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Hesselø South

Site Wind Conditions Assessment

Prepared for Energinet

By EMD International A/S

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0	2024-09-27	All	Draft report
1	2024-10-25	All	Final report
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3	2025-12-23	All	2025 revision due to revised measurement heights

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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 Hesselø South offshore wind farm project in the Kattegat Sea, Denmark.

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 former 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 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 two floating LiDAR buoys (SWLB059 and WS190) 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 Kattegat floating LiDAR (KG-1-LB), 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 Hesselø South Wind Farm and the data quality.

Site condition parameters are supported by data from secondary sources.

Calculations are done in windPRO 4.2, 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 four selected positions for the Hesselø South OWF area. All values refer to 150 m height above sea level (ASL).

Parameter	HS-1-LB	HS-A	HS-B	HS-C
Mean wind speed	9.70 m/s	9.78 m/s	9.69 m/s	9.77 m/s
Weibull distribution, A parameter (scale)	10.96 m/s	11.04 m/s	10.94 m/s	11.03 m/s
Weibull distribution, k parameter (shape)	2.22	2.23	2.22	2.22
Normal wind profile power law exponent	0.090	0.090	0.090	0.090
Turbulence intensity mean value (TI_{μ}) at a 10-min average wind speed of 15m/s*	4.9%	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%	2.0%
Turbulence intensity 90% quantile at a 10-min average wind speed of 15m/s*	7.5%	7.5%	7.5%	7.5%
Mean air density	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3
Mean air temperature	9.0°C	9.0°C	9.0°C	9.0°C
50-year extreme wind speed	40.1 m/s	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	31.5 m/s
Wind shear for extreme wind speed extrapolation	0.13	0.13	0.13	0.13
Characteristic turbulence intensity at 50-year extreme wind speed	12.0%	12.0%	12.0%	12.0%
Air density for extreme wind	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3
Lightning	1.18 flash/year/km^2	1.18 flash/year/km^2	1.18 flash/year/km^2	1.18 flash/year/km^2
Solar irradiance, mean	121 W/m^2	121 W/m^2	121 W/m^2	121 W/m^2
Solar irradiance, peak	880 W/m^2	880 W/m^2	880 W/m^2	880 W/m^2
Relative Humidity, mean	82.8%	82.8%	82.8%	82.8%

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

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

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.

2025 Revision

In November 2025, Fugro announced that the measurement heights for buoy WS190 were incorrect and released revised data.

Approximately a third of the measurement period on Hesselø South was covered by WS190.

The actual measurement heights of WS190 are not 1:1 matches with SWLB059 measurement heights.

EMD has reprocessed the measurement data to gain a full year data period at the original heights. Where the height is missing in the WS190 data, a time series is constructed through interpolation, or in the case of the tallest heights, extrapolation of existing measurements.

All results based on the measured time series are updated accordingly.

While the quality of the final dataset is reduced, it is not critically so due to the low uncertainty on the interpolation. Data from extrapolated heights must be considered with higher uncertainty.

Recommendations

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

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1. Introduction

EMD International A/S has been tasked by Energinet to provide a site wind condition assessment for the Hesselø South 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 (Extreme Wind Model)
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 to the Hesselø South wind farm zone.

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.

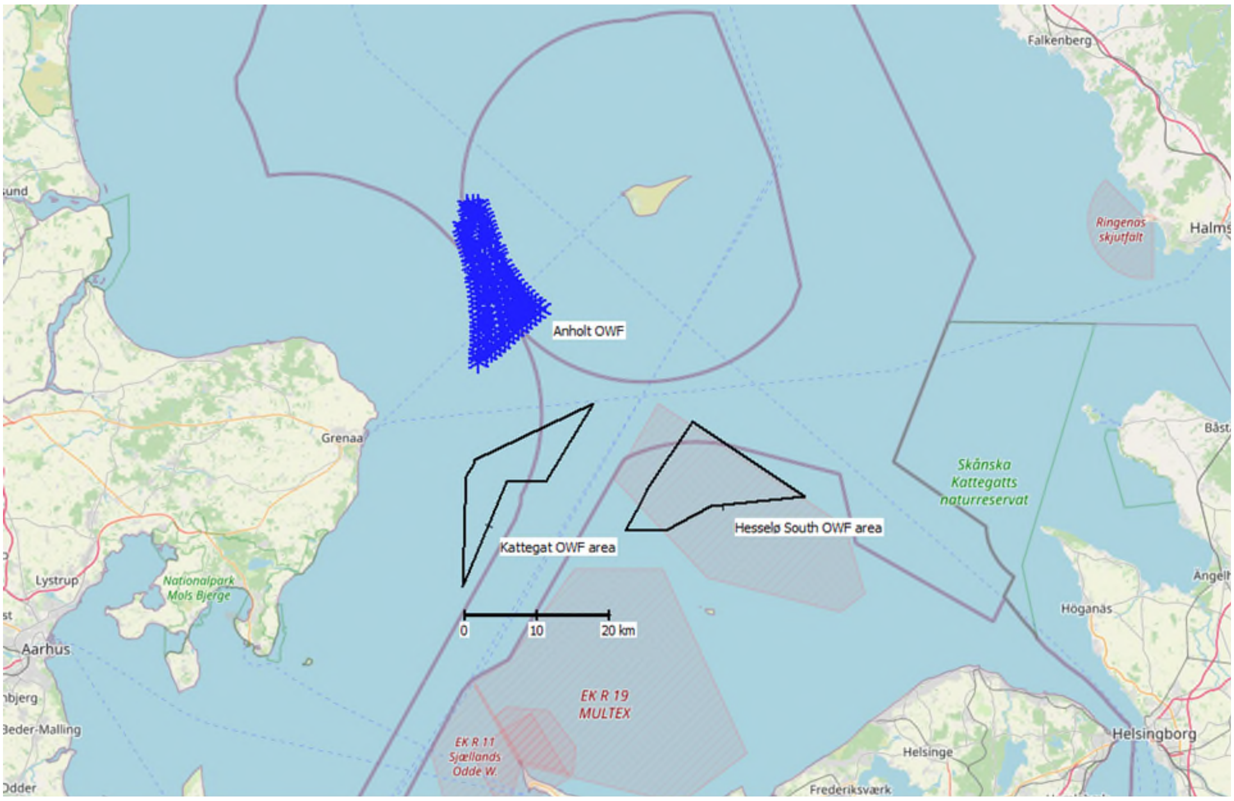
2. Site Description

Hesselø South project area is located 40 km east of the Djursland peninsular, Denmark, protruding into Kattegat Sea and 33 km north of the Island of Zealand (Figure 1).

The Hesselø South OWF area is defined through a shape file provided by Energinet.

Closest distance to land from the OWF area is 33 km to the southeast (Zealand), although the small island of Hesselø is merely 13 km south of the OWF area.

The neighbouring wind farm, Anholt, is located adjacent to the Northen part of the neighbouring Kattegat OWF project and 26 km from the Hesselø South OWF area. Additional wind farms are planned in this part of the Kattegat Sea, such as the Kattegat OWF, planned about 15 km to the west.



area and the existing Anholt OWF (in blue).

The wind farm zone is located in open water with sufficient distance to any shoreline (minimum 33 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 zone is between 18 m and 30 m.

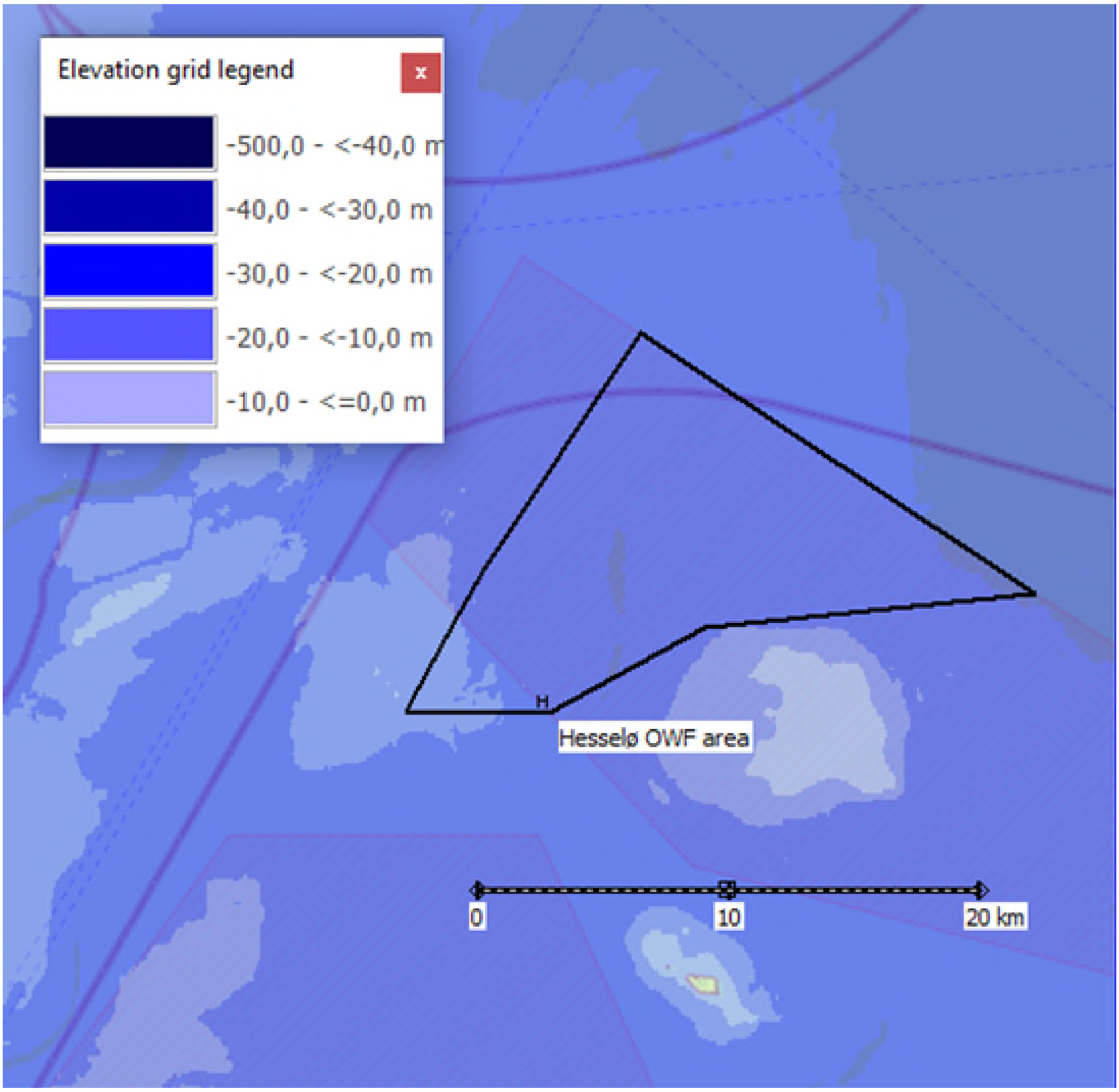


Figure 2. Bathymetric map of Hesselø South OWF zone (source: EMODnet – 115 m grid resolution)

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), Hesselø South (HS-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 Kattegat floating LiDAR (KG-1-LB), Hesselø floating LiDAR (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.

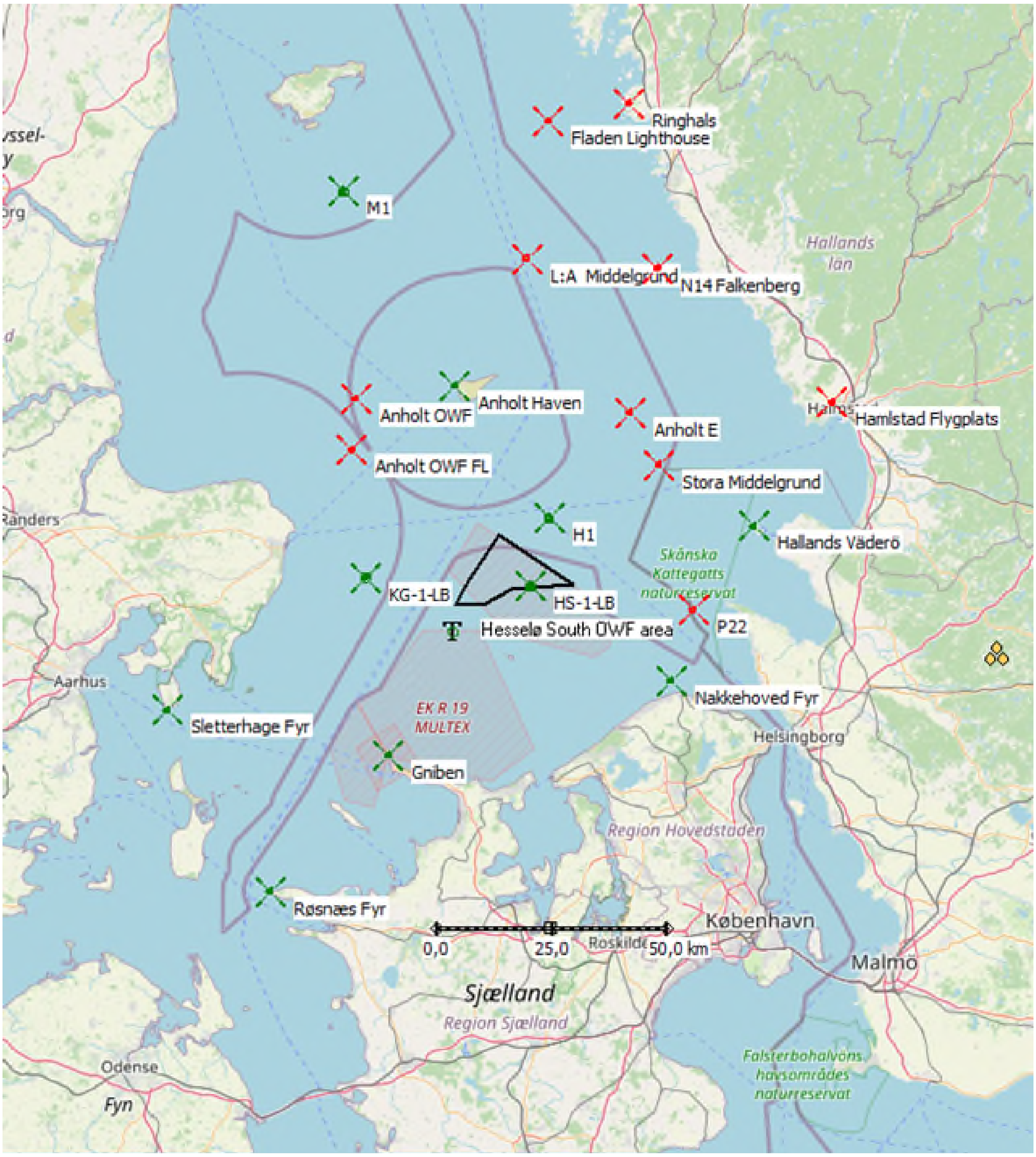
NAME	TYPE	MEASUREMENT HEIGHT [M] ASL	MEASUREMENT PERIOD	LENGTH [YEARS]
Hesselø South (HS-1-LB)	Floating LiDAR System	12 - 300	07/2023 – 07/2024	1
Kattegat (KG-1-LB)	Floating LiDAR System	12 - 300	07/2023 – 07/2024	1
Hesselø (H1)	Floating LiDAR System	12 - 240	02/2021 - 02/2022	1
FINO2	Offshore Met-Mast	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 ANH	LiDAR System	Unknown	01/2013 - 01/2014	1
Anholt OWF	Unknown	Unknown	03/2010 - 05/2010	0.16
Anholt E	Unknown	Unknown	01/1983 -	-
Fladen Lighthouse	Climate Met-Mast	Unknown	01/1988 - 12/1999	11
Hamlstad Flygplats	Climate Met-Mast	Unknown	02/1945 -	-
L:A Middelgrund	Unknown	Unknown	01/1978 -	-
N14 Falkenberg	Unknown	Unknown	01/1996 -	-
P22	Unknown	Unknown	09/2021 - 03/2022	0.53
Ringhals	Climate Met-Mast	Unknown	01/1967 -	-
Stora Middelgrund	Unknown	Unknown	01/1978 -	-

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

NAME	LONGITUDE [° E]	LATITUDE [° N]	Z, A.S.L [m]	PROVIDER (CODE#)
Hesselø South (HS-1-LB)	11.7723	56.3340	0	Energinet
Kattegat (KG-1-LB)	11.2010	56.3506	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)



and discarded ones in red (black line: Hesselø South wind farm area).

South wind farm area).

4. On-Site Floating LiDAR Measurements

Energinet has commissioned floating LiDAR measurements on site, operated by Fugro Norway AS. The deployment location is labelled HS-1-LB. Two buoys have been in operation on this location: First SWLB059 and as replacement, WS190. The campaign commenced on 21/07/2023 and it ended on 04/08/2024.

EMD has received documentation as listed in Table 5.

Revised data for buoy WS190 was received from Fugro in November 2025. The revised data included different measurement heights for the LiDAR on WS190 than provided with the original dataset.

EMD has received measurement data as individual files for each buoy, covering the period 21/07/2023 to 21/07/2024, hence covering consecutive 12 months. However, the metocean measured data (non-LiDAR data) were not included in the updated files from November 2025, therefore EMD has used the dataset provided in 2024 for this component.

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	REF
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]

Final Campaign Report for Hesselø South	Fugro	13/11/2025	General information of the measurement campaign, configurations, post-processing, quality control, post-processed data availability and data presentations.	[14]
ZX1277, 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 ZX1277, mounted on SWLB059	[15]
SWLB059, Independent performance verification of Seawatch Wind LiDAR Buoy at Frøya, Norway	DNV	13/07/2023	Pre-deployment verification document for SWLB059	[16]
ZX809, Independent analysis and reporting of ZX LiDARs performance verification executed by Zephir Ltd. at the UK Remote Sensing Test Site	DNV	22/10/2022	LiDAR verification report for ZX809, mounted on WS190	[17]
WS190, Independent performance verification of Seawatch Wind LiDAR Buoy at Frøya, Norway	DNV	15/08/2023	Pre-deployment verification document for WS190	[18]

4.1. Buoy Positions

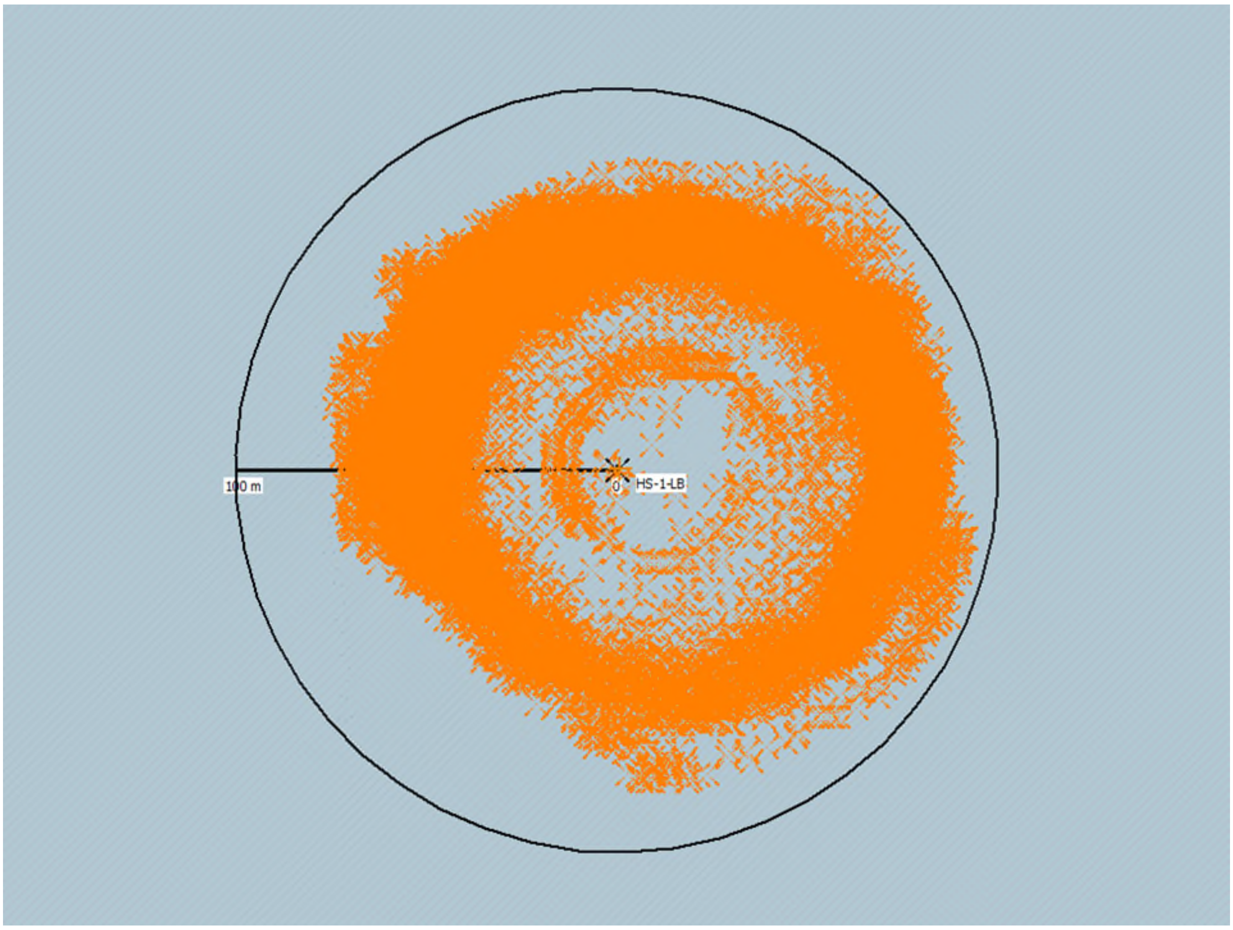
The buoy deployment positions are reported by Fugro as listed in Table 6.

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.

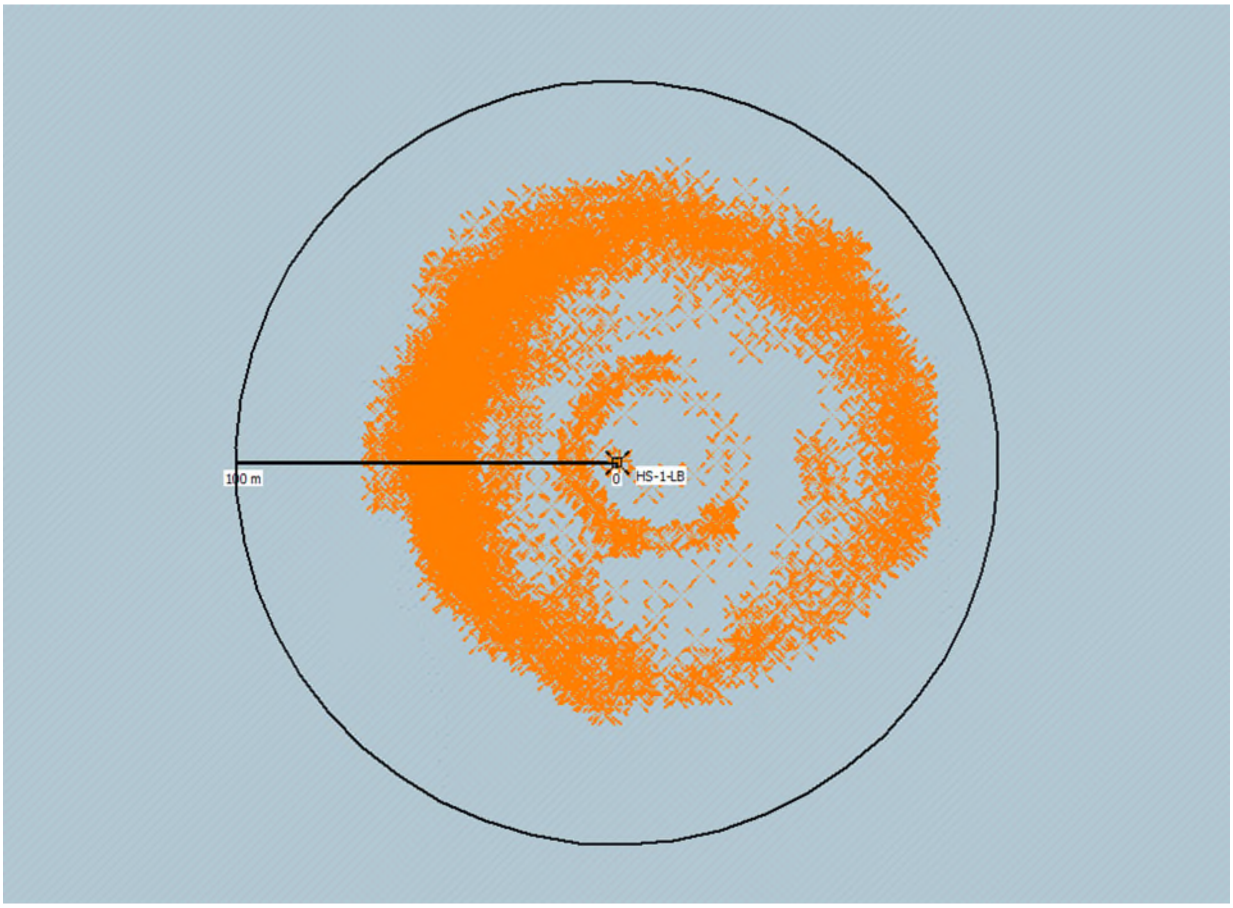
On the 23/03/2024 the SWLB059 buoy was replaced by WS190 buoy. Figure 6 presents the logged positions after replacement and confirms that the general locations of measurement are unchanged.

Table 6. List of wind speed measurement locations.

STATION	UTM WGS84, Zone 32		GEOGRAPHICAL COORDINATES WGS84	
HS-1-LB	671,382	6,246,708	11.7723°	56.3340°



of stated location (black "X").



unchanged (black "X").

4.2. Instrumentation

The SEAWATCH Wind LiDAR buoy (SWLB) and instrumentation is described in the measurement plan [11]. The instrumentation on the SWLB059 and WS190 is for all practical purposes identical. 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 LiDAR Ltd. This LiDAR model is classified by DNV [19] and has reached Stage 3 maturity [20].

Both LiDAR's (ZX1277 and ZX809) were verified at the Pershore, UK, an onshore test site operated by DNV-GL [15], [17].

Once mounted on the buoy, the LiDAR's were verified again by DNV at Frøya Norway against a ground-mounted onshore LiDAR of the brand ZephIR ZX300 [16], [18].

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

The LiDAR window is located at the top of the buoy and is as such elevated above sea level. This elevation 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 WindSonic 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 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 wind 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 buoys [12]. Of these, only two events have had impact on the LiDAR data:

- Since 24/02/2024, the lidar has intermittently been unavailable to measure wind data due to insufficient input power from an unhealthy fuel cell. This problem was resolved remotely on 02/03/2024 by adjusting the internal fuel cell process.
- On 23/03/2024 the SWLB059 was recovered and replaced by WS190.
- The buoy was decommissioned on 04/08/2024.

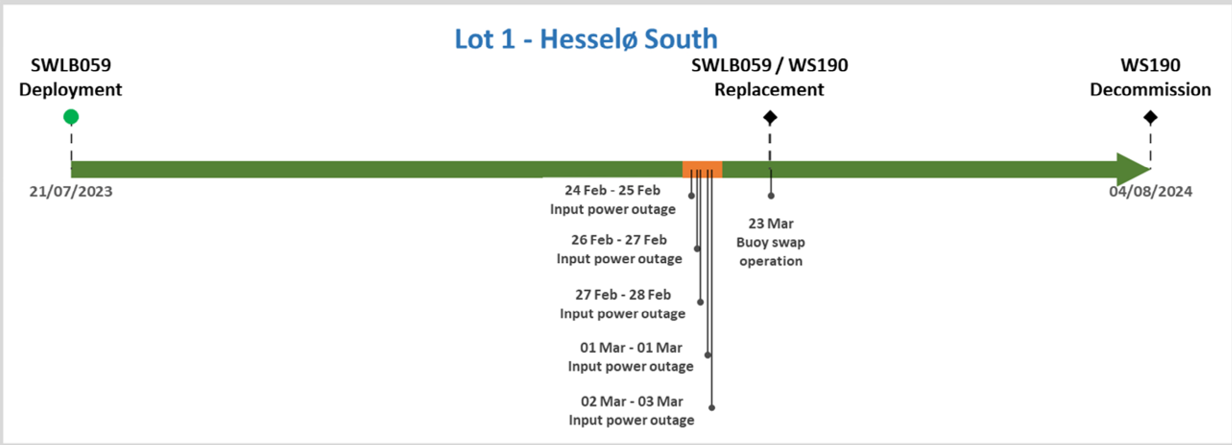


Figure 7. Timeline chart of buoy deployment on Hesselø South site (HS-1-LB). Buoy IDs (SWLB059 and WS190) are indicated, green colour marks provided data, orange colour marks data gaps.

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 LiDAR's 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
-

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

The data from Fugro is consisting of following files:

- Wind speed, wind direction and turbulence data were supplied as separate files for each buoy, named *"HS-1-LB_SWLB059_ZX1277_WindSpeedDirectionTI.csv"* and *"HS-1-LB_WS190_ZX809_WindSpeedDirectionTI.csv"*
- Temperature, humidity and pressure data were supplied in monthly files named *"HS-1-LB_Mxx_MetOceanData.csv".*

It is understood that this filtering setup is identical to the one used during the verification procedure and that the verification is valid with these filter settings.

4.4.2. Quality Control and Filtering Performed by EMD

EMD has conducted a qualitative, manual filtering process by comparing the LiDAR data with several mesoscale-derived datasets (EMD-WRF and NORA3). Data points where wind speed and wind 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).

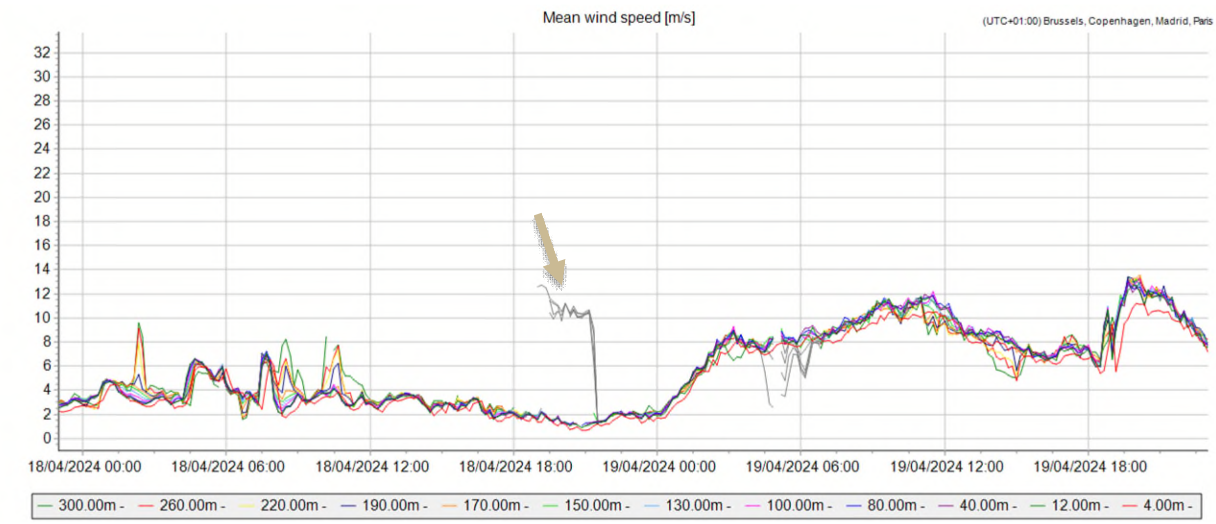


Figure 8. Example of short bursts of high wind speed at tall height disconnected from wind speed at lower height. Buoy WS190.

According to Fugro report [11], the primary sensor for wind direction is measuring relative to true north. EMD has compared the wind direction signal against a mesoscale derived dataset (EMD-WRF) at 150 m height. For the period during which buoy SWLG059 was deployed, the average difference at equivalent heights is 1.5°. For the period with buoy WS190, the average differences at the measured heights of 140 m and 160 m are 0.0° and 0.9°, respectively. Therefore, EMD has applied a 1.5° offset on the wind direction data only for the period when SWLG059 was in use.

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.

A few cases were observed where wind speed at very tall heights (>200m) were lower than at medium heights (100-150m). In an isolated case, this would be considered erroneous, but the phenomenon was found at the same time on both the Kattegat (KG-1-LB) and the Hesselø South (HS-1-LB) LiDAR's and it can therefore not be ruled out that it is natural and not instrument error. This could be linked to the phenomenon of low-level jets.

4.4.3. Recovery Rate and Data Substitution

With the industry filter disabled, the data recovery rate for the LiDAR measurements is substantially higher than is sometimes seen with ZX LiDAR instruments. Notably, the data recovery rates decrease with increasing height above sea level (ASL), and these rates are detailed in Table 8. 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-LB), referred to as vertical repair and another using data from Kattegat LiDAR (KG-1-LB), referred to as horizontal repair. The vertical repair procedure is prioritized over the horizontal repair due to its expected lower uncertainty.

The vertical 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 8. 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 wind direction in the recorded dataset. However, the Turbulence Intensity (TI) signal is not reconstructed; instead, it is simply copied from the data at a lower height.

Because the measurement heights differ between the two buoys, equivalent heights had to be generated for the WS190 buoy. Similar to the vertical repair described above, this was achieved using a shear matrix created from the surrounding heights. The heights used in this process are also detailed in Table 9.

The resulting synthesized dataset from buoy WS190 is subsequently merged with the measured data at equivalent heights from buoy SWLB059 and then used in the horizontal repair procedure.

The horizontal repair involves transferring data between the two LiDAR datasets (at KG-1-LB and HS-1-LB) 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 10). 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

order, while those for direction are zero-order functions (constants). The process avoids residual resampling to prevent random scatter. Only wind speed and wind direction data are repaired, with turbulence intensity data missing in the repaired time steps.

Table 8 lists the results of each repair procedure. The 12 m 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 SWLB059 (from 21.7.2023 till 23.03.2024). 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	-0.03	0.02	0.04	0.06	0.06	0.17	0.20	0.17	0.08	0.10	0.12	0.04
02-04	0.03	-0.03	-0.13	0.06	0.09	0.12	0.06	0.12	0.10	0.11	0.06	0.07
04-06	0.02	-0.06	-0.35	0.03	0.01	0.03	0.12	0.05	0.11	0.08	0.06	0.05
06-08	-0.04	0.02	-0.17	0.04	0.04	0.08	0.05	0.16	0.14	0.10	0.19	0.05
08-10	-0.02	-0.02	0.03	0.01	0.07	0.13	0.09	0.12	0.13	0.10	0.07	0.14
10-12	-0.03	-0.27	0.08	0.05	0.08	0.03	0.07	0.17	0.14	0.13	0.12	0.13
12-14	0.13	0.07	0.04	0.12	0.08	0.10	0.03	0.16	0.08	0.09	0.11	0.08
14-16	0.07	0.02	-0.05	0.10	0.10	0.07	0.12	0.15	0.11	0.12	0.05	0.01
16-18	0.00	-0.03	-0.12	0.09	0.10	0.02	0.13	0.14	0.06	0.13	0.13	-0.03
18-20	0.02	-0.01	-0.05	0.04	0.01	0.08	0.03	0.20	0.10	0.12	0.19	0.10
20-22	-0.07	0.02	-0.07	0.09	0.07	0.07	0.12	0.10	0.11	0.09	0.23	0.01
22-24	-0.16	-0.02	-0.08	0.12	0.07	0.07	0.15	0.20	0.10	0.08	0.18	0.07
All	-0.01	0.03	-0.05	0.07	0.07	0.08	0.11	0.15	0.11	0.11	0.12	0.06

Table 8. Results of vertical repair at SWLB059 buoy.

REPAIRED HEIGHT [m]	80	100	130	150	170	190	220	260	300
Source height [m]	40	80	100	130	150	170	190	220	260
Shear matrix heights [m]	40, 80, 100	80, 100, 130	100, 130, 150	130, 150, 170	150, 170, 190	170, 190, 220	190, 220, 260	220, 260, 300	220, 260, 300
Recovery rate before repair	96.2%	95.5%	95.0%	94.7%	94.6%	94.3%	94.0 %	93.1%	93.1%
Recovery rate after shear repair	98.3%	96.3%	95.6%	95.1%	94.9%	94.7%	94.5%	94.1%	93.7%
Share of shear repaired data	2.1%	0.8%	0.6%	0.4%	0.3%	0.4%	0.5%	1.1%	0.6%

Table 9. Results of data vertical repair at WS190 buoy.

REPAIRED HEIGHT [m]	80	100	120	140	160	180	200	250	
Source height [m]	60	80	100	120	140	160	180	200	
Shear matrix heights [m]	60, 80, 100	80, 100, 120	100, 120, 140	120, 140, 160	140, 160, 180	160, 180, 200	180, 200, 250	180, 200, 250	
Recovery rate before repair	98.6%	98.5%	98.4%	98.4%	98.3%	98.3%	98.2%	97.8%	
Recovery rate after shear repair	99.2%	98.7%	98.6%	98.5%	98.5%	98.4%	98.3%	98.3%	
Share of shear repaired data	0.6%	0.2%	0.2%	0.1%	0.2%	0.1%	0.1%	0.5%	
Final height (interpolated / extrapolated) [m]	**80**	**100**	**130**	**150**	**170**	**190**	**220**	**260**	**300**
Source height [m]	-	-	120	140	160	180	200	250	250
Shear matrix heights [m]	-	-	120, 140	140, 160	160, 180	180, 200	200, 250	200, 250	200, 250

height.

MEASUREMENT HEIGHT [m]	CORRELATION COEFFICIENT, r [%]
12	91.8
40	92.3
80	92.7
100	92.9
130	93.3
150	93.6
170	93.9
190	94.1
220	94.4
260	94.7
300	94.8

Table 11. Results of data horizontal repair at HS-1-LB (SWLB059 + WS190 – equivalent heights merged).

REPAIRED HEIGHT [m]	80	100	130	150	170	190	220	260	300
Recovery rate after merge	98.6%	97.1%	96.5%	96.2%	96.1%	95.9%	95.7%	95.5%	95.2%
Recovery rate after horizontal repair	99.8%	99.0%	98.6%	98.4%	98.3%	98.2%	98.1%	97.9%	97.8%
Share of horizontal repaired data	1.2%	1.9%	2.1%	2.2%	2.2%	2.3%	2.4%	2.5%	2.7%

4.5. Data Analysis

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

4.5.1. Wind Speed

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

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

Table 12. Weibull parameters of the repaired datasets at Hesselø South (HS-1-LB).

HEIGHT [m]	**PERIODS [MONTHS]**	**AFTER DATA SUBSTITUTION**			
		ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL – A PARAMETER	WEIBULL – k PARAMETER
4	12	7.21	7.25	8.19	2.23
12	12	7.84	7.85	8.86	2.23
40	12	8.83	8.85	9.99	2.25
80	12	9.50	9.54	10.78	2.24
100	12	9.72	9.77	11.03	2.22
130	12	9.97	10.00	11.29	2.170
150	12	10.10	10.13	11.44	2.15
170	12	10.20	10.22	11.54	2.11
190	12	10.30	10.3	11.63	2.09
220	12	10.42	10.41	11.75	2.05
260	12	10.57	10.52	11.88	2.00
300	12	10.70	10.63	11.99	1.97

Further details on 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 HS-1-LB 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 10.2 degrees from 40 m to 300 m, amounting to a rate of 0.039 degrees/m (Figure 10).

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

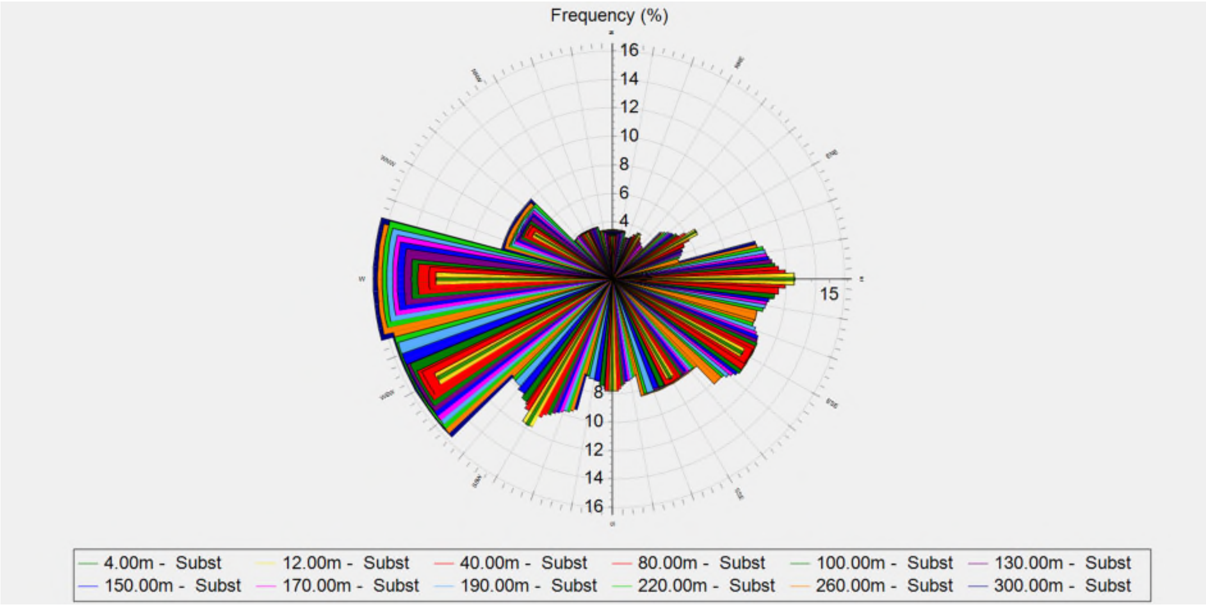


Figure 9. Directional distribution at selected heights of Hesselø South (HS-1-LB) LiDAR measurements.

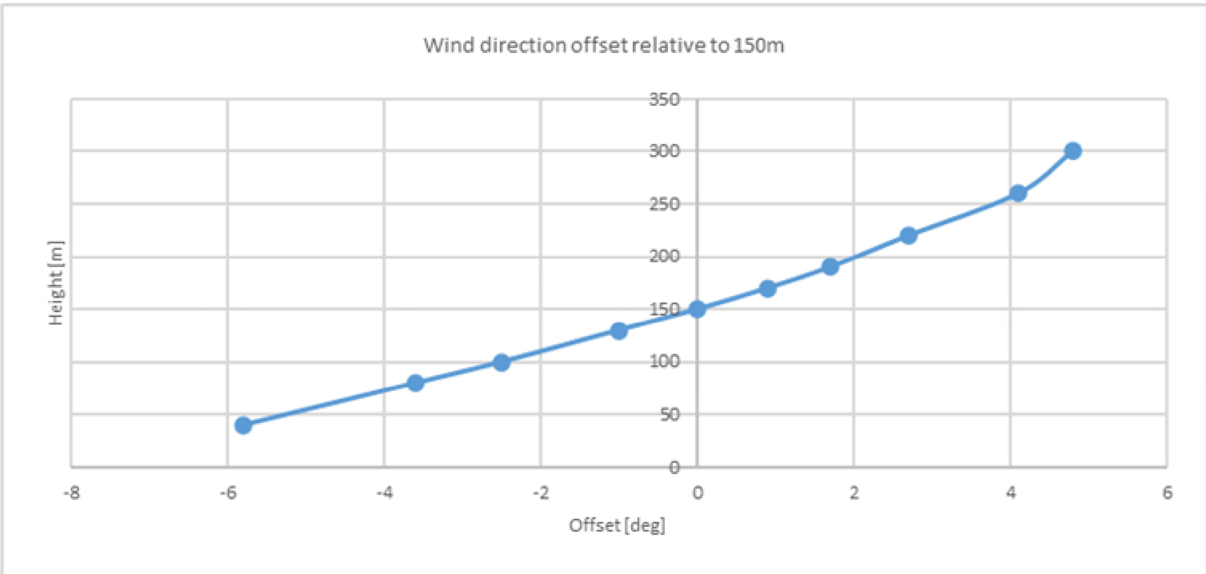


Figure 10. Rotation of wind direction relative to 150 m measurements at Hesselø South (HS-1-LB) LiDAR.

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.

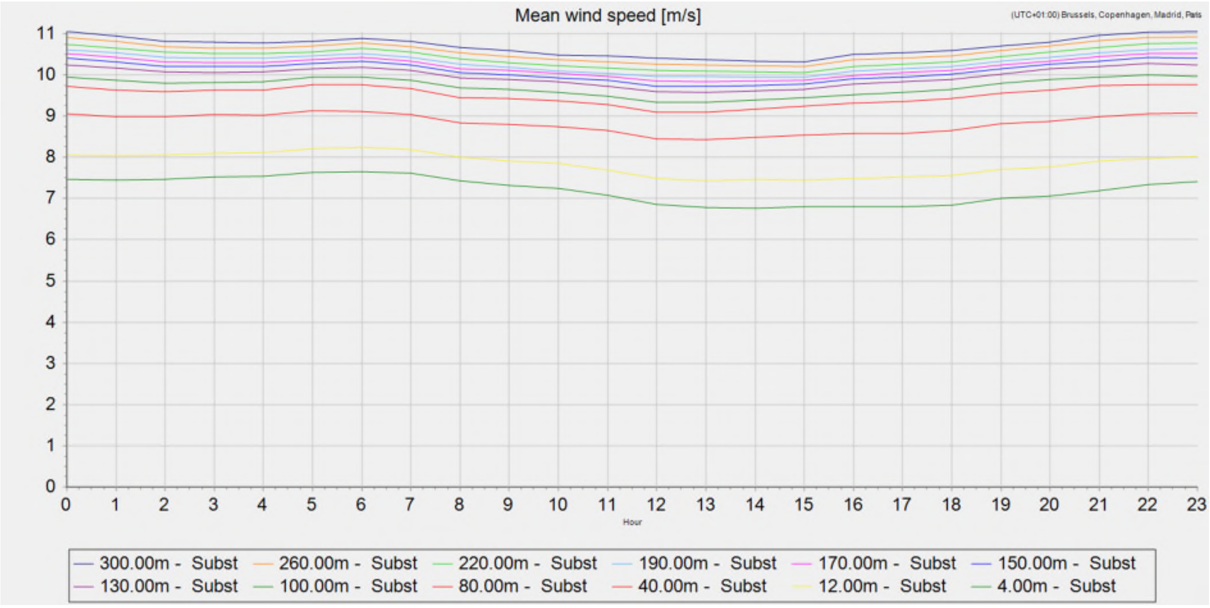


Figure 11. Diurnal wind speed variation at Hesselø South (HS-1-LB) LiDAR.

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

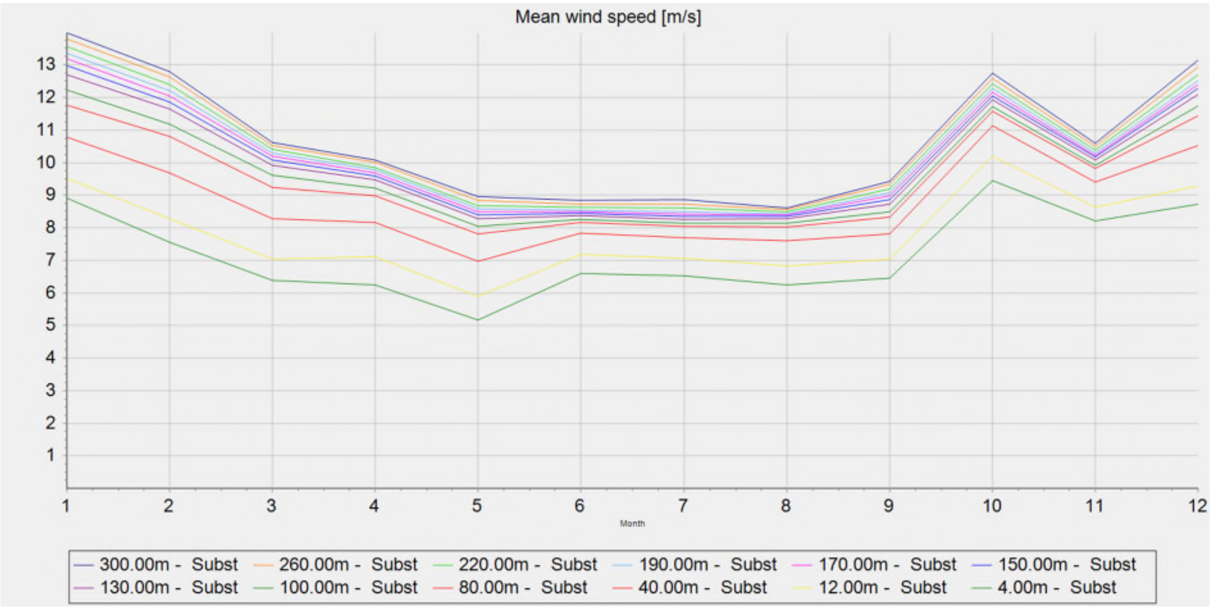


Figure 12. Monthly mean wind speed at Hesselø South (HS-1-LB) LiDAR.

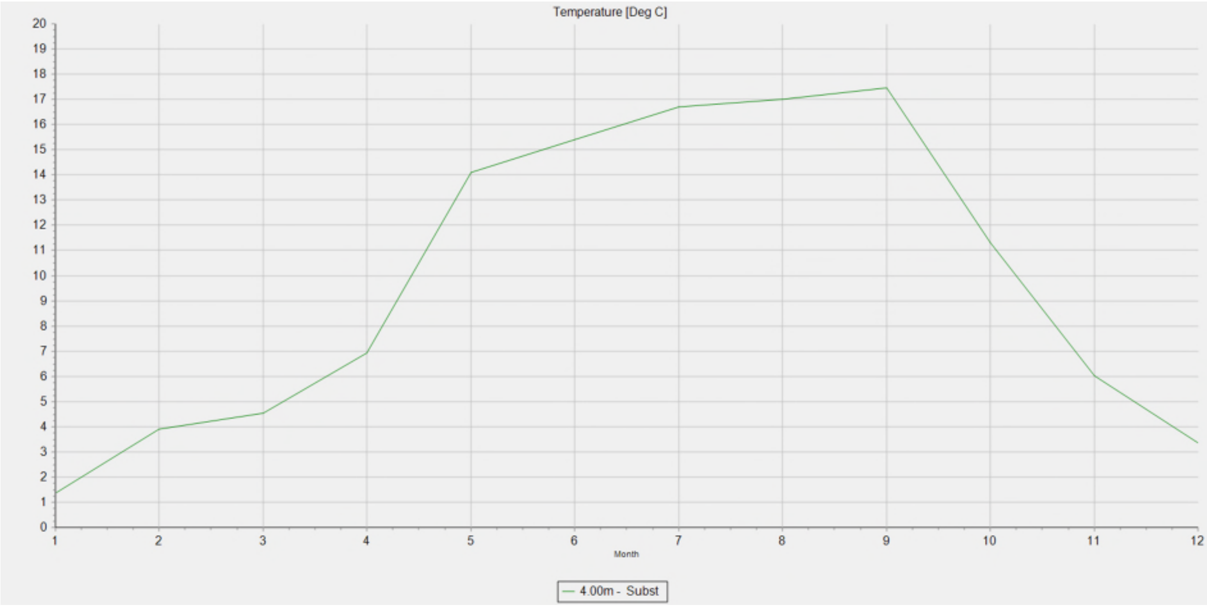


Figure 13. Monthly mean temperature at Hesselø South (HS-1-LB) LiDAR.

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 [19] as 1.41% (average from 130 m 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 SWLB059 and WS190 buoy-mounted LiDAR's was provided in [16], [18]. The test site was at the Frøya, Norway.

In these studies the Key Performance Indicators (KPI) according to the OWA Roadmap [21] are tested and the verification uncertainty is here calculated according to the method suggested by the CT/OWA LiDAR Uncertainty Standard Review [22]. All KPI's were successfully fulfilled.

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

The verification uncertainties of the SWLB059 and WS190 buoy-mounted LiDAR's from the verification reports are included in Appendix B for 140 m and 160 m, the closest heights to 150 m. The average of the two uncertainty assessments is used. Verification uncertainty is calculated by frequency weighting the uncertainty at each wind speed. For the SWLB059 LiDAR this uncertainty is 1.88% and 1.83% at 140 m and 160 m height, respectively. For the WS190 LiDAR this uncertainty is 1.81% and 1.80% at 140 m and 160 m height, respectively. Hence the average of the two buoys is 1.83%.

The uncertainty from the vertical data repair is found by assuming a 20% uncertainty on the wind speed change from source to destination. The wind speed difference is 1.4% (from 130 m to 150 m) for SWBL059 LiDAR and 1.65% (from 120 m to 140 m) for WS190 LiDAR, which results in an additional uncertainty on wind speed of the synthesized data of 0.28% and 0.33%, respectively. The vertically synthesized data contribution is 0.4% at 150 m for SWBL059 and 0.1% at 140 m for WS190. The resulting vertical data repair uncertainty is thus 0.0012% at SWLB059 and 0.0003% for WS190.

At WS190 LiDAR, an additional vertical interpolation process was caried out for non-equivalent heights (as described in section 4.4.3 and in Table 9). Considering that the interpolation is done between relatively closed heights (140 m and 160 m) and the fact that the WS190 data set covers only 4 months from the entire 12-month period, the uncertainty related to vertical interpolation is estimated to be 0.5%.

For the horizontal data repair at 150 m, a linear regression method is used to transfer data from the KG-1-LB dataset to the HS-1-LB dataset (buoy SWLB059/WS190). The transfer function has a mean bias error of -0.10% and an RMS error on hourly basis of 15.9%. Using the same procedure as used for assessing LiDAR verification uncertainty (wind speed binned mean deviation), the transfer function uncertainty is assessed to 5.2%. This additional uncertainty applies to the horizontally synthesized part of the dataset at HS-1-LB (2.24%), resulting in an uncertainty component of 0.117%.

Combined, vertical and horizontal data repair contribute 0.617% uncertainty to the measurement dataset at HS-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 (Table 13).

Table 13. Wind speed measurement uncertainty at 150 m ASL at Hesselø South (HS-1-LB) LiDAR.

Dataset	Classification uncertainty	Verification uncertainty	Data repair uncertainty	Total measurement uncertainty
HS-1-LB (SWLB059/WS190)	1.41%	1.83%	0.617%	2.39%

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 zone. 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) [23] 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 [24], 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 [25] 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 HS-1-LB is presented in Figure 14 and Table 14. All data are extracted through windPRO software.

Table 14. Reference datasets position and period length. Positions are given in Geographic degrees, WGS84.

	EMD-WRF	ERA5(T)	NORA3
Position/Node	11.772°E 56.334°N	11.250°E 56.750°N	11.754°E 56.316°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

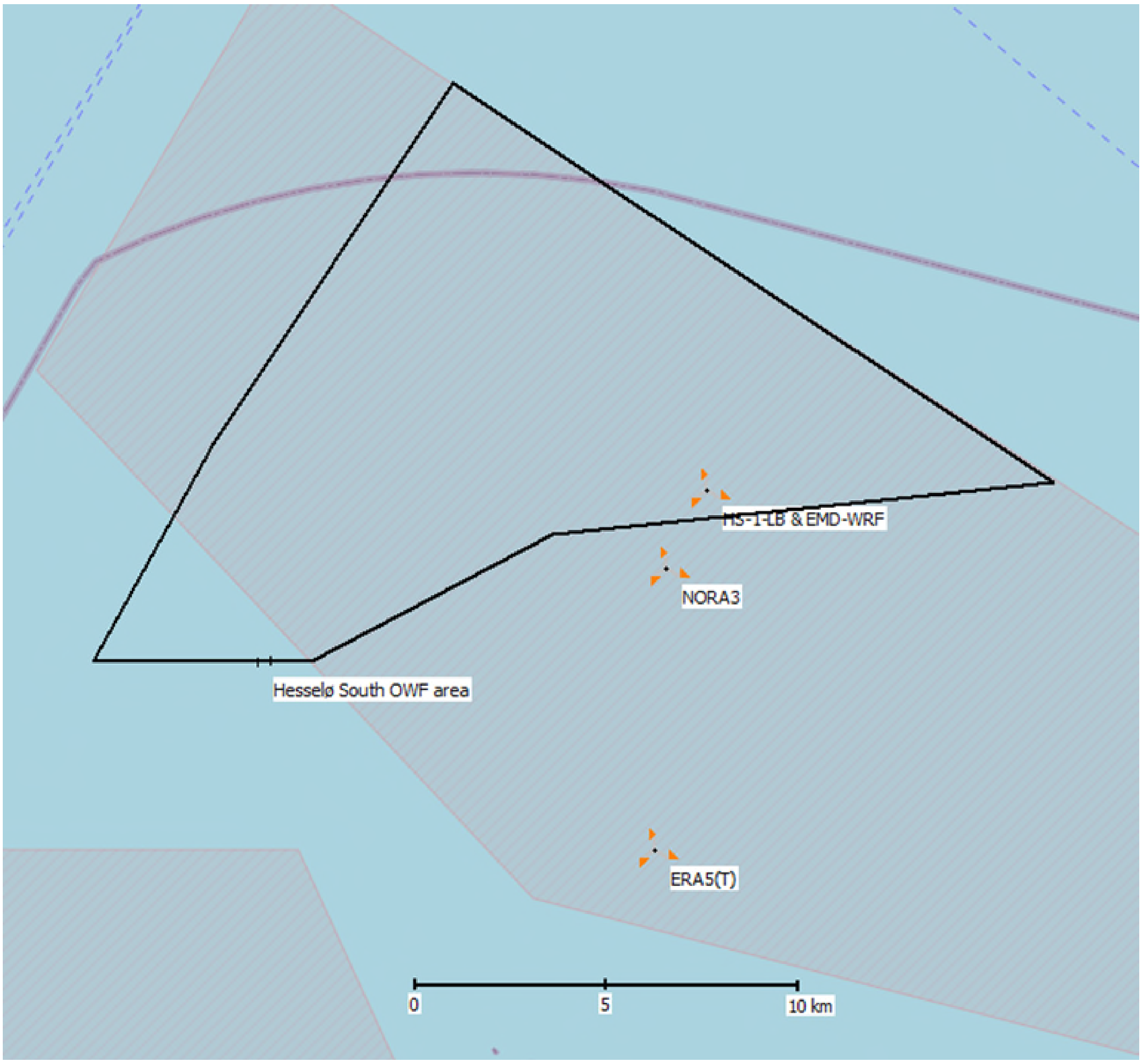


Figure 14. Location of reference datasets near HS-1-LB.

6. Long-term Correction

6.1. Review of Reference Data

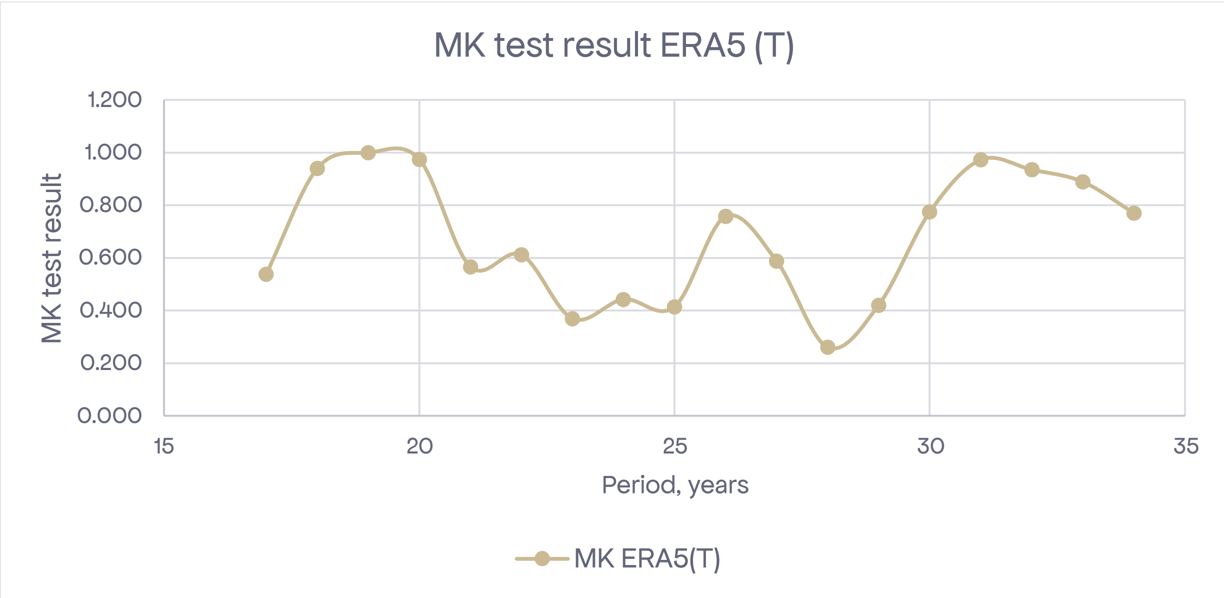
6.1.1. Long-term Consistency & Selection of Reference Period

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) [26] test value above 0.4, but preferably higher. Analysis of the ERA5(T) dataset using the Mann-Kendall trend test [26] indicated the dataset back to 1993 (31 years) results in a high MK value (0.973) with close to no trend in the time series. The mean wind speed of the 31-year period 1993-2023 at 100 m of the ERA5(T) dataset is 8.86 m/s. Similar results of high MK value (0.935) and similar wind speed (8.86 m/s) can be observed with a 32-year period (1992-2023) or 33-year period (1991-2023) and their respective MK value of 0.935 and 0.889 and mean wind speed of 8.86 m/s and 8.86 m/s (Figure 15). Such periods can be qualified as long-term representative and consistent. Similar results of mean wind speed and good MK value (0.758) can be observed as well for a 26-year period (1998-2023).

