RENEWABLE ENERGY WIND MAPPING FOR ZAMBIA

24-month Site Resource Report

The World Bank

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Project name:	Renewable Energy Wind Mapping for Zambia	Garrad Hassan America, Inc.
Report title:	24-month Site Resource Report	(DNV GL)
Customer:	The World Bank	9665 Chesapeake Drive, Suite 435
	1818 H Street, N.W. Washington, DC 20433	Tel: +1 (703) 795 - 8103 Enterprise No.: 94-3402236
Contact person:	Tigran Parvanyan	
Date of issue:	24 April 2019	
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Task and objective:

Wind resource assessment at eight mast locations across Zambia, and energy estimates for eight preliminary wind farms.

Prepared by:	Verified by:	Approved by:
S. Bourne Senior Engineer	J. Ziegler Senior Engineer	S. Dokouzian Senior Project Manager, Development and Engineering Services

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A	24 April 2019	Initial revision for review	S. Bourne	J. Ziegler	S. Dokouzian

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EXECUTIVE SUMMARY

The World Bank (the "Customer") retained Garrad Hassan America, Inc. (DNV GL) to complete a 24-month Site Resource Report, which consists of an independent analysis of the wind regime and energy production at eight locations across Zambia, as part of the Renewable Energy Wind Mapping for Zambia (part of the ESMAP Program). The results of the work are reported here.

The overall mandate consists of providing a preliminary mesoscale wind atlas for Zambia, including associated deliverables and wind energy development training courses. In addition, meteorological data is collected at eight sites over a 2-year period. The 24-month Site Resource Report provides wind resource statistics at the eight masts and energy production estimates for generic wind farms in the vicinity of the masts. The program's goal is to provide Zambian policy makers, stakeholders, and independent power producers with accurate and valuable knowledge of the national wind resource, including complementary tools, which can be of direct practical use, both for formulating energy policy and implementing wind projects.

The eight meteorological masts were installed and commissioned in November and December 2016. Based on two years of data collection, DNV GL has evaluated the wind resource at each location, the long-term wind regime, and the estimated energy production based on a generic 4 MW wind turbine, with a rotor of 140 m and a hub height of 130 m. A brief summary of the key results is presented in the table below.

Results	Choma	Mwinilunga	Lusaka	Mpika
Average air density at hub elevation [kg/m^3]	1.00	0.99	1.03	1.00
On-site measurement period [years]	2.3	2.2	2.2	2.2
Long-term reference period [years]	17.0	17.0	17.0	17.1
Long-term hub height wind speed at met mast [m/s]	7.1	7.2	7.8	7.0
Average turbine wind speed [m/s]	7.1	7.2	8.0	7.0
10-year P50 Net Energy [GWh/annum]	303.7	318.2	394.7	319.7
10-year P50 Net Capacity Factor [%]	34.6%	36.3%	45.0%	36.5%

Results	Chanka	Petauke	Mansa	Malawi
Average air density at hub elevation [kg/m^3]	1.01	1.04	1.01	1.04
On-site measurement period [years]	2.2	2.2	2.2	2.1
Long-term reference period [years]	17.0	17.0	17.0	17.0
Long-term hub height wind speed at met mast [m/s]	7.2	6.5	6.8	6.9
Average turbine wind speed [m/s]	7.2	6.9	7.2	7.1
10-year P50 Net Energy [GWh/annum]	344.8	303.3	330.0	328.5
10-year P50 Net Capacity Factor [%]	39.3%	34.6%	37.6%	37.5%

Other key conclusions and recommendations from the study are as follows:

- The net energy predictions presented above represent the long-term mean, 50% exceedance level, for the annual energy production of the generic wind farms. These values are the best estimate of the long-term mean values to be expected from the project. There is therefore a 50% chance that, even when taken over very long periods, the mean energy production will be less than the values given.

- The standard error associated with the prediction of energy capture has been calculated and the confidence limits for the prediction are given in the table below.

Site	Choma	Mwinilunga	Lusaka	Mpika
Probability of exceedance	**10-year average [GWh/annum]**			
50%	303.7	318.2	394.7	319.7
75%	274.9	293.8	366.8	294.2
90%	248.8	271.1	341.1	270.8
95%	233.4	257.2	324.7	256.2
99%	204.6	230.8	292.7	229.6

Site	Chanka	Petauke	Mansa	Malawi
Probability of exceedance	**10-year average [GWh/annum]**			
50%	344.8	303.3	330.0	328.5
75%	315.6	274.3	303.3	300.2
90%	288.1	248.5	278.6	273.7
95%	271.3	232.3	263.4	257.6
99%	239.0	203.4	234.0	226.6

- Some of the uncertainties in the table above are considered to be high based on DNV GL expectations for a modern utility-scale wind farm. The largest contributors to uncertainty in the estimates above included the evaluation of the long-term wind regime, wind shear extrapolation, and horizontal extrapolation. DNV GL notes the following observations and opinions regarding uncertainty:
  - The uncertainty in the long-term analysis was driven by the lack of viable ground-stations to verify the reanalysis data used to conduct the long-term analysis. For this reason, there is increased uncertainty in the long-term wind regime at each site.
  - The uncertainty associated with the vertical extrapolation to hub height was elevated at all sites due to the large extrapolation distance. It was particularly high at Mwinilunga, Lusaka, Mansa, and Malawi where low wind speeds and strong thermal heating patterns resulting in high values of measured wind shear at the met mast locations. There is uncertainty that these measurements will remain constant to the estimated turbine hub height of 130 m and additional uncertainty where the wind turbines are site large distances away from the met mast where the measurements were taken. To reduce the uncertainty associated with the vertical wind speed extrapolation, DNV GL strongly recommends the use of taller met masts and/or remote sensing to characterize the wind regime above the existing mast height.
  - The uncertainty associated with the horizontal extrapolation of the wind speeds is high at some sites due to the distance of the turbine locations from the proposed met mast and the

unavailability of high resolution elevation data. Some turbines were sited in locations far from the met masts in an effort to maximize energy production. For a bankable wind energy assessment, DNV GL recommends placing measurements at the location of the proposed wind turbines, with each of the wind turbines at least 2 km from a met mast.

- The proposed wind turbine layouts are preliminary and consider general siting requirements, but not detailed environmental, technical, or construction constraints. A more thorough feasibility analysis shall be undertaken to evaluate if the areas can host wind turbines and interconnect to the transmission network. The purpose of the analysis is to provide a general understanding of how a generic wind farm would be sited and how it would perform, while taking into consideration the uncertainties and recommendations above.
- The turbine capacity [MW] and power curve for the generic turbine is a conservative representation of current technology and reflects the type of technology that is expected to be deployed in the near future. The turbine power curve was updated for the 24-month Report. Careful selection of a wind turbine model suitable for the site should be considered, including transportation logistics feasibility.
- The met masts were sited in their current locations primarily for the purpose of an eventual validation of the national wind atlas, upon completion of 24 months of data acquisition. Some of the locations may also be suitable for large scale wind development, but not all are ideal for this purpose. As such, DNV GL recommends that stakeholders wishing to develop a wind project in Zambia not restrict their site selection to the eight mast locations, as there is wind energy potential in locations across the country that are not currently well-represented by a met mast.

To conclude, there is now an established network of state-of-the-art wind measurement masts in Zambia that can be used to support stakeholder wind analysis activities and future utility-scale wind development in-country. In the future, this network of masts will also provide the industry with a source of long-term reference station data which could greatly reduce uncertainties for potential developers. The data collected from the eight met masts are considered very good both in terms of data quality and data coverage. Further investment by stakeholders in well-organized measurement campaigns and in feasibility analysis that are focused on reducing uncertainties will help support future growth of the Zambian wind market.

1 INTRODUCTION

The World Bank (the "Customer") retained Garrad Hassan America, Inc. (DNV GL) to complete a 24-month Site Resource Report, which consists of an independent analysis of the wind regime and energy production at eight locations across Zambia, as part of the Renewable Energy Wind Mapping for Zambia (part of the ESMAP Program). The results of the work are reported here.

This report presents a description of the project sites and turbine technology. It then describes the available measurements and analysis of the wind data followed by an evaluation of the expected project gross and net energy for preliminary wind farms in the vicinity of the masts, as influenced by assumed losses and uncertainties. Finally, it presents DNV GL's observations and recommendations.

The overall mandate consists of providing a preliminary mesoscale wind atlas for Zambia, including associated deliverables and wind energy development training courses. In addition, meteorological data is collected at eight sites over a 2-year period. The 24-month Site Resource Report provides wind resource statistics at the eight masts and energy production estimates for preliminary wind farms in the vicinity of the masts. The program's goal is to provide Zambian policy makers, stakeholders, and independent power producers with accurate and valuable knowledge of the national wind resource, including complementary tools, which can be of direct practical use, both for formulating energy policy and implementing wind projects.

2 PROJECT DESCRIPTION

The masts that form part of the ESMAP program are located across Zambia to inform the wind mapping studies. Measurements of the wind regime have been made at eight meteorological (met) masts locations across Zambia as shown in Figure 2-1. DNV GL has analyzed a preliminary 25-turbine layout for a Generic 4 MW wind turbine at a hub height of 130 m close to each mast location to assess the potential energy production at each location.

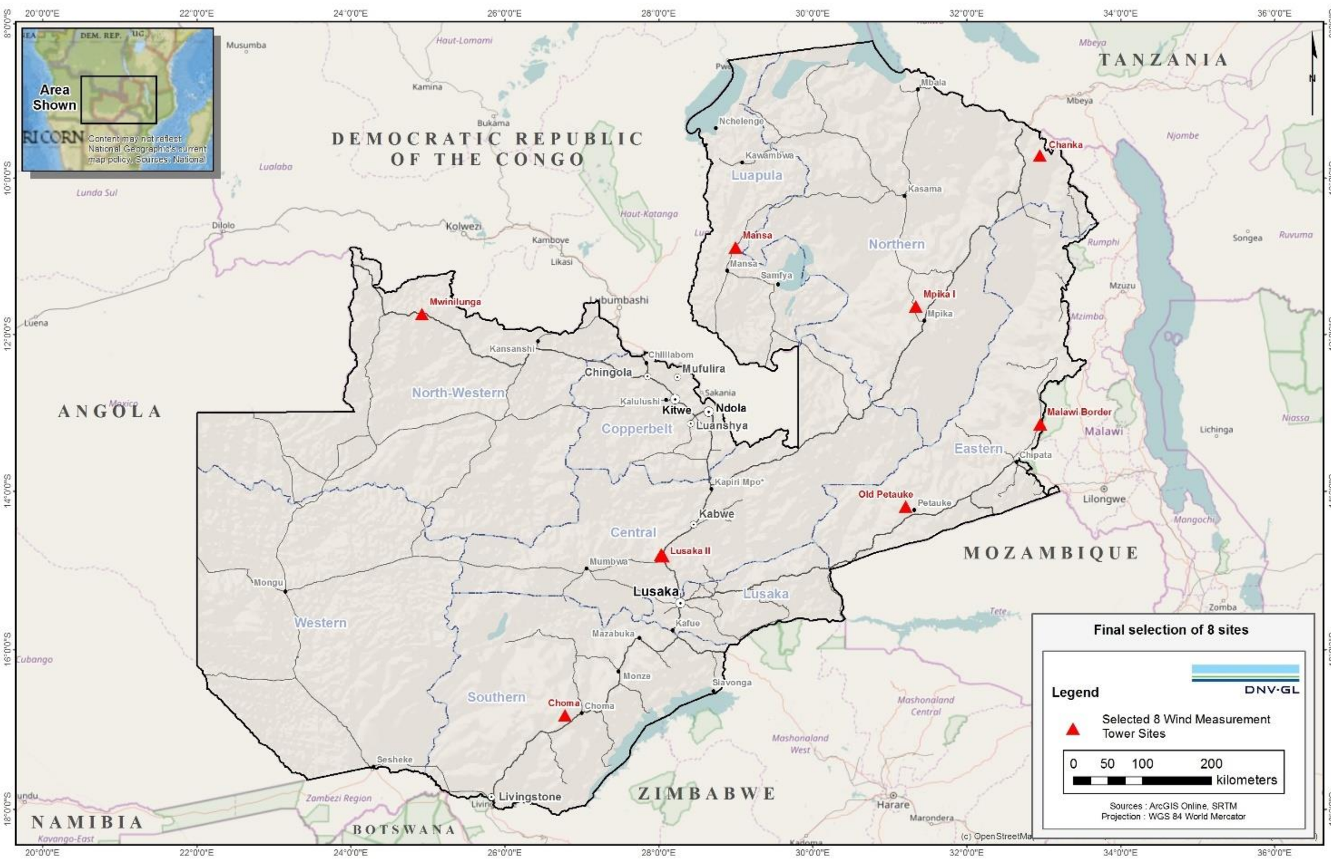


Figure 2-1 Mast locations

2.1 Site description

The met masts and proposed preliminary wind farms are located throughout Zambia, and the terrain complexity and ground cover vary from site to site. DNV GL has generated a preliminary turbine layout for each site based on a Generic 4 MW wind turbine at a hub height of 130 m. Figures showing the location of the proposed wind turbines and the met masts for each site are provided in Appendix C.

DNV GL commissioned the eight masts, therefore the measurement equipment has been inspected and the ground cover at the eight mast locations has been assessed. Table 2-1 below provides a brief summary of each site in terms of the terrain and ground cover and also provides insight into the range of turbine base elevations. Note that some wind turbine layouts are at significant distances from the masts in an effort to maximize energy production.

Table 2-1 Site descriptions

Site location	Brief description	Turbine base elevations [m]
Choma	The site is located in an area of rural agricultural land approximately 20 km west of the town of Choma in the Southern Province. The ground cover consists mainly of low shrub-like vegetation interspersed with small trees and residences.	1346-1390
Mwinilunga	The site is located on a slightly elevated and lightly forested plateau approximately 60 km southeast of the town of Mwinilunga in the North-West Province. The ground cover consists mainly of shrub-like vegetation interspersed with trees.	1512-1545
Lusaka	The site is located in an area of flat, rural agricultural land approximately 70 km northwest of the city of Lusaka in the Central Province. The ground cover consists mainly of low crops interspersed with trees and residences.	1157-1183
Mpika	The site is located in an area of low lying bush and rural agricultural land approximately 25 km northwest of the town of Mpika in the Northern Province. The ground cover consists mainly of low shrub-like vegetation interspersed with trees and sparse residences.	1383-1415
Chanka	The site is located in an area of rural agricultural land approximately 80 km northeast of the town of Isoka in the Northern Province. The site is located between 35 and 50 km from the Malawi and Tanzanian borders, respectively on the crest of a plateau. The ground cover consists mainly of low shrub-like vegetation interspersed with small residences.	1273-1332
Petauke	The site is located in an area of rolling hills approximately 15 km northwest of the town of Petauke in the Eastern Province. The ground cover consists mainly of low lying crops and bush interspersed with small trees.	982-1090
Mansa	The site is located in on a small southwest-northeast ridge approximately 35 km north of the town of Mansa in the Luapula Province. The ground cover consists mainly of low shrub-like vegetation.	1300-1390
Malawi	The site is located in an area of flat, rural agricultural land approximately 80 km east of the town of Chipata in the Eastern Province. The ground cover consists mainly of low lying crops and bush interspersed with small trees.	1039-1080

A map of each site is presented in Appendix C showing the meteorological mast and turbine locations.

2.2 Turbine technology

The power curve used in this analysis represents a blended generic turbine model that has been generated by DNV GL. It has been updated for this 24-month Report. Table 2-2 summarizes the turbine model under consideration for each site.

Table 2-2 Proposed turbine model parameters

Turbine	Rated power [MW]	Hub height [m]	Peak power coefficient [C_p]	Valid PC density [kg/m^3]	Valid PC turbulence intensity range [%]
Generic 4 MW	4.0	130	0.47	1.225	6-12

Given the preliminary nature of the generic power curve used in this assessment, DNV GL recommends that potential stakeholders conduct a thorough market review of available technologies when assessing a potential wind farm site in Zambia. Turbine manufacturers should be approached at an early stage to gain acceptance of proposed turbine layouts and turbine suitability for each site and evaluate the need, if any, for mitigation of fatigue loads through wind sector management. It shall also be noted that some turbine models may provide better energy capture and therefore improve the overall performance at the sites.

2.3 Neighboring wind farms

To DNV GL's knowledge, there are no utility-scale operational wind farms currently in Zambia. Therefore, no external wake effects are considered in the analysis.

3 ON-SITE WIND MONITORING

3.1 Wind resource measurements

Wind resource measurements have been recorded at the eight sites using met masts with measurements taken from November 2016 to February 2019. The characteristics of these measurements are summarized in Table 3-1.

Table 3-1 Met mast summary

Mast	Anemometer heights	Anemometer manufacturer and model	Period	Calibration certificate by MEASNET facility?	Anemometer(s) mounted in compliance with IEC guidance?[a]
Choma	80 m (x2), 60 m (x2), 42 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	November 2016 – February 2019	Yes	Compliant
Mwinilunga	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	December 2016 – February 2019	Yes	Compliant
Lusaka	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	November 2016 – February 2019	Yes	Compliant
Mpika	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	November 2016 – February 2019	Yes	Compliant
Chanka	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	November 2016 – February 2019	Yes	Compliant
Petauke	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	December 2016 – February 2019	Yes	Compliant
Mansa	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	November 2016 – February 2019	Yes	Compliant
Malawi	80 m (x2), 60 m (x2), 41 m (x2), 20 m (x2)	Thies FCA, NRG Class 1	December 2016 – February 2019	Yes	Compliant

a. IEC 61400-12:2005 E [1]

The mounting arrangements of the instrumentation at the site masts are consistent with the recommendations of the IEC [1] and therefore considered to be in accordance with industry best practice for good quality wind measurements. Additional details about the configuration of each mast are available in the mast Commissioning Reports [2].

3.2 Data processing

Raw data from the met mast at each site have been collected by DNV GL. The wind data have been subject to a quality checking procedure by DNV GL to identify records which were affected by equipment malfunction and other anomalies. These records were excluded from the analysis. To minimize mast effects in the measured wind speed data, selective averaging was undertaken of the data recorded at the all instrumentswhere parallel measurements were available.

The duration, basic statistics, and data coverage for the masts are summarized in Appendix A. Wind data coverage is generally very good, with only minor data loss. Overall data coverage levels for the key parameters and instruments on each mast are shown in the following Table 3-2.

Table 3-2 Summary of site masts data coverage

Mast	Height [m]	Available period [years]	Valid period [years]	Measured wind speed [m/s]	Wind speed data coverage [%]
Choma	80	2.3	2.3	6.4	100
Mwinilunga	80	2.2	2.2	6.0	100
Lusaka	80	2.2	2.2	6.3	100
Mpika	80	2.2	2.2	6.1	100
Chanka	80	2.2	2.2	6.5	99
Petauke	80	2.2	2.2	5.6	100
Mansa	80	2.2	2.2	5.8	100
Malawi	80	2.1	2.1	5.9	100

4 WIND ANALYSIS

The analysis of the site wind regime involved several steps. A summary of the results for each step of the process are provided in the following sections.

4.1 Measurement height wind regime

4.1.1 Site period wind speeds

Data were recorded at the site masts up to a measurement height of 80 m and over data period ranging from November 2016 to February 2019. Data coverage at the eight masts was between 99% and 100% and the measured mean wind speeds ranged from 5.6 m/s to 6.5 m/s. The values for each individual site are shown in Table 4-1 and in Appendix A.

