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EXECUTIVE SUMMARY

North-south power flows are forecast to increase due to increased generation capacity connecting to the electricity network at all levels, transmission and distribution. There is particular growth forecast in offshore wind and interconnection capacity in Scotland and the North East of England. This will put pressure on the existing network in and during periods of high wind generation and interconnection imports, which may result in constraint action being taken to restrict power flows to ensure equipment capabilities are not exceeded. The cost of these constraint actions is ultimately passed on to consumers and, without sufficient network reinforcement, will result in sub-optimal operation of the network in the long-term.

There is a requirement to invest in network reinforcements to accommodate a number of customer connections in the North East of England, and also increase power flow capability across boundaries B7, B7a and B8. This need is reinforced by the recommendations contained in the Network Options Assessment (NOA) 2018/19 and 2019/20.

A strategic options appraisal has been undertaken in order to identify a reinforcement which meets the Project Need Case and National Grid's statutory and licence obligations. Over 300 potential strategic options were identified and assessed as part of staged appraisal process in accordance with National Grid's Options Appraisal Guidance. A shortlist of 90 options were subject to a detailed appraisal with thorough consideration given to a range of technical, socio-economic, environmental, cost and programme issues. During the course of the appraisal, a further six sub-options comprising upgrades to existing infrastructure were identified.

All options that meet the Project Need Case, given the extent of the requirement, require a new transmission circuit to be constructed. However, the strategic options vary significantly in terms of circuit length and their use of existing infrastructure. Some entirely new build options are included, however, these are typically larger and require longer overhead line or underground cables routes to be delivered. In contrast, those options which include upgrading existing infrastructure are typically smaller and require shorter overhead line or underground cables routes. This results in differences in engineering complexity, capital cost, environmental and socio-economic impacts and programme. It is considered that options which require upgrading or enhancing of existing infrastructure are typically preferable to wholly new build options over the same distance.

Following completion of the strategic options assessment, a Strategic Proposal has been identified which is to construct a new 400kV double circuit overhead line from a point on the Norton - Osbaldwick overhead line to Poppleton substation. This would be a new c.6 km route (point-to-point distance) and is considered to be the most economical, technically preferred option and in environmental/socio-economic terms has comparatively less impact than other new build alternative options which would be in the range of 19 to 40km long. This would be coupled with reconductoring the existing 275kV route from Poppleton to Monk Fryston (XC route) to increase the capacity of the existing route. Whilst uprating the existing 275kV XC route to 400kV would provide additional capacity, it is not to meet the Project Need Case, but could be considered if additional customers are looking to connect in the area in the future.

The full scope of the Strategic Proposal is:

- A double tee-off from the existing Norton - Osbaldwick 400kV overhead line (2TW line) and approximately 6km of new build 400kV overhead line to Poppleton substation.

- Installation of two cable sealing end compounds (SECs), and short section of underground cable to duck one circuit under the Existing 2TW 400kV overhead line.
- Extension and reconfiguration of the existing Poppleton 275kV substation to install new inter-bus transformers and convert to a four-switch mesh substation.
- Installation of power control devices along one circuit of the new 400kV overhead line, assumed to be at Poppleton substation.
- Reconductoring of approximately 38km of the existing Poppleton - Monk Fryston 275kV overhead line (XC line).
- Construction of two SECs at the junction of the XC and XD 275kV overhead lines at Tadcaster and short section of underground cable.
- Installation of a circuit breaker and isolator at the existing Osbaldwick Substation.

Whilst the Strategic Proposal would require less new-build infrastructure than alternative options, there are some potential constraints or issues which will require careful consideration including development of a new 400kV overhead line close to York. Subject to endorsement of the Strategic Proposal, the next step in the development of the Project would be to develop it through the Options Identification & Selection stage taking account of National Grid's statutory obligations as well as undertaking stakeholder engagement. This will also include back-checking the decision making at key stages in the Project development process to ensure that the rationale for the Strategic Proposal remains robust.

GLOSSARY OF KEY TERMS

Term	Definition
Back check	Process undertaken at key Project milestones to ensure that the assumptions in relation to the Strategic Proposal remain valid, and/or where potentially material changes to the Project may arise. The purpose of back check is to provide a sense check, using the appraisal process to ascertain whether the Strategic Proposal remains the overall best option for the Project.
Benefit filter	Filtering of strategic options to remove any option that does not offer some material benefit over another option (to prevent assessment of multiple options which do the same thing).
Circuit breaker	A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current from an overload or short circuit. Its basic function is to interrupt current flow after a fault is detected.
Constraint costs	Annual payment made to constrain generation and manage power flows where forecast power flows are unable to be met by reinforcing the boundary (of the electricity transmission system).
Double circuit	Double Circuit Transmission Line refers to the arrangement in which a total of six conductors are provided to make two different Transmission Circuit. In Double Circuit Transmission Line, there are two circuits each consisting of three conductors corresponding to three phases.
Double tee	A connection from both circuits on either side of the same structure, creating a third and fourth circuit on another structure.
Earliest in-Service Date (EISD)	Date by which the Project must be delivered to meet the Project Need Case.
Eastern Link	Project for two bi-directional high voltage direct current subsea links between Scotland and the north of England to reinforce network capability issues.
Electricity System Operator (ESO)	Body required to support and guide the future development of the electricity transmission system in Britain.
Electricity transmission system	The electricity transmission system is made up largely of 400kV, 275kV and 132kV assets connecting separately owned generators, interconnectors, large demands fed directly from the transmission system, and distribution systems. The 'transmission' classification applies to assets at 132kV or above in Scotland or offshore. In England and Wales, it relates to assets at 275kV and above. The electricity transmission system is designed to make sure there is sufficient transmission capacity to ensure that the system can be operated in an economic and efficient way by the ESO, ensuring power

Term	Definition
	can be moved from where it is generated to demand centres across Britain. This planning and development of the electricity transmission system is governed by the SQSS which ensure that the network is developed and operated securely and is resilient to any foreseeable network faults and disruption.
Future Energy Scenarios (FES)	Published annually by the ESO to indicate future power requirements and where future connections may occur across the network.
Gas Insulated Line (GIL)	GIL consists of a tubular aluminium conductor to carry the current, enclosed in a rigid metallic tube that is filled with an insulating gas (usually sulphur hexafluoride or a mixture of nitrogen and sulphur hexafluoride gases).
Isolator	Isolator is a manually operated mechanical switch which separates a part of the electrical power. Isolators are used to open a circuit under no load. Its main purpose is to isolate one portion of the circuit from the other and is not intended to be opened while current is flowing in the line.
National Grid	National Grid operate the national electricity transmission network across Great Britain and own and maintain the network in England and Wales, providing electricity supplies from generating stations to local distribution companies. It does not distribute electricity to individual premises, but its role in the wholesale market is vital to ensuring a reliable, secure and quality supply to all.
Network Options Assessment (NOA)	Where a requirement for additional transmission network capacity has been identified, this is the process to identify a range of reinforcement options, and cost benefit analysis of those options (undertaken by ESO) to determine if a reinforcement is economic and should be progressed.
Options Identification & Selection	Work undertaken to determine the preferred corridor and preliminary routeing and siting options for the Yorkshire Green Energy Enablement **(**GREEN) Project. It is intended to demonstrate how National Grid's statutory duties, licence obligations, policy considerations, environmental, socio-economic, technical, cost, and programme issues have been considered and provide information on the approach to the identification and appraisal of route corridors and siting locations.
Overhead Line (OHL)	Conductor (wire) carrying electric current, strung from pylon to pylon.
Power control devices	Power control devices are designed to increase or decrease the apparent reactance of a line, thereby pushing power away from or pulling more power towards the circuit on which they are installed on
Project Need Case	Sets out the reasons why the Project is required.
Reconductoring	The replacement of old conductors (wires), insulators, earthwires, etc

