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1 GENERAL

1.1 Purpose

This document constitutes the Employer's electrical basis of design, system studies and models requirements for the Works of the Projects.

The Contractor shall design, supply, test, install and commission all Works for the converter stations in accordance with the Contract and this specification and relevant European, Country and Employer standards and shall apply Good Industry Practice for the execution of the Works. This specification shall be read in conjunction with the full Employer's Requirements.

Subject to the requirements outlined here, the design objective is to provide the required functionality and the most cost-effective solution (CAPEX, OPEX and availability) for the Design Lifetime of the Project.

The information provided in this document is preliminary and based on standard available information to allow the Contractor perform the electrical design until more detailed, specific information from Other Works Contractors is available.

2 General Requirements and Information

2.1 General

This document defines the minimum general electrical requirements for the design, engineering, manufacture, assembly, inspection, testing, certification and supply of the electrical systems for the Works.
The supplied equipment shall be in full compliance with all requirements stated in this document. Any exception or deviation to these shall be identified by the Contractor and listed separately for consideration by the Employer.

Any deviation from this document shall be clearly defined by the Contractor. No deviations shall be permitted during the engineering/construction period without written acceptance from the Employer or their accredited agent in advance.

Where the Contractor identifies inconsistent information then they shall refer to the Employer for clarification. If a clarification is not requested or provided then the Contractor shall proceed with the legally mandated and/or most onerous requirement.

With reference to the power transmission capacity, the terms nominal and rated shall be understood as the same value.

2.2 HVDC Transmission Link

The HVDC transmission link comprises a step-up voltage transformation and a converter station for conversion to DC voltage at the OSS. From the OSS, DC cables transmit the wind power onshore, where a converter station again converts back to AC. At the Onshore Substation an interfacing transformer is also necessary in order to optimize the HVDC system and meet the grid code requirements. The Offshore Grid Entry Point (OGEP) is defined at the 66kV terminals of the offshore transformers connected to the array feeder bays. The HVDC transmission system shall ensure stable operation and is responsible for the control and protection of the system.

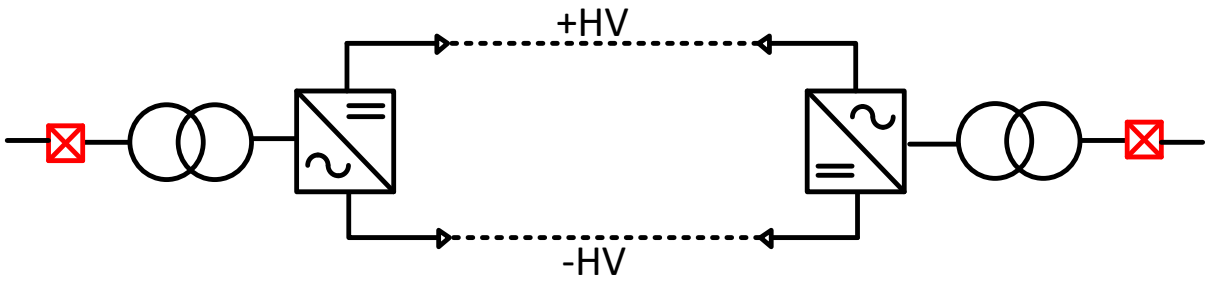

Figure 1 Symmetrical Monopole

The HVDC transmission system shall be a symmetrical monopole system with one converter station connected to the Wind Farm and another to the grid. In the symmetrical monopole application two high voltage cable in opposite polarity are used, depending on the power direction one or the other will be used as a return current path.

The Contractor shall supply all Works from the terminal of the Inter array cables (IAC) to the terminals of the 400kV AC cable connecting to the Necton AC substation (see figure 3). This shall naturally include all primary and secondary equipment both at the ONS and OSS. The converter transformer can both be single phase or three phase however fast exchange of failed transformers shall be possible.

The transmission link shall be designed and supplied such that the Availability Warranty is met.

The Offshore Works shall be provided in such a manner that the no single point of failures will occur. In order to connect the Wind Farm, an offshore array cable grid is necessary. This grid can be seen as a collector of all wind power from the WTGs. This array grid is built by the Employer using subsea cables, all of which are connected to the Offshore substation (OSS). The HVDC transmission link is also connected to the OSS, receiving the power from the WTGs.

3 Scope of work

3.1 Scope

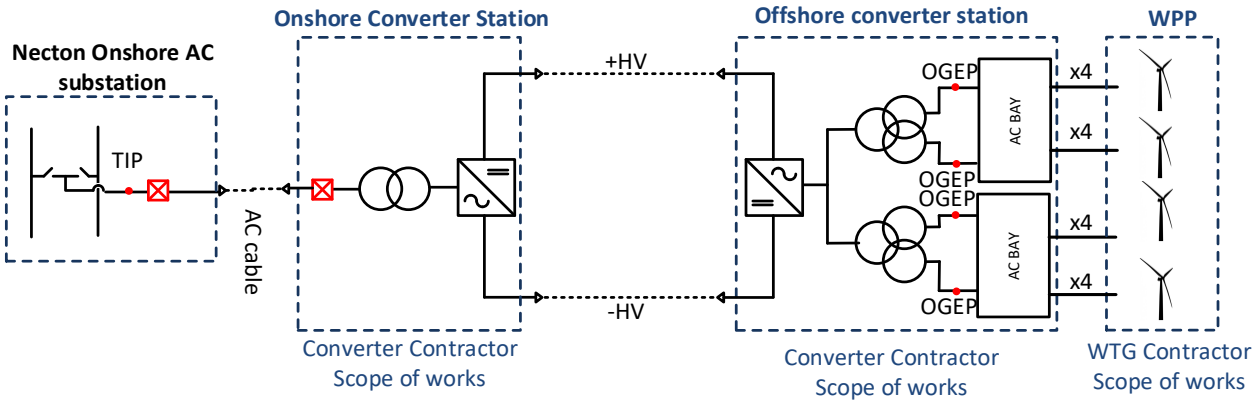

Figure 2 Example of 1320 HVDC transmission system

The transmission system shall connect the Projects, reference is made to Appendix 9. The transmission system shall be using one VSC symmetrical monopoles of ±320 kV-1320MW HVDC transmission systems for each Project that will connect each approximately 1400MW of Wind Farm capacity (including overplanting) to the UK national transmission grid. The connection point of the Onshore Site is located nearby the Necton 400kV substation. The power level shall be met at the offshore grid entry point (OGEP) as stated by National Grid's Security and Quality of Supply Standard (SQSS).

The Contractor shall deliver the OSS and 400kV cables with all electrical installations, primary and secondary systems, including interfaces to third parties as defined in HVDC-VAT-A-LA-0002 [Employer's Requirements Annex 6.1 – Master Interface Matrix]. The Contractor shall design, deliver, test and commission all 66kV equipment located on the OSS. The ownership split shall be at the terminations within the switchgear of the connection to the offshore transformers. Employer will control the equipment on the array feeders and therefore Contractor shall deliver the interface to Employer's SCADA in accordance with HVDC-VAT-E-FD-8902 [Employer's Requirements Annex 8.11 - Control and Protection Concept].

The Contractor shall be liable for fulfilling the grid code requirements of the TSO, based on but not limited to the following information to be provided by the Employer:

- TSO grid connection requirements,
- TSO standards (SQSS, CUSC)
  - *Operational Notification Compliance Checklist*
  - Operational Notification & Compliance Testing
- WTG specification including reactive power capability,

- Inter Array Cable and Export cable specifications, and
- Wind report (NVW-VAT-Z-RA-0001 Employer's Requirements Annex 15.2 – Metocean Data]

3.2 Offshore AC System specifications

For AC System specifications please refer to ECC and grid code requirements. The Offshore Substation shall meet the following unbalance requirements, but not be limited to:

- System requirements: unbalance of less or equal to 2% negative sequence for design purpose
- System requirements: unbalance of less or equal to 1.5% for zero sequence for design purpose

Please refer to EN 61000-2-4 and EN 61000-4-27 to meet offshore voltage unbalance requirements.

AC SYSTEM CONDITIONS	OFFSHORE PROJECT
MAXIMUM SHORT CIRCUIT LEVEL	Contractor to suggest for employers approval.
MINIMUM SHORT CIRCUIT LEVEL	Contractor to suggest for employers approval.
X/R RATIO	Contractor to suggest for employers approval.
SHORT CIRCUIT CURRENT RATING (TO BE USED FOR FEED BUT WILL FURTHER BE INVESTIGATED IN DETAIL DESIGN)	25 kA for 1s

Table 1 Offshore short circuit values

The offshore transmission system shall withstand the requirements for all operational points. The HVDC transmission system shall be designed to withstand the Transient Overvoltage (TOV) level. The following shall be used

- 1.3pu for 300ms.

3.2.1.1 Frequency

Nominal frequency of the system in the UK is 50 Hz. The OSS and ONS shall be able to operate without limitations within the AC system frequency variations according to the grid code requirements.

3.2.1.2 Electrical Safety Clearance

- The converter stations shall be designed according to the Insulation coordination study based on the following standards. BS/EN 60071-1 Insulation co-ordination – Part 1: Definitions, principles and rules
- BS/EN 60071-2 Insulation co-ordination. Application guidelines
- BS/EN 60071-5 Insulation co-ordination. Procedures for high-voltage direct current (HVDC) converter stations

The Contractor shall ensure that the electrical clearances are not less than the values specified in BS/EN 60071 standard.

At the DC side of the converter, the safety distance shall be stated by the Contractor and shall be based on an insulation coordination study. The safety distance shall be greater than the electrical clearance by a margin of at least 0.3 m. In case a different safety distance clearance margin is used the Contractor shall justify the change for approval from the Employer.

3.2.1.3 Creepage Distance

The OSS shall have a pollution class of heavy based on IEC 60815-1 (Selection and dimensioning of high-voltage insulators intended for use in polluted conditions). The minimum creepage distances for bushings and insulators in the converter stations shall be based on the root mean square (rms) phase-to-earth value of the maximum steady-state system voltage, or the maximum continuous DC voltage, which shall be:

Equipment	*Minimum creepage distance [mm/kV*
Site Pollution Severity Class	**Heavy**
AC Voltage	53.7 mm / kV
DC Voltage	50 mm / kV
AC and DC (Porcelain)	60 mm / kV
AC and DC (Composite)	50 mm / kV
DC & AC (Valve Equipment)	14-20 mm / kV
DC (Valve Hall Bus and Bushings)	20 mm / kV
DC (DC Hall Equipment)	30 mm / kV

Table 2 Creepage distances

If the Contractor proposes other values this has to be presented and agreed with the Employer.

3.2.1.4 Offshore AC System Protection

The offshore Earthing fault factor shall be purposed by Contractor for Employers approval. Onshore AC System specifications, As seen in Table 3 Onshore short circuit requirements the data from the BCA including important ECC and grid code requirements for the Contractor's convenience. However for clarity please refer to BCA to avoid copy/paste or version errors. Below Contractor can find onshore short circuit values provided by the TSO, The Employer does not take responsibility for the correctness of these values stated herein.

SQSS Condition	3-phase		1-phase			Purpose (It is recommended the relevant fault levels are used for the following purposes)
	Sub-Transient Current (kA)	Make X/R Ratio Break X/R Ratio	Sub-transient Current (kA)	Make X/R Ratio Break X/R Ratio	X0/X1 Ratio	
Minimum fault level	20.12	14.9 17.1	16.39	11.6 15.5	1.4	Protection settings with additional appropriate safety margins. Electromagnetic transient study in relation to CC.6.1.7(a) and (b) and TOV (TGN 288). Any study in relation to unbalance.

Post fault mini-mum fault level	9.60	17.4 18.9	8.94	14.4 18.6	1.2	Fault ride through Transient active and reactive power exchange studies For SSTI and control interac-tion studies the part of network around the point-of-interest is usually mod-elled. Post fault minimum fault level, which rep-resent a N-1-D condition on a summer mini-mum scenario should be in-cluded in the study cases.
Winter fault level	36.60	20.6 24.5	39.16	19.0 23.4	0.7	
Winter fault level	44.94	22.0 24.8	47.07	19.9 23.1	0.7	Siemens requested a fault level considering fu-ture connections and transmission reinforce-ments in the area.

Future contracted background (G74)						This fault level data considers the G74 methodology, future contracted generators and future reinforcements in East Anglia that are known at this moment.

Table 3 Onshore short circuit requirements

The Transient Overvoltage TOV is seen after a short circuit fault, the withstand capability shall be as defined in TGN(E) 288 with particular reference to Figure 1. For clarity 1pu=420kV.

3.2.1.5 Onshore Geographical and Environment

For additional detail see HVDC-VAT-Z-FD-0001 General basis of design document

Item	*Value*	*Unit*
Ambient temperatures of air Max	+35	C
Ambient temperatures of air Min	-10	C
Earth Resistivity (only to be used during feed and in case soil investigation is not finalized)	50	Ωm
Lightning flash density	1.0	Km^2/year
Ice loading (radial thickness)	10	mm

Table 4 Ambient conditions onshore

3.2.1.6 Frequency

The onshore grid frequency requirements are also found in the grid code requirements.

3.2.1.7 Electrical Safety Clearances

The Onshore clearance requirements are similar to section 3.2.1.2.

3.2.1.8 Creepage Distances

The Onshore Creepage Distances requirements are similar to section 3.2.1.3.

3.2.1.9 AC System Protection

Contractor shall define the maximum earth fault factor as follows and as stated in the grid code requirements.

3.3 Earthing Facility

The Contractor shall comply with the earthing requirements specified in Bilateral Connection agreement Appendix 1.
The Contractor shall ensure that the equipment is designed and installed such that the rise of earth potential (ROEP) at the Onshore Substation conforms to the touch, step and transfer voltage limits which are defined in ENA TS 41 – 24. For the Offshore Substation the earthing of the HVDC Converter shall be designed in such a way as to avoid DC stray current flowing through the earthing system during normal operation and to minimise earth current during faulty or unbalanced load conditions.

In order to minimise corrosion issues, the requirements for HVDC earthing is specified under BS EN 50162, BS EN 12954. With regards to safe touch voltage threshold the requirements for HVDC earthing for the DC current path is defined in IEC/TS 60479-1 which is referenced under BS EN 50522.

The entire HVDC system design shall consider the possible maximum level of DC stray currents to which buried or immersed metal structures may be exposed even at a substation distance from the terminal earths of the HVDC converter.

3.4 Impulse Voltage

For impulse voltage onshore and offshore, the margin between the withstand level and the protective level shall be as stated in the Table 5 below as per IEC 60071-5.

	Impulse Type	***Insulation Margin***
DC Side Equipment	Lightning	20%
	Switching	15%

	Steep front	25%
AC Side Equipment	Lightning	25%
	Switching	20%
	Steep front	25%

Table 5 Insulation margins

For Oil insulated equipment shall have a margin of at least 25 % for all stresses. An acceptable definition could be that the DC Side Equipment. For the converter transformer Employer can accept a deviation from 25% if previously agreed between Contractor and Employer. shall be all equipment on the converter side of the converter transformer (secondary). AC Side Equipment shall be all equipment on the grid side of the converter transformer (primary).

3.5 DC Cable Data

Table 6 provides and overview of preliminary electrical DC cable data. Final data will be provided by the Employer at a later stage. The provision of final data will be agreed with the Contractor in the interface schedule. The Contractor shall provide list of data required from the DC cable contractor prior to the Base Date.

Item	*Notation*	*Value*	*Unit*
Rated DC voltage	U_0	320	kV
Maximum DC voltage	U_{0max}	330	kV
DC ripple	$U_{0ripple}$	3	%
Rated power at sending end	U_{P1}	1320	MW
Lightning Impulse Withstand Voltage	U_{LIWL}	2.1	Per unit
Switching Impulse Withstand Voltage same polarity	U_{SIWL_SP}	1.85	Per unit

Switching Impulse Withstand Voltage opposite polarity	U_{SIWL_OP}	1.2	Per unit
Design DC fault current – Magnitude	I_{fault}	20	kA
Design DC fault current – Duration	t_{fault}	0.3	s
DC Test voltage minimum - TOV	Ut	1.85	Per unit
DC Test voltage duration	Tt	0.1	s

Table 6 DC side and DC cable requirements

The following preliminary data can be used until final data is available.

	Land	*Submarine*	*Unit*
Distance East	60	102	km
Distance West	60	80	km
Between east and west	0	44	km
Boreas	60	129	Km
Resistance @ 90°C	TBD	TBD	mΩ per km
Capacitance	TBD	TBD	mF per km
Inductance	TBD	TBD	µH per km

Table 7 DC cable data

Due to the cable termination (if placed indoors) and the cable temperature restrictions, the maximum allowed ambient temperature at the cable sealing end (DC hall) shall not exceed 40 degrees.

The Contractor shall confirm the DC current maximum steady state, dynamic and transient overcurrents including DC short circuit current to the purchaser in their documentations.

3.6 Design Lifetime

The Works delivered by Contractor for the Project shall be designed for the Design Lifetime under the environmental condition that prevails in the respective areas (reference is made to NVW-VAT-Z-RA-0001 [Employer's Requirements Annex 15.2 - Metocean Data). If individual components have a lifetime of less then Design Lifetime the Contractor shall declare those and list them for Employers approval. Furthermore, the Contractor shall ensure that the Availability of such components is maintained throughout the Design Lifetime of the Project or shall be part of Contractors obsolescence plan.

3.7 Spares and Special tools

The Contractor shall supply sufficient spare parts as defined in HVDC-VAT-O-FD-0002 [Employer's Requirements Annex 14.1 – Operation & Maintenance].

The system shall be designed to minimise downtime during replacement of critical spares.
The Contractor shall provide a spare parts list that is required over the Design Lifetime of the Project. Where sub-assemblies or components may be expected to become obsolete (such as IGBTs, electronic systems) the Contractor shall state the spares holding required to maintain the specified reliability and availability until mid-life refurbishment.
The Contractor shall determine the size of the spares building based on the reliability and availability requirements. A building of adequate size shall be provided for the storage of spares that require indoor storage or controlled environment.
In addition, the Contractor shall provide guarantee on the spare parts consumption and failure rate of critical equipment that can affect the availability and reliability of the scheme.

The Contractor shall provide all special tools (incl. software and programmes) and maintenance equipment required for the proper operation and maintenance of the supplied equipment.

4 Performance

The requirements specified in this chapter sets out the general requirements of the Employer in relation to the performance of the Works. It is the Contractor's responsibility to provide design solutions, which meet these requirements, and to demonstrate that full compliance is achieved. Employer expects that testing are done in as a minimum in accordance with Cigre TB 97 and IEC 61975.

4.1 Power rating

4.1.1 Active power rating

The rated active power for the HVDC transmission system is 1320 MW for each Project. The power transmission capacity for the transmission system refers to the AC onshore grid interface point referred to as OGEP, see Figure 2Figure 2 Example of 1320 HVDC transmission system. Rated current is the phase current on the offshore HV side of the converter transformer at minimum continuous operating voltage at rated active and reactive power. In normal operation, active power flow is mainly from offshore to onshore, however it shall be possible to transmit power in both directions. Hence, the transmission system shall be capable to deliver the necessary power to supply all consumers on the OSS (please refer to HVDC-VAT-E-FD-8001_02 [Employer's Requirements Annex 8.28 - Low Voltage Distribution System Concept-Offshore] .

The system shall be able to deliver full power in all continues operation cases at ambient temperature up to 35 degrees Celsius. Above the ambient of 35 degrees Celsius the Contractor shall take measures to ensure the Design Lifetime of the equipment is not endangered (e.g. by increasing cooling capacity or reducing the power without tripping the system). The Contractor shall supply the power reduction curve with increased temperature. The Contractor shall ensure that requirements set in Employers Requirements Appendix 2, Appendix 4 and Appendix 5 and the grid code requirements are satisfied.

The HVDC link shall be able to operate within the frequency range and AC system voltage ranges as defined in section 0.

If the AC onshore and/or offshore system voltage are below the minimum continuous operating voltage described in chapter **Error! Reference source not found.** and grid code requirements, the HVDC transmission system shall be able to continue to operate with rated AC current at the 400 kV/66kV side of the converter transformer.

4.1.2 Reactive Power Rating

The reactive power capability of both the onshore and offshore converters shall be sized to meet the grid code requirements in both sending and receiving modes at rated active power. The reactive power sizing shall be calculated for the active power of 1320MW. When operating below maximum capacity, the OSS and ONS shall be capable of satisfying the reactive power capability requirements as stated in the grid code requirements.

During detailed design the Contractor shall evaluate the inherent reactive power capability and produce a report that shows the capability at different operating points and identify the restricting components. The Employer shall be able to fully utilize the inherent reactive capability of the VSC-HVDC converters in the complete operating range. The Contractor shall present the reactive power capability in the range from zero up to rated active power, in both directions, within the specified AC system voltages. During disturbances in the AC grid the converters shall be able to support the AC grid with dynamic reactive power, please refer to HVDC-VAT-E-FD-8902 [Employer's Requirements Annex 8.11 - Control and Protection Concept]. Similarly, the Contractor shall rate the HVDC equipment to meet the requirements such as, but not be limited to, fault ride through, fault current injection as specified in the grid code requirements and Employers HVDC Control and HVDC-VAT-E-FD-8902 [Employer's Requirements Annex 8.11 - Control and Protection Concept].

4.1.3 AC harmonics

This section sets out the power quality requirements in terms of the harmonic contribution introduced by the connection of the HVDC transmission link to the connected grid.

4.1.3.1 Onshore

The Contractor shall comply with the grid code and BCA requirements for harmonic contribution and amplification. The Contractor shall provide harmonic information minimum, but not be limited to:

- incremental rise of harmonics at TIP
- rise of background harmonics at TIP
- current contribution at TIP.

The provided information shall include the harmonic order 2^{nd} -100^{th} for both the ONS and OSS.

NGET will use the onshore information to determine the performance limits (incremental and aggregate) applicable to the ONS and OSS as well as providing the system harmonic impedance for Necton 400kV.

The converter shall be, as a minimum, be able to operate without restriction for harmonics up to the compatibility levels as defined in Engineering Recommendation G5/5 (2015) (see also HVDC-VAT-E-FD-8901_03 [Employer's Requirements Annex 8.15 - Norfolk Vanguard West

Limited - Appendix F]). The equipment shall be designed and rated such that the compatibility levels are not exceeded, taking into account existing background harmonic distortion (HVDC-VAT-E-FD-8901_06 [Employer's Requirements Annex 8.18 - Harmonic Report]) HVDC-VAT-E-FD-8901_03 [Employer's Requirements Annex 8.15 - Norfolk Vanguard West Limited - Appendix F]).

4.1.3.2 Offshore

Offshore harmonics limits are provided in HVDC-VAT-E-FD-8901_06 [Employer's Requirements Annex 8.12, Appendix 2 - Norfolk Vanguard West - Appendix OF]Harmonic emission limits are defined at the 66 kV level. To meet the harmonic planning levels in the offshore grid, the planning levels for the high voltage grid given in IEC TR 61000-3-6 shall be split between all PPMsof the Wind Farm, and the offshore HVDC converter, using the equation (15) given in IEC TR 61000-3-6. All connected parties shall plan for and take measures to fulfil the requirements. IEC 61000 shall be used. The Total Harmonic Voltage Distortion (THDu) from the Converter shall be less than 3.0%. In the calculation of THDu the value of *n*-max shall be set to 65 as a minimum. Furthermore, an inter-harmonic voltage limit of 0.2% according to IEC 61000-3-6 shall also be considered. Existing harmonic background voltage distortion at the AC busbars shall be set to 50% of the planning level provided in IEC 61000-3-6 for all compliance studies. Please note that these requirements are initial requirements to establish an understanding and a way forward in case misunderstandings/misalignment. However during detailed design a harmonic study will be executed by Contractor and reviewed by both Employer and WTG Contractor. In case any of the limits are breached however does not cause any negative effect on equipment connected to the offshore grid nor cause any adverse behaviour an agreement can be reached between all parties to allow the breach of the above Harmonic requirements for the offshore grid. In case relevant final data needed to calculate the actual background harmonics have not been provided by Employer. Contractor shall include design margins in the proposed offshore harmonic study to allow for minor changes in data.

In case of background amplification phenomena at the offshore OGEP, there shall be a joint analysis between Employer and Contractors to determine the most efficient mitigation actions to remove the excessive distortion points.

Studies shall be performed by the Contractor to analyse the offshore harmonic stability. Contractor has the responsibility with support from the Employer and WTG Contractor to study, validate and propose mitigation solutions so that the overall offshore system operates correctly under all specified contingencies and operating conditions. This will also be the case if any control interaction is detected. In case Contractor identifies harmonic issues, mitigation measures shall be proposed by Contractor. These mitigation measures will be implemented in accordance

to the agreement between Employer and Contractor. In case WTG Contractor is to provide mitigation measures Employer will lead the discussion.

Harmonic damping controlling functions as part of the Control and Protection (C&P) system of the OSS are required to effectively mitigate resonance problems during steady-state but also transient operating conditions.

4.1.3.3 AC inter-harmonics

Contingent upon the connection being compliant with Engineering Recommendation ER P28 for flicker, if the predicted sub-harmonic and inter-harmonic voltage emissions from an item of equipment or aggregate load are less than 0.1% of the fundamental voltage, connections may be made without any further assessment.

In the United Kingdom, it is assumed that ripple control systems are not being used and therefore a customer's load, having individual sub- or inter-harmonic emissions less than the following ***Table 8*** DC Inter-harmonic limits limit values may be connected without assessment

FREQUENCY [HZ]	IHD [%V_1]
80	0.2
90	0.5

Table 8 DC Inter-harmonic limits

Limits for particular inter-harmonic frequencies between 80 and 90 Hz may be interpolated linearly from the limits given in ***Table 8*** DC Inter-harmonic limits. Each individual inter-harmonic subgroup shall be evaluated according to IEC 61000-4-30 and related IEC 61000-4-7.

4.1.4 DC harmonics

The DC voltage ripple is defined as the peak-peak amplitude of the ripple divided by the DC voltage between conductor and earth.

The voltage shall be calculated for:

- valve side of the smoothing/converter reactor
- cable side of the smoothing/converter reactor.

The DC voltage ripple (V_{DC_ripple}) in the submarine- and underground HVDC cables shall not exceed 3%.

4.1.5 Power Line Carrier (PLC) Filtering

The limits for emissions entering the NGET system are specified in the Bilateral Connection Agreement between the Employer and NGET.

4.1.6 Telephone Interference Factor

The Contractor shall ensure the Telephone Influence Factor (TIF) is ≤50, in accordance with IEC-62001 and Cigré TB139. The TIF factor of ≤50 is per link and not for all three transmission links.

4.2 Radio Frequency Interference and HF Filtering

The radio interference shall, by suitable design of the plant, be limited so as to minimize the risk of radio interference and satisfy the relevant requirements in:

- CIGRE Technical Brochure 391: Guide for measurement of radio frequency interference from HV and MV substations
- CISPR 16-1 Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus
- CISPR 16-1 Amendment #1
- CISPR 18-2 Radio interference characteristics of overhead power lines and high voltage equipment – Part 2: Methods of measurement and procedure for determining limits
- CISPR 18-2 Amendment #1
- CISPR 18-2 Amendment #2

Each converter shall be required to be within “Limit 2” for Substation RFI Limits and “Limit 4” for Line RFI limits of Table F.1 of TB391 as described in the sections below.

The verification shall be performed after the installation has passed the corona tests.

4.2.1 RFI Measurement Procedure

Measurements of RFI around the ONS and it’s connected lines shall be taken at the distances shown in Figure 3 below. Circled T’s indicate particular measurement positions of interest. The distances d1 d2 and d3 are shown below.

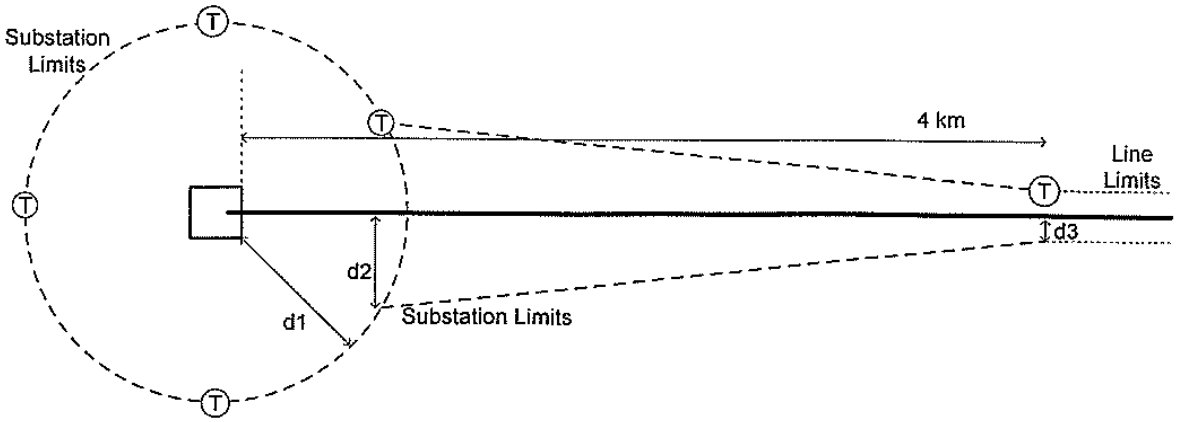

Figure 3 RFI Measurement Locations

4.2.2 RFI Limits at the Converter Station

With the Converter Station working in the range of the foreseen values of voltage and power previously defined, the RI field at d1 from the closest active part of the substation (considering background noise) shall be lower than the values reported in Table 9The closest active part of the ONS can be the wall of the ONS building or the closest high voltage device.

4.2.3 RFI Limits around the line close to the substation

The RI field at 200m from the closest active part of the Converter Station and at one third of 200m from the closest conductor of the line, shall be lower than the values reported in ***Table 9*** - RFI Limits (extracted from TB391 Table F.1).

4.2.4 RFI Limits around the line far from the substation

The RI field measured at least 4km far from the Converter Station and at 30 m from the closest conductor of the line, shall be lower than the values reported in ***Table 9*** - RFI Limits (extracted from TB391 Table F.1).

4.2.5 RFI Limits

Below in ***Table 9*** - RFI Limits (extracted from TB391 Table F.1) are the limits extracted from CIGRE Technical Brochure 391 F.1 which represents the graph below in Figure 7.

RFI Limits		Around the Converter Station	Lines close to the substation	Lines far from the substation
Measuring Distance (m)		d_1 = 200m	d_2 = 66m	d_3 = 30m
RFI Limit (dB / µV.m)	Frequency Range (MHz)	RFI Limit*		RFI Limit*
	0.009 – 0.1	60 - 20log(f)		45 - 22log(f)
	0.1 – 0.15	50 - 30log(f)		45 - 22log(f)
	0.15 – 1.0	50 - 30log(f)		45 - 22log(f)
	1.0 – 30	50 - 10log(f)		45 - 18log(f)
	30 – 230	35 dB/µV.m		30 dB/µV.m
	230 – 1000	37dB/µV.m		37dB/µV.m
Measurement Method		Quasi-Peak	Quasi-Peak	

Table 9 - RFI Limits (extracted from TB391 Table F.1)

* Note that some limits are expressed in terms of the frequency (MHz) of the RFI.

In accordance with CISPR 16-1 and TB 391, the tests shall be made with the following bandwidths.

200Hz	In the range of 9 – 150kHz
9kHz	In the range of 0.15 – 30MHz
120kHz	In the range of 30MHz to 1GHz
1MHz	In the range above 1GHz

The limits in the table are drawn in Figure 4 below.

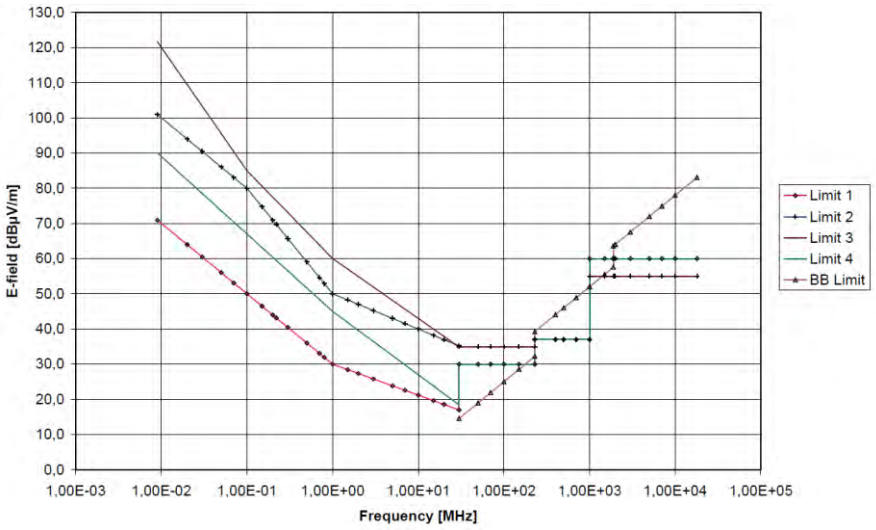

Figure 4 - RFI Limits (Extracted from TB391 Figure F.1)

Based on the last Radio interference study report in the FEED (NVW-SEN-E-RF-0002_P01 - Electrical Interference Study.pdf), the Contractor is not able to confirm compliance to the limit of CIGRE 391 across the complete frequency range as specified. In addition to the mitigations stated in the TQ "Radio Interference Limits P-018055_TQ003", it was agreed that Contractor will carry out the field measurement of environmental background noises (in the frequency range as specified for the RI requirement) at beginning of the project near the planned converter station site. In the surrounding area of the HVDC onshore station, third parties, e.g. the existing radio services that may affect the RI with the HVDC will be evaluated. The output will be fed back into the detailed system design to optimize the RI results of HVDC. The purpose is secure the third parties in the surrounding area are not disturbed or influenced by radiated emissions created by high power converter and its installations, not to suppress the RI under the CIGRE 391 limits.

If during Commissioning, Trial Operation or the Defects Notification Period a third party complains about radio interference and the radiated emission is above the CIGRE391 limit, the Contractor is responsible for the rectification. The purpose of this correction is the elimination of the interference and not a complete reduction of the interference noise under the CIGRE391 limit.

4.3 Flicker

Flicker emission as defined in IEC61000-3-7 shall be limited to the values from the ***Table*** 10 below.

EPsti	EPlti
0.35	0.25

Table 10 – Flicker

4.4 Rapid voltage changes

Rapid voltage changes (or Voltage Fluctuations) shall be within the criteria of ECC.6.1.7 of the grid code requirements. Measurement of rapid voltage changes shall be performed according to IEC 61000-4-30.

4.5 Unbalance

Contractor shall ensure that the magnitude of current produced in any one phase by the converter station is not greater the grid code requirements.

4.6 Electrical and magnetic field strength

Areas within the converter station perimeter that exceed the action limits provided by the European Workers Directive 2013/35/EU shall be identified and marked in drawings. These action limits are:

- 20 kV/m for Electric Fields determined 1 metre above the ground
- 500 µT (DC fields) or 1000 µT for Magnetic Fields determined 1 metre above the ground

At the converter fence the ICNIRP 2010 Public Exposure Guidelines must not be exceeded at the converter station fence. These reference levels for general public exposure at 50Hz are:

- 5 kV/m for Electric Fields determined 1 metre above the ground
- 200 µT for Magnetic Fields determined 1 metre above the ground

The Contractor shall demonstrate the compliance of these requirements during performance tests, any non-performance shall be identified and rectified.

The Contractor shall calculate the magnetic fields and ensure that they are lower than the UK or EU guidelines for occupational personnel and members of the public. A report on the evaluation of electric and magnetic fields shall be issued by the Contractor for review by the Employer.

4.7 Availability and Reliability

An availability and reliability study shall be undertaken as described in the “HVDC-VAT-E-FD-8901 Plant Design”. The HVDC transmission converter system without DC cables shall meet the following availability and reliability minimum performance. Note that the data provided in Table 11 are for information only, to help Contractor when doing the study.

Energy Availability (EA)	*≥ 98.5% comprising:* - *1% (88 hours) Scheduled Energy Unavailability (SEU)* - *0.5% (44 hours) Forced Energy Unavailability (FEU)*
Forced Outage Rate (FOR) *(HVDC link outages per year)*	- Suppler to give guaranteed and Expected

Table 11 – RAM – *check values in commercial documents

The Energy Availability (EA) assumptions (mobilization time, flight time etc.) used by the Contractor shall be accepted by Employer. Where no information is available, the Contractor shall make reasonable assumptions based on previous experience. All definitions used by Contractor shall be as defined in the CIGRE 590 – Protocol for reporting the operational performance of HVDC Transmission Systems."

Furthermore, an evaluation and recommendation with respect to software upgrading and control system mid-life refurbishment of the control and protection system shall be presented to Employer.

5 Applicable Standards, Norms & Regulations

The following ***Table 12*** describes the technical regulations applicable to this system or subsystem.

Standard	Title / Description
ECC	European Connection Conditions
SQSS	Security and Quality of Supply Standard
VCA	Bilateral Connection Agreement
RES	NGET Relevant Electrical Standards
DNVGL-ST-0145	Offshore Substations
DNV-OS-D201	Electrical Installations
DNV-OS-D202	Automation, safety and telecommunication systems
DNV-OS-D301	Fire Protection
2006/42/EG	EU Machine Directive
DIN EN 60079-0:2014-06	Explosive atmospheres - Part 0: Equipment - General requirements
DIN EN 60079-14:2014-10	Explosive atmospheres - Part 14: Electrical installations design, selection and erection
BS/EN 60071	Insulation co-ordination
IEC 60815-1	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
BS EN 50162	Protection against corrosion by stray current from direct current systems
BS EN 12954	General principles of cathodic protection of buried or immersed onshore metallic structures
IEC/TS 60479-1	Effects of current on human beings and livestock
BS EN 50522	Earthing of power installations exceeding 1 kV a.c.
IEC TR 61000	Electromagnetic compatibilty (EMC)
IEC TR 61000-3-6	Electromagnetic compatibilty (EMC)
IEC 61000-4-30	Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods
IEC 61000-4-7	Electromagnetic compatibilty (EMC) Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics

Standard	Title / Description
	measurements and instrumentation, for power supply systems and equipment connected thereto
IEC 62751	Power Losses in VSC Values for HVDC Systems",
IEC 61803	Determination of power losses in high voltage direct current (HVDC) convertor stations
CIGRE WG B4.48	Components Testing of VSC System for HVDC Applications"
CIGRE 590	Protocol for reporting the operational performance of HVDC Transmission Systems
CIGRE TB 391	Guide for measurement of radio frequency interference from HV and MV substations
CISPR 16-1	Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus
CISPR 18-2	Radio interference characteristics of overhead power lines and high voltage equipment – Part 2: Methods of measurement and procedure for determining limits

Table 12 List of applicable standards, norms and regulations

6 References

The following ***Table 13*** describes all references used in this document.

