Base Load Power Hub (BLPH)

Electrical System Description & Design Philosophy

Document Number: 123A90-DDL-EL-SP-20141

Document Class: 2

01	02/10/2024	Accepted for Construction (AFC)	LMA	LMA/AMA	MDO
00	05/06/2024	Issue for Review (IFR)	LMA	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 REFERENCE PROJECT DOCUMENTS 8

2.2 Regulations; National Codes & Standards 10

2.3 DEFINITIONS AND ABBREVIATIONS 11

3 ELECTRICAL SYSTEM PHILOSOPHY 15

3.1 Main objectives and purposes 15

3.2 Simplified process diagram for the system electrification 15

3.3 Process describtion 16

3.4 Power distribution system general description 17

3.5 OPERATING MODES 17

3.6 ELECTRICAL SCENARIOS 20

3.6.1 Islanding 20

3.6.2 Recover from island 21

3.6.3 Black start 21

4 ELECTRICAL LOAD CLASSIFICATIONS 24

4.1 Non-Essential (Normal) Service Loads 24

4.2 Essential Service Loads 24

4.3 Vital Service Loads 24

5 ELECTRICAL LOAD LISTS 25

6 ELECTRICAL EQUIPMENT 26

6.1 General 26

6.2 SWITCHGEARS 26

6.3 TRANSFORMERS 27

6.4 Uninterruptable Power Systems (UPS) 27

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

6.5 EMC Compliance 28
6.6 Cathodic Protection 28
6.7 Trace Heating 28
6.8 CabLES 29
6.9 Lighting System 30
6.10 Earthing & Lightning Protection System (LPS): 30
6.11 Hazardous Area Classification 31
6.12 PROTECTION 31

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 5
Figure 2 - Wind Park Details 6
Figure 3 – BLPH Concept 6
Figure 4 – BLPH simplified process diagram 16

List of tables

Table 1 - Reference Documents 10
Table 2 – Regulations, National Codes & Standards 11
Table 3 - Definitions and Abbreviations 14
Table 4 – Operating modes 20
Table 5 – Minimum required IP rating 26

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.

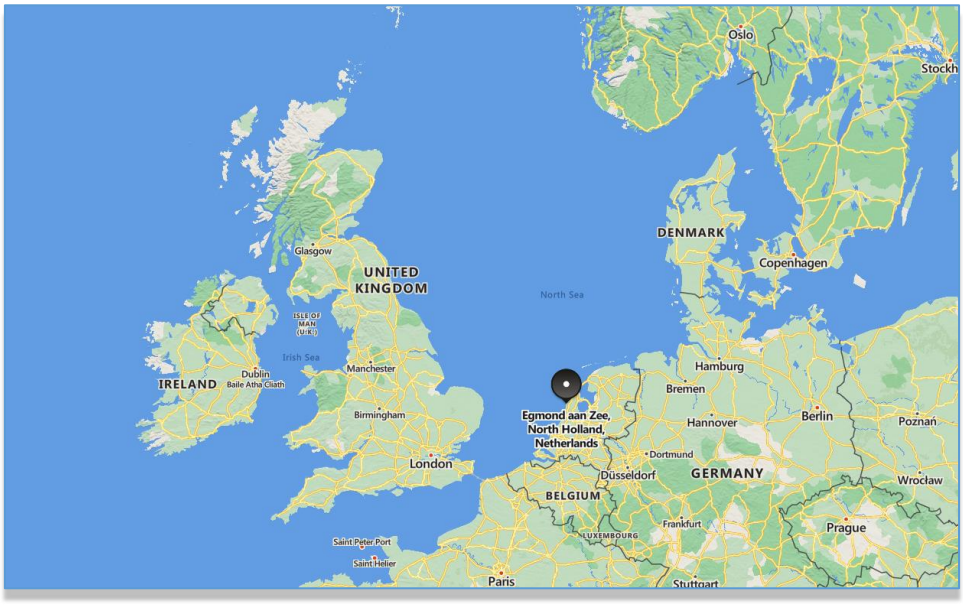


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

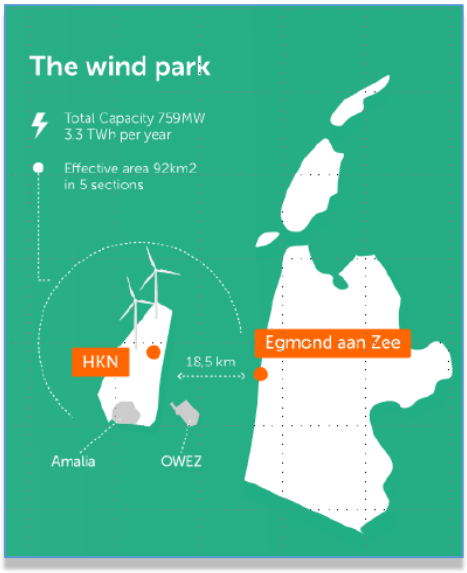


Figure 2 - Wind Park Details

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.

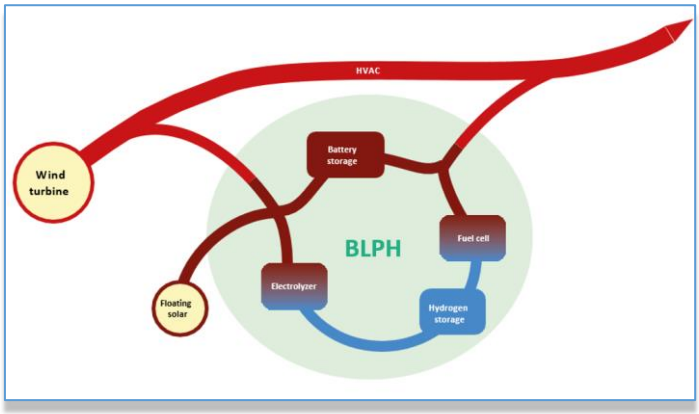


Figure 3 – BLPH Concept

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

The scope of this specification is to provide the references and the main philosophy for the BLPH electrical system design.

