nationalgrid

RIIO-T3

Warley 275kV Substation Replacement

Eligibility Letter Submission – Track 2

Confidential

May 2026

National Grid Electricity Transmission's Business Plan

Electricity Transmission

Table of Contents

Summary Table

Field	Description
Name of Project	Warley 275kV Substation Replacement
TO's preferred re-opener track	Load Re-opener Track 2 Eligibility Letter (EL) Investment
RRP References	[redacted]
BPDT Project Reference	[redacted]
Load Board Reference	[redacted]
Investment driver(s)	The replacement of Warley 275kV is driven by: • New connections; a DNO and [redacted] direct customer connections to NGET's network and embedded customer connections via the DNO [redacted] • [redacted] the condition of the existing Warley 275kV substation needs remediation. • NESO: tCSNP2 refresh for uprating the Transmission Network 275kV to 400KV from Tilbury to Waltham Cross via TWNC
PASE Compliance	Not PASE
Outputs	A new 400kV GIS double busbar substation on [redacted] just south of the existing Warley 275kV substation connected via 400kV OHL. At present the design includes/ enables: • 6 x 460MVA 400/132kV SGTs • 1 x 150MVA 400/33kV SGT • 1km OHL refurbishment The new substation will allow data centres and renewable energy to be connected both directly and through the DNO. Section 3.7.2 summarises how recent outcomes of connections reform and system requirements are impacting refinement of the design.
Short list of strategic options considered	We assessed five strategic options (including existing assets vs new builds; 275kV vs 400kV), completed a siting study across eight candidate sites, and evaluated technical configurations (AIS vs GIS; OHL vs cable). This process produced three shortlisted options for detailed assessment: Option E5 (400kV AIS), Option E7 (400kV GIS), and Option E8 (400kV AIS with ZB OHL diversion).
Indicative preferred solution and explanatory narrative on the rationale	The preferred option is to build a new 400kV double busbar GIS substation on a [redacted] (a greenfield site immediately south of the existing Warley) with relocation of the feeder terminal towers. The GIS option offers the following benefits: • Improved safety during construction as new oversailing risk present under the GIS option. • Improved likelihood to obtain planning and consents given minimisation of land take needed to prove "Very Special Circumstances for greenbelt development. • Enhanced opportunities for future extendibility to meet the current and future demand growth in the region. • Better compliance in accordance with Construction Design Management regulation where a high volume of cables coming into site (including [redacted] circuits) can be enabled • Enables [redacted] 132kV substation to be sited adjacent to the new 400kV substation and cabling between. • Reduced environmental impacts on the greenbelt, less earthworks [redacted] and lower carbon emissions.
Expected Forecast Cost	[redacted] in 23/24 price base

Delivery year	We plan for the first ACL completion dates for the scheme and energisation of Warley 400kV to occur in [redacted] with staggered phased ACL dates following this up to [redacted] as additional customers come online and the existing Warley 275kV substation is also demolished. The project's planning submission is scheduled for [redacted], with contracts expected to be awarded by [redacted], ahead of First Site Access (FSA) in [redacted]		
Applicable Reporting Tables	BPDT 10.5 ET Pipeline log and RRP 2024-25 E1.11_ET Pipeline Log.		
Historic funding interaction	The estimated remaining Regulated Asset Value (RAV), using our statutory Fixed Asset Register for these works, is [redacted]		
Interactive projects	The Warley 275kV replacement investment interacts with several other regional investments: • The Tilbury substation rebuild from 275kV to 400kV (separate Load Re-opener 2025 May Eligibility Letter submission.) This is required to allow the uprating of the network to 400kV and minimise the use of interbus SGTs. • Uprating of the Tilbury to Warley OHL from 275kV to 400kV (included in a previous T3 EJP. Required to allow the uprating of the network to 400kV in the region. • TWNC (included in the BPDT) – a NESO driven tCSNP2 investment identified in the Network Options Assessment (NOA) to uprate from 275kV to 400kV from Tilbury to Waltham Cross via Warley and this project will deliver the Elstree/Waltham OHL 400kV uprating.		
Spend Apportionment	T2 (FY 2022- 2026) [redacted]	T3 (FY 2027 – FY 2031) [redacted]	T4+ (FY 2032 – FY 2037+) [redacted]

Executive Summary

Project Summary

The Warley 400kV site strategy is designed to deliver value to consumers by facilitating Gate 2 connections in accordance with signed agreements. This investment also aims to mitigate operational and [redacted] risks through the replacement of life-expired equipment at the Warley site. Additionally, the strategy supports regional 400kV reinforcement by meeting NESO's TWNC requirements and enhancing east–west transfer capability.

Submission purpose

This paper seeks:

- approval of the project's eligibility for submission via the Load Re-opener and Price Control Deliverable under Special Condition 3.18,
- continued acceptance of the track proposal already discussed with Ofgem, which is that the project should follow Track 2 EL of the re-opener process for Option E7.
- approval of Pre-Construction Funding (PCF) allowances under Special Condition 3.15.

Need

We will replace the existing Warley 275kV substation with a new 400kV double busbar GIS substation on [redacted], connected via 400kV overhead line. This investment is required to

(i) deliver connections for a DNO and four direct contracted customer connections

(ii) address urgent [redacted] risks at the existing site, and

(iii) enable NESO's planned 275kV-to-400kV uprating in the region

Without this investment, we cannot meet our connection obligations, maintain an efficient and economical system, or deliver the enabling works required for the TWNC investment.

Optioneering to date

We assessed five strategic options (including existing assets vs new builds; 275kV vs 400kV), completed a siting study across eight candidate sites, and evaluated technical configurations (AIS vs GIS; OHL vs cable). This process produced three shortlisted options for detailed assessment: Option E5 (400kV AIS), Option E7 (400kV GIS), and Option E8 (400kV AIS with ZB OHL diversion).

Each option comprises the initial installation of 24 bays, with provisional space for four spare bays to accommodate future connections and maintain system flexibility.

We select Option E7 as the preferred option. It is the lowest-cost shortlisted option and provides the most deliverable solution at the preferred siting location, by reducing land take and consenting risk in the green belt, improving constructability, and reducing environmental and carbon impacts. These reasons include:

- **Lower consenting risks and fewer potential programme delays** - supporting the case for "Very Special Circumstances" predicated on minimising environmental impacts wherever possible on greenbelt land through a smaller footprint. Helps to address known strong local opposition to development in an area with numerous resident groups petitioning against a data centre project, and mitigates permanent loss of greenbelt land.
- **Reduced impact on ecological factors on site** – unlike the AIS option, it minimises encroachment on [redacted] and enables flexibility in siting to prevent encroachment on both veteran trees and the adjacent woodland.
- **Better technical performance and possibility to extend in the future** – enabling OHL circuits to connect directly to the 400kV via GIB connections, rather than the need for cable connections under an AIS solution. Creates more space for future site expansion.

- **Reduced health and safety risks in construction** – enables more space for [redacted] cables, enables sufficient space for a CDM compound without oversailing hazards, which are present for the AIS solution.
- **Shorter and simpler construction programme** – removes dependency on both NGET and [redacted] access to system outages, as well as less civils and earthworks needed on site.
- **Substantially reduced earthworks, vehicle movements** and therefore lower carbon emissions – estimated to require 28,409 less lorry loads and 13% less emissions.

The GIS substation solution is favored due to its smaller footprint, enhanced safety, lower environmental and carbon impacts, improved constructability, and reduced third-party disruption. Taken together, these factors make Option E7 the most deliverable solution with the lowest overall risk to delay and construction.

Cost Estimates

Our preferred solution has a cost estimate in 23/24 prices of [redacted]. This differs slightly from other shortlisted preferred options considered through the investment which are circa [redacted]

Indicative delivery program

We plan to deliver the first ACL in [redacted] with enabling works from [redacted]. We will submit the planning application in [redacted] and expect to award contracts by [redacted], ahead of first site access in [redacted]. Delivery remains dependent on securing planning consent and regulatory approvals.

1. Introduction

1.1 Warley 275kV Replacement

This paper presents an Eligibility Letter application under the 'Load Re-opener and Price Control Deliverable' Special Condition (3.18 of the RIIO-ET3 Licence) for an investment to replace the existing Warley 275kV AIS mesh corner substation with a new 400kV SF6-free GIS substation.

This Eligibility Letter application requests the following outcomes from Ofgem's review:

a. the approval of project eligibility for submission under the Load Re-opener and Price Control Deliverable under Special Condition 3.18,

c. confirmation of Track 2 as discussed with Ofgem prior to submission,

d. the approval of Pre-Construction Funding (PCF) under Special Condition 3.15 (Pre-Construction Funding Re-opener, Price Control Deliverable).

The investment will replace the Warley 275kV substation with a 400kV SF6-free GIS double busbar substation connected by OHL on a new site just south of the existing. It will connect a DNO, four direct customer investments, address [redacted] issues at the existing site, and support NESO's TWNC tCSNP2 project to increase and futureproof capacity in a high-demand region of the network.

1.1.1 Eligibility and Track

This investment qualifies under Special Condition 3.18 as it is classified as a shared driver project, including both load and non-load drivers, scheduled for delivery within the T3 price control period. To date there have been no allowances provided for this investment within the previous or current price controls.

The project applying to be submitted under Track 2 of the Load Re-opener. Therefore, following approval of this Eligibility Letter, the project will advance to submit its Project Assessment (PA).

As a proposed Track 2 EL, this submission provides a summary of the investment rationale and the optioneering undertaken. It outlines the reasons we believe the project serves the interests of both current and future consumers.

1.1.2 Pre-Construction Funding Request

Under Special Condition 3.15 of the Electricity Transmission licence, this investment qualifies for allowances equal to 8.2% of its total forecasted cost [redacted] at the time of this Load Re-opener Eligibility Letter submission).

Based on our current forecast we have provided below breakdown of costs amounting [redacted] as part of this submission. This equates to [redacted] of the "latest total forecast costs project costs.

Table 1 below summarises the activities covered by the application of these PCF allowances based on our current progress of PCF and EEW spend. This position will be updated as we continue to mature this investment and ultimately reconciled at Project Assessment stage of the re-opener.

We confirm that no PCF activity included in this submission has been funded through baseline allowances, other re-openers, or alternative licence mechanisms.

Table 1: *Estimated costs for pre-construction activities (£m, 23/24 prices)*

No	Description	Total Forecast Costs £m
1	Surveys	[redacted]
2	Planning Consent approvals	
3	Optioneering and Feed development	
4	Project Design activities	
5	Early Enabling Works	
6	Stakeholder Engagement and Consultation activities	
Total		

1.2 Background

1.2.1 Chronology of Investment

The background to the investment commenced in 2022 with the signing of the first customer connection at Warley. A summary of the chronology surrounding the development of the investment is provided in Figure 1. The drivers underpinning the need for investment evolved over time, influencing the options that were evaluated throughout each stage of the project's development.

2022

The need for investment at Warley is triggered.

- The need to invest at 275kV Warley substation was first triggered from a ModApp from UKPN (the DNO) to rebuild their 132kV site and increase the number of 275/132kV SGTs. this was to facilitate an embedded [redacted] Data Centre connection on their site.
- It is quickly ascertained that Warley 275kV is an aging substation at full capacity and cannot be extended or upgraded.

2022 - 2023

We assess a 275kV solution to accommodate intiial contracted customer connections.

- Five additional BESS connections were signed at Warley 275kV.
- UKPN's embedded data centre customer pivots to seek a staged connection across 3 phases.
- Optioneering at the time focused on rebuilding a 275kV substation in fitting with the regional network voltage and providing a temporary connection to UKPN for their data centre customer.
- Connection offers with ACL dates between 2029-2030 were given to these customers based on delivering a 275kV solution.

2024

NESO Requirements to uprate trigger the need for a 400kV solustion

- In April 2024, we learnt of NESO's direction for the TWNC tCSNP2 investment to uprate the Waltham Cross to Wymondley circuit to 400kV. An additional BESS customer connection was also signed.
- A review was triggered to strategically align this new NESO driver with all existing customer and asset health drivers into one site strategy in line with NGET's 2023 Network Strategy principles.
- The need to replace the substation at 400kV rather than 275kV was therefore identified and subsequent customer dates were therefore pushed out to the mid 2030s to reflect a longer progran duration.

2024

An additional ask to connect strategic customers at pace is explored but focus remains on Warley 400kV

- Given this proposed delay and the sentivitiy of the DNO's embedded data centre customer, UKPN escalated to NESO requesting the original connection date of [redacted] be reinstated.
- Although the 400kV solution proceeded as intended, we offered a temporary solution to install a fourth 240MVA SGT at the existing 275kV Warley site and disconnect the existing MSC. The remaining 132kV bay can then be repurposed for UKPN to operate a secondary circuit to [redacted] (previously referred to as [redacted] The temporary connection will be funded via a one-off charge by the DNO and not by consumers.

Figure 1 – Summary of chronology for the Warley project

1.2.2 Regional and Network Context

The transmission system in the Central and Greater London area includes an outer 400kV route that supplies power to the region, and two inner routes (275kV and 400kV). These inner routes are in the process of being upgraded.

The region consumes 20% of the nation's electricity, requiring substantial upgrades and reinforcements to keep pace with the region's rising demand for power. National and regional decarbonisation targets are increasing this need. For example, London's aim to achieve net zero emissions by 2040, via the electrification of both transport and heat networks. Furthermore, the Governments Modern Industrial Strategy, which is encouraging growth in AI Data Centres near the capital, are increasing capacity requirements on both NGET and DNO networks in the area.

Figure 2 presents a Picasso line diagram of the network regional to Warley and Figure 3 a map of where the Warley substation sits on the UK network.

As demand rises in the region, significant investment is underway to strengthen circuits and substations – particularly to uprate circuits to 400kV in the London East region. This includes the TWNC tCSNP2 project, (which is discussed both as a key driver for this project in Section 2.1 and the interactive investment section 1.2.2.1 below). There are also plans to possibly extend this enhanced 400kV route into North London, reaching as far as Iver.

In addition, the ATNC project—will provide upgrades on the Tilbury to Norwich OHL and construct a new Grid Supply Point (GSP) at Southfields substation (previously called Tilbury North). The existing Tilbury 275kV substation will also be rebuilt to 400kV like Warley, and NGET is also exploring a new node in the London East area. Planning for these projects will ensure coordination with supplementary works to avoid hindering future development proposals.

It is also worth noting other investments in the region which are characteristic of the region's general agenda for growth and related to this submission. Investment has been granted to develop the Lower Thames Crossing to connect Essex and Kent. Furthermore, Network Rail is being engaged, by National Grid, to reinforce their own network through investment of the FS44 Warley Street Bridge, which will enable movement of the SGTs required for Warley 400kV.

