# Offshore Connections and Infrastructure Options Note

| | | | | |
|---|---|---|---|---|
| **User** | East Anglia Offshore Wind Limited | | | |
| **Site Name** | East Anglia Two | | | |
| **NETS Reference Number** | | | | |
| **Application Steering Group Members** (Delete As Applicable) | **NETSO** | NGET | **Lead details** Name: Contact No: Email: | [redacted] |
| | **Affected TO 1** | NGET | **Lead details** Name: Contact No: Email: | |
| | **Other Affected TO** | EAOW (as OTSDUW User) | **Lead details** Name: Contact No: Email: | |
| **Application Type** | Offshore Wind Generator Modification Application | | | |
| **Overview of the application** (Short description of the application) | East Anglia TWO Wind Farm was a 1200MW offshore wind farm connection. In [redacted]. An East Anglia TWO Modification Application was submitted in [redacted] to relocate the offshore platforms. There was a subsequent Modification Application in [redacted] to change the connection date and also reallocate capacity between East Anglia TWO and ONE North.<br><br>The User has indicated it wishes to receive an SQSS compliant offer and standard ownership boundary connection as set out in CUSC for the East Anglia TWO project. | | | |

| Revision Number | Date of Revision | Reason for Revision | Revised by |
|---|---|---|---|
| [redacted] | | | |

***Notes for Completion:***

1. *Please complete the table above when the document is first used for a scheme and when any subsequent revisions are made to any of the information in the live document.*

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## East Anglia zone overview

Following the first Government announcement on subsidy levels through the Contract for Difference (CfD) in 2014, EAOW undertook a strategic review of the zonal development plan for the East Anglia zone; this included a review of project sizes and locations as well as connection technology with the aim of identifying projects within the zone which provide the lowest cost of energy, and of a suitable size to bring them in line with likely subsidies.

[redacted]

East Anglia Offshore Wind Limited (EAOW) developing projects in the southern half of the zone.

[redacted]

A new modification application was submitted to National Grid in [redacted]. This was for a reallocation of capacity between EA ONE North and EA TWO (to create an even split of 860MW for each project), and to modify the connection dates. The application was deemed competent on [redacted] and therefore also forms part of this ongoing CION assessment. The Agreement to Vary was received on [redacted] and became effective on [redacted]

The East Anglia Zone as it relates to EAOW/SPRUK is now be reflected as:

- EA ONE 680MW
- EA ONE North 860MW
- EA TWO 860MW
- EA THREE 1200MW

**Figure 1**: East Anglia zone platform locations

## EA TWO

The EA TWO project is located in the west of the EA ONE. It is at a distance approximately 35km from shore. The project has a capacity of 860MW. The recent Agreement to Vary dated [redacted] has changed the Completion Date to 1st April 2026.

Currently, EA TWO is contracted to be connected to Bramford Substation. The development of the EA TWO wind farm and OTSDUW assets is in progress. The EA ONE cable route from the landfall at Bawdsey to Bramford substation will also be used by EA THREE and the Development Consent Order for EA ONE contains ducting for the cables required. Due to the change in design for EA ONE requiring addtional cables for AC, the consented cable route is now constrained and only ducts for EA THREE can be installed during the EA ONE construction works.

The EA TWO project is investigating routing alongside the EA ONE/EA THREE project, with possible extensions and/or diversions from this cable route to reach Bramford. It is anticipated that it is still possible to reach Bramford. However alternative route options including a [redacted] has begun to be assessed as part of the development work continuing in this area.

The Environmental Impact Assessment and associated surveys for EA TWO OTSDUW assets are underway The full scope of surveys cannot be determined until the connection point, substation locations and ro[redacted]options are confirmed in [redacted] A scoping opinion for EA TWO is planned to be sought in late [redacted] based on the decided routing option. The current programme is to submit Preliminary Environmental Information during [redacted] followed by the Development Consent Order submission in [redacted] *NB. EA ONE North is being developed in conjunction with EA TWO and connection options for both projects will be considered in parallel.*

The CION process therefore considers the options in addition to the already contracted connection point at Bramford, which was previously deemed to be the most economic and efficient.

In the previous assessments HVDC technology was considered as an appropriate export technology when considering connection distance, 1200MW project capacities and readily available connection interface point (at Bramford) [redacted]. EA TWO is closer to shore with a potentially shorter connection distance and therefore an HVAC is being reconsidered in this CION.

## Onshore Interface Points

Potential Onshore Interface Points included a number of existing NGET substations as well as those that would require new NGET 400kV substations, requiring an extension of the existing 400kV network.

