Base Load Power Hub (BLPH)

CONTROL SYSTEM PHILOSOPHY

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Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)

HOLDS LIST

No.	Description
1	Location of the Onshore Equipment Room to be confirmed by COMPANY.
2	Location of the Central Control Room to be confirmed by COMPANY.
3	COMPANY shall advise if Autonomy times are to be optimised.
4	The contractor to clarify number of packages and wheter these are UCP controlled or non-UCP controlled.
5	Number of FO Cores to be clarified by contractor to ensure segregation and capacity on networks between BHLP and Control room.
6	TQ sent to company to clartify FGS Connections, 123A90-PML-PM-TQ-00039 "Fire & Gas Detectors Connection and Voting Logic for CPI".

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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.

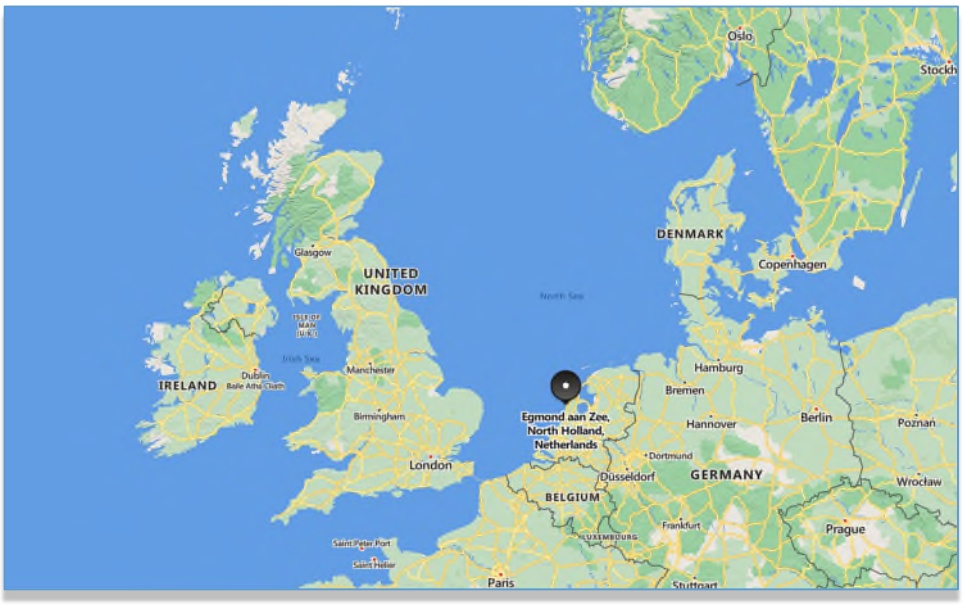


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

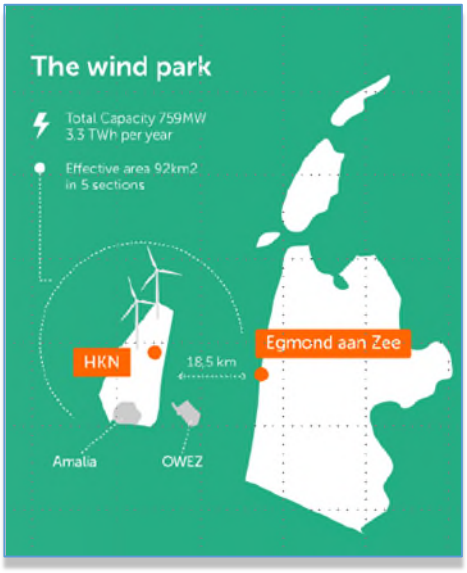


Figure 2 - Wind Park Details

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.

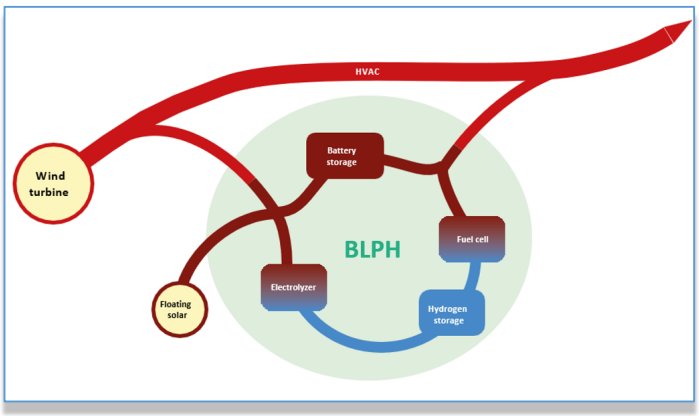


Figure 3 – BLPH Concept

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.

1.2. PURPOSE & OBJECTIVES

The project Engineering objectives are:

- Development and full integration of the key innovative technologies (e.g., electrolysis, BESS and FC) which are critical success factors.
- Full BLPH scope definition allowing for Engineering Procurement Construction (EPC) Tendering.
- Full definition of operating modes, strategies, and constraints.
- Demonstrating grid compliance.
- Creating confidence in Cost (-10% /+15%) and Schedule.
- Full risk assessment and mitigation.
- Developing Operation and Maintenance Strategies:
  - Unmanned operation.
  - Low planned maintenance interval six (6) months.

1.3. PROJECT VALUE DRIVERS

The project main value drivers are:

- Project delivery to Rijksdienst Voor Ondernemend (RVO) – The Netherlands Enterprise Agency
- BLPH needs to be commissioned in Q3 2025 and demonstrated successfully in line with the commitments to RVO. The essence of the BLPH is in the demonstration of the concept of time shifting flexibility of the renewable generation through an integrated energy storage system designed to work which:
  - Results in reduction of intermittent wind power output through energy storage using battery and hydrogen systems, and complementary floating Solar Photo Voltaic (PV) generation
  - Is located a harsh offshore environment, in the North Sea
  - Is an unmanned facility with planned maintenance / six (6) months intervals;

  - Delivers up to 1MW of "gross" power for 99% of the time of the year. This means that during low wind power output, the combination of the WTG + BESS + FC + solar PV will create an output of up to 1MW excluding the utility consumption of the BLPH.
  - Delivers knowledge and learnings on steps required to integrate intermittent wind power; which can be shared by CrossWind in order to support the building of a sustainable energy system

- Cost:
  - Project to be delivered with a ceiling value to the Capital Expenditure (CAPEX) addressing 2-year project lifetime cost
- Transparency and Learning:
  - Project to be delivered in a manner which ensures integration transparency and knowledge transfer from CONTRACTOR and Vendors to Owner (CrossWind)
- Constructability and Maintenance:
  - Simplification of approach to construct & maintenance with limited on-platform work. The platform shall be unmanned and subject to a six (6) month maintenance frequency.

Safety shall not be trade-off between design choices, but Safety-in-Design shall be a given in the design of the BLPH project. All safety related hazards and risks will be reduced to ALARP.

