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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 based on 12 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 12 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 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 4.1, 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 (KG-1-LB, KG-A, KG-B) 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	9.60 m/s	9.59 m/s	9.62 m/s
Weibull distribution, A parameter (scale)	10.83 m/s	10.82 m/s	10.86 m/s
Weibull distribution, k parameter (shape)	2.27	2.26	2.27
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 supporting the turbulence assessment with additional local turbulence measurements from suitable sources, preferably cup anemometer measurements, in the Kattegat Sea.

Contents

List of Figures

List of Tables

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

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 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.

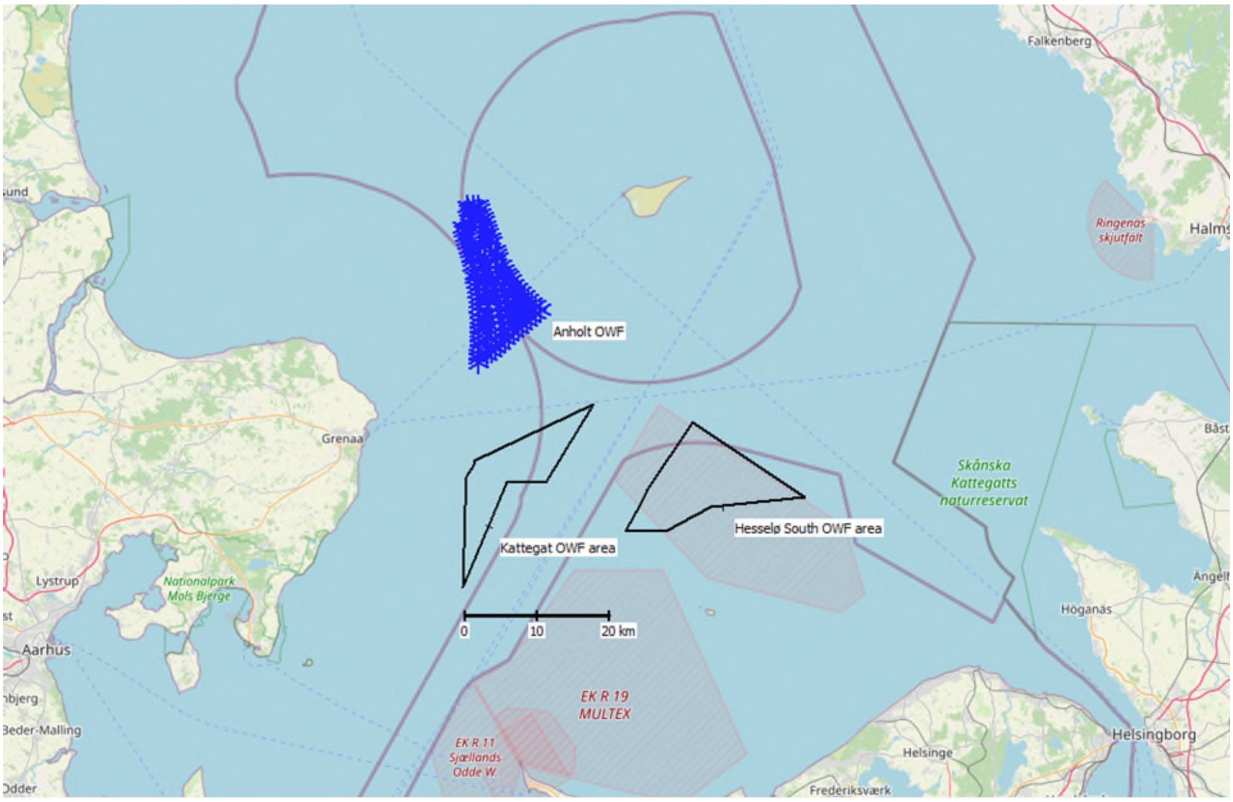


Figure 1. Regional map with location of the Kattegat OWF area together with Hesselø South OWF area and the existing Anholt OWF (in blue).

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.

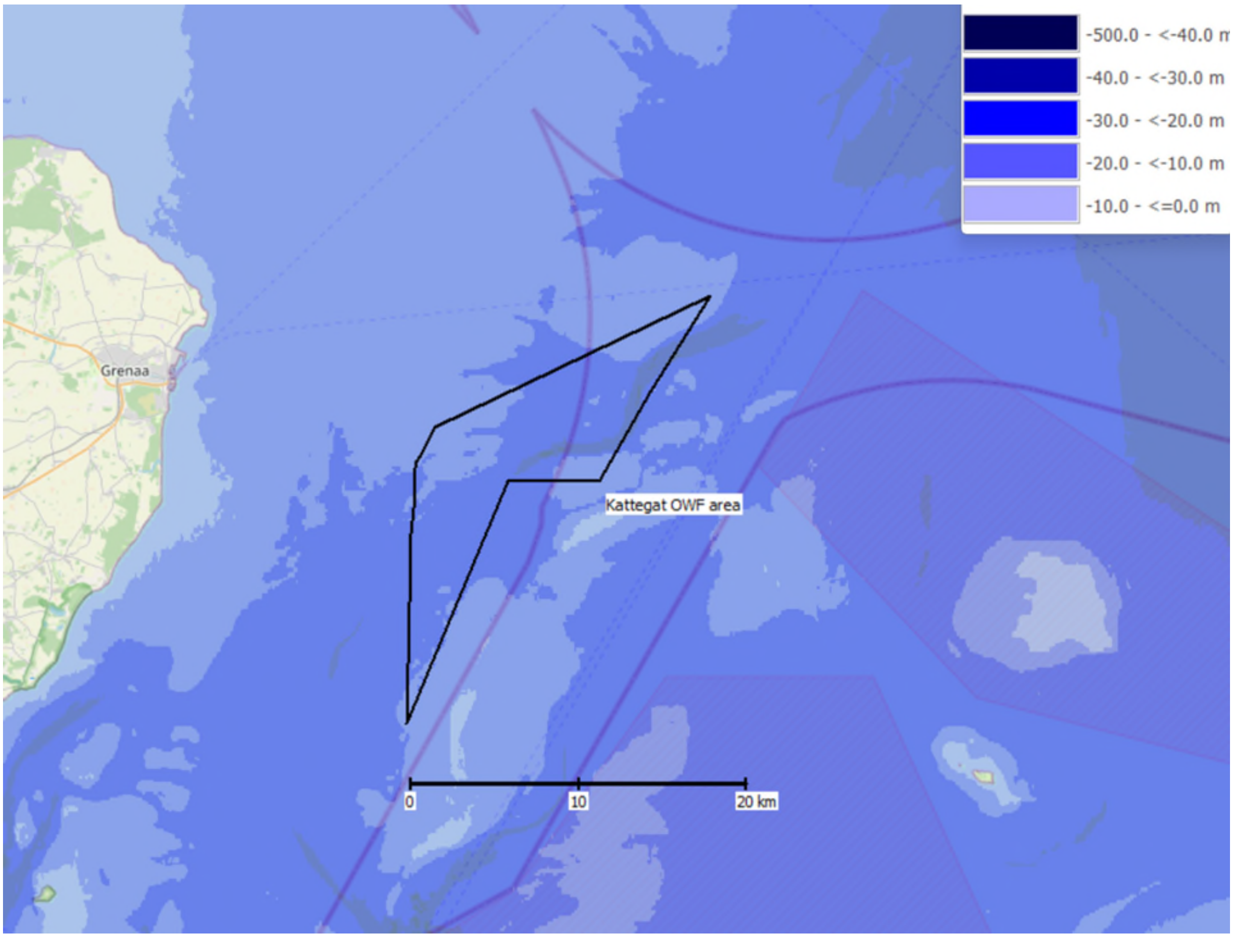


Figure 2. Bathymetric map of Kattegat OWF area (source: EMODnet – 115 m grid resolution)

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) named KG-1-LB, 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 FLS (HS-1-LB), Hesselø FLS (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 – 07/2024	1
Hesselø South (HS-1-LB)	Floating LiDAR System	12 - 300	07/2023 – 07/2024	1
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	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-LB)	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)

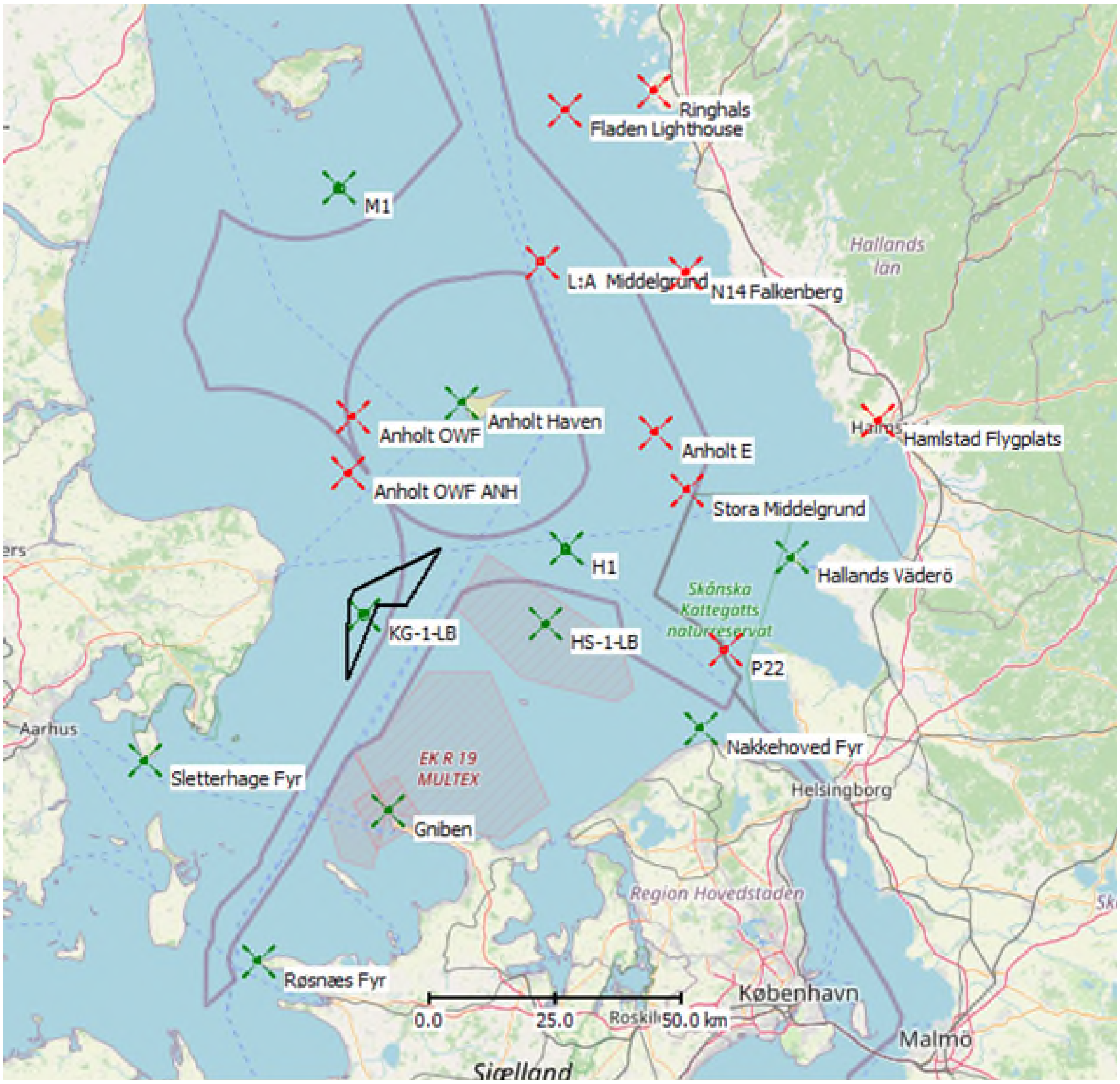


Figure 3. Location of considered measurement stations in Kattegat Sea, with used stations in green and discarded ones in red (black line: Kattegat wind farm area).

Figure 4. Location of measurement stations 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 ended on 04/08/2024.

EMD has received documentation as listed in Table 5.

EMD has received measurement data as monthly batches covering the period 21/07/2023 to 21/07/2024, hence covering 12 consecutive 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 (11 instalments)	Fugro	19/01/2024 – 12/07/2024	11 monthly reports on operation and measurements. Reports available 21 July 2023 – 21 June 2024	[12]
Danish Offshore Wind 2030 – Floating LiDAR Measurements, Service Report, Kattegat and Hesselø South, (4 instalments)	Fugro	20/03/2024 – 30/04/2024	4 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°

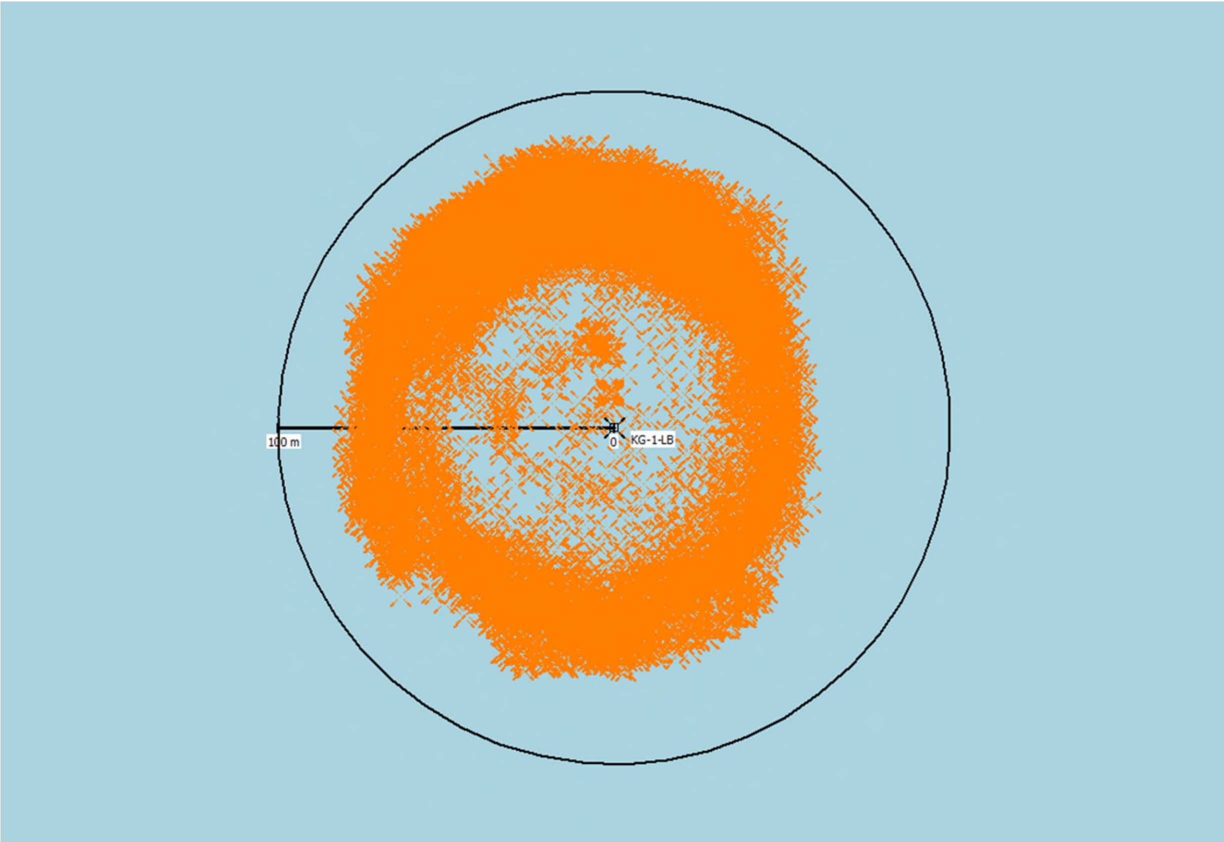


Figure 5. Position logs before recovering (18 February 2024) confirm a drift within 100 m (black circle) of stated location (black "X").

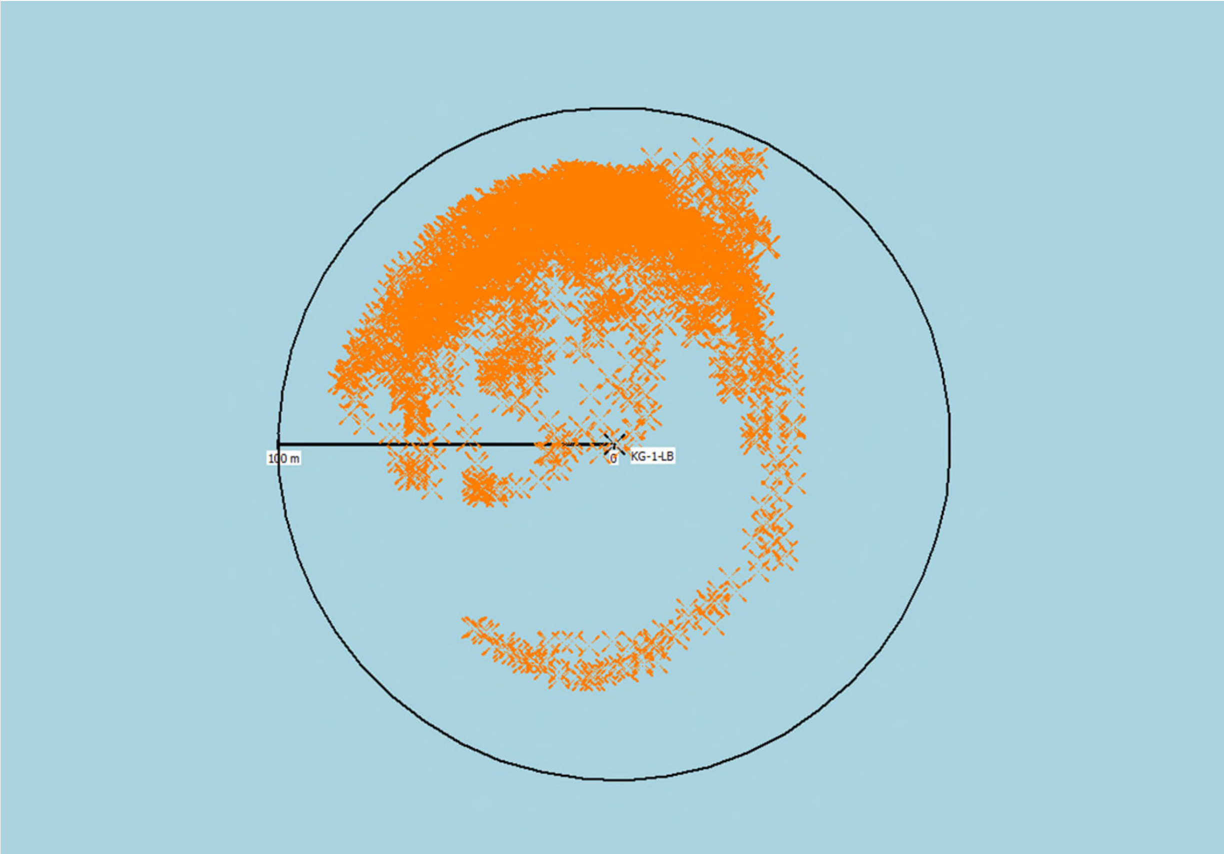


Figure 6. Position logs after redeployment (22 February 2024) confirm that the locations are unchanged (black "X").

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 a sudden 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.

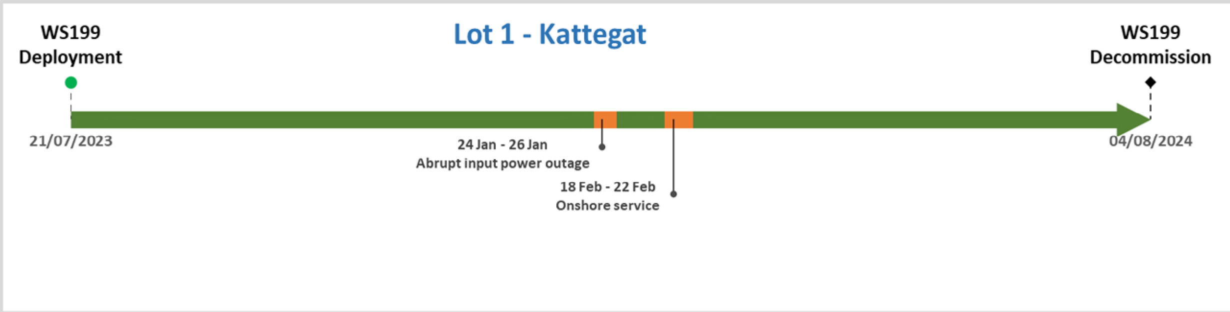


Figure 7. Timeline chart of buoy deployment on Kattegat site (KG-1-LB). Buoy ID (WS199) is indicated, green color marks provided data, orange color marks data gaps.

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_Mxx_WindSpeedDirectionTI.csv”.
- The package counter information was supplied in files named “KG-1-LB_Mxx_WindStatus.csv”.
- Temperature, humidity and pressure data was supplied in files named “KG-1-LB_Mxx_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 KG-1-LB 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.

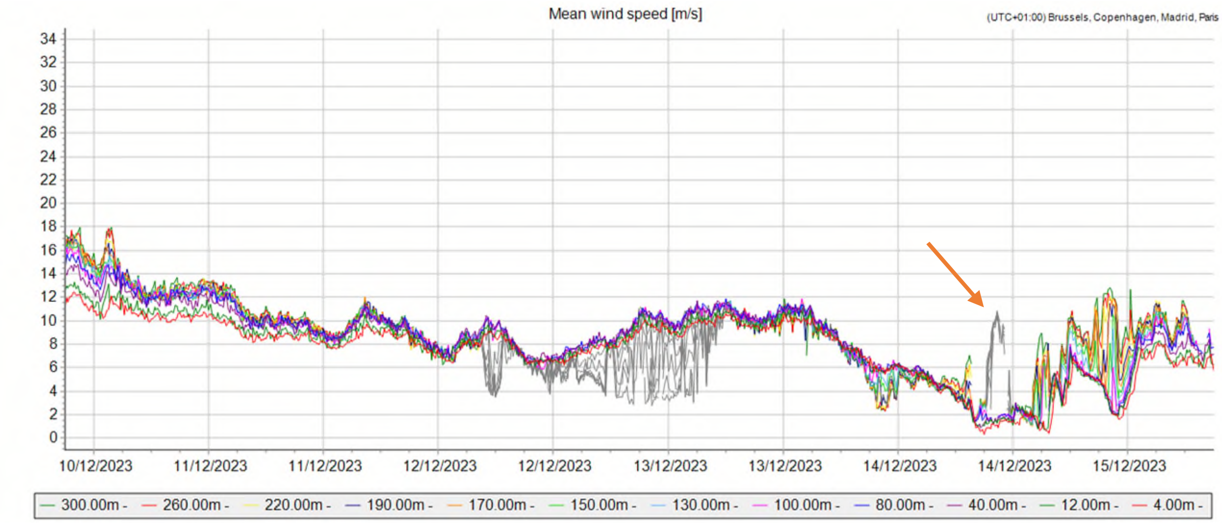


Figure 8. Example of short bursts of high wind speed at tall heights disconnected from wind speed at lower height. KG-1-LB , buoy WS199.

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 KG-1-LB 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 heights 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-LB 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 m 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. The values are the shear exponents α, which are calculated using data from three different heights: 130 m, 150 m and 170 m.

Hour	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
00-02	0.01	-0.09	0.06	0.14	0.15	0.10	0.18	0.07	0.11	0.17	0.13	-0.06
02-04	-0.03	0.00	-0.05	0.06	0.06	0.05	0.11	0.11	0.09	0.18	0.15	0.12
04-06	0.02	0.05	-0.02	0.07	0.09	-0.02	0.08	0.10	0.04	0.16	0.11	0.00
06-08	0.01	0.00	0.04	0.00	0.09	0.03	0.13	0.10	0.11	0.14	0.15	0.01
08-10	0.04	0.02	-0.01	0.06	0.06	0.06	-0.01	0.07	0.09	0.14	0.17	0.09
10-12	0.05	-0.05	0.05	0.04	0.01	0.05	0.08	0.04	0.11	0.17	0.09	0.05
12-14	-0.05	0.04	0.03	0.10	0.07	0.09	0.07	0.06	0.03	0.14	0.12	0.03
14-16	0.02	-0.05	-0.03	0.14	0.10	0.13	0.08	0.03	0.08	0.12	0.09	0.00
16-18	-0.09	-0.14	-0.01	0.14	0.14	0.14	-0.01	0.08	0.14	0.11	0.13	0.11
18-20	0.05	-0.14	-0.04	0.05	0.11	0.09	0.05	0.08	0.08	0.12	0.01	0.03
20-22	0.00	0.10	-0.05	0.10	0.06	0.11	0.12	0.12	0.11	0.15	0.06	0.02
22-24	0.06	0.03	-0.05	0.08	0.10	0.08	0.18	0.09	0.12	0.14	0.19	-0.03
All	**0.03**	**0.00**	**0.00**	**0.08**	**0.08**	**0.07**	**0.10**	**0.08**	**0.09**	**0.14**	**0.12**	**0.03**

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

MEASUREMENT HEIGHT [m]	CORRELATION COEFFICIENT, r [%]
12	91.3
40	92.4
80	92.4
100	92.8
130	93.1
150	93.5
170	93.8
190	94.1
220	94.3
260	94.6
300	94.8

Table 9. Results of data repair at KG-1-LB.

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	96.6%	96.1%	95.3%	95.1%	94.9%	94.8%	94.7%	94.5%	94.4%
Recovery rate after shear repair	98.2%	96.6%	96.2%	95.4%	95.2%	95.0%	94.9%	94.7%	94.6%
Recovery rate after shear and horizontal repair	100.0%	99.0%	98.6%	98.4%	98.3%	98.2%	98.1%	97.9%	97.9%
Share of repaired data	3.4%	2.9%	3.3%	3.4%	3.5%	3.5%	3.5%	3.5%	3.6%

Note that for the main height of 150 m, the share of data repaired from the vertical extrapolation (shear) is 0.3%. From the horizontal extrapolation, the share of repaired data is 3.0%.

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 at KG-1-LB.

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	12	7.21	7.20	7.16	8.09	2.199
12	12	7.78	7.78	7.71	8.71	2.195
40	12	8.76	8.78	8.73	9.86	2.246
80	12	9.42	9.42	9.39	10.6	2.235
100	12	9.62	9.63	9.59	10.83	2.214
130	12	9.86	9.87	9.84	11.12	2.188
150	12	9.99	10.00	9.97	11.26	2.168
170	12	10.10	10.11	10.08	11.38	2.148
190	12	10.20	10.21	10.18	11.49	2.132
220	12	10.33	10.34	10.32	11.65	2.110
260	12	10.49	10.50	10.47	11.82	2.079
300	12	10.64	10.64	10.6	11.96	2.045

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 data package produced as part of the deliverables.

4.5.3 Wind Direction

The wind direction distribution for the 12 months of measurements is presented in Figure 9. There is a rotation of the wind direction clockwise with increasing height of 10.8 degrees from 40 m to 300 m, amounting to a rate of 0.042 degrees/m (Figure 10).

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

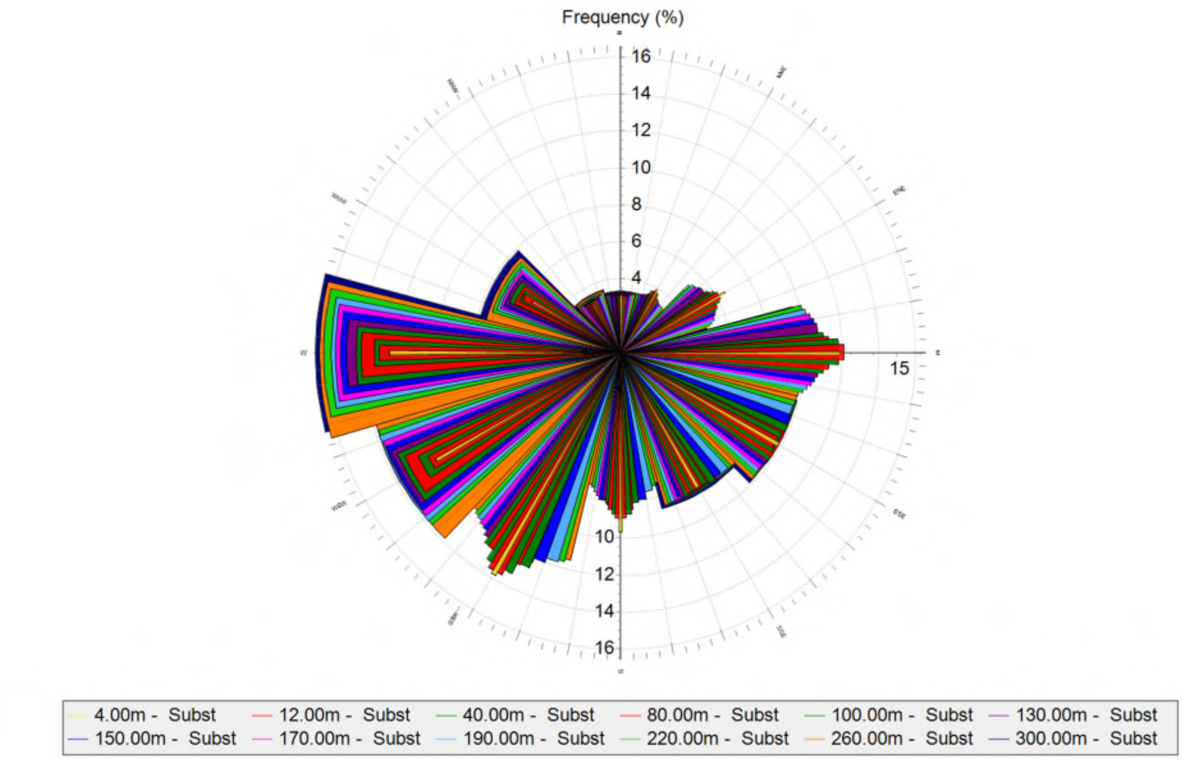


Figure 9. Directional distribution at selected heights of KG-1-LB LiDAR measurements.

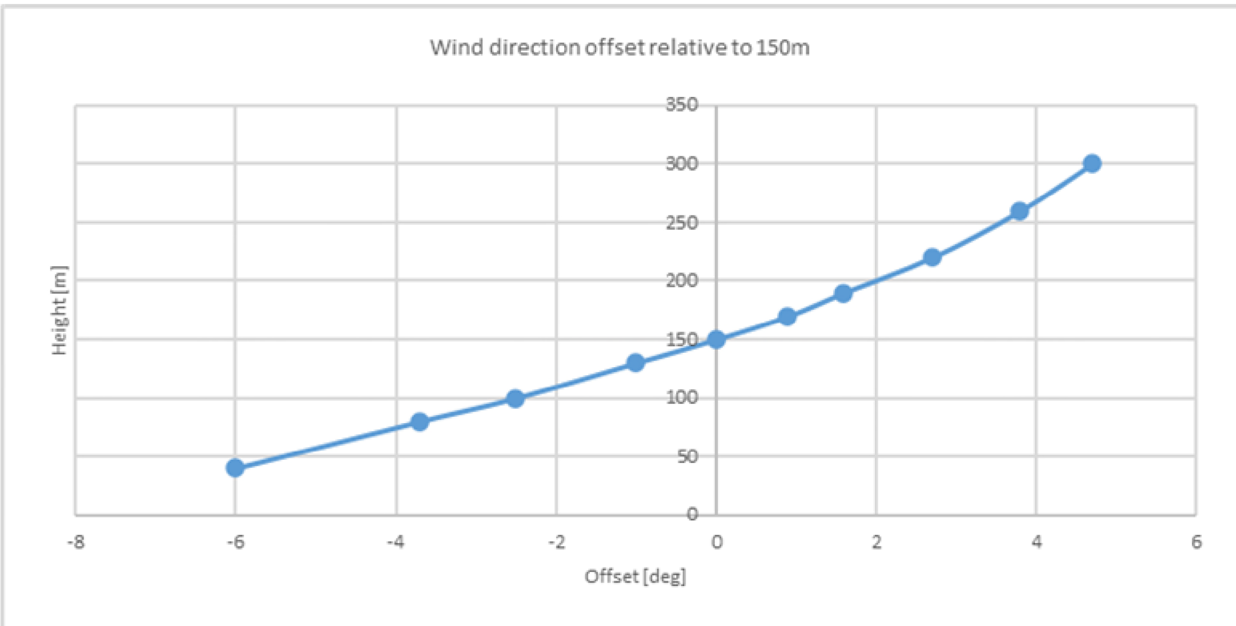


Figure 10. Rotation of wind direction relative to 150 m measurements at KG-1-LB.

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.

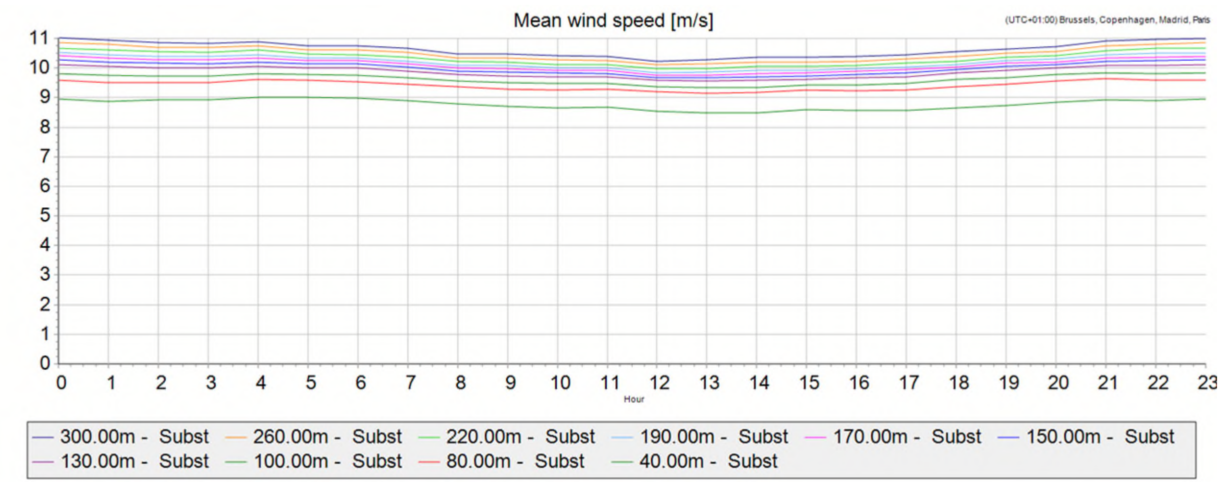


Figure 11. Diurnal wind speed variation at selected heights at KG-1-LB.

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 September.

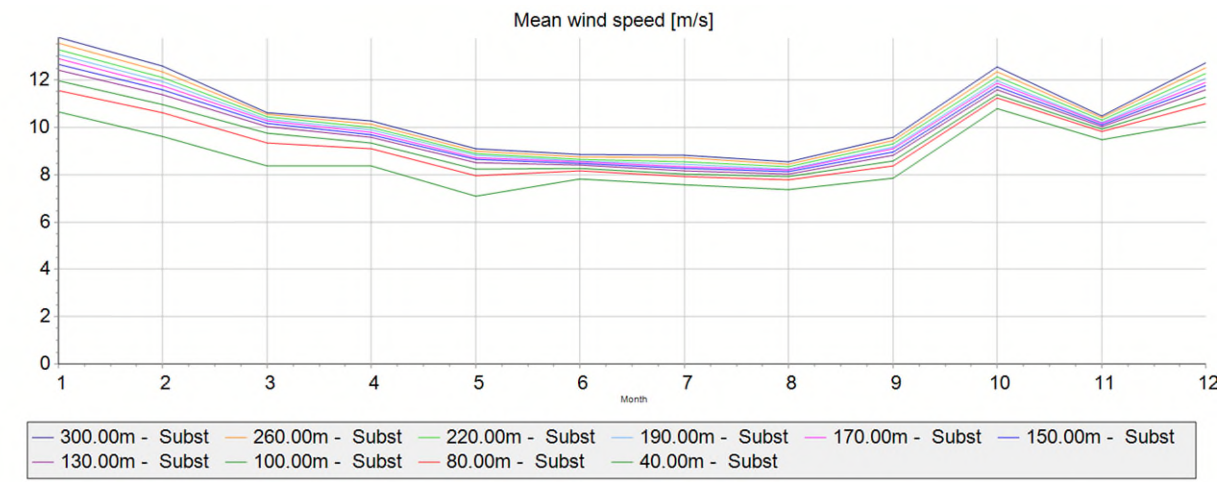


Figure 12. Monthly mean wind speed at selected heights at KG-1-LB.

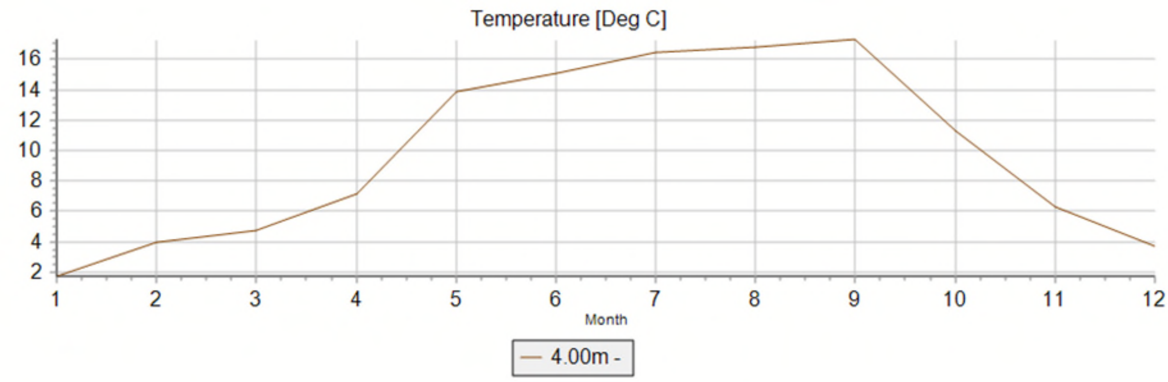


Figure 13. Monthly mean temperature at KG-1-LB.

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 LiDAR 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. This uncertainty is 1.98 % and 1.99 % at 140 m and 160 m height, respectively, hence the average of the two heights is 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 0.26% on wind speed of the synthesized data. At 150 m, the vertically synthesized data contribute 0.31% of the dataset at KG-1-LB (see Table 9). Resulting vertical data repair uncertainty is 0.001% at KG-1-LB at 150 m.

For the horizontal data repair at 150 m, a linear regression method is used to transfer data from the HS-1-LB dataset (Buoy SWLB059/WS190) to the KG-1-LB dataset (Buoy WS199). The transfer function has a mean bias error of -0.20% and an RMS error on hourly basis of 15.7%. Using the same procedure as used for assessing LiDAR verification uncertainty (wind speed binned mean deviation), the transfer function uncertainty is assessed to 4.6%. This additional uncertainty applies to the horizontally synthesized part of the dataset at KG-1-LB (3.0% of the data sets, see Table 9), resulting in an uncertainty component of 0.14%.

Combined, vertical and horizontal data repair contribute 0.14% uncertainty to the measurement dataset at KG-1-LB at 150 m.

The verification, classification and data repair uncertainty are combined into a total uncertainty on the LiDAR measurements at 150 m LiDAR (Table 11).

Table 11. Wind speed measurement uncertainty for KG-1-LB at 150 m ASL.

DATASET	CLASSIFICATION UNCERTAINTY	VERIFICATION UNCERTAINTY	DATA REPAIR UNCERTAINTY	TOTAL MEASUREMENT UNCERTAINTY
KG-1-LB (WS199)	1.41%	1.98%	0.14%	2.44%

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 dataset. 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 3 months 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 31/03/2024.

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. Reference datasets coordinates (in geographic degrees, WGS84) 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)	31/07/2024	31/07/2024	31/03/2024

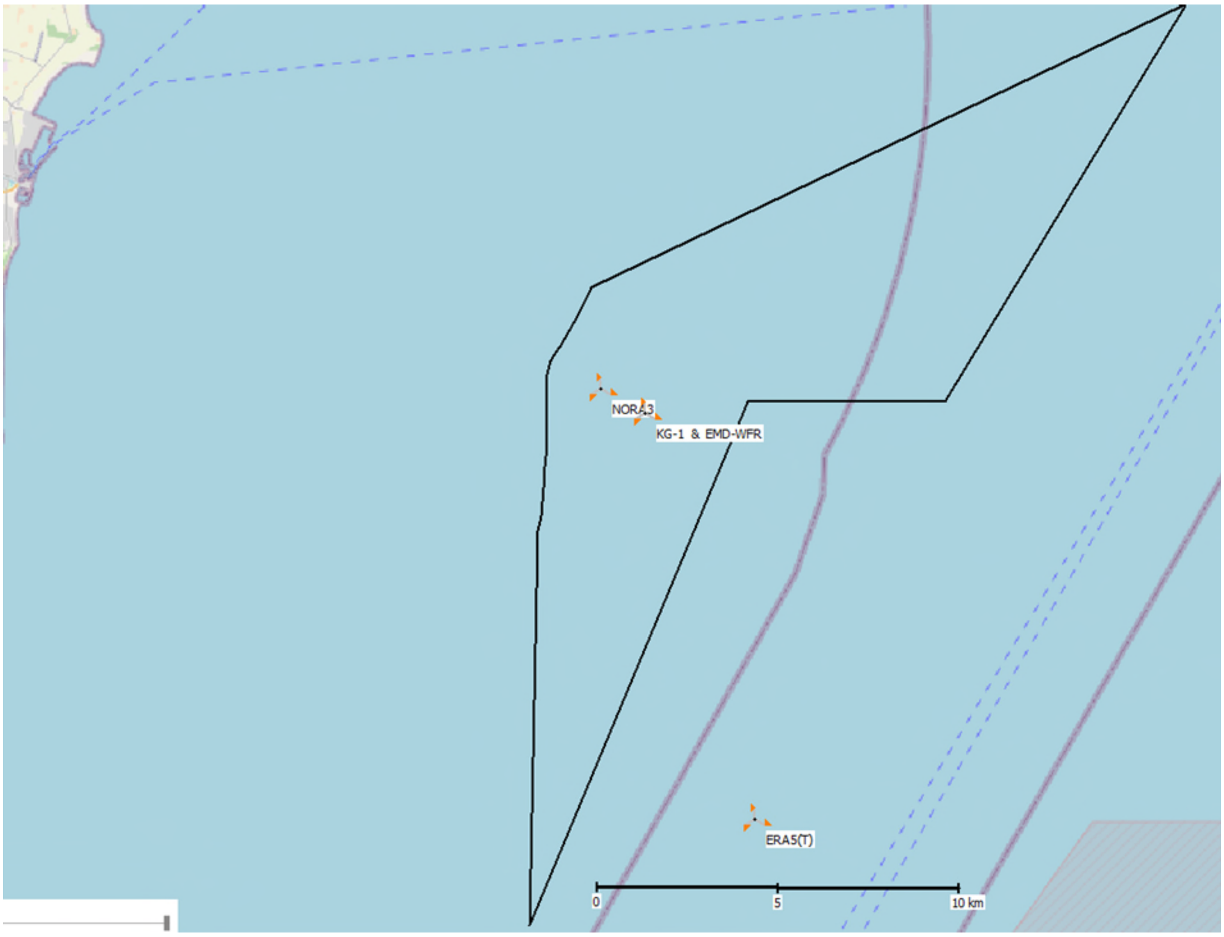


Figure 14. Location of reference datasets near KG-1-LB.

6 Long-term Correction

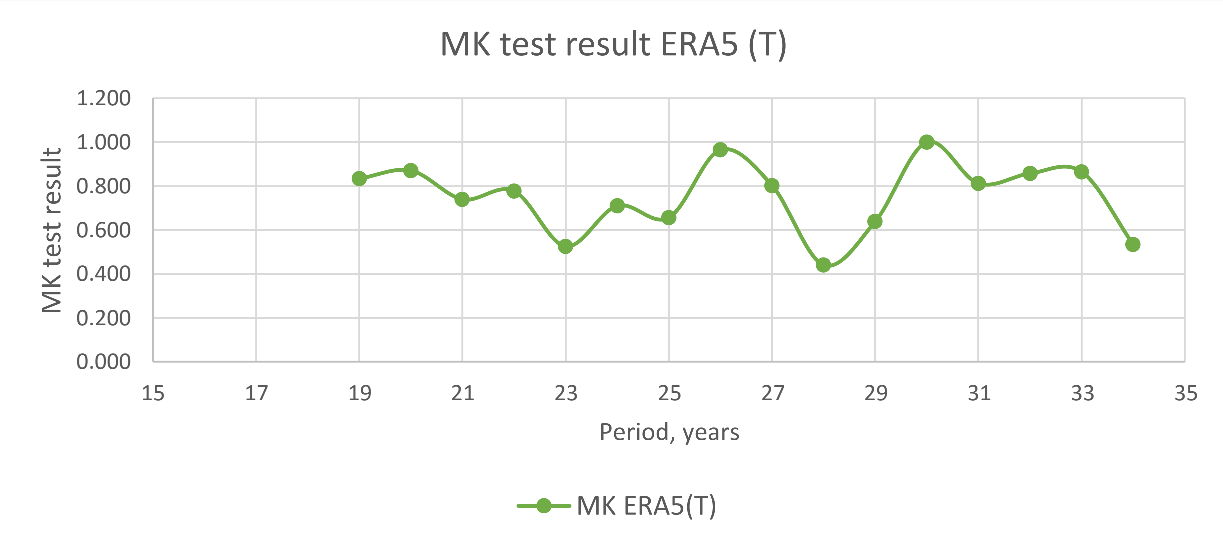
6.1 Review of Reference Data

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 datasets 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 dataset, 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.



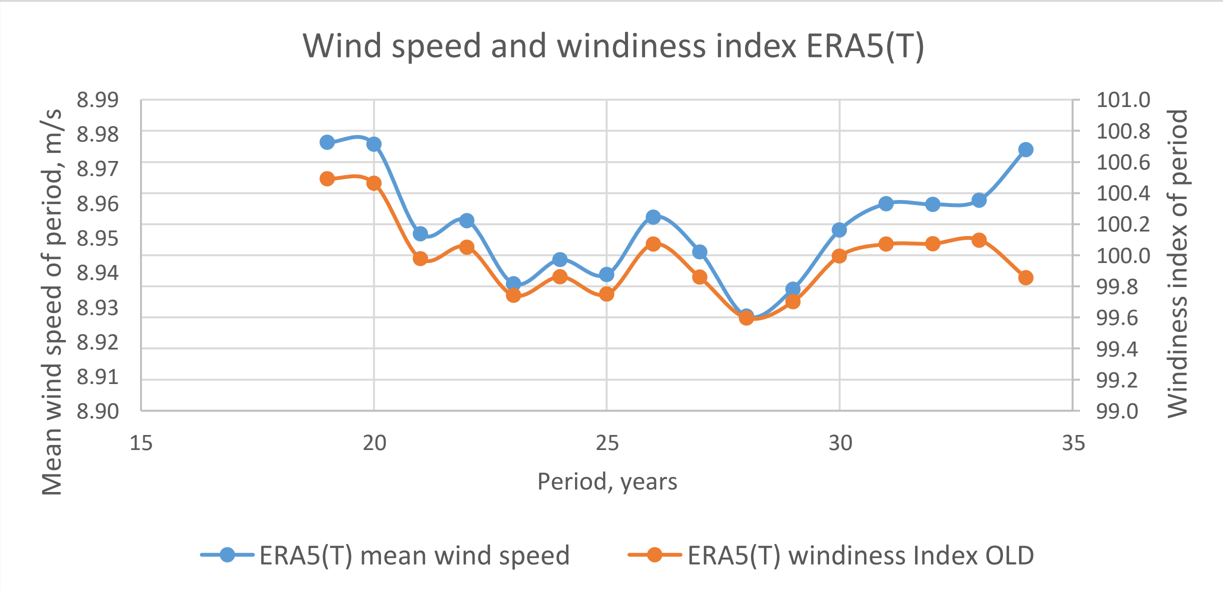


Figure 15. Consistency tests on ERA5(T) data. Period length in years dating back from January 1st, 2024, are analyzed for M-K trend test, mean wind speed and windiness (energy) index of period. Baseline period 1993-2023.

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 both have 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 of EMD-WRF data.

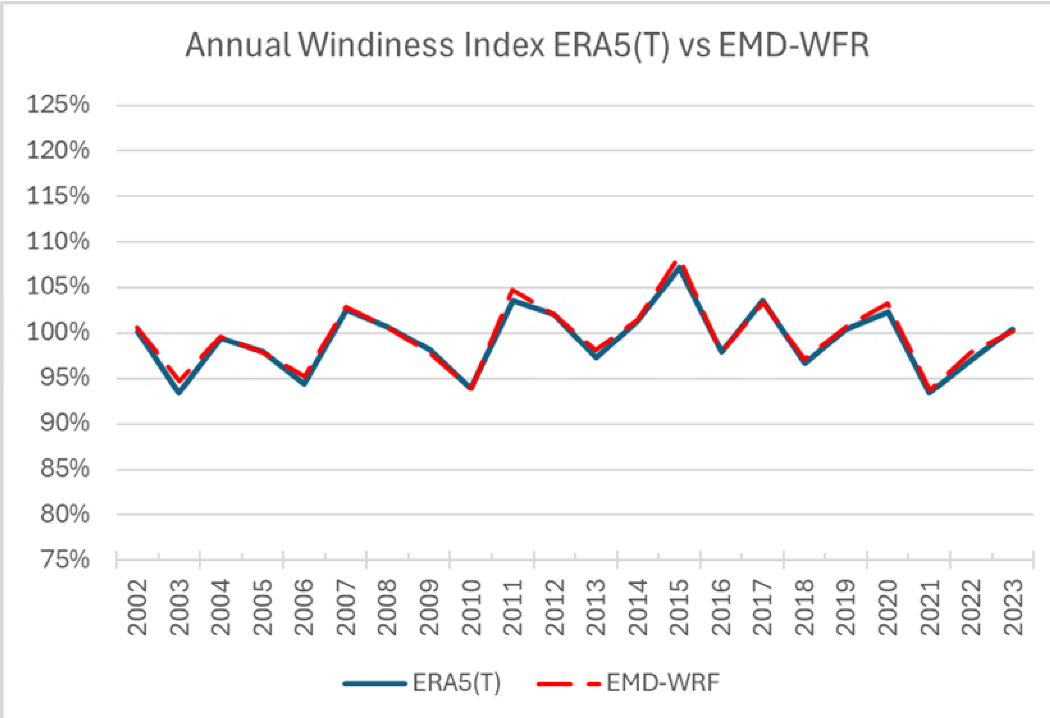


Figure 16. Annual windiness (energy) index for ERA5(T) and EMD-WRF data. Baseline period: 2002-2023.

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 has similar problems. There are here three distinct periods: Until 1999, from 1999 to 2012 and after 2012 with large offsets between each period 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.

