Base Load Power Hub (BLPH)

System Specification for Main Automation Contractor

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1. INTRODUCTION

1.1. PROJECT OVERVIEW

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

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

1.1.1. Project Location

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

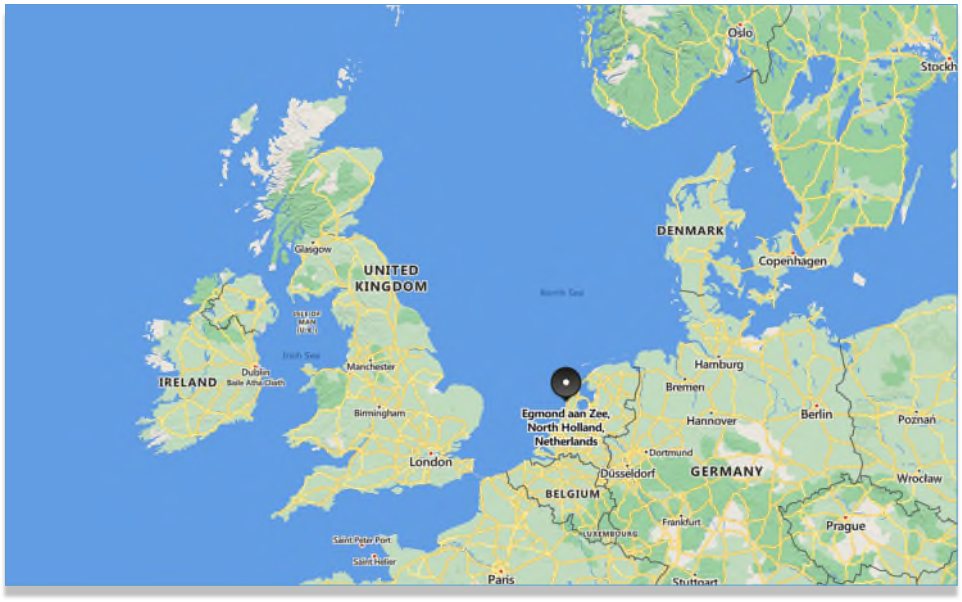


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



Figure 2 - Wind Park Details

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

1.1.2. Project Concept

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

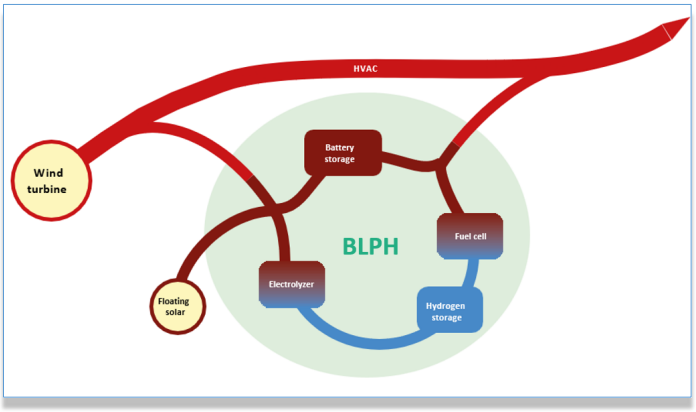


Figure 3 – BLPH Concept

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

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

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2. DOCUMENT SCOPE

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.

The design of the PAS Control System shall be:

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

2.1. REFERENCES

123A90-DDL-IN-RE-40093	1. Control System Philosophy
123A90-DDL-EL-SP-20141	2. Electrical System Description & Design Philosophy (Electrical Design Basis)
123A90-DDL-TL-SP-45007	3. Telecom System Philosophy & Specifications
123A90-DDL-IN-DD-40019	4. Data Network Architecture Drawings
123A90-DDL-IN-DD-40096	5. Control Systems Architecture Detailed Drawing
123A90-DDL-SAF-RE-30001	6. Fire Protection Philosophy
123A90-DDL-IN-CE-40000	7. Process Safety Cause & Effect Matrix
123A90-DDL-IN-CE-40002	8. Fire & Gas Cause & Effect Matrix
123A90-DDL-IN-DL-40012	9. Layout Drawings (Onshore CCR, Offshore ITER)
123A90-DDL-IN-SP-40098	10. Control System Specification
123A90-DDL-IN-SP-40100	11. Safety System (ESD, Fire and Gas)

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
EMCS	Electric Monitoring Control System
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
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
PAS	Process Automation, 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.
PCS	Process Control System
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 MACs responsibility to ensure complete compliance in their design, inclusive of all sub-suppliers. 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 as detailed in this specification.

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- Applicable 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 – Applicable DEPs

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 33.64.10.32	Electrical Network Monitoring and Control System for Global Application
DEP 37.76.10.10	HVAC for Offshore Installations (Amendments/Supplements to ISO 15138)

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.

The functional requirements of DEP 33.64.10.32 shall be adhered to by MAC to ensure safe and effective operation of all relevant electrical equipment.

DEP 37.76.10.10 and ISO 15138 shall apply for offshore equipment rooms, i.e., the ITER.

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
ISO 11801	Information technology — Generic cabling for customer premises
EN 61131	Programmable Controllers
IEC 60079	Installation & Maintenance of Electrical apparatus for use in Potential explosive atmosphere
IEC 60331	Fire resisting characteristics for electrical cables (all parts)
IEC 60332	Tests on electric cables under fire conditions
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
IEC 62682	Management of Alarm Systems for the Process Industries
ISO 15138	Petroleum and natural gas industries - Offshore production installations - Heating, ventilation and air-conditioning
ISO 14001	Environmental Management System
ISO 9001	Certifications of Quality Management System

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4. GENERAL OVERVIEW

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.

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).

Additionally, BLPH shall receive power from an external floating solar farm, by others.

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

- A Central Control System (CCS), consisting of PCS and EMCS; 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.

