



FOWPI

FIRST OFFSHORE WIND
PROJECT OF INDIA

Weather Windows for Installation



This Project is funded by The European Union



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1 About FOWPI

The First Offshore Wind Project of India (FOWPI) is part of the “Clean Energy Cooperation with India (CECI) “, which aims at enhancing India's capacity to deploy low carbon energy production and improve energy efficiency, thereby contributing to the mitigation of global climate change. Project activities will support India's efforts to secure the energy supply security, within a well-established framework for strategic energy cooperation between the EU and India.

FOWPI is planned to achieve the first 200MW sized offshore wind farm near the coast of Gujarat, 25km off Jafarabad. Project will emphasis on bringing the vast experience of offshore wind rich European countries to India which aims to provide technical assistance for setting up the wind-farm and creation of a knowledge centre in the country.

FOWPI will be led by COWI A/S (Denmark) with key support from WindDForce Management Ltd. (India). The project is supported by European Union (EU), Ministry of New and Renewable Energy- India (MNRE) and National Institute of Wind Energy- India (NIWE).

Project is awarded under the Indo-European co-operation on Renewable Energy Program and funded through European Union.

FOWPI will focus on finalisation of design and technical specification of the windfarm including foundation, electrical network, turbines etc.. This will also include undertaking specific technical studies for the selected site (based on the outcome of FOWIND project), including coastal surveys, environmental assessments, cost-benefit analysis, transmission layouts, monitoring systems, safety measures, and other relevant technical studies as identified.

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4 Acknowledgements

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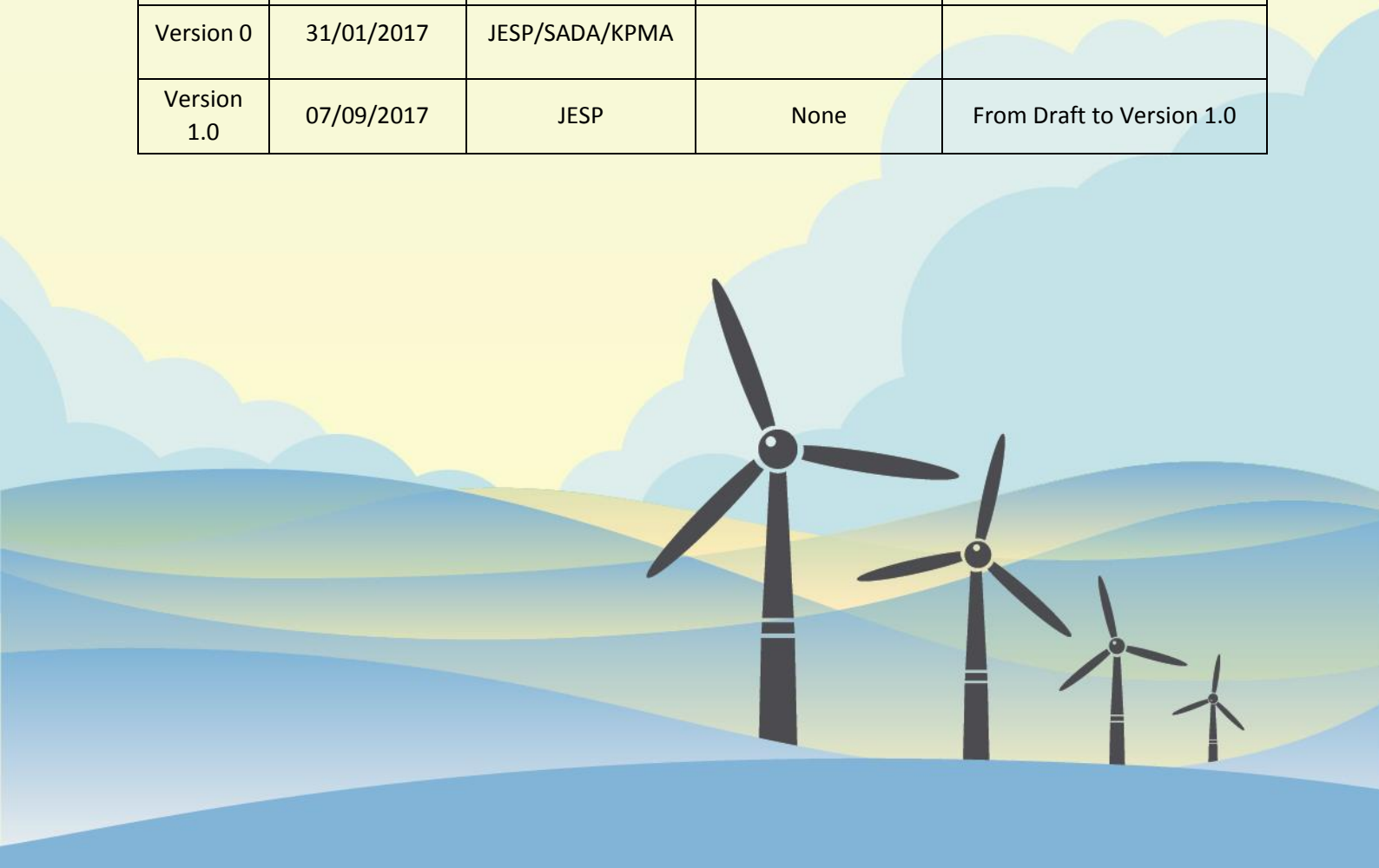
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Weather Windows for Installation

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COWI

SEPTEMBER 2017
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1 Introduction

Weather windows and weather downtime are of importance for transportation, installation and maintenance of an offshore wind farm (cf. Ref. /1/ and Ref. /2/). Adverse weather conditions may become governing for the possible operation period for the above tasks. Accessibility and safety as well as the choice of an appropriate service vessel depend on the knowledge of weather windows and weather downtime.

The present report gives the weather windows and weather downtime to be used at the location of a planned wind farm site in Gulf of Khambhat, Gujarat, India.

The weather windows and downtime are derived on basis of the hindcast time series data of wind speed and significant wave heights derived in the preliminary metocean study by COWI (cf. Ref. /3/). It is recommended to update the results of the present study when long-duration specific wind measurements becomes available.

2 References and abbreviations

2.1 References

- Ref. /1/ IEC 61400-3. Wind turbines - Part 3: Design requirements for offshore wind turbines. Edition 1.0 2009-02
- Ref. /2/ DNVGL-ST-0437. Standard: Loads and site conditions for wind turbines. Edition November 2016
- Ref. /3/ A073635-014-001. Gujarat Metocean Report. COWI
- Ref. /4/ <https://www.mikepoweredbydhi.com/products/mike-c-map>

2.2 Abbreviations

The main abbreviations and symbols used in the present report are listed below.