Table 4-1 Site period wind speeds

Mast	Height [m]	Data Period	Data coverage [%]	Measured mean wind speed [m/s]
Choma	80.0	01/11/2016 – 08/02/2019	100	6.4
Mwinilunga	80.0	03/12/2016– 08/02/2019	100	6.0
Lusaka	80.0	21/11/2016– 08/02/2019	100	6.3
Mpika	80.0	20/11/2016– 08/02/2019	100	6.1
Chanka	80.0	23/11/2016– 08/02/2019	99	6.5
Petauke	80.0	09/12/2016– 08/02/2019	100	5.6
Mansa	80.0	26/11/2016– 08/02/2019	100	5.8
Malawi	80.0	21/12/2016– 08/02/2019	100	5.9

It should be noted that the wind speeds presented in Table 4-1 represent only the measured period of data at each location. DNV GL conducts a review of the representativeness of the measured data of the long-term wind regime in the following sections of this report.

4.1.2 Extension of the site period to the reference period

The inclusion of quality reference data can reduce the uncertainty in the estimate of the long-term wind regime at the site. When selecting appropriate reference data for this purpose it is important that the reference data's wind regime is driven by similar factors as the site wind regime and the reference data are consistent over the measurement period being considered.

4.1.2.1 Reference data considered

DNV GL has undertaken a review of the sources of reference data at each site in order to identify appropriate long-term reference stations for this analysis. Given the lack of viable ground station networks in Zambia with long-term, consistent data periods, this analysis has relied heavily upon reanalysis and virtual datasets. At each site, DNV GL has correlated the measured wind data to DNV GL's Virtual Met Data (VMD), ERA-5 and MERRA-2. It is noted that the 12-month report considered the ERA-Interim dataset instead of the ERA-5 dataset. At the time of the release of the 12-month report, the ERA-5 dataset was not publicly available. With the release of ERA-5, DNV GL has considered this dataset in the analysis to replace the outdated ERA-Interim dataset. More information about these reference stations are provided in Appendix B. Table 4-2 summarizes the stations considered.

Table 4-2 Reference data sets considered for correlation to site data

Site location	Meteorological data source	Network	Distance from site	Start date	End date
Choma	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	158 km northeast	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	67 km northwest	01 Jan 2002	31 Jan 2019
Mwinilunga	VMD	DNV GL	On-site	01 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	115 km northwest	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	82 km north	01 Jan 2002	31 Jan 2019
Lusaka	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	79 km northeast	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	35 km north	01 Jan 2002	31 Jan 2019
Mpika	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	78 km northwest	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	80 km west	01 Jan 2002	31 Jan 2019
Chanka	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	110 km northwest	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	80 km north	01 Jan 2002	31 Jan 2019
Petauke	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	50 km west	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	34 km south	01 Jan 2002	31 Jan 2019
Mansa	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	70 km northwest	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	59 km northeast	01 Jan 2002	31 Jan 2019
Malawi	VMD	DNV GL	On-site	02 Jan 2002	27 Dec 2018
	ERA-5	ECMWF	97 km northeast	01 Jan 2002	31 Dec 2018
	MERRA-2	NASA	52 km northwest	01 Jan 2002	31 Jan 2019

To determine whether use of reference data will reduce uncertainty, a correlation of monthly mean wind speeds between each consistent reference station and the site was completed. The results of this analysis are summarized in Table 4-3.

Table 4-3 Reference data sets considered for correlation to site data

Site	Coefficient of determination, R^2		
	VMD	ERA-5	MERRA-2
Choma	0.84	0.94	0.47
Mwinilunga	0.96	0.97	0.92
Lusaka	0.86	0.96	0.88
Mpika	0.87	0.99	0.92
Chanka	0.93	0.98	0.91
Petauke	0.90	0.97	0.95
Mansa	0.92	0.99	0.94
Malawi	0.85	0.97	0.94

During the analysis, DNV GL evaluates each long-term reference source for each site based on:

- how representative the location at which the reference source is defined is of the mast location,
- the strength of the correlation between the reference source data and the site mast data, and
- the consistency of the reference source data.

DNV GL's resulting choice of reference data sources and the corresponding long term adjustment for each site are shown in Table 4-4.

Table 4-4 Applied long-term wind speed adjustments

Site	Reference data sources included in long-term adjustment	Long term adjustment	Long-term adjusted mean wind speed, [m/s]
Choma	ERA-5	-0.4%	6.3
Mwinilunga	ERA-5	-1.1%	5.9
Lusaka	ERA-5	0.4%	6.3
Mpika	ERA-5	0.3%	6.1
Chanka	ERA-5	-0.6%	6.4
Petauke	ERA-5	0.0%	5.6
Mansa	ERA-5	0.6%	5.8
Malawi	ERA-5	-0.6%	5.8

It is noted that there is a lack of viable ground-station reference data to evaluate the consistency of the reanalysis and virtual datasets considered in this assessment. For this reason, there is increased uncertainty in the long-term wind regime at each site. This elevated uncertainty is considered in Section 6.

4.2 Hub-height wind regime

4.2.1 Hub-height wind speed

To extrapolate the wind speed estimates from the measurement height to the 130 m hub height, the average power law at the site masts has been evaluated between all relevant measurement heights and applied to the upper level measurements. The results of this analysis are shown in Table 4-5.

Table 4-5 Shear exponents and hub height wind speeds

Mast	Long-term upper measurement height wind speed [m/s]	Wind shear exponent	Hub Height wind speed estimate [m/s]
Choma	6.3	0.24	7.1
Mwinilunga	5.9	0.28	7.2
Lusaka	6.3	0.34	7.8
Mpika	6.1	0.20	7.0
Chanka	6.4	0.21	7.2
Petauke	5.6	0.26	6.5
Mansa	5.8	0.31	6.8
Malawi	**5.8**	0.35	6.9

It is noted that the measured wind shear at some mast locations is considered to be high (>0.25). Based on further review, DNV GL determined that the high wind shear measured at these masts is driven by the low wind speeds experienced on-site and thermal heating and cooling close to the ground surface. The thermal convection from the ground decreases wind speeds at the surface and this attenuating effect tends to decrease with altitude as the flow becomes more free stream and laminar. The thermal heating and cooling at the surface results in relatively high magnitudes of measured wind shear at some of the met masts. There is uncertainty that the wind shear measured at the met masts will remain constant with increasing altitude, and this uncertainty is higher when the estimated wind shear exponents are higher.

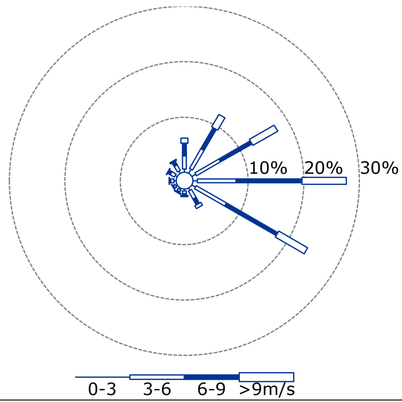
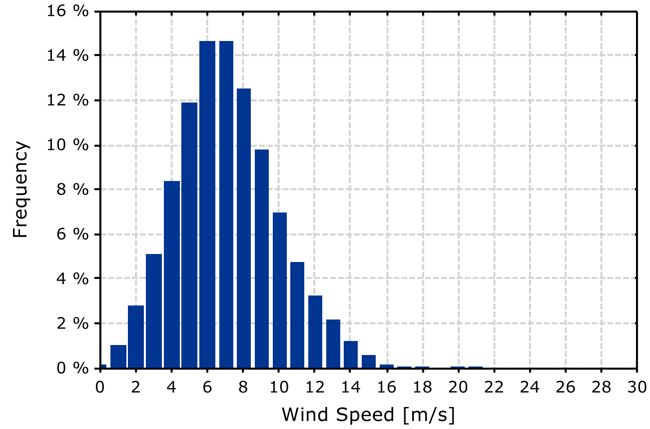
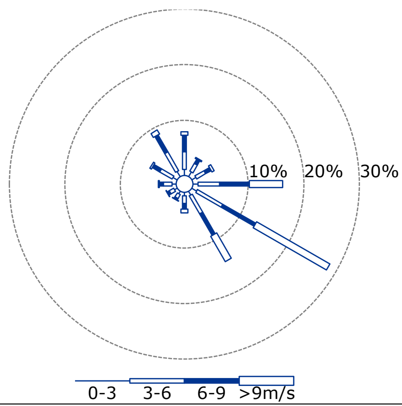
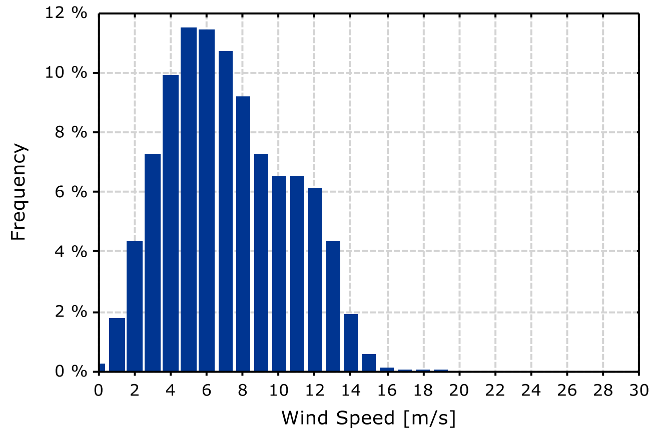
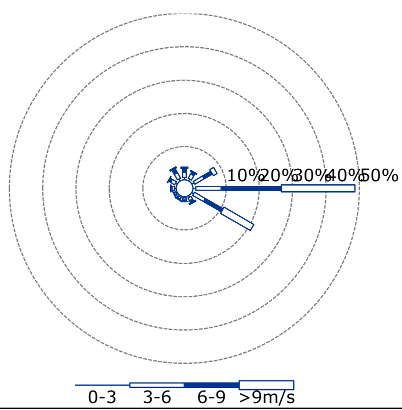
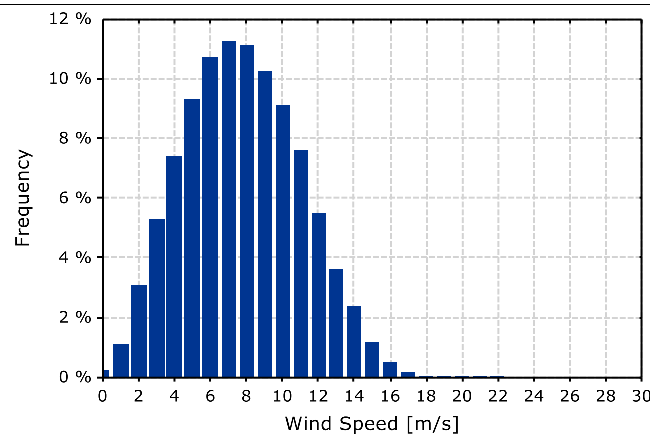
DNV GL recommends the use of remote sensing for site prospecting in Zambia, in order to more accurately characterize the vertical wind speed profile. Remote sensing measurements will further the understanding of the vertical wind speed profile and has the potential to drastically reduce the vertical extrapolation uncertainty, especially at sites where the extrapolation distance is large.

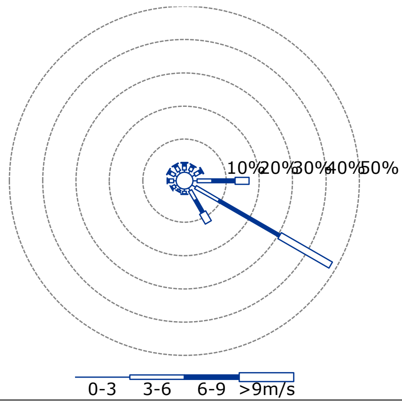
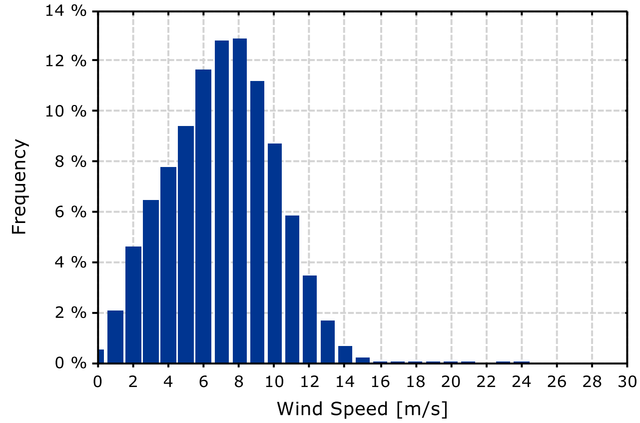
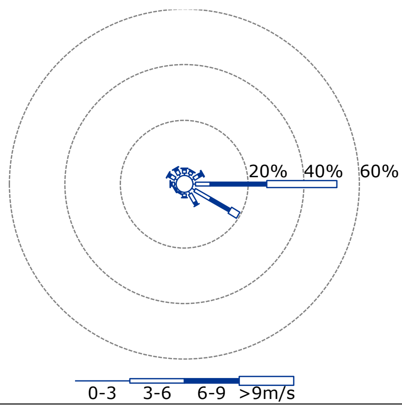
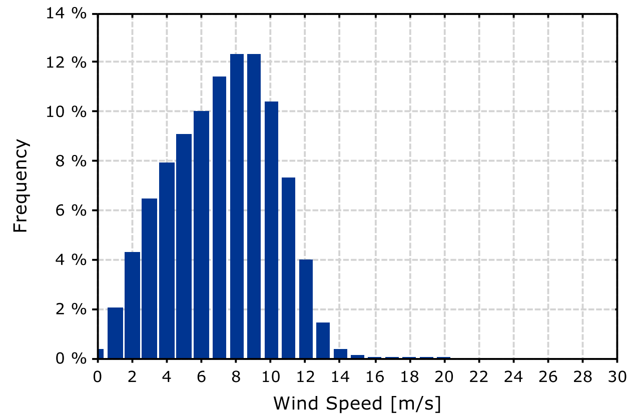
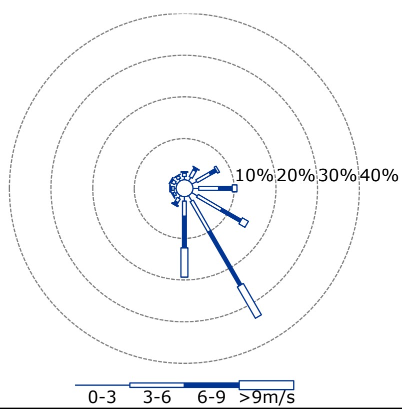
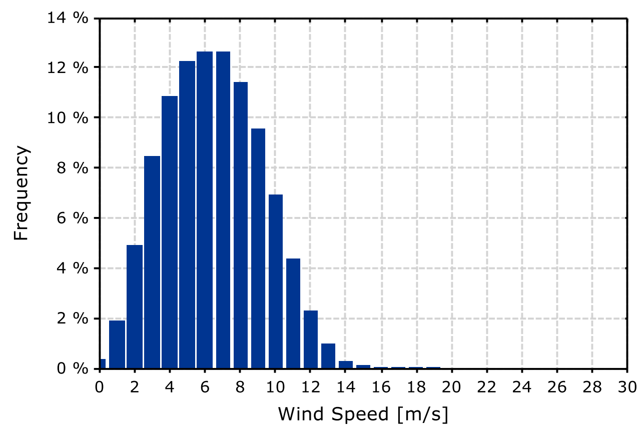
4.2.2 Hub-height wind speed and direction distributions

The hub-height wind speed and direction distributions were developed by extrapolating the measured wind speed data on a time series basis. Key project specific aspects of the analysis were:

- The distribution from each site mast was used as the basis of the analysis.
- The frequency distribution of each site mast was scaled to the representative long term hub height mean wind speed.

A representative long-term hub-height wind rose and wind speed histogram for each site are shown in Figure 4-1.

Choma		
Mwinilunga		
Lusaka		

Mpika		
Chanka		
Petauke		

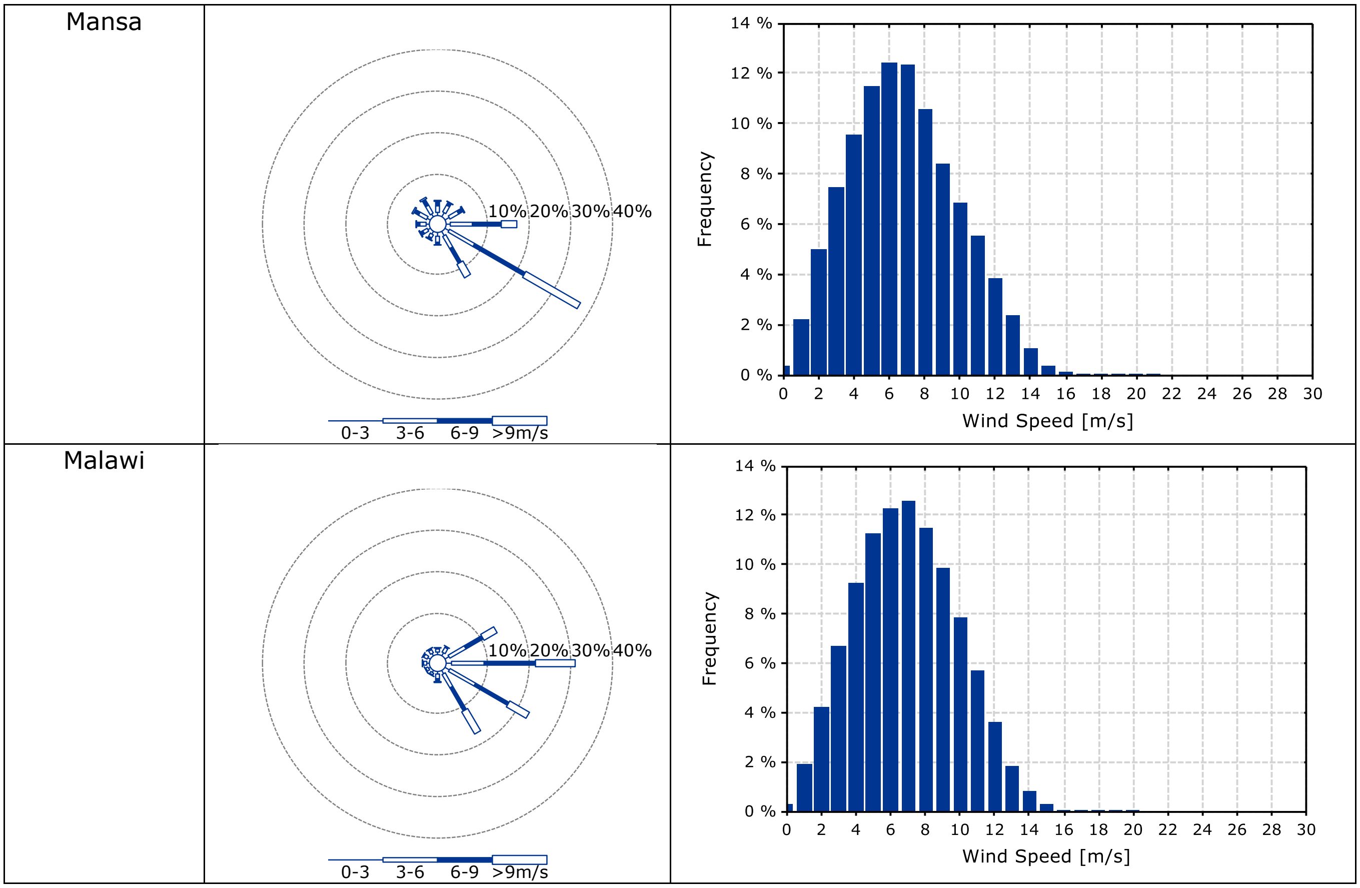


Figure 4-1 Long-term hub-height frequency distribution and wind roses

DNV GL notes that most of the wind speed frequency distributions measured by the site masts do not exhibit a standard Weibull shape. This factor should be considered when modeling the energy production at proposed sites across Zambia, as it could lead to inaccuracies in energy production estimates.