The onshore Interface Points that have been considered in this CION (as shown in Figure 2) are described below:

- Bramford 400kV substation (current Onshore Interface Point)

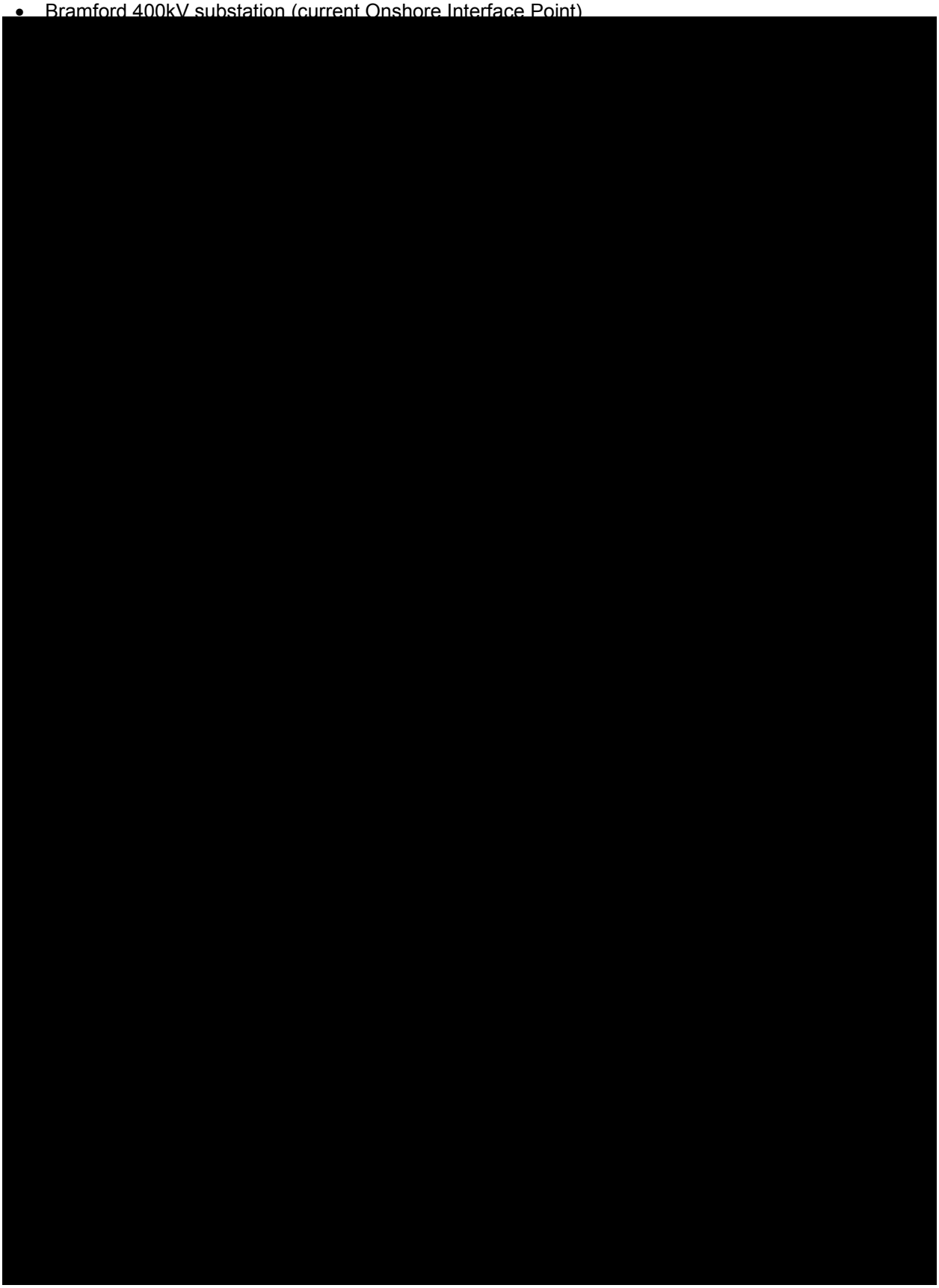


**Figure 2:** East Anglia zone potential onshore Interface Points

Interface Points located north of [redacted] and south of [redacted] were discounted as they provide no benefit over closer Interface Points due to the technical issues and much higher cost involved with longer offshore routes.

## Initial Options Appraisal

To comply with the statutory duties under Section 9 of the Electricity Act, the preferred connection design should be the most economic and efficient when considering both offshore and onshore works. Under the requirements of the Transmission Licence, the network design should be compliant with the minimum deterministic criteria of the NET SQSS.

