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Kattegat

Site Wind Conditions Assessment

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Kattegat, Site Wind Conditions Assessment

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LIABILITIES

According to contract.

Executive Summary

Objective

The objective of this technical report is to present the findings of the Site Wind Conditions Assessment conducted by EMD International A/S for Energinet in relation to the Kattegat offshore wind farm project in the Kattegat Sea.

Background

The Danish Energy Agency has tasked Energinet with undertaking site wind conditions assessments for the development of five Offshore Wind Farm (OWF) areas within the Danish Exclusive Economic Zone. The site wind conditions assessments are a part of the technical basis for future public tenders on the development of the projects. The OWF areas are divided into three lots, respectively in the Kattegat, Baltic and North Sea. In the Kattegat Sea, two OWF projects are considered, Hesselø South and Kattegat, the later being the subject of this report.

Methodology

The site wind condition assessment is an early assessment after 8 months of onsite measurements using floating LiDAR systems (FLS) in the Kattegat OWF areas and delivers the early site wind condition parameters according to IEC 61400-1 [1], IEC 61400-3-1 [2] and in addition refers to Eurocode EN1991-1-4 [3] including the Danish annex [4], DS 472 ed.2 [5] and IEC 61400-15-1 [6].

The site wind conditions assessment is intended to serve as basis for:

- Preliminary site-suitability analysis of the Wind Turbine Generator (WTG) and Rotor Nacelle Assembly (RNA)
- Front-End Engineering and Design (FEED) of offshore support structures for WTGs and other structures.

The report includes a presentation and analysis of onsite data from one floating LiDAR buoy (WS199) deployed on site as well as secondary measurements surrounding the site and sourced for this purpose. A wind model has been created for the site through long-term correction of 8 months of onsite LiDAR data with 22 years of EMD-WRF mesoscale data (labelled “Primary Wind Model”).

The Primary Wind Model has been backed up by three alternative models, based on data from the Hesselø South floating LiDAR (HS-1), Hesselø floating LiDAR (H1) and Læsø meteorological mast (M1). The three alternative models are in good agreement with the Primary Model on mean wind speed for the site, given the distance from the Kattegat Wind Farm and the data quality.

Due to seasonal bias, the short measurement period and the nature of the LiDAR measurements, the site condition parameters are supported by data from secondary sources.

Calculations are done in windPRO 4.0, developed by EMD International A/S.

Results

The site condition parameters are summarized in Table 1.

Table 1. Summary table of site wind condition parameters at the three selected positions for the Kattegat OWF area. All values refer to 150 m height above sea level (ASL).

Parameter	KG-1-LB	KG-A	KG-B
Mean wind speed	9.64 m/s	9.63 m/s	9.66 m/s
Weibull distribution, A parameter (scale)	10.88 m/s	10.87 m/s	10.91 m/s
Weibull distribution, k parameter (shape)	2.32	2.32	2.33
Normal wind profile power law exponent	0.092	0.092	0.092
Turbulence intensity mean value (TI_{μ}) at a 10-min average wind speed of 15m/s*	4.9%	4.9%	4.9%
Turbulence intensity standard deviation (TI_{σ}) at a 10-min average wind speed of 15m/s*	2.0%	2.0%	2.0%
Turbulence intensity 90% quantile at a 10-min average wind speed of 15m/s*	7.5%	7.5%	7.5%
Mean air density	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3
Mean air temperature	9.1°C	9.1°C	9.1°C
50-year extreme wind speed	40.1 m/s	40.1 m/s	40.1 m/s
1-year extreme wind speed	31.5 m/s	31.5 m/s	31.5 m/s
Wind shear for extreme wind speed extrapolation	0.13	0.13	0.13
Characteristic turbulence intensity at 50-year extreme wind speed	12.0%	12.0%	12.0%
Air density for extreme wind	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3
Lightning	1.18 flashes/year/km^2	1.18 flashes/year/km^2	1.18 flashes/year/km^2
Solar radiation, mean	121 W/m^2	121 W/m^2	121 W/m^2
Solar radiation, peak	880 W/m^2	880 W/m^2	880 W/m^2
Relative Humidity, mean	83.8%	83.8%	83.8%

*Turbulence values at other wind speeds can be found in Appendix G

The datasets produced by this study are available in a data package prepared for Energinet.

Climate change effects on the wind conditions assessed above has been investigated. From this investigation it appears that wind speed is likely unaffected, the models are inconclusive concerning extreme wind speed while there is clear indication of an up to 2˚C increase in temperature for the medium term (2041-2060), resulting in an 0.7% decrease in air density. An increase in precipitation is expected for both near and medium term.

Recommendations

EMD recommends updating this site wind conditions parameter assessment once the measurement campaign has been concluded.

EMD recommends supporting the turbulence assessment with additional local turbulence measurements from suitable sources, preferably cup anemometer measurements, in the Kattegat Sea.

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1 Introduction

EMD International A/S has been tasked by Energinet to provide a site wind condition assessment for the Kattegat offshore wind farm.

The objectives of the site wind condition assessment are outlined in the Scope of Services Site Wind Conditions Assessment [7] provided by Energinet and aims for a site wind condition assessment adequate for a preliminary site-suitability analysis for the Wind Turbine Generator (WTG) and Rotor Nacelle Assembly as well as input for Front-End Engineering and Design (FEED) of offshore support structures for WTGs and other structures.

The parameters for the wind condition assessment are listed in Table 2 and are defined according to IEC61400-1 [1], IEC 61400-3-1 [2] and IEC 61400-15-1 [6].

Table 2. List of Site Wind Conditions Parameters.

SITE WIND PARAMETERS AT 150 M MSL	
Normal Conditions Parameters	**Extreme Conditions Parameters**
Mean wind speed	Maximum 10-minute mean wind speed for a 50-year EWM
Omni-directional Weibull wind speed distribution parameters	/
Wind profile for wind speed extrapolation with elevation	Wind shear for extreme wind speed extrapolation with elevation
Wind profile for Integrated Load Analysis, Normal Wind Profile (NWP)	Wind profile for integrated load analysis
Normal Turbulence Model (NTM)	Extreme Turbulence Model (ETM)
/	Turbulence intensity at extreme wind speed
Mean air density	Mean air density
Mean air temperature	/
Salinity	/
Solar radiation	/
Earthquake	/
Relative humidity	/

The site wind condition parameter list is populated through a wind condition and resource assessment based on onsite floating LiDAR data from one location and mesoscale WRF data. This model is supported by a selection of secondary stations located within meaningful distance of the Kattegat wind farm area.

Beside the present report, measurement data as well as mesoscale WRF and long-term corrected datasets are provided in the form of time series text files.

All elevations throughout are referred to as Above Sea Level (ASL) with the reference sea level being the mean sea level.

A naming convention is used for turbulence conditioned on wind speed where 'mean turbulence' is the mean of 10 min wind speed standard deviations (σ) within a wind speed bin. The 'standard deviation of turbulence' is the standard deviation across 10 min wind speed standard deviations ($\sigma\sigma$) in a wind speed bin. Both these quantities (mean and standard deviation of turbulence) may be normalized to the wind speed of the wind speed bin in question, in this case the normalized turbulence is referred to as Turbulence Intensity (TI), either mean or standard deviation.

2 Site Description

Kattegat project area is located 20 km east of the Djursland peninsular, Denmark, protruding into Kattegat Sea (Figure 1).

The Kattegat OWF area is defined through a shape file provided by Energinet. The shape file is provided as a deliverable.

Closest distance to land from the OWF area is 15 km to the west (Grenå Port).

The neighbouring wind farm, Anholt, is located adjacent to the Northen part of the Kattegat II OWF project. Additional wind farms are planned in this part of the Kattegat Sea, such as the Hesselø South OWF, planned about 15 km to the east.

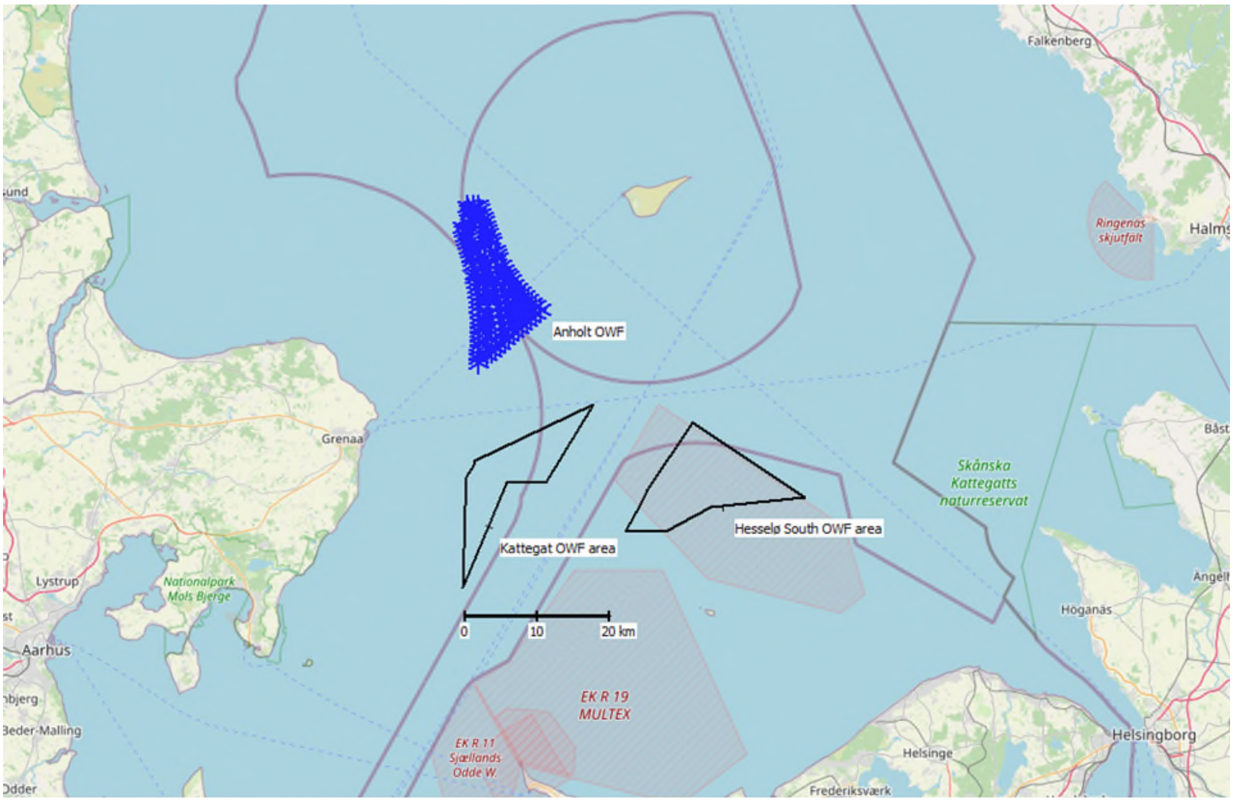


Figure 1. Regional map with location of the Kattegat OWF area together with Hesselø South OWF area and the existing Anholt OWF (in blue).

The wind farm area is located in open water with sufficient distance to any shoreline (minimum 15 km). The effect of the shorelines on the wind speed gradient across the site will therefore be better represented by mesoscale effects. For this reason, no further terrain assessment has been conducted. The water depth within the OWF area is between 17 and 38 m.

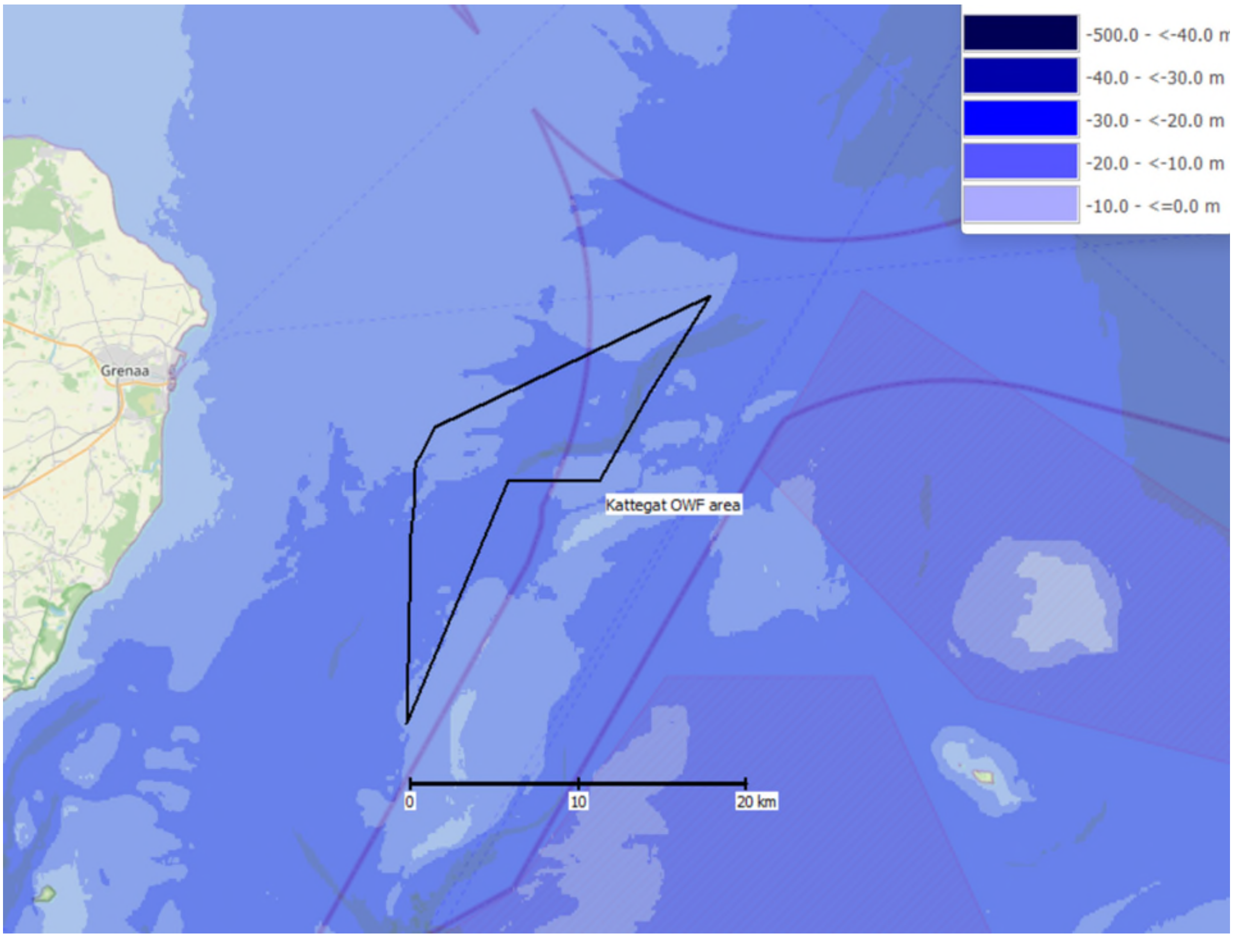


Figure 2. Bathymetric map of Kattegat OWF area (source: EMODnet – 115 m grid resolution)

3 Overview of Available Wind Data

A host of wind data measurements was considered for the wind condition and resource analysis. Each source is listed in Table 3 and Table 4 and considered in the following.

The onsite Floating LiDAR System (FLS), commissioned by Energinet, is the primary source of information and is used for the primary wind model. The data are described in section 4.

For the validation of the primary wind model, data from Hesselø South (HS-1), Hesselø (H1), and Læsø met mast (M1) are used.

For the turbulence model, data from FINO2 and FINO3 offshore met masts are used.

Meteorological stations data from the Danish Meteorological Institute (DMI) [8] and the Swedish Meteorological and Hydrological Institute (SMHI) [9] are primarily used to verify the long-term variation in wind climate or the temperature profile for the site. Some of the stations included are done so with only limited contribution to the study as far as data quality permits.

A number of other meteorological stations were considered, but not used in this study as it was found that their data were of insufficient quality, not representative for the site or redundant.

Table 3 lists all the meteorological stations suggested by Energinet.

The measurement locations are plotted on a map in Figure 3.

All secondary data used in this study are presented in Appendix A.

Table 3.List of considered measurement stations, with measured heights and period. In bold are the used measurements stations.

NAME	TYPE	MEASUREMENT HEIGHT [M] ASL	MEASUREMENT PERIOD	LENGTH [YEARS]
Kattegat (KG-1-LB)	Floating LiDAR System	12 - 300	07/2023 - ongoing	0.66
Hesselø South (HS-1)	Floating LiDAR System	12 - 300	07/2023 - ongoing	0.66
Hesselø (H1)	Floating LiDAR System	12 - 240	02/2021 - 02/2022	1
FINO2	Offshore Met-Mast	102.5	08/2008 - 08/2015	7
FINO3	Offshore Met-Mast	107, 101, 91, 81, 71, 61, 51, 41, 31	01/2010 - 12/2013	4
Læsø (M1)	Offshore Met-Mast	15, 30, 45, 58, 62	07/1999 - 07/2003	4
Anholt	Climate Met-Mast	10	05/2000 - 05/2024	24
Gniben	Climate Met-Mast	10	05/2003 - 05/2024	21
Nakkehoved Fyr	Climate Met-Mast	10	05/2001 - 05/2024	23
Hallands Väderö	Climate Met-Mast	2	01/1996 - 01/2024	28
Røsnæs Fyr	Climate Met-Mast	10	05/2002 - 05/2024	22
Sletterhage Fyr	Climate Met-Mast	10	05/2002 - 05/2024	22
Anholt OWF ANH	LiDAR System	Unknown	01/2013 - 01/2014	1
Anholt OWF	Unknown	Unknown	03/2010 - 05/2010	0.16
Anholt E	Unknown	Unknown	01/1983 -	-
Fladen Lighthouse	Climate Met-Mast	Unknown	01/1988 - 12/1999	11
Hamlstad Flygplats	Climate Met-Mast	Unknown	02/1945 -	-
L:A Middelgrund	Unknown	Unknown	01/1978 -	-
N14 Falkenberg	Unknown	Unknown	01/1996 -	-
P22	Unknown	Unknown	09/2021 - 03/2022	0.53
Ringhals	Climate Met-Mast	Unknown	01/1967 -	-
Stora Middelgrund	Unknown	Unknown	01/1978 -	-

Table 4. Coordinates and data provider of the considered measurement stations (geographic coordinates, datum WGS84).

NAME	LONGITUDE [° E]	LATITUDE [° N]	Z, A.S.L [m]	PROVIDER (CODE#)
Kattegat (KG-1-LB)	11.2010	56.3506	0	Energinet
Hesselø South (HS-1)	11.7723	56.3340	0	Energinet
Hesselø (H1)	11.8351	56.4642	0	Energinet
FINO2	13.1542	55.0069	0	BHS
FINO3	7.1583	55.1950	0	BHS
Læsø (M1)	11.1232	57.0842	0	Energinet
Anholt Haven	11.5098	56.7169	1	DMI (#06079)
Gniben	11.2787	56.0083	14	DMI (#06169)
Nakkehoved Fyr	12.2580	56.1524	0	DMI (#06168)
Hallands Väderö	12.5453	56.4496	8	SMHI (#62260)
Røsnæs Fyr	10.8694	55.7435	1	DMI (#06159)
Sletterhage Fyr	10.5135	56.0955	2	DMI (#06073)
Anholt OWF ANH	11.1527	56.5957	25.6	Ørsted
Anholt OWF	11.1658	56.6925	0	Energinet
Anholt E	12.1167	56.6667	0	SMHI (#40009)
Fladen Lighthouse	11.8333	57.2167	0	SMHI (#35068)
Hamlstad Flygplats	12.8167	56.6863	21	SMHI (#62410)
L:A Middelgrund	11.7583	56.9583	0	SMHI (#40058)
N14 Falkenberg	12.2117	56.9400	0	SMHI (#40068)
P22	12.3360	56.2888	0	SMHI (#33037)
Ringhals	12.1125	57.2497	0	SMHI (#02105)
Stora Middelgrund	12.2167	56.5667	0	SMHI (#40087)

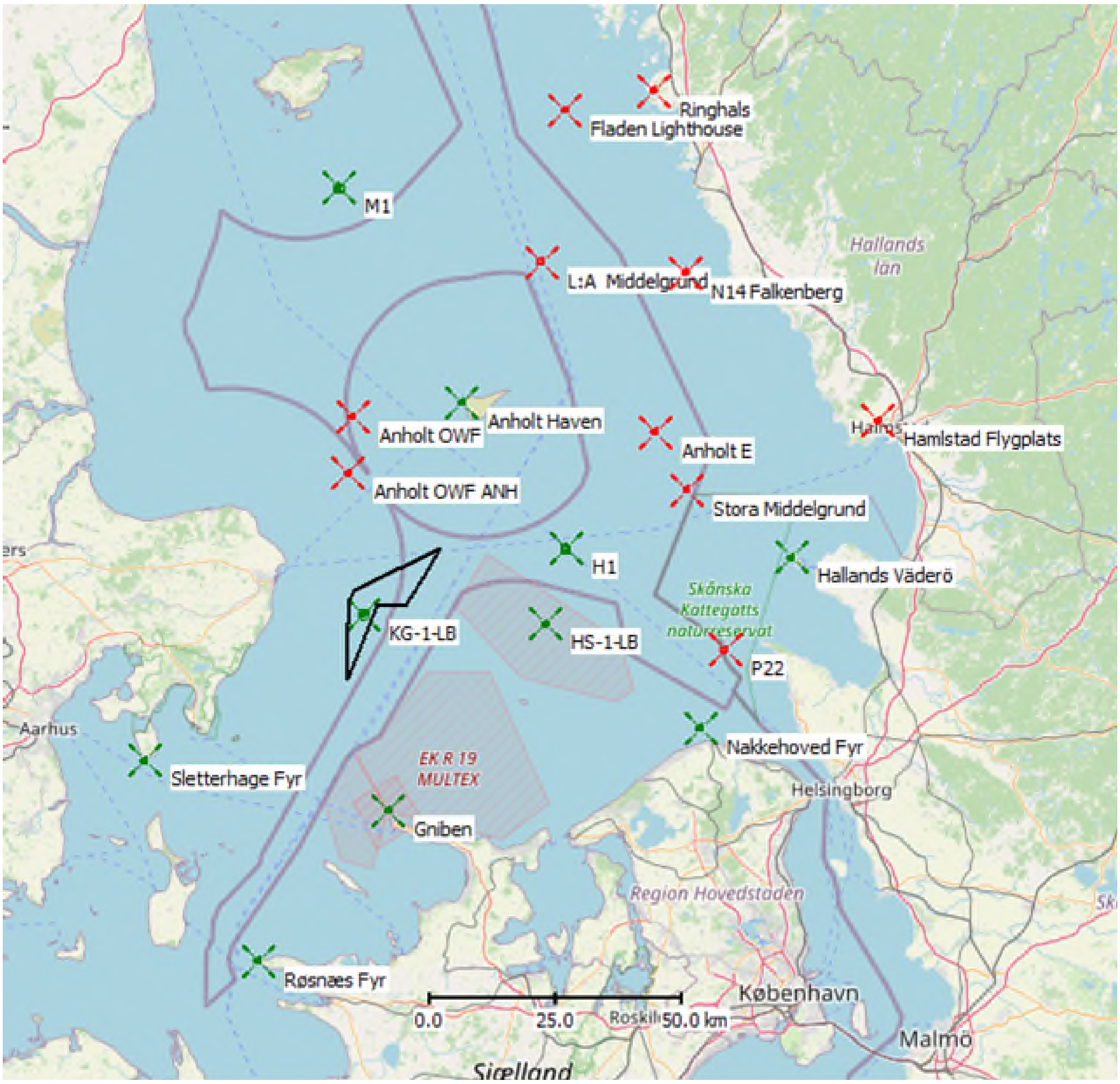


Figure 3. Location of considered measurement stations in Kattegat Sea, with used stations in green and discarded ones in red (black line: Kattegat wind farm area).

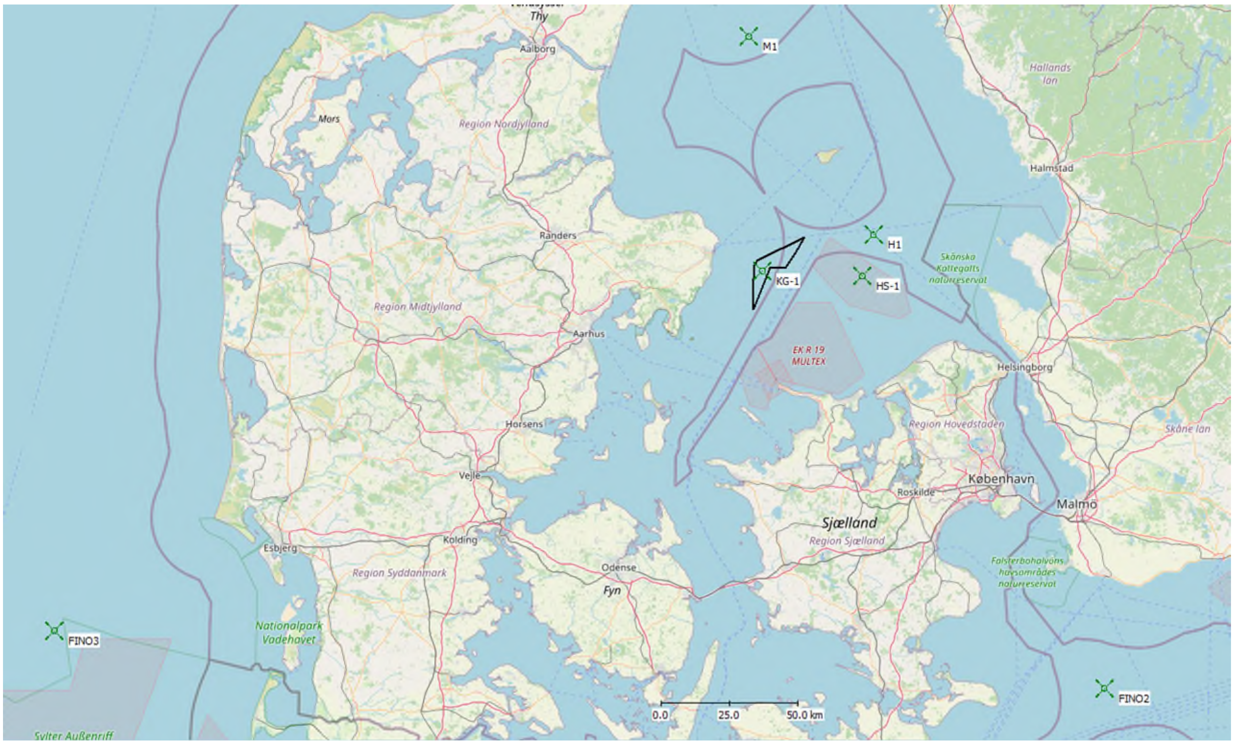


Figure 4. Location of measurement stations finally used for siting parameters (black line: Kattegat wind farm area).

4 On-Site Floating LiDAR Measurements

Energinet has commissioned one floating LiDAR measurements on site, operated by Fugro Norway AS. The deployment location is labelled KG-1-LB and the only buoy deployed on this location is WS199. The campaign was commenced on 21/07/2023 and it is still ongoing.

EMD has received documentation as listed in Table 5.

EMD has received measurement data as monthly batches covering the period 21/07/2023 to 21/03/2024, hence covering consecutive 8 months.

No motion correction is applied. Averaging over 10 minutes is considered sufficient to remove motion effects on mean wind speed data. This was verified during pre-deployment verification. The detrimental effects of motion on the turbulence measurements remain.

EMD has received documentation and measurements beyond those mentioned here, but those are not used directly in this study.

Table 5. List of documentation received on the Floating LiDAR Systems (FLS).

TITLE	SOURCE	DATE	CONTENT	REFERENCE
SWLB measurements - Danish Offshore Wind 2030, Project Measurement Plan, All Lots	Fugro	25/11/2023	Project Measurement Plan	[10]
SWLB measurements at Danish Offshore Wind 2030 – Lot 1	Fugro	05/12/2023	Description of instrument deployment, data collection and processing.	[11]
Danish Offshore Wind 2030 – Floating LiDAR Measurements, Monthly report (8 instalments)	Fugro	19/01/2024 – 11/04/2024	8 monthly reports on operation and measurements. Reports available 21 July 2023 – 21 March 2024	[12]
Danish Offshore Wind 2030 – Floating LiDAR Measurements, Service Report, Kattegat and Hesselø South, (3 instalments)	Fugro	20/03/2024 – 21/03/2024	3 service reports describing preparation and deployment of the buoy and current profiler	[13]
ZX1741, Independent analysis and reporting of ZX LiDARs performance verification executed by Zephir Ltd. at the UK Remote Sensing Test Site	DNV	23/05/2023	LiDAR verification report for ZX1741, mounted on WS199	[14]
WS199, Independent performance verification of Seawatch Wind LiDAR Buoy at Frøya, Norway	DNV	13/07/2023	Pre-deployment verification document for WS199	[15]

4.1 Buoy Positions

The buoy deployment positions are reported by Fugro as listed in Table 6.

The buoys positions are recorded in the logged data series. EMD has plotted a section of these and can confirm that the drift of the buoys is within 100 m (Figure 5). For all practical purposes the buoys can be considered stationary.

During the period 18/02/2024 to 22/02/2024, the buoy was recovered, repaired and redeployed. Figure 6 presents the logged positions after redeployment and confirms that the general locations of measurement are unchanged.

Table 6. List of wind speed measurement locations.

STATION	UTM WGS84, Zone 32		GEOGRAPHICAL COORDINATES WGS84	
KG-1-LB	636,013	6,247,276	11.2010°	56.3506°

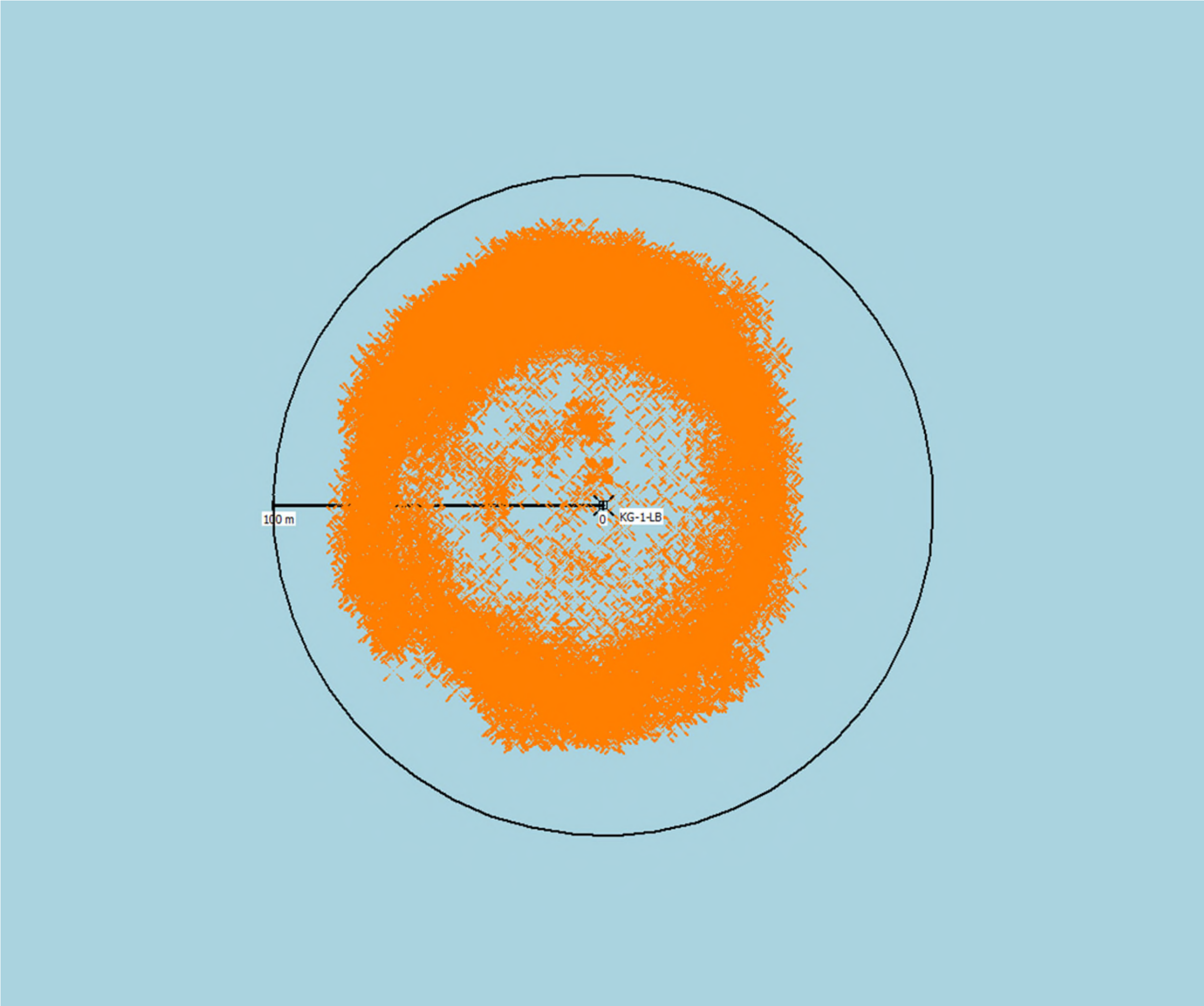


Figure 5. Position logs before recovering (18 February 2024) confirm a drift within 100 m (black circle) of stated location (black "X").

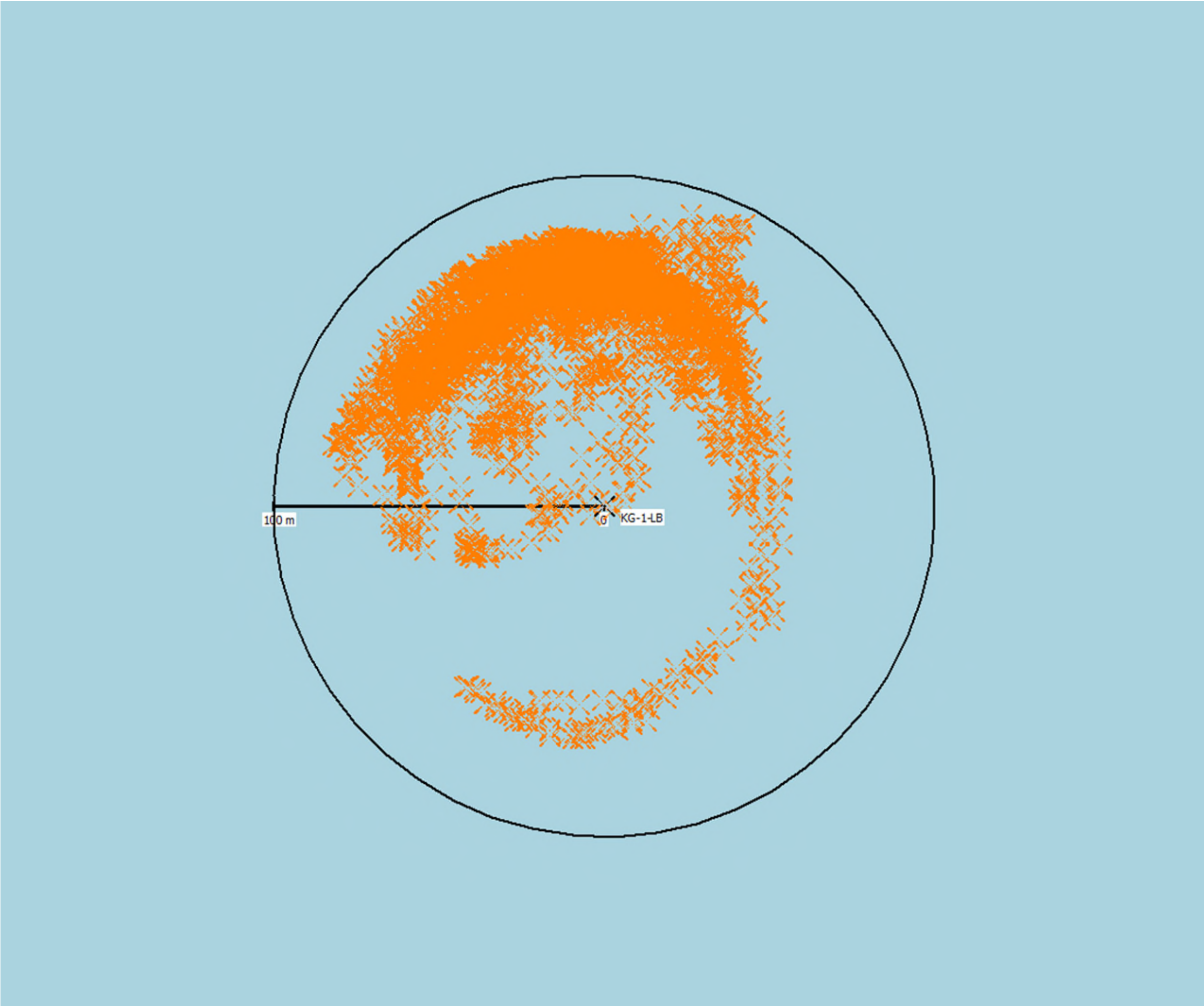


Figure 6. Position logs after redeployment (22 February 2024) confirm that the locations are unchanged (black "X").

4.2 Instrumentation

The SEAWATCH Wind LiDAR buoy (SWLB) and instrumentation is described in the measurement plan [11]. In the following, only instruments relevant for the analysis of the site wind conditions are described.

4.2.1 LiDAR

The LiDAR mounted on the buoy is a ZX300M LIDAR from ZX Lidars Ltd. This LiDAR model is classified by DNV [16] and has reached Stage 3 maturity [17].

The LiDAR (ZX1741) was verified at the Pershore, UK, an onshore test site operated by DNV-GL [14].

Once mounted on the buoy, the LiDARs was verified again by DNV at Frøya Norway against a ground-mounted onshore LiDAR of the brand ZephIR ZX300 [18].

The information from the classification and the verification is used to assess the measurement uncertainty of the LiDAR.

The LiDAR window is located at the top of the buoy and is as such elevated above sea level. This difference is compensated for in the provided data files, so that the stated height is height above sea level, not height above buoy.

4.2.2 Wind Direction

The Fugro buoys are equipped with three different wind direction sensors:

- A magnetic compass that indicates the wind direction relative to magnetic north.
- The Differential GPS (DGPS) system that provides wind direction relative to true north.
- A wind direction signal from the LiDAR meteorological station.

The DGPS is the primary source for wind direction data. If the DGPS is unavailable, the magnetic compass is used as a backup. The LiDAR met station's signal serves as the third option for measuring wind direction. To ensure accuracy and resolve any potential 180-degree direction ambiguities, the data are compared with readings from the Gill wind sensor. Consequently, the wind direction data from the buoys should be interpreted as relative to true north.

4.2.3 Additional Instrumentation

The Fugro buoys are equipped with additional meteorological instruments, including the Gill WindSonic ultrasonic wind sensor package, a Vaisala PTB330A air pressure sensor, and a Vaisala HMP155 sensor for measuring air temperature and humidity. Details of these specifications are outlined in reference [10].

Air pressure readings are taken at actual sea level. Measurements of temperature, humidity, wind speed, and direction are conducted at a height of 4.1 meters above sea level. However, as they are not used for shear or wind model analysis, they are assigned a standard height of 4.0 m by EMD.

The air temperature data is used for the assessment of site temperature and air density.

4.3 Operation History

The measurement campaign started on 21/07/2023. Fugro has submitted event logs tracking faults and flaws of the buoy [12]. Of these, only two events have had impact on the LiDAR data:

- The LIDAR stopped data collection for two days starting on 24/01/2024 due to abrupt input power outage.
- The buoy had been recovered for repairs on 18/02/2024 and redeployed on 22/02/2024. Therefore, the dataset has a 2-day gap due to service. EMD has verified and confirmed that the buoy was redeployed to the same location.

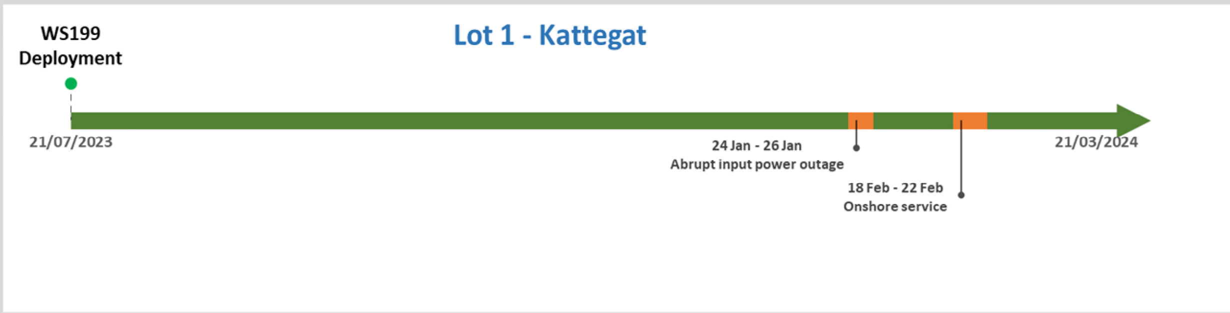


Figure 7. Timeline chart of buoy deployment on Kattegat site (KG-1-LB). Buoy ID (WS199) is indicated, green color marks provided data, orange color marks data gaps.

4.4 Post-Processing of Data

4.4.1 Quality Control and Filtering Performed by Fugro

Fugro has provided some information on the post-processing of the LIDAR data [11]. ZX LiDARs typically equip their instruments with a standard data filter, known as industry filter, designed to ensure the acquisition of high-quality data by eliminating data points that have a low signal-to-noise ratio. Fugro has disabled the industry data filter on the LiDAR data and has implemented a simpler filtering algorithm [10]. The processing of the LiDAR data by Fugro involves the following steps:

- Removing values outside of those times where the system is deployed at the target position.
- Check that data was saved for all 10-min intervals. Out of the 36-37 data packages produced every 10 minutes, a minimum of 9 packages (25%) are required to qualify as a valid measurement.
- Check for duplicates measurements.
- Removing out of range values (e.g. speed below 0.001 m/s and above 58 m/s, wind direction above 360˚)
- Apply 180˚ ambiguity fix on LiDAR wind directions using Gill directions.

Beyond the 9-data-package filter already provided by Fugro, EMD has determined that increasing the threshold for the number of data packets does not enhance the quality of the data. Therefore, no additional filtering based on packet count has been conducted.

The data from Fugro were organized into monthly files:

- Wind speed, wind direction and turbulence data were supplied in files named “KG-1-LB_M0x_WindSpeedDirectionTI.csv”.
- The package counter information was supplied in files named “KG-1-LB-LB_M0x_Status.csv”.
- Temperature, humidity and pressure data was supplied in files named “KG-1-LB_M05_MetOceanData.csv”.

It is understood that this setup is identical to the verification setup and that the verification is therefore valid with these filter settings.

4.4.2 Quality Control and Filtering Performed by EMD

EMD has conducted a qualitative, manual filtering process by comparing the LiDAR data with several mesoscale-derived datasets (EMD-WRF and NORA3). Data points where wind speed and direction substantially differ from these datasets have been excluded. Although the industry-standard filter was disabled, which may have allowed some faulty data points to pass through Fugro's simpler filtering, EMD has found that the overall quality of the dataset is good, with only a few such discrepancies identified.

Typical anomalies identified in the dataset include instances of peak wind speeds at great heights (over 130 meters) that occur for very brief periods and are not consistent with the wind speed and shear observed at lower altitudes. These discrepancies were specifically targeted during the manual filtering process to ensure the reliability of the dataset.

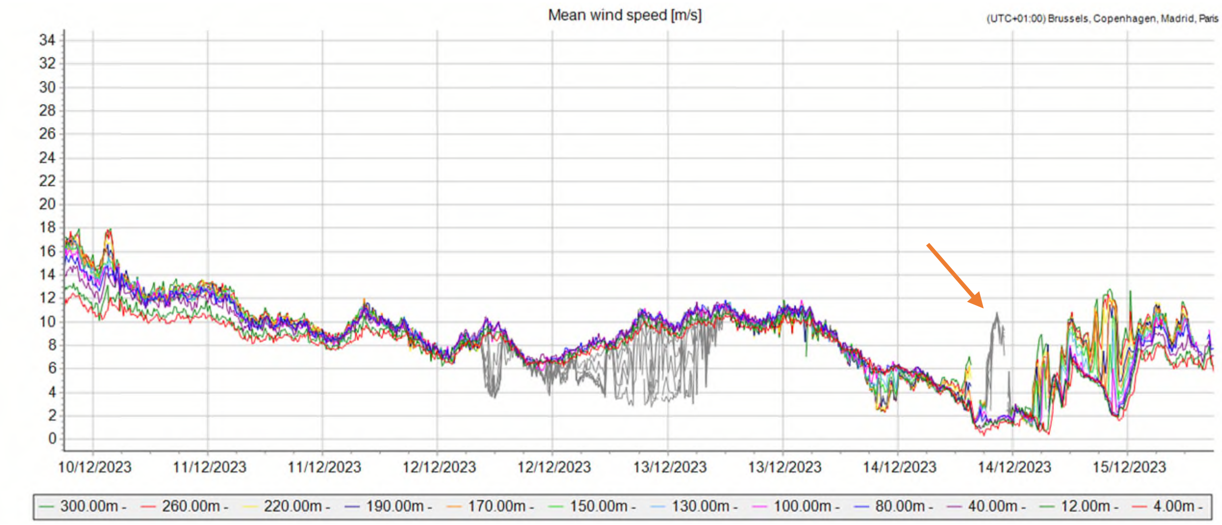


Figure 8. Example of short bursts of high wind speed at tall height disconnected from wind speed at lower height. Buoy WS199.

According to Fugro reports [11], the primary sensor for wind direction is measuring relative to true north. EMD has compared the wind direction signal against mesoscale derived dataset (EMD WRF) and finds the average difference within 1˚ at equivalent heights. EMD therefore finds the wind direction data correct with no need for adjustment.

However, at very low wind speeds, some remnants of the 180-degree ambiguity in wind direction measurements persist. Given the high uncertainty of wind direction at these low speeds, EMD has decided not to make any corrections to these data.

4.4.3 Recovery Rate and Data Substitution

With the industry filter disabled, the data recovery rate for the LiDAR measurements is substantially higher than is sometimes seen with ZX LiDAR instruments. Notably, the data recovery rates decrease with increasing height above sea level (ASL), and these rates are detailed in Table 9. Additionally, a small data recovery loss is still experienced due to the applied filtering.

To address some of the data loss, data substitution procedures were implemented: one based on measured shear on the Kattegat LIDAR (KG-1-LB), referred to as "shear repair" and another using data from Hesselø South LIDAR (HS-1), referred to as "horizontal repair". The shear repair procedure is prioritized over the horizontal repair due to its expected lower uncertainty.

The shear data substitution is based on a shear matrix created from the surrounding heights. Which height are used to create the shear matrix for each repair are listed in Table 9. The shear matrix is applied to the source height, also listed in below tables, to produce a synthesized dataset. An example of a shear matrix is presented in Table 7.

The synthesized data fills in gaps and replaces disabled data for wind speed and direction in the recorded dataset. However, the Turbulence Intensity (TI) signal is not reconstructed; instead, it is simply copied from data at a lower height.

The horizontal repair involves transferring data between the two LiDAR datasets (at KG-1 and HS-1) at the same measurement heights using a sectorial linear regression function based solely on original data (data generated through the shear repair procedure are not used in these transfers). High correlation between datasets from the two buoy datasets increase confidence in the transferred data (Table 8). To prevent distortions due to thermal stability, data transfers occur only between the same heights.

For each data transfer, 360 transfer functions are created for each 1˚ direction bin, using data from a 30˚ sector window. The functions for wind speed are first-order, while those for direction are zero-order functions (constants). The process avoids residual resampling to prevent random scatter. Only wind speed and direction data are repaired, with turbulence intensity data missing in the repaired time steps.

Table 9 lists the results of each repair procedure. The 12- and 40-meter heights are repaired only using the horizontal repair procedure, and the outcome of those repairs are not included in the presented table.

Table 7. Example of shear matrix, here for 150 m height ASL at KG-1-LB. Values are shear exponents α, which are calculated using data from three different height: 130 m, 150 m and 170 m.

Hour	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
00-02	-0.02	-0.11	0.01	0.11	0.03	0.09	0.10	0.05	0.13	0.18	0.17	-0.06
02-04	-0.11	0.03	-0.17	0.06	-0.02	0.06	0.13	0.12	0.12	0.13	0.20	0.17
04-06	0.04	0.00	0.00	0.05	0.01	0.04	0.15	0.16	0.06	0.16	0.09	0.01
06-08	0.02	0.11	0.04	0.03	0.05	0.05	0.14	0.12	0.11	0.13	0.13	0.00
08-10	0.01	0.04	0.04	0.04	0.07	0.06	0.08	0.07	0.09	0.14	0.14	0.14
10-12	0.00	-0.06	0.05	0.08	-0.01	0.04	0.10	0.06	0.11	0.14	0.22	0.06
12-14	-0.01	-0.02	0.01	0.14	0.09	0.07	0.05	0.05	0.08	0.14	0.12	0.01
14-16	0.00	0.08	0.02	0.20	0.03	0.07	0.11	0.07	0.11	0.14	0.10	-0.04
16-18	-0.06	-0.17	0.02	0.06	0.13	-0.02	-0.01	0.08	0.14	0.17	0.09	0.01
18-20	-0.05	0.00	0.00	0.05	0.02	0.06	0.07	0.07	0.07	0.14	0.13	0.06
20-22	0.01	0.01	-0.05	0.03	0.05	0.12	0.11	0.14	0.12	0.17	0.09	0.01
22-24	0.02	-0.05	-0.04	0.01	0.04	0.07	0.15	0.13	0.12	0.15	0.18	-0.01
All	**0.01**	**0.04**	**0.00**	**0.07**	**0.05**	**0.06**	**0.11**	**0.10**	**0.12**	**0.14**	**0.16**	**-0.01**

Table 8. Correlation coefficient, r, between KG-1-LB and HS-1 measurements at the equivalent height.

MEASUREMENT HEIGHT [m]	CORRELATION COEFFICIENT, r [%]
12	93.2
40	93.5
80	93.6
100	93.9
130	94.3
150	94.5
170	94.7
190	94.9
220	95.1
260	95.3
300	95.3

Table 9. Results of data repair.

REPAIRED HEIGHT [m]	80	100	130	150	170	190	220	260	300
Source height [m]	40	80	100	130	150	170	190	220	260
Shear matrix heights [m]	40, 80, 100	80, 100, 130	100, 130, 150	130, 150, 170	150, 170, 190	170, 190, 220	190, 220, 260	220, 260, 300	220, 260, 300
Recovery rate before repair	95.4%	94.8%	93.7%	93.5%	93.3%	93.1%	93.0%	92.7%	92.6%
Recovery rate after shear repair	97.3%	95.5%	94.9%	93.8%	93.5%	93.3%	93.2%	93.0%	92.9%
Recovery rate after shear and horizontal repair	100.0%	98.8%	98.2%	97.9%	97.8%	97.7%	97.5%	97.3%	97.2%
Share of repaired data	4.6%	4.0%	4.6%	4.5%	4.6%	4.7%	4.6%	4.7%	4.7%

4.5 Data Analysis

EMD has combined the datafiles, forming time series of wind speed, wind direction, turbulence intensity and data package count for each measurement height. For 4 m height, temperature, relative humidity and pressure is added. The signals for maximum wind speed and vertical wind speed are only added to the 150 m height dataset.

4.5.1 Wind Speed

The mean wind speed on the LiDAR measurements is calculated both as arithmetic mean wind speed and as Weibull-derived mean wind speed through a Weibull fit. The Weibull fitting is done in windPRO using an energy conservation condition.

The following table summarizes the resulting wind speeds before and after data substitution.

Table 10. Weibull parameters of the repaired datasets.

HEIGHT [m]	PERIODS [MONTHS]	BEFORE DATA SUBSTITUTION	AFTER DATA SUBSTITUTION			
		ARITHMETIC MEAN WIND SPEEDS [m/s]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL – A PARAMETER	WEIBULL – k PARAMETER
4	8	7.76	7.74	7.73	8.72	2.314
12	8	8.32	8.32	8.29	9.36	2.290
40	8	9.28	9.29	9.27	10.46	2.281
80	8	9.93	9.93	9.90	11.18	2.263
100	8	10.14	10.15	10.13	11.44	2.256
130	8	10.40	10.41	10.42	11.77	2.246
150	8	10.54	10.55	10.57	11.94	2.234
170	8	10.66	10.67	10.71	12.09	2.221
190	8	10.77	10.78	10.83	12.23	2.210
220	8	10.92	10.93	10.98	12.40	2.184
260	8	11.10	11.11	11.16	12.60	2.155
300	8	11.26	11.27	11.31	12.77	2.114

Further details on the directional wind speed and Weibull distribution can be found in Appendix C.

4.5.2 Turbulence Intensity

Standard deviation of wind speed and hence turbulence intensity from LiDAR measurements are not immediately comparable to those of cup anemomters. The standards reffered to in this study do not recognize turbulence intensity mesurements from LiDARs and the observed turbulence data from KB-1 are therefore not used or documented here. They are however included in the datapackage produced as part of the deliverables.

4.5.3 Wind Direction

The wind direction distribution for the 8 months of measurements is presented in Figure 9. There is a rotation of the wind direction clockwise with increasing height of 10.3 degrees from 40 m to 300 m, amounting to a rate of 0.040 degrees/m (Figure 10).

The direction distribution for each height can be found in Appendix C.

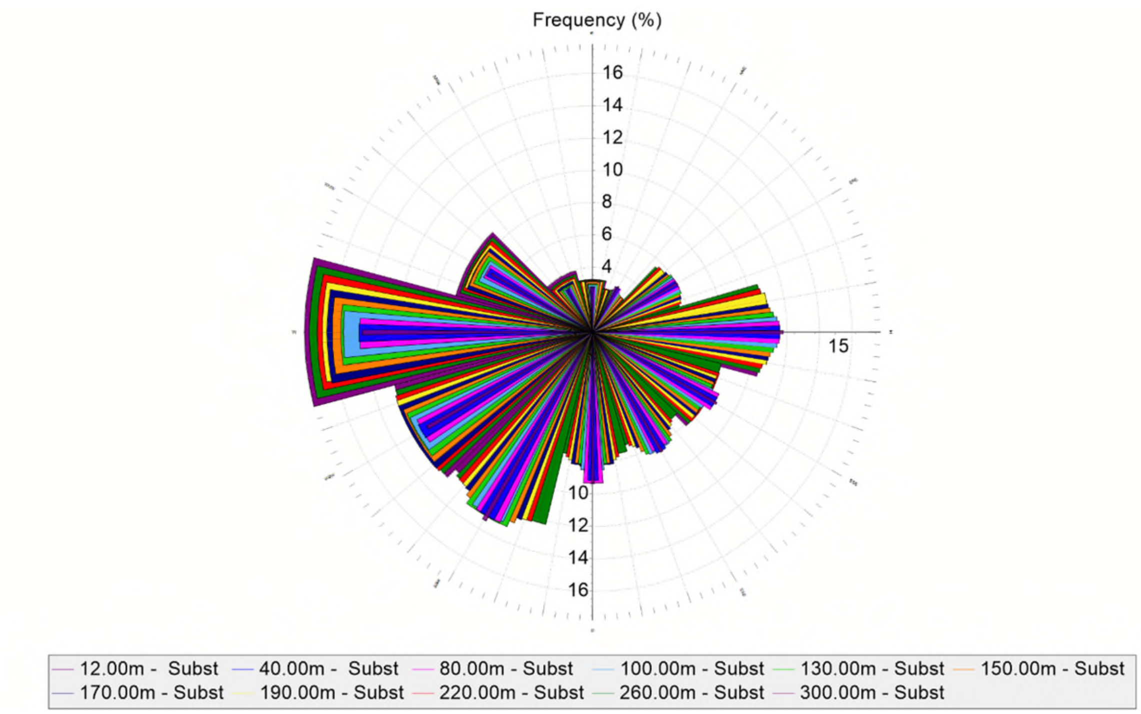


Figure 9. Directional distribution at selected heights of LiDAR measurements.

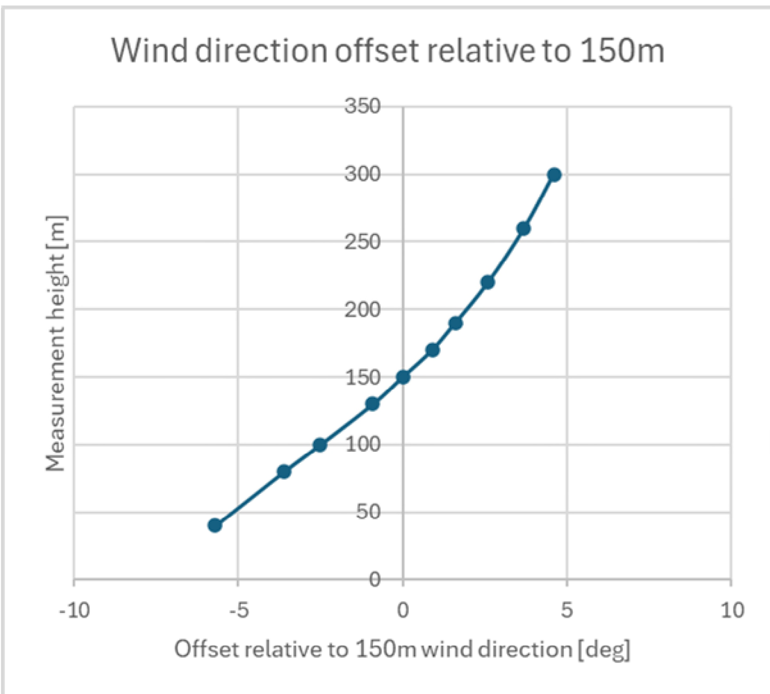


Figure 10. Rotation of wind direction relative to 150 m measurements.

4.5.4 Diurnal Variations

There is a minor variation in wind speed across the day with marginally higher wind speed at night and lower wind speed at daytime.

The temperature at the buoy is almost uniform across the day.

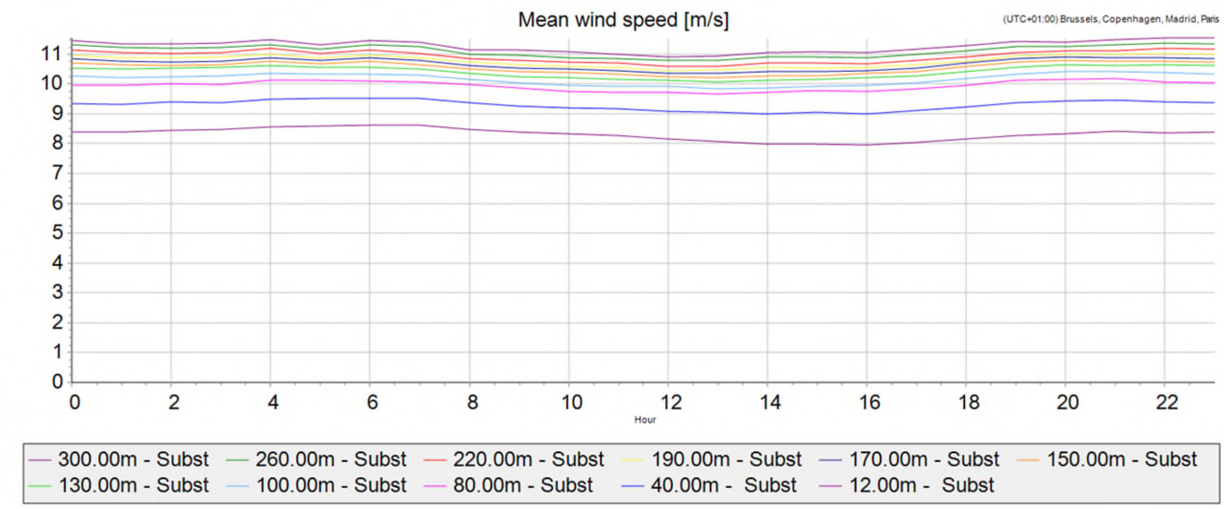


Figure 11. Diurnal wind speed variation.

4.5.5 Seasonal Variations

The specific year of measurement has the typical pattern for the region with higher wind speed during winter than during summer.

The temperature at 4 m height varies across the year from a mean temperature in January of 1.7˚C to 17.3˚C in August.

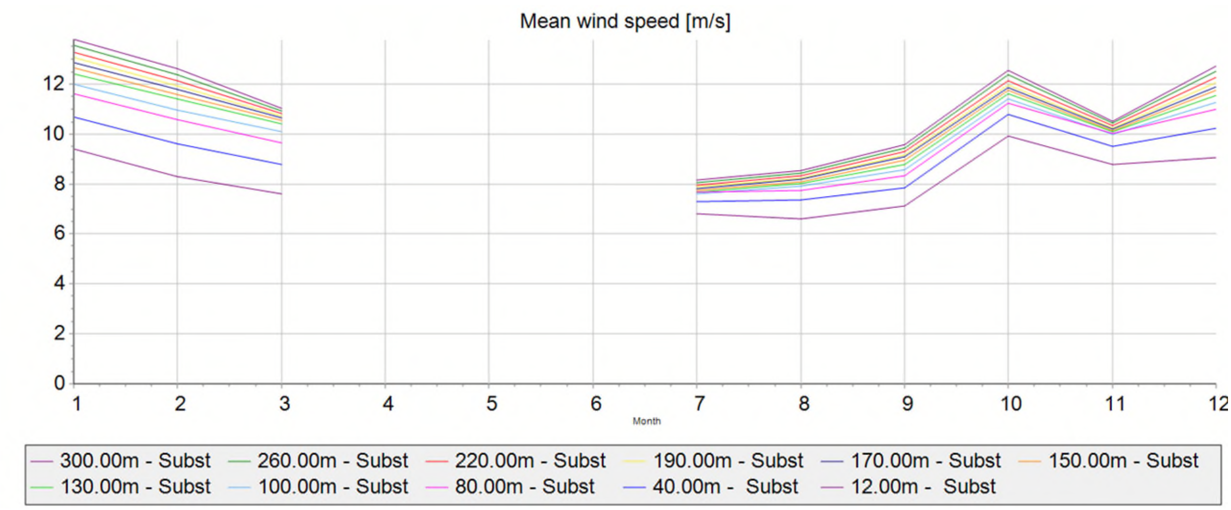


Figure 12. Monthly mean wind speed.

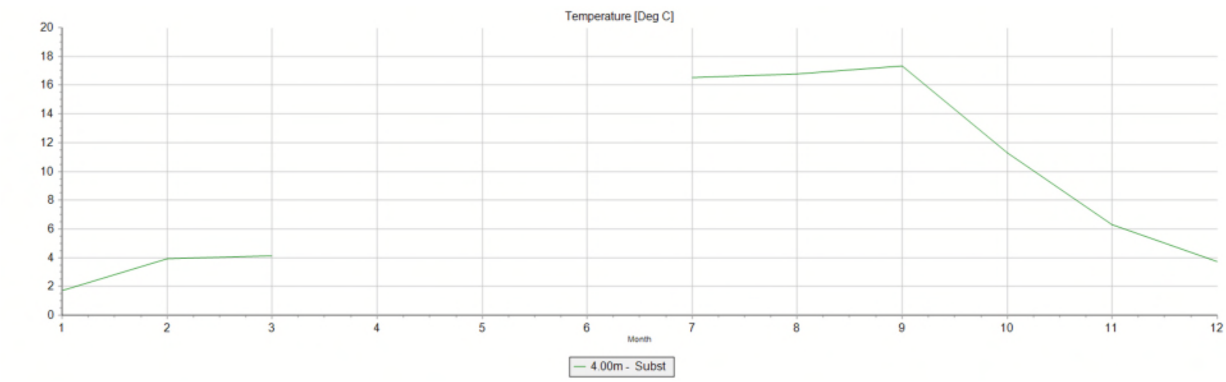


Figure 13. Monthly mean temperature.

4.6 Measurement Uncertainty

Measurement uncertainty of the LiDAR measurement consists of three components:

- Classification uncertainty
- Verification uncertainty
- Data repair uncertainty

The classification uncertainty, giving the maximum expected uncertainty, is obtained from the ZX300 classification document [16] as 1.41% (average at 130 and 135 m height). These heights are the tallest heights reported and are here considered representative of the 150 m measuring height. The classification table is included in Appendix B.

The verification of the WS199 buoy mounted LiDARs was provided [15]. The test site was at the Frøya, Norway.

In this studies the Key Performance Indicators (KPI) according to the OWA Roadmap [19] are tested and the verification uncertainty is here calculated according the method suggested by the CT/OWA LiDAR Uncertainty Standard Review [20]. All KPI's were successfully fulfilled.

The reference LiDAR at Frøya is also ZX Z300 LiDAR and both reference LiDAR and the buoy mounted LiDARs were verified prior to the verification test at Pershore test site, UK.

The verification uncertainties from the verification reports are included in Appendix B for 140 m and 160 m, the closest heights to 150 m. The average of the two uncertainty assessments is used. Verification uncertainty is calculated by frequency weighting the uncertainty at each wind speed. For both 140 m and 160 m this uncertainty is 1.98%, hence the average of the two heights is also 1.98%.

The uncertainty from the vertical data repair is found by assuming a 20% uncertainty on the wind speed change from source to destination. With a 1.3% wind speed difference (from 130 m to 150 m), this results in an additional uncertainty of 0.32% on wind speed of the synthesized data. At 150 m, the vertically synthesized data contribute 0.2% of the dataset at KG-1-LB. Resulting vertical data repair uncertainty is 0.001% at KG-1-LB.

For the horizontal data repair at 150 m, a linear regression method is used to transfer data from the HS-1 dataset (Buoy SWLB059/WS190) to the KG-1-LB dataset. The transfer function has a mean bias error of -0.15% and an RMS error on hourly basis of 14%. Using the same procedure as used for assessing LiDAR verification uncertainty (wind speed binned mean deviation), the transfer function uncertainty is assessed to 3.8%. This additional uncertainty applies to the horizontally synthesized part of the dataset at KG-1-LB (4.2%), resulting in an uncertainty component of 0.159%.

Combined, vertical and horizontal data repair contribute 0.16% uncertainty to the measurement dataset at KG-1-LB at 150 m.

The verification and classification uncertainty are combined together with a contribution from the data repair to a combined uncertainty on the LIDAR measurements at 150 m (Table 11).

Table 11. Wind speed measurement uncertainty at 150 m ASL.

DATASET	CLASSIFICATION UNCERTAINTY	VERIFICATION UNCERTAINTY	DATA REPAIR UNCERTAINTY	TOTAL MEASUREMENT UNCERTAINTY
KG-1-LB (WS199)	1.41%	1.98%	0.16%	2.43%

5 Reference Data

Mesoscale data have been obtained for the dual purpose of long-term correcting the onsite measurements and calculating a wind speed gradient across the wind farm area. The period length is limited by the data availability and has afterwards, through a consistency analysis, been curtailed to an appropriate length.

Different mesoscale and re-analysis products have been used as long-term data sources:

- 34 years of ERA5 merged with the preliminary ERA5(T) [21] for the last 3 months, hourly data at a height of 100 m AGL have been obtained. ERA5 is a climate reanalysis dataset developed through the Copernicus Climate Change Service (C3S) and processed/delivered by ECMWF. ERA5(T) is the initial release of ERA5 with availability 5 days behind real time. ERA5 is final data with availability 2-3 months behind real time, hence the merging of ERA5(T) to the ERA5 data for the missing months of the period. The locations are the closest available data node to the buoy.
- 25 years of EMD-WRF On-Demand [22], high resolution mesoscale data have been obtained. The mesoscale model developed by EMD (http://www.emd.dk) has been run for the location of the Kattegat measurements. ERA5(T) data from ECMWF (http://www.ecmwf.int) has been used as the global boundary data set. The temporal resolution is hourly. Similar datasets have been obtained for the locations of selected supporting datasets including the location of a third location for the site parameter analysis.
- 25 years and 1 month of NORA3 [23] data have been obtained. The NORA3 data have been sourced from the Norwegian Meteorological Institute. The NORA3 dataset uses a combination of ERA5 reanalysis data and an extensive surface model database. Instead of a WRF model, the NORA3 model is processed using the HARMONIE-AROME model. The model grid is 3 km, and the temporal resolution is hourly. The closest available node is used. The data is available until 31/01/2024.

The location of the mesoscale reference data around KG-1-LB is presented in Figure 14 and Table 12. All data are extracted through windPRO software.

Table 12. Mesoscale data position and period length.

	EMD-WRF	ERA5(T)	NORA3
Position/Node	11.201°E 56.350°N	11.250°E 56.250°N	11.181°E 56.357°N
Start (data used)	01/01/1999	01/01/1990	01/01/1999
Stop (data used)	01/04/2024	21/03/2024	01/02/2024

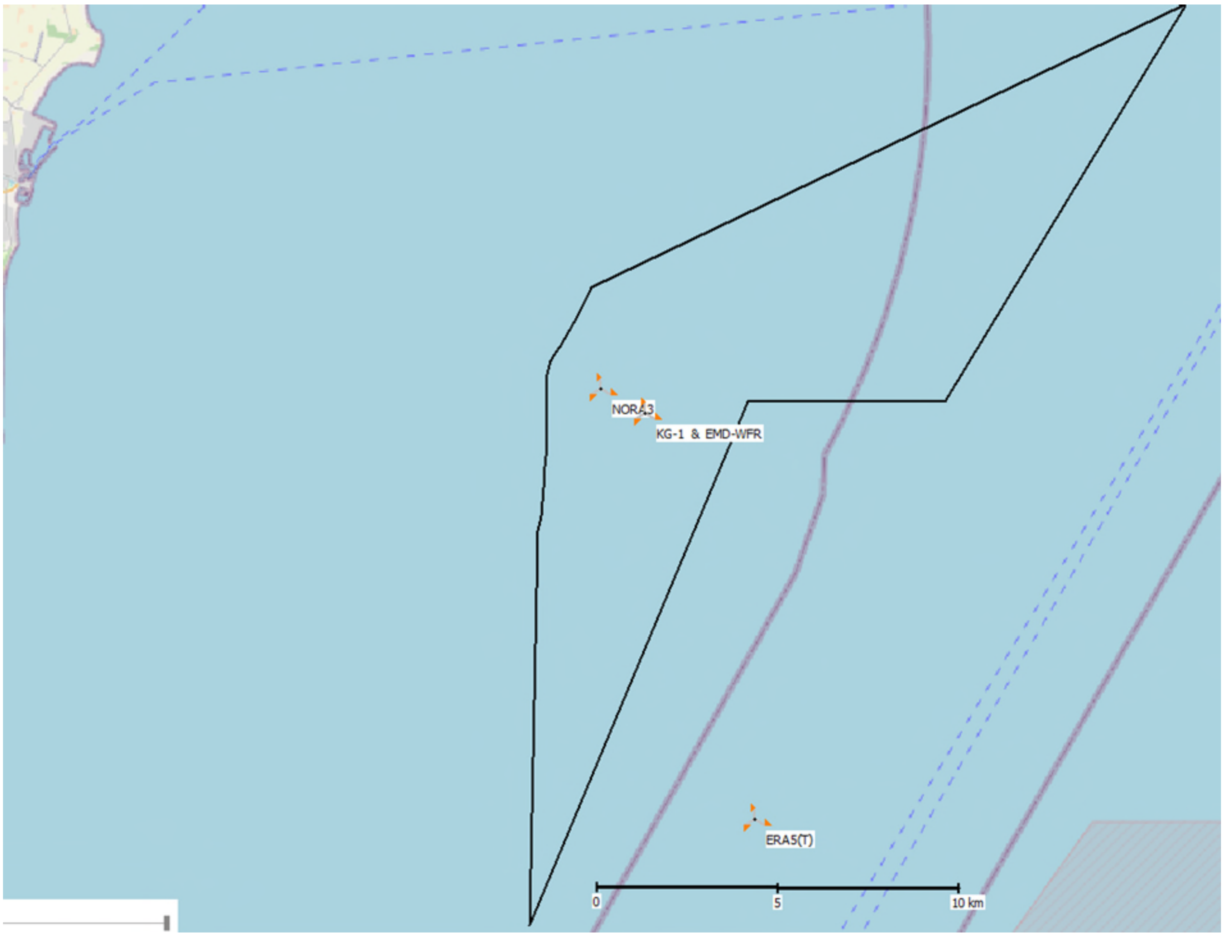


Figure 14. Location of modelled and mesoscale reference data near KG-1-LB.

