Base Load Power Hub (BLPH)

Noise Assessment Study Report

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1 INTRODUCTION

The main objective of this document is to analyze the noise levels that will be generated during the different operating phases of the BLPH, in order to ensure the safety of workers attending the plant and to comply with noise exposure levels.

The Base Load Power Hub (BLPH) is an innovative project that involves the testing of an offshore system combining water electrolysis, fuel cells, and a lithium-ion battery on a monopile. This system will be integrated with one of the wind turbines at the Hollandse Kust Noord (HKN) wind farm. The goal is to provide a continuous base load of at least 20% of the average power output of the Wind Turbine Generator (WTG), equivalent to 1 MW, 99% of the time, regardless of wind conditions. This will demonstrate the ability to shift energy over periods from hours to days, reducing the intermittent nature of wind power.

The study are carried out by ICARO, a 3rd party qualified specialist, not involved in the project development.

1.1 DEFINITIONS AND ABBREVIATIONS

dB(A):

A unit of measurement decibels(A) of sound pressure level which has its frequency characteristics modified by a filter ("A-weighted") so as to more closely approximate the frequency response of the human ear.

Sound Power Level (Lw or SWL):

It is a logarithmic measure of the sound power, which refers to the total sound energy radiated by a source per unit of time, as a relation to the threshold of hearing; it is measured in decibel (dB).

Lw = 10 log (sound power/reference power)

Sound Pressure Level (Lp or SPL):

is a logarithmic measure of the sound pressure of a sound relative to a reference value, Sound pressure is the difference between the pressure produced by a sound wave and the barometric pressure p0 at a given point in space. It is measured in decibel (dB). For example the Sound Pressure Level formula for air is:

Lp = 20 log (p/p0) dB

where p is the sound pressure, measured in Pascal and p0 is the reference sound pressure (20 microPa).

Work area noise limit:

Noise limits defined to prevent hearing damage for the personnel and expressed as sound pressure level limits at worker location which in general is not less than 1 m from equipment surface accessible to personnel.

Abbreviations

Below is a table of commonly used abbreviations for this project:

BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
FEED	Front End Engineering Design
HKN	Hollandse Kust Noord
SPL	Sound pressure levels

Table 1 – Abbreviations

1.3 TERRITORIAL AND PROJECT FRAMEWORK

1.3.1 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.

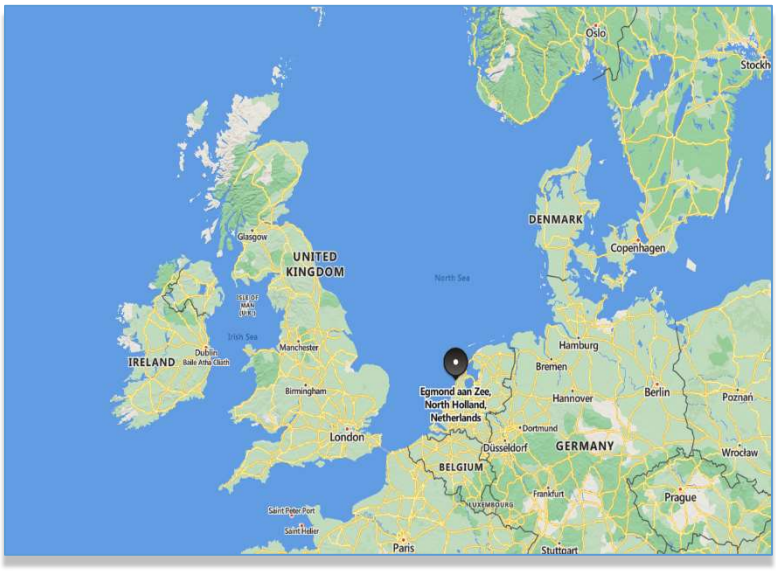


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map



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.

1.3.2 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.

