MULBARTON PARISH COUNCIL

GRID CONNECTIONS

27th June 2020

Introduction

This discussion paper describes a connection scheme for Round 3 offshore wind farms and Round 2 extension projects off the coast of Norfolk. The aim is to show a progression from radial connections towards integrated offshore transmission with no additional delay.

The scheme is based on the findings of the IOTP (East) feasibility study of August 2015 and can be expanded to include the forthcoming Round 4 wind farm projects.

The feasibility study is discussed in more detail in Appendix 1.

Connection scheme

Figure 1 shows the Hornsea Three wind farm connected to the grid at Walpole, and the Norfolk Vanguard and Boreas projects connected at Bramford. The grid connection points reflect the need to bring offshore wind energy into the grid as far to the south as possible.

In this scheme, there could be some environmental impact arising from the installation of an export cable to Walpole, but only one designated route is required in the longer term. At Bramford, several export cables are already in place, or are planned for other projects.

An expansion of grid capacity at both Walpole and Bramford is required for any scheme as there is no other route available to take electricity generated by the Round 3 projects to the main centres of demand in London and the south-east.

Figure 2 shows the additional connections needed for integrated offshore transmission. These additional links allow spare capacity in the export cables to carry power from north to south, avoiding the need for onshore grid reinforcements elsewhere. They also provide alternative routes if an export cable fails, or is interrupted for scheduled maintenance.

Figure 3 shows the Round 2 extension projects for Dudgeon and Sheringham Shoal connected to the grid at Necton. In this scheme the two projects share one export cable, following the same route to Necton as used by the original Dudgeon offshore wind farm.

Some expansion of grid capacity would be required at Necton from the existing level of 400MW for Dudgeon, to 1120MW with the Round 2 extension projects added. This is one quarter of what would be needed to connect Norfolk Vanguard and Boreas at Necton.

Social, economic and environmental impacts

The grid connections shown in the figures minimise negative impacts on the agriculture, tourism, and leisure sectors. Longer term job creation in offshore construction and services is dependent upon the offshore aspects of the projects, and is unchanged. Environmental impacts are minimised by avoiding the need for one new export cable for each project.

Conclusions

This connection scheme shows how integrated offshore transmission can be achieved without any significant delay to existing project timescales. It offers a positive cost benefit analysis outcome, minimises any negative social, economic and environmental impacts, reduces the longer term costs passed on to consumers, and increases energy security.

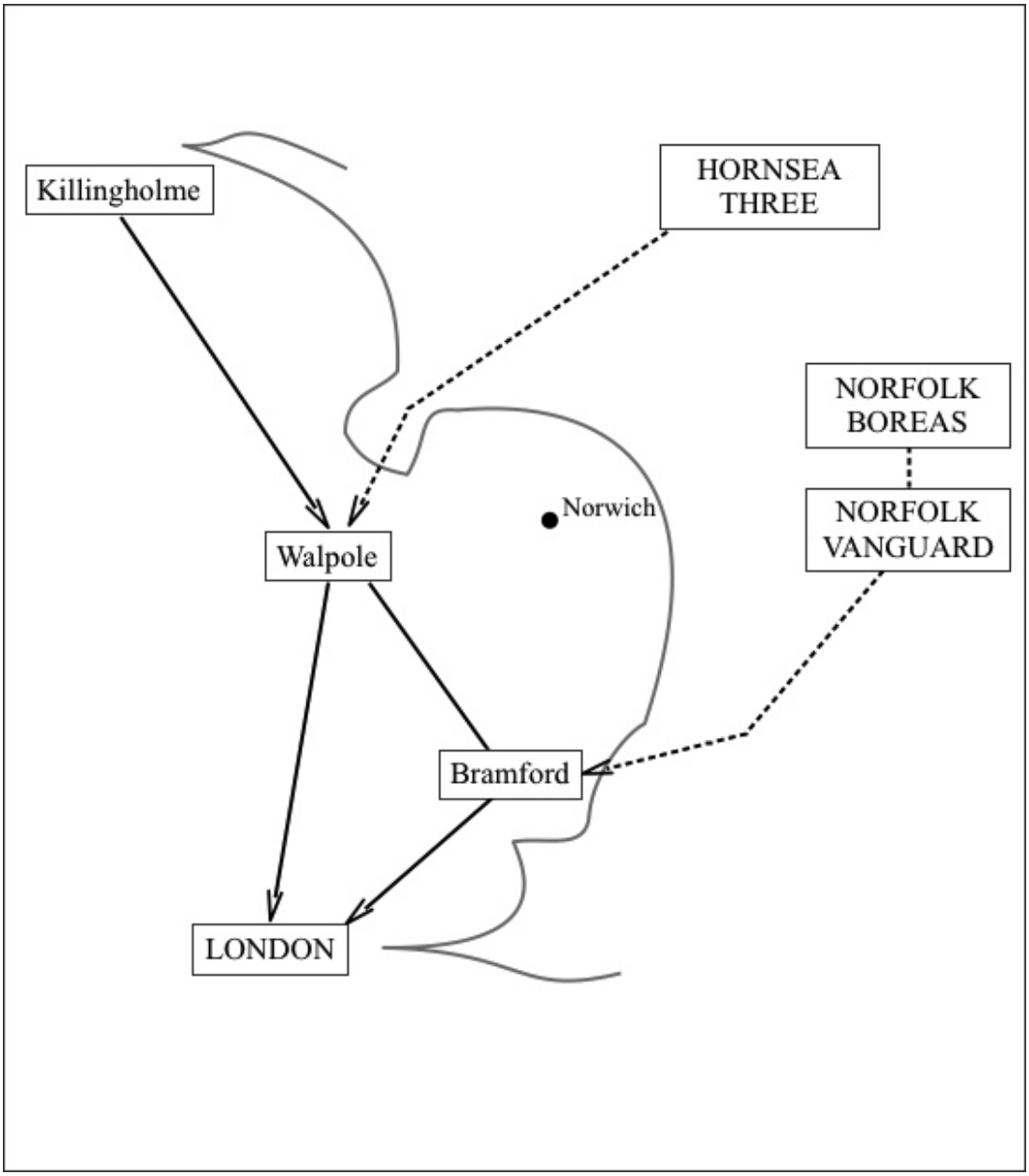


Figure 1: Radial connection of Round 3 projects

Notes:

Initially, radial connections are used to connect the Round 3 wind farms to the main centres of demand in London and the south east. This enables each project to control the construction of its own export cable, minimises financial risk, and avoids any delay to project timescales.

