2024 National Grid Electricity Transmission Response to the ESO East Anglia Network Study (March 2024)

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Contents

Executive summary

This report provides a response of National Grid Electricity Transmission (NGET) to the ESO East Anglia Network Study (the ESO Study) published by the Electricity System Operator (ESO) in March 2024. The ESO Study responds to the UK Government's ongoing Offshore Coordinated Support Scheme (OCSS). The ESO Study explores (without making recommendations) the underlying network changes in the region, including planned onshore electricity network infrastructure, that could be considered should the coordinated network design prove a viable solution and the wind farms choose to proceed with it.

As the ESO Study states, the "options assessed within this study come with critical trade-offs to be made" and that "there is no single option that minimises impacts across all the metrics". The ESO Study has not put forward an option for an 'offshore ring main' on viability grounds.

Economic

The economic analysis in the ESO Study clearly shows that Option 3 – the current Norwich to Tilbury project with the addition of a new Friston to EACN substation line – would be the economically optimal solution if OCSS coordination between Sea Link and the two offshore wind farms progresses. This is the case in the event of delay up to as late as 2033, across a range of generation and demand scenarios and if capex or constraint costs are reduced or increased.

The delay sensitivity demonstrates that any of the options, if assumed to be delivered in 2034, would result in at least £962m additional costs to consumers relative to delivering Option 3 in 2030. AC overhead line options are also more adaptable to varying future scenarios than HVDC cable options.

Environment and Community

Option 3 is less constrained than offshore options from an environmental perspective. The ESO Study identifies the consenting risks associated with converter stations for some of the options using HVDC.

The community sentiment aspect of the ESO Study's appraisal does not form part of the HND methodology. NGET is committed to taking into account community feedback on its proposals. In line with processes and guidance from the Planning Act 2008 and National Policy Statements, stakeholders and the public are consulted during the proposed project's evolution allowing for feedback to have influence in the development of the location, design and mitigation proposals of our schemes.

Deliverability

Generally, we concur with the deliverability challenges identified for all options. We agree with the ESO that there are technological complications with extensive HVDC underground cabling. We believe that the ESO Study's methodology is likely to understate capex costs for HVDC options.

Whilst we and the ESO consider that all options would have impacts, none present in-principle environmental issues that could not be mitigated with careful consideration of routeing and use of appropriate technologies to specific constraints, as is consistent with the National Policy

Statements (NPSs) against which proposals for nationally significant infrastructure projects are assessed.

Next Steps

The grant funding awarded under the OCSS does not change the requirement for the EACN substation as part of the Norwich to Tilbury project. Until connection agreements are modified (as the case may be), NGET must continue to meet its licence obligations and progress with the proposed Norwich to Tilbury project. In the event that full offshore coordination between North Falls, Five Estuaries and Sealink is formally confirmed, options for the reinforcement between Norwich to Tilbury will be further reviewed.

1. Introduction and purpose

1.1 Background and context

1.1.1 This report provides a response of National Grid Electricity Transmission (NGET) to the ESO East Anglia Network Study[1] (the ESO Study) published by the Electricity System Operator (ESO) in March 2024.

1.1.2 The ESO Study is the outcome of the ESO's study into electricity network infrastructure in East Anglia, in response to the UK Government's ongoing Offshore Coordinated Support Scheme (OCSS). The OCSS asks developers who are already at an advanced stage of development to voluntarily assess the opportunity of coordinating offshore infrastructure, such as offshore wind farms and transmission infrastructure.

1.1.3 In December 2023, the Department for Energy Security and Net Zero (DESNZ) announced that a consortium of three projects – North Falls Offshore Wind Farm, Five Estuaries Offshore Wind Farm and NGET's Sea Link project (a new 2 GW HVDC offshore circuit between Friston, East Anglia and Richborough, Kent) – have received funding to explore coordination in further detail. The OCSS proposal is for the two offshore wind farms to connect into an offshore platform into Sea Link. Whilst continuing to progress their projects in accordance with existing plans for individual 'radial' connections to East Anglia, the developers of these projects are currently exploring the feasibility of the OCSS proposal, and DESNZ will decide whether to continue funding further development work.

1.1.4 In parallel with the ongoing OCCS proposal described above, the proposed North Falls and Five Estuaries offshore wind projects are contracted to connect to a new substation – known as East Anglia Connection Node (EACN) substation – which would be developed as part of the proposed Norwich to Tilbury project. Norwich to Tilbury is a proposal by NGET to reinforce the high voltage power network in East Anglia between the existing substations at Norwich Main in Norfolk, Bramford in Suffolk and Tilbury in Essex.

1.1.5 Norwich to Tilbury would comprise approximately 184 km of new electricity transmission reinforcement mostly using overhead line and pylons, along with some underground cables and a new 400 kV substation. Norwich to Tilbury and Sea Link have been identified as 'HND essential' options in the Holistic Network Design (HND) strategic network planning process and have been identified as Accelerated Strategic Transmission Investment (ASTI) projects by Ofgem. The ASTI framework has been created to expedite the delivery of the UK Government's 2030 ambitions.

1.2 The ESO Study

1.2.1 The ESO Study explores the underlying network changes in the region, including planned onshore electricity network infrastructure, that could be considered should the coordinated network design prove a viable solution and the wind farms choose to proceed with an offshore grid connection. The Study sets out an assessment of 10

[1] download (nationalgrideso.com)

options against four key criteria (deliverability, environment, community and economic). The ESO Study explains why it does not make recommendations about which options would be considered optimal. The ESO Study states that:

"Following this publication, we expect NGET to consider the assessment findings as part of their ongoing development of the Norwich to Tilbury circuit route. We also shortly expect the *UK Government and relevant OCSS developers to decide upon their progression to the next stage of the OCSS. We hope that this study provides all stakeholders with a range of options that could meet the network capacity needs of the region."*

1.2.2 The ESO Study also recognises:

"It is important to note that a decision from government to grant OCSS funding does not result in immediate or automatic changes to existing, signed connection agreements between us [the ESO] *and offshore wind projects. It is our understanding that all developers in scope of the OCSS are pursuing the exploration of voluntary offshore coordination alongside progressing their existing connection agreements".*

1.2.3 The ESO invites NGET to consider the assessment findings from the ESO Study as part of NGET's ongoing development of the Norwich to Tilbury circuit route, which we have done and in ways which we summarise in this response.