4.3 Wind regime across the site

The variation in wind speed over each site was predicted using the industry standard commercial WAsP wind flow modelling software. Each mast has been used to initiate the wind flow modeling used to predict the long-term wind regimes at the turbine locations at its respective site. The average extrapolation distances across the eight sites ranges from 3.6 km at Mpika to 24.1 km at Chanka. Through this approach, the predicted long-term mean wind speeds at each turbine at the proposed hub height are presented in Appendix D. Table 4-6 summarizes the average turbine wind speed at each site at 130 m.

It should be noted that WAsP calculations have high uncertainties when calculations: extend over large spatial distances; are initiated from positions with markedly different elevations, wind climates or exposure to those of the proposed turbine locations. The WAsP wind flow model is also not suited to stable atmospheric conditions. For further wind assessment studies in Zambia, DNV GL recommends the use of CFD wind flow modeling to decrease horizontal extrapolation uncertainties.

Table 4-6 Average long-term hub height wind speed estimates at the turbine locations

Site	Average turbine wind speed at 130 m [m/s]
Choma	7.1
Mwinilunga	7.2
Lusaka	8.0
Mpika	7.0
Chanka	7.2
Petauke	6.9
Mansa	7.2
Malawi	7.1

5 ENERGY ANALYSIS

5.1 Preliminary wind turbine layouts

DNV GL produced 100 MW preliminary wind turbine layouts in the vicinity of the eight masts. The proposed wind turbine layouts are preliminary and consider general siting requirements, but not detailed environmental, technical, or construction constraints. The purpose of the layouts is to provide a general understanding of how a wind farm would be sited and how it would perform, while taking into consideration the uncertainties and recommendations throughout this report.

The layouts are comprised of 25 – 4 MW generic wind turbines, with a rotor of 140 m and a hub height of 130 m. DNV GL designed the preliminary wind farm layouts with the objective of maximizing the energy output of the wind farm, while generally considering balance-of-plant (BOP). In addition to best practices, the following parameters were considered:

- A minimum of 3 rotor diameters spacing perpendicular to prevailing winds.
- A minimum of 6 rotor diameters spacing parallel to prevailing winds.
- No turbines in areas of terrain slope greater than 15%.
- Nearby roadway access, and access in terrain with slopes no greater than 10%.
- No turbines in general environmentally constrained areas as defined at the national level under the initial site selection report [3]. Site-specific and in-depth analysis of environmental constraints were not conducted.
- Reasonable setbacks to dwellings and settlements, broadly identified using aerial imagery. Site specific review and field validation of inhabited areas was not conducted and firm setbacks to be established for a more final layout optimization study.

In addition, DNV GL did not consider mechanical loading on wind turbines to ensure suitability with site conditions, sound levels at nearby inhabited areas, and interconnection feasibility.

The wind turbine layouts are presented in Appendix C, and the coordinates in Appendix D.

5.2 Gross and net energy estimates

The gross energy production at the individual turbine locations has been calculated using the WindFarmer software and the results of the wind flow modeling.

A theoretical and generic power curve was created by DNV GL for a 4 MW wind turbine. The power curve is shown in Table 5-1 for an air density of 1.225 kg/m^3.

Table 5-1 Generic power curve

Wind speed [m/s]	Power production [kW]
0 - 2	0
3	57
4	190
5	556
6	1010
7	1640
8	2458
9	3342
10	3963
11	4000
12 - 25	4000

The projected net energy production of each wind farm shown in Table 5-2 was calculated by applying a number of energy loss factors to the gross energy production. The predictions represent the estimate of the annual production expected over the first 10 years of operation. The individual turbine results are presented in Appendix D.

Table 5-2 Energy production summary

Scenario	Choma	Mwinilunga	Lusaka	Mpika	Chanka	Petauke	Mansa	Malawi
Wind Farm Rated Power [MW]	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Gross Energy Output [GWh/annum]	**367.6**	**379.6**	**456.9**	**375.2**	**398.2**	**363.1**	**383.3**	**384.8**
Array effects [%]	94.2	95.1	98.0	96.6	97.7	94.5	97.6	96.6
Availability [%]	94.0	94.1	94.1	94.1	94.1	94.1	94.1	94.1
Electrical efficiency [%]	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
Turbine performance [%]	95.7	96.2	96.1	96.1	96.7	96.4	96.2	96.4
Environmental [%]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Curtailments [%]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Losses (%)	**82.6**	**83.8**	**86.4**	**85.2**	**86.6**	**83.5**	**86.1**	**85.4**
Asymmetric production effect [%]	99.9	99.9	100.0	100.0	100.0	99.9	100.0	100.0
Net Energy Output [GWh/annum]	**303.7**	**318.2**	**394.7**	**319.7**	**344.8**	**303.3**	**330.0**	**328.5**
Net Capacity Factor [%]	**34.6**	**36.3**	**45.0**	**36.5**	**39.3**	**34.6**	**37.6**	**37.5**

Table 5-2 includes potential sources of energy loss that have been either assumed to be the DNV GL standard values or estimated for this project. Project specific aspects of the loss estimates are provided in the following bullets:

- Array effect – The array effects have been calculated using the WindFarmer 5 wake model and consider internal and external array effects. No neighboring or future wind farms are currently considered in the loss estimates.
- Availability – This category considers turbine availability, balance of plant, and grid availability. Considering the Generic 4 MW turbine model, the turbine availability for year 1 of operation was estimated to be 94.0% and for years 2-5 to be 96.0%. Subsequent years were adjusted in accordance with DNV GL's standard method. Generic values were used to estimate balance of plant and grid availability losses.
- Operational electrical efficiency – Details of the specific balance of plant infrastructure and grid connection point have not been considered. Therefore, DNV GL has considered a standard loss value.
- Turbine performance – As part of the turbine performance category, DNV GL has considered high wind speed hysteresis, site specific power curve adjustment, and performance degradation over time.
- Environmental – Detailed environmental losses were not considered in this analysis.
- Curtailments – Detailed curtailment losses were not considered in this analysis.

5.3 Seasonal and diurnal distributions

The expected seasonal and diurnal variation in energy production at 130 m is presented at each site in Appendix E in the form of a 12-month by 24-hour (12 x 24) matrix, and generally presented in Figure 5-1 below. It is noted that the uncertainty associated with the prediction of any given month or hour of day is significantly greater than that associated with the prediction of the annual energy production.

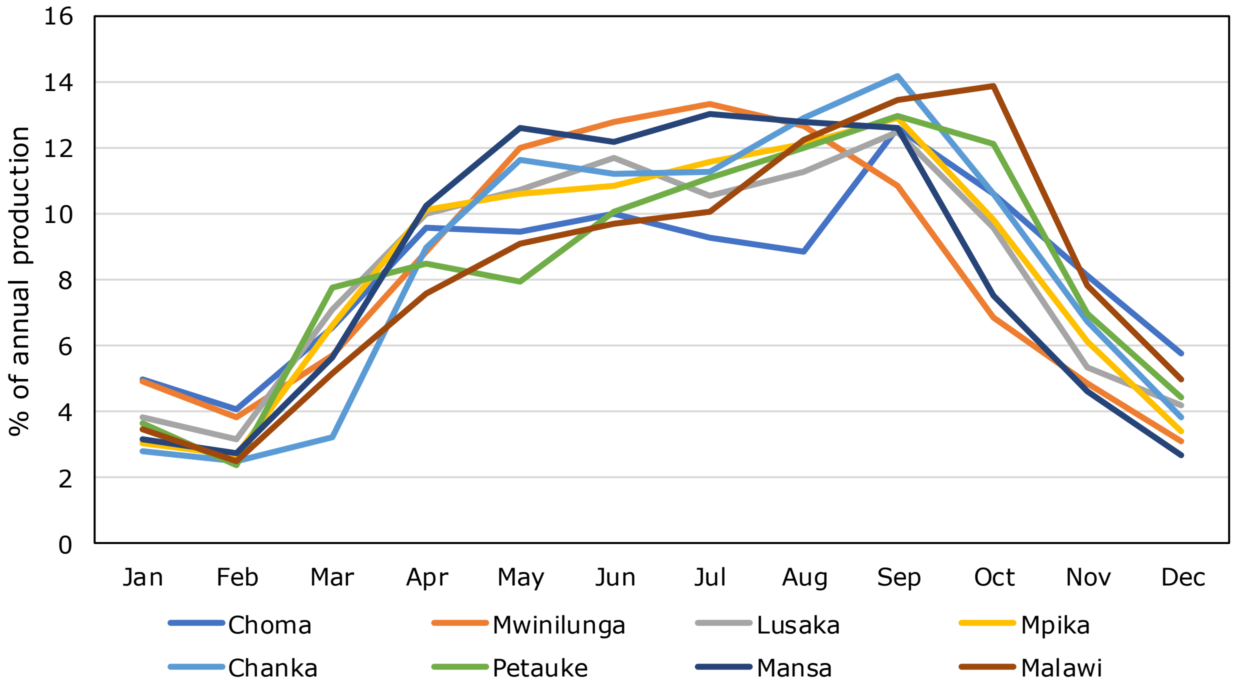


Figure 5-1 Annual energy production profiles

6 UNCERTAINTY

The main sources of deviation from the central estimate (P50) have been quantified and combined using a probabilistic model, assuming full independence between the sources. The results of the probabilistic simulation of net energy production are summarized for the Generic 4 MW scenario in Table 6-1 and detailed in Appendix F. The average calculated sensitivity ratio for variations of 10% on wind speed is shown in Table 6-2.

Table 6-1 Summary of project net average energy production for each site

Site	Choma, [GWh/annum]		Mwinilunga, [GWh/annum]		Lusaka, [GWh/annum]		Mpika, [GWh/annum]	
Probability of exceedance	1-Year	10-year average	1-Year	10-year average	1-Year	10-year average	1-Year	10-year average
50%	303.5	303.7	318.4	318.2	395.4	394.7	320.0	319.7
75%	266.3	274.9	286.4	293.8	358.2	366.8	284.0	294.2
90%	231.8	248.8	255.6	271.1	322.5	341.1	250.5	270.8
95%	211.3	233.4	236.5	257.2	300.0	324.7	230.0	256.2
99%	174.4	204.6	200.0	230.8	256.5	292.7	192.8	229.6

Site	Chanka, [GWh/annum]		Petauke, [GWh/annum]		Mansa, [GWh/annum]		Malawi, [GWh/annum]	
Probability of exceedance	1-Year	10-year average	1-Year	10-year average	1-Year	10-year average	1-Year	10-year average
50%	345.9	344.8	303.5	303.3	330.3	330.0	328.7	328.5
75%	306.0	315.6	266.2	274.3	295.4	303.3	291.4	300.2
90%	268.3	288.1	231.7	248.5	262.2	278.6	256.6	273.7
95%	245.0	271.3	210.7	232.3	241.7	263.4	234.7	257.6
99%	202.1	239.0	172.4	203.4	203.1	234.0	194.5	226.6

Table 6-2 Site average sensitivity ratios

Site	Sensitivity ratio
Choma	2.00
Mwinilunga	1.61
Lusaka	1.47
Mpika	1.96
Chanka	1.86
Petauke	1.93
Mansa	1.68
Malawi	1.81

7 SITE CONDITIONS

The site meteorological conditions assessment reported here uses inputs and analysis detailed in the energy production assessment of each site, and it is recommended that this is considered in conjunction with the present report.

It is noted that this report provides a comparison of the on-site meteorological conditions to the limits of the wind class, using the assumption that all the sites are Class IIIA. A generic turbine power curve has been used in this assessment, and therefore, a conclusion on the suitability of the turbine is not appropriate. However, it is recommended that the turbine manufacturer being considered for each site considers suitable margins in the context of confirming turbine suitability, turbine supply agreement and warranties, and that the results of this assessment are reviewed with consideration of the inherent uncertainties.

7.1 Turbulence Intensity

7.1.1 Frandsen design equivalent turbulence intensity at the turbine locations

Fatigue loading on wind turbines and their support structures is primarily the result of stochastic loading, originating from wind turbulence. In order to fully capture the turbulence conditions for the purposes of such load calculations, the cumulative effect of the ambient flow characteristics of the site and the wind farm must be taken into account, as differing layout spacing will result in differing fatigue loading for deeply embedded turbines. According to IEC 61400-1 [4], increased loading due to turbine wakes can be represented through the use of effective turbulence intensity, as defined by Frandsen [5]. This parameter characterises the effect of loading of ambient and wake induced turbulence.

The Frandsen methodology is one of several methods accepted for certification studies. This methodology is based on the calculation of an effective turbulence intensity that accounts for both wake and non-wake turbulence intensity contributions. For a given wind speed, an effective turbulence intensity is calculated based on the ambient measured turbulence intensity at a representative mast location and the proximity of neighbouring turbines and results in a curve of turbulence intensity against wind speed.

One of the main input parameters in this model is the thrust coefficient curve of the specific turbine model under consideration. The thrust curve for the generic turbine model under consideration has been generated by DNV GL. Therefore, the turbulence intensity estimates using the Frandsen methodology in this analysis should be considered indicative only, as they do not represent a specific turbine model in the market at present. However, the indicative results can be used to gauge possible levels of effective turbulence at each of the site locations.

The individual effective turbulence values for all turbines at the sites are presented in Appendix G. These tables show any turbines that are predicted to exceed IEC subclass A for wind speeds within the $0.2V_{ref}$ to $0.4V_{ref}$ range, and turbines which exceed the profile at lower wind speeds. It is noted that there is a low data coverage of measurements available to define the turbulence intensity profile at high wind speeds, leading to increased uncertainty in these values. The site minimum, maximum and average profiles for the Mpika mast are presented in Figure 7-1 along with the profiles for the turbulence subclasses. Refer to Appendix G for all of the masts.

It is recommended that turbine suppliers be approached at an early stage to gain approval for the proposed layout and to ensure that sufficient warranty provisions are in place to address the predicted effective turbulence at each site.

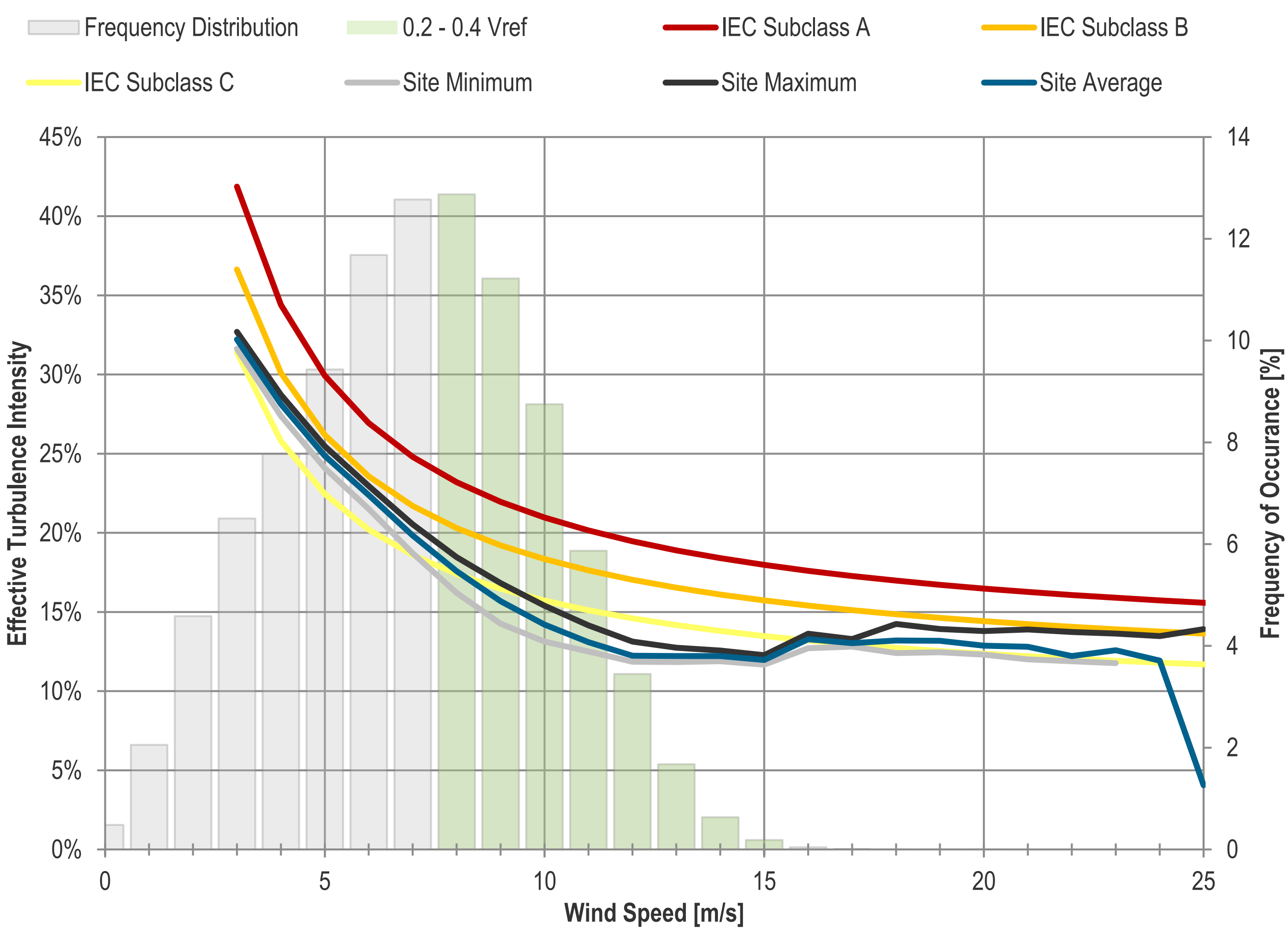
It should also be noted that the Frandsen method is a generic means of estimating design equivalent turbulence intensity, and there is scope for uncertainty in its application to the specific site and turbine type considered in this study. A list of potential sources of uncertainty that should be considered when interpreting the results for load analysis is provided below:

- Statistical scatter in the turbulence at any mean wind speed and consequent non-linear impacts on wind turbine loads.
- Non-linear behaviour of the turbine, most notably in the control system and the aerodynamics. Explicit time-domain simulations would be required to model these effects.
- It should be noted that the predictions of ambient turbulence intensity as input to the representative turbulence calculations rely on the assumption that the standard deviation of wind speed recorded at the mast location remains constant over the site area. Therefore, it is important that the mast is reasonably representative of the turbine locations. Due to this assumption, the predictions do not include any estimation of the effects of the varying ground roughness around the turbines.
- The effective turbulence intensity values estimated by the Frandsen method do not account for all the environmental parameters which influence turbine loads. The effect of wind shear, upflow angles and air density should all be included if a more rigorous load analysis is required. This would be achieved through explicit time-domain load simulations of the turbine on the site of interest.
- It is noted that DNV GL has assumed a Wöhler coefficient of 10 to be appropriate for this calculation, as it is understood that the turbine blades will likely consist of glass fibre.
- The fatigue loading of a wind turbine is, in general, not a simple direct function of turbulence intensity but depends on other sources of loading including, but not limited to, gravity, centrifugal loads and dynamic response.
- The specific implementation used for the calculation has a relevant influence on the results. It should be noted that DNV GL considered only generic turbine thrust curves and not a specific turbine curve.

