Energinet Eltransmission A/S

Hesselø South Offshore Wind Farm

Supplementary Note - Sea Ice Site Condition Assessment

REPORT

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C2Wind ApS | Vesterballevej 5 | 7000 Fredericia | Denmark

C2WIND

Document information and change log

Revision	Date	Status / Reason for Issue	Author	Checker
0	2026-04-30	Issued for internal review	JLW	CFN
1	2026-05-01	Issued for Client	JLW	CBM
2	2026-05-04	Updated based on Client comments	JLW	JOG

Section	Summary of Changes (latest revision only)
Executive Summary	Added clarification statement that only Section 10 has been updated.

Changes made in the most recent revision are marked with yellow highlighting. For figures and tables, this means that the first part of the caption, i.e. the word "Figure" or "Table", has been highlighted.

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Table of Contents

List of abbreviations and parameter descriptions

[There are no changes in this section]

Executive summary

There are no changes to the values in this section. The only change compared to [HSSIA] is an update of the wind-ice drift directional misalignment and directional wind distribution in Section 10. This update has no impact on any other parameters in the report.

1. Introduction

Energinet Eltransmission A/S (EE, or “the Client”) has appointed C2Wind ApS (C2Wind) to carry out a Site Ice Conditions Assessment for the Hesselø South Offshore Wind Farm (HS) project, located in Kattegat. The purpose of this document is to serve as a supplement to the Site Ice Conditions Assessment [HSSIA] due to updates to the wind conditions at hub height at HS, which are outlined in the newest revision of [WA]. The reason for the update was incorrect measurement elevations of the WS190 buoy, which resulted in updated Weibull parameters and wind directional distribution. Since the Weibull parameters are used as an input to the calculation of the misalignment between the wind direction at hub height and the ice drift direction, this report has been updated as a consequence of revised Weibull parameters in [WA]. The wind directional distribution table has also been updated.

The numbering of tables and figures in this document preserves the numbering used in [HSSIA]. Similarly, the list of references in this document does not reproduce in full that of [HSSIA], but rather lists only the documents that are cited herein.

1.1 Geographical location

[There are no changes in this section]

2. General considerations

[There are no changes in this section]

3. Applied standards and guidelines

[There are no changes in this section]

4. Overview of data sources

[There are no changes in this section]

5. Pre-processing of input data and review of data quality

[There are no changes in this section]

6. Sheet ice thickness

[There are no changes in this section]

7. Ice ridge parameters

[There are no changes in this section]

8. Crushing failure mode ice strength coefficient

[There are no changes in this section]

9. Flexural failure mode parameters

[There are no changes in this section]

10. Wind direction-ice drift coming direction misalignment

Due to the updated Weibull parameters in [WA], compared to those applied in [HSSIA], the misalignment between the hub height wind and the ice drift has been revised in this section. In addition, the wind directional distribution has also been updated.

10.1 Applied data

The only update to this section is the reference to the Weibull parameters, which are taken for point HS-1-LB from Table 1 of [WA]. The parameters are presented in Table 10-1.

10.2 Ice drift direction

In this section, the Weibull parameters have been updated in Table 10-1. All other parameters of Table 10-1 are unaltered. The misalignment table in Table 10-2 is revised compared to [HSSIA]. The wind directional distribution in Table 10-3 has also been updated.

Parameter	Variable	Unit	Value	Reference
Wind drag coefficient.	C_w	[-]	0.004	*[No change to this value]*
Density of air.	ρ_a	[kg/m^3]	1.23	*[No change to this value]*
Wind velocity.	$\vec{U}_W$	[m/s]	-	*[No change to this value]*
Current drag coefficient.	C_c	[-]	0.006	*[No change to this value]*
Density of water.	ρ_w	[kg/m^3]	1023	*[No change to this value]*
Current velocity.	$\vec{U}_c$	[m/s]	-	*[No change to this value]*
Pack ice load vector.	$\overrightarrow{PL}$	[-]	-	*[No change to this value]*
Wind, Weibull scale parameter @ 150 mDVR90.	A	[m/s]	10.96	For point HS-1-LB from Table 1 of [WA].
Wind Weibull shape parameter @ 150 mDVR90.	k	[-]	2.22	

Table 10-1: Input parameters to the drag force on ice.