1.3 Summary of our observations

General

1.3.1 We generally agree with the ESO Study's comments that the "options assessed within this study come with critical trade-offs to be made" and that "there is no single option that minimises impacts across all the metrics". We note that some options were excluded, for example, the 'offshore ring main' as it did not meet the Terms of Reference for the ESO Study and was not technically viable in the timescales set out in the study. It would also result in changes in connection location for projects not exploring voluntary coordination through the OCSS.

Appraisal methodology

1.3.2 The ESO Study assesses options against four criteria (deliverability, environment, community and economic) and presents the results in a Black, Red, Amber, or Green (BRAG) tabular format. The ESO Study explains how it is not its role to make a recommendation based on this balance and instead that is for NGET to undertake.

1.3.3 NGET has factored in the importance of consumer value (for example, we note that there are options with up to £2bn of additional consumer detriment) and potential planning risk given that 'consenting' is assessed in 'deliverability', with separate criteria for 'environmental' and 'community' considerations.The basis for rating consenting for options with onshore elements is based on the information available to the ESO and their methodologies, which we have considered alongside our own work to date. From our understanding of the ESO Study, we and the ESO share the view that the relevant National Policy Statements offer policy support for such forms of development, with mitigation such as careful routeing and underground cables where necessary.

Economic analysis

1.3.4 The economic analysis shows that Option 3 – the current Norwich to Tilbury project with the addition of a new Friston to EACN substation line – would be the economically optimal solution and would remain so with a delay from 2030 up to 2033 and across a range of generation and demand scenarios. Sensitivity tests on capex and constraint cost reductions show the economic case for Option 3 is robust.

1.3.5 While the ESO Study tests delay of the onshore options with earlier delivery dates being delayed to 2034, it does not test any delay of those assumed to be delivered in 2034. The ESO recognises that the delivery of multiple HVDC circuits might be at risk of delay to later than 2034 because of known supply chain issues and the novel nature and scale of this technology. Any such delay would add significant costs to the consumer for these options.

1.3.6 It is also important to note that this delay sensitivity demonstrates that any of the options, if assumed to be delivered in 2034, would result in at least £962m of additional costs to consumers, relative to delivery of Option 3 in 2030 (i.e. the economic analysis does not support delay of delivery to 2034).

1.3.7 We have reviewed the comparison between HVDC and an AC solution with no power flow control or voltage support. The power flow control and voltage support can be achieved on an AC system at much lower cost than the HVDC solution and would also reduce constraint costs.

1.3.8 AC options are also potentially more adaptable to varying future scenarios than HVDC options. The economic analysis shows that Option 3 is optimal:

- on a 'least worst regrets' basis across the four Future Energy Scenarios (£301m vs £2,439m for the next best Option 8);
- when constraint costs are increased by 40%; and
- in all scenarios when constraint costs are decreased by 40% (i.e. there are no regrets).

Deliverability and consenting

1.3.9 With regard to the deliverability appraisal, the distinctions made in the 'consenting' sub-criterion appear to be driven by factors such as concentration of infrastructure in addition to what is already planned, and the potential impact of the EACN substation on the Dedham Vale National Landscape. Whilst we consider that all options would have impacts, none present in-principle environmental issues that could not be mitigated with careful consideration of routeing and use of appropriate technologies to specific constraints, as is consistent with the National Policy Statements (NPSs) against which proposals for nationally significant infrastructure projects are assessed.

1.3.10 The ESO Study notes that NPS EN-5 "*states that the UK Government's position is the use of overhead lines as the starting presumption for electricity network development*". NGET has undertaken a detailed appraisal of the proposals against the NPSs in reaching its view that Norwich to Tilbury is both suitable and consentable. We also note the ESO's 'amber' rating on environmental factors for onshore Options 3 and 4 implies that these options are "likely to be viable" from an environmental perspective.

1.3.11 The ESO Study identifies the consenting risks associated with converter stations for some of the options using HVDC technology. We support the principle that any assessment of the environment and community impacts would need to address the

risks converter stations may pose to community receptors such as National Landscapes and settlements. Our community appraisal of Option 3 has sought to address potential effects to socio-economic receptors such as the settlement of Ipswich.

Community sentiment

1.3.12 The ESO Study includes a separate analysis of 'community sentiment', which is distinct from the consideration of environment and community factors in the HND methodology. Given the differing geographical locations of alternative options to the current Norwich to Tilbury proposals forming Option 3, it is not clear from the ESO Study if or how the probable sentiment of the communities local to the other options has been taken into account. It is also not clear how the sentiment of potentially affected communities has been assessed by the ESO and the numbers that have been engaged with to determine an appraisal score nor what bearing the community sentiment ratings are expected to have on options appraisal.

1.3.13 NGET is committed to taking into account community feedback on its proposals. In line with processes and guidance from the Planning Act 2008 and National Policy Statements, stakeholders and the public are consulted during the proposed project's evolution allowing for feedback to have influence in the development of the location, design and mitigation proposals of our schemes.

1.4 Next steps

1.4.1 The grant funding awarded under the OCSS does not change the requirement for the EACN substation as part of the Norwich to Tilbury project. Until such time as the OCSS assessment is better understood and tested and, depending on the outcome, connection agreements are modified (as the case may be), NGET must continue to meet its licence obligations and progress with studies to fulfil the signed agreements for connections at the EACN substation. The customers with signed connection agreements at the EACN substation are currently continuing to progress their projects connecting at the EACN substation.

1.4.2 In the event that full offshore coordination between North Falls, Five Estuaries and Sealink is formally confirmed, options for the reinforcement between Norwich to Tilbury will be further reviewed.

2. Summary of ESO Study assessment

2.1.1 Following an initial screening exercise, the ESO Study describes an 'Holistic Assessment' of 10 network configuration options in East Anglia. These network configuration options range from onshore network configurations to a network configuration involving no new overhead lines within East Anglia. The Holistic Assessment uses the OCSS proposals (connection of the two wind farms into an offshore platform into Sea Link) as its baseline, rather than currently planned connections (into the EACN substation). The needs cases for NGET's planned projects currently reflect the contracted position.

