Base Load Power Hub (BLPH)

ALARP Terms of Reference

Document Number: 123A90-DDL-SAF-RE-30011

Document Class: 3

01	25/11/2024	Issue for Information (IFI)	G. Giani	C. Caracciolo	D. Lo Sterzo
00	06/06/2024	Issue for Information (IFI)	G. Giani	C. Caracciolo	D. Lo Sterzo
Rev.	Date	Description	Prepared	Reviewed	Approved

ICARO

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

Revision / Change Log

Rev.	Description
00	Issue for Information (IFI)
01	Issue for Information (IFI)

HOLDS LIST

No.	Description
1	
2	
3	
4	

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

Table of contents

1 INTRODUCTION 5
1.1 PROJECT OVERVIEW 5
1.1.1 Project Location 5
1.1.2 Project Concept 6
1.2 DOCUMENT SCOPE 7
2 MAIN REFERENCES 8
3 DEFINITIONS AND ABBREVIATIONS 10
3.1.1 Definitions 10
3.1.2 Abbreviations 11
4 METHODOLOGY 12
4.1 SCOPE AND OBJECTIVES 12
4.2 GENERAL ALARP METHODOLOGY 12
4.3 Cost Benefit Analysis (CBA) 14
4.4 Project assumptions 14
4.5 Project risk ranking 15
5 ALARP TEAM MEMBERS 16
6 SCHEDULE AND VENUE 17
6.1 SCHEDULING 17
6.2 VENUE 17
7 RECORDING AND REPORTING 18
7.1 Reporting 18
7.2 Actions 18
APPENDIX 1 – RISK MATRIX 19
APPENDIX 2 – ALARP TEMPLATE 20
APPENDIX 3 – ACTION SHEET TEMPLATE 23

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

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 5
Figure 2 - Wind Park Details 6
Figure 3 – BLPH Concept 6
Figure 4 – ALARP Diagram (as per UK HSE - Guidance on ALARP Decisions in COMAH) 13

List of tables

Table 1 - Reference Documents 9
Table 2 - Definitions 11
Table 3 - Abbreviations 11
Table 4 - Region of risk (as per IEC 61511-3) 13
Table 5 - Individual risk tolerability limits (as per UK HSE - Guidance on ALARP Decisions in COMAH) 14

