nationalgrid

MSIP Necton

National Grid Electricity Transmission
Medium Sized Investment Project

January 2025

Contents

Investment Summary

Project Name	Necton 400kV Extension	**Delivery year**	[redacted]
Drivers for the Investment	**Generation Connection – to enable the connection of 3960MW of renewable electricity generation.** Three contracted customer connections under RWE (previously Vattenfall) to connect three 1320MW offshore windfarms on the coast of East Anglia. These three windfarms are for three sub entities of RWE: Boreas, Vanguard East, and Vanguard West.		
Key considerations & challenges	Key considerations and challenges in delivering the investment include: • **CION** – Reflecting outcomes from the collaborative Connection and Infrastructure Options Note process between NESO, the customer and NGET. • **SQSS** – To facilitate an SQSS compliant connection for all three offshore windfarm contracts to connect to the substation. • **Economic efficiency** – minimising costs to ensure the most economical solution for consumers. • **Technical complexity** – streamlining the complexity of the scope to deliver all three connections on the existing Necton site. • **Delivery phasing -** opting for the most efficient delivery approach despite variances in customer connection dates.		
Optioneering	NGET undertook two phases of optioneering. The first via the collaborative CION together with NESO and the customer, to identify the most efficient landing and connection site solutions for the offshore windfarms: this process identified Necton as the most efficient connection site. NGET then applied this to its standard optioneering procedure, seeking to find the best overall design for consumers, considering a total of seven high level options across five categories. • Three option categories (A - doing nothing, B - market and C - whole system solutions) which could not provide a physical connection. • Three options (D-1, D-2 & D-3) to extend the existing Necton substation which could deliver the required connections and which were taken forward for detailed assessment • One option (E-1) to build a new substation. We assessed this as disproportionately expensive and not in line with the outcome of the CION process. Three options to make use of the existing Necton 400kV substation were shortlisted for detailed analysis: the three options differ in their proposition to delay or include cable transposition works, or to remove or make use of an existing Cable Sealing End Compound (CSEC).		
Proposed Solution	Extend the existing Necton 400kV AIS double bus bar substation to the east and west to accommodate an additional 12 bays. This includes: • Three user bays to accommodate the three connecting offshore windfarms, four bus section bays, two bus coupler bays, and three Feeder bays. Reconfiguration of the OHL circuits from a double-tee to a double turn-in arrangement, coming from Walpole via a new terminal tower and Norwich Main via another new terminal tower, to AIS feeder bays on the west and eastern sides of the site. The existing Cable Sealing End Connection (CSEC) will be disconnected to enable this, including removal of existing cable duck-under CSEs and a section of cable within the NECT4 substation.		
Outputs of the Investment	Three 1320MW generation connections for offshore wind farms off the East Anglian cost. Supporting the delivery of an additional 3.9GW of renewable generation onto the network in line with our decarbonisation goals and national targets such as Clean Power 2030 and Net Zero 2050.		
PCD Primary Output	Extend the existing 400kV Necton substation by 12 bays and amend the OHL from a double-tee to double turn-in arrangement to connect three offshore windfarms – [redacted]		
Total Cost (price base 18/19)	Our total cost for the investment and funding allowance being sought is for: [redacted] The current total cost of the project is [redacted]		
Spend profile	**T2 (FY2022 – FY2026):** [redacted]	**T3 (FY 2027 – FY2031):** [redacted]	**T4+ (FY 2032+):** [redacted]
Reporting table	Annual RRP - PCD Table	**PCD Modification Process**	Special Condition 3.14, Appendix 1
Historic funding interactions	No existing funding in RIIO-T1 or RIIO-T2.		

1. Executive summary

1.1 Context

This paper, together with the associated Cost Benefit Analysis (CBA) , summarises NGET's proposed investment to **extend** the existing 400kV AIS substation at Necton, in order to facilitate connection of three offshore windfarms and seeks to demonstrate the consumer interest in the associated investment. The substation will also be configured from a double tee arrangement to a double turn-in from Walpole and Norwich Main circuits, as well as installing an ISS fence.

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.

1.2 What is the background to this Investment?

This investment is to connect generation from RWE's three Norfolk offshore wind farms (previously under Vattenfall) at the Necton 400kV AIS substation, enabling 3.9GW of renewable generation onto the network.

The wider East Anglia region is characterised by strong growth in wind generation as the UK seeks to increase the presence of renewable generation in the energy mix and realise its Clean Power 2030 ambitions. Together the three wind farm projects are designed to have a capacity of 3.9GW and are situated 50 to 80km off Norfolk's coast.[1] All three projects have obtained Development Consent Orders (DCO), seabed rights and all essential permits, they are undergoing construction work at site. We therefore have high confidence in these projects proceeding.

A brief history of the project is explained below:

- In 2016 – NGET received connection requests for two offshore windfarms (Vanguard West and Boreas) for 1800MW connections in 2026 and 2027, respectively.
- NGET began optioneering for the project via the multilateral Connection and Infrastructure Options Note (CION) process in collaboration with the NESO and customer.
- Between 2022 and 2024, the customer went on to submit a number of ModApps to continually increase both the size and number of its connections from two 900MW agreements to three 1320MW connections, and later to move the ACL dates for two of the windfarms to 2029 and 2030.
- In 2023, construction on the Necton substation commenced. Later in the same year the ownership of the windfarms changed hands from Vattenfall to RWE, who is now the current owner.
- It is also worth noting that [redacted] a connection application for a Synchronous Condenser at Necton as part of the NESO Stability 'Pathfinder Phase 3' process, to provide grid stability services in the East of England.

Upon completion, this project will contribute to the United Kingdom's decarbonisation objectives, including Clean Power 2030 and Net Zero 2050, by facilitating the integration of additional renewable energy sources into the national grid. Additionally, this project has the potential to support the UK's economic growth targets and Ofgem's regulatory growth duty, given the significant investment and job creation associated with investment in the East Anglia region.

[1] https://uk.rwe.com/project-proposals/norfolk/

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

NGET evaluated a range of solutions to meet the investment drivers in a way that best serves the interests of consumers. In evaluating options, NGET focused particularly on outcomes of the collaborative CION optioneering process, ensuring timely SQSS compliant connections for all three offshore windfarms, consideration of an efficient approach to phasing delivery of the works, the presence of a potential Point on Bar (PoB) issue on site, and futureproofing space for an additional Pathfinder connection also contracted on site.

Whilst further detail regarding the optioneering process is provided in Sections 4 and 5 of this submission, a brief summary of the options considered is explained below.

NGET's optioneering was split into two key phases:

- The first being the collaborative tripartite analysis undertaken by NGET, NESO and the customer via the NESO's CION process – a process applicable to offshore wind connections and interconnectors. This process resulted in the selection of a mutually identified and agreed onshore connection point to the transmission network at Necton 400kV AIS substation via cable [redacted].
- The second phase of analysis was underpinned by NGET's consideration of the most efficient connection solution at the Necton 400kV substation. NGET considered a total of seven high level options under five headline categories to identify the best option for consumers.

With the CION process having identified Necton 400kV AIS substation as the most suitable connection point and a number of other requirements, such as amending to a double turn-in OHL arrangement and installing an ISS fence, were consistently necessary across all options, NGET's options analysis instead focused on resolving a potential PoB issue identified in system studies with the NESO.

Following the reopener guidance set out by Ofgem, we considered assessed a "do nothing" option and a market based and whole system option **(Options A, B and C)**. All three were discounted as they did not provide a compliant and viable connection for RWE.

Building a new substation **(Option E)** to deliver the contracted connections was dismissed following the CION process, which identified existing assets that could facilitate the investment. This approach reduced additional costs to consumers and avoided delays in meeting the contracted ACL dates.

NGET focused on three options to **extend or utilise the existing Necton 400kV AIS substation** taking into account a potential PoB issue on the site **(Options D1-D3).** These options considered the most efficient way to connect the three offshore windfarms using the available space, OHLs and cables already on site. Considerations of whether to undertake cable transposition works and make use of, or remove, the existing Cable Sealing End Compound (CSEC), was a primary factor of analysis between options. All three options were taken forward for detailed analysis.