The wind farm system is operated by an independent control system called HV-SCADA, provided by others. The CCS and the Safety System shall operate independently but shall interface fully with the HV-SCADA system via the network infrastructure described in section 5.11.

The control system on BLPH shall:

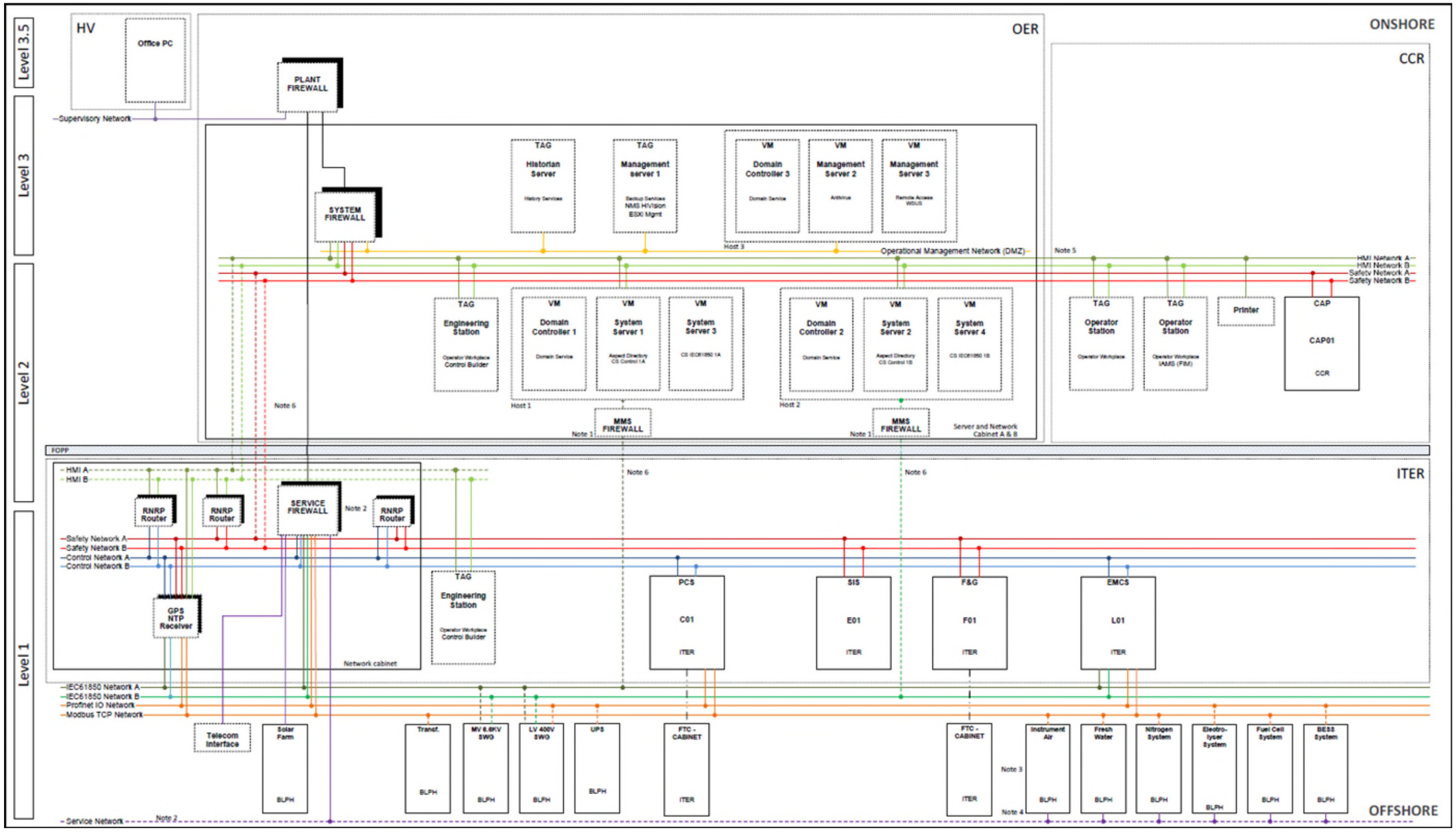
- Be suited for continuous operation given that hydrogen is a constant presence in normal operation;
- Operate as unmanned facility with minimal operator intervention only; and
- Be designed such that the planned maintenance schedules expected to be at six (6) month intervals.

There shall be no single point of failure of main element which could lead to an emergency shutdown or result in a loss of production.

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

A general description of BLPH, including the different equipment, is described in the draft topology diagram shown in Figure 4. Full details of the architecture are provided in the control architecture [5].

Figure 4 - Draft Network Topology



5. HARDWARE REQUIREMENTS

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

The PAS control system shall be based on the latest proven technology using MACs standard range of equipment and applications software. No hardware that is specially developed or specially modified shall be used for the BLPH project.

The number of different types of hardware that make up the PAS control system shall be minimised. This will help reduce the number of spare parts required. The MAC shall ensure that the equipment supplied for the different parts of the system comply with the requirements detailed in this specification.

PAS control system hardware design shall comply with following general rules:

- CCS and safety system elements shall be physically segregated on the network but have the ability to seamlessly exchange data peer to peer across the networks;
- Safety critical data exchanged between physically segregated logic solvers shall be via appropriately rated SIL data links;
- No PAS single control system or ancillary component (example power supply, communications) fault/failure shall affect the availability of the asset;
- System architecture shall be designed with sufficient redundancy to facilitate any future on-line system hardware and/or software upgrades;
- All control and safety system hardware that supports the processing of critical control; process trip functions; critical information and/or safety related information shall have fully redundant architecture with 'hot swap'/automatic change over capability; and
- 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 EMC directives 2014/30/EU.

5.1. OPERATING CONDITIONS

5.1.1. Internal Atmosphere

The PAS Control System shall be suitable for operation in the following normal (internal) environmental conditions:

- Temperature range: 15 to 25 ºC
- Relative humidity: 30 to 70% RH
- Control room(s) Noise Level: < 70dB
- Equipment room(s) Noise level: Noise emission from any source shall be less than 70dB.