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

1 INTRODUCTION

1.1 PROJECT OVERVIEW

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

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

1.1.1 Project Location

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

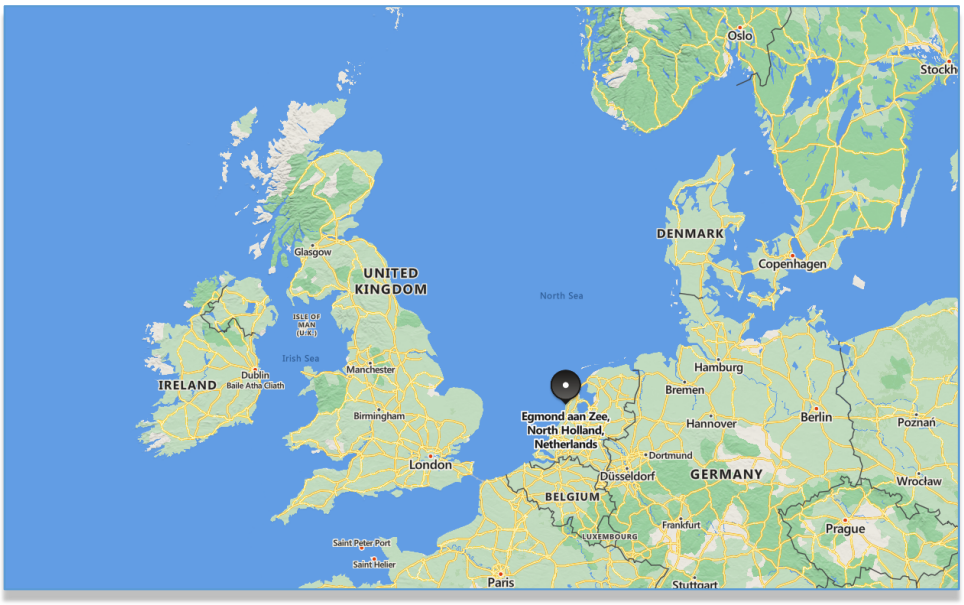


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

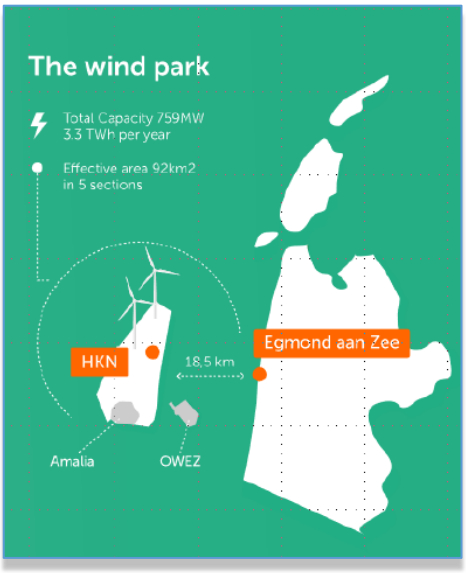


Figure 2 - Wind Park Details

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

1.1.2 Project Concept

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

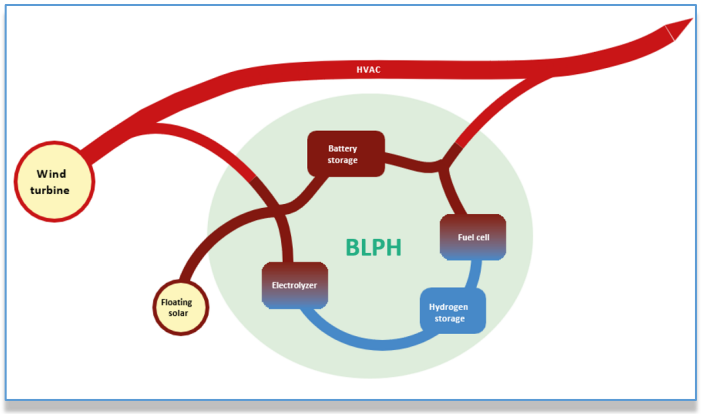


Figure 3 – BLPH Concept

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

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

1.2 DOCUMENT SCOPE

The purpose of this Terms of Reference Document is to outline the scope, purpose, arrangements including timings, attendees and pre-read information and methodology for the ALARP Workshop that is tentatively scheduled on the second week of July 2024 (HOLD 1).

It also provides details of the proposed review schedule and indications about the reporting of the outcomes together with the follow-up and close-out of actions raised within the review.

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

2 MAIN REFERENCES

Ref.	Description
[1]	ISO 17776 - Petroleum and natural gas industries – Offshore production installations – Major accident hazard management during the design of new installations
[2]	UK HSE - Guidance on ALARP Decisions in COMAH – UK Health and Safety Executive (UK HSE), SPC/Permissioning/37, 2001
[3]	IEC 61511-3:2016 - Functional safety - Safety instrumented systems for the process industry sector - Part 3: Guidance for the determination of the required safety integrity levels
[4]	123A90-DDL-SAF-RE-30003 - Safety Critical ELEMENTS (SCE) and Performance Standard
[5]	- BLPH Base Load Power Hub Plot Plan
[6]	123A90-DDL-SAF-RE-30004 - HSSE Action Tracking Register and Close out report
[7]	123A90-DDL-SAF-RE-30046 – HSE Design Philosophy
[8]	123A90-DDL-PR-BL-80002 – H&MB
[9]	123A90-DDL-SAF-RE-30019 - Quantified Risk Assessment (QRA) Report
[10]	123A90-DDL-SAF-RE-30020 - Fire and Explosion Risk Analys (FERA) report
[11]	123A90-DDL-SAF-RE-30015 - Evacuation, Escape and Rescue Assessment (EERA) Report
[12]	123A90-DDL-SAF-RE-30018 - Dropped Object and Swinging Loads Study
[13]	123A90-DDL-SAF-RE-30041 - Noise Assessment Study Report
[14]	123A90-DDL-SAF-RE-30006 – HAZOP Report
[15]	123A90-DDL-SAF-RE-30009 – HAZID Report
[16]	123A90-DDL-SAF-RE-30021 - Vent Gas Dispersion and Potential Radiation Study
[17]	123A90-DDL-SAF-RE-30036 - LOPA Allocation report
[18]	123A90-DDL-SAF-RE-30040 - Safety Critical Task Analyses Report
[19]	123A90-DDL-SAF-CA-30047 - FIRE DURATION CALCULATION INSIDE CONTAINERS
[20]	123A90-DDL-SAF-RE-30049 - Human Factors Engineering Report