A very close mean wind speed of 8.87 m/s is met for a 22-year period (2002-2023), allowing us to consider this period as a proper reference period as well. The 21-year period (2003-2023) has a mean wind speed of 8.86 m/s as the 31-year period. However, the 22-year period is preferred since it has a better MK value than the 21-year period (respectively 0.612 and 0.566). The 22-year period has a lower MK value than the 31-year period, but it is still considered adequate. Using a 22 year-period allows to include more datasets which would not have been available for a 26 or 31-year period, considering the available long-term datasets concurrent with the measured wind data from the floating LiDAR.

An alternative measure of considering consistency in long-term data is to compare the 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 1993-2023 as baseline, reflecting the long period of data available in the ERA5 dataset. This is plotted in Figure 15 as average index of period.



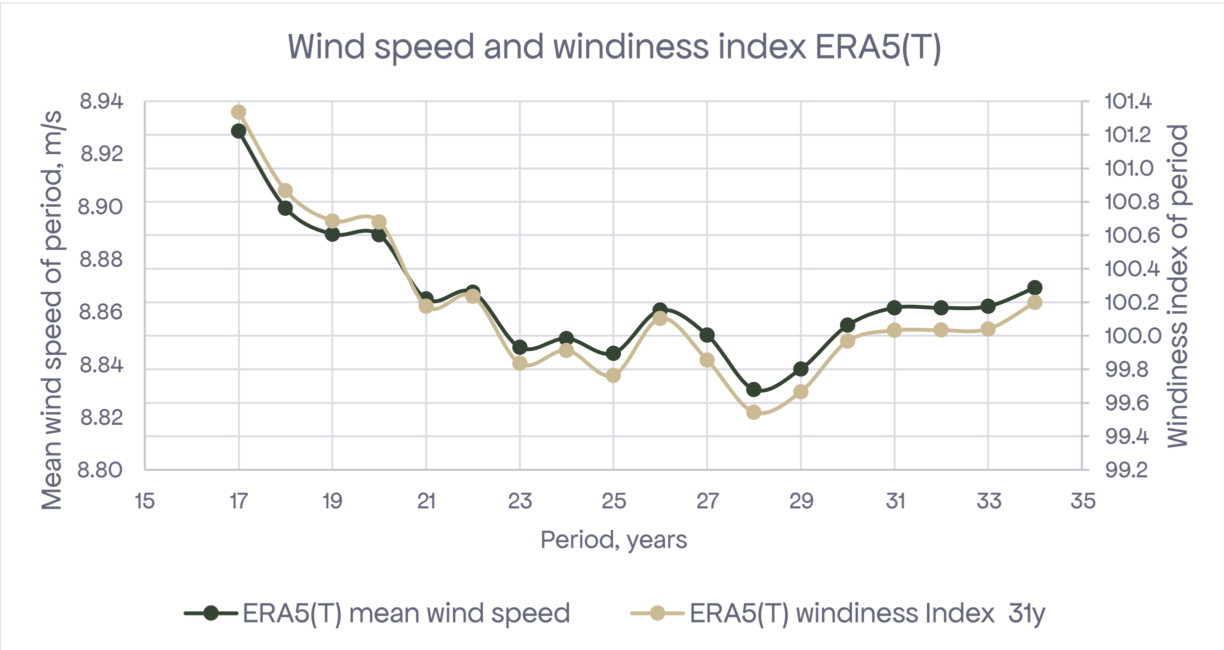


Figure 15. Consistency tests on ERA5(T) data. Period length in years dating back from January 1st, 2024, are analyzed for M-K trend test (top graph) and mean wind speed and windiness (energy)

Based on the 31-year baseline period, the index of different periods as plotted in Figure 15 varies between 99.5 and 101.4 with a median value of 100.1. The 31, 30-, 26- and 22-year periods have a relative index value of 100.0. 100.0, 100.1 and 100.2, which confirms that these periods are consistent with each other and are 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, 30- year and 31-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.

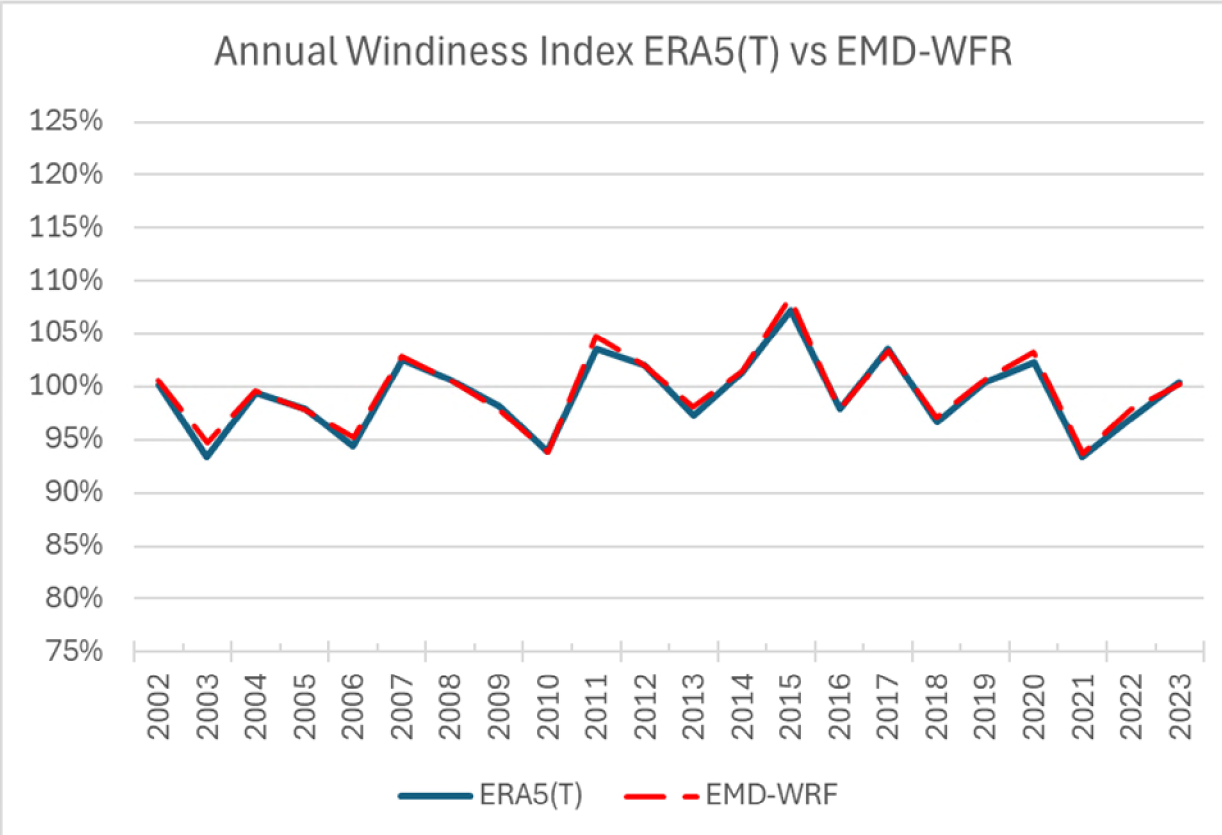


Figure 16. Annual windiness (energy) index for ERA5(T) and EMD-WRF data. Baseline period: 2002-2023.

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 Anholt 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.

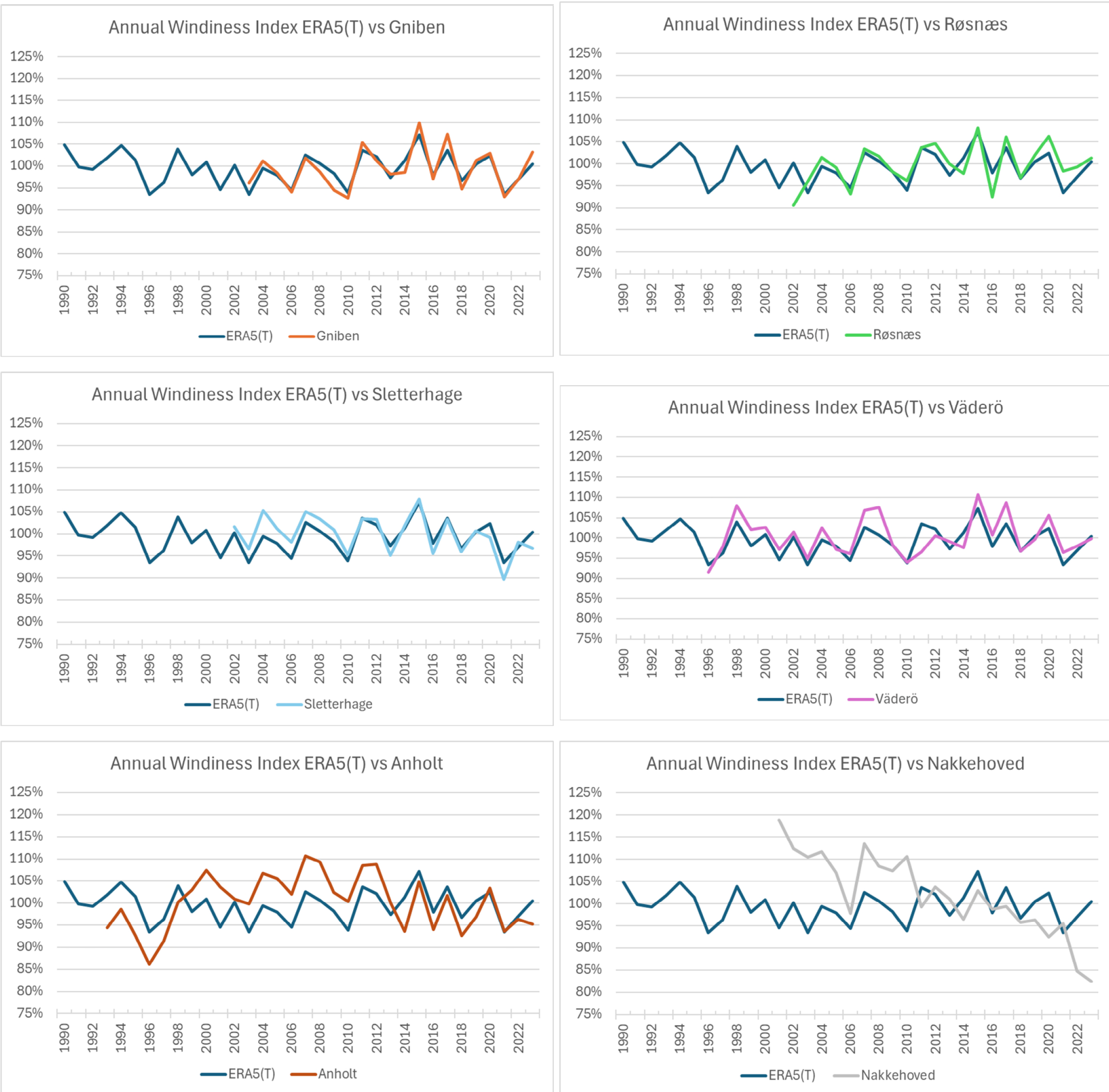


Figure 17. Annual windiness indices for a selection of secondary meteorological stations.

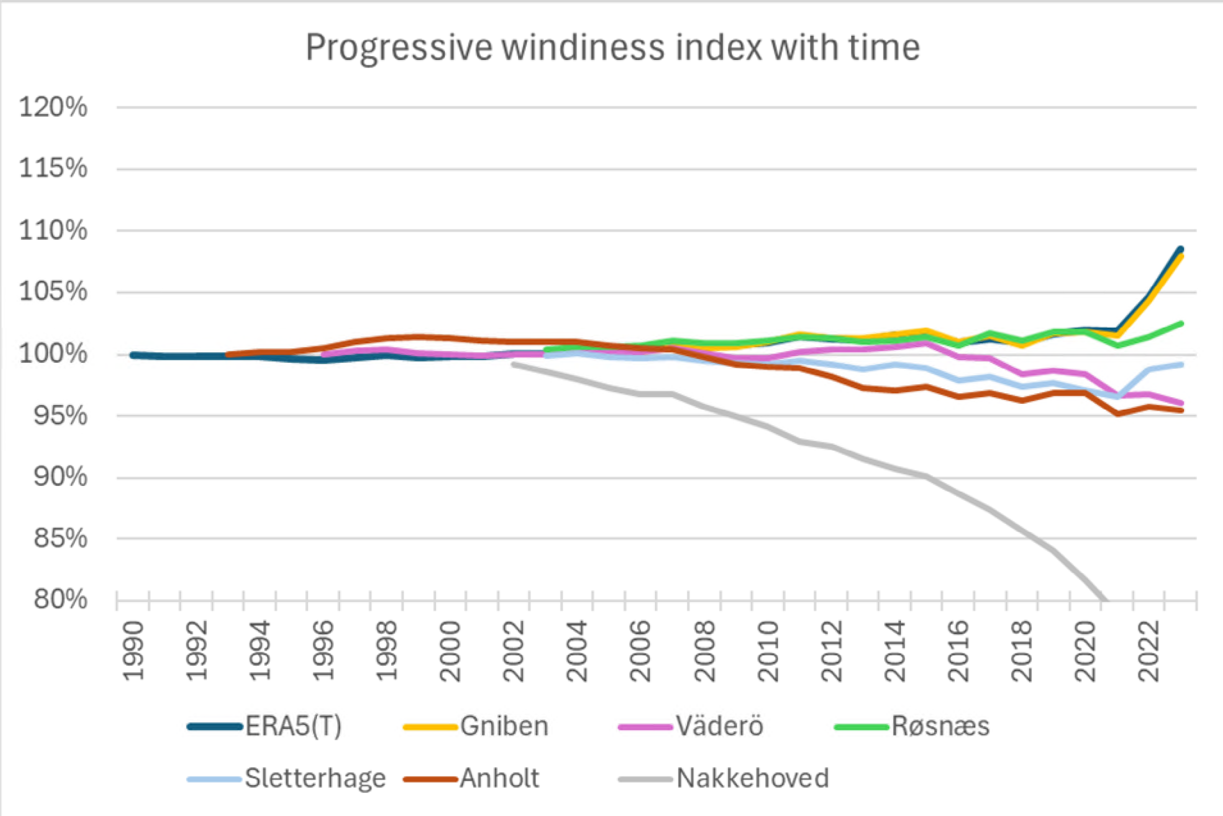


Figure 18. Progressive windiness index with time. The index of each year is the average of all following years.

6.1.2. Selection of Reference Data

Three potential reference datasets were considered for long-term correction of the LiDAR measurements from HS-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 all three references and three different methodologies is limited to 0.04 m/s on the 150 m height measurements. There is a good match in predicted long- term wind speed across the selection of reference data and the MCP methodologies. The overall best performances are obtained with EMD-WRF data together with the Matrix methodology as described in section 6.2. EMD has decided to proceed with EMD-WRF as reference.

The reference dataset is 22 years of EMD-WRF data at the HS-1-LB location, 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 EMD-WRF data is 12 months (21/07/2023 to 21/07/2024).

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

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

REF: EMD-WRF	HS-1-LB
Wind Speed Correlation, r [%] hourly	95.2
Wind Energy Correlation, r [%] monthly	99.0

6.2.2. Wind Direction Correlation

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

There is a good match of wind direction roses between the LiDAR (150 m) and EMD-WRF (150 m) on the 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.

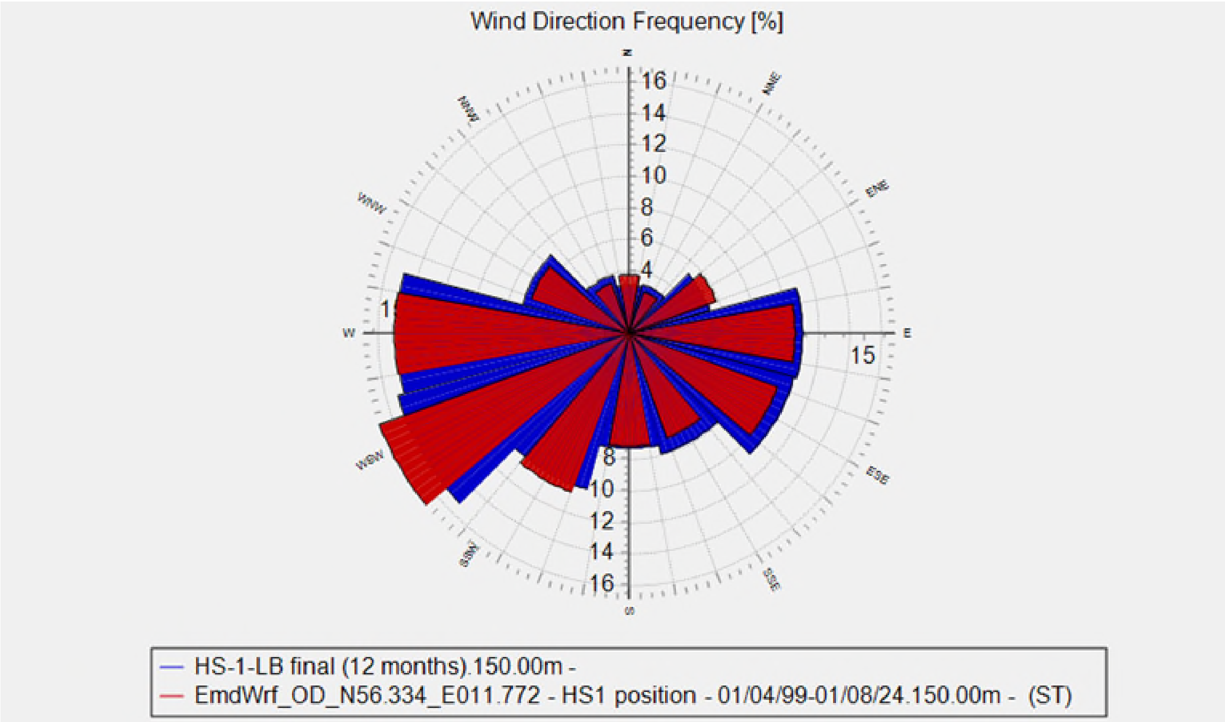


Figure 19. Wind direction roses for the concurrent period of Hesselø South (HS-1-LB) LiDAR (blue) and EMD-WRF (red) data.

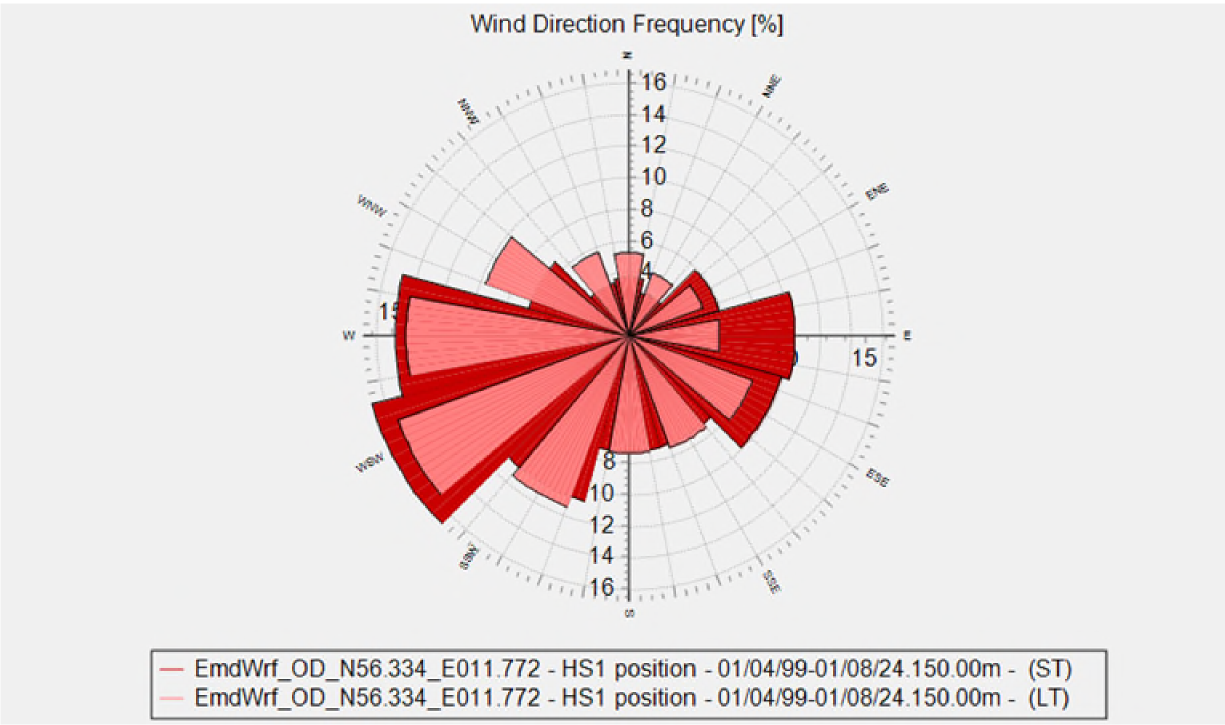


Figure 20. Wind direction roses for EMD-WRF data. Light red represents the entire long-term period (22 years) and deep red the period concurrent with Hesselø South (HS-1-LB) LiDAR measurements (1 year).

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 [27].

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 16.

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 16. 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 [27].

The Neural network methods is disqualified since it gives high MBE on the production output for the sef-test (predicting the same period as the training period). The linear regression method generally produces the smallest error. The matrix method gives acceptable MBE and the best results in predicting the direction distribution and Weibull distribution shape (the K-S test).

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

Table 16. 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. (at Hesselø South (HS-1-LB) - 150 m data).

REFERENCE: EMD-WRF LOCAL DATA: HS-1-LB, 150M	LINEAR REGRESSION	NEURAL NETWORK	MATRIX
MBE, 24-hour slicing test, % production	0.31	0.05	0.81
MBE, Concurrent period test, % production	-0.32	-1.34	-0.32
Kolmogorov-Smirnov test, %	2.14	1.76	0.74
Predicted long-term mean wind speed, m/s	9.56	9.59	9.60

The synthesized time series from EMD-WFR and matrix method represent the long-term wind climate. Time series are generated for all the heights of the Hesselø South (HS-1-LB) LiDAR (12 m to 300 m). The EMD-WFR data at the closest height of a given LiDAR height is used for the long-term correction. Similar to the 150 m data, the EMD-WFR data at 10, 25, 50, 75, 100 and 200 m give good correlation and performance indicators for the long-term correction.

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

6.3. Long-Term Wind Climate

6.3.1. Long-term Wind Speed Distribution

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

Table 17. Weibull parameters of the long-term wind data at HS-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	7.60	7.69	8.68	2.37
40	22	8.44	8.55	9.65	2.39
80	22	9.06	9.19	10.37	2.34
100	22	9.24	9.36	10.57	2.31
130	22	9.46	9.59	10.82	2.27
150	22	9.60	9.70	10.96	2.22
170	22	9.69	9.79	11.05	2.18
190	22	9.79	9.89	11.16	2.17
220	22	9.90	9.99	11.28	2.13
260	22	10.05	10.10	11.40	2.08
300	22	10.16	10.20	11.51	2.05

6.3.2. Long-term Wind Direction Distribution

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

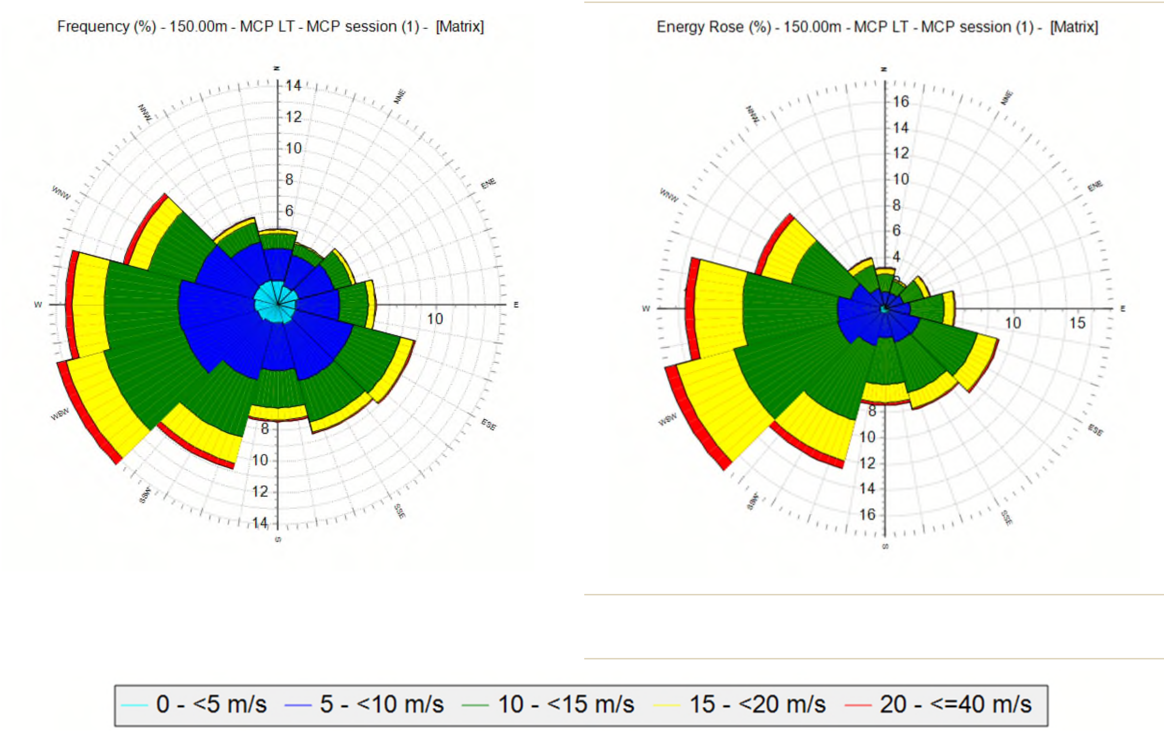


Figure 21. Left: Wind direction distribution of long-term corrected LiDAR data (HS-1-LB) at 150 m. Right: Energy distribution of long-term corrected LiDAR data (HS-1-LB) at 150 m, both divided in wind speed intervals.

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).

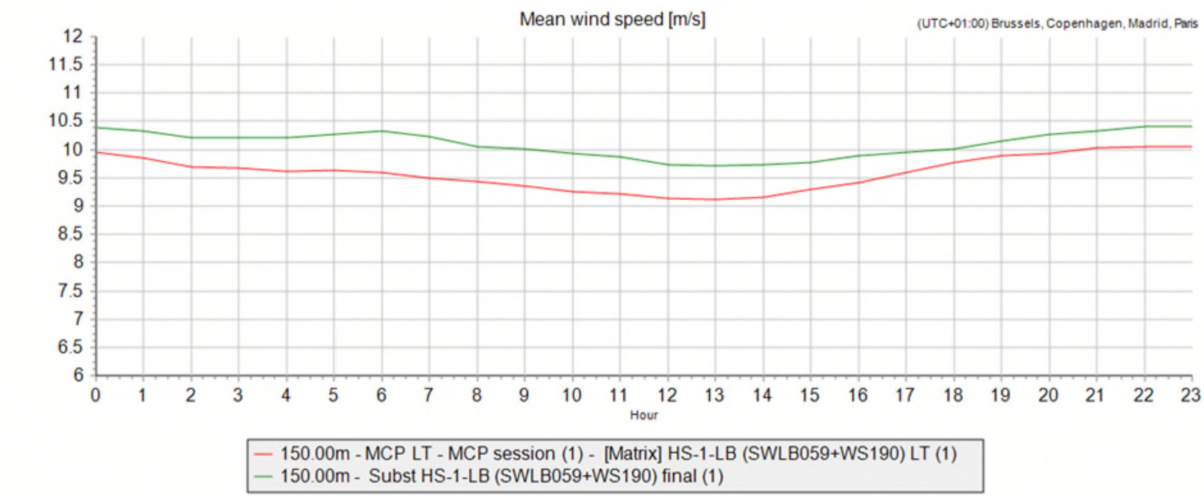


Figure 22. Diurnal wind speed, long-term corrected (red) and observed (green), at HS-1-LB LiDAR.

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.

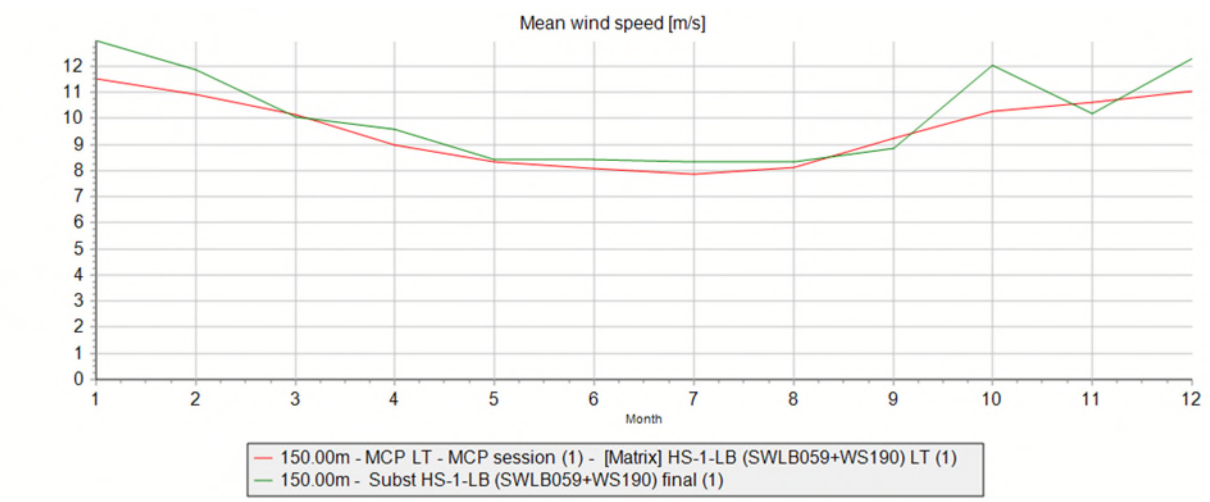


Figure 23. Seasonal variation of long-term corrected dataset (red) and observed dataset (green) at 150 m, at HS-1-LB LiDAR.

-emd

7. Validation of Wind Model

7.1. Secondary Models

The wind resource at Position HS-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 Kattegat (KG-1-LB), Hesselø (H1) and Læsø (M1) to the site. The Hesselø (H1) and the Kattegat (KG-1-LB) datasets are located relatively close to HS-1-LB. The M1 mast is at a greater distance, north of HS-1-LB. These were used to validate the primary wind model at Hesselø South OWF. The locations of the secondary datasets are presented in Figure 24.

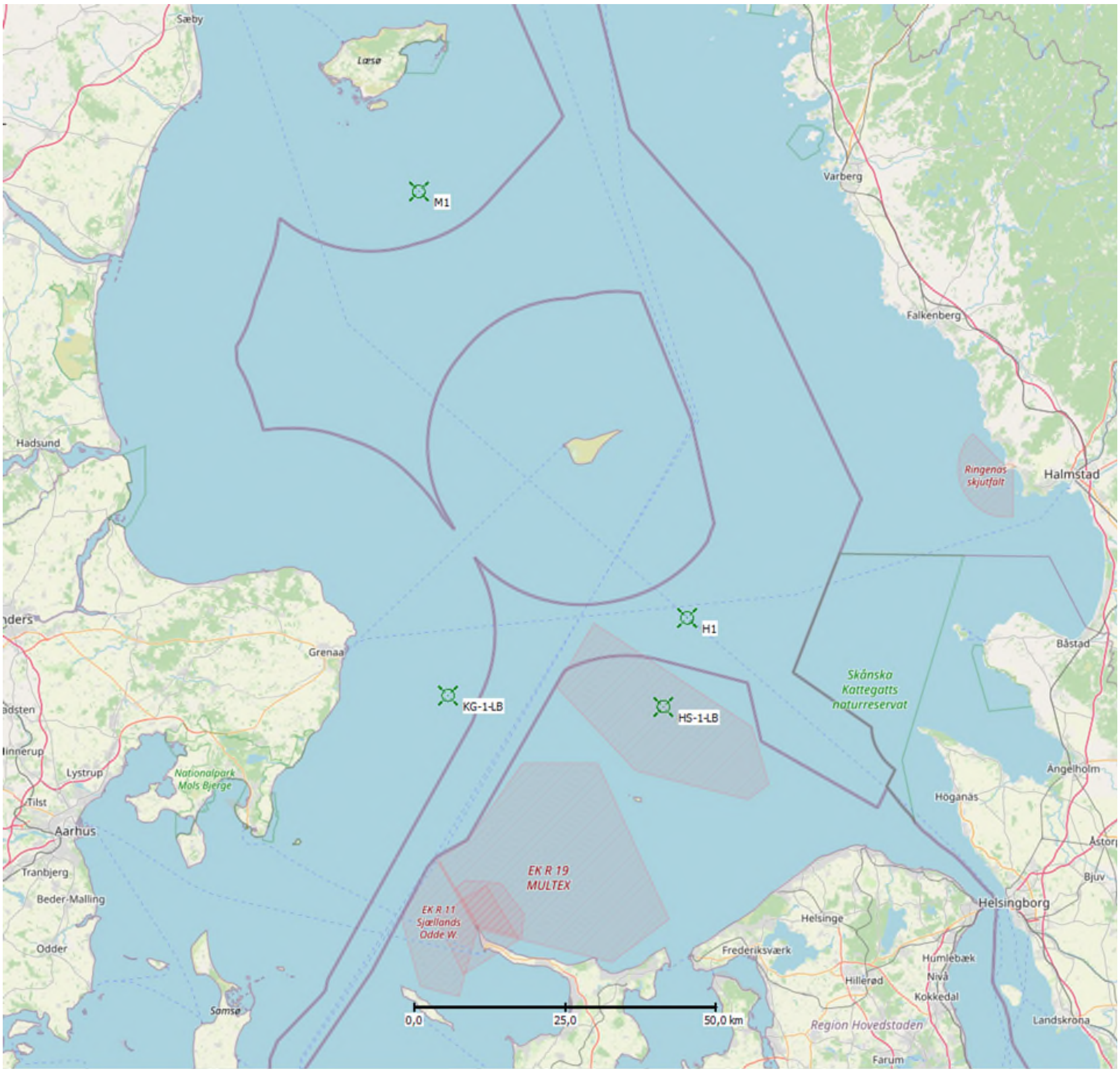


Figure 24. Location of KG-1-LB, H1 LiDAR buoys and Læsø meteorological mast M1 relative to HS-1-LB LiDAR buoy.

For the validation, the secondary datasets are transferred from their locations to HS-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 datasets, 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. Kattegat Floating LiDAR (KG-1-LB)

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

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

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

An EMD-WRF dataset was extracted at the KG-1-LB buoy location (section 5). The correlation between the KG-1-LB LiDAR data and EMD-WRF is very high, both on wind speed, monthly energy content and directional distribution. Although ERA5 was eventually the preferred long-term correction dataset for KG-1-LB (Appendix A.1.1), EMD-WRF correlates well enough to be used for the data transfer between KG-1-LB and 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 transfer both the wind direction and the energy content in each direction.

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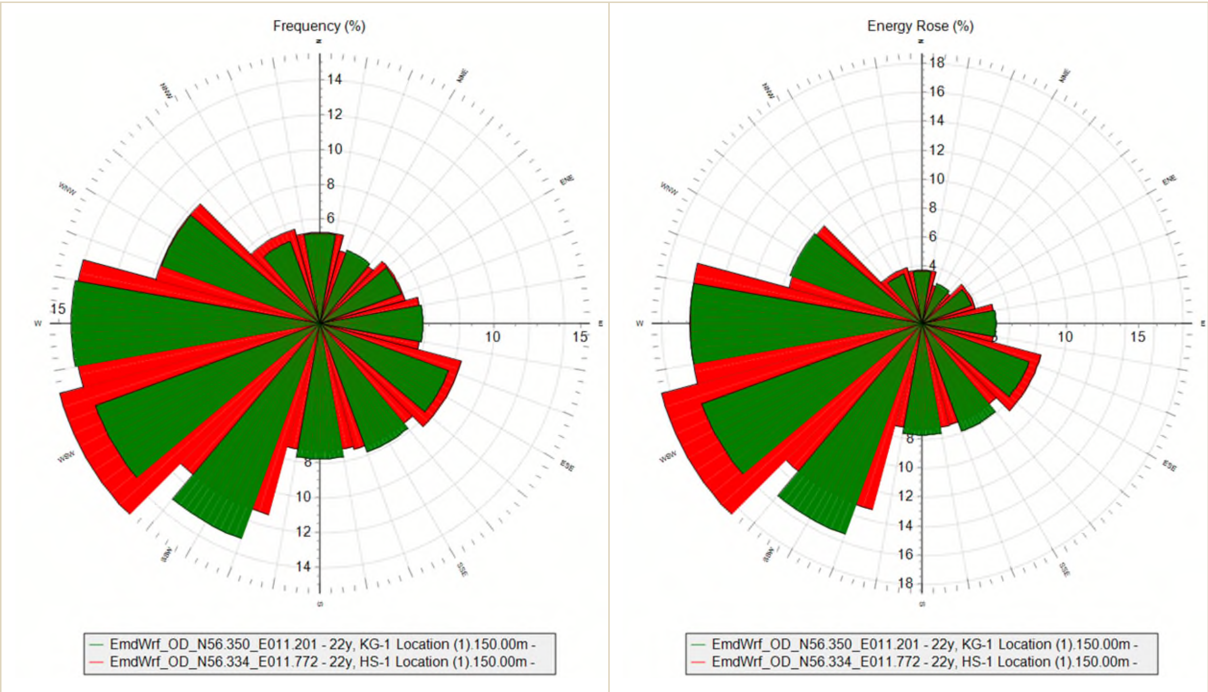


Figure 25. Left: Directional distribution between EMD-WRF at KG-1-LB (green) and EMD-WRF at HS-1-LB (red), 22 years. Right: Energy rose of same two datasets, 22 years.

A translation function is created using linear regression with a translation function for every 1° direction bin, using data in a +/-15° sector 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 KG-1-LB data, creating a 22-year dataset at HS-1-LB.

A comparison of directional distribution of transferred KG-1-LB data at 150 m with long-term corrected HS-1-LB data is presented in Figure 26. The match between the original HS-1-LB and the transfered data is good. A small discrepancy is noted on the energy rose, which can be attributed to the difference in EMD-WRF data from the two locations. Overall the data alignment remains robust.

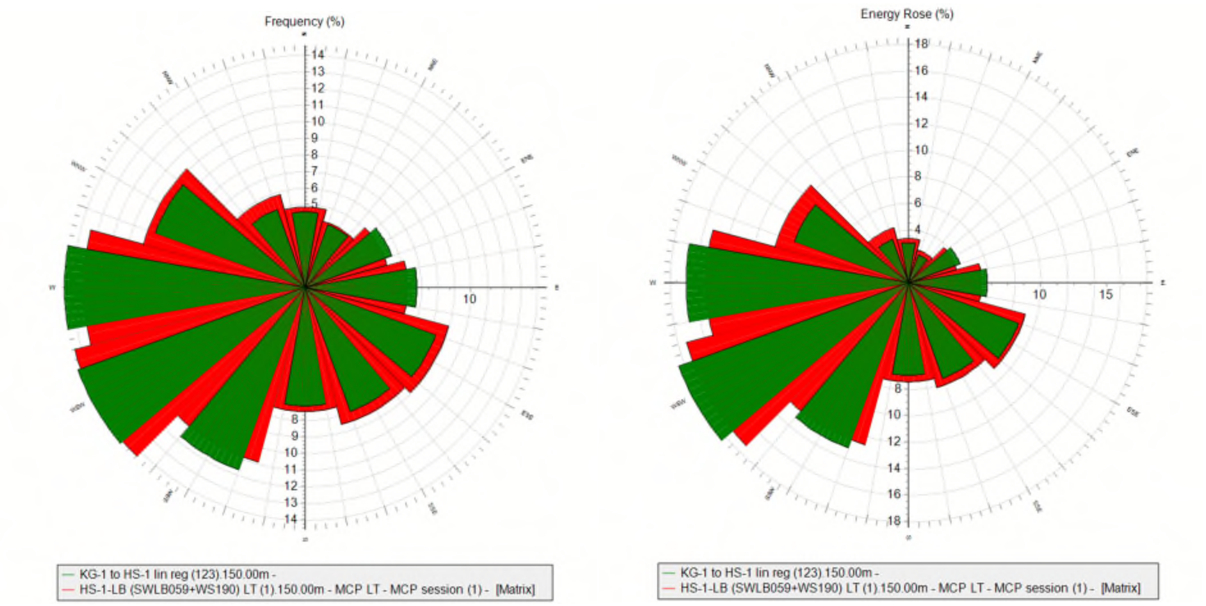


Figure 26. Comparison of directional distribution (left) and energy rose (right) of transferred KG-1-LB data (green) with HS-1-LB (red) (22 years).

The mean wind speed through the steps can be followed in Table 18. The wind distribution and Weibull fit can be found in detail in Appendix F.

Table 18. Mean wind speed through the transfer stages, at KG-1-LB data.

STAGE	ARITHMETIC MEAN WIND SPEED [M/S]
12 months of measured, KG-1-LB, 150 m	10.00
22 years, long-term corrected KG-1, 150 m	9.51
22 years, transferred to KG-1-LB, 150 m	9.48

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 HS-1-LB. The height of interest is at 150 m (shear extrapolated from measurement height 140 m).

The H1 buoy is located about 15 km north of HG-1-LB buoy (Figure 24). The buoys are similarly exposed to the impact of land and is relatively close to HS-1-LB, with similar heights of measurements and technology, but the dataset was recorded for a different year than that of HS-1-LB.

For the validation of the wind model for HS-1-LB, the long-term corrected dataset at H1 is transferred to the location and height of the HS-1-LB 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 HS-1-LB and EMD-WRF data at H1, the difference in directional distribution and energy distribution is very small (Figure 27).

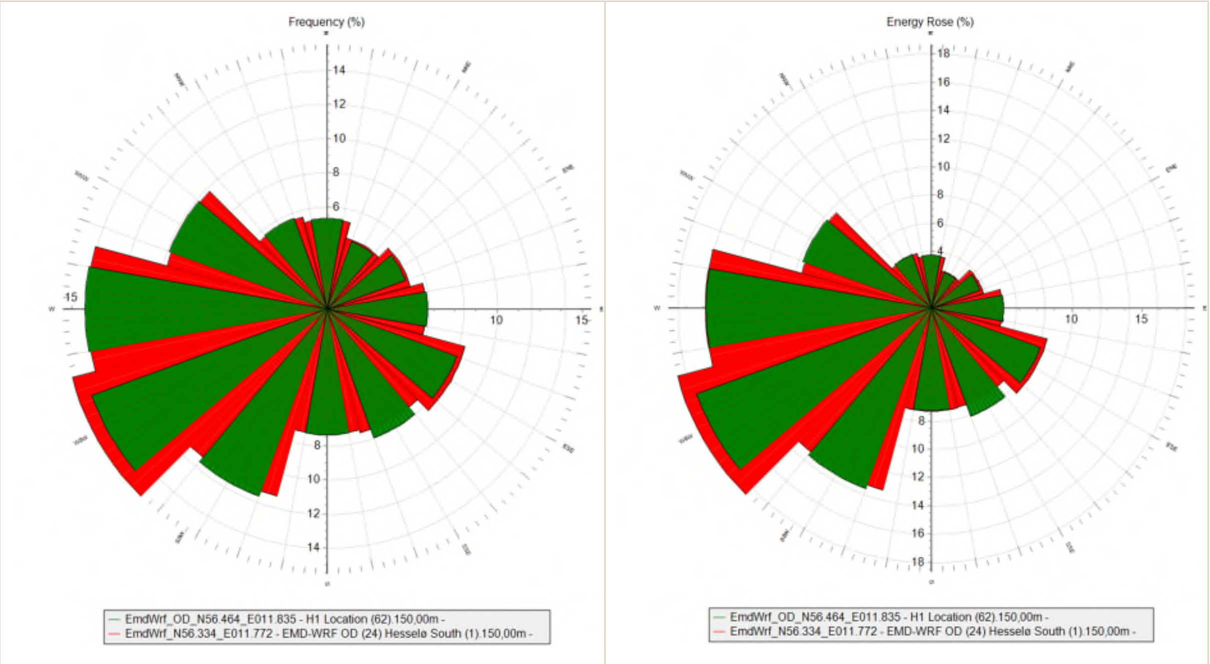


Figure 27. Left: Directional distribution between EMD-WRF at HS-1-LB (red) and EMD-WRF at H1(green), 22 years. Right: Energy rose of same two datasets, 22 years.

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

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

A comparison of directional distribution of transferred H1 data at 150 m with long-term corrected HS-1-LB data is presented in Figure 28. The match is very good with only minor deviation.

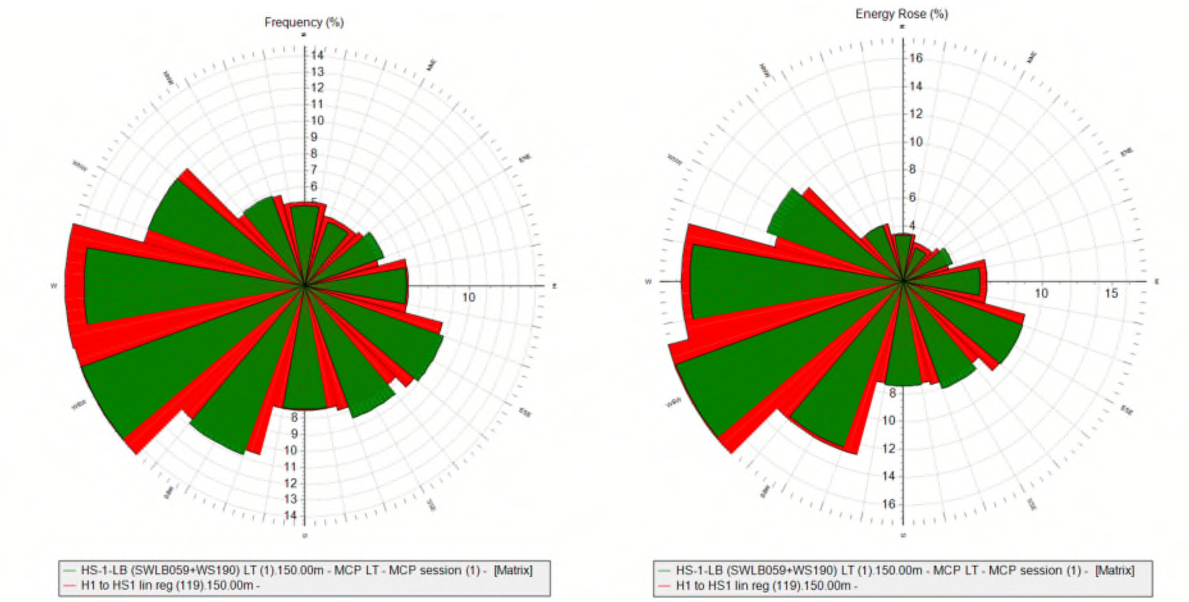


Figure 28. Comparison of directional distribution of transferred H1 data (red) with HS-1-LB (green) (22 years). Left: by frequency, right: by energy.

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

Table 19. 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 HS-1-LB, 150 m	9.70

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 HS-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 HS-1-LB buoy, as presented in Figure 24.

For the validation of the wind model for HS-1-LB, the long-term corrected dataset at M1, 62 m, is transferred to the location and height of the HS-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 HS-1-LB, a difference in directional distribution is noted (Figure 29). A transfer function is therefore required to transfer both the wind directions and the energy content in each direction.

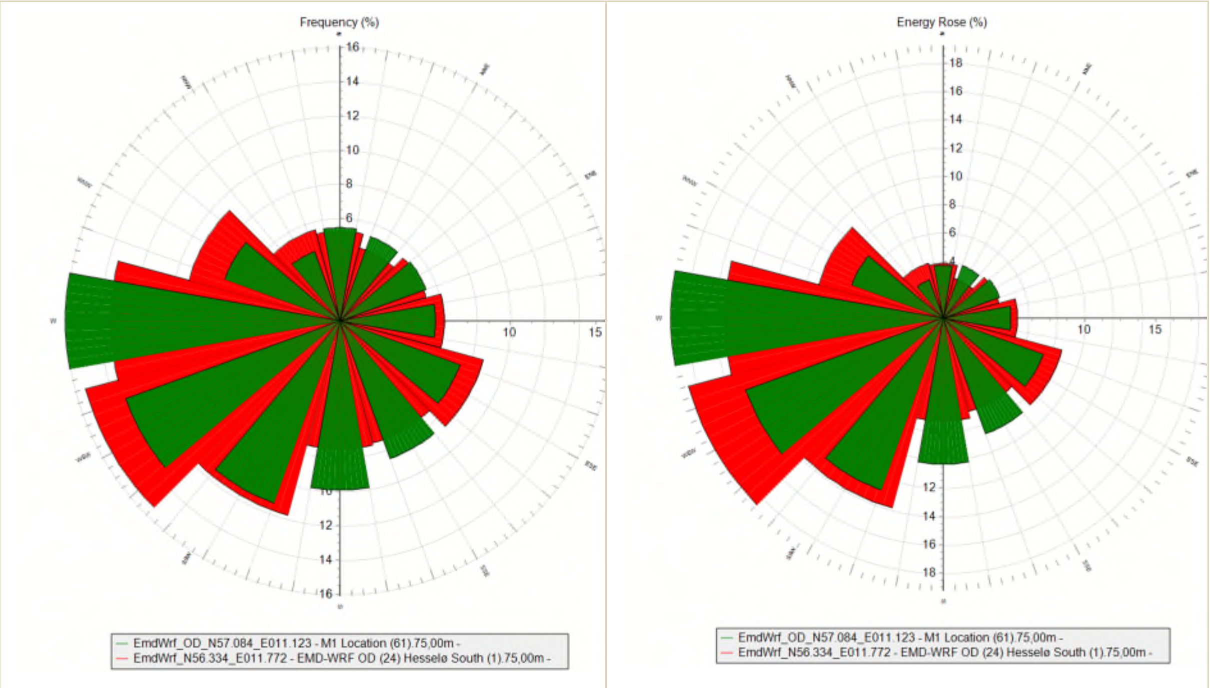


Figure 29. Left: directional distribution between EMD-WRF, 75 m at M1 (green) and EMD-WRF, 75 m at HS-1-LB (red). Right: Energy rose of same two datasets.

A translation function is thus created using linear regression with a translation function for every 1° direction, used data in a +/-15° window, giving a scale and offset on wind speed as well as an offset on wind direction. This transfer function is then applied to the 22 year of long-term corrected 62 m M1 data, creating a 22-year dataset at HS-1-LB.

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

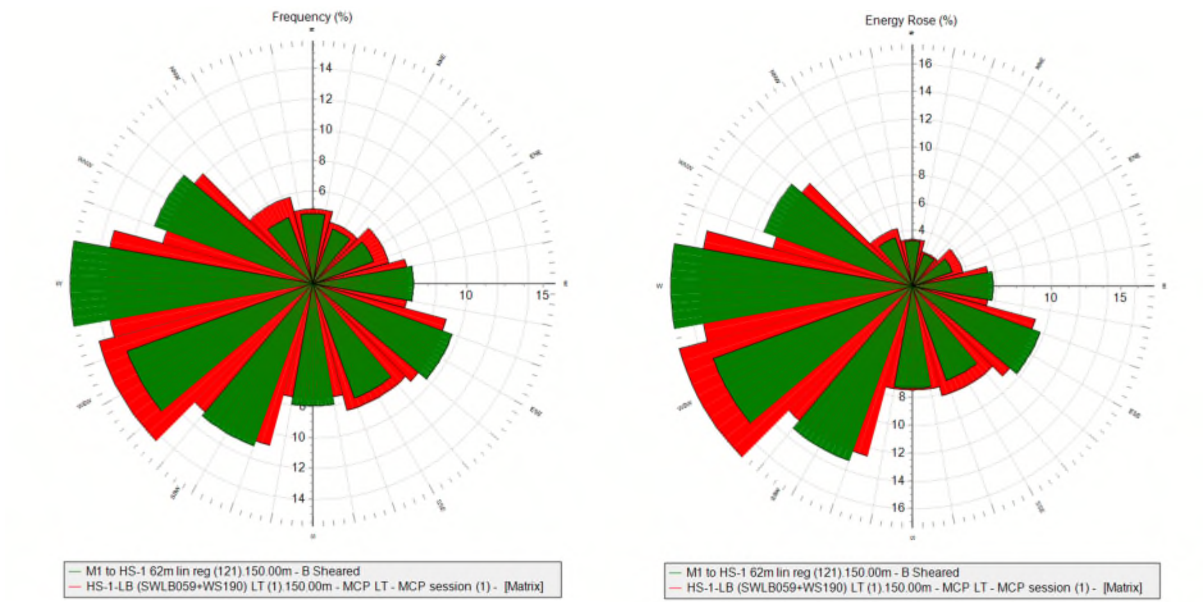


Figure 30. Comparison of directional distribution of transferred M1 data, 62 m (green) with HS-1-LB, 80 m (red) (22 years). Left: by frequency, right: by energy.

The transfered data at 62 m ASL at HS-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 ([28]).

The method applied is to use a shear based on 1 year of observations on HS-1-LB. This is the observed shear on the location where the transfer is taking place.

The shear used to extrapolate the 62 m M1 data translated to HS-1-LB from 62 m to 150 m is thus calculated from the long-term data at HS-1-LB from 100 m to 150 m (Table 20).

Table 20. Shear by season, based on measurements at HS-1-LB from 40 m to 150 m.

Direction /hour	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
Shear	0.15	0.12	0.08	0.06	0.07	0.09

The mean wind speed through the steps can be followed in Table 21. The wind distribution and Weibull fit can be found in detail in Appendix F.

Table 21. Mean wind speed through the transfer stages atM1 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 HS-1-LB, 62 m	8.85
22 years, transferred to HS-1-LB, shear extrapolated to 150 m	9.61

7.2. Comparison of Primary Model with Secondary Models

The wind resource at HS-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 Kattegat (KG-1-LB), Hesselø (H1) and Læsø (M1) to the site. They cover different directions and distances from the Hesselø South OWF and all have advantages and disadvantages as described previously.

The results of these tests are summed up in Table 22.

The long-term corrected mean wind speeds of the primary model are supported by the secondary models, with a maximum deviation of 1.2% on the mean wind speed at 150 m ASL, which is within 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 Hesselø 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 models are submitted below and in Appendix E.

Table 22. Comparison of model results at HS-1-LB, 150 m ASL.

	PRIMARY MODEL	TRANSFERRED KG-1-LB MODEL	TRANSFERRED H1 MODEL	TRANSFERRED M1 MODEL
Wind speed [m/s]	9.60	9.48	9.70	9.61
Wind speed relative to primary model		98.8%	101.0%	100.1%

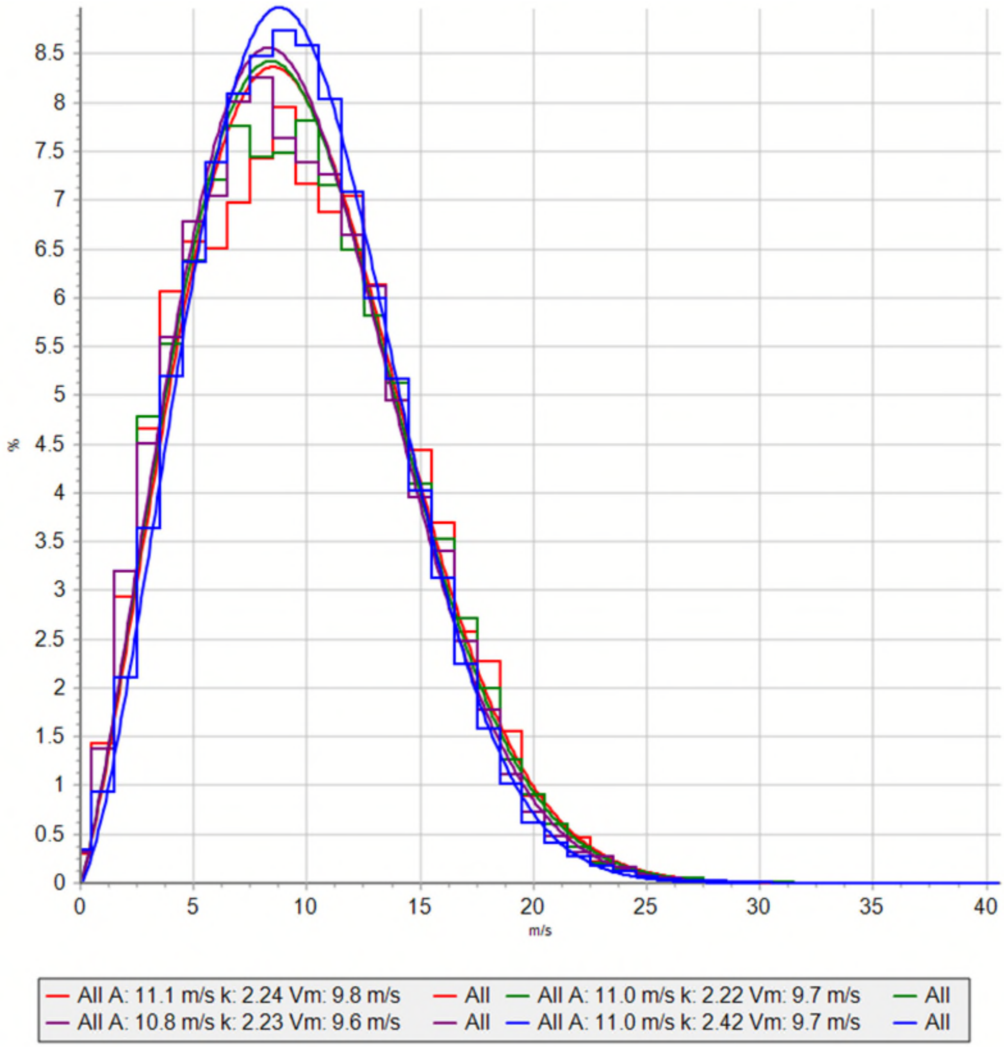


Figure 31. Wind speed probability function for the four datasets at HS-1-LB position. Primary model, HS-1-LB (green), KG-1-LB model (purple), H1 (red) and M1 (blue).

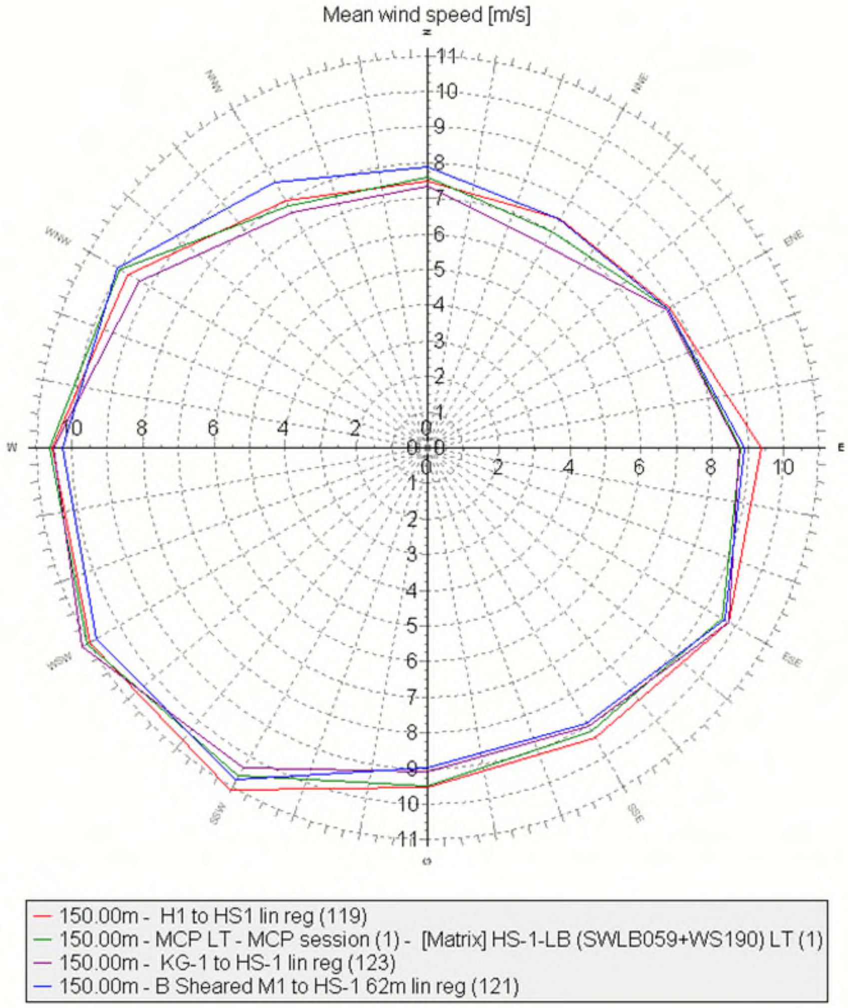


Figure 32. Mean wind speed per direction for the four datasets at HS-1-LB position. Primary model, HS-1-LB (green), KG-1-LB model (purple), H1 (red) and M1 (blue).