The atmosphere within control and equipment rooms shall be filtered.

In the event of a failure of the HVAC system the conditions will be more severe. The equipment shall therefore be designed to operate under the following conditions:

- Design Temperature range: 5 to 45 ºC
- Design Relative Humidity : 10 to 93% RH

MAC shall clearly advise limitations of operating hardware in ITER outside of expected internal conditions.

5.1.2. External Atmosphere

The external atmosphere is 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, see section 8.

5.2. EXTERNAL LOCATIONS

All externally located equipment shall be suitable for long term exposure to the following environmental conditions:

- Temperature: -8.4 to 25 ºC
- Relative humidity: 64 to 93% RH
- Atmosphere: Saliferous

5.3. EQUIPMENT RATING

All equipment shall be suited or suitably protected to the following requirements for use in the North Sea, under the authority of the government of The Netherlands. As such, IEC regulations shall apply to the project in full.

5.3.1. Hazardous area classification

The platform will be located in areas that are classified as either hazardous or unclassified areas. As per Hazardous Area Certification Schedule [7], equipment located in areas classified as a Zone 2 hazardous area shall be certified suitable for operation in Zone 2 Group IIC T1, as a minimum by an approved certifying authority.

Equipment located in open non-hazardous areas shall also be classified suitable for operation in Zone 2 Group IIC T1, to allow interchangeability of equipment, instrumentation and minimise spares holding.

MAC may supply equipment or instrumentation suited for IIB +H2 in place of IIC.

All designs shall comply with IEC 60079.

Where equipment is certified with special conditions, MAC shall comply with these conditions both for equipment selection and design.

5.3.2. Ingress Protection Rating

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

All cabinets inside environmentally controlled rooms, e.g., control or equipment rooms, shall be rated for IP42, in accordance with IEC 60529.

5.4. FUNCTIONAL SYSTEMS

5.5. CCS

The CCS is responsible for the normal operations of BLPH, with an independent system to the elements of the Safety System.

The components that CCS is required to control are outlined in Figure 4, which including all process (power generation) systems, utilities systems, and electrical equipment on the platform. As agreed with operations, a single operator shall be required for both electrical and process systems on BLPH.

The CCS must also perform calculations to react appropriately to the changes from the HKN wind farm and floating solar farm, as per input from HV-SCADA. The environmental changes to the wind farm and floating solar farm will impact the operating modes that the CCS must control.

The CCS shall act independently of the safety system and shall not interfere with any of its functions.

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. This shall be developed into more detail by electrical engineering team and shall form part of the control narratives. BLPH shall plan its power output based on the forecast 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.

5.5.1. Electronic Power Systems

The CCS shall have supervisory control of the Motor Control Centre (MCC), transformers and the Switch Gear on BLPH. It therefore functions to not only control the electronic power systems on BLPH, but also the more conventional automation processes, i.e., power generation, as well as the utilities, see Figure 4.

The CCS shall be suited to function as the controller of the electronic power systems, including covering the required functional levels of an electrical network monitoring and control system. BLPH does not utilise an independent electrical network monitoring and control system, as all required functionality is to be covered in the CCS.

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

The CCS, via the Switch Gear, shall control the different equipment on-board the platform via the circuit breaker.

The CCS shall be designed such that rapid cycling / quick switching of the BESS, Fuel Cell and Electrolyser is minimised to prevent damage to these systems. This shall be a collaborative effort with the package vendors.

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 CCS controllers shall comply with IEC61311.

5.5.2. Performance Requirements

The CCS shall be suited to dealing with the functional requirements of controlling all the electronic power systems on BLPH. The applicable requirements of the different systems shall be described by the electrical

control narratives to be provided by the EPCI contractor. This includes but is not limited to software functions, management of Generic Object-Oriented Substation Event (GOOSE), load shedding, calculations etc.

The type of equipment, including but not limited to controllers, shall be suited to electronic power systems and further shall have proven experienced of controlling such equipment.

The functional requirements of DEP 33.64.10.32 shall be adhered to by MAC to ensure safe and effective operation of all relevant electrical equipment.

As per the requirements of DEP 33.64.10.32, the CCS shall be designed to perform event time stamping at 1 ms. However, given the nature of the plant, load shedding and upset conditions are not expected to be as prominent as in traditional hydrocarbon plants with turbine compressors and generators. As such, data recording at 1 ms may prove to be excessive, i.e., recording of uneventful events. Therefore, the response of the system shall be rationalised for the upset conditions that are identified by EPCI contractor through HAZOP and SAFOP studies.

As BLPH receives external power to the platform, then this power being tripped is the most significant upset condition the plant. In the event of an upset condition, load shedding commands to participating circuit breakers shall be initiated within 40 ms, to allow the circuit breakers operate within 100 ms. The MAC, including but not limited to controllers, shall be designed to suit this requirement.

Note: the complete loss, i.e., failure, of communications from BLPH to the CCR would also include the process historian.

The CCS shall interface with the BESS, Fuel Cell and Electrolyser in accordance with IEC 61850 communications protocol.

The different operating modes are included in the Electrical System Description & Design Philosophy [2].

5.5.3. Process and Utility Automation

The CCS shall also be responsible for controlling, monitoring and / or supervising the process and utilities within the desired operating conditions.

The operator will monitor and control the facilities through the operator workstation displays. The operation of the CCS shall not be affected by the failure of the operator HMI or the communications systems. All systems shall continue to monitor, control and display safety related functions via normal operator workstations and the CAP.

UCP controlled vendor packages, i.e., inclusive vendors own PLC systems, will be directly controlled by those UCP with the CCS acting in supervisory mode. The packaged equipment operation and status shall be monitored by the CCS via IEC61158 (full details of communications are included in section 5.11). The CCS shall automatically request status information or initiate a start or stop command depending on the process control narratives (by EPCI contractor). All safety critical functions shall be hardwired from the vendor UCP to the Safety System.

