Client: Suffolk County Council

Project: ScottishPower Renewables East Anglia ONE North and East Anglia TWO Offshore Wind Farms Grid Connection Review

Project number: 105000662

AFRY
ÅF PÖYRY

Disclaimer and Rights

This report has been prepared by AFRY Solutions UK Ltd ("AFRY" or the "Consultant") solely for use by Suffolk County Council and its advisers (the "Recipient"). All other use is strictly prohibited and no other person or entity is permitted to use this report, unless otherwise agreed in writing by Pöyry. By accepting delivery of this report, the Recipient acknowledges and agrees to the terms of this disclaimer.

It is the good faith and belief of AFRY that the estimates and conclusions contained in this report are reliable. However, no representation or warranty is made by AFRY as to the accuracy and completeness of any of the information contained in the report, and nothing in the report is or shall be relied upon as a promise or representation as to the future. Use of the report shall, therefore, be at the user's sole risk.

AFRY expressly disclaims any and all liability arising out of or relating to the use of this report except to the extent that a court of competent jurisdiction shall have determined by final judgment (not subject to further appeal) that any such liability is the result of the wilful misconduct or gross negligence of AFRY. AFRY also hereby disclaims any and all liability for special, economic, incidental, punitive, indirect, or consequential damages. Under no circumstances shall AFRY have any liability relating to the use of this report in excess of the fees actually received by AFRY for the preparation of this report.

All information contained in this report is confidential and intended for the exclusive use of the Recipient. The Recipient may transmit the information contained in this report to its directors, officers, employees or professional advisors provided that such individuals are informed by the Recipient of the confidential nature of this report. All other use is strictly prohibited.

Authors
Peter Bradshaw
Andrew Coakley
Phone
+44 1403 916 265
Mobile
[redacted]
E-mail
andrew.coakley@afry.com

Date
16/11/2020

Project ID
105000625

Client
Suffolk County Council

ScottishPower Renewables East Anglia ONE North and East Anglia TWO Offshore Wind Farms Grid Connection Review

Contents

Report history

Ver.		Checked status	Sign	Approval	Sign
0	Initial release	13/11/2020	PB	13/11/2020	AC
1	Updated after client review	16/11/2020	PB	16/11/2020	AC

1 Introduction

On 25 October 2019, ScottishPower Renewables (SPR) submitted applications to the Planning Inspectorate for Development Consent Orders to construct and operate two new wind farms, East Anglia ONE North (EA1N) and East Anglia TWO (EA2), off the Suffolk coast.

Suffolk County Council (SCC) engaged AFRY to provide technical assistance to inform and support SCC's representations to the Planning Inspectorate in response to SPR's applications, through the review of selected documents from the DCO Application submissions and reporting on their findings.

AFRY was tasked with reviewing the option to combine the two offshore windfarm substations into one unit, and assessing whether the current proposals for an onshore substation, comprising a GIS substation for each of the two offshore wind farms together with an AIS National Grid substation, could be significantly reduced in size and impact from what is currently proposed.

Additionally, commentary was requested on the use of SF_6 as insulating medium in gas-insulated switchgear (GIS). Finally, SCC provided detailed questions, which have been addressed in Appendix A, related to the general areas of review.

2 Connection Infrastructure

The ScottishPower Renewables offshore wind farm developments under consideration are:

- East Anglia ONE North – 800 MW
- East Anglia TWO – 900 MW

These follow on from the 714 MW East Anglia ONE (EA1) offshore wind farm development that is coming on stream in 2020.

The proposal is that these two projects will connect via offshore and onshore cables to a pair of substations adjacent to a new National Grid 400 kV substation to be located approximately 6 km inland from the coast.

Each development will have two offshore/onshore cables which terminate in substations which will consist of:

- GIS switchgear
- Shunt reactors – 2 off
- Interbus transformers – 2 off
- Static compensators – 2 off
- Harmonic filters (if required in the future)
- Associated protection and control systems

The onshore cables route length is approximately 9 km. The offshore cable route lengths are:

- East Anglia TWO – 31 km
- East Anglia ONE North – 36 km

This compares with the East Anglia ONE project where the offshore route was 85 km and the onshore route was 37 km. We therefore expect that the capacity of the compensation

equipment for EA1N and EA2 will be approximately one-third that of the earlier project (although not necessarily one-third the physical size) and is it possible that the individual plot sizes could be less than the 190 m x 190 m stated.