No	Document No.	Description
[1]	HVDC-VAT-Z-FD-0001	General Basic Design Concept
[2]	HVDC-VAT-E-FD-8906	"Studies & Model Concept
[3]	HVDC-VAT-E-FD-8801	"Lightning Protection & Earthing Concept Offshore
[4]	HVDC-VAT-E-FD-8802	Lightning Protection & Earthing Concept Onshore
[5]	HVDC-VAT-E-FD-8902	Control and Protection Concept
[6]	NVW-VAT-Z-RA-0001	MetaOcean data
[7]	HVDC-VAT-A-AA-0002	Terms & Abbreviations

Table 13 References to additional documentation

7 Document Metadata Tags

HVDC, simulation, studies, models, philosophy, concept, process control, SCADA, monitoring, mid-level automation, subsystem automation

8 Appendices

Si. No	Document Title
1.	Appendix 1 - Norfolk Vanguard West - Restated BCA v1.pdf
2.	Appendix 2 - Norfolk Vanguard West - Appendix OF.pdf
3.	Appendix 3 - Harmonic Report.pdf
4.	Appendix 4 - Norfolk Vanguard West Limited - Appendix D.pdf
5.	Appendix 5 - Norfolk Vanguard West Limited - Appendix F.pdf
6.	Appendix 6 - SKT02 NVB 3x1320MW_NomenclatureProposal_GLD

DATED 22 NOVEMBER 2010

NATIONAL GRID ELECTRICITY SYSTEM OPERATOR LIMITED (1)

and

NORFOLK VANGUARD LIMITED (2)

THE CONNECTION AND USE OF SYSTEM CODE

BILATERAL CONNECTION AGREEMENT

FOR THE
DIRECTLY CONNECTED
VANGUARD OFFSHORE WIND FARM
At

VANGUARD
275/66KV OFFSHORE SUBSTATION

Reference: A/EAWL/10/5284-3EN(6-9)

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3. The Connection Site and Transmission Connection Assets

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Appendix F5 Site Specific Technical Conditions - Other Technical Requirements

THIS **BILATERAL CONNECTION AGREEMENT** is made on the 22nd day of November 2010

BETWEEN

(1) **NATIONAL GRID ELECTRICITY SYSTEM OPERATOR LIMITED** a company registered in England and Wales with number 11014226 whose registered office is at 1-3 Strand, London, WC2N 5EH ("**The Company**", which expression shall include its successors and/or permitted assigns); and

(2) **NORFOLK VANGUARD LIMITED** a company registered in England and Wales with number 08141115 whose registered office is at First Floor, Tudor Street, London, EC4Y 0AH (the "**User**", which expression shall include its successors and/or permitted assigns).

WHEREAS

(A) Pursuant to the **Transmission Licence**, **The Company** is required to prepare a Connection and Use of System Code ("**CUSC**") setting out the terms of the arrangements for connection to and use of the **National Electricity Transmission System** and the provision of certain **Balancing Services**.

(B) The **User** has applied for connection to and use of the **National Electricity Transmission System** and pursuant to the **Transmission Licence The Company** is required to offer terms in this respect.

(C) The **User** has applied for connection and use in the capacity of a **Power Station** directly connected to the **National Electricity Transmission System** as set out in Paragraph 1.2.4 of the **CUSC**.

(D) The **Power Station** is located **Offshore**.

(E) **The Company** and the **User** are parties to the **CUSC Framework Agreement** (being an agreement by which the **CUSC** is made contractually binding between **CUSC Parties**).

(F) This **Bilateral Connection Agreement** is entered into pursuant to the **CUSC** and shall be read as being governed by it.

(G) The parties are also on even date herewith entering into a **Construction Agreement**.

NOW IT IS HEREBY AGREED as follows:

1. DEFINITIONS, INTERPRETATION AND CONSTRUCTION

1.1 Unless the subject matter or context otherwise requires or is inconsistent therewith, terms and expressions defined in Section 11 of the **CUSC** have the same meanings, interpretations or constructions in this **Bilateral Connection Agreement** and the following terms and expressions shall have the meaning set out below:-

Backfeed Date	as defined in the **Construction Agreement**.
Charging Date	as defined in the **Construction Agreement**.
Connection Site	the **Connection Site** in respect of the **Vanguard Offshore Wind Farm** (as more specifically identified in Appendix A) to this **Bilateral Connection Agreement**.
Construction Agreement	the agreement made between **The Company** and the **User** (Ref: A/EAWL/10/5284-3EN(0)) (as amended) for the carrying out of the **Onshore Construction Works**.
Diagram	the diagram attached at Appendix D showing the restricted **Relevant Circuits**.
Notification of Circuit Outage	means the notification issued by **The Company** to the **User** in accordance with Clause 13.2 and 13.3 of this **Bilateral Connection Agreement**.
Notification of Circuit Restriction	means the notification issued by **The Company** to the **User** in accordance with Clause 13.6 and Clause 13.7 of this **Bilateral Connection Agreement**.
Notification of Restrictions on Availability	means a **Notification of Circuit Outage** and/or a **Notification of Circuit Restriction** as applicable.
One Off Charge	the charge (if any) as specified in Appendix B.
Onshore Construction works	as defined in the **Construction Agreement**.
Outage Conditions	the planned and/or unplanned unavailability in

	full or in part of any of the **Relevant Circuits** such conditions being as set out in Appendix D Part 2.
Outage Period	the period of time during which the **Outage Conditions** and/or reduced circuit capability apply.
Relevant Circuits	the **Transmission** circuits as described in Appendix D Part 1 and shown on the **Diagram**. In the event of any inconsistency between the text in Appendix D Part 1 and the **Diagram**, the text in Appendix D Part 1 shall prevail.
Restrictions on Availability	the restrictions on availability for the purposes of Clause 13 as set out in Appendix D.
Transmission Charge (Backfeed)	the charge(s) described and specified as such (on an indicative basis) in Appendix B.
Transmission Related Agreement	the agreement of that name made between **The Company** and the **User** (Ref: A/EAWL/10/5284-3EN(0)) (as amended) for the provision of and payment for **Balancing Services** in respect of **Bid-Offer Acceptances** pursuant to Clause 13 of this **Bilateral Connection Agreement**.
Vanguard Offshore Wind Farm	means the 1200MW offshore windfarm.

1.2 Although the substation to which the **Vanguard Offshore Wind Farm** is to be connected is referred to by the name of "Vanguard" the final name of the substation has yet to be determined and references in this **Bilateral Connection Agreement** to "Vanguard substation" shall be construed accordingly.

2. COMMENCEMENT

This **Bilateral Connection Agreement** shall commence on the date hereof.

3. THE CONNECTION SITE AND TRANSMISSION CONNECTION ASSETS

The **Connection Site** and the **Transmission Connection Assets** to which this **Bilateral Connection Agreement** relates are more particularly described in Appendix A.

4. CONNECTION CHARGES

4.1 The **Connection Charges** payable by the **User** in accordance with the **CUSC** in respect of the **Transmission Connection Assets** at the **Connection Site** as set out in Appendix A (including the **One Off Charge** (if any)) are set out in Appendix B. These **Connection Charges** shall be payable by the **User** from the **Charging Date**.

4.2 **Transmission Charge (Backfeed)**

4.2.1 The **User** shall be liable to **The Company** for the **Transmission Charge (Backfeed)** from the **Backfeed Date** until the date specified as the last date of payment of such charge in the first Table in Appendix B Part 5. The **Transmission Charge (Backfeed)** shall be payable by monthly instalments from the **Backfeed Date** and shall be treated as a recurrent monthly charge for the purposes of **CUSC** Paragraph 6.6.2.

4.2.2 **The Company** shall be entitled to invoice the **User** on the basis of the indicative **Transmission Charge (Backfeed**) and as soon as practicable after the **Charging Date** and in any event within one year thereof **The Company** shall provide the **User** with a statement showing the **Transmission Charge (Backfeed)** payable based on the actual cost of carrying out the **Onshore Construction Works** relevant to the calculation of the **Transmission Charge (Backfeed)**.

4.2.3 In the event that the **Transmission Charge (Backfeed**) specified in the statement issued under Clause 4.2.2 is greater than the indicative **Transmission Charge (Backfeed)** paid by the **User**, the **User** shall pay to **The Company** the difference between the two amounts plus interest on a daily basis from the date of payment by the **User** of the indicative **Transmission Charge (Backfeed)** to the date of payment by the **User** of the difference at the **Base Rate**. In the event that the **Transmission Charge (Backfeed)** specified in the statement issued under Clause 4.2.2 is less than the indicative **Transmission Charge (Backfeed) The Company** shall pay to the **User** the difference between the two amounts plus interest on a daily basis from the date of payment by the **User** of the indicative **Transmission Charge (Backfeed)** to the date of repayment by **The Company** of the difference at the **Base Rate**. Such payment of reconciliation

shall be made by one party to the other within twenty-eight (28) days of the statement issued under Clause 4.2.2.

4.3 The **One Off Charge** (other than, for the avoidance of doubt, the **Transmission Charge (Backfeed)**) shall be payable on the **Charging Date** or such other date as specified for payment in Appendix B.

5. USE OF SYSTEM

The right to use the **National Electricity Transmission System** in the case of the **Vanguard Offshore Wind Farm** shall commence on and **Use of System Charges** shall be payable by the **User** from the **Charging Date**.

6. CREDIT REQUIREMENTS

The amount (if any) to be secured by the **User** is set out in the **Secured Amount Statement** issued from time to time and as varied from time to time in accordance with Section 2 of the **CUSC**.

7. CONNECTION ENTRY CAPACITY AND TRANSMISSION ENTRY CAPACITY

7.1 The **Connection Entry Capacity** in relation to the **Generating Units** and the **Connection Site** and the **Transmission Entry Capacity** in relation to the **Vanguard Offshore Wind Farm** are specified in Appendix C.

7.2 Part 3 of Appendix C will set out the **BM Unit Identifiers** of the **BM Units** registered at the **Connection Site** under the **Balancing and Settlement Code**. The **User** will provide **The Company** with the information needed to complete details of these **BM Unit Identifiers** as soon as practicable after the date hereof and thereafter in association with any request to modify the **Transmission Entry Capacity** and **The Company** shall prepare and issue a revised Appendix C incorporating this information. The **User** shall notify **The Company** prior to any alteration in the **BM Unit Identifiers** and **The Company** shall prepare and issue a revised Appendix C incorporating this information.

7.3 **The Company** shall monitor the **User's** compliance with its obligation relating to **Transmission Entry Capacity** at the **Connection Site** against the sum of metered volumes of the **BM Units** set out in Part 3 of Appendix C submitted by the **User** for each **Settlement Period**.

8. COMPLIANCE WITH SITE SPECIFIC TECHNICAL CONDITIONS

The site specific technical conditions applying to the **Connection Site** are set out in the Appendices F1 to F5 to this **Bilateral Connection Agreement** as modified from time to time in accordance with Paragraph 2.9.3 of the **CUSC**.

9. TERM

Subject to the provisions for earlier termination set out in the **CUSC** this **Bilateral Connection Agreement** shall continue in respect of the **Connection Site** until the **User's Equipment** at the **Connection Site** is **Disconnected** from the **National Electricity Transmission System** in accordance with Section 5 of the **CUSC**.

10. VARIATIONS

10.1 Subject to the other Clauses within this **Bilateral Connection Agreement** and Clauses 10.2, 10.3, 10.4, 10.5 and 10.6 below, no variation to this **Bilateral Connection Agreement** shall be effective unless made in writing and signed by or on behalf of both **The Company** and the **User**.

10.2 **The Company** and the **User** shall effect any amendment required to be made to this **Bilateral Connection Agreement** by the **Authority** as a result of a change in the **CUSC** or the **Transmission Licence**, an order or direction made pursuant to the **Act** or a **Licence**, or as a result of settling any of the terms hereof. The **User** hereby authorises and instructs **The Company** to make any such amendment on its behalf and undertakes not to withdraw, qualify or revoke such authority or instruction at any time.

10.3 **The Company** has the right to vary Appendices A and B in accordance with this **Bilateral Connection Agreement** and the **CUSC** including any variation necessary to enable **The Company** to charge in accordance with the **Charging Statements**, or upon any change to the **Charging Statements**.

10.4 Appendices A and B shall be varied automatically to reflect any change to the **Onshore Construction Works** or **Transmission Connection Assets** as provided for in the **Construction Agreement** and Appendix C as provided for in Clause 7 of the **Construction Agreement**.

10.5 **The Company** has the right to vary this **Bilateral Connection Agreement** as provided for in Clause 1.3 and Clause 15 of the **Construction Agreement**.

10.6 **The Company** has the right to vary Appendices F1 to F5 to the **Bilateral Connection Agreement** to reflect any amendment or additions to the Site Specific Technical Conditions.

10.7 If the terms of the **Bilateral Connection Agreement** are in dispute and are referred by either party to the **Authority** for determination pursuant to C9 of the **Transmission Licence** prior to acceptance then the **User** acknowledges that **The Company** shall be entitled to amend this **Bilateral Connection Agreement** as necessary to reflect the consequences of any delay in the **User** acceptance of the **Bilateral Connection Agreement**.

11. GENERAL PROVISIONS

Paragraph 6.10 and Paragraphs 6.12 to 6.26 of the **CUSC** are incorporated into this **Bilateral Connection Agreement** *mutatis mutandis*.

Notwithstanding this Clause 11 and **CUSC** Paragraph 6.14.1, **The Company** agrees that the **User** shall have the right to assign, novate or otherwise transfer its rights, obligations, title and interest in this **Bilateral Connection Agreement** to an **Affiliate**, subject to such **Affiliate** complying with the conditions as set out in **CUSC** Paragraph 6.14.1.2 which the purchaser (as referred to in **CUSC** Paragraph 6.14.1) would be required to comply with.

12. OWNERSHIP BOUNDARY

12.1 For the purposes of **CUSC** Paragraph 2.12.1, and subject to Clause 12.2, the division of **Plant** and **Apparatus** at the **Connection Site** shall be at the busbar side of each of the 33kV transformer circuit breakers on the platform.

12.2 Once the design of the **Offshore** substation, which is of a gas insulated switchgear design, has been finalised **The Company** shall consider the appropriate division of ownership for the purposes of **CUSC** Paragraph 2.12.1 and in the event that this is otherwise than in accordance with **CUSC** Paragraph 2.12(e) or Clause 12.1 above **The Company** shall advise the **User** accordingly and **The Company** shall be entitled to make such changes to this **Bilateral Connection Agreement** as necessary to reflect this division of ownership and the consequences of the same.

13. RESTRICTIONS ON AVAILABILITY

13.1 As the connection design which provides for connection to the **National Electricity Transmission System** of the **Vanguard Offshore Wind Farm** is of an **Offshore Standard Design**, **Restrictions on Availability** will apply as follows.

13.2 **The Company** shall issue to the **User** a notice that advises the **User** of the occurrence of the **Outage Conditions** and where practicable the expected **Outage Period**. Such notice shall be issued:

13.2.1 In the event that the **Notification of Circuit Outage** relates to a **Planned Outage** on the **National Electricity Transmission System**, where practicable, in accordance with **Grid Code** OC2 requirements; or

13.2.2 In the event that the **Notification of Circuit Outage** relates to something other than a **Planned Outage** on the **National Electricity Transmission System** or relates to a **Planned Outage** on the **National Electricity Transmission System** but it is not practicable for such notice to be in accordance with **Grid Code** OC2 requirements, as soon as reasonably practicable and **The Company** and the **User** shall agree as soon as practicable after the date hereof the method of such notification.

13.2.3 **The Company** shall promptly notify the **User** when the **Outage Period** will or has ceased.

13.3 **The Company** shall be entitled to revise the **Notification of Circuit Outage** given under Clause 13.2 above at any time.

13.4 The **User** will acknowledge receipt of such **Notification of Circuit Outage** and where practicable shall revise its **Output Useable** forecast for the affected **BM Unit** accordingly.

13.5 Following such **Notification of Circuit Outage** in accordance with Clause 13.2:

13.5.1 In respect of the **Outage Conditions**, the **User** shall (i) ensure that the **Maximum Export Limit** and **Maximum Import Limit** for the **BM Units** relating to the **Vanguard Offshore Wind Farm** reflects the requirements at Appendix D Part 2 and (ii) operate the **Vanguard Offshore Wind Farm** to reflect the outage of the **Relevant Circuits** for all **Settlement Periods** or parts thereof falling within the **Outage Period**.

13.5.2 In the event that the **User** does not comply with Clause 13.5.1 above, **The Company** shall issue **Bid-Offer Acceptances** to the **User** to reduce the export from and/or import to the affected **BM Units** so that the effect is as if the **User** had complied with the relevant Clause, and the provisions of the **Transmission Related Agreement** shall apply.

13.6 **The Company** shall issue to the **User** a notice that advises the **User** of an event or circumstance on or directly affecting the **Relevant Circuits** leading to a reduced circuit capability of the **Relevant Circuits** and where practicable the expected **Outage Period**. Such notice (including any revision) shall be issued:

13.6.1 In the event that the **Notification of Circuit Restriction** relates to a **Planned Outage** on the **National Electricity Transmission System**, where practicable, in accordance with **Grid Code** OC2 requirements; or

13.6.2 In the event that the **Notification of Circuit Restriction** relates to something other than a **Planned Outage** on the **National Electricity Transmission System** or relates to a **Planned Outage** on the **National Electricity Transmission System** but it is not

practicable for such notice to be in accordance with **Grid Code** OC2 requirements, such notice shall be given as soon as reasonably practicable and **The Company** and the **User** shall agree as soon as practicable after the date hereof the means of such notification.

13.6.3 **The Company** shall promptly notify the **User** when the period of reduced circuit capability will or has ceased.

13.7 **The Company** shall be entitled to revise the **Notification of Circuit Restriction** given under Clause 13.6 above at any time.

13.8 Following such **Notification of Circuit Restriction** in accordance with Clause 13.6:

13.8.1 In respect of the reduction in capability of the **Relevant Circuits**, the **User** shall (i) ensure that the **Maximum Export Limit** and **Maximum Import Limit** for the **BM Units** relating to the **Vanguard Offshore Wind Farm** reflects the reduction in capability of the **Relevant Circuits** and (ii) operate the **Vanguard Offshore Wind Farm** to reflect the reduction in capability of the **Relevant Circuits** for all **Settlement Periods** or parts thereof falling within the **Outage Period**.

13.8.2 In the event that the **User** does not comply with Clause 13.8.1 above, **The Company** shall issue **Bid-Offer Acceptances** to the **User** to reduce the export from and/or import to the affected **BM Units** so that the effect is as if the **User** had complied with the Clause, and the provisions of the **Transmission Related Agreement** shall apply.

14. CONSEQUENCES OF OPERATIONAL RESTRICTIONS

14.1 Where the **User** becomes aware or is notified by **The Company** of any breach of Clause 13.5 or Clause 13.8 above the **User** shall forthwith take all reasonable steps to comply with the provisions of that Clause.

14.2 Where the **User** breaches in whole or in part the provisions of Clause 13.5 or Clause 13.8 above, the **User** shall at **The Company's** request explain to **The Company's** satisfaction (acting reasonably) the reason for the breach and demonstrate to **The Company's** satisfaction that appropriate steps have been taken to ensure that such breach will not reoccur. In the event that the **User** does not do this **The Company** may give notice to the **User** reducing the **Transmission Entry Capacity** of the **Connection Site** and Appendix C of this **Bilateral Connection Agreement** shall be varied accordingly. This **Transmission Entry Capacity** shall apply until such time as the **User** has explained to **The Company's** reasonable satisfaction the reason for the breach and has demonstrated that appropriate steps have been taken to ensure that such breach will not reoccur and Appendix C shall be automatically amended thereafter to reflect the reinstatement of the **Transmission Entry Capacity**.

14.3 If within 3 months of a breach of Clause 13.5 or Clause 13.8 above which entitled **The Company** to take action under Clause 15.2 above, the **User** has still failed to provide the explanation and/or demonstration required by **The Company** under Clause 14.2 then **The Company** may treat such breach as an **Event of Default** for the purposes of Section 5 of the **CUSC** and following such breach may give notice of termination to the **User** whereupon this **Bilateral Connection Agreement** shall terminate and the provisions of **CUSC** Paragraph 5.4.7 shall apply.

14.4 For the avoidance of doubt any **Deenergisation** resulting from the **Outage Conditions** as set out in the relevant **Notification of Restrictions on Availability** constitutes an **Allowed Interruption**.

14.5 **The Company** and the **User** shall act in accordance with **Good Industry Practice** to minimise so far as reasonably practicable the occurrence and duration of (i) the **Outage Conditions** and (ii) an **Event** leading to reduced circuit capability of the **Relevant Circuits**. **The Company** and the **User** will, recognising the effect of the **Outage Conditions** and the reduced circuit capability on the **User's** operations, coordinate the **Outage Conditions** and the reduced circuit capability on the **National Electricity Transmission System** (where they occur as a result of a **Planned Outage**) and the **User's Plant** and **Apparatus** in accordance with **Good Industry Practice** and to the extent practicable. **The Company** and the **User** acknowledge however that even where **Planned Outages** are coordinated and agreed that **The Company** and\or the **User** may need to cancel or change such **Planned Outage**.

14.6 **The Company** and the **User** hereby acknowledge and agree that, where reasonably practicable, alternative operating arrangements shall be implemented to minimise the effect of **Outage Conditions** and reduced circuit capability. In the event that **The Company** and the **User** implement alternative operating arrangements in respect of **Outage Conditions** and reduced circuit capability, the provisions of Clause 13.5 and Clause 13.8 and shall not apply to the extent that the alternative operating arrangements mitigate the restrictions (whether in whole or in part) that would otherwise apply to the **User** under Clause 13 for all **Settlement Periods** or parts thereof falling within the **Outage Period** or period of reduced circuit capability.

15 FINANCING

Where reasonably requested by the **User** to do so, **The Company** agrees to enter into a direct agreement in a form as may be reasonably required by the **User** for the benefit of a funder or funders undertaking a project financing (or refinancing) or providing other material funding or credit support in respect of the **Vanguard Offshore Wind Farm** to which this **Bilateral Connection Agreement** relates which shall include (without limitation) the funder (or funders) being given the right to step into this **Bilateral Connection Agreement** in given situations and to procure novation of the **User's** rights and obligations under this **Bilateral Connection Agreement**.

16 OTSDUW Build

16.1 Where the **Transmission Interface Site** is to be **Operational** prior to the **OTSUA Transfer Time**, during such period the following provisions shall apply and the other provisions of this **Bilateral Connection Agreement** shall be construed accordingly.

16.2 The **OTSUA** will be connected to the **National Electricity Transmission System** at the **Transmission Interface Point** and:

(i) until the **OTSUA Transfer Time** the provisions of **CUSC** Paragraphs 2.2, 2.3 and 2.4 shall apply by reference to the **Transmission Interface Site** rather than the **Connection Site**;

(ii) until the **OTSUA Transfer Time** the obligation at **CUSC** Paragraph 2.5 shall apply by reference to the **Transmission Plant** and **Transmission Apparatus** at the **Transmission Interface Site**;

(iii) until the **OTSUA Transfer Time**, in addition to its obligations at Clause 8 of this **Bilateral Connection Agreement**, the **User** shall operate the **OTSUA** in accordance with Appendices OF3 and OF4 to the **Construction Agreement**;

(iv) until the **OTSUA Transfer Time** the **User** shall comply with the site specific technical conditions set out in Appendix OF5 to the **Construction Agreement** and **CUSC** Paragraph 2.9.3 shall also apply by reference to Appendices OF1, OF3, OF4 and OF5 as attached to the **Construction Agreement**;

(v) the division of ownership of **Plant** and **Apparatus** at the **Transmission Interface Site** is at the busbar clamp on the busbar side of the busbar isolators on the **Offshore Transmission** circuits at Necton 400kV substation and will be confirmed once the design of this substation (GIS or AIS) is decided;

(vi) until the **OTSUA Transfer Time** the **Connection Charges** and **Use of System Charges** shall not take account of any **OTSUA** that will, at the **OTSUA Transfer Time**, become **Transmission Connection Assets**;

(vii) at and after the **OTSUA Transfer Time** the **Connection Charges** and **Use of System Charges** shall take account of the **OTSUA** (including any **OTSUA** that will become **Transmission Connection Assets**);

(viii) until the **OTSUA Transfer Time** the **Offshore Restrictions on Availability** shall not apply;

(ix) at the **OTSUA Transfer Time** the **Offshore Restrictions on Availability** shall apply.

IN WITNESS WHEREOF the hands of the duly authorised representatives of the parties hereto at the date first above written

SIGNED BY)

Name)

for and on behalf of)

NATIONAL GRID ELECTRICITY)

SYSTEM OPERATOR LIMITED)

SIGNED BY)

Name)

for and on behalf of)

NORFOLK VANGUARD LIMITED)

APPENDIX OF

SITE SPECIFIC TECHNICAL CONDITIONS
CONTENTS

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Contents

OF1 Agreed Ancillary Services

OF2 Derogated Plant

OF3 Special Automatic Facilities

OF4 Relay Settings & Protection

OF5 Other Technical Requirements

Terms

For the purposes of the body of this Appendix OF only, the term "OTSDUW User" is used when referring to the OTSDUW User in its capacity as a Generator connecting to the Offshore Transmission Network at the Offshore Grid Entry Point and the term "OTSDUW User" (where OTSDUW stands for Offshore Transmission System Developer User Works) is used when referring to the User in its role in undertaking the design, construction and commissioning of the OTSDUW Plant and Apparatus between the Transmission Interface Point and Offshore Grid Entry Point. The OTSDUW User shall be responsible for the design, installation and commissioning of the Offshore Transmission Network until the OTSUA (Offshore Transmission System User Assets) Transfer Time from when the responsibilities of the Offshore Transmission Network will rest with the appointed Relevant Transmission Licensee (RTL).

For the purpose of this Agreement it is assumed that the OTSDUW Plant and Apparatus (which includes the Offshore Transmission System) comprises one or more Transmission DC Converter(s).

For the purposes of this agreement the OTSDUW User would be considered to own or operate either DC Connected Power Park Modules or Synchronous Power Generating Modules.

General

The requirements of this Appendix OF apply to all OTSDUW Plant and Apparatus which utilise a Transmission DC Converter from the Transmission Interface Point to the Offshore Grid Entry Point.

Electrical Standards

(PC.1, PC.2.1, PC.6.4, PC.6.5, PC.6.6, PC.6.7, PC Appendix E, PC Appendix F, ECC.6.2.1.2)

Note: This shall include steady state, fault level, dynamic and transient analysis including insulation co-ordination together with voltage waveform quality assessment.

The OTSDUW User shall inform The Company of the standards used in designing the OTSDUW Plant and Apparatus and shall ensure that it is suitably designed to operate in a marine environment.

These appendices contain references to the Relevant Electrical Standards (RES) throughout. The OTSDUW Plant and Apparatus contained within the Transmission busbar protection zone at the Transmission Interface Point (see Grid Code ECC 6.2.1.2) is required to comply with the RES. The OTSDUW User can access this document from The Company's website which is available at:-

https://www.nationalgrideso.com/uk/electricity/codes/grid-code/electrical-standards-documents-including-specifications-electronic

The RES are updated periodically. If the RES is updated in the period between issuing the Connection Offer and the OTSDUW Plant and Apparatus being connected to the Onshore Transmission System, then The Company and Onshore Transmission Licensee will seek agreement with the OTSDUW User to use the updated RES at the Transmission Interface Point in respect of the OTSDUW Plant and Apparatus.

Data Submission
(DRC.6.1.18)

The Company and Onshore Transmission Licensee will need to model the OTSDUW Plant and Apparatus. To enable this process to take place, the OTSDUW User shall submit data in accordance with the applicable requirements of the Grid Code which shall include but is not limited to PC.4.4, PC.8 and DRC.6.1.18.

APPENDIX OF1

SITE SPECIFIC TECHNICAL CONDITIONS
BALANCING SERVICES

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Agreed Ancillary Services

No Commercial Transmission System to Generator Operational Intertripping Schemes have been identified at this time. However, should such a requirement be identified prior to the OTSUA Transfer Time, the OTSDUW User shall co-operate with The Company in developing these facilities, and will not unreasonably withhold its agreement to any such proposals.

The OTSDUW User shall co-operate with The Company in installing, enhancing, and amending these facilities, should The Company require this prior to the OTSUA Transfer Time, and will not unreasonably withhold its agreement to any such proposals.

APPENDIX OF2

SITE SPECIFIC TECHNICAL CONDITIONS
DEROGATED PLANT

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Derogated Plant

Not applicable.

APPENDIX OF3

SITE SPECIFIC TECHNICAL CONDITIONS
SPECIAL AUTOMATIC FACILITIES

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Special Automatic Facilities

1. Operational Intertripping schemes

Facilitation of Transmission System to Generating Unit Intertripping Schemes

Appendix OF3 of this Bilateral Connection Agreement places obligations on the EU Code User to trip under certain Transmission outage conditions. The OTSDUW User shall provide communication routes and monitoring facilities between the Transmission Interface Point at Necton 400 kV Onshore Substation and the Offshore Grid Entry Point at Norfolk Vanguard 66 kV Offshore Platform in order to facilitate this intertripping scheme.

The Onshore Transmission Licensee will provide the required signals to facilitate this intertripping facility to a marshalling cubicle located at the Transmission Interface Point. The OTSDUW User will provide for the installation and maintenance of duplicated communications routes between the Offshore Grid Entry Point at Norfolk Vanguard 66 kV Offshore Substation and the Onshore Transmission Licensee's marshalling cubicle at the Transmission Interface Point. Once in operation (after the OTSUA Transfer Time), the ownership of part or the whole of the communication equipment will be transferred to the appointed Offshore Transmission Licensee from when each party (Eu Code User and Offshore Transmission Licensee) will then be responsible for the maintenance of their own assets.

Once installed, the intertripping scheme will be monitored to ensure it is healthy at all times and provide indications to The Company for all selections as specified in Schedule 2 of this OF3. Specific requirements to be agreed in the detailed design phase.

The functionality, performance, availability, accuracy, dependability, security, protocol and repair times of the communications links, trip facilities and monitoring facilities, from the marshalling cubicles located at the Transmission Interface Point to the Offshore Grid Entry Point shall be agreed between the Onshore Transmission Licensee, The Company and the OTSDUW User at least 24 months before the Completion Date unless otherwise agreed. These requirements shall apply up to the OTSUA Transfer Time from when these responsibilities shall lie with the Offshore Transmission Licensee.

No single hardware, software, system, communication, interface or power supply failure or depletion of facility shall result in failure to trip within the specified time or an incorrect control action.

The OTSDUW User shall ensure that the OTSDUW Plant and Apparatus is fully robust and protected against total disconnection from the National Electricity Transmission System.

2. General

The EU Code User and OTSDUW User shall co-operate with The Company and Onshore Transmission Licensee in enhancing/amending these facilities, should The Company or Onshore Transmission Licensee require this prior to the OTSUA Transfer Time, and will not unreasonably withhold its agreement to any such proposals.

3. Other Facilities
(ECC.6.2.2.7)

Requirement	
Automatic Open/ Closure Schemes	Not applicable unless specified.
System Splitting/Islanding Schemes	Not applicable unless specified.

4. Synchronising requirements at the Transmission Interface Point

The OTSDUW User will be required to interface with the National Electricity Transmission System substation synchronising system in accordance with the TS.3.24.60_RES. In circumstances where the OTSDUW User does not synchronise at the Transmission Interface Point, the OTSDUW User is required to participate in the Onshore Transmission Licensee's voltage selection scheme.

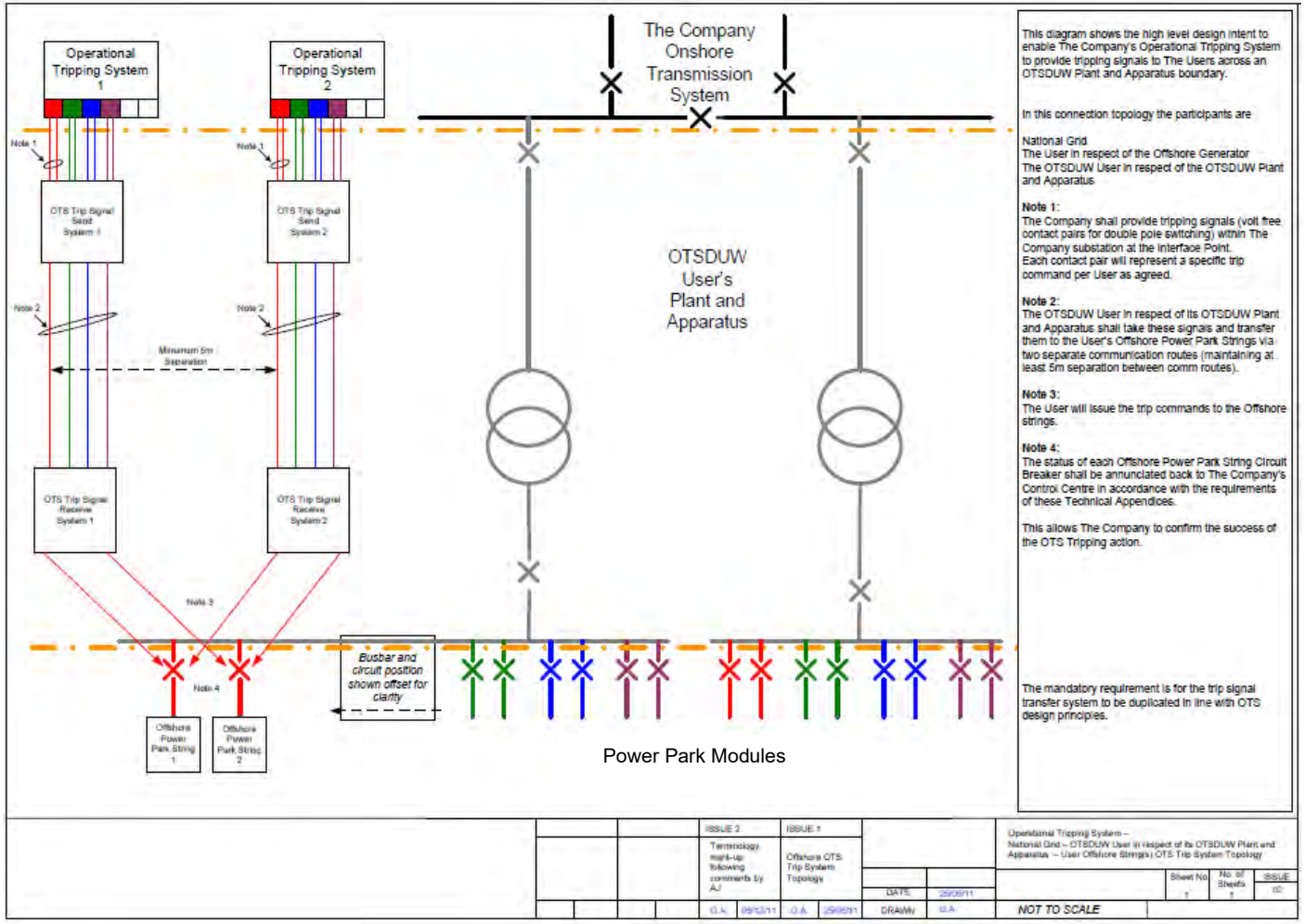
In addition the OTSDUW User is required to meet the requirements of ECC.6.2.2.9.

5. Synchronising requirements at the Offshore Grid Entry Point

The OTSDUW User will be required to satisfy the requirements of ECC.6.2.2.9.4 at the Offshore Grid Entry Point and ensure that the OTSDUW User's Plant and Apparatus interfaces with the Voltage Selection Scheme.

The voltage selection scheme is defined as the voltage signal information (e.g. magnitude, phase and angle) derived from a suitable voltage transformer (VT) across the boundary at the Offshore Grid Entry Point for the purposes of safe synchronising or energisation between the OTSDUW User and OTSDUW User.

Appendix OF3 – Schedule 1
Site Specific Technical Conditions – Operational Intertripping Installation and Connection Arrangements



Note: The minimum separation (indicatively shown as 5 m) for the operational tripping system communication channels shall be agreed between the Onshore Transmission Licensee (via The Company), EU Code User and OTSDUW User in Detail Design Phase.

APPENDIX OF4

SITE SPECIFIC TECHNICAL CONDITIONS
RELAY SETTINGS & PROTECTION

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Relay Settings and Protection

1.1 Relay Settings
(ECC.6.2.2.5, ECC.6.2.2.6)

The OTSDUW User shall complete the attached blank protection schedule pro-forma (Schedule 1 of this Appendix) in respect of the OTSDUW Plant and Apparatus at the Transmission Interface Point at Necton 400kV Onshore Substation. The OTSDUW User shall submit the protection coordination report and settings on its plant for agreement with The Company and Onshore Transmission Licensee. This shall include details of the following:

a) Circuit diagrams of both ac connections and tripping for the purposes of interpreting the schedule.

b) Protection co-ordination report confirming compliance with the applicable clauses of the Grid Code Connection Conditions. The report shall also show how co-ordination with the Transmission Owner's existing system backup protection is achieved including proposed back-up protection grading curves.

c) Details of the Protection Dependability Index per protected zone. (ECC 6.2.2.2.2 d)

Not less than 3 months before the Commissioning Programme Commencement Date (as defined in the CUSC/Appendix J of this Agreement) for the agreed works, the OTSDUW User shall have agreed the protection settings on the OTSDUW Plant and Apparatus at the Transmission Interface Point with The Company and the Onshore Transmission Licensee. The Company and the Onshore Transmission Licensee shall then finalise the protection settings on the Onshore Transmission Licensee's equipment, complete the protection schedule with supporting details where necessary, and supply it to the OTSDUW User (or Offshore Transmission Licensee) following the OTSDUA Transfer Time.

Any subsequent alterations to the protection settings, prior to the OTSUA Transfer Time (whether by the OTSDUW User, the Onshore Transmission Licensee or The Company) shall be agreed between The Company, the Onshore Transmission Licensee and the OTSDUW User in accordance with the Grid Code (ECC.6.2.2.5).

No OTSDUW Plant and Apparatus at the Transmission Interface Point shall be energised until the protection settings have been finalised. The OTSDUW User shall agree with The Company and Onshore Transmission Licensee, and carry out a combined commissioning programme for the protection systems, and generally, to a minimum standard as specified in the in the Onshore Transmission Licensee Transmission Procedure (TP) 106 which is available from the Onshore Transmission Licensee's Extranet. Access to The Company's Extranet can be requested via email to:- transmission.documentcontrol@nationalgrid.com.

HVDC System Owners should also be aware of the general protection and control requirements in ECC.6.2.2.8.

1.2. Relay Settings at the Offshore Grid Entry Point

(ECC.6.2.2.5)

The OTSDUW User shall agree the Protection settings submitted by the OTSDUW User (as provided by the OTSDUW User to The Company). For the avoidance of doubt the OTSDUW User is required to submit the protection schedule pro-forma (Schedule 1 of Appendix F4 of the Bilateral Connection Agreement to The Company) and the following information: -

a) Circuit diagrams of both ac connections and tripping for the purposes of interpreting the schedule.

b) Proposed back-up protection grading curves to allow The Company to assess adequacy of co-ordination.

c) Details of the Protection Dependability Index per protected zone. (ECC 6.2.2.2.2 (d))

The OTSDUW User must finalise the protection settings for the OTSDUW Plant and Apparatus at the Offshore Grid Entry Point with the OTSDUW User via The Company.

Any subsequent alterations to the protection settings by the OTSDUW User prior to the OTSUA Transfer Time shall be agreed with the OTSDUW User (via The Company), in accordance with the Grid Code (ECC.6.2.2.5).

No OTSDUW User Plant and Apparatus at the Offshore Grid Entry Point shall be energised until the protection settings have been finalised. The OTSDUW User shall agree the OTSDUW User's commissioning programme for the protection systems at the Offshore Grid Entry Point with the OTSDUW User (via The Company).

2.1 Protection Arrangements at the Transmission Interface Point
(ECC 6.2.2.2)

The fault clearance time (from fault inception to circuit breaker arc extinction) for faults on the OTSDUW Plant and Apparatus directly connected to the Onshore Transmission System shall meet the following minimum requirement(s): -

400kV within 80ms.