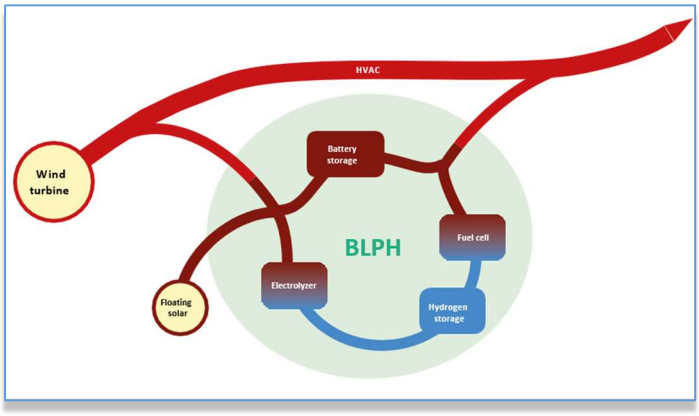


Figure 3 – BLPH Concept

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.

1.4 MAIN REFERENCES

Ref.	Description
1	K559-2254-PM-PLN-003 – Basis Design Engineering Package rev-02, 06/07/23
2	123A90-DDL-SAF-LIS-30014, Assumption Register, revision 01
3	BLPH-CROSSWIND-25-03-2024 (3D model of platform, last issue available during vent study preparation
4	K559-2254-PR-REP-001 – Process Description (note: study for FEED phase)
5	K559-2254-SE-REP-013 - Noise Study (note: study for FEED phase)
6	K559-2254-ME-MEL-001 - Mechanical Equipment List
7	123A90-DDL-PP-DL-70070_02 – BLPH PLOT PLAN

Table 2 – Main References

1.5 APPLICABLE REGULATIONS

The standards have been utilized are summarized below:

- Harmful Noise Levels Regulation (Netherlands): This regulation mandates that employers must take measures to prevent hearing damage if employees are exposed to noise levels of 80 dB(A) or higher. If noise levels exceed 85 dB(A) for 8 hours, hearing protection is required. Employers must also provide hearing tests and create an action plan to mitigate noise risks.
- Noise and Machinery Directive 2006/42/EC: This directive sets essential health and safety requirements for machinery placed on the EU market. It includes provisions for measuring and declaring noise levels. If the emission sound pressure level at workstations exceeds 80 dB(A), sound power must be declared. The directive ensures machinery is designed to minimize noise and protect workers.
- EU Directive 2003/10/EC mandates that noise control measures be incorporated during the planning and design phases of new facilities, setting a general noise limit of 85 dB(A) for work areas that cannot restrict access. This limit applies as the maximum sound pressure level at any location within the work area, measured at least 1 meter away from noisy installations. If the 85 dB(A) limit is not feasible, a 90 dB(A) limit may be implemented. Individual employees' daily noise exposure should not exceed 85 dB(A), with specific exposure limits outlined for varying durations. Sound pressure levels in work areas must not exceed 110 dB(A) under any conditions.

1.6 NOISE LIMIT

The BLPH has been designed for a relatively short operational lifespan and will be operated remotely, with maintenance personnel only present during commissioning, essential maintenance, and decommissioning. Consequently, our noise control measures have been focused on ensuring the safety of maintenance workers and complying with EU Directive 2003/10/EC on noise exposure levels. This directive mandates that noise control measures must be integrated during the planning and design phases of new facilities, with a maximum allowable noise level of 85 dB(A) in any work area that remains accessible during normal operations.

Specifically, the general noise limit in work areas is set at 85 dB(A). This limit is defined as the maximum sound pressure level permitted at any location within the working area, measured at least 1 meter away from equipment and other noise sources. In situations where maintaining the 85 dB(A) limit is impractical, a higher limit of 90 dB(A) may be applied. Additionally, the individual employee's daily noise exposure (Leq,8h) must not exceed 85 dB(A), as indicated in the following table.

Exposure Time	Noise LevelLAeq [dB(A)]
24 hours	80
16 hours	82
12 hours	83
10 hours	84
8 hours	85
4 hours	88
2 hours	91
1 hour	94
30 minutes	97
15 minutes	100

Table 3 – Noise limits

Limits applicable for operation condition only and not for start-up, shut down, emergency or any other unusual condition. In any case the sound pressure level in the work area shall never exceed 115 dB (A). These limits will be considered as a reference basis for the evaluation of noise compatibility within all areas identifiable as a working environment, outside of containers and equipment shelters.

2 NOISE STUDY

2.1 SOFTWARE

The model used in this study is SoundPLAN, developed by Braunstein + Berndt GmbH and widely used internationally. SoundPLAN is a predictive model that allows the study of acoustic phenomena generated by industrial, road, railway, and airport noise sources, using internationally recognized standards.