3 Consolidation of Connection Infrastructure at the Friston Site

3.1 National Grid 400 kV Substation

The proposal is a large footprint air-insulated substation (AIS). The combined land area occupied by National Grid and the wind farm substations is:

a) 81,050 m^2 (NG as AIS) – 100%
b) 52,900 m^2 (NG as GIS) – 65%

An AIS substation has a marginally lower profile than a GIS (it is stated that the EA1N onshore substation will have a maximum building height of 15 m and external electrical equipment up to 18 m in height compared with the 400 kV AIS equipment, which has a height of 11.5 m plus one 13 m high overhead line gantry). Whether this is significant from a planning perspective, we cannot say.

National Grid Policy[1] states that "*Outdoor Air Insulated Switchgear (AIS) will be used at pollution severity Class III (or less) sites, except where other elements of this policy are overriding.*

…

GIS substations shall only be considered where lifetime-related conditions (such as pollution, permanent space restriction, or public visual amenity) preclude the use of open terminal equipment (AIS)."

It further states that "*Should a GIS substation be proposed for a project where there is a technically feasible AIS solution, written evidence including a risk assessment shall be provided at project sanction to justify the GIS option. In particular, it must be shown that variation from the preferred (AIS) solution can be justified as being reasonably practicable. National Grid will endeavour to provide a value for SF6 or alternative gases to be used in the risk assessment.*".

National Grid stipulates that "*GIS technology may only be considered where it offers the lowest lifetime cost solution. It must be demonstrated that a balanced review of safety, environmental implications, project delivery and whole life costs has been considered.*".

The proposed AIS substation is technically feasible for this site, and National Grid would therefore require a risk assessment and justification that the GIS option is reasonably practicable. Furthermore, the assessment would be required to demonstrate that GIS would offer the lowest lifetime cost for this site, based on a balanced review of safety, environmental, project delivery, and whole life costs considerations.

With reference to the pollution severity classification of the site, no independent monitoring or assessment was available for review, so we rely on the National Grid definition detailed

[1] PS(T)023, Substation Primary Insulation (Air/Gas) - November 2019.

in their policy: "*Sites in the following locations shall be considered to be severity Class IV unless confirmed otherwise by pollution severity monitoring or previous site experience:*

a) Within 5 km of the coast unless the site is reliably and demonstrably afforded protection from onshore winds by hills or structures.
b) Within 10 km downwind of a low stack coal-fired power station.
c) Adjacent to a chemical plant with halide emissions.
d) *Adjacent to a low-level wet cooling tower."*

The location that has been proposed, Grove Wood, Friston is at 52.190283N, 1.5291840E (Grid Reference TM 41318 60543). This is 5.9 km from the shoreline (see Figure 1) and is not located adjacent to, or within the stated distances from, the specified pollutant sources, and therefore it is not considered to be a Class IV pollution severity site according to the criteria above.