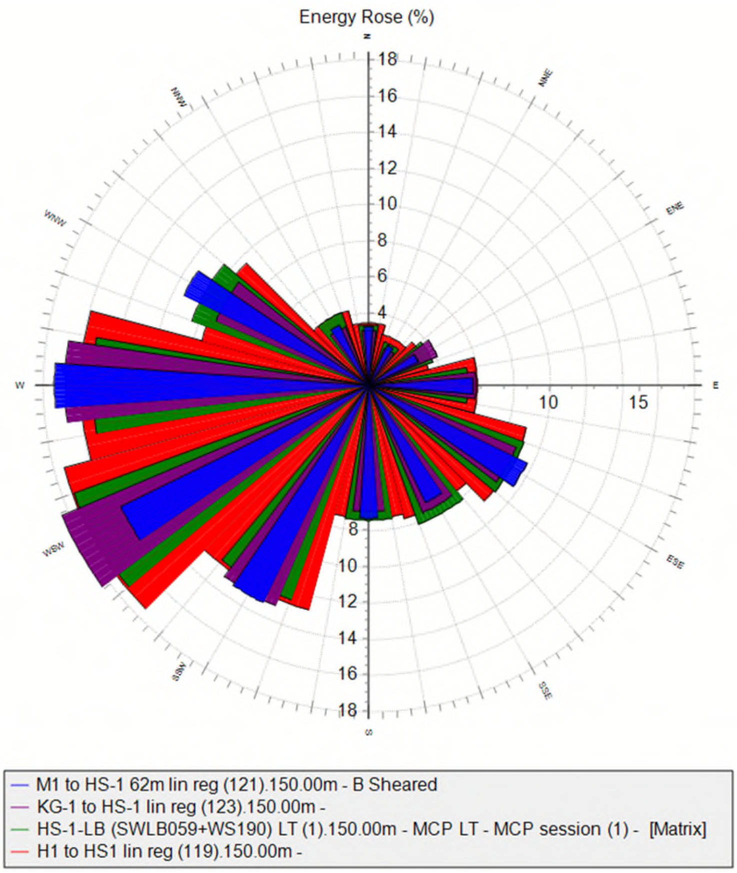


Figure 33. Directional distribution of the four long-term wind models at HS-1-LB position. Primary model, HS-1-LB (green), KG-1-LB model (purple), H1 (red) and M1 (blue).

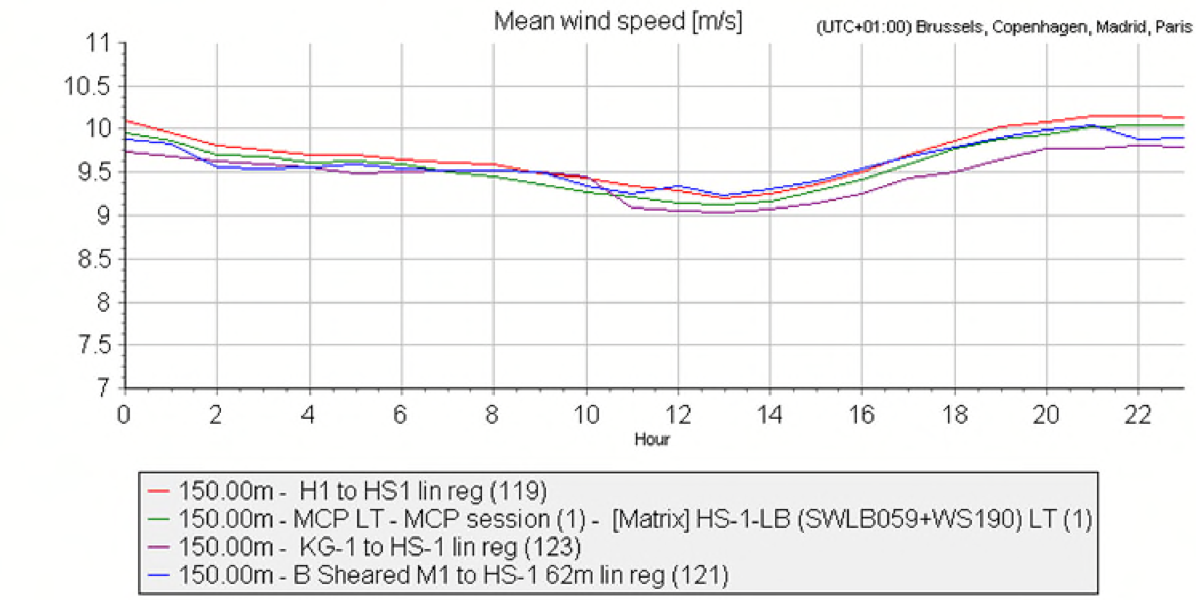


Figure 34. Diurnal wind speed of the four long-term wind models at HS-1-LB position. Primary model, HS-1-LB (green), KG-1-LB model (purple), H1 (red) and M1 (blue).

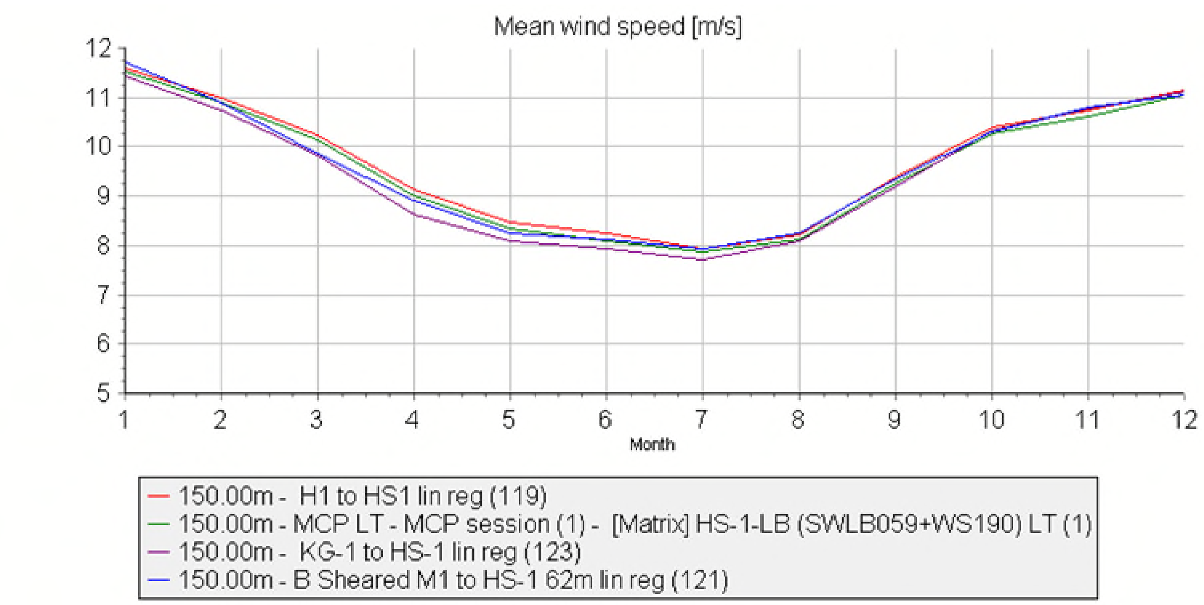


Figure 35. Seasonal variation of the four long-term wind models at HS-1-LB position. Primary model, HS-1-LB (green), HS-1 model (purple), H1 (red) and M1 (blue).

7.3. Uncertainty of Primary Wind Model

7.3.1. Measurement Uncertainty

Uncertainty on measurements was discussed in section 4.6. The results are summarized in Table 23.

Table 23. Measurement uncertainty.

BUOY	TOTAL MEASUREMENT UNCERTAINTY
HS-1-LB	2.39%

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 [29], 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 1.3% for HS-1-LB.

We therefore consider an uncertainty on long-term correction of 1.5% a reasonable value for long-term correction of the primary data from the buoy.

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 [29], we estimate that for a 20-year dataset in this region this uncertainty is 1.5 % on wind speed.

This is supported by [30] who indicates a 20-year multidecadal variability amplitude of the Kattegat on yield around 3%. Given a yield to wind speed ratio near unity, this translates well to wind speed and results in an uncertainty of wind speed of 1.5%.

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

7.3.4. Year-to-year Variability

Based on the annual variation on the EMD-WRF data the inter-annual variability is 4.1% at HS-1-LB. Over a 20-year lifetime this uncertainty is reduced to 0.9%.

7.3.5. Total Uncertainty

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

The results from the secondary data provide a standard deviation on the four reported wind speed results for the HS-1-LB location at 1.0%. Due to the horizontal extrapolation distortion and in some cases poorer measurement uncertainty than at the buoy, the uncertainty on the transferred secondary data should be considered higher than on the local data, however the standard deviation of the results from the four different models remain within the uncertainty of the total wind speed uncertainty of the primary model (Table 24) and therefore confirms the primary model.

Table 24. Combined uncertainty on long-term wind data. Uncertainty given as one standard deviation wind speed.

	HS-1-LB	
Wind data uncertainty	1 year	20 years
Measurement uncertainty	2.39%	2.39%
Long-term correction uncertainty	1.5%	1.5%
Very long-term uncertainty	1.5%	1.5%
Annual variability	4.1%	0.9%
Total	**5.20%**	**3.32%**

8. Flow Modelling

To calculate the wind resource for the whole Hesselø South 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 three additional positions (HS-A, HS-B and HS-C) within the Hesselø South OWF area and a wind resource map for the whole development area.

8.1. WFR Model

Due to the distance from the coast, mesoscale modelling is most suitable for flow modelling on the Hesselø South OWF 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 25 km from the northern boundary of the Hesselø South area, in northwest direction.

The wake influence of the planned Kattegat 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 [31] 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 when 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).

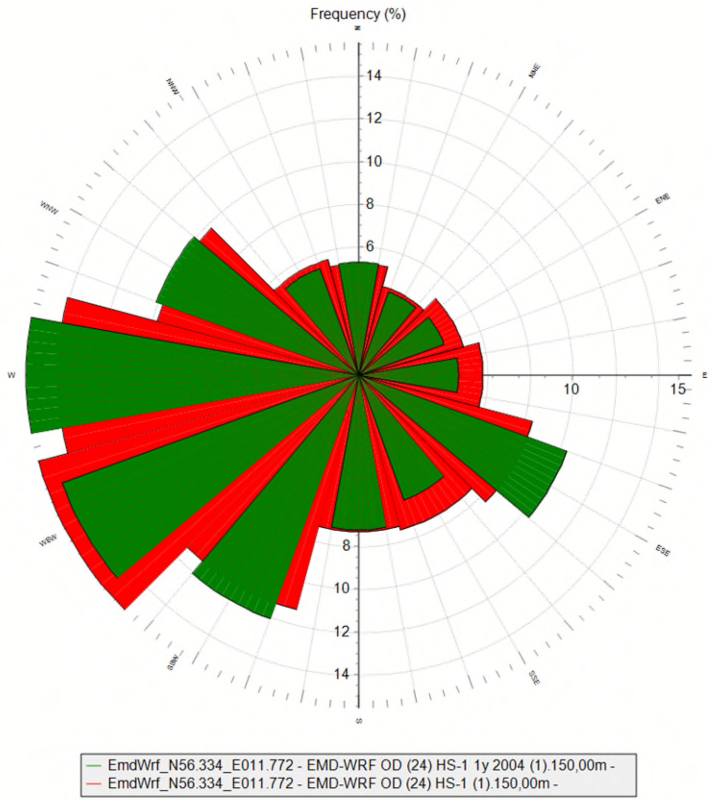


Figure 36. Direction distribution of EMD-WRF mesoscale data at HS-1-LB position in 2004 (green) compared to the 22-year period (red).

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 Hesselø South 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 is presented in Figure 37, as the ratio on the average Weibull wind speed at 150 m height ASL between the two scenarios.

The impact of the Anholt wind farm on the wind resource is limited. Only the northwestern part of the Hesselø South OWF area is affected and that only mildly (<0.1%). The wind speed reduction in direct wake wind directions is higher, with a maximum of 0.4% reduction of mean wind speed along the northwestern edge of the wind farm zone. 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 are 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 modelling 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.

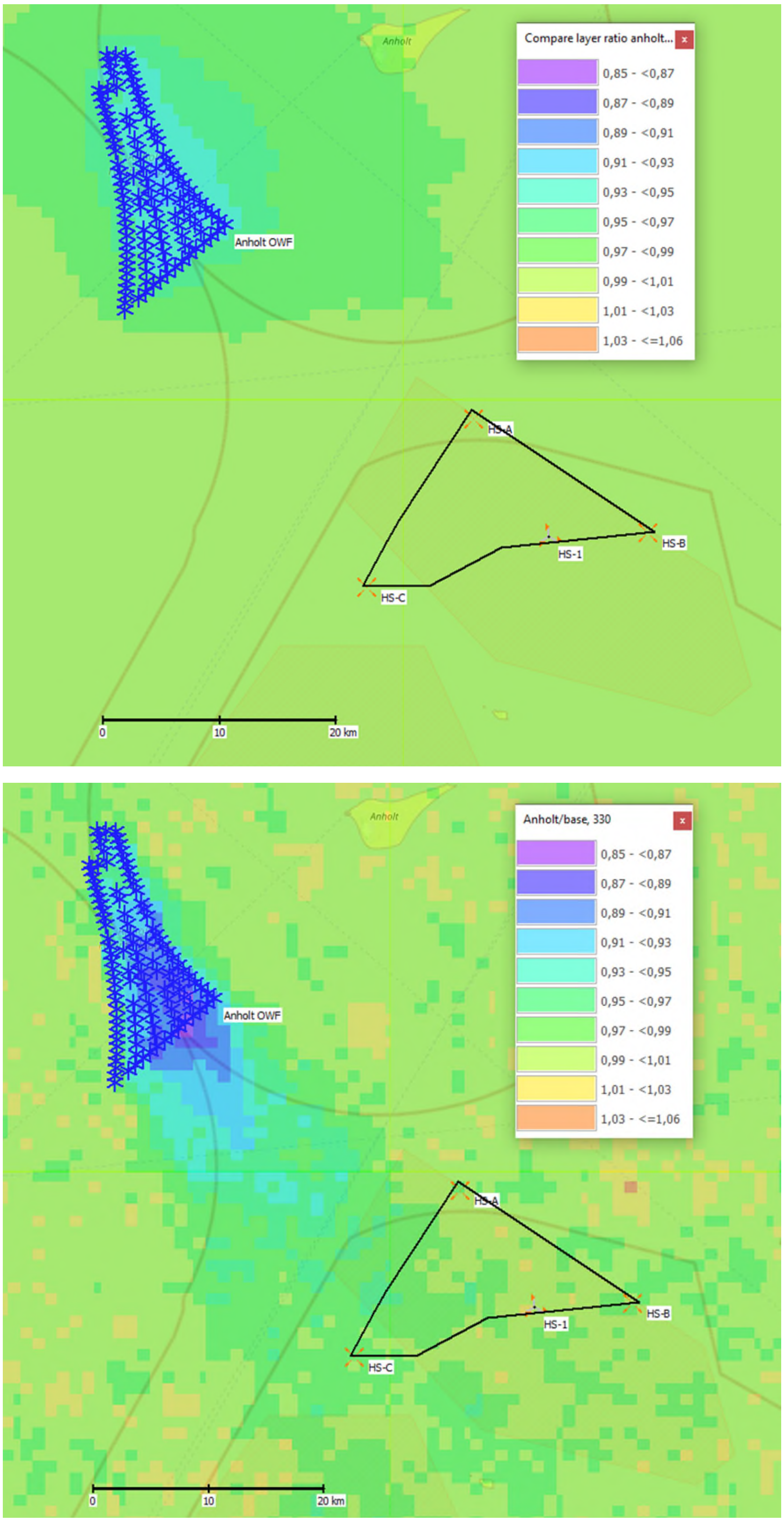


Figure 37. Map of the ratio between Weibull mean wind speed calculated by mesoscale modelling

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 HS-A, HS-B and HS-C

The location of three additional positions (HS-A, HS-B and HS-B) for siting parameters have been provided by Energinet. The coordinates are presented in Table 25. The three positions are located in the extreme locations of the triangle formed by the area.

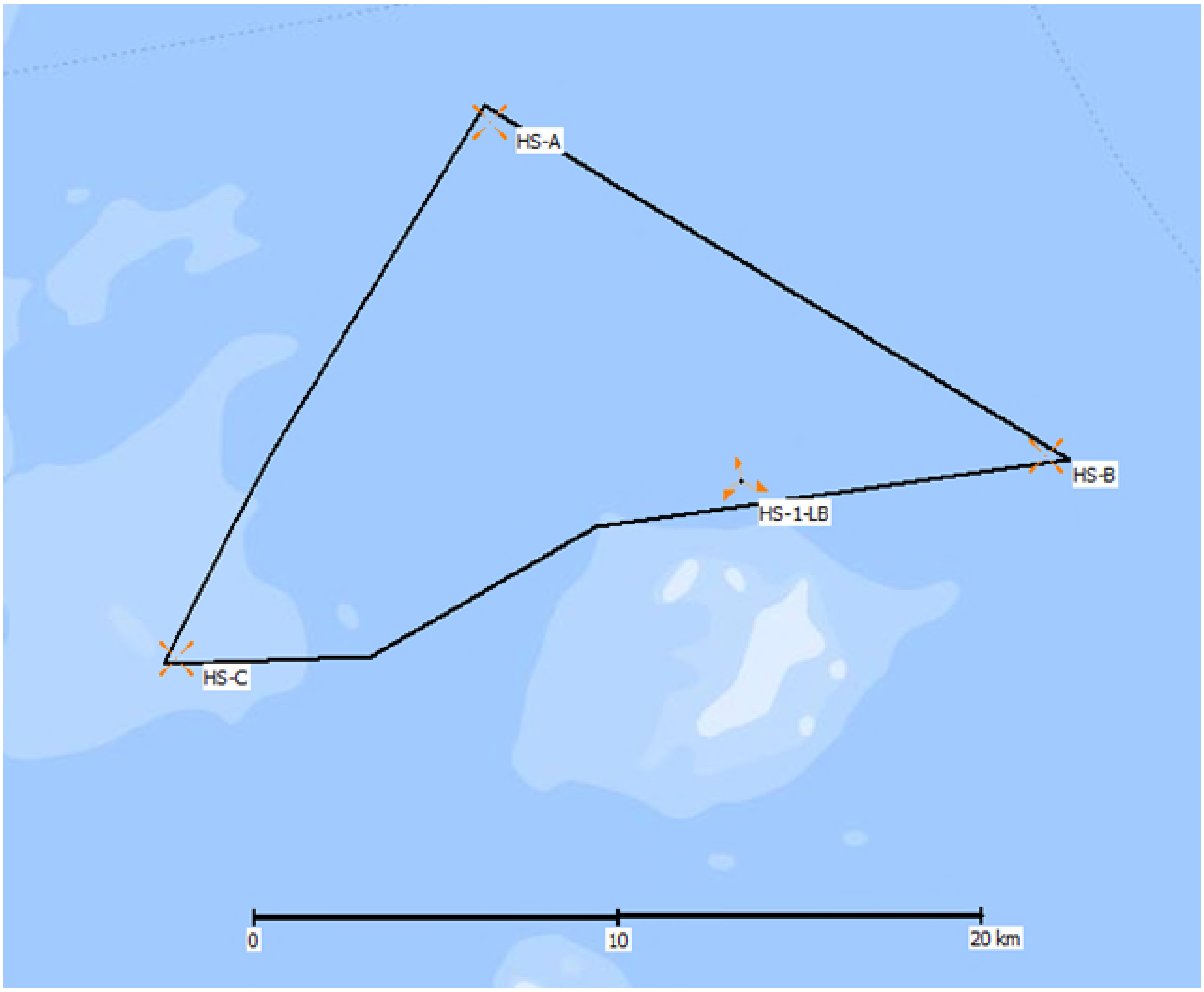


Figure 38. Location of the measurement point (HS-1-LB) and additional positions (HS-A, HS-B and HS-C) for siting parameters within the Hesselø South OWF boundaries.

Table 25. Coordinates for Additional Siting Parameters Positions

NAME	UTM WGS84 ZONE 32		GEOGRAPHICAL COORDINATES WGS84	
HS-A	664482	6256563	11.666997°	56.424910°
HS-B	679789	6247376	11.908553°	56.336895°
HS-C	655863	6241814	11.518653°	56.295454°

For HS-A, HS-B and HS-C, 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 (HS-1-LB) and the prediction location (HS-A, HS-B and HS-C) 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 HS-1-LB, HS-A, HS-B and HS-C. There is a marginal difference in wind direction, but small enough to assume that a similar direction distribution is valid.

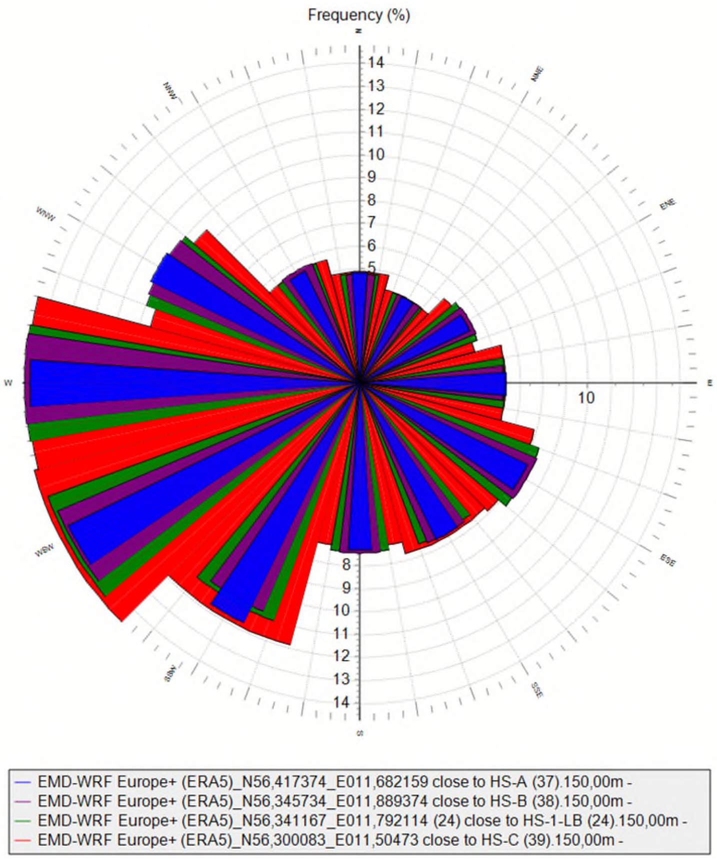


Figure 39. Comparison of 22 years direction distribution between EMD-WRF Europe + data for locations close to HS-1-LB (green), HS-A (blue), HS-B (purple) and HS-C (red).

For HS-A, HS-B and HS-C the resulting time series at 150 m was generated using the long-term corrected time series for HS-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 HS-A, HS-B and HS-C includes wind speed and wind direction for 22 years in an hourly resolution.

The arithmetic mean wind speed and Weibull parameters for HS-A, HS-B and HS-C are presented in Table 26. Details can be found in Appendix D.

Table 26. Weibull parameters of the long-term wind data, HS-A, HS-B and HS-C.

NAME	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER [m/s]	WEIBULL - k PARAMETER
HS-A, 150 m	22	9.67	9.78	11.04	2.23
HS-B, 150 m	22	9.58	9.69	10.94	2.22
HS-C, 150 m	22	9.65	9.76	11.03	2.22

8.3. Wind Resource Map

The wind resource map for the Hesselø South area is calculated from the long-term corrected measurements at HS-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.

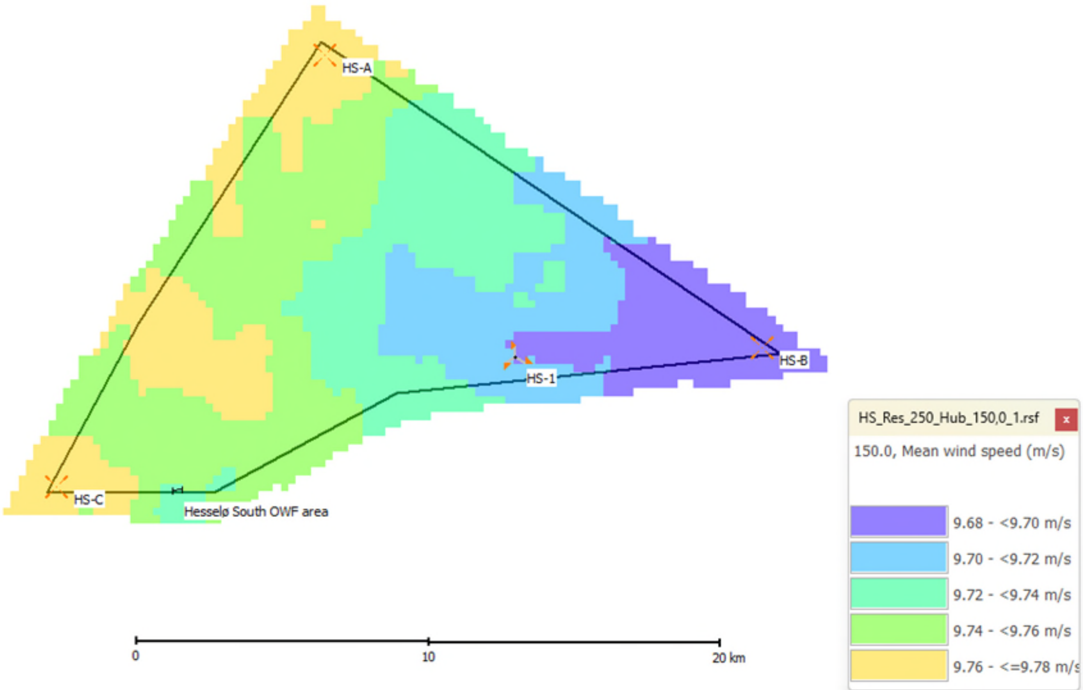


Figure 40. Wind resource map at 150 m for the Hesselø South OWF area.

9. Siting Parameters

This chapter outlines the requested siting parameters for assessment of structural integrity of wind turbines in accordance with the relevant design standards: IEC 61400-1 Ed. 4 [1], IEC 61400-3-1 Ed. 1 [2], IEC 61400-15-1 CD [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.

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 CD [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 Hesselø South (HS-1-LB) 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 28. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, HS-1-LB. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	10.96	2.22	100.00	9.70
0-N	8.44	1.81	4.86	7.50
1-NNE	8.00	2.18	4.14	7.09
2-ENE	8.85	2.02	5.13	7.84
3-E	10.02	2.32	6.19	8.88
4-ESE	10.94	2.53	8.98	9.71
5-SSE	10.48	2.44	8.54	9.29
6-S	10.87	2.34	7.49	9.63
7-SSW	12.26	2.44	10.91	10.87
8-WSW	12.60	2.53	14.43	11.18
9-W	12.07	2.45	13.41	10.71
10-WNW	11.34	2.15	10.11	10.04
11-NNW	8.84	1.94	5.81	7.84

Table 29. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, transferred to HS-A. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	11.04	2.23	100.00	9.78
0-N	8.40	1.82	4.86	7.46
1-NNE	8.01	2.19	4.14	7.09
2-ENE	9.12	2.02	5.13	8.08
3-E	10.20	2.32	6.19	9.04
4-ESE	11.11	2.54	8.98	9.86
5-SSE	10.66	2.43	8.54	9.45

6-S	10.99	2.35	7.49	9.74
7-SSW	12.10	2.44	10.91	10.73
8-WSW	12.66	2.54	14.43	11.23
9-W	12.11	2.45	13.41	10.74
10-WNW	11.43	2.15	10.11	10.12
11-NNW	9.09	1.95	5.81	8.06

Table 30. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, transferred to HS-B. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	10.94	2.22	100.00	9.69
0-N	8.48	1.82	4.86	7.53
1-NNE	8.01	2.19	4.14	7.10
2-ENE	8.89	2.02	5.13	7.88
3-E	9.83	2.31	6.19	8.71
4-ESE	10.82	2.54	8.98	9.60
5-SSE	10.59	2.44	8.54	9.39
6-S	10.84	2.35	7.49	9.60
7-SSW	12.30	2.44	10.91	10.91
8-WSW	12.55	2.53	14.43	11.14
9-W	11.96	2.44	13.41	10.60
10-WNW	11.50	2.15	10.11	10.18
11-NNW	8.76	1.93	5.81	7.77

Table 31. Weibull distribution parameters based on long-term corrected LiDAR data at 150 m ASL, transferred to HS-C. Wind speeds are derived from the Weibull distribution.

SECTOR	A PARAMETER [m/s]	k PARAMETER [-]	FREQUENCY [%]	MEAN WIND SPEED [m/s]
Mean	11.03	2.22	100.00	9.77
0-N	8.25	1.80	4.86	7.33
1-NNE	7.87	2.20	4.14	6.97
2-ENE	9.19	2.01	5.13	8.14
3-E	10.38	2.31	6.19	9.19
4-ESE	11.10	2.54	8.98	9.85
5-SSE	10.62	2.44	8.54	9.42
6-S	11.05	2.34	7.49	9.79
7-SSW	12.23	2.44	10.91	10.85
8-WSW	12.62	2.53	14.43	11.20
9-W	12.16	2.45	13.41	10.78
10-WNW	11.43	2.15	10.11	10.12
11-NNW	8.59	1.93	5.81	7.62

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 Hesselø South (HS-1-LB) LiDAR measurements. The results are summarised in the table below.

For position HS-A, HS-B and HS-C, the shear from HS-1-LB can be assumed.

WIND SHEAR POWER LAW EXPONENT [-]	HESSELØ SOUTH HS-1-LB (12 months)	HESSELØ H1 (12 months)
Hub height range 130 m to 170 m	0.075	0.094
Rotor range 40 m to 260 m	0.090	0.096

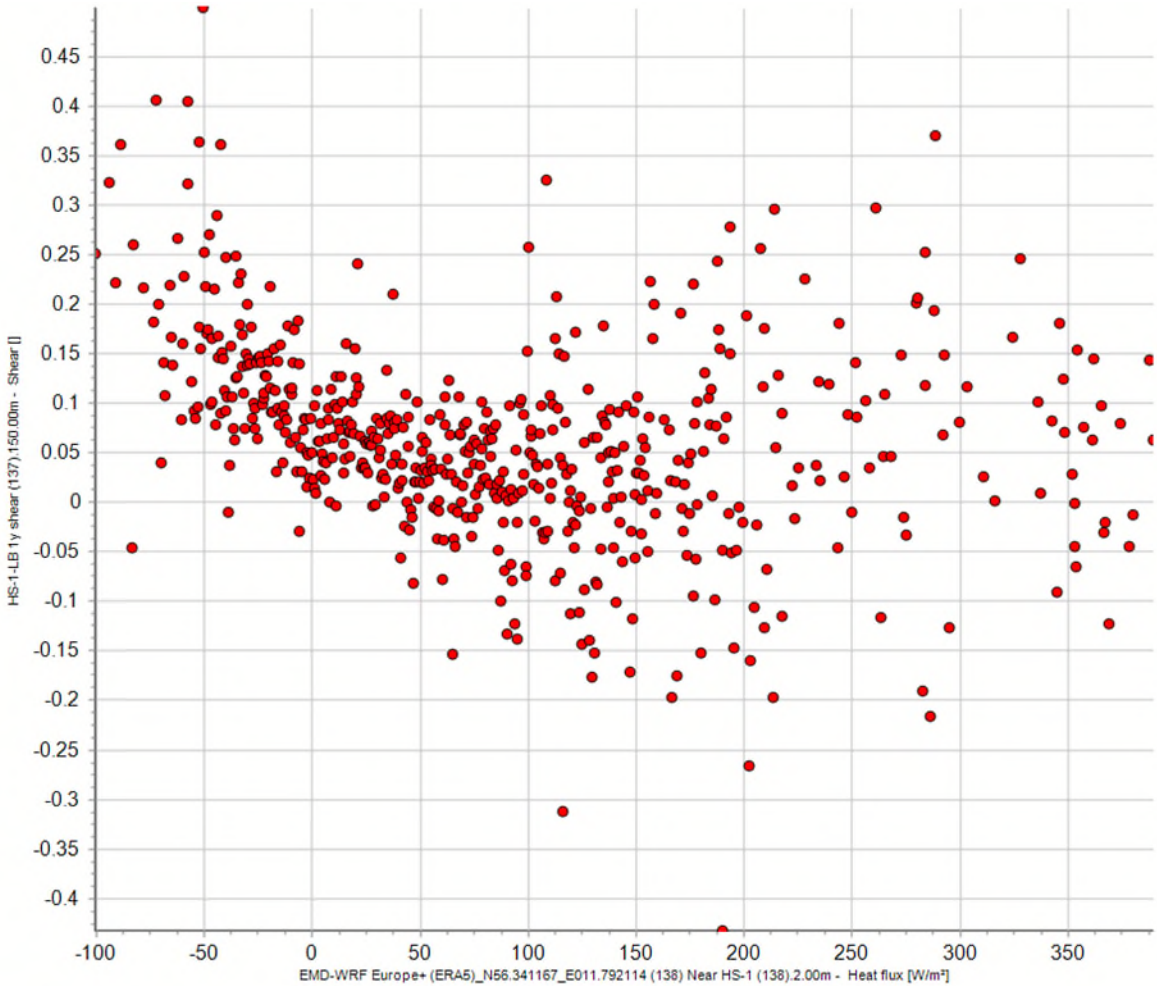
9.1.2.1. Wind profile characteristics

The observed wind profile at Hesselø South is presented as a function of heat flux (Table 33). 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 33.

Kattegat (HS-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	15%	53%	31%
Typical shear range	0.1 - 0.3	0.00 - 0.1	-0.15 - 0.20



Stability classes are defined though the Monin Obukhov length, here using three categories as described in Table 34. The 1/L (rmol) signal in the EMD-WRF data is used to describe stability at Hesselø South 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 34. Range of observed shear as a function of stability class at Hesselø South.

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	13%	29%	57%
Typical shear range	-1 - 1	-0.1 - 0.2	-1 - 1

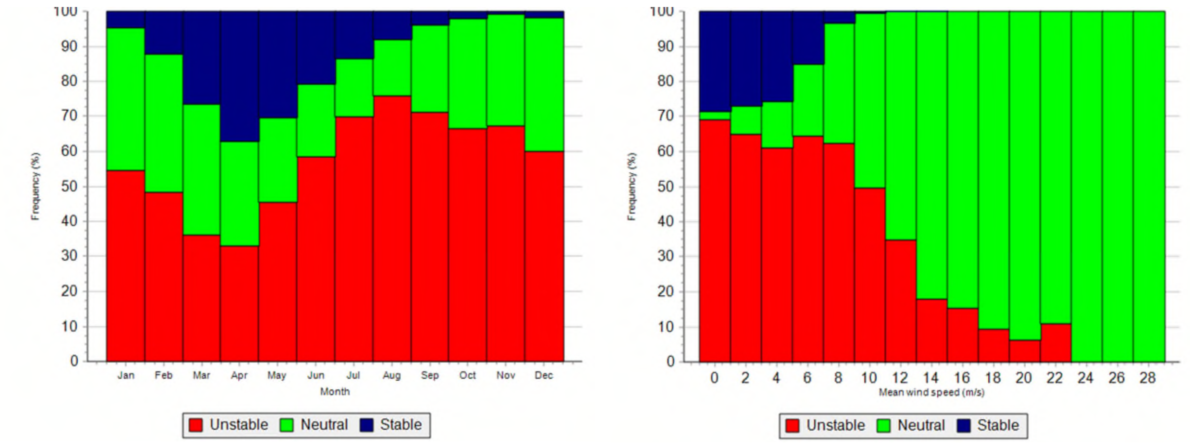
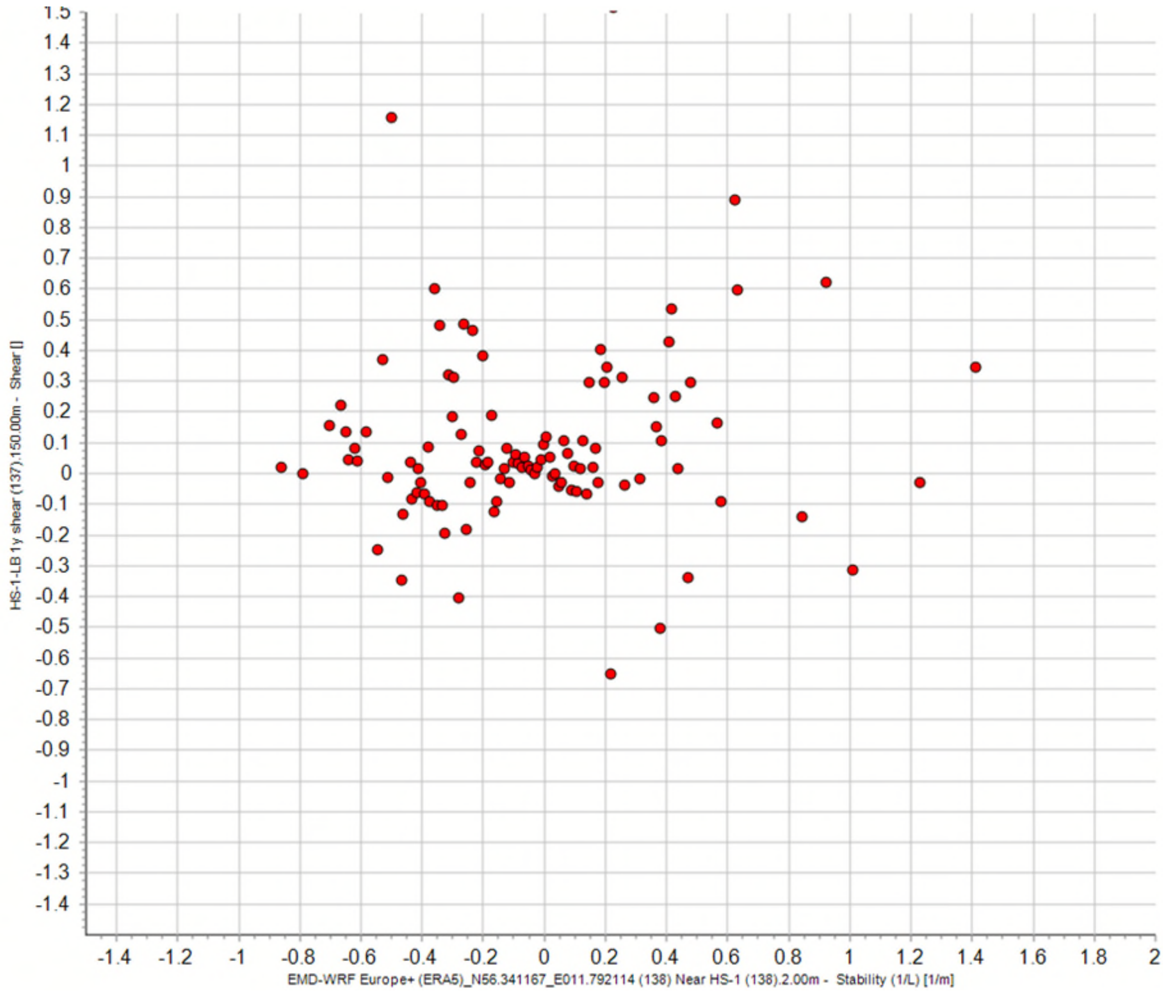


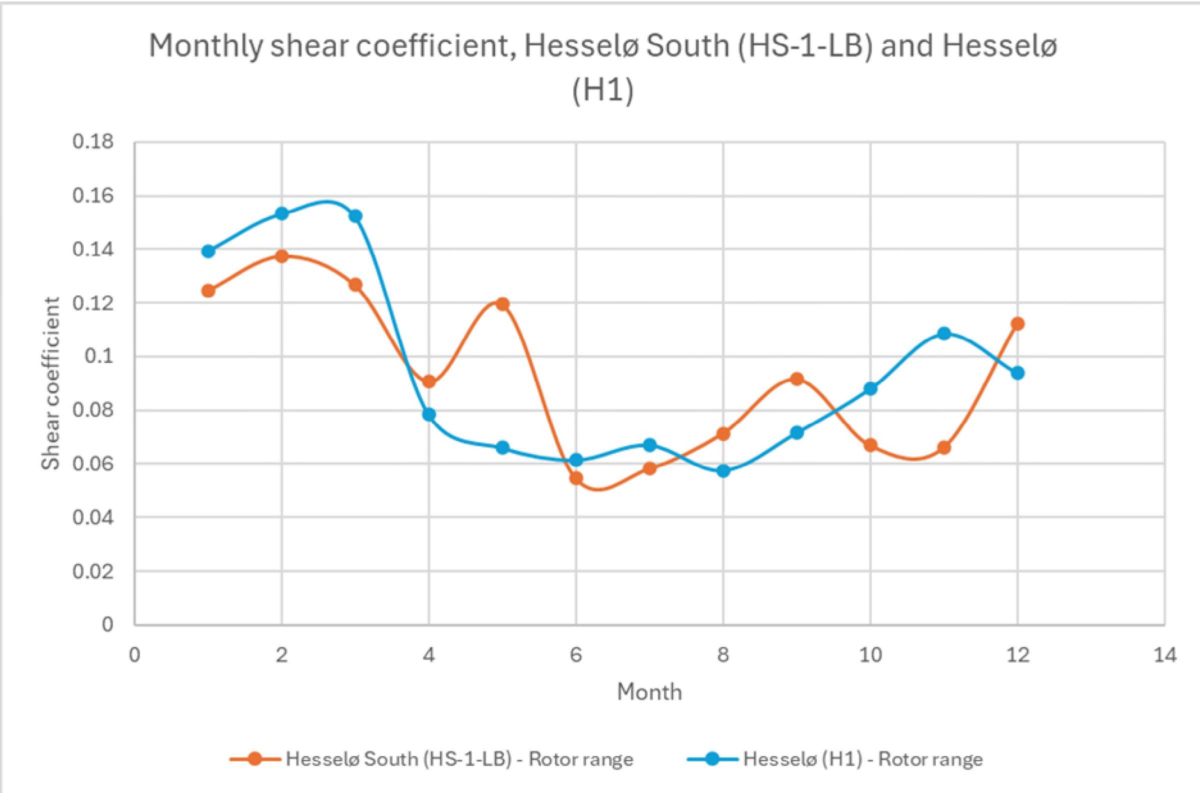
Figure 42. Frequency of stability classes as a function of month and wind speed, EMD-WRF at location of HS-1-LB.

Shear as a function of stability (1/L) at Hesselø South 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.



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 Hesselø South (HS-1-LB) LiDAR 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.



α across the rotor at Hesselø South (HS-1-LB) and Hesselø (H1).

9.1.3. Normal Turbulence Model (NTM)

9.1.3.1. 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:

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

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

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

9.1.3.2. Selection of Turbulence data

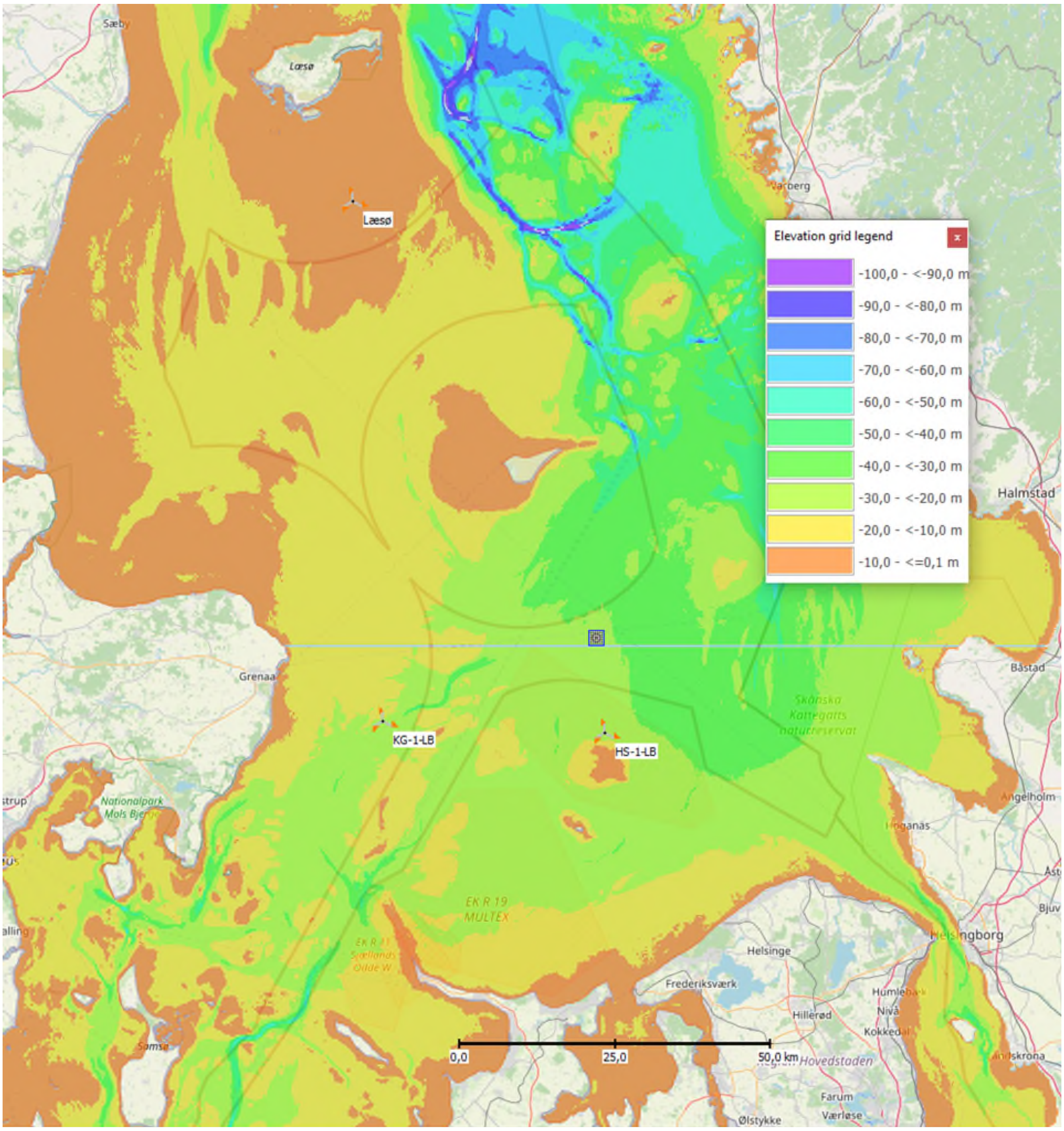
The models and safety factors forming the basis of the IEC 61400-1 and IEC 61400-3-1 are calibrated using turbulence measured by cup anemometers. LiDARs measure turbulence in a different way than cup anemometers, as they represent a volumetric average contrary to the point observation of a cup. No industry 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 [32]. 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 Hesselø South 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 Hesselø South site. For comparison, the Læsø turbulence data are presented in Appendix A.

EMD is in possession of more representative turbulence data for the Hesselø South 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 [33] and Site Wind Conditions Assessment, Energy Island Baltic Sea [34].

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).



Sæby
Læsø
Læsø
Varberg
Elevation grid legend
-100,0 - <-90,0 m
-90,0 - <-80,0 m
-80,0 - <-70,0 m
-70,0 - <-60,0 m
-60,0 - <-50,0 m
-50,0 - <-40,0 m
-40,0 - <-30,0 m
-30,0 - <-20,0 m
-20,0 - <-10,0 m
-10,0 - <=0,1 m
Halmstad
Båstad
Grenaa
KG-1-LB
HS-1-LB
Nationalpark Mols Bjerge
Ängelholm
Höganäs
EK R 19 MULTEX
Helsinge
Helsingborg
Frederiksværk
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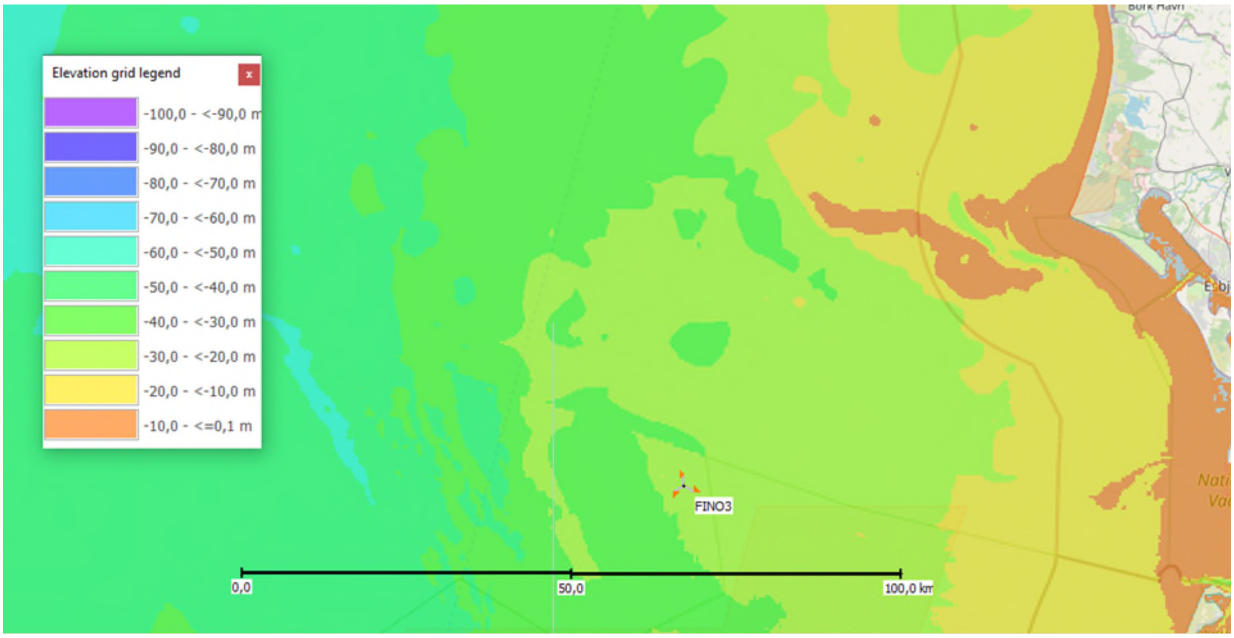


Figure 46. Water depth around the FINO3 mast.

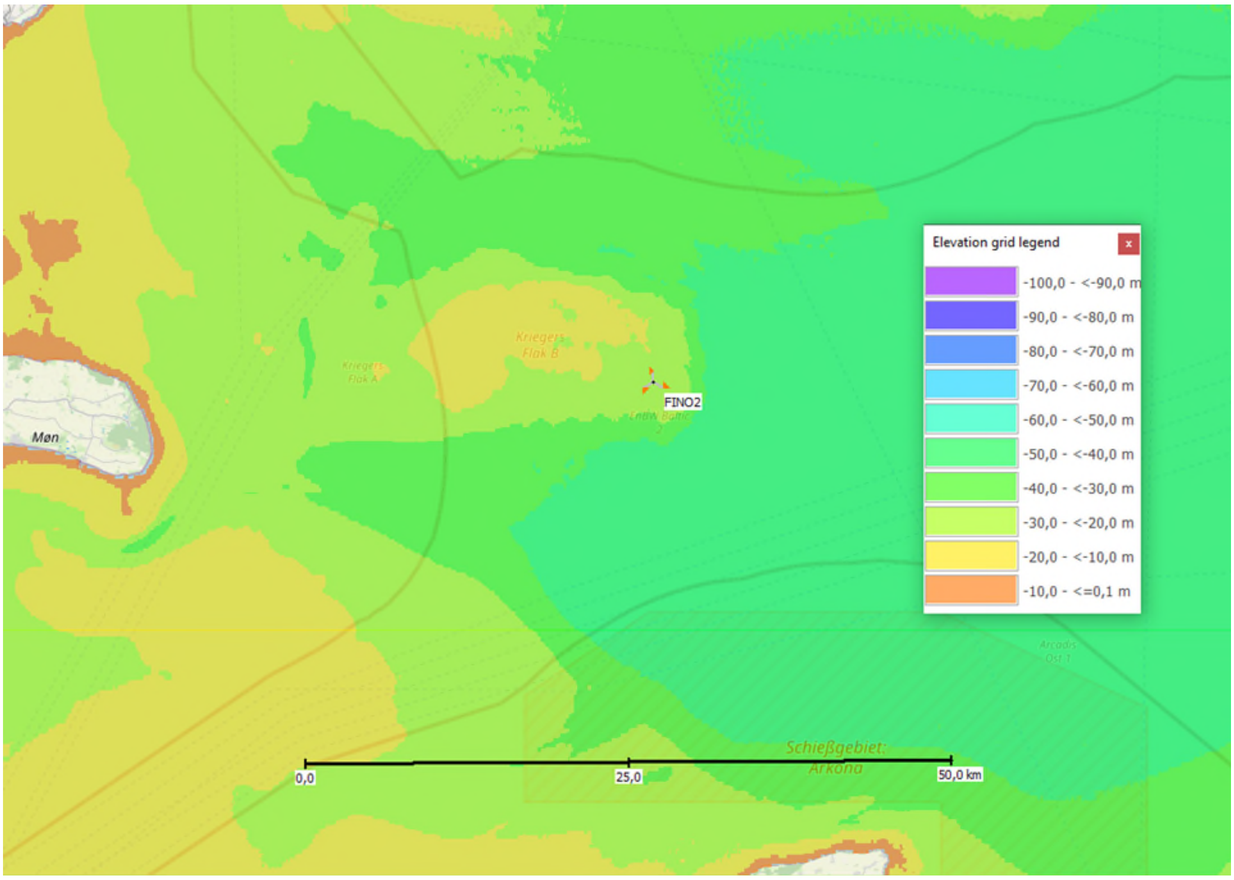


Figure 47. Water depth around the FINO2 mast.

The master thesis [32] 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 ASL. 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 [33].

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 FINO2 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 [34].

9.1.3.3. 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 Hesselø South 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).

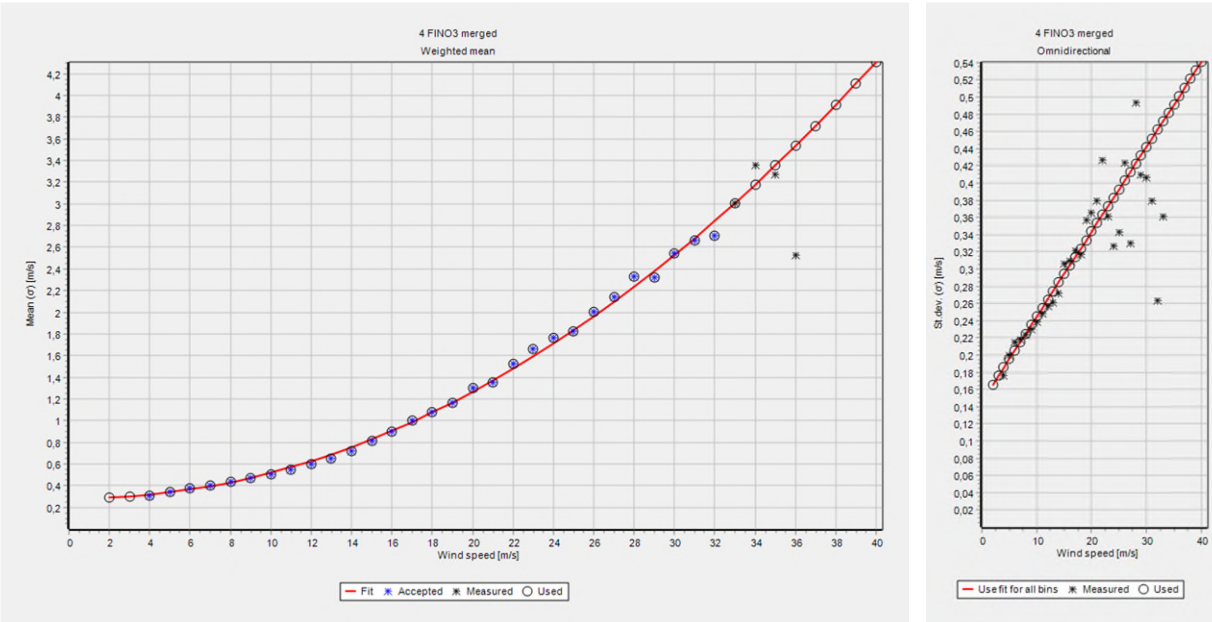


Figure 48. Left: observed mean turbulence versus wind speed at FINO3 91 m including the second

9.1.3.4. Vertical extrapolation at Fino3

The target height of 150 m for the Hesselø South 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 [32]. 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 [32]. 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.

$\boldsymbol{f(u) = \left(h/_{91m}\right)^{\alpha(u)}}$	**(4)**
$\sigma_{\mu,h}(u) = A_{\sigma_\mu} + B_{\sigma_\mu}(u/f(u)) + C_{\sigma_\mu}(u/f(u))^2$	(5)
$\sigma_{\sigma,h}(u) = A_{\sigma_\sigma} + B_{\sigma_\sigma} u\, f(u)$	(6)

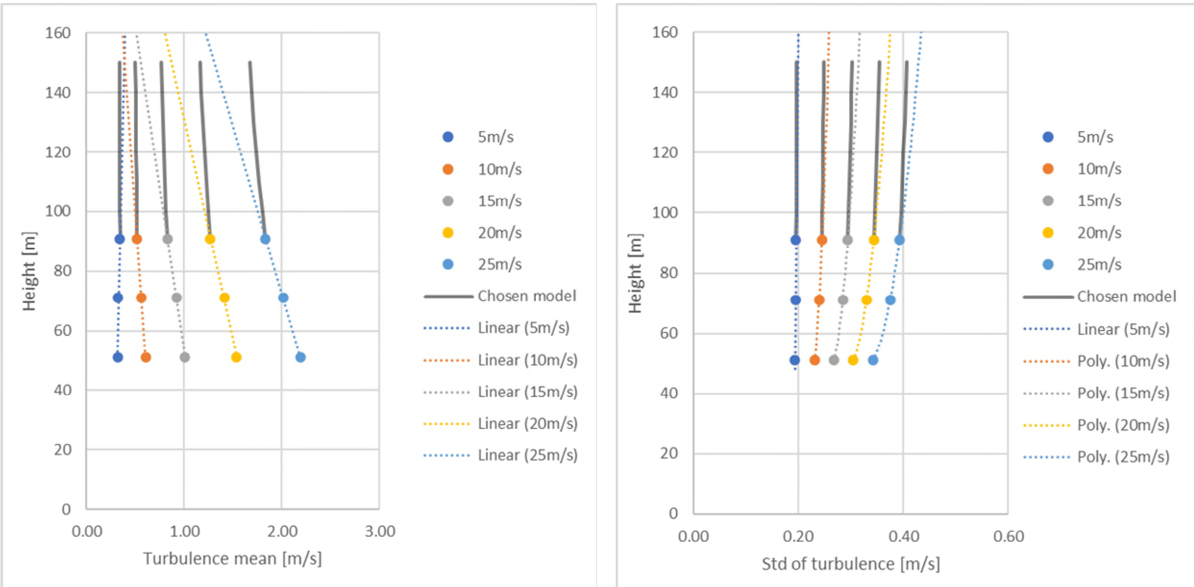


Figure 49. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the three

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 35, 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 35. 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

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%

9.1.3.5. Fit of the turbulence at FINO2

As for FINO3, a second-order fit is required at FINO2 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

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).

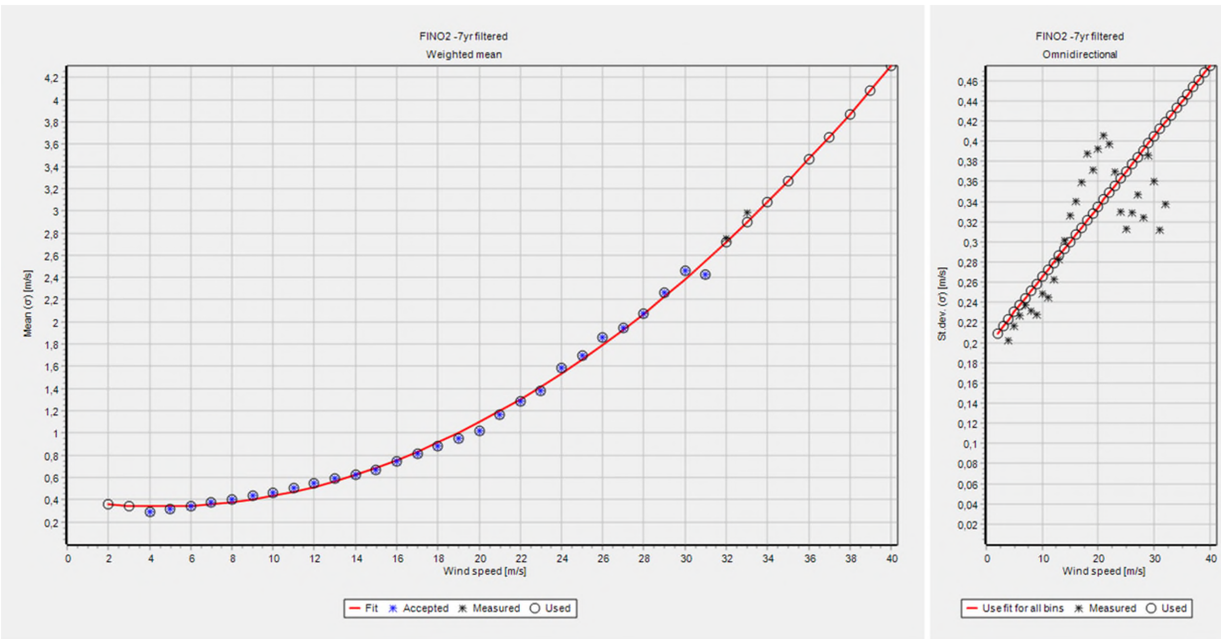


Figure 50. Left: observed mean turbulence versus wind speed at FINO2 102 m including the

9.1.3.6. Vertical extrapolation at Fino2

The target height of 150 m for the Hesselø South 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.