For faults on transformers the clearance time is specified for the HV side (e.g. for a fault on an interconnecting transformer the maximum clearance time is 120ms). Where tripping is required to open the remote end circuit breakers, the overall fault clearance time shall not be extended by more than 60ms (total 180ms in this example) to allow such intertripping to operate.

2.2 Protection Arrangements at the Offshore Grid Entry Point
(Grid Code ECC 6.2.2.2.2)

The fault clearance time (from fault inception to circuit breaker arc extinction) for faults on all the OTSDUW User's Plant and Apparatus connected to the Offshore Grid Entry Point shall be agreed between the OTSDUW User and OTSDUW User (via The Company) in the detailed design phase. At the very least this shall be 18 months before the Completion Date unless otherwise agreed.

APPENDIX OF4 - Schedule 1

PROTECTION AND INTERTRIPPING DETAILS AT THE ONSHORE TRANSMISSION LICENSEE/OTSDUW USER INTERFACE

SITE NAME:

CIRCUIT NAME*:
* where a feeder exists between two sites, a separate schedule will be required for each end.

CIRCUIT BREAKER TO BE OPERATED	PROTECTION					SPECIFIED CLEARANCE TIME (See F4 Item 2)	MOST PROBABLE CLEARANCE TIME					FAULT SETTING		RELAY SETTINGS PLUS COMPONENT VALUES	CT RATIO
	PROTECTED ZONE	FUNCTION	MAKE	TYPE/ RATING	DEPENDABILITY INDEX		PROT^{N}	TRIP RELAY	CB	INTER TRIP	TOTAL	PHASE-PHASE	PHASE-EARTH		

OTSDUW User Representative Name: Date: Signature:

Onshore Transmission Licensee Representative Name: Date: Signature:

APPENDIX OF5

SITE SPECIFIC TECHNICAL CONDITIONS
OTHER TECHNICAL REQUIREMENTS

OTSDUW User:	Norfolk Vanguard Limited
EU Code User	Norfolk Vanguard Limited
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Other Technical Requirements

The OTSDUW User can gain access to the technical specifications from the Relevant Transmission Licensee's Extranet website. Access to the Relevant Transmission Licensee's Extranet website can be requested via email to:- transmission.documentcontrol@nationalgrid.com .

	Criteria	**Grid Code Ref – OTSDUW User to comply with:**	**Obligations**
1.	Protection of interconnecting connections at the Transmission Interface Point	ECC 6.2.2.3.1 ECC.6.2.2.2.2	Defined as connections between current transformers on the circuit side of the OTSDUW Plant and Apparatus of the circuit breaker and the busbar clamps on the busbar side of the busbar selector disconnectors at the Transmission Interface Point. Onshore Transmission Licensee: Shall design the protection scheme for the Interconnection Connections at the site once the Construction Programme has commenced. The OTSDUW User: Shall install auxiliary components on its circuits compatible with those of the Onshore Transmission Licensee to provide the required dependability and setting for the protection.

			Provide two current transformers type PX-B cores in each of the EU Code User's bays in accordance with TS 3.02.04_RES exclusively for use by Onshore Transmission Licensee for the protection of the Interconnecting Connections. This will ensure compatibility with Onshore Transmission Licensee's interconnecting connections protection system. All protection equipment capable of tripping the interconnecting circuit breaker shall comply with ECC.6.2.2.2.2 of the Grid Code.
2.	Protection of interconnecting connections at the Offshore Grid Entry Point	ECC 6.2.2.3.1	<u>The OTSDUW User:</u> To agree the requirements for the protection of the Interconnecting Connections at the Offshore Grid Entry Point with the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date unless otherwise agreed.
3.	Circuit Breaker Fail Protection at the Offshore Grid Entry Point	ECC.6.2.2.3.2	<u>The OTSDUW User:</u> To agree the requirements for Circuit Breaker Fail Protection installed as part of the OTSDUW User's Plant and Apparatus at the Offshore Grid Entry Point with The OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date unless otherwise agreed.
4.	Circuit Breaker Fail Protection at the Transmission Interface Point	ECC.6.2.2.3.2	<u>The OTSDUW User:</u> To install circuit breaker fail protection equipment on all OTSDUW Plant and Apparatus circuit breakers operating at Supergrid Voltage that interface directly with the Onshore Transmission System. The OTSDUW User shall provide Circuit breaker fail back trip facilities to integrate with the Onshore Transmission Licensee's back tripping scheme. Alarms and Indications associated with the Circuit Breaker Fail Scheme must be provided to The Company and Onshore Transmission Licensee to indicate operation of circuit breaker fail protection. In the event that the Circuit Breaker Fail is an integral function of the Onshore Transmission Licensee's busbar protection scheme, the OTSDUW User shall provide CT signals, plant status and initiation contacts from their bay(s) to The Company and the Onshore Transmission Licensee. The OTSDUW User shall accept trip commands from the Onshore Transmission Licensee's Busbar Protection/Circuit Breaker Fail scheme to the OTSDUW User's circuit breaker trip systems. All provisions are to be in accordance with TS.3.24.39_RES.
5.	Fault Disconnection Facilities		<u>The OTSDUW User:</u> To make provision for tripping of the circuit breakers forming part of the OTSDUW Plant and Apparatus at the Transmission Interface Point by the Onshore Transmission Licensee's protection systems in accordance with RES. Fault Disconnection Facilities at the Offshore Grid Entry Point are to be installed only if agreed between the OTSDUW User and OTSDUW User (via The Company).

6.	Reactive capability at the Transmission Interface Point	ECC.6.3.2.4	The OTSDUW User: Required to meet the requirements of ECC.6.3.2.4 of the Grid Code.
7.	Paralleling		Any requirements for paralleling shall be discussed and agreed between the OTSDUW User, The Company and the Onshore Transmission Licensee in the detailed design phase.
8.	Voltage Control Requirements at the Transmission Interface Point	ECC.6.3.8.4 ECC.A.7	The OTSDUW User: The OTSDUW Plant and Apparatus shall be capable of controlling the voltage at the Transmission Interface Point as defined in ECC.6.3.8.4. The voltage control performance requirements at the Transmission Interface Point are detailed in Appendix 7 of the Grid Code Connection Conditions.
9.	Fault Ride Through		The OTSDUW User: Is required to ensure that its OTSDUW Plant and Apparatus meets the requirements of ECC.6.3.15 of the Grid Code where applicable. The maximum fault clearance time on the National Electricity Transmission System shall be taken as 140ms. For Supergrid Voltage dips exceeding 140ms but less than 800ms the OTSDUW User shall perform studies (and submit results thereof to The Company and Onshore Transmission Licensee) to determine the time to recovery to the pre-fault Active Power output following fault clearance. Studies should include the case where the OTDSUW Plant and Apparatus is operating at the Transmission Interface Point Capacity MVA Output (i.e. maximum rated Real and Reactive Power Output). The OTSDUW User will provide a copy of the studies to The Company and Onshore Transmission Licensee and details of the speed of Active Power recovery following fault clearance. Any additional requirements for Real and Reactive Power injection during and immediately after the fault shall be discussed and agreed between the OTSDUW User, the Onshore Transmission Licensee and The Company as soon as reasonably practicable which should be at least 36 months before the Completion Date unless otherwise agreed with The Company and the Onshore Transmission Licensee.
10.	Power Modulation, Power Oscillation Damping and Active Power Dynamic Control for the Provision of Wider Transmission System Stability		The Company (in collaboration with the Onshore Transmission Licensee): If appropriate The Company may define requirements for design of the damping control by a date defined in Appendix J of the Construction Agreement. The OTSDUW User: If required, to make provision for installation of the damping controller. To provide details to The Company and Onshore Transmission Licensee of the proposed control, settings and time constants of this equipment in the Detailed Design Phase (User to provide date of data submission) to enable collaborative analysis.

			To increase Transmission System Stability during a remote large signal disturbance on the NETS, each HVDC Converter within an HVDC System shall reduce Active Power Output whilst maximising the injection of Reactive Power for the duration of the fault: • Active Power reduced to zero MW in 100ms (unless otherwise agreed with The Company and the Onshore Transmission Licensee) and maintained at zero MW (import/export) within an agreed tolerance for the duration of the fault (up to 140ms); • Active Power to then be gradually restored in co-ordination with fault ride through requirements; • Performance of each HVDC Converter within the HVDC System during the fault shall not generate instability on other EU Code User's Plant and Apparatus. The performance of this controller shall be agreed with The Company and Onshore Transmission Licensee.
11.	Harmonic Performance at the Transmission Interface Point	ECC.6.1.5 (a) ECC.6.1.7	<u>The OTSDUW User:</u> Confirm that the harmonic limits previously specified and reported in report "Harmonic Loci and Limits – Norfolk R3 Projects Harmonic Compliance", 12182-07, 03-July-2020 still satisfies the requirements for TEC increase from 1200MW to 1320MW for the project as carried out in accordance with procedures specified in Engineering Recommendation (ER) G5/5. The OTSDUW User shall comply with the limits specified by The Company (in collaboration with the Onshore Transmission Licensee). The OTSDUW User shall undertake Harmonic voltage distortion assessments in accordance with Grid Code Conditions ECC.6.1.5(a). Any inter-harmonic component produced by the OTSDUW User's equipment shall be determined in accordance with relevant sections in ER G5/5. If the predicted level of inter-harmonic distortion is below 0.1%, no further assessment is required. If the inter-harmonic distortion is above 0.1%, the OTSDUW User shall inform The Company, The Company will then (in consultation with the Onshore Transmission Licensee) specify inter-harmonic distortion limits to the OTSDUW User. The timeframe for provision of inter-harmonic distortion limits shall be agreed between The Company, the Onshore Transmission Licensee and the OTSDUW User. The OTSDUW User will provide The Company (for onward transmission to the Onshore Transmission Licensee) with Harmonic Assessment information (as specified in PC.4.4.2, PC.4.5, PC.A.5.4.3.4, DRC.6.1.1 Schedule 1 and DRC.6.1.5 Schedule 5 of the Grid Code) and also, in accordance with ER G5/5, submit a report to confirm compliance with limits specified (including inter-harmonic distortion) by the date specified in Appendix J of the Construction Agreement.
12.	Power Quality Monitoring at the Transmission Interface Point		<u>The OTSDUW User:</u> To provide three phase voltage transducers on the OTSDUW Plant and Apparatus of suitable accuracy and performance. These shall be appropriately sited at the Transmission Interface Point to enable continuous power quality voltage monitoring to be undertaken whether or not the OTSDUW User's Plant and Apparatus is energised.

			Examples of suitable voltage traducers are detailed in TS 3.02.05_RES "Voltage Transformers" (with particular reference to section 1.3) or, alternatively, in TS 3.02.12_RES "Voltage Dividers." Also, to provide three phase current transducers of suitable accuracy and performance on the OTSDUW Plant and Apparatus at the Transmission Interface Point to enable continuous power quality current monitoring to be undertaken. The current transducers in the DC Converter feeder shall be sited such that the monitored currents include any contribution from reactive power compensation and/or harmonic mitigation equipment, if any. (A current transducer would be suitable for power quality monitoring if it is also compliant with International Standard IEC 61869-1 and IEC 61869-2). The transducers would be required to meet TS 3.02.04_RES "Current Transformers for Protection and General Use." The OTSDUW User shall provide the output signal of these voltage and current transducers to The Company and the Onshore Transmission Licensee. <u>The Onshore Transmission Licensee:</u> To install permanent, Class A power quality monitors as defined in IEC 61000 4-30 at the Transmission Interface Point in order to check compliance against the specified limits. Also, to provide cubicle space, power supplies, and ancillary equipment within Necton 400kV Substation, and the OTSDUW User shall provide CT and VT signals (as specified above) to a suitable termination point within the cubicle. The Onshore Transmission Licensee shall undertake a four week period of continuous power quality voltage measurements using the above facilities immediately prior to the energisation of the OTSDUW Plant and Apparatus feeders to establish a baseline for compliance with the Grid Code. Continuous power quality monitoring shall then be performed during and after commissioning of the OTSDUW Plant and Apparatus both with and without the connection of any Offshore Generation.
13.	Voltage Phase Unbalance	ECC.6.1.5(b) ECC.6.1.6	<u>The OTSDUW User:</u> To provide Voltage Unbalance Assessment information as specified in PC.4.4.1, PC.4.4.2, PC.4.5, PC.A.4.7 and DRC.6.1.5 Schedule 5, of the Grid Code. The HVDC System shall be designed for a negative phase sequence component of 1.5% of the National Electricity Transmission System voltage for the determination of the HVDC System performance. The HVDC System shall be designed for continuous operation with a Phase (Voltage) Unbalance of up to 2%, which can prevail on the transmission system. (Note: The Phase Unbalance is calculated from the ratio of root mean square (rms) of negative phase sequence voltage to rms of positive phase sequence voltage, based on 10-minute average values, in accordance with IEC 61000 4-30).

			<u>The Onshore Transmissioni Licensee:</u> Required to carry out an unbalance assessment in accordance with Grid Code Conditions ECC.6.1.5(b) and ECC.6.1.6. Following the assessment, The Company (upon advice from the Onshore Transmission Licensee) will specify to the OTSDUW User by written notice, the negative phase sequence current limits to which the OTSDUW User will comply. The results of this assessment shall be published as a formal statement of compliance.
14.	Electromagnetic Transients	ECC.6.1.7(a) ECC.6.1.7(b)	<u>The OTSDUW User:</u> To take appropriate measures to minimise the probability and severity of electromagnetic voltage transients which may occur when the OTSDUW Plant and Apparatus (or any material subsystem) is connected to or disconnected from the National Electricity Transmission System. To provide The Company (for onward transmission to the Onshore Transmission Licensee) with details of such measures and an assessment of the predicted probability and severity of such transients in the detailed design phase and at least 18 months prior to completion. <u>The Onshore Transmission Licensee:</u> To provide the latest fault level information to enable the assessment detailed above. Note: The OTSDUW User may wish to make reference to guidance documents including, but not limited to, IEC 60071-4. To minimise the probability and severity of electromagnetic voltage transients or transformer inrush at the Grid Entry Point which may occur when the OTSDUW User's Plant and Apparatus, Generating Unit or any material subsystem is connected to or disconnected from the National Electricity Transmission System. The OTSDUW User shall provide The Company (for onward transmission to the Relevant Transmission Licensee) with details of such measures and an assessment of the predicted probability and severity of such transients or transformer inrush. In the event that The Company/Relevant Transmission Licensee needs to undertake transient overvoltage assessments or voltage assessment studies, the OTSDUW User will be required to provide the data required under PC.A.6.2.1 or PC.A.6.5 of the Grid Code.
15.	Control Telephony	ECC.6.5.2 to ECC.6.5.5	<u>The OTSDUW User:</u> To fulfil the obligations defined in Schedule 2 of this Appendix.
16.	Control Point	ECC.7.9	<u>The OTSDUW User:</u> As required under BC2.9 of the Grid Code, the OTSDUW User will be required to respond to Emergency Instructions, some examples of which are described in BC.2.9.1. In order to fulfil these requirements, it is envisaged that the OTSDUW User has the ability to de-energise all their electrical equipment at the OTSDUW User's control centre by ensuring it can open circuit breakers remotely and safely without delay

			and, where applicable, has the ability to open/close its busbar disconnectors at the Grid Entry Point remotely and safely from the OTSDUW User's control centre without delay. For the avoidance of doubt, this functionality is generally required to enable timely restoration of the Transmission System and prevent delays to the return to service of User's Plant and Apparatus following receipt of such an instruction.
17.	Operational Metering Requirements in respect of The Company and the Onshore Transmission Licensee.	ECC.6.5.6	The OTSDUW User: To fulfil the metering obligations defined in Schedule 3 of this appendix in respect of The Company and the Onshore Transmission Licensee. Required to supply the signals defined in Schedule 3 to Necton 400kV Substation. The functionality, performance, availability, accuracy, dependability, security, protocol and repair times of the equipment generating and supplying the signals (ie the meters and communication links) shall be agreed with The Company and Onshore Transmission Licensee at least 18 months before the Completion Date . The OTSDUW User will also be responsible for the installation, delivery, infrastructure, maintenance and monitoring of the Operational Metering signals from the Offshore Grid Entry Point to the Transmission Interface Point in order to facilitate the transfer of the Offshore Generator's operational metering signals. For the avoidance of doubt, once in operation (after the OTSUA Transfer Time), the ownership of part or the whole of the communication equipment will be transferred to the appointed Offshore Transmission Licensee from when each party (Eu Code User and Offshore Transmission Licensee) will then be responsible for the maintenance of their own assets. The Onshore Transmission Licensee will provide a marshalling cubicle at the Transmission Interface Point within Necton 400kV Onshore Substation in order to receive the Operational Metering Signals. In the event that any part of the OTSDUW User's Operational Metering equipment, including the communications links to Necton 400kV Substation fails, then the OTSDUW User will be required to repair such equipment within 5 working days of notification of the fault from The Company unless otherwise agreed. In addition to the above requirements, the OTSDUW User shall also be required to satisfy the requirements of ECC.6.5.6.5 to ECC.6.5.6.8 and TS_3.24.100 (Operational Data Transmission).
18.	Dynamic System Monitoring	ECC.6.6	The OTSDUW User: Shall provide Dynamic System Monitoring and fault recording facilities on its OTSDUW Plant and Apparatus at the Transmission Interface Point to monitor system dynamic performance and fault recording (ECC.6.6) and provide communication facilities allowing remote access of data to The Company. The Dynamic System Monitoring and Fault Recording requirements are contained in Schedule 4 of this Appendix OF5 and detailed in TS 3.24.70_RES (Dynamic System Monitoring (DSM) and TS 3.24.71_RES (Fault Recording).

			The OTSDUW Plant and Apparatus shall supply the signals generated by the Dynamic System Monitors and Fault Recorders to the Transmission Interface Point at the Necton 400kV Onshore Substation. The interfacing and connection arrangements for the Dynamic System Monitoring signals at the Transmission Interface Point at the Necton 400kV Onshore Substation shall be agreed with The Company as soon as reasonably practicable and no later than 18 months before the Completion Date . In addition, the OTSDUW User shall also be responsible for the delivery, infrastructure, maintenance and monitoring of the Dynamic System Monitoring signals between the Offshore Grid Entry Point and the Transmission Interface Point (until the OTSUA Transfer Time) in order to facilitate the provision of the Dynamic System Monitoring signals provided by the Offshore Generator. There may be a need to change the above requirements depending upon the exact boundary between the Onshore Transmission Licensee and the OTSDUW User. When the Interface Point boundary has been defined The Company will define the exact requirements for the Dynamic System Monitoring which shall be agreed between the OTSDUW User and The Company in the detail design phase. The OTSDUW Plant and Apparatus is also required to supply the Dynamic System Monitoring signals provided by the Offshore Generator to the Transmission Interface Point. The OTSDUW User will be responsible for the delivery and installation of the communications routes between the Offshore Grid Entry Point and Transmission Interface Point in order to facilitate the delivery of the Offshore Generator's Dynamic System Monitoring signals. The Onshore Transmission Licensee will provide facilities at the Transmission Interface Point in order to receive the Dynamic System Monitoring data. In the event that any part of the OTSDUW Plant and Apparatus fails (including the communications routes) between the Offshore Grid Entry Point and the Transmission Interface Point, then the OTSDUW User (prior to the OTSUA Transfer Time) will be required to repair the fault within 5 working days of notification of the fault unless otherwise agreed. In addition, the OTSDUW User shall advise The Company of the nature of the fault, its expected repair time and the time at which it is expected to be returned to service. The Company will advise the OTSDUW User of any such measures that may be required to manage the situation when the Dynamic System Monitoring equipment is out of service.
19.	Communication Faculties for Ancillary Services monitoring		Not applicable.
20.	Safety and Operational Interlocking at the		<u>The OTSDUW User:</u>

	Transmission Interface Point		To provide electrical and mechanical interlocking on the OTSDUW Plant and Apparatus located within the zone covered by the Onshore Transmission Licensee's substation busbar protection at the Transmission Interface Site in accordance with TS.3.01.01_RES.
21.	Safety and Operational Interlocking at the Offshore Grid Entry Point		The OTSDUW User: Shall install electrical and mechanical interlocking on the OTSDUW User's Plant and Apparatus to prevent inadvertent operation during outage conditions and ensure the maintenance and safety of both plant and personnel. The detailed requirements will be agreed with the OTSDUW User and the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 12 months before the Completion Date .
22.	Earthing Requirements at the Transmission Interface Point		Earth Mats: All earth mats on the OTSDUW User's site(s) and the Onshore Transmission Licensee's site(s) where these are adjacent may be bonded together. The Onshore Transmission Licensee's site earth mats can be bonded to the OTSDUW User's site earth mat. The Onshore Transmission Licensee will provide at least two points within its substation(s) to facilitate any bonding with the OTSDUW User's site if required. The OTSDUW User: Shall carry out an earthing survey of their sites prior to construction of the OTSDUW User's Plant and Apparatus. The earthing system is to be designed to withstand a short circuit current of 40kA for 3 seconds. Also shall ensure that it's Plant and Apparatus is designed and installed such that the rise of earth potential (ROEP) at Necton 400kV Substation conforms to the touch, step and transfer voltage limits which are defined in ENA TS 41 – 24. Where intertripping (second main protection) is required to open circuit breakers, the overall fault clearance time shall not be more than 180ms at 66kV Substations. The OTSDUW User's earthing system design review shall take the Onshore Transmission Licensee's earthing system design into account and the OTSDUW User shall collaborate with the Onshore Transmission Licensee (via The Company) to ensure that compliance has been demonstrated at the Transmission Interface Point and mitigation of 3rd party impact as required. It should also be noted that the earthing system at Necton 400kV Substation shall be designed to comply with ESQCR 2002 and BS EN50522.
23.	Earthing Requirements at the Offshore Grid Entry Point		The OTSDUW User: To agree the requirements for Earthing at the Offshore Grid Entry Point with the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date unless otherwise agreed. To ensure its Plant and Apparatus at the Offshore Grid Entry Point is adequately Earthed in accordance with appropriate standards and does not pose a risk to plant or personnel.

24.	OTSDUW Plant and Apparatus Compliance Process	ECP	The OTSDUW User: To demonstrate compliance with the requirements of the Grid Code as required in the European Compliance Processes. After the OTSUA Transfer Time, the Offshore Transmission Licensee will cooperate with the OTSDUW User, the Onshore Transmission Licensee and The Company to ensure that all aspects of compliance required by the Grid Code and STC are completed.
25.	Site Specific HV equipment requirements		The OTSDUW User: Not applicable.
26.	Changes to Control Schemes and Settings	ECC.6.2.2.6, ECC.6.2.2.7, ECC.6.2.2.8 and ECC.6.2.2.9.10	The OTSDUW User: Shall ensure all control schemes (including different control modes) and settings shall be agreed with The Company and the Onshore Transmission Licensee as required in ECC.6.2.2.6, ECC.6.2.2.7, ECC.6.2.2.8 and ECC.6.2.2.9.10. Any subsequent changes once commissioned shall not be implemented unless otherwise agreed with The Company and Onshore Transmission Licensee.
27.	System Voltage Variations at the Transmission Interface Point	ECC.6.1.4	OTSDUW User Plant and Apparatus: In addition to withstanding the requirements of ECC.6.1.4 of the Grid Code, the OTSDUW User's Plant and Apparatus shall also be capable of withstanding typical fundamental frequency temporary overvoltages that may occur on the onshore transmission system and should not produce, by means of their equipment switching or otherwise, TOVs exceeding the limits stated by the Onshore Transmission Licensee. For clarification please reference the following document: TGN(E) 288 – Issue 1 – May 2016 https://www.nationalgrid.com/sites/default/files/documents/TGN%28E%29_288_0.pdf
28.	Overall OTSDUW Plant and Apparatus Protection and Control Facilities		The OTSDUW User: To ensure that no harmful interactions exist between the OTSDUW Plant and Apparatus and the National Electricity Transmission System which may adversely affect either the OTSDUW Plant and Apparatus protection system or the National Electricity Transmission protection systems. The OTSDUW User shall ensure that its OTSDUW Plant and Apparatus control systems shall be stable in all situations and be self-protected. Where applicable, the OTSDUW Plant and Apparatus control systems shall co-ordinate with the Dynamic VAr Compensation Equipment for the purpose of Reactive Compensation and/or Voltage control. The OTSDUW User shall declare the control strategy which shall be discussed and agreed with The Company as soon as reasonably practicable. In any event this shall be no later than 18 months before the Completion Date unless otherwise agreed with The Company or Onshore Transmission Licensee.

<table>
<tr><td></td><td></td><td></td><td>In satisfying these requirements, the OTSDUW User should be aware of and comply with the applicable sections of TS 3.24.90_RES (Protection and Control for HVDC Systems).</td></tr>
<tr><td>29.</td><td>Short Circuit Levels at the Transmission Interface Point</td><td></td><td>
<u>The OTSDUW User:</u>
The Converter Station must continue to operate satisfactorily and keep fundamental frequency over-voltages to within the limit specified under ‘System Voltage Variations at the Transmission Interface Point,’ using minimum fault levels as described in the Table 1 below:
<table>
<tr><td>SQSS Condition</td><td colspan="3">3-phase</td><td colspan="4">1-phase</td><td>Purpose
(It is recommended the relevant fault levels are used for the following purposes)</td></tr>
<tr><td></td><td>Sub-Transient Current (kA)</td><td>Make X/R Ratio</td><td>Break X/R Ratio</td><td>Sub-Transient Current (kA)</td><td>Make X/R Ratio</td><td>Break X/R Ratio</td><td>X0/X1 Ratio</td><td></td></tr>
<tr><td>Minimum fault level</td><td>20.12</td><td>14.9</td><td>17.1</td><td>16.39</td><td>11.6</td><td>15.5</td><td>1.4</td><td>1- Protection settings with additional appropriate safety margins.
2- Electromagnetic transient study in relation to ECC.6.1.7(a) and (b) and TOV (TGN 288).
3- Any study in relation to unbalance.</td></tr>
<tr><td>Post fault minimum fault level</td><td>9.60</td><td>17.4</td><td>18.9</td><td>8.94</td><td>14.4</td><td>18.6</td><td>1.2</td><td>1- Fault ride through
2- Transient active and reactive power exchange studies
3- For SSTI and control interaction studies the part of network around the point-of-interest is usually modelled. Post fault minimum fault level,</td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>which represent a N-1-D condition on a summer minimum scenario should be included in the study cases.</td></tr>
<tr><td>Winter Fault Level</td><td>36.60</td><td>20.6</td><td>24.5</td><td>39.16</td><td>19.0</td><td>23.4</td><td>0.7</td><td></td></tr>
<tr><td>Winter Fault Level (Future Contracted Background (G74))</td><td>44.94</td><td>22.0</td><td>24.8</td><td>47.07</td><td>19.9</td><td>23.1</td><td>0.7</td><td>Siemens requested a fault level considering future connections and transmissionreinforcements in the area.</td></tr>
</table>
<u>Table 1</u>
Please note that the values in Table 1 are indicative of the predicted landscape at the time of your offer. As the connection date approaches and the surrounding landscape becomes more fixed, more accurate values will be provided on request as defined in PC.A.8.
</td></tr>
<tr><td>30.</td><td>Fast Recovery from DC Faults</td><td>ECC.6.1.17.3</td><td><u>The OTSDUW User:</u>
Shall be capable of fast recovery from transient faults within the HVDC System. The detailed requirements shall be discussed and agreed between the OTSDUW User and The Company in the detailed design phase which shall take the topology of the HVDC System into account.</td></tr>
<tr><td>31.</td><td>Fast Fault Current Injection</td><td>ECC.6.3.16</td><td><u>OTSDUW User:</u>
Is required to satisfy the requirements of ECC.6.3.16.</td></tr>
<tr><td>32.</td><td>Injected/Induced Noise Mitigation</td><td></td><td><u>The OTSDUW User:</u>
The OTSDUW User’s DC Converter shall not on the AC side generate noise higher than –35dBm as measured at the Transmission Interface Pointin the frequency bands:
156 kHz carrier frequency, bandwidth of 4kHz
256 kHz carrier frequency, bandwidth of 4kHz

For frequencies outside the ranges described above, the limit could be raised to -10dBm for the remainder of the 70kHz to 700 kHz..</td></tr>
</table>

33.	Direct Current Injection into the Onshore Transmission Licensee's Earthing System and Corrosion		<u>The OTSDUW User:</u> To design the earthing of the OTSDUW DC Converter in such a way as to avoid DC stray current flowing through the earthing system during normal operation and to minimise earth current during faulty or unbalanced load conditions. In order to minimise corrosion issues, the requirements for HVDC earthing is specified under BS EN 50162, BS EN 12954 and regarding safe touch voltage threshold for the DC current path, it is defined in IEC/TS 60479-1 which is referenced under BS EN 50522. The entire HVDC system design shall consider the possible maximum level of DC stray currents to which buried or immersed metal structures may be exposed even at a substation distance from the terminal earths of the OTSDUW's DC Converter.
34.	Real-Time Frequency Signals	ECC.6.3.3.1.1 (f)	The OTSDUW User shall be capable of providing a fast frequency signal to the EU Code User in accordance with the requirements of ECC.6.3.3.1.1(f).
35.	Non-standard Frequency Ranges	ECC.6.1.2.2.4	In the case of a remote end HVDC system where the nominal frequency is not 50Hz the frequency ranges and any additional requirements shall be specified in the Detailed Design Phase.
36.	Dynamic performance and Interactions	ECC.6.3.17 ECC.6.1.9 ECC.6.1.10 PC.A.6.1.3	<u>The OTSDUW User:</u> Is required to satisfy the requirements of PC.A.6.1.3, ECC.6.1.9, ECC.6.1.10 and ECC.6.3.17. Dynamic Performance Study (DPS) results are required to demonstrate that the expected steady state and dynamic performance of the OTSDUW User's Plant and Apparatus has been met. To ensure its HVDC converters (including controllers) within the HVDC System do not cause negatively or lightly damped resonances or interactions on the NETS, adequate damping control facilities to be installed if there is a risk of the following phenomena: • Sub-synchronous oscillations due to interactions between the OTSDUW User's Plant and Apparatus and the NETS. For clarity, sub-synchronous torsional oscillation with other User's Plant and Apparatus shall be included in the study. • Control interaction due to interactions between the OTSDUW User's Plant and Apparatus, network and/or any plant directly or indirectly connected to the NETS. For clarity, Control Interaction with the network and other User's Plant and Apparatus shall be studied in the sub-synchronous and super-synchronous frequency ranges where the OTSDUW's Plant and Apparatus is identified to be responsive. To provide data and results to The Company in consultation with the Onshore Transmission Licensee including full EMT and RMS models (models to be provided 3 years prior to connection, ideally to be included in tender documents) and updated version of the model to be provided after commissioning.

			Specification for the models to be agreed with The Company and OnshoreTransmission Licensee of all OTSDUW User's plant to enable the following studies: • Transient Analysis studies – electromechanical and electromagnetic. • Frequency Domain studies – including eigenvalue analysis and damping torque assessments for all OTSDUW User's equipment. • Detailed requirements in relation to the above studies can be agreed with The Company and the Onshore Transmission Licensee at a time convenient to the OTSDUW User. The results of these studies must be provided to The Company and the Onshore Transmission Licensee by the date defined in the Appendix J. The OTSDUW User shall provide The Company with any relevant information required in the above assessments. Please note the following: <u>Power Factory RMS model(s):</u> This includes model(s) and any associated set up script(s) that form part of the model delivery to The Company and should be compliant with PC.A.5. Any set up scripts should be demonstrated as compatible with the Powerfactory network used by The Company. Also, the RMS model should not require the use of integration time steps less than 10ms due to the time to run a set of simulations on a large network with a large number of models and should not include DLL codes. <u>Power Factory version:</u> Model(s) to be delivered in a version of Powerfactory to be agreed with The Company. After the PF model is provided, the model validation report which compares results against simulation results of PF model and FAT results should be submitted. <u>EMT Model:</u> After the EMT model is provided, the equipment model validation report which compares results against simulation result of EMT model and equipment FAT results should be submitted. Specification for the model (including time step) should be agreed in advance between The Company in consultation with Relevant Transmission Licensee and the OTSDUW User. <u>Additional Note</u> Both The Company and the OTSDUW

			User endeavour to revise and update as applicable the contents of this clause up to 42 months before Completion date, unless otherwise agreed, in accordance with the Grid Code applicable at the time. <u>The Company</u> To outline the detailed requirements and the extent of the studies to be performed, and the criteria to demonstrate compliance with, depending on the static and dynamic models of onshore transmission network, other relevant Users and User/OTSDUW User that are available 42 months before Completion date. The results of these studies must be provided to The Company and the Onshore Transmission Licensee by the date defined in the Appendix J unless otherwise agreed.

Appendix OF5 – Schedule 1
Site Specific Technical Conditions – Harmonic Performance. (ECC.6.1.5(a))

1.1 The OTSDUW User shall ensure that its OTSDUW Plant and Apparatus together with the contribution of any Generation connected to the Offshore Grid Entry Point is designed and constructed to limit the contribution of injected harmonic currents such that the incremental harmonic voltage distortion at the Transmission Interface Point conforms to the limits specified in Table 1.

Harmonic Order 'h'	Incremental Voltage Distortion Limits (due to harmonic current injection) at the Transmission Interface Point (% of fundamental)
2	TBC
3	TBC
4	TBC
5	TBC
6	TBC
7	TBC
8	TBC
9	TBC
10	TBC
11	TBC
12	TBC
13	TBC
14	TBC
15	TBC
16	TBC
17	TBC
18	TBC
19	TBC
20	TBC
21	TBC
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34	TBC
35	TBC
36	TBC
37	TBC
38	TBC
39	TBC
40	TBC
41	TBC
42	TBC
43	TBC
44	TBC
45	TBC
46	TBC
47	TBC
48	TBC
49	TBC
50	TBC

Table 1- Incremental Voltage Emission Limit

1.2 The OTSDUW User shall ensure that its OTSDUW Plant and Apparatus, (together with the contribution of any connected Offshore Generation) at the Transmission Interface Point is designed and constructed such that the total harmonic voltage distortion (due to harmonic components injected by the OTSDUW Plant and Apparatus together with any Offshore Generation) at the Transmission Interface Point conform to the limits specified in Table 2.

1.3 Table 2 also provides the levels of background harmonic voltage distortion at the Transmission Interface Point prior to the connection of the OTSDUW Plant and Apparatus.

1.4 The limits specified in Table 1 and Table 2 shall apply for all possible conditions of the Offshore Power Park Modules, and all possible conditions of the OTSDUW Plant and Apparatus. They shall apply for all credible conditions of the Onshore System (which includes the Onshore Transmission Network and relevant Distribution or OTSDUW User's networks). whose system impedance envelopes at the Transmission Interface Point will be specified by The Company (upon advice from the Onshore Transmission Licensee) to the OTSDUW User, unless otherwise agreed. The outage specification will describe the network states to be included in the envelopes. This shall be in the detailed design phase which shall be at least 24 months before the Completion Date unless otherwise agreed.

Harmonic Order 'h'	Background voltage distortion at the Transmission Interface Point prior to the connection of the OTSDUW Plant and Apparatus and associated Offshore Generation (% of fundamental)	Total Harmonic Voltage Emission Limits (% of fundamental)
2	TBC	TBC
3	TBC	TBC
4	TBC	TBC
5	TBC	TBC
6	TBC	TBC
7	TBC	TBC
8	TBC	TBC
9	TBC	TBC
10	TBC	TBC
11	TBC	TBC
12	TBC	TBC
13	TBC	TBC
14	TBC	TBC
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36	TBC	TBC
37	TBC	TBC
38	TBC	TBC
39	TBC	TBC
40	TBC	TBC
41	TBC	TBC
42	TBC	TBC
43	TBC	TBC
44	TBC	TBC
45	TBC	TBC
46	TBC	TBC
47	TBC	TBC
48	TBC	TBC
49	TBC	TBC
50	TBC	TBC

Table 2- Background Harmonic Voltage Distortion and Total Harmonic Voltage Distortion Limits.

2.0 Harmonic Voltage Distortion Limits for the above the 50th harmonic

2.1 The OTSDUW User shall ensure that its OTSDUW Plant and Apparatus combined with any contribution from the Offshore Generation is designed to limit the contribution of injected harmonic currents with a frequency above 2.5kHz such that the incremental harmonic voltage distortion at the Transmission Interface Point conform to the limits specified in Table 3.

Harmonic Order 'h'	Harmonic Voltage Limit (% of fundamental)
All frequencies above 2.5kHz	TBC

Table 3- Limits for Contribution (Emission) from the OTSDUW Plant and Apparatus including any contribution from the Offshore Generation at the Transmission Interface Point

2.2 The OTSDUW User shall also ensure its OTSDUW Plant and Apparatus (including the effect of any Offshore Generation) is designed such that the total harmonic voltage distortion (due to harmonic components injected by the OTSDUW Plant and Apparatus including the Offshore Generation and background distortion as modified by the OTSDUW Plant and Apparatus and any connected Offshore Generation) for frequencies above 2.5kHz at the Transmission Interface Point conform to the limits specified in Table 4.

2.3 Table 4 also provides the levels of background harmonic voltage distortion at the Transmission Interface Point prior to the connection of the OTSDUW Plant and Apparatus and associated Offshore Generation.

Harmonic Order 'h' All harmonics above 2.5kHz	Existing Background (% of fundamental)	Total Harmonic Voltage Limits (% of fundamental)
51	TBC	TBC
52	TBC	TBC
53	TBC	TBC
54	TBC	TBC
55	TBC	TBC
56	TBC	TBC
57	TBC	TBC
58	TBC	TBC
59	TBC	TBC
60	TBC	TBC
61	TBC	TBC
62	TBC	TBC
63	TBC	TBC
64	TBC	TBC
65	TBC	TBC
66	TBC	TBC
67	TBC	TBC

68	TBC	TBC
69	TBC	TBC
70	TBC	TBC
71	TBC	TBC
72	TBC	TBC
73	TBC	TBC
74	TBC	TBC
75	TBC	TBC
76	TBC	TBC
77	TBC	TBC
78	TBC	TBC
79	TBC	TBC
80	TBC	TBC
81	TBC	TBC
82	TBC	TBC
83	TBC	TBC
84	TBC	TBC
85	TBC	TBC
86	TBC	TBC
87	TBC	TBC
88	TBC	TBC
89	TBC	TBC
90	TBC	TBC
91	TBC	TBC
92	TBC	TBC
93	TBC	TBC
94	TBC	TBC
95	TBC	TBC
96	TBC	TBC
97	TBC	TBC
98	TBC	TBC
99	TBC	TBC
100	TBC	TBC

Table 4 - Background Harmonic Voltage Distortion and Total Harmonic Voltage Distortion Limits

2.4 The OTSDUW Plant and Apparatus shall further conform to the Total Harmonic Distortion (THD) level, at the Transmission Interface Point as calculated in accordance with Engineering Recommendation G5/4 and IEC 61000-4-30, given in Table 5 below.

Frequency Range	THD
≥100Hz	3%
>2.5kHz	0.8%

Table 5- Total Harmonic Distortion Limits

2.5 The limits specified in Table's 3, 4 and 5 shall apply for all possible OTSDUW Plant and Apparatus and Offshore Power Park Module generating conditions and National Electricity Transmission System operating conditions whose system impedance envelopes at the Transmission Interface Point for frequencies above 2.5kHz up to 5kHz will be specified by The Company (upon advice from the Onshore Transmission Licensee) in the detailed design phase which shall be at least 24 months before the Completion Date unless otherwise agreed.