2.1 REFERENCE PROJECT DOCUMENTS

Doc. No.	Description
123A90-DDL-EL-DD-20090	Electrical Typical Installation Details - Earthing System
123A90-DDL-EL-DD-20091	Electrical Typical Installation Details - Lighting System
123A90-DDL-EL-DD-20092	Electrical Typical Installation Details - Power System
123A90-DDL-EL-DD-20093	Electrical Typical Installation Details - Cable Routes System
123A90-DDL-EL-DG-20014	Electrical Control, Protection and Metering Diagrams
123A90-DDL-EL-DG-20015	Electrical Single Line Diagram 6.6kV Systems
123A90-DDL-EL-DG-20158	Overall-Key Single Line Diagram
123A90-DDL-EL-DG-20159	Electrical Single Line Diagrams LV System
123A90-DDL-EL-DG-20160	Electrical Single Line Diagrams AC UPS Systems
123A90-DDL-EL-DG-20161	Electrical Single Line Diagrams DC UPS System
123A90-DDL-EL-DG-20162	Electrical Single Line Diagrams (Distribution Board BoP)
123A90-DDL-EL-DG-20163	Electrical Typical Schematic Diagrams (Distribution Boards, AC UPS, DC UPS, etc)
123A90-DDL-EL-DG-20185	Electrical Single Line Diagram HV Systems
123A90-DDL-EL-DL-20132	Earthing and Lightining Layout - Top Deck
123A90-DDL-EL-DL-20133	Earthing and Lightining Layout - Lower Deck
123A90-DDL-EL-DL-20134	Earthing & Lightining Layout - Below Lower deck
123A90-DDL-EL-DL-20136	Earthing & Lightining Layout - HV Switchroom
123A90-DDL-EL-DL-20137	Earthing and Lightining Layout - LV Switchroom
123A90-DDL-EL-DL-20138	Earthing and Lightining Layout - UPSs and Batteries Switchroom
123A90-DDL-EL-DS-20002	Technical Data Sheet (TDS) for 66-6.9 kV Power Transformers
123A90-DDL-EL-DS-20003	Technical Data Sheet (TDS) for 6.6-0.42 kV Power Transformers
123A90-DDL-EL-DS-20004	Technical Data Sheet (TDS) for 6.6-0.8 kV Power Transformers
123A90-DDL-EL-DS-20010	Technical Data Sheet (TDS) for 66kV Switchgear (GIS)

123A90-DDL-EL-DS-20011	Technical Data Sheet (TDS) - Neutral Earthing Resistor (NER)
123A90-DDL-EL-DS-20020	Technical Data Sheet (TDS) - 6.6kV Switchgear
123A90-DDL-EL-DS-20024	Technical Data Sheet (TDS) - LV Switchgear
123A90-DDL-EL-DS-20028	Technical Data Sheet (TDS) - LV Distribution Boards
123A90-DDL-EL-DS-20032	Technical Data Sheet (TDS) - AC UPS Systems
123A90-DDL-EL-DS-20036	Technical Data Sheet (TDS) - DC UPS System
123A90-DDL-EL-LIS-20016	Electrical Load List & Balance (CCS MODE 1 -IMPORT-)
123A90-DDL-EL-LIS-20142	Electrical Equipment List
123A90-DDL-EL-LIS-20143	Electrical Load List and Balance (CCS MODE 3 -HOT STANDBY-)
123A90-DDL-EL-LIS-20144	Electrical Load List and Balance (CCS MODE 2 -EXPORT-)
123A90-DDL-EL-LIS-20145	Electrical Load List and Balance (CCS MODE 4 -COLD STANDBY-)
123A90-DDL-EL-LIS-20146	Electrical Load List and Balance (CCS MODE 4A -EMERGENCY MODE (Island)
123A90-DDL-EL-LIS-20147	Electrical Load List and Balance (CCS MODE 5 -POWER OUT (Blackout))
123A90-DDL-EL-RE-20151	Cable Sizing Calculation Report
123A90-DDL-EL-RE-20152	Electrical Equipment Sizing Calculation Report
123A90-DDL-EL-RE-20153	Lighting Calculation Study Report
123A90-DDL-EL-RE-20154	Lightning Protection System Calculation Report
123A90-DDL-EL-RE-20155	UPS and Battery Sizing Calculations
123A90-DDL-EL-RE-20168	Electrical Protection Relay Selectivity Study Report
123A90-DDL-EL-RE-20170	Electrical System Study Report - Load Flow
123A90-DDL-EL-RE-20171	Electrical System Study Report - Short Circuit
123A90-DDL-EL-RE-20172	Electrical System Study Report - Arc Flash Energy Calculation
123A90-DDL-EL-RE-20174	Electrical System Study Report - Vital Supply Recovery
123A90-DDL-EL-RE-20175	Electrical System Study Report - Power Factor Compensation
123A90-DDL-EL-RE-20176	Electrical System Study Report - Transient In-Rush
123A90-DDL-EL-RE-20177	Electromagnetic Compatibility Study
123A90-DDL-EL-SP-20001	Technical Specification, IDS and DDS for Power Transformers
123A90-DDL-EL-SP-20006	Technical Specification, IDS and DDS for Neutral Earthing Resistor (NER)
123A90-DDL-EL-SP-20009	Technical Specification, IDS and DDS for 66kV Switchgear (GIS)
123A90-DDL-EL-SP-20019	Technical Specification, IDS and DDS for 6.6kV 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 System
123A90-DDL-EL-SP-20166	Electrical Protection Philosophy

Table 1 - Reference Documents

2.2 REGULATIONS; NATIONAL CODES & STANDARDS

Code	Title
2011/65/EU	PB Free Directive
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2014/34/EU	ATEX Directive
2014/35/EU	Low Voltage Directive
94/9/EC	Equipment intended for use in Potentially Explosive Atmospheres
99/92/EC	Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
DNVGL-ST-0145	Offshore Sub-stations
IEC / TR 61000-5-2	Electromagnetic Compatibility (EMC) - Part 5: Installation and Mitigation Guidelines - Section 2: Earthing and Cabling
IEC / TS 60479-1	Effects of current on human beings and livestock - Part 1: General aspects
IEC / TS 60479-4	Effects of current on human beings and livestock - Part 4: Effects of lightning strokes
IEC 31010	Risk management, Risk assessment techniques
IEC 60076	Power Transformers
IEC 60079	Installation & Maintenance of Electrical apparatus for use in Potential explosive atmosphere
IEC 60092	Electrical Installations in Ships
IEC 60364	Low-voltage Electrical Installations
IEC 60502	Power Cables with Extruded Insulation and Their Accessories for Rated Voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV)
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)