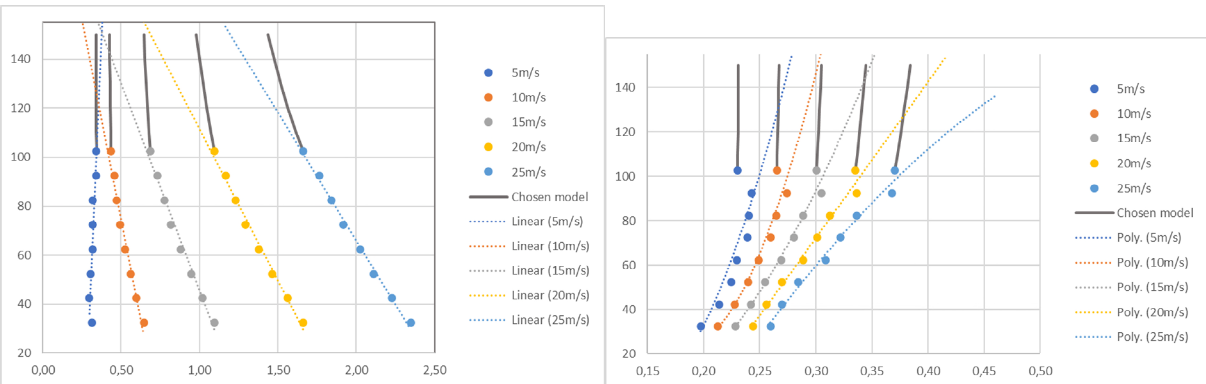


Figure 51. Variation of turbulence with height (y-axis) shown for wind speeds 5, 10, 15, 20 and 25 m/s. Turbulence mean (left) and standard deviation of turbulence (right), shown for the eight

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 36, 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 36. 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

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%

9.1.3.7. Combined model for Kattegat

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.

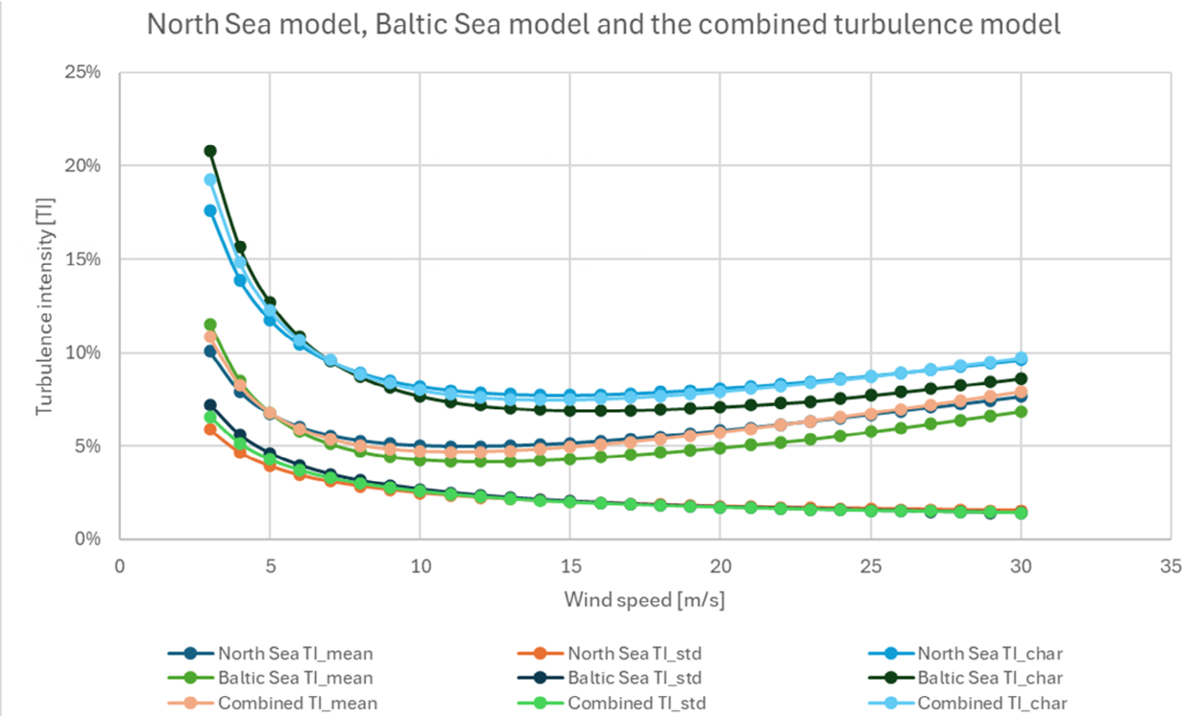


Figure 52. Turbulence intensity models for the North Sea and the Baltic Sea as well as the

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 37. Turbulence intensity at 150 m for the North Sea model, the Balic Sea Model and the

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 Hesselø South site are presented in Table 38. 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 38. Turbulence model parameters at the Hesselø South site (150 m) for the chosen model. See equations (1), (2) and (3).

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

9.1.4. Air Density

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

Based on long-term mean temperature found in section 9.1.5, air density is calculated at 150 m elevation assuming standard pressure at this height of 995 hPa. The resulting air density is for HS-1-LB is 1.229 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 [35] 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 HS-1-LB, HS-A, HS-B and HS-C. This secondary result corroborates the primary result.

Hence the air density average value at 150 m ASL of 1.23 kg/m^3 is assumed.

Mean air density (150 m)	**1.23 kg/m^3**

9.1.5. Air Temperature

Air temperature was measured on the Hesselø South 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 40.

The temperature at 150 m height has been found using the atmospheric lapse rate of -4.4 K/km

The EMD-WRF Europe+ time series at 150 m has been calibrated to represent the LiDAR position

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 39. The probability of temperatures falling outside the defined ranges is assessed by Gaussian distributions fitted to either the 10% highest or lowest temperatures [36].

For HS-A, HS-B and HS-C, the same temperature as at HS-1-LB can be assumed.

Table 39. Temperature assessment at HS-1-LB – Hesselø South 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	2,892	0.400	3.29
Extreme range	-15.0	40.0	0.041	0.000	0.041
Mean air temperature				9.0°C	
Standard deviation air temperature				6.6°C	
Maximum temperature				29.2°C	
Minimum temperature				-10.2°C	

Table 40. 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

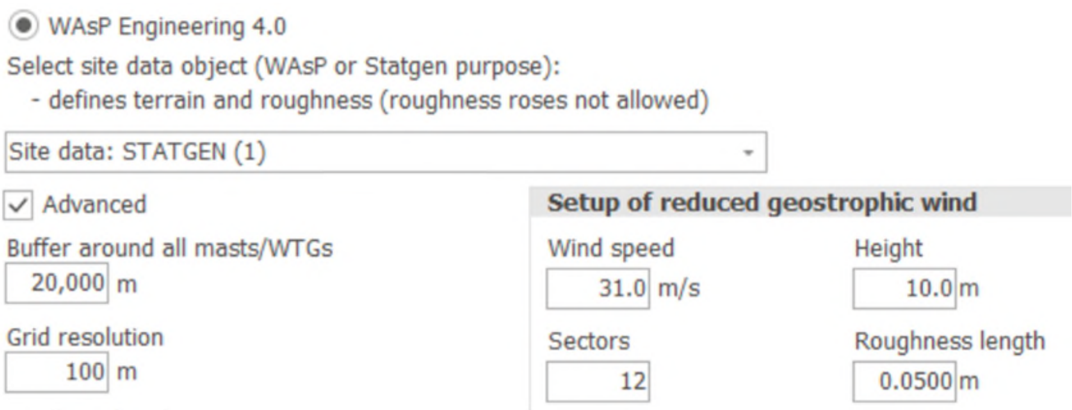
9.2.1. Extreme Wind Speed Model (EWM)

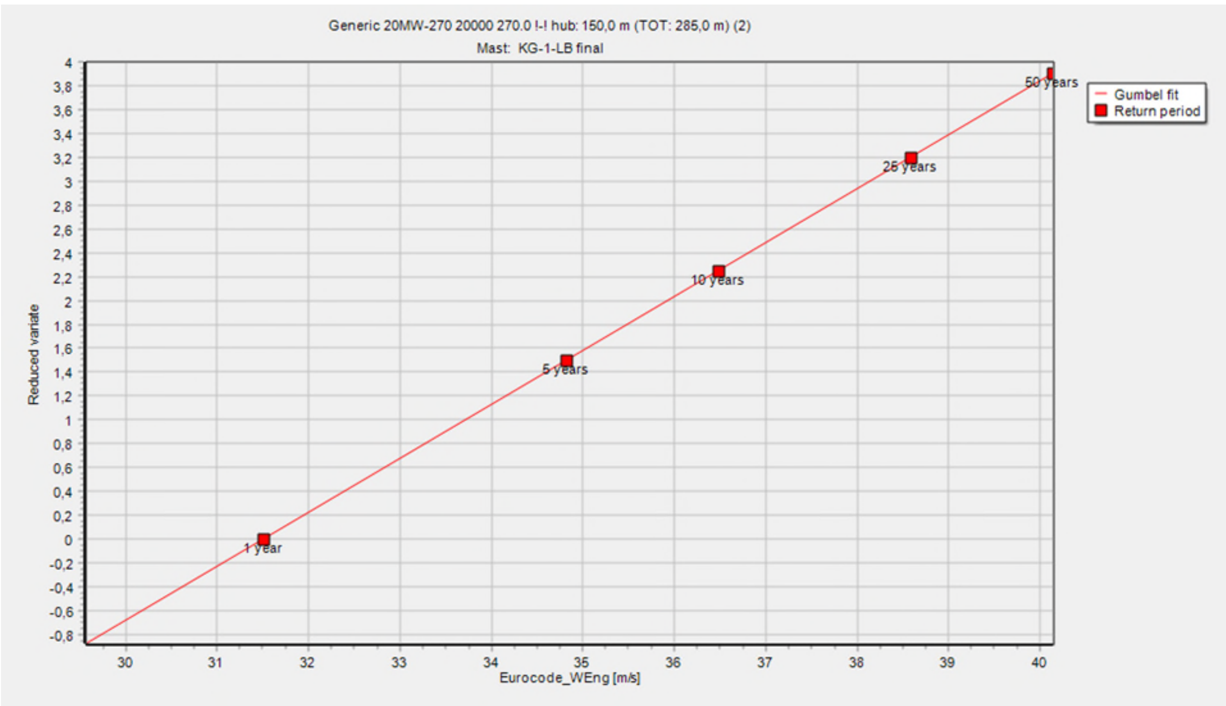
The site-specific extreme wind speed model is characterized by the extreme wind speed with a 50-year return period [1], which for offshore conditions is supplemented by the extreme wind speed with a 1-year return period [2].

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 [37]. The analysis was performed through Site Compliance in windPRO with settings as shown below:





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

Table 41. Extreme wind speed results at HS-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. [35]. For the method details of AM, see [38]. 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.

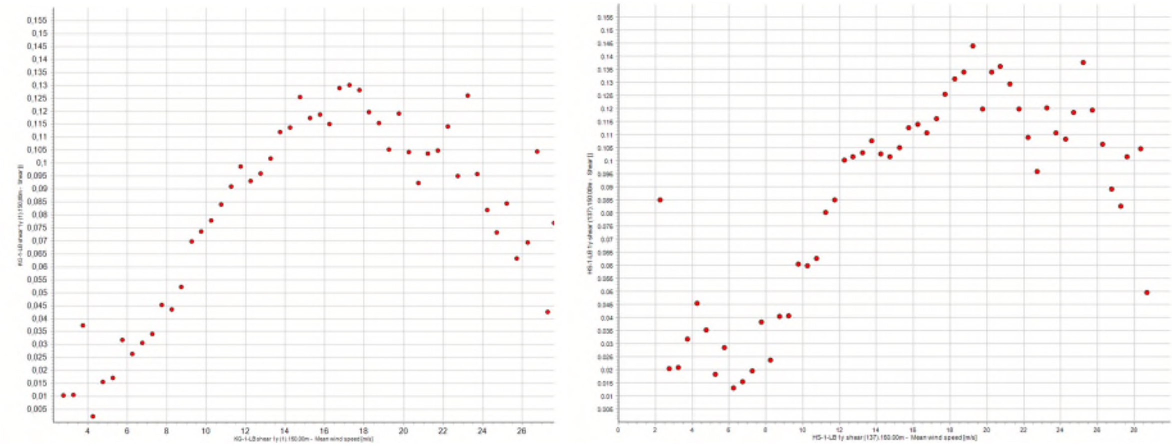
Table 42. Extreme wind speed alternative results using different methods (150 m).

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)	41.0
AM Mesoscale (20y) + Spectral correction (site specific)	41.3
POT (N=20, Δt_{min}=4 days)	39.0

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 South 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.



(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 43. 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 [39] and [40] 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 [41] 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]:

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

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

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:

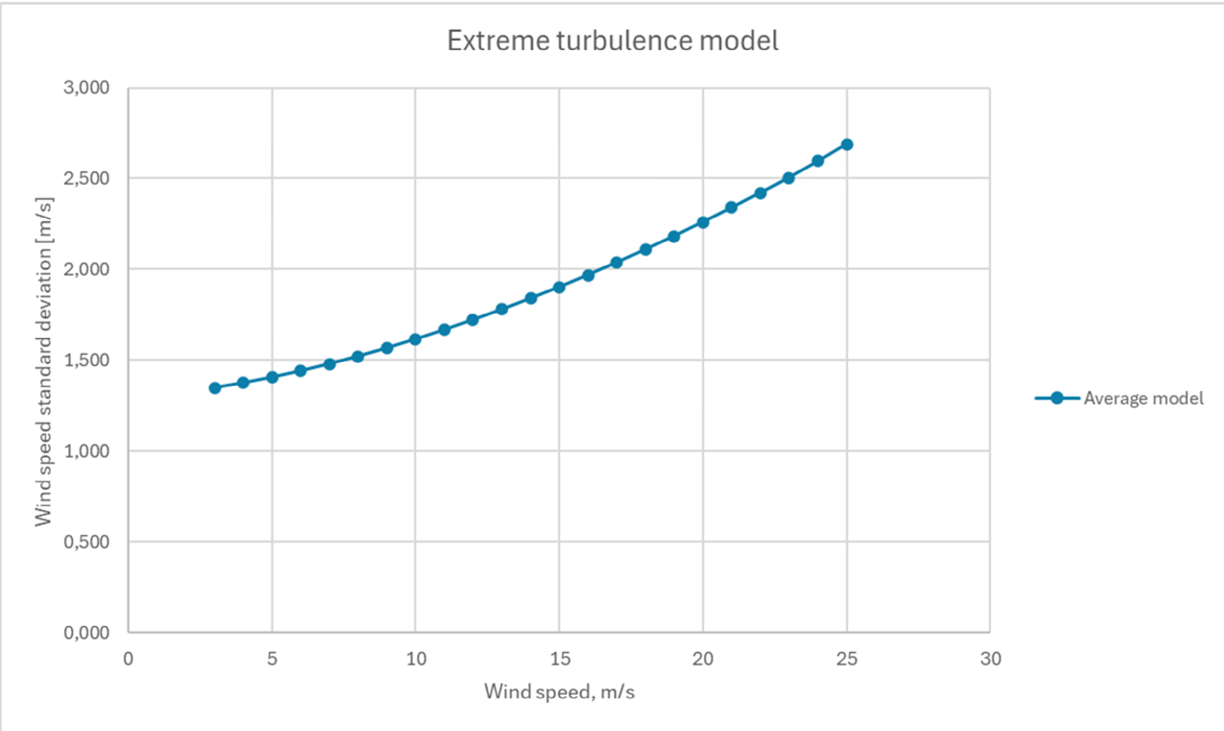


Figure 55. Extreme turbulence model. Turbulence is standard deviation of wind speed.

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 HS-1-LB. Alternatively, the air density for extreme wind conditions can be taken from GASP [35], which results in a value of 1.22 kg/m^3.

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

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

9.3. Additional Site parameters

9.3.1. Salinity

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

The salinity is assessed though the Copernicus Marine Service [42]. 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 [43], the lightning frequency of the site is 1.18 flashes/year/km^2.

9.3.3. Solar Radiation

Based on Heliosat, SARAH3 data [44] the average solar irradiance during the period 2004 to 2024 is 121 W/m^2. Peak solar irradiance does not exceed 880 W/m^2.

9.3.4. Earthquake

The site rates as Low Hazard with a peak ground acceleration of 0.22 m/s^2 [45]. With the low hazard rating, earthquakes need not be investigated further [2].

9.3.5. Relative Humidity

The HS-1-LB buoy measures the humidity near sea level. Based on 12 months of measurements the average relative humidity is 82.8% with a standard deviation of 9.6%.

9.4. Climate Change

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

- Mean wind speed
- Extreme wind

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

Of these parameters, all, except for extreme winds, are covered by the Copernicus Interactive Climate Atlas [46]. 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 Hesselø South 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 [47]. 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 [48] 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).

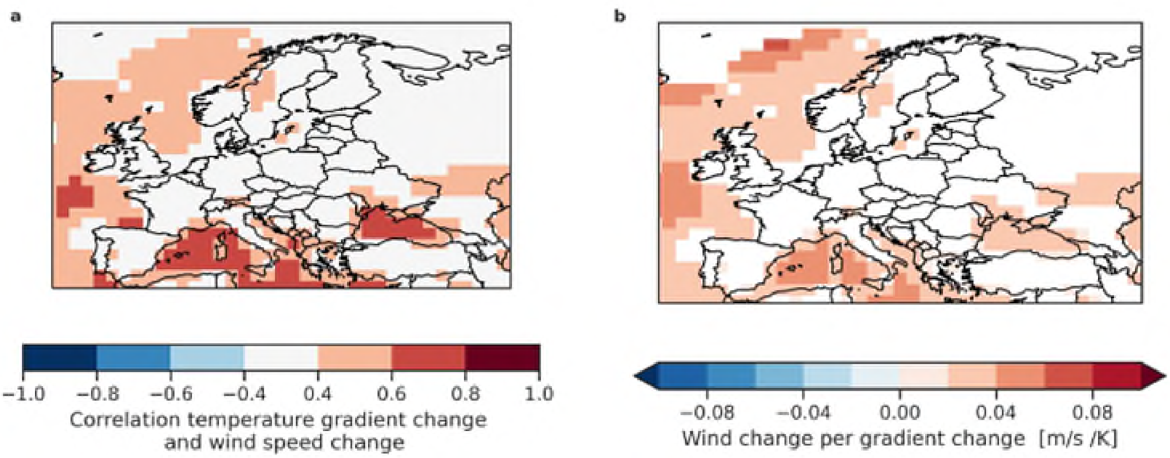


Figure 56. Relationship between changes in wind speed and the equator-to-pole gradient in Europe in the full CMIP6 ensemble. Correlations between changes (a) and the slope of a linear regression in locations where correlations exceed absolute values of 0.4 (b) [48]

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 [49]. Therefore, it is advisable to investigate multidecadal oscillations separately.

Wohland et al [50] 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.

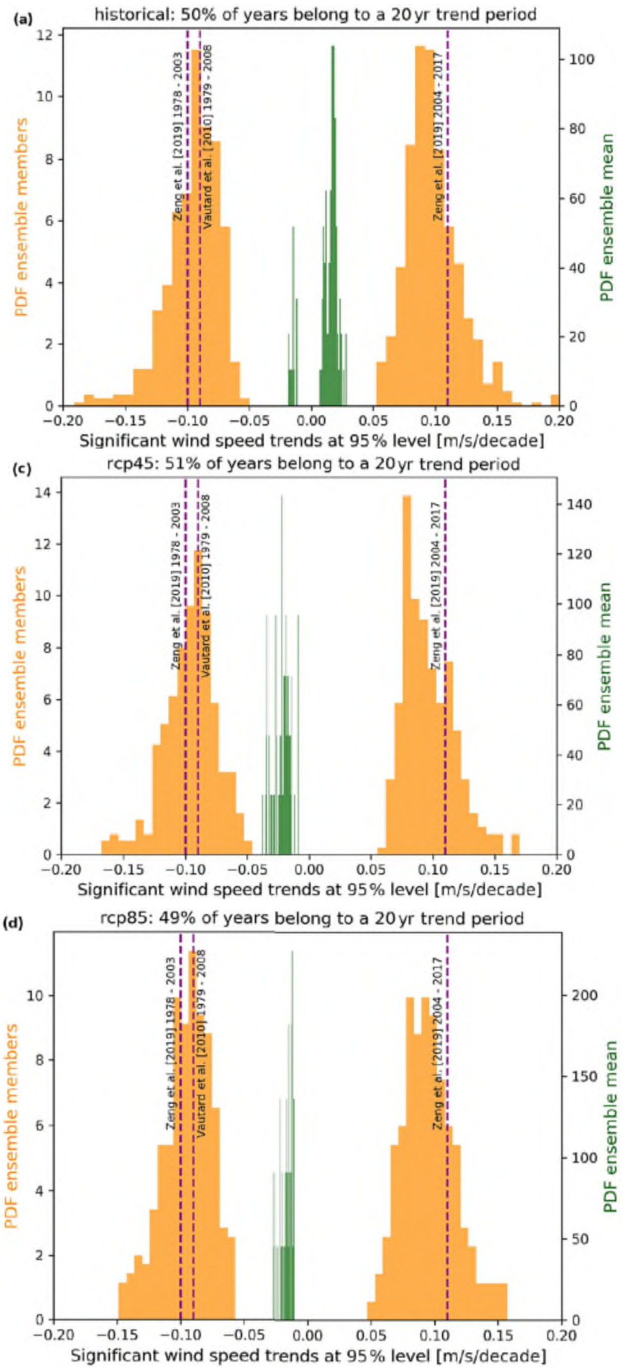


Figure 57. Twenty-year trends in European annual mean wind speed in Max Planck Institute - Grand Ensemble (MPI-GE) under historic (a) and future climate conditions (c) and (d). Trends are computed for each ensemble member after subtraction of ensemble mean (orange – representing internal variability)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

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 [51].

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 [52]. 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 [51].

For temperature, however, the Copernicus Interactive Climate Atlas [46] shows a robust signal when compared to the period 1991-2020. The absolute temperatures are illustrated in Figure 58.

0.7% lower air density, which will impact the power production of wind turbines in the area.

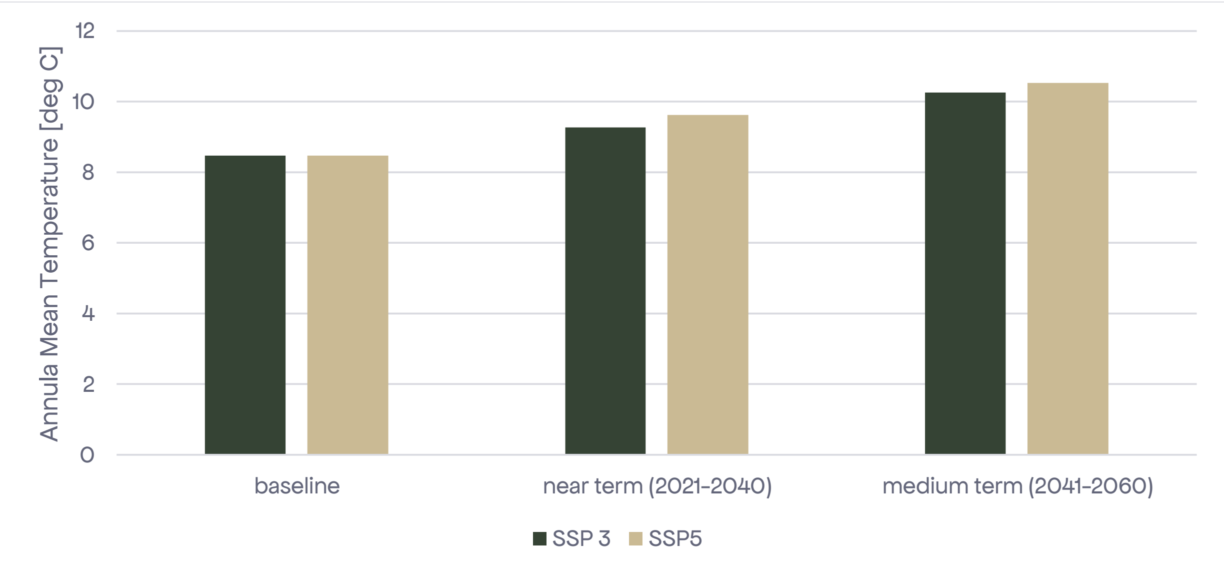


Figure 58. Development of the absolute annual temperature in the Hesselø South area.

To evaluate the changes of precipitation, the daily accumulated precipitation in mm/day was analysed from the Copernicus Interactive Climate Atlas [46]. 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 44.

Table 44. Summary table of siting parameters (150 m) at Hesselø South.

Parameter	HS-1-LB	HS-A	HS-B	HS-C
Mean wind speed	9.70 m/s	9.78 m/s	9.69 m/s	9.77 m/s
Weibull distribution, A parameter (scale)	10.96 m/s	11.04 m/s	10.94 m/s	11.03 m/s
Weibull distribution, k parameter (shape)	2.22	2.23	2.22	2.22
Normal wind profile power law exponent	0.090	0.090	0.090	0.090
Turbulence intensity mean value (TI_{μ}) at a 10-min average wind speed of 15m/s*	4.9%	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%	2.0%
Turbulence intensity 90% quantile at a 10-min average wind speed of 15m/s*	7.5%	7.5%	7.5%	7.5%
Mean air density	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3	1.23 kg/m^3
Mean air temperature	9.0°C	9.0°C	9.0°C	9.0°C
50-year extreme wind speed	40.1 m/s	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	31.5 m/s
Wind shear for extreme wind speed extrapolation	0.13	0.13	0.13	0.13
Characteristic turbulence intensity at 50-year extreme wind speed	12.0%	12.0%	12.0%	12.0%
Air density for extreme wind	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3	1.25 kg/m3
Lightning	1.18 flash/year/km^2	1.18 flash/year/km^2	1.18 flash/year/km^2	1.18 flash/year/km^2
Solar irradiance, mean	121 W/m^2	121 W/m^2	121 W/m^2	121 W/m^2
Solar irradiance, peak	880 W/m^2	880 W/m^2	880 W/m^2	880 W/m^2
Relative Humidity, mean	82.8%	82.8%	82.8%	82.8%

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

10. Data Package

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

10.1. Filtered and Repaired LiDAR Data

Datasets for the filtered and repaired datasets are provided in folder "20 Analysis/22 Filtered time series". The filter and repair process is described in section 4.4.3. The dataset represents 12 months of data. The text file can be imported directly into windPRO, but as an open format, it is generally accessible.

- HS-1-LB_12 month.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 45.

The dataset is also included as windPRO Meteo objects in an Object export file.

- HS-1-LB_12 months.wpobjects

The object export file can be imported into windPRO 4.2 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

Table 45. 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 data packages 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.....	Data status for other parameters.
OtherUID_xx,xm	Info flag at height xx.x m
TemperatureUID_4.0m,xm	
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 HS-1-LB, HS-A, HS-B and HS-C are included in the data package in the folder “20 Analysis/23 Long-term time series”. Position HS-1-LB includes all LiDAR measurement heights. Positions HS-A, HS-B and HS-C only include the 150 m height.

- HS-1-LB LTC.txt
- HS-A LTC.txt
- HS-B LTC.txt
- HS-C 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 HS-1-LB, HS-A, HS-B, HS-C.wpobjects

The object export file can be imported into windPRO 4.2 by right-clicking in the Object list and select Import -> Import from windPRO object import file.

10.3. EMD-WRF Dataset

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

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

The data columns are described in Table 46.

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

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

The object export file can be imported into windPRO 4.2 by right-clicking in the Object list and select Import -> Import from windPRO object import file. The object export file includes more parameters than presented in the text file.

Table 46. Column explanation for EMD-WRF data time series.

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

10.4. Wind Resource Map

The wind resource map calculated in section 8.3 is provided as an .rsf file (recognized WAsP format) in in the folder “50 Wind resource maps”:

- HS_Res_250_Hub_150.0_1.rsf

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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 A.1. The A.2 section deals with data analysis of different parameters. Finally, the long-term correction of the relevant supporting data is described in A.3.

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.

A.1.1. Kattegat Floating LiDAR (KG-1-LB)

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

A.1.1.1. Instrumentation

The LiDAR is a ZX300M LiDAR from ZXLiDARs Ltd and is mounted on the WS199 buoy (Figure 59).

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

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

This LiDAR model is classified by DNV-GL [19]. The LiDAR buoy WS199 has been pre-validated and passed Best Practice Criteria for all wind speed and direction ranges at all heights, except wind speed slope at 40 m [53].

Table 47. 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 WS199 is equipped with two additional meteorological sensors. Vaisala PTB330A measuring air pressure, Vaisala HMP155 measuring air temperature and humidity.

Operation history

Wind LiDAR buoy WS199 was deployed at Kattegat on 21st of July 2023. Fugro has submitted event logs tracking faults and flaws of the buoy [54]. Of these, only two events have had impact on the LiDAR data:

- The LiDAR stopped data collection for two days starting on 24/01/2024 due to abrupt input power outage.
- The buoy had been recovered for repairs on 18/02/2024 and redeployed on 22/02/2024. Therefore, the dataset has a 2-day gap due to service. EMD has verified and confirmed that the buoy was redeployed to the same location.
- The buoy was decommissioned on 04/08/2024.

A.1.1.2. 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)
-

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.

A.1.1.3. 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-

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.

A.1.1.4. 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 48. 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 vertical repair and another using data from Hesselø South LiDAR (HS-1-LB), referred to as horizontal repair. The vertical repair procedure is prioritized over the horizontal repair due to its expected lower uncertainty. The process is detailed in section 4.4.3

Table 48 lists the results of each repair procedure. The 12 m and 40 m heights are repaired only using the horizontal repair procedure, and the outcome of those repairs are not included in the mentioned table.

The horizontal repair was performed with HS-1-LB data before revision of heights on the WS190 buoy. As these potentially faulty data constitute only a 1/3 of the HS-1-LB dataset and are used to repair 3% of the KG-1-LB dataset, the error introduced is considered extremely small and no action was considered necessary to correct for this error.

Table 48. Results of data repair.

REPAIRED HEIGHT [M]	80	100	130	150	170	190	220	260	300
Source height [m]	40	80	100	130	150	170	190	220	260
Shear matrix heights [m]	40, 80, 100	80, 100, 130	100, 130, 150	130, 150, 170	150, 170, 190	170, 190, 220	190, 220, 260	220, 260, 300	220, 260, 300
Recovery rate before repair	96.6%	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%

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	9.97	95.5
Filtered	150	21/07/2023	21/07/2024	12	9.99	95.1
Repaired	150	21/07/2023	21/07/2024	12	10.00	98.4

A.1.2. 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.

A.1.2.1. 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 [55]. In the following, only instruments relevant for the site wind conditions are described.

This LiDAR model is classified by DNV-GL [19]. A similar model, but not the same instrument was verified at the Pershore, UK, test site by DNV-GL [56]. The specific instrument deployed on the Eolos FLS200-E01 was verified by Multiversum at the TNO Lichteiland Goeree Offshore Test Site, NL [57].

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 [55].

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: [55].

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 , 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.

A.1.2.2. 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

A.1.2.3. Eolos Post-processing of Data

Eolos has provided some information on the post-processing of the LiDAR data [58].

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 a 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.

A.1.2.4. EMD Filtering of LiDAR Data

Eolos reports [58] 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 [57], 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.

A.1.2.5. 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 [36].

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 50 lists the properties of each repair procedure.

Table 50. 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 51. 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**

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

A.1.3. Læsø Offshore Met Mast (M1)

Wind data from an offshore measurement mast has been provided by Energinet. The met mast was setup in Kattegat Sea about 17 km south of the island of Læsø. The distance to Danish and Swedish coast is about 45 km and 66 km. The available measurements used are shown in Table 53.

Table 53. Measurement data at Læsø met mast

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

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

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

EMD had access to a wind resources report [59] analysing the measured data until November 2002 and describing the equipment installed and mast details. According to the documentation available [59] EMD has not received any calibration reports nor installation report describing the type of sensors and the detials of the mounting (boom orientation, length, distance to lightning finial). It has thus not been possible to check if the installation has been conducted according to the IEC standards [60]. 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 54.

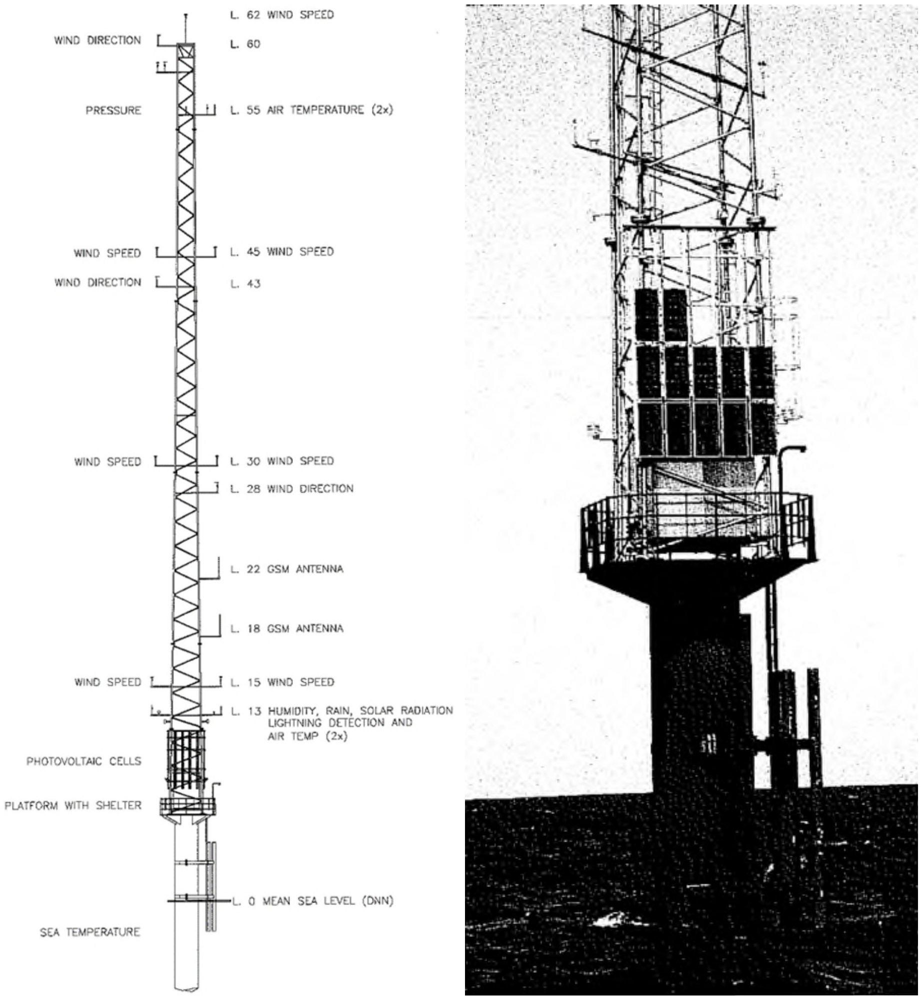


Figure 61. Pictures and details from Læsø met mast, source: [59]

Table 54. 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

30	CUP30SV	Cup Anemomter Unknown type	225°	4.75 m	Unknown
30	CUP30NO	Cup Anemomter Unknown type	45°	4.75 m	Unknown
15	CUP15SV	Cup Anemomter Unknown type	225°	5.40 m	Unknown
15	CUP15NO	Cup Anemomter Unknown type	45°	5.40 m	Unknown
60	DIR60SV	Wind vane Unknown type	225°	4.20 m	Unknown
58	DIR58M	Wind vane Unknown type	0°	Unknown	Unknown
43	DIR43SV	Wind vane Unknown type	225°	4.40 m	Unknown
28	DIR28SV	Wind vane Unknown type	225°	4.80 m	Unknown
55	TEMPA55NO	Temperature sensor, absolute	45°	Unknown	Unknown
13	TEMPA13NO	Temperature sensor, absolute	45°	Unknown	Unknown

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

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

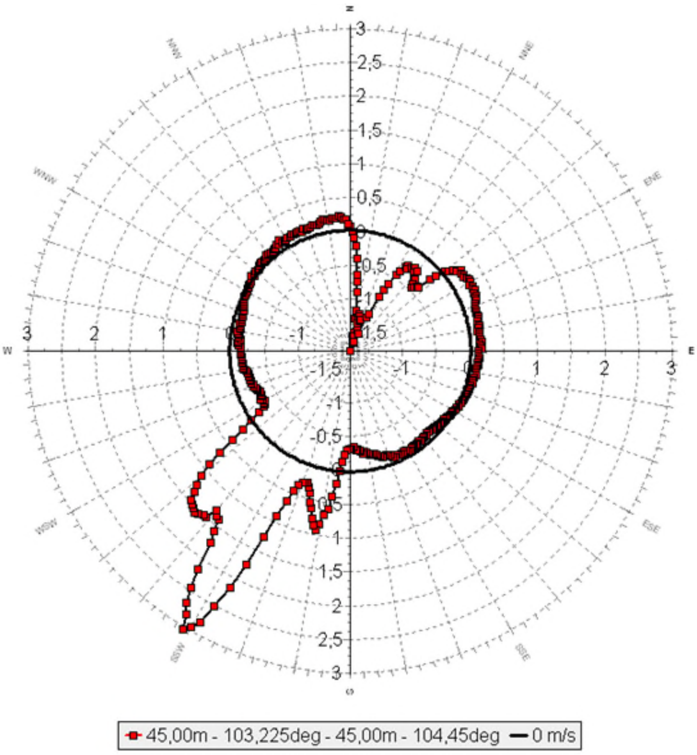


Figure 62. Wind speed difference between 45 m SV and 45 m NE, binned by direction at Læsø

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

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

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

A final of 4 full years, from 01/07/1999-01/07/2003, have been selected. The data from the 62 m anemometer is the primary data from the Læsø met mast considered in the study. The recovery rate of the data for this period (94.7%) complies with the minimum requirements of MEASNET [61]. 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 55. 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

A.1.3.1. FINO2 Met Mast

Wind data from the FINO2 offshore measurement mast has been used to assess the expected turbulence conditions on the Hesselø South 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 HS-1-LB is about 170 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: [62]).

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).

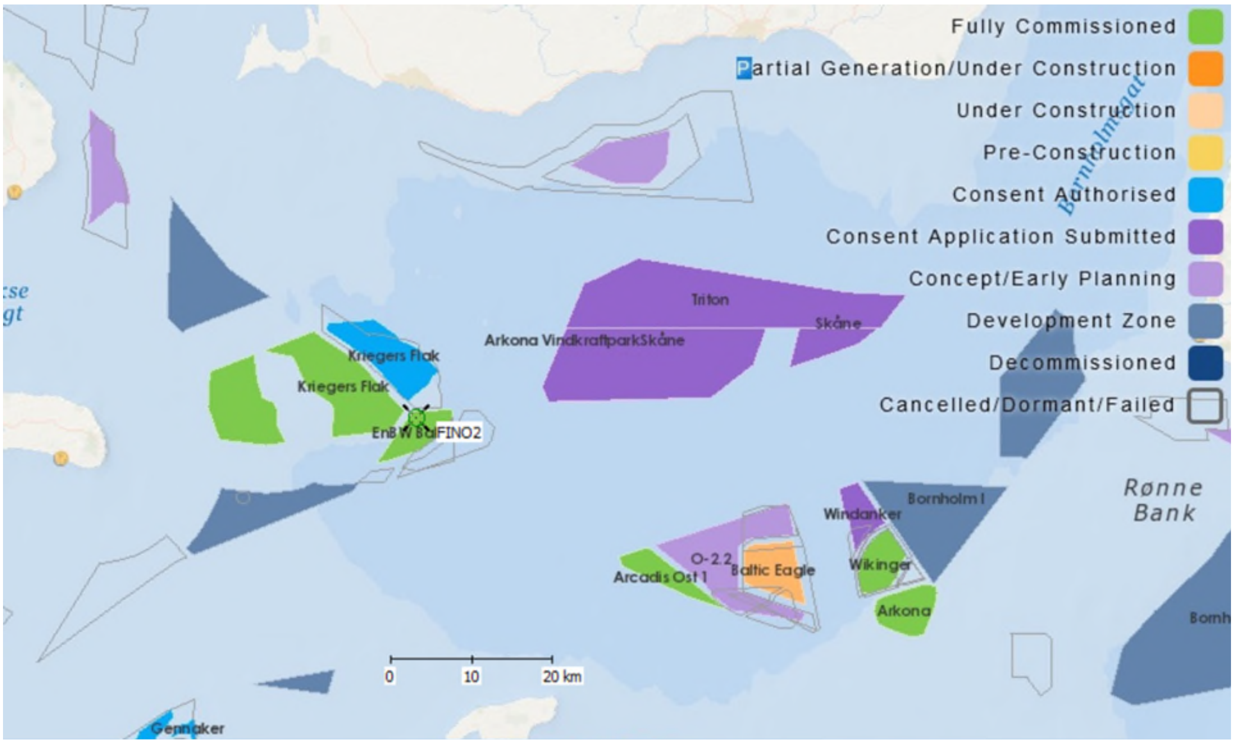


Figure 64. Indicative location map for FINO2 with existing wind farms in green (background map: 4C Offshore [63]).

EMD has access to a mast report [64] 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 [64], FINO2 design and installation has not been conducted fully according to the IEC standards [60], 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 56. 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

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.

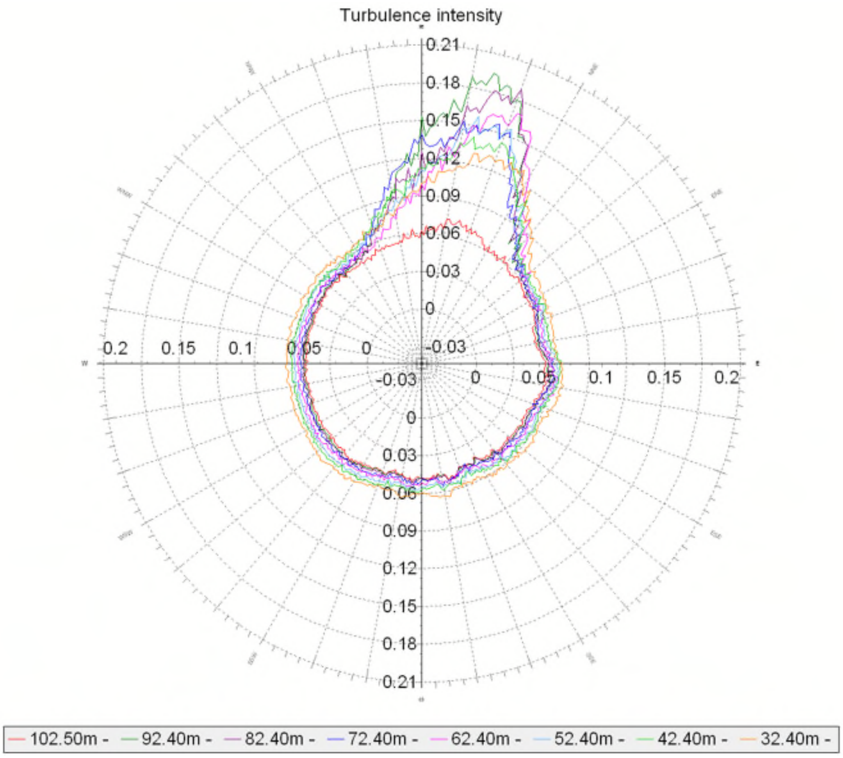


Figure 65. Directional Turbulence Intensity for the cup anemometers, FINO2.

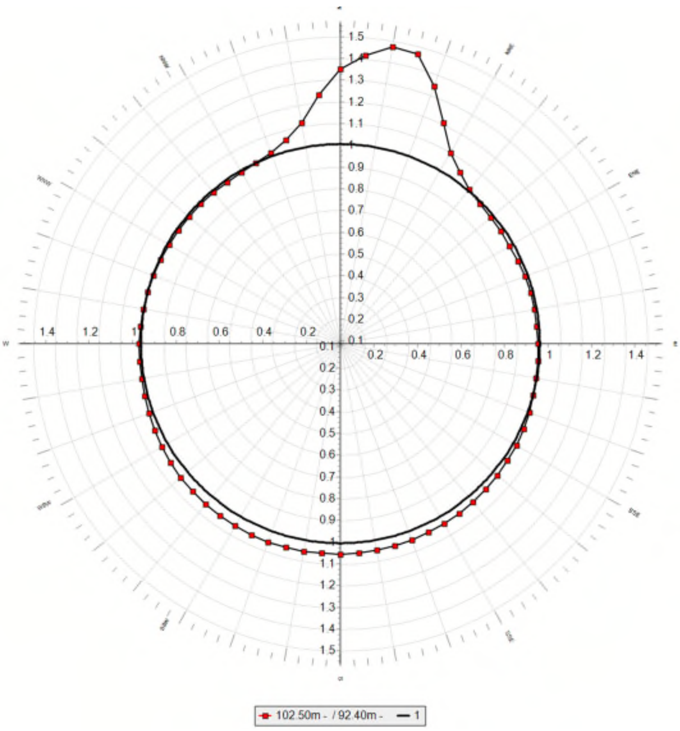


Figure 66. Directional wind speed ratio between 102.5 m and 92.5 m data, FINO2.

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 [60].

A.1.3.2. FINO3 Met Mast

Wind data from the FINO3 offshore measurement mast has been used to assess the expected turbulence conditions on the Hesselø South 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 300 km southeast of the HS-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.

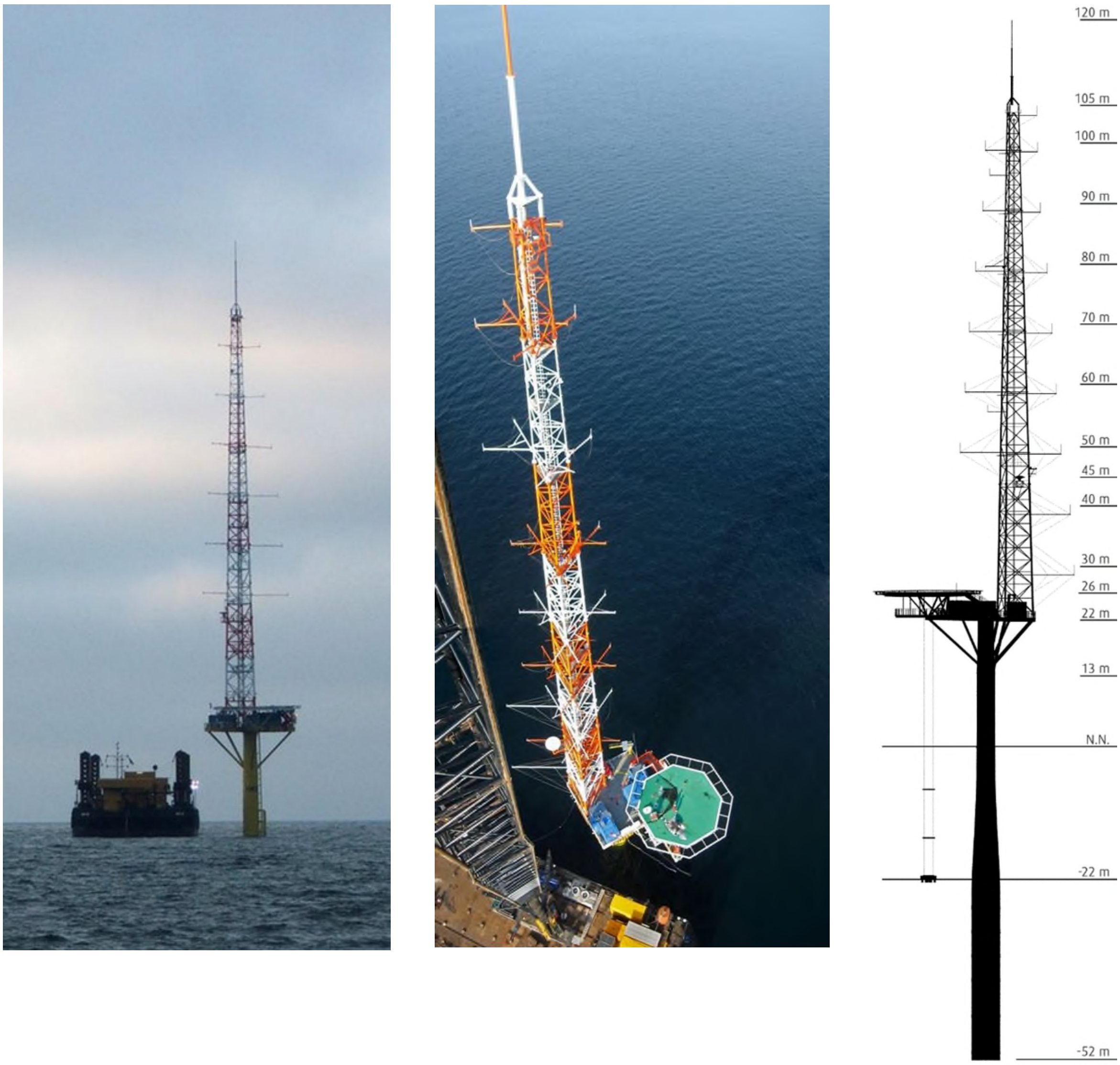


Figure 67. Pictures and details from FINO3, source: [65]

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 [64] 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 [64], FINO3 design and installation has not been conducted according to the IEC standards [60], especially in relation to the sizes of the mast and booms.

Table 57. Mounting of sensors on the FINO3 mast

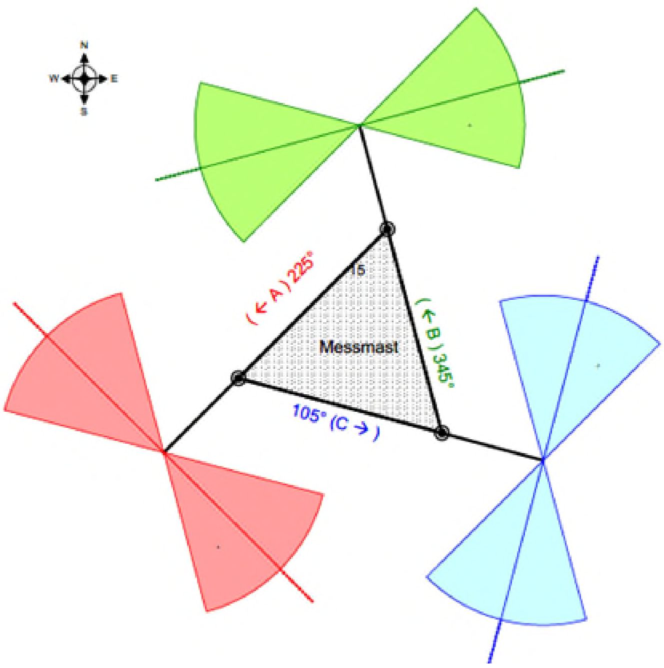
HEIGHT ASL [M]	INSTRUMENT IDENTIFICATION	DESCRIPTION	MOUNTING AND ORIENTATION	HORIZONTAL BOOM LENGTH [m]	VERTICAL BOOM LENGTH [m]
107	AN 107m - B	Cup anemometer - Vector A100L2	345°	3.5	1.75
101	AN 101m - B	Cup anemometer - Vector A100L2	345°	3.2	1.75
101	Sonic 101m - A	Ultrasonic anemometer - RM Young 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
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 56 and Figure 68. The data has been merged based on the detected distortions (Figures 65 and 70).



directions, source: [64]

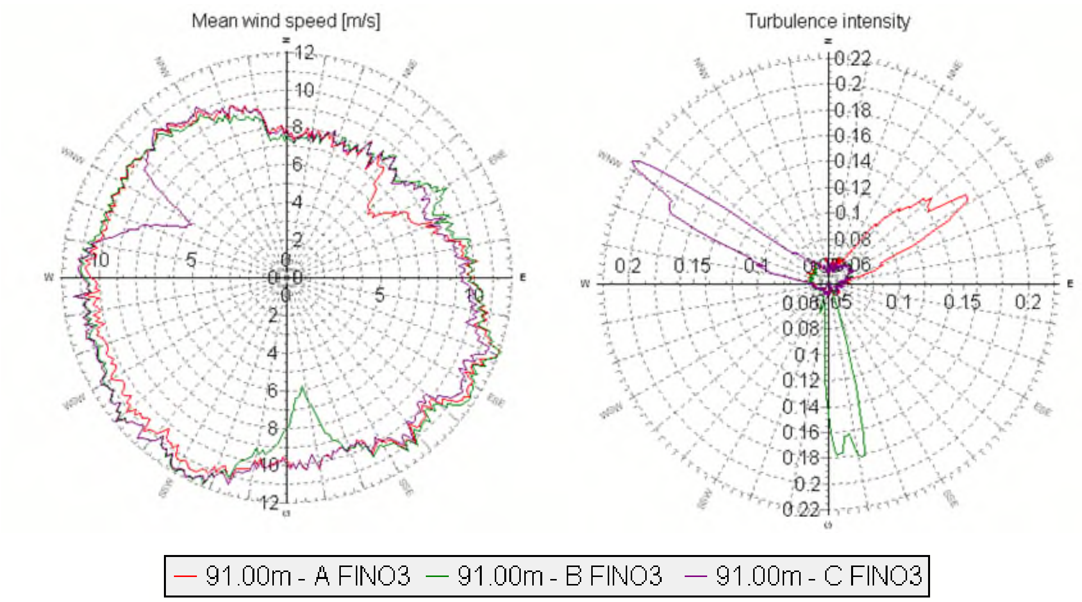


Figure 69. Directional Mean wind speed (left) and Turbulence Intensity (right) for the 3 cup anemometers at 91 m, before merging.

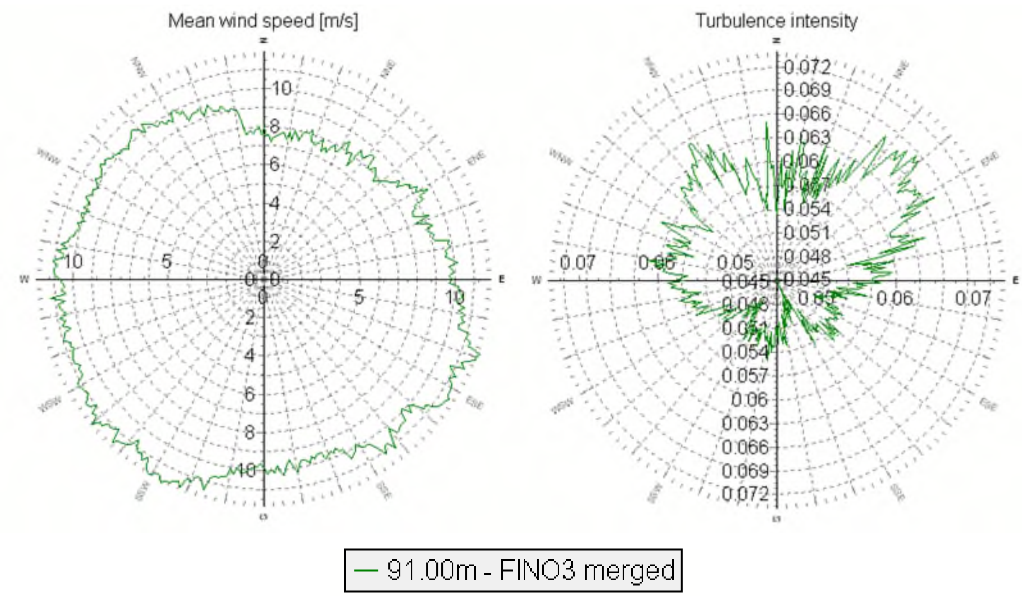


Figure 70. Directional Mean wind speed (left) and Turbulence Intensity (right) at 91 m, after merging.

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 [60] and compensating for the possibility to correct the mast distortion.

A.1.4. Ground Meteo Stations

A.1.4.1. 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 58.

Table 58. Measuring information of Anholt meteorological station

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

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

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

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

Raw data verification and data treatment

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

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

The data is trimed to 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%.

A.1.4.2. Gniben

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

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

Observations at Gnibben have been conducted in different periods, characterized by different time interval and locations, as provided by DMI [8]. The locations are shown on Figure 72 and listed on Table 59.

Table 59. 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%.

A.1.4.3. 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 60. The actual position ("Na2" on Figure 73) which is valid for the 10 minutes interval datasets 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 60. 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%.

A.1.4.4. 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 61. 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%.

A.1.4.5. 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 62 and Figure 75.

Table 62. 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%.

A.1.4.6. 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 62 and Figure 75.

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

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%.

A.1.5. 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 have been considered redundant with Anholt Haven station. They are also considered to be too far away from the analyzed wind farm area.

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

A.2. Data Analysis of Supporting Data

A.2.1. Wind Speed Distribution

The following table summarizes the resulting measured wind speeds.

Table 64. 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
Kattegat (KG-1-LB)	150	10.00	32.02	9.97	11.26	2.17
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

A.2.2. 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.

Kattegat (KG-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)

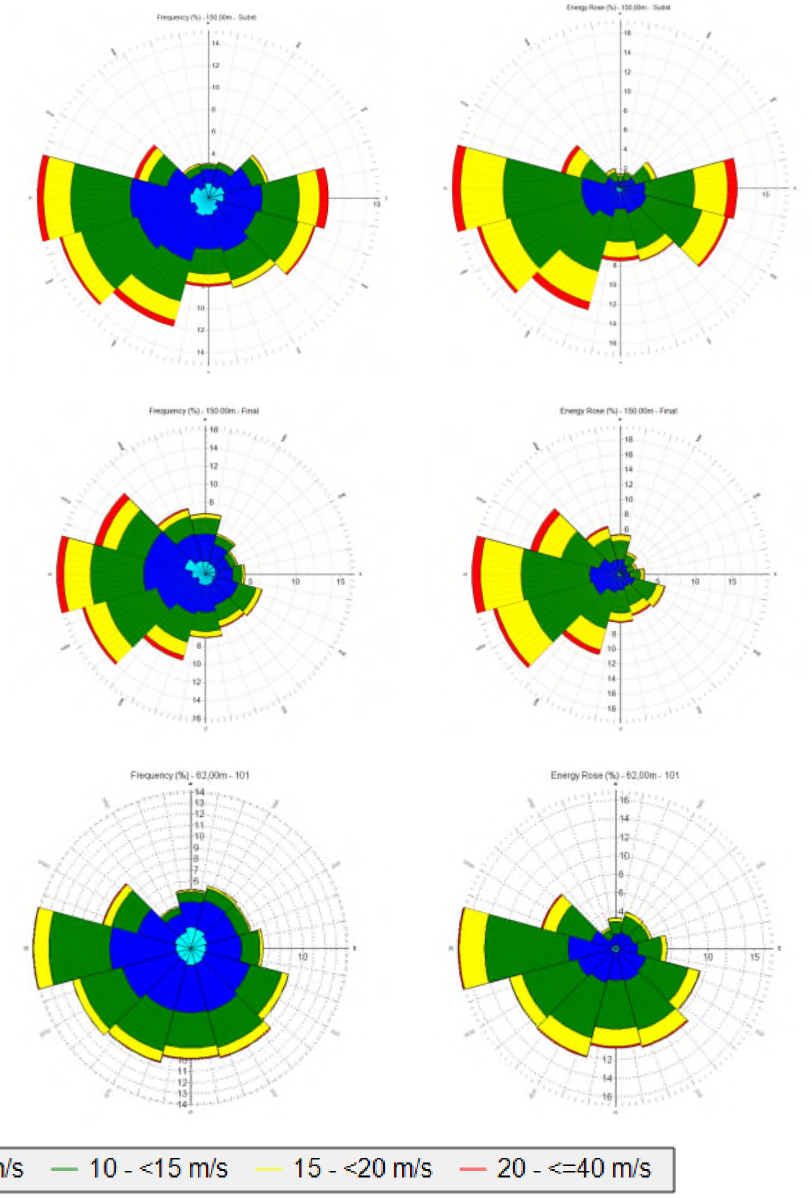


Figure 77. Supporting data wind direction frequency (on the left) and energy (on the right) distribution.