Due to these issues the turbulence predictions presented should be reviewed with consideration of the inherent assumptions and large uncertainties.

It should be noted that the Frandsen method provides only an estimate of the loading levels to be experienced at the turbine locations. For a detailed study of the fatigue loading at the turbines, explicit time-domain simulations would be required.

Figure 7-1 Predicted profiles of site minimum, maximum and average design equivalent turbulence intensity for the Mpika site using a Generic 4.0 MW wind turbine at a hub height of 130 m



7.1.2 Uncertainty in turbulence prediction

It should be noted that all the predictions of turbulence intensity, ambient and design equivalent, rely on the assumption that the standard deviation of wind speed recorded at the site mast location remains constant over the area of the site with respect to the measured values, is representative of the turbine locations, and does not vary with height.

This standard assumption inherently implies that the turbulence predictions do not explicitly account for the effects of the varying ground roughness around the turbines i.e. this is only modelled through the associated variations in mean wind speeds. Therefore, it is important that the mast is reasonably representative of the turbine locations.

7.2 Extreme wind speeds

The extreme wind speed at a site is best determined by a Method of Independent Storms (MIS) or Gumbel analysis, using data recorded at the site over a period of at least 7 years. At the sites, approximately one year of 10-minute mean wind speed data were available. This period is less than ideal to obtain an accurate prediction. Despite this, estimates using the MIS method are provided below but it should be noted that the estimates are subject to a very high level of uncertainty given the limited on-site measurement period.

Furthermore, for indicative purposes the maximum value recorded on site is presented in Section 7.2.2.

7.2.1 Method of Independent Storms (MIS)

DNV GL has undertaken a Gumbel analysis, using the Method of Independent Storms (MIS) defined by Cook [6] and further developed by Harris [7][8]. This method has been employed to provide an estimate based on the measured data available at the site masts, as detailed below.

It is possible to use the Method of Independent Storms (MIS) to determine a 10-minute mean extreme wind speed for a return period of 50 years from a continuous time series. Guidance within Cook recommends that a data set of at least 7 years' duration is ideally used for an MIS analysis. As the site dataset used in this analysis is limited to a single year, caution must be exercised in the interpretation of the extreme gust wind speeds determined from this analysis. Using the code and inputs described above, DNV GL has undertaken an MIS analysis as follows.

The measured time series at the masts were extrapolated to the proposed hub height of 130 m using time series based shear method, in order to derive a continuous time series at hub height at each mast location.

Applying the MIS procedure to these time series, the extreme 10-minute mean wind speed for a return period of 50 years was estimated at the locations of the mast.

The predicted 10 minute and 3 second gust extreme wind speeds for each mast are presented in. The 3 second gust wind speeds were predicted by applying appropriate wind speed ratios to the extreme 10-minute wind speeds.

The highest extreme 10-minute mean and 3 second gust obtained from the MIS analysis, over a 50-year return period, are predicted to be 25.0 m/s at the Chanka mast and 42.0 m/s at the Petauke mast, respectively.

It is however noted that there are no values exceeding the IEC Class III for 10-minute average and 3-second gust extreme wind speed thresholds.

Table 7-1 Predicted extreme wind speeds by Method of Independent Storms (MIS) at selected turbine locations

Turbine ID	Maximum 10-minute mean with a return period of 50 years at 130 m [m/s]	Maximum 3-sec gust with a return period of 50 years at 130 m [m/s]
Choma	24.5	39.5
Mwinilunga	20.0	46.0
Lusaka	25.5	40.5
Mpika	28.5	38.5
Chanka	25.5	39.5
Petauke	22.5	38.5
Mansa	25.0	38.0
Malawi	23.0	40.0
Class III limit	**37.5**	**52.5**

7.2.2 Extreme wind speeds recorded at the masts

A review of the maximum wind speeds recorded on site was also undertaken. The loggers installed at the masts have been programmed to record 1-second gust values and 10-minute averages.

The Wieringa equation has been used to derive a conversion factor to adjust the predicted 1-second gusts measured at the mast location to 3-second gusts. The Wieringa equation is defined as follows:

$$\gamma_t(t) = 1 + 0.42 \times I \times ln\left(\frac{T}{t}\right)$$

Where: γ_t is the gust ratio;

I is the turbulence intensity;

T is the averaging period in seconds;

t is the gust period in seconds.

Using the measured period at the masts, the maximum 10-minute mean wind speed and the maximum 3-second gust wind speed are provided in Table 7-2.

Table 7-2 Maximum 10-min and 3-sec wind speeds at mast locations

Turbine ID	Maximum 10-minute mean wind speed at Mast at 130 m [m/s]	Maximum 3-sec measured at Mast at 80 m [m/s]
Choma	20.9	30.7
Mwinilunga	18.0	27.6
Lusaka	21.2	26.9
Mpika	22.8	27.2
Chanka	19.9	27.7
Petauke	18.9	31.5
Mansa	20.7	26.0
Malawi	20.2	26.0

8 OBSERVATIONS AND RECOMMENDATIONS

DNV GL makes the following observations and recommendations regarding this analysis:

1. The met masts were sited in their current locations primarily for the purpose of an eventual validation of the national wind atlas. Some of the locations may also be suitable for large scale wind development, but not all are ideal for this purpose. As such, DNV GL recommends that stakeholders wishing to develop a wind project in Zambia not restrict their site selection to the eight mast locations, as there is wind energy potential in locations across the country that are not currently well-represented by a met mast.
2. Based on approximately two years of wind data, DNV GL evaluated the representativeness of the on-site data to the long-term wind regime based on DNV GL VMD, the ERA-5 data set and the MERRA-2 data set. Where applicable, long-term adjustments were applied to the on-site wind data to adjust the data to represent long-term expectations. It is noted that there is a lack of viable ground-station reference data to evaluate the consistency of the reanalysis and virtual datasets considered in this assessment. For this reason, there is increased uncertainty in the long-term wind regime at each site, which has been considered in the uncertainty analysis.
3. DNV GL evaluated the measured wind shear at the masts. DNV GL applied the measured wind shear at each mast to the upper-level wind speeds on a timeseries basis to estimate hub height wind speeds. Thermal heating and cooling at the surface results in relatively high magnitudes of measured wind shear at some of the met masts. There is uncertainty that the wind shear measured at the met masts will remain constant with increasing altitude, and this uncertainty is higher when the estimated wind shear exponents are higher. DNV GL would recommend the use of remote sensing for site prospecting in Zambia, in order to more accurately characterize the vertical wind speed profile. Remote sensing measurements will further the understanding of the vertical wind speed profile and has the potential to drastically reduce the vertical extrapolation uncertainty, especially at sites where the extrapolation distance is large.
4. The table below summarizes the measured mast height wind speeds, long-term mast height wind speeds, and long-term hub height wind speeds at each of the eight met mast locations.

Mast	Measured mean wind speed at mast height [m/s]	Long-term mean wind speed at mast height [m/s]	Long-term hub height mean wind speed [m/s]
Choma	6.4	6.3	7.1
Mwinilunga	6.0	5.9	7.2
Lusaka	6.3	6.3	7.8
Mpika	6.1	6.1	7.0
Chanka	6.5	6.4	7.2
Petauke	5.6	5.6	6.5
Mansa	5.8	5.8	6.8
Malawi	5.9	5.8	6.9

5. The average horizontal extrapolation distances across the eight sites ranges from 3.6 km at Mpika to 24.1 km at Chanka. It should be noted that WAsP calculations have high uncertainties when calculations: extend over large spatial distances; are initiated from positions with markedly different elevations, wind climates or exposure to those of the proposed turbine locations. The WAsP wind flow model is also not suited to stable atmospheric conditions. For further wind assessments studies

in Zambia, DNV GL would recommend the use of CFD wind flow modeling to decrease horizontal extrapolation uncertainties.

6. The power curve used in this analysis represents a generic turbine model that has been generated by DNV GL. Given the preliminary nature of the generic power curve used in this assessment, DNV GL recommends that potential stakeholders conduct a thorough market review of available technologies when assessing a potential wind farm site in Zambia.
7. There are a number of losses and uncertainties for which DNV GL's standard assumptions have been made at this stage, or for which an analysis was out of DNV GL's scope of work. It is recommended that The World Bank considers each of the loss categories carefully when using the results in this report for stakeholder engagement. They may vary materially from standard assumptions and can often be mitigated to some extent, especially in early years of the project, through appropriate contractual provisions.
8. DNV GL notes the following observations and opinions regarding uncertainty.
    a. Aside from inter-annual variability, the uncertainty in the analysis is driven by spatial extrapolation and the vertical extrapolation from mast height to hub height.
    b. DNV GL recommends that all proposed turbine locations be within 2 km of a measurement mast that is at least ¾ of the proposed hub height and that wind measurements are conducted to fully represent typical turbine exposures and reasonably characterize the expected range of the wind climate on site. The distance criterion is generally not met and some turbines are located as far as 24 km from the nearest mast. The height criterion has also not been met for a suggested hub height of 130 m. DNV GL recommends that future development in Zambia be conducted in accordance with the guidelines set forth above, so as to minimize the uncertainty in future energy production estimates.
    c. The wind speed predictions have been based on WAsP modeling, which provides elevated uncertainty in predicting the wind flow variation across the sites over large extrapolation distances or complex terrain.
9. The results of the energy production assessments are provided in the tables below.

Site	Choma	Mwinilunga	Lusaka	Mpika
Probability of exceedance	**10-year average [GWh/annum]**			
50%	303.7	318.2	394.7	319.7
75%	274.9	293.8	366.8	294.2
90%	248.8	271.1	341.1	270.8
95%	233.4	257.2	324.7	256.2
99%	204.6	230.8	292.7	229.6

Site	Chanka	Petauke	Mansa	Malawi
Probability of exceedance	**10-year average [GWh/annum]**			
50%	344.8	303.3	330.0	328.5
75%	315.6	274.3	303.3	300.2
90%	288.1	248.5	278.6	273.7
95%	271.3	232.3	263.4	257.6
99%	239.0	203.4	234.0	226.6

9 CONCLUSION

The overall Zambia ESMAP program consists of providing a preliminary mesoscale wind atlas for Zambia, including associated deliverables and wind energy development training courses. Inaddition, meteorological data is collected at eight sites over a 2-year period. This 24-month Site Resource Report provides wind resource statistics at the eight masts and energy production estimates for preliminary wind farms in the vicinity of the masts. The program's goal is to provide Zambian policy makers, stakeholders and independent power producers with accurate and valuable knowledge of the national wind resource, including complementary tools, which can be of direct practical use, both for formulating energy policy and implementing wind projects.

A key conclusion from this study is that there is now an established network of state-of-the-art wind measurement masts in Zambia that can be used to support stakeholder wind analysis activities and future utility-scale wind development in-country. In the future, this network of masts will also provide the industry with a source of long-term reference station data which could greatly reduce uncertainties for potential developers. The data collected from the eight met masts are considered very good both in terms of data quality and data coverage. The primary goal of the met masts was not to provide potential wind farm locations, but instead to eventually validate a country-wide wind map. However, and as a secondary goal, it is noted that from this analysis, several met mast locations are sited in areas where wind development could be considered viable and potentially bankable with current turbine technology. Further investment by stakeholders in well-organized measurement campaigns and in feasibility analysis that are focused on reducing uncertainties will help support future growth of the Zambian wind market.

10 REFERENCES

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APPENDIX A WIND DATA STATISTICS

Choma Monthly Statistics and Data Coverage

	Month					Mean wind speed [m/s]					Wind speed data coverage [%]					Wind direction data coverage [%]		
Height [m]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Nov-16	6.6	6.6	6.1	6.1	5.5	5.5	4.3	4.4	97	97	97	97	97	97	97	97	97	97
Dec-16	5.3	5.3	4.9	4.9	4.4	4.4	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Jan-17	5.0	5.0	4.6	4.6	4.1	4.2	3.3	3.3	100	100	100	100	100	100	100	100	100	100
Feb-17	5.1	5.1	4.6	4.7	4.1	4.2	3.2	3.2	100	100	100	100	100	100	100	100	100	100
Mar-17	5.6	5.7	5.2	5.3	4.7	4.8	3.7	3.8	100	100	100	100	100	100	100	100	100	100
Apr-17	6.8	6.9	6.3	6.4	5.6	5.7	4.3	4.3	100	100	100	100	100	100	100	100	100	100
May-17	6.5	6.5	6.1	6.2	5.5	5.5	4.0	4.1	100	100	100	100	100	100	100	100	100	100
Jun-17	6.9	6.9	6.4	6.5	5.8	5.8	4.2	4.3	100	100	100	100	100	100	100	100	100	100
Jul-17	6.5	6.5	6.1	6.1	5.5	5.5	4.1	4.2	100	100	100	100	100	100	100	100	100	100
Aug-17	6.6	6.5	6.1	6.1	5.5	5.5	4.2	4.3	90	100	90	100	90	100	100	100	91	91
Sep-17	7.9	7.7	7.3	7.2	6.5	6.4	4.8	4.9	61	100	61	100	61	100	100	100	61	61
Oct-17	7.0	7.0	6.5	6.5	5.8	5.8	4.5	4.5	100	100	100	100	100	100	100	100	100	100
Nov-17	6.0	6.0	5.5	5.5	4.9	5.0	3.8	3.9	100	100	100	100	100	100	100	100	100	100
Dec-17	5.5	5.5	5.1	5.1	4.6	4.6	3.5	3.6	100	100	100	100	100	100	100	100	100	100
Jan-18	5.6	5.6	5.2	5.3	4.7	4.7	3.6	3.6	100	100	100	100	100	100	100	100	100	100
Feb-18	5.5	5.5	5.0	5.1	4.5	4.6	3.6	3.6	100	100	100	100	100	100	100	100	100	100
Mar-18	5.5	5.5	5.1	5.2	4.6	4.6	3.5	3.5	100	100	100	100	100	100	100	100	100	100
Apr-18	5.9	5.9	5.5	5.5	4.9	5.0	3.8	3.8	100	100	100	100	100	100	100	100	100	100
May-18	6.5	6.5	6.1	6.1	5.5	5.5	4.0	4.0	100	100	100	100	100	100	100	100	100	100
Jun-18	6.2	6.2	5.8	5.9	5.3	5.3	4.0	4.0	100	100	100	100	100	100	100	100	100	100
Jul-18	7.4	7.4	6.9	6.9	6.2	6.2	4.7	4.8	100	100	100	100	100	100	100	100	100	100
Aug-18	7.7	7.7	7.1	7.1	6.3	6.3	4.7	4.7	100	100	100	100	100	100	100	100	100	100
Sep-18	7.5	7.5	6.9	6.9	6.1	6.2	4.7	4.7	100	100	100	100	100	100	100	100	100	100
Oct-18	7.2	7.2	6.7	6.7	6.1	6.1	4.7	4.8	100	100	100	100	100	100	100	100	100	100
Nov-18	6.5	6.5	6.0	6.0	5.4	5.4	4.2	4.3	100	100	100	100	100	100	100	100	100	100
Dec-18	5.8	5.9	5.3	5.3	4.8	4.8	3.7	3.8	100	67	100	100	100	100	100	100	100	100
Jan-19	5.2	5.2	4.7	4.8	4.3	4.3	3.3	3.3	100	78	100	100	100	100	100	100	100	100
Feb-19	5.6	5.6	5.3	5.3	4.8	4.8	3.8	3.8	28	28	28	28	28	28	28	28	28	28

Mwinilunga Monthly Statistics and Data Coverage

	Month					Mean wind speed [m/s]					Wind speed data coverage [%]					Wind direction data coverage [%]		
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Dec-16	4.1	4.1	3.7	3.8	3.2	3.3	2.4	2.4	92	92	92	92	92	92	92	92	92	92
Jan-17	4.8	4.8	4.3	4.3	3.6	3.7	2.6	2.7	100	100	100	100	100	100	100	100	100	100
Feb-17	4.5	4.6	4.0	4.1	3.4	3.5	2.6	2.6	100	100	100	100	100	100	100	100	100	100
Mar-17	5.0	5.1	4.5	4.5	3.8	3.9	2.7	2.8	100	100	100	100	100	100	100	100	100	100
Apr-17	6.4	6.5	5.7	5.8	4.8	4.9	3.3	3.4	100	100	100	100	100	100	100	100	100	100
May-17	7.3	7.3	6.4	6.5	5.3	5.4	3.4	3.6	100	100	100	100	100	100	100	100	100	100
Jun-17	7.7	7.7	6.7	6.8	5.6	5.6	3.6	3.7	100	100	100	100	100	100	100	100	100	100
Jul-17	7.7	7.8	6.8	6.9	5.6	5.7	3.7	3.8	100	100	100	100	100	100	100	100	100	100
Aug-17	7.5	7.5	6.6	6.7	5.5	5.6	3.7	3.8	100	100	100	100	100	100	100	100	100	100
Sep-17	7.0	7.1	6.3	6.3	5.3	5.3	3.5	3.6	100	100	100	100	100	100	100	100	100	100
Oct-17	5.5	5.5	4.9	5.0	4.2	4.3	3.0	3.1	100	100	100	100	100	100	100	100	100	100
Nov-17	4.9	4.9	4.4	4.4	3.7	3.8	2.7	2.8	100	100	100	100	100	100	100	100	100	100
Dec-17	4.1	4.1	3.7	3.8	3.2	3.2	2.4	2.4	100	100	100	100	100	100	100	100	100	100

Jan-18	4.2	4.3	3.8	3.9	3.3	3.4	2.5	2.6	100	100	100	100	100	96	100	100	100	100
Feb-18	4.5	4.5	4.0	4.1	3.5	3.5	2.5	2.6	100	100	100	100	100	96	100	79	100	100
Mar-18	4.5	5.2	4.1	4.1	3.5	3.8	2.6	2.6	100	45	100	100	100	71	100	83	100	100
Apr-18	5.7	_	5.1	5.2	4.3	4.4	2.9	3.0	100	0	100	100	100	92	100	99	100	100
May-18	7.0	7.2	6.2	6.2	5.1	5.1	3.3	3.3	99	50	99	99	99	99	99	99	99	99
Jun-18	7.6	7.6	6.7	6.7	5.4	5.5	3.5	3.6	100	100	100	100	100	100	100	100	100	100
Jul-18	7.8	7.8	6.9	6.9	5.7	5.8	3.8	4.0	100	100	100	100	100	100	100	100	100	100
Aug-18	6.9	6.9	6.2	6.2	5.1	5.2	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Sep-18	6.2	6.3	5.6	5.6	4.7	4.8	3.2	3.2	100	100	100	100	100	100	100	100	100	100
Oct-18	6.6	6.6	5.9	6.0	5.0	5.0	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Nov-18	5.1	5.2	4.6	4.7	3.9	4.0	2.8	2.8	100	100	100	100	100	100	100	100	100	100
Dec-18	4.2	4.3	3.9	3.9	3.3	3.4	2.5	2.5	100	100	100	100	100	100	100	87	100	100
Jan-19	4.4	4.5	4.0	4.1	3.4	3.5	2.5	2.5	100	100	100	100	100	100	100	98	100	100
Feb-19	4.0	4.0	3.7	3.7	3.1	3.2	2.3	2.3	28	28	28	28	28	28	28	28	28	28

