Base Load Power Hub (BLPH)

Electromagnetic Compatibility Study

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

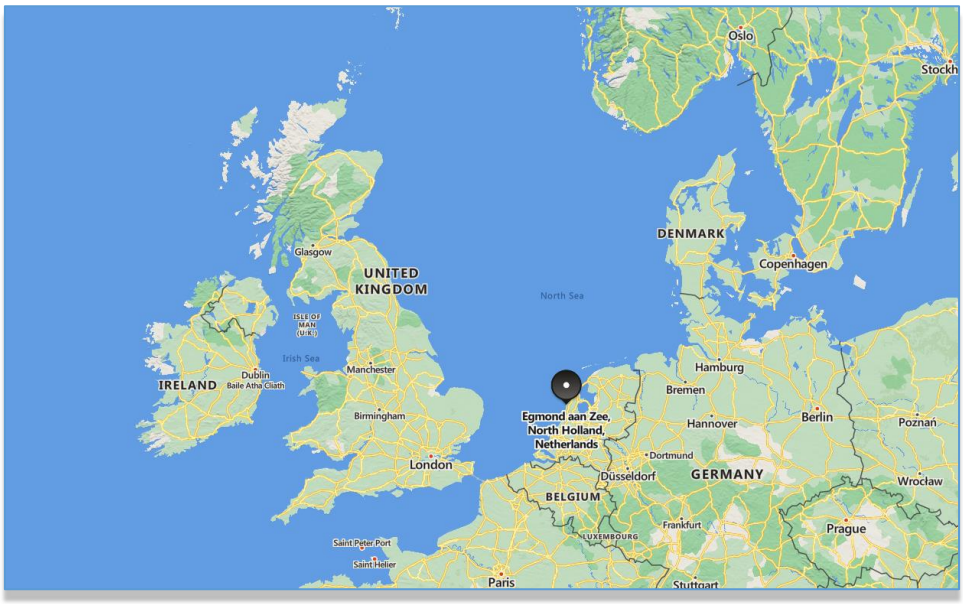


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

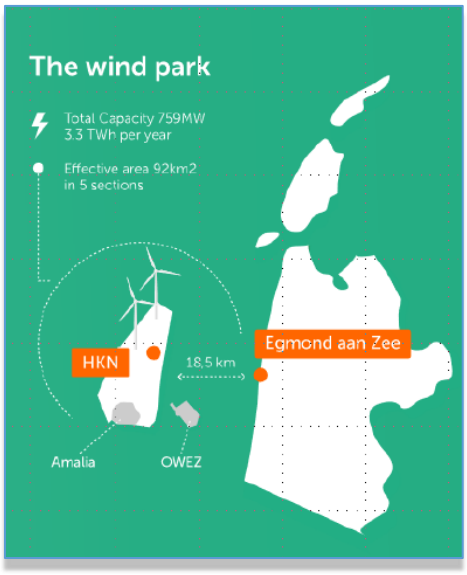


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

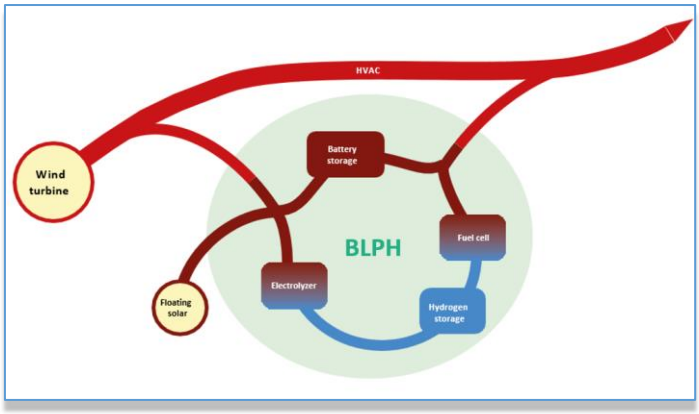


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

This document covers the Electromagnetic Compatibility for equipment delivered to the Crosswind – BLPH project.

Knowledge of EMC design requirement at an early stage of the design process will assure the best technical and economical compromise in achieving EMC.

Emissions and immunity shall be considered for BLPH project equipment. This is regulated by standards, which each equipment manufacturer should fulfil.

