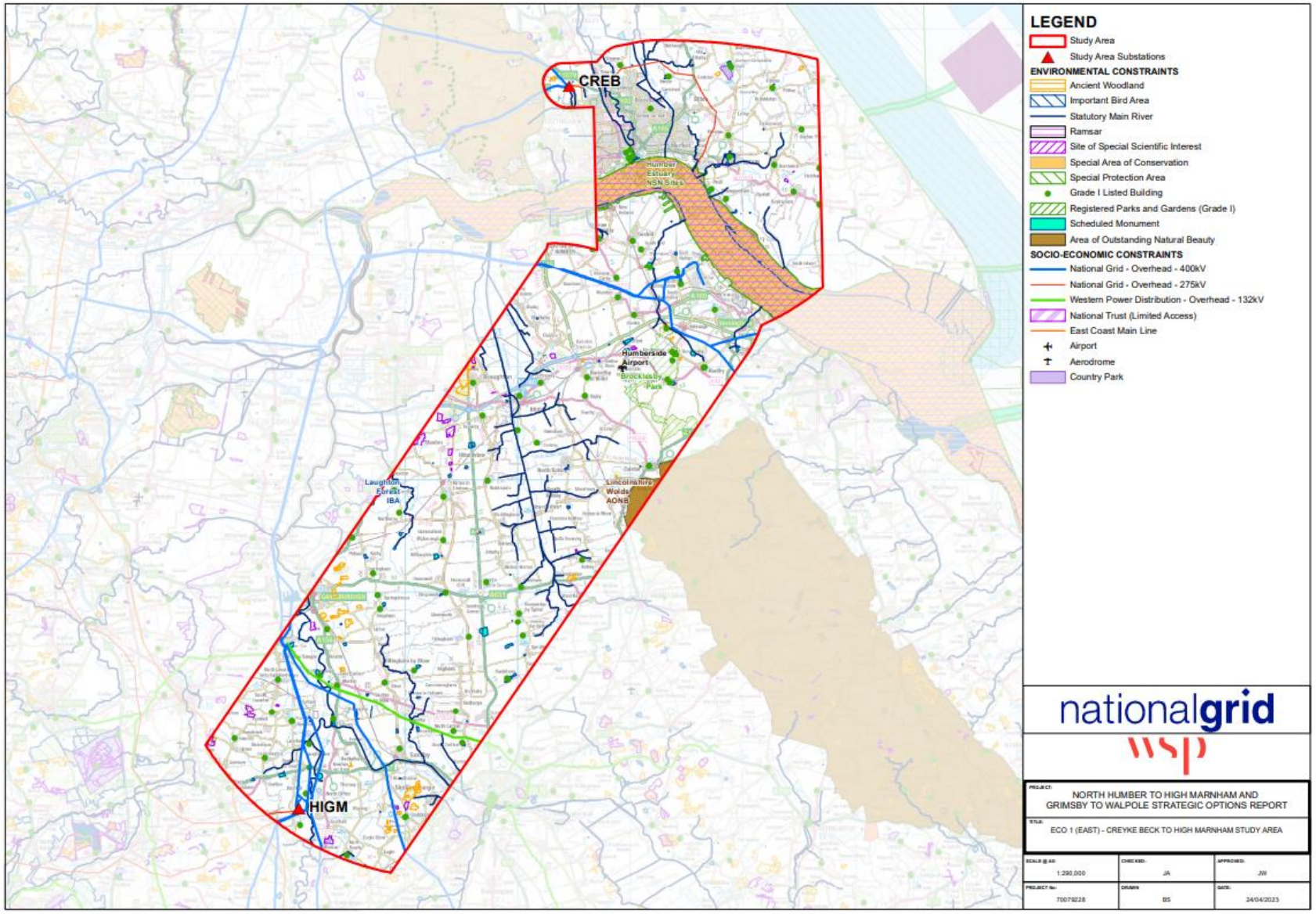
1.3.36 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the 17km CAA suggested safeguarding zone for Humberside Airport, the 30km safeguarding zone for Doncaster Sheffield Airport, the 17km safeguarding zone for Retford Gamston Airport and the 5km safeguarding zone. All of the study area is located within a MoD low flying zone, the majority of which is low priority but also including an area of high priority. Part of the southern portion of the study area is within a Met Radar Zone.

1.3.37 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-1 (Eastward Direction) Summary

1.3.38 Overall this option is relatively constrained in relation to ecological considerations. Tunnelling beneath the Humber, whilst removing the impact of bird strike, could still

have adverse effects upon the Humber Estuary through disturbance and potential hydrogeological impacts. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). There is potential for adverse effects on the setting of a number of Registered Parks and Gardens including Brocklesby Park as a result of a new OHL, although it is likely that any such effects could be avoided through careful routeing. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
HIGM
Humber Estuary NSN Sites
Humberside Airport
Brocklesby Park
Laughton Forest IBA
Lincolnshire Wolds AONB
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Statutory Main River
Ramsar
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
East Coast Main Line
Airport
Aerodrome
Country Park
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 1 (EAST) - CREYKE BECK TO HIGH MARNHAM STUDY AREA
1:250,000
JA
JW
70079228
BS
24/04/2023

1.4 ECO-2 Creyke Beck to Cottam (Westward Direction)

1.4.1 In order to undertake the environmental and socio-economic appraisal of the ECO-2 (West) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-2 (West), it was identified that a straight line route direct from Creyke Beck to Cottam would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route west from Creyke Beck around Kingston upon Hull and then southwards to Cottam. The appraisal assumes that the substation equipment required at Creyke Beck and Cottam would be delivered by others hence new substation works are excluded from this option; the appraisal does however assume a requirement for a new Sealing End Compound at Cottam. Sites and features that might constrain the development of this option are detailed below.

ECO-2 (Westward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.4.2 The nature of the landscape of the study area, with the exception of the Yorkshire Wolds in the north, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief. The Yorkshire Wolds National Trail crosses the Wolds within the northern portion of the study area.

1.4.3 Whilst it should be possible with this option to avoid some potential adverse effects on the landscape and visual amenity, the Yorkshire Wolds (currently identified as an Important Landscape Area in the East Riding Local Plan 2012 - 2029) would need to be crossed by the option.

1.4.4 Consideration would need to be given to the potential benefits of running in close parallel to the existing 4ZQ 400kV OHL in this landscape to reduce the impacts of introducing a new OHL route into the landscape, although this also has potential to intensify the appearance of wirescape in the landscape.

1.4.5 In summer 2022, Natural England consulted on the Yorkshire Wolds Designation Project to consider the possible designation of a new Yorkshire Wolds Area of Outstanding Natural Beauty (AONB). A Provisional Candidate Area was released as part of a public consultation evaluation stage in June 2022 to obtain feedback on the proposals. The Provisional Candidate Area is located to the north of Market Weighton and is hence outside the Creyke Beck to Cottam study area. Based on existing information, AONB designation of the area of Yorkshire Wolds within the study area is not anticipated.

1.4.6 West of the Wolds and along the Trent Valley, the generally open intensive agricultural landscape means that there is wide visibility, however the landscape is likely to be able to accommodate an OHL with limited disturbance to landscape character. There is potential to use, or parallel with, the existing ZDA 400kV OHL to avoid introducing a new OHL route, although this has potential to intensify the appearance of wirescape in the landscape.

1.4.7 It is likely some residual permanent effects would occur for residents along affected settlement edges and at scattered properties due to the number present within the study

area. There is also potential for some adverse visual effects on users of the National Trail.

1.4.8 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.4.9 There are a number of scheduled monuments scattered throughout the study area including three scheduled monuments (Fleet Plantation moated site, Site of medieval town and Torksey Castle) located within 2km of the existing Cottam substation. It is anticipated that direct impacts on scheduled monuments can be avoided through careful routeing and siting due to their scattered nature.

1.4.10 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings approximately 1.5km to the north, south and west of the existing Cottam substation boundary within and close to the villages of Cottam, Church Laneham and Rampton respectively and approximately 2km to the east of the substation boundary within and close to the village of Torksey

1.4.11 There are two registered parks and gardens within the northern portion of the study area: Risby Hall and Thwaite Hall.

1.4.12 It is likely that listed buildings and registered parks and gardens could be avoided by sensitive routeing and siting.

1.4.13 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and new Sealing End Compound infrastructure required at Cottam.

1.4.14 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.4.15 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.4.16 The Humber Estuary SAC, SPA, Ramsar site and SSSI between Creyke Beck and High Marnham presents a major constraint for the routeing of the new OHL alignment; these designated sites extend from east to west across the study area. The sites also extend south along the River Trent. There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, and Beckingham Marshes to the west of Gainsborough. There is potential for adverse effects on important habitats and breeding bird populations associated with the Humber

Estuary. Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.

1.4.17 The Thorne and Hatfield Moors SPA and IBA, Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, Humberhead Peatlands National Nature Reserve and Laughton Forest IBA are located within the central section of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated both during construction and operation.

1.4.18 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon Thorne and Hatfield Moors SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). If this is not possible, localised undergrounding could be used to avoid or mitigate unacceptable effects where necessary. Benefits from undergrounding to mitigate bird collision and mortality would need to be considered comparatively with potential adverse impacts that may arise from land and habitat disturbance due to undergrounding within, and in close proximity to, designated sites.

1.4.19 There are a number of additional SSSIs within the study area including Scotton and Laughton Forest Ponds SSSI, Laughton SSSI, Risby Warren SSSI, as well as a number along linear features such as ditches and canals. There are also several areas of ancient woodland scattered throughout the study area. It is anticipated that direct impacts on these designated assets can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.4.20 Any OHL route between Creyke Beck and Cottam would have to cross over several unavoidable watercourses and associated floodplains including the River Ouse. There is an opportunity to parallel the existing 4ZQ 400kV OHL which crosses the River Ouse and to parallel the existing ZDA 400kV OHL which crosses the River Don. Any OHL would run parallel to the River Trent which flows to the north through the study area. There could be a need for multiple crossings of this river to avoid other constraints.

1.4.21 Areas of GSPZ are present within the study area and are largely concentrated within and around Creyke Beck.

1.4.22 Flood Zones 2 and 3 cover a large section of the study area including areas around the existing Cottam substation. Given the extent of Flood Zones 2 and 3 across the study area, it is likely that a significant amount of development would be located within the floodplain.

1.4.23 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new Sealing End Compound infrastructure at Cottam. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 2 (Westward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.4.24 There are a number of large urban areas within the study area including Kingston-Upon-Hull, Scunthorpe and Gainsborough together with numerous smaller settlements scattered throughout which are a constraint for routeing and siting. There is an opportunity to parallel the existing 4ZQ 400kV OHL and the existing ZDA 400kV OHL to avoid urban areas; however, the presence of existing settlements may limit opportunities for paralleling of the existing 400kV OHLs.

1.4.25 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.4.26 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 BMV land particularly south of the Humber and along the Trent Valley. Grade 3 BMV agricultural land is the most prominent land type classification within the study area south of Gainsborough. Temporary effects on agricultural land would occur during the construction phase. A small percentage of agricultural land would be permanently lost due to the footprint of the pylons. Standard best practice guidelines should be followed to reinstate agricultural land following construction.

Tourism and Recreation Appraisal

1.4.27 The Yorkshire Wolds National Trail crosses the northern portion of the study area crossing the Wolds. There are a number of NCN routes located within the northern portion of the study area including the Trans Pennine Trail which extends from east to west across the study area, as well as an NCN in the central portion of the study area in proximity to Scunthorpe.

1.4.28 There is the potential for temporary adverse effects associated with severance should the National Trail and NCN routes need to be temporarily closed during construction, however effects would be temporary. There is the potential for some adverse visual effects on users of the National Trail which are set out in the landscape and visual appraisal, and these effects would be permanent.

1.4.29 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes and National Trail should part of these routes be closed during construction.

1.4.30 There are three Country Parks within the study area: Waters Edge and Humber Bridge Country Parks located either side of the Humber Estuary, and Normanby Hall located north of Scunthorpe. These sites are considered to be avoidable.

Infrastructure Appraisal

1.4.31 The road network within the Study Area comprises major routes including the M62, M18 and M180 which connect the large settlements of Goole, Thorne, Stainforth and Hatfield. Both the M180 and M62/A63 would need to be crossed.

1.4.32 There are also a number of trunk roads within the study area a number of which would need to be crossed where they extend across the study area from east to west.

1.4.33 There are also several railway lines running within the study area including a number that would be unavoidable and would need to be crossed.

1.4.34 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new OHL.

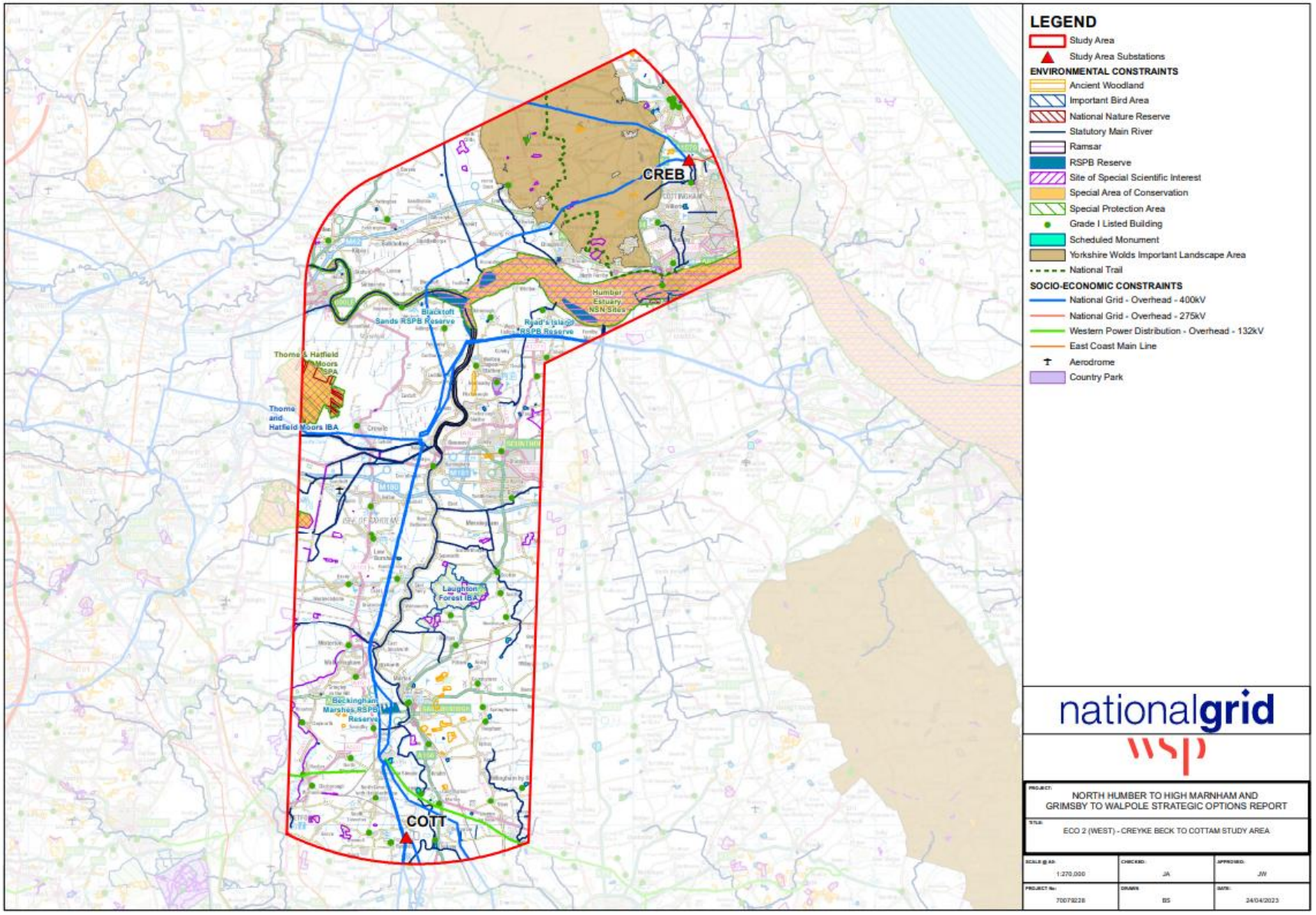
1.4.35 There are numerous airfields within the study area. The airfields are considered to be avoidable.

1.4.36 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the 30km CAA suggested safeguarding zone for Doncaster Sheffield Airport and the 17km safeguarding zone for Retford Gamston Airport. All of the study area is located within a MoD low flying zone, the majority of which is low priority but also including an area of high priority. Part of the southern portion of the study area is within a Met Radar Zone.

1.4.37 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-2 (Westward Direction) Summary

1.4.38 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. The OHL would cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst other ecologically designated sites including Thorne and Hatfield Moors SPA and IBA, Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne, Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are depending on routeing. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The OHL would also cross the Yorkshire Wolds Important Landscape Area. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. There is potential for adverse effects on the setting of Scheduled Monuments and listed buildings depending on the proximity of the new Sealing End Compound infrastructure required at Cottam. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Scheduled Monument
Yorkshire Wolds Important Landscape Area
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
East Coast Main Line
Aerodrome
Country Park
CREB
COTT
Blacktoft Sands RSPB Reserve
Humber Estuary NSN Sites
Thorne & Hatfield Moors SPA
Thorne and Hatfield Moors IBA
Laughton Forest IBA
Beckingham Marshes RSPB Reserve
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 2 (WEST) - CREYKE BECK TO COTTAM STUDY AREA
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1.5 ECO-2 Creyke Beck to Cottam (Eastward Direction)

1.5.1 In order to undertake the environmental and socio-economic appraisal of the ECO-2 (East) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-2 (East), it was identified that a straight line route direct from Creyke Beck to Cottam would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck around Kingston upon Hull and then south-west to Cottam. The appraisal assumes that the substation equipment required at Creyke Beck and Cottam would be delivered by others hence new substation works are excluded from this option; the appraisal does however assume a requirement for a new Sealing End Compound at Cottam. Sites and features that might constrain the development of this option are detailed below.

ECO-2 (Eastward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.5.2 The nature of the landscape of the study area is predominantly open expansive landscapes under intensive agriculture, with simple landscape patterns. There is little major development outside the main settlements, particularly in the wider area east of Kingston-Upon-Hull and through the centre of the area south of the Humber. The Lincolnshire Wolds AONB encroaches very minimally into the eastern edge of the study area but would be avoided.

1.5.3 The generally low-lying open character with long views increases the risk of wide visibility, however the same open character can allow tall structures to be absorbed. The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from high ground) as far as possible.

1.5.4 Visibility of the new OHL is likely to be extensive due to the low-lying open character of the landscape. However, it is considered that the existing landscape patterns are unlikely to be disturbed by the introduction of a new OHL.

1.5.5 There is an opportunity to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to reduce the impacts of introducing a new OHL route into the landscape. Similarly, there is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.5.6 Further south, the density of existing overhead lines may lead to the creation of a wirescape in the Trent valley.

1.5.7 It is likely some residual permanent effects may occur for residents along affected settlement edges and at scattered properties due to the number present within the study area.

Historic Environment Appraisal

1.5.8 There are a number of scheduled monuments scattered throughout the study area including three scheduled monuments (Fleet Plantation moated site, Site of medieval town and Torksey Castle) located within 2km of the existing Cottam substation. It is

anticipated that direct impacts on scheduled monuments can be avoided through careful routeing and siting due to their scattered nature.