SoundPLAN uses the following inputs:

- Emission characteristics and location of the noise sources (point, line, or area sources)
- Topography of the study area
- Presence of obstacles such as buildings, noise barriers, etc.
- Location of the receivers.

SoundPLAN calculates, using appropriate algorithms recognized by international standardization organizations, the propagation of sound and assesses environmental noise at each point within the calculation area, considering both the contribution of directly propagated noise and the contribution of reflections from various surfaces.

The results are provided as specific data at the identified receivers and as maps of isophonic curves, which are lines connecting points with the same sound pressure level.

The software version used for the modelling is SoundPlan version 8.1.

2.2 NOISE STUDY

The noise assessment methodology include the following steps:

- Creation of model input data: o definition of a flat terrain model and assignment of water propagation data, o definition of the calculation area, o creation of a three-dimensional calculation grid limited to the perimeter, o identification and characterization of noise sources, o creation of a three-dimensional model of the installation including all noise sources;
- Calculation of sound pressure level (SPL) values in the study area using the simulation model, including all sources, throughout the entire noise study area, including containers and equipment cabinets.
- Analysis of the results and comparison with the limit values identified for the project.

The calculation results are presented in this document through acoustic pressure maps generated by the software's "maps graph" application.

The simulation of industrial noise sources will be performed following the ISO 9613 noise propagation standard. Based on the available project documents (e.g., equipment list), the list of noise sources will be characterized according to the following key information:

- Noise source name/description,
- Project coordinates (x, y, z) referring to the provided layout reference point,
- Sound power levels [dB(A)].

The sound power level for each source was calculated based on sound pressure level data or derived from similar projects, vendor information, or specific databases.

Equipment noise levels and spectra used in the model will be based on equipment datasheets or field measurement experience with similar design/capacity equipment and will be estimated for levels based on their maximum anticipated operational duty under normal operating conditions.

The total sound power level (Lw) will be defined considering:

- The enveloping surface dimension of each noise source, where the enveloping surface is the minimum surface that contains the noise source itself, determined by examining the unit plot plans,
- The sound pressure level (Lp) measured 1 meter from each noise source, as determined by relevant noise equipment datasheets and project specifications.

To obtain the sound power level (Lw) of each noise source starting from its sound pressure level (SPL), the calculation will be performed according to the UNI EN ISO3746 standard "Acoustics, Determination of sound power levels of noise sources - Survey method."

To account for noise levels at each deck of the installation, multiple grids will be created, one for each deck. Each deck simulation considers all noise sources within the installation area.

The software will be configured with the following parameters:

- Grid size: 1.0 m,
- Calculation height: 1.5 m above each deck level,
- Number of reflections: 3.

The environmental data input into the simulation software are as follows:

- Temperature: 10.5°C,
- Humidity: 83%,
- Atmospheric pressure: 1013.3 mbar,
- Ground factor G: 0.0 (corresponding to hard ground such as asphalt, water, or industrial sites).

2.3 SCENARIOS

For the analysis, two distinct operational scenarios were thoroughly evaluated: normal operation of the facility and maintenance conditions.

- In the **normal operation scenario**, the facility will function without personnel on-site. During this period, several key systems will be active, specifically the Fuel cel, Electrolyser, Water Treatment Systems and Battery Energy Storage Systems (BESS).
- In the **maintenance and emergency scenario**, personnel may potentially be present. During the maintenance phase, in the event of an emergency depressurization, the electrolysis and water treatment systems will be deactivated. Instead, the emergency depressurization systems will be activated, along with the valves and fuel cell, which will play a key role in maintaining operational stability. In addition, the HVAC systems will remain operational to ensure a controlled and safe working environment for maintenance personnel.

Maintenance scenario, without emergency, is not considered in the evaluation because this is significantly less impactful than the operating condition, already compliant with the applicable limits as assessed below, due to the numerous sources not active in this scenario.

By evaluating these two scenarios, we can gain a comprehensive understanding of noise exposure levels and operational safety protocols under varying conditions, allowing us to implement effective noise control measures and ensure the well-being of all personnel involved.

For the sources positioned inside the cabins, the walls of the main shelters were also included in the simulation model as calculation elements, as an obstacle and attenuation of the noise propagation. The external sources were instead represented as punctual.

For details of the emission sources, and noise sources input data, included in the simulation scenarios, please refer to the following chap. 5.