CD	Chart Datum
DT	Downtime
FOWPI	First Offshore Wind Project in India
H_{m0}	Significant wave height [m]
LAT	Lowest Astronomical Tide [m]
MSL	Mean Sea Level [m]
ORP	Operation Reference Period
UTM	Universal Transverse Mercator, grid-based coordinate system

WGS84 World Geodetic System, reference coordinate system

WS Reference 10-minute average Wind Speed at 10 m above MSL [m/s]

WW Weather Window

3 Location

The location of the First Offshore Wind Project of India (FOWPI) is in the Gulf of Khambhat in Gujarat region, which is located on the North West coast of India, as shown in Figure 3-1.

The set-up of the FOWPI site is shown on the map in Figure 3-2 while the bathymetry in the local area (as extracted from MIKE C-Map, Ref. /4/) is shown in Figure 3-3.

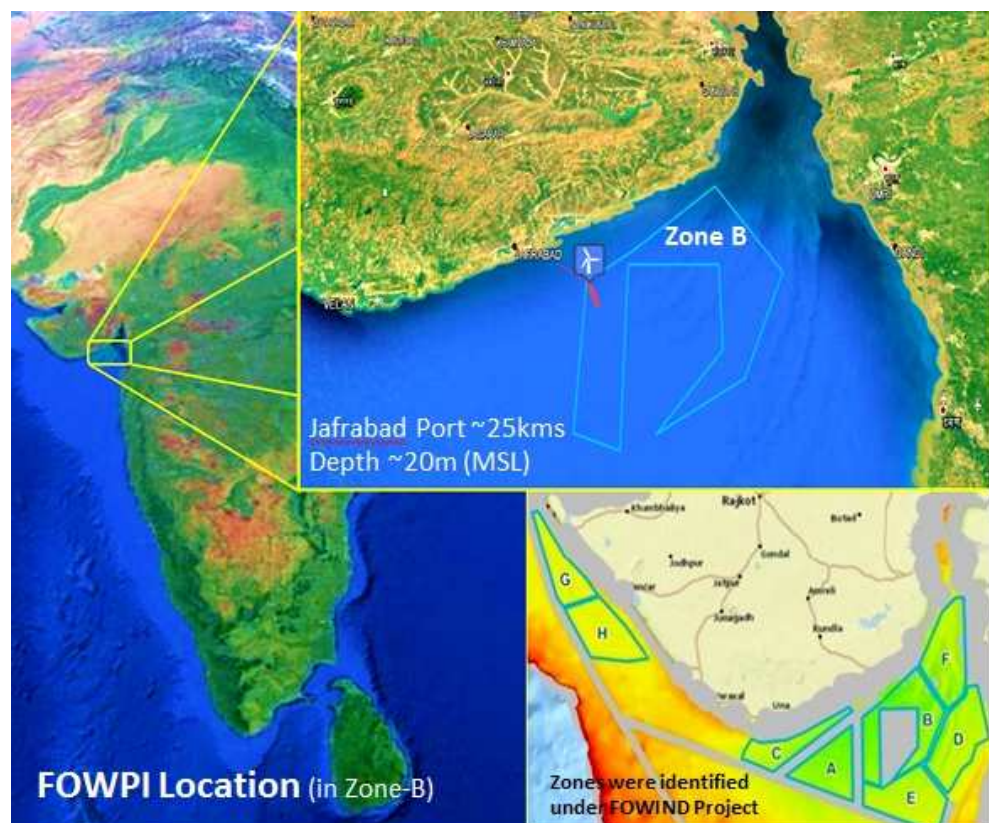


Figure 3-1 Location of FOWPI project in the Gujarat region of India

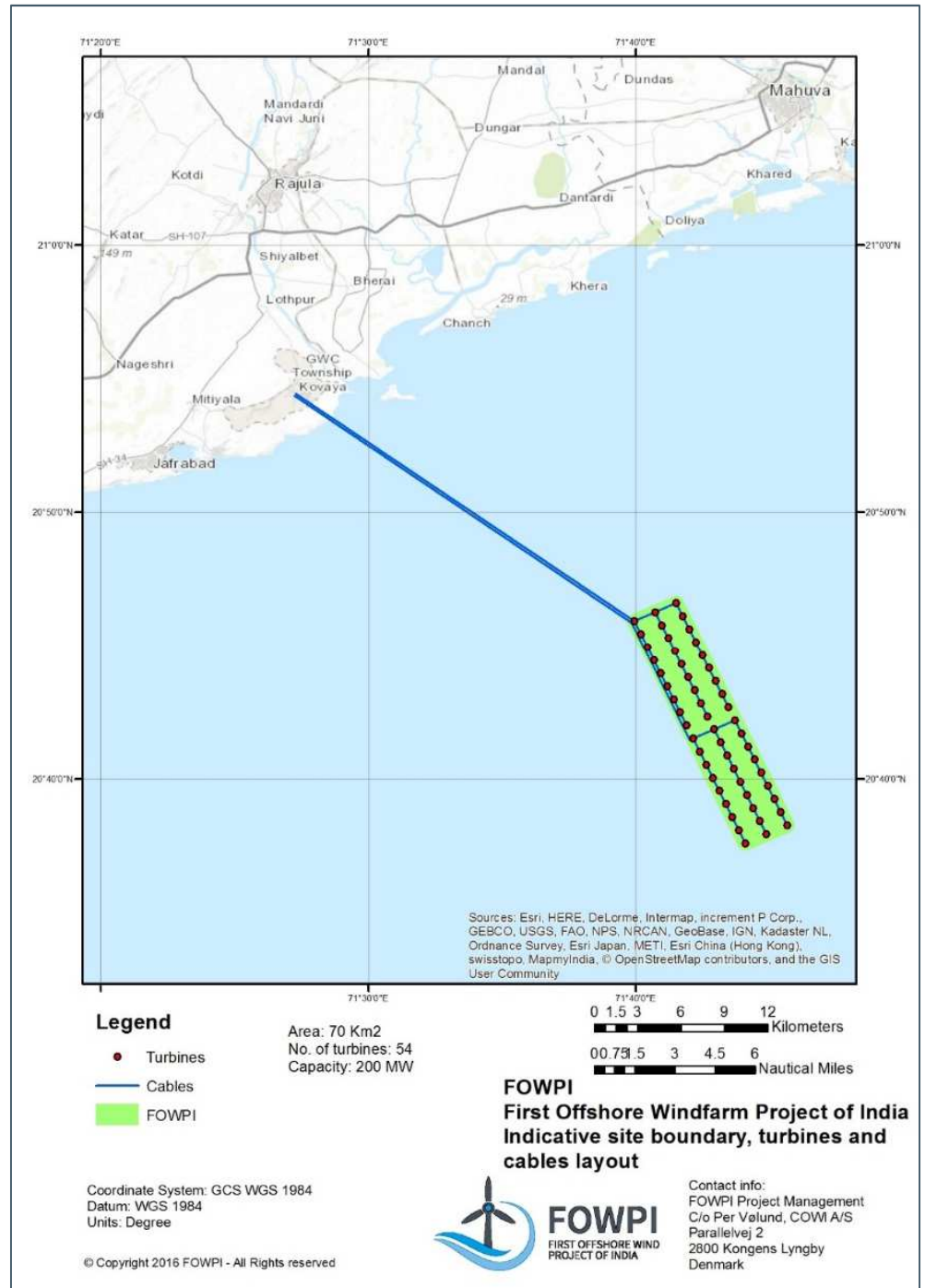


Figure 3-2 Indicative WTG layout, project boundary and cable route.

The derived weather window and downtime data presented in this report are derived on basis of the continuous hindcast time series of significant wave height, H_{m0} , and 10-minute averaged wind speed, WS , at a height of 10 mMSL from the extraction point P2 shown in Figure 3-3. The duration of the time series is 5 years (2010-01-01 to 2014-12-31) and the location of the extraction point P2 is given in Table 3-1.

Table 3-1 Location of data extraction point P2

Extraction point	UTM42, Easting [m]	UTM42, Northing [m]	Longitude [deg E]	Latitude [deg N]
P2	783217	2290278	71.7188	20.6906

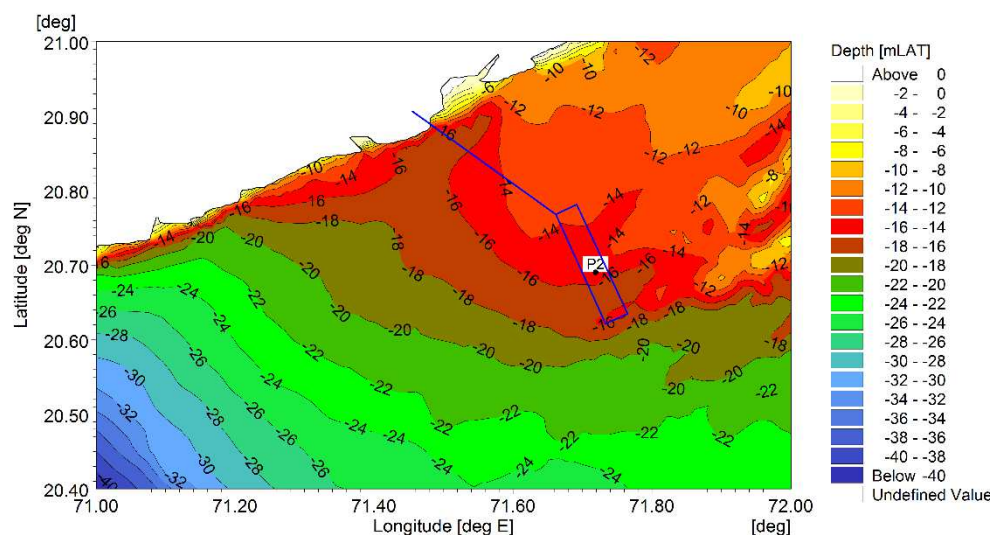


Figure 3-3 Bathymetry at FOWPI site. Indicative site boundary and cable route. Water depths are extracted from MIKE C-Map (Ref. /4/) and are given with respect to CD. The point, P2, indicates the location of the metocean data extraction point used in the weather window and downtime analysis.

The data presented in this report are based on the continuous 5 year long hindcast time series from Ref. /3/. The hindcast does not contain cyclones, but given the nature and rarity of cyclones in the region, these types of events will most likely have a minor influence on the number and average duration of weather windows or weather downtime. It is thus considered justified to omit cyclones from the present analyses.

4 Weather Windows and Downtime

In the present analyses, the concepts of Weather Window and Downtime are defined as follows:

- > **Weather Window (WW):** A continuous period of time in which a given parameter (H_{m0} or WS) does not exceed a given value. The WW is given with respect to an Operation Reference Period (ORP) which is the time needed for a given operation. Hence, a WW of e.g. 2 hours will not be considered in the analysis if the ORP is 3 hours. The presentation of a WW during a given period of time (e.g. one calendar month) is given as the probability of total WW duration relative to the total duration of the period of concern.
- > **Downtime (DT):** A continuous period of time in which a given parameter (H_{m0} or WS) exceeds a given value. The DT is given with respect to an Operation Reference Period (ORP) which is the time needed for a given operation. Hence, a DT of e.g. 2 hours will not be considered in the analysis if the ORP is 3 hours. The presentation of a DT during a given period of time (e.g. one calendar month) is given as the probability of total DT duration relative to the total duration of the period of concern.

Disregarding the ORP the DT becomes equal to the exceedance probability of a given parameter and the WW becomes equal to the non-exceedance probability of a given parameter.

All the following tables are given for monthly data as well as for annual data and are based on five years of data from 2011 to 2015. The data tables represent the average frequency of exceedance and number of weather windows in the five years (i.e. average of five Januarys, Februarys, etc.).

The exceedance probability for the significant wave height, H_{m0} , for monthly and annual data is given in Table 4-1 while the exceedance probability for the 10-minute average wind speed at a height of 10m above MSL for monthly and annual data is given in Table 4-2.

The probabilities of WW and DT in which the wave height or wind speed is smaller/larger than a given threshold value have been determined. The minimum durations of ORP analyses are defined as time intervals of 3, 6, 12, 18, 24, 36, 48, 72 and 96 hours, respectively. The following threshold values have been used for H_{m0} and WS :

- > The significant wave height, H_{m0} , is smaller/larger than 0.25m, 0.50m, 0.75m, 1.00m, 1.25m, 1.50m, 1.75m, 2.00m, 2.25m, 2.50m, 2.75m or 3.00m
- > The wind speed, WS , (10-minute average at 10 mMSL) is smaller/larger than 1.0m/s, 2.0m/s, 3.0m/s, 4.0m/s, 5.0m/s, 6.0m/s, 7.0m/s, 8.0m/s, 9.0m/s, 10.0m/s, 11.0m/s or 12.0m/s

Weather windows for all significant wave height criteria are presented in Table 4-3 and Table 4-4, whereas weather windows for all wind speed criteria are presented in Table 4-6 and Table 4-7. Notice at a WW of 0 hours corresponds to the non-exceedance probability.