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

Ref.	Description
[21]	CWHKN-INN-BPH-RPT-00007 - Operating Modes Review Report

Table 1 - Reference Documents

3 DEFINITIONS AND ABBREVIATIONS

3.1.1 Definitions

COMPANY or Client (CPY)	Crosswind
EPC CONTRACTOR (CTR)	ROSETTI MARINO S.p.A.
PROJECT	HOLLANDSE KUST NOORD WIND PARK Project
ALARP	is short for "as low as reasonably practicable, s the concept of "reasonably practicable"; this involves weighing a risk against the trouble, time and money needed to control it. Thus, ALARP describes the level to which we expect to see workplace risks controlled.
CONSEQUENCES	The outcome of an event. For the purpose of this project, the outcome is identified in terms of harm to exposed persons and assets.
EVENT	Occurrence or change of a particular set of circumstances.
FERA	Fire and Explosion Risk Assessment. A comprehensive risk evaluation directed to the analysis of the effects of fire and explosion scenarios (due to LOCs of hazardous substance handled in an equipment to be installed during project development) on process equipment, structures and buildings.
FIRE	The outcome of combustion of flammable substance released in the atmosphere as a consequence of a LOC, which can produce effects to exposed persons and to process equipment and structure due to thermal radiation.
FREQUENCY	The estimated number of events per defined unit of time (normally refereed to one-year time).
MAJOR ACCIDENT	A MAHs is defined from at least one of the following categories: • an incident involving an explosion, fire, or release of gas or dangerous substances with a significant potential to cause multiple fatalities; • an incident leading to serious damage to the asset involving, or with a significant potential to cause, multiple fatalities; • any other incident with a potential to lead to greater than 3 fatalities

	• any major environmental incident resulting from incidents referred to in points above.
QRA	Quantitative Risk Assessment. For the purpose of this study, a comprehensive risk evaluation focused on the identification of the impact to persons (workers and external population) due to effects of accident scenarios due to LOCs of hazardous substance handled in equipment to be installed during project development.
RISK	Combination of frequency and consequence of scenarios. For the purpose of the present project, the risk is evaluated on exposed persons and on project equipment, due to the effects of events caused by LOC of hazardous substances

Table 2 - Definitions

3.1.2 Abbreviations

ALARP	As Low As Reasonably Practicable
AOB	Any Other Business
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
DNV	Det Norske Veritas
EERA	Escape, Evacuation and Rescue Assessment
FERA	Fire and Explosion Risk Assessment
H&MB	Heat and Material Balance
HKN	Hollandse Kust Noord
HyRAM	Hydrogen Risk Assessment Model
HSE	Health, Safety and Environment
QRA	Quantitative Risk Assessment

Table 3 - Abbreviations

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

4 METHODOLOGY

4.1 SCOPE AND OBJECTIVES

The workshop will consider all elements in the scope of work of the BLPH platform.

The following items are excluded:

- Construction/Commissioning activities, that shall be analysed during a Constructability workshop/ SIMOPS workshop,
- Decommissioning.

The objectives of this workshop review are to:

- List the identified hazards that results in Major Accident due to loss of containment, injury to persons, damage to equipment or structures and in environmental impacts.
- Evaluate the adequacy of in place controls, safeguards, mitigation and recovery measures.
- Risk rank hazards and, where necessary, issue any recommendations for further work, design or engineering change to improve the next phases of the Project.

4.2 GENERAL ALARP METHODOLOGY

The ALARP demonstration is established when all hazards are known and understood, particularly Major Accident Hazards. All the Major Accidents/Hazards identified in safety workshops and studies will be analysed one by one and studied in the main barriers provided in order to demonstrate that the work is at ALARP (As Low As Reasonably Practicable) level.

The ALARP principle is illustrated in Figure 4. The triangle represents an increasing level of cumulative risk (all risks, or the total risk, that a person, or population is exposed to) from a low risk, represented by green at the base of the triangle, to a high risk, represented by red at the top of the triangle.