1.5.9 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings approximately 1.5km to the north, south and west of the existing Cottam substation boundary within and close to the villages of Cottam, Church Laneham and Rampton respectively and approximately 2km to the east of the substation boundary within and close to the village of Torksey.

1.5.10 There are a limited number of registered parks and gardens within the study area. These include Burton Constable north of the Humber, Brocklesby Park south of the Humber, and Fillingham Castle in the southern portion of the study area.

1.5.11 It is likely that listed buildings and registered parks and gardens could be avoided by sensitive routeing and siting.

1.5.12 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and new Sealing End Compound infrastructure required at Cottam.

1.5.13 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.5.14 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.5.15 The Humber Estuary SAC, SPA, Ramsar site and Site of Special SSSI between Creyke Beck and High Marnham presents a major constraint for the routeing of the new OHL alignment; these designated sites extend from east to west across the study area. It is assumed that this option would require a 6km cable in a tunnel beneath the Humber. Any tunnelling whilst removing the impact of bird strike, could still have negative effects upon the Humber Estuary through disturbance and potential hydrogeological impacts particularly if above-ground infrastructure associated with tunnelling is sited close to the Humber.

1.5.16 There would be a need to follow the Habitats Regulations Assessment process to consider the effects on qualifying species. Any project would need to demonstrate that it would not affect the integrity of the Humber Estuary designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.5.17 The opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull should be considered to reduce the impacts of introducing a new OHL route. Similarly, there is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.5.18 There are a number of additional SSSIs within the study area including Lea Marsh SSSI, Kingerby Beck Meadows SSSI and Normanby Meadow SSSI. There are also several areas of ancient woodland scattered throughout the study area, particularly to the east of Gainsborough. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.5.19 Any OHL route between Creyke Beck and High Marnham would have to cross over several unavoidable watercourses and associated floodplains including the River Trent near High Marnham and rivers around Cottam.

1.5.20 Areas of GSPZ are present throughout the study area.

1.5.21 Areas of Flood Zones 2 and 3 extend across the study area mainly associated with the Humber, the River Trent and the River Ancholme. Flood Zones 2 and 3 cover areas outside the existing Cottam substation.

1.5.22 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new Sealing End Compound infrastructure at Cottam. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 2 (Eastward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.5.23 The large urban area of Kingston-Upon-Hull presents a constraint for routeing of a new OHL south between Creyke Beck and the Humber. There is an opportunity for the new 400kV OHL to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to allow avoidance of this urban area. However, urban sprawl and future major allocations should be a consideration to the north and east of Kingston-Upon-Hull given the limited space between the YYW 275kV OHL and the outskirts of the urban area. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.5.24 The area to the south of the Humber is not as densely populated and urban areas would be less of a constraint for routeing in this area. The area around the Port of Hull and Port of Immingham is congested with existing infrastructure and may be a constraint for routeing and siting.

1.5.25 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.5.26 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land south of the Humber. Grade 3 BMV agricultural land is the most prominent land type classification within the southern section of the study area. Temporary effects on agricultural land would occur during the construction phase. A small percentage of agricultural land

would be permanently lost due to the footprint of the pylons. Standard best practice guidelines should be followed to reinstate agricultural land following construction.

Tourism and Recreation Appraisal

1.5.27 There are a number of NCN routes located within the northern portion of the study area in the vicinity of Kingston-Upon-Hull, as well as an NCN which crosses from east to west across the extent of the study area south of the Humber.

1.5.28 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.5.29 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes be closed during construction.

1.5.30 There is one Country Park within the study area: Burton Constable. This site is considered to be avoidable.

Infrastructure Appraisal

1.5.31 The road network within the study area includes the M180, however this could potentially be avoided depending on routeing. There are also a number of trunk roads within the study area, a number of which would need to be crossed where they extend across the study area from east to west.

1.5.32 There are several railway lines running within the study area mainly in and around the Port of Hull and Port of Immingham. A number of these would be unavoidable and would need to be crossed.

1.5.33 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

1.5.34 The Port of Hull and the Port of Immingham are located in the northern portion section of the study area and would present a constraint to routeing.

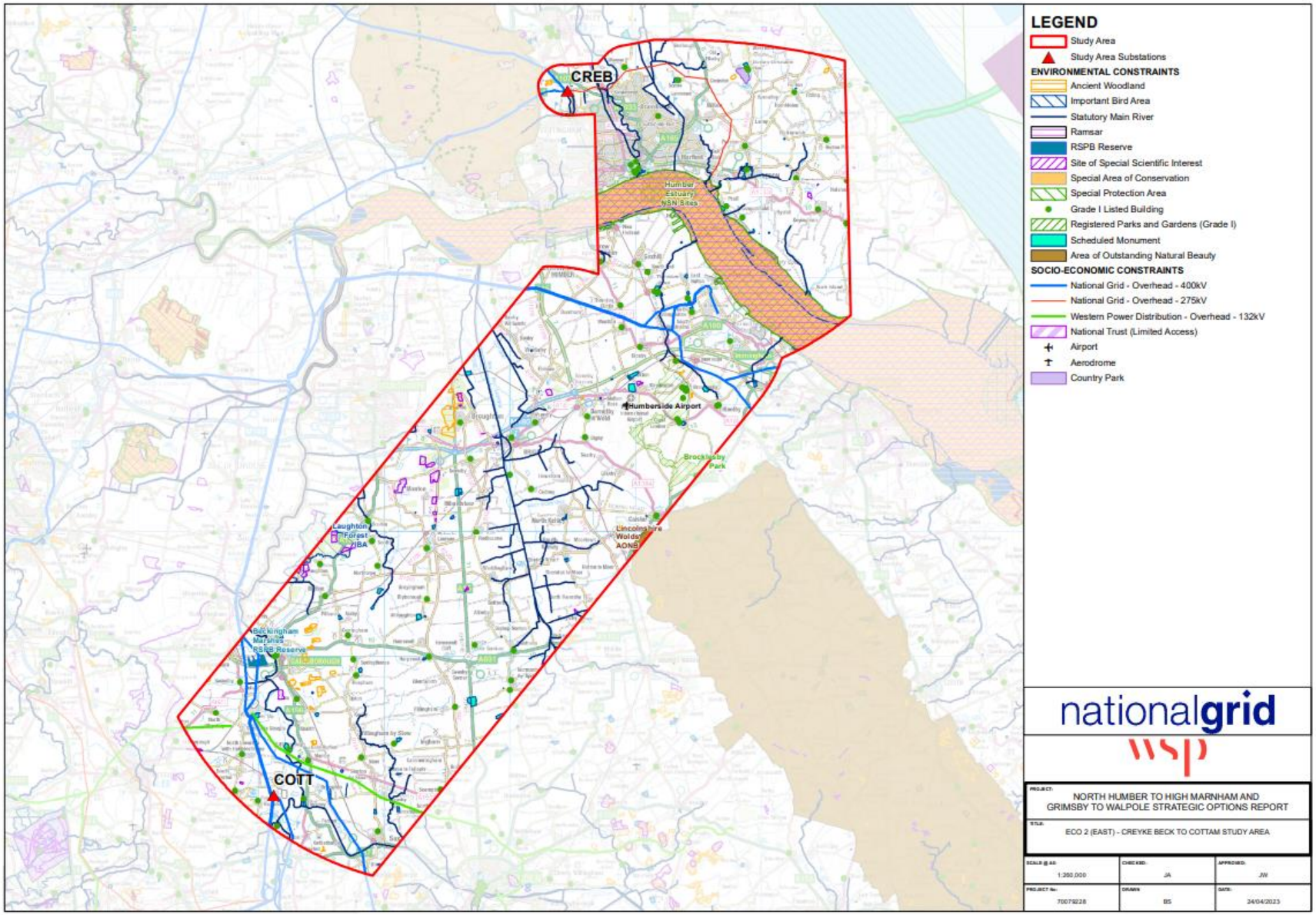
1.5.35 Humberside Airport and Aerodrome and RAF Kirton are located within the study area. There are numerous additional airfields within the study area. The Airport/Aerodrome and airfields would be considered to be avoidable.

1.5.36 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the 17km CAA suggested safeguarding zone for Humberside Airport, the 30km safeguarding zone for Doncaster Sheffield Airport, the 17km safeguarding zone for Retford Gamston Airport and the 5km safeguarding zone. All of the study area is located within a MoD low flying zone, the majority of which is low priority but also including an area of high priority. Part of the southern portion of the study area is within a Met Radar Zone.

1.5.37 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-2 (Eastward Direction) Summary

1.5.38 Overall this option is relatively constrained in relation to ecological considerations. Tunnelling beneath the Humber, whilst removing the impact of bird strike, could still have adverse effects upon the Humber Estuary through disturbance and potential hydrogeological impacts. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). There is potential for adverse effects on the setting of Scheduled Monuments and listed buildings depending on the proximity of the new Sealing End Compound infrastructure required at Cottam. Similarly there is potential effects for adverse effects on the setting of a number of Registered Parks and Gardens including Brocklesby Park as a result of a new OHL, although it is likely that any such effects could be avoided through careful routeing. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
COTT
Humber Estuary WSN Sites
Humberside Airport
Laughton Forest SPA
Lincolnshire Wolds AONB
Beckingham Marshes RSPB Reserve
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Airport
Aerodrome
Country Park
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 2 (EAST) - CREYKE BECK TO COTTAM STUDY AREA
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1.6 ECO-3 Creyke Beck to Grimsby West, Grimsby West to Walpole (Western Direction)

1.6.1 In order to undertake the environmental and socio-economic appraisal of the ECO-3 (West) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-3 (West), it was identified that a straight line route direct from Creyke Beck to Walpole would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route west from Creyke Beck around Kingston upon Hull, then heading south-east to a connection at Grimsby West, and southwards to Walpole. The appraisal assumes that the additional substation equipment required at Creyke Beck would be delivered by others hence new substation works at Creyke Beck are excluded from this option. The appraisal assumes new substation equipment would be required at Grimsby West and Walpole. Sites and features that might constrain the development of this option are detailed below.

ECO-3 (Western Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.6.2 The nature of the landscape of the study area, with the exception of the Yorkshire Wolds in the northern portion of the study area and the Lincolnshire Wolds AONB located along the western extent of the central portion of the study area, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief.

1.6.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB, coastal tourist resorts along the coastline of the study area, and users of the Yorkshire Wolds National Trail which crosses the Wolds within the northern portion of the study area.

1.6.4 In summer 2022, Natural England consulted on the Yorkshire Wolds Designation Project to consider the possible designation of a new Yorkshire Wolds Area of Outstanding Natural Beauty (AONB). A Provisional Candidate Area was released as part of a public consultation evaluation stage in June 2022 to obtain feedback on the proposals. The Provisional Candidate Area is located to the north of Market Weighton and is hence outside the Creyke Beck to Walpole study area. Based on existing information, AONB designation of the area of Yorkshire Wolds within the study area is not anticipated.

1.6.5 In the northern portion of the study area, the OHL would need to cross the Yorkshire Wolds escarpment and the settlements along the scarp foot. There is an opportunity to parallel the existing 4ZQ and 2KN 400kV OHLs to minimise the impact associated with construction of a new OHL route in the landscape.

1.6.6 Within the central portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the central and southern portions of the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.6.7 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.6.8 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.6.9 In the central portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to both avoid the AONB and avoid intruding on views from AONB.

1.6.10 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.6.11 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole.

1.6.12 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.6.13 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.6.14 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings within 1km of the existing Grimsby West substation and Walpole substation. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing and siting.

1.6.15 There are a number of registered parks and gardens within the study area, the largest of which is the Grade I listed Registered Park and Garden of Brocklesby Park. Routeing to the west of Grimsby would need to avoid this registered park and garden.

1.6.16 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and new substation infrastructure.

1.6.17 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.6.18 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously

unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.6.19 The Humber Estuary SAC, SPA, Ramsar site and SSSI presents a major constraint for the routeing of the new OHL alignment in the northern portion of the study area; these designated sites extend from east to west across the study area. The sites also extend south along the River Trent. There is potential for adverse effects on important habitats and breeding bird populations associated with the Humber Estuary. Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.

1.6.20 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast SAC, the North Norfolk Coast Ramsar Site, IBA and SSSI, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated both during construction and operation.

1.6.21 There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.6.22 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon The Wash SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). If this is not possible, localised undergrounding could be used to avoid or mitigate unacceptable effects where necessary. Benefits from undergrounding to mitigate bird collision and mortality would need to be considered comparatively with potential adverse impacts that may arise from land and habitat disturbance due to undergrounding within, and in close proximity to, designated sites.

1.6.23 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.6.24 Any OHL route between Creyke Beck and Walpole would have to cross over several unavoidable watercourses and associated floodplains including the River Ouse, the River Ancholme, the River Witham, the River Welland and the River Nene. There is an opportunity to parallel the existing 4ZQ 400kV OHL which crosses the River Ouse.

1.6.25 Areas of GSPZ are present within the northern and central portions of the study.

1.6.26 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area. Given the extent of Flood Zones 2 and 3 across the study area, it is likely that a significant amount of development would be located within the floodplain.

1.6.27 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Walpole. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 3 (Westward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.6.28 There are a number of large urban areas within the study area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint. There is an opportunity for the new OHL to parallel the existing 4ZQ and 2KN/4KG 400kV OHLs especially to the northwest of Grimsby West.

1.6.29 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.6.30 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly south of the Humber, southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West and Walpole.

Tourism and Recreation Appraisal

1.6.31 The Yorkshire Wolds National Trail crosses the northern portion of the study area crossing the Wolds. There are a number of National Cycle Networks (NCN) routes which extend across the study area including the Trans Pennine Trail north of the Humber, NCN1 which runs from Lincoln to Kingston-upon-Hull, the NCN110 south of Grimsby, the Water Way Trail to Boston and NCN1 from Boston towards Wisbech.

1.6.32 There is the potential for temporary adverse effects associated with severance should the National Trail and NCN routes need to be temporarily closed during construction, however effects would be temporary. There is the potential for some adverse visual effects on users of the National Trail which are set out in the landscape and visual appraisal, and these effects would be permanent.

1.6.33 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes and National Trail should part of these routes or trails be closed during construction.

1.6.34 There are seven Country Parks within the study area. These include Waters Edge and Humber Bridge Country Parks located either side of the Humber Estuary, Normanby

Hall Country Park located north of Scunthorpe, and Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.6.35 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.6.36 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.6.37 The road network within the northern portion of the study area comprises major routes including the M62, M181 and M180. Both the M180/A180 and M62/A63 would need to be crossed.

1.6.38 There are also a number of trunk roads and A roads within the study area including the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.6.39 There are several railway lines running within the study area particularly in the area around Scunthorpe, Immingham and Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford. A number of these railway lines would be unavoidable and would need to be crossed.

1.6.40 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

1.6.41 Humberside Airport and Aerodrome and Fenland Aerodrome are located within the study area. RAF Wainfleet and RAF Holbeach are located on the eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The Airport, Aerodrome, RAF bases and airfields would be considered to be avoidable.

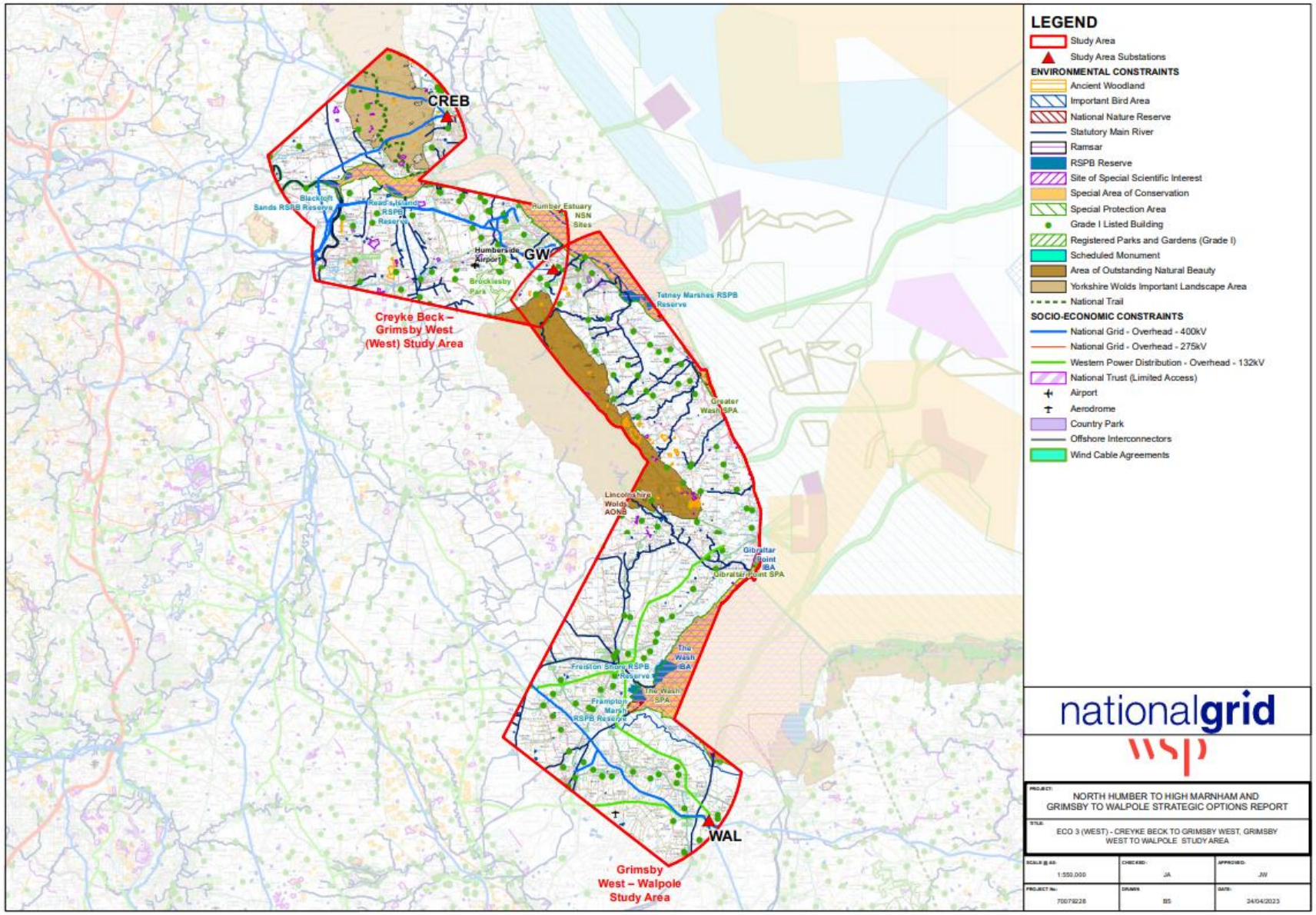
1.6.42 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area and partially within the safeguarding zone for Fenland Aerodrome in the south. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority but also including an area of high priority at the northern end.

1.6.43 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons.