The hub height wind ice drift direction misalignment plot in Figure 10-1 has been updated.

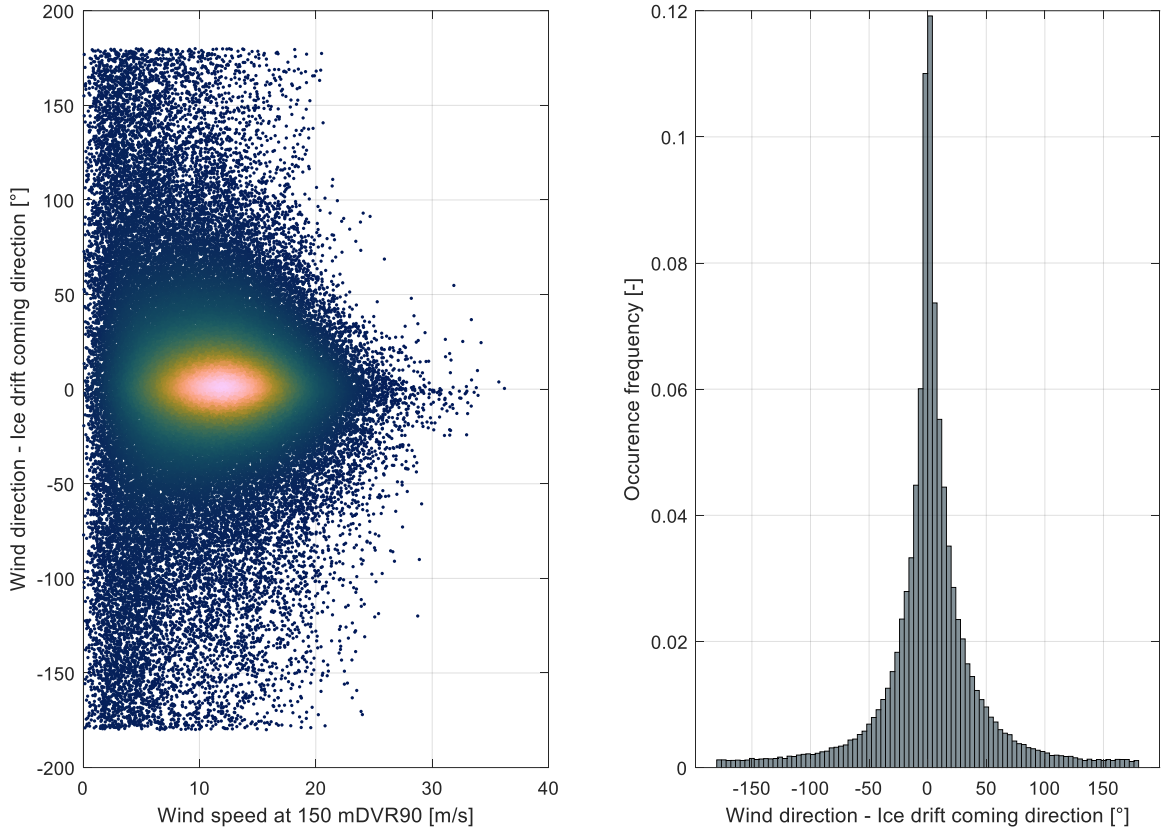

Figure 10-1: Density scatter plot of wind-ice drift coming direction misalignment as a function of wind speed at 150 mDVR90 (left) and histogram of wind-ice drift coming direction misalignment occurrences (right).