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

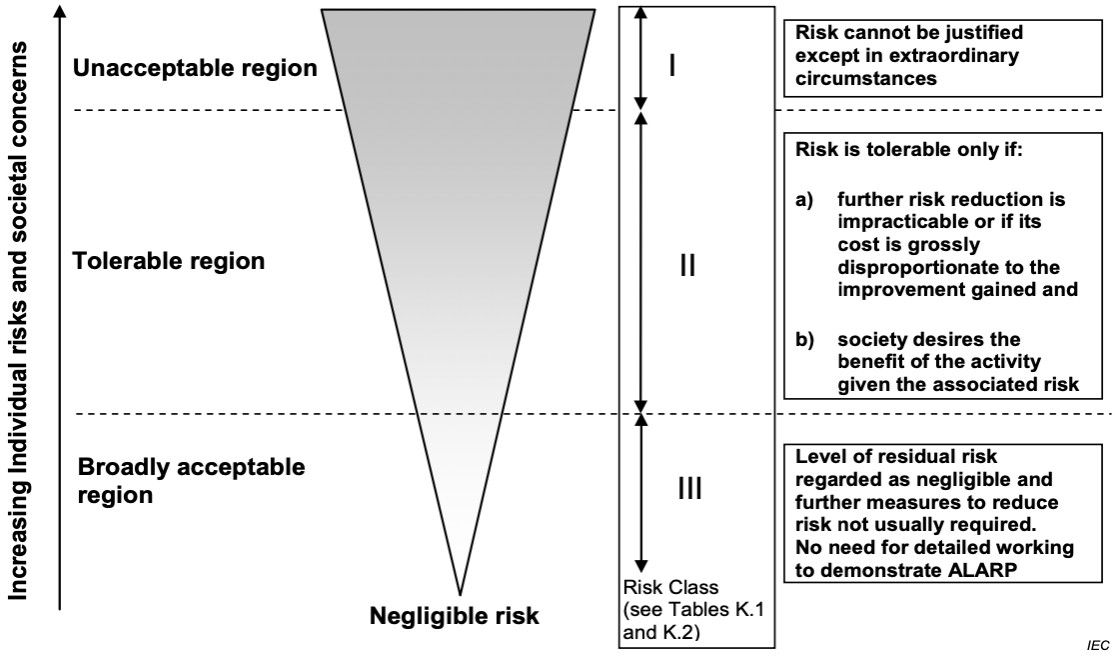


Figure 4 – ALARP Diagram (as per IEC 61511-3, ref. [3])

A risk is considered to fall in one of three regions classified as "unacceptable", "tolerable" or "broadly acceptable" (see **Errore. L'origine riferimento non è stata trovata.**4).

Region	Description
Unacceptable region	Risk cannot be justified except in extraordinary circumstances
Tolerable / ALARP region	Risk is tolerable only if: - further risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained and - society desires the benefit of the activity given the associated risk
Broadly acceptable region	Level of residual risk regarded as negligible and further measures to reduce risk not usually required. No need for detailed working to demonstrate ALARP

Table 4 - Region of risk (as per IEC 61511-3, ref. [3])

Tolerability limits for individual risk are based on the risk of death per year (IRPA) and are defined by the UK Health and Safety Executive (HSE) to be:

Tolerability limit (Risk of death per year)	
Lower Tolerability Limit for the public and workers	1 x 10-6
Upper Tolerability Limit for the public	1 x 10-4
Upper Tolerability Limit for workers	1 x 10-3

Table 5 - Individual risk tolerability limits (as per UK HSE - Guidance on ALARP Decisions in COMAH)

One of the methods of demonstrating reasonable practicality is cost benefit analysis (CBA). This should however be used with some caution, especially with regard to high consequence outcomes since the costing of such outcomes is difficult to determine and there is a perceived and actual aversion to high consequence accidents. CBA cannot generally be used to avoid the use of "good practice".

4.3 COST BENEFIT ANALYSIS (CBA)

The cost benefit analysis (CBA) is based on a comparison of:

- The Value of Preventing a Major Accident (VPA),
- The Cost of Preventing a Major Accident (CPA),

The ratio of these two costs, CPH / VPH, is the Proportion Factor (PF).

If the Proportion Factor for a risk reduction measure is calculated to be higher than a defined value, then the costs are said to be "grossly disproportionate" to the benefit achieved and implementation of the measure would not be reasonably practicable. The definition of the PF is not a fixed number but it depends on the risk level that a Company can take, in any case the common sense has to be used with the opinion of experts.

4.4 PROJECT ASSUMPTIONS

Following assumptions will be applied during ALARP execution:

- CPIs will be included in the discussion based on Company information only.
- The analysis is based on the results of the safety studies present at the moment of the review.
- Major Accidents are related only with what happens inside the parts of the project Scope of Work, hazards coming from outside, or not reasonable expected and credible, are not part of the present study.