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

IEC 60840	Power Cables with Extruded Insulation and Their Accessories for Rated Voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV)
IEC 60947	Low Voltage Switch gear and Control Gear
IEC 61000	Generic Standards – Immunity for industrial environments
IEC 61000	Immunity standards for industrial environments
IEC 61340	Protection of Electronic Devices from Electrostatic Phenomena
IEC 61400-24	Wind energy generation systems - Part 24: Lightning protection
IEC 61439	Low Voltage Switch gear and Control Gear Assemblies
IEC 61508	Functional Safety of Electrical / Electronic / Programmable Electronic Safety-related Systems
IEC 61892	Mobile and fixed offshore units. Electrical installations.
IEC 62061	Part 1: General requirements and conditions
IEC 62271	Safety of Machinery – Functional Safety of Safety-related Control Systems
IEC 62305	High Voltage Switchgear and Control Gear - Common Specifications for Alternating Current Switchgear and Control Gear
IEC 62477	Protection Against Lightning
IEC 62485	Safety requirements for power electronic converter systems and equipment
IEC 62619	Safety requirements for secondary batteries and battery installations
IEC 62682	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications
IEC 62933	Management of Alarm Systems for the Process Industries
ISO 9000	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems
ISO 9001	Quality Management and Quality Assurance Standards.

Table 2 – Regulations, National Codes & Standards

2.3 DEFINITIONS AND ABBREVIATIONS

AC	Alternating Current
ACB	Air Circuit Breaker

ALARP	As Low As Reasonably Practicable
ATEX	Atmosphères Explosibles (French, Explosive Atmospheres)
BESS	Battery Energy Storage System
BfD	Basis for Design
BLPH	Base Load Power Hub
BMS	Battery Management System
CAPEX	Capital Expenditure
CCR	Central Control Room
CCS	Central Control System
CSU	Construction Start-up
CW	CrossWind
DC	Direct Current
DCS	Distributed Control System
DEP	Design Engineering Practice
DNV	Det Norske Veritas (Norwegian based international accredited registrar and classification society)
EMCS	Electrical Monitoring & Control System
FC	Fuel Cell
FEED	Front End Engineering Design
FGS	Fire & Gas System
GIS	Gas-Insulated Switchgear
HKN	Hollandse Kust Noord
HSSE	Health, Safety, Security and Environment
HV	High Voltage
HVAC	Heating Ventilation and Air Conditioning
I/O	Input/Output
IAC	Inter Array Cable
ICCP	Impressed current Cathodic Protection
IEC	International Electrotechnical Commission
LV	Low Voltage
MCB	Miniature Circuit Breaker

MCCB	Moulded Case Circuit Breaker
MEL	Master Equipment List
MP	Monopile
MW	Mega Watt
NUI	Normally Unmanned Installation
OCTC	Open Circuit Tap Changer.
OFW	Offshore Wind Farm
OHVS	Offshore High Voltage Station
OLTC	On Load Tap Changer
PAGA	Public Address and General Alarm
PAS	Process Automation System
PCC	Point Of Common Coupling
PCE	Power Conversion Equipment
PEFS	Process Engineering Flowschemes
PLC	Programmable Logic Controller
PQS	Power Quality Study
PV	Photovoltaic
RfG	Network Code Requirements for Generators (RfG)
RVO	Rijksdienst voor ondernemend Nederland – The Netherlands Enterprise Agency
SCADA	Supervisory Control and Data Acquisition
SF	Solar Farm
SF6	Sulfur Hexafluoride
SGSI	Shell Global Solutions International
SIS	Safety Instrumented System
SLD	Single Line Diagram
SoC	State of Charge
SOLAS	Safety of Life At Sea
TNO	Toegepast Natuurwetenschappelijk Onderzoek (Dutch Research Organization for Applied Natural Sciences)
TSO	Transmission System Operator

UCP	Unit Control Panel (PLC provided by each Key Package VENDOR)
UPS	Uninterrupted Power Supply
VC	Vacuum Contactor
VCB	Vacuum Circuit Breaker
WF	Wind Farm
WTG	Wind Turbine Generator

Table 3 - Definitions and Abbreviations

3 ELECTRICAL SYSTEM PHILOSOPHY

3.1 MAIN OBJECTIVES AND PURPOSES

This document is intended to outline the functionality and minimum acceptable technical requirements, as per the detailed design for the electrical equipment and systems onboard the BLPH platform in integration with the innovative technologies which demonstrated in readiness for upscaling of wind power with a floating solar farm and battery / water electrolysis and fuel-cell packages. To this end mainly following objectives to be followed:

- To be a Normally Unmanned Installation (NUI) platform.
- Operate autonomously as a pilot for the potential upscaling of a 'round trip' (battery with water electrolysis & fuel-cell) process located off-shore.
- Be capable of operating as a self-sustaining plant for a limited period (whilst not connected to either the wind or solar farms) due to unfavorable weather or any other operational or maintenance driven requirement.
- Employ 'plug-and-play' equipment to reduce the maintenance necessary to any individual component ('whole unit' replacement is encouraged).
- Develop and provide the knowledge and learnings from that integration of renewable energy sources (intermittent wind & sun power) for Crosswind's use in the design of future enhanced sustainable energy system projects.
- Ensure safety in the operation of all electrical equipment and systems.
- Ensure the design is adequate for the safety and health of all personnel that work onboard and whilst during all operations of the process.
- Simplify the design and system approach to construction, function, operation, protection, control and measuring.
- Minimize the amount of work needed to be done for offshore process and functional operation.

3.2 SIMPLIFIED PROCESS DIAGRAM FOR THE SYSTEM ELECTRIFICATION

The below diagram simply illustrates the general process of the project with different alternative energy sources such as floating solar 2x0.25 with MW BaseLoad Power Hub (WTG 70) and connection through Wind turbine HNA5 (WTG 57) to offshore HV Substation

The BLPH platform will be located on the 70th monopile (designated as HKN-70) and it will be electrically connected to the wind turbine HNA5. The connection is done by a 66kV sub-sea cable. The solar farm connection to BLPH is done by a separate sub-sea cable. At BLPH, the sub-sea cable will be connected to a single busbar 66kV GIS switchgear.