Hornsea Three is connected at Walpole, and the Norfolk Vanguard and Norfolk Boreas projects are connected at Bramford as described in the baseline case of the IOTP (East) feasibility study.

Each wind farm has an export cable large enough to carry its whole output. Because the wind is variable, these cables are used up to an average loading of 50% in winter, and 25% in summer.

Spare capacity in the wind farm export cables cannot be used for other purposes. If either of the two export cables fails, or is interrupted for maintenance, there is no alternative path available.

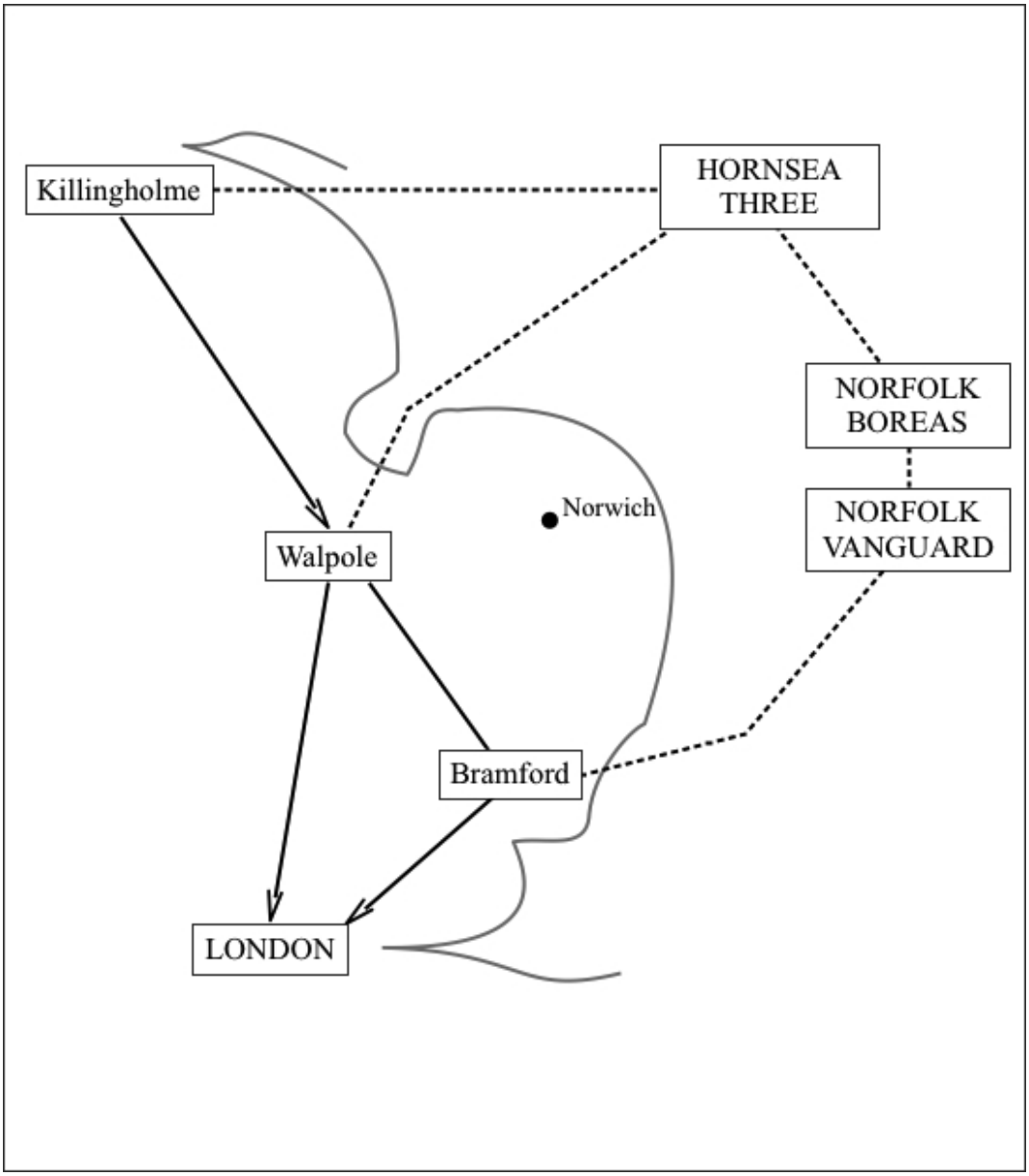


Figure 2: Offshore integration of Round 3 projects

Notes:

The Hornsea Three wind farm shares a connection to Killingholme with Hornsea One and Two. This allows additional power to flow from north to south using spare offshore transmission capacity.

An offshore link is also provided between Hornsea Three, and Norfolk Vanguard and Boreas. The cost of this connection is offset by the savings made in onshore national grid reinforcements, and an increase in the amount of energy transferred over the lifetime of the offshore wind farms.

If one of the export cables fails, or is interrupted for maintenance, there is an alternative route available by using the other export cable. This increases the overall security of energy supply.

