Base Load Power Hub (BLPH)

Electrical Equipment Sizing Calculation Report

Document Number: 123A90-DDL-EL-RE-20152

Document Class: 2

01	10/07/2024	Accepted for Construction (AFC)	SPU	LMA-AMA	MDO
00	06/05/2024	Issue for Review (IFR)	SPU	LMA-AMA	MDO
Rev.	Date	Description	Prepared	Reviewed	Approved

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Accepted for Construction (AFC)

HOLDS LIST

No.	Description

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

Table of contents

1 INTRODUCTION 5

1.1 PROJECT OVERVIEW 5

1.1.1 Project Location 5

1.1.2 Project Concept 6

2 DOCUMENT SCOPE 8

2.1 REFERENCES 8

2.2 DEFINITIONS AND ABBREVIATIONS 9

3 DESIGN BASIS 10

3.1 SYSTEM STUDIES BACKGROUND 10

3.2 TRANSFORMER SIZING 11

3.2.1 Transformers Data 11

3.2.2 Transformers Loading Data 11

3.3 SWITCHGEAR SIZING 12

3.3.1 Switchgear Data 12

3.3.2 Switchgears Loading Data 12

3.3.3 Switchgears Short Circuit Data 12

4 CONCLUSION 14

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 5
Figure 2 - Wind Park Details 6
Figure 3 – BLPH Concept 6

List of tables

Table 1 - Reference Documents 8
Table 2 - Definitions and Abbreviations 9
Table 3 - Data for Main Transformers 11
Table 4: Transformer Loading Factor 11
Table 5 – Data for Main Switchgears 12
Table 6: Bus Loading Factor 12
Table 7: Short circuit Busbar Peak Capability Verification 12
Table 8: Circuit Breaker Capability Verification 13

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

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.