The three shortlisted options taken forward for detailed analysis included:

- Option D-1: Extend the Necton 400kV substation, delay cable transposition works and disconnect the Cable Sealing End Compound (CSEC)
- Option D-2: Extend the Necton 400kV substation, delay cable transposition works and re-use the existing CSEC.
- Option D-3: Extend the Necton 400kV substation, complete cable transposition works and re-use the existing CSEC

Table 1 provides a summary of the three shortlisted options against key criteria for the project.

Table 1: Summary of shortlisted options against key criteria

	Option E-1	Option E-2	Option E-3
Time	Enables a 2027 connection date	Enables a 2027 connection date	Enables a 2027 connection date
SQSS Compliance	Enables SQSS compliant connections for all 3 windfarms	Enables SQSS compliant connections for all 3 windfarms	Enables SQSS compliant connections for all 3 windfarms
Technical Complexity	No cable works reduces complexity on site	Cable works increases complexity	Cable works increases complexity
NESO's guidance to resolve a PoB Issue	Follows NESO guidance on delaying transposition works	Follows NESO guidance on delaying transposition works	Conducts transposition works upfront to resolve PoB issue
Futureproofing	Enables space for Pathfinder connection	Does not enable space for Pathfinder Connection	Does not enable space for Pathfinder Connection

We also considered the timing of the investment delivery, particularly whether to complete all work now, despite one offshore wind farm not connecting until [redacted] Due to concurrent programmes and system access constraints, the proposed delivery strategy is to let a single contract and deliver all works for the 3 windfarm projects together. NGET's analysis found that completing all work upfront is more cost-efficient for consumers than staging each extension, which would significantly extend the overall project duration incurring additional project preliminaries and impact the bulk earthworks strategy, and contractor mobilisations. This also reduces the system access required and NGET SAP and commissioning resource requirements.

Since commencing construction [redacted] NGET have been able to start to realise these efficiency and economic gains for the consumer and customers. This decision is supported by the high demand for connections in the region. There are other connections in the pipeline that could fill in use for these additional bays in the eventuality that one of the offshore windfarms were to fall away, providing strong demand resiliency. Other contracted agreements in the region include:

- A 500MW BESS and PV connection – [redacted]
- [redacted] A 1GW mixed generation connection containing BESS/PV/SNR/Wind/Hydrogen under [redacted]
- A 720MW solar generation connection [redacted]
- A 800MW BESS via [redacted]
- A 650MW BESS/ PV connection [redacted]
- A 850MW BESS and PV connection [redacted]

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

The preferred option is to extend the existing Necton 400kV AIS double bus bar substation to the east and west to accommodate an additional 12 bays, defer cable transposition works and remove the existing CSEC (Option D-1). This option aligns with the key investment drivers, which include delivering an SQSS compliant solution for all three offshore windfarms, maximising cost efficiency for the scheme, reducing technical complexity and enabling space to facilitate the connection of another customer's planned reactive compensator at the site.

Further details of scope included within the preferred option are detailed below:

- Of the 12 additional bays to be extended onto the Necton substation:
  - three are user bays to accommodate the 3 connecting offshore windfarms,
  - four are bus section bays,
  - two are bus coupler bay and,
  - three are Feeder bays.
- Configuration of the OHL circuits from a double-tee to a double turn-in coming from Walpole via a new terminal tower and Norwich Main directly, to AIS feeder bays on the west and eastern sides of the site, respectively.
- The existing Cable Sealing End Connection (CSEC) will be disconnected to enable this, including removal of existing cable duck-under CSEs and a section of cable within the NECT4 substation.

Based on our quantitative assessment undertaken at the time of optioneering, Option D-1 has a marginally better NPV than Option D-2 and D-3 which makes use of the existing CSEC. Looking qualitatively Option D-1 also provides other benefits, such as the ability to facilitate space for an additional bay for the Pathfinder connection and reducing technical complexity in delivering the works. Given these factors, we identified option D-1 as the most favourable solution for consumers.

Funding allowances are sought as part of this MSIP submission. The direct costs for this investment are [redacted] (18/19 prices). 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?

The proposed solution to deliver the investment makes use of the existing Necton 400kV AIS substation which is located in proximity to the three connecting offshore windfarms driving this scheme. The Necton 400kV AIS substation was a new substation constructed in 2016, to connect the 400MW Dudgeon Offshore Wind farm, and was designed to include sufficient physical and electrical space to facilitate additional future connections. The current design of the Necton substation allows for extension to its maximum technical capability (5GW).

Through the multi-lateral optioneering process, NGET, NESO and the customer identified that making use of this spare capacity at Necton represented the most efficient solution to deliver the connections. On extending the substation to utilise this spare capacity, Necton will come close to reaching the 5GW precedent of maximum electrical capacity on any single substation.

However, we are enabling further development at Necton by removing the CSEC as part of our preferred option. This will opens space for a further bay into which a new customer is planning to connect [redacted]. This customer is [redacted] installing a reactive compensator as part of a NESO 'Pathfinder Phase 3 stability' project. NGET was not aware of these works [redacted] until after placing a contract for the extension of the Necton substation, [redacted]. As such, this additional customer connection on the site is independent of the scope NGET are presenting in this MSIP.

Looking ahead there is a high level of demand for connections across the East Anglia region, surrounding substations like Necton and Norwich Main (which is also being extended and for which there is a separate January 2025 MSIP submission). The 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 noted the potential for eight new substations in the area to support the pipeline of demand. However, we recognise that the outcomes of Clean Power 2030 and Connections Reform will be critical inputs in refining the number, type and location of new investments in the East Anglia region 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:

- **Outage availability**: Outages for the project are yet to be confirmed. There are risks due to other major projects in the region, making it especially difficult to achieve outages for the OHL works. NGET is in close contact with NESO to organise outage availability according to the project schedule.
- **NG SAP and Commissioning resource** - The availability of SAP and commissioning resources is crucial for meeting programme deadlines. NGET attends cross-functional meetings to monitor any resource risks that could cause delays.

- **Interfacing:** between customer works on site and NGET's substation work at Necton could impact program delivery if not managed properly. NGET and the customer are maintaining close communication to mitigate this.

In response to the growth in renewable generation in the East Anglia region, NGET has assessed a range of options for enabling the connection of three offshore windfarms, with a combined capacity of 3.9GW. To address this connection demand, NGET has assessed options to identify the best solution for consumers. Working with NESO and the customer, we concluded through the CION process that an extension at Necton would be most suitable, enabling timely project delivery at a proportionate cost to consumers. Specific design considered by NGET within this assessment differed by their approach to transposition of cables and removal of the CSEC.

Our preferred solution following this assessment is an extension to the existing Necton AIS 400kV substation by 12 bays and amending the double-tee circuit arrangement to a double turn-in configuration. This proposed solution will enable NGET to meet the contracted connection dates for all three agreements, whilst considering the needs of consumers for a cost-efficient solution and providing space for one additional connection in the future, in the interest of future consumers. [redacted]

2. Introduction

2.1 Project background

This paper provides evidence for the investment needs case and associated efficient costs for extending the existing Necton 400kV AIS double bus bar substation to the east and west to accommodate connection of three new offshore windfarms under the Norfolk Offshore wind portfolio, owned by RWE. The project is referred to as Necton.

Necton is a 400kV double busbar substation recently constructed for the connection of the 400MW Dudgeon offshore wind farm. Necton is currently connected as a double-tee into the Norwich Main-Walpole 1 & 2 circuits.

2.1.1. MSIP Eligibility

Of the three offshore windfarms connecting into Necton under this investment, two (Vanguard East and Boreas) fall outside of the T2+2 window. However, NGET is proposing to streamline the building work required for all three connections upfront, delivering them as a single project to enable a more efficient delivery programme. This will reduce costs for consumers by avoiding the need for multiple mobilisation and demobilisation activities. Further detail related to the analysis underpinning NGET's decision to invest for all three connections upfront is provided in section 4.