Term	Definition
	on an existing overhead line.
Sealing End Compound (SEC)	Electrical infrastructure used as the transition point between overhead lines and underground cables. A compound on the ground acts as the principal transition point.
Security and Quality of Supply Standards (SQSS)	The SQSS sets out a coordinated set of criteria and methodologies that the Transmission Licencees shall use in the planning and operation of the national electricity transmission system.
Strategic options appraisal	A robust and transparent process used to compare options and to assess the positive and negative effects they may have across a wide range of criteria including environmental, socio-economic, technical and cost factors. The outcome is to identify a Strategic Proposal for the Project.
Strategic Proposal	The outcome of the strategic options appraisal; the Strategic Proposal is then taken forward to the Options Identification & Selection stage.
Substation	Electrical equipment in an electric power system through which electrical energy is passed for transmission, transformation, distribution or switching.
Sulphur Hexafluoride Gas (SF_6)	An extremely potent and persistent man-made greenhouse gas that is primarily utilized as an excellent electrical insulator and arc suppressant. It is inorganic, colourless, odourless, non-flammable, and non-toxic.
Technical filter	Filtering of strategic options to remove any option that does not meet the need case or otherwise would not meet the standards set out in the Security and Quality of Supply Standards (SQSS).
Underground Cable (UGC)	An insulated conductor designed for underground installation.
Uprating	Changing the capacity of existing overhead line by replacing the existing conductors with larger capacity conductors.
Yorkshire Green Energy Enablement (GREEN) Project (the Project)	The Project is required to reinforce the north to south boundary flow by 2027 enabling National Grid to meet future system demands which include several Green Energy customer connections such as Eastern Link (wind/hydro), Continental Interconnector (Wind) and Hornsea SuperConnection (Wind).

1. INTRODUCTION

1.1 Introduction

1.1.1 This report summarises the findings of the strategic options appraisal undertaken in order to identify a Strategic Proposal for the Yorkshire Green Energy Enablement (GREEN) Project (hereinafter referred to as the Project).

1.1.2 The report draws upon and summarises the work which has been undertaken to date to inform the identification of a Strategic Proposal including:

- The need case for Project – setting out background to the project and key drivers and sensitivities.
- The identification of strategic options – how and what strategic options have been identified.
- The review of substation connection points to be potentially utilised by strategic options.
- The key findings of the appraisal of strategic options – the results of specialist appraisals undertaken of strategic options.

2. PROJECT NEED CASE

2.1 Introduction

2.1.1 This section should be read with reference to the Yorkshire GREEN Project Need Case (hereinafter referred to as the Project Need Case). In summary, the fundamental need case for the Project is based on providing additional capability across network boundaries in the North East of England and to increase capability to accommodate increased north-south power flows on the network. This is due to the Future Energy Scenarios (FES) identifying increasing quantities of power generation (particularly onshore and offshore wind generation as well as interconnection capacity) in Scotland and the North East of England which will significantly increase north-south power flows over time. Since publication of the last FES National Grid has signed connection agreements with customers which identify the requirement for the Project. These contractual commitments further strengthen the need for the Project.

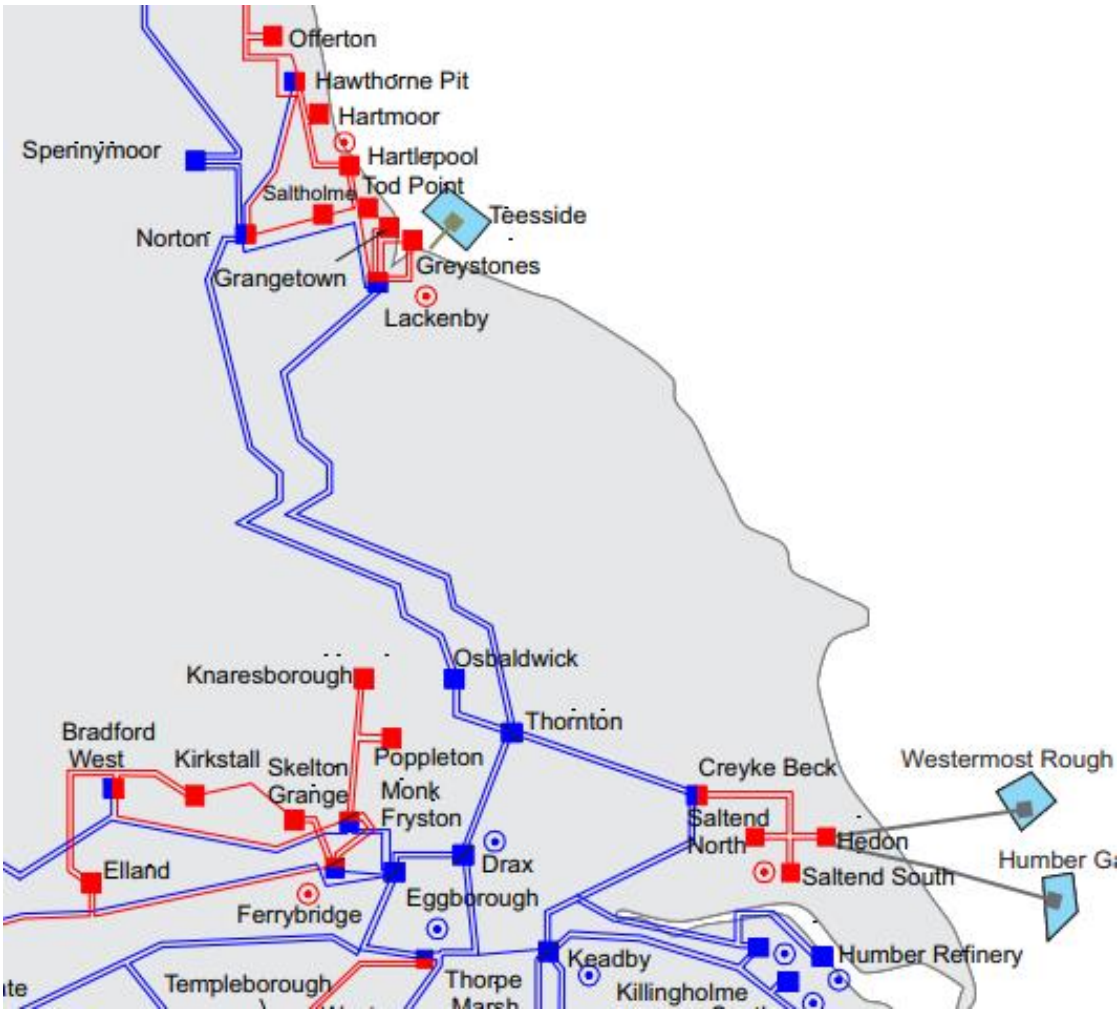
2.2 Network Options Assessment

2.2.1 A network boundary is used to represent areas of high-power flow between network areas. When flows across a network boundary are forecast to be above the capability of the network, generation needs to be managed to ensure that the capability of equipment is not exceeded. This is done by paying a generator on one side of the boundary not to generate and paying another generator on the other side of the boundary to generate to ensure demand and generation are always balanced. Therefore, a shortfall in boundary capability results in additional costs to operate the network: these payments are called 'constraint' payments or costs.