Following points will be applied during ALARP execution:

- External factors: Temperature, humidity, ducting, smoke etc. directly influence the performance of the controls systems. Also, if there is power, air, or hydraulic system failure, then control systems cannot work.

4.5 PROJECT RISK RANKING

Risk ranking process will be performed according to the COMPANY Risk Matrix already used during the other project workshops, before the meeting start severity and likelihood shall be clearly defined and agreed with all the team. This is a five-by-six matrix on which risks can be assessed for Health & Safety and Environmental, based on:

- Likelihood – a measure of how frequently the risk will be realized;
- Severity – a measure of the size of consequences should the risk be realized, in various categories.

Risk Matrix is reported in **Appendix 1**.

Ranking will not carry out:

- When consequences are considered negligible (e.g. minor temporary operation upset).
- For standard "design" scenario (e.g. external fire).
- In case of shut-down associated to trip activation that will generate only loss of production.

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

5 ALARP TEAM MEMBERS

The ALARP session will be conducted by a third-party Facilitator, who will ensure the correct application of the ALARP methodology.

The ALARP team shall include all functions involved in the platform design and it shall be composed, indicatively, by the following figures:

- Facilitator - Consultant for ALARP session
- Scribe - Consultant for ALARP session
- PM representative from Company and Contractor side
- Safety Representatives from Company and Contractor side
- Process Representatives from Company and Contractor side
- Others on call.

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

6 SCHEDULE AND VENUE

6.1 SCHEDULING

The ALARP session is foreseen to last one day on the 4rd of December 2024.

Before the session start, a pre-ALARP screening for the TOP EVENT identification will be performed by the Facilitator, in order to prepare the list of Major Accident to be revised. Additional hazards, that create a potential loss of life can be investigated and discussed during the workshop.

The session will start at 09:00 and the scheduled completion is at 17:30. There will be a one-hour break for lunch at 13:00 and two 15 minutes coffee breaks at 11:00 and at 16:00.

The agenda expected will be as follow:

AGENDA	
09.00 – 09.15	Round table presentation and methodology presentation
09.15 – 11-00	Starting with the identified Major Accident
11.00 – 11-10	break
11.10 – 13-00	Discussion on Major Accident
13.00 – 14.00	lunch
14.00 – 16.00	Discussion on Major Accident
16.00 – 16.10	break
16.10 – 17.45	Additional risk not leading to Major Accident
17-45 – 18.00	AOB and wrap-up

6.2 VENUE

The session will be held at the offices of Rosetti Marino in Assago (MI) and could be followed also in Videoconference by means of Teams.

7 RECORDING AND REPORTING

At the end of the ALARP sessions, a report will be produced with the intent of recording all the main aspects of the activity.

The output of the various review sessions will be recorded by the Scribe under the management of the Facilitator, by means of word/excel sheets.

The worksheets and the recording process will be projected onto a screen during the session so that the workshop team can view, comment and amend as necessary the generated content as it is produced.

The following information as a minimum will be recorded for each item:

- Scenario number
- Major Accident identified
- Description of scenario
- Cause
- Consequence
- Accident phenomenon
- Safeguards, controls, mitigating and recovery measures (grouped as Safeguards)
- Qualitative risk assessment
- Recommendations
- Action Party

An example of this template format is shown in **Attachment 2**.