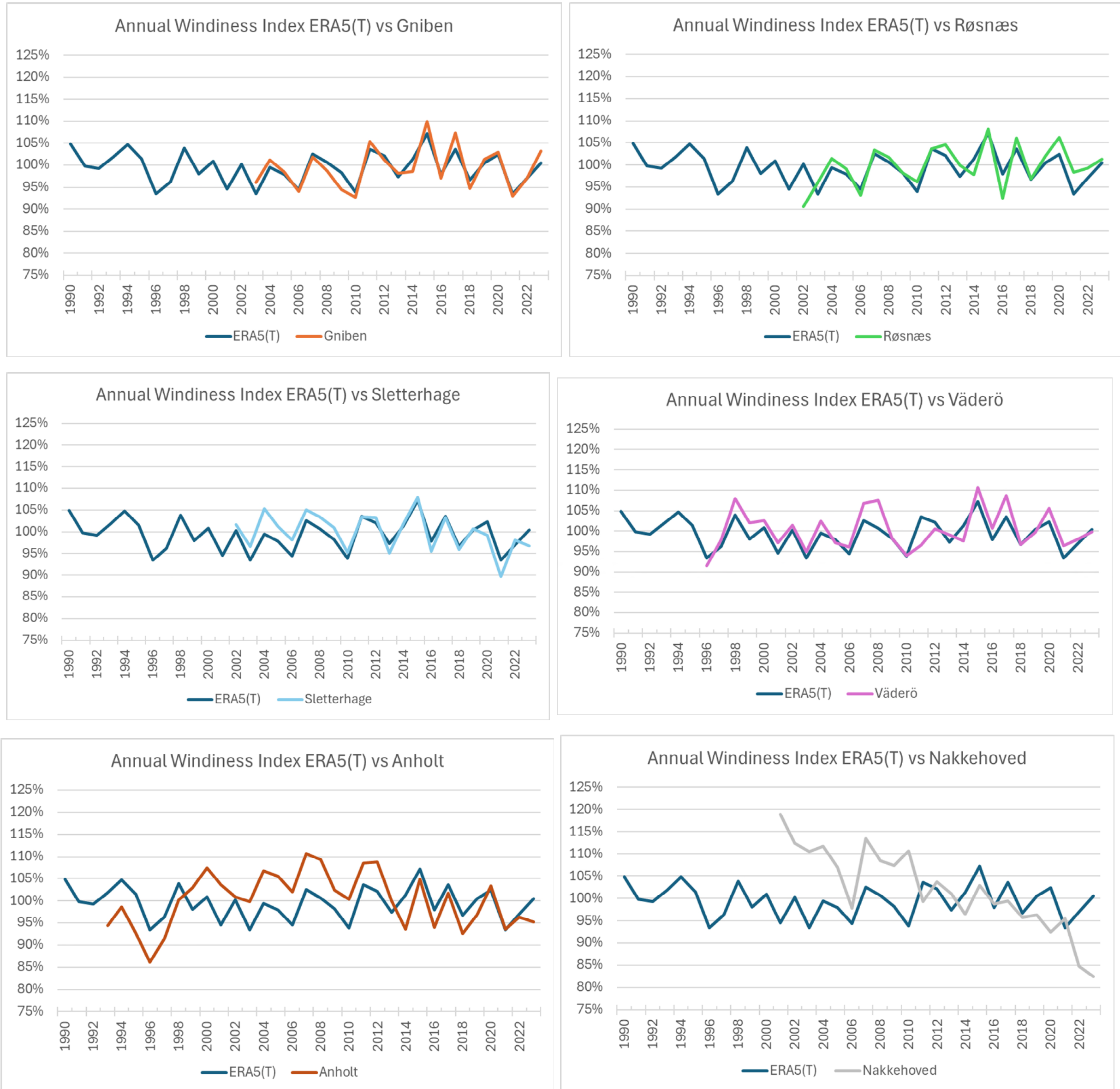


Figure 17. Annual windiness indices for a selection of secondary meteorological stations.

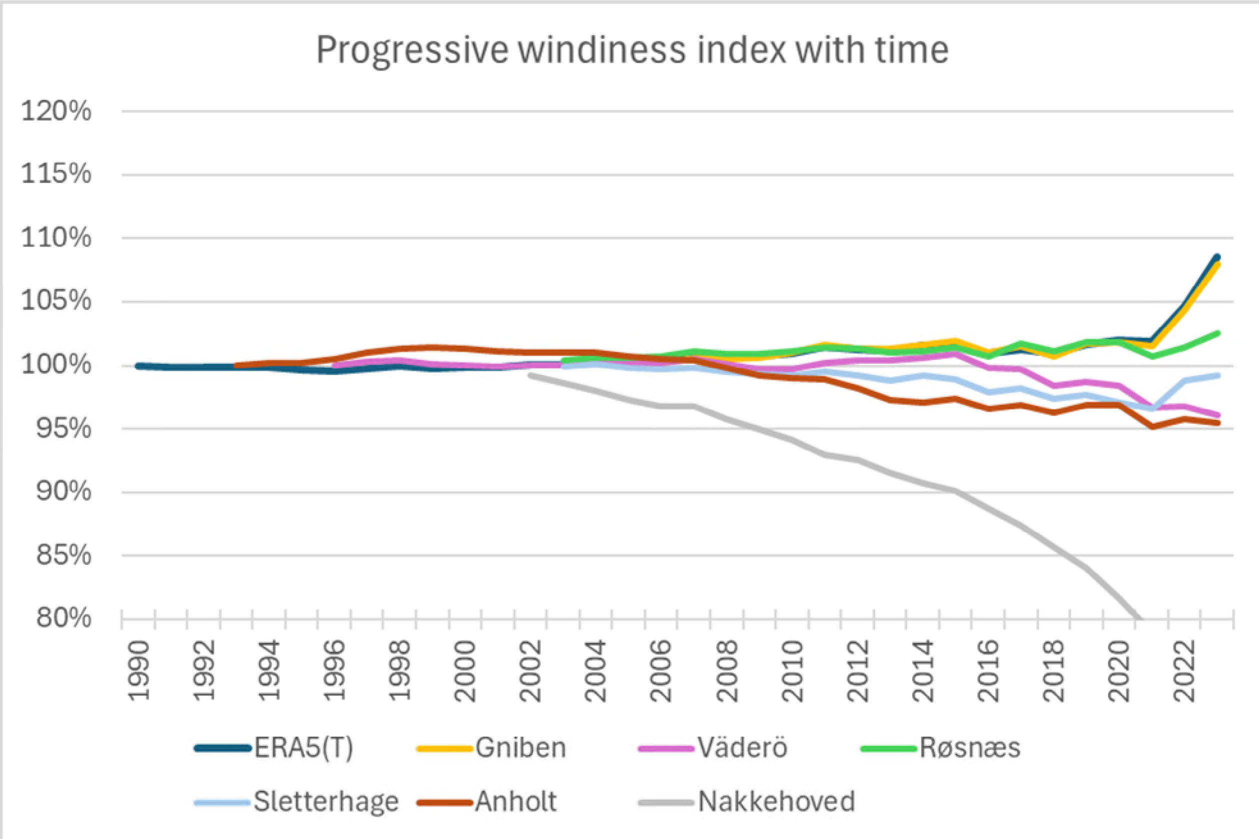


Figure 18. Progressive windiness index with time. The index of each year is the average of all following years.

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 datasets with the LiDAR data is equally high for all datasets. NORA3 does not cover the entire measurement period (8.3 concurrent months with the LiDAR). This places it for at a disadvantage compared to the other datasets which are covering the whole measurements period (12 months). 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 0.04 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 ERA5(T) data together with the matrix methodology as described in section 6.2. EMD has decided to proceed with ERA5(T) as reference.

The reference dataset is 22 years of ERA5(T) data at KG-1-LB covering the period 01/01/2002 to 31/12/2023. The dataset is available in the data package where the entire 25-year dataset is submitted.

6.2 Correlation between Onsite and Reference Data

6.2.1 Wind Speed and Energy Correlation

The concurrent period of LiDAR data and ERA5(T) data is 12 months (21/07/2023 to 21/07/2024).

The correlation of the wind speed between LiDAR measurements and ERA5(T) 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 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 represents the match in seasonal variation in production output between reference and local data.

Table 13. Correlation coefficient r between the reference data (ERA5(T), 100 m) and the onsite floating LiDAR (KG-1-LB) data at 150 m ASL.

REF: EMD-WRF	KG-1-LB
Wind Speed Correlation, r [%] hourly	94.4
Wind Energy Correlation, r [%] monthly	99.4

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 ERA5(T)data an average deviation in wind direction was found within 0.1˚, confirming that the measured wind direction is correct.

There is a good match of wind direction roses between the LiDARs (150 m) and ERA5(T) (100 m) concurrent data (Figure 19).

The measurement period does not seem perfectly representative of the long term as shown 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.

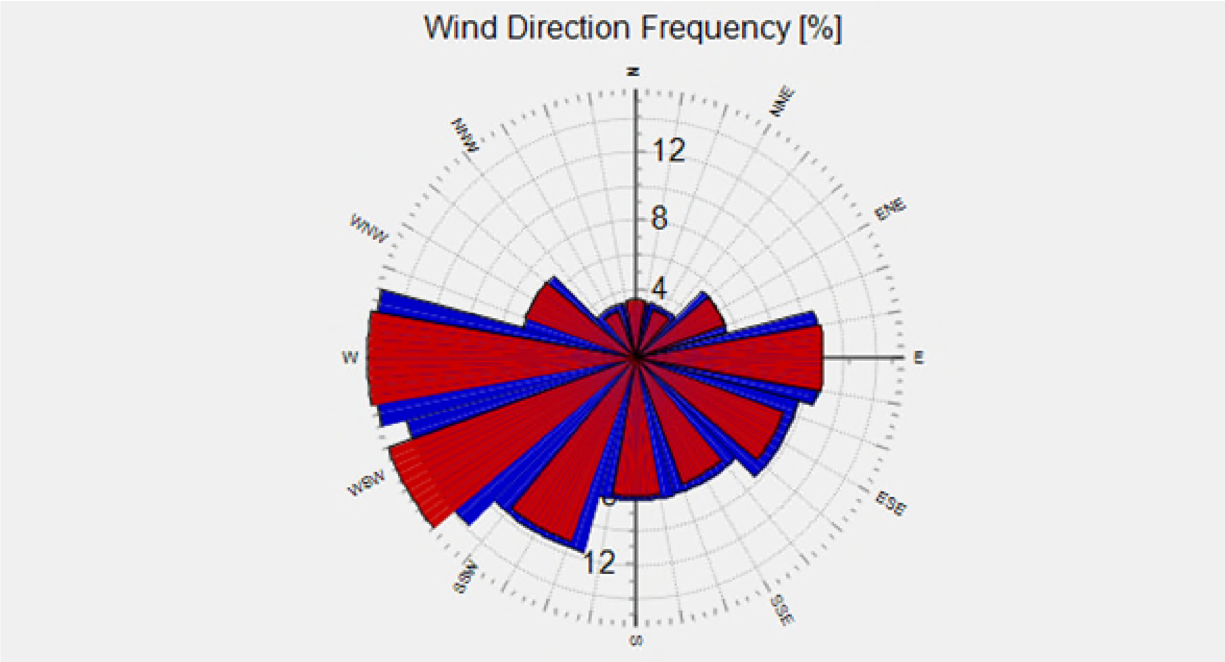


Figure 19. Wind direction roses for the concurrent period of KG-1-LB LiDAR (blue) and ERA5(T) (red) data.

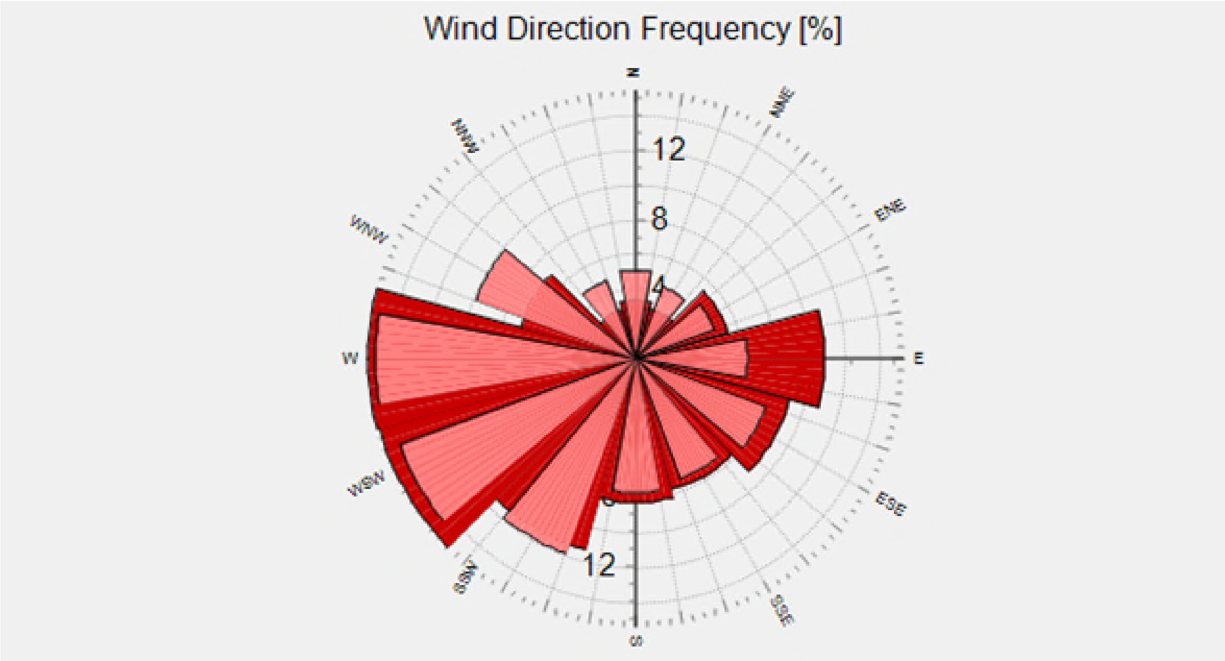


Figure 20. Wind direction roses for ERA5(T) data. Light red represents the entire long-term period and deep red the period concurrent with KG-1-LB LiDAR measurements.

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].

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 on every second day of the dataset 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 for both training and testing, 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. This relationship matrix is applied to all the long-term wind data to determine the estimated site wind climate data. This method corrects for changes in both wind speed and wind 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: ERA5(T) LOCAL DATA: KG-1-LB, 150M	LINEAR REGRESSION	NEURAL NETWORK	MATRIX
MBE, 24-hour slicing test, % production	1.38	3.86	1.84
MBE, Concurrent period test, % production	0.33	1.87	0.37
Kolmogorov-Smirnov test, %	3.14	2.62	0.67
Predicted long-term mean wind speed, m/s	9.44	9.55	9.51

The results of the long-term correction performed with EMD-WFR and matrix method has similar MBE on the self-prediction of production than with ERA5 (T). It is the higher K-S value (1.65 versus 0.67 for ERA5(T)) which speaks in favour of the results obtained with ERA5(T) rather than with EMD-WFR. The long-term mean wind speed predicted with EMD-WFR data of 9.50 m/s is still very close to the final long-term wind speed predicted with ERA5(T) of 9.51 m/s.

The artificially generated time series from ERA5(T) 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 ERA5(T) data at the closest height of a given LiDAR height is used for the long-term correction. Similar to the 100 m data, the ERA5(T) data at 10 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	7.48	7.5	8.46	2.33
40	22	8.48	8.52	9.62	2.38
80	22	8.94	9.04	10.2	2.39
100	22	9.15	9.24	10.43	2.36
130	22	9.38	9.47	10.69	2.30
150	22	9.51	9.6	10.83	2.27
170	22	9.62	9.7	10.95	2.24
190	22	9.72	9.8	11.06	2.21
220	22	9.87	9.93	11.21	2.17
260	22	10.03	10.09	11.4	2.15
300	22	10.17	10.23	11.55	2.11

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.

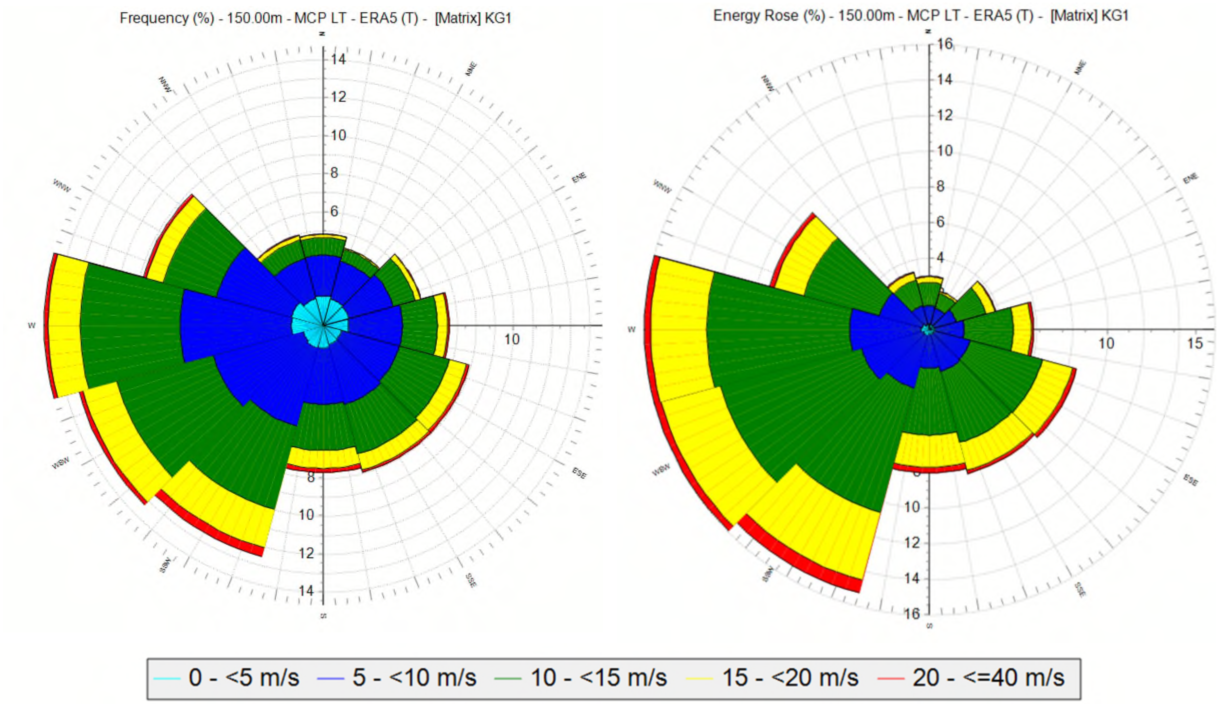


Figure 21. Left: Wind direction distribution of long-term corrected LiDAR data (KG-1-LB) at 150 m. Right: Energy distribution of long-term corrected LiDAR data (KG-1-LB) at 150 m, both divided in wind speed intervals.

6.3.3 Long-term Diurnal Variations

The diurnal long-term wind speed has similar variations with the measured mean wind speed but adjusted to a lower level for the long-term dataset (Figure 22). Note that the anomaly seen for the long-term corrected data at KG-1-LB at around 10:00 is inherent to the ERA5(T) data.

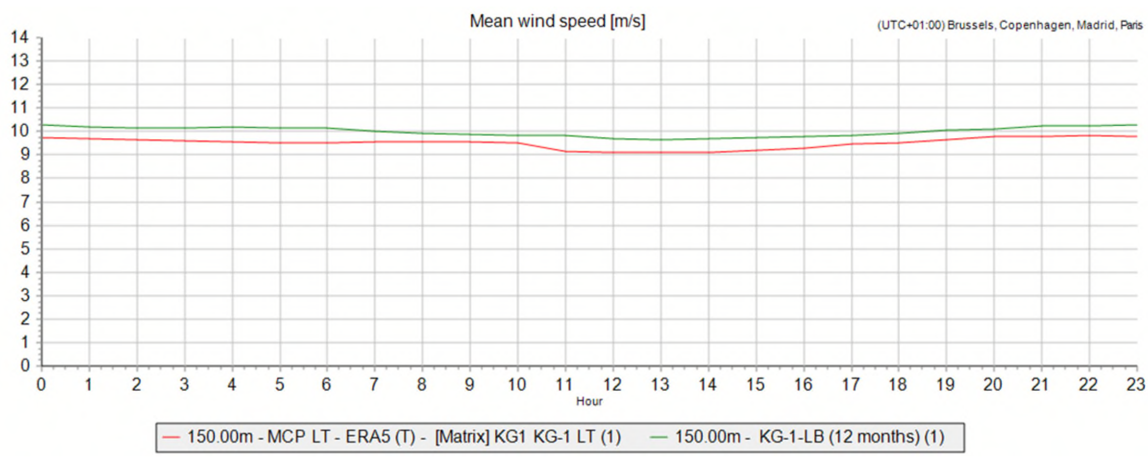


Figure 22. Diurnal wind speed, long-term corrected (red) and observed (green), from KG-1-LB at 150 m.

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 12 months, the seasonal variation of the long-term timeseries is an average of 22 years of data and therefore predictably smoother.

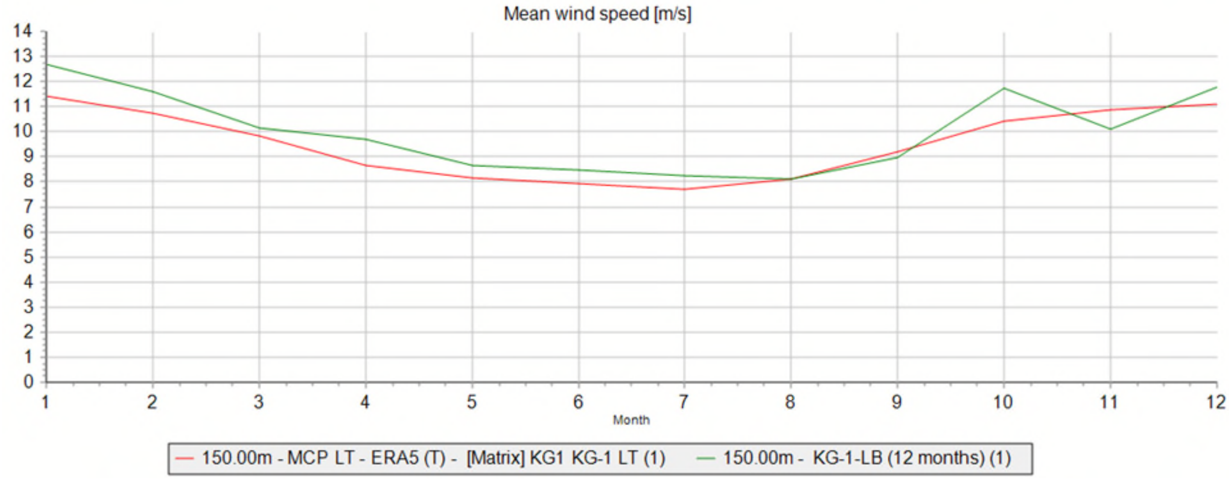


Figure 23. Seasonal variation of long-term corrected dataset (red) and observed dataset at 150 m, KG-1-LB.

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-LB), Hesselø (H1) and Læsø (M1) to the site. The two Hesselø datasets 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 datasets are presented in Figure 24.

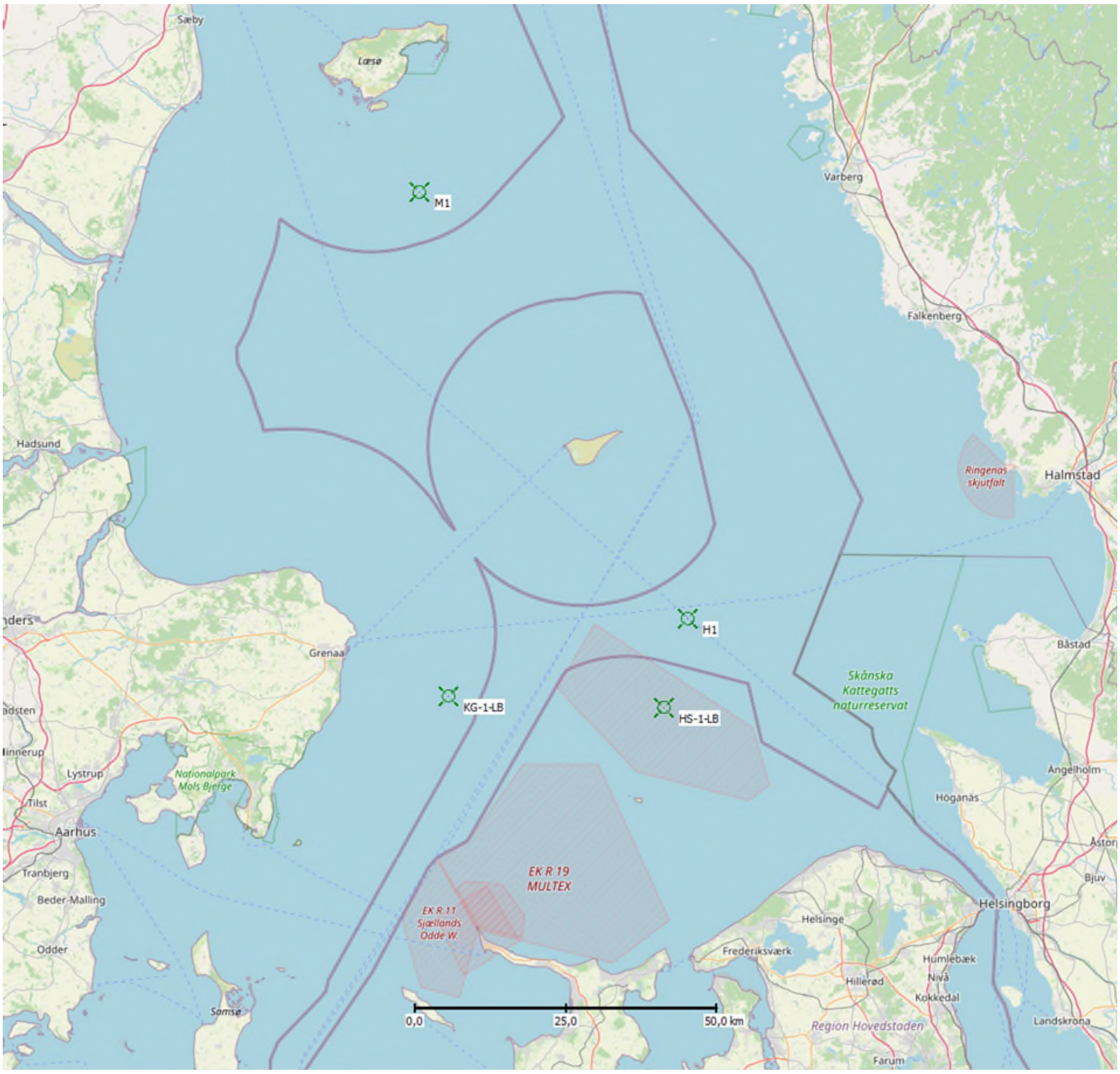


Figure 24. Location of HS-1-LB, H1 LiDAR buoys and Læsø meteorological mast M1 relative to KG-1-LB LiDAR buoy.

For the validation, the secondary datasets 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 of the three onsite dataset, an EMD-WRF dataset was extracted (section 5). The correlation in terms of wind speed, energy content and wind 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-LB)

Based on 12 months of LiDAR measurements on the buoy deployed for the Hesselø South site (HS-1-LB), 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-LB buoy is located 35 km east of KG-1-LB buoy (Figure 24). The HS-1-LB and KG-1-LB buoys are exposed differently to the impact of land. Still the HS-1-LB 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-LB 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-LB buoy location (section 5). The correlation between the HS-1-LB 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-LB.

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

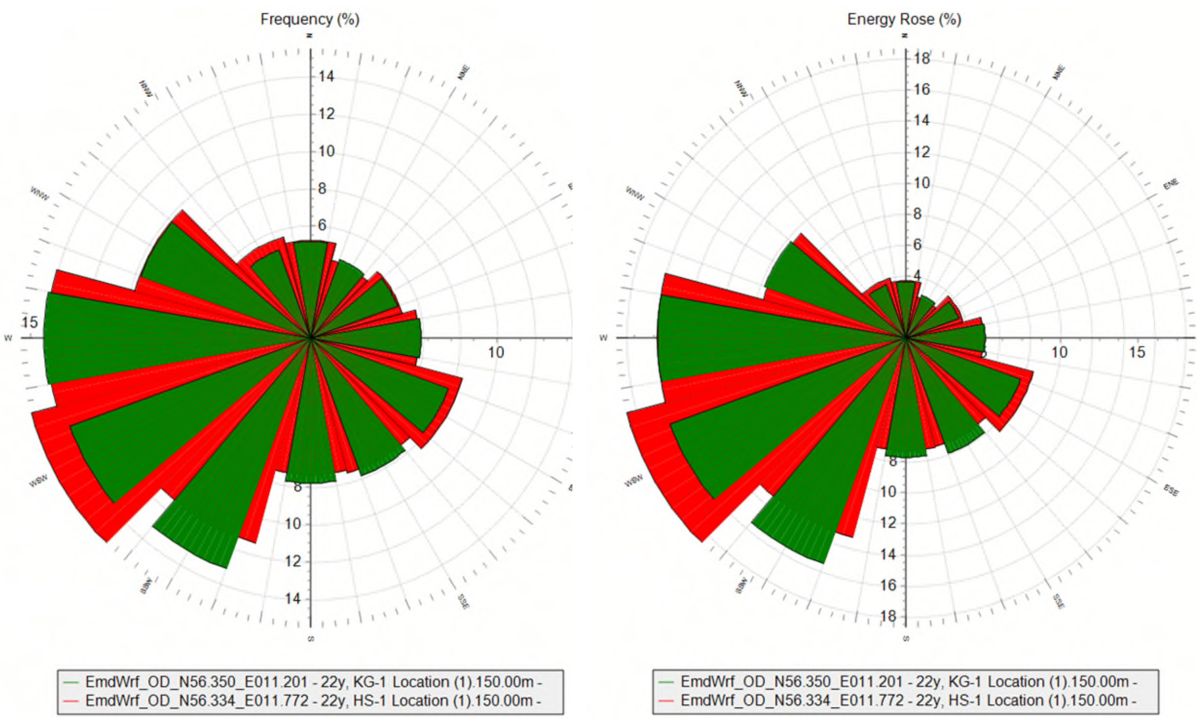


Figure 25. Left: Directional distribution between EMD-WRF at KG-1-LB (green) and EMD-WRF at HS-1-LB (red), 22 years. Right: Energy rose of same two datasets, 22 years.

A translation function is created using linear regression with a translation function for every 1° direction bin, using 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-LB data, creating a 22-year dataset at KG-1-LB.

A comparison of directional distribution of transferred HS-1-LB 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.

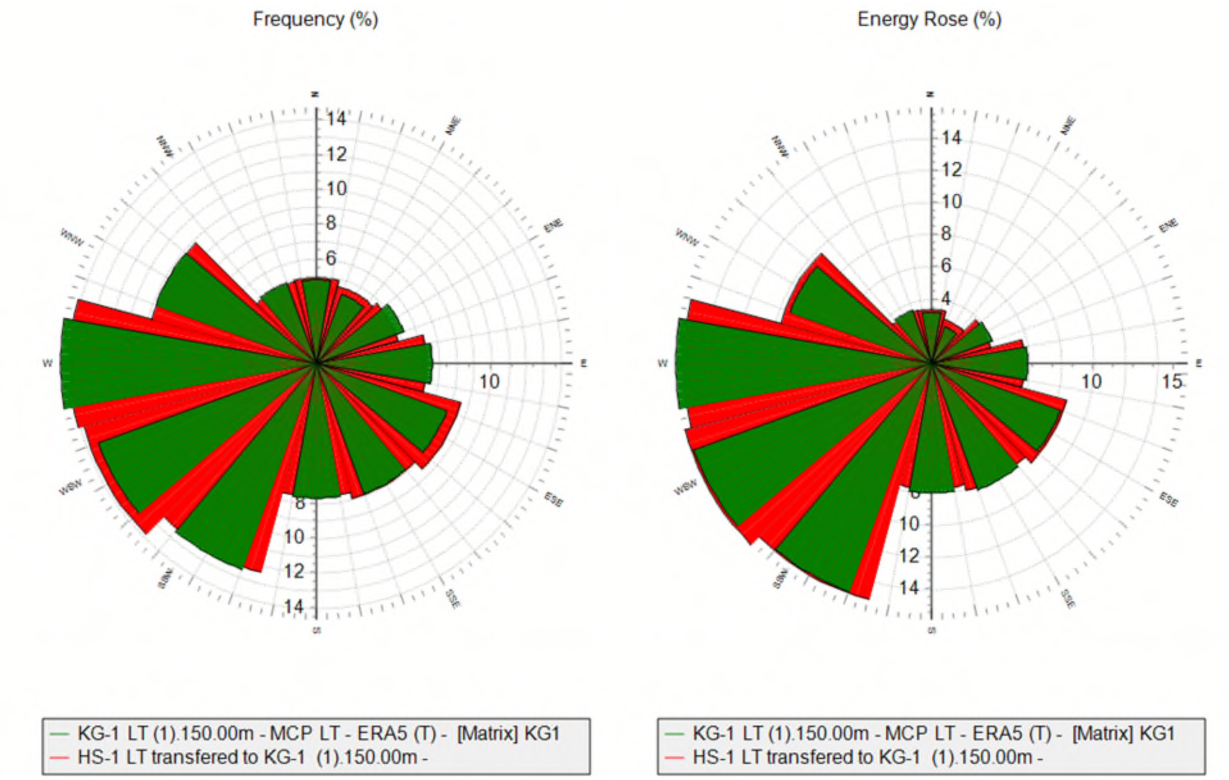


Figure 26. Comparison of directional distribution of transferred KG-1-LB data (green) with HS-1-LB (red) (22 years) at 150 m. Left: by frequency. Right: by energy.

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, at 150 m, HS-1-LB data.

Stage	Arithmetic Mean Wind Speed [m/s]
12 months of measured, HS-1-LB, 150 m	10.05
22 years, long-term corrected HS-1-LB, 150 m	9.51
22 years, transferred to KG-1-LB, 150 m	9.51

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 (shear extrapolated from measurement height at 140 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 of 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, the difference in directional distribution and energy distribution is very small (Figure 27).

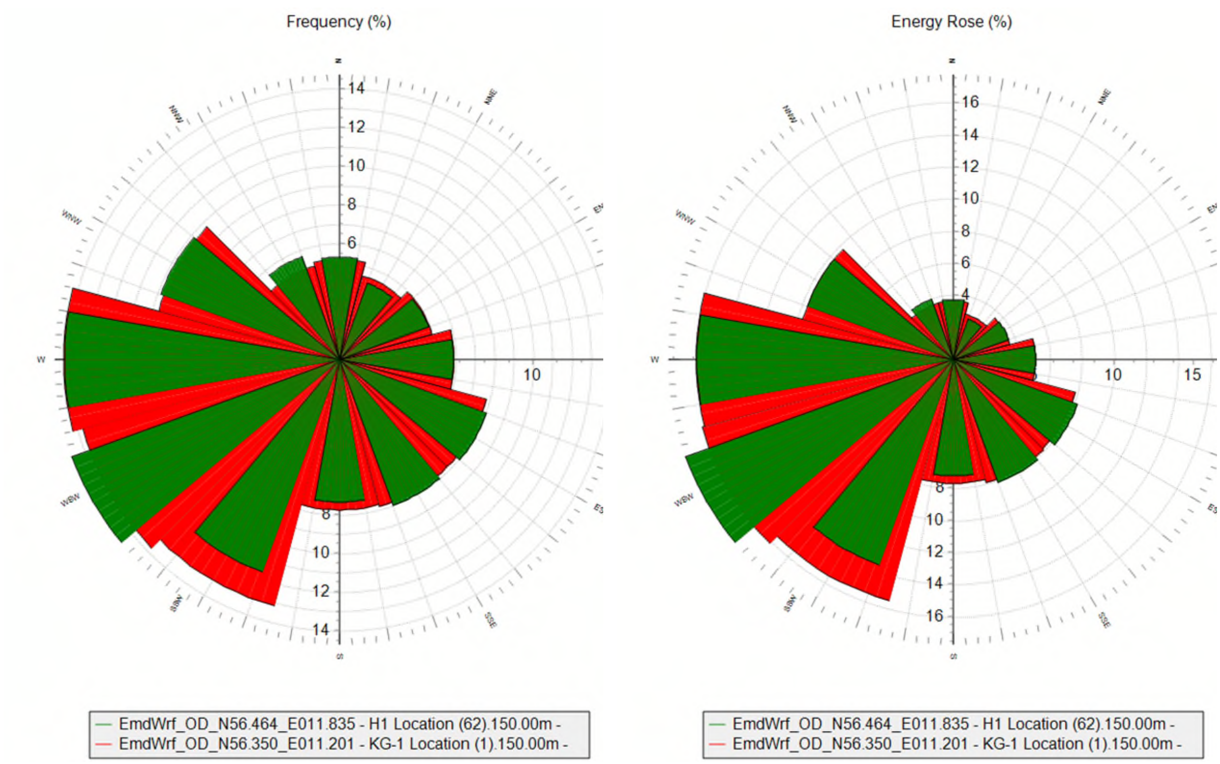


Figure 27. Left: Directional distribution between EMD-WRF at KG-1-LB (red) and EMD-WRF at H1(green), 22 years. Right: Energy rose of same two datasets, 22 years.

A transfer function is created using linear regression. A translation function is created for every 1° direction, using data in a +/-15° sector window. The output of the function is 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 very good but with only minor deviations.

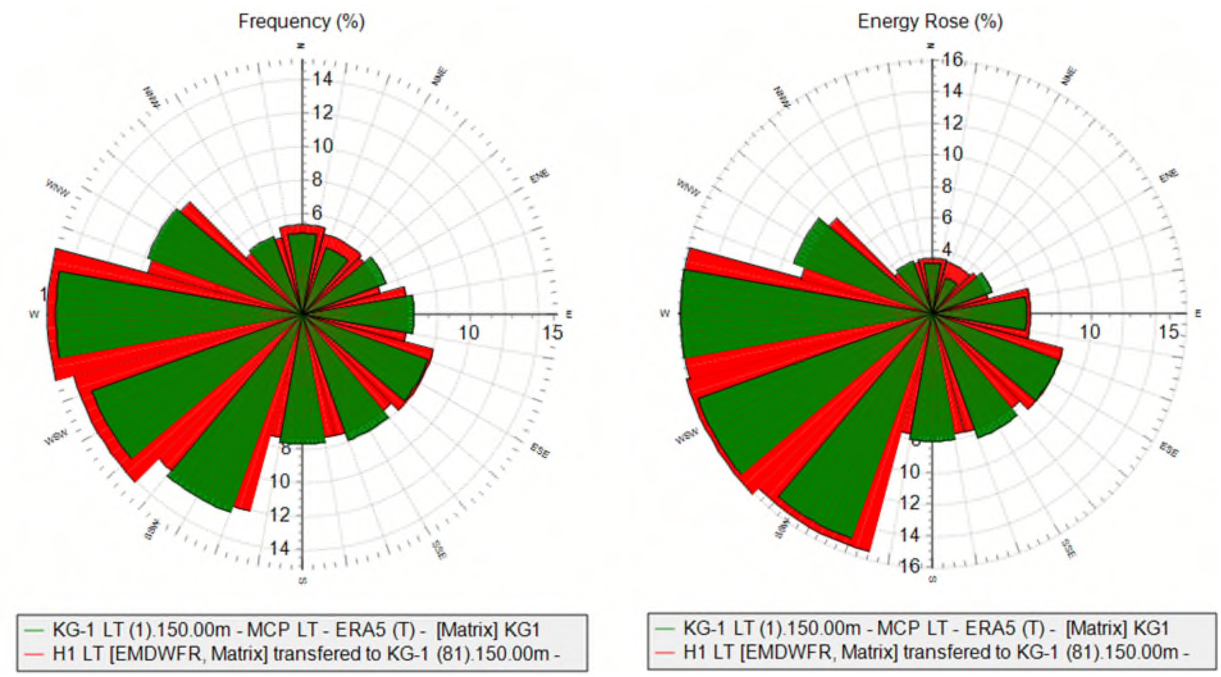


Figure 28. Comparison of directional distribution of transferred H1 data (red) with KG-1-LB (green) (22 years) at 150 m. Left: by frequency. Right: by energy.

The mean wind speed through the steps can be followed in Table 17. The wind distribution and Weibull fit are presented 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	9.51

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.

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

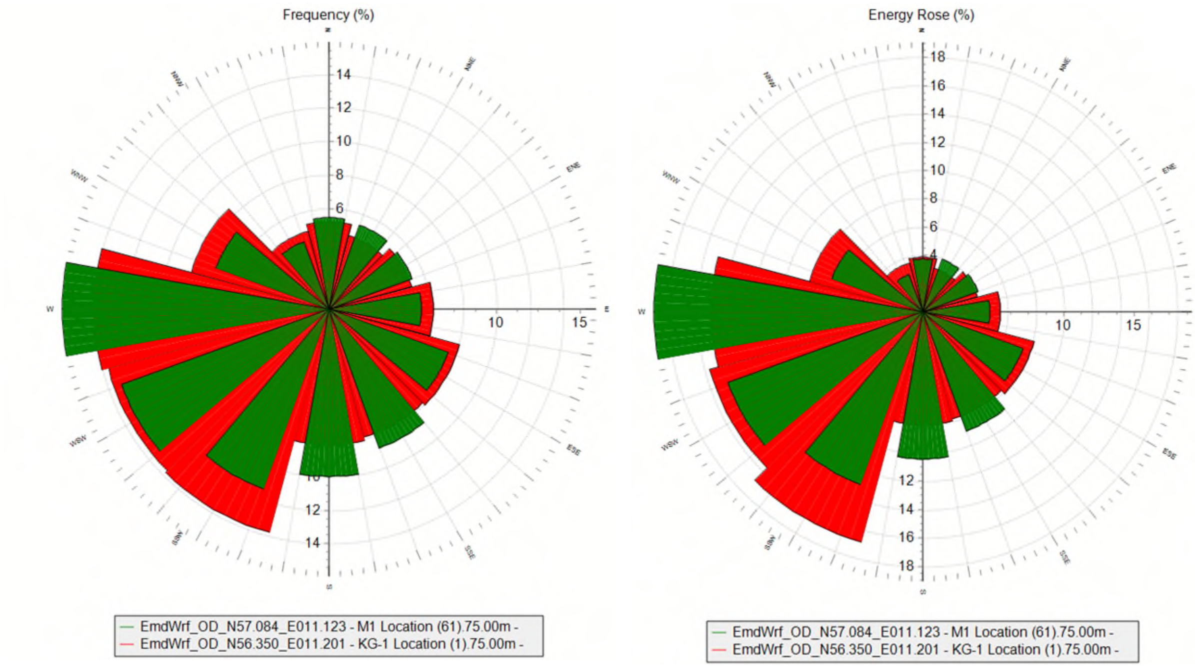


Figure 29. Left: directional distribution between EMD-WRF, 75 m at M1 (green) and EMD-WRF at 75 m at KG-1-LB (red). Right: Energy rose of same two datasets.

A transfer function is created using linear regression. A translation function is created for every 1° direction, using data in a +/-15° sector window. The output of the function is a scale and offset on wind speed as well as an offset on wind direction.

This transfer 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.

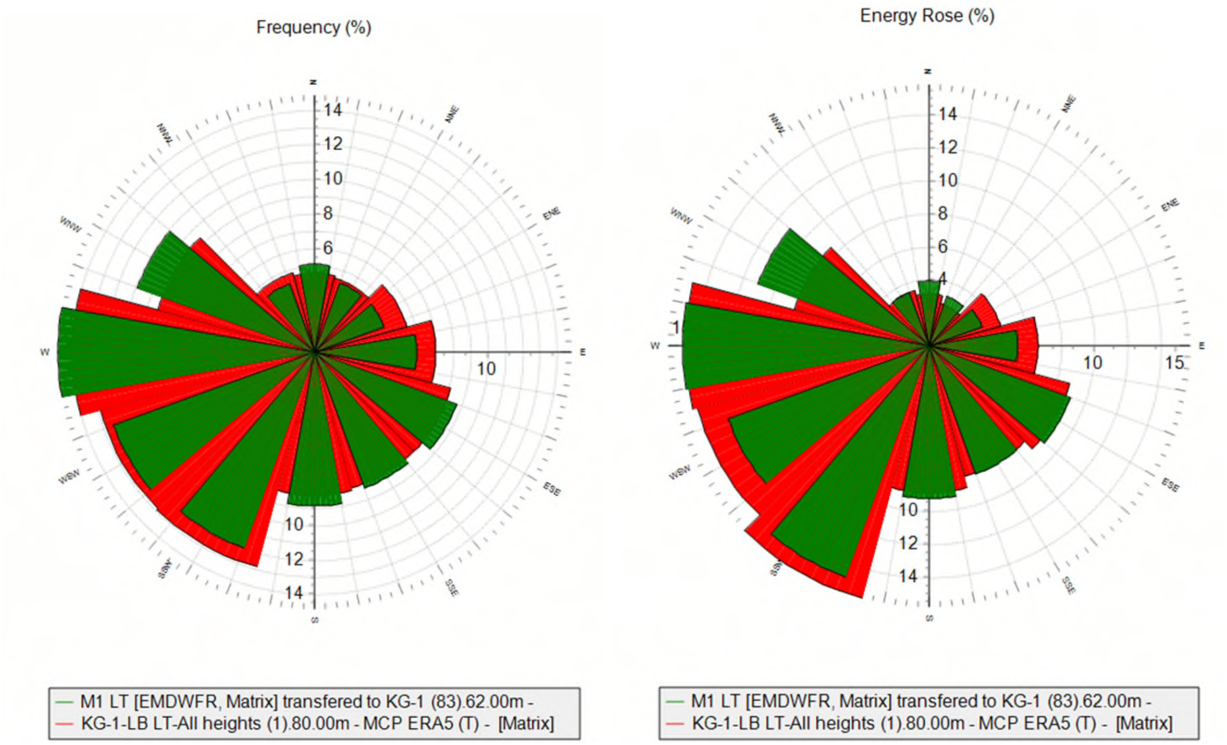


Figure 30. Comparison of directional distribution of transferred M1 data, 62 m (green) with KG-1-LB, 80 m (red) (22 years). Left: by frequency, right: by energy.

The transfered data at 62 m ASL at KG-1-LB had 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 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 used 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, 130 m and 150 m (Table 18).

Table 18. Shear by season, based on long-term corrected measurements at KG-1-LB 100 m to 150 m.

Direction /hour	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
Shear	0.11	0.08	0.08	0.07	0.1	0.11

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	9.56

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-LB), Hesselø (H1) and Læsø (M1) to the site. They cover different directions and distances from the Kattegat OWF and all have advantages and disadvantages as described previously.

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

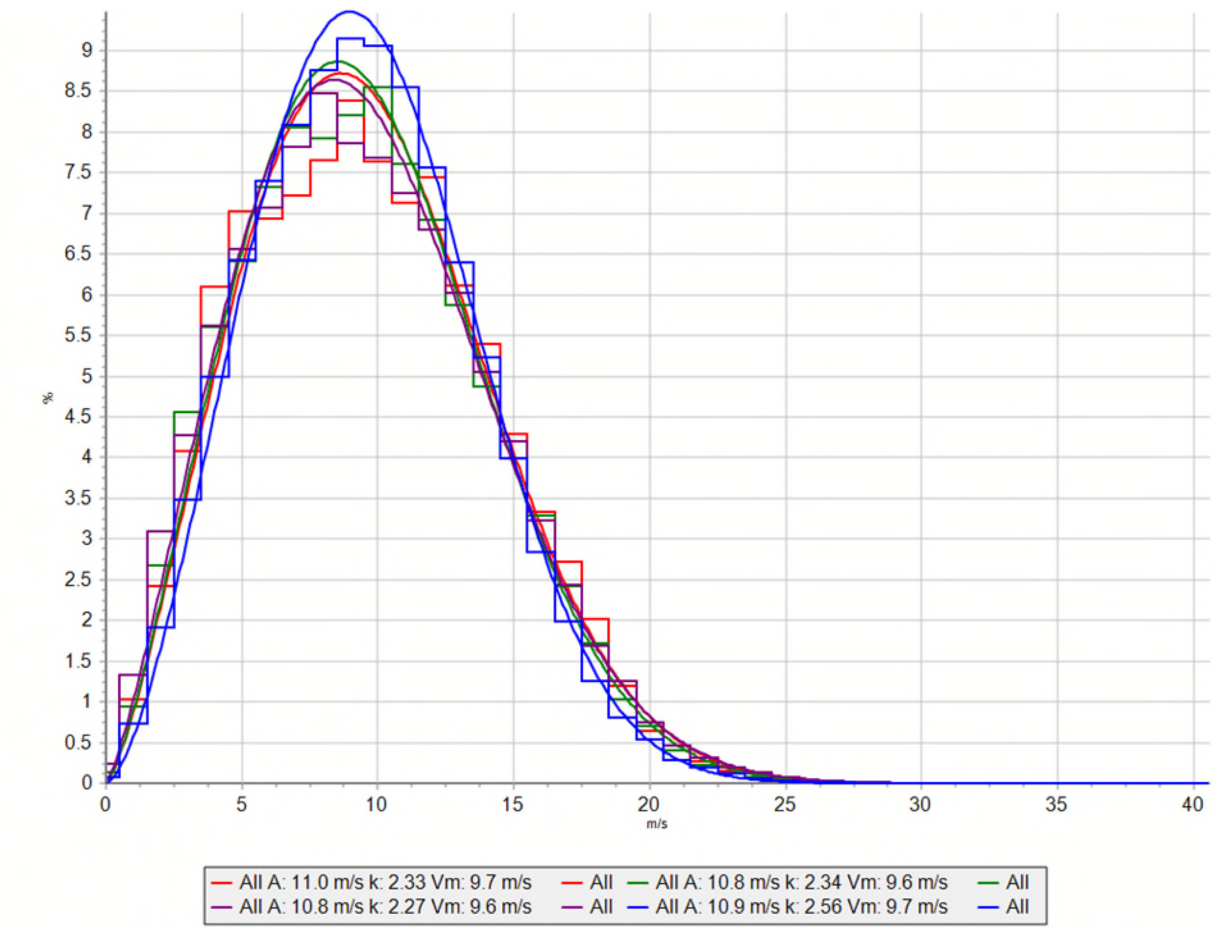
The long-term corrected mean wind speeds of the primary model are supported by the secondary models, especially the one obtained from HS-1-LB and M1 with respectively 0% and -0.5% deviation. Considering all secondary models, the maximum deviation of 1.5% on the mean wind speed at 150 m ASL is inside 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.

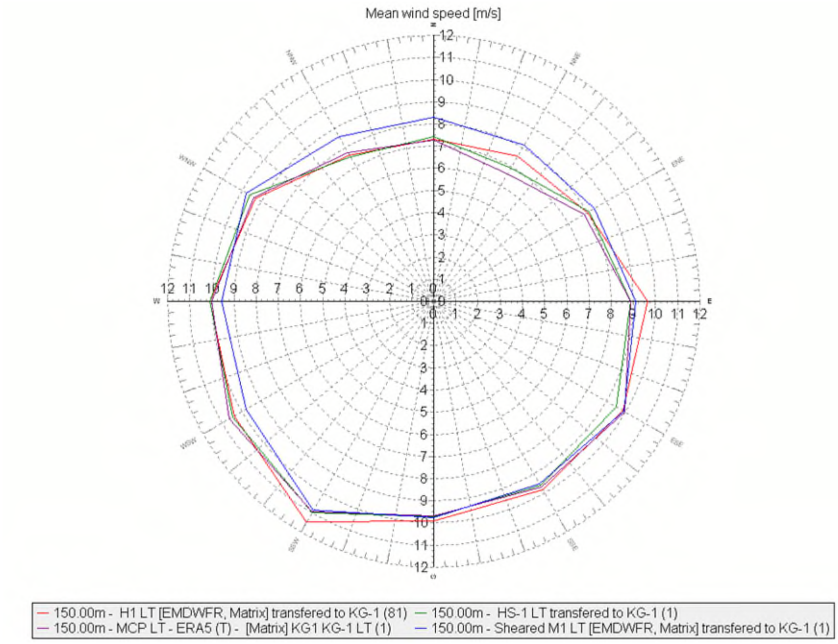
Table 20. Comparison of model results at KG-1-LB, 150 m ASL.