Lusaka Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]					Wind direction data coverage [%]				
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Nov-16	4.7	4.8	4.3	4.4	3.7	3.8	2.9	2.9	31	31	31	31	31	31	31	31	31	31
Dec-16	4.5	4.6	4.1	4.1	3.5	3.6	2.6	2.6	100	100	100	100	100	100	100	100	100	100
Jan-17	4.4	4.5	4.0	4.0	3.4	3.5	2.5	2.5	100	100	100	100	100	100	100	100	100	100
Feb-17	4.3	4.4	3.9	4.0	3.4	3.4	2.4	2.4	100	100	100	100	100	100	100	100	100	100
Mar-17	5.6	5.7	5.0	5.0	4.2	4.3	3.0	3.0	100	100	100	100	100	100	100	100	100	100
Apr-17	6.8	6.9	6.0	6.0	5.0	5.1	3.5	3.6	100	100	100	100	100	100	100	100	100	100
May-17	6.9	6.9	6.1	6.1	5.0	5.1	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Jun-17	7.6	7.6	6.7	6.7	5.5	5.6	3.6	3.7	100	100	100	100	100	100	100	100	100	100
Jul-17	6.9	6.9	6.2	6.2	5.2	5.2	3.5	3.6	100	100	100	100	100	100	100	100	100	100
Aug-17	7.2	7.2	6.4	6.4	5.4	5.5	3.8	3.8	100	100	100	100	100	100	100	100	100	100
Sep-17	7.9	7.9	7.0	7.0	5.9	5.9	4.1	4.2	100	100	100	100	100	100	100	100	100	100
Oct-17	6.7	6.7	5.9	6.0	5.0	5.1	3.6	3.7	98	98	98	98	98	98	98	98	98	98
Nov-17	5.3	5.3	4.8	4.8	4.1	4.2	3.0	3.0	95	95	95	95	95	95	95	95	95	95
Dec-17	4.7	4.7	4.2	4.3	3.6	3.7	2.6	2.6	100	100	100	100	100	100	100	99	100	100
Jan-18	5.1	5.1	4.5	4.6	3.9	3.9	2.7	2.7	100	100	100	99	100	100	100	100	100	100
Feb-18	4.8	4.8	4.2	4.4	3.7	3.7	2.7	2.7	100	100	100	96	100	100	100	100	100	100
Mar-18	5.0	5.0	4.4	4.5	3.8	3.8	2.6	2.6	100	100	100	97	100	100	100	100	100	100
Apr-18	6.2	6.3	5.5	5.5	4.7	4.7	3.2	3.2	100	100	100	100	100	100	100	100	100	100
May-18	7.1	7.1	6.2	6.2	5.2	5.2	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Jun-18	6.9	6.9	6.2	6.2	5.2	5.2	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Jul-18	7.8	7.9	6.9	6.9	5.8	5.8	4.0	4.0	100	100	100	100	100	100	100	100	100	100
Aug-18	7.9	7.9	7.0	7.0	5.9	5.9	4.0	4.0	100	100	100	100	100	100	100	100	100	100
Sep-18	7.8	7.8	6.9	6.9	5.8	5.8	4.1	4.1	100	100	100	100	100	100	100	100	100	100
Oct-18	7.4	7.4	6.5	6.5	5.5	5.6	3.9	3.9	100	100	100	100	100	100	100	100	100	100
Nov-18	6.2	6.2	5.5	5.6	4.8	4.8	3.4	3.5	100	100	100	100	100	100	100	100	100	100
Dec-18	4.9	5.0	4.4	4.5	3.8	3.9	2.8	2.8	100	91	100	99	100	100	100	100	100	100
Jan-19	4.5	4.5	4.0	4.3	3.5	3.5	2.5	2.6	100	97	100	59	100	100	100	99	100	100
Feb-19	5.0	5.0	4.5	5.0	3.9	3.9	2.8	2.8	28	28	28	21	28	28	28	28	28	28

Mpika Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]					Wind direction data coverage [%]				
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Nov-16	5.6	5.6	5.2	5.1	4.6	4.6	3.7	3.6	35	35	35	35	35	35	35	35	35	35
Dec-16	4.3	4.2	4.0	3.9	3.5	3.5	2.8	2.7	100	100	100	100	100	100	100	100	100	100
Jan-17	3.9	3.9	3.7	3.6	3.3	3.2	2.6	2.5	100	100	100	100	100	100	100	100	100	100
Feb-17	4.2	4.1	3.9	3.8	3.5	3.4	2.7	2.6	100	100	100	100	100	100	100	100	100	100
Mar-17	5.5	5.5	5.1	5.0	4.5	4.4	3.6	3.4	100	100	100	100	100	100	100	100	100	100
Apr-17	6.9	6.9	6.5	6.4	5.7	5.6	4.5	4.4	100	100	100	100	100	100	100	100	100	100
May-17	7.0	7.0	6.5	6.5	5.8	5.7	4.5	4.4	100	100	100	100	100	100	100	100	100	100
Jun-17	7.2	7.2	6.7	6.7	5.9	5.9	4.5	4.4	100	100	100	100	100	100	100	100	100	100
Jul-17	7.3	7.3	6.8	6.7	6.0	6.0	4.6	4.4	100	100	100	100	100	100	100	100	100	100
Aug-17	7.5	7.5	7.0	6.9	6.2	6.1	4.7	4.6	100	100	100	100	100	100	100	100	100	100
Sep-17	7.9	7.9	7.3	7.3	6.5	6.5	5.1	5.0	100	100	100	100	100	100	100	100	100	100
Oct-17	6.7	6.7	6.3	6.2	5.6	5.5	4.4	4.3	100	100	100	100	100	100	100	100	100	100
Nov-17	5.4	5.4	5.0	5.0	4.4	4.4	3.5	3.4	100	100	100	100	100	100	100	100	100	100
Dec-17	4.3	4.3	4.1	4.0	3.6	3.6	2.9	2.8	100	100	100	100	100	100	100	100	100	100
Jan-18	4.4	4.4	4.2	4.1	3.7	3.6	2.9	2.8	100	100	100	100	100	100	100	100	100	100
Feb-18	4.4	4.4	4.1	4.0	3.6	3.6	2.8	2.7	98	100	100	100	100	100	100	100	100	100
Mar-18	4.7	4.0	4.2	4.2	3.8	3.7	3.0	2.9	92	47	100	100	98	100	100	100	100	100
Apr-18	6.3	6.4	5.9	5.8	5.2	5.1	4.0	3.8	100	88	100	100	100	100	100	100	100	100
May-18	7.0	7.0	6.6	6.5	5.8	5.8	4.4	4.3	100	100	100	100	100	100	100	100	100	100
Jun-18	7.2	7.0	6.6	6.5	5.8	5.7	4.4	4.2	94	100	100	100	100	100	100	100	100	100
Jul-18	7.7	7.8	7.3	7.2	6.4	6.3	4.9	4.8	100	100	100	100	100	100	100	100	100	100
Aug-18	7.0	7.0	6.5	6.5	5.8	5.8	4.5	4.4	96	100	100	100	100	100	100	100	100	100
Sep-18	7.3	7.3	6.9	6.8	6.1	6.0	4.8	4.7	100	100	100	100	100	100	100	100	100	100
Oct-18	7.2	7.1	6.6	6.6	5.9	5.8	4.6	4.5	96	100	100	100	100	100	100	100	100	100
Nov-18	6.2	5.9	5.5	5.4	4.8	4.8	3.8	3.7	83	100	100	100	100	100	100	100	100	100
Dec-18	4.4	4.3	4.0	3.9	3.6	3.5	2.8	2.7	95	100	100	100	100	100	100	100	100	100
Jan-19	4.0	3.9	3.7	3.6	3.3	3.2	2.6	2.5	98	100	100	100	100	100	100	100	100	100
Feb-19	3.9	3.9	3.8	3.6	3.3	3.2	2.5	2.5	28	28	26	28	28	28	28	28	28	28

Chanka Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]					Wind direction data coverage [%]				
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Nov-16	5.9	5.9	5.6	5.5	5.1	5.1	4.4	4.3	25	25	25	25	25	25	25	25	25	25
Dec-16	4.7	4.7	4.4	4.4	4.0	4.0	3.3	3.3	100	100	100	100	100	100	100	100	100	100
Jan-17	4.0	4.0	3.8	3.8	3.5	3.5	2.9	2.9	100	100	100	100	100	100	100	100	100	100
Feb-17	4.3	4.2	4.0	3.9	3.6	3.6	3.0	3.0	100	100	100	100	100	100	100	100	100	100
Mar-17	4.6	4.6	4.3	4.3	3.9	3.9	3.3	3.3	100	100	100	100	100	100	100	100	100	100
Apr-17	7.0	6.9	6.5	6.5	6.0	5.9	5.1	5.0	100	100	100	100	100	100	100	100	100	100
May-17	7.7	7.7	7.2	7.2	6.6	6.6	5.6	5.5	100	100	100	100	100	100	100	100	100	100
Jun-17	7.7	7.7	7.2	7.2	6.6	6.6	5.6	5.6	100	100	100	100	100	100	100	100	100	100
Jul-17	7.6	7.6	7.2	7.1	6.5	6.5	5.6	5.5	100	100	100	100	100	100	100	100	100	100
Aug-17	8.1	8.1	7.7	7.6	7.1	7.1	6.1	6.1	100	100	100	100	100	100	100	100	100	100
Sep-17	8.8	8.8	8.4	8.4	7.7	7.8	6.8	6.7	100	100	100	100	100	100	100	100	100	100
Oct-17	7.4	7.4	7.0	7.0	6.5	6.5	5.7	5.6	100	100	100	100	100	100	100	100	100	100
Nov-17	6.0	5.9	5.7	5.6	5.2	5.2	4.5	4.5	100	100	100	100	100	100	100	100	100	100

Dec-17	4.7	4.7	4.4	4.4	4.0	4.0	3.5	3.4	100	100	100	100	100	100	100	100	100	100
Jan-18	4.1	4.0	3.8	3.8	3.4	3.4	2.9	2.9	100	100	100	100	100	100	100	100	100	100
Feb-18	4.7	4.6	4.4	4.3	4.0	4.0	3.3	3.3	100	100	100	100	100	100	100	100	100	100
Mar-18	4.6	4.5	4.3	4.2	3.9	3.9	3.2	3.2	93	93	93	93	93	93	93	93	93	93
Apr-18	5.9	5.9	5.6	5.5	5.1	5.1	4.4	4.3	92	92	92	92	92	92	92	92	92	92
May-18	7.9	7.9	7.4	7.4	6.8	6.8	5.9	5.9	100	100	100	100	100	100	100	100	100	100
Jun-18	7.2	7.2	6.8	6.7	6.2	6.2	5.3	5.3	100	100	100	100	100	100	100	100	100	100
Jul-18	7.7	7.6	7.2	7.1	6.6	6.6	5.7	5.6	100	100	100	100	100	100	100	100	100	100
Aug-18	8.2	8.1	7.7	7.7	7.1	7.1	6.2	6.2	100	100	100	100	100	100	100	100	100	100
Sep-18	8.6	8.6	8.2	8.2	7.7	7.7	6.8	6.8	100	100	100	100	100	100	100	100	100	100
Oct-18	8.1	8.1	7.8	7.7	7.2	7.2	6.4	6.3	100	100	100	100	100	100	100	100	100	100
Nov-18	6.1	6.1	5.8	5.7	5.3	5.3	4.6	4.6	100	100	100	100	100	100	100	100	100	100
Dec-18	4.4	4.2	4.0	4.0	3.7	3.6	3.1	3.1	90	100	100	100	100	100	100	100	100	100
Jan-19	4.1	4.1	3.9	3.9	3.5	3.5	2.9	3.0	99	100	100	100	100	100	96	100	100	100
Feb-19	4.2	4.1	3.9	3.9	3.5	3.5	2.9	3.0	28	28	28	28	28	28	28	28	28	28

Petauke Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]								Wind direction data coverage [%]	
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Dec-16	4.2	4.2	3.9	3.9	3.5	3.5	2.8	2.9	73	73	73	73	73	73	73	73	73	73
Jan-17	4.0	4.0	3.6	3.7	3.2	3.3	2.5	2.6	100	100	100	100	100	100	100	100	100	100
Feb-17	3.8	3.9	3.5	3.6	3.1	3.2	2.5	2.5	100	100	100	100	100	100	100	100	100	100
Mar-17	5.5	5.4	5.0	5.0	4.5	4.5	3.6	3.7	100	100	100	100	100	100	100	100	100	100
Apr-17	5.8	5.8	5.4	5.4	4.8	4.8	3.9	3.9	100	100	100	100	100	100	100	100	100	100
May-17	5.6	5.6	5.1	5.1	4.6	4.6	3.7	3.8	100	100	100	100	100	100	100	100	100	100
Jun-17	6.2	6.2	5.7	5.7	5.1	5.1	4.1	4.2	100	100	100	100	100	100	100	100	100	100
Jul-17	6.4	6.4	5.9	5.9	5.3	5.3	4.3	4.3	100	100	100	100	100	100	100	100	100	100
Aug-17	6.7	6.7	6.2	6.2	5.6	5.5	4.6	4.6	100	100	100	100	100	100	100	100	100	100
Sep-17	7.1	7.1	6.5	6.5	5.8	5.8	4.8	4.8	100	100	100	100	100	100	100	100	100	100
Oct-17	6.8	6.8	6.3	6.3	5.6	5.6	4.6	4.6	100	100	100	100	100	100	100	100	100	100
Nov-17	5.3	5.3	5.0	5.0	4.5	4.5	3.7	3.7	100	100	100	100	100	100	100	100	100	100
Dec-17	4.7	4.7	4.3	4.4	3.9	3.9	3.1	3.2	100	99	100	100	100	100	100	100	100	100
Jan-18	4.9	4.9	4.5	4.6	4.1	4.1	3.3	3.3	100	100	100	100	100	100	100	100	100	100
Feb-18	4.5	4.4	4.1	4.2	3.7	3.7	2.9	2.9	100	62	100	100	100	100	100	100	100	100
Mar-18	4.2	4.2	3.8	3.9	3.4	3.5	2.7	2.8	100	99	100	100	100	100	100	100	100	100
Apr-18	5.6	5.5	5.1	5.1	4.5	4.5	3.6	3.7	100	100	100	100	100	100	100	100	100	100
May-18	5.2	5.2	4.7	4.8	4.2	4.3	3.4	3.4	100	100	100	100	100	100	100	100	100	100
Jun-18	6.2	6.2	5.7	5.7	5.1	5.0	4.0	4.1	100	100	100	100	100	100	100	100	100	100
Jul-18	7.2	7.2	6.7	6.7	6.1	6.1	5.1	5.1	100	100	100	100	100	100	100	100	100	100
Aug-18	6.2	6.2	5.6	5.7	4.9	5.0	3.9	3.9	100	100	100	100	100	100	100	100	100	100
Sep-18	6.9	6.9	6.3	6.3	5.6	5.6	4.4	4.5	100	100	100	100	100	100	100	100	100	100
Oct-18	6.9	6.9	6.5	6.5	5.9	5.9	4.9	4.9	100	100	100	100	100	100	100	100	100	100
Nov-18	6.0	6.0	5.6	5.7	5.1	5.1	4.3	4.3	100	100	100	100	100	100	100	100	100	100
Dec-18	4.5	4.7	4.2	4.2	3.7	3.7	3.0	3.0	100	86	100	100	100	100	100	100	100	100
Jan-19	4.1	4.3	3.8	3.9	3.4	3.4	2.7	2.7	100	90	100	100	100	99	100	100	100	100
Feb-19	4.1	4.2	3.8	3.8	3.4	3.4	2.7	2.7	28	25	28	28	28	28	28	28	28	28

Mansa Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]					Wind direction data coverage [%]				
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Nov-16	4.7	4.6	4.3	4.2	3.8	3.7	3.1	3.0	15	15	15	15	15	15	15	15	15	15
Dec-16	4.1	4.0	3.7	3.6	3.3	3.2	2.7	2.6	100	100	100	100	100	100	100	100	100	100
Jan-17	4.1	4.0	3.7	3.7	3.3	3.2	2.7	2.6	100	100	100	100	100	100	99	100	100	100
Feb-17	4.2	4.1	3.8	3.8	3.4	3.3	2.7	2.6	100	100	100	100	100	100	100	100	100	100
Mar-17	4.9	4.9	4.5	4.4	3.9	3.9	3.1	3.0	100	100	100	100	100	100	100	100	100	100
Apr-17	6.5	6.5	6.0	5.9	5.2	5.1	4.1	3.9	100	100	100	100	100	100	100	100	100	100
May-17	7.0	7.0	6.4	6.3	5.5	5.4	4.2	4.0	100	100	100	100	100	100	100	100	100	100
Jun-17	7.0	7.0	6.3	6.3	5.4	5.3	4.1	3.9	100	100	100	100	100	100	100	100	100	100
Jul-17	7.1	7.1	6.4	6.4	5.6	5.5	4.2	4.1	100	100	100	100	100	100	100	100	100	100
Aug-17	7.1	7.1	6.4	6.3	5.6	5.5	4.3	4.1	100	100	100	100	100	100	100	100	100	100
Sep-17	7.2	7.3	6.6	6.5	5.8	5.7	4.6	4.4	100	100	100	100	100	100	100	100	100	100
Oct-17	5.6	5.6	5.2	5.1	4.6	4.5	3.6	3.5	100	100	100	100	100	100	100	100	100	100
Nov-17	4.8	4.8	4.4	4.3	3.9	3.8	3.1	3.0	100	100	100	100	100	100	100	100	100	100
Dec-17	3.9	3.9	3.6	3.6	3.2	3.2	2.6	2.5	100	100	100	100	100	100	97	100	100	100
Jan-18	4.1	4.1	3.8	3.7	3.3	3.3	2.7	2.6	100	100	100	100	100	100	99	100	100	100
Feb-18	4.4	4.3	4.0	3.9	3.5	3.4	2.9	2.7	100	100	100	100	100	100	95	100	100	100
Mar-18	4.3	4.2	3.9	3.9	3.5	3.4	3.1	2.7	100	100	100	100	100	100	72	100	100	100
Apr-18	5.5	5.5	5.0	4.9	4.3	4.2	3.4	3.2	100	100	100	100	100	100	83	100	100	100
May-18	6.7	6.7	6.1	6.0	5.2	5.1	3.9	3.8	100	100	100	100	100	100	100	100	100	100
Jun-18	7.1	7.1	6.4	6.3	5.5	5.3	4.1	4.0	100	100	100	100	100	100	100	100	100	100
Jul-18	7.5	7.6	6.8	6.8	5.9	5.8	4.5	4.4	100	100	100	100	100	100	100	100	100	100
Aug-18	7.0	7.0	6.3	6.2	5.4	5.3	4.1	4.0	100	100	100	100	100	100	100	100	100	100
Sep-18	6.7	6.8	6.1	6.1	5.4	5.3	4.2	4.1	100	100	100	100	100	100	99	100	100	100
Oct-18	6.5	6.4	5.9	5.9	5.3	5.2	4.2	4.1	100	100	100	100	100	100	100	100	100	100
Nov-18	4.9	4.8	4.5	4.4	4.0	3.9	3.2	3.1	100	100	100	100	100	100	97	100	100	100
Dec-18	4.1	4.1	3.8	3.7	3.4	3.3	2.7	2.7	100	100	100	100	100	100	96	100	100	100
Jan-19	4.0	3.9	3.6	3.6	3.2	3.2	2.6	2.6	100	100	100	100	100	100	95	100	100	100
Feb-19	3.7	3.7	3.4	3.4	3.0	3.0	2.3	2.4	28	28	28	28	28	28	27	28	28	28