Bramford was identified as the preferred IP for EA TWO (previously named EA FOUR) in the original grid connection offer in 2010 [redacted] This was when EA TWO was considered as 1200MW capacity. As the project capacity has now been decreased to maximum of 860MW, the reduced project size could change some of the assumptions that were made in the original connection options, hence triggering the reopening of the CION.

The initial options appraisal considered all of the IPs identified based on a high level assessment of programme, construction complexity, land availability, environmental / consenting issues and cost. IPs that were identified to have no benefit over other IPs were parked. Table 1 provides a brief summary of the Initial Options Appraisal results.

| Potential Interface Point (s) | Justification | Decision |
|---|---|---|
| Bramford | Current Interface Point for EA TWO. | Carried forward |
| [redacted] | The new OHL circuits and new substations required to establish the Interface Points at these locations would mean that the IP would not be available for the customer connection date. | Discounted |
| | The new OHL circuit and new substation needed to establish the Interface Point would require National Grid to seek a full consenting and consultation process as part of a Development Consent Order (DCO). Therefore the IP would not be available for the requested customer connection date. | Discounted |
| | These are a greater distance from the EA TWO project meaning that longer cables/technology would be required. They don't bring any benefits in terms of Network Infrastructure savings as described earlier, and will not be cost competitive in terms of OFTO investment. The alternative options that offer a shorter connection distance are considered in the document as being similar to [redacted], i.e. a connection at those points would require the same infrastructure investment as a connection at [redacted] A further reason for parking them is that these closer Interface Point sites has no existing National Grid Substation, NGET works would be a new substation and minor OHL works. | Parked |

| | | |
|---|---|---|
| [redacted] | If capacity can be ([redacted] made available at [redacted] this IP potentially becomes the most economic and efficient connection and therefore would be preferred. However, even if this capacity were not to become available, it may be possible to connect by extending the existing 400kV substation within the power station. The capacity of the existing overhead circuits from [redacted] could also be increased if required,therefore the IP may be available for t [redacted] mer connection date. The existing [redacted] substation is surrounded by the Suffolk Coast and Heaths AONB, which present a land and environmental constraint to the extension of the existing substation but this may be acceptable in local planning terms. This potential Interface Point should be assessed as a possible option. | Carried forward |
| | In the immediate vicinity of [redacted] Connection at [redacted] in terms of impact on the system is expected to be exactly the same as connecting at [redacted] If capacity can be made available at this IP a connection could be made available at [redacted]. This is likely to involve redevelopment of the [redacted] substation to accommodate all proposed offshore wind projects and land/ environmental aspects will require to be considered in the local planning application process. | Carried forward |

**Table 1**: Summary of Initial Options Appraisal

Therefore, the Onshore Interface Points shortlisted to be carried forward for further considerations are:

[redacted]

As the ModApp for EA TWO were submitted at the same time as EA ONE North, the two projects are interactive and the CION considers the different combinations of connecting the two projects at the substations listed above. Considering that the two projects are of the same size and similar connection date, it is assumed that there will be no difference which particular project are connected to which substation in the combination (i.e. the network impact of connecting EA TWO to Substation A and EA ONE North to Substation B is identical if the connection is swapped (EA TWO to Substation B and EA ONE North to Substation A). Therefore the Onshore Interface Connection Points combination options considered are as following:

- Both connecting to [redacted] Substation
- Both connecting to [redacted] Substation
- Both connecting to [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation
- One each connecting to [redacted] Substation and [redacted] Substation

Note that as [redacted] Substation is radially connected to [redacted] Substation, it is assumed that connection to [redacted] Substation will have an identical network impact as connection to [redacted] Substation.

## Technology Options

[redacted]

The power can be transmitted from the platforms to the onshore Interface Points using different transmission technologies, such as HVAC or HVDC, and the output from multiple wind farms strings can be collected for bulk transmission. Due to the number of Interface Points, the different transmission technologies available, the different options for interconnecting platforms offshore and the potential technological advances over the timescales of the projects, a number of assumptions have been made in order to limit the number of scenarios considered for this initial comparative assessment.

[redacted]. HVDC links should be considered when factors such as rated power, system design, Grid Code compliance, land availability, circuit corridor width, ground conditions lead to an HVAC connection being impractical or uneconomic. However none of the issues are problematic at this stage for EA TWO (and also EA ONE North) with an HVAC connection.

HVDC technology could only be considered if they prove to be more technically reliable, commercially viable and reduce costs over an HVAC connection. For the connection of EA TWO, via the possible interface points, the OTSDUW party has confirmed that utilisation of HVAC is the preferred technology

for the connection of EA TWO (implied from EA ONE – being constructed).Therefore connection to an Interface Point with an existing HVAC substation maximising deployment of HVAC technology represents an economic and efficient method for the connection of EA TWO.