Appendix OF5 - Schedule 2
Site Specific Technical Conditions - Communications Plant. (ECC.6.5)

Description	Location	Source	Provided By	Comments
Control Telephone	OTSDUW Plant and Apparatus Control Centre	The Transmission Substation Exchange or as agreed with The Company.	OTSDUW User to provide and install cross site wiring at the OTSDUW Plant and Apparatus Control Centre.	Control Telephony provides secure point to point telephony for routine Control calls, priority Control calls and emergency Control Calls. The OTSDUW User's control point must be immediately and directly contactable by The Company at all times and operators should be able to communicate in clear plain English. If the OTSDUW User intends to have a nominated Trading Point/Control Point outside of GB, The Company will provide the communication routes and Control Telephony facilities to the OTSDUW User's Control point but will charge the OTSDUW User for the overseas element of this work including any ongoing regular maintenance. Any subsequent relocation of Control Point will be charged to the OTSDUW User by The Company.
Facsimile Machine (ECC.6.5.9)	OTSDUW Plant and Apparatus Control Centre.	Public Telephone Operator.	OTSDUW User to provide and install facsimile machine and wiring to PTO.	

Note: Separate operational telephony facilities in respect of the OTSDUW Plant and Apparatus must be in place at the OTSUA Transfer Time. It will not be possible to have common Control Telephony facilities in respect of the OTSDUW User's Equipment and OTSDUW Plant and Apparatus.

Appendix OF5 - Schedule 3

Site Specific Technical Conditions - Operational Metering Requirements in respect of The Company and Onshore Transmission Licensee (ECC.6.5.6)

Description	Units	Type	Provided from	Comments
Generator Operational Metering Signals	Various	Various	OTSDUW User but transmitted by the OTSDUW Plant and Apparatus from the Offshore Grid Entry Point to the Transmission Interface Point	The OTSDUW User is required to transmit the signals provided from each Offshore Generator pursuant to the Grid Code without appreciable attenuation or delay to a suitably terminated location at the Transmission Interface Point, until the OTSUA Transfer Time when the Offshore transmission assets will transfer to an Offshore Transmission Licensee. The Onshore Transmission Licensee will access these signals from the Transmission Interface Point. The responsibilities, procurement, functionality, reliability, configuration, delivery point and protocol of the operational metering requirements shall be specified in the detailed design phase which shall be at least 18 months before the Completion Date . The signals may be presented at a marshalling kiosk located either within the host TO's substation or the OTSDUW User's substation as agreed between The Company, Onshore Transmission Licensee, the OTSDUW User and the OTSDUW User during the detailed design phase.
OTSDUW Plant and Apparatus Feeders, Transformers, Quad Boosters, Busbars and General Site.	Volts, MW, MVAr, Amps and Frequency	Analogues	OTSDUW Plant and Apparatus	The specific requirements will be provided by The Company and the Onshore Transmission Licensee in the detailed design phase which shall be at least 18 months before the Completion Date . The OTSDUW User to provide a Single Line Diagram showing location of CT/VT equipment and nomenclature of HV Apparatus. The Company and the Onshore Transmission Licensee will use this information to notify the OTSDUW User of which HV circuit breaker, disconnector positions (i.e. status indications), analogues, digitals and alarms are required. The nomenclature of all HV apparatus is to be in accordance with OC11 of the Grid Code.
Alarms	Various	Digitals Analogues	OTSDUW Plant and Apparatus	
All OTSDUW Plant and Apparatus circuit HV and LV circuit breaker(s) and disconnector(s) as agreed with The Company.	Open/Closed Indication	Status Indication	OTSDUW Plant and Apparatus	
Each OTSDUW Plant and Apparatus transformer Tap Position Indication (TPI).	TPI	Tap Position Indication	OTSDUW Plant and Apparatus	
Reactive Power Output and status indications of compensation and filtering equipment installed on the OTSDUW Plant and Apparatus.	MVAr Open/Closed indications	Analogues and Status indication	OTSDUW Plant and Apparatus	

The OTSDUW User should be aware that following the OTSUA Transfer Time, the appointed Offshore Transmission Licensee will be required to satisfy the Real Time Data Provisions specified in STCP02-1, STCP04-1, STCP04-2, STCP04-3 and STCP04-6. The OTSDUW User should therefore consider these requirements when designing the Operational Metering scheme for the Offshore Transmission Network.

Appendix OF5 – Schedule 4
Site Specific Technical Conditions – Dynamic System Monitoring and Fault Recording. (ECC.6.6.1)
The OTSDUW User is required to provide the dynamic system monitoring facilities in respect of each Type C and Type D Power Generating Module and provide communication facilities allowing remote access of data to The Company.

Description	Type	Provided by	Notes
3 phase voltage and current at Necton 400kV Substation.	AC Waveforms	OTSDUW User.	The functionality, performance, availability, accuracy, dependability, security, configuration, delivery point, protocol and repair times of the equipment generating and supplying the signals (ie. the inputs, monitors and communication links) shall be agreed with The Company/the Relevant Transmission Licensee at least 12 months before the Completion Date .
Dynamic System Monitoring and remote communications and interfacing on OTSDUW User Circuits at the Relevant Transmission Licensee's Necton 400kV Substation.	Monitors	OTSDUW User.	Connection to enable data to be retrieved from Dynamic System Monitoring equipment. Connection to The Company with connection, monitoring and security arrangements to be agreed with The Company/the Relevant Transmission Licensee at least 12 months before the Completion Date .
	Communications Channels	OTSDUW User to provide signals and interface at the Relevant Transmission Licensee's Necton 400kV Substation.	

In the event that any part of the OTSDUW User's equipment fails to deliver the information required at Necton 400kV substation (including the communications routes) then the OTSDUW User shall be required to repair the equipment within 5 working days of notification of the fault from The Company unless otherwise agreed. The OTSDUW User shall also provide facilities to allow The Company to monitor the health of the Dynamic System Monitoring equipment up to the Grid Entry Point.

Note:- The specification and performance requirements for Dynamic System Monitoring is detailed in Technical Specification TS 3.24.70-RES (Dynamic System Monitoring (DSM)).

USEFUL LINKS

The Grid Code:

https://www.nationalgrideso.com/uk/electricity/codes/grid-code

Electrical Standards:

https://www.nationalgrideso.com/uk/electricity/codes/grid-code/electrical-standards-documents-including-specifications-electronic

Extranet (ID and password required, email transmission.documentcontrol@nationalgrid.com to request access):

https://extranet.nationalgrid.com/

Connection Policies and Guidance:

https://www.nationalgrideso.com/connections/registers-reports-and-guidance

Procurement Guidelines and Balancing Principles:

https://www.nationalgrideso.com/uk/electricity/market-operations-and-data/transmission-licence-c16-statements-and-consultations

A specialist energy consultancy

Harmonic Loci and Limits

Norfolk R3 Projects Harmonic Compliance

Vattenfall Wind Power Ltd

14808-01
07 October 2021

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1 Introduction

This document, which supersedes the previous report 12182-07, describes the analysis performed to calculate harmonic impedance loci limits for the Vanguard and Boreas Offshore Wind Farms (VBOWF) at the onshore Interface Point (IP). The purpose of these limits is to prevent harmonic distortion at the IP and busbars in the wider network exceeding G5 planning limits, as a result of the connection of VBOWF. The methodology in ENA ER G5 Issue 5 (Stage 3) has been used to calculate these limits. This methodology apportions harmonic distortion headroom available in the network and covers the calculation of both incremental and total distortion limits at the IP. Incremental harmonic distortion at the IP refers to distortion which may be caused by the emission of harmonic currents from equipment within the VBOWF networks only. Total harmonic distortion refers to the overall combined distortion at the IP resulting from every source of distortion in the national electricity network. The IP for VBOWF is the 400 kV busbar at Necton. The connections considered in this report are three 1320 MW connections.

It is understood that the third 1320 MW link will be constructed in stages, and that wider works in the transmission network are required before the final 360 MW of TEC is granted. It was not possible to include the impedance of these wider works in the impedance loci presented in this report.

It should be noted that while the impedance envelopes presented in this report are based on the information provided by NGET at the Interface Point (IP) for all three links, when Link 2 or Link 3 connects, preceding links will already have connected and the impedance of these links cannot be included in the impedance envelopes presented in this report. If designing Link 2 or Link 3 based on the information in this report, the impedance of the preceding connected links should additionally be taken into account.

The analysis described in this report forms part of the harmonic assessment being carried out for VBOWF. Section 2 of the report provides a brief outline of the methodology developed by NGET. This process was developed to provide the required data to the Offshore Transmission System Development User Works (OTSDUW) user to enable the OTSDUW user to perform the harmonic assessment which has previously been undertaken by NGET. The purpose of the overall harmonic assessment is to determine the network impedance loci at the onshore grid IP and incremental voltage limits at this busbar, to ensure that G5/5 planning limits are not exceeded at other studied busbars in the wider network.

In section 3 the process followed to finalise the Outage Study Specification (OSS) submitted to NGET is discussed.

Sections 4 and 5 describe the process used to develop the impedance loci and presents the loci.

Sections 6 and 7, describe the process used to calculate incremental and total limits at Necton 400 kV, and presents these limits.

1.1 Scope of study

The limits which have been determined in this work consider the allowable incremental distortion at Necton 400 kV which will ensure busbars in the wider network do not exceed G5/5 planning limits, along with total distortion limits at Necton 400 kV. Harmonic compliance at Necton 400 kV, the VBOWF IP, has not been assessed during this work.

Harmonic distortion at Necton 400 kV will be comprised of two components:

a) ‘Incremental distortion’ resulting from sources of distortion within the VBOWF networks.

b) 'Background distortion' resulting from sources of distortion in the network to which VBOWF is connecting. This may be increased or decreased at various frequencies by the connection of VBOWF.

The level of background distortion will be highly dependent upon the self impedance at the IP busbar. This self impedance will in turn be highly dependent upon the equipment connected in the VBOWF network. Some items of equipment in the VBOWF network, such as harmonic filters for example, will not be finalised until later in the wind farm design process. It is, therefore, not appropriate to assess distortion at Necton 400 kV at present.

The Electrical Contractor for VBOWF will assess the final predicted distortion at Necton 400 kV using the results of the work described in this report as input. It may be that connecting VBOWF increases the 'background distortion' at the IP (at a certain frequency) such that the remaining distortion 'headroom' available at the IP for incremental distortion is less than the incremental limit calculated in this report. The incremental limits calculated in this report, as noted, have been calculated to ensure remote nodes remain within G5/5 limits. In this case the incremental distortion at this frequency would need to be lower than the values determined in this study, in order to ensure that Necton 400 kV, in addition to the busbars in the wider network considered in this work, are within G5/5 limits.

2 Outline of NGET Methodology

In the enduring offshore regime, the OTSDUW User, in the role of Offshore Transmission System Operator (OFTO) (or the OFTO for early build), is responsible for completing the harmonic assessment for the new connection. In order to perform a suitable harmonic assessment, an impedance model of the NGET system and harmonic distortion limits (incremental and total) at the Interface Point (IP) are required. The impedance model, in the form of a set of harmonic impedance loci, describes the NGET system impedance at the IP. Incremental harmonic distortion limits are calculated to ensure that harmonic distortion from the wind farm does not cause harmonic distortion at nodes within the National Electricity Transmission System (NETS) or connected lower voltage networks to exceed G5 planning limits. In practice it is not possible to study every node in the network and a pragmatic selection of nodes to study is made in the OSS for the project. NGET have developed a methodology to allow a generator build project in the enduring regime to determine these items. This methodology is summarised below.

1. The OTSDUW user selects a set of network nodes and list of network outages (conditions) to study and provides these to NGET in a specification, termed the OSS. The agreed OSS methodology for VBOWF is described in section 3.
2. NGET performs a set of impedance frequency sweeps in their system model to calculate the self impedance at each specified node and transfer impedance from each specified node to all other specified nodes. These impedances are calculated for each network outage specified in the OSS. This information is delivered to the OTSDUW user.
3. The OTSDUW user assesses the impedance scan information to determine which network nodes should be studied in detail. This is done by performing a harmonic gain analysis from the onshore interface point to the remote nodes specified in the OSS. This set of selected nodes would include the IP.
4. Existing harmonic measurements are obtained at the network nodes which will be studied in detail.
5. The OTSDUW user calculates incremental and total harmonic voltage distortion limits that ensure compliance in accordance with G5 at all network nodes.
6. The OTSDUW user develops the impedance loci at the IP.
7. The OTSDUW user performs a harmonic assessment and designs any harmonic mitigation equipment to ensure that the connection meets the determined harmonic limits at the IP calculated in step 5.

Based on the final calculated distortion values with any required filtering modelled from step 7 of the process, a table of performance specification values for the Bilateral Connection Agreement (BCA) Appendix OF5 would be prepared. The wind farms harmonic compliance post connection would be measured against these values.

3 Outage Study Specification

Following discussions with NGET and Vattenfall, an OSS was prepared and submitted to NGET on 11th January 2018. This OSS contained 57 nodes and 463 outages to be considered over three system loading levels (100 %, 60 % and 30 % of the Average Cold Spell (ACS)).

After OSS submission, NGET made some adaptations to the nodes and outage scenarios to match their model. In brief, nodes were adapted to account for running arrangements, the network state and DNO nodes modelled in the NGET ETSYS model. Outage scenarios were adapted to account for the network topology at the time of the Vanguard wind farm connection and data available to NGET. These adaptations resulted in 38 nodes and 367 outages (during each loading level) being included in the OSS study. Final data was received from NGET on 21st June 2018. A detailed description of the data received is given in TNEI report 12182-03-R0.

4 Impedance Loci Analysis Methodology

The self impedance information provided by NGET for Necton 400 kV in response to the submitted OSS was examined to produce the set of impedance loci. Initially harmonic orders were combined into overlapping groups. In grouping the harmonic orders into loci care was taken to ensure that critical resonances are not on the boundary between two groups. This was done by plotting impedance against frequency and ensuring, as far as possible, that resonant points are in the middle of the band of frequencies which were grouped together. The grouping has been done in a pragmatic manner to try and have a practical number of harmonic orders in each locus. Having many separate loci would be onerous on the harmonic filter designer, whereas having too many orders in one locus may result in an 'over designed' system. A harmonic locus was then developed for each selected frequency band by:

i. The impedance points for each studied network condition were plotted on a scatter chart with resistance and reactance axis.

ii. To allow for impedance calculation sensitivity and contingency a percentage margin of:

$$\delta(\%) = \frac{(1\% \times \sqrt[\alpha]{h})}{2}$$

Where h = harmonic order

α = 1 for h < 5; 1.4 for 5 ≤ h ≤ 10; 2 for h > 10

was added to each impedance point (R^h, X^h) generating a set of additional points ($R^h \pm \delta(\%)$, $X^h \pm \delta(\%)$).

The locus for each frequency band was then drawn to encompass all ($R^h \pm \delta(\%)$, $X^h \pm \delta(\%)$) points.

For groups 8 (h=20.5 to 26.5) and 16 (h=49.25 to 55.75) the loci has been drawn right up the location of the raw impedance values with no contingency added. This has been done in the "top left" regions of the loci, as indicated by the magnified sections of the loci in Figure 5-14 and Figure 5-22.

5 Impedance Loci Results

The impedance profiles at Necton 400 kV are shown below in Figure 5-1, Figure 5-2 and Figure 5-3. Based on these charts it was determined to group harmonic orders into the groups detailed in Table 5-1 when creating impedance loci.

As mentioned in section 1, it should be noted that while the impedance envelopes presented in this report are based on the information provided by NGET at the Interface Point (IP) for all three links, when Link 2 or Link 3 connects, preceding links will already have connected and the impedance of these links cannot be included in the impedance envelopes presented in this report. If designing Link 2 or Link 3 based on the information in this report, the impedance of the preceding connected links should additionally be taken into account.

5.1 Harmonic order grouping

Table 5-1 harmonic order grouping

Group	Harmonic orders
1	1.00 – 3.5
2	3.25 – 5.75
3	5.25 – 7.75
4	7.50 – 8.50
5	8.25 – 11.50
6	11.25 – 14.50
7	14.25 – 20.75
8	20.50 – 26.50
9	26.25 – 29.75
10	29.50 – 32.50
11	32.25 – 35.50
12	35.25 – 38.75
13	38.50 – 41.75
14	41.50 – 46.50
15	46.25 – 49.50
16	49.25 – 55.75
17	55.50 – 61.75
18	61.50 – 70.50
19	70.25 – 80.50
20	80.25 – 86.75
21	86.50 – 92.75
22	92.50 – 97.75
23	97.50 – 101.00

5.2 Impedance profiles

Figure 5-1 Impedance profiles at Necton 400 kV

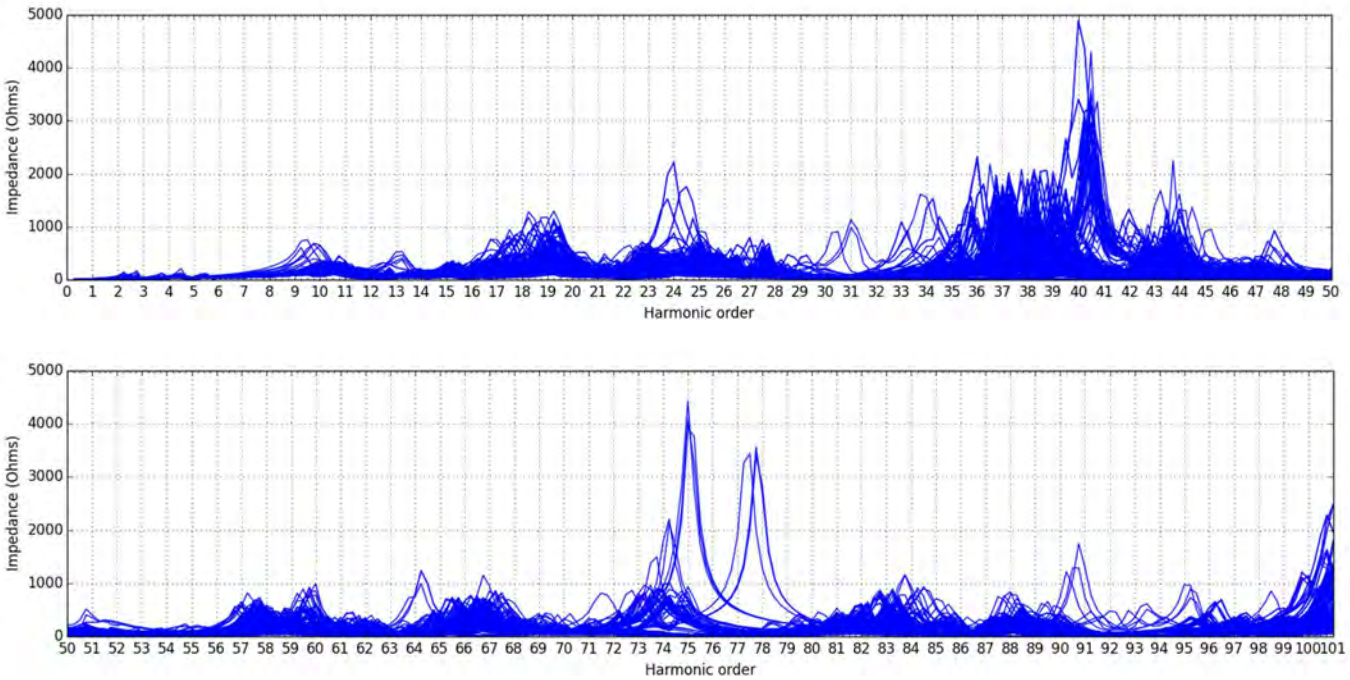


Figure 5-2 Reactance profiles at Necton 400 kV

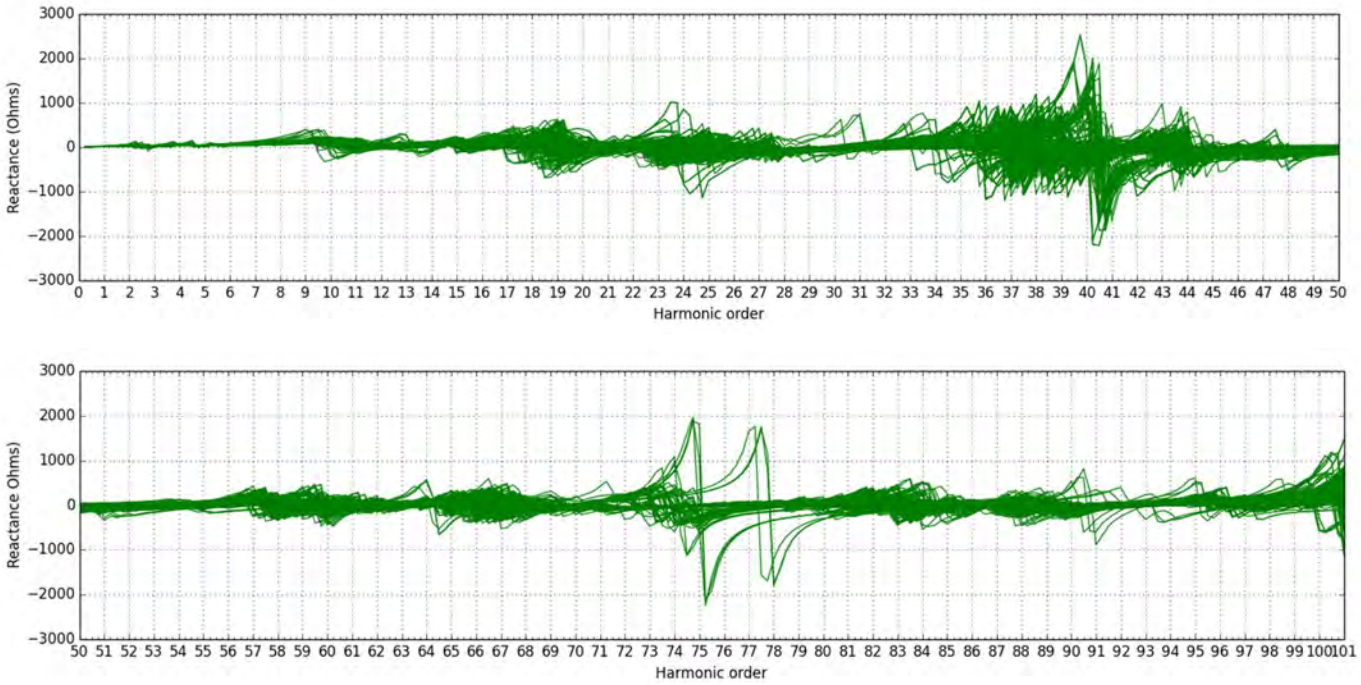
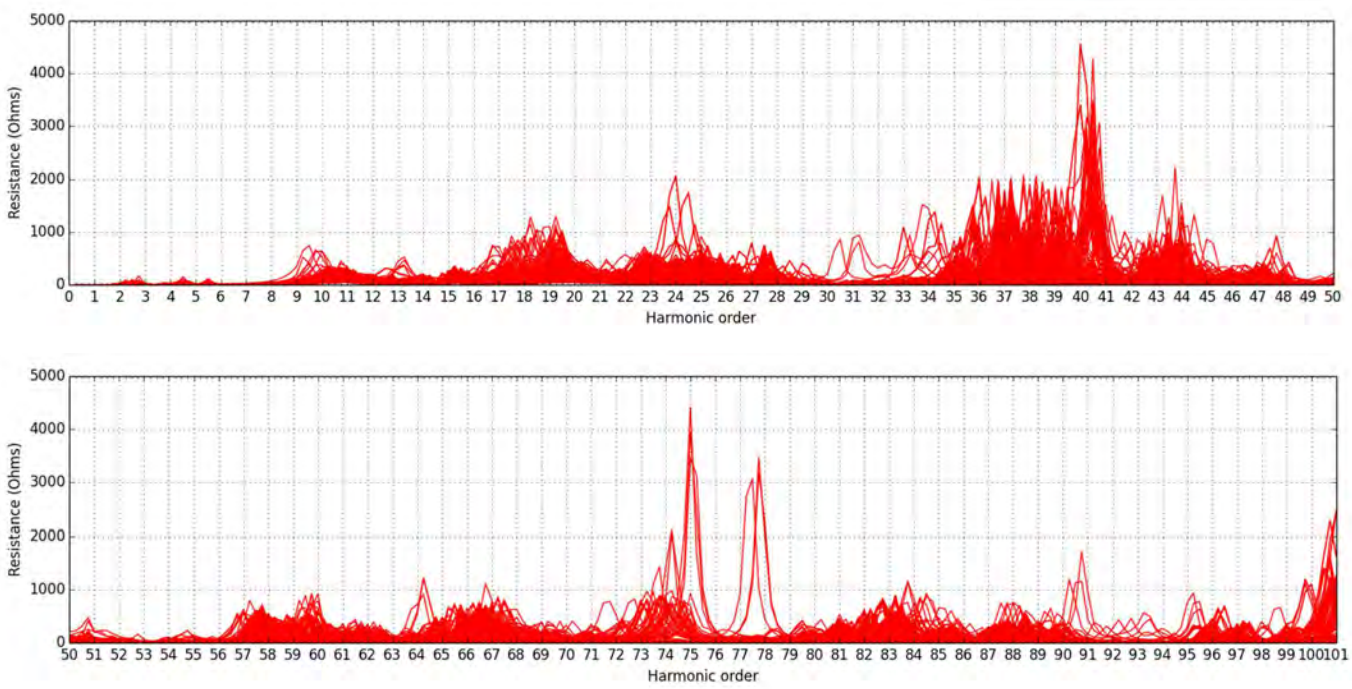


Figure 5-3 Resistance profiles at Necton 400 kV



5.3 Impedance loci

5.3.1 Loci overview

An overview of the groupings of impedance profiles at Necton 400 kV is presented below. These are plotted on an R/X axis with the allowance for 'calculation sensitivity and contingency' as described in section 4 shown in red. A locus has been drawn around the plotted points of each group of harmonic orders. These are presented in section 5.3.2.

Figure 5-4 Loci overview, groups 1 to 9

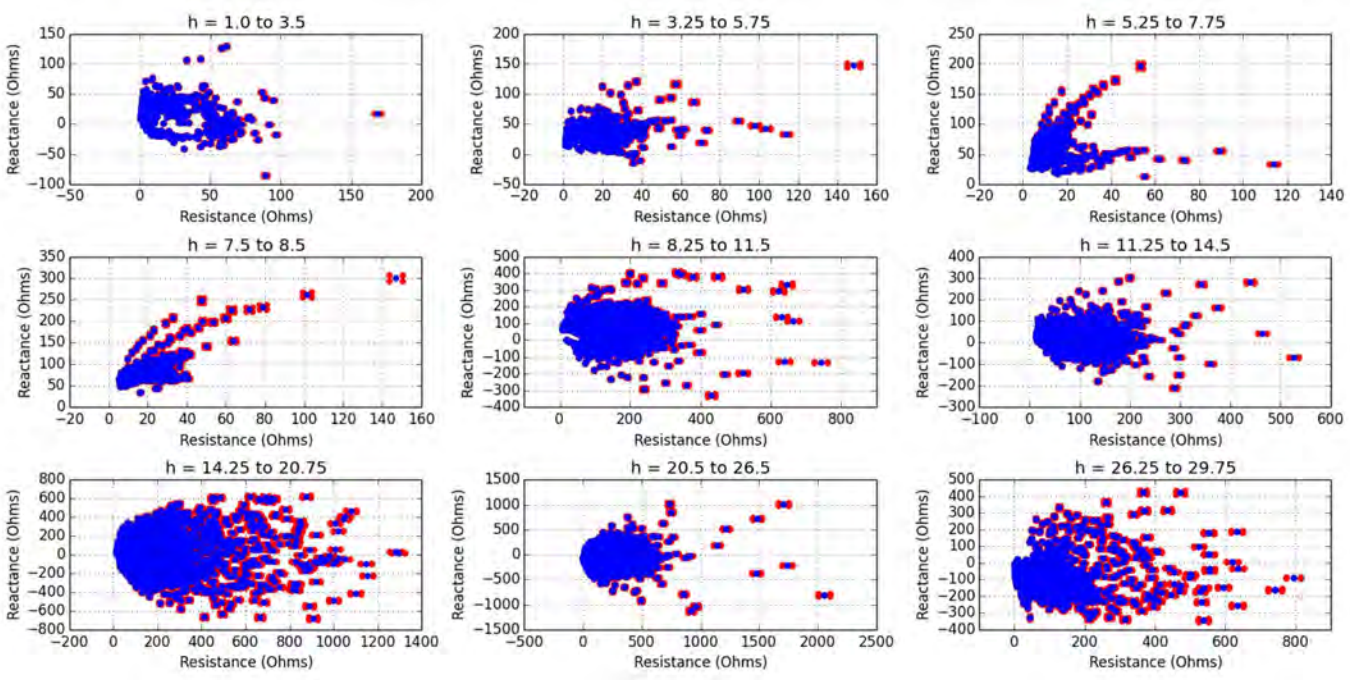


Figure 5-5 Loci overview, groups 10 to 18

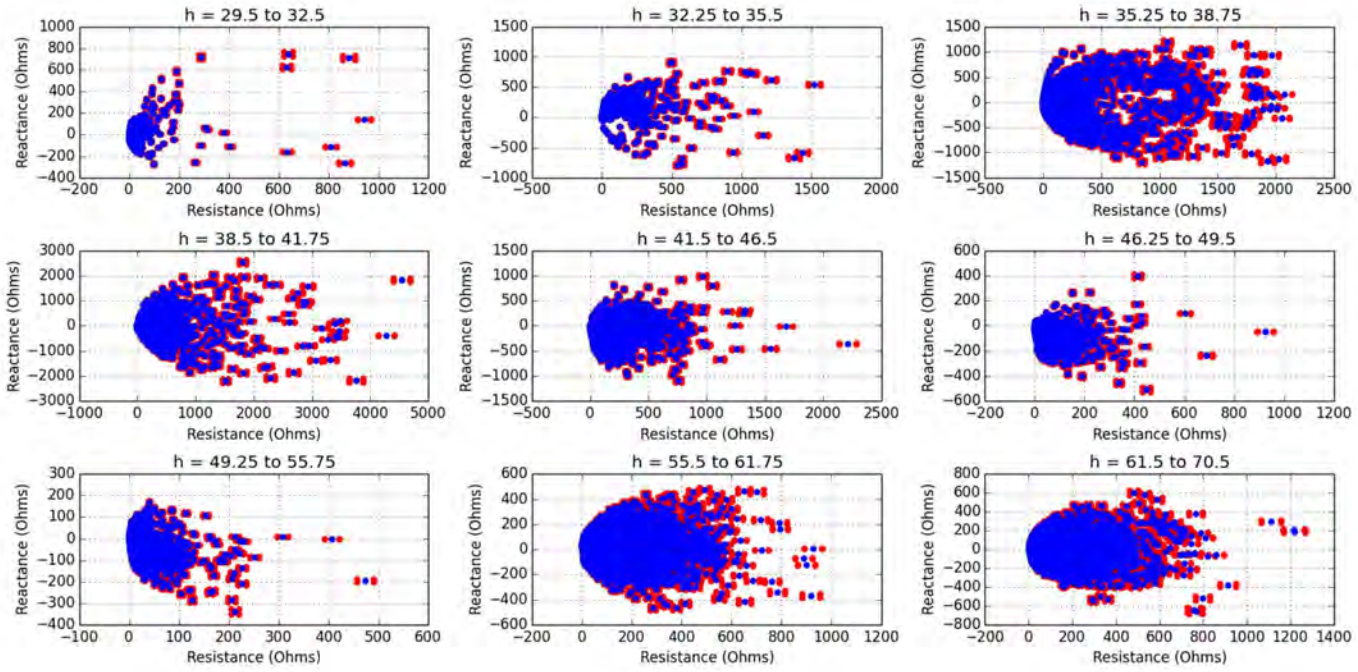
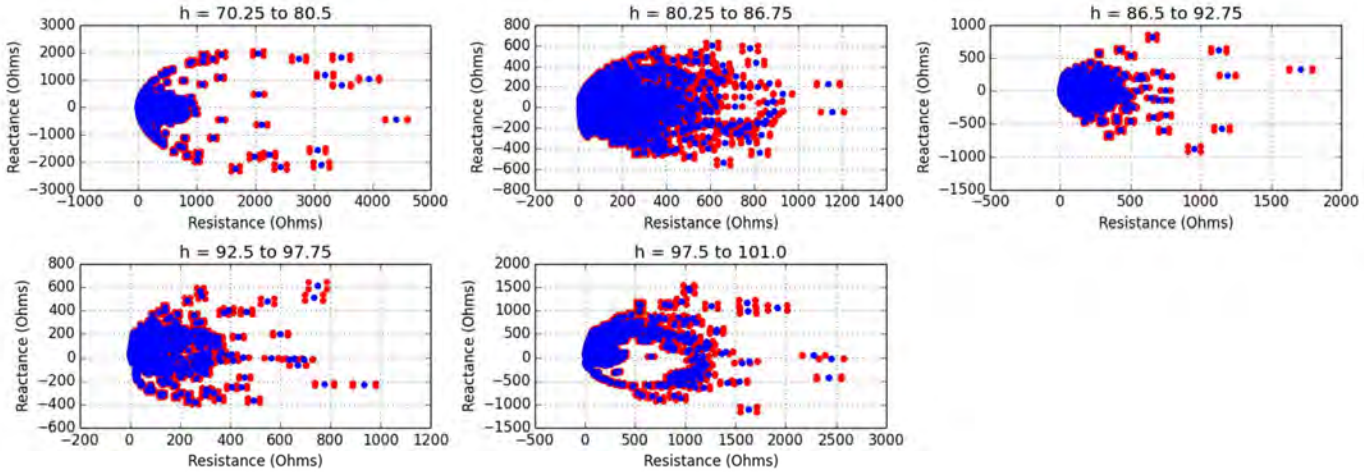


Figure 5-6 Loci overview, groups 19 to 23



5.3.2 Individual loci

Figure 5-7 Locus for group 1, orders 1 to 3.5 inclusive

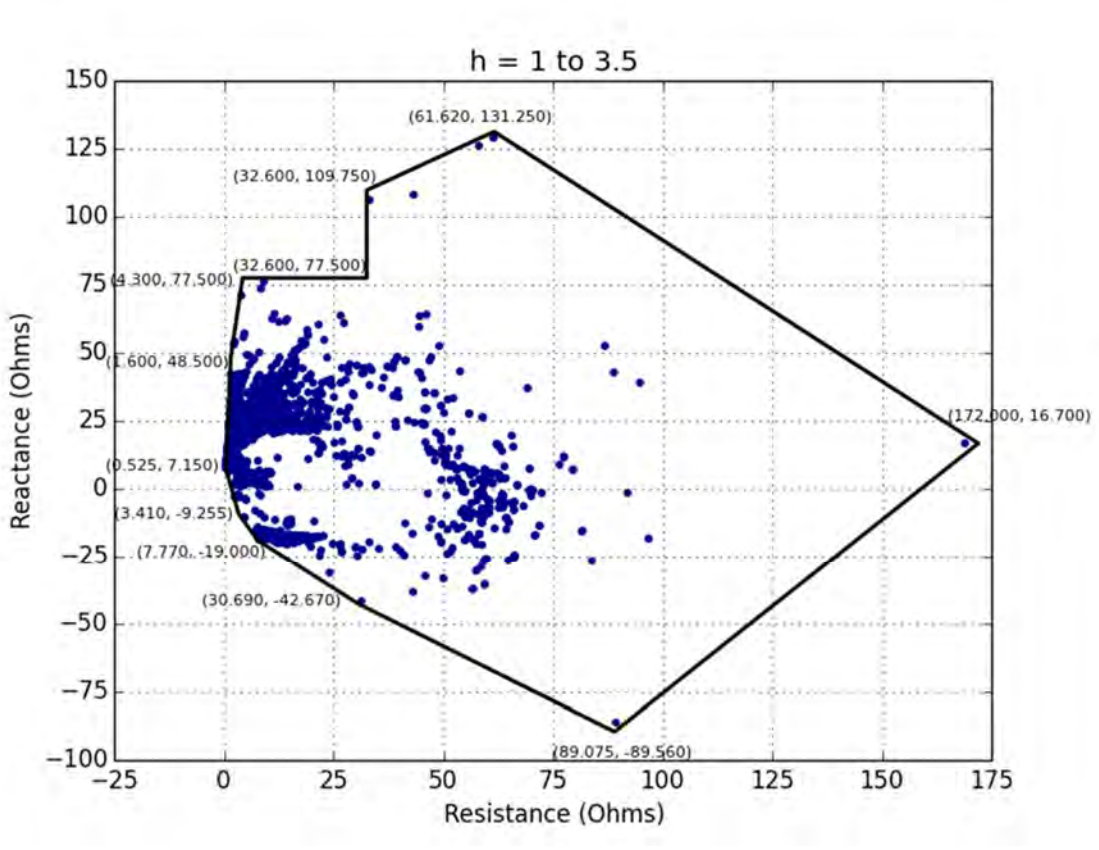


Table 5-2 Vertices of locus for group 1

R (Ohms)	X (Ohms)
0.525	7.150
1.600	48.500
4.300	77.500
32.600	77.500
32.600	109.750
61.620	131.250
172.000	16.700
89.075	-89.560
30.690	-42.670
7.770	-19.000
3.410	-9.255

Figure 5-8 Locus for group 2, orders 3.25 to 5.75 inclusive

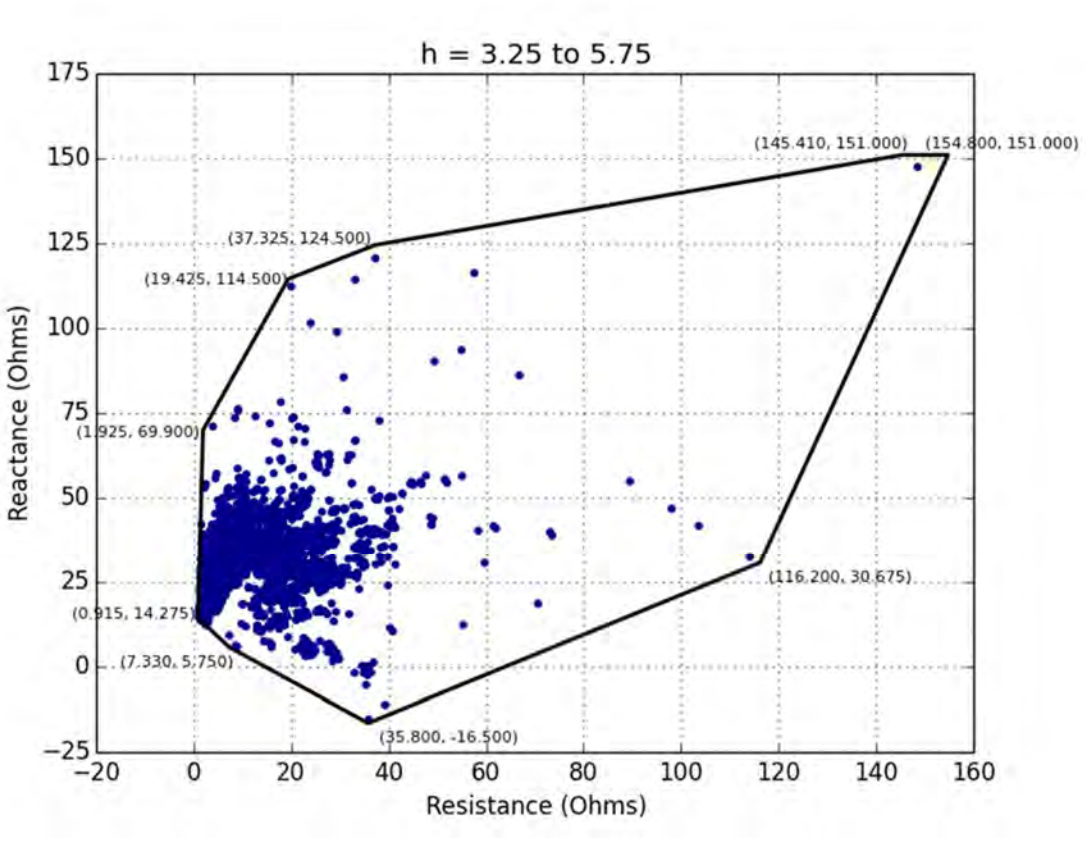


Table 5-3 Vertices of locus for group 2

R (Ohms)	X (Ohms)
0.915	14.275
1.925	69.900
19.425	114.500
37.325	124.500
145.410	151.000
154.800	151.000
116.200	30.675
35.800	-16.500
7.330	5.750