	PRIMARY MODEL	TRANSFERRED HS-1-LB MODEL	TRANSFERRED H1 MODEL	TRANSFERRED M1 MODEL
Wind speed [m/s]	9.51	9.51	9.65	9.56
Wind speed relative to primary model		100.0%	101.5%	100.5%



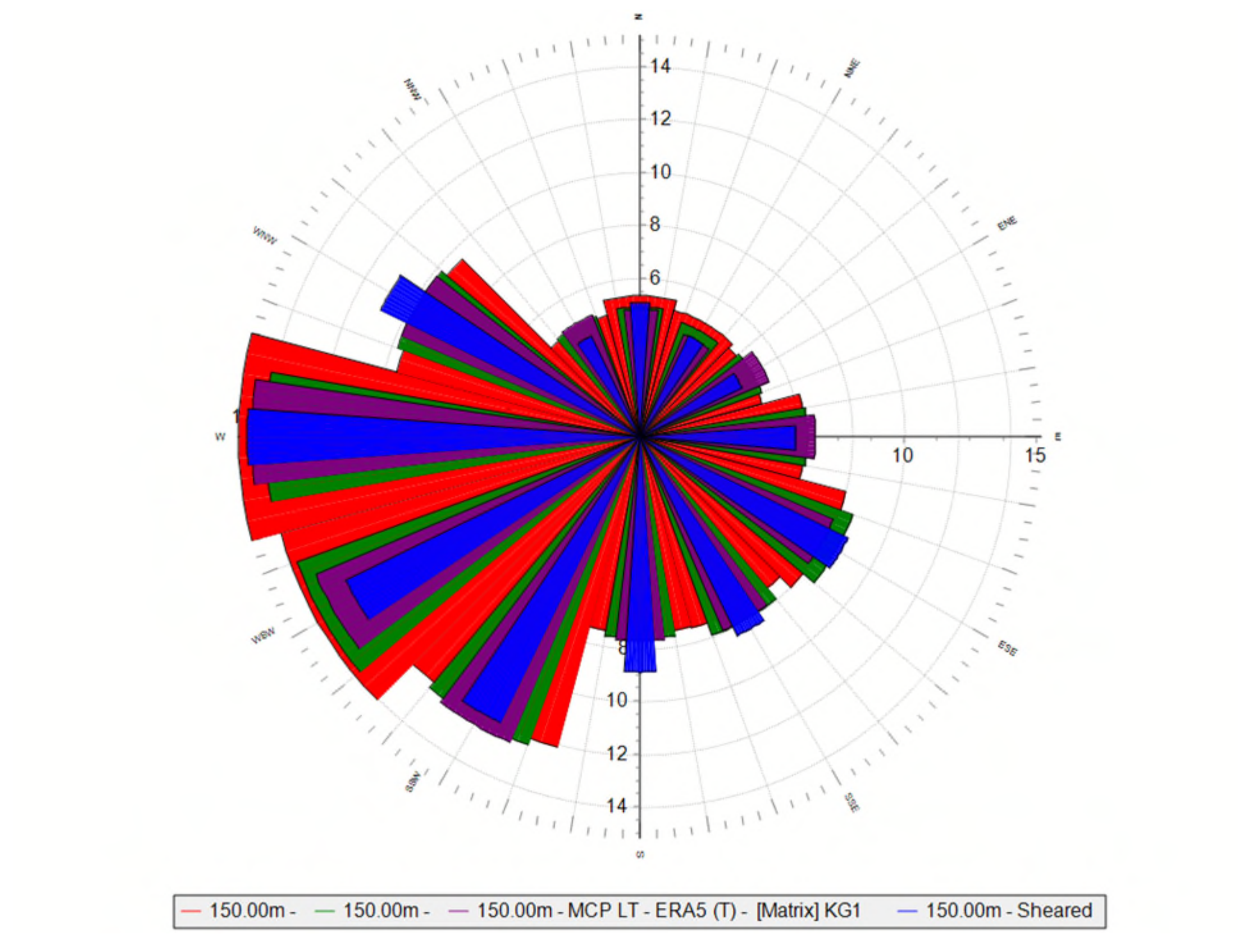
Primary model KG-1-LB *(purple), HS-1-LB model (green), H1 (red) and M1 (blue)*

Figure 31. Wind speed probability function for the four datasets at KG-1-LB position, 150 m ASL.



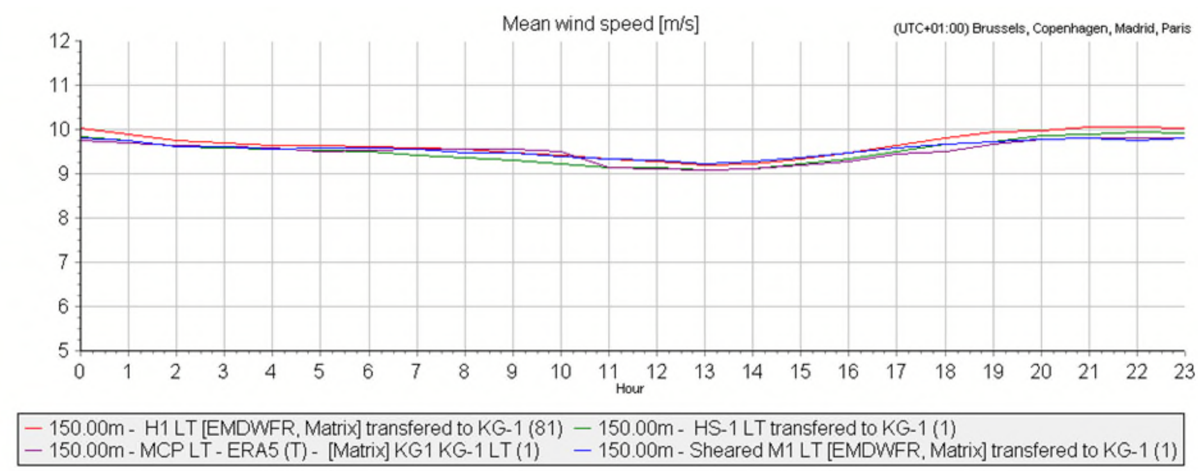
Primary model KG-1-LB *(purple), HS-1-LB model (green), H1 (red) and M1 (blue).*

Figure 32. Mean wind speed per direction for the four datasets at KG-1-LB position, 150 m ASL.



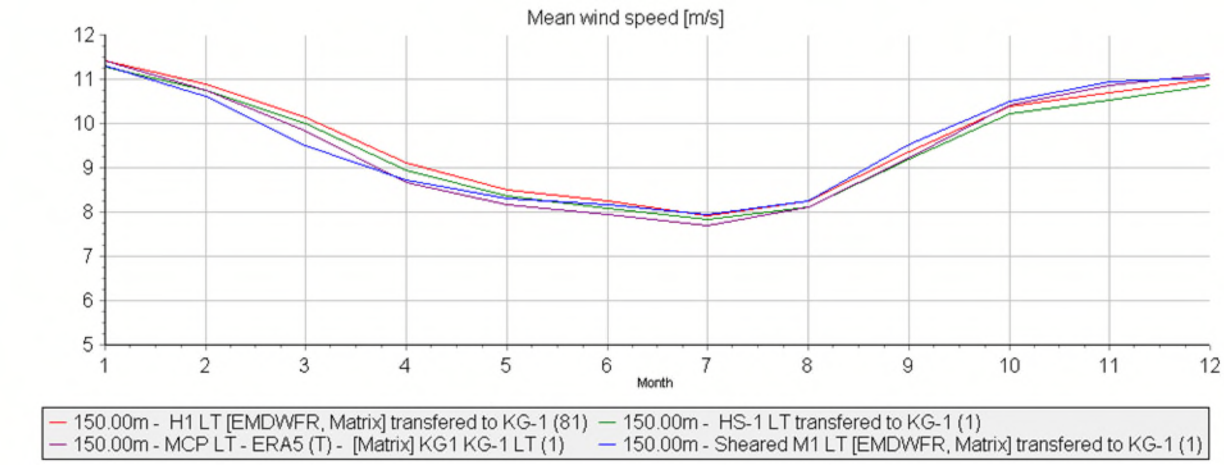
Primary model KG-1-LB *(purple), HS-1-LB model (green), H1 (red) and M1 (blue).*

Figure 33. Directional distribution of the four long-term wind models at 150 m, at KG-1-LB position.



Primary model KG-1-LB *(purple), HS-1-LB model (green), H1 (red) and M1 (blue).*

Figure 34. Diurnal wind speed of the four long-term wind models at 150 m at KG-1-LB position.



Primary model KG-1-LB *(purple), HS-1-LB model (green), H1 (red) and M1 (blue).*

Figure 35. Seasonal variation of the four long-term wind models at 150 m at KG-1-LB position.

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	2.44%

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 moderate uncertainty, which is the measurement period of 12 month. This is therefore the dominant uncertainty with very minor contributions from other components.

Based on [27], the combined long-term correction uncertainty of a 12-month period will range between 1.5 % and 4%.

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 0.4 %. Alternatively, the range from minimum to maximum resulting wind speed can be used as an indicator of the uncertainty. This range is 1.2% for KG-1-LB.

We therefore consider an uncertainty on long-term correction of 1.5% as reasonable value for long-term correction of the primary data from the KG-1-LB.

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] which indicates 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 ERA5(T) data the inter-annual variability is 3.7% on wind speed at KG-1-LB. Over a 20-year lifetime this uncertainty is reduced to 0.8%.

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 three reported wind speed results for the KG-1-LB location of 0.7%. 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 three 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 on wind speed.

	KG-1-LB	
WIND DATA UNCERTAINTY	1 YEAR	20 YEARS
Measurement uncertainty	2.44%	2.44%
Long-term correction uncertainty	1.5%	1.5%
Very long-term uncertainty	1.5%	1.5%
Annual variability	3.7%	0.8%
Total	**4.91%**	**3.33%**

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 existing wind turbines at 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 wake influence of the planned Hesselø South OWF has not been included in the model.

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).

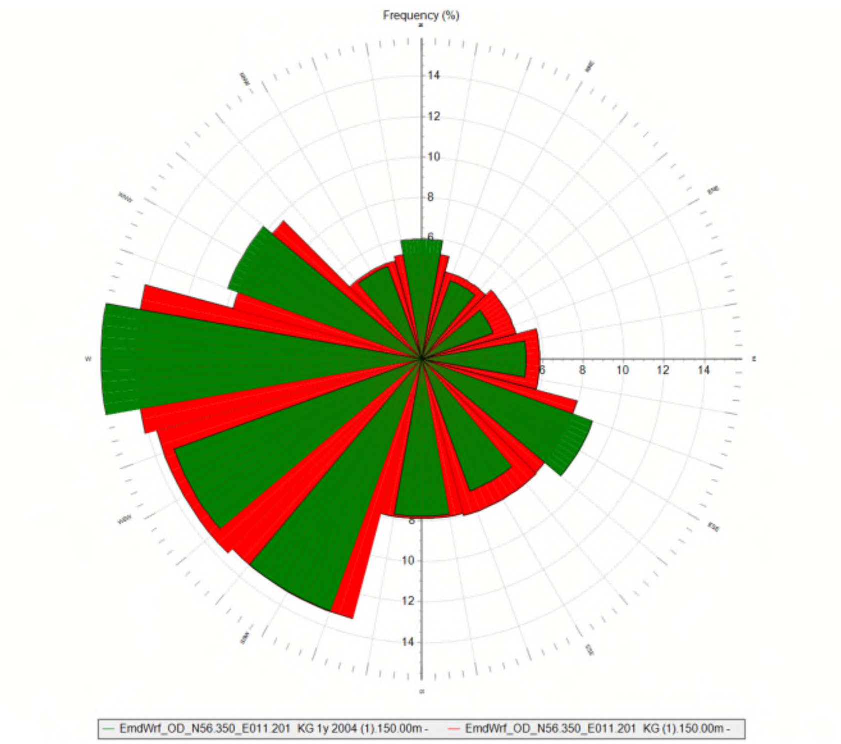


Figure 36. Direction distribution of EMD-WRF mesoscale data at KG-1-LB position in 2004 (green) compared to the 22-year period (red).

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.

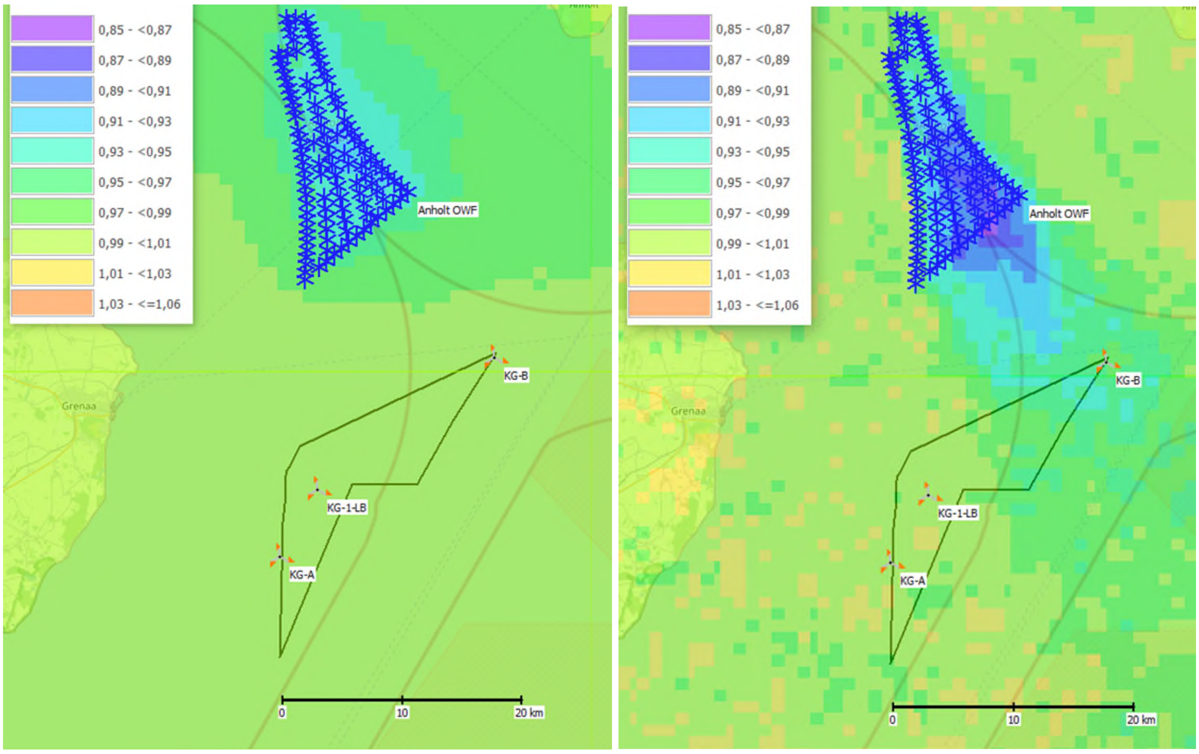


Figure 37. Map of the ratio between Weibull mean wind speed calculated by mesoscale modelling with and without Anholt OWF; left for all wind directions; right: for the most impacted wind direction (330 degrees).

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.

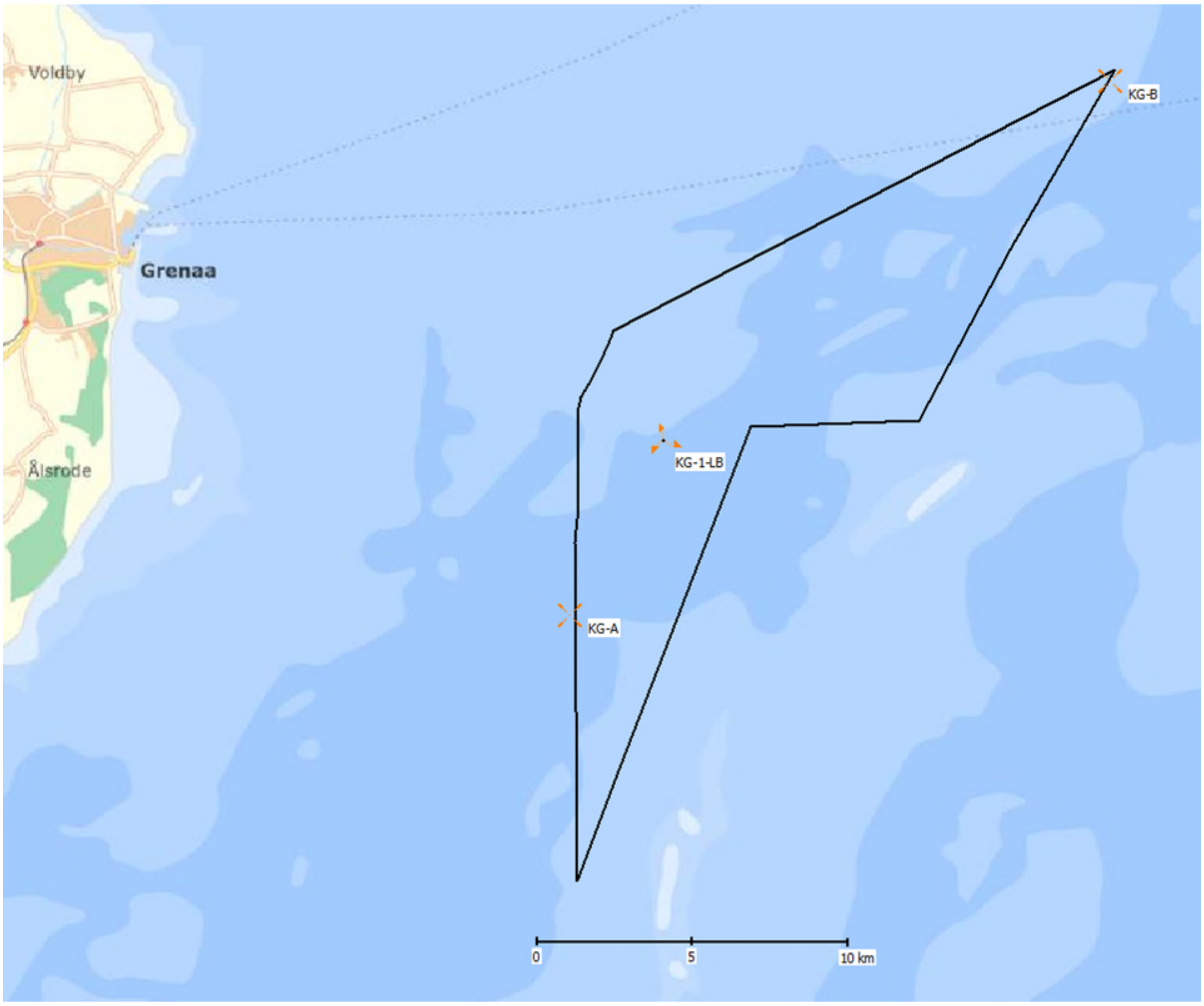


Figure 38. Location of the measurement point and additional positions (KG-A, KG-B) for siting parameters within the Kattegat OWF boundaries.

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 at 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 parameters of the Weibull distributions are read from the gradient map (the wind resource map) 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.

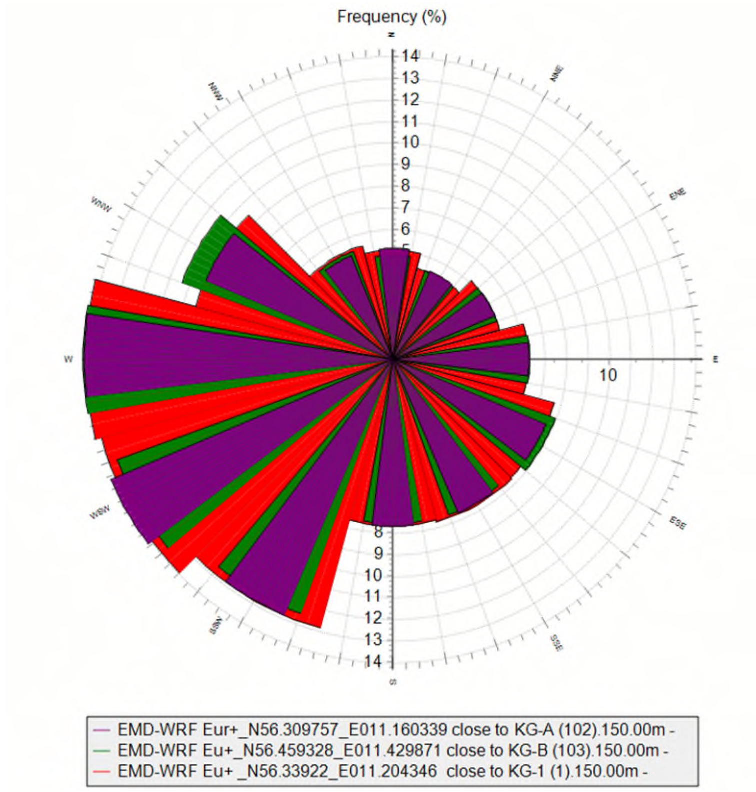


Figure 39. Comparison of 22 years direction distribution between EMD-WRF Europe + data for locations close to KG-1-LB (red), KG-A (purple) and KG-B (green).

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	9.50	9.59	10.82	2.26
KG-B, 150 m	22	9.53	9.62	10.86	2.27

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 which includes 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.

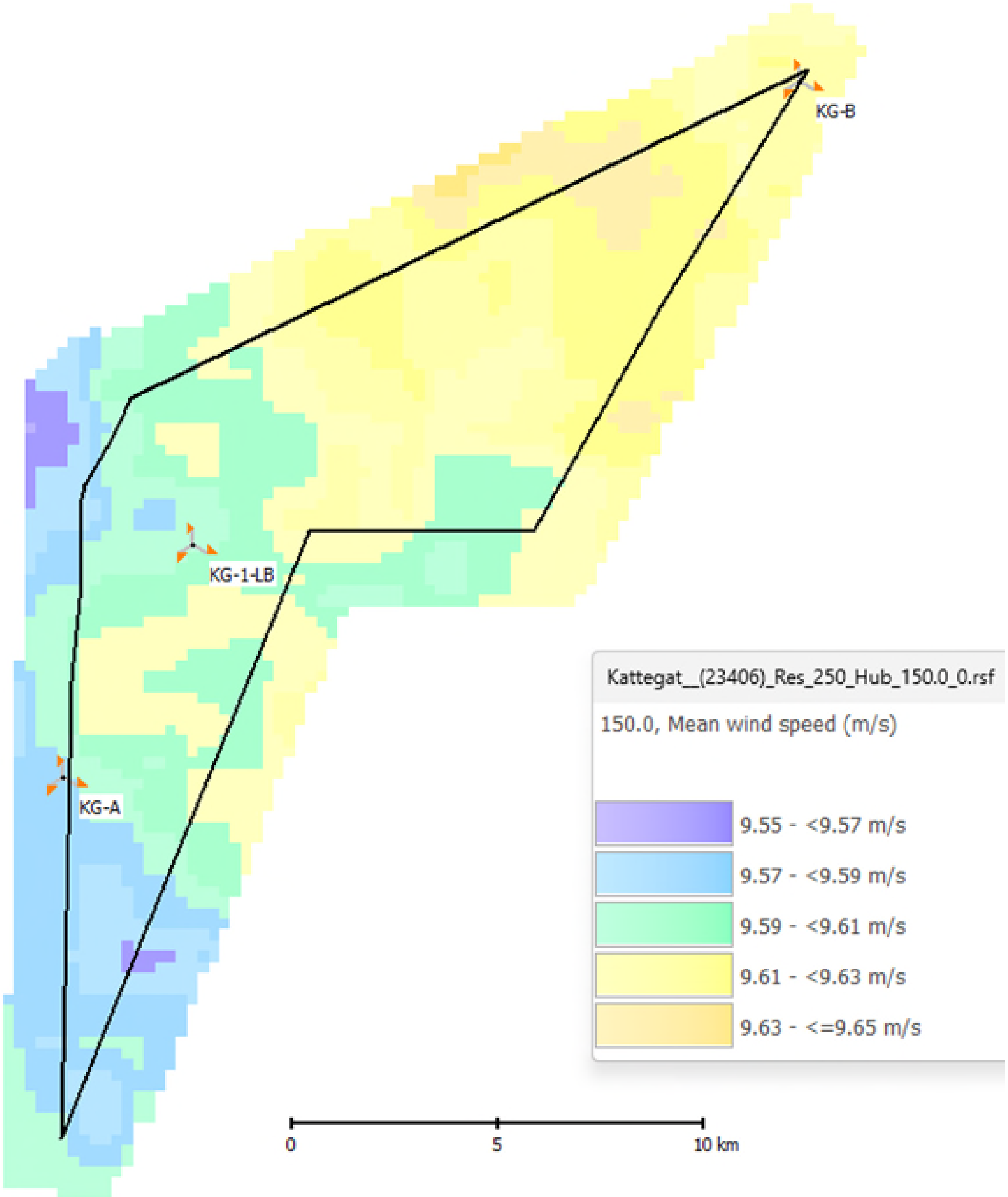


Figure 40. Wind resource map for the Kattegat OWF area at 150 m.

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	10.83	2.27	100.00	9.60
0-N	8.18	1.90	4.82	7.26
1-NNE	7.60	2.07	4.22	6.73
2-ENE	8.93	2.03	5.33	7.91
3-E	10.06	2.13	6.64	8.91
4-ESE	11.34	2.46	7.96	10.06
5-SSE	11.13	2.47	7.97	9.87
6-S	11.28	2.23	7.73	9.99
7-SSW	12.48	2.52	12.56	11.08
8-WSW	12.03	2.80	13.33	10.71
9-W	11.36	2.57	14.69	10.09
10-WNW	10.49	2.21	9.81	9.29
11-NNW	8.59	1.91	4.94	7.62

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	10.82	2.26	100.00	9.59
0-N	8.17	1.90	4.82	7.25
1-NNE	7.59	2.07	4.22	6.72
2-ENE	8.85	2.03	5.33	7.84
3-E	10.05	2.13	6.64	8.90
4-ESE	11.25	2.45	7.96	9.98
5-SSE	11.03	2.46	7.97	9.79
6-S	11.51	2.23	7.73	10.19
7-SSW	12.48	2.52	12.56	11.07
8-WSW	12.04	2.80	13.33	10.72
9-W	11.32	2.57	14.69	10.05
10-WNW	10.45	2.21	9.81	9.26
11-NNW	8.61	1.92	4.94	7.64

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	10.86	2.27	100.00	9.62
0-N	8.71	1.90	4.82	7.73
1-NNE	7.85	2.05	4.22	6.95
2-ENE	8.98	2.03	5.33	7.96
3-E	9.90	2.13	6.64	8.77
4-ESE	11.59	2.46	7.96	10.27
5-SSE	10.97	2.47	7.97	9.73
6-S	11.27	2.23	7.73	9.98
7-SSW	12.33	2.53	12.56	10.94
8-WSW	12.19	2.82	13.33	10.85
9-W	11.46	2.57	14.69	10.18
10-WNW	10.36	2.21	9.81	9.18
11-NNW	8.41	1.92	4.94	7.46

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 12 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. For comparison purposes a shear is calculated for the Hesselø floating LiDAR (H1). Here 12 months of data 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 (12 months)	HESSELØ SOUTH (12 MONTHS)
Hub height range 130 m to 170 m	0.083	0.094
Rotor range 40 m to 260 m	0.090	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, at KG-1-LB, 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	16%	52%	32%
Typical shear range	0.05 - 0.30	0.04 - 0.12	-0.15 - 0.20

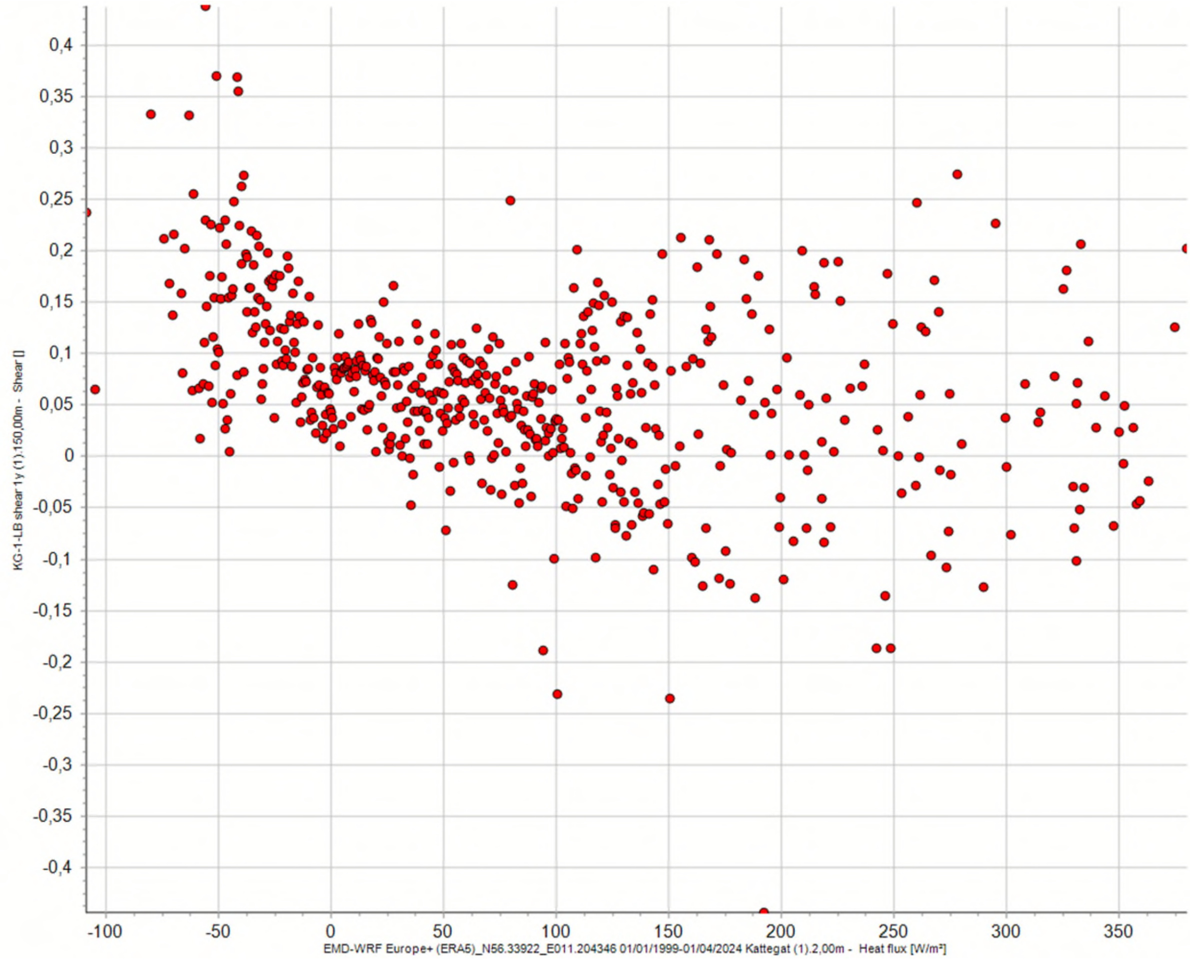


Figure 41. Shear power law coefficient as a function of heat flux at Kattegat.

Stability classes are defined though the Monin Obukhov length, here using three categories as described in Table 31. The 1/L (rmol) 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. Note the difference in the prevalence of the stability classes based on heat flux and rmol. This is due to the strong dependency on friction velocity in the 1/L expression (used in the third power). For this reason, heat flux may be the better descriptor of stability conditions.

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	14%	28%	57
Typical shear range	-0.6 - 0.6	-0.1 - 0.2	-0.7 - 0.7

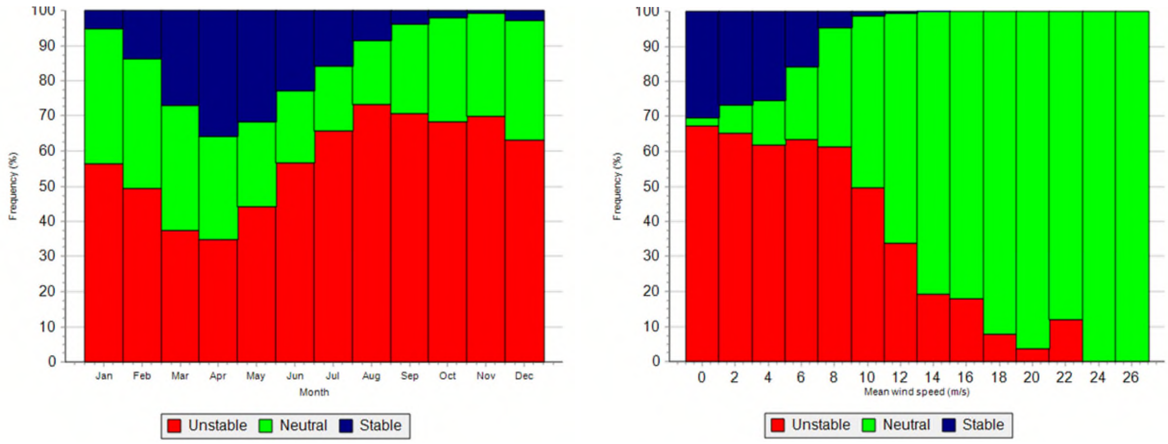


Figure 42. Frequency of stability classes as a function of month and wind speed, EMD-WRF at location of KG-1-LB at 150 m.

Shear as a function of stability (1/L) at Kattegat is presented in Figure 43. In this period, only in the neutral case is there a consistent shear. Both unstable and stable conditions are characterized by very large scatter in shear. This also demonstrates that 1/L has a weaker link to shear than heat flux does.

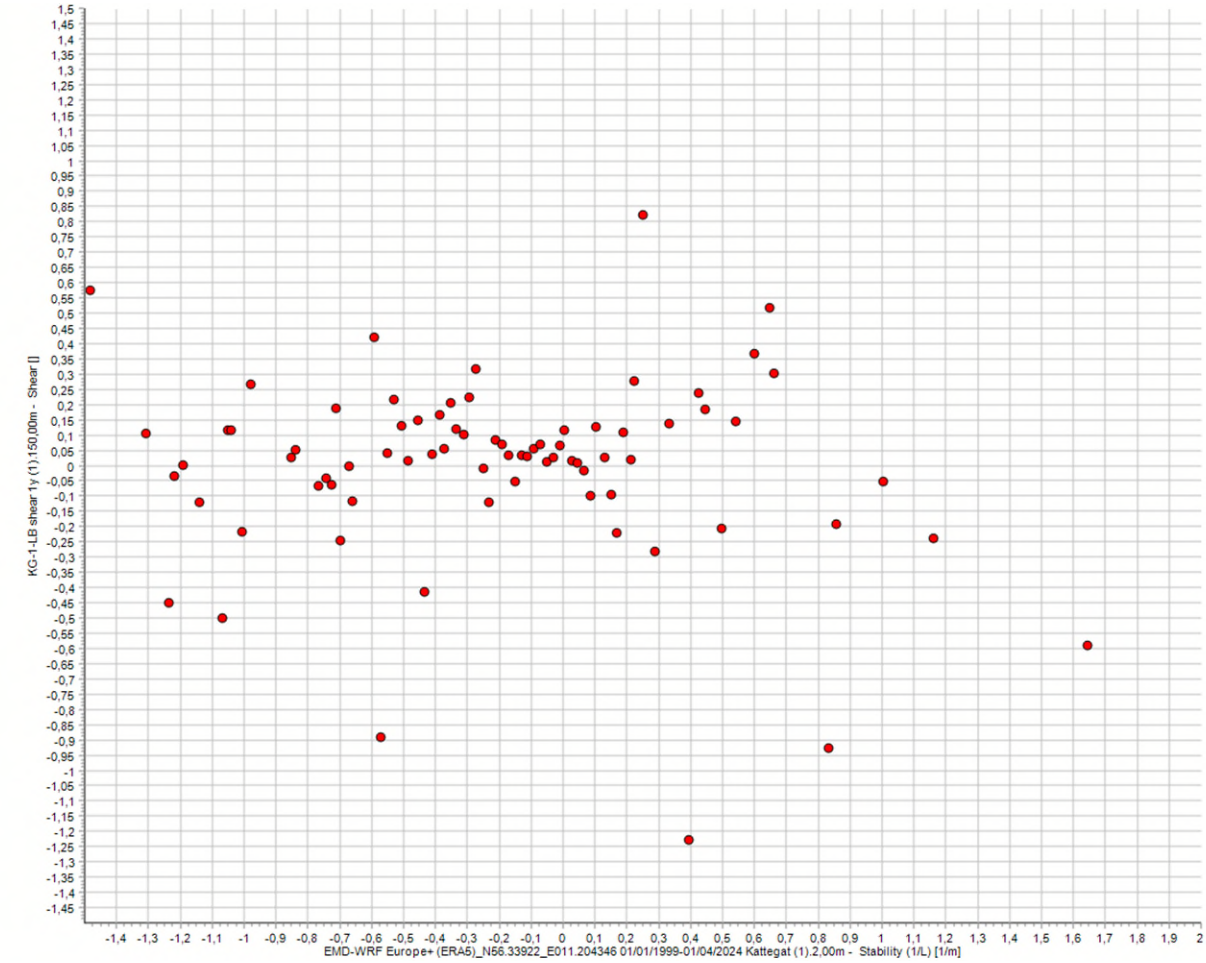


Figure 43. Shear coefficient as a function of stability (1/L), based on KG-1-LB and EMD-WRF data at 150 m.

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.

The monthly shear at Kattegat is plotted against the monthly shear observed at the older 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.

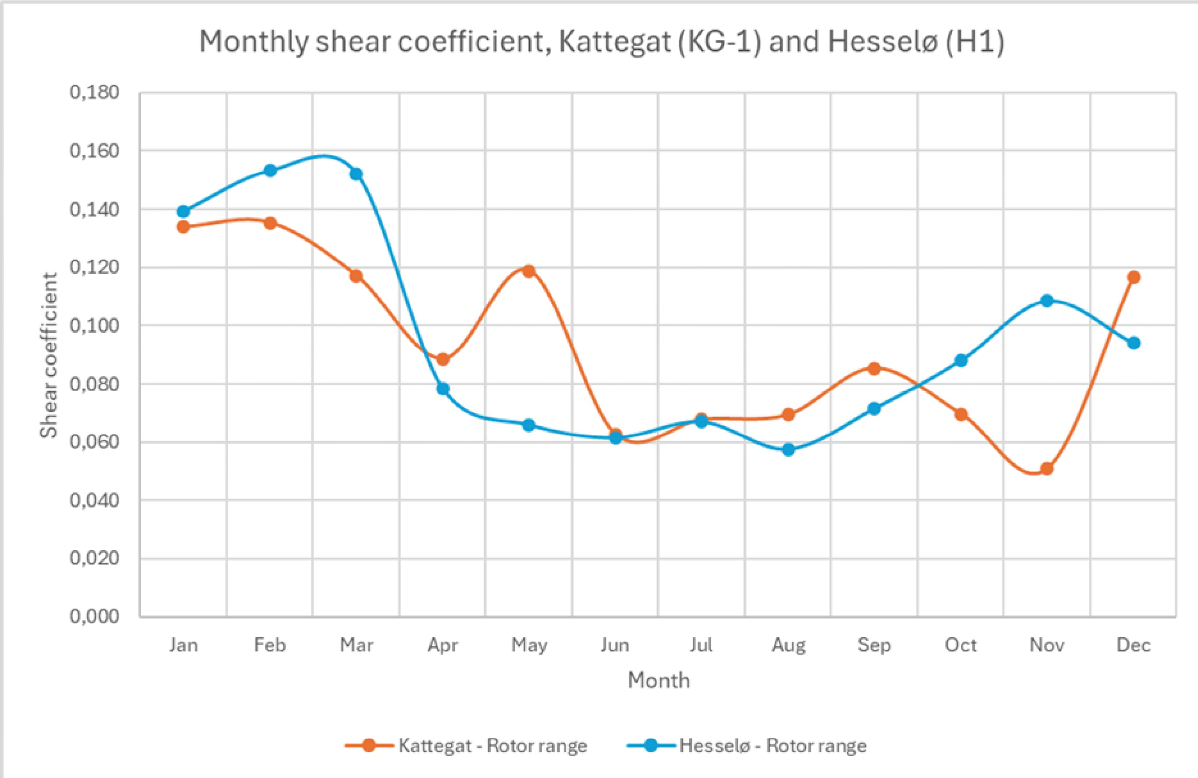


Figure 44. Monthly shear coefficient α across the rotor at Kattegat (KG-1-LB) and Hesselø (H1).

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 ASL 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).

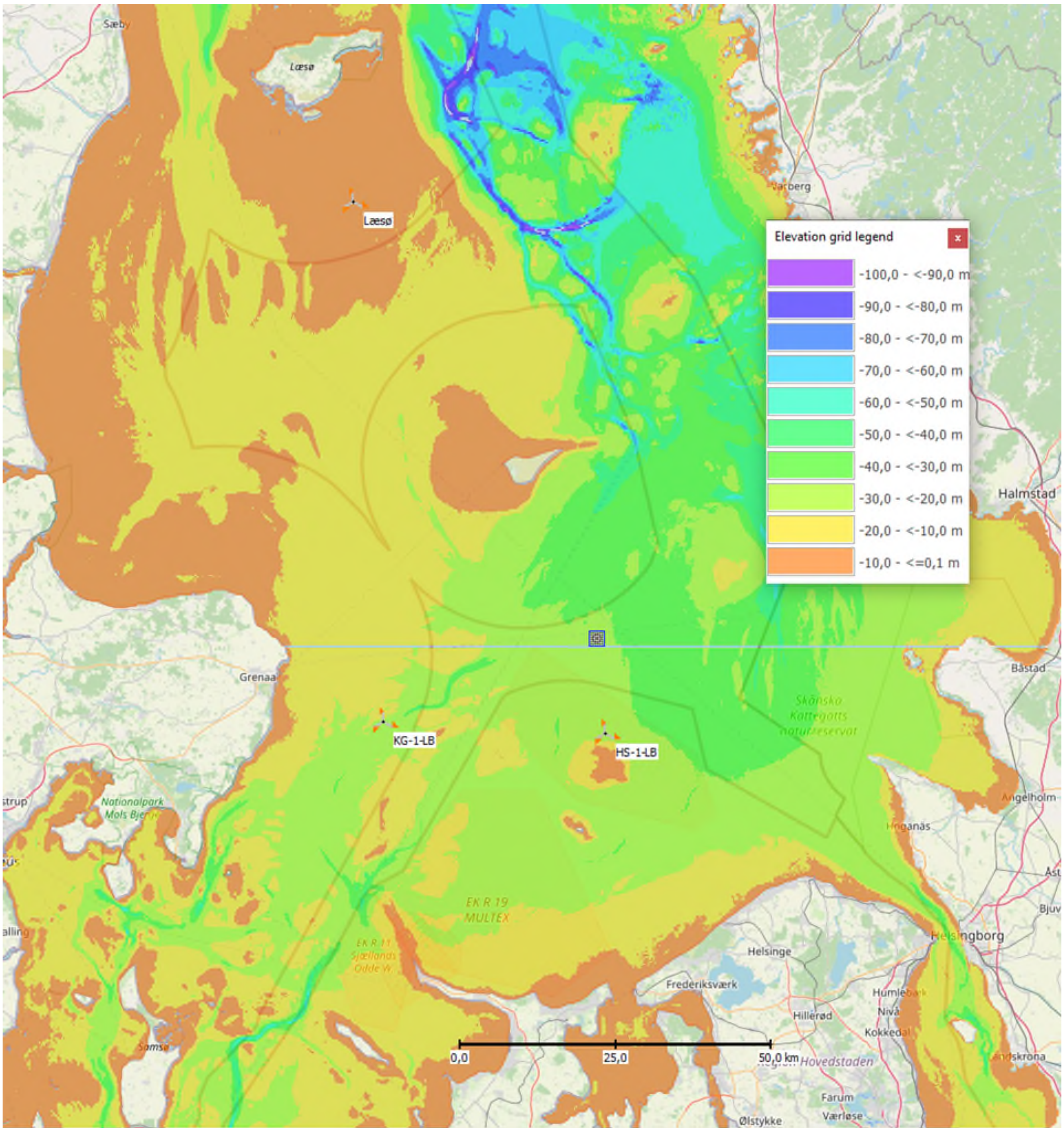


Figure 45. Plot showing the bathymetry of the Kattegat and the relative positions of the Læsø mast to the Kattegat (KG-1-LB) and Hesselø (HS-1) buoys.

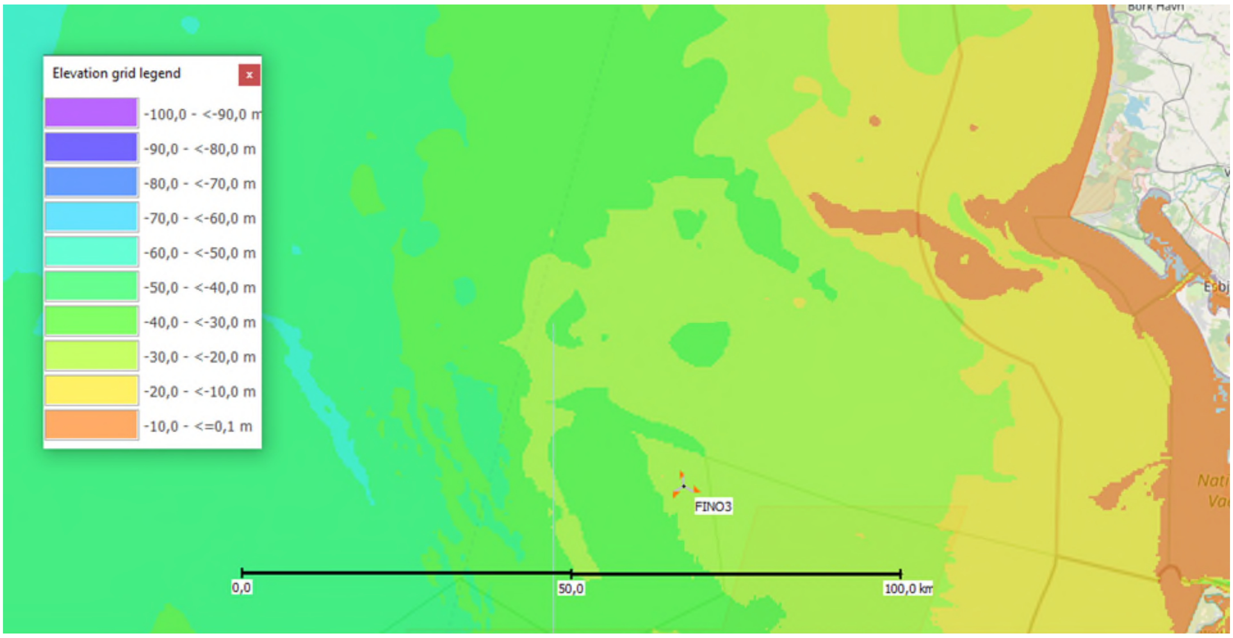


Figure 46. Water depth around the FINO3 mast.

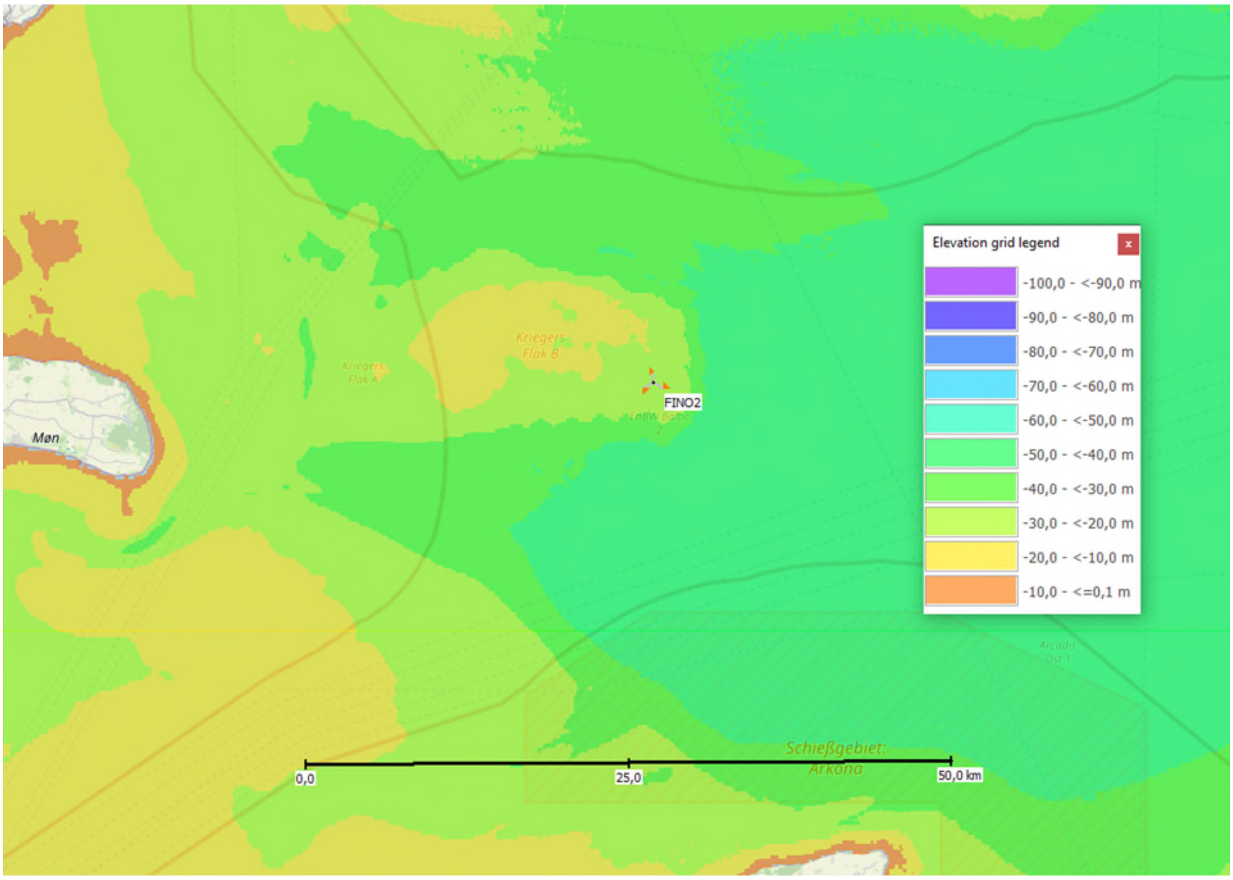


Figure 47. Water depth around the FINO2 mast.

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 summarizes 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).

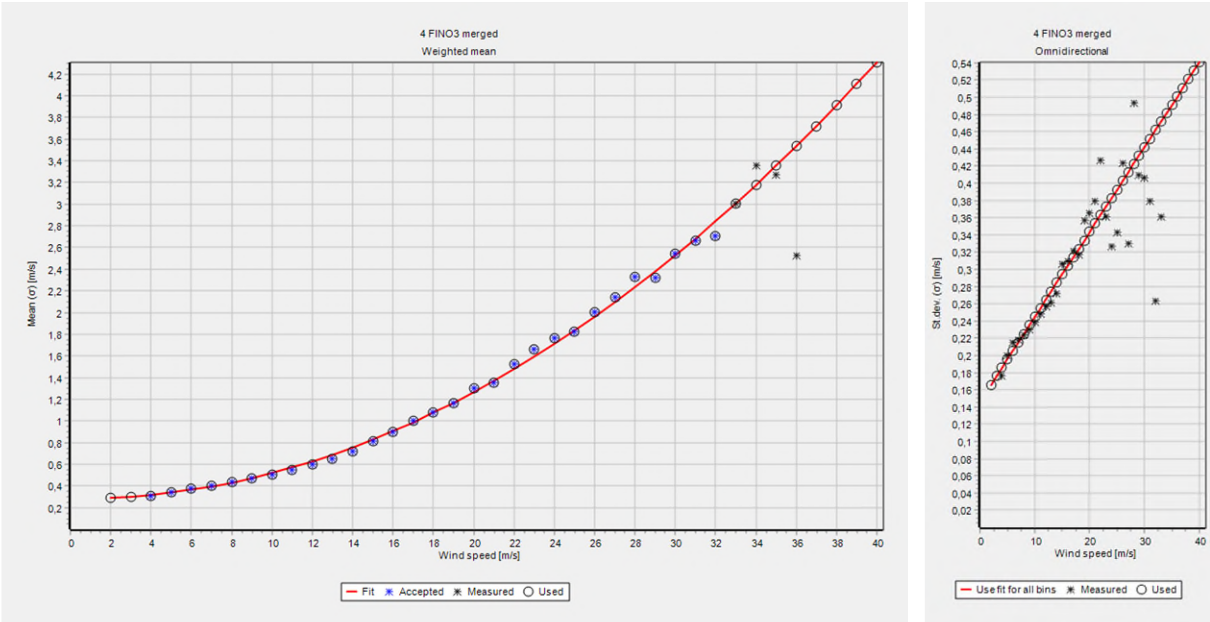


Figure 48. Left: observed mean turbulence versus wind speed at FINO3 91 m including the second order fit. Stars are observations and circles are model values. If the bin has enough samples the star is inside the circle and the bin will contribute to the fit. Right: observed standard deviation of the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

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

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

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

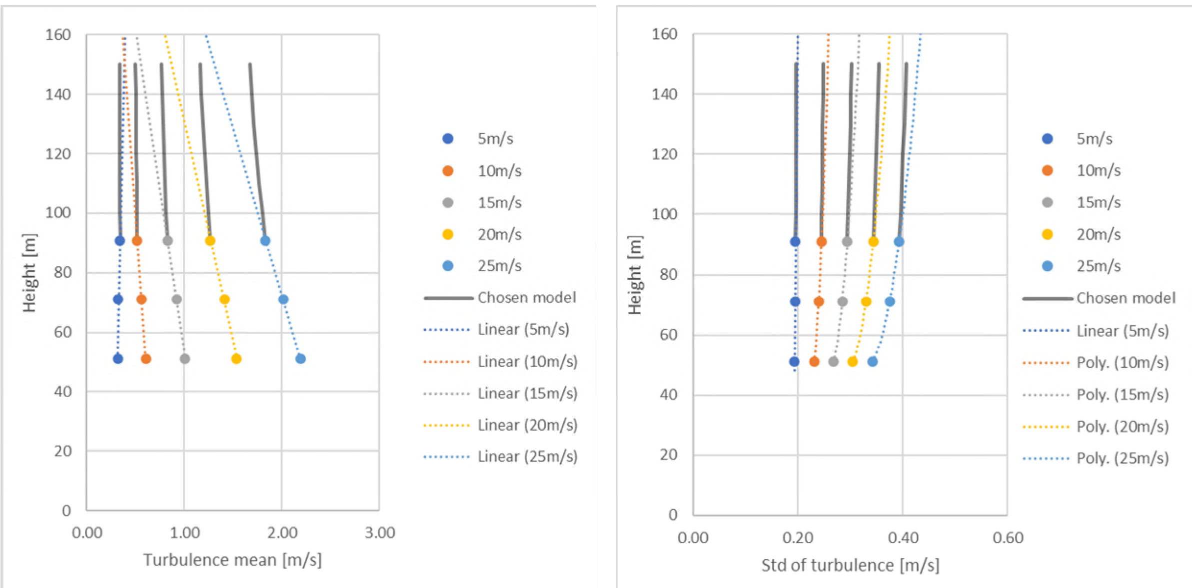


Figure 49. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the three heights at FINO3: 51 m, 71 m and 91 m, together with possible fits to extrapolate across heights as well as 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 performed with FINO3 data (see above), a second order fit is required for the FINO2 data 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).