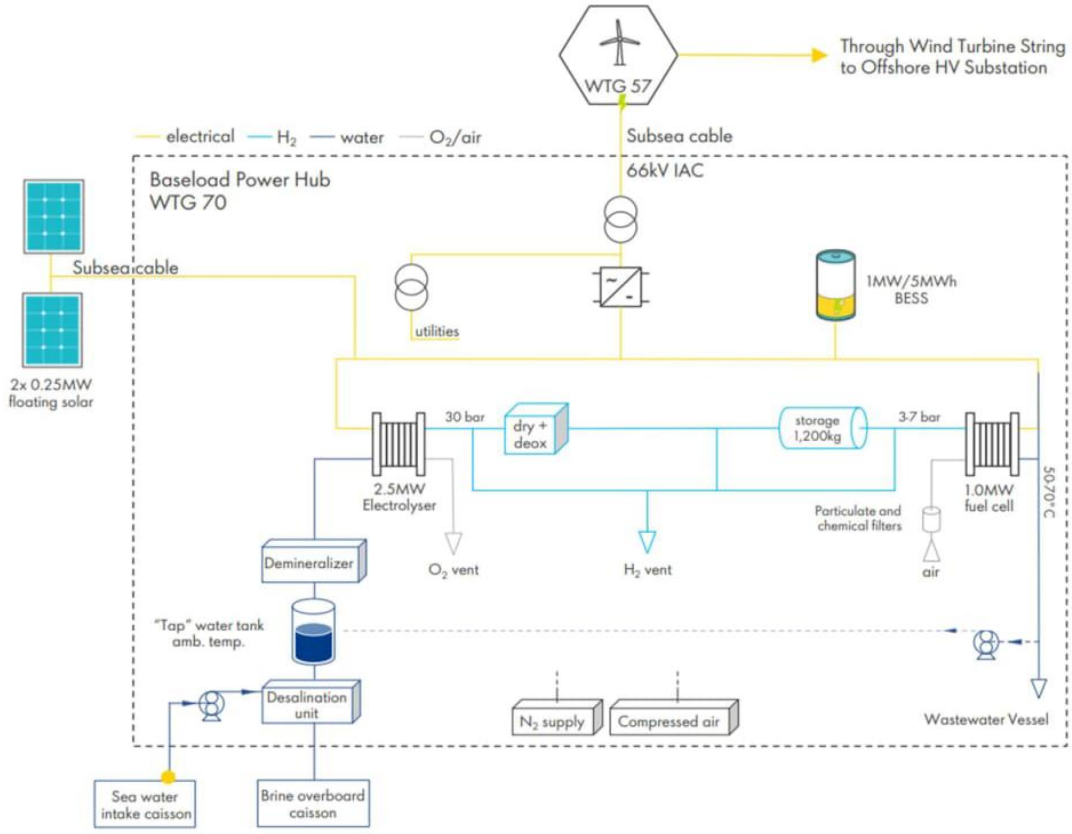


Figure 4 – BLPH simplified process diagram

3.3 PROCESS DESCRIBTION

The dips and peaks associated with offshore wind production need balancing for better integration with the power grid; to this end the wind farm will include several new technological showcases to demonstrate and prove the potential improvement and usage for their future implementation at larger scale.

The technologies being demonstrated at BLPH are:

1. Floating Solar Park.
2. Short-term Battery Energy Storage System (BESS).
3. Long-term Hydrogen Energy Storage (Electrolyzer to create green hydrogen).
4. Fuel-Cell.

Monitoring and control of BLPH will be remote (shore based control room) and the solar farm, battery and fuel-cell shall act cooperatively so that power from all sources will be combined to export power regardless of the prevailing weather.

The fuel-cell is slow-acting whilst the BESS is fast acting. Therefore, the BESS (whenever available) will be used as 'lead supply' / 'load follower' and operate in its most efficient / effective manner with the fuel cell operating in parallel or series to optimise both the efficiency and availability of the entire system.

Whenever possible the fuel-cell will consume the platform's stored hydrogen prior to discharging the battery to ensure SoC is maintained high for it to react instantly to each demand for power.

3.4 POWER DISTRIBUTION SYSTEM GENERAL DESCRIPTION

Power distribution system serves mainly four different voltage level in order to feed the system equipment; those levels respectively from high to low voltage are 66 kV,6.6 kV, 800 V and 400 V which feeds the system electrical equipment such as transformers, switchgears, MCCs, auxiliary systems as well as process packages through busbars and cables (feeders) at each voltage level as per "123A90-DDL-EL-DG-20158 - Overall Key Single Line Diagram".

The 66 kV AC power will be stepped down from the 66 kV gas insulated switchgear HNA6-AFA70 to 6.6 kV AIS switchgear SG-100D1 by a distribution transformer (TR-100AD1).

From the 6.6 kV switchgear, a further step-down transformer (TR-200DE1) will connect to the 400 V switchgear SG-200N1 to supply power to the platform's auxiliary loads. The 6.6 kV AIS switchgear will distribute power to the platform's 6.6 kV rated equipment: BESS, Fuel Cell, Electrolyzer, Solar Array. The solar farm, in particular, will be fed at 800 V, through a dedicated step-up transformer (TR-200ED1).

3.5 OPERATING MODES

When wind turbine HNA5 is connected / operating and providing at least 1 MW to the wind farm 'surplus' power will potentially be available for import to BLPH. This renewable surplus energy will be used to run the plant whilst simultaneously charging the BESS and/or running the electrolyser to create & store hydrogen. Conversely, when wind turbine HNA5 provides less than 1 MW, BLPH will export solar power (if available) and/or the energy stored in the BESS or hydrogen to ensure the wind farm continues to receive at least 1 MW.

The BLPH power system will be synchronised and connected to the wind farm's power system with both 66 kV and 6.6 kV circuit breakers being equipped with a synch. check relay to ensure the AC supplies are synchronised before a circuit breaker will be allowed to close.

An operation mode that involves the simultaneous charging of the BESS and/or running the Electrolyser whilst also discharging the BESS and/or running the Fuel Cell is not considered for the design.

The CCS will control all equipment and packages during 'Normal' (wind farm connected) and 'Abnormal' (windfarm not connected) periods of plant operation selecting one of the operation modes described below.

The solar farm, BESS, fuel cell and electrolyser will all be constantly monitored by the CCS for their operating status / mode e.g. 'Ready' (equipment 'hot standby' = immediately ready to operate) or 'Not Ready' (equipment 'cold standby' = not immediately ready to operate).

