nationalgrid

MSIP Norwich

National Grid Electricity Transmission
Medium Sized Investment Project

January 2025

Contents

Investment Summary

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<u>Primary drivers:</u> To connect 4.75GW of generation to the Norwich Main 400kV substation from Equinor's Dudgeon and Sheringham Shoal offshore windfarms extension, [redacted] and Ørsted's Hornsea P3 offshore wind farm – which is set to be the largest single offshore windfarm in the world.

<u>Secondary drivers:</u> Security and Quality of Supply Standard (SQSS) works have been triggered due to the generation volume for this project and the subsequent need for reinforcement. This investment will expand the footprint of the substation to accommodate the proposed Norwich to Tilbury overhead line (OHL); costs associated with this component of the extension are being sought through a separate ASTI mechanism, but the works will be delivered as part of the extension for efficiency.</td></tr>
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Land and consent: While most of the Town and County Planning Act (TCPA) conditions have been discharged, we are awaiting approval on site drainage. This is not due until the site becomes operational [redacted]
Future network requirements: Preference to deliver sufficient capacity from the outset to facilitate efficient connection of additional customers in the future, benefiting current and future consumers via cost and efficiency savings.</td></tr>
<tr><td>Optioneering</td><td colspan="4">We assessed 7 options, including 3 option categories (doing nothing, market, and whole system solutions) which would not provide a physical connection. We assessed 1 option to construct a new substation, and 3 options to utilise an existing substation (Norwich Main):
• Option D-1: Eastern and western Air Insulated Switchgear (AIS) extension with Equinor connection in western bay.
• Option D-2: Eastern and western Hybrid Insulated Switchgear (HIS) extension with Equinor connection in the western bay.
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Options D-1 and D-3 were shortlisted for detailed analysis.</td></tr>
<tr><td>Proposed solution</td><td colspan="4">An extension of Norwich Main 400kV substation to the east and west [redacted]. The investment includes related works to facilitate future extension, including constructing a new 400kV circuit breaker and a new bus coupler, driving value for money for consumers by conducting requisite works concurrently. By taking future connections into account during design, this solution minimises future constraints on the system caused by outages, as well as the environmental and economic impact on consumers of repeated work. This minimises the need for rework and offers a value for money solution for consumers.</td></tr>
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1. Executive Summary

1.1 Context

This paper, together with the associated Cost-Benefit Analysis (CBA), summarises NGET's proposed investment to extend the Norwich Main 400kV substation, and seeks to demonstrate the consumer interest in the associated investment. This extension will enable the construction of four offshore electricity transmission (OFTO) bays to facilitate the connection of Hornsea P3, one OFTO bay to facilitate the connection of Equinor's Dudgeon and Sheringham Shoal Wind Farms Extension (referred to throughout this document as 'Equinor' or the 'Equinor extension'), and one bay for [redacted] resulting in 4.75GW of renewable generation and aligning strongly with the UK's net zero goals.

This Medium Sized Investment Project (MSIP) seeks approval of the need for the investment, as well as approval of the proposed solution and requested funding allowances for efficient spend on the project.

The works completed as part of this extension will also enable the connection of the Norwich to Tilbury (N-T) OHL, a project which the National Energy System Operator (NESO) has identified as critical to delivering a network which supports Clean Power 2030. The extension will include the development of 2 bays for the N-T OHL, however, the costs associated with this work are being addressed separately through an ASTI Project Assessment Framework Early Construction Funding (ECF) Submission [redacted] The costs associated with the infrastructure for the two N-T OHL bays are subsequently not in scope for this MSIP.

1.2 What is the background to this Investment?

National Grid Electricity Transmission (NGET) has two contracted connection offers for offshore windfarms (Ørsted's Hornsea P3 and the Equinor extension) and a signed offer to connect the [redacted] into the existing Norwich Main 400kV AIS substation, located approximately 3 miles south of the city of Norwich.

Once delivered, Hornsea P3 is expected to be the largest single offshore windfarm in the world, while the Equinor extension project is expected to double the site's existing capacity.

The connection agreement for Hornsea P3 was signed in [redacted] [redacted]. NGET began optioneering for the project via the multilateral Connection and Infrastructure Options Note (CION) process in collaboration with NESO and the customer [redacted] and was re-opened following a Mod App in [redacted] which sought to increase TEC from 2000MW to 3000MW. An overview of the CION process can be found at Section 4.1 of this paper.

The Equinor connection agreement was signed in [redacted]. This was subsequently followed by a Mod App that postponed the connection date for Equinor [redacted] Concurrent site extensions at Norwich Main will enable the connection of the [redacted]

The Norwich Main extension will enable the connection of two new bays for the Norwich to Tilbury OHL, [redacted] however the costs for this infrastructure work are being addressed through a separate ASTI ECF process. For this reason, these bays are included in our optioneering but are not included in this MSIP's funding request.

The Norwich Main site extension is being delivered as a 'site strategy'. As outlined in our T3 Load Strategy, site strategy investments are used where the number of customers and the confidence we have in these justifies a site-scale solution that considers the needs of multiple customer drivers. Site strategy investments typically have multiple drivers that can include a mix of connections, other load investments, and non-load drivers. By delivering the works at Norwich Main as part of a site strategy, in this way, we are taking the opportunity to address future drivers, reducing the need to rework the site and thereby reducing costs. This allows us to deliver a more efficient overall solution that enables strong value for consumers.

The Norwich Main extension also aligns with a broader programme of regional investment by NGET, including at the substation. There is currently a grid park in development at Norwich Main that will facilitate the connection of an extra 150MW. This grid park will connect onto a Super Grid Transformer (SGT) in the north of Norwich Main – funding for this is not in scope as part of this

MSIP. Despite this, these works impacted on decisions made in the optioneering process for the Norwich Main extension, outlined in Chapter 4.

The UK Government has committed to quadruple offshore wind power production in the UK by the end of the decade.[1] NESO's Clean Power 2030 report notes that offshore wind will be the bedrock of a clean power system in 2030, forecast to provide over half of Great Britain's generation.[2] The report also identifies the Norwich to Tilbury OHL as one of three projects critical to delivering a clean power network. This OHL will be supported by the extension of the Norwich Main substation.

Set to be the world's single largest offshore windfarm, Hornsea P3 will be capable of generating 3GW of electricity, enough to power over 3 million homes.[3] This project will make a significant contribution to the UK's energy security and the local and national economy, while enabling the delivery of a substantial volume of clean energy to consumers, aligning strongly with the UK's net zero objectives. The Equinor extension will enable the connection of 1.35GW of renewable electricity, doubling the site's existing capacity to power an additional 785,000 homes. The project is anticipated to support more than 1,800 full time jobs per year.

Given the size of the Hornsea P3 connection and the Government's target to achieve 50GW of offshore wind by 2030, it is pertinent to ensure this connection is delivered on schedule to enable consumers to reap the benefits of this significant source of renewable electricity.

1.3 What have we considered in developing options for this investment?

NGET assessed a range of solutions to meet the investment drivers in a way that best serves the interest of consumers. We considered a total of 7 options under 3 categories. In evaluating options to deliver this investment in a way that best serves the interest of consumers, we considered technology type, pace of delivery, and futureproofing.

The optioneering process was originally conducted on the basis of only including the connections for Hornsea P3, Equinor, and the N-T OHL [redacted]). An efficiency was identified following the selection of a preferred option that would enable the connection of [redacted] This is outlined in section 1.4 below.

In line with the reopener guidance set out by Ofgem, we considered 3 options as standard, which were discounted due to their inability to provide a compliant and viable customer connection. These were: **do nothing (Option A), market based (Option B)**, and **whole system solutions (Option C)**.