3 CALCULATION RESULTS

The following simulation maps show the results obtained, in the two scenarios, at the upper deck level and at the lower deck level.

3.1 SCENARIO 1: NORMAL OPERATION

Upper deck level results:

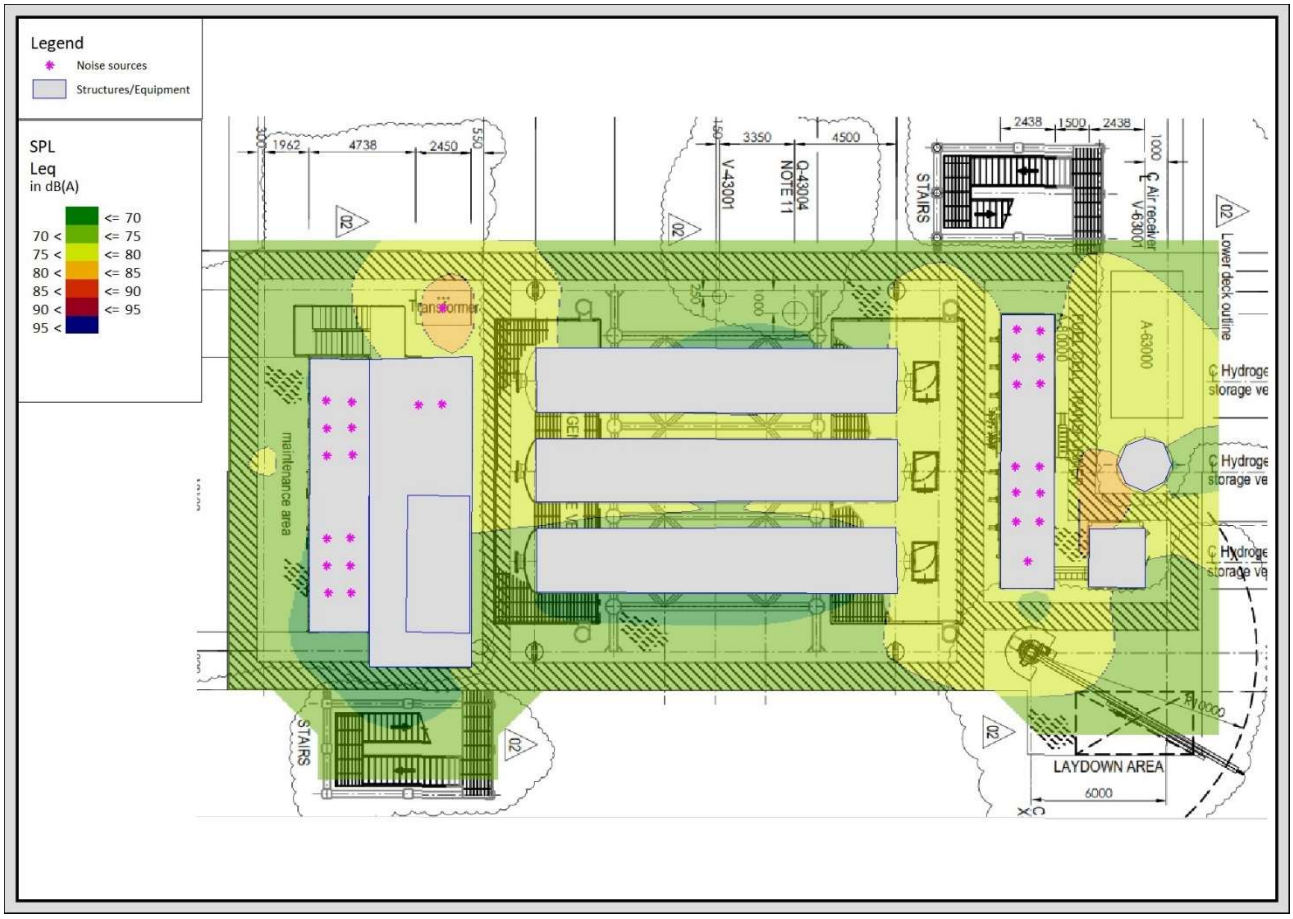


Figure 4 – Calculation results – Normal Operation – Upper Deck

Lower deck level results:

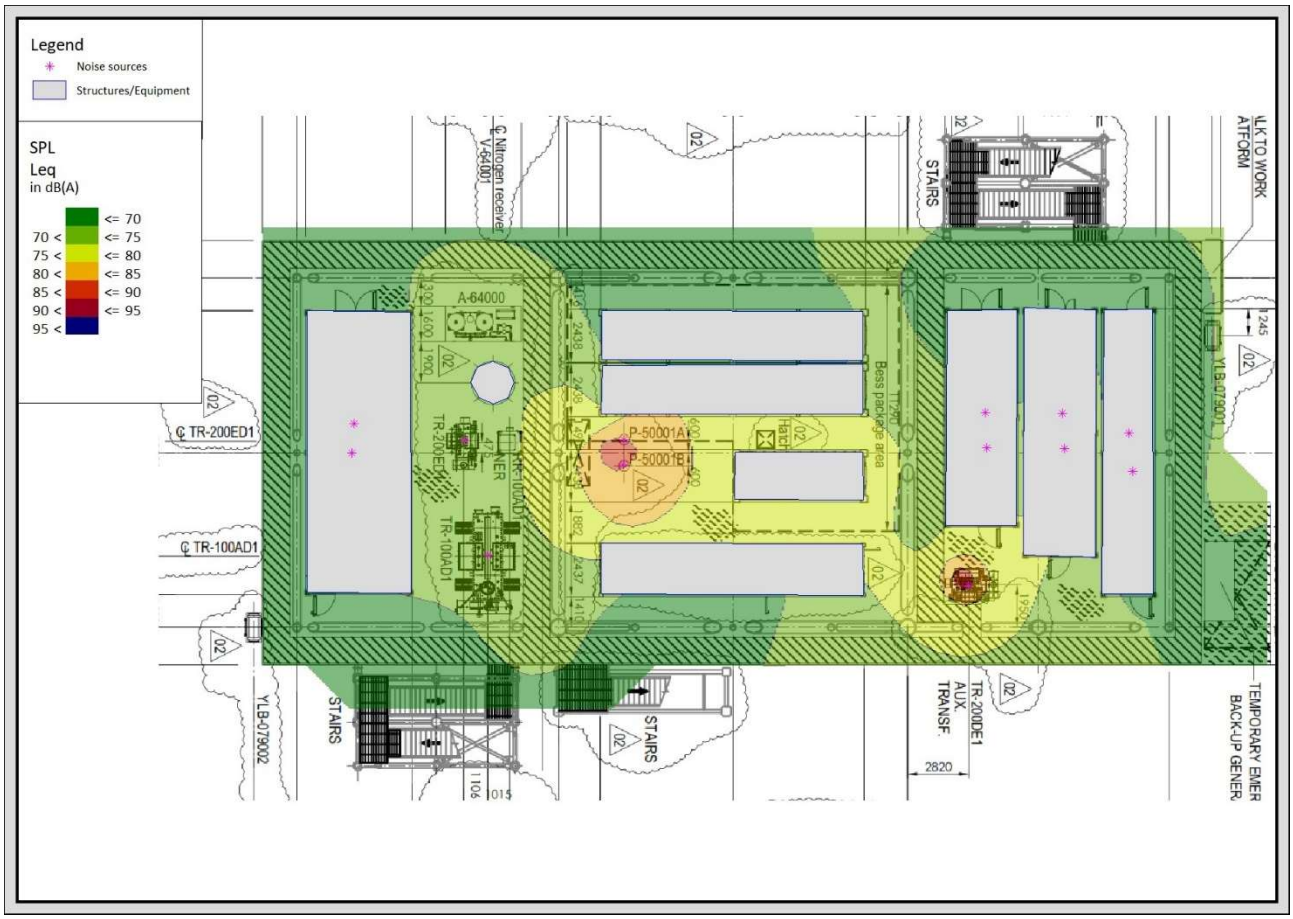


Figure 5 – Calculation results – Normal Operation – Lower Deck

3.3 SCENARIO 2: EMERGENCY

Upper deck level results:

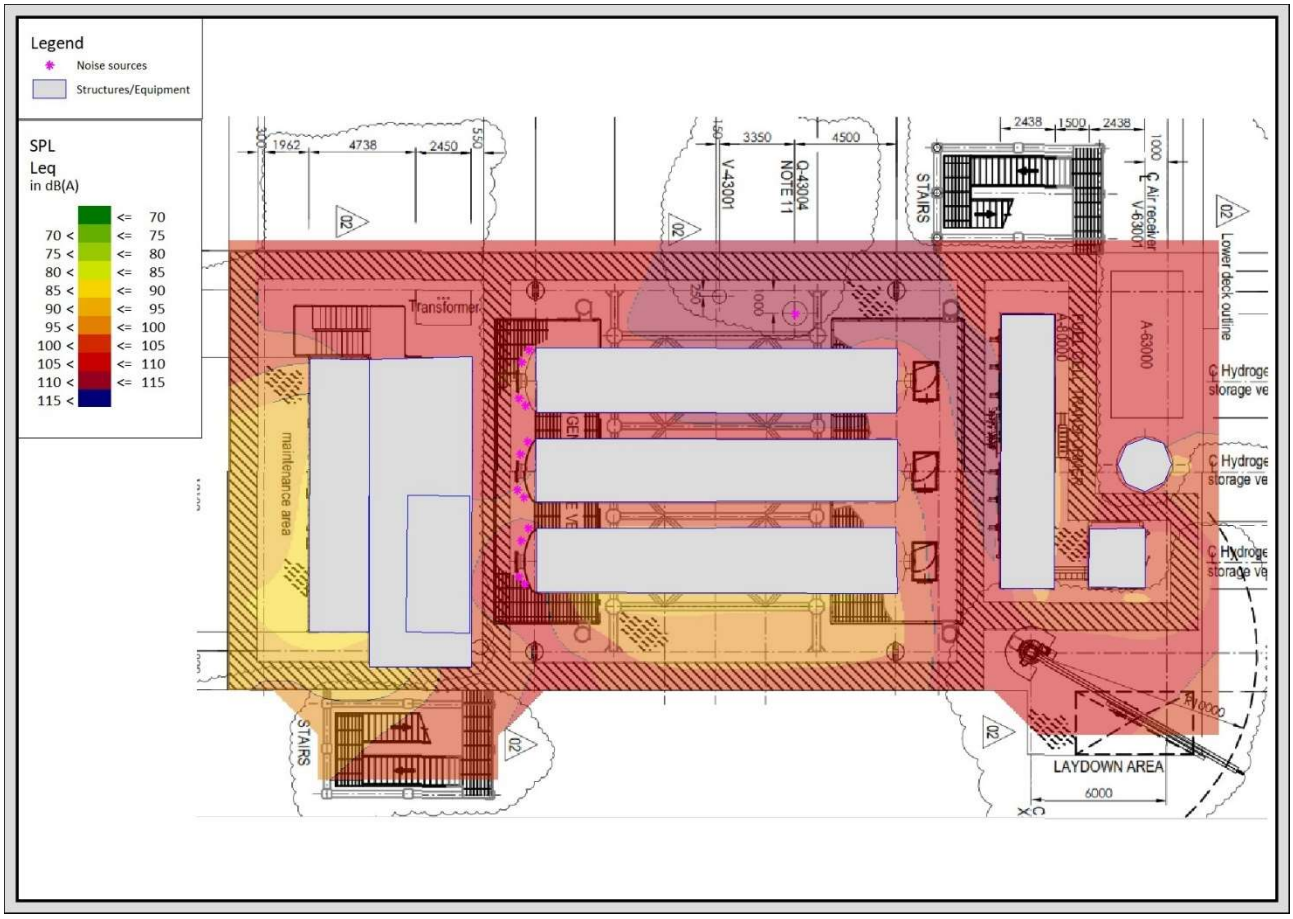


Figure 6 – Calculation results – Emergency – Upper Deck

Lower deck level results:

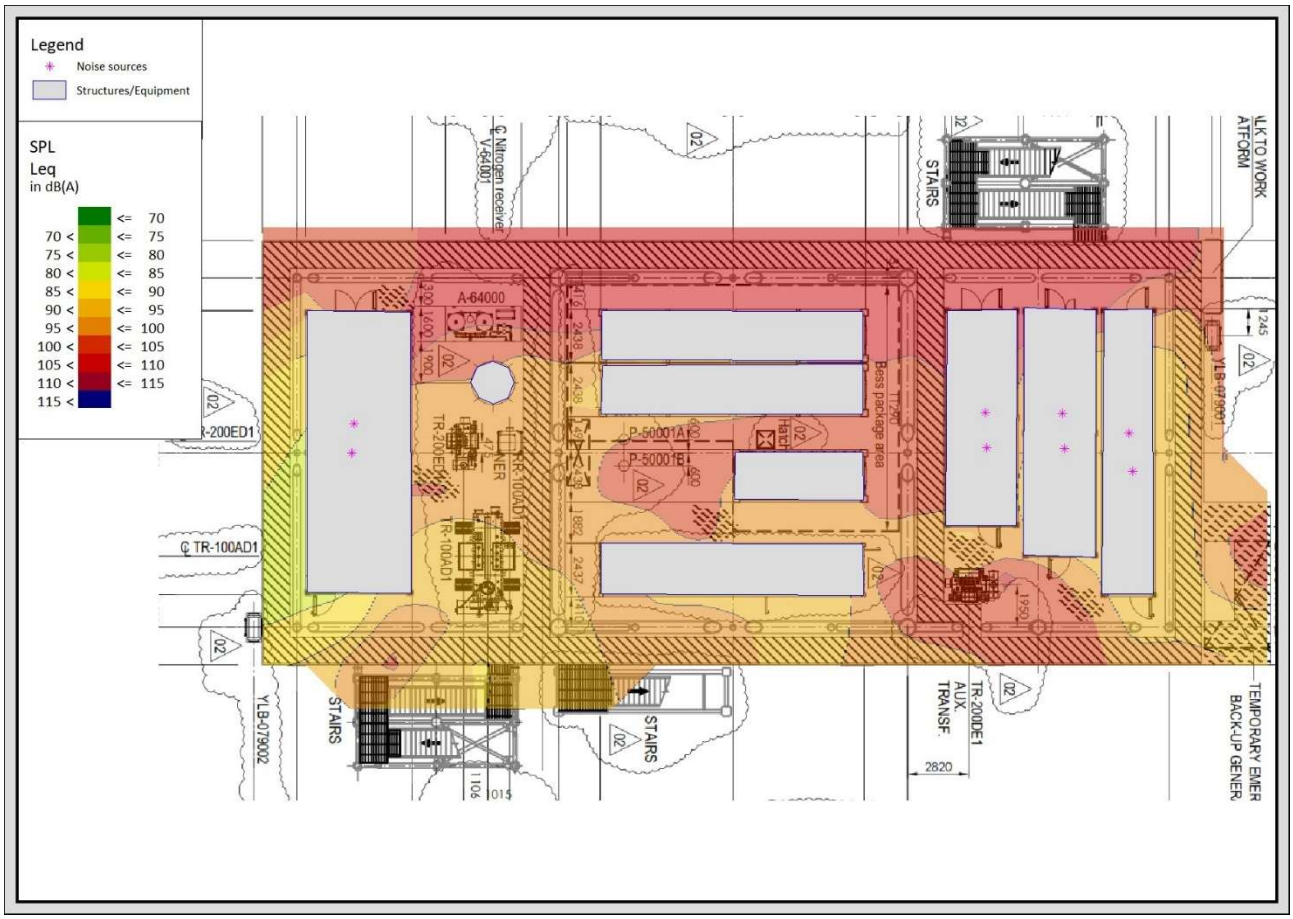


Figure 7 – Calculation results – Emergency – Lowerr Deck

4 CONCLUSION

As expected, the noise produced by the installations under study is limited during normal operating conditions, due to the small scale of the activities and the relatively low power of the noise sources.The main sources of noise will be the air coolers protecting the Fuel Cell equipment and the HVAC ventilation systems for the Fuel Cell, Electrolyser and the Battery Energy Storage System (BESS).

Noise levels on both the Upper and Lower Decks are predicted to not exceed the work area noise limit of 85 dB(A) during "normal" equipment operation (see Figure 4 & 5).

Noise levels, on emergency condition, are predicted to not exceed the absolute work area noise limit of 115 dB(A) (see Figure 6 & 7). In this scenario, in which many equipment are not active compared to the previous one, it presents significant noise values entirely attributable to the noise produced by the depressurization vent.

4.1 RESTRICTED AREAS

According to the requirements of the EU Noise Directive, any area where the average sound pressure level (SPL) during normal operation exceeds 80 dB(A) must be marked as 'noise hazardous'.