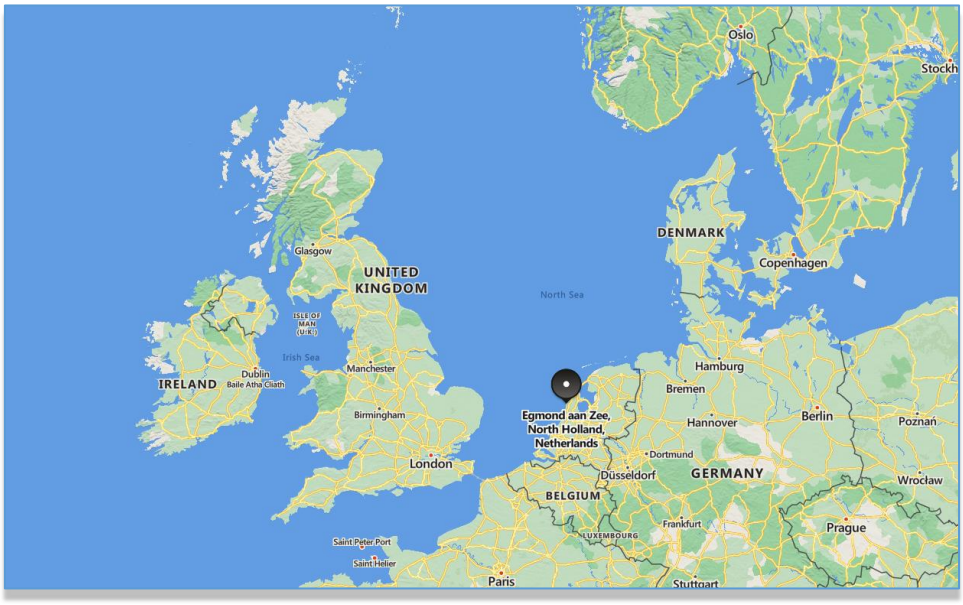


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

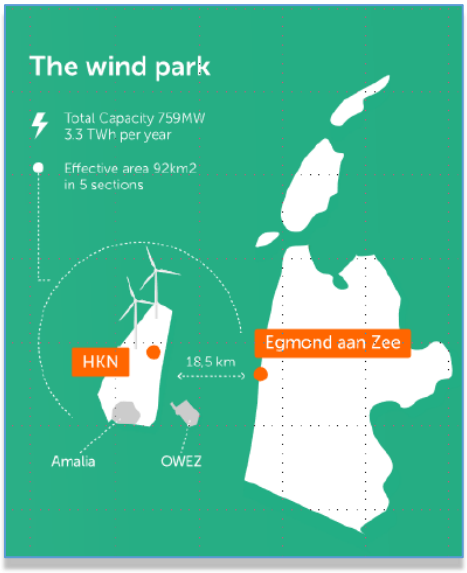


Figure 2 - Wind Park Details

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.

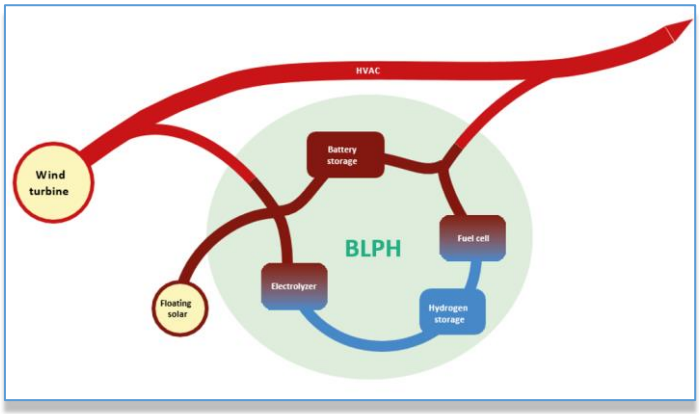


Figure 3 – BLPH Concept

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.

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

2 DOCUMENT SCOPE

This document is intended to summarize the results of the analysis on electrical network model, in terms of main electrical equipment dimensioning.

2.1 REFERENCES

Doc. No.	Description
123A90-DDL-EL-LIS-20148 Rev 00	Electrical Power and Control Cable Schedule
123A90-DDL-EL-LIS-20016 Rev. 2	Electrical Load List & Balance (CCS Mode 'Import)
123A90-PML-PM-TQ-00033	Technical Query – Electrical data of WTG-57
123A90-DDL-EL-RE-20170 Rev. 1	Electrical System Study Report – Load Flow
123A90-DDL-EL-RE-20171 Rev. 1	Electrical System Study Report – Short circuit
123A90-DDL-EL-DG-20158 Rev. 1	Overall Single Line Diagram
144671-TKF-IAC-INS-SPE-0001	Technical specification – 66 kV Al 3X400 CONF143350 specification (incl. Drain wire)
IEC-60092-352 (2005-09)	Electrical installations in ships – Part 352: Choice and installation of electrical cables
2XS(FL)2Y HDPE High Voltage 36/60 (72.5) kV Cable	Cable catalogue for HV cable
123A90-PML-PM-TQ-00033_REPLY	Technical Query N. 33
123A90-DDL-EL-LIS-20143_ATT1	CCS MODE 3: HOT STANDBY
123A90-DDL-EL-LIS-20144_ATT1	CCS MODE 2: EXPORT
123A90-DDL-EL-LIS-20145_ATT1	CCS MODE 4: COLD STANDBY
123A90-DDL-EL-LIS-20146_ATT1	CCS MODE 5 : EMERGENCY MODE (Island)
123A90-DDL-EL-LIS-20147_ATT1	CCS MODE 6: POWER OUT (Blackout)
123A90-DDL-EL-LIS-20016_ATT1	CCS MODE 1: Import Charging

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

Al	Aluminium
AN	Air Natural
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
Cu	Copper
COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
HV	High Voltage
KNAN	Non mineral oil natural Air Natural
LV	Low Voltage
MV	Medium Voltage
N/A	Not Applicable
NER	Neutral Earthing Resistor
OCTC	Off Circuit Tap Changer
OLTC	On Load Tap Changer
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
U_k	Short-circuit impedance
WTG	Wind Turbine Generator
XLPE	Cross-linked PolyEthylene

Table 2 - Definitions and Abbreviations

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

3 DESIGN BASIS

In the following paragraphs, main equipment data of the electrical network under analysis are summarized and verified, based on load flow and short circuit calculations results.