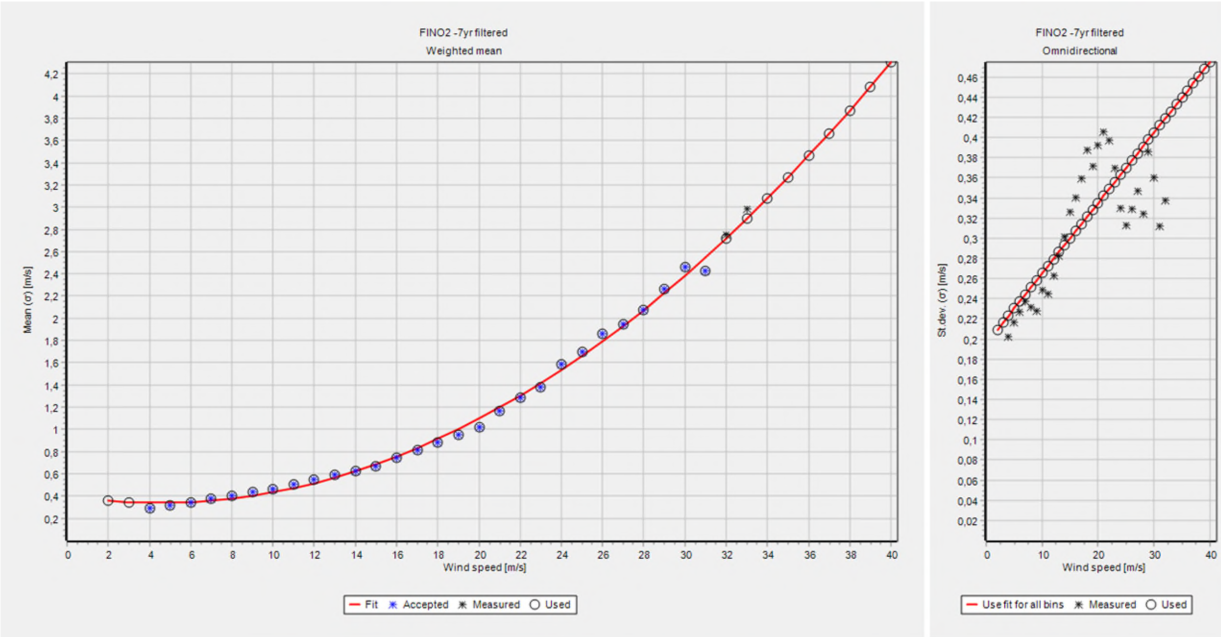


Figure 50. Left: observed mean turbulence versus wind speed at FINO2 102 m including the second order fit. Stars are observations and circles are model values. If the bin has enough samples the star is inside the circle and the bin will contribute to the fit. Right: observed standard deviation of the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

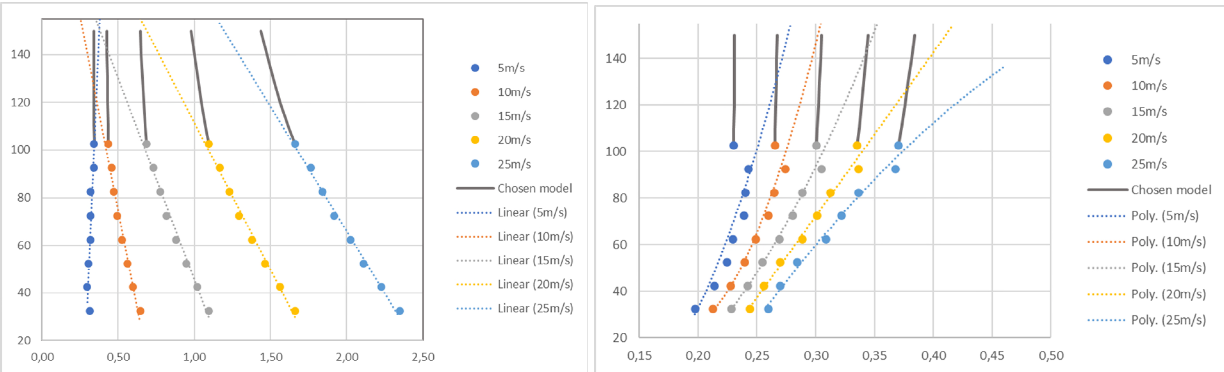


Figure 51. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the eight heights at FINO2: 32.4 m to 102.5 m together with possible fits to extrapolate across heights as well as the 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.

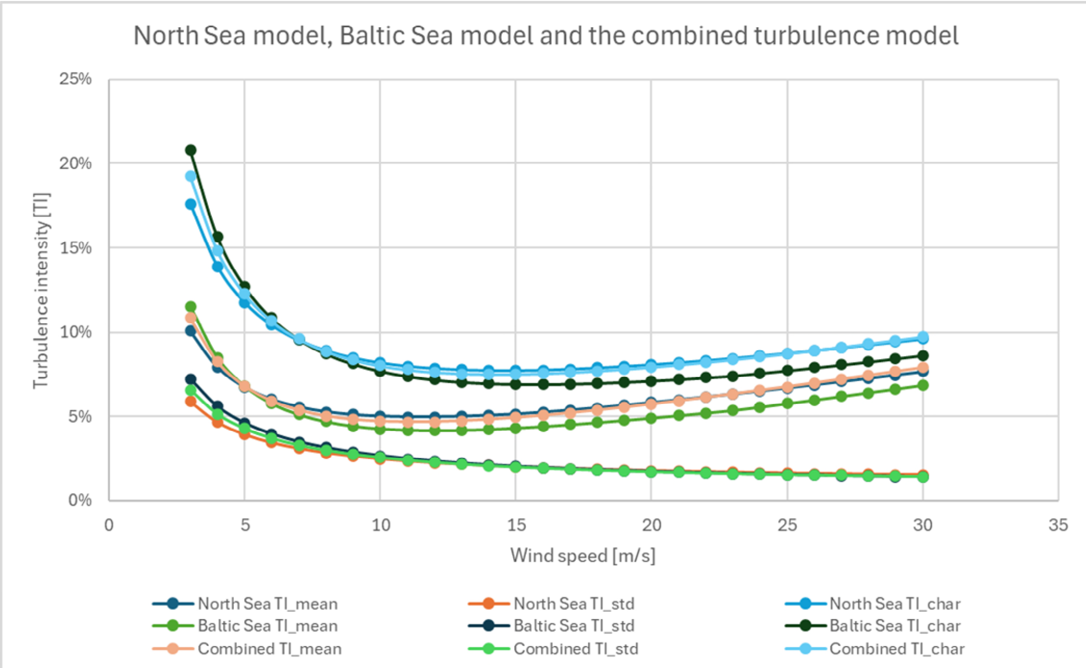


Figure 52. Turbulence intensity models for the North Sea and the Baltic Sea as well as the combined model for Kattegat, which is the average of the North Sea and Baltic Sea models. TI_mean signifies mean turbulence intensity, TI std is standard deviation of turbulence intensity and TI_char is the characteristic 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 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 12 months of operation. The average temperature measured during that period was 9.9°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 -4.2 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 KG-1-LB LiDAR position at 150 m height by applying and offset 0.8˚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 as 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	1.204	0.263	1.467
Extreme range	-15.0	40.0	0.009	0.000	0.009
Mean air temperature				9.1°C	
Standard deviation air temperature				6.4°C	
Maximum temperature				28.4°C	
Minimum temperature				-9.2°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:

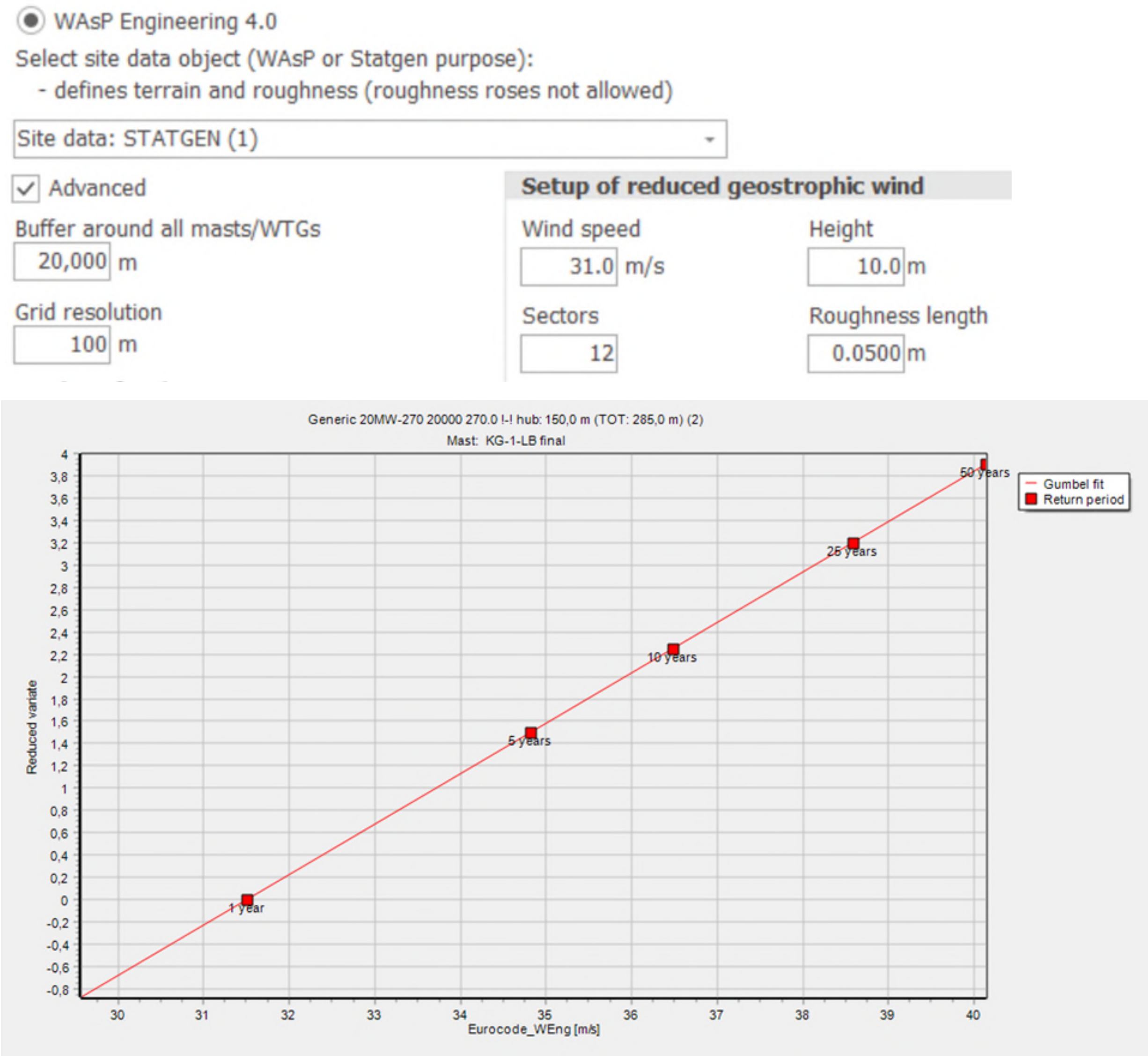


Figure 53. WAsP Engineering settings and output from modelling in windPRO, Site Compliance.

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)	39.4
AM Mesoscale (20y) + Spectral correction (site specific)	39.4
POT (N=20, Δt_{min}=4 days)	38.3

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.

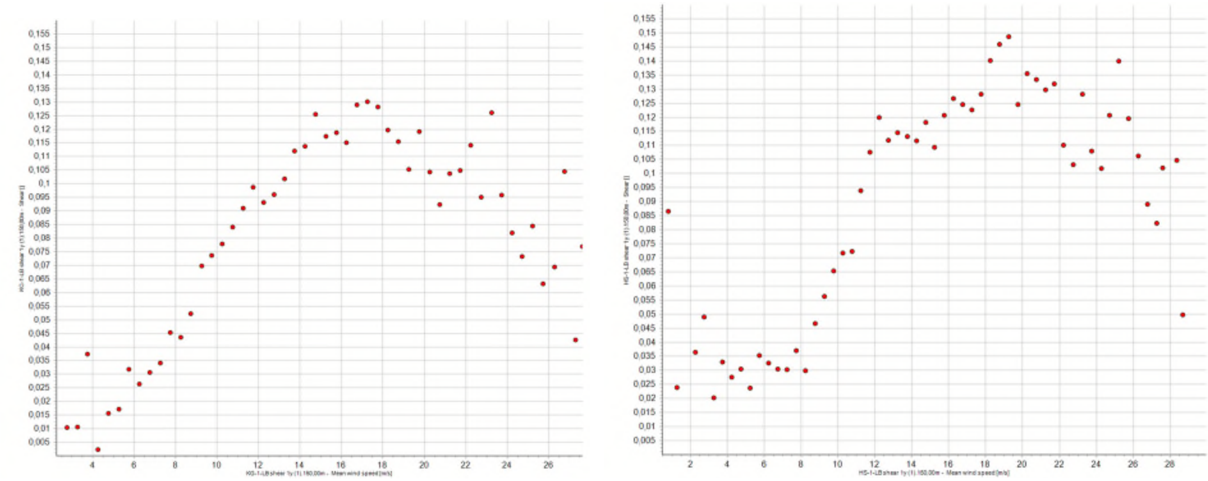


Figure 54. Observed wind shear versus wind speed (0.5 m/s bins) at the Kattegat KG-1-LB buoy (left) and the Hesselø South HS-1-LB buoy (right). For both buoys, the wind shear clearly levels off at around 0.13 for wind speeds above ca. 17m/s. At lower wind speeds the wind shear increases linearly.

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:

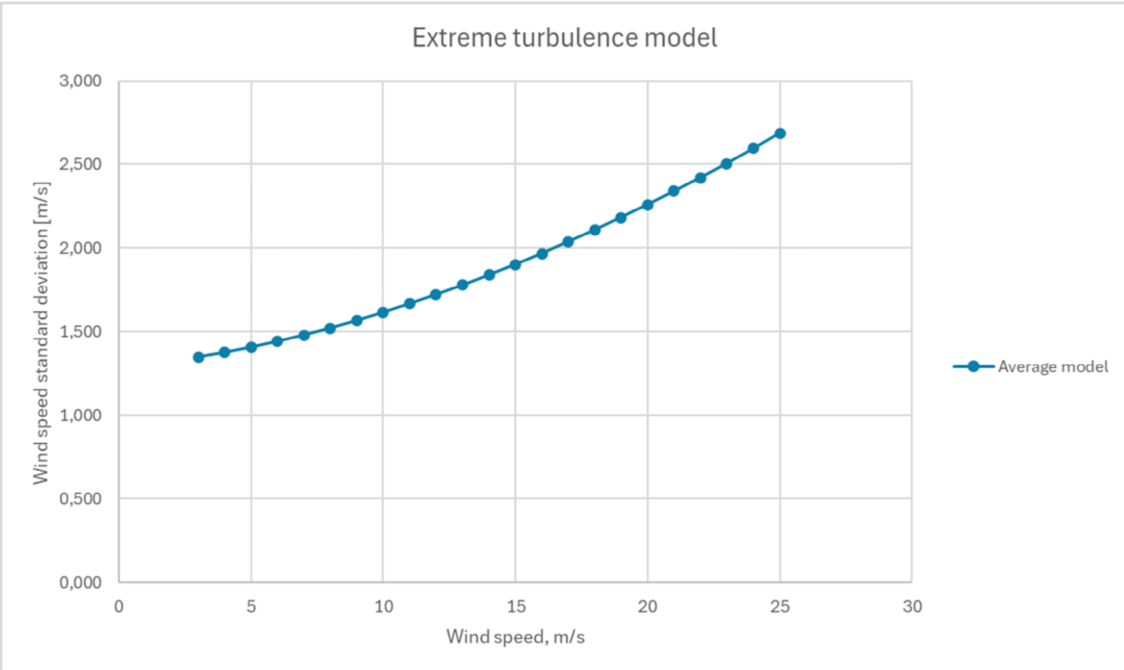


Figure 55. Extreme turbulence model. Turbulence is standard deviation of wind speed.

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 KG-1-LB 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 KG-1-LB buoy measures the humidity near sea level. Based on 12 months of measurements the average relative humidity is 83.8% with a standard deviation of 9.3%.

9.4 Climate Change

In the context of this report, the impact of the climate change is considered 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 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).

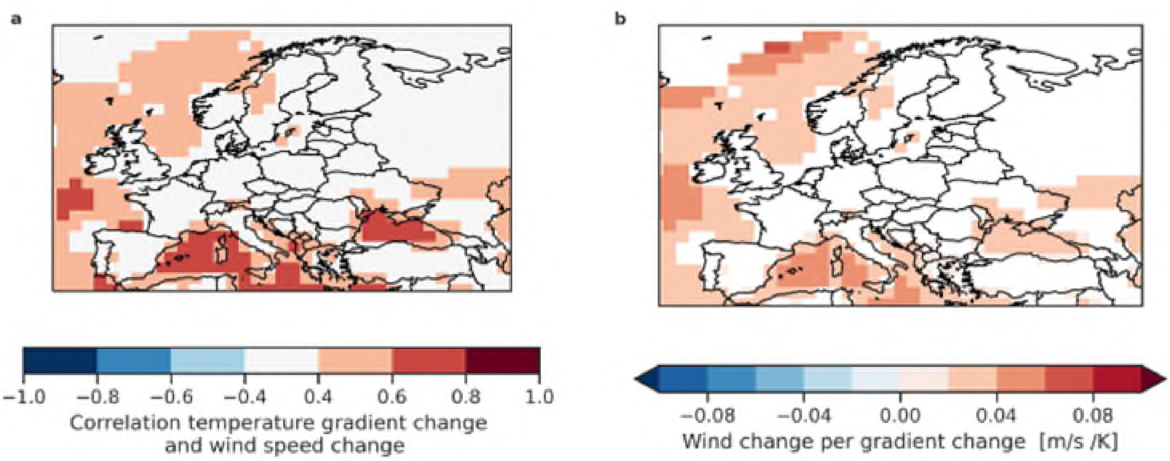


Figure 56. Relationship between changes in wind speed and the equator-to-pole gradient in Europe in the full CMIP6 ensemble. Correlations between changes (a) and the slope of a linear regression in locations where correlations exceed absolute values of 0.4 (b) [46]

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.

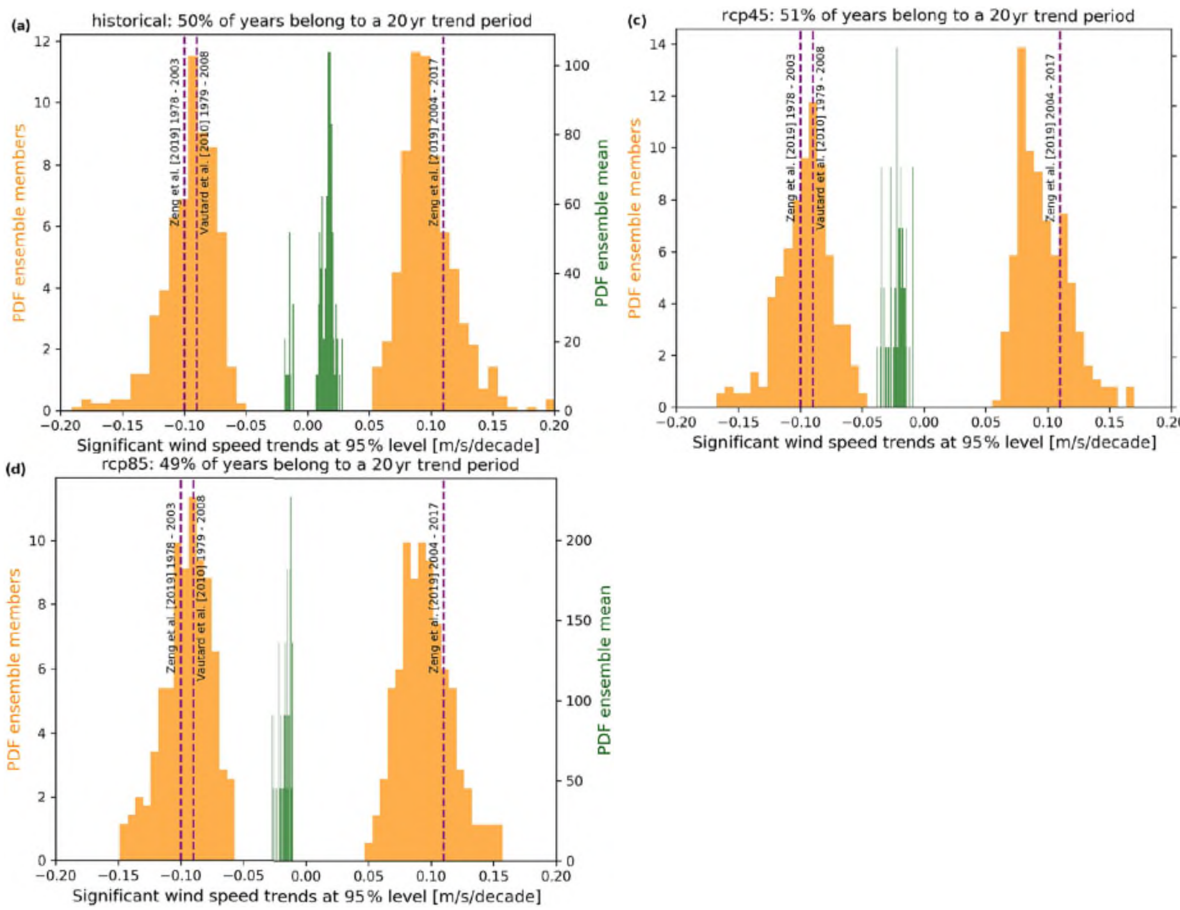


Figure 57. Twenty-year trends in European annual mean wind speed in Max Planck Institute - Grand Ensemble (MPI-GE) under historic (a) and future climate conditions (c) and (d). Trends are computed for each ensemble member after subtraction of ensemble mean (orange – representing internal variability) 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. Other studies conclude the same [49].

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 [50]. 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. Other studies conclude the same [49].

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.

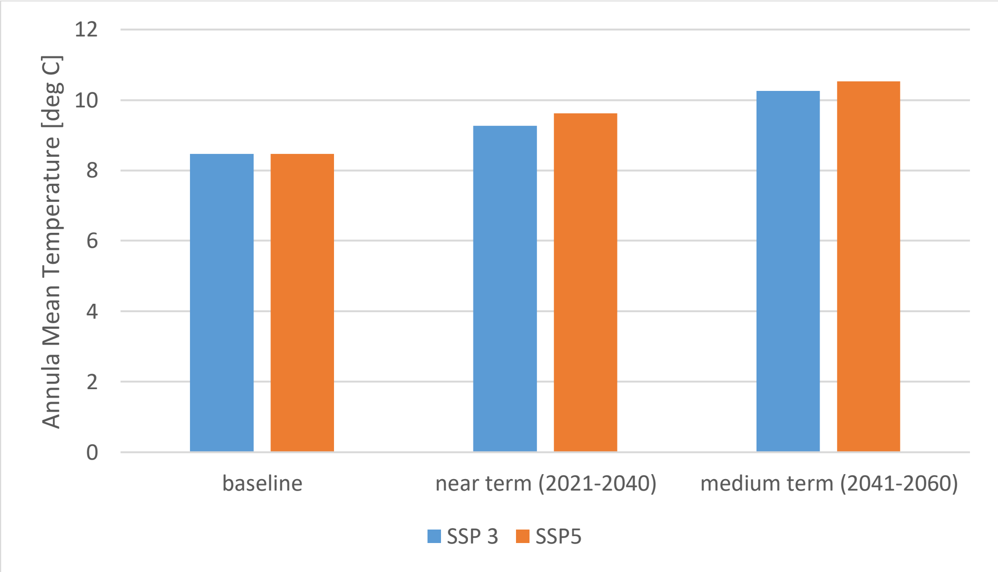


Figure 58. Development of the absolute annual temperature in the Kattegat area

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	9.60 m/s	9.59 m/s	9.62 m/s
Weibull distribution, A parameter (scale)	10.83 m/s	10.82 m/s	10.86 m/s
Weibull distribution, k parameter (shape)	2.27	2.26	2.27
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 “300 PART C (Kattegat 12 months)/320 Analysis/322 Filtered time series”. The filter and repair process is described in section 4.4.3. The dataset represents 12 months of data. The text file can be imported directly into windPRO, but as an open format, it is generally accessible.

- KG-1-LB_12 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

- KG-1-LB_12 months.wpobjects

The object export file can be imported into windPRO 4.1 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 “300 PART C (Kattegat 12 months)/320 Analysis/323 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 4.1 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

10.3 ERA5(T) Dataset

The ERA5(T) dataset close to the positions of KG-1-LB is included in the data package in the folder "300 PART C (Kattegat 12 months)/310 Models" as a text file export with selected parameters:

- ERA(T) nearKG-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.

- ERA5(T) near KG-1-LB.wpobjects

The object export file can be imported into windPRO 4.1 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

Table 43. Column explanation for ERA5(T) 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
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.
TemperatureUID_2,0m	Temperature at height 2.0 m
SolarRadiationUID_2.0m	Solar irradiation at height 2.0 m (not used)
StabilityUID_2.0m	Stability (1/L) at height 2.0 m (not used)
RelativeHumidityUID_2.0m	Relative humidity at height 2.0 m (not used)

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 "300 PART C (Kattegat 12 months)/350 Wind resource maps":

- Kattegat_Res_250_Hub_150.0_00.rsf

The file "Kattegat_Res_250_Hub_150.0_00.emdinfo" is a helping file which contains information about the coordinates system that can be used in windPRO software.

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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

Two buoys have been in operation on this location: SWLB059 and WS190. The general measurement setup, sensors, configurations, and measurement scheme are described in the measurement plan [10]. The instrumentation on the SWLB059 and the WS190 is for all practical purposes identical. The LiDAR is a ZX300M LiDAR from ZXLiDARs Ltd (Figure 59).

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 Fugro buoys (SWLB059 and WS190) have 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 [51], [52].

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 Fugro buoys are 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 on the 23rd of March 2024 was replaced by WS190 buoy. The measuring campaign has stopped on 4th of August 2024.

Data gaps:

24/02/2024 – 02/03/2024 – The LiDAR had intermittently been unavailable to measure wind data due to insufficient input power from an unhealthy fuel cell.

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 is 1.3˚ at equivalent heights. EMD therefore applied a 1.3˚ offset on the wind direction data.

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 is 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	97.1%	96.5%	96.1%	95.9%	95.8%	95.6%	95.4%	94.9%	94.8%
Recovery rate after shear repair	98.7%	97.2%	96.6%	96.2%	96.1%	95.9%	95.7%	95.5%	95.3%
Recovery rate after shear and horizontal repair	99.8%	99.1%	98.6%	98.4%	98.3%	98.2%	98.1%	98.0%	97.9%
Share of repaired data	2.7%	2.6%	2.5%	2.5%	2.5%	2.6%	2.8%	3.2%	3.2%

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

Phase of treatment	Height [m]	Start	End	Period [Months]	Arithmetic mean wind speeds [m/s]	Recovery rate [%]
Raw	150	21/07/2023	21/07/2024	12	10.09	95.9
Filtered	150	21/07/2023	21/07/2024	12	10.09	95.9
Repaired	150	21/07/2023	21/07/2024	12	10.05	98.4

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 ZX LiDARs Ltd (Figure 59).

The instrumentation on the Eolos FLS200-E01 is described in [53]. 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 [54]. The specific instrument deployed on the Eolos FLS200-E01 was verified by Multiversum at the TNO Lichteiland Goeree Offshore Test Site, NL [55].

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 [53].

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: [53].

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 can measure 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 [56].

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 [56] 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 [55], 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 installed 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.

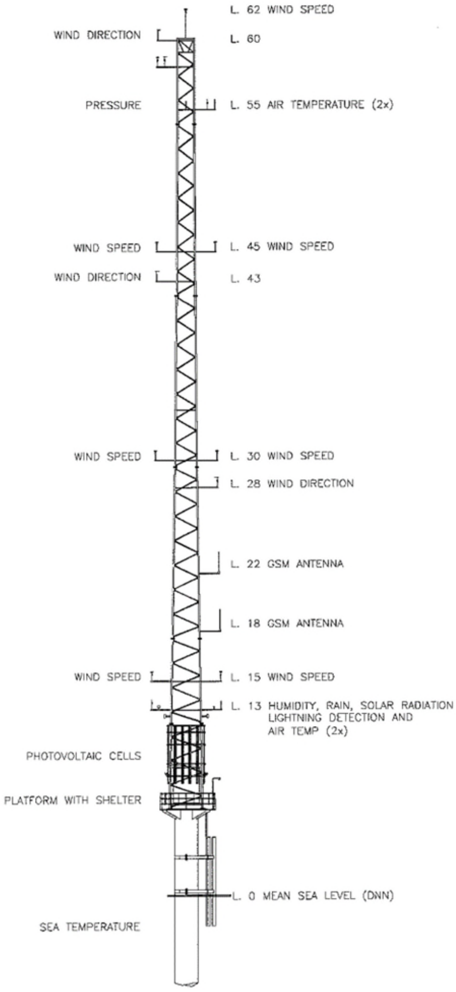
Table 50. Measurement data at Læsø met mast

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 resource report [57] analysing the measured data until November 2002 and describing the equipment installed and mast details. According to the documentation available [57] EMD has not received any calibration reports nor installation report describing the type of sensors and the details 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 [58]. 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.



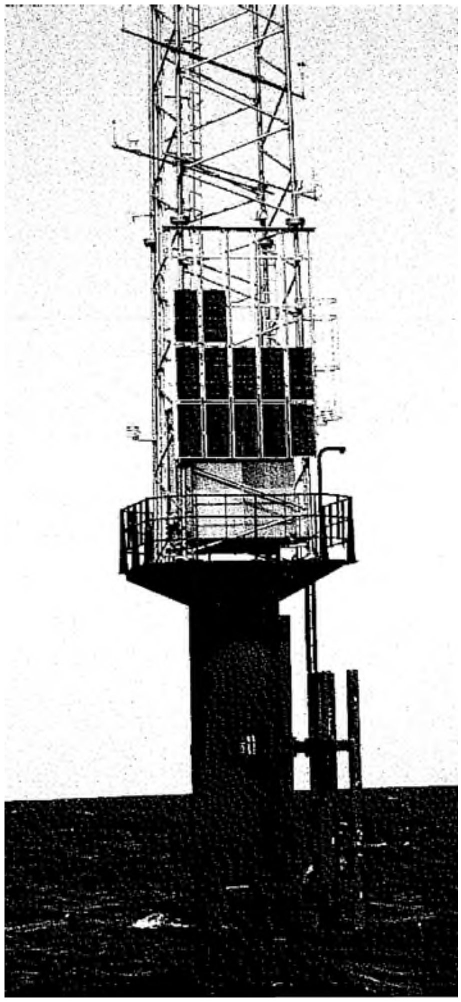


Figure 61. Pictures and details from Læsø met mast, source: [57]

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.

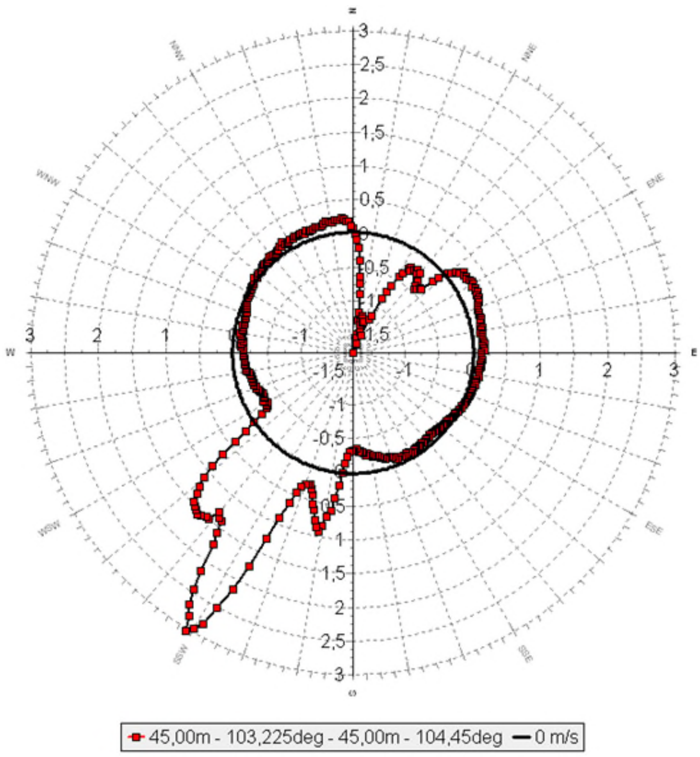


Figure 62. Wind speed difference between 45 m SV and 45 m NE, binned by direction at Læsø met mast.

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 period 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: [59]).

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).

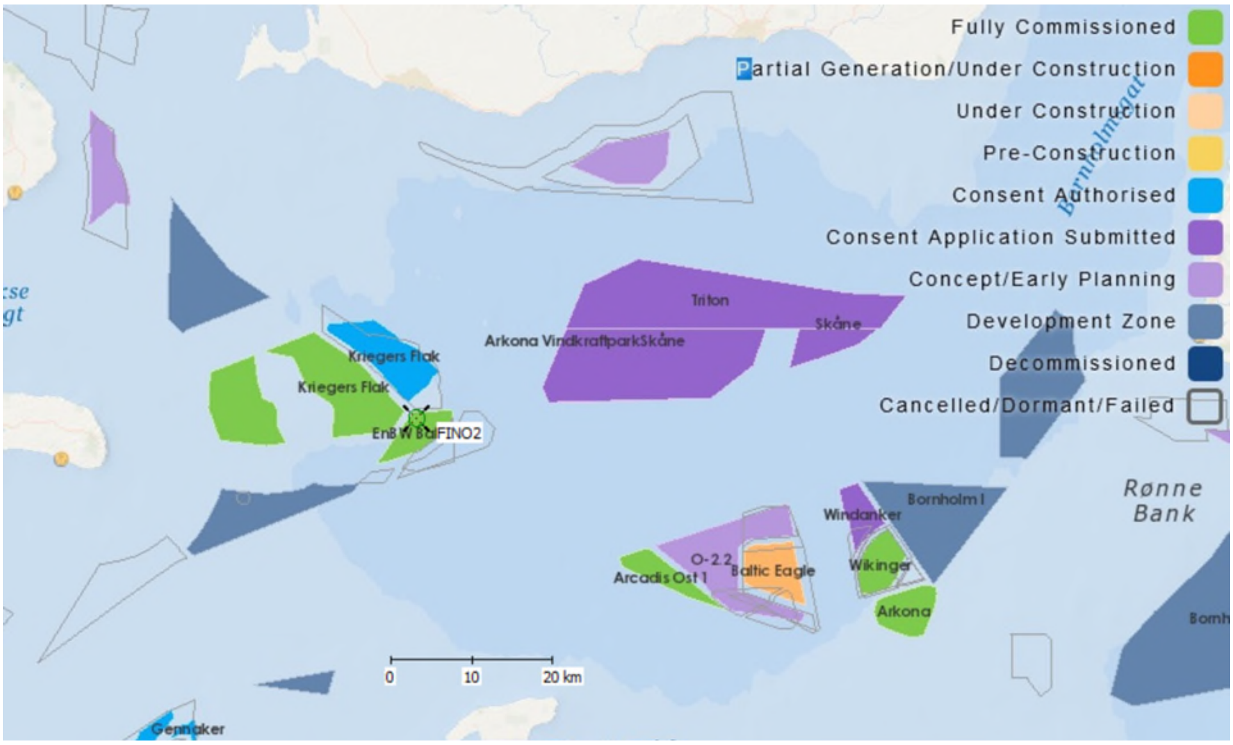


Figure 64. Indicative location map for FINO2 with existing wind farms in green (background map: 4C Offshore [60]).

EMD has access to a mast report [61] 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 [61], FINO2 design and installation has not been conducted fully according to the IEC standards [58], 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.

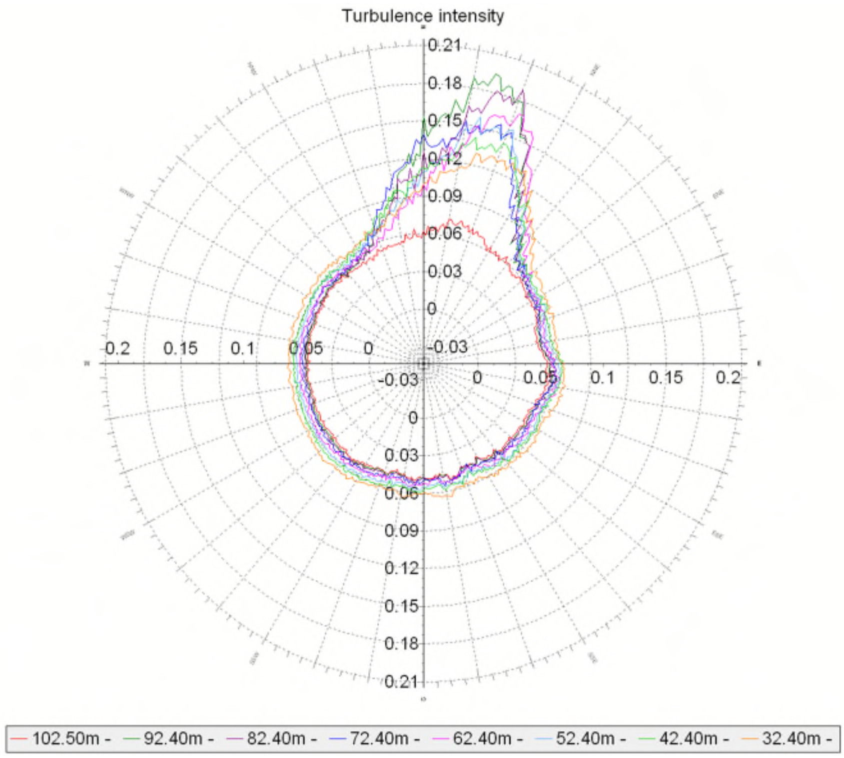


Figure 65. Directional Turbulence Intensity for the cup anemometers, FINO2.

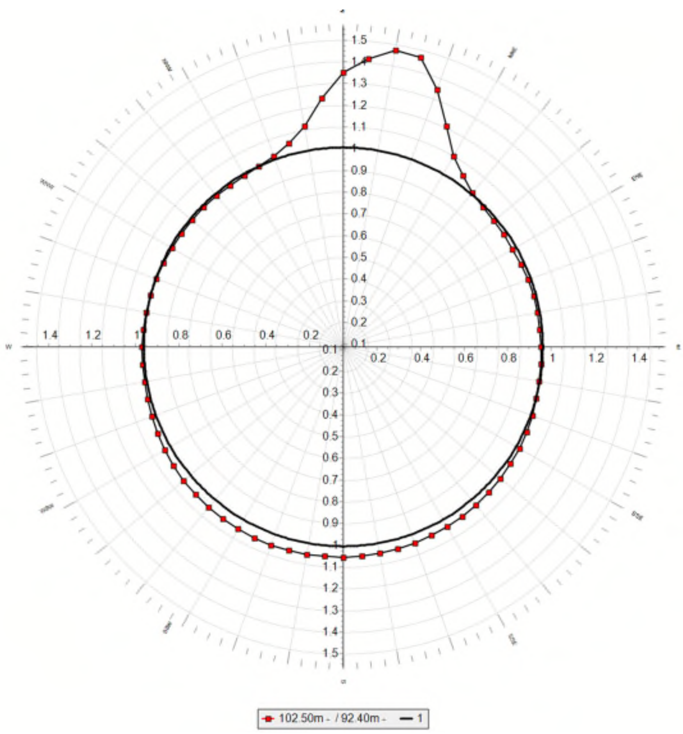


Figure 66. Directional wind speed ratio between 102.5 m and 92.5 m data, FINO2.

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 [58].

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.

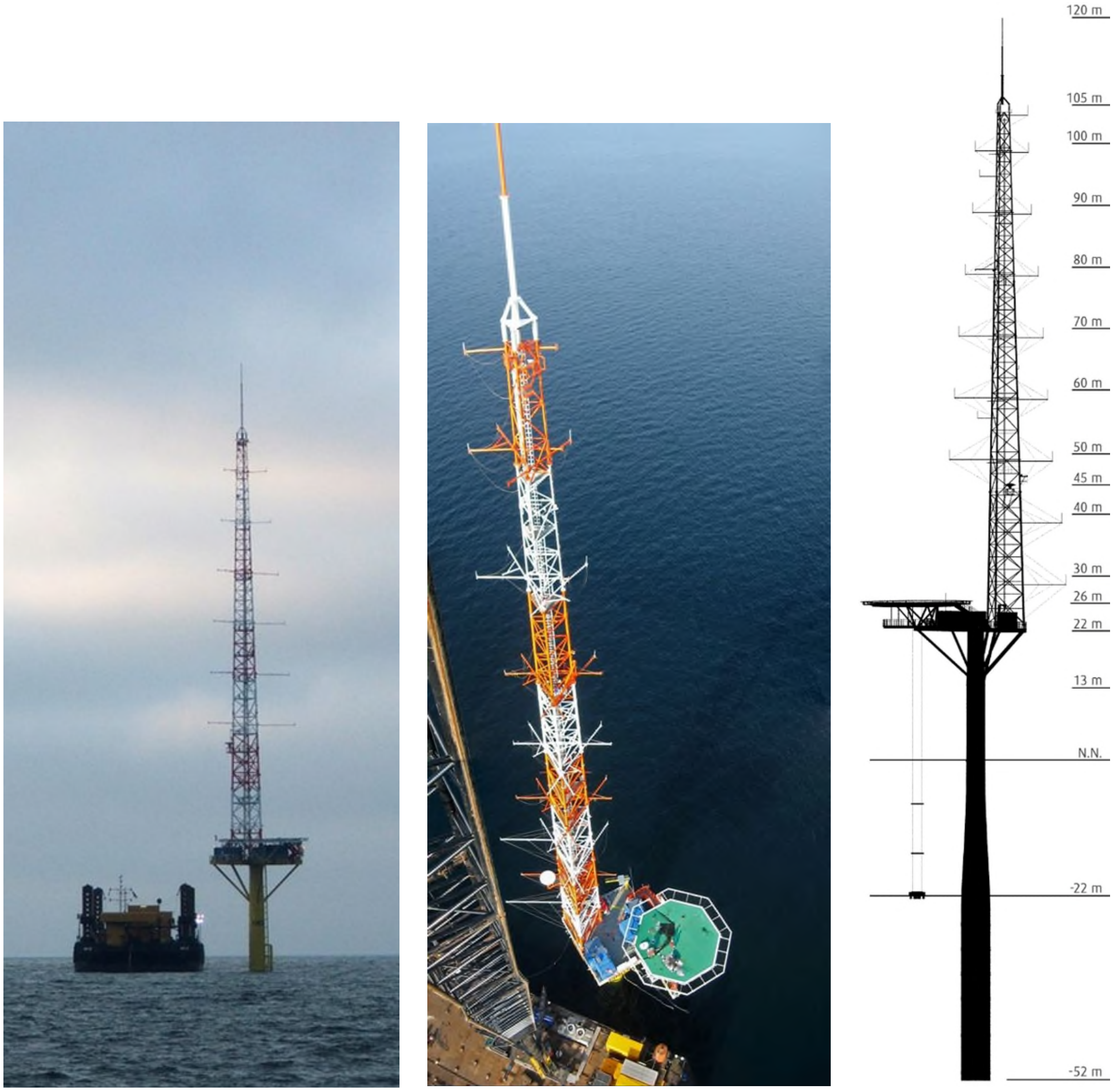


Figure 67. Pictures and details from FINO3, source: [62]

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 [61] 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 [61], FINO3 design and installation has not been conducted according to the IEC standards [58], 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).

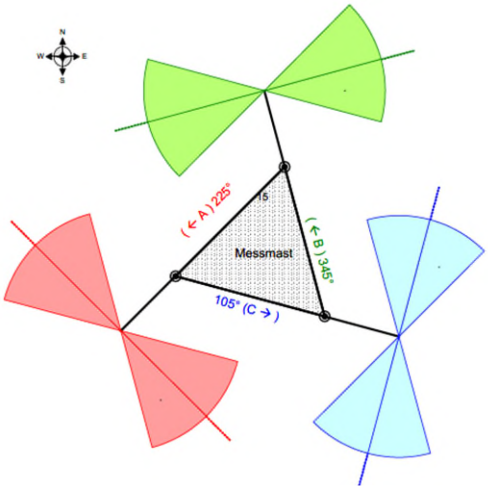


Figure 68. Representation of the boom's positioning in FINO3 and the undisturbed inflow directions, source: [61]

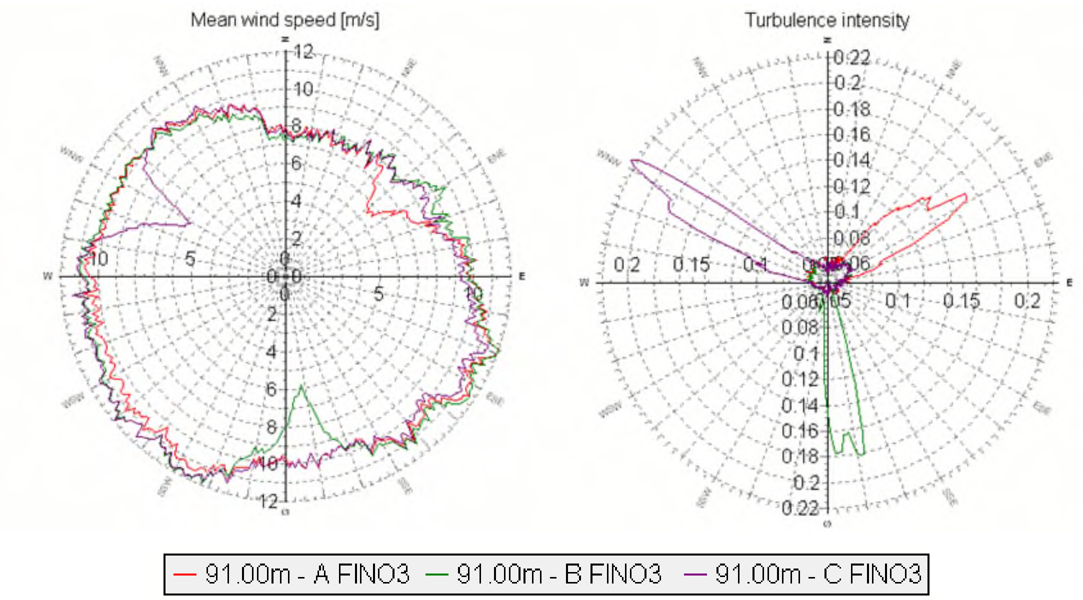


Figure 69. Directional Mean wind speed (left) and Turbulence Intensity (right) for the 3 cup anemometers at 91 m, before merging.

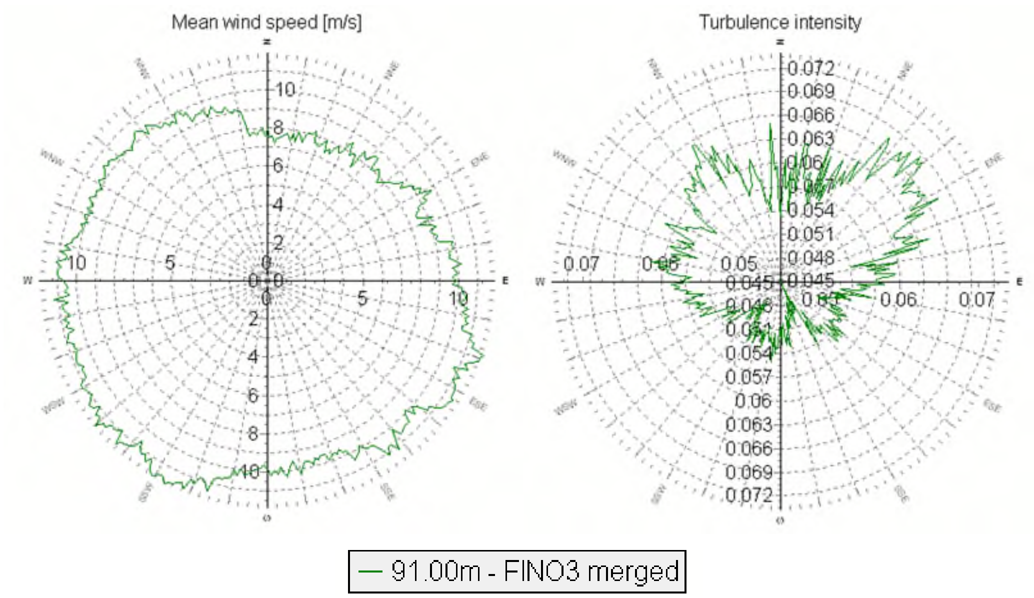


Figure 70. Directional Mean wind speed (left) and Turbulence Intensity (right) at 91 m, after merging.

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 [58] 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 with 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 24 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 not 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 minutes 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 hourly 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 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 are considered redundant with Anholt Haven station present. They are also 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-LB)	150	10.05	29.95	10.07	11.37	2.14
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.

