Base Load Power Hub (BLPH)

Safety Critical Task Analysis Terms of Reference

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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.

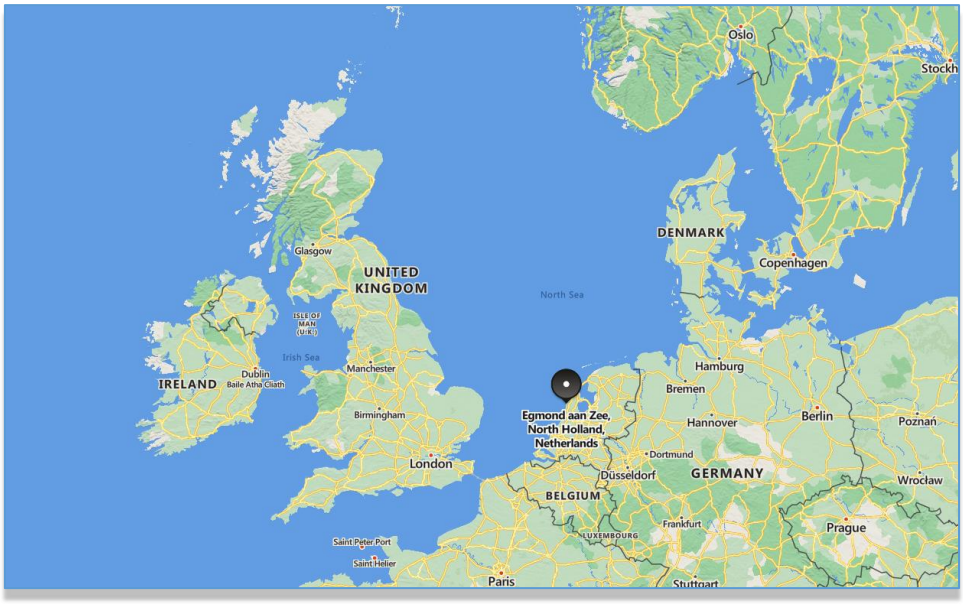


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

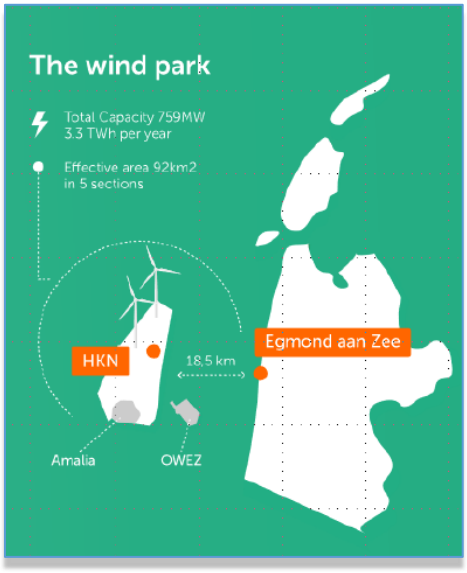


Figure 2 - Wind Park Details

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.

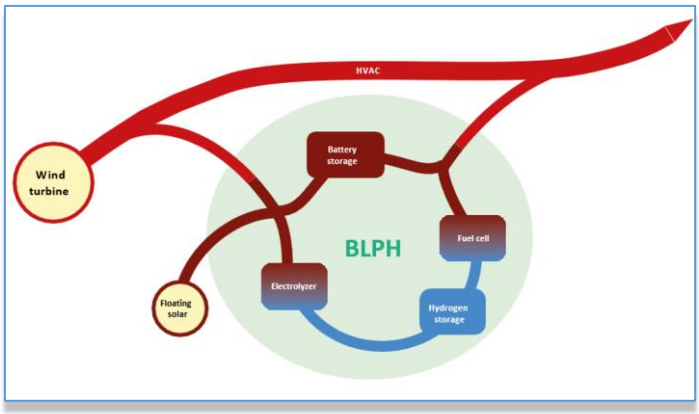


Figure 3 – BLPH Concept

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.

2 DOCUMENT SCOPE

This document has the purpose of detailing the methodology to be applied for the SCTA (safety critical task analysis) study in the scope of BLPH project.

2.1 MAIN REFERENCES

Ref.	Description
1	Human factors engineering in projects, IOGP Report No. 454, 2020
2	EU Framework Directive: Council Directive of 12 June 1989 on the introduction of measures to encourage improvement in the safety of workers at work
3	Guidance on human factors safety critical task analysis, Energy Institute 2020
4	ICARO Guideline, 2017 - "Specification for Human Factor Engineering in projects"
5	3D model of platform / layouts
6	123A90-DDL-PR-RE-80040 – Process Design Philosophy
7	123A90-DDL-SAF-RE-30046 – HSE Design Philosophy

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

2.2.1 Definitions

COMPANY or Client (CPY):	Crosswind
EPC CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
RISK	Combination of frequency and consequence of scenarios.
MAJOR ACCIDENT	An occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation leading to serious danger to human health or the environment

Table 2 - Definitions

2.2.2 Abbreviations

ALARP	As Low As Reasonably Practicable
HKN	Hollandse Kust Noord
HFE	Human Factor Engineering
HSE	Health, Safety and Environment
IOGP	International Association of Oil & Gas Producers
MAH	Major accident hazard
PIF	Performance influencing factors
SCT	Safety Critical Task
SCTA	Safety Critical Task Analysis
SECE	Safety and Environmental Critical Element
TOR	Terms of Reference

Table 3 – Abbreviations

3 METHODOLOGY

Task analysis can be simply defined as the study of what a person is required to do, in terms of actions and mental processes, to achieve a goal. It involves describing how a task is done, often through a series of smaller subtasks.