A.2.3. Turbulence Intensity

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

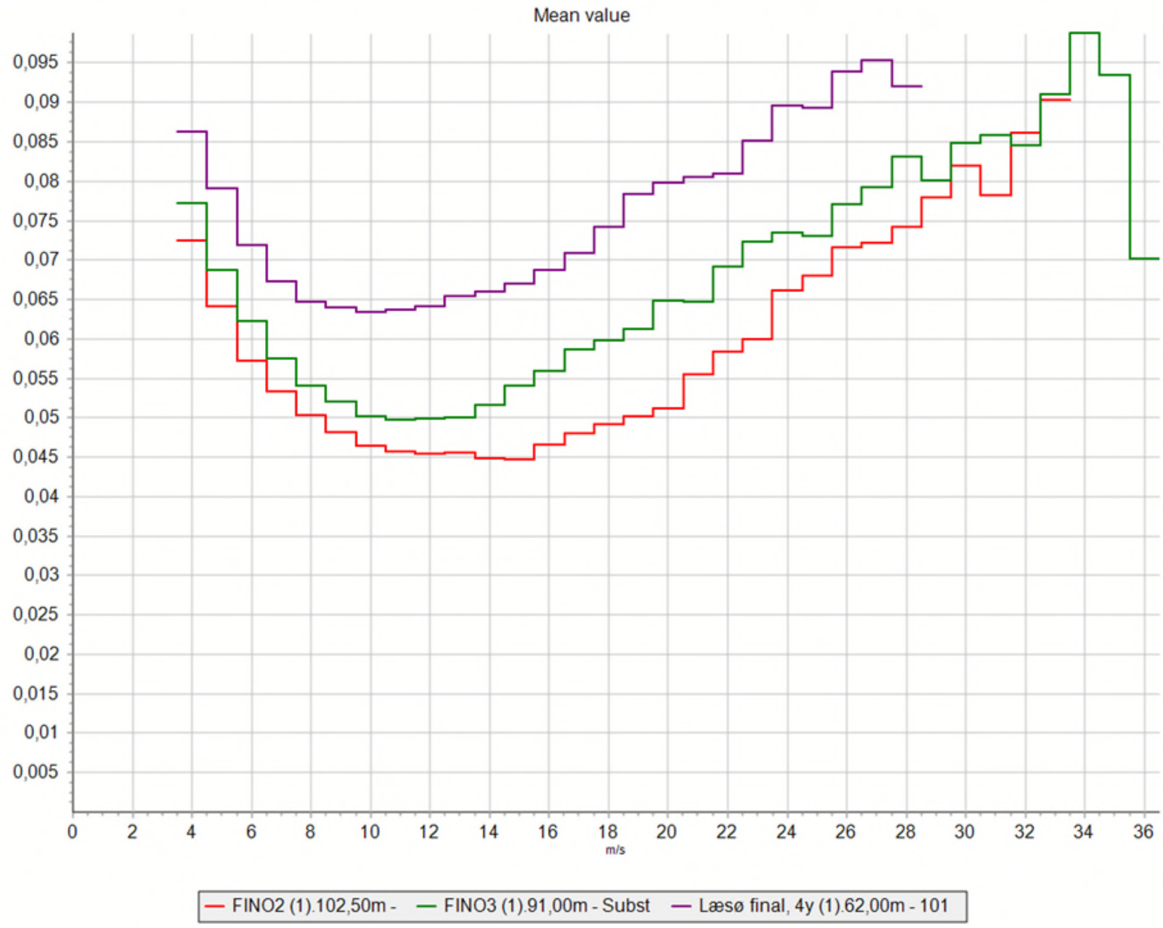


Figure 78. Turbulence intensity measured at FINO3, FINO2 and Læsø

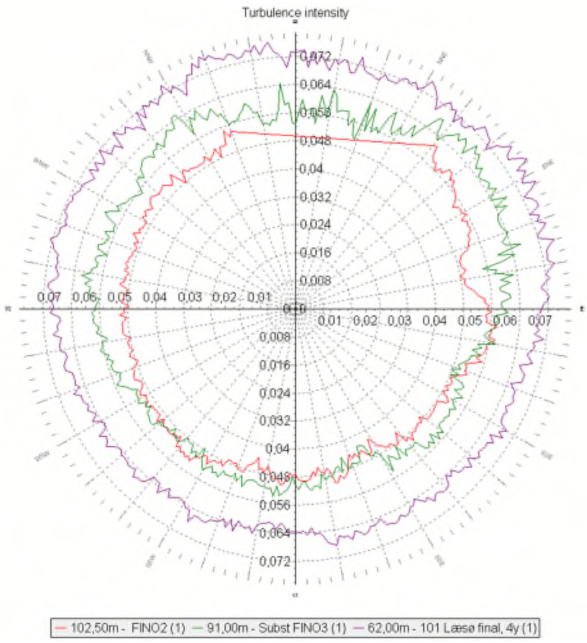


Figure 79. Measured turbulence intensity measured at FINO3, FINO2 and Læsø by wind direction.

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

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

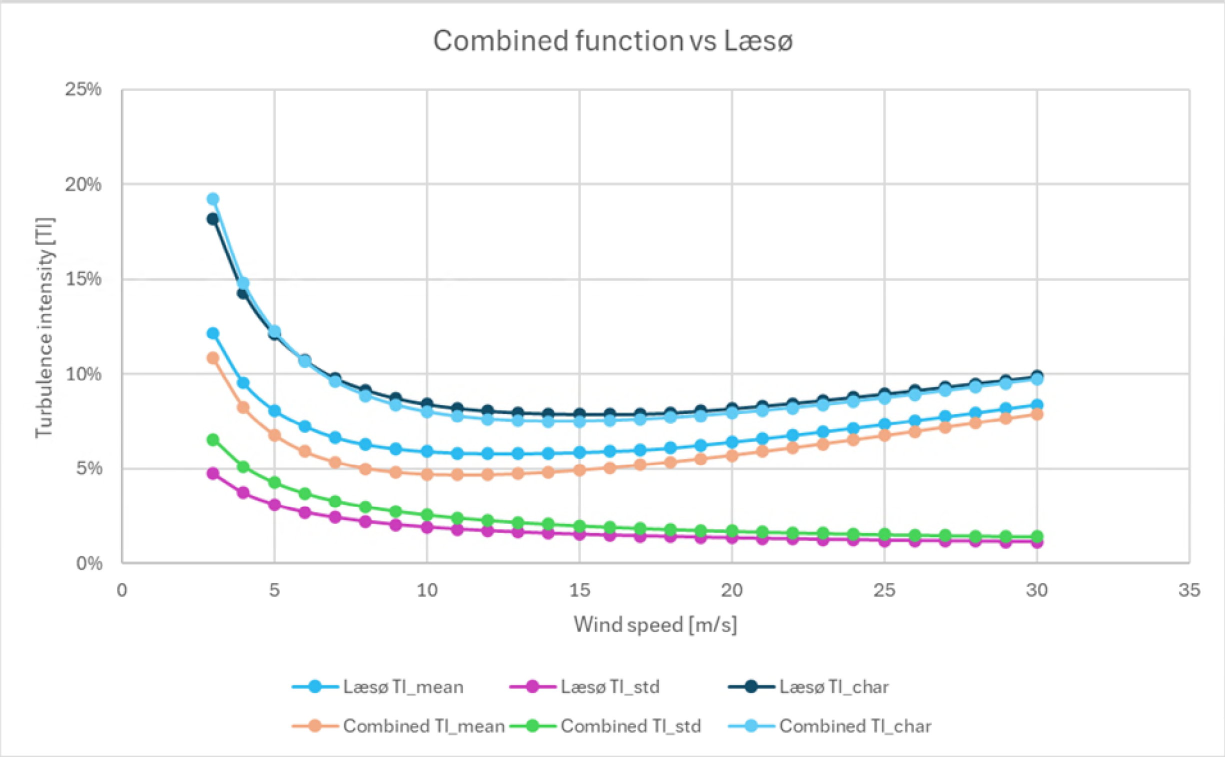


Figure 80. Mean turbulence intensity (TI_mean), Standard deviation of turbulence intensity (TI_std) and Characteristic turbulence intensity for the Combined model and Læsø turbulence extrapolated to 150 m.

A.2.4. Diurnal Variation Wind speed

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

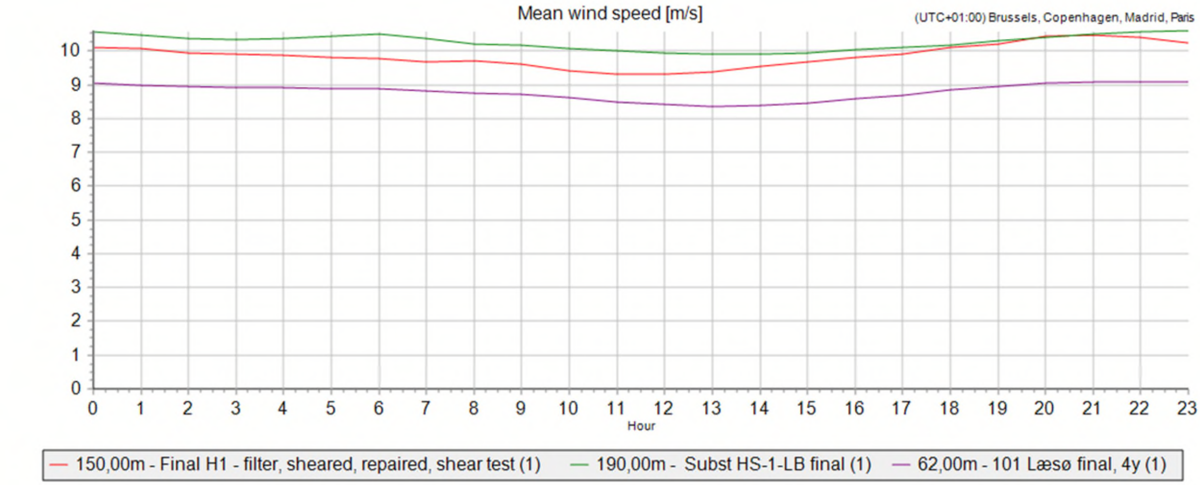


Figure 81. Daily variation of wind speed at H1, 1 year - 150 m (red), HS-1, 1 year 150 m (green) and M1, 4-year, 62 m (purple).

A.2.5. Seasonal Variation Wind speed

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

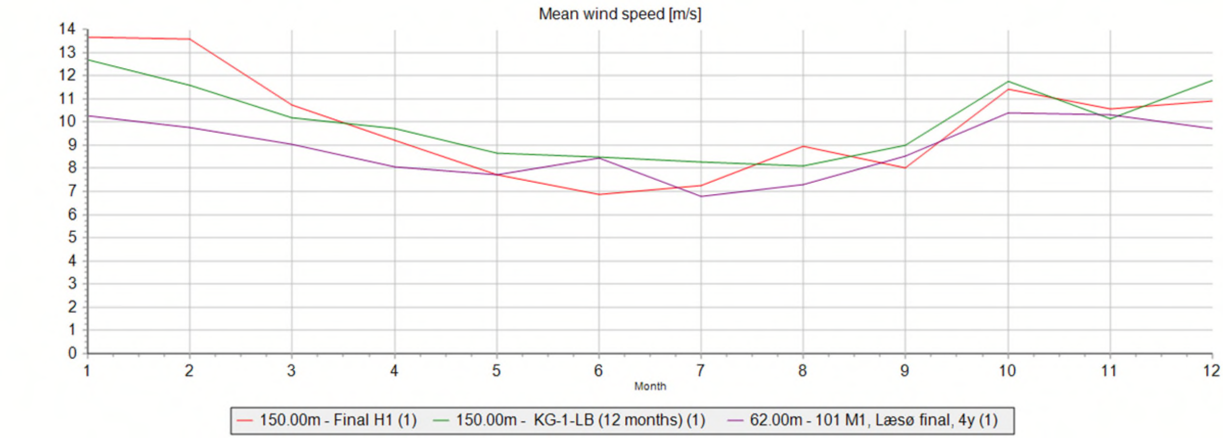


Figure 82. Monthly variation of wind speed measured at H1 - 150 m (1 year) (in red), KG-1-LB - 150 m (1 year) (in green) and M1 - 62 m (4 years) (in purple).

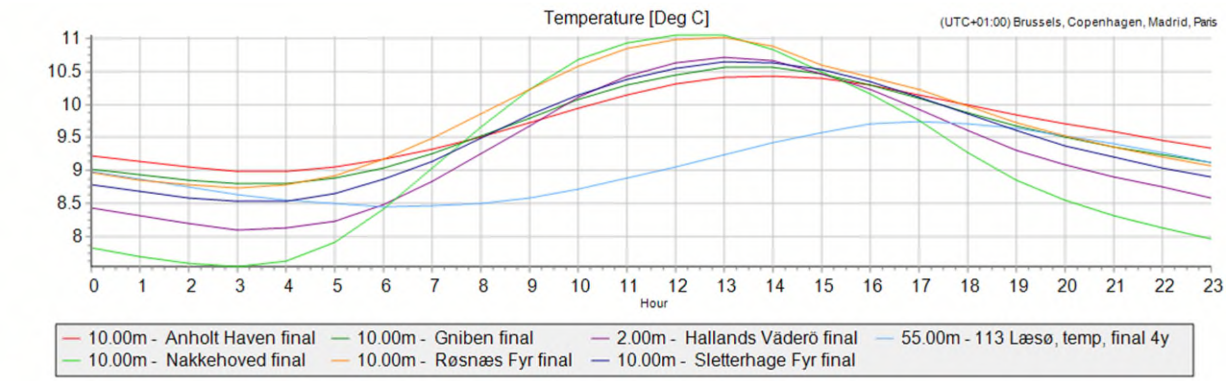
A.2.6. Temperature

A summary of the mean temperature measured on the 9 secondary data sources is presented in Table 65.

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 Hesselø South OWF more than the onshore stations Figure 83.

Table 65. Summary of Secondary Temperature data

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



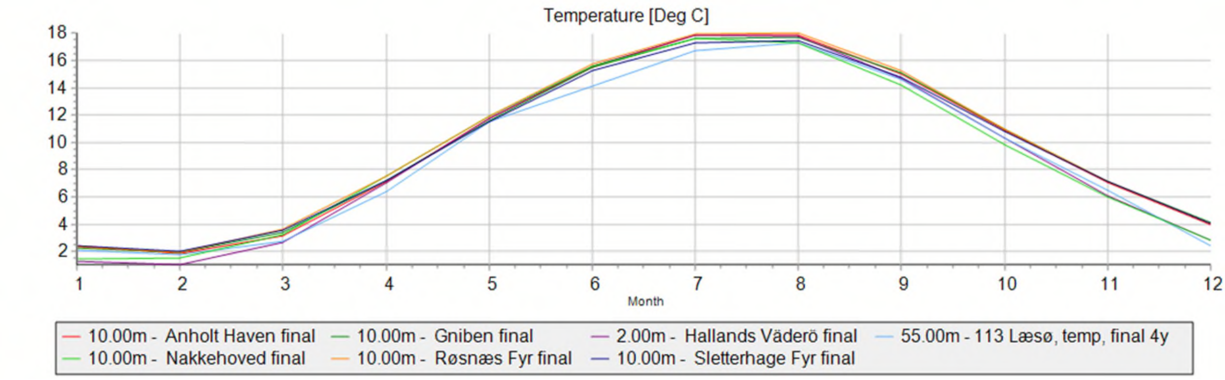


Figure 83. Diurnal and monthly variation of absolute temperature at the 7 secondary data sources.

A.3. Long-term Correction of Supporting Data

The measurement data from Kattegat (KG-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.

A.3.1. 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 [27].

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 66.

Table 66. Best performing reference data and long-term correction methodology (LTC) for each secondary dataset.

REF: EMD-WRF	KG-1-LB	H1	M1
Reference dataset	ERA5(T)	EMD-WRF	EMD-WRF
Correlation, r [%] Wind Speed, hourly	94.4	94.9	93.5
Correlation, r [%] Wind Energy, monthly	99.4	99.8	99.1
LTC methodology	Matrix	Matrix	Matrix
MBE, 24-hour slicing test, % production	1.84	0.75	-0.64
MBE, Concurrent period prediction test, % production	0.37	0.23	-0.03

A.3.2. Long-term Wind Speed Distribution

The long-term corrected wind speeds and wind distributions are presented in Table 67.

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

Table 67. Long-term corrected wind speed and wind distribution, secondary data.

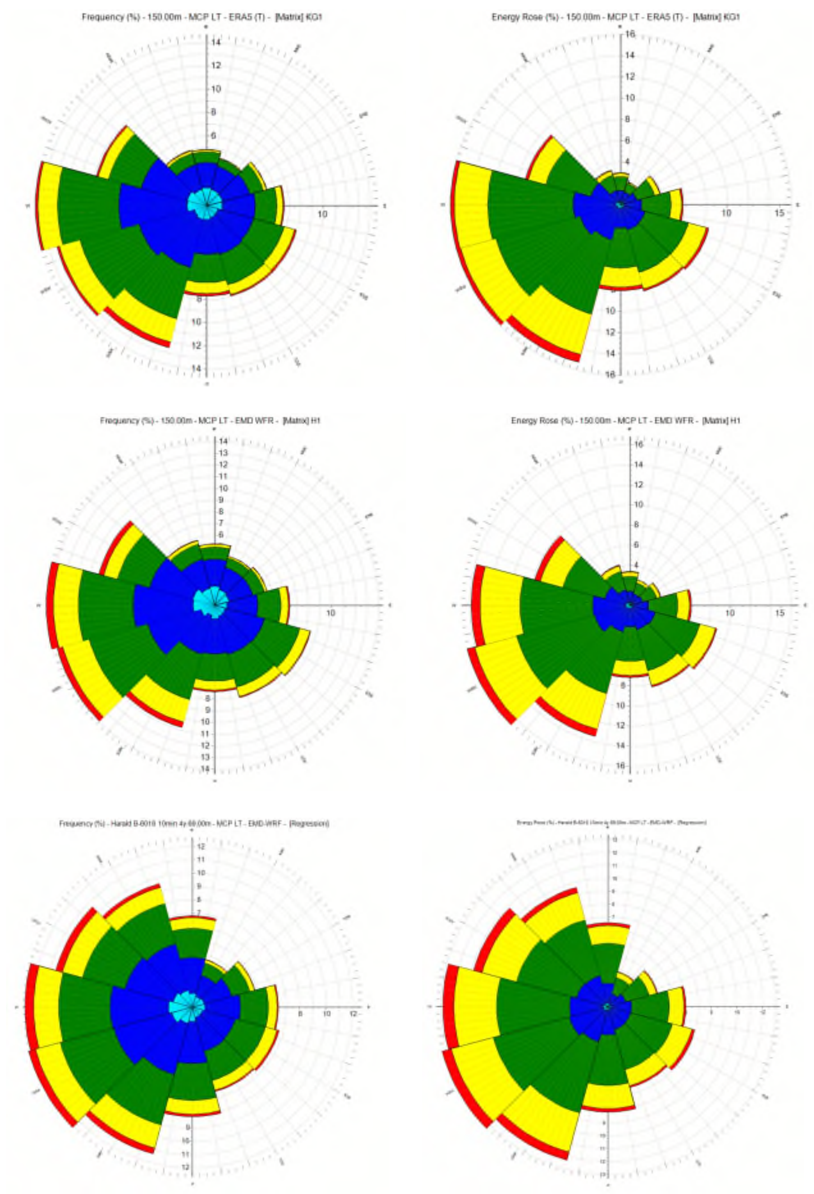
	ELEVATION ASL [m]	PERIOD [Y]	ARITHMETIC MEAN WIND SPEEDS [m/s]	WEIBULL MEAN [m/s]	WEIBULL - A PARAMETER	WEIBULL - k PARAMETER
KG-1-LB	150	22	9.51	9.60	10.83	2.27
H1	150	22	9.73	9.86	11.13	2.21
M1	62	22	8.98	9.14	10.31	2.40

A.3.3. Long-term Wind Direction Distribution

KG-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)



0 - <5 m/s — 5 - <10 m/s — 10 - <15 m/s — 15 - <20 m/s — 20 - <=40 m/s

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

A.3.4. Long-term Diurnal Variations

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

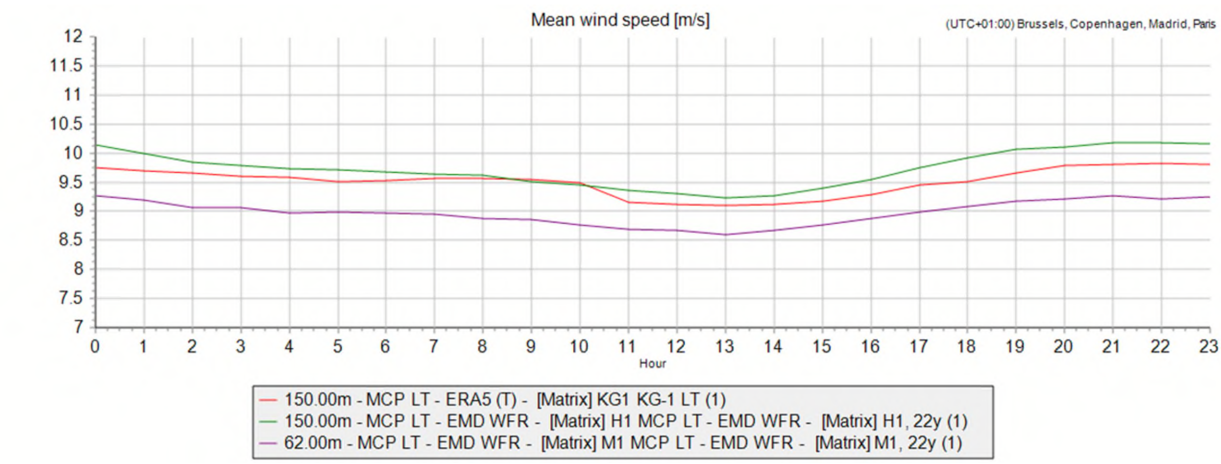


Figure 85. Long-term corrected diurnal variation, secondary data. Red: KG-1-LB, green: H1, purple: M1.

A.3.5. Long-term seasonal variations

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

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

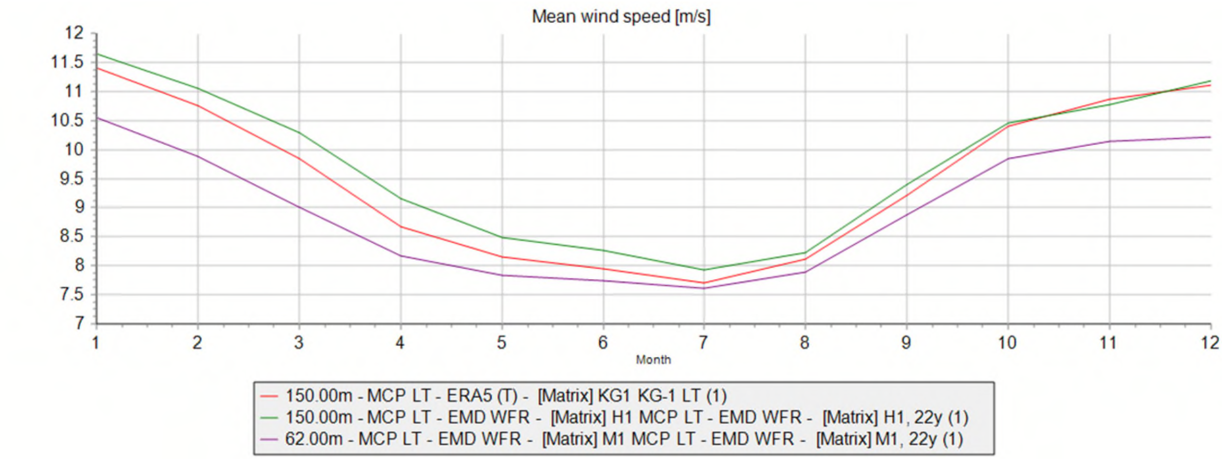


Figure 86. Long-term corrected seasonal variation, secondary data. Red: KG-1-LB, green: H1, purple: M1.

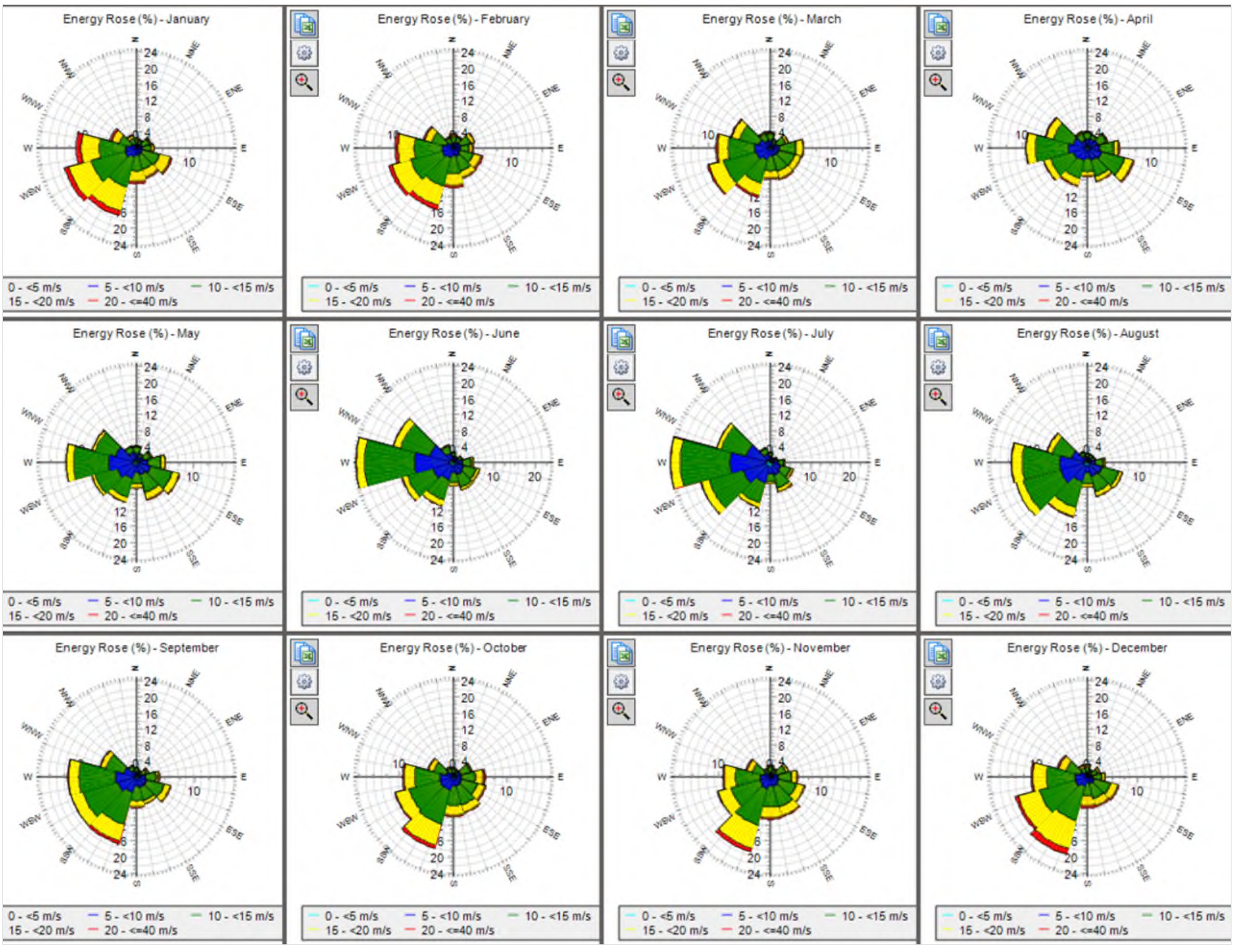
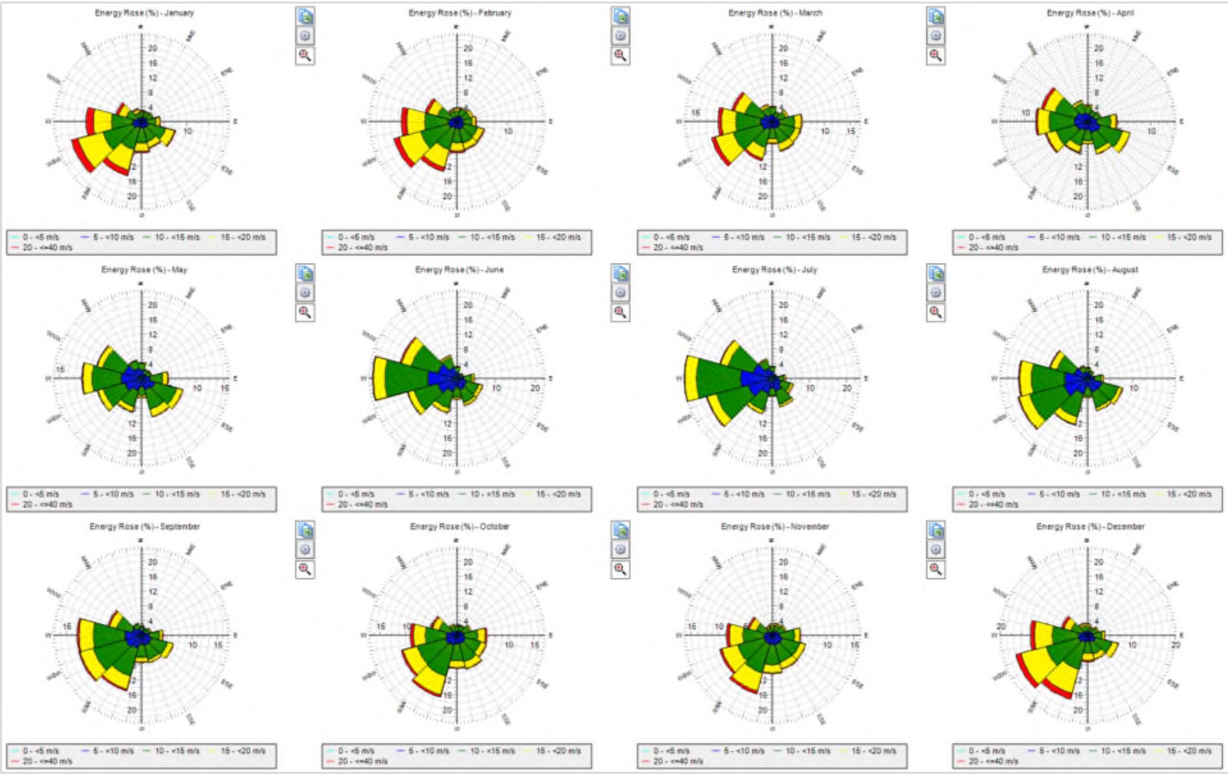
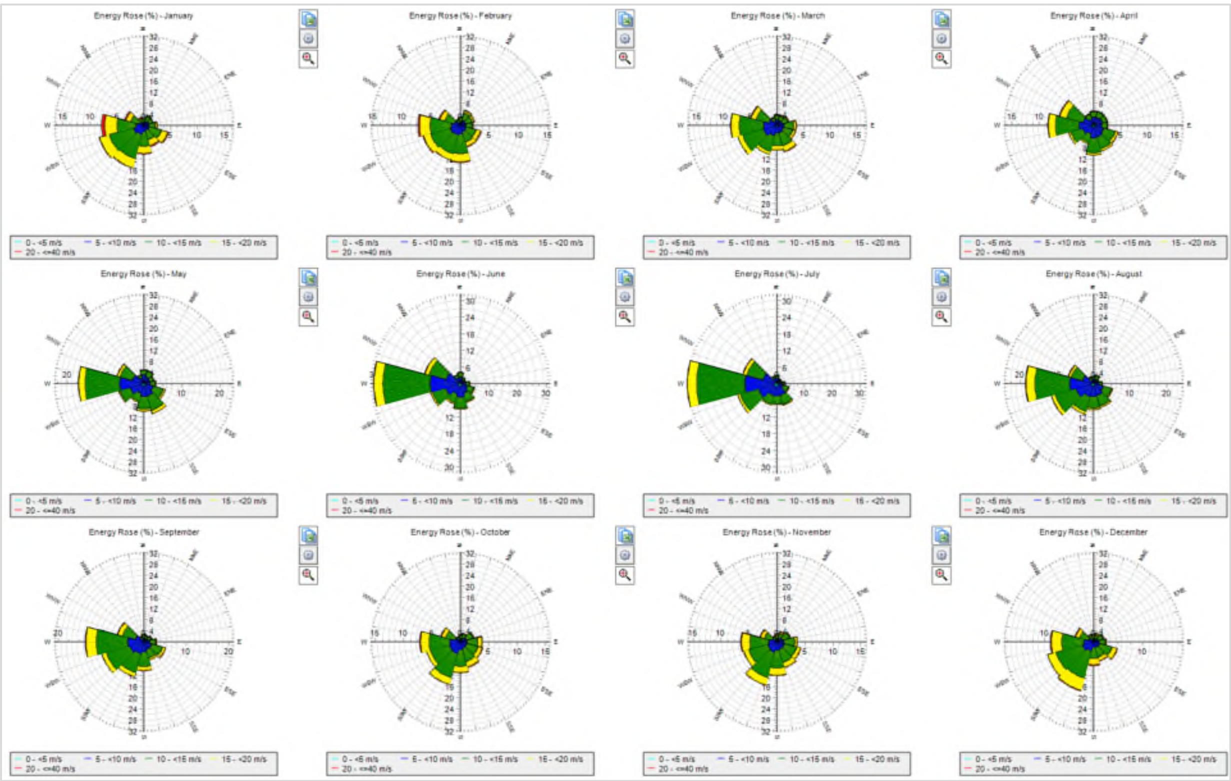


Figure 87. Long-term monthly energy roses, KG-1-LB (first line: January-April; second line: May-August; last line: September-December).



last line: September-December).



last line: September-December)

Appendix B Verification and Classification Uncertainty

Verification uncertainty at 160 m height for SWLB059 [16].

Table 6-4 Uncertainty calculation at 160 m

SWLB059 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	128	4.06	4.01	4.93	3.45	0.25	0.022	1.29%	0.50%	0.25%	1.94%	**2.46%**
4.25	4.75	142	4.53	4.51	5.36	3.85	0.26	0.022	0.52%	0.50%	0.25%	1.63%	**1.87%**
4.75	5.25	148	5.03	5.00	5.70	4.30	0.23	0.019	0.55%	0.50%	0.25%	1.70%	**1.91%**
5.25	5.75	181	5.51	5.51	6.20	4.38	0.32	0.023	-0.07%	0.50%	0.25%	1.76%	**1.89%**
5.75	6.25	198	6.01	5.99	6.63	4.97	0.27	0.019	0.31%	0.50%	0.25%	1.63%	**1.77%**
6.25	6.75	226	6.52	6.51	7.66	5.58	0.28	0.019	0.12%	0.50%	0.25%	1.63%	**1.75%**
6.75	7.25	173	6.97	6.99	8.70	5.77	0.29	0.022	-0.17%	0.50%	0.25%	1.47%	**1.61%**
7.25	7.75	143	7.45	7.49	8.32	6.07	0.31	0.026	-0.54%	0.50%	0.25%	1.45%	**1.68%**
7.75	8.25	151	7.98	8.00	9.04	6.51	0.29	0.024	-0.28%	0.50%	0.25%	1.46%	**1.62%**
8.25	8.75	156	8.51	8.50	9.78	7.65	0.31	0.025	0.10%	0.50%	0.25%	1.42%	**1.56%**
8.75	9.25	117	8.91	8.98	10.10	7.79	0.30	0.027	-0.77%	0.50%	0.25%	1.39%	**1.71%**
9.25	9.75	73	9.33	9.48	10.07	7.88	0.39	0.046	-1.56%	0.50%	0.25%	1.37%	**2.21%**
9.75	10.25	32	9.99	9.98	10.88	9.34	0.35	0.063	0.17%	0.50%	0.25%	1.37%	**1.62%**
10.25	10.75	46	10.46	10.48	11.45	8.63	0.42	0.062	-0.21%	0.50%	0.25%	1.33%	**1.58%**
10.75	11.25	18	11.05	10.97	12.84	10.58	0.51	0.120	0.76%	0.50%	0.25%	1.34%	**1.97%**
11.25	11.75	20	11.56	11.48	12.14	10.84	0.27	0.060	0.71%	0.50%	0.25%	1.39%	**1.74%**
11.75	12.25	12	12.17	12.07	12.67	11.72	0.26	0.075	0.88%	0.50%	0.25%	1.37%	**1.83%**
12.25	12.75	35	12.69	12.48	13.39	12.22	0.33	0.056	1.65%	0.50%	0.25%	1.42%	**2.29%**
12.75	13.25	33	13.06	12.99	13.70	12.46	0.35	0.061	0.55%	0.50%	0.25%	1.35%	**1.63%**
13.25	13.75	24	13.50	13.49	14.27	12.72	0.37	0.075	0.12%	0.50%	0.25%	1.43%	**1.63%**
13.75	14.25	35	14.25	14.03	15.66	13.59	0.49	0.082	1.59%	0.50%	0.25%	1.45%	**2.30%**
14.25	14.75	22	14.52	14.48	15.74	12.95	0.56	0.119	0.24%	0.50%	0.25%	1.58%	**1.88%**
14.75	15.25	28	15.06	15.01	16.11	14.31	0.53	0.100	0.34%	0.50%	0.25%	1.39%	**1.68%**
15.25	15.75	17	15.64	15.54	16.80	14.47	0.48	0.117	0.61%	0.50%	0.25%	1.33%	**1.74%**
15.75	16.25	13	16.06	15.98	18.04	14.94	0.81	0.226	0.50%	0.50%	0.25%	1.84%	**2.43%**

Verification uncertainty at 140 m height for SWLB059 [16]

Table 6-5 Uncertainty calculation at 140 m

SWLB059 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	127	4.04	4.00	4.91	2.72	0.29	0.026	1.05%	0.50%	0.25%	1.94%	**2.37%**
4.25	4.75	140	4.51	4.52	5.34	3.53	0.30	0.025	-0.17%	0.50%	0.25%	1.63%	**1.82%**
4.75	5.25	155	5.03	5.01	6.21	3.56	0.29	0.024	0.29%	0.50%	0.25%	1.70%	**1.87%**
5.25	5.75	177	5.49	5.51	6.15	4.02	0.31	0.023	-0.40%	0.50%	0.25%	1.76%	**1.93%**
5.75	6.25	201	5.97	6.00	7.36	4.66	0.32	0.022	-0.39%	0.50%	0.25%	1.63%	**1.80%**
6.25	6.75	214	6.51	6.50	7.73	5.31	0.26	0.018	0.18%	0.50%	0.25%	1.63%	**1.75%**
6.75	7.25	210	7.01	7.00	8.11	6.21	0.27	0.018	0.16%	0.50%	0.25%	1.47%	**1.60%**
7.25	7.75	165	7.45	7.50	9.13	6.25	0.31	0.024	-0.73%	0.50%	0.25%	1.45%	**1.75%**
7.75	8.25	143	8.01	8.00	9.60	6.79	0.34	0.028	0.07%	0.50%	0.25%	1.46%	**1.60%**
8.25	8.75	152	8.44	8.49	9.23	7.32	0.27	0.022	-0.66%	0.50%	0.25%	1.42%	**1.68%**
8.75	9.25	121	8.89	8.97	9.67	7.73	0.27	0.024	-0.87%	0.50%	0.25%	1.39%	**1.75%**
9.25	9.75	67	9.38	9.45	10.47	7.80	0.45	0.055	-0.79%	0.50%	0.25%	1.37%	**1.78%**
9.75	10.25	49	10.05	10.01	11.26	8.83	0.37	0.053	0.44%	0.50%	0.25%	1.37%	**1.63%**
10.25	10.75	28	10.59	10.48	12.71	10.09	0.47	0.089	1.05%	0.50%	0.25%	1.33%	**1.98%**
10.75	11.25	19	11.03	10.95	11.67	10.26	0.33	0.076	0.75%	0.50%	0.25%	1.34%	**1.78%**
11.25	11.75	14	11.49	11.44	11.96	11.07	0.25	0.066	0.41%	0.50%	0.25%	1.39%	**1.66%**
11.75	12.25	25	12.24	12.04	12.87	11.74	0.26	0.053	1.65%	0.50%	0.25%	1.37%	**2.26%**
12.25	12.75	38	12.65	12.49	13.30	11.89	0.37	0.059	1.22%	0.50%	0.25%	1.42%	**2.01%**
12.75	13.25	29	13.15	13.03	14.45	12.46	0.36	0.067	0.95%	0.50%	0.25%	1.35%	**1.82%**
13.25	13.75	37	13.70	13.56	15.34	12.12	0.59	0.098	1.05%	0.50%	0.25%	1.43%	**1.99%**
13.75	14.25	35	14.04	13.98	15.25	12.80	0.44	0.075	0.45%	0.50%	0.25%	1.45%	**1.70%**
14.25	14.75	18	14.70	14.50	15.96	13.44	0.67	0.158	1.34%	0.50%	0.25%	1.58%	**2.40%**
14.75	15.25	19	15.06	14.95	15.77	14.47	0.41	0.095	0.73%	0.50%	0.25%	1.39%	**1.78%**
15.25	15.75	20	15.77	15.47	17.12	15.20	0.44	0.099	1.99%	0.50%	0.25%	1.33%	**2.54%**
15.75	16.25	16	15.66	15.91	16.53	15.04	0.40	0.100	-1.55%	0.50%	0.25%	1.84%	**2.55%**

Verification uncertainty at 160 m height for WS190 [18].

Table 6-4 Uncertainty calculation at 160 m

WS190 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	281	4.06	4.01	6.39	2.98	0.31	0.018	1.26%	0.50%	0.20%	1.94%	**2.42%**
4.25	4.75	358	4.57	4.51	6.07	3.42	0.31	0.016	1.28%	0.50%	0.20%	1.63%	**2.17%**
4.75	5.25	344	5.06	5.01	7.59	3.39	0.36	0.019	0.95%	0.50%	0.20%	1.70%	**2.06%**
5.25	5.75	330	5.53	5.51	6.69	3.56	0.32	0.018	0.40%	0.50%	0.20%	1.76%	**1.91%**
5.75	6.25	390	6.02	5.99	8.14	3.39	0.37	0.019	0.35%	0.50%	0.20%	1.63%	**1.77%**
6.25	6.75	289	6.49	6.50	7.67	5.34	0.32	0.019	-0.07%	0.50%	0.20%	1.63%	**1.74%**
6.75	7.25	222	6.96	6.99	7.97	5.01	0.33	0.022	-0.38%	0.50%	0.20%	1.47%	**1.64%**
7.25	7.75	199	7.43	7.50	8.54	6.19	0.36	0.025	-0.91%	0.50%	0.20%	1.45%	**1.82%**
7.75	8.25	187	7.99	8.00	9.26	5.90	0.41	0.030	-0.11%	0.50%	0.20%	1.46%	**1.61%**
8.25	8.75	231	8.55	8.51	9.98	7.27	0.36	0.024	0.51%	0.50%	0.20%	1.42%	**1.63%**
8.75	9.25	238	9.05	9.00	10.82	7.61	0.38	0.025	0.53%	0.50%	0.20%	1.39%	**1.60%**
9.25	9.75	211	9.51	9.49	11.77	7.84	0.48	0.033	0.27%	0.50%	0.20%	1.37%	**1.53%**
9.75	10.25	142	10.01	9.98	11.83	8.71	0.45	0.038	0.25%	0.50%	0.20%	1.37%	**1.54%**
10.25	10.75	103	10.56	10.50	11.62	9.07	0.44	0.043	0.63%	0.50%	0.20%	1.33%	**1.62%**
10.75	11.25	105	11.07	11.00	17.00	9.42	0.81	0.079	0.73%	0.50%	0.20%	1.34%	**1.77%**
11.25	11.75	64	11.49	11.49	12.29	9.88	0.41	0.051	0.02%	0.50%	0.20%	1.39%	**1.56%**
11.75	12.25	72	12.03	12.01	12.98	10.94	0.35	0.042	0.17%	0.50%	0.20%	1.37%	**1.52%**
12.25	12.75	87	12.46	12.44	15.90	11.72	0.50	0.053	0.19%	0.50%	0.20%	1.42%	**1.59%**
12.75	13.25	50	13.07	12.97	14.16	12.24	0.45	0.064	0.72%	0.50%	0.20%	1.35%	**1.70%**
13.25	13.75	43	13.65	13.53	14.56	12.76	0.40	0.061	0.89%	0.50%	0.20%	1.43%	**1.82%**
13.75	14.25	53	14.24	14.00	15.40	13.29	0.47	0.065	1.69%	0.50%	0.20%	1.45%	**2.33%**
14.25	14.75	36	14.69	14.52	15.35	14.01	0.38	0.064	1.16%	0.50%	0.20%	1.58%	**2.08%**
14.75	15.25	36	15.23	14.98	16.85	13.82	0.59	0.098	1.68%	0.50%	0.20%	1.39%	**2.34%**
15.25	15.75	36	15.74	15.52	17.12	14.71	0.60	0.101	1.44%	0.50%	0.20%	1.33%	**2.13%**
15.75	16.25	30	16.10	16.02	17.23	15.34	0.55	0.101	0.52%	0.50%	0.20%	1.84%	**2.08%**

Verification uncertainty at 140 m height for WS190 [18].

Table 6-5 Uncertainty calculation at 140 m

WS190 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	309	4.04	4.00	5.29	3.17	0.28	0.016	1.11%	0.50%	0.20%	1.94%	**2.33%**
4.25	4.75	351	4.56	4.51	6.60	3.36	0.31	0.017	1.14%	0.50%	0.20%	1.63%	**2.10%**
4.75	5.25	398	5.02	5.00	6.26	3.67	0.27	0.014	0.54%	0.50%	0.20%	1.70%	**1.88%**
5.25	5.75	338	5.54	5.51	7.04	4.24	0.30	0.017	0.47%	0.50%	0.20%	1.76%	**1.92%**
5.75	6.25	407	6.00	5.99	7.87	4.09	0.33	0.016	0.22%	0.50%	0.20%	1.63%	**1.75%**
6.25	6.75	289	6.48	6.48	7.65	5.64	0.30	0.018	0.02%	0.50%	0.20%	1.63%	**1.73%**
6.75	7.25	256	7.01	6.99	7.84	6.02	0.28	0.018	0.30%	0.50%	0.20%	1.47%	**1.61%**
7.25	7.75	220	7.43	7.50	8.82	5.68	0.37	0.025	-0.86%	0.50%	0.20%	1.45%	**1.80%**
7.75	8.25	184	8.08	8.02	9.72	6.69	0.41	0.030	0.72%	0.50%	0.20%	1.46%	**1.75%**
8.25	8.75	266	8.52	8.50	9.86	6.80	0.35	0.022	0.18%	0.50%	0.20%	1.42%	**1.55%**
8.75	9.25	254	9.05	8.99	11.49	7.66	0.39	0.025	0.62%	0.50%	0.20%	1.39%	**1.63%**
9.25	9.75	197	9.52	9.49	10.59	7.95	0.41	0.029	0.27%	0.50%	0.20%	1.37%	**1.53%**
9.75	10.25	120	10.03	9.98	11.43	8.37	0.44	0.040	0.52%	0.50%	0.20%	1.37%	**1.61%**
10.25	10.75	113	10.50	10.49	12.34	8.77	0.49	0.046	0.05%	0.50%	0.20%	1.33%	**1.50%**
10.75	11.25	99	11.04	11.00	14.17	9.78	0.56	0.056	0.37%	0.50%	0.20%	1.34%	**1.58%**
11.25	11.75	58	11.57	11.47	12.49	10.89	0.32	0.042	0.87%	0.50%	0.20%	1.39%	**1.77%**
11.75	12.25	98	12.04	12.01	13.26	11.13	0.38	0.038	0.24%	0.50%	0.20%	1.37%	**1.53%**
12.25	12.75	55	12.57	12.48	14.23	11.63	0.44	0.059	0.75%	0.50%	0.20%	1.42%	**1.76%**
12.75	13.25	44	13.10	13.00	14.14	12.35	0.47	0.070	0.78%	0.50%	0.20%	1.35%	**1.73%**
13.25	13.75	49	13.79	13.52	15.66	12.69	0.55	0.078	1.99%	0.50%	0.20%	1.43%	**2.57%**
13.75	14.25	46	14.08	13.99	15.23	13.19	0.45	0.066	0.60%	0.50%	0.20%	1.45%	**1.72%**
14.25	14.75	36	14.68	14.48	16.26	14.12	0.44	0.074	1.37%	0.50%	0.20%	1.58%	**2.22%**
14.75	15.25	34	15.16	14.94	16.38	14.28	0.49	0.085	1.43%	0.50%	0.20%	1.39%	**2.14%**
15.25	15.75	43	15.73	15.49	16.96	14.42	0.60	0.091	1.59%	0.50%	0.20%	1.33%	**2.22%**
15.75	16.25	22	16.19	15.99	17.30	15.31	0.50	0.106	1.23%	0.50%	0.20%	1.84%	**2.37%**

Type specific classification uncertainty from classification report for ZX300 by DNV-GL [19]

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: HS-1-LB

The frequency table (Tab data) is presented for each height and then the Weibull data is presented for each height.

Project:
23406 Hesselø South

Licensed user:
EMD International A/S
Niels Jernes Vej 10
DK-9220 Aalborg Ø
+45 6916 4850
Thomas Sørensen / ts@emd.dk
Calculated:
15/12/2025 10:51

Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

300.00m - Subst

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			10.70	6.86	6.22	7.92	11.53	10.94	9.40	9.74	10.98	11.56	12.58	11.64	8.28
0		0.49	2	0	0	0	0	2	0	0	0	0	0	0	0
1	0.50	1.49	493	38	35	37	42	47	44	78	48	39	38	23	24
2	1.50	2.49	1222	78	137	116	100	117	117	108	108	106	96	64	75
3	2.50	3.49	2080	191	153	205	197	140	177	206	182	192	164	125	148
4	3.50	4.49	2761	192	194	239	231	180	280	217	250	307	234	229	208
5	4.50	5.49	3160	275	141	210	287	273	324	256	248	328	324	252	242
6	5.50	6.49	3575	248	152	267	329	307	334	283	329	401	454	292	179
7	6.50	7.49	3707	176	184	241	354	318	288	251	325	543	540	323	164
8	7.50	8.49	3741	115	225	179	334	312	319	241	353	643	578	277	165
9	8.50	9.49	3397	68	133	156	313	363	364	166	383	570	518	234	129
10	9.50	10.49	3452	67	83	158	243	387	353	254	350	652	530	259	116
11	10.50	11.49	3469	97	59	121	252	412	322	236	296	722	611	247	94
12	11.50	12.49	2891	77	18	84	286	372	321	201	263	464	493	225	87
13	12.50	13.49	2599	50	3	79	289	354	273	176	258	443	374	219	81
14	13.50	14.49	2332	29	0	64	267	298	162	187	244	423	458	170	30
15	14.50	15.49	2457	22	0	69	353	329	200	170	258	362	510	165	19
16	15.50	16.49	2070	14	0	47	329	245	151	152	215	390	384	125	18
17	16.50	17.49	1617	11	0	14	191	265	92	95	164	317	332	107	29
18	17.50	18.49	1430	10	1	16	210	170	67	83	144	285	329	93	22
19	18.50	19.49	1155	5	5	36	182	104	39	86	82	218	290	91	17
20	19.50	20.49	941	11	3	19	146	91	26	45	80	176	260	73	11
21	20.50	21.49	791	2	6	13	71	48	24	26	63	154	286	80	18
22	21.50	22.49	601	2	2	9	64	38	10	14	54	99	223	66	20
23	22.50	23.49	490	0	3	4	69	21	4	12	45	73	171	71	17
24	23.50	24.49	383	0	0	3	43	4	0	16	25	48	157	73	14
25	24.50	25.49	252	0	0	3	46	0	1	5	29	33	79	45	11
26	25.50	26.49	167	0	0	1	22	0	0	4	12	32	53	38	5
27	26.50	27.49	115	0	0	0	6	0	0	0	15	29	24	37	4
28	27.50	28.49	83	0	0	0	2	0	0	1	15	18	8	39	0
29	28.50	29.49	48	0	0	0	1	0	0	0	16	6	3	21	1
30	29.50	30.49	36	0	0	0	0	0	0	0	13	7	1	15	0
31	30.50	31.49	36	0	0	0	0	0	0	0	16	6	0	14	0
32	31.50	32.49	9	0	0	0	0	0	0	0	7	1	0	1	0
33	32.50	33.49	3	0	0	0	0	0	0	0	3	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: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

260.00m - Subst

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			10.57	6.90	6.26	7.98	11.35	10.81	9.25	9.71	10.95	11.46	12.41	11.34	8.16
0		0.49	3	0	0	0	0	2	1	0	0	0	0	0	0
1	0.50	1.49	496	36	35	35	46	46	44	76	50	39	41	20	28
2	1.50	2.49	1255	76	142	120	106	105	133	111	108	112	96	61	85
3	2.50	3.49	2108	192	156	203	195	156	188	205	188	201	152	131	141
4	3.50	4.49	2764	186	197	218	250	185	287	223	239	295	242	246	196
5	4.50	5.49	3203	252	138	240	283	286	339	253	241	325	333	258	255
6	5.50	6.49	3616	277	141	270	338	309	331	270	341	396	455	305	183
7	6.50	7.49	3741	170	196	224	375	316	303	261	328	564	531	311	162
8	7.50	8.49	3743	107	230	204	320	328	333	215	372	650	539	282	163
9	8.50	9.49	3488	70	130	185	325	382	362	198	383	581	510	244	118
10	9.50	10.49	3522	67	87	154	232	405	378	241	358	630	572	273	125
11	10.50	11.49	3469	105	51	130	262	442	320	245	308	703	581	236	86
12	11.50	12.49	2881	70	20	75	321	374	324	185	252	473	491	206	90
13	12.50	13.49	2661	66	2	82	283	358	260	205	282	459	397	201	66
14	13.50	14.49	2468	24	0	74	310	320	181	199	250	419	501	166	24
15	14.50	15.49	2396	22	0	66	338	301	186	179	286	381	467	151	19
16	15.50	16.49	2056	22	0	45	327	253	142	139	214	390	390	114	20
17	16.50	17.49	1645	9	0	19	200	265	91	91	187	315	326	116	26
18	17.50	18.49	1394	6	2	20	204	136	60	102	123	281	349	85	26
19	18.50	19.49	1104	5	7	30	175	106	37	67	85	214	270	93	15
20	19.50	20.49	911	8	3	20	103	93	26	35	80	173	278	81	11
21	20.50	21.49	780	4	6	17	71	53	14	29	71	155	286	60	14
22	21.50	22.49	527	0	2	10	54	26	6	15	55	80	187	70	22
23	22.50	23.49	463	0	3	4	65	10	1	15	35	78	167	70	15
24	23.50	24.49	320	0	2	5	49	1	0	11	32	36	108	59	17
25	24.50	25.49	226	0	1	2	43	0	0	6	18	39	71	38	8
26	25.50	26.49	127	0	0	0	16	0	0	1	17	29	30	30	4
27	26.50	27.49	123	0	0	0	3	0	0	0	24	30	16	46	4
28	27.50	28.49	59	0	0	0	1	0	0	0	15	6	3	34	0
29	28.50	29.49	41	0	0	0	0	0	0	0	20	2	0	19	0
30	29.50	30.49	18	0	0	0	0	0	0	0	10	0	1	7	0
31	30.50	31.49	7	0	0	0	0	0	0	0	3	2	0	2	0
32	31.50	32.49	7	0	0	0	0	0	0	0	6	1	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

220.00m - Subst

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			10.42	6.82	6.27	8.04	11.19	10.68	9.11	9.56	10.94	11.32	12.16	11.05	8.05
0		0.49	4	0	0	0	1	1	2	0	0	0	0	0	0
1	0.50	1.49	510	34	32	32	47	55	37	85	40	41	54	25	28
2	1.50	2.49	1334	98	136	111	120	103	142	122	112	125	101	89	75
3	2.50	3.49	2139	181	177	206	211	147	193	207	200	194	153	120	150
4	3.50	4.49	2739	184	182	208	240	209	274	209	233	285	267	240	208
5	4.50	5.49	3246	274	127	234	275	291	373	258	242	334	335	262	241
6	5.50	6.49	3624	235	155	273	377	287	323	257	343	434	439	301	200
7	6.50	7.49	3874	175	211	250	412	321	282	291	355	546	563	308	160
8	7.50	8.49	3747	101	232	215	332	359	349	218	367	664	487	253	170
9	8.50	9.49	3523	63	136	219	314	369	347	229	393	550	519	253	131
10	9.50	10.49	3613	73	86	161	263	426	395	271	342	665	570	249	112
11	10.50	11.49	3497	94	51	132	311	447	337	228	321	672	595	221	88
12	11.50	12.49	2899	68	17	93	336	378	338	176	256	487	464	200	86
13	12.50	13.49	2748	54	1	86	325	361	258	227	266	479	435	195	61
14	13.50	14.49	2613	37	0	68	314	367	192	202	313	444	495	155	26
15	14.50	15.49	2370	21	0	68	376	304	166	189	255	378	449	151	13
16	15.50	16.49	1972	19	0	39	312	264	111	123	233	375	373	109	14
17	16.50	17.49	1630	9	0	19	176	223	96	104	186	334	349	104	30
18	17.50	18.49	1395	6	6	29	216	126	63	88	117	279	343	100	22
19	18.50	19.49	1030	5	6	32	151	108	19	50	88	233	251	71	16
20	19.50	20.49	925	8	2	17	93	91	14	35	93	197	277	84	14
21	20.50	21.49	655	3	6	18	61	37	13	22	60	122	239	55	19
22	21.50	22.49	515	0	2	8	71	13	1	17	52	76	178	75	22
23	22.50	23.49	374	0	5	3	59	3	0	10	34	61	135	52	12
24	23.50	24.49	295	0	0	3	55	0	0	9	40	42	90	45	11
25	24.50	25.49	181	0	0	0	38	0	0	3	33	18	47	32	10
26	25.50	26.49	135	0	0	0	4	0	0	0	27	26	24	49	5
27	26.50	27.49	73	0	0	0	3	0	0	0	14	4	4	47	1
28	27.50	28.49	36	0	0	0	1	0	0	1	14	2	1	17	0
29	28.50	29.49	16	0	0	0	0	0	0	0	12	0	0	4	0
30	29.50	30.49	9	0	0	0	0	0	0	0	8	0	0	1	0
31	30.50	31.49	2	0	0	0	0	0	0	0	1	0	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	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:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

190.00m - Subst

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			10.30	6.77	6.35	7.97	11.11	10.55	9.03	9.54	10.84	11.18	11.99	10.78	7.93
0		0.49	4	0	0	0	0	1	0	2	0	1	0	0	0
1	0.50	1.49	562	42	34	34	52	65	46	86	49	38	51	32	33
2	1.50	2.49	1334	102	118	118	131	108	139	124	90	139	89	87	89
3	2.50	3.49	2174	181	186	195	200	155	198	190	239	201	160	114	155
4	3.50	4.49	2697	179	174	194	244	219	238	208	241	274	267	243	216
5	4.50	5.49	3261	266	130	248	264	297	384	249	235	339	337	284	228
6	5.50	6.49	3677	229	157	303	354	305	336	269	333	419	441	327	204
7	6.50	7.49	3868	167	219	274	448	293	306	280	372	550	524	288	147
8	7.50	8.49	3869	99	230	231	319	394	330	257	372	689	508	269	171
9	8.50	9.49	3570	69	137	230	324	385	376	249	379	531	509	253	128
10	9.50	10.49	3652	87	84	167	297	435	400	256	348	651	573	244	110
11	10.50	11.49	3576	84	50	126	341	469	351	229	317	706	583	227	93
12	11.50	12.49	2936	51	20	104	328	402	315	209	276	488	470	184	89
13	12.50	13.49	2847	63	1	86	346	357	261	249	274	481	472	203	54
14	13.50	14.49	2676	34	0	63	340	400	198	221	321	452	494	128	25
15	14.50	15.49	2337	21	0	77	381	321	148	184	257	384	428	122	14
16	15.50	16.49	1894	19	0	34	262	263	105	129	224	348	387	110	13
17	16.50	17.49	1603	10	0	17	197	192	89	107	166	332	359	105	29
18	17.50	18.49	1351	7	3	28	211	141	53	74	130	281	309	92	22
19	18.50	19.49	1021	5	7	37	130	99	25	33	95	227	270	81	12
20	19.50	20.49	862	8	5	14	87	76	14	29	92	179	269	71	18
21	20.50	21.49	595	2	2	13	67	19	6	25	68	115	192	67	19
22	21.50	22.49	462	0	6	5	74	12	2	16	50	79	142	57	19
23	22.50	23.49	362	0	6	3	64	1	0	10	44	52	113	55	14
24	23.50	24.49	247	0	0	0	50	0	0	8	33	25	80	40	11
25	24.50	25.49	150	0	0	1	24	0	0	4	25	16	25	48	7
26	25.50	26.49	104	0	0	0	4	0	0	0	20	9	18	49	4
27	26.50	27.49	53	0	0	0	2	0	0	1	17	3	3	27	0
28	27.50	28.49	13	0	0	0	1	0	0	0	9	0	0	3	0
29	28.50	29.49	10	0	0	0	0	0	0	0	9	0	0	1	0
30	29.50	30.49	3	0	0	0	0	0	0	0	2	0	0	1	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:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