2.1.2 The options assessed were as follows:

Table 2.1 – Options assessed

	Option	Description
1	Predominately offshore option – variation without EACN substation	Two HVDC circuits Norwich-Grain; two HVDC circuits Friston-Kent.
2	Predominately offshore option – variation with EACN substation	As above with addition of an onshore circuit to connect EACN substation to Bramford Substation.
3	Onshore option	The currently proposed Norwich to Tilbury project as well as an additional circuit between Friston and EACN substation.
4	Alternative onshore option – variation without Bramford to EACN substation	Similar to Option 3, but with the Bramford-EACN substation route removed.
5	Alternative onshore option – variation without EACN substation	This configuration is similar to Option 4, but with the proposed substation at EACN substation also excluded.
5b	Alternative onshore option – variation without EACN substation – sensitivity	Sensitivity relating to interconnectors (three interconnectors connecting at Friston rather than the two at Friston / one at Grain assumed in Option 5).
6	Hybrid onshore and offshore option – variation with EACN substation	This option proposes replacing the northern part of the Norwich to Tilbury route (from Norwich to Bramford to EACN substation) with two offshore HVDC circuits.
7	Hybrid onshore and offshore option – variation without EACN substation	This option is a variation of Option 6 removing the proposed EACN substation.
8	Onshore HVDC option	This network configuration has three routes across and out of East Anglia, comprising of three circuits. This option replaces the AC onshore network configuration – Option 3 – with an equivalent undergrounded HVDC route.
9	Predominantly offshore option – utilising Bradwell as a landing point	This configuration is a variation of Option 1 and explores using Bradwell as a landing point for an HVDC cable, to remove power from the wider region and negate the need for additional infrastructure at Friston.

2.1.3 The ESO Study notes that:

"The design criteria methodology we use helps us to balance the impacts of new infrastructure *with the benefits it can bring. This methodology was originally approved by the UK Government as part of their Offshore Transmission Network Review (OTNR) and later adopted into our wider onshore network planning process."*

2.1.4 The criteria used are as follows:

- **Criteria 1:** Can be delivered and operated in a timely and practical way;
- **Criteria 2:** Minimise the impact, where possible, on the natural environment;
- **Criteria 3:** Minimise the impact, where possible, on the communities that host this infrastructure; and
- **Criteria 4:** Can be delivered in an economic and efficient way, ensuring the best value for consumers.

2.1.5 The ESO Study explains how it is not its role to make a recommendation based on the outcomes of its analysis and instead that is for NGET to undertake.

2.1.6 To assess and compare the deliverability and operability, environmental impact and community impact, the ESO used Black, Red, Amber, or Green (BRAG) rating. The results are summarised in Table 7 of the ESO Study, which is reproduced below.

	Option description	Delivery date	Deliverability and operability ranking	Environmental ranking	Community ranking	Economic rating (on-time delivery)	Economic rating (2034 Delivery)
1	Predominately offshore option – variation without East Anglia Connection Node (EACN)	2034	Red	Red	Amber	£4.2 bn	£4.2 bn
2	Predominately offshore option – variation with EACN	2034	Red	Red	Red	£4.8 bn	£4.8 bn
3	Onshore option	2030	Red	Amber	Red	£0 bn	£1.6 bn
4	Alternative Onshore option – variation with EACN	2030	Red	Amber	Amber	£2.0 bn	£3.6 bn
5	Alternative Onshore option – variation without Bramford to EACN	2034	Amber	Amber	Amber	£10.3 bn	£10.3 bn
5b	Alternative Onshore option – variation without Bramford to EACN – sensitivity	2034	Amber	Amber	Amber	£1.4 bn	£1.4 bn
6	Hybrid onshore and offshore option – variation with EACN	2034[41]	Red	Red	Amber	£1.7 bn	£2.1 bn
7	Hybrid onshore and offshore option – variation without EACN	2034	Amber	Red	Amber	£1.8 bn	£1.8 bn
8	Onshore HVDC Option	2034	Red	Amber	Amber	£1.0 bn	£1.0 bn
9	Using Bradwell as a landing point	2034	Black	Red	Amber	£9.0 bn	£9.0 bn

Table 7: Summary of options assessment

2.1.7 Assuming equal weighting, the BRAG tabular format used could imply a simple scoring method across the four criteria (i.e. the one with most 'green' ratings / least 'red' ratings would be optimal). NGET has factored in the importance of consumer value (for example, we note that there are options with up to £2bn of additional consumer detriment relative to the top ranked option).

2.1.8 NGET has also factored in planning risk, given that 'consenting' is assessed in 'deliverability', with separate criteria for 'environmental' and 'community' considerations. Additionally, the basis for rating consenting as 'red' for options with onshore elements is based on the information available to the ESO and their methodologies, which we have considered alongside our own work to date. From our understanding of the ESO Study, we and ESO share the view that the relevant National Policy Statements offer policy support for such forms of development, with mitigation such as careful routeing and underground cables where necessary (as is covered further in Section 6).

2.1.9 We agree with the overall conclusion of the ESO Study that the "options assessed within this study come with critical trade-offs to be made" and that "there is no single option that minimises impacts across all the metrics". The ESO's conclusions against the four criteria are reproduced below, alongside NGET's commentary. Where relevant, NGET's views are given in further detail later in this report.