	CCS OPERATION MODES
0	MODE 0 - IDLE MODE BLPH will import power to harvest energy from either / both renewable sources (wind farm and solar park). This operating mode is selected by the CCS whenever HNA5-AFA70 circuit breaker QA1 is OPEN or the turbine itself is faulty and unable to produce power (even though it's windy). Supply Guarantee is considered ACTIVE and there are no constraints on the power import.
1	MODE 1 - IMPORT BLPH will import power to harvest energy from either / both renewable sources (wind farm and solar farm). Power generation from HNA5 is greater than 1 MW. Surplus renewable energy is imported to BLPH from wind farm for charging BESS and running the electrolyser whilst also feeding the BLPH loads. 1. If connected, the Solar Farm will provide whatever amount of power it can at any time of the day. 2. Wind turbine HNA5 produces sufficient 'surplus' power at any time (night or day). Supply Guarantee is considered ACTIVE.
2	MODE 3 - HOT STANDBY BLPH is capable of exporting power should generation from HNA5 drop below 1 MW. Renewable energy is imported to BLPH from wind farm and/or solar farm for feeding the BLPH loads. Solar farm, Fuel Cell and BESS are synchronized and connected to the 6.6 kV power system, ready to generate. 1. BESS is fully charged and healthy. 2. H2 vessels are fully loaded. 3. Solar Farm will provide power for the period possible on any particular day. Supply Guarantee is considered ACTIVE.

	CCS OPERATION MODES
3	MODE 2 - EXPORT Power generation from HNA5 has dropped below 1 MW. Export of power is required from BLPH from BESS, Fuel Cell and/or solar farm to support HNA5 production. BLPH exports power from the Solar Farm, BESS and/or Fuel Cell to support wind turbine HNA5. 1. BLPH will use available power from solar, battery and/or fuel cell to export not more than what's necessary for wind turbine HNA5 to provide the wind farm with >1MW (to maximise the period of assistance that will be provided). Supply Guarantee is considered ACTIVE.
4	MODE 4 - COLD STANDBY BLPH is not capable of exporting power (stored and/or non-stored renewable energy) should generation from HNA5 drop below 1 MW. Renewable energy is imported to BLPH from wind farm and/or solar farm for feeding the BLPH loads. Supply Guarantee is considered ACTIVE and there are no constraints on the power import.
4A	MODE 4A - EMERGENCY MODE (Island) BLPH is operating as an 'Island' and is not connected to Wind Farm. 1. BESS and/or Fuel Cell will use their stored energy to support BLPH for the maximum time possible. 2. BLPH plant utility loads will consume the stored energy in BESS and hydrogen (hydrogen will be consumed first) and/or the renewable energy from the solar farm. Supply Guarantee is considered INACTIVE.
5	MODE 5 - POWER OUT (Black-out) BLPH is operating as an 'Island' and is not connected to Wind Farm, BESS and Fuel-Cell have consumed all their stored energy whilst supporting BLPH. Only essential loads are supplied by UPS systems. 1. It is possible to connect a temporary generation in order to avoid power loss to the essential loads according to the document 123A90-DDL-EL-RE-20174 - Electrical System Study Report - Vital Supply Recovery. NOTE: The temporary power supply will be connected to a junction box located nearest the 400V Switchroom (B-200) to supply all Essential loads. Supply Guarantee is considered INACTIVE.
6	MODE 6 - MAINTENANCE BLPH will intentionally enter and remain in this MODE, under operator request, only during normal maintenance in BLPH. Supply Guarantee is command by operator in ACTIVE/INACTIVE.

	CCS OPERATION MODES
7	MODE 7 - RESEARCH BLPH will intentionally enter and remain in this MODE, under operator request. The CCS will be switched to fully 'manual' operation for research activities to proceed with the amount of power generated by wind turbine HNA5 no longer being relevant. Main and auxiliary equipment will be switched to import or export power, as necessary to satisfy the research criteria. Auxiliaries needed for the platform to remain safe and permit the research to proceed will be prevented from being shut down in this operation mode. Supply Guarantee is command by operator in ACTIVE/INACTIVE.
8	MODE 8 – NONE MODE This is the default mode for the CCS, for example at the CCS initialization after a complete black-out or as an entrance status and last fallback if no other status is possible due to unmanaged logic conditions, if any.

Table 4 – Operating modes

NOTE: "Supply Guarantee" refers to if the Wind Farm is Connected or Disconnected from the BLPH.

A more detailed description of the Platform operating modes and the status of all users and equipment is shown in the specification 1724000594-IN-SP-00019 "EMCS Software Functional Design Specification (FDS-SW)".

3.6 ELECTRICAL SCENARIOS

In the transition between some operating modes three different electrical scenarios could be identified, which required automatic or manual procedure to adjust the electrical system configuration making possible the following operating mode.

These scenarios are:

1. Islanding
2. Recover from island
3. Black start

3.6.1 Islanding

Sudden disconnection from the grid could occur in case of opening of the 66 kV breaker or the incoming breaker on the 6.6 kV switchgear.

These two breakers can be manually opened or, most likely, can be opened automatically by the protection system, which could detect a grid failure.

In both cases, the 6.6 kV system could remain in operation with the power generation feeding the auxiliary loads on the 6.6. kV switchgear.

In particular the BESS system should change its control system switching to "grid forming" status, so that it can control the voltage and the frequency of the isolated system, balancing the load demand.

In this transition there is no need of any manual operation, since all actions needed are taken automatically by protection and control system, being necessary a very fast action to try to keep the 6.6 kV system alive.

3.6.2 Recover from island

Once the voltage is back on the wind farm up to the BLPH 66 kV GIS, it is possible to reconnect the 6.6 kV system, which was operating in island, to the grid by means of manual procedure.

The operator first of all has to close the line switches and the circuit breaker of the 66 kV GIS in order to energize the step-up transformer TR-100AD1, to be ready to take the load from the 6.6 kV system.

Once the transformer is energized, the operator will request from the CCS to close the incoming breaker on the 6.6 kV switchgear.

The closure of the breaker will be managed by the BESS system, which has the facilities necessary to synchronize the isolated 6.6 kV system with the grid.

With the closure of the 6.6 kV incoming breaker, the 6.6 kV system will be connected back to the grid and the BLPH platform will return in the operating mode requested by the battery limit condition in that moment.

3.6.3 Black start

When the BLPH is disconnected from the grid (windfarm) and there is no power supply from solar, BESS and fuel cell, BLPH enters the power out mode of operation. This is an electrical blackout condition, and the vital loads will be maintained solely by the DC, AC UPS systems and Navigation System.