2.2.2 A network with no constraints would indicate that there has been over-investment in the network as a level of constraints is part of the economic operation of a network. However, excessive constraints will result in sub-optimal operation of the network and result in an excessive number of customers on one side of a boundary being restricted from operating. The Electricity Ten Year Statement (ETYS) (2019), published by the Electricity System Operator (ESO), shows a forecast of future boundary requirements based on the FES (2019). The FES are intended to identify a range of credible scenarios across gas and electricity demand and supply. The ESO has indicated that in future publications the FES will evolve to take account of net zero policies and targets established by the UK Government. This is a step change in the policy and approach from the previous FES, that would indicate future scenarios will be more aggressive than those set out in previous years.

2.2.3 The Network Options Assessment (NOA) process, completed by ESO each year, undertakes economic analysis to understand the balance between managing power flows across network boundaries by making constraint payments and the cost of asset-based reinforcement options proposed by the Transmission Owners (TOs) (NOA 2019/20). This cost-benefit analysis allows recommendations to be made to the TOs as to which reinforcements will be economic to develop and the optimal timing of those reinforcements. The need for the Project has been assessed through this process.

Figure 2.1: Electricity Transmission System – Study Area



2.3 Network and Customer Requirements

2.3.1 Given the historic requirements of the transmission network in North England, it is mainly oriented for north-south power flows with largely centralised generation and demand. In recent years, and looking forward, there will be significant growth in the connection of renewable generation and interconnection capacity on the extremities of the network. At times of high levels of generation there will be increased power flows from north to south with power coming from generation and interconnectors in Scotland and the North East of England. If unmanaged, during these periods of high-power flow existing infrastructure would be overstressed, and therefore constraint action has to be taken by the ESO to restrict power flows to ensure equipment capabilities are not exceeded.

2.3.2 Both the ETYS and the FES predict increased onshore and offshore wind generation in Scotland will significantly increase north-south boundary transfer requirements. In addition, increased low carbon generation and interconnectors connecting in the North and North East of England will result in increased power transfer requirements significantly exceeding existing boundary transfer capabilities. The projected boundary flows across boundaries B7, B7a and B8 all

exceed the current boundary capabilities by the mid 2020's in almost all scenarios as illustrated in the Project Need Case:

- Boundary B7: The boundary capability for B7 is 6.3 GW. Under all scenarios the north to south flows are predicted to increase significantly over the next 20 years, with the Two Degrees scenario showing transfer flows of nearly 20 GW by 2039.
- Boundary B7a: The boundary capability for B7 is 8.7 GW. Under all north to south flows are predicted to increase significantly over the next 20 years, with the Two Degrees scenario showing transfer flows of in excess of 20 GW by 2039. Even the Consumer Evolution scenario, which is showing only a steady increase in boundary flows, will significantly exceed the boundary capability by the 2030's.
- Boundary B8: The boundary capability for B7 is 10.3 GW. Under all four scenarios the ESO are predicting that the north to south flows will increase over the next 20 years, with the Two Degrees scenario showing transfer flows of approximately 20GW by 2039.

2.3.3 It should be noted that not all of the boundary transfer capability identified above is required to be delivered by the Project. Other smaller, incremental reinforcements will be delivered in the interim ahead of the Project which meets longer term boundary requirements.

2.3.4 The projections and requirements in the FES and ETYS are reinforced by the contracted position with customers. Whilst there is uncertainty that every customer will connect, the Project is identified as being required for the following customer offers which are not accounted for the in the FES:

- Continental Link: A 1.8 Gigawatt (GW) Interconnector between England and Scandinavia with a signed connection agreement to connect to Creyke Beck Substation, close to Hull, by 2027.
- Atlantic SuperConnector: A 1 GW Interconnector from Iceland expected to connect in the North East by 2027. Currently the customer has a connection offer to connect into a substation the North East but has not yet signed.
- Hornsea Phase 4: A Modification Application for 1.1 GW (taking total capacity to excess of 2.6 GW) of offshore wind generation with an offer to connect in the North East by 2030. Currently a customer has a connection offer to connect into a substation the North East but has not yet signed.

2.3.5 In addition, the Project is also critical to fully deliver the benefits of the Eastern Link project should it connect to the network in the North East. The strategic options appraisal process for Eastern Link currently identifies a connection to Hawthorn Pit (in the North East) as one of two preferred options which is consistent with the 'proceed' signal for such an option identified in NOA 2019/20. The Project is required to fully accommodate north south power flows from Scotland and the North East.

2.4 Limitations of the Existing Network

2.4.1 There are two double circuit transmission lines from the north-east part of the network feeding into Thornton 400kV substation. Thornton substation is then connected to the southern parts of the system via two double circuit transmission lines; one eastward to Salt End 275kV substation and the wider Humber area, and the other southwards to Drax 400kV substation.

2.4.2 With the anticipated rise in north-south flows in this region, the loss (planned or unplanned) of one of the north to south transmission routes particularly loss of a circuit south of Thornton will result in excessive overloading of the remaining circuits if no constraint action is taken. If no action is taken this would lead to tripping of the overloaded circuit, and potentially trigger a consequential cascade of circuit tripping, leading to a loss of supply and widespread system disturbance. The most onerous fault is the loss of the Creyke Beck to Keadby/Keadby – Killingholme double circuit which leaves the Drax – Thornton circuits as the only route for flows from the North East and the Saltend group. Conversely, a fault on the Drax – Thornton double circuit transmission line also results in overloading of the remaining circuits from Creyke Beck to Keadby. The study area is illustrated below.

2.4.3 Whilst network reinforcement actions such as reconductoring to upgrade thermal rating have been undertaken in recent years to manage increasing flows; such reinforcement would not be enough to cope with the anticipated increase in flows in the future.

2.4.4 Failure to deliver such a reinforcement would restrict generation and be in conflict with National Grid's contractual obligations. It is expected that the development of any adopted reinforcement that addressed boundary capability shortfalls across the B7, B7a and B8 boundaries must also fulfil the requirements for any signed customer connections.

2.4.5 Through the NOA process the ESO have recommended that National Grid proceed with a boundary reinforcement in this area (primarily a new 400kV overhead line) to mitigate the anticipated high constraint costs of managing this set of boundaries. In the 2018/19 NOA a central Yorkshire reinforcement was given a 'proceed' recommendation (assumed at that time to be a new 33km circuit from Eggborough to Osbaldwick). This is because the delays to the Project and an increase in boundary transfer capability across B7, B7a and B8 would result in higher constraint costs in the region of £37 million per year the project is delayed based on analysis in this year's NOA 2019/20. This also gives the Project the 'proceed' signal (although a different version of the Project, which is aligned to the Strategic Proposal in this report).