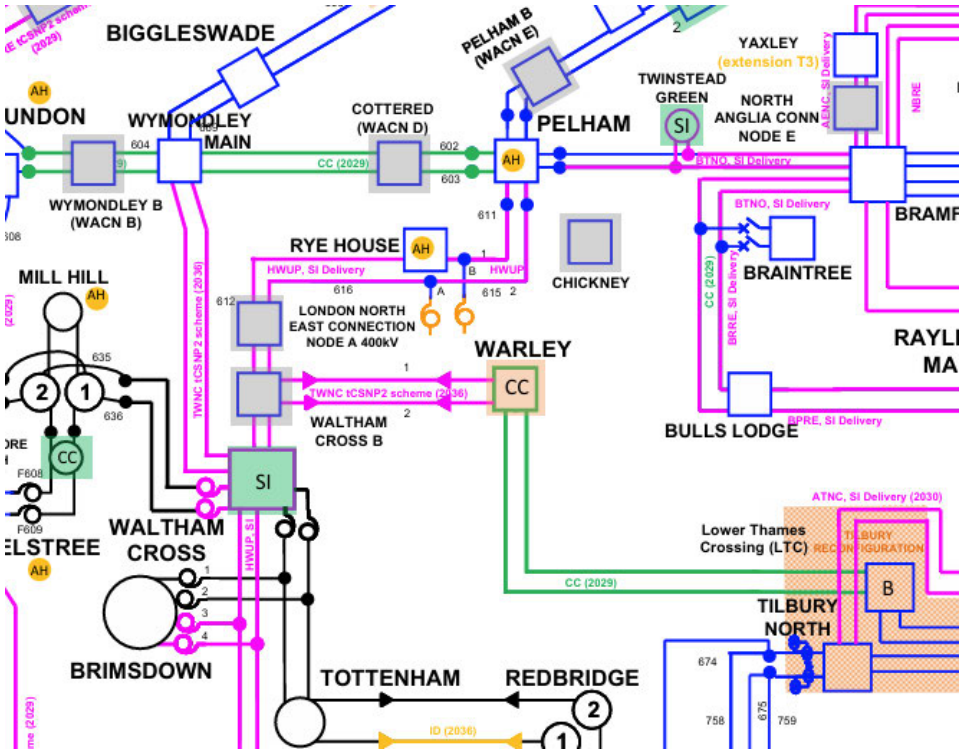

Figure 2: Regional line diagram indicating Warley and its interaction with nearby projects.

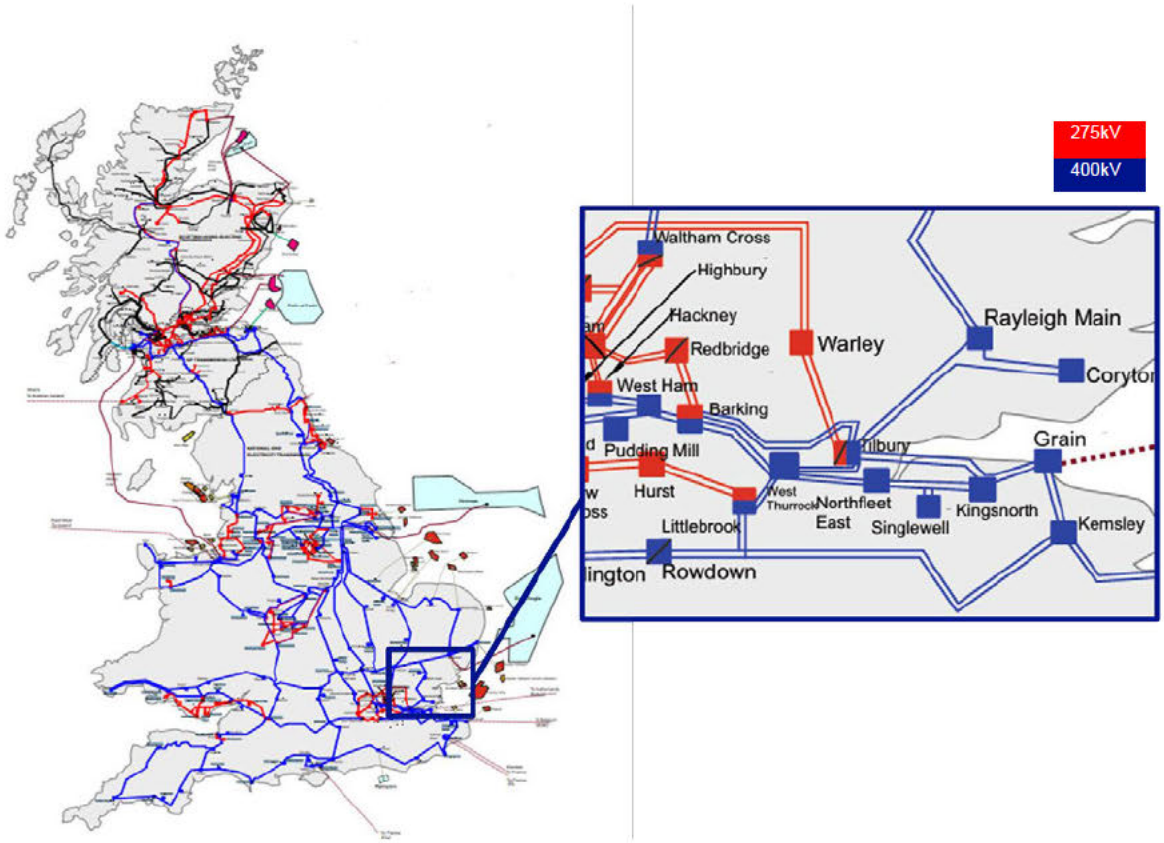

Figure 3: NGET Network Map of region around Warley.

1.2.2.1 Interactive Investments

In conjunction with the broader capacity enhancements and upgrades within the region, additional projects are currently underway near Warley that both influence and facilitate the substation replacement. To provide a concise overview, these related investments include:

- TWNC – a NESO driven tCSNP2 project to uprate the northeast London ring from 275kV to 400kV, specifically from Tilbury to Waltham Cross via Warley.
- Reconductoring of the Tilbury to Warley overhead line to 400kV, identified under project 103777, which serves as an enabler for energising both the new Warley and Tilbury substations at 400kV. Possible efficiencies in scope and system access are being explored by NGET given the Lower Thames Crossing investment may already be seeking a diversion of the current ZB route.
- Like Warley, the Tilbury 275kV substation is also being rebuilt as a 400kV substation.
- Migration of two tertiary customers (one connected and one soon to connect) at the existing Warley 275kV substation on [redacted] respectively to the new Warley 400kV substation once built.

The local DNO [redacted] are further reinforcing their own network including replacement of the existing 132kV Warley substation and development of the nearby [redacted] substation for capacity and resilience reasons.

1.2.3 Site Background

The existing Warley 275kV substation is located east of London in the London Borough of Havering, just outside the M25 ring. The site is surrounded by hedgerows and agricultural fields, and the closest residential property lies 250m west of the existing substation.

The Warley 275kV substation is one of the oldest in our network and has been in operation since 1965, consequently many assets have reached or exceeded their service life and are in poor condition. The current substation is an outdoor four-switch mesh station, linked by three SGTs to the DNO, [redacted] 132kV AIS double busbar substation. This adjacent substation was built next to the 275kV site around the same period. There are fault level limitations at the Warley 132kV substation and NGET operates three SGT 132kV bays within it.

Figure 4 below, shows a Single Line Diagram (SLD) of the existing substation. Figure 5 shows an aerial view of the existing substation in relation to other known customers and substations in the vicinity.

After the tertiary connection of a BESS to existing substation in [redacted], along with planned connection of a final tertiary BESS in [redacted] the current Warley 275kV and 132kV substations do not have enough capacity or available spare bays to accommodate more customers given the other customer drivers that have come along. Their rating and capability are insufficient for additional connections. Furthermore, the mesh corner design also limits further extension, and the site is constrained by available space.

Two sets of overhead lines feed Warley from Tilbury to the south and Elstree to the north. Space to the southeast and west of the existing substation have consented customers already lined up to construct or have constructed their own investments, for example [redacted]'s own customer has constructed it's BESS to the west of the existing substation.

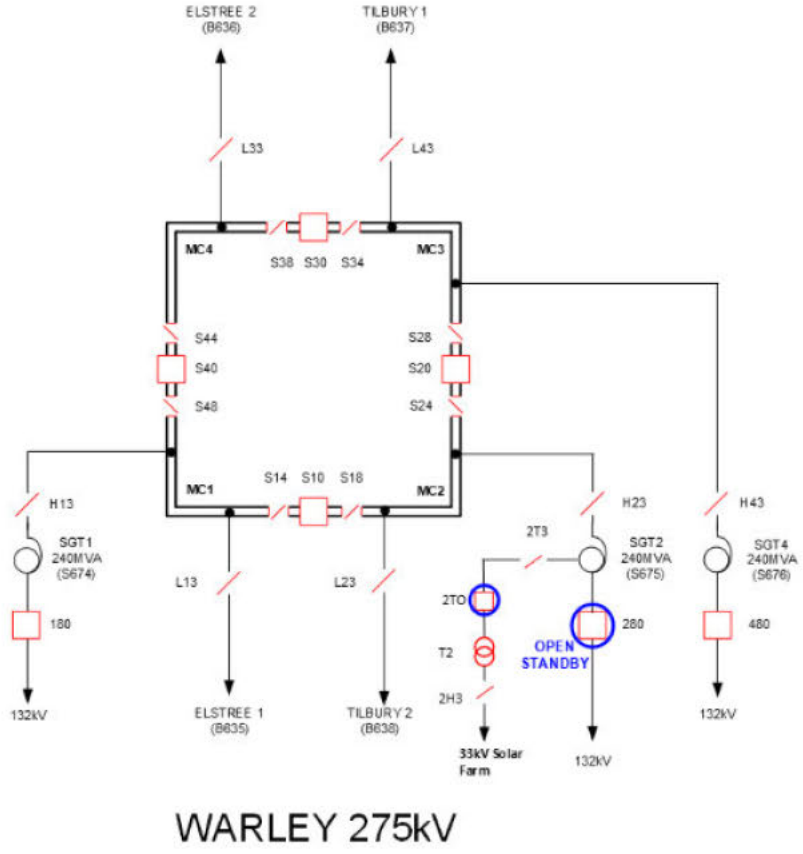

Figure 4 – Single Line Diagram (SLD) of the existing Warley 275kV substation

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Figure 5: Existing Warley AIS 275kV Substation and adjacent 132kV [redacted] *AIS substation*

1.2.4 Historical Funding

The estimated remaining Regulated Asset Value (RAV), using our statutory Fixed Asset Register for these works, is [redacted].

2. Drivers and Needs Case

Investment at Warley is driven by rising customer connections, [redacted] needs, and NESO's requirement for a 400kV upgrade in the region. These factors, along with awareness of potential impacts from connection reforms, shaped the preferred design for the Warley 400kV project to address all current drivers to date – further detail regarding the basis of the design underpinning the solution during optioneering is discussed in section 3.7.2.

Table 2 below therefore summarises the known live drivers for the Warley 275kV replacement. Customer-related drivers affected by Connections Reform are excluded but further discussed in Sections 2.1

Table *2: Project Drivers Summary Table*

Driver	Description	ACL Date
[redacted]	A [redacted] demand connection for [redacted], the local DNO who are rebuilding their 132kV GIS substation to facilitate embedded demand connections on their network and resolve aging assets on their site. Their main embedded customer is a [redacted] (an increased ask of [redacted] their previous contract) [redacted] who are constructing their data centre over [redacted] and will be seeking a temporary one-off customer funded connection at [redacted] substation in [redacted] It is known that [redacted] investment in the region has garnered local opposition due to being sited in the greenbelt. [redacted] build our bays within their newly built 132kV substation as User Self-Build (USB) works for the LV SGT & MSC bays.	October 2029 (temporary connection at existing Warley 275kV) With staged connections at new Warley 400kV from [redacted] up until [redacted] (for the full [redacted]
[redacted]	A [redacted] BESS Generation connection. [redacted] hold this contract as a Bilateral Embedded Generation Agreement (BEGA) with [redacted] – but this contract will fall away once NGET connects [redacted].	[redacted]
[redacted]	An existing tertiary PV/Solar generation connection at the Warley 275kV substation. The connections cable will be diverted to the new Warley 400kV substation in the future under an [redacted]	Already connected at existing Warley 275kV Estimated to be transferred to new Warley 400kV between [redacted]
[redacted]	Tertiary BESS generation connection to be connected at the Warley 275kV substation in [redacted] The connections cable will be diverted to the new Warley 400kV substation in the future under an [redacted]	[redacted] (at existing Warley 275kV) Estimated transfer to new Warley 400kV between [redacted]
[redacted]	[redacted]	[redacted]
NESO	NESO NOA: TWNC • The TWNC project sets out to uprate the network to 400kV between Wymondley to Waltham Cross. • Rebuilding the Warley and Tilbury 275kV substations at 400kV are critical enablers of this	[redacted]

Driver	Description	ACL Date
	investment, as well as upgrading the Tilbury to Warley overhead line. • The TWNC project is essential for enabling power flows west-east and east-west, supporting renewable, nuclear, and interconnector sources. • Upgrades at Warley and Waltham Cross are also needed for power exports along the south coast.	

There is another Gate 2 customer with an existing contracted connection at the replacement Warley substation – however, following changes to their connection request after our options assessment (from [redacted] BESS to a [redacted] data centre) we are currently revisiting the most efficient Point of Connection (POC) for the customer.

This is particularly in the context of having sufficient space to accommodate the connection alongside additional emerging system requirements (such as the possible need for reactive compensation, series reactors and a possible third circuit on the site). This emerging update has been communicated to the customer, and early discussions are ongoing.

Further details related to how this emerging analysis is affecting refinement of the outcome of our optioneering process, is described in section 3.7.2.

Driver	Description	ACL Date
[redacted]	A [redacted] data centre. The customer was previously and during the time of optioneering for the substation, a [redacted]	[redacted]

2.1 Customer

Table 3 summarises all current and previous customer drivers contracted to connect at Warley. From 2022 to 2024, customer connections surged, mainly due to BESS investments.

The customer ACL dates presented in this submission reflect the existing P6 programme. The testing and setting of ACL dates for customer contracts within scope of connections reform is ongoing throughout 2026. Confirmation of agreed ACL dates will therefore be presented in the next stage of submission which will be the Project Assessment.

In fitting with a known oversubscription of BESS investments in the queue five BESS projects did not receive Gate 2 offers and lost their firm contracts at Warley. As section 3 explains, these known connections were included in our development of the project as known when optioneering and whilst this represents a drop of circa [redacted] of generation connections seeking connection at Warley, the need for investment has not dropped away. As sections 2.2 and 2.3 explain, additional [redacted] drivers at the existing 275kV site and enabling the 400kV uprating in the region to facilitate NESO's TWNC investments, remain as key drivers to rebuild the Warley substation alongside the remaining [redacted] of demand and [redacted] of generation customer connections that received Gate 2 offers at Warley.