2. DOCUMENT SCOPE

The purpose of the of the document is to define the functional requirements and the minimum acceptable technical requirements for delivering the control system to be used for BLPH project.

2.1. REFERENCES

Doc. No.	Description
Revision F, 26 Sept 2022.	1. Shell, "Basis for Design Base Load Power Hub (BLPH)"
K559-2254-EL-PHI-002, rev 1	2. KBR, "Electrical System Description & Design Philosophy"
K559-2254-IC-SPE-002.	3. KBR, "Telecommunications Specification"
K559-2254-EL-PHI-001.	4. KBR, "System Specification for Main Automation Contractor"
K559-2254-IC-BLD-002, rev 1.	5. KBR, "Telecommunications Architecture"
K559-2254-IC-BLD-001, rev 1.	6. KBR, "Control Systems Architecture"
K559-2254-SE-PHI-001, rev 0.	7. KBR, "Fire Protection Philosophy"
K559-2254-SE-PHI-003, rev 0.	8. KBR, "Escape Route Philosophy and Life Raft Positioning"
123A90-DDL-IN-CE-40000	9. Process Safety Cause & Effect Matrix
123A90-DDL-IN-CE-40002	10. Fire & Gas Cause & Effect Matrix

Table 1 - Reference Documents

2.2. DEFINITIONS AND ABBREVIATIONS

ALARP	As Low as Reasonably Possible
AMS	Alarm Management System
ATEX	Appareils destinés à être utilisés en ATmosphères EXplosibles (Equipment intended for use in explosive atmospheres)
BESS	Battery Energy Storage System

BLPH	Base Load Power Hub
CAP	Critical Action Panel
CAPEX	Capital Expenditure
CAT	Category
CCN	Central Control Network
CCR	Central Control Room
CCS	Central Control System
CCTV	Closed Circuit Television
COMPANY	Crosswind
CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
CTV	Crew Transfer Vessel
DEM	Design Engineering Manual
DEP	Design and Engineering Practice
DMZ	Demilitarised-Zone
DOCUMENT NAME	Document Title
EMC	Electromagnetic Compatibility
EN	Engineering Notice
EPC	Engineering Procurement Construction
EPIRB	Emergency Position Indicating Radio Beacon
EWS	Engineering Workstation
Ex	Explosion Proof
FC	Fuel Cell
FEED	Front End Engineering Design
FEED CONTRACTOR	Organisation contracted directly by COMPANY to provide engineering, design, or other services.
FGS	Fire & Gas System
FO	Fibre Optic
FOPP	Fibre Optic Patch Panel
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positional Satellite
HART	Highway Addressable Remote Transducer

HAZOP	Hazardous Operability Study
HKN	Hollandse Kust Noord
HMI	Human Machine Interface
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HV-SCADA	The given name for the COMPANY's control system for the HKN wind farm infrastructure. BLPH's control system shall operate autonomously but will interface with HV-SCADA.
IACS	Industrial Automation and Control Systems
IAMS	Instrument Asset Management System
IDCS	Intrusion Detection Control System
IEC	International Electrotechnical Commission
IP	Ingress Protection
IP	Internet Protocol
IS	Intrinsically Safe
ISO	International Organization for Standardization
ITER	Instrument & Telecoms Equipment Room
LACS	Local Access Control System
LAN	Local Area Network
LOPA	Layers of Protection Analysis
LHVS	Land High Voltage Station
LV	Low Voltage
MAC	Main Automation Contractor, ABB AS
MCC	Motor Control Centre
NAMUR	Interessengemeinschaft Automatisierungstechnik der Prozessindustrie (User Association of Automation Technology in Process Industries)
NIS	Non-Intrinsically Safe
OHVS	Offshore High Voltage Station
OWS	Operator Workstation
PAGA	Public Address and General Alarm

P&ID	Piping and Instrument Diagram
PACO	Process, Automation, Control and Optimisation (PACO) is the term used to describe all functionality required for the monitoring and controlling of all process, safety and fire and gas systems selected for the project.
PROJECT	HOLLANDSE KUST NOORD WIND PARK Project
PV	Photo Voltaic
PURCHASER	The organisation placing a purchase order for the supply of equipment or services for the Project. The Purchaser could be the COMPANY or the Contractor or some other party appointed by the COMPANY or Contractor.
RVO	Rijksdienst voor ondernemend Nederland – The Netherlands Enterprise Agency
SART	Search and Rescue Transponder
SCADA	Supervisory Control and Data Acquisition
SGSI	Shell Global Solutions International
SHALL	An absolute requirement.
SHOULD	This word indicates a recommendation that whilst preferred may not be implemented provided some equivalent is proposed and agreed by COMPANY. The full implications must be understood and carefully weighed before choosing a different course.
SIF	Safety Instrumented Function
SIL	Safety Instrumented Level
SIS	Safety Instrumented System
SOLAS	Safety of Life at Sea
TETRA	Terrestrial Trunked Radio
TSO	Transmission System Operator
TQ	Technical Query
UCP	Unit Control Panel
UHF	Ultra-High Frequency
UPS	Uninterruptible Power Supply
VENDOR	Manufacturer/Supplier of equipment and services to perform the duties specified by the Purchaser.

VHF	Very High Frequency
VLAN	Virtual Local Area Network
WAN	Wide Area Network
WTG	Wind Turbine Generator

Table 2 - Definitions and Abbreviations

3. APPLICABLE CODES, STANDARDS, AND REGULATIONS

3.1. GENERAL

The equipment shall be designed, manufactured, tested, and delivered in accordance with this philosophy and the Project documents, codes, standards, and regulations listed below. It is the Vendors responsibility to ensure complete compliance in their design, inclusive of all sub-vendors. The normative documents listed below contain requirements that, through reference in this text, constitute the requirements of this Project. Latest editions of all referenced documents shall apply.

The following requirements shall apply as a minimum with the design being fit for purpose for the technical requirements listed in section 4 and for the functional requirements described in sections 5, 6 and 7.

The project shall apply relevant standards and codes in the following order:

1. Regulations
2. Selected DEM-1 and DEM-2 requirements.
3. Industry Codes and Standards.

The applicable industry codes and standards are details in sections 3.2, 3.3 and 3.4.

3.2. REGULATIONS

Table 3 - Regulations

Document Name	Document Title
1999/92/EC	ATEX 153 Workplace Directive
2011/65/EU	Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment
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

3.3. APPLICABLE DESIGN ENGINEERING PRACTICES

Design Engineering Practices (DEP) have a limited rollout on BLPH.

3.3.1. Fully Applicable DEP

The following DEP are identified as being fully applicable to the project.