Malawi Monthly Statistics and Data Coverage

Month	Mean wind speed [m/s]								Wind speed data coverage [%]					Wind direction data coverage [%]				
Height [m]	80[1]	80[1]	60[2]	60[2]	41[3]	41[3]	20[4]	20[4]	80[1]	80[1]	60[2]	60[2]	42[3]	42[3]	20[4]	20[4]	77	58
Dec-16	5.2	5.2	4.8	4.7	4.2	4.1	3.3	3.3	34	34	34	34	34	34	34	34	34	34
Jan-17	4.0	3.9	3.6	3.5	3.2	3.1	2.6	2.5	100	100	100	100	100	100	100	100	100	100
Feb-17	3.8	3.8	3.5	3.4	3.0	3.0	2.5	2.4	100	100	100	100	100	100	100	100	100	100
Mar-17	4.8	4.8	4.4	4.3	3.9	3.8	3.2	3.1	100	100	100	100	100	100	100	100	100	100
Apr-17	5.8	5.8	5.2	5.2	4.6	4.5	3.6	3.6	100	100	100	100	100	100	100	100	100	100
May-17	6.1	6.1	5.5	5.4	4.7	4.6	3.7	3.6	100	100	100	100	100	100	100	100	100	100
Jun-17	6.2	6.2	5.6	5.5	4.7	4.7	3.7	3.6	100	100	100	100	100	100	100	100	100	100
Jul-17	6.2	6.2	5.7	5.6	4.8	4.8	3.7	3.6	100	100	100	100	100	100	100	100	100	100
Aug-17	6.9	6.9	6.2	6.1	5.3	5.3	4.2	4.1	100	100	100	100	100	100	100	100	100	100

Sep-17	7.4	7.4	6.7	6.7	5.7	5.7	4.6	4.5	100	100	100	100	100	100	100	100	100	100
Oct-17	7.3	7.4	6.6	6.6	5.8	5.8	4.7	4.7	100	100	100	100	100	100	100	100	100	100
Nov-17	5.7	5.7	5.2	5.2	4.6	4.6	3.9	3.8	100	100	100	100	100	100	100	100	100	100
Dec-17	4.5	4.5	4.1	4.0	3.6	3.6	3.0	2.9	100	100	100	100	100	100	100	100	100	100
Jan-18	4.5	4.5	4.1	4.0	3.6	3.6	2.9	2.9	100	100	100	100	100	100	100	100	100	100
Feb-18	4.8	4.8	4.3	4.2	3.7	3.7	2.9	2.8	100	100	100	100	100	100	97	100	100	100
Mar-18	4.4	4.4	4.0	3.9	3.4	3.4	2.7	2.7	100	100	100	100	100	100	100	100	100	100
Apr-18	5.8	5.8	5.2	5.2	4.5	4.5	3.5	3.4	100	100	100	100	100	100	100	100	100	100
May-18	6.3	6.4	5.6	5.6	4.8	4.8	3.7	3.6	100	100	100	100	100	100	100	100	100	100
Jun-18	6.1	6.1	5.5	5.5	4.7	4.6	3.6	3.5	100	100	100	100	100	100	100	100	100	100
Jul-18	6.9	6.9	6.3	6.2	5.5	5.4	4.4	4.3	100	100	100	100	100	100	100	100	100	100
Aug-18	7.1	7.1	6.3	6.3	5.3	5.3	4.1	4.1	100	100	100	100	100	100	100	100	100	100
Sep-18	8.1	8.2	7.3	7.3	6.4	6.4	5.1	5.0	100	100	100	100	100	100	100	100	100	100
Oct-18	7.1	7.2	6.5	6.5	5.8	5.8	4.8	4.7	100	100	100	100	100	100	100	100	100	100
Nov-18	6.2	6.2	5.6	5.6	5.0	4.9	4.1	4.0	100	100	100	100	100	100	100	100	100	100
Dec-18	4.2	4.2	3.8	3.8	3.3	3.3	2.7	2.7	100	100	100	100	100	100	100	100	100	100
Jan-19	3.9	3.9	3.6	3.5	3.2	3.2	2.6	2.6	34	100	100	100	100	100	100	100	100	100
Feb-19	_	3.9	3.5	3.4	3.1	3.0	2.5	2.5	0	28	28	28	28	28	28	28	28	28

APPENDIX B REFERENCE STATIONS CONSIDERED

DNV GL Virtual Met Data (VMD)

The DNV GL Virtual Met Data (VMD) is developed from a mesoscale-model-based downscaling system that provides high-resolution long-term reference time series data for any location in the world. DNV GL VMD is primarily based on the Weather Research and Forecasting (WRF) Model, a mesoscale model developed and maintained by a consortium of more than 150 international agencies, laboratories, and universities. VMD is driven by a number of new high-resolution inputs, such as MERRA, global 25 km resolution 3-hourly and daily analyses of soil temperature and moisture, sea surface temperature, sea ice, and snow depth. A sophisticated land surface model predicts surface fluxes of heat and moisture to the atmosphere, reflected shortwave radiation, and longwave radiation emitted to the atmosphere. Data is typically produced as a virtual hourly time series on a 2 km horizontal resolution grid, centred on the subject wind farm site at the location of a met-mast on the site.

ERA-Interim Reanalysis data

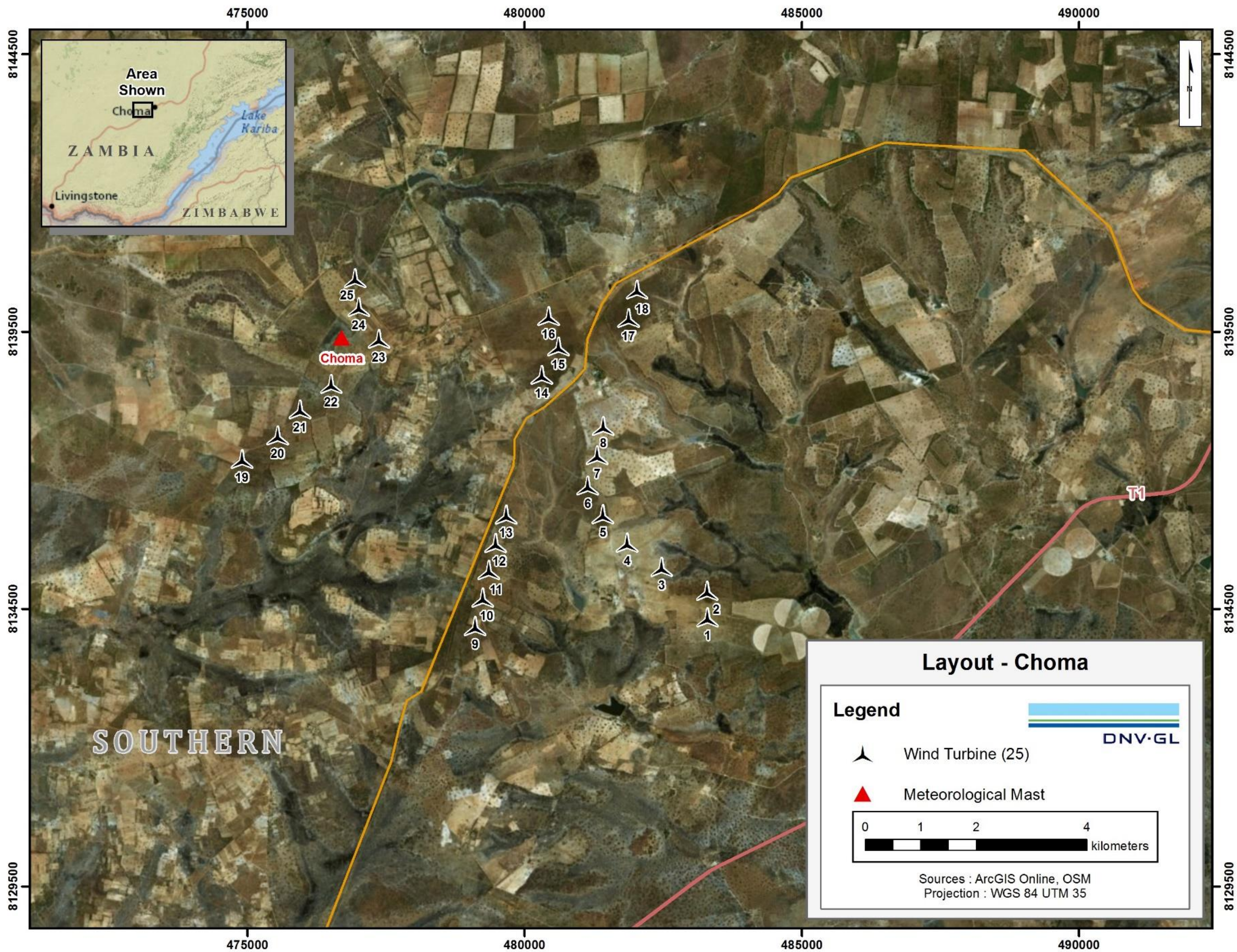
DNV GL has considered ERA-Interim data as part of this analysis. The ECMWF Interim Reanalysis (ERA-Interim) is a global atmospheric reanalysis product of the European Centre for Medium-Range Weather Forecasts (ECMWF). The ERA-Interim dataset uses weather measurements from a number of sources as inputs to a numerical atmospheric model in order to produce a description of the state of the atmosphere, including wind speed. The analysis is performed at a spatial resolution of 0.75° longitude by 0.75° latitude with a 6 hourly temporal resolution. DNV GL has some concerns over the long-term consistency of reanalysis data, and hence in order to mitigate against potential inclusion of inconsistent data in the long-term analysis, DNV GL has considered the same long-term reference period for the ERA-Interim dataset as for the MERRA datasets, i.e. from January 2002 to the present. DNV GL procured 6-hourly time series of two-dimensional diagnostic data, at a surface height of 10 m for the nearest grid points near the project site.

MERRA-2 Reanalysis data

The Modern Era Retrospective-analysis for Research and Applications, Version 2 (MERRA-2) data set has been produced by the National Aeronautics and Space Administration (NASA) by assimilating satellite observations with conventional land-based meteorology measurement sources using the Goddard Earth Observing System Data Assimilation System Version 5.12.4 (GEOS-5.12.4) atmospheric data assimilation system. The analysis is performed at a spatial resolution of 0.625° longitude by 0.5° latitude. MERRA-2 replaces the MERRA dataset previously produced by NASA. DNV GL typically procures hourly time series of two-dimensional diagnostic data, at a surface height of 50 m for suitable grid cells near the project site.

DNV GL has some concerns over the long-term consistency of reanalysis data and has conducted investigations into the consistency of the MERRA-2 dataset close to the site. On the basis of these investigations the long-term reference period considered for the MERRA-2 dataset is from January 2002 to the present.

APPENDIX C WIND FARM SITE INFORMATION AND LAYOUTS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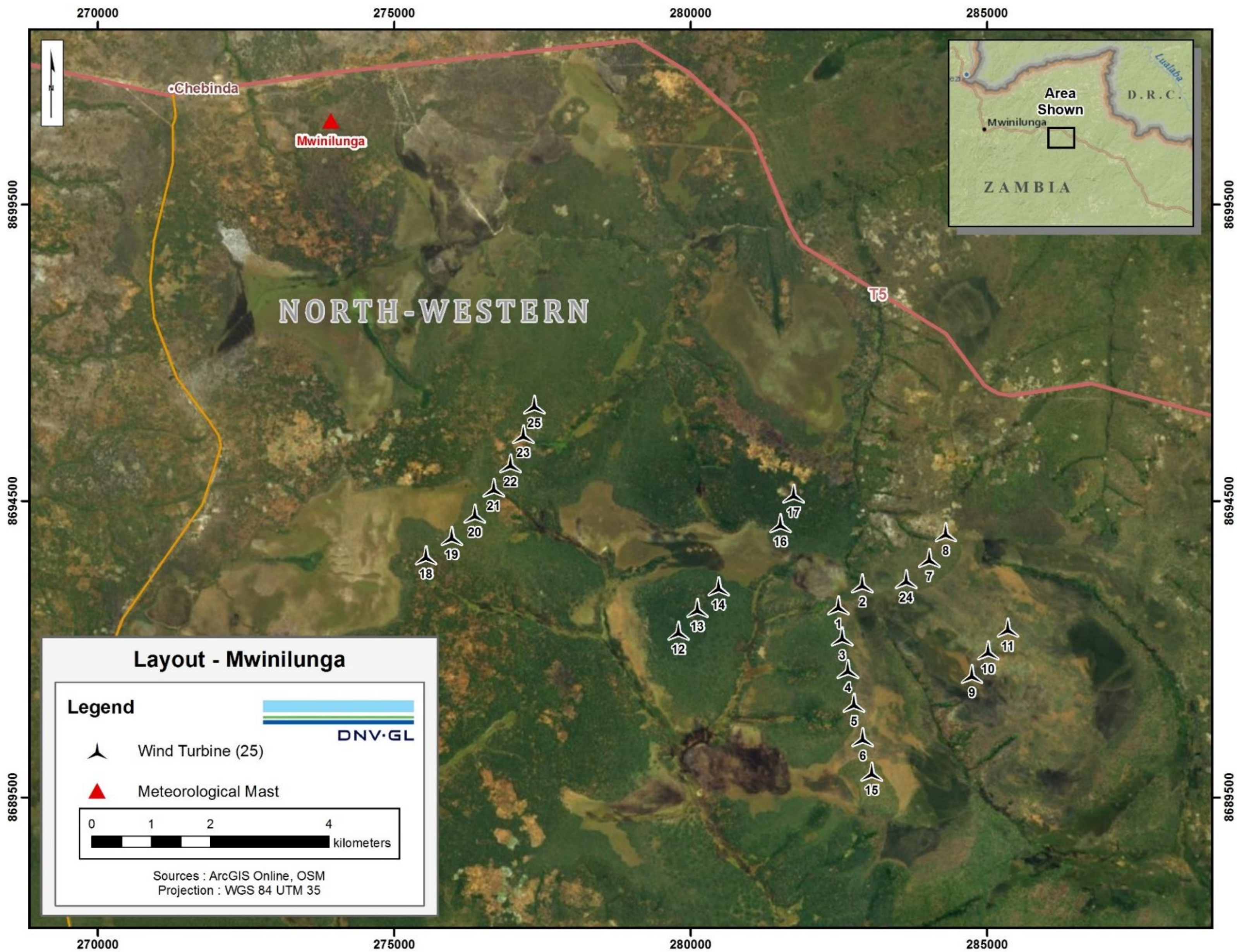
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kilometers
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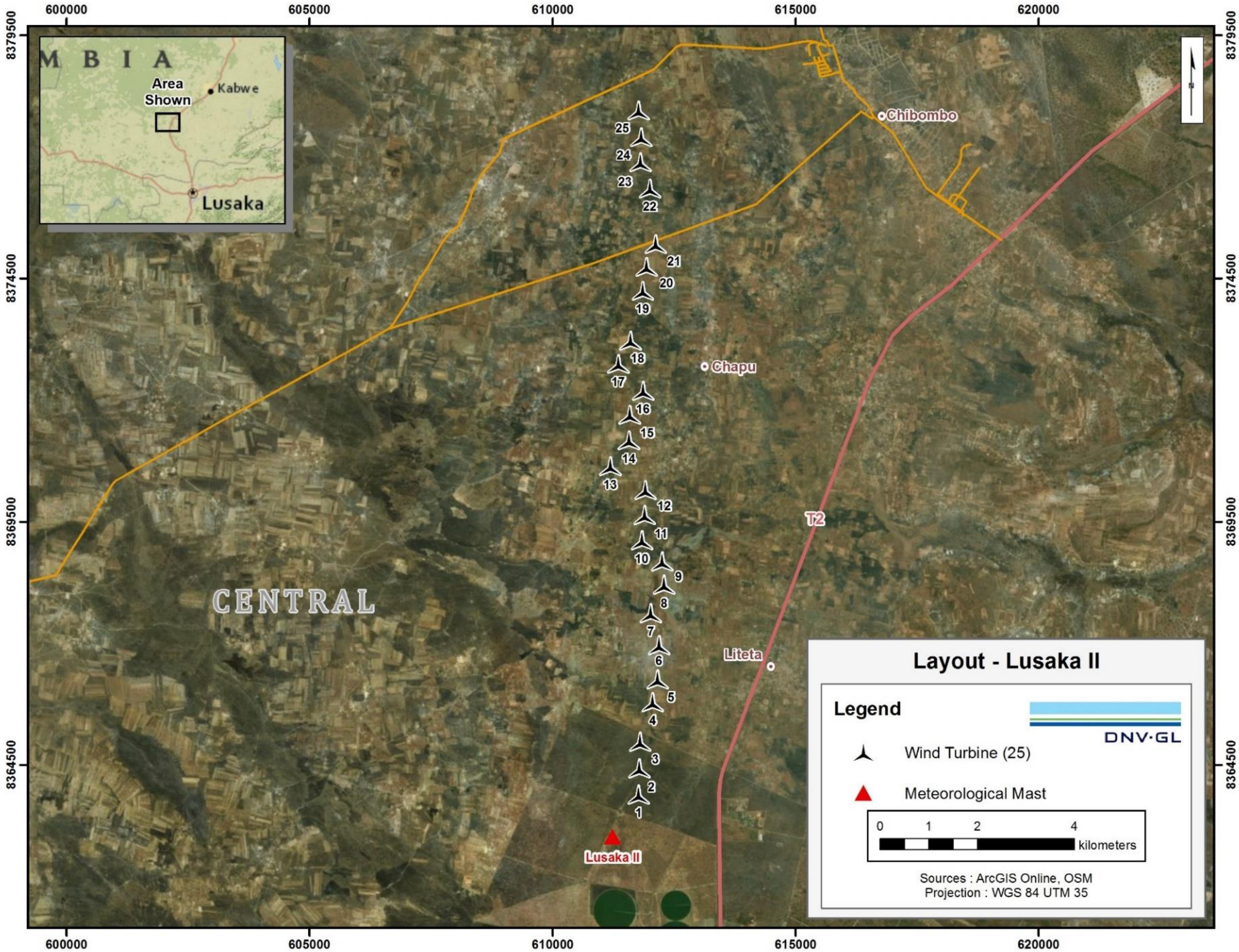
Projection : WGS 84 UTM 35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Chapu
Liteta
T2
CENTRAL
Lusaka II
25
24
23
22
21
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Layout - Lusaka II
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Wind Turbine (25)
Meteorological Mast
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kilometers
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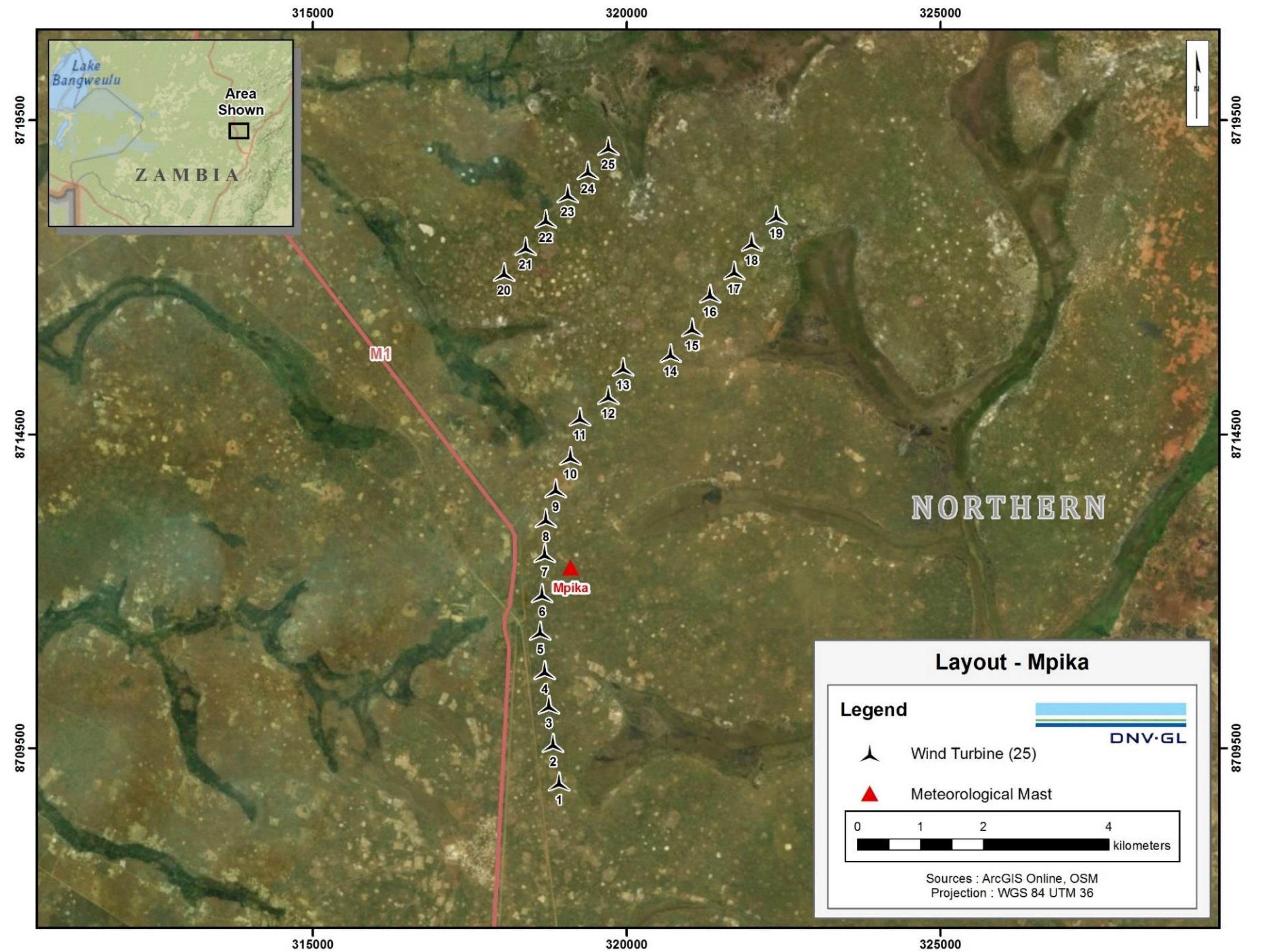
Projection : WGS 84 UTM 35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Lake Bangweulu
Area Shown
ZAMBIA
M1
NORTHERN
Mpika
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Layout - Mpika
Legend
DNV·GL
Wind Turbine (25)
Meteorological Mast
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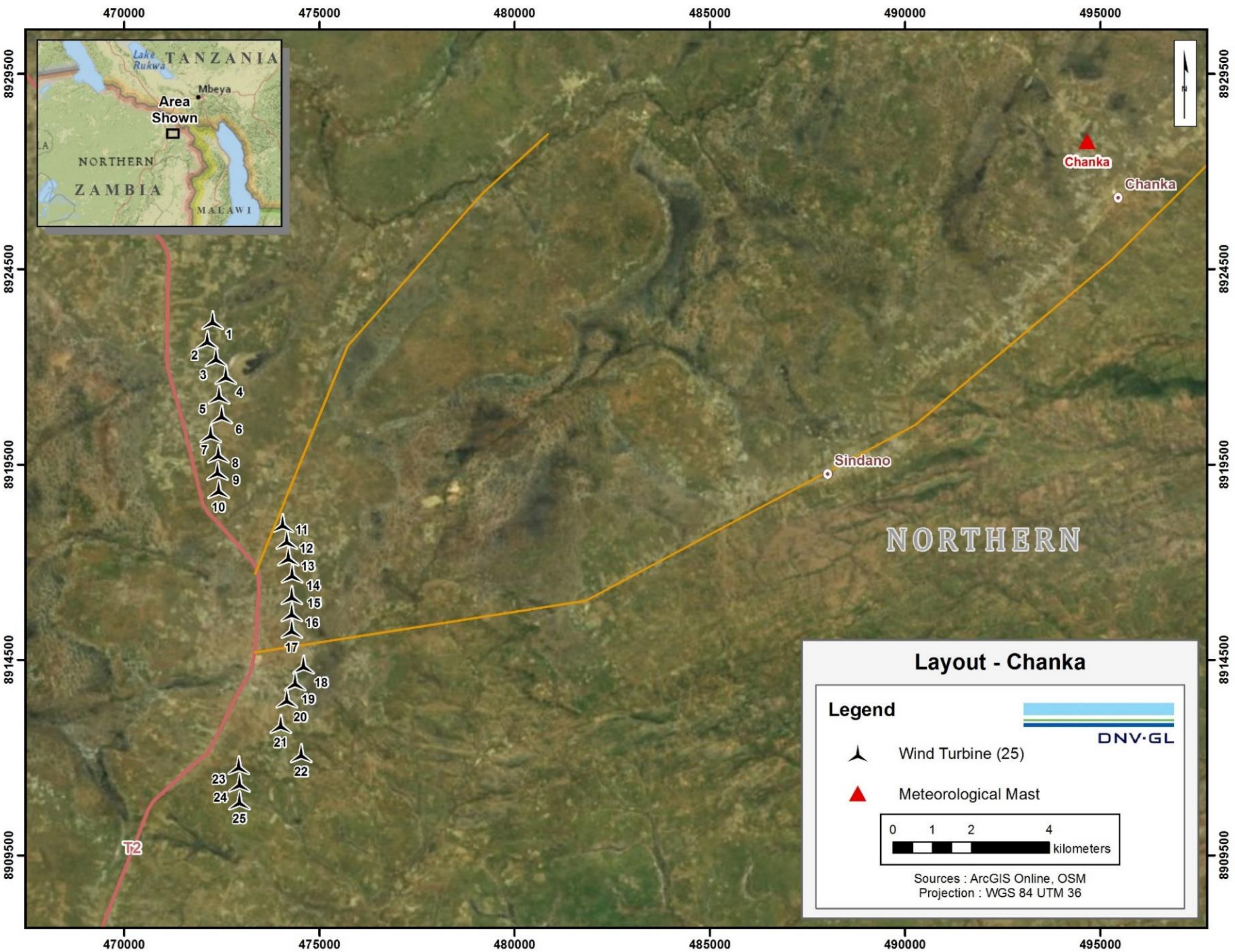
4
kilometers
Sources : ArcGIS Online, OSM
Projection : WGS 84 UTM 36