We then considered options to **extend or utilise existing substations (Option D)** and to **build a new substation (Option E)**. Option E was not shortlisted because it would not enable us to meet the Hornsea P3 ACL. This is because it would require us to acquire additional land, install additional infrastructure including new OHLs and potentially have to secure additional planning consents – all of which would increase the cost and timeline of the project. This would drive additional cost to the consumer, and risk delaying delivery of the project, which would not be in consumers' interests given the wider benefits of connecting this major source of low carbon generation.

We subsequently focused on options to extend or utilise existing substations (Option D). It was determined that Norwich was the most appropriate substation at which to deliver these customer connections because of its proximity to the landing site for both offshore wind connections, while having enough remaining capacity to enable the connection of this significant volume of additional power.

Additionally, for Hornsea P3, the CION process indicated that Norwich Main was the most economical solution of the substations considered, [redacted]

We subsequently considered three options to extend or utilise the existing Norwich Main substation:

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[1] UK Parliament: House of Lords Library, "Offshore wind energy", 4 September 2024.

[2] NESO, "Clean Power 2030: Advice on achieving clean power for Great Britain by 2030", November 2024.

[3] Ørsted, "About the Project: Hornsea 3".

- D-1: Eastern and western AIS extension with Equinor connection in western bay.
- D-2: Eastern and western HIS extension with Equinor connection in the western bay.[4]
- D-3: Eastern and western AIS extension with Equinor connection in the eastern bay.

Two of these options were progressed to detailed options analysis (D-1 and D-3). D-2 was not progressed to detailed analysis as it was determined this option would be non-compliant with SQSS requirements.

Table 1: Summary of Norwich Main site extension shortlisted options against key criteria

Options	D-1	D-3
Technology choice: NGET's preference to favour AIS over GIS	AIS	AIS
Land required	Extends beyond current land ownership in west – requires additional land acquisition.	Eastern extension overlaps the proposed Pivot Power BESS facility for which Planning Permission has been granted.
Design and technical complexities	Routing Hornsea P3 cables through the west extension inside Equinor bay could mitigate the Equinor/Hornsea P3 cable crossing.	Added costs and complexity of cable duck under to avoid added network constraint of undersailing OHL conductors.

1.4 What is the preferred option and what outputs does it deliver?

In evaluating these options to consider which would deliver the strongest consumer benefit, we determined that the **preferred option is D-1, to build an eastern and western extension at the Norwich substation to connect Hornsea P3 into 4 new AIS bays, with an Equinor connection point in the western extension**.

Under this option, the Hornsea P3 connection cables will connect individually using one full bay width per cable connection – with two in an eastern extension and two in a western extension. Equinor will be connected in a new bay in the western extension. [redacted]

This option utilises AIS technology and is subsequently aligned with our policy preference for AIS solutions over GIS solutions where possible, due to its flexibility for future expansion and relatively lower SF6 gas emissions.[5] Additionally, this option required a smaller eastern extension when compared to E-3, meaning it would not infringe on the boundary to Pivot Power, a separate project scheduled to the east of the Norwich Main substation.

The original design for Option D-1 included two spare bays to connect two National Energy System Operator (NESO) Pathfinders. However, this component was later removed after NESO confirmed in November 2023 that they no longer required space at Norwich Main for the Pathfinders.

Consequently, the two bays that were initially reserved under the preferred option for NESO became available again, and adjustments were made during the detailed design stage. Bus Coupler 4 was repositioned to occupy the space available from one of the original NESO pathfinder bays, while the other former NESO bay was reallocated as a connection point for the [redacted] This approach allowed us to repurpose existing plans and avoid unnecessary construction.

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[4] HIS is a compact and modular substation configuration that combines SF6 gas-insulated switchgear (GIS) with air insulated switchgear (AIS) components. It is designed to reduce the footprint of traditional AIS substations while maintaining flexibility and ease of operation and are suitable for outdoor applications.

[5] PS(T) 023 Substation Primary Insulation (Air/Gas).

Funding allowances are sought as part of this MSIP submission. The current total cost of the project is [redacted] and the funding allowance being sought is: [redacted]. Further details related to the makeup of these requested allowances are detailed within the cost model available alongside this submission.

1.5 How has future proofing been considered in the proposed investment?

In addition to connecting the primary offshore wind customer (Ørsted), delivering this project as a site strategy enables us to extend the overall footprint of the substation to accommodate future customer connections and infrastructure planned between now and 2031. In doing so it minimises the overall volume of work, reduces the duration of future outages and maximises NGET resource availability – delivering strong consumer outcomes by reducing duplication, maximising project efficiency, and avoiding the need for repeated bite size expansions.

The current design of the Norwich Main substation allows for extension to its maximum technical capability (5GW). Much of the works associated with this site strategy will be constructed offline – with only the breaker and coupler to be constructed when loaded – to ensure efficient use of both outage and resource capability in what is a busy part of the network.

[redacted]

By taking future connections into account during design, the project minimises future constraints on the system caused by outages, as well as the environmental impact of repeated work. It also minimises rework, thereby offering value for money for consumers.

Looking ahead there is a high level of demand for connections across the East Anglia region surrounding substations like Norwich Main and Necton (which is also being extended and for which there is a separate January 2025 MSIP submission). This high volume of demand for grid connections necessitates a strategic approach to new investment in the area. In our T3 Future Network Blueprint for the region, we presented a need for a potential eight new substations in the area to support this pipeline of demand.

However, we recognise that the implementation of Connections Reform, in tandem with the Government's Clean Power 2030 Action plan, will have a significant impact on the connections landscape at both a national and regional level. This will, in turn, help us to refine the number, type and location of new investments in East Anglia moving forward.

1.6 What are the uncertainties and how have they been accounted for?

Several risks and uncertainties have been considered in relation to the option selected. Project risks include:

- **Planning Permission**: The process to obtain approval under the TCPA is ongoing, with additional conditions relating to site drainage still to be discharged prior to the site becoming operational. To mitigate this risk, we are maintaining ongoing liaison with the council, and additional float time has been incorporated into the programme.
- **Prerequisite Busbar Protection Replacement**: The replacement work is scheduled to be carried out [redacted]. Any delays in completing this work could affect subsequent project phases.
- **Supply Chain Constraints**: Long lead-time items such as switchgear, protection panels, and the LVAC board pose a risk to the project schedule. To address this, a Preliminary Work Study (PWS) has been conducted, and these items have already been ordered in advance.

- **Substation Fault Rating**: The scope is currently being defined to uprate the substation fault rating from 50 kA to 63 kA to meet the new fault level requirements and remain SQSS compliant. [redacted]

This paper, together with the associated Cost-Benefit Analysis (CBA), summarises NGET's proposed investment to extend the Norwich Main 400kV substation to connect multiple renewable energy projects, including Hornsea P3 – set to be the world's largest offshore wind farm – the Equinor extension, and [redacted] Together, these projects will add 4.75GW of renewable energy to the grid. This investment aligns with the UK's net-zero goals and Government strategies to increase offshore wind power. The preferred solution involves an extension of the Norwich Main substation to accommodate eight new AIS bays for imminent and future connections – providing strong consumer benefit by avoiding the need for repeated works at site.

2. Introduction

2.1 Project background

This paper presents the investment case and associated efficient costs for our preferred solution for extending the Norwich Main substation to connect two offshore wind customers and one solar farm customer. The scope of this investment is to enable successful connection of Hornsea P3, the Equinor extension [redacted] This submission demonstrates the consumer benefit in completing the site extension required to enable these connections concurrently, minimises future constraints on the system caused by outages and reducing costs by minimising the need for rework.

2.1.1 Chronology to the request

The primary driver of this investment is the customer connection of Hornsea P3 – set to be the world's single largest offshore wind farm – the Equinor extension [redacted]. The Norwich Main 400kV extension will enable the connection of 4.75 GW of renewable electricity generation to the transmission network. Meeting the targeted programme is essential to align with the Government's goal of achieving 50GW of offshore wind capacity by 2030.