ECO-3 (Westward Direction) Summary

1.6.44 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. The OHL would cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst The

Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The OHL would cross the Yorkshire Wolds Important Landscape Area, and although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB from the OHL. There is potential for adverse effects on the setting of Brocklesby Park Registered Park and Garden as a result of the new OHL depending on routeing. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
GW
WAL
Creyke Beck – Grimsby West (West) Study Area
Grimsby West – Walpole Study Area
Humber Estuary NSN Sites
Humberside Airport
Tetney Marshes RSPB Reserve
Greater Wash SPA
Gibraltar Point IBA
Gibraltar Point SPA
The Wash IBA
The Wash SPA
Frampton Marsh RSPB Reserve
Freiston Shore RSPB Reserve
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
Yorkshire Wolds Important Landscape Area
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Airport
Aerodrome
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 3 (WEST) - CREYKE BECK TO GRIMSBY WEST, GRIMSBY WEST TO WALPOLE STUDY AREA
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1.7 ECO-3 Creyke Beck to Grimsby West, Grimsby West to Walpole (Eastward Direction)

1.7.1 In order to undertake the environmental and socio-economic appraisal of the ECO-3 (East) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-3 (East), it was identified that a straight line route direct from Creyke Beck to Walpole would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck around Kingston upon Hull, then heading south-east to a connection at Grimsby West, and southwards to Walpole. The appraisal assumes that the substation equipment required at Creyke Beck would be delivered by others hence new substation works at Creyke Beck are excluded from this option. The appraisal assumes new substation equipment would be required at Grimsby West and Walpole. Sites and features that might constrain the development of an OHL for the option are detailed below.

ECO-3 (Eastward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.7.2 The nature of the landscape of the study area, with the exception of the Lincolnshire Wolds AONB located along the western extent of the central portion of the study area, is predominantly open expansive landscapes under intensive agriculture, with simple landscape patterns. There is little major development outside the main settlements.

1.7.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts.

1.7.4 In the northern portion of the study area, there is little major development outside the main settlements, particularly in the wider area east of Kingston-Upon-Hull. Within the central portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the central and southern portions of the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.7.5 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.7.6 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.7.7 There is an opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull and 2AD 400kV OHL south of the Humber to prevent the introduction of a completely new OHL route and concentrate landscape and visual effects in one location. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.7.8 In the central portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to both avoid the AONB and avoid intruding on views from AONB.

1.7.9 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.7.10 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole.

1.7.11 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.7.12 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.7.13 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings within 1km of the existing Grimsby West substation and Walpole substation. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing and siting.

1.7.14 There are a number of registered parks and gardens within the study area including Well Hall and Gunby Park which would be considered to be avoidable.

1.7.15 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and substation infrastructure.

1.7.16 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.7.17 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.7.18 The Humber Estuary SAC, SPA, Ramsar site and SSSI presents a major constraint for the routeing of the new OHL alignment in the northern portion of the study area; these designated sites extend from east to west across the study area. It is assumed that this option would require a 6km cable in a tunnel beneath the Humber. Any tunnelling whilst

removing the impact of bird strike, could still have negative effects upon the Humber Estuary through disturbance and potential hydrogeological impacts particularly if above-ground infrastructure associated with tunnelling is sited close to the Humber.

1.7.19 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast SAC, the North Norfolk Coast Ramsar Site, IBA and SSSI, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of the sites are designated both during construction and operation.

1.7.20 There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.7.21 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon The Wash SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.7.22 There is an opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull and 2AD 400kV OHL south of the Humber to prevent the introduction of a completely new OHL route and concentrate ecological effects in one location. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.7.23 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.7.24 Any OHL route between Creyke Beck and Walpole would have to cross over several unavoidable watercourses and associated floodplains including the Steeping River, the River Witham, the River Welland and the River Nene.

1.7.25 Areas of GSPZ are present throughout the study area.

1.7.26 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area.

1.7.27 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Walpole. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 3 (Eastward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.7.28 The large urban area of Kingston-Upon-Hull presents a constraint for routeing of a new OHL north of the Humber. Similarly, the urban areas of Grimsby and Boston present a constraint for routeing of a new OHL in the central and southern portion of the study area. There are also numerous smaller towns and settlements scattered throughout the study area and therefore limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.

1.7.29 There is an opportunity for the new OHL to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to allow avoidance of this urban area. However, urban sprawl and future major allocations should be a consideration to the north and east of Kingston-Upon-Hull given the limited space between the YYW 275kV OHL and the outskirts of the urban area. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.7.30 Temporary adverse impacts associated with noise, air quality and construction traffic could arise if the OHL is situated within proximity to settlements during construction. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.7.31 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West and Walpole.

Tourism and Recreation Appraisal

1.7.32 There are a number of National Cycle Networks (NCN) routes which extend across the study area including the Trans Pennine Trail north of the Humber, the NCN110 south of Grimsby, the Water Way Trail to Boston, the NCN1 running south from Boston and NCN1 from Boston towards Wisbech.

1.7.33 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.7.34 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes or trails be closed during construction.

1.7.35 There are five Country Parks within the study area. These include Burton Constable Country Park east of Kingston-Upon-Hull and Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.7.36 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.7.37 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.7.38 The road network within the study area includes a number of A roads including the A165 to Kingston-Upon-Hull, the A180 to Grimsby, the A158 and A52 to Skegness, the A52 and A1121 to Boston, and the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.7.39 There are several railway lines running within the study area particularly in and around the Port of Hull, Port of Immingham and Port of Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford, and from Sleaford to Spalding. A number of these would be unavoidable and would need to be crossed.

1.7.40 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

1.7.41 The Port of Hull, the Port of Immingham and the Port of Grimsby are located in the northern portion section of the study area and would present a constraint to routeing.

1.7.42 Humberside Airport and Aerodrome and Fenland Aerodrome are located within the study area. RAF Wainfleet and RAF Holbeach are located on the eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The Airport, Aerodrome, RAF bases and airfields would be considered to be avoidable.

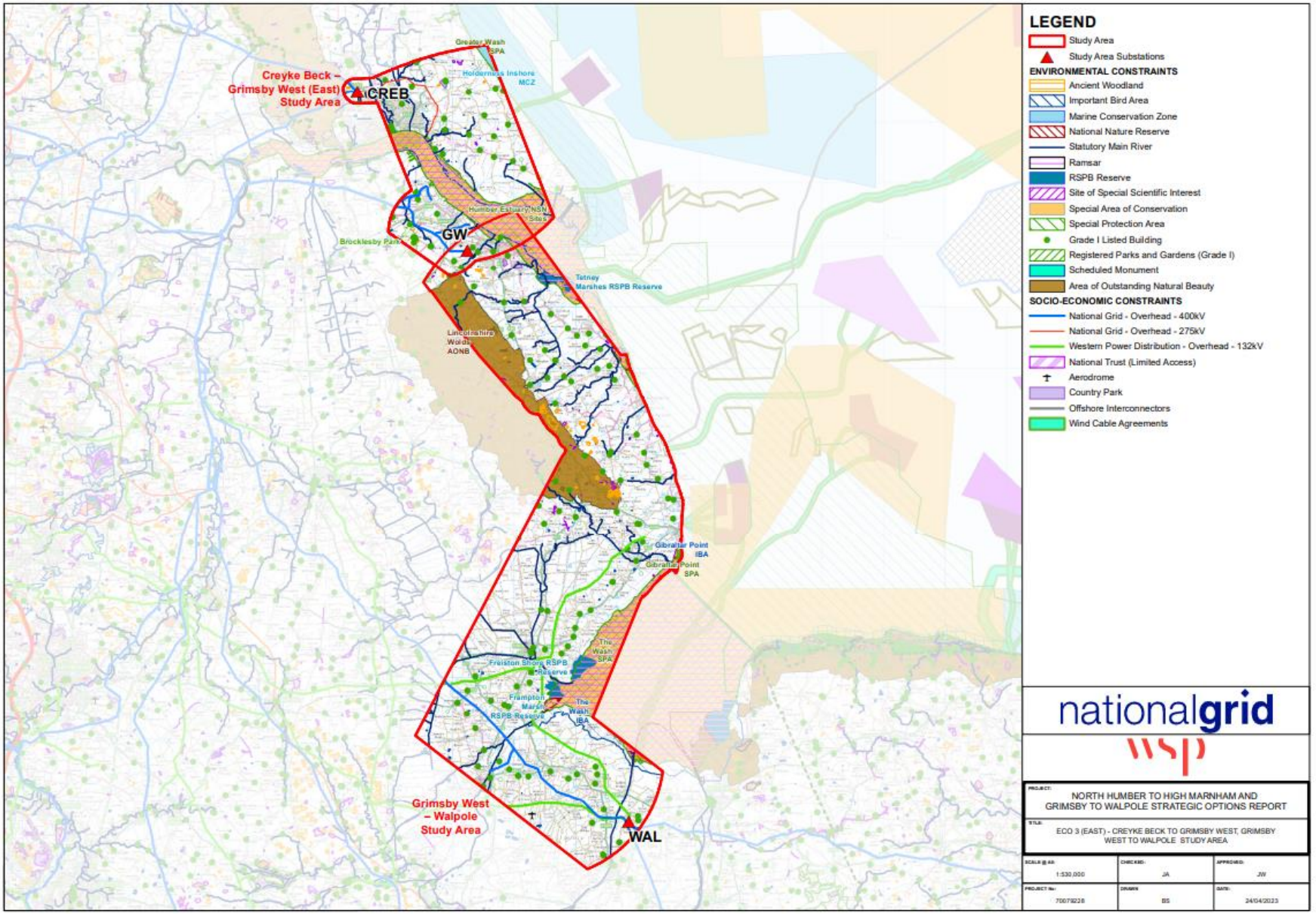
1.7.43 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area and partially within the safeguarding zone for Fenland Aerodrome in the south. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority but also including an area of high priority at the northern end.

1.7.44 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-3 (Eastward Direction) Summary

1.7.45 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. Tunnelling beneath the Humber, whilst removing the impact of bird strike, could still have adverse effects upon the Humber Estuary through disturbance and potential hydrogeological impacts. Whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at

this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). Although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


Creyke Beck – Grimsby West (East) Study Area
CREB
GW
Grimsby West – Walpole Study Area
WAL
Greater Wash SPA
Holderness Inshore MCZ
Humber Estuary NSN Site A
Brocklesby Park
Tetney Marshes RSPB Reserve
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
The Wash SPA
Freiston Shore RSPB Reserve
Frampton Marsh RSPB Reserve
The Wash IBA
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Marine Conservation Zone
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Aerodrome
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 3 (EAST) - CREYKE BECK TO GRIMSBY WEST, GRIMSBY WEST TO WALPOLE STUDY AREA
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1.8 ECO-4 Creyke Beck to Grimsby West, Grimsby West to Weston Marsh (Westward Direction)

1.8.1 In order to undertake the environmental and socio-economic appraisal of the ECO-4 (West) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-4 (West), it was identified that a straight line route direct from Creyke Beck to Weston Marsh would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route west from Creyke Beck around Kingston upon Hull, then heading south-east to a connection at Grimsby West and southwards to Weston Marsh. The appraisal assumes that the substation equipment required at Creyke Beck would be delivered by others hence new substation works at Creyke Beck are excluded from this option. The appraisal assumes new substation equipment would be required at Grimsby West and Weston Marsh. Sites and features that might constrain the development of this option are detailed below.

ECO-4 (Westward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.8.2 The nature of the landscape of the study area, with the exception of the Yorkshire Wolds in the northern portion of the study area and the Lincolnshire Wolds AONB located along the western extent of the central portion of the study area, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief.

1.8.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB, coastal tourist resorts along the coastline of the study area, and users of the Yorkshire Wolds National Trail which crosses the Wolds within the northern portion of the study area.

1.8.4 In summer 2022, Natural England consulted on the Yorkshire Wolds Designation Project to consider the possible designation of a new Yorkshire Wolds Area of Outstanding Natural Beauty (AONB). A Provisional Candidate Area was released as part of a public consultation evaluation stage in June 2022 to obtain feedback on the proposals. The Provisional Candidate Area is located to the north of Market Weighton and is hence outside the Creyke Beck to Walpole study area. Based on existing information, AONB designation of the area of Yorkshire Wolds within the study area is not anticipated.

1.8.5 In the northern portion of the study area, to the OHL would need to cross the Yorkshire Wolds escarpment and the settlements along the scarp foot. There is an opportunity to parallel the existing 4ZQ and 2KN 400kV OHLs to minimise the impact associated with construction of a new OHL route in the landscape.

1.8.6 Within the central portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the central and southern portions of the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.8.7 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.8.8 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.8.9 In the central portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to both avoid the AONB and avoid intruding on views from AONB.

1.8.10 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, this is not considered to be significant, and opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.8.11 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Weston Marsh[23] into a landscape which currently has very little major infrastructure outside the larger settlements.

1.8.12 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.8.13 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.8.14 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. These include listed buildings within 1km of the existing Grimsby West substation. The majority of these are associated with the settlements scattered throughout the study area. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing.

1.8.15 There are a number of registered parks and gardens within the study area, the largest of which is the Grade I listed Registered Park and Garden of Brocklesby Park. Routeing to the west of Grimsby would need to avoid this registered park and garden.

1.8.16 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and substation infrastructure.

[23] assumed to be at a location close to the existing 4ZM route, however exact location subject to routing / siting

1.8.17 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.8.18 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.8.19 The Humber Estuary SAC, SPA, Ramsar site and SSSI presents a major constraint for the routeing of the new OHL alignment in the northern portion of the study area; these designated sites extend from east to west across the study area. The sites also extend south along the River Trent. There is potential for adverse effects on important habitats and breeding bird populations associated with the Humber Estuary. Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.

1.8.20 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast SAC, the North Norfolk Coast Ramsar Site, SSSI and IBA, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated both during construction and operation.

1.8.21 There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.8.22 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon The Wash SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). If this is not possible, localised undergrounding could be used to avoid or mitigate unacceptable effects where necessary. Benefits from undergrounding to mitigate bird collision and mortality would need to be considered comparatively with potential adverse impacts that may arise from land and habitat disturbance due to undergrounding within, and in close proximity to, designated sites.

1.8.23 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated assets can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.8.24 Any OHL route between Creyke Beck and Weston Marsh would have to cross over several unavoidable watercourses and associated floodplains including the River Ouse, the River Ancholme, the River Witham and the River Welland. There is an opportunity to parallel the existing 4ZQ 400kV OHL which crosses the River Ouse.

1.8.25 Areas of GSPZ are present within the northern and central portions of the study area.

1.8.26 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent. Given the extent of Flood Zones 2 and 3, it is likely that a significant amount of development would be located within the floodplain. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Weston Marsh.

1.8.27 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 4 Socio-economic Appraisal (Westward Direction)

Settlements and Populations Appraisal

1.8.28 There are a number of large urban areas within the study area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint. There is an opportunity for the new OHL to parallel the existing 4ZQ and 2KN/4KG 400kV OHLs especially to the northwest of Grimsby West.

1.8.29 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the OHL and substation sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the substation infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal. The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly south of the Humber, southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West and Weston Marsh.

Tourism and Recreation Appraisal

1.8.30 The Yorkshire Wolds National Trail crosses the northern portion of the study area crossing the Wolds. There are a number of National Cycle Networks (NCN) routes which extend across the study area including the Trans Pennine Trail north of the Humber, NCN1 which runs from Lincoln to Kingston-upon-Hull, the NCN110 south of Grimsby, the Water Way Trail to Boston and the NCN1 running south from Boston.

1.8.31 There is the potential for temporary adverse effects associated with severance should the National Trail and NCN routes need to be temporarily closed during construction, however effects would be temporary. There is the potential for some adverse visual

effects on users of the National Trail which are set out in the landscape and visual appraisal, and these effects would be permanent.

1.8.32 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes and National Trail should part of these routes or trails be closed during construction.

1.8.33 There are seven Country Parks within the study area. These include Waters Edge and Humber Bridge Country Parks located either side of the Humber Estuary, Normanby Hall Country Park located north of Scunthorpe, and Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.8.34 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable by an overhead line.

1.8.35 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.8.36 The road network within the northern portion of the study area comprises major routes including the M62, M181 and M180. Both the M180/A180 and M62/A63 would need to be crossed.

1.8.37 There are also a number of trunk roads and A roads within the study area the A180 to Grimsby, the A158 and A52 to Skegness, the A52 and A1121 to Boston, and the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.8.38 There are several railway lines running within the study area particularly in the area around Scunthorpe, Immingham and Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford. A number of these railway lines would be unavoidable and would need to be crossed.

1.8.39 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

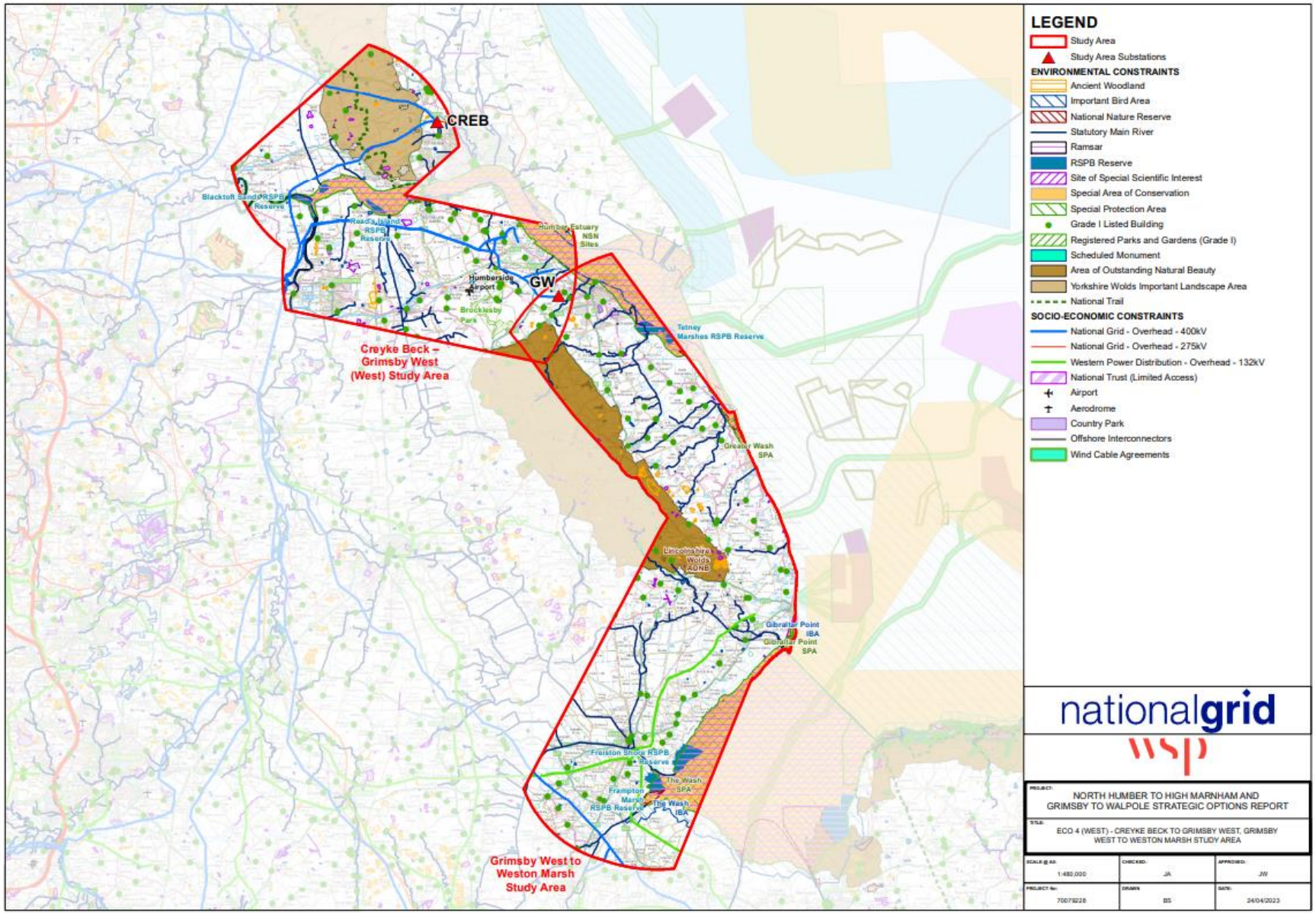
1.8.40 Humberside Airport and Aerodrome is located within the study area. RAF Wainfleet and RAF Holbeach are located on the very eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The Airport, Aerodrome, RAF bases and airfields would be considered to be avoidable.