3. IDENTIFICIATION OF STRATEGIC OPTIONS

3.1 Approach to Identifying Strategic Options

3.1.1 The response to the Project Need Case has focused on the identification of a reinforcement which would relieve the boundary constraints and provide additional capacity to avoid the existing circuits overloading. This can only be achieved by delivering a new circuit. In order to achieve the required circuit rating, a double circuit route would be required and has been assumed for all options. A two-step process was followed in order to identify strategic options which should be subject to a detailed appraisal:

- Firstly the identification of a longlist of strategic options by selecting 'start' and 'end' points (illustrated in **Figure 3.1** and **Figure 3.2** respectively) which would provide opportunities to meet the Project Need Case as described in the previous section.
- Secondly, the identification of a shortlist of strategic options, by applying technical and benefit filters to the longlist list in accordance with National Grid's Options Appraisal Guidance.

3.2 Longlist of Strategic Options

3.2.1 Potential 'start' and 'end' points on the existing network were identified taking into account the boundaries which require to be reinforced. For completeness this exercise included identification of 'start' and 'end' points from existing substations as well as tee-in and tee-out points from existing overhead lines either side of the existing Thornton - Drax double circuit.

3.2.2 For each option identified (i.e. combination of 'start' and 'end' points), three technologies have been considered: Overhead Line (OHL), Underground Cable (UGC) and Gas Insulted Line (GIL).

3.2.3 During the appraisal process, National Grid updated its SF_6 policy to minimise the use SF_6. GIL technology is currently only available with the use of this gas, and while a clean air alternative is potentially going to be developed it is unlikely that it would be available in the project's timescales. GIL options would have a greater potentially greater climate change impact than alternative technologies and are therefore not considered appropriate for this project and have been discounted.

3.2.4 Given the scale of the Project it has been assumed the use of Direct Current (DC) technology is neither economic or efficient due to the requirement for expensive AC/DC conversion and consequently this has been discounted. A marine solution would also not be viable, as the need for this Project is to relieve/bypass the Thornton Drax circuits, which are not located in close proximity to the coast. Any potential marine option would be significantly longer and more expensive than any onshore solution, so the technology has not been taken forward for consideration on this Project.