Batteries in DC UPS system are located within the B-100 HV equipment room on the lower deck.

Batteries in AC UPS systems and Navigation System are located within the B-300 UPS equipment room on the lower deck.

If the blackout condition lasts long such that the batteries are close to full discharge and hence, no longer available, then BLPH suffers a total loss of power.

In this case a black start of the platform via an offshore mobile power source will be needed to supply to recover the supply to vital loads by charging the batteries in DC and AC UPS systems, and to feed the vital loads under the main LV switchgear SG-200N1 until the network is recovered so that it is possible to reconnect the BLPH platform to the grid (windfarm).

The black start will require the following manual procedure to recover the supply to the vital loads.

3.6.3.1 STEP 0

Before starting any black start the following preliminary checks must be completed:

1. Complete power blackout condition exists in the BLPH platform.
   - All the switchgears are disconnected.
   - Batteries in DC and AC UPS systems are fully discharged.
2. All the feeders of the main LV switchgear SG-200N1 shall be manually opened, if not already disconnected.
3. The offshore mobile power source shall be connected to the junction box outside the B-200 room.

3.6.3.2 STEP 1

This step is fundamental for platform reinstatement (a manual delay in black start procedure will be considered between start of each item, due to transformers in-rush currents):

4. The back-up incomer on the main LV switchgear SG-200N1 shall be manually closed, following the relevant procedure.
   - The 400 V busbar on SG-200N1 becomes live.
5. Feeder to the AC PAS UPS system (UP-200F3) is switched on manually on SG-200N1.
   - According to Vendor procedure, the system is live and able to supply energy to CCS and UCPs HVAC
   - Batteries in AC PAS UPS system (UP-200F3) start to be recharged.
6. Feeder to the AC F&G UPS system (UP-200F4) is switched on manually on SG-200N1.
   - According to Vendor procedure, the system is live and able to supply energy to F&G and Network panel.
   - Batteries in AC F&G UPS system (UP-200F4) start to be recharged.
7. Feeder to DC UPS system (UP-200F1) is switched on manually on SG-200N1.
   - According to Vendor procedure, the system is live and able to supply energy to GIS's Local control panel and auxiliary of SG-100D1 (6.6kV switchgear)
   - Batteries in DC UPS system (UP-200F1) start to be recharged.
8. Feeder to the AC UPS system (UP-200F2) in the Navigational Aid System is switched on manually on SG-200N1.
   - After Vendor black start procedure, the system is live and able to supply NavAid items.
   - Batteries in AC UPS system (UP-200F2) start to be recharged.

3.6.3.3 STEP 2

This step is needed to keep the platform safe.

9. Container's HVAC systems feeders are switched on manually on SG-200N1.
   - The system has power to start the ventilation
10. Emergency lighting from BoP distribution board
    - The system has power to re-charge the internal batteries of lamps and in case of night, to work properly
11. Lighting circuits from container's internal distribution boards
    - The system has power to work properly the lamps inside the container (B-100/B-200/B-300 and B-400)

3.6.3.4 STEP 3 –

12. GIS connection to grid by closing from EMCS the 66 kV line switches and circuit breaker and the 6.6 kV breakers/contactors.
    - BLPH electrical restart
    - BLPH can restart with all power necessary to re do the platform.

3.6.3.5 STEP 4

13. Start-up of the IA Package and N2 generator package
    - systems can purge the H2 tanks.

4 ELECTRICAL LOAD CLASSIFICATIONS

Electrical loads are classified as being a 'Vital' or 'Essential' or 'Non-Essential' service as defined in DEP 33.64.10.10-Gen.

4.1 NON-ESSENTIAL (NORMAL) SERVICE LOADS

A 'non-essential' service is any electrical service that is neither 'vital' nor 'essential' and will not be backed up.

At BLPH non-essential loads will be disconnected from the supply system by 'smart' switchgear that communicates with the EMCS and PCS to open MCCBs for load to be removed from the system due to a set of pre-determined circumstances e.g. BLPH has become an Island or has become reliant purely on BESS power, etc.

4.2 ESSENTIAL SERVICE LOADS

A service, which, if it fails in operation or when called upon will affect the continuity, quality or quantity of the product or could result in equipment damage or extended downtime but would not harm people or the environment. An 'essential' service will be provided with either partial or complete duplication of its power supply and/or equipment with automatic re-starting or supply change-over system.

The provision of an essential supply is an economics matter and therefore, partial or complete duplication of energy source, lines of supply or the equipment itself together with automatic re-starting / change-over equipment shall be evaluated in relation to the consequences of a service interruption. Examples include duplicated pump sets, process analysers having duplicate / change-over power supplies and security lighting / plant area lighting.

At BLPH all essential loads will be maintained after the non-essential loads are disconnected by the EMCS / PCS. However, not all essential loads will be always maintained according to their relative importance.

4.3 VITAL SERVICE LOADS

A 'vital' service will be supplied from duplicate power supplies to ensure it will remain uninterrupted due to failure of either one.

Supply interruption is not permitted as a safety matter for any load that's required to be in service to ensure the safe shut-down of a process or its critical instrumentation, electrical control and protection systems or fire & gas detection / alarm / suppression system.

Each AC UPS shall be a redundant system with a battery sized to support the rated load of each unit for the project autonomy times

Containers pressurization system is not considered as vital loads because the HVAC system for each container guarantee a negligible air leakage.

5 ELECTRICAL LOAD LISTS

Schedules of all installed / connected and spare (future) loads are summarized in the electrical load lists to ascertain both the maximum demand and peak demand for the system as required by DEP 05.00.10.80-Gen on the basis that equipment operates continuously or non-continuously (intermittently or as a standby). Only the worst-case demand values are considered to determine equipment ratings (highest) and the stored power (energy) consumption rate (lowest), as follows:

Continuous (C) all loads that may continuously be required for normal operation - including lighting and workshops.

Intermittent (I) only loads required for intermediate pumping, storage, loading, etc.

Standby (S) only loads required in an emergency (fire water pumps and those of all normally not running electrically driven units e.g. standby for a normally running steam driven pump (charge pumps, boiler feed pumps, etc.). NOTE: Spare pumps (the B of A & B combinations shall not be considered a 'Standby' load.

Diversity factors (X / Y / Z) used in the calculations are as follows:

- X = 100%
- Y = 30% (or single largest load).
- Z = 10% (or single largest load).