Hornsea P3

- NGET began optioneering for Hornsea P3 via the multilateral Connection and Infrastructure Options Note (CION) process in collaboration with NESO and the customer [redacted]
- Following a [redacted] Mod App, the CION process identified Norwich Main as the preferred connection location for Hornsea P3.
- Hornsea P3's Development Consent Order (DCO) was approved [redacted]
- Customer Final Investment Decision (FID) for the Hornsea P3 project was achieved [redacted].
- [redacted]
- The ACL connection date is scheduled [redacted] and the project is anticipated to proceed as planned.

Equinor

- Equinor submitted their DCO application [redacted]. An outcome is anticipated [redacted]
- We are working to build the Equinor bay prior [redacted] or financial, resource and outage efficiency.
- Given its strategic importance, confidence in this project remains high [redacted]
- The ACL connection date for Equinor [redacted]

[redacted]

- [redacted]

The Norwich to Tilbury OHL project is also undergoing a DCO application, as of December 2024. Investment efforts are focused on facilitating the connection of the proposed Norwich to Tilbury OHL. Coordination between schemes continues for both technical and consenting purposes.

Other works are also occurring at Norwich Main, however, as outlined in Section 1.2, we are seeking to recover the associated allowances for these through separate mechanisms:

[redacted]The N-T OHL: This Norwich Main extension will enable the construction of two new bays for the Norwich to Tilbury OHL [redacted]

[redacted]

2.1.2 MSIP eligibility

The Norwich Main 400kV substation extension project is eligible as an atypical MSIP reopener. The project is connecting generation load to the Electricity Transmission network. However, current total costs for delivering the investment exceed the net allowances available via the Generation Connection Volume Drivers by circa [redacted]

The comparative funding to expenditure ratio triggers an atypical generation connection MSIP (SpC 3.14.6 category a). A breakdown of eligible volume driver allowances is provided in Appendix A.

NGET is submitting this MSIP in the January 2025 window including total funding allowances for the Norwich Main extension project [redacted]

2.1.3 Importance of the investment

Offshore wind is a cornerstone of the UK's strategy to achieve its net zero targets. The Government's goal to achieve 50GW of offshore wind capacity by 2030 underscores the importance of enabling the rapid connection of projects like Hornsea P3 and the Equinor extension.

Hornsea P3, set to be the world's single largest offshore wind farm, will contribute significantly to the UK's clean energy targets and energy security. The project is poised to deliver up to £8.5 billion to the local, national, and global economy through supply chain investments and the creation of thousands of high-skilled jobs during both its construction and ongoing operation and maintenance.[6] Situated 160 km off the Yorkshire coast and 120 km off the Norfolk coast, Hornsea P3 will feature up to 231 offshore wind turbines spread over a 696 km² area, capable of producing enough clean electricity to meet the average daily needs of over 3.3 million homes.

The Equinor extension also represents a significant advancement in the UK's renewable energy infrastructure. Located to the north and east of the existing Sheringham Shoal Wind Farm and to the north and southeast of the Dudgeon Wind Farm, the extension of these two existing windfarms will enhance the country's capacity to generate renewable electricity.

The Sheringham Shoal Wind Farm currently has a generation capacity of 317MW and 88 wind turbines, and the Dudgeon Wind Farm has a capacity of 402MW with 67 turbines. Equinor's

[6] Ørsted, "About the Project: Hornsea 3".

extension project is expected to increase the combined generating capacity of these sites by 1.35GW.

During the construction of this expansion project, it is estimated that up to 1,730 full-time jobs could be created. Once operational, these projects are expected to sustain approximately 270 jobs, assuming that all direct operations and maintenance employment is based in the UK for the lifetime of the projects.

2.2 Regional and strategic context

The proposed investment site is the Norwich Main 400kV substation (Figure 1), part of our East Anglia electricity transmission network area. Our existing substation at Norwich Main has been in service for around 50 years. Extending the site will enable new sources of electricity generation to connect into the grid – including Hornsea P3, the Equinor extension [redacted] This investment is critical to enable NGET to transmit the offshore wind generated in the region to the south of the country without system constraints.

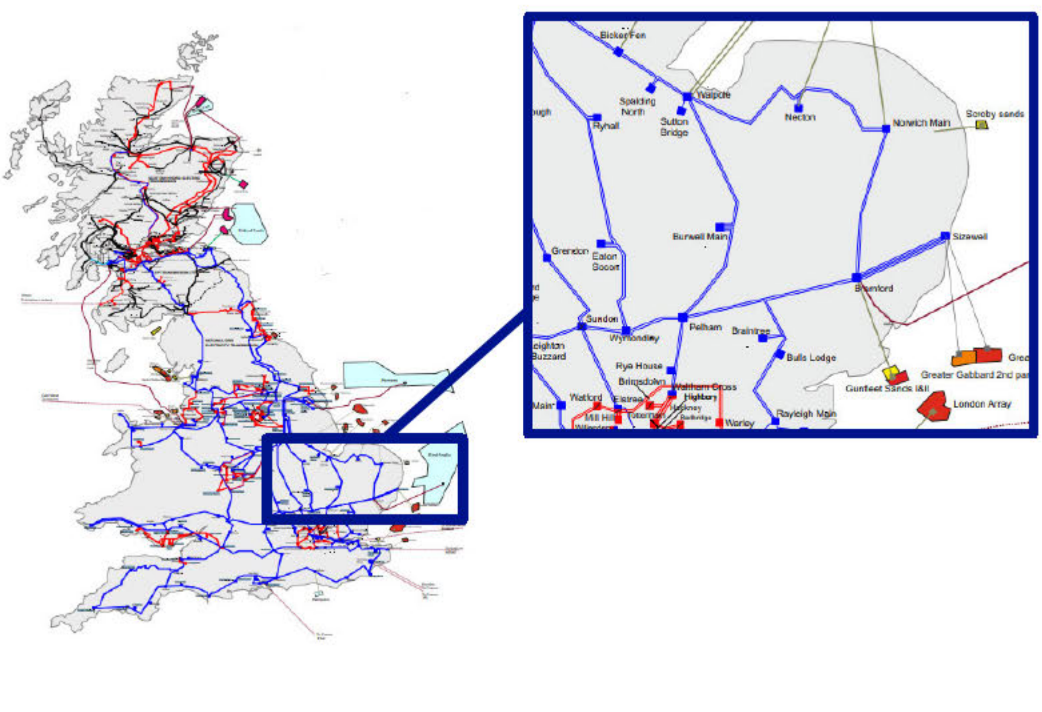
As outlined in Section 2.1, the project addresses the need to enable the connection of significant offshore wind assets to the grid. NESO's Clean Power 2030 report, published in November 2024, noted that offshore wind must be the bedrock of the UK's clean power system by 2030. NESO's analysis on pathways to clean power by 2030 reports that the rollout of offshore wind is needed at over double the highest rate ever achieved in Great Britain.

The report also noted that the Norwich to Tilbury OHL, which this investment will help enable by providing space for the Norwich connection point, forms a critical component of achieving the UK's clean power objectives. The OHL is being delivered via two ASTI projects and while the associated infrastructure will be delivered as part of this site strategy, finance for this element of the site strategy is being secured through a separate ASTI mechanism.

The East Anglian electricity transmission network (Figure 1) has historically been a net importer of power and is developing into a net exporting region. The existing network can also be influenced by future development outside of the region such as wind generation in the North and flows on the interconnectors to Europe on the South Coast. The general pattern of power flow in the East Anglia transmission network will be north-south flows carrying power to London and Southeast England from offshore wind and nuclear power stations. As East Anglia develops into an exporting region, the East Anglian network must be made capable of carrying power towards London and interconnector exports.

About one third of the UK's current energy demand could be met by the energy that will be coming into East Anglia by the end of the decade. While East Anglia is currently predominantly a net importer, growing renewable electricity generation connecting to this region means East Anglia is becoming a net exporter of power. In the coming years, the region must facilitate the coordination of new offshore generation and interconnectors.