It is due to this timing that NGET is seeking funding approval via the MSIP reopener mechanism for all three connections in the Jan 2025 window. Only the Vanguard West connection falls within T2+2 and as such, it is the only connection eligible for funding via the Generation Connection Volume Driver. Moreover, as the connection is staggered only 400MW of generation will connect in T2+2. Given NGET is investing at Necton for all three windfarms now, rather than staggered in line with the respective ACL dates, total expenditure to be incurred exceeds the +/-£11.84m variance permissible around the Volume Driver allowances. Indeed, based on a 400MW load, NGET would be eligible for only [redacted] worth of Volume Driver funding, compared to a total estimated cost of c. [redacted] The comparative funding to expenditure ratio triggers an a-typical generation connection MSIP (SpC 3.14.6 category a). A breakdown of eligible volume driver allowances is provided in Appendix A.

Despite the extensive timeline of the project, we have been unable to present the investment at Necton as an MSIP until now. This is primarily due to delays related to the signing off of the DCO discharge and recent modifications to the customer's request. Without the DCO discharge, there was insufficient confidence in the progression of the customer's connection request for NGET to move forward with securing a contract to deliver the works. After achieving the DCO, the customer submitted an additional modification application amending the connection date for the Boreas connection. These factors have significantly impacted the confidence and scope of the investment, consequently preventing NGET from confidently submitting a funding request via the MSIP reopener until the January 25 window.

2.1.2. Chronology to the request

The current Necton project has been through a notable amount of change since its establishment in 2016. The majority of this change related to updates requirements from the customer as it refined the needs for its offshore windfarm. A brief chronology is provided below:

[redacted]n 2016 – NGET received connection requests for two 900MW offshore windfarms (Boreas and Vanguard West) [redacted]

- NGET offered connections in line with these dates and began optioneering for the project on the basis of these connections.
- Between 2015 and 2016 the tripartite Connections and Infrastructure Option Note (CION) process commenced between NGET, the customer and NESO in establishing the most efficient connection approach for the offshore windfarms.
- The customer then went through a series of ModApps and changes between 2020 and 2024, refining the nature of the connection requirements:
    - In April 2020 a ModApp updated the load requirements from two 900MW connections to three 1200MW connections (adding in Vanguard East), [redacted]

- In 2022, Vattenfall further increased the load requirements to three 1320MW connections for each of the offshore windfarms.
- In 2023, construction started on the NGET substation and later that year the customer ownership of the projects changed hands from Vattenfall to RWE who acquired the Norfolk Offshore Wind portfolio.
- In April 2024, RWE submitted a further ModApp, this time amending the ACL dates of the Vanguard East and Boreas [redacted]

2.1.3 Importance of the investment

This investment is required to accommodate the contracted renewable generation connections from three offshore windfarms on the East Anglian coast by customer RWE. Combined, these offshore windfarms will provide 3.9GW of renewable wind generation onto the National Grid Electricity Transmission network. Once live, the Norfolk Zone will be one of the largest wind clusters globally, producing enough renewable energy to power the equivalent of 4 million UK households[2]. Together the three wind farms will be made up of 276 wind turbines and will deliver electricity [redacted] located circa 40m from NGET's onshore Necton substation. Figure 1 provides an aerial representation of where the three offshore windfarms will set off the East Anglian cost and the relative onshore landing and substation connection point at Necton.

This paper provides evidence for the investment needs case and preferred connection location and technology solution for extending the existing Necton 400kV AIS double bus bar substation to the east and west to accommodate connection of three new offshore windfarms. The project is referred to as Necton.

Facilitating the establishment and connection of offshore wind is a fundamental part of achieving the UK's energy ambitions. In their 2024 Clean Power 2030 report, NESO highlighted that clean power can only be enabled via the mass deployment of offshore wind with a sustained rollout needed at over "double the highest rate ever achieved in Great Britain".[3] With a requirement to achieve 45-50GW of offshore wind by 2030, NESO note within the report that the cost and success of clean power as a whole for the UK will be made or broke by the right investment signals, contracting arrangements and delivery environments surrounding offshore wind projects.

Figure 1 – Aerial map of Norfolk Offshore Wind zone and connection to Necton

[2] https://norfolkzone.rwe.com/about-norfolk
[3] Clean Power 2030 (2024) National Energy System Operator

2.2 Regional and strategic context

The East Anglia electricity transmission network is currently a net importer of electricity but is set to become a net exporter of power. The region continues to be influenced by strong developments in wind generation in the north of the region and interconnector behaviour in the south. Figure 2 presents an overview of current generation connection offers within East Anglia out to 2034. The general flow of power in the East Anglia region is north to south carrying power to London and the Southeast of England. Looking to the future the network will need to be capable of taking on this growth in renewable generation and pertaining the right infrastructure to carry it south. Current forecasts indicate that about a third of the UK's current energy demand could be met by energy that will be coming into East Anglia by the end of the decade.

The National Electricity System Operator's (ESO) recent Future Energy Scenario's 2024 publication mapped the need to meet the UK's ambitions for 50GW of offshore wind by 2030 and anticipated that only the 'Holistic Transition' pathway would enable this target to be met, with both 'Electric Engagement' and 'Hydrogen Evolution' falling shortly behind. The report highlights that offshore wind generation remains one of the lowest cost options to meet the UK's energy needs.[4] As of February 2024, customers have contracts for new connections totalling 63 GW of generation capacity in this region. The majority of these connections, approximately 60%, are battery or hybrid-battery systems, followed by around 15 GW of offshore wind and 4.5 GW of new interconnectors.

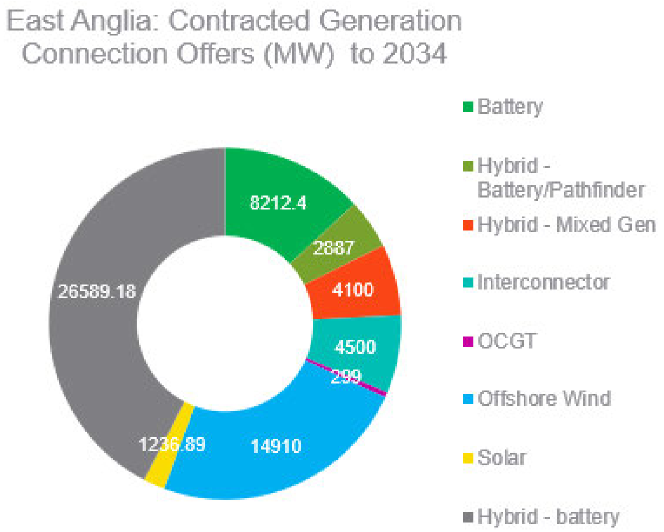

Figure 2 – Pie chart of generation connection offers in East Anglia out to 2034

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 outline in NGET's RIIO-T3 Business Plan. Necton substation is in the East Anglia region.

By delivering the works at Necton substation as part of a site strategy, NGET is ensuring this investment meets the primary goal of connecting 3.9GW of renewable electricity to the grid as part of the Norfolk Offshore Wind zone. This investment – and the associated Necton Site Strategy - aligns with the Future Network Blueprint for the region as outlined in our T3 Business Plan by facilitating future customer connections and delivering the infrastructure needed to accommodate the significant growth in new energy generation in the region. This investment also aligns with Consumer Outcomes embedded across our T3 plan, a summary of these is detailed in Table 2 below.

[4] NESO (2024) Future Energy Scenarios - https://www.neso.energy/document/321041/download

Table 2 - Alignment with Ofgem T3 consumer outcomes

Infrastructure fit for a low-cost transition to net zero	Enabling the three offshore windfarms to connect at Necton will facilitate an additional 3.9GW of renewable energy onto the grid, supporting the UK's transition to net zero.
System efficiency and long-term value for money.	Extending the existing Necton substation and phasing investment for all three windfarms upfront, present cost efficient approach to delivering these customer connections in the interest of consumer spend.

Within T3, NGET will also continue work on a number of strategic upgrades as part of the Great Grid Upgrade, including reconductoring of circuits between:

- Grendon to Sundon 1 and 2 (SGRE),
- Pelham to Sundon,
- Sundon to Wymondley,
- Bramford-Pelham-Braintree-Rayleigh (BPRE), and
- Elstree to Sundon 2 (SER1).