6 Long-term Correction

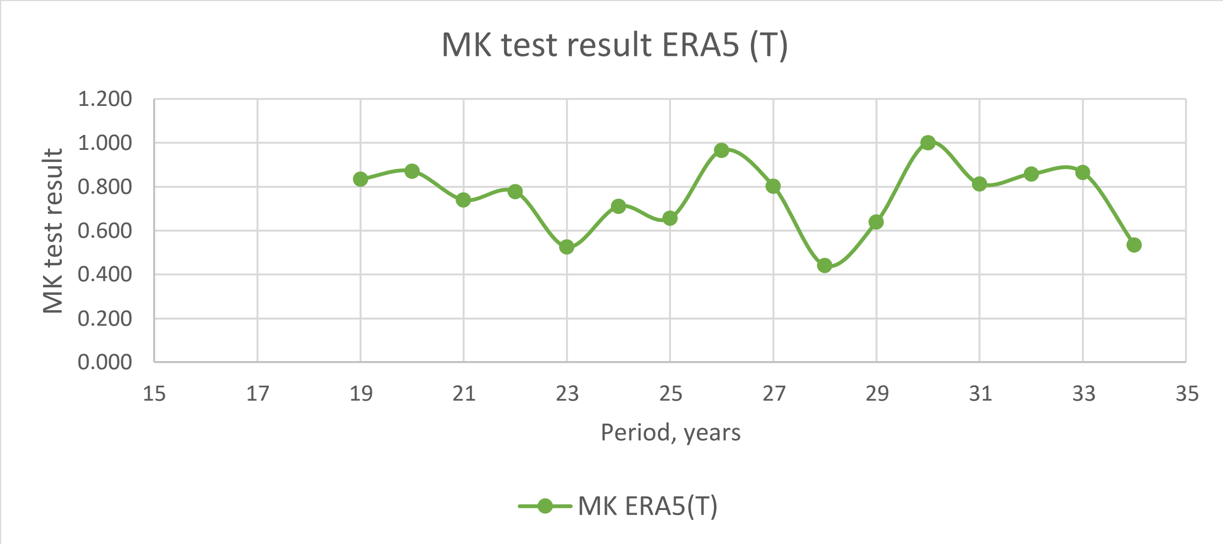
6.1 Review of Reference Data

6.1.1 Long-term Consistency & Selection of Reference Period

The consistency of historical wind reference data is of vital importance when determining the long-term variation of wind speed. EMD has conducted consistency checks on the data sets in order to ensure that these would be suitable for use. These checks aim to identify trends and to establish a suitable baseline period. Two metrics have been used: The Mann-Kendall trend test and production indices.

To avoid trends in the data set, EMD recommends, based on experience, a Mann-Kendall (MK) [24] test value above 0.4, but preferably higher. Analysis of the ERA5(T) dataset using the Mann-Kendall trend test [24] indicated the dataset back to 1994 (30 years) results in a high MK value (1.00) with no trend in the time series. The mean wind speed of the 30-year period 1994-2023 at 100 m of the ERA5(T) dataset is 8.95 m/s. Similar results of high MK value (0.965) and wind speed (8.96 m/s) with a 26-year period (1998-2023) can be observed in Figure 15. Such periods can be qualified as long-term representative and consistent. The mean wind speed for a 22-year period (2002-2023) can also be considered as a proper reference period since it also has a mean wind speed of 8.96 m/s. This period has a lower but still good MK value of 0.778. Using a 22-period allows to include more data sets which wouldn't have been available for a 26 or 30-year period.

An alternative measure of considering consistency in long-term data is to compare windiness index. A windiness index can be constructed by scaling the wind speed to the expected long-term wind speed at the site, applying a power curve to each record and dividing by the average of the records. The index value serves as an energy index value for each period considered. As a starting point, a windiness index was calculated using the period 1994-2023 as baseline, reflecting the long period of data available in the ERA5 dataset. This is plotted in Figure 15 as average index of period.



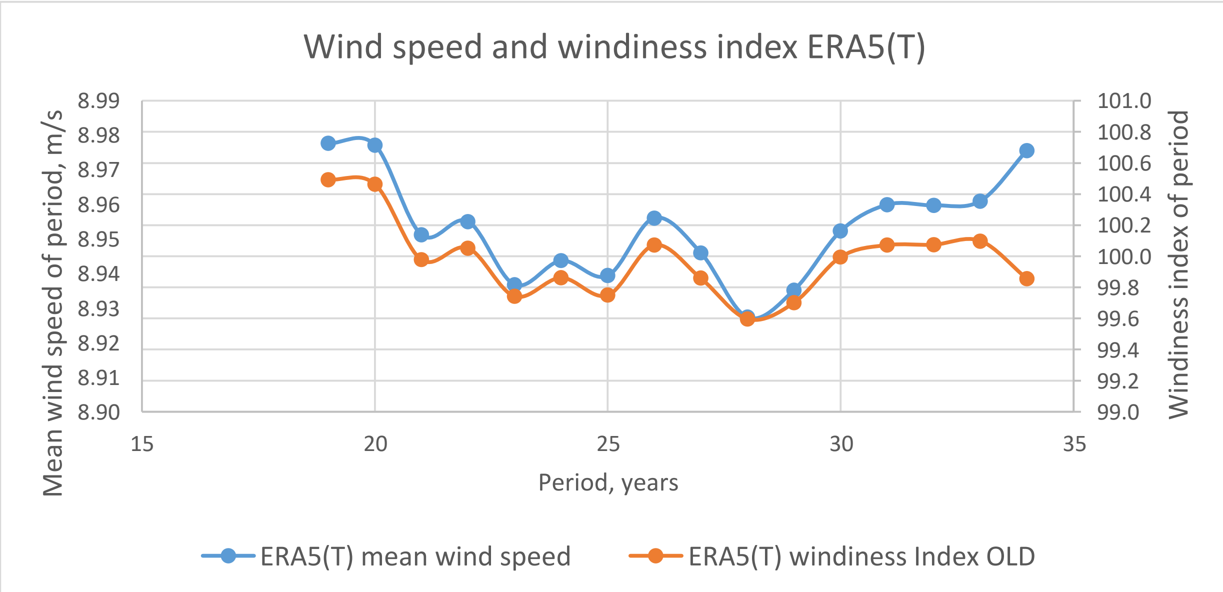


Figure 15. Consistency tests on ERA5(T) data. Period length in years dating back from January 1st, 2024, are analyzed for M-K trend test, mean wind speed and windiness (energy) index of period. Baseline period 2002-2023.

Based on the 30-year base line period, the index of different periods as plotted in Figure 15 varies between 99.6 and 100.5 with a median value of 99.9. The 26- and 22-year periods have both an index value of 100.1, which confirms that these periods are consistent with each other and also representative of the long-term energy level.

It can be noted that the variations of mean wind speed and energy index of different periods is rather limited.

Finally, the 22-year period of 2002-2023 is selected as the base line period since it has proven to be consistent, based on wind speed comparison with the 26-year and 30-year period, and for this shorter period the population of available reference data is larger. The 22-year period can therefore be considered representative to the long-term period for even longer periods than 22 years.

Since EMD-WRF data and to some extent NORA3 data are derived from ERA5/ERA5(T), these datasets can be expected to have similar consistency properties. A comparison of the ERA5(T)-based wind index with the EMD-WRF-based wind index confirms that the above conclusions based on ERA5 are also valid for EMD-WRF. The index of the ERA5 data for the period 2002-2023 is indeed perfectly correlating with the index for EMD-WRF data.

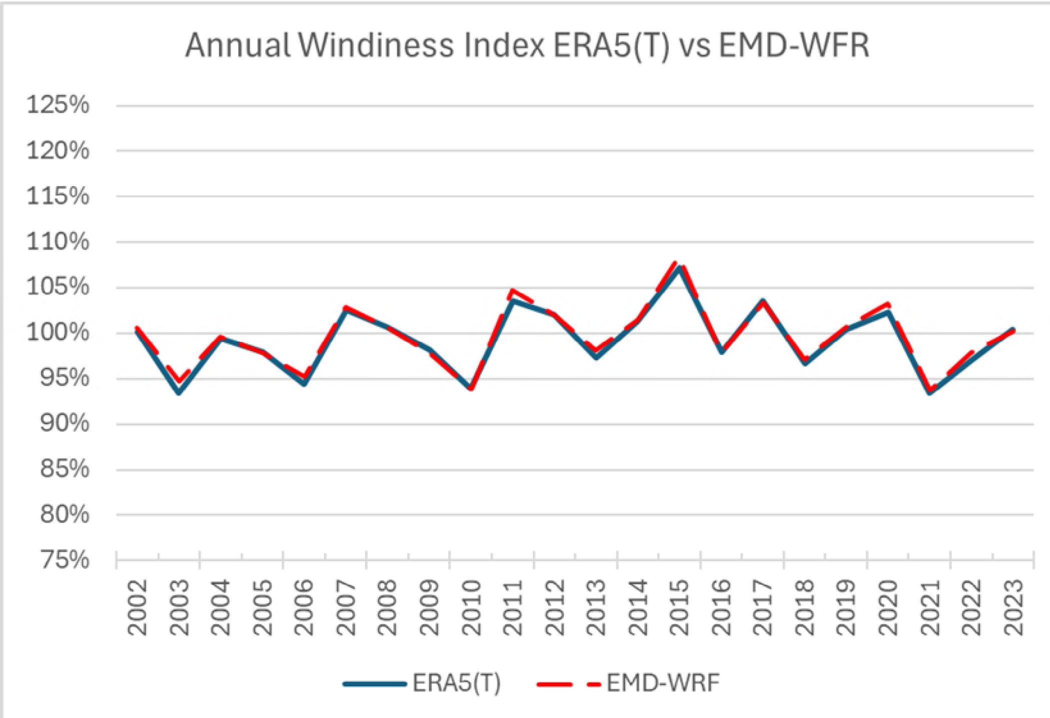


Figure 16. Annual windiness (energy) index for ERA5(T) and EMD-WRF data. Baseline period: 2002-2023.

Similar plots are made with six of the secondary ground stations described in Appendix A, where a long continuous time series are available. It is clear that Nakkehoved is very trended and unsuited to verify the trend at Kattegat. The Anholt data have similar problems. There are here three distinct periods: Until 1999, from 1999 to 2012 and after 2012 with larges offsets between each which could mean the mast may have been moved or significantly changed. In any case, it cannot be used to verify the trend at Kattegat. Data from Gniben and Røsnæs are of higher quality, consistency-wise, and while not giving a perfect match, go a long way to confirm the pattern seen in the ERA5(T) data. Data from Väderö show a good match as well, except for the years impacted by data recovery issues. Sletterhage shows a downward trend.

A diagram superimposing the windiness index of progressively longer periods (Figure 18), show the trends of ERA5 imitated by Gniben and Røsnæs.

The analysis of windiness indices from secondary data therefore confirms the selection of the period of 2003 to 2023 as long-term representative and consistent.

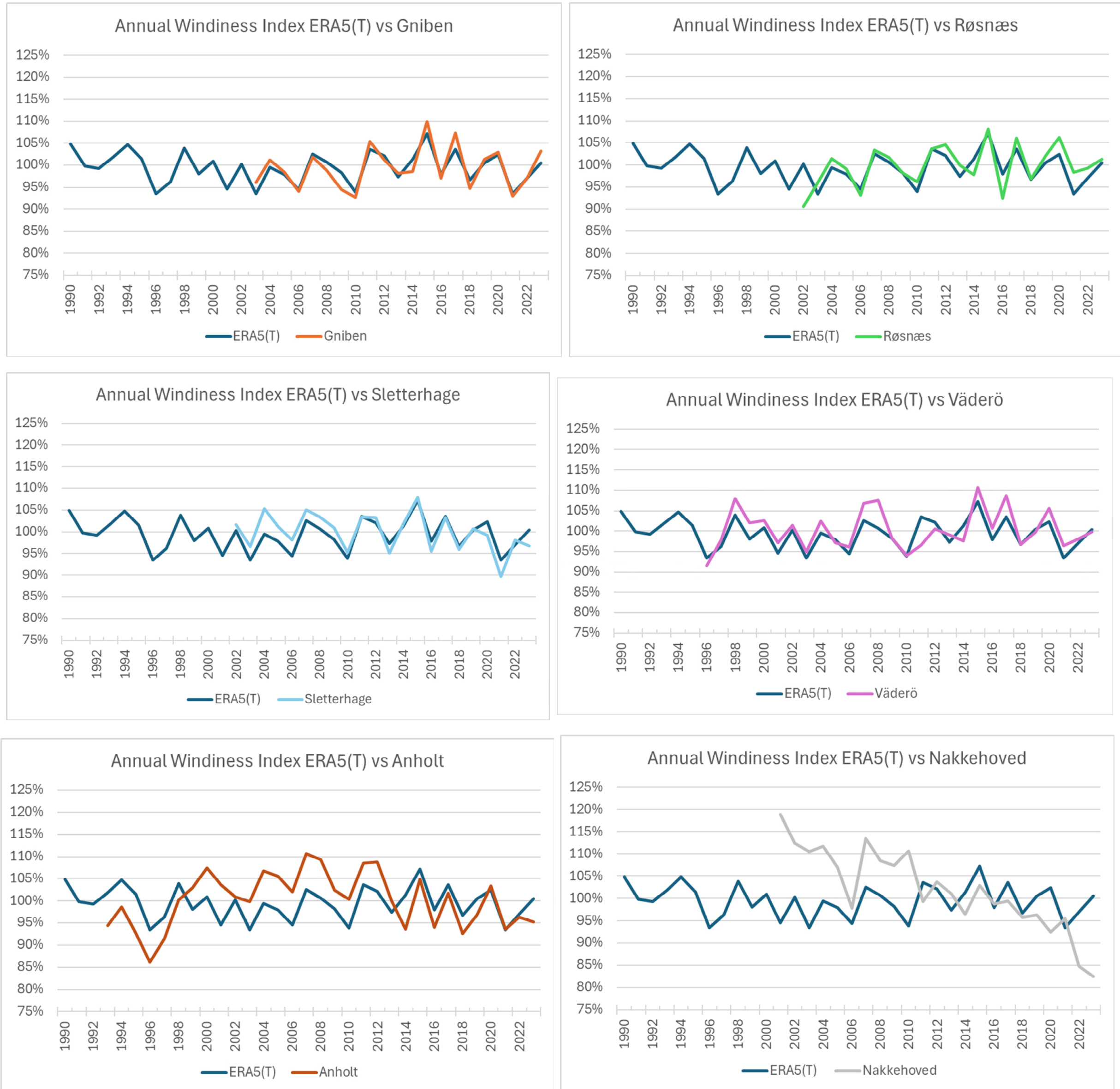


Figure 17. Annual windiness indices for a selection of secondary meteorological stations.

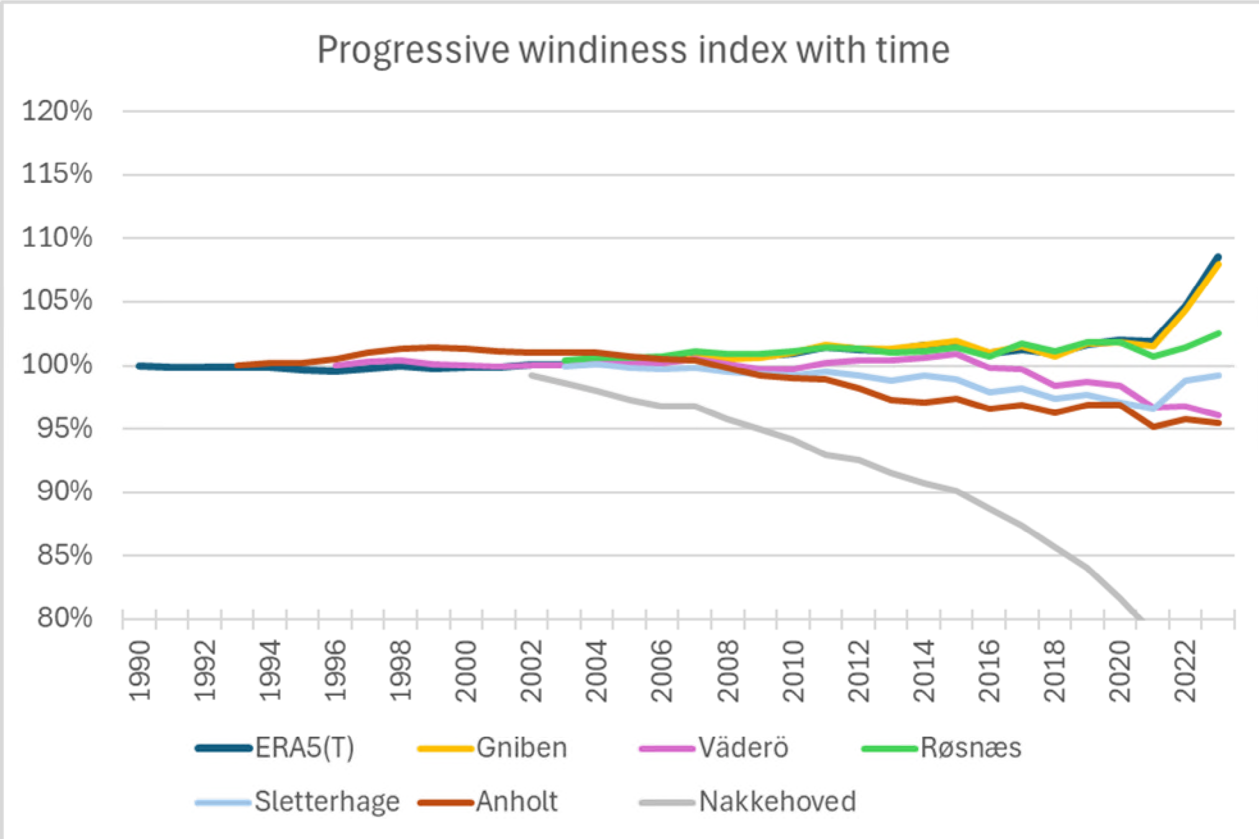


Figure 18. Progressive windiness index with time. The index of each year is the average of all following years.

6.1.2 Selection of Reference Data

Three potential reference datasets were considered for long-term correction of the LiDAR measurements from KG-1-LB. These are the three datasets described in section 5: EMD-WRF, ERA5(T) and NORA3. The data have all been successfully evaluated for use as long-term reference, passing all tests as described above. The correlation r of the data sets with the LiDAR data is equally high for all datasets. NORA3 does not cover the entire measurement period (6.3 concurrent months with the LiDAR). This places it for at a disadvantage compared to the other datasets which are covering the whole measurements period (8 months). Since the measurement period does not cover a full year, priority must be given to datasets allowing for the longest concurrency between the reference and the measured datasets. NORA3 remains useful though as validation of the long-term correction.

The standard deviation on the resulting long-term wind speed across references and three different methodologies is limited to 0.09 m/s on 150 m measurements. There is a good match in predicted long-term wind speed across the selection of reference data and MCP methodologies. The overall best performances are obtained with EMD-WRF data together with the Matrix methodology as described in section 6.2. EMD has decided to proceed with EMD WRF as reference.

The reference dataset is 22 years of EMD-WRF data at KG-1-LB covering the period 01/01/2003 to 31/12/2022. The dataset is available in the data package.

6.2 Correlation between Onsite and Reference Data

6.2.1 Wind Speed and Energy Correlation

The concurrent period of LiDAR data and EMD-WRF data is 8 months (21/07/2023 to 21/03/2024).

The correlation of the wind speed between LiDAR measurements and EMD-WRF data is high.

Correlation coefficient, r, is calculated without averaging. That means that the 10-minute data of the LiDAR measurements are correlated with the hourly value of the reference data with the assumption that the hourly reference data value represents the last 10-minute period of the hour. That may not actually be the case, but the observed scatter is from the 10-minute measurements are important for the following long-term correction.

The wind energy dataset is calculated by applying a power curve (NREL IEA 15 MW reference turbine) to the measured and reference data time series and divide with the average production. This is a measure of what a turbine would produce in a given period relative to average. Correlation is calculated on monthly averages and represent the seasonal variation in production output.

Table 13. Correlation coefficient r between the reference data (EMD-WRF, 150 m) and the onsite floating LiDAR data at 150 m ASL.

REF: EMD-WRF	KG-1-LB
Wind Speed Correlation, r [%] hourly	0.95
Wind Energy Correlation, r [%] monthly	0.99

6.2.2 Wind Direction Correlation

According to the instrument description from Fugro [11], the wind direction of measurements is referenced to true north with a secondary compass oriented against magnetic north (see section 4.2.2). Upon verification with EMD-WRF data an average deviation in wind direction was found within -0.8˚, confirming that the measured wind direction is correct.

There is a good match of wind direction roses between the LiDARs (150 m) and EMD-WRF (150 m) concurrent data (Figure 19).

The 8 months of concurrent data does not represent a long-term representative directional distribution, as the comparison of EMD-WFR data on the measurement period and on the long-term period shows on Figure 20. For example, the eastern and western sectors have been more frequent during the measurement periods than on the long-term. It must be expected that a long-term correction of data will change the observed directional distribution.

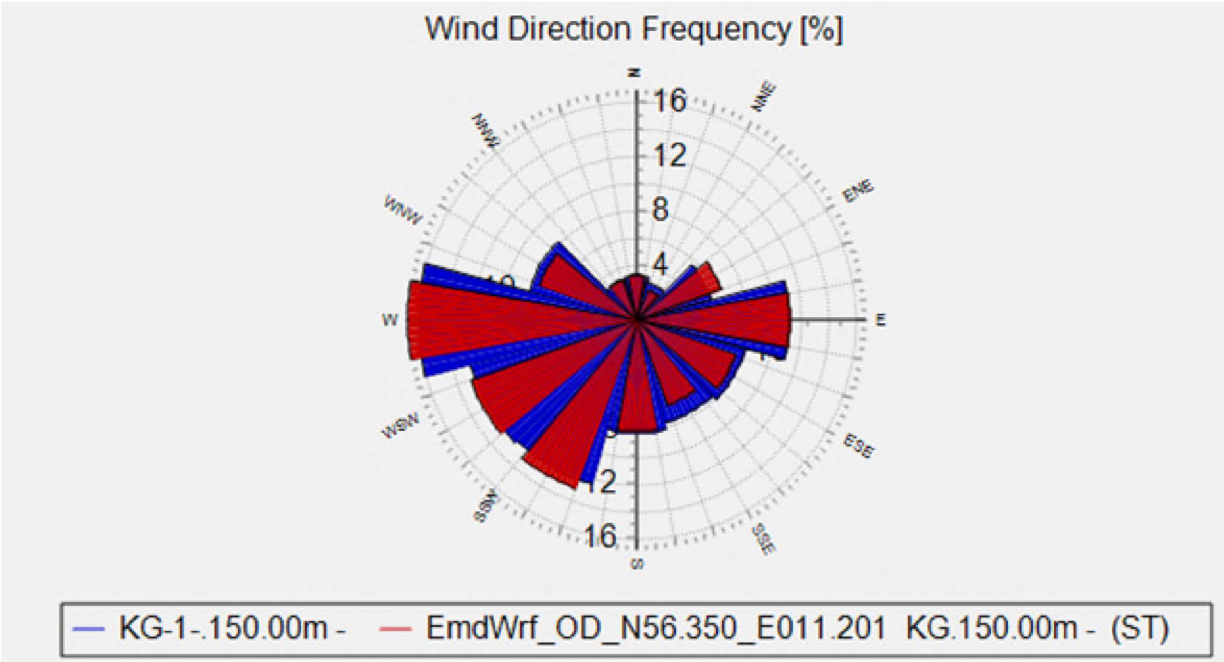


Figure 19. Wind direction roses for the concurrent period of LiDAR (blue) and EMD-WRF (red) data.

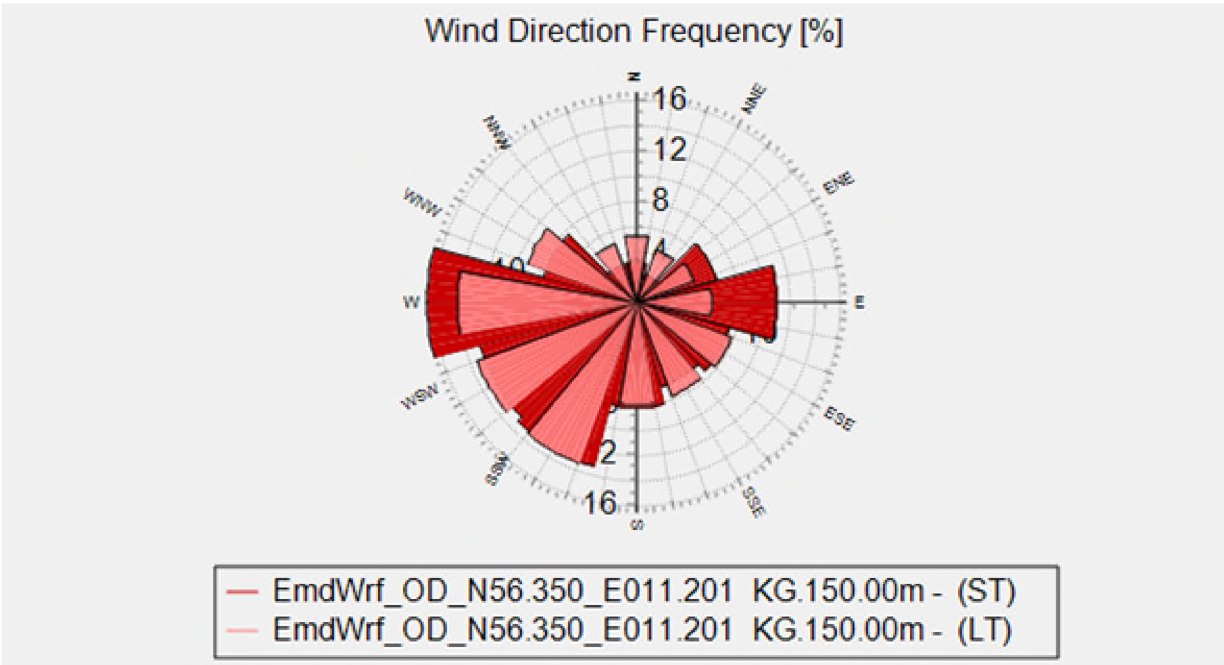


Figure 20. Wind direction roses for EMD-WRF data. Light red represents the entire long-term period and deep red the period concurrent with LiDAR measurements.

6.2.3 Long-term Correction and Validation

EMD has several long-term correction methodologies at disposal. A full description of these can be found in the windPRO reference document on Measure-Correlate-Predict (MCP) methods [25].

With 8 month of data coverage, there is a high risk of seasonal bias. There is no need to curtail the period of the measured data.

The relevant windPRO methodologies that will correct for the wind direction are linear regression, neural network and the matrix methods.

The performance of each method is tested through a 24-hour slicing test. In this test, the transfer function is trained of every second day of the data set and used to predict a period consisting of every other day. The metric for comparison is the Mean Bias Error (MBE) on production output, which is comparable to the difference in turbine production in percentage between using measured or predicted data. The result of this test is presented in Table 14.

A similar test is done using the entire concurrent period, which amounts to a self-test.

Additionally, the Kolmogorov-Smirnov (K-S) test metrics using each method are presented in Table 14. The K-S test measures the maximum difference between measured and predicted wind distribution and is an expression of how well the observed wind distribution is captured by the prediction [25].

The Neural network methods is disqualified since it gives high MBE on the production output. The matrix method generally produces the smallest error and gives satisfying results in predicting the direction distribution and Weibull distribution shape (the K-S test). The matrix method provides the median predicted mean wind speed value.

The long-term correction has been performed using a wind speed/direction matrix. The windPRO Matrix MCP method is described by developing a relationship matrix for the wind speed bins and direction bins between the wind data at the reference and a concurrent period of wind data from the local site and applying this relationship matrix to all the long-term wind data to determine the estimated site data wind climate. This method corrects for changes in both wind speed and direction.

Table 14. Prediction test using a 24-hour slicing method and a self-test using the entire concurrent period. The parameter presented is over-prediction of production in percent. (KG-1-LB - 150 m data).

REFERENCE: EMD-WRF LOCAL DATA: KG-1-LB, 150M	LINEAR REGRESSION	NEURAL NETWORK	MATRIX
24-hour slicing test, % production	-0.20	2.67	-0.08
Concurrent period test, % production	0.35	2.08	-0.10
Kolmogorov-Smirnov test, %	3.31	3.94	1.33
Predicted long-term mean wind speed, m/s	9.49	9.60	9.56

The artificially generated time series from EMD-WFR and Matrix method represent the long-term wind climate. Time series are generated for all the heights of the LiDAR (12 m to 300 m). The EMD-WFR data at the closest height of a given LiDAR height is used for the long-term correction. Similar to the 150 m data, the EMD-WFR data at 10, 25, 50, 75, 100 and 200 m give good correlation and performance indicators for the long-term correction.

The resulting artificial time series is presented in the following chapter, focusing on the 150 m results.

6.3 Long-Term Wind Climate

6.3.1 Long-term Wind Speed Distribution

The long-term wind speeds for the KG-1-LB buoy in Kattegat OWF are summarized in the following tables. A detailed breakdown of the Weibull parameters can be found in Appendix D.

Table 15. Weibull parameters of the long-term wind data from KG-1-LB (all heights).

HEIGTH [m]	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER [m/s]	WEIBULL - k PARAMETER
12	22	7.53	7.55	8.52	2.37
40	22	8.44	8.51	9.59	2.46
80	22	9.04	9.13	10.29	2.44
100	22	9.22	9.32	10.52	2.41
130	22	9.47	9.57	10.8	2.36
150	22	9.56	9.64	10.88	2.32
170	22	9.67	9.76	11.02	2.30
190	22	9.75	9.84	11.11	2.28
220	22	9.87	9.95	11.23	2.23
260	22	10.05	10.13	11.44	2.21
300	22	10.19	10.27	11.6	2.17

6.3.2 Long-term Wind Direction Distribution

The long-term frequency and energy distribution for the long-term corrected LiDAR data from KG-1-LB at 150 m ASL indicate a main wind direction from west to south-southwest.

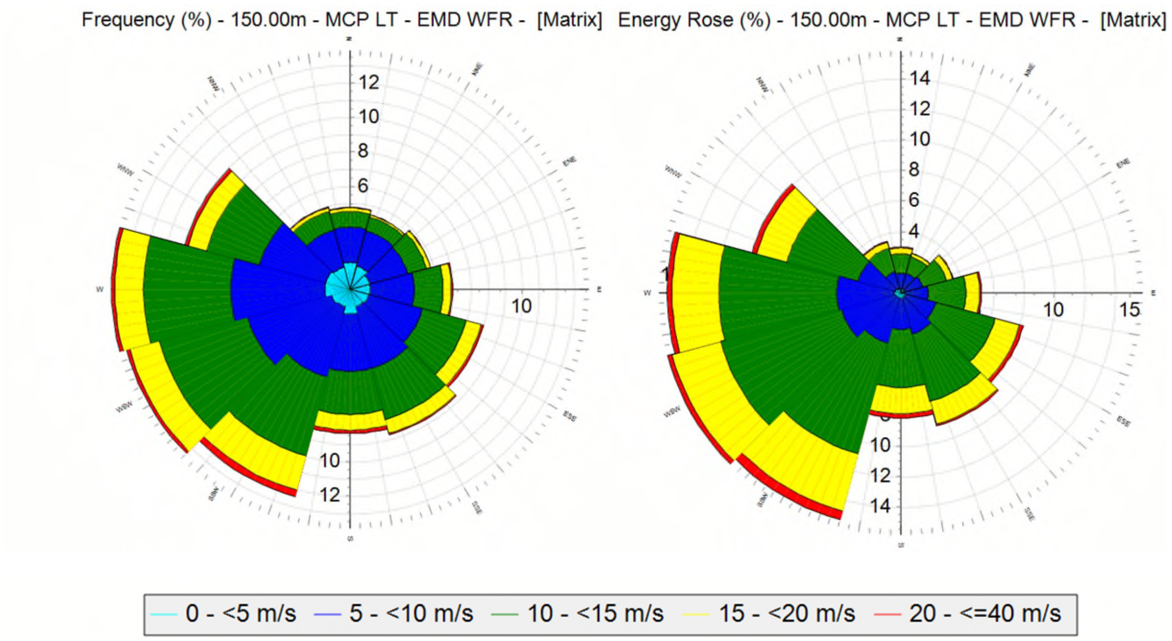


Figure 21. Left: Wind direction distribution of long-term corrected LiDAR data (KG-1-LB) at 150 m. Right: Energy distribution of long-term corrected LiDAR data (KG-1-LB) at 150 m, both divided in wind speed intervals.

6.3.3 Long-term Diurnal Variations

The diurnal long-term wind speed has similar variations than the measured mean wind speed but adjusted to a lower level for the long-term dataset (Figure 22).

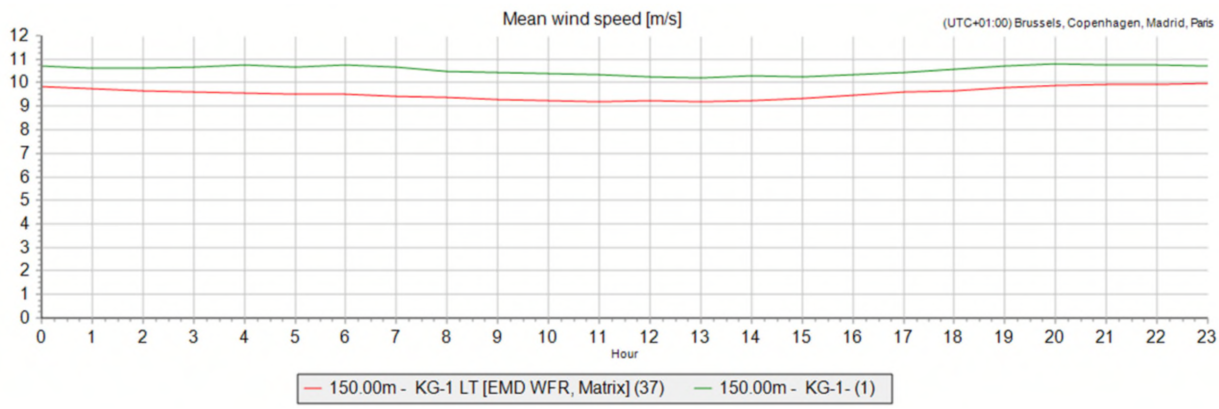


Figure 22. Diurnal wind speed, long-term corrected (red) and observed (green), KG-1-LB.

6.3.4 Long-term Seasonal Variations

The long-term seasonal variation of wind speed at 150 m is presented in Figure 23 and compared to the actual observations. Whereas the seasonal variation of the measurements is based on 8 months, the seasonal variation of the long-term timeseries is an average of 22 years of data and therefore predictably smoother.

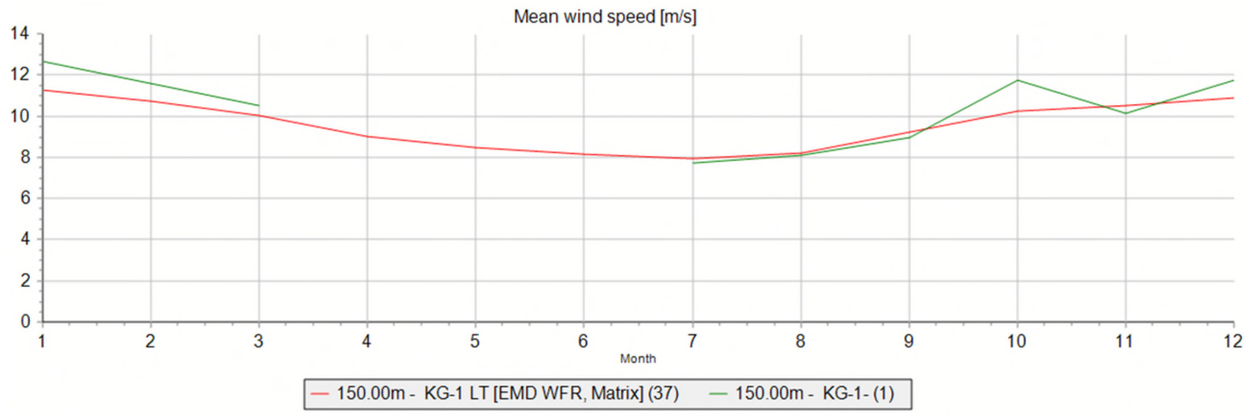


Figure 23. Seasonal variation of long-term corrected dataset (red) and observed dataset at 150 m, KG-1-LB.

7 Validation of Wind Model

7.1 Secondary Models

The wind resource at Position KG-1-LB was assessed through long-term correction of measured LiDAR data. This remains the primary model for the site.

Three secondary models were tested, translating secondary measured data from Hesselø South (HS-1), Hesselø (H1) and Læsø (M1) to the site. The two Hesselø data sets are located relatively close to KG-1-LB further from the coast to the west. The M1 mast is at a greater distance, north of KG-1-LB. These were used to validate the primary wind model at Kattegat OWF. The locations of the secondary data sets are presented in Figure 24.

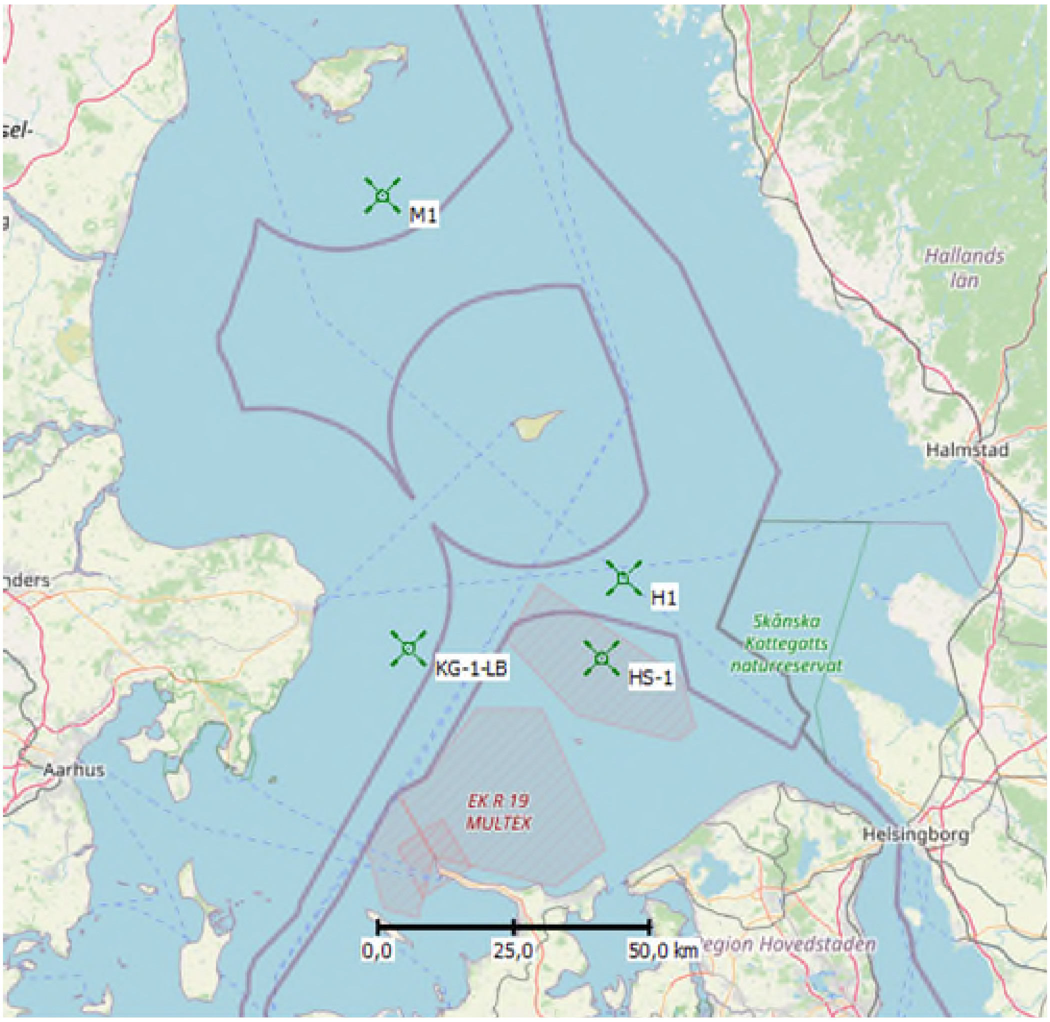


Figure 24. Location of HS-1, H1 LiDAR buoys and Læsø meteorological mast M1 relative to KG-1-LB LiDAR buoy.

For the validation, the secondary data sets are transferred from their locations to KG-1-LB using the relative differences resulting from the comparison of mesoscale data. This transfer is based on the assumption that the difference between the two sites can be fully described by the difference observed in mesoscale data.

For each data set, an EMD-WRF dataset was extracted (section 5). The correlation in terms of wind speed, energy content and direction has been analysed for sufficiency. If mismatches are identified, a transfer function has been developed to mitigate the differences.

The datasets are described and adjusted to long-term wind climate in Appendix A.

7.1.1 Hesselø South Floating LiDAR (HS-1)

Based on 8 months of LiDAR measurements on the buoy deployed for the Hesselø South site (HS-1), a 22-year dataset was produced with the same reference period as for KG-1-LB. The height of interest is at 150 m ASL.

The HS-1 buoy is located 35 km east of KG-1-LB buoy (Figure 24). The HS-1 and KG-1-LB buoys are exposed differently to the impact of land. Still the HS-1 buoy has the advantages of being relatively close to KG-1-LB, with concurrent wind data, same height of measurements and technology.

For the validation of the wind model for KG-1-LB, the long-term corrected dataset at HS-1 is transferred to the location and height of the buoy following the below-described methodology.

An EMD-WRF dataset was extracted for the HS-1 buoy location (section 5). The correlation between the HS-1 LiDAR data and EMD-WRF is very high, both on wind speed, monthly energy content and directional distribution as discussed in Appendix A and the EMD-WRF data can therefore be said to capture the wind dynamics very well at HS-1.

Comparing the wind direction distribution between EMD-WRF data at KG-1-LB and EMD-WRF data at HS-1, a difference in directional distribution and particularly energy distribution is noted (Figure 27). A transfer function is therefore required to both transfer the directions and the energy content in each direction.

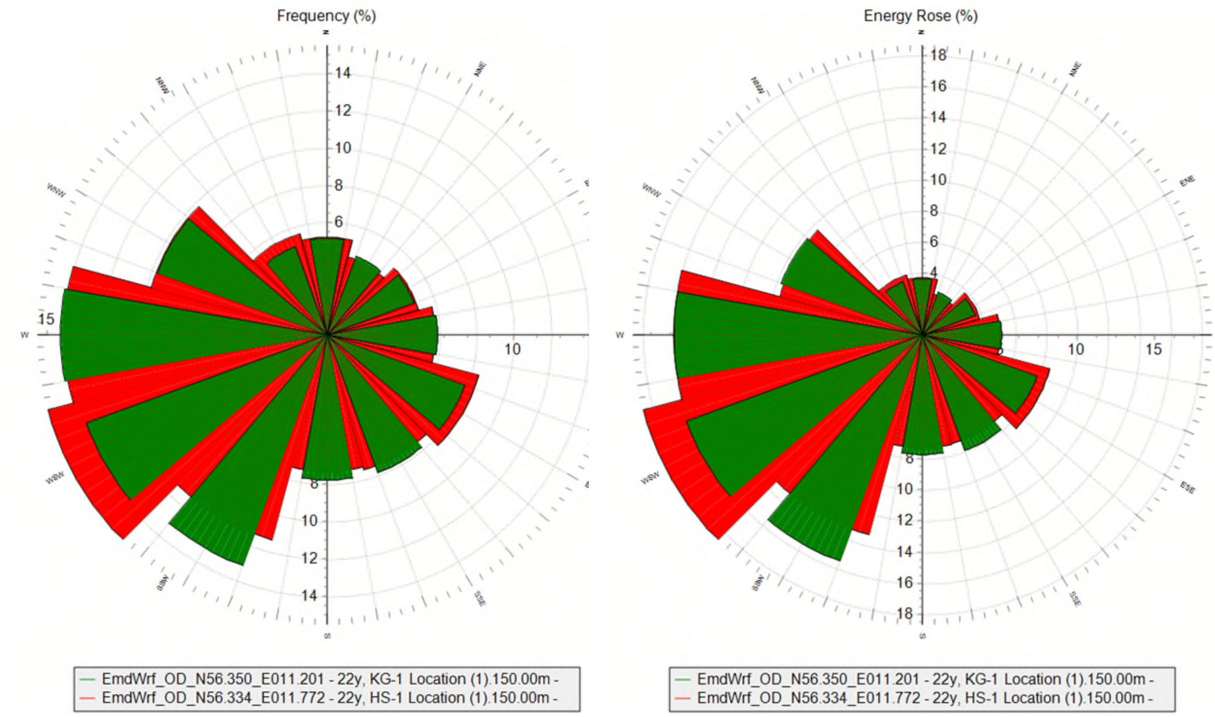


Figure 25. Left: Directional distribution between EMD-WRF at KG-1-LB (green) and EMD-WRF at HS-1(red), 22 years. Right: Energy rose of same two datasets, 22 years.

A translation function is created using linear regression with a translation function for every 1° direction, used data in a +/-15° window, giving a scale and offset on wind speed as well as an offset on wind direction.

This translation function is then applied to the 22-year of long-term corrected 150 m HS-1 data, creating a 22-year dataset at KG-1-LB.

A comparison of directional distribution of transferred HS-1 data at 150 m with long-term corrected KG-1-LB data is presented Figure 26. The match is very good with almost identical wind energy roses.

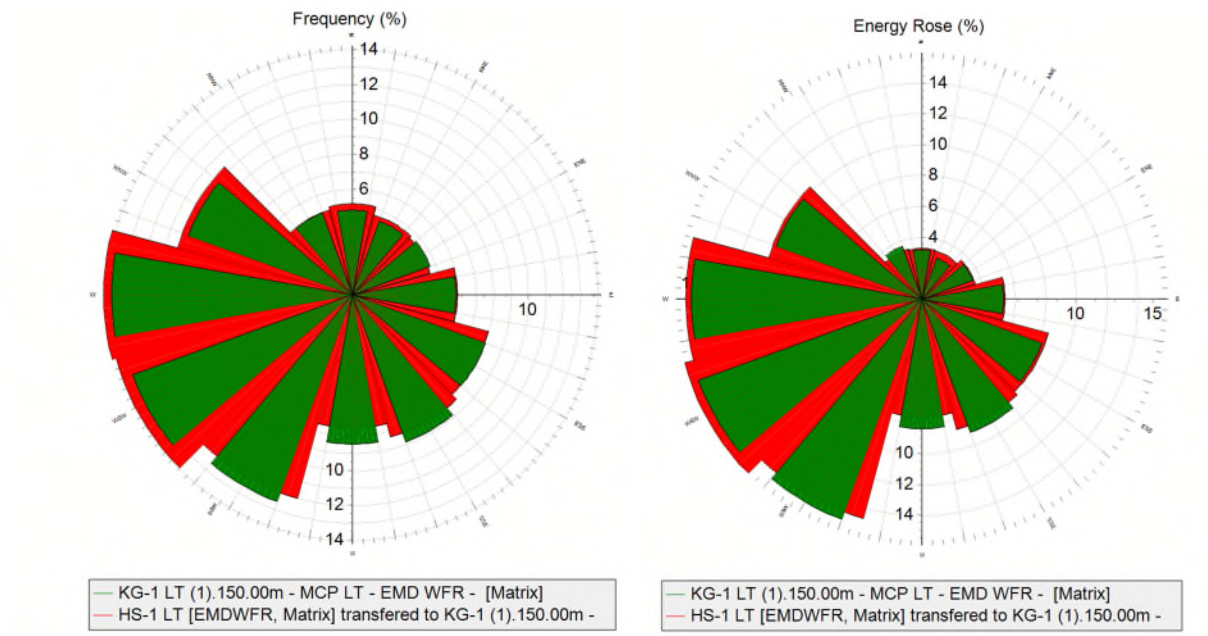


Figure 26. Comparison of directional distribution of transferred KG-1-LB data (green) with HS-1 (red) (22 years). Left: by frequency, Right: by energy.

The mean wind speed through the steps can be followed in Table 16. The wind distribution and Weibull fit can be found in detail in Appendix F.

Table 16. Mean wind speed through the transfer stages, HS-1 data.

Stage	Arithmetic Mean Wind Speed [m/s]
8 months of measured, HS-1, 150 m	10.75
22 years, long-term corrected HS-1, 150 m	9.69
22 years, transferred to KG-1-LB, 150 m	9.64

7.1.2 Hesselø Floating LiDAR (H1)

Based on 12 months of LiDAR measurements on the buoy deployed for the "Old" Hesselø site (H1), a 22-year dataset was produced with the same reference period as for KG-1-LB. The height of interest is at 150 m.

The H1 buoy is located about 41 km east-northeast of KG-1-LB buoy (Figure 24). The buoys are differently exposed to the impact of land. Still the H1 buoy has the advantages of covering one full year (although not concurrent to KG-1-LB), and being relatively closed to KG-1-LB, with similar heights of measurements and technology.

For the validation of the wind model for KG-1-LB, the long-term corrected dataset at H1 is transferred to the location and height of the buoy following the below-described methodology.

An EMD-WRF dataset was extracted for the H1 buoy location (section 5). The correlation between the H1 LiDAR data and EMD-WRF is very high, both on wind speed, monthly energy content and directional distribution as discussed in Appendix A and the EMD-WRF data can therefore be said to capture the wind dynamics very well at H1.

Comparing the wind direction distribution between EMD-WRF data at KG-1-LB and EMD-WRF data at H1, a small difference in directional distribution and energy distribution is noted (Figure 27). A transfer function is therefore required to both transfer the directions and the energy content in each direction.

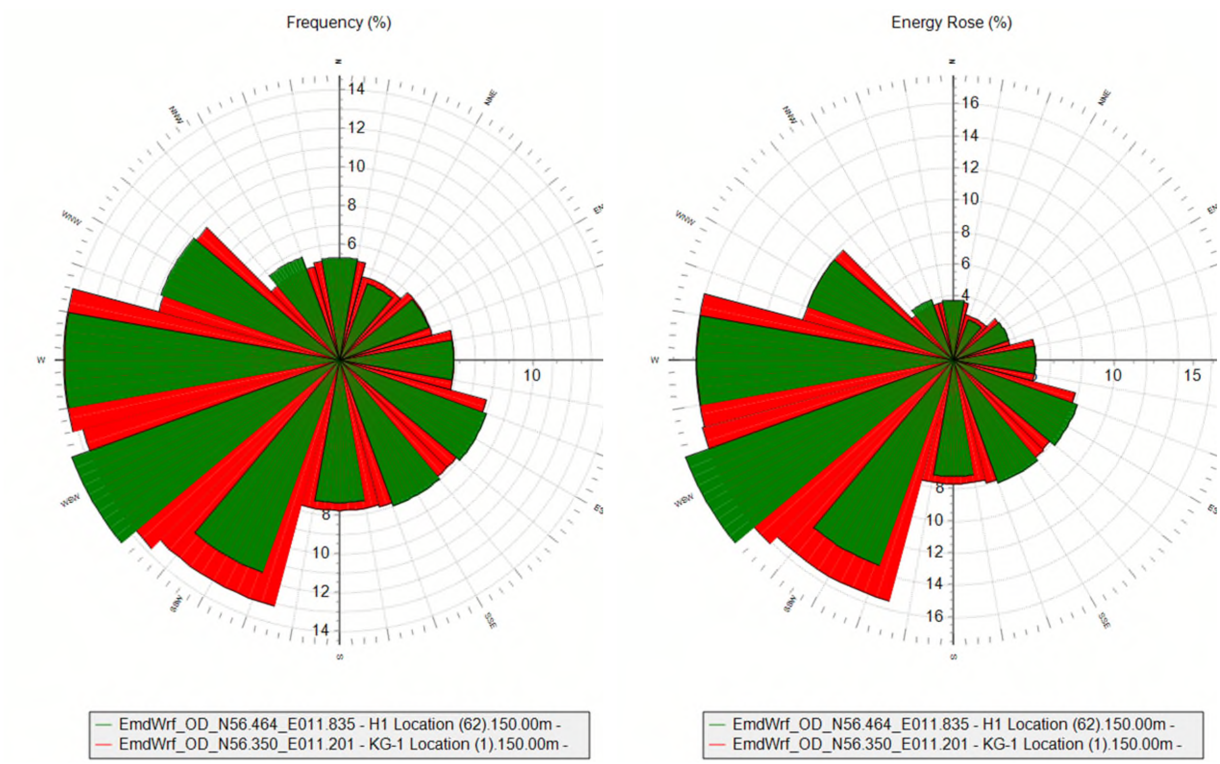


Figure 27. Left: Directional distribution between EMD-WRF at KG-1-LB (red) and EMD-WRF at H1(green), 22 years. Right: Energy rose of same two datasets, 22 years.

A translation function is created using linear regression with a translation function for every 1° direction, used data in a +/-15° window, giving a scale and offset on wind speed as well as an offset on wind direction.

This translation function is then applied to the 22-year of long-term corrected 150 m H1 data, creating a 22-year dataset at KG-1-LB.

A comparison of directional distribution of transferred H1 data at 150 m with long-term corrected KG-1-LB data is presented in Figure 28. The match is good but with slight overprediction of the transferred data from H1 in the two main wind sectors (W and WNW).

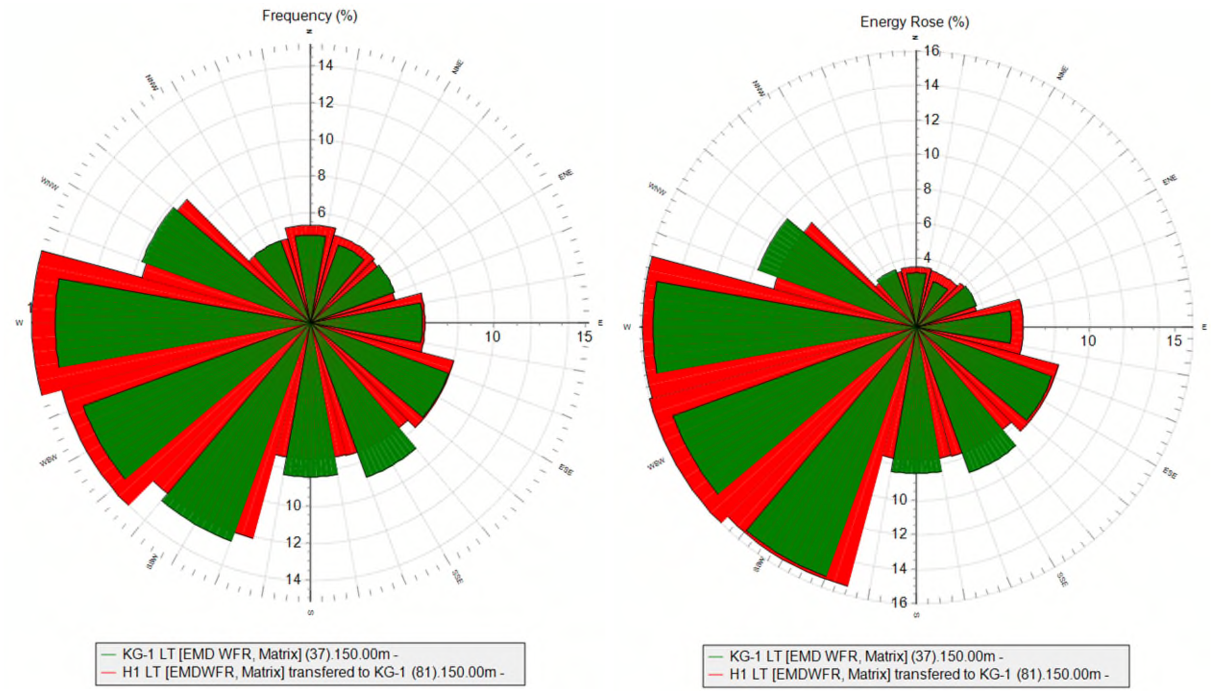


Figure 28. Comparison of directional distribution of transferred H1 data (red) with KG-1-LB (green) (22 years). Left: by frequency, right: by energy.

The mean wind speed through the steps can be followed in Table 17. The wind distribution and Weibull fit can be found in detail in Appendix F.

Table 17. Mean wind speed through the transfer stages, H1 data.

STAGE	ARITHMETIC MEAN WIND SPEED [M/S]
12 months, measured, H1, 140 m	9.80
12 months, shear extrapolated, H1, 150 m	9.87
22 years, long-term corrected, H1, 150 m	9.73
22 years, transferred to KG-1-LB, 150 m	9.65

7.1.3 Læsø Mast (M1)

Based on 4 years of mast measurements at Læsø offshore met mast (M1), a 22-year dataset was produced with the same reference period as for KG-1-LB (Appendix A). The measurement height of interest is at 62 m ASL.

The location of the M1 mast is about 82 km north relative to the KG-1-LB buoy, as presented in Figure 24.

For the validation of the wind model for KG-1-LB, the long-term corrected dataset at M1, 62 m, is transferred to the location and height of the KG-1-LB buoy.

An EMD-WRF dataset was extracted for the M1 mast location (section 5). The correlation between the M1 data and EMD-WRF is very high, both on wind speed, monthly energy content and directional distribution as discussed in Appendix A and the EMD-WRF data can therefore be said to capture the wind dynamics very well at M1.

Comparing the wind direction distribution between EMD-WRF data at M1 and EMD-WRF data at KG-1-LB, shows a difference in directional distribution (Figure 29). A transfer function is therefore required to both transfer the directions and the energy content in each direction.

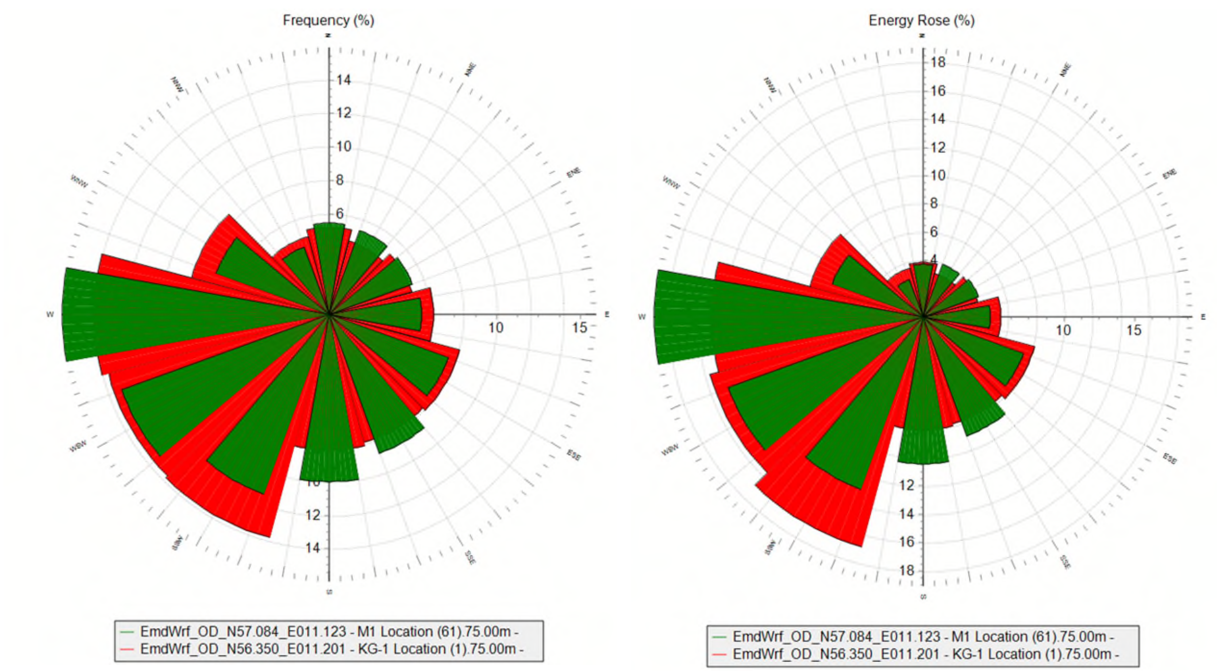


Figure 29. Left: directional distribution between EMD-WRF, 75 m at M1 (green) and EMD-WRF at KG-1-LB (red). Right: Energy rose of same two datasets.

A translation function is thus created using linear regression with a translation function for every 1° direction, used data in a +/-15° window, giving a scale and offset on wind speed as well as an offset on wind direction.

This translation function is then applied to the 22 year of long-term corrected 62 m M1 data, creating a 22-year dataset at KG-1-LB.

A comparison of directional distribution of transferred M1 data at 62 m with long-term corrected KG-1-LB data at 80 m is presented in Figure 30. The match is reasonably good but with some deviation in the south-southeast sector.

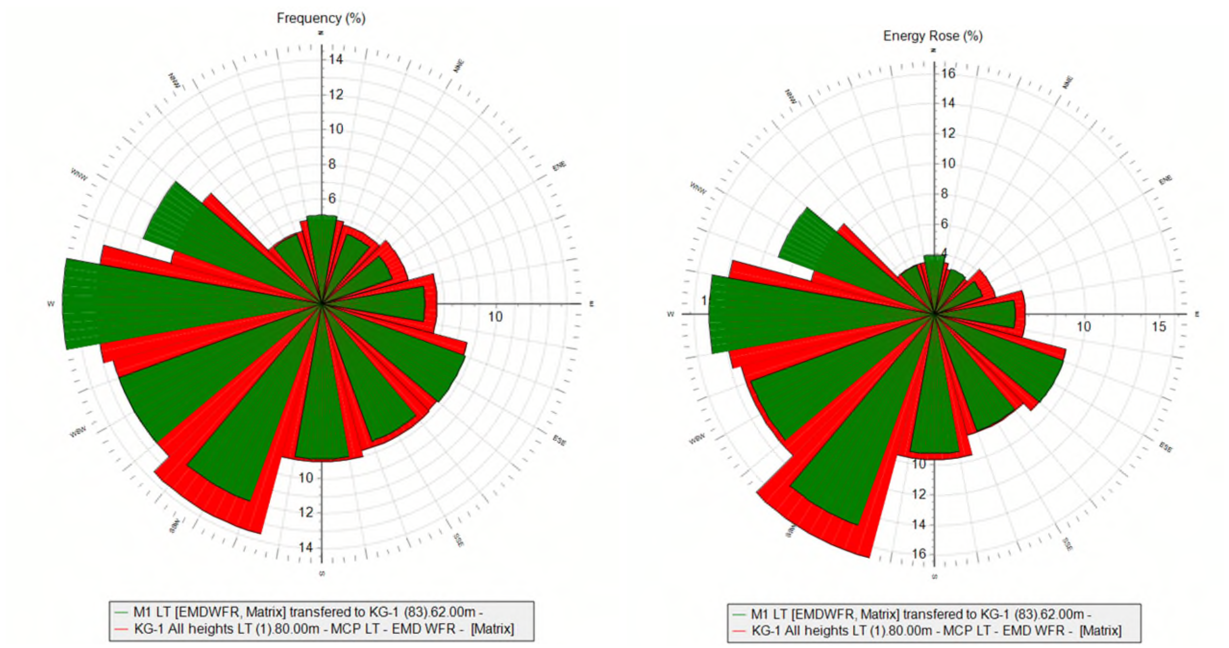


Figure 30. Comparison of directional distribution of transferred M1 data, 62 m (green) with KG-1-LB, 80 m (red) (22 years). Left: by frequency, right: by energy.

The translated data are at 62 m ASL at KG-1-LB need to be extrapolated to 150 m ASL. The obvious way to do this is through a shear extrapolation. This is however not trivial. A shear extrapolation from 62 m to 150 m is far outside the 2/3 ratio set by the MEASNET guideline ([26]).

The shear based on the measurements at KG-1-LB is not optimal because it has a seasonal bias due to 8 months of available data.

The available shear from the floating LiDAR H1 at Hesselø is not used either because it is not expected to be representative of the directional shear distribution on the Kattegat OWF site. Kattegat OWF area is indeed more affected by the coast than at the Hesselø (H1) location.

The alternative is to use a shear based on long-term corrected observations at KG-1-LB. Due to the inherrent random scatter in the matrix MCP function usde in the long-term correction, and the resulting noise in the directional and diurnal shear values, the most robust shear extrapolation was found to be a shear matrix based on long-term corrected data using only seasonal binning. Analysis on the data from the floating LiDAR H1 have proven that the shear based on data obtained by long-term transformation can reproduce the measured sheared with a small discrepancy (0.4% on wind speed, when extrapolating from 70 m to 160 m at H1).

The shear used to extrapolate the 62 m M1 data translated to KG-1-LB from 62 m to 150 m is thus calculated from the long-term data at KG-1-LB from 100 m to 150 m (Table 18).

Table 18. Shear by season, based on long-term corrected measurements at KG-1-LB 100 m to 160 m.

Direction /hour	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
Shear	0.11	0.10	0.05	0.04	0.08	0.09

The mean wind speed through the steps can be followed in Table 19. The wind distribution and Weibull fit can be found in detail in Appendix F.

Table 19. Mean wind speed through the transfer stages, M1 data.

Stage	Arithmetic Mean Wind Speed [m/s]
4 years of measured mean wind speed, 62 m	8.80
22 years, long-term corrected at 62 m	8.98
22 years, transferred to KG-1-LB, 62 m	8.82
22 years, transferred to KG-1-LB, shear extrapolated to 150 m	9.46

7.2 Comparison of Primary Model with Secondary Models

The wind resource at KG-1-LB was assessed through long-term correction of measured LiDAR data. This remains the primary model for the site. Three secondary models were tested, translating measured data from Hesselø South (HS-1), Hesselø (H1) and Læsø (M1) to the site. They cover different directions and distances from the Kattegat OWF and have all advantages and disadvantages as described previously.

The results of these tests are summed up in Table 20.

The long-term corrected mean wind speeds of the primary model are strongly supported by the secondary models, with a maximum deviation of 1% on the mean wind speed at 150 m ASL, which is far inside the expected uncertainty.

The results from the M1 met mast deviate slightly more when looking at the wind speed distribution (Figure 31), mean wind speed per sector (Figure 32), frequency distribution (Figure 33) , diurnal and monthly variations (Figure 34, Figure 35). The difference may well be explained by the distance between M1 and the Kattegat OWF.

The secondary models support the primary wind model, but it is also clear that the primary model is stronger than any of the secondary models. Therefore, only the primary model is submitted in the data package. The frequency distributions and Weibull parameters of the secondary model are submitted in Appendix E and Appendix F.

Table 20. Comparison of model results at KG-1-LB, 150 m ASL.

	PRIMARY MODEL	TRANSFERRED HS-1 MODEL	TRANSFERRED H1 MODEL	TRANSFERRED M1 MODEL
Wind speed [m/s]	9.55	9.64	9.65	9.46
Wind speed relative to primary model		100.9%	101.0%	99.1%

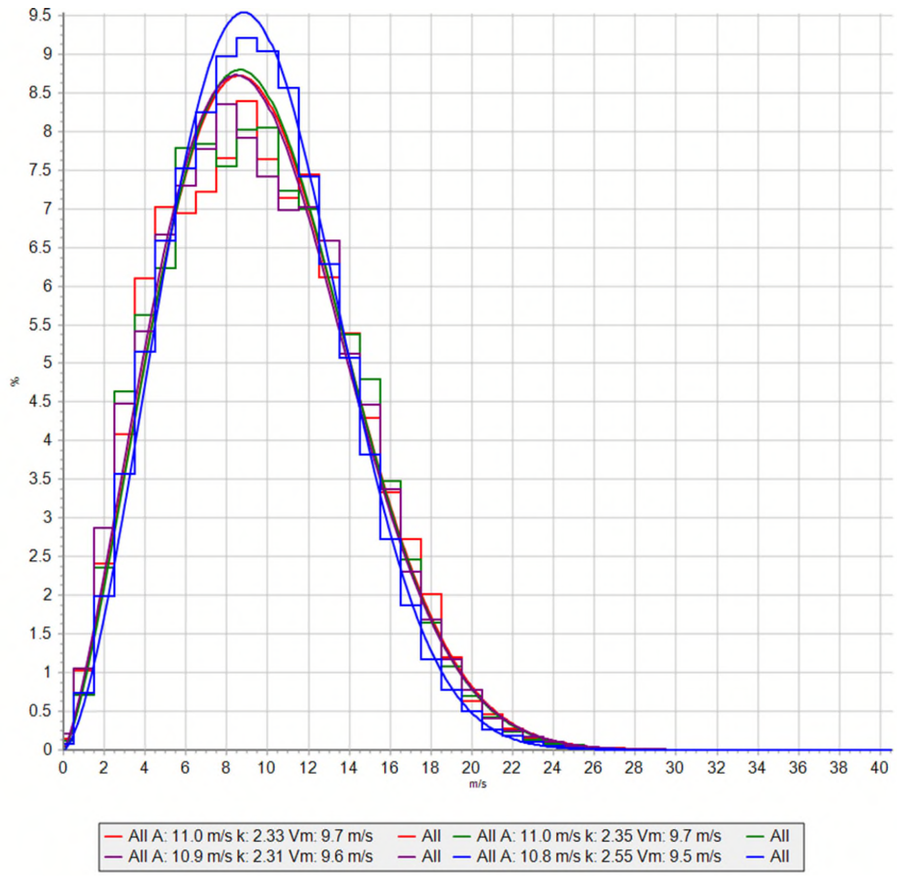


Figure 31. Wind speed probability function for the four datasets at KG-1-LB position. Primary model (purple), HS-1 model (green), H1 (red) and M1 (blue).