The control narratives for the UCP vendor packages shall be provided by the respective vendors.

Alternatively, there shall conventional hardwired system on BLPH directly monitored and controlled by the CCS as shown in Figure 4.

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

All functional processing equipment of the Safety System shall be located in the ITER with the exception of any equipment required for a hardwired/soft Critical Action Panel (CAP) located in the onshore control room – see section 5.6.3.

All SIS and FGS elements shall communicate as direct point-to-point control using the 4-20mA Smart HART revision 7 protocol. This includes hardwired signals to Vendor packages with UCPs and electronic power systems.

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

All functions of the SIS and FGS shall be automatic in line with the Cause-and-Effect Diagrams which shall be developed by EPCI contractor.

5.6.1. 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.

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.

The SIS shall be based on programmable equipment and shall meet the requirements of IEC 61511 and be certified to use in SIL3 applications by an organisation accredited by national accreditation authority to certify safety products as per IEC 61508.

The systems shall, detect process and utility upset conditions and react to these upsets; by initiating shutdowns and isolations as required to safeguard personnel and protect equipment. The systems shall be designed to minimise the impact of shutdowns on unrelated equipment and reduce the risk of spurious shutdowns and isolations.

Field mounted transmitters monitor the process and utility conditions. The preferred method for sensing process upsets shall be to use analogue transmitters. The trip points shall be set in the software of the SIS.

Equipment that is used as the normal method for process control shall not be used as the means to detect process upsets and cause process shutdowns. Separate transmitters, switches, solenoid valves and isolators will be used to initiate shutdowns.

In the event of a process upset that cannot be brought under control, either automatically or with operator intervention, a field installed device will be capable of initiating a shutdown via the SIS. When a confirmed gas leakage or fire is detected, the SIS shall isolate the plant and stop production by:

- Isolating sources of hydrogen feed to the process containing hydrogen inventories; and
- Under certain circumstances, as per cause and effect, reduce hydrogen gas inventories by depressurising to vent.

The operator shall have a number of manually operated devices available to initiate various levels of shutdown. In addition, Start-Up Bypass Control and output logic Reset shall be provided.

CAP shall provide executive action push buttons or similar and trip status information.

The SIS shall be a programmable safety system. The system shall incorporate the following features:

- Duplicated central processors;
- Duplicated Input/Output modules;
- Support of "single fault tolerant" communication networks;
- On-line modification facility for software upgrades.

The function performed by the system must be independent from the actions of other systems and not be detrimentally affected by failures in operation of other control systems.

This data exchange shall provide the necessary information between the logic relating to their actions and also allow action in response to fire and gas hazards.

The system outputs that result in the shutdown of UPS battery will be designed as "energise to trip" SIS outputs; these outputs will be line monitored. All other SIS system outputs shall be designed as a failsafe system such that they are deactivated on trip. This implies that in the non-alarm state, closed input sensor switches are healthy.

All SIS alarms must be acknowledged at the CCR. Initiation, acceptance and clearance of alarms shall be logged by the Alarm Management System. All inputs to the SIS and all output actions and all operator actions shall be displayed on the operator workstation.

5.6.2. 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 and shutdown levels shall be defined 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 [6].

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.

Addressable type fire and gas equipment shall not be used on BLPH.

Fire and Gas devices shall be routed back to the BLPH Safety System to ensure that devices remain operational upon gas detection. This allows the operator to have visibility during any loss of containment issues.

Inputs and outputs shall be hardwired directly to/from the system I/O modules. The I/O cards shall provide the features required for the FGS I/O interfaces. EPCI contractor shall work with MAC to fully demonstrate interface capabilities with selected detectors at an early stage in the project. These confidence tests shall cover hardware interfacing and software.

FGS field circuits shall be continuously monitored by the F&G system for fault conditions, (open and short circuit faults). Generally, the FGS inputs and outputs shall not be fail-safe type circuits but shall be normally de-energised. All normally de-energised signals shall be line monitored. Final details concerning signal types will be finalised during Detailed Design.

Analogue inputs and outputs shall be monitored for a valid signal state, alarm state and fault state. A failure or out of range signal from the field transmitter shall be alarmed to the operator.

Hardwired connections only shall be used to transfer operator control room manual executive actions for extinguishant releases and ventilation shutdowns to the relevant field devices.

5.6.3. Critical Action Panel

A CAP shall be developed implementing dedicated video pages on HMI. The ability to partially shut down some of the process units shall be considered. The CAP contains the SIS and FGS functions for emergency operator actions.

5.7. RELIABILITY, AVAILABILITY AND MAINTENANCE

The maintenance cycle of this two (2) year project is expected to every six (6) months with the facility remaining unmanned otherwise. All equipment shall be designed such that no maintenance shall be required between visits. All software / electronic modifications shall be available to operations remotely, i.e., at CCR or onshore equipment room, via the engineering workstation.

The facility must contractually export power to the grid system. Even when the platform is not exporting power, the electrolyser can still produce hydrogen and platform can still be storing hydrogen, both of which must be continuously monitored and controlled by the CCS and Safety System. As such, the availability of all components of the PAS control system must satisfy these criteria at a minimum. The MAC shall clearly stipulate any predicted downtime during the two (2) life of the facility and highlight any potential areas for concern to the project for discussion and resolution.

The consequences of the facility needing to depressurise to vent requires significant time for re-purging of the hydrogen storage vessels, possibly affecting the export requirement. As such, the reliability of the PAS control system must be designed to better this. No single point of failure, including but not limited to spurious alarms and trips, networking functions, etc., shall be permitted.

The CCS, SIS and FGS shall be designed to provide necessary levels of reliability and availability with minimised maintenance to meet these criteria. All bids are expected to address these expectations with MAC design targets.