## Detailed Options Appraisal

Four IP options for the connection of EA TWO (with all possible combination of connections in conjunction with EA ONE North) were assessed in greater detail by undertaking a desk-based constraint mapping exercise to identify potential substation locations and connection routes and assessing project specific costs. Figure 3 shows the location of all four shortlisted IPs.

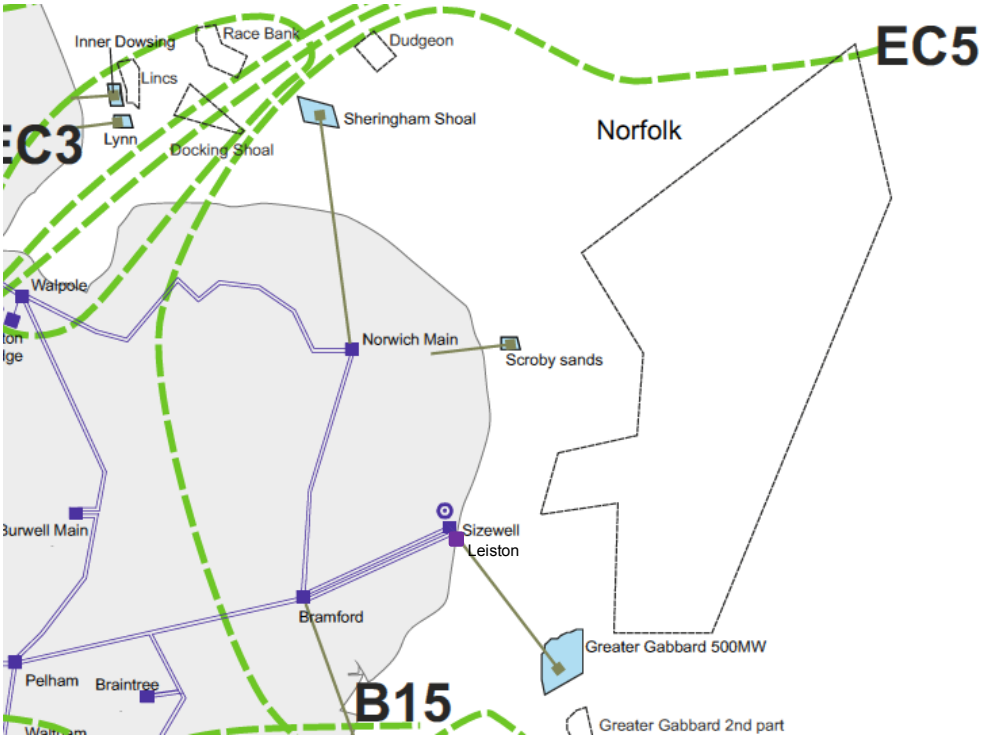



**Figure 3:** Onshore Interface Points shortlisted for Detailed Options Appraisal.

Sections 1 and 2 of this document provide detail of the cost comparison and technical assumptions.

Table 2 provides the route distance and OFTO cost summary of the Interface Points considered in the detailed assessment. In the Options Appraisal Matrix for completeness this is expanded to consider different combinations of connections for both projects (EA TWO and EA ONE North).

| | Interface Point | Offshore | Onshore | Total (km) | OFTO Cost |
|---|---|---|---|---|---|
| 1 | [redacted] | | | | |
| 2 | | | | | |
| 3 | | | | | |

N

**Table 2**: Route distance for each shortlisted Interface Point and OFTO cost to connect EA TWO

Table 3 shows the summary of the appraisal of the non-quantifiable factors in the Detailed Options Appraisal:

| Option No. | Interface Points Combination | Level of Onshore TO Works | Technical Risk | Consent Risk | Preliminary Ranking |
|---|---|---|---|---|---|
| 1 | [redacted] | Minimal | Low - Medium | Low - Medium | 1 |
| 2 | | Extensive | Medium | Medium | 3 |
| 3 | | Local | Low | Medium - High | 2 |
| 4 | | Extensive | Low - Medium | High | 7 |
| 5 | | Local / Extensive | Low - Medium | Medium – High | 4 |
| 6 | | Moderate / Extensive | Low - Medium | High | 6 |
| 7 | | Moderate / Extensive | Low-Medium | High | 5 |