Beyond T3 as part of agreed ASTI investments, NGET will also develop and design new circuits between Norwich and Tilbury South and North (ATNC and AENC), reinforce the network between Bramford and Twinstead (BTNO) and develop the HVDC Sea Link between Suffolk and Kent (SCD1).

Looking ahead there is a high level of demand for connections across the East Anglia region, surrounding substations like Necton and Norwich Main (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.

Our T3 submission included plans for several Asset Health interventions across our network. We have assessed the condition of assets on the Necton substation in developing this investment. Given the relative age of the substation, a minimal number of assets require intervention during the T3 period - a brief summary of the asset health of the substation is included in Appendix B of this submission. Whilst these interventions are not in the scope of the MSIP funding submission presented here, they were included in our T3 business plan submission shared in December.

2.4 System Design Table

NGET developed a System Design Table comparing potential high level options for extension or building new, to respond to three offshore windfarm connections, as presented in Table 3 below.

Table 3: System Design Table for Necton

System Design Table	Circuit/Project	Extend and existing Necton 400kV AIS substation to connect Offshore Customers (Options D-1, D-2, D-3)	Construction of a new 12 bays 400kV AIS substation (Option E)
Thermal and Fault Design	Existing Voltage (if applicable)	[redacted]	[redacted]
	New Voltage	[redacted]	[redacted]
	Existing Continuous Rating (if applicable)	[redacted]	[redacted]
	New Continuous Rating	[redacted]	[redacted]
	Existing Fault Rating (if applicable)	[redacted]	[redacted]
	New Fault Rating	[redacted]	
ESO Dispatchable Services	Existing MVAr Rating (if applicable)	[redacted]	[redacted]
	New MVAr Rating (if applicable)	[redacted]	
	Existing GVA Rating (if applicable)	[redacted]	
	New GVA Rating	[redacted]	
System Requirements	Present Demand (if applicable)	[redacted]	
	2050 Future Demand	[redacted]	

		[redacted]	
	Present Generation (if applicable)	[redacted]	[redacted]
	Future Generation Count	[redacted]	

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

3. Establishing Need

3.1 Overview

Table 4: Summary of Investment Driver

Summary of Primary Driver		Date
Customer Connection	**Generation Connection – to provide new connections for three offshore windfarms.** The NESO signed a connection agreement with RWE to connect three new offshore windfarms, Boreas, Vanguard East and Vanguard West, under their Norfolk Zone project off the East Anglian coast. When live these three offshore windfarms will supply 3.9GW of renewable generation onto the network.	[redacted]

3.2 Load related drivers

NESO signed a connection agreement with Vattenfall (later changing to RWE) in 2016. Following a number of ModApps, the request is to provide a 3.9GW generation supply connection at NGET's Necton substation in Norfolk. The construction and connection of the three offshore windfarms are staggered across 3 years, with the first ACL falling in 2027 and the last in 2030.

Table 5: Details of Load drivers

Customer Name	Project Name	Project Type	MVA Demand	ACL[5] Date	Customer Status
RWE	Vanguard West	Offshore Wind renewable generation	1320MW	[redacted]	[redacted]
RWE	Vanguard East	Offshore Wind renewable generation	1320MW	[redacted]	[redacted]
RWE	Boreas	Offshore Wind renewable generation	1320MW	[redacted]	[redacted]

In addition to these windfarms, NGET is aware of an existing Pathfinder scheme also connecting at Necton 400kV. Whilst not in the scope of this MSIP paper, NGET has considered the needs of this additional customer when identifying the most efficient solution in our optioneering process, detailed in Sections 4 and 5. To briefly summarise, we have selected an option which creates space to enable the customer to connect their reactive compensator.

3.3 Customer Drivers

The NESO is implementing a programme of reforms which aims to reduce the size of the queue and speed up connections. Given the rapid growth of the connections pipeline, NGET had helped to triage potential connections using a connection certainty methodology. NESO continue to work on the connection reforms which will also go further in refining and updating the long and growing list of connections, however outputs of this work are not yet known.

To navigate this uncertainty and 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.

The contracted projects at Necton as part of this site strategy are shown below in Table 6. The contracted connections that trigger the need for this investment demonstrate an average confidence score [redacted] high' confidence) with none of the three connections considered weak in confidence.

As such NGET has a high degree of confidence in these connection requests. RWE has achieved and commenced execution of Development Consent Orders (DCOs) for all three offshore wind farms and invested £963m in purchase of the windfarm from previous owner Vattenfall[6]. They have commenced construction of their cable routes and connections into the new Necton extensions delivered under this MSIP.

Table 6: Customer confidence assessment

Customer Name	Project Name	Project Type	MW	ACL Date[7]	RAG confidence
RWE – Vanguard West	Vanguard West Offshore Windfarm	Offshore wind	1320	[redacted]	[redacted]
RWE – Vanguard East	Vanguard East Offshore Windfarm	Offshore wind	1320	[redacted]	[redacted]
RWE – Boreas	Boreas Offshore Windfarm	Offshore wind	1320	[redacted]	[redacted]

3.4 Existing and planned future network

NGET's Necton substation is the second closest existing connection point to the [redacted] landing point of the three RWE offshore wind farms, sitting an aerial distance of 60km from [redacted] Other substations located locally include Norwich Main, which sits at an aerial distance of 27km from [redacted] Looking further, the next closest NGET substations sit at Leiston and Walpole, both 69 and 95km distance, respectively.

The Necton substation was constructed in 2016 and currently facilitates another offshore wind farm customer, Dudgeon Offshore Wind Farm, which has a 400MW generation connection at the site.

Our proposed investment at the Necton site fits into a wider backdrop of investment across the region. 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.[8]

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6 https://www.rwe.com/en/press/rwe-offshore-wind-gmbh/2023-12-21-rwe-acquires-4-2-gigawatt-uk-offshore-wind-development-portfolio-from-vattenfall/

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

8 https://www.nationalgrid.com/electricity-transmission/network-and-infrastructure/infrastructure-projects/norwich-to-tilbury

Additional offshore wind farm connections are also connecting into the proximate Norwich Main substation. [redacted] Finally, as a result of this growth in energy generation, strategic reinforcements of the high voltage network are being developed between Norwich Main substation and Tilbury in Essex, to facilitate the increased load and power flows in the area – these projects are ASTI schemes AENC and ATNC.

We have also assessed the condition of assets on the Necton substation in developing this investment. Given the relative age of the substation, a minimal number of assets require intervention during the T3 period - a brief summary of the asset health of the substation is included in Appendix B of this submission. Whilst these interventions are not in the scope of the MSIP funding submission presented here, they were included in our T3 business plan submission shared in December.

Figure 3 – Aerial map of key substations in East Anglia

4. Optioneering

This section summarises our assessment of options to address the needs case established in the previous section. The optioneering undertaken on the scheme can be separated into two specific tranches, both of which will be summarised in this section:

The first section discusses the context that influenced NGET's optioneering process. These include the results of the collaborative three-way CION process (section 4.1 of this paper) and the identification of the need for potential transposition works to address a Point on Bar (PoB) issue (section 4.2 of this paper). To summarise both elements:

- The CION process involves NESO, the customer, and NGET, aiming to determine the optimal onshore and offshore connection location and design to support offshore wind farms. As a result of this process, Necton 400kV AIS was identified as the most efficient onshore substation connection for the investment.
- The consideration of circuit transposition works to resolve a potential PoB issue, conducted with NESO's support, indicated that delaying transposition works was economically advantageous.

The second section explores NGET's own internal optioneering process for identifying the most efficient connection solution on the Necton 400kV AIS substation. 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 non-transmission, whole system solutions;
D. Identification of options for making use of existing NGET substations;
E. Identification of possible options for a new substation.

In summary, details provided below:

- Options A-C were discounted because they would not deliver a compliant connection.
- Three variations of Option D (use of an existing substation) were considered in the light of a potential PoB issue identified at the Necton given the substantial increase in the substation load.
- Option E (building a new substation). This was discounted given the outcomes of the CION process. It would have taken longer to deliver, had greater delivery risk and cost more for consumers, compared to utilising existing NGET assets.