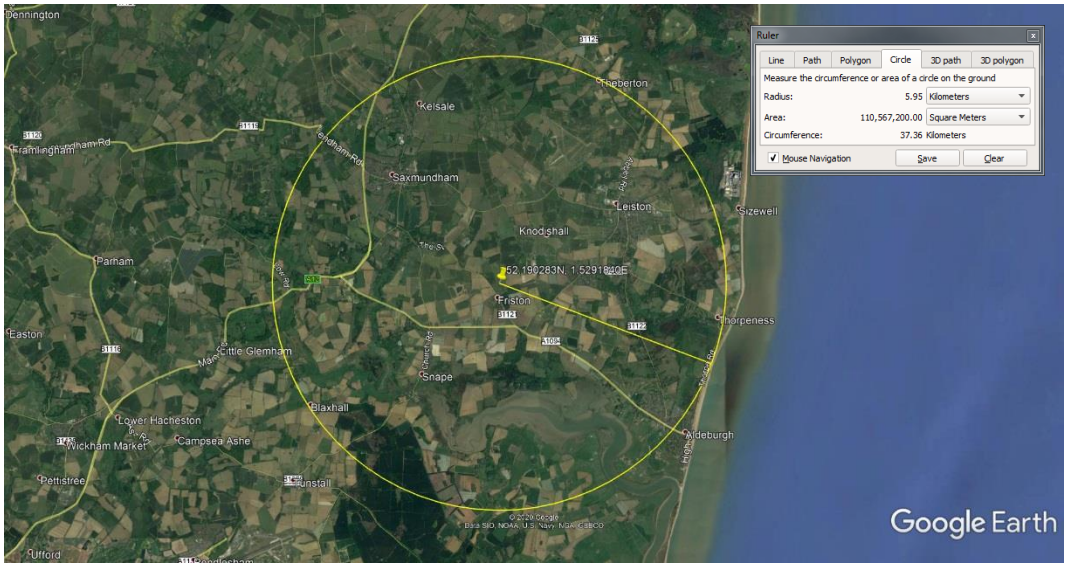

Figure 1 – Distance of the Friston Substation site from the shoreline

The documents indicate a land area of 44,950 m^2 compared with 16,800 m^2 for a GIS substation footprint (Table 6.28). It is noted that Bramford substation (to which EA1 is connected) is 23 km from the sea.

3.2 SPR Onshore Substations

The layout proposed for each wind farm-receiving substation is 190 m x 190 m. The technology shown for the EHV switchgear is GIS; no voltage level is given but we expect that it will either be 220 kV, the same voltage level as EA1, or 275 kV.

4 Combining the SPR Substations

The two terminal substations will largely consist of heat-generating plant such as transformers and reactive compensation equipment, which cannot realistically be located indoors. There will also be a limited amount of switchgear and it matters little in terms of space requirements whether these are AIS, GIS, or hybrid form.

The two substations will need to be separate from the NG substation to establish clear boundaries of responsibility between the generator and NG. From a practical perspective they are likely to be separate from one another due to differences in construction phasing. All could be essentially on the same site but separated by fencing.

Combining the two offshore windfarm substations into one unit has marginal benefit as far as we can see since the transformers and reactive compensation equipment will be dedicated to the individual circuits; the capacity of the 220/400 kV transformers to handle the output of the two windfarms (900 MW and 800 MW respectively) is greater than the largest current SGT on NG's system (1100 MVA) and we do not therefore see how the two windfarms could have any common equipment. Combining the two transformers of each facility into one unit might be feasible but would reduce the reliability/availability of the design.

The substations each have their own GIS and Control Buildings and there is potential for saving in land area if the two are combined. Based on the layout provided and the single line diagram for EA1, saving in land area will be relatively modest.

Below is an aerial photo of the East Anglia One substation, which is located adjacent to NG's existing Bramford substation.