Wind Speed @150 mDVR90,			Misalignment angle (WindDir – Ice drift coming dir). Bins span Centre +/- 15°, including lower limit only.												Sum over all misalignment angles
Bin min [m/s]	Bin mean [m/s]	Bin max [m/s]	0	30	60	90	120	150	180	210	240	270	300	330	
0	1.25	2.5	5.31E-03	3.99E-03	3.12E-03	2.09E-03	1.79E-03	1.61E-03	1.63E-03	1.66E-03	1.68E-03	1.99E-03	2.51E-03	3.16E-03	3.05E-02
2.5	3	3.5	7.10E-03	4.39E-03	2.54E-03	1.81E-03	1.33E-03	1.30E-03	9.70E-04	1.14E-03	1.13E-03	1.55E-03	2.25E-03	3.41E-03	2.89E-02
3.5	4	4.5	1.11E-02	6.03E-03	3.28E-03	1.94E-03	1.24E-03	9.24E-04	9.93E-04	1.08E-03	1.31E-03	1.70E-03	2.64E-03	4.96E-03	3.72E-02
4.5	5	5.5	1.60E-02	8.25E-03	3.20E-03	1.86E-03	1.18E-03	9.62E-04	7.03E-04	9.47E-04	1.30E-03	1.49E-03	2.77E-03	5.55E-03	4.43E-02
5.5	6	6.5	2.04E-02	9.26E-03	2.95E-03	1.91E-03	1.14E-03	7.94E-04	6.80E-04	6.03E-04	9.17E-04	1.47E-03	2.58E-03	7.58E-03	5.03E-02
6.5	7	7.5	2.77E-02	9.79E-03	3.70E-03	1.50E-03	9.93E-04	6.26E-04	5.42E-04	5.73E-04	7.03E-04	1.28E-03	2.72E-03	8.07E-03	5.82E-02
7.5	8	8.5	3.13E-02	1.16E-02	3.64E-03	1.44E-03	8.40E-04	3.82E-04	5.96E-04	4.20E-04	6.19E-04	1.04E-03	2.39E-03	8.30E-03	6.26E-02
8.5	9	9.5	3.79E-02	1.17E-02	3.90E-03	1.48E-03	5.96E-04	4.28E-04	4.20E-04	3.44E-04	5.80E-04	1.10E-03	2.30E-03	9.20E-03	6.99E-02
9.5	10	10.5	4.27E-02	1.25E-02	3.87E-03	1.62E-03	6.57E-04	5.27E-04	4.28E-04	3.51E-04	5.65E-04	1.05E-03	2.54E-03	9.01E-03	7.58E-02
10.5	11	11.5	4.53E-02	1.27E-02	3.48E-03	1.18E-03	7.03E-04	3.06E-04	4.28E-04	3.74E-04	6.87E-04	8.78E-04	2.22E-03	9.22E-03	7.75E-02
11.5	12	12.5	4.83E-02	1.22E-02	3.61E-03	1.19E-03	6.26E-04	3.06E-04	3.06E-04	2.90E-04	5.73E-04	1.02E-03	2.17E-03	8.93E-03	7.95E-02
12.5	13	13.5	4.49E-02	1.24E-02	3.65E-03	1.06E-03	4.35E-04	2.22E-04	2.83E-04	2.67E-04	3.90E-04	8.78E-04	1.92E-03	8.10E-03	7.45E-02
13.5	14	14.5	4.05E-02	1.07E-02	3.26E-03	1.03E-03	2.90E-04	1.99E-04	1.60E-04	3.74E-04	5.27E-04	7.49E-04	1.74E-03	8.04E-03	6.76E-02
14.5	15	15.5	3.65E-02	9.46E-03	2.33E-03	7.10E-04	2.14E-04	2.14E-04	1.37E-04	2.90E-04	4.12E-04	7.94E-04	1.55E-03	6.71E-03	5.93E-02
15.5	16	16.5	2.85E-02	7.71E-03	2.02E-03	5.73E-04	1.60E-04	1.30E-04	1.22E-04	1.99E-04	2.29E-04	4.66E-04	1.27E-03	6.13E-03	4.75E-02
16.5	17	17.5	2.28E-02	6.16E-03	1.54E-03	4.66E-04	1.30E-04	1.07E-04	1.07E-04	1.22E-04	2.75E-04	4.74E-04	1.08E-03	4.95E-03	3.82E-02
17.5	18	18.5	1.67E-02	5.06E-03	1.31E-03	2.90E-04	1.53E-04	6.87E-05	6.87E-05	1.22E-04	2.44E-04	3.51E-04	1.11E-03	3.82E-03	2.93E-02
18.5	19	19.5	1.25E-02	3.54E-03	8.48E-04	1.99E-04	7.64E-05	6.11E-05	6.87E-05	1.30E-04	2.22E-04	3.59E-04	9.78E-04	3.63E-03	2.26E-02
19.5	20	20.5	8.03E-03	2.36E-03	3.74E-04	9.17E-05	7.64E-06	1.53E-05	6.11E-05	7.64E-05	1.07E-04	2.52E-04	5.04E-04	2.68E-03	1.46E-02
20.5	21	21.5	6.60E-03	1.62E-03	1.76E-04	4.58E-05	1.53E-05	7.64E-06	7.64E-06	4.58E-05	6.11E-05	1.60E-04	5.27E-04	1.91E-03	1.12E-02
21.5	22	22.5	4.49E-03	1.00E-03	1.15E-04	3.82E-05	-	-	-	4.58E-05	3.06E-05	1.37E-04	3.44E-04	1.32E-03	7.52E-03
22.5	23	23.5	2.86E-03	5.96E-04	1.53E-05	1.53E-05	-	-	-	3.06E-05	6.87E-05	5.35E-05	2.90E-04	9.17E-04	4.84E-03
23.5	24	24.5	1.90E-03	3.44E-04	7.64E-06	1.53E-05	-	-	1.53E-05	7.64E-06	3.06E-05	6.11E-05	1.22E-04	7.03E-04	3.21E-03
24.5	25	25.5	1.10E-03	1.15E-04	7.64E-06	7.64E-06	-	-	-	-	1.53E-05	6.11E-05	9.93E-05	3.90E-04	1.79E-03
25.5	26	26.5	6.80E-04	1.07E-04	7.64E-06	-	-	-	-	-	-	1.53E-05	5.35E-05	2.14E-04	1.08E-03
26.5	27	27.5	4.81E-04	7.64E-05	-	-	-	-	-	-	-	1.53E-05	4.58E-05	2.14E-04	8.33E-04
27.5	28	28.5	2.22E-04	6.87E-05	7.64E-06	-	-	-	-	-	-	-	7.64E-06	1.37E-04	4.43E-04
28.5	29	29.5	2.06E-04	3.06E-05	-	-	-	-	-	-	7.64E-06	7.64E-06	7.64E-06	3.82E-05	2.98E-04
29.5	30	30.5	9.93E-05	-	-	-	-	-	-	-	-	-	-	4.58E-05	1.45E-04
30.5	31	31.5	9.93E-05	2.29E-05	-	-	-	-	-	-	-	-	-	1.53E-05	1.37E-04
31.5	32	32.5	8.40E-05	7.64E-06	7.64E-06	-	-	-	-	-	-	-	-	1.53E-05	1.15E-04
32.5	33	33.5	6.11E-05	1.53E-05	-	-	-	-	-	-	-	-	-	7.64E-06	8.40E-05
33.5	34	34.5	3.06E-05	7.64E-06	-	-	-	-	-	-	-	-	-	-	3.82E-05
34.5	35	35.5	-	-	-	-	-	-	-	-	-	-	-	-	-
35.5	36	36.5	1.53E-05	-	-	-	-	-	-	-	-	-	-	-	1.53E-05