Table 4 - DEP

Document Name	Document Title
DEP 32.01.20.12	Industrial Automation and Control Systems (IACS) Security
DEP 30.00.60.15	Humans Factors Engineering – Control Room Design

DEP 32.01.20.12 shall be applied to the project in full, in conjunction with IEC 62443, for the cybersecurity design.

DEP 30.00.60.15 shall be applied to the project for the design of the Control Room.

3.3.2. DEM-1 Process Safety Only DEP

The following DEPs shall have the DEM-1 'Process Safety' requirements applied to the project.

Document Name	Document Title
DEP 32.30.20.11	Fire, Gas and Smoke Detections
DEP 32.80.10.10	Safety Instrumented Systems
DEP 32.80.10.14	Alarm Management (Amendment/Supplements to IEC 62682)
DEP 62.10.08.11	Inspection and Function Testing of Instruments

3.4. INDUSTRY STANDARDS

Table 5 – Industry standards

Document Name	Document Title
EN 1127	Explosive Atmospheres, Explosion Prevention and Protection, Basic Concepts and Methodology
EN 61131	Programmable Controllers
IEC 60079	Installation & Maintenance of Electrical apparatus for use in Potential explosive atmosphere
IEC 60364	Low-voltage Electrical Installations
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 61158	Industrial communication networks
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61511	Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Framework, Definitions, System, Hardware, and Application Programming Requirements
IEC 61850	Communication Networks and Systems for Power Utility Automation
IEC 62305	Protection Against lightning
IEC 62443	Cyber Security for Industrial Automation and Control Systems

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IEC 62682	Management of Alarm Systems for the Process Industries
ISO 14001	Environmental Management System
ISO 9001	Certifications of Quality Management System

4. GENERAL TECHNICAL REQUIREMENTS

4.1. DESIGN LIFE

The design life of the facility is 2 years as this is a proof-of-concept project.

4.2. ENVIRONMENTAL CONDITIONS

The facility shall be located in a harsh marine environment in the North Sea. All equipment shall be suitable for installation and operation and for the environmental conditions in the Meteorological and Oceanographic Data of the BLPH Basis for Design [1].

4.3. UNITS OF MEASUREMENT

The international System of Units are to be used for the project, with the following limited exceptions which are conventional in the hydrocarbon industry. The Units of Measurement for:

- Pressure will be in Bar;
- Nominal Pipe size will be in inches;
- Conventional volumetric flow rate will be used e.g., m^3/h; and
- Conventional mass flow rate will be used kg/h.

4.4. LANGUAGE

The project language shall be in English. This includes all correspondence, deliverables, hardware tagging / signage and control systems software.

4.5. GENERAL ELECTRICAL EQUIPMENT DESIGN

BLPH is located in the North Sea, under the authority of the government of The Netherlands. As such, IEC regulations apply to the project in full. Refer to section 3.4 for a list of applicable standards.

4.6. INGRESS PROTECTION RATING

The Ingress Protection code, for equipment exposed to the environment, shall be IP66 in accordance with according to IEC 60529.

4.7. EQUIPMENT INTENDED FOR USE IN EXPLOSIVE ATMOSPHERES

All equipment shall be certified for use in hazardous areas. Design shall comply with IEC 60079 and be ATEX rated for IIC or rated for IIB + H2. All equipment specified for use in a hazardous area shall be suitable for hydrogen production. All outdoor electrical and instrumentation equipment shall, as minimum, be suitable for use in hazardous area zone 2, gas group 2C (or 2B+H2), Temperature Class T1 max.surface.

Items located in the hazardous area (hydrogen environment) shall be explosion-proof Ex-d certified. Ex-I technique shall be avoided. Junction boxes in the hazardous area shall be Ex-e certified. ATEX marking shall be on all ATEX certified equipment.

All instruments and outside equipment shall be suited for a harsh offshore marine environment. If necessary, items shall be installed with a weather-cap or housing. This counts also for junction boxes, cabling, ducts, and glands.

4.8. 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.

This is to ensure that the requirements for electromagnetic compatibility are considered during the various stages of design, construction, and installation. All as aspects of the control system shall be certified to 2014/30/EU. The vendor shall provide a Declaration of Conformity for their package stating as such.

5. FUNCTIONAL OVERVIEW

The design of the PACO control system shall be:

- Inherently safe;
- Cost effective with a justify-in design;
- Satisfy reliability and availability requirements; and
- Achieve operational and maintenance requirements.

BLPH is intended to be a greenfield platform whose purpose is to balance the power supply from HKN wind farm primarily through hydrogen generation and storage. The platform shall provide short-term energy storage through a BESS and long-term energy production and storage by producing and storing green hydrogen through electrolysis.

BLPH is an unmanned facility with planned maintenance schedules expected to be at six (6) month intervals. The platform must be capable of autonomously operating without the need for local operator intervention for that period, with the remote operator largely providing oversight only.

The facility shall receive power by external means from the Dutch grid (through the HKN wind park) and a floating solar farm. The facility is directly coupled to WTG57 through an inter array cable string that connects to the Dutch grid.

Power production from BLPH will be governed by the real-time out data signals coming from Wind Turbine Generator number 57 (WTG57).

The PACO control system developed for BLPH shall comprise of two (2) interconnected, but independent systems:

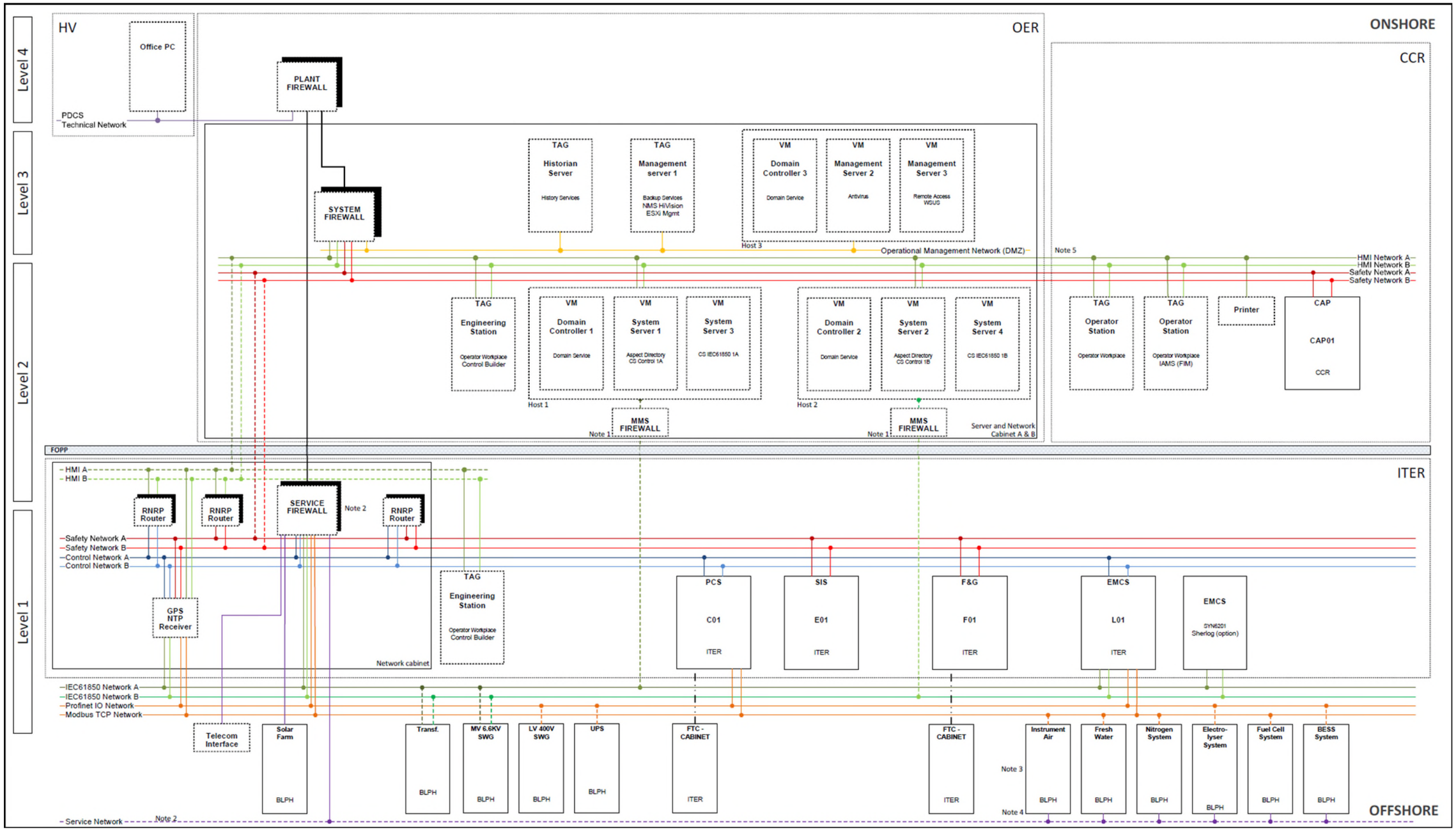
- A Central Control System (CCS); and
- A combined Fire and Gas System (FGS) and Safety Instrumented System (SIS), which shall be referred to collectively as the Safety System.

The CCS shall be responsible for the monitoring and control of the facility, whilst the Safety System shall be responsible for the overall safeguarding of BLPH.

A general description of BLPH, including the different equipment, is described in the topology diagram shown in Figure 4. Note that the topology is not final and are under development.

Full details of the architecture are provided in the telecommunications architecture [5] and control architecture [6].

Figure 4- Network topology (Draft)



6. PACO REQUIREMENTS

All elements of the PACO control system are to be designed for continuous operation given that hydrogen is a constant presence. However, the system shall be designed for alternating between different operating modes, including but limited to turning power generation equipment (see Figure 4) on and off.

The facility shall operate as an unmanned facility connected to a remote Central Control Room (CCR) via a Fibre Optic (FO) cable. The subsea FOs shall be installed on the facility, by others, via the Offshore High Voltage Station (OHVS) which is an offshore platform approximately 20km away. The OHVS platform is not the responsibility of BLPH project other than to operate as an interface to shore. From OHVS, the FO cable will run to shore at a facility called Land High Voltage Station (LHVS), which is a further 60km away from OHVS. At LHVS, the FO cable shall terminate into an existing network. This existing network provides for connection to the remote CCR and for interfacing with HV-SCADA.

The Safety System shall be functionally independent of the CCS, including all Controllers, signals, and logic. The CCS shall not impact the ability of the Safety System to execute protective and mitigation actions.

There shall be no single point of failure of any element which could lead to an emergency shutdown or result in a loss of production, including an interruption to the hydrogen storage or power generation systems.

All signals connected to the CCS, or the Safety System shall have redundant cards and power conditioners. It is a requirement to minimize the need for manual operator intervention in the field and all necessary data to operate the plant safely and efficiently should be available via the Operator Workstation (OWS) and Engineering Workstation (EWS), wherever these stations reside.

Functionality shall be provided for a remote restart of the facility from Remote CCR.

The CCS and the Safety System shall be provided by the Main Automation Contractor (MAC).

6.1. CCS

The CCS bears overall responsibility for the control of the facility, and it shall operate independently of the Safety System. All controllers associated with the CCS shall be located on the platform in the Instrument and Telecommunications Equipment Room (ITER).

The CCS shall not only be responsible for controlling the equipment on the platform but also to react appropriately to the changes to the HKN wind farm and floating solar farm as per input from HV-SCADA, see sections 6.1.1, 6.1.2 and 6.5.2. The environmental changes to the wind farm and floating solar farm will impact the operating modes that the CCS must control.

Access to the OWS and EWS shall come via a Safe Network through a secure link with a secure access route, e.g., firewall, to ensure compliance with IEC 62243. All elements shall wherever possible be integrated into CCS for ease of use for the operator.

Numerous equipment shall be designed and delivered as packaged vendor equipment with integrated proprietary control systems for BLPH. Such systems shall be referred to as Unit Control Panels (UCP). The CCS shall be designed to operate in a supervisory control capacity of this equipment to IEC 61850 for

intelligent electronic power systems and IEC 61158 for the remaining systems. All Ethernet systems shall operate over CAT6A cables with RJ45 connections.

All remaining systems shall be directly controlled by the CCS in a point-to-point configuration using 4-20mA Smart HART revision 7 protocol.

These UCPs shall control the step sequences for each equipment with the CCS acting as supervisory control.

All CCS equipment shall communicate over the Central Control Network (CCN).

The MAC shall ensure that the CCS has the ability to operate all UCPs with an appropriate speed of response.

6.1.1. Control Narrative Development

A control narrative giving a description of the project's process functions shall be developed in the engineering phase of the project by process and electrical engineering teams. This narrative shall include the necessary interactions of the UCP vendor packages with the Vendor UCPs responsible for their own equipment. The control narratives for the UCP vendor packages shall be provided by the respective vendors.

6.1.2. Basic Requirements and Objectives of CCS

The CCS shall be designed such that rapid cycling / quick switching of the BESS, Fuel Cell and Electrolyser is minimized to prevent damage to these systems.

The objective of the BLPH is to demonstrate time shifting flexibility and capability of providing 1MW Power output using the full capacity of the inventory stored on the platform. This shall be developed into more detail by electrical engineering team and as well as consideration given towards the inclusion of a power quality meter to prove that plant output meets its objectives.

BLPH shall plan its power output based on the production of WTG57 and the floating solar farm whilst considering the technical constraints of energy storage from the BESS and the Hydrogen Storage Vessels.