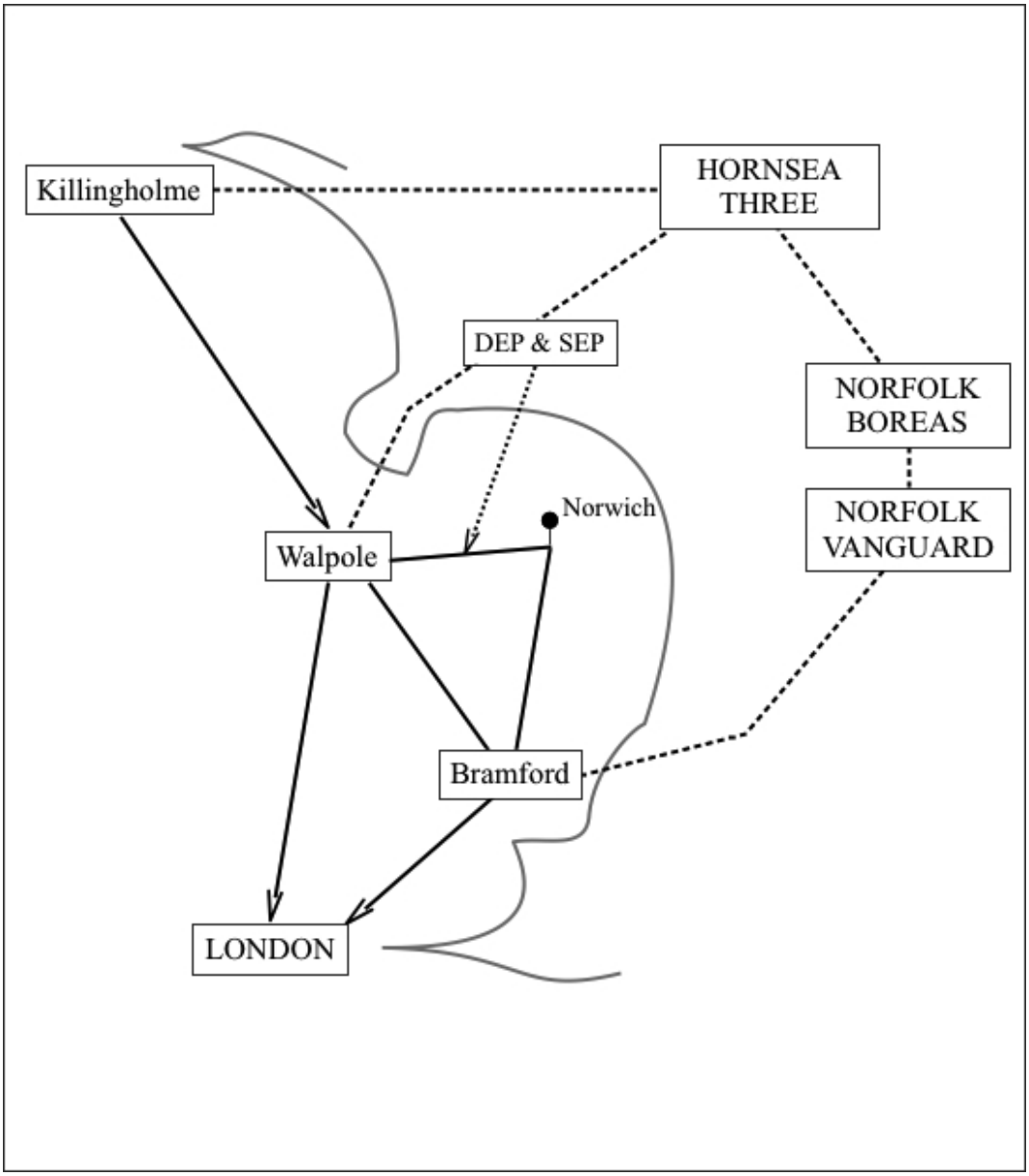


Figure 3: Connection of Round 2 extension projects

Notes:

The Dudgeon and Sheringham Shoal extension projects (DEP & SEP) are connected at Necton with a single export cable, using the same onshore cable route as the existing Dudgeon wind farm.

Because of the smaller scale of these projects, if the shared export cable fails or is interrupted for maintenance, there is only a limited loss of energy supply.

The nominal capacity and grid connection points of the projects shown above are:

Hornsea 3	2.4 GW	Walpole
Norfolk Vanguard & Norfolk Boreas	3.6 GW	Bramford
Dudgeon & Sheringham Shoal extensions	0.7 GW	Necton
Total	6.7 GW	

Appendix 1

IOTP (East) Feasibility Study

Introduction

The feasibility study examined many different schemes for connecting east coast wind farms to the onshore national grid. These were tested against four scenarios, combining two different rates of construction with two different levels of installed capacity.

A detailed cost benefit analysis was carried out using a variety of different methods and the results were further tested against the possibility of project delays or cost increases.

Offshore wind deployment

The levels of installed capacity used in the feasibility study were 10GW and 17.2GW. The study concluded that integrated offshore transmission is justified, beyond reasonable doubt, by an expected level of installed east coast capacity of 10GW or more.

Table A1 compares the 10GW and 17.2GW levels used in the study with the Round 3 projects currently planned or under construction, and shows that the higher 17.2GW level is being achieved over the next few years. Table A2 shows that the inclusion of smaller east coast projects takes the expected level of deployment to more than 22GW.

Cost benefit analysis

The baseline case used radial export cables from the Hornsea and East Anglia zones to Walpole and Bramford without offshore integration. Onshore grid reinforcements of £870m were found to be required to make the baseline case operationally feasible.

All of the integrated transmission alternatives studied resulted in superior cost benefit analysis outcomes when compared to the baseline case of radial export connections only.

In the study, no Round 3 projects were connected to either Necton or Swardeston, as this would produce a less satisfactory cost benefit result than the radial baseline case.

Network design

A common feature of the integrated network designs studied is the additional offshore link between the Hornsea and East Anglia zones. This is illustrated in Figure A1 below.

More detailed examples of the recommended network design can be found within the feasibility study. Design 5b, with its associated cost details, is shown on pages 8 and 9.

Recommendations [1]

The report concludes that offshore integration offers the greatest economic value and reduces the risk of unjustified investments (the ‘least worst regret’ analysis). It also finds that offshore integration with some larger capacity links is the preferred overall approach.

The report makes clear that “In no circumstance does the radial connection design offer economic advantage, even when coupled with a £870m onshore reinforcement package.”

It also recommends that the option of moving towards integrated offshore transmission should be kept open in the design of the initial radial connections. Within the terms of the feasibility study, failing to allow for this option would lead to the worst possible outcome.