Table 3: Details of customers with Gate 1 and Gate 2 contracted connections

Customer name	Project name	Technology Type	Embedded Generation/ Demand	Output (MW/MVA)	Voltage	Firm Connection Date	Additional bays
Gate 2 Offers							
[redacted]		DNO - Demand	Data Centre – [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		BESS	[redacted]		[redacted]		
		BESS	[redacted]		[redacted]		
		PV/Solar	[redacted]		[redacted]		
		Current Gate 2 offer in early stage d			ng an alternative POC		
		Demand – Data Centre	[redacted]		[redacted]		

[1] Contract is to be updated to 400kV following contracts being re-issued as a result of Connections Reform
[2] Connection dates to the existing Warley 275kV, however [redacted] will need to be organised with both customers to transfer them to the new Warley 400kV. We anticipate this to happen between [redacted]

The following customers, who had prior contracts to connect at Warley, have now received Gate 1 offers because of the latest Connections Reform outcome. Consequently, these customers no longer hold active contracted offers with NESO for site connection. Their inclusion illustrates the number of connections previously considered during the investment optioneering process. Although these drivers are currently on hold, we have ensured that our proposed preferred solution continues to be the most appropriate and efficient approach to meet the confirmed Gate 2 customers and any other relevant drivers.

Table 4: Prior Contracts - Gate 1

Customer name	Project name	Technology Type	Embedded Generation/ Demand	Output (MW/MVA)	Voltage	Firm Connection Date	Additional bays
Gate 1 Offers							
[redacted]			BESS	[redacted]	[redacted]		[redacted]
			Battery Storage – Lithium Ion Battery				
			Other Energy Storage System				
			BESS				
			Battery Storage – Lithium Ion Battery				

2.2 [redacted]

[redacted]

2.3 National Energy System Operator (NESO)

Table 6 – Summary of NESO driver

Driver	Description	Date
NESO Network Reinforcement	• NESO identified the need to boost circuit capacity in the constrained and high demand north London region – by installing a new OHL from Waltham Cross to Wymondley as well as uprating the OHL from Tilbury to Waltham Cross (turn in the Elstree circuit) via Warley. • The TWNC project is essential for enabling power flows west-east and east-west, supporting renewable, nuclear, and interconnector sources. • Upgrades at Warley and Waltham Cross are also needed for power exports along the south coast.	[redacted]

Finally, another key driver underpinning the need to rebuild the existing Warley substation and the primary trigger for rebuilding at 400kV, as summarised in Table 6 above, is the need to facilitate critical uprating and reinforcement works driven from NESO's (National Energy System Operator) tCSNP2 publication in March 2024 which included a refresh to the 2021/2022 Network Options Assessment (NOA).

Included in this plan was TWNC, which seeks to install a new circuit between Wymondley and Waltham Cross and increase operating voltage of the network within the area - this circuit includes uprating the existing 275kV circuit between Tilbury and Warley to 400kV. NESO states in their March 2024 publication regarding competition of relevant tCSNP2 projects, that TWNC is dependent on Warley being uprated to a 400kV substation to increase operating voltage in the network are by [redacted]

3. Optioneering

We follow a structured, multi-factor optioneering process to select the most economic and efficient solution, in the interest of consumers. In line with the Electricity Transmission Design Principles, our optioneering process considers engineering, environmental, deliverability, economic and stakeholder factors. We start by assessing the most suitable strategic options.

3.1 Strategic Options

In line with our standard optioneering process, we considered the following broad strategic options summarised in Table 7:

Table 7: Strategic Options Summary Table

Option Number	Option Name	Option Description
A	Do nothing	The network is kept in its current state, and no new connections are facilitated.
B	Market based solution	Increased customer demand is accommodated through the procurement and use of ancillary services only.
C	Whole systems solution	The required customer connection is accommodated by a DNO.
D	Make use of existing assets	Facilitating the requested connection by utilising the existing substation (extension, uprating, etc.)
E	New build	Facilitating the requested connection by building a new substation.

Due to licence and contractual obligations and the inability to facilitate connection requests, Options A, B and C were discounted early in our optioneering process. We considered both options D and E in our high-level assessment to meet the drivers, but as shown below, concluded that the drivers could be effectively met by building a new substation. A descriptive rationale is explained in Section 3.3, table 9.

3.2 Siting

As option E would require a new site, a siting study was conducted to locate the most suitable location for a 400kV substation. Eight candidate sites (capable of both AIS & GIS layouts) were assessed, and [redacted] selected as the preferred site, after taking into consideration various consenting and programme risk constraints.

The study shortlisted three sites against environmental, planning, socio-economic and grid-connection criteria. The eight options assessed for the Warley Siting Study [redacted]

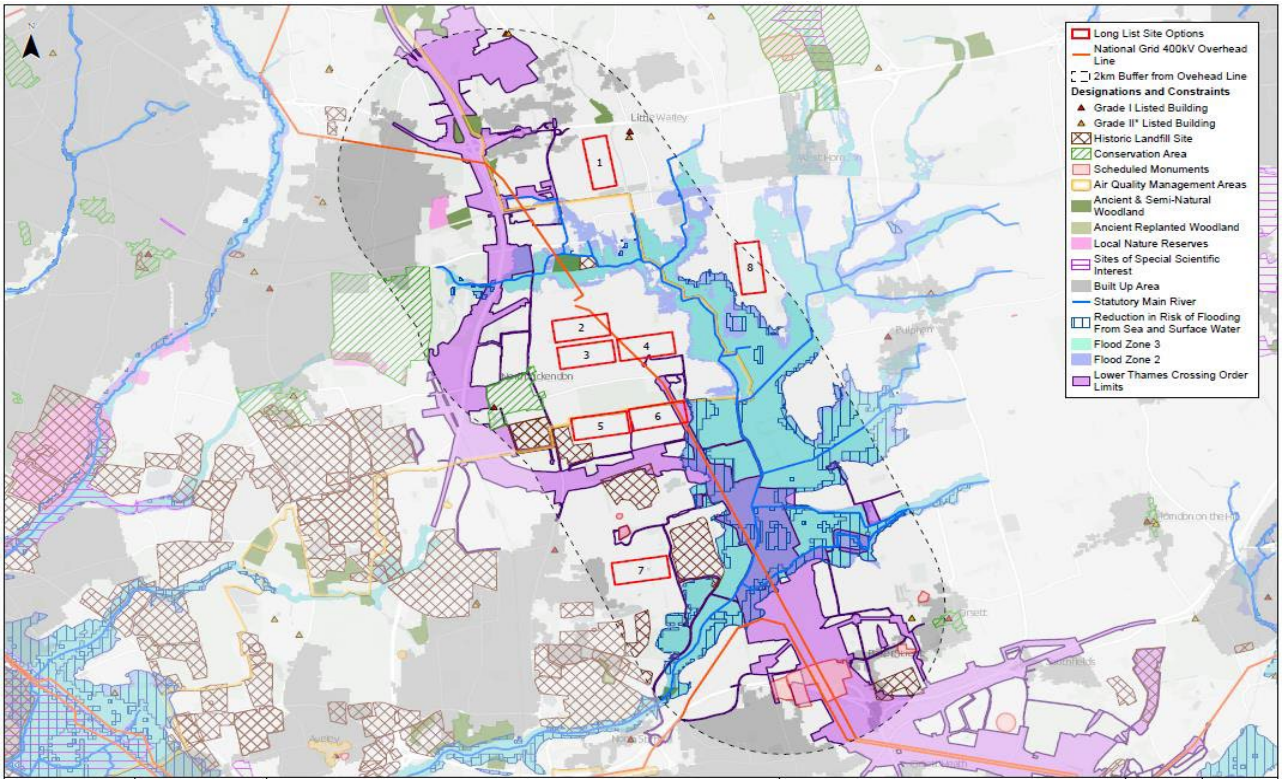


Figure 6: Map of long list sites considered sites 1-8

Following the assessment, five of the eight shortlisted options were excluded from the siting study. Reasons for exclusion include conflicts with existing developments, direct interference with Public Rights of Way (PRoW), landscape and visual amenity impacts, ecology, historic environment, noise and vibration, soils and geology, water, constructability challenges associated with elevated landforms and landfill operations, as well as considerable distance from the existing overhead line (OHL).

The shortlisted site location options taken forward [redacted] Figure 7 highlights the shortlisted sites in relation to each other. As part of our Environmental study, “RAG” (Red, Amber, Green) analysis was conducted for these three shortlisted site Options, with a summary of the results shown in Table 8 below.

R

Figure 7: Map of shortlisted sites 2, 5 & 8

Table 8: Qualitative analysis table of remaining site options

Site Option	2	5	8
Biodiversity	Located partially within the [redacted] Site of Importance for Nature Conservation (SINC)'. Also features some wet ditches, hedgerows and arable field margins. Regulatory and legal reviews therefore needed to assess this and put mitigations in place.	Limited habitat complexity. Ecological interest largely confined to boundary features, including hedgerows and small group of deciduous trees associated with the adjacent golf course. No designated sites lie within site boundary.	Site with least ecological constraints. Situated the greatest distance from both statutory and non-statutory ecologically designated sites. Contains fewer habitats of principal importance.
Landscape and Visual	Has limited views due to the flat terrain and existing boundary vegetation. In fitting with the current terrain given the existing substation and industrial area.	Proximity to [redacted] could increase visual impacts for the local community.	In an open area and close to a residential location, not all visual impacts will be possible to mitigate and will likely encounter greater community opposition.
Historic Environment	There are no significant heritage impacts, with the nearest heritage asset being a Grade II listed building 470 meters away.	500m from several Grade II listed buildings, with minimal impact on heritage receptors due to distance and screening.	Closer to heritage assets - 230m from the nearest heritage receptor, but minimal impacts predicted due to distance and screening.
Geodiversity and Agricultural Land	Site is located within ALC Grade 3 land, meaning the land has	Site is located within ALC Grade 3 land, meaning the land has	Site is located within ALC Grade 3 land, meaning the land has

	moderate limitations for agriculture.	moderate limitations for agriculture.	moderate limitations for agriculture.
Water Environment	Within Flood Zone 1, indicating a low probability of flooding	Within Flood Zone 1, indicating a low probability of flooding	Adjacent to Flood Zones 2 and 3, increasing probability of flood risk.
Noise	Close to small clusters of residential and commercial receptors nearby. Closest to M25 so a level of noise already set in the region.	Close to small clusters of residential and commercial receptors nearby. Second closest to M25 so a level of noise already set in the region	Close to small clusters of residential and commercial receptors nearby. Furthest from M25 so could have a larger relative impact in the area to other options.
Transport & Traffic	Challenges for Abnormal Indivisible Load (AIL) access due to nearby bridges, requiring further exploration of potential routes.	Also faces challenges for AIL access, with significant local and council agreement needed for repeated vehicle movements. New access road required.	Best option for minimising traffic disruption, although requires a new access road. It avoids some bridge restrictions affecting [redacted]
Technical (OHL)	Located adjacent to the existing OHL network – reducing construction time and minimising environmental impacts associated with longer cable routes.	Further away from the existing Warley substation making the circuit migration challenging – would require longer cable connections into the OHL and for eventual customers	Furthest away from the existing Warley substation making the circuit migration challenging – would require longer cable connections into the OHL and for eventual customers.
Technical (Constructability)	Located 130 meters south of the existing Warley site. Access achievable via a small extension of the existing Warley substation access road – minimising need for new road construction.	Would require construction of a new access road to site, subject to landowner agreement and technical feasibility, that may disrupt local communities and traffic.	Would require construction of a new access road to site, subject to landowner agreement and technical feasibility, that may disrupt local communities and traffic.
Cost	Cost-effective given close location to the existing Warley substation and OHLs, minimising need for re-routing.	Would require longer cable connections into the OHL and for eventual customers, increasing construction costs	Longer cable connections into the OHL and for customers would increase construction costs.
Consenting, Lands and Programme	A small section falls within the boundary of [redacted] this has been confirmed as manageable via micro siting with the developer.	Installing longer cable connections into the OHL increase program timeframes. Would require new OHL infrastructure to be built in a green belt area, likely facing increased local opposition	Installing longer cable connections into the OHL would increase programme timeframes. A DCO may be required for lengthy new OHL infrastructure to be built in a green belt area, likely facing increased local opposition. [redacted]

3.2.1 Outcome of the siting study

[redacted] emerged as the preferred site due to its proximate location to the existing substation, OHL and limited visual implication for local residents, already industrial landscape.

[redacted] was selected as the most favourable option from the siting study. Consistent criteria applied to the three sites showed that [redacted] offered the best combination of technical feasibility, consideration of environmental factors, and minimal disruption to the local community. [redacted] offers the lowest visual impact due to its proximity to the Warley substation and OHLs, the closest to flat terrain out of all options, and boundary vegetation. It minimally affects Green Belt openness and is in Flood Zone 1 therefore avoiding flood risks. Most importantly [redacted] is also the most cost-effective and technically feasible site, requiring minimal OHL re-routing for both the DNO and NGET, in comparison to Sites 5 and 8 sited much further away from the existing infrastructure. Figure 8 is an indicative layout of the substation (red block) in the area and showcases its indicative close location to the existing Warley 275kV and 132kV substations (yellow block).

Figure 8: Recommended site option – Site Option 2

3.3 Summary of all identified design options

A summary of all long list options considered to deliver the drivers is included in Table 9, with rationale why these options were discounted or taken forward for further optioneering. During the optioneering phase, a significant number of drawings were generated to evaluate the various options and alternatives considered. References to all drawings are provided in Appendix A. To maintain the paper's manageability, only the drawings related to shortlisted options have been showcased within this paper in section 3.4 and appendices C-E, however other drawings can be provided at request.

Table 9: Summary of long list options and down selection

Short-List Options	Option description	Relevant Diagrams or Layout References	Consenting Risks & Environmental Constraints	Rationale
A: Do nothing **Rejected**	The network is kept in its current state, and no new connections are facilitated.	**N/A**	N/A	• **Contractual and Licence compliance:** Compliant customer connection not delivered, and it would be against our contractual and license obligations.
B: Market-based solution **Rejected**	Increased customer demand is accommodated through the procurement and use of ancillary services only.	**N/A**	N/A	• **Contractual and Licence compliance:** Compliant customer connection not delivered, and the option does not comply with our licence obligations to provide connections.
C: Whole systems solution **Rejected**	The required customer connection is accommodated by a DNO.	**N/A**	N/A	• **Contractual and Licence compliance:** Compliant customer connection not delivered, and the option does not comply with our licence obligations to provide connections • **Deliverability:** Warley requires intervention to facilitate the 400kV uprating requirements regardless of connection outcomes, and with customers located nearby there is no viable DNO capacity alternative as [redacted] also rebuilds their substation.
Option D **Rejected**	Using existing Warley 275kV	N/A	N/A	• **Contractual and Licence compliance:** Compliant customer connections cannot be delivered, and the option does not comply with the contracted requirement to enable the TWNC 400kV uprating of the network.
Option E1: **Rejected**	In situ replacement of Warley 275kV substation	See Appendix A for full list	N/A	We made sure to explore why an in-situ replacement of the existing NG Warley 275kV substation @ 400kV would not be feasible to deliver the drivers. Reasons include: • Converting from a four-switch mesh to double busbar AIS substation via the existing compound would be highly complex and require a high volume of costly commissioning resources and outages to enable a new substation alongside existing supply of connections. • To meet all revised driver requirements would need three sections, two 400/275kV transformers and other added bays which would be constrained within the existing site.