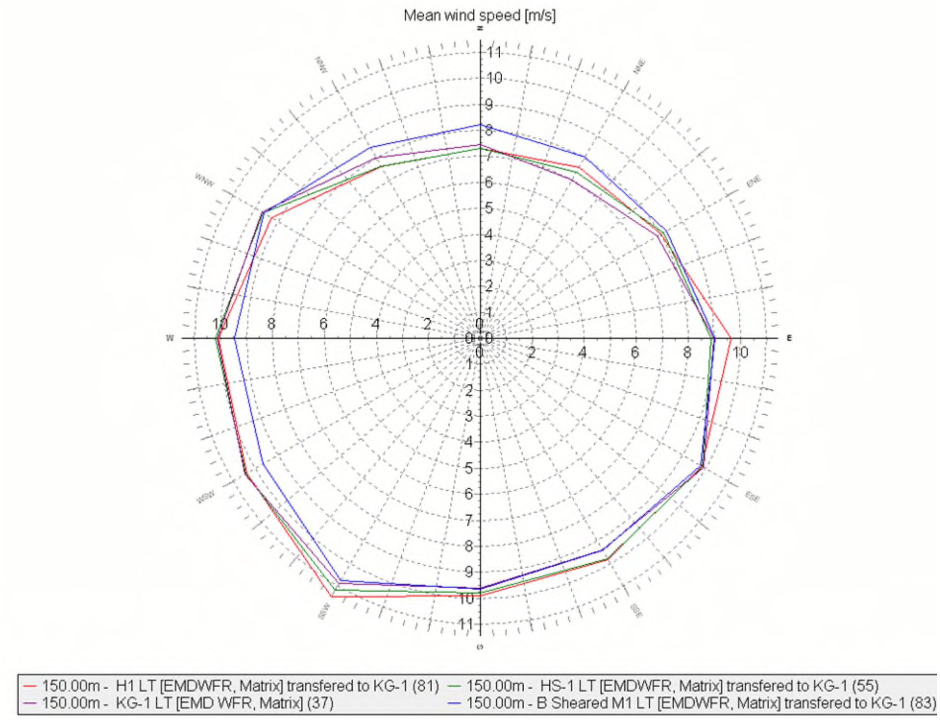


Figure 32. Mean wind speed per direction for the four datasets at KG-1-LB position. Primary model (purple), HS-1 model (green), H1 (red) and M1 (blue).

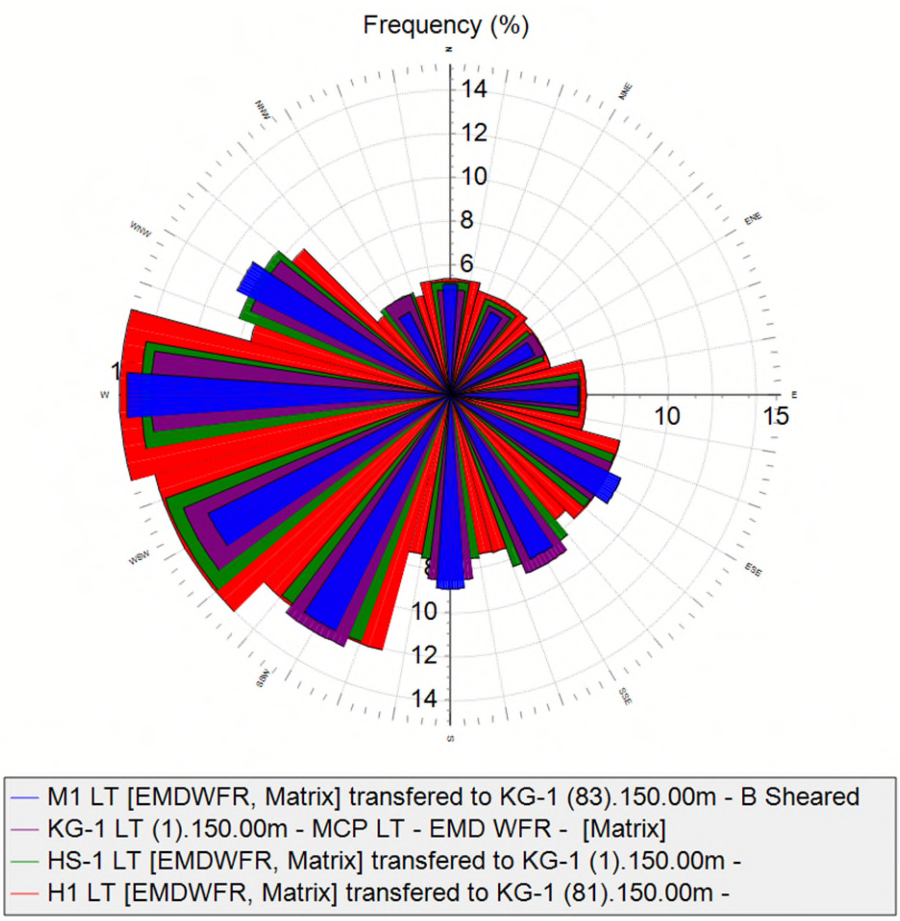


Figure 33. Directional distribution of the four long-term wind models at KG-1-LB position. Primary model (purple), HS-1 model (green), H1 (red) and M1 (blue).

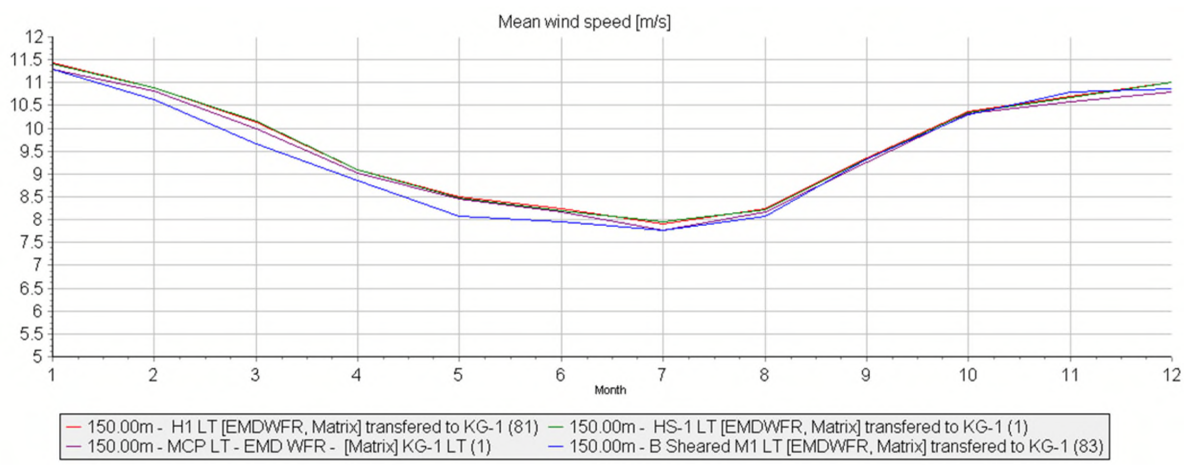


Figure 34. Diurnal wind speed of the four long-term wind models at KG-1-LB position. Primary model (purple), HS-1 model (green), H1 (red) and M1 (blue).

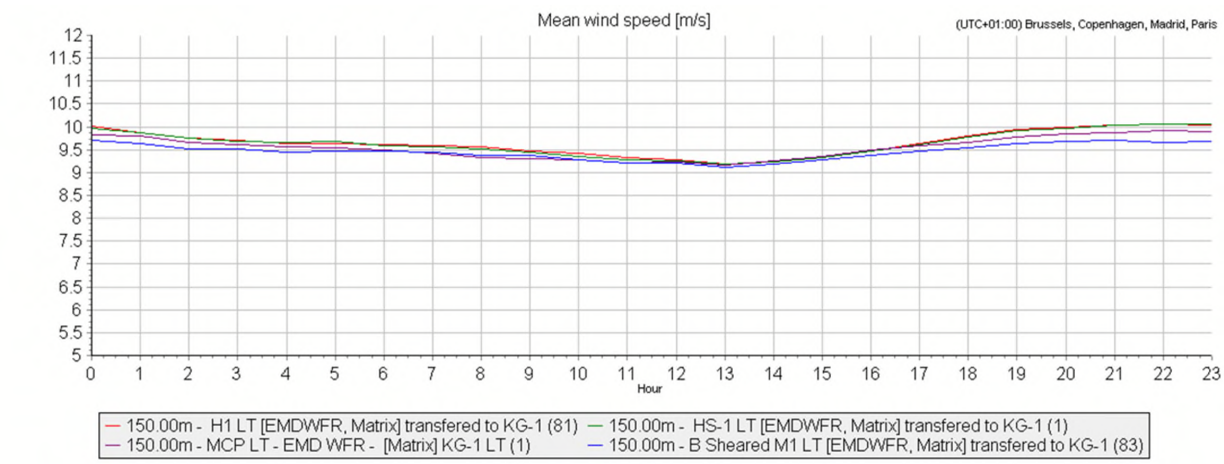


Figure 35. Seasonal variation of the four long-term wind models at KG-1-LB position. Primary model (purple), HS-1 model (green), H1 (red) and M1 (blue).

7.3 Uncertainty of Primary Wind Model

7.3.1 Measurement Uncertainty

Uncertainty on measurements was discussed in section 4.6. The results are summarized in Table 21.

Table 21. Measurement uncertainty.

BUOY	TOTAL MEASUREMENT UNCERTAINTY
KG-1-LB	2.43%

7.3.2 Long-term Correction Uncertainty

The long-term correction uncertainty consists of components with very low uncertainty (correlation, reference consistency, reference period length) and one component with high uncertainty, which is the measurement period of 8 month. This is therefore the dominant uncertainty with very minor contributions from other components.

Based on [27], the combined long-term correction uncertainty of an 8-month period is of the scale of 5%. The long-term correction changes the wind speed from 8 months to 22 years by 10%. In this context, a high uncertainty is expected.

For the long-term correction three different references (EMD-WRF, ERA5 and NORA3) were tested using four different methods in a sensitivity analysis. The standard deviation on predicted wind speed of these was 0.9%. Alternatively, the range from minimum to maximum resulting wind speed can be used as an indicator of the uncertainty. This range is 2.2% for KG-1-LB.

While this indicates a high level of agreement among references and methodologies, it does not remove the potential for seasonal bias. The references are not entirely independent from each other as they are all based on ERA5 boundary data. The potential for seasonal bias means that the calculated uncertainty is overridden by the higher uncertainty for an 8-month period of 5% as presented above.

We therefore consider an uncertainty on long-term correction of 5% a reasonable though likely conservative value for long-term correction of the primary data from the buoys. This uncertainty will drop significantly when the measurement campaign is complete.

7.3.3 Very Long-term Uncertainty

The future climate uncertainty is the potential difference in mean wind speed of the next 20 years from the past period considered in the wind study. Northern Europe is subject to longwave oscillations meaning that a 20-year operation period can be quite different from the very long-term average. As suggested by [27], we estimate that for a 20-year dataset in this region this uncertainty is 1.5 % on wind speed.

This is supported by [28] who indicate 20-year multidecadal variability amplitude of the Kattegat on yield around 3%. Given a yield to wind speed ratio near unity, this translates well to wind speed and results in an uncertainty of wind speed of 1.5%.

While the reference period applied in this study is 22 years, we do not consider this materially different when considering the conclusions above for a 20-year reference period.

7.3.4 Year-to-year Variability

Based on the annual variation on the EMD-WRF data the inter-annual variability is 4.5% at KG-1-LB. Over a 20-year lifetime this uncertainty is reduced to 1.0%.

7.3.5 Total Uncertainty

The uncertainty components are combined to a total wind speed uncertainty. A total is given for 1- and 20-year periods.

The results from the secondary data provide a standard deviation on the four reported wind speed results for the KG-1-LB location at 0.9%. Due to the horizontal extrapolation distortion and in some cases poorer measurement uncertainty than at the buoy, the uncertainty on the transferred secondary data should be considered higher than on the local data, however the standard deviation of the results from the four different models remain within the uncertainty of the total wind speed uncertainty of the primary model (Table 22) and therefore confirms the primary model.

Table 22. Combined uncertainty on long-term wind data. Uncertainty given as one standard deviation wind speed.

	KG-1-LB	
WIND DATA UNCERTAINTY	1 YEAR	20 YEARS
Measurement uncertainty	2.43%	2.43%
Long-term correction uncertainty	5.0%	5.0%
Very long-term uncertainty	1.5%	1.5%
Annual variability	4.5%	1.0%
Total	**7.31%**	**5.84%**

8 Flow Modelling

To calculate the wind resource for the whole Kattegat OWF area from the primary wind model (long-term corrected LiDAR data), it is necessary to establish a flow model to account for the variation in wind speed distribution across the site. This modelling is used to calculate the wind resource at two additional positions (KG-A and KG-B) within the Kattegat OWF area and a wind resource map for the whole development area.

8.1 WFR Model

Due to the distance from the coast, a mesoscale modelling is most suitable for flow modelling on the Kattegat area. EMD has customized WRF model runs including the wake energy drain from the surrounding existing wind turbines from the Anholt wind farm. This wind farm is located at the closest about 12 km from the northern boundary of the Kattegat area, in North-northwest direction.

The WRF model used is version 4.5 with ERA5 data as the boundary data.

The wind turbines are represented in the WRF model using a Fitch scheme [29] with TKE advection.

A representative year is used as input data to reduce the calculation time, while to a sufficient degree maintaining the correct wind speed level and direction distribution.

The criteria for being a representative year is that the windiness index (production output index) must be close to unity and the wind direction distribution should be close to the long-term distribution. Windiness index is preferred to wind speed index as this ensures that the wind speed distribution in the range producing wakes is representative.

A twenty two-year period, 2002 to 2023 of EMD-WRF data was considered. From this period, 2012 to 2023 was excluded since it corresponds to the time where Anholt OWF was built and in operation. From the remaining period, the year 2004 was selected as representative with a windiness index of 99.4 and a direction distribution close to the 22-year average (Figure 36).

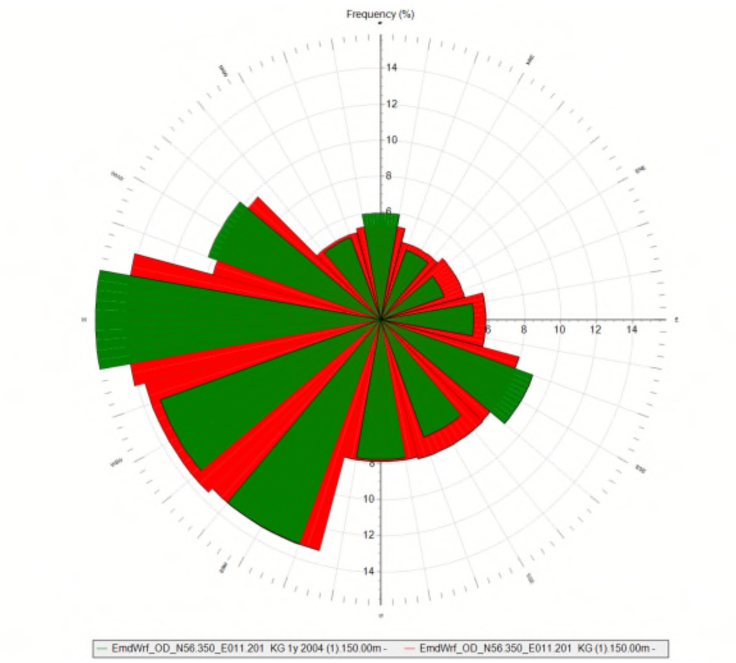


Figure 36. Direction distribution of EMD-WRF mesoscale data at KG-1-LB position in 2004 (green) compared to the 22-year period (red).

The WRF run is based on a domain of 200 by 200 km and produces a grid of time series with 1 km resolution, centered on the Kattegat wind farm area.

The temporal resolution of the output time series is 1 hour (internal model steps are of the order of seconds to ensure numerical stability).

The simulation is run for two scenarios: a baseline scenario 1 with no wind turbines, and a scenario 2, with the currently operating wind farm of Anholt.

The relative change in wind speed between the two scenarios are presented in Figure 37, as the ratio on the average Weibull wind speed at 150 m height ASL between the scenarios.

The impact of the Anholt wind farm on the wind resource is limited. Only the northern part of the Kattegat OWF area is affected. For example, on the KG-B location (Figure 37), the calculated mean Weibull wind speed is 0.2% lower when Anholt is included in the modelling than without. The wind speed reduction in direct wake wind directions is of course higher, with a 1.9% lower mean Weibull wind speed in the 330 degrees direction (Figure 37). This direction is however not a main wind direction. It must be noted that the mentioned wind speed ratios consider all wind speed bins and is not calculated per wind speed bins. It is expected that the impact of an operating wind farm is larger for the wind speed bins with high thrust curve values (5-20 m/s), and that the relative difference between the modeling with and without the Anholt turbine would then be wind speed dependent. Nevertheless, EMD has deemed that it was not necessary to generate mesoscale modelling by wind speed bin because the impact is small and concerns wind directions with low frequency.

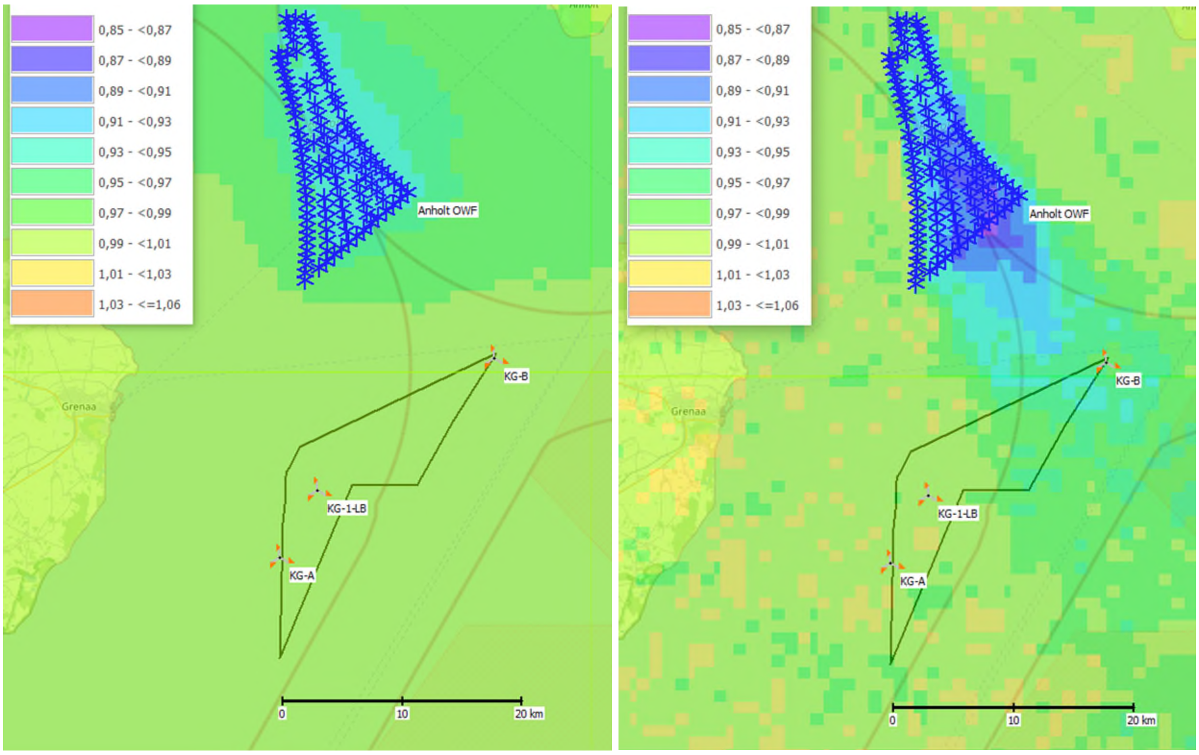


Figure 37. Map of the ratio between Weibull mean wind speed calculated by mesoscale modelling with and without Anholt OWF; left for all wind directions; right: for the most impacted wind direction (330 degrees).

Finally, the mesoscale gradient file including the Anholt OWF is the WFR model used to calculate the wind resource in the project area, as presented in the following sections.

8.2 Wind Resource for Positions KG-A & KG-B

The location of two additional positions (KG-A and KG-B) for siting parameters have been provided by Energinet. The coordinates are presented in Table 23. KG-A is placed about 6 km southwest from the central position of KG-1-LB. KG-B is located about 18 km northeast of KG-1-LB.

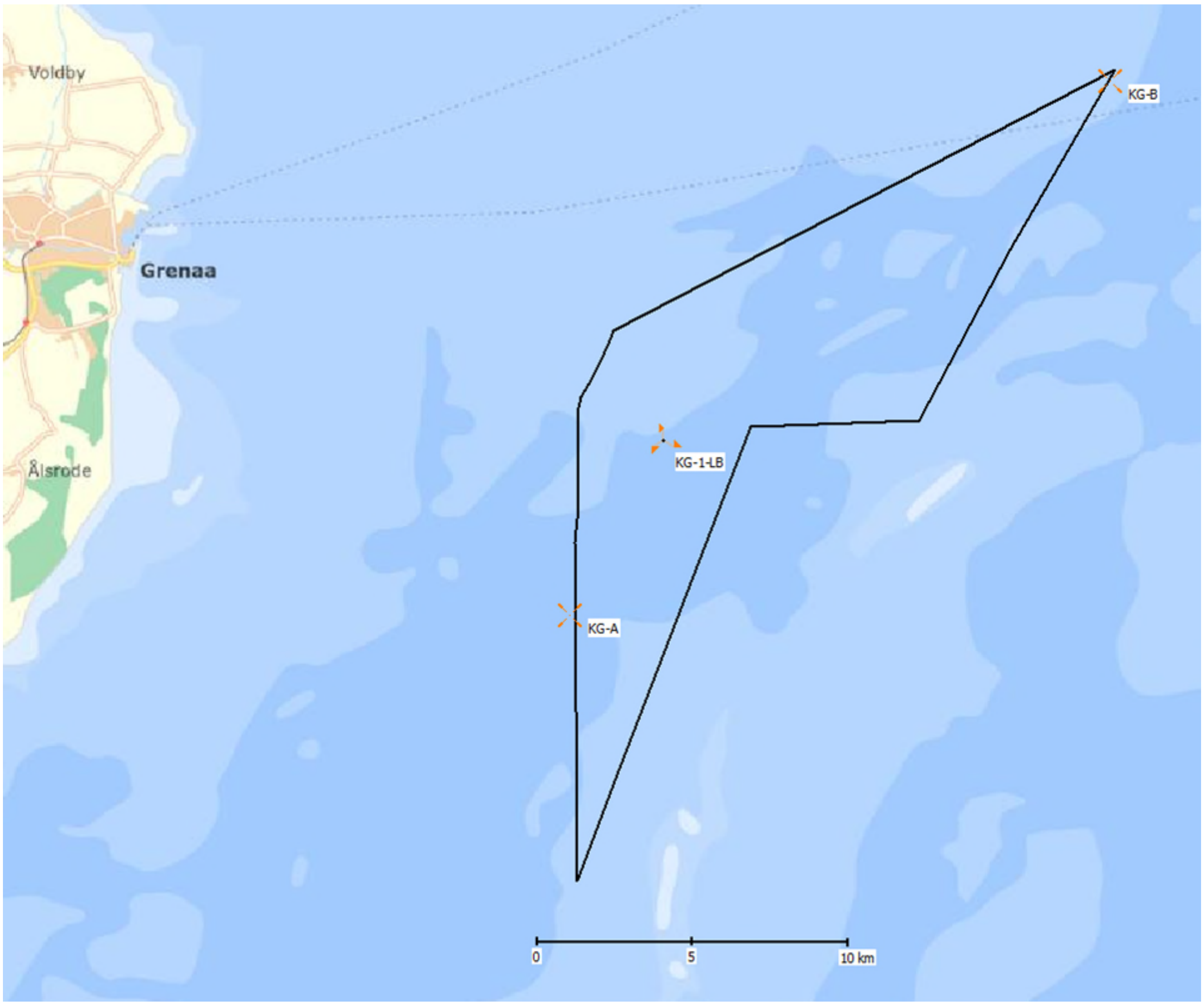


Figure 38. Location of the measurement point and additional positions (KG-A, KG-B) for siting parameters within the Kattegat OWF boundaries.

Table 23. Coordinates for Additional Siting Parameters Positions

NAME	UTM WGS84 ZONE 32		GEOGRAPHICAL COORDINATES WGS84	
KG-A	633033	6241637	11.149960° E	56.300810° N
KG-B	650360	6258787	11.439540° E	56.449580° N

For KG-A and KG-B, a long-term time series has been produced for 150 m ASL.

This is achieved through the gradient file method available in windPRO. With this method observed data are moved around the site using a mesoscale gradient file (section 8.1): Weibull A parameter of the Weibull distribution is picked up from the location of the observed data (KG-1-LB) and the prediction location (KG-A and KG-B) and the ratio is applied to the observed time series. A specific ratio is found for each of 12 direction sectors. No change is made to the wind direction data.

The validity of this assumption is tested by comparing the long-term directional distribution of EMD-WRF data for the locations close to KG-1-LB, KG-A and KG-B. There is a marginal difference in wind direction, but small enough to assume that a similar direction distribution is valid.

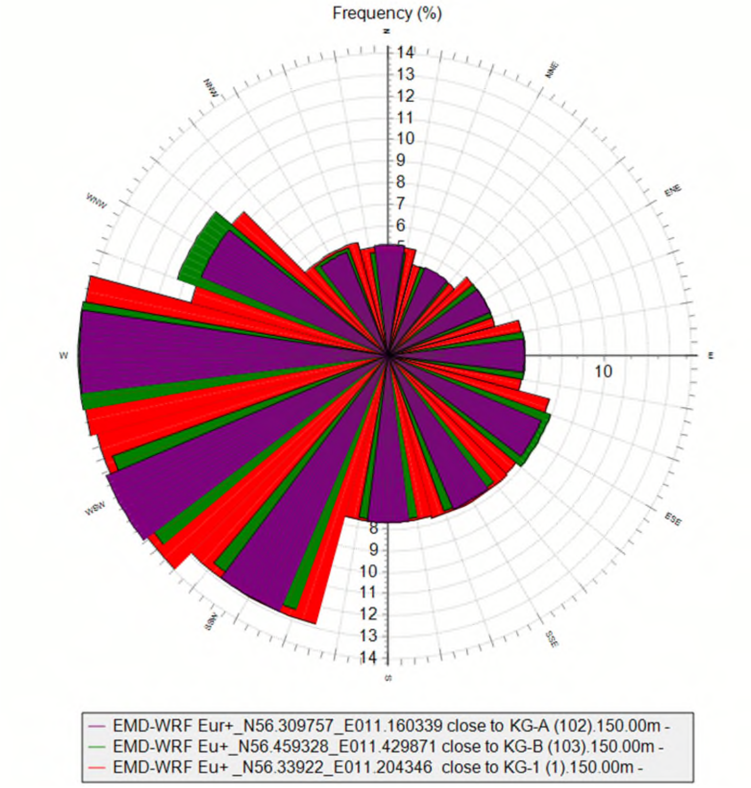


Figure 39. Comparison of 22 years direction distribution between EMD-WRF Europe + data for locations close to KG-1-LB (red), KG-A (purple) and KG-B (green).

For KG-A and KG-B the resulting time series at 150 m was generated using the long-term corrected time series for KG-1-LB at 150 m and the mesoscale wind gradient.

With this method, a time series can be extracted for any location on the site using the wind data time series and the gradient file. The time series are included as deliverables. The time series for KG-A and KG-B includes wind speed and wind direction for 22 years in an hourly resolution.

The arithmetic mean wind speed and Weibull parameters are for KG-A and KG-B are presented in Table 24. Details can be found in Appendix D.

Table 24. Weibull parameters of the long-term wind data, KG-A and KG-B.

NAME	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER [m/s]	WEIBULL - k PARAMETER
KG-A, 150 m	22	9.55	9.63	10.87	2.32
KG-B, 150 m	22	9.58	9.66	10.91	2.33

8.3 Wind Resource Map

The wind resource map over the Kattegat area is calculated from the long-term corrected measurements at KG-1-LB and the mesoscale gradient calculated by the WFR modelling described above and including the impact of Anholt OWF.

The resulting recalibrated wind resource map with 250 m resolution is presented in Figure 40 and provided as a deliverable.

As expected, the wind resource is increasing with the distance to the coast.

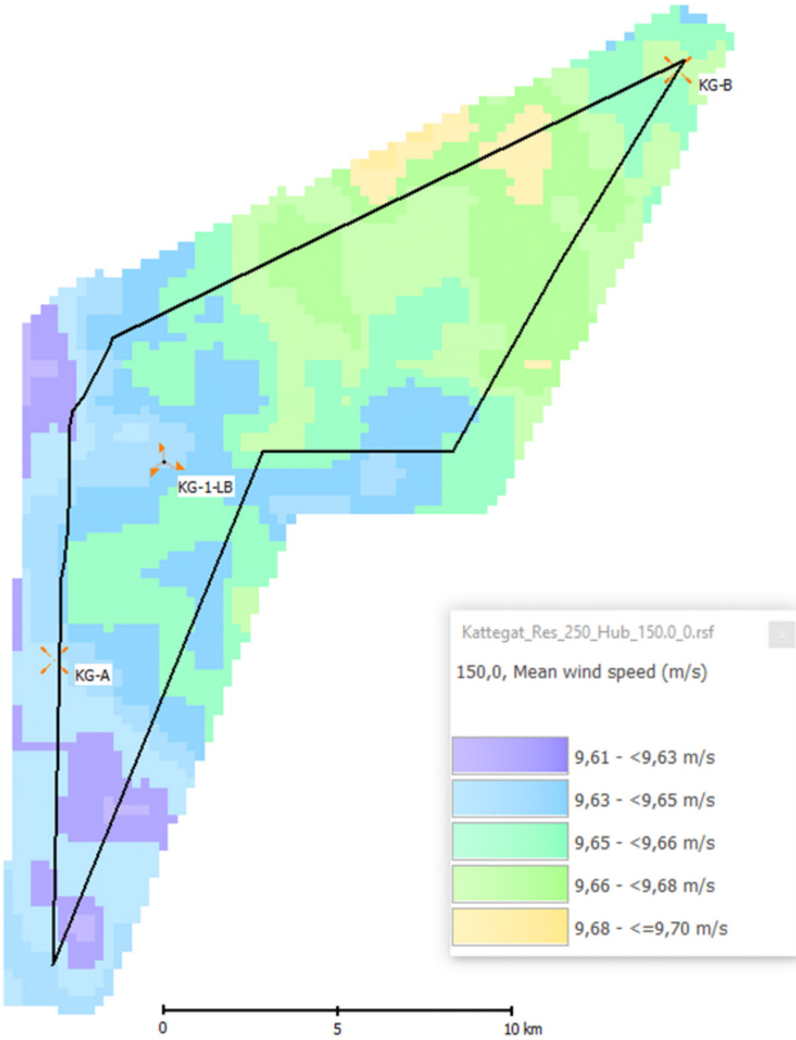


Figure 40. Wind resource map for the Kattegat OWF area.

9 Siting Parameters

This chapter outlines the requested siting parameters for assessment of structural integrity of wind turbines in accordance with the relevant design standards: IEC 61400-1 Ed. 4 [1], IEC 61400-3-1 Ed. 1 [2], IEC 61400-15-1 [6], DS 472 Ed 2. [5], and EN1991-1-4 including the Danish Annex DK NA EN1991-1-4 [3] [4].

For siting parameters that require turbine specific information, the following has been assumed.

Table 25. Turbine specific information used for siting parameters.

TURBINE SPECIFICATION	VALUE
Hub height	150 m
Rotor diameter	240 m
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Wind turbine class	II

9.1 Normal Wind Conditions

Normal wind conditions have been derived in accordance with IEC 61400-3-1 Ed. 1 [2], IEC 61400-1 Ed. 4 [1] and IEC 61400-15-1 [6]. All parameters except for the wind speed distribution have been estimated as omnidirectional characteristic values. This is in line with the IEC 61400-3-1, which allows omnidirectional values to be considered for offshore sites that are far away from the coast where the environment generally exhibits little directional variation.

Due to the site location being offshore, the terrain is classified as “not complex” (terrain complexity factor is 1.0) and the wind flow is assumed without any inclination (flow inclination 0°).

9.1.1 Wind Speed Distribution

The 10-min mean wind speed probability distribution at hub height is modelled by a Weibull distribution for each direction [1]. The distributions are estimated based on long-term corrected data from the LiDAR. Note that the temporal resolution of this data is 1 hour but according to IEC 61400-3-1 the long-term probability distribution of mean wind speed may be assumed to be independent of averaging periods between 10 minutes and 3 hours. The results are summarized in the table below. Mean wind speed is derived from the Weibull distribution. Details can be found in Appendix D.

Table 26. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, KG-1-LB. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	10.88	2.32	100.00	9.64
0-N	8.26	1.82	4.78	7.34
1-NNE	8.10	2.03	4.50	7.17
2-ENE	9.01	2.14	4.85	7.98
3-E	10.10	2.17	5.97	8.95
4-ESE	11.11	2.37	8.04	9.85
5-SSE	10.99	2.62	8.74	9.77
6-S	10.85	2.17	8.38	9.61
7-SSW	12.52	2.68	12.45	11.13
8-WSW	11.91	2.82	13.49	10.61
9-W	11.50	2.62	13.90	10.22
10-WNW	11.04	2.31	9.95	9.78
11-NNW	8.84	2.01	4.96	7.83

Table 27. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, transferred to KG-A. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	10.87	2.32	100.00	9.63
0-N	8.24	1.82	4.78	7.33
1-NNE	8.08	2.03	4.50	7.16
2-ENE	8.94	2.14	4.85	7.92
3-E	10.10	2.17	5.97	8.94
4-ESE	11.03	2.37	8.04	9.77
5-SSE	10.90	2.61	8.74	9.68
6-S	11.06	2.16	8.38	9.79
7-SSW	12.51	2.69	12.45	11.13
8-WSW	11.92	2.82	13.49	10.61
9-W	11.46	2.62	13.90	10.18
10-WNW	11.00	2.31	9.95	9.74
11-NNW	8.86	2.02	4.96	7.85

Table 28. Weibull distribution parameters based on long-term corrected LIDAR data at 150 m ASL, transferred to KG-B. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	10.91	2.33	100.00	9.66
0-N	8.78	1.82	4.78	7.81
1-NNE	8.34	1.99	4.50	7.39
2-ENE	9.07	2.15	4.85	8.03
3-E	9.96	2.18	5.97	8.82
4-ESE	11.36	2.38	8.04	10.07
5-SSE	10.83	2.61	8.74	9.62
6-S	10.84	2.17	8.38	9.60
7-SSW	12.35	2.68	12.45	10.98
8-WSW	12.06	2.83	13.49	10.74
9-W	11.60	2.62	13.90	10.31
10-WNW	10.90	2.31	9.95	9.65
11-NNW	8.62	2.00	4.96	7.64

9.1.2 Normal Wind Profile (NWP)

The site-specific normal wind profile is characterised by the mean wind shear power law coefficient (α_c). According to IEC 61400-1 Ed. 4 [1] the site-specific omnidirectional characteristic wind shear should be evaluated as the energy-weighted average of the sector-wise values.

The repaired 8 months LiDAR dataset was used to calculate the characteristic shear. Two values are offered: A power law coefficient based on heights 130 m, 150 m, and 170 m, the expected hub height range, and, secondly, the shear across to expected rotor range, based on 40 m, 150 m, and 260 m height data. As a full year is not available yet, the shear values are preliminary values. For comparison shear is calculated for the Hesselø floating LiDAR (H1). Here 12 months are available, though for a different year. Hub height range shear is calculated for 120 m, 140 m, 160 m and 180 m. Rotor range shear is based on 40 m, 140 m and 240 m measurement heights. The shear values are consistent with the Kattegat LiDAR measurements. The results are summarised in the table below.

For Position KG-A- and KG-B, the shear from KG-1-LB can be assumed.

Table 29. Site specific omnidirectional wind shear exponent.

WIND SHEAR POWER LAW EXPONENT [-]	KATTEGAT (8 months)	HESSELØ (12 MONTHS)
Hub height range 130 m to 170 m	0.095	0.094
Rotor range 40 m to 260 m	0.092	0.096

WIND PROFILE CHARACTERISTICS.

The observed wind profile at Kattegat is presented as a function of heat flux (Table 30). The heat flux is obtained from EMD-WRF data at buoy location. Three distinct zones can be found Figure 41:

1. Negative heat flux, typical for stable conditions, with a clear link between shear and heat flux,
2. A middle range, typical for neutral condition, with a well-defined shear
3. Positive heat flux with a substantial scatter in shear.

The different regimes are summarized in Table 30.

Table 30. Range of observed shear by heat flux, Kattegat

Kattegat (KG-1-LB)	LOW HEAT FLUX	CENTRAL RANGE HEAT FLUX	HIGH HEAT FLUX
Heat flux range	<5 W/m^2	5 – 25 W/m^2	>25 W/m^2
Frequency of range	23%	51%	26%
Typical shear range	0.1 - 0.3	0.04 - 0.1	-0.06 - 0.16

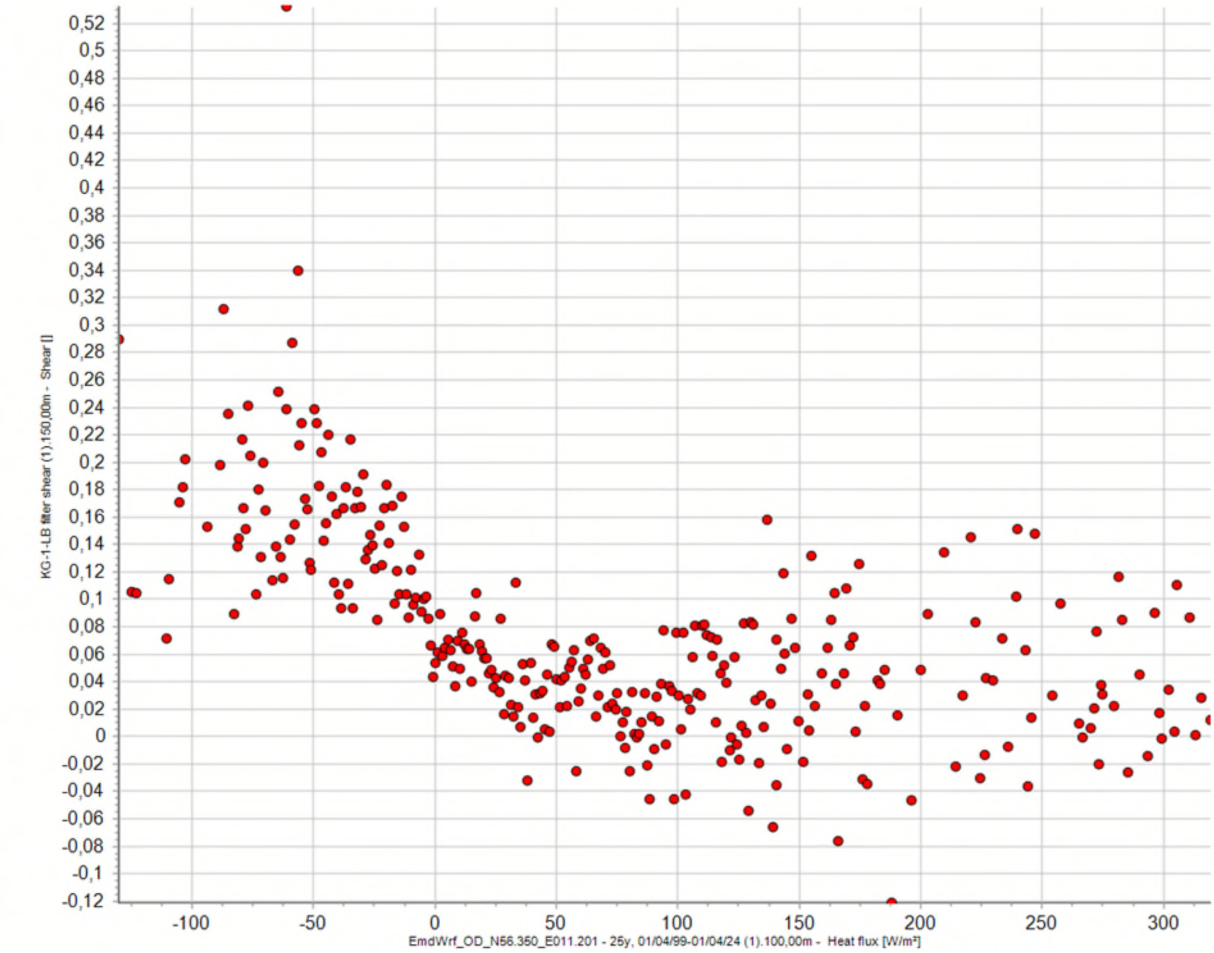


Figure 41. Shear power law coefficient as a function of heat flux at Kattegat.

Stability classes are defined though the Monin Obukhov length, here using three categories as described in Table 31. The 1/L signal in the EMD-WRF data is used to describe stability at Kattegat in Figure 42. Stable conditions are fairly rare and typical for the spring months. Both stable and unstable conditions are suppressed at high wind speed.

Table 31. Range of observed shear as a function of stability class.

KG-1-LB	Stable	Neutral	Unstable
Inverse Monin-Obukhov length [m]	1/L > 0.005	-0.005 > 1/L > 0.005	1/L <- 0.005
Frequency	23%	51%	26%
Typical shear range	0.1 - 0.3	0.04 - 0.1	-0.06 - 0.16

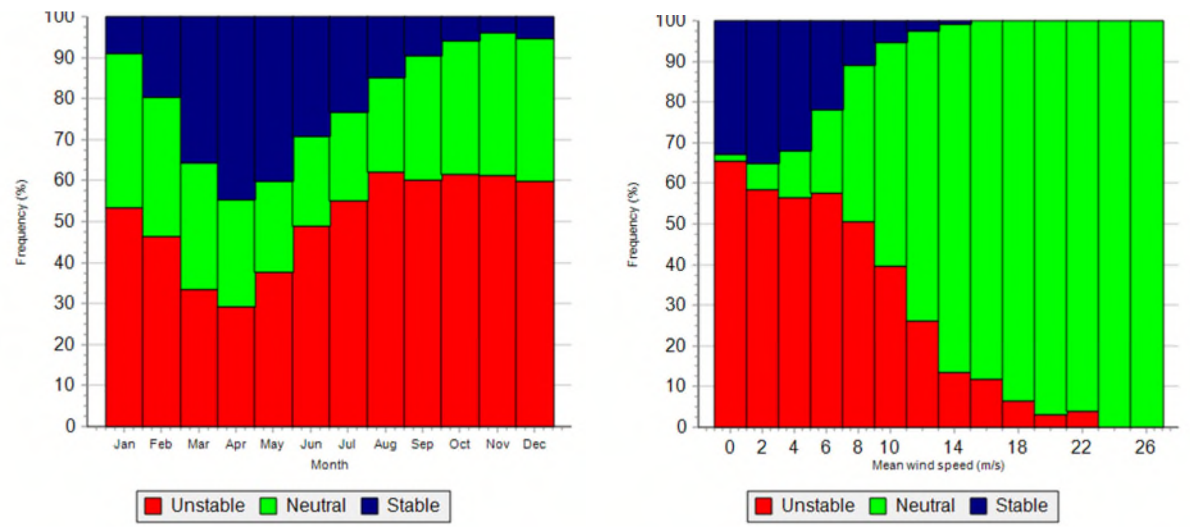


Figure 42. Frequency of stability classes as a function of month and wind speed, EMD-WRF at location of KG-1-LB.

Shear as a function of stability (1/L) at Kattegat is presented in Figure 43. It is clear that unstable conditions result in low shear in the range of -0.2 to 0.2 while during stable conditions, the scatter increase, and much higher shear can occur. Note that the 8 months of data exclude the period of most frequent stable conditions (see Figure 42).

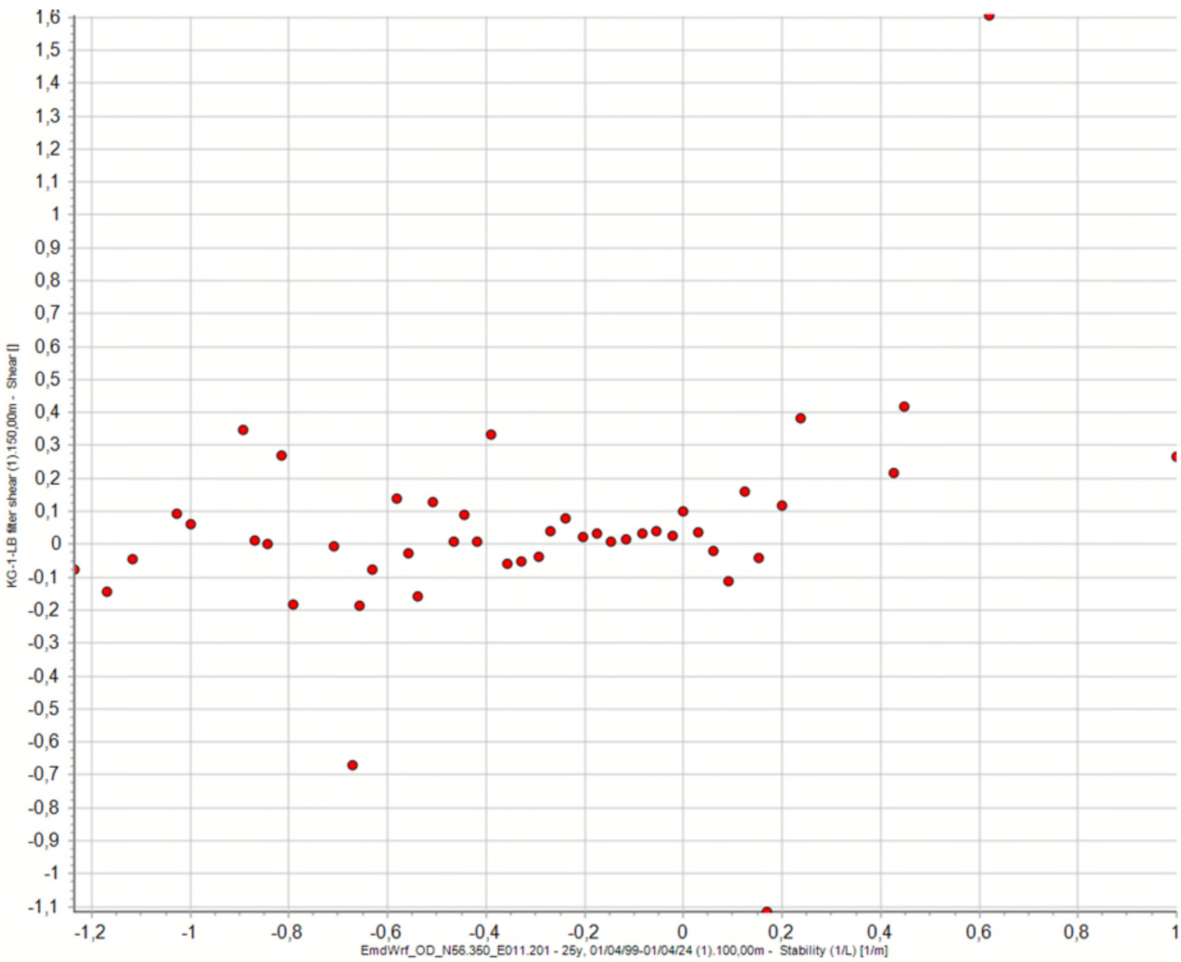


Figure 43. Shear coefficient as a function of stability (1/L), based on KG-1-LB and EMD-WRF data.

At offshore locations, the main driver of the shear coefficient is seasonal rather than diurnal and a plot of rotor radius shear as a function of month (Figure 44) fits well with distribution of stability over the year and shear for different stability regimes with higher shear and stability in spring months.

As Kattegat data are only available for 8 months, monthly shear is also plotted for the Hesselø LiDAR buoy (H1). The H1 data was collected during a different year and while it demonstrates the expected difference in shear between summer and winter, it also shows that for individual months the shear can be quite different from year to year. Using the H1 data to adjust the KG-1-LB shear to a full year is therefore problematic and the observed 8-month shear is preferred until a full year of measurements become available.

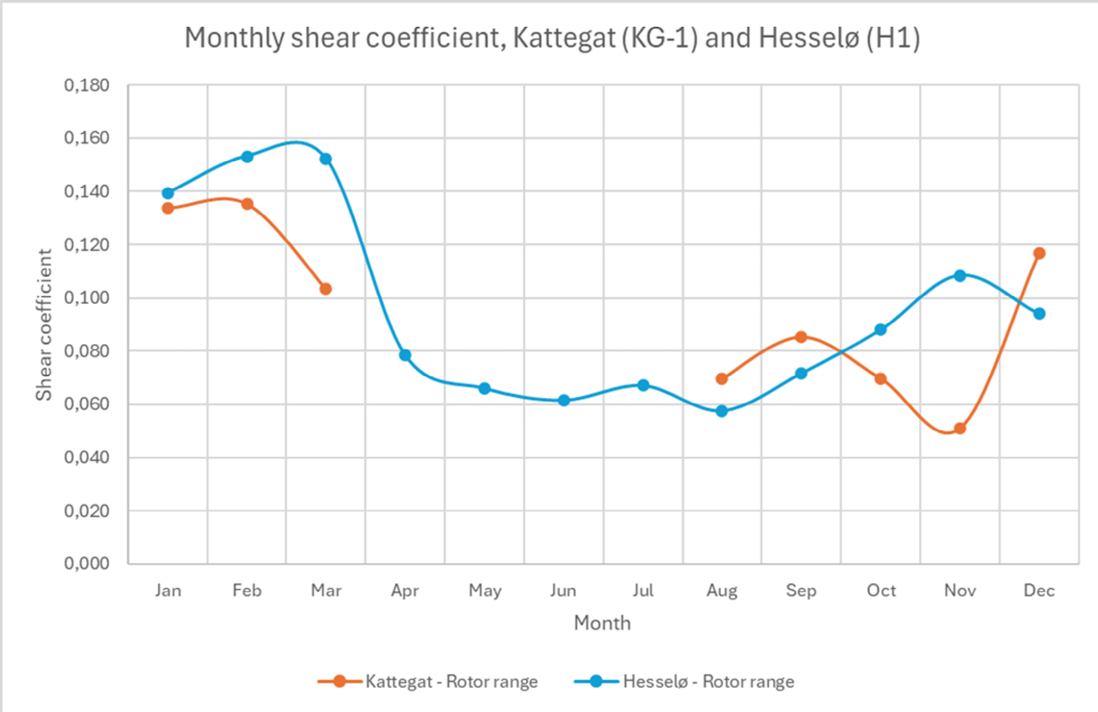


Figure 44. Monthly shear coefficient α across the rotor at Kattegat (KG-1-LB) and Hesselø (H1).

9.1.3 Normal Turbulence Model (NTM)

TURBULENCE MODEL AND FIT

The normal turbulence model in the IEC 61400-1 [1] standard defines a linear relationship between the characteristic 90% quantile of turbulence ($\sigma_{c,90}$) and wind speed. For offshore sites, this is not representative, due to the Charnock effect, which adds a second order effect to the turbulence increase with wind speed [2]. A special purpose offshore model is therefore considered where the turbulence mean value (σ_μ) is modelled as a second order function of wind speed, and the turbulence standard deviation (σ_σ) is modelled as a linear function of wind speed. The models are outlined by the equations:

$$\sigma_\mu(u) = A_{\sigma_\mu} + B_{\sigma_\mu} u + C_{\sigma_\mu} u^2 \quad (1)$$

$$\sigma_\sigma(u) = A_{\sigma_\sigma} + B_{\sigma_\sigma} u \quad (2)$$

The characteristic turbulence required for structural design can be calculated by combining the two models as [1]:

$$\sigma_{c,90}(u) = \sigma_\mu(u) + 1.28\sigma_\sigma(u) \quad (3)$$

SELECTION OF TURBULENCE DATA

The models and safety factors forming the basis of the IEC 61400-1 and IEC 61400-3-1 are calibrated using turbulence measured by cup anemometers. LiDARs measure turbulence in a different way than cup anemometers, as they represent a volumetric average contrary to the point observation of a cup. No industry standard has yet been established to define corrections of LiDAR turbulence for use in site assessments and loads, although attempts are ongoing as e.g. CFARS. On top of this limitation floating LiDARs are exposed to wave movements which are amplified with increasing height. This movement appears as an additional contribution to the apparent turbulence seen by a floating LiDAR. As a consequence, floating LiDARs are not consistent with the requirements in IEC61400-1 or IEC61400-3 for assessment of turbulence and cannot be used to characterise the site turbulence.

Luckily, far offshore conditions are relatively uniform, at least regionally, which is documented in the highly relevant master thesis [30]. Causes of local variations are mainly due to coastal effects and changes in wave-seabed interaction in areas of shallow water affecting the waves. The closest alternative data sources based on cup anemometry, which are available to this study is the Læsø measurement mast. The Læsø mast is located 80 km north of the Kattegat buoy at sufficient distance from shore, but at shallow water (5 m water depth) extending at least 10 km in all directions around the mast (Figure 45). EMD has investigated the turbulence data recorded at 62 m height AMSL and find the turbulence conditions not representative to a deep-water site, like the Kattegat site. For comparison, the Læsø turbulence data are presented in Appendix A.

EMD is in possession of more representative turbulence data for the Kattegat site, but due to confidentiality these data cannot be disclosed.

Instead, a pragmatic solution is found by combining the turbulence model for the North Sea and the turbulence model for the Baltic Sea as reported by EMD for the Site Wind Conditions Assessment, Energy Island North Sea [31] and Site Wind Conditions Assessment, Energy Island Baltic Sea [32].

These two turbulence models are based on data from the FINO3 and FINO2 masts, both of which are located at similar water depth albeit in two different bodies of water(Figure 46 and Figure 47).

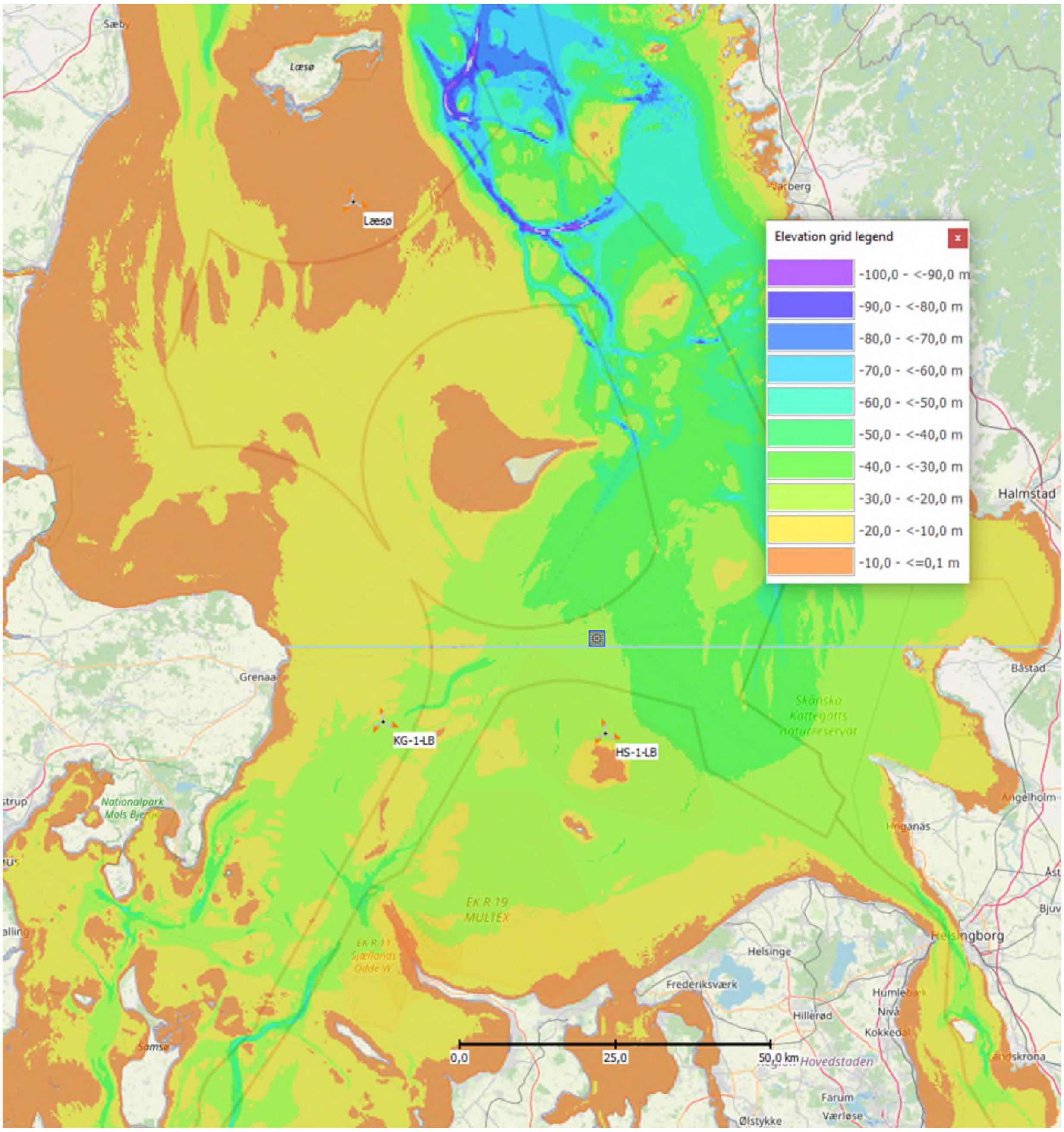


Figure 45. Plot showing the bathymetry of the Kattegat and the relative positions of the Læsø mast to the Kattegat (KG-1-LB) and Hesselø (HS-1) buoys.

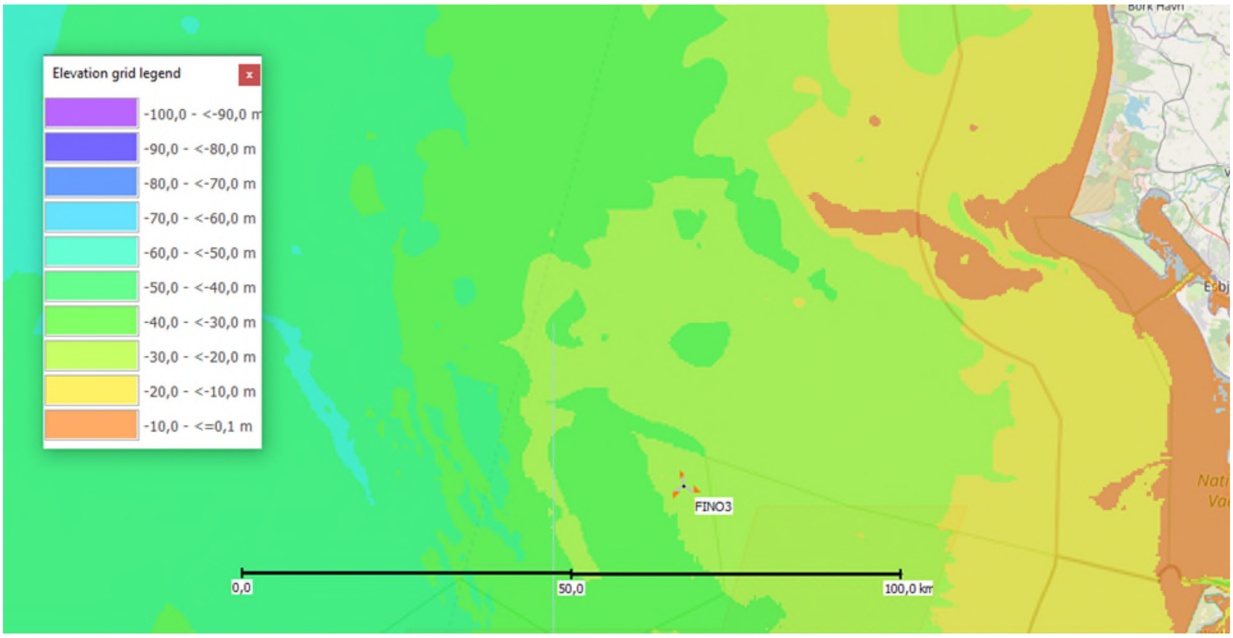


Figure 46. Water depth around the FINO3 mast.

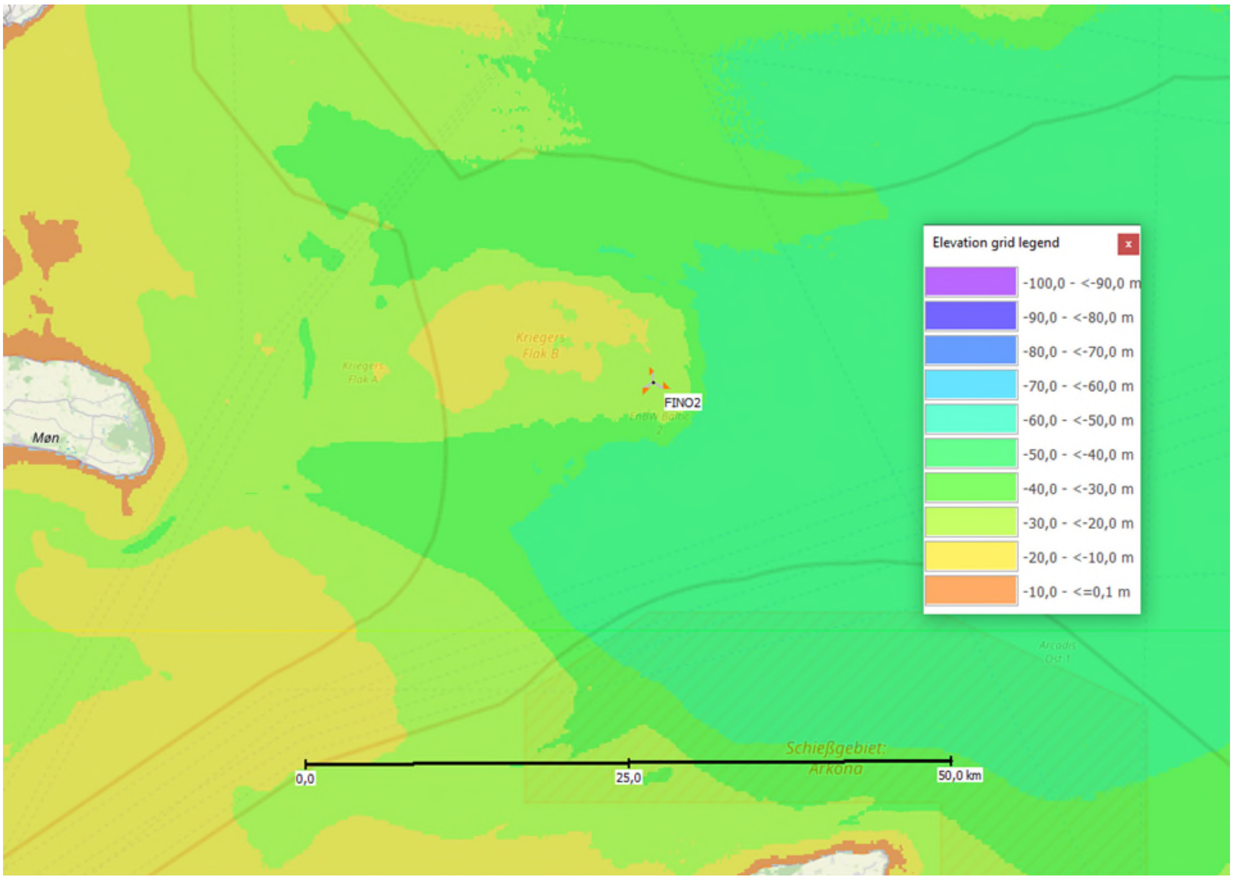


Figure 47. Water depth around the FINO2 mast.

The master thesis [30] documents that the turbulence level at a given height as a function of wind speed is surprisingly uniform and consistent across masts in the entire North Sea, even including the Irish Sea. While the two Site Wind Conditions Assessment reports document a difference between the North Sea and the Baltic Sea, it is a reasonable assumption that the turbulence conditions in Kattegat will form a gradient between the two bodies of water.

FINO3 was the primary source of turbulence information for the Site Wind Conditions Assessment, Energy Island North Sea where it was documented there that the FINO3 turbulence is representative of turbulence conditions in the North Sea. The measurements used for turbulence assessment is at 91 m height AMSL. The FINO3 mast is described in Appendix A. The below presentation of turbulence at FINO3 summarized the findings of the Energy Island North Sea study [31].

FINO2 was the primary source of turbulence information for the Site Wind Conditions Assessment, Energy Island Baltic Sea where it was documented there that the FINO3 turbulence is representative of turbulence conditions in the Baltic Sea. The measurements used for turbulence assessment is at 102 m height AMSL. The FINO2 mast is described in Appendix A. The below presentation of turbulence at FINO2 summarized the findings of the Energy Island Baltic Sea study [32].

FIT OF THE TURBULENCE AT FINO3

As described above, a second-order fit is required to fit the mean turbulence offshore whereas a linear fit is sufficient for the offshore standard deviation of turbulence. According to [2] turbulence may be considered omnidirectional far offshore, which is the setting for the FINO3 data and Kattegat site, hence, the turbulence data are fitted independently of direction.

Figure 51 shows the turbulence observations and associated omnidirectional fits for the 91 m level at FINO3. Notice the clear non-linear effects for the mean turbulence due to wave interaction (i.e. the 'Charnock' effect).

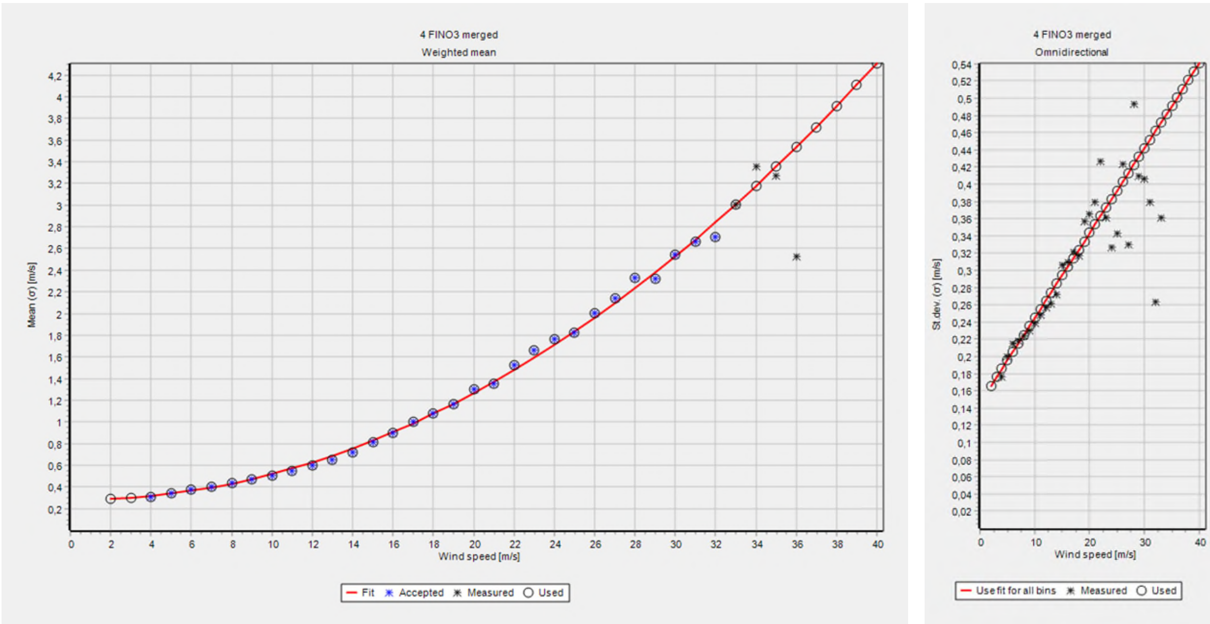


Figure 48. Left: observed mean turbulence versus wind speed at FINO3 91 m including the second order fit. Stars are observations and circles are model values. If the bin has enough samples the star is inside the circle and the bin will contribute to the fit. Right: observed standard deviation of the turbulence versus wind speed at FINO3 91 m including the first order fit.

VERTICAL EXTRAPOLATION AT FINO3

The target height of 150 m for the Kattegat site means 64% extrapolation from the 91 m turbulence data at FINO3. Utilizing the variation of turbulence across the three measurement heights 51 m, 71 m, and 91 m has been considered for the vertical extrapolation model. Figure 49 shows the turbulence data (parameterized) at winds speeds from 5 m/s to 25 m/s as a function of height. For each wind speed a fit modelling the variation with height has been added as dashed lines. For the mean turbulence the best fit type is linear and shows as expected a decrease with height. The decrease with height increases with wind speed. For the standard deviation of turbulence, a second order fit is a better match, showing a slightly increasing positive gradient with wind speed but also an increasing nonlinearity.

Due to the large extrapolation, there is a high risk that turbulence gradients or fits for heights between 51 m and 91 m are not representative of the conditions from 91 m to 150 m. In particular, for the mean turbulence the fits predict a very strong decrease for large wind speeds, with an associated risk of non-conservatism for the resulting loads. Therefore, a simpler and more conservative vertical extrapolation model has been chosen for the mean turbulence. This model bases the extrapolation on the local wind shear as a function of wind speed ($\alpha(u)$) estimated at the Energy Island North Sea site. It reproduces the patterns of variation with height and wind speed seen in [30]. For the mean turbulence the wind speed in the expressions for mean and standard deviation of turbulence is scaled by the speed-up factor relative to 91 m due to the local wind speed dependent shear. This is consistent to assuming a constant wind speed standard deviation (i.e. turbulence mean) with height and assuming only the wind speed changes due to shear. This is in line with the proposal in IEC 61400-15-1 [6] that the wind speed standard deviation may be kept constant while wind speed is extrapolated upwards to hub height.

For the standard deviation of turbulence, the behaviour is opposite that for the mean as it increases with height, again showing stronger gradients at larger wind speeds. Hence, pragmatically the reverse model is adopted as it reproduces the general patterns in [30]. Both models lead to less adjustment of the original 91 m turbulence data and their expressions are given below, with *f(u)* representing the speed-up from 91 m to height *h* due to shear.

$$f(u) = \left({}^{h}/_{91m}\right)^{\alpha(u)} \tag{4}$$

$$\sigma_{\mu,h}(u) = A_{\sigma_\mu} + B_{\sigma_\mu}(u/f(u)) + C_{\sigma_\mu}(u/f(u))^2 \tag{5}$$

$$\sigma_{\sigma,h}(u) = A_{\sigma_\sigma} + B_{\sigma_\sigma} u\, f(u) \tag{6}$$

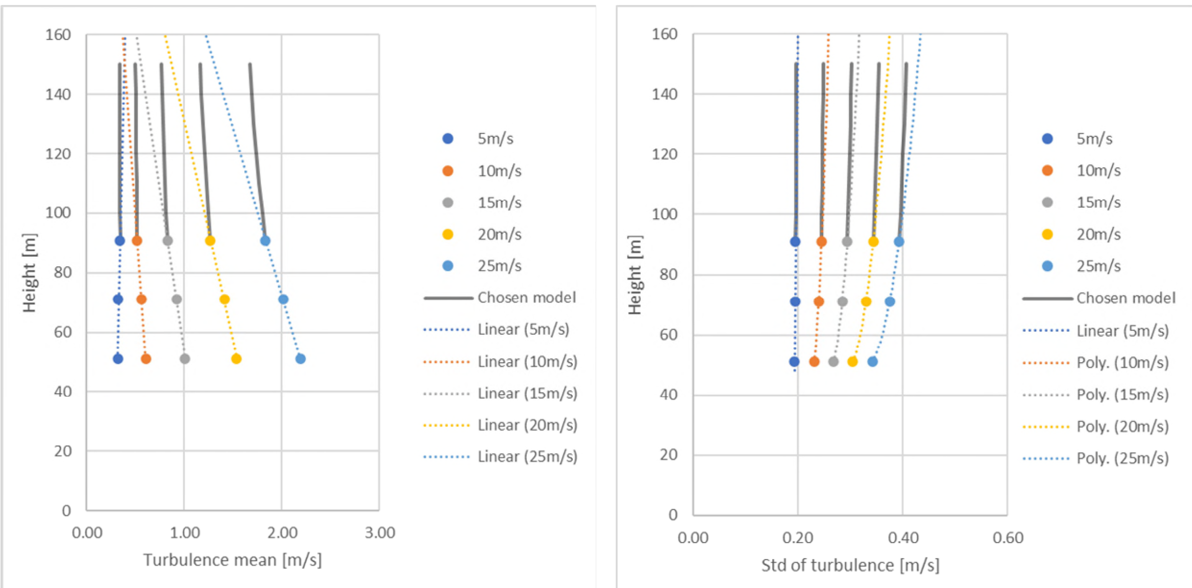


Figure 49. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the three heights at FINO3: 51 m, 71 m and 91 m, together with possible fits to extrapolate across heights as well as the chosen model based on scaling using the wind speed dependent shear.