1 These recommendations can be found in the IOTP (East) Report, Appendix 3, paragraph 7.2, page 36.

Table A1: Offshore wind deployment levels

	10 GW level	17.2 GW level	Built or planned
Dogger Bank			
Projects 1 to 6	4.0 GW	6.0 GW	
Projects A, B & C			3 x 1.2 GW
Teesside B / Sofia			1.4 GW
Sub-total:	**4.0 GW**	**6.0 GW**	**5.0 GW**
Hornsea			
Project 1	1.0 GW	1.0 GW	1.2 GW
Project 2	1.0 GW	1.0 GW	1.4 GW
Project 3	1.0 GW	1.0 GW	2.4 GW
Project 4		1.0 GW	1.0 GW
Sub-total:	**3.0 GW**	**4.0 GW**	**6.0 GW**
East Anglia			
Projects 1, 3 & 4	3.0 GW	3.6 GW	
Projects 2, 5 & 6		3.6 GW	
Norfolk Boreas			1.8 GW
Norfolk Vanguard			1.8 GW
East Anglia 1, 2 & 3			3.0 GW
Sub-total:	**3.0 GW**	**7.2 GW**	**6.6 GW**
TOTAL:	**10.0 GW**	**17.2 GW**	**17.6 GW**

Table A2: Smaller east coast wind deployments

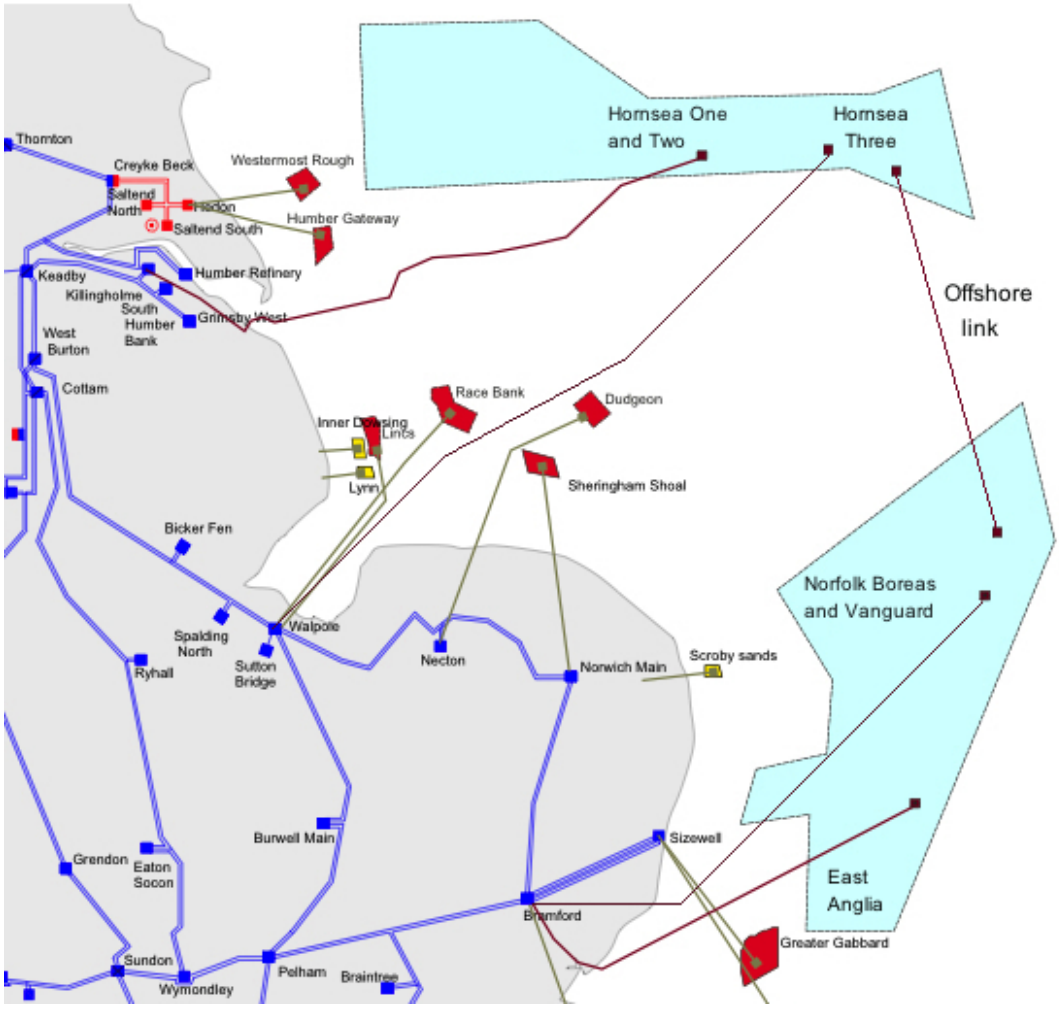
	Built or planned
East Anglia	
Dudgeon and Sheringham Shoal	0.72 GW
Dudgeon and Sheringham Shoal extensions	0.72 GW
Smaller east coast projects (see note below)	3.37 GW
Total:	**4.81 GW**

Note:

Smaller east coast projects include: Westermost Rough (210MW), Humber Gateway (220MW), Triton Knoll (800MW), Lynn and Inner Dowsing (200MW), Lincs (270MW), Race Bank (600MW), Scroby Sands (50MW), Greater Gabbard (500MW), Galloper (350MW), Gunfleet Sands (170MW).

These smaller projects bring the total built or planned east coast deployment up to 22.4GW.

Figure A1: Integrated offshore transmission



Notes:

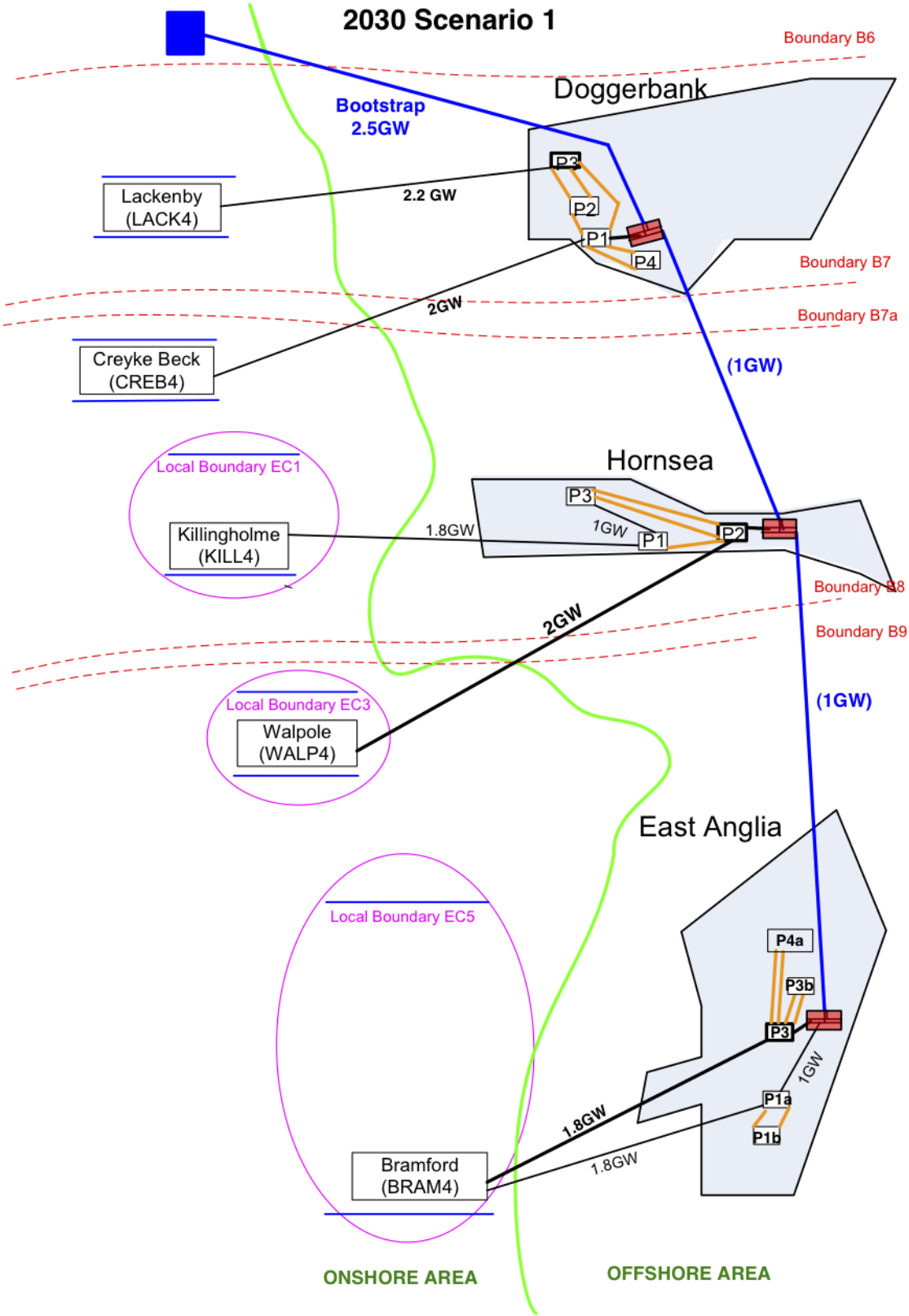
This diagram is reproduced from the latest Electricity Ten Year Statement, Appendix A page A2, *GB Existing Transmission System*, as issued by National Grid ESO in November 2019. It shows the existing export cables from Hornsea One to Killingholme, and from East Anglia to Bramford.

Additions have been made to the diagram to show the proposed Hornsea Three export cable to Walpole, an offshore transmission link between Hornsea Three and Norfolk Boreas and Vanguard, and a shared route for the proposed export cables from Norfolk Boreas and Vanguard to Bramford.

The proposed export cable for the Dudgeon and Sheringham Shoal extensions would follow the existing route from the Dudgeon wind farm to Necton.

The Triton Knoll wind farm and its export cable to Bicker Fen are under construction, but not yet shown on the original diagram.

Design 5b – Offshore 1GW Mesh with 2GW links to Shore



Design 5b – Cost Breakdown

	Radial Cost (£m)	Reinforcement / Integration Cost (£m)	TOTAL
Dogger Bank			
HVDC 2GW radial link at a distance of 212.5km between P1 and CREB4 including cable installation cost and 2GW onshore VSC Converter	967.71		
HVDC 2.2GW radial link at a distance of 222.80km between P3 and LACK4 including cable installation cost and 2.2GW onshore VSC Converter	1069.77		
Two 500MW HVAC Cables at a distance of 41.2km from P3 to P2 including cable installation cost	64.83		
Two 500MW HVAC Cables at a distance of 30.6km from P4 to P1 including cable installation cost	48.15		
300MW HVAC link at a distance of 72.9km from P2 to P1 including installation cost		84.16	
300MW HVAC link at a distance of 28.2km from P1 to P3 including installation cost		32.56	
HVDC 1GW Integrating T-Platform located at Dogger Bank		50	
HVDC 1.2GW at a distance of 120km from Dogger Bank to Hornsea including cable installation cost		171.24	
2.5GW VSC Converter located in Scotland		176.17	
2.5GW HVDC Cable from Scottish Transmission Network to Dogger Bank at a distance of 200km		322.80	
Hornsea			
HVDC 1.8GW radial link at a distance of 150km between P1 and KILL4 including cable installation cost and 1.8GW onshore VSC Converter	852.93		
HVDC 2GW radial link at a distance of 125km between P2 and WALP4 including cable installation cost and 2GW onshore VSC Converter	829.06		
Two 500MW HVAC Cables at a distance of 38km from P3 to P2 including cable installation cost	59.79		
Integration HVDC link at a distance of 64km from P1 to P3 including cable installation cost		89.66	
HVDC 1GW Integrating T-Platform located at Hornsea		50	
HVDC 1.2GW at a distance of 120km from Hornsea to East Anglia including installation cost		168.12	
HVAC 300MWlink at a distance of 27km from P1 to HVDC Integration T-Platform located at P2		31.17	
East Anglia			
HVDC 1.8GW radial link at a distance of 73km between P1(1.2GW) and BRAM4 including cable installation cost and 1.8GW onshore VSC Converter	739		
HVDC 1.8GW radial link at a distance of 140km between P3(1.2GW) and BRAM4 including cable installation cost and 1.8GW onshore VSC Converter	838.13		
Two 300MW HVAC Cables at a distance of 30km from P4a to P3 including cable installation cost	69.27		
HVDC 1GW Integrating T-Platform located at East Anglia		50	
HVDC 1GW link at a distance of 30km from P1 to HVDC Integration T-Platform located at P3		42.03	
TOTAL	**5538.64**	**1258.90**	**6797.53**

MULBARTON PARISH COUNCIL

CUMULATIVE IMPACTS

25th July 2020

Introduction

This contribution addresses the cumulative impacts of the Norfolk Vanguard and Boreas DCO applications in the South Norfolk area.