**Table 3**: Detailed Options Appraisal Summary

All the options listed in Table 3 are put into Boundary Capability Studies to identify the impact of each connection combination (including reinforcement works required) on the capability of Boundary EC5. The result is as shown in Table 4:

| Capacity per year (MW) | NORM - NORM | NORM – SIZE NORM - BRFO | SIZE - SIZE LEIS-LEIS BRFO - BRFO |
|---|---|---|---|
| **2024** | [redacted] | | |
| **2025** | | | |
| **2026** | | | |
| **2027** | | | |
| **2028** | | | |
| **2029** | | | |
| **2030** | | | |
| **2031** | | | |
| **2032** | | | |

**Table 4**: Effect of the connection combinations on the EC5 Boundary Capability.

It can be seen that any connection combination is increasing the capability of Boundary EC5 hence all options are then carried forward for CBA. Table 5 shows the Least Worst Regret of all the shortlisted connections.

| Regret (£m) | GG | SP | CP | NP | Worst Regret |
|---|---|---|---|---|---|
| Sizewell /Leiston (1720) | [redacted] | | | | |
| Bramford (1720) | | | | | |
| Norwich (1720) | | | | | |
| Bramford (860) Sizewell (860) | | | | | |
| Norwich (860) Sizewell (860) | | | | | |
| Norwich (860) Bramford (860) | | | | | |

**Table 5**: Least Worst Regret for Connection Combination Options for EA2 and EA1N.

The Least Worst Regret in Table 5 shows that in all Future Energy Scenarios, connection to either [redacted] has the Least Worst Regret. [redacted] share the same results as [redacted] is radially connected to [redacted].

The CBA concluded that Option 2 or 3 (Connecting both EA TWO and EA ONE North to Sizewell or Leiston Substation) is the most economic solution.

[redacted]

## Conclusion

Eventhough the non-quantifiable factors identified Option 1 (Connecting both EA TWO and EA ONE North at [redacted] Substation) as the most preferred option, the substantial difference in the Least Worst Regret between Option 2/3 (Connecting both at [redacted] and the other options means that Option 2/3 is the most economic and efficient connection option. The CION party discussed this over and agreed that the most preferred option is to connect EA TWO to a new substation near Leiston Substation using HVAC Technology.

## SECTION 1 – Preferred Option Assessment

| | **Summary** (Short overview description of each option) | **Major Risks** | **Onshore TO Cost £m** | **Offshore TO Cost £m** | **Overall Total Cost £m** |
|---|---|---|---|---|---|
| **Option 1** | Connecting to Bramford 400kV substation via HVAC link | **TO**<br>Nil<br><br>**OFTO**<br>[redacted] | [redacted] | | |

| | | | |
|---|---|---|---|
| **Option 2** | Connecting to [redacted] 400kV substation via HVAC link | **TO**<br>There are risks associate[redacted]nding a suitable location for substation infrastructure. [redacted] infrastructure is land locked within the perimeter of the nuclear site.<br><br>**OFTO (Comments apply to both [redacted] options)**<br>[redacted] | [redacted] |

| | | | |
|---|---|---|---|
| **Option 3** | Connecting to [redacted] 400kV substation via HVAC link | **TO**<br>Proposed 400kV substation is situated within Suffolk Coast & Heaths AONB. Sizewell Marshes SSSI less than 50m to the NE. Leiston Aldeburgh SSSI and Sandlings SPA approx. 500m to the SW. New substation will require Planning Permission. Ecologically and politically sensitive area. Reconductoring should be covered under the exisiting S37 consent.<br><br>**OFTO (Comments apply to both [redacted] options)**<br>[redacted] | [redacted] |

| | | | |
|---|---|---|---|
| **Option 4** | Connecting to [redacted] 400kV substation via HVAC link. | **TO**<br>[redacted] Few existing constraints to extending this substation. Dependant on size of extension there is a rail line to the east. Dunston Hall Hotel and golf course to east of subsation but site it already well screened by existing intervening woodlands. Small Local Nature Reserve to east part of of existing woodland surrounding the hotel. Gowthorpe Manor (Grade II* listed building) is to west of site although likely to be screened by existing woodland blocks depending on where extension would be located. Would need to review any local planning policies for any specific requirements relating to this location.<br>**OFTO**<br>[redacted] | [redacted] |