The consequence of choice of vertical extrapolation model is shown in Table 32, which compares the mean, standard deviation and characteristic turbulence values at 15 m/s. As the table shows the extrapolation based on the fitting of the height variation at lower heights ('extrapolation') leads to considerably lower turbulence levels than the shear scaling method described above. The shear scaling method is therefore preferred.

Table 32. Comparison of the extrapolation models at 150 m with observations at 91 m for the different turbulence values at a wind speed of 15 m/s at FINO3. The shear scaling is chosen as the final model for the North Sea.

at 15 m/s	TURBULENCE MEAN VALUE	STANDARD DEVIATION OF TURBULENCE	TURBULENCE CHARACTERISTIC VALUE
91 m observation	5.5%	2.0%	8.1%
150 m shear scaling	**5.1%**	**2.0%**	**7.7%**
150 m extrapolation through fitting of observations	3.7%	2.1%	6.4%

FIT OF THE TURBULENCE AT FINO2

As for FINO3, a second-order fit is required to fit the mean turbulence offshore whereas a linear fit is sufficient for the offshore standard deviation of turbulence. According to [2] turbulence may be considered omnidirectional far offshore, which is also the setting for the FINO2 data, hence, the turbulence data are fitted independently of direction. This also allows the exclusion of the wind direction interval from 340˚ to 40˚ where significant measurement disturbances were detected (see Appendix A).

Figure 50 shows the turbulence observations and associated omnidirectional fits for the 102 m level at FINO2. Notice the clear non-linear effects for the mean turbulence due to wave interaction (i.e. the 'Charnock' effect).

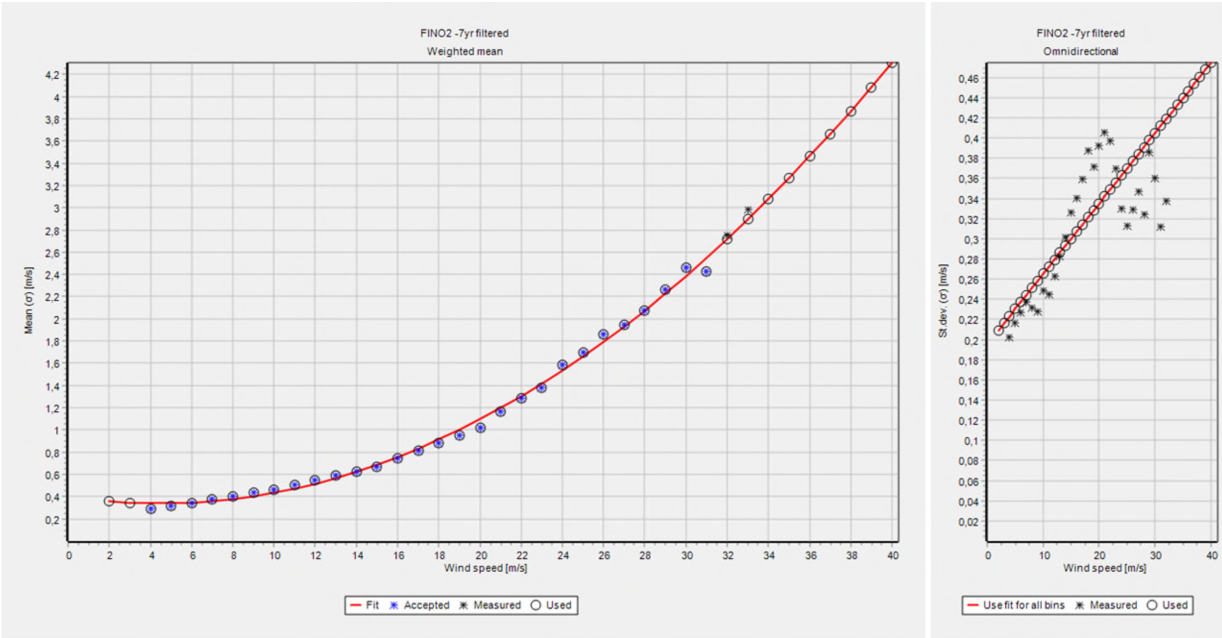


Figure 50. Left: observed mean turbulence versus wind speed at FINO2 102 m including the second order fit. Stars are observations and circles are model values. If the bin has enough samples the star is inside the circle and the bin will contribute to the fit. Right: observed standard deviation of the turbulence versus wind speed at FINO2 102 m including the first order fit.

VERTICAL EXTRAPOLATION AT FINO2

The target height of 150 m for the Kattegat site means approximately 50% extrapolation from the 102 m turbulence data at FINO2. Utilizing the variation of turbulence across the eight measurement heights from 32 m to 102 m has been considered for the vertical extrapolation model. Figure 51 shows the turbulence data (parameterized) at winds speeds from 5 m/s to 25 m/s as a function of height. For each wind speed a fit modelling the variation with height has been added as dashed lines. For the mean turbulence the best fit type is linear and shows as expected a decrease with height. The decrease with height increases with wind speed. For the standard deviation of turbulence, a second order fit is a better match, showing a slightly increasing positive gradient with wind speed but also an increasing nonlinearity.

The extrapolation model used for FINO3 is also used on the FINO2 data. The local wind shear is here the observed shear at the Energy Island Baltic Sea.

It may also be noted that there is an odd jump from 92 m to 102 m on the standard deviation of turbulence curves. The jump results in a lower standard deviation of turbulence based on 102 m data than based on 92 m data and is consistent for all wind speed bins. Below 92 m results for all heights are consistent. The primary difference between the 102 m and the lower measurements is that 102 m anemometer is top mounted while at the lower heights they are side mounted on booms that are not long enough to be IEC compliant. Our understanding is therefore that the mounting of the side anemometers is the cause of a higher-than-expected standard deviation of turbulence and that the top mounted anemometer is correct. The extrapolation of standard deviation of turbulence is therefore based on the 102 m measurements.

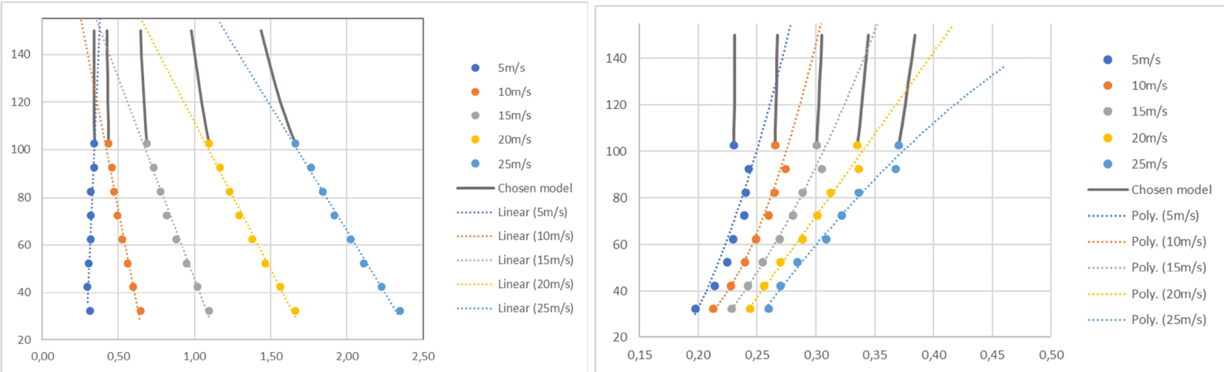


Figure 51. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the eight heights at FINO2: 32.4 m to 102.5 m together with possible fits to extrapolate across heights as well as the chosen model based on scaling using the wind speed dependent shear. Note the offset at 102.5 m for standard deviation of turbulence. The extrapolation is based on the top-mounted anemometer.

The consequence of the choice of vertical extrapolation model is shown in Table 33, which compares the mean, standard deviation and characteristic turbulence values at 15 m/s. As the table shows the extrapolation based on the fitting of the height variation at lower heights ('extrapolation') leads to considerably lower turbulence levels than the shear scaling method described above. The shear scaling method is therefore preferred.

Table 33. Comparison of the extrapolation models at 150 m with observations at 102 m for the different turbulence intensity values at a wind speed of 15 m/s at FINO2. The shear scaling is chosen as the final model for the Baltic Sea.

At 15 m/s	TURBULENCE MEAN VALUE	STANDARD DEVIATION OF TURBULENCE	TURBULENCE CHARACTERISTIC VALUE
102.5 m observation	4.6%	2.0%	7.1%
150 m shear scaling	**4.3%**	**2.0%**	**6.9%**
150 m extrapolation through fitting of observations	2.5%	2.3%	5.5%

COMBINED MODEL FOR KATTEGAT

As a pragmatic solution, the turbulence model suggested for the Kattegat body of water is an average of the North Sea and the Baltic Sea model.

The combination is done by averaging the turbulence model parameters (A, B and C) for mean turbulence and standard deviation of turbulence of the North Sea and the Baltic Sea models. The characteristic turbulence is then calculated from the resulting mean and standard deviation of turbulence.

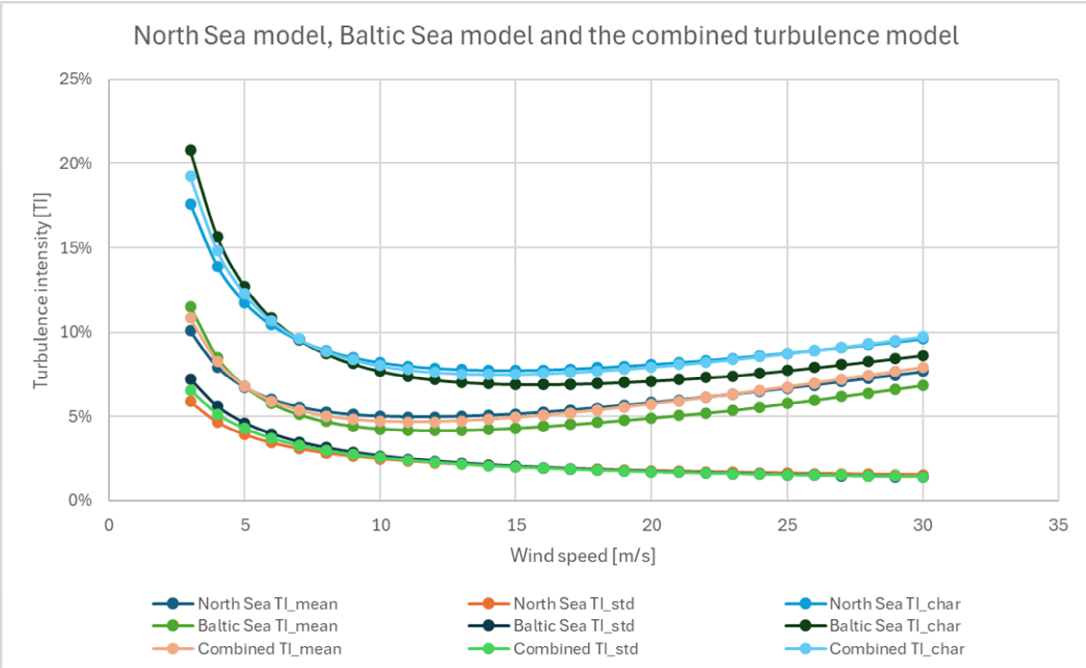


Figure 52. Turbulence intensity models for the North Sea and the Baltic Sea as well as the combined model for Kattegat, which is the average of the North Sea and Baltic Sea models. TI_mean signifies mean turbulence intensity, TI std is standard deviation of turbulence intensity and TI_char is the characteristic turbulence intensity.

EMD has verified the combined model for Kattegat with internally available data for the Kattegat region and finds a very good match with the combined model, especially on the characteristic turbulence intensity. The turbulence model should however be considered uncertain and EMD recommends obtaining local turbulence measurements from the Kattegat area.

Table 34. Turbulence intensity at 150 m for the North Sea model, the Balic Sea Model and the combined model for Kattegat.

at 15 m/s	TURBULENCE MEAN VALUE	STANDARD DEVIATION OF TURBULENCE	TURBULENCE CHARACTERISTIC VALUE
150 m North Sea model	5.1%	2.0%	7.7%
150 m Baltic Sea model	4.3%	2.0%	6.9%
150 m combined model	**4.9%**	**2.0%**	**7.5%**

Coefficients of the final turbulence model at the Kattegat site are presented in Table 35. The chosen final model is based on the average of the North Sea and the Baltic Sea models. A, B and C represent the zeroth, first and second order terms, respectively.

Table 35. Turbulence model parameters at the Kattegat site (150 m) for the chosen model. See equations (1), (2) and (3).

TURBULENCE MODEL PARAMETERS AT THE SITE	TURBULENCE MEAN VALUE	STANDARD DEVIATION OF TURBULENCE	TURBULENCE CHARACTERISTIC VALUE
A [m/s]	0.3446	0.1710	0.5634
B [-]	-0.0148	0.0086	-0.0038
C [s/m]	0.0027		0.0027

9.1.4 Air Density

Air density during normal wind conditions is characterised by its average value at hub height, which is here set to 150 m. Two sources for air density information have been used.

Based on long-term mean temperature found in section 9.1.5, air density is calculated at 150 m elevation assuming standard pressure at this height of 995 hPa. The resulting air density is for KG-1-LB is 1.228 kg/m^3. This is used as primary result.

Alternatively, the air density at 150 m elevation is estimated based on the recent Global Atlas and Siting Parameters (GASP). GASP is the outcome of an EUDP sponsored project by DTU and EMD [33] where site parameters such as air density are defined for the heights 50 m, 100 m and 150 m. The air density based on GASP data is found to be 1.227 kg/m^3 for position KG-1-LB, KG-A and KG-B. This secondary result corroborates the primary result.

Hence the air density average value at 150 m ASL of 1.23 kg/m³ is henceforth assumed.

Mean air density (150 m)	**1.23 kg/m³**

9.1.5 Air Temperature

Air temperature was measured on the Kattegat Buoy (4.1 m) throughout 8 months of operation. The average temperature measured during that period was 8.8°C. The temperature has been long-term corrected with EMD-WRF Europe+ data from the buoy location to 9.7°C. This temperature conforms with temperatures at surrounding meteorological stations Table 37. The limited local measurement period is expected to have only marginal impact on the uncertainty of the temperature assessment.

The temperature at 150 m height has been found using the atmospheric lapse rate of -4.3 K/km derived from the EMD-WRF Europe+ data. The result is 9.1˚C at the Kattegat buoy.

The EMD-WRF Europe+ time series at 150 m has been calibrated to represent the LiDAR position at 150 m height by applying and offset 0.9˚C (difference between EMD-WRF Europe+ and measurements). The resulting time series has then been used to estimate how many hours the temperature is outside the normal and extreme temperature ranges defined in the IEC 61400-3-1 as -10°C to 30°C and -15°C to 40°C, respectively. The results are summarized in Table 36. The probability of temperatures falling outside the defined ranges is assessed by Gaussian distributions fitted to either the 10% highest or lowest temperatures [34].

For KG-A and KG-B, the same temperature than at KG-1-LB can be assumed.

Table 36. Temperature assessment at KG-1-LB – Kattegat buoy (150 m).

CHECK	TMIN [°C]	TMAX [°C]	< TMIN [H/YEAR]	> TMAX [H/YEAR]	TOTAL HOURS OUTSIDE RANGE [H/YEAR]
Normal range	-10.0	30.0	1.104	0.288	1.392
Extreme range	-15.0	40.0	0.008	0.000	0.008
Mean air temperature				9.1°C	
Standard deviation air temperature				6.4°C	
Maximum temperature				28.5°C	
Minimum temperature				-9.1°C	

Table 37. Temperature measurements from surrounding stations.

STATION	HEIGHT ASL [M]	PERIOD LENGTH [Y]	TEMPERATURE [°C]
Anholt Harbour	10	24	9.7
Gniben	10	21	9.6
Hallands Väderö	2	28	9.3
Nakkehoved	10	23	9.2
Røsnæs Fyr	10	22	9.8
Sletterhage Fyr	10	22	9.5

9.2 Extreme Wind Conditions

9.2.1 Extreme Wind Speed Model (EWM)

The site-specific extreme wind speed model is characterized by the extreme wind speed with a 50-year return period [1], which for offshore conditions is supplemented by the extreme wind speed with a 1-year return period [2].

Typically, more onsite data is required to reliably estimate extreme events, than what is currently available to this project. The site-specific extreme wind speeds have therefore been estimated using the approach recommended by the Eurocode for wind loads on structures EN1991-1-4 [3] including its Danish Annex DK NA EN1991-1-4 [4] as well as the Danish Standard DS 472 [5]. This result is supplemented with alternative methods/data.

EN1991-1-4 [3] defines a fundamental value of the basic wind speed ($v_{b,0}$) which corresponds to a 50-year extreme wind speed at 10 m height, independent of direction and time of year and with a standard surface roughness length of $z_{0,II} = 0.05\ m$. Inland in Denmark this basic wind speed is set to 24 m/s [4]. It is specified that this value also covers the inner seas of Denmark where the current site is located.

Instead of the simplified method to vertically extrapolate extreme winds in EN 1991-1-4 [3], the dedicated flow model WAsP Engineering (WEng) has been used for this purpose. WEng includes the effects of waves, formulated by Charnock, including the effect of upstream fetch on wave development and resulting roughness and vertical speed-up. It is noted that atmospheric conditions are assumed neutral in WEng which matches with high wind speed conditions [35]. The analysis was performed through Site Compliance in windPRO with settings as shown below:

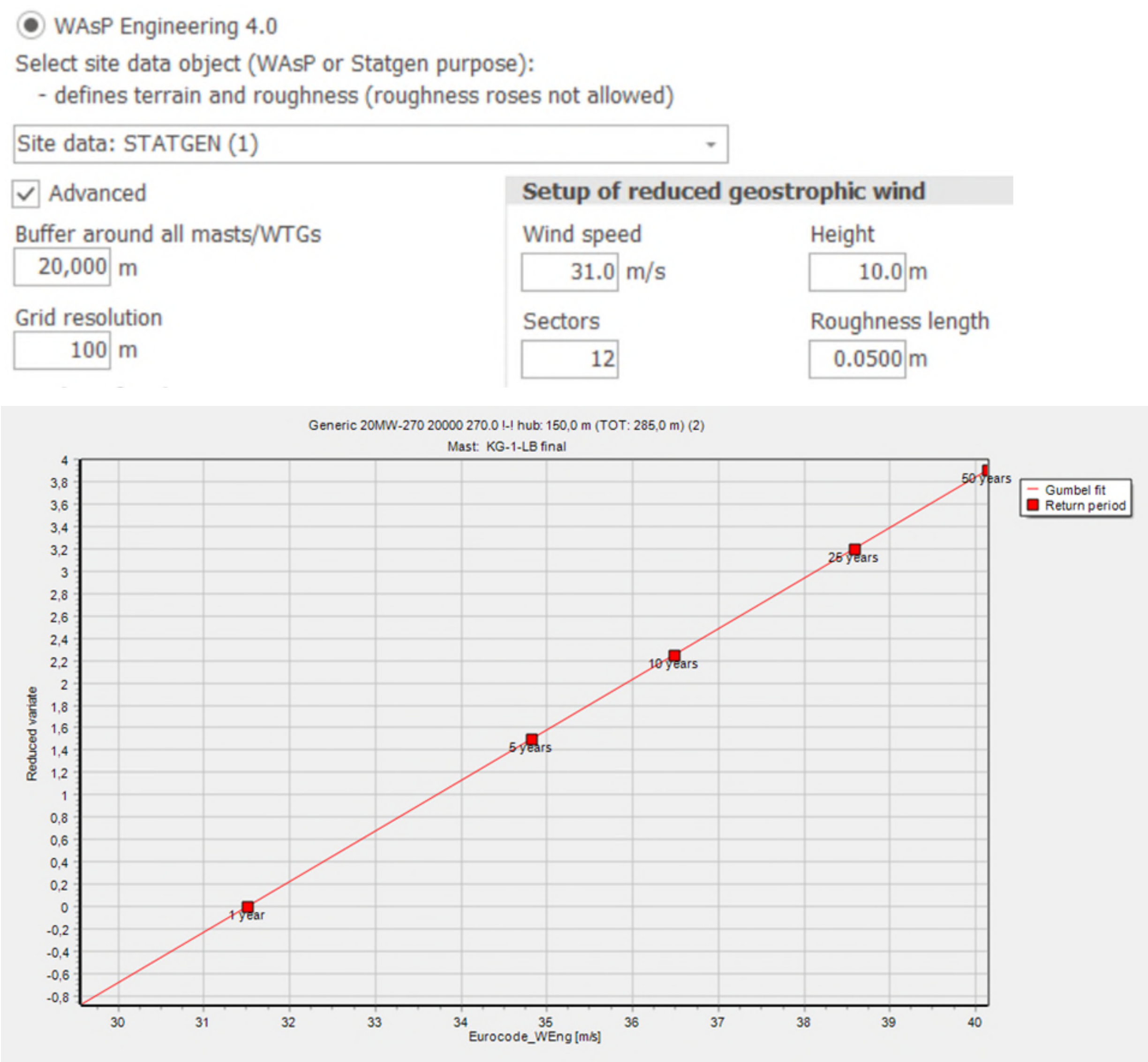


Figure 53. WAsP Engineering settings and output from modelling in windPRO, Site Compliance.

The resulting 1-year and 50-year extreme wind speeds are summarized in the table below:

Table 38. Extreme wind speed results at KG-1-LB (150 m).

TIME HORIZON	EXTREME WIND SPEED [m/s]
1-year	31.5
50-year	40.1

For comparison, we also include two alternative estimates of the onsite extreme wind speeds based on mesoscale data and the annual maximum method (AM) combined with a spectral correction to compensate for the use of mesoscale data, see e.g. [33]. For the method details of AM, see [36]. The spectral correction may be based either on a theoretical assumption about the slope of an undampened spectrum at high frequencies or on a site estimate of the actual spectral slope using onsite measurements. Below we include both spectral correction estimates, the theoretical and the site specific for the buoy.

Finally, as a fourth option the peak-over-threshold (POT) method is used based on the onsite buoy data.

Table 39. Extreme wind speed alternative results using different methods (150 m).

EXTREME WIND METHOD	50-YEAR EXTREME WIND SPEED [m/s]
EN1991-1-4 + WEng + DS472	40.1 (main result)
AM Mesoscale (20y) + Spectral correction (theoretical)	39.5
AM Mesoscale (20y) + Spectral correction (site specific)	39.9
POT (N=20, Δt_{min}=4 days)	40.9

It is noted that the alternative estimates are surprisingly consistent around 40 m/s even if they are based mostly on different data and statistical methods. However, using the Danish Standard [5] directly focused on offshore design conditions for wind turbines is still considered the best alternative as it is based on decades of building experience and knowledge of regional extremes condensed into the building codes.

9.2.2 Wind Shear at Extreme Wind Speed

The site-specific wind profile associated with extreme wind speed events has been estimated based on the on-site LiDAR data at the Kattegat and the Hesselø buoys. The plot below shows the wind shear exponent versus wind speed at 150 m above sea level for the two buoys. The wind shear exponent is estimated for each time step and then averaged in 0.5 m/s bins. Notice the linear increase in shear from around 0.01 at 5 m/s, to 0.13 around 17 m/s. Above 17 m/s wind shear levels out at 0.17 but with a noticeable scatter. As the dataset covers only 8 months of data, the plot is very noisy. During this short period, there are very few data points at high wind speed.

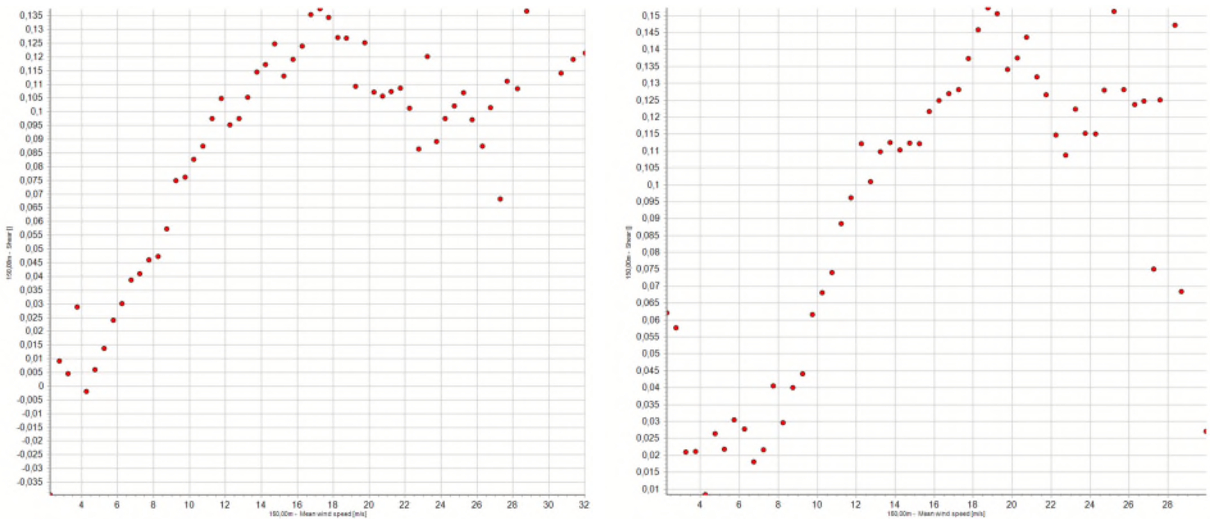


Figure 54. Observed wind shear versus wind speed (0.5 m/s bins) at the Kattegat KG-1-LB buoy (left) and the Hesselø South HS-1 buoy (right). For both buoys, the wind shear clearly levels off at around 0.13 for wind speeds above ca. 17m/s. At lower wind speeds the wind shear increases linearly.

Given these observations the expected wind shear at extreme wind speeds is summarized below.

Expected wind shear at extreme wind speeds	**0.13**

9.2.3 Extreme Wind Shear (EWS)

To estimate the site-specific extreme wind shear, it is recommended to use equations (27) and (28) in section 6.3.3.7 of the IEC 61400-1 [1] with site-specific values for the ambient turbulence standard deviation together with the site-specific wind shear exponent.

9.2.4 Turbulence at Extreme Wind speed

In addition to the extreme turbulence model, the IEC 61400-3-1 [2] requires that the site-specific turbulence for extreme wind speed is defined. Using the turbulence model defined in section 9.1.3 the turbulence is estimated at the site estimate of the 50-year extreme wind speed as shown below:

Table 40. Turbulence at extreme wind speed.

50-YEAR WINDSPEED (@HUB HEIGHT) [M/S]	TURBULENCE INTENSITY MEAN [%]	STD. DEV OF TURBULENCE INTENSITY [%]	TURBULENCE INTENSITY CHARACTERISTIC [%]
40.1	10.3	1.3	12.0

Wave development and growth is limited, such that, for a given wind speed, the significant wave height and peak wave lengths stop growing above a certain wind speed. In effect, this means that the sea surface roughness will eventually saturate as the wind speed becomes increasingly extreme, and the Charnock effect (second order effect) will cease to grow. In [37] and [38] it was reported that the 10 m wind speed required for saturation of the surface roughness is in the range 33-40 m/s while [39] indicates saturation at 35 m/s in 10 m height. In this work the latter saturation value of 35m/s at 10 m height is adopted. The saturation estimates correspond to a virtually infinite fetch, and prolonged wind duration for full wave development, it is therefore expected that the wind speed required for saturation at the real sites will be lower than 35 m/s, making this assumption conservative.

9.2.5 Extreme Turbulence Model (ETM)

The site-specific extreme turbulence model as function of wind speed (σ_{ETM}) is assessed using the peak factor method described in the IEC 61400-1 footnote 32 [1]:

$$\sigma_{ETM}(V_{hub}) = \sigma_{mean}(V_{hub}) + k_p(V_{hub}) \cdot \sigma_{stddev}(V_{hub}), \quad [7]$$

$$k_p = 0.01\left(\frac{V_{ave}}{(m/s)} - 21\right)\left(\frac{V_{hub}}{(m/s)} - 5\right) + 5 \quad [8]$$

Omnidirectional values are used for the mean wind speed (V_{ave}) as well as the mean and standard deviation of turbulence. The extreme turbulence values are plotted below:

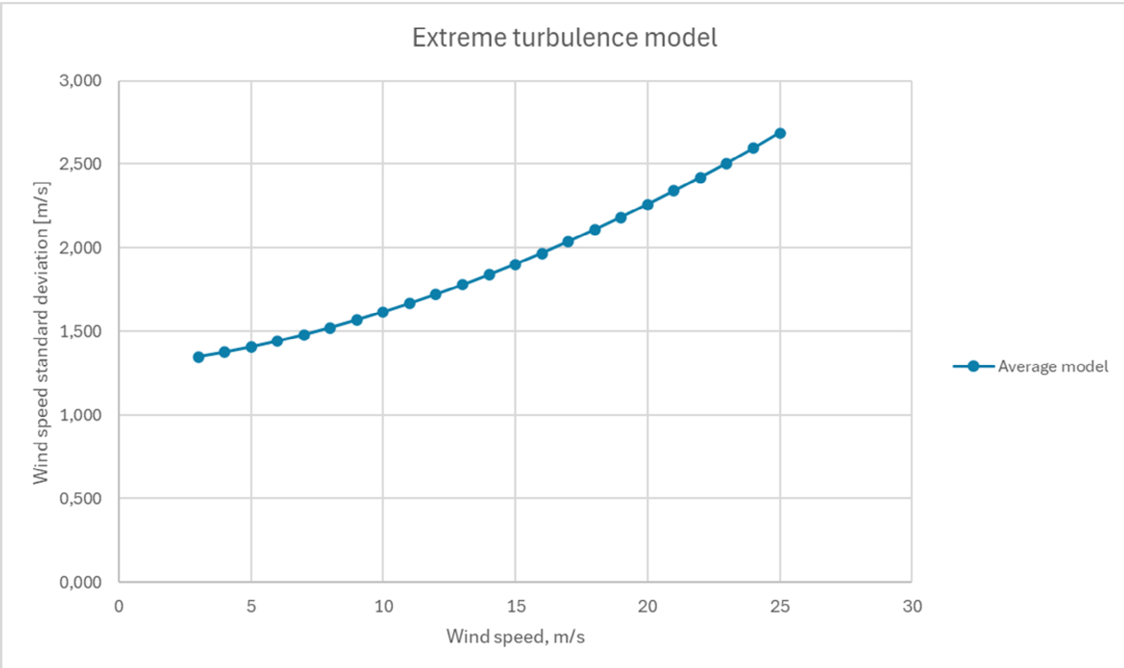


Figure 55. Extreme turbulence model. Turbulence is standard deviation of wind speed.

9.2.6 Air Density for Extreme Wind

The air density for extreme wind conditions is found based on average temperature at high wind speed events. This is calculated as 1.25 kg/m^3 for the position of KG-1-LB. Alternatively, the air density for extreme wind conditions can be taken from GASP [33], which results in a value of 1.23 kg/m^3.

It was decided to proceed with the air density for extreme wind speeds from the buoy.

Air density for extreme wind speeds (150 m)	**1.25 kg/m^3**

9.3 Additional Site parameters

9.3.1 Salinity

The IEC 61400-1 [1] does not specify details when assessing the salinity of the site. EMD proposes to use the salinity of the upper part of the water column as salinity figure. The water can form droplets at high wind speed which get in contact with the wind turbine structure.

The salinity is assessed though the Copernicus Marine Service [40]. The average salinity at surface level based on the period 2021-2024 is found to be 22.5 g/m2.

9.3.2 Lightning

The IEC 61400-1 [1] does not specify details when assessing the impact of lightning on the site. Based on data from NASA, Global Hydrology and Climate Center [41], the lightning frequency of the site is 1.18 flashes/year/km2.

9.3.3 Solar Radiation

Based on Heliosat, SARAH3 data [42] the average solar irradiation during the period 2004 to 2024 is 121 W/m2. Peak solar radiation does not exceed 880 W/m2.

9.3.4 Earthquake

The site rates as Low Hazard with a peak ground acceleration of 0.22 m/s2 [43]. With the low hazard rating, earthquakes need not be investigated further [2].

9.3.5 Relative Humidity

The buoy measures the humidity near sea level. Based on 8 months of measurements the average relative humidity is 83.8% with a standard deviation of 9.3%. As a full year is not yet available, this value may be seasonally biased.

9.4 Climate Change

In the context of this report, the impact of the climate change is consired relevant for the following signals types :

- Mean wind speed
- Extreme wind

- Temperature (and therefore air density)
- Rain (as being driver for blade degradation)

Of these parameters, all, except for extreme winds, are covered by the Copernicus Interactive Climate Atlas [44]. The atlas contains 25 models for each scenario. Two scenarios have been considered, SSP3-7.0 and SSP5-8.5, which are estimated to be the most realistic with the current development of emissions. The two terms which cover the operational period of the planned project are studied: near-term (2021-2040) and medium term (2041-2060).

For the relevant area in Kattegat the Copernicus Interactive Climate Atlas finds no change of the annual mean wind speed signal or no robust signal for neither of the two scenarios under consideration. Also, the seasonal mean wind speed signals show no change or no robust signal. A robust signal is defined through the requirement that at least 80% of the models agree on the sign of change and at least 66% of the models show a change greater than the internal-variability threshold. Note that while the average annual mean wind speed might remain unaffected, there are indications of an increase in prolonged weather patterns [45]. These patterns may be characterized by extended periods of either low wind speeds, such as during high-pressure omega blocks, or high wind speeds.

Other studies [46] identify a significant correlation around 0.9 between equator-to-pole temperature gradient and wind speed reduction, which imply that that the arctic amplification is a risk for European offshore wind energy. While the North Sea seems clearly affected, the project area does not indicate a significant correlation (Figure 56).

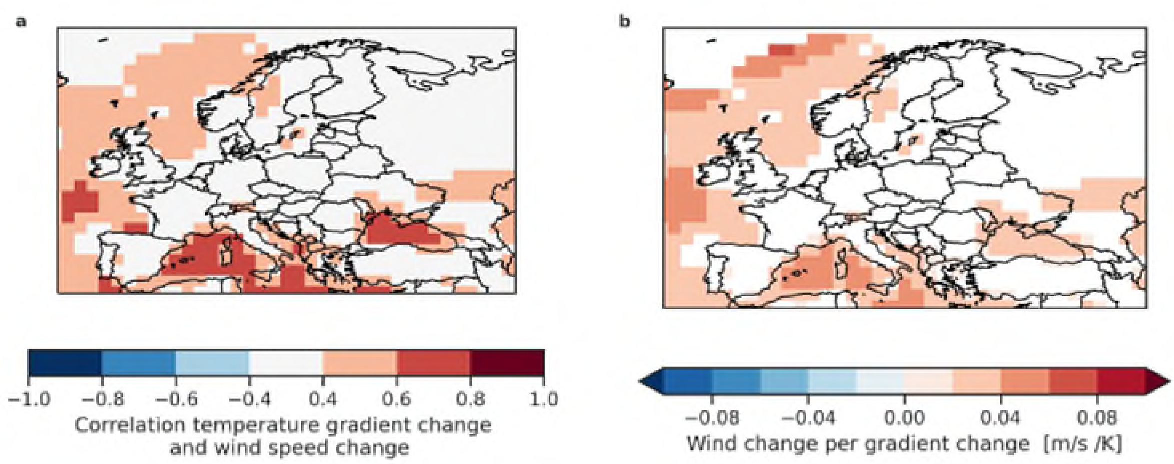


Figure 56: Relationship between changes in wind speed and the equator-to-pole gradient in Europe in the full CMIP6 ensemble. Correlations between changes (a) and the slope of a linear regression in locations where correlations exceed absolute values of 0.4 (b) [46]

Not only forcing like global warming affect mean wind speeds, but also natural variations, like Atlantic Multidecadal Oscillation (AMO). Some work indicates that CMIP6 shows weaknesses and does not capture the AMO sufficiently [47]. Therefore, it is advisable to investigate multidecadal oscillations separately.

Wohland et al [48] compares natural oscillations with forced wind speed changes: For the historic period the trends of the forced wind speed changes for the are at the order of 0.01m/s per decade (green histogram, Figure 57 a), while the observed trends are 1 order of magnitude larger (orange histogram). The trend in the forced wind speed changes increase for increased radiative forcing (green histogram in Figure 57 c and d) but stay still at below 1/4 of the natural changes.

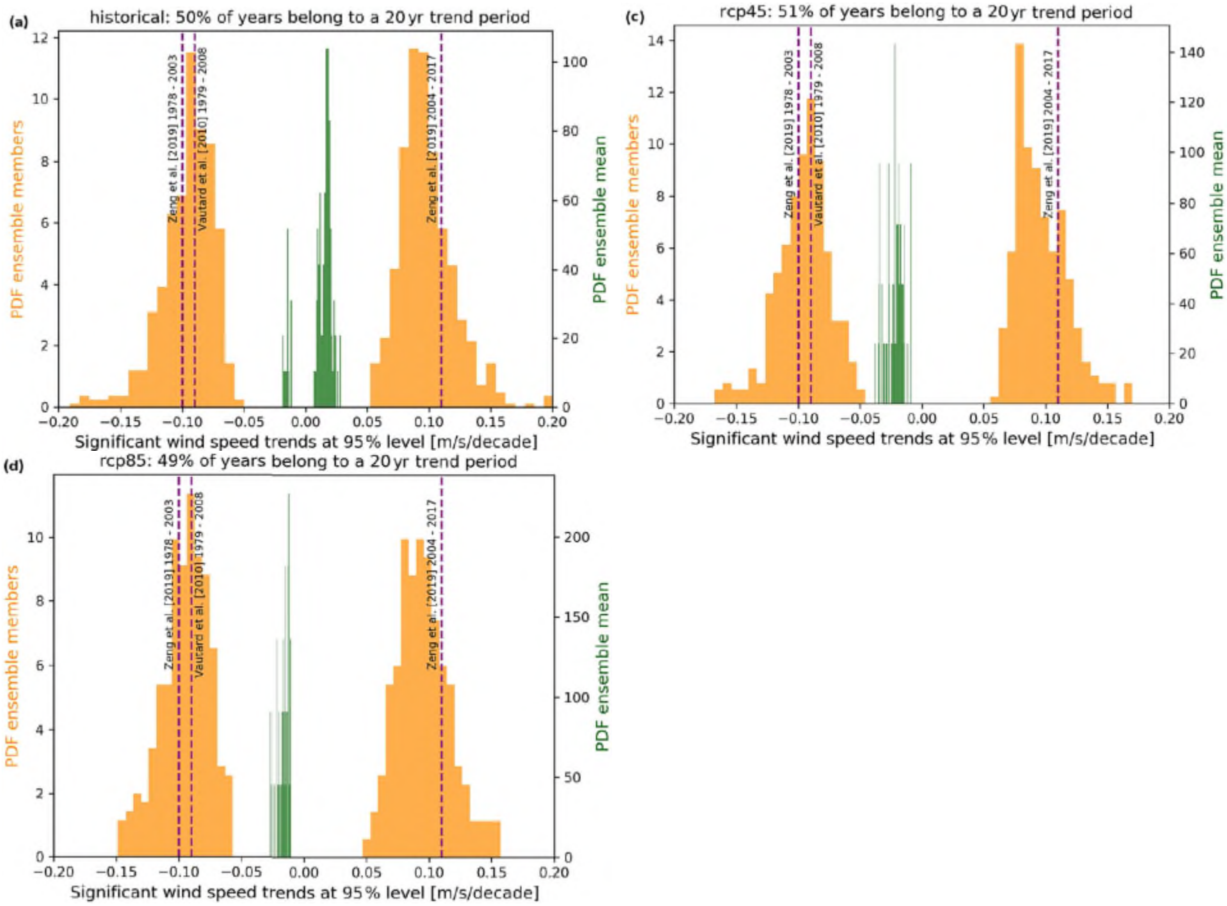


Figure 57: Twenty-year trends in European annual mean wind speed in Max Planck Institute - Grand Ensemble (MPI-GE) under historic (a) and future climate conditions (c) and (d). Trends are computed for each ensemble member after subtraction of ensemble mean (orange – representing internal variability) and for the ensemble mean (green – representing forced changes). Different subplots show different experiments. Trends are only shown if they are different from zero at a 95% significance level.

We conclude that the potential change of mean wind speed in the Baltic Sea is smaller than the natural variability.

Among many studies on climate change impact, the impact on extreme wind conditions is one of those that does not lead to clear conclusions. We refer to the recent work of Xiaoli Guo Larsén et al, DTU [49]. A selection of models from the SSP5 scenario were compared with reanalysis data (ERA5) and the offshore masts Fino 1-3. The near-term period from 2020 to 2049 was analysed, which overlaps well with the operational period of the planned projects. In contrast to the North Sea, Larsén finds no significant signal for most of the SSP5 ensemble models for the projected area in the Baltics.

For temperature, however, the Copernicus Interactive Climate Atlas [44] shows a robust signal when compared to the period 1991-2020. The absolute temperatures are illustrated in Figure 58. In the worst case (SSP5, medium term), the temperature will increase by 2˚C corresponding to 0.7% lower air density, which will impact the power production of wind turbines in the area.

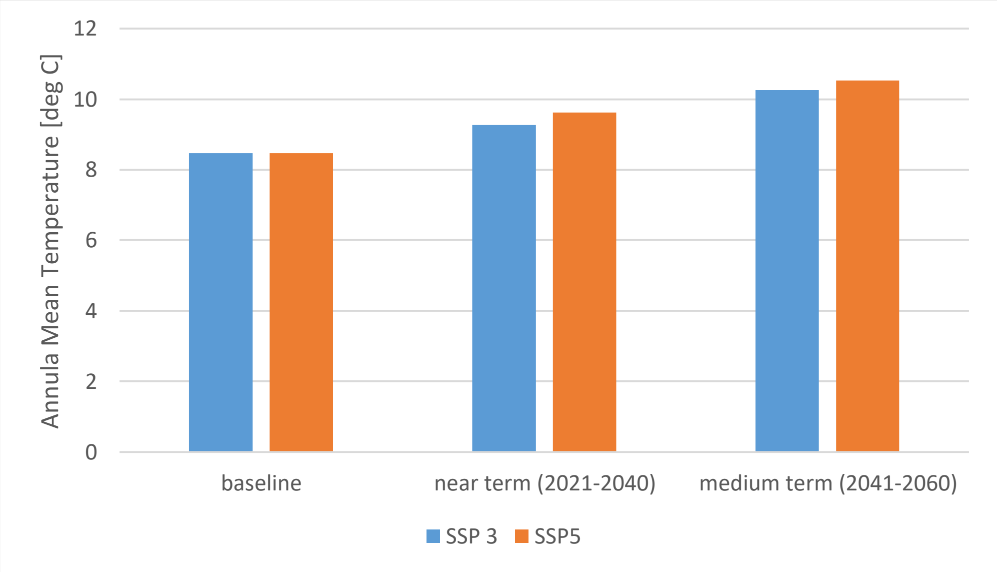


Figure 58: Development of the absolute annual temperature in the Kattegat area

To evaluate the changes of precipitation, the daily accumulated precipitation in mm/day was analysed from the Copernicus Interactive Climate Atlas [44]. Here SSP3 shows a robust signal showing an increase of precipitation, both for near and medium term. An increase of precipitation might lead to more blade degradation. SSP5 shows no signal or no robust signal.

9.5 Summary Table of Siting Parameters

The requested omnidirectional siting parameters are summarized in Table 41.

Table 41. Summary table of siting parameters (150 m).

Parameter	KG-1-LB	KG-A	KG-B
Mean wind speed	9.64 m/s	9.63 m/s	9.66 m/s
Weibull distribution, A parameter (scale)	10.88 m/s	10.87 m/s	10.91 m/s
Weibull distribution, k parameter (shape)	2.32	2.32	2.33
Normal wind profile power law exponent	0.092	0.092	0.092
Turbulence intensity mean value (TI_{μ}) at a 10-min average wind speed of 15m/s*	4.9%	4.9%	4.9%
Turbulence intensity standard deviation (TI_{σ}) at a 10-min average wind speed of 15m/s*	2.0%	2.0%	2.0%
Turbulence intensity 90% quantile at a 10-min average wind speed of 15m/s*	7.5%	7.5%	7.5%
Mean air density	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3
Mean air temperature	9.1°C	9.1°C	9.1°C
50-year extreme wind speed	40.1 m/s	40.1 m/s	40.1 m/s
1-year extreme wind speed	31.5 m/s	31.5 m/s	31.5 m/s
Wind shear for extreme wind speed extrapolation	0.13	0.13	0.13
Characteristic turbulence intensity at 50-year extreme wind speed	12.0%	12.0%	12.0%
Air density for extreme wind	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3
Lightning	1.18 flashes/year/km^2	1.18 flashes/year/km^2	1.18 flashes/year/km^2
Solar radiation, mean	121 W/m^2	121 W/m^2	121 W/m^2
Solar radiation, peak	880 W/m^2	880 W/m^2	880 W/m^2
Relative Humidity, mean	83.8%	83.8%	83.8%

**Turbulence values at other wind speeds can be found in Appendix H*

10 Data Package

EMD has submitted datasets in support of this study. These are as far as it is possible provided in accessible formats.

10.1 Filtered and Repaired LIDAR Data

Datasets for the filtered and repaired datasets are provided in folder “20 Analysis/22 Filtered time series”. The filter and repair process is described in section 4.4.3. The dataset represents 8 months of data. The text file can be imported directly into windPRO, but as an open format, it is generally accessible.

- WS199_8 months.txt

The text file includes measurements at all heights. Measurements on the buoy (non-LiDAR data) are for practical reasons set at 4 m. The dataset is organized in columns, grouped by height. Data for a given height with Sample Status flagged as “1” is disabled by EMD.

The content of the columns is explained in Table 42.

The data set is also included as windPRO Meteo objects in an Object export file

- WS199_8 months.wpobjects

The object export file can be imported into windPRO 4.0 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

Table 42. Column explanation for data time series.

COLUMN LABEL	DESCRIPTION
TimeStamp	Date and time, dd/mm/yyyy hh.mm
MeanWindSpeedUID_xx,xm	Mean wind speed at height xx.x m, m/s
DirectionUID_xx,xm	Wind direction at height xx.x m, m/s
TurbIntUID_xx,xm	Turbulence intensity at height xx.x m
OtherUID_xx	Number of datapackages received at height xx.x m, m/s
Comment_xx,xm	Comments for height xx.x m (not used)
TimeStampStatus_xx.xm	Internal setting for WindPRO
SampleStatus_xx.xm	Status flag on entire sample: 0: OK, 1: disabled, 2: below limit, 4: above limit, 8: duplicate, 16: null value, 32: missing, 128: other error
DataStatus_yyyy_xx,xm	Status flag for parameter yyyy flagged at height xx.x m. Settings as for Sample Status.
DataStatus…..	Datastatus for other parameters.
OtherUID_xx,xm	Info flag at height xx.x m
TemperatureUID_4.0m,xm	Temperature at 4m, ˚C
RelativeHumidity_UID_4.0m,xm	Relative humidity at 4m, %
PressureUID_4.0m,xm	Pressure at 4m, hPa

10.2 Long-term Corrected LiDAR data

The long-term corrected time series at the positions of KG-1-LB, KG-A and KG-B are included in the data package in the folder "20 Analysis/23 Long-term time series". Position KG-1-LB include all LiDAR measurement heights. Position KG-A and KG-B only includes the 150 m height.

- KG-1-LB LTC.txt
- KG-A LTC.txt
- KG-B LTC.txt

Parameters included are wind speed and wind direction. Data format follows the format described above. The text file can be imported directly into windPRO, but as an open format, it is generally accessible.

All three datasets are included as windPRO Meteo objects in an Object export file.

- LTC Position KG-1-LB, KG-A, KG-B.wpobjects

The object export file can be imported into windPRO 4.0 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

10.3 EMD-WRF Dataset

The EMD-WRF dataset for the positions of KG-1-LB is included in the data package in the folder "10 Models" as a text file export with selected parameters:

- EMD-WRF Position KG-1-LB.txt

The data columns are described in Table 43.

The EMD-WRF datasets is included as windPRO Meteo objects in an Object export file.

- EMD-WRF KG-1-LB position.wpobjects

The object export file can be imported into windPRO 4.0 by right-clicking in the Object list and select Import -> Import from windPRO object import file. The object export file includes more parameters than presented in the text file.

Table 43. Column explanation for EMD-WRF data time series.

COLUMN LABEL	DESCRIPTION
TimeStamp	Date and time, dd/mm/yyyy hh.mm
MeanWindSpeedUID_xx,xm	Mean wind speed at height xx.x m, m/s
DirectionUID_xx,xm	Wind direction at height xx.x m, m/s
TurbIntUID_xx,xm	Turbulence intensity at height xx.x m
TemperatureUID_100,0m	Temperature at height xx.x m
Comment_xx,xm	Comments for height xx.x m (not used)
TimeStampStatus_xx.xm	Internal setting for WindPRO
SampleStatus_xx.xm	Status flag on entire sample: 0: OK, 1: disabled, 2: below limit, 4: above limit, 8: duplicate, 16: null value, 32: missing, 128: other error
DataStatus_yyyy_xx,xm	Status flag for parameter yyyy flagged at height xx.x m. Settings as for Sample Status.
DataStatus	Datastatus for other parameters.

10.4 Wind Resource Map

The wind resource map calculated in section 8.3 (coordinates system: UTM-WGS84, Zone 32) is provided as an .rsf file (recognized WAsP format) in the folder “50 Wind resource maps”:

- Kattegat_Res_250_Hub_150.0_0.rsf

The file “Kattegat_Res_250_Hub_150.0_0.emdinfo” is a helping file which contains information about the coordinates system that can be used in windPRO software.

11 References

[1] IEC, International Standard IEC 61400-1 ed. 4: Wind Turbines - Part 1: Design Requirements, 2019.

[2] IEC, International Standard IEC 61400-3-1 ed. 1, Wind Energy generation systems - Part 3-1: Design requirements for fixed offshore wind turbines, 2019.

[3] Eurocode, EN1991-1-4: Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions., 2005.

[4] Eurocode, EN1991-1-4 DK NA, 2007.

[5] Dansk Standard, DS 472 Ed. 2: Forudsætninger for vindmøllekonstruktioner i Danmark, 2007.

[6] IEC, International Standard IEC PRV 61400-15-1, Wind energy generation systems – Part 15-1: Site suitability input conditions for wind power plants, 2024.

[7] Energinet, "Scope of Services - Site Wind Conditions Assessment," 2023.

[8] DMI, "Danish Meteorological Institute - Open Data," Danish Meteorological Institute , [Online]. Available: https://confluence.govcloud.dk/display/FDAPI/Meteorological+Observation.

[9] SMHI, "SMHI Open Data API Docs - Meteorological Observations," Swedish Meteorological and Hydraulic Institute, [Online]. Available: https://opendata.smhi.se/apidocs/metobs/index.html.

[10] Fugro Norway AS, "SWLB measurements - Danish Offshore Wind 2030, Project Measurement Plan, All Lots, DNV report C75516/C75517/C75518_Project_Measurement_Plan_All_Lots 09, 25 November 2023," 2023.

[11] Fugro Norway AS, "C75516-PEP 07, SWLB measurements at Danish Offshore Wind 2030 – Lot 1 Project Execution Plan Lot 1, 5 December 2023," 2023.

[12] Fugro Norway AS, "Danish Offshore Wind 2030 – Floating LiDAR Measurements, Monthly report (8 instalments)," 2024.

[13] Fugro, "Service Report, Kattegat and Hesselø South, C75516-KG-HS-SER," 2023.

[14] DNV, "ZX1741, Independent analysis and reporting of ZX LiDARs performance verification executed by Zephir Ltd. at the UK Remote Sensing Test Site. DNV GL report 10422597-A-38, Rev. A. 2023-05-23," 2023.

[15] DNV, "Independent performance verification of Seawatch Wind Lidar Buoy WS199 at Frøya. DNV GL report 10422674-R-11, Rev. B. 2023-07-13," 2023.

[16] DNV-GL, "Type ZX300 LIDAR, Remote Sensing Device Type-specific Classification Summary, Report No.: GLGH-4275 18 14741 258-R-0003, Rev. D," 2018.

[17] DNV, "Technical Letter 10299802-L-1-B, SEAWATCH Wind LiDAR Buoy Stage 3 confirmation, 2022-02-17," 2022.

[18] DNV, "Independent performance verification of Seawatch Wind Lidar Buoy WS199 at Frøya. DNV GL report 10422674-R-11, Rev. B. 2023-07-13," 2023.

[19] Carbon Trust , "Carbon Trust Offshore wind Accelerator Roadmap for the Commercial Acceptance of Floating LiDAR Technology, Version 2.0," 2018.

[20] OWA, "Lidar Uncertainty Standard Review Methodology Review and Recommendations, OWA Report 2017-001," 2018.

[21] EMD International A/S, "ERA5 Gaussian Grid," [Online]. Available: https://help.emd.dk/mediawiki/index.php?title=ERA5_(Gaussian_Grid).

[22] EMD International A/S, "EMD-WRF On-Demand," [Online]. Available: https://help.emd.dk/mediawiki/index.php?title=EMD-WRF_On-Demand_and_Custom-Area.

[23] EMD International A/S, "NORA3," [Online]. Available: https://help.emd.dk/mediawiki/index.php/NORA3.

[24] T. Pohlert, Non-Parametric Trend Tests and Change-Point Detection, 2017.

[25] EMD International A/S, "WindPRO / MCP, An Introduction to the MCP Facilities in windPRO," 2021.

[26] MEASNET, Evaluation of Site Specific Conditions v3, 2022.

[27] S. Liléo, E. Berge, O. Undheim, R. Klinkert and R. Bredesen, "Long-term correction of wind speed measurements - State of the art, guidelines and future work," Kjeller Vindteknikk, Norway, 2013.

[28] J. e. a. Wohland, "Mitigating a century of European renewable variability with transmission and informed siting," *Enivron. Res. Lett.,* vol. 16, no. 064026, 2021.

[29] A. C. Fitch, J. B. Olson, J. K. Lundquist, J. Dudhia, A. K. Gupta, J. Michalakes and I. Barstad, "Local and Mesoscale Impacts of Wind Farms as Parameterized in a Mesoscale NWP Model," *Monthly Weather Review,* vol. 140, no. 9, 2012.

[30] D. A. Pollak, “Characterization of ambient offshore turbulence intensity from analysis of nine offshre meteorological masts in Norhtern Europe,” Master Thesis - European Wind Energy Masters Program -EWEM- Wind Physics Track, 2014.

[31] EMD International A/S, “Site Wind Conditions Assessment, Energy Island North Sea,” 2023.

[32] EMD International A/S, “Site Wind Conditions Assessment, Energy Island Baltic Sea,” 2023.

[33] X. G. e. a. Larsén, “DTU Wind Energy E-Report-0208: Calculation of Global Atlas of Siting Parameters,” 2020.

[34] EMD International A/S, “WindPRO 4.0 User Manual,” 2023.

[35] A. Pena, “Sensing the Wind Profile,” Risø DTU, 2009.

[36] L. Svenningsen, “windPRO LOADS user manual,” EMD International A/S, [Online]. Available: https://help.emd.dk/knowledgebase/content/windPRO3.6/c5-UK_windPRO3.6-LOADS.pdf. [Accessed March 2023].

[37] A. V. e. a. Babanin, “Waves and Swells in High Wind and Extreme Fetches, Measurements in the Southern Ocean,” *Front. Mar. Sci,* vol. 6, no. Jul, pp. 1-12, 2019.

[38] M. D. Powell, P. J. Vickery and T. A. Reinhold, “Reduced drag coefficient for high wind speeds in tropical cyclones,” *Nature,* vol. 422, no. 6929, pp. 279-283, 2003.

[39] B. A. Harper, J. D. Kepert and J. D. Ginger, “Guidelines for converting between various wind averaging periods in tropical cyclone conditions,” World Meteorological Organization (WMO), Geneva, 2010.

[40] Copernicus Programme, “Copernicus Marine Service,” [Online]. Available: https://marine.copernicus.eu/.

[41] NASA, Global Hydrology and Climate Center, “GHRC Portal,” [Online]. Available: https://ghrc.nsstc.nasa.gov/home/.

[42] EUMETSAT CM SAF, “EUMETSAT CM SAF,” [Online]. Available: https://www.cmsaf.eu/EN/Home/home_node.html.

[43] GSHAP, Global Seismic Hazard Assessment Program., “GSHAP, Global Seismic Hazard Assessment Program.,” [Online]. Available: http://www.seismo.ethz.ch/static/GSHAP/.

[44] “Copernicus Interactive Climate Atlas,” Copernicus Climate Change Service, [Online]. Available: https://atlas.climate.copernicus.eu/atlas.

[45] G. Rapelle, D. Faranda, M. Gaetani, P. Drobinski and M. Ginesta, “Climate change on extreme winds already affects offshore wind power availability in Europe,” *Environmental Research Letters,* vol. 18 034040, 2023.

[46] J. Wohland, “Process-based climate change assessment for European winds using EURO-CORDEX and global models,” *Environmental Research Letters,* vol. 17, 2022.

[47] J. Coburn and S. Pryor, “Differential Credibility of Climate Modes in CMIP6,” *Journal of Climate,* vol. 34, no. 21, p. 8145–8164 , 2021.

[48] J. Wohland, D. Folini and B. Pickering, “Wind speed stilling and its recovery due to internal climate variability,” *Earth Syst. Dynam.,* vol. 12, p. 1239–1251, 2021.

[49] X. Larsen, M. Imberger, Á. Hannesdóttir and A. Hahmann, “The impact of climate change on extreme winds over northern Europe according to CMIP6,” *WInd Energy Science,* 2023.

[50] DNV-GL, “SWLB059 Independent performance verification of Seawatch Wind Lidar Buoy at Frøya, Norway, 10332389-R-6, Rev. A,” 2022.

[51] EOLOS, “HESSELØ FINAL DATA REPORT (28/02/2021 00:00 UTC - 27/02/2022 23:50 UTC), report code EOL-HSS59 rev 05,” 2022.

[52] DNV-GL, “Independent analysis and reporting of ZX Lidars performance verification executed by Zephir Ltd. at Pershore test site, including IEC compliant validation analysis”.

[53] Multiversum, “Assessment of EOLOS FLS-200 E01 Floating Lidar PRE-Deployment Verification at the TNO Lichteiland Goeree Offshore Test Site, NL”.

[54] Eolos, “Measurement Plan, HESSELØ Project, report code EOL-HSS07 rev 05, 17/02/2022,” 2022.

[55] Tech-wise A/S, “Wind Resources at Laesoe Syd, Report no.: D-160950, December 2002,” 2002.

[56] IEC, “International Standard IEC 61400-50-1, Ed. 1: Wind measurements - Application of meteorological mast, nacelle and spinner mounted instrumnets,” 2022.

[57] FuE-Zentrum FH Kiel GmbH, “FINO2 Research Platform,” 2023. [Online]. Available: https://www.fino2.de/en/. [Accessed 14th August 2023].

[58] 4. Offshore, “https://map.4coffshore.com/offshorewind/,” [Online]. Available: https://map.4coffshore.com/offshorewind/.

[59] BSH - Bundesamt für Schifffahrt und Hydrographie, “Standardisierung und vergleichende Analyse der meteorologischen FINO-Messdaten (FINO123),” Hamburg, 2016.

[60] FuE-Zentrum FH Kiel GmbH, “FINO3 Research Platform,” 2023. [Online]. Available: https://www.fino3.de/en/. [Accessed 21rst February 2023].

Appendix A. Supporting Data

Several data sources have been used to support the assessment of site wind conditions. These data are of different types and quality and have thus been used for different purposes. The description of the measurement setup, data quality check and processing are presented in section Appendix A.1. The Appendix A.2 section deals with data analysis of different parameters. Finally, the long-term correction of the relevant supporting data is described in Appendix A.3.

Appendix A.1. Available Data, Data Treatment and Quality Check

For an overview of the measurements station please refer to Table 3,

Table 4, Figure 3 and Figure 4.

i. Hesselø South Floating LiDAR (HS-1)

The LiDAR was commissioned by Energinet and operated by Fugro Norway AS. The LiDAR was located in Kattegat Sea, 20 km east of Djursland peninsula, in Denmark.

Instrumentation

The LIDAR is a ZX300M LIDAR from ZXLiDARs Ltd and is mounted on the SWLB059 buoy (Figure 59).

The general measurement setup, sensors, configurations, and measurement scheme are described in the measurement plan [10]. In the following, only instruments relevant for the site wind conditions are described.

Figure 59. ZXLidars – ZX300M, source: www.zxlidars.com

This LIDAR model is classified by DNV-GL [16]. The LiDAR buoy SWLB059 has been pre-validated and passed Best Practice Criteria for all wind speed and direction ranges at all heights, except wind speed slope at 40 m [50].

Table 44. LIDAR measurement height levels

Level	Measurement height [m]
11	300
10	260
9	220
8	190
7	170
6	150
5	130
4	100
3	80
2	40
1	12

The SWLB059 is equipped with two additional meteorological sensors. Vaisala PTB330A measuring air pressure, Vaisala HMP155 measuring air temperature and humidity.

Operation history

Wind LiDAR buoy SWLB059 was deployed at Hesselø South on 21st of July 2023 and the measuring campaign is ongoing.

Data gaps:

30/11/2023 – unknown reason

Since 24 February 2024, lidar had intermittently been unavailable to measure wind data due to insufficient input power from an unhealthy fuel cell. This problem was resolved remotely on 2 March 2024 by adjusting the internal fuel cell process .

23/03/2024 - The buoy had been replaced with WS190.

Fugro post-processing of Data

Fugro has provided some information on the post-processing of the LIDAR data [11]. ZX LiDARs typically equip their instruments with a standard data filter, known as industry filter, designed to ensure the acquisition of high-quality data by eliminating data points that have a low signal-to-noise ratio. Fugro has disabled the industry data filter on the LiDAR data and has implemented a simpler filtering algorithm [10]. The processing of the LiDAR data by Fugro involves the following steps:

- Removing values outside of those times where the system is deployed at the target position.
- Check that data was saved for all 10-min intervals. Out of the 36-37 data packages produced every 10 minutes, a minimum of 9 packages (25%) are required to qualify as a valid measurement.
- Check for duplicates measurements.
- Removing out of range values (e.g. speed below 0.001 m/s and above 58 m/s, degrees above 360)
- Apply 180˚ ambiguity fix on LiDAR wind directions using Gill directions.

Beyond the 9-data-package filter already provided by Fugro, EMD has determined that increasing the threshold for the number of data packets does not enhance the quality of the data. Therefore, no additional filtering based on packet count has been conducted.

EMD Filtering of LIDAR Data

EMD has conducted a qualitative, manual filtering process. EMD has found that the overall quality of the dataset is quite good, with very few discrepancies identified.

Typical anomalies identified in the dataset include instances of peak wind speeds at great heights (over 130 meters) that occur for very brief periods and are not consistent with the wind speed and shear observed at lower altitudes. These discrepancies were specifically targeted during the manual filtering process to ensure the reliability of the dataset.

According to Fugro reports [11], the primary sensor for wind direction is measuring relative to true north. EMD has compared the wind direction signal against mesoscale derived dataset (EMD WRF) and finds the average difference within 1˚ at equivalent heights. EMD therefore finds the wind direction data correct with no need for adjustment.

However, at very low wind speeds, some remnants of the 180-degree ambiguity in wind direction measurements persist. Given the high uncertainty of wind direction at these low speeds, EMD has decided not to make any corrections to these data.

Recovery Rate and Data Substitution

With the industry filter disabled, the data recovery rate for the LiDAR measurements is substantially higher than is sometimes seen with ZX LiDAR instruments. Notably, the data recovery rates decrease with increasing height above sea level (ASL), and these rates are detailed in Table 45. Additionally, a small data recovery loss is still experienced due to the applied filtering.

To address some of the data loss, data substitution procedures were implemented: one based on measured shear on the Hesselø South LIDAR (HS-1), referred to as "shear repair" and another using data from Kattegat LIDAR (KG-1-LB), referred to as "horizontal repair". The shear repair procedure is prioritized over the horizontal repair due to its expected lower uncertainty. The process il detailed in section 4.4.3

Table 45 lists the results of each repair procedure. The 12- and 40-meter heights are repaired only using the horizontal repair procedure, and the outcome of those repairs are not included in the mentioned table.

Table 45. Results of data repair.

REPAIRED HEIGHT [M]	80	100	130	150	170	190	220	260	300
Source height [m]	40	80	100	130	150	170	190	220	260
Shear matrix heights [m]	40, 80, 100	80, 100, 130	100, 130, 150	130, 150, 170	150, 170, 190	170, 190, 220	190, 220, 260	220, 260, 300	220, 260, 300
Recovery rate before repair	96.2%	95.5%	95.0%	94.7%	94.6%	94.3%	94.0%	93.4%	93.5%
Recovery rate after shear repair	98.3%	96.3%	95.3%	95.1%	94.6%	94.7%	94.5%	94.2%	94.0%
Recovery rate after shear and horizontal repair	99.8%	98.8%	98.3%	97.9%	97.%	97.7%	97.5%	97.3%	97.2%
Share of repaired data	3.7%	3.5%	3.5%	3.4%	3.4%	3.6%	3.7%	4.2%	4.0%

Table 46. Treatment summary of the primary wind data source from HS-1 floating LiDAR.

Phase of treatment	Height [m]	Start	End	Period [Months]	Arithmetic mean wind speeds [m/s]	Recovery rate [%]
Raw	150	21/07/2023	21/03/2024	8	10.81	94.7
Filtered	150	21/07/2023	21/03/2024	8	10.81	94.7
Repaired	150	21/07/2023	21/03/2024	8	10.75	97.9

ii. Hesselø Floating LiDAR (H1)

The LiDAR was commissioned by Energinet and operated by EOLOS Floating LiDAR Solutions. The LiDAR was located in Kattegat Sea, between north of Zealand coastline and the island of Anholt, in Denmark.

Instrumentation

The LIDAR mounted on the Eolos FLS200-E01 is a ZX300M LIDAR from ZXLiDARs Ltd (Figure 59).

The instrumentation on the Eolos FLS200-E01 is described in documents [51]. In the following, only instruments relevant for the site wind conditions are described.

This LIDAR model is classified by DNV-GL [16]. A similar model, but not the same instrument was verified at the Pershore, UK, test site by DNV-GL [52]. The specific instrument deployed on the Eolos FLS200-E01 was verified by Multiversum at the TNO Lichteiland Goeree Offshore Test Site, NL [53].

The LiDAR window is located 1.6m above sea level. This should be compensated for when interpreting the measurement results together with an 0.4 m offset built into the tidal correction of the data processing by Eolos. This means a 2 m offset between the measurement height reported and the real heights. This results in measurement heights according to Final Data report [51].

Floating LIDAR Measurement heights	
Level	**Configured LIDAR height + offset (m)**
10	238+2 = 240
9	198+2 =200
8	178+2 = 180
7	158+2 = 160
6	138+2 =140
5	118+2 = 120
4	98+2 = 100
3	68+2 = 70
2	38+2 = 40 (ZX reference height)
1	10+2 = 12

Figure 60. LIDAR measurement height levels, source: [51].

The Eolos FLS200-E01 is equipped with two additional meteorological stations. These are a Vaisala WXT536 package and the second is an Aimar 200WX package. Both are capable of measuring standard parameters: Wind speed, wind direction, air pressure, temperature, humidity and rainfall.

The mounting of the instruments is 3.25 m above the waterline, however as they are not used for shear or wind model analysis, they are by EMD assigned a generic height of 10 m.

In the datafiles provided by Eolos only one sensor signal for each parameter is reported and it is not clear which of the stations provide the input. Hence, the two weather stations are considered as a single unit called METEO by Eolos.

Operation history

The measurement campaign has run for a period of 12 months. EMD has received measurement data starting from 28/02/2021 to 28/02/2022.

Data gaps:

19/03/2021 - corrective maintenance

14/07/2021 -17/07/2021 - control box replacement

23/12/2021 – ADCP replacement

Eolos Post-processing of Data

Eolos has provided some information on the post-processing of the LIDAR data [54].

Wind direction data are corrected for the yaw of the buoy and the homodyne behaviour of the LIDAR. This is the 180-degree ambiguity in the LIDAR measurements. The METEO data are used for this correction.

No motion correction is applied. Eolos states that this is a valid approach.

Eolos corrects for tidal variations. It is understood that this makes the measurements comparable with a fixed structure, such as a mast or a wind turbine, but it also means that the actual measurement height above sea level is variable, within the range of tidal variations. The tidal correction includes an 0.4m offset to convert the 1.6 m window height to 2 m.

Data are filtered if:

- buoy location is outside maximum drift radius + 20 m (97 + 20 = 117 m)
- the LIDAR returns invalid values, such as N/A, 9998 or 9999, representing poor quality data.
- out of wind speed (V < 0 m/s or V > 50 m/s) or wind direction (Dir < 0° or Dir > 360°) range.

Eolos has applied a quality control algorithm to the raw measurement data and defines four states:

0 – System not available

1 – System available & post-processed data passing quality checks

2 – System available but data filtered for not passing quality checks

3 – System available & postprocessed data are passing quality checks for wind speed but not direction

State 0 and state 3 are not present in the datasets. EMD has disabled data records with state 2.

EMD Filtering of LIDAR Data

Eolos reports [54] that the wind direction sensor used in the datafiles is that of the ZX LIDAR. In a comparison with EMD-WRF data an average offset of -7.9 degrees is noted. In the validation study [53], Multiversum finds good agreement between reference station direction and the buoy main compass, but a -6.5-degree offset to the ZX LIDAR wind direction measurements. As these two offsets are in agreement, EMD has applied a 6.5 degree offset on the LIDAR wind direction measurements.

EMD has used the code setting 2 (section 3.2.5) to filter the data. This has effectively removed the inherent ZX error settings (n/a, 9998 and 9999).

No filtering has been done on the METEO data. They are provided as is.

Recovery Rate and Data Substitution

The LIDAR dataset suffers data loss as a result of above filtering. In order to recover some of this loss a data substitution procedure was done.

The recovery rate on the LIDAR is higher at lower heights than at taller heights. The substitution procedure transfers lower height measurements upwards in the profile with a shear transfer function.

The shear matrix transformation method is described in detail in the WindPRO manual, section 12.3.3.4.2.1 [34].

For each height repaired, the height one or two levels below was used as source. A shear matrix was built using the most relevant heights (immediately above or equal to the height and below the repaired height), including the source height. The binning for the matrix consists of 12 diurnal bins and 12 directional bins. No seasonal binning was used in order to increase the count of data records in each bin. Only data concurrent at all selected heights feed into the shear matrix. The shear value in each bin is calculated based on a Weibull derived mean wind speed for each selected height.

The synthesized data replaces gaps and disabled data in the recorded dataset (wind speed and direction). Table 47 lists the properties of each repair procedure.

Table 47. Results of data repair.