2.1 REFERENCES

Doc. No.	Description
123A90-DDL-EL-SP-20001	Technical Specification, IDS and DDS for Power Transformers
123A90-DDL-EL-SP-20009	Technical Specification, IDS and DDS for 66 kV Switchgear (GIS)
123A90-DDL-EL-SP-20019	Technical Specification, IDS and DDS for 6.6 kV Switchgear
123A90-DDL-EL-SP-20023	Technical Specification, IDS and DDS for LV Switchgear
123A90-DDL-EL-SP-20031	Technical Specification, IDS and DDS for AC UPS Systems
123A90-DDL-EL-SP-20035	Technical Specification, IDS and DDS for DC UPS Systems
123A90-DDL-EL-SP-20087	Technical Specification, IDS and DDS for Navigation Aid Systems
123A90-DDL-EL-DD-20090	Electrical Typical Installation Details - Earthing System
123A90-DDL-EL-DL-20132	Earthing and Lightning Layout - Top Deck
123A90-DDL-EL-DL-20133	Earthing and Lightning Layout - Lower Deck
123A90-DDL-EL-DL-20134	Earthing and Lightning Layout – Below Lower Deck
123A90-DDL-EL-DL-20136	Earthing & Lightining Layout - HV Switchroom
123A90-DDL-EL-DL-20137	Earthing & Lightining Layout – LV Switchroom
123A90-DDL-EL-DL-20138	Earthing & Lightining Layout – UPSs and Batteries Switchroom

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

AC	Alternating Current
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
DC	Direct Current
EMC	Electro Magnetic Compatibility
HV	High Voltage
LV	Low Voltage
MV	Medium Voltage
PEC	Parallel Earthing Conductor
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
UPS	Uninterrupted Power Supply

Table 2 - Definitions and Abbreviations

3 BASIS OF EMC DESIGN

This chapter specifies requirements and gives recommendations (EMC measures) for the installations at BLPH.

Specifications are provided for equipment emission and immunity & earthing and bonding / mitigation methods to reduce electromagnetic interference and ensure undisturbed operation of the substation.

To assure EMC, three types of steps should be applied as necessary:

- at the source of disturbances: reduction of emissions.
- at the coupling: reduction of coupling.
- at the victim: increase of immunity.

3.1 EMC SPECIFIC REQUIREMENT

EMC standard requirements for the following BLPH equipment are provided:

- UPS
- MV & LV switchgear
- Transformers
- NavAid system
- 66 kV equipment in BLPH platform
- HVAC control panels in BLPH platform
- Vendor package
- Impressed current cathodic protection system

3.1.1 UPS

3.1.1.1 AC UPS

As per 123A90-DDL-EL-SP-20031 Technical Specification, IDS and DDS for AC UPS Systems, BLPH shall follow the International Association of Oil and Gas Producers (IOGP) "Supplementary Specification to IEC 62040-3 AC Uninterruptible Power Systems (UPS)".

As per Table 4 in IEC 62040-3 Uninterrupted Power Supply (UPS) – Part 3: Method of specifying the performance and test requirements:

Table 4 – Compatibility levels for individual harmonic distortion of voltage in industrial plants and non-public low-voltage power supply systems

Odd harmonics non-multiple of 3		Odd harmonics multiple of 3 [a]		Even harmonics	
Harmonic order	Harmonic voltage	Harmonic order	Harmonic voltage	Harmonic order	Harmonic voltage
n	%	n	%	n	%
5	8	3	6	2	3
7	7	9	2,5	4	1,5
11	5	15	2	6	1
13	4,5	21	1,75	8	1
$17 \leq n \leq 39$	$4,5 \times (17/n) - 0,5$	$21 \leq n \leq 39$	1	$10 \leq n \leq 40$	1

NOTE 1 All of the harmonic levels in this table are assumed not to occur simultaneously.

NOTE 2 Table 4 is derived from Class 3 compatibility levels in Table 2, Table 3 and Table 4 of IEC 61000-2-4:2002.

NOTE 3 In some cases where part of an industrial network is dedicated to large non-linear **loads**, the compatibility levels for that part of the network may be 1,2 times the above values.

[a] The levels given for odd harmonics that are multiples of three apply to zero sequence harmonics. Also, on a three-phase network without a neutral conductor or without **load** connected between line and ground, the values of the 3rd and 9th harmonics may be much lower than the compatibility levels, depending on the unbalance of the system.

Figure 4: Screenshot of Table 4 from IEC 62040-3:2021

As per chapter 5.1.4 in Supplementary Specification to IEC 62040-3 AC Uninterruptible Power Systems (UPS):

The UPS shall conform to the electromagnetic emission and immunity levels in IEC 62040-2 for the specified category level.

As per chapter 5.2.1 in Supplementary Specification to IEC 62040-3 AC Uninterruptible Power Systems (UPS):

For industrial networks, total harmonic distortion of voltage ≤ 8 % as per class 1 compatibility levels, with a maximum level of individual harmonic voltages in accordance with IEC 61000-2-4, Table 2, Table 3 and Table 4. Refer to IEC 61892-1 for offshore installations.