Alongside this optioneering, NGET also considered the most efficient approach for delivering the works, considering the staggered nature of connection dates across the three offshore windfarms. A brief summary of this consideration is also provided in section 4.3 below.

4.1 Connection and Infrastructure Options Note (CION)

Before reviewing NGET's high-level options for delivering the customer connections, it is important to highlight that a number of key optioneering decisions underpinning the investment were established multilaterally between NGET, the customer (representing the OFTO [Offshore Transmission Owner]) and the NESO, via the CION process.

4.1.1. Introduction to CION

The CION process documents and records the results of a collaborative effort 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, Vattenfall (now RWE), and NESO identified the best connection option for the three offshore windfarms which had been previously referred to as 'East Anglia Tranche 1'.

The CION details the chosen connection option, considering technical, commercial, regulatory, environmental, planning, and deliverability factors. It addresses the onshore connection point, onshore transmission design, and offshore transmission system design for the three offshore wind farms.

The CION serves as a dynamic document that guides investment decisions and planning by all parties involved in the process. Although the NESO coordinates its development, each party is responsible for ensuring their information is accurate and collaborating to approve the CION.

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 Vattenfall (now RWE), 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 Necton CION process

The initial CION process for this investment began in November 2015, with the final version completed in July 2016. The key considerations and outcomes were:

1. Firstly, looking onshore, three preferred interface points where the subsea cable could land were identified along the East Anglian coast: [redacted] Correspondingly, three viable onshore connection points to the transmission system were proposed at **Necton**, **Norwich Main**, and **Eye Airfield**, each offering sufficient capacity and feasible connection routes.
2. Secondly looking offshore, four alternative OFTO designs were evaluated, including two with covered interfaces at transmission substations and one with a coastal interface. Each option considered onshore and offshore route lengths and system costs. This stage also included a constructability assessment and review of offshore cable corridors. Following this stage of the assessment six options advanced. These all included a preferred offshore cable interface at Bacton and either cabling onshore to either Norwich or Necton substation via either OHL or cable.
3. Thirdly, as the OFTO party, Vattenfall then considered timescales for connection options in the context of the UK Government's Contract for Difference (CfD) . As a result of this assessment, the three parties agreed ruling out any OHL options, as these would require NGET, as the onshore TO, to obtain development consent orders for the new OHLs. This was recognised as a timely process which may have resulted in connection dates beyond the CfD cut off.

   Connections via cable at Necton and Norwich were then jointly considered in more detail, a routing workshop was undertaken to assess the feasibility and cost of both options. This analysis fed into the overall efficiency assessment coordinated by the NESO.
4. The final outcome of the CION was an identification that the preferred option for the connection was the customer landing their connection [redacted] and connecting into NGET's transmission system at the **Necton 400kV substation**.

Whilst briefly presented, this section has sought to outline that a significant level of optioneering was conducted multilaterally between the three parties as part of the NESO's established CION process. This work directed NGET to focus on establishing options to facilitate the investment at Necton 400kV substation, supporting the customer to connect their offshore windfarms via cable running from [redacted]. The following section now explores in greater detail these identified options at Necton 400kV.

4.2 Point on Bar (PoB) Issue

Through system studies in 2021, NGET identified that based on the contracted background of the connections and significant growth in load at Necton, a potential Point on Bar (PoB) issue could occur at Necton. A PoB issue refers to a situation where conductors in a multi-conductor system can experience diverging electrical conditions during operation which can reduce system performance, increasing imbalance in loads on the network. In turn this reduces thermal performance, increases transmission losses and can cause generation to become constrained.

In the specific case of Necton, this PoB issue was identified as having the possibility of occurring during a busbar outage and from two distinct double-line fault conditions (1) after turn-in works and before the ASTI BTNO scheme completes and (2) post completion of the ASTI BTNO scheme and prior to the AENC scheme completing. After both the BTNO and AENC scheme are completed, the possibility of a PoB issue at Necton 400kV substation is removed.

As outlined in the options table in section 4.4, NGET considered one approach to address the PoB issue before the completion of the ASTI projects. This included performing circuit transposition works on-site to balance the load on the substation and minimise the risk of negative outcomes from a potential PoB issue during busbar outages within predefined periods.

NGET collaborated with NESO to evaluate the value of undertaking these works at the Necton site for the connected Norwich Main and Walpole circuits. Both parties conducted quantitative analyses to assess the relative value and cost efficiency of performing these transposition works, compared to potential constraint costs, prior to the completion of the BTNO and AENC projects, which would eventually fully resolve the PoB issue.

Both NGET and NESO concluded - via their qualitative and quantitative analyses - that deferring circuit transposition works represented the least worst regret option when it came to connecting the thee offshore windfarms, relative to the estimated constraint costs associated with any PoB issue materialising. [redacted] On this basis NGET took consideration of the value of conducting PoB mitigation works into its optioneering analysis.

4.3 Phasing of works

NGET assessed the most efficient method for connecting three offshore wind farms to the grid [redacted] to NGET's confidence in the timely connection of these wind farms (refer to section 3.2), it was determined that completing all necessary works upfront would be more efficient than staging them according to each agreement's connection date.

This approach minimises the need to repeatedly mobilise and demobilise the Necton site, thereby substantially reducing contractor costs associated with these activities. Furthermore, it reduces the cost to consumers of multiple system access requirements. Additionally, it allows the customer to construct all three of its bays within NGET's substation in one go, providing a more favourable arrangement for the customer.

By consolidating the investment for all three connections upfront, this strategy enhances efficiency in both delivery timescales and overall construction costs. NGET estimates that this approach could result in total savings of approximately £10m. As detailed in section 3.2, NGET remains confident in the compliance with contracted dates by all three offshore wind farms, as they have secured Development Consent Orders (DCOs).

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4.4 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 action to enable connection of the three offshore windfarms.	**Not taken forward** – the option does not comply with NGET licence obligations to provide connections.	Compliant customer connections not delivered.
B	Market-based solution	Increased customer demand 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 connections not delivered.
C	Whole systems solution	The required customer connection is accommodated by a Distribution Network	**Not taken forward –** the option does not comply with NGET licence obligations to provide connections.	**Capacity and future development potential** The DNO network does not have capacity to facilitate the load required by the three 1320MW connections. A DNO connection

Option	Option title	Option description	Taken Forward to Detailed Optioneering?	Rationale
		Operator (DNO) instead of NGET.		was not established via the CION process between the three parties.
D-1	Use existing assets	Extend the Necton 400kV substation, defer cable transposition works and disconnect the Cable Sealing End Compound (CSEC). Amend the OHL connections to a double turn-in arrangement from Norwich Main and Walpole 1&2 circuits.	**Taken forward to detailed assessment**	Enables compliant customer connections and makes use of available capacity at an existing site. Considers NESO's recommendation to reduce inefficient spend on transposition works. Creates additional space to facilitate the additional Pathfinder connection also contracted on site.
D-2	Use existing assets	Extend the Necton 400kV substation, defer cable transposition works and re-use the existing CSEC. Amend the OHL connections to a double turn-in arrangement from Norwich Main and Walpole 1&2 circuits.	**Taken forward to detailed assessment**	Enables compliant customer connections and makes use of available capacity at an existing site. Considers NESO's recommendation to reduce inefficient spend on transposition works. However, does not make available additional space to facilitate an additional known [redacted] pathfinder on site.
D-3	Use existing assets	Extend the Necton 400kV substation, complete cable transposition works and re-use the existing CSEC. Amend the OHL connections to a double turn-in arrangement from Norwich Main and Walpole 1&2 circuits.	**Taken forward to detailed assessment**	Enables compliant customer connections and makes use of available capacity at an existing site. Does not consider NESO's recommendation to reduce inefficient spend on transposition works. Does not make available additional space to facilitate an additional known [redacted] pathfinder on site.

Option	Option title	Option description	Taken Forward to Detailed Optioneering?	Rationale
E-1	Build new	Construct a new substation to facilitate the connection.	**Not taken forward** – the option disproportionately increases delivery timescales and costs to consumers.	**Cost & Timing of programme and resources** Construction of a new substation was not considered in detail given the CION process which established Necton as the preferred onshore connection point (as detailed in section 4.1). Constructing a new substation would disproportionately increase costs for consumers given the availability of an existing proximate site with available capacity for connections. Moreover, increased delivery timescales to design, commission and build a new substation would risk missing the initial [redacted] connection date for the Vanguard West contract.