Table 10-2: Omni directional probabilities for wind-ice drift coming direction misalignment, given as $\theta_{Wind} - \theta_{Ice}$, as well as their sums over all misalignment angles (rightmost column) for all relevant wind speed bins.

This wind directional distribution for point HS-1-LB has also been updated in [WA] and is reproduced in Table 10-3.

Directional bin centre [°N]	0	30	60	90	120	150	180	210	240	270	300	330
Occurrence frequency [%]	4.86	4.14	5.13	6.19	8.98	8.54	7.49	10.91	14.43	13.41	10.11	5.81

Table 10-3: Directional occurrence frequencies (in percent) for the wind rose for point HS-1-LB; reproduced from Table 28 of [WA].

11. Limiting mechanisms and ice action speeds

[There are no changes in this section]

12. Notes on DLCs D1, D2, and D5

[There are no changes in this section]

13. Effects of climate change on sea ice conditions

[There are no changes in this section]

14. References

[HSSIA] **C2Wind**
Hesselø South Offshore Wind Farm - Sea Ice Site Condition Assessment
Energinet Eltransmission A/S
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[WA] **EMD international A/S**
Hesselø South, Site Wind Conditions Assessment
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Revision: 3
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Appendices

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Appendix A. Sea ice observations

[There are no changes in this section]

Appendix B. Thermal ice growth model

[There are no changes in this section]

Appendix C. Thermal ice growth results

[There are no changes in this section]

Appendix D. Supplementing ice atlases

[There are no changes in this section]