The facility can be operated remotely from on-shore Control room, and has the ability to shut down, start-up, re-start after a trip, to adjust and/or tune, to connect and disconnect to the grid and to monitor BHLP.

6.1.3. Intelligent Electronic Power Systems

The CCS shall be responsible for the supervisory control of the Motor Control Centre (MCC) and the Switch Gear. It therefore functions as a combined process control and electrical network monitoring and control system. All required functionality of an electrical network monitoring and control system shall be provided for within the design of the CCS.

The approach to have a single control system for electrical and process equipment is in line with Technical Query-010 (TQ-010) between the FEED CONTRACTOR and COMPANY. Further, as affirmed by TQ-010, the COMPANY shall provide for operator training to support electrical and process functions and technology of BLPH. The MAC is to provide operator training simulators to facilitate this.

The CCS, via the Switch Gear, shall control the different transformers and converters on-board the platform via the breaker switches. This includes the solar farm transformer that will be located on BLPH platform.

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The MCC shall be responsible for controlling and monitoring all motors and compressors on BLPH via contactors.

The Electrolyser, BESS and Fuel Cell systems do not interact with each other directly, and it is the responsibility of the CCS to coordinate their operations. The full detail of the electrical scope is captured under the Electrical System Description & Design Philosophy [2].

The communication protocol between the CCS and the MCC and Switch Gear shall be in accordance with IEC 61850. All Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

The UCPs for this equipment shall be located in the Electrical Equipment Room.

6.2. SAFETY SYSTEM

The design of the Safety System shall adhere to IEC 61511 and shall comprise of all elements of the SIS and FGS and shall undertake protection or mitigation actions within the process and utility plants.

All functional processing equipment of the Safety System shall be located in the ITER with the exception of any equipment required for a hardwired Critical Action Panel (CAP) located in the onshore control room – see section 6.2.3.

The CCS shall not impact the ability of the Safety System to execute the protective and mitigation actions. All Safety System functionality shall be provided to the Remote CCR to ensure effective and safe control of the facility.

Field mounted emergency shutdown pushbuttons shall be included on the BLPH platform, and inside the ITER.

All SIS and FGS elements shall communicate as direct point-to-point control using the 4-20mA Smart HART revision 7 protocol.

All Safety System equipment shall communicate over the Safety Network.

All functions of the SIS and FGS shall be automatic in line with the Cause and Effects Diagrams provided by the project [9] [10], including the vendor packaged equipment.

6.2.1. SIS

The SIS shall provide an independent layer of protection on top of the CCS. This will be called upon when the operational personnel cannot mitigate the potential risk. The SIS shall activate safety critical functions and act to isolate the plant via any emergency shutdown valves. The SIS acts, based on a process excursion, to shutdown individual equipment and prevent a hazard from occurring.

The SIS shall comprise a full set of components, including sensors, logic solvers, and final control elements, whose purpose is to take a process to a safe state when a predetermined hazardous condition arises.

Safety Instrumented Functions (SIF) shall be determined by a HAZOP study undertaken by the project. These SIFs shall be subject to a Layers of Protection Analysis (LOPA) review to establish the required Risk Reduction Factor. In general, any instrumentation that is part of the SIS, including final elements (e.g., valves), shall, as

a minimum, be certified for use in a Safety Integrity Level (SIL) 2 SIF with a minimum proof test interval of two (2) years, to be developed during HAZOP and LOPA exercises.

Provision shall be included for a Demand on Safety System tool that can provide information on genuine SIF activations. This information is required in order to compare actual and predicted demands of each SIF.

Cause and Effect Diagrams shall be developed in Detail Design phase of the project to fully document the required functionality.

6.2.2. FGS

This system will undertake mitigation actions within the process and utility plant on the detection of fire or gas release. It shall include all fire and gas detection and mitigation systems required for the individual fire zones. Executive actions, shutdown levels and associated Cause and Effect Diagrams shall be developed to fully document the required functionality.

The objectives for the FGS shall be defined by the Fire Protection Philosophy [7].

Any executive action on detection of fire or gas shall be based on a 2ooN voting arrangement. All active extinguishing systems shall be energized-to-operate.

6.2.3. Critical Action Panel

A CAP shall be located at the CCR with dedicated switches for SIS and FGS functions. All required equipment for the CAP switches shall be included for at the CCR as it is not clear if the location of the CCR shall be adjacent to the onshore equipment room (Hold - 1).

The CAP is to be physical panel in the onshore control room. The CAP controller in CCR will be connected to the safety network on BLPH offshore. The CAP contains the SIS and FGS hardwired pushbutton and indicators for emergency operator actions. To minimize the CAP matrix size in the control room, the associated I / O should be considered based on the chosen technology and available space and the fire zone status indicators displayed via operator workstation.

6.3. POWER GENERATION AND STORAGE EQUIPMENT

The Power Generation and Storage Equipment, as detailed in Figure 4, comprise the main process functions of the facility.

6.3.1. UCP Controlled

The Electrolyser, the BESS and the Fuel Cell shall all be controlled via UCP.

The communication protocol between the CCS and the Electrolyser, BESS and Fuel Cell systems shall be in accordance with IEC 61158, preferably Profinet. All Safety System communications shall be 4-20mA Smart HART revision 7 protocol.H2

Local interfaces are to be included by the Electrolyser, BESS and Fuel Cell systems, by others.

The UCPs for this equipment shall be included in packaged vendor skid. The function of the UCP shall include for normal operations and any safety requirements associated with SIS. The design of the vendor UCP shall be compliant with IEC61508.

Fire and Gas devices shall be routed back to the BLPH Safety System to ensure that devices remain operational upon gas detection. COMPANY to clarify connection and voting logic (Hold - 6). This allows the operator to have visibility during any loss of containment issues.

6.3.2. Non-UCP Controlled

The Hydrogen Storage system is not supplied with a UCP. The CCS shall directly control this system and its functions point-to-point via 4-20mA Smart HART revision 7 protocol.

All Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

6.4. UTILITIES

6.4.1. UCP Controlled

The following utility systems shall be delivered with UCPs. The communication protocol between the CCS and these units shall be designed to IEC 61158, specifically Modbus. All Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

The Contractor shall clarify further need and scope of packages with regards to which are UCP controlled and Non-UCP controlled (Hold - 4).

- Fresh Water;
- Instrument Air; and
- Nitrogen.

6.4.2. Non-UCP Controlled

The following utility systems are not supplied with a UCP and shall be controlled directly from the CCS, point-to-point. All CCS and Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

- Sea Water;
- De-Mineralized Water: and
- Wastewater.

6.5. EXTERNAL INTERFACES

6.5.1. Fibre Optic Communications

The following FO cores shall be terminated onto BLPH platform for communicating between the HKN wind farm and BLPH. These shall all be via the Inter Array Cable from WTG57.