Following the high level options assessment, three options for making use of the existing Necton 400kV AIS substation were identified as the most suitable options to be taken forward for detailed assessment, which is set out in Section 5. The shortlisted options were chosen based on their ability to deliver capacity for all three compliant connections, whilst also considering the outcomes of the CION process. The three shortlisted options were:

- Option D-1: Extend the Necton 400kV substation, defer cable transposition works and disconnect the CSEC
- Option D-2: Extend the Necton 400kV substation, defer cable transposition works and re-use the existing CSEC
- Option D-3: Extend the Necton 400kV substation, complete cable transposition works and re-use the existing CSEC.

5. Detailed options analysis

This section provides a detailed qualitative and quantitative assessment of the three shortlisted options identified in Section 4. It also outlines considerations NGET gave to the most efficient approach to phasing the work. The section concludes by setting out our recommended option.

5.1 Description of the options

The three shortlisted options each address the potential Point on Bar issue at the substation differently, considering the increase in load connections and the need to change the substation connection to a double turn-in arrangement. Options D-1 and D-2 propose to delay the cable transposition works based on their assessed value from NESO studies, while Option D-3 suggests conducting the cable transposition works. Additionally, Option D-1 includes removing the existing CSEC to create space for a spare bay, whereas Options D-2 and D-3 propose reusing the CSEC to either improve circuit rating, or complete the full transposition works, respectively.

All drawing provided are also included at larger scale within Appendix C.[9]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Due to the additional generation connecting at Necton, a double-circuit overhead line turn-in is also required off the existing Norwich Main-Walpole 1 & 2 400kV circuits, which are currently a double-tee arrangement.

This option defers the transposition of the feeder circuits which system studies by the NESO have confirmed is not efficient and as such are not required.

Extension to the west of the substation allows for a simple turn-in of the existing Norwich-Walpole 4VV OHL route by addition of a new terminal tower (4VV124) in line with the existing OHL route.

The existing cable and CSEC, which forms a 'duck-under' the existing OHL to achieve the current double-tee connection will thus become redundant and space will be made for a spare bay in its place.

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[9] All drawings provided were developed around the period in which the customer was considering a ModApp to their agreement to increase requirements to 3x1200MW connections. However, these were produced before this was formalised and much prior to the customer's subsequent ModApp to increase their connection further to 3x1320MW.

[redacted]

This option defers the transposition of the feeder circuits. However, it proposes to reuse the existing CSEC and install additional cables to achieve the required circuit rating in the period prior to the OHL double-turn in being completed. Currently Necton 400kV substation is connected to Walpole-Necton-Norwich main circuit 1 via a cable with a rating of 1364MVA post fault winter. If reusing the CSE NGET would be required to increase the rating of this cable to match the OHL rating (3326MVA post fault winter).

The double-circuit overhead line turn-in would then be achieved by designing a new terminal tower (4VV125) to enable the Walpole 1 circuit to be strung to in the future and terminating into the Norwich Main 2 bay. As part of this work, the Norwich Main 2 bay would also be transferred to a new feeder bay on Busbar 3.

[redacted]

This option completes the transposition of the feeder circuits by re-using the existing CSEC and cabling Norwich Main 1 circuit to a new feeder bay on the West side of the substation (on Busbar 2).

Due to the additional generation connecting at Necton, a double-circuit overhead line turn-in would still be required off the existing Norwich Main-Walpole 1 & 2 400kV circuits, which are currently a double-tee arrangement.

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 three options.

Table 8: Summary of qualitative analysis of shortlisted options

Option #	D-1	D-2:	D-3:
Option title	**Extend Necton, delay cable transposition works, and remove the CSEC**	**Extend Necton, delay cable transposition works and reuse CSEC**	**Extend Necton, complete cable transposition works and reuse the CSEC.**
Capacity & future development potential Preferred option: D-1	• Creates space for a spare bay [redacted] • Once all three wind farms are connected, Necton will approach the 5GW maximum capacity for any single substation currently established as the standard.	• Does not create space for an additional bay [redacted] • Would require uprating of existing cables • Once all three wind farms are connected, Necton will approach the 5GW maximum capacity for any single substation currently established as the standard.	• Does not create space for an additional bay [redacted] • Would require uprating of existing cables • Once all three wind farms are connected, Necton will approach the 5GW maximum capacity for any single substation currently established as the standard.
Design & technical complexities Preferred option: D-1	• Extends the existing AIS substation using AIS technology, our preferred switchgear. • The OHL works to move the substation from a double-tee to double turn-in arrangement will resolve the PoB issue once completed.	• Extends the existing AIS substation using AIS technology, our preferred switchgear • Requires installation of additional cables to achieve the required circuit rating in the period prior to the OHL double-turn in being completed	• Extends the existing AIS substation using AIS technology, our preferred switchgear. • Despite the cable transposition works being undertaken upfront to resolve the PoB issue, a double-circuit overhead line turn-in would still be required given the load connecting to the substation. This will eventually remove the PoB issue entirely and as such this represents a more costly option to consumers.

Option #	D-1	D-2:	D-3:
Option title	**Extend Necton, delay cable transposition works, and remove the CSEC**	**Extend Necton, delay cable transposition works and reuse CSEC**	**Extend Necton, complete cable transposition works and reuse the CSEC.**
Operations & maintenance Preferred option: D-1	• Maintenance is only required for the AIS equipment installed, there will be no cable maintenance requirements	• Maintenance will be required for both the AIS equipment and cables installed as part of the scope • Additional cable works required under this option would likely have required a longer outage window to account for working near live HV cables.	• Maintenance will be required for both the AIS equipment and cables installed as part of the scope • Additional cable works required under this option would likely have required a longer outage window to account for working near live HV cables.
Safety, health & security Preferred option: D-3	• PoB issue resolved on completion of a double turn-in configuration enabled on site.	• PoB issue resolved on completion of a double turn-in configuration enabled on site.	• The completion of the cable transposition works on the site would in turn resolve the PoB issue upfront, rather than waiting for the OHL works to resolve the issue.
Planning, land & consent Preferred option: No overall advantage to any option	• Makes use of space on and existing NGET substation. • No additional planning or consenting requirements.	• Makes use of space on and existing NGET substation. • No additional planning or consenting requirements.	• Makes use of space on and existing NGET substation. • No additional planning or consenting requirements.
Third party impact & network coordination Preferred option: No overall advantage to any option	• No difference between options.	• No difference between options.	• No difference between options.

Option #	D-1	D-2:	D-3:
Option title	**Extend Necton, delay cable transposition works, and remove the CSEC**	**Extend Necton, delay cable transposition works and reuse CSEC**	**Extend Necton, complete cable transposition works and reuse the CSEC.**
Environment & sustainability Preferred option: No overall advantage to any option	• Scope is delivered on an existing NGET substation, not impacting on additional land or local habitat • No difference between options.	• Scope is delivered on an existing NGET substation, not impacting on additional land or local habitat • No difference between options	• Scope is delivered on an existing NGET substation, not impacting on additional land or local habitat • No difference between options
Timing of programme & resources Preferred option: No overall advantage to any option	• During optioneering this option was identified as being capable of facilitating all three offshore windfarms ACL dates.	• During optioneering this option was identified as being capable of facilitating all three offshore windfarms ACL dates.	• During optioneering this option was identified as being capable of facilitating all three offshore windfarms ACL dates.

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 completing circuit transposition works upfront, which would be required in Option D-3 and circuit uprating works in Option D-2, following analysis conducted by NGET and NESO to identify the value of these works is negligible.
- **Futureproofing:** Option D-1 is the only option which removes the CSEC to make space which can be used for an additional bay, enabling the contracted NESO Phase 3 stability Pathfinder, [redacted] to connect.

The next section outlines our quantitative assessment of the three 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. 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 in line with our preferred solution, option D-1 has a more favourable NPV in comparison to D-2 and D-3, due to a lower discounted cost, as benefits are similar for all options. Whilst a summary of the CBA analysis is included here, the full CBA is provided in Appendix D alongside this submission.