Grid connections

The IOTP (East) feasibility study of August 2015 has already been introduced into the Vanguard and Boreas examinations, and its main findings need not be repeated here.[1]

The feasibility study considered two levels of offshore wind deployment, set at 10.0GW and 17.2GW. As previously shown, the need to connect the Norfolk Vanguard and Boreas projects, and the increase in the planned output of Hornsea Three, are both distinguishing features of the higher 17.2GW level, and the findings of the study are therefore relevant.[2]

In July 2015, just prior to the finalisation of the IOTP (East) feasibility study report, the development rights for the East Anglia Zone were divided between SPR (Scottish Power Renewables) and Vattenfall. It was agreed between the companies that SPR would take over the grid connection agreements at Bramford, and that Vattenfall would take over the connections at Lowestoft and Bacton, as shown in the IOTP (East) network designs.[3]

Vattenfall were then advised by National Grid that connections at Lowestoft and Bacton would not be possible. An alternative grid connection at Bramford was considered, but not progressed to the point of a firm connection offer. The applicant has not disclosed what capacity was available at Bramford, but it seems reasonable to assume that it would be equal to the planned output of the proposed Sizewell C development, which is 3.2GW.

Offers were made by National Grid, and accepted by Vattenfall, for new connections at Necton in July 2016 for Norfolk Vanguard, and in November 2016 for Norfolk Boreas. This had the effect of displacing both Hornsea Three, and the Dudgeon and Sheringham Shoal extension projects, from Necton to an alternative grid connection point at Swardeston.

The Dudgeon and Sheringham Shoal Extension DCO application is therefore predicated on the assumption that Hornsea Three, Norfolk Vanguard, and Boreas will all be approved. It is now known that Hornsea Three, and Vanguard, were not recommended for approval.

In August 2015, Ørsted acquired SMart Wind and the rights to the Hornsea zone. This included a grid connection agreement of 2.0GW at Walpole, as shown in the IOTP report.[4]

---

1 The report was submitted to the Vanguard examination as EN010079-003084 (REP8-063) on 30th May 2019, and to the Boreas examination as EN010087-001737 (REP5-050), Appendix 4 in February 2020.

2 The five participants in the IOTP (East) feasibility study were: National Grid, Scottish Power Renewables, Vattenfall, SMart Wind – a joint venture of Mainstream Renewable Power and Siemens Project Ventures, and Forewind – a consortium of SSE, RWE, Statoil (now known as Equinor), and Statkraft.

3 Summarised from the Norfolk Vanguard and Boreas document EN10079-002147, *Strategic Approach to Selecting a Grid Connection Point*, and Boreas document EN010087-000712, which contains similar text.

4 See, for example, Design 15c and its associated costings as set out in IOTP (East), Appendix 3, pp63-65.

Ørsted then initiated a 'review' of its pre-existing grid connection agreement for Hornsea Three. National Grid advised Ørsted that the 2.4GW capacity requested was not available at Walpole, or any locations further north, and that Necton was no longer available. In July 2016, National Grid offered a connection of 2.4GW at Swardeston, and this was accepted three months later, in October 2016.[5]

The Dudgeon and Sheringham Shoal extension projects (DEP & SEP) are being jointly developed by Equinor. In April 2019 an offer was made by National Grid for a connection at Swardeston that would accommodate both projects. This was accepted in May 2019.[6]

These developments show that grid connection agreements can, and do, change over time. In the event that the Norfolk Boreas application is not approved, no purpose would be served by bringing the DEP & SEP cables to a new connection point at Swardeston.

Comparison of alternatives

Figure 1 shows a scheme of grid connection based on the IOTP (East) feasibility study.

Hornsea Three is connected to the grid at Walpole with the original capacity of 2.0GW.

Connections for Norfolk Boreas and Norfolk Vanguard are shown at Bramford, in lieu of alternative grid connections at Bacton and Lowestoft. In view of the Secretary of State's recent announcements, it seems likely that these connections are feasible and realistic.

The offshore link between Hornsea Three and Norfolk Boreas takes advantage of the difference in wind speed statistics for the two projects. A link capacity of 0.4GW is sufficient to compensate for the smaller grid connection capacity available at Walpole and Bramford, and can also be used to offset onshore grid reinforcement costs elsewhere.

Figure 2 shows the point-to-point connections presented in the DCO applications as an alternative to the findings of the IOTP (East) analysis. There is no evidence to suggest that anything is gained by adopting this scheme that could outweigh all of its negative impacts.

The IOTP (East) feasibility study addressed these issues in terms of economic impacts, and also considered the effect on overall security of supply, through the integration of the offshore cable network, and the impact of lost generation due to network constraints. In all cases, integrated offshore transmission offered a better result than radial connections.

The study estimated a difference of 0.1GW (0.83 TWh pa) of lost generation between the baseline radial case and integrated transmission. For the point-to-point connections of the separate DCO applications, the volume of lost generation is likely to be even higher. This may be a significant amount, in proportion to the increased size of grid connections sought by the applicants for Norfolk Vanguard, Norfolk Boreas, and Hornsea Three.[7]

It has not been demonstrated within the DCO process, for example, whether the same overall delivery of renewable energy can still be achieved with a connection at Necton, as compared with a somewhat smaller grid connection at Bramford that allows for a degree of offshore integration. The feasibility study suggests that the benefits of offshore integration may outweigh the relatively small difference in the size of the individual grid connections.

5 Summarised from the Hornsea Three documents EN010080-000529, *Site Selection and Consideration of Alternatives*, and EN010080-000562, *Grid Connection and Refinement of the Cable Landfall*.