Downtime for all significant wave height criteria are presented in Table 4-5 , whereas downtime for all wind speed criteria are presented in Table 4-8. Notice at a DT of 0 hours corresponds to the exceedance probability.

Table 4-1 Exceedance probability [%] of significant wave height, H_{m0} , at P2 for each month and annual

[illegible]

Table 4-2 Exceedance probability [%] of 10-minute average wind speed, WS, at a height of 10mMSL at P2 for each month and annual

[illegible]

Table 4-3

[illegible][illegible][illegible][illegible]

Weather Window: 24 Hours

[illegible]

Weather Window: 36 Hours

[illegible]**Weather Window: 48 Hours**[illegible]

Weather Window: 72 Hours

[illegible]

Weather Window: 96 Hours

[illegible]

Table 4-4

MINIMUM WEATHER WINDOW [Hours]										
H _{m0} < 0.25m	0	3	6	12	18	24	36	48	72	96
January	12.31	12.20	11.85	10.19	9.44	7.77	5.97	1.67	0.00	0.00
February	14.30	14.15	13.06	10.34	8.24	8.24	3.96	1.65	0.00	0.00
March	1.59	1.59	1.40	1.13	0.67	0.67	0.00	0.00	0.00	0.00
April	0.44	0.28	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October	2.12	2.12	1.88	1.88	1.88	1.88	1.10	0.00	0.00	0.00
November	3.58	3.50	3.19	1.72	1.39	0.86	0.00	0.00	0.00	0.00
December	10.38	10.28	9.87	8.88	7.53	5.27	4.52	1.40	0.00	0.00

MINIMUM WEATHER WINDOW [Hours]										
H _{mo} < 0.50m	0	3	6	12	18	24	36	48	72	96
January	53.23	53.01	52.69	50.22	48.25	46.10	44.62	41.16	28.31	16.64
February	61.73	61.61	61.23	58.98	55.59	52.25	50.47	45.54	39.30	32.33
March	33.47	33.15	31.64	26.13	20.62	15.97	13.41	12.20	3.20	3.20
April	12.97	12.69	11.83	8.72	6.03	5.42	3.78	3.78	3.78	3.78
May	0.22	0.22	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September	1.92	1.92	1.92	1.75	1.36	1.36	1.36	1.36	0.00	0.00
October	28.66	28.44	27.77	24.49	21.72	20.05	18.52	15.11	11.94	2.74
November	43.36	43.08	42.03	37.92	33.75	30.47	26.53	23.08	14.44	7.08
December	48.43	48.10	47.03	42.56	38.36	37.83	33.63	29.06	19.05	16.90

MINIMUM WEATHER WINDOW [Hours]										
H _{mo} < 0.75m	0	3	6	12	18	24	36	48	72	96
January	90.35	90.30	89.92	89.09	87.55	85.99	85.99	84.92	83.33	76.40
February	94.89	94.80	94.80	94.12	93.14	93.14	93.14	91.93	91.05	88.27
March	89.52	89.46	88.58	87.90	86.67	85.56	85.56	83.55	82.74	76.59
April	62.19	62.06	60.92	57.08	51.53	46.72	46.19	43.08	41.39	36.67
May	5.97	5.86	5.13	3.01	2.69	2.18	1.77	1.77	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September	11.11	11.03	10.64	8.56	7.86	7.31	6.44	5.44	4.11	4.11
October	75.22	75.00	73.87	70.83	70.40	69.33	69.33	67.12	67.12	60.97
November	85.08	85.03	84.61	82.33	81.94	80.28	79.61	79.61	78.19	75.64
December	90.77	90.75	90.56	90.02	89.62	89.10	89.10	87.97	84.34	82.03

[illegible]

MINIMUM WEATHER WINDOW [Hours]**MINIMUM WEATHER WINDOW [Hours]****MINIMUM WEATHER WINDOW [Hours]****MINIMUM WEATHER WINDOW [Hours]**

MINIMUM WEATHER WINDOW [Hours]**MINIMUM WEATHER WINDOW [Hours]**MINIMUM WEATHER WINDOW [Hours]**MINIMUM WEATHER WINDOW [Hours]**

Table 4-5 **Downtime** probability for significant wave height criteria ($H_{m0}>x$). Tables for wave height criteria of $H_{m0}>0.25m$, $0.50m$, $0.75m$, $1.00m$, $1.25m$, $1.50m$, $1.75m$, $2.00m$, $2.25m$, $2.50m$, $2.75m$ and $3.00m$ are presented

MINIMUM DOWNTIME [Hours]										
$H_{m0} > 0.25m$	0	3	6	12	18	24	36	48	72	96
January	87.69	87.53	87.31	87.10	87.10	86.59	85.05	83.84	79.09	73.33
February	85.70	85.64	84.66	83.19	82.42	80.50	79.55	75.83	73.85	70.57
March	98.41	98.41	98.33	98.33	98.33	98.33	98.33	98.33	98.33	98.33
April	99.56	99.56	99.56	99.56	99.56	97.25	97.25	97.25	97.25	97.25
May	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
June	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
July	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
August	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
September	99.94	99.94	99.94	99.94	99.94	99.94	99.94	99.94	99.94	99.94
October	97.88	97.82	97.82	97.82	97.82	97.82	97.82	97.82	97.82	97.82
November	96.42	96.39	96.28	95.25	94.78	94.28	94.28	94.28	94.28	94.28
December	89.62	89.53	89.16	88.08	87.27	87.27	87.27	86.17	86.17	86.17

MINIMUM DOWNTIME [Hours]										
$H_{m0} > 0.50m$	0	3	6	12	18	24	36	48	72	96
January	46.77	46.61	45.70	42.26	40.46	39.33	36.21	31.67	20.65	17.53
February	38.27	38.18	37.50	34.43	32.45	30.14	28.19	22.10	11.26	7.86
March	66.53	66.18	64.92	61.26	54.65	50.97	49.49	45.00	32.69	27.20
April	87.03	87.03	86.94	85.33	80.89	75.89	75.06	75.06	71.44	64.58
May	99.78	99.78	99.78	99.78	99.78	99.78	99.78	99.78	99.78	99.78
June	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
July	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
August	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
September	98.08	98.03	97.92	97.92	97.92	97.92	97.92	97.92	97.92	97.92
October	71.34	71.10	70.24	67.93	65.48	64.44	63.52	63.52	58.55	53.87
November	56.64	55.94	55.00	50.25	48.08	46.97	46.97	46.97	38.64	29.92
December	51.57	51.22	50.63	46.41	41.46	39.36	37.10	31.26	24.13	12.05