Figure 1: NGET's transmission network routes in East Anglia.



2.3 T3 interactions

Although this MSIP is being submitted under the RIIO-T2 price control, it interacts with and forms part of the same regional strategy outlined in NGET's RIIO-T3 Business Plan. Norwich Main substation is located within our East Anglia Region. During the T3 period, five major substation interventions are scheduled across this region, along with the construction of eight new substations.

By delivering the works at Norwich Main substation as part of a site strategy, we are ensuring this investment meets the goal of connecting 4.75GW of generation to the Norwich Main substation, while also enabling the connection of the N-T OHL – part of our Great Grid Upgrade. The N-T OHL will support the UK's net zero target by connecting new low-carbon energy generation and reinforcing the regional transmission network. This investment aligns with the future network blueprint for the region as outlined in our T3 Business Plan by anticipating and facilitating future customer connections and delivering the infrastructure needed to accommodate the significant growth in new energy generation in the region.

The Norwich Main site strategy works outlined in this MSIP support initiatives in our T3 business plan and align with the future network blueprint for the East Anglia region.[7] This investment will play an important role in supporting the UK's clean energy transition, ensuring new clean energy projects are connected to the grid in a strategic way that prioritises the need to minimise costs to consumers.

Looking ahead there is a high level of demand for connections across the East Anglia region surrounding substations like Norwich Main and Necton (which is also being extended and for which there is a separate January 2025 MSIP submission). This high volume of demand for grid connections necessitates a strategic approach to new investment in the area. However, we recognise that the implementation of Connections Reform, in tandem with the Government's Clean Power 2030 Action plan, will have a significant impact on the connections landscape at both a national and regional level. This will, in turn, help us to refine the number, type and location of new investments in East Anglia moving forward.

Table 2: Alignment with Ofgem T3 consumer outcomes

Infrastructure fit for a low-cost transition to net zero	Enabling the connection of two major windfarm projects, one of which is set to be the world's single largest offshore windfarm, as well as a new solar farm will facilitate an additional 4.75GW of renewable energy onto the grid, supporting the UK's transition to net zero.
System efficiency and long-term value for money	Delivering this project as a site strategy enables us to extend the footprint of the substation to accommodate future customers. This minimises the overall volume of work, reduces the duration of future outages and maximises NGET resources – delivering strong consumer outcomes by reducing duplication, maximising project efficiency, and avoiding the need for repeated bite size expansions.

[7] National Grid Electricity Transmission, "East Anglia: Future Network Blueprint", January 2025.

2.5 System Design Table

NGET has identified 2 credible system design options to respond to the customer connection drivers, as presented in Table 3 below.

Table 3: System Design Table

[redacted]

	New GVA Rating	[redacted]
System Requirements	Present Demand (if applicable)	[redacted]
	2050 Future Demand	[redacted]
	Present Generation (if applicable)	[redacted]
	Future Generation Count	[redacted]

		[redacted]
	Future Generation Capacity	
Initial Design Considerations	Limiting Factor	
	AIS/ GIS	
	Busbar Design	
	Cable/ OHL/ Mixed	
	SI Strategic Investment	

3. Establishing Need

3.1 Overview

This section sets out the key drivers of the investment need, which is summarised in Table 4 below.

Table 4: Norwich Main Site Strategy – Summary of Key Investment Driver

Summary of Primary Driver		Date
Customer Connections	NGET has signed three connection agreements with customers. Two of these customers, Ørsted and Equinor, are seeking to connect two separate offshore wind farm projects. [redacted] NGET has a high degree of confidence that the two offshore wind customers will require their connections and network capacity in the timescales indicated. The growth of renewable energy projects in the region highlights demand resilience, [redacted]	[redacted]

Further details on the timeline of customer connection requests and confidence in these customers can be found in the Section 3.2.

3.2 Load related drivers

NGET has signed three connection agreements – with Ørsted, Equinor and [redacted] Two of the customers are seeking to connect major offshore wind projects, [redacted] The request is to provide connections to the grid for Ørsted [redacted] for Equinor [redacted]. Details of the load-related drivers for this project are presented in Table 5 below. As outlined previously, the upgrades to the Norwich Main substation will enable the connection of these three customers, as well as the N-T OHL.

Table 5: Details of Load drivers

Customer Name	Project Name	Project Type	MW	ACL Date[8]	Customer Status
Ørsted	Hornsea P3	Offshore wind	3000	[redacted]	Planning permission under a DCO and FID in place.
Equinor	Sheringham and Dudgeon wind farm expansion	Offshore wind	1350	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[8] The Available for Commercial Load (ACL) date refers to the date that a customer requests in its connection request to NGET.

3.3 Customer drivers

Our contracted connections pipeline is growing at an unprecedented rate. To help develop the network in a way which delivers value for consumers, we have developed a consistent and repeatable methodology for assessing our confidence in each contracted customer connection project proceeding to connect. This methodology is outlined in our T3 Business Plan submission. This methodology results in a score and associated RAG rating that demonstrates the relative likelihood that a contracted project will proceed to connect to our network based on its technology, characteristics, and progress against key milestones. Projects scoring:

- ≥7 are rated green and are most likely to connect.
- ≥ 5 but < 7 are rated amber and have some chance of proceeding.
- <5 are rated red and are less likely to proceed.

It is important to recognise that because the scores are relative, a customer assessed as 'most likely to connect' is not guaranteed to connect and a customer that is 'less likely' to proceed could proceed to connect. We also recognise that the implementation of Connections Reform, in tandem with the Government's Clean Power 2030 Action plan, will have a significant impact on the connections landscape at both a national and regional level.

The contracted projects at Norwich Main as part of this site strategy are shown below in Table 6. [redacted]

Table 6: Customer confidence assessment

Customer Name	Project Name	Project Type	MW	ACL Date[9]	RAG confidence
Ørsted	Hornsea P3	Offshore wind	3000	[redacted]	[redacted]
Equinor	Sheringham and Dudgeon wind farm expansion	Offshore wind	1350	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

3.4 Existing and planned future network

The Norwich Main substation is located approximately 3 miles south of the city of Norwich and is owned and maintained by NGET. Other substations located in the region include Necton and Walpole, located approximately 40km and 87km away from Norwich Main respectively (Figure 2).

Our investment at the Norwich Main substation comes against a backdrop of broader network investment in the region. East Anglia's 400kV electricity transmission network was built in the 1960s to supply regional demand, centred around Norwich and Ipswich. With the growth in new energy generation from offshore wind and other sources, there will be more electricity connected in East Anglia than the network can currently accommodate. Over the next decade, NGET anticipate over 15,000MW of new generation will need to connect in the region.[10]

In its current state, the high voltage electricity network in East Anglia does not have sufficient capacity to accommodate this new generation. As a result, NGET is developing a new Norwich to

[9] The Available for Commercial Load (ACL) date refers to the date that a customer requests in its connection request to NGET.
[10] National Grid Electricity Transmission, "Norwich to Tilbury".

Tilbury OHL, currently being progressed under the ASTI framework. The new OHL consists of two projects:

- [redacted]
- [redacted]

These projects – working in conjunction with [redacted] provides the additional required network capacity.

[redacted]

Figure 2: Aerial map of key substations in East Anglia.

4. Optioneering

This section summarises the options we considered to address the needs case established in the previous section in a way that best serves the interest of current and future consumers.

In line with our optioneering process, we identified the following high-level options:

A. Identification of a do-nothing option as the counterfactual option.
B. Identification of a market-based solution.
C. Identification of a non-transmission, whole systems solution.
D. Identification of options for making use of existing NGET substations.
E. Identification of possible options for a new substation.