3.1.1.2 DC UPS

As per 123A90-DDL-EL-SP-20035 Technical Specification, IDS and DDS for DC UPS Systems, BLPH shall follow the International Association of Oil and Gas Producers (IOGP) "Supplementary Specification to IEC 62040-5-3 DC Uninterruptible Power Systems (UPS)".

As per chapter 5.1.4 in Supplementary Specification to IEC 62040-5-3 DC Uninterruptible Power Systems (UPS):

The DC UPS shall conform to the electromagnetic emission and immunity levels in IEC 62040-2 for the specified category level.

As per chapter 5.2.1 in Supplementary Specification to IEC 62040-5-3 DC Uninterruptible Power Systems (UPS):

For industrial networks, total harmonic distortion of voltage ≤ 8 % as per class 1 compatibility levels, with a maximum level of individual harmonic voltages in accordance with IEC 61000-2-4, Table 2, Table 3 and Table 4. Refer to IEC 61892-1 for offshore installations.

3.1.2 MV & LV switchgears

The 6.6 kV MV switchgear and 0.4 kV LV switchgear units should be tested for their EMC compliance as per the relevant EMC standards and certified/declared for the electromagnetic compatibility.

3.1.2.1 6.6 kV MV switchgear

As per 123A90-DDL-EL-SP-20019 Technical Specification, IDS and DDS for 6.6 kV Switchgear, BLPH shall follow the International Association of Oil and Gas Producers (IOGP) "Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear".

As per chapter 6.19 in IEC 62271-200 High Voltage Switchgear and Controlgear – Part 200: AC metal enclosed switchgear for rated voltages above 1 kV and up to and including 52 kV:

Subclause 6.19 of IEC 62271-1:2017 is applicable.

As per chapter 5.18 in Supplementary Specification to IEC 62271-200 High-voltage switchgear and controlgear:

The EMC requirements specified in IEC 62271-1 subclause 7.9.1.2 onwards and Annex J.5 shall be satisfied.

3.1.2.2 0.4 kV LV switchgear

As per 123A90-DDL-EL-SP-20023 Technical Specification, IDS and DDS for LV Switchgear, BLPH shall follow the International Association of Oil and Gas Producers (IOGP) "Supplementary Specification to IEC 61439-1 & 2 LV Switchgear & Controlgear".

As per chapter 9.4 in IEC 61439-1 Low voltage switchgear and controlgear assemblies – Part 1: General rules:

For EMC-related performance requirements, see J.9.4.

As per chapter 9.4 in Supplementary Specification to IEC 61439-1 & 2 LV Switchgear & Controlgear:

Default EMC environment shall be Environment A unless otherwise defined in the Data Sheets.

3.1.3 Transformers

As per 123A90-DDL-EL-SP-20001 Technical Specification, IDS and DDS for Power Transformers, BLPH shall follow the International Association of Oil and Gas Producers (IOGP) "Supplementary Specification to IEC 60076-1 Transformers – S720".

As per chapter 1.2 in Supplementary Specification to IEC 60076-1:2011-04 Transformers – S720, the scope of this specification includes the following types of transformers:

- *Dry type transformers*
  - 18T1 (BESS package transformer – 1.25MVA, 7/0.62 kV)
  - TA30 (Fuel cell package transformer – 1.25MVA, 6.6/0.4 kV)
- *Converter transformers*
  - T4 (Electrolyser package transformer – 3.2MVA, 6.6/0.36/0.36 kV)
- *Liquid filled transformers equipped with a breather and a conservator*
  - TR-100AD1 (Distribution transformer – 7MVA, 66/6.6 kV)
- *Sealed type liquid filled transformers*
  - TR-200DE1 (Distribution transformer – 1.6MVA, 6.6/0.4 kV)
  - TR-200ED1 (Solar package transformer –0.5MVA, 6.6/0.8 kV)

The dry type transformers and converter transformers have their own IEC standard – IEC 60076-11 and IEC 61378-1 respectively. For dry type transformers and converter transformers, this supplementary specification is applicable only when it is specifically called up by cross reference in their respective standards.

3.1.3.1 Dry type transformers

As per relevant standard for dry type transformers, IEC60076-11 Power transformers – Part 11: Dry-type transformers (Chapter 4.3):

Transformers shall be considered as passive elements in respect to emission of, and immunity to, electromagnetic disturbances. Passive elements are not liable to cause electromagnetic disturbances and their performance is not liable to be affected by such disturbances.