MINIMUM DOWNTIME [Hours]										
$H_{m0} > 0.75m$	0	3	6	12	18	24	36	48	72	96
January	9.65	9.41	8.79	6.64	4.41	3.44	2.63	1.59	0.00	0.00
February	5.11	5.11	4.05	2.81	1.51	0.00	0.00	0.00	0.00	0.00
March	10.48	10.16	9.57	7.96	7.31	2.42	1.59	1.59	1.59	1.59
April	37.81	37.47	36.67	31.47	27.86	23.19	23.19	18.56	18.56	16.22
May	94.03	94.03	94.03	93.28	90.91	87.96	87.96	86.75	85.38	82.93
June	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
July	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
August	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
September	88.89	88.67	87.89	87.33	86.64	86.14	86.14	85.14	85.14	85.14
October	24.78	24.44	23.06	20.94	20.16	18.55	16.72	13.12	13.12	10.46
November	14.92	14.67	14.03	12.25	11.03	10.50	8.81	5.50	2.31	0.50
December	9.23	9.17	8.82	7.75	6.78	5.92	5.81	3.63	2.02	0.00

MINIMUM DOWNTIME [Hours]										
$H_{m0} > 1.00m$	0	3	6	12	18	24	36	48	72	96
January	0.65	0.65	0.65	0.35	0.00	0.00	0.00	0.00	0.00	0.00
February	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	0.65	0.65	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8.42	8.25	7.67	6.53	5.25	3.67	3.67	2.67	0.00	0.00
May	55.08	54.97	53.79	45.89	40.86	37.72	36.88	35.83	28.63	24.52
June	99.86	99.86	99.86	99.86	99.86	99.86	99.86	99.86	99.86	99.75
July	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
August	98.12	98.04	97.93	97.55	97.55	97.55	97.55	97.55	97.55	97.55
September	71.06	70.97	69.08	66.97	66.50	64.83	64.83	63.81	63.81	63.81
October	5.43	5.43	5.43	5.16	5.16	5.16	3.39	3.39	3.39	3.39
November	0.86	0.86	0.50	0.50	0.06	0.06	0.06	0.06	0.06	0.06
December	1.13	1.13	1.02	0.81	0.00	0.00	0.00	0.00	0.00	0.00

MINIMUM DOWNTIME [Hours]**MINIMUM DOWNTIME [Hours]****MINIMUM DOWNTIME [Hours]****MINIMUM DOWNTIME [Hours]**

Table 4-6

[illegible][illegible][illegible][illegible]

Weather Window: 24 Hours

[illegible]

Weather Window: 36 Hours

[illegible]

Weather Window: 48 Hours

[illegible]

Weather Window: 72 Hours

[illegible]

Weather Window: 96 Hours

[illegible]

Table 4-7 **Weather Windows** probability for wind speed criteria ($WS < x$). Tables for wind speed criteria of $WS < 1.0\text{m/s}$, 2.0m/s , 3.0m/s , 4.0m/s , 5.0m/s , 6.0m/s , 7.0m/s , 8.0m/s , 9.0m/s , 10.0m/s , 11.0m/s , 12.0m/s , 13.0m/s and 14.0m/s are presented

MINIMUM WEATHER WINDOW [Hours]										
WS < 1m/s	0	3	6	12	18	24	36	48	72	96
January	0.51	0.48	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
February	0.53	0.24	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	0.89	0.46	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	0.25	0.25	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	0.19	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	0.13	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September	0.31	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October	3.58	2.72	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
November	0.92	0.33	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December	0.27	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MINIMUM WEATHER WINDOW [Hours]										
WS < 2m/s	0	3	6	12	18	24	36	48	72	96
January	1.83	1.51	1.10	0.40	0.00	0.00	0.00	0.00	0.00	0.00
February	3.31	3.01	1.54	0.38	0.00	0.00	0.00	0.00	0.00	0.00
March	4.68	4.22	2.53	0.83	0.00	0.00	0.00	0.00	0.00	0.00
April	3.00	2.61	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.38	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	1.50	1.33	0.86	0.42	0.00	0.00	0.00	0.00	0.00	0.00
July	0.16	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	1.67	1.48	0.75	0.40	0.00	0.00	0.00	0.00	0.00	0.00
September	4.72	4.28	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October	19.44	18.76	14.62	10.30	5.48	2.31	0.00	0.00	0.00	0.00
November	6.14	5.50	3.67	0.69	0.00	0.00	0.00	0.00	0.00	0.00
December	2.18	1.96	1.24	0.32	0.00	0.00	0.00	0.00	0.00	0.00

MINIMUM WEATHER WINDOW [Hours]										
WS < 3m/s	0	3	6	12	18	24	36	48	72	96
January	6.29	5.81	4.97	2.26	1.10	0.00	0.00	0.00	0.00	0.00
February	11.82	11.26	9.37	4.85	2.60	0.80	0.00	0.00	0.00	0.00
March	14.92	14.01	10.51	3.49	2.42	2.42	0.00	0.00	0.00	0.00
April	12.64	11.86	7.81	1.58	0.00	0.00	0.00	0.00	0.00	0.00
May	1.85	1.61	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	3.61	3.31	2.75	1.03	0.56	0.00	0.00	0.00	0.00	0.00
July	1.13	0.99	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August	6.32	5.99	4.97	2.77	2.39	1.77	1.77	1.77	0.00	0.00
September	16.78	16.03	14.53	9.08	7.06	4.19	2.28	0.00	0.00	0.00
October	42.23	41.53	39.27	31.13	22.85	19.11	15.32	10.16	0.00	0.00
November	17.92	17.22	15.81	10.36	5.39	2.58	1.14	0.00	0.00	0.00
December	8.47	7.91	6.91	3.44	2.66	2.18	1.53	1.53	0.00	0.00