Hesselø South (HS-1-LB) FLS
150 m ASL
(07/2023 - 04/2024)

Hesselø (H1) FLS
150 m ASL
(02/2021 - 02/2022)

Læsø mast 4 years
62 m ASL
(07/1999 - 07/2003)

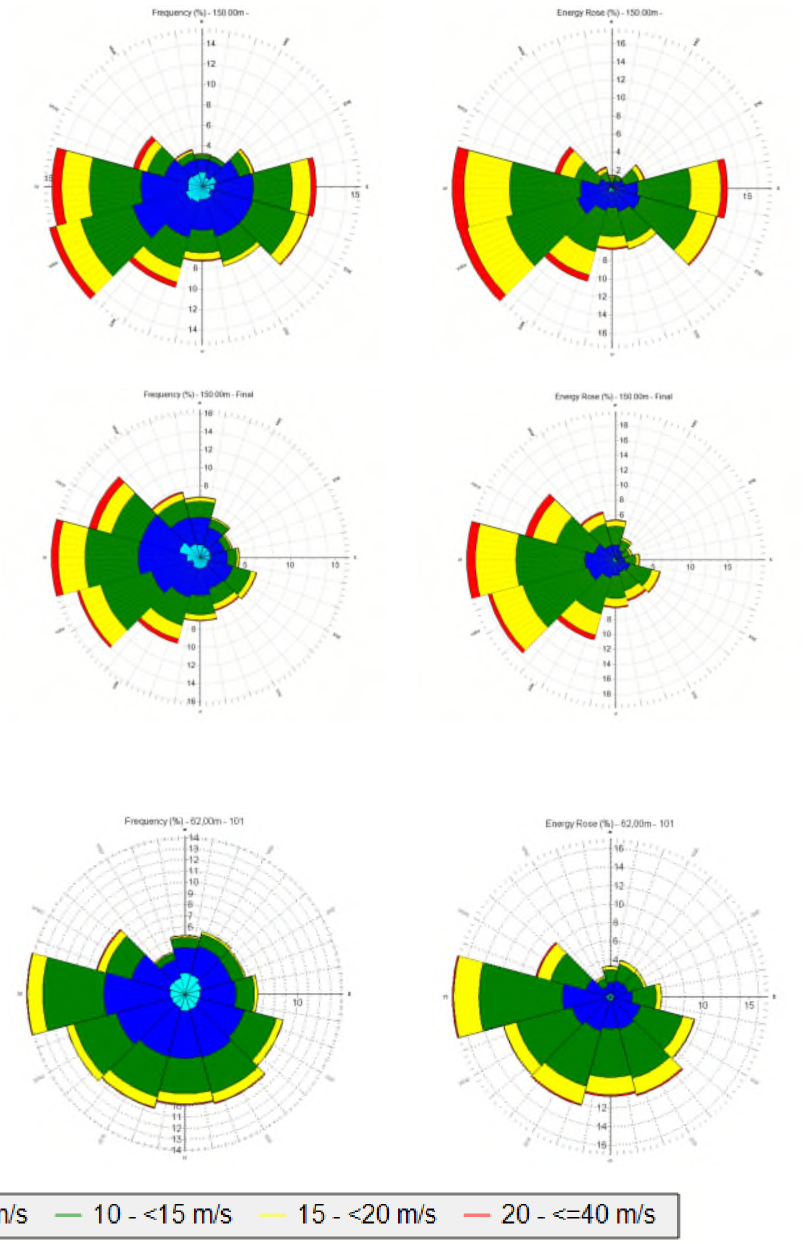


Figure 77. Supporting data wind direction frequency (on the left) and energy (on the right) distribution.

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.

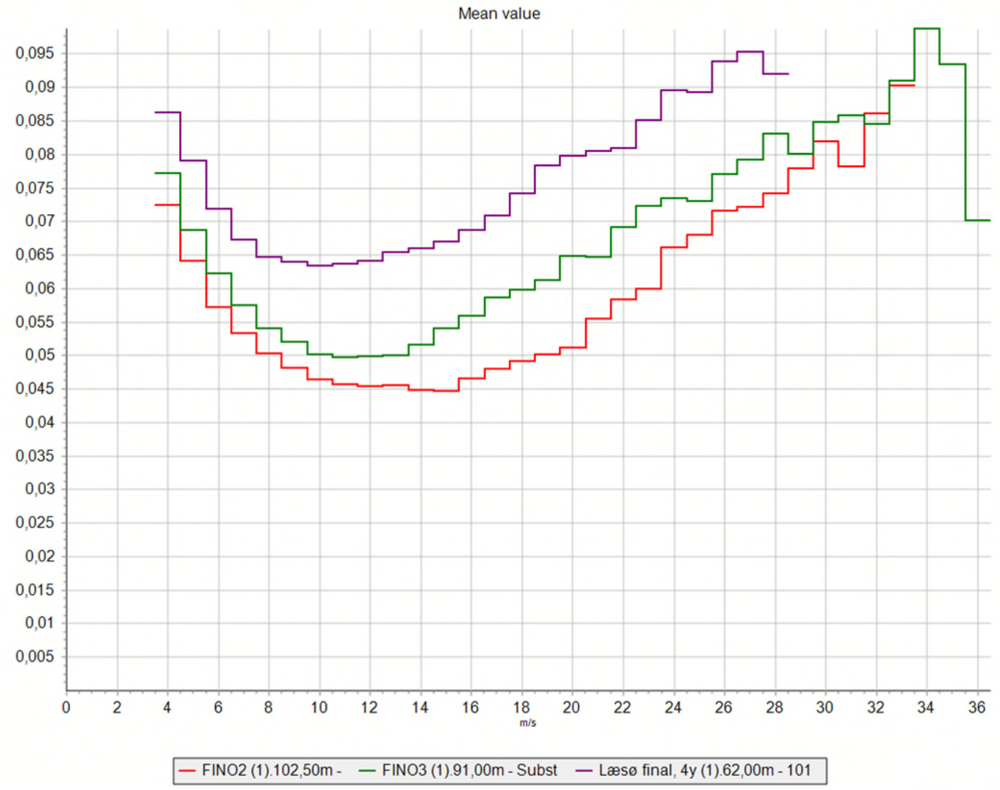


Figure 78. Turbulence intensity measured at FINO3 (red), FINO2 (green) and Læsø (purple).

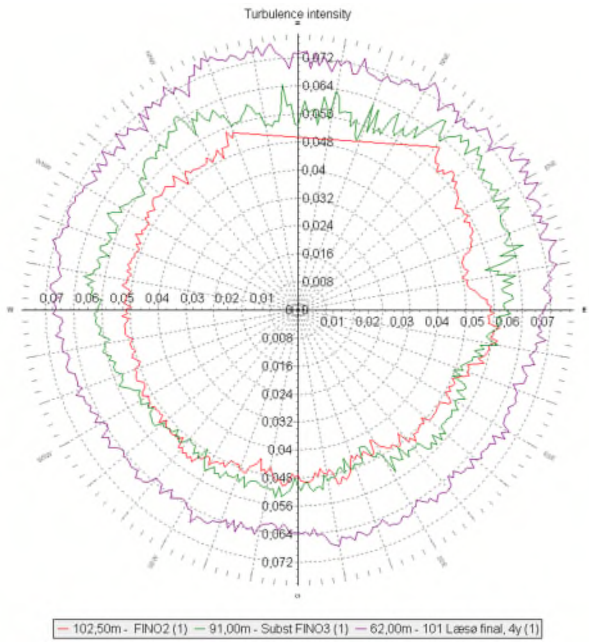


Figure 79. Measured turbulence intensity measured at FINO3 (red), FINO2 (green) and Læsø (purple) by wind direction.

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 Sea area that confirms the combined turbulence model with good match on mean, standard deviation and characteristic turbulence from 12 m/s and up.

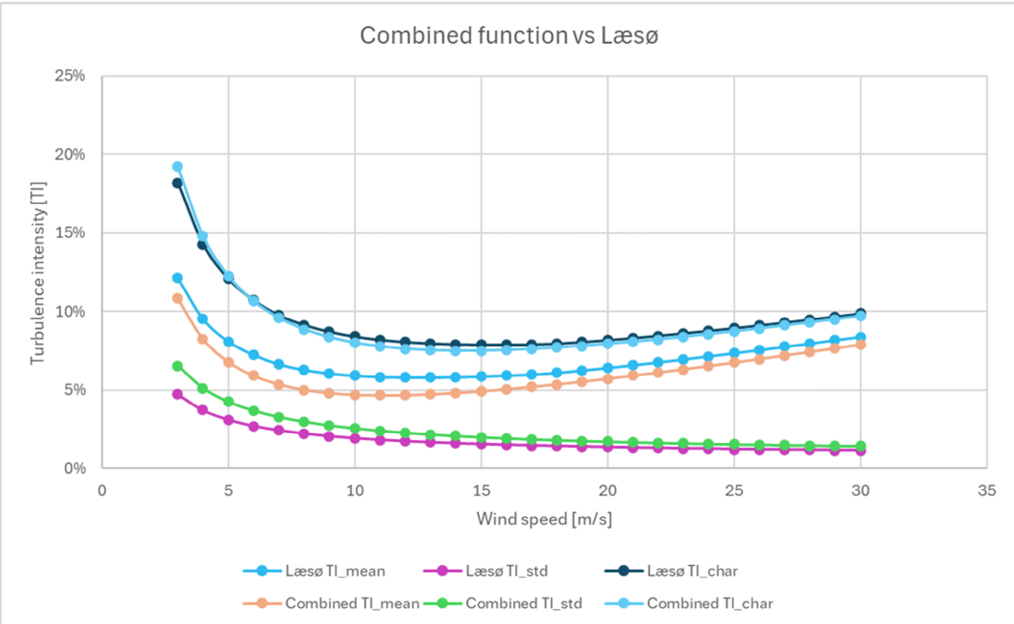


Figure 80. Mean turbulence intensity (TI_mean), Standard deviation of turbulence intensity (TI_std) and Characteristic turbulence intensity for the Combined model and Læsø turbulence extrapolated to 150 m.

DIURNAL VARIATION WIND SPEED

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

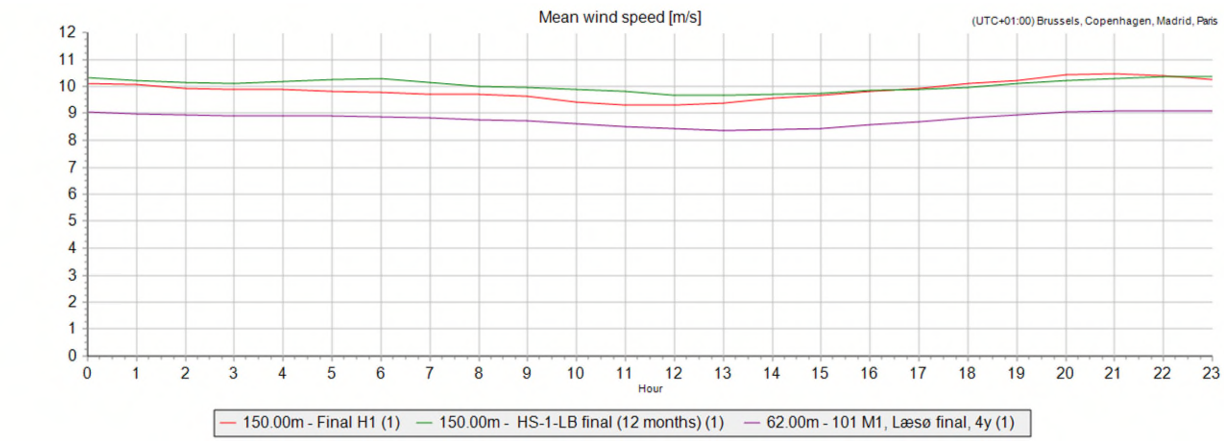


Figure 81. Daily variation of wind speed at H1, 1 year - 150 m (red), HS-1-LB, 12 months 150 m (green) and M1, 4 years, 62 m (purple).

SEASONAL VARIATION WIND SPEED

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

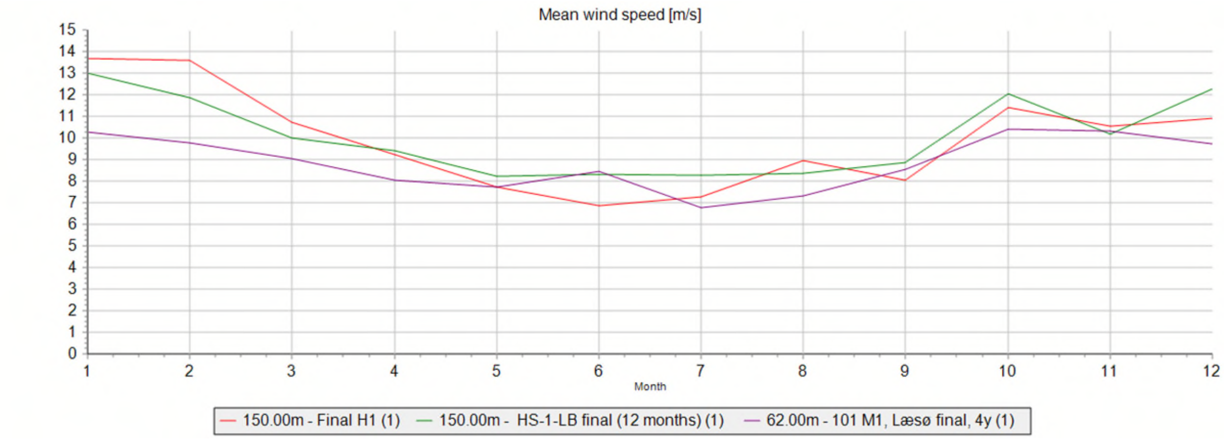


Figure 82. Monthly variation of wind speed measured at H1 - 150 m (1 year) (in red), HS-1-LB - 150 m (1 year) (in green) and M1 - 62 m (4 years) (in purple).

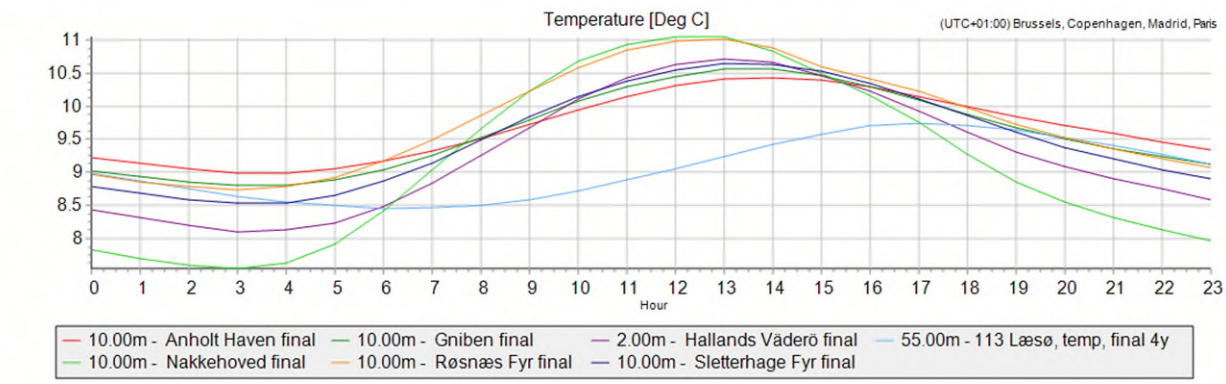
TEMPERATURE

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



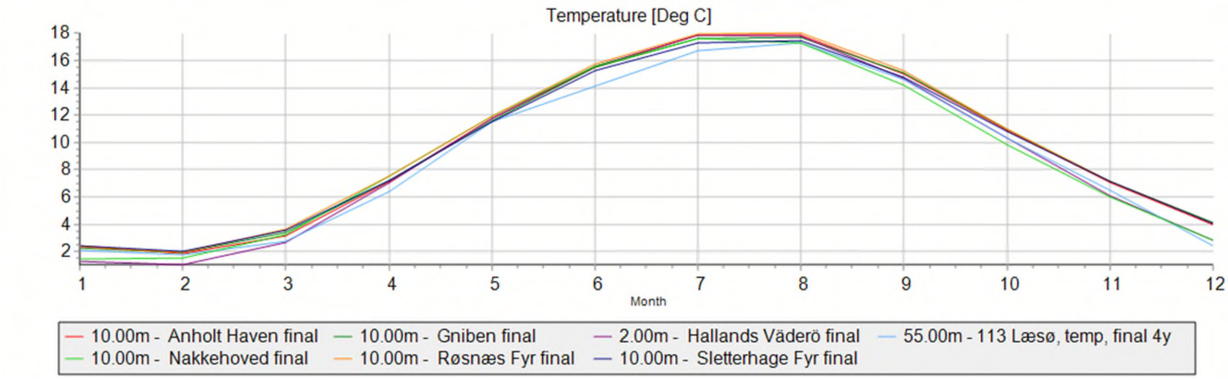


Figure 83. Diurnal(top) and monthly (bottom) variation of absolute temperature at the 7 secondary data sources.

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

The measurement data from Hesselø South (HS-1-LB), 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].

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-LB	H1	M1
Reference dataset	EMD-WRF	EMD-WRF	EMD-WRF
Correlation, r [%] Wind Speed, hourly	95.0	94.9	93.5
Correlation, r [%] Wind Energy, monthly	99.1	99.8	99.1
LTC methodology	Matrix	Matrix	Matrix
MBE, 24-hour slicing test, % production	0.69	0.75	-0.64
MBE, Concurrent period prediction test, % production	-0.16	0.23	-0.03

LONG-TERM WIND SPEED DISTRIBUTION

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

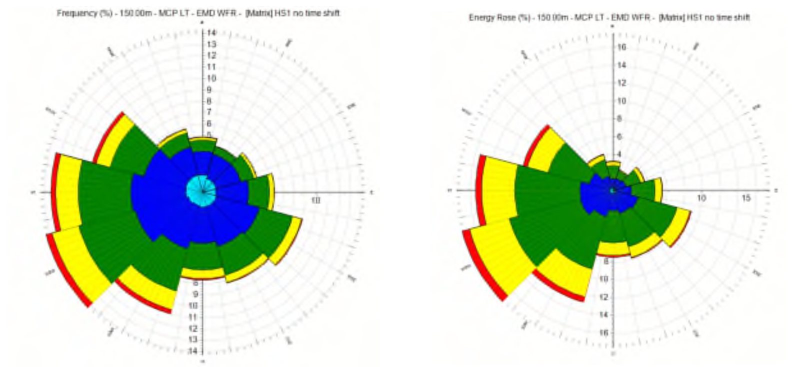
Frequency tables for each dataset can be found in appendix E.

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

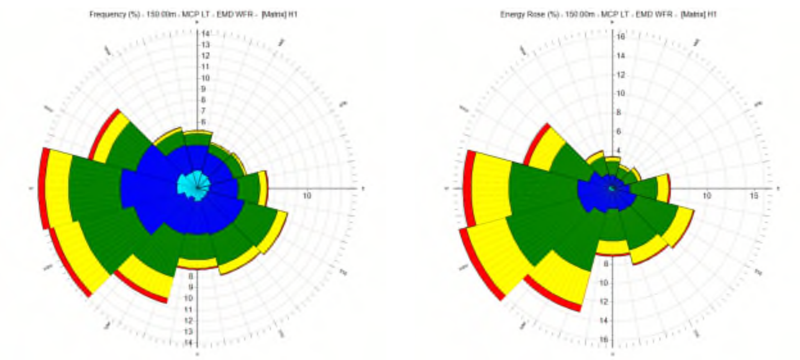
	ELEVATION ASL [m]	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER	WEIBULL - k PARAMETER
HS-1-LB	150	22	9.55	9.66	10.91	2.23
H1	150	22	9.73	9.86	11.13	2.21
M1	62	22	8.98	9.14	10.31	2.40

LONG-TERM WIND DIRECTION DISTRIBUTION

HS-1-LB, 22 years
150 m ASL
(01/2002 - 12/2023)



H1, 22 years
150 m ASL
(01/2002 - 12/2023)



M1, 22 years
62 m ASL
(01/2002 - 12/2023)

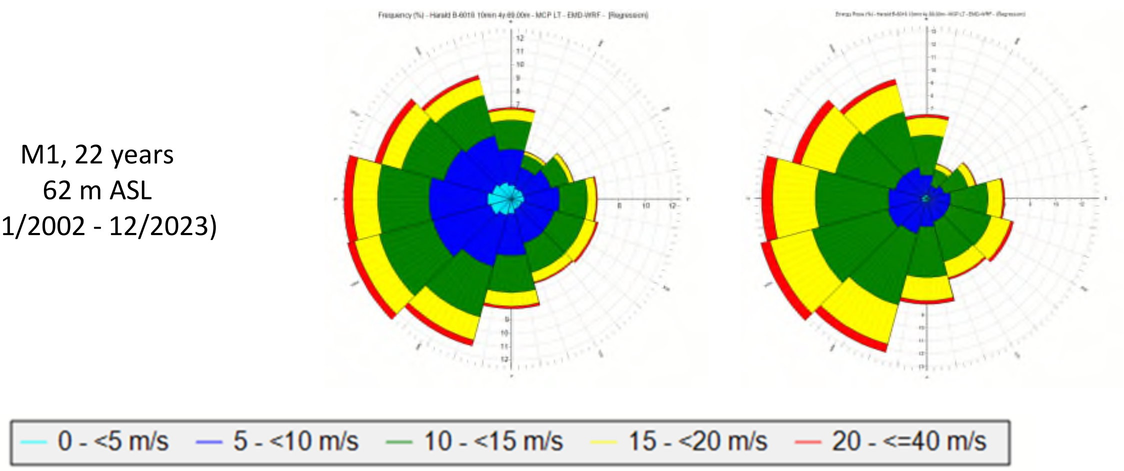


Figure 84. Long-term corrected frequency (left) and energy roses (right), at secondary data.

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 was observed in the measured data.

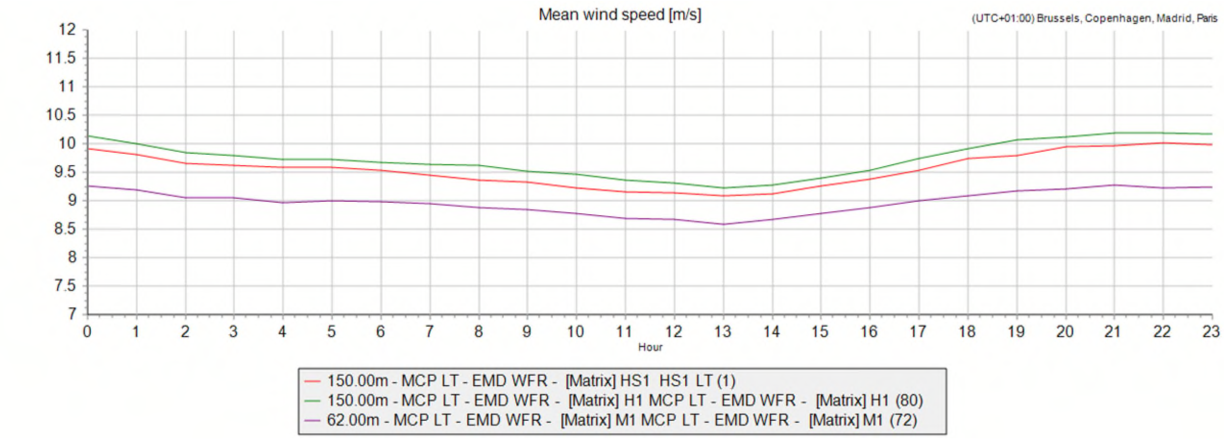


Figure 85. Long-term corrected diurnal variation, at secondary data. Red: HS-1_LB, green: H1, purple: M1.

LONG-TERM SEASONAL VARIATIONS

The long-term seasonal variations mirrors the variations from the short term measurements, with high wind speed at winter and lower wind speed in summer. The long-term variations are more regular in shape (Figure 86).

There is a distinctly different directional energy distribution summer and winter common for all three datasets (Figure 87).

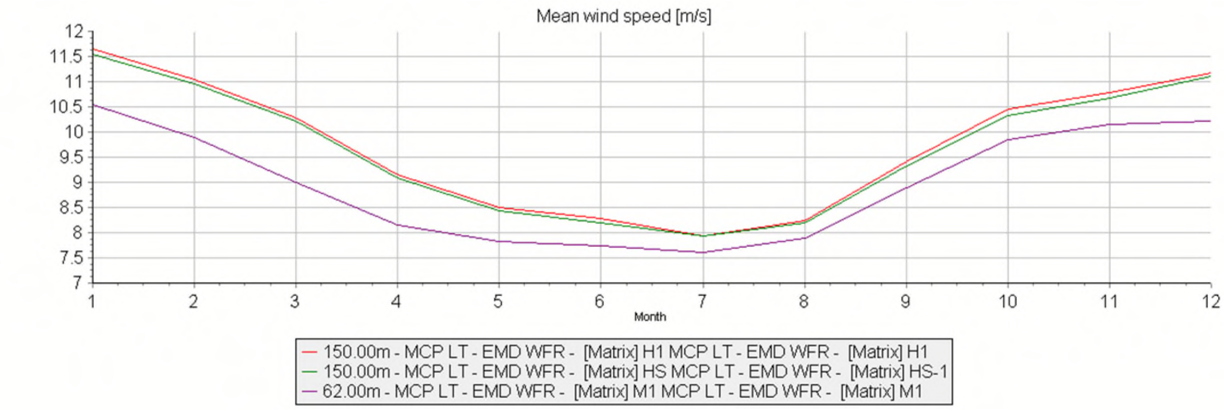


Figure 86. Long-term corrected seasonal variation, at secondary data. Red: H1, green: HS-1-LB, purple: M1.

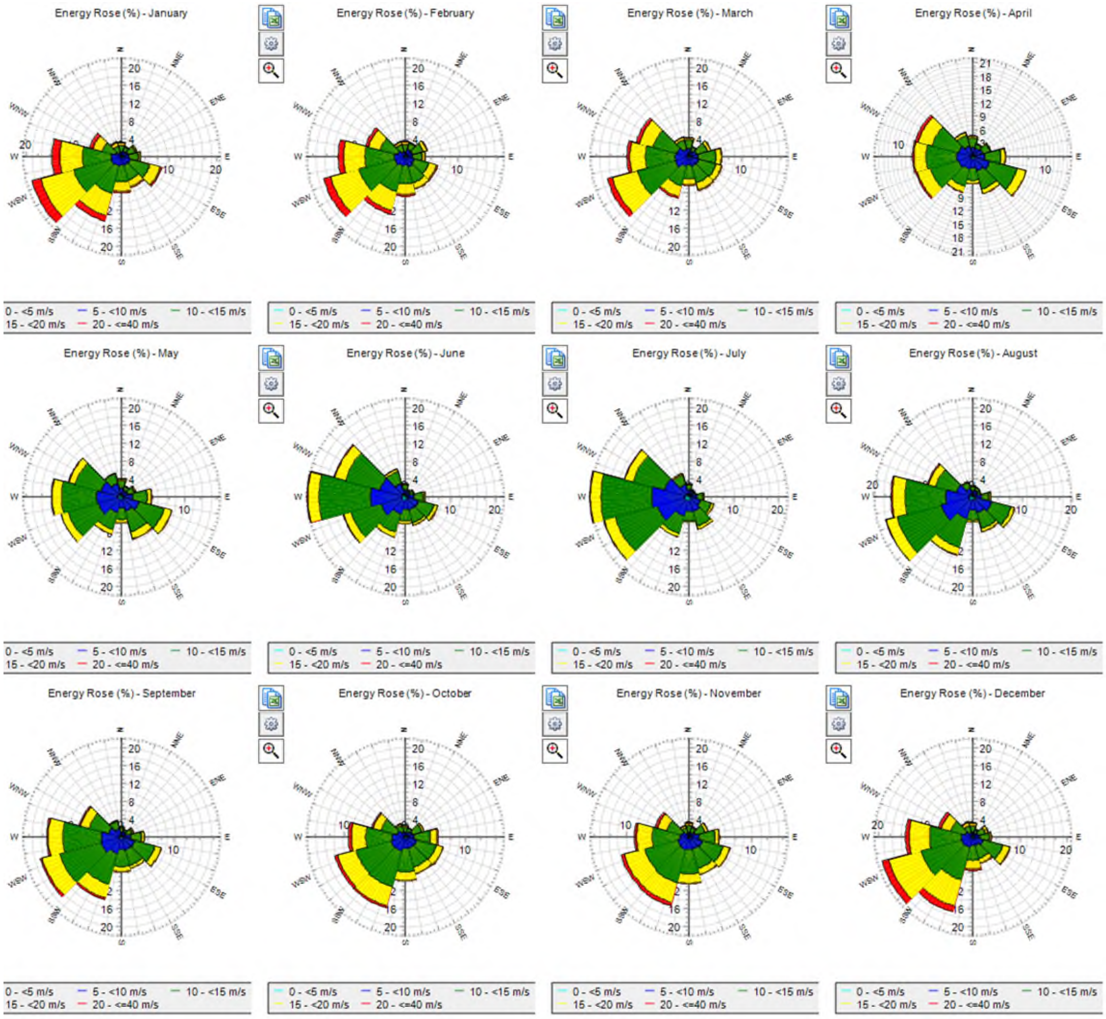


Figure 87. Long-term monthly energy roses, HS-1-LB (first line: January-April; second line: May-August; last line: September-December).

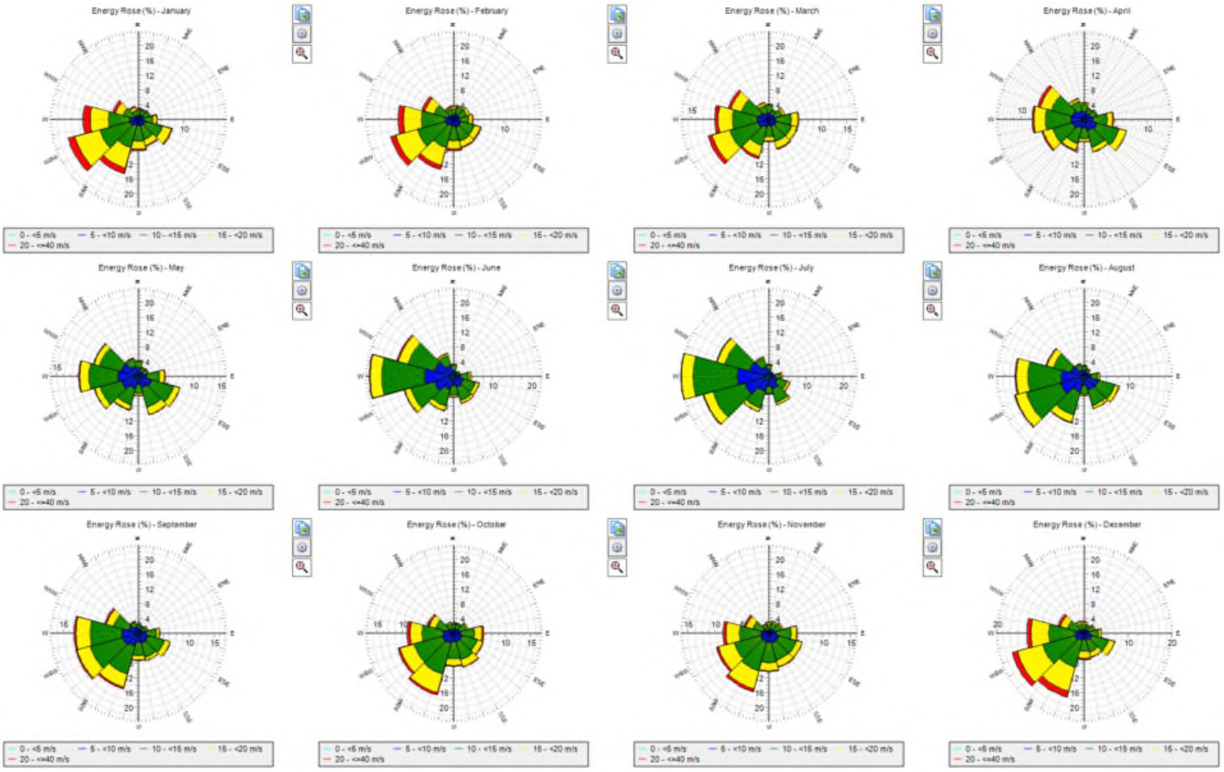


Figure 88. Long-term monthly energy roses, H1 (first line: January-April; second line: May-August; last line: September-December).

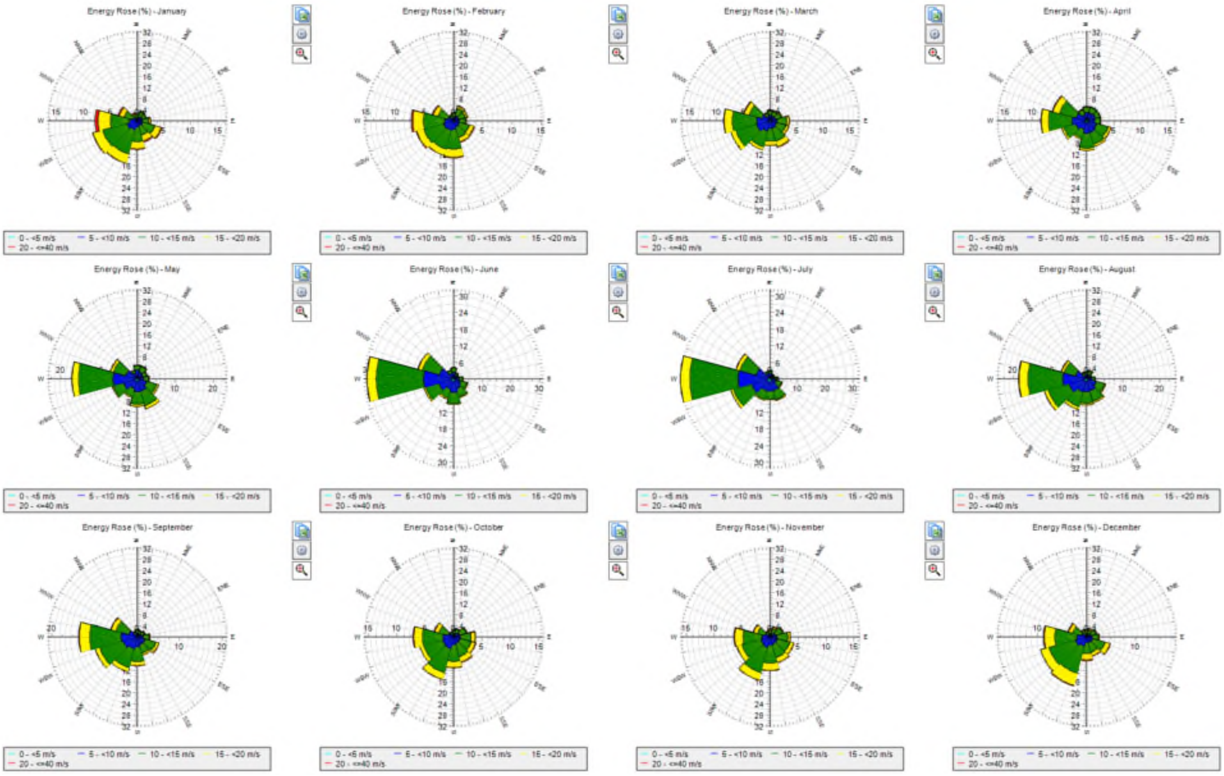


Figure 89. Long-term monthly energy roses, M1 (first line: January-April; second line: May-August; last line: September-December)

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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.64	6.90	6.83	7.77	11.72	10.98	9.58	9.82	11.07	11.34	12.18	11.78	8.09
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	364	36	44	41	27	24	56	47	25	19	10	8	27
2	1.50	2.49	1207	137	99	112	86	99	134	124	100	78	61	75	102
3	2.50	3.49	1883	114	114	218	198	164	207	215	174	148	108	103	120
4	3.50	4.49	2690	167	186	233	216	203	233	325	312	266	230	183	136
5	4.50	5.49	3218	227	211	219	262	291	380	284	318	310	344	201	171
6	5.50	6.49	3584	256	178	283	365	276	327	261	362	335	502	285	154
7	6.50	7.49	3663	165	159	249	381	276	339	252	416	388	511	307	220
8	7.50	8.49	3854	111	195	208	286	342	275	259	466	612	606	303	191
9	8.50	9.49	3742	149	232	159	258	376	309	239	439	592	565	282	142
10	9.50	10.49	3603	82	115	226	256	398	357	207	418	593	592	239	120
11	10.50	11.49	3411	85	40	160	235	397	399	186	363	596	648	211	91
12	11.50	12.49	2864	46	17	85	241	323	301	148	331	532	563	199	78
13	12.50	13.49	2772	33	11	79	279	343	268	164	274	454	554	230	83
14	13.50	14.49	2550	40	1	56	263	277	245	130	310	389	570	222	47
15	14.50	15.49	2171	24	0	58	255	216	165	162	345	328	446	154	18
16	15.50	16.49	2127	16	0	42	245	311	153	169	264	339	416	151	21
17	16.50	17.49	1812	16	4	22	184	294	115	159	190	329	345	127	27
18	17.50	18.49	1392	4	18	16	175	175	66	102	169	245	285	115	22
19	18.50	19.49	1246	1	25	6	202	145	56	67	161	212	258	100	13
20	19.50	20.49	958	3	12	9	163	86	31	69	90	96	291	102	6
21	20.50	21.49	723	4	7	12	108	55	35	41	73	56	225	90	17
22	21.50	22.49	515	5	0	6	36	33	28	24	53	48	177	98	7
23	22.50	23.49	339	0	0	2	51	6	14	16	42	32	96	72	8
24	23.50	24.49	276	0	0	9	81	1	4	6	27	28	69	49	2
25	24.50	25.49	243	0	0	4	63	0	1	14	28	39	50	44	0
26	25.50	26.49	159	0	0	0	37	0	0	6	37	21	29	29	0
27	26.50	27.49	93	0	0	0	17	0	0	7	14	16	9	29	1
28	27.50	28.49	55	0	0	0	9	0	0	4	8	10	0	24	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.50	6.80	6.68	7.79	11.55	10.99	9.53	9.77	10.99	11.18	11.90	11.43	8.06
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	374	31	46	33	30	24	47	57	27	22	10	14	33
2	1.50	2.49	1222	150	109	122	96	85	134	122	94	75	66	79	90
3	2.50	3.49	1960	120	146	243	195	179	205	219	196	139	103	106	109
4	3.50	4.49	2684	173	182	222	218	188	240	330	306	249	246	190	140
5	4.50	5.49	3258	213	209	226	275	286	346	286	336	341	358	210	172
6	5.50	6.49	3599	238	178	285	387	268	338	263	359	337	500	289	157
7	6.50	7.49	3749	177	163	259	407	279	320	243	401	406	562	309	223
8	7.50	8.49	3917	118	195	215	297	367	279	271	489	606	612	282	186
9	8.50	9.49	3797	137	235	182	265	367	314	232	455	640	576	252	142
10	9.50	10.49	3671	81	103	239	270	392	351	224	446	607	603	236	119
11	10.50	11.49	3344	75	41	151	265	369	386	190	362	561	634	212	98
12	11.50	12.49	3000	40	20	105	246	334	332	164	338	576	570	193	82
13	12.50	13.49	2869	39	7	80	299	354	260	168	286	486	588	222	80
14	13.50	14.49	2515	36	2	59	263	261	252	150	334	397	541	181	39
15	14.50	15.49	2220	23	0	64	287	243	163	176	338	332	420	160	14
16	15.50	16.49	2158	12	0	31	243	337	167	165	257	375	403	148	20
17	16.50	17.49	1676	15	3	25	173	273	102	146	207	287	304	110	31
18	17.50	18.49	1406	5	22	14	165	164	55	93	199	240	309	115	25
19	18.50	19.49	1168	2	19	11	207	152	54	80	127	173	260	78	5
20	19.50	20.49	914	2	16	12	148	74	45	67	91	90	258	103	8
21	20.50	21.49	659	5	2	9	88	75	21	40	61	57	205	85	11
22	21.50	22.49	429	3	0	8	32	19	11	22	58	33	148	83	12
23	22.50	23.49	293	0	0	5	54	2	8	10	35	30	75	69	5
24	23.50	24.49	260	0	0	3	84	1	2	8	25	33	62	42	0
25	24.50	25.49	211	0	0	4	64	0	0	11	43	23	29	37	0
26	25.50	26.49	140	0	0	0	41	0	0	8	33	16	9	32	1
27	26.50	27.49	67	0	0	0	10	0	0	7	14	14	2	20	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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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.34	6.73	6.70	7.82	11.44	10.91	9.43	9.68	10.97	10.94	11.63	10.97	7.92
0		0.49	2	1	0	0	0	0	0	0	0	0	0	1	0
1	0.50	1.49	367	36	35	35	32	20	52	49	27	23	14	18	26
2	1.50	2.49	1227	137	134	129	108	82	130	117	82	74	69	74	91
3	2.50	3.49	1972	138	114	245	202	173	201	241	190	124	113	132	99
4	3.50	4.49	2751	175	191	213	211	197	258	336	304	259	267	190	150
5	4.50	5.49	3300	220	220	232	291	286	331	300	333	327	373	207	180
6	5.50	6.49	3662	214	179	308	393	257	340	284	376	351	523	286	151
7	6.50	7.49	3852	182	165	258	401	292	313	259	421	427	559	357	218
8	7.50	8.49	3884	101	211	228	309	347	301	249	494	608	584	269	183
9	8.50	9.49	3942	137	235	185	281	414	330	227	473	667	577	278	138
10	9.50	10.49	3764	78	101	240	286	389	332	222	443	672	644	245	112
11	10.50	11.49	3317	68	37	176	276	354	368	215	371	576	613	171	92
12	11.50	12.49	3135	45	24	100	258	345	351	174	353	589	626	192	78
13	12.50	13.49	2981	48	5	94	311	344	335	165	304	493	584	225	73
14	13.50	14.49	2511	25	1	61	275	301	221	173	348	399	491	185	31
15	14.50	15.49	2256	20	0	60	299	262	164	192	348	348	406	144	13
16	15.50	16.49	2108	11	2	37	244	328	156	172	263	349	388	135	23
17	16.50	17.49	1604	18	4	20	174	269	87	124	229	274	273	100	32
18	17.50	18.49	1346	4	21	9	183	161	67	84	194	226	305	79	13
19	18.50	19.49	1119	1	22	15	205	117	40	93	117	134	278	88	9
20	19.50	20.49	825	2	14	14	127	85	31	62	77	81	245	79	8
21	20.50	21.49	576	4	2	12	77	50	15	33	72	47	168	87	9
22	21.50	22.49	325	4	0	5	39	11	7	11	42	20	107	66	13
23	22.50	23.49	269	0	0	7	66	1	4	7	30	30	65	59	0
24	23.50	24.49	253	0	0	6	78	0	0	14	44	22	48	40	1
25	24.50	25.49	169	0	0	1	56	0	0	13	42	13	14	29	1
26	25.50	26.49	104	0	0	0	32	0	0	5	37	8	3	19	0
27	26.50	27.49	46	0	0	0	15	0	0	5	10	2	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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25/09/2024 11:45

Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.21	6.71	6.68	7.81	11.39	10.82	9.34	9.62	10.87	10.82	11.36	10.62	7.92
0		0.49	1	0	0	0	0	0	0	0	0	0	0	1	0
1	0.50	1.49	365	38	28	39	31	22	56	41	28	17	19	22	24
2	1.50	2.49	1285	134	136	142	125	85	133	132	72	83	75	87	81
3	2.50	3.49	1994	135	134	252	188	179	194	265	176	129	112	135	95
4	3.50	4.49	2787	193	191	174	228	207	252	346	303	257	263	209	164
5	4.50	5.49	3243	216	199	247	282	257	335	290	323	328	398	204	164
6	5.50	6.49	3722	221	197	337	370	249	337	295	376	371	528	286	155
7	6.50	7.49	3889	153	170	261	411	312	323	257	457	396	579	357	213
8	7.50	8.49	4025	124	226	253	350	327	305	275	521	627	562	270	185
9	8.50	9.49	3963	126	217	190	284	410	354	213	490	684	580	282	133
10	9.50	10.49	3856	73	90	249	310	407	339	227	477	696	654	230	104
11	10.50	11.49	3395	66	48	193	288	366	347	217	348	607	638	183	94
12	11.50	12.49	3229	51	18	106	256	368	354	197	397	595	612	196	79
13	12.50	13.49	2933	43	4	101	322	338	336	180	301	478	557	201	72
14	13.50	14.49	2632	25	2	65	298	337	249	193	385	426	459	162	31
15	14.50	15.49	2240	19	0	50	312	255	152	208	325	352	410	140	17
16	15.50	16.49	2060	18	0	41	241	339	136	171	256	351	370	113	24
17	16.50	17.49	1559	9	9	17	179	232	82	105	258	270	277	96	25
18	17.50	18.49	1289	4	19	15	175	165	49	109	179	209	279	71	15
19	18.50	19.49	1075	2	27	15	205	110	48	95	102	119	248	93	11
20	19.50	20.49	697	2	11	12	118	69	29	43	70	59	199	83	2
21	20.50	21.49	492	8	0	10	67	35	13	22	73	41	143	67	13
22	21.50	22.49	286	2	0	5	47	4	4	11	28	31	76	70	8
23	22.50	23.49	258	0	0	5	70	0	1	11	32	25	67	45	2
24	23.50	24.49	215	0	0	4	74	0	1	15	45	12	27	37	0
25	24.50	25.49	139	0	0	1	56	0	0	11	40	6	5	18	2
26	25.50	26.49	79	0	0	0	32	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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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.11	6.63	6.65	7.82	11.35	10.73	9.23	9.54	10.85	10.70	11.14	10.44	7.93
0		0.49	1	0	0	0	0	0	0	1	0	0	0	0	0
1	0.50	1.49	366	35	35	39	33	22	54	31	29	22	18	30	18
2	1.50	2.49	1303	140	135	146	111	88	139	143	67	81	80	86	87
3	2.50	3.49	1991	135	136	245	183	160	213	277	174	124	114	137	93
4	3.50	4.49	2796	193	196	172	239	221	264	333	279	275	281	201	142
5	4.50	5.49	3252	224	211	256	264	250	334	291	337	300	402	208	175
6	5.50	6.49	3682	204	172	313	365	257	337	308	369	371	529	306	151
7	6.50	7.49	4022	162	168	290	445	316	313	281	478	410	609	341	209
8	7.50	8.49	4115	134	240	245	359	343	330	259	547	613	575	280	190
9	8.50	9.49	4071	93	214	199	314	427	354	237	521	711	596	266	139
10	9.50	10.49	3917	78	102	253	328	401	325	249	466	714	659	238	104
11	10.50	11.49	3401	65	37	193	301	364	347	228	350	600	663	173	80
12	11.50	12.49	3248	52	12	120	257	361	354	201	393	612	592	200	94
13	12.50	13.49	3036	43	5	105	341	366	335	218	345	483	526	205	64
14	13.50	14.49	2644	20	1	62	332	349	249	205	372	415	455	160	24
15	14.50	15.49	2189	20	0	44	312	272	143	198	307	366	395	116	16
16	15.50	16.49	1996	18	0	36	222	308	128	180	290	346	341	100	27
17	16.50	17.49	1571	10	10	20	184	245	58	109	271	274	275	91	24
18	17.50	18.49	1260	2	24	9	201	144	56	110	168	186	262	87	11
19	18.50	19.49	965	1	22	17	181	101	43	75	108	97	220	90	10
20	19.50	20.49	638	5	12	15	112	57	25	29	83	45	178	73	4
21	20.50	21.49	417	4	2	7	63	27	13	18	52	37	111	70	13
22	21.50	22.49	281	2	0	5	57	3	5	9	29	21	80	59	11
23	22.50	23.49	228	0	0	4	64	0	1	17	41	18	44	38	1
24	23.50	24.49	209	0	0	9	73	0	1	15	52	7	23	29	0
25	24.50	25.49	127	0	0	0	52	0	0	11	32	4	7	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			10.00	6.59	6.65	7.90	11.27	10.63	9.12	9.45	10.77	10.56	10.94	10.23	7.85
0		0.49	1	0	0	0	0	0	0	0	0	0	1	0	0
1	0.50	1.49	360	40	32	44	36	28	40	38	23	21	25	16	17
2	1.50	2.49	1356	143	155	142	110	99	130	161	79	84	92	83	78
3	2.50	3.49	1981	132	121	246	184	148	226	265	165	138	121	134	101
4	3.50	4.49	2808	209	189	188	225	223	273	326	281	253	293	204	144
5	4.50	5.49	3308	219	209	238	275	249	356	316	346	295	400	232	173
6	5.50	6.49	3732	200	171	316	371	273	331	316	366	398	530	291	169
7	6.50	7.49	4022	147	183	281	461	305	315	277	476	440	591	345	201
8	7.50	8.49	4213	133	229	258	389	335	329	283	573	623	582	292	187
9	8.50	9.49	4201	94	228	216	318	437	361	253	554	705	613	291	131
10	9.50	10.49	3944	74	108	252	361	404	331	255	453	734	657	215	100
11	10.50	11.49	3517	67	42	224	298	374	345	234	366	607	672	199	89
12	11.50	12.49	3295	46	11	106	256	391	345	238	412	606	598	196	90
13	12.50	13.49	3014	39	3	115	340	401	326	228	349	490	494	173	56
14	13.50	14.49	2622	30	1	58	360	361	220	223	344	420	438	143	24
15	14.50	15.49	2232	22	0	53	316	251	160	203	321	367	408	115	16
16	15.50	16.49	1894	12	1	30	210	291	99	169	357	327	284	83	31
17	16.50	17.49	1570	12	9	24	201	237	58	133	244	270	282	84	16
18	17.50	18.49	1133	2	20	16	182	133	55	89	142	143	247	90	14
19	18.50	19.49	881	2	29	15	181	96	45	46	113	78	183	88	5
20	19.50	20.49	578	7	8	18	101	50	18	31	67	49	147	71	11
21	20.50	21.49	367	1	0	8	65	12	10	17	42	26	104	73	9
22	21.50	22.49	256	3	0	5	47	3	1	15	40	16	76	44	6
23	22.50	23.49	239	0	0	8	77	0	2	17	50	10	40	32	3
24	23.50	24.49	159	0	0	3	72	0	0	11	35	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			9.87	6.51	6.60	7.95	11.18	10.49	8.97	9.39	10.66	10.38	10.75	9.95	7.79
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	384	38	51	42	31	41	39	27	20	27	28	20	20
2	1.50	2.49	1346	148	138	147	116	92	134	164	76	89	82	90	70
3	2.50	3.49	2029	126	138	241	164	164	227	268	175	139	137	139	111
4	3.50	4.49	2786	207	193	177	224	221	286	317	254	250	301	201	155
5	4.50	5.49	3364	210	223	244	277	260	361	306	352	304	413	250	164
6	5.50	6.49	3840	191	168	330	379	282	362	323	391	378	545	323	168
7	6.50	7.49	4064	154	173	293	452	298	317	275	508	454	606	340	194
8	7.50	8.49	4271	126	252	230	409	346	356	279	578	662	552	304	177
9	8.50	9.49	4341	101	210	232	366	402	367	271	622	731	615	295	129
10	9.50	10.49	4062	73	104	286	396	428	347	250	469	701	682	216	110
11	10.50	11.49	3589	67	39	221	294	436	342	252	380	609	646	220	83
12	11.50	12.49	3312	38	15	115	288	358	362	245	428	625	566	176	96
13	12.50	13.49	3094	42	4	110	349	473	324	243	361	481	501	164	42
14	13.50	14.49	2567	27	1	57	373	335	196	250	356	421	425	103	23
15	14.50	15.49	2241	18	0	55	306	236	149	202	322	405	407	123	18
16	15.50	16.49	1823	12	1	35	213	271	88	153	386	289	269	78	28
17	16.50	17.49	1483	11	13	22	194	245	69	120	243	219	260	72	15
18	17.50	18.49	1035	3	26	20	175	126	46	89	135	114	201	84	16
19	18.50	19.49	765	3	26	18	163	72	35	35	91	68	165	84	5
20	19.50	20.49	517	3	5	12	105	40	18	26	52	31	127	89	9
21	20.50	21.49	319	2	0	10	54	3	4	7	41	20	109	54	15
22	21.50	22.49	242	0	0	5	53	2	2	19	45	8	66	38	4
23	22.50	23.49	214	0	0	9	76	0	0	16	49	9	30	23	2
24	23.50	24.49	143	0	0	4	63	0	0	11	33	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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Meteo data report - Frequency distribution (TAB file data)