Table 2.2 – ESO Study outcomes

ESO outcome	Summary of NGET observations
Economic	
"*Our economic analysis compares the cost of moving power around the system posed by each option compared to its capital cost. The capital cost and the cost of managing a lack of capacity in the system is borne by bill payers.* *When combined with overall system impact, the onshore option ranks highest as it is deliverable earlier (in 2030), however if a later delivery of 2034 is assumed then the undergrounded HVDC option as well as hybrid onshore and offshore options are comparable in ranking.* *The options under assessment have been benchmarked against European (Scottish and equivalent schemes in Great Britain). The offshore options utilising HVDC technology and onshore AC technology are within the price range that we would expect. Further information on this benchmarkng and additional economic sensitivities undertaken can be found in our appendix."*	The economic analysis in the ESO Study shows that Option 3 – the current Norwich to Tilbury project with the addition of a new Friston to EACN substation line – would be the economically optimal solution if OCSS coordination between Sea Link and the two offshore wind farms progresses. This is the case in the event of: • delay up to as late as 2033; • across a range of generation and demand scenarios in addition to the core Leading the Way scenario used to determine the economic ranking; and • Capex or constraint costs are reduced or increased. The delay sensitivity demonstrates that any of the options, if assumed to be delivered in 2034, would result in at least £962m additional costs to consumers, relative to delivering Option 3 in 2030.
Environment and Community	
"In general, all options under assessment face environmental constraints. Some of the offshore circuits present more challenges due to the complexity of the marine environment. Bradwell is particularly environmentally challenging as a landing point for offshore cables compared with other landing points within the study. This is because Bradwell has more overlapping sites of international designation than other proposed landing points. *Typically, more communities are impacted by onshore network configurations within this assessment than offshore options. To reflect the sentiment when engaging with local elected officials, we have scored each option against community sentiment, reflecting*	The accompanying East Anglia Onshore and Offshore Cable Routing Environment and Community Appraisal follows the Holistic Network Design (HND) Methodology. The appraisal identifies the environmental risks within large study areas for the options. The offshore options are assigned a 'red' BRAG environment rating reflecting the large number of significant, overlapping receptors that these options would interface with. Option 3 is assigned an 'amber' rating reflecting the fact it is less constrained than offshore options from an environmental perspective. The ESO Study identifies the consenting risks associated with converter stations for some of the options using HVDC technology. We support the principle that any assessment of the environment and community impacts

that our community metric is high level and uses geo-spatial data. Most of the network options result in areas with a concentration of infrastructure (substation, converter station and associated overhead lines or underground cabling) at key proposed nodes along the coast. This is likely to have significant cumulative impact in these areas."	would need to address the risks converter stations may pose to community receptors such as National Landscapes and settlements. It is not entirely clear whether all aspects of the potential infrastructure required for each option have been considered when assigning the environmental and community BRAG ratings in the East Anglia Onshore and Offshore Cable Routing Environment and Community Appraisal. Based on the narrative included within the community appraisal, it appears that the presence of the settlement of Ipswich, as well as other smaller settlements, is the reason for the 'red' BRAG community rating for Option 3. In response, we point to the potential routeing and other mitigation options that can be considered to reduce risks to these receptors. The community sentiment aspect of the appraisal reported in the ESO Study does not form part of the HND methodology. NGET is committed to taking into account community feedback on its proposals. In line with processes and guidance from the Planning Act 2008 and National Policy Statements, stakeholders and the public are consulted during the proposed project's evolution allowing for feedback to have influence in the development of the location, design and mitigation proposals of our schemes.
Deliverability	
While all technology faces supply chain issues, HVDC circuits face supply chain issues due to limited suppliers and global demand for this technology. This means that options with multiple offshore HVDC circuits are more challenging to deliver. *NGET note: Onshore options 3 and 4 are rated as 'red' for consenting, which results in overall red rating for deliverability.*	Generally, we concur with the deliverability challenges identified for all options. The distinctions made in the 'consenting' sub-criterion appear to be driven by factors such as concentration of infrastructure in addition to what is already planned and the potential impact of the EACN substation on the Dedham Vale National Landscape. Whilst we consider that all options would have impacts, none present in-principle environmental issues that could not be mitigated with careful consideration of routeing and use of appropriate technologies to specific constraints, as is consistent with the National Policy Statements (NPSs) against which proposals for nationally significant infrastructure projects are assessed.

3. Power system methodology

3.1 Overall methodology

3.1.1 The Holistic Assessment assumes that all offshore generators connect at contracted locations with the exception of the OCSS generators, North Falls and Five Estuaries, which connect to Sea Link. Interconnectors have been modelled both at their contracted connection sites and at other locations as sensitivities. As noted above, NGET's needs cases currently reflect the contracted position and would take account of any changes resulting from the OCSS process as and when they are contractually adopted through its back check and review process.

3.1.2 The ESO Study focusses on the East Anglia region and has sought to address the capacity short falls in the region set out in both the NGET Need Case and the Norwich to Tilbury 2024 Strategic Options Backcheck and Review (2024 SOBR). In particular, additional capability needs across the EC5 and EC5N boundaries, and out of the Sizewell Generation Group, have been considered. Sea Link also provides capability to the network in Kent. We note that the terms of reference for the ESO Study do not include a full assessment of the OCSS proposed scheme on these requirements and we recognise that a full assessment of the requirements in Kent will be required if the OCSS proposals are progressed.

3.2 The ESO's views on other onshore reinforcements

3.2.1 We agree with the ESO's confirmation that the Bramford to Twinstead (BTNO) project is essential under all scenarios to the East Anglia network and will, in its current form submitted to the Planning Inspectorate for development consent, deliver the essential capacity the system requires to accommodate imminent generation connections.

3.2.2 In comparison to the current East Anglia needs case, to maintain compliance with NETS (National Electricity Transmission System) generation connection criteria, in Option 3 an extra circuit between Friston and EACN substation would be required in addition to the current Norwich to Tilbury proposals. All other options considered in the ESO Study (with the exception of Option 9) include an additional onshore or offshore circuit from Friston to resolve the generation connection criteria of the NETS SQSS (Security and Quality of Supply Standards) which is a transmission licence requirement and cannot be breached.

3.2.3 As noted above, we recognise that the ESO Study's focus is on the East Anglia region and the impact of the OCSS scheme proposals on Kent, and the interaction of the proposals with the second Transitional Centralised Strategic Network Plan (tCSNP2) schemes that affect Kent. We recognise that a full assessment of the requirements in Kent will be required if the OCSS proposals are progressed.

3.3 Comparability of AC and DC options

3.3.1 NGET has factored in the advantages and disadvantages of HVDC and AC solutions. Some of the advantages of HVDC systems relate to their controllability, which may support increased boundary flows. We have reviewed the comparison between HVDC

and an AC solution with no power flow control or voltage support. The power flow control and voltage support can be achieved on an AC system at much lower cost than the HVDC solution and would improve boundary uplift to reduce constraints costs.