MINIMUM WEATHER WINDOW [Hours]										
WS < 4m/s	0	3	6	12	18	24	36	48	72	96
January	20.11	19.57	18.06	13.33	9.25	5.67	3.84	1.42	1.42	0.00
February	31.24	30.53	27.42	20.51	15.46	13.27	6.00	4.82	3.28	0.00
March	35.75	34.97	31.32	20.51	6.94	5.22	4.35	0.00	0.00	0.00
April	33.36	32.78	30.25	17.08	2.94	0.69	0.00	0.00	0.00	0.00
May	8.23	7.18	5.62	1.48	1.10	1.10	1.10	0.00	0.00	0.00
June	6.94	6.53	5.31	3.72	1.69	1.69	1.69	1.69	0.00	0.00
July	3.71	3.28	2.39	1.32	0.56	0.00	0.00	0.00	0.00	0.00
August	14.97	14.41	13.12	9.70	8.84	8.31	6.75	5.48	2.04	0.00
September	35.31	34.81	33.03	29.42	23.61	19.36	16.33	11.56	7.47	3.03
October	65.78	65.54	62.90	57.63	51.91	48.17	43.60	33.79	21.42	16.85
November	39.42	38.69	36.97	30.00	19.25	14.36	13.06	8.06	6.28	3.94
December	22.30	21.74	20.12	16.41	11.49	9.31	6.94	2.39	2.39	0.00

MINIMUM WEATHER WINDOW [Hours]

WS < 5m/s	0	3	6	12	18	24	36	48	72	96
January	39.38	39.09	37.31	34.52	28.20	22.93	18.39	12.50	4.89	2.96
February	58.39	58.19	56.74	51.65	43.65	38.18	33.57	30.44	15.66	10.02
March	68.84	68.52	67.12	62.02	51.24	40.43	32.15	27.10	10.48	0.00
April	60.19	59.67	56.92	49.94	32.50	13.28	11.31	7.61	2.11	0.00
May	24.46	23.52	20.91	10.70	2.69	1.18	1.18	0.00	0.00	0.00
June	13.72	13.14	11.22	7.89	6.00	4.33	4.33	3.28	0.00	0.00
July	8.68	8.25	7.63	3.63	3.20	2.61	1.10	0.00	0.00	0.00
August	24.33	24.09	22.88	20.91	19.68	15.40	14.76	14.76	14.76	3.06
September	53.25	52.94	51.61	49.19	44.42	40.64	37.97	35.50	33.53	27.25
October	84.84	84.76	84.03	80.03	74.97	72.12	69.68	69.68	64.70	54.54
November	62.97	62.53	60.92	54.89	47.47	42.89	42.00	36.14	27.78	27.78
December	44.23	43.74	41.35	35.57	30.37	27.47	25.85	16.28	9.17	6.78

MINIMUM WEATHER WINDOW [Hours]

WS < 6m/s	0	3	6	12	18	24	36	48	72	96
January	59.68	59.09	58.47	55.22	51.67	47.20	44.62	33.33	25.83	21.13
February	77.54	77.39	76.51	72.67	66.70	64.89	64.04	55.50	48.20	43.23
March	89.30	89.25	88.98	87.28	82.53	79.84	78.66	78.66	73.90	65.16
April	84.94	84.75	84.17	81.50	71.94	62.25	60.25	56.61	46.31	36.06
May	51.10	50.62	47.90	41.56	16.02	6.91	6.26	4.06	3.09	3.09
June	27.33	26.36	24.14	17.86	16.39	13.42	12.58	10.22	5.44	2.97
July	17.53	16.51	14.09	10.19	8.28	6.88	5.35	5.35	2.18	0.00
August	35.48	34.73	33.47	29.65	26.77	23.82	22.90	21.64	19.76	15.51
September	65.28	64.97	64.00	61.19	58.58	54.92	52.25	51.17	49.58	49.58
October	93.66	93.66	93.39	93.39	90.27	86.37	86.37	85.13	81.75	79.62
November	83.69	83.39	82.83	81.33	78.44	76.72	73.44	72.36	62.03	52.78
December	67.34	66.75	65.64	61.69	55.07	51.98	48.67	47.13	40.36	27.25

MINIMUM WEATHER WINDOW [Hours]

WS < 7m/s	0	3	6	12	18	24	36	48	72	96
January	76.21	75.94	75.35	72.02	67.34	67.34	67.34	65.30	53.49	48.04
February	88.03	87.97	87.80	86.76	84.16	83.60	82.62	81.29	79.34	76.68
March	96.61	96.56	96.42	96.05	95.46	94.33	94.33	94.33	92.50	92.50
April	95.33	95.33	95.33	95.33	92.08	87.97	86.36	83.97	80.19	79.58
May	73.66	73.41	72.72	69.84	53.36	36.34	35.67	32.28	23.71	15.32
June	45.11	44.36	42.06	37.69	31.00	27.50	25.14	22.78	13.94	9.39
July	34.27	33.15	29.95	25.78	20.51	15.54	12.82	9.49	5.08	0.00
August	53.04	52.20	50.13	46.34	41.24	35.81	34.87	32.50	32.50	30.46
September	75.33	74.75	73.58	70.97	68.28	64.53	63.75	61.69	59.89	57.50
October	97.74	97.72	97.63	97.45	97.45	97.45	97.45	97.45	96.91	96.91
November	94.83	94.83	94.14	93.44	92.53	91.53	90.81	89.72	86.44	83.94
December	86.63	86.39	85.79	83.05	80.23	79.20	78.53	77.27	69.71	66.32

MINIMUM WEATHER WINDOW [Hours]

WS < 8m/s	0	3	6	12	18	24	36	48	72	96
January	92.93	92.88	92.34	91.32	88.58	88.01	88.01	88.01	84.38	77.58
February	95.42	95.33	95.09	93.85	92.20	92.17	92.17	92.17	92.17	89.45
March	99.25	99.25	99.25	98.98	98.98	98.44	98.44	98.20	98.20	98.20
April	99.03	99.03	99.03	99.03	99.03	97.42	97.42	95.31	95.31	94.36
May	89.81	89.78	89.46	88.79	84.68	76.56	76.56	72.98	69.33	65.59
June	62.28	61.69	60.00	57.83	50.97	48.25	47.31	44.94	43.31	33.83
July	55.73	55.00	51.85	45.73	41.05	33.98	32.23	28.84	24.25	24.25
August	71.75	70.97	68.52	65.16	61.96	57.55	56.13	51.37	45.78	43.31
September	87.33	87.22	86.47	84.08	81.17	76.97	76.97	73.69	71.78	71.78
October	99.70	99.70	99.70	99.70	99.70	99.70	98.79	98.79	98.79	98.79
November	99.19	99.19	99.08	98.61	98.61	98.61	97.64	96.36	96.36	96.36
December	95.51	95.43	95.29	94.89	94.43	93.92	93.92	93.92	93.92	89.21