In summary:

- **Options A-C** were discounted because they would not deliver a compliant connection.
- Three configurations of **Option D** (making use of an existing NGET substation) were considered, differing on the basis of technology (AIS or HIS) and site configuration. Due to their capacity and SQSS requirements, the four Hornsea P3 bays must be positioned on separate bus sections – meaning an eastern and western extension was required in all options.
    - **Option D-1** considers both an eastern and western AIS extension, with Equinor connection in a western bay.
    - **Option D-2** considers both an eastern and western HIS extension, with Equinor connecting in a western bay.
    - **Option D-3** considers both an eastern and western AIS extension, with Equinor connecting in an eastern bay.
- **Option E** (developing a new substation) was discounted. While NGET considered the viability of constructing a substation next to the Hornsea P3 landing point, this would require the acquisition of new land and the development of additional infrastructure, including new OHLs. Additionally, this option would necessitate additional planning approval, which would likely impact the project timelines. Given the critical [redacted] for Hornsea P3, and the importance of this connection in enabling the UK to meet its 2030 decarbonisation targets, NGET concluded that pursuing this option would pose a significant risk to project delivery deadlines and would incur additional costs that would not be in the best interest of consumers when existing assets could instead be utilised (as in Option-D). As outlined in section 4.1 below, the CION process had also identified Norwich Main as the appropriate connection point.

The optioneering process originally only considered the need to connect Hornsea P3, Equinor, and the N-T OHL – [redacted]. In 2021, system design specifications also identified the need for a bus coupler to be present on each bus section.

Following the initial consideration of these options in light of these requirements, NGET shortlisted two options (D-1 and D-3) and conducted a detailed assessment of these options, outlined in Section 5.

4.1 Connection and Infrastructure Options Note (CION)

For the Hornsea P3 connection, the decision to pursue Norwich Main as the preferred connection point was determined multilaterally between NGET, the customer (representing the OFTO [Offshore Transmission Owner]) and the NESO, via the CION process.

4.1.1. Introduction to CION

CION is a collaborative process between TOs, OFTOs, and NESO to find the most cost-effective and coordinated connection option for offshore transmission and interconnector projects. For this project, NGET, Ørsted, and NESO identified the best connection option for Hornsea P3.

The CION details the chosen connection option, considering technical, commercial, regulatory, environmental, planning, and deliverability factors. It facilitates an appraisal of a variety of options and identifies the preferred onshore connection points and offshore transmission network configuration. The CION serves as a dynamic document that guides investment decisions and planning by all parties involved in the process.

Key roles within the CION include:

- Onshore TOs, NGET in this case, assess feasible onshore connection points and transmission construction works.
- Offshore TOs, in this case Ørsted, assess feasible offshore connection designs and required offshore transmission construction works.
- The NESO records the economic assessments to determine the most economic connection option and records this, together with the selection rationale as agreed by the TO and Developer parties.

4.1.2. Outcomes of the Hornsea P3 CION process

The initial CION process for the Hornsea P3 investment began in 2016, with a second version delivered in 2020 following a Mod App to increase the TEC from 2000MW to 3000MW. Key considerations and outcomes are:

1. [redacted] locations were initially identified in the CION process [redacted] The final location at Norwich Main 400kV substation was identified as most economical solution in the 2016 CION.
2. Following the submission of the 2018 Mod App, a CION Stage 1 appraisal by NGET reviewed the status of the existing onshore network and potential options for the connection of the project. Based on this initial review, only Norwich Main and [redacted] substations are taken forward in the 2020 CION process.
3. [redacted] NESO subsequently recommend Norwich Main to connect the Hornsea P3 wind farm.

The result of this CION process directed NGET to focus on establishing options to facilitate the connection of Hornsea P3 at Norwich Main substation. The following section explores in greater detail the options to facilitate all customer connections at Norwich Main.

4.1 Assessment of high-level options

As above, a summary of our assessment of the high-level options identified to meet the customer need is set out below. Each of these is assessed against the following criteria:

- Capacity and future development potential
- Design and technical complexities
- Operation and maintenance
- Safety, health and security
- Planning, land and consent
- Third party impact and network coordination
- Environment and Sustainability
- Timing of programme and resources
- Cost

A summary of our initial options assessment is in Table 7 below.

Table 7: Summary of initial options assessment

Option	Option title	Option description	Taken Forward to Detailed Optioneering?	Rationale
A	Do nothing	NGET does not undertake any activity.	**Not taken forward** – the option does not comply with NGET licence obligations to provide customer connections.	Compliant customer connection not delivered.
B	Market-based solution	Customer connection is accommodated through the procurement and use of ancillary services only.	**Not taken forward** – the option does not comply with NGET licence obligations to provide connections.	Compliant customer connection not delivered.
C	Whole systems solution	The required customer connection is accommodated by a Distribution Network Operator (DNO) instead of NGET.	**Not taken forward**	The scale of the customer connections required could not feasibly be accommodated via a DNO.
D-1	Use existing assets	**Eastern and western AIS extension with Equinor connection in western bay.**	**Taken forward to detailed assessment**	**Delivers compliant customer connection**

Option	Option title	Option description	Taken Forward to Detailed Optioneering?	Rationale
		[redacted]		Delivers a compliant customer connection with an AIS solution. The Hornsea P3 cables are individually connected using one full bay width per cable connection.
D-2	Use existing assets	**Eastern and western HIS[11] extension with Equinor connection in western bay.** [redacted]	**Not taken forward to detailed assessment**	**Does not deliver compliant customer connection** While originally considered, NGET determined that this option would not deliver a compliant customer connection, as it did not include the necessary additional bus coupler required. The Hornsea P3 cables are individually connected but using two bay widths only.
D-3	Use existing assets	**Eastern and western AIS extension with Equinor connection in eastern bay.** [redacted]	**Taken forward to detailed assessment**	**Delivers compliant customer connection** Delivers a compliant customer connection with an AIS solution. Reduces the size of the western extension required. Additional bus coupler is compliant with the revised System Design Specification requirements.

[11] HIS is a compact and modular substation configuration that combines SF6 gas-insulated switchgear (GIS) with air insulated switchgear (AIS) components. It is designed to reduce the footprint of traditional AIS substations while maintaining flexibility and ease of operation and are suitable for outdoor applications.

Option	Option title	Option description	Taken Forward to Detailed Optioneering?	Rationale
E-1	Build new	Construction of new substation adjacent to customer connection landing point.	**Not taken forward**	**Cost and timing – inefficient and unnecessary** Although this option would achieve a compliant customer connection, it would result in higher costs and extended timelines. Additionally, land acquisition would become necessary, posing various planning constraints that need to be addressed. Furthermore, additional infrastructure, such as new overhead lines (OHL), would be required to integrate power into the grid, which would also face associated planning constraints.

Following this initial optioneering assessment, two options were identified as the most suitable options to be taken forward to detailed assessment, which is set out in Section 5. The shortlisted options are:

- Option D-1: Eastern and western AIS extension with Equinor connection in western bay. [redacted]
- [redacted] Option D-3: Eastern and western AIS extension with Equinor connection in eastern bay. [redacted]

5. Detailed Options Analysis

In Section 4, two options (D-1 and D-3) were identified to be taken forward to the detailed options assessment. The key difference between these two shortlisted options relates to the location of new bays within the substation (with Equinor either on the eastern or western extension).

This section provides a qualitative and quantitative (CBA) assessment of the alternative technology options and bay configurations that led NGET to identify the preferred option for an eastern and western AIS extension of the existing Norwich Main 400kV substation.

5.1 Description of the options

Two shortlisted options were considered: an eastern and western AIS extension with an Equinor connection in the western bay (D-1) and an eastern and western AIS extension with an Equinor connection in eastern bay (D-3).

Due to their capacity, the four Hornsea P3 bays need to be on separate bus sections (east and west). Optioneering subsequently focused on the location of the Equinor connection (either east or west).