Short-List Options	Option description	Relevant Diagrams or Layout References	Consenting Risks & Environmental Constraints	Rationale
				• A long construction programme would be needed to maintain existing supply whilst replacing, which would delay customer connection dates and increase risk of disruption to security of supply. • Health and safety risk associated with working within an operational substation environment.
Option E2 **Rejected**	Building a new offline GIS 275kV on the NGET boundary using existing NGET owned land – we had considered three variations of this option: A) with new in-situ OHL gantries B) with new offline built OHL gantries C) with new offline built OHL gantries and optimised SGT locations	See Appendix A for full list	N/A	We previously considered utilising available non-operational land to build a new 275kV substation to deliver known customer drivers, which could reduce land costs and ease planning requirements – at the time three variants of this option were considered and early design solutions were explored. However, following knowledge of the TWNC driver, the need to build at 400kV quickly ruled out these options and required that any option building at 275kV would not be feasible.
Option E3 **Rejected**	Building a new offline GIS 400kV on the NG boundary using existing NGET land – we considered three variations of this: A) with 240MVA SGTs sited closer to the new 132kV B) with 240MVA SGTs optimising space on site C) with 460MVA SGTs and completing the 400kV uprating	See Appendix A for full list	Siting studies showed that National Grid's land at Warley was too small and irregular for an offline AIS at 400kV, so this solution was excluded.	After ruling out the 275kV option, we examined three GIS 400kV alternatives north of Warley's 275kV substation. Utilising available non-operational land, we already owned to potentially reduce land costs and ease planning requirements. However, these alternatives were dismissed due to multiple substantial health and safety risks associated with establishing a 400kV GIS substation within such constrained areas: • The space located north of the existing Warley 275kV substation is insufficient to accommodate safe construction, operation, and maintenance of a new 400kV substation and its supporting infrastructure. Other parcels of land are unavailable because of the siting of existing and approved Battery Energy Storage Systems customers (BESS). • Construction activities would necessitate extensive work in proximity to electrical and structural hazards within an operational substation environment. [redacted] construction traffic and complex work boundaries.

Short-List Options	Option description	Relevant Diagrams or Layout References	Consenting Risks & Environmental Constraints	Rationale
Option E4 **Rejected**	**400kV AIS substation with 400kV cable connections** *It is to be noted we had also considered two earlier design variations:* *A) with [redacted] x 240MVA SGTs and the Tilbury terminal tower retained* *B) [redacted] x 460MVA SGTs and the Tilbury terminal tower retained*	See Appendix A for full list	• Excavations potentially risk encountering asbestos. • Some existing tree plantations require removal to facilitate cables. • Watercourse diversion may pose a challenge due to constrained space between the proposed site and residential area • Larger AIS footprint may make accommodating statutory on-site 10% BNG requirement difficult • AIS site will require [redacted] hectares of land. • The proposed cable route requires crossing an existing access road that serves nearby residential properties, resulting in increased disruption to local residents. • Very close to residential properties (500m away).	This option was dismissed due to the complexity and constraints created by: • Connecting four northern circuits across several cable crossings, which would limit space for customer connections on site, • Restricting [redacted] in connecting their 132kV circuit and therefore tiggering the need to divert their OHL • Trenching through the existing Warley 275kV substation posing a risk of encountering asbestos-contaminated soils. • Needing proximity outages on the Tilbury and Elstree circuits to carry out the 400kV cabling works from the proposed interbus transformer to the new Warley 400kV site. Moreover, given the land take required by an AIS substation, the option would: • Limit further site expansion by constraints on all sides of the site (by the DNO, residents, overhead lines, pressurised gas main, existing substation, and data centre) • Create considerable earthworks to facilitate the size of land take required which could disrupt residents and extend the construction program duration. • Increase health and safety risks from the construction compound needing to be located is on the opposite side of the Tilbury OHL,
Option E5 **Taken Forward**	**400kV AIS substation with 400kV OHL connections** *It is to be noted we had also considered two earlier design variations:* *A) with 4 x 460MVA SGTs and the Tilbury terminal tower relocated* *B) with 7 x 240MVA SGTs and the Tilbury terminal tower relocated*	Layout provided in Section 3.4.1	• Requires land within the local [redacted], for OHL works. • A temporary tower will likely fall on the existing environmental screening area. • Watercourse diversion may pose a challenge due to constrained space between the proposed site and residential area • Larger AIS footprint may make accommodating statutory on-site 10% BNG requirement difficult • AIS site will require [redacted] hectares of land.	This option was taken forward because initial studies indicated that placing the AIS here could be feasible, subject to further detailed assessment. Connecting it via overhead lines (OHL) would avoid disturbing potentially asbestos-contaminated Made Ground soils in the existing 275kV substation, thereby reducing the risk of project delays and additional costs compared to other alternatives. However, we were aware that: • Future expansion beyond the two included spare bays would be limited by the size of land available and constraints on all sides of the site (by the DNO, residents, overhead lines, pressurised gas main, existing substation, and data centre.) • Limited space would be available for [redacted] to connect its circuits to the new 132kV substation • Considerable earthworks would be needed to facilitate the size of land take required [redacted] and extend the construction program duration.

Short-List Options	Option description	Relevant Diagrams or Layout References	Consenting Risks & Environmental Constraints	Rationale
			• The large footprint of the project site may lead to issues related to visual impact.	• The construction compound would need to be located on the opposite side of the Tilbury OHL, increasing health & safety risks associated with construction movement.
Option E6 **Rejected**	**400kV GIS substation with 400kV cable connections** *It is to be noted we had also considered two earlier design variations:* *A) with 7 x 240MVA SGTs and the Tilbury terminal tower retained* *B) with 4 x 460MVA SGTs and the Tilbury terminal tower retained*	See Appendix A for full list	• Some existing tree plantation removal to facilitate cables. • Decreased visual impact with smaller footprint and environmental screening • The proposed GIS Substation will require approx. [redacted] hectares of land. • Distanced from residents and away from the existing 132kV [redacted] OHL circuit. • The [redacted] circuit will not require diversion. • The proposed cable route requires crossing an existing access road that serves nearby residential properties, resulting in increased disruption to residents.	Although this GIS option would allow more space for [redacted] and enable space for future site expansion, it was rejected due to the complexity and constraints of connecting four northern circuits across several cable crossings, which limits space for customer connections. Additionally, trenching through the existing Warley 275kV substation poses a risk of encountering asbestos-contaminated soils.
Option E7 **Taken Forward**	**400kV GIS substation with 400kV OHL connections** *It is to be noted we had also considered two earlier design variations:* *A) with 4 x 460MVA SGTs and the Tilbury terminal tower relocated* *B) with 7 x 240MVA SGTs and the Tilbury terminal tower relocated*	Layout provided in Section 3.4.2	• Requires land within the local [redacted], for OHL works. • A temporary tower will likely fall on the existing environmental screening area. • Decreased visual impact with a smaller footprint and environmental screening • The proposed GIS Substation will require approx. [redacted] hectares of land. • Distanced from residents and away from the existing 132kV [redacted] OHL circuit. • The [redacted] circuit will not require diversion.	Technically viable and creates more space for future expansion of the substation, including space for additional bays in the GIS building upfront. Moreover, as an OHL connected solution, it would avoid risks and delays from working with potentially asbestos-containing soils at the 275kV substation. As a smaller land take option, significantly less earthworks required and no oversailing hazards present as the construction compound can be located on the same side of the substation area, improving safety in construction,

Short-List Options	Option description	Relevant Diagrams or Layout References	Consenting Risks & Environmental Constraints	Rationale
Option E8 **Taken Forward**	**400kV AIS substation with 400kV ZB OHL re-routing** Requires relocation of terminal towers to the Warley substation and an eastward diversion of the ZB route, starting from tower ZB048 for about 1.5 km.	Layout provided in Section 3.4.3	• The Elstree OHL diversion sterilises a larger portion of the [redacted] user area. • Space is available for environmental screening area. • Larger AIS footprint may make accommodating statutory on-site 10% BNG requirement difficult • Would be subject to agreement with data centre [redacted] to agree new OHL corridor route – would oversail expected building/equipment. • An additional new tower will also be required within the masterplan of the data centre site. • Very close to residential properties (500m).	This option was considered slightly later than options E-1 to E-5, based on seeing if diversion of the OHL route would enable a better fit for an AIS substation on [redacted] given land constraints. Initial studies suggested siting this AIS option may be technically possible, creating extra space for the [redacted] cable corridor to connect to the new 132kV GIS without diverting the existing 132kV OHL circuit. Moreover, as an OHL connected solution, it would avoid risks and delays from working with potentially asbestos-containing soils at the 275kV substation. However, expansion is restricted by land requirements and constraints from the DNO, residents, overhead lines, pressurised gas main, existing substation, and data centre on all sides of the site. Program delays may also arise from negotiating OHL diversion routes with [redacted].
Option E9 **Rejected**	**400kV AIS back-to-back substation with OHL connections** Relocation of both terminal tower locations to new Warley via OHL but a wraparound substation arrangement, around the main busbar while bay connections are arranged back-to back resulting in wider but shorter site.	See Appendix A for full list	• Large land area take of [redacted] hectares • Accommodating 10% BNG likely difficult • High volume of waste materials require transport away from the site which may disrupt residents • Encroaches on plantation trees • Temporary tower will likely fall on the existing environmental screening area. • Watercourse diversion may pose a challenge due to constrained space between the proposed site and residential area.	This option was considered slightly later than options E-1 to E-5, based on seeing if a back to back arrangement would enable a better fit for an AIS substation on [redacted] given land constraints. However, it introduces an oversailing hazard (where busbars are vertically above each other), not in accordance with Safety by Design and CDM regulations. The arrangement complicates future extension due to the wrap around arrangement and still requires substantial earthworks to create a level platform as well as encroaching on the existing 132kV [redacted] OHL.

Based on the rationale explained in Section 3.3, we have discounted Options A, B, C and D because they will not allow us to facilitate the connection requests or NESO drivers and consequently, we will not meet our contractual and licence obligations. Options E1 and E2 were discounted as the network requirement to facilitate a 400 kV substation could also not be facilitated. E3 whilst being a 400kV solution, was not taken forward due to significant constraints in being able to deliver the substation within the constrained non-operational land especially without significant health and safety risks. Whilst looking at other 400kV solutions on the newly identified [redacted] options E4 and E- were rejected due to the complexity and cost of connecting the site via cable connections in a site were there would be multiple difficult cable crossings to deliver. Option E9 was rejected due to the health and safety concerns presented from oversailing, as well as the limited option for future expansion.

Options E5, E7 and E8 were progressed to the shortlist for their ability to meet the project drivers with anticipated reduced technical complexities, reduced health and safety in construction and lower cable costs.

3.3.1 Influence of stakeholders on shortlisting

During optioneering, we have engaged with key stakeholders and related parties to help inform the likelihood, feasibility and assessment of options. A summary of notable insights from these engagements are included below:

Landowner Engagement:

We have engaged with the main landowner and stakeholders impacted by our preferred site following the siting study. [redacted]

DNO Engagement

Due to the volume of cables from all parties that will need to be directed towards the new Warley complex, connecting all the customers will be complex. [redacted] raised numerous concerns with us on the AIS options as main points listed below:

- No space for the installation of [redacted] circuits. Would require 132kV cable routes through the 400kV compound or tunnels constructed below.
- Programme very likely to be extended to accommodate challenges associated with construction co-ordination and cable route issues.
- Severely constrained site with no obvious future replacement site available.
- Suggests that access to [redacted] site is via NGET's access road through the 400kV substation - not acceptable as a long-term solution. [redacted] requires a dedicated access road.
- Access for construction would need to be through the 400kV NGET compound. No apparent space for a dedicated [redacted] access road - access cannot be via the 400kV site (different safety rules).
- No [redacted] CDM area shown - limited / no space available.
- Limited / no space for BNG mitigation

Furthermore, during optioneering, [redacted] continued to state their requirement to obtain power in line with their original contracted ACL date [redacted] (first signed when NGET was still considering the feasibility of a 275kV replacement).

[redacted] have requested a staged connection prior to the new Warley 400kV replacement being built to enable this early connection. Collaborative workshops were held [redacted], and it was proposed to install a fourth 240MVA SGT at existing Warley 275kV and disconnect the existing MSC where the 132kV bay will be repurposed for [redacted] to run a secondary circuit [redacted] These works are being paid [redacted] as a One-Off charge. The diagram below shows the proposal which is to be signed in due course. Figure 9 includes a line diagram of the temporary connection provided and funded by [redacted].

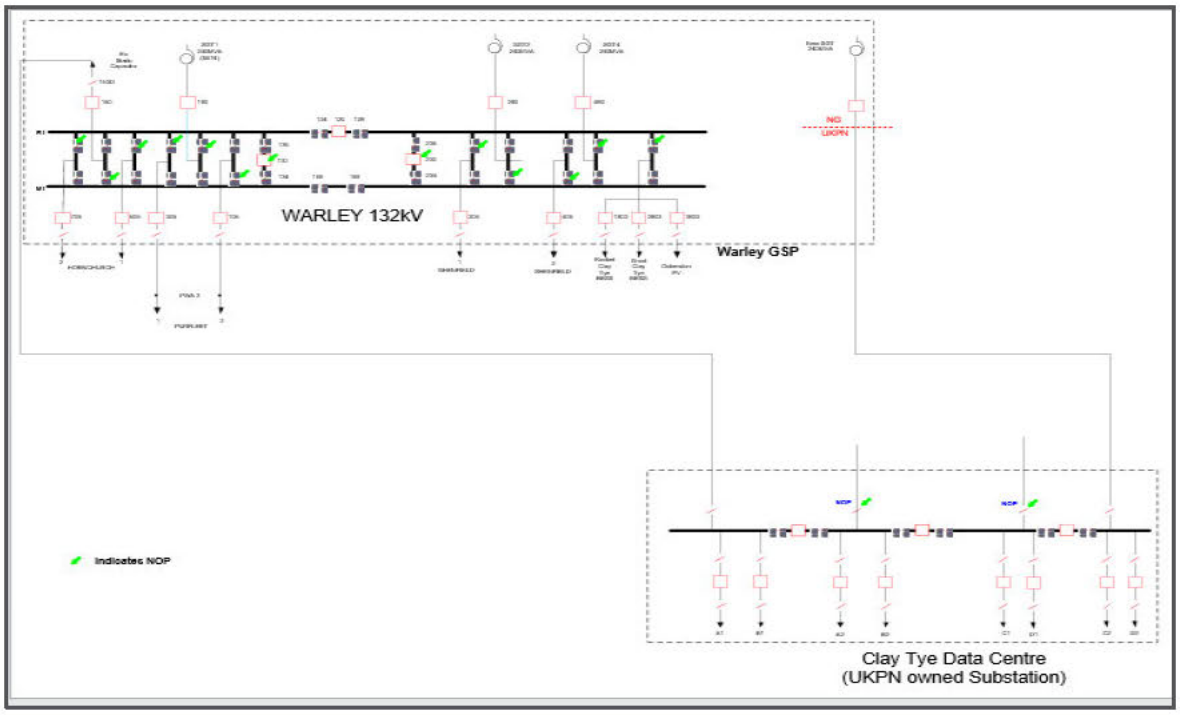


Figure 9: Single Line Diagram of [redacted] funded works to Clay Tye Data Centre

Wider Stakeholders

NGET are aware of high level of stakeholder opposition to further development in the green belt and local area, especially due to the visual impact on residents. [redacted] have expressed strong opposition to potential data centre development in the area which encroaches on the green belt. NGET has been mindful of these stakeholders' views when optioneering between solutions that will have differing footprints on the greenbelt, visual implications on residents and therefore likely ability to be consented in the area.