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

## SECTION 2 - Preferred option

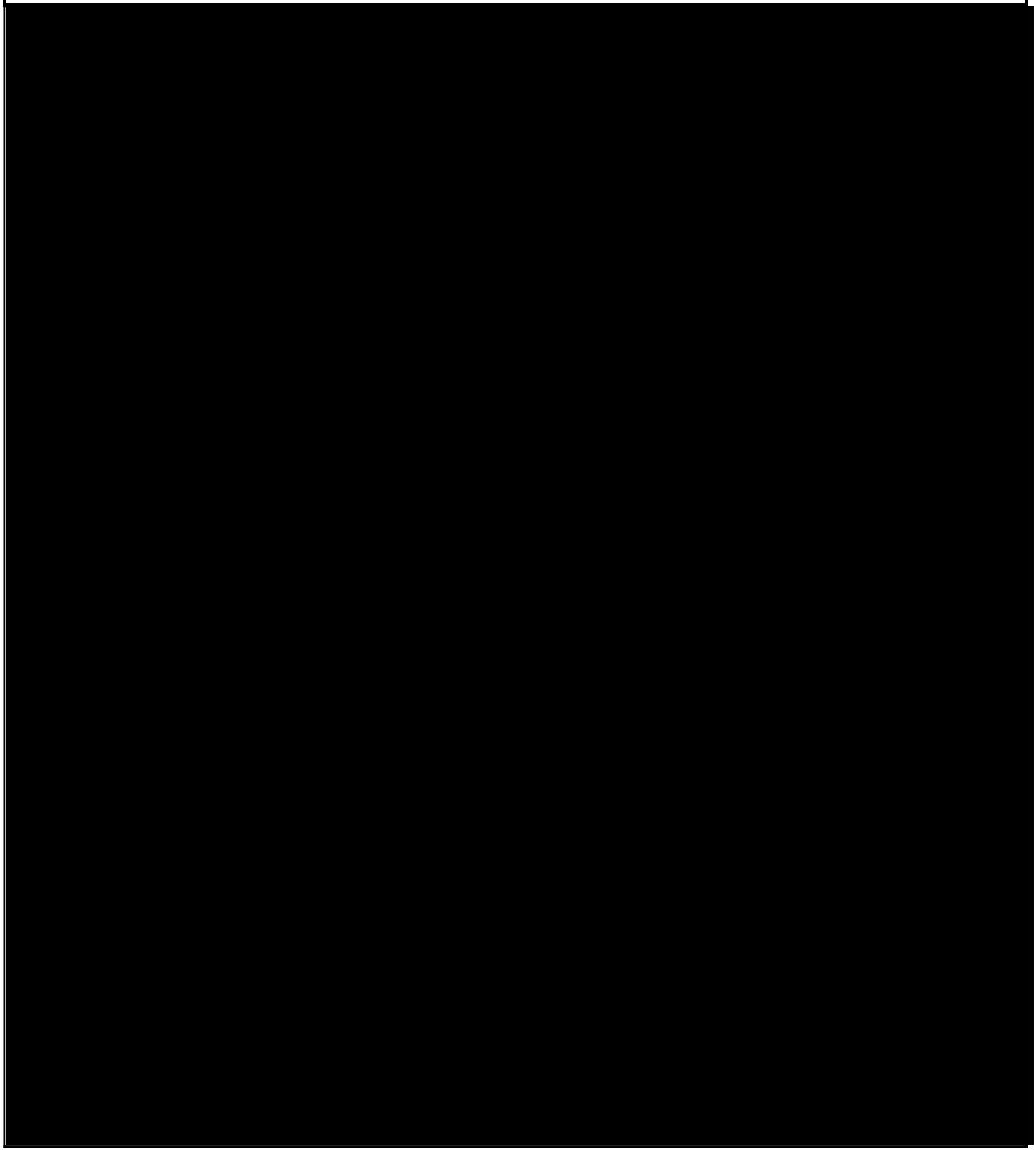
**Option -** The preferred option is **Option 3** where the 860MW of wind generation in EA TWO is connected to the onshore IP at Leiston. [redacted] An onshore substation of 860MW OFTO substation will be built adjacent to the Leiston substations. The offshore platform and onshore substation will be connected via two 220kV HVAC circuits. 400kV underground cables will connect the OFTO substation to the Leiston substation.

However it is recognised that this option may not be possible therefore HVAC connection to [redacted] will also be considered.

| Details of Option 3 – Connecting to Leiston 400kV Substation via an HVAC link | | |
|---|---|---|
| **Offshore Works** | **Description of Works** (Detailed description of the works) | [redacted] |
| | **Cost** | |
| | **Completion Date** | |
| | **Issues, Risks & Comments** | |
| | **Outage Requirements** | |
| **Onshore Works** | **Description of Works** (Detailed description of the works) | |
| | **Cost** | |
| | **Completion Date** | |
| | **Issues, Risks & Comments** | |
| | **Outage Requirements** | |