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

Options	Total (£m)			
	Costs (discounted)	Benefits (discounted)	NPV	Difference to baseline
D-1	[redacted]	[redacted]	[redacted]	[redacted]
D-2	[redacted]	[redacted]	[redacted]	[redacted]
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]
D-3	[redacted]	[redacted]	[redacted]

The difference within the CAPEX cost can be accounted for by the difference in scope between the three options. Option D-1 and D-2 propose to delay cable transportation works.

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 2026, the replacement costs will commence in 2066. 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]
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]

Although the outage lengths may vary slightly between Option D-1 and Options D-2 and D-3, which involve work near live cable, estimating outage costs is heavily assumption-driven. For this reason, constraint costs have not been included in the CBA.

5.3.2.3 Summary of costs

A summary of the costs included 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 costs included in assessment (£m)
D-1	[redacted]	[redacted]	[redacted]
D-3	[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 windfarm connections at Boreas in [redacted] Vanguard East [redacted] and Vanguard West [redacted]

Each connection has a capacity of 1320 MW and 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 – combined cycle gas turbine), 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)
D-1	[redacted]
D-2	[redacted]
D-3	[redacted]

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 G^3 leakages 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. 14 below illustrates the non-SF6 disbenefits for the analysis.

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

Option	G^3 leakages (kg)	Gas emissions (tCO_2e)	Economic value of the benefit (£m)
D-1	[redacted]	[redacted]	[redacted]
D-2	[redacted]	[redacted]	[redacted]
D-3	[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 tCO_2 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.

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-2	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]

5.3.3.1 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)	
D-1	[redacted]	[redacted]	[redacted]	[redacted]
D-2	[redacted]	[redacted]	[redacted]	[redacted]
D-3	[redacted]	[redacted]	[redacted]	[redacted]

5.4 Preferred solution

Based on the qualitative and quantitative analysis, we have recommended Option D-1 as the preferred solution in the interest of current and future consumers to deliver the investment driver. Out of the three shortlisted options, Option D-1 is the solution with the best NPV. It represents the most efficient option for consumers in the long term whilst meeting the needs of the contracted customers.

The key factors influencing our decision included identifying an efficient solution that enables SQSS-compliant connections in a timely manner, meeting contracted connection dates to support the development of offshore wind renewable generation, which is both environmentally and economically significant. We also aimed to utilise existing network assets for consumer efficiency and adequately future-proof other known connections on site, [redacted] The proposed option is for construction of a new extension to the west of the existing Necton 400kV AIS Double busbar (DBB) site.

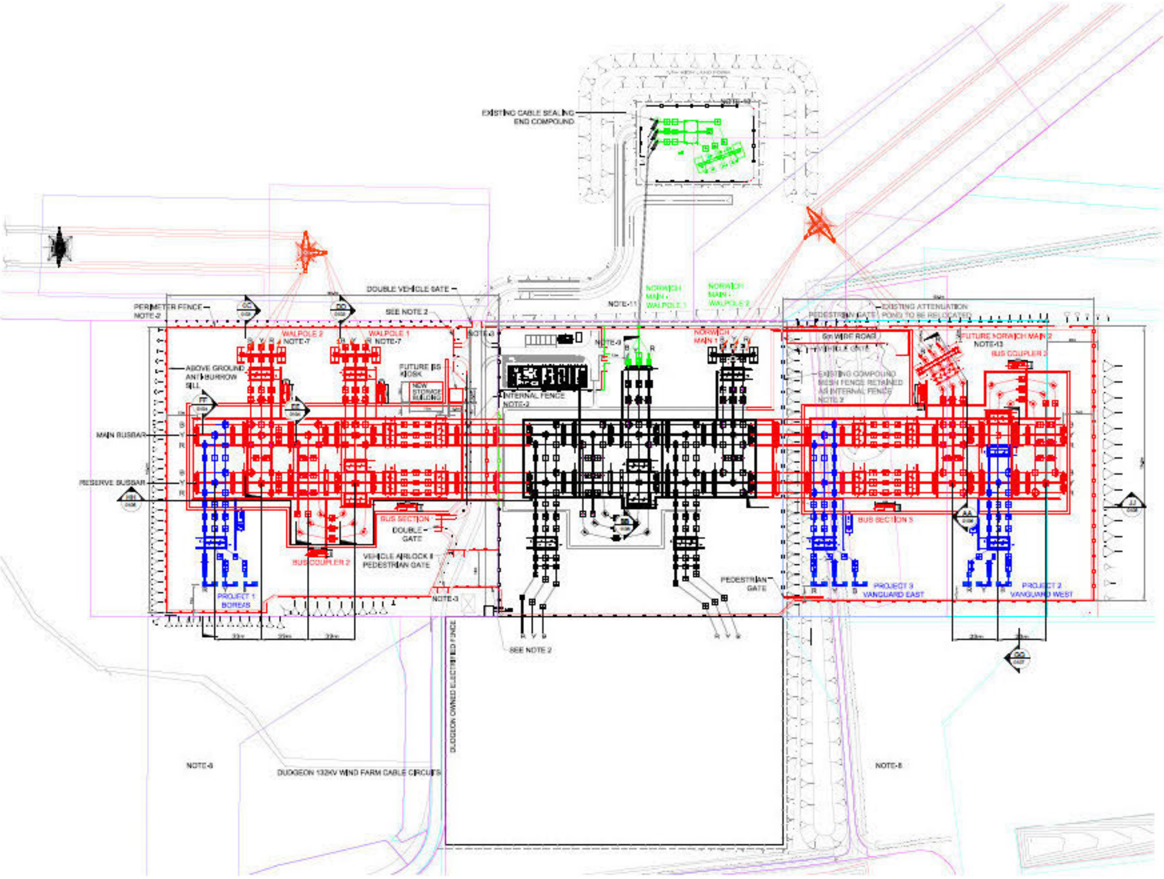

Figure 7 – Drawing of preferred option (D-1) at Necton substation

The scope of work for the preferred option is:

[redacted]

6. Detailed cost for preferred solution

6.1 Introduction

This section provides a breakdown of the overall costs and funding allowance request for Necton, 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 E Necton 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:

6.2 Total Allowance Request

6.3. Cost Estimate

6.4 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 (£)							
	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	Total
Total project costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CAI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Allowance request - Direct only*	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

*Remainder to be funded via Opex escalator

6.3 Cost Summary

The total cost to develop and deliver the investment at Necton project is [redacted] including indirect costs and costs incurred to date.

Table 18 below shows a summary of total project costs.

Element	Total (2018/19 price base, £)	CAI/Direct
Contractor Costs		
[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
1 - Fixed	[redacted]	[redacted]
2 - Agreed remeasurable	[redacted]	[redacted]
3 - Agreed remeasurable future information	[redacted]	[redacted]
4 - Estimated	[redacted]	[redacted]
5 - Early Estimate	[redacted]	[redacted]
Total	[redacted]	

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

7. Deliverability and risk

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 Deliverability

7.1.1 Delivery Programme

The project programme is summarised in the table 20 below:

Table 20: Necton high level programme milestones

Milestone	Date Achieved/ Planned
Feed Start	[redacted]
Sanction – Project Investment Decision	[redacted]
Gate C – Internal Sign Off Proceed to Tender	[redacted]
Contract Award – Substation	[redacted]
Contract Award – OHL	[redacted]
First Site Access	[redacted]
ACL First connection	[redacted]

We are mostly complete with the civil works on the project, excluding the substation fence. So far, the substation platform and equipment foundations have been installed, with the earth mat also nearly installed along with half of all steel structures. The OHL contractor has now also been mobilised to site and is undertaking necessary survey work prior to commencing installation. An aerial image of progress at the Necton substation as of January 2025 is included in Figure 8.

[redacted]

We continue to work collaboratively with the customer and maintain ongoing communication to ensure every party is updated. The customer has been onsite [redacted] building their bays adjacent to the work NGET is undertaking. The customer is invited to weekly SHESQ meetings chaired by the Principal Contractor, following NGET SR163 compliance.[10] We also continue multiple design, programme and CDM meetings on a monthly basis which have been ongoing for the last 18 months and have recently introduced quarterly update meetings at a senior level between both parties.