Figure 5-9 Locus for group 3, orders 5.25 to 7.75 inclusive

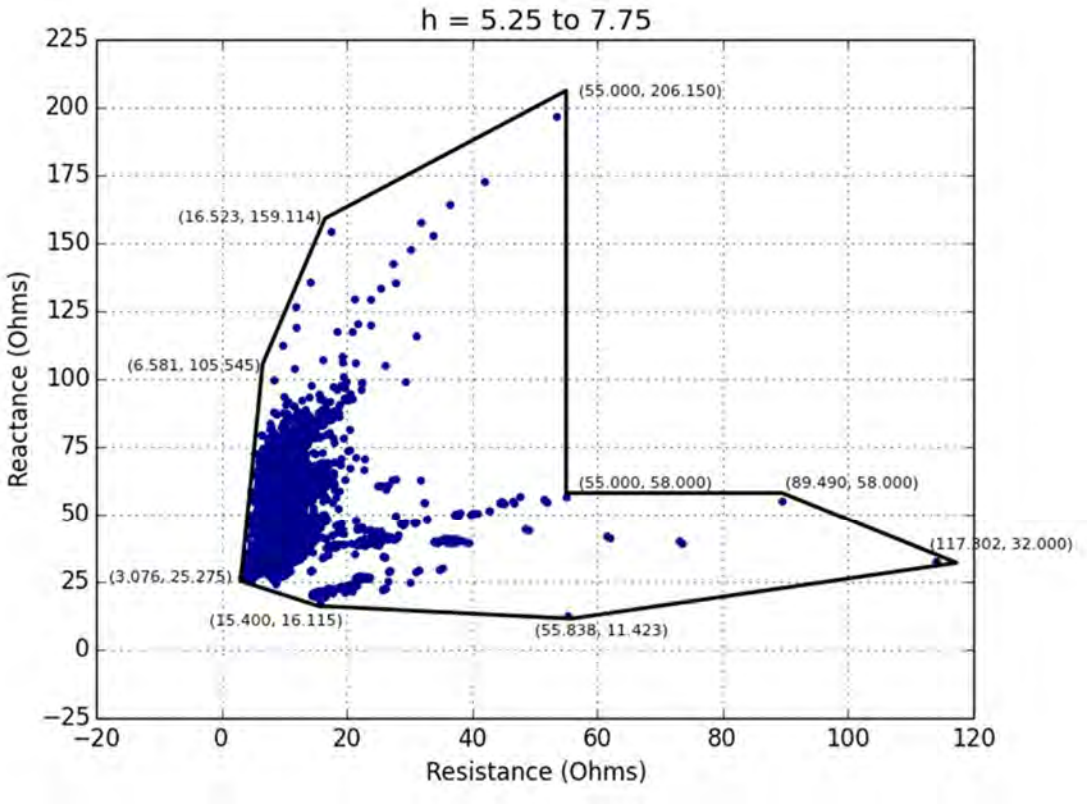


Table 5-4 Vertices of locus for group 3

R (Ohms)	X (Ohms)
15.400	16.115
3.076	25.275
6.581	105.545
16.523	159.114
55.000	206.150
55.000	58.000
89.490	58.000
117.302	32.000
55.838	11.423

Figure 5-10 Locus for group 4, orders 7.5 to 8.5 inclusive

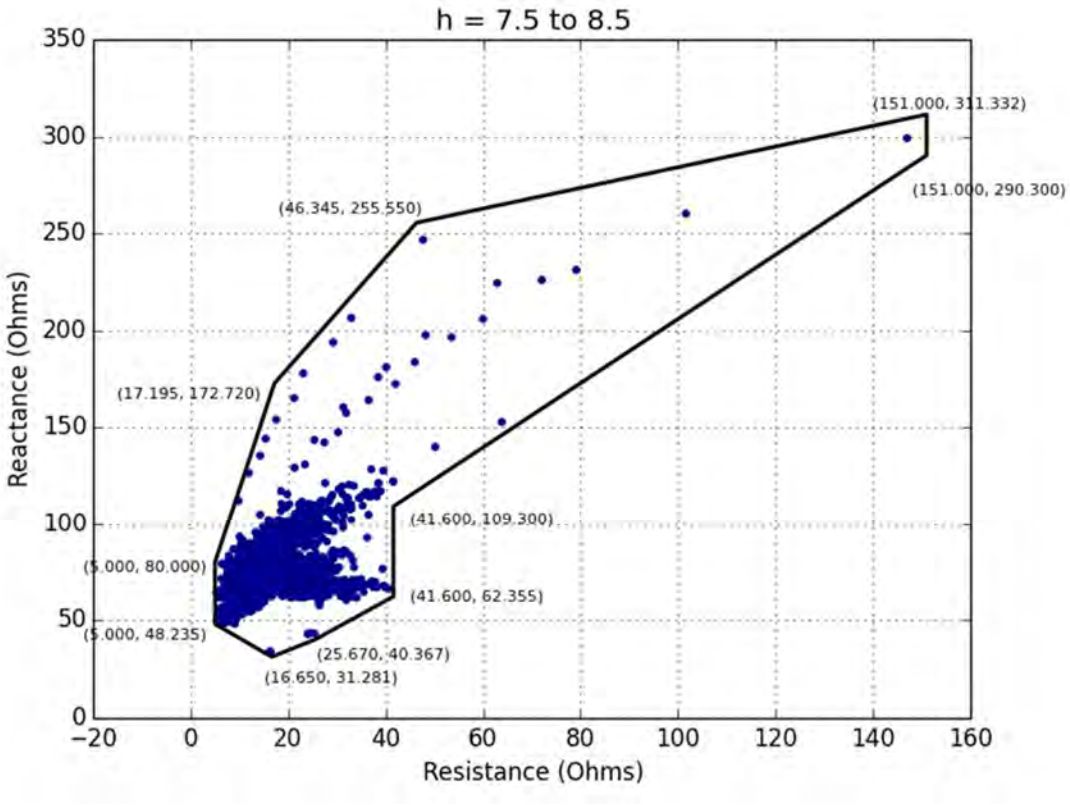


Table 5-5 Vertices of locus for group 4

R (Ohms)	X (Ohms)
16.650	31.281
5.000	48.235
5.000	80.000
17.195	172.720
46.345	255.550
151.000	311.332
151.000	290.300
41.600	109.300
41.600	62.355
25.670	40.367

Figure 5-11 Locus for group 5, orders 8.25 to 11.5 inclusive

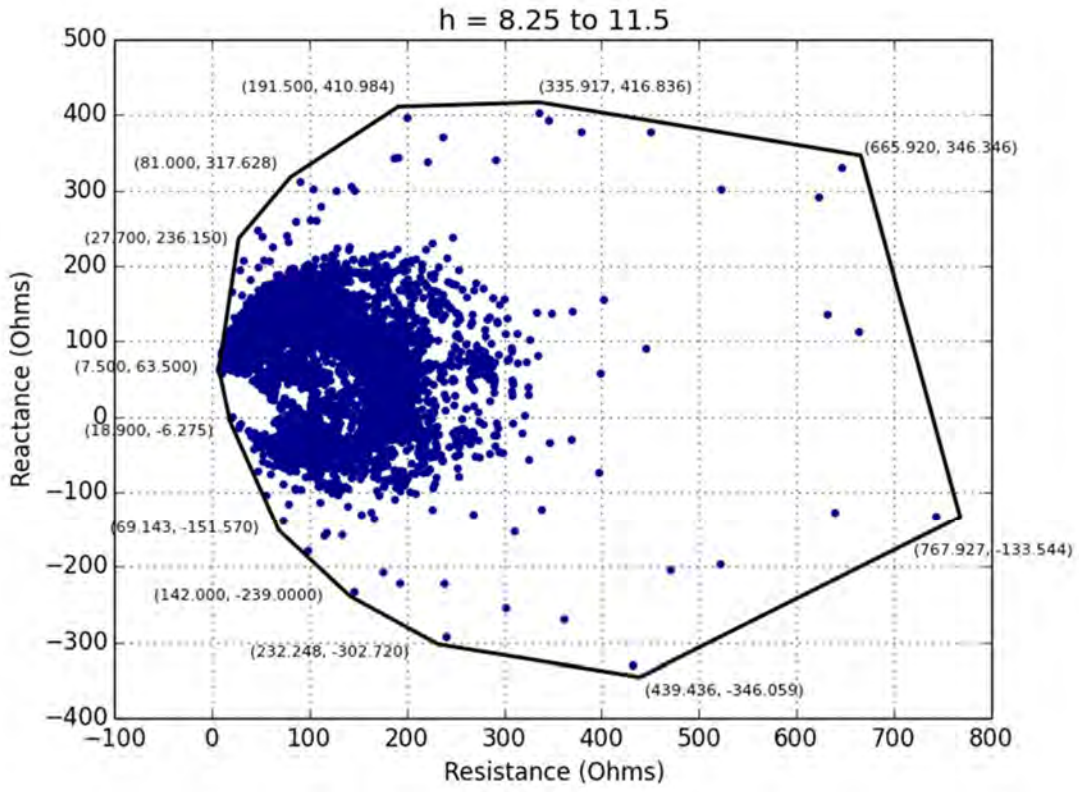


Table 5-6 Vertices of locus for group 5

R (Ohms)	X (Ohms)
18.900	-6.275
7.500	63.500
27.700	236.150
81.000	317.628
191.500	410.984
335.917	416.836
665.920	346.346
767.927	-133.544
439.436	-346.059
232.248	-302.720
142.000	-239.000
69.143	-151.570

Figure 5-12 Locus for group 6, orders 11.5 to 14.5 inclusive

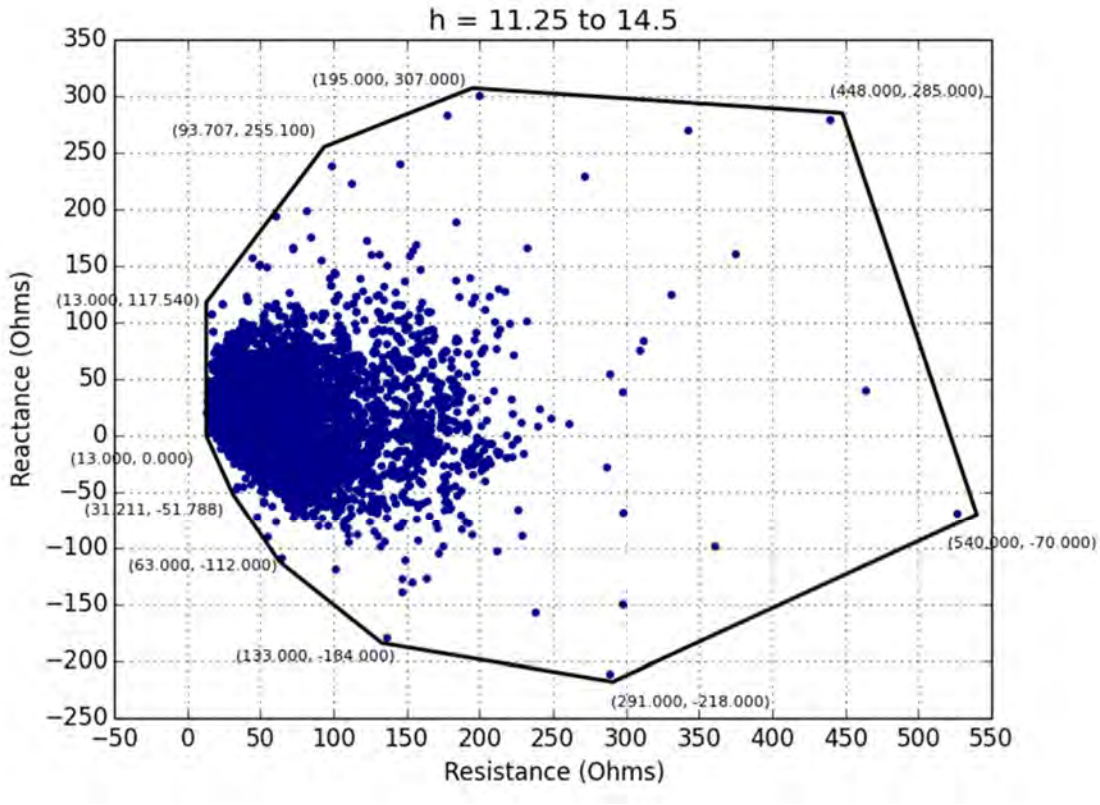


Table 5-7 Vertices of locus for group 6

R (Ohms)	X (Ohms)
13.000	0.000
13.000	117.540
93.707	255.100
195.000	307.000
448.000	285.000
540.000	-70.000
291.000	-218.000
133.000	-184.000
63.000	-112.000
31.211	-51.788

Figure 5-13 Locus for group 7, orders 14.25 to 20.75 inclusive

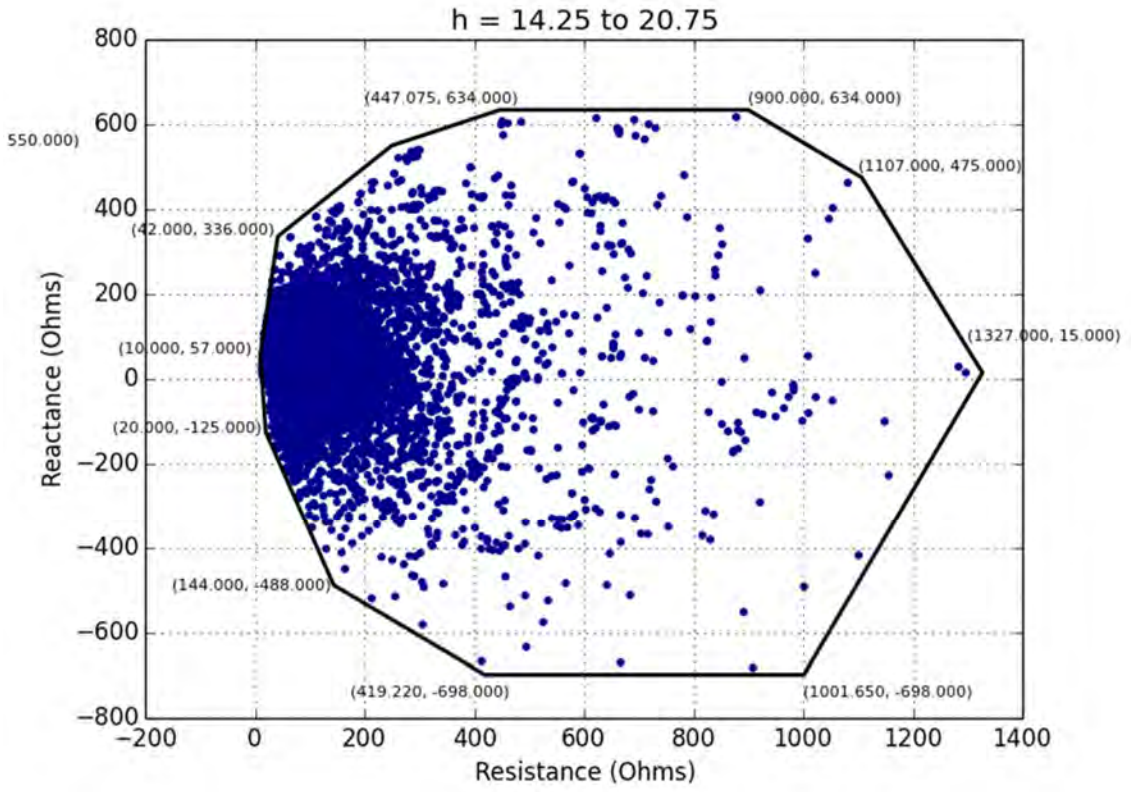
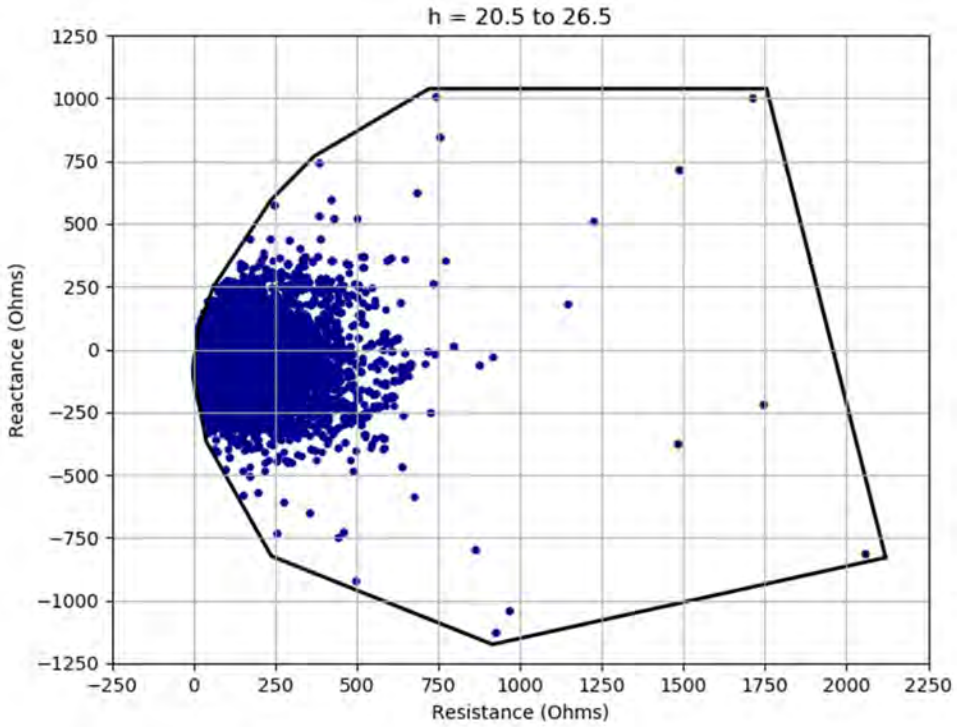


Table 5-8 Vertices of locus for group 7

R (Ohms)	X (Ohms)
144.000	-488.000
20.000	-125.000
10.000	57.000
42.000	336.000
250.000	550.000
447.075	634.000
900.000	634.000
1107.000	475.000
1327.000	15.000
1001.650	-698.000
419.220	-698.000

Figure 5-14 Locus for group 8, orders 20.5 to 26.5 inclusive



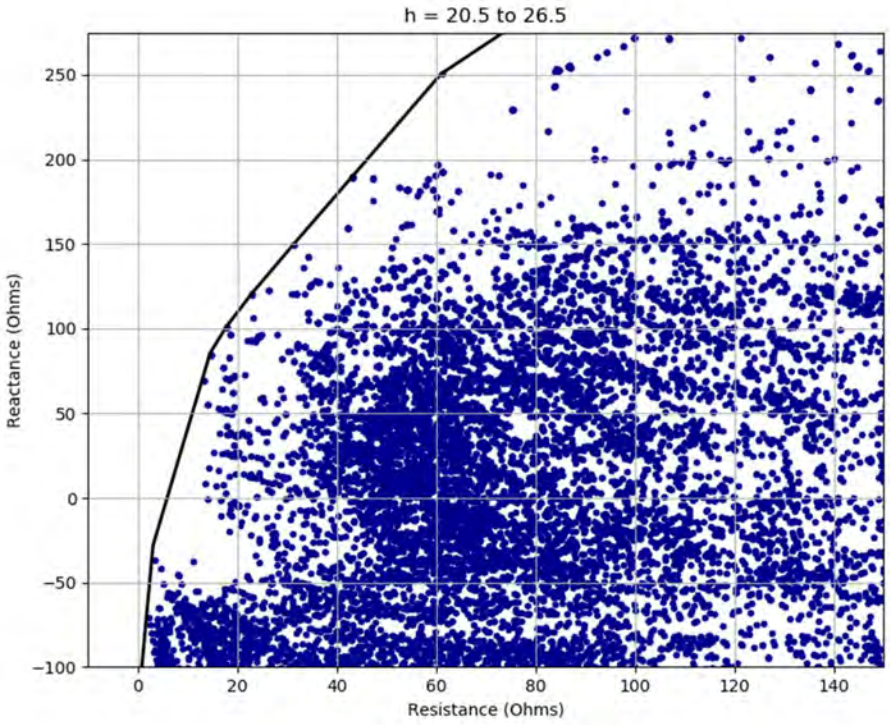


Table 5-9 Vertices of locus for group 8

R (Ohms)	X (Ohms)
38.000	-366.000
0.460	-112.000
3.100	-28.000
14.500	85.000
17.800	100.800
22.850	120.200
31.300	149.500
43.100	189.600
61.000	250.500
237.000	595.000
368.000	768.000
721.000	1038.000
1755.000	1038.000
2120.000	-829.270
915.000	-1175.000
237.773	-823.171

Figure 5-15 Locus for group 9, orders 26.25 to 29.75 inclusive

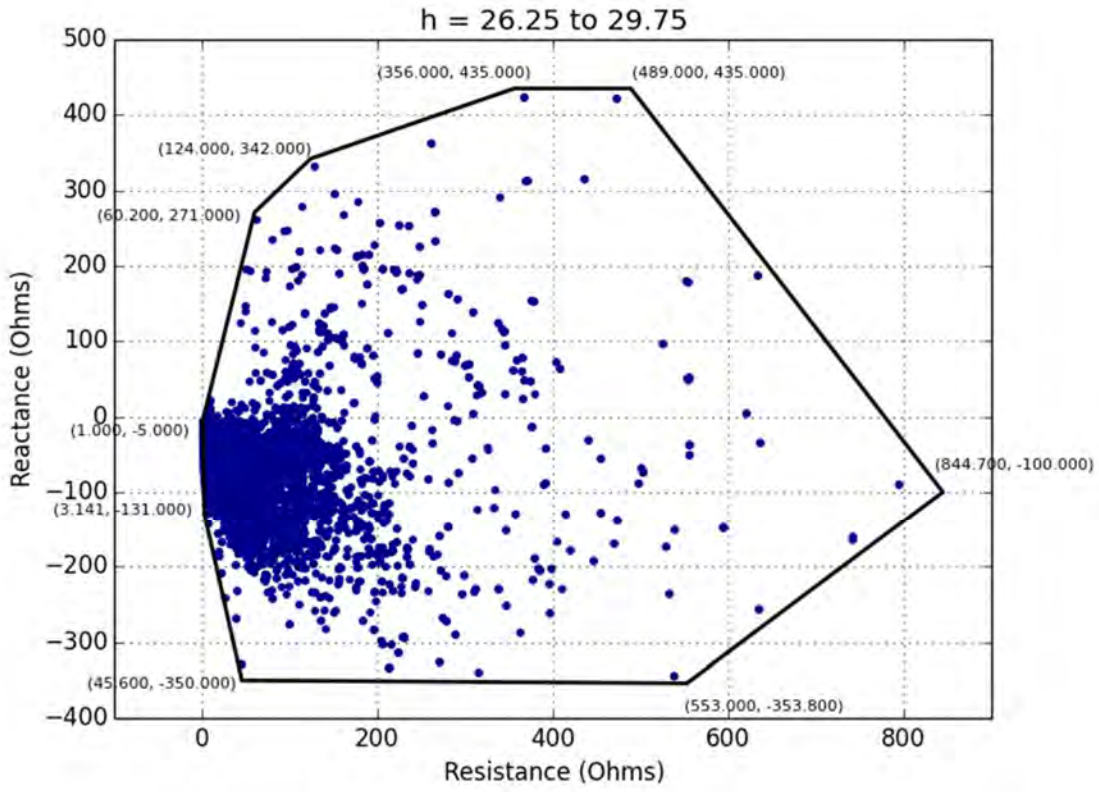


Table 5-10 Vertices of locus for group 9

R (Ohms)	X (Ohms)
45.600	-350.000
3.141	-131.000
1.000	-5.000
60.200	271.000
124.000	342.000
356.000	435.000
489.00	435.000
844.700	-100.000
553.000	-353.800

Figure 5-16 Locus for group 10, orders 29.5 to 32.5 inclusive

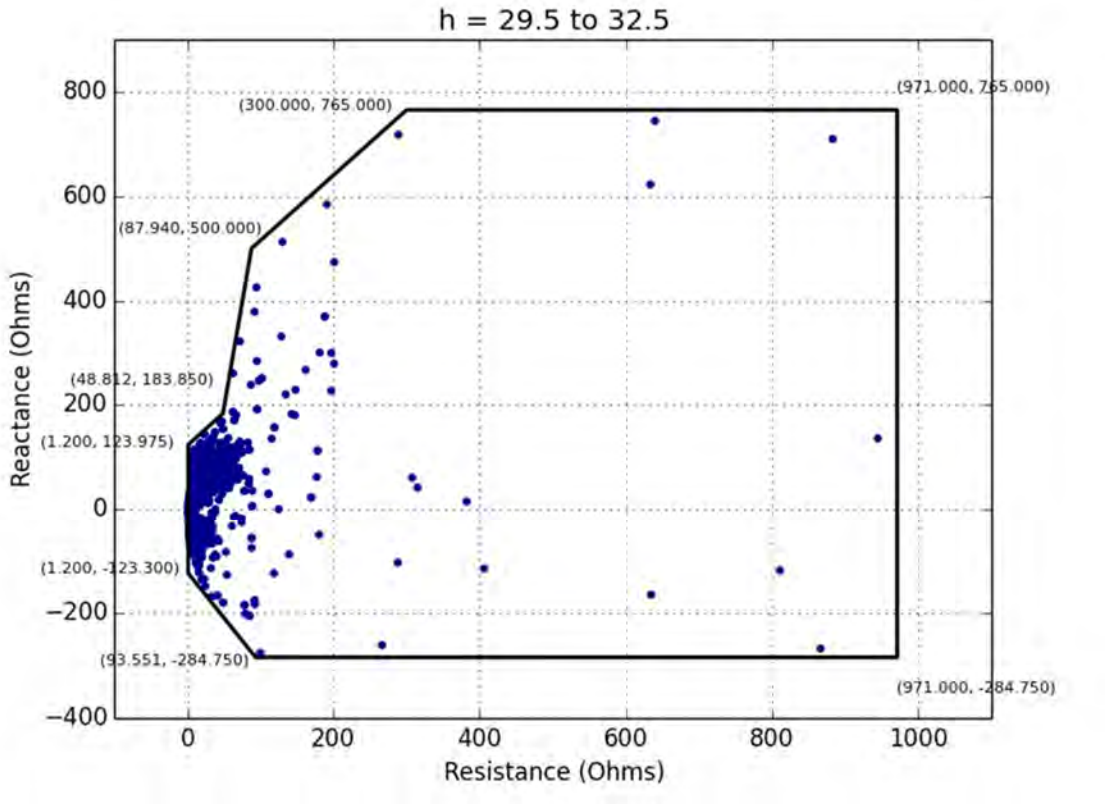


Table 5-11 Vertices of locus for group 10

R (Ohms)	X (Ohms)
1.200	-123.300
1.200	123.975
48.812	183.850
87.940	500.000
300.000	765.000
971.000	765.000
971.000	-284.750
93.551	-284.750

Figure 5-17 Locus for group 11, orders 32.25 to 35.5 inclusive

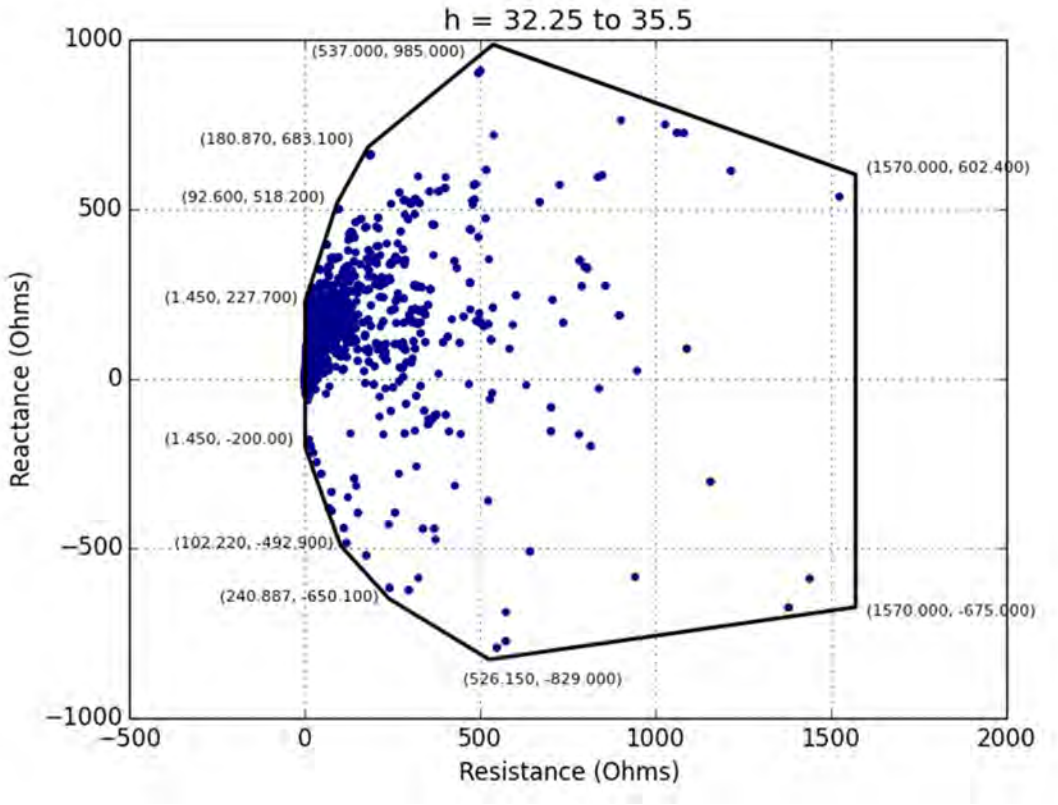


Table 5-12 Vertices of locus for group 11

R (Ohms)	X (Ohms)
1.450	-200.00
1.450	227.700
92.600	518.200
180.870	683.100
537.000	985.000
1570.000	602.400
1570.000	-675.000
526.150	-829.000
240.887	-650.100
102.220	-492.900

Figure 5-18 Locus for group 12, orders 35.25 to 38.75 inclusive

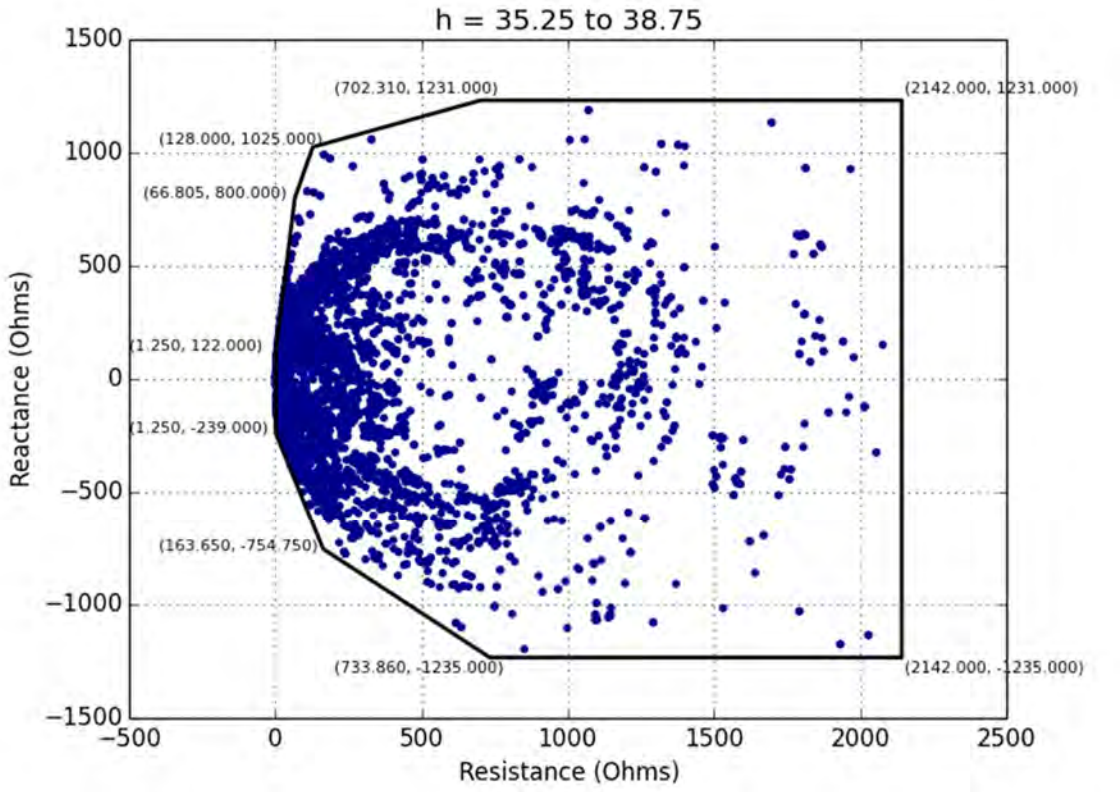


Table 5-13 Vertices of locus for group 12

R (Ohms)	X (Ohms)
1.250	-239.000
1.250	122.000
66.805	800.000
128.000	1025.000
702.310	1231.000
2142.000	1231.000
2142.000	-1235.000
733.860	-1235.000
163.650	-754.750

Figure 5-19 Locus for group 13, orders 38.5 to 41.75 inclusive

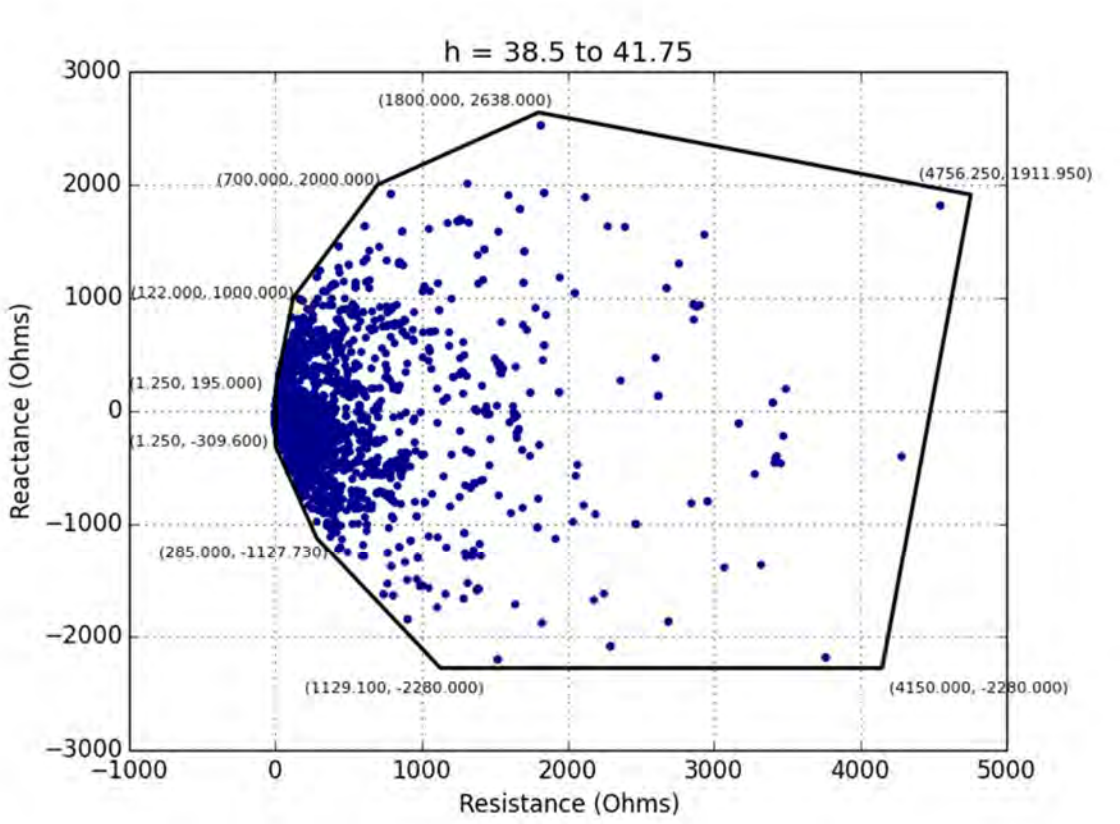


Table 5-14 Vertices of locus for group 13

R (Ohms)	X (Ohms)
1.250	-309.600
1.250	195.000
122.000	1000.000
700.000	2000.000
1800.000	2638.000
4756.250	1911.950
4150.000	-2280.000
1129.100	-2280.000
285.000	-1127.730

Figure 5-20 Locus for group 14, orders 41.5 to 46.5 inclusive

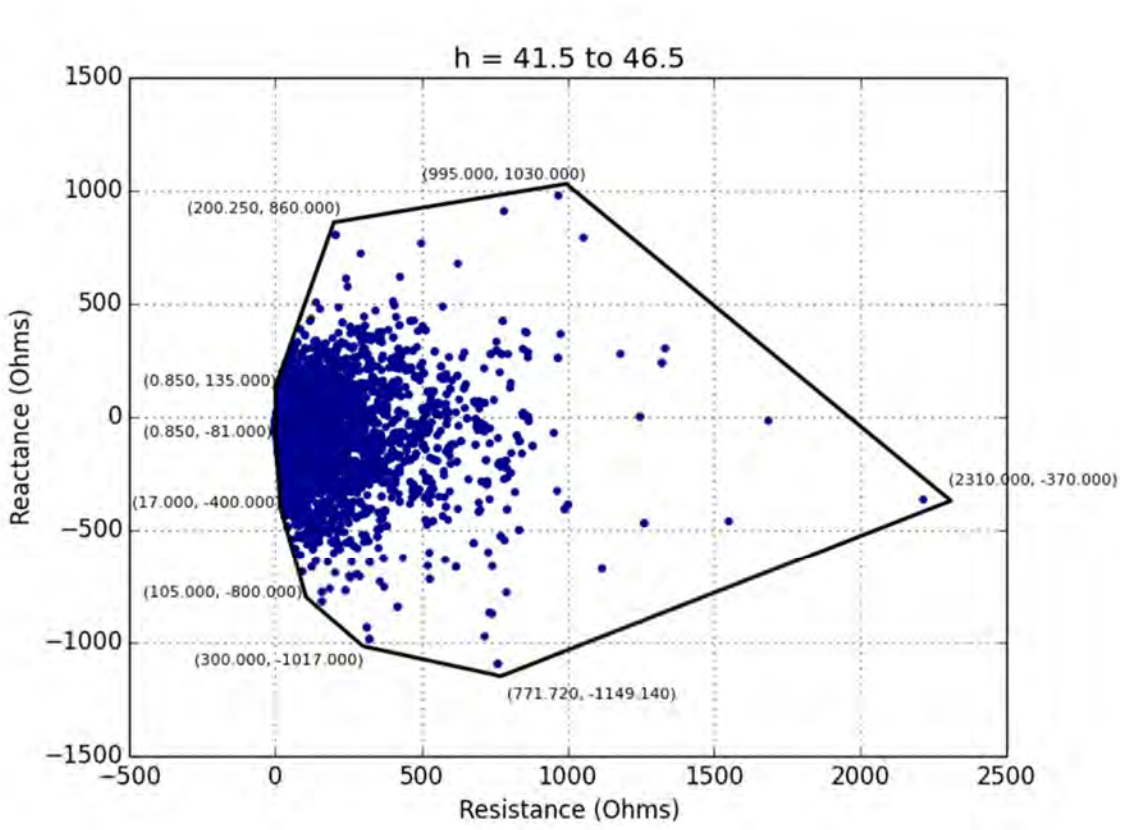


Table 5-15 Vertices of locus for group 14

R (Ohms)	X (Ohms)
0.850	-81.000
0.850	135.000
200.250	860.000
995.000	1030.000
2310.000	-370.000
771.720	-1149.140
300.000	-1017.000
105.000	-800.000
17.000	-400.000