5.8. PAS CONTROL SYSTEM CABINETS AND EQUIPMENT ROOMS

The Instrument and Telecoms Equipment Room (ITER) shall be located on the BLPH platform and house the CCS, the elements of the Safety System and the EWS along with any associated servers / cabinets required to operate the facility.

The PAS(Control and Safety Systems) will be installed inside the ITER. ITER is housed inside a shipping container supplied by OTHER. Ref to Layout Drawings (Onshore CCR, Offshore ITER) [9]

The container shall include an integrated HVAC, fire dampers, smoke detectors and gas detectors along with manual alarm call points wired into the SIS. The design of the HVAC system shall comply with DEP 37.76.10.10. ISO 15138, which DEP 37.76.10.10 is based on, shall also.

The electronic equipment shall be mounted in free-standing, standard cabinets, painted to manufacturers standard finish and colour suited to conditions in the North Sea as detailed in section 5.1.

ITER floor shall suited to hold cabinets, which may exceed 25kg in weight.

Cabinets should all be front entry and mounted against back wall. The dimensions of the cabinets should be 800mm deep, 806mm wide and include split front doors for controller and I/O Cabinets and 800mm deep, 800mm wide and include split front doors for S800 I/O Cabinets. However, the server and telecoms cabinets should be 1000mm deep, 800mm wide and again mounted against a back wall.

UCPs for BESS, Fuel Cell and Electrolyser shall be included in vendors packaged skids and as such there are no specific cabinets required in the ITER for these. The electrical rooms shall house the necessary equipment for the Switch Gear, MCC and transformers and as such no dedicated cabinets are located in the ITER for these. The remaining UCPs, listed below, are installed in field.

- Fresh Water
- Instrument Air
- Nitrogen

A preliminary layout is shown below:

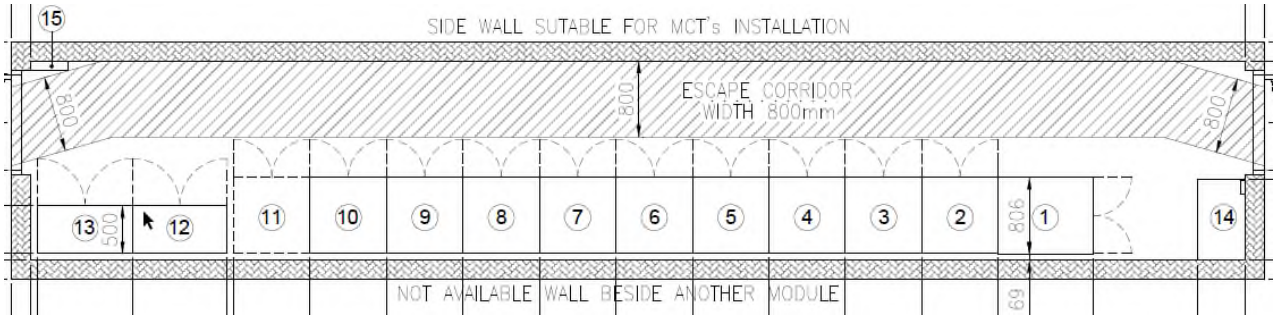


Figure 5 - ITER Preliminary layout

Access points should be permitted at either end of container, HVAC unit at one end only and other end functioning as equipment access only.

Separate termination areas and trunking shall be provided for AC supplies, DC supplies, IS circuits and communication circuits.

Cables shall enter the ITER from the top and drop down into the cabinets via suitable gland plates into the container. The MAC shall produce gland plate loading density calculations for marshalling and system cabinets. MAC shall ensure IP42 (minimum) is maintained.

5.9. POWER SUPPLIES

An Uninterruptible Power Supply (UPS) system shall feed the PAS cabinets in ITER, by others. MAC shall provide a load list with detailed power consumption data for the sizing of the UPS systems. The load list shall provide switch on in-rush current, normal load, quiescent load, maximum load, and crest factor for each electrical consumer. The final format of the load list shall be agreed with the Project. Additionally, MAC shall provide for the heat dissipation loads.

The UPS power supply PAS control system will be 230V, 50 Hz, TN-S – 1ph+N+PE.

The 24 Vdc power for field instruments shall be provided by "n+1" redundant power supplies in the marshalling cabinets receiving AC power from the power distribution system. The 24 Vdc nominal supply voltage value shall be adjustable up to 28 Vdc to suit the field equipment requirements where extended transmission distances are anticipated.

The power supply cables within cabinets shall be provided by the MAC. All cabling going to/from different rooms shall be responsibility of EPCI contractor.

Inadvertent trips (e.g., during commissioning) may occur, leading to abrupt server shutdowns and subsequent server power-up. MAC to confirm this will not lead to re-booting/initialisation problems affecting the availability of the PAS control system. It shall be possible to shutdown servers and workstations automatically based on defined events from the SIS to allow planned shutdown prior to total loss of UPS power.

5.9.1. Power Distribution

Power Distribution shall be completed through two separate supply lines to each system cabinet, UPS-A and UPS-B. Each system cabinet has an internal main isolator for the incoming UPS backed mains supply cable, internal distribution busbars and 2 pole MCBs for the outgoing single-phase mains supplies to the various users/utilities. All MCBs include an alarm contact wired to provide trip signalling to HMI

5.9.2. Marshalling and System Cabinets

Each of the cabinets shall be powered by two independent 230 Vac single-phase UPS backed mains supplies, supplied from the power distribution cabinets. Each cabinet also requires a 230 Vac utility supply (wired as a ring main) for the cabinet internal RCD mains socket. The cabinets have internal main isolators for each incoming UPS backed mains supply and independent mains distribution MCBs supplying the internal mains powered devices:

- 24 Vdc Power Supply Units;
- Cabinet ventilation fans;
- Cabinet internal lights.

Each of these devices are duplicated and powered from the separate mains supplies to provide redundancy.

There shall be no three-phase power entering any of the PAS cabinets.