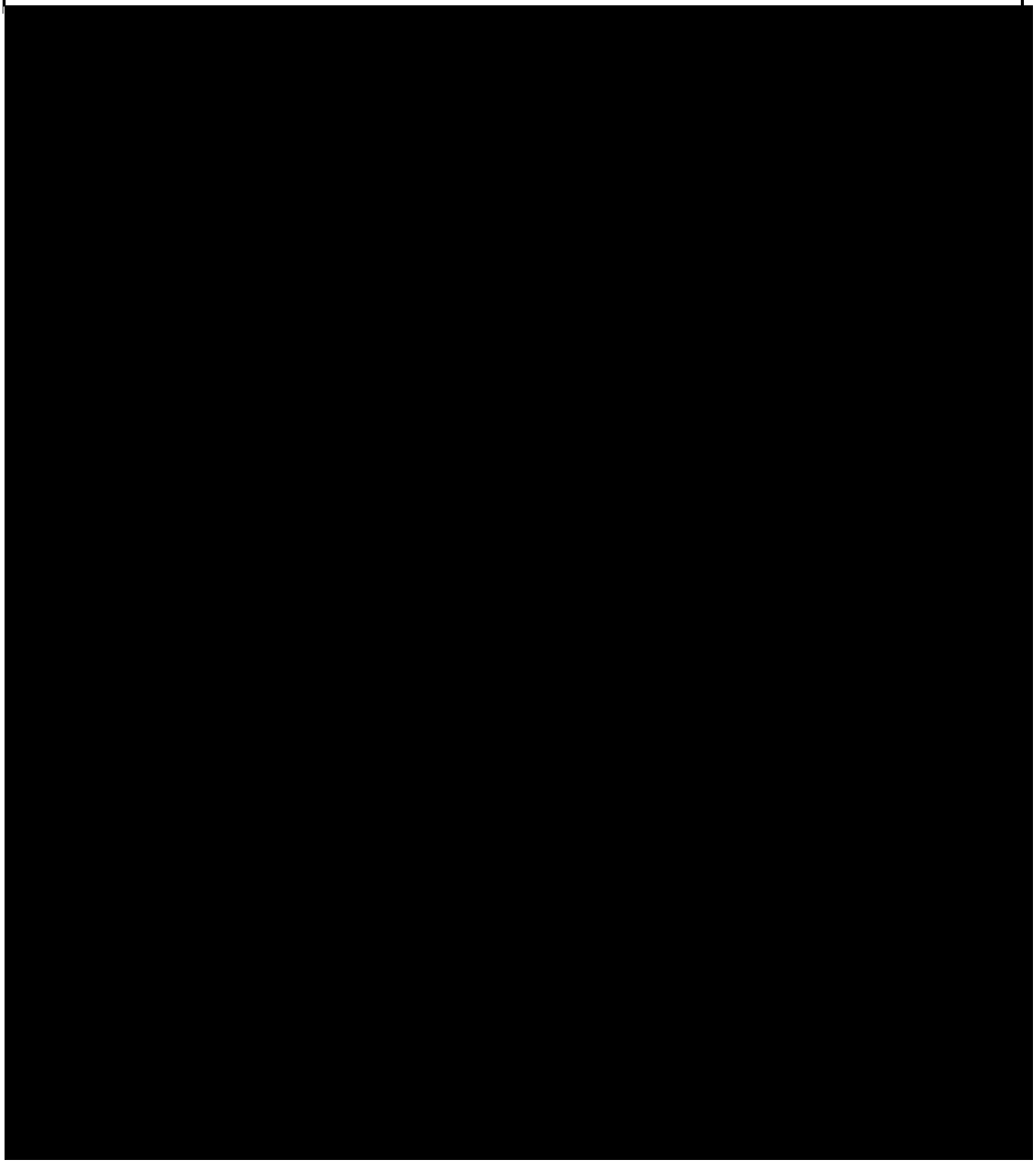
**Details of Option 3–** Connecting to Leiston 400kV Substation an HVAC link