Figure 5-21 Locus for group 15, orders 46.25 to 49.5 inclusive

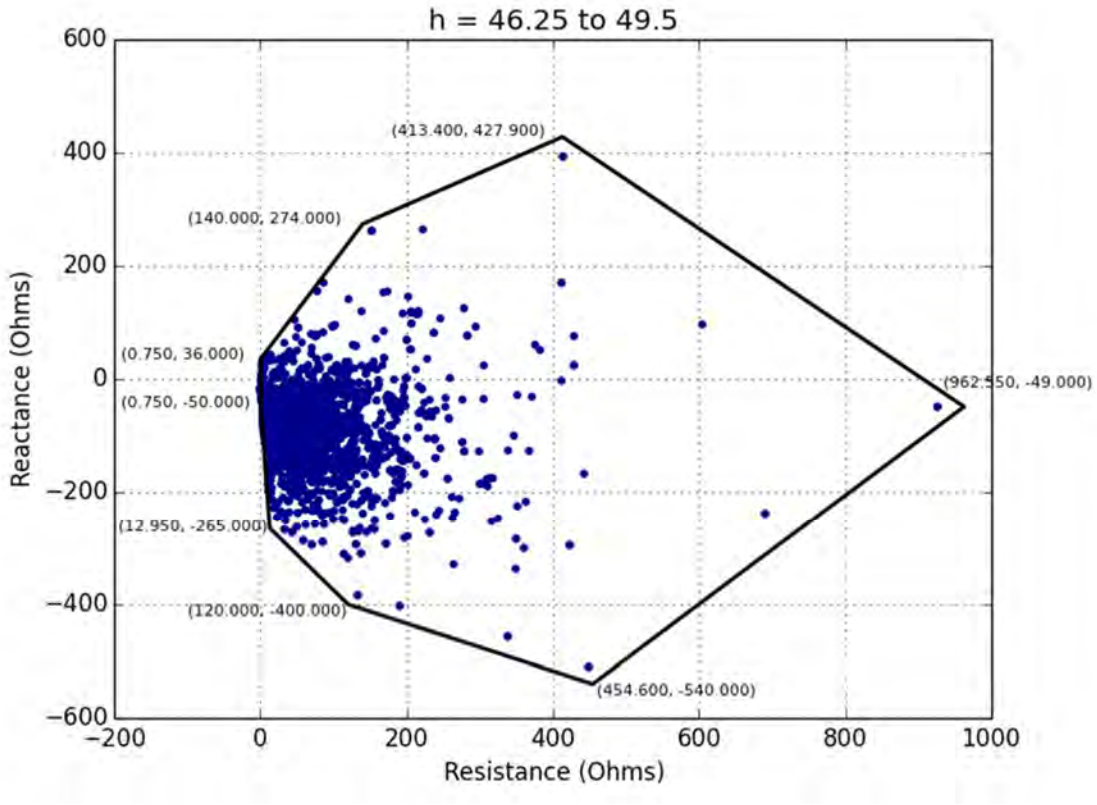
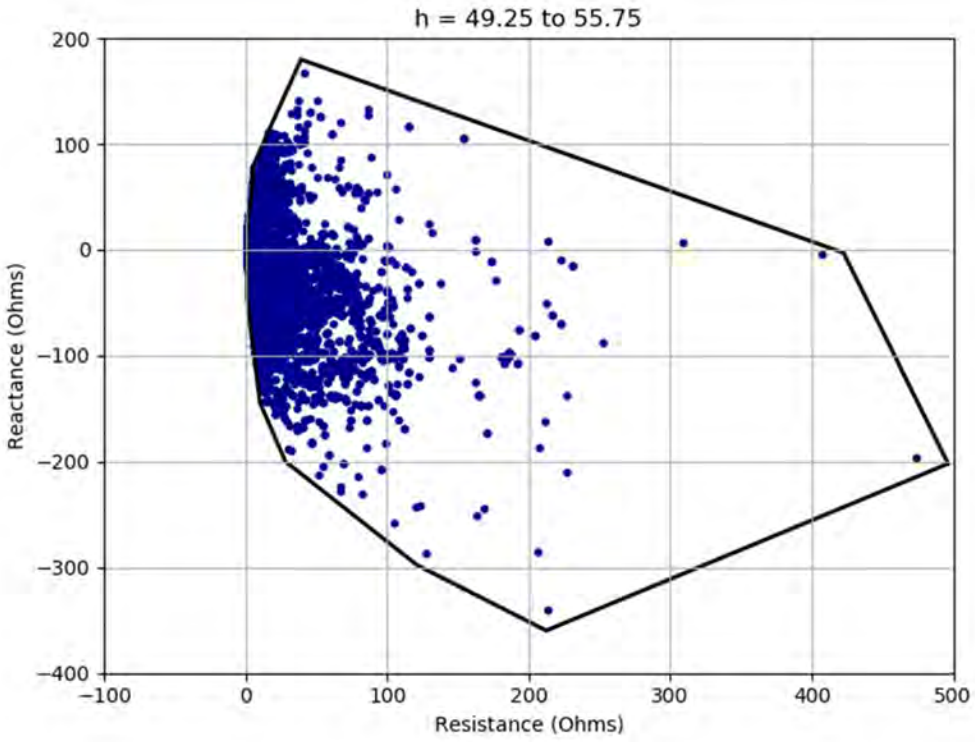


Table 5-16 Vertices of locus for group 15

R (Ohms)	X (Ohms)
0.750	-50.000
0.750	36.000
140.000	274.000
413.400	427.900
962.550	-49.000
454.600	-540.000
120.000	-400.000
12.950	-265.000

Figure 5-22 Locus for group 16, orders 49.25 to 55.75 inclusive



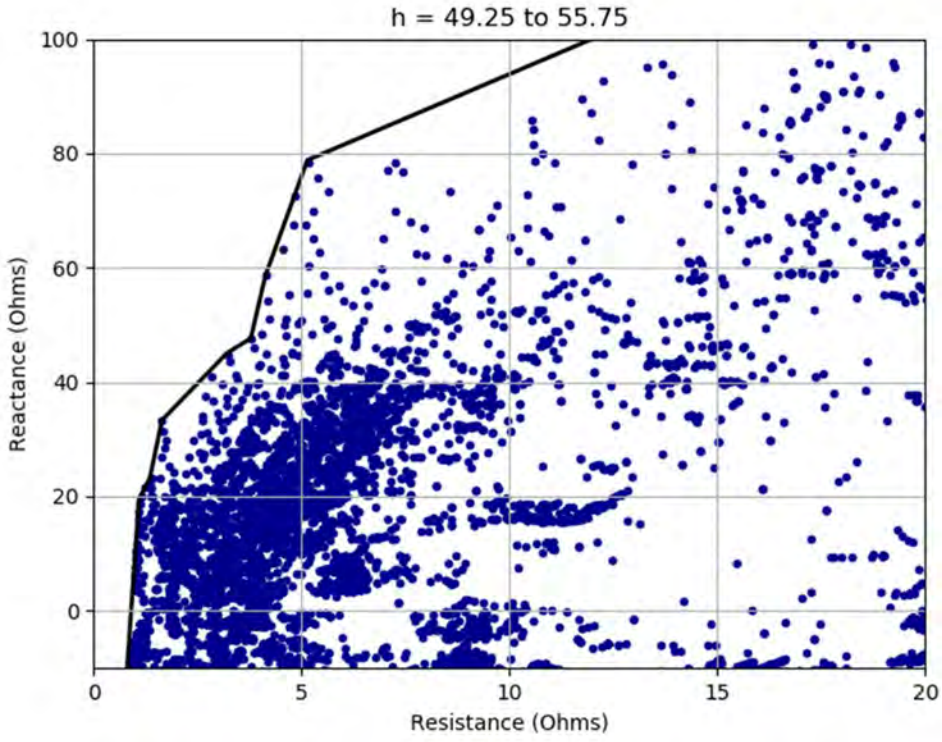


Table 5-17 Vertices of locus for group 16

R (Ohms)	X (Ohms)
0.810	-46.645
0.810	-9.500
1.090	19.500
1.350	23.140
1.643	33.300
3.200	45.000
3.780	47.620
4.130	58.590
5.140	78.800
15.400	110.575
39.000	180.000
422.500	-3.000
496.500	-202.000
212.340	-360.000
121.000	-298.000
28.000	-200.000
10.000	-144.500

Figure 5-23 Locus for group 17, orders 55.5 to 61.75 inclusive

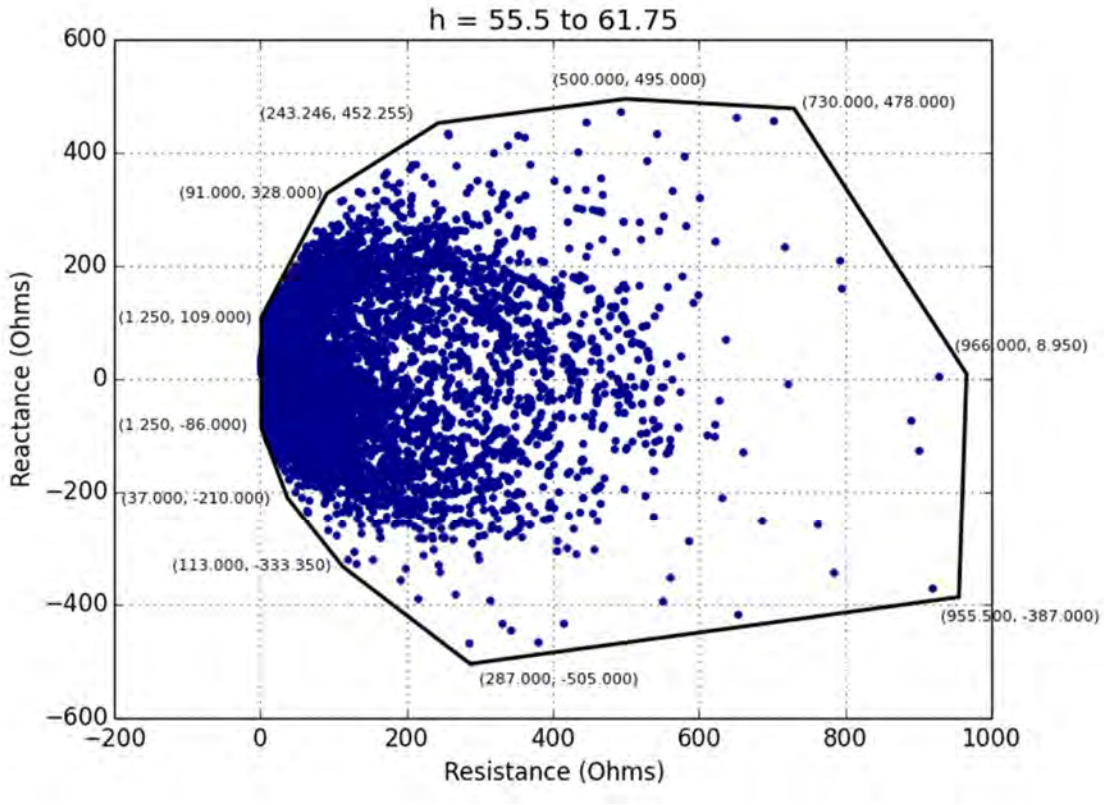


Table 5-18 Vertices of locus for group 17

R (Ohms)	X (Ohms)
1.250	-86.000
1.250	109.000
91.000	328.000
243.246	452.255
500.000	495.000
730.000	478.000
966.000	8.950
955.500	-387.000
287.000	-505.000
113.000	-333.350
37.000	-210.000

Figure 5-24 Locus for group 18, orders 61.5 to 70.5 inclusive

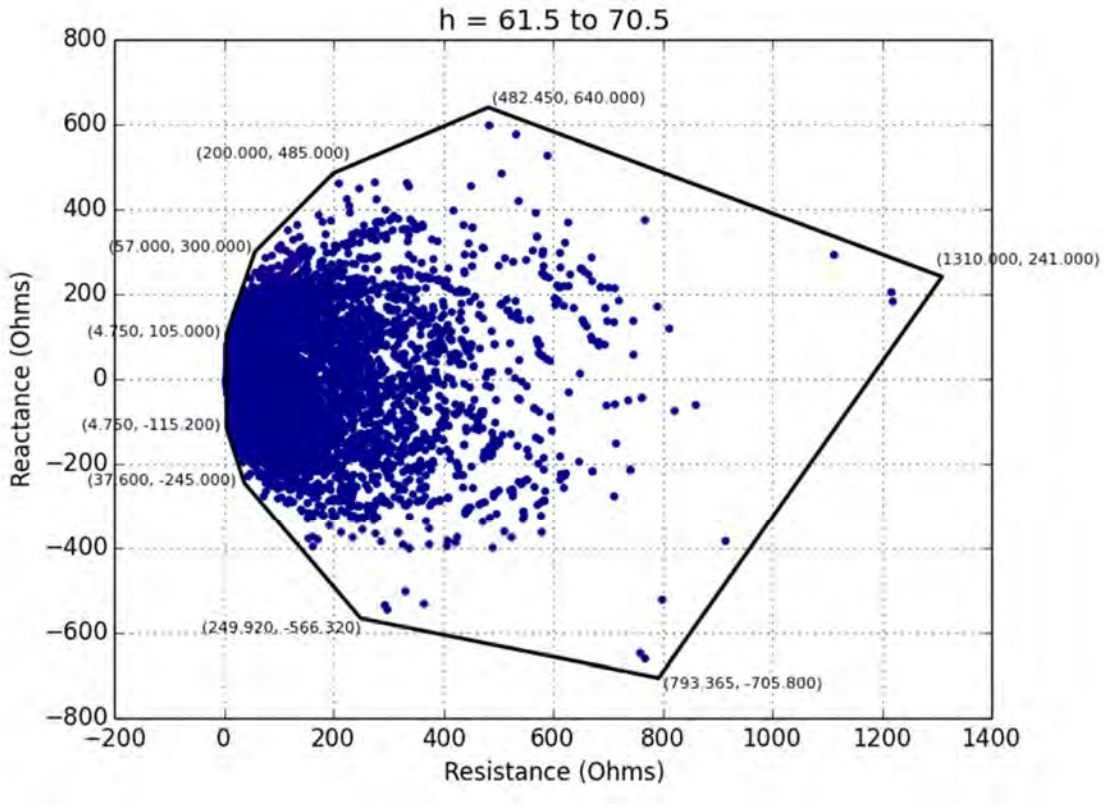


Table 5-19 Vertices of locus for group 18

R (Ohms)	X (Ohms)
4.750	-115.200
4.750	105.000
57.000	300.000
200.000	485.000
482.450	640.000
1310.000	241.000
793.365	-705.800
249.920	-566.320
37.600	-245.000

Figure 5-25 Locus for group 19, orders 70.25 to 80.5 inclusive

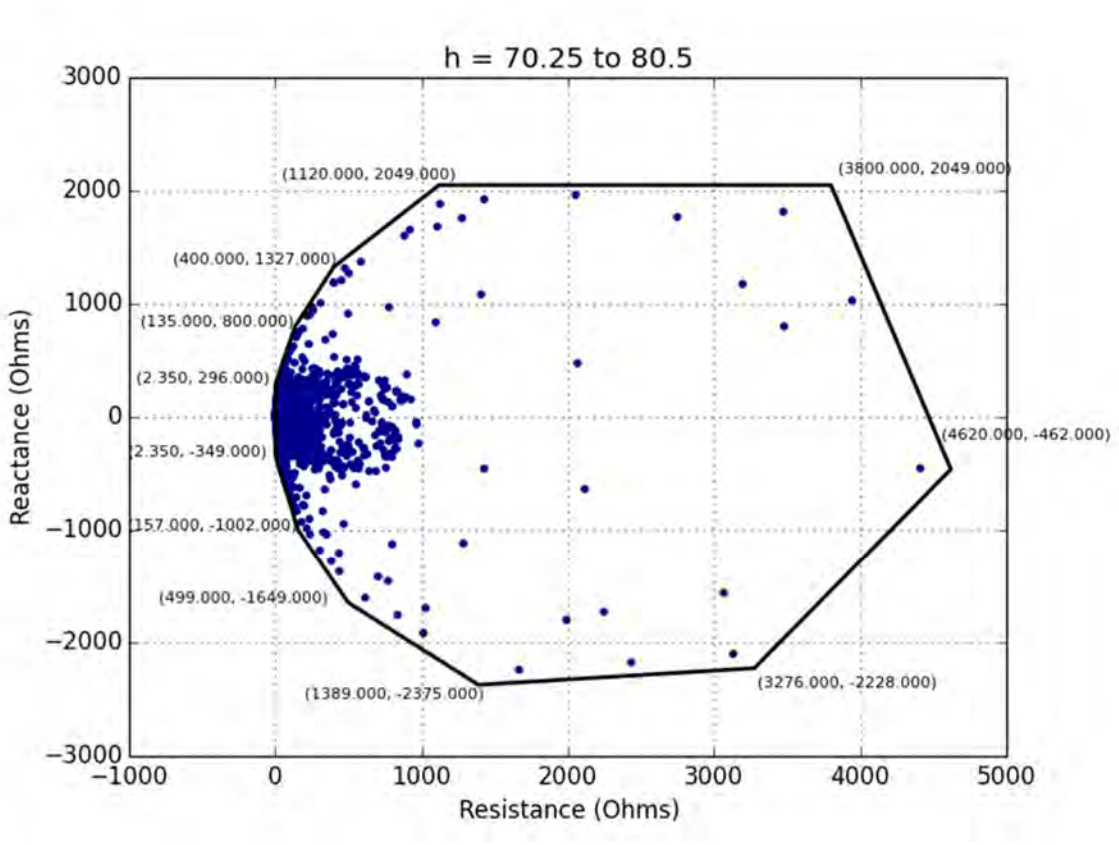


Table 5-20 Vertices of locus for group 19

R (Ohms)	X (Ohms)
2.350	-349.000
2.350	296.000
135.000	800.000
400.000	1327.000
1120.000	2049.000
3800.000	2049.000
4620.000	-462.000
3276.000	-2228.000
1389.000	-2375.000
499.000	-1649.000
157.000	-1002.000

Figure 5-26 Locus for group 20, orders 80.25 to 86.75 inclusive

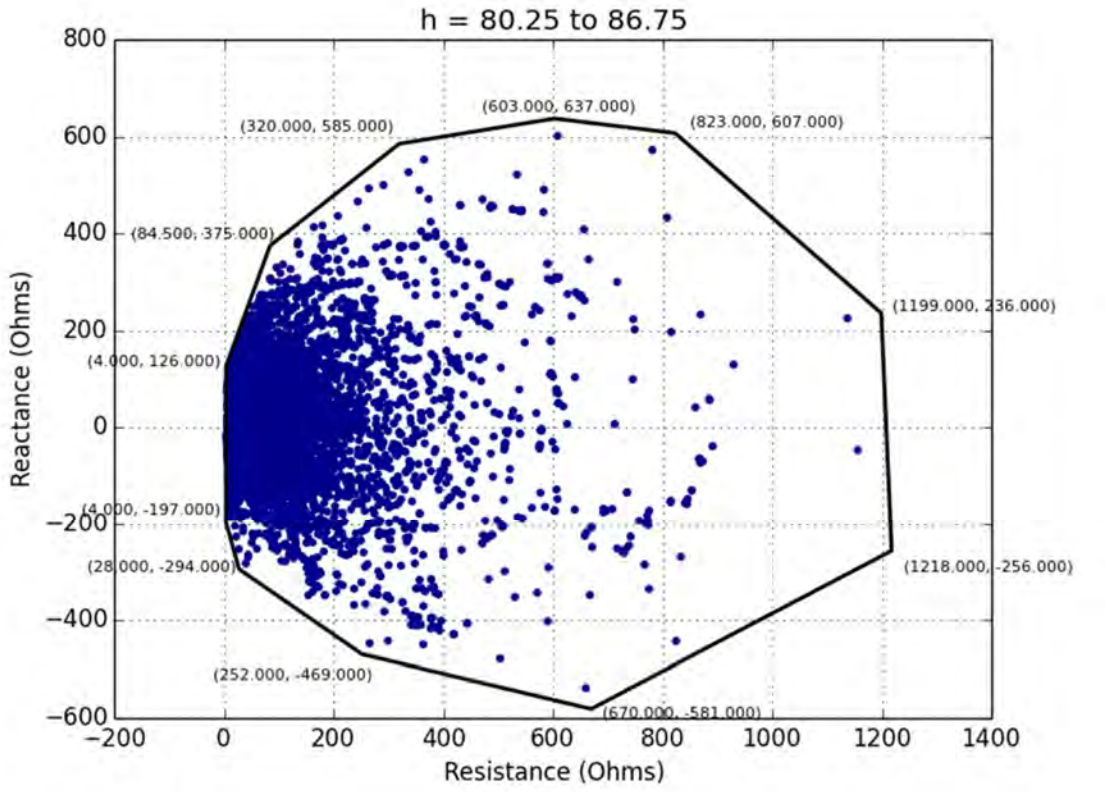


Table 5-21 Vertices of locus for group 20

R (Ohms)	X (Ohms)
4.000	-197.000
4.000	126.000
84.500	375.000
320.000	585.000
603.000	637.000
823.000	607.000
1199.000	236.000
1218.000	-256.000
670.000	-581.000
252.000	-469.000
28.000	-294.000

Figure 5-27 Locus for group 21, orders 86.5 to 92.75 inclusive

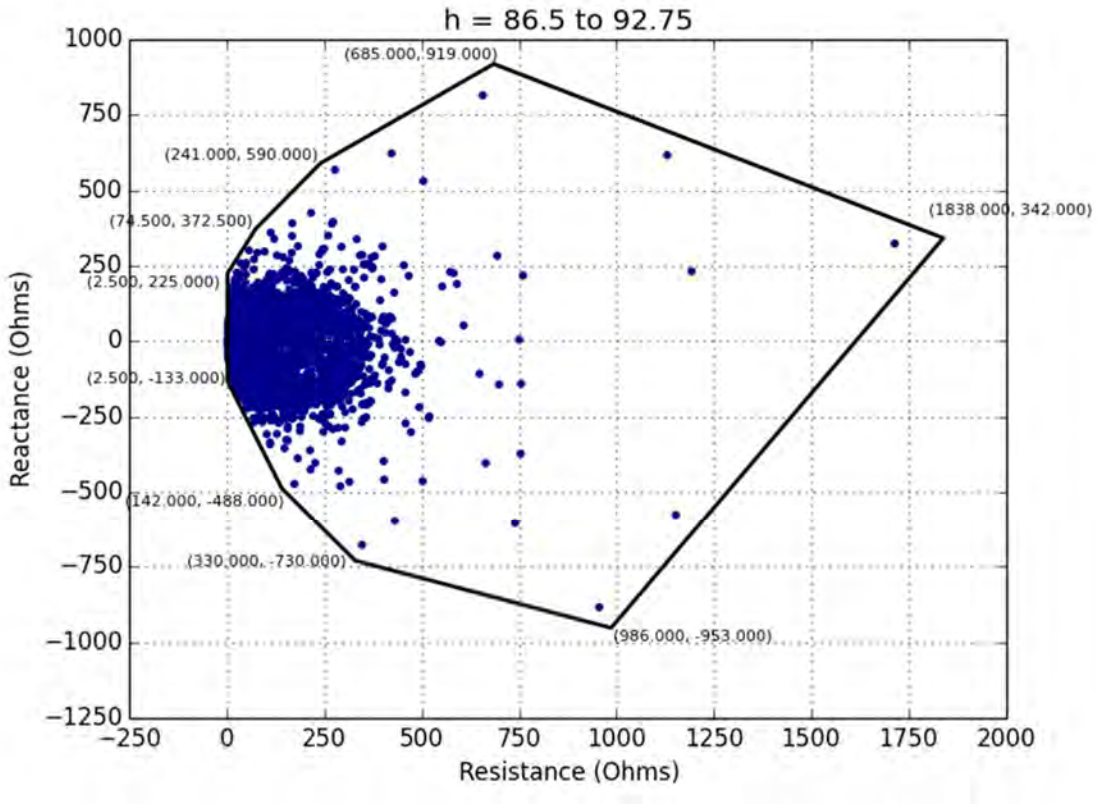


Table 5-22 Vertices of locus for group 21

R (Ohms)	X (Ohms)
2.500	-133.000
2.500	225.000
74.500	372.500
241.000	590.000
685.000	919.000
1838.000	342.000
986.000	-953.000
330.000	-730.000
142.000	-488.000

Figure 5-28 Locus for group 22, orders 92.5 to 97.75 inclusive

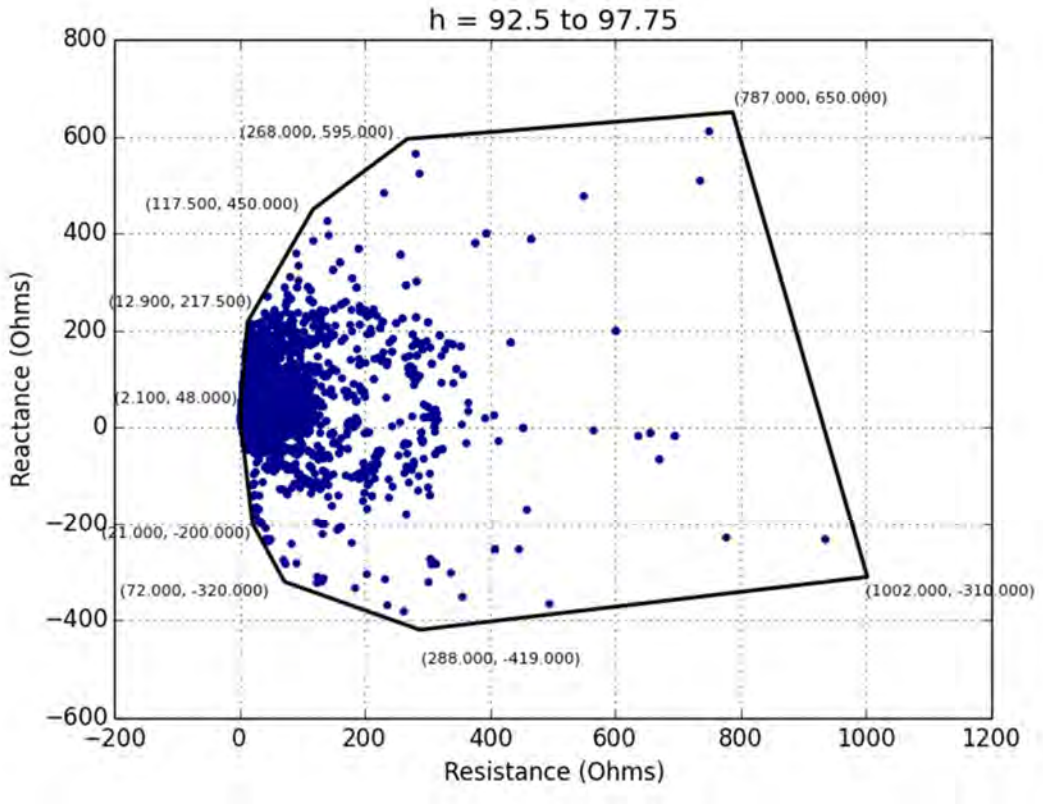


Table 5-23 Vertices of locus for group 22

R (Ohms)	X (Ohms)
2.100	6.600
2.100	48.000
12.900	217.500
117.500	450.000
268.000	595.000
787.000	650.000
1002.000	-310.000
288.000	-419.000
72.000	-320.000
21.000	-200.000

Figure 5-29 Locus for group 23, orders 97.5 to 101 inclusive

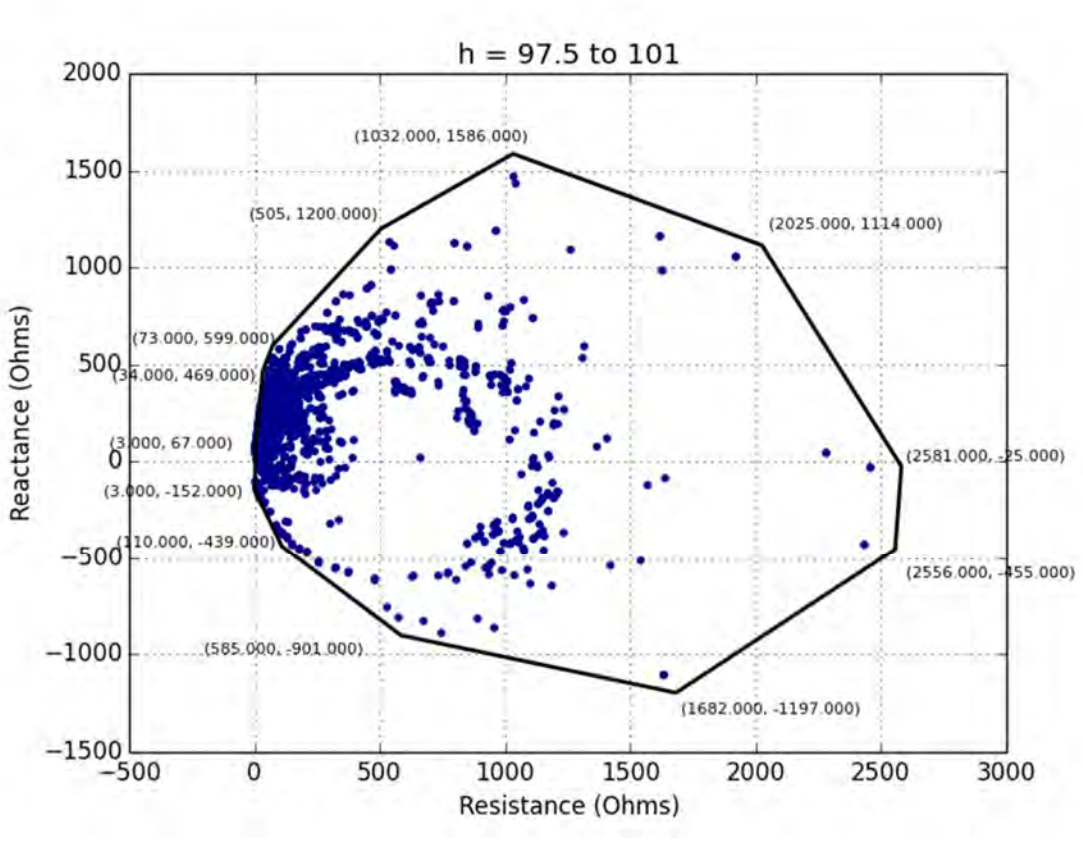


Table 5-24 Vertices of locus for group 23

R (Ohms)	X (Ohms)
3.000	-152.000
3.000	67.000
34.000	469.000
73.000	599.000
505.000	1200.000
1032.000	1586.000
2025.000	1114.000
2581.000	-25.000
2556.000	-455.000
1682.000	-1197.000
585.000	-901.000
110.000	-439.000

6 Limits Calculation

As noted in section 1, the methodology in ENA ER G5/5 has been used to calculate the limits. In this methodology aggregate total distortion limits lower than the ER G5/5 planning limits are calculated, by apportioning the 'distortion headroom' available at the IP based on the capacity of the new connection in MVA.

Incremental distortion limit, is the limit on the level of distortion which may be caused at the IP solely from harmonic emissions from equipment within the VBOWF networks. This is calculated with the aim of ensuring nodes within the wider network are not detrimentally impacted by the connection of VBOWF.

Total distortion limit, is the total aggregate limit of distortion at the IP after VBOWF connection taking into account emissions from the VBOWF networks and existing network background distortion. This is calculated with the aim of keeping distortion at the IP below G5/5 planning levels. A portion of the headroom available at the IP being available to the new connection based on its MVA capacity.

The methodology presented in ENA ER G5/5 for concurrent connections at the same busbar has been used to calculate limits for all three links from the wind farms. Using this methodology limits are calculated for link 1 based on the existing harmonic headroom (at Necton and remote nodes). Limits are then calculated for link 2, by assuming that link 1 takes up its full harmonic distortion limit allocation, and reducing the harmonic headroom at Necton and remote nodes accordingly. The process is then repeated for link 3, assuming that link 2 takes up its full harmonic distortion limit allocation.

6.1 Studied Nodes

The process of harmonic gain analysis by which busbars in the NGET\DNO networks were selected for study is described in the TNEI report 12182-04-R0. It was subsequently not possible to obtain distortion measurements at the Sheringham Shoal Offshore Wind Farm 132 kV busbar. This node has therefore been omitted from the limit calculations. Earlham 132 kV is included in the study, and is radially before and relatively close to Sheringham Shoal. Omission of Sheringham Shoal should not therefore adversely impact the harmonic compliance of VBOWF. The 37 nodes selected for study are listed below in Table 6-1.

Table 6-1 – Nodes studied

Code	Location
NECT4 M1(1)	Necton 400 kV (The IP)
BICF1 M2	Bicker Fen 132 kV
BICF4 M1	Bicker Fen 400 kV
BRAI4A	Braintree 400 kV (A)
BRAI4B	Braintree 400 kV (B)
BRFO1 M1	Bramford 132 kV (M1)
BRFO1 R1	Bramford 132 kV (R1)
BRFO4 M6	Bramford 400 kV
BULL4 M1	Bulls Lodge 400 kV
BURW4 MC1	Burwell 400 kV
EAHA11	Earlham 132 kV
EYEP4 M1	Eye 400 kV
KINL4 M1	Kings Lynn 400 kV
M1	Norwich Trowse 132 kV (M1)
NORM4 M2	Norwich Main 400 kV
PELH1 M1	Pelham 132 kV (M1)
PELH1 R1	Pelham 132 kV (R1)
PELH4 M1	Pelham 400 kV
R1	Norwich Trowse 132 kV (R1)
RYEH4 M1	Rye House 400 kV
SIZE4 M1	Sizewell 400 kV
SPLN4 M1	Spalding North 400 kV
SUTB4A	Sutton Bridge 400 kV
WALP4 M1	Walpole 400 kV (M1)
WALP4 M2	Walpole 400 kV (M2)
WBUR4 M2	West Burton 400 kV (M2)
WBUR4 R1/2	West Burton 400 kV (R1/2)
WYMO4 M1	Wymondley 400 kV
DUDO1 MB1	Dudgeon onshore substation 132 kV (MB1)
DUDO1 MB2	Dudgeon onshore substation 132 kV (MB2)
LINS1 M1	Lincs offshore wind farm 132 kV (M1)
LINS1 M2	Lincs offshore wind farm 132 kV (M2)
RACB2 M1	Race Bank wind farm 220 kV (M1)
RACB2 M2	Race Bank wind farm 220 kV (M2)
RAAYL4 M1	Rayleigh 400 kV
WALX2 M1	Waltham Cross 275 kV (M1)
WALX2 M2	Waltham Cross 275 kV (M2)

6.2 Background Distortion

Harmonic distortion at the selected busbars shown in Table 6-1 were provided by the transmission network operators. These results are shown in Table 6-2 (orders 2 to 50) and Table 6-3 (orders 51 to 100).