- One (1) FO cores for ICCP package terminating on BLPH platform and is separate to any PACO functions;
- One (1) FO cores provided directly to 66KV switchgear to permit HV-SCADA to directly control breaker switch; and
- Four (4) FO cores provided for PACO communications with two (2) FO cores dedicated to the CCN, and a further two (2) FO cores dedicated to the SN.

The contractor shall clarify the number of FO cores is enough to allow for the needed capacity and segregation required by CSS and SIS (Hold - 5).

Additionally, the following FO comes directly from the LV Power Cable from Floating Solar

- One (1) FO cores incoming from floating solar farm which is connected into the CCN.

FO cores shall land on BLPH with FOPP provided by contractor. The FOPP on OHVS, LHVS and floating solar farm shall be by others.

6.5.2. HV-SCADA

The CCS shall interface with the HKN wind farm control system, called HV-SCADA. The HV-SCADA shall provide time sensitive critical input regarding the status of the wind and solar farms to permit BLPH to know which operating modes to be in.

The CCS shall tie into, what will be by the time of installation, an existing network (by others). This tie-in will occur onshore at LHVS. The CCS and HV-SCADA shall operate independently of each other.

The CCS shall receive information from HKN wind farms via HV-SCADA, specifically current and predicted power output of WTG57. This information shall form part of the BLPH control logic governing the charging / discharging of Hydrogen and BESS as dictated by the control narrative.

6.5.3. 66kV Switchgear on BLPH

CCS shall have control of the 66kV breaker and earth switches through the dedicated switchgear on BLPH platform.

Additionally, a dedicated FO shall be provided for HV-SCADA to directly control the 66kV breaker switches on the BLPH platform, as shown in Figure 4. This FO shall be installed directly to 66kV Switchgear and shall be completely independent to the CCS.

6.5.4. Floating Solar Farm

A floating solar farm shall have one (1) LV power cable with integrated FO cable terminating onto BLPH, separate to the inter array cable from WTG57. A floating solar transformer and switchgear shall be located on BLPH with the floating solar breaker and earth switches controllable via the CCS.

The floating solar farm shall have its own control system, provided by others. HV-SCADA shall have control of floating solar farm via a dedicated VLAN.

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6.6. ENHANCED PERFORMANCE SYSTEMS

The following systems shall be included for in the design of the BLPH PACO Control System.

- Instrument Asset Management System (IAMS);
- Alarm Management System (AMS); and
- Process Historian.

These systems shall not be located on BLPH in the ITER but in an onshore equipment room. The location of the systems is to be decided in future by COMPANY (Hold - 1).

The equipment shall operate over the Technical Network. Depending on suitability, (as determined by the MAC vendor) the equipment may be housed on virtual servers. These virtual servers shall ensure that necessary segregation is achieved. The full functionality of these systems is to be available to the Control Room Operator to ensure the facility is operated efficiently and safely.

Information on these servers shall be accessible over the COMPANY's secure external network whilst adhering to the cybersecurity requirements.

6.6.1. Instrument Asset Management System

An Instrument Asset Management System (IAMS) covering instrumentation shall be provided to maximise the diagnostic and monitoring abilities of the facility. The functionality of this shall be largely provided for by hardwired instrumentation via the 4-20mA HART revision 7 protocol. Packaged Vendor equipment with UCPs shall also provide diagnostic data over the Modbus interface.

6.6.2. Alarm Management System

An Alarm Management System (AMS) shall be included for BLPH. The function of the AMS is to indicate to the operator that an abnormal situation has occurred, and that operator can and must take timely action. The AMS shall be designed to minimise the number of alarms presented to Operations during an upset condition. All alarms shall be reviewed and justified before being implemented into the design. This includes minimising the generation of unnecessary alarms, e.g., when equipment is not running or is out of service, rather than generating and then masking.

The alarm management system shall conform to the requirements of IEC 62682. Development of the project specific AMS shall be undertaken in conjunction with the:

- Process discipline, particularly during the (Piping and Instrument Diagram) P&IDs development;
- Mechanical discipline, particularly during vendor package P&ID / serial interfaces development;
- Electrical discipline, particularly during electrical switchgear serial interface development;
- PACO discipline, particularly for control system alarms and instrument package interfaces development; and
- Safety discipline, particularly identification of safety related alarms.

The use of alarm grouping, particularly for package interfaces, should be used to optimise the way alarms are presented to the operator and reduce the quantity of individual alarms. Any UCP vendors shall be required to support the alarm grouping and rationalisation review process.

The CCS and Safety System shall incorporate the following features to provide advanced alarm handling:

- Alarm Shelving;
- Alarm Hiding, both manual and automatic;
- Alarm Suppression
- Alarm Blocking
- Conditional alarming;
- Alarm Grouping;
- Alarm Priority; and
- Alarm Classification.

6.6.3. Process Historian

A process historian shall be included with considerations for both short-term and long-term storage with ease of access data retrieval. The methodology of data storage shall be suited to meet the needs of BLPH. Multiple databases of repeated information should be minimised.

The historian shall have facilities to include:

- Real time capture of all process tags with an appropriate sampling rate of all process variables and controller outputs;
- Storage of process measurements, alarms, and events for one month (no data compression);
- Trend data storage;
- Report generation; and
- Real time data transfer to higher level Enterprise Historian.

Simple calculations deriving KPIs should be performed within the control system and then written into the plant historian as separate tag items.

The local historian should be the only source of historical data for Human-Machine Interface (HMI) trending applications and higher data analysis packages.

6.6.4. Condition Monitoring

Given the two (2) year lifespan of the project, a dedicated condition monitoring system is not a requirement for the project.

6.7. WORKSTATION INTERFACES

The facility shall be remotely operated via an OWS at a location to be confirmed by COMPANY (Hold – 2). An EWS, shall be included in the ITER. An additional EWS may be provided in the onshore equipment room depending on the MAC feedback.

The EWS and OWS shall communicate over the client server network. The EWS shall give access to all maintenance, monitoring, and controllable elements.

The MAC shall clearly communicate what functions are possible by the EWS when in use on the platform and when in use at shore, when plugged into any network.

The OWS shall be capable of the full range of functionality required to operate the facility. Any OWS shall have the capability to access any display in the system to provide maximum redundancy and flexibility of operation. During the detailed design stage, the operator console shall be subject to a detailed human factors study covering all operating scenarios, with particular emphasis on alarm and trip situations. Personnel undertaking this study must have relevant (and recent) operating experience.

The involvement of Operations will be sought at all stages of the design, development, and testing of operator interfaces. Full consideration is to be given to ergonomics and human factors in determining the detailed design and disposition of all PACO equipment. The number and configuration of the OWS will be agreed after confirmation of CCR location.

Whilst the functions of the SIS and FGS must operate independently of the CCS and in accordance with IEC 61511, all elements shall wherever possible be integrated into and controlled from the common operator HMIs.