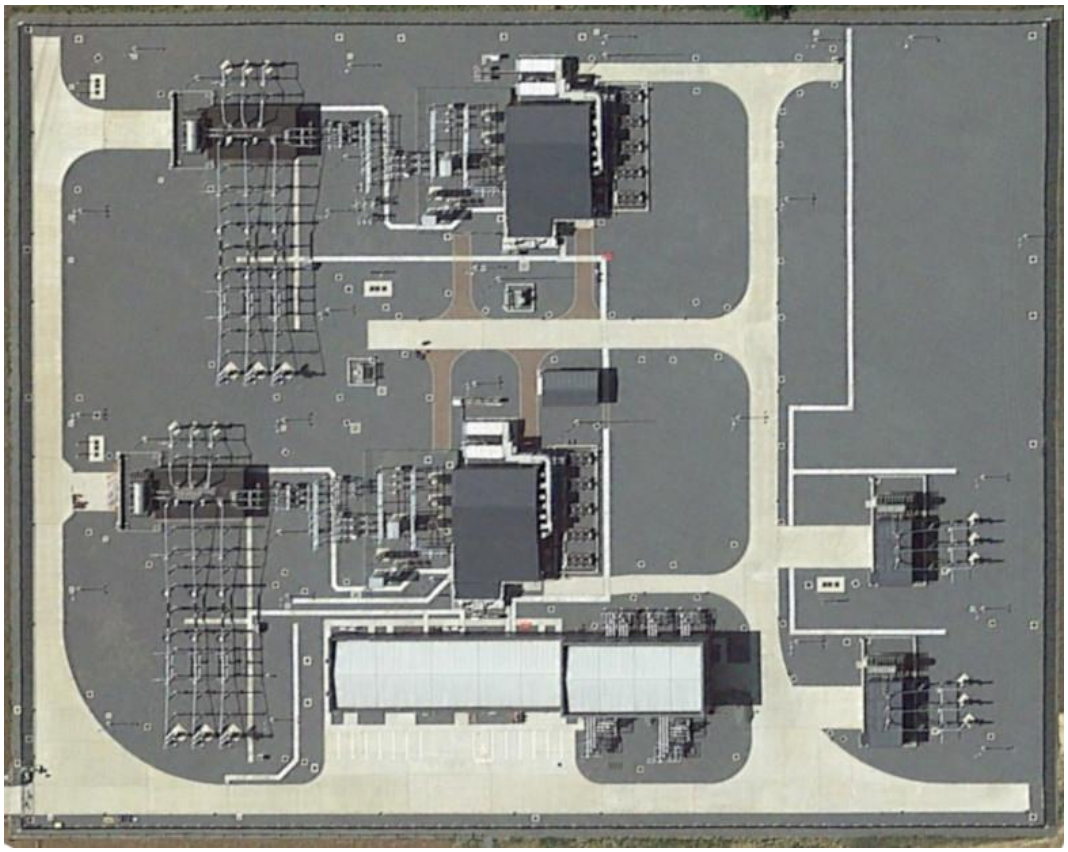

Figure 2 - East Anglia ONE Substation near NGET Bramford

Comparing this with the representations produced for the EA1N and EA2 projects, there appears to be a lot of space between the static compensators (statcoms) and the internal

road suggesting a possible location for AIS 220 kV switchgear instead of the GIS switchgear shown towards the bottom. The control building does seem to be rather large (13 x 40 m) but perhaps accommodates office, messing, etc. and suggests that some of the facilities could be shared between EA1N and EA2.

5 Use Of SF_6 Gas

AFRY was requested to provide commentary in respect of the use of Sulphur Hexafluoride (SF_6) as an insulating medium and the relative costs of the existing solution compared to a GIS solution as described above.

AFRY is in agreement with Applicants' Responses[2] Item 1.0.22, which includes the following:

> *"The deployment of equipment using SF_6 in the UK electricity transmission system is controlled by Policy Statements PS(T) 005 and PS(T) 023. The processes for managing and monitoring the use of SF_6 within National Grid UK Electricity Transmission are specified in NGUK/PM/SHE/207. …"*

Furthermore, a National Grid Policy[3] document states that the following technology milestones have been established:

a) No further procurement of 400 kV gas-insulated switchgear containing SF_6 (excluding circuit breakers) from 2024
b) No further procurement of 400 kV circuit breaker containing SF_6 (AIS or GIS) from 2026

Since it is likely that the NG 400 kV switchgear would be procured before 2024, SF_6 insulated GIS might be permitted for this project. At the present time no SF_6-free 400 kV GIS switchgear is available on the market, although manufacturers are working on developing GIS with alternative gas (such as General Electric's g_3 gas, which has been used in GIL at NG Sellindge 400kV Substation). We note that an AIS substation would require approximately 675 kg (for 9 circuits); the equivalent GIS substation would require approximately 2,500 kg of SF_6.

6 Future Connections

The substation footprint shown in the RAG Assessment[4] provided for two future customer circuits in the 325 m width. Each new AIS circuit bay occupies 21 m width.

In the Non-Technical Summary[5] the NG substation width has shrunk to approximately 310 m width and provision for the two future circuits has disappeared. This plot plan shows three cable sealing end compounds along the routes of the two overhead lines. It would not be possible to accommodate the two future circuits within this layout; there appears to be room to expand back to the original width or more.

[2] Applicants' Responses to Examining Authority's Written Questions, Volume 2 – 1.0 Overarching, general and cross-topic questions – November 2020
[3] PS(T)005, Sulphur Hexafluoride (SF_6) Gas - December 2019
[4] Appendix 4.2 Red/Amber/Green (RAG) Assessment for Onshore Substations Site Selection in the Sizewell Area – October 2019
[5] Document Reference 6.4: Non-Technical Summary October 2019

In the Applicants' Response[6] Item 1.6.1 it appears that space for future transmission connections to this substation have been excluded from this application. Also Item 1.0.18 of Ref[11] suggests that the future projects are not being considered.