For each sub task performed during maintenance, SCTA analysis will assess possible causes of operator error and expected consequences, in terms of safety for operators and assets, in order to identify the tasks that might lead to major accident. For such task, available safeguards in order to avoiding risk from human failure or to mitigate the effect of the scenario will be listed. If the team agrees that additional safeguards will be required, a dedicate recommendation will be issued.

SCT is a task where human factors could cause, or contribute to, a major accident or fail to reduce the effect of one, including during:

- operational tasks;
- prevention and detection;
- control and mitigation, and
- emergency response.

This definition implies that maintenance activities performed on all SECEs are SCTs.

SCTA analysis can be done in many different ways. The methodology described below was developed on the basis of the information contained in the "Guidance on human factors safety critical task analysis" and on the basis of ICARO experience in risk assessment. Considering the phase of the project, and the limited availability of information regarding maintenance activity, a simplified approach will be followed.

Considering that the platform is unmanned and normal operations which requires operator intervention are not foreseen, the expected people presence is due only for planned maintenance activities (2 days/year, 8 hour per days as for project philosophy).

On the basis of project philosophy, during maintenance activity is not foreseen the depressurization of the storage vessel containing H2, only the electrolyser and fuel cell package will be not in service during people presence in the platform.

Considering that the platform is unmanned and that is not yet in operation, some considerations have been made to make the analysis more adherent to the actual situation and to allow a greater focus on the most relevant tasks.

3.1 SAFETY CRITICAL TASK ANALYSIS PROCESS

A simple step-wise process for SCTA has been developed:

1. Identify maintenance tasks performed by operators.
2. Identify possible human failures.
3. Identify the consequences of human failures.
4. Determine safety measures to control risk of human failures.
5. Identify recommendations, if agreed by the team.

STEP 1: IDENTIFY MAINTENANCE TASKS PERFORMED BY OPERATORS

Considering that the platform is unmanned, the presence of operator is required only during maintenance activities. The present SCTA will be focused on the most critical maintenance activities connected with hazardous substances handling equipment, in order to identify the critical task which can lead to major accident.

In order to define the critical tasks to be analyzed and collect the required information, specific reference to:

- Operating manuals and procedures (if available) or any existing information related to the task
- Outputs from existing risk tools (e.g. HAZOP, fault trees etc.)
- Previously published SCT lists (if available)

shall be done.

Following information shall be collected for each main maintenance task activity:

- Description of the sub tasks (if any).
- Frequency and duration of the task.
- Location.
- Equipment / tools used.
- Operators involved (number and job).

Not every step (sub-tasks) in a SCT is necessarily worthy of detailed analysis. Only critical steps/sub-tasks should be deeply analysed.

It is preferable that this step be done before the workshop and that the necessary information (list of critical activities and related specific information listed above) be available for consultation at least 2 weeks before the workshop.

STEP 2: IDENTIFY HUMAN FAILURES

For each critical task steps identified in the previews point, potential human errors need to be identified.

A set of common guidewords is given in the next Table. The application of these guidewords to the SCTs produces a list of potential human failures (the below guide words represent a list of possible actions in order to identify the misoperation in the step under analysis, **is not required to apply all guidewords** to the task).

Action failures	Checking failures
A1 Operation too long/short	C1 Check omitted
A2 Operation mistimed	C2 Check incomplete
A3 Operation in wrong direction	C3 Right check on wrong object
A4 Operation too little/too much	C4 Wrong check on right object
A5 Operation too fast/too slow	**Selection failures**
A6 Misalign	S1 Selection omitted
A7 Right operation on wrong object	S2 Wrong selection made
A8 Wrong operation on right object	**Information retrieval failures**
A9 Operation omitted	R1 Information not obtained
A10 Operation incomplete	R2 Wrong information obtained
A11 Operation too early/late	R3 Information retrieval incomplete
A12 Operation in wrong order	R4 Information incorrectly interpreted
A13 Misplacement	
Planning failures	**Information communication failures**
P1 Plan omitted	I1 Information not communicated
P2 Plan omitted	I2 Wrong information communicated
Violations	I3 Information communication incomplete
V1 Deliberate actions	I4 Information retrieval unclear

Table 4 – Example human failure identification guidewords

The previous guidewords should be considered in order to identify the worst - case in terms of possible expected consequences.