Table 6-2 Background measurements, orders 2 to 50

Harmonic Order	NECT4 M1(1)	BICF1 M2	BICF4 M1	BRAI4A	BRAI4B	BRFO1 M1	BRFO1 R1	BRFO4 M6	BULL4 M1	BURW4 MC1	EAHA11	EYEP4 M1	KINL4 M1	M1	NORM4 M2	PELH1 M1	PELH1 R1	PELH4 M1	R1
2	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.18	0.01	0.00	0.03	0.03	0.03	0.00
3	0.11	0.21	0.10	0.16	0.18	0.21	0.11	0.12	0.16	0.10	0.10	0.12	0.42	0.15	0.11	0.19	0.19	0.19	0.10
4	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.10	0.00	0.00	0.02	0.02	0.02	0.00
5	0.18	0.55	0.27	0.26	0.26	0.77	0.14	0.18	0.27	0.38	0.41	0.20	0.46	1.47	0.20	0.35	0.35	0.35	0.33
6	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.11	0.58	0.23	0.15	0.21	0.53	0.10	0.11	0.15	0.34	0.11	0.12	0.14	1.07	0.12	0.31	0.31	0.31	0.00
8	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
9	0.03	0.14	0.00	0.00	0.00	0.09	0.00	0.00	0.02	0.06	0.00	0.00	0.00	0.10	0.00	0.04	0.04	0.04	0.00
10	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.11	0.19	0.24	0.10	0.16	0.21	0.27	0.10	0.09	0.27	0.00	0.11	0.11	0.23	0.10	0.10	0.10	0.10	0.10
12	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.10	0.11	0.10	0.10	0.10	0.05	0.10	0.10	0.08	0.08	0.00	0.12	0.10	0.06	0.10	0.10	0.10	0.10	0.10
14	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.02	0.09	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.03	0.03	0.00
16	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.05	0.14	0.00	0.00	0.16	0.12	0.00	0.00	0.03	0.07	0.00	0.00	0.00	0.06	0.00	0.10	0.10	0.10	0.00
18	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.03	0.13	0.00	0.00	0.10	0.06	0.00	0.00	0.05	0.10	0.10	0.11	0.00	0.09	0.10	0.09	0.09	0.09	0.10
20	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.02	0.12	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.07	0.00	0.03	0.03	0.03	0.00
22	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.08	0.13	0.00	0.10	0.13	0.00	0.00	0.00	0.11	0.00	0.28	0.18	0.10	0.06	0.10	0.02	0.02	0.02	0.24
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.06	0.06	0.10	0.11	0.38	0.00	0.00	0.00	0.11	0.00	0.21	0.26	0.10	0.04	0.10	0.03	0.03	0.03	0.17
26	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.01	0.04	0.00	0.00	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.06	0.00	0.00	0.11	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.06	0.00	0.00	0.10	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.01	0.10	0.00	0.29	0.24	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.00
36	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.02	0.11	0.00	0.11	0.10	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00
38	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.01	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Harmonic Order	RYEH4 M1	SIZE4 M1	SPLN4 M1	SUTB4A	WALP4 M1	WALP4 M2	WBUR4 M2	WBUR4 R1/2	WYMO4 M1	DUDO1 MB1	DUDO1 MB2	LINS1 M1	LINS1 M2	RACB2 M1	RACB2 M2	RAAYL4 M1	WALX2 M1	WALX2 M2
2	0.01	0.05	0.00	0.02	0.26	0.27	0.02	0.02	0.01	0.12	0.11	0.28	0.28	0.02	0.02	0.00	0.00	0.00
3	0.73	0.70	0.10	0.76	0.22	0.64	0.13	0.15	0.10	0.12	0.10	0.00	0.00	0.15	0.14	0.16	0.36	0.36
4	0.01	0.02	0.00	0.00	0.12	0.12	0.02	0.02	0.01	0.04	0.04	0.00	0.00	0.01	0.01	0.00	0.00	0.00
5	0.37	0.53	0.32	0.74	0.21	0.66	0.35	0.23	0.18	0.20	0.19	0.54	0.54	0.11	0.12	0.23	0.14	0.18
6	0.00	0.01	0.00	0.00	0.04	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.08	0.17	0.29	0.15	0.13	0.17	0.27	0.38	0.25	0.07	0.06	0.06	0.06	0.00	0.00	0.14	0.26	0.26
8	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.09	0.14	0.10	0.01	0.00	0.00	0.02	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.16	0.16	0.36	0.07	0.06	0.11	0.07	0.07	0.07	0.05	0.01	0.00	0.00	0.00	0.00	0.14	0.00	0.10
12	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.09	0.08	0.11	0.02	0.06	0.10	0.10	0.09	0.04	0.07	0.06	0.00	0.00	0.00	0.00	0.10	0.00	0.15
14	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.07	0.12	0.00	0.00	0.00	0.00	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.07	0.09	0.00	0.01	0.00	0.00	0.09	0.10	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.11	0.00	0.00
18	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.09	0.17	0.00	0.04	0.00	0.00	0.05	0.05	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.10	0.00
20	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.02	0.03	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.03	0.05	0.00	0.08	0.00	0.10	0.05	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.10	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.05	0.08	0.00	0.09	0.00	0.10	0.03	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.22	0.10	0.00
26	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.10
27	0.03	0.04	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.04	0.03	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.05	0.10	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.09	0.05	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.19	0.10	0.29
36	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
37	0.04	0.03	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.25	0.10
38	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	0.39	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.08	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6-3 Background measurements, orders 51 to 100

Harmonic Order	NECT4 M1(1)	BICF1 M2	BICF4 M1	BRAI4A	BRAI4B	BRFO1 M1	BRFO1 R1	BRFO4 M6	BULL4 M1	BURW4 MC1	EAHA11	EYEP4 M1	KINL4 M1	M1	NORM4 M2	PELH1 M1	PELH1 R1	PELH4 M1	R1
51	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Harmonic Order	RYEH4 M1	SIZE4 M1	SPLN4 M1	SUTB4A	WALP4 M1	WALP4 M2	WBUR4 M2	WBUR4 R1/2	WYMO4 M1	DUDO1 MB1	DUDO1 MB2	LINS1 M1	LINS1 M2	RACB2 M1	RACB2 M2	RAAYL4 M1	WALX2 M1	WALX2 M2
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.10
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6.3 Methodology

6.3.1 Link 1 limit calculation methodology

6.3.1.1 Calculation of harmonic headroom

The first stage of setting the incremental and total distortion limits, is to calculate the harmonic distortion headroom at each busbar studied at every order. This was calculated using the equation below:

$$H_n^h = \sqrt[\propto]{(V_{PL}^h)^{\propto} - (V_{bg}^h)^{\propto}}$$

Where:

H_n^h: is the harmonic voltage headroom at busbar *n*, order *h.*

V_{PL}^h: is the G5/5 planning level for harmonic order *h* at the voltage level of busbar *n*.

V_{bg}^h: is the existing 'background' harmonic voltage distortion at order *h* at busbar *n*.

$\propto$: 1 for h < 5; 1.4 for 5 ≤ h ≤ 10; 2 for h > 10.

Headroom at nodes remote from the VBOWF IP is then transferred to the IP, using the harmonic gain as shown below. Calculation of harmonic gain factors has been described in TNEI report 12182-04-R0. The headroom of node *n* at order *h*, transferred to the IP is the amount of incremental distortion at the IP which would cause the resulting distortion at node *n* to reach the G5/5 planning level.

$$H_{n-ip}^h = \frac{H_n^h}{G_{ip-n}^h}$$

Where:

H_{n-ip}^h: Is the harmonic headroom of node *n* transferred to the IP.

G_{ip-n}^h: Is the harmonic gain factor from the IP to node *n*.

6.3.1.2 Calculation of incremental distortion limit

Firstly, the minimum H_{n-ip}^h at each order, across all nodes studied (this includes the IP) is determined and this value is then multiplied by an apportionment factor to determine the incremental limit, as below.

$$V_{limit-increment}^h = M\ x\ minimum\left(H_{n-ip}^h, H_{ip}^h\right)$$

The apportionment multiplier, M, was determined using the following formula, resulting in a factor of 0.587467. Where, S_i is the connection MVA of the link which is 1320 for each link.

$$M = \left(\frac{16}{75} \times k\right) + \frac{67}{150}$$

$$k = \frac{S_i}{2000}$$

6.3.1.3 Calculation of the total aggregate harmonic limit

The total aggregate harmonic limit at each harmonic order at the IP is calculated by multiplying headroom available at the IP by the apportionment multiplier, M, and adding this to the existing distortion at the IP, as below.

$$V_{limit-total}^{h} = \sqrt[\alpha]{\left(V_{bg}^{h}\right)^{\propto} + \left(M \times H_{ip}^{h}\right)^{\alpha}}$$

6.3.1.4 Minimum limit

Where a final calculated limit at the IP was less than 0.1 %, as agreed with Vattenfall and in line with section 10.6 of EREC G5/5, the limit value has been rounded up to 0.1 %. It was only necessary to apply this rounding to the incremental limits, $V_{limit-incremental}^{h}$.

6.3.2 Link 2 limit calculation methodology

The limits for the connection of Link 2 were calculated using the methodology in section 6.3.1, except the harmonic headroom available was modified to assume that the Link 1 connection takes up its full limit allocation.

Harmonic headroom at the IP (Necton 400 kV) was calculated as:

$$H_{IP-Link2}^{h} = \sqrt[\propto]{\left(V_{PL}^{h}\right)^{\propto} - \left(V_{limit-total-link\ 1}^{h}\right)^{\propto}}$$

Where:

$H_{IP-Link2}^{h}$: is the harmonic voltage headroom at the IP, order *h*, available for the Link 2 connection.

$V_{limit-total-link\ 1}^{h}$: is the total voltage distortion limit calculated for the Link 1 connection in section 6.3.1.3.

The transferred headroom from remote nodes to the IP was modified by the incremental limit calculated for the Link 1 connection as:

$$H_{n-IP-Link\ 2}^{h} = \sqrt[\propto]{\left(H_{n-IP}^{h}\right)^{\propto} - \left(V_{limit-incremental-Link\ 1}^{h}\right)^{\propto}}$$

Where:

$H_{n-IP-Link\ 2}^{h}$: is the harmonic headroom of node *n*, transferred to the IP, available for the Link 2 connection.

H_{n-IP}^{h}: is the harmonic headroom of node *n*, transferred to the IP, available for the Link 1 connection, calculated in section 6.3.1.1.

$V_{limit-incremental-Link1}^{h}$: is the incremental voltage limit, order *h*, calculated for the Link 1 connection in section 6.3.1.2.

6.3.3 Link 3 limit calculation methodology

The methodology described in section 6.3.2 was repeated, considering Link 2 and Link 3 rather than Link 1 and Link 2.

7 Voltage Distortion Limits

7.1 Link 1 distortion limits

The calculated voltage distortion limits at the Necton IP, along with the NGET measured background distortion are shown in Table 7-1 to Table 7-3.

Table 7-1 Network distortion at Necton 400 kV prior to Link 1 connection (% fundamental)

h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)
		26	0.010	51	0.00	76	0.000
2	0.050	27	0.010	52	0.00	77	0.010
3	0.110	28	0.000	53	0.01	78	0.000
4	0.020	29	0.000	54	0.00	79	0.010
5	0.180	30	0.000	55	0.01	80	0.000
6	0.010	31	0.000	56	0.00	81	0.000
7	0.110	32	0.000	57	0.00	82	0.000
8	0.010	33	0.000	58	0.00	83	0.000
9	0.030	34	0.000	59	0.00	84	0.000
10	0.010	35	0.010	60	0.00	85	0.000
11	0.110	36	0.000	61	0.00	86	0.000
12	0.010	37	0.020	62	0.00	87	0.000
13	0.100	38	0.000	63	0.00	88	0.000
14	0.000	39	0.000	64	0.00	89	0.000
15	0.020	40	0.000	65	0.00	90	0.000
16	0.000	41	0.010	66	0.00	91	0.000
17	0.050	42	0.000	67	0.00	92	0.000
18	0.000	43	0.010	68	0.00	93	0.000
19	0.030	44	0.000	69	0.00	94	0.000
20	0.000	45	0.000	70	0.00	95	0.000
21	0.020	46	0.000	71	0.01	96	0.000
22	0.000	47	0.010	72	0.00	97	0.000
23	0.080	48	0.000	73	0.00	98	0.000
24	0.000	49	0.010	74	0.00	99	0.000
25	0.060	50	0.000	75	0.00	100	0.000

Table 7-2 Calculated Link 1 Incremental distortion harmonic voltage limits, $V_{h\ limit\ inc}$ (% fundamental)

h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)
		26	0.100	51	0.100	76	0.100
2	0.205	27	0.100	52	0.100	77	0.100
3	0.100	28	0.100	53	0.100	78	0.100
4	0.370	29	0.100	54	0.100	79	0.100
5	0.177	30	0.100	55	0.100	80	0.100
6	0.134	31	0.100	56	0.100	81	0.100
7	1.098	32	0.100	57	0.100	82	0.100
8	0.197	33	0.100	58	0.100	83	0.100
9	0.236	34	0.100	59	0.100	84	0.100
10	0.130	35	0.100	60	0.100	85	0.100
11	0.179	36	0.100	61	0.100	86	0.100
12	0.100	37	0.100	62	0.100	87	0.100
13	0.147	38	0.100	63	0.100	88	0.100
14	0.100	39	0.100	64	0.100	89	0.100
15	0.100	40	0.100	65	0.100	90	0.100
16	0.100	41	0.100	66	0.100	91	0.100
17	0.134	42	0.100	67	0.100	92	0.100
18	0.100	43	0.100	68	0.100	93	0.100
19	0.251	44	0.100	69	0.100	94	0.100
20	0.100	45	0.100	70	0.100	95	0.100
21	0.100	46	0.100	71	0.100	96	0.100
22	0.100	47	0.100	72	0.100	97	0.100
23	0.100	48	0.100	73	0.100	98	0.100
24	0.100	49	0.100	74	0.100	99	0.100
25	0.127	50	0.100	75	0.100	100	0.100

Table 7-3 Calculated Link 1 total harmonic voltage limits, $V_{h\ limit\ total}$ (% fundamental)

h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)
		26	0.118	51	0.117	76	0.117
2	0.608	27	0.118	52	0.117	77	0.232
3	0.927	28	0.117	53	0.284	78	0.117
4	0.478	29	0.421	54	0.117	79	0.229
5	1.207	30	0.117	55	0.278	80	0.117
6	0.295	31	0.402	56	0.117	81	0.117
7	1.191	32	0.117	57	0.117	82	0.117
8	0.236	33	0.117	58	0.117	83	0.224
9	0.298	34	0.117	59	0.267	84	0.117
10	0.236	35	0.369	60	0.117	85	0.221
11	0.886	36	0.117	61	0.262	86	0.117
12	0.118	37	0.356	62	0.117	87	0.117
13	0.885	38	0.117	63	0.117	88	0.117
14	0.117	39	0.117	64	0.117	89	0.217
15	0.177	40	0.117	65	0.253	90	0.117
16	0.117	41	0.333	66	0.117	91	0.214
17	0.706	42	0.117	67	0.249	92	0.117
18	0.117	43	0.323	68	0.117	93	0.117
19	0.588	44	0.117	69	0.117	94	0.117
20	0.117	45	0.117	70	0.117	95	0.210
21	0.119	46	0.117	71	0.242	96	0.117
22	0.117	47	0.305	72	0.117	97	0.208
23	0.474	48	0.117	73	0.238	98	0.117
24	0.117	49	0.297	74	0.117	99	0.117
25	0.472	50	0.117	75	0.117	100	0.117

7.2 Link 2 distortion limits

The calculated voltage distortion limits at the Necton IP, along with the NGET measured background distortion are shown in Table 7-4 to Table 7-6.

Table 7-4 Estimated network distortion at Necton 400 kV prior to Link 2 connection (% fundamental)

h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)
		26	0.118	51	0.12	76	0.117
2	0.608	27	0.118	52	0.12	77	0.232
3	0.927	28	0.117	53	0.28	78	0.117
4	0.478	29	0.421	54	0.12	79	0.229
5	1.207	30	0.117	55	0.28	80	0.117
6	0.295	31	0.402	56	0.12	81	0.117
7	1.191	32	0.117	57	0.12	82	0.117
8	0.236	33	0.117	58	0.12	83	0.224
9	0.298	34	0.117	59	0.27	84	0.117
10	0.236	35	0.369	60	0.12	85	0.221
11	0.886	36	0.117	61	0.26	86	0.117
12	0.118	37	0.356	62	0.12	87	0.117
13	0.885	38	0.117	63	0.12	88	0.117
14	0.117	39	0.117	64	0.12	89	0.217
15	0.177	40	0.117	65	0.25	90	0.117
16	0.117	41	0.333	66	0.12	91	0.214
17	0.706	42	0.117	67	0.25	92	0.117
18	0.117	43	0.323	68	0.12	93	0.117
19	0.588	44	0.117	69	0.12	94	0.117
20	0.117	45	0.117	70	0.12	95	0.210
21	0.119	46	0.117	71	0.24	96	0.117
22	0.117	47	0.305	72	0.12	97	0.208
23	0.474	48	0.117	73	0.24	98	0.117
24	0.117	49	0.297	74	0.12	99	0.117
25	0.472	50	0.117	75	0.12	100	0.117

Table 7-5 Calculated Link 2 Incremental distortion harmonic voltage limits, $V_{h\ limit\ inc}$ (% fundamental)

h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)
		26	0.100	51	0.100	76	0.100
2	0.100	27	0.100	52	0.100	77	0.100
3	0.100	28	0.100	53	0.100	78	0.100
4	0.153	29	0.100	54	0.100	79	0.100
5	0.112	30	0.100	55	0.100	80	0.100
6	0.100	31	0.100	56	0.100	81	0.100
7	0.693	32	0.100	57	0.100	82	0.100
8	0.125	33	0.100	58	0.100	83	0.100
9	0.149	34	0.100	59	0.100	84	0.100
10	0.100	35	0.100	60	0.100	85	0.100
11	0.144	36	0.100	61	0.100	86	0.100
12	0.100	37	0.100	62	0.100	87	0.100
13	0.119	38	0.100	63	0.100	88	0.100
14	0.100	39	0.100	64	0.100	89	0.100
15	0.100	40	0.100	65	0.100	90	0.100
16	0.100	41	0.100	66	0.100	91	0.100
17	0.109	42	0.100	67	0.100	92	0.100
18	0.100	43	0.100	68	0.100	93	0.100
19	0.203	44	0.100	69	0.100	94	0.100
20	0.100	45	0.100	70	0.100	95	0.100
21	0.100	46	0.100	71	0.100	96	0.100
22	0.100	47	0.100	72	0.100	97	0.100
23	0.100	48	0.100	73	0.100	98	0.100
24	0.100	49	0.100	74	0.100	99	0.100
25	0.103	50	0.100	75	0.100	100	0.100

Table 7-6 Calculated Link 2 total harmonic voltage limits, $V_{h\ limit\ total}$ (% fundamental)

h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)
		26	0.151	51	0.151	76	0.151
2	0.838	27	0.151	52	0.151	77	0.298
3	1.263	28	0.151	53	0.365	78	0.151
4	0.667	29	0.542	54	0.151	79	0.295
5	1.603	30	0.151	55	0.357	80	0.151
6	0.398	31	0.517	56	0.151	81	0.151
7	1.596	32	0.151	57	0.151	82	0.151
8	0.318	33	0.151	58	0.151	83	0.288
9	0.399	34	0.151	59	0.343	84	0.151
10	0.318	35	0.475	60	0.151	85	0.285
11	1.136	36	0.151	61	0.337	86	0.151
12	0.151	37	0.458	62	0.151	87	0.151
13	1.135	38	0.151	63	0.151	88	0.151
14	0.151	39	0.151	64	0.151	89	0.279
15	0.227	40	0.151	65	0.326	90	0.151
16	0.151	41	0.428	66	0.151	91	0.276
17	0.907	42	0.151	67	0.320	92	0.151
18	0.151	43	0.415	68	0.151	93	0.151
19	0.756	44	0.151	69	0.151	94	0.151
20	0.151	45	0.151	70	0.151	95	0.270
21	0.152	46	0.151	71	0.311	96	0.151
22	0.151	47	0.392	72	0.151	97	0.268
23	0.607	48	0.151	73	0.306	98	0.151
24	0.151	49	0.383	74	0.151	99	0.151
25	0.606	50	0.151	75	0.151	100	0.151

7.3 Link 3 distortion limits

The calculated voltage distortion limits at the Necton IP, along with the NGET measured background distortion are shown in Table 7-4 to Table 7-6.

Table 7-7 Estimated network distortion at Necton 400 kV prior to Link 3 connection (% fundamental)

h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)	h	Background harmonic level (%)
		26	0.151	51	0.15	76	0.151
2	0.838	27	0.151	52	0.15	77	0.298
3	1.263	28	0.151	53	0.37	78	0.151
4	0.667	29	0.542	54	0.15	79	0.295
5	1.603	30	0.151	55	0.36	80	0.151
6	0.398	31	0.517	56	0.15	81	0.151
7	1.596	32	0.151	57	0.15	82	0.151
8	0.318	33	0.151	58	0.15	83	0.288
9	0.399	34	0.151	59	0.34	84	0.151
10	0.318	35	0.475	60	0.15	85	0.285
11	1.136	36	0.151	61	0.34	86	0.151
12	0.151	37	0.458	62	0.15	87	0.151
13	1.135	38	0.151	63	0.15	88	0.151
14	0.151	39	0.151	64	0.15	89	0.279
15	0.227	40	0.151	65	0.33	90	0.151
16	0.151	41	0.428	66	0.15	91	0.276
17	0.907	42	0.151	67	0.32	92	0.151
18	0.151	43	0.415	68	0.15	93	0.151
19	0.756	44	0.151	69	0.15	94	0.151
20	0.151	45	0.151	70	0.15	95	0.270
21	0.152	46	0.151	71	0.31	96	0.151
22	0.151	47	0.392	72	0.15	97	0.268
23	0.607	48	0.151	73	0.31	98	0.151
24	0.151	49	0.383	74	0.15	99	0.151
25	0.606	50	0.151	75	0.15	100	0.151

Table 7-8 Calculated Link 3 Incremental distortion harmonic voltage limits, $V_{h\ limit\ inc}$ (% fundamental)

h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)	h	Incremental harmonic voltage limit (%)
		26	0.100	51	0.100	76	0.100
2	0.100	27	0.100	52	0.100	77	0.100
3	0.100	28	0.100	53	0.100	78	0.100
4	0.100	29	0.100	54	0.100	79	0.100
5	0.100	30	0.100	55	0.100	80	0.100
6	0.100	31	0.100	56	0.100	81	0.100
7	0.437	32	0.100	57	0.100	82	0.100
8	0.100	33	0.100	58	0.100	83	0.100
9	0.100	34	0.100	59	0.100	84	0.100
10	0.100	35	0.100	60	0.100	85	0.100
11	0.117	36	0.100	61	0.100	86	0.100
12	0.100	37	0.100	62	0.100	87	0.100
13	0.100	38	0.100	63	0.100	88	0.100
14	0.100	39	0.100	64	0.100	89	0.100
15	0.100	40	0.100	65	0.100	90	0.100
16	0.100	41	0.100	66	0.100	91	0.100
17	0.100	42	0.100	67	0.100	92	0.100
18	0.100	43	0.100	68	0.100	93	0.100
19	0.164	44	0.100	69	0.100	94	0.100
20	0.100	45	0.100	70	0.100	95	0.100
21	0.100	46	0.100	71	0.100	96	0.100
22	0.100	47	0.100	72	0.100	97	0.100
23	0.100	48	0.100	73	0.100	98	0.100
24	0.100	49	0.100	74	0.100	99	0.100
25	0.100	50	0.100	75	0.100	100	0.100

Table 7-9 Calculated Link 3 total harmonic voltage limits, $V_{h\ limit\ total}$ (% fundamental)

h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)	h	Total harmonic voltage limit (%)
		26	0.170	51	0.170	76	0.170
2	0.933	27	0.170	52	0.170	77	0.335
3	1.402	28	0.170	53	0.410	78	0.170
4	0.745	29	0.608	54	0.170	79	0.331
5	1.796	30	0.170	55	0.401	80	0.170
6	0.447	31	0.580	56	0.170	81	0.170
7	1.792	32	0.170	57	0.170	82	0.170
8	0.358	33	0.170	58	0.170	83	0.323
9	0.448	34	0.170	59	0.385	84	0.170
10	0.358	35	0.533	60	0.170	85	0.319
11	1.273	36	0.170	61	0.378	86	0.170
12	0.170	37	0.514	62	0.170	87	0.170
13	1.273	38	0.170	63	0.170	88	0.170
14	0.170	39	0.170	64	0.170	89	0.313
15	0.255	40	0.170	65	0.365	90	0.170
16	0.170	41	0.480	66	0.170	91	0.309
17	1.018	42	0.170	67	0.359	92	0.170
18	0.170	43	0.465	68	0.170	93	0.170
19	0.848	44	0.170	69	0.170	94	0.170
20	0.170	45	0.170	70	0.170	95	0.304
21	0.170	46	0.170	71	0.349	96	0.170
22	0.170	47	0.440	72	0.170	97	0.301
23	0.680	48	0.170	73	0.344	98	0.170
24	0.170	49	0.429	74	0.170	99	0.170
25	0.679	50	0.170	75	0.170	100	0.170

8 Recommendations

It is recommended to use the values shown in section 7 in the design of the Vanguard and Boreas Offshore wind farms.

The impedance information for the transmission network, after the works required for the final 360 MW of TEC are completed, should be obtained, and used in the harmonic design. It was not possible to include this information in the impedance loci presented in this report.

APPENDIX D

RESTRICTIONS ON AVAILABILITY (OFFSHORE)

User:	Norfolk Vanguard West Limited
Connection Site:	Norfolk Vanguard West 66 kV Offshore Platform
Transmission Interface Site:	Necton 400 kV Substation

Note: The restrictions in this Appendix D will need to be updated in the detailed design phase.

Part 1

Part 1 shows the circuits on the National Electricity Transmission System that are relevant for the purposes of the Restrictions on Availability.

Relevant Circuits:

Circuit A	The **Transmission** assets between **Offshore Grid Entry Point** and the **Transmission Interface Point**.

Part 2 – Outage Conditions

Each and any of the following constitute an Outage Condition for the purposes of the relevant Clause of the Bilateral Connection Agreement will apply:-

In the event of:

Outage Condition A	The EU Code User will MEL down to 0MW.

Where:

Outage Condition A	is the planned and/or unplanned unavailability in full or in part of Circuit A.

APPENDIX F

SITE SPECIFIC TECHNICAL CONDITIONS
CONTENTS

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Contents

F1 Agreed Ancillary Services

F2 Derogated Plant

F3 Special Automatic Facilities

F4 Relay Settings & Protection

F5 Other Technical Requirements

Terms

For the purposes of the body of this Appendix F only, the term “EU Code User” is used when referring to the EU Code User in its capacity as a EU Generator connecting to the National Electricity Transmission System at the Offshore Grid Entry Point and the term “OTSDUW User” is used when referring to the EU Code User in its role in undertaking the design, construction and commissioning of the OTSDUW Plant and Apparatus between the Transmission Interface Point and Offshore Grid Entry Point. For the avoidance of doubt the OTSDUW User shall be responsible for the design, installation and commissioning of the Offshore Transmission Network until the OTSUA Transfer Time from when the responsibilities of the Offshore Transmission Network will rest with the appointed Offshore Transmission Licensee.

General

The requirements of this Appendix F apply to all the EU Code User’s Power Park Modules up to the Offshore Grid Entry Point.

Electrical Standards at the Offshore Connection Site

The EU Code User shall ensure that all EU Code User’s Equipment contained within the busbar protection zone at the Offshore Grid Entry Point (see Grid Code ECC 6.2.1.2) complies with applicable IEC, BS and any other relevant electrical standards unless otherwise agreed with The Company and Onshore Transmission Licensee and shall be suitably designed to operate in a marine environment.

APPENDIX F1

SITE SPECIFIC TECHNICAL CONDITIONS
BALANCING SERVICES

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Agreed Ancillary Services

The Connection and Use of System Code (CUSC) and the Grid Code detail The Company's requirements for provision of Mandatory Ancillary Services (CUSC Clause 1.3.3, Section 4 and Schedule 2 - Exhibit 4 and Grid Code ECC.8).

The EU Code User may wish to consider, prior to the construction phase of its project, whether it intends to negotiate the provision of additional Balancing Services (Agreed Ancillary Services) in order that it can install the necessary hardware to allow monitoring of such services.

Details of the types of Balancing Service and methods of securing them are contained in The Company's Procurement Guidelines and Balancing Principles.

General

The Company may wish to approach the EU Code User to establish a valid bilateral payment arrangement for the establishment of a Commercial Transmission System to Generator Operational Intertripping Scheme in the future. This approach would be made at such time that The Company has established certainty in the local generation background.

The EU Code User shall co-operate with The Company in installing, enhancing, and amending these facilities and will not unreasonably withhold its agreement to any such proposals should The Company require this at a later date.

Any changes to this Appendix F1 and/or to The Company's and/or EU Code User's obligations shall be subject to the provisions of Paragraph 2.9.3 of the CUSC which states that if either party wishes to modify, alter or change the site specific technical conditions it shall be deemed to be a Modification for the purposes of the CUSC unless CUSC 4.2B.3 (Agreed Ancillary Services) applies. CUSC 4.2B.3 states that if both parties have failed to reach agreement within a reasonable period then The Company is entitled to initiate the procedure for resolution as an "Other Dispute." This does not apply in the case of Maximum Generation or System to Generator Operational Intertripping.

APPENDIX F2

SITE SPECIFIC TECHNICAL CONDITIONS
DEROGATED PLANT

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Derogated Plant

Not applicable.

APPENDIX F3

SITE SPECIFIC TECHNICAL CONDITIONS
SPECIAL AUTOMATIC FACILITIES

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Special Automatic Facilities

1. Transmission System to Generating Unit Intertripping Schemes

Category/Substation	Grid Code Ref	CUSC ref	Trip within (s) from receipt of the trip signal	Obligation
Category 2 / Norfolk Vanguard West 66kV Offshore Platform	BC2.10.2(a)	CUSC4.2A CUSC2.9.3	9.88	See schedule X for associated trips/outage combinations

1.1 Category 2 Intertripping Scheme at Norfolk Vanguard West 66kV Offshore Platform

This Transmission System to Generating Unit(s) intertrip is classified as a category 2 intertripping scheme, as defined in the Grid Code.

Where the EU Code User is required to provide a generator intertrip facility, the EU Code User shall include all information in accordance to those provisions within Appendix F4 and include all relevant information within Schedule 1 of Appendix F4.

The EU Code User agrees that The Company shall, in operational timescales issue an Ancillary Services instruction for the arming of the intertrip facility pursuant to the Grid Code BC2.10.2(a) and CUSC 4.2A. The Company shall issue an instruction to arm the intertripping scheme for one or more of the outage combinations as specified in Schedule X of Appendix F3.

In the event that the intertrip is not healthy The Company shall issue an instruction to the EU Code User with the course of action to be taken.

General

The EU Code User shall co-operate with The Company in installing, enhancing, and amending these facilities, should The Company require this at a later date, and will not unreasonably withhold its agreement to any such proposals.

For the avoidance of doubt, except where CUSC 4.2A.6 applies, any such changes of this Appendix F3 and/or to The Company's and/or the EU Code User's obligations in respect therefore shall be subject to the provisions of Paragraph 2.9.3 of the CUSC.

Technical Requirements and Obligations Relating to Operational Intertripping

The EU Code User is required to install and maintain an intertripping facility such that on receipt of an appropriate signal(s) from the OTSDUW Plant and Apparatus or National Electricity Transmission System, the Power Park Module(s) will trip by opening the Power Park Module(s) circuit breaker(s) within 9.88s of receiving the signal. This shall form part of the EU Code User's System.

The Onshore Transmission Licensee will provide the required signals to facilitate this intertripping facility to a marshalling cubicle located at the Transmission Interface Point at Necton 400kV Onshore Substation. The EU Code User shall be responsible for the installation and maintenance of duplicated communications routes between the Offshore Grid Entry Point at Norfolk Vanguard West 66kV Offshore Substation and the Power Park Modules.

The intertripping scheme will be monitored by the EU Code User to ensure it is healthy at all times and provide indications to The Company for all selections (for F3 intertrips this is as specified in Schedule 1). It is however acknowledged by The Company that the actual implementation of the intertripping scheme may vary from the indicative diagram shown in Schedule 2 and therefore the specific requirements will be agreed between The Company and the EU Code User in the detailed design phase.

The OTSDUW User will be responsible for the installation and maintenance of duplicated communications routes between the Transmission Interface Point at Necton 400kV Onshore Substation and the Offshore Grid Entry Point at Norfolk Vanguard West 66kV Offshore substation. Once in operation, the ownership of part or the whole of the communication equipment will be transferred to the appointed OTL where each party (the EU Code User and OTL) will then be responsible for the maintenance of their own assets.

The functionality, performance, availability, accuracy, dependability, security, protocol and repair times of the communications links, trip facilities and monitoring facilities from the marshalling cubicles located at Norfolk Vanguard West 66kV Offshore Substation to the EU Code User's circuit breakers, shall be agreed with The Company and Onshore Transmission Licensee as soon as reasonably practicable and at least 24 months before the Completion Date .

The System shall be fail safe such that no single hardware, software, system, communication, interface or power supply failure or depletion of facility shall result in failure to trip within the specified time or an incorrect control action.

The EU Code User shall install isolation facilities to locally switch the intertrip facility out of service. The EU Code User shall not isolate the intertripping facility unless otherwise agreed with The Company.

The EU Code User shall ensure that each Offshore Power Park Module is fully robust and protected against total disconnection from the OTSDUW Plant and Apparatus or National Electricity Transmission System.

2. Other Facilities
(ECC.6.2.2.7)

Requirement	
Automatic Open/ Closure Schemes	Not applicable unless specified.
System Splitting/Islanding Schemes	Not applicable unless specified.

3. Synchronising and Voltage Selection
(ECC.6.2.2.9)
Each Offshore Power Park Unit (forming part of an Offshore Power Park Module) shall be required to be fitted with Synchronising facilities in accordance with ECC.6.2.2.9.

There is no requirement for synchronising facilities to be installed at the Offshore Grid Entry Point between the EU Code User's generating equipment and the OTSDUW Plant and Apparatus. However the EU Code User's System (i.e. between the Offshore Power Park Units and Offshore Grid Entry Point) must always be de-energised prior to closure of the EU Code User's circuit breakers at the Offshore Grid Entry Point.

The EU Code User shall ensure that appropriate provisions are made to prevent the EU Code User's circuit breakers at the Offshore Grid Entry Point from being closed when the Power Park Strings are energised.

The EU Code User's Plant and Apparatus will be required to interface with the OTSDUW Plant and Apparatus voltage selection scheme at the Offshore Grid Entry Point.

In the case of DC connected Power Park Modules, the EU Code User shall also provide synchronisation signals specified via The Company as required by the Offshore Transmission Licensee.

In addition, during synchronisation of a DC connected Power Park Module it shall have the capability to limit any voltage changes to a Steady State Level specified via The Company as required by the Offshore Transmission Licensee. This shall not exceed 5% of the pre-synchronisation voltage. Any additional limits including magnitude, duration and transient over-voltage requirements will be specified via The Company as required by the Offshore Transmission Licensee.

4. Control Schemes and Settings
(ECC.6.2.2.7)

Where the EU Code User installs any equipment which may have an impact on the National Electricity Transmission System, they shall be discussed and agreed with The Company and the Onshore Transmission Licensee during the detailed design phase.

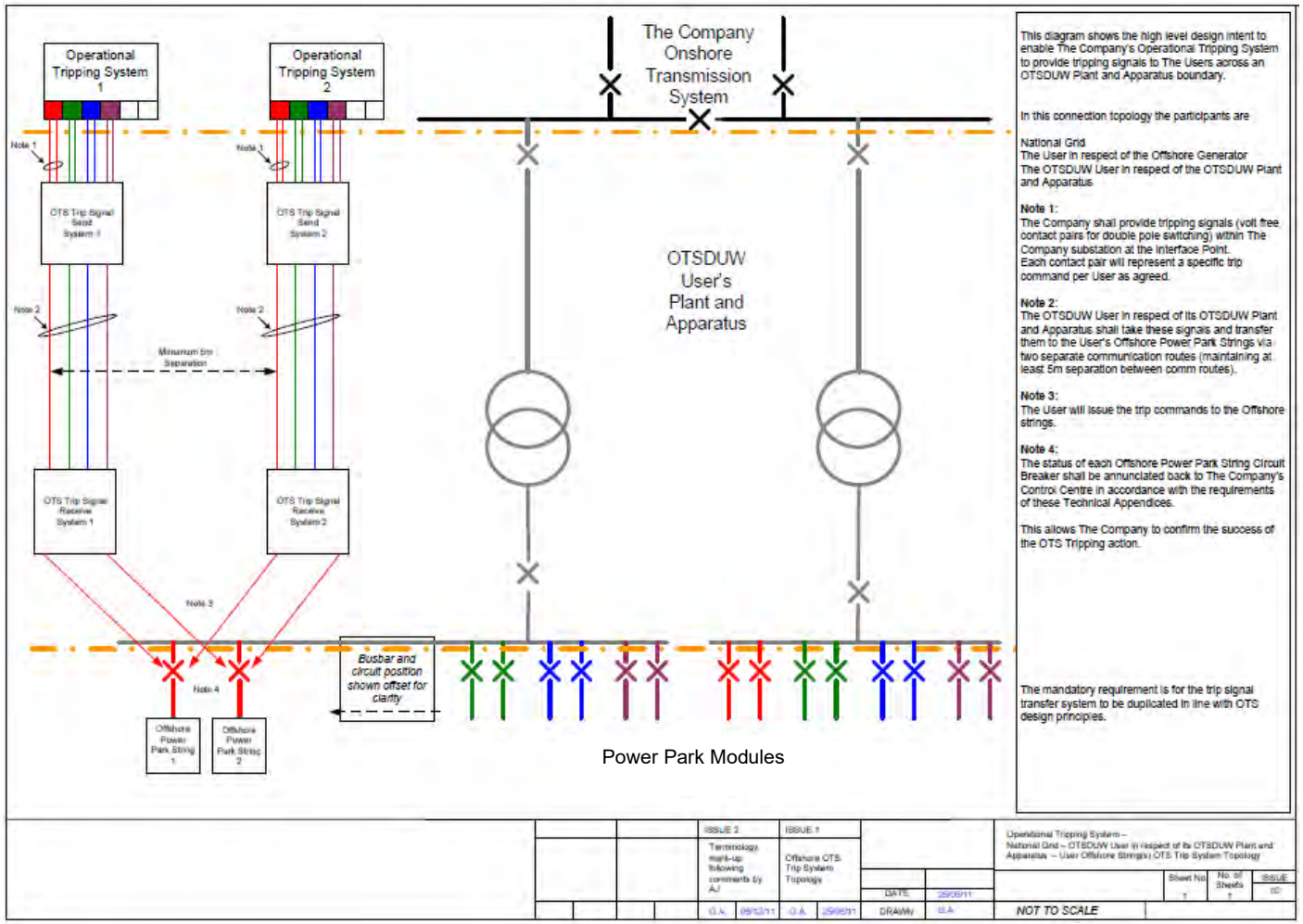
Once the EU Code Users Plant and Apparatus has been commissioned, any changes to the EU Code User's control system or settings shall be discussed and agreed with The Company and the Onshore Transmission Licensee prior to any change being made.

Appendix F3 – Schedule 1
Site Specific Technical Conditions – Circuits to be selected for Operational Intertripping.

Selection	System Maintenance Condition	Trip Condition	Overload Condition
1.	Norwich – Yaxley – Bramford 400kV circuit 1	Walpole- King's Lynn/ Walpole- Necton 400kV double circuit fault	Thermal overload on Norwich – Yaxley – Bramford 400kV circuit 2
2.	Norwich – Yaxley – Bramford 400kV circuit 2	Walpole- King's Lynn/ Walpole- Necton 400kV double circuit fault	Thermal overload on Norwich – Yaxley – Bramford 400kV circuit 1
3.			
4.			
5.			
6.			

Appendix F3 – Schedule 2

Site Specific Technical Conditions – Operational Intertripping Installation and Connection Arrangements



Note: The minimum separation (indicatively shown as 5 m) for the operational tripping system communication channels shall be agreed between the Onshore Transmission Licensee (via The Company), EU Code User and OTSDUW User in Detail Design Phase.

APPENDIX F4

SITE SPECIFIC TECHNICAL CONDITIONS
RELAY SETTINGS & PROTECTION

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Relay Settings and Protection

1. Relay Settings
(ECC.6.2.2.5, ECC.6.2.2.6, ECC.6.2.2.8)

The EU Code User shall complete the attached blank protection schedule pro-forma (Schedule 1 of this Appendix). The EU Code User shall submit the protection coordination report and settings on its plant for agreement by the OTSDUW User. This shall include details of the following:

a) Circuit diagrams of both ac connections and tripping for the purposes of interpreting the schedule.
b) Protection co-ordination report confirming compliance with the applicable clauses of the Grid Code Connection Conditions. The report shall also show how co-ordination with the Onshore Transmission Owner's existing system backup protection is achieved including proposed back-up protection grading curves.
c) Details of the Protection Dependability Index per protected zone. (ECC 6.2.2.2.2 d)

Not less than 3 months before the Commissioning Programme Commencement Date for the agreed works, the EU Code User shall have agreed the protection settings on the EU Code User's equipment with the OTSDUW User and confirmed this via The Company. Prior to commissioning, EU Code Users should also be aware of the requirements in ECC.6.2.2.8.

Any subsequent alterations to the protection settings by the EU Code User shall be notified to The Company via a submission of an amended version of Schedule 1 of this Appendix F4 in accordance with the Grid Code (ECC.6.2.2.5) for agreement with the OTSDUW User (or Offshore Transmission Licensee if after the OTSDUA transfer time).

In addition, any subsequent alterations to the protection settings on the OTSDUW Plant and Apparatus shall be notified to The Company and agreed between the EU Code User and OTSDUW User in accordance with the Grid Code (ECC.6.2.2.5).

No EU Code User equipment shall be energised until the protection settings have been finalised. The EU Code User shall agree with the OTSDUW User (via The Company), and carry out a commissioning programme for the protection systems for the EU Code User's Equipment at the Offshore Grid Entry Point. The EU Code User shall agree the Commissioning Programme with the OTSDUW User via The Company.