1.8.41 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority but also including an area of high priority at the northern end.

1.8.42 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons.

ECO-4 (Westward Direction) Summary

1.8.43 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. The OHL would cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk) that are a qualifying feature of these designations. Whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The OHL would cross the Yorkshire Wolds Important Landscape Area, and although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB. There is potential for adverse effects on the setting of Brocklesby Park Registered Park and Garden as a result of the new OHL depending on routeing. There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure at Weston Marsh in a landscape which currently has little major development. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
GW
Creyke Beck – Grimsby West (West) Study Area
Grimsby West to Weston Marsh Study Area
Blacktoft Sands RSPB Reserve
Read's Island RSPB Reserve
Humber Estuary NSN Sites
Humberside Airport
Brocklesby Park
Tetney Marshes RSPB Reserve
Greater Wash SPA
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
Freiston Shore RSPB Reserve
The Wash SPA
Frampton Marsh RSPB Reserve
The Wash IBA
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
Yorkshire Wolds Important Landscape Area
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Airport
Aerodrome
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 4 (WEST) - CREYKE BECK TO GRIMSBY WEST, GRIMSBY WEST TO WESTON MARSH STUDY AREA
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1.9 ECO-4 Creyke Beck to Grimsby West, Grimsby West to Weston Marsh (Eastward Direction)

1.9.1 In order to undertake the environmental and socio-economic appraisal of the ECO-4 (East) option, a study area was established in which the project could reasonably be expected to be developed. For ECO-4 (East), it was identified that a straight line route direct from Creyke Beck to Weston Marsh would be unrealistic due to the densely built-up urban centre of Kingston Upon Hull; routeing of any new infrastructure would need to avoid this area. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck around Kingston upon Hull, then heading south-east to a connection at Grimsby West, and southwards to Weston Marsh. The appraisal assumes that the substation equipment required at Creyke Beck would be delivered by others hence new substation works at Creyke Beck are excluded from this option. The appraisal assumes new substation equipment would be required at Grimsby West and Weston Marsh. Sites and features that might constrain the development of this option are detailed below.

ECO-4 (Eastward Direction) Environmental Appraisal

Landscape and Visual Appraisal

1.9.2 The nature of the landscape of the study area, with the exception of the Lincolnshire Wolds AONB located along the western extent of the central portion of the study area, is predominantly open expansive landscapes under intensive agriculture, with simple landscape patterns. There is little major development outside the main settlements.

1.9.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts.

1.9.4 In the northern portion of the study area, there is little major development outside the main settlements, particularly in the wider area east of Kingston-Upon-Hull. Within the central portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the central and southern portions of the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.9.5 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.9.6 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.9.7 There is an opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull and 2AD 400kV OHL south of the Humber to prevent the introduction of a completely new OHL route and concentrate landscape and visual effects in one location. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.9.8 In the central portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to avoid both the AONB and avoid intruding on views from AONB.

1.9.9 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.9.10 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Weston Marsh into a landscape which currently has very little major infrastructure outside the larger settlements.

1.9.11 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.9.12 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature. There is potential for adverse effects on the setting of Scheduled Monuments on both banks of the River Humber which present a constraint to the siting of the connection point between OHL and the tunnel.

1.9.13 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. These include listed buildings within 1km of the existing Grimsby West substation. The majority of these are associated with the settlements scattered throughout the study area. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing.

1.9.14 There are a number of registered parks and gardens within the study area including Well Hall and Gunby Park which would be considered to be avoidable.

1.9.15 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and substation infrastructure.

1.9.16 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.9.17 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.9.18 The Humber Estuary SAC, SPA, Ramsar site and SSSI presents a major constraint for the routeing of the new OHL alignment in the northern portion of the study area; these designated sites extend from east to west across the study area. It is assumed that this option would require a 6km cable in a tunnel beneath the Humber. Any tunnelling whilst removing the impact of bird strike, could still have negative effects upon the Humber Estuary through disturbance and potential hydrogeological impacts particularly if above-ground infrastructure associated with tunnelling is sited close to the Humber.

1.9.19 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast SAC, the North Norfolk Coast Ramsar Site, IBA and SSSI, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area. Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of the sites are designated both during construction and operation.

1.9.20 There are a number of RSPB Reserves within the study area including Read's Island and Blacktoft Sands associated with the Humber Estuary, Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.9.21 There would be a need to follow the Habitats Regulations Assessment process to consider the effects of a crossing of the Humber. This would also need to encompass impacts upon The Wash SPA/SAC depending upon distance. Any project would need to demonstrate that it would not affect the integrity of these designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.9.22 There is an opportunity to parallel the YYW 275kV OHL east of Kingston-Upon-Hull and 2AD 400kV OHL south of the Humber to prevent the introduction of a completely new OHL route and concentrate ecological effects in one location. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.9.23 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated assets can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.9.24 Any OHL route between Creyke Beck and Weston Marsh would have to cross over several unavoidable watercourses and associated floodplains including the Steeping River, the River Witham and the River Welland.

1.9.25 Areas of GSPZ are present throughout the study area.

1.9.26 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Weston Marsh.

1.9.27 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 4 (Eastward Direction) Socio-economic Appraisal

Settlements and Populations Appraisal

1.9.28 The large urban area of Kingston-Upon-Hull presents a constraint for routeing of a new OHL north of the Humber. Similarly, the urban areas of Grimsby and Boston present a constraint for routeing of a new OHL in the central and southern portion of the study area. The area around the Port of Hull and Port of Immingham is congested with existing infrastructure and may be a constraint for routeing and siting. There are also numerous smaller towns and settlements scattered throughout the study area and therefore limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.

1.9.29 There is an opportunity for the new OHL to parallel the YYW 275kV OHL to the east of Kingston-Upon-Hull to allow avoidance of this urban area. However, urban sprawl and future major allocations should be a consideration to the north and east of Kingston-Upon-Hull given the limited space between the YYW 275kV OHL and the outskirts of the urban area. There is also an option to consider replacement of the existing YYW 275kV OHL with the new OHL route.

1.9.30 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the OHL and substation sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the substation infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.9.31 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West and Weston Marsh.

Tourism and Recreation Appraisal

1.9.32 There are a number of National Cycle Networks (NCN) routes which extend across the study area including the Trans Pennine Trail north of the Humber, the NCN110 south of Grimsby, the Water Way Trail to Boston and the NCN1 running south from Boston.

1.9.33 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.9.34 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes or trails be closed during construction.

1.9.35 There are five Country Parks within the study area. These include Burton Constable Country Park east of Kingston-Upon-Hull and Cleethorpes and Weelsby Woods Country

Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.9.36 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.9.37 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.9.38 The road network within the study area includes a number of A roads including the A165 to Kingston-Upon-Hull, the A180 to Grimsby, the A158 and A52 to Skegness, the A52 and A1121 to Boston, and the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.9.39 There are several railway lines running within the study area particularly in and around the Port of Hull, Port of Immingham and Port of Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford. A number of these would be unavoidable and would need to be crossed.

1.9.40 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

1.9.41 The Port of Hull, the Port of Immingham and the Port of Grimsby are located in the northern portion section of the study area and would present a constraint to routeing.

1.9.42 Humberside Airport and Aerodrome is located within the study area. RAF Wainfleet and RAF Holbeach are located on the very eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The Airport, Aerodrome, RAF bases and airfields would be considered to be avoidable.

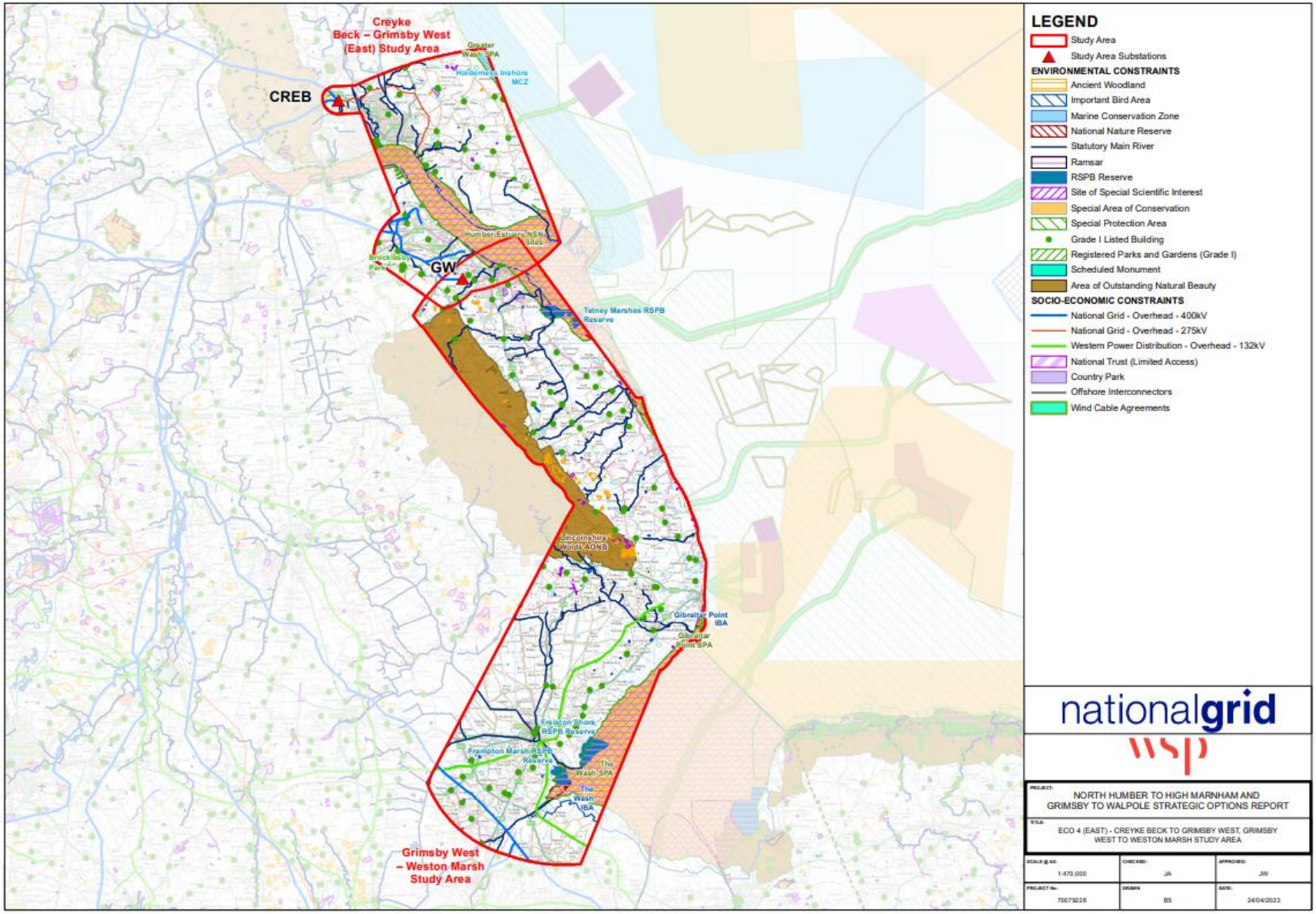
1.9.43 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority but also including an area of high priority at the northern end.

1.9.44 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons. Mitigation may be necessary for the Met Radar Zone.

ECO-4 (Eastward Direction) Summary

1.9.45 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. Tunnelling beneath the Humber, whilst removing the impact of bird strike, could still have adverse effects upon the Humber Estuary through disturbance and potential hydrogeological impacts. Whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential

for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). The OHL would cross the Yorkshire Wolds Important Landscape Area, and although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB. There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure at Weston Marsh in a landscape which currently has little major development. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


Creyke Beck – Grimsby West (East) Study Area
CREB
GW
Grimsby West – Weston Marsh Study Area
Greater Wash SPA
Holderness Inshore MCZ
Humber Estuary NSN Sites
Tetney Marshes RSPB Reserve
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
Freiston Shore RSPB Reserve
Frampton Marsh RSPB Reserve
The Wash SPA
The Wash IBA
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Marine Conservation Zone
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 4 (EAST) - CREYKE BECK TO GRIMSBY WEST, GRIMSBY WEST TO WESTON MARSH STUDY AREA
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1.10 ECSS 1 Creyke Beck to Walpole Subsea (Norfolk Coast)

1.10.1 In order to undertake the environmental and socio-economic appraisal of the ECSS 1 (Norfolk Coast) option, a study area was established in which the project could reasonably be expected to be developed. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck to the coast, then routeing southwards in the marine environment to avoid routeing for long extents within ecologically designated sites (including the Greater Wash SPA, Inner Dowsing, Race Bank and North Ridge SAC, The Wash SPA, and The Wash and North Norfolk Coast SAC) as far as possible, to facilitate landfall on the Norfolk coast then routeing to Walpole. The appraisal assumes an underground and subsea cable and new converter station equipment at both Creyke Beck and Walpole. Sites and features that might constrain the development of this option are detailed below. The description of sites and features is presented separately for i) the northern portion of the study area between Creyke Beck and the Lincolnshire coast, ii) the southern onshore portion of the study area between the Norfolk coast and Walpole, and iii) the marine portion of the study area. Note, an option to landfall via The Wash was considered to have a high likelihood of causing significant effects on The Wash SPA/SAC sites which form part of the UK's National Site Network, and hence a subsea option via The Wash was discounted.

ECSS 1 (Norfolk Coast) Environmental Appraisal

Northern onshore portion of the study area between Creyke Beck and the Lincolnshire coast

Landscape and Visual Appraisal

1.10.2 The nature of the landscape in the northern onshore portion of the study area between Creyke Beck and the Lincolnshire coast outside the urban area of Kingston-Upon-Hull is predominantly open expansive landscapes under intensive agriculture, with simple landscape patterns. Generally, the open intensive agricultural landscape and low-lying topography would likely be able to accommodate an underground cable with limited disturbance to landscape character.

1.10.3 It is likely some adverse residual permanent effects may occur during the operational phase of the converter stations at Creyke Beck.

Historic Environment Appraisal

1.10.4 There are a number of scheduled monuments scattered throughout the study area including a scheduled monument located within 1km of the existing Creyke Beck substation. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing and siting due to their scattered nature.

1.10.5 A number of listed buildings and four registered parks and gardens including Burton Constable are located within the study area. It is expected that listed buildings and registered parks and gardens could be avoided by selecting an appropriate cable route corridor.

1.10.6 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the converter station infrastructure at Creyke Beck.

1.10.7 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.10.8 Mitigation onshore is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.10.9 There are a number of scattered ecological designations within the study area including SSSIs including Hornsea Mere and areas of ancient woodland. It is anticipated that direct impacts on these designations can be avoided through careful routeing due to their scattered nature.

1.10.10 The Greater Wash SPA would need to be crossed via the subsea cable (see marine appraisal below). There is potential for adverse temporary effects on important habitats associated with this designated site.

Physical Environment Appraisal

1.10.11 The onshore cable would have to cross over several unavoidable watercourses and associated floodplains associated with the rivers around Creyke Beck. Areas of GSPZ are present and are largely concentrated within and around Creyke Beck.

1.10.12 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of GSPZ and potentially areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new converter station infrastructure at Creyke Beck. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area.

ECSS 1 Southern onshore portion of the study area between the Norfolk coast and Walpole

Landscape and Visual Appraisal

1.10.13 The Norfolk Coast AONB is located within the southern onshore portion of the study area between the Norfolk coast and Walpole. Crossing of the AONB at the coast would be unavoidable for this option. A section of the AONB to the northeast of Kings Lynn would also need to be considered as part of routeing studies. The North Norfolk Heritage Coast is also partially located within the study area.

1.10.14 Key sensitive visual receptors within the study area include users of the Norfolk Coast AONB, North Norfolk Heritage Coast and coastal tourist resorts along the coastline of the study area.

1.10.15 Views within and from both the AONB and Heritage Coast are likely to be affected albeit for a temporary period during the construction phase.

1.10.16 Peddar's Way and Norfolk Coast Path National Trail crosses the extent of the study area in two locations; along the coast and to the east of Kings Lynn. There is potential for adverse temporary visual effects on users of the National Trails.

1.10.17 It is likely some adverse residual permanent effects may occur during the operational phase of the converter stations at Walpole.

Historic Environment Appraisal

1.10.18 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing and siting due to their scattered nature.

1.10.19 A number of listed buildings and registered parks and gardens including are located within the study area including registered parks and gardens at Holkham Hall, Hougton Hall and Sandringham House, and listed buildings within 1km of the existing Walpole substation. It is expected that listed buildings and registered parks and gardens could be avoided by selecting an appropriate cable route corridor.

1.10.20 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the converter station infrastructure at Walpole.

1.10.21 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.10.22 Mitigation onshore is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.10.23 There are numerous ecological designations within the study area, particularly along the north Norfolk coastline where the cable would landfall. Designations include The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast SAC, the North Norfolk Coast Ramsar Site, IBA and SSSI, Blakeney National Nature Reserve, and Holkham National Nature Reserve. Crossing of a number of these designations would be unavoidable.

1.10.24 The Greater Wash SPA would need to be crossed via the subsea cable (see marine appraisal below).

1.10.25 There are a number of additional SAC, Ramsar, National Nature Reserves and SSSI sites within the study area including Roydon Common and Dersingham Bog SAC, Ramsar, National Nature Reserve and SSSI sites, River Wensum SSSI, River Nar SSSI and Norfolk Valley Fens SAC. It is anticipated that the majority of these designated sites could be avoided through careful routeing.

1.10.26 There is one RSPB Reserve (Snettisham) and a number of areas of ancient woodland within the study area. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature. There is the potential for adverse effects on the interest features (habitats and species) for which the ecological sites within the study area are designated during construction. The potential for a likely significant effect would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

Physical Environment Appraisal

1.10.27 The onshore cable would have to cross over several unavoidable watercourses and associated floodplains within the study area including the River Hull as well as a large number of drainage ditches.

1.10.28 Areas of GSPZ are present within the study area. Areas of Flood Zones 2 and 3 are mainly located along the coast and to the west of Kings Lynn.

1.10.29 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for converter station siting at Walpole. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area.

ECSS 1 (Norfolk Coast) Socio-economic Appraisal

Northern onshore portion of the study area between Creyke Beck and the Lincolnshire coast

Settlements and Populations Appraisal

1.10.30 The large urban area of Kingston-Upon-Hull present a constraint for cable routeing. There are also numerous smaller settlements scattered throughout the study area which limit routeing opportunities at several points.

1.10.31 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the cable route and converter station sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the converter station infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.10.32 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land south of the Humber. Grade 2 and 3 BMV agricultural land is the most prominent land type classification within the study area. Temporary effects on agricultural land would occur during the cable construction phase. Standard best practice guidelines should be followed to reinstate agricultural land following construction. Agricultural land would be permanently lost due to the footprint of the converter stations at Creyke Beck.

Tourism and Recreation Appraisal

1.10.33 There are a number of NCN routes within the study area including the Trans Pennine Trail which extends across the study area. There is the potential for temporary adverse effects associated with severance should this NCN route need to be temporarily closed during construction, however effects would be temporary.