REPAIRED HEIGHT [M]	100	120	140	160	180	200	240
Source height [m]	70	100	100	120	140	160	180
Shear matrix heights [m]	70, 100, 120	100, 120, 140	100, 120, 140	120, 140, 160	140, 160, 180	160, 180, 200	180, 200, 240
Recovery rate before repair	92.6%	89.6%	88.2%	87.2%	84.6%	81.7%	80.0%
Recovery rate after shear repair	95.0%	93.0%	93.1%	90.4%	88.9%	87.7%	85.9%
Share of repaired data	2.40%	3.40%	4.90%	3.20%	4.30%	6.00%	5.90%

Finally, the repaired data at 140 m has been extrapolated to the height of interest for the model validation of 150 m. A shear matrix was built using the heights from 120, 140 and 160 m, with 12 diurnal bins and 12 directional bins.

Table 48. Shear matrix used to extrapolate 140 m data to 150 m height. Values are shear exponent α.

Hour	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
00-02	0.04	0.07	0.09	0.05	0.11	0.17	0.13	0.11	0.09	0.10	0.13	0.13
02-04	-0.06	0.00	0.08	0.07	0.11	0.08	0.16	0.07	0.10	0.13	0.09	0.05
04-06	0.00	0.06	0.07	0.09	0.10	0.10	0.10	0.13	0.11	0.13	0.12	0.10
06-08	0.09	0.08	0.20	0.08	0.07	0.01	0.03	0.11	0.13	0.13	0.14	0.04
08-10	0.07	0.26	0.00	0.07	0.12	0.07	0.07	0.18	0.14	0.11	0.09	0.09
10-12	0.06	0.10	0.01	0.01	0.06	0.08	0.11	0.13	0.08	0.13	0.07	0.09
12-14	-0.17	-0.01	0.04	0.12	0.09	0.11	0.18	0.07	0.11	0.14	0.11	0.07
14-16	-0.03	-0.06	0.07	-0.14	0.11	0.12	0.09	0.13	0.10	0.14	0.09	0.09
16-18	0.00	0.01	0.05	0.11	0.11	0.11	0.10	0.14	0.07	0.10	0.12	0.12
18-20	0.06	-0.07	0.11	0.00	0.07	0.11	0.13	0.13	0.10	0.11	0.09	0.09
20-22	0.05	-0.03	0.01	0.14	0.06	0.08	0.12	0.13	0.15	0.13	0.13	0.09
22-24	0.16	0.08	0.26	0.06	0.09	0.14	0.11	0.16	0.10	0.13	0.14	0.07
All	**0.05**	**0.04**	**0.06**	**0.06**	**0.09**	**0.10**	**0.12**	**0.13**	**0.10**	**0.12**	**0.11**	**0.09**

Table 49. Treatment summary of the primary wind data source from H1 floating LiDAR.

Phase of treatment	Height [m]	Start	End	Period [Months]	Arithmetic mean wind speeds [m/s]	Recovery rate [%]
Raw	140	28/02/2021	28/02/2022	12	9.75	93.7
Filtered	140	28/02/2021	28/02/2022	12	9.82	88.2
Repaired	140	28/02/2021	28/02/2022	12	9.80	93.1
Shear extrapolated	150	28/02/2021	28/02/2022	12	9.87	93.1

iii. Læsø Offshore Met Mast (M1)

Wind data from an offshore measurement mast has been provided by Energinet. The met mast was setup in Kattegat Sea about 17 km south of the island of Læsø. The distance to Danish and Swedish coast is about 45 km and 66 km. The available measurements used are shown in Table 50.

Table 50. Measurement data at Læsø met mast

Measurement type	Heights ASL [m]	Parameter	Averaging period
Wind speed	62, 58, 45, 45, 30, 30, 15, 15	mean, min, max and standard deviation	10-min
Wind direction	60, 58, 43, 28	mean, min, max and standard deviation	10-min
Absolute temperature	55, 13	mean, min, max, standard deviation	10-min

Besides the analysed data, the Læsø mast was also equipped with relative humidity, atmospheric pressure and solar radiation sensors.

The available data covers a period of 4 years and 8 months from 24/04/1999 until 09/12/2003. However, the wind speed data from the anemometer at 58 m ends on 18/04/2000. This data is therefore not considered further on in the analysis.

EMD had access to a wind resources report [55] analysing the measured data until November 2002 and describing the equipment installed and mast details. According to the documentation available [55] EMD has not received any calibration reports nor installation report describing the type of sensors and the detials of the mounting (boom orientation, length, distance to lightning finial). It has thus not been possible to check if the installation has been conducted according to the IEC standards [56]. The only information available comes from the csv files itself, from which the setup of the mast has been deducted and is presented in Table 51.

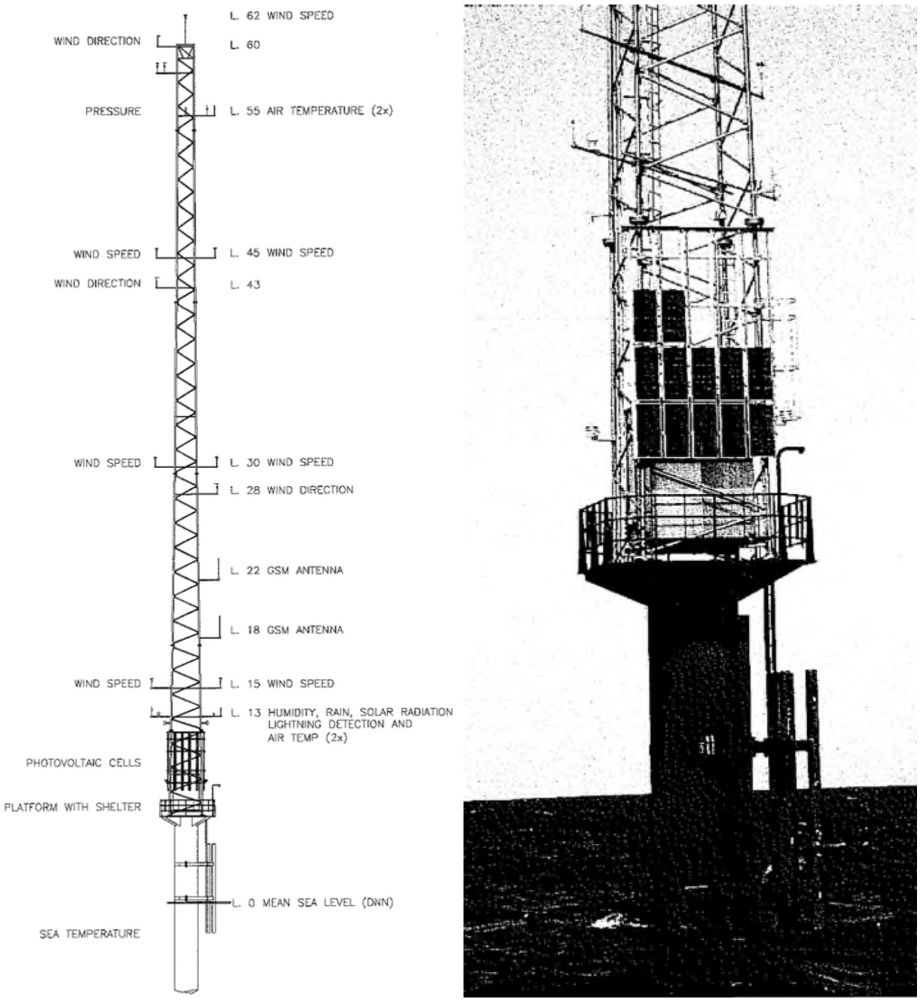


Figure 61. Pictures and details from Læsø met mast, source: [55]

Table 51. Mounting of sensors on the Læsø met mast

Height AGL [m]	Channel Name	Description	Mounting and Orientation	Horizontal boom	Vertical boom
62	CUP62M	Cup Anemomter Unknown type	Top mounted	Top mounted	Unknown
58	CUP58M	Cup Anemomter Unknown type	0°	Unknown	Unknown
45	CUP45SV	Cup Anemomter Unknown type	225°	4.35 m	Unknown
45	CUP45NO	Cup Anemomter Unknown type	45°	4.35 m	Unknown

Height AGL [m]	Channel Name	Description	Mounting and Orientation	Horizontal boom	Vertical boom
30	CUP30SV	Cup Anemomter Unknown type	225°	4.75 m	Unknown
30	CUP30NO	Cup Anemomter Unknown type	45°	4.75 m	Unknown
15	CUP15SV	Cup Anemomter Unknown type	225°	5.40 m	Unknown
15	CUP15NO	Cup Anemomter Unknown type	45°	5.40 m	Unknown
60	DIR60SV	Wind vane Unknown type	225°	4.20 m	Unknown
58	DIR58M	Wind vane Unknown type	0°	Unknown	Unknown
43	DIR43SV	Wind vane Unknown type	225°	4.40 m	Unknown
28	DIR28SV	Wind vane Unknown type	225°	4.80 m	Unknown
55	TEMPA55NO	Temperature sensor, absolute	45°	Unknown	Unknown
13	TEMPA13NO	Temperature sensor, absolute	45°	Unknown	Unknown

EMD has obtained access to the data as csv files. Therefore, the conversion of the raw data could not be verified.

A discrepancy between the documented boom direction (from the file) and the observed direction can be noticed on the wind speed difference graph between anemometers at same height. For example the booms for the 45 m anemometers seem to be orientated at 15 deg (instead of 45 deg) and 210 deg (instead of 225 deg), as seen on Figure *62*. No wind veer has been applied to the data since it correlates well with other data sources wind direction.

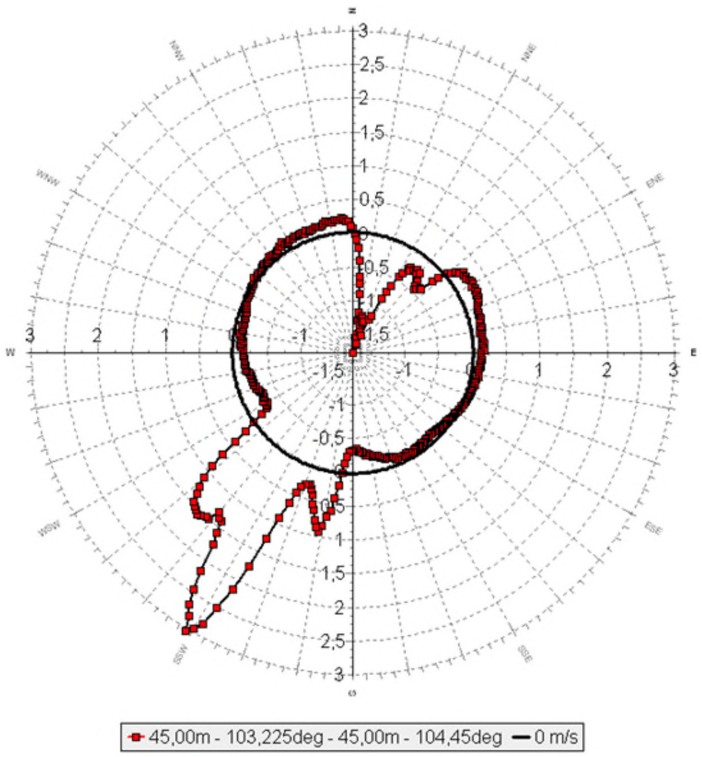


Figure 62. Wind speed difference between 45 m SV and 45 m NE, binned by direction at Læsø

The data at 45, 30 and 10 m have been merged to remove the tower shadowing, based on the observed distortions.

From Figure *62* it can also be observed that not only the shadowing of the mast creates a difference larger than 0. It could be due to the vicinity of the wind vane.

In general, the data quality is good. The correlation of the wind directions data and wind speed data at different heights is as expected. The data has been filtered for faulty equipment and failures.

A final of 4 full years, from 01/07/1999-01/07/2003, have been selected. The data from the 62 m anemometer is the primary data from the Læsø met mast considered in the study. The recovery rate of the data for this period (94.7%) complies with the minimum requirements of MEASNET [26]. The following major gaps (consecutive days with missing or erroneous data) in the wind data (wind speed at 62 m and wind direction at 58 m) can be noted:

- 35 days from 12/01/2000
- 25 days from 04/01/2002, gap concerning all channels
- 3 days from 01/11/2002

At this stage, the 62 m data has not been extrapolated to the height of interest 150 m. The shear determined from the available measured data at 62, 45 and 30 m would indeed not be representative of the expected shear at 150 m.

Table 52. Treatment of the primary wind data source from Læsø met mast.

Phase of treatment	Height [m]	Start	End	Period [Months]	Arithmetic mean wind speeds [m/s]	Recovery rate [%]
Raw	62	24/04/1999	09/12/2003	56	8.36	97.6
Filtered	62	24/04/1999	09/12/2003	56	8.85	93.2
Trimmed	62	01/07/1999	01/07/2003	48	8.94	94.7

iv. FINO2 Met Mast

Wind data from the FINO2 offshore measurement mast has been used to assess the expected turbulence conditions on the Kattegat site.

The data was made available by the FINO (Forschungsplattformen in Nord- und Ostsee) initiative, which was funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK) on the basis of a decision by the German Bundestag, organised by the Projektträger Jülich (PTJ) and coordinated by the German Federal Maritime and Hydrographic Agency (BSH).

The FINO2 mast is mounted on a platform and is part of the FINO research project. The met mast was setup in the Baltic Sea about 38 km north of the German coast, 39 km east of the Danish coast and 40 km south of Swedish coast. The distance from the FINO2 mast to KG-1-LB is about 190 km Figure 4.

The collected measurements considered in this report are:

- wind speed from cup anemometers at 102.5, 92.4, 82.4, 72.4, 62.4, 52.4, 42.4, and 32.4 m above MSL as 10-minute values (mean, min, max and standard deviation)
- wind direction at 91.8, 71.8, 51.8 and 31.8 m above MSL as 10-minute values (mean, min, max and standard deviation)
- wind speed and wind direction from sonic anemometers at 82.1, 62.1 and 42.1 m above MSL as 10-minute values (mean, min, max and standard deviation)
- absolute temperature at 99.3, 70.3, 50.3, 40.3 and 30.3 m above MSL, as 10 minutes values (mean values)

Besides the data obtained, the FINO2 mast was also equipped with sonic anemometers, relative humidity, air pressure, precipitation, and global irradiance sensors.

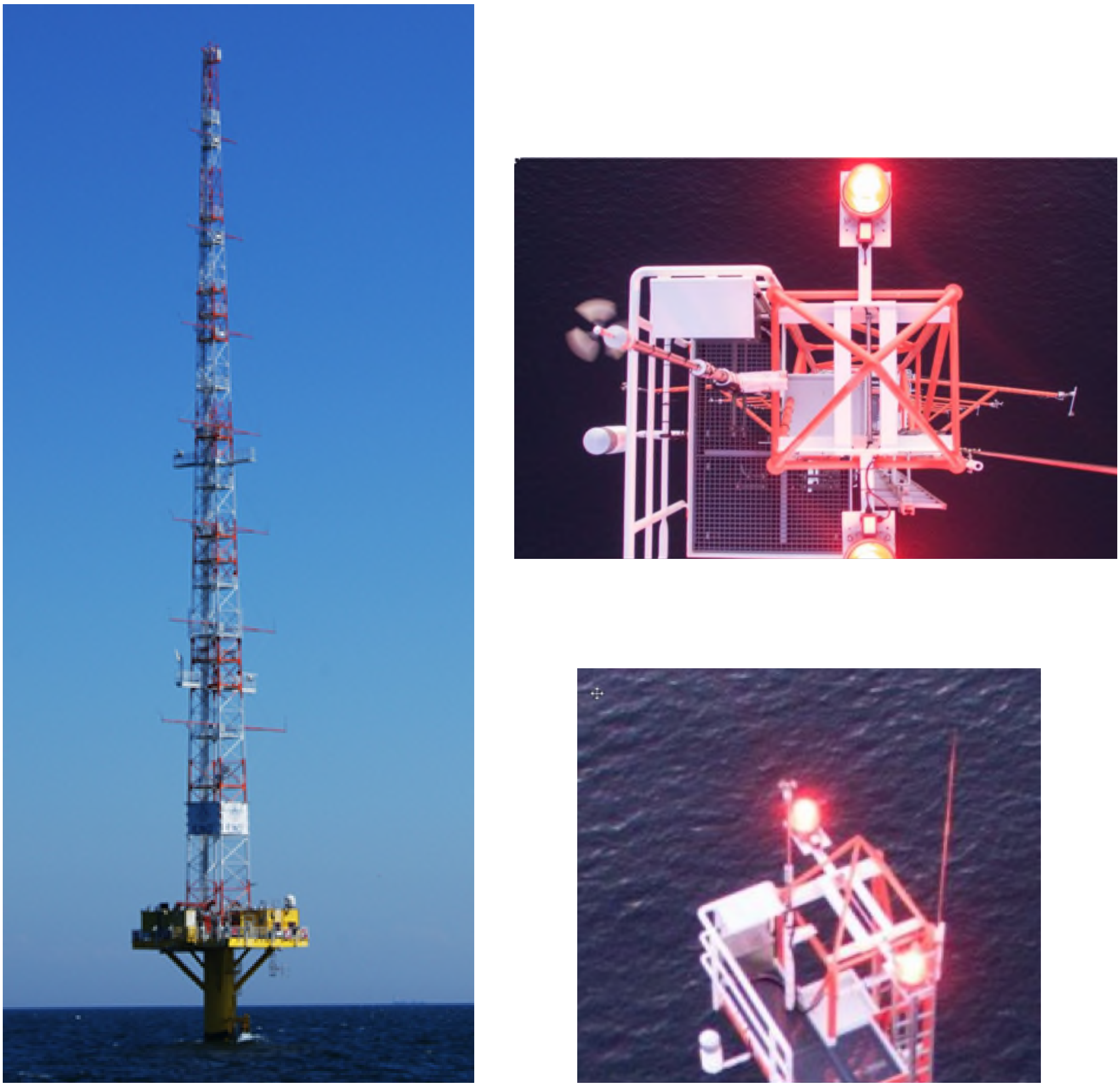


Figure 63. Picture of FINO2 met mast, and view on the top anemometer from top and southeast (source: [57]).

The available data covers a period of around 14.8 years, from April/2008 to February/2023. However, the series was trimmed to 7 full years, from 31/08/2008 to 31/08/2015, in order to avoid the influence of wakes from the neighbouring wind farm installed after September 2015 (EnBW Baltic 2/Kriegers Flak 1) (Figure 64).

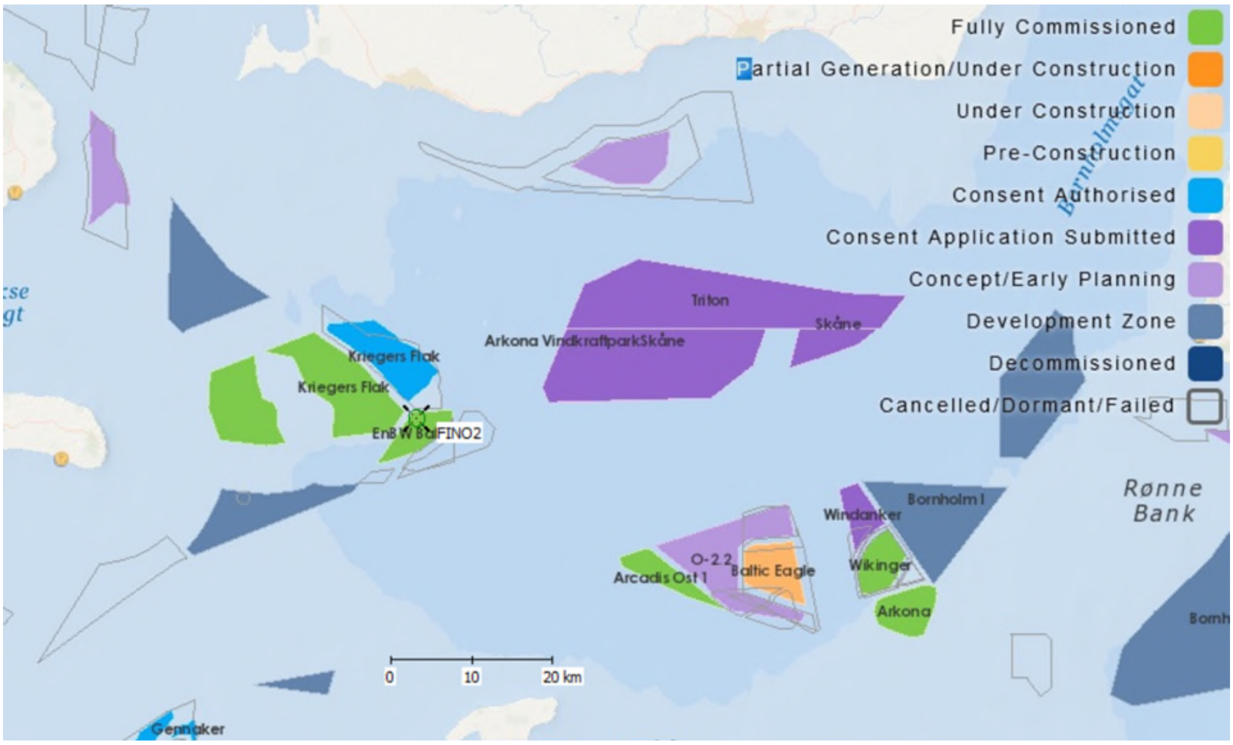


Figure 64. Indicative location map for FINO2 with existing wind farms in green (background map: 4C Offshore [58]).

EMD has access to a mast report [59] describing the equipment installed and mast details. EMD has not received any anemometer calibration reports. The data obtained was considered to be logged with the right calibration factors. EMD has obtained access to the data as csv files. Therefore, the conversion of the raw data could not be verified.

According to the documentation available [59], FINO2 design and installation has not been conducted fully according to the IEC standards [56], especially in relation to the sizes of the mast and booms for the side anemometers (92.4, 82.4, 72.4, 62.4, 52.4, 42.4, and 32.4 m).

Table 53. Mounting of sensors on the FINO2 mast.

HEIGHT AMSL[M]	DESCRIPTION	MOUNTING AND ORIENTATION	HORIZONTAL BOOM LENGTH [m]	VERTICAL BOOM LENGTH [m]
102.5	Cup anemometer – Vector A100L2	Top	-	-*
92.4	Cup anemometer – Vector A100L2	180°	2.92	1.5
82.4	Cup anemometer – Vector A100L2	180°	3.5	1.5
72.4	Cup anemometer – Vector A100L2	180°	4.5	1.5

HEIGHT AMSL[M]	DESCRIPTION	MOUNTING AND ORIENTATION	HORIZONTAL BOOM LENGTH [m]	VERTICAL BOOM LENGTH [m]
62.4	Cup anemometer – Vector A100L2	180°	5.0	1.5
52.4	Cup anemometer – Vector A100L2	180°	6.1	1.5
42.4	Cup anemometer – Vector A100L2	180°	6.5	1.5
32.4	Cup anemometer – Vector A100L2	180°	7.7	1.50
82.1	Ultrasonic anemometer – Thies 4.383021.400	0°	3.5	-
62.1	Ultrasonic anemometer – Thies 4.383021.400	0°	5.0	-
42.1	Ultrasonic anemometer – Thies 4.383021.400	0°	6.5	1.5
91.8	Wind vane – Thies 4.3120.22.012	0°	2.9	1.5
71.8	Wind vane – Thies 4.3120.22.012	0°	4.5	0.8
51.8	Wind vane – Thies 4.3120.22.012	0°	6.1	0.8
31.8	Wind vane – Thies 4.3120.22.012	0°	7.7	0.8
99.3	Thermometer – Thies 1.1005.50.015	180°	-	-
70.3	Thermometer – Thies 2.1260.00.000	180°	-	-
50.3	Thermometer – Thies 1.1005.50.015	180°	-	-
40.3	Thermometer – Thies 2.1260.00.000	180°	-	-
30.3	Thermometer – Thies 1.10005.54.241	180°	-	-

* Information not available

As FINO2 is a large offshore mast, the observed mast disturbance on the wind speed measurements is significant, especially for the anemometers mounted on horizontal booms. On Figure 65 it can be seen how the turbulence intensity is increasing with heights (except for the top anemometer at 102.5 m) in the sector where anemometers are affected by mast shadowing.

The top anemometer is not installed on the very top of the mast structure, but on the side facing south (Figure 63). The lightning finial (in the northwest corner) as well as the pyramidal top of the mast are expected to cause flow disturbance of the 102.5 m measurements. On Figure 66, the wind speed measured at 92.5 m is indeed greater than the wind speed measured 102.5 m in east northeast sector. It has not been possible to remove the tower shadowing from the data since no double nor triple cup anemometry has been available at the same heights.

Data from sonic anemometers has not been deemed reliable for the purpose of this analysis (low data availability) and couldn't be used to remove the shadowing either.

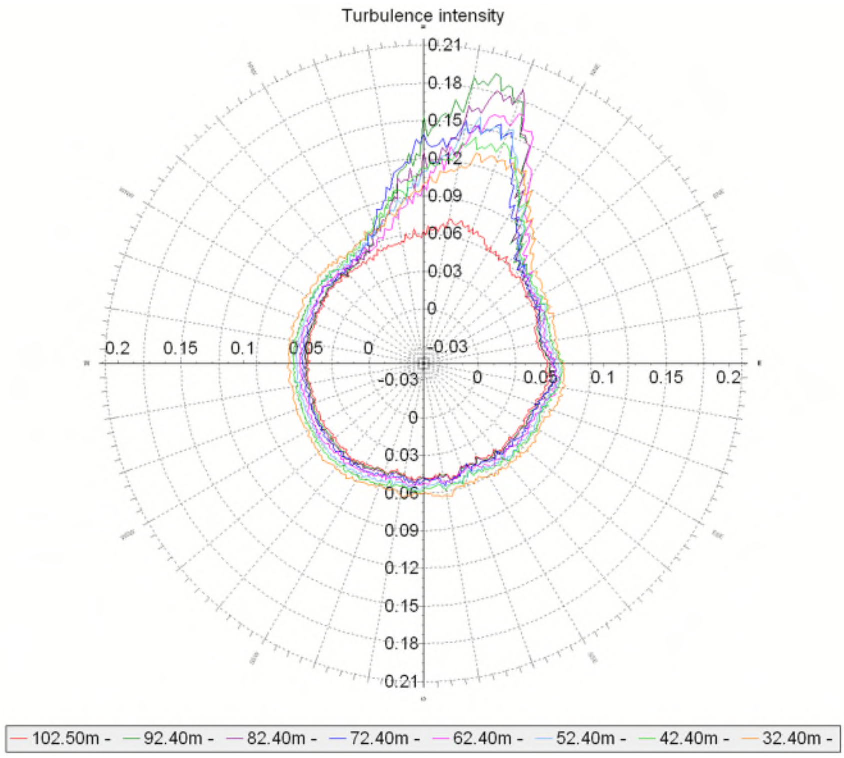


Figure 65. Directional Turbulence Intensity for the cup anemometers, FINO2.

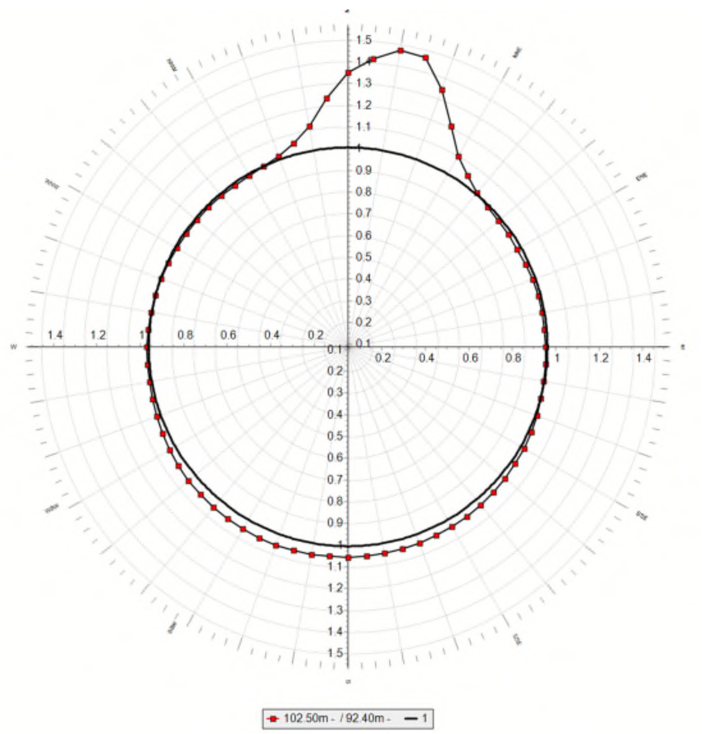


Figure 66. Directional wind speed ratio between 102.5 m and 92.5 m data, FINO2.

In general, the data quality is good. The wind directions and wind speed data at each height correlates well with the data at the other heights. The data has been filtered for faulty equipment and failures. Where possible, the missing direction data has been substituted with data from the available closest wind vanes.

7 full years have been selected from 01/09/2008 to 31/08/2015. The data from the 102.5 m anemometer is the primary data from the FINO2 met mast considered in the study. The recovery rate of the final data for the 7-year period is 93.3%.

For the turbulence intensity evaluation, the data heavily affected by shadowing has been excluded (340-40 degrees).

The following major gaps (consecutive days with missing or erroneous data) in the wind data (wind speed at 102.5 and wind direction at 91.8 m) can be noted:

- 15 days from 30/11/2009
- 7.5 days from 09/09/2010
- 20.5 days from 15/05/2011
- 11 days from 22/05/2012
- 11.5 days from 08/06/2012
- 16.5 days in January 2015 (divided in about 5 different periods)
- 10 days from 19/03/2015

Due to the unavailability of some information, as mast's maintenance and instrument certification, it was not possible to precisely assess an uncertainty on FINO2's measurements. The uncertainty on FINO2 measurements was estimated to be in the magnitude of 3.5%, taking into account the lack of information and the noncompliance to the standards [56].

v. FINO3 Met Mast

Wind data from the FINO3 offshore measurement mast has been used to assess the expected turbulence conditions on the Kattegat site.

The data was made available by the FINO (Forschungsplattformen in Nord- und Ostsee) initiative, which was funded by the German Federal Ministry of Economic Affairs and Climate Action (BMWK) on the basis of a decision by the German Bundestag, organised by the Projektträger Jülich (PTJ) and coordinated by the German Federal Maritime and Hydrographic Agency (BSH).

The FINO3 mast is mounted on a platform and is part of the FINO research project. The met mast was setup in the North Sea about 84 km west of the island of Rømø, on the Danish coast. It is located at about 285 km southeast of the KG-1-LB buoy (Figure 4).

The collected measurements are:

- wind speed at 107, 101, 91, 81, 71, 61, 51, 41 and 31 m as 10-minute values (mean, min, max and standard deviation)
- wind direction at 101, 61 and 29 m as 10-minute values (mean, min, max and standard deviation)
- absolute temperature at 95 and 29 m, as 10 minutes values (mean values)

Besides the data obtained, the FINO3 mast was also equipped with relative humidity, air pressure, precipitation, and global irradiance sensors.

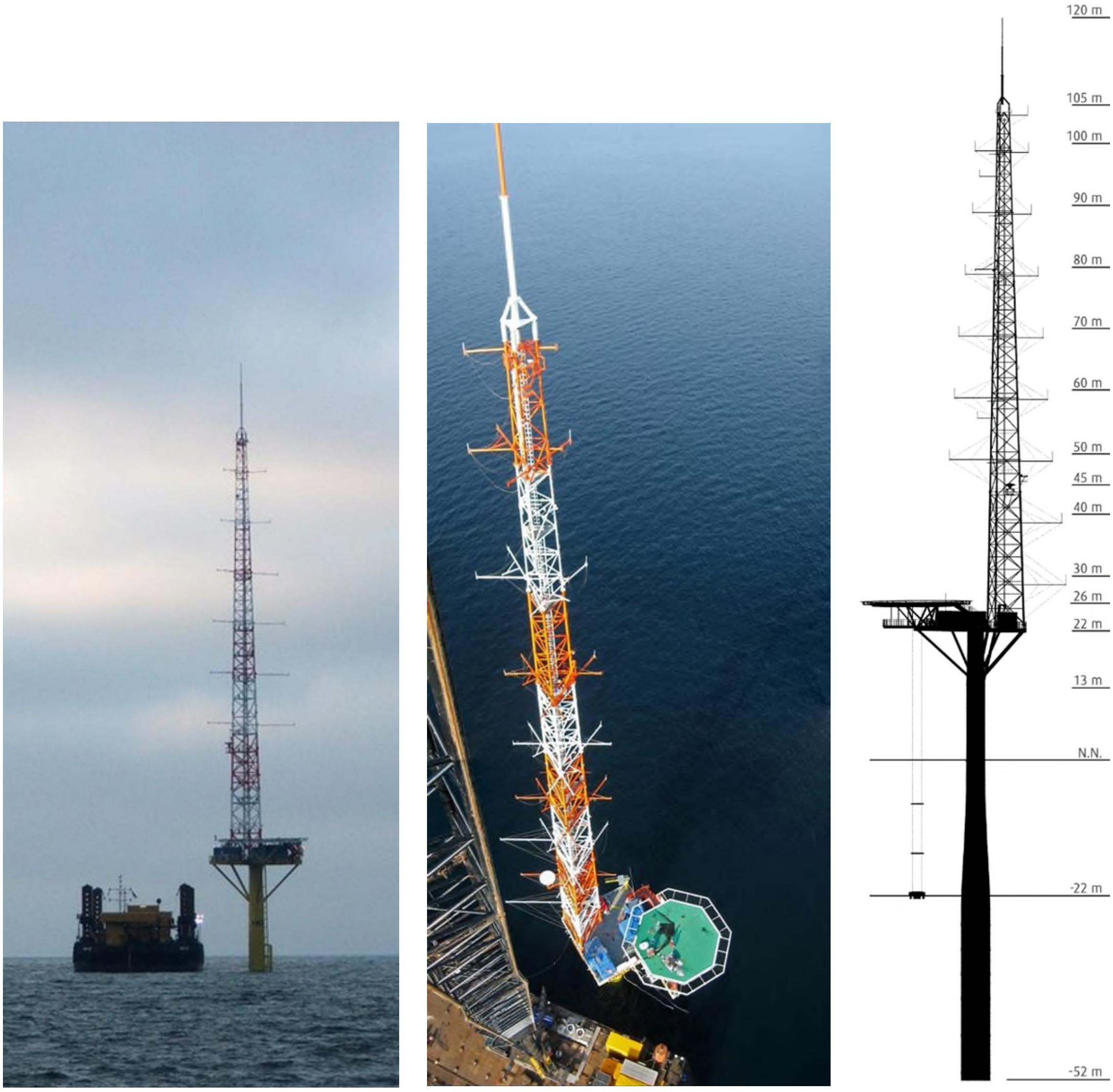


Figure 67. Pictures and details from FINO3, source: [60]

The available data covers a period of around 13.5 years, from September/2009 to February/2023. However, the series was trimmed to 4 full years, from 01/01/2010 to 31/12/2013, in order to avoid the influence of wakes from the neighbouring wind farm installed after 2014 (DanTysk OWF).

EMD had access to a mast report [59] describing the equipment installed and mast details. EMD has not received any anemometer calibration reports. The data obtained was considered to be logged with the right calibration factors. According to the documentation available [59], FINO3 design and installation has not been conducted according to the IEC standards [56], especially in relation to the sizes of the mast and booms.

Table 54. Mounting of sensors on the FINO3 mast

HEIGHT ASL [M]	INSTRUMENT IDENTIFICATION	DESCRIPTION	MOUNTING AND ORIENTATION	HORIZONTAL BOOM LENGTH [m]	VERTICAL BOOM LENGTH [m]
107	AN 107m - B	Cup anemometer - Vector A100L2	345°	3.5	1.75
101	AN 101m - B	Cup anemometer - Vector A100L2	345°	3.2	1.75
101	Sonic 101m - A	Ultrasonic anemometer - RM Young Mod 81000	225°	3.2	1.50
91	AN 91m - B	Cup anemometer - Vector A100L2	345°	3.9	1.75
91	AN 91m - A	Cup anemometer - Vector A100L2	225°	3.9	1.50
91	AN 91m - C	Cup anemometer - Vector A100L2	105°	3.9	2.00
81	AN 81m - B	Cup anemometer - Vector A100L2	345°	4.6	1.75
81	AN 81m - A	Cup anemometer - Vector A100L2	225°	4.6	1.50
71	AN 71m - B	Cup anemometer - Vector A100L2	345°	5.4	1.75
71	AN 71m - C	Cup anemometer - Vector A100L2	105°	5.4	2.00
71	AN 71m - A	Cup anemometer - Vector A100L2	225°	5.4	1.50
61	AN 61m - B	Cup anemometer - Vector A100L2	345°	6.2	1.75
61	Sonic 61m - A	Ultrasonic anemometer - RM Young Mod 81000	225°	6.2	1.50
51	AN 51m - C	Cup anemometer - Vector A100L2	105°	6.7	2.00

HEIGHT ASL [M]	INSTRUMENT IDENTIFICATION	DESCRIPTION	MOUNTING AND ORIENTATION	HORIZONTAL BOOM LENGTH [m]	VERTICAL BOOM LENGTH [m]
51	AN 51m - B	Cup anemometer - Vector A100L2	345°	6.7	1.75
51	AN 51m - A	Cup anemometer - Vector A100L2	225°	6.7	1.50
41	AN 41m - B	Cup anemometer - Vector A100L2	345°	7.5	1.75
31	AN 31m - B	Cup anemometer - Vector A100L2	345°	8.4	1.75
101	Dir 101m	Wind vane - Friedrichs 41211000	105°	3.2	2.00
81	Dir 81m*	Wind vane - Friedrichs 41211000	105°	4.6	2.00
61	Dir 61m*	Wind vane - Friedrichs 41211000	105°	6.2	2.00
29	Dir 29m	Wind vane - Vector W200P	180°	8.4	-
95	Temp 95m	Thermometer – Thies 1.10005.54.241	180°	3.9	-
55	Temp 55m	Thermometer – Thies 1.10005.54.241	180°	6.7	-
29	Temp 29m	Thermometer – Thies 1.10005.54.241	180°	8.4	-

*Although those instruments are listed on the mast description, they were not included in the data files EMD had access to.

EMD has obtained access to the data as csv files. Therefore, the conversion of the raw data could not be verified.

As FINO3 is a large offshore mast, the observed mast disturbance on the wind speed measurements is significantly. Only for the data at 91, 71 and 51 m it has been possible to remove most of the tower shadowing thanks to the 3 cup anemometers in different direction for each height, as shown in Table 53 and Figure 68. The data has been merged based on the detected distortions (Figures 65 and 70).

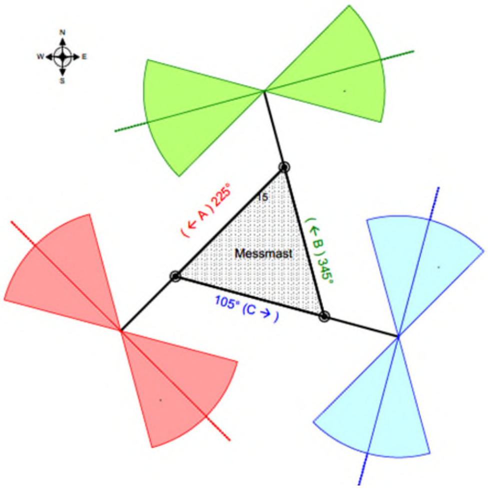


Figure 68. Representation of the boom's positioning in FINO3 and the undisturbed inflow directions, source: [59]

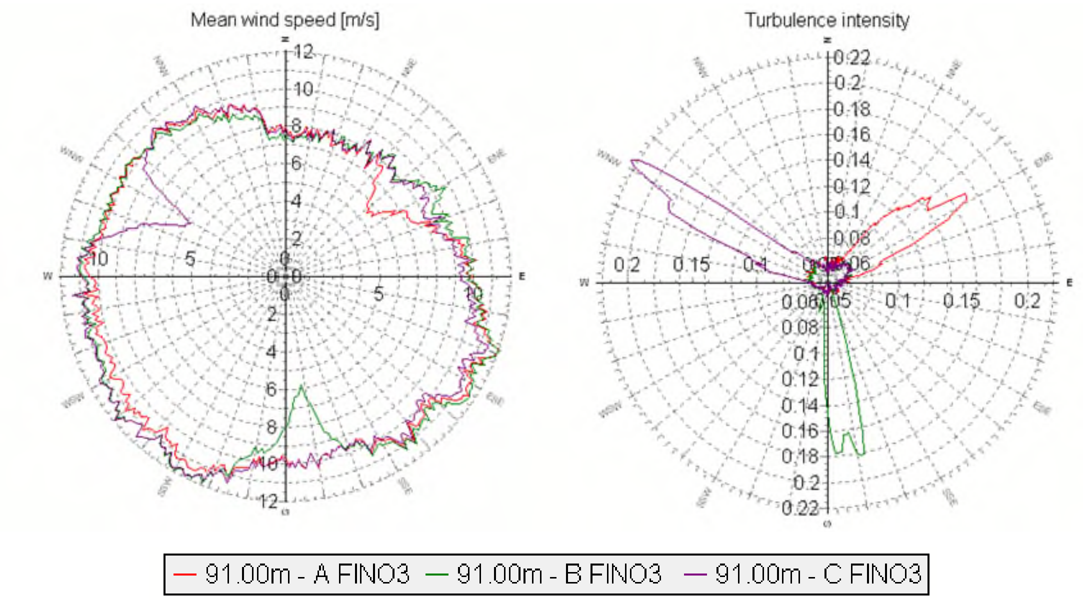


Figure 69. Directional Mean wind speed (left) and Turbulence Intensity (right) for the 3 cup anemometers at 91 m, before merging.

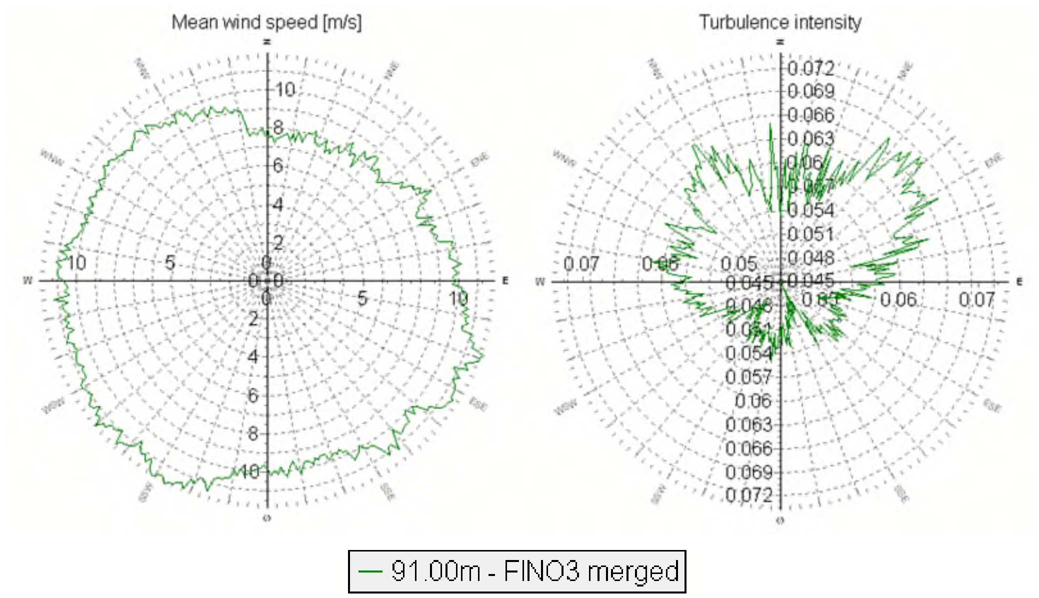


Figure 70. Directional Mean wind speed (left) and Turbulence Intensity (right) at 91 m, after merging.

In general, the data quality is good. The wind directions data at each height correlates well with wind direct at the other heights and wind speed data at each height correlates well with wind speed data at the other heights. The data has been filtered for faulty equipment and failures.

4 full years have been selected from 01/01/2010-31/12/2013. The data from the 91 m anemometer is the primary data from the FINO3 met mast considered in the study. It is deemed more reliable than the 101 and 107 m data, heavily impacted by the mast shadowing. The recovery rate of the merged data for the 4-year period is 92.2%. The following major gaps (consecutive days with missing or erroneous data) in the wind data (wind speed at 91 m-B and wind direction at 101 m) can be noted:

- 50 days from 14/01/2013
- 35 days from 03/07/2013
- 17 days from 08/11/2010, gap concerning all channels.
- 11 days from 01/01/2011, gap concerning all channels.
- 9 days from 11/01/2012, gap concerning all channels.
- 8 days from 27/07/2011, gap concerning all channels.

Due to the unavailability of some information, as mast's maintenance and instrument certification, it was not possible to precisely assess an uncertainty on FINO3's measurements. The uncertainty on FINO3 measurements was estimated to be in the magnitude of 3.5%, taking into account the lack of information, the noncompliance to the standards [56] and compensating for the possibility to correct the mast distortion.

vi. Ground Meteo Stations

ANHOLT

The observations made at Anholt come from a meteorological mast (#06079) from Danish Meteorological Institute (DMI) [8]. Wind speed and direction measurements are recorded at 10 m AGL. Temperature measurements are recorded at 2 m AGL. No turbulence data are available. The observations have been conducted from several locations during the measurement period as shown on Figure 71 and Table 55.

Table 55. Measuring information of Anholt meteorological station

Location	Longitude	Latitude	Measured period	Resolution
An1	11.6511	56.7360	01/01/1961 - 31/10/1965	3 hours
An2	11.5470	56.7034	01/10/1967 - 24/11/1976	4 hours
An3	11.5436	56.7011	25/11/1976 - 06/04/1980	4 hours
An4	11.5098	56.7169	01/05/1993 - 28/09/1999 29/09/1999 - 01/05/2024	1 hour 10 minutes

The coordinates available for the first three positions cannot be validated from the orthophoto map.

The forth position can be confirmed satellite imagery from Google Earth. The mast is located about 17-25 m from the pier, at an altitude of 2.3 m ASL. The mast does not seem obstructed by local obstacles in the main wind direction. However, effects can be expected from a building about 50 m south-east of the mast. The setup of the anemometer on the mast is unknown, which prevents the assessment of possible distortion from the mast.

Figure 71. Four positions of Anholt met mast (DMI #06079) over time. Source: windPRO European Satellite Imagery.

Raw data verification and data treatment

In general, the data quality is good. The data have been filtered for faulty equipment and failures due to weather conditions.

To ensure the consistency of data in terms of location and time resolution, only the data from the last period of measurements and with 10 minute resolution is kept for this analysis (29/09/1999 – 01/05/2024).

The data is trimed to 22 full years (01/05/2000 – 01/05/2024). The recovery rate of the wind data for this period is very good with 98.9%. The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 5 days in 09/2000
- 7 days in 07/2001
- 7 days in 10/2006
- 14 days in 04/2013
- 1 months between 04/05/2013 and 03/06/2013
- 2 days in 02/2018
- 5 days in 03/2022

The reasons for missing data is unknown.

The recovery rate of the temperature data is also good with 95.7%.

GNIBEN

The observations made at Gniben come from a meteorological mast (#06169) from Danish Meteorological Institute (DMI) [8]. Wind speed and direction measurements are recorded at 10 m AGL. Temperature measurements are recorded at 2 m AGL. No turbulence data are available

The DMI met mast of Gniben is located on Sjællands Odde peninsula. At this outermost point, the peninsula is only 200 m wide, so the location of the met mast is well exposed to the open sea. However, the site is elevated from the sea level by 14 m at the position of the mast. At 23 m south of the met mast, one can notice a large (about 6 m wide) and tall (about 60 m high) lattice tower. Flow distortion from this tower can be expected on the measurements, however with a minimum impact as it does not concern any primary wind directions. Buildings east of the met mast are less than the measurement height and far enough to impact the flow. Steep slopes 80 m upwind in the western direction may affect the flow and hence the quality of the measurements. The setup of the anemometer on the mast is unknown, which prevents the assessment of possible distortion from the mast.

Observations at Gnibben have been conducted in different periods, characterized by different time interval and locations, as provided by DMI [8]. The locations are shown on Figure 72 and listed on Table 56.

Table 56. Measuring information of Gniben meteorological station

Location	Longitude	Latitude	Measured period	Resolution
Gn1	11.2805	56.0067	01/01/1961 - 31/07/1974	3 hours
Gn2	11.2792	56.0064	01/08/1974 - 24/11/1976	3 hours
Gn3	11.2787	56.0083	03/04/1979 - 14/02/1983	3 hours
Gn4	11.2787	56.0083	15/02/1983 - 06/08/2002 28/08/2002 - 01/05/2024	1 hour 10 minutes

Figure 72. Four positions of Gniben met mast (DMI #06069)

Raw data verification and data treatment

In general, the data quality is good. The data have been filtered for faulty equipment and failures due to weather conditions.

To ensure the consistency of data in terms of location and time resolution, only the data from the last period of measurements is kept for this analysis. Out of this period, only 21 full years of 10 minutes values have been selected (01/05/2003 - 01/05/2024). The recovery rate of the wind data for this period is very good with 98.1%.

The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 6 days in 08/2006
- 2 and 7 days in 04/2011
- 23 days between 05/2011 and 06/2011
- 32 days between 12/2012 and 01/2013
- 1 day in 04/2014
- 3 days in 12/2021

The reasons for missing data is unknown.

The recovery rate of the temperature data is also good with 97.4%.

NAKKEHOVED

The observations made at Nakkehoved comes from a meteorological mast (#06168) from Danish Meteorological Institute (DMI) [8]. Wind speed and direction measurements are recorded at 10 m AGL. Temperature data is measured at 2 m AGL. No turbulence data are available.

The met mast of Nakkehoved is located on the northern coast of Sjælland, about 100 m from the shore. The surroundings are characterized by high roughness terrain with forest and cities (Gilleleje and Munkerup). The vicinity of trees (5-10 m tall) just next to the mast compromises the quality of the measurements due to the turbulences and displacement of the wind flow created by the canopy. The elevation of the mast is 36.4 m ASL.

Observations at Nakkehoved have been conducted with different time intervals. Two very similar and close sets of coordinates are available, see Table 57. The actual position ("Na2" on Figure 73) which is valid for the 10 mintutes interval data sets can be verified from the Danish Orthophoto Mosaic (source: Geodatastyrelsen). The setup of the anemometer on the mast is unknown, which prevents the assessment of possible distortion from the mast.

Table 57. Measuring information of Nakkehoved meteorological station.

Location	Longitude	Latitude	Measured period	Resolution
Na1	12.3429	56.1193	07/02/1982 – 28/10/1983 02/09/1986 – 29/09/1999 30/09/1999 – 17/01/2001	3 hours 1 hour 10 minutes
Na2	11.2792	56.0064	18/01/2001 – 01/05/2024	10 minutes

Figure 73. Two positions of Nakkehoved met mast (DMI #06068)

Raw data verification and data treatment

In general, the data quality is good. The data have been filtered for erroneous data usually due to faulty equipment and failures due to weather conditions.

To ensure the consistency of data in terms of location and time resolution, only the data from the last period of measurements is kept for this analysis. Out of this period, only 23 full years of 10 minutes values have been selected (01/05/2001 - 01/05/2024). The recovery rate of the wind data for this period is very good with 98.7%.

The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 1 day in 07/2005
- 43 days between 01/2007 and 02/2007
- 27 days in 03/2014
- 17 days between 07/2021 and 08/2021

The reasons for missing data is unknown.

The recovery rate of the temperature data is also good with 98.5%.

HALLANDS VÄDERÖ

The observations made at Hallands Väderö come from a meteorological mast (#62260) from Swedish Meteorological and Hydraulic Institute (SMHI) [9]. The met mast is located on the northwest part of the island of Hallands-Väderö in Sweden. Wind speed, wind direction and temperature data are measured at 2 m AGL. No turbulence data are available.

Observations at Väderö have been conducted during two different periods at different locations. The first period consists of about 4.5 years (between 1961 and 1965), 540 m from the west coast of the island. The second period starts in 1995 (still ongoing) in the vicinity of the lighthouse, about 140 m from the west coast and at an elevation of 8.3 m ASL. The lighthouse and its dwelling are located about 25 - 32 m in the western direction. Flow distortion from these obstacles can affect the quality of measurements made at 2 m AGL. The landscape is open, but with low vegetation to the east.

The wind data is available as 10-minute averages delivered every hour. The temperature data are instantaneous values, also available as hourly data.

Table 58. Measuring information of Hallands-Väderö meteorological station.

Location	Longitude	Latitude	Measured period	Resolution
Va1	12.5500	56.4500	01/01/1951 – 30/06/1965	6 hours
Va2	12.5453	56.4496	01/08/1995 – 01/01/2024	1 hour

Figure 74. Two positions of Hallands-Väderö met mast (SMHI #62260).

Raw data verification and data treatment

In general, the data quality is good. No filtering of erroneous data has been necessary. The data seems already filtered.

28 full years of h ourly data have been selected from 01/01/1996 - 01/01/2024. The recovery rate of the data for this period is good with 95.3%. The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 12 days in 02/1996
- 1 day in 10/1996
- 14 days in 08/1997
- 7 days in 05/1998
- 10 days in 05/1999
- 4 days in 07/2000
- 34 days between 04/2002 – 05/2002
- 2 days in 09/2003
- 3, 4, 3 and 10 days in 10/2003
- 2 and 1 days in 11/2003
- 7 and 1 days in 03/2004

- 43 days between 01/2005 – 02/2005
- 8 and 4 days in 03/2005
- 9 days in 07/2005
- 24 days between 03/2011 – 04/2011
- 4 days in 05/2011
- 59 days between 11/2011 – 01/2012
- 8 days between 06/2017 – 07/2017
- 20 days in 03/2018
- 40 days between 02/2020 – 04/2020
- 22 days between 07/2021 – 08/2021
- 57 days between 02/2023 – 04/2023

Possible reasons for missing data:

- the station or transmitter has been out of order.
- the station has only delivered values with quality code Red (R).

The recovery rate of the temperature data is also good at 96.3%.

RØSNÆS FYR

The observations made at Røsnæs Fyr comes from a meteorological mast (#06159) from Danish Meteorological Institute (DMI) [8]. Wind speed and direction measurements are recorded at 10 m AGL. Temperature data is measured at 2 m AGL. No turbulence data are available.

The met mast of Røsnæs Fyr is located on the western coast of Sjælland, about 30 m from the shore. At this outermost point, the peninsula is only 90 m wide, so the location of the met mast is well exposed to the open sea, and the site elevation is only 1 m ASL at the position of the mast. At 10 m west of the met mast, one can notice a water tower (about 4 m wide and about 10 m high). Flow distortion from this tower is expected on the measurements. The vicinity of buildings and trees just next to the mast, also compromises the quality of the measurements due to the turbulences and displacement of the wind flow created by the canopy. The setup of the anemometer on the mast is unknown, which prevents the assessment of possible distortion from the mast.

Observations at Røsnæs Fyr have been conducted with different time intervals and from two different locations, see Table 59 and Figure 75.

Table 59. Measuring information of Røsnæs Fyr meteorological station.

Location	Longitude	Latitude	Measured period	Resolution
Ro1	10.8691	55.7436	01/01/1959 – 14/11/2001	3 hours
Ro2	10.8694	55.7435	15/11/2001 – 01/05/2024	10 minutes

Figure 75. Two positions of Røsnæs Fyr met mast (DMI #06159)

Raw data verification and data treatment

In general, the data quality is good. The data have been filtered for erroneous data usually due to faulty equipment and failures due to weather conditions.

To ensure the consistency of data in terms of location and time resolution, only the data from the last period of measurements is kept for this analysis. Out of this period, only 22 full years of 10 minutes values have been selected (01/05/2002 - 01/05/2024). The recovery rate of the wind data for this period is very good with 98.9%.

The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 1 day in 04/2006
- 8 days between 12/2007 and 01/2008
- 19 days in 02/2008
- 5 days in 09/2011
- 1 day in 09/2014
- 1 day in 10/2014
- 7 days in 04/2015
- 2 days in 02/2016
- 6 days in 09/2023

The reasons for missing data is unknown.

The recovery rate of the temperature data is also good with 98.9%.

SLETTERHAGE FYR

The observations made at Sletterhage Fyr comes from a meteorological mast (#06073) from Danish Meteorological Institute (DMI) [8]. Wind speed and direction measurements are recorded at 10 m AGL. Temperature data is measured at 2 m AGL. No turbulence data are available.

The met mast of Sletterhage Fyr is located on the southern coast of Sjælland, about 30 m from the shore. At this outermost point, the peninsula is only 90 m wide, so the location of the met mast is well exposed to the open sea, and the site elevation is only 1 m ASL at the position of the mast. The vicinity of buildings and trees just next to the mast, compromises the quality of the measurements due to the turbulences and displacement of the wind flow created by the canopy. The setup of the anemometer on the mast is unknown, which prevents the assessment of possible distortion from the mast.

Observations at Sletterhage Fyr have been conducted with different time intervals and from two different locations, see Table 59 and Figure 75.

Table 60. Measuring information of Sletterhage Fyr meteorological station.

Location	Longitude	Latitude	Measured period	Resolution
Sl1	10.5134	56.0954	01/07/1977 – 30/04/1985	3 hours
Sl2	10.5135	56.0955	21/05/2001 – 01/05/2024	10 minutes

Figure 76. Two positions of Sletterhage Fyr met mast (DMI #06073)

Raw data verification and data treatment

In general, the data quality is good. The data have been filtered for erroneous data usually due to faulty equipment and failures due to weather conditions.

To ensure the consistency of data in terms of location and time resolution, only the data from the last period of measurements is kept for this analysis. Out of this period, only 22 full years of 10 minutes values have been selected (01/05/2002 - 01/05/2024). The recovery rate of the wind data for this period is very good with 99.4%.

The following gaps (consecutive days with missing or erroneous data) in the wind data can be noted:

- 2 days in 07/2004
- 3 days in 09/2005
- 6 days in 06/2017
- 2 and 1 days in 11/2017
- 6 days between 02/2022 and 03/2022

The reasons for missing data is unknown.

The recovery rate of the temperature data is also good with 99.2%.

vii. Measuring Stations Not Used

Several other meteorological stations were considered, but not used in this study for different reasons which are presented below.

The data measured by the LiDAR ("ANH") located on a platform inside the Anholt OWF has not been used. Besides incomplete available information, the data is heavily impacted by the Anholt wind turbines. The use of turbulence data in from undisturbed sectors are not relevant because they are deemed unreliable when measured from a LiDAR.

Data (of salinity and temperature) from meteorological stations Anholt E, L:A Middelgrund, N14 Falkenberg, Stora Middelgrund could not been found on the SMHI website [9]. With data otherwise available, this information would have been redundant and the issue was not pursued.

The data measured from the Fladen Lighthouse and Ringhals have not been selected as they have been considered redundant with Anholt Haven station. They are also considered to be too far away from the analyzed wind farm area.

The period of the measured data from the Anholt OWF, Hamlstad Flygplats and P22 are too short and therefore not suitable for the study. The goal of these type of data being to check the long-term consistency and the air temperature.

Appendix A.2. Data Analysis of Supporting Data

WIND SPEED DISTRIBUTION

The following table summarizes the resulting wind speeds.

Table 61. Summary of secondary data wind speed

Station	HEIGHT [m]	ARITHMETIC MEAN WIND SPEEDS [m/s]	MAX MEAN WIND SPEED [m/s]	WEIBULL MEAN [m/s]	WEIBULL – A PARAMETER	WEIBULL – K PARAMETER
Hesselø South (HS-1)	150	10.75	29.95	10.79	12.18	2.19
Hesselø (H1)	150	9.87	33.42	9.98	11.27	2.17
Læsø (M1)	62	8.8	28.39	8.94	10.09	2.36

WIND DIRECTION DISTRIBUTION

The frequency and energy distributions indicate that there is not only one defined main direction, but scattered distribution, being the third and fourth quadrant, from South-southwest to Northwest, the most dominant wind directions.

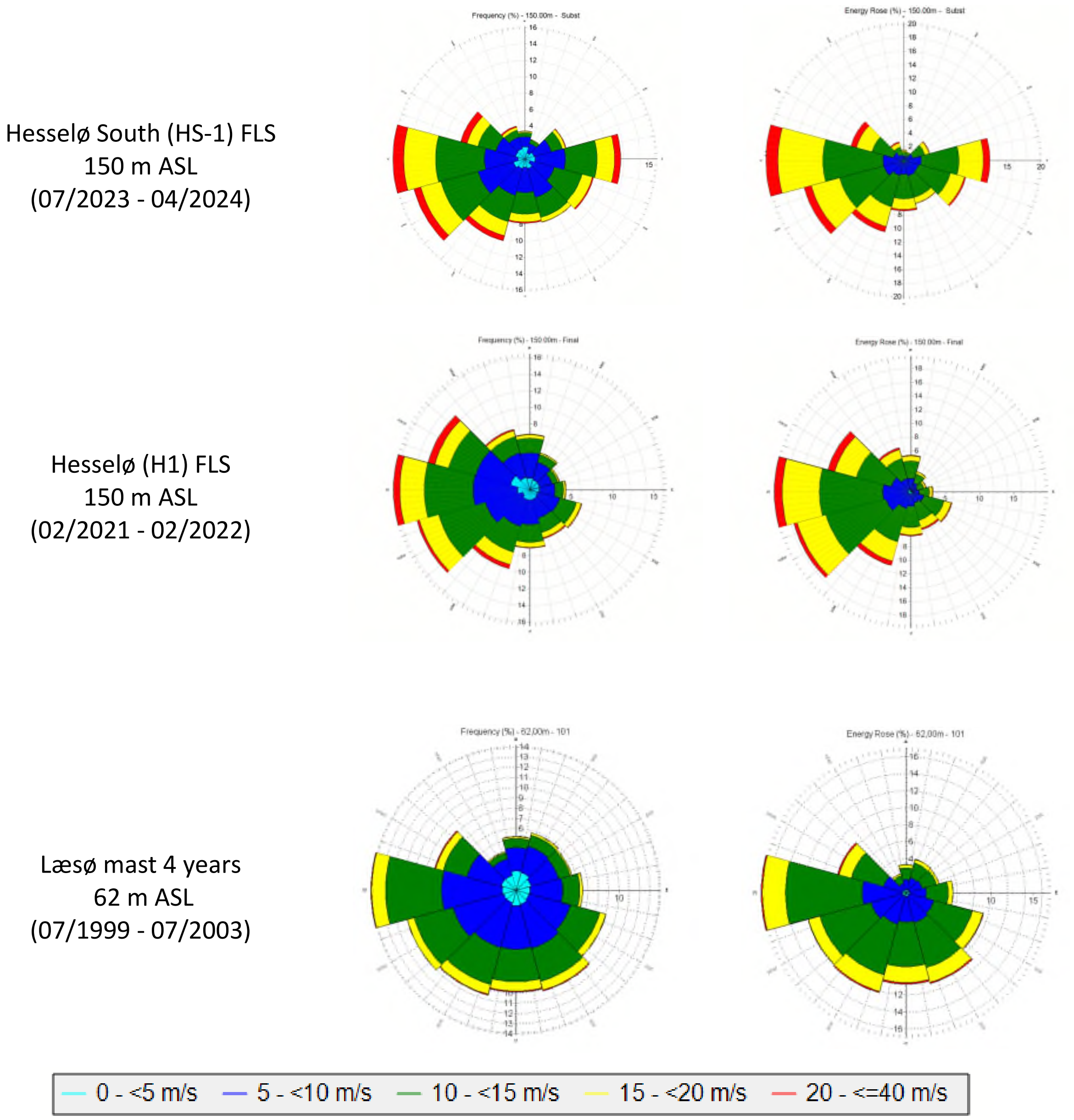


Figure 77. Supporting data wind direction frequency (on the left) and energy (on the right) distribution.

TURBULENCE INTENSITY

The turbulence intensity calculated from the mean wind speed and its standard deviation is presented in Figure 78. For FINO3, the 91 m mean turbulence intensity is presented while FINO2 the 102 m mean turbulence intensity is presented. The observed mean turbulence intensity for Læsø at 62 m is added for comparison. As observed on Figure 79 the turbulence intensity has a uniform distribution across the direction sectors in all three observations.

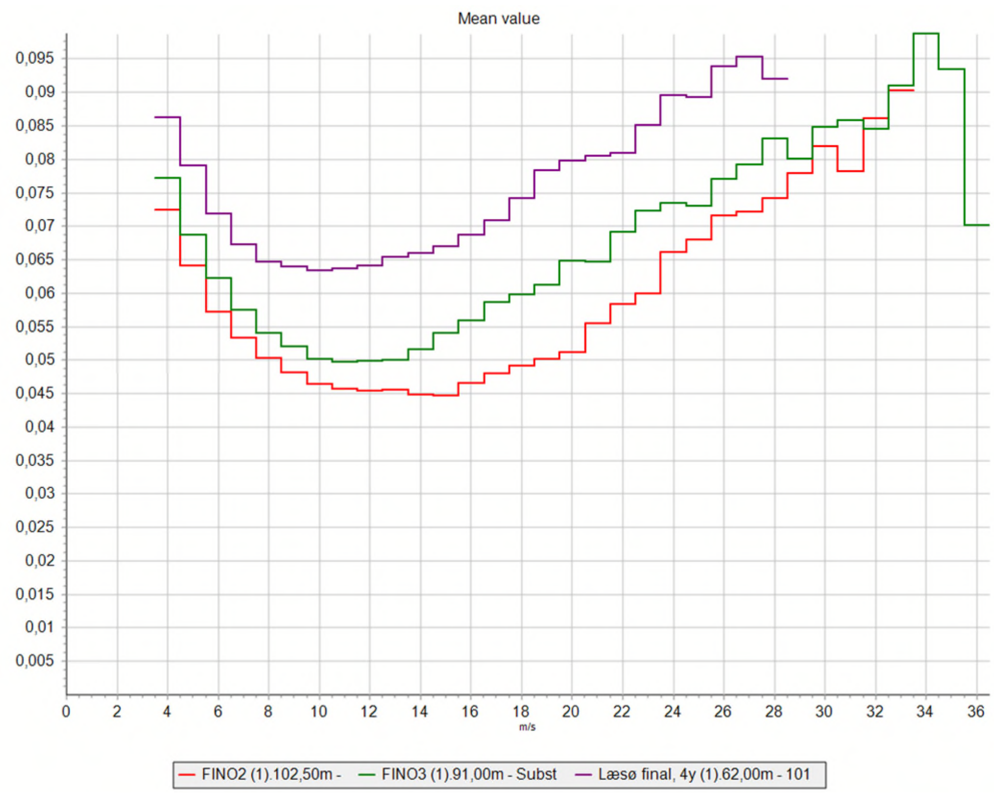


Figure 78. Turbulence intensity measured at FINO3, FINO2 and Læsø

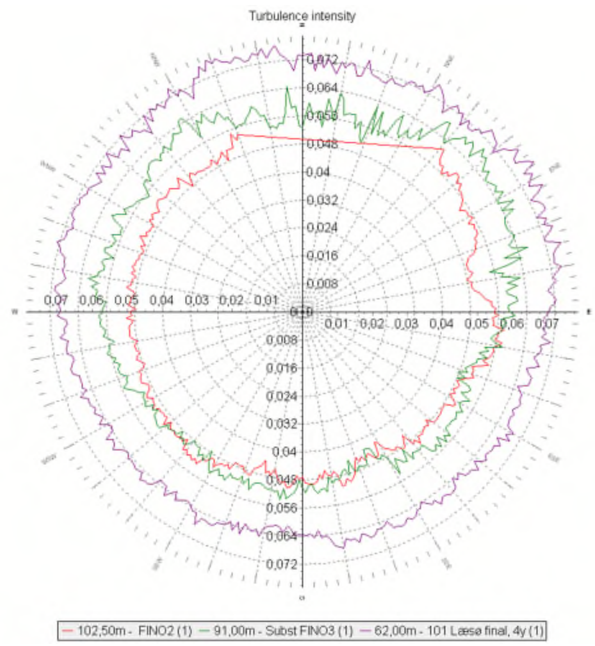


Figure 79. Measured turbulence intensity measured at FINO3, FINO2 and Læsø by wind direction.

The Læsø turbulence measurements are considered not representative of the Kattegat site, due to very low water depth at Læsø, and they were disqualified in the discussion in section 9.1.3. It is, however, interesting to compare the combined turbulence function based on FINO2 and FINO3 with a turbulence model at 150 m based on Læsø data (Figure 80). The match on mean and standard deviation is poor, but the characteristic turbulence functions are surprisingly close.

EMD has verified the combined model against confidential measurement in the Kattegat that confirms the combined turbulence model with good match on mean, standard deviation and characteristic turbulence from 12 m/s and up.

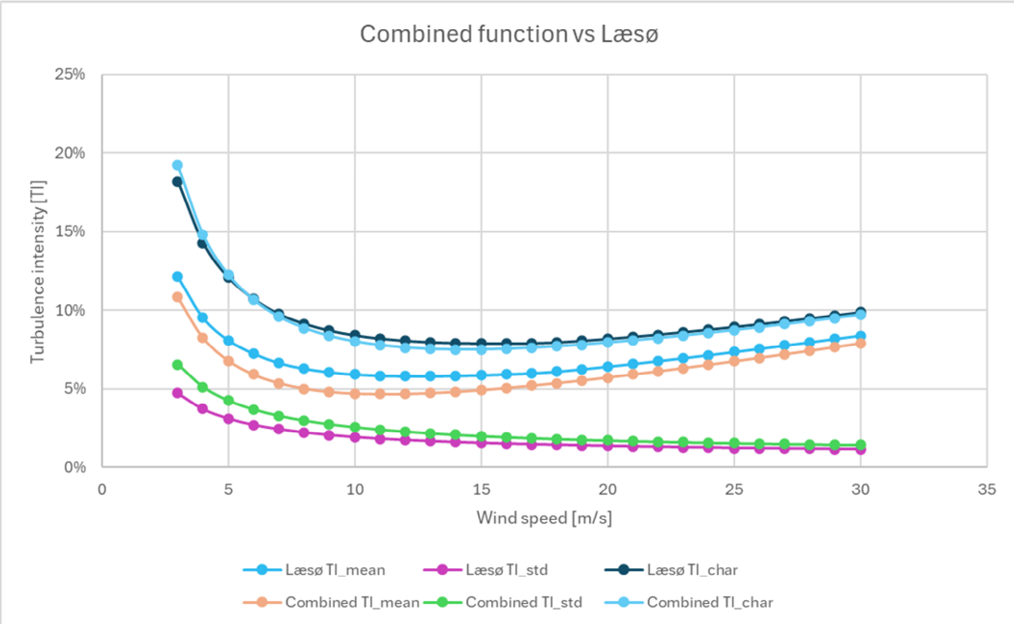


Figure 80. Mean turbulence intensity (TI_mean), Standard deviation of turbulence intensity (TI_std) and Characteristic turbulence intensity for the Combined model and Læsø turbulence extrapolated to 150 m.

DIURNAL VARIATION WIND SPEED

The wind speed is lowest at midday and highest during the night.