Ranking of protection and control shall be in accordance with ECC.6.2.2.8.1.

2. Generating Unit and Power Park Module Protection Arrangements
(ECC 6.2.2.2)

The fault clearance time (from fault inception to circuit breaker arc extinction) for faults on all the EU Code User's Equipment (i.e. from the Offshore Grid Entry Point to each Power Park

String) directly connected to the Offshore Grid Entry Point shall be agreed with the OTSDUW User (via The Company) in the detailed design phase. At the very least this shall be 18 months before the Completion Date , unless otherwise agreed with The Company and OTSDUW User.

APPENDIX F4 - Schedule 1

PROTECTION AND INTERTRIPPING DETAILS AT THE GENERATOR / OTSDUW USER INTERFACE

SITE NAME:

CIRCUIT NAME*:
* where a feeder exists between two sites, a separate schedule will be required for each end.

CIRCUIT BREAKER TO BE OPERATED	PROTECTION					SPECIFIED CLEARANCE TIME (See F4 Item 2)	MOST PROBABLE CLEARANCE TIME					FAULT SETTING		RELAY SETTINGS PLUS COMPONENT VALUES	CT RATIO
	PROTECTED ZONE	FUNCTION	MAKE	TYPE/ RATING	DEPENDABILITY INDEX		PROT^{N}	TRIP RELAY	CB	INTER TRIP	TOTAL	PHASE-PHASE	PHASE-EARTH		

EU Code User Representative Name: Date: Signature:

OTSDUW User Representative Name: Date: Signature:

APPENDIX F5

SITE SPECIFIC TECHNICAL CONDITIONS
OTHER TECHNICAL REQUIREMENTS

User:	Norfolk Vanguard West Limited
Type of User:	EU Code User Type D
Offshore Connection Site:	Norfolk Vanguard West 66kV Offshore Platform
Transmission Interface Point:	Necton 400kV Substation

Other Technical Requirements

The EU Code User can gain access to the technical specifications from the Relevant Transmission Licensee's Extranet website. Access to the Relevant Transmission Licensee's Extranet website can be requested via email to:- transmission.documentcontrol@nationalgrid.com .

	Criteria	**Grid Code Ref – EU Code User to comply with:**	**Obligations**
1.	Protection of interconnecting connections	ECC 6.2.2.3.1	The requirements for the protection of the Interconnecting Connections at the Offshore Grid Entry Point shall be agreed with the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date , unless otherwise agreed with The Company and OTSDUW User.
2.	Circuit Breaker Fail Protection	ECC.6.2.2.3.2	The requirements for the EU Code User's Circuit Breaker Fail Protection at the Offshore Grid Entry Point shall be agreed with the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date unless otherwise agreed with The Company and OTSDUW User.
3.	Fault Disconnection Facilities		Not applicable unless otherwise agreed between the EU Code User and the OTSDUW User (via The Company).
4.	Reactive capability	ECC.6.3.2.5 ECC.6.3.2.6	In the case of an Offshore Configuration 1 DC connected Power Park Module, the EU Code User is required to meet the requirements of ECC.6.3.2.5 of the Grid Code at the Offshore Grid Entry Point.

			In the case of an Offshore Configuration 2 DC connected Power Park Module, the EU Code User is required to meet the requirements of ECC.6.3.2.6 of the Grid Code at the Offshore Grid Entry Point. If the EU Code User chooses to provide a wider reactive capability range than that specified in ECC.6.3.2.5 or ECC.6.3.2.6 they should advise The Company of the full reactive capability range of which they are prepared to provide as soon as reasonably practicable and no later than 12 months before the Completion Date unless otherwise agreed with The Company.
5.	Black Start Capability	ECC.6.3.5	The EU Code User: There is no requirement for the EU Code User's plant to provide a Black Start facility.
6.	Quick Resynchronisation Capability	ECC.6.3.5.6	The EU Code User: Generators are not permitted to automatically re-synchronise to the System unless instructed to do so by The Company in accordance with BC2.5.2. Notwithstanding this, Type C and Type D Offshore Power Generating Modules shall be capable of satisfying the requirements of ECC.6.3.5.6. The requirements for Houseload Operation including the minimum operating time, shall be agreed between The Company and EU Code User in the detailed design phase which shall be dependent upon the prime mover technology.
7.	Frequency Response	ECC.6.3.7	The EU Code User: In respect of each of its Type A, Type B, Type C and Type D Offshore Power Generating Modules shall be required to satisfy the applicable requirements of ECC.6.3.7.1. In addition, the EU Code User in respect of each of its Type C or D Type Offshore Power Generating Modules shall also be required to satisfy the applicable requirements of ECC.6.3.7.2 and ECC.6.3.7.3.
8.	Control Performance Requirements	ECC.6.3.8	The EU Code User: Is required to meet the control system performance requirements in accordance with ECC.6.3.8.5. Where an EU Code User has opted to satisfy the requirements of ECC.6.3.2.5.1 in respect of a Configuration 1 DC connected Offshore Power Park Module, then each Configuration 1 DC connected Offshore Power Park Module shall be required to satisfy the requirements of ECC.A.7.3. Where an EU Code User has opted to satisfy the requirements of ECC.6.3.2.5.2 in respect of a Configuration 1 DC connected Offshore Power Park Module, then each Configuration 1 DC connected Offshore Power Park Module shall be required to satisfy the requirements of ECC.A.7 (excluding ECC.A.7.3 and ECC.A.7.4) with appropriate adjustments made to the reactive capability limits. Where an EU Code User has opted to satisfy the requirements of ECC.6.3.2.6.1 in respect of a Configuration 2 DC connected Offshore Power Park Module, then each Configuration 2 DC connected Offshore Power Park Module shall be required to satisfy the requirements of ECC.A.8. Where an EU Code User has opted to satisfy the requirements of ECC.6.3.2.6.3 in respect of a Configuration 2 DC connected Offshore Power Park Module, then each Configuration 2 DC connected Offshore Power Park Module shall be required to satisfy the requirements

			of ECC.A.7 (excluding ECC.A.7.3 and ECC.A.7.4) with appropriate adjustments made to the reactive capability limits.
9.	Power Oscillation Damping	BC.2.11.2	The EU Code User: There is no requirement for the automatic control system of each Power Park Module to be fitted with a Power System Stabiliser (PSS). However, if the EU Code User chooses to install a PSS within the Power Park Module control system, its settings and performance shall be agreed with The Company and commissioned in accordance with BC.2.11.2 of the Grid Code. Where the EU Code User opts to install a PSS, the OTSDUW User to supply maximum and minimum fault levels at the Transmission Interface Point and any other data which may reasonably be required for the above analysis.
10.	Dynamic performance and Interactions	ECC.6.1.9 ECC.6.1.10 ECC.6.3.17.1.5 PC.A.6.1.3	The EU Code User: Is required to satisfy the requirements of PC.A.6.1.3 and ECC.6.3.17.1.5 and assist The Company to ensure compliance with ECC.6.1.9, ECC.6.1.10. Please note the following: Power Factory RMS model(s): This includes model(s) and any associated set up script(s) that form part of the model delivery to The Company and should be compliant with PC.A.5. Any set up scripts should be compatible with the Powerfactory network used by The Company. Also, the RMS model should not require the use of integration time steps less than 10ms due to the time to run a set of simulations on a large network with a large number of models and should not include DLL codes. Power Factory version: Model(s) to be delivered in a version of Powerfactory to be agreed with The Company. After the PF model is provided, the model validation report which compares results against simulation results of PF model and FAT results should be submitted. Dynamic Performance Study (DPS) results may be required to demonstrate that the expected steady state and dynamic performance of the EU Code User's Plant and Apparatus has been met. To ensure its converters (including controllers) within the System do not cause negatively or lightly damped resonances or interactions on the NETS, adequate damping control facilities to be installed if there is a risk of the following phenomena:

			• Sub-synchronous oscillations due to interactions between the EU Code User's Plant and Apparatus and the NETS. For clarity, sub-synchronous torsional oscillation with other User's Plant and Apparatus shall be included in the study. • Control interaction due to interactions between the EU Code User's Plant and Apparatus, network and/or any plant directly or indirectly connected to the NETS. For clarity, Control Interaction with the network and other User's Plant and Apparatus shall be studied in the sub-synchronous and super-synchronous frequency ranges where the EU Code User's Plant and Apparatus is identified to be responsive. To provide data and results to The Company in consultation with the Relevant Transmission Licensee including full EMT and RMS models (models to be provided 3 years prior to connection, ideally to be included in tender documents) and updated version of the model to be provided after commissioning. Specification for the models to be agreed with The Company and Relevant Transmission Licensee of all EU Code User's plant to enable the following studies: • Transient Analysis studies – electromechanical and electromagnetic. • Frequency Domain studies – including eigenvalue analysis and damping torque assessments for all EU Code User's equipment. Detailed requirements in relation to the above studies can be agreed with The Company and the Relevant Transmission Licensee at a time convenient to the EU Code User. The results of these studies must be provided to The Company and the Relevant Transmission Licensee by the date defined in the Appendix J. The EU Code User shall provide The Company with any relevant information required in the above assessments. <u>EMT Model:</u> After the EMT model is provided, the equipment model validation report which compares results against simulation result of EMT model and equipment FAT results should be submitted. Specification for the model (including time step) should be agreed in advance between The Company in consultation with Relevant Transmission Licensee and the EU Code User. <u>Additional Note</u> Both The Company and the EU Code User endeavour to revise and update as applicable the contents of this clause before Completion date, unless otherwise agreed, in accordance with the Grid Code applicable at the time.

			The Company To outline the detailed requirements and the extent of the studies to be performed, and the criteria to demonstrate compliance with (depending on the static and dynamic models of the transmission network) other relevant Users before the Completion date. The results of these studies must be provided to The Company and the Relevant Transmission Licensee by the date defined in the Appendix J unless otherwise agreed.
11.	Fault Ride Through	ECC.6.3.15	The EU Code User: To meet the requirements of ECC.6.3.15. In the case of a DC connected Power Park Module any site specific requirements including short circuit levels at the Offshore Grid Entry Point shall be provided via The Company from the Offshore Transmission Licensee.
12.	Fast Fault Current Injection	ECC.6.3.16	The EU Code User: Is required to satisfy the requirements of ECC.6.3.16. Where the EU Code User identifies the need for blocking, the EU Code User shall advise and agree the control strategy employed with The Company which shall be at least 36 months before the Completion Date which must also include the approach to de-blocking.
13.	Trading Point Electronic Data Transfer (EDT), Control Points, Control Telephony and Control Point Electronic Dispatch and Logging (EDL)	ECC.6.5.8(a) ECC.7.9 OC.7 BC.2 ECC.6.5.2 to ECC.6.5.5 ECC.6.5.8, ECC.6.5.9 and BC.1.4.1 ECC.6.5.8(b)	The EU Code User: To fulfil the obligations defined in Schedule 1 of this Appendix.
14.	Control Point	ECC.7.9	The EU Code User: As required under BC2.9 of the Grid Code, the EU Code User will be required to respond to Emergency Instructions, some examples of which are described in BC.2.9.1. In order to fulfil these requirements, it is envisaged that the EU Code User has the ability to de-energise all their electrical equipment by ensuring it can

			open circuit breakers remotely and safely from their Control Point without delay and, where applicable, has the ability to open/close its busbar disconnectors at the Grid Entry Point remotely and safely from their Control Point without delay. For the avoidance of doubt, this functionality is generally required to enable timely restoration of the Transmission System and prevent delays to the return to service of EU Code User's Plant and Apparatus following receipt of such an instruction.
15.	Operational Metering	ECC.6.5.6	The EU Code User: To fulfil the obligations defined in Schedule 2 of this Appendix. Is required to provide the Operational Metering Signals to the Offshore Grid Entry Point.
16.	Fault Recording and Dynamic System Monitoring	ECC.6.6.1	The EU Code User: Is required to fulfil the obligations defined in Schedule 3 of this Appendix in respect of all Offshore Type C and Type D Power Generating Modules. Also, to provide Dynamic System Monitoring facilities on the EU Code User's circuits to monitor system dynamic performance (ECC.6.6) and provide communication facilities allowing remote access of data by The Company and Onshore Transmission Licensee. The EU Code User is required to supply the signals generated by the Dynamic System Monitors to the Offshore Grid Entry Point. In the event that any part of the EU Code User's Dynamic System Monitoring, including the communications links from the EU Code User's Equipment to the Offshore Grid Entry Point fails, then the EU Code User will be required to repair the fault as soon as reasonably practicable. In addition, the EU Code User shall advise The Company of the nature of the fault, its expected repair time and the time at which it is expected to be returned to service. The Company will advise the EU Code User of any such measures that may be required to manage the situation when the Dynamic System Monitoring equipment is out of service. In addition to the above requirements, each Offshore Type C and Type D Power Generating Module shall be fitted with fault recording equipment as required in TS.3.24.71_RES which is available from the following link: https://www.nationalgrideso.com/sites/default/files/documents/TS_3.24.71_RES_i1_0.pdf
17.	Frequency Response monitoring	ECC.6.6.2	The EU Code User: To install Frequency Response Monitoring equipment on each Type C and Type D Offshore Power Generating Module and provide communication facilities allowing remote access of the data to The Company. The Frequency Response Monitoring equipment shall be capable of recording values of Active Power output, Reactive Power output and frequency with a minimum sampling rate of 1Hz derived from Settlement Metering as specified in Schedule 2. The Ancillary Services Monitoring requirements are detailed in TS 3.24.95_RES (Ancillary Services Monitoring).

			The signals should be compatible with any equipment installed or being installed by the Onshore Transmission Licensee at the Transmission Interface Point. The EU Code User is required to supply the signals generated by the Ancillary Services Monitors to the Offshore Grid Entry Point. In addition, the EU Code User shall also provide facilities to allow The Company to monitor the health of the Ancillary Services Monitoring equipment up to the Offshore Grid Entry Point. In the event that any part of the EU Code User's Ancillary Services Monitoring equipment including the communications links from the EU Code User's Equipment to the Offshore Grid Entry Point fails, then the EU Code User will be required to repair the fault as soon as reasonably practicable. In addition, the EU Code User shall advise The Company of the nature of the fault, its expected repair time and the time at which it is expected to be returned to service. The Company will advise the EU Code User of any such measures that may be required to manage the situation when the Ancillary Services Monitoring equipment is out of service. For the avoidance of doubt, the OTSDUW User will be responsible for the installation of the communications routes from the Offshore Grid Entry Point to the Transmission Interface Point in order to facilitate this requirement. Once in operation, the ownership of part or the whole of the communication equipment will be transferred to the appointed Offshore Transmission Licensee following the OTSUA Transfer Time when each party (EU Code User and Offshore Transmission Licensee) will then be responsible for the maintenance and monitoring of their own assets. The Company will provide facilities at the Transmission Interface Point within Necton 400kV Onshore Substation in order to receive the Ancillary Services Monitoring data.
18.	Voltage Waveform Quality	ECC.6.1.5(b) ECC.6.1.6	<u>The EU Code User:</u> To provide The Company with Voltage Quality Assessment information as specified in PC.4.4.1, PC.4.4.2, PC4.5, PC.A.5.42(h), DRC.6.1.1 Schedule 1 and DRC.6.1.5 Schedule 5 of the Grid Code to enable the OTSDUW User to carry out assessments of harmonic voltage distortion and voltage fluctuation in accordance with Grid Code conditions ECC.6.1.5(a) and ECC.6.1.7 respectively (equivalent to Section K paragraph 7 of the STC). These requirements apply at the Offshore Grid Entry Point and shall include all Offshore Power Park Modules and associated EU Code User's Equipment up to the Offshore Grid Entry Point. Following this assessment, the Onshore Transmission Licensee may specify to the EU Code User (by written notice via The Company), the harmonic voltage distortion or harmonic current emission limits (as appropriate) in conjunction with impedance loci and background levels, and voltage fluctuation (flicker) limits. The Company (upon advice from the OTSDUW User) will specify any additional requirements to the EU Code User in the detailed design phase.

			The requirement (if any) for Power Quality emission limits at the Offshore Grid Entry Point will be notified by The Company but specified by the OTSDUW User.
19.	Phase (Voltage) Unbalance	ECC6.1.5 (b) ECC6.1.6	The EU Code User: To provide The Company of Voltage Unbalance Assessment information as specified in PC.4.4.1, PC.4.4.2, PC.4.5, PC.A.4.7 and DRC.6.1.5 Schedule 5, DRC.6.1.7 Schedule 7 of the Grid Code to enable the OTSDUW User to carry out an unbalance assessment in accordance with Grid code Conditions ECC.6.1.5(b) and ECC.6.1.6 (equivalent to Section K paragraph 7 of the STC). Following the above assessment, the OTSDUW User may specify to the EU Code User (by written notice via The Company), the negative phase sequence current limits. The EU Code User shall comply with the above limits.
20.	Power Quality Monitoring		The EU Code User: May be required to provide suitable and practicable voltage or current transducers at the Offshore Grid Entry Point, to enable compliance monitoring by the OTSDUW User, contingent upon the assessment of voltage waveform quality constraints. The Company: To notify the EU Code User of any such requirement specified by the OTSDUW User in the detailed design phase.
21.	Electromagnetic Transients	PC.A.6.2.1	The EU Code User: To take appropriate measures to minimise the probability and severity of electromagnetic voltage transients or transformer inrush at the Offshore Grid Entry Point which may occur when the Offshore Power Park Module (or any material subsystem) is connected to or disconnected from the Offshore Grid Entry Point. The EU Code User shall provide The Company with details of such measures and an assessment of the predicted probability and severity of such transients or transformer inrush transients in the detailed design phase at least 18 months prior to completion. In the event that The Company (upon advice from the OTSDUW User) needs to undertake transient overvoltage assessments or voltage assessment studies, the EU Code User will be required to provide the data required under PC.A.6.2.1 or PC.A.6.5 of the Grid Code. The fault levels that should be used for the Electromagnetic Transient studies are described in Table 1 below, in the section headed 'Short Circuit Levels' The OTSDUW User (via The Company): To provide the latest fault level information at the Grid Entry Point to enable the assessment detailed above.
22.	Short Circuit Levels		The EU Code User: The Converter Station must continue to operate satisfactorily and keep fundamental frequency over-voltages to within the limit specified under 'System Voltage Variations at the Transmission Interface Point,' using minimum fault levels as described in the Table 1 below:

SQSS Condition	3-phase			1-phase				**Purpose** (It is recommended the relevant fault levels are used for the following purposes)
	Sub-Transient Current (kA)	Make X/R Ratio	Break X/R Ratio	Sub-Transient Current (kA)	Make X/R Ratio	Break X/R Ratio	X0/X1 Ratio	
Minimum fault level	20.12	14.9	17.1	16.39	11.6	15.5	1.4	1- Protection settings with additional appropriate safety margins. 2- Electromagnetic transient study in relation to ECC.6.1.7(a) and (b) and TOV (TGN 288). 3- Any study in relation to unbalance.
Post fault minimum fault level	9.60	17.4	18.9	8.94	14.4	18.6	1.2	1- Fault ride through 2- Transient active and reactive power exchange studies 3- For SSTI and control interaction studies the part of network around the point-of-interest is usually modelled. Post fault minimum fault level, which represent a N-1-D condition on a summer minimum scenario should be included in the study cases.

			Winter Fault Level	36.60	20.6	24.5	39.16	19.0	23.4	0.7	
			Winter Fault Level (Future Contracted Background (G74))	44.94	22.0	24.8	47.07	19.9	23.1	0.7	Siemens requested a fault level considering future connections and transmissionreinforcements in the area.
			Table 1 Please note that the values in Table 1 are indicative of the predicted landscape at the time of your offer. As the connection date approaches and the surrounding landscape becomes more fixed, more accurate values will be provided on request as defined in PC.A.8.								
23.	Paralleling		The EU Code User: To ensure there is no paralleling of The National Electricity Transmission System through the EU Code User's System.								
24.	Safety and Operational Interlocking		The EU Code User: To install electrical and mechanical interlocking on the EU Code User's Equipment to prevent inadvertent operation during outage conditions and ensure the maintenance of safety of both plant and personnel. The detailed requirements will be agreed with the EU Code User and the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 12 months before the Completion Date .								
25.	Earthing Facility		The requirements for Earthing at the Offshore Grid Entry Point will be agreed between the EU Code User and the OTSDUW User (via The Company) as soon as reasonably practicable and no later than 24 months before the Completion Date .								
26.	Compliance Testing		The EU Code User: Is responsible for demonstrating compliance in accordance with the requirements of the Grid Code. After the OTSUA Transfer Time, the EU Code User shall co-operate with the Offshore Transmission Licensee and The Company to ensure that all aspects of compliance required by the Grid Code and the STC are completed.								
27.	Settlement Metering	ECC.6.2.2.3.5	The EU Code User: To provide CTs/VTs that comply with the relevant metering Code of Practice required for Settlement. To provide the Settlement Meters and register compliant items of Metering Equipment for Settlement purposes. All of the above to be completed prior to energisation and in accordance with the Balancing and Settlement Code (BSC).								

28.	Switching Groups	PC.A.3.2.2(k) PC.A.3.2.4 OC2.4.2.1(f)	The EU Code User: To notify The Company of any change to the number, type or configuration of Power Park Units within each Offshore Power Park String and the number of Offshore Power Park Strings within each Offshore Power Module as required under PC.A.3.2.2(k), PC.A.3.2.4 and OC2.4.2.1(f). In addition to the requirements of PC.A.3.2.2(k), PC.A.3.2.4 and OC2.4.2.1(f), the EU Code User shall also ensure that each Power Park Module is capable of meeting the full requirements of the Grid Code and this Bilateral Agreement (including but not limited to matters of quality of supply requirements, fault infeed and reactive capability) irrespective of the connection configuration of each Power Park Unit within each Power Park Module.
29.	BMU Configuration		The EU Code User: Shall confirm and agree with The Company, the number and arrangement of Power Park Modules within each Balancing Mechanism Unit (BMU) and confirm and register these arrangements with Elexon. In order to ensure that the OTSDUW User's assets are not put at risk by any change to the number of Offshore Power Park Units within each Offshore Power Park String and the number of Offshore Power Park Strings within each Offshore Power Park Module, the EU Code User shall not reconfigure either of Offshore Balancing Mechanism Units to exceed the number set out in Appendix C Part 3 of this agreement.
30.	Additional data for new types of Power Stations and configurations	PC.A.7	The EU Code User: Should be aware that The Company may reasonably require additional data to correctly represent the performance of the EU Code User's Plant and Apparatus where the present data submissions would prove insufficient for the purpose of meaningful studies.
31.	Real-Time Frequency Signals	ECC.6.3.3 (f)	The EU Code User: Shall be capable of receiving a fast frequency signal from the OTSDUW User in accordance with the requirements of ECC.6.3.3.1.1(f).
32.	Frequency Range	ECC.6.1.2.3	The EU Code User: Shall be capable of satisfying the frequency ranges at the Offshore Grid Entry Point as defined in ECC.6.1.2.3.
33.	Non-standard Frequency Ranges	ECC.6.1.2.3	In the case of a remote end HVDC system where the nominal frequency is not 50Hz the frequency ranges and any additional requirements shall be specified in the Detailed Design Phase. Where the nominal frequency of the remote end HVDC Converter system is operating at a nominal frequency other than 50Hz, the voltage ranges and time periods shall be discussed and agreed between The Company and the EU Code User in the Detailed Design Phase as provided for in ECC.6.1.4.2.5.
34.	Voltage Ranges	ECC.6.1.4.2	The EU Code User: Shall be capable of satisfying the voltage ranges at the Offshore Grid Entry Point as defined in ECC.6.1.4.2.

			Any non-standard requirements shall be discussed and agreed in the Detailed Design Phase as provided for in ECC.6.1.4.2.4.
35.	Control Schemes and Settings	ECC.6.2.2.6, ECC.6.2.2.7, ECC.6.2.2.8	The EU Code User: Shall ensure all control schemes (including different control modes) and settings shall be agreed with The Company and the Relevant Transmission Licensee as required in ECC.6.2.2.6, ECC.6.2.2.7, ECC.6.2.2.8 and ECC.6.2.2.9.10. Any subsequent changes once commissioned shall not be implemented unless otherwise agreed with The Company and the Relevant Transmission Licensee.
36.	Flicker		The EU Code User: To follow EREC P28-Issue 2 and provide a report to show that their flicker impact is below 0.5. If the EU Code User's emissions are greater than 0.5, then The Company (upon advice from the Relevant Transmission Licensee) shall issue appropriate limits in accordance with Stage 3 assessment procedure within EREC P28-Issue 2.

Appendix F5 – Schedule 1

Site Specific Technical Conditions - Communications Plant. (ECC.6.5)

Description	Location	Source	Provided By	Comments
Control Telephone ECC.6.5.2 to ECC.6.5.5, ECC.6.5.8, ECC.6.5.9 and BC.1.4.1	Control Point	Transmission Substation Exchange	The EU Code User to provide and install wiring from the EU Code User's Control Point to the Transmission substation exchange, and install free issue handset. The Relevant Transmission Licensee to provide communications path to the EU Code User's Control Point site (Great Britain only) in conjunction with the EU Code User. The Relevant Transmission Licensee to provide Green handset only.	Control Telephony provides secure point to point telephony for routine Control Calls, priority Control Calls and emergency Control Calls. If the EU Code User intends to have a nominated Trading Point/Control Point outside of GB, The Company will provide the communication routes and Control Telephony facilities to the EU Code User's Control point but will charge the EU Code User for the overseas element of this work including any ongoing regular maintenance. Any subsequent relocation of Control Point will be charged to the EU Code User by The Company. The green handset (via dedicated communications routes) should provide control telephony facilities to The Company at the National Electricity Control Centre at Wokingham.
Trading Point Data Transfer (EDT) (ECC.6.5.8(a) and BC.1.4.1)	Trading Point	Transmission Substation Exchange.	The EU Code User to provide and install EDT terminal. The EU Code User to provide communications path to the EDT terminal in conjunction with The Company in order to submit the data required by the Grid Code.	The Company to include site in instructor database and commission. Facility provided via Control Telephone and/or Facsimile machine. The EU Code User will provide the communications path for the EDT terminal from the EU Code User's Trading Point and can elect to send this to two locations (Warwick or Wokingham). The Company will provide the necessary connection and interfacing equipment at both locations. If the EU Code User intends to have a nominated Trading Point outside Great Britain, the responsibilities, functionality, dependability, security, procurement, configuration, delivery points, protocol and repair times of the communication links to be agreed with The Company 6 months prior to Completion Date .
Data Entry Terminals (Electronic Despatch & Logging (EDL)) (ECC.6.5.8(b))	Control Point	Public Telephone Operator.	The EU Code User to provide and install EDL terminal approved by The Company which will permit submission and acceptance of Grid Code data between the EU Code User's Control Point and The Company continuously. The Company to provide communications path to the EDL	The Company will only provide the communications path to the EDL terminal where the EU Code Users Control Point is located in Great Britain. If the EU Code User intends to have a nominated Trading Point/Control Point outside of GB, The Company will provide the communication routes and Control Point Electronic Dispatch and Logging facilities to the EU Code User's Control point but will

			terminal (Great Britain only) in conjunction with the EU Code User.	charge the EU Code User for the overseas element of this work including any ongoing regular maintenance. Any subsequent relocation of Control Point will be charged to the EU Code User by The Company.
Facsimile Machine (ECC.6.5.9)	Trading Point and Control Point	Public Telephone Operator.	EU Code User to provide and install facsimile machine and wiring to PTO.	

NB: The specifications for Control Telephony, EDT and EDL are defined in the Annex to the General Conditions of the Grid Code which is available on The Company's website. Please see reference to Electrical Standards hyperlinks page at the end of this Appendix.

Appendix F5 - Schedule 2

Site Specific Technical Conditions - Operational Metering. (ECC.6.5.6)

Description	Units	Type	Provided by	Notes
MW and MVAr for each Balancing Mechanism Unit and Station Supplies derived from Boundary Point Settlement Metering System.	MW MVAr	Signals to have a 1Hz update rate or better and provide input to the Ancillary Services Monitoring equipment.	EU Code User.	The EU Code User is required to install a Remote Terminal Unit (RTU) and supply the signals defined in this schedule. The Company will install the communications channels to Norfolk Vanguard West 66kV Offshore Platform in order to interface with the EU Code User's Operational Metering signals. The functional performance, availability, accuracy, dependability, security, delivery point, protocol and repair times of the equipment generating and supplying the signals (i.e. the meters and communication links) shall be agreed with The Company and the Onshore Transmission Licensee at least 12 months before the Completion Date . In the event that any part of the EU Code User's Operational Metering equipment, including the communications links to Offshore Transmission Licensee's Norfolk Vanguard West 66kV Offshore Platform fails, then the EU Code User will be required to repair the fault as soon as reasonably practicable. In addition, the EU Code User shall advise The Company of the nature of the fault, its expected repair time and the time at which it is expected to be returned to service. The Company will advise the EU Code User of any such measures that may be required to manage the situation when the operational metering equipment is out of service. In the worst case, The EU Code User may be required to reduce its Maximum Export Limit (MEL) as required by The Company. The OTSDUW User will be responsible for the installation and maintenance of the communications routes between the Offshore Grid Entry Point and Transmission Interface Point in order to facilitate this requirement. The Offshore Transmission Licensee (or as agreed in the Detailed Design Phase) will provide a marshalling cubicle at the Transmission Interface Point at Necton 400kV Onshore Substation in order to receive the Operational Metering Signals. Once in operation, the ownership of part of the communication equipment will be transferred to the appointed OTL following the OTSUA Transfer Time from when each party (EU Code User and OTL) will be then responsible for the maintenance of their own assets. EU Code User to provide Single Line Diagram showing location of CT/VT equipment and nomenclature of HV Apparatus. The Company will use this information to notify the EU Code User of which HV circuit breaker and disconnector positions (ie status indications) are required. The nomenclature of EU Code Users equipment should be in accordance with OC11 of the Grid Code. The signals may be presented at a marshalling kiosk located either within the host TO's substation or the EU Code OTSDUW User's substation as agreed
Voltage for each generator bay connection to Norfolk Vanguard West 66kV Offshore substation.	kV	Signals to have a 1Hz update rate or better.	EU Code User. Note: the EU Code User shall also make this signal available at its own Control Point for responding to Voltage Control Instructions from The Company.	
Frequency	Hz	Signals to have a 1Hz update rate or better and provide input to the Ancillary Services Monitoring equipment.	EU Code User.	
Status of generator circuit(s) HV and LV circuit breaker(s) and disconnector(s), as agreed with The Company.	Open/ Closed Indication	Double point off dedicated auxiliary contacts (1 n/o and 1 n/c).	EU Code User.	
EU Code User transformer Tap Position Indication (TPI) at the Offshore Grid Entry Point as applicable and as agreed with The Company.	TPI	Tap Position Indication	EU Code User.	

				between The Company, the EU Code User and the EU Code OTSDUW User during the detailed design phase.
Representative wind speed and direction of each Power Park Module.	m/s Degrees from North in a clockwise direction	Signals to have a 0.2Hz update rate or better.	EU Code User.	
Power Available	MW	Signals to have 1Hz update rate or better.	EU Code User.	Power Available is defined in the Grid Code and is used by The Company to determine the Headroom available for the purposes of calculating Frequency response volumes and net System Reserve.
Reactive Power Output and status indications of compensation equipment and filtering as applicable.	MVAr Open/Closed Indication	Signals to have 1Hz update rate or better.	EU Code User.	

Note: The term “Boundary Point Metering System” is defined in the Balancing and Settlement Code. In the event that any part of the EU Code User’s Operational Metering equipment, including the communications links to Norfolk Vanguard West 66kV Offshore Platform fails, then the EU Code User will be required to repair such equipment within 5 working days of notification of the fault from The Company or Relevant Transmission Licensee unless otherwise agreed. The EU Code User shall also provide facilities to allow The Company and the Relevant Transmission Licensee to monitor the health of the Operational Metering equipment up to the Grid Entry Point.

Appendix F5 – Schedule 3

Site Specific Technical Conditions – Dynamic System Monitoring and Fault Recording. (ECC.6.6.1)

The EU Code User is required to provide the dynamic system monitoring facilities in respect of each Type C and Type D Power Generating Module and provide communication facilities allowing remote access of data to The Company.

Description	Type	Provided by	Notes
3 phase voltage and current at Norfolk Vanguard West 66kV Offshore Platform.	AC Waveforms	EU Code User.	The functionality, performance, availability, accuracy, dependability, security, configuration, delivery point, protocol and repair times of the equipment generating and supplying the signals (ie. the inputs, monitors and communication links) shall be agreed with The Company/the Relevant Transmission Licensee at least 12 months before the Completion Date .
Dynamic System Monitoring and remote communications and interfacing on EU Code User Circuits at the Relevant Transmission Licensee's Necton 400kV Substation.	Monitors	EU Code User.	Connection to enable data to be retrieved from Dynamic System Monitoring equipment. Connection to The Company with connection, monitoring and security arrangements to be agreed with The Company at least 18 months before the Completion Date . The EU Code User will be responsible for the delivery and infrastructure of the Dynamic System Monitoring signals between the Offshore Grid Entry Point and the Transmission Interface Point in order to facilitate the provision of Dynamic System Monitoring signals from the EU Code User to The Company. Once in operation, the ownership of part or the whole of the communication equipment will be transferred to the appointed Offshore Transmission Licensee following the OTSUA Transfer Time when each party (EU Code User and Offshore Transmission Licensee) will be then responsible for the maintenance and monitoring of their own assets.
	Communications Channels	EU Code User to provide signals and interface at the Relevant Transmission Licensee's Norfolk Vanguard West 66kV Offshore Platform.	

In the event that any part of the EU Code User's Dynamic System Monitoring, including the communications links from the EU Code User's Equipment to the Offshore Grid Entry Point fails, then the EU Code User will be required to repair the fault as soon as reasonably practicable. In addition, the EU Code User shall advise The Company of the nature of the fault, its expected repair time and the time at which it is expected to be returned to service. The Company will advise the EU Code User of any such measures that may be required to manage the situation when the Dynamic System Monitoring equipment is out of service.

Note:- The specification and performance requirements for Dynamic System Monitoring is detailed in Technical Specification TS 3.24.70-RES (Dynamic System Monitoring (DSM)).

USEFUL LINKS

The Grid Code:

https://www.nationalgrideso.com/uk/electricity/codes/grid-code

Electrical Standards:

https://www.nationalgrideso.com/uk/electricity/codes/grid-code/electrical-standards-documents-including-specifications-electronic

Extranet (ID and password required, email transmission.documentcontrol@nationalgrid.com to request access):

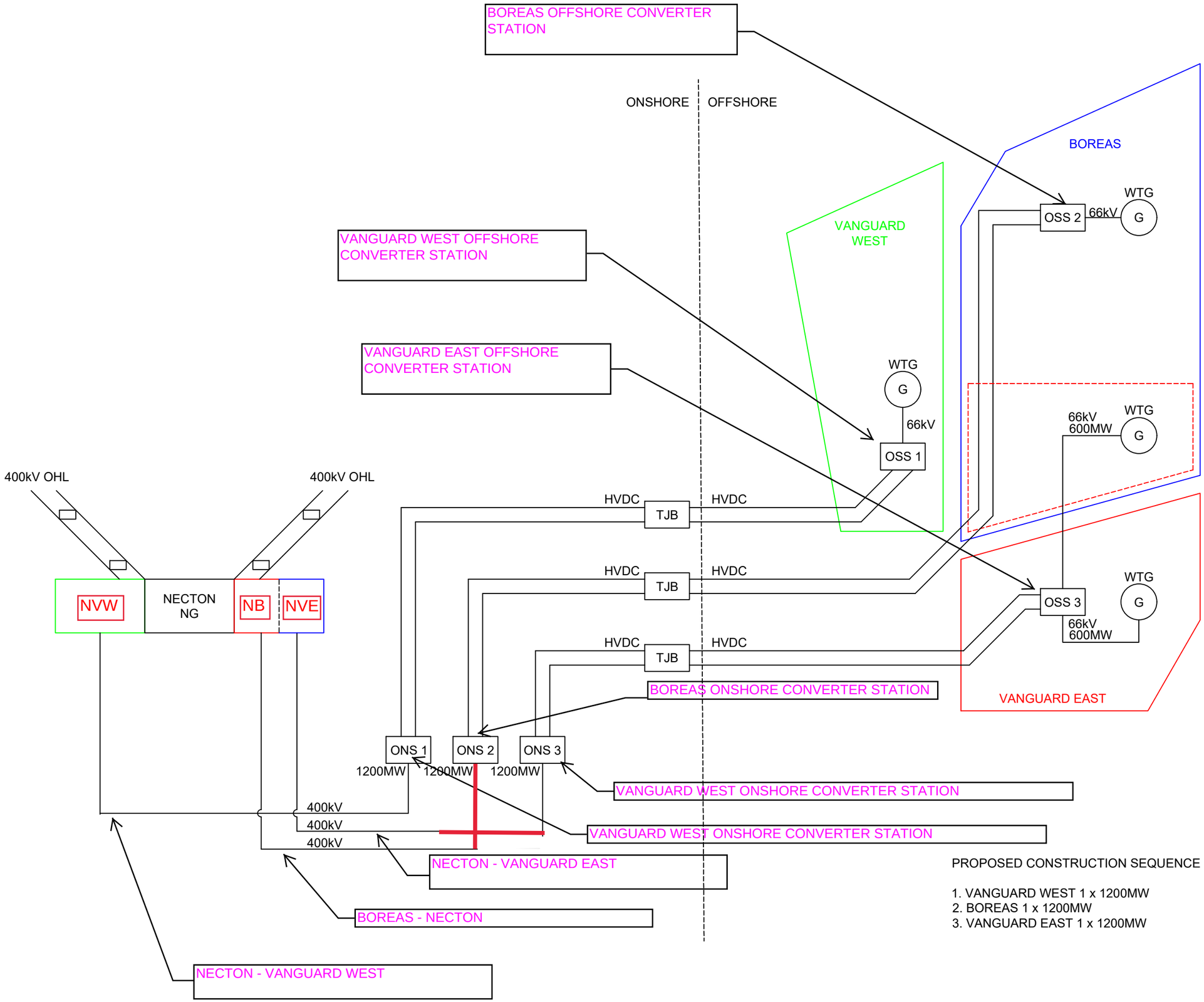
https://extranet.nationalgrid.com/

Connection Policies and Guidance:

https://www.nationalgrideso.com/connections/registers-reports-and-guidance

Procurement Guidelines and Balancing Principles:

https://www.nationalgrideso.com/uk/electricity/market-operations-and-data/transmission-licence-c16-statements-and-consultations



NOTES:

1. OSS AND ONS NUMBERS TO BE CONFRIMED

TJB - TRANSITION JOINT BAY

ONS - ONSHORE HvDC CONVERTOR SUBSTATION

OSS - OFFSHORE HvDC CONVERTOR SUBSTATION

WTG - WIND TURBINE GENERATOR

Rev	Drawn	Date	Description

Client

Project

NORFOLK VANGUARD AND BOREAS
3 x 1200MW

Drawing Title

INDICATIVE ELECTRICAL LAYOUT
DRAFT FOR DISCUSSION

VATTENFALL

Vattenfall Wind Power Ltd

Scale	Date
1:1 A3	14.01.20
Drawing No: SKT02	Revision
Contract	Checked
Drawn By: MR	