**Single Line Diagram**

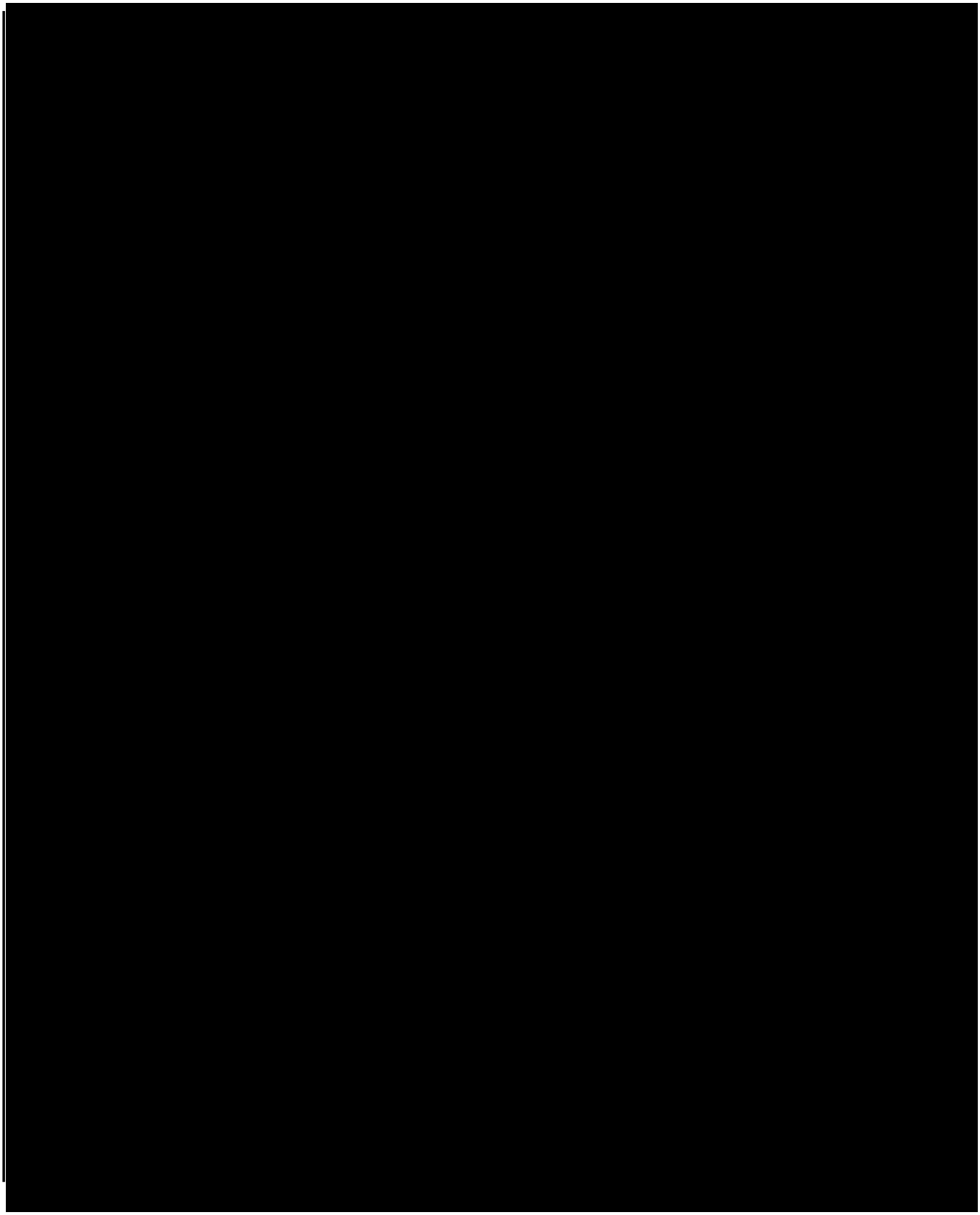


| **Details of Option 1 –** Connecting to [redacted] 400kV substation via an HVAC link | | |
|---|---|---|
| **Offshore Works** | **Description of Works** (Detailed description of the works) | [redacted] |
| | **Cost** | |
| | **Completion Date** | |
| | **Issues, Risks & Comments** | |
| | **Outage Requirements** | |
| **Onshore Works** | **Description of Works** (Detailed description of the works) | |
| | **Cost** | |
| | **Completion Date** | |
| | **Issues, Risks & Comments** | |
| | **Outage Requirements** | |

| **Details of Option 1 –** Connecting to [redacted] 400kV substation via HVAC link |
|---|
| **Single Line Diagram** |



## SECTION 3 – Offshore Transmission Owner Cost Assumptions



## SECTION 4 – Onshore Transmission Owner Cost Assumptions

An indicative capital cost estimate for the overall scope of works for each of the Onshore Interface Point has been prepared. All estimates were made based on high level project specific design information and based on assumptions about the scope of works required. National Grid's capital cost estimates include costs for the transmission equipment and also for the installation of that equipment and are based on generalised unit costs for the key elements of the option. The generalised unit cost information reflects recent contract values and/or budget estimates from equipment manufacturers/suppliers or specialist consultants and provides a consistent basis for preparing capital cost estimates. The IET, PB/CCI Report[1] presents cost information in size of transmission circuit capacity categories for each circuit design that was considered as part of the independent study.

[1] "Electricity Transmission Costing Study – An Independent Report Endorsed by the Institution of Engineering & Technology" by Parsons Brinckerhoff in association with Cable Consulting International. Page 10 refers to Double circuit capacities.

## APPENDIX A – Options Appraisal Matrix