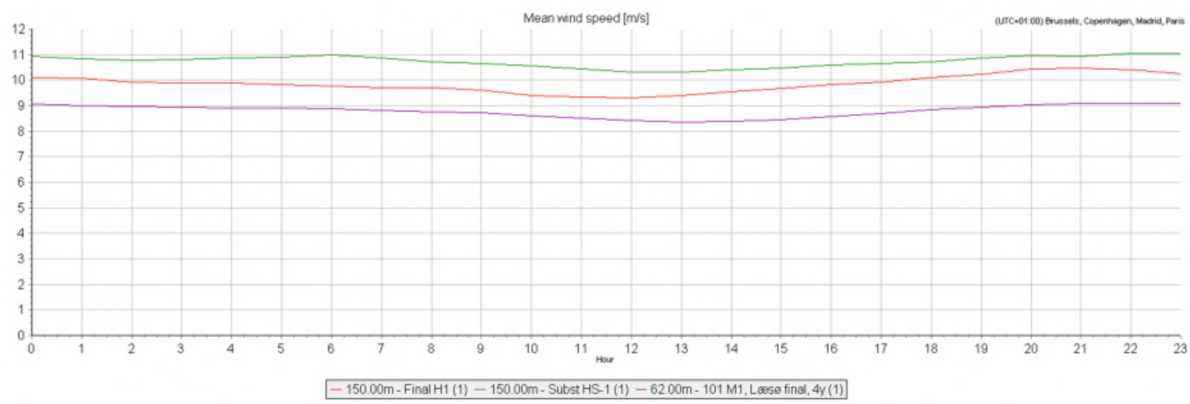


Figure 81. Daily variation of wind speed at H1, 1 y - 150 m (red), HS-1, 8 months 150 m (green) and M1, 4 year, 62 m (purple).

SEASONAL VARIATION WIND SPEED

The monthly wind speed variations point to highest wind speeds during the late autumn and winter.

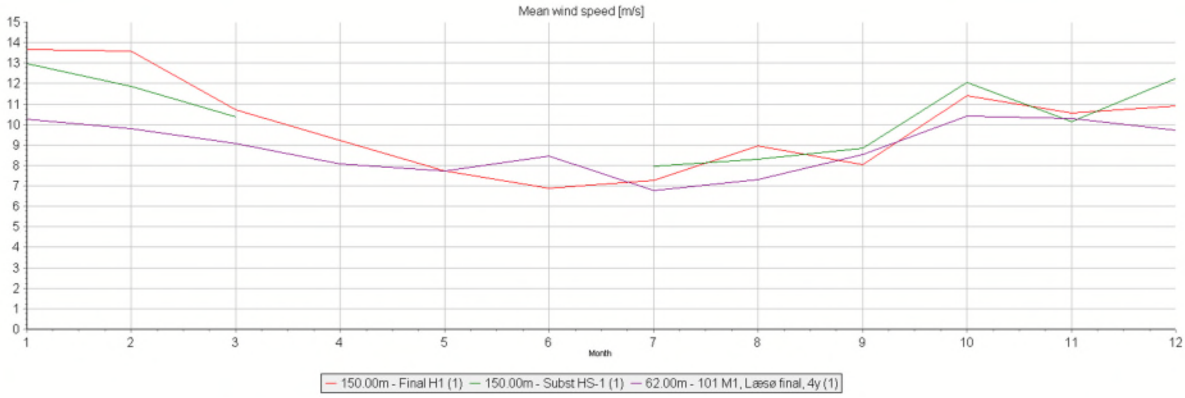


Figure 82. Monthly variation of wind speed measured at H1 - 150 m (1 y) (in red), HS-1 - 150 m (8 months) (in green) and M1 - 62 m (4 years) (in purple).

TEMPERATURE

A summary of the mean temperature measured on the 9 secondary data sources is presented in Table 62.

The diurnal distribution of temperature shows a distinct difference between onshore and offshore stations. The amplitude is far smaller on the offshore sites as expected, which will resemble the Kattegat OWF more than the onshore stations Figure 83.

Table 62. Summary of Secondary Temperature data

Source	Height (ASL) [m]	Position	Period		Mean Temperature [°C]
Læsø (M1)	55	Offshore	07/1999 - 07/2003	4	9.5
Anholt Haven	10	Onshore	05/2000 - 05/2024	24	9.44
Gniben	10	Onshore	05/2003 - 05/2024	21	9.54
Nakkehoved Fyr	10	Onshore	05/2001 - 05/2024	23	9.12
Hallands Väderö	2	Onshore	01/1996 - 01/2024	28	9.02
Røsnæs Fyr	10	Onshore	05/2002 - 05/2024	22	9.72
Sletterhage Fyr	10	Onshore	05/2002 - 05/2024	22	9.48

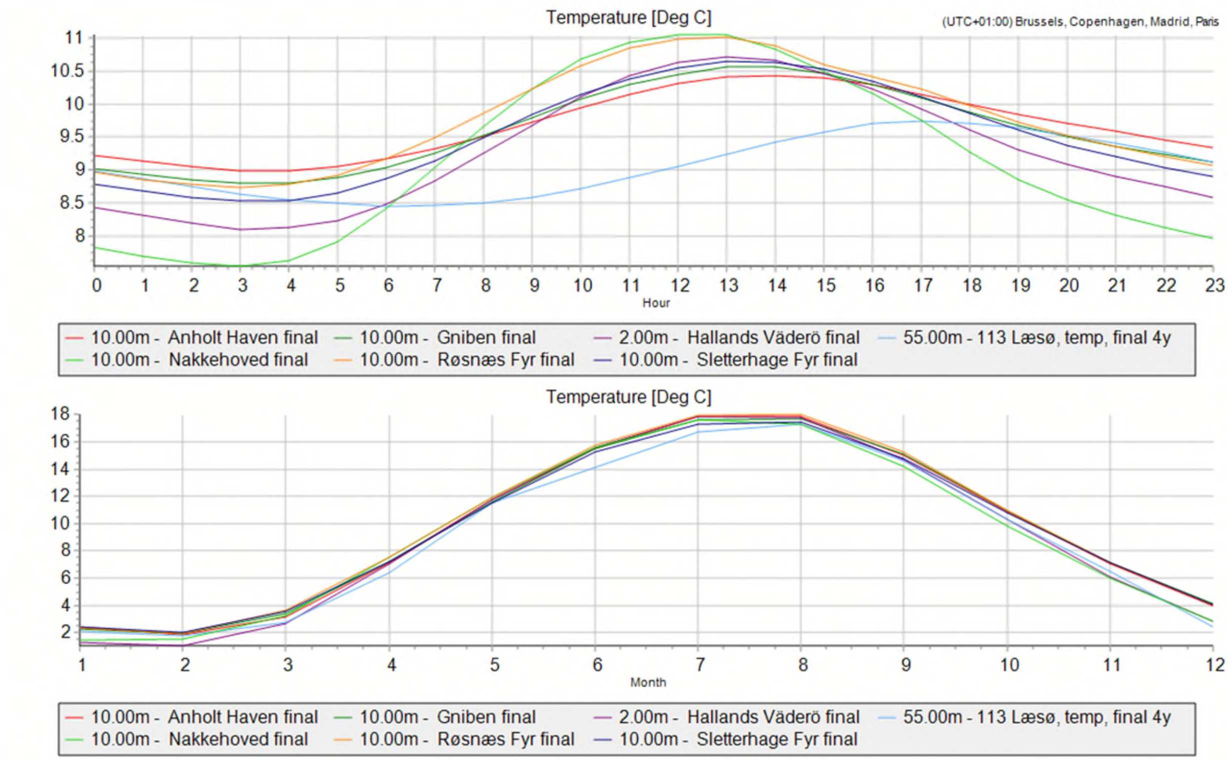


Figure 83. Diurnal and monthly variation of absolute temperature at the 7 secondary data sources.

Appendix A.3. Long-term Correction of Supporting Data

The measurement data from Hesselø South (HS-1), Hesselø (H1) and Læsø (M1) have been long-term corrected for wind model validation use. The reference period used is 2002-2023 (22 years). The argumentation for use of this period is presented in section 6.1.2.

REFERENCE DATA AND CORRELATION

For each dataset, three different reference datasets were considered: EMD-WRF, ERA5(T) and NORA3. These reference datasets are discussed in section 5. The closest node to each location was used.

EMD has several long-term correction methodologies at disposal. A full description of these can be found in the WindPRO reference document on Measure-Correlate-Predict (MCP) methods [25].

As for KG-1-LB, the uncomplete year of measurements at HS-1, there is a of seasonal bias when performing the long-term correction based on the with 8 months of available data.

In each case correlation on wind speed, monthly correlation on energy content (index), self-prediction (concurrent period) and 24-hour slicing test (both converted to production output) as well as the ability to correctly reproduce observed directional distribution and wind speed frequency distribution was considered. The reference data and methodology with the best combined success was selected. This is summarized in Table 63.

Table 63. Best performing reference data and long-term correction methodology (LTC) for each secondary dataset.

Ref: EMD-WRF	HS-1	H1	M1
Reference dataset	EMD-WRF	EMD-WRF	EMD-WRF
Correlation, r [%] Wind Speed, hourly	96.1	94.9	93.5
Correlation, r [%] Wind Energy, monthly	99.0	99.8	99.1
LTC methodology	Matrix	Matrix	Matrix
24-hour slicing test, % production	2.85	0.75	-0.64
Concurrent period prediction test, % production	-0.09	0.23	-0.03

LONG-TERM WIND SPEED DISTRIBUTION

The long-term corrected wind speeds and wind distributions are presented in Table 64.

Frequency tables for each dataset can be found in appendix E.

Table 64. Long-term corrected wind speed and wind distribution, secondary data.

	ELEVATION ASL [m]	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER	WEIBULL - k PARAMETER
HS-1	150	22	9.69	9.80	11.06	2.25
H1	150	22	9.73	9.86	11.13	2.21
M1	62	22	8.98	9.14	10.31	2.40

LONG-TERM WIND DIRECTION DISTRIBUTION

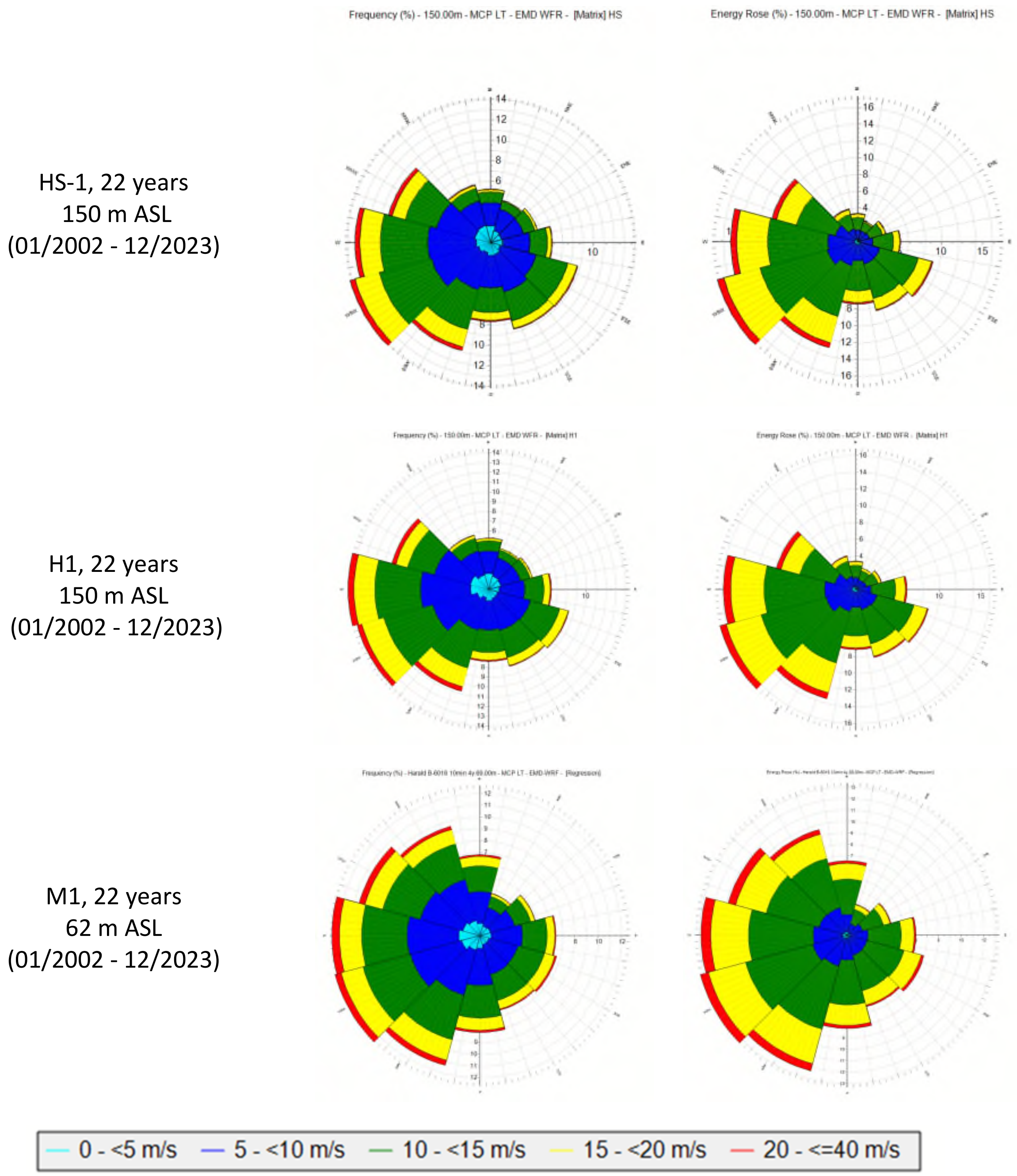


Figure 84. Long-term corrected frequency and energy roses, secondary data.

LONG-TERM DIURNAL VARIATIONS

Daily variation of the three long-term corrected datasets is presented in Figure 85. All data sets are quite parallel with higher wind speed at night than at daytime, the same pattern observed in the measured data.

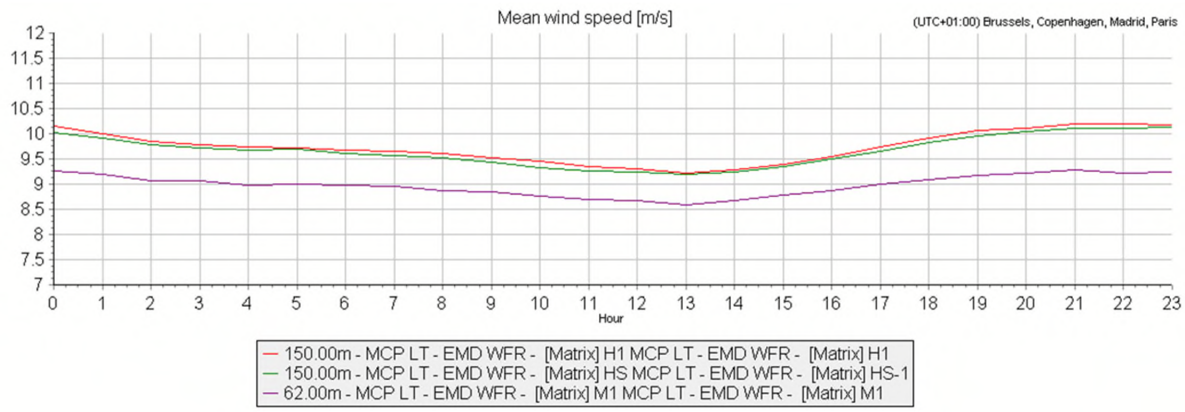


Figure 85. Long-term corrected diurnal variation, secondary data. Red: H1, green: HS-1, purple: M1.

LONG-TERM SEASONAL VARIATIONS

The long-term seasonal variation mirrors that of the observation but is not more regular in shape with high wind speed at winter and lower wind speed in summer.

There is a distinctly different directional energy distribution summer and winter common for all three datasets.

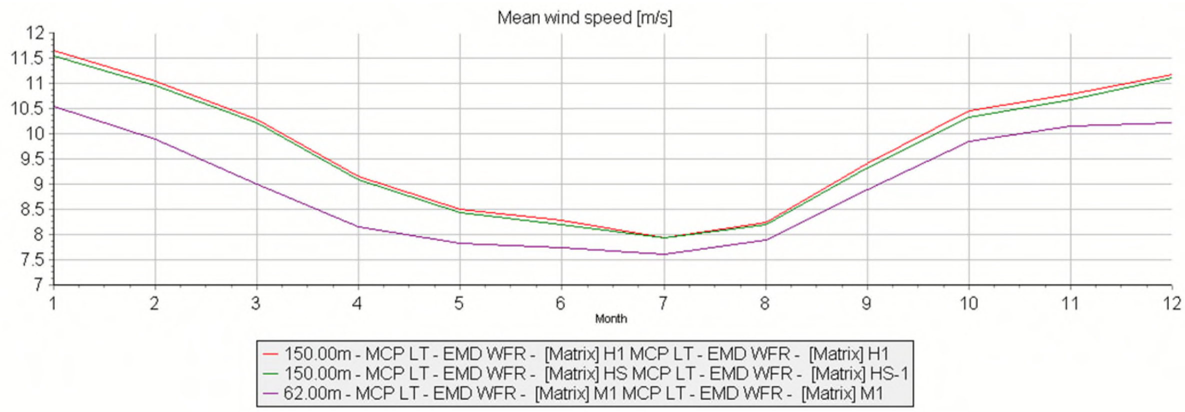


Figure 86. Long-term corrected seasonal variation, secondary data. Red: H1, green: HS-1, purple: M1.

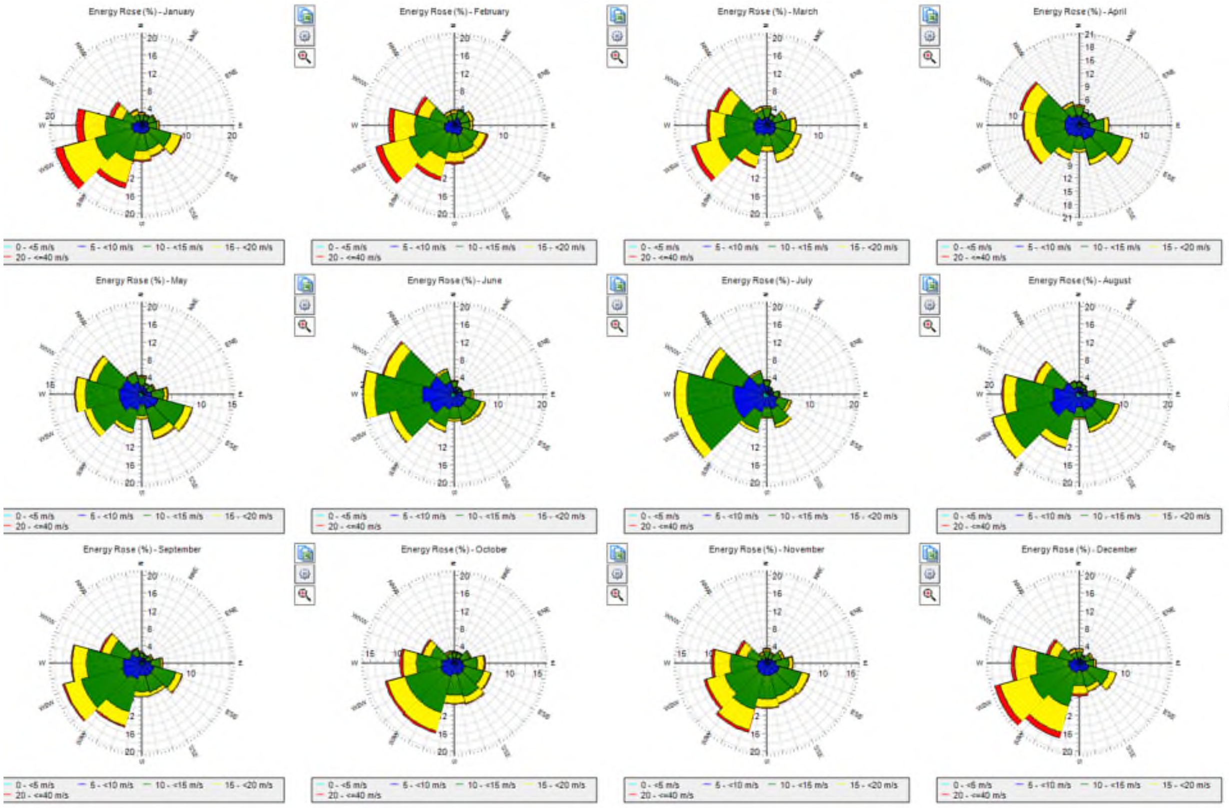


Figure 87. Long-term monthly energy roses, HS-1 (first line: January-April; second line: May-August; last line: September-December).

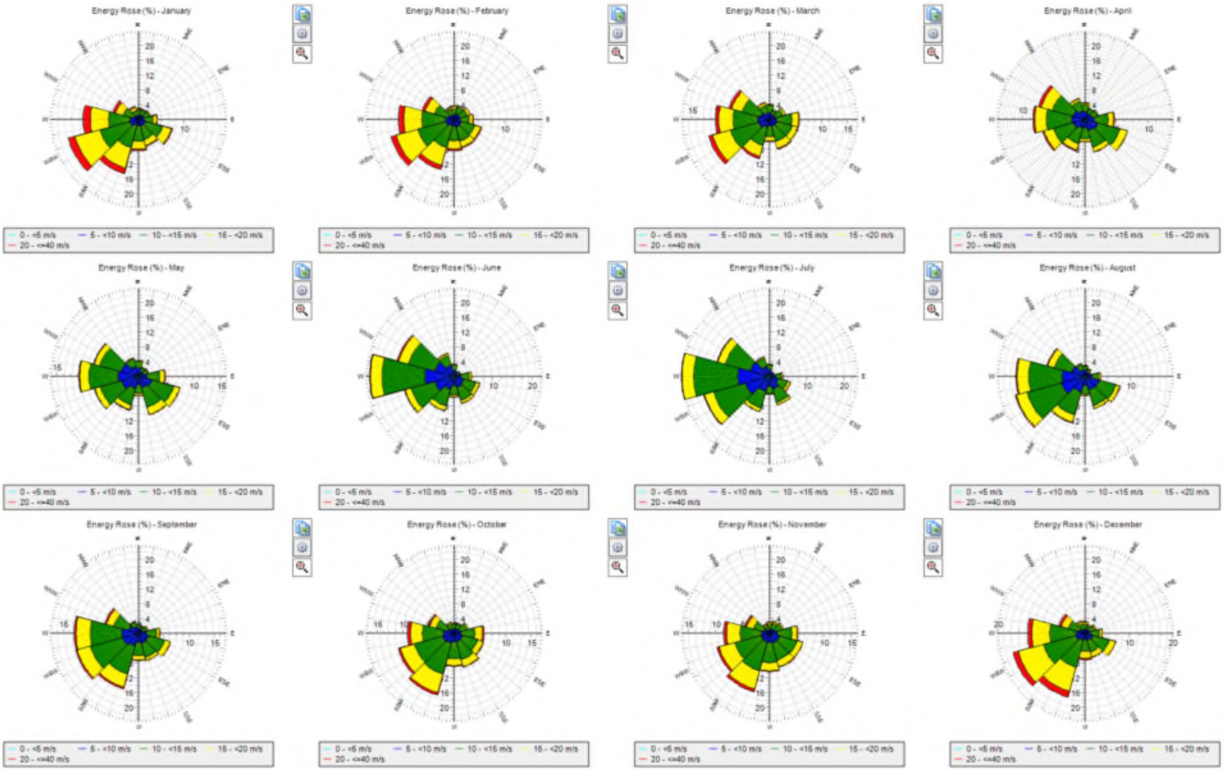


Figure 88. Long-term monthly energy roses, H1 (first line: January-April; second line: May-August; last line: September-December).

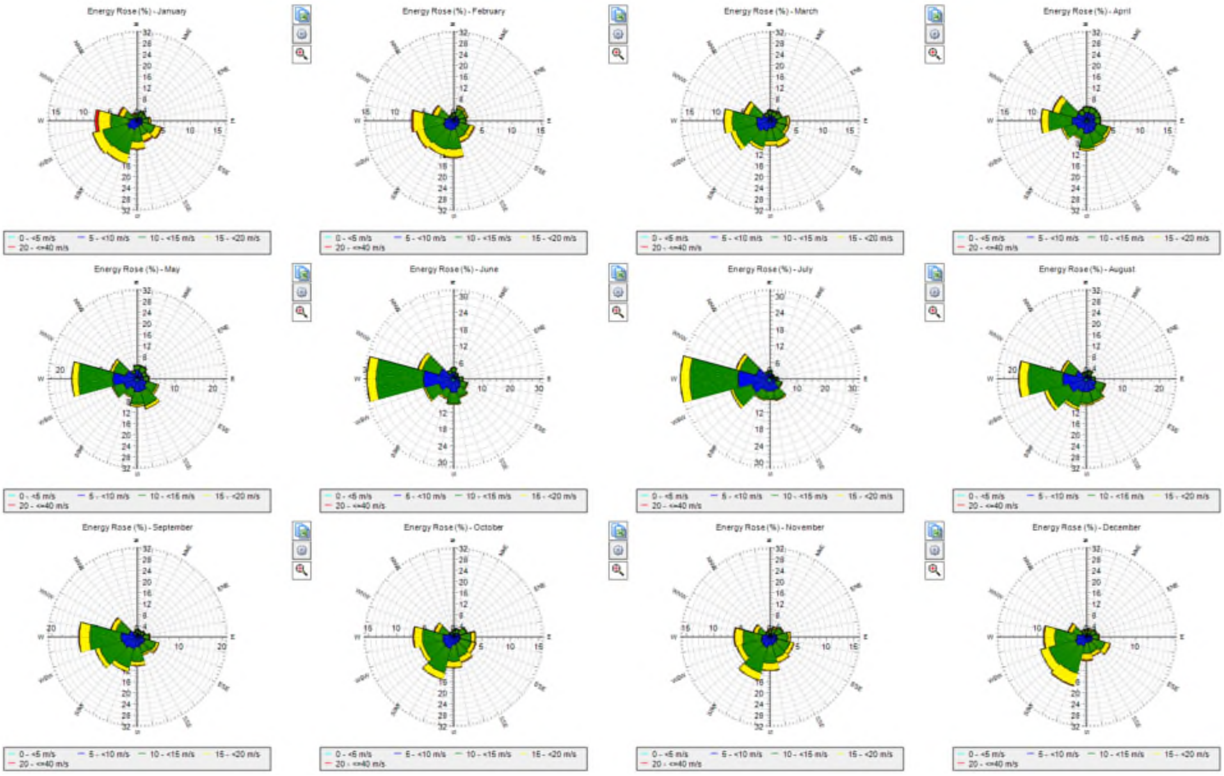


Figure 89. Long-term monthly energy roses, M1 (first line: January-April; second line: May-August; last line: September-December)

Appendix B. Verification and Classification Uncertainty

Verification uncertainty at 160 m height for WS199 [15].

WS199 height 160 m													
BIN lower [m/s]	BIN upper [m/s]	# of 10 min data sets	V_{FLS} [m/s]	V_{REF} [m/s]	V_{FLSmax} [m/s]	V_{FLSmin} [m/s]	Std_{VFLS} [m/s]	$Std_{VFLS}/\sqrt{n}$ [m/s]	Mean deviation [%]	Mounting uncertainty [%]	Separation Uncertainty [%]	V_{REF} Uncertainty [%]	**V_{FLS} Uncertainty (k=1) [%]**
3.75	4.25	48	3.94	3.95	4.43	3.33	0.22	0.031	-0.38%	0.50%	0.28%	1.68%	**1.98%**
4.25	4.75	37	4.50	4.48	5.67	3.86	0.39	0.064	0.37%	0.50%	0.28%	1.60%	**2.25%**
4.75	5.25	25	4.98	4.96	6.60	4.26	0.45	0.089	0.44%	0.50%	0.28%	1.57%	**2.49%**
5.25	5.75	45	5.58	5.53	6.18	5.14	0.26	0.039	0.88%	0.50%	0.28%	1.68%	**2.10%**
5.75	6.25	84	6.10	6.00	7.53	5.55	0.36	0.039	1.61%	0.50%	0.28%	1.70%	**2.49%**
6.25	6.75	87	6.59	6.49	7.83	5.94	0.28	0.030	1.56%	0.50%	0.28%	1.80%	**2.50%**
6.75	7.25	57	7.05	7.00	7.56	6.50	0.25	0.033	0.69%	0.50%	0.28%	1.76%	**2.03%**
7.25	7.75	48	7.51	7.50	8.12	6.98	0.29	0.042	0.05%	0.50%	0.28%	1.63%	**1.81%**
7.75	8.25	39	8.00	7.99	8.74	5.93	0.52	0.084	0.14%	0.50%	0.28%	1.56%	**1.97%**
8.25	8.75	45	8.43	8.50	8.97	5.16	0.55	0.083	-0.81%	0.50%	0.28%	1.48%	**2.03%**
8.75	9.25	47	9.03	8.99	9.64	7.93	0.35	0.051	0.42%	0.50%	0.28%	1.36%	**1.64%**
9.25	9.75	47	9.42	9.47	10.09	8.61	0.31	0.045	-0.54%	0.50%	0.28%	1.36%	**1.64%**
9.75	10.25	31	9.91	9.95	10.47	9.21	0.30	0.054	-0.40%	0.50%	0.28%	1.38%	**1.64%**
10.25	10.75	41	10.55	10.52	11.64	9.46	0.39	0.062	0.34%	0.50%	0.28%	1.34%	**1.60%**
10.75	11.25	39	11.01	10.96	12.22	10.12	0.45	0.072	0.43%	0.50%	0.28%	1.38%	**1.69%**
11.25	11.75	57	11.63	11.52	13.19	11.03	0.41	0.054	0.99%	0.50%	0.28%	2.04%	**2.39%**
11.75	12.25	43	11.99	11.95	13.24	10.45	0.46	0.070	0.37%	0.50%	0.28%	1.36%	**1.63%**
12.25	12.75	43	12.74	12.49	14.17	11.57	0.57	0.088	1.98%	0.50%	0.28%	1.39%	**2.58%**
12.75	13.25	44	13.20	13.03	13.91	12.41	0.44	0.067	1.33%	0.50%	0.28%	1.49%	**2.14%**
13.25	13.75	51	13.51	13.54	14.76	12.53	0.48	0.067	-0.22%	0.50%	0.28%	1.43%	**1.64%**
13.75	14.25	52	14.07	13.99	14.80	12.99	0.45	0.062	0.52%	0.50%	0.28%	1.49%	**1.74%**
14.25	14.75	31	14.56	14.52	15.31	13.70	0.43	0.077	0.26%	0.50%	0.28%	1.49%	**1.70%**
14.75	15.25	20	15.10	14.99	15.89	14.10	0.40	0.090	0.75%	0.50%	0.28%	1.49%	**1.86%**
15.25	15.75	31	15.48	15.48	16.55	14.08	0.48	0.086	-0.04%	0.50%	0.28%	1.49%	**1.69%**
15.75	16.25	22	16.29	15.98	17.80	15.39	0.56	0.120	1.96%	0.50%	0.28%	1.49%	**2.63%**

Verification uncertainty at 140 m height for WS199 [15]

WS199 height 140 m													
BIN lower [m/s]	BIN upper [m/s]	# of 10 min data sets	V_{FLS} [m/s]	V_{REF} [m/s]	V_{FLSmax} [m/s]	V_{FLSmin} [m/s]	Std_{VFLS} [m/s]	$Std_{VFLS}/\sqrt{n}$ [m/s]	Mean deviation [%]	Mounting uncertainty [%]	Separation Uncertainty [%]	V_{REF} Uncertainty [%]	**V_{FLS} Uncertainty (k=1) [%]**
3.75	4.25	56	3.92	3.95	4.42	3.45	0.21	0.028	-0.94%	0.50%	0.28%	1.68%	**2.13%**
4.25	4.75	33	4.47	4.51	5.34	3.75	0.36	0.063	-0.88%	0.50%	0.28%	1.60%	**2.38%**
4.75	5.25	31	5.02	4.99	6.54	4.00	0.47	0.084	0.65%	0.50%	0.28%	1.57%	**2.46%**
5.25	5.75	44	5.58	5.51	6.80	5.13	0.33	0.050	1.19%	0.50%	0.28%	1.68%	**2.31%**
5.75	6.25	100	6.08	6.00	7.67	5.44	0.32	0.032	1.34%	0.50%	0.28%	1.70%	**2.30%**
6.25	6.75	76	6.54	6.48	7.44	6.00	0.28	0.032	0.92%	0.50%	0.28%	1.80%	**2.16%**
6.75	7.25	67	6.99	6.98	7.61	6.48	0.23	0.028	0.16%	0.50%	0.28%	1.76%	**1.91%**
7.25	7.75	52	7.55	7.51	7.96	6.73	0.28	0.039	0.53%	0.50%	0.28%	1.63%	**1.88%**
7.75	8.25	45	8.00	7.98	8.78	6.28	0.37	0.055	0.24%	0.50%	0.28%	1.56%	**1.82%**
8.25	8.75	49	8.61	8.55	9.25	7.89	0.27	0.039	0.70%	0.50%	0.28%	1.48%	**1.79%**
8.75	9.25	57	8.98	9.04	9.63	5.54	0.56	0.074	-0.66%	0.50%	0.28%	1.36%	**1.82%**
9.25	9.75	34	9.56	9.51	10.28	8.73	0.35	0.061	0.52%	0.50%	0.28%	1.36%	**1.69%**
9.75	10.25	30	9.91	10.01	10.99	9.25	0.37	0.067	-0.94%	0.50%	0.28%	1.38%	**1.89%**
10.25	10.75	40	10.59	10.51	11.87	9.86	0.42	0.067	0.78%	0.50%	0.28%	1.34%	**1.77%**
10.75	11.25	45	11.09	11.04	12.57	10.22	0.42	0.063	0.42%	0.50%	0.28%	1.38%	**1.65%**
11.25	11.75	56	11.53	11.51	13.18	10.30	0.47	0.062	0.24%	0.50%	0.28%	2.04%	**2.20%**
11.75	12.25	39	12.07	12.01	13.96	11.24	0.54	0.086	0.57%	0.50%	0.28%	1.36%	**1.73%**
12.25	12.75	33	12.70	12.50	13.71	11.71	0.50	0.087	1.64%	0.50%	0.28%	1.39%	**2.33%**
12.75	13.25	41	13.20	13.00	14.13	12.16	0.43	0.066	1.51%	0.50%	0.28%	1.49%	**2.26%**
13.25	13.75	67	13.52	13.51	14.59	12.33	0.49	0.060	0.03%	0.50%	0.28%	1.43%	**1.61%**
13.75	14.25	37	14.11	14.01	14.91	13.09	0.38	0.063	0.74%	0.50%	0.28%	1.49%	**1.81%**
14.25	14.75	28	14.53	14.49	16.01	13.53	0.59	0.111	0.30%	0.50%	0.28%	1.49%	**1.79%**
14.75	15.25	28	15.17	14.98	15.99	14.09	0.41	0.078	1.28%	0.50%	0.28%	1.49%	**2.11%**
15.25	15.75	26	15.48	15.49	16.80	14.00	0.59	0.115	-0.09%	0.50%	0.28%	1.49%	**1.76%**
15.75	16.25	28	16.21	16.02	18.05	15.40	0.53	0.100	1.19%	0.50%	0.28%	1.49%	**2.08%**

Type specific classification uncertainty from classification report for ZX300 by DNV-GL [16]

ZX300 Type Class Table											
EVs / Heights	Max influence (m x Range)								Preliminary accuracy	Type specific class	Standard uncertainty
	Temperature Gradient	Air Temperature	Turbulence Intensity	Wind Veer	Wind Shear	Air Density	Rain	Flow inclination angle			
[m]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
135	-1.85	-1.81	0.46	0.60	-2.48	*	-0.59	0.71	3.78	2.67	1.54
130	-2.03	-1.34	0.62	0.57	-1.14	*	-0.60	1.17	3.11	2.20	1.27
125	-1.80	-1.37	0.70	0.59	-1.20	*	-0.96	1.07	3.07	2.17	1.25
120	-1.91	-1.13	0.78	0.58	-0.61	*	-0.92	0.96	2.83	2.00	1.16
115	-1.97	-0.90	0.87	0.57	-0.02	*	-0.87	0.86	2.70	1.91	1.10
110	-2.03	-0.66	0.95	0.57	0.57	*	-0.82	0.76	2.71	1.92	1.11
105	-2.09	-0.42	1.04	0.56	1.16	*	-0.77	0.65	2.88	2.04	1.18
100	-1.52	2.50	1.71	0.00	1.02	-0.45	-0.01	0.55	3.61	2.55	1.47
95	-1.18	1.96	1.47	0.12	1.17	-0.33	0.20	0.22	2.99	2.12	1.22
90	-0.82	1.42	1.43	0.23	1.31	-0.20	0.23	-0.11	2.57	1.81	1.05
85	-0.46	0.91	1.40	0.34	1.52	-0.07	0.25	-0.66	2.43	1.72	0.99
80	-0.10	0.57	1.50	0.47	1.68	0.05	0.28	-0.63	2.47	1.75	1.01
75	0.11	0.61	1.61	0.60	2.23	0.18	0.30	-0.59	2.96	2.10	1.21
70	0.14	1.11	1.33	0.72	2.79	0.31	0.28	-0.56	3.43	2.43	1.40
65	0.23	1.35	1.09	0.89	2.36	0.75	0.26	-0.52	3.21	2.27	1.31
60	0.23	1.77	0.86	1.04	2.05	1.13	0.24	-0.49	3.28	2.32	1.34
55	0.25	2.07	0.71	0.45	1.91	1.51	0.23	*	3.32	2.34	1.35
50	0.28	1.03	0.52	0.61	1.60	1.89	0.28	*	2.83	2.00	1.15
45	0.32	0.41	0.39	0.77	1.29	2.27	0.31	*	2.82	2.00	1.15
40	0.16	-0.22	0.27	0.93	0.99	2.66	0.35	*	3.03	2.14	1.24
35	0.10	-0.61	0.41	0.45	0.13	0.48	0.38	*	1.07	0.75	0.44
30	0.03	-0.76	0.53	0.34	-0.44	-0.41	0.41	*	1.23	0.87	0.50
25	0.02	-0.78	0.67	0.29	-1.01	-1.30	0.45	*	2.01	1.42	0.82
20	0.00	-0.71	0.82	0.23	-1.58	-2.18	0.48	*	2.95	2.09	1.21

* EV was not assessed in the height

Appendix C. Filtered & Repaired Dataset: KG-1-LB

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

300.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			11.27	7.28	7.18	8.33	12.32	11.36	9.54	10.59	11.69	11.72	12.99	12.90	8.66
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	171	27	26	29	13	9	12	8	8	10	8	7	14
2	1.50	2.49	670	74	64	85	43	39	59	53	55	53	38	50	57
3	2.50	3.49	1102	55	71	132	114	70	128	116	114	103	51	71	77
4	3.50	4.49	1650	111	114	139	144	109	126	185	183	180	151	119	89
5	4.50	5.49	2002	168	97	128	155	171	218	156	201	211	237	135	125
6	5.50	6.49	2185	185	92	167	192	127	153	201	230	207	332	201	98
7	6.50	7.49	2346	93	78	180	244	140	184	185	299	204	354	217	168
8	7.50	8.49	2415	71	101	165	231	195	169	182	308	326	346	179	142
9	8.50	9.49	2151	70	93	137	208	176	172	169	279	290	320	114	123
10	9.50	10.49	2327	32	84	200	194	235	227	124	263	344	398	121	105
11	10.50	11.49	2148	62	26	130	153	215	255	121	231	334	411	131	79
12	11.50	12.49	1760	40	13	63	169	159	161	98	236	293	329	145	54
13	12.50	13.49	1825	32	10	55	240	188	163	127	181	231	342	188	68
14	13.50	14.49	1788	40	1	44	231	159	145	95	195	197	437	207	37
15	14.50	15.49	1482	24	0	57	184	95	68	112	242	158	383	142	17
16	15.50	16.49	1555	16	0	42	173	145	45	147	211	228	380	148	20
17	16.50	17.49	1384	16	4	22	119	170	51	127	161	260	302	125	27
18	17.50	18.49	1097	4	18	16	106	104	32	82	150	212	237	115	21
19	18.50	19.49	1013	1	25	6	145	90	24	52	141	184	232	100	13
20	19.50	20.49	838	3	12	9	118	77	18	58	78	86	270	102	7
21	20.50	21.49	646	4	7	12	79	52	28	38	60	44	215	90	17
22	21.50	22.49	452	5	0	6	31	27	16	17	41	33	171	98	7
23	22.50	23.49	305	0	0	3	50	5	5	10	35	21	96	72	8
24	23.50	24.49	263	0	0	8	81	1	3	6	20	18	69	55	2
25	24.50	25.49	229	0	0	4	63	0	1	14	23	32	50	42	0
26	25.50	26.49	153	0	0	0	38	0	0	6	37	15	29	28	0
27	26.50	27.49	85	0	0	0	16	0	0	7	14	9	9	29	1
28	27.50	28.49	50	0	0	0	9	0	0	4	8	8	0	21	0
29	28.50	29.49	42	0	0	0	3	0	0	6	13	8	0	11	1
30	29.50	30.49	20	0	0	0	0	0	0	0	15	2	0	3	0
31	30.50	31.49	9	0	0	0	0	0	0	0	9	0	0	0	0
32	31.50	32.49	2	0	0	0	0	0	0	0	2	0	0	0	0
33	32.50	33.49	2	0	0	0	0	0	0	0	2	0	0	0	0
34	33.50	34.49	3	0	0	0	0	0	0	0	3	0	0	0	0
35	34.50	35.49	2	0	0	0	0	0	0	0	2	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

260.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			11.11	7.25	7.02	8.36	12.16	11.33	9.48	10.58	11.57	11.54	12.71	12.44	8.63
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	178	19	26	27	13	6	10	12	11	14	7	13	20
2	1.50	2.49	668	92	66	84	48	32	61	50	54	45	38	53	45
3	2.50	3.49	1128	45	85	147	109	68	136	123	125	98	49	74	69
4	3.50	4.49	1638	110	110	130	144	111	129	184	191	155	157	128	89
5	4.50	5.49	2056	158	111	133	166	171	192	157	208	235	252	143	130
6	5.50	6.49	2216	173	82	160	214	139	165	200	244	219	331	198	91
7	6.50	7.49	2361	97	80	183	257	145	172	178	282	203	368	226	170
8	7.50	8.49	2451	85	102	169	237	204	176	195	306	333	339	168	137
9	8.50	9.49	2235	59	94	162	212	176	191	164	287	324	323	122	121
10	9.50	10.49	2360	40	74	210	193	241	206	129	280	354	398	136	99
11	10.50	11.49	2103	59	30	123	166	194	246	131	233	309	397	134	81
12	11.50	12.49	1865	36	14	73	182	177	179	114	236	320	335	141	58
13	12.50	13.49	1942	37	7	54	251	203	155	121	204	263	395	192	60
14	13.50	14.49	1748	36	2	52	218	145	150	112	204	194	430	170	35
15	14.50	15.49	1538	23	0	61	197	105	59	130	253	167	375	155	13
16	15.50	16.49	1581	12	0	31	179	165	60	142	194	272	362	145	19
17	16.50	17.49	1272	15	3	25	101	154	47	123	184	224	257	108	31
18	17.50	18.49	1152	5	22	14	112	97	24	71	179	207	281	115	25
19	18.50	19.49	956	2	19	11	144	105	22	73	112	154	232	76	6
20	19.50	20.49	798	2	16	12	106	66	33	57	74	77	243	104	8
21	20.50	21.49	585	5	2	9	69	64	17	40	46	43	194	85	11
22	21.50	22.49	381	3	0	8	27	15	9	10	48	23	143	83	12
23	22.50	23.49	269	0	0	5	54	2	3	9	24	20	76	71	5
24	23.50	24.49	249	0	0	3	85	1	2	8	20	26	61	43	0
25	24.50	25.49	199	0	0	4	64	0	0	11	37	19	29	35	0
26	25.50	26.49	137	0	0	0	41	0	0	8	33	13	9	32	1
27	26.50	27.49	59	0	0	0	9	0	0	7	14	8	2	19	0
28	27.50	28.49	43	0	0	0	9	0	0	3	13	4	0	12	2
29	28.50	29.49	19	0	0	0	1	0	0	4	12	0	0	2	0
30	29.50	30.49	9	0	0	0	0	0	0	1	6	1	0	1	0
31	30.50	31.49	7	0	0	0	0	0	0	0	6	0	0	1	0
32	31.50	32.49	1	0	0	0	0	0	0	0	1	0	0	0	0
33	32.50	33.49	2	0	0	0	0	0	0	0	2	0	0	0	0
34	33.50	34.49	1	0	0	0	0	0	0	0	1	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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28/06/2024 09.09

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

220.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.93	7.16	7.03	8.43	12.07	11.18	9.43	10.55	11.51	11.26	12.43	11.91	8.45
0		0.49	1	1	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	174	26	18	23	13	6	15	9	16	8	11	13	16
2	1.50	2.49	675	88	79	83	51	36	63	43	49	45	42	48	48
3	2.50	3.49	1134	58	72	160	108	61	126	131	116	86	62	92	62
4	3.50	4.49	1689	111	120	118	149	113	149	189	190	160	171	132	87
5	4.50	5.49	2073	157	116	129	171	182	173	164	212	235	249	147	138
6	5.50	6.49	2284	163	84	183	224	130	181	204	264	226	343	195	87
7	6.50	7.49	2399	95	77	171	244	162	159	192	288	228	365	255	163
8	7.50	8.49	2405	69	105	175	245	201	203	172	295	325	314	162	139
9	8.50	9.49	2351	59	96	166	215	204	207	156	305	351	322	151	119
10	9.50	10.49	2443	42	79	212	209	229	202	133	275	393	417	166	86
11	10.50	11.49	2091	57	23	142	156	187	241	155	239	324	383	110	74
12	11.50	12.49	1997	42	17	71	198	187	191	120	248	346	386	145	46
13	12.50	13.49	2022	46	5	64	260	193	184	128	209	251	421	199	62
14	13.50	14.49	1735	25	1	51	211	173	125	128	217	199	404	175	26
15	14.50	15.49	1575	20	0	59	190	110	71	158	270	186	362	138	11
16	15.50	16.49	1562	11	2	37	175	156	60	144	205	269	346	134	23
17	16.50	17.49	1257	18	4	20	111	156	50	99	209	221	237	100	32
18	17.50	18.49	1102	4	21	9	127	102	29	73	174	198	273	79	13
19	18.50	19.49	949	1	22	15	148	90	19	82	101	116	259	87	9
20	19.50	20.49	717	2	14	14	92	70	24	54	64	67	228	80	8
21	20.50	21.49	500	4	2	12	60	42	14	22	51	37	160	87	9
22	21.50	22.49	292	4	0	5	33	7	7	9	31	13	102	68	13
23	22.50	23.49	251	0	0	7	66	1	4	7	20	22	65	59	0
24	23.50	24.49	242	0	0	6	78	0	0	14	36	18	48	41	1
25	24.50	25.49	167	0	0	1	58	0	0	13	41	10	14	29	1
26	25.50	26.49	98	0	0	0	30	0	0	5	37	5	3	18	0
27	26.50	27.49	44	0	0	0	15	0	0	5	10	0	0	14	0
28	27.50	28.49	20	0	0	0	5	0	0	6	2	0	0	6	1
29	28.50	29.49	12	0	0	0	1	0	0	2	9	0	0	0	0
30	29.50	30.49	4	0	0	0	0	0	0	0	4	0	0	0	0
31	30.50	31.49	5	0	0	0	0	0	0	0	4	0	0	1	0
32	31.50	32.49	2	0	0	0	0	0	0	0	2	0	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	1	0	0	0	0
34	33.50	34.49	1	0	0	0	0	0	0	0	1	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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28/06/2024 09.09

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

190.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.78	7.15	7.08	8.42	11.99	11.17	9.29	10.46	11.43	11.15	12.11	11.48	8.42
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	170	24	13	23	8	4	19	11	16	7	10	17	18
2	1.50	2.49	694	94	75	79	58	37	65	44	40	51	49	55	47
3	2.50	3.49	1145	57	79	168	109	66	121	144	105	81	62	97	56
4	3.50	4.49	1728	123	116	104	153	111	152	206	194	146	174	156	93
5	4.50	5.49	2025	148	107	132	181	173	173	156	209	228	268	135	115
6	5.50	6.49	2326	165	89	200	200	129	194	208	261	237	354	195	94
7	6.50	7.49	2423	80	84	168	258	169	183	189	299	215	362	259	157
8	7.50	8.49	2482	81	105	187	265	180	192	190	311	344	307	175	145
9	8.50	9.49	2406	51	97	165	214	214	233	142	299	371	351	163	106
10	9.50	10.49	2490	42	71	221	203	245	218	136	307	406	404	159	78
11	10.50	11.49	2156	55	32	159	179	185	235	148	221	373	379	119	71
12	11.50	12.49	2098	47	13	68	202	205	195	148	275	344	391	159	51
13	12.50	13.49	2003	42	4	70	261	193	187	132	200	252	424	186	52
14	13.50	14.49	1757	25	2	59	199	167	132	153	258	211	375	153	23
15	14.50	15.49	1631	19	0	49	215	124	62	169	250	210	380	135	18
16	15.50	16.49	1548	18	0	41	167	184	60	143	210	260	327	114	24
17	16.50	17.49	1242	9	9	17	111	145	38	83	236	228	245	96	25
18	17.50	18.49	1080	4	19	15	123	109	28	100	162	183	251	71	15
19	18.50	19.49	910	2	27	15	143	90	22	80	89	101	237	93	11
20	19.50	20.49	599	2	11	12	90	57	22	31	54	53	182	83	2
21	20.50	21.49	435	8	0	10	55	34	12	15	51	32	138	67	13
22	21.50	22.49	264	2	0	5	39	4	4	12	22	23	72	73	8
23	22.50	23.49	236	0	0	5	69	0	1	11	25	14	66	43	2
24	23.50	24.49	207	0	0	4	74	0	1	15	39	9	26	39	0
25	24.50	25.49	136	0	0	1	57	0	0	11	38	5	5	17	2
26	25.50	26.49	78	0	0	0	31	0	0	7	23	1	3	13	0
27	26.50	27.49	30	0	0	0	11	0	0	7	5	0	0	6	1
28	27.50	28.49	17	0	0	0	3	0	0	1	8	0	0	5	0
29	28.50	29.49	6	0	0	0	1	0	0	1	3	0	0	1	0
30	29.50	30.49	5	0	0	0	0	0	0	0	5	0	0	0	0
31	30.50	31.49	3	0	0	0	0	0	0	0	3	0	0	0	0
32	31.50	32.49	1	0	0	0	0	0	0	0	1	0	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	1	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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28/06/2024 09.09

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

170.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.67	7.09	7.05	8.42	11.94	11.09	9.22	10.39	11.40	11.01	11.88	11.24	8.41
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	170	22	19	22	12	2	19	8	14	10	8	21	13
2	1.50	2.49	702	96	71	82	52	38	71	52	39	45	53	52	51
3	2.50	3.49	1140	59	79	158	108	61	128	138	106	75	69	103	56
4	3.50	4.49	1744	120	118	117	153	110	167	194	186	158	183	157	81
5	4.50	5.49	2001	151	114	120	159	174	173	155	216	207	268	136	128
6	5.50	6.49	2347	159	85	192	217	132	191	219	257	243	358	205	89
7	6.50	7.49	2490	89	70	189	277	168	189	203	308	228	374	244	151
8	7.50	8.49	2538	74	115	174	281	183	216	182	326	346	308	190	143
9	8.50	9.49	2509	45	95	176	223	229	227	154	314	399	364	181	102
10	9.50	10.49	2551	43	74	219	217	242	217	161	289	433	410	168	78
11	10.50	11.49	2117	61	28	157	180	179	239	160	209	367	371	113	53
12	11.50	12.49	2148	47	7	79	201	197	197	151	262	361	416	168	62
13	12.50	13.49	2035	41	5	73	270	180	198	154	227	259	401	184	43
14	13.50	14.49	1800	20	1	56	213	185	126	175	260	207	381	155	21
15	14.50	15.49	1594	20	0	43	224	129	66	166	224	226	365	115	16
16	15.50	16.49	1524	18	0	36	154	171	56	142	253	258	309	100	27
17	16.50	17.49	1292	10	10	20	125	162	37	95	249	228	242	90	24
18	17.50	18.49	1040	2	24	9	131	102	29	92	151	161	240	88	11
19	18.50	19.49	820	1	22	17	137	80	20	60	92	83	209	89	10
20	19.50	20.49	547	5	12	15	90	48	19	22	58	39	162	73	4
21	20.50	21.49	377	4	2	7	49	27	13	13	38	31	108	72	13
22	21.50	22.49	254	2	0	5	50	3	5	9	20	14	77	58	11
23	22.50	23.49	213	0	0	4	64	0	1	17	33	11	44	38	1
24	23.50	24.49	204	0	0	9	73	0	1	15	48	5	24	29	0
25	24.50	25.49	126	0	0	0	52	0	0	11	32	4	6	20	1
26	25.50	26.49	58	0	0	0	32	0	0	7	9	1	0	8	1
27	26.50	27.49	16	0	0	0	6	0	0	1	3	0	0	5	1
28	27.50	28.49	20	0	0	0	4	0	0	4	7	0	0	5	0
29	28.50	29.49	5	0	0	0	0	0	0	0	5	0	0	0	0
30	29.50	30.49	3	0	0	0	0	0	0	0	3	0	0	0	0
31	30.50	31.49	2	0	0	0	0	0	0	0	2	0	0	0	0
32	31.50	32.49	2	0	0	0	0	0	0	0	2	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

150.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.55	7.10	7.04	8.52	11.86	11.07	9.06	10.30	11.32	10.82	11.68	10.97	8.27
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	154	23	11	25	9	7	12	14	8	9	11	12	13
2	1.50	2.49	732	96	85	80	55	41	71	58	47	42	57	53	47
3	2.50	3.49	1129	55	68	141	108	55	139	128	104	93	73	102	63
4	3.50	4.49	1779	127	118	142	150	101	186	180	183	148	196	155	93
5	4.50	5.49	2008	142	105	111	166	166	186	177	221	190	272	154	118
6	5.50	6.49	2387	160	91	188	215	136	203	222	257	259	352	203	101
7	6.50	7.49	2481	86	83	172	289	170	191	196	297	259	348	254	136
8	7.50	8.49	2606	73	101	191	289	183	226	191	351	355	316	195	135
9	8.50	9.49	2605	45	101	183	234	242	232	166	314	397	394	208	89
10	9.50	10.49	2596	49	79	219	227	232	223	178	286	476	405	152	70
11	10.50	11.49	2182	60	30	181	180	174	227	168	222	364	372	138	66
12	11.50	12.49	2175	40	6	71	190	197	219	171	276	349	433	163	60
13	12.50	13.49	2039	36	3	84	266	210	198	167	227	272	386	154	36
14	13.50	14.49	1789	30	1	48	234	177	122	185	230	221	377	142	22
15	14.50	15.49	1667	22	0	51	221	136	70	166	258	231	380	116	16
16	15.50	16.49	1463	12	1	30	144	170	40	137	304	253	256	85	31
17	16.50	17.49	1302	12	9	22	133	171	41	117	228	217	254	83	15
18	17.50	18.49	945	2	20	16	117	95	28	72	132	130	229	90	14
19	18.50	19.49	751	2	29	15	143	80	21	39	86	71	172	88	5
20	19.50	20.49	499	7	8	18	82	47	12	24	46	36	137	71	11
21	20.50	21.49	328	1	0	8	51	12	10	12	33	21	97	74	9
22	21.50	22.49	237	3	0	5	44	3	1	15	32	9	76	43	6
23	22.50	23.49	225	0	0	8	75	0	2	17	43	5	40	32	3
24	23.50	24.49	156	0	0	3	72	0	0	11	32	3	17	16	2
25	24.50	25.49	107	0	0	1	48	0	0	9	26	3	1	19	0
26	25.50	26.49	38	0	0	1	23	0	0	5	5	0	0	4	0
27	26.50	27.49	24	0	0	0	11	0	0	2	5	0	0	6	0
28	27.50	28.49	13	0	0	0	2	0	0	1	7	0	0	3	0
29	28.50	29.49	4	0	0	0	0	0	0	0	4	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	4	0	0	0	0	0	0	0	4	0	0	0	0
32	31.50	32.49	1	0	0	0	0	0	0	0	1	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

130.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.41	6.96	7.01	8.56	11.81	10.94	8.98	10.21	11.17	10.60	11.46	10.66	8.29
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	169	18	23	23	10	14	11	7	7	14	16	14	12
2	1.50	2.49	723	102	74	79	59	41	66	65	42	50	48	57	40
3	2.50	3.49	1163	47	78	145	88	60	142	126	111	99	91	108	68
4	3.50	4.49	1777	136	116	123	154	107	191	169	173	154	204	150	100
5	4.50	5.49	2038	146	118	111	163	168	197	177	218	190	279	162	109
6	5.50	6.49	2448	152	91	195	211	142	217	231	286	248	350	225	100
7	6.50	7.49	2522	86	75	185	279	165	211	194	329	274	352	248	124
8	7.50	8.49	2635	69	109	170	306	194	248	184	341	360	312	221	121
9	8.50	9.49	2724	60	98	182	261	226	225	179	375	421	398	210	89
10	9.50	10.49	2675	45	74	245	254	226	250	182	289	458	412	164	76
11	10.50	11.49	2232	56	29	176	191	185	243	178	234	357	365	157	61
12	11.50	12.49	2200	33	9	76	196	173	257	178	288	354	432	145	59
13	12.50	13.49	2087	40	4	78	256	244	214	178	236	265	393	146	33
14	13.50	14.49	1755	27	1	49	239	175	94	194	242	227	382	102	23
15	14.50	15.49	1684	18	0	54	212	131	62	167	266	257	376	123	18
16	15.50	16.49	1471	12	1	29	152	178	51	130	341	225	246	78	28
17	16.50	17.49	1237	11	13	20	127	178	46	108	221	193	233	72	15
18	17.50	18.49	863	3	26	18	123	94	19	73	117	100	191	83	16
19	18.50	19.49	660	3	26	17	134	67	14	28	66	59	156	85	5
20	19.50	20.49	449	3	5	12	87	38	13	20	33	25	115	89	9
21	20.50	21.49	291	2	0	10	45	3	4	7	33	14	104	54	15
22	21.50	22.49	227	0	0	5	50	2	2	19	37	4	67	37	4
23	22.50	23.49	208	0	0	10	76	0	0	16	43	7	31	23	2
24	23.50	24.49	140	0	0	3	63	0	0	11	31	5	8	19	0
25	24.50	25.49	78	0	0	1	43	0	0	7	12	0	0	15	0
26	25.50	26.49	37	0	0	0	24	0	0	0	8	0	0	5	0
27	26.50	27.49	15	0	0	0	8	0	0	1	3	0	0	3	0
28	27.50	28.49	13	0	0	0	3	0	0	2	6	0	0	2	0
29	28.50	29.49	2	0	0	0	0	0	0	0	2	0	0	0	0
30	29.50	30.49	1	0	0	0	0	0	0	0	1	0	0	0	0
31	30.50	31.49	3	0	0	0	0	0	0	0	3	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Calculated:
28/06/2024 09.09

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

100.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.15	6.78	6.97	8.64	11.68	10.65	8.76	9.99	10.84	10.26	11.08	10.27	8.20
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	173	19	20	22	11	17	11	8	12	16	12	14	11
2	1.50	2.49	731	98	77	85	46	44	66	63	45	55	48	57	47
3	2.50	3.49	1189	52	89	139	96	55	140	127	109	108	102	105	67
4	3.50	4.49	1791	133	120	113	149	114	186	187	161	174	209	147	98
5	4.50	5.49	2111	146	114	100	182	143	223	185	203	194	302	200	119
6	5.50	6.49	2584	153	95	202	210	193	248	236	309	233	363	247	95
7	6.50	7.49	2575	89	73	200	258	185	247	152	329	314	351	255	122
8	7.50	8.49	2847	63	114	185	330	185	271	228	422	376	330	239	104
9	8.50	9.49	2878	54	113	183	317	244	231	186	392	473	397	209	79
10	9.50	10.49	2755	42	60	256	261	219	259	214	331	440	420	168	85
11	10.50	11.49	2322	50	28	183	198	183	269	186	297	340	393	127	68
12	11.50	12.49	2234	26	12	73	199	210	276	208	267	348	430	130	55
13	12.50	13.49	2127	31	4	87	252	247	200	195	253	301	391	130	36
14	13.50	14.49	1804	28	1	64	250	154	72	233	268	224	375	111	24
15	14.50	15.49	1735	16	0	44	228	165	58	166	380	272	295	97	14
16	15.50	16.49	1416	13	3	38	137	205	59	121	287	207	238	83	25
17	16.50	17.49	1012	9	17	14	140	156	28	80	158	140	171	80	19
18	17.50	18.49	716	3	28	24	140	76	15	37	63	66	172	85	7
19	18.50	19.49	501	1	23	13	107	36	12	16	46	34	120	88	5
20	19.50	20.49	379	4	2	17	84	8	4	11	31	17	123	68	10
21	20.50	21.49	268	1	0	7	42	3	0	25	50	6	78	41	15
22	21.50	22.49	204	0	0	5	57	0	0	16	34	8	50	28	6
23	22.50	23.49	160	0	0	9	79	0	0	12	23	3	17	17	0
24	23.50	24.49	105	0	0	3	55	0	0	5	19	2	4	17	0
25	24.50	25.49	58	0	0	0	43	0	0	0	6	0	0	9	0
26	25.50	26.49	26	0	0	1	14	0	0	4	4	0	0	3	0
27	26.50	27.49	11	0	0	0	5	0	0	0	5	0	0	1	0
28	27.50	28.49	6	0	0	0	1	0	0	1	2	0	0	2	0
29	28.50	29.49	4	0	0	0	0	0	0	0	4	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	1	0	0	0	0	0	0	0	1	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

80.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.93	6.76	6.73	8.67	11.55	10.30	8.58	9.84	10.51	9.94	10.83	10.05	8.12
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	200	20	25	17	20	16	14	13	11	17	19	18	10
2	1.50	2.49	759	90	92	84	51	44	76	65	59	51	55	49	43
3	2.50	3.49	1203	61	106	127	98	61	125	124	108	110	118	99	66
4	3.50	4.49	1865	152	130	119	135	117	178	206	169	201	210	146	102
5	4.50	5.49	2164	135	129	95	174	164	234	209	187	204	317	206	110
6	5.50	6.49	2714	137	94	216	232	227	273	235	324	257	376	252	91
7	6.50	7.49	2699	83	81	191	251	227	288	150	360	338	332	266	132
8	7.50	8.49	3052	65	108	206	376	219	279	262	445	396	361	232	103
9	8.50	9.49	3025	53	113	187	325	232	251	205	399	534	428	203	95
10	9.50	10.49	2746	40	60	259	271	219	248	227	347	414	424	145	92
11	10.50	11.49	2446	48	22	183	212	190	289	255	289	354	412	128	64
12	11.50	12.49	2463	25	13	84	222	249	295	288	318	372	429	119	49
13	12.50	13.49	2050	27	3	81	254	213	153	226	277	273	387	119	37
14	13.50	14.49	1882	31	2	52	241	157	63	236	340	279	357	106	18
15	14.50	15.49	1676	13	0	51	232	194	70	189	338	235	249	89	16
16	15.50	16.49	1211	16	1	34	145	210	39	97	217	142	194	91	25
17	16.50	17.49	849	10	24	19	139	127	23	47	73	110	192	73	12
18	17.50	18.49	597	1	30	20	131	48	13	25	59	41	141	80	8
19	18.50	19.49	479	1	18	17	120	14	6	12	38	24	140	83	6
20	19.50	20.49	361	4	2	13	75	6	0	26	40	16	111	55	13
21	20.50	21.49	222	3	0	6	41	1	0	20	38	6	67	31	9
22	21.50	22.49	173	0	0	7	61	0	0	13	21	5	36	28	2
23	22.50	23.49	133	0	0	5	73	0	0	7	23	3	6	15	1
24	23.50	24.49	87	0	0	7	61	0	0	0	7	0	2	10	0
25	24.50	25.49	50	0	0	1	29	0	0	1	8	0	0	11	0
26	25.50	26.49	23	0	0	0	11	0	0	3	8	0	0	1	0
27	26.50	27.49	9	0	0	0	4	0	0	1	2	0	0	2	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	4	0	0	0	0	0	0	0	4	0	0	0	0
30	29.50	30.49	1	0	0	0	0	0	0	0	1	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

40.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.29	6.61	6.57	8.42	11.10	9.59	8.05	8.89	9.60	9.09	10.24	9.47	7.87
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	239	23	27	25	20	13	20	17	14	21	18	24	17
2	1.50	2.49	788	101	96	74	47	45	80	89	56	52	66	49	33
3	2.50	3.49	1310	76	109	128	99	102	129	142	111	121	115	115	63
4	3.50	4.49	1983	127	148	128	142	133	187	197	203	234	220	159	105
5	4.50	5.49	2530	132	145	103	189	244	285	257	238	254	329	235	119
6	5.50	6.49	2989	115	121	208	240	303	341	253	346	322	361	296	83
7	6.50	7.49	3074	88	72	225	313	247	298	291	450	377	339	250	124
8	7.50	8.49	3353	65	116	219	439	216	269	280	472	492	432	229	124
9	8.50	9.49	3241	43	113	224	365	247	283	269	493	534	407	164	99
10	9.50	10.49	2968	40	50	241	267	203	331	280	399	479	430	161	87
11	10.50	11.49	2751	39	25	162	194	223	342	318	432	399	458	119	40
12	11.50	12.49	2449	33	5	89	237	233	200	273	474	322	444	104	35
13	12.50	13.49	1920	27	0	74	252	203	102	212	300	254	346	119	31
14	13.50	14.49	1514	29	1	51	263	202	52	137	223	138	284	116	18
15	14.50	15.49	1076	16	2	45	184	226	29	79	116	91	185	79	24
16	15.50	16.49	799	11	9	27	142	138	19	33	71	90	160	80	19
17	16.50	17.49	585	5	32	15	143	52	7	12	49	48	126	86	10
18	17.50	18.49	532	2	30	20	129	21	3	34	38	29	140	79	7
19	18.50	19.49	369	3	6	16	96	6	0	24	26	14	106	63	9
20	19.50	20.49	222	3	0	9	51	0	0	9	29	8	65	33	15
21	20.50	21.49	173	0	0	10	77	0	0	6	15	5	33	25	2
22	21.50	22.49	120	0	0	5	76	0	0	3	20	1	7	8	0
23	22.50	23.49	87	0	0	3	56	0	0	2	12	0	1	13	0
24	23.50	24.49	42	0	0	0	30	0	0	3	6	0	0	3	0
25	24.50	25.49	14	0	0	0	9	0	0	1	4	0	0	0	0
26	25.50	26.49	6	0	0	0	2	0	0	0	3	0	0	1	0
27	26.50	27.49	2	0	0	0	0	0	0	0	2	0	0	0	0
28	27.50	28.49	1	0	0	0	0	0	0	0	1	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Frequency distribution (TAB file data)

12.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			8.32	6.21	6.11	7.88	10.02	8.60	7.18	7.66	8.32	7.94	9.26	8.69	7.39
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	310	29	46	27	32	22	20	19	19	29	28	25	14
2	1.50	2.49	899	108	125	85	53	51	98	106	53	69	67	45	39
3	2.50	3.49	1624	81	101	131	111	147	191	175	168	134	141	161	83
4	3.50	4.49	2670	146	166	144	177	291	274	284	265	316	301	202	104
5	4.50	5.49	3161	134	129	124	272	335	358	343	376	348	389	249	104
6	5.50	6.49	3512	102	124	261	369	252	360	382	495	416	382	272	97
7	6.50	7.49	3554	82	89	239	433	193	307	359	605	519	355	236	137
8	7.50	8.49	3821	57	128	210	394	209	337	359	656	650	482	220	119
9	8.50	9.49	3507	38	100	258	311	256	340	345	550	504	542	176	87
10	9.50	10.49	2963	45	30	236	219	229	321	281	496	421	478	142	65
11	10.50	11.49	2340	33	14	99	266	267	199	176	340	290	506	117	33
12	11.50	12.49	1882	39	2	94	287	256	96	171	245	126	382	144	40
13	12.50	13.49	1385	28	0	64	282	259	54	129	141	52	251	105	20
14	13.50	14.49	1029	24	1	46	201	195	22	46	88	105	178	96	27
15	14.50	15.49	674	9	20	26	141	91	6	18	44	81	137	88	13
16	15.50	16.49	632	2	44	21	164	36	4	38	51	40	134	88	10
17	16.50	17.49	444	2	13	21	118	4	1	19	23	12	130	87	14
18	17.50	18.49	238	4	1	9	66	2	0	4	20	7	77	37	11
19	18.50	19.49	183	0	0	8	108	0	0	8	18	6	19	13	3
20	19.50	20.49	121	0	0	8	73	0	0	5	20	0	2	13	0
21	20.50	21.49	62	0	0	0	44	0	0	2	10	0	1	5	0
22	21.50	22.49	21	0	0	1	14	0	0	3	3	0	0	0	0
23	22.50	23.49	9	0	0	0	2	0	0	0	6	0	0	1	0
24	23.50	24.49	2	0	0	0	0	0	0	0	2	0	0	0	0
25	24.50	25.49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25.50	26.49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26.50	27.49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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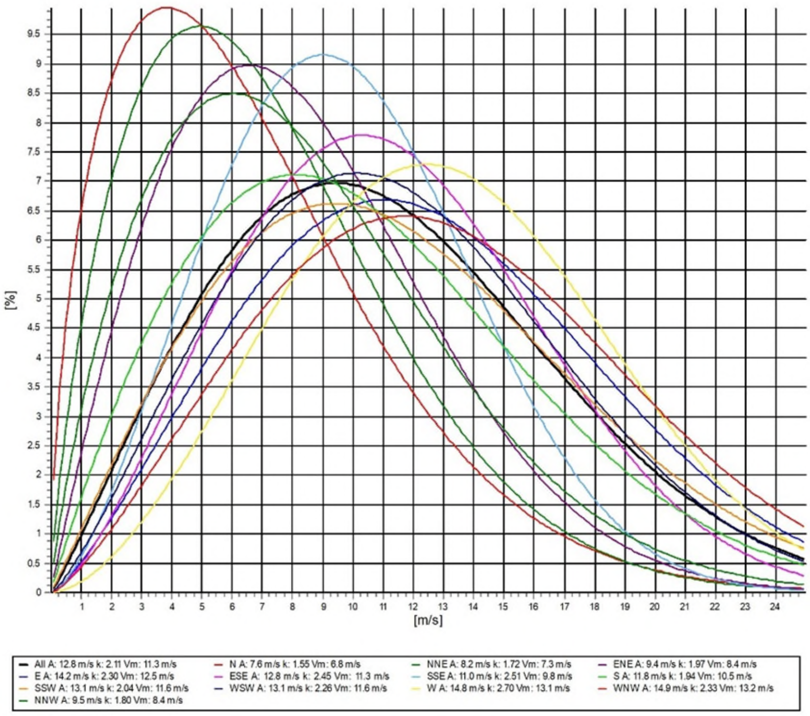
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **300.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.55	1.547	3.32	6.79
1-NNE	8.15	1.721	2.74	7.27
2-ENE	9.44	1.965	5.38	8.37
3-E	14.16	2.303	10.38	12.55
4-ESE	12.77	2.451	8.07	11.33
5-SSE	11.05	2.506	7.21	9.80
6-S	11.81	1.937	7.33	10.48
7-SSW	13.11	2.038	11.85	11.61
8-WSW	13.09	2.263	12.59	11.60
9-W	14.77	2.704	18.13	13.13
10-WNW	14.90	2.329	8.97	13.21
11-NNW	9.47	1.799	4.03	8.42
Mean	**12.77**	**2.114**	**100.00**	**11.31**