Maximum Demand: sum of all loads with continuous duty + sum of all loads with intermittent duty (or single largest), each one with corresponding diversity factors applied = 100% Continuous + 30% Intermittent (or single largest).

Peak Demand: sum of all loads with continuous duty + sum of all loads with Intermittent duty (or single Largest) + sum of all loads with standby duty (or single largest), each one with corresponding diversity factors applied = 100% Continuous + 30% Intermittent (or single largest) + 10% Standby (or single largest).

The system demand estimate associated with each of the following six CCS operation modes is shown in the following electrical load lists:

1. CCS MODE IMPORT (123A90-DDL-EL-LIS-20016)
2. CCS MODE 'HOT STANDBY' (123A90-DDL-EL-LIS-20143)
3. CCS MODE EXPORT (123A90-DDL-EL-LIS-20144)
4. CCS MODE 'COLD STANDBY' (123A90-DDL-EL-LIS-20145)
5. CCS MODE 'EMERGENCY (Island)' (123A90-DDL-EL-LIS-20146)
6. CCS MODE 'POWER OUT (Blackout)' (123A90-DDL-EL-LIS-20147)

6 ELECTRICAL EQUIPMENT

6.1 GENERAL

Each electrical equipment room will be a self-contained unit with fire and gas detection, lighting, small power socket outlets and ventilation fans required to maintain a positive air pressure.

Each electrical enclosure shall be located inside a non-hazardous (safe) area and be capable of withstanding a pressurized water washdown.

All equipment located outside shall be suitable for the harsh off-shore marine environment (North Sea) and where necessary have a suitable weather-cap or housing. The minimum Ingress Protection ratings shall be as shown below in accordance with IEC 60529.

Equipment Type / Outdoor & Naturally Ventilated Locations	Minimum Required IP Rating
Motors	IP56
Cable Glands	IP66
Junction Boxes	IP56
Trace Heating Junction Boxes	IP55
MV Switchgears	IP30
LV Switchgears	IP30
Transformers	IP55
With enclosures open, all live parts shall be shrouded to provide IP2X.	

Table 5 – Minimum required IP rating

Two suitable earthing lugs shall be provided on the exterior of equipment (typically base frames) ready for bonding connections to be made to the platform structure.

6.2 SWITCHGEARS

BLPH 6.6kV MV switchgears shall be the Miniver C type with Vacuum Circuit Breaker VD4 type 630A 25kA incoming MCB .

LV Switchgears will be Imesa type 2500 A 50kA with MCB incoming busbar. (refer to123A90-DDL-IN-RE-20171 and 123A90-DDL-IN-DG-20158)

The 66kV and 6.6kV Switchgear will occupy the same equipment room on the lower deck and have both pressurisation fans and a self-contained cooling system (A/C).

66kV disconnector / earth switches and circuit breaker at BLPH shall be arranged to permit Crosswind to Lock-Out / Tag-Out (LOTO).

The 6.6kV Switchgear will utilise a circuit breaker for the Incomer and the feeder to the Elctrolyser, while it will use fused & latched-contactors used to supply the other equipment and transformers.

Each Key Package Vendor shall be provided with a separate 'Essential' 400V supply (to ensure the demand will minimised whilst BLPH operates in 'Emergency Mode'.

The 400 V Switchgear will be in a separate equipment room on the lower deck and have both pressurisation fans and a self-contained cooling system (A/C).

The potential risk of pulling in hydrogen and/or potentially hazardous air into any room / container / enclosure will be prevented by the air inlets being ducted from a safe location with both flammable gas and smoke detection at the inlet.

Isolators shall be lock-able in the open position and be in accordance with IEC 60947-3.

All cables for interlocking, alarm and/or communication purposes shall be wired out to terminal blocks.

6.3 TRANSFORMERS

Transformers will be filled with biodegradable, synthetic ester type oil (insulating liquid with a fire point >300°C) and utilise cooling method KNAN.

Distribution transformers will have an Open Circuit Tap Changer (OCTC), while the step-up transformer will be equipped with On Load Tap Changer (OLTC), as shown on the project Key SLD.

Each transformer will be equipped with Buchholz, pressure relay, oil level switch, oil and winding temperature detectors, according to the project protection philosophy and transformers specification and data sheet.

BLPH will have three transformers located on the lower deck, as follows:

- TR-100AD1: 7 MVA, 66±8x1.25%/6.9 kV, Dyn11, Zcc=8%, KNAN
- TR-200DE1: 1.6 MVA, 6.6±2x2.5%/0.42 kV, Dyn11, Zcc=6%, KNAN
- TR-200ED1: 0.5 MVA, 6.6±2x2.5%/0.8 kV, Dyn11, Zcc=6%, KNAN

6.4 UNINTERRUPTABLE POWER SYSTEMS (UPS)

The AC UPS will be located within a dedicated enclosure on the lower deck that has both pressurisation fans and a self-contained cooling system (A/C).

Each UPS and its associated power distribution system shall have an overall availability of higher than 99.95% and be used to supply all HSSE critical equipment.

Each AC UPS shall be a redundant system that has two 50% rated batteries (each unit's battery shall be rated for the full rated load and half the autonomy time). The battery type shall be Sealed Gell Filled VRLA, housed within the UPS cabinet.

Battery voltage and capacity shall fulfil the inverter's input power requirements when delivering the rated kVA output (whilst also maintaining the output voltage and frequency within permissible tolerances for the entire autonomy time).

The autonomy of the AC UPS will be the following:

- UP-200F2: AC UPS for NavAid system, Obstruction light and Status light 96 hours
- UP-200F3: AC UPS for PCS, SIS, EMCS, Marshalling cabinets and Field instrument or UCP's package (no CPI) 30 minutes
- UP-200F4: AC UPS for F&G system and Network Cabinet 8 hours

Vital loads shall be energized by one line coming for UPS system and one from MCC (or sub-distribution panel) and in each Vital Load it will be present a device to change the supply line by normal power to UPS power.

The Battery System (DC UPS) will be located within the 66kV / 6.6kV Equipment room on the lower deck and have two 100% rated rectifiers connected to a common (shared) battery.

6.5 EMC COMPLIANCE

The specifications, design, testing, installation, operation and maintenance of all electrical power systems, electrical / electronic instrumentation and control equipment / systems shall comply with EMC directives.

Reference shall be made to the document 123A90-DDL-EL-RE-20177 - Electromagnetic Compatibility Study.