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Lake Rukwa
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Area Shown
NORTHERN
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Chanka
Chanka
Sindano
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Layout - Chanka
Legend
DNV·GL
Wind Turbine (25)
Meteorological Mast
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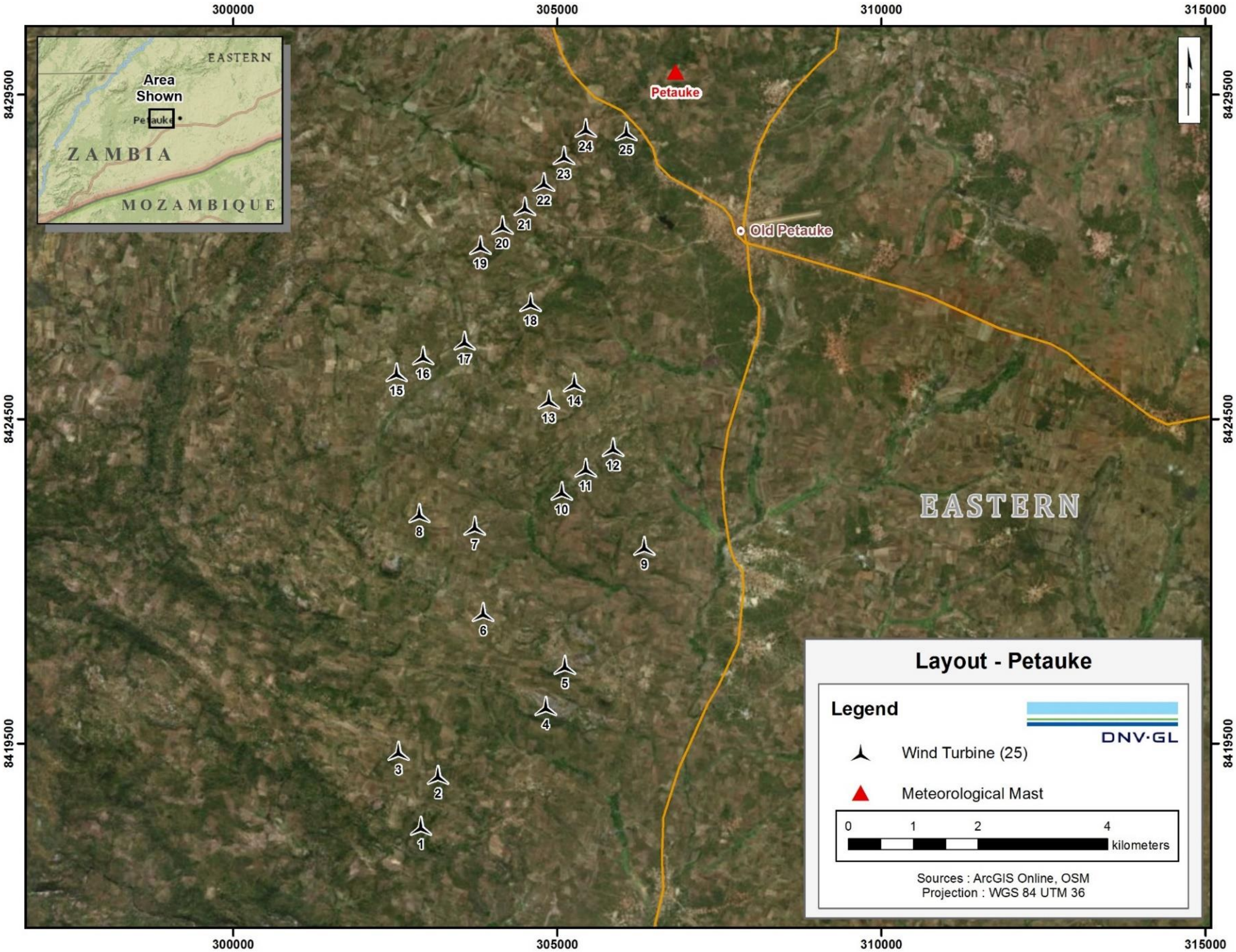
kilometers
Sources : ArcGIS Online, OSM
Projection : WGS 84 UTM 36



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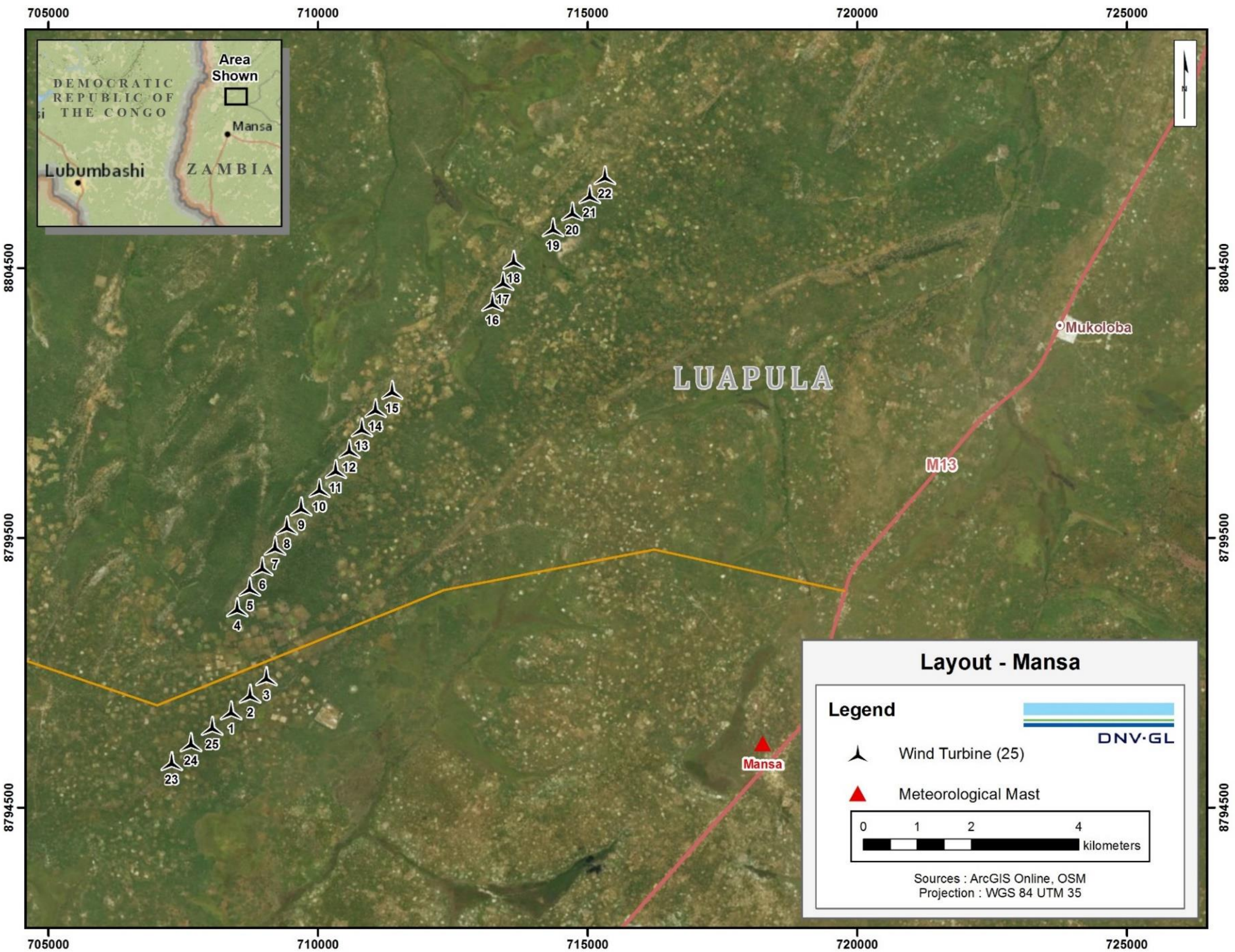
Area Shown
Petauke
ZAMBIA
MOZAMBIQUE
Petauke
Old Petauke
EASTERN
Layout - Petauke
Legend
DNV·GL
Wind Turbine (25)
Meteorological Mast
0 1 2 4
kilometers
Sources : ArcGIS Online, OSM
Projection : WGS 84 UTM 36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8794500
DEMOCRATIC REPUBLIC OF THE CONGO
Area Shown
Mansa
Lubumbashi
ZAMBIA
LUAPULA
Mukoloba
M13
Mansa
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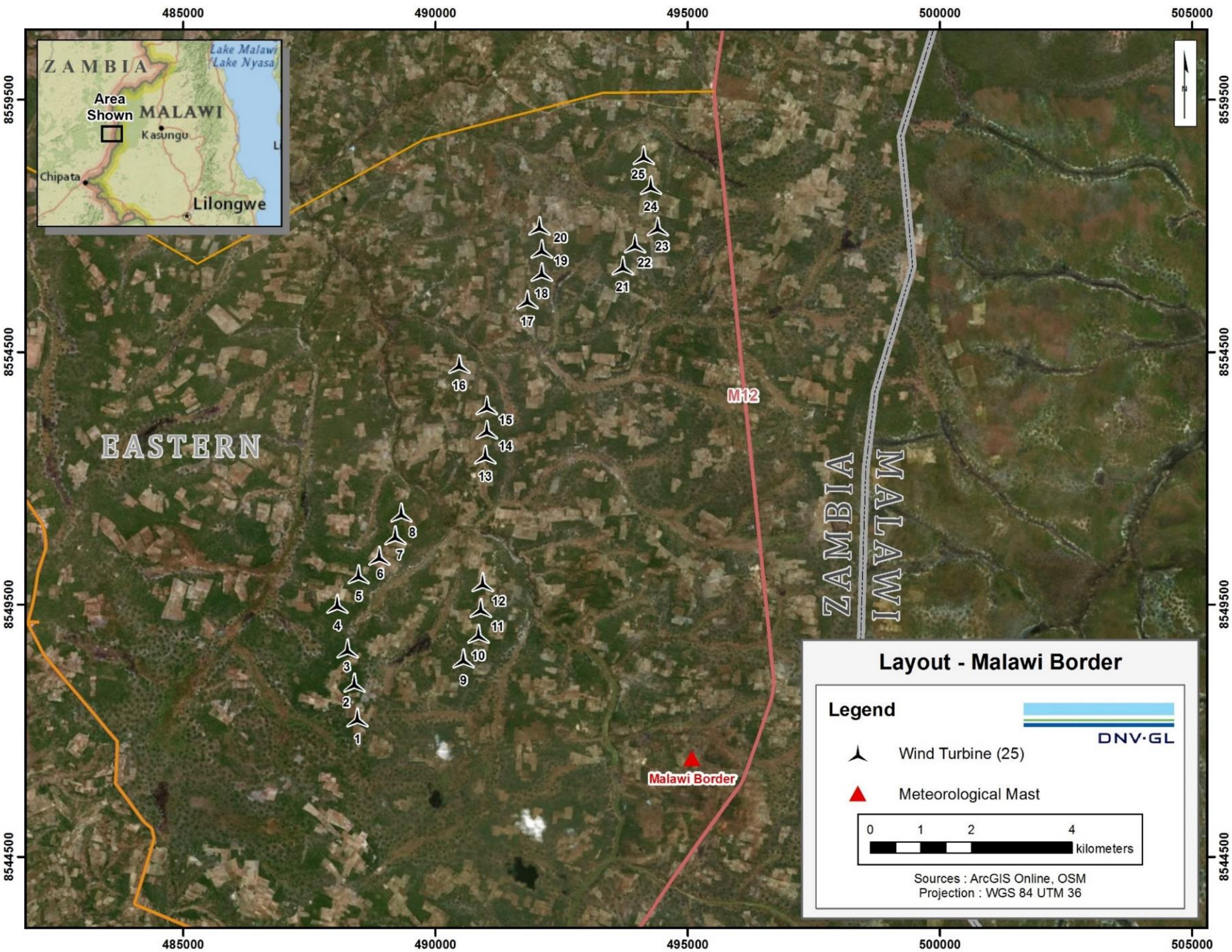
Layout - Mansa
Legend
DNV·GL
Wind Turbine (25)
Meteorological Mast
0 1 2 4
kilometers
Sources : ArcGIS Online, OSM
Projection : WGS 84 UTM 35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ZAMBIA
MALAWI
Lake Malawi
Lake Nyasa
Area Shown
Kasungu
Chipata
Lilongwe
EASTERN
M12
ZAMBIA
MALAWI
Malawi Border
Layout - Malawi Border
Legend
DNV·GL
Wind Turbine (25)
Meteorological Mast
0 1 2 4
kilometers
Sources : ArcGIS Online, OSM
Projection : WGS 84 UTM 36

APPENDIX D TURBINE LAYOUT RESULTS

Choma turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Cho_01	130	483,294	8,134,287	1,348	7.2	12.7	97.2
Cho_02	130	483,290	8,134,764	1,346	7.1	12.6	98.7
Cho_03	130	482,472	8,135,199	1,350	7.1	12.0	93.9
Cho_04	130	481,847	8,135,635	1,355	7.2	12.1	93.1
Cho_05	130	481,410	8,136,148	1,360	7.1	12.3	95.1
Cho_06	130	481,135	8,136,669	1,365	7.1	12.1	94.8
Cho_07	130	481,308	8,137,210	1,365	7.1	12.2	96.1
Cho_08	130	481,416	8,137,738	1,371	7.1	12.7	98.4
Cho_09	130	479,109	8,134,131	1,365	7.1	12.0	94.0
Cho_10	130	479,246	8,134,643	1,370	7.2	12.1	92.9
Cho_11	130	479,352	8,135,139	1,367	7.1	11.7	91.4
Cho_12	130	479,473	8,135,627	1,365	7.1	11.4	89.9
Cho_13	130	479,669	8,136,142	1,363	7.1	11.6	91.3
Cho_14	130	480,310	8,138,661	1,385	7.1	11.8	91.7
Cho_15	130	480,609	8,139,176	1,390	7.2	12.4	95.4
Cho_16	130	480,435	8,139,721	1,389	7.1	12.2	94.7
Cho_17	130	481,878	8,139,687	1,388	7.2	12.6	96.4
Cho_18	130	482,029	8,140,198	1,382	7.1	12.8	99.2
Cho_19	130	474,906	8,137,142	1,368	7.1	11.9	91.9
Cho_20	130	475,548	8,137,568	1,374	7.2	11.9	91.5
Cho_21	130	475,951	8,138,040	1,370	7.1	11.6	90.7
Cho_22	130	476,508	8,138,500	1,368	7.1	11.9	92.3
Cho_23	130	477,371	8,139,308	1,377	7.2	12.4	94.4
Cho_24	130	477,008	8,139,886	1,370	7.2	12.2	93.4
Cho_25	130	476,939	8,140,408	1,365	7.2	12.4	95.5
Average				**1,369**	**7.1**	**12.1**	**94.2**
Total						**303.7**	

a. Coordinate system is UTM Zone 35, datum WGS84.
b. Wind speed at the location of the turbine, not including wake effects.
c. Individual turbine output figures include all wind farm losses.
d. Individual turbine wake loss including all wake effects.