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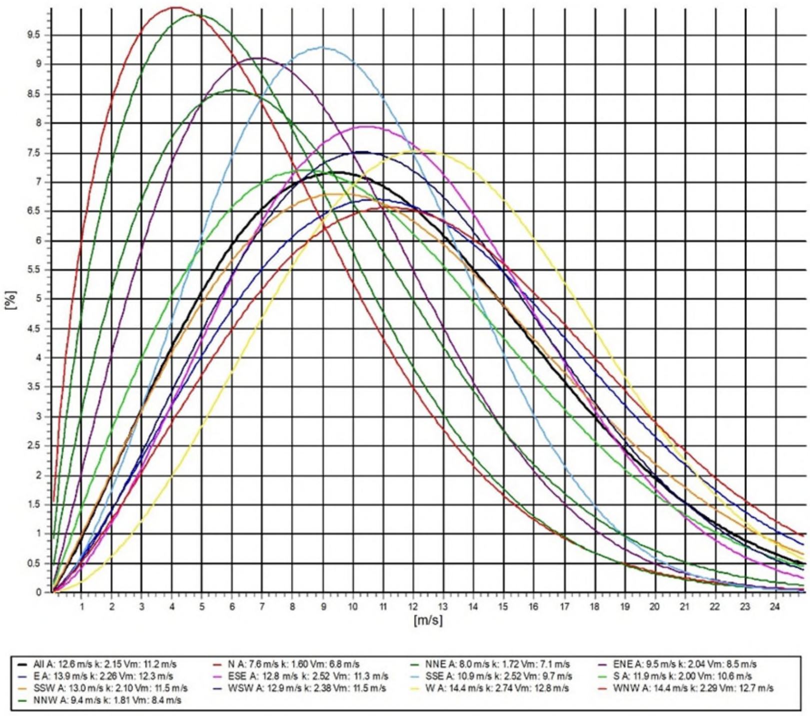
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **260.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.63	1.600	3.25	6.84
1-NNE	7.98	1.719	2.76	7.11
2-ENE	9.54	2.042	5.53	8.45
3-E	13.93	2.258	10.55	12.34
4-ESE	12.78	2.519	8.14	11.35
5-SSE	10.93	2.519	7.14	9.70
6-S	11.91	1.998	7.50	10.55
7-SSW	13.01	2.095	12.06	11.52
8-WSW	12.95	2.382	12.64	11.48
9-W	14.44	2.740	17.78	12.85
10-WNW	14.39	2.295	8.73	12.75
11-NNW	9.43	1.815	3.91	8.39
Mean	**12.60**	**2.154**	**100.00**	**11.16**



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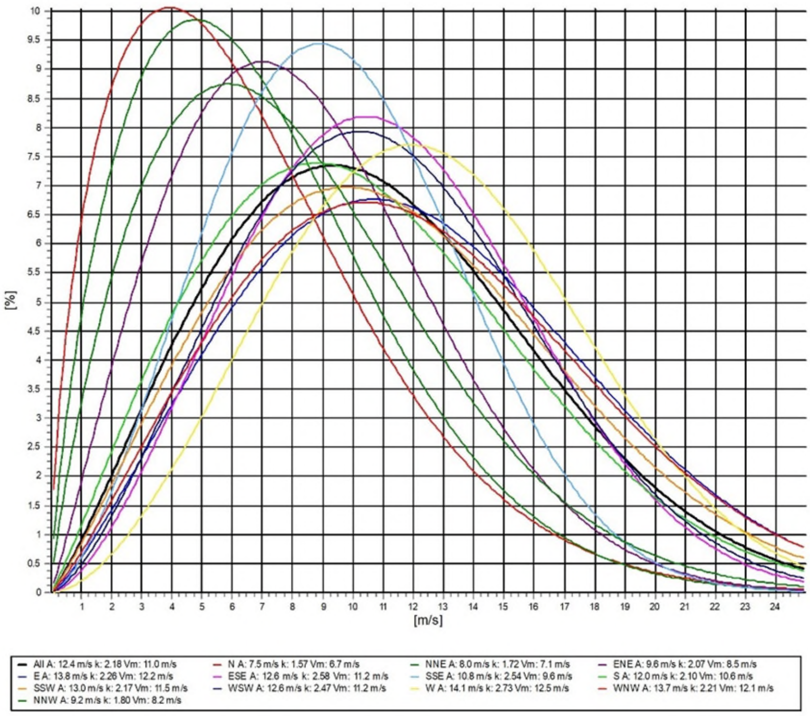
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **220.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.51	1.570	3.22	6.75
1-NNE	7.97	1.717	2.79	7.11
2-ENE	9.62	2.072	5.64	8.52
3-E	13.82	2.263	10.63	12.24
4-ESE	12.63	2.575	8.16	11.21
5-SSE	10.83	2.540	7.29	9.61
6-S	11.98	2.096	7.64	10.61
7-SSW	12.99	2.168	12.24	11.51
8-WSW	12.61	2.470	12.66	11.18
9-W	14.10	2.733	17.47	12.55
10-WNW	13.67	2.206	8.55	12.10
11-NNW	9.21	1.803	3.72	8.19
Mean	**12.40**	**2.184**	**100.00**	**10.98**



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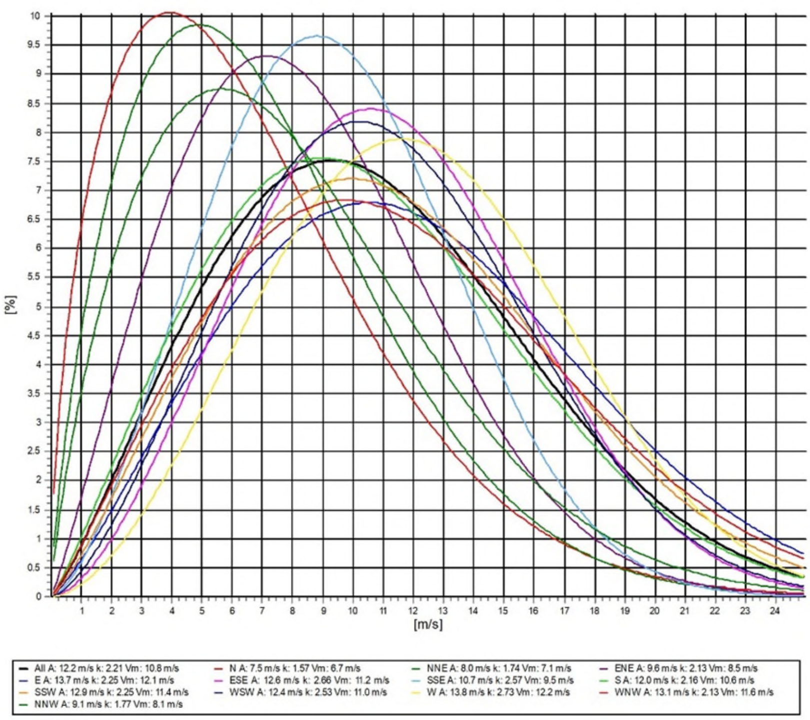
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **190.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.51	1.569	3.20	6.74
1-NNE	8.01	1.736	2.78	7.14
2-ENE	9.62	2.134	5.76	8.52
3-E	13.70	2.246	10.72	12.13
4-ESE	12.63	2.658	8.23	11.23
5-SSE	10.68	2.568	7.42	9.48
6-S	11.96	2.160	7.84	10.59
7-SSW	12.92	2.247	12.29	11.44
8-WSW	12.45	2.527	12.77	11.05
9-W	13.76	2.731	17.02	12.24
10-WNW	13.11	2.132	8.40	11.61
11-NNW	9.10	1.765	3.57	8.10
Mean	**12.23**	**2.210**	**100.00**	**10.83**



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Calculated:
28/06/2024 09.09

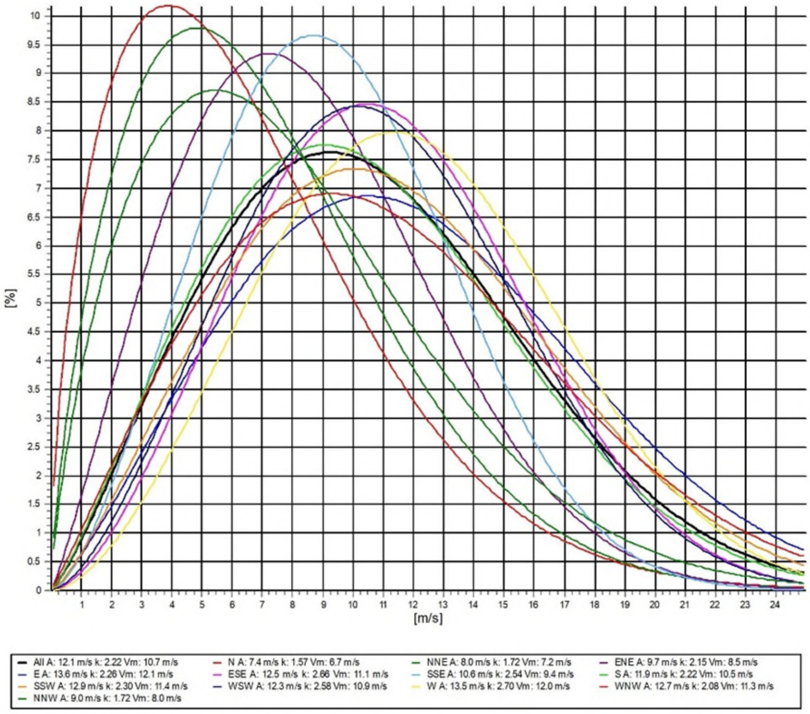
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **170.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.42	1.570	3.17	6.67
1-NNE	8.02	1.718	2.77	7.15
2-ENE	9.65	2.152	5.75	8.55
3-E	13.62	2.263	10.92	12.07
4-ESE	12.52	2.657	8.15	11.13
5-SSE	10.58	2.541	7.58	9.39
6-S	11.88	2.216	8.03	10.52
7-SSW	12.90	2.301	12.34	11.43
8-WSW	12.28	2.579	12.79	10.90
9-W	13.48	2.703	16.72	11.99
10-WNW	12.74	2.080	8.34	11.29
11-NNW	9.03	1.723	3.46	8.05
Mean	**12.09**	**2.221**	**100.00**	**10.71**



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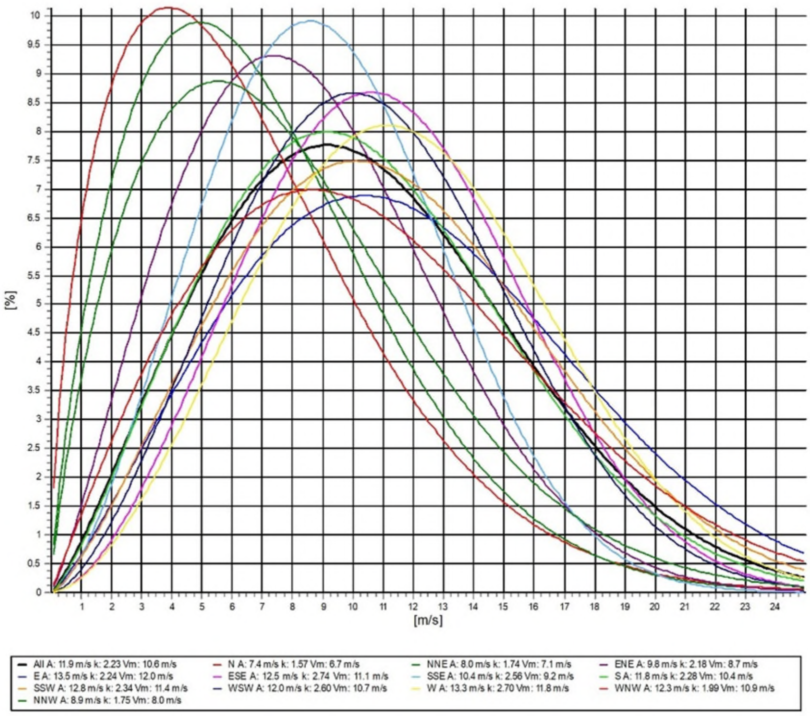
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **150.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.45	1.569	3.15	6.69
1-NNE	8.00	1.743	2.76	7.13
2-ENE	9.78	2.183	5.85	8.66
3-E	13.50	2.244	10.97	11.96
4-ESE	12.52	2.735	8.15	11.14
5-SSE	10.39	2.563	7.73	9.23
6-S	11.78	2.281	8.21	10.43
7-SSW	12.81	2.339	12.40	11.35
8-WSW	12.04	2.601	12.82	10.69
9-W	13.26	2.699	16.41	11.79
10-WNW	12.25	1.994	8.18	10.86
11-NNW	8.94	1.751	3.37	7.97
Mean	**11.94**	**2.234**	**100.00**	**10.57**



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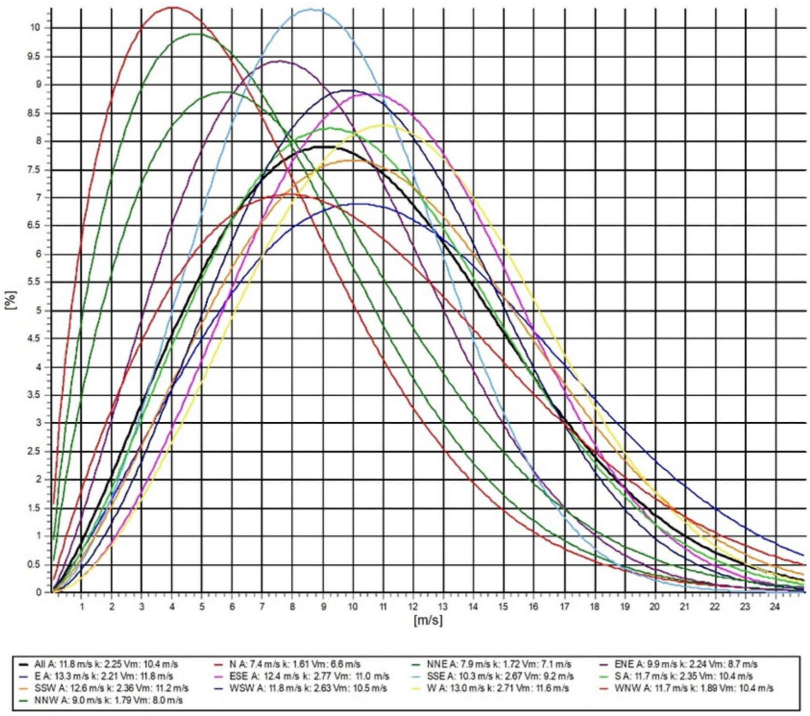
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **130.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.36	1.611	3.10	6.59
1-NNE	7.93	1.719	2.81	7.07
2-ENE	9.86	2.244	5.84	8.74
3-E	13.34	2.212	11.05	11.82
4-ESE	12.41	2.768	8.14	11.04
5-SSE	10.30	2.668	8.04	9.15
6-S	11.70	2.352	8.20	10.37
7-SSW	12.59	2.358	12.73	11.16
8-WSW	11.82	2.632	12.63	10.50
9-W	13.04	2.714	16.11	11.60
10-WNW	11.72	1.889	8.10	10.41
11-NNW	9.03	1.787	3.26	8.04
Mean	**11.77**	**2.246**	**100.00**	**10.42**



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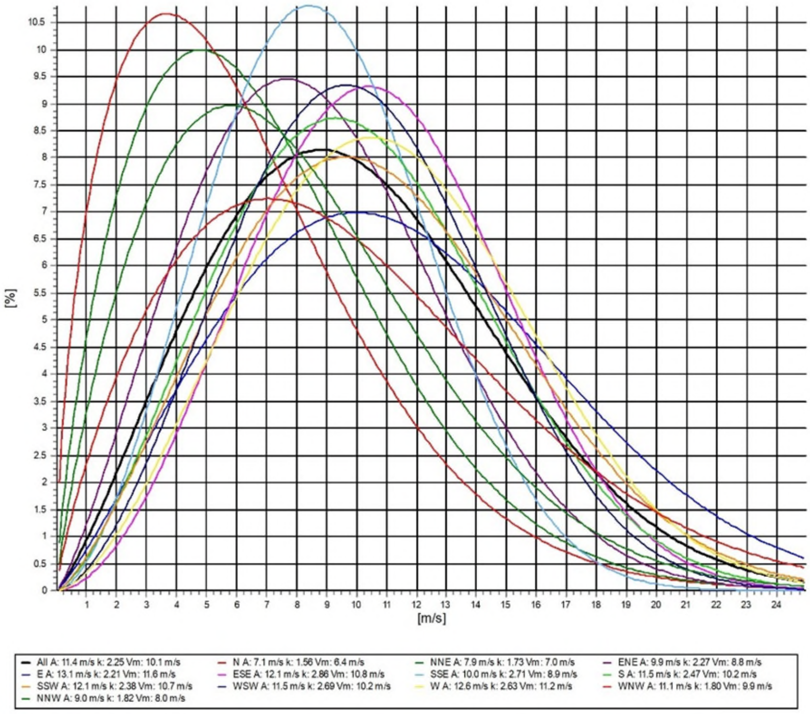
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **100.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.08	1.564	2.97	6.36
1-NNE	7.90	1.735	2.86	7.04
2-ENE	9.92	2.273	5.95	8.79
3-E	13.13	2.206	11.21	11.63
4-ESE	12.09	2.856	8.18	10.78
5-SSE	9.98	2.712	8.28	8.87
6-S	11.47	2.474	8.36	10.17
7-SSW	12.13	2.381	12.99	10.75
8-WSW	11.47	2.690	12.53	10.20
9-W	12.57	2.632	15.53	11.17
10-WNW	11.10	1.797	7.94	9.87
11-NNW	9.02	1.815	3.20	8.02
Mean	**11.44**	**2.253**	**100.00**	**10.13**



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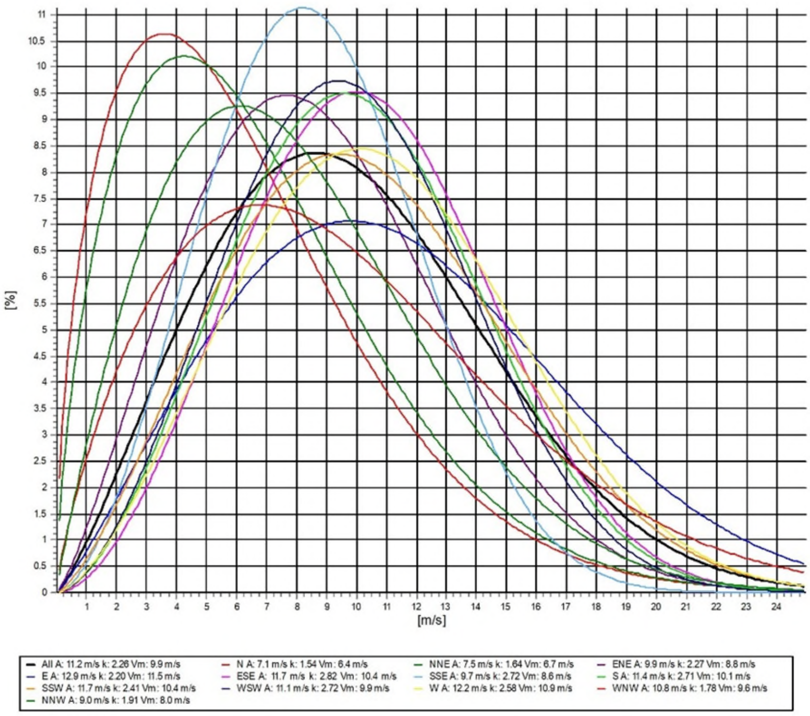
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **80.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.06	1.540	2.89	6.36
1-NNE	7.53	1.640	3.00	6.74
2-ENE	9.91	2.271	5.92	8.78
3-E	12.94	2.198	11.34	11.46
4-ESE	11.68	2.816	8.35	10.40
5-SSE	9.72	2.720	8.30	8.64
6-S	11.36	2.712	8.94	10.10
7-SSW	11.75	2.407	12.83	10.41
8-WSW	11.11	2.721	12.47	9.88
9-W	12.24	2.575	15.26	10.87
10-WNW	10.83	1.776	7.56	9.64
11-NNW	9.01	1.913	3.14	7.99
Mean	**11.18**	**2.263**	**100.00**	**9.90**



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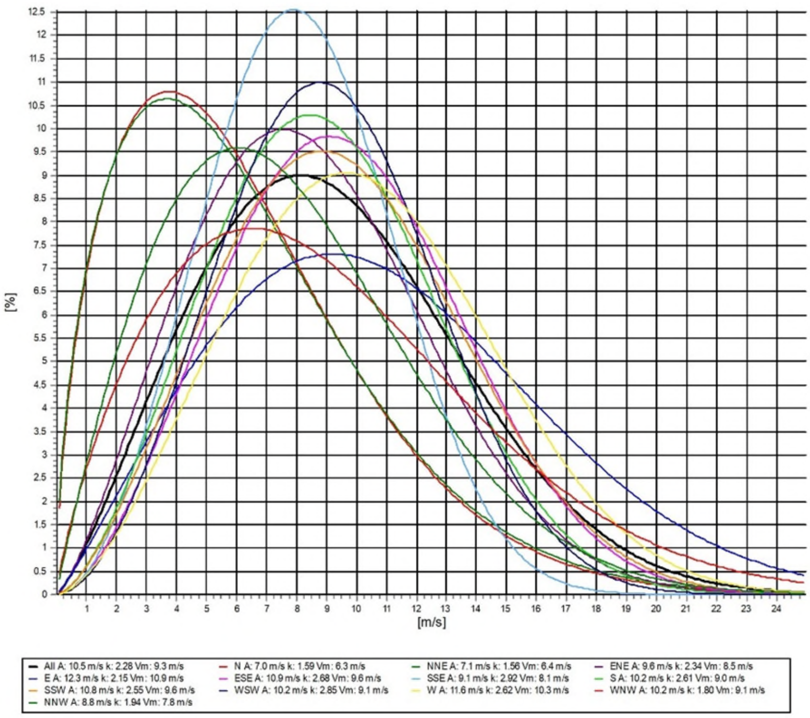
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **40.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.02	1.585	2.78	6.30
1-NNE	7.09	1.561	3.15	6.37
2-ENE	9.61	2.340	5.98	8.52
3-E	12.32	2.148	11.56	10.91
4-ESE	10.85	2.675	8.70	9.65
5-SSE	9.13	2.915	8.47	8.15
6-S	10.16	2.610	9.17	9.03
7-SSW	10.76	2.546	13.10	9.56
8-WSW	10.23	2.849	12.20	9.11
9-W	11.60	2.623	14.43	10.31
10-WNW	10.24	1.799	7.43	9.10
11-NNW	8.77	1.942	3.03	7.78
Mean	**10.46**	**2.281**	**100.00**	**9.27**



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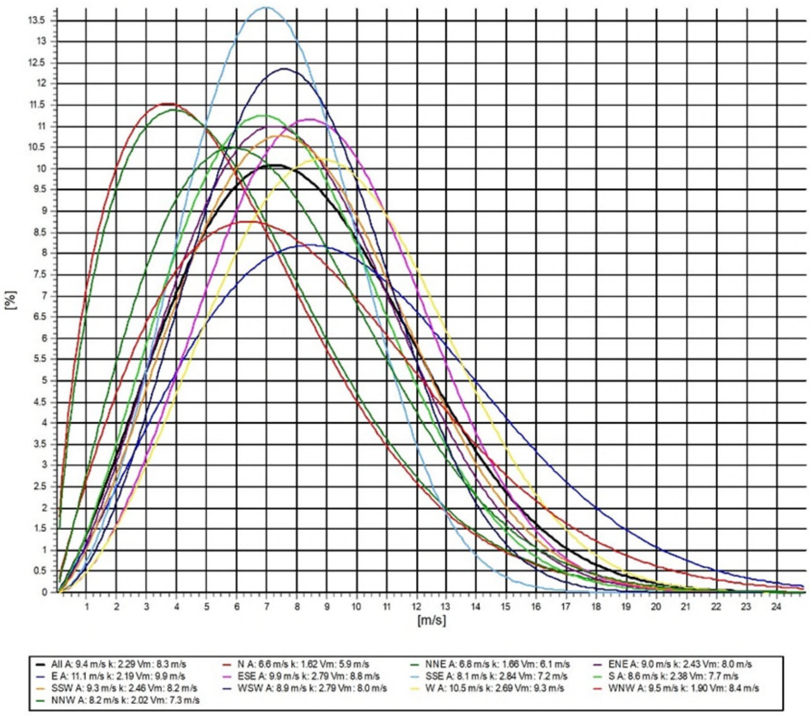
Meteo data report - Weibull data overview

Mast: KG-1 ST **Period:** Full period: 21/07/2023 - 21/03/2024 (8.0 months)

Height: **12.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.64	1.624	2.75	5.94
1-NNE	6.80	1.663	3.23	6.07
2-ENE	8.99	2.434	6.03	7.97
3-E	11.14	2.191	11.81	9.87
4-ESE	9.89	2.787	8.83	8.80
5-SSE	8.13	2.841	8.53	7.24
6-S	8.65	2.385	9.34	7.66
7-SSW	9.25	2.461	13.39	8.21
8-WSW	8.93	2.786	11.77	7.95
9-W	10.46	2.686	14.22	9.30
10-WNW	9.47	1.897	7.20	8.41
11-NNW	8.24	2.025	2.91	7.30
Mean	**9.36**	**2.290**	**100.00**	**8.29**



Appendix D. Long-term Corrected Dataset: KG-1-LB, KG-A and KG-B

Project:
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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

300.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.19	7.83	7.22	7.84	9.17	10.16	9.90	9.98	11.16	11.55	11.13	11.18	8.57
0		0.49	421	33	41	77	48	34	49	13	27	31	33	28	7
1	0.50	1.49	1764	192	202	194	92	101	103	150	122	137	154	137	180
2	1.50	2.49	5350	394	332	612	441	271	568	588	476	406	314	535	413
3	2.50	3.49	7741	503	446	607	668	557	704	860	806	681	535	696	678
4	3.50	4.49	10595	847	967	712	696	905	804	933	1073	1019	1087	745	807
5	4.50	5.49	12698	1264	947	771	626	1003	1184	1070	1053	1169	1667	1067	877
6	5.50	6.49	13546	1138	846	885	911	860	981	1075	1379	1144	1809	1556	962
7	6.50	7.49	13820	874	731	778	1024	1169	1124	1133	1490	1434	1765	1180	1118
8	7.50	8.49	13352	714	690	627	642	1181	1054	901	1579	1777	1716	1293	1178
9	8.50	9.49	13528	662	737	645	784	1310	1181	827	1380	1705	1832	1158	1307
10	9.50	10.49	13565	575	431	722	828	1056	1364	856	1354	1846	2409	1329	795
11	10.50	11.49	12483	522	257	530	596	847	1018	738	1337	2069	2478	1349	742
12	11.50	12.49	11684	456	308	465	727	957	990	634	1173	1698	2131	1602	543
13	12.50	13.49	11398	472	248	283	558	945	1190	849	1059	1697	1873	1716	508
14	13.50	14.49	10740	261	154	362	617	680	797	663	1460	1988	1926	1544	288
15	14.50	15.49	9553	174	118	226	482	590	884	738	1315	1709	1644	1312	361
16	15.50	16.49	7897	144	93	123	387	659	577	817	967	1498	1437	967	228
17	16.50	17.49	6328	77	52	112	258	592	433	468	979	1287	874	974	222
18	17.50	18.49	4691	48	37	91	185	373	365	356	930	1020	648	523	115
19	18.50	19.49	3693	53	49	62	105	384	253	307	510	644	727	522	77
20	19.50	20.49	2398	33	13	24	64	211	152	254	464	418	427	284	54
21	20.50	21.49	1821	33	9	17	33	117	152	148	242	314	377	322	57
22	21.50	22.49	1432	24	3	6	18	67	68	126	316	242	270	259	33
23	22.50	23.49	709	22	4	0	11	37	26	61	156	142	121	112	17
24	23.50	24.49	545	5	1	3	11	14	18	42	79	123	146	88	15
25	24.50	25.49	397	7	0	1	6	7	7	23	116	100	56	70	4
26	25.50	26.49	278	5	0	2	1	4	0	24	63	67	63	46	3
27	26.50	27.49	143	4	0	2	2	1	2	24	36	32	17	18	5
28	27.50	28.49	115	0	0	0	0	1	5	8	25	22	15	27	12
29	28.50	29.49	53	2	0	0	0	0	0	2	17	13	7	11	1
30	29.50	30.49	40	0	0	0	0	0	1	5	16	0	9	9	0
31	30.50	31.49	27	1	0	0	0	0	0	1	3	1	10	10	1
32	31.50	32.49	15	1	0	0	0	0	0	2	1	0	6	5	0
33	32.50	33.49	10	0	0	0	0	0	0	0	4	1	2	3	0
34	33.50	34.49	4	0	0	0	0	0	0	0	1	0	2	1	0
35	34.50	35.49	2	1	0	0	0	0	0	0	0	1	0	0	0
36	35.50	36.49	2	1	0	0	0	0	0	1	0	0	0	0	0
37	36.50	37.49	2	0	0	0	0	0	0	0	0	1	1	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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25/06/2024 18.37

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

260.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.05	7.69	7.18	7.89	9.09	10.08	9.91	9.68	11.21	11.35	10.92	10.83	8.37
0		0.49	371	10	34	95	33	28	48	52	11	24	9	12	15
1	0.50	1.49	1823	206	177	203	204	77	96	152	111	106	164	152	175
2	1.50	2.49	5274	446	426	560	417	233	518	692	452	400	311	470	349
3	2.50	3.49	7862	453	514	621	553	624	785	947	818	572	544	829	602
4	3.50	4.49	11173	830	1025	724	710	879	814	1113	1169	1096	1190	824	799
5	4.50	5.49	12788	1361	903	676	772	988	1140	1114	996	1291	1640	1043	864
6	5.50	6.49	13472	1066	987	860	927	896	980	1058	1350	1206	1664	1550	928
7	6.50	7.49	13693	964	680	769	964	1263	1036	1074	1515	1325	1850	1080	1173
8	7.50	8.49	14124	758	712	654	686	1303	1210	1024	1535	1759	1727	1327	1429
9	8.50	9.49	13693	589	732	673	878	1265	1093	844	1401	1877	1981	1315	1045
10	9.50	10.49	13656	557	463	720	800	1124	1248	801	1289	1852	2403	1400	999
11	10.50	11.49	12639	590	287	527	668	814	1213	775	1242	2226	2332	1382	583
12	11.50	12.49	12272	397	290	489	724	933	1210	700	1296	1876	2179	1686	492
13	12.50	13.49	11847	426	287	316	616	905	1153	829	1200	1877	2082	1686	470
14	13.50	14.49	10592	276	160	304	484	652	872	728	1612	1934	1904	1347	319
15	14.50	15.49	9355	139	147	279	562	759	815	824	1212	1709	1537	1165	207
16	15.50	16.49	7673	124	91	142	343	637	617	672	992	1561	1269	1028	197
17	16.50	17.49	5826	85	56	109	197	552	463	479	1180	1081	740	695	189
18	17.50	18.49	4684	55	64	81	162	395	371	317	846	936	778	578	101
19	18.50	19.49	3112	39	24	49	144	372	295	291	456	559	501	342	40
20	19.50	20.49	2226	27	13	23	68	174	154	201	429	365	406	320	46
21	20.50	21.49	1663	15	3	14	28	98	80	173	277	314	351	266	44
22	21.50	22.49	1167	15	4	4	23	61	44	115	280	246	171	173	31
23	22.50	23.49	666	15	3	3	17	20	14	61	234	94	109	80	16
24	23.50	24.49	505	11	1	2	7	9	13	40	125	85	116	91	5
25	24.50	25.49	250	5	0	0	6	5	9	21	83	49	38	33	1
26	25.50	26.49	161	5	0	2	2	1	2	20	54	29	22	20	4
27	26.50	27.49	98	6	0	0	0	0	0	15	14	13	17	24	9
28	27.50	28.49	62	1	0	1	1	0	2	8	13	6	10	17	3
29	28.50	29.49	43	1	0	0	0	0	0	4	15	5	9	8	1
30	29.50	30.49	28	0	0	0	0	0	0	0	4	3	12	9	0
31	30.50	31.49	13	0	0	0	0	0	0	0	5	0	4	4	0
32	31.50	32.49	12	0	0	0	0	0	1	0	4	1	2	3	1
33	32.50	33.49	4	0	0	0	0	0	0	0	1	0	3	0	0
34	33.50	34.49	10	1	0	0	0	0	0	1	7	1	0	0	0
35	34.50	35.49	1	0	0	0	0	0	0	0	0	1	0	0	0
36	35.50	36.49	2	1	0	0	0	0	0	0	1	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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25/06/2024 18.37

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

220.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.87	7.60	7.08	7.88	9.08	9.92	9.84	9.59	11.12	11.09	10.56	10.46	8.18
0		0.49	378	14	13	23	44	74	64	56	18	22	11	21	18
1	0.50	1.49	1877	197	209	221	171	108	110	178	80	90	203	155	155
2	1.50	2.49	5364	476	504	615	428	266	498	583	431	362	347	525	329
3	2.50	3.49	8332	572	506	565	549	652	824	985	824	624	620	937	674
4	3.50	4.49	10880	769	1048	760	707	890	858	1061	1140	1011	1213	677	746
5	4.50	5.49	12837	1344	881	700	763	969	1028	1030	1152	1355	1698	1050	867
6	5.50	6.49	13727	1022	870	885	878	977	1004	1153	1472	1158	1850	1466	992
7	6.50	7.49	14027	871	713	761	990	1324	1019	1089	1538	1416	1807	1263	1236
8	7.50	8.49	14595	677	771	682	721	1297	1435	1100	1545	1693	1855	1487	1332
9	8.50	9.49	14358	576	705	739	864	1292	1152	855	1557	2053	2122	1383	1060
10	9.50	10.49	14233	710	512	754	873	1048	1134	848	1412	2052	2558	1508	824
11	10.50	11.49	12593	505	273	534	658	843	1124	809	1371	2378	2235	1277	586
12	11.50	12.49	12469	413	280	436	688	1001	1292	833	1295	1794	2243	1740	454
13	12.50	13.49	12458	433	234	386	599	989	1256	903	1278	2107	2174	1688	411
14	13.50	14.49	10041	253	169	286	553	687	897	739	1740	1775	1603	1059	280
15	14.50	15.49	9279	121	127	255	534	762	789	840	1287	1715	1487	1179	183
16	15.50	16.49	7040	118	86	142	339	623	594	528	1069	1494	1040	816	191
17	16.50	17.49	5334	70	44	75	170	510	480	441	1156	1041	659	578	110
18	17.50	18.49	4605	47	62	95	211	446	378	379	853	773	753	493	115
19	18.50	19.49	2657	46	25	50	86	278	242	275	517	415	380	294	49
20	19.50	20.49	2160	28	17	19	64	190	137	157	438	337	392	320	61
21	20.50	21.49	1304	20	4	10	39	88	52	130	355	203	180	190	33
22	21.50	22.49	913	19	2	6	18	32	57	89	262	129	150	127	22
23	22.50	23.49	550	12	4	2	14	11	16	42	147	86	120	84	12
24	23.50	24.49	351	9	0	2	6	12	8	51	95	64	74	26	4
25	24.50	25.49	204	5	0	0	3	2	5	18	65	26	41	36	3
26	25.50	26.49	97	0	0	2	1	0	2	11	27	9	11	27	7
27	26.50	27.49	62	3	0	0	1	0	1	7	18	6	14	12	0
28	27.50	28.49	41	1	0	0	0	0	1	4	13	4	8	9	1
29	28.50	29.49	29	1	0	1	0	0	1	2	5	3	8	8	0
30	29.50	30.49	25	1	0	0	0	0	0	1	6	2	8	7	0
31	30.50	31.49	9	0	0	0	0	0	0	1	2	1	5	0	0
32	31.50	32.49	2	0	0	0	0	0	0	0	1	0	1	0	0
33	32.50	33.49	4	0	0	0	0	0	0	0	3	1	0	0	0
34	33.50	34.49	4	0	0	0	0	0	0	0	3	0	1	0	0
35	34.50	35.49	1	0	0	0	0	0	0	0	0	1	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

190.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.75	7.72	7.00	7.91	8.95	9.99	9.74	9.56	10.98	10.80	10.40	10.16	8.06
0		0.49	412	11	10	11	53	64	84	42	30	42	17	31	17
1	0.50	1.49	1996	192	205	203	196	104	154	216	119	113	144	212	138
2	1.50	2.49	5185	416	519	581	515	223	502	508	336	373	351	513	348
3	2.50	3.49	8470	515	530	635	581	623	781	1023	860	636	691	908	687
4	3.50	4.49	10806	816	972	766	642	836	888	1046	1252	1042	1149	643	754
5	4.50	5.49	12946	1364	917	754	770	921	1052	1012	1100	1348	1756	1078	874
6	5.50	6.49	13701	935	864	886	899	1000	1147	1258	1531	1181	1766	1327	907
7	6.50	7.49	14111	805	665	852	997	1219	904	1031	1599	1445	1770	1568	1256
8	7.50	8.49	15100	713	859	632	761	1374	1438	1131	1635	1881	1907	1576	1193
9	8.50	9.49	14738	629	605	747	929	1290	1309	902	1619	2100	2237	1489	882
10	9.50	10.49	14198	775	487	775	781	1028	1235	954	1402	2146	2510	1396	709
11	10.50	11.49	13732	514	322	564	759	1025	1258	806	1440	2478	2606	1318	642
12	11.50	12.49	13003	439	261	497	722	985	1230	956	1378	2155	2070	1918	392
13	12.50	13.49	12138	376	217	330	581	966	1215	921	1661	1906	2073	1459	433
14	13.50	14.49	9755	247	151	318	571	739	1071	760	1616	1553	1454	1074	201
15	14.50	15.49	9237	171	113	234	519	776	839	781	1311	1730	1519	1041	203
16	15.50	16.49	7061	118	75	170	283	674	689	574	1319	1428	880	683	168
17	16.50	17.49	5004	72	62	101	213	514	385	350	1068	911	664	534	130
18	17.50	18.49	4040	51	46	92	160	374	369	466	759	590	677	373	83
19	18.50	19.49	2752	43	19	44	102	306	183	250	654	409	389	317	36
20	19.50	20.49	1688	30	9	24	56	136	103	149	409	244	240	241	47
21	20.50	21.49	1074	17	4	8	35	83	59	122	254	139	177	139	37
22	21.50	22.49	663	19	4	1	14	25	30	62	149	101	145	102	11
23	22.50	23.49	416	13	2	6	8	11	5	59	96	58	97	49	12
24	23.50	24.49	262	5	0	1	4	7	4	24	96	45	36	32	8
25	24.50	25.49	134	6	0	0	5	2	2	10	36	24	22	25	2
26	25.50	26.49	77	6	0	1	2	1	0	15	13	6	14	13	6
27	26.50	27.49	56	3	0	0	0	0	0	3	17	5	19	8	1
28	27.50	28.49	40	2	0	0	0	0	0	2	10	4	12	9	1
29	28.50	29.49	25	0	0	1	0	0	0	4	10	0	7	3	0
30	29.50	30.49	10	1	0	0	0	0	0	1	2	1	4	0	1
31	30.50	31.49	2	0	0	0	0	0	0	0	0	0	2	0	0
32	31.50	32.49	3	0	0	0	0	0	0	0	2	0	1	0	0
33	32.50	33.49	4	0	0	0	0	0	0	0	4	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	1	0	0	0	0	0	0	0	0	1	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

170.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.67	7.58	7.08	7.81	9.00	9.96	9.63	9.52	10.96	10.75	10.34	9.94	8.02
0		0.49	349	1	15	39	65	32	53	58	18	12	12	28	16
1	0.50	1.49	2037	183	240	223	176	103	178	175	139	185	152	176	107
2	1.50	2.49	5328	438	588	587	432	231	522	617	350	349	411	467	336
3	2.50	3.49	8492	537	551	684	574	598	789	1095	804	568	713	916	663
4	3.50	4.49	10634	880	1055	771	638	887	923	894	1101	862	1175	730	718
5	4.50	5.49	12826	1290	852	653	814	847	1142	1040	1299	1322	1567	1117	883
6	5.50	6.49	13587	938	911	924	976	952	1041	1260	1286	1166	1801	1352	980
7	6.50	7.49	14914	881	864	816	1091	1379	1059	1165	1649	1603	1741	1494	1172
8	7.50	8.49	15457	803	838	691	765	1280	1320	1117	1738	1980	2071	1636	1218
9	8.50	9.49	15053	559	706	778	868	1271	1307	871	1666	2166	2245	1706	910
10	9.50	10.49	14050	646	601	853	869	926	1098	985	1452	2280	2518	1174	648
11	10.50	11.49	13163	444	369	601	656	897	1167	1048	1383	2042	2468	1531	557
12	11.50	12.49	13616	444	381	512	835	1066	1425	901	1612	2367	2038	1552	483
13	12.50	13.49	12471	335	243	366	707	1121	1418	955	1550	1936	2016	1436	388
14	13.50	14.49	10187	218	207	269	552	787	913	860	1657	1640	1677	1158	249
15	14.50	15.49	8647	184	113	199	494	695	822	671	1455	1684	1393	772	165
16	15.50	16.49	6935	129	52	131	314	639	586	485	1346	1400	994	691	168
17	16.50	17.49	5034	81	57	128	199	580	421	452	990	816	764	449	97
18	17.50	18.49	3566	64	55	69	144	292	307	375	789	597	501	315	58
19	18.50	19.49	2495	35	14	33	127	221	164	237	623	383	372	252	34
20	19.50	20.49	1630	17	5	16	50	160	87	182	425	212	229	200	47
21	20.50	21.49	902	26	3	7	21	67	49	112	200	104	164	118	31
22	21.50	22.49	561	18	3	5	17	25	16	75	90	85	127	83	17
23	22.50	23.49	373	5	2	2	6	15	10	68	119	29	73	39	5
24	23.50	24.49	246	6	0	2	6	3	8	26	95	28	35	31	6
25	24.50	25.49	113	2	0	0	0	5	1	15	23	16	19	24	8
26	25.50	26.49	75	0	1	2	3	0	0	10	13	12	15	16	3
27	26.50	27.49	50	0	0	0	0	1	0	6	15	3	13	12	0
28	27.50	28.49	26	0	0	0	1	0	0	2	3	4	7	9	0
29	28.50	29.49	12	0	0	0	0	0	0	0	0	2	7	3	0
30	29.50	30.49	7	0	0	0	0	0	0	1	0	0	4	2	0
31	30.50	31.49	2	0	0	0	0	0	0	0	0	0	2	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	1	0	0	0	0	0	0	0	0	1	0	0	0
35	34.50	35.49	1	0	0	0	0	0	0	0	0	1	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP LT - EMD WFR - [Matrix]

Bin Mean	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1.50	2.49	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2.50	3.49	0	0	0	0	0	0	0	0	0	0	0	0	0
4	3.50	4.49	0	0	0	0	0	0	0	0	0	0	0	0	0
5	4.50	5.49	0	0	0	0	0	0	0	0	0	0	0	0	0
6	5.50	6.49	0	0	0	0	0	0	0	0	0	0	0	0	0
7	6.50	7.49	0	0	0	0	0	0	0	0	0	0	0	0	0
8	7.50	8.49	0	0	0	0	0	0	0	0	0	0	0	0	0
9	8.50	9.49	0	0	0	0	0	0	0	0	0	0	0	0	0
10	9.50	10.49	0	0	0	0	0	0	0	0	0	0	0	0	0
11	10.50	11.49	0	0	0	0	0	0	0	0	0	0	0	0	0
12	11.50	12.49	0	0	0	0	0	0	0	0	0	0	0	0	0
13	12.50	13.49	0	0	0	0	0	0	0	0	0	0	0	0	0
14	13.50	14.49	0	0	0	0	0	0	0	0	0	0	0	0	0
15	14.50	15.49	0	0	0	0	0	0	0	0	0	0	0	0	0
16	15.50	16.49	0	0	0	0	0	0	0	0	0	0	0	0	0
17	16.50	17.49	0	0	0	0	0	0	0	0	0	0	0	0	0
18	17.50	18.49	0	0	0	0	0	0	0	0	0	0	0	0	0
19	18.50	19.49	0	0	0	0	0	0	0	0	0	0	0	0	0
20	19.50	20.49	0	0	0	0	0	0	0	0	0	0	0	0	0
21	20.50	21.49	0	0	0	0	0	0	0	0	0	0	0	0	0
22	21.50	22.49	0	0	0	0	0	0	0	0	0	0	0	0	0
23	22.50	23.49	0	0	0	0	0	0	0	0	0	0	0	0	0
24	23.50	24.49	0	0	0	0	0	0	0	0	0	0	0	0	0
25	24.50	25.49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25.50	26.49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26.50	27.49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

130.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.47	7.72	6.89	7.82	8.92	9.80	9.32	9.43	10.79	10.41	10.01	9.60	7.87
0		0.49	546	10	52	49	78	38	39	73	93	44	22	21	27
1	0.50	1.49	2095	195	284	157	119	133	263	154	150	177	190	205	68
2	1.50	2.49	5654	432	458	627	457	287	497	743	520	442	472	446	273
3	2.50	3.49	8021	493	691	626	565	482	794	822	651	597	760	896	644
4	3.50	4.49	10628	961	1085	665	659	819	1103	970	967	813	1125	791	670
5	4.50	5.49	13373	1368	843	764	855	1037	1190	1129	1345	1179	1646	1135	882
6	5.50	6.49	13504	946	879	842	873	1007	995	1371	1409	1261	1683	1358	880
7	6.50	7.49	14976	911	862	965	1169	1123	1188	1049	1597	1674	1755	1542	1141
8	7.50	8.49	16315	679	783	742	1008	1512	1187	1206	1840	2342	2413	1835	768
9	8.50	9.49	15917	836	870	777	934	1275	1435	1119	1712	2163	2294	1512	990
10	9.50	10.49	15213	792	624	851	926	1049	1182	1100	1465	2273	2537	1448	966
11	10.50	11.49	13666	610	357	827	685	773	1108	980	1588	2292	2577	1487	382
12	11.50	12.49	13679	607	269	408	696	1331	1687	1115	1665	2278	1967	1293	363
13	12.50	13.49	12340	432	184	329	732	1202	1278	1034	2096	1843	1840	1147	223
14	13.50	14.49	9997	242	137	225	649	919	965	878	1556	1657	1639	924	206
15	14.50	15.49	8395	167	106	223	390	531	666	739	1759	1711	1277	710	116
16	15.50	16.49	6377	114	58	124	396	707	461	533	1350	1090	878	557	109
17	16.50	17.49	4470	80	52	92	169	456	418	452	1039	694	535	376	107
18	17.50	18.49	2972	46	54	85	142	231	183	323	648	391	440	345	84
19	18.50	19.49	1948	35	11	21	85	175	134	200	467	252	266	258	44
20	19.50	20.49	902	19	7	7	34	79	53	88	184	132	149	125	25
21	20.50	21.49	779	16	5	4	20	49	29	91	199	83	161	101	21
22	21.50	22.49	522	6	1	5	14	25	10	78	195	53	77	45	13
23	22.50	23.49	221	5	5	2	7	11	5	33	59	25	38	25	6
24	23.50	24.49	142	3	0	4	4	5	2	24	27	10	27	30	6
25	24.50	25.49	79	0	0	2	1	0	0	14	20	6	17	19	0
26	25.50	26.49	46	0	0	1	1	2	0	7	8	6	9	12	0
27	26.50	27.49	29	0	1	0	1	0	0	6	8	3	5	5	0
28	27.50	28.49	24	0	0	0	0	0	0	2	4	1	9	8	0
29	28.50	29.49	5	0	0	0	0	0	0	0	1	1	3	0	0
30	29.50	30.49	1	0	0	0	0	0	0	0	1	0	0	0	0
31	30.50	31.49	2	0	0	0	0	0	0	0	0	0	2	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	1	0	0	0
34	33.50	34.49	1	0	0	0	0	0	0	0	0	1	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

100.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.22	7.68	6.85	7.87	8.82	9.67	8.98	9.38	10.51	9.85	9.69	9.29	7.67
0		0.49	519	21	78	30	27	61	53	41	79	38	26	22	43
1	0.50	1.49	2164	162	230	250	155	175	246	125	161	222	138	159	141
2	1.50	2.49	5642	465	528	544	451	288	502	616	494	595	432	451	276
3	2.50	3.49	8036	533	618	590	655	484	699	799	666	646	844	856	646
4	3.50	4.49	11187	1011	1107	692	600	822	1287	1072	823	968	1210	916	679
5	4.50	5.49	13695	1333	824	592	963	1127	1336	1091	1404	1214	1648	1170	993
6	5.50	6.49	13961	948	866	994	931	971	1197	1191	1515	1289	1741	1472	846
7	6.50	7.49	15691	867	961	779	1157	1271	1320	1187	1692	1831	1844	1733	1049
8	7.50	8.49	16972	618	866	820	1128	1332	1291	1357	2059	2523	2571	1731	676
9	8.50	9.49	16620	880	1018	811	1008	1448	1302	970	1782	2553	2347	1558	943
10	9.50	10.49	15602	784	489	770	1026	1037	1195	1260	1760	2272	2790	1385	834
11	10.50	11.49	14841	624	403	844	722	1030	1516	1285	1773	2337	2508	1324	475
12	11.50	12.49	14074	518	272	493	669	1500	1604	1256	2121	2294	2074	1057	216
13	12.50	13.49	11716	488	162	329	723	1356	1232	945	1830	1558	1806	1081	206
14	13.50	14.49	9737	264	118	244	601	793	742	897	2130	1551	1432	789	176
15	14.50	15.49	7755	161	75	204	484	682	597	718	1724	1268	1071	628	143
16	15.50	16.49	5436	110	70	128	293	636	473	548	1124	833	636	466	119
17	16.50	17.49	3478	71	36	75	178	428	286	405	783	356	413	350	97
18	17.50	18.49	2304	44	54	63	133	160	120	208	507	312	296	314	93
19	18.50	19.49	1331	23	13	26	75	120	74	131	251	164	196	223	35
20	19.50	20.49	913	26	6	14	21	60	22	96	262	98	161	123	24
21	20.50	21.49	465	12	2	8	16	29	22	70	95	61	93	45	12
22	21.50	22.49	317	6	2	4	14	12	1	50	86	37	55	35	15
23	22.50	23.49	176	7	2	3	12	8	4	20	26	14	29	46	5
24	23.50	24.49	89	1	1	1	2	2	0	17	14	8	23	19	1
25	24.50	25.49	55	0	0	1	1	3	0	10	12	8	15	5	0
26	25.50	26.49	29	0	0	0	0	0	0	3	4	4	8	10	0
27	26.50	27.49	20	0	0	1	0	0	0	2	3	3	8	3	0
28	27.50	28.49	6	0	0	0	0	0	0	1	0	0	3	2	0
29	28.50	29.49	5	0	0	0	0	0	0	0	4	0	0	1	0
30	29.50	30.49	2	0	0	0	0	0	0	1	0	0	1	0	0
31	30.50	31.49	1	0	0	0	0	0	0	0	0	1	0	0	0
32	31.50	32.49	1	0	0	0	0	0	0	0	0	1	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

80.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.04	7.47	6.87	7.76	8.76	9.49	8.79	9.15	10.21	9.58	9.57	9.05	7.73
0		0.49	588	12	58	83	59	48	79	85	56	31	14	19	44
1	0.50	1.49	2380	174	259	265	172	183	197	242	216	314	133	132	93
2	1.50	2.49	5415	441	592	609	319	254	554	572	528	456	408	412	270
3	2.50	3.49	8078	538	635	562	514	460	689	879	693	705	878	893	632
4	3.50	4.49	11312	1052	1045	671	681	887	1214	1084	852	1000	1214	958	654
5	4.50	5.49	13414	1264	907	607	949	1176	1348	1054	1348	1065	1477	1301	918
6	5.50	6.49	14596	880	820	1020	1073	1157	1369	1348	1473	1451	1703	1523	779
7	6.50	7.49	16763	929	947	861	1097	1335	1333	1355	1989	2025	2066	1965	861
8	7.50	8.49	17731	765	1029	861	1331	1414	1332	1274	1976	2627	2485	1715	922
9	8.50	9.49	17478	787	932	928	1223	1332	1214	1026	2008	2627	2888	1513	1000
10	9.50	10.49	15920	755	454	916	929	1001	1332	1305	2106	2374	2495	1470	783
11	10.50	11.49	15195	652	416	762	766	1161	1764	1563	1858	2201	2353	1276	423
12	11.50	12.49	13861	500	282	450	722	1484	1338	1208	2223	2068	2322	994	270
13	12.50	13.49	11456	320	169	311	758	1306	978	1010	2186	1867	1589	797	165
14	13.50	14.49	10043	207	131	317	586	904	860	897	2381	1454	1329	812	165
15	14.50	15.49	6487	130	97	175	406	740	553	631	1448	858	794	517	138
16	15.50	16.49	4673	103	73	110	250	541	322	572	953	504	596	523	126
17	16.50	17.49	2906	53	67	86	132	238	226	253	596	407	439	329	80
18	17.50	18.49	1784	30	28	39	134	160	127	154	334	239	221	250	68
19	18.50	19.49	1189	31	11	24	54	92	36	140	177	133	237	206	48
20	19.50	20.49	743	15	11	8	27	55	26	110	163	63	173	74	18
21	20.50	21.49	298	2	4	4	12	15	10	67	58	33	42	40	11
22	21.50	22.49	234	6	3	6	15	14	6	40	37	23	25	44	15
23	22.50	23.49	139	4	2	0	4	3	0	18	17	13	34	33	11
24	23.50	24.49	72	1	0	2	10	2	0	11	5	8	18	13	2
25	24.50	25.49	41	0	0	3	1	0	0	7	6	3	13	8	0
26	25.50	26.49	32	0	0	0	0	0	0	5	11	2	9	5	0
27	26.50	27.49	4	0	0	1	0	0	0	0	0	0	2	1	0
28	27.50	28.49	2	0	0	0	0	0	0	0	0	0	1	1	0
29	28.50	29.49	3	0	0	0	0	0	0	0	1	0	1	1	0
30	29.50	30.49	3	0	0	0	0	0	0	0	0	2	0	1	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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25/06/2024 18.37

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

40.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			8.44	7.23	6.55	7.65	8.25	8.89	8.22	8.35	9.33	8.69	8.99	8.47	7.57
0		0.49	489	17	13	43	76	52	45	28	50	75	37	24	29
1	0.50	1.49	2533	173	288	247	215	160	288	241	195	270	156	118	182
2	1.50	2.49	5936	453	650	588	456	334	576	730	504	511	346	482	306
3	2.50	3.49	8794	538	736	574	596	640	758	969	773	782	878	929	621
4	3.50	4.49	12485	1118	1185	676	792	957	1221	1141	1110	1253	1371	1065	596
5	4.50	5.49	15160	1266	916	653	1047	1412	1590	1224	1432	1442	1595	1680	903
6	5.50	6.49	16516	936	1040	972	1235	1372	1569	1512	1762	1753	1948	1633	784
7	6.50	7.49	18893	909	968	1082	1467	1348	1340	1739	2409	2424	2297	1959	951
8	7.50	8.49	19888	814	933	970	1414	1562	1516	1471	2569	3099	2876	1709	955
9	8.50	9.49	18560	753	788	989	1166	1342	1606	1437	2539	2780	2705	1474	981
10	9.50	10.49	17624	602	457	892	870	1219	1925	1563	2625	2582	2850	1442	597
11	10.50	11.49	15413	531	314	625	731	1467	1391	1479	3344	2202	2060	968	301
12	11.50	12.49	13348	460	216	500	761	1266	1346	1270	2454	1810	1930	1006	329
13	12.50	13.49	9624	275	175	314	710	1077	822	894	1890	1048	1320	886	213
14	13.50	14.49	6336	174	116	255	502	746	577	612	1109	635	873	526	211
15	14.50	15.49	4218	139	48	143	298	562	330	401	655	448	541	470	183
16	15.50	16.49	2691	84	55	111	229	334	152	136	392	313	411	378	96
17	16.50	17.49	1727	34	93	65	125	157	69	120	357	214	227	208	58
18	17.50	18.49	1209	41	26	28	64	94	48	119	181	139	221	203	45
19	18.50	19.49	652	23	8	19	45	63	22	57	104	61	141	75	34
20	19.50	20.49	375	10	8	6	22	32	8	55	52	31	90	45	16
21	20.50	21.49	168	6	2	2	9	15	4	21	29	15	28	26	11
22	21.50	22.49	84	2	2	2	5	9	1	10	7	6	15	21	4
23	22.50	23.49	53	2	0	2	0	1	0	10	7	4	16	10	1
24	23.50	24.49	35	2	0	2	5	0	0	2	6	2	12	4	0
25	24.50	25.49	13	1	0	0	0	0	0	0	1	3	6	2	0
26	25.50	26.49	13	0	0	0	0	0	0	0	2	1	5	5	0
27	26.50	27.49	1	0	0	0	0	0	0	0	0	0	1	0	0
28	27.50	28.49	1	0	0	0	0	0	0	0	0	1	0	0	0
29	28.50	29.49	1	0	0	0	0	0	0	0	0	1	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

12.00m - MCP LT - EMD WFR - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			7.53	6.19	5.90	6.85	7.33	7.92	7.37	7.44	8.18	7.70	8.15	7.70	6.93
0		0.49	469	34	98	23	50	45	43	18	36	58	24	34	6
1	0.50	1.49	3215	328	409	223	320	239	286	311	196	347	259	211	86
2	1.50	2.49	6921	631	792	641	554	425	645	936	555	498	516	417	311
3	2.50	3.49	11651	1019	969	771	769	915	998	1114	1028	955	1329	1161	623
4	3.50	4.49	16898	1440	1341	1003	1090	1456	1598	1536	1532	1859	1608	1477	958
5	4.50	5.49	18333	1273	946	889	1515	1412	1762	1788	2190	1881	2050	1629	998
6	5.50	6.49	19867	887	1085	1267	1749	1273	1474	1898	2481	2615	2310	1966	862
7	6.50	7.49	22414	881	979	1226	1444	1604	2051	1957	3382	3153	2510	1925	1302
8	7.50	8.49	21560	622	729	909	1277	1681	1793	2008	3609	3239	3237	1643	813
9	8.50	9.49	18307	503	531	841	997	1438	1863	1836	2971	2432	2865	1413	617
10	9.50	10.49	16152	345	415	509	884	1525	1554	1489	2886	2458	2564	1189	334
11	10.50	11.49	12460	301	292	497	850	1132	1044	1245	2182	1509	2078	1028	302
12	11.50	12.49	9191	381	217	391	652	910	749	861	1545	759	1529	936	261
13	12.50	13.49	6188	250	125	231	427	723	544	706	937	674	853	454	264
14	13.50	14.49	3579	121	81	176	308	419	272	208	551	407	491	432	113
15	14.50	15.49	2629	77	93	115	201	270	151	205	331	339	389	351	107
16	15.50	16.49	1492	38	42	57	98	144	57	86	256	145	295	213	61
17	16.50	17.49	819	40	11	19	51	100	32	79	107	64	155	122	39
18	17.50	18.49	345	15	3	10	18	36	9	53	43	25	63	57	13
19	18.50	19.49	193	7	4	3	12	17	0	35	41	14	31	28	1
20	19.50	20.49	97	7	3	1	5	6	0	12	27	7	14	13	2
21	20.50	21.49	23	1	0	2	0	1	0	2	5	1	7	4	0
22	21.50	22.49	19	1	0	1	0	0	0	4	1	1	6	5	0
23	22.50	23.49	15	0	0	0	0	0	0	3	4	1	5	2	0
24	23.50	24.49	2	0	0	0	0	0	0	0	1	1	0	0	0
25	24.50	25.49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25.50	26.49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26.50	27.49	1	0	0	0	0	0	0	1	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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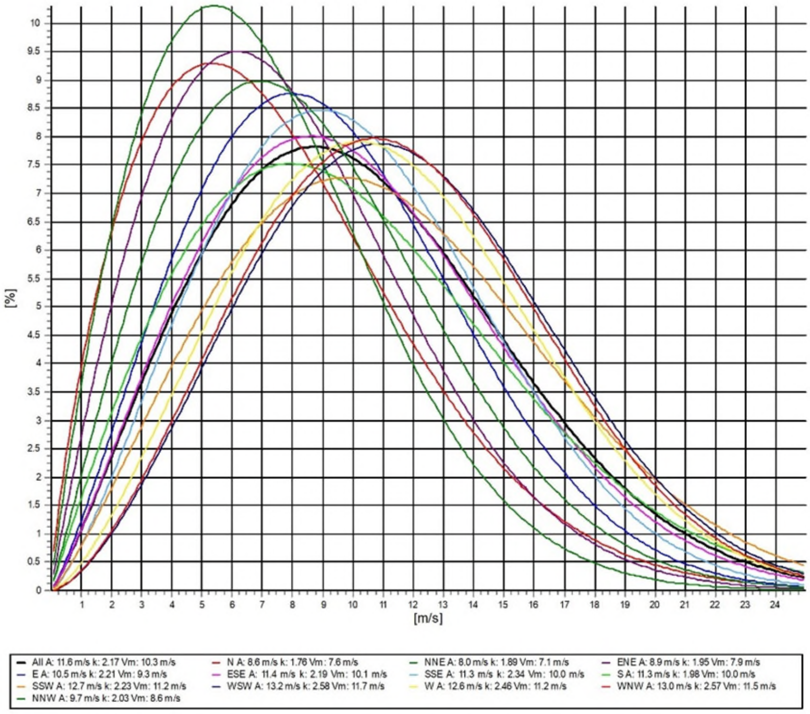
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **300.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.56	1.762	4.95	7.62
1-NNE	8.03	1.892	4.00	7.13
2-ENE	8.89	1.954	4.64	7.89
3-E	10.49	2.210	5.61	9.29
4-ESE	11.38	2.186	7.74	10.08
5-SSE	11.34	2.344	8.33	10.05
6-S	11.32	1.977	7.62	10.03
7-SSW	12.70	2.225	11.41	11.24
8-WSW	13.16	2.581	13.71	11.68
9-W	12.61	2.462	14.82	11.18
10-WNW	12.97	2.572	11.15	11.51
11-NNW	9.65	2.032	6.02	8.55
Mean	**11.60**	**2.171**	**100.00**	**10.27**



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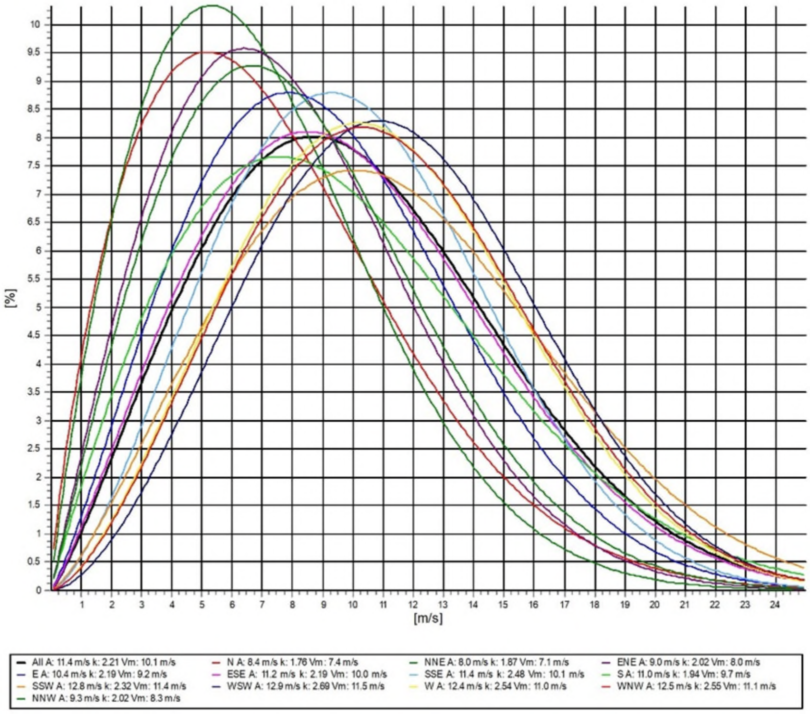
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **260.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.36	1.758	4.91	7.44
1-NNE	7.98	1.875	4.19	7.08
2-ENE	9.01	2.017	4.62	7.98
3-E	10.39	2.191	5.70	9.20
4-ESE	11.25	2.186	7.81	9.96
5-SSE	11.42	2.482	8.45	10.13
6-S	10.99	1.943	7.85	9.75
7-SSW	12.83	2.320	11.53	11.37
8-WSW	12.92	2.690	13.73	11.49
9-W	12.40	2.544	14.56	11.01
10-WNW	12.52	2.546	10.87	11.12
11-NNW	9.33	2.023	5.78	8.26
Mean	**11.44**	**2.205**	**100.00**	**10.13**



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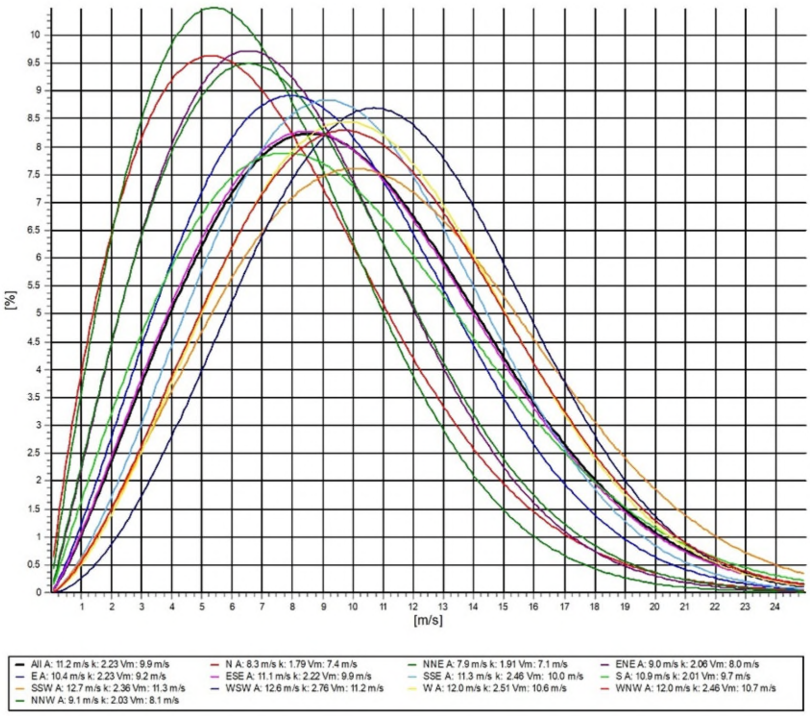
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **220.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.34	1.793	4.84	7.42
1-NNE	7.95	1.913	4.18	7.05
2-ENE	9.01	2.064	4.67	7.98
3-E	10.38	2.229	5.69	9.19
4-ESE	11.13	2.216	7.97	9.86
5-SSE	11.30	2.464	8.53	10.02
6-S	10.92	2.014	7.88	9.67
7-SSW	12.70	2.363	12.02	11.26
8-WSW	12.59	2.760	13.59	11.21
9-W	11.98	2.508	14.45	10.63
10-WNW	12.01	2.456	10.60	10.65
11-NNW	9.13	2.030	5.58	8.09
Mean	**11.23**	**2.228**	**100.00**	**9.95**



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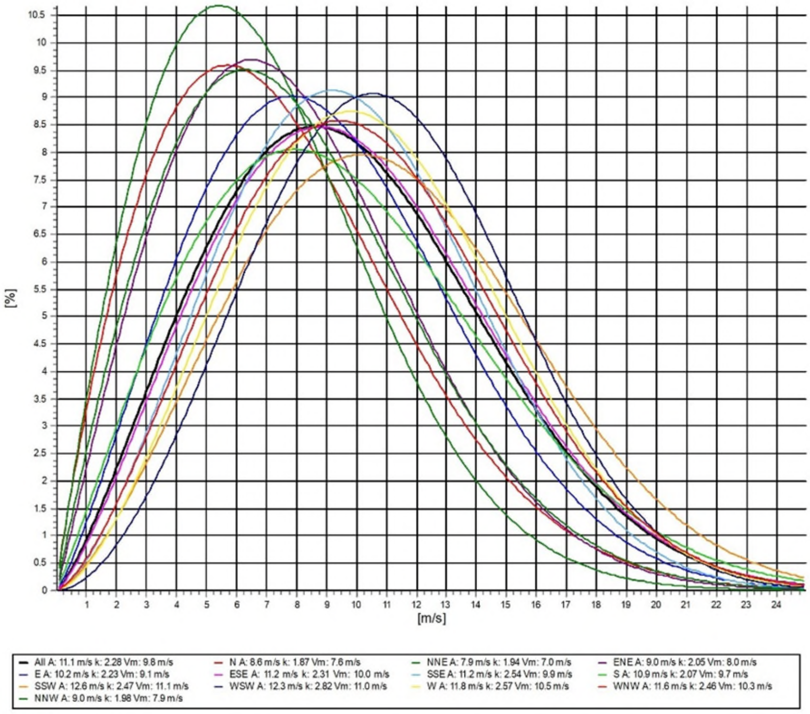
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **190.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.58	1.870	4.82	7.62
1-NNE	7.87	1.937	4.11	6.98
2-ENE	9.00	2.052	4.79	7.98
3-E	10.25	2.228	5.79	9.08
4-ESE	11.24	2.315	7.94	9.96
5-SSE	11.19	2.537	8.78	9.93
6-S	10.91	2.072	8.01	9.66
7-SSW	12.57	2.467	12.34	11.15
8-WSW	12.30	2.820	13.53	10.95
9-W	11.82	2.574	14.21	10.50
10-WNW	11.64	2.463	10.41	10.32
11-NNW	8.96	1.981	5.28	7.95
Mean	**11.11**	**2.283**	**100.00**	**9.84**



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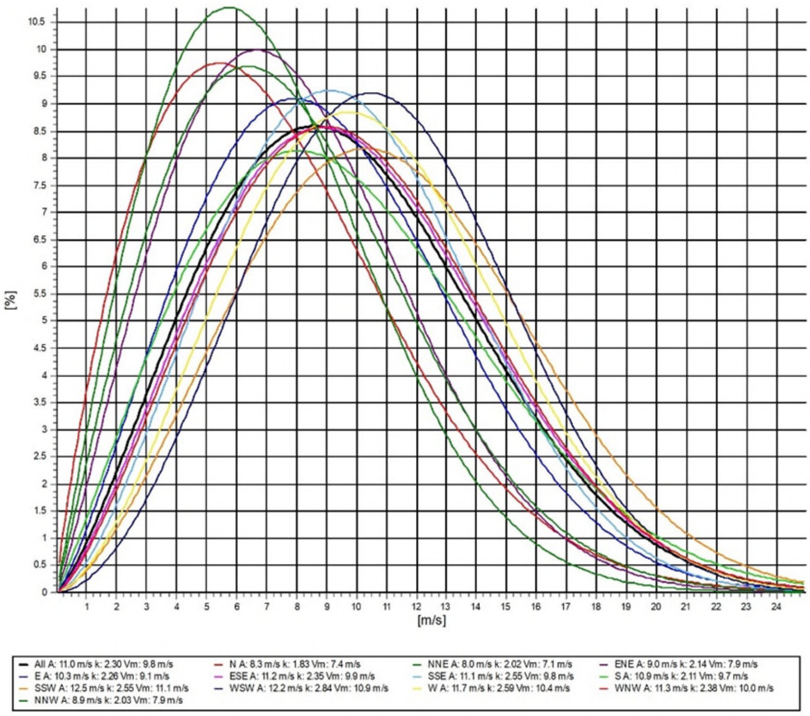
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **170.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.33	1.831	4.75	7.40
1-NNE	8.02	2.023	4.52	7.11
2-ENE	8.98	2.136	4.85	7.95
3-E	10.28	2.262	5.91	9.10
4-ESE	11.22	2.345	7.82	9.94
5-SSE	11.08	2.546	8.73	9.83
6-S	10.92	2.108	8.17	9.67
7-SSW	12.54	2.548	12.39	11.13
8-WSW	12.19	2.842	13.41	10.87
9-W	11.75	2.591	14.17	10.43
10-WNW	11.32	2.379	10.11	10.03
11-NNW	8.93	2.026	5.17	7.91
Mean	**11.02**	**2.301**	**100.00**	**9.76**