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			9.63	6.35	6.57	8.02	11.03	10.12	8.69	9.22	10.41	10.10	10.41	9.62	7.67
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	380	37	46	47	27	44	38	25	25	26	27	20	18
2	1.50	2.49	1335	145	134	137	108	99	143	153	82	87	85	85	77
3	2.50	3.49	2129	131	162	240	161	171	231	294	171	160	158	135	115
4	3.50	4.49	2791	212	207	177	220	228	292	322	239	253	299	192	150
5	4.50	5.49	3481	213	220	233	301	248	398	300	323	322	438	293	192
6	5.50	6.49	4069	214	172	362	386	347	378	338	426	360	567	358	161
7	6.50	7.49	4147	149	170	305	424	327	337	257	526	510	607	343	192
8	7.50	8.49	4493	122	249	229	456	345	407	321	673	676	537	314	164
9	8.50	9.49	4562	110	233	240	448	423	356	274	654	768	638	294	124
10	9.50	10.49	4282	60	90	305	409	502	346	288	505	711	705	235	126
11	10.50	11.49	3659	58	37	229	312	432	378	254	475	599	621	172	92
12	11.50	12.49	3377	30	18	123	320	424	352	302	419	581	572	154	82
13	12.50	13.49	3109	33	4	111	397	461	306	264	383	511	464	136	39
14	13.50	14.49	2548	28	1	70	401	229	177	282	385	426	415	109	25
15	14.50	15.49	2216	16	0	51	315	264	106	197	449	384	322	97	15
16	15.50	16.49	1718	13	3	41	214	284	86	140	332	240	257	83	25
17	16.50	17.49	1213	9	17	23	182	206	54	94	182	155	191	81	19
18	17.50	18.49	837	3	28	24	174	82	37	45	91	80	181	85	7
19	18.50	19.49	568	1	23	13	122	38	27	22	60	39	131	87	5
20	19.50	20.49	413	4	2	17	91	8	9	15	33	22	134	68	10
21	20.50	21.49	277	1	0	7	44	3	0	25	54	10	78	40	15
22	21.50	22.49	217	0	0	5	58	0	0	16	41	13	50	28	6
23	22.50	23.49	166	0	0	9	79	0	0	12	27	5	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			9.42	6.26	6.40	8.00	10.83	9.76	8.49	9.11	10.15	9.83	10.21	9.42	7.51
0		0.49	1	1	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	417	44	51	43	45	32	42	31	21	28	33	26	21
2	1.50	2.49	1368	143	155	141	114	109	142	145	95	85	92	74	73
3	2.50	3.49	2218	153	186	231	165	181	242	300	176	159	176	131	118
4	3.50	4.49	2897	242	210	192	221	235	285	345	247	285	282	195	158
5	4.50	5.49	3585	206	237	225	298	291	413	313	316	324	463	297	202
6	5.50	6.49	4234	199	196	394	400	385	389	339	448	390	577	355	162
7	6.50	7.49	4329	148	158	287	446	375	398	262	568	528	598	357	204
8	7.50	8.49	4669	132	242	259	495	372	399	368	700	690	550	301	161
9	8.50	9.49	4801	107	218	259	501	454	365	286	665	827	684	282	153
10	9.50	10.49	4374	64	93	304	417	555	345	317	563	666	712	213	125
11	10.50	11.49	3755	56	30	238	342	407	373	320	465	610	633	181	100
12	11.50	12.49	3707	29	18	133	389	489	394	396	492	608	565	136	58
13	12.50	13.49	2954	28	3	100	445	341	255	277	421	478	444	122	40
14	13.50	14.49	2537	31	2	61	376	227	133	275	464	457	387	106	18
15	14.50	15.49	2087	13	0	55	325	273	114	214	412	302	274	89	16
16	15.50	16.49	1479	16	1	43	198	283	71	115	252	170	214	91	25
17	16.50	17.49	997	10	24	21	165	144	52	56	105	121	213	74	12
18	17.50	18.49	684	1	30	20	153	52	35	32	73	51	150	79	8
19	18.50	19.49	514	1	18	17	126	15	12	15	40	28	153	83	6
20	19.50	20.49	374	4	2	13	77	6	0	27	44	19	115	54	13
21	20.50	21.49	234	3	0	6	41	1	0	20	43	13	67	31	9
22	21.50	22.49	181	0	0	7	61	0	0	13	24	10	36	28	2
23	22.50	23.49	137	0	0	5	73	0	0	7	27	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			8.78	6.05	6.25	7.69	10.18	8.94	7.82	8.31	9.30	9.02	9.71	8.91	7.12
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	469	48	51	58	39	34	42	43	29	30	33	31	31
2	1.50	2.49	1388	153	156	134	108	109	148	154	100	94	90	83	59
3	2.50	3.49	2474	171	194	256	185	223	289	338	176	192	170	151	129
4	3.50	4.49	3194	222	242	242	235	275	322	316	315	331	307	210	177
5	4.50	5.49	4093	206	276	266	332	387	471	381	371	377	478	327	221
6	5.50	6.49	4741	174	232	386	427	477	460	412	564	476	562	392	179
7	6.50	7.49	4900	169	164	315	527	438	423	409	705	590	629	331	200
8	7.50	8.49	5264	123	249	280	665	490	385	399	775	786	602	293	217
9	8.50	9.49	5152	83	197	276	635	543	378	371	811	781	703	235	139
10	9.50	10.49	4638	49	85	290	501	457	427	376	655	735	707	238	118
11	10.50	11.49	4164	43	34	241	448	384	437	415	668	647	652	154	41
12	11.50	12.49	3416	33	8	135	426	349	279	342	654	511	529	112	38
13	12.50	13.49	2529	27	0	90	375	262	187	248	421	380	382	126	31
14	13.50	14.49	1904	29	1	64	318	236	116	171	304	216	317	114	18
15	14.50	15.49	1249	16	2	47	206	255	54	85	151	119	210	80	24
16	15.50	16.49	886	11	9	27	144	162	22	47	88	103	176	78	19
17	16.50	17.49	625	5	32	15	143	58	7	15	51	60	146	83	10
18	17.50	18.49	546	2	30	20	129	21	3	35	42	32	147	78	7
19	18.50	19.49	377	3	6	16	96	6	0	24	28	18	109	62	9
20	19.50	20.49	233	3	0	9	51	0	0	9	36	12	65	33	15
21	20.50	21.49	184	0	0	10	77	0	0	6	20	11	33	25	2
22	21.50	22.49	123	0	0	5	76	0	0	3	23	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-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 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			7.78	5.55	5.73	7.10	8.93	7.90	6.82	7.15	8.04	7.95	8.83	8.14	6.49
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	595	57	76	57	47	57	52	47	41	48	45	38	30
2	1.50	2.49	1702	169	198	160	134	141	217	188	104	112	101	98	80
3	2.50	3.49	3135	216	206	294	238	314	383	400	301	221	200	199	163
4	3.50	4.49	4501	263	355	350	370	474	451	457	417	466	407	280	211
5	4.50	5.49	5170	236	247	271	523	525	553	552	618	497	568	352	228
6	5.50	6.49	5592	166	199	398	699	478	506	549	785	626	605	359	222
7	6.50	7.49	5695	126	163	326	789	491	431	512	932	788	622	309	206
8	7.50	8.49	5881	109	241	282	633	491	448	450	1054	977	739	300	157
9	8.50	9.49	5321	56	173	341	552	463	448	456	890	727	858	249	108
10	9.50	10.49	4190	47	41	298	395	364	434	342	656	632	721	193	67
11	10.50	11.49	3196	33	20	156	419	351	292	221	498	448	598	127	33
12	11.50	12.49	2345	39	2	110	358	300	138	204	331	245	427	151	40
13	12.50	13.49	1654	28	0	64	296	281	60	161	221	138	283	102	20
14	13.50	14.49	1133	24	1	46	200	227	23	58	102	129	202	94	27
15	14.50	15.49	730	9	20	26	141	108	6	21	46	97	155	88	13
16	15.50	16.49	651	2	44	21	164	37	4	38	53	50	141	87	10
17	16.50	17.49	455	2	13	21	118	4	1	19	30	15	132	86	14
18	17.50	18.49	250	4	1	10	67	2	0	4	23	14	77	37	11
19	18.50	19.49	193	0	0	7	107	0	0	8	25	11	19	13	3
20	19.50	20.49	123	0	0	8	74	0	0	5	21	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	20	0	0	1	13	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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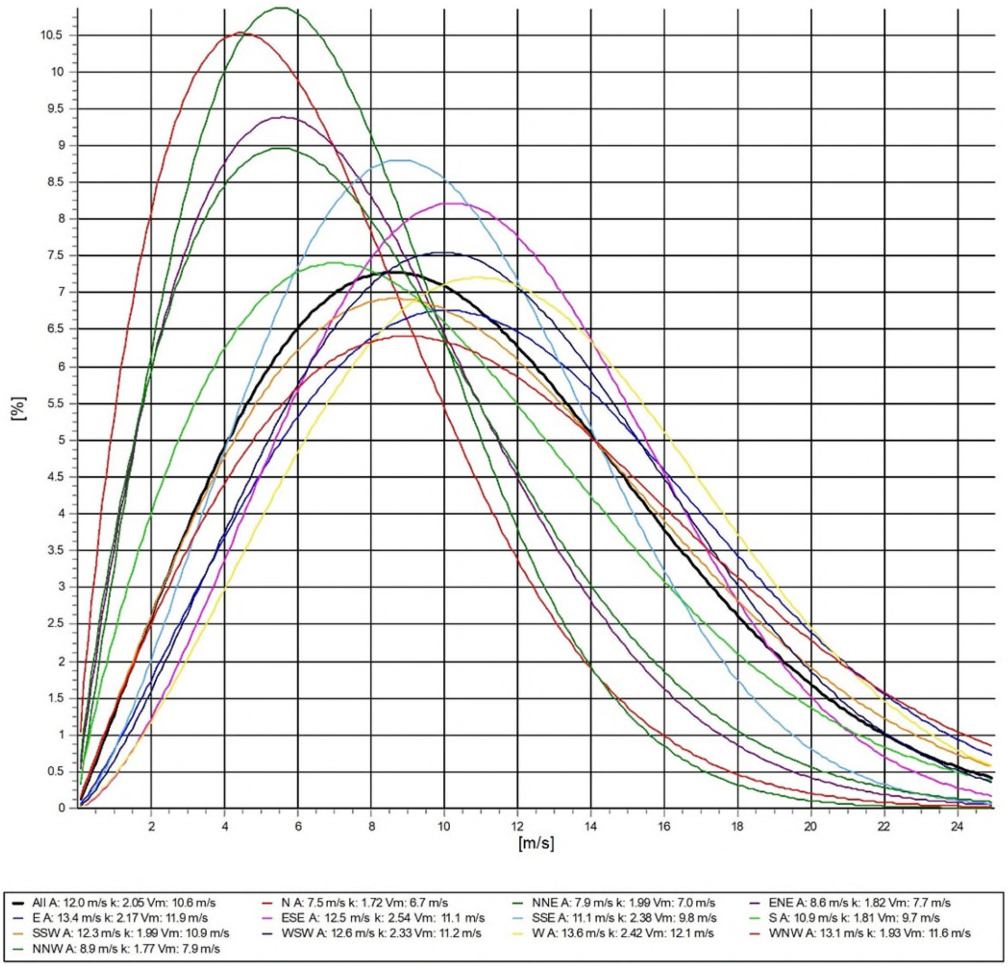
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **300.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.46	1.717	3.34	6.65
1-NNE	7.87	1.988	3.23	6.97
2-ENE	8.64	1.824	4.87	7.68
3-E	13.41	2.167	9.66	11.87
4-ESE	12.45	2.541	9.91	11.05
5-SSE	11.06	2.383	8.72	9.80
6-S	10.93	1.815	7.16	9.71
7-SSW	12.35	1.987	11.35	10.94
8-WSW	12.65	2.325	13.80	11.21
9-W	13.64	2.416	16.59	12.09
10-WNW	13.11	1.935	7.84	11.62
11-NNW	8.89	1.766	3.54	7.91
Mean	**11.96**	**2.045**	**100.00**	**10.60**



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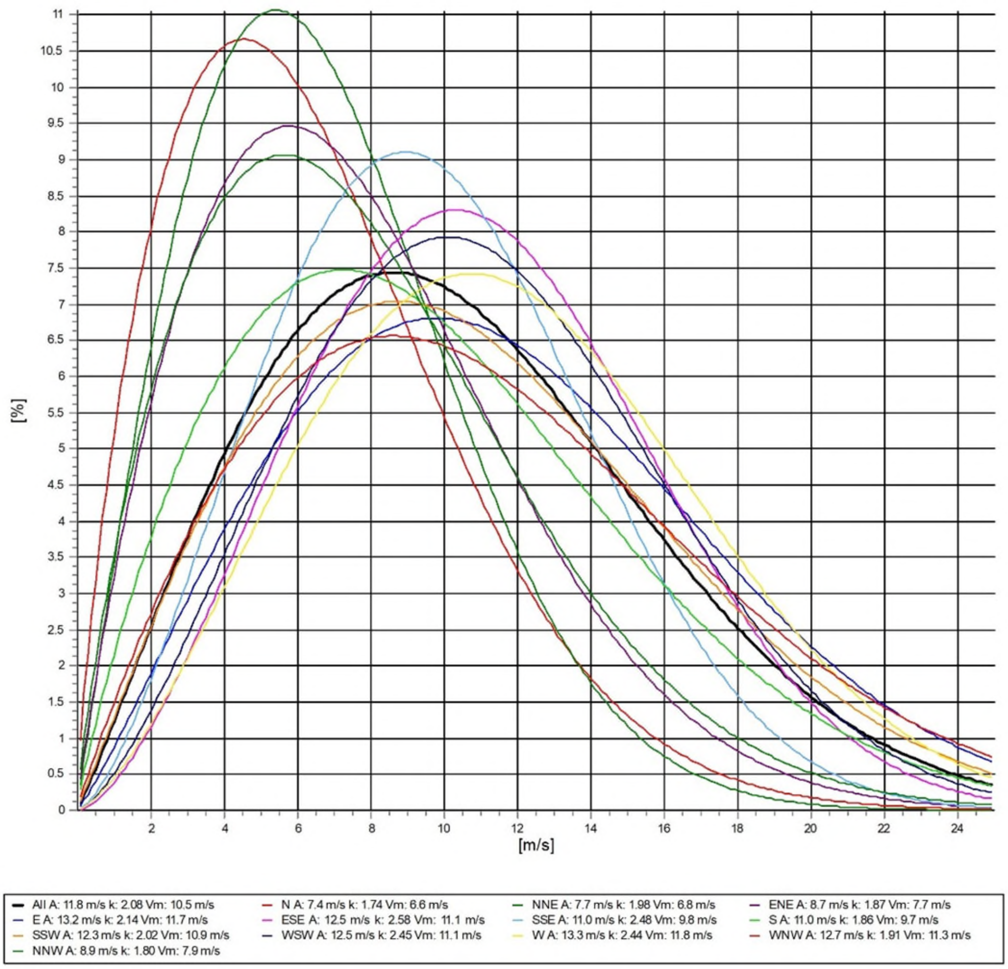
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **260.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.41	1.740	3.28	6.60
1-NNE	7.70	1.983	3.29	6.83
2-ENE	8.69	1.871	5.05	7.72
3-E	13.16	2.135	9.91	11.66
4-ESE	12.48	2.581	9.86	11.08
5-SSE	11.00	2.476	8.58	9.76
6-S	10.96	1.860	7.28	9.73
7-SSW	12.26	2.021	11.54	10.86
8-WSW	12.51	2.446	13.85	11.10
9-W	13.32	2.436	16.37	11.81
10-WNW	12.70	1.911	7.50	11.27
11-NNW	8.86	1.796	3.49	7.88
Mean	**11.82**	**2.079**	**100.00**	**10.47**



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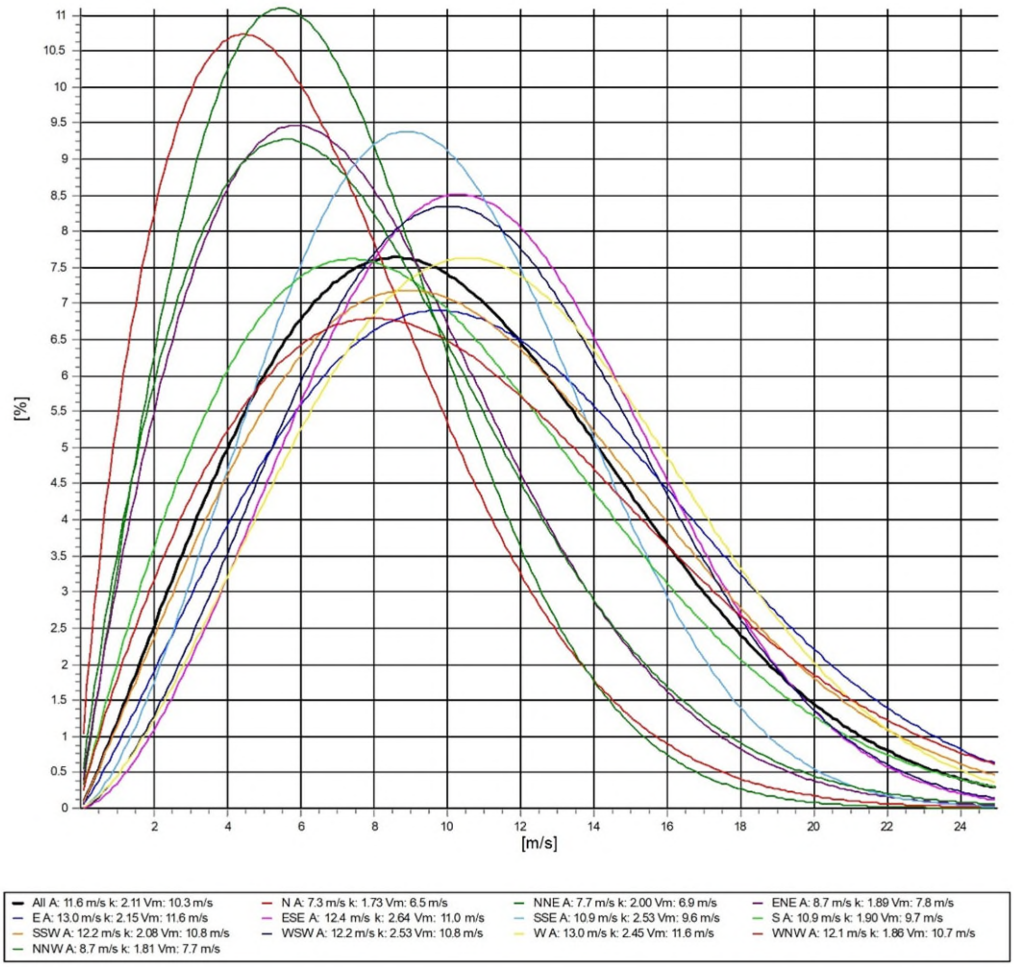
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **220.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.34	1.727	3.23	6.54
1-NNE	7.74	2.003	3.32	6.86
2-ENE	8.74	1.891	5.20	7.76
3-E	13.05	2.148	10.12	11.55
4-ESE	12.38	2.636	9.83	11.00
5-SSE	10.86	2.529	8.57	9.64
6-S	10.92	1.905	7.41	9.69
7-SSW	12.25	2.078	11.69	10.85
8-WSW	12.22	2.534	13.81	10.85
9-W	13.04	2.455	16.12	11.57
10-WNW	12.09	1.864	7.30	10.73
11-NNW	8.72	1.814	3.37	7.75
Mean	**11.65**	**2.110**	**100.00**	**10.32**



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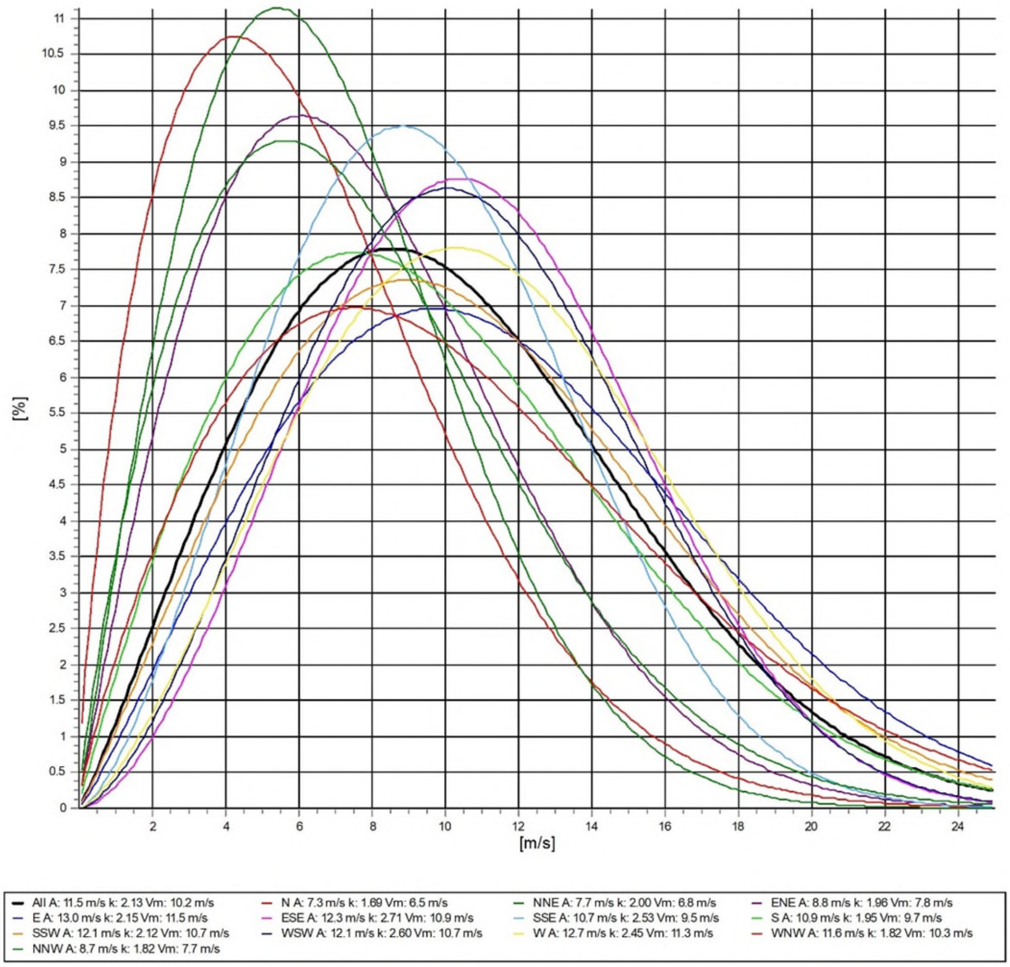
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **190.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.26	1.693	3.21	6.48
1-NNE	7.69	1.996	3.33	6.81
2-ENE	8.77	1.956	5.38	7.77
3-E	12.95	2.151	10.30	11.47
4-ESE	12.30	2.711	9.80	10.94
5-SSE	10.75	2.534	8.55	9.54
6-S	10.91	1.952	7.62	9.67
7-SSW	12.11	2.118	11.80	10.73
8-WSW	12.09	2.603	13.85	10.74
9-W	12.73	2.449	15.72	11.29
10-WNW	11.63	1.823	7.11	10.34
11-NNW	8.71	1.823	3.31	7.75
Mean	**11.49**	**2.132**	**100.00**	**10.18**



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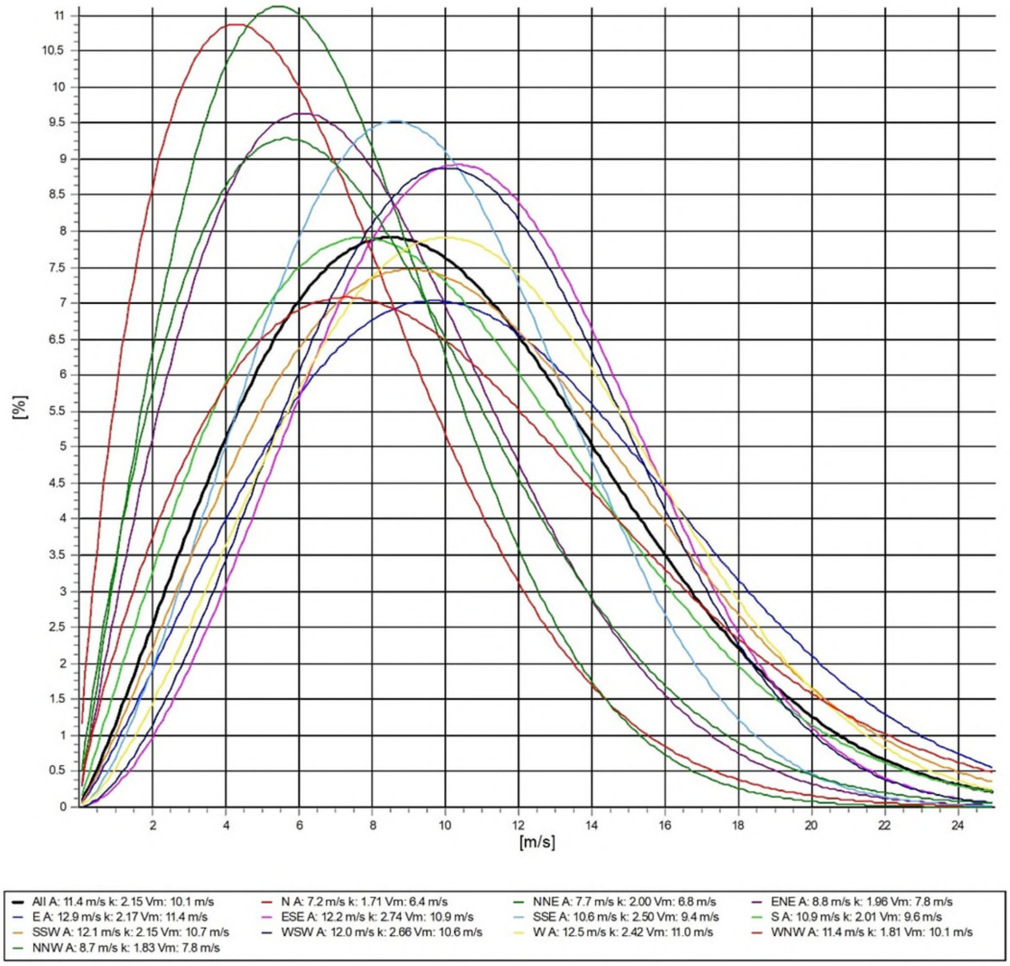
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **170.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.20	1.705	3.16	6.42
1-NNE	7.71	1.998	3.35	6.83
2-ENE	8.78	1.960	5.41	7.79
3-E	12.87	2.165	10.49	11.40
4-ESE	12.20	2.741	9.80	10.85
5-SSE	10.60	2.499	8.53	9.41
6-S	10.87	2.009	7.80	9.64
7-SSW	12.08	2.155	11.94	10.70
8-WSW	11.96	2.661	13.76	10.63
9-W	12.46	2.423	15.50	11.04
10-WNW	11.40	1.808	6.99	10.13
11-NNW	8.74	1.829	3.26	7.77
Mean	**11.38**	**2.148**	**100.00**	**10.08**



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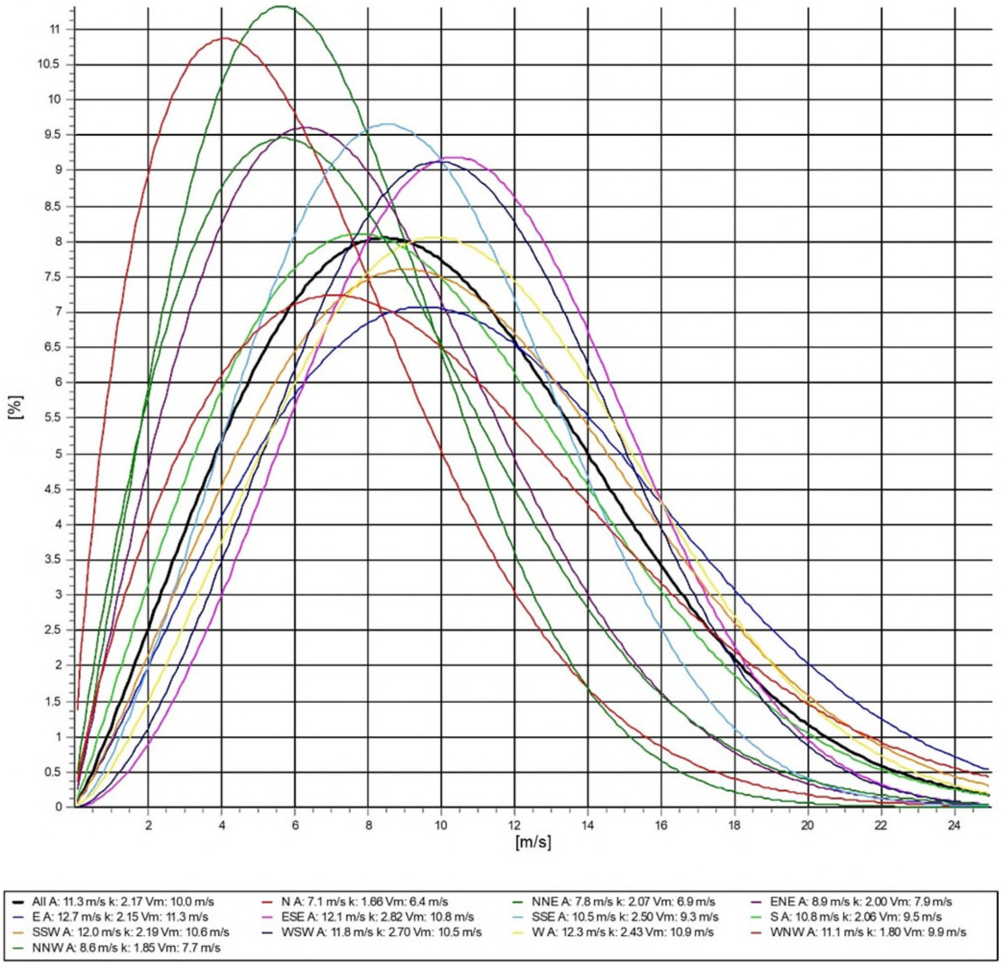
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **150.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.12	1.662	3.15	6.36
1-NNE	7.75	2.070	3.37	6.87
2-ENE	8.92	1.997	5.52	7.91
3-E	12.74	2.151	10.64	11.28
4-ESE	12.11	2.815	9.83	10.79
5-SSE	10.46	2.501	8.44	9.28
6-S	10.78	2.055	8.02	9.55
7-SSW	11.99	2.186	12.05	10.62
8-WSW	11.78	2.702	13.70	10.48
9-W	12.25	2.429	15.22	10.86
10-WNW	11.12	1.799	6.83	9.89
11-NNW	8.64	1.850	3.23	7.67
Mean	**11.26**	**2.168**	**100.00**	**9.97**



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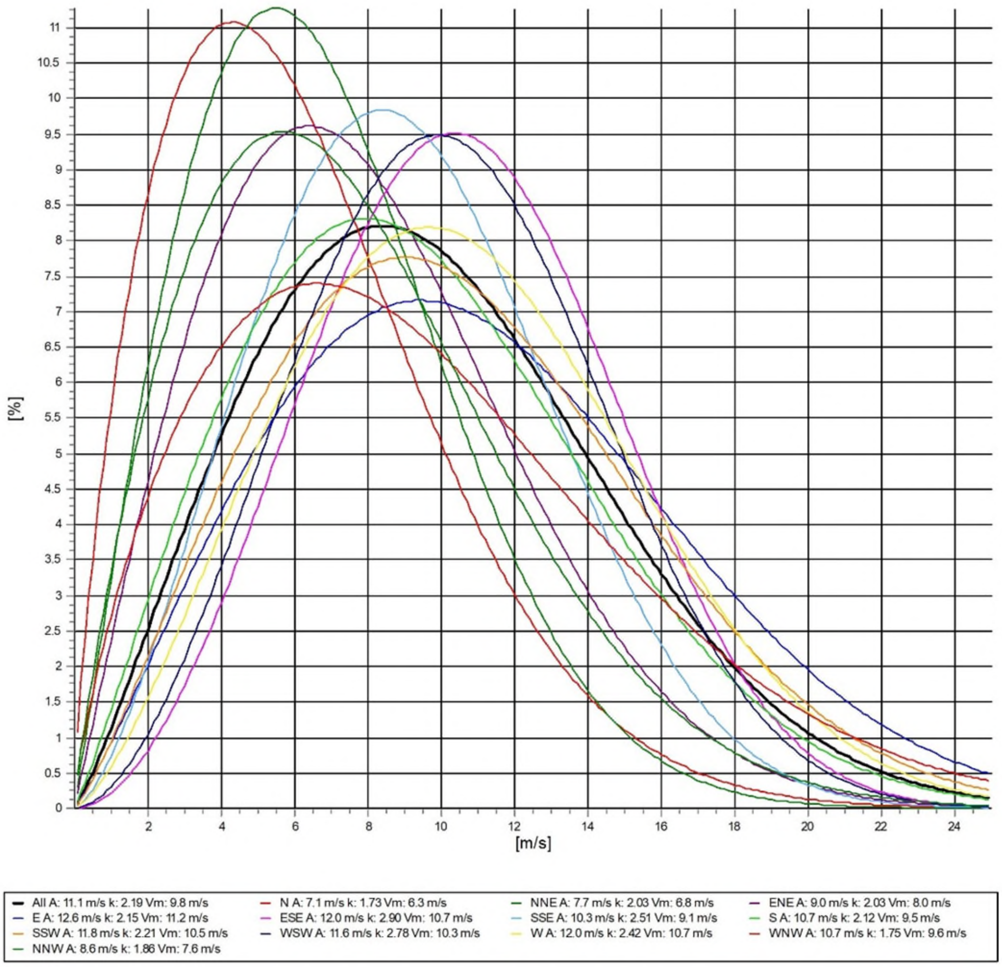
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **130.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.11	1.729	3.08	6.34
1-NNE	7.67	2.027	3.42	6.80
2-ENE	9.00	2.026	5.61	7.97
3-E	12.60	2.153	10.77	11.16
4-ESE	11.99	2.897	9.87	10.69
5-SSE	10.28	2.506	8.52	9.12
6-S	10.74	2.121	8.00	9.51
7-SSW	11.84	2.211	12.32	10.49
8-WSW	11.62	2.782	13.54	10.34
9-W	12.04	2.424	14.89	10.67
10-WNW	10.73	1.754	6.79	9.56
11-NNW	8.60	1.863	3.18	7.64
Mean	**11.12**	**2.188**	**100.00**	**9.84**



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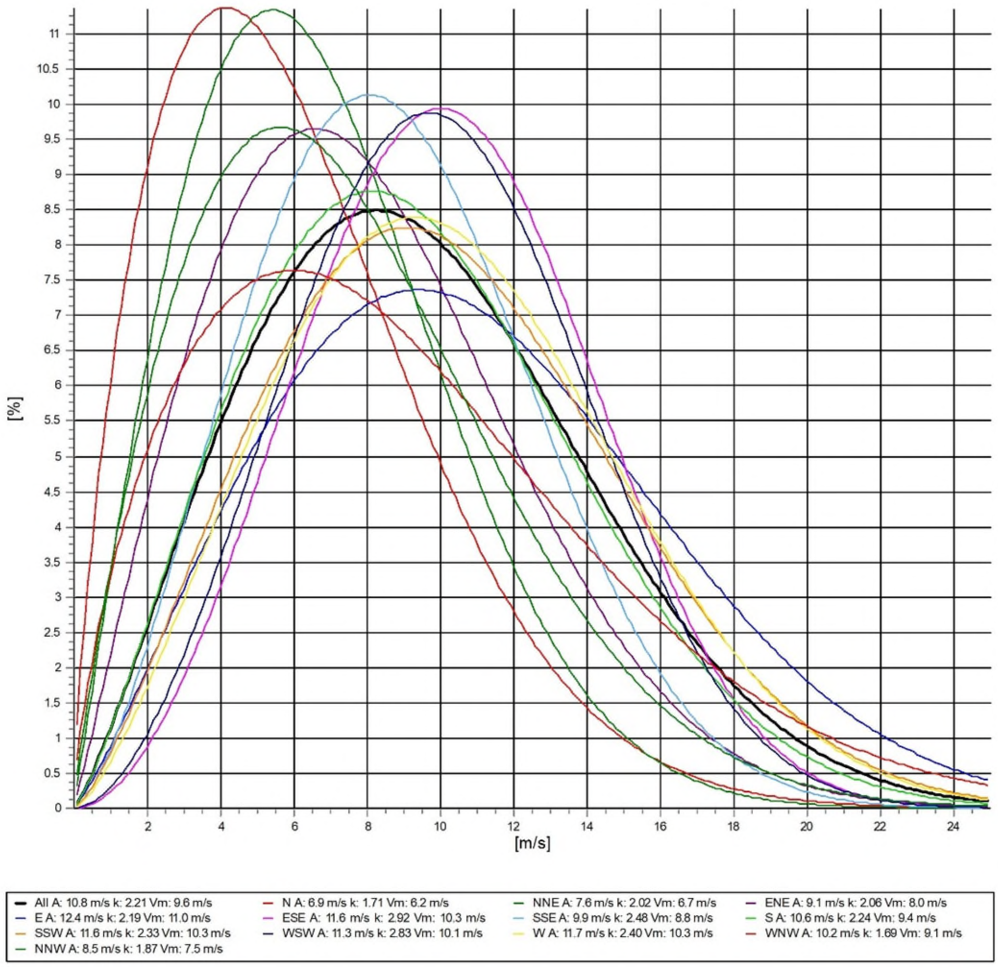
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **100.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.90	1.715	3.04	6.16
1-NNE	7.61	2.018	3.48	6.74
2-ENE	9.07	2.062	5.75	8.03
3-E	12.40	2.193	11.05	10.99
4-ESE	11.56	2.922	9.90	10.31
5-SSE	9.91	2.484	8.54	8.79
6-S	10.60	2.243	8.14	9.39
7-SSW	11.57	2.326	12.64	10.25
8-WSW	11.30	2.825	13.30	10.07
9-W	11.66	2.402	14.36	10.33
10-WNW	10.19	1.688	6.62	9.10
11-NNW	8.49	1.867	3.18	7.54
Mean	**10.83**	**2.214**	**100.00**	**9.59**



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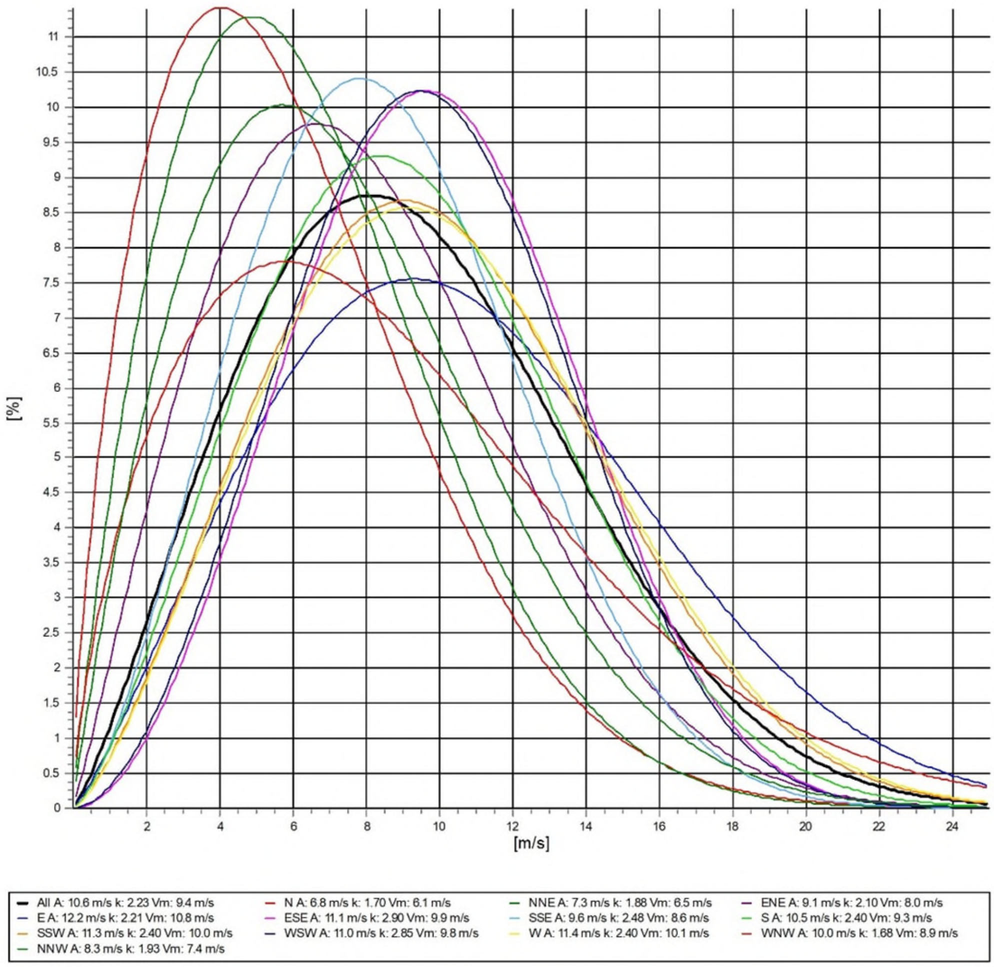
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **80.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.84	1.697	3.09	6.10
1-NNE	7.30	1.878	3.56	6.48
2-ENE	9.07	2.096	5.81	8.03
3-E	12.18	2.211	11.34	10.79
4-ESE	11.15	2.898	9.92	9.94
5-SSE	9.65	2.483	8.46	8.56
6-S	10.51	2.398	8.50	9.32
7-SSW	11.30	2.403	12.69	10.02
8-WSW	11.00	2.851	13.00	9.80
9-W	11.43	2.403	14.09	10.13
10-WNW	9.97	1.679	6.34	8.90
11-NNW	8.35	1.926	3.20	7.40
Mean	**10.60**	**2.235**	**100.00**	**9.39**



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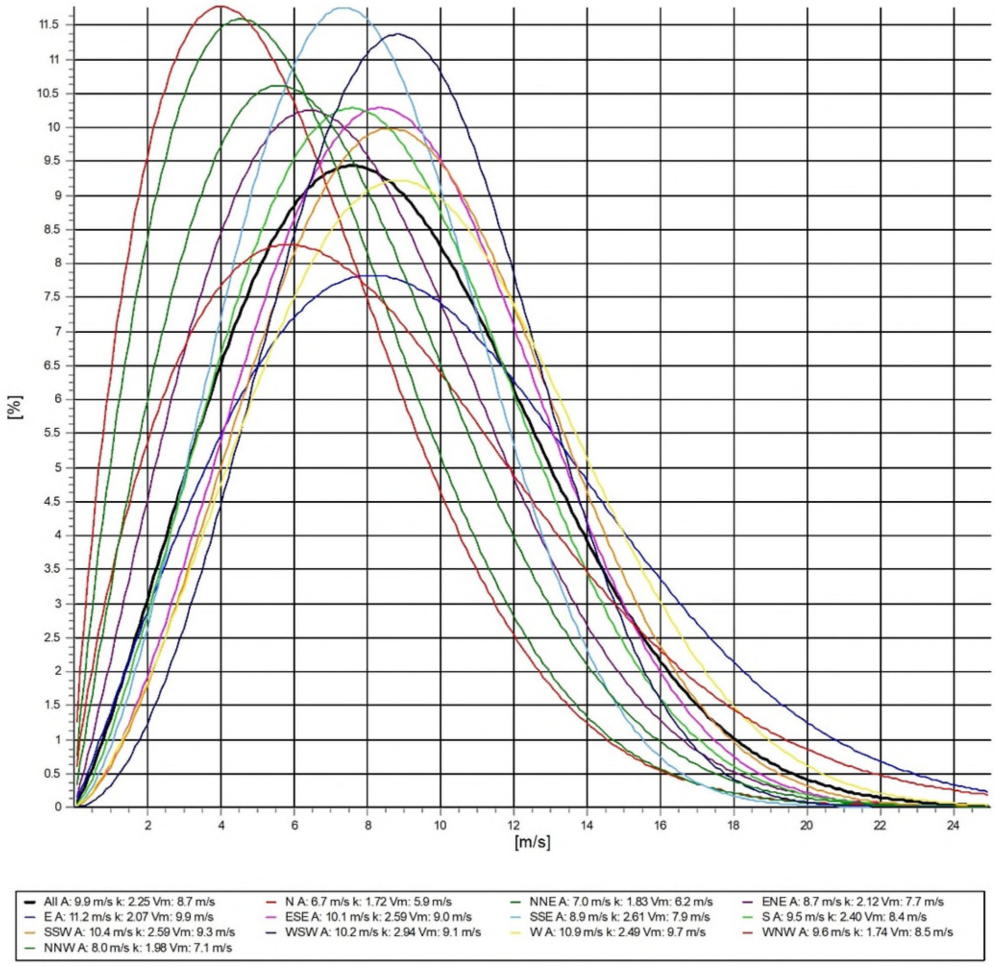
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **40.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.67	1.719	2.98	5.95
1-NNE	7.01	1.831	3.73	6.23
2-ENE	8.70	2.118	6.04	7.71
3-E	11.20	2.067	11.84	9.92
4-ESE	10.10	2.591	9.80	8.97
5-SSE	8.89	2.609	8.44	7.89
6-S	9.50	2.398	8.74	8.42
7-SSW	10.42	2.594	13.31	9.25
8-WSW	10.17	2.941	12.34	9.07
9-W	10.90	2.486	13.39	9.67
10-WNW	9.56	1.742	6.19	8.52
11-NNW	8.02	1.977	3.20	7.11
Mean	**9.86**	**2.246**	**100.00**	**8.73**



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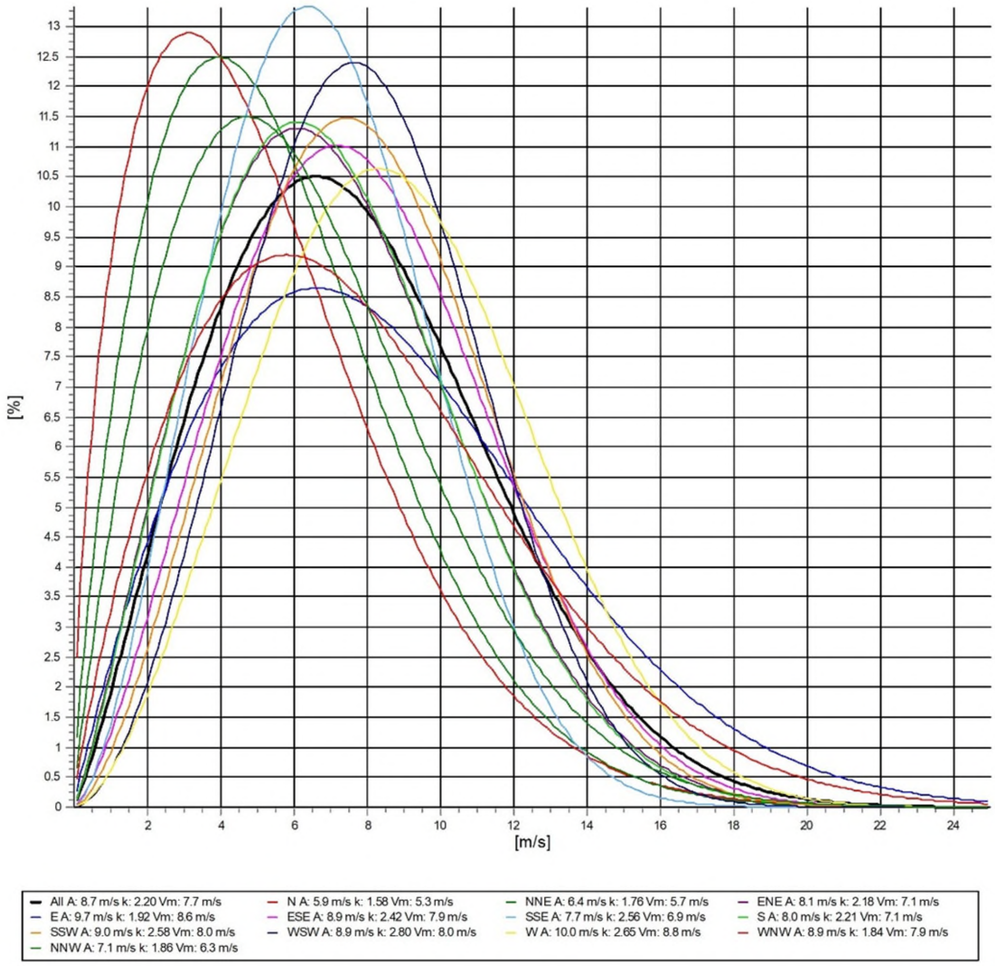
Meteo data report - Weibull data overview

Mast: KG-1-LB (12 months); KG-1-LB **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **12.00m -**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	5.88	1.583	3.01	5.28
1-NNE	6.37	1.762	3.80	5.67
2-ENE	8.06	2.184	6.17	7.14
3-E	9.68	1.925	12.13	8.59
4-ESE	8.94	2.423	9.71	7.92
5-SSE	7.72	2.561	8.45	6.86
6-S	8.04	2.206	8.93	7.12
7-SSW	9.01	2.576	13.63	8.00
8-WSW	8.94	2.803	11.86	7.96
9-W	9.95	2.650	13.12	8.84
10-WNW	8.87	1.843	6.05	7.88
11-NNW	7.14	1.863	3.12	6.34
Mean	**8.71**	**2.195**	**100.00**	**7.71**



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

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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

300.00m - MCP ERA5 (T) - [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			10.17	7.70	6.74	7.72	9.14	10.13	9.93	10.20	11.39	11.75	11.20	10.77	8.15
0		0.49	490	57	68	61	31	55	52	41	28	24	16	10	47
1	0.50	1.49	2447	193	251	226	144	187	299	329	157	148	117	127	269
2	1.50	2.49	5835	493	398	609	554	523	602	617	506	353	300	417	463
3	2.50	3.49	7395	531	610	736	605	554	631	740	726	635	487	640	500
4	3.50	4.49	10518	871	874	967	764	818	745	855	947	930	987	953	807
5	4.50	5.49	12574	1088	953	937	945	1000	1054	915	1098	919	1433	1273	959
6	5.50	6.49	12589	1039	836	795	1032	826	883	896	1089	1136	1752	1397	908
7	6.50	7.49	13418	775	746	676	952	1103	1003	884	1451	1482	1811	1375	1160
8	7.50	8.49	14932	946	890	495	748	1291	1115	837	1613	2124	2166	1680	1027
9	8.50	9.49	13962	721	767	686	804	1163	1126	827	1403	1764	1997	1618	1086
10	9.50	10.49	13451	615	313	706	749	1015	1171	787	1292	2048	2429	1506	820
11	10.50	11.49	12729	547	229	524	695	932	1055	956	1228	1927	2422	1555	659
12	11.50	12.49	11566	475	296	472	670	882	783	575	1251	2106	2159	1379	518
13	12.50	13.49	10741	418	172	346	586	890	819	617	1092	1823	1949	1552	477
14	13.50	14.49	9959	236	113	475	580	689	721	692	1455	1831	1609	1290	268
15	14.50	15.49	9174	162	125	272	525	780	912	686	1178	1762	1606	961	205
16	15.50	16.49	7723	137	39	140	381	669	633	789	945	1408	1497	958	127
17	16.50	17.49	5859	84	29	89	274	593	470	478	891	1144	905	759	143
18	17.50	18.49	4855	71	22	76	279	357	425	409	939	1049	707	431	90
19	18.50	19.49	3734	45	14	39	187	356	311	352	555	727	696	420	32
20	19.50	20.49	2536	43	11	30	93	210	109	279	380	493	563	278	47
21	20.50	21.49	2031	15	4	15	46	177	168	223	405	295	329	321	33
22	21.50	22.49	1602	16	3	6	16	114	130	133	285	317	305	235	42
23	22.50	23.49	777	2	2	0	9	41	41	78	129	166	159	128	22
24	23.50	24.49	608	4	0	1	9	21	12	41	166	151	109	82	12
25	24.50	25.49	481	3	0	4	8	7	3	28	152	178	52	41	5
26	25.50	26.49	298	0	0	0	3	4	1	31	88	91	39	36	5
27	26.50	27.49	232	0	0	0	3	1	0	29	79	58	24	35	3
28	27.50	28.49	141	0	0	0	1	0	0	12	25	32	15	47	9
29	28.50	29.49	79	0	0	0	0	0	0	5	18	28	11	15	2
30	29.50	30.49	30	0	0	0	0	0	0	1	9	9	6	5	0
31	30.50	31.49	22	0	0	0	0	0	0	1	3	4	7	7	0
32	31.50	32.49	17	0	0	0	0	0	0	1	7	0	5	4	0
33	32.50	33.49	15	0	0	0	0	0	0	0	11	1	1	2	0
34	33.50	34.49	9	0	0	0	0	0	0	0	2	2	1	4	0
35	34.50	35.49	6	0	0	0	0	0	0	0	2	2	0	2	0
36	35.50	36.49	2	0	0	0	0	0	0	0	1	0	0	1	0
37	36.50	37.49	3	0	0	0	0	0	0	0	1	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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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