7.1 REPORTING

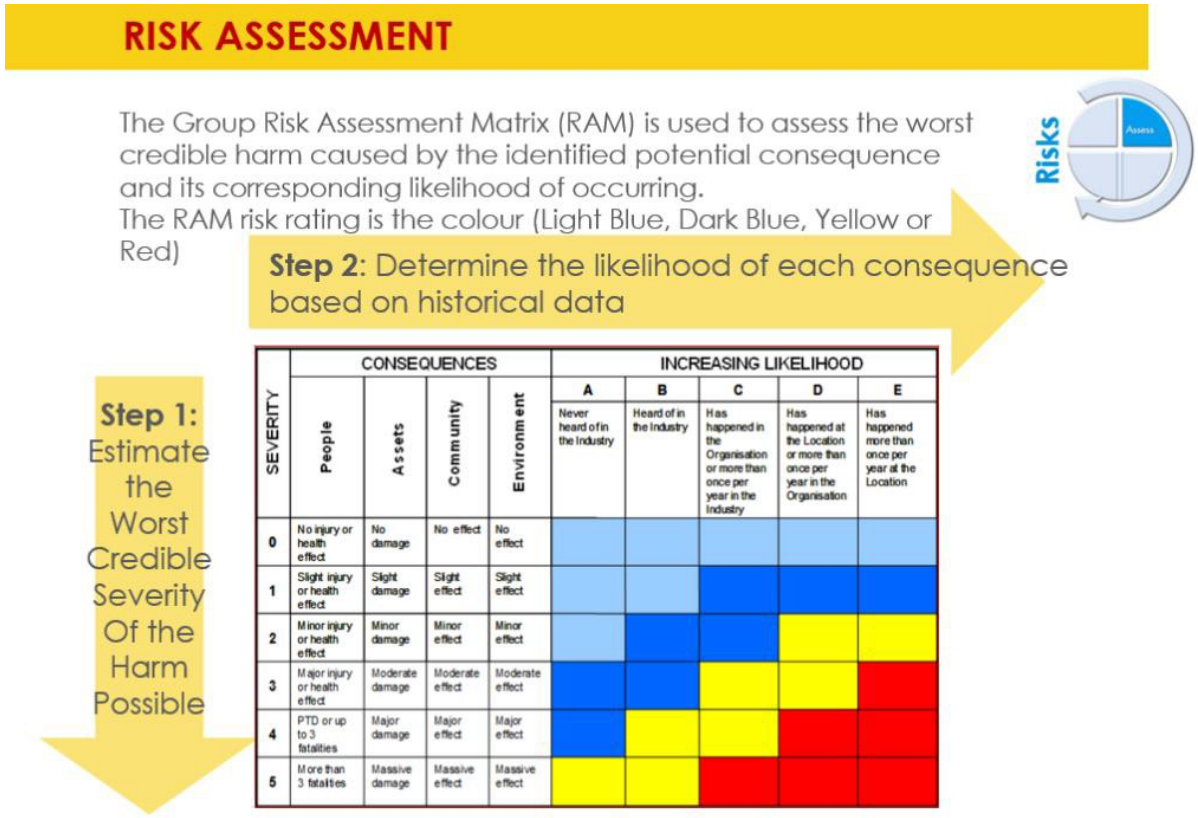
A draft report of all content created by the workshop, including any required supporting material will be produced after the workshop for comment.

The report will contain the assumptions made and the main output of the workshop, as a detailed worksheet and the action-sheets for each recommendation raised during the sessions.

7.2 ACTIONS

Recommendations raised will be collected with the HSSE Action Tracking Register and Close out report (ref.[6]). Each action-sheet will indicate the recommendation, with the responsible of closing the action, the answer showing how the recommendation is properly closed.

APPENDIX 1 – RISK MATRIX



SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

APPENDIX 2 – ALARP TEMPLATE

IDENTIFY	Problem Definition
	HSSE Issues and Potential Risk
	HSSE Issues Potential Risks
	HSSE Standard and Tolerability Criteria
ASSESS	Options Considered
	A number of controls or mitigation measures have been identified and considered for reducing risk of enclosing the equipment:
	Basis for Selection &e Uncertainties
	Option Discussion:
	Justification for Chosen Option
	Justification for Rejected Options (e.g. Options not incorporated as considered beyond ALARP)
CONTROL & EVALUATION	Residual HSSE Risk
	Recommendations for Next Project Phase
	None
	Requirements for the Operations HSSE-Plan
	All safety critical equipment to be operated and maintained to the Performance Standards.

The following list resume the scenarios that will be discussed during the ALARP workshop.

N.	Major Accident
1	H2 release from single tank
2	Escalation event of H2 from all storage area
3	BESS runaway
4	H2 release inside Electrolizer container
5	Potential for explosion inside electrolizer due to membrane failure