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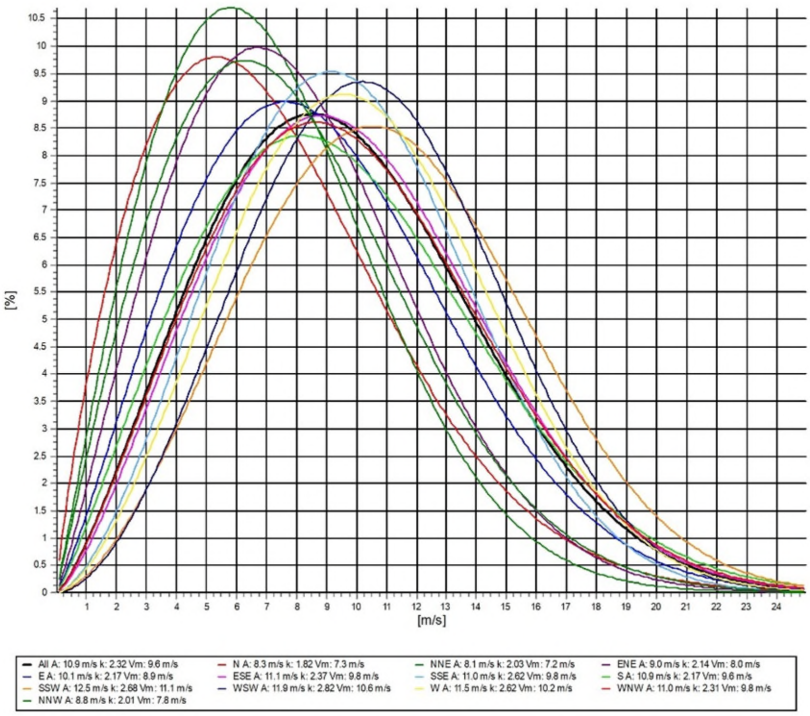
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.26	1.819	4.78	7.34
1-NNE	8.10	2.032	4.50	7.17
2-ENE	9.01	2.143	4.85	7.98
3-E	10.10	2.172	5.97	8.95
4-ESE	11.11	2.374	8.04	9.85
5-SSE	10.99	2.619	8.74	9.77
6-S	10.85	2.172	8.38	9.61
7-SSW	12.52	2.681	12.45	11.13
8-WSW	11.91	2.818	13.49	10.61
9-W	11.50	2.622	13.90	10.22
10-WNW	11.04	2.311	9.95	9.78
11-NNW	8.84	2.013	4.96	7.83
Mean	**10.88**	**2.322**	**100.00**	**9.64**



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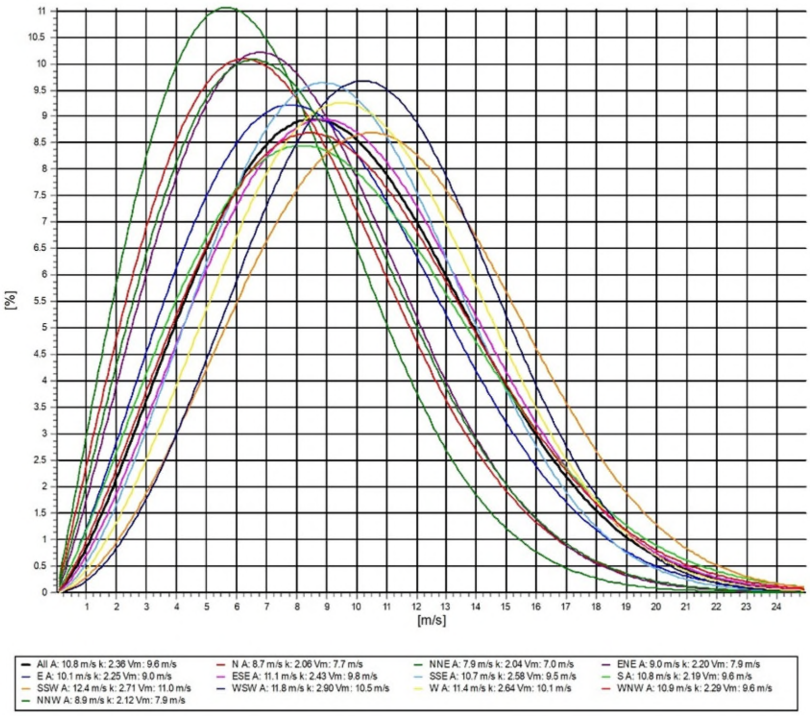
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **130.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.66	2.058	5.19	7.67
1-NNE	7.87	2.045	4.50	6.97
2-ENE	8.96	2.199	4.89	7.94
3-E	10.12	2.254	6.05	8.96
4-ESE	11.05	2.433	7.91	9.80
5-SSE	10.75	2.581	8.75	9.54
6-S	10.81	2.191	8.47	9.57
7-SSW	12.41	2.712	12.77	11.04
8-WSW	11.81	2.902	13.22	10.53
9-W	11.39	2.638	13.90	10.12
10-WNW	10.86	2.289	9.67	9.62
11-NNW	8.87	2.123	4.67	7.85
Mean	**10.80**	**2.364**	**100.00**	**9.57**



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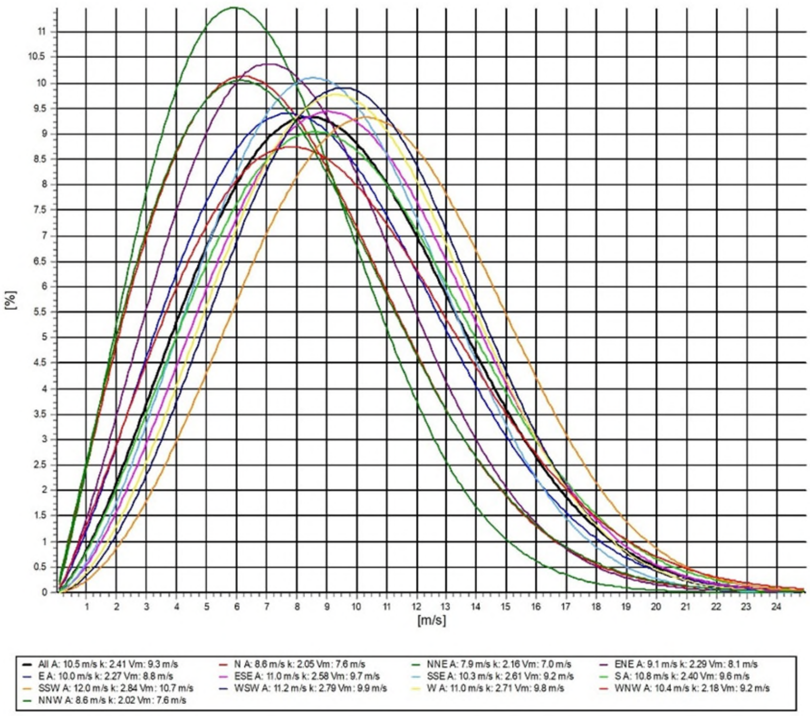
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **100.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.61	2.053	5.17	7.63
1-NNE	7.89	2.165	4.56	6.99
2-ENE	9.09	2.290	4.83	8.05
3-E	9.98	2.272	6.25	8.84
4-ESE	10.96	2.577	8.21	9.74
5-SSE	10.34	2.607	8.88	9.19
6-S	10.81	2.398	8.49	9.59
7-SSW	12.03	2.839	13.06	10.72
8-WSW	11.17	2.794	12.99	9.94
9-W	11.04	2.710	13.70	9.82
10-WNW	10.41	2.181	9.32	9.22
11-NNW	8.60	2.025	4.53	7.62
Mean	**10.52**	**2.413**	**100.00**	**9.32**



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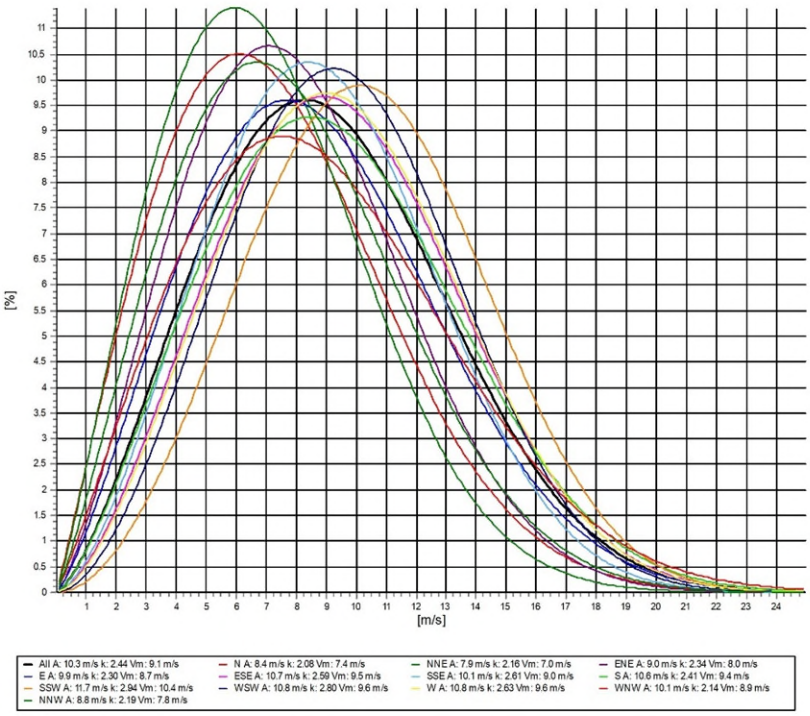
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **80.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.38	2.080	5.00	7.42
1-NNE	7.93	2.160	4.65	7.02
2-ENE	9.01	2.345	5.02	7.98
3-E	9.86	2.301	6.34	8.74
4-ESE	10.74	2.592	8.28	9.54
5-SSE	10.11	2.610	8.77	8.98
6-S	10.58	2.410	8.77	9.38
7-SSW	11.67	2.937	13.33	10.41
8-WSW	10.83	2.795	12.73	9.64
9-W	10.79	2.627	13.46	9.59
10-WNW	10.09	2.140	9.24	8.94
11-NNW	8.84	2.193	4.41	7.83
Mean	**10.29**	**2.435**	**100.00**	**9.13**



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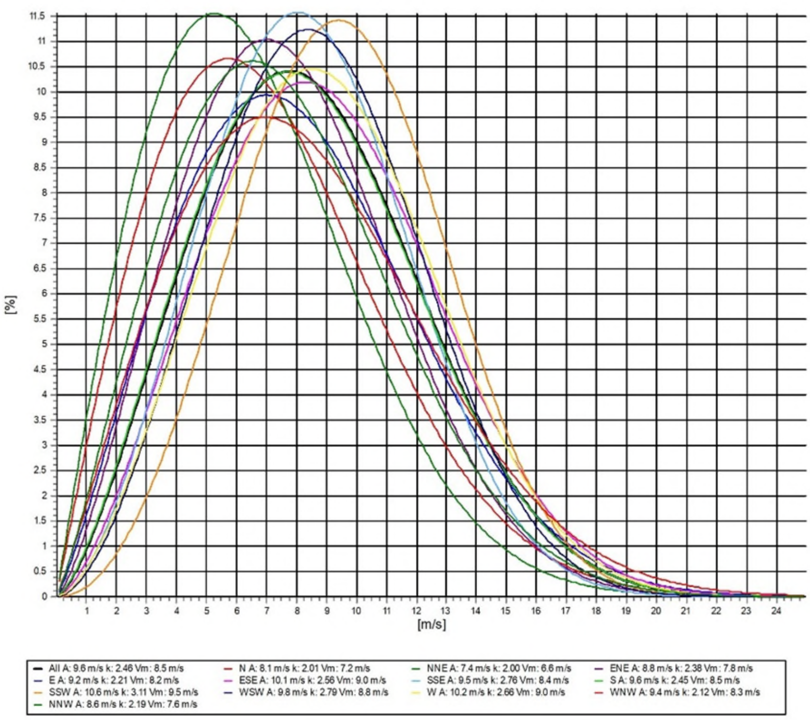
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **40.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.07	2.008	4.86	7.15
1-NNE	7.44	2.003	4.69	6.59
2-ENE	8.81	2.382	5.06	7.81
3-E	9.24	2.206	6.66	8.18
4-ESE	10.09	2.556	8.41	8.95
5-SSE	9.46	2.758	8.92	8.42
6-S	9.56	2.449	8.94	8.48
7-SSW	10.64	3.112	13.77	9.51
8-WSW	9.83	2.788	12.40	8.75
9-W	10.16	2.661	12.94	9.03
10-WNW	9.41	2.123	9.00	8.33
11-NNW	8.62	2.195	4.36	7.64
Mean	**9.59**	**2.463**	**100.00**	**8.51**



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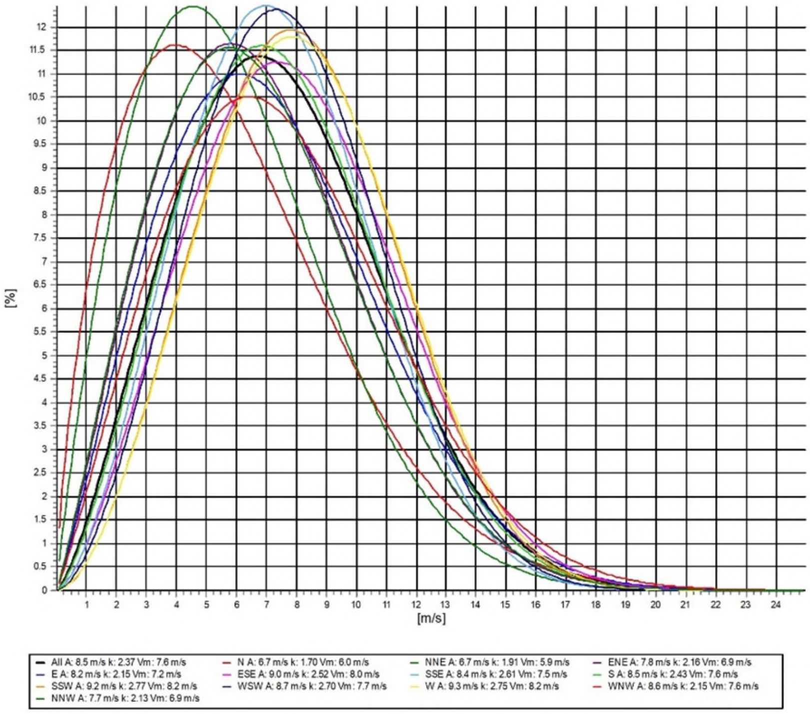
Meteo data report - Weibull data overview

Mast: KG-1 LT; KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **12.00m - MCP LT - EMD WFR - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.73	1.699	4.77	6.01
1-NNE	6.69	1.907	4.75	5.94
2-ENE	7.75	2.155	5.08	6.86
3-E	8.18	2.146	6.88	7.25
4-ESE	9.04	2.520	8.18	8.02
5-SSE	8.41	2.614	8.78	7.47
6-S	8.52	2.431	9.54	7.55
7-SSW	9.19	2.767	13.95	8.18
8-WSW	8.70	2.703	12.16	7.74
9-W	9.27	2.753	13.06	8.24
10-WNW	8.58	2.152	8.67	7.60
11-NNW	7.74	2.126	4.19	6.85
Mean	**8.52**	**2.373**	**100.00**	**7.55**



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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-A LT; KG-A **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - Scaled Anholt gradient

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.55	7.47	7.15	7.78	8.95	9.79	9.46	9.64	10.87	10.53	10.07	9.71	8.01
0		0.49	402	26	22	39	39	42	28	41	68	17	35	21	24
1	0.50	1.49	1993	215	201	274	126	89	169	136	206	136	174	174	93
2	1.50	2.49	5455	415	507	535	491	275	593	573	388	456	414	459	349
3	2.50	3.49	8559	591	609	715	572	634	765	1058	740	618	782	918	557
4	3.50	4.49	10443	893	1028	709	651	946	1011	975	996	735	1078	778	643
5	4.50	5.49	12759	1361	851	712	753	815	1024	924	1318	1343	1621	1118	919
6	5.50	6.49	14033	938	1002	853	986	1096	1090	1374	1347	1279	1843	1354	871
7	6.50	7.49	15128	805	745	854	1143	1255	1149	1226	1574	1710	1710	1622	1335
8	7.50	8.49	16127	775	704	771	998	1471	1375	1120	1728	2103	2141	1881	1060
9	8.50	9.49	15340	641	911	702	941	1336	1254	935	1613	2283	2402	1514	808
10	9.50	10.49	14396	625	576	887	809	876	1183	905	1398	2428	2554	1388	767
11	10.50	11.49	13511	395	417	630	698	938	1217	1145	1458	2173	2487	1528	425
12	11.50	12.49	13772	438	341	490	712	1248	1492	1019	1748	2369	2087	1298	530
13	12.50	13.49	12609	331	261	351	692	1206	1429	966	1798	1844	1974	1432	325
14	13.50	14.49	9828	217	184	217	506	806	1029	910	1567	1566	1571	994	261
15	14.50	15.49	8585	153	117	216	502	638	680	726	1705	1755	1224	708	161
16	15.50	16.49	6549	142	66	137	310	634	488	575	1343	1347	828	548	131
17	16.50	17.49	4447	80	61	134	201	535	407	425	864	675	544	431	90
18	17.50	18.49	3225	62	47	75	159	262	194	349	814	400	453	333	77
19	18.50	19.49	2229	40	17	26	119	218	149	243	508	316	311	240	42
20	19.50	20.49	1523	23	3	12	53	113	65	223	403	209	180	193	46
21	20.50	21.49	756	20	5	6	25	32	28	97	138	103	171	106	25
22	21.50	22.49	462	16	2	3	16	21	14	97	110	64	77	35	7
23	22.50	23.49	299	6	2	3	6	11	9	44	85	38	54	36	5
24	23.50	24.49	200	6	1	1	5	2	3	37	55	17	30	40	3
25	24.50	25.49	85	1	1	1	2	1	3	16	17	10	12	15	6
26	25.50	26.49	53	0	0	1	1	1	0	13	10	2	15	10	0
27	26.50	27.49	34	0	0	0	0	0	0	4	2	7	8	13	0
28	27.50	28.49	20	0	0	0	0	0	0	3	4	0	10	3	0
29	28.50	29.49	13	0	0	0	0	0	0	0	4	1	4	4	0
30	29.50	30.49	1	0	0	0	0	0	0	0	0	0	1	0	0
31	30.50	31.49	1	0	0	0	0	0	0	0	0	0	1	0	0
32	31.50	32.49	1	0	0	0	0	0	0	0	0	0	1	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	1	0	0	0
34	33.50	34.49	1	0	0	0	0	0	0	0	0	1	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Calculated:
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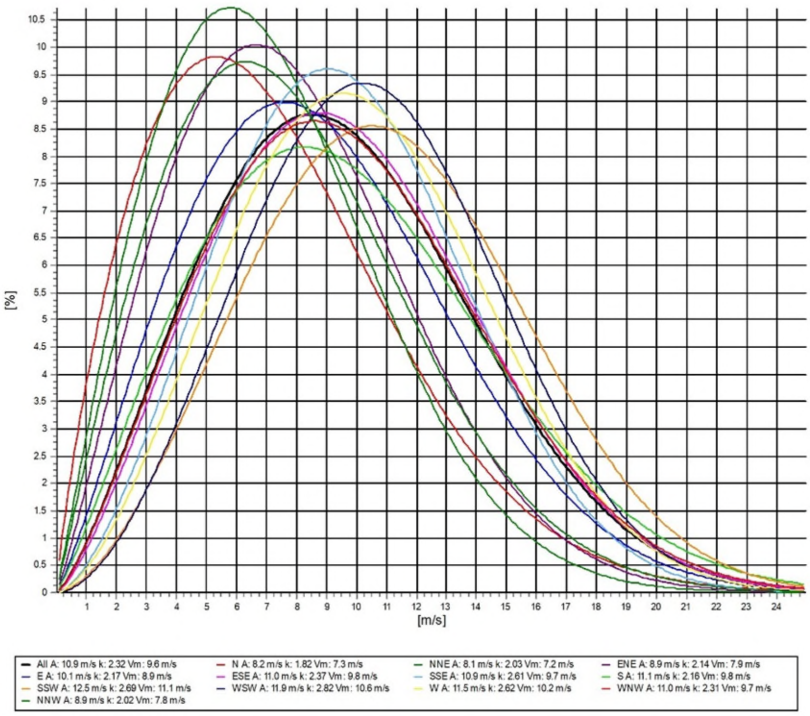
Meteo data report - Weibull data overview

Mast: KG-A LT; KG-A **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.24	1.820	4.78	7.33
1-NNE	8.08	2.031	4.50	7.16
2-ENE	8.94	2.139	4.85	7.92
3-E	10.10	2.172	5.97	8.94
4-ESE	11.03	2.374	8.04	9.77
5-SSE	10.90	2.613	8.74	9.68
6-S	11.06	2.156	8.38	9.79
7-SSW	12.51	2.687	12.45	11.12
8-WSW	11.92	2.816	13.49	10.61
9-W	11.46	2.621	13.90	10.18
10-WNW	11.00	2.312	9.95	9.74
11-NNW	8.86	2.016	4.96	7.85
Mean	**10.87**	**2.319**	**100.00**	**9.63**



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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-B LT; KG-B **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - Scaled Anholt gradient

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.58	7.96	7.43	7.89	8.82	10.08	9.40	9.44	10.73	10.65	10.20	9.62	7.82
0		0.49	401	25	20	39	39	42	28	41	70	17	34	22	24
1	0.50	1.49	1963	182	183	266	135	86	183	149	205	124	168	181	101
2	1.50	2.49	5437	395	484	522	505	248	597	593	408	455	399	465	366
3	2.50	3.49	8500	488	557	687	596	604	780	1131	764	606	769	933	585
4	3.50	4.49	10159	769	940	720	643	867	1013	940	1037	703	1051	781	695
5	4.50	5.49	12705	1192	868	679	795	846	1026	1019	1334	1315	1541	1167	923
6	5.50	6.49	14210	1088	945	850	1011	999	1108	1407	1377	1288	1845	1366	926
7	6.50	7.49	15155	737	821	832	1190	1215	1166	1216	1606	1564	1679	1718	1411
8	7.50	8.49	15751	753	597	778	963	1355	1383	1123	1747	2105	2057	1866	1024
9	8.50	9.49	15184	649	858	699	916	1412	1254	895	1622	2254	2371	1473	781
10	9.50	10.49	14486	595	700	818	880	906	1224	1006	1393	2408	2498	1347	711
11	10.50	11.49	13740	542	422	733	655	869	1240	1159	1526	2080	2498	1576	440
12	11.50	12.49	13469	365	360	461	726	1063	1462	981	1714	2414	2120	1327	476
13	12.50	13.49	13147	414	292	401	699	1292	1473	1039	1953	1937	1938	1386	323
14	13.50	14.49	9763	293	213	220	496	939	934	829	1452	1553	1642	946	246
15	14.50	15.49	8685	200	160	232	461	633	668	740	1773	1684	1264	731	139
16	15.50	16.49	6486	127	82	117	285	626	475	513	1200	1475	923	524	139
17	16.50	17.49	4607	131	66	143	171	616	379	401	873	768	574	408	77
18	17.50	18.49	3257	83	62	83	156	357	203	305	732	425	459	327	65
19	18.50	19.49	2347	69	28	44	100	242	134	250	532	315	342	238	53
20	19.50	20.49	1426	34	8	10	46	153	62	151	318	236	205	175	28
21	20.50	21.49	759	23	5	9	25	73	26	102	111	112	176	86	11
22	21.50	22.49	489	20	4	4	11	33	18	82	104	80	84	45	4
23	22.50	23.49	325	19	2	3	6	12	9	41	90	36	69	33	5
24	23.50	24.49	189	15	2	2	5	9	3	21	36	25	31	33	7
25	24.50	25.49	76	6	0	0	0	2	0	13	17	12	15	11	0
26	25.50	26.49	56	1	2	2	1	1	0	8	6	5	18	12	0
27	26.50	27.49	27	0	0	0	0	1	0	2	2	4	8	10	0
28	27.50	28.49	22	0	0	0	0	0	0	2	5	3	8	4	0
29	28.50	29.49	13	0	0	0	0	0	0	0	2	1	7	3	0
30	29.50	30.49	2	0	0	0	0	0	0	0	0	0	2	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	1	0	0	0	0	0	0	0	0	0	1	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	0	1	0	0
34	33.50	34.49	2	0	0	0	0	0	0	0	0	2	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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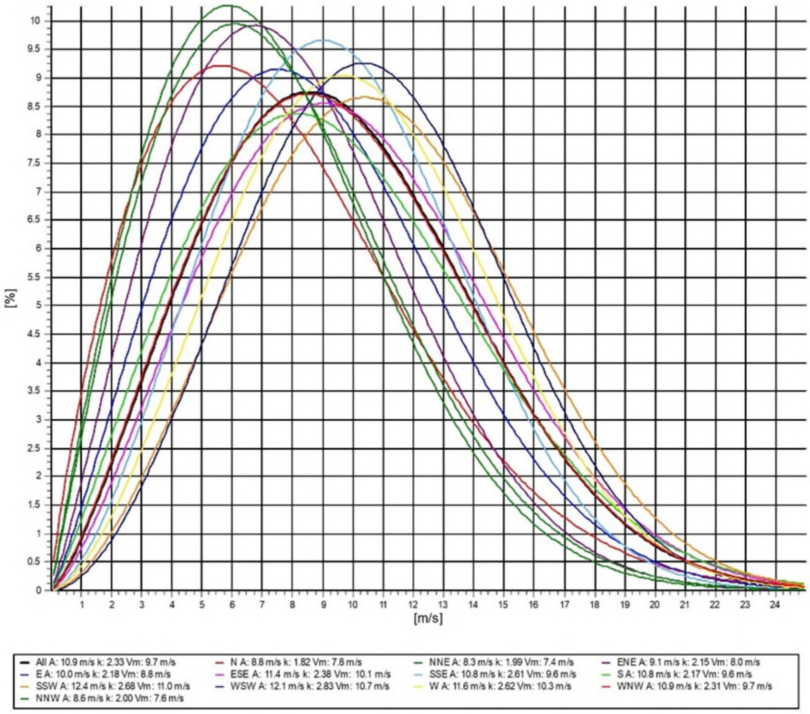
Meteo data report - Weibull data overview

Mast: KG-B LT; KG-B **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.78	1.819	4.78	7.81
1-NNE	8.34	1.994	4.50	7.39
2-ENE	9.07	2.146	4.85	8.03
3-E	9.96	2.184	5.97	8.82
4-ESE	11.36	2.380	8.04	10.07
5-SSE	10.83	2.611	8.74	9.62
6-S	10.84	2.170	8.38	9.60
7-SSW	12.35	2.683	12.45	10.98
8-WSW	12.06	2.826	13.49	10.74
9-W	11.60	2.622	13.90	10.31
10-WNW	10.89	2.309	9.95	9.65
11-NNW	8.62	2.000	4.96	7.64
Mean	**10.91**	**2.327**	**100.00**	**9.66**



Appendix E. Long-term Corrected Datasets: HS-1, H1 and M1

Project:
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Meteo data report - Frequency distribution (TAB file data)

Mast: MCP LT - EMD WFR - [Matrix] HS-1, 22y; MCP LT - EMD WFR - [Matrix] HS-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP LT - EMD WFR - [Matrix] HS-1

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.69	7.68	7.25	8.04	8.75	9.78	9.39	9.48	10.70	11.06	10.67	10.12	7.95
0		0.49	452	11	41	26	69	42	60	56	30	46	14	22	35
1	0.50	1.49	2208	138	162	129	171	168	276	205	223	263	173	122	178
2	1.50	2.49	5962	377	387	510	454	456	443	446	753	625	523	416	572
3	2.50	3.49	9417	691	686	811	669	606	655	618	917	1007	1081	972	704
4	3.50	4.49	9933	1018	762	604	823	731	833	597	741	1010	1050	1003	761
5	4.50	5.49	12412	1536	734	536	729	933	1145	1004	876	1119	1206	1324	1270
6	5.50	6.49	14602	1096	852	766	931	1276	1250	1213	1179	1720	1486	1523	1310
7	6.50	7.49	14962	844	786	899	1037	1350	1271	1235	1277	1526	1800	1659	1278
8	7.50	8.49	13772	558	876	845	902	1186	1376	1162	1382	1335	1616	1586	948
9	8.50	9.49	14010	606	733	830	836	1253	1337	1249	1436	1935	1799	1234	762
10	9.50	10.49	14736	888	749	665	862	1228	1137	994	1342	2215	2400	1389	867
11	10.50	11.49	13429	631	425	409	920	1188	1377	1078	1258	2014	1838	1524	767
12	11.50	12.49	13138	454	279	512	801	1398	1309	1159	1518	2047	1732	1320	609
13	12.50	13.49	11585	442	223	386	536	1215	974	861	1545	1945	1809	1278	371
14	13.50	14.49	10040	225	161	358	594	1104	975	789	1276	1633	1615	1080	230
15	14.50	15.49	8615	179	91	296	532	861	739	568	1343	1604	1297	948	157
16	15.50	16.49	7061	125	70	145	231	518	611	439	1018	1649	1391	695	169
17	16.50	17.49	5372	147	49	90	191	427	436	395	622	1261	909	684	161
18	17.50	18.49	3788	65	23	71	99	236	204	261	634	1035	647	419	94
19	18.50	19.49	2518	50	14	49	82	182	103	134	384	567	513	345	95
20	19.50	20.49	1854	24	9	11	40	89	65	106	390	455	320	282	63
21	20.50	21.49	1180	15	3	4	24	68	24	51	312	350	187	108	34
22	21.50	22.49	665	15	0	6	5	24	7	42	131	175	141	94	25
23	22.50	23.49	377	7	1	1	5	9	0	25	47	87	101	58	36
24	23.50	24.49	317	7	1	3	4	5	0	10	48	63	97	70	9
25	24.50	25.49	145	1	1	0	1	1	0	9	30	26	35	34	7
26	25.50	26.49	89	1	0	0	1	0	1	3	17	17	20	28	1
27	26.50	27.49	103	0	0	0	0	0	0	2	7	10	22	60	2
28	27.50	28.49	28	0	0	0	0	0	0	0	3	6	9	10	0
29	28.50	29.49	25	0	0	0	0	0	0	0	3	1	8	13	0
30	29.50	30.49	18	0	0	0	0	0	0	1	2	2	5	8	0
31	30.50	31.49	13	0	0	0	0	0	0	0	1	0	8	4	0
32	31.50	32.49	6	0	0	0	0	0	0	0	0	0	1	5	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	0	1	0	0
34	33.50	34.49	4	0	0	0	0	0	0	0	0	0	1	3	0
35	34.50	35.49	3	0	0	0	0	0	0	0	0	2	1	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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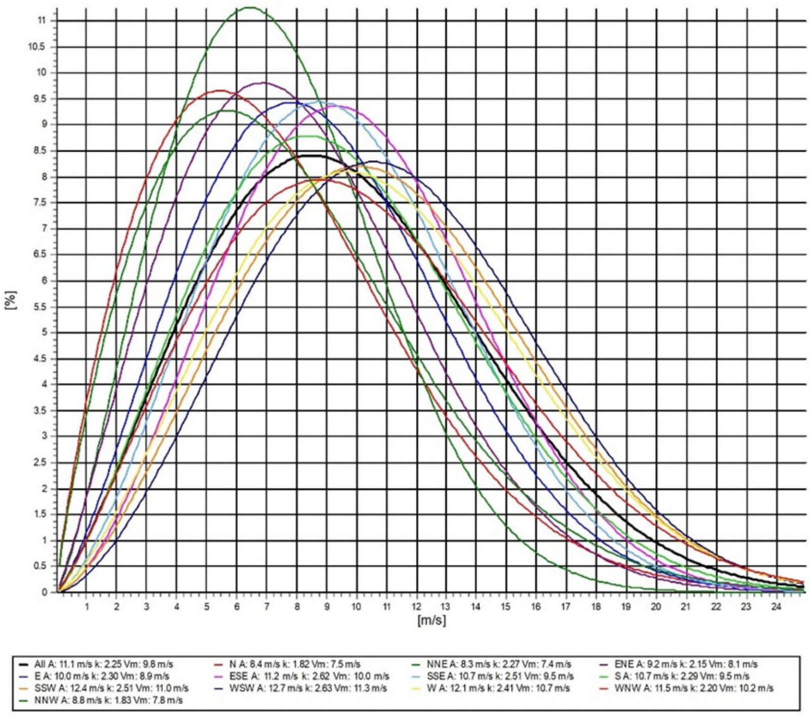
Meteo data report - Weibull data overview

Mast: MCP LT - EMD WFR - [Matrix] HS-1, 22y; MCP LT - EMD WFR - [Matrix] HS-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - MCP LT - EMD WFR - [Matrix] HS-1**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.40	1.825	5.26	7.47
1-NNE	8.32	2.267	4.21	7.37
2-ENE	9.18	2.148	4.65	8.13
3-E	10.03	2.296	5.99	8.88
4-ESE	11.20	2.618	8.58	9.95
5-SSE	10.72	2.508	8.61	9.52
6-S	10.75	2.293	7.63	9.52
7-SSW	12.36	2.511	10.76	10.97
8-WSW	12.69	2.628	14.39	11.27
9-W	12.12	2.411	13.41	10.75
10-WNW	11.53	2.200	10.54	10.22
11-NNW	8.76	1.828	5.97	7.78
Mean	**11.06**	**2.249**	**100.00**	**9.80**



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19/06/2024 14.39

Meteo data report - Frequency distribution (TAB file data)

Mast: MCP LT - EMD WFR - [Matrix] H1, 22y **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP LT - EMD WFR - [Matrix] H1

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.73	7.47	7.29	7.72	9.40	9.80	9.77	9.53	11.20	10.81	10.59	9.90	7.99
0		0.49	766	73	102	128	131	25	22	74	58	29	49	41	34
1	0.50	1.49	3020	390	159	393	276	226	216	173	147	279	301	214	246
2	1.50	2.49	5929	545	391	477	463	380	432	353	426	680	636	589	557
3	2.50	3.49	9184	739	895	593	466	609	526	582	839	1305	991	1022	617
4	3.50	4.49	11559	866	983	648	587	690	800	926	1107	1538	1267	1242	905
5	4.50	5.49	12725	1066	868	843	765	1184	963	1137	975	1252	1427	1172	1073
6	5.50	6.49	12243	976	685	834	1006	1333	778	952	847	1164	1335	1275	1058
7	6.50	7.49	13065	938	678	776	894	1093	991	1000	905	1240	1873	1630	1047
8	7.50	8.49	13863	831	625	546	926	1039	1356	1002	1404	1570	1976	1570	1018
9	8.50	9.49	15201	768	604	487	1085	1184	1542	1181	1440	1869	2434	1650	957
10	9.50	10.49	13930	670	408	559	910	1388	1427	991	1247	1745	2256	1424	905
11	10.50	11.49	12869	658	596	721	730	1158	1136	957	1298	1932	1967	1028	688
12	11.50	12.49	13351	463	465	784	878	1322	1325	1176	1424	1976	1849	1140	549
13	12.50	13.49	11618	343	347	394	776	1022	962	957	1501	2029	1933	977	377
14	13.50	14.49	9488	188	243	249	352	1085	1072	715	1244	1572	1613	916	239
15	14.50	15.49	8791	158	154	175	680	874	646	413	1366	1693	1509	920	203
16	15.50	16.49	7076	188	117	117	536	749	515	494	1086	1232	1125	725	192
17	16.50	17.49	5369	90	43	112	419	557	311	337	872	1093	797	595	143
18	17.50	18.49	4307	82	40	63	219	249	323	333	925	915	552	511	95
19	18.50	19.49	3318	57	12	23	140	154	244	186	759	747	526	403	67
20	19.50	20.49	1870	27	9	6	69	60	71	96	344	426	486	230	46
21	20.50	21.49	1099	18	3	4	39	28	24	70	170	222	315	159	47
22	21.50	22.49	870	7	6	3	12	10	25	57	264	202	156	97	31
23	22.50	23.49	529	7	0	3	8	4	16	20	88	98	168	104	13
24	23.50	24.49	298	4	0	1	8	1	3	12	37	75	84	61	12
25	24.50	25.49	197	2	0	3	1	0	0	5	25	36	72	49	4
26	25.50	26.49	125	1	0	0	5	0	0	7	15	10	45	40	2
27	26.50	27.49	52	2	0	0	1	0	0	1	2	7	26	11	2
28	27.50	28.49	42	0	0	0	1	0	0	0	4	7	22	8	0
29	28.50	29.49	32	1	0	0	0	0	0	0	2	6	10	13	0
30	29.50	30.49	20	0	0	0	1	0	0	0	1	2	9	7	0
31	30.50	31.49	11	0	0	0	0	0	0	0	0	0	8	3	0
32	31.50	32.49	10	0	0	0	0	0	0	0	0	0	6	4	0
33	32.50	33.49	3	0	0	0	0	0	0	0	0	0	2	1	0
34	33.50	34.49	3	0	0	0	0	0	0	0	0	0	2	1	0
35	34.50	35.49	4	0	0	0	1	0	0	0	0	1	1	1	0
36	35.50	36.49	2	0	0	0	0	0	0	0	1	1	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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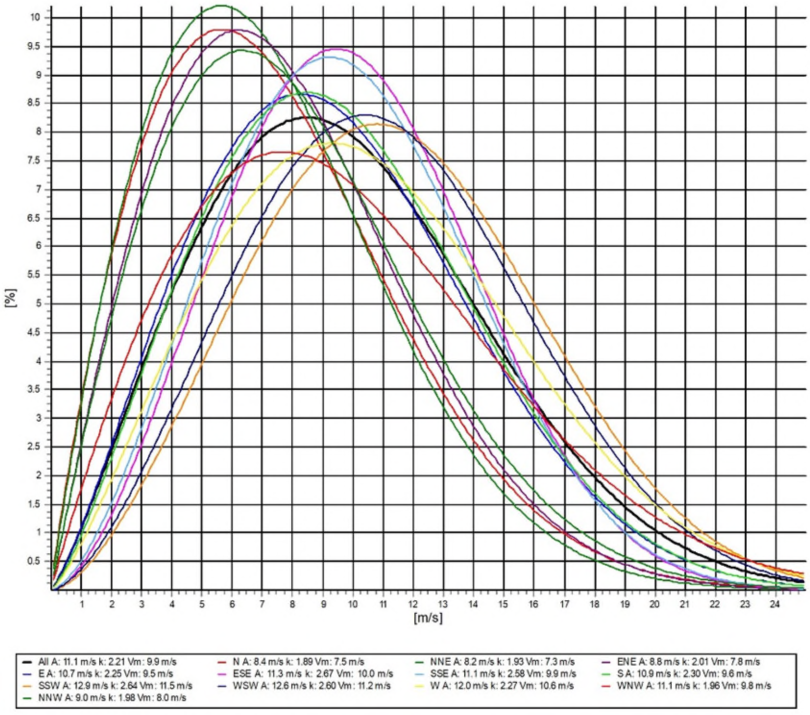
Meteo data report - Weibull data overview

Mast: MCP LT - EMD WFR - [Matrix] H1, 22y **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - MCP LT - EMD WFR - [Matrix] H1**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.44	1.887	5.27	7.49
1-NNE	8.22	1.933	4.37	7.29
2-ENE	8.78	2.006	4.64	7.78
3-E	10.73	2.246	6.42	9.51
4-ESE	11.27	2.670	8.52	10.02
5-SSE	11.14	2.584	8.15	9.89
6-S	10.88	2.297	7.37	9.64
7-SSW	12.95	2.636	10.80	11.50
8-WSW	12.56	2.598	13.98	11.15
9-W	12.00	2.269	14.43	10.63
10-WNW	11.05	1.958	10.28	9.80
11-NNW	9.05	1.982	5.77	8.02
Mean	**11.13**	**2.210**	**100.00**	**9.86**



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Meteo data report - Frequency distribution (TAB file data)

Mast: MCP LT - EMD WFR - [Matrix] M1, 22y **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

62.00m - MCP LT - EMD WFR - [Matrix] M1

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			8.98	7.11	7.46	7.56	8.15	9.06	9.10	9.39	9.66	9.42	10.07	9.15	7.16
0		0.49	1223	100	87	105	81	110	148	95	73	97	108	116	103
1	0.50	1.49	3521	244	269	293	267	313	364	330	319	264	327	275	256
2	1.50	2.49	6090	495	554	459	471	517	550	515	496	496	523	513	501
3	2.50	3.49	8693	677	718	684	707	696	718	669	653	799	928	839	605
4	3.50	4.49	11338	813	880	920	904	812	820	982	1051	1213	1098	1089	756
5	4.50	5.49	13289	1081	1025	850	884	910	1009	1038	1275	1541	1530	1248	898
6	5.50	6.49	14381	1142	854	944	987	1109	1084	1298	1412	1604	1792	1275	880
7	6.50	7.49	15616	1189	868	822	1030	1264	1292	1378	1514	1735	2133	1528	863
8	7.50	8.49	16285	993	800	954	1103	1286	1541	1557	1446	1965	2373	1491	776
9	8.50	9.49	16878	994	926	906	1016	1140	1434	1477	1712	2311	2738	1502	722
10	9.50	10.49	16181	594	748	852	931	1273	1367	1568	1868	2273	2830	1399	478
11	10.50	11.49	15396	430	593	715	777	1151	1313	1607	1911	2476	2854	1190	379
12	11.50	12.49	13594	294	575	623	694	1138	1064	1279	1736	2194	2557	1088	352
13	12.50	13.49	11542	179	339	454	657	886	895	1211	1668	1786	2346	910	211
14	13.50	14.49	9180	137	180	194	527	656	849	1013	1445	1377	1844	785	173
15	14.50	15.49	6746	115	134	111	267	551	610	733	1043	895	1457	702	128
16	15.50	16.49	4772	120	138	113	146	381	464	531	675	511	1034	561	98
17	16.50	17.49	3044	98	84	61	144	329	287	321	327	222	697	393	81
18	17.50	18.49	1874	56	34	20	54	194	211	240	231	129	404	257	44
19	18.50	19.49	1186	18	29	11	27	109	145	159	129	172	227	140	20
20	19.50	20.49	859	17	16	8	11	74	96	81	62	111	227	133	23
21	20.50	21.49	535	8	17	8	12	56	49	55	49	49	122	94	16
22	21.50	22.49	262	8	3	6	7	25	25	42	20	21	66	33	6
23	22.50	23.49	140	2	4	2	1	6	13	29	8	12	43	16	4
24	23.50	24.49	75	0	4	1	0	2	5	5	6	10	32	10	0
25	24.50	25.49	81	0	0	3	0	0	2	6	6	19	32	13	0
26	25.50	26.49	19	0	3	0	0	0	0	2	4	0	8	2	0
27	26.50	27.49	17	0	0	0	0	0	0	1	0	2	8	6	0
28	27.50	28.49	13	0	0	0	0	0	0	0	0	2	7	4	0
29	28.50	29.49	4	0	0	0	0	0	0	0	0	0	4	0	0
30	29.50	30.49	3	0	0	0	0	0	0	0	1	1	1	0	0
31	30.50	31.49	2	0	0	0	0	0	0	0	0	0	1	1	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	0	1	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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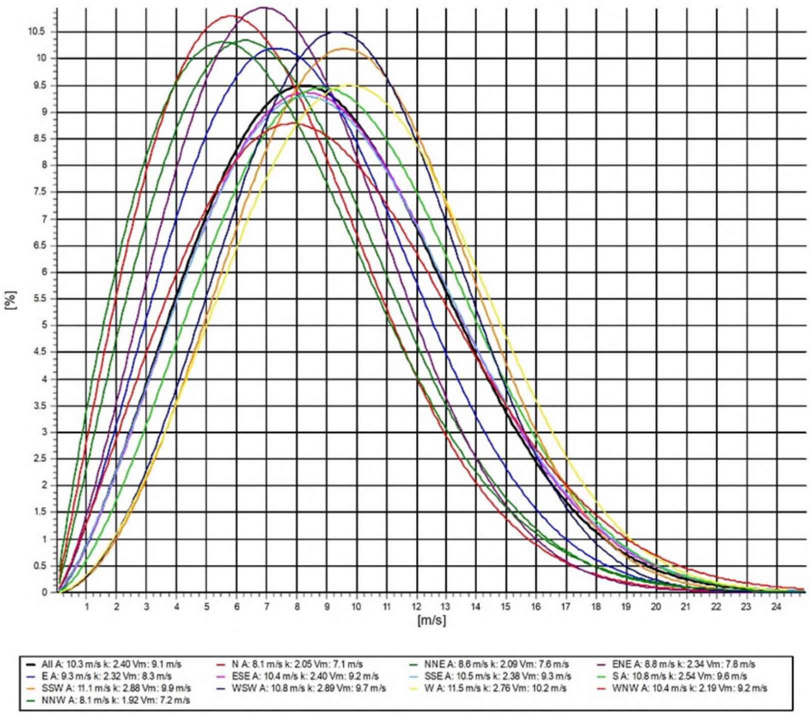
Meteo data report - Weibull data overview

Mast: MCP LT - EMD WFR - [Matrix] M1, 22y **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **62.00m - MCP LT - EMD WFR - [Matrix] M1**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.06	2.046	5.08	7.14
1-NNE	8.55	2.094	5.12	7.57
2-ENE	8.76	2.343	5.25	7.76
3-E	9.35	2.322	6.07	8.28
4-ESE	10.42	2.396	7.77	9.24
5-SSE	10.45	2.379	8.48	9.27
6-S	10.81	2.538	9.45	9.59
7-SSW	11.14	2.881	10.96	9.93
8-WSW	10.83	2.888	12.59	9.66
9-W	11.51	2.757	15.74	10.24
10-WNW	10.39	2.190	9.13	9.20
11-NNW	8.10	1.920	4.34	7.19
Mean	**10.31**	**2.404**	**100.00**	**9.14**



Appendix F. Translated to Position KG-1-LB: HS-1, H1, M1

Project:
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Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.64	7.34	7.49	8.13	8.92	9.90	9.80	9.81	11.11	10.51	10.19	9.72	7.61
0		0.49	221	25	26	21	45	34	3	16	0	0	0	8	43
1	0.50	1.49	1369	174	171	92	150	150	152	131	31	35	46	56	181
2	1.50	2.49	4550	430	383	431	376	389	337	340	248	339	390	356	531
3	2.50	3.49	8937	800	683	788	657	538	566	591	898	860	1073	863	620
4	3.50	4.49	10859	1114	907	667	834	659	765	584	1074	1218	1212	1103	722
5	4.50	5.49	12028	1423	841	511	726	832	972	801	885	1185	1421	1350	1081
6	5.50	6.49	15024	1169	931	762	898	1166	1321	1217	1124	1754	1750	1676	1256
7	6.50	7.49	15127	725	817	842	1037	1259	1140	1161	1490	1741	2168	1787	960
8	7.50	8.49	14552	554	967	897	936	1125	1378	1254	1535	1585	1838	1685	798
9	8.50	9.49	15480	708	794	842	846	1186	1243	1324	1744	2444	2447	1294	608
10	9.50	10.49	15520	835	841	675	807	1154	1142	1129	1625	2386	2592	1486	848
11	10.50	11.49	13959	570	527	420	964	1154	1236	975	1581	2280	2139	1682	431
12	11.50	12.49	13493	498	321	505	846	1277	1402	1121	1581	2125	2063	1213	541
13	12.50	13.49	12107	322	297	402	571	1128	1115	918	1913	1893	2011	1312	225
14	13.50	14.49	10373	209	198	349	529	1033	970	818	1639	1844	1581	1068	135
15	14.50	15.49	9246	115	127	285	595	859	849	657	1581	1726	1601	722	129
16	15.50	16.49	6700	113	89	153	271	505	571	470	1310	1345	1011	705	157
17	16.50	17.49	4748	108	87	87	180	415	538	426	806	842	720	450	89
18	17.50	18.49	3182	59	32	70	119	231	248	306	680	515	468	365	89
19	18.50	19.49	2088	28	25	45	78	175	122	159	463	385	284	259	65
20	19.50	20.49	1345	24	12	11	51	87	82	82	428	209	207	108	44
21	20.50	21.49	814	10	6	3	22	68	36	65	293	105	113	74	19
22	21.50	22.49	447	10	3	6	10	24	4	47	100	35	112	70	26
23	22.50	23.49	255	9	3	2	4	10	3	29	53	22	46	53	21
24	23.50	24.49	160	2	1	2	4	4	0	14	56	11	26	36	4
25	24.50	25.49	122	0	1	0	2	1	0	8	31	8	18	52	1
26	25.50	26.49	58	0	1	0	1	0	1	6	11	1	13	22	2
27	26.50	27.49	29	0	0	0	0	0	0	1	8	1	7	12	0
28	27.50	28.49	22	0	0	0	0	0	0	2	4	0	7	9	0
29	28.50	29.49	11	0	0	0	0	0	0	0	3	0	3	5	0
30	29.50	30.49	6	0	0	0	0	0	0	0	2	0	1	3	0
31	30.50	31.49	6	0	0	0	0	0	0	0	0	1	2	3	0
32	31.50	32.49	2	0	0	0	0	0	0	1	1	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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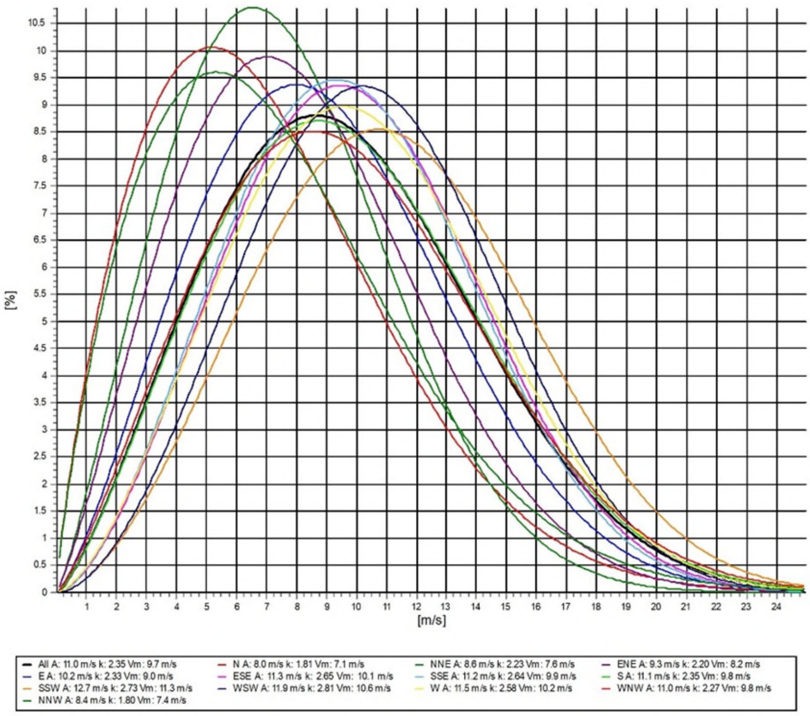
Meteo data report - Weibull data overview

Mast: HS-1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.03	1.812	5.20	7.14
1-NNE	8.58	2.230	4.71	7.60
2-ENE	9.27	2.198	4.60	8.21
3-E	10.19	2.325	5.99	9.03
4-ESE	11.31	2.648	8.02	10.06
5-SSE	11.17	2.644	8.40	9.92
6-S	11.05	2.348	7.60	9.80
7-SSW	12.70	2.729	12.03	11.30
8-WSW	11.92	2.814	13.95	10.61
9-W	11.54	2.575	14.19	10.24
10-WNW	11.03	2.272	10.31	9.77
11-NNW	8.37	1.796	4.99	7.45
Mean	**10.95**	**2.354**	**100.00**	**9.70**



Project:
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Meteo data report - Frequency distribution (TAB file data)

Mast: H1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.65	7.31	7.57	8.01	9.64	9.85	9.82	9.89	11.47	10.38	10.09	9.27	7.63
0		0.49	273	81	24	52	49	5	2	13	0	0	0	3	44
1	0.50	1.49	1979	390	201	299	204	118	81	120	61	35	77	142	251
2	1.50	2.49	4659	604	317	514	422	329	304	209	201	370	416	480	493
3	2.50	3.49	7878	734	764	542	404	520	508	448	538	957	991	970	502
4	3.50	4.49	11763	940	1199	632	575	623	644	779	1095	1733	1417	1290	836
5	4.50	5.49	13550	1110	983	835	690	1054	900	1071	1311	1617	1726	1277	976
6	5.50	6.49	13384	973	900	899	948	1310	826	1171	1142	1397	1610	1362	846
7	6.50	7.49	13916	1005	809	860	933	1157	847	897	998	1474	2281	1755	900
8	7.50	8.49	14761	811	765	610	859	1003	1283	1197	1397	1825	2610	1585	816
9	8.50	9.49	16187	809	678	518	1104	1188	1538	1051	1690	2106	2971	1661	873
10	9.50	10.49	14735	717	536	553	932	1325	1361	1182	1656	2146	2378	1245	704
11	10.50	11.49	13763	590	649	685	764	1194	1110	962	1507	2367	2332	1128	475
12	11.50	12.49	14359	462	575	885	867	1306	1229	1226	1735	2272	2320	1045	437
13	12.50	13.49	11790	266	395	478	785	1049	928	1054	1812	1940	1984	880	219
14	13.50	14.49	10402	196	295	276	374	1013	1045	837	1619	1933	1716	927	171
15	14.50	15.49	8271	171	191	201	671	815	584	492	1547	1380	1316	723	180
16	15.50	16.49	6438	152	144	128	549	737	457	433	1275	1138	778	532	115
17	16.50	17.49	5253	93	58	133	439	426	307	357	1115	1000	698	521	106
18	17.50	18.49	3899	73	50	68	208	219	309	327	1033	646	615	283	68
19	18.50	19.49	2315	45	14	24	136	104	112	210	746	319	403	166	36
20	19.50	20.49	1229	24	9	8	67	44	30	110	362	217	210	103	45
21	20.50	21.49	882	14	4	3	36	17	26	80	264	131	192	90	25
22	21.50	22.49	526	10	6	3	12	7	9	60	184	70	87	64	14
23	22.50	23.49	282	5	0	3	12	3	4	33	63	36	73	40	10
24	23.50	24.49	129	2	0	1	4	1	0	10	38	10	29	27	7
25	24.50	25.49	93	2	0	3	1	0	0	9	13	13	31	21	0
26	25.50	26.49	49	3	0	0	4	0	0	3	9	3	14	12	1
27	26.50	27.49	39	0	0	0	1	0	0	3	6	5	17	7	0
28	27.50	28.49	15	1	0	0	1	0	0	0	4	0	6	3	0
29	28.50	29.49	11	0	0	0	1	0	0	0	1	1	4	4	0
30	29.50	30.49	3	0	0	0	0	0	0	0	0	0	2	1	0
31	30.50	31.49	3	0	0	0	0	0	0	0	0	1	1	1	0
32	31.50	32.49	1	0	0	0	0	0	0	0	0	1	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	1	0	0	0	0
34	33.50	34.49	1	0	0	0	1	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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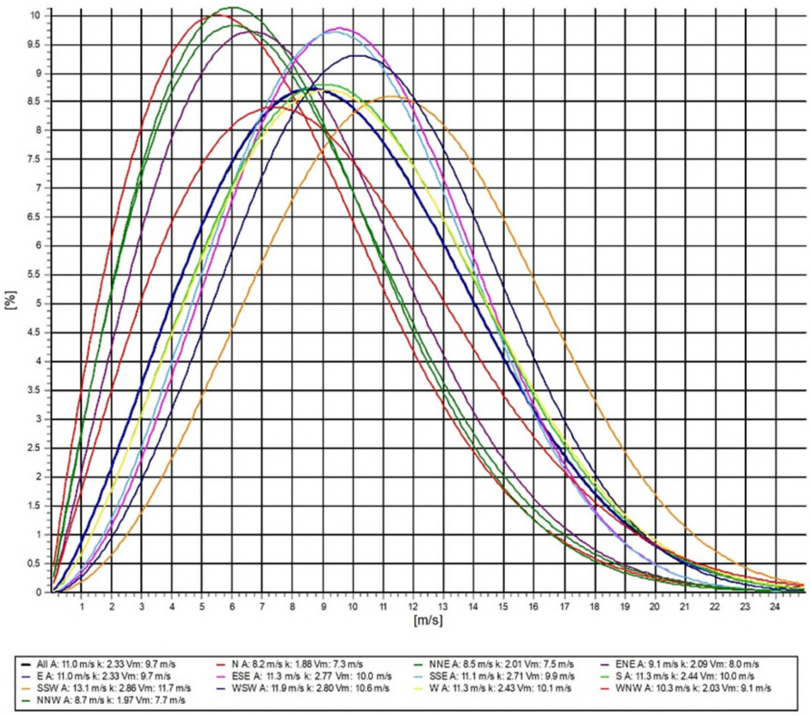
Meteo data report - Weibull data overview

Mast: H1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.25	1.881	5.33	7.32
1-NNE	8.48	2.008	4.96	7.52
2-ENE	9.08	2.089	4.78	8.05
3-E	10.95	2.333	6.25	9.70
4-ESE	11.25	2.774	8.07	10.01
5-SSE	11.12	2.715	7.49	9.89
6-S	11.26	2.445	7.44	9.99
7-SSW	13.13	2.862	12.15	11.70
8-WSW	11.91	2.801	14.08	10.60
9-W	11.34	2.431	15.20	10.06
10-WNW	10.31	2.035	9.51	9.14
11-NNW	8.66	1.974	4.74	7.67
Mean	**10.97**	**2.334**	**100.00**	**9.72**



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Meteo data report - Frequency distribution (TAB file data)

Mast: M1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - B Sheared

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.46	8.21	8.05	8.28	9.02	9.78	9.40	9.66	10.74	9.67	9.45	9.64	8.48
0		0.49	143	0	0	0	0	0	0	48	41	46	8	0	0
1	0.50	1.49	1434	86	45	60	25	4	133	237	234	202	240	105	63
2	1.50	2.49	3839	242	188	238	206	256	423	421	443	392	459	349	222
3	2.50	3.49	6886	482	478	410	451	561	579	629	606	701	879	688	422
4	3.50	4.49	9936	695	678	614	637	797	848	906	832	1102	1189	1125	513
5	4.50	5.49	12691	806	854	787	947	957	959	968	1180	1467	1660	1423	683
6	5.50	6.49	14497	1021	896	749	984	1165	1125	1154	1393	1582	1975	1604	849
7	6.50	7.49	15899	1150	745	770	978	1408	1246	1311	1430	1743	2406	1772	940
8	7.50	8.49	17295	1161	742	729	1079	1599	1595	1458	1488	1924	2718	1980	822
9	8.50	9.49	17768	1021	749	810	1137	1499	1612	1453	1486	2272	3004	1914	811
10	9.50	10.49	17438	932	796	775	1039	1446	1472	1420	1715	2251	3079	1791	722
11	10.50	11.49	16517	609	582	700	924	1553	1410	1461	1832	2346	2847	1724	529
12	11.50	12.49	14303	479	558	563	769	1349	1142	1256	1894	2123	2406	1391	373
13	12.50	13.49	12131	297	349	491	685	1239	942	1028	1831	1844	1911	1191	323
14	13.50	14.49	9786	212	176	220	612	894	874	997	1721	1411	1361	1087	221
15	14.50	15.49	7367	131	130	142	399	732	599	755	1505	983	957	876	158
16	15.50	16.49	5264	107	115	79	211	481	449	576	1210	608	618	681	129
17	16.50	17.49	3608	120	54	68	127	406	285	386	935	317	340	476	94
18	17.50	18.49	2254	115	19	21	93	227	197	252	572	143	215	302	98
19	18.50	19.49	1498	60	12	9	43	140	121	189	323	123	179	235	64
20	19.50	20.49	973	37	10	11	23	77	86	104	220	132	78	135	60
21	20.50	21.49	515	20	5	7	12	41	30	62	134	77	41	67	19
22	21.50	22.49	358	8	2	4	9	27	22	59	73	36	44	52	22
23	22.50	23.49	192	3	4	3	1	10	8	22	51	19	26	32	13
24	23.50	24.49	108	6	0	1	0	2	4	20	26	19	10	13	7
25	24.50	25.49	61	1	1	2	0	0	0	7	14	14	7	11	4
26	25.50	26.49	38	1	2	1	0	0	0	1	8	3	9	13	0
27	26.50	27.49	18	0	0	0	0	0	0	2	6	0	2	8	0
28	27.50	28.49	12	0	0	0	0	0	0	1	8	0	0	3	0
29	28.50	29.49	6	0	0	0	0	0	0	1	0	3	1	1	0
30	29.50	30.49	2	0	0	0	0	0	0	0	0	0	1	1	0
31	30.50	31.49	2	0	0	0	0	0	0	0	0	1	0	1	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	1	0	0	0	0	0	0	0	1	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: M1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

62.00m -

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			8.82	7.66	7.49	7.69	8.39	9.10	8.77	9.00	9.98	9.01	8.85	9.01	7.92
0		0.49	161	0	0	0	0	0	0	54	43	53	11	0	0
1	0.50	1.49	1683	100	53	75	37	14	163	265	270	224	274	130	78
2	1.50	2.49	4475	282	239	284	256	309	459	486	500	449	534	424	253
3	2.50	3.49	7959	555	585	489	507	637	688	700	658	808	1020	816	496
4	3.50	4.49	11470	819	768	714	790	949	906	1021	1025	1285	1337	1279	577
5	4.50	5.49	14326	899	952	824	1080	1109	1108	1075	1313	1631	1944	1602	789
6	5.50	6.49	16078	1149	882	875	1006	1337	1241	1340	1531	1768	2220	1737	992
7	6.50	7.49	17710	1316	816	761	1141	1498	1491	1438	1610	1988	2669	2048	934
8	7.50	8.49	19238	1160	764	864	1227	1852	1811	1604	1588	2317	3125	2041	885
9	8.50	9.49	19019	1049	911	863	1166	1518	1646	1526	1718	2442	3318	2070	792
10	9.50	10.49	18339	774	665	792	1044	1727	1531	1592	2013	2501	3169	1850	681
11	10.50	11.49	16210	507	647	628	857	1496	1341	1477	2071	2433	2725	1610	418
12	11.50	12.49	13623	380	387	533	728	1377	1061	1147	2022	2055	2234	1331	368
13	12.50	13.49	10832	211	180	243	703	980	960	1109	1883	1532	1583	1212	236
14	13.50	14.49	7900	140	136	127	379	772	659	831	1640	1047	1068	931	170
15	14.50	15.49	5386	127	117	89	193	504	445	549	1272	594	606	758	132
16	15.50	16.49	3479	135	43	59	143	374	270	377	932	251	295	484	116
17	16.50	17.49	2034	101	18	14	66	216	182	234	447	138	246	280	92
18	17.50	18.49	1309	51	7	7	40	99	112	157	276	166	131	201	62
19	18.50	19.49	690	25	11	10	13	57	50	69	183	94	49	92	37
20	19.50	20.49	432	11	2	6	9	32	25	72	91	45	49	68	22
21	20.50	21.49	234	3	4	3	6	11	10	30	61	22	35	30	19
22	21.50	22.49	119	7	0	1	0	2	2	18	28	20	11	21	9
23	22.50	23.49	67	1	3	3	0	0	0	8	17	14	7	12	2
24	23.50	24.49	29	0	0	0	0	0	0	2	4	3	7	12	1
25	24.50	25.49	17	0	0	0	0	0	0	1	8	0	1	7	0
26	25.50	26.49	14	0	0	0	0	0	0	2	7	1	1	3	0
27	26.50	27.49	3	0	0	0	0	0	0	0	0	2	1	0	0
28	27.50	28.49	3	0	0	0	0	0	0	0	0	1	0	2	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	1	0	0	0	0	0	0	0	1	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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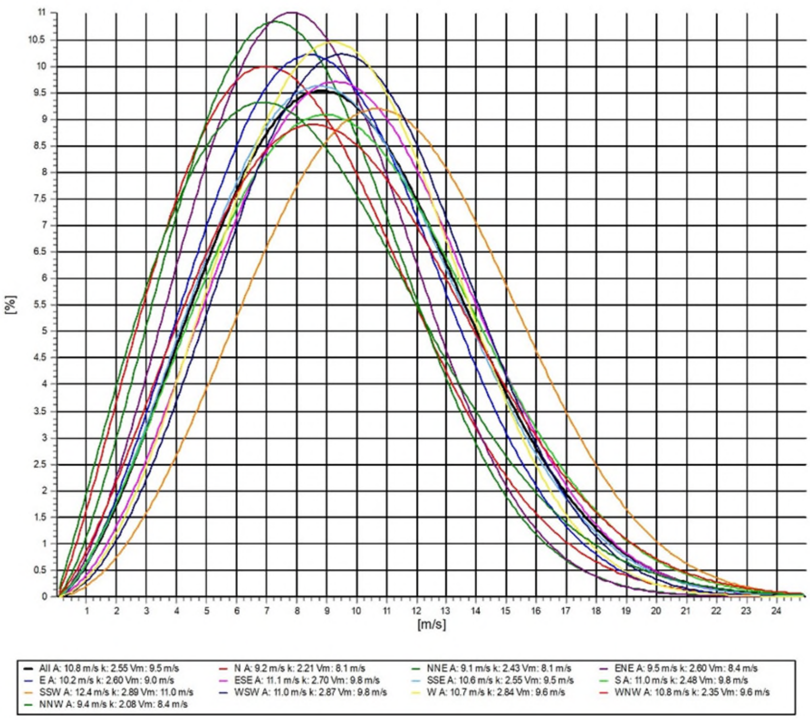
Meteo data report - Weibull data overview

Mast: M1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - B Sheared**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	9.19	2.209	5.08	8.14
1-NNE	9.10	2.427	4.25	8.07
2-ENE	9.46	2.597	4.29	8.40
3-E	10.19	2.595	5.91	9.05
4-ESE	11.05	2.695	8.75	9.83
5-SSE	10.65	2.546	8.38	9.45
6-S	11.04	2.478	8.91	9.79
7-SSW	12.37	2.886	12.04	11.02
8-WSW	11.05	2.866	12.39	9.85
9-W	10.73	2.842	14.87	9.56
10-WNW	10.83	2.355	10.92	9.60
11-NNW	9.44	2.076	4.23	8.36
Mean	**10.75**	**2.549**	**100.00**	**9.54**



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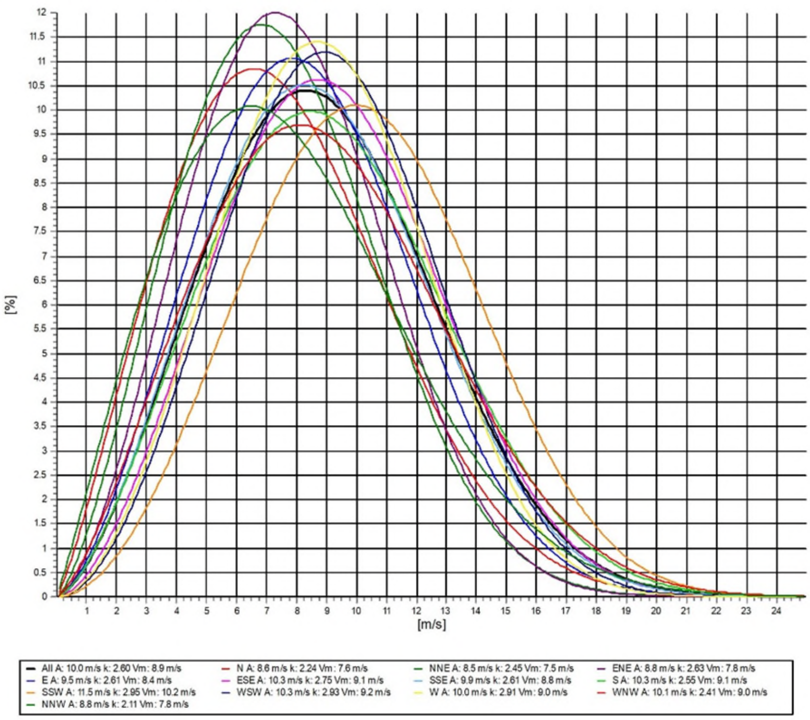
Meteo data report - Weibull data overview

Mast: M1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **62.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.56	2.242	5.08	7.58
1-NNE	8.46	2.453	4.25	7.51
2-ENE	8.78	2.634	4.29	7.80
3-E	9.46	2.613	5.91	8.40
4-ESE	10.28	2.754	8.75	9.15
5-SSE	9.94	2.609	8.38	8.83
6-S	10.29	2.550	8.91	9.13
7-SSW	11.48	2.954	12.04	10.25
8-WSW	10.29	2.928	12.39	9.17
9-W	10.05	2.915	14.87	8.96
10-WNW	10.14	2.414	10.92	8.99
11-NNW	8.81	2.105	4.23	7.80
Mean	**10.02**	**2.602**	**100.00**	**8.90**



Appendix G. Normal Turbulence Model (150 m)

Wind speed [m/s]	Turbulence intensity mean value (TI_μ) [%]	Turbulence intensity standard deviation (TI_σ) [%]	Turbulence intensity 90% quantile [%]
3	10.8	6.6	19.2
4	8.2	5.1	14.8
5	6.8	4.3	12.3
6	5.9	3.7	10.7
7	5.4	3.3	9.6
8	5.0	3.0	8.9
9	4.8	2.8	8.3
10	4.7	2.6	8.0
11	4.7	2.4	7.8
12	4.7	2.3	7.6
13	4.7	2.2	7.5
14	4.8	2.1	7.5
15	4.9	2.0	7.5
16	5.1	1.9	7.5
17	5.2	1.9	7.6
18	5.4	1.8	7.7
19	5.5	1.8	7.8
20	5.7	1.7	7.9
21	5.9	1.7	8.1
22	6.1	1.6	8.2
23	6.3	1.6	8.4
24	6.5	1.6	8.5
25	6.8	1.5	8.7

Wind speed [m/s]	TURBULENCE MEAN VALUE (σ_μ) [M/S]	TURBULENCE STANDARD DEVIATION (σ_σ) [M/S]	Turbulence 90% QUANTILE [m/s]
3	0.32	0.20	0.58
4	0.33	0.21	0.59
5	0.34	0.21	0.61
6	0.35	0.22	0.64
7	0.38	0.23	0.67
8	0.40	0.24	0.71
9	0.43	0.25	0.75
10	0.47	0.26	0.80
11	0.51	0.27	0.85
12	0.56	0.27	0.91
13	0.62	0.28	0.98
14	0.67	0.29	1.05
15	0.74	0.30	1.12
16	0.81	0.31	1.20
17	0.89	0.32	1.29
18	0.97	0.33	1.38
19	1.05	0.33	1.48
20	1.15	0.34	1.58
21	1.24	0.35	1.69
22	1.35	0.36	1.81
23	1.45	0.37	1.93
24	1.57	0.38	2.05
25	1.69	0.39	2.18