6.6 CATHODIC PROTECTION

The free-issued Impressed Current Cathodic Protection (ICCP) system will be provided with a 400V TP+E, 40 A rated (non-essential) supply. (The ICCP will only be activated once the topsides have been installed)

6.7 TRACE HEATING

Trace-heating shall be designed and installed in accordance with IEC 62395, ATEX and VENDOR instructions / recommendations. Trace-heating shall be provided to all piping, fittings, valves, instruments and vessels as shown on the P&IDs and piping isometrics / piping line-lists.

The trace-heating shall be suitable for use in a hazardous area should this be applicable.

A single trace heating sub-circuit (self regulated cable) shall supply one process line and relative instruments.

Multiple lines or instruments on the same process systems shall be fed from a single 30mA RCBO at 230VAC from BoP distribution board DP-200N1.

All heat tracing lines will be fed from a sub distribution section inside the BoP distribution board DP-200N1, operated a 400 V TPN+E. Each outgoing circuit shall be protected by a suitably sized MCB and 30mA RCD to provide sensitive earth leakage protection.

6.8 CABLES

The power connection to wind turbine HNA5 is a 66kV sub-sea IAC that enters the monopile and rises on cable ladder to terminate below the BLPH 66kV switchgear using a suitable 'T-Connector'.

66 kV IAC and cable extension to the GIS, will be joined with a dedicated frame for T-connectors, instead of inside an interface JB, for the following reasons:

- Difficulty in finding a JB suitable for the installation of the T-connectors. Especially considering that on IAC cable the T-connector has already been mounted.
- The interface JB is intended only for protection against accidental contacts and approach of unqualified personnel: protection of personnel can be guaranteed by suitable access restriction to the area close to the frame.
- T-connectors are suitable for marine environment and for the project environmental conditions.

66 kV cables will all be terminated with T-Connectors, so that there are no air insulated points on the 66 kV system that will require significant insulation distances.

The power connections to the floating solar farm will also enter the monopile and will be terminated inside an interface Junction box where cables are terminated with cable lugs, in order to be "spliced" with the 800 V cables installed on the platform up the 800 V switchgear SG-200D2.

All other cables onboard BLPH will be adequately supported using either cable racks or trays of suitable width that are protected against mechanical damage and are heavy duty, galvanised type carefully routed to avoid hot surfaces or any area subject to increased fire risk. Appropriate segregation will be provided between cables operating at different voltages and for different purposes e.g. power, control, communication, vital service cables, etc.

The following cables will be armoured:

- lighting circuits on upper deck
- power cables between UPS cabinets and battery banks (through isolator battery box)
- power cables starting from Distribution section of each UPS to various items.
- NavAid system.

Cables for the BLPH project in safe areas, instead, will be unarmoured, according to the following reasons:

- lower deck, according to Safety layout 123A90-DDL-SAF-DL-30022, is considered safe area.
- upper deck, according to Safety layout 123A90-DDL-SAF-DL-30023, shows hazardous area only in limited areas (2 m around H_2 vessels and related valves/pipes)
- all containers (B-100/200/300/400) are considered safe area.

In addition to the above considerations, unarmoured cables allow for a reduction of weight and smaller bending radius with respect to armoured ones.

All cables passing or arriving in a classified area will be protected in compliance with the requirements of the IEC 60079-14 and cables external to the equipment will have flame propagation properties according to IEC 60332-1-1.

6.9 LIGHTING SYSTEM

The lighting onboard BLPH shall comprise of the following:

- Normal
- Emergency
- Escape
- Aircraft Warning, Obstruction & Navigation Lights

Normal lighting shall be supplied from a 400/230V TPN+E distribution board and shall be arranged to provide sufficient illumination for personnel to move around the platform safely to perform all necessary operations e.g. read field instruments and operate valves or perform maintenance, make adjustments, etc. to the equipment.

Emergency lighting shall be provided to all areas with escape lighting arranged to enable safe escape in an emergency and for critical control operations to be made whilst the normal lighting is not available. The following areas shall be provided with escape lighting:

- Instruments Room
- Electrical Rooms

Escape lights will be supplied with internal battery for each lighting fixture with a back-up battery of 3 hours and energized only by Normal power.

6.10 EARTHING & LIGHTNING PROTECTION SYSTEM (LPS):

Earthing and Lightning shall be full compliance with the requirements of IEC 62305, IEC 61400-24, IEC / TR 61000-5-2, IEC 61892 and IEC/TS 60479-1 & 4 and per Earthing system philosophy and Earthing and Lightning drawings.

Each Key Package VENDOR shall be responsible for ensuring that earthing down of their DC system will not cause interference on the platform's AC power supply system.

The Controls & Instrumentation (C&I) equipment shall be provided with a suitable 'clean' earth system.

The metallic enclosure of all electrical equipment shall be adequately earthed. Additionally, both electrical and non-electrical equipment having a metallic enclosure shall be provided with adequately sized equipotential bonding conductors (between all parts not otherwise considered satisfactorily bonded e.g. mechanically bolted or welded together).

Earthing lugs shall be provided on the exterior of all equipment and be unpainted stainless-steel having 16 mm diameter hole ready for the connection of a lug that extends beyond the applied insulation.

Earthing within hazardous areas shall be in accordance with IEC 60079.

A yellow/green conductor will be laid inside the non-metallic cable trays to assure equipotential bonding across the plant between metallic enclosures.

6.11 HAZARDOUS AREA CLASSIFICATION

Electrical and instrumentation rooms shall be within a safe area. nternal equipment and areas may be made safe by use of pressurisation fans with ignition protected fans and hazardous source control (gas detection trip philosophy).

All electrical equipment located inside a potentially hazardous area shall comply with IEC 60079 and ATEX rated IIC (or IIB + H2) and be suitable for use with hydrogen. The equipment shall explosion-proof (Exd) and the use of Exi is to be avoided. All junction boxes shall be certified Exe.

Electrical equipment located inside a potentially hazardous area shall be suitable for the appropriate zone (Zone 1 / Zone 2) and Gas Group IIC / Temp. Class T1 (based on an area classification drawing developed in accordance with IEC 60079).

6.12 PROTECTION

The electrical system shall be equipped with adequate protection to operate in the event of an equipment failure or system maloperation.

Reference shall be paid to the documents 123A90-DDL-EL-DG-20014 - Electrical Control, Protection and Metering Diagrams and 123A90-DDL-EL-SP-20166 - Electrical Protection Philosophy