1.10.34 There is one Country Park within the study area: Burton Constable Country Park. This site is considered to be avoidable.

Infrastructure Appraisal

1.10.35 The road network within the study area includes a number of A roads including the A165 which runs north-south through the study area and the A1079. Both of these A roads would need to be crossed. A crossing of a railway line would be required to the east of Creyke Beck.

1.10.36 Beverley Aerodrome is located in the north western portion of the study area and RAF Cowden is located on the eastern boundary of the study area. Both would be considered to be avoidable.

1.10.37 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Beverley Aerodrome. All of the study area is located within a MoD low flying zone, the majority of which is low priority but also including an area of high priority around RAF Cowden. The low flying zone is not considered to be a constraint to routeing due to the underground nature of the cable. Aircraft flightpaths should be considered when siting the converter stations.

Southern onshore portion of the study area between the Norfolk coast and Walpole

Settlements and Populations Appraisal

1.10.38 The urban area of Kings Lynn as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.

1.10.39 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the cable route and converter station sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the converter station infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.10.40 Grade 2 and 3 BMV agricultural land is the most prominent land type classification within the study area. West of King's Lynn Grade 1 and Grade 2 BMV agricultural land is most prominent. Temporary effects on agricultural land would occur during the cable construction phase. Standard best practice guidelines should be followed to reinstate agricultural land following construction. Agricultural land would be permanently lost due to the footprint of the converter stations at Walpole.

Tourism and Recreation Appraisal

1.10.41 There are a number of NCN routes located within the study area including in the vicinity of Kings Lynn.

1.10.42 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.10.43 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes be closed during construction.

1.10.44 There is one Country Park within the study area: Sandringham. This site is considered to be avoidable.

1.10.45 There is a National Trust holding present within the study area located at Blakeney which is potentially avoidable.

1.10.46 The north Norfolk coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.10.47 There are also a number of A roads within the study area including the A149, A10 and A17, some of which may need to be crossed.

1.10.48 There are railway lines in the vicinity of Kings Lynn and Wells-next-the-Sea which may need to be crossed.

1.10.49 All of the study area is located within a MoD low flying zone, the majority of which is low priority. The low flying zone is not considered to be a constraint to routeing due to the underground nature of the cable. Aircraft flightpaths should be considered when siting the converter stations.

ECSS 1 (Norfolk Coast) Marine Appraisal

1.10.50 Offshore there are a number of marine designated sites within the study area. At the north of the study area this includes the Holderness Inshore Marine Conservation Zone (MCZ), Holderness Offshore MCZ, and the Southern North Sea Special SAC which are all located off the coast to the east of Holderness. Although the Southern North Sea SAC and Holderness Offshore MCZ could potentially be avoided, the Holderness Inshore MCZ which extends along the coastline north of Spurn Head north of the Humber and is designated for subtidal habitats and ocean quahog, is within the study area and would require a cable crossing. It is acknowledged that the study area could be extended further north to avoid a crossing of the Holderness MCZ however this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC.

1.10.51 The Greater Wash SPA, which is designated for both breeding and non-breeding bird interests, falls with the study area at the coastal locations at both the north and south of the study area and would be unavoidable.

1.10.52 Appropriate routeing and mitigation would need to be considered at both these locations to avoid likely significant effects. The potential for a likely significant effect on these designated sites would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

1.10.53 In the southern section of the study area along and off the north Norfolk coast are further marine designated sites including Cromer Shoal Chalk Beds MCZ, Holkham National Nature Reserve, Blakeney National Nature Reserve, North Norfolk Coast Ramsar site, North Norfolk Coast SSSI, North Norfolk Coast IBA, and The Wash and North Norfolk Coast SAC.

1.10.54 The majority of the remainder of these designated areas are likely to be avoidable when considered in isolation; however, due to the number and proximity of the designated

sites along the north Norfolk coast – including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast Ramsar, SSSI and IBA - it would not be possible to avoid all of these designated areas, therefore careful routeing would need to be considered. The North Norfolk Coast SSSI, which supports nationally and internationally important numbers of various species of breeding or wintering waterbirds, covers the majority of the study area along the north Norfolk coast, therefore whilst avoiding it would be possible, to do so would limit options of subsea cable routes and landfall locations.

1.10.55 Within the study area other marine infrastructure is present including Westermost Rough offshore wind farm, Triton Knoll offshore wind farm, Sheringham Shoal offshore wind farm (and the proposed Sheringham Shoal Extension to the north and the east of the existing wind farm), Dudgeon Extension offshore wind farm (and the proposed Dudgeon Extension to the north of the existing wind farm), cable routes associated with Westermost Rough, Triton Knoll, Sheringham Shoal, Dudgeon and Hornsea One, Two and Three offshore wind farms, Viking Link marine cable route and various pipelines and oil and gas infrastructure. Whilst the offshore wind farms are avoidable, it is unlikely that crossings of cables and pipelines could be avoided entirely, including the Hornsea One and Two offshore wind farm cable routes and the Viking Link marine cable route.

1.10.56 There are a number of marine aggregate dredging areas within the study area; these are mainly concentrated to the east of the Humber Gateway offshore wind farm and would influence cable routeing within the study area.

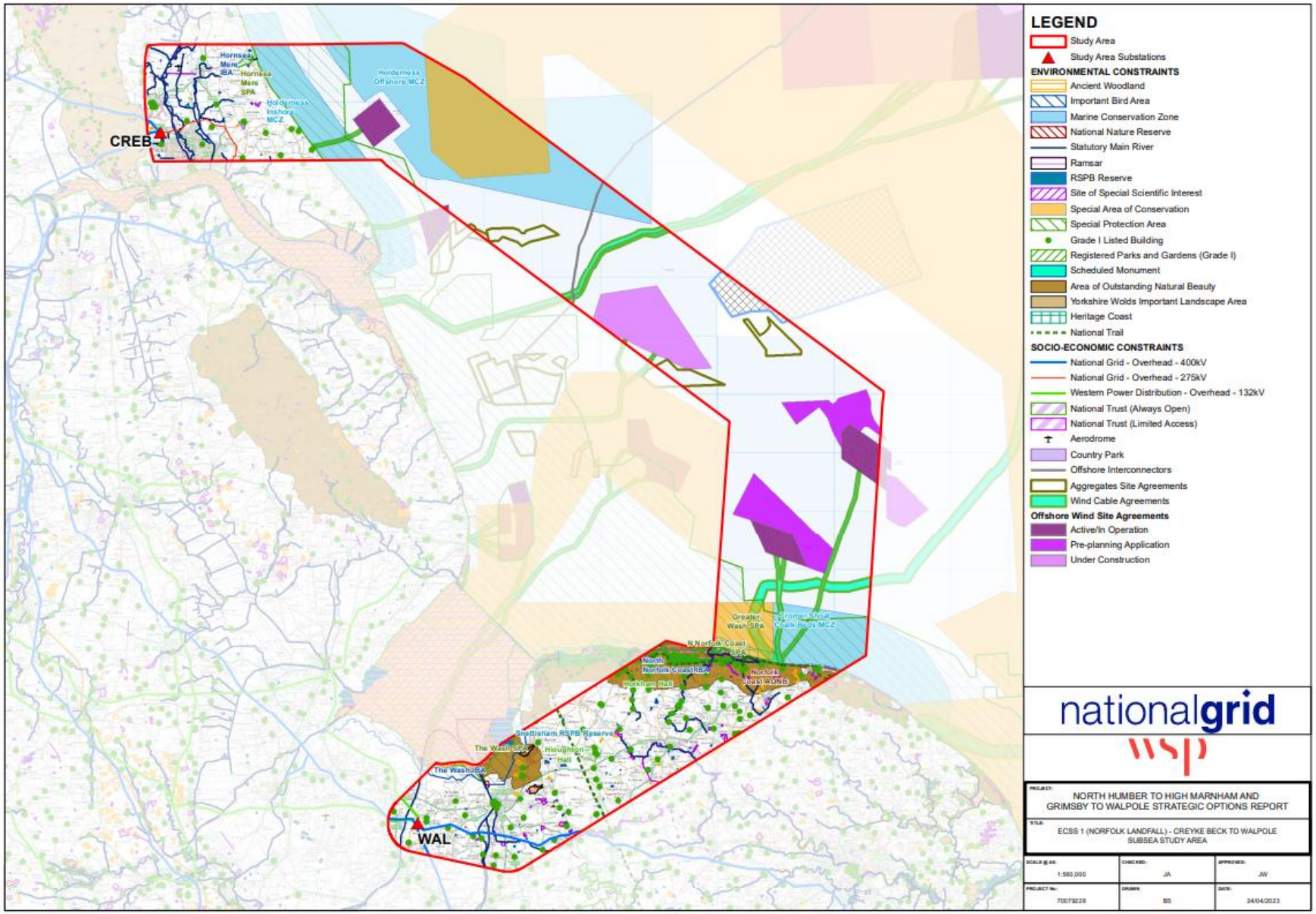
1.10.57 Shipping and navigation constraints may influence subsea cable routeing within the study area. The study area carries a moderate amount of traffic with several important commercial shipping routes to/from UK ports, particularly passenger vessels, oil and gas support vessels and cargo ships. In particular there are anchorages and traffic separation zones around the mouth of the Humber which coincide with vessel movements to/out of the Humber associated with access to various ports and harbours. Commercial shipping routes also exist to ports within The Wash including the Port of Boston.

1.10.58 There are a number of sandbanks, sandbank systems and other notable seabed features within the study area which may pose engineering challenges.

ECSS 1 (Norfolk Coast) Summary

1.10.59 Overall, this option is constrained in relation to ecological considerations. The Holderness Inshore MCZ and The Greater Wash SPA are within the study area and would require cable crossings. Although the study area could be extended further north to avoid a crossing of the Holderness MCZ, this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC. Also, due to the number and proximity of designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast Ramsar, SSSI and IBA it would not be possible to avoid all of these designated areas. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are also potential heritage constraints which may result in potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Other key environmental and socio-economic constraints are

considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
WAL
Hornsea Mere IBA
Hornsea Mere SPA
Holderness Offshore MCZ
Holderness Inshore MCZ
Greater Wash SPA
Cromer Shoal Chalk Beds MCZ
N Norfolk Coast SPA
North Norfolk Coast IBA
Norfolk Coast AONB
Holkham Hall
Snettisham RSPB Reserve
The Wash SPA
The Wash IBA
Houghton Hall
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Marine Conservation Zone
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
Yorkshire Wolds Important Landscape Area
Heritage Coast
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Always Open)
National Trust (Limited Access)
Aerodrome
Country Park
Offshore Interconnectors
Aggregates Site Agreements
Wind Cable Agreements
Offshore Wind Site Agreements
Active/In Operation
Pre-planning Application
Under Construction
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECSS 1 (NORFOLK LANDFALL) - CREYKE BECK TO WALPOLE SUBSEA STUDY AREA
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1.11 ECSS 1 Creyke Beck to Walpole Subsea (Lincolnshire Coast)

1.11.1 In order to undertake the environmental and socio-economic appraisal of the ECSS 1 (Lincolnshire Coast) option, a study area was established in which the project could reasonably be expected to be developed. The study area encompasses an area approximately 20km wide based on a broad route east from Creyke Beck to the coast, then routeing southwards in the marine environment to facilitate landfall on the Lincolnshire coast avoiding landfall within ecologically designated sites associated with the Humber Estuary and The Wash as far as possible, then routeing to Walpole. The appraisal assumes an underground and subsea cable and new converter station equipment at both Creyke Beck and Walpole. Sites and features that might constrain the development of this option are detailed below. The description of sites and features is presented separately for i) the northern portion of the study area between Creyke Beck and the Lincolnshire coast, ii) the southern onshore portion of the study area between the Norfolk coast and Walpole, and iii) the marine portion of the study area.

ECSS 1 (Lincolnshire Coast) Environmental Appraisal

Northern onshore portion of the study area between Creyke Beck and the Lincolnshire coast

1.11.2 The environmental appraisal for the northern portion of the onshore study area for ECSS 1 (Lincs) between Creyke Beck and the Lincolnshire coast would be as for the northern portion of the onshore study area for ECSS 1 (Norfolk).

Southern onshore portion of the study area between the Lincolnshire coast and Walpole

Landscape and Visual Appraisal

1.11.3 The nature of the landscape of the study area, with the exception of the Lincolnshire Wolds AONB located west of Burgh le Marsh, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief.

1.11.4 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts along the coastline of the study area.

1.11.5 The Lincolnshire Wolds AONB itself would be expected to be avoided. It is likely some adverse residual permanent effects may occur during the operational phase of the converter stations at Walpole.

Historic Environment Appraisal

1.11.6 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.11.7 There are a number of registered parks and gardens within the study area including Well Hall and Gunby Park which would be considered to be avoidable.

1.11.8 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the converter station infrastructure at Walpole.

1.11.9 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.11.10 Mitigation onshore is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.11.11 There are numerous ecological designations within the study area, particularly along the Lincolnshire coastline where the cable would landfall. Designations include the Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI. Subject to landfall selection there is the potential to impact statutory ecological designations.

1.11.12 The Greater Wash SPA would need to be crossed via the subsea cable (see marine appraisal below).

1.11.13 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, and The Wash and North Norfolk Coast IBA and SAC are located along the eastern boundary in the southern portion of the study area. There are two RSPB Reserves within the study area: Freiston Shore and Frampton Marsh to the southeast of Boston. Whilst these sites are avoidable there is the potential for adverse effects on the interest features, both habitats and species, for which a number of these sites are designated during construction.

1.11.14 The potential for a likely significant effect would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

1.11.15 There are a number of additional SSSIs including Chapel Point to Wolla Bank SSSI and areas of ancient woodland within the study area although these are smaller scattered sites which could be avoided by through careful routeing.

Physical Environment Appraisal

1.11.16 The onshore cable would have to cross over several unavoidable watercourses and associated floodplains including the Steeping River, the River Witham, the River Welland and the River Nene, as well as a large number of drainage ditches.

1.11.17 Areas of GSPZ are present throughout the study area.

1.11.18 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area.

1.11.19 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of converter station infrastructure at Walpole. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECSS 1 (Lincolnshire Coast) Socio-economic Appraisal

Northern onshore portion of the study area between Creyke Beck and the Lincolnshire coast

1.11.20 The socio-economics appraisal for the northern portion of the onshore study area for ECSS 1 (Lincs) between Creyke Beck and the Lincolnshire coast would be as for the northern portion of the onshore study area for ECSS 1 (Norfolk).

Southern onshore portion of the study area between the Lincolnshire coast and Walpole

Settlements and Populations Appraisal

1.11.21 The urban area of Boston as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable. A key characteristic of a number of the coastal settlements is that they tend to have a linear pattern and extend along the coast as opposed to extending inland. This increases the built development fronting onto the coastline and in a number of areas would limit opportunities for cable landfall.

1.11.22 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the cable route and converter station sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the converter station infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal. Grade 1 and 2 BMV agricultural land is the most prominent land type classification within the study area. Temporary effects on agricultural land would occur during the cable construction phase. Standard best practice guidelines should be followed to reinstate agricultural land following construction. Agricultural land would be permanently lost due to the footprint of the converter stations at Walpole.

Tourism and Recreation Appraisal

1.11.23 There are a number of National Cycle Networks (NCN) routes which extend across the study area including the Water Way Trail to Boston, the NCN1 running south from Boston and NCN1 from Boston towards Wisbech.

1.11.24 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.11.25 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes be closed during construction.

1.11.26 There are two Country Parks within the study area: Witham Way and Havenside Country Parks located to the west and east of Boston respectively. These sites are linear in nature and would need to be considered during routeing.

1.11.27 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.11.28 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.11.29 The road network within the study area includes a number of A roads including the A158 and A52 to Skegness, the A52 and A1121 to Boston, and the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.11.30 There is a railway line running south from Skegness to Boston onwards to Sleaford. This railway line would be unavoidable and would need to be crossed.

1.11.31 Fenland Aerodrome is located to the southwest of Spalding. RAF Wainfleet and RAF Holbeach are located on the eastern boundary of the study area. The Aerodrome and RAF bases and would be considered to be avoidable.

1.11.32 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Fenland Aerodrome. All of the study area is located within a MoD low flying zone, the majority of which is low priority. The low flying zone is not considered to be a constraint to routeing due to the underground nature of the cable. Aircraft flightpaths should be considered when siting the converter stations.

ECSS 1 (Lincolnshire Coast) Marine Appraisal

1.11.33 Offshore there are a number of marine designated sites within this study area. These includes the Holderness Inshore Marine Conservation Zone (MCZ), Holderness Offshore MCZ, and the Southern North Sea Special SAC which are all located off the coast to the east of Holderness. Although the Southern North Sea SAC and Holderness Offshore MCZ could potentially be avoided, the Holderness Inshore MCZ which extends along the coastline north of Spurn Head north of the Humber and is designated for subtidal habitats and ocean quahog, is within the study area and would require a cable crossing. Although the study area could be extended further north to avoid a crossing of the Holderness MCZ, this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC.

1.11.34 The Greater Wash SPA, which is designated for both breeding and non-breeding bird interests, falls within the study area at the coastal locations at both the north and south of the study area and would be unavoidable.

1.11.35 Appropriate routeing and mitigation would need to be considered at both these locations to avoid likely significant effects. The potential for a likely significant effect on these designated sites would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

1.11.36 The Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI extend into the southern section of the study area along the Lincolnshire coastline;

however these designated sites are potentially avoidable subject to landfall selection and subsea cable installation methods.

1.11.37 Within the study area other marine infrastructure is present including Westermost Rough offshore wind farm and Humber Gateway offshore wind farm, cable routes associated with the aforementioned offshore wind farms, Triton Knoll and Hornsea One, Two and Three offshore wind farm cable routes, Viking Link marine cable route and various pipelines and oil and gas infrastructure. Whilst the offshore wind farms are avoidable, it is unlikely that crossings of cables and pipelines could be avoided entirely, including the Hornsea One and Two offshore wind farm cable routes and the Viking Link marine cable route.