6 Summarised from the DEP & SEP Scoping Report, October 2017, EN010109-000007, para 73, p27.

7 IOTP (East) Feasibility Study Report, Appendix 3, *Constraint bid volumes*, pp 85-86.

Economic and environmental impacts

The cumulative effect of the changes summarised above is a shift from the underlying principles of the IOTP (East) feasibility study of 2015, to the highly fragmented approach of the several DCO applications now in hand. These cumulative onshore effects need to be weighed, not against the entire benefit of all of the offshore wind farm projects, but against the specific difference between the original and the modified methods of grid connection.

The cumulative impacts arising across North Norfolk from this change of approach have been well described in other representations. The overall economic difference between the two schemes is also relevant. For the higher 17.2GW offshore wind deployment scenario, the maximum economic penalty arising from this change of approach for East Coast wind farm projects, as estimated by National Grid in 2015, is between £7,469m and £8,017m.[8]

Cumulative impacts in South Norfolk

The local impacts of the Hornsea Three scheme in South Norfolk are similar to those identified in North Norfolk, and have been set out in the many representations made to the examination. Typical examples include the choice of high ground for the substation site, an increase of 94% in HGV traffic on a minor road, and large-scale industrial development in a protected landscape zone.

At the close of the Hornsea Three examination, the applicant had not made a decision between AC or DC transmission for the onshore cable system and substations. This in turn leaves open the final size and scale of the onshore substation, and the number of onshore relay stations. This level of design flexibility was accepted by the Examining Authority.

The cumulative impacts of the addition of the Dudgeon and Sheringham Shoal projects will not be estimated or evaluated in detail until a later stage in that examination, and it seems likely that local communities will need to re-state their representations to a further enquiry. In view of the Secretary of State's recent announcements concerning the Norfolk Vanguard and Hornsea Three projects, these representations may have very little effect.

Cumulative impacts, over and above those already identified for Hornsea Three, would therefore arise directly from a decision to approve the present Norfolk Boreas application.

Conclusion

The cumulative effects of the Norfolk Boreas application will be felt across wide areas of the county of Norfolk for many years. These negative impacts surely need to be evaluated, not against the undoubted renewable energy benefits of the overall project, but against the difference between the two available methods of onshore connection. A major factor in the balance is the economic penalty of up to £8,017m embedded within the present approach.

In our view, the case for abandoning the grid connection opportunities at Walpole and Bramford in the interest of a small increase in notional output has not been made, and it is entirely possible that there is no significant difference in the delivery of renewable energy to the main centres of demand. It is difficult to see how the negative economic, social and environmental impacts of the onshore portion of the DCO application can be justified.

Mulbarton Parish Council therefore objects to the entirety of the onshore component of the Norfolk Boreas DCO application as currently presented.

8 IOTP (East) Feasibility Study Report, Appendix 3, *Net present value of the design options*, pp 23-25.

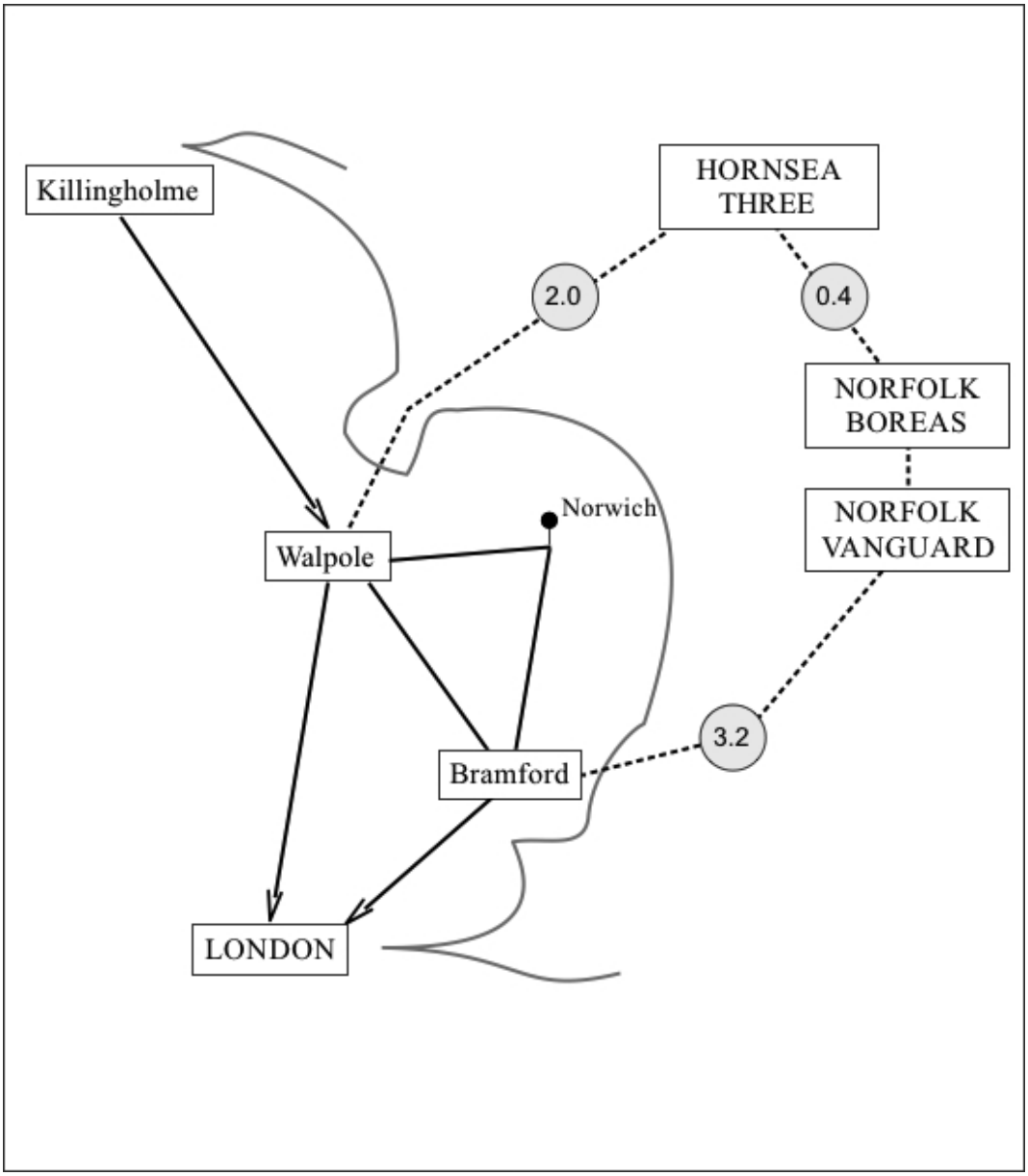


Figure 1: Direct connections

Notes:

The Hornsea Three project is connected to the grid at Walpole, with a capacity of 2.0GW.