3.2.5 The outcome of the workshop was the identification of a longlist of 379 strategic options.

Figure 3.1: 'Start' Points for Strategic Options

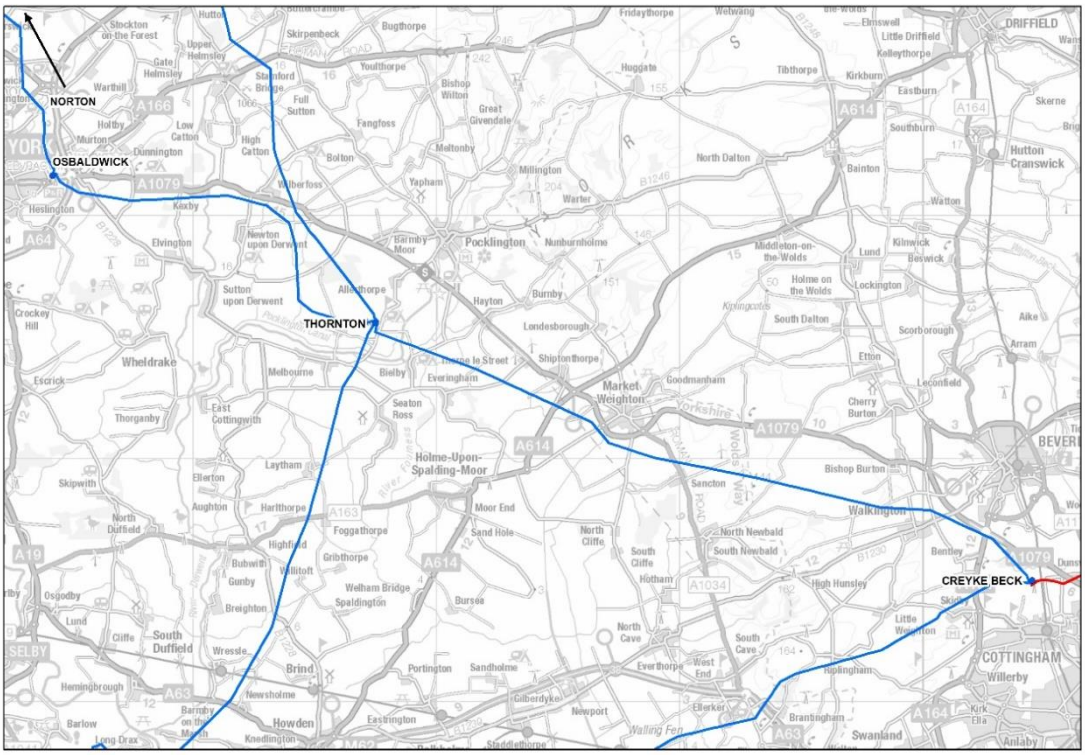


Figure 3.2: 'End' Points for Strategic Options

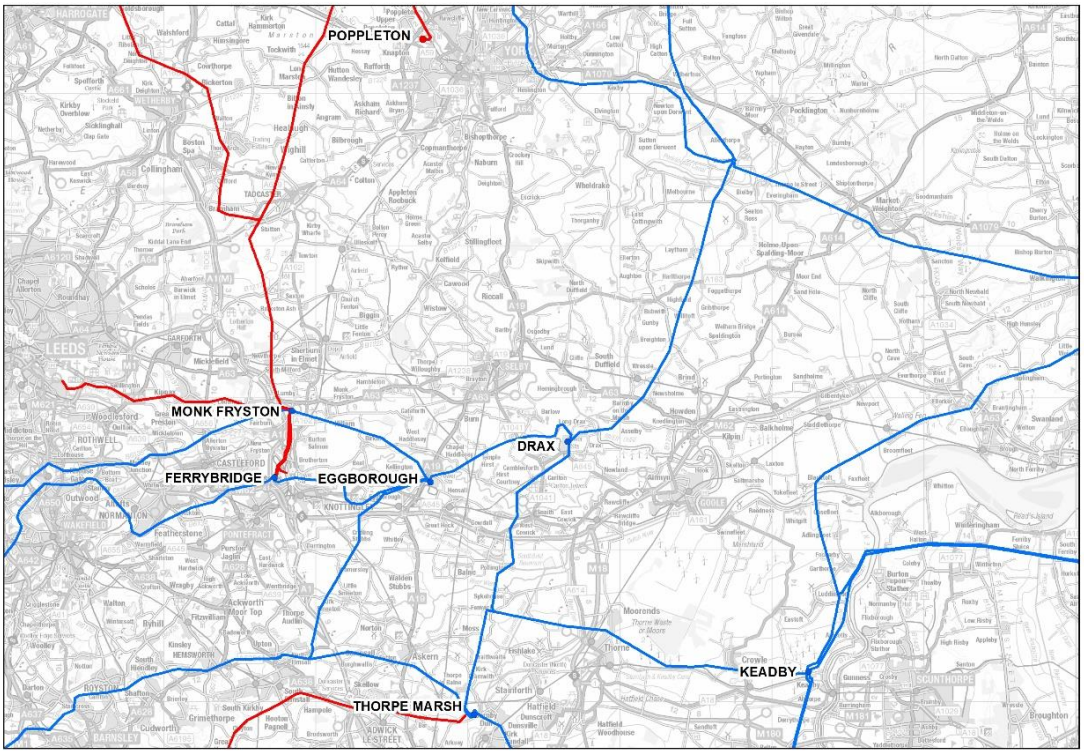
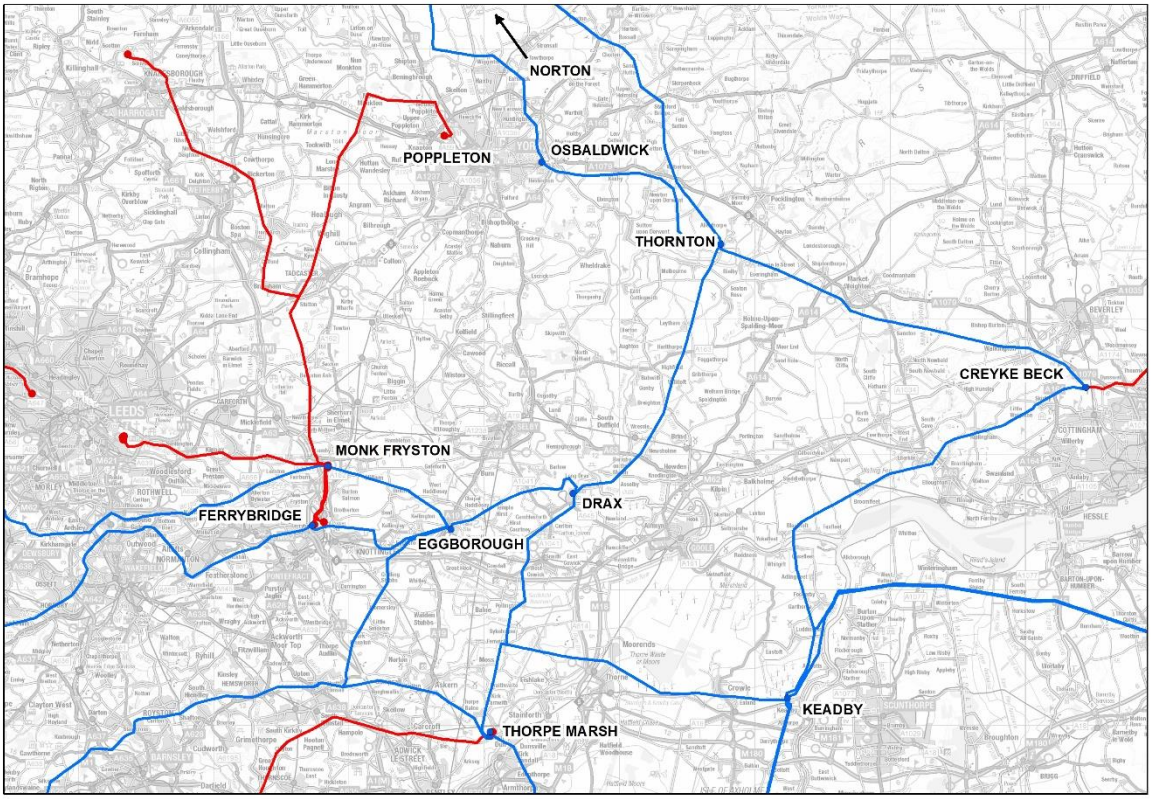


Figure 3.3: 'Start' and 'End' Points for Strategic Options



3.3 Shortlisted Strategic Options

3.3.1 In order to filter the longlist down to a shortlist of strategic options, a high-level review was undertaken. Each option was subject to review by the use of technical and benefit filters consistent with National Grid's Options Appraisal Guidance:

- Technical filter: Strategic options which do not meet the need case or otherwise would not meet the standards set out in the Security and Quality of Supply Standards (SQSS) should be discounted.
- Benefit filter: Strategic options for which there are no distinct or material benefits over other strategic options which would do the same thing should be discounted.

A number of options were discounted using the benefit filter. These were typically options which would require longer routes than alternatives which would do the same thing i.e. the additional length was not considered to offer benefits relative to other options and resulted in those options being discounted. A limited number of options were discounted using the technical filter. It was noted that a number of options would require substantially more works to ensure they would comply with SQSS, however, these were taken forward for more complete appraisal. This exercise resulted in a shortlist of 90 strategic options.

Table 3.1 identifies the shortlisted 'start' and 'end' points and the **straight-line** distance between them. For each of these options a study area was identified in which the Project could reasonably be expected to be developed. As noted above for each 'start' and 'end' point combination, OHL, UGC and GIL technology solutions have been considered.

Table 3.1: Shortlisted Strategic Options

OAST Reference*	'Start' Point	'End' Point	Approx. Length (km)**
THO-DRA-CYR	Thornton substation	Drax substation	21
THO-EGG-CYR	Thornton substation	Eggborough substation	29
THO-KEA-CYR	Thornton substation	Keadby substation	34
THO-MON-CYR	Thornton substation	Monk Fryston substation	33
THO-FER-CYR	Thornton substation	Ferrybridge substation	37
OSB-DRA-CYR	Osbaldwick substation	Drax substation	25
OSB-EGG-CYR	Osbaldwick substation	Eggborough substation	28
OSB-MON-CYR	Osbaldwick substation	Monk Fryston substation	27
OSB-FER-CYR	Osbaldwick substation	Ferrybridge substation	32
CRE-DRA-CYR	Creyke Beck substation	Drax substation	39
CRE-KEA-CYR	Creyke Beck substation	Keadby substation	32
2TW-NOR/OSB-POP-CYR	Norton - Osbaldwick OHL	Poppleton substation	6
4ZR-THO/CRE-DRA-CYR	Thornton - Creyke Beck OHL	Drax substation	27
4ZR-THO/CRE-KEA-CYR	Thornton - Creyke Beck OHL	Keadby substation	29
4ZR-OSB/THO-DRA-CYR	Osbaldwick - Thornton OHL	Drax substation	24