In regard to agreeing outages, we submitted a Scheme Requirements Document to NGET planning for submission to NESO. However, we are currently aware of some challenges related to resource and system access clashes with other major projects in the area [redacted] such as the Norwich Main extension project and the Bramford to Twinstead Reinforcement project (BTNO). Given The Necton project has a later ACL date than some of the other projects in the area, we are working internally to determine a new programme of proposed outages which consider the likely progress of other projects.

[10] NGET SR163 is a standard for hosting weekly SHESQ meetings on construction projects for managing Construction Design Management (CDM) interface at site level.

[redacted]

7.1.2 Procurement and Contracting Strategy

Given their specialist skill sets and supply chains, NGET's preferred procurement strategy was to award two contractors to each deliver all of the substation and OHL works, respectively.

<u>Substation Works</u>

NGET has completed a competitive tender on the Electricity Procurement and Construction (EPC) Framework, for Substation Construction, [redacted]

<u>OHL Works</u>

NGET launched a competitive tender on the OHL Framework, for Overhead Line Construction works [redacted]

7.2 Risk & 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 21 below lists the key risks identified for the Project, although the full Risk Register is included within tab 4.1 of the Cost Model appended to this submission.

Table 21: Delivery risks for Necton

Risks	Mitigation
Cancellation or Amendment of Planned Outages for the OHL If planned outages for the OHL works are cancelled or amended this could result in significant impacts in programme delay.	The Project Manager on the scheme has and continues to attend Cross Functional Meetings between all parties for early identification of issues which could result in a cancelled or amended planned outage for the OHLs. Required outages issued to NESO for acceptance.
NG SAP & Commissioning Resources OHL The availability of NG SAP & Commissioning Resources is critical for continued delivery of the programme to time. If these key resources are not available this could impact in delivery of the OHL works to programme delivery dates.	The Project Manager on the scheme has and continues to attend Cross Functional Meetings between all parties for early identification of issues which could result in planned resource not being available for the project as per programme delivery. The project is also reviewed in the Central Scheme Meetings with the NGET Asset Operations Planning Team focusing on SAP and commissioning resource.
Cancellation or Amendment of Planned Outages for the main substation works If planned outages for the main substation works are cancelled or amended this could result in significant impacts in programme delay.	The Project Manager on the scheme has and continues to attend Cross Functional Meetings between all parties for early identification of issues which could result in a cancelled or amended planned outage for the OHLs.
Interfacing works (Customer & DNO) OHL The alignment of Interfacing works between those works being delivered by the customer and the works being delivered by NGET on the substation could impact the delivery of the OHL programme. If the interfacing of works becomes difficult, this could impact in additional design costs and delays to programme delivery.	NGET continues to hold regular programme reviews with the Customer and substation Principle Works Contractor, this includes staying up to date as to the progress of the DNO works.
Customer Design Delays OHL Customer Design Delay impacts OHL works and design programme. Impacts in additional design costs and Programme delay	NGET continues to hold regular programme reviews with the Customer and substation Principle Works Contractor, this includes staying up to date as to the progress of the Customer's design works.

8. Conclusion

This document is NGET's MSIP re-opener submission to Ofgem for the Necton substation expansion in East Anglia. It is submitted with reference to Special Condition 3.14 (paragraph a) of NGET's Transmission Licence.

Table 22 below summarises the main investment driver, the selected option, estimated costs and expected outputs.

Table 22: Necton Project Investment Summary

<table>
<tr><td>Main drivers</td><td colspan="3">Generation Connection – to enable the connection of 3960MW of renewable electricity generation.

Three contracted customer connections under RWE (previously Vattenfall) to connect three 1320MW offshore windfarms on the coast of East Anglia. These three windfarms are for three sub entities of RWE: Boreas, Vanguard East, and Vanguard West.</td></tr>
<tr><td>Selected Option</td><td colspan="3">Extend the existing Necton 400kV AIS double bus bar substation to the east and west to accommodate an additional 12 bays. This includes:
• 3 user bays to accommodate the 3 connecting offshore windfarms, 4 bus section bays, 2 bus coupler bays, and 3 Feeder bays.
Reconfiguration of the OHL circuits from a double-tee to a double turn-in arrangement, coming from Walpole via a new terminal tower and Norwich Main via another new terminal tower, to AIS feeder bays on the west and eastern sides of the site.
The existing Cable Sealing End Connection (CSEC) will be disconnected to enable this, including removal of existing cable duck-under CSEs and a section of cable within the NECT4 substation.</td></tr>
<tr><td rowspan="2">Estimated Cost</td><td colspan="3">The total cost of the project is [redacted]
The total direct cost of the project is [redacted]</td></tr>
<tr><td>T2 (FY2022 – FY2026):
[redacted]</td><td>T3 (FY 2027 – FY2031):
[redacted]</td><td>T4+ (FY 2032+):</td></tr>
<tr><td>Outputs</td><td colspan="3">Network Capacity: 3 x 1320MW generation connections for offshore wind farms off the East Anglian cost. Supporting the delivery of an additional 3.9GW of renewable generation onto the network in line with our decarbonisation goals and national targets such as Clean Power 2030 and Net Zero 2050.</td></tr>
<tr><td>PCD Primary Output</td><td colspan="3">Extend the existing 400kV Necton substation by 12 bays and amend the OHL from a double-tee to double turn-in arrangement to connect three offshore windfarms[redacted]</td></tr>
</table>

In response to the growth in renewable generation in the East Anglia region, NGET has robustly assessed a range of options for enabling the connection of 3 offshore windfarms, with a combined capacity of 3.9GW. To address this connection demand, NGET has assessed options to identify the best solution for consumers. Working with NESO and the customer, we concluded through the CION process that an extension at Necton would be most suitable, enabling timely project delivery at a proportionate cost to consumers. Specific design Options considered by NGET within this assessment differed by their approach to transposition of cables and removal of the CSEC.

Our preferred solution following this assessment is an extension to the existing Necton AIS 400kV substation by 12 bays and amending the double-tee circuit arrangement to a double turn-in configuration. This proposed solution will enable NGET to meet the contracted connection dates for all 3 agreements, whilst considering the needs of consumers for an cost-efficient solution and providing space for one additional connection in the future, in the interest of future consumers.

9. RIIO-T1 and RIIO-T2 allowances

There were no investments proposed for this project during either RIIO-T1 or T2 business plans submissions and so no funding was received. The Project does not have funding through any other price control mechanism.

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 Allowance Calculator

An excel file demonstrating difference between total volume driver allowances the investment is eligible for, compared to total efficient costs is provided alongside this submission attached with title “Appendix A – Volume Driver Allowance Calculator – Necton – Jan 25 MSIP.xslm”.

Appendix B: Asset Health

Necton 400kV

Substation	Asset/ No of Assets	Asset Group	Present Health	Future health (8 years)	Future health (20 years)	Present Risk	Main Health Drivers
Necton 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Necton 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Asset Types which have a Low/Medium risk

Where an asset type appears in more than one category, numbers in brackets indicate the number of assets under that group:

[redacted]

Walpole 400kV

Substation	Asset/ No of Assets	Asset Group	Present Health	Future health (8 years)	Future health (20 years)	Present Risk	Main Health Drivers
Walpole 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Walpole 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Walpole 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Walpole 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Walpole 400kV	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Asset Types which have a Low/ Medium risk

Where an asset type appears in more than one category, numbers in brackets indicate the number of assets under that group:

[redacted]

[redacted]

[redacted]

[redacted]

Appendix D: CBA

An excel files demonstrating the CBA for the investment is provided alongside this submission attached with title “Appendix D – Necton CBA - Jan 25 MSIP.xslm”.

Appendix E: Cost Model

Excel files demonstrating the funding allowance request for the investment are provided alongside this submission attached with titles:

- “Appendix E.1 – Necton Cost Model - Jan 25 MSIP.xslm”.
- “Appendix E.2 – Necton Estimated Inflation - Jan 25 MSIP.xslm”.

Appendix F: 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
EV	Electric Vehicle
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

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