Facilities for system fault analysis, diagnostics, troubleshooting and programming together with facilities for alarm setpoint and instrument range configuration, loop tuning and configuration changes etc., shall be provided for via an Engineering Workstation (EWS).

6.8. CONTROL AND EQUIPMENT ROOMS

6.8.1. Instrument and Telecoms Equipment Room

The Instrument and Telecoms Equipment Room (ITER) shall be located on the offshore platform and house the CCS, the Safety System and the EWS along with any associated cabinets and network equipment required to operate the facility.

The ITER shall be:

- Suited to the harsh marine environment of the North Sea;
- Supplied fully equipped with a HVAC system suited to safeguard the equipment stored within and any persons inside;
- Suitable egression system to protect the contents of the container; and
- Supplied in accordance with the general technical requirements outlined in section 4.

6.8.2. Central Control Room

The design of the CCR shall comply with DEP 30.00.60.15 (Human factors Engineering - Control Room Design). Approval of the control room design shall be subject to human factors and working environment engineering which will occur during Detail Design. The OWS shall be developed by MAC.

The operating principle is that the day-to-day monitoring and control of the facilities will be undertaken from this CCR. This control room shall contain all the required operator interface facilities for management of the process and utility systems and the management of fire, gas, and other incidents through the PACO control system.

As detailed in 6.2.3, there shall be a CAP hardwired to the SIS and FGS for pre-defined emergency safety operations. All equipment to support functionality of the OWS and CAP to be provided for in the CCR.

The location of the CCR is not yet determined by company (Hold - 2).

6.8.3. Onshore Equipment Room

An onshore equipment room shall be provided to house the equipment shown in Figure 4. The location of this equipment is not decided by COMPANY (Hold - 1). It is possible that the equipment room may be in an existing facility.

6.9. NETWORKING DESIGN AND CONSIDERATIONS

The location of the CCR and the onshore equipment room is not known. It is likely that the location of the CCR and possibly the onshore equipment room may necessitate the use of a public internet infrastructure in the Netherlands. MAC vendor shall take this into account during design including, but not limited to, cybersecurity, reliability, availability, and maintainability.

6.9.1. Backup Communications

No backup communications are necessary for BLPH as the platform will autonomously go to a safe state on loss of the Watchdog. See section 6.9.2 for more detail.

6.9.2. Watchdog System

BLPH shall employ a watchdog system. Upon the loss of FO optic communications, the design intent is that the unattended platform shall proceed towards a safe shutdown based on predefined control logic. This system shall operate within the allocated autonomy time.

6.9.3. Time Synchronization

The PACO control system shall act as the master clock with a built-in Global Positional Satellite (GPS) receiver for all other real-time systems, such as the CCS.

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6.10. IACS CYBERSECURITY

All network architecture and security shall be designed as per DEP 32.01.20.12 (IACS Security) and IEC 62243. The BLPH functional processes shall be implemented onto new networks but shall tie into an already existing network in the region which is referred to as HV-SCADA.

The MAC shall be the responsible party for designing the cybersecurity requirements for PACO control system, including packaged vendor equipment with UCPs and the intelligent electronic power systems. The design of the security shall permit for UCPs to be fully controlled, monitored and maintained from the Remote CCR.

The ability and extent to remotely update the operating systems and any security software (e.g., anti-virus, firewalls, etc.) shall be evaluated and advised by the MAC.

All communications between the IACS zone and all other zones located outside the IACS zone shall be routed through a Demilitarized-Zone (DMZ) or a unidirectional security gateway that restricts communications to authorized protocols and only between authorised devices.

A cyber security risk assessment of the IACS, including the SIS, shall be carried out by the service provider to determine the necessary security controls and countermeasures required to reduce the cyber security risk to a level acceptable by the asset owner.

The IACS shall provide the capability to terminate a remote session, originating outside the IACS zone, either automatically, after a configurable period of inactivity, or manually by an authorized user. Remote access to the SIS engineering workstation and the asset management system, if managing SIS assets, shall be restricted to authorized devices located in the IACS zone.

The conceptual IACS architecture design for BLPH is based upon the HV-SCADA and its distinct levels are:

Table 6 - IACS Architecture

Security Level	Definition	Description
1	Field Process Functions	Field devices
2	Basic Control and Safety Functions	PACO controllers and third-party controllers
3	Supervisory Control and Asset Management	OWS, EWS, AMS, IAMS, etc.
3.5	Common Service and Management Functions	Cyber security services, Interface with Supervisory System, i.e., HV SCADA

More detail is included in the preliminary control systems architecture [6] and telecoms architecture [5]. The MAC shall develop control architecture and network architecture diagrams with the necessary cybersecurity detail.

6.11. INSTRUMENTATION

Instrumentation on BLPH shall be 4-20mA Smart HART Revision 7. Any discrete contacts shall be line monitored to avoid single point of failure.

Foundation Fieldbus shall not be used on BLPH.

All devices shall be thoroughly investigated as to their suitability with their MAC control system. Equipment vendor packages shall be supplied with own standard instrumentation and as such interfacing and aligning with these vendors shall be required.

HART Revision 7 and wireless device diagnostic information shall be presented and be available on engineering / maintenance workstations.

All transmitters shall be NAMUR NE43 compliant for defining and differentiating when the process variable is within normal range, out of range but fault-free or when fault detection has occurred.

Instrument signals shall have segregated earthing for protective, reference and intrinsically safe.

Earthing in hazardous areas shall adhere to IEC 60079-14.

All instrumentation shall be loop powered 24VDC.

In general, any instrument that is part of the SIS including final elements (e.g., valves), shall, as a minimum, be certified for use in a Safety Integrity Level (SIL) 2 SIF with a minimum proof test interval of two (2) years (to be developed during HAZOP and LOPA exercise).

6.12. VALVE DIAGNOSTICS

Necessary PACO control system software shall be included to support advanced valve control, partial stroke testing and diagnostics for any safety critical on / off valves. These applications shall be identified by HAZOP and LOPA evaluations.

6.13. REDUNDANCY AND SPARES

Redundant and fault tolerant technology shall be incorporated in the design of the PACO. As a minimum, redundant configuration shall be provided for the following equipment:

- Central Processing Units;
- Input / Output Cards;
- Power supplies, including Input / Output Cards; and
- Communication hardware, including network switches.

Common mode failure points shall be avoided within the system design for all processing and communications.

Failure of any one component, i.e., hardware failure, software failure, power supply failure or the loss of one power feed in a dual feeder system, shall not interrupt functions of the system.

All redundant system components shall be hot-swappable. Installed and wired spare I/O shall be 10%. HAZOP study shall identify critical equipment and instrumentation for sparing. The design of the PACO shall include for an obsolescence management system.