System cabinets shall include for:

- Servers;
- Workstations;
- Network Switches;
- Rack mount monitor;
- 24 Vdc PSU;
- Cabinet ventilation fans;
- Cabinet internal lights.

An Auto Transfer Switch (ATS) will be installed to provide redundant power to mains powered equipment which only has a single mains input (e.g., Thin Clients and network switches).

5.9.3. DC Power

The control system cabinets and any other cabinet internal equipment generally require 24 Vdc supplies. Where appropriate, each PAS Control System cabinet will incorporate redundant DC power supply units as required. These will be configured to maintain the 24 Vdc distribution even in the event of failure of a single DC PSU or failure of an incoming mains supply.

For discrete output circuits only, the 24Vdc distribution will comprise of suitably rated quick blow fuses.

5.10. EARTH SYSTEMS

The PAS control systems shall be provided with earth bars as required, for connection to the facility earth system. The PAS control system earth systems shall include clearly identified:

- Protective Earth;
- Clean Earth; and
- Intrinsically Safe Earth.

Field cable armour will be glanded (by others) at the termination cabinet gland plates and connected to the cabinet protective earth. Field cable screens will generally be earthed only at the termination cabinet end. The individual cable screen earthing shall be via an earth terminal.

Cable screens for Intrinsically Safe (IS) and Non-Intrinsically Safe (NIS) signals shall be terminated separately with intrinsically safe earth for IS signals and reference earth for NIS.

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

5.11. NETWORKING INFRASTRUCTURE AND COMMUNICATIONS

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.

The MAC shall be responsible for the design of all end-to-end communications between the platform and the CCR, ensuring that communications are maintained so as not to impede operations. This includes ensuring that suitable systems are in place for any transmission of data over public infrastructure.

The CCN and SN is comprised of a fully redundant ethernet network including all necessary equipment. The networks shall operate on IEC61158 communication protocol over CAT6A cables with RJ45 connectors. This includes automatic switchover of communications to the backup network to maintain a 100% communications uptime on the CCN and SN. MAC shall ensure all transmission distances stay within 100m ethernet technology limitation. MAC shall ensure that the design of the network infrastructure maximises the data rate of transmission.

5.11.1. Fibre Optic Infrastructure

BLPH shall operate as an unmanned facility connected to a remote Central Control Room (CCR) via a Fibre Optic (FO). This 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 tunneled connection to the remote CCR and for interfacing with HV-SCADA.

For PAS communications there are four (4) FO cores shall be provided by COMPANY via the Inter Array Cable to permit communications from BLPH platform back to CCR. This allows for two (2) FO cores dedicated to the CCN, and a further two (2) FO cores dedicated to the SN.

5.11.2. 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 PAS 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 PAS communications with two (2) FO cores dedicated to the CCN, and a further two (2) FO cores dedicated to the SN.

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

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

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

5.11.3. Communications and Signals

Signals from the field mounted instrumentation and packages will be interfaced to the PAS control system by different methods.

Table 6 - Interface Schedule

Description	UCP Vendor Package	Electrical Protocol (IEC 61850)	Instrument Protocol (IEC 61158)	Hardwired CCS (4-20mA HART rev 7)	Hardwired Safety System (4-20mA HART rev 7)
Switchgear	N/A - Electrical	Yes	No	No	Yes
MCC	N/A - Electrical	Yes	No	No	Yes
Transformer	N/A - Electrical	Yes	No	No	Yes
BESS	Yes	No	Yes	No	Yes
Fuel Cell	Yes	No	Yes	No	Yes
Electrolyser	Yes	No	Yes	No	Yes
Hydrogen Vessels	No	No	No	Yes	Yes
Fresh Water Package(s)	Yes	No	Yes	No	Yes
Instrument Air	Yes	No	Yes	No	Yes
Nitrogen	Yes	No	Yes	No	Yes
Sea Water	No	No	No	Yes	Yes
De-Mineralised Water	No	No	No	Yes	Yes
Wastewater	No	No	No	Yes	Yes

Field mounted instrumentation shall be hardwired back to the marshalling cabinets and via junction boxes. The communication protocol shall be 4-20mA HART revision 7 for CCS and the elements of the Safety System.

HART interface for all hardwired smart transmitters including shutdown systems. HART interface at the PAS control system end shall be direct through I/O cards i.e., without needing additional HART couplers or multiplexers.

Interface with vendor package control systems is preferably Profinet (or Modbus TCP/IP).

The control and safety systems must be based on equipment that is of high reliability and arranged to avoid a loss of control or shutdown due to a single failure.

There shall no fieldbus on BLPH.

There shall be no wireless communications on BLPH, including Wireless Local Area Network (WLAN) or Bluetooth.

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.

5.11.4. Signal Budget

Based on the Piping and Instrument Diagrams (P&IDs); the following is the provisional I/O estimate for the project.

Table 7 - Signal Budget

CCS			
AI	**AO**	**DI**	**DO**
66	49	40	0
SIS			
AI	**AO**	**DI**	**DO**
13	0	25	23
FGS			
AI	**AO**	**DI**	**DO**
16	0	12	16

The above does not include anything not on P&IDs and assumes all non-SIS interfaces with packages/pumps is by Modbus only.

The above also does not include for motor signals which are expected to be on the Modbus connection.

MAC shall ensure that installed and wired spare I/O is 10%, which shall be over and above the signal budget.

5.11.5. 66kV Switchgear on BLPH

The CCS shall receive status information from HV-SCADA on the 66kV breaker switches.

5.11.6. 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. HV-SCADA shall have control of floating solar farm via a dedicated VLAN over the CCN.

5.11.7. Backup Communications

Due to the prototype nature of the project, there shall be no backup communications for BLPH. This will align BLPH with the philosophy taken by CrossWind. Upon the loss of communications, a watchdog timer shall be initiated (see section 6.10).