NGET has set up a dedicated website for this project: [Warley replacement substation | National Grid]

In [redacted] introductory letters were issued to the residents of Warley along with a latest update letter to the Havering council. NGET prepared a further update for Havering Council (leadership and ward members) on [redacted] This introduced discussion around the proposed design for the substation.

Further information about the proposed design will come into our next phase of outreach planned around [redacted]

3.4 Shortlisted Options

We took forward three options for further detailed qualitative and quantitative analysis. A short high-level summary of the differences between the options is noted below. Options taken forward were:

- Option E5: 400kV AIS Substation with OHL connection
- Option E7: 400kV GIS Substation with OHL connection
- Option E8: 400kV AIS Substation with OHL connection and ZB OHL rerouting

These options, as assessed were based on a consistent like for like running arrangement in fitting with the SLD provided here in Figure 10 and Appendix B.

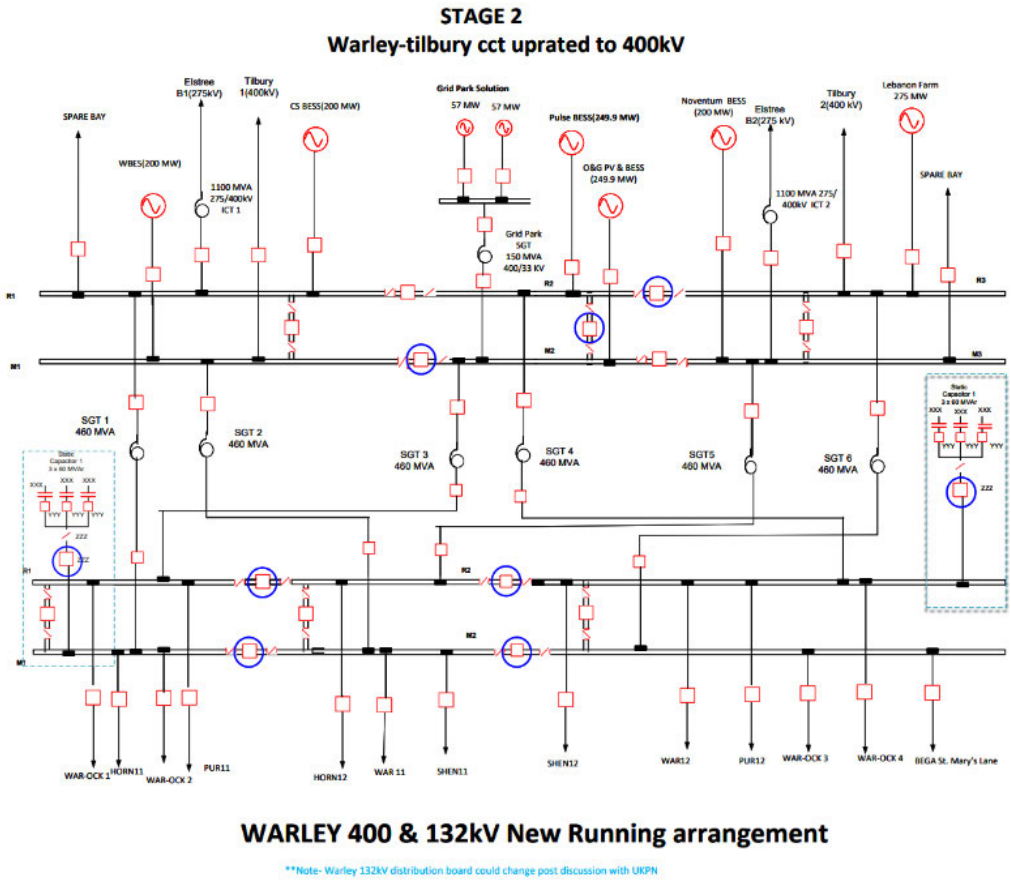


Figure 10: Single Line Diagram of proposed running arrangement underpinning assessment of shortlisted options.

3.4.1 Option E5 – 400kV AIS Substation with OHL Connection

A new 400kV AIS substation at [redacted] (south of existing Warley 275kV) which will require both Elstree & Tilbury terminal tower locations to be relocated to the new 400kV Warley substation, with OHLs providing the connection.

Tilbury 1&2 circuits will be uprated to 400kV. Elstree 1&2 circuits will be connected to 1100MVA 400/275kV SGTs along with 6 x 460MVA SGTs. The existing Warley 275kV substation will be demolished

Figure 11: Option E5 – PDD-101659-LAY-059 AIS Substation with OHL connection (Appendix C)

The AIS option with an OHL connection offers the same bays, location, equipment, and infrastructure as all other shortlisted options, however the Tilbury 400kV circuit (scheduled for uprating) and the 275kV Elstree circuits will connect to Warley 400kV via overhead lines. Interbus transformers for the Elstree circuit will be installed within the new substation's boundaries, allowing complete decommissioning of the existing Warley 275kV substation after the load transfer from [redacted] It was assumed this will enable the TWNC scheme carry on with its 400kV OHL uprating from Warley to Waltham Cross by turning in the Elstree circuits.

The option would create present a number of oversailing risks which would require the CDM compound to be moved further away from the site (see red box furthest to the right of the SLD above). In turn, creating additional complexity and distance when moving between the compound and site.

[redacted] Compared to AIS Option E4 which proposed a 400kV cable instead of OHL and was not taken forward to shortlisting, this arrangement avoids geotechnical risks such as asbestos-contaminated soils.

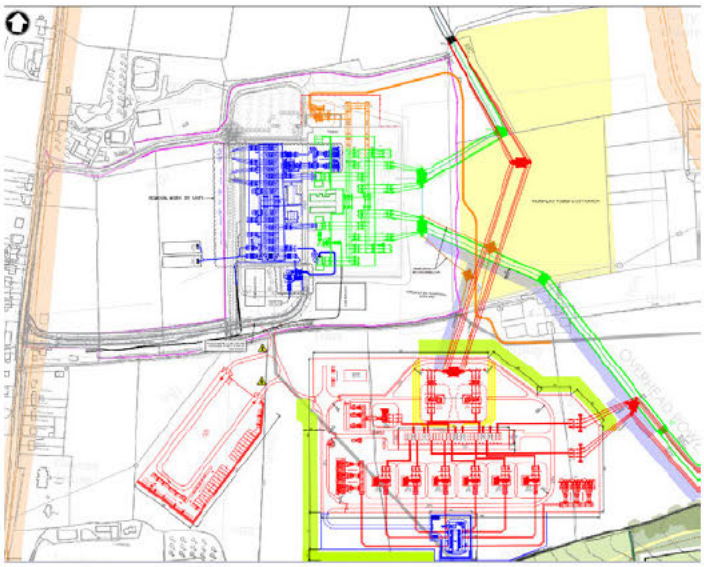
However, this option still demands more land, earthworks, and imported materials than a GIS substation. Based on desktop assessment an AIS solution would incur [redacted] of total wasted material from excavation of the site and stripping of the topsoil, to be filled with [redacted] of imported material such as stone chopping's or Type 1 materials. These requirements for cut and fill are estimated to be [redacted] than a GIS solution, respectively. [redacted]

When considering these lorry movements through the aspect of time, estimates point to option E5 resulting in a longer construction programme. Based on general estimates [redacted]

[redacted], the earthworks required to deliver an AIS substation with OHL connections is considerably more extensive than the other shortlisted GIS substation option (option E7).

[redacted]

3.4.2 Option E7 – 400kV GIS substation with OHL connections



A new 400kV GIS substation at [redacted] (south of existing Warley 275kV) which will require both Elstree & Tilbury terminal tower locations to be relocated to the new 400kV Warley substation, with OHLs providing the connection.

Tilbury 1&2 circuits will be uprated to 400kV. Elstree 1&2 circuits will be connected to 1100MVA 400/275kV SGTs along with 6 x 460MVA SGTs. The existing Warley 275kV substation will be demolished

Figure 12: Option E7 – PDD-101659-LAY 058 GIS Substation with OHL connection (Appendix D)

The GIS option with an OHL connection will provide the same number of bays, location, equipment, and associated infrastructure as both shortlisted AIS options E5 and E8. The Tilbury 400kV circuit (scheduled for uprating) and the 275kV Elstree circuits will connect to Warley 400kV via overhead lines. Interbus transformers for the Elstree circuit will be installed within the new substation's boundaries, allowing complete decommissioning of the existing Warley 275kV substation after the load transfer from [redacted] It was assumed this will enable the TWNC scheme carry on with its 400kV OHL uprating from Warley to Waltham Cross by turning in the Elstree circuits.

The option enables the CDM compound to be sited closer to the site (see red box furthest to the left of the SLD above).

It is envisaged that the area required for the new 400kV GIS substation site with Tilbury and Elstree circuits connected via OHL is [redacted]

Option E7 is considerably favourable in terms of geotechnical aspects in relation to the other shortlisted AIS substation options and in turn supports a shorter overall construction programme.

A GIS substation requires much less land, earthworks, and imported materials than an AIS substation. According to desktop assessment, site excavation and topsoil removal would produce [redacted] ^{3} of imported fill like stone chippings or Type 1 materials. These cut and fill volumes are estimated to be [redacted]

When considering these lorry movements through the aspect of time, estimates point to option E7 resulting in a shorter construction programme. [redacted]

[redacted], the earthworks required to deliver a GIS substation with OHL connections is considerably less extensive than the other AIS substation options incurring less cost to consumers and time taken to complete the work.

[redacted]

3.4.3 Option E8 – 400kV AIS with 400kV OHL Connections with ZB OHL Rerouting

A new 400kV AIS substation at [redacted] (south of existing Warley 275kV) which will require both Elstree & Tilbury terminal tower locations to be relocated to the new 400kV Warley substation, with OHLs providing the connection.

Tilbury 1&2 circuits will be uprated to 400kV. Elstree 1&2 circuits will be connected to 1100MVA 400/275kV SGTs along with 6 x 460MVA SGTs. The existing Warley 275kV substation will be demolished

Figure 13: Option E8 – PDD-101659-LAY 060 AIS Substation with OHL connection ZB OHL diversion Appendix E)

Option E8 is a variation of option E5 which was subsequently explored to identify whether an AIS arrangement could be better fitted into [redacted] through movement of the Tilbury OHL from its current location. The option therefore proposes to divert the existing 275kV ZB OHL route [redacted] and requires [redacted] new tower spans. However, the diversion would increase oversailing hazards on the [redacted] data centre building and equipment based on its current siting position in the area.

Under this option, the CDM compound would need to be configured differently to avoid the oversailing 132kV [redacted] OHL.

[redacted]

The significant earthworks—and consequently the extended project timeline—required by the cut-and-fill specifications of an AIS solution compared to GIS, as outlined in sections 4.4.1 and 4.4.2 for options E5 and E7 above, would be approximately amplified circa [redacted] more under option E8 compared to option E5.

3.4.4 System Design Table

A System Design Table comparing the relative technical factors of each shortlisted option is provided in Appendix F. On the basis that option E8 is a variant of E5, differing only by the diverted routing of the OHL routing, both shortlisted AIS options are presented in the table under one column.

3.5 Detailed Qualitative Assessment Table

Table 10 – Multifactorial analysis of shortlisted options E5, E7 and E8

	Optioneering Categories				
Option	**Engineering**	**Environmental**	**Deliverability**	**Economic/Consumer Value**	**Consenting /Stakeholder**
Option E5 400kV AIS with OHL connection	• AIS technology is a familiar technology type. • Maintenance and repair works for AIS switchgear is well established. • Avoid any underground works and interfaces with the existing below ground services. • Non-SF6 400kV AIS circuit breakers are not yet type registered. • Construction of the entire AIS substation is limited by the presence of the existing [redacted] 132kV OHL. • Diversion of this [redacted] OHL circuit is required • Cable connections are required to connect at least one circuit each for Tilbury and Elstree OHL circuits to its dedicated AIS bay. These cable circuits would cross other user cables that may cause de-rating issues. Therefore, cable system design may pose a challenge to meet the require ratings	• Insulating gases are not a proponent source of [redacted] emissions. • [redacted] Due to the extensive excavation area and large substation platform, a large volume of construction vehicle movements are required on and off site for the AIS substation – [redacted] • Space is limited to provide environmental screening. • Will require the removal of veteran tress to accommodate the larger footprint and facilitate cable connection into and out of the substation. • Encroaches into the woodlands along the southern site boundary, increasing loss of habitat, root protection area (RPA) intrusion and increased disturbance to vegetation. • The AIS solution is estimated to emit [redacted]	• New substation construction works is outside NG safety rules. • Cable construction for the User cables on the northern side of the proposed AIS substation is restricted by the construction access corridor. • System access to the [redacted] 132kV overhead line (OHL) circuit is required to enable diversion away from the proposed AIS site. This introduces project risk, as it depends on the timely completion of diversion works and is subject to outage restrictions on the [redacted] OHL circuit. • AIS substation options require a larger construction area than GIS which increases H&S risks. • The CDM compound will pass beyond the substation site, and therefore vehicle movements between the construction compound	• 2 spare bays are included in the scope, however further extension of the AIS substation is restricted by land availability. • AIS equipment is generally less expensive than GIS switchgear • Due to the substantial earthworks, a longer program duration (minimum 2 years longer) which will delay benefits of enabling local data centre connections(supporting local economic growth) and reducing constraints in the local network (from TWNC).	• The OHL diversion is [redacted] for all options (AIS and GIS) and therefore requires Section 37 (S37) consent. • The AIS substation requires a larger footprint [redacted] which is circa 50% larger than the other GIS alternative - which may drive higher local pushback and reduce how consentable the project is. • The shortlisted option proposes development within the greenbelt, [redacted] n AIS substation, compared to a GIS substation, would have a greater impact on the greenbelt and carries a higher risk of appeal, potentially adding circa 2–3 years to the consenting programme, with an increased risk of rejection

	Optioneering Categories				
Option	**Engineering**	**Environmental**	**Deliverability**	**Economic/Consumer Value**	**Consenting /Stakeholder**
		higher tCO2e emissions compared to the non-SF6 GIS design through material, transportation, and construction emissions.	and site are exposed to the oversailing Tilbury OHL, introducing additional H&S risks. • Limited space for [redacted] cable circuits, and construction activities will be constrained by both the restricted area and the new AIS substation equipment.		
	Detractor	Detractor	Detractor	Neutral	Detractor
Option E7 400kV GIS with OHL connection	• As per the latest NG PS(T)005, non-SF_6 GIS equipment is currently undergoing NG Type Registration and is expected to be installed in other NG projects soon. • Experience with non-SF6 equipment for both AIS and GIS solutions is still relatively new. • Replacement works for GIS switchgear is generally considered more complex than AIS switchgear. • Reduced complexity in construction, installation and space management as E7 enables OHL circuits to be connected directly to the 400 kV substation via GIB connection and avoids need for cable connections. Due to the	• Insulating gases are a proponent source of emissions. • Still impacts the greenbelt and builds on greenfield land. • Requires land within the [redacted] OHL works. • One of the temporary towers for Tilbury circuits will likely fall on the existing environmental screening area. • However, Option E7 allows for more space to implement environmental screening and BNG onsite. • Its reduced land take and compact design contribute to improved visual amenity, helping it blend more effectively with the surrounding area.	• Majority of the construction works is outside NG safety rules. • The GIS site compound is still compact and may create some restriction and complexity for managing cable routes. • Diversion works required as two drainage routes are located within the proximity of the proposed works. • Provides more space for [redacted] cable circuits and an environmental screening area. • The existing Tilbury OHL can remain in service throughout the construction of the GIS substation. An outage will only be necessary when diverting the OHL to connect with the new GIS substation,	• Although future extension of the GIS substation may depend on OEM technology availability, option E7 offers advantages in space and design layout that support the potential for further site expansion in the future. • GIS equipment is generally expected to be more expensive than AIS equipment. • However, the option is estimated to be [redacted] initial investment than the next cheapest AIS option. Driven largely by a shorter program duration and reduced earthworks.	• The OHL diversion is less than 2km for all options (AIS and GIS) and therefore requires Section 37 (S37) consent. • The GIS substation requires a smaller footprint [redacted] which is circa 50% smaller than the other AIS alternative - which may drive more favourable local acceptance and increase how consentable the project is • The GIS substation option has a smaller footprint compared to AIS, which presents fewer risks to planning consent and is more likely to receive approval • The GIS requires less land area in the Greenbelt compared to AIS.