Option D-3 would require [redacted]

The D-3 design also fails to account for the two spare bays, one of which is later assigned for Innova in D-1. [redacted]

[redacted]

In Option D-1, each Hornsea P3 connection is integrated into a double AIS bay, with two in an eastern extension and two in a western extension at the site. One spare bay is designated for a bus coupler, while Equinor is connected to a new section on the west. An additional bus coupler bay will be installed between the Equinor and Bramford 4 circuits on bus section 4.

D-1: Changes made during detailed design

[redacted]

The Option D-1 design had originally accounted for two additional spare bays for the possible connection of two National Energy System Operator (NESO) Pathfinders. However, this element was later removed from the scope of the site strategy following NESO confirmation in November 2023 that they no longer required space at the Norwich Main site for the pathfinders.

As a result, two bays which had originally been reserved for this NESO work were made available again, and this option was adjusted during the detailed design stage. Bus Coupler 4 was repositioned to be placed where one of the original NESO pathfinder bays was planned, while the other former NESO bay was reallocated as a connection point for [redacted]. This solution enabled us to repurpose existing plans and avoid building more than required, particularly noting the 5GW capacity limit at Norwich Main.

This modified layout is shown in Section 5.4 Figure 5.

[redacted]

Option D-3 includes both an eastern and western extension to connect the four Hornsea P3 connections into four new bays. Under this option, the Equinor connection would have been relocated from a western extension (as in D-1) to an eastern extension, adjacent to the eastern extension for the Hornsea P3 connection. This option would also include the associated bus section and bus coupler bays, as well as the relocation of the Bramford 2 OHL circuit.

5.2 Qualitative options analysis

Table 8 below provides a summary of our detailed qualitative assessment of the relevant technical, environmental, planning, and socio-economic considerations pertaining to the shortlisted options.

Table 8: Summary of qualitative analysis of shortlisted options

Option #	D-1	D-3
Option title	**Eastern and western AIS extension with Equinor connection in western bay**	**Eastern and western AIS extension with Equinor connection in eastern bay**
Capacity & future development potential Preferred option: D-1.	• Low risk of creating stranded assets if Equinor does not connect. • Accounts for two extra bays – one of which can be repurposed to accommodate [redacted]	• Does not incorporate extra two bays. • Potential of avoiding installation of bus coupler until Equinor connects.
Design & technical complexities Preferred option: D-1.	• Likely requires cable crossing of Hornsea P3 and Equinor. However, cable crossing of Hornsea P3 and Equinor cables could be mitigated by routing Hornsea P3 cables through west extension inside Equinor bay.	• Reduces the size of the western extension required. • Added costs and complexity of cable duck under to avoid added network constraint of undersailing OHL conductors.
Operations & maintenance Preferred option: D-1.	• Due to the close proximity of bays in the western extension there could be a requirement for proximity outages during maintenance. Mitigation might be to increase segregation. • There is a risk in having the Equinor bay between 2 Bramford feeder bays.	• Should cable duck under not be feasible, there is a need for proximity outage during maintenance on the oversailing OHL.
Safety, health & security Preferred option: No overall advantage to either option.	• No significant difference between options.	• No significant difference between options.
Planning, land & consent Preferred option: D-1	• Extension for customer connections will extend beyond current land ownership on the west of the site, therefore land acquisition required.	• Minimises the size of the western extension required by moving Equinor bay to an expanded eastern extension.

Option #	D-1	D-3
Option title	Eastern and western AIS extension with Equinor connection in western bay	Eastern and western AIS extension with Equinor connection in eastern bay
		• Extension for customer connections will extend beyond current land ownership on west of the site, therefore land acquisition required. • Eastern extension overlaps the proposed [redacted] Therefore, this option was considered not feasible due to lack of physical space.
Third party impact & network coordination Preferred option: D-2	• Cable crossing of Hornsea P3 and Equinor cables could be mitigated by routing Hornsea P3 cables through west extension inside Equinor bay.	• Potential for no cable crossing for Equinor – Hornsea P3.
Environment & sustainability Preferred option: No overall advantage to either option.	• AIS solution; avoids the additional SF6 associated with GIS solution.	• AIS solution; avoids the additional SF6 associated with GIS solution.
Timing of programme & resources Preferred option: No overall advantage to either option.	• No significant difference between options.	• No significant difference between options.

Based on the qualitative analysis of shortlisted options detailed in the table above, **Option D-1 is the preferred option**, offering what we consider to be the most advantageous option for consumers, considering the broad range of factors:

- **Design and technical complexities:** Option D-1 avoids the added costs and complexity of cable duck under, which would be required in Option D-3 to avoid added network constraint of undersailing OHL conductors.
- **Lands and Consents:** Both Option D-1 and D-3 require land acquisition to the west of the site as the extension for customer connections will extend beyond current land ownership. However, Option D-1 is preferred to Option D-3 because the larger eastern extension in Option D-3 would overlap with

the proposed [redacted] for which Planning Permission has already been granted. As a result, Option D-3 was considered not feasible due to lack of physical space.

The next section outlines our quantitative assessment of the two options. We have considered both the outcome of this qualitative assessment and the follow quantitative assessment in making our final decision.

5.3 Quantitative options analysis

5.3.1 Lifetime Cost-Benefit analysis (CBA)

The CBA was carried out using the NGET CBA/NPV (net present value) tool which is based on Ofgem RIIO-T2 CBA template spreadsheet, assuming a capitalisation rate of 85% and a pre-tax (weighted average cost of capital) WACC of 3.27%, in line with Ofgem's guidelines.

A summary of the lifetime CBA results is presented in the table below. The full CBA is appended alongside this submission in Appendix B. Costs and benefits are discounted at a rate of 3.5% for the first thirty years, and at 3% after that, in line with Ofgem guidance. Costs and benefits are presented relative to a 'do minimum' counterfactual.

The results shown in the table below demonstrate that option D-1 has a more favourable NPV in comparison to D-3.

Table 9: Lifetime Cost-Benefit analysis (discounted 2018/19 prices)

Options	Total (£m)			
	Costs (discounted)	Benefits (discounted)	NPV	Difference to baseline
"Do minimum"	[redacted]	[redacted]	[redacted]	[redacted]
Option D-1	[redacted]	[redacted]	[redacted]	[redacted]
Option D-3	[redacted]	[redacted]	[redacted]	[redacted]

5.3.2 Costs

5.3.2.1 Capex costs

All CAPEX cost estimates are derived from the NGET Project Development Cost Book (August 2024 with 2018/19 prices), which is based on historical tender returns and project data. The cost estimations are based on pre-tender award estimates and are subject to change based on actual tendered solutions. The illustrated options are assessed against a "do minimum" counterfactual.

We have used Estimating Units Lines (EULs) to generate cost estimates based on the scope of work and the new assets to be constructed for each option, including risk contingency.

Table 10: Summary of costs (undiscounted 2018/19 prices)

Option	Total CAPEX (£m)	Carbon cost of construction (£m)	Total (£m)
D-1	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]

It can be assumed that the slight difference within the CAPEX cost can be accounted for by the slight difference in scope between the two options. [redacted]

Future replacements cost of new assets

To assess the costs of the investment, future replacement costs of the new assets were included within the CBA. It has been assumed that the assets on average would have a lifespan of 40 years after the first year of construction. With initial construction commencing in 2025, the replacement costs will commence in 2065. It has also been assumed that the replacement cost would mirror the absolute cost and timespan occurred in the initial construction. The replacement costs will also impact the carbon cost of construction. In line with Ofgem guidance, the CBA spans 50 years commencing 2023. As both the construction and replacement occur within the 50-year appraisal, the replacement cost has been taken into account within the assessment.

Table 11: Summary of replacement costs (undiscounted 2018/19 prices)

Option	Replacement Spend Profile (£m)	Carbon cost of construction (£m)	Total (£m)
D-1	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]

5.3.2.2 OPEX costs

Annual maintenance costs [applies to no option]

Given that the maintenance costs do not differ amongst options, and that estimation of these costs would be heavily assumption-driven, annual maintenance costs have been excluded from the CBA.