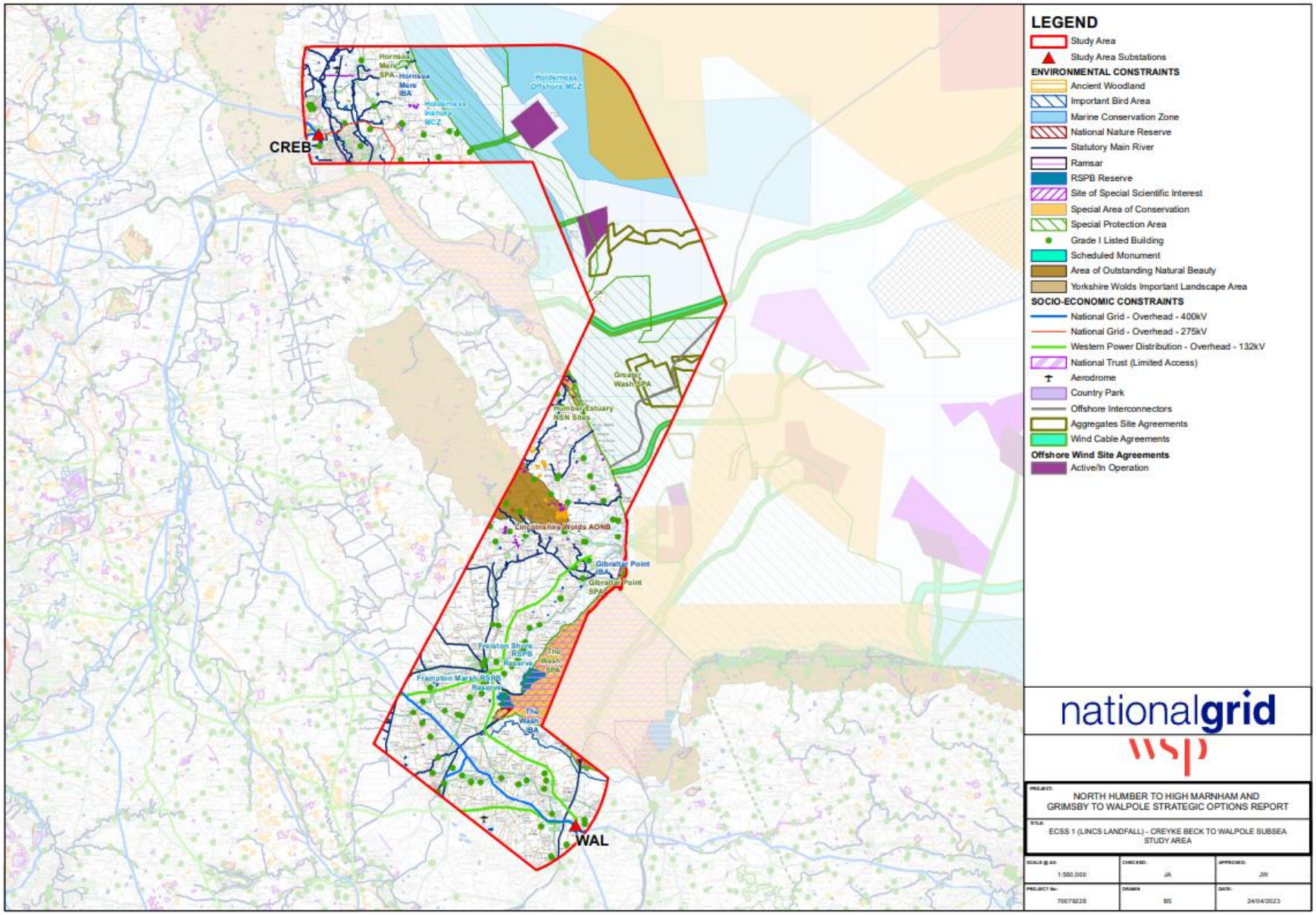
1.11.38 There are a number of marine aggregate dredging areas within the study area; these are mainly concentrated to the east of the Humber Gateway offshore wind farm and approximately 10km east of the coast at Mablethorpe, all of which would influence cable routeing within the study area.

1.11.39 Shipping and navigation constraints may influence subsea cable routeing within the study area. Shipping routes tend to be located further offshore and orientated north to south, however, there are anchorages and traffic separation zones around the mouth of the Humber within inshore waters which coincide with vessel movements to/out of the Humber associated with access to various ports and harbours.

1.11.40 The MoD Donna Nook Military Practice and Exercise Area (PEXA) which extends along the coast south of Northcotes Point to north of Theddlethorpe St Helens and out into inshore waters for approximately 15 km is partially within the study area.

ECSS 1 (Lincolnshire Coast) Summary

1.11.41 Overall, this option is relatively less constrained that ECSS 1 (Norfolk Coast) in relation to ecological considerations. The Holderness Inshore MCZ and The Greater Wash SPA are within the study area and would require cable crossings. Although the study area could be extended further north to avoid a crossing of the Holderness MCZ, this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ. Designated sites along the Lincolnshire coastline are potentially avoidable subject to landfall selection and subsea cable installation methods. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are also potential heritage constraints which may result in potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


CREB
WAL
Holderness Offshore MCZ
Holderness Inshore MCZ
Hornsea Mere SPA
Hornsea Mere IBA
Greater Wash SPA
Humber Estuary NSN Sites
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
Frampton Marsh RSPB Reserve
Freiston Shore RSPB Reserve
The Wash SPA
The Wash SPA
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Marine Conservation Zone
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Scheduled Monument
Area of Outstanding Natural Beauty
Yorkshire Wolds Important Landscape Area
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
National Grid - Overhead - 275kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Aerodrome
Country Park
Offshore Interconnectors
Aggregates Site Agreements
Wind Cable Agreements
Offshore Wind Site Agreements
Active/In Operation
nationalgrid
wsp
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECSS 1 (LINCS LANDFALL) - CREYKE BECK TO WALPOLE SUBSEA STUDY AREA
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1.12 ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole

1.12.1 In order to undertake the environmental and socio-economic appraisal of the ECO-5 option, a study area was established in which the project could reasonably be expected to be developed. The study area encompasses an area approximately 20km wide based on a broad route from Grimsby West southwards to two Lincolnshire Connection substation(s) (assumed to be located within a broad strategic zone between the Coast and the Lincolnshire Wolds AONB) and onwards to Walpole. The appraisal assumes new substation equipment would be required at Grimsby West, two Lincolnshire Connection Substations and Walpole. Sites and features that might constrain the development of this option are detailed below.

ECO-5 Environmental Appraisal

Landscape and Visual Appraisal

1.12.2 The nature of the landscape of the study area, with the exception of the Lincolnshire Wolds AONB located along the western extent of the northern portion of the study area, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief.

1.12.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts along the coastline of the study area.

1.12.4 Within the northern portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.12.5 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.12.6 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.12.7 In the northern portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to both avoid the AONB and avoid intruding on views from AONB.

1.12.8 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.12.9 New substation infrastructure at the Lincolnshire Connection Substation(s) would introduce transmission infrastructure in a landscape which currently has little major development. The coastal settlements and the coastal strip are likely to be particularly sensitive. Consideration would need to be given to avoid siting of each of the two Lincolnshire Connection Substation(s) in an open position or in close proximity to the coastline where substation infrastructure is likely to be considered intrusive. There may be potential for views of the new Lincolnshire Connection Substation(s) infrastructure from within the Lincolnshire Wolds AONB depending on site selection.

1.12.10 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole.

1.12.11 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.12.12 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.12.13 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings within 1km of the existing Grimsby West substation and Walpole substation. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing and siting.

1.12.14 There are a number of registered parks and gardens within the study area, the largest of which is the Grade I listed Registered Park and Garden of Brocklesby Park. Routeing to the west of Grimsby would need to avoid this registered park and garden.

1.12.15 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and new substation infrastructure.

1.12.16 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.12.17 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Assessment

1.12.18 The Humber Estuary SAC, SPA, Ramsar site and SSSI are located along the coast in the northern portion of the study area.

1.12.19 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area.

1.12.20 There are a number of RSPB Reserves within the study area including Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.12.21 Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated both during construction and operation. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.12.22 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.12.23 Any OHL route between Grimsby West and Walpole would have to cross over several unavoidable watercourses and associated floodplains including the River Witham, the River Welland and the River Nene.

1.12.24 Areas of GSPZ are present within the northern and central portions of the study.

1.12.25 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area. Given the extent of Flood Zones 2 and 3 across the study area, it is likely that a significant amount of development would be located within the floodplain.

1.12.26 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Walpole, and potentially at the Lincolnshire Connection Substation(s). Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 5 Socio-economic Appraisal

Settlements and Populations Appraisal

1.12.27 There are a number of large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.

1.12.28 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the OHL and substation sites are situated within proximity to settlements. The potential for permanent adverse impacts would be

dependent upon the proximity of the substation infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.12.29 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West, the Lincolnshire Connection Substation(s) and Walpole.

Tourism and Recreation Appraisal

1.12.30 There are a number of National Cycle Networks (NCN) routes which extend across the study area including the NCN110 south of Grimsby, the Water Way Trail to Boston and NCN1 from Boston to Wisbech.

1.12.31 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.12.32 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes or trails be closed during construction.

1.12.33 There are four Country Parks within the study area. These include Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.12.34 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.12.35 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.12.36 There are a number of trunk roads and A roads within the study area including the A16 and A17 which run north-south through the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.12.37 There are several railway lines running within the study area particularly in the area around Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford. A number of these railway lines would be unavoidable and would need to be crossed.

1.12.38 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

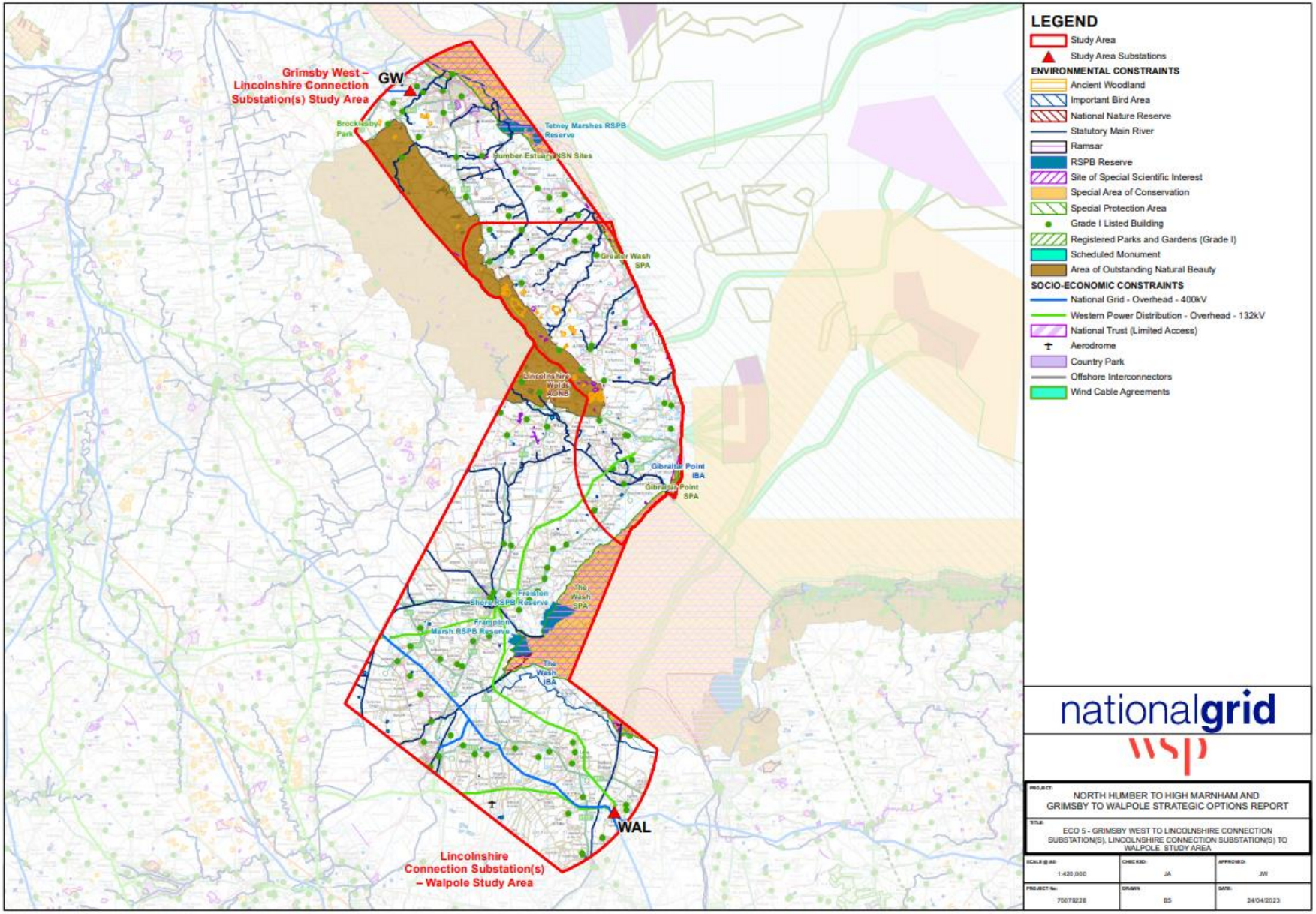
1.12.39 RAF Wainfleet and RAF Holbeach are located on the eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The RAF bases and airfields would be considered to be avoidable.

1.12.40 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area and partially within the safeguarding zone for Fenland Aerodrome in the south. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority.

1.12.41 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons.

ECO-5 Summary

1.12.42 Overall, this option is relatively constrained in relation to both ecological, landscape and visual considerations. Whilst Humber Estuary SAC, SPA, Ramsar site and SSSI, The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account). Although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB from both the OHL and substation infrastructure at the Lincolnshire Connection Substation(s). There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at the Lincolnshire Connection Substation(s) in a landscape which currently has little major development. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


Grimsby West – Lincolnshire Connection Substation(s) Study Area
GW
Brocklesby Park
Tetney Marshes RSPB Reserve
Humber Estuary SSSI Sites
Greater Wash SPA
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
Freiston Shore RSPB Reserve
The Wash SPA
Frampton Marsh RSPB Reserve
The Wash IBA
WAL
Lincolnshire Connection Substation(s) – Walpole Study Area
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Aerodrome
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
NORTH HUMBER TO HIGH MARNHAM AND GRIMSBY TO WALPOLE STRATEGIC OPTIONS REPORT
ECO 5 - GRIMSBY WEST TO LINCOLNSHIRE CONNECTION SUBSTATION(S), LINCOLNSHIRE CONNECTION SUBSTATION(S) TO WALPOLE STUDY AREA
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1.13 ECO-6 – Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole

1.13.1 In order to undertake the environmental and socio-economic appraisal of the ECO-6 option, a study area was established in which the project could reasonably be expected to be developed. The study area encompasses an area approximately 20km wide based on a broad route southwards from Grimsby West to two Lincolnshire Connection Substations (assumed to be located within a broad strategic zone between the Coast and the Lincolnshire Wolds AONB) and onwards to Weston Marsh and Walpole. The appraisal assumes new substation equipment would be required at Grimsby West, two Lincolnshire Connection Substations, Weston Marsh and Walpole. Sites and features that might constrain the development of this option are detailed below.

ECO-6 Environmental Appraisal

Landscape and Visual Appraisal

1.13.2 The nature of the landscape of the study area, with the exception of the Lincolnshire Wolds AONB located along the western extent of the northern portion of the study area, is predominantly low-lying flat lands, under intensive agriculture, with smaller areas of gentle relief.

1.13.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts along the coastline of the study area.

1.13.4 Within the northern portion of the study area the overall landform of the study area is flat and open, and generally rises towards the Lincolnshire Wolds. The predominant land use throughout the study area is arable farmland with little existing infrastructure outside of the road network, settlements, and a few onshore wind farms. The presence of wind farms off the Lincolnshire coast is recognised.

1.13.5 The Lincolnshire Wolds AONB itself would be avoided by the OHL and therefore direct impacts are unlikely, however views from the AONB are likely to be affected by the introduction of the new OHL infrastructure particularly given the low-lying open topography with views from the Wolds to the coast.

1.13.6 The OHL would need to be routed taking into account the pattern of the landscape to avoid settlements, visitor attractions and long-distance open views (particularly from the AONB and high ground) as far as possible.

1.13.7 In the northern portion of the study area there is a potential opportunity to use the landform of the Wolds as a backdrop to reduce visual impact of the OHL, however this would need to be balanced with the need to both avoid the AONB and avoid intruding on views from AONB.

1.13.8 Subject to site selection there may be views of new substation infrastructure at Grimsby West substation from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

1.13.9 New substation infrastructure at the Lincolnshire Connection Substation(s) would introduce transmission infrastructure in a landscape which currently has little major development. The coastal settlements and the coastal strip are likely to be particularly sensitive. Consideration would need to be given to avoid siting of each of the two Lincolnshire Connection Substations in an open position or in close proximity to the coastline where substation infrastructure is likely to be considered intrusive. There may be potential for views of new Lincolnshire Connection Substation(s) infrastructure from within the Lincolnshire Wolds AONB depending on site selection.

1.13.10 In the southern portion of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Weston Marsh into a landscape which currently has very little major infrastructure outside the larger settlements.

1.13.11 At the southern end of the study area there is potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole.

1.13.12 This option is constrained in relation to landscape and visual considerations, with a number of opportunities to avoid constraints and for mitigation through more detailed assessment and siting which would prevent and/or reduce potential for adverse landscape and visual effects.

Historic Environment Appraisal

1.13.13 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.13.14 A large number of listed buildings have been recorded throughout the study area, with the vast majority being Grade II listed, with fewer Grade I and II* listed buildings. The majority of these are associated with the settlements scattered throughout the study area. These include listed buildings within 1km of the existing Grimsby West substation and Walpole substation. It is likely that listed buildings could be avoided by selecting appropriate route corridors and sensitive routeing and siting.

1.13.15 There are a number of registered parks and gardens within the study area, the largest of which is the Grade I listed Registered Park and Garden of Brocklesby Park. Routeing to the west of Grimsby would need to avoid this registered park and garden.

1.13.16 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the OHL and new substation infrastructure.

1.13.17 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these were not assessed as part of this options appraisal.

1.13.18 Mitigation is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets. The design of any above ground infrastructure required, as well as screening/planting, could potentially mitigate impacts on the setting of designated assets where relevant.

Biological Environment Appraisal

1.13.19 The Humber Estuary SAC, SPA, Ramsar site and SSSI are located along the coast in the northern portion of the study area.

1.13.20 The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are located along the eastern boundary in the southern portion of the study area.

1.13.21 There are a number of RSPB Reserves within the study area including Tetney Marshes to the south of Cleethorpes and Frampton Marsh to the southeast of Boston.

1.13.22 Whilst these sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated both during construction and operation. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account).

1.13.23 There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient woodland within the study area are located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.13.24 Any OHL route between Grimsby West and Walpole would have to cross over several unavoidable watercourses and associated floodplains including the River Witham, the River Welland and the River Nene.

1.13.25 Areas of GSPZ are present within the northern and central portions of the study.

1.13.26 Flood Zones 2 and 3 cover large extents of the study area, in particular south of Skegness where Flood Zones 2 and 3 cover almost the entire extent of the study area. Given the extent of Flood Zones 2 and 3 across the study area, it is likely that a significant amount of development would be located within the floodplain.

1.13.27 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new substation infrastructure at Walpole, and potentially at the Lincolnshire Connection Substation(s). Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

ECO 6 Socio-economic Appraisal

Settlements and Populations Appraisal

1.13.28 There are a number of large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.

1.13.29 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the OHL and substation sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the substation infrastructure. There is the potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.13.30 The study area has a large amount of BMV agricultural land considered to be an economic resource. This includes areas of Grade 1 and Grade 2 BMV land particularly southeast of Grimsby and in the southern portion of the study area south of Skegness. Agricultural land would be permanently lost due to the footprint of the pylons and substations at Grimsby West, the Lincolnshire Connection Substation(s), Weston Marsh and Walpole.

Tourism and Recreation Appraisal

1.13.31 There are a number of National Cycle Networks (NCN) routes which extend across the study area including the NCN110 south of Grimsby, the Water Way Trail to Boston and NCN1 from Boston towards Wisbech.

1.13.32 There is the potential for temporary adverse effects associated with severance should the NCN routes need to be temporarily closed during construction, however effects would be temporary.

1.13.33 Standard best practice guidelines should be followed to provide appropriate signage, diversion routes and notice for the users of the NCN routes should part of these routes or trails be closed during construction.

1.13.34 There are four Country Parks within the study area. These include Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing.

1.13.35 There is one National Trust holding present within the study area located at Gunby Park, near Spilsby which is considered to be avoidable.