	Optioneering Categories				
Option	**Engineering**	**Environmental**	**Deliverability**	**Economic/Consumer Value**	**Consenting /Stakeholder**
	position of the bays this would be unavoidable for the AIS solution.	• The expected footprint of the site is c.50% smaller than its AIS counterpart, reducing relative impact on [redacted] he greenbelt land. [redacted] he option requires a smaller excavation area,and therefore a smaller volume, but still notable volume, of construction vehicle movements are required– [redacted] • Current estimates indicate a non-SF^6 GIS solution will generate [redacted] fewer tCO2e emissions compared to the AIS design through material, transportation, and construction emissions. • Substation falls within a single plot of land limiting hedgerow removal. • Avoids encroachment into protected tree zones and adjacent woodland, thereby materially reducing environmental risk and supports compliance with arboriculture and ecological requirements.	reducing overall system access risk • The reduced transportation movements from smaller earthworks, compared to an AIS solution could reduce the overall construction programme by 2 years compared to E5. • A reduced footprint provides [redacted] with extra space to route their circuits to the new substation, facilitating more efficient cable design, minimising health and safety risks associated with working in confined areas, and decreasing the impact of construction near third-party assets and existing tree lines. • The CDM compound can be sited on the western side of the new substation, avoiding the need for interaction between construction movements and the Tilbury OHL, reducing health and safety risks from oversailing under option E5.		• The GIS substation option offers greater benefits to third parties during both construction and operation phases. During construction, reduced vehicle movements for transporting materials on and off-site help minimize disruption. • During operation, the smaller footprint and reduced visual impact contribute to lower community and environmental concerns.
	Detractor	Benefit	Benefit	Neutral	Strong Benefit

	Optioneering Categories				
Option	**Engineering**	**Environmental**	**Deliverability**	**Economic/Consumer Value**	**Consenting /Stakeholder**
Option E8 400kV AIS substation, OHL connection & ZB rerouting	• AIS technology is a familiar technology type. • Maintenance and repair works for AIS switchgear is well established. • More space is made available for [redacted] cable corridor to connect to their new 132kV GIS, than under option E5. • No Temporary towers/mast will be required as the temporary connection can be achieved with existing towers. • Non-SF_6 400kV AIS circuit breakers are not yet type registered. • Space is available for [redacted] cable corridor to connect to the new 132kV GIS • Construction of the entire AIS substation is limited by the presence of the existing NGET 275kV Tilbury OHL. Diversion of this NGET Tilbury OHL circuit is required • Cable connections are required to connect at least one circuit each for Tilbury and Elstree OHL circuits to its dedicated AIS bay. These cable circuits would cross other user cables that may cause de-rating	• Due to the extensive excavation area and the need to establish a large substation platform, a large volume of construction vehicle movements are required on and off site for the AIS substation [redacted] option E7, taking an additional 2 years. • Located further away from residential properties to the southwest, providing great er opportunity for additional environmental screening and reduced visual impact however space is limited to provide environmental screening • Requires the largest land take footprint of all options and therefore will have the largest impact on the greenbelt. • Will require the removal of veteran tress to accommodate the larger footprint and facilitate cable connection into and out of the substation. • Encroaches into the woodlands along the southern site boundary, increasing loss of habitat,	• Majority of the construction works is outside NG safety rules. • The construction compound can be located on the same side of the substation area, thereby avoiding oversailing National Grid overhead line (OHL) circuits and facilitating safe construction access and movement. • Multiple outages on the Tilbury OHL circuit are required to facilitate permanent diversion and diverting the connection to the new AIS substation. • Cable construction for the customer user cables on the northern side of the proposed AIS substation is restricted by the construction access corridor. • System access to the [redacted] 132kV overhead line (OHL) circuit is required to enable diversion away from the proposed AIS site. This introduces project risk, as it depends on the timely completion of diversion works and is subject to outage	• Whilst 2 spare bays are included, further extension of the AIS substation is restricted by space available. • AIS equipment is generally less expensive than GIS switchgear • Due to the substantial earthworks, a longer program duration (minimum 2 years longer) which will delay benefits of enabling local data centre connections(supporting local economic growth) and reducing constraints in the local network (from TWNC).	• The OHL diversion is less than 2km for all options (AIS and GIS) and therefore requires Section 37 (S37) consent • Located further away from residential properties to the southwest which may improve some local reception to the option compared to E5, however still likely to be much less welcomed than option E7. • Requires a larger footprint than all options [redacted] which is circa 50% larger than the other GIS alternative - which may drive higher local pushback and reduce how consentable the project is. • [redacted] An AIS substation, compared to a GIS substation, would have a greater impact on the greenbelt and carries a higher risk of appeal, potentially adding circa 2–3 years to the consenting programme, with an increased risk of rejection

	Optioneering Categories				
Option	**Engineering**	**Environmental**	**Deliverability**	**Economic/Consumer Value**	**Consenting /Stakeholder**
	issues. Cable system design may pose a challenge to meet the require ratings.	root protection area (RPA) intrusion and increased disturbance to vegetation. • The AIS solution is estimated to emit [redacted] higher tCO2e emissions compared to the non-SF^6 GIS design through material, transportation, and construction emissions.	restrictions on the [redacted] OHL circuit. • AIS substation options require a larger construction area than GIS which increases H&S risks • Re-routing of 400kV OHL impacts on [redacted] customer Data Centre build zones.		
	Detractor	Detractor	Detractor	Neutral	Detractor

3.5.1 Summary of Detailed Qualitative Assessment

The preferred option for the new Warley 400kV Substation is a GIS substation connected by OHL (option E7). Reflecting on the multi-criteria analysis, there are several areas where the GIS option provides significant advantages compared to the relative AIS options, including:

- **Lower consenting risks and fewer potential programme delays** - supporting the case for "Very Special Circumstances" predicated on minimising environmental impacts wherever possible on greenbelt land through a smaller footprint. Helps to address known strong local opposition to development in an area with numerous resident groups petitioning against a local data centre project and mitigates permanent loss of greenbelt land.
- **Reduced impact on ecological factors on site** – unlike the AIS option, it minimises encroachment on [redacted] and enables flexibility in siting to prevent encroachment and removal of the veteran trees and encroachment to the adjacent woodland.
- **Better technical performance and possibility to extend in the future** – enabling OHL circuits to connect directly to the 400kV via GIB connections, rather than the need for cable connections under an AIS solution. Also enables the space required to site reactive compensation and a third OHL circuit identified as necessary for system requirements. Creates more space for future site expansion.
- **Reduced health and safety risks in construction** – enables more space for [redacted] cables and avoids the need to work around any oversailing hazards, enabling the CDM compound to be sited closer to the substation.
- **Shorter and simpler construction programme** – removes dependency on both NGET and [redacted] access to system outages, as well as substantially less civils and earthworks needed on site.
- **Reduced earthworks, vehicle movements** and therefore lower carbon emissions – estimated to require [redacted]

3.5.2 PASE

This investment is advanced in its development, with planning applications for the proposed solution due to be submitted [redacted] The preferred design, technical development and the rationale for discounting alternative options were established prior to the introduction of PASE.

Option E7 is consistent with some principles of PASE, with its double busbar layout and future proofed, adaptable design. Furthermore, we assessed options (E5 and E8) which we can retrospectively consider as being PASE aligned due to using AIS switchgear, but they were assessed to offer a range of more challenging environmental, health and safety, deliverability and programme timing challenges and therefore discounted.

The predominant reasons for selecting the GIS option, despite not being PASE aligned, are as described in Table 10 and section 3.5.1 above.

3.6 Detailed Quantitative analysis of Shortlisted Options

3.6.1 Cost Estimates for shortlisted options

When assessing the emerging options for delivering the 400kV Warley replacement, indicative capital cost estimates for each shortlisted option have been determined to enable comparison.

To assess the shortlisted options, cost estimates have been created for quantitative economic comparison. All capex costs are derived from NGET's latest Cost Book (23/24 prices). Estimating Units Lines (EULs) have been used to generate cost estimates based on the scope of work and the new assets to be acquired for each option. For each EUL, we have applied a 13.8% contingency, based on historic project analysis, to account for unforeseen circumstances and to mitigate risks during implementation.

Tables 11 provides a breakdown of the costs estimates for each short-listed option under consideration.

Table 11 - Cost Estimate Breakdown

Options	OHL (£m)	Cables (£m)	Substation (£m)	Total (exc. risk) (£m)	Biodiversity (5%)	Total (incl. 13.8% risk) (£m)
Option E5 (AIS)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option E7 (GIS)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Option E8 (AIS & OHL Diversion)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

3.6.1.1 Cost Drivers

Within the cost breakdowns detailed above, the primary driver of cost difference between options E5 and E8 with option E7, is the substantial cut and fill works required to enable [redacted] enable an AIS option. Notwithstanding the extended program duration needed to enable these substantial earthwork and civil works to happen.

3.6.2 Cost Benefit Analysis

Purpose and approach.

Our Cost Benefit Analysis (CBA) evaluates the economic efficiency and consumer value of the proposed transmission investments. This analysis aligns with Ofgem's Load Re-opener Guidance and Submission Requirements.

The CBA process integrates monetised benefits such as constraint cost savings, system efficiency improvements, and consumer bill impacts, alongside a comprehensive Whole-Life Cost Analysis (WLCA) that captures capital expenditure, operational and maintenance costs, replacement cycles, carbon impacts, and future extendibility. This dual approach ensures a balanced assessment of both short-term economic benefits and long-term cost efficiency, avoiding the risk of asset stranding or future inefficiencies.

Our CBA considers:

- **Robust optioneering and sensitivity testing:** We have evaluated credible alternatives, including 'do nothing' and 'do minimum' scenarios, to confirm that the preferred solution delivers the optimal balance of technical performance, environmental impact, and economic benefit.

- **Quantification of constraint cost reductions:** Using system operator modelling outputs and historical data, we quantify expected savings from reduced system constraints, which translate into direct consumer bill benefits.
- **Assessment of delay impacts:** The financial consequences of potential project delays on constraint costs and consumer bills are modelled through risk-adjusted scenarios, providing a clear understanding of the value of timely delivery.
- **Inclusion of socio-economic benefits:** Where quantification is challenging, qualitative evidence supported by stakeholder engagement and regional development plans highlights the wider economic benefits, including job creation and inward investment.
- **Consideration of non-monetised benefits:** We explicitly identify benefits that are qualitative or not readily monetisable, such as enhanced system operability, resilience, and environmental improvements, ensuring full transparency of the value proposition.
- **Alignment with policy and government targets including Net Zero and AI Growth Zones:** The CBA reflects the influence of national and local policies, including Clean Power 2030, net zero commitments, and economic growth plans demonstrating how the investment supports the broader energy transition.

We have assessed consumer value by comparing the whole-life costs and benefits of five shortlisted connection and substation delivery options using Ofgem's RIIO-ET3 CBA template. The assessment is completed relative to a counterfactual and on a discounted basis over a 40-year appraisal period (2027–2076), consistent with the CBA methodology.

For each option considered, we have quantified:

(i) Initial CAPEX investment required

(ii) Future end of life replacement costs

(iii) monetised benefits, including environmental impacts, system outcomes and wider socio-economic impacts (where applicable).

This provides a consistent, evidence-led view of which option delivers best value for consumers.

Shortlisted options.

The CBA compares the discounted costs and benefits for consumers for the following three shortlisted options (set out below).

- Option E5: 400kV AIS substation with OHL connection
- Option E7: 400kV SF_6 free GIS Substation with OHL connection
- Option E8: 400kV AIS substation with OHL connection and the diversion of the ZB OHL

3.6.2.1 CBA Outcome

Table 12: Lifetime Cost-Benefit Analysis by Price Control period (2023/2024 base prices, central carbon pricing, discounted values)

Option	Initial Investment (£m)	PV of Lifetime Costs (£m)	PV of Monetised Benefits (£m)	NPV (£m)
Option E5 (AIS)	[redacted]	[redacted]	[redacted]	[redacted]
Option E7 (GIS)	[redacted]	[redacted]	[redacted]	[redacted]
Option E8 (AIS & OHL Diversion)	[redacted]	[redacted]	[redacted]	[redacted]

On the basis of the discounted lifetime CBA results (Table 12), Option E7 delivers the highest NPV [redacted] 2023/2024 base prices) and therefore represents the preferred option on consumer value grounds. Options E5 and E8 deliver lower NPVs compared to Option E7, [redacted] for Option E5 and [redacted] for Option E8 respectively. This recommendation is subject to confirmation through deliverability, consents/land, outage and risk considerations, and any CBA sensitivities (e.g. carbon price trajectories) set out in the assumptions below.