Hence the EMC compatibility is not applicable for dry type transformers.

3.1.3.2 Converter transformers

As per relevant standard for converter transformers, IEC61378-1 Converter transformers – Part 1: Transformers for industrial applications, there is no EMC compatibility requirement for transformers.

3.1.3.3 Liquid-filled transformers

As per IEC 60076-1 Power transformers – Part 1: General (Chapter 12):

Power transformers shall be considered as passive elements in respect to emission of, and immunity to, electromagnetic disturbances. Passive elements are not liable to cause electromagnetic disturbances and their performance is not liable to be affected by such disturbances.

Hence the EMC compatibility is not applicable for liquid filled transformers.

As per Supplementary Specification to IEC 60076-1 Transformers – S720 (Chapter 12):

Accessories shall conform to IEC 61000-6-2 and IEC 61000-6-4 for industrial type installations, for both immunity and emissions.

3.1.3.4 Sealed type liquid-filled transformers

As per IEC 60076-1 Power transformers – Part 1: General (Chapter 12): Power transformers shall be considered as passive elements in respect to emission of, and immunity to, electromagnetic disturbances. Passive elements are not liable to cause electromagnetic disturbances and their performance is not liable to be affected by such disturbances.

Hence the EMC compatibility is not applicable for sealed type liquid filled transformers.

As per Supplementary Specification to IEC 60076-1 Transformers – S720 (Chapter 12): Accessories shall conform to IEC 61000-6-2 and IEC 61000-6-4 for industrial type installations, for both immunity and emissions.

3.1.4 NavAid system

As per chapter 7 in 123A90-DDL-EL-SP-20087 Technical Specification, IDS and DDS for Navigation Aid Systems, the equipment shall comply with IEC 61000-6-4 Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments, for emission and IEC 61000-6-2 Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments, for immunity.

3.1.5 66 kV equipment in BLPH platform

As per chapter 4 in 123A90-DDL-EL-SP-2009 Technical Specification, IDS and DDS for 66 kV Switchgear (GIS), 66 kV equipment in BLPH shall comply with IEC 61000 Electromagnetic Compatibility (EMC).

3.1.6 HVAC control panels in BLPH platform

The HVAC panels in BLPH shall comply and certify according to the European Directive EMC 2014/30/EU.

3.2 EARTHING, BONDING AND CABLING

Proper earthing, bonding and cabling of the system design is the system level measures of reducing electromagnetic disturbances inside the plants.

The main goal of these principles is to reduce the coupling by means of appropriate practice of earthing and bonding and the selection and installation of the various cables used in the plant.

The following technical requirements apply:

- An earthing network will be installed within the plant, incorporating all earthing functions such as safety, lightning protection; the basis of this earthing concept is a meshed grid connecting the whole plant.
- The design focus shall be on bonding of all structural elements, including concrete reinforcement, steel constructions, equipment cabinets, junction boxes and cable tray/trench to the earth grid to provide a low impedance ground plane reference for a wide range of frequencies.
- Cables shall be routed along a Parallel Earthing Conductor (PEC) which is connected at both sides to the local earth of the apparatus.

- IEC/TR 61000-5-2 Electromagnetic Compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling (chapter 7.3) shall be the base of detail design for cables and wire installation. Those EMC rules will decrease susceptibility and will increase immunity for disturbances simultaneously.
- It shall be noted that the earthing system design principle: shunting of unwanted power frequency and high frequency currents; lowering the voltage difference between two points of the system, are the same for lightning, personnel safety, installation protection and EMC.

Each one of these considerations places constraints on the design:

- Lightning and personnel safety dictate the design of the earth electrode.
- Safety and installation protection dictate the size for the earthing conductors.
- The EMC behavior requirements determine the layout of the earthing network.

3.3 OTHER EQUIPMENT (NOT IN RM SCOPE)

The below listed equipment's are out of RM scope of delivery. The same EMC compliance declaration /certificate for this equipment like for those under the scope in this document should be verified by the installer/ owner. Also, manufacturers installation recommendation shall be followed for EMC compliance.

- Vendor package
    - BESS package
    - Electrolyser package
    - Fuel cell package
    - Solar package (outside BLPH platform)
- Impressed current cathodic protection system

4 CONCLUSION

- The manufacturer recommendation of equipment installation shall be followed to comply the EMC requirements.
- Earthing, Bonding and Cabling design shall be done according standard (IEC/TR 61000-5-2) to mitigation of disturbances in installations with sensitive and interconnected electronic and electrical systems.