Based on the assessments made, for normal operating conditions, the sign is necessary in three very limited areas close to equipment (2 on the upper deck and 1 on the lower deck – Cfr. Figures 4 and 5). The signs must indicate that hearing protection is mandatory in these areas.

There are no areas where sound pressure levels are expected to exceed 85 dB(A) beyond a distance of 1 m from equipment.

4.2 EMERGENCY NOISE LIMITS

As anticipated the maximum value of sound pressure level, during emergency condition, not exceed the limit of 115 dB (A). These limits will be considered as a reference basis, even for emergency condition, for the evaluation of noise compatibility within all areas identifiable as a working environment, outside of containers and equipment shelters.

The limit value is approached exclusively in some external areas of the upper deck, near the emergency depressurization vent. The induced sound pressure values, at the lower deck, are reduced and never close to the limit value applicable to emergency conditions.

5 SOUNDPLAN MODEL SOURCE DETAILS

	Name of the equipment	Pressure level (dB(A)@1m of distance)	Power level (dB(A))	Number of sources	Source type
Lower Deck	BESS 01	50,5		1	Volumetric
	BESS 02	50,5		1	Volumetric
	PCS CONTAINER	77,1		1	Volumetric
	A5000 - WATER TREATMENT PACKAGE (1)	<80		1	Volumetric
	P-50001A/B (SEAWATER LIFT PUMPS)	85		2	Point
	TR-100AD1 TRANSFORMER MAIN 66kV/6,6kV		68	1	Point
	TR-200DE1 TRASFORMER AUX 6,6 kV/0,4 kV		50	1	Point
	TR-200ED TRASFORMER		50	1	Point
	HVAC	82		8	Point
	Electrical filter room (2)		65	1	Volumetric
	HV switchroom (2)		65	1	Volumetric
	LV switchroom (2)		65	1	Volumetric
	Plant electrical room		65	1	Volumetric
Upper Deck	FUEL CELL - HT COLEER FAN	84		6	Point
	FUEL CELL - LT COOLER FAN	78		6	Point
	FUEL CELL - HT PUMP (3)	63		1	Point
	FUEL CELL - CONTAINER VENTILATION INLET	89		1	Point
	FUEL CELL - CONTAINER VENTILATION OUTLET	81		1	Point
	FUEL CELL - FC WAVE (INSIDE CONTAINER) (3)	83		1	Point
	FUEL CELL - FC WAVE (OUTSIDE CONTAINER)	63		1	Point
	CHILLER 1/2	80		2	Point
	TRASFORMER	80		1	Point
	VALVES	77		12	Point
	ELECTROLYSER - CENTRIFUGAL PUMP (3)	60		1	Point
	ELECTROLYSER - CENTRIFUGAL PUMP (3)	79		1	Point
	ELECTROLYSER - DRY COOLER	82		12	Point
	ELECTROLYSER - CENTRIFUGAL PUMP (3)	60		1	Point
	ELECTROLYSER - NEEDLE VALVE (3)	74		1	Point
	ELECTROLYSER - NEEDLE VALVE (3)	58		1	Point
	ELECTROLYSER - NEEDLE VALVE (3)	65		1	Point
	ELECTROLYSER - RESSURE REDUCING VALVE (3)	31		1	Point
	ELECTROLYSER - PRESSURE REDUCING VALVE (3)	78		1	Point
	ELECTROLYSER - PRESSURE REDUCING VALVE (3)	31		1	Point

	Name of the equipment	Pressure level (dB(A)@1m of distance)	Power level (dB(A))	Number of sources	Source type
	ELECTROLYSER - RESTRICTION ORIFICE (3)	50		1	Point
	ELECTROLYSER - RESTRICTION ORIFICE (3)	50		1	Point
	ELECTROLYSER - SOLENOID VALVE NC (3)	44		1	Point
	ELECTROLYSER - H2 Vent	69		1	Point
	ELECTROLYSER - O2 Vent	67		1	Point
	ELECTROLYSER - STACK EXTRACTOR (3)	57		1	Point
	Safety Depressurization VENT (4)		146,6	1	Point

(1) Defined on base of a respect of project specification(SPL <80 dB(A) @1m of distance) for each sources inside the equipment shelter
(2) Sound power defined conservatively as there are no significant internal noise sources
(3) Inside equiment shelter
(4) Active only in case of emergency depressurization