7 Conclusion

We have examined the proposals for the new onshore substation and conclude the following:

1) The adoption of AIS technology for the National Grid 400 kV substation is consistent with NG's policy of applying AIS to sites with pollution severity Class III, or less. However, the adoption of GIS technology for the National Grid 400 kV substation may be considered for sites where public visual amenity is a project threat. Such an adoption would require a risk assessment and motivation to National Grid based on a balanced review of safety, environmental, project delivery, and whole life costs considerations.
2) The adoption of AIS technology would reduce the quantity of SF_6 gas required and the potential for contribution to greenhouse emissions. NG's policy is to not build new GIS substations beyond 2024 and not employ SF_6 interrupters beyond 2026.
3) The EA1N and EA2 onshore substations employ GIS technology. Since ScottishPower Renewables are not governed by the same policies as National Grid, we presume that the use of SF_6-filled GIS is acceptable.
4) While there is possible scope to reduce the footprint of the two onshore substations by combining the control buildings and after consideration of the capacity/size of the primary equipment, the overall impact on the plot size it unlikely to be significant. For planning purposes, the adoption of an identical plot size to EA1 seems reasonable.

[6] Applicants' Response to ExA WQ1 Volume 8, November 2020

APPENDIX A – QUESTIONS & ANSWERS

National Grid Substation

1) *A gas-insulated (GIS) option is discussed but has not been assessed in the EIA because the AIS option is deemed to be worst case.*

Noted.

2) *It is known that further connections will be required for future projects and that additional bays will be required to facilitate connections.*

Each new bay will add 21 m to the width of the 400 kV AIS substation. The original footprint of the NG substation (325 m x 140 m) had included for two future connections – these have now been removed. An additional two future bays (i.e. 4 bays in total would increase the width to 367 m which is approximately the same as the sum of the two adjacent offshore connection substations (190 x 2 = 380 m).

   a) *On the basis that further connections are required would it be more rational to use GIS technology to provide additional capacity for further connections on the site in terms of land take and impinging on residential amenity?*

The use of GIS technology for the National Grid 400 kV substation would reduce the land take by 60%. Each additional bay increases the width by approximately 3.6 m.

We have superimposed a GIS substation on the AIS substation in the sketch below to illustrate the difference in size:

b) What are the likely additional costs of such an approach?

The cost of GIS vs AIS technology is difficult to quantify, being subject to market conditions. GIS is up to 140% of the cost of AIS, excluding consideration of the cost of land acquisition.

c) What is the likely footprint reduction? Submitted material suggests one third of the AIS design, in one building 16 m high.

The documents say that the NG substation footprint is 45,500 m^2 for AIS and 16,800 m^2 for GIS, with heights of 13 m and 16 m respectively. We would not dispute these figures.

d) Is the requirement for SF_6, given its status in the Kyoto Protocol, significant or are there realistic alternatives available to use in the UK?

GIS technology employs substantially more SF_6 gas than AIS technology (circa 4x).

Current National Grid Policy dictates that GIS substations containing SF_6 gas should not be procured beyond 2024. At present there is no alternative tested solution for the provision of filling with other gas at this voltage level (400kV); manufacturers are working to develop solutions.

SPR Onshore Substations

1) It appears that the only rationale for the use of two project connection substations is that this is an artifact of the developer build OFTO model that has been selected. Is this correct?

Between the two projects there are four incoming cable circuits. Each circuit requires shunt connected compensation equipment and each has been connected to the NG 400 kV substation by its own interbus transformer (400 MVA in the case of EA1). Based on the connection arrangements for EA1 we consider that the 220 kV GIS switchgear is required to be two electrically separate between the projects. Accommodating the switchgear in a single building and having a common control building appears to be feasible and would offer some saving in space.

2) Setting aside the regulatory constraints would it be feasible to construct a single project substation for the two projects?

The various equipment requirements mitigate against any reduction in the equipment count. Whether this is all within one fenced area or two is not likely to save much of the footprint and separate areas would in any case be needed for the phased construction.

3) If this is feasible technically, what could be expected in terms of footprint reduction by using this approach?

Very little – as noted above, an assessment of the physical size of the compensation equipment might reveal that the plot sizes can be reduced when compared with EA1.