260.00m - MCP ERA5 (T) - [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			10.03	7.56	6.74	7.73	9.14	10.11	9.94	10.09	11.30	11.49	10.96	10.42	7.96
0		0.49	504	57	74	52	41	50	45	64	31	27	26	9	28
1	0.50	1.49	2526	222	223	243	243	171	314	292	154	128	127	138	271
2	1.50	2.49	5768	579	501	613	545	455	563	591	471	341	284	411	414
3	2.50	3.49	7523	549	609	722	583	578	598	782	717	596	585	671	533
4	3.50	4.49	10682	838	889	853	637	858	766	918	1045	932	1043	989	914
5	4.50	5.49	12756	1053	992	923	1038	938	1036	985	1165	1007	1462	1244	913
6	5.50	6.49	12643	932	792	901	1040	859	905	866	1108	1214	1697	1395	934
7	6.50	7.49	13529	814	759	688	944	1048	923	878	1552	1516	1746	1453	1208
8	7.50	8.49	15303	1056	900	585	788	1276	1190	908	1550	2027	2248	1735	1040
9	8.50	9.49	13883	622	741	611	811	1155	1080	758	1491	1996	2030	1567	1021
10	9.50	10.49	14234	659	343	676	837	1087	1185	853	1369	1947	2663	1774	841
11	10.50	11.49	12881	530	249	515	695	978	1148	901	1252	2141	2340	1452	680
12	11.50	12.49	11935	492	277	452	678	851	918	683	1320	2277	2118	1431	438
13	12.50	13.49	11141	338	188	418	681	824	827	721	1279	1861	2065	1503	436
14	13.50	14.49	9961	266	142	456	605	734	764	714	1375	1897	1759	1023	226
15	14.50	15.49	8935	131	91	259	516	794	869	867	1180	1741	1455	911	121
16	15.50	16.49	7418	106	59	169	371	752	721	649	853	1401	1301	916	120
17	16.50	17.49	5513	86	35	76	291	536	377	423	1104	1149	745	537	154
18	17.50	18.49	4711	57	20	58	213	412	486	376	909	907	751	451	71
19	18.50	19.49	3216	39	15	43	211	289	288	277	458	559	671	338	28
20	19.50	20.49	2419	30	17	30	107	179	137	268	459	433	403	307	49
21	20.50	21.49	1894	24	6	14	43	147	147	225	301	352	331	267	37
22	21.50	22.49	1256	9	3	5	21	103	69	127	323	205	234	130	27
23	22.50	23.49	723	2	0	1	12	34	42	76	217	113	117	93	16
24	23.50	24.49	568	6	1	1	10	13	10	51	176	151	81	60	8
25	24.50	25.49	330	0	0	2	5	6	3	39	121	85	37	29	3
26	25.50	26.49	245	0	0	0	2	4	0	37	70	54	35	40	3
27	26.50	27.49	167	1	0	0	3	1	0	16	43	55	15	26	7
28	27.50	28.49	88	1	0	0	1	0	0	7	27	14	12	22	4
29	28.50	29.49	33	0	0	0	0	0	0	2	14	3	7	6	1
30	29.50	30.49	29	0	0	0	0	0	0	2	5	2	7	12	1
31	30.50	31.49	10	0	0	0	0	0	0	0	2	0	3	5	0
32	31.50	32.49	5	0	0	0	0	0	0	0	3	2	0	0	0
33	32.50	33.49	6	0	0	0	0	0	0	0	1	2	1	2	0
34	33.50	34.49	1	0	0	0	0	0	0	0	1	0	0	0	0
35	34.50	35.49	2	0	0	0	0	0	0	0	1	0	0	1	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	1	0	0	0	0	0	0	0	1	0	0	0	0
38	37.50	38.49	1	0	0	0	0	0	0	0	0	1	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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18/09/2024 09:52

Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

220.00m - MCP ERA5 (T) - [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	7.37	6.65	7.85	9.00	10.03	9.93	9.98	11.20	11.27	10.61	10.15	7.89
0		0.49	470	59	78	33	26	42	40	68	26	43	22	16	17
1	0.50	1.49	2458	277	275	217	215	190	256	271	117	120	170	167	183
2	1.50	2.49	5889	568	523	686	565	400	545	606	493	338	379	390	396
3	2.50	3.49	7957	637	601	684	641	663	630	861	790	546	582	694	628
4	3.50	4.49	10776	854	945	928	685	844	766	903	1071	853	1081	948	898
5	4.50	5.49	12678	1122	909	930	1051	911	983	904	1110	1072	1520	1251	915
6	5.50	6.49	12848	926	823	869	984	917	842	938	1289	1198	1715	1383	964
7	6.50	7.49	14159	916	793	708	1012	1096	1008	832	1385	1594	1942	1590	1283
8	7.50	8.49	15166	892	930	611	864	1221	1111	930	1807	1964	2304	1636	896
9	8.50	9.49	14652	570	719	637	801	1182	1137	859	1507	2048	2432	1777	983
10	9.50	10.49	14356	674	324	716	819	1118	1157	964	1438	2146	2599	1491	910
11	10.50	11.49	12899	532	220	579	695	1011	1065	804	1405	2157	2423	1404	604
12	11.50	12.49	12365	499	278	515	604	884	1082	763	1328	2163	2192	1565	492
13	12.50	13.49	11048	310	145	431	658	856	887	732	1380	1881	2111	1313	344
14	13.50	14.49	9995	181	159	430	578	845	973	820	1465	1797	1577	956	214
15	14.50	15.49	8860	157	114	351	583	826	680	747	1206	1735	1470	877	114
16	15.50	16.49	6738	111	52	152	344	700	595	541	1037	1345	1013	712	136
17	16.50	17.49	5648	58	31	93	284	472	470	471	1242	1159	776	485	107
18	17.50	18.49	4356	55	16	54	234	415	464	383	754	759	732	439	51
19	18.50	19.49	3061	33	20	58	169	294	264	315	550	508	500	306	44
20	19.50	20.49	2337	39	10	30	75	189	153	254	486	372	403	283	43
21	20.50	21.49	1518	23	3	9	37	129	106	205	315	206	236	202	47
22	21.50	22.49	931	10	2	3	15	70	39	86	275	157	131	116	27
23	22.50	23.49	593	4	3	4	6	17	22	64	185	138	89	54	7
24	23.50	24.49	366	4	0	2	8	5	6	44	120	75	63	32	7
25	24.50	25.49	355	0	0	1	3	5	3	41	127	101	34	37	3
26	25.50	26.49	146	0	0	0	2	1	1	16	37	32	22	28	7
27	26.50	27.49	99	0	0	0	4	0	1	23	20	13	10	26	2
28	27.50	28.49	60	1	0	0	0	0	0	6	21	6	10	15	1
29	28.50	29.49	20	0	0	0	0	0	0	2	3	4	4	7	0
30	29.50	30.49	17	0	0	0	0	0	0	2	1	0	9	5	0
31	30.50	31.49	10	0	0	0	0	0	0	0	8	0	0	2	0
32	31.50	32.49	5	0	0	0	0	0	0	0	2	2	0	1	0
33	32.50	33.49	3	0	0	0	0	0	0	0	2	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	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

190.00m - MCP ERA5 (T) - [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			9.72	7.39	6.61	7.80	8.94	10.04	9.83	9.77	11.17	11.00	10.37	9.81	7.79
0		0.49	464	38	51	19	46	38	54	56	50	35	26	20	31
1	0.50	1.49	2584	225	287	253	211	207	249	256	132	169	169	178	248
2	1.50	2.49	5940	560	578	720	528	438	567	708	396	311	386	436	312
3	2.50	3.49	8073	643	623	689	634	583	653	830	717	589	696	769	647
4	3.50	4.49	10874	898	945	950	699	753	767	991	1077	947	1125	909	813
5	4.50	5.49	12360	1148	913	969	994	794	954	902	1014	983	1604	1192	893
6	5.50	6.49	13457	817	747	942	1114	985	904	1023	1300	1269	1823	1516	1017
7	6.50	7.49	14350	861	831	683	1028	1104	949	866	1507	1601	1928	1645	1347
8	7.50	8.49	15726	895	1022	596	920	1287	1207	899	1833	1923	2447	1682	1015
9	8.50	9.49	14650	574	628	713	936	1148	1182	890	1543	2137	2397	1705	797
10	9.50	10.49	14571	620	333	697	888	1124	1247	980	1545	2265	2675	1428	769
11	10.50	11.49	13333	532	292	652	717	980	1140	890	1279	2237	2465	1492	657
12	11.50	12.49	12670	480	225	540	691	913	1056	814	1497	2388	2167	1490	409
13	12.50	13.49	11370	322	147	404	628	974	996	745	1470	2011	2025	1286	362
14	13.50	14.49	10102	220	152	471	565	982	963	902	1580	1667	1483	908	209
15	14.50	15.49	8501	132	106	282	549	823	747	667	1232	1578	1504	770	111
16	15.50	16.49	6450	101	52	158	338	630	604	485	1188	1341	834	578	141
17	16.50	17.49	5195	79	28	103	246	428	376	444	1160	1136	694	416	85
18	17.50	18.49	3959	55	20	68	216	352	448	442	734	528	672	372	52
19	18.50	19.49	3104	34	16	53	170	355	248	256	649	474	533	292	24
20	19.50	20.49	1674	35	18	21	66	153	138	233	295	176	281	219	39
21	20.50	21.49	1336	15	3	17	27	115	83	152	363	232	162	117	50
22	21.50	22.49	863	6	0	4	21	41	35	110	225	148	159	85	29
23	22.50	23.49	416	2	4	1	16	15	12	59	106	74	77	43	7
24	23.50	24.49	388	6	0	2	7	4	6	41	159	80	43	35	5
25	24.50	25.49	200	0	0	1	4	2	0	22	72	44	25	22	8
26	25.50	26.49	87	0	0	0	1	0	0	7	36	10	11	20	2
27	26.50	27.49	65	0	0	0	2	0	0	9	12	9	14	19	0
28	27.50	28.49	40	0	0	0	0	0	0	7	9	3	9	10	2
29	28.50	29.49	17	0	0	0	0	0	0	2	6	0	3	6	0
30	29.50	30.49	14	0	0	0	0	0	0	1	5	1	4	3	0
31	30.50	31.49	2	0	0	0	0	0	0	0	1	0	1	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	2	0	0	0	0	0	0	0	1	1	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	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

170.00m - MCP ERA5 (T) - [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			9.62	7.39	6.61	7.81	8.94	10.00	9.73	9.69	11.04	10.83	10.23	9.54	7.78
0		0.49	484	28	47	42	50	56	61	61	39	42	23	29	6
1	0.50	1.49	2586	265	311	241	217	176	270	259	137	169	190	168	183
2	1.50	2.49	5875	510	511	721	572	388	553	775	438	278	380	399	350
3	2.50	3.49	8225	689	630	604	603	608	745	805	693	628	744	771	705
4	3.50	4.49	10921	900	1031	843	725	838	773	893	1043	972	1117	913	873
5	4.50	5.49	12215	1084	868	974	942	784	971	955	1034	1014	1517	1298	774
6	5.50	6.49	13405	774	728	983	1120	939	830	1041	1253	1231	1851	1626	1029
7	6.50	7.49	14882	945	899	736	1134	1136	991	893	1635	1657	1983	1644	1229
8	7.50	8.49	16100	820	1011	671	922	1308	1183	959	1924	2121	2480	1761	940
9	8.50	9.49	14927	568	588	675	960	1209	1181	912	1638	2187	2382	1759	868
10	9.50	10.49	14826	673	352	765	926	1044	1128	1032	1579	2354	2710	1513	750
11	10.50	11.49	13646	524	307	643	725	1040	1101	885	1395	2227	2622	1655	522
12	11.50	12.49	12571	458	221	562	754	934	1104	974	1584	2295	2006	1232	447
13	12.50	13.49	11958	367	155	408	718	1157	1110	816	1573	2025	2006	1232	391
14	13.50	14.49	9737	204	137	408	634	893	932	806	1409	1752	1568	833	161
15	14.50	15.49	8176	142	83	276	434	795	716	678	1299	1633	1288	706	126
16	15.50	16.49	6387	109	67	140	396	612	464	455	1308	1236	948	493	159
17	16.50	17.49	5037	63	29	91	231	485	466	453	1238	918	655	338	70
18	17.50	18.49	3671	45	17	86	214	368	384	388	687	507	581	345	49
19	18.50	19.49	2857	40	14	39	148	266	286	352	608	441	395	235	33
20	19.50	20.49	1611	27	11	21	74	147	112	166	409	212	242	154	36
21	20.50	21.49	991	12	12	12	26	111	59	116	178	157	153	114	41
22	21.50	22.49	631	7	5	7	14	37	32	90	94	111	127	82	25
23	22.50	23.49	483	4	0	1	15	8	14	61	154	107	78	29	12
24	23.50	24.49	319	2	0	1	5	6	2	39	135	59	41	25	4
25	24.50	25.49	147	1	1	1	5	4	0	24	47	16	18	23	7
26	25.50	26.49	68	0	0	0	3	0	1	8	20	12	16	7	1
27	26.50	27.49	46	1	0	0	2	0	0	5	14	0	7	16	1
28	27.50	28.49	34	0	0	0	1	0	0	2	7	1	8	13	2
29	28.50	29.49	10	0	0	0	0	0	0	0	2	1	5	2	0
30	29.50	30.49	7	0	0	0	0	0	0	0	2	3	2	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	2	0	0	0	0	0	0	0	0	0	1	1	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	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	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP ERA5 (T) - [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			9.51	7.27	6.62	7.82	8.87	9.95	9.67	9.68	10.94	10.62	10.03	9.35	7.76
0		0.49	474	24	33	37	52	62	39	54	54	45	38	21	15
1	0.50	1.49	2573	281	278	278	239	181	223	247	165	168	225	161	127
2	1.50	2.49	5956	542	523	717	545	412	597	736	477	260	363	410	374
3	2.50	3.49	8257	705	658	655	630	563	672	875	690	613	756	820	620
4	3.50	4.49	10846	993	1030	835	708	797	750	905	1025	880	1147	905	871
5	4.50	5.49	12665	1083	839	1045	971	777	985	905	1127	1096	1675	1267	895
6	5.50	6.49	13629	751	829	946	1105	931	941	1029	1261	1287	2016	1574	959
7	6.50	7.49	15084	956	919	754	1202	1136	955	831	1645	1785	1943	1730	1228
8	7.50	8.49	16355	794	940	692	1024	1345	1196	932	1951	2050	2503	1961	967
9	8.50	9.49	15158	609	735	712	1006	1209	1243	902	1744	2237	2485	1597	679
10	9.50	10.49	14831	615	288	783	1027	1118	1133	1002	1560	2327	2770	1444	764
11	10.50	11.49	13977	474	287	728	701	1089	1161	1021	1598	2202	2621	1620	475
12	11.50	12.49	13107	485	242	508	717	1009	1043	962	1612	2475	2241	1248	565
13	12.50	13.49	11628	348	171	453	666	1201	1069	868	1615	1870	1933	1144	290
14	13.50	14.49	9735	206	140	397	677	878	1027	921	1483	1597	1484	771	154
15	14.50	15.49	8101	133	106	331	502	733	641	632	1562	1510	1310	559	82
16	15.50	16.49	6224	94	51	130	312	551	491	548	1450	1247	787	433	130
17	16.50	17.49	4711	59	27	109	250	504	487	464	968	743	613	379	108
18	17.50	18.49	3264	52	15	72	183	355	286	338	781	363	505	272	42
19	18.50	19.49	2422	45	14	51	163	250	233	263	498	356	302	206	41
20	19.50	20.49	1434	22	8	25	67	124	124	153	302	191	212	146	60
21	20.50	21.49	904	7	4	8	22	79	47	125	216	142	141	87	26
22	21.50	22.49	595	11	4	2	10	27	19	68	132	125	131	49	17
23	22.50	23.49	381	1	1	2	12	6	10	49	134	70	58	33	5
24	23.50	24.49	251	5	0	0	11	10	4	34	99	26	29	27	6
25	24.50	25.49	152	0	0	1	3	3	1	24	41	25	15	26	13
26	25.50	26.49	53	0	0	0	2	0	0	9	12	2	14	12	2
27	26.50	27.49	31	0	0	0	1	0	0	7	7	2	7	7	0
28	27.50	28.49	18	0	0	0	0	0	0	1	5	1	6	4	1
29	28.50	29.49	14	0	0	0	0	0	0	2	4	2	4	2	0
30	29.50	30.49	5	0	0	0	0	0	0	1	3	0	1	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	3	0	0	0	0	0	0	0	3	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	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	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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18/09/2024 09:52

Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

130.00m - MCP ERA5 (T) - [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			9.38	7.19	6.48	7.88	8.87	9.88	9.48	9.66	10.81	10.41	9.84	9.11	7.66
0		0.49	480	21	51	49	67	37	43	49	53	53	21	24	12
1	0.50	1.49	2658	319	346	246	232	164	270	227	125	199	215	210	105
2	1.50	2.49	6047	559	544	655	514	417	579	723	507	315	398	444	392
3	2.50	3.49	8298	707	720	656	631	567	681	879	589	594	830	814	630
4	3.50	4.49	10895	941	1073	863	711	763	859	882	1014	837	1118	955	879
5	4.50	5.49	12838	1018	825	1070	924	839	1076	933	1143	1134	1698	1268	910
6	5.50	6.49	13909	849	877	972	1114	911	885	1005	1340	1403	1982	1622	949
7	6.50	7.49	15157	854	852	680	1206	1157	1015	927	1719	1775	2075	1782	1115
8	7.50	8.49	16912	793	1016	754	1055	1299	1166	929	1991	2254	2606	2091	958
9	8.50	9.49	15557	675	715	739	1173	1260	1233	977	1843	2189	2540	1507	706
10	9.50	10.49	15233	564	292	860	1001	1214	1197	974	1575	2357	2872	1579	748
11	10.50	11.49	14322	497	282	739	701	1141	1024	1173	1897	2237	2574	1477	580
12	11.50	12.49	12907	460	238	537	676	1133	1159	1063	1463	2325	2196	1209	448
13	12.50	13.49	11441	317	162	511	767	1142	1132	883	1685	1884	1762	985	211
14	13.50	14.49	9870	178	147	423	677	914	962	836	1479	1698	1649	775	132
15	14.50	15.49	7945	129	92	263	434	678	576	697	1788	1610	1154	426	98
16	15.50	16.49	5681	94	42	150	310	517	560	592	1274	961	663	396	122
17	16.50	17.49	4477	45	23	96	261	575	412	424	1030	661	545	317	88
18	17.50	18.49	2836	56	17	73	185	317	263	326	628	298	366	257	50
19	18.50	19.49	2152	27	18	48	161	183	198	265	469	275	272	188	48
20	19.50	20.49	1240	31	3	18	50	119	91	128	259	171	184	133	53
21	20.50	21.49	814	10	3	11	16	54	30	114	173	127	173	83	20
22	21.50	22.49	492	4	3	0	10	9	14	76	133	98	80	51	14
23	22.50	23.49	315	4	1	2	15	9	6	44	117	35	43	27	12
24	23.50	24.49	185	2	0	0	10	6	0	22	55	33	25	24	8
25	24.50	25.49	84	0	0	1	2	1	0	14	21	9	18	15	3
26	25.50	26.49	41	0	0	0	2	0	0	10	8	2	7	11	1
27	26.50	27.49	25	0	0	0	1	0	0	2	5	2	10	4	1
28	27.50	28.49	12	0	0	0	0	0	0	2	4	0	5	1	0
29	28.50	29.49	9	0	0	0	0	0	0	1	3	2	2	1	0
30	29.50	30.49	3	0	0	0	0	0	0	1	2	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	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	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	1	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

100.00m - MCP ERA5 (T) - [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			9.15	7.10	6.62	7.91	8.74	9.62	9.17	9.46	10.56	10.00	9.55	8.84	7.43
0		0.49	477	31	53	29	52	53	63	32	47	47	25	13	32
1	0.50	1.49	2625	286	297	241	253	242	216	200	166	212	199	198	115
2	1.50	2.49	5970	579	579	644	508	408	602	758	414	354	373	411	340
3	2.50	3.49	8399	739	657	657	629	541	754	809	529	684	911	776	713
4	3.50	4.49	10866	960	1055	849	617	764	886	979	889	886	1062	1048	871
5	4.50	5.49	13789	1061	956	1069	1018	959	1006	914	1228	1194	1812	1539	1033
6	5.50	6.49	13960	776	804	1022	1158	975	989	1001	1353	1319	1942	1678	943
7	6.50	7.49	15634	777	852	651	1279	1142	1194	1127	1890	1984	2169	1660	909
8	7.50	8.49	17582	816	1030	790	1150	1268	1275	1088	2079	2326	2590	2202	968
9	8.50	9.49	17049	686	768	816	1312	1523	1158	972	1908	2529	2938	1583	856
10	9.50	10.49	15955	539	320	841	1004	1331	1276	1132	1791	2348	2934	1664	775
11	10.50	11.49	14707	569	335	776	739	1177	1155	1398	1797	2279	2402	1450	630
12	11.50	12.49	13240	322	239	637	748	1220	1244	1125	1745	2474	2269	995	222
13	12.50	13.49	10815	298	178	413	742	1235	1127	886	1663	1704	1613	769	187
14	13.50	14.49	9897	170	187	443	652	825	671	932	2082	1718	1484	642	91
15	14.50	15.49	7150	127	96	249	424	715	657	764	1658	1154	815	373	118
16	15.50	16.49	5147	99	43	166	268	634	491	531	1200	666	568	372	109
17	16.50	17.49	3336	57	22	105	201	366	280	415	667	434	455	258	76
18	17.50	18.49	2556	53	27	83	216	247	241	281	582	274	260	248	44
19	18.50	19.49	1501	26	9	32	90	122	111	141	284	226	212	208	40
20	19.50	20.49	867	23	6	12	23	60	37	96	112	135	216	122	25
21	20.50	21.49	603	3	5	7	24	17	20	99	153	104	110	46	15
22	21.50	22.49	301	3	5	1	14	15	5	39	91	51	35	24	18
23	22.50	23.49	213	6	0	1	11	8	2	14	84	25	32	20	10
24	23.50	24.49	73	0	0	1	5	0	0	10	16	9	14	17	1
25	24.50	25.49	67	0	0	1	3	0	0	11	11	7	9	23	2
26	25.50	26.49	29	0	0	0	2	0	0	4	8	1	9	4	1
27	26.50	27.49	18	0	0	0	0	0	0	2	1	0	10	3	2
28	27.50	28.49	8	0	0	0	0	0	0	0	1	2	2	3	0
29	28.50	29.49	2	0	0	0	0	0	0	0	1	0	1	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	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	1	0	0	0	0	0	0	0	1	0	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

80.00m - MCP ERA5 (T) - [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			8.94	7.09	6.49	7.79	8.71	9.43	8.91	9.18	10.26	9.69	9.35	8.65	7.35
0		0.49	497	14	49	74	57	31	55	57	42	42	20	16	40
1	0.50	1.49	2643	319	319	238	213	152	270	274	153	234	176	158	137
2	1.50	2.49	6022	580	578	643	451	413	589	735	447	357	461	443	325
3	2.50	3.49	8575	636	813	644	633	573	737	819	592	739	869	822	698
4	3.50	4.49	11432	946	1070	952	589	806	1001	941	925	992	1166	1108	936
5	4.50	5.49	13941	998	958	982	1031	1020	1112	1043	1337	1234	1781	1460	985
6	5.50	6.49	14502	791	760	1082	1243	1094	1069	1149	1331	1399	1948	1696	940
7	6.50	7.49	16520	918	814	721	1243	1221	1255	1031	1919	2135	2326	1951	986
8	7.50	8.49	18248	795	992	854	1355	1217	1291	1149	2306	2354	2758	2130	1047
9	8.50	9.49	16990	614	747	793	1489	1566	1221	983	1879	2405	2911	1517	865
10	9.50	10.49	16423	596	335	829	1017	1308	1283	1316	1912	2473	2781	1757	816
11	10.50	11.49	14892	425	348	800	793	1140	1243	1459	1921	2501	2525	1308	429
12	11.50	12.49	13823	336	238	640	878	1452	1446	1248	2100	2259	2243	778	205
13	12.50	13.49	10585	362	163	450	798	971	773	894	1993	1851	1484	707	139
14	13.50	14.49	9543	156	157	401	596	902	686	897	2176	1512	1276	649	135
15	14.50	15.49	6335	125	83	248	404	699	697	739	1417	805	658	336	124
16	15.50	16.49	4308	77	41	126	214	547	369	475	919	452	516	457	115
17	16.50	17.49	2691	53	25	78	153	236	244	296	522	358	420	230	76
18	17.50	18.49	1946	44	24	69	165	163	189	218	362	204	239	219	50
19	18.50	19.49	1179	30	15	28	91	124	88	73	149	172	212	160	37
20	19.50	20.49	740	12	6	12	46	40	29	92	159	96	157	66	25
21	20.50	21.49	439	7	6	1	16	12	7	55	106	101	75	36	17
22	21.50	22.49	248	7	1	1	11	10	2	20	72	41	41	35	7
23	22.50	23.49	159	2	0	2	5	5	0	20	49	20	18	24	14
24	23.50	24.49	88	1	0	3	7	0	0	6	20	14	15	19	3
25	24.50	25.49	27	0	0	1	2	0	0	5	5	4	5	4	1
26	25.50	26.49	27	0	0	0	3	0	0	2	5	5	7	5	0
27	26.50	27.49	5	0	0	0	0	0	0	0	1	2	2	0	0
28	27.50	28.49	5	0	0	0	0	0	0	0	1	0	4	0	0
29	28.50	29.49	2	0	0	0	0	0	0	0	2	0	0	0	0
30	29.50	30.49	2	0	0	0	0	0	0	0	2	0	0	0	0
31	30.50	31.49	1	0	0	0	0	0	0	1	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	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	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-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

40.00m - MCP ERA5 (T) - [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			8.48	6.78	6.32	7.53	8.36	8.97	8.45	8.66	9.56	8.93	8.97	8.23	7.00
0		0.49	525	18	46	68	40	34	64	39	57	71	29	35	24
1	0.50	1.49	2819	287	361	305	293	165	194	245	184	217	172	217	179
2	1.50	2.49	6085	595	690	610	464	418	580	729	442	419	397	391	350
3	2.50	3.49	9093	666	789	805	709	729	787	810	629	796	835	822	716
4	3.50	4.49	12264	1021	1127	886	679	966	941	868	998	1163	1306	1350	959
5	4.50	5.49	15053	989	1042	1139	1134	1100	1221	1128	1359	1398	1882	1609	1052
6	5.50	6.49	16839	955	918	1106	1452	1242	1177	1370	1772	1751	2474	1725	897
7	6.50	7.49	18979	833	972	1074	1348	1371	1409	1339	2382	2331	2615	2070	1235
8	7.50	8.49	19369	715	883	858	1475	1587	1395	1174	2604	2885	3026	1757	1010
9	8.50	9.49	17404	525	685	828	1257	1450	1318	1307	2441	2607	2695	1486	805
10	9.50	10.49	17060	430	340	814	1041	1439	1656	1568	2385	2494	2804	1469	620
11	10.50	11.49	15254	369	256	619	942	1287	1407	1479	2906	2426	2354	996	213
12	11.50	12.49	12784	295	258	606	814	1057	1152	1237	2532	1997	1814	805	217
13	12.50	13.49	9479	243	184	492	580	883	923	1050	1883	1177	1264	629	171
14	13.50	14.49	7248	142	169	372	488	897	659	755	1384	899	946	428	109
15	14.50	15.49	4559	143	66	217	379	623	382	306	732	488	710	411	102
16	15.50	16.49	3115	80	38	119	211	389	209	212	558	347	525	333	94
17	16.50	17.49	1976	48	34	106	223	213	97	153	338	218	275	205	66
18	17.50	18.49	1311	34	22	46	118	152	34	156	131	106	246	223	43
19	18.50	19.49	743	32	7	11	69	64	8	76	138	75	165	64	34
20	19.50	20.49	429	8	5	2	26	31	1	31	102	70	82	52	19
21	20.50	21.49	267	1	0	2	8	11	0	19	100	44	40	33	9
22	21.50	22.49	106	0	0	0	9	2	0	8	40	10	15	17	5
23	22.50	23.49	39	0	0	1	5	0	0	6	12	1	10	4	0
24	23.50	24.49	24	0	0	0	3	0	0	4	4	2	6	4	1
25	24.50	25.49	7	1	0	0	0	0	0	1	1	0	3	1	0
26	25.50	26.49	4	0	0	0	0	0	0	0	0	0	2	2	0
27	26.50	27.49	1	0	0	0	0	0	0	0	1	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	1	0	0	0	0	0	0	0	1	0	0	0	0
30	29.50	30.49	2	0	0	0	0	0	0	0	0	1	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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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

12.00m - MCP ERA5 (T) - [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			7.48	6.18	5.78	6.93	7.31	7.82	7.36	7.39	8.17	7.84	8.10	7.48	6.37
0		0.49	558	43	85	55	60	41	29	36	54	51	36	45	23
1	0.50	1.49	3295	395	424	297	261	289	238	324	202	232	219	238	176
2	1.50	2.49	7924	792	835	793	561	591	732	875	615	536	544	496	554
3	2.50	3.49	12394	870	1136	969	899	1168	1046	1188	1031	986	1074	1100	927
4	3.50	4.49	16051	1239	1248	1068	1221	1393	1288	1425	1468	1478	1666	1531	1026
5	4.50	5.49	18859	1076	983	1123	1753	1387	1525	1656	2225	1953	2435	1666	1077
6	5.50	6.49	20019	781	778	1048	1996	1512	1593	1646	2595	2470	2572	1890	1138
7	6.50	7.49	21603	753	995	943	1444	1509	1728	1769	3199	3065	2853	2210	1135
8	7.50	8.49	20867	613	841	971	1280	1479	1442	1528	3488	3123	3375	1858	869
9	8.50	9.49	18965	515	559	968	1116	1420	1577	1573	3225	2866	2982	1516	648
10	9.50	10.49	15720	427	299	720	869	1435	1536	1390	2406	2303	2816	1211	308
11	10.50	11.49	11694	343	252	668	737	1164	1092	1131	1906	1488	1915	820	178
12	11.50	12.49	9496	327	250	458	608	1028	817	912	1739	953	1441	731	232
13	12.50	13.49	5989	215	158	343	422	708	456	587	1030	641	850	423	156
14	13.50	14.49	3718	134	75	225	304	562	295	198	491	435	533	345	121
15	14.50	15.49	2709	72	52	138	269	288	104	252	376	317	443	315	83
16	15.50	16.49	1497	43	29	80	175	159	41	112	216	146	253	188	55
17	16.50	17.49	734	35	8	33	91	103	6	72	64	63	137	78	44
18	17.50	18.49	398	16	4	2	26	18	2	26	108	59	83	35	19
19	18.50	19.49	210	7	3	2	12	9	0	13	86	21	20	34	3
20	19.50	20.49	85	2	0	1	3	1	0	4	29	8	15	18	4
21	20.50	21.49	32	0	0	0	3	0	0	3	12	0	6	6	2
22	21.50	22.49	17	0	0	0	4	0	0	2	1	4	2	3	1
23	22.50	23.49	5	0	0	0	0	0	0	0	1	0	0	4	0
24	23.50	24.49	1	0	0	0	0	0	0	0	1	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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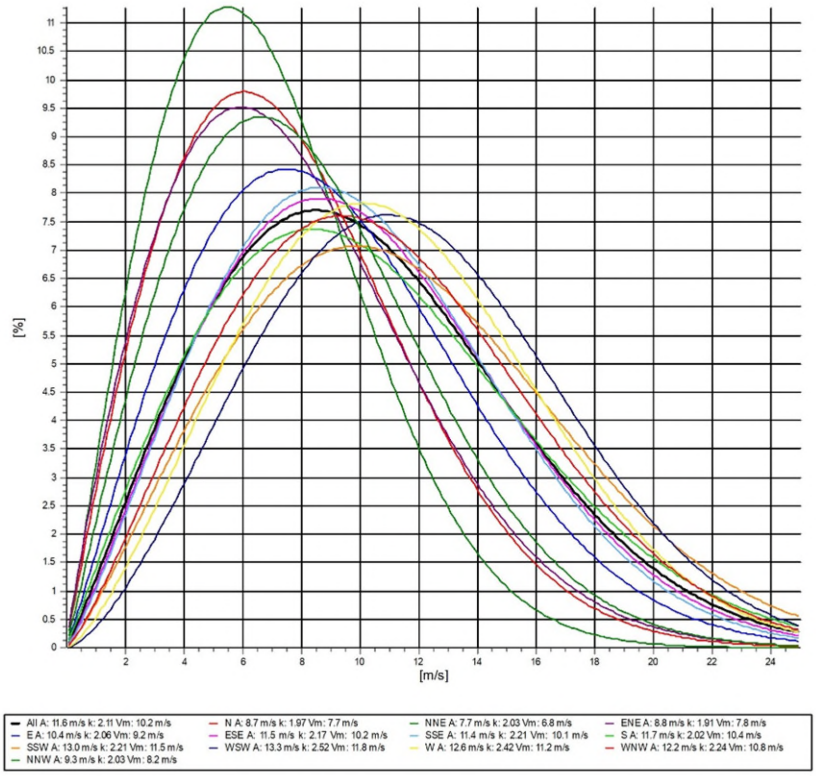
Meteo data report - Weibull data overview

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

Height: **300.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.68	1.970	4.97	7.69
1-NNE	7.67	2.028	4.03	6.80
2-ENE	8.75	1.910	4.87	7.77
3-E	10.37	2.056	6.06	9.18
4-ESE	11.46	2.169	7.91	10.15
5-SSE	11.35	2.214	7.92	10.05
6-S	11.73	2.022	7.33	10.39
7-SSW	12.98	2.205	11.20	11.49
8-WSW	13.34	2.522	14.09	11.84
9-W	12.58	2.422	14.87	11.15
10-WNW	12.21	2.242	11.17	10.81
11-NNW	9.26	2.028	5.57	8.20
Mean	**11.55**	**2.111**	**100.00**	**10.23**



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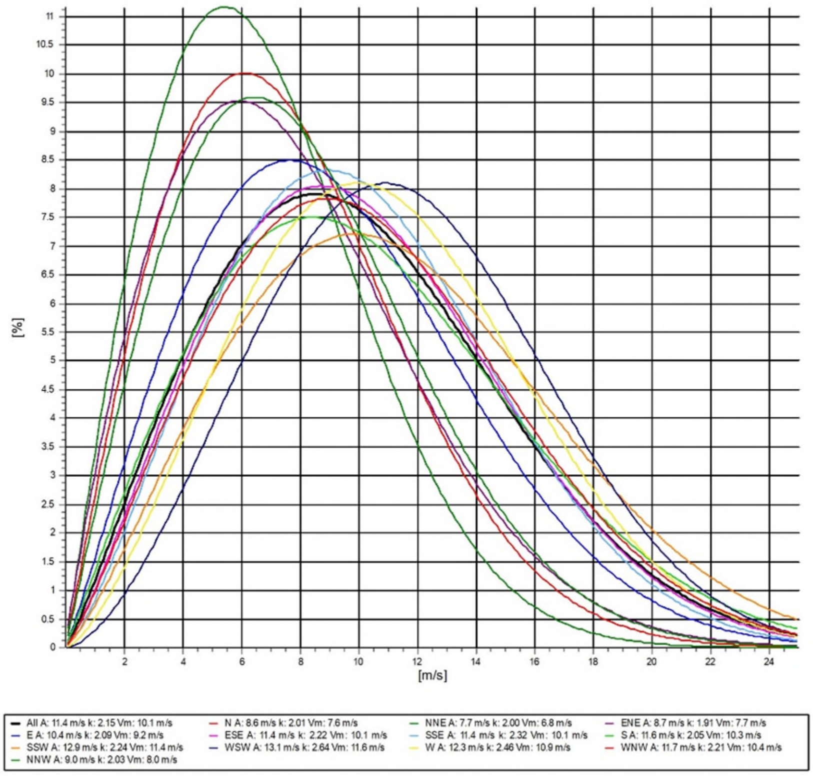
Meteo data report - Weibull data overview

Mast: KG-1-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **260.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.60	2.013	4.93	7.62
1-NNE	7.68	1.999	4.11	6.80
2-ENE	8.73	1.908	4.86	7.75
3-E	10.42	2.095	6.21	9.22
4-ESE	11.45	2.217	7.85	10.14
5-SSE	11.43	2.316	7.99	10.12
6-S	11.64	2.055	7.44	10.31
7-SSW	12.87	2.240	11.49	11.40
8-WSW	13.05	2.642	14.07	11.60
9-W	12.32	2.460	14.73	10.93
10-WNW	11.73	2.207	10.86	10.39
11-NNW	9.02	2.029	5.47	7.99
Mean	**11.40**	**2.150**	**100.00**	**10.09**



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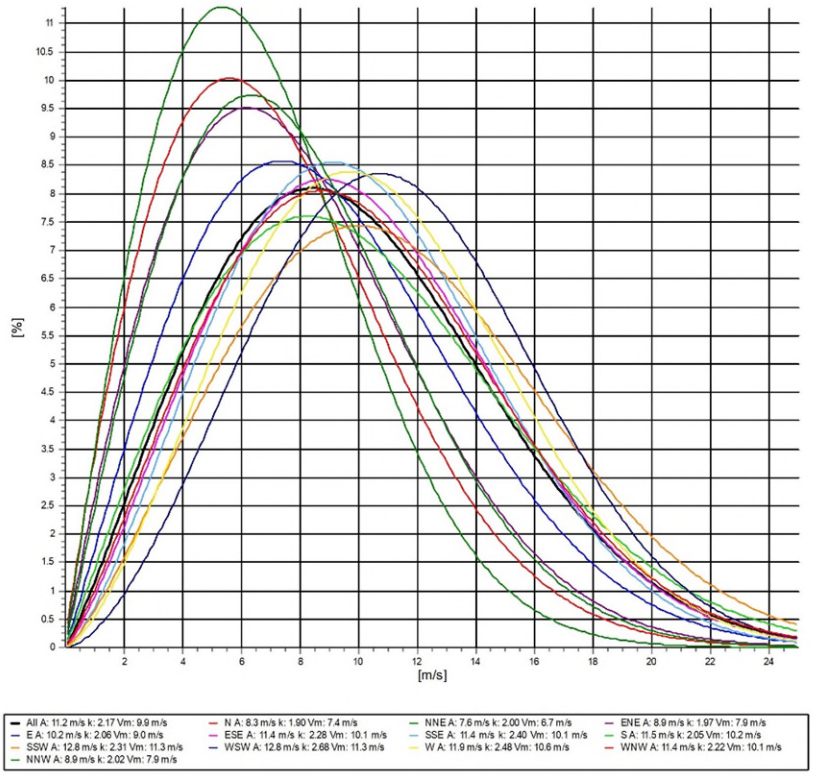
Meteo data report - Weibull data overview

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

Height: **220.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.28	1.903	4.93	7.35
1-NNE	7.59	1.998	4.13	6.73
2-ENE	8.91	1.965	5.05	7.90
3-E	10.20	2.061	6.20	9.03
4-ESE	11.40	2.280	7.94	10.09
5-SSE	11.42	2.397	7.93	10.12
6-S	11.47	2.051	7.50	10.17
7-SSW	12.77	2.309	11.93	11.31
8-WSW	12.76	2.675	13.76	11.34
9-W	11.94	2.475	14.81	10.59
10-WNW	11.44	2.217	10.48	10.13
11-NNW	8.87	2.022	5.35	7.86
Mean	**11.21**	**2.171**	**100.00**	**9.93**



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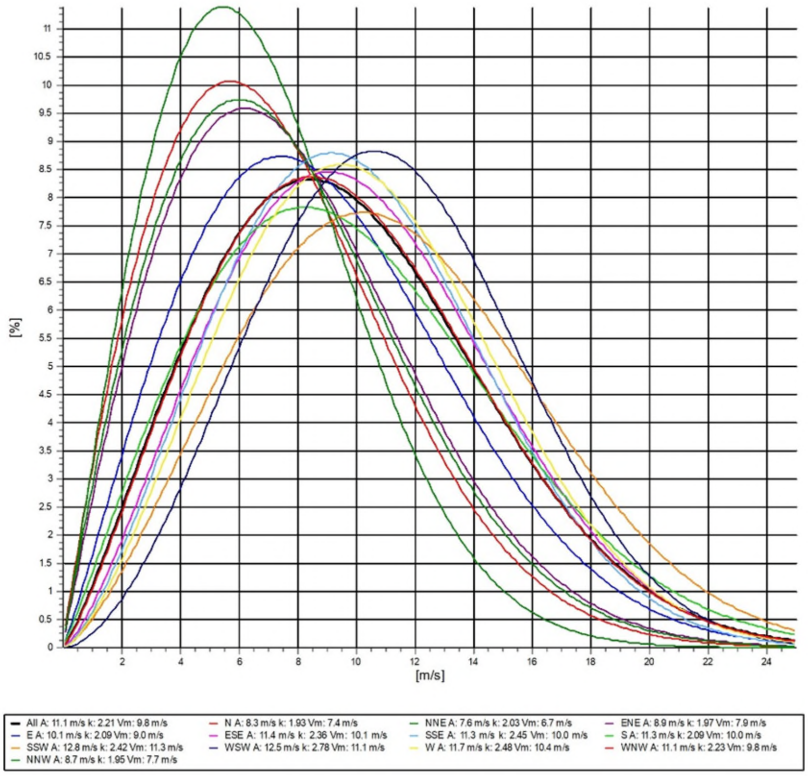
Meteo data report - Weibull data overview

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

Height: **190.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.33	1.929	4.82	7.39
1-NNE	7.61	2.031	4.16	6.74
2-ENE	8.87	1.972	5.19	7.87
3-E	10.13	2.092	6.36	8.97
4-ESE	11.42	2.361	7.90	10.12
5-SSE	11.32	2.455	8.08	10.04
6-S	11.28	2.087	7.62	9.99
7-SSW	12.75	2.423	12.03	11.31
8-WSW	12.47	2.776	13.67	11.10
9-W	11.68	2.477	14.75	10.36
10-WNW	11.07	2.234	10.20	9.81
11-NNW	8.67	1.952	5.23	7.69
Mean	**11.06**	**2.214**	**100.00**	**9.80**



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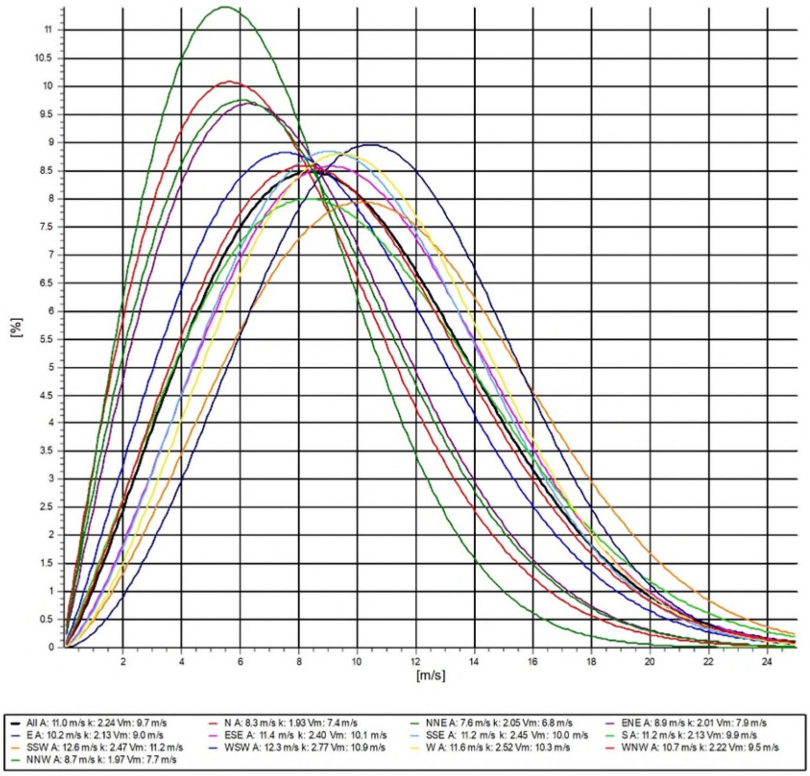
Meteo data report - Weibull data overview

Mast: KG-1-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **170.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.31	1.927	4.80	7.37
1-NNE	7.63	2.047	4.17	6.76
2-ENE	8.89	2.012	5.16	7.87
3-E	10.15	2.132	6.52	8.99
4-ESE	11.40	2.400	7.96	10.10
5-SSE	11.23	2.449	8.02	9.96
6-S	11.20	2.133	7.73	9.92
7-SSW	12.58	2.467	12.23	11.15
8-WSW	12.26	2.774	13.67	10.91
9-W	11.56	2.523	14.59	10.26
10-WNW	10.73	2.220	10.07	9.50
11-NNW	8.69	1.965	5.08	7.70
Mean	**10.95**	**2.241**	**100.00**	**9.70**



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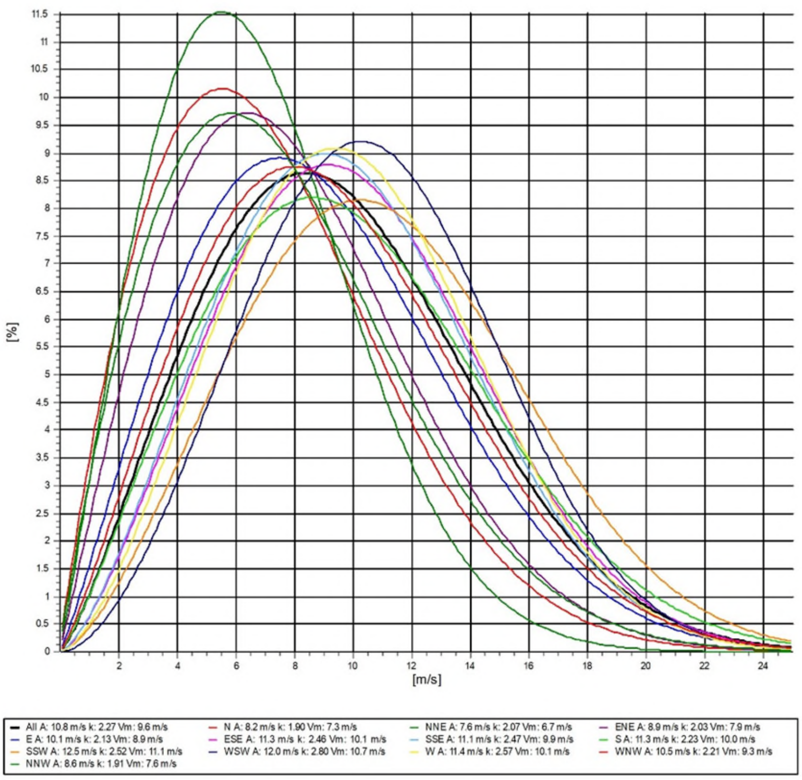
Meteo data report - Weibull data overview

Mast: KG-1-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.18	1.901	4.82	7.26
1-NNE	7.60	2.070	4.22	6.73
2-ENE	8.93	2.035	5.33	7.91
3-E	10.06	2.134	6.64	8.91
4-ESE	11.34	2.459	7.96	10.06
5-SSE	11.13	2.470	7.97	9.87
6-S	11.28	2.226	7.73	9.99
7-SSW	12.48	2.522	12.56	11.08
8-WSW	12.03	2.798	13.33	10.71
9-W	11.36	2.570	14.69	10.09
10-WNW	10.49	2.208	9.81	9.29
11-NNW	8.59	1.913	4.93	7.62
Mean	**10.83**	**2.266**	**100.00**	**9.60**



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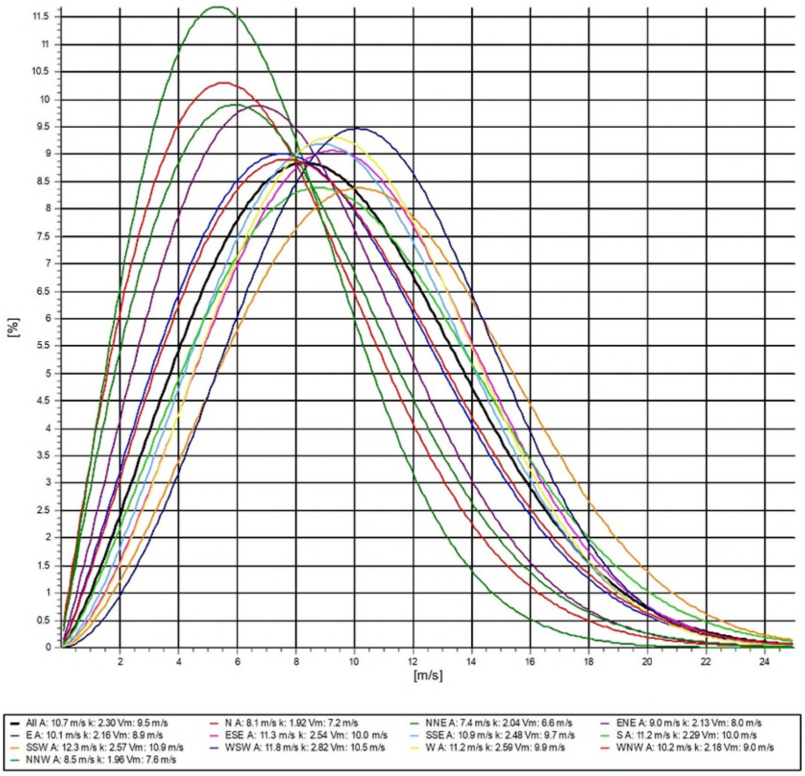
Meteo data report - Weibull data overview

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

Height: **130.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.12	1.924	4.75	7.20
1-NNE	7.44	2.042	4.33	6.59
2-ENE	9.05	2.126	5.40	8.01
3-E	10.05	2.163	6.69	8.90
4-ESE	11.28	2.541	8.00	10.01
5-SSE	10.93	2.484	8.00	9.70
6-S	11.25	2.289	7.87	9.97
7-SSW	12.31	2.568	12.65	10.93
8-WSW	11.79	2.825	13.24	10.50
9-W	11.15	2.588	14.56	9.90
10-WNW	10.20	2.176	9.68	9.04
11-NNW	8.55	1.959	4.82	7.58
Mean	**10.69**	**2.297**	**100.00**	**9.47**



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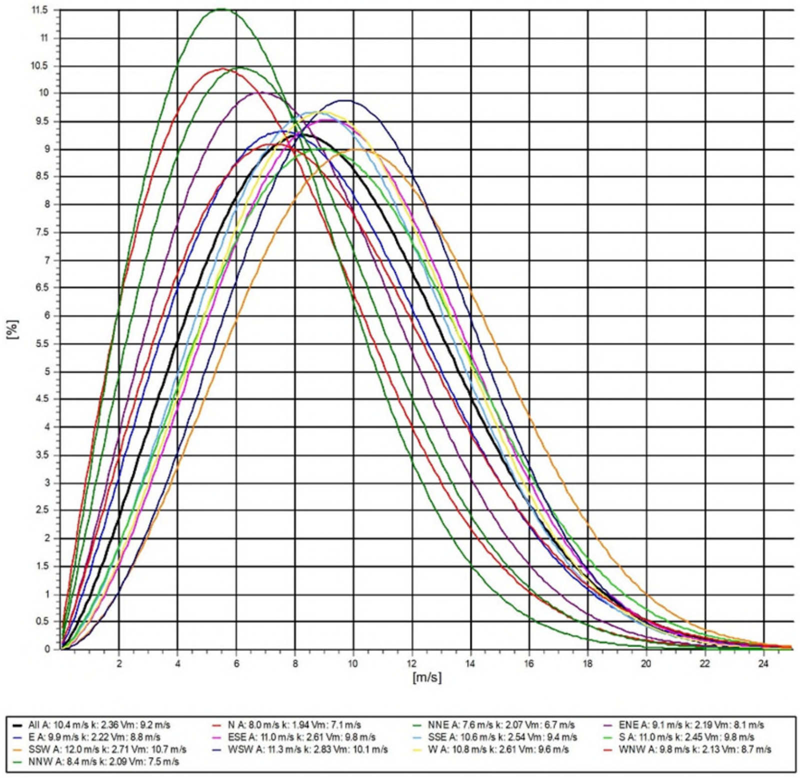
Meteo data report - Weibull data overview

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

Height: **100.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.05	1.936	4.67	7.14
1-NNE	7.60	2.065	4.42	6.74
2-ENE	9.11	2.188	5.46	8.07
3-E	9.90	2.223	6.81	8.77
4-ESE	10.98	2.614	8.22	9.76
5-SSE	10.57	2.538	8.02	9.38
6-S	11.03	2.448	8.17	9.78
7-SSW	12.00	2.714	12.68	10.67
8-WSW	11.32	2.830	13.04	10.09
9-W	10.80	2.606	14.25	9.59
10-WNW	9.85	2.130	9.52	8.72
11-NNW	8.44	2.089	4.74	7.48
Mean	**10.43**	**2.359**	**100.00**	**9.24**