Further details are available in the ETAP printout plots and calculations reports in attachments of document no. 123A90-DDL-EL-RE-20171_01 (Electrical System Study Report - Short Circuit) and of document no. 123A90-DDL-EL-RE-20170_01 (Electrical System Study Report - Load Flow).

As detailed in these documents, to perform all electrical calculations, plant loading data have been considered as per the Electrical Load List and Balance for the main operating scenarios.

3.1 SYSTEM STUDIES BACKGROUND

According to the design philosophy, 9 operation modes are defined. Load flow shall be performed for only 5 operation modes and the results are presented in the study.

These modes of operation are as listed below:

1. CCS MODE 1: IMPORT / CHARGING (corresponding to project IDLE and IMPORT modes): power generation from WTG-57 is greater than 1 MW, or WTG-57 is out of service (IDLE mode). Surplus renewable energy is imported to BLPH from wind farm and/or solar farm for charging BESS and running the electrolyser whilst also supplying the balance of plant loads.
2. CCS MODE 2: EXPORT: Power generation from WTG-57 has dropped below 1 MW. Export of power is required from BLPH from all sources available i.e. BESS, Fuel Cell and/or solar farm.
3. CCS MODE 3: HOT STANDBY: BLPH is capable of exporting power should generation from WTG-57 drop below 1 MW. In this mode the power generation from WTG-57 is greater than 1 MW, so renewable energy is imported to BLPH from wind farm and/or solar farm for feeding the BLPH loads.
4. CCS MODE 4: COLD STANDBY: BLPH is not capable of exporting power, being power generation from WTG-57 below 1 MW. Renewable energy is imported to BLPH from wind farm and/or solar farm for feeding the BLPH loads.
5. CCS MODE 5: EMERGENCY/ISLAND: Windfarm is no longer connected. BLPH consumes its stored renewable energy and/or renewable energy from the solar farm.

3.2 TRANSFORMER SIZING

3.2.1 Transformers Data

ITEM	An [kVA]	V1n/V2n [kV]	I1n/I2n [A]	Zcc [%]	X/R [pu]	Vector Group
TR-100AD1	7000.0	66.0+/-8x1.25%/0.69	61.2/585.7	8.0	16.01	Dyn11
TR-200DE1	1600.0	6.6/0.42	139.9/2199.5	6.0	7.94	Dyn11
TR-200ED1	500.0	6.6/0.8	43.7/360.8	6.0	7.63	Dyn11

Table 3 - Data for Main Transformers

3.2.2 Transformers Loading Data

With reference to load flow calculations, in the following table, transformers loading data relevant to the worst loading conditions are summarized.

Transformer ID	RATED POWER [kVA]	PRIMARY RATED VOLTAGE [kV]	SECONDARY RATED VOLTAGE [kV]	CALCULATED OPERATING LOADING CONDITIONS								
				Case 1			Case 2			Case 3		
				[kVA]	[%]	TAP [%]	[kVA]	[%]	TAP [%]	[kVA]	[%]	TAP [%]
TR-100AD1	7000.00	66.000	6.900	5264.83	75.21	1.25 (*)	1998.29	28.55	3.75 (*)	682.52	9.75	3.75 (*)
TR-200DE1	1600.00	6.600	0.420	963.23	60.20	2.50	587.26	36.70	2.50	679.07	42.44	2.50
TR-200ED1	500.00	6.600	0.800				480.00	96.00	0.0			