3.3.2 AC options are also potentially more adaptable to varying future scenarios than HVDC options, given the expense of HVDC cable systems.

3.3.3 HVDC solutions are typically available in multiples of 2GW (or 1.4GW) capacity, meaning that, were the required boundary transfer to increase beyond the need anticipated, there would be significant additional costs to build an HVDC solution with equivalent capacity to a 6930MW overhead line (i.e. an additional one or two 2GW or 1.4GW cables with associated converter stations).

3.3.4 Making future demand or generation connections could require the ability for an HVDC connection to be multi-terminal with new switching and converter station requirements to make a connection. An AC solution is more adaptable to future connections as it only requires the establishment of a new substation to accommodate future demand or generation connections.

3.3.5 Conversely, in scenarios where generation is reduced, HVDC cable solutions could result in overinvestment, whereas the 6930MW capacity of AC overhead lines gives the ability to economically connect both the contracted background and reduced generation capacity.

3.3.6 The economic analysis discussed in Section 5 shows that Option 3 is the optimal option in three of the four generation backgrounds in the Future Energy Scenarios – including the core Leading the Way scenario – and remains so in the sensitivity test increasing constraint costs by 40% (indicative of higher generation capacity). The sensitivity test on reducing constraint costs by 40% (indicative of lower generation capacity) makes Option 3 optimal in all scenarios.

4. Technology and options assessment

4.1 Technology assessment

4.1.1 The ESO Study assesses the same transmission technologies described within the Norwich to Tilbury 2024 SOBR, with the exception of Gas Insulated Lines (GIL). NGET includes GIL technology as it contrasts with cable technology in regard to effects of electrical capacitance, and the impact on the distance that cables can be installed without additional above ground compounds to install switching and reactor stations.

4.1.2 We agree there are technological complications with extensive underground cabling. We note the ESO Study puts the maximum viable underground cable distance at 20km before needing surface infrastructure. GIL has its own complexities and is unproven technology over buried distances greater than a few kms.

4.2 Options assessment

4.2.1 The ESO Study has taken account of five community proposed options and has taken them through a screening assessment process where three of the options have been progressed to the Holistic Assessment stage. The assessment criteria and methodology are different to NGET's and include factors such as constraint costs and the sensitivity of these constraint costs to changes to delivery timescales.

4.2.2 That said, we understand the overall logic used to discount options, given the constraints placed on the ESO Study from OCSS (for example, the exclusion of multi-purpose interconnectors and connection locations of customers outside the scope of OCSS).

4.2.3 The two options excluded from the ESO's assessment were:

- Two or more multi-purpose interconnectors (MPIs) with wind farms connecting into them, utilising Bradwell in Essex as an onshore interface point as well as areas in Kent; and
- An offshore ring main, connecting all wind farms around the coast of the region, utilising brownfield sites for onshore interface points, such as Bradwell and areas in Kent.

4.2.4 In both cases, two reasons were cited for excluding these options:

1) the proposals were outside the Study's Terms of Reference; and

2) the proposals would require a change in connection location for non-OCSS projects.

In the case of the offshore ring main, the option was also found not to be technically feasible in the timescales the capacity is needed.

4.2.5 The *DNV Independent Report on Network Topology Assessment*[2] published alongside the ESO Study expresses concerns over the readiness of the multi-terminal HVDC technology that would be needed for the offshore ring main option. This is because the

[2] https://www.nationalgrideso.com/document/304491/download

HVDC circuit breaker technology required to connect links together at capabilities greater 1.8GW is still in development.

4.2.6 The DNV report states that:

"there is uncertainty as to when the first products will become commercially available for transmission networks, with estimates ranging from mid 2030s to post 2040" (p.66).

5. Economic analysis

5.1 Constraint costs

5.1.1 Appendix 2 of the ESO Study notes that:

"In two of the net-zero scenarios (LtW and CT), the onshore HVDC (option 8) performs most effectively at reducing constraint costs. In two of the net-zero scenarios (ST and FS), the onshore option (option 3) performs most effectively."

5.1.2 Table 6 of Appendix 2 of the ESO Study, showing constraint costs across options and Future Energy Scenarios (FES), is reproduced below:

Constraint costs relative to best option per scenario	FES Scenario			
	Leading the Way	Consumer Transformation	System Transformation	Falling Short
Option 1	£1,642m	£3,177m	£1,378m	£1,041m
Option 2	£2,148m	£4,234m	£1,787m	£1,584m
Option 3	£0,569m	£1,832m	£0	£0
Option 4	£2,856m	£6,136m	£1,020m	£2,106m
Option 5	£11,263m	£16,275m	£11,593m	£8,633m
Option 5b	£2,346m	£5,324m	£1,865m	£1,361m
Option 6	£0,526m	£1,852m	£1,093m	£0,708m
Option 7	£0,759m	£1,644m	£1,232m	£0,404m
Option 8	£0	£0	£0,909m	£0,216m
Option 9	£7,784m	£12,083m	£3,004m	£7,095m

Table 6: Constraint costs associated with each option, under the FES scenarios

5.1.3 Option 8 results in the overall lowest constraint savings in Leading the Way and Consumer Transformation, despite delivery in 2034 (vs. 2030 for Option 3). We have reviewed the comparison between HVDC and an AC solution with no power flow control or voltage support. It is possible that the greater uplift potentially provided by AC options with additional power flow or voltage support would result in greater constraint savings in these scenarios.

5.2 Lifetime cost assessment

5.2.1 The lifetime cost assessment in the ESO Study compares the capital costs of each option with the constraint costs across the FES. Appendix 2 of the ESO Study notes that:

"In three FES scenarios (LW, ST and FS) Option 3 - Onshore option, has the lowest overall cost to consumer. In one scenario (CT), Option 8 – Onshore HVDC option performs best being £300 million better than Option 3."