OAST Reference*	'Start' Point	'End' Point	Approx. Length (km)**
4ZR-OSB/THO-EGG-CYR	Osbaldwick - Thornton OHL	Eggborough substation	29
4ZR-OSB/THO-MON-CYR	Osbaldwick - Thornton OHL	Monk Fryston substation	31
4ZR-OSB/THO-FER-CYR	Osbaldwick - Thornton OHL	Ferrybridge substation	35
THO-ZDA-KEA/THM-CYR	Thornton substation	Keadby - Thorpe Marsh OHL	33
THO-4VJ-DRA/EGG-CYR	Thornton substation	Drax - Eggborough OHL	24
THO-4YS-MON/EGG-CYR	Thornton substation	Monk Fryston - Eggborough OHL	30
THO-XC-POP/MON-CYR	Thornton substation	Poppleton - Monk Fryston OHL	32
OSB-4VJ-DRA/EGG-CYR	Osbaldwick substation	Drax - Eggborough OHL	25
OSB-4YS-MON/EGG-CYR	Osbaldwick substation	Monk Fryston - Eggborough OHL	26
OSB-XC-POP/MON-CYR	Osbaldwick substation	Poppleton - Monk Fryston OHL	19
CRE-ZDA-KEA/THM-CYR	Creyke Beck substation	Keadby - Thorpe Marsh OHL	40
2TW-NOR/OSB-XC-POP/MON-CYR	Norton - Osbaldwick OHL	Poppleton - Monk Fryston OHL	31
4ZR-OSB/THO-4VJ-DRA/EGG-CYR	Osbaldwick - Thornton OHL	Drax - Eggborough OHL	25
4ZR-OSB/THO-4YS-MON/EGG-CYR	Osbaldwick - Thornton OHL	Monk Fryston - Eggborough OHL	29
4ZR-OSB/THO-XC-POP/MON-CYR	Osbaldwick - Thornton OHL	Poppleton - Monk Fryston OHL	24

* For each combination of 'start' and 'end' points considerations has been given to three technologies (OHL, UGC and GIL).

** Approximate lengths are based on **straight line** distances between 'start' and

OAST Reference*	'Start' Point	'End' Point	Approx. Length (km)**
'end' points.			

3.3.2 For each of the substations listed in **Table 3.1**, a review was undertaken to identify if any major constraints in relation to lands, planning or engineering were present which would discount them. This concluded that, whilst development at some substations would be more challenging than at others, none should be discounted on this basis.

3.4 Sub-Options

3.4.1 A number of strategic options were identified which would connect to either Poppleton 275kV substation or the existing Poppleton - Monk Fryston 275kV overhead line (the XC route). During the course of the options appraisal, it was confirmed that additional works would be required to the XC route in order to meet the Project Need Case and deliver the optimal benefits from these strategic options. **Table 3.2** summarises the sub-options identified and the affected strategic options. The sub-options have been considered as part of the appraisal of relevant strategic options.

Table 3.2: Additional Sub-Options

Sub-Option	Description	Affected Strategic Options
A	Reconductor the 275kV OHL from Poppleton to Monk Fryston (approx. 38 km) and operate at 275kV.	For strategic options connecting directly to Poppleton substation only.
B	Uprate the 275kV OHL from Poppleton to Monk Fryston (approx. 38 km) to operate at 400kV.	For strategic options connecting directly to Poppleton substation only.
C	Reconductor the 275kV OHL from XC tee off to Monk Fryston (approx. 13.5km) and operate at 275kV.	For strategic options connecting to the XC route (Knaresborough) tee-off point.
D	Uprate the 275kV OHL from XC tee off to Monk Fryston (approx. 13.5km) and operate at 400kV.	For strategic options connecting to the XC route (Knaresborough) tee-off point.
E	Reconductor the 275kV OHL From XC substation (near Poppleton) to Monk Fryston operate at 275kV.	For strategic options connecting to the XC route anywhere between Poppleton and Monk Fryston.

4. APPRAISAL OF STRATEGIC OPTIONS

4.1 Approach to and Scope of Appraisal

4.1.1 Each of the shortlisted strategic options has been appraised in accordance with National Grid's Options Appraisal Guidance and considers a range of technical, environmental, socio-economic and cost issues for each strategic option. **Table 4.1** below identifies the range of issues considered by the options appraisal. The objective of the options appraisal has been to identify a Strategic Proposal which meets the Project Need Case whilst also taking account of National Grid's statutory and licence obligations as well as key differentiators or issues which may make particular options unfeasible and/or more or less preferable.

Table 4.1: Scope of Options Appraisal

Topic	Sub-topic Considerations
Technical Appraisal	System Operation Construction/Delivery Operational/Maintenance Technology Commercial/Regulatory/Third Party
Environmental Appraisal	Physical Environment Biological Environment Landscape and Visual Historic Environment
Socio-economic Appraisal	Settlement and Population Tourism and Recreation Land Use Infrastructure
Programme Appraisal	Likely Route to Consent Duration to Consent Duration to Construct Earliest in-Service Date (EISD)
Cost Appraisal	Capital Cost Lifetime Cost Cost Benefit Appraisal
Boundary Transfer Capability	Boundary Transfer
* Note – Boundary transfer capability was not considered to be a significant	

Topic	Sub-topic Considerations
differentiating factor between strategic options so was undertaken for all options. It has been undertaken for a shorter list of preferable options.	

4.2 Key Findings of the Appraisal

4.2.1 For each strategic option, technical, environmental, socio-economic, cost and programme appraisals have been undertaken. This section provides a summary of the appraisal results highlighting the key findings which influence the selection of a Strategic Proposal.

4.2.2 The main differences between strategic options relate to their size or length and use of existing infrastructure; entirely new build options typically had longer route lengths, whilst those options which include upgrading existing infrastructure typically have shorter route lengths for the new-build elements. In general terms this results in significant differences in engineering complexity, capital cost, environmental and socio-economic impacts and programme (duration to Earliest in-Service Date (EISD)) e.g. larger new build projects are typically more expensive, have a greater impact and will take longer to build compared to shorter alternatives.

4.2.3 In terms of technology, three technologies have been considered: OHL, UGC and GIL. GIL is much more technically complex than alternative OHL or UGC solutions and as noted above given the change SF_6 policy is considered much less preferable. From a technical and cost perspective OHL was considered to be more preferable as it's a proven technology and less expensive than UGC. UGC solutions were not discounted but are considered less preferable. At this stage in the development of the project there are no planning policy reasons (e.g. nationally designated landscapes or national parks) which would require UGC to be used instead of an OHL. However, appropriate consideration would be given to UGC should there be constraints identified that would necessitate its use in line with National Grid's mitigation hierarchy.

4.3 Selection of a Strategic Proposal

4.3.1 In order to identify a Strategic Proposal, National Grid is required to balance technical, socio-economic, environmental and cost considerations in line with its statutory and licence obligations. A workshop was held in order to identify a Strategic Proposal taking into account the finding of specialist appraisals which have been undertaken e.g. environmental, technical and cost.

4.3.2 A key consideration which influenced the selection of the Strategic Proposal is the ability to upgrade or enhance existing infrastructure; as a starting presumption National Grid considers these options to be preferable to options which would require wholly new infrastructure. This approach is consistent with National Grid's statutory duty to have regard to amenity under section 38 of the Electricity Act and promotes more sustainable development. National Grid will only propose to build wholly new infrastructure where existing infrastructure cannot be technically or economically upgraded to meet system security standards and regulatory obligations.

4.3.3 In the case of the Project, there are a number of strategic options which would involve a combination of new infrastructure as well as upgrades of existing infrastructure. These options are therefore considered to be more preferable to those requiring entirely new infrastructure to achieve the same network benefit, many of which would require longer OHL/UGC/GIL routes in the range of 19km to 40km.