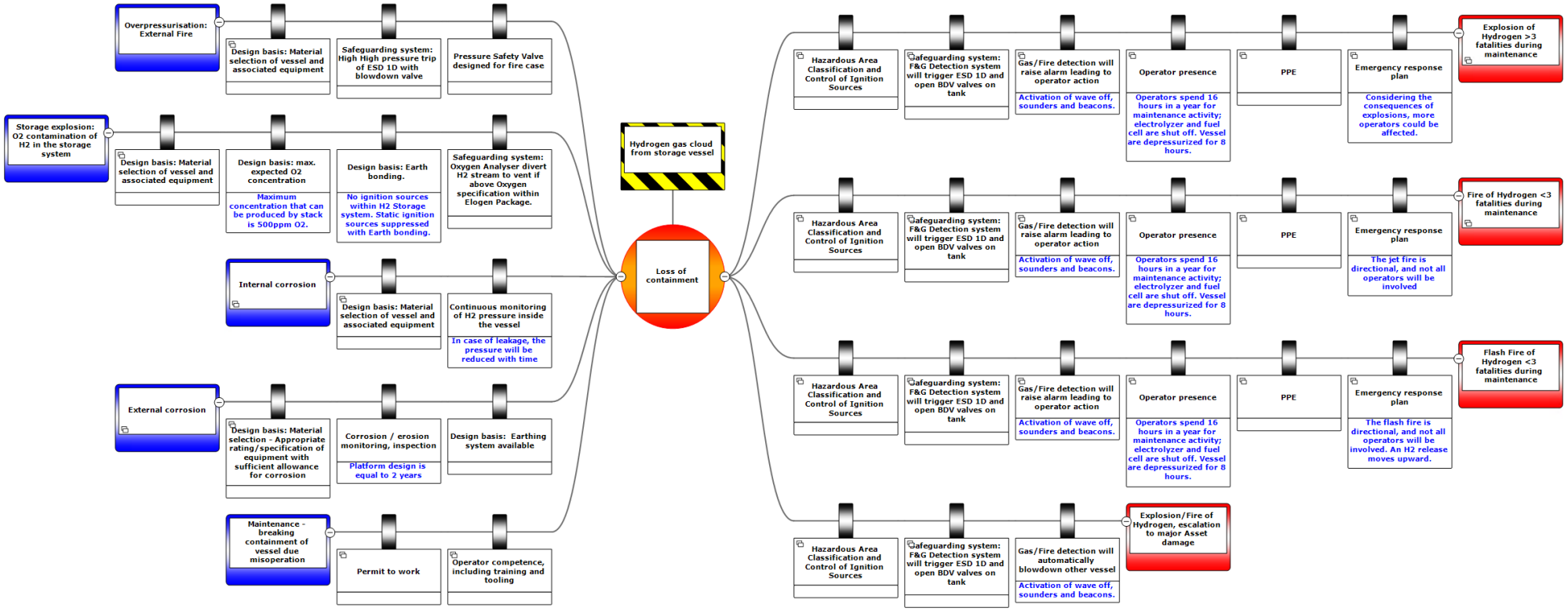
6	H2 release inside Fuel Cell container
7	Location of H2 piping on the lower deck
8	Fire in technical rooms
9	Vent location – possible operators injuries
10	Possible damage to the platform – Elogen transformer location