Constraint costs [applies to no option]

Given that estimation of outages would be heavily assumption driven, we have not included constraint costs within the assessment of options.

5.3.2.3 Summary of costs

A summary of the costs within the assessment is illustrated within the following table:

Table 12: Cost Summary £m (undiscounted 2018/19 prices)

Option	Initial cost (£m)	Replacement cost (£m)	Total cost (£m)
D-1	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]

5.3.3 Benefits

Avoided carbon cost of generation

During the lifespan of the new connection point, energy will be created that originates from renewable sources. This proposal suggests three connections including a Ørsted [redacted] Equinor [redacted] (both offshore wind) and [redacted]

Each connection assists with the development of utilising renewable energy sources that lead to avoided carbon emission in comparison to other sources. This is estimated using the NGET CBA tool based on cost of carbon for displaced generation (assumes CCGT), for type of connection, year, load factor and annual output. The table below illustrates the benefit for each option:

Table 13: Avoided carbon cost of generation (undiscounted 2018/19 prices)

Option	Avoided carbon cost of generation (£m)
[redacted]	[redacted]
[redacted]	[redacted]

SF6 – leakages

No SF6 leakage data was identified and therefore not included within the assessment.

G3 – leakages

Upon operation gas leaks will be unavoidable. The disbenefit of these leaks is accounted for by the monetisation of the economic value of 1kg of CO_2 emissions. The disbenefit was quantified by the multiplication of the total non-SF6 weight by 0.5% which captures the leakage and disbenefit to society. The value was divided by a thousand and multiplied by the 326 which represents the equivalent of G^3 weight into CO_2. The equivalent CO_2 weight is multiplied by the carbon price to calculate the disbenefit. Table 13 below illustrates the non-SF6 disbenefits for the analysis.

No SF6 leakage data was identified and therefore not included within the assessment.

Table 14: Gas leak disbenefit (undiscounted 2018/19 prices)

Option	SF_6 emissions (kg)	G^3 emissions (kg)	G3 emissions (tCO_2e)	Economic value of the benefit (£m)
D-1	[redacted]	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]	[redacted]

Transmission losses

Transmission losses occur when energy is lost in equipment due to forces such as friction which turn the electricity into heat. Within the assessment the loss of electricity has been accounted for as a disbenefit to society as the lost electricity that could have been utilised.

The disbenefit is calculated utilising the transmission loss estimates from the cost book for each option. The loss is assumed to occur during and after the ACL for 40 years as explained in the template. The total estimation is divided by the 30 years to obtain an annual disbenefit. The value is then divided by the total losses to understand the transmission loss as a proportion of the total loss. The yearly loss is then divided by the electricity GHG conversion factor (tonnes per MWh) to calculate the annual MWh loss per year across the lifespan.

The value is converted into tCO2 equivalent utilising the electricity GHG conversion factor. The value of the disbenefit is then multiplied by the traded carbon price to obtain a quantified value. In addition, the value of gas loss was calculated by multiplying the annual MWH loss with the GHG reduction factor divided by a million. This was then multiplied by the cost per unit of MWh loss. The addition of the gas and CO2 equivalent loss created the disbenefit presented below.

The outputs are illustrated in the table below:

Table 15: Transmission losses (undiscounted 2018/19 prices)

Option	Total MWh loss	Emissions associated with losses (tCO_2e)	Value of loss (£m)
D-1	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]

5.3.3.2 Summary of benefits

A summary of benefits included in the analysis is illustrated in the following table:

Table 16: Benefits summary (undiscounted 2018/19 prices)

Option	Environmental benefits			Total benefits (£m)
	Carbon cost of construction (£m)	Gas leak (£m)	Transmission loss (£m)	
'Do minimum'	-	-	-	-
D-1	[redacted]	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]	[redacted]

5.4 Preferred solution

The preferred solution is Option D-1. As outlined in Section 5.1.1, this option originally accounted for two additional spare bays for the possible connection of two National Energy System Operator (NESO) Pathfinders. However, this element was later removed from the scope of the site strategy following NESO confirmation in November 2023 that they no longer required space at the Norwich Main site for the pathfinders.

As a result, two bays which had originally been reserved for this NESO work were made available again, and this option was adjusted during the detailed design stage. Bus Coupler 4 was repositioned to be placed where one of the original NESO pathfinder bays was planned, while the other former NESO bay was reallocated as a connection point for [redacted]. This solution enabled us to repurpose existing plans and avoid building more than required, particularly noting the 5GW capacity limit at Norwich Main.

As a result, the final preferred solution is to extend Norwich Main 400kV substation to the east and west to accommodate the addition of eight new bays (Figure 5). [redacted]

Based on the qualitative and quantitative analysis, we have recommended Option D-1 as the solution for this investment driver. By taking future connections into account during design, this proposed solution minimises future constraints on the system caused by outages, as well as the environmental and economic impact on consumers of repeated work. This minimises the need for rework and offers a value for money solution for consumers.

This option will allow NGET to deliver at pace to meet the Hornsea P3 [redacted] date, supporting the consumer interest in delivering this crucial net zero investment.

The scope of work for the preferred solution, Option D-1, is as follows:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

6. Detailed Cost for Preferred Solution

6.1 Introduction

This section provides a breakdown of the overall costs for the Norwich Main substation extension including an expenditure profile for all Regulatory Years of delivery.

The following cost estimate breakdown represents our latest view of costs for the proposed investment and all costs are presented in 2018/19 price base, unless otherwise stated.

Appendix C Cost Model submitted alongside this document provides a breakdown of the costs in more detail and should be reviewed alongside this chapter.

This Chapter is broken down into the following sections:

4.3.2 Total Allowance Request

4.3.3. Cost Estimate

4.4.4. Cost Firmness

6.2 Total Allowance Request

Total project costs are [redacted]. NGET requests [redacted] allowance is provided through the MSIP reopener mechanism to recover the direct portion of costs and deliver works described above. The MSIP reopener mechanism is subject to the Opex escalator and therefore indirect costs will be funded under this route.

Table 17 - Allowance request – Cost Model tab reference 1.0

	2018/19 price base (£)							
	T1 & Prior Costs	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	Total
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6.3 Cost Summary

The total cost to develop and deliver the Norwich Main site extension project is [redacted] including indirect costs and costs incurred to date.

Table 18 below shows a summary of total project costs.

Table 18 - Cost Summary – Cost Model tab reference 1.1

Element	Total (2018/19 price base, £)	Source
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	

6.4 Cost Firmness

Table 19 below shows the assessment of cost firmness using the classification outlined in the Ofgem LOTI reopener guidance document published on 29th March 2021. This shows that [redacted] of the total costs (firmness 1 and 2) are either incurred or have been contracted, giving high confidence in our cost submission.

Table 19 - Cost Firmness – Cost Model Tab reference 1.9

Cost Firmness	Total (£)	Notes
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	

Estimated costs relate to National Grid resource costs, calculated based on forecast days and standard rates, as well as risk for the remainder of the project.

7. Deliverability and risk

7.1 Deliverability

This section sets out a summary of the key activities pertaining to the delivery of the project, including the current high-level programme plan, procurement strategy and anticipated risks.

7.1.1 Delivery Programme

Hornsea P3 is being delivered [redacted]

The Equinor project will also be delivered [redacted]

[redacted]

7.1.2. Stakeholder engagement

During consents process, throughout 2024, stakeholder engagement took place four times. This was through two webinars and two in-person townhall meetings.

This included NGET project managers, consents officers and NGET's media managers. It also involved Norwich to Tilbury representatives. The aim of the sessions was to inform the local population of the project.

7.1.3 Procurement and Contracting Strategy

NGET awarded the contract for this investment [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7.2 Risk and Risk Management

A risk management process has been used for managing reasonably foreseeable risks. The process employed is in line with ISO 31000:2009, Risk Management – Principles and Guidelines.