170.00m - Subst

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			10.20	6.64	6.35	8.05	11.03	10.41	8.97	9.45	10.77	11.14	11.80	10.66	7.96
0		0.49	1	0	0	0	0	0	0	0	1	0	0	0	0
1	0.50	1.49	593	37	40	42	49	63	73	89	54	41	43	32	30
2	1.50	2.49	1342	119	117	99	120	121	138	121	106	132	95	81	93
3	2.50	3.49	2152	174	175	189	199	155	184	195	226	204	180	118	153
4	3.50	4.49	2761	194	182	195	235	239	246	216	252	266	268	243	225
5	4.50	5.49	3252	260	127	244	260	319	357	236	222	367	336	290	234
6	5.50	6.49	3684	237	156	301	383	300	336	277	327	422	438	302	205
7	6.50	7.49	3946	163	232	281	453	316	295	303	368	553	525	307	150
8	7.50	8.49	3837	98	231	242	341	379	346	274	390	655	487	237	157
9	8.50	9.49	3691	68	136	231	350	405	386	238	398	560	494	274	151
10	9.50	10.49	3728	73	90	187	287	455	413	262	355	671	569	256	110
11	10.50	11.49	3529	79	46	137	369	450	373	222	309	673	572	207	92
12	11.50	12.49	3075	61	20	81	357	433	331	229	290	507	474	202	90
13	12.50	13.49	2872	43	1	98	354	406	221	264	291	470	461	192	71
14	13.50	14.49	2689	38	0	72	371	406	192	221	296	450	490	130	23
15	14.50	15.49	2340	20	0	65	353	331	141	193	274	382	461	109	11
16	15.50	16.49	1788	18	0	41	250	221	94	119	230	332	353	113	17
17	16.50	17.49	1637	11	0	24	197	192	98	96	187	341	354	110	27
18	17.50	18.49	1333	6	4	28	195	140	52	63	143	294	301	86	21
19	18.50	19.49	1007	6	5	36	114	105	19	31	107	228	276	61	19
20	19.50	20.49	777	5	7	13	90	51	12	26	84	193	211	73	12
21	20.50	21.49	556	2	6	10	68	20	4	20	53	114	162	71	26
22	21.50	22.49	410	0	3	9	79	4	2	11	37	86	111	50	18
23	22.50	23.49	329	0	4	2	57	0	0	15	45	33	104	53	16
24	23.50	24.49	216	0	0	1	41	0	0	5	33	20	65	43	8
25	24.50	25.49	136	0	0	0	24	0	0	1	26	11	25	44	5
26	25.50	26.49	94	0	0	0	4	0	0	2	19	5	12	49	3
27	26.50	27.49	31	0	0	0	1	0	0	0	12	1	3	13	1
28	27.50	28.49	12	0	0	0	1	0	0	0	8	0	0	3	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	1	0	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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15/12/2025 10:51

Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

150.00m - Subst

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			10.10	6.58	6.41	8.13	10.94	10.30	8.91	9.33	10.67	11.05	11.63	10.49	7.86
0		0.49	4	0	0	0	0	0	1	0	2	1	0	0	0
1	0.50	1.49	602	36	42	35	54	59	71	84	52	69	37	38	25
2	1.50	2.49	1321	101	108	107	121	120	122	134	109	131	84	86	98
3	2.50	3.49	2165	213	152	186	172	190	172	185	236	195	183	119	162
4	3.50	4.49	2823	191	198	211	243	233	248	209	263	275	277	242	233
5	4.50	5.49	3230	255	117	251	266	321	328	225	251	361	353	284	218
6	5.50	6.49	3624	230	176	266	341	333	349	300	297	412	408	320	192
7	6.50	7.49	4068	156	227	300	493	324	324	327	397	561	537	281	141
8	7.50	8.49	3956	105	228	243	372	384	342	278	393	687	502	250	172
9	8.50	9.49	3685	74	151	253	366	392	395	261	387	515	489	265	137
10	9.50	10.49	3814	79	89	204	306	459	438	251	372	681	576	246	113
11	10.50	11.49	3603	81	50	143	394	481	368	213	317	696	545	225	90
12	11.50	12.49	3212	51	18	94	406	451	322	273	296	498	495	211	97
13	12.50	13.49	2913	44	0	92	341	471	212	236	308	483	482	182	62
14	13.50	14.49	2633	29	1	68	362	396	175	259	294	434	477	116	22
15	14.50	15.49	2298	19	0	79	345	321	114	166	301	380	445	116	12
16	15.50	16.49	1769	18	0	40	257	216	103	107	217	334	361	101	15
17	16.50	17.49	1625	10	0	14	171	199	91	92	205	355	349	111	28
18	17.50	18.49	1317	5	6	34	192	138	41	49	135	329	290	78	20
19	18.50	19.49	924	7	4	38	104	78	15	32	106	227	237	64	12
20	19.50	20.49	697	4	5	18	89	39	12	24	65	181	167	74	19
21	20.50	21.49	503	3	8	11	70	14	5	13	62	98	142	60	17
22	21.50	22.49	385	0	3	6	72	3	2	13	41	62	113	47	23
23	22.50	23.49	296	0	2	4	56	0	0	10	51	22	84	56	11
24	23.50	24.49	180	0	1	1	39	0	0	4	20	14	42	48	11
25	24.50	25.49	128	0	0	0	18	0	0	0	27	7	28	45	3
26	25.50	26.49	65	0	0	0	4	0	0	0	17	4	12	27	1
27	26.50	27.49	12	0	0	0	2	0	0	0	6	0	0	4	0
28	27.50	28.49	8	0	0	0	0	0	0	0	3	0	0	5	0
29	28.50	29.49	5	0	0	0	0	0	0	0	4	0	0	1	0
30	29.50	30.49	1	0	0	0	0	0	0	0	0	0	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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15/12/2025 10:51

Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

130.00m - Subst

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			9.97	6.55	6.30	8.21	10.84	10.10	8.78	9.22	10.55	10.90	11.46	10.38	7.74
0		0.49	2	0	0	0	1	0	0	0	0	0	1	0	0
1	0.50	1.49	587	31	49	33	48	63	69	78	70	58	30	27	31
2	1.50	2.49	1406	98	108	94	134	142	130	134	141	126	103	82	114
3	2.50	3.49	2146	213	170	164	168	198	184	181	224	203	162	127	152
4	3.50	4.49	2865	182	220	207	235	243	257	218	274	291	258	249	231
5	4.50	5.49	3264	252	130	245	266	329	332	218	214	383	376	283	236
6	5.50	6.49	3724	229	173	273	374	356	353	341	318	427	383	296	201
7	6.50	7.49	4071	129	245	294	497	322	344	318	416	535	538	304	129
8	7.50	8.49	3999	114	219	262	387	379	358	301	386	669	503	248	173
9	8.50	9.49	3831	77	172	257	389	391	429	295	402	544	453	272	150
10	9.50	10.49	3920	80	78	235	337	491	401	258	386	721	585	242	106
11	10.50	11.49	3718	79	58	161	410	500	375	246	305	685	579	225	95
12	11.50	12.49	3294	61	15	91	423	486	330	280	312	493	473	228	102
13	12.50	13.49	2888	31	1	97	354	441	209	265	320	492	469	151	58
14	13.50	14.49	2659	25	0	72	337	422	155	248	310	459	493	114	24
15	14.50	15.49	2167	19	0	69	349	278	106	155	305	370	391	114	11
16	15.50	16.49	1815	15	0	30	245	215	103	101	230	348	401	108	19
17	16.50	17.49	1591	8	0	20	187	194	87	74	220	357	332	86	26
18	17.50	18.49	1203	6	3	35	159	122	36	46	124	314	255	82	21
19	18.50	19.49	859	7	7	34	127	56	8	22	93	231	204	60	10
20	19.50	20.49	621	3	8	17	88	21	14	21	77	151	134	69	18
21	20.50	21.49	437	3	4	11	64	8	2	12	52	76	121	63	21
22	21.50	22.49	349	0	4	9	67	1	0	16	41	36	101	58	16
23	22.50	23.49	267	0	2	2	63	0	0	6	41	15	73	55	10
24	23.50	24.49	160	0	0	1	32	0	0	2	16	5	46	51	7
25	24.50	25.49	100	0	0	0	11	0	0	0	25	2	19	40	3
26	25.50	26.49	29	0	0	0	3	0	0	0	13	3	2	7	1
27	26.50	27.49	11	0	0	0	1	0	0	0	4	0	1	5	0
28	27.50	28.49	7	0	0	0	1	0	0	0	3	0	0	3	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	1	0	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: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

100.00m - Subst

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	6.43	6.41	8.24	10.65	9.77	8.55	9.01	10.28	10.60	11.13	10.02	7.63
0		0.49	2	0	0	0	0	0	0	0	0	1	0	1	0
1	0.50	1.49	602	38	41	30	43	71	68	73	83	55	38	31	31
2	1.50	2.49	1422	98	87	109	135	154	109	136	145	154	104	89	102
3	2.50	3.49	2203	227	167	152	174	208	204	173	223	192	154	149	180
4	3.50	4.49	2947	165	240	209	222	291	261	238	283	302	268	242	226
5	4.50	5.49	3395	255	147	257	295	317	353	225	258	404	357	306	221
6	5.50	6.49	3831	226	162	283	397	397	377	348	323	420	392	299	207
7	6.50	7.49	4159	125	260	305	500	303	359	361	404	572	527	299	144
8	7.50	8.49	4069	107	224	259	406	415	389	287	399	622	517	267	177
9	8.50	9.49	4067	79	165	288	446	416	478	313	407	581	471	288	135
10	9.50	10.49	4202	93	105	241	399	503	408	258	421	793	626	247	108
11	10.50	11.49	3972	78	49	186	450	578	365	316	384	647	561	249	109
12	11.50	12.49	3310	56	7	94	412	509	321	336	314	515	481	167	98
13	12.50	13.49	2842	25	0	92	330	434	179	290	337	493	482	131	49
14	13.50	14.49	2589	17	0	85	381	394	140	216	317	442	470	107	20
15	14.50	15.49	2151	20	0	71	325	238	89	131	305	401	439	121	11
16	15.50	16.49	1816	14	0	36	221	212	121	74	257	389	363	110	19
17	16.50	17.49	1407	10	0	19	166	179	54	51	177	368	285	74	24
18	17.50	18.49	1029	5	10	38	158	75	22	32	120	288	183	81	17
19	18.50	19.49	621	5	6	27	108	27	5	18	70	157	121	61	16
20	19.50	20.49	471	1	10	18	77	11	3	11	66	67	124	67	16
21	20.50	21.49	380	3	7	12	74	0	0	22	49	33	102	55	23
22	21.50	22.49	315	0	2	6	68	1	0	4	40	20	97	62	15
23	22.50	23.49	198	0	0	3	46	0	0	2	20	8	50	60	9
24	23.50	24.49	129	0	0	2	27	0	0	2	21	3	31	37	6
25	24.50	25.49	42	0	0	0	6	0	0	0	12	2	9	13	0
26	25.50	26.49	20	0	0	0	4	0	0	0	7	1	1	7	0
27	26.50	27.49	6	0	0	0	2	0	0	0	1	0	0	3	0
28	27.50	28.49	4	0	0	0	0	0	0	0	4	0	0	0	0
29	28.50	29.49	1	0	0	0	0	0	0	0	0	0	0	1	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:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

80.00m - Subst

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	6.48	6.29	8.27	10.45	9.48	8.42	8.82	9.98	10.34	10.90	9.74	7.59
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	630	34	47	36	52	64	62	82	80	61	44	40	28
2	1.50	2.49	1416	99	96	85	128	161	111	142	154	149	106	85	100
3	2.50	3.49	2324	202	215	168	174	246	200	179	233	208	147	159	193
4	3.50	4.49	3045	178	236	195	232	301	290	241	297	317	274	264	220
5	4.50	5.49	3507	240	163	259	326	338	364	251	264	411	354	300	237
6	5.50	6.49	3951	210	206	283	444	401	365	344	374	414	394	313	203
7	6.50	7.49	4212	129	240	338	474	309	392	378	409	556	519	310	158
8	7.50	8.49	4310	109	229	262	443	431	418	361	454	638	504	278	183
9	8.50	9.49	4235	92	177	268	480	506	484	279	416	631	505	274	123
10	9.50	10.49	4495	101	104	282	479	530	412	302	458	788	670	245	124
11	10.50	11.49	4114	74	48	182	509	590	432	357	394	653	547	223	105
12	11.50	12.49	3360	50	8	101	426	496	275	366	342	559	468	179	90
13	12.50	13.49	2823	20	0	104	323	406	184	299	340	495	482	129	41
14	13.50	14.49	2565	19	0	80	371	341	132	201	355	475	462	112	17
15	14.50	15.49	2128	18	0	73	300	240	102	85	322	437	412	125	14
16	15.50	16.49	1716	13	0	37	185	197	99	67	220	446	341	93	18
17	16.50	17.49	1211	11	3	30	184	130	37	40	134	301	240	76	25
18	17.50	18.49	732	3	10	37	127	45	9	15	81	191	137	62	15
19	18.50	19.49	467	4	8	22	93	20	1	16	68	67	92	57	19
20	19.50	20.49	420	4	10	16	74	5	0	17	59	35	109	66	25
21	20.50	21.49	369	2	6	14	86	0	0	17	30	27	99	64	24
22	21.50	22.49	279	1	2	0	68	0	0	6	30	10	86	64	12
23	22.50	23.49	163	0	0	2	41	0	0	2	20	6	46	39	7
24	23.50	24.49	89	0	0	0	20	0	0	0	17	2	26	20	4
25	24.50	25.49	34	0	0	0	6	0	0	0	7	2	5	14	0
26	25.50	26.49	8	0	0	0	4	0	0	0	1	1	0	2	0
27	26.50	27.49	7	0	0	0	2	0	0	0	4	0	0	1	0
28	27.50	28.49	3	0	0	0	0	0	0	0	3	0	0	0	0
29	28.50	29.49	1	0	0	0	0	0	0	0	0	0	0	1	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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Calculated:
15/12/2025 10:51

Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

40.00m - Subst

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			8.83	6.15	6.20	7.97	9.82	8.68	7.72	8.12	9.14	9.42	10.24	9.29	7.26
0		0.49	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.50	1.49	634	39	49	32	61	65	63	80	72	62	39	44	28
2	1.50	2.49	1524	126	111	88	124	145	117	148	186	158	118	92	111
3	2.50	3.49	2583	211	197	179	209	319	218	242	265	219	169	173	182
4	3.50	4.49	3362	186	198	278	263	350	334	239	315	378	277	285	259
5	4.50	5.49	4015	255	209	324	403	399	422	285	362	444	395	299	218
6	5.50	6.49	4130	195	244	314	433	405	416	376	402	420	408	307	210
7	6.50	7.49	4906	134	231	369	524	479	475	513	500	636	536	313	196
8	7.50	8.49	5050	118	232	266	680	577	499	359	551	767	542	277	182
9	8.50	9.49	4820	81	171	298	650	551	500	330	468	850	516	272	133
10	9.50	10.49	4872	74	97	275	511	582	519	439	502	872	659	216	126
11	10.50	11.49	4111	59	34	190	497	514	332	416	474	720	571	216	88
12	11.50	12.49	3087	33	3	125	337	415	214	279	496	517	440	174	54
13	12.50	13.49	2659	22	0	107	348	330	108	187	320	576	503	133	25
14	13.50	14.49	2191	17	0	104	308	244	99	98	255	492	434	123	17
15	14.50	15.49	1508	19	0	64	219	171	45	56	197	301	320	91	25
16	15.50	16.49	862	15	2	20	146	114	16	20	108	132	183	82	24
17	16.50	17.49	623	2	9	33	147	47	1	17	68	79	126	74	20
18	17.50	18.49	478	8	8	26	109	22	0	17	52	53	90	75	18
19	18.50	19.49	382	4	9	20	81	5	0	14	43	21	96	74	15
20	19.50	20.49	369	2	7	9	100	0	0	10	35	18	95	69	24
21	20.50	21.49	251	1	4	6	60	0	0	1	22	10	82	49	16
22	21.50	22.49	171	0	0	1	59	0	0	2	16	7	49	29	8
23	22.50	23.49	74	0	0	0	23	0	0	0	15	3	20	10	3
24	23.50	24.49	29	0	0	0	6	0	0	0	4	2	4	13	0
25	24.50	25.49	7	0	0	0	2	0	0	0	5	0	0	0	0
26	25.50	26.49	4	0	0	0	0	0	0	0	2	0	0	2	0
27	26.50	27.49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

12.00m - Subst

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			7.84	5.74	5.76	7.49	8.68	7.62	6.70	7.05	8.05	8.21	9.28	8.37	6.56
0		0.49	50	2	6	3	6	4	4	4	7	2	5	3	4
1	0.50	1.49	755	50	41	47	65	79	63	75	100	77	55	53	50
2	1.50	2.49	1993	165	133	118	185	212	163	216	233	173	141	108	146
3	2.50	3.49	3242	203	250	271	304	398	277	291	322	289	185	229	223
4	3.50	4.49	4302	222	273	306	402	532	465	312	395	472	350	314	259
5	4.50	5.49	4874	267	268	384	532	527	554	423	466	481	419	348	205
6	5.50	6.49	5135	176	251	342	718	435	499	533	574	602	470	327	208
7	6.50	7.49	5734	134	224	370	728	575	517	546	676	850	579	285	250
8	7.50	8.49	5471	74	228	334	717	564	516	453	714	946	557	230	138
9	8.50	9.49	5248	67	136	396	518	470	490	364	725	1045	674	247	116
10	9.50	10.49	4175	95	69	329	457	393	303	296	537	738	648	215	95
11	10.50	11.49	3225	57	16	186	396	407	147	225	419	593	550	170	59
12	11.50	12.49	2701	21	0	154	393	324	95	177	356	443	540	164	34
13	12.50	13.49	1853	21	0	85	285	227	83	89	256	270	394	117	26
14	13.50	14.49	1207	20	1	59	248	144	18	48	135	163	253	94	24
15	14.50	15.49	718	12	3	27	152	90	3	23	65	87	156	75	25
16	15.50	16.49	614	4	13	45	137	50	0	16	69	63	101	97	19
17	16.50	17.49	480	5	7	29	109	20	0	16	49	24	110	84	27
18	17.50	18.49	358	4	13	13	104	1	0	5	25	11	100	62	20
19	18.50	19.49	272	1	3	9	75	0	0	3	24	9	86	47	15
20	19.50	20.49	134	0	0	2	48	0	0	0	14	8	35	22	5
21	20.50	21.49	53	0	0	1	19	0	0	0	9	5	8	11	0
22	21.50	22.49	12	0	0	0	6	0	0	0	3	0	0	3	0
23	22.50	23.49	3	0	0	0	0	0	0	0	1	0	0	2	0
24	23.50	24.49	0	0	0	0	0	0	0	0	0	0	0	0	0
25	24.50	25.49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25.50	26.49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26.50	27.49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Frequency distribution (TAB file data)

4.00m - Subst

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			7.21	5.29	5.34	6.95	8.07	6.96	6.06	6.40	7.37	7.56	8.52	7.81	6.08
0		0.49	110	6	11	5	13	7	9	5	15	13	8	9	9
1	0.50	1.49	1075	75	76	70	110	100	90	118	143	100	66	60	67
2	1.50	2.49	2497	198	172	129	239	301	234	286	262	216	163	127	170
3	2.50	3.49	3923	229	283	339	375	485	386	337	370	343	257	257	262
4	3.50	4.49	4994	239	286	387	479	599	565	406	477	548	428	336	244
5	4.50	5.49	5280	291	249	334	722	566	618	470	536	535	413	329	217
6	5.50	6.49	5756	139	225	368	682	531	497	646	679	777	618	344	250
7	6.50	7.49	5901	128	222	379	751	572	542	491	791	997	559	252	217
8	7.50	8.49	5759	85	202	402	622	534	568	366	866	1096	631	267	120
9	8.50	9.49	4774	91	110	367	469	412	359	330	581	911	773	246	125
10	9.50	10.49	3779	53	42	303	480	435	185	265	451	655	646	196	68
11	10.50	11.49	2879	41	2	156	359	342	110	190	367	459	630	172	51
12	11.50	12.49	2091	19	0	86	348	287	79	105	284	303	424	139	17
13	12.50	13.49	1353	27	0	71	302	182	12	43	143	154	282	109	28
14	13.50	14.49	741	8	3	14	185	77	5	21	60	91	143	108	26
15	14.50	15.49	646	6	14	49	175	27	0	22	73	57	100	100	23
16	15.50	16.49	511	7	15	30	103	6	0	11	48	28	136	92	35
17	16.50	17.49	372	3	9	20	120	0	0	8	27	16	103	48	18
18	17.50	18.49	205	0	0	4	90	0	0	1	28	10	35	27	10
19	18.50	19.49	58	0	0	0	32	0	0	0	8	3	1	14	0
20	19.50	20.49	8	0	0	0	2	0	0	0	5	0	0	1	0
21	20.50	21.49	1	0	0	0	0	0	0	0	0	0	0	1	0
22	21.50	22.49	0	0	0	0	0	0	0	0	0	0	0	0	0
23	22.50	23.49	0	0	0	0	0	0	0	0	0	0	0	0	0
24	23.50	24.49	0	0	0	0	0	0	0	0	0	0	0	0	0
25	24.50	25.49	0	0	0	0	0	0	0	0	0	0	0	0	0
26	25.50	26.49	0	0	0	0	0	0	0	0	0	0	0	0	0
27	26.50	27.49	0	0	0	0	0	0	0	0	0	0	0	0	0
28	27.50	28.49	0	0	0	0	0	0	0	0	0	0	0	0	0
29	28.50	29.49	0	0	0	0	0	0	0	0	0	0	0	0	0
30	29.50	30.49	0	0	0	0	0	0	0	0	0	0	0	0	0
31	30.50	31.49	0	0	0	0	0	0	0	0	0	0	0	0	0
32	31.50	32.49	0	0	0	0	0	0	0	0	0	0	0	0	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	0	0	0	0	0	0	0	0	0	0	0	0	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36.50	37.49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37.50	38.49	0	0	0	0	0	0	0	0	0	0	0	0	0
39	38.50	39.49	0	0	0	0	0	0	0	0	0	0	0	0	0
40	39.50	40.49	0	0	0	0	0	0	0	0	0	0	0	0	0
41	40.50		0	0	0	0	0	0	0	0	0	0	0	0	0

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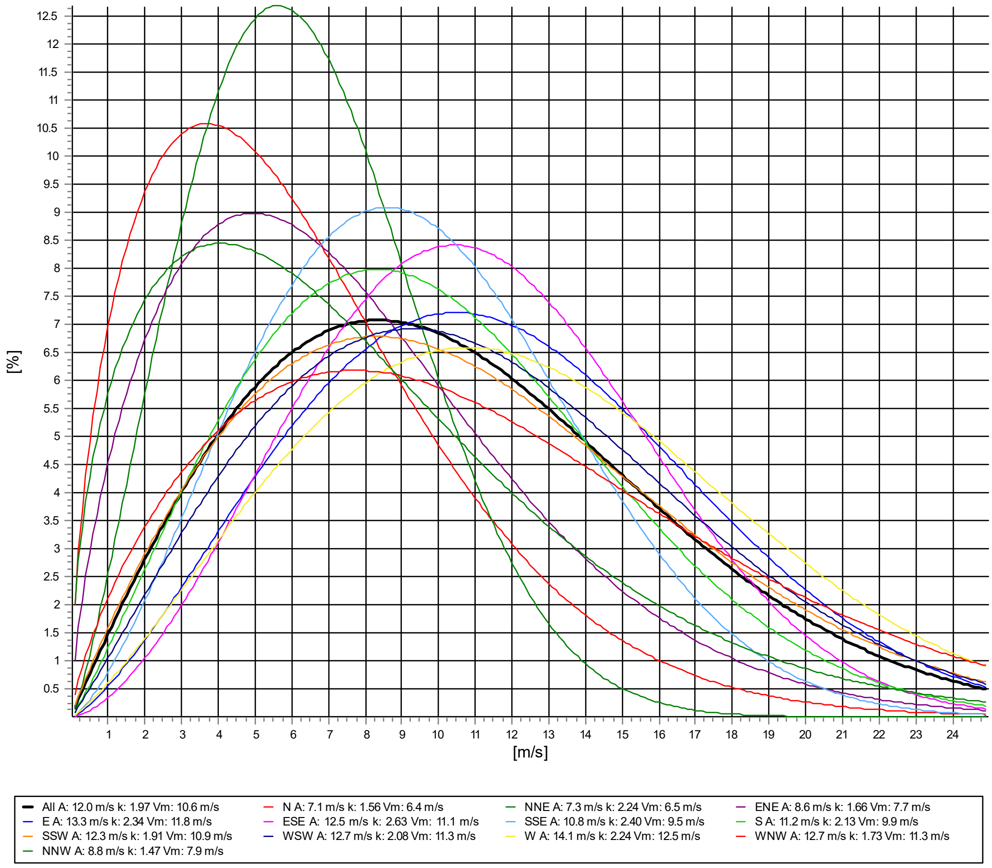
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **300.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.12	1.560	3.45	6.40
1-NNE	7.32	2.244	2.98	6.49
2-ENE	8.60	1.661	4.63	7.69
3-E	13.30	2.341	10.20	11.78
4-ESE	12.50	2.632	10.08	11.11
5-SSE	10.76	2.401	8.32	9.54
6-S	11.22	2.132	6.92	9.93
7-SSW	12.26	1.907	9.49	10.87
8-WSW	12.71	2.077	15.68	11.26
9-W	14.07	2.239	16.53	12.46
10-WNW	12.73	1.725	7.94	11.34
11-NNW	8.78	1.473	3.78	7.95
Mean	**11.99**	**1.969**	**100.00**	**10.63**



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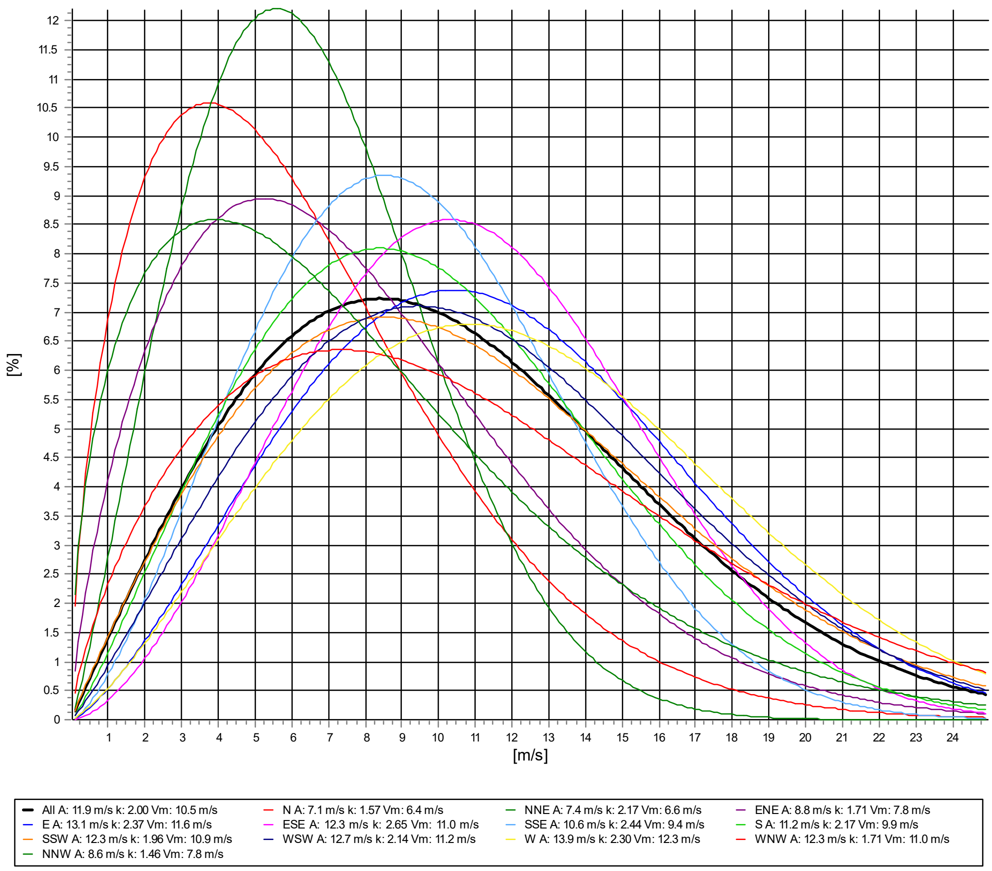
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **260.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.14	1.569	3.44	6.41
1-NNE	7.42	2.166	3.00	6.57
2-ENE	8.75	1.707	4.75	7.81
3-E	13.12	2.368	10.26	11.63
4-ESE	12.34	2.653	10.19	10.97
5-SSE	10.59	2.436	8.42	9.39
6-S	11.19	2.167	6.93	9.91
7-SSW	12.26	1.961	9.65	10.87
8-WSW	12.65	2.144	15.61	11.21
9-W	13.92	2.295	16.25	12.33
10-WNW	12.32	1.706	7.78	10.99
11-NNW	8.63	1.463	3.73	7.81
Mean	**11.88**	**2.004**	**100.00**	**10.52**



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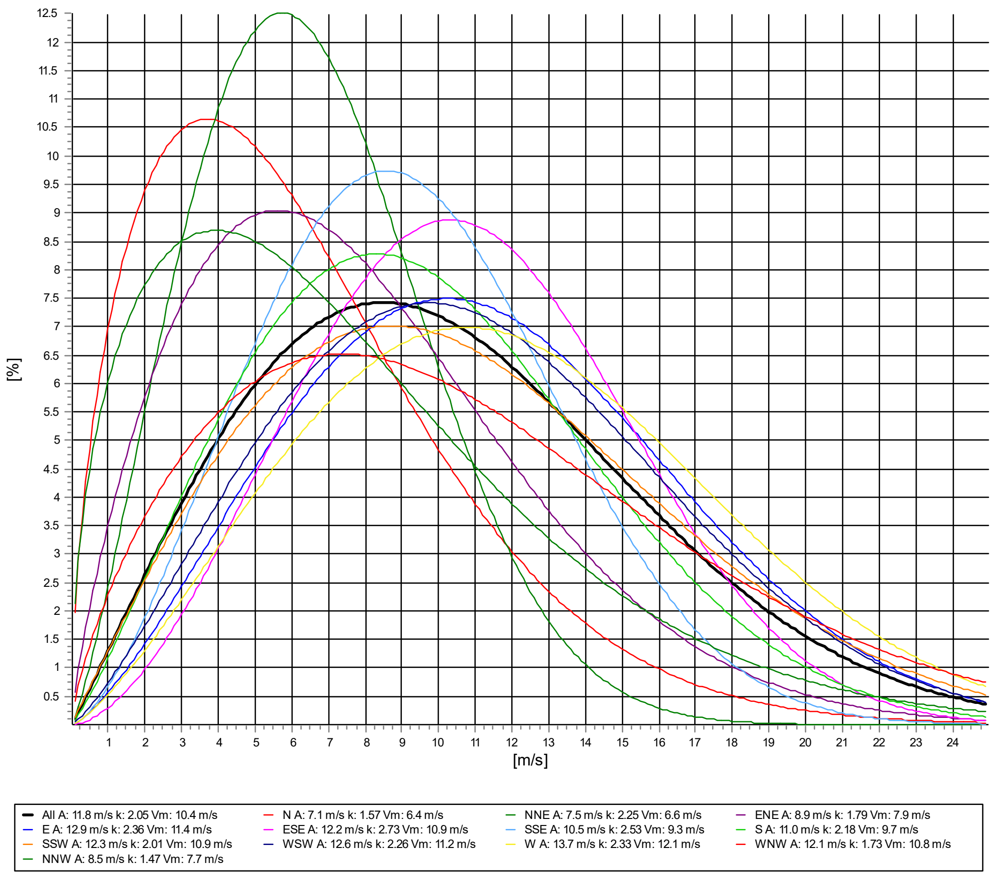
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)
Height: **220.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.09	1.567	3.37	6.37
1-NNE	7.45	2.254	3.04	6.60
2-ENE	8.88	1.794	4.88	7.90
3-E	12.90	2.363	10.62	11.43
4-ESE	12.21	2.726	10.23	10.86
5-SSE	10.46	2.530	8.36	9.29
6-S	11.00	2.182	7.02	9.74
7-SSW	12.27	2.011	9.76	10.87
8-WSW	12.60	2.259	15.60	11.16
9-W	13.67	2.328	15.93	12.12
10-WNW	12.10	1.732	7.48	10.79
11-NNW	8.53	1.470	3.72	7.72
Mean	**11.75**	**2.053**	**100.00**	**10.41**



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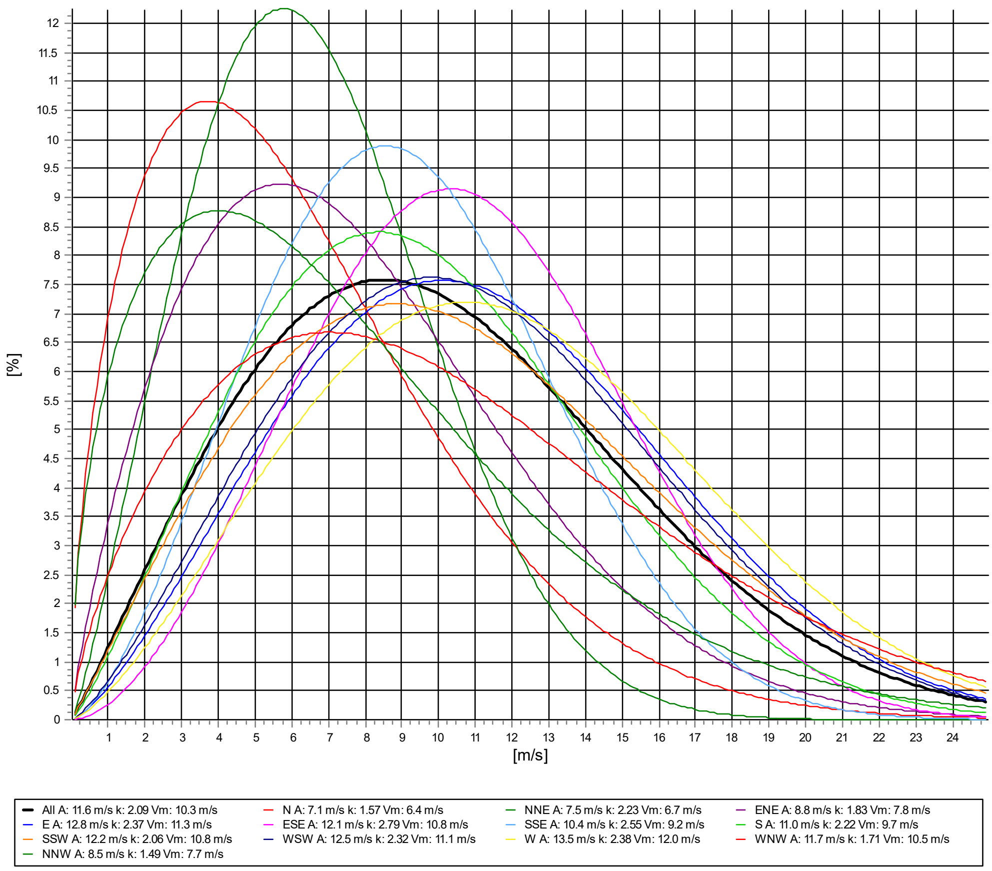
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)
Height: **190.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.09	1.572	3.33	6.37
1-NNE	7.54	2.227	3.03	6.68
2-ENE	8.79	1.826	5.03	7.81
3-E	12.78	2.367	10.70	11.32
4-ESE	12.09	2.792	10.45	10.76
5-SSE	10.38	2.553	8.34	9.22
6-S	10.97	2.219	7.14	9.71
7-SSW	12.20	2.058	9.83	10.81
8-WSW	12.49	2.317	15.47	11.07
9-W	13.51	2.382	15.59	11.97
10-WNW	11.74	1.712	7.36	10.47
11-NNW	8.48	1.490	3.72	7.66
Mean	**11.63**	**2.086**	**100.00**	**10.30**



Project:
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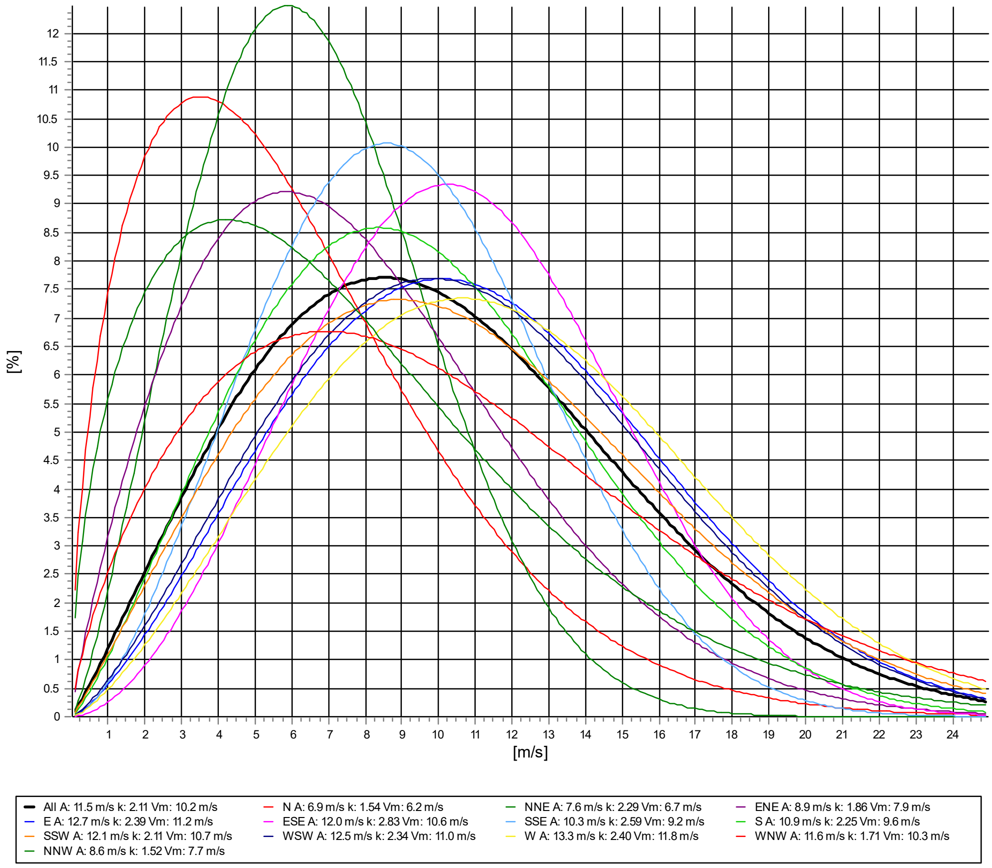
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)
Height: **170.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.91	1.545	3.30	6.21
1-NNE	7.56	2.289	3.05	6.69
2-ENE	8.89	1.856	5.07	7.89
3-E	12.67	2.386	10.81	11.23
4-ESE	11.95	2.826	10.63	10.65
5-SSE	10.33	2.593	8.32	9.18
6-S	10.85	2.252	7.20	9.61
7-SSW	12.13	2.107	9.93	10.75
8-WSW	12.46	2.338	15.46	11.04
9-W	13.31	2.399	15.19	11.80
10-WNW	11.59	1.713	7.24	10.34
11-NNW	8.57	1.521	3.80	7.73
Mean	**11.54**	**2.110**	**100.00**	**10.22**



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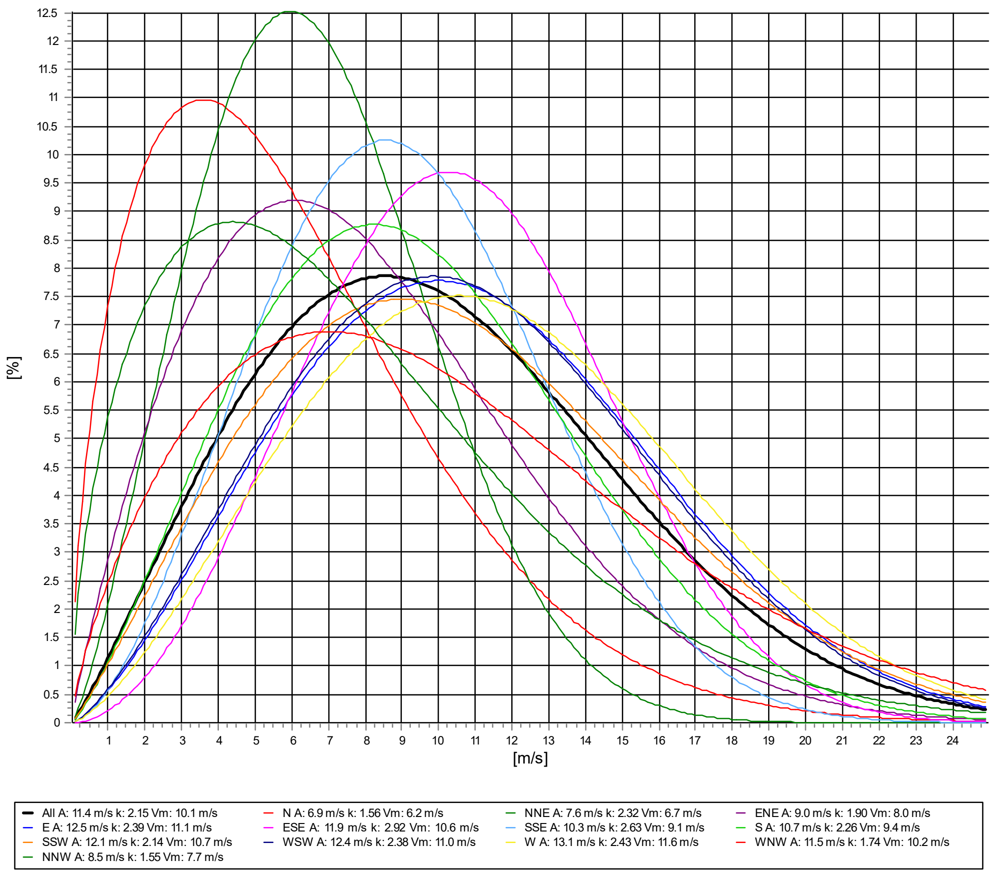
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)
Height: **150.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.87	1.560	3.30	6.18
1-NNE	7.60	2.317	3.06	6.74
2-ENE	9.03	1.899	5.20	8.01
3-E	12.54	2.394	10.91	11.11
4-ESE	11.86	2.924	10.84	10.58
5-SSE	10.26	2.630	8.19	9.12
6-S	10.66	2.262	7.22	9.44
7-SSW	12.05	2.141	10.09	10.67
8-WSW	12.39	2.385	15.45	10.98
9-W	13.12	2.428	14.87	11.64
10-WNW	11.48	1.739	7.14	10.22
11-NNW	8.54	1.552	3.73	7.68
Mean	**11.44**	**2.145**	**100.00**	**10.13**



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Calculated:
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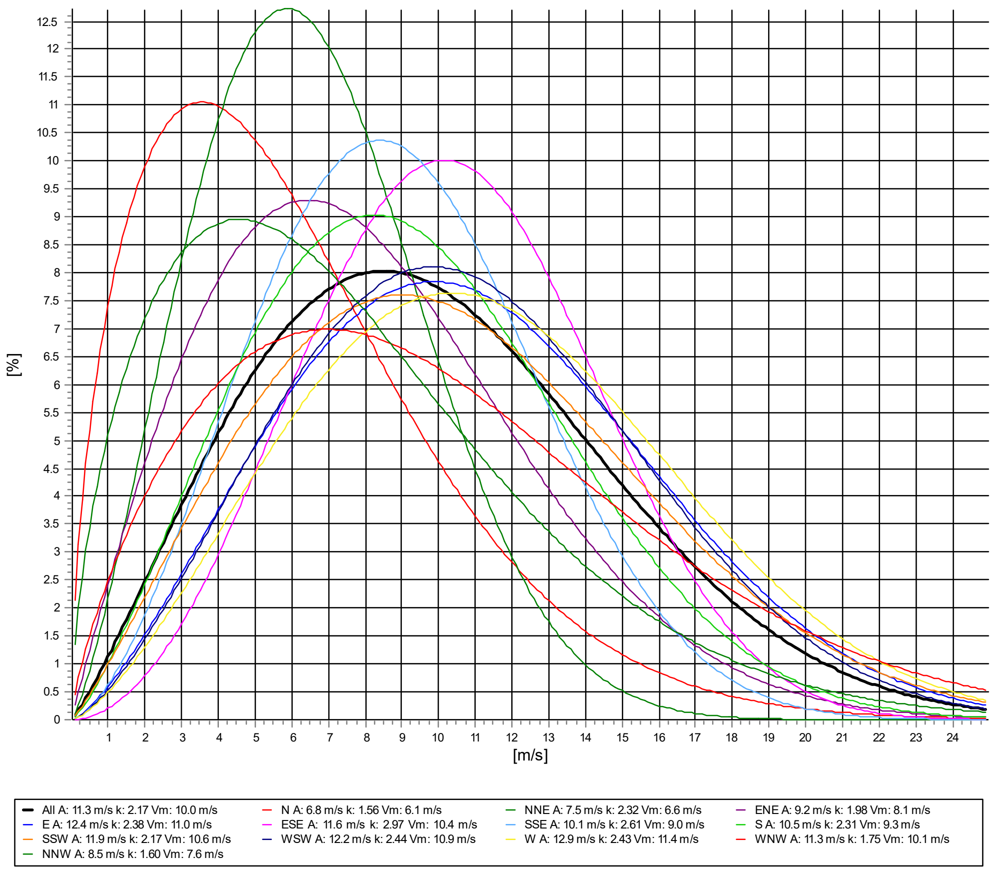
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)
Height: **130.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.83	1.561	3.20	6.13
1-NNE	7.48	2.318	3.20	6.63
2-ENE	9.18	1.983	5.22	8.13
3-E	12.39	2.380	11.07	10.98
4-ESE	11.65	2.974	10.88	10.40
5-SSE	10.09	2.612	8.24	8.96
6-S	10.52	2.312	7.38	9.32
7-SSW	11.94	2.172	10.24	10.57
8-WSW	12.24	2.444	15.38	10.85
9-W	12.91	2.425	14.40	11.44
10-WNW	11.34	1.746	7.02	10.10
11-NNW	8.49	1.595	3.78	7.62
Mean	**11.29**	**2.169**	**100.00**	**10.00**



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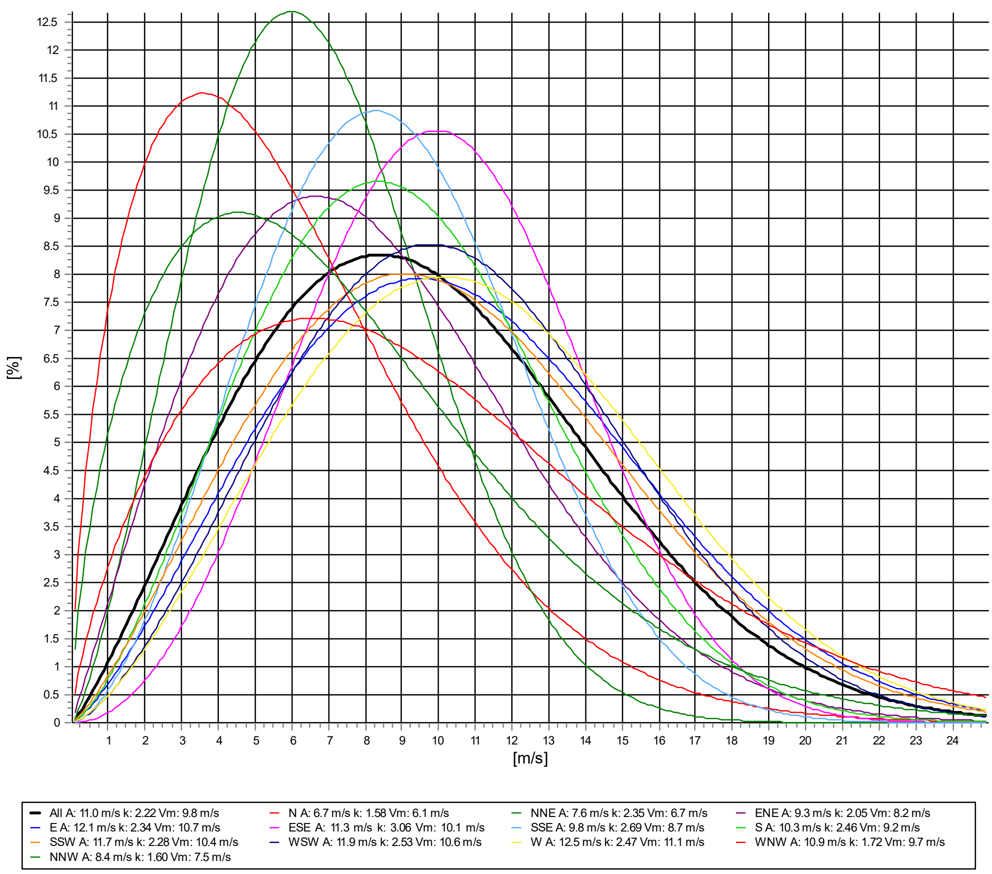
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **100.00m - Subst**

Weibull data

Sector	A	k	f	Mean wind speed
	[m/s]			[m/s]
0-N	6.75	1.581	3.16	6.06
1-NNE	7.58	2.348	3.24	6.71
2-ENE	9.27	2.046	5.41	8.21
3-E	12.08	2.335	11.25	10.70
4-ESE	11.31	3.060	10.98	10.11
5-SSE	9.82	2.692	8.25	8.73
6-S	10.33	2.462	7.50	9.16
7-SSW	11.72	2.276	10.43	10.38
8-WSW	11.92	2.525	15.19	10.58
9-W	12.55	2.466	13.89	11.13
10-WNW	10.89	1.721	6.94	9.71
11-NNW	8.37	1.602	3.76	7.50
Mean	**11.03**	**2.217**	**100.00**	**9.77**



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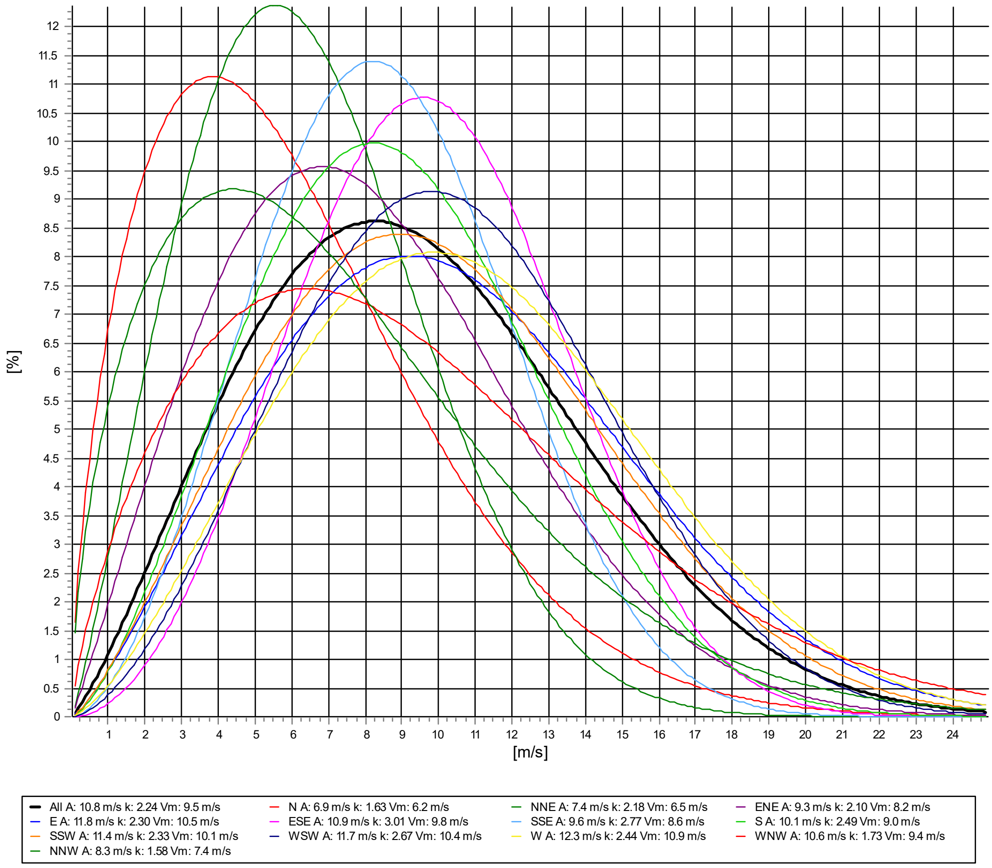
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) final **Period:** Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **80.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.89	1.631	3.07	6.17
1-NNE	7.36	2.178	3.44	6.52
2-ENE	9.27	2.100	5.46	8.21
3-E	11.81	2.297	11.50	10.46
4-ESE	10.95	3.010	10.94	9.78
5-SSE	9.65	2.774	8.30	8.59
6-S	10.10	2.491	7.69	8.96
7-SSW	11.38	2.327	10.58	10.09
8-WSW	11.69	2.675	14.98	10.39
9-W	12.25	2.436	13.44	10.87
10-WNW	10.59	1.727	6.83	9.44
11-NNW	8.27	1.584	3.77	7.42
Mean	**10.78**	**2.240**	**100.00**	**9.54**



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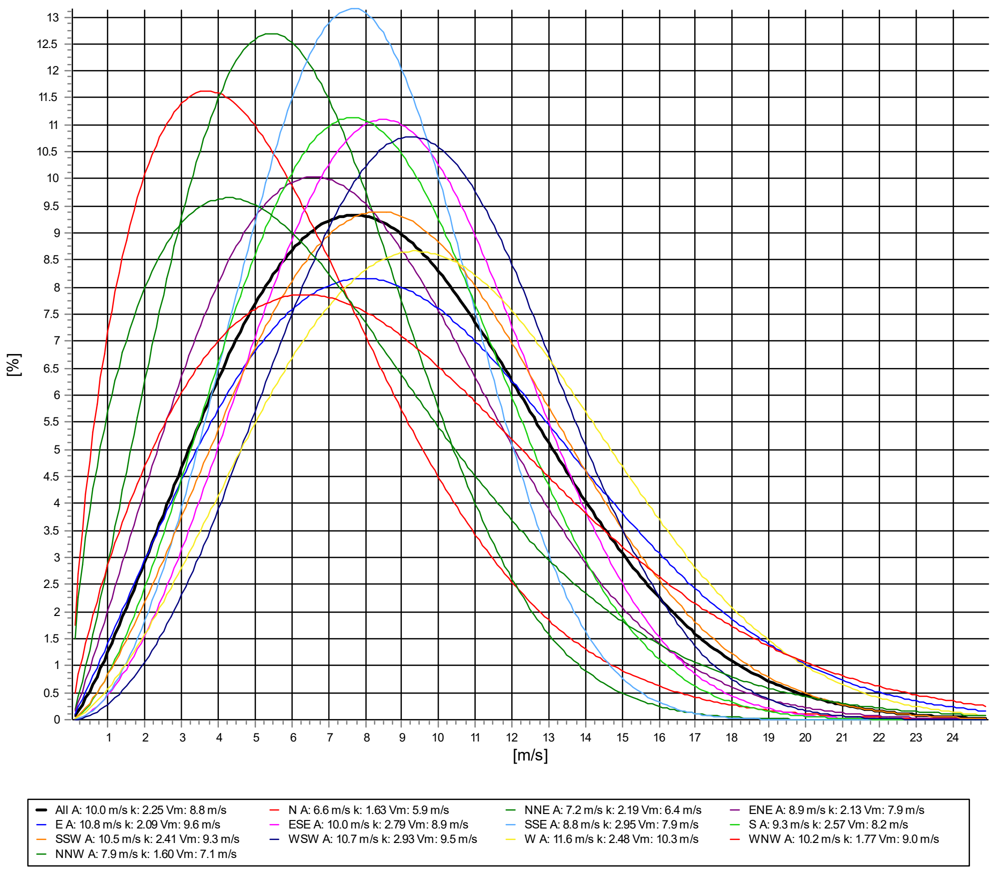
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **40.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.60	1.631	3.04	5.91
1-NNE	7.19	2.187	3.44	6.36
2-ENE	8.90	2.125	5.94	7.89
3-E	10.83	2.093	11.95	9.59
4-ESE	9.95	2.791	10.88	8.86
5-SSE	8.81	2.951	8.31	7.86
6-S	9.26	2.568	7.83	8.23
7-SSW	10.45	2.414	10.88	9.27
8-WSW	10.68	2.929	14.68	9.53
9-W	11.56	2.475	12.66	10.26
10-WNW	10.16	1.773	6.63	9.04
11-NNW	7.88	1.597	3.76	7.07
Mean	**9.99**	**2.254**	**100.00**	**8.85**



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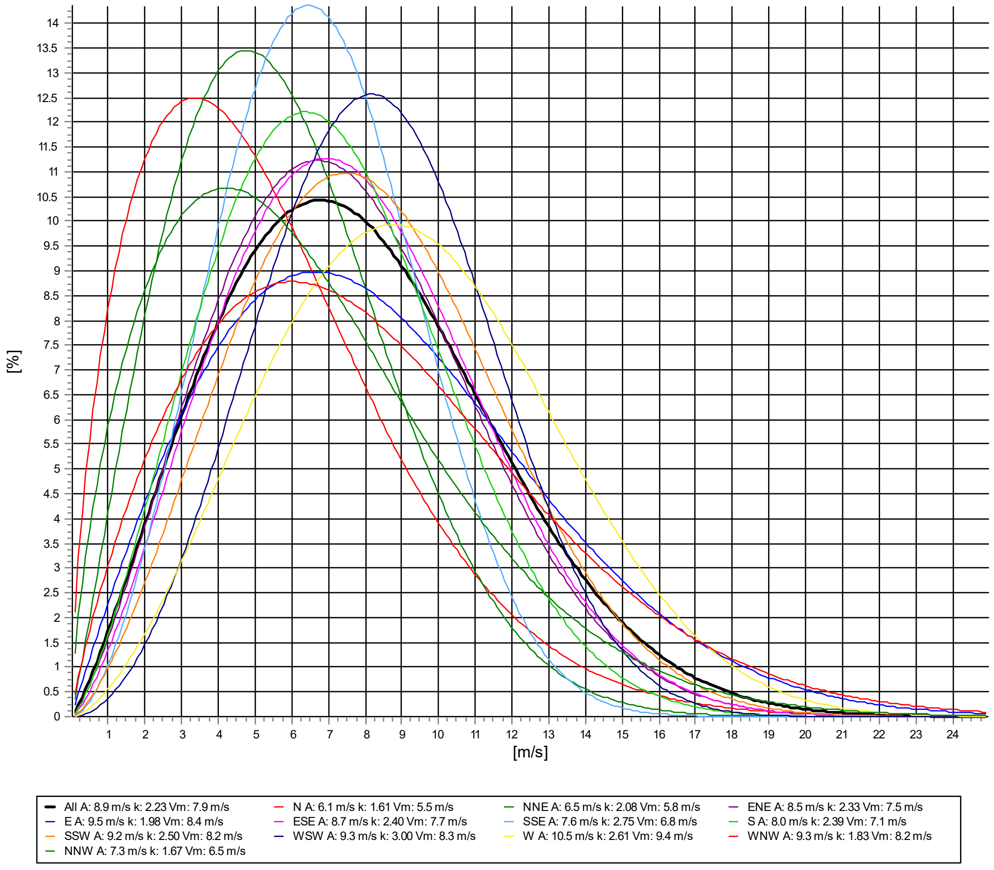
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **12.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.11	1.614	3.04	5.48
1-NNE	6.54	2.080	3.68	5.80
2-ENE	8.52	2.333	6.67	7.55
3-E	9.49	1.979	12.55	8.41
4-ESE	8.68	2.401	10.36	7.69
5-SSE	7.60	2.751	7.98	6.76
6-S	7.99	2.392	7.82	7.08
7-SSW	9.19	2.497	11.74	8.15
8-WSW	9.35	2.998	13.97	8.35
9-W	10.53	2.613	12.20	9.36
10-WNW	9.26	1.833	6.29	8.23
11-NNW	7.26	1.672	3.70	6.49
Mean	**8.86**	**2.227**	**100.00**	**7.85**



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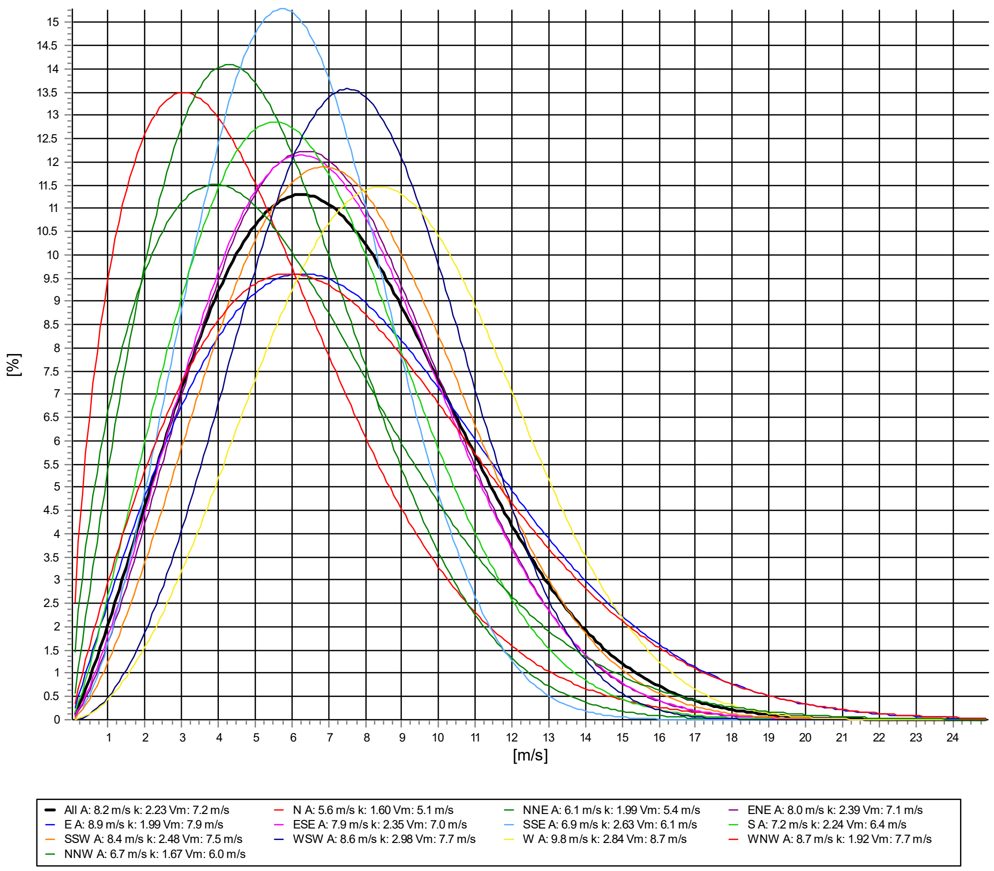
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) final **Period:**Full period: 21/07/2023 - 21/07/2024 (12.0 months)

Height: **4.00m - Subst**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	5.64	1.597	3.12	5.06
1-NNE	6.06	1.990	3.64	5.38
2-ENE	7.98	2.394	6.66	7.07
3-E	8.91	1.993	12.63	7.90
4-ESE	7.92	2.350	10.36	7.02
5-SSE	6.88	2.631	8.08	6.11
6-S	7.21	2.239	7.82	6.39
7-SSW	8.44	2.483	11.79	7.49
8-WSW	8.62	2.982	13.87	7.69
9-W	9.77	2.836	12.17	8.70
10-WNW	8.71	1.921	6.14	7.73
11-NNW	6.73	1.671	3.71	6.02
Mean	**8.19**	**2.228**	**100.00**	**7.25**



Appendix D Long-term Corrected Dataset: HS-1-LB, HS-A, HS-B and HS-C

For each dataset (called “mast” on the following pages), the frequency table (Tab data) is presented for each height and then the Weibull data is presented for each height.