5.12. INTEGRITY AND DIAGNOSTICS

The facility for on-line testing, maintenance, calibration and repair shall be designed into the system for both software and hardware. There shall also be the facility to monitor all components of input and output signal circuitry and generate a specific fault signal at the operator workstation in the event of any malfunctions.

All diagnostics shall be reported back to the CCS for evaluation by operations team.

The CCS shall include on-line and off-line diagnostic aids to assist in system maintenance and troubleshooting. Routine and breakdown maintenance procedures shall be available electronically. Diagnostics must be provided for each major system component and peripheral. The diagnostics shall not interfere with the normal system operation. Faults shall be alarmed and displayed at the operator workstations.

In the event of CCS primary network degradation full view of process and control functionality shall be maintained by providing bump-less transition to standby equipment without any loss of network uptime. Key telecommunications fault indications identifying the faulty unit shall be presented to the operator via the HMI.

5.13. RADIO FREQUENCY AND ELECTROMAGNETIC INTERFERENCE

The PAS control system shall be designed to prevent the emission of, and susceptibility to, Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI), and therefore shall not be unduly affected by the emissions of nearby equipment. Emissions shall not initiate unpredictable or undesirable actions/responses, measurement errors, communications faults etc.

The application of RFI/EMI protection components or configurations such as filtering, shielding, minimal physical discontinuities and bonding shall be employed. This includes unit construction and packaging to enable easy serviceability and ensure the integrity of RFI/EMI features are not degraded during normal maintenance conditions.

5.14. NETWORK TIME SERVER

The MAC shall provide for a Network Time Server and hence the PAS 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, SIS, FGS and all telecoms equipment.

5.15. 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 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.

5.16. VALVE DIAGNOSTICS

Necessary PAS 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 LOPA exercises.

5.17. REDUNDANCY AND SPARES

Redundant and fault tolerant technology shall be incorporated in the design of the PAS. 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 PAS shall include for an obsolescence management system.

5.18. PAGA

A Public Address and General Alarm (PAGA) system is not a requirement for BLPH. 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.

5.19. AUTONOMY TIME FOR CCS AND SAFETY SYSTEM

Autonomy time for the CCS and SIS equipment shall be 30 minutes. Autonomy time for the FGS shall be 8 hours. Where there is an overlap of SIS and FGS, the SIS shall be supplied with 8 hours in-line with FGS.

5.20. OPERATOR TRAINING SIMULATOR

For the CCS to handle both process and electrical equipment as described in section 5.5, the MAC shall include for Operator Training Simulators inclusive of any necessary hardware and software ahead of the project's implementation in 2025.

5.21. 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. SOFTWARE REQUIREMENTS

The PAS Control System shall be self-diagnosing and shall provide the engineer with accurate information about system faults. The system shall have embedded system health monitoring tools to monitor communication loading, memory use, Central Processing Unit (CPU) loading etc. The PAS Control system shall be capable to remotely perform any functional modifications of the CCS, FGS and SIS, via the EWS. This includes software updates, operating system patching, anti-virus.

6.1. OPERATING SYSTEM

The PAS Control System shall utilise an open system environment. A universally acceptable (rather than proprietary) operating system shall be used for the operator interface. This will minimise the interfacing efforts and facilitate the use of application packages. The above operating system shall have a proven track record with the CONTRACTOR. The CONTRACTOR shall also provide details of the proprietary operating system for the programmable control equipment.

All components of the PAS Control System shall comply with IEC 62243.

6.2. SOFTWARE STRUCTURE, ANNOTATION AND CONTROL

The PAS Control System software shall be developed using a structured and consistent approach in compliance with the applicable standards.

PAS Control System shall be self-documenting, providing revision, version, approval control and ability to reload any previous configuration files (i.e., return to a known safe configuration state). All changes shall be accurately recorded with provision for appropriate authorisation and auditing of modification. CONTRACTOR shall also provide details of all the version control methods used in the PAS Control System.

All software logic, function blocks, fault tables etc. shall be accessible from an engineering workstation. It must be possible to add, delete, change or reconfigure data base points “online” without affecting system operation.

6.3. TAG NUMBERS AND SERVICE DESCRIPTOR

PAS Control System equipment tagging is to be jointly developed by the EPCI contractor and the MAC.

6.4. CCS

The CCS shall:

- Maintain the process within the desired operating conditions;
- Provide facilities for alarm and event logging, trending and historical data storage;
- Perform low criticality sequencing functions; and
- Interface to process and utility packages, see Figure 4.

Software systems shall:

- Comply with IEC 61131 to allow control function / sequence programming in ladder logic (graphical), function block diagram (graphical “drag drop connect”), structured text (textual) and/or instruction list (textual).

- Have ability to "bulk build" example auto configuration from instrument relational database like SPI.

6.5. SAFETY SYSTEM

The SIS and FGS monitors the process and utility systems and initiate shutdowns and isolations as a result of a process or utility upset, manual shutdown requests, or with exchange of signals between the SIS and FGS.

The Safety system shall perform the following functions:

- SIS / FGS signal processing including scaling, ranging, alarming, voting, etc.;
- Standard set of logic, timer, and function blocks to allow configuration of SIS / FGS cause and effect logic;
- SIS / FGS sequencing logic;
- SIS / FGS special application logic;
- SIS / FGS input inhibit logic;
- FGS interface logic;
- CAP logic;
- Start-up logic;
- Complex input voting systems, with input deviation monitoring and appropriate alarm generation provided;
- Timer driven logic;
- Maintenance inhibits, with only one input to any voted system being allowed to be overridden at any one time (maintenance overrides shall not be provided on output devices);
- Output resets;
- De-Energise to trip (default for SIS); and
- (Where required) any energise to trip SIS / FGS field circuits shall be continuously line monitored by the system for fault conditions, i.e., device faults, open and short circuit faults, etc.

Logic operations shall be viewable in real time (via OWS/EWS) for operational and engineering purposes.

The SIS / FGS shall have ability to create "first up fault" alarms that allow control room operator to quickly interrogate trips through HMI with one keystroke.