5.2.2 Table 7 of Appendix 2 is reproduced below:

Total additional cost compared to the best option, per scenario	FES Scenario			
	Leading the Way	Consumer Transformation	System Transformation	Falling Short
Option 1	£4,211m	£4,785m	£4,517m	£4,180m
Option 2	£4,832m	£5,956m	£5,040m	£4,837m
Option 3	£0m	£301m	£0m	£0m
Option 4	£2,037m	£4,356m	£771m	£1,857m
Option 5	£10,340m	£14,389m	£11,239m	£8,278m
Option 5b	£1,422m	£3,439m	£1,510m	£1,006m
Option 6	£1,672m	£2,037m	£2,809m	£2,423m
Option 7	£1,794m	£1,718m	£2,836m	£2,009m
Option 8	£962m	£0m	£2,439m	£1,747m
Option 9	£8,981m	£12,318m	£4,771m	£8,862m

Table 7: Cost Benefit Analysis of each option, per FES scenario

5.2.3 The ESO Study uses the costs under the Leading the Way FES to conclude that Option 3 – analogous to the current Norwich to Tilbury project with an additional Friston to EACN substation route – is the "cheapest over its lifetime compared to all other options if delivered in 2030", noting that "it has a relatively low capital cost, and is efficient at mitigating constraints from 2030". The next best option (Option 8) has additional costs to consumers of £962m relative to Option 3.

5.2.4 Furthermore, on a 'least worst regrets' basis, the case for Option 3 relative to other options is strengthened: the worst regret of Option 3 being £301m (in Consumer Transformation FES), compared to £2,439m (in System Transformation) for Option 8. Option 8 has relatively high regret in all scenarios other than Consumer Transformation, whereas Option 3 has no regret in any scenario other than Consumer Transformation, making Option 3 a lower regret option in the round (i.e. likely to lead to greater consumer benefits across a broader range of future generation and demand scenarios). As noted in Section 3, this may suggest that AC options are more adaptable to varying future scenarios than HVDC options.

5.3 Delay sensitivity

5.3.1 Appendix 2 of the ESO Study explains that:

"We [the ESO] *have also undertaken a sensitivity on delay for the build of the onshore part of* the *network (as this is the part originally scheduled in 2030), with the capacity instead being delivered in 2032, 2033 or 2034. The last date aligns with when an 'offshore network' is expected to be able to be built. The table shows the results for Leading the Way."*

5.3.2 Table 8 of Appendix 2, showing the delay sensitivity test, is reproduced below:

Total additional cost compared to the chepest overall (Option 3 in 2030)	2030	2032	2033	2034
Option 1	Not delivered	Not delivered	Not delivered	£4,211m
Option 2	Not delivered	Not delivered	Not delivered	£4,832m
Option 3	£0m	£246 m	£781m	£1,643m
Option 4	£2,037	£2,206m	£2,741m	£3,587m
Option 5	Not delivered	Not delivered	Not delivered	£10,340m
Option 5b	Not delivered	Not delivered	Not delivered	£1,422m
Option 6	£1,672	£1,723m	£1,733m	£2,131m
Option 7	Not delivered	Not delivered	Not delivered	£1,794m
Option 8	Not delivered	Not delivered	Not delivered	£962m
Option 9	Not delivered	Not delivered	Not delivered	£8,981m

Table 8: Impact of delaying the delivery date for some options.

5.3.3 Appendix 2 states that:

"Option 3 and Option 4 are the two options with substantive delivery date of 2030. Therefore, they have a delay cost associated with delivering them in 2032, 2033 or 2034. Option 6 is delivered in total in 2034, but there are onshore elements in the hybrid design that are delivered from 2030 onwards so delay over time is shown. As discussed in the report Option *8 becomes the overall cheapest option if everything is delivered in 2034, with a number of options (Options 3, 5b, 6 and 7) also having comparable lifetime costs."*

5.3.4 This demonstrates that, in the Leading the Way scenario, Option 3 would remain the optimal option if delayed as late as 2033.

5.3.5 It is also important to note that this delay sensitivity demonstrates that any of the options, if assumed to be delivered in 2034, would result in at least £962m of additional costs to consumers (i.e. the economic analysis does not support delay of delivery to 2034).

5.3.6 Only the Leading the Way scenario is used in the delay sensitivity, and Appendix 2 therefore does not show a similar sensitivity test for other FES. However, given the constraint costs given in Table 6 above – which shows Option 3 is the overall best option in constraint relief in both System Transformation and Falling Short scenarios – it would be likely that delivery in 2034 (or later) could still be optimal against more costly 2034 offshore solutions.

5.3.7 The ESO Study tests delay of the onshore options with delivery dates before 2034 but does not test delay of those assumed to be delivered in 2034. The ESO recognises that the delivery of multiple HVDC circuits might be at risk of delay. For example, in the case of Option 8, the ESO Study rates 'Deliverability & Operability' as 'red' with the following explanation:

"Challenging delivery with multiple HVDC circuits. Limited suppliers of HVDC and known supply chain delays*. A solution of this nature and scale has never been delivered in Great Britain which increases the risk."*

5.3.8 We also note that the ESO analysis, given the conceptual nature of the options, has not assessed the deliverability and cost issues potentially caused by any crossings of waterways and transport routes or challenging ground conditions. These would be expected to have a disproportionate impact on cable design and cost, relative to predominantly overhead line solutions.

5.3.9 Delay to the 2034 offshore options might therefore be considered as likely, or even more likely, than delay to conventional onshore solutions. This delay would be expected to cause similarly large additional annual constraint costs. It is important to note that a 2034 date would only notionally be achievable by beginning development work immediately. The delivery dates for these options would be delayed further if the OCSS process concludes later.

5.4 Other sensitivities

5.4.1 The sensitivity test of a 20% increase in capex costs of all options (Table 9 of Appendix 2) shows that Option 3, given its lower capex cost relative to Option 8 and other 2034 options, would be optimal across all scenarios. The sensitivity testing reduction of capex costs by 20% (Table 10 of Appendix 2) shows that Option 3 is still optimal across three of the four scenarios, including the core Leading the Way scenario. However, regret in Consumer Transformation increases to £608m from £301m.