1.13.36 The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.13.37 There are a number of trunk roads and A roads within the study area including the A16 and A17 which run north-south through the study area. A number of these roads would need to be crossed particularly where they extend across the study area from east to west.

1.13.38 There are several railway lines running within the study area particularly in the area around Grimsby. Further south there is a railway line running south from Skegness to Boston onwards to Sleaford. A number of these railway lines would be unavoidable and would need to be crossed.

1.13.39 The crossing of roads and railways overhead is unlikely to be a major constraint given the required above ground clearance levels of the new 400kV OHL.

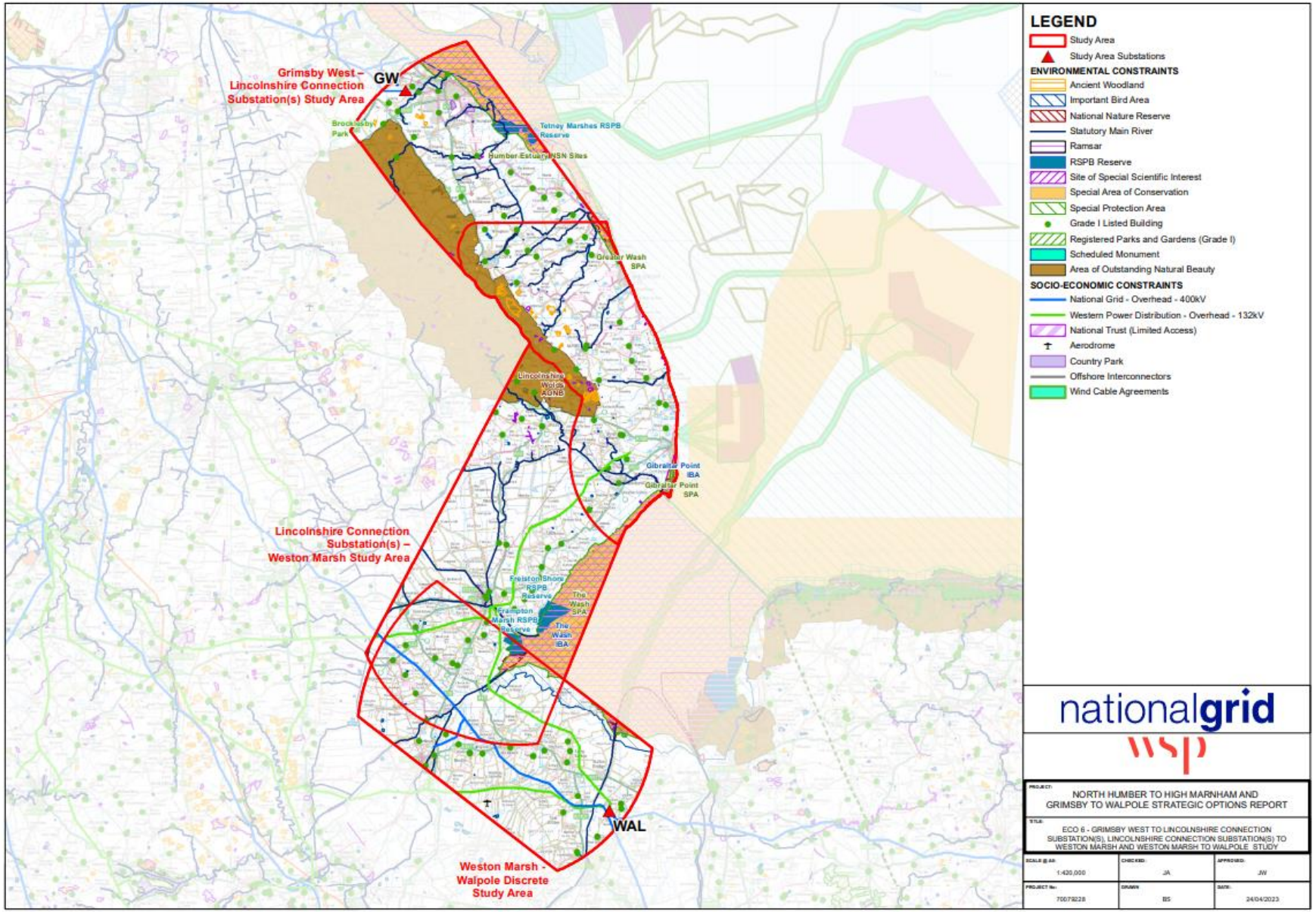
1.13.40 RAF Wainfleet and RAF Holbeach are located on the eastern boundary of the southern portion of the study area. There are also numerous additional airfields within the study area. The RAF bases and airfields would be considered to be avoidable.

1.13.41 There is potential for aircraft flightpaths to cross the study area. The study area is partially within the CAA suggested safeguarding zone for Humberside Airport in the northern portion of the study area and partially within the safeguarding zone for Fenland Aerodrome in the south. All of the study area is located within a Ministry of Defence (MoD) low flying zone, the majority of which is low priority.

1.13.42 Aircraft flightpaths would need to be considered when routeing and siting the pylons. Aviation warning lighting may be required on the pylons.

ECO-6 Summary

1.13.43 Overall, this option is relatively constrained in relation to both ecological, and landscape and visual considerations. Whilst Humber Estuary SAC, SPA, Ramsar site and SSSI, The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated. Any project would need to demonstrate that it would not affect the integrity of designated sites. Based on the information available at this stage of the project's development, it is considered that a route could be identified at the routing and siting stage that would not affect the integrity of designated sites (once appropriate mitigation was taken into account. Although the Lincolnshire Wolds AONB would be avoided by the OHL, there is potential for long-term effects on views from the AONB from both the OHL and substation infrastructure at the Lincolnshire Connection Substation(s). There is potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at the Lincolnshire Connection Substation(s) sites and at Weston Marsh in a landscape which currently has little major development. There would however be opportunities through more detailed assessment to prevent and/or reduce the potential for adverse effects. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


Grimsby West – Lincolnshire Connection Substation(s) Study Area
GW
Tetney Marshes RSPB Reserve
Humber Estuary MSN Sites
Greater Wash SPA
Lincolnshire Wolds AONB
Gibraltar Point IBA
Gibraltar Point SPA
Lincolnshire Connection Substation(s) – Weston Marsh Study Area
Freiston Shore RSPB Reserve
Frampton Marsh RSPB Reserve
The Wash SPA
The Wash IBA
WAL
Weston Marsh - Walpole Discrete Study Area
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
Western Power Distribution - Overhead - 132kV
National Trust (Limited Access)
Aerodrome
Country Park
Offshore Interconnectors
Wind Cable Agreements
nationalgrid
wsp
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ECO 6 - GRIMSBY WEST TO LINCOLNSHIRE CONNECTION SUBSTATION(S), LINCOLNSHIRE CONNECTION SUBSTATION(S) TO WESTON MARSH AND WESTON MARSH TO WALPOLE STUDY
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1.14 ECSS 2 Grimsby West to Walpole Subsea

1.14.1 In order to undertake the environmental and socio-economic appraisal of the ECSS 2 option, a study area was established in which the project could reasonably be expected to be developed. The study area encompasses an area based on a broad route east from Grimsby West to the Lincolnshire coast, then routeing southwards in the marine environment to facilitate landfall on the Norfolk coast, then routeing to Walpole. The appraisal assumes an underground and subsea cable, new converter station equipment at both Grimsby West and Walpole, and an offshore HVDC connection platform. Sites and features that might constrain the development of this option are detailed below. Note, an option to landfall via The Wash was considered to have a high likelihood of causing significant effects on The Wash SPA/SAC sites which form part of the UK's National Site Network, and hence a subsea option via The Wash was discounted.

ECSS 2 – Environmental Appraisal

Northern onshore portion of the study area between Grimsby and the Lincolnshire coast

Landscape and Visual Appraisal

1.14.2 The Lincolnshire Wolds AONB can be avoided as any underground cable routes would be located between the coastline and the Grimsby West area.

1.14.3 Key sensitive visual receptors within the study area include users of the Lincolnshire Wolds AONB and coastal tourist resorts along the coastline of the study area. Subject to site selection there may be views of the Grimsby West converter stations from within the Lincolnshire Wolds AONB, however, opportunities exist to develop mitigation. The proximity of the existing Grimsby West substation to the fringes of the existing settlement may increase the potential for visual impacts.

Historic Environment Appraisal

1.14.4 There are a number of scheduled monuments scattered throughout the study area. It is anticipated that direct impacts on these historic assets can be avoided through careful routeing due to their scattered nature.

1.14.5 A number of listed buildings and one registered parks and gardens are located within the study area. These include listed buildings within 1km of the existing Grimsby West substation. It is expected that listed buildings and the registered parks and garden could be avoided by selecting an appropriate cable route corridor.

1.14.6 Whilst designated heritage assets are likely to be avoidable there is the potential for adverse impacts on the setting of such assets depending on the proximity of the converter station infrastructure at Grimsby West.

1.14.7 Physical impacts are likely to be limited to non-designated assets and previously unrecorded assets, although these have not been assessed as part of this options appraisal.

1.14.8 Mitigation onshore is expected to be required and could include a phased programme of works including geophysical survey, archaeological evaluation trenching, and archaeological excavation to mitigate physical impacts to non-designated assets / previously unrecorded assets.

Biological Environment Appraisal

1.14.9 Ecological designations occur along the coastline extending to the north of Mablethorpe. These include the Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI. A number of these designations may be avoidable depending on landfall selection. The Greater Wash SPA would need to be crossed via the subsea cable.

1.14.10 There is potential for adverse temporary effects on important habitats associated with the designated sites located along the coast.

1.14.11 The potential for a likely significant effect would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

1.14.12 There are a number of additional scattered ecological designations within the study area including SSSIs and areas of ancient woodland. It is anticipated that direct impacts on these designations can be avoided through careful routeing due to their scattered nature.

Physical Environment Appraisal

1.14.13 The onshore cable would have to cross over several unavoidable watercourses and associated floodplains. Areas of GSPZ are present. Flood Zones 2 and 3 cover the coastal extents of the study area.

1.14.14 Crossings of main rivers, Flood Zone 2 or 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be a constraint for the siting of new converter station infrastructure at Walpole. Standard protection measures would need to be applied during the construction phase and consider the areas of GSPZ and flood risk zones within the study area. Foundations would need to be designed accordingly.

Southern onshore portion of the study area between the Norfolk coast and Walpole.

1.14.15 The environmental appraisal for the southern portion of the onshore study area for ECSS 2 between the Norfolk coast and Walpole would be as for the southern portion of the onshore study area for ECSS 1 (Norfolk).

ECSS 2 Socio-economic Appraisal

Northern onshore portion of the study area between Grimsby and the Lincolnshire coast

Settlements and Populations Appraisal

1.14.16 The large urban area of Grimsby would present a constraint for cable routeing. There are also numerous towns and smaller settlements scattered throughout the study area which limit routeing opportunities at several points. A key characteristic of a number of the coastal settlements is that they tend to have a linear pattern and extend along the coast as opposed to extending inland. This increases the built development fronting onto the coastline and in a number of areas would limit opportunities for cable landfall.

1.14.17 Temporary adverse impacts associated with noise, air quality and construction traffic during construction could arise if the cable route and converter station sites are situated within proximity to settlements. The potential for permanent adverse impacts would be dependent upon the proximity of the converter station infrastructure. There is the

potential for some adverse visual effects which are set out in the landscape and visual appraisal.

1.14.18 Grade 3 BMV agricultural land is the most prominent land type classification within the study area. Smaller areas of Grade 1 and 2 BMV occur including southeast of Grimsby Temporary effects on agricultural land would occur during the cable construction phase. Standard best practice guidelines should be followed to reinstate agricultural land following construction. Agricultural land would be permanently lost due to the footprint of the converter stations at Grimsby West.

Tourism and Recreation Appraisal

1.14.19 There are a number of NCN routes within the study area including the NCN110 south of Grimsby which extends across the study area. There is the potential for temporary adverse effects associated with severance should this NCN route need to be temporarily closed during construction, however effects would be temporary.

1.14.20 There are two Country Parks within the study area: Cleethorpes and Weelsby Woods Country Parks near Cleethorpes. These sites are considered to be avoidable.

1.14.21 The Lincolnshire coast is a popular tourist destination with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.

Infrastructure Appraisal

1.14.22 The road network within the study area includes a number of A roads including the A46, A16 and A18 which may need to be crossed.

1.14.23 RAF Donna Nook and Theddlethorpe Range MOD Establishment are located on the eastern boundary of the study area. The RAF and MOD bases and would need to be considered when routeing the cable.

1.14.24 There is potential for aircraft flightpaths to cross the study area. The northern portion of the study area is partially within the CAA suggested safeguarding zone for Humberside Airport. All of the study area is located within a MoD low flying zone, the majority of which is low priority, with an area of high priority in the vicinity of RAF Donna Nook. The low flying zone is not considered to be a constraint to routeing due to the underground nature of the cable. Aircraft flightpaths should be considered when siting the converter stations.

Southern onshore portion of the study area between the Norfolk coast and Walpole.

1.14.25 The socio-economic appraisal for the southern portion of the onshore study area for ECSS 2 between the Norfolk coast and Walpole would be as for the southern portion of the onshore study area for ECSS 1 (Norfolk).

ECSS 2 Summary of Marine Appraisal

1.14.26 The Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI extend into the northern section of the marine study area along the Lincolnshire coastline however these designated sites are potentially avoidable depending on landfall selection and subsea cable installation methods.

1.14.27 The Inner Dowsing, Race Bank and North Ridge SAC extends across the majority of the study area; this site could potentially be avoided depending on subsea cable routeing and offshore HVDC connection platform siting.

1.14.28 The Greater Wash SPA, which is designated for both breeding and non-breeding bird interests, falls with the study area at the coastal locations at both the north and south of the study area and would be unavoidable.

1.14.29 Appropriate routeing and siting and mitigation would need to be considered to avoid likely significant effects. The potential for a likely significant effect would need to be considered in relation to the Conservation of Habitats and Species Regulations 2017.

1.14.30 In the southern section of the study area along and off the north Norfolk coast are further marine designated sites including Cromer Shoal Chalk Beds MCZ, Holkham National Nature Reserve, Blakeney National Nature Reserve, North Norfolk Coast RAMSAR site, North Norfolk Coast SSSI, North Norfolk Coast IBA, and The Wash and North Norfolk Coast SAC.

1.14.31 The majority of the remainder of these designated areas are likely to be avoidable when considered in isolation; however due to the number and proximity of the designated sites along the north Norfolk coast – including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, Blakeney National Nature Reserve and North Norfolk Coast RAMSAR, SSSI and IBA - it would not be possible to avoid all of these designated areas, therefore careful routeing would need to be considered. The North Norfolk Coast SSSI, which supports nationally and internationally important numbers of various species of breeding or wintering waterbirds, covers the majority of the study area along the north Norfolk coast, therefore whilst avoiding it would be possible, to do so would limit options of cable routes and landfall locations.

1.14.32 Within the study area other marine infrastructure is present including, Triton Knoll offshore wind farm, Race Bank offshore wind farm, Inner Dowsing offshore wind farm, Lincs offshore wind farm, Sheringham Shoal offshore wind farm (and the proposed Sheringham Shoal Extension to the north and the east of the existing wind farm), the proposed Dudgeon Extension, cable routes associated with Race Bank and Triton Knoll, and Hornsea One, Two and Three offshore wind farms, the Viking Link marine cable route and various pipelines and oil and gas infrastructure. Whilst the offshore wind farms are avoidable, it is unlikely that crossings of cables and pipelines could be avoided entirely, including the Triton Knoll and Hornsea One and Two offshore wind farm cable routes and the Viking Link marine cable route.

1.14.33 There are a number of marine aggregate dredging areas within the study area; these are mainly concentrated off the coast at Mablethorpe and south of the Triton Knoll offshore wind farm, all of which would influence cable routeing within the study area.

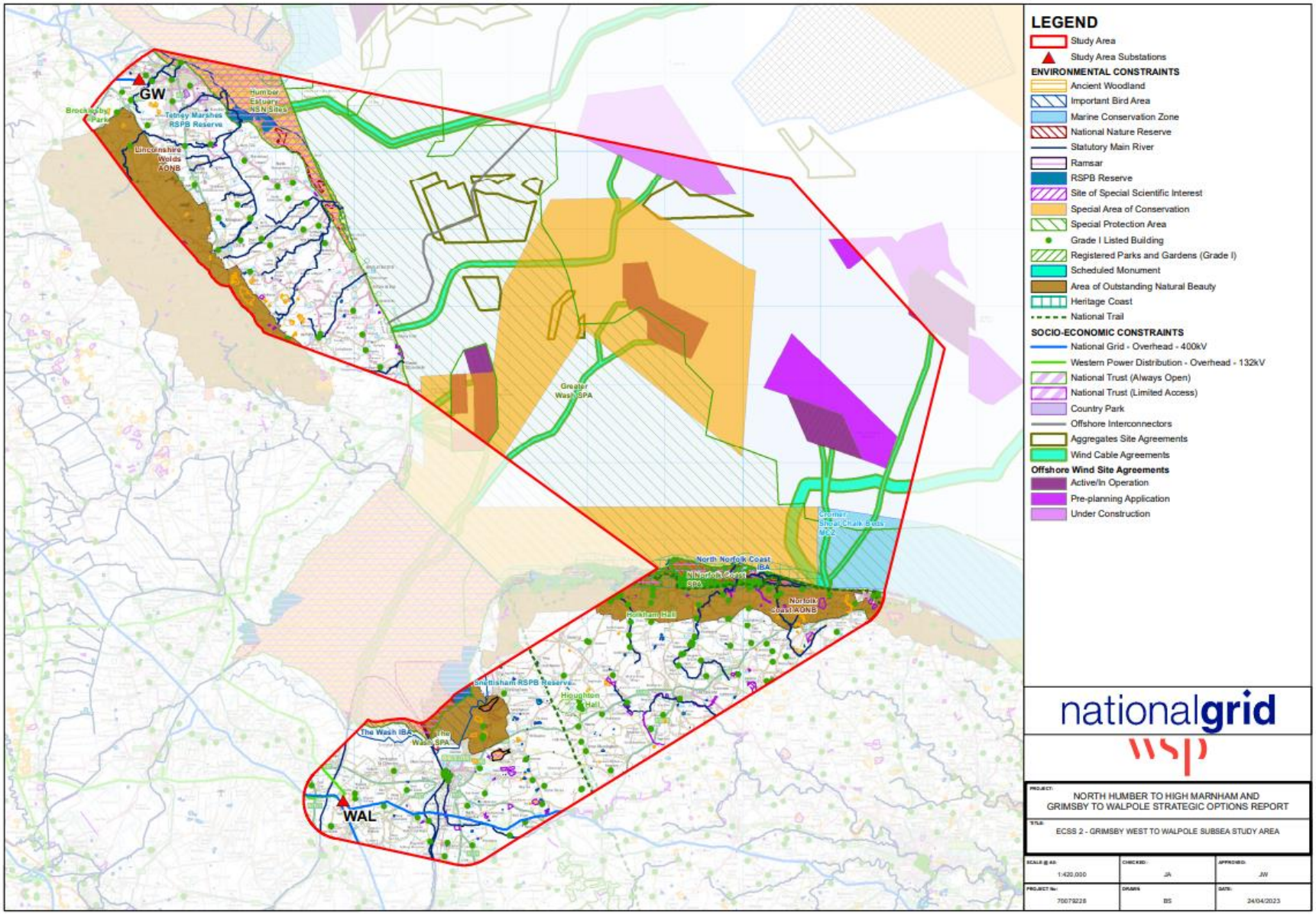
1.14.34 Shipping and navigation constraints may influence subsea cable routeing within the study area. The study area carries a moderate amount of traffic with several important commercial shipping routes to/from UK ports, particularly passenger vessels, oil and gas support vessels and cargo ships. In particular there are anchorages and traffic separation zones around the mouth of the Humber which coincide with vessel movements to/out of the Humber associated with access to various ports and harbours. Commercial shipping routes also exist to ports within The Wash including the Port of Boston.