MINIMUM WEATHER WINDOW [Hours]										
WS < 9m/s	0	3	6	12	18	24	36	48	72	96
January	98.95	98.95	98.95	98.68	98.68	98.68	98.68	98.68	98.68	96.67
February	99.47	99.47	99.35	99.02	98.55	98.55	98.55	98.55	98.55	98.55
March	99.97	99.97	99.97	99.97	99.97	99.97	99.97	99.97	99.97	99.97
April	99.92	99.92	99.92	99.92	99.92	99.92	99.92	99.92	99.92	99.92
May	95.89	95.89	95.65	95.19	94.76	93.68	93.68	93.68	93.68	93.68
June	77.67	76.58	74.22	72.06	69.61	66.92	66.92	61.92	61.92	59.61
July	74.78	74.14	72.28	69.11	62.39	54.89	53.55	49.89	46.29	37.88
August	85.13	84.89	83.63	81.24	79.33	74.25	73.33	69.87	67.96	62.26
September	93.92	93.86	93.50	92.67	92.33	89.42	88.44	87.25	85.33	85.33
October	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
November	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
December	99.44	99.44	99.33	99.06	98.65	98.04	98.04	98.04	98.04	98.04

[illegible][illegible][illegible]

[illegible][illegible]

Table 4-8 **Downtime** probability for wind speed criteria ($WS > x$). Tables for wind speed criteria of $WS > 1.0\text{m/s}$, 2.0m/s , 3.0m/s , 4.0m/s , 5.0m/s , 6.0m/s , 7.0m/s , 8.0m/s , 9.0m/s , 10.0m/s , 11.0m/s , 12.0m/s , 13.0m/s and 14.0m/s are presented

MINIMUM DOWNTIME [Hours]										
WS > 1m/s	0	3	6	12	18	24	36	48	72	96
January	99.49	99.44	99.44	99.44	99.44	98.58	98.58	98.58	98.58	98.58
February	99.47	99.47	99.47	99.23	98.37	98.11	98.11	98.11	98.11	98.11
March	99.11	99.11	99.11	98.84	97.93	96.21	96.21	95.19	93.47	93.47
April	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75
May	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
June	99.81	99.81	99.67	99.67	99.28	99.28	99.28	99.28	99.28	99.28
July	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
August	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87	98.47	98.47
September	99.69	99.69	99.69	99.69	99.25	99.25	98.44	98.44	96.47	96.47
October	96.42	96.37	95.65	95.40	93.01	90.32	85.46	84.41	79.97	73.15
November	99.08	99.08	99.00	99.00	98.61	96.86	95.11	92.56	90.78	90.78
December	99.73	99.73	99.73	99.73	99.73	99.22	99.22	99.22	99.22	99.22

MINIMUM DOWNTIME [Hours]										
WS > 2m/s	0	3	6	12	18	24	36	48	72	96
January	98.17	98.17	98.17	97.20	96.51	95.46	94.65	93.41	93.41	93.41
February	96.69	96.69	96.60	96.34	95.63	91.99	91.99	90.66	84.93	84.93
March	95.32	95.22	94.95	94.22	91.67	89.52	88.06	84.62	77.10	73.01
April	97.00	96.97	96.83	96.83	96.00	93.78	93.06	88.53	86.78	82.08
May	99.62	99.62	99.62	99.62	99.62	98.52	98.52	97.34	97.34	97.34
June	98.50	98.50	98.28	98.28	97.33	97.33	95.72	95.72	93.86	93.86
July	99.84	99.84	99.84	99.27	99.27	99.27	99.27	99.27	99.27	99.27
August	98.33	98.31	98.01	96.67	95.91	95.32	95.32	95.32	95.32	93.15
September	95.28	95.14	94.61	93.86	93.08	88.64	87.22	84.75	75.14	74.47
October	80.56	80.27	78.04	72.42	67.55	63.33	60.38	56.77	51.24	43.49
November	93.86	93.78	93.36	91.03	89.22	84.67	83.81	80.44	77.67	67.81
December	97.82	97.77	97.63	96.58	96.58	96.07	96.07	96.07	90.77	90.77

MINIMUM DOWNTIME [Hours]										
WS > 3m/s	0	3	6	12	18	24	36	48	72	96
January	93.71	93.63	93.15	91.56	90.59	89.01	88.25	86.08	80.99	72.31
February	88.18	88.03	87.03	85.93	81.06	78.07	78.07	75.80	59.40	49.29
March	85.08	84.97	84.65	83.44	70.83	56.99	56.26	45.83	41.08	35.97
April	87.36	87.36	87.17	86.36	76.39	56.89	52.56	50.11	41.14	33.61
May	98.15	98.15	98.15	98.15	97.39	96.26	95.56	94.49	94.49	92.07
June	96.39	96.31	96.03	95.39	92.83	91.67	91.67	91.67	89.89	87.25
July	98.87	98.87	98.76	98.36	97.90	97.28	97.28	97.28	97.28	97.28
August	93.68	93.58	93.09	91.51	89.44	88.33	88.33	87.23	85.81	81.13
September	83.22	83.00	81.83	76.92	73.08	68.75	67.94	63.42	57.92	57.31
October	57.77	56.56	54.52	48.95	41.29	36.32	32.66	28.20	23.92	15.16
November	82.08	81.81	80.86	78.83	74.89	66.28	65.56	58.56	53.50	45.53
December	91.53	91.44	90.64	88.75	85.34	81.46	81.46	81.46	76.59	70.14

MINIMUM DOWNTIME [Hours]										
WS > 4m/s	0	3	6	12	18	24	36	48	72	96
January	79.89	79.68	78.15	75.70	71.24	68.55	68.55	66.59	53.28	48.04
February	68.76	68.29	66.37	61.97	54.02	46.90	41.93	34.69	28.19	21.75
March	64.25	63.87	62.04	52.20	36.99	25.27	23.66	17.39	6.88	4.35
April	66.64	66.56	65.47	56.69	39.94	22.19	20.67	13.81	10.03	7.81
May	91.77	91.69	91.48	90.51	84.46	75.22	74.54	71.13	59.68	54.84
June	93.06	92.97	92.61	90.11	87.61	86.42	85.50	83.33	79.75	75.11
July	96.29	96.26	95.65	94.27	92.55	90.86	90.11	88.84	88.84	88.84
August	85.03	84.70	83.23	80.32	79.11	77.90	77.15	76.32	71.29	68.87
September	64.69	64.28	61.94	57.44	53.92	50.50	48.86	47.92	47.92	45.47
October	34.22	33.44	31.18	24.41	16.42	13.71	13.71	11.32	9.89	7.77
November	60.58	59.94	58.11	52.67	42.03	33.44	31.58	27.06	21.86	17.28
December	77.70	77.37	76.65	73.72	70.00	65.38	64.60	61.04	52.49	44.63