5.4.2 Tables 11 and 12 test increases and decreases of 40% in the cost of constraints. Where constraint costs are increased, Option 3 is still optimal across three of the four scenarios, including the core Leading the Way scenario, but with greater regret (£1,034m) in Consumer Transformation. A decrease of 40% makes Option 3 optimal across all scenarios.

5.4.3 Finally, Table 13 sets out a sensitivity where:

"the demand in the region is increased by 2 GW to model something like a large new data centre, or gigafactory. The hypothesis being that more demand locally may change the balance for which option is preferred."

5.4.4 In this sensitivity, Option 3 is still optimal across three of the four scenarios, including the core Leading the Way scenario, but with slightly greater regret (£424m) in Consumer Transformation. Notably, Option 8 has greater regret in the Leading the Way scenario than in the main results (£1,531m vs. £962m).

5.5 Capital costs

5.5.1 The ESO Study uses a different method to NGET's for including capital and lifetime costs in overall scheme costs, as set out in the Norwich to Tilbury 2024 SOBR. Whereas the ESO uses ratios, we use a unit cost calculation. While we do not disagree with the broad terms of the ratios set out, in our view the NGET assessment provides more accuracy across a range of transmission technologies and ratings required.

5.5.2 We believe that the ESO Study's methodology is likely to understate capex costs across all options, and possibly to a somewhat greater extent for HVDC options than onshore AC options. Recent manufacturer engagements have shown that the ESO reported costs are likely to be much lower than achievable in the market in the foreseeable future, particularly for HVDC equipment.

5.5.3 The appendix to the ESO Study states:

"The costs included within this Study are for indicative purposes only. They provide a high-level indication of the costs associated with delivering the network infrastructure, based on principles and assumptions of the level of functionality required. This is particularly the case for the community options (Option 8 and 9) which were late additions to development of this Study. It is important to advise, these costs have not been derived *from any detailed assessments, and we understand from the National Grid Electricity Transmission that these costs are likely to underestimate the full deliverable costs of schemes, especially those involving HVDC converter stations - given the complexity of the global market. If any scheme was to be taken forward, from the current high-level design included within the Study into more detailed design, the costs would all be subject to detailed revision".*

5.5.4 We support the view that, should the OCSS scheme be progressed, a more rigorous costing assessment would be required before a conclusion on the preferred option could be reached.

5.6 Summary of NGET views on economic analysis

5.6.1 Overall, the economic analysis in the ESO Study shows that Option 3 – the current Norwich to Tilbury project with the addition of a new Friston to EACN line – would be the economically optimal solution if OCSS coordination between Sea Link and the two offshore wind farms progresses. This is the case in the event of:

- delay up to as late as 2033;
- across a range of generation and demand scenarios in addition to the core Leading the Way scenario used to determine the economic ranking; and
- capex or constraint costs are reduced or increased.

5.6.2 It is also important to note that the delay sensitivity demonstrates that any of the options, if assumed to deliver in 2034, would result in at least £962m additional costs to consumers, relative to delivering Option 3 in 2030.

6. Environment and community

6.1 Introduction

6.1.1 The East Anglia Onshore and Offshore Cable Routing Environmental and Community Appraisal (Jacobs, March 2024) informs the ESO Study and presents the potential environment and community constraints that may be encountered when developing the options.

6.1.2 The Jacob's report considers onshore, offshore and landfall aspects of each option within a series of high-level study areas. The individual appraisal of each subcomponent of an option within the Jacobs report (e.g. Friston to Tilbury (HVDC onshore), Bramford to EACN substation (HVDC onshore)) is then combined to provide an overall environmental and community appraisal ranking in the ESO Study for each option. The appraisal is undertaken in accordance with the HND methodology and is a strategic-level appraisal determining the level of risk and constraint the environment and community receptors would present to the further development of an option. Application of this methodology identifies high-level risks and whether avoidance or a reduced level of interaction with receptors may be possible recognising that more detailed routeing and design work (with mitigation as necessary) would be required. Whilst we recognise the strategic nature of the ESO Study, the basis for some outputs of the appraisals, and whether all required infrastructure has been considered in the appraisal of the offshore options, is not entirely clear.

6.2 Environmental appraisal

6.2.1 Option 3 is assigned an overall ‘amber’ environmental BRAG rating which the ESO Study defines as *“Moderately constrained Option. Likely viable however, may have to overcome some environmental issues”.* This conclusion reflects the fact that whilst the option may have impacts, none would present in-principle environmental issues that could not be mitigated with careful consideration of routeing and development of specific mitigation measures as is consistent with the National Policy Statements (NPSs) against which proposals for nationally significant infrastructure projects are assessed. We note that ESO Option 3 is the closest to NGET's current N-T proposals but that it is not a direct comparison for several reasons. Specifically, in terms of the description of likely development and the analysis of likely consequential environmental effects. For example, Option 3 includes significantly more overhead line (some 50km - Friston to EACN substation). This and other differences (for example in the collection of baseline data on potential sensitive receptors) may be a significant factor in the Amber rating.

6.2.2 The environmental appraisal in the Jacobs report (and the summary within the ESO Study) also highlights the significant risks associated with the offshore options, particularly Option 9 that utilises Bradwell as a landing point, owing to the presence of multiple, overlapping constraints such as Special Areas of Conservation, Special Protection Areas and Ramsar sites. Other options that include offshore components also have similar challenges, with any options requiring an HVDC connection from Norwich to Grain or Tilbury for example, being heavily constrained both on and offshore. These option components are assigned a ‘red’ BRAG rating in part due to the

fact that an offshore option would pose greater environmental risks than an onshore option given that many European and nationally designated sites are unlikely to be avoidable. In addition, because there is no reference to converter stations in the environmental appraisal results in the Jacobs Report, it is not entirely clear to what extent the converter station infrastructure has been considered within the environment appraisal and therefore whether this risk has been fully captured by the appraisal in respect of all HVDC options.

6.3 Community appraisal

6.3.1 The community appraisal ranking for Option 3 is red which is defined as: *"Heavily constrained Option. Potentially viable however, will have to overcome many social/community issues".* This BRAG rating appears to be driven by the Bramford to EACN substation overhead line subcomponent and specifically the residual risks to major settlements and small scale settlements. The appraisal cites the potential changes to visual amenity in Ipswich and wider changes to visual amenity in small-scale settlements as the reason. NGET has taken into account the potential routeing and other mitigation options that can be considered to reduce risks to these receptors.