3.6.2.1 Assumptions of the CBA Analysis

Core assumptions and sensitivities. The CBA results are based on the following high-level assumptions (with sensitivities used to test robustness where appropriate):

- Appraisal period of 50 years [redacted] with costs and benefits discounted and presented relative to the counterfactual.
- Cost base: 2023/2024 prices, aligned to the Ofgem RIIO-ET3 CBA template inputs (including treatment of replacement CAPEX and maintenance).
- Carbon: central base case carbon price applied for monetising construction carbon, SF_6/alternative gas leakage and losses, with scenario testing for alternative carbon price trajectories.
- Benefits scope applied consistently across options; where option-specific benefits exist (e.g. constraints), the basis and evidence are documented and applied consistently.
- Socio-economic impacts (GVA and employment) estimated using the Input-Output model described in Appendix G and treated as supporting evidence alongside the core CBA outputs.
- Key sensitivities considered (as applicable): timing/phasing, CAPEX uncertainty ranges, delivery/outage risk, and benefit parameter uncertainty (including losses and leakage assumptions).

3.6.2.2 Costs

3.6.2.2.1 Capex Costs

The CBA considers the main capital cost estimate of the works, the following costs have been included within the CBA:

- Initial CAPEX investment required
- Future end of life replacement costs

Table 13: Summary of all additional Capex costs (2023/2024 base prices)

	Capex		
	Initial works (£m)	Future replacement (40yr) (£m)	Total costs (£m)
Option E5 (AIS)	[redacted]	[redacted]	[redacted]
Option E7 (GIS)	[redacted]	[redacted]	[redacted]
Option E8 (AIS & OHL Diversion)	[redacted]	[redacted]	[redacted]

3.6.2.2.1 Opex Costs

No associated direct OPEX costs have been considered for all options within the CBA as maintenance costs have been assumed to be same for all options at this stage.

3.6.2.3 Benefits

3.6.2.3.2 Monetised benefits

The following benefits have been included within the CBA:

- SF_6 / Alternative gas leakage reduction
- Carbon cost of construction reduction
- Transmission loss reduction

- Summary of all Benefits

Table 14 presents the summary of all (undiscounted) benefits, including environmental and non-environmental benefits, considering the central base case carbon price.

Table 14: Summary of all benefits

Option	Environmental Benefits		Non-Environmental Benefits	Total Benefits (£m)
	Carbon costs of construction (£m)	Gas leakage (£m)	Transmission loss (£m)	
Option E5 (AIS)	[redacted]	[redacted]	[redacted]	[redacted]
Option E7 (GIS)	[redacted]	[redacted]	[redacted]	[redacted]
Option E8 (AIS & OHL Diversion)	[redacted]	[redacted]	[redacted]	[redacted]

3.7 Preferred Solution

Based on the outputs of our multifactorial analysis and CBA, our preferred solution is option E7 to replace the existing Warley 275kV AIS mesh corner substation with a new GIS 400kV double busbar substation at [redacted] (immediately south of the existing site) where the existing terminal OHL circuits are relocated to the new Warley 400kV.

The CBA evidence shows that this option has a higher NPV than other shortlisted AIS options, option E7 also offers notable advantages in health and safety, system accessibility, environmental considerations, programme timeline, resource allocation, and community effects.

It allows all drivers to be accommodated comfortably within the site in a way that is practical for construction. In contrast, the AIS options would make constructing the substation—especially when factoring in all known drivers—more difficult and potentially unfeasible.

3.7.1 Project Benefits & Outputs

In replacing Warley 275kV with a GIS 400kV substation, the proposed investment will at present deliver:

- 24 bays (plus space for four spare bays)
- It will turn in Elstree-Warley 275kV ZB OHL via 2 x 1100MVA interbus SGTs – the use of inter-bus transformers will help to de-risk programme interdependency with the TWNC project until further certainty is achieved in the project
- The installation 6x 400/132kV 460MVA SGTs along with 132kV cables and bays (USB) into [redacted]s 132kV GIS substation
- Turn in the uprated Tilbury-Warley ZB OHL to 400kV (which is being delivered via a separate investment)

Although this is the current substation design, we are still assessing how the latest outcomes from Connections Reform and our continued analysis of optimal customer connection points could affect the detailed solution design. These changes could, at most, result in fewer bays or SGTs being constructed initially – however, these outcomes will not change the analysis or conclusion that constructing a new 400kV GIS substation with OHL connections on [redacted] remains the most efficient solution for consumers overall to meet the investment drivers. More information provided in section 3.7.2 below.

This investment will provide several benefits, including:

- Facilitating existing connection demands while preparing for future expansion in the area.
- Enables the compliant connection of circa [redacted] of contracted demand to be connected at new Warley

- Enables the transition of the Northeast London ring transmission line from 275kV to 400kV allowing higher capacity power in the region – continuing to support the growth in the region in critical data centre and technology infrastructure.
- The solution enables vital regional uprating, and reinforcement works across the LE1 boundary, through enablement of NESO's TWNC tCSNP2 investment. TWNC will enable bi-directional power flows from wind and nuclear generation sources both in the North and East of the country and interconnectors in the Southeast to alleviate known current constraints on the boundary

[redacted]

- The solution minimises the substation's footprint and the environmental impacts and reduces the extent of visual impact in the area, lowering risk of consenting and local stakeholder challenges through the Town and Country Planning Act (TCPA) process.
- By mitigating the chance of delay through consenting challenge and land acquisition, Option E7 enables the connection of CP2030 aligned customers sooner.

3.7.2 Futureproofing

The design has been planned from the beginning to allow for future capacity needs in the region. This approach purposefully mitigates the risk of restricting future connections or necessitating substantial rework, thereby adhering to the 'build it once' principle, aligning with NESOs Electricity Transmission Design Principle's to "anticipate future needs to minimise recurring updates".

- The upgrade from 275kV to 400kV has already been catered for as a fundamental driver for the investment in the region.
- During the optioneering stage, the substation design accommodated all signed customers across the shortlisted options, allowing for direct comparison during the CBAs. Section 3.4 of this paper explains the basis of the design of the substation for the purposes of optioneering at the time. It included for:
    - All BESS customers who have since received Gate 1 offers through Connections Reform.
    - [redacted] demand (and its own embedded signed customers). This is especially given DNO networks associated with Warley have specifically been identified by the NESO as an area with strategic demand drivers that need to be considered for proactive investment in the ED3 price control by 2034.
    - The BESS originally contracted for connection with [redacted] which only submitted and signed a ModApp to become a data centre connection later.

3.7.2.1 Refinement of the option design following Connections Reform and changing customer contracts

Following the outcome of our optioneering process, we have continued to work on refining the final detailed design of the solution. This takes into account changes such as:

- Outcomes of Connections Reform, for example several BESS customers contracted at Warley have received Gate 1 offers.
- Changes to the Clearstone contract from a [redacted] BESS to a [redacted] data centre - which would necessitate 3x additional SGTs at Warley 400kV
- Emerging system requirements which are still being assessed, for example the need for additional reactive compensators, series reactors and subject to Connections Reform later in [redacted] possibly a third OHL circuit.

While we must ensure the substation design is both efficient and responsive to these factors, building a 400kV GIS substation south of the existing Warley site remains the preferred option for all previously stated reasons.

As we adjust to these changes, the main impact may at most be on the number of bays and SGTs units included in the detailed design of the solution which will be firmed up before the investment submits for Project Assessment. We are confident however, that our broader approach—futureproofing the substation and leaving room for growth—is the right strategy for consumers in an area experiencing significant demand increases. A more definite position on customer requirements and final design will be provided in the Project Assessment submission.

To provide some initial insight onto the different refinements of Option E7 we are considering given these changes – we are in the process of exploring two variations. These include:

- A running arrangement which continues to include for connecting [redacted] under its new contract as a [redacted] data centre at the Warley 400kV substation (Figure 14 and Appendix G). This arrangement includes for 3 additional SGTs along with two of the spare four spays reserved for reactive compensation, which would occupy any remaining space at the new site. However, under this option a third OHL circuit, should one be identified as required following Connections Reform could not also be sited.
- The other running arrangement (Figure 15 and Appendix H) instead considers it more efficient to site [redacted] data centre at a different POC, at a [redacted] proposed to be constructed in the future for other customers, where only 1 additional SGT would be required to connect the [redacted] data centre. Under this running arrangement the reactive compensation, series reactor and possibility of a third OHL circuit could also be feasibly sited.

As we continue to review these refined designs we, acknowledge that any suggestion to shift the customer to another POC—while potentially improving network efficiency and helping meet technical requirements—would ultimately impact the customer's delivery date.

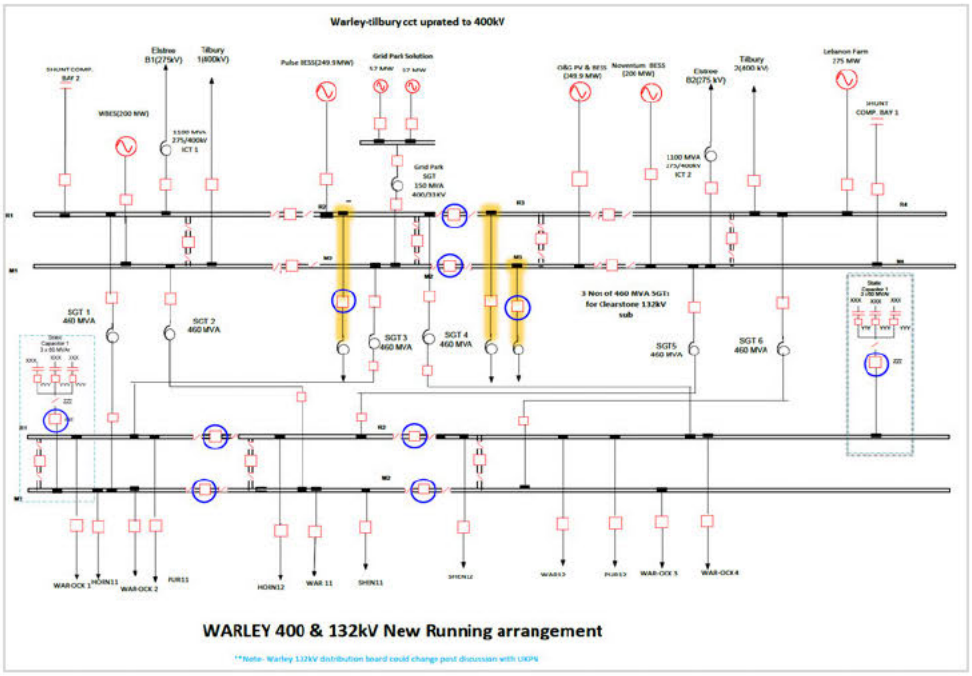


Figure 14: Single Line Diagram of proposed running arrangement with the Clearstone customer as a Data Centre (with 3 additional SGTs) (Appendix G)

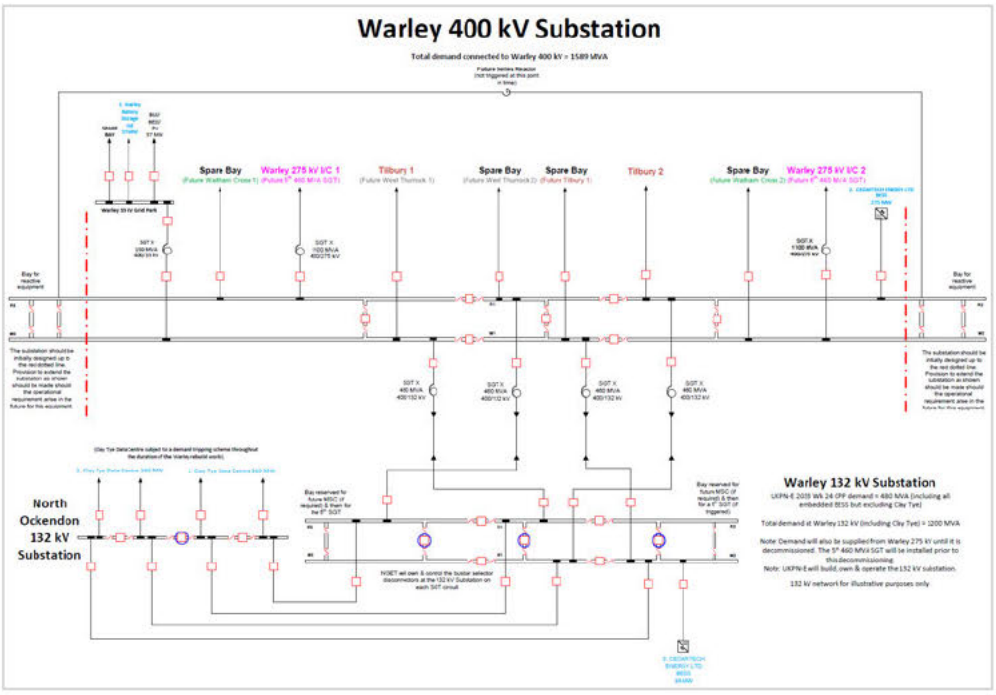


Figure 15: Single Line Diagram of proposed running arrangement with the future series reactor and future 3rd OHL circuit (Appendix H)

4. Delivery

We plan for the first ACL completion dates for the scheme and energisation of Warley 400kV to occur in [redacted] with staggered phased ACL dates following this [redacted] as additional customers come online and the existing Warley 275kV substation is also demolished.

The project's planning submission is scheduled for [redacted], with contracts expected to be awarded by the [redacted], ahead of First Site Access (FSA) [redacted] Figure 16 below presents an overview of the project timeline in the form of a high-level Gantt chart.

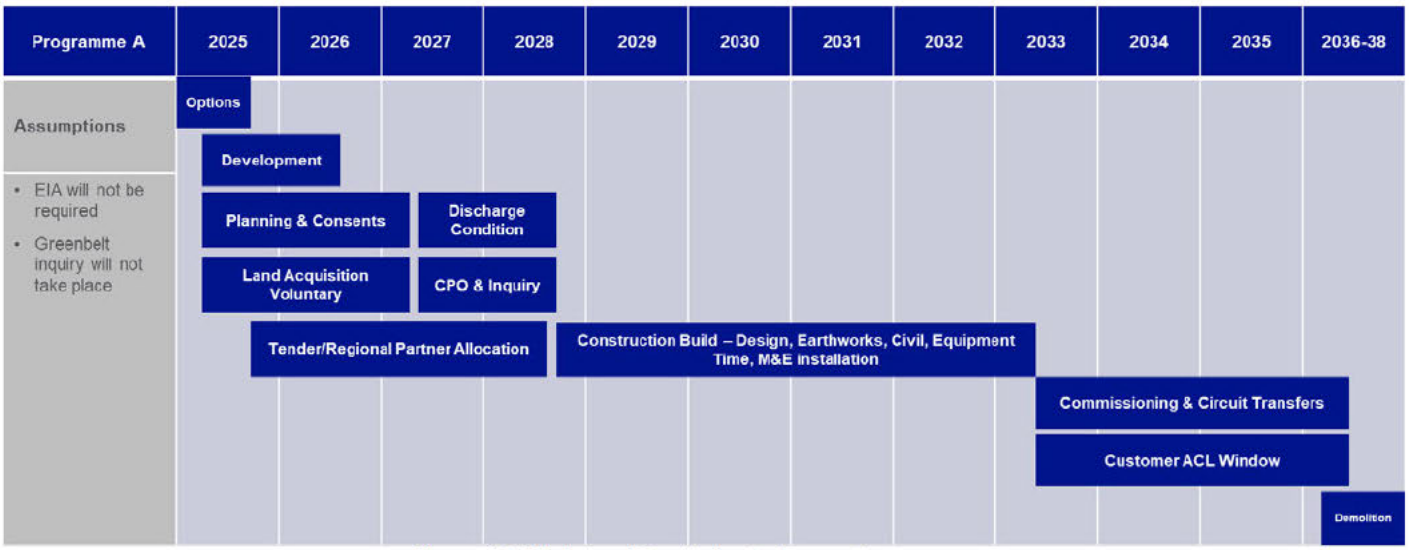


Figure 16: High level Gantt chart of current program

4.1 Procurement and Contracting Strategy

The scope and design of the works will be developed [redacted]

The proposed procurement is for the project to be delivered via [redacted] regional allocation where it is mutually beneficial to further enhance growth and social value.