In addition, factors with the potential to affect human performance, e.g. work conditions (noise, lighting), time pressure, interface design, lack of stimulation during monotonous supervisory task will be take in consideration as causes of operator misoperation.

All this information will be collected during the workshop through interviews with personnel who know how to carry out the tasks. Relevant background information should be gathered (e.g. if the tasks are conducted as per the written procedures).

STEP 3 – IDENTIFY THE CONSEQUENCES OF HUMAN FAILURES

For each task steps identified in the previews point, the potential consequences of task failure will be analysed, in terms of possible consequences for people and asset. If there are no MAH safety related consequences, then further analysis is not needed for this failure in terms of SCTA. However, if there are significant environmental or business-related consequences this may be fed into parallel or future studies.

STEP 4 – DETERMINE SAFETY MEASURES TO CONTROL RISK OF HUMAN FAILURES

Once potential human failures have been identified, possible available safeguards will be listed. Safeguards can be classified as preventive measures, if the scope is to avoid operator wrong operation or mitigative, if the scope is to mitigate the effect of the incorrect task.

STEP 5 – RECOMMENDATIONS

In order to identify possible additional safety measures, the following hierarchy of additional risk controls should be considered:

- Can the hazard be removed?
- Can the human contribution be removed, e.g. by a more reliable automated system?
- Can the consequences of the human failure be prevented (or mitigated), e.g. by additional barriers in the system?
- Can human performance be assured by mechanical or electrical means? Actions of individuals alone should not be relied upon to control a major hazard.
- Can the working conditions be optimised, (e.g. improve access to equipment, increase lighting, provide more time available for the task, improve supervision, revise procedures or address training needs)?

All the information gathered during all the steps described above, will be collected in a specific excel form and shared between the participants during the workshop (see Annex 1 – SCTA form).

The form will be prepared specifically for the Base Load Power Hub (BLPH).

3.2 REPORTING

All the information collected during the workshop will be recorded and processed by ICARO specialists in the days following the meetings. All the results of the studies and corrective measures will be resumed into

dedicated worksheets that will be delivered for sharing and discussion of the results to all the interested parties within two weeks after the workshop.

After completion of the SCTA Study, a dedicated report will be issued describing the following main topics:

- introduction;
- study scope / objectives;
- reference to the adopted procedures / standards;
- list of reference drawings and documents;
- Worksheets / check lists (completed);
- List of proposed additional safety measures to control risk of human failures.

3.3 DOCUMENTATION

The basic documentation required to properly carry out the SCTA Study includes, but is not limited to the following:

- Operating manuals and procedures (if available) or any existing written procedure related to the tasks
- BLPH 3D Model
- BLPH plot plans
- Project Design basis.
- Process description.
- Equipment / facilities layout.
- Material Handling Report (if available)
- outputs from existing risk tools (e.g. HAZOP, fault trees etc.)

It will also be necessary to have specific information on the working methods of the operators in the plant. All the documentation should be provided at least two weeks before the Workshop.

3.4 WORKING GROUP

The working group shall be a highly experienced multidisciplinary group. The members are requested to be proactive in providing input and information essential for the study successful execution and recognition of all the HSE issues.

The key figures required for a successful development of the activity, are:

- SCT analyst
- 3D Model Expert

- Project Engineering Manager
- Piping Engineer
- HSE Engineer
- Process Engineer
- Mechanical (Static, Rotating), structural, architectural, electrical and I&C department representative (Presence can be requested part Time base)
- Operation / Maintenance representative members from Company side

All the team members shall be present or available on call to provide the requested information in the most appropriate manner of communication (web conference, e-mail, phone call) when required. In case information is not available a recommendation will be raised.

4 LOCATION, DATE & TIME

The SCTA workshop will be held at Rosetti Marino offices, located at Assago (Milano).

The meetings will take place Thursday 05th of September.

The session is scheduled to start at 9.00 am and end at 6.00pm, with a lunch break approximately between 12.30 am to 1.30 pm.

The following facilities will be provided:

- Sufficient room and tabletop lay-down area for team members to deploy drawings and documents
- Wall area to stick up master copies of drawings if necessary
- Laptop computer and software tool fit for purpose
- Electronic Projector for 3D model.

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ANNEX 1 – SCTA FORM

SCTA CHECKLIST

#	Maintenance task activity	Sub task #	Description of the sub task		Potential human errors during the activity	Potential consequences due to human error	Major accident	Existing safety measures	#	Actions / Recommendations	By
1	Maintenance on H2 circuit	1,1	Maintenance on PSV				NO				
		1,2	Maintenance on BDV				YES				
		1,3	Maintenance on SDV								
		1,4	Maintenance on controll loop								
		1,5	Maintenance on transmitter/equipment								
		1,6	Maintenance on Storage vessel								
2	Maintenance on water treatment package	2,1	Water pumps								
		2,2									
		2,3									
3	Lifting operations	3,1	Lifting of equipment for maintenance								