6.3.2 Whilst the appraisal of offshore and HVDC technology options addresses the risks associated with the cable components both on and offshore as well as the landfall infrastructure which is assumed to be referring to transition joint bays, the environment and community appraisals within the Jacobs report do not specifically make reference to the converter stations and their potential effects. In view of the scale and the number of converter stations that may be required for some options, it is not entirely clear whether the full extent of the risks associated with the HVDC technology options has been presented. For example, siting a converter station in the vicinity of Friston, over and above what is already planned, may be challenging in view of the Suffolk Coast and Heaths National Landscape. The community appraisal presented on page 231 of the Jacobs report, which appraises an HVDC offshore reinforcement between Friston in Suffolk and Sellindge in Kent, acknowledges the presence of two National Landscapes (one in the northern section and one in the southern section). The narrative suggests that the northern extent of the project is not severely constrained as there is opportunity for avoidance through the routeing process or undergrounding. However, the narrative acknowledges the potentially greater challenges in the southern section of the study area, making reference to appropriate routeing as mitigation. Whilst this may be appropriate for the required cabling, it does not appear to consider the potential risks of converter station siting.

6.3.3 Some of the options such as Option 4 (Alternative onshore option – variation without Bramford to EACN substation) would require a converter station at Friston, as well as a new AC onshore circuit and, therefore, a concentration of further new infrastructure at Friston. The community appraisal for Option 8 within the Jacobs report concludes an 'amber' BRAG rating for the Bramford to EACN substation HVDC onshore, a 'green' BRAG rating for the Friston to Tilbury HVDC onshore and a 'green' BRAG rating for Norwich to Bramford HVDC onshore components. The community appraisal for Option 8 does not make reference in the accompanying narrative to the converter station infrastructure and so it is not entirely clear if this has been explicitly considered when undertaking the appraisal and assigning these ratings. The ESO Study does acknowledge the presence of the converter stations and the risks they may pose, albeit within the consenting aspect of the appraisal and not the community appraisal where effects on landscapes, heritage assets and settlements (communities) should be considered within the methodology.

6.4 Community sentiment

6.4.1 Within the ESO Study, community sentiment is appraised for each option. This is not a part of the Jacobs report, reflecting the fact that this is not an aspect of the HND environment and community methodology. The conclusions of the ESO Study appear to merge the results of the community appraisal following the HND methodology and the community sentiment results.

6.4.2 Given the differing geographical locations of alternative options to the current Norwich to Tilbury proposals forming Option 3, it is not entirely clear from the ESO Study if or how the probable sentiment of the communities local to the other options has been taken into account. It is also not clear how the sentiment of potentially affected communities has been assessed by the ESO and the numbers that have been engaged with to determine an appraisal score nor what bearing the community sentiment ratings are expected to have on options appraisal. NGET is committed to taking into account community feedback on its proposals. In line with processes and guidance from the Planning Act 2008 and National Policy Statements, stakeholders and the public are consulted during the proposed project's evolution allowing for feedback to have influence in the development of the location, design and mitigation proposals of our schemes.

7. Deliverability

7.1.1 The ESO Study identified deliverability challenges for all options and highlighted the challenges particular to HVDC as follows:

"While all technology faces supply chain issues, HVDC circuits face supply chain issues due to limited suppliers and global demand for this technology. This means that options with multiple offshore HVDC circuits are more *challenging to deliver."*

7.1.2 The ESO has made its own distinctions in the 'consenting' sub-criterion, which drive overall 'red' ratings for Deliverability for onshore Options 3 and 4 (and hybrid Option 6). This appears to be driven by factors such as concentration of infrastructure such as at Friston, and the potential impact on the EACN substation and the Dedham Vale. We have addressed these and other considerations of deliverability in the Norwich to Tilbury project documentation which will be the subject of review with all stakeholders.

7.1.3 Alongside the ESO Study's appraisal of the 'red' consenting rating, NGET has reviewed the proposed Norwich to Tilbury project against the National Policy Statements. The ESO Study notes that NPS EN-5 "*states that the UK Government's position is the use of overhead lines as the starting presumption for electricity network development*".

7.1.4 We acknowledge the ESO Study's 'amber' rating for the environmental assessment of these options, which states:

"mitigation such as detailed route planning, should be able to reduce the impact on many of the significant onshore environmental constraints."

7.1.5 In the case of Option 3, the community assessment also states that:

"*undergrounding may need to be considered as a mitigation where avoidance was not possible".*

7.1.6 The NPSs for energy infrastructure set out a critical national priority (CNP) for the provision of nationally significant low carbon infrastructure, including all power lines, and associated infrastructure such as substations, within the scope of NPS EN-5. NPS EN-5 states at para. 1.1.5 that "*these are viewed by the government as being CNP infrastructure and should be progressed as quickly as possible*", whilst para. 2.1.6 makes clear that "*the assessment principles outlined in Section 4 of EN-1 continue to apply to CNP infrastructure*" and that "*applicants must show how any likely significant negative effects would be avoided, reduced, mitigated or compensated for, following the mitigation hierarchy*".

7.1.7 Para. 2.9.20 of EN-5 states the following:

"Although it is the government's position that overhead lines should be the strong starting presumption for electricity networks developments in general, this presumption is reversed when proposed developments will cross part of a nationally designated landscape (i.e. National Park, The Broads, or Area of Outstanding Natural Beauty)."

7.1.8 As explained fully in the Norwich to Tilbury 2024 SOBR, whilst we consider that all options would have impacts, none present in-principle environmental issues that could not be mitigated with careful consideration of routeing and use of appropriate

technologies to specific constraints, as is consistent with the NPSs against which proposals for nationally significant infrastructure projects are assessed.

7.1.9 We also consider that the ‘amber’ rating for consenting for predominantly offshore options may understate the complexity involved – relative to onshore options – in consenting converter stations and offshore cables. For example, these options would typically involve additional new onshore infrastructure at coastal locations each with their own set of circumstances and challenges.

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