(*) On load Tap changer

Transformer ID	RATED POWER [kVA]	PRIMARY RATED VOLTAGE [kV]	SECONDARY RATED VOLTAGE [kV]	CALCULATED OPERATING LOADING CONDITIONS					
				Case 4			Case 5		
				[kVA]	[%]	TAP [%]	[kVA]	[%]	TAP [%]
TR-100AD1	7000.00	66.000	6.900	655.50	9.36	3.75 (*)			
TR-200DE1	1600.00	6.600	0.420	652.35	40.77	2.50	585.80	36.61	2.50
TR-200ED1	500.00	6.600	0.800						

(*) On load Tap changer

Table 4: Transformer Loading Factor

3.3 SWITCHGEAR SIZING

3.3.1 Switchgear Data

ITEM	Rated Voltage [kV]	Rated Ampacity [A]	Short Circuit Rating [kA - s]
HNA6-AFA70	66.0	1250.0	31.5 - 1s
SG-100D1	6.6	630.0	25.0 – 1s
SG-200N1	0.4	2500.0	50.0 – 1s

Table 5 – Data for Main Switchgears

3.3.2 Switchgears Loading Data

With reference to load flow calculations, in the following table, switchgears loading data relevant to the worst loading conditions are summarized.

BUS ID	RATED VOLTAGE [kV]	RATED AMPACITY [A]	CALCULATED OPERATING LOADING CONDITIONS									
			Case 1		Case 2		Case 3		Case 4		Case 5	
			[A]	[%]	[A]	[%]	[A]	[%]	[A]	[%]	[A]	[%]
HKN57	66.000	1250.0	44.8	3.6	17.2	1.4	5.3	0.4	5.2	0.4		
HNA6-AFA70	66.000	1250.0	46.0	3.7	17.5	1.4	5.9	0.5	5.7	0.5		
SG-100D1	6.600	630.0	446.1	70.8	217.3	34.5	59.3	9.4	56.9	9.0	51.3	8.1
SG-200N1	0.400	2500.0	1348.7	53.9	823.7	32.9	954.8	38.2	917.0	36.7	825.8	33.0

Table 6: Bus Loading Factor

3.3.3 Switchgears Short Circuit Data

With reference to short circuit calculations, in the following table, switchgears short circuit data relevant to the worst short circuit conditions are summarized.

Bus ID	Voltage kV	BUSES DUTY SUMMARY	
		Device Capacity	Calculated SC Current
		Peak [kA]	Peak [kA]
HKN57	66.000	78.75	38.03
HNA6-AFA70	66.000	78.75	34.47
SG-100D1	6.600	62.50	20.54
SG-200N1	0.400	105.00	74.15

Table 7: Short circuit Busbar Peak Capability Verification

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

Bus ID	Voltage kV	INTERRUPTING DUTY SUMMARY							
		Device Capacity				Calculated SC Currents			
		Making [kA]	Ib sym. [kA]	Ib asym. [kA]	Idc [kA]	Peak [kA]	Ib sym. [kA]	Ib asym. [kA]	Idc [kA]
HKN57	66.000	78.75	31.50	32.39	7.53	38.03	15.54	15.64	1.78
HNA6-AFA70	66.000	78.75	31.50	32.39	7.53	34.47	14.72	14.73	0.72
SG-100D1	6.600	62.50	25.00	25.70	5.98	20.54	8.07	8.30	1.92
SG-200N1	0.400	105.00	50.00			74.15	31.67		

Table 8: Circuit Breaker Capability Verification

This document undergoes an issuance cycle within EDMS Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

4 CONCLUSION

The switchgear have minimum 20% spare capacity.

Transformers are not overloaded (>100%) in any of the 5 modes of operations.

The switchgears are adequately rated in terms of momentary and interrupting capability: devices SC rating is always above 110 % of calculated short circuit current values.