6.14. COMMISSIONING

Selection of all equipment and instrumentation shall maximise the ability for pre-sail away commissioning activities. The UCPs shall be responsible for their own commissioning activities but MAC shall support compete dynamic commissioning of all systems.

6.15. PAGA

A Public Address and General Alarm (PAGA) system is not a requirement for BLPH. As detailed in section 7, all visitors to the BLPH platform shall have two-way radios. Emergency phones shall be located at muster stations to provide for necessary communications. General alarm functionality shall be provided by means of dedicated sounders and beacons which are part of the FGS. Manual call-points shall also be provided throughout the platform.

6.16. CCTV

Closed Circuit Television (CCTV) is not a requirement of BLPH as clarified by TQ-009.

6.17. AUTONOMY TIME FOR CCS AND SAFETY SYSTEM

The CCS and SIS related functions of the Safety System shall be provided with 30 minutes of Uninterruptible Power Supply (UPS) power, as defined by the project's Basis for Design [1].

The FGS related functions of the Safety System shall be provided with 8 hours of UPS power, as defined by the project's Basis for Design [1].

COMPANY shall advise if the autonomy times are to be optimized further (Hold - 3).

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7. TELECOMMUNICATIONS

The design of telecommunications on BLPH shall be carefully considered given the limitations in place with the number of available fibre optic cores. In consideration of the overall Internet Protocol (IP) based architecture of the Control and Safety Networks, it is envisaged that the Telecommunications System shall also be IP based with each individual system being allocated an individual IP sub-net and/or VLAN accordingly.

7.1. TELECOMS FIBRE OPTIC COMMUNICATION

There shall be four (4) off fibre optic cores provided for BLPH from OHVS (Hold - 5). Two (2) cores are reserved for Client/Server Network. The telecoms and floating solar farm communications shall be routed separately. Full details of the communications are included under section 6.5.1.

The complexities and overall limitations and concerns to overlapping the telecoms scope onto the CCN with all the CCS communication multiplexing shall be evaluated and advised by the MAC. Safety critical telecommunications equipment shall be provided in accordance with the facility safety case or documented demonstration of ALARP and meet the minimum functional requirements defined by COMPANY. Figure 4 provides clarity to this. The Telecoms Architecture Drawing [5] shall provide further detail.

7.2. PORTABLE AND EXPOSED ELECTRONIC DEVICES

All portable electronics devices and any electronics devices installed in unprotected areas subject to the marine environment and subject to any hydrogen gas, shall be designed to meet the requirements stated under section 4.

7.3. EMERGENCY TELECOMMUNICATIONS SYSTEMS

Emergency Telecommunications Systems shall be provided for in the following areas:

- Muster areas;
- Totally Enclosed Motor Propelled Survival Craft (TEMPSC) embarkation point; and
- Evacuation chute.

7.4. LIFE RAFTS

BLPH shall have two (2) life rafts and as such both life rafts shall be equipped in the same manner as TEMPSC. Each life raft shall be equipped with:

- Search And Rescue Transponder (SART), operating in the 9 GHz marine radar frequency band
- Emergency Position Indicating Radio Beacon (EPIRB) operating on the international satellite distress frequency of 406 MHz

Additionally, each life raft shall be equipped with a Marine Very High Frequency (VHF) Radio with Global Maritime Distress and Safety System (GMDSS).

7.5. MUSTER POINTS

Muster stations shall be included on BLPH with ruggedised Explosion Proof (Ex) telephones which are suited to external environmental conditions and requirements given in section 4.

7.6. TELECOMS FUNCTIONAL EQUIPMENT

The following shall be included as part of the Telecommunications scope for BLPH:

- IP (Internet Protocol) Telephone;
- Local Area Network (LAN) / Wide Area Network (WAN) network;
- Local Access Control System (LACS); and
- Intrusion Detection Control System (IDCS).

A VLAN shall be included for the LACS and IDCS.

7.7. TWO WAY RADIOS

UHF radio infrastructure is provided in the area by others, as provided by the response to TQ-009. Intention is for BLPH to operate off this infrastructure and to procure similar / compatible handheld devices. The telecoms specification [3] shall detail full requirements.

Where the existing UHF Radio is Trunked or Terrestrial Trunked Radio (TETRA), handset portable radios for BLPH platform shall be integrated into that radio system by the creation of a new user group specifically for BLPH platform.

7.8. SATELLITE TELEPHONE

As directed by the Engineering Basis for Design [1], any operations and maintenance teams visiting the platform shall carry satellite telephones, provided for by others.

7.9. SOLAS

Given that BLPH shall have life rafts and a Crew Transfer Vessel (CTV), emergency equipment on BLPH shall be designed to be compliant with Safety of Life at Sea (SOLAS) requirements.

Details of escape routes are available in Escape Route Philosophy and Life Raft Positioning [8].

7.10. AUTONOMY TIME FOR TELECOMMUNICATIONS EQUIPMENT

All telecommunications equipment shall be provided with 8 hours of UPS by the platform's inherent facilities [1].

COMPANY shall advise if the autonomy times are to be optimized further (Hold - 3).

APPENDIX A METEOROLOGICAL AND OCEANOGRAPHIC DATA

Figure 5 - Meteorological and Oceanographic Data (source: HKN2018 data @ (1979-2018) [1]

Description	Unit	Value
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	°C	-8.4 / 10.5 / 25.0
Atmospheric Pressure (nominal) – hourly @ +10m	mbar	1013.7
Specific Humidity (min/nom/max) – hourly @ +10m	x 10^{-3}	4.2/6.5/9.5
Wind Conditions		
Annual average wind speed (at 100 m)	m/s	9.56
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	m/s	33.1
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	m/s	41.0
Marine Conditions		
Sea Water Temperature (min/max)	°C	1.3 / 20.2
Average Sea Water Density	kg/m^3	1025
Highest Astronomical Tide (HAT)	m	2.2 (LAT)
Lowest Astronomical Tide (HAT)	m	0 (LAT)
Extreme High-Water Level for 50 -Year Recurrence Period	m	12.3 (LAT)
Extreme High-Water Level for 1-Year Recurrence Period	m	9.1 (LAT)
Extreme Low-Water Level for 1-Year Recurrence Period	m	-0.5 (LAT)
Extreme Low-Water Level for 50-Year Recurrence Period	m	-1.0 (LAT)

Figure 6 - Rain Fall (source: SGSI) [1]

Rain Fall [mm]													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Min	14.1	18.1	9.1	1.2	10.3	17.3	6.2	20.7	27.2	43.0	22.2	28.1	646.6
Mean	75.0	62.5	48.6	39.6	47.4	47.9	58.2	73.0	91.0	102.7	108.5	89.3	843.6
Max	143.2	119.4	106.4	79.8	92.7	117.9	160.7	154.7	178.6	188.7	179.3	138.1	1056.1