1.14.35 The MoD Donna Nook Military Practice and Exercise Area (PEXA) which extends along the coast south of Northcotes Point to north of Theddlethorpe St Helens and out into inshore waters for approximately 15 km is within the study area.

1.14.36 There are a number of sandbanks, sandbank systems and other notable seabed features within the study area which may pose engineering challenges.

ECSS 2 Summary

1.14.37 Overall, this option is constrained in relation to ecological considerations. The Greater Wash SPA is unavoidable and would require cable crossings. Due to the number and proximity of designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast Ramsar, SSSI and IBA it would not be possible to avoid all of these designated areas. It may be possible to avoid ecologically designated sites associated with the Humber Estuary, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point along the Lincolnshire coast depending on landfall siting. The potential for likely significant effects on designated sites would need to be considered in relation to the Habitats Directive. There are potential heritage constraints which may result in potential effects on the setting of a number of Scheduled Monuments and listed buildings depending on converter station siting at Grimsby West. Other key environmental and socio-economic constraints are considered to be less influential with the potential to mitigate adverse impacts through careful consideration of routeing and siting and the use of appropriate technologies.


GW
WAL
Humber Estuary NSN Sites
Tetney Marshes RSPB Reserve
Lincolnshire Wolds AONB
Greater Wash SPA
North Norfolk Coast IBA
North Norfolk Coast SPA
Norfolk Coast AONB
Houghton Hall
The Wash IBA
The Wash SPA
LEGEND
Study Area
Study Area Substations
ENVIRONMENTAL CONSTRAINTS
Ancient Woodland
Important Bird Area
Marine Conservation Zone
National Nature Reserve
Statutory Main River
Ramsar
RSPB Reserve
Site of Special Scientific Interest
Special Area of Conservation
Special Protection Area
Grade I Listed Building
Registered Parks and Gardens (Grade I)
Scheduled Monument
Area of Outstanding Natural Beauty
Heritage Coast
National Trail
SOCIO-ECONOMIC CONSTRAINTS
National Grid - Overhead - 400kV
Western Power Distribution - Overhead - 132kV
National Trust (Always Open)
National Trust (Limited Access)
Country Park
Offshore Interconnectors
Aggregates Site Agreements
Wind Cable Agreements
Offshore Wind Site Agreements
Active/In Operation
Pre-planning Application
Under Construction
nationalgrid
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1.15 Environmental and Socio-economic Appraisal Summary Table

Table G.1 below presents a summary of the key differentiators across the strategic options. The table excludes the eastern sub-options for ECO-1, ECO-2, ECO-3 and ECO-4 all of which would involve a tunnel across the Humber, and which on balance when considered against environment, socio-economic, technology and cost, were not preferred over the western sub-options.

Table G.1: Options providing 6GW increase to B8 and Generation connections to Creyke Beck by 2031

	ECO-1 (West) Creyke Beck to High Marnham	**ECO-2 (West) Creyke Beck to Cottam**	**ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole**	**ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh**	**ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)**	**ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)**
Assumptions	Full OHL option. Creyke Beck and High Marnham substations delivered by others.	Full OHL option. Creyke Beck and Cottam substations delivered by others. Sealing End Compound at Cottam.	Full OHL option. Creyke Beck substation delivered by others. New Grimsby West substation. New Walpole substation.	Full OHL option. Creyke Beck substation delivered by others. New Grimsby West substation. Weston Marsh substation.	Underground/subsea cable. 3 converter stations at Creyke Beck. 3 converters stations at Walpole. Norfolk landfall.	Underground/subsea cable. 3 converter stations at Creyke Beck. 3 converter stations at Walpole. Lincs landfall.
Approx. corridor length	85km	75km	180km	160km	250km	190km
ENVIRONMENTAL						
Biological	OHL will cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species	The OHL will cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species	The OHL will cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk). Paralleling	The OHL will cross the Humber Estuary SPA, Ramsar and SSSI with potential for direct effects on breeding, over-wintering and passage bird species (collision risk). Paralleling the existing 4ZQ 400kV OHL route to the	Direct effects on the Greater Wash SPA and Holderness Inshore MCZ both of which are within the study area and would require a cable crossing. It is acknowledged that the study area could be extended further north to avoid a	Direct effects on the Greater Wash SPA and Holderness Inshore MCZ both of which are within the study area and would require a cable crossing. It is acknowledged that the study area could be extended further north to avoid a

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
	(collision risk). Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.	(collision risk). Paralleling the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.	the existing 4ZQ 400kV OHL route to the west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.	west of Kingston-Upon-Hull and south over the River Ouse would potentially reduce impacts on protected species, including potential bird strikes.	crossing of the Holderness MCZ however this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ or the Southern North Sea Special SAC.	crossing of the Holderness MCZ however this would extend the overall cable length and potentially require a crossing of the Holderness Offshore MCZ.
	Whilst Thorne and Hatfield Moors SPA and IBA, Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne,	Whilst Thorne and Hatfield Moors SPA and IBA, Thorne Moor SAC, Hatfield Moor SAC, Hatfield Moors SSSI, Thorne,	Whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point	Whilst The Wash Ramsar Site, SSSI, SPA, IBA and National Nature Reserve, The Wash and North Norfolk Coast IBA and SAC, and Gibraltar Point Ramsar Site and IBA are	Potential for direct effects on designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham	Potential for effects on designated sites along the Lincolnshire coast including Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
	Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are depending on routeing.	Crowle and Goole Moors SSSI, and Laughton Forest IBA are avoidable there is the potential for adverse effects on the interest features (habitats and species) for which a number of these sites are depending on routeing	Ramsar Site and IBA are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated.	avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated.	National Nature Reserve, and North Norfolk Coast RAMSAR, SSSI and IBA; it would not be possible to avoid all designated areas.	Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI at the landfall depending on routeing.
	There are a number of additional SSSIs within the study area including Scotton and Laughton Forest Ponds SSSI,	There are a number of additional SSSIs within the study area including Scotton and Laughton Forest Ponds SSSI,	There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful	There are a number of additional SSSIs within the study area although these are smaller scattered sites which could be avoided by through careful routeing. Areas of ancient	Potential for effects on additional designated ecological sites including River Nar SSSI depending on onshore cable routeing.	There are a number of additional SSSIs including Chapel Point to Wolla Bank SSSI and areas of ancient woodland within the study area although these are smaller scattered sites which could be

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
	Laughton SSSI, Risby Warren SSSI, as well as a number located along linear features such as ditches and canals. There are several areas of ancient woodland scattered throughout the study area. It is anticipated that direct impacts on these designated assets could be avoided through careful routeing due to their	Laughton SSSI, Risby Warren SSSI, as well as a number along linear features such as ditches and canals. There are several areas of ancient woodland scattered throughout the study area. It is anticipated that direct impacts on these designated assets could be avoided through careful routeing due to their scattered nature.	routeing. Areas of ancient woodland within the study area are mainly located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites could be avoided through careful routeing due to their scattered nature.	woodland within the study area are mainly located in the northern and central portions of the study area. It is anticipated that direct impacts on these designated sites could be avoided through careful routeing due to their scattered nature.		avoided by through careful routeing.

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
	scattered nature.					
Landscape & Visual	Potential long-term landscape and visual effects on the Yorkshire Wolds Important Landscape Area. Potential for adverse visual effects on users of the Yorkshire Wolds National Trail. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	Potential long-term landscape and visual effects on the Yorkshire Wolds Important Landscape Area. Potential for adverse visual effects on users of the Yorkshire Wolds National Trail. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	Potential long-term landscape and visual effects on the Yorkshire Wolds Important Landscape Area. Potential for adverse visual effects on users of the Yorkshire Wolds National Trail. The Lincolnshire Wolds AONB itself would be avoided by the OHL, however there is potential for long-term effects on views from the AONB particularly given the low-lying open topography with views from the Wolds to the coast.	Potential long-term landscape and visual effects on the Yorkshire Wolds Important Landscape Area. Potential for adverse visual effects on users of the Yorkshire Wolds National Trail. The Lincolnshire Wolds AONB itself would be avoided by the OHL, however there is potential for long-term effects on views from the AONB particularly given the low-lying open topography with views from the Wolds to the coast. Potential for long term landscape and visual effects due to	Temporary landscape and visual effects, including impacts on the landscape of the Norfolk Coast AONB which could not be avoided. Views within and from both the AONB and North Norfolk Heritage Coast may be temporary period during construction. Potential for temporary adverse visual effects on users of the Peddar's Way and Norfolk Coast Path National Trail. Potential for adverse residual permanent effects during the operational phase of the converter stations at Creyke Beck and Walpole.	The Lincolnshire Wolds AONB itself would be expected to be avoided. . Potential for adverse residual permanent effects during the operational phase of the converter stations at Creyke Beck and Walpole.

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
			Potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	the introduction of new substation infrastructure at Weston Marsh in a landscape which currently has little major development. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties		
Historic Environment	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on routeing.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on routeing. Potential effects on the setting of Scheduled	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on routeing and siting. Potential effects on the setting of Brocklesby Park Registered Park and Garden.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on routeing and siting. Potential effects on the setting of Brocklesby Park Registered Park and Garden.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on converter station siting especially in the Creyke Beck area.

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
		Monuments and listed buildings depending on the proximity of the new Sealing End Compound infrastructure required at Cottam.				
Physical	Crossings of main rivers (including the River Ouse), Flood Zone 2 and 3 and GSPZ are expected to be unavoidable.	Crossings of main rivers (including the River Ouse), Flood Zone 2 and 3 and GSPZ are expected to be unavoidable.	Crossings of main rivers (including the River Ancholme, the River Witham, the River Welland and the River Nene). Flood Zone 2 and 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation	Crossings of main rivers (including the River Ouse, the River Ancholme, the River Witham and the River Welland). Flood Zone 2 and 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Weston Marsh.	The onshore cable would have to cross over several unavoidable watercourses including main rivers and associated floodplains including the River Hull as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of converter station infrastructure at Walpole.	The onshore cable would have to cross over several unavoidable watercourses including main rivers and associated floodplains including the Steeping River, the River Witham, the River Welland and the River Nene, as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of converter

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
			infrastructure at Walpole.			station infrastructure at Walpole.
SOCIO-ECONOMIC						
Settlements and Population	Numerous large urban areas within the study area including Kingston-Upon-Hull, Scunthorpe and Gainsborough as well as numerous smaller settlements scattered throughout.	Numerous large urban areas within the study area including Kingston-Upon-Hull, Scunthorpe and Gainsborough together with numerous smaller settlements scattered throughout.	Numerous large urban areas within the study area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	Numerous large urban areas within the study area including Scunthorpe, Immingham, Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	The large urban areas of Kingston-Upon-Hull and Kings Lynn as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.	The large urban areas of Kingston-Upon-Hull and Boston as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
Tourism and Recreation	The Yorkshire Wolds National Trai and Trans Pennine Trail NCN cross the northern portion of the study area. A number of other NCNs cross the study area.	The Yorkshire Wolds National Trai land Trans Pennine Trail NCN cross the northern portion of the study area. A number of other NCNs cross the study area.	The Yorkshire Wolds National Trail and Trans Pennine Trail NCN cross the northern portion of the study area. A number of other NCNs cross the study area. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive	The Yorkshire Wolds National Trail and Trans Pennine Trail NCN cross the northern portion of the study area. A number of other NCNs cross the study area. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the	The Trans Pennine Trail NCN extends across the northern portion of the study area. A number of other NCNs cross the study area including routes to/from Kings Lynn. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.	The Trans Pennine Trail NCN extends across the northern portion of the study area. A number of other NCNs cross the study area. The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
			areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design.	local tourist economy could be minimised through careful routing and design.		careful routing and design.
Infrastructure	Both the M180 and M62/A63 would need to be crossed. A number of trunk roads would also need to be crossed where they extend across the study area from east to west. Several railway lines would need to be crossed.	Both the M180 and M62/A63 would need to be crossed. A number of trunk roads would also need to be crossed where they extend across the study area from east to west. Several railway lines would need to be crossed.	Both the M180/A180 and M62/A63 would need to be crossed. There are also a number of trunk roads and A roads within the study area including the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would	Both the M180/A180 and M62/A63 would need to be crossed. There are also a number of trunk roads and A roads within the study area including the A16 and A17 which run north-south through the central and southern portions of the study area. A number of these roads would need to be crossed particularly where they extend across	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of

	ECO-1 (West) Creyke Beck to High Marnham	ECO-2 (West) Creyke Beck to Cottam	ECO-3 (West) Creyke Beck to Grimsby West, Grimsby West to Walpole	ECO-4 (West) Creyke Beck to Grimsby West, Grimsby West to Weston Marsh	ECSS 1 (Norfolk) Creyke Beck to Walpole Subsea (Norfolk Coast)	ECSS 1 (Lincs) Creyke Beck to Walpole Subsea (Lincs Coast)
			need to be crossed particularly where they extend across the study area from east to west. Several railway lines would need to be crossed.	the study area from east to west. Several railway lines would need to be crossed.	subsea cable routeing. Onshore road and rail crossings required.	subsea cable routeing. Onshore road and rail crossings required.

Table G.2: Options providing additional 6GW increase to B8, 6GW capacity to B9 and Generation connections to Coastal Connection Substation by 2033

	ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole	ECO-6 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole	ECSS 2 Grimsby West to Walpole Subsea
Assumptions	Full OHL option. New substation at Grimsby West. New substation at Walpole. 2 Lincolnshire Connection substations.	Full OHL option. New substation at Grimsby West. Substation at Weston Marsh. New substation at Walpole 2 Lincolnshire Connection substations.	Underground/subsea cable. 3 converter stations at Grimsby West. 3 converter stations at Walpole. Norfolk coast landfall. Offshore AC/HVDC platform(s).

	ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole	ECO-6 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole	ECSS 2 Grimsby West to Walpole Subsea
Approx. corridor length	120km	120km	200km
ENVIRONMENTAL			
Biological	Whilst The Humber and The Wash designated sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated.	Whilst The Humber and The Wash designated sites are avoidable there is the potential for adverse effects on the interest features both habitats and species for which a number of these sites are designated.	Potential effects on Humber Estuary SAC, SPA, Ramsar site and SSSI, Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and Saltfleetby-Theddlethorpe Sand Dunes SSSI depending on landfall selection. Potential for direct effects on designated sites along the north Norfolk coast including Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC, Holkham National Nature Reserve, and North Norfolk Coast RAMSAR, SSSI and IBA; it would not be possible to avoid all designated areas. Direct effects on the Greater Wash SPA which would be unavoidable offshore and would require a cable crossing. Potential for effects on additional designated ecological sites including River Nar SSSI depending on onshore routeing.

	ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole	ECO-6 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole	ECSS 2 Grimsby West to Walpole Subsea
Landscape & Visual	The Lincolnshire Wolds AONB itself would be avoided by the OHL, however there is potential for long-term effects on views from the AONB particularly given the low-lying open topography with views from the Wolds to the coast. Potential for views of new Lincolnshire Connection Substation(s) infrastructure from within the Lincolnshire Wolds AONB depending on site selection. Potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at a Lincolnshire Connection Substation(s) in a landscape which currently has little major development. Potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	The Lincolnshire Wolds AONB itself would be avoided by the OHL, however there is potential for long-term effects on views from the AONB particularly given the low-lying open topography with views from the Wolds to the coast. Potential for views of new Lincolnshire Connection Substation(s) infrastructure from within the Lincolnshire Wolds AONB depending on site selection. Potential for long term landscape and visual effects due to the introduction of new substation infrastructure, particularly at Lincolnshire Connection Substation(s) and Weston Marsh in a landscape which currently has little major development. Potential for adverse landscape and visual impacts due to the introduction of a new substation at Walpole. Potential effects on visual amenity for residents along affected settlement edges and at scattered properties.	Temporary landscape and visual effects, including impacts on the landscape of the Norfolk Coast AONB which could not be avoided. Views within and from both the AONB and North Norfolk Heritage Coast may be temporary period during construction. The Lincolnshire Wolds AONB would be avoided. Potential for temporary adverse visual effects on users of the Peddar's Way and Norfolk Coast Path National Trail. Potential for adverse residual permanent effects during the operational phase of the converter stations at Grimsby West and Walpole.

	ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole	ECO-6 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole	ECSS 2 Grimsby West to Walpole Subsea
Historic Environment	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on OHL routeing.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on OHL routeing.	Potential effects on the setting of a number of Scheduled Monuments and listed buildings dependent on converter station siting at Grimsby West and Walpole.
Physical	Crossings of main rivers (including the River Witham, the River Welland and the River Nene.). Flood Zone 2 and 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Walpole.	Crossings of main rivers (including the River Witham, the River Welland and the River Nene.). Flood Zone 2 and 3 and GSPZ are expected to be unavoidable. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of new substation infrastructure at Weston Marsh, Walpole.	The onshore cable would have to cross several unavoidable watercourses including main rivers and associated floodplains including the Great Ouse, as well as a large number of drainage ditches. Areas of Flood Zone 2 or 3 are expected to be unavoidable for the siting of converter station infrastructure at Walpole.
SOCIO-ECONOMIC			
Settlements and Population	Numerous large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	Numerous large urban areas within the study area including Grimsby and Boston as well as numerous smaller towns and settlements scattered throughout. These areas would limit routeing opportunities at several points, particularly to the west and south of Grimsby where the Lincolnshire Wolds AONB is also a constraint.	The large urban areas of Grimsby and Kings Lynn as well as numerous smaller towns and settlements scattered throughout the study area present a constraint for routeing of an underground cable.

	ECO-5 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Walpole	ECO-6 Grimsby West to Lincolnshire Connection Substation(s), Lincolnshire Connection Substation(s) to Weston Marsh, Weston Marsh to Walpole	ECSS 2 Grimsby West to Walpole Subsea
Tourism and Recreation	The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. A number of NCN cross the study area. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design	The Witham Way and Havenside Country Parks located to the west and east of Boston respectively are linear in nature and would need to be considered during routeing. A number of NCN cross the study area. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design	A number of NCN cross the study area including routes to/from Grimsby and to/from Kings Lynn. The Lincolnshire coast and north Norfolk coast are popular tourist destinations with a number of coastal resorts and extensive areas of holiday accommodation. It is considered that effects upon the local tourist economy could be minimised through careful routing and design
Infrastructure	There are a number of trunk roads and A roads within the study area including the A16 and A17. A number of these roads would need to be crossed particularly where they extend across the study area from east to west. Several railway lines would need to be crossed.	There are a number of trunk roads and A roads within the study area including the A16 and A17. A number of these roads would need to be crossed particularly where they extend across the study area from east to west. Several railway lines would need to be crossed.	Numerous marine infrastructure present including offshore wind farms, offshore cable routes and various pipelines and oil and gas infrastructure; it is unlikely that crossings of cables and pipelines could be avoided entirely. There are a number of marine aggregate dredging areas and shipping and navigation constraints which would need to be considered as part of subsea cable routeing. Onshore road and rail crossings required.

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