The staging and focus of the contract strategy are summarised below:

- Stage 1a (Constructability Advice):

  This involves the engagement of a [redacted] It focuses on the provision of advice to NGET in relation to the construction sequencing, methodology and value engineering prior to the completion of the front-end engineering design (FEED). [redacted]

- Stage 1b (Procurement of Long Lead Items & Detailed Design):

  Completion of the FEED and production of a detailed design for the investment. This stage also involves the procurement of all necessary long lead equipment for the works, excluding SGTs. [redacted]

  We intend to use the APM to secure long-lead items for this project and so have requested Bespoke Procurement allowances through our April 2026 APM Reopener.

- Stage 2 (Construction and Decommissioning of the Existing Substation):

  This Stage will focus on the construction and commissioning of the project. It also includes decommissioning of the existing 275kV substation.

To achieve successful completion of early stage works, the partner is required to submit a detailed proposal for providing each stage of works. Each proposal includes assessment of total prices, an associated programme of works, details of the required methodology and an updated mitigated risk register. NGET will assess and review all such proposals [redacted]

By delivering this type of strategy [redacted], NGET's supply chain will have the opportunity to apply industry best practice to provide the works and improve its overall ability to deliver the required outcomes for its various stakeholders.

4.2 Risk and Risk Management

The top 5 risks currently being assessed and mitigated for the investment are summarised in Table 15. A full list of all risks being managed for the investment will be provided as part of the Project Assessment submission.

Table 15 – Risk Summary Table

Risks	Mitigation
Planning / Consents Obtaining planning consent for non-approved purposes i.e., construction of a new substation, in a green belt area requires the demonstration of "Very Special Circumstances". These circumstances are regarded an especially high threshold of criteria to obtain consents.	[redacted] The project is ensuring internal robust scrutiny of this and supporting documentation, including record keeping, audit trail and robustness of decision making throughout the project lifecycle. Continued engagement with key stakeholders to keep them updated on developments and quick turnaround of request for information.

Outages There are various NGET projects in the local vicinity such as the Warley-Tilbury OHL uprate, Tilbury 275kV to 400kV rebuild, Lower Thames Crossing OHL diversion work and ATNC. Delays resulting from these interacting projects may impact system access.	Initial system design specifications and outage sequence works will be shared between the respective projects. HV system coordination discussions have initiated and will continue the design and planning stage. The Main Works contractor will liaise with NGET to plan and coordinate with the respective interacting project teams.
[redacted]	[redacted]
External Stakeholder Interfaces: Multiple external construction activities, including the Lower Thames Crossing, several data centres and BESS customers building in the vicinity. Failure to coordinate these activities may impact the programme.	As part of the planning application, a transport assessment and outline construction management plan will be produced. A key recommendation is to establish a construction interface working group with these external bodies. The Main Works contractor, in liaison with NGET, will lead on coordinating the interface working group to ensure major deliveries and construction activities are planned and coordinated with each other in advance.
AIL route Due to National Highways reclassification of road assessments, the previous AIL route has been degraded for use so an alternative is required in time to prevent programme delays	NGET has undertaken an AIL options report and the preferred solution is to utilise the Network Rail bridge, which requires reinforcing, however as a backup a slip road off M25 is also being explored

5. Conclusion

This submission outlines a preferred solution to satisfy the investment drivers. It seeks confirmation of eligibility under Special Condition 3.18, confirmation of eligibility for PCF under Special Condition 3.15, confirmation of re-opener Track 2 EL and formal approval of the preferred option.

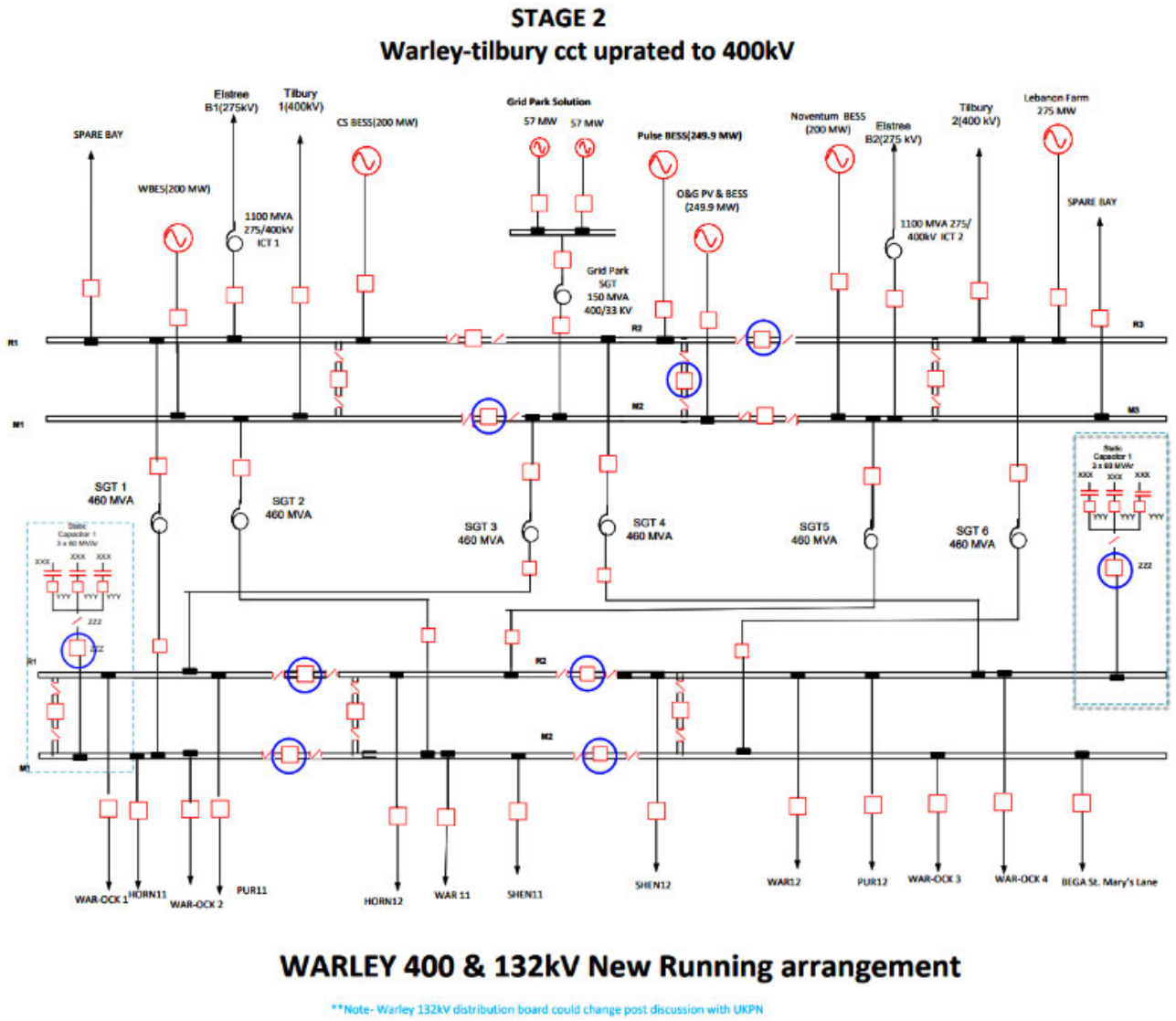
6. Appendix

Appendix A – List of SLD & layout drawings for all Long List Options

This list contains all diagrams and drawings created for every long list option and variant listed in Table 9. To ensure this submission is manageable these drawings can be requested as required following submission.

Option		Drawings
A: Do nothing	The network is kept in its current state, and no new connections are facilitated.	**N/A**
B: Market-based solution	Increased customer demand is accommodated through the procurement and use of ancillary services only.	**N/A**
C: Whole systems solution	The required customer connection is accommodated by a DNO.	**N/A**
Option D	Using existing Warley 275kV	N/A
Option E1:	In situ replacement of Warley 275kV substation	[redacted]
Option E2	Building a new offline GIS 275kV on the NGET boundary using existing NGET owned land – we had considered three variations of this option: A) with new in-situ OHL gantries B) with new offline built OHL gantries C) with new offline built OHL gantries and optimised SGT locations	
Option E3	Building a new offline GIS 400kV on the NG boundary using existing NGET land – we considered three variations of this: A) with 240MVA SGTs sited closer to the new 132kV B) with 240MVA SGTs optimising space on site C) with 460MVA SGTs and completing the 400kV uprating	

Option E4	**400kV AIS substation with 400kV cable connections** *It is to be noted we had also considered two earlier design variations:* *A) with 7 x 240MVA SGTs and the Tilbury terminal tower retained* *B) with 4 x 460MVA SGTs and the Tilbury terminal tower retained*	[redacted]
Option E5	**400kV AIS substation with 400kV OHL connections** *It is to be noted we had also considered two earlier design variations:* *A) with 4 x 460MVA SGTs and the Tilbury terminal tower relocated* *B) with 7 x 240MVA SGTs and the Tilbury terminal tower relocated*	
Option E6	**400kV GIS substation with 400kV cable connections** *It is to be noted we had also considered two earlier design variations:* *A) with 7 x 240MVA SGTs and the Tilbury terminal tower retained* *B) with 4 x 460MVA SGTs and the Tilbury terminal tower retained*	
Option E7	**400kV GIS substation with 400kV OHL connections** *It is to be noted we had also considered two earlier design variations:* *A) with 4 x 460MVA SGTs and the Tilbury terminal tower relocated* *B) with 7 x 240MVA SGTs and the Tilbury terminal tower relocated*	
Option E8	**400kV AIS substation with 400kV ZB OHL re-routing**	
Option E9	**400kV AIS back-to-back substation with OHL connections**	



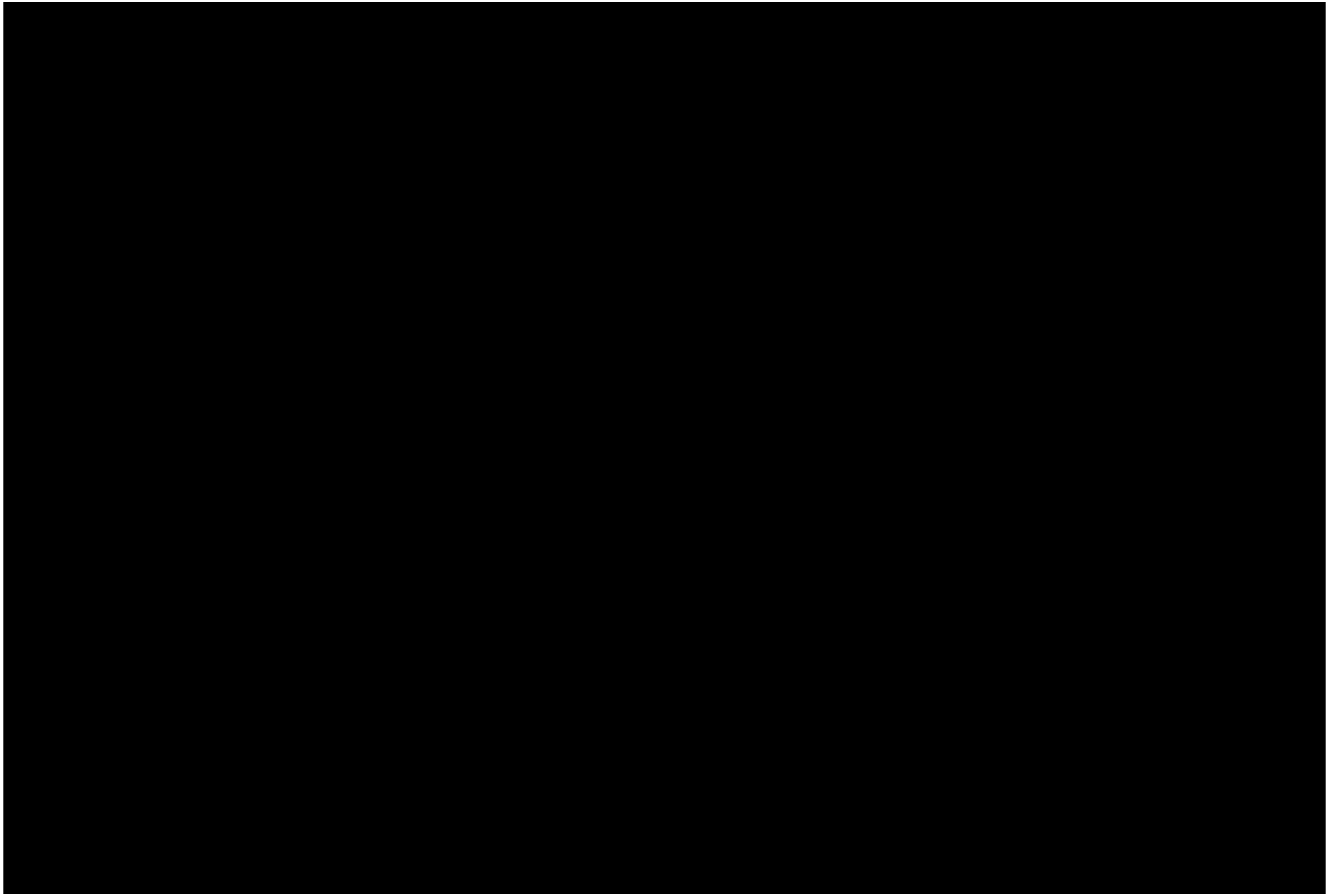
WARLEY 400 & 132kV New Running arrangement

**Note- Warley 132kV distribution board could change post discussion with UKPN

Appendix C – Enlarged drawing of Option E5 (see zip file ‘Warley – Appendix C,D,E,G,H’)

Appendix D – Enlarged drawing of Option E7 (see zip file ‘Warley – Appendix C,D,E,G,H’)

Appendix E – Enlarged drawing of Option E8 (see zip file ‘Warley – Appendix C,D,E,G,H’)



Appendix G - Enlarged drawing of Figure 14 (see zip file ‘Warley – Appendix C,D,E,G,H’)

Appendix H - Enlarged drawing of Figure 15 (see zip file ‘Warley – Appendix C,D,E,G,H’)

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