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Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

300.00m - MCP LT - MCP session (11) - [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			10.16	7.88	6.68	7.77	9.17	10.04	9.77	9.82	11.09	11.74	11.30	11.03	8.31
0		0.49	353	21	21	11	27	46	59	48	17	21	13	16	53
1	0.50	1.49	2482	187	278	233	182	214	268	291	185	142	250	130	122
2	1.50	2.49	5671	357	506	581	404	460	430	350	533	570	582	457	441
3	2.50	3.49	8519	788	689	764	619	697	617	630	702	794	926	590	703
4	3.50	4.49	11177	970	767	731	810	706	913	848	1033	1118	1157	1030	1094
5	4.50	5.49	11681	1114	750	858	803	813	959	818	1010	1113	1256	1093	1094
6	5.50	6.49	13630	957	782	754	833	1060	1254	912	1131	1594	1658	1609	1086
7	6.50	7.49	13631	738	763	710	902	1170	1164	845	1151	1854	1755	1475	1104
8	7.50	8.49	13766	551	881	648	749	1302	1320	987	1289	1759	1689	1464	1127
9	8.50	9.49	13413	457	576	595	848	1308	1316	976	1317	1880	1978	1321	841
10	9.50	10.49	13819	685	500	452	735	1307	1278	1058	1156	2152	2133	1548	815
11	10.50	11.49	12869	704	349	395	833	1094	1112	883	1170	2032	2102	1423	772
12	11.50	12.49	11753	568	208	456	800	1015	1053	777	1253	1796	1658	1437	732
13	12.50	13.49	10663	395	148	478	680	863	803	733	1208	1686	1677	1486	506
14	13.50	14.49	9031	258	119	301	650	802	802	609	986	1575	1610	1041	278
15	14.50	15.49	8927	172	79	327	558	773	731	695	1179	1682	1444	1040	247
16	15.50	16.49	7583	191	50	132	356	649	707	420	925	1540	1485	954	174
17	16.50	17.49	5710	145	26	53	209	583	547	377	726	1146	1153	644	101
18	17.50	18.49	4807	92	21	112	180	409	369	354	608	969	895	591	207
19	18.50	19.49	3646	52	2	43	92	305	264	286	494	827	771	418	92
20	19.50	20.49	2486	37	2	44	78	163	154	138	334	695	498	289	54
21	20.50	21.49	2427	20	3	9	26	136	121	128	454	514	508	439	69
22	21.50	22.49	1498	8	0	7	22	58	51	67	277	402	352	231	23
23	22.50	23.49	944	5	0	0	10	42	28	40	143	252	202	186	36
24	23.50	24.49	767	5	0	0	6	31	10	33	82	265	151	160	24
25	24.50	25.49	453	4	0	2	1	4	0	14	40	137	159	81	11
26	25.50	26.49	350	2	0	1	1	2	2	7	36	176	62	60	1
27	26.50	27.49	243	0	0	0	2	1	1	7	34	75	41	82	0
28	27.50	28.49	181	0	0	0	1	1	0	6	50	65	25	31	2
29	28.50	29.49	114	0	0	0	0	0	0	2	22	29	24	33	4
30	29.50	30.49	119	0	0	0	0	0	0	2	18	62	17	18	2
31	30.50	31.49	51	0	0	0	0	0	0	0	4	16	20	11	0
32	31.50	32.49	28	0	0	0	0	0	0	0	7	2	9	10	0
33	32.50	33.49	14	0	0	0	0	0	0	0	3	0	6	5	0
34	33.50	34.49	12	0	0	0	0	0	0	0	2	0	7	3	0
35	34.50	35.49	12	0	0	0	0	0	0	0	2	0	4	6	0
36	35.50	36.49	8	0	0	0	0	0	0	0	2	1	3	2	0
37	36.50	37.49	1	0	0	0	0	0	0	0	0	0	0	1	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		1	0	0	0	0	0	0	0	0	1	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

260.00m - MCP LT - MCP session (10) - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			10.05	7.85	6.74	7.81	9.02	9.95	9.66	9.76	11.04	11.60	11.12	10.82	8.20
0		0.49	346	33	22	16	36	48	49	48	14	13	14	16	37
1	0.50	1.49	2533	175	247	228	202	208	271	273	204	186	246	127	166
2	1.50	2.49	5910	432	495	603	366	474	442	354	576	632	600	439	497
3	2.50	3.49	8680	788	715	719	681	676	635	685	771	794	932	639	645
4	3.50	4.49	10900	892	734	739	799	729	940	812	948	1080	1133	1018	1076
5	4.50	5.49	12173	1219	805	895	877	823	1052	850	922	1119	1350	1114	1147
6	5.50	6.49	13630	906	780	735	886	1091	1175	1013	1124	1593	1675	1572	1080
7	6.50	7.49	13689	830	764	678	877	1143	1187	878	1255	1915	1659	1435	1068
8	7.50	8.49	13868	489	776	804	786	1288	1284	956	1326	1690	1742	1629	1098
9	8.50	9.49	13390	491	606	541	833	1440	1398	1038	1285	1842	1877	1277	762
10	9.50	10.49	13955	668	477	479	834	1300	1269	967	1175	2078	2245	1572	891
11	10.50	11.49	13118	748	410	406	787	1125	1157	960	1306	2016	2070	1400	733
12	11.50	12.49	12018	521	185	548	797	979	1013	805	1251	1970	1740	1458	751
13	12.50	13.49	10440	403	168	401	692	896	803	779	1156	1613	1620	1415	494
14	13.50	14.49	9708	251	127	324	645	933	883	719	1116	1778	1613	1058	261
15	14.50	15.49	8753	209	97	347	577	743	709	614	1171	1642	1501	959	184
16	15.50	16.49	7418	232	45	107	325	650	648	422	1025	1531	1393	883	157
17	16.50	17.49	5563	133	25	82	193	531	532	431	703	1125	1025	639	144
18	17.50	18.49	4783	87	19	103	128	384	425	331	547	979	974	621	185
19	18.50	19.49	3270	45	4	45	107	262	175	209	446	855	647	404	71
20	19.50	20.49	2643	35	2	35	53	203	142	151	460	634	535	327	66
21	20.50	21.49	1885	18	4	9	22	89	112	147	339	428	385	294	38
22	21.50	22.49	1392	9	1	5	21	70	41	52	295	369	283	212	34
23	22.50	23.49	871	2	0	2	10	26	14	36	123	300	175	160	23
24	23.50	24.49	573	5	0	0	2	8	3	31	64	187	140	108	25
25	24.50	25.49	393	2	0	2	2	3	2	11	60	128	109	63	11
26	25.50	26.49	366	2	0	1	3	1	1	7	49	194	59	49	0
27	26.50	27.49	161	0	0	0	0	1	1	9	30	50	29	39	2
28	27.50	28.49	125	0	0	0	0	0	0	2	34	17	27	43	2
29	28.50	29.49	113	0	0	0	0	0	0	3	20	21	22	42	5
30	29.50	30.49	92	0	0	0	0	0	0	0	18	37	23	13	1
31	30.50	31.49	24	0	0	0	0	0	0	0	4	4	6	10	0
32	31.50	32.49	21	0	0	0	0	0	0	0	3	1	9	8	0
33	32.50	33.49	13	0	0	0	0	0	0	0	3	0	7	3	0
34	33.50	34.49	12	0	0	0	0	0	0	0	2	0	6	4	0
35	34.50	35.49	9	0	0	0	0	0	0	0	2	1	2	4	0
36	35.50	36.49	1	0	0	0	0	0	0	0	0	0	0	1	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		1	0	0	0	0	0	0	0	0	1	0	0	0

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Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

220.00m - MCP LT - MCP session (9) - [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			9.90	7.72	6.84	7.80	8.97	9.87	9.44	9.64	10.97	11.40	10.95	10.59	8.14
0		0.49	428	21	30	11	36	70	48	49	33	34	46	18	32
1	0.50	1.49	2642	184	282	215	149	217	305	253	222	204	288	171	152
2	1.50	2.49	6201	473	569	673	434	437	492	443	625	622	504	452	477
3	2.50	3.49	8534	764	655	734	618	701	625	648	720	814	946	658	651
4	3.50	4.49	10997	971	796	741	756	737	1012	755	1112	1026	1135	968	988
5	4.50	5.49	12246	1115	734	873	902	916	1024	822	856	1177	1361	1278	1188
6	5.50	6.49	13701	872	834	829	910	1063	1147	1007	1209	1599	1648	1495	1088
7	6.50	7.49	14106	794	831	745	935	1283	1251	1047	1251	1873	1606	1372	1118
8	7.50	8.49	13678	534	748	710	824	1369	1283	943	1213	1703	1681	1529	1141
9	8.50	9.49	13823	508	687	662	890	1304	1402	1036	1413	1853	1928	1386	754
10	9.50	10.49	13907	670	473	498	813	1384	1270	964	1130	2049	2283	1479	894
11	10.50	11.49	13430	614	407	474	869	1274	1188	962	1399	2029	2106	1441	667
12	11.50	12.49	12066	509	232	554	779	1031	980	854	1238	1885	1859	1374	771
13	12.50	13.49	10666	353	208	373	708	991	892	860	1226	1830	1549	1271	405
14	13.50	14.49	10449	277	150	346	636	1057	952	764	1380	1865	1637	1125	260
15	14.50	15.49	8505	166	106	336	503	814	603	522	1247	1700	1514	843	151
16	15.50	16.49	7049	220	59	125	283	636	633	483	947	1378	1349	789	147
17	16.50	17.49	5651	123	36	99	195	493	499	393	646	1111	1085	798	173
18	17.50	18.49	4210	77	29	90	122	346	304	245	507	1049	823	460	158
19	18.50	19.49	3178	46	5	49	95	260	150	230	551	728	628	372	64
20	19.50	20.49	2454	29	1	33	45	194	132	142	499	581	379	350	69
21	20.50	21.49	1573	12	4	6	32	39	55	102	273	414	368	229	39
22	21.50	22.49	1135	12	2	5	11	41	20	46	230	364	216	158	30
23	22.50	23.49	719	2	0	1	12	18	6	44	127	211	138	135	25
24	23.50	24.49	581	6	0	0	1	5	1	12	118	180	148	93	17
25	24.50	25.49	336	2	0	1	2	1	0	8	82	114	63	56	7
26	25.50	26.49	203	2	0	2	3	2	2	9	37	74	28	44	0
27	26.50	27.49	113	0	0	0	0	0	0	2	44	19	24	22	2
28	27.50	28.49	113	0	0	0	0	0	0	3	7	13	29	59	2
29	28.50	29.49	63	0	0	0	0	0	0	0	3	16	23	16	5
30	29.50	30.49	26	0	0	0	0	0	0	1	4	3	7	11	0
31	30.50	31.49	18	0	0	0	0	0	0	0	5	1	8	4	0
32	31.50	32.49	16	0	0	0	0	0	0	0	3	1	8	4	0
33	32.50	33.49	14	0	0	0	0	0	0	0	3	0	5	6	0
34	33.50	34.49	6	0	0	0	0	0	0	0	0	2	2	2	0
35	34.50	35.49	2	0	0	0	0	0	0	0	0	0	1	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	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	1	0	0	0	0	0	0	0	0	1	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: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

190.00m - MCP LT - MCP session (8) - [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			9.79	7.63	6.82	7.90	8.92	9.77	9.35	9.56	10.86	11.27	10.80	10.37	8.03
0		0.49	461	9	31	23	33	104	43	49	33	58	34	23	21
1	0.50	1.49	2747	262	255	216	165	231	318	299	235	189	241	172	164
2	1.50	2.49	6222	504	641	611	447	444	481	407	633	628	504	427	495
3	2.50	3.49	8757	797	659	755	603	655	631	649	803	818	954	675	758
4	3.50	4.49	10713	921	734	653	708	773	1028	765	1064	973	1134	1027	933
5	4.50	5.49	12259	1145	774	854	816	850	1110	791	891	1203	1372	1302	1151
6	5.50	6.49	13843	827	828	899	1038	1121	1127	959	1208	1597	1663	1438	1138
7	6.50	7.49	14256	818	825	802	969	1282	1313	1088	1294	1870	1539	1412	1044
8	7.50	8.49	14302	535	827	762	877	1446	1290	1029	1263	1664	1808	1658	1143
9	8.50	9.49	13484	541	686	666	888	1325	1402	1008	1333	1688	1834	1325	788
10	9.50	10.49	14451	621	417	569	923	1460	1292	1035	1254	2149	2385	1566	780
11	10.50	11.49	13696	497	433	527	917	1287	1191	937	1504	2019	2087	1486	811
12	11.50	12.49	12249	561	225	532	716	1156	1032	972	1222	1927	1815	1400	691
13	12.50	13.49	11272	342	225	443	764	1002	998	984	1450	1790	1578	1281	415
14	13.50	14.49	10186	278	166	345	606	1033	888	782	1440	1844	1679	937	188
15	14.50	15.49	8182	166	106	353	454	853	626	535	1077	1586	1526	764	136
16	15.50	16.49	6927	242	52	95	263	606	618	492	887	1441	1276	809	146
17	16.50	17.49	5448	126	34	106	215	443	432	286	632	1194	1069	752	159
18	17.50	18.49	4096	69	22	102	127	356	262	241	622	1001	651	482	161
19	18.50	19.49	2902	44	4	46	68	228	208	200	511	700	523	300	70
20	19.50	20.49	2329	30	3	25	40	117	89	123	501	552	469	322	58
21	20.50	21.49	1348	17	2	9	33	50	38	66	302	376	251	168	36
22	21.50	22.49	957	9	1	5	18	27	14	55	212	300	153	131	32
23	22.50	23.49	674	2	0	0	5	12	1	24	147	230	141	87	25
24	23.50	24.49	421	5	0	0	2	5	2	9	88	104	106	89	11
25	24.50	25.49	232	3	0	3	2	1	0	11	41	59	46	66	0
26	25.50	26.49	141	0	0	1	0	0	0	10	33	29	35	32	1
27	26.50	27.49	118	0	0	0	0	1	0	2	11	19	31	53	1
28	27.50	28.49	62	0	0	0	0	0	0	0	3	15	19	22	3
29	28.50	29.49	42	0	0	0	0	0	0	0	6	9	15	10	2
30	29.50	30.49	19	0	0	0	0	0	0	1	3	1	7	7	0
31	30.50	31.49	20	0	0	0	0	0	0	0	4	2	9	5	0
32	31.50	32.49	13	0	0	0	0	0	0	0	3	0	4	6	0
33	32.50	33.49	7	0	0	0	0	0	0	0	0	1	4	2	0
34	33.50	34.49	3	0	0	0	0	0	0	0	0	2	0	1	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	1	0	0	0	0	0	0	0	1	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:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

170.00m - MCP LT - MCP session (7) - [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			9.69	7.67	6.92	7.68	8.87	9.66	9.24	9.54	10.77	11.17	10.75	10.17	7.91
0		0.49	544	6	37	65	55	64	62	91	37	46	39	32	10
1	0.50	1.49	2750	210	227	256	140	182	391	284	208	232	225	227	168
2	1.50	2.49	6301	509	553	622	497	456	487	470	612	660	540	348	547
3	2.50	3.49	8930	792	642	842	513	610	675	606	853	804	989	764	840
4	3.50	4.49	10508	961	752	739	782	861	926	685	974	1074	970	908	876
5	4.50	5.49	12309	1154	745	744	731	971	1125	939	949	1124	1268	1418	1141
6	5.50	6.49	14269	894	894	997	1137	1137	1181	1049	1241	1504	1584	1506	1145
7	6.50	7.49	14596	760	817	950	1021	1394	1241	1080	1296	1847	1707	1514	969
8	7.50	8.49	14173	618	856	756	928	1481	1381	1073	1293	1532	1631	1441	1183
9	8.50	9.49	14167	552	729	714	805	1359	1379	1107	1333	1997	1949	1398	845
10	9.50	10.49	14720	529	446	619	905	1472	1400	1110	1374	2172	2313	1653	727
11	10.50	11.49	13274	651	425	509	986	1258	1129	995	1385	1938	2055	1216	727
12	11.50	12.49	12276	492	257	439	755	1154	1121	992	1360	1850	1744	1367	745
13	12.50	13.49	11274	399	216	495	621	1095	900	845	1454	2078	1636	1125	410
14	13.50	14.49	10129	274	146	369	606	1014	929	841	1263	1757	1763	1001	166
15	14.50	15.49	7911	185	88	271	470	740	586	537	1130	1588	1350	843	123
16	15.50	16.49	6853	169	68	103	295	614	509	499	1056	1395	1256	731	158
17	16.50	17.49	5284	148	41	91	196	347	532	417	646	1181	961	581	143
18	17.50	18.49	4171	88	15	102	110	392	275	244	624	1032	699	483	107
19	18.50	19.49	2782	46	4	31	74	158	126	176	494	714	554	332	73
20	19.50	20.49	2118	28	6	28	38	107	86	116	453	529	384	295	48
21	20.50	21.49	1309	13	4	5	33	67	35	71	309	354	201	189	28
22	21.50	22.49	805	5	1	5	18	32	11	40	185	261	145	78	24
23	22.50	23.49	489	2	0	2	1	8	1	35	74	148	128	64	26
24	23.50	24.49	321	6	0	2	3	6	1	14	40	79	81	65	24
25	24.50	25.49	228	2	0	1	4	3	0	13	42	52	59	48	4
26	25.50	26.49	147	0	0	0	0	2	0	5	32	17	29	60	2
27	26.50	27.49	75	0	0	0	0	0	0	2	12	11	18	28	4
28	27.50	28.49	51	0	0	0	0	0	0	1	4	5	23	18	0
29	28.50	29.49	25	0	0	0	0	0	0	1	5	5	7	7	0
30	29.50	30.49	20	0	0	0	0	0	0	0	2	2	10	6	0
31	30.50	31.49	15	0	0	0	0	0	0	0	0	1	7	7	0
32	31.50	32.49	7	0	0	0	0	0	0	0	0	2	3	2	0
33	32.50	33.49	2	0	0	0	0	0	0	0	0	1	0	1	0
34	33.50	34.49	2	0	0	0	0	0	0	0	0	0	0	2	0
35	34.50	35.49	3	0	0	0	0	0	0	0	0	2	1	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	1	0	0	0	0	0	0	0	0	0	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: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - MCP LT - MCP session (1) - [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			9.60	7.61	6.99	7.81	8.79	9.56	9.17	9.47	10.63	11.03	10.61	10.00	7.85
0		0.49	619	8	29	63	45	62	66	111	52	74	38	47	24
1	0.50	1.49	2670	200	215	218	145	214	380	217	208	298	203	196	176
2	1.50	2.49	6169	502	482	592	500	513	433	472	652	599	480	371	573
3	2.50	3.49	9233	831	664	808	564	633	688	661	912	829	1028	800	815
4	3.50	4.49	10654	993	782	848	774	868	868	676	951	1088	992	967	847
5	4.50	5.49	12310	1134	679	658	785	1016	1109	935	974	1134	1242	1448	1196
6	5.50	6.49	13910	817	940	888	1110	1123	1273	1047	1208	1506	1546	1399	1053
7	6.50	7.49	14977	734	814	1019	1092	1477	1195	1110	1380	1833	1739	1480	1104
8	7.50	8.49	14359	599	883	795	974	1460	1444	1084	1293	1635	1665	1496	1031
9	8.50	9.49	14444	529	720	757	861	1347	1509	1165	1432	1883	1917	1437	887
10	9.50	10.49	15063	631	547	714	918	1555	1318	1076	1422	2250	2312	1534	786
11	10.50	11.49	13803	616	387	496	1027	1280	1227	1067	1362	2023	2011	1514	793
12	11.50	12.49	12520	490	241	526	792	1276	1164	1049	1530	1793	1815	1206	638
13	12.50	13.49	11214	397	219	422	579	1134	945	863	1424	2067	1689	1081	394
14	13.50	14.49	9886	237	162	407	576	936	836	837	1217	1754	1739	1008	177
15	14.50	15.49	7904	178	84	284	515	784	586	542	1267	1441	1274	849	100
16	15.50	16.49	6819	151	52	130	235	570	630	487	972	1542	1322	578	150
17	16.50	17.49	5235	158	45	117	178	450	442	410	614	1188	837	636	160
18	17.50	18.49	3844	78	21	71	109	270	184	250	716	999	654	406	86
19	18.50	19.49	2455	39	10	40	88	152	93	136	447	634	454	287	75
20	19.50	20.49	1742	28	5	18	30	102	59	88	357	397	320	304	34
21	20.50	21.49	1158	11	2	4	28	48	18	61	340	386	145	83	32
22	21.50	22.49	711	6	0	5	9	29	3	50	140	230	134	86	19
23	22.50	23.49	410	1	1	1	2	10	1	16	57	94	107	79	41
24	23.50	24.49	293	7	0	1	4	2	1	12	47	61	90	58	10
25	24.50	25.49	160	0	0	1	4	3	0	13	31	42	32	29	5
26	25.50	26.49	84	0	0	0	0	0	0	3	10	16	15	36	4
27	26.50	27.49	97	0	0	0	0	0	0	2	9	9	26	51	0
28	27.50	28.49	35	0	0	0	0	0	0	1	4	6	11	11	2
29	28.50	29.49	20	0	0	0	0	0	0	0	1	3	10	6	0
30	29.50	30.49	15	0	0	0	0	0	0	0	2	2	7	4	0
31	30.50	31.49	18	0	0	0	0	0	0	0	0	4	5	9	0
32	31.50	32.49	2	0	0	0	0	0	0	0	0	1	0	1	0
33	32.50	33.49	1	0	0	0	0	0	0	0	0	0	0	1	0
34	33.50	34.49	4	0	0	0	0	0	0	0	0	2	1	1	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	0	0	1	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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15/12/2025 12:58

Meteo data report - Frequency distribution (TAB file data)

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

130.00m - MCP LT - MCP session (6) - [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			9.46	7.63	6.93	7.92	8.71	9.33	9.04	9.36	10.49	10.80	10.47	9.83	7.76
0		0.49	605	15	48	24	30	81	75	100	75	56	42	22	37
1	0.50	1.49	2794	234	213	183	217	299	322	200	263	290	214	156	203
2	1.50	2.49	6367	495	458	503	513	531	459	471	654	633	534	508	608
3	2.50	3.49	9297	843	759	751	569	722	732	712	939	827	886	732	825
4	3.50	4.49	10635	979	829	843	695	842	860	659	975	1138	1023	961	831
5	4.50	5.49	12459	992	694	706	810	1138	1217	915	969	1184	1241	1396	1197
6	5.50	6.49	13860	731	940	937	1034	1251	1193	1217	1190	1500	1545	1357	965
7	6.50	7.49	15031	604	856	1007	1112	1457	1354	1193	1325	1741	1706	1588	1088
8	7.50	8.49	14930	679	873	707	1095	1446	1399	1081	1389	1664	1777	1618	1202
9	8.50	9.49	15073	609	818	796	961	1461	1537	1185	1486	2085	1966	1347	822
10	9.50	10.49	15234	606	533	760	1016	1594	1313	1057	1457	2287	2317	1388	906
11	10.50	11.49	14264	629	413	551	1038	1388	1187	1166	1539	1939	2081	1564	769
12	11.50	12.49	12796	472	290	581	800	1268	1278	1027	1605	1930	1837	1116	592
13	12.50	13.49	11097	315	201	401	585	1167	969	881	1376	1900	1869	1078	355
14	13.50	14.49	9342	261	150	334	531	850	670	830	1482	1655	1535	881	163
15	14.50	15.49	8152	186	83	280	416	713	624	611	1168	1619	1355	956	141
16	15.50	16.49	6699	149	48	126	250	635	599	362	970	1526	1216	651	167
17	16.50	17.49	4663	152	38	84	169	433	388	401	704	1010	779	401	104
18	17.50	18.49	3531	92	14	111	115	164	168	235	674	880	566	404	108
19	18.50	19.49	2329	38	5	36	70	151	76	122	497	630	357	284	63
20	19.50	20.49	1297	22	5	16	42	93	40	60	294	313	188	194	30
21	20.50	21.49	840	11	2	7	15	33	12	53	196	240	160	78	33
22	21.50	22.49	577	6	1	3	11	19	0	46	111	151	132	70	27
23	22.50	23.49	417	3	0	2	2	5	0	20	51	90	131	89	24
24	23.50	24.49	223	4	0	1	2	1	0	12	30	51	64	53	5
25	24.50	25.49	130	1	0	1	0	0	0	10	12	18	38	48	2
26	25.50	26.49	54	0	0	0	0	0	0	1	4	14	9	24	2
27	26.50	27.49	59	1	0	0	0	0	0	1	4	10	19	21	3
28	27.50	28.49	34	0	0	0	0	0	0	0	5	2	14	13	0
29	28.50	29.49	22	0	0	0	0	0	0	0	2	3	9	8	0
30	29.50	30.49	15	0	0	0	0	0	0	0	1	4	6	4	0
31	30.50	31.49	5	0	0	0	0	0	0	0	0	0	5	0	0
32	31.50	32.49	2	0	0	0	0	0	0	0	0	1	1	0	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	1	1	0	1	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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15/12/2025 12:58

Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

100.00m - MCP LT - MCP session (5) - [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			9.24	7.12	6.97	7.94	8.54	9.23	8.88	9.09	10.31	10.50	10.23	9.47	7.67
0		0.49	595	29	64	35	33	53	61	94	80	52	35	33	26
1	0.50	1.49	2921	197	247	224	187	336	273	282	295	278	256	160	186
2	1.50	2.49	6480	675	447	494	453	484	513	449	715	632	528	492	598
3	2.50	3.49	9477	761	870	626	559	744	739	778	889	970	785	834	922
4	3.50	4.49	10717	917	852	712	873	857	852	718	936	1125	1011	1071	793
5	4.50	5.49	12994	1031	736	885	935	1138	1224	1021	898	1250	1266	1390	1220
6	5.50	6.49	14531	768	980	925	1164	1304	1292	1196	1238	1543	1539	1589	993
7	6.50	7.49	14777	700	967	857	1110	1420	1353	1228	1271	1682	1668	1484	1037
8	7.50	8.49	15780	748	942	829	1058	1604	1638	1198	1439	1690	1926	1610	1098
9	8.50	9.49	15828	608	871	876	995	1472	1554	1188	1565	2333	2148	1328	890
10	9.50	10.49	15933	713	623	758	1101	1656	1290	1063	1716	2342	2319	1470	882
11	10.50	11.49	14559	507	381	611	912	1447	1367	1352	1731	1846	2165	1510	730
12	11.50	12.49	11982	442	300	436	756	1227	1162	1235	1449	1828	1582	1077	488
13	12.50	13.49	11355	246	201	446	677	1196	984	944	1465	2128	1847	899	322
14	13.50	14.49	9544	156	169	386	520	1048	651	617	1438	1793	1645	950	171
15	14.50	15.49	7747	117	115	244	369	639	676	513	1217	1525	1394	757	181
16	15.50	16.49	6142	137	77	135	193	480	490	420	1093	1507	1008	465	137
17	16.50	17.49	4345	64	38	124	179	334	247	354	835	953	664	423	130
18	17.50	18.49	2734	31	27	71	112	229	121	150	539	637	366	359	92
19	18.50	19.49	1743	20	10	20	60	120	54	71	345	482	261	254	46
20	19.50	20.49	930	5	5	14	20	45	29	71	152	250	179	136	24
21	20.50	21.49	704	4	5	4	11	31	11	45	178	154	139	90	32
22	21.50	22.49	391	4	0	3	7	8	3	25	47	72	122	60	40
23	22.50	23.49	255	3	0	1	3	2	0	18	24	59	91	49	5
24	23.50	24.49	151	0	1	1	0	2	0	6	15	33	33	46	14
25	24.50	25.49	92	0	0	0	0	0	0	4	11	11	24	40	2
26	25.50	26.49	52	0	0	0	1	0	0	1	4	13	14	19	0
27	26.50	27.49	31	0	0	0	0	0	0	0	6	2	13	10	0
28	27.50	28.49	16	0	0	0	0	0	1	0	0	6	5	4	0
29	28.50	29.49	15	0	0	0	0	0	0	0	1	1	10	3	0
30	29.50	30.49	11	0	0	0	0	0	0	0	0	1	5	5	0
31	30.50	31.49	4	0	0	0	0	0	0	0	0	2	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	2	0	0	0	0	0	0	0	0	1	0	1	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:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

80.00m - MCP LT - MCP session (4) - [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			9.06	7.03	6.98	7.96	8.41	9.03	8.72	8.91	10.13	10.21	9.99	9.32	7.44
0		0.49	650	37	28	37	50	81	72	81	83	59	58	36	28
1	0.50	1.49	2975	179	206	180	244	336	324	332	299	336	247	149	143
2	1.50	2.49	6383	685	506	441	408	525	444	480	590	606	563	509	626
3	2.50	3.49	9648	716	888	663	597	769	700	751	995	894	844	887	944
4	3.50	4.49	11046	838	883	683	841	866	1002	790	940	1222	1033	1123	825
5	4.50	5.49	13402	1029	870	877	1006	1236	1139	982	932	1284	1314	1400	1333
6	5.50	6.49	14531	837	955	1000	1206	1288	1324	1294	1183	1466	1424	1463	1091
7	6.50	7.49	15650	645	1024	846	1062	1472	1447	1200	1376	1912	1871	1690	1105
8	7.50	8.49	16064	719	936	856	1225	1604	1639	1182	1660	1846	1769	1523	1105
9	8.50	9.49	16374	657	963	918	1107	1695	1461	1207	1603	2355	2232	1426	750
10	9.50	10.49	16758	725	710	817	1060	1571	1602	1367	1895	2359	2313	1426	913
11	10.50	11.49	14274	479	372	670	937	1464	1388	1375	1573	2115	2085	1181	635
12	11.50	12.49	12138	323	230	460	782	1305	1173	1165	1638	1871	1678	1100	413
13	12.50	13.49	11334	189	205	445	590	1141	858	967	1658	2222	1840	970	249
14	13.50	14.49	9620	121	157	322	488	966	721	642	1651	1860	1540	950	202
15	14.50	15.49	7172	114	103	231	348	576	583	353	1240	1532	1224	712	156
16	15.50	16.49	5711	155	98	151	219	472	450	407	1039	1169	910	522	119
17	16.50	17.49	3378	58	44	100	172	249	155	245	662	779	432	359	123
18	17.50	18.49	2072	29	31	61	82	132	72	138	355	493	344	260	75
19	18.50	19.49	1305	12	14	21	51	125	42	85	242	263	199	209	42
20	19.50	20.49	1002	11	7	12	22	47	19	54	156	264	195	177	38
21	20.50	21.49	556	4	4	6	12	29	5	38	107	85	152	83	31
22	21.50	22.49	317	5	2	3	1	10	0	19	50	57	95	59	16
23	22.50	23.49	194	3	0	1	3	5	0	14	12	44	64	42	6
24	23.50	24.49	119	0	0	1	1	0	0	6	11	27	24	47	2
25	24.50	25.49	73	0	2	0	0	0	0	2	8	8	18	32	3
26	25.50	26.49	31	0	0	0	1	0	0	0	2	5	12	9	2
27	26.50	27.49	26	0	0	0	0	0	0	0	2	4	10	10	0
28	27.50	28.49	20	0	0	0	0	0	0	0	1	4	10	5	0
29	28.50	29.49	10	0	0	0	0	0	0	1	0	1	5	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	3	0	0	0	0	0	0	0	0	1	0	2	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	0	1	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: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

40.00m - MCP LT - MCP session (3) - [Matrix]

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			8.44	6.77	6.83	7.60	7.89	8.49	8.05	8.25	9.25	9.24	9.43	8.76	7.07
0		0.49	608	37	21	31	68	50	48	110	86	65	44	11	37
1	0.50	1.49	3136	247	244	200	271	238	329	283	341	369	221	168	225
2	1.50	2.49	7017	698	556	420	409	649	546	555	646	700	561	580	697
3	2.50	3.49	10750	836	849	875	745	836	866	837	1092	1047	788	1072	907
4	3.50	4.49	11840	880	790	848	948	1024	969	703	1017	1379	1131	1251	900
5	4.50	5.49	14726	1045	970	961	1262	1430	1341	1052	1078	1420	1413	1517	1237
6	5.50	6.49	15528	837	1013	1048	1219	1406	1517	1386	1484	1570	1549	1386	1113
7	6.50	7.49	18712	766	1065	969	1599	1820	1752	1604	1741	2094	2049	1842	1411
8	7.50	8.49	18360	694	1030	852	1475	1852	1863	1326	1997	2411	2155	1575	1130
9	8.50	9.49	17289	689	770	937	1197	1648	1564	1427	2007	2650	2322	1264	814
10	9.50	10.49	17495	655	606	873	1038	1788	1764	1641	2065	2585	2342	1489	649
11	10.50	11.49	15085	408	387	651	773	1471	1321	1341	2417	2450	2027	1293	546
12	11.50	12.49	12008	326	293	610	620	1208	892	1082	1704	2170	1722	1061	320
13	12.50	13.49	10338	158	236	435	563	1083	738	659	1737	1918	1662	966	183
14	13.50	14.49	7381	116	155	254	430	663	495	406	1129	1400	1341	803	189
15	14.50	15.49	4829	154	97	140	272	365	316	341	973	721	837	489	124
16	15.50	16.49	2742	111	51	70	150	242	178	107	341	440	563	383	106
17	16.50	17.49	1762	32	21	98	111	203	62	110	206	315	254	238	112
18	17.50	18.49	1276	24	14	33	65	120	26	82	231	244	162	229	46
19	18.50	19.49	725	13	6	11	35	42	11	26	142	144	166	91	38
20	19.50	20.49	567	5	6	5	13	19	4	19	83	113	167	92	41
21	20.50	21.49	296	7	1	3	8	7	0	15	30	64	84	58	19
22	21.50	22.49	131	1	0	2	1	1	0	6	9	26	52	32	1
23	22.50	23.49	77	0	0	1	1	1	2	1	13	13	20	24	1
24	23.50	24.49	87	0	0	1	1	0	0	0	2	8	18	52	5
25	24.50	25.49	35	0	0	0	0	0	0	0	1	5	7	19	3
26	25.50	26.49	19	0	0	0	0	0	0	0	1	1	9	8	0
27	26.50	27.49	7	0	0	0	0	0	0	0	0	1	1	5	0
28	27.50	28.49	10	0	0	0	0	0	1	0	0	2	1	6	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	2	0	0	0
31	30.50	31.49	1	0	0	0	0	0	0	0	0	0	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	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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15/12/2025 12:58

Meteo data report - Frequency distribution (TAB file data)

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

12.00m - MCP LT - MCP session (2) - [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			7.60	6.10	6.18	6.97	7.22	7.78	7.35	7.43	8.29	8.07	8.51	7.94	6.36
0		0.49	830	50	54	123	88	65	52	55	68	88	66	54	67
1	0.50	1.49	3522	321	291	198	314	305	306	342	350	356	285	231	223
2	1.50	2.49	8587	786	695	671	672	698	546	723	908	837	753	566	732
3	2.50	3.49	12527	953	903	797	942	1186	916	847	1161	1353	1070	1225	1174
4	3.50	4.49	15607	1149	1039	1116	1324	1470	1317	1132	1245	1616	1424	1425	1350
5	4.50	5.49	17118	1352	1210	1166	1535	1408	1599	1408	1432	1774	1599	1442	1193
6	5.50	6.49	18867	863	1045	1000	1521	1420	1818	1612	1854	2365	2025	1997	1347
7	6.50	7.49	20342	655	1051	1149	1759	1825	1938	1868	2298	2760	2199	1521	1319
8	7.50	8.49	20007	619	842	1074	1486	1976	1825	1727	2656	3099	2438	1413	852
9	8.50	9.49	18852	575	705	946	1092	1689	1570	1556	2829	3258	2355	1604	673
10	9.50	10.49	16118	628	464	692	1064	1525	1356	1283	2313	2639	2276	1204	674
11	10.50	11.49	12994	378	269	499	820	1449	887	1101	2156	2008	1997	1060	370
12	11.50	12.49	10331	193	265	607	766	1003	888	696	1684	1523	1512	995	199
13	12.50	13.49	6544	158	178	352	524	559	391	446	1018	917	1192	655	154
14	13.50	14.49	4141	156	81	126	230	417	211	252	628	601	851	461	127
15	14.50	15.49	2665	59	39	91	169	281	154	180	317	375	481	406	113
16	15.50	16.49	1820	21	24	103	73	213	76	80	275	297	342	252	64
17	16.50	17.49	964	13	4	16	44	118	28	34	192	120	201	145	49
18	17.50	18.49	443	6	4	4	21	37	14	37	44	61	122	63	30
19	18.50	19.49	261	3	4	5	4	14	5	8	22	39	85	52	20
20	19.50	20.49	147	1	1	2	3	4	1	4	14	19	42	49	7
21	20.50	21.49	85	0	0	1	2	1	2	0	4	6	24	43	2
22	21.50	22.49	41	0	0	0	1	0	2	0	1	3	13	17	4
23	22.50	23.49	11	0	0	0	0	0	0	0	0	1	4	6	0
24	23.50	24.49	9	0	0	0	0	0	0	0	0	0	3	5	1
25	24.50	25.49	3	0	0	0	0	0	0	0	1	1	0	1	0
26	25.50	26.49	3	0	0	0	0	0	0	0	0	2	0	1	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	1	0	0	0	0	0	0	0	0	0	0	1	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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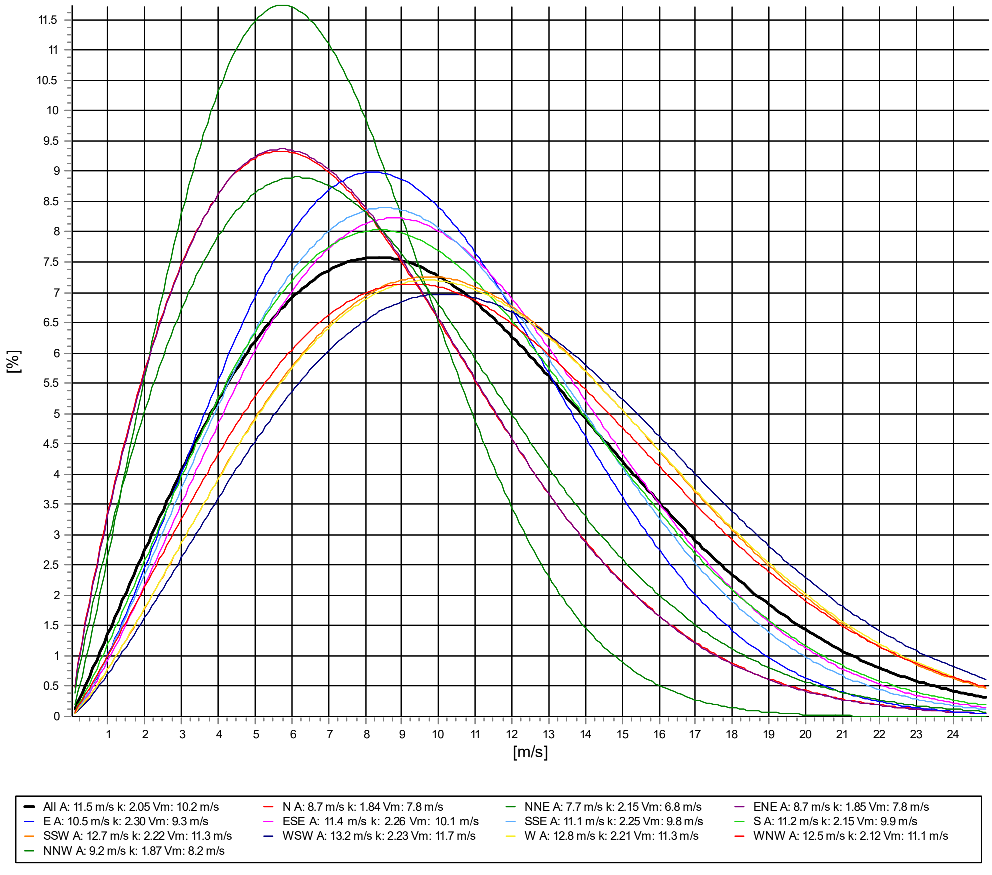
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **300.00m - MCP LT - MCP session (11) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.73	1.839	4.92	7.76
1-NNE	7.69	2.154	3.90	6.81
2-ENE	8.73	1.849	4.51	7.75
3-E	10.54	2.301	5.92	9.33
4-ESE	11.37	2.263	8.30	10.07
5-SSE	11.08	2.247	8.47	9.82
6-S	11.22	2.150	6.92	9.94
7-SSW	12.72	2.225	10.16	11.27
8-WSW	13.25	2.227	15.01	11.73
9-W	12.78	2.213	14.67	11.32
10-WNW	12.49	2.120	11.11	11.06
11-NNW	9.24	1.870	6.13	8.20
Mean	**11.51**	**2.052**	**100.00**	**10.20**



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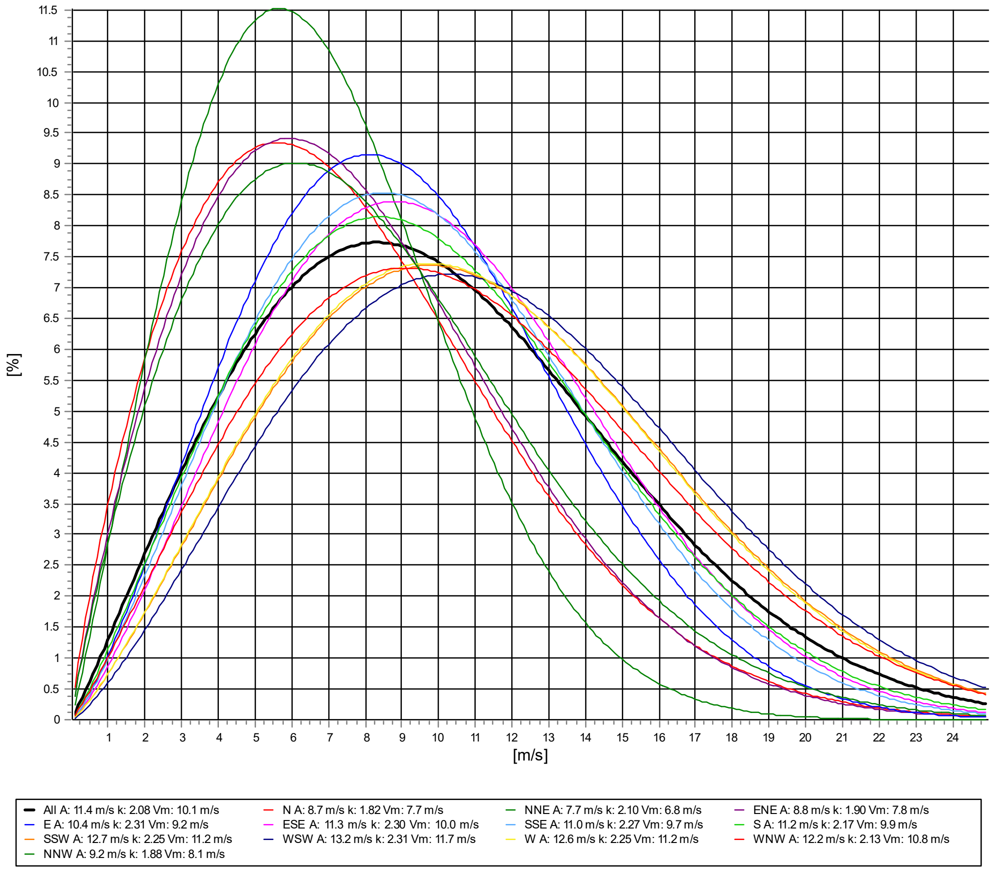
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **260.00m - MCP LT - MCP session (10) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.67	1.824	4.99	7.71
1-NNE	7.70	2.102	3.89	6.82
2-ENE	8.80	1.896	4.59	7.81
3-E	10.38	2.313	5.98	9.19
4-ESE	11.28	2.301	8.36	9.99
5-SSE	10.97	2.268	8.49	9.71
6-S	11.16	2.175	7.05	9.88
7-SSW	12.67	2.253	10.28	11.22
8-WSW	13.17	2.313	14.95	11.66
9-W	12.61	2.253	14.45	11.17
10-WNW	12.25	2.135	10.92	10.84
11-NNW	9.15	1.881	6.04	8.12
Mean	**11.40**	**2.084**	**100.00**	**10.10**



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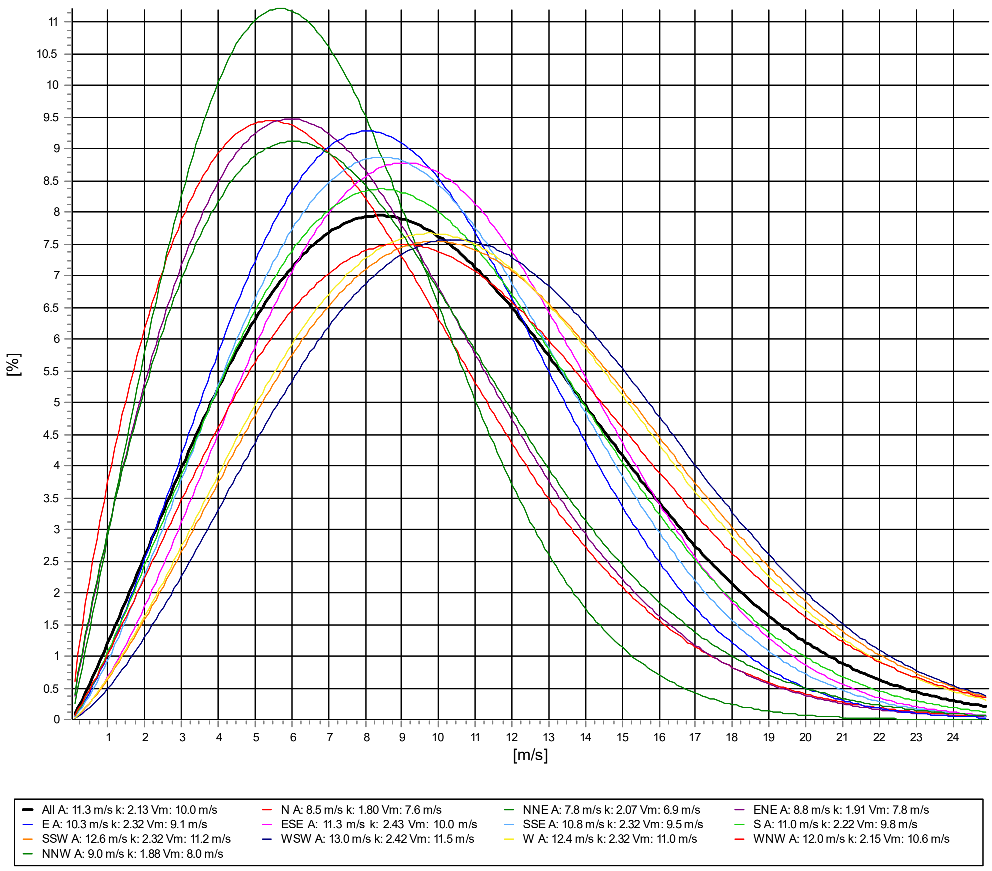
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Height: **220.00m - MCP LT - MCP session (9) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.52	1.798	4.85	7.57
1-NNE	7.82	2.070	4.09	6.93
2-ENE	8.80	1.912	4.76	7.81
3-E	10.28	2.324	6.00	9.11
4-ESE	11.26	2.435	8.65	9.98
5-SSE	10.75	2.324	8.44	9.53
6-S	11.04	2.225	7.08	9.78
7-SSW	12.64	2.322	10.56	11.20
8-WSW	12.98	2.417	14.79	11.51
9-W	12.44	2.325	14.22	11.03
10-WNW	12.00	2.147	10.61	10.63
11-NNW	9.04	1.877	5.95	8.03
Mean	**11.28**	**2.135**	**100.00**	**9.99**



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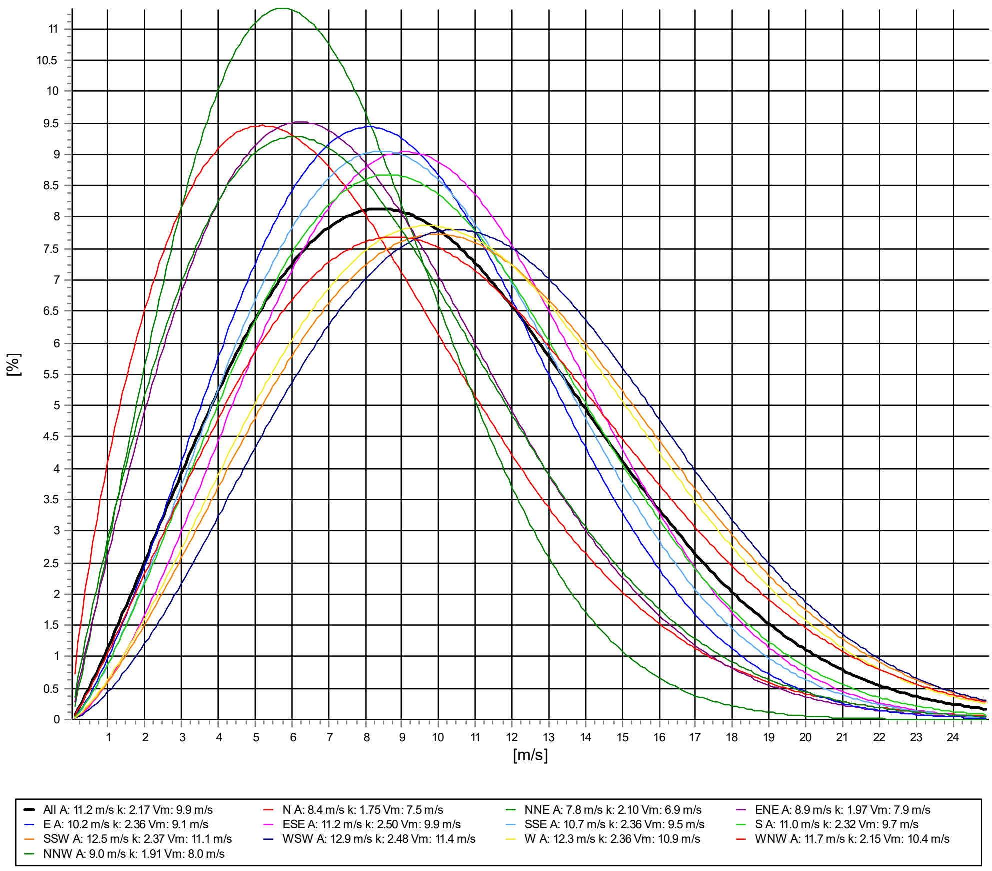
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **190.00m - MCP LT - MCP session (8) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.39	1.754	4.86	7.47
1-NNE	7.83	2.102	4.12	6.94
2-ENE	8.93	1.970	4.88	7.91
3-E	10.23	2.360	6.07	9.06
4-ESE	11.17	2.499	8.75	9.91
5-SSE	10.67	2.363	8.52	9.45
6-S	10.99	2.324	7.16	9.74
7-SSW	12.53	2.369	10.74	11.11
8-WSW	12.87	2.481	14.54	11.41
9-W	12.27	2.360	13.98	10.88
10-WNW	11.74	2.155	10.49	10.40
11-NNW	8.96	1.906	5.89	7.95
Mean	**11.16**	**2.174**	**100.00**	**9.89**



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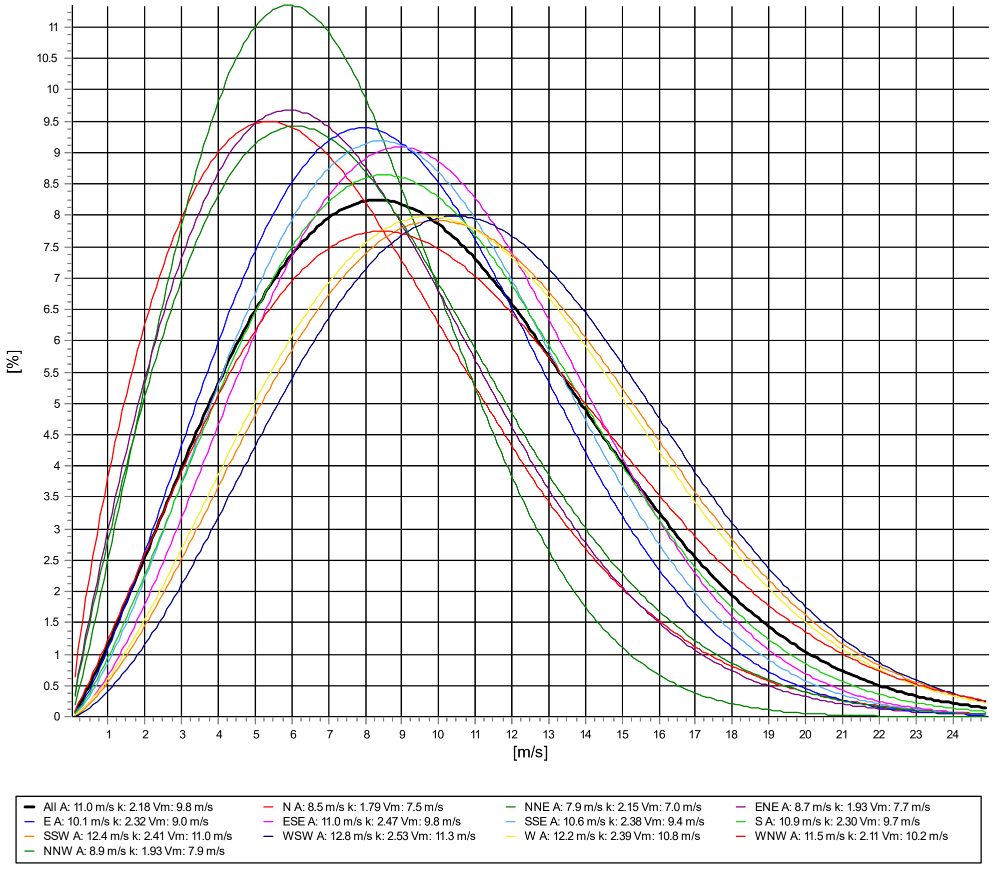
Meteo data report - Weibull data overview

Mast: HS-1-LB (SWLB059+WS190) LT **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **170.00m - MCP LT - MCP session (7) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.46	1.793	4.92	7.52
1-NNE	7.93	2.147	4.13	7.02
2-ENE	8.65	1.927	5.06	7.68
3-E	10.13	2.318	6.08	8.98
4-ESE	11.01	2.471	8.81	9.77
5-SSE	10.59	2.383	8.55	9.38
6-S	10.94	2.297	7.44	9.69
7-SSW	12.41	2.415	10.76	11.01
8-WSW	12.76	2.529	14.52	11.33
9-W	12.21	2.391	13.65	10.83
10-WNW	11.47	2.108	10.25	10.16
11-NNW	8.90	1.930	5.84	7.89
Mean	**11.05**	**2.183**	**100.00**	**9.79**



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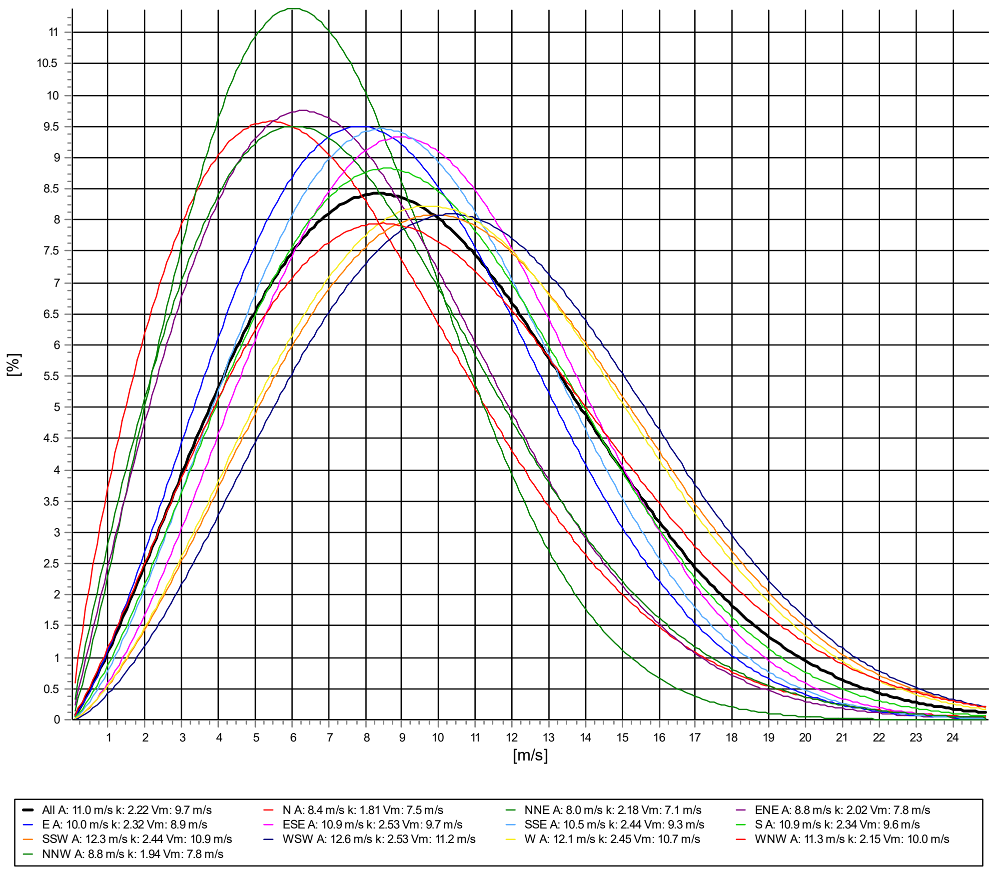
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - MCP LT - MCP session (1) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.44	1.814	4.86	7.50
1-NNE	8.00	2.184	4.14	7.09
2-ENE	8.85	2.018	5.12	7.84
3-E	10.02	2.317	6.19	8.88
4-ESE	10.94	2.533	8.98	9.71
5-SSE	10.48	2.444	8.54	9.29
6-S	10.87	2.341	7.49	9.63
7-SSW	12.26	2.440	10.91	10.87
8-WSW	12.60	2.532	14.43	11.18
9-W	12.07	2.449	13.41	10.71
10-WNW	11.34	2.151	10.11	10.04
11-NNW	8.84	1.936	5.81	7.84
Mean	**10.96**	**2.223**	**100.00**	**9.70**