MINIMUM DOWNTIME [Hours]										
WS > 5m/s	0	3	6	12	18	24	36	48	72	96
January	60.62	60.27	58.98	55.51	48.71	46.64	45.78	34.62	28.68	20.46
February	41.61	40.96	39.07	32.92	25.65	23.37	20.89	19.47	13.89	6.94
March	31.16	30.54	26.80	19.78	10.83	8.01	8.01	4.65	1.48	0.00
April	39.81	39.08	34.72	21.89	11.25	2.97	2.22	2.22	2.08	0.00
May	75.54	75.16	74.54	67.69	51.56	42.18	40.73	37.39	27.82	18.98
June	86.28	85.89	84.81	82.50	78.36	75.92	75.03	75.03	67.14	64.53
July	91.32	91.21	89.92	88.49	85.78	85.22	84.57	84.57	83.98	80.94
August	75.67	75.32	74.41	72.63	71.83	70.24	68.79	66.45	60.78	60.78
September	46.75	46.17	44.78	40.72	37.94	37.42	36.56	35.47	30.92	28.50
October	15.16	14.38	12.61	8.98	6.08	5.56	3.90	2.96	2.37	0.00
November	37.03	36.56	35.06	27.72	20.69	17.39	16.53	15.22	10.53	3.83
December	55.77	55.31	53.75	49.48	41.16	35.70	33.58	25.69	17.97	12.81

MINIMUM DOWNTIME [Hours]										
WS > 6m/s	0	3	6	12	18	24	36	48	72	96
January	40.32	39.87	38.49	35.00	27.93	24.09	20.00	13.49	10.08	6.24
February	22.46	21.87	20.83	17.94	11.79	8.42	6.41	3.87	3.16	3.16
March	10.70	10.35	8.66	5.62	3.76	2.72	2.72	0.00	0.00	0.00
April	15.06	14.47	11.36	4.00	0.00	0.00	0.00	0.00	0.00	0.00
May	48.90	48.39	46.53	27.58	19.60	12.42	11.02	9.92	9.52	7.15
June	72.67	72.36	70.11	66.44	59.61	54.06	53.17	45.89	40.28	35.39
July	82.47	81.94	80.32	75.94	73.47	69.44	68.09	66.26	62.90	60.97
August	64.52	63.98	62.37	58.17	55.75	54.06	52.69	49.95	44.35	42.31
September	34.72	34.31	33.61	31.08	29.67	26.42	25.69	22.17	19.53	19.53
October	6.34	5.91	5.22	3.39	2.96	2.96	2.18	2.18	2.18	0.00
November	16.31	15.72	14.44	11.64	9.47	8.36	7.36	4.08	2.25	0.00
December	32.66	31.96	30.43	25.13	19.80	17.73	14.99	8.99	5.11	0.00

MINIMUM DOWNTIME [Hours]										
WS > 7m/s	0	3	6	12	18	24	36	48	72	96
January	23.79	23.60	22.63	18.71	13.04	10.73	7.90	2.66	0.00	0.00
February	11.97	11.85	11.14	9.13	5.29	5.29	3.66	3.66	2.98	2.98
March	3.39	3.28	2.93	0.97	0.00	0.00	0.00	0.00	0.00	0.00
April	4.67	4.33	3.78	1.03	0.00	0.00	0.00	0.00	0.00	0.00
May	26.34	25.78	22.28	10.30	8.09	6.34	6.34	6.34	6.34	3.15
June	54.89	54.25	51.89	43.72	38.08	35.33	34.36	32.03	32.03	27.08
July	65.73	64.70	61.80	56.64	51.94	47.23	45.91	41.96	35.03	26.40
August	46.96	46.10	43.68	38.55	36.10	34.41	34.41	29.54	26.32	21.75
September	24.67	24.47	22.08	19.17	17.50	14.11	11.75	9.03	9.03	6.61
October	2.26	2.20	2.10	1.16	0.75	0.75	0.00	0.00	0.00	0.00
November	5.17	5.00	4.25	2.22	1.33	0.81	0.00	0.00	0.00	0.00
December	13.37	12.81	11.84	8.74	6.86	5.30	3.87	3.31	0.00	0.00

MINIMUM DOWNTIME [Hours]										
WS > 8m/s	0	3	6	12	18	24	36	48	72	96
January	7.07	6.67	6.10	3.60	1.67	0.75	0.00	0.00	0.00	0.00
February	4.58	4.46	3.72	1.71	0.95	0.95	0.00	0.00	0.00	0.00
March	0.75	0.67	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	0.97	0.78	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	10.19	9.84	7.34	4.19	4.19	4.19	4.19	4.19	2.34	0.00
June	37.72	37.25	35.56	29.03	26.50	25.22	22.44	21.17	17.58	13.03
July	44.27	43.60	40.59	33.12	29.25	27.04	20.00	18.90	12.90	10.89
August	28.25	27.39	24.09	20.35	18.17	15.35	14.14	12.15	9.22	6.85
September	12.67	12.22	11.28	8.36	6.67	5.56	4.64	3.42	3.42	3.42
October	0.30	0.27	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
November	0.81	0.47	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
December	4.49	4.39	4.06	2.99	2.18	1.64	1.56	1.56	0.00	0.00

MINIMUM DOWNTIME [Hours]										
WS > 9m/s	0	3	6	12	18	24	36	48	72	96
January	1.05	1.05	0.73	0.19	0.00	0.00	0.00	0.00	0.00	0.00
February	0.53	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	4.11	4.06	3.09	2.66	2.66	2.66	2.66	1.69	0.00	0.00
June	22.33	21.56	19.08	14.33	10.64	8.17	6.56	2.92	0.00	0.00
July	25.22	24.44	21.48	14.84	11.85	8.58	5.94	4.70	0.00	0.00
August	14.87	14.25	12.77	9.70	9.01	7.96	6.61	6.61	0.00	0.00
September	6.08	5.86	5.19	4.19	2.50	2.50	2.50	2.50	2.50	0.00
October	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
November	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
December	0.56	0.46	0.38	0.19	0.00	0.00	0.00	0.00	0.00	0.00

[illegible][illegible][illegible]

[illegible][illegible]





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