4.3.4 There are five strategic options which would include a combination of new infrastructure as well as upgrades to existing infrastructure. These comprise:

- (1) strategic options connecting into Poppleton substation and then upgrades to the existing Poppleton - Monk Fryston 275kV overhead line (the XC route), or
- (2) strategic options connecting onto the Poppleton - Monk Fryston 275kV overhead line and then upgrades to the existing XC route.

4.3.5 Combining the new infrastructure with an upgrade to the XC route (e.g. one of the sub-options in **Table 3.2**) would meet the Project Need Case, be consistent with National Grid's policy regarding making best use of existing infrastructure and have additional benefits of enhancing reliability of supply at Poppleton.

4.3.6 The focus of identifying a Strategic Proposal has comprised two elements; firstly identification of the new infrastructure works and secondly identification of any required upgrades of existing infrastructure.

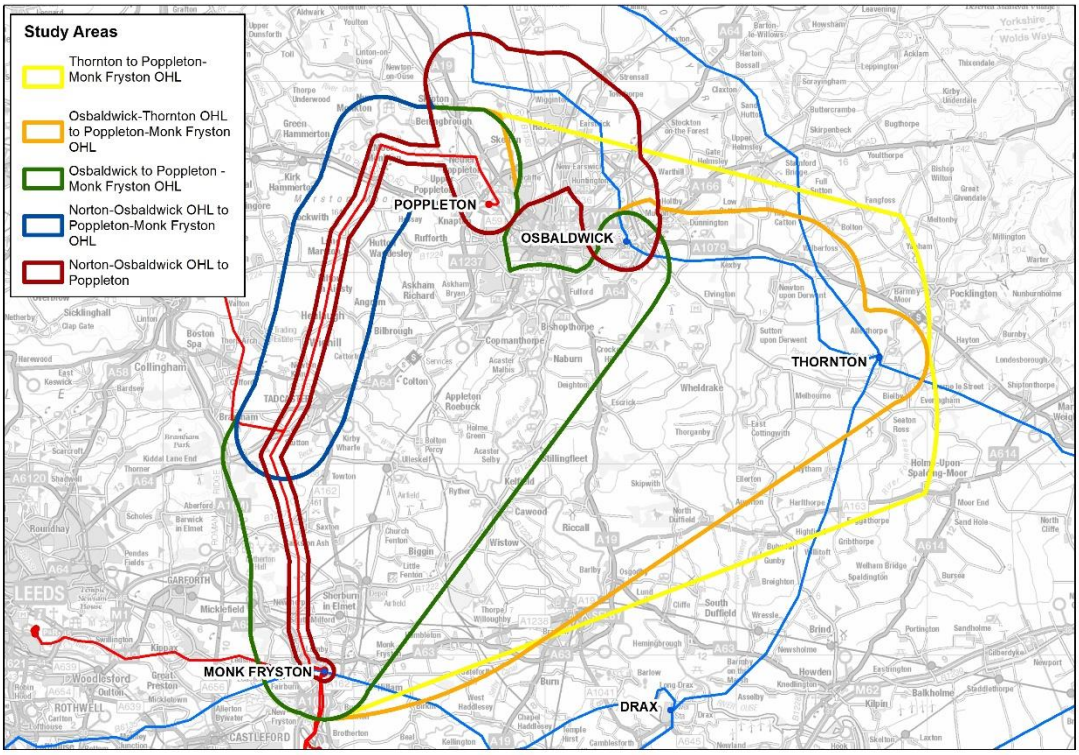
4.3.7 **Table 4.2** summarises the new infrastructure options. The majority of 'start' points are located to the east of Poppleton and York (see **Figure 4.1**). They would require a longer new build route around the south of York resulting in the potential for greater environmental impacts, in particular landscape and visual impacts, as well as increased cost and are therefore considered less preferable to options which 'start' north or west of York.

4.3.8 There are two options which 'start' on the existing Norton - Osbaldwick overhead line (2TW) and 'end' either at Poppleton substation or on the existing XC route. It is considered more preferable to connect directly into the existing substation as opposed to routeing past it to connect onto the XC route which would require a new substation. Whilst this requires an extension to the substation and increases the length of the XC route to be reconductored, space for the extension is available and it reduces the amount of new build infrastructure required. A new c.6 km route from the Norton - Osbaldwick overhead line to the existing Poppleton substation is the most economical, technically preferred option and in environmental/socio-economic terms has comparatively less impact than longer alternatives. However, it should be noted that in appraising the options, there are no major environmental or socio-economic constraints which would rule out a route. Consequently, the key differentiator which results in the selection of the Strategic Proposal is the significantly shorter length.

Table 4.2: Strategic Options utilising Upgraded Infrastructure

'Start' Point	'End' Point	New Works Required
Norton - Osbaldwick OHL	Poppleton substation	New 6 km route
Thornton substation	Poppleton - Monk Fryston OHL	New 32 km route
Osbaldwick substation	Poppleton - Monk Fryston OHL	New 19 km route
Norton - Osbaldwick OHL	Poppleton - Monk Fryston OHL	New 31 km route
Osbaldwick - Thornton OHL	Poppleton - Monk Fryston OHL	New 24 km route

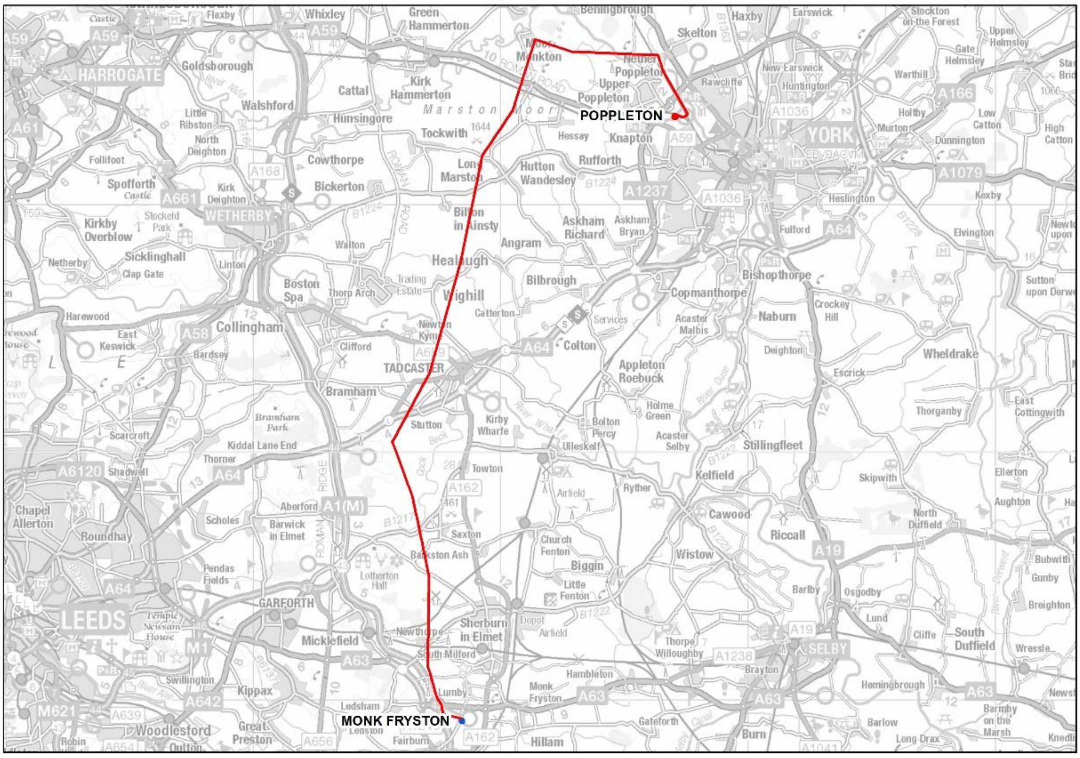
Figure 4.1: Strategic Options connecting to Poppleton Substation or the XC Route



4.3.9 As set out in **Table 3.2**, six sub-options comprising upgrades to the existing network (see **Figure 4.2**) were identified depending on where new infrastructure connects to it. On the basis of a preference for direct connection to Poppleton substation as described above, two sub-options were considered feasible: reconductoring of the XC route and continuing to operate it at a 275kV or uprating of the XC route to operate it at 400kV.