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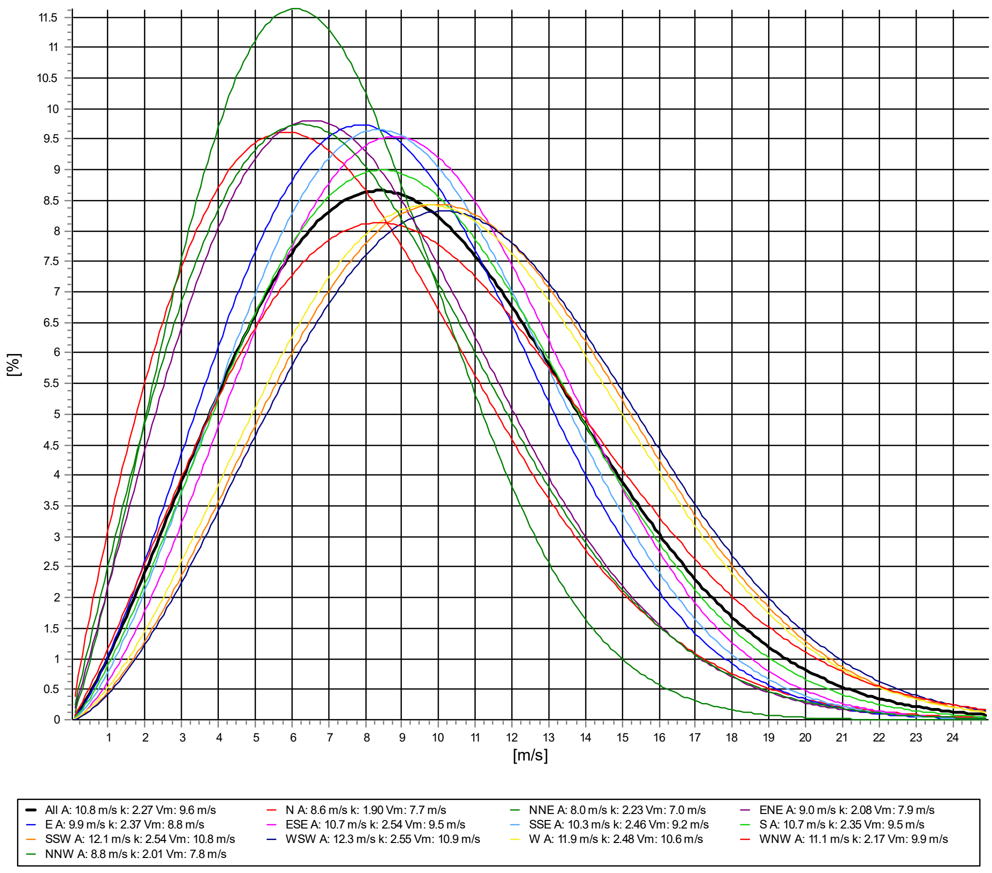
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **130.00m - MCP LT - MCP session (6) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.64	1.902	4.73	7.67
1-NNE	7.95	2.230	4.29	7.04
2-ENE	8.97	2.076	5.06	7.94
3-E	9.94	2.366	6.27	8.81
4-ESE	10.71	2.536	9.20	9.50
5-SSE	10.34	2.464	8.54	9.17
6-S	10.71	2.354	7.59	9.49
7-SSW	12.13	2.540	11.12	10.77
8-WSW	12.32	2.549	14.21	10.94
9-W	11.93	2.485	13.29	10.59
10-WNW	11.14	2.166	9.86	9.87
11-NNW	8.82	2.006	5.85	7.82
Mean	**10.82**	**2.268**	**100.00**	**9.59**



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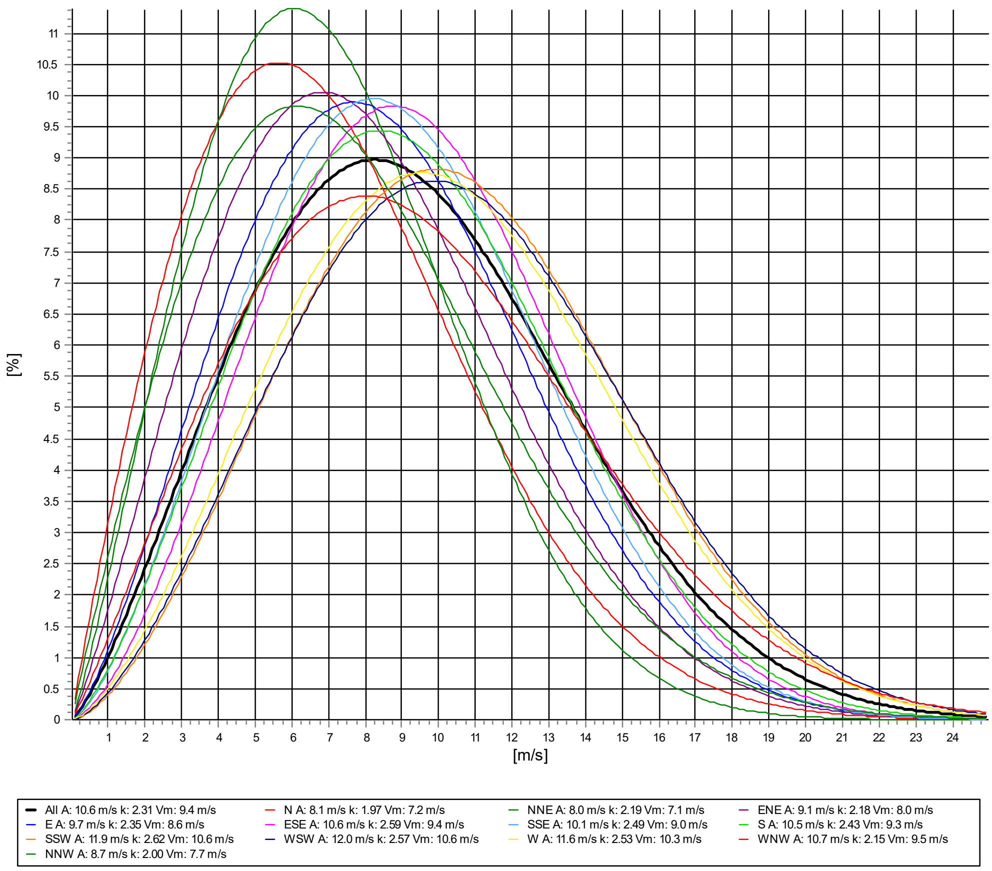
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **100.00m - MCP LT - MCP session (5) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.08	1.973	4.61	7.16
1-NNE	8.02	2.191	4.63	7.10
2-ENE	9.06	2.183	5.04	8.03
3-E	9.72	2.349	6.37	8.62
4-ESE	10.58	2.595	9.27	9.40
5-SSE	10.12	2.489	8.60	8.98
6-S	10.45	2.428	7.80	9.27
7-SSW	11.91	2.625	11.20	10.58
8-WSW	11.97	2.572	14.11	10.62
9-W	11.65	2.534	12.99	10.34
10-WNW	10.73	2.148	9.66	9.50
11-NNW	8.72	1.997	5.73	7.72
Mean	**10.57**	**2.305**	**100.00**	**9.36**



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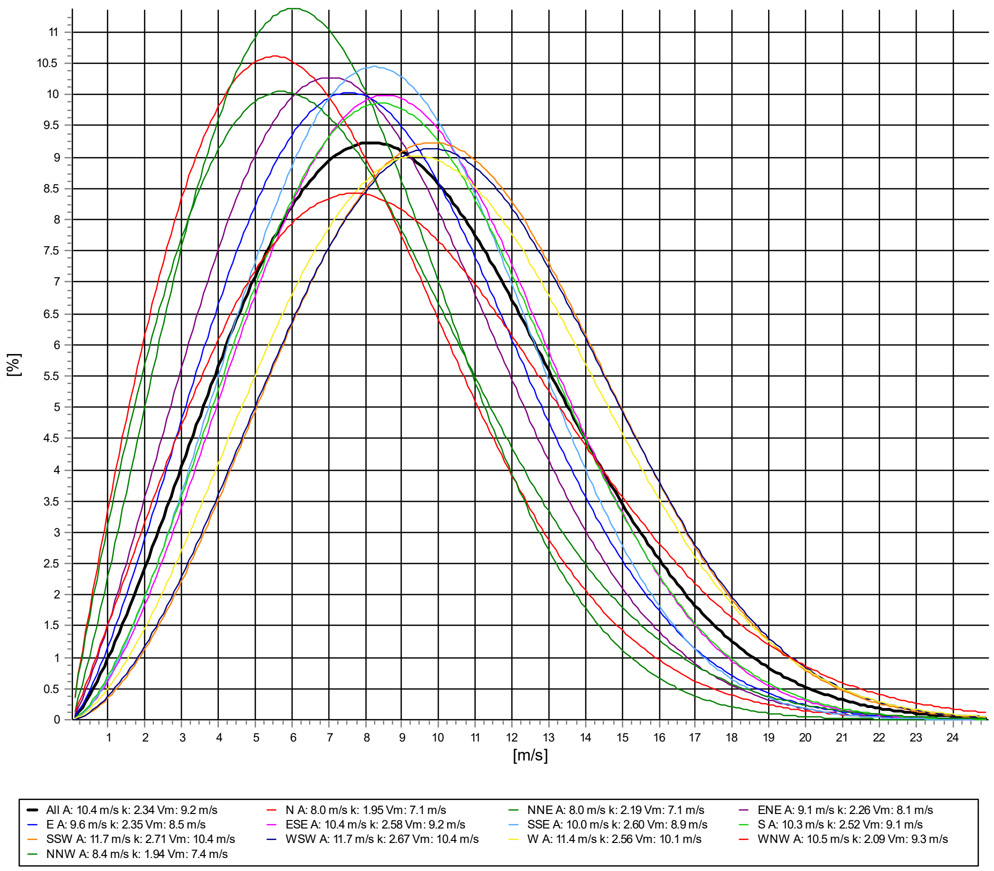
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **80.00m - MCP LT - MCP session (4) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.96	1.953	4.44	7.06
1-NNE	8.01	2.185	4.79	7.10
2-ENE	9.10	2.263	5.08	8.06
3-E	9.58	2.346	6.49	8.49
4-ESE	10.35	2.575	9.32	9.19
5-SSE	9.97	2.599	8.62	8.86
6-S	10.31	2.521	7.87	9.15
7-SSW	11.67	2.709	11.39	10.38
8-WSW	11.67	2.673	14.08	10.38
9-W	11.41	2.556	12.71	10.13
10-WNW	10.49	2.091	9.52	9.29
11-NNW	8.36	1.937	5.69	7.42
Mean	**10.37**	**2.337**	**100.00**	**9.19**



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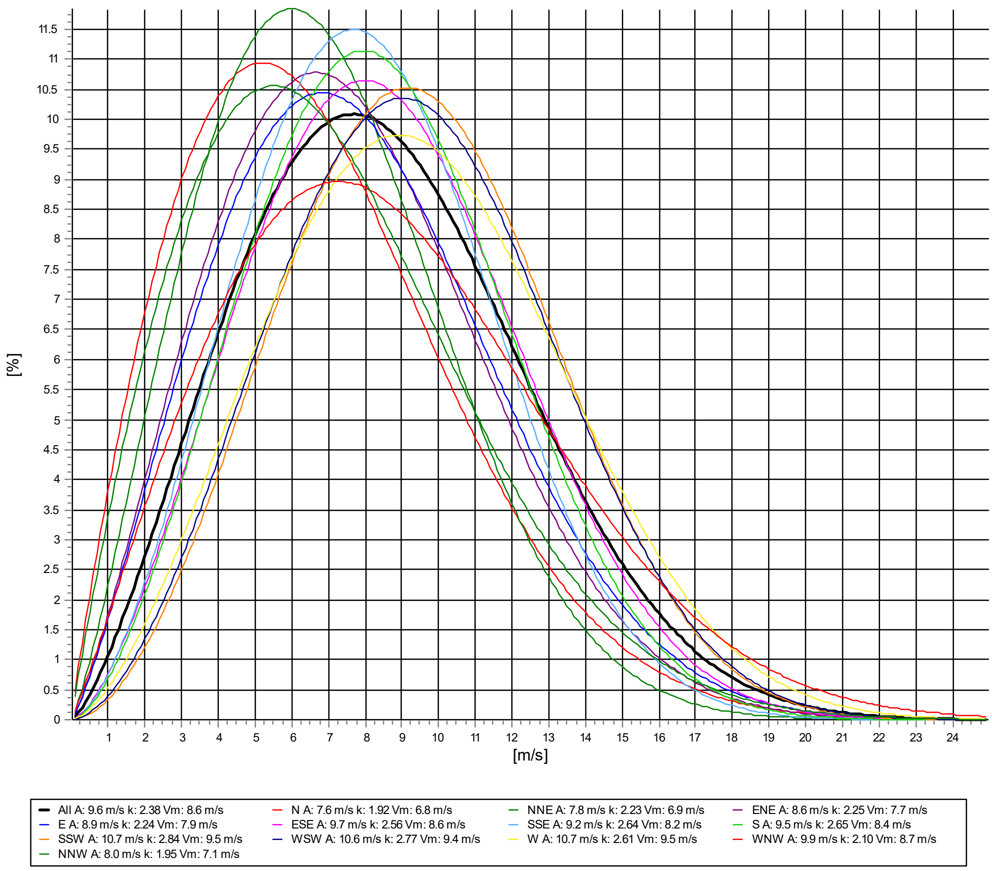
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **40.00m - MCP LT - MCP session (3) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	7.64	1.919	4.53	6.78
1-NNE	7.82	2.234	4.76	6.93
2-ENE	8.65	2.253	5.36	7.66
3-E	8.89	2.241	6.88	7.88
4-ESE	9.67	2.563	9.42	8.59
5-SSE	9.19	2.645	8.61	8.17
6-S	9.50	2.650	7.84	8.44
7-SSW	10.67	2.843	11.71	9.50
8-WSW	10.61	2.771	13.65	9.44
9-W	10.73	2.610	12.27	9.53
10-WNW	9.88	2.097	9.34	8.75
11-NNW	7.98	1.946	5.63	7.08
Mean	**9.65**	**2.385**	**100.00**	**8.55**



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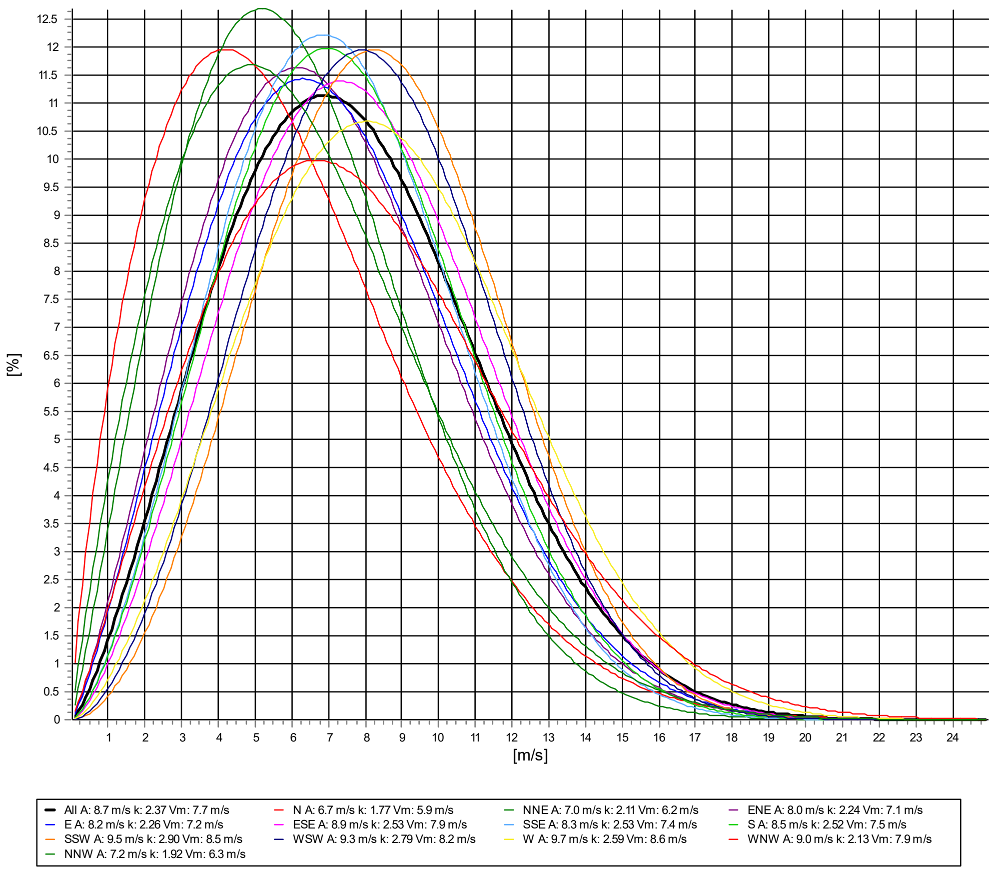
Meteo data report - Weibull data overview

Mast:HS-1-LB (SWLB059+WS190) LT **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **12.00m - MCP LT - MCP session (2) - [Matrix]**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	6.67	1.774	4.64	5.94
1-NNE	7.01	2.114	4.75	6.21
2-ENE	7.98	2.241	5.57	7.06
3-E	8.17	2.263	7.50	7.24
4-ESE	8.94	2.527	9.16	7.93
5-SSE	8.34	2.534	8.25	7.41
6-S	8.49	2.524	7.98	7.53
7-SSW	9.54	2.897	12.17	8.50
8-WSW	9.25	2.793	13.54	8.24
9-W	9.71	2.586	12.11	8.62
10-WNW	8.97	2.133	8.76	7.94
11-NNW	7.16	1.923	5.57	6.35
Mean	**8.68**	**2.366**	**100.00**	**7.69**



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Meteo data report - Frequency distribution (TAB file data)

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

Frequency distribution (TAB file data)

150.00m - Subst 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			9.67	7.56	6.99	8.04	8.95	9.70	9.33	9.57	10.50	11.08	10.64	10.08	8.06
0		0.49	617	8	29	62	45	61	65	111	53	74	38	47	24
1	0.50	1.49	2617	199	214	205	142	206	371	215	217	293	202	194	159
2	1.50	2.49	6027	514	483	543	463	498	417	464	663	596	478	361	547
3	2.50	3.49	9093	839	664	767	556	616	672	651	939	823	1020	784	762
4	3.50	4.49	10542	1014	787	852	762	834	840	654	961	1083	991	943	821
5	4.50	5.49	12102	1133	683	640	761	1003	1058	915	991	1116	1229	1426	1147
6	5.50	6.49	13723	796	922	833	1056	1105	1238	1046	1236	1495	1543	1409	1044
7	6.50	7.49	14743	735	820	968	1077	1420	1171	1083	1417	1817	1725	1447	1063
8	7.50	8.49	14372	607	899	849	974	1485	1414	1049	1304	1623	1664	1500	1004
9	8.50	9.49	14334	539	706	734	897	1244	1487	1167	1434	1853	1908	1420	945
10	9.50	10.49	14905	624	555	689	822	1580	1329	1083	1460	2219	2288	1523	733
11	10.50	11.49	14094	630	387	587	1048	1317	1224	1065	1379	2075	2027	1502	853
12	11.50	12.49	12362	462	242	457	835	1218	1148	1067	1535	1769	1823	1231	575
13	12.50	13.49	11432	417	217	447	597	1147	968	837	1431	2058	1664	1078	571
14	13.50	14.49	10046	220	153	414	565	971	877	873	1208	1770	1762	1036	197
15	14.50	15.49	8049	174	90	340	533	823	574	563	1279	1452	1267	845	109
16	15.50	16.49	6924	148	51	172	318	602	661	473	922	1537	1327	584	129
17	16.50	17.49	5263	158	45	121	174	445	473	418	585	1203	857	631	153
18	17.50	18.49	4183	74	15	93	121	354	283	288	737	1018	656	439	105
19	18.50	19.49	2475	41	14	59	87	158	89	149	352	658	471	303	94
20	19.50	20.49	1863	19	5	29	56	105	69	93	398	414	316	310	49
21	20.50	21.49	1190	10	2	12	25	60	34	75	293	378	161	106	34
22	21.50	22.49	691	5	1	6	19	43	8	46	87	244	130	84	18
23	22.50	23.49	418	3	0	2	1	10	1	23	60	106	106	80	26
24	23.50	24.49	326	5	0	1	5	5	1	12	48	60	94	59	36
25	24.50	25.49	157	1	0	1	3	4	0	15	21	41	34	32	5
26	25.50	26.49	84	0	0	0	2	0	0	2	9	19	17	31	4
27	26.50	27.49	104	0	0	0	0	0	0	3	8	10	28	52	3
28	27.50	28.49	39	0	0	0	0	0	0	1	1	7	11	18	1
29	28.50	29.49	22	0	0	0	0	0	0	0	3	3	10	5	1
30	29.50	30.49	14	0	0	0	0	0	0	0	0	2	6	6	0
31	30.50	31.49	19	0	0	0	0	0	0	0	0	4	6	9	0
32	31.50	32.49	3	0	0	0	0	0	0	0	0	1	0	2	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	5	0	0	0	0	0	0	0	0	2	1	2	0
35	34.50	35.49	0	0	0	0	0	0	0	0	0	0	0	0	0
36	35.50	36.49	2	0	0	0	0	0	0	0	0	1	1	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:
23406 Hesselø South

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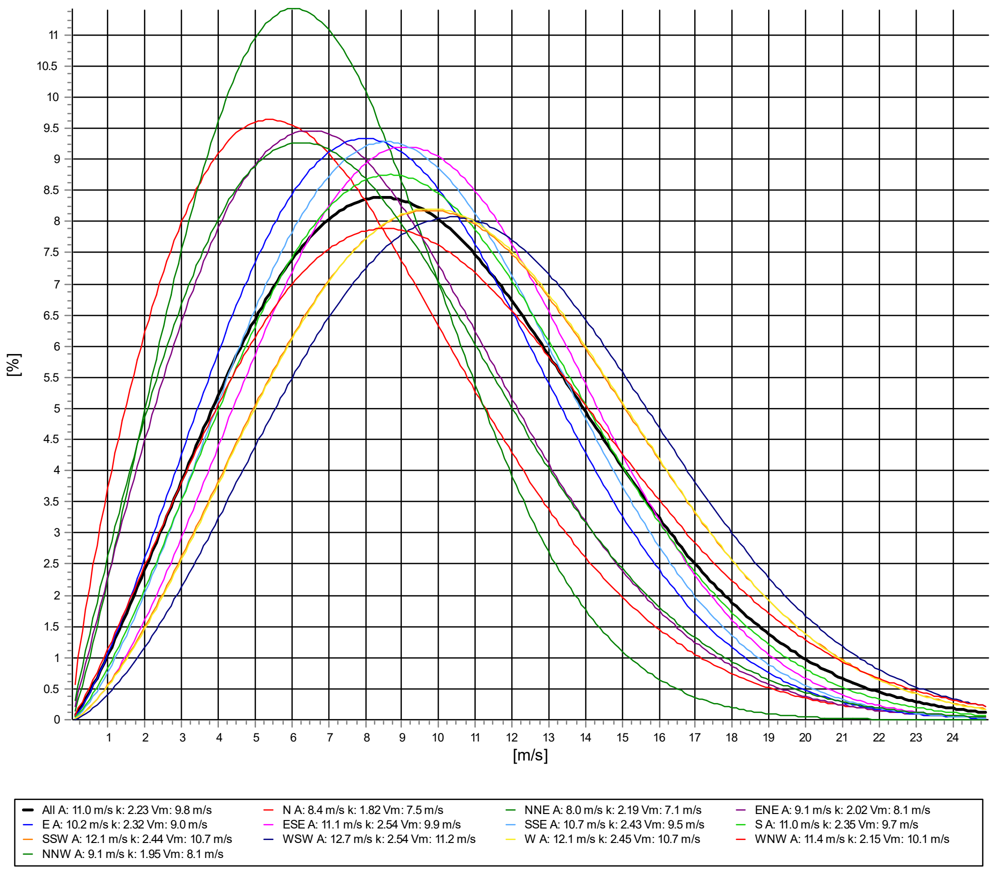
Calculated:
15/12/2025 13:30

Meteo data report - Weibull data overview

Mast: HS-A LT rev 1; Complete period **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - Subst Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.40	1.818	4.86	7.46
1-NNE	8.01	2.194	4.14	7.09
2-ENE	9.12	2.020	5.12	8.08
3-E	10.20	2.317	6.19	9.04
4-ESE	11.11	2.540	8.98	9.86
5-SSE	10.66	2.435	8.54	9.45
6-S	10.99	2.350	7.49	9.74
7-SSW	12.10	2.438	10.91	10.73
8-WSW	12.66	2.536	14.43	11.23
9-W	12.11	2.452	13.41	10.74
10-WNW	11.43	2.150	10.11	10.12
11-NNW	9.09	1.945	5.81	8.06
Mean	**11.04**	**2.233**	**100.00**	**9.78**



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15/12/2025 13:27

Meteo data report - Frequency distribution (TAB file data)

Mast: HS-B LT rev1; Complete period **Period:** Full period: 01/01/2002 - 31/12/2023 (264.0 months)

Frequency distribution (TAB file data)

150.00m - Subst Scaled Anholt gradient

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9.58	7.63	7.00	7.84	8.63	9.45	9.27	9.44	10.67	10.98	10.51	10.15	7.78
0		0.49	621	8	29	63	46	63	66	112	51	74	39	46	24
1	0.50	1.49	2671	196	214	217	153	219	372	217	206	299	203	193	182
2	1.50	2.49	6195	497	481	578	513	529	428	479	647	609	496	357	581
3	2.50	3.49	9243	833	659	811	580	633	672	662	908	830	1049	774	832
4	3.50	4.49	10669	976	786	842	808	887	853	684	944	1105	1001	923	860
5	4.50	5.49	12325	1130	678	663	804	1045	1066	954	975	1143	1262	1413	1192
6	5.50	6.49	14005	824	932	876	1152	1159	1267	1030	1198	1519	1582	1396	1070
7	6.50	7.49	14989	732	823	1016	1098	1521	1183	1120	1361	1850	1746	1423	1116
8	7.50	8.49	14379	601	876	798	984	1470	1415	1082	1296	1617	1681	1520	1039
9	8.50	9.49	14429	528	726	748	837	1347	1491	1163	1440	1918	1978	1388	865
10	9.50	10.49	15266	632	548	721	1017	1555	1343	1081	1403	2274	2337	1532	823
11	10.50	11.49	13672	627	389	499	1009	1293	1219	1087	1362	1975	1984	1479	749
12	11.50	12.49	12495	477	242	537	707	1254	1137	1041	1525	1847	1817	1251	660
13	12.50	13.49	11261	404	217	418	597	1147	985	884	1425	2059	1724	1061	340
14	13.50	14.49	9879	243	160	406	589	922	840	815	1221	1735	1718	1058	172
15	14.50	15.49	7837	179	87	290	459	749	581	540	1274	1446	1275	848	109
16	15.50	16.49	6763	151	53	133	206	533	651	476	981	1550	1276	598	155
17	16.50	17.49	5161	158	45	112	153	464	468	400	618	1162	809	628	144
18	17.50	18.49	3863	84	20	78	93	221	247	245	701	986	638	459	91
19	18.50	19.49	2408	41	11	47	78	143	89	133	475	602	404	319	66
20	19.50	20.49	1685	26	5	15	24	77	66	91	358	391	281	313	38
21	20.50	21.49	1227	14	2	7	22	55	24	54	346	387	160	133	23
22	21.50	22.49	674	4	0	5	5	16	7	46	151	216	116	80	28
23	22.50	23.49	405	2	1	1	4	7	1	16	53	93	111	81	35
24	23.50	24.49	279	8	0	1	4	3	1	11	50	59	75	60	7
25	24.50	25.49	149	0	0	1	2	2	0	12	32	35	26	33	6
26	25.50	26.49	87	0	0	0	0	0	0	3	13	15	17	36	3
27	26.50	27.49	88	0	0	0	0	0	0	2	10	10	24	42	0
28	27.50	28.49	52	0	0	0	0	0	0	1	4	6	11	28	2
29	28.50	29.49	19	0	0	0	0	0	0	0	1	2	9	7	0
30	29.50	30.49	15	0	0	0	0	0	0	0	2	2	5	6	0
31	30.50	31.49	17	0	0	0	0	0	0	0	0	4	5	8	0
32	31.50	32.49	5	0	0	0	0	0	0	0	0	1	0	4	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	5	0	0	0	0	0	0	0	0	2	1	2	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	0	0	1	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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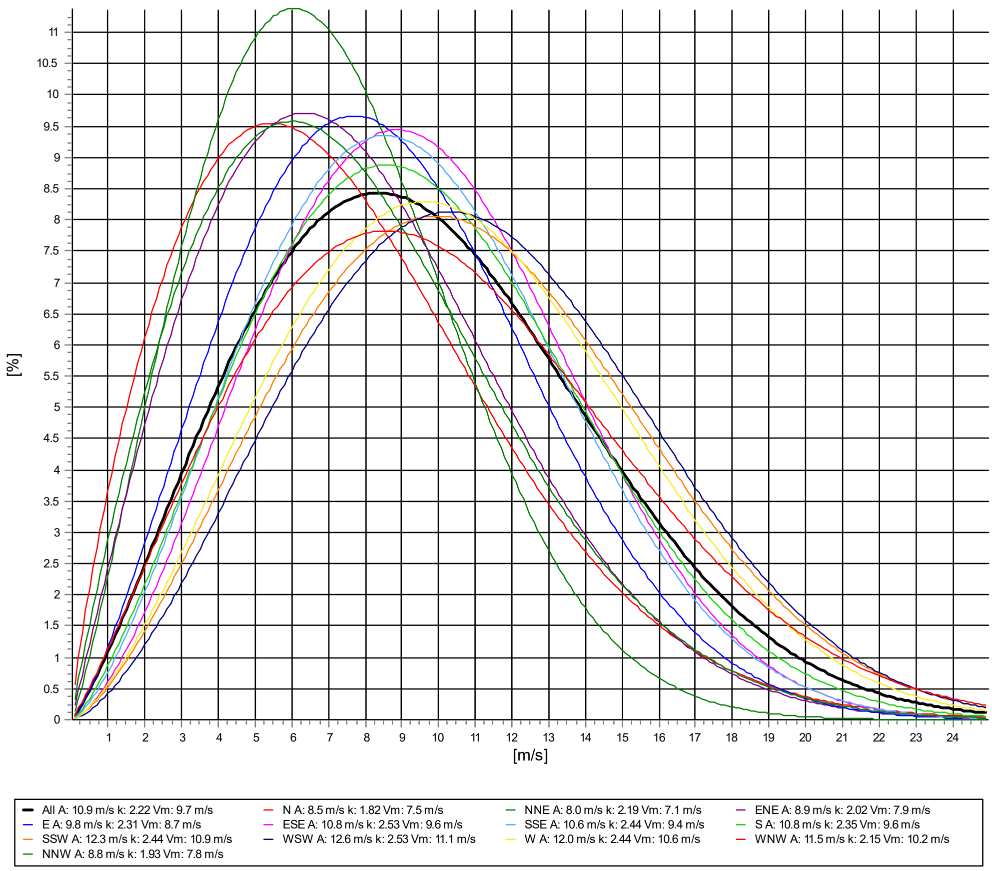
15/12/2025 13:27

Meteo data report - Weibull data overview

Mast:HS-B LT rev1; Complete period **Period:**Full period: 01/01/2002 - 31/12/2023 (264.0 months)
Height: **150.00m - Subst Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.48	1.818	4.86	7.53
1-NNE	8.01	2.187	4.14	7.10
2-ENE	8.89	2.019	5.12	7.87
3-E	9.83	2.311	6.19	8.71
4-ESE	10.82	2.535	8.98	9.60
5-SSE	10.59	2.441	8.54	9.39
6-S	10.84	2.351	7.49	9.60
7-SSW	12.30	2.443	10.91	10.91
8-WSW	12.55	2.533	14.43	11.14
9-W	11.96	2.444	13.41	10.60
10-WNW	11.50	2.145	10.11	10.18
11-NNW	8.76	1.932	5.81	7.77
Mean	**10.94**	**2.222**	**100.00**	**9.69**



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

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

Frequency distribution (TAB file data)

150.00m - Subst 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			9.65	7.45	6.86	8.10	9.11	9.69	9.30	9.63	10.61	11.04	10.68	10.08	7.62
0		0.49	616	8	31	61	45	61	66	110	52	74	38	46	24
1	0.50	1.49	2653	205	222	203	138	206	372	214	210	297	197	195	194
2	1.50	2.49	6076	535	493	534	435	500	422	455	649	599	478	365	611
3	2.50	3.49	9179	866	679	754	546	621	673	648	924	826	1008	789	845
4	3.50	4.49	10676	1044	809	856	733	838	846	641	948	1087	985	944	945
5	4.50	5.49	12089	1106	697	633	748	1009	1056	916	978	1127	1222	1430	1167
6	5.50	6.49	13733	819	938	815	1019	1096	1268	1033	1217	1505	1528	1402	1093
7	6.50	7.49	14818	753	841	963	1049	1428	1172	1080	1379	1836	1722	1467	1128
8	7.50	8.49	14469	578	936	863	987	1479	1402	1050	1295	1624	1661	1503	1091
9	8.50	9.49	14102	553	655	714	898	1257	1500	1161	1435	1870	1882	1398	779
10	9.50	10.49	15018	649	560	684	778	1566	1344	1068	1422	2245	2282	1513	907
11	10.50	11.49	13802	619	347	609	1025	1316	1218	1048	1368	2038	2030	1497	687
12	11.50	12.49	12466	462	234	438	863	1231	1133	1090	1524	1778	1806	1243	664
13	12.50	13.49	11079	368	208	460	644	1145	976	798	1432	2071	1671	1047	259
14	13.50	14.49	9991	217	142	415	538	975	864	911	1220	1758	1766	1040	145
15	14.50	15.49	8060	164	74	344	554	801	588	571	1271	1449	1281	852	111
16	15.50	16.49	7129	145	47	190	393	608	655	485	961	1545	1326	602	172
17	16.50	17.49	5253	145	41	128	179	454	459	414	611	1184	878	637	123
18	17.50	18.49	4164	70	12	100	142	334	264	301	736	1009	671	429	96
19	18.50	19.49	2500	31	12	62	92	164	87	167	414	640	486	301	44
20	19.50	20.49	1835	14	4	34	72	103	69	93	370	402	324	313	37
21	20.50	21.49	1210	11	1	12	27	60	28	81	328	388	154	103	17
22	21.50	22.49	745	5	1	4	24	41	8	41	128	229	143	85	36
23	22.50	23.49	416	5	0	5	5	12	1	26	57	96	101	83	25
24	23.50	24.49	291	3	0	0	2	5	1	17	47	60	97	55	4
25	24.50	25.49	172	0	0	1	4	4	0	16	29	41	43	31	3
26	25.50	26.49	91	0	0	1	3	0	0	2	12	17	16	37	3
27	26.50	27.49	99	0	0	0	1	0	0	3	7	10	29	47	2
28	27.50	28.49	41	0	0	0	0	0	0	0	3	6	12	20	0
29	28.50	29.49	23	0	0	0	0	0	0	1	2	3	10	7	0
30	29.50	30.49	14	0	0	0	0	0	0	0	2	2	5	5	0
31	30.50	31.49	19	0	0	0	0	0	0	0	0	4	6	9	0
32	31.50	32.49	4	0	0	0	0	0	0	0	0	1	1	2	0
33	32.50	33.49	0	0	0	0	0	0	0	0	0	0	0	0	0
34	33.50	34.49	5	0	0	0	0	0	0	0	0	2	1	2	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	0	0	1	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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Calculated:
15/12/2025 13:28

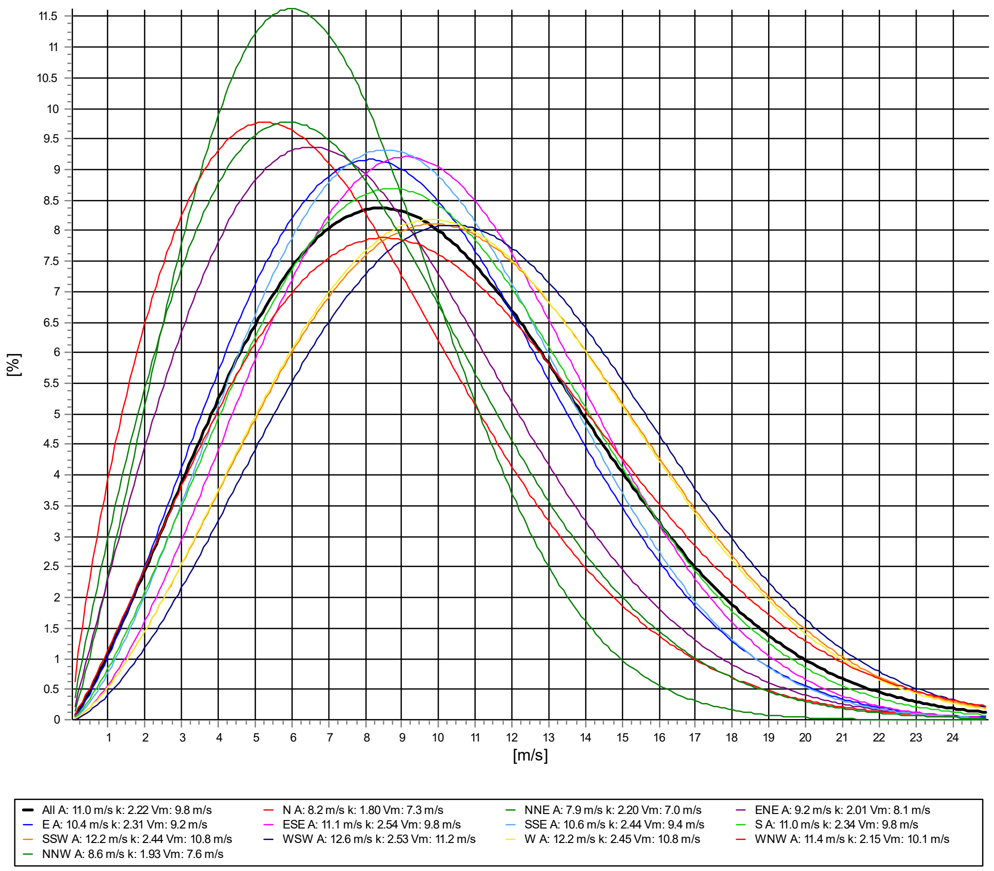
Meteo data report - Weibull data overview

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

Height: **150.00m - Subst Scaled Anholt gradient**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8.25	1.803	4.86	7.33
1-NNE	7.87	2.198	4.14	6.97
2-ENE	9.19	2.011	5.12	8.14
3-E	10.38	2.312	6.19	9.19
4-ESE	11.10	2.537	8.98	9.85
5-SSE	10.62	2.440	8.54	9.42
6-S	11.05	2.344	7.49	9.79
7-SSW	12.23	2.443	10.91	10.85
8-WSW	12.62	2.534	14.43	11.20
9-W	12.16	2.452	13.41	10.78
10-WNW	11.43	2.148	10.11	10.12
11-NNW	8.59	1.934	5.81	7.62
Mean	**11.03**	**2.222**	**100.00**	**9.76**



Appendix E Secondary models KG-1-LB, H1, M1

Project:
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23/09/2024 13.06

Meteo data report - Frequency distribution (TAB file data)

Mast: Secondary model KG-1 transferred to HS-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			9,48	7,35	6,56	7,76	8,75	9,79	9,04	9,11	10,37	11,21	10,52	9,34	7,61
0		0,49	598	1	11	20	35	23	37	60	155	93	69	84	10
1	0,50	1,49	2644	133	161	186	162	155	294	329	367	198	246	269	144
2	1,50	2,49	6164	464	509	669	533	358	678	764	588	280	369	548	404
3	2,50	3,49	8686	670	588	772	675	601	750	914	872	671	706	830	637
4	3,50	4,49	10779	878	1025	879	727	889	843	786	985	870	1068	906	923
5	4,50	5,49	13083	1137	889	1151	1017	824	1100	981	1124	1101	1496	1320	943
6	5,50	6,49	13581	784	850	1041	1177	1017	932	896	1367	1266	1831	1432	988
7	6,50	7,49	15425	929	980	850	1291	1284	1202	913	1700	1640	1754	1651	1231
8	7,50	8,49	15912	812	943	754	1091	1476	1242	839	1703	2070	2171	1838	973
9	8,50	9,49	14729	584	658	802	1090	1340	1241	889	1528	2180	2316	1411	690
10	9,50	10,49	14231	595	233	855	1011	1257	1232	1048	1371	2204	2378	1297	750
11	10,50	11,49	13995	482	318	739	742	1209	1157	931	1544	2291	2588	1502	492
12	11,50	12,49	12817	480	197	544	766	1207	1082	870	1390	2318	2219	1191	553
13	12,50	13,49	11783	303	145	442	688	1253	1104	898	1456	2269	1922	1060	243
14	13,50	14,49	9546	160	117	462	708	865	711	651	1241	1972	1739	782	138
15	14,50	15,49	7632	120	63	226	397	725	526	542	1437	1593	1353	566	84
16	15,50	16,49	6564	88	31	139	317	586	529	466	1126	1566	1121	464	131
17	16,50	17,49	4792	50	17	111	228	451	287	335	896	1246	723	356	92
18	17,50	18,49	3423	56	16	61	198	342	204	276	591	783	564	290	42
19	18,50	19,49	2156	32	8	36	99	154	113	130	346	458	481	261	38
20	19,50	20,49	1403	12	5	11	29	115	41	109	292	296	295	145	53
21	20,50	21,49	938	7	3	8	12	34	18	63	125	279	225	140	24
22	21,50	22,49	603	2	1	2	12	8	10	46	132	155	149	70	16
23	22,50	23,49	526	6	0	0	13	8	3	37	111	170	125	49	4
24	23,50	24,49	330	0	0	1	4	4	1	14	78	95	89	34	10
25	24,50	25,49	136	0	0	0	2	0	0	6	28	40	31	21	8
26	25,50	26,49	95	0	0	0	1	0	0	3	16	28	23	24	0
27	26,50	27,49	46	0	0	0	0	0	0	1	3	12	14	14	2
28	27,50	28,49	26	0	0	0	0	0	0	1	4	3	10	8	0
29	28,50	29,49	20	0	0	0	0	0	0	1	4	2	7	6	0
30	29,50	30,49	9	0	0	0	0	0	0	0	1	2	5	1	0
31	30,50	31,49	4	0	0	0	0	0	0	0	1	0	2	1	0
32	31,50	32,49	5	0	0	0	0	0	0	0	1	2	2	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	2	0	0	0	0	0	0	0	1	1	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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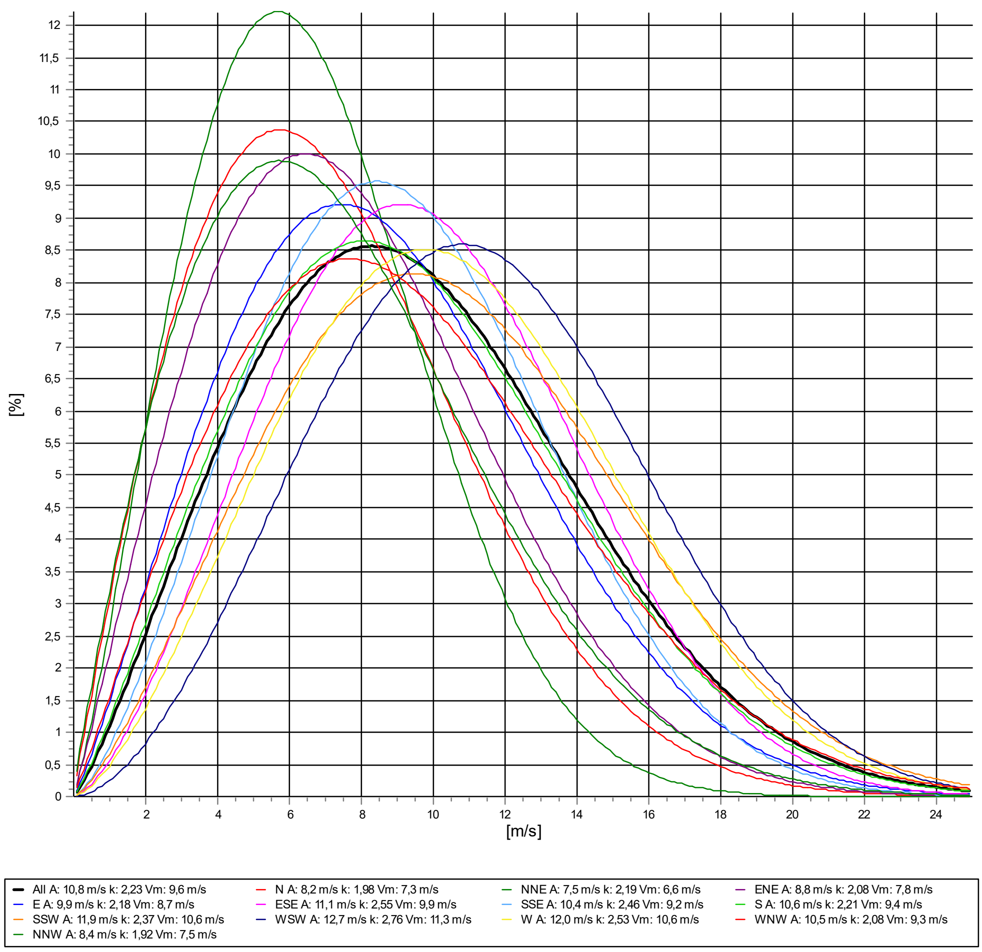
Meteo data report - Weibull data overview

Mast: Secondary model KG-1 transferred to HS-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	8,20	1,975	4,56	7,27
1-NNE	7,49	2,194	4,03	6,63
2-ENE	8,82	2,085	5,58	7,81
3-E	9,88	2,181	6,76	8,75
4-ESE	11,12	2,546	8,40	9,87
5-SSE	10,43	2,463	7,96	9,25
6-S	10,63	2,211	7,16	9,41
7-SSW	11,92	2,372	11,72	10,56
8-WSW	12,74	2,760	14,61	11,34
9-W	11,96	2,526	14,58	10,62
10-WNW	10,52	2,080	9,64	9,32
11-NNW	8,44	1,916	4,99	7,48
Mean	**10,82**	**2,235**	**100,00**	**9,58**



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Meteo data report - Frequency distribution (TAB file data)

Mast: Secondary model H1 transferred to HS-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			9,70	7,47	7,43	7,85	9,38	9,76	9,42	9,52	11,07	10,95	10,55	9,72	7,99
0		0,49	593	76	66	88	88	9	11	67	63	25	20	40	40
1	0,50	1,49	2754	380	166	364	259	150	206	150	147	233	223	217	259
2	1,50	2,49	5657	525	324	479	451	372	420	327	436	636	531	603	553
3	2,50	3,49	8984	715	825	554	444	592	542	591	841	1251	979	1046	604
4	3,50	4,49	11674	854	1054	630	580	683	822	918	1101	1615	1278	1243	896
5	4,50	5,49	12662	1020	844	837	735	1179	950	1161	955	1279	1468	1172	1062
6	5,50	6,49	12530	946	729	842	1008	1402	758	1055	832	1226	1411	1296	1025
7	6,50	7,49	13436	904	701	813	914	1193	1083	1023	930	1307	1893	1639	1036
8	7,50	8,49	14322	796	661	571	944	1129	1526	1066	1411	1559	2075	1587	997
9	8,50	9,49	15312	734	592	476	1070	1269	1497	1226	1413	1911	2532	1646	946
10	9,50	10,49	13805	667	441	545	900	1405	1271	1013	1224	1802	2314	1337	886
11	10,50	11,49	13258	612	598	677	740	1290	1232	1022	1336	1935	2055	1074	687
12	11,50	12,49	13558	463	485	851	907	1347	1230	1205	1375	2096	1969	1109	521
13	12,50	13,49	11816	325	357	426	723	1140	997	993	1487	2090	1926	945	407
14	13,50	14,49	9539	188	256	260	375	1019	900	709	1203	1700	1755	942	232
15	14,50	15,49	8558	144	164	187	645	904	514	439	1357	1749	1439	825	191
16	15,50	16,49	7120	179	121	112	551	791	397	499	1030	1344	1156	743	197
17	16,50	17,49	4971	92	51	126	374	438	269	312	819	1140	696	513	141
18	17,50	18,49	4373	84	41	61	193	240	290	345	915	976	605	523	100
19	18,50	19,49	2991	56	12	26	120	101	78	190	665	810	539	329	65
20	19,50	20,49	1724	26	9	6	60	47	35	74	289	469	454	208	47
21	20,50	21,49	941	17	3	4	30	18	19	72	172	248	200	111	47
22	21,50	22,49	913	7	6	3	10	11	13	56	252	223	197	106	29
23	22,50	23,49	433	7	0	3	8	3	5	18	60	111	123	80	15
24	23,50	24,49	276	4	0	0	3	2	0	9	38	75	81	54	10
25	24,50	25,49	169	1	0	3	1	0	0	6	19	44	52	35	8
26	25,50	26,49	100	2	0	0	4	0	0	5	11	17	32	29	0
27	26,50	27,49	50	2	0	0	2	0	0	1	2	5	24	11	3
28	27,50	28,49	40	0	0	0	0	0	0	0	5	9	15	11	0
29	28,50	29,49	28	1	0	0	1	0	0	0	0	6	8	12	0
30	29,50	30,49	16	0	0	0	0	0	0	0	1	2	10	3	0
31	30,50	31,49	8	0	0	0	0	0	0	0	0	0	3	5	0
32	31,50	32,49	7	0	0	0	0	0	0	0	0	0	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	3	0	0	0	1	0	0	0	0	0	1	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	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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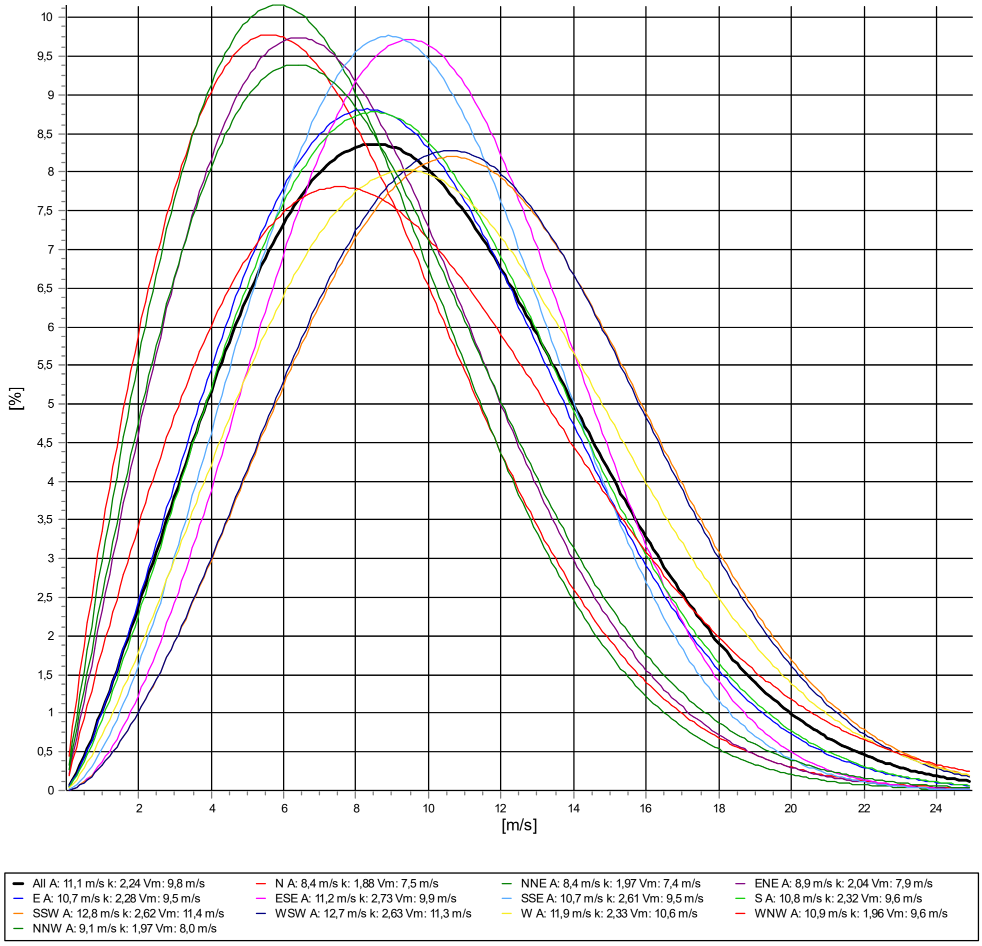
Meteo data report - Weibull data overview

Mast: Secondary model H1 transferred to HS-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	8,44	1,878	5,10	7,49
1-NNE	8,36	1,968	4,42	7,41
2-ENE	8,92	2,040	4,64	7,90
3-E	10,68	2,283	6,30	9,46
4-ESE	11,18	2,734	8,69	9,95
5-SSE	10,71	2,611	7,82	9,52
6-S	10,85	2,317	7,55	9,61
7-SSW	12,79	2,619	10,59	11,36
8-WSW	12,71	2,630	14,48	11,29
9-W	11,93	2,333	14,57	10,57
10-WNW	10,85	1,964	10,12	9,62
11-NNW	9,06	1,974	5,71	8,03
Mean	**11,08**	**2,236**	**100,00**	**9,82**



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Meteo data report - Frequency distribution (TAB file data)

Mast: Secondary model M1 to HS-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264,0 months)

Frequency distribution (TAB file data)

150,00m - B Sheared

Bin	Start	End	Sum	0-N	1-NNE	2-ENE	3-E	4-ESE	5-SSE	6-S	7-SSW	8-WSW	9-W	10-WNW	11-NNW
Mean			9,61	7,88	7,41	7,80	8,89	9,65	8,93	8,98	10,77	10,77	10,26	10,08	8,58
0		0,49	654	0	0	0	0	0	112	237	178	116	11	0	0
1	0,50	1,49	1818	35	32	62	1	27	331	346	317	242	238	144	43
2	1,50	2,49	4061	211	195	264	193	279	491	528	496	416	423	353	212
3	2,50	3,49	7001	410	506	453	454	620	714	733	605	644	774	665	423
4	3,50	4,49	10019	717	748	655	700	879	824	839	899	1009	1141	1034	574
5	4,50	5,49	12282	785	838	810	1053	1043	990	983	1068	1279	1408	1347	678
6	5,50	6,49	14226	1042	807	852	1110	1325	1056	1108	1253	1440	1846	1471	916
7	6,50	7,49	15596	1163	748	760	1214	1599	1267	1239	1310	1454	2210	1630	1002
8	7,50	8,49	16340	1064	737	800	1252	1758	1480	1266	1277	1570	2443	1776	917
9	8,50	9,49	16836	925	783	876	1344	1728	1379	1226	1360	1712	2796	1825	882
10	9,50	10,49	16541	751	572	781	1195	1723	1318	1294	1454	1916	2966	1795	776
11	10,50	11,49	15480	510	516	663	1088	1680	1219	1157	1562	1998	2854	1623	610
12	11,50	12,49	13642	340	331	526	870	1572	983	957	1567	1977	2660	1462	397
13	12,50	13,49	11557	227	169	264	759	1282	796	865	1477	1903	2212	1259	344
14	13,50	14,49	9965	155	119	153	599	998	758	734	1508	1726	1839	1119	257
15	14,50	15,49	7768	152	75	83	341	690	505	569	1349	1482	1406	933	183
16	15,50	16,49	6025	111	29	60	209	542	350	383	1169	1211	1014	794	153
17	16,50	17,49	4336	72	18	13	121	371	256	333	893	882	697	568	112
18	17,50	18,49	3058	47	9	6	53	221	171	178	682	612	522	454	103
19	18,50	19,49	1964	24	5	9	33	121	122	128	421	414	325	311	51
20	19,50	20,49	1201	11	7	5	15	79	59	94	272	222	194	196	47
21	20,50	21,49	800	4	1	3	10	41	37	64	180	132	167	133	28
22	21,50	22,49	539	2	1	2	1	13	24	28	138	112	110	87	21
23	22,50	23,49	351	2	0	2	1	5	15	17	52	125	52	63	17
24	23,50	24,49	242	1	1	1	0	1	5	10	46	81	37	43	16
25	24,50	25,49	134	0	0	0	0	1	1	7	32	39	28	23	3
26	25,50	26,49	88	2	0	0	0	0	0	5	13	29	23	13	3
27	26,50	27,49	52	0	0	0	0	0	0	1	7	19	10	15	0
28	27,50	28,49	40	1	0	0	0	0	0	2	9	15	7	6	0
29	28,50	29,49	25	0	0	0	0	0	0	1	4	11	5	4	0
30	29,50	30,49	19	0	0	0	0	0	0	0	2	3	6	8	0
31	30,50	31,49	9	0	0	0	0	0	0	0	3	2	1	3	0
32	31,50	32,49	2	0	0	0	0	0	0	0	0	0	1	1	0
33	32,50	33,49	4	0	0	0	0	0	0	0	0	2	1	1	0
34	33,50	34,49	2	0	0	0	0	0	0	0	0	1	1	0	0
35	34,50	35,49	1	0	0	0	0	0	0	0	0	1	0	0	0
36	35,50	36,49	0	0	0	0	0	0	0	0	0	0	0	0	0
37	36,50	37,49	0	0	0	0	0	0	0	0	0	0	0	0	0
38	37,50	38,49	1	0	0	0	0	0	0	0	1	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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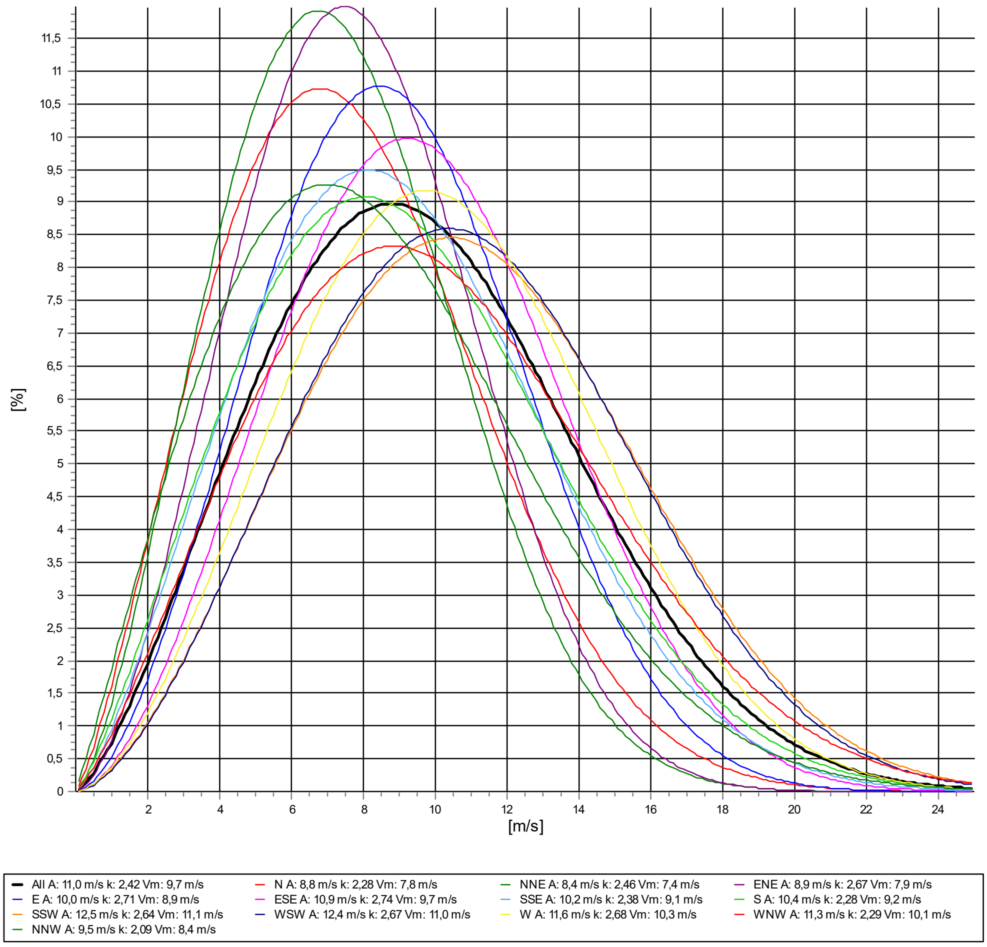
Meteo data report - Weibull data overview

Mast: Secondary model M1 to HS-1 **Period:** Full period: 01/01/2002 - 31/12/2023 (264,0 months)
Height: **150,00m - B Sheared**

Weibull data

Sector	A [m/s]	k	f	Mean wind speed [m/s]
0-N	8,76	2,279	4,55	7,76
1-NNE	8,35	2,455	3,76	7,41
2-ENE	8,90	2,673	4,21	7,91
3-E	10,01	2,711	6,55	8,91
4-ESE	10,90	2,736	9,65	9,70
5-SSE	10,23	2,378	7,92	9,07
6-S	10,37	2,284	7,96	9,19
7-SSW	12,48	2,640	11,21	11,09
8-WSW	12,39	2,669	12,87	11,01
9-W	11,63	2,675	15,79	10,34
10-WNW	11,35	2,293	10,98	10,05
11-NNW	9,53	2,091	4,55	8,44
Mean	**10,96**	**2,417**	**100,00**	**9,71**



Appendix F 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