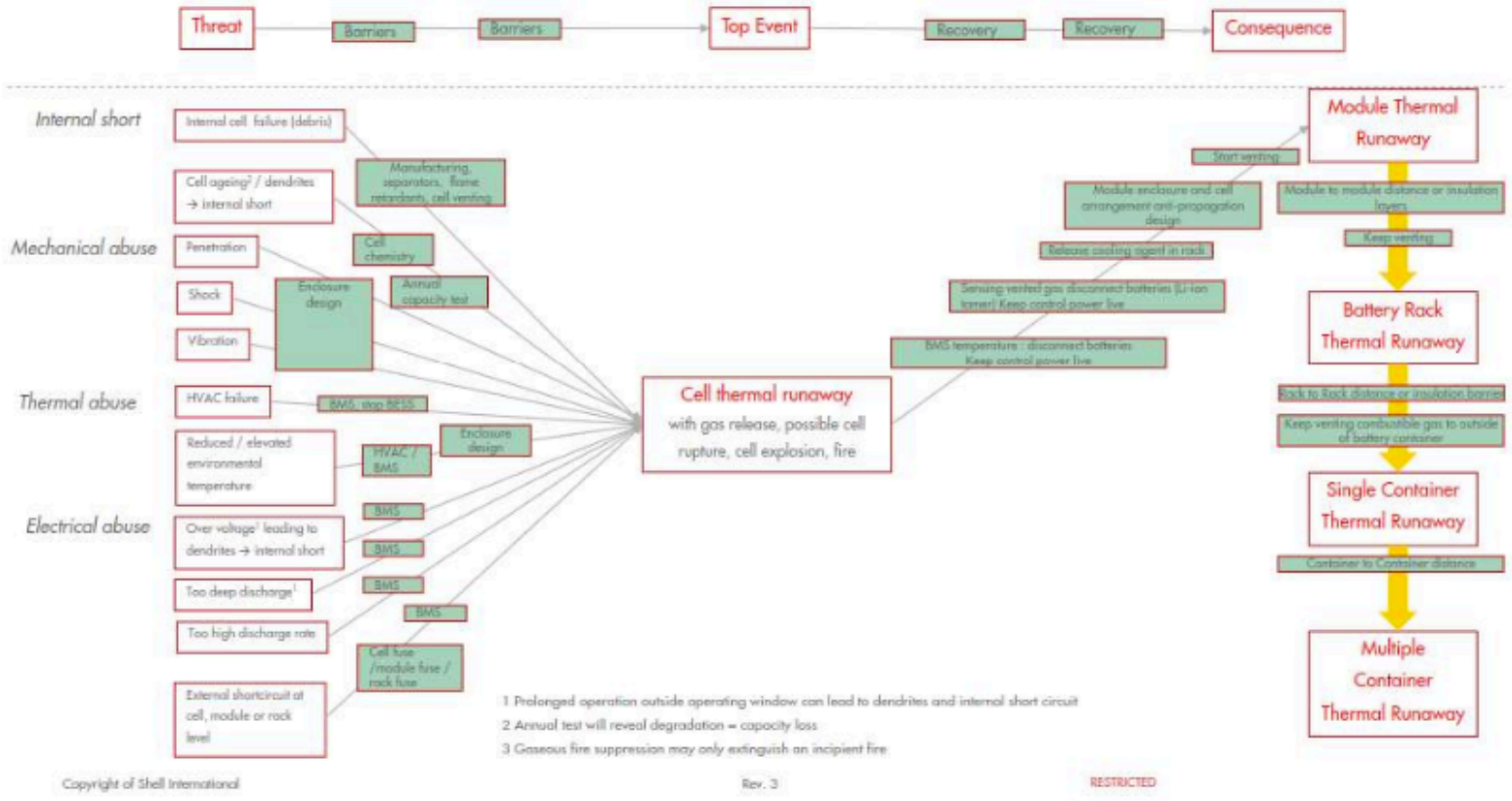
APPENDIX 3 – ACTION SHEET TEMPLATE

CROSSWIND	ROSETTI MARINO
HOLLANDSE KUST NOORD WIND PARK Project **Base Load Power Hub (BLPH)**	
Action N :	**Rev.:**
Action Title:	**Date:**
Reference Document n:	
Hazard/Parameter:	**Deviation**
Cause:	
Consequence:	
Safeguards:	
Recommendation:	
Responsible Part:	
Response:	
Ref. Docs / Dwgs.:	

RESPONSE ACCEPTANCE		
Discipline Leader:	**Signature:**	**Date:**
HSE Leader:	**Signature:**	**Date:**
Project Engineering Manager:	**Signature:**	**Date:**
Company:	**Signature:**	**Date:**

APPENDIX 4 – BOW-TIE




Threat
Barriers
Barriers
Top Event
Recovery
Recovery
Consequence
Internal short
Internal cell failure (debris)
Cell ageing[2] / dendrites → internal short
Manufacturing, separators, flame retardants, cell venting
Mechanical abuse
Penetration
Cell chemistry
Shock
Enclosure design
Annual capacity test
Vibration
Thermal abuse
HVAC failure
BMS: stop BESS
Reduced / elevated environmental temperature
HVAC / BMS
Enclosure design
Electrical abuse
Over voltage[1] leading to dendrites → internal short
BMS
Too deep discharge[1]
Too high discharge rate
Cell fuse /module fuse / rack fuse
External shortcircuit at cell, module or rack level
Cell thermal runaway
with gas release, possible cell rupture, cell explosion, fire
Start venting
Module enclosure and cell arrangement anti-propagation design
Release cooling agent in rack
Sensing vented gas disconnect batteries (Li-ion inner) Keep control power live
BMS temperature : disconnect batteries Keep control power live
Module Thermal Runaway
Module to module distance or insulation layers
Keep venting
Battery Rack Thermal Runaway
Rack to Rack distance or insulation barrier
Keep venting combustible gas to outside of battery container
Single Container Thermal Runaway
Container to Container distance
Multiple Container Thermal Runaway
1 Prolonged operation outside operating window can lead to dendrites and internal short circuit
2 Annual test will reveal degradation = capacity loss
3 Gaseous fire suppression may only extinguish an incipient fire
Copyright of Shell International
Rev. 3
RESTRICTED