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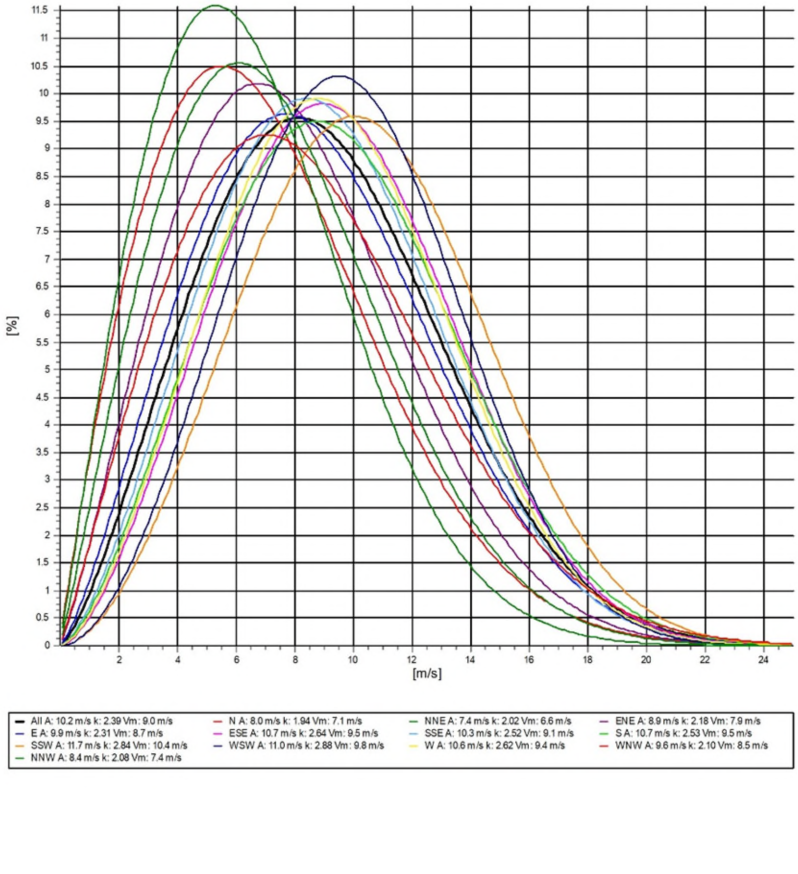
Meteo data report - Weibull data overview

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

Height: **80.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.01	1.940	4.59	7.10
1-NNE	7.45	2.021	4.43	6.60
2-ENE	8.94	2.182	5.53	7.92
3-E	9.86	2.310	7.00	8.74
4-ESE	10.74	2.637	8.14	9.54
5-SSE	10.27	2.524	8.12	9.11
6-S	10.72	2.526	8.30	9.51
7-SSW	11.69	2.839	12.87	10.42
8-WSW	11.01	2.884	12.84	9.82
9-W	10.57	2.617	14.05	9.39
10-WNW	9.58	2.103	9.38	8.49
11-NNW	8.35	2.084	4.75	7.40
Mean	**10.20**	**2.392**	**100.00**	**9.04**



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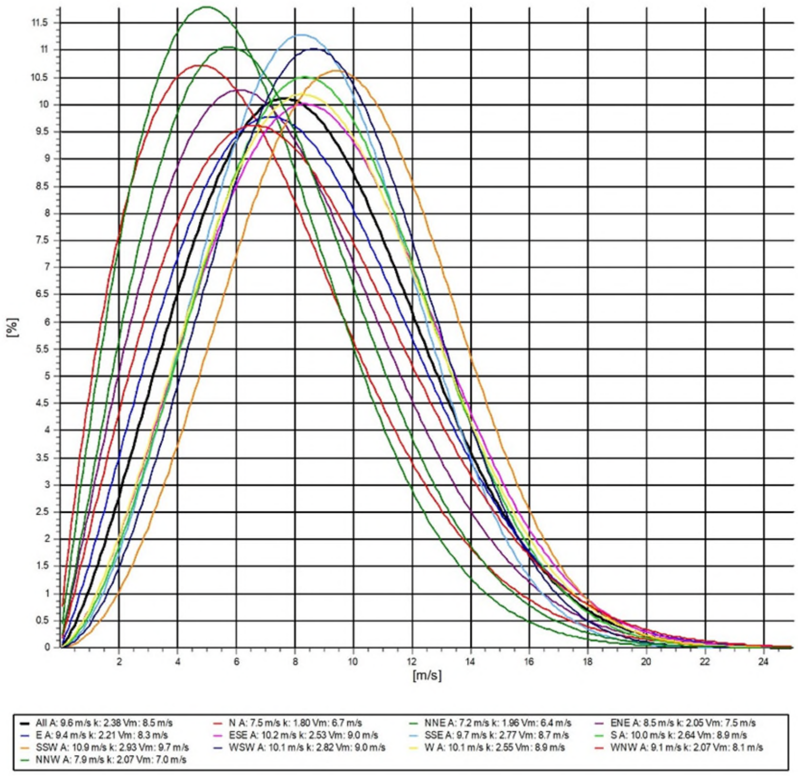
Meteo data report - Weibull data overview

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

Height: **40.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.51	1.800	4.37	6.67
1-NNE	7.18	1.963	4.61	6.37
2-ENE	8.49	2.048	5.75	7.52
3-E	9.41	2.213	7.14	8.33
4-ESE	10.20	2.533	8.35	9.05
5-SSE	9.72	2.768	8.10	8.65
6-S	10.04	2.638	8.33	8.92
7-SSW	10.85	2.935	13.54	9.68
8-WSW	10.10	2.817	12.44	9.00
9-W	10.07	2.552	13.84	8.94
10-WNW	9.12	2.068	8.89	8.08
11-NNW	7.94	2.071	4.63	7.03
Mean	**9.62**	**2.383**	**100.00**	**8.52**



Project:
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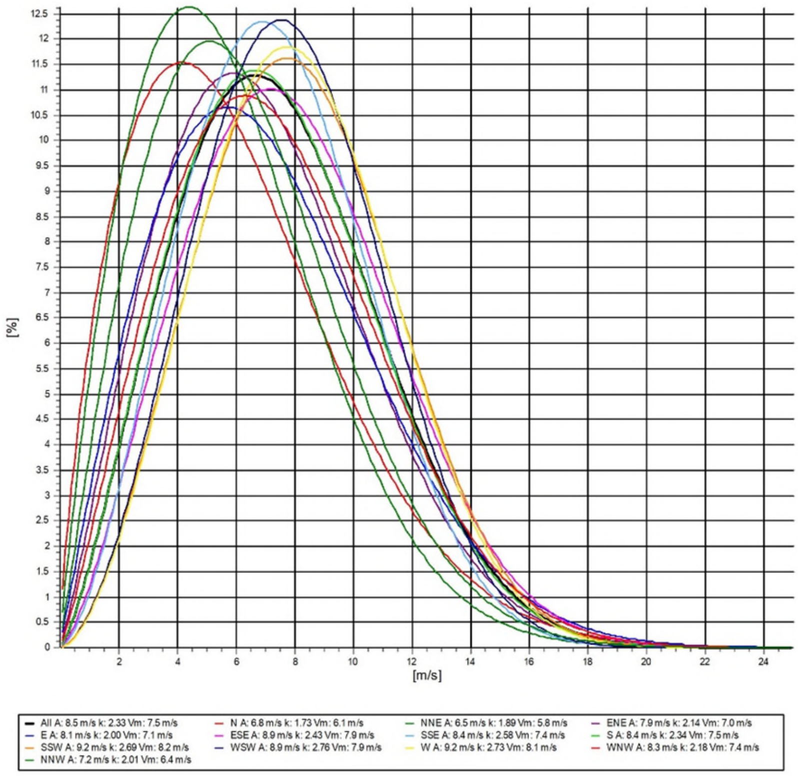
Calculated:
18/09/2024 09:52

Meteo data report - Weibull data overview

Mast: KG-1-LB LT-All heights **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **12.00m - MCP ERA5 (T) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.83	1.732	4.51	6.09
1-NNE	6.55	1.888	4.67	5.81
2-ENE	7.93	2.140	5.65	7.02
3-E	8.05	2.003	7.32	7.14
4-ESE	8.95	2.426	8.43	7.93
5-SSE	8.39	2.580	8.06	7.45
6-S	8.42	2.339	8.67	7.46
7-SSW	9.20	2.685	13.78	8.18
8-WSW	8.86	2.765	12.03	7.88
9-W	9.16	2.731	13.62	8.15
10-WNW	8.35	2.177	8.69	7.39
11-NNW	7.19	2.006	4.55	6.37
Mean	**8.46**	**2.330**	**100.00**	**7.50**



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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

150.00m - transfered from KG-1 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			9.50	7.26	6.61	7.76	8.86	9.88	9.60	9.88	10.93	10.63	9.99	9.31	7.78
0		0.49	476	24	33	37	52	62	42	53	54	45	38	21	15
1	0.50	1.49	2580	284	280	285	238	183	222	236	166	168	229	162	127
2	1.50	2.49	5960	542	527	727	547	422	599	711	476	259	367	412	371
3	2.50	3.49	8248	706	663	650	631	564	691	833	686	612	759	835	618
4	3.50	4.49	10940	1003	1032	868	708	812	760	912	1027	881	1161	910	866
5	4.50	5.49	12692	1076	838	1034	974	785	996	877	1144	1094	1695	1281	898
6	5.50	6.49	13578	749	828	943	1105	932	934	1007	1252	1290	2016	1571	951
7	6.50	7.49	15233	960	923	780	1206	1179	1007	827	1651	1770	1955	1750	1225
8	7.50	8.49	16325	794	939	679	1021	1338	1193	914	1933	2051	2521	1982	960
9	8.50	9.49	15215	610	739	722	1010	1236	1263	864	1769	2232	2510	1570	690
10	9.50	10.49	14778	611	278	796	1028	1109	1110	947	1553	2323	2793	1473	757
11	10.50	11.49	13947	473	285	708	700	1088	1189	1032	1592	2197	2585	1612	486
12	11.50	12.49	13139	489	243	510	714	1025	1059	970	1615	2483	2234	1233	564
13	12.50	13.49	11546	346	169	441	668	1195	1035	852	1609	1866	1929	1136	300
14	13.50	14.49	9740	200	144	415	690	841	1020	922	1498	1605	1487	764	154
15	14.50	15.49	8038	134	100	285	484	756	615	671	1585	1510	1273	544	81
16	15.50	16.49	6226	95	49	131	308	525	511	573	1431	1256	785	432	130
17	16.50	17.49	4677	58	28	113	254	492	459	484	950	740	606	387	106
18	17.50	18.49	3273	50	14	67	180	359	283	383	765	370	496	262	44
19	18.50	19.49	2341	47	13	46	164	216	200	255	511	355	294	199	41
20	19.50	20.49	1492	21	8	22	67	126	119	220	306	191	212	141	59
21	20.50	21.49	860	7	4	7	20	65	42	119	208	144	135	81	28
22	21.50	22.49	610	10	4	2	10	21	16	90	138	126	127	49	17
23	22.50	23.49	389	1	1	2	12	7	7	60	137	70	54	32	6
24	23.50	24.49	248	5	0	0	12	11	4	38	90	27	28	27	6
25	24.50	25.49	157	0	0	1	2	1	1	27	44	25	17	26	13
26	25.50	26.49	59	0	0	0	2	0	0	19	12	2	12	11	1
27	26.50	27.49	26	0	0	0	1	0	0	3	5	2	7	7	1
28	27.50	28.49	25	0	0	0	0	0	0	5	7	1	7	4	1
29	28.50	29.49	10	0	0	0	0	0	0	1	4	2	2	1	0
30	29.50	30.49	6	0	0	0	0	0	0	2	3	0	1	0	0
31	30.50	31.49	1	0	0	0	0	0	0	1	0	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	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	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	1	0	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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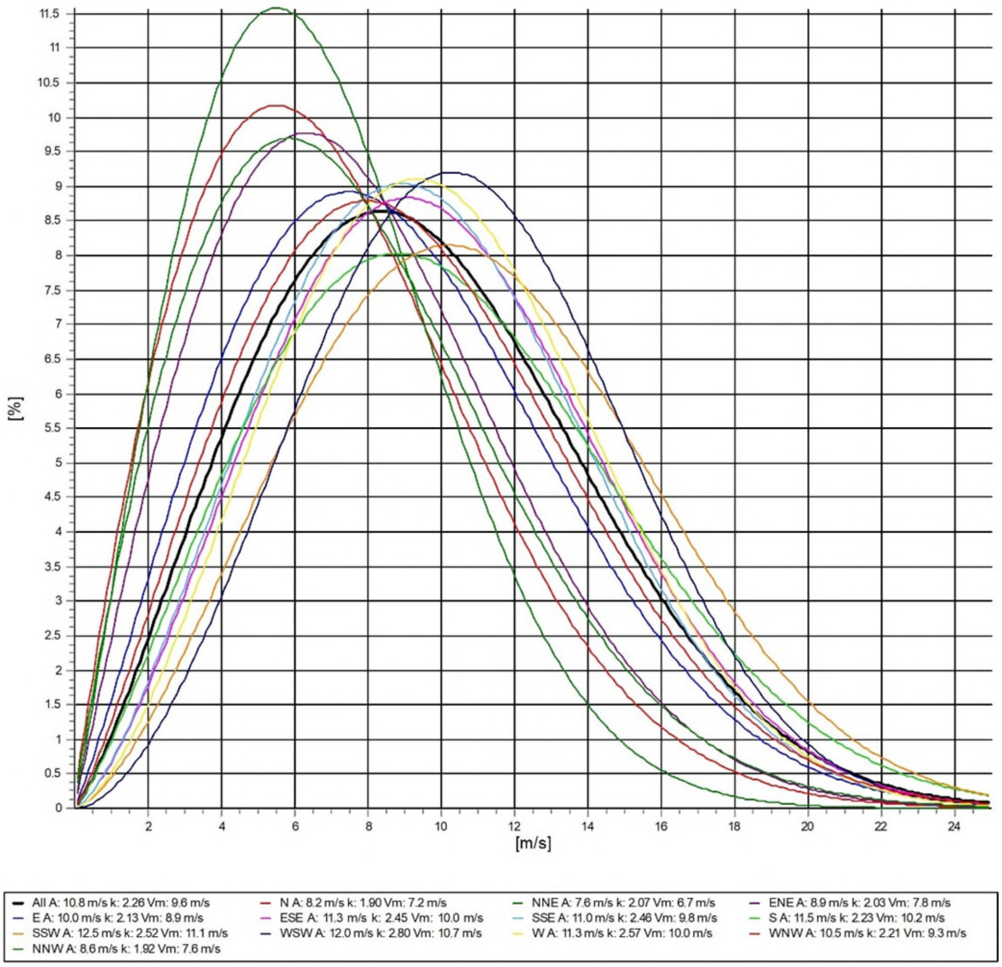
Meteo data report - Weibull data overview

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

Height: **150.00m - transfered from KG-1 Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.17	1.902	4.82	7.25
1-NNE	7.59	2.073	4.22	6.72
2-ENE	8.85	2.026	5.33	7.84
3-E	10.05	2.135	6.64	8.90
4-ESE	11.25	2.451	7.96	9.98
5-SSE	11.03	2.462	7.97	9.79
6-S	11.51	2.228	7.73	10.19
7-SSW	12.47	2.521	12.56	11.07
8-WSW	12.04	2.801	13.33	10.72
9-W	11.32	2.566	14.69	10.05
10-WNW	10.45	2.211	9.81	9.26
11-NNW	8.61	1.916	4.93	7.64
Mean	**10.82**	**2.263**	**100.00**	**9.59**



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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

150.00m - Transfered from KG1 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			9.53	7.74	6.86	7.87	8.73	10.16	9.53	9.67	10.79	10.75	10.12	9.23	7.59
0		0.49	469	21	33	36	52	59	41	54	55	44	38	21	15
1	0.50	1.49	2527	240	263	268	249	178	230	248	171	162	221	166	131
2	1.50	2.49	5922	487	500	715	566	383	610	736	490	259	362	422	392
3	2.50	3.49	8170	661	593	650	626	548	690	880	714	579	722	859	648
4	3.50	4.49	10701	814	970	823	750	781	777	898	1041	874	1138	908	927
5	4.50	5.49	12774	1081	867	1034	1012	738	995	910	1166	1063	1635	1353	920
6	5.50	6.49	13662	792	795	960	1123	900	936	1029	1303	1261	1973	1588	1002
7	6.50	7.49	14894	814	850	757	1231	1071	1051	835	1676	1707	1923	1768	1211
8	7.50	8.49	16291	853	898	673	1003	1299	1191	934	1962	2003	2489	2031	955
9	8.50	9.49	15177	659	819	717	1041	1231	1239	891	1790	2177	2427	1485	701
10	9.50	10.49	14763	536	416	783	1003	1100	1158	1010	1507	2288	2732	1512	718
11	10.50	11.49	14138	529	235	710	708	1108	1151	1040	1696	2226	2656	1602	477
12	11.50	12.49	12965	449	275	522	693	955	1071	939	1576	2433	2221	1286	545
13	12.50	13.49	11706	457	180	464	666	1146	1096	874	1689	1906	1971	1023	234
14	13.50	14.49	9831	302	151	379	699	992	936	920	1428	1634	1517	739	134
15	14.50	15.49	8169	176	126	358	417	714	612	627	1637	1522	1330	564	86
16	15.50	16.49	6455	129	72	131	305	603	550	550	1358	1326	852	411	168
17	16.50	17.49	4607	83	38	117	243	510	387	459	931	803	616	364	56
18	17.50	18.49	3378	61	22	82	185	393	287	341	728	423	529	280	47
19	18.50	19.49	2367	52	13	52	139	316	209	272	428	350	320	162	54
20	19.50	20.49	1434	39	12	23	42	147	90	143	298	231	226	144	39
21	20.50	21.49	891	25	6	10	18	108	46	125	163	136	147	83	24
22	21.50	22.49	642	17	5	4	12	40	14	61	161	145	129	45	9
23	22.50	23.49	416	10	2	2	13	13	9	57	117	80	78	30	5
24	23.50	24.49	230	2	1	0	8	10	1	29	82	28	27	28	14
25	24.50	25.49	140	6	0	1	2	6	0	27	30	27	21	18	2
26	25.50	26.49	50	0	0	0	2	1	0	9	7	5	13	12	1
27	26.50	27.49	32	0	0	0	0	0	0	6	6	2	10	8	0
28	27.50	28.49	15	0	0	0	0	0	0	1	5	1	6	1	1
29	28.50	29.49	13	0	0	0	0	0	0	2	4	1	4	2	0
30	29.50	30.49	6	0	0	0	0	0	0	1	2	1	2	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	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	1	0	0	0	0	0	0	0	0	1	0	0	0
36	35.50	36.49	1	0	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

Project:
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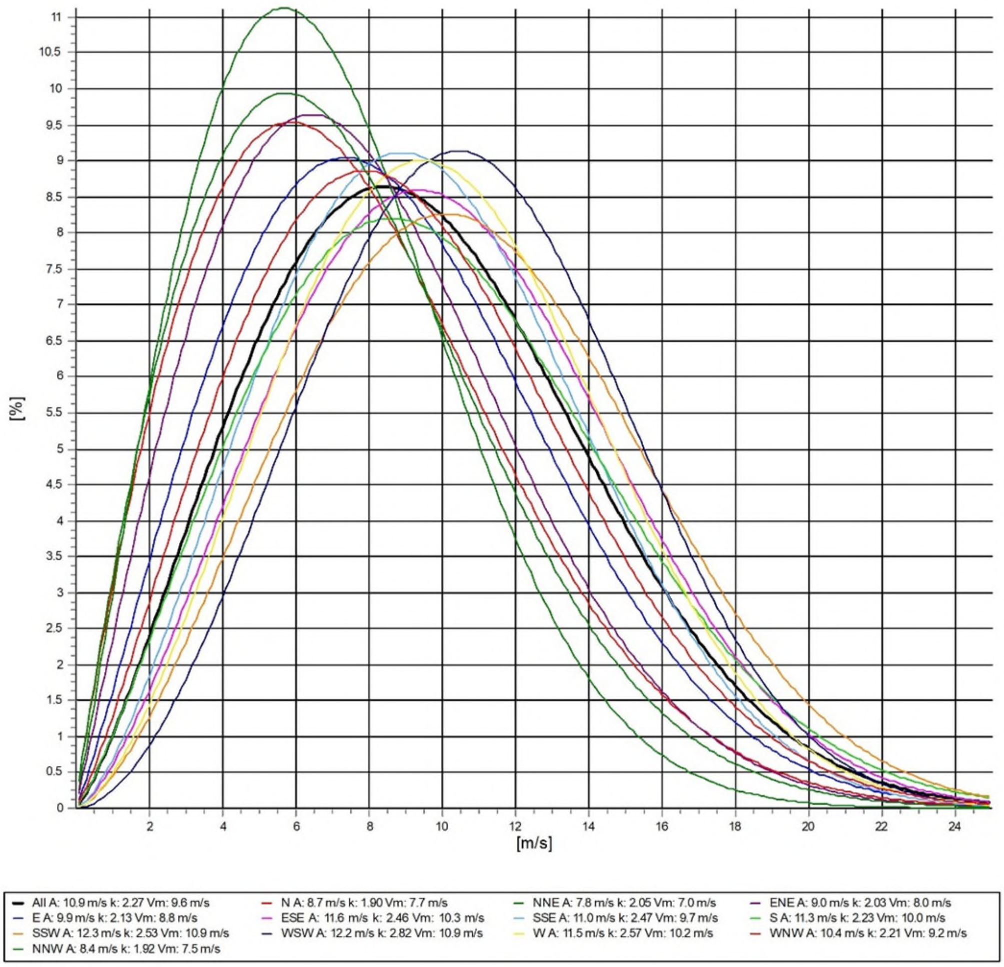
Meteo data report - Weibull data overview

Mast: KG-B LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - Transfered from KG1 Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.71	1.901	4.82	7.73
1-NNE	7.85	2.055	4.22	6.95
2-ENE	8.98	2.031	5.33	7.96
3-E	9.90	2.130	6.64	8.77
4-ESE	11.58	2.456	7.96	10.27
5-SSE	10.97	2.470	7.97	9.73
6-S	11.27	2.229	7.73	9.98
7-SSW	12.33	2.528	12.56	10.94
8-WSW	12.18	2.816	13.33	10.85
9-W	11.46	2.570	14.69	10.18
10-WNW	10.36	2.207	9.81	9.18
11-NNW	8.41	1.920	4.93	7.46
Mean	**10.86**	**2.275**	**100.00**	**9.62**



Appendix E. Long-term Corrected Datasets: HS-1-LB, H1 and M1

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Meteo data report - Frequency distribution (TAB file data)

Mast: HS1 LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP LT - EMD WFR - [Matrix] HS1

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	7.63	6.81	8.00	8.68	9.42	9.15	9.37	10.56	11.01	10.55	9.97	7.89
0		0.49	613	14	49	36	72	44	78	71	62	45	36	58	48
1	0.50	1.49	2681	164	184	179	184	249	326	268	249	304	208	166	200
2	1.50	2.49	6161	560	448	466	483	532	420	480	744	604	486	402	536
3	2.50	3.49	9552	932	830	748	601	628	655	772	902	840	1019	901	724
4	3.50	4.49	10280	876	841	743	760	796	795	675	848	1047	995	1014	890
5	4.50	5.49	12674	1156	663	706	914	1189	1127	942	1053	1225	1234	1339	1126
6	5.50	6.49	13615	763	873	837	998	1307	1172	1159	1195	1441	1580	1307	983
7	6.50	7.49	14868	700	919	980	1163	1344	1224	1148	1270	1750	1802	1509	1059
8	7.50	8.49	14919	643	1017	807	956	1472	1438	1162	1346	1673	1658	1545	1202
9	8.50	9.49	14487	527	614	747	975	1552	1478	1300	1485	1875	1758	1377	799
10	9.50	10.49	15462	650	589	749	963	1584	1320	1000	1551	2257	2478	1440	881
11	10.50	11.49	14143	621	388	547	1041	1339	1223	1107	1516	2016	2038	1536	771
12	11.50	12.49	12738	503	225	514	846	1264	1168	995	1564	1902	1900	1246	611
13	12.50	13.49	10966	386	200	413	562	1121	794	873	1354	1993	1800	1089	381
14	13.50	14.49	9498	243	120	393	577	904	780	814	1208	1677	1670	934	178
15	14.50	15.49	7656	177	64	248	462	692	627	581	1183	1494	1151	863	114
16	15.50	16.49	6467	143	46	147	218	489	569	475	1028	1426	1181	593	152
17	16.50	17.49	5146	176	41	104	158	468	398	426	631	1112	826	638	168
18	17.50	18.49	3848	81	6	93	110	222	172	268	816	1046	586	370	78
19	18.50	19.49	2448	47	8	42	92	170	89	122	387	603	478	340	70
20	19.50	20.49	1770	26	4	12	42	102	59	84	331	483	291	284	52
21	20.50	21.49	1045	9	1	7	20	49	18	53	289	311	164	95	29
22	21.50	22.49	731	5	0	4	6	26	0	43	141	244	159	81	22
23	22.50	23.49	342	6	1	1	5	5	1	16	43	74	100	58	32
24	23.50	24.49	294	5	0	2	3	4	0	15	42	69	87	62	5
25	24.50	25.49	182	0	0	1	0	0	0	8	38	38	42	44	11
26	25.50	26.49	75	0	0	0	1	0	0	7	12	21	13	21	0
27	26.50	27.49	80	0	0	0	0	0	0	2	7	8	18	45	0
28	27.50	28.49	45	0	0	0	0	0	0	2	6	3	17	15	2
29	28.50	29.49	20	0	0	0	0	0	0	0	1	3	9	7	0
30	29.50	30.49	14	0	0	0	0	0	0	0	1	1	8	4	0
31	30.50	31.49	6	0	0	0	0	0	0	0	1	2	2	1	0
32	31.50	32.49	8	0	0	0	0	0	0	0	0	1	6	1	0
33	32.50	33.49	2	0	0	0	0	0	0	0	0	0	1	1	0
34	33.50	34.49	2	0	0	0	0	0	0	0	0	1	0	1	0
35	34.50	35.49	2	0	0	0	0	0	0	0	1	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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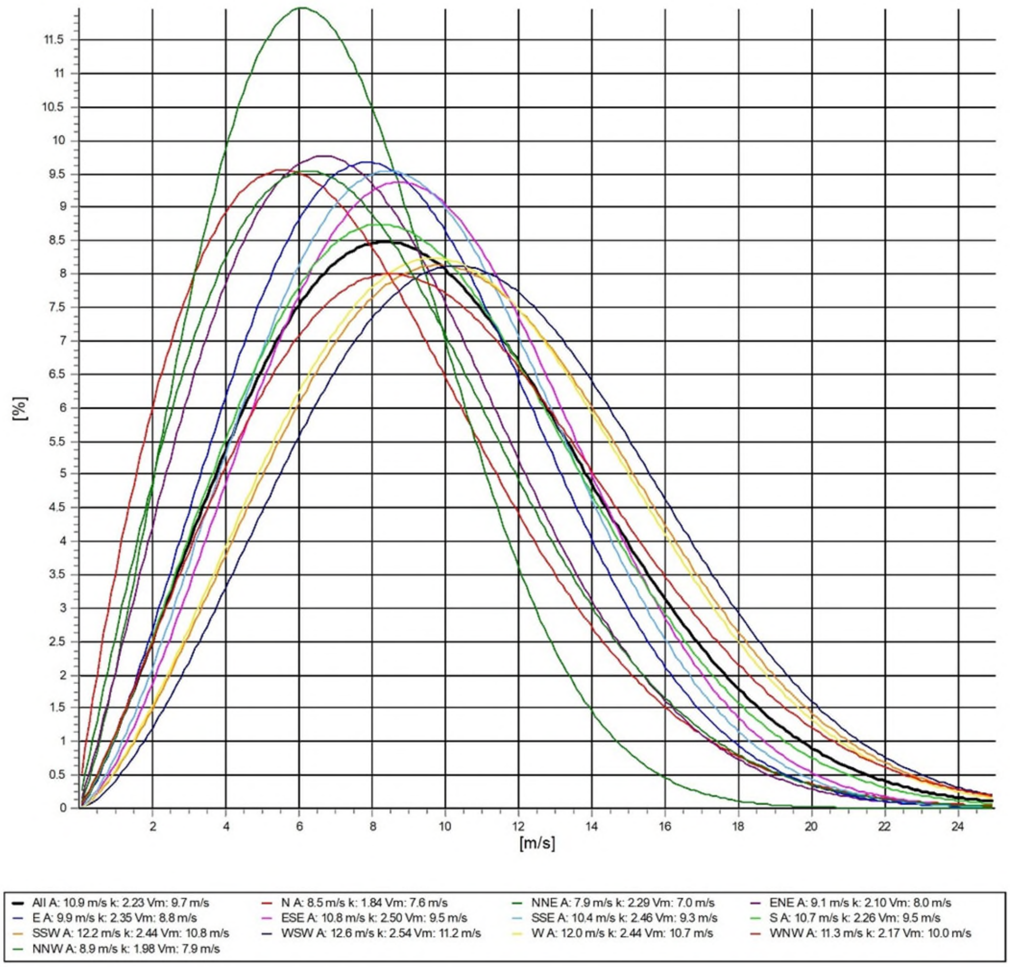
Meteo data report - Weibull data overview

Mast: HS1 LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - MCP LT - EMD WFR - [Matrix] HS1**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.53	1.839	4.88	7.57
1-NNE	7.86	2.286	4.22	6.97
2-ENE	9.08	2.102	4.94	8.04
3-E	9.95	2.349	6.33	8.81
4-ESE	10.76	2.497	9.10	9.55
5-SSE	10.44	2.459	8.26	9.26
6-S	10.68	2.259	7.71	9.46
7-SSW	12.18	2.439	11.05	10.80
8-WSW	12.57	2.536	14.31	11.16
9-W	12.01	2.436	13.38	10.65
10-WNW	11.33	2.169	10.05	10.04
11-NNW	8.93	1.980	5.77	7.92
Mean	**10.91**	**2.231**	**100.00**	**9.66**



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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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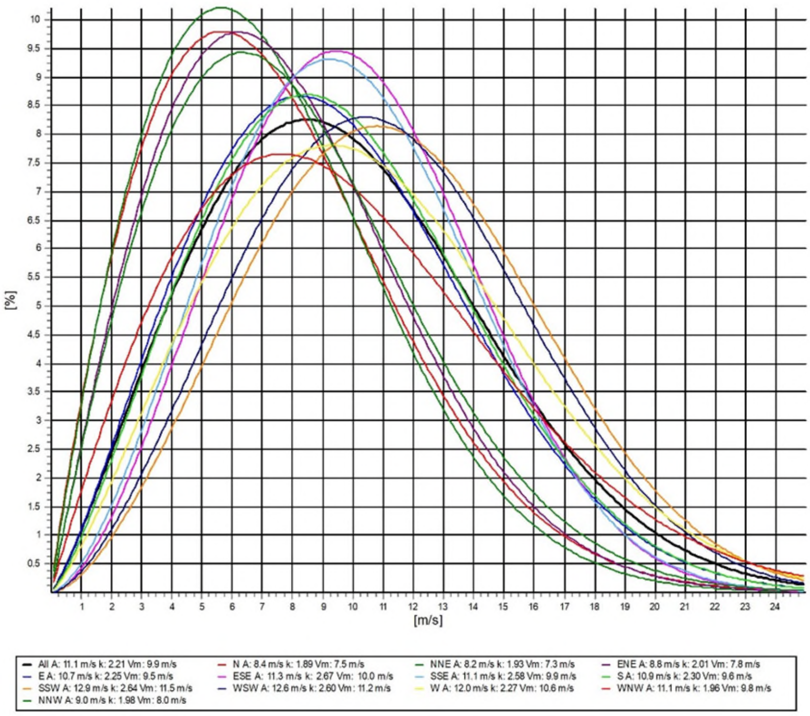
Meteo data report - Weibull data overview

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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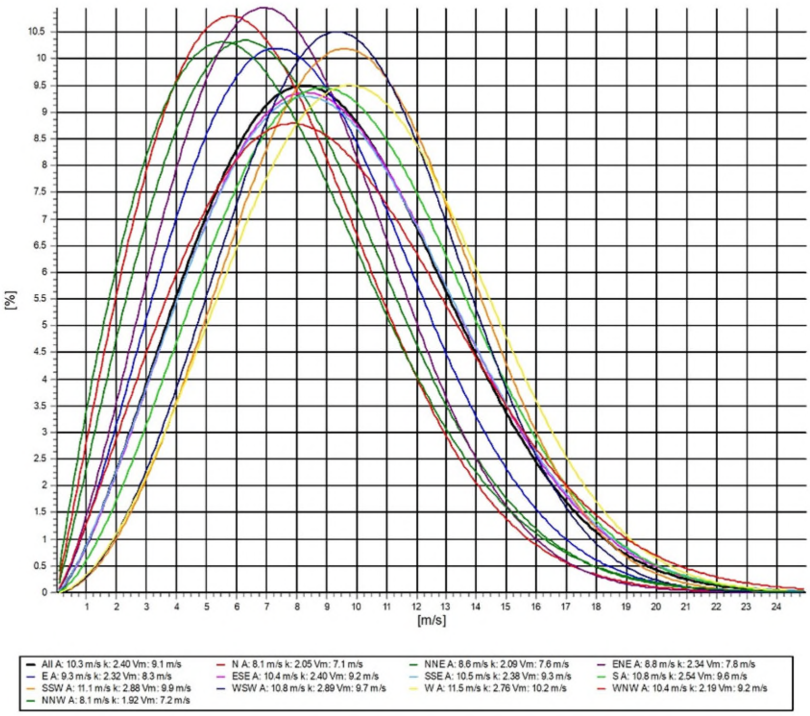
Meteo data report - Weibull data overview

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-LB, H1, M1

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Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1 LT 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			9.51	7.45	6.95	8.08	8.87	9.52	9.58	9.71	11.00	10.47	10.08	9.58	7.54
0		0.49	256	32	39	21	49	28	6	11	0	0	0	14	56
1	0.50	1.49	1806	198	174	146	163	220	199	203	63	44	80	124	192
2	1.50	2.49	5169	668	484	419	425	475	355	377	290	379	400	373	524
3	2.50	3.49	8801	881	843	676	568	590	510	657	897	785	985	795	614
4	3.50	4.49	10801	986	940	823	747	716	722	725	1071	1033	1133	1059	846
5	4.50	5.49	12374	1036	749	660	886	1098	963	805	1000	1304	1462	1461	950
6	5.50	6.49	14138	799	911	845	1009	1181	1200	1094	1362	1591	1845	1410	891
7	6.50	7.49	15536	691	985	980	1133	1278	1117	1112	1518	1967	2174	1603	978
8	7.50	8.49	15283	590	1108	827	1014	1380	1323	1232	1477	1844	1943	1625	920
9	8.50	9.49	15842	600	702	764	977	1490	1393	1300	1732	2324	2458	1450	652
10	9.50	10.49	16493	679	629	753	909	1525	1432	1232	1748	2472	2716	1546	852
11	10.50	11.49	14687	627	458	554	1078	1281	1155	955	1899	2173	2422	1582	503
12	11.50	12.49	13337	494	249	502	881	1178	1202	1076	1832	2238	2106	1061	518
13	12.50	13.49	11344	339	242	415	607	1078	960	818	1687	1881	2001	1145	171
14	13.50	14.49	9392	224	137	392	563	860	765	807	1536	1659	1447	902	100
15	14.50	15.49	8115	168	87	253	503	676	693	654	1454	1500	1395	617	115
16	15.50	16.49	6338	149	54	148	256	463	564	520	1224	1254	892	666	148
17	16.50	17.49	4658	143	57	103	164	452	455	440	851	869	639	403	82
18	17.50	18.49	3322	76	9	96	115	220	229	352	809	555	451	353	57
19	18.50	19.49	1994	37	8	33	98	160	80	142	551	336	234	258	57
20	19.50	20.49	1347	21	3	11	48	112	72	83	394	248	229	88	38
21	20.50	21.49	769	7	3	6	18	45	27	63	277	115	108	85	15
22	21.50	22.49	435	6	0	4	10	34	2	43	95	46	101	70	24
23	22.50	23.49	219	9	1	1	6	3	1	21	44	25	47	50	11
24	23.50	24.49	143	1	0	2	1	4	0	10	55	16	15	27	12
25	24.50	25.49	117	0	0	1	2	0	0	8	34	4	25	42	1
26	25.50	26.49	54	0	0	0	1	0	0	3	12	2	11	24	1
27	26.50	27.49	32	0	0	0	0	0	0	4	5	1	12	9	1
28	27.50	28.49	17	0	0	0	0	0	0	1	7	2	4	3	0
29	28.50	29.49	13	0	0	0	0	0	0	2	3	0	6	2	0
30	29.50	30.49	5	0	0	0	0	0	0	0	1	1	3	0	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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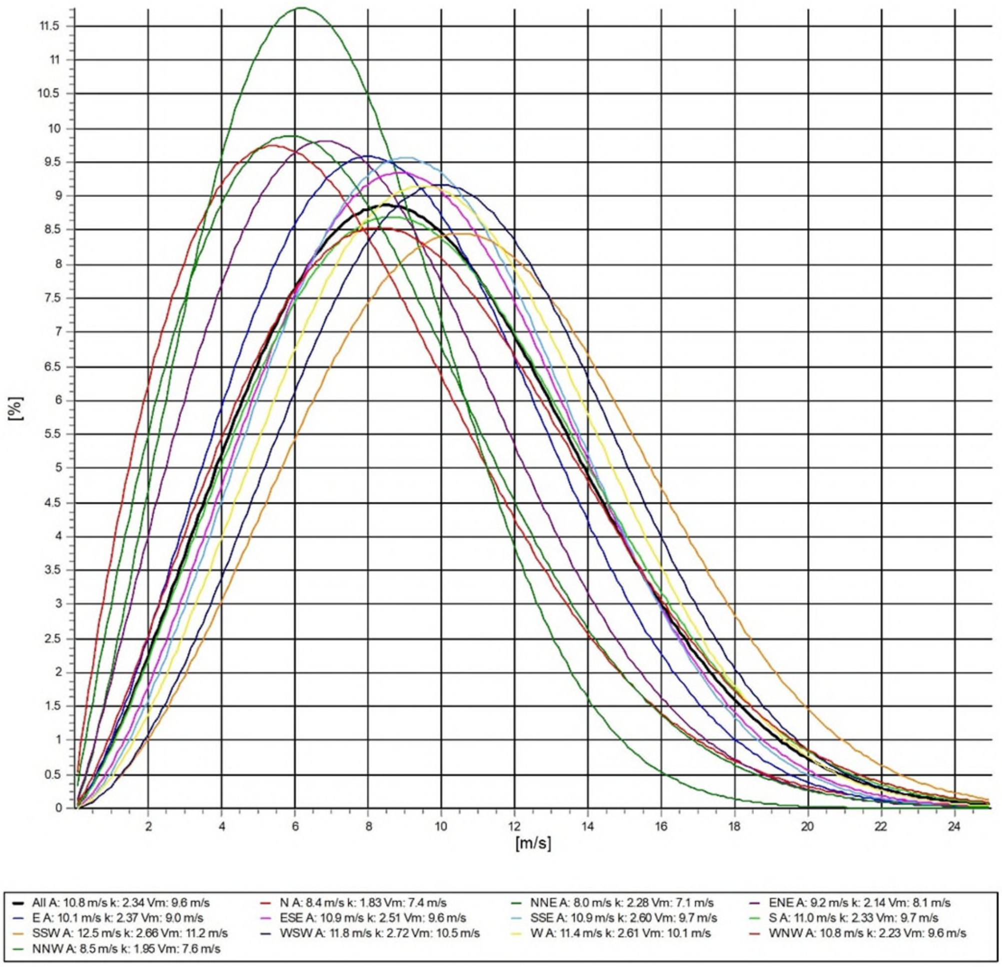
Meteo data report - Weibull data overview

Mast: HS-1 LT 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	8.35	1.835	4.91	7.42
1-NNE	7.99	2.280	4.60	7.08
2-ENE	9.15	2.140	4.89	8.11
3-E	10.11	2.371	6.34	8.96
4-ESE	10.85	2.514	8.58	9.63
5-SSE	10.88	2.596	8.00	9.67
6-S	10.99	2.330	7.65	9.74
7-SSW	12.55	2.657	12.41	11.15
8-WSW	11.82	2.725	13.83	10.51
9-W	11.42	2.609	14.18	10.15
10-WNW	10.83	2.230	9.77	9.59
11-NNW	8.52	1.945	4.84	7.56
Mean	**10.81**	**2.338**	**100.00**	**9.58**



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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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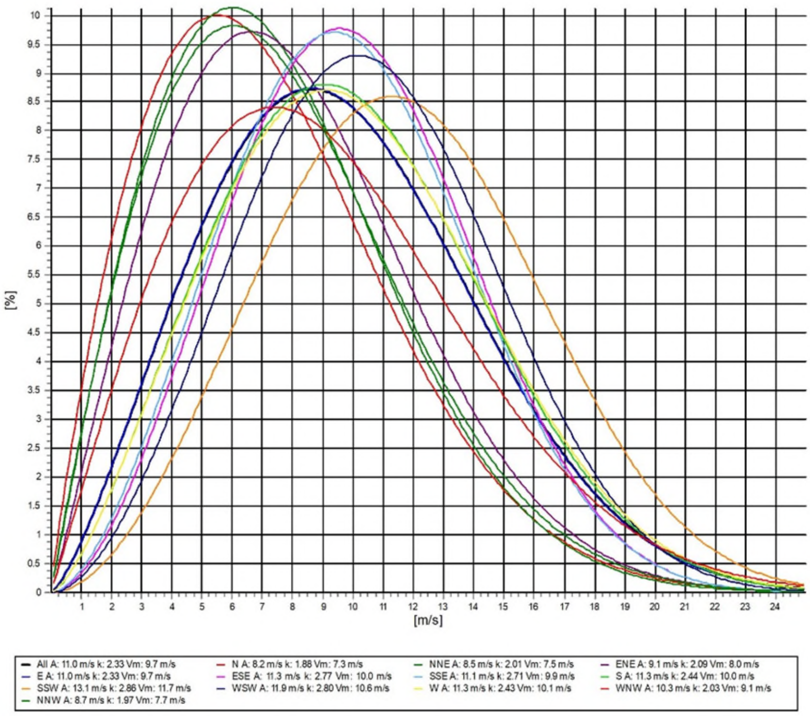
Meteo data report - Weibull data overview

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 - 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			9.56	8.29	8.12	8.36	9.11	9.89	9.50	9.76	10.86	9.77	9.57	9.75	8.56
0		0.49	140	0	0	0	0	0	0	46	41	46	7	0	0
1	0.50	1.49	1404	83	45	58	20	4	132	234	233	194	232	106	63
2	1.50	2.49	3695	233	180	236	204	251	407	400	416	387	439	332	210
3	2.50	3.49	6713	472	467	390	435	528	564	627	599	665	880	670	416
4	3.50	4.49	9616	672	661	602	612	786	824	874	798	1082	1137	1075	493
5	4.50	5.49	12386	789	824	785	953	946	922	940	1139	1431	1566	1420	671
6	5.50	6.49	14283	1004	924	729	977	1137	1125	1128	1379	1558	1930	1565	827
7	6.50	7.49	15600	1136	730	794	954	1356	1210	1298	1426	1685	2367	1691	953
8	7.50	8.49	16907	1170	752	715	1054	1554	1535	1419	1456	1917	2590	1947	798
9	8.50	9.49	17649	1006	732	794	1137	1535	1612	1446	1469	2225	2969	1909	815
10	9.50	10.49	17474	962	812	780	1044	1424	1502	1415	1648	2222	3104	1844	717
11	10.50	11.49	16490	645	568	707	923	1577	1381	1449	1857	2278	2847	1703	555
12	11.50	12.49	14578	463	566	565	780	1351	1187	1308	1866	2209	2448	1439	396
13	12.50	13.49	12329	325	369	495	662	1233	963	1059	1820	1871	1987	1214	331
14	13.50	14.49	10078	211	187	246	652	939	885	996	1696	1463	1464	1110	229
15	14.50	15.49	7711	135	134	147	428	748	647	787	1559	1048	1043	869	166
16	15.50	16.49	5483	110	120	85	212	520	454	592	1259	634	643	732	122
17	16.50	17.49	3843	113	60	70	137	404	306	404	998	374	357	523	97
18	17.50	18.49	2431	124	22	26	111	259	214	263	627	152	234	300	99
19	18.50	19.49	1561	65	11	12	46	148	129	192	337	120	189	241	71
20	19.50	20.49	1045	40	10	7	24	80	90	122	234	144	91	149	54
21	20.50	21.49	555	22	7	9	11	46	37	56	148	79	41	71	28
22	21.50	22.49	382	10	2	5	9	30	21	68	83	39	44	53	18
23	22.50	23.49	225	3	4	2	6	12	10	28	58	19	30	35	18
24	23.50	24.49	109	7	0	2	0	2	4	19	23	17	11	14	10
25	24.50	25.49	67	1	2	1	0	0	0	8	20	15	6	10	4
26	25.50	26.49	37	1	1	2	0	0	0	2	4	6	8	13	0
27	26.50	27.49	22	0	0	0	0	0	0	2	10	0	3	7	0
28	27.50	28.49	11	0	0	0	0	0	0	1	5	0	1	4	0
29	28.50	29.49	11	0	0	0	0	0	0	1	3	3	1	3	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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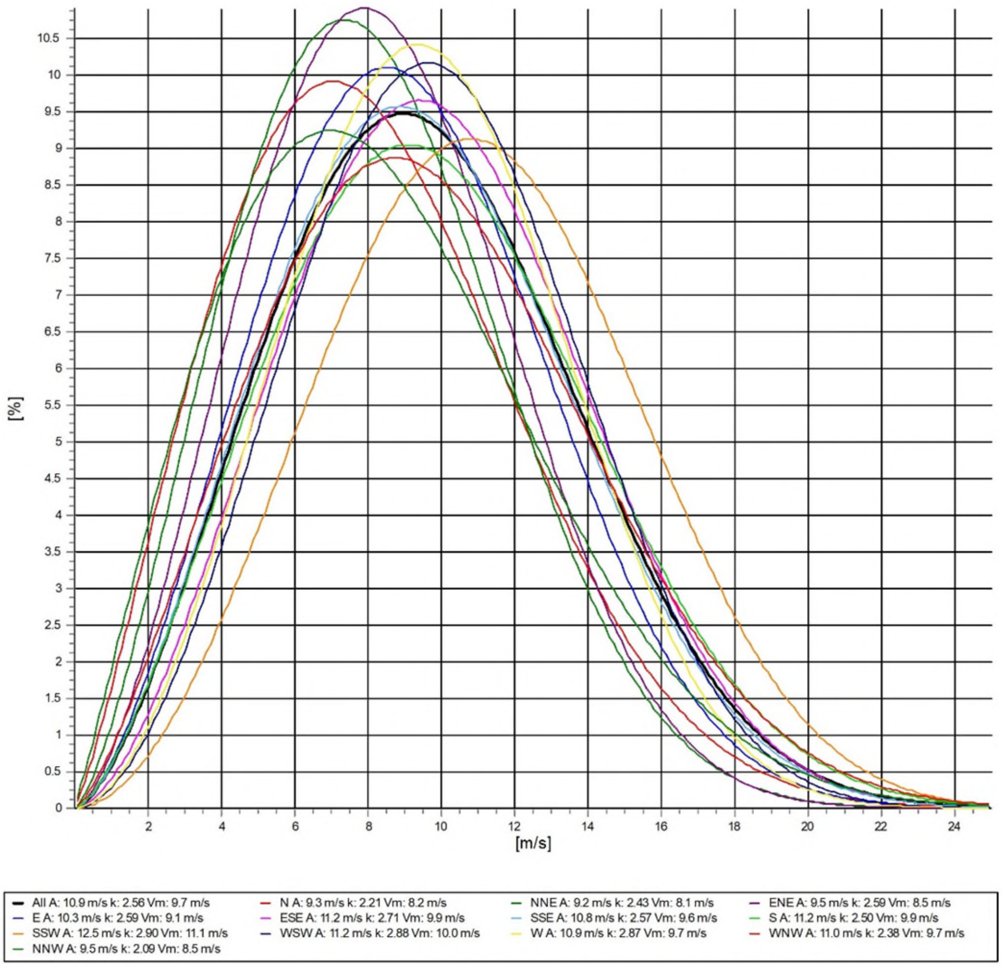
Meteo data report - Weibull data overview

Mast: M1 LT [EMDWFR, Matrix] transfered to KG-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **150.00m - Sheared**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	9.27	2.209	5.08	8.21
1-NNE	9.17	2.428	4.25	8.13
2-ENE	9.53	2.595	4.29	8.46
3-E	10.29	2.591	5.91	9.13
4-ESE	11.17	2.711	8.75	9.93
5-SSE	10.77	2.566	8.38	9.56
6-S	11.16	2.501	8.91	9.90
7-SSW	12.50	2.901	12.04	11.15
8-WSW	11.17	2.881	12.39	9.96
9-W	10.87	2.874	14.87	9.69
10-WNW	10.96	2.382	10.92	9.71
11-NNW	9.55	2.088	4.23	8.45
Mean	**10.87**	**2.564**	**100.00**	**9.65**



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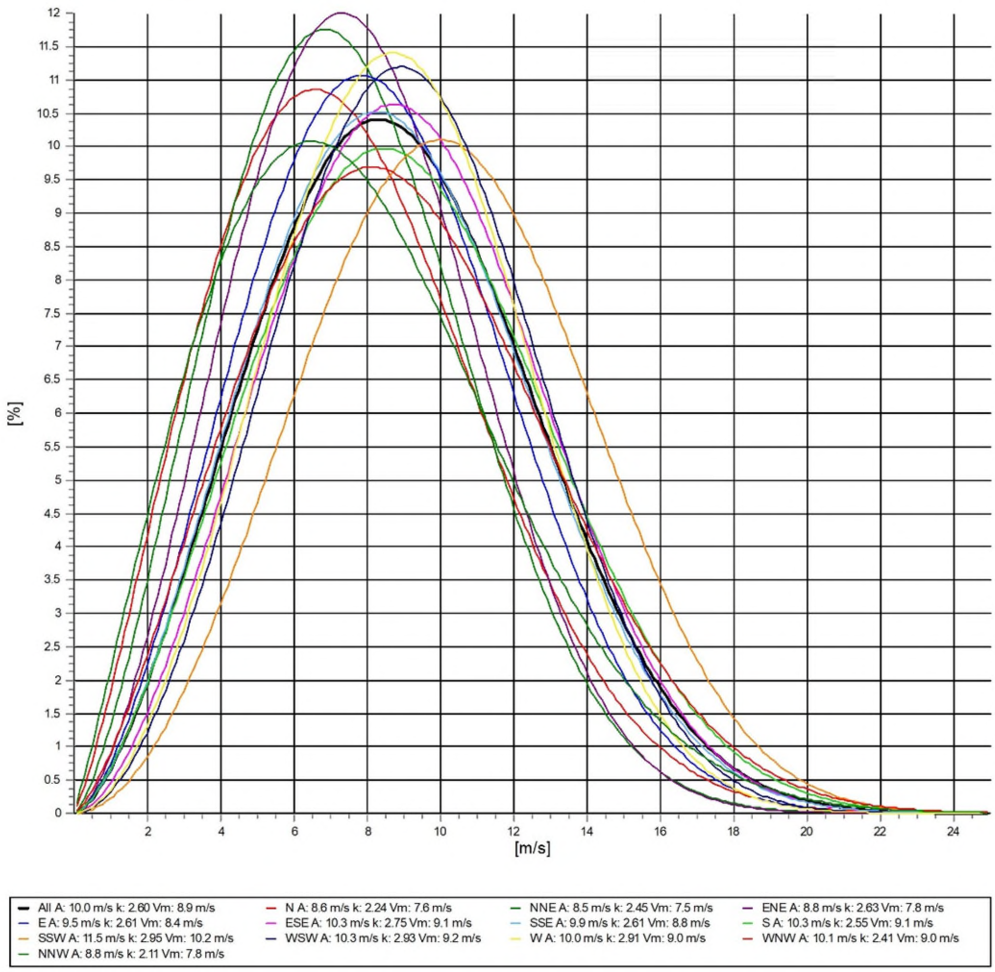
Meteo data report - Weibull data overview

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