For commissioning purposes, an ability to apply logic gate input and output forces shall be provided subject to correct access levels defined during detail design.

Additional access levels shall be provided to restrict modification of SIS / FGS software as distinct from the CCS.

All SIS / FGS analogue and digital data shall be displayed at the operator workstation displays.

Each SIS / FGS input shall have the facility for a maintenance inhibit to enable testing without causing a shutdown. The inhibits shall be selected and applied through the operator workstation displays. The inhibit shall only become active when the CAP is enabled. The inhibit state shall be indicated on the SIS / FGS graphic displays. Input inhibits shall only affect SIS / FGS logic, not input alarming, i.e., inhibited inputs shall alarm to the Operator.

Start-up overrides shall be provided for selected inputs. The start-up overrides shall normally be automatic reset type. Some services will require manual start up overrides. Failure of a start-up override to reset shall be alarmed to the operator.

The SIS / FGS shall also provide any safety-related control or sequencing logic, e.g., partial closure test.

Critical loops shall be provided with special logic that shall be able to identify straight line traces or transmitters that deviate away from other voted transmitters, or the CCS measured value.

The activation of a shutdown level will normally result in the initiation of the lower category shutdown levels.

The number and sub-division of shutdown levels and descriptors for these levels will be finalized.

Shutdown trip settings shall be set and adjusted through the OWS but shall be password protected.

It shall be possible to change the logic of the system online without shutting the system down (with appropriate access levels).

6.6. SEQUENCE OF EVENTS RECORDING

The PAS Control System shall include a Sequence of Events Recorder (SOER) capability. Change of states of digital signals, whether generated in the field or within the control system shall be date and time stamped at the point of entry to the PAS Control System.

The SER facility shall also include event data received from vendor packaged equipment. The SER facility shall include 'first up' alarm trapping logic that will enable the operators to easily identify the cause of a trip.

Event resolution for the SIS / FGS will depend upon the scan time of the logic solvers and shall meet the requirements in section 5.5.2. The time stamp accuracy between the logic solvers and the time sync server shall be within 1ms.

Event resolution for the CCS shall be dependent on the requirements of the BESS, Fuel Cell and Electrolyser but can be set at a reduced rate for slower acting control loops e.g., an utility application where no safety critical functions are required. This includes the time stamp accuracy between the controller and the time sync server.

To cater for SOER communication failure, at least two hundred (200) events shall also be buffered in the SIS and the FGS. SOER logs shall be viewed and interrogated via the operator workstation. The vendor shall advise any limitations that will affect the time tagging of signals.

The signals to be recorded shall include:

- CCS alarms and change of states;
- FGS alarms, shutdowns and change of states;

- SIS alarms, shutdowns and change of states; and
- Inhibits, overrides, resets, software forces being applied or removed.

6.7. 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.

For the overall integrity and safe operation of the power grid, CrossWind HV-SCADA would have certain supervisory and emergency control communication with BLPH. They include signals for normal operation, non-time-sensitive emergency signals and time-sensitive emergency signals (via OPC-UA interface(s). At this stage, ESDs from BLPH to CrossWind have not been specified yet, but these shall be secured by CONTRACTOR.

The total estimated signals from CrossWind are in this phase:

Table 8 - CrossWind Estimated Signals

Description	# I/O's
For Normal Operator Action	22
For Emergency Action - not time-sensitive	10
For Emergency Action - time-sensitive	0, but might be increased to 4
time-sensitive action - redundant signals.	0
Total I/O (initial estimate)	36

The BLPH-HMI graphics and historian server shall include the signals from CrossWind.

6.8. ENHANCED PERFORMANCE SYSTEMS

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

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

These systems shall not be located on BLPH (in the ITER) but in an onshore equipment room. The CCS, SIS and FGS shall interface with the above systems.

Where FO communications are lost or interrupted, the PACO control systems in the ITER shall have capability to store event data, temporarily, that would otherwise proceed to the above systems or to a Sequence of Events Recorder, for the duration of the autonomy times (as listed in section 5.19).

The equipment shall operate over the Management 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.

6.8.1. Instrument Asset Management System

An Instrument Asset Management System (IAMS) covering instrumentation and final elements 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.

6.8.2. 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;
- PAS 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.

6.8.3. 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.

6.8.4. Condition Monitoring

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

6.9. WORKSTATION INTERFACES

The facility shall be remotely operated via an OWS at a location to be confirmed by COMPANY. An EWS, in the form of a cabinet mounted computer shall be included in the ITER. An additional EWS may be provided in the onshore equipment room depending on the MAC feedback.

The EWS shall operate over the Client/ server Network such that all maintenance, monitoring, and controllable elements shall be fully accessible.

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. The design of the OWS shall be based on the thin client philosophy. 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 PAS 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).

6.10. WATCHDOG SYSTEM

BLPH shall employ a watchdog system. Upon the loss of FO optic communications, the Watchdog system shall initiate a predetermined response to drive the facility to a safe state.

7. 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 PAS 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 Demilitarised-Zone (DMZ) or a unidirectional security gateway that restricts communications to authorised 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 authorised user. Remote access to the SIS engineering workstation and the asset management system, if managing SIS assets, shall be restricted to authorised 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 9 - IACS Architecture

Security Level	EC 61443-1-1	Description
0	Process	Field instruments and devices that directly measure or controls the process.
1	Local or Basic Control	PACO controllers and third-party controllers, I/O, and Fieldbus communication.
2	Supervisory Control	OWS, EWS, AMS, IAMS, etc.
3	Operations management	Devices that add functionality but are not critical to the operation of the facility.
3.5	Enterprise systems	Customers local IT structure with office computers and other business-related systems. Cyber security services,

		Interface with Supervisory System, i.e., HVSCADA

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

8. METEOROLOGICAL AND OCEANOGRAPHIC DATA

Figure 6 - 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 7 - 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

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