Table 20 below lists the key risks identified for the project. The full Risk Register is included in tab 4.1 of the Cost Model appended to this submission.

Table 20: Delivery risks for Norwich Main Site Strategy

Risks	Mitigation
Outage availability: NGET outages may not be available to meet planned project schedule or are cancelled or amended at short notice. This would be likely to lead to delays and an inability to complete works within schedule.	This is being mitigated through monthly cross-functional and cross-DV meetings to discuss project dependencies.
Ground conditions: Ground conditions are variable. There is a risk that ground contamination is more extensive than expected, which may delay project schedule and increase costs to remove any contaminated ground.	This is being mitigated by carrying out regular site inspections.
Second busbar protection system: Due to the size of the substation, a second busbar protection system is likely to be triggered, which would require additional work to install, thereby delaying the programme schedule and increasing costs.	This is being mitigated through internal engagement with Asset Operations to determine if works are required and define scope.
Substation rating: The increase in fault current triggered by additional generation is likely to result in a requirement to upgrade the substation rating to 63kA. This will delay the programme and impact costs.	A site rating survey is to be carried out to help mitigate the risks associated with this.
[redacted]	[redacted]
Landscaping plan changes: There is a risk that the Council requests changes to the landscaping strategy in order to discharge planning requirements. This could require re-design works and more extensive bulk civil works.	To mitigate this risk, we are maintaining ongoing liaison with the council, and additional float time has been incorporated into the programme.

8. Conclusion

This document is NGET's formal MSIP re-opener submission to Ofgem for the Norwich Main substation expansion in East Anglia. It is submitted with reference to Special Condition 3.14.6 of NGET's Transmission Licence.

Table 21 below summarises the main investment driver, the selected option, estimated costs and expected outputs.

Table 21: Norwich Main Site Strategy Project Investment Summary

<table>
<tr><td rowspan="1">Main drivers</td><td colspan="3">Generation connection – to enable the connection of 4.75GW of renewable electricity generation.

Primary driver: To connect 4.75GW of electricity generation from Hornsea P3, the Equinor extension, and [redacted] to the Norwich Main 400kV substation, and to expand the footprint of the substation to accommodate the Norwich to Tilbury overhead line (OHL).

Secondary driver: Security and Quality of Supply Standard (SQSS) works have been triggered due to the generation volume for this project and the subsequent need for reinforcement infrastructure.</td></tr>
<tr><td>Selected Option</td><td colspan="3">The extension of Norwich Main 400kV substation to the east and west to accommodate the addition of 8 new bays. [redacted]

The investment will also include related works to facilitate future extension, including constructing a new 400kV circuit breaker and a new bus coupler, driving value for money for future consumers by conducting requisite works concurrently.</td></tr>
<tr><td rowspan="2">Estimated Cost (price base 2018/19)</td><td colspan="3">The current total cost of the project is [redacted]
The direct costs and funding allowance being sought is: [redacted]</td></tr>
<tr><td>T2 (FY2022 – FY2026):
[redacted]</td><td>T3 (FY 2027 – FY2031):
[redacted]</td><td>T4+ (FY 2032+):
[redacted]</td></tr>
<tr><td>Outputs</td><td colspan="3">Network capacity: This investment will provide a 4.75GW SQSS compliant generation connection for two major offshore wind farms and a [redacted]</td></tr>
</table>

This paper, together with the associated Cost-Benefit Analysis (CBA), summarises NGET's proposed investment to extend the Norwich Main 400kV substation to connect multiple renewable energy projects, including Hornsea P3 – set to be the world's largest offshore wind farm – the Equinor extension, and [redacted]. Together, these projects will add 4.75GW of renewable energy to the grid. This investment aligns with the UK's net-zero goals and Government strategies to increase offshore wind power. The preferred solution involves an extension of the Norwich Main substation to accommodate eight new AIS bays for imminent and future connections – providing strong consumer benefit by avoiding the need for repeated works at site.

9. RIIO-T1 and RIIO-T2 Allowances

The Hornsea P3 component of the Norwich Main extension was allocated [redacted] in bridging funding under the T2 price control.

The request in this MSIP submission is on the basis that this funding is maintained.

The differential between the volume driver and the funding request has been based on the assumption that this bridging funding is maintained.

T1/T2	Ofgem Ref No	Scheme Title	Allowances (net, excluding CAI)
[redacted]	[redacted]	[redacted]	[redacted]

10. Assurance and Point of Contact

Attached to this submission is the assurance statement letter, providing written confirmation in line with the assurance requirements set out in Ofgem's Re-opener Guidance and Application Requirements Document, dated 17th February 2023. This confirmation is provided by the Head of Future Price Controls, Electricity Transmission.

They provide the following statements below regarding how this MSIP application has been prepared and submitted in relation to each of the three assurance points requested by Ofgem:

a. It is accurate and robust, and that the proposed outcomes of the MSIP submission are financeable and represent best value for consumers.

b. There are quality assurance processes in place to ensure the licensee has provided high-quality information to enable Ofgem to make decisions which are in the interests of consumers.

c. The application has been subject to internal governance arrangements and received sign off at an appropriate level within the licensee.

NGET's designated point of contact for this MSIP application is Leo Michelmore, Strategic Upgrade Regulatory Manager (leo.michelmore@nationalgrid.com).

Appendix A: Volume Driver

Please see the accompanying Volume Driver calculation submitted alongside this MSIP: ‘Appendix A Norwich – MSIP Jan 25 – Volume Driver’.

Appendix B: Cost Benefit Analysis

Please see the accompanying Cost Benefit Analysis submitted alongside this MSIP: ‘Appendix B Norwich – MSIP Jan 25 – CBA’.

Appendix C: Cost Model

Please see the accompanying Cost Model submitted alongside this MSIP: ‘Appendix C Norwich – MSIP Jan 25 – Cost Model’.

Appendix D: Enlarged Drawing of Final Option

Please see the accompanying files submitted alongside this MSIP: ‘Appendix D Norwich – MSIP Jan 25 – Drawing’.

Appendix E: Glossary

Acronym	Definition
ACL	Available for Commercial Load
AIS	Air Insulated Switchgear
ATF	Automotive Transformation Fund
BESS	Battery Energy Storage System
BNG	Biodiversity Net Gain
CATO	Competitively Appointed Transmission Operator
CBA	Cost-Benefit Analysis
DNO	Distribution Network Operator
EA	Eligibility Assessment
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
EMFs	Electromagnetic Fields
EPC	Engineering, Procurement and Construction
ESO	Electricity System Operator
FID	Final Investment Decision
FNC	Final Needs Case
GBA	Green Belt Assessment
GDP	Gross Domestic Product
GIB	Gas Insulated Busbar
GIS	Gas Insulated Switchgear
GSP	Grid Supply Point
GVA	Gross Value Added
iDNO	Independent Distribution Network Operator
kV	Kilovolt
LDO	Local Development Order
LEP	Local Enterprise Partnership
LOTI	Large Onshore Transmission Investment
MVA	Megavolt Amperes
NDP	Network Development Process
NG	National Grid
NGET	National Grid Electricity Transmission
OEM	Original Equipment Manufacturer
OHL	Overhead Lines
SDS	System Design Specification
SF_6	Sulphur Hexafluoride
SGT	Super Grid Transformer
SQSS	Security and Quality of Supply Standard
SWOT	Strengths, Weaknesses, Opportunities and Threats
tCO2e	Carbon Dioxide Equivalent
UG	Underground Cable

Appendix F: Asset Health

Norwich Main 400kV

Substation	Asset/ No of Assets	Asset Group	Present Health	Future health (end of T3)	Future health (20 years)	Present Risk	Main Health Drivers
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Asset Types which have a medium-low to medium-high risk
This list refers to longer term priorities (from 5 to 10 years) and does not include 'age' related drivers.
Where an asset type appears in more than one category, numbers in brackets indicate the number of assets under that group:

[redacted]

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