4.3.10 The Project Need Case can be met by reconductoring the existing XC route and continuing to operate it at 275kV. Whilst uprating to 400kV would provide additional capacity for future connections, it is not currently considered economical to do so. It is important that this is considered if this changes during subsequent stages of the Project.

Figure 4.2: Existing Poppleton – Monk Fryston 275kV Overhead Line (the XC Route)



4.3.11 Whilst the Strategic Proposal would require less new-build infrastructure than alternative options there are some potential constraints or issues which should be noted. In particular the requirement for a new 400kV overhead line in close proximity to York is expected to result in challenges on landscape and visual grounds as well as in relation to potential impacts on the setting of York Minster. Similarly, the location of Poppleton substation in relative proximity to settlement, York ring road, emerging new development and flood risk areas may result in challenges with regard to both overhead line entries and wider infrastructure requirements. Such issues will require careful consideration as the Project is progressed through the Options Identification & Selection stage as well as stakeholder engagement. This will also include back checking the decision making at key stages in the Project development process to ensure that the rationale for the Strategic Proposal remains robust.

5. CONCLUSIONS

5.1.1 As described in the **Section 2** of this report, the ESO anticipate increasing volumes of generation, particularly onshore and offshore wind, connected across the Scottish TO networks to double the north-to-south transfer requirements across the Anglo-Scottish constraint boundaries within the next 10 years. Additionally, growth in low carbon generation and interconnector connections is expected, and as set out above is indeed already contracted in the north of England. The Project is identified as being required in these customer connection agreements further strengthening the need case.

5.1.2 The Project is also critical to fully deliver the benefits of the Eastern Link. This also has a 'proceed' signal in the 2019/20 NOA assuming that it connects into Hawthorn Pit by 2027 (which is also the recommendation of the strategic options appraisal process for Eastern Link). Without the Project in place and in service aligned to Eastern Link, the power flow being transferred south from Scotland by Eastern Link, will not be able to be fully accommodated due to the constrained network. Consequently, the full benefits of Eastern Link would not be realised.

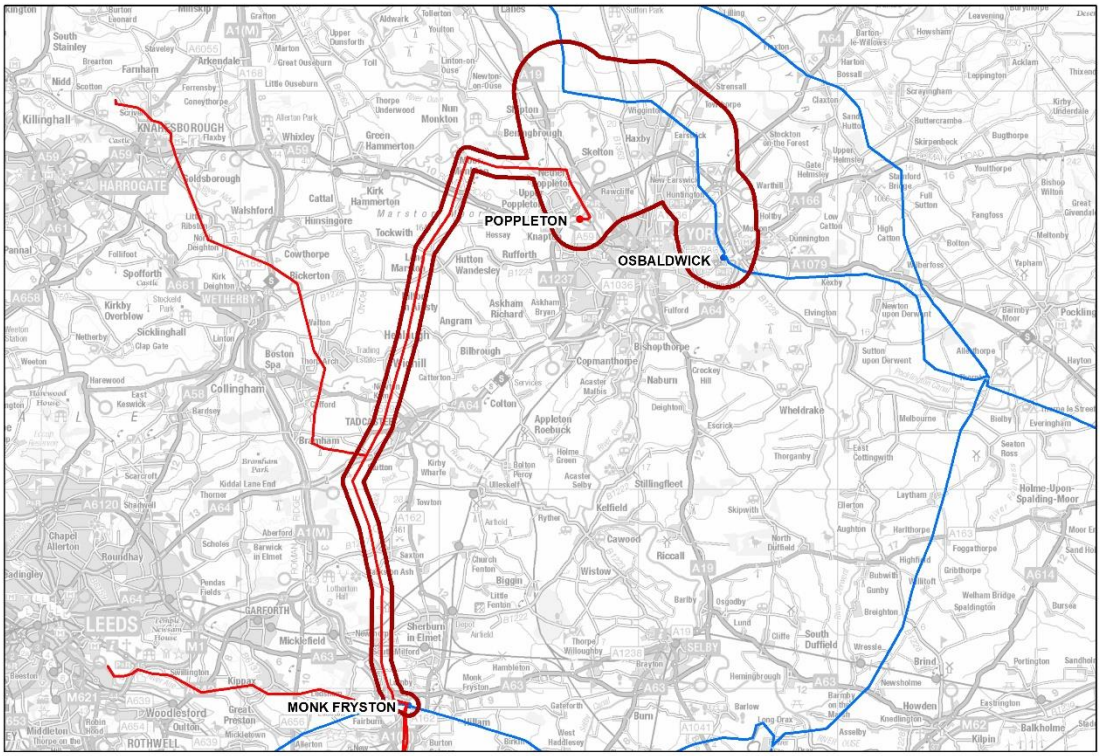
5.1.3 Strategic options appraisal has been undertaken in order to identify a reinforcement which meets the Project Need Case and best balances National Grid's statutory and licence obligations. Initially over 300 potential strategic options were identified and assessed through a staged process in accordance with National Grid's Options Appraisal Guidance. Thorough consideration has been given to a range of technical, socio-economic, environmental and cost issues.

5.1.4 Having regard to National Grid's statutory and licence duties a Strategic Proposal has been identified. This takes into account a range of technical, socio-economic, environmental and cost issues as well as EISDs. The Strategic Proposal is illustrated in **Figure 5.1**. This would comprise new-build and upgrade infrastructure:

- A double tee-off from the existing Norton - Osbaldwick 400kV overhead line (2TW line) and approximately 6km of new build 400kV overhead line to Poppleton substation.
- Installation of two cable sealing end compounds (SECs), and short section of underground cable to duck one circuit under the existing 2TW 400kV overhead line.
- Extension and reconfiguration of the existing Poppleton 275kV substation to install new inter-bus transformers and convert to a four-switch mesh substation.
- Installation of power control devices along one circuit of the new 400kV overhead line, assumed to be at Poppleton substation.
- Reconductoring of approximately 38km of the existing Poppleton - Monk Fryston 275kV overhead line (XC line).
- Construction of two SECs at the junction of the XC and XD 275kV overhead lines at Tadcaster and short section of underground cable.

- Installation of a circuit breaker and isolator at the existing Osbaldwick substation.

Figure 5.1: Strategic Proposal



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