The Norfolk Boreas and Vanguard projects are both connected to the grid at Bramford, with a combined capacity of 3.2GW. This is similar to the expected capacity requirement for Sizewell C.

The wind correlation factor between the Hornsea, and Boreas and Vanguard, projects is 64%.[9]

The offshore link has a capacity of at least 0.4GW. As shown in the IOTP (East) feasibility study, a larger link capacity of 1.0GW is likely to be justified by onshore grid reinforcement cost savings.

The Dudgeon and Sheringham Shoal extension projects (not shown above) are both connected at Necton, using a shared export cable with sufficient capacity for their whole output (0.72GW).

9 IOTP (East) Feasibility Study Report, Appendix 3, p12: *ELSI wind generation correlation matrix*.

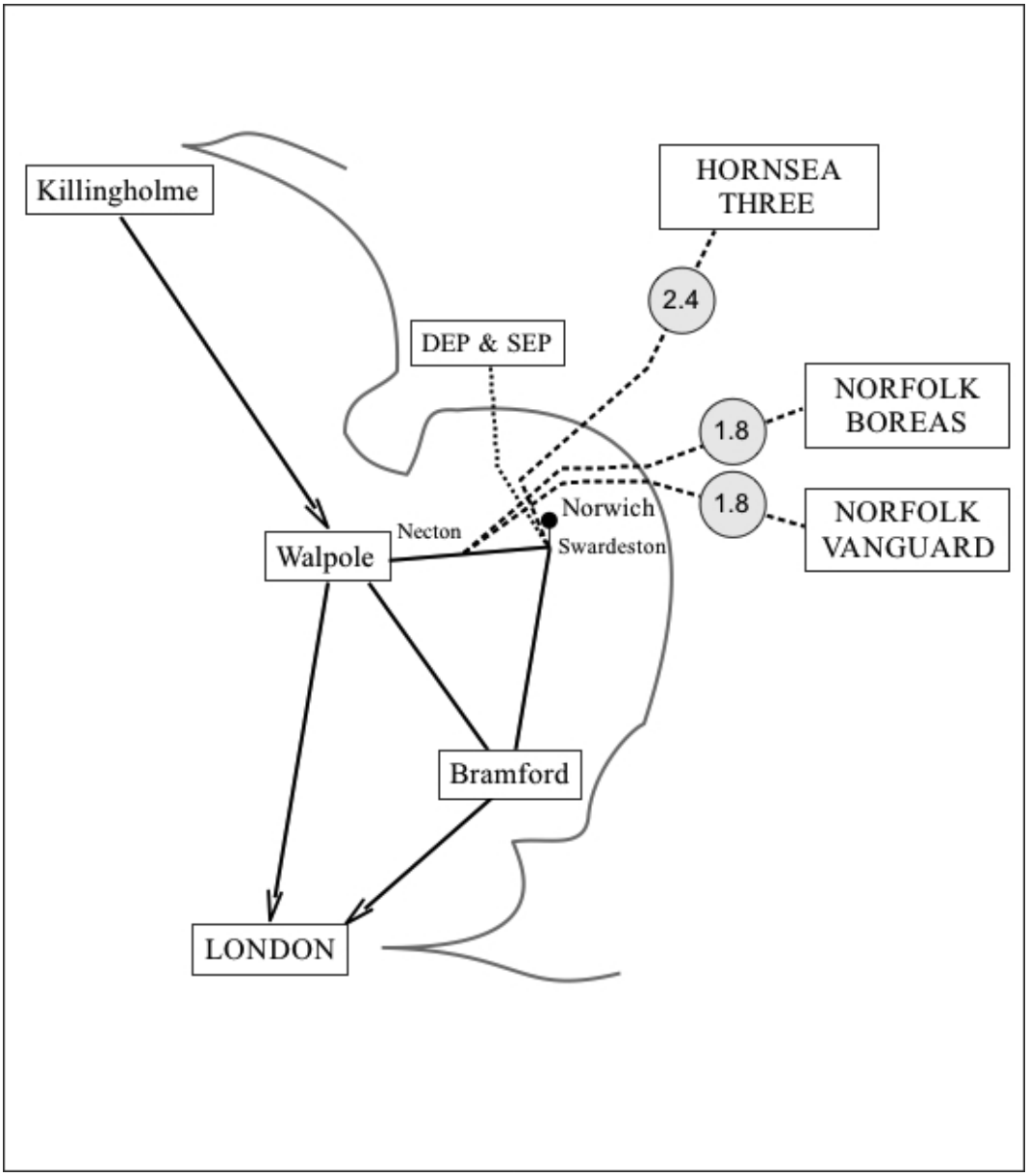


Figure 2: Crossed connections

Notes:

The Norfolk Boreas and Vanguard projects are both connected at Necton, with a combined connection capacity of 3.6GW. The average annual utilisation of the grid connection is 37.4%.[10]

The Hornsea Three project is diverted to Swardeston, with a capacity of 2.4GW, crossing over the cables from Boreas and Vanguard. The average annual utilisation of the connection is 37.1%.

The Dudgeon and Sheringham Shoal extension projects (DEP & SEP) are also diverted, from Necton to Swardeston, and cross over the cables from Norfolk Boreas and Vanguard to Necton.

If an export cable fails, there is no other path available. Due to the choice of grid connection points, an offshore link cable cannot be used to offset grid reinforcement costs elsewhere.

10 IOTP (East) Feasibility Study Report, Appendix 3, p11: *Wind generation load factors and characteristics*.