Mwinilunga turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Mwi_01	130	282,492	8,692,683	1,520	7.4	12.9	93.6
Mwi_02	130	282,892	8,693,051	1,525	7.4	12.6	91.9
Mwi_03	130	282,556	8,692,155	1,525	7.3	12.6	92.4
Mwi_04	130	282,652	8,691,610	1,526	7.3	12.6	93.3
Mwi_05	130	282,748	8,691,040	1,525	7.3	12.7	94.0
Mwi_06	130	282,897	8,690,458	1,524	7.2	12.6	94.3
Mwi_07	130	284,023	8,693,483	1,530	7.3	13.0	95.2
Mwi_08	130	284,298	8,693,918	1,535	7.3	13.4	97.6
Mwi_09	130	284,738	8,691,525	1,523	7.2	13.1	96.7
Mwi_10	130	285,014	8,691,921	1,530	7.3	13.1	96.6
Mwi_11	130	285,350	8,692,305	1,530	7.2	13.1	97.8
Mwi_12	130	279,793	8,692,256	1,515	7.1	12.3	94.6
Mwi_13	130	280,113	8,692,640	1,515	7.1	12.2	93.4
Mwi_14	130	280,470	8,693,003	1,512	7.1	12.3	93.6
Mwi_15	130	283,052	8,689,877	1,525	7.2	12.8	96.6
Mwi_16	130	281,511	8,694,070	1,526	7.2	12.5	93.1
Mwi_17	130	281,737	8,694,566	1,530	7.2	12.7	94.6
Mwi_18	130	275,536	8,693,525	1,545	7.1	12.8	97.0
Mwi_19	130	275,968	8,693,854	1,545	7.1	12.7	96.4
Mwi_20	130	276,360	8,694,230	1,545	7.1	12.6	96.2
Mwi_21	130	276,680	8,694,670	1,545	7.2	12.8	96.1
Mwi_22	130	276,960	8,695,078	1,545	7.2	12.7	95.9
Mwi_23	130	277,176	8,695,574	1,534	7.1	12.5	95.5
Mwi_24	130	283,635	8,693,124	1,528	7.3	12.8	94.1
Mwi_25	130	277,360	8,696,070	1,533	7.2	12.8	96.6
Average				**1,529**	**7.2**	**12.7**	**95.1**
Total						**318.2**	

e. Coordinate system is UTM Zone 35, datum WGS84.
f. Wind speed at the location of the turbine, not including wake effects.
g. Individual turbine output figures include all wind farm losses.
h. Individual turbine wake loss including all wake effects.

Lusaka turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Lus_01	130	611,766	8,363,817	1,183	7.9	15.6	98.4
Lus_02	130	611,782	8,364,359	1,180	7.9	15.6	98.1
Lus_03	130	611,796	8,364,904	1,180	7.8	15.4	98.5
Lus_04	130	612,055	8,365,719	1,180	8.0	15.7	98.2
Lus_05	130	612,154	8,366,186	1,180	8.0	15.9	98.3
Lus_06	130	612,189	8,366,888	1,179	8.0	15.9	98.2
Lus_07	130	612,019	8,367,551	1,177	8.0	15.9	98.1
Lus_08	130	612,293	8,368,131	1,177	8.0	15.8	97.8
Lus_09	130	612,252	8,368,612	1,176	8.1	15.9	97.8
Lus_10	130	611,840	8,369,047	1,174	8.0	15.5	96.0
Lus_11	130	611,895	8,369,562	1,173	8.1	15.9	97.7
Lus_12	130	611,909	8,370,082	1,170	8.1	16.0	98.3
Lus_13	130	611,187	8,370,572	1,164	8.0	15.6	95.6
Lus_14	130	611,574	8,371,105	1,165	8.0	15.9	98.0
Lus_15	130	611,590	8,371,630	1,165	8.0	15.9	97.9
Lus_16	130	611,858	8,372,123	1,165	8.0	15.8	98.1
Lus_17	130	611,351	8,372,678	1,162	8.0	15.7	97.2
Lus_18	130	611,599	8,373,159	1,163	8.0	15.8	98.5
Lus_19	130	611,855	8,374,183	1,163	8.0	15.8	98.3
Lus_20	130	611,933	8,374,672	1,162	8.0	15.8	98.2
Lus_21	130	612,121	8,375,140	1,163	8.0	16.0	98.7
Lus_22	130	612,004	8,376,287	1,161	8.0	15.7	98.3
Lus_23	130	611,802	8,376,825	1,160	8.0	15.7	98.0
Lus_24	130	611,822	8,377,341	1,160	8.0	15.9	98.2
Lus_25	130	611,763	8,377,887	1,157	8.0	15.9	98.9
Average				**1,169**	**8.0**	**15.8**	**98.0**
Total						**394.7**	

i. Coordinate system is UTM Zone 35, datum WGS84.
j. Wind speed at the location of the turbine, not including wake effects.
k. Individual turbine output figures include all wind farm losses.
l. Individual turbine wake loss including all wake effects.

Mpika turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Mpi_01	130	318,920	8,708,915	1,414	7.0	12.8	98.4
Mpi_02	130	318,825	8,709,528	1,415	7.1	13.2	97.8
Mpi_03	130	318,758	8,710,141	1,415	7.1	13.1	97.9
Mpi_04	130	318,691	8,710,687	1,415	7.1	13.3	97.8
Mpi_05	130	318,623	8,711,319	1,415	7.1	13.1	98.0
Mpi_06	130	318,652	8,711,913	1,415	7.0	13.0	98.3
Mpi_07	130	318,693	8,712,552	1,415	7.0	12.9	98.2
Mpi_08	130	318,714	8,713,112	1,415	7.0	12.8	98.1
Mpi_09	130	318,865	8,713,587	1,411	7.0	12.9	98.3
Mpi_10	130	319,102	8,714,104	1,409	7.1	13.0	98.2
Mpi_11	130	319,253	8,714,729	1,410	7.1	13.2	98.0
Mpi_12	130	319,706	8,715,073	1,410	7.1	13.0	97.7
Mpi_13	130	319,943	8,715,526	1,410	7.0	12.7	96.6
Mpi_14	130	320,697	8,715,741	1,405	7.0	12.9	97.9
Mpi_15	130	321,042	8,716,151	1,402	7.1	13.1	98.1
Mpi_16	130	321,322	8,716,690	1,400	7.1	13.3	98.1
Mpi_17	130	321,710	8,717,056	1,399	7.1	13.3	98.1
Mpi_18	130	321,990	8,717,508	1,397	7.1	13.2	98.2
Mpi_19	130	322,378	8,717,939	1,395	7.0	12.9	98.6
Mpi_20	130	318,046	8,717,034	1,398	7.0	11.7	91.0
Mpi_21	130	318,391	8,717,444	1,401	7.0	12.0	91.9
Mpi_22	130	318,714	8,717,875	1,399	7.0	12.0	92.0
Mpi_23	130	319,059	8,718,284	1,395	7.0	12.1	92.3
Mpi_24	130	319,382	8,718,650	1,389	7.0	12.1	92.5
Mpi_25	130	319,706	8,719,038	1,383	6.9	12.0	93.4
Average				**1,405**	**7.0**	**12.8**	**96.6**
Total						**319.7**	

m. Coordinate system is UTM Zone 36, datum WGS84.

n. Wind speed at the location of the turbine, not including wake effects.

o. Individual turbine output figures include all wind farm losses.

p. Individual turbine wake loss including all wake effects.

Chanka turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Cha_01	130	472,264	8,923,114	1,320	7.1	13.4	98.5
Cha_02	130	472,132	8,922,609	1,320	7.1	13.6	97.7
Cha_03	130	472,349	8,922,165	1,320	7.2	13.6	97.1
Cha_04	130	472,605	8,921,703	1,318	7.2	13.7	98.1
Cha_05	130	472,427	8,921,205	1,324	7.2	13.6	97.9
Cha_06	130	472,493	8,920,699	1,327	7.2	13.9	98.1
Cha_07	130	472,214	8,920,211	1,326	7.2	13.8	97.7
Cha_08	130	472,408	8,919,699	1,332	7.3	14.1	97.5
Cha_09	130	472,393	8,919,253	1,332	7.3	14.0	96.8
Cha_10	130	472,422	8,918,790	1,327	7.3	13.9	96.4
Cha_11	130	474,056	8,917,915	1,332	7.3	14.1	97.9
Cha_12	130	474,166	8,917,485	1,330	7.3	14.0	97.6
Cha_13	130	474,207	8,917,058	1,327	7.3	14.0	97.6
Cha_14	130	474,302	8,916,626	1,322	7.2	13.8	98.0
Cha_15	130	474,286	8,916,069	1,313	7.1	13.7	98.1
Cha_16	130	474,290	8,915,638	1,312	7.2	13.9	97.9
Cha_17	130	474,293	8,915,204	1,315	7.3	14.0	98.0
Cha_18	130	474,592	8,914,296	1,311	7.1	13.5	98.5
Cha_19	130	474,375	8,913,861	1,310	7.1	13.6	98.3
Cha_20	130	474,166	8,913,424	1,312	7.2	13.7	98.2
Cha_21	130	474,007	8,912,771	1,315	7.3	14.2	98.1
Cha_22	130	474,530	8,912,025	1,302	7.2	13.9	98.3
Cha_23	130	472,928	8,911,715	1,316	7.3	13.6	95.0
Cha_24	130	472,955	8,911,272	1,288	7.1	13.6	97.8
Cha_25	130	472,955	8,910,818	1,273	7.1	13.7	98.2
Average				**1,317**	**7.2**	**13.8**	**97.7**
Total						**344.8**	

q. Coordinate system is UTM Zone 36, datum WGS84.
r. Wind speed at the location of the turbine, not including wake effects.
s. Individual turbine output figures include all wind farm losses.
t. Individual turbine wake loss including all wake effects.

Petauke turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Pet_01	130	302,892	8,418,177	982	6.6	11.6	99.0
Pet_02	130	303,159	8,418,963	993	6.6	11.4	97.4
Pet_03	130	302,547	8,419,330	1,005	6.6	11.0	91.9
Pet_04	130	304,823	8,420,025	1,040	7.1	13.4	98.9
Pet_05	130	305,117	8,420,656	1,059	7.3	14.1	98.6
Pet_06	130	303,859	8,421,473	1,025	6.6	11.4	95.2
Pet_07	130	303,726	8,422,801	1,025	6.7	11.4	93.1
Pet_08	130	302,873	8,422,997	1,030	6.6	11.1	92.5
Pet_09	130	306,342	8,422,491	995	6.9	12.9	99.2
Pet_10	130	305,068	8,423,340	1,035	6.9	12.4	96.1
Pet_11	130	305,438	8,423,700	1,041	7.0	12.4	94.0
Pet_12	130	305,863	8,424,016	1,065	7.3	13.6	96.4
Pet_13	130	304,872	8,424,751	1,067	7.0	11.8	89.6
Pet_14	130	305,264	8,425,012	1,070	7.1	12.4	91.0
Pet_15	130	302,522	8,425,170	1,057	6.9	11.9	92.8
Pet_16	130	302,931	8,425,431	1,060	6.9	12.1	92.7
Pet_17	130	303,568	8,425,660	1,063	6.9	11.8	92.5
Pet_18	130	304,590	8,426,250	1,052	6.8	11.6	92.3
Pet_19	130	303,813	8,427,130	1,090	7.2	12.5	90.1
Pet_20	130	304,156	8,427,440	1,050	6.9	11.9	92.4
Pet_21	130	304,499	8,427,726	1,045	6.9	12.2	94.5
Pet_22	130	304,793	8,428,102	1,048	6.8	12.0	94.9
Pet_23	130	305,103	8,428,510	1,044	6.7	11.7	95.3
Pet_24	130	305,438	8,428,935	1,057	6.8	11.9	95.0
Pet_25	130	306,067	8,428,882	1,080	6.9	12.6	97.9
Average				**1,043**	**6.9**	**12.1**	**94.5**
Total						**303.3**	

u. Coordinate system is UTM Zone 36, datum WGS84.
v. Wind speed at the location of the turbine, not including wake effects.
w. Individual turbine output figures include all wind farm losses.
x. Individual turbine wake loss including all wake effects.

Mansa turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Man_01	130	708,393	8,796,244	1,374	7.2	13.0	97.2
Man_02	130	708,740	8,796,547	1,385	7.3	13.2	97.0
Man_03	130	709,041	8,796,870	1,381	7.2	13.1	97.5
Man_04	130	708,499	8,798,153	1,380	7.1	12.8	96.9
Man_05	130	708,731	8,798,527	1,386	7.2	13.1	97.5
Man_06	130	708,967	8,798,908	1,390	7.3	13.3	97.6
Man_07	130	709,206	8,799,290	1,390	7.3	13.3	97.6
Man_08	130	709,423	8,799,668	1,390	7.3	13.3	97.5
Man_09	130	709,688	8,800,021	1,389	7.4	13.6	97.5
Man_10	130	710,026	8,800,360	1,375	7.3	13.5	97.6
Man_11	130	710,329	8,800,711	1,360	7.3	13.5	97.7
Man_12	130	710,583	8,801,086	1,350	7.3	13.4	97.7
Man_13	130	710,812	8,801,485	1,335	7.2	13.2	97.7
Man_14	130	711,063	8,801,848	1,327	7.2	13.1	97.5
Man_15	130	711,377	8,802,184	1,316	7.2	13.2	98.2
Man_16	130	713,233	8,803,811	1,305	7.2	13.1	98.0
Man_17	130	713,432	8,804,196	1,300	7.2	13.3	97.5
Man_18	130	713,630	8,804,589	1,304	7.3	13.5	98.1
Man_19	130	714,359	8,805,195	1,303	7.2	13.2	97.6
Man_20	130	714,718	8,805,486	1,320	7.4	13.6	97.3
Man_21	130	715,040	8,805,804	1,320	7.3	13.5	97.4
Man_22	130	715,320	8,806,159	1,310	7.2	13.4	98.3
Man_23	130	707,288	8,795,300	1,343	7.0	12.6	98.0
Man_24	130	707,643	8,795,651	1,351	7.0	12.4	97.4
Man_25	130	708,036	8,795,954	1,361	7.1	12.7	97.3
Average				**1,350**	**7.2**	**13.2**	**97.6**
Total						**330.0**	

y. Coordinate system is UTM Zone 35, datum WGS84.
z. Wind speed at the location of the turbine, not including wake effects.
aa. Individual turbine output figures include all wind farm losses.
bb. Individual turbine wake loss including all wake effects.

Malawi turbine layout with predicted wind speed and energy production

Turbine	Hub height	Easting[1]	Northing[1]	Elevation	Long-term wind speed at hub height[2]	Energy output[3]	Wake Loss[4]
		[m]	[m]	[m]	[m/s]	[GWh/annum]	[%]
Mal_01	130	488,449	8,547,193	1,075	7.1	13.3	98.3
Mal_02	130	488,391	8,547,880	1,074	7.2	13.3	96.5
Mal_03	130	488,251	8,548,555	1,068	7.1	12.9	94.6
Mal_04	130	488,047	8,549,442	1,065	7.1	13.0	94.6
Mal_05	130	488,469	8,550,030	1,060	7.2	12.8	93.0
Mal_06	130	488,880	8,550,401	1,054	7.2	13.1	94.5
Mal_07	130	489,195	8,550,805	1,050	7.1	13.1	95.4
Mal_08	130	489,316	8,551,257	1,050	7.2	13.2	95.6
Mal_09	130	490,547	8,548,361	1,054	7.1	13.3	98.9
Mal_10	130	490,853	8,548,851	1,055	7.1	13.6	99.0
Mal_11	130	490,898	8,549,364	1,051	7.1	13.5	98.5
Mal_12	130	490,936	8,549,874	1,046	7.1	13.4	98.8
Mal_13	130	490,983	8,552,399	1,060	7.1	13.6	99.1
Mal_14	130	491,019	8,552,895	1,054	7.1	13.4	98.5
Mal_15	130	491,019	8,553,379	1,045	7.1	13.2	98.4
Mal_16	130	490,466	8,554,199	1,039	7.1	12.9	94.5
Mal_17	130	491,821	8,555,470	1,057	7.1	13.3	97.8
Mal_18	130	492,106	8,556,024	1,055	7.2	13.2	95.5
Mal_19	130	492,106	8,556,479	1,061	7.1	12.5	92.6
Mal_20	130	492,060	8,556,939	1,065	7.2	12.8	92.8
Mal_21	130	493,713	8,556,152	1,070	7.0	13.1	98.5
Mal_22	130	493,949	8,556,582	1,070	7.0	12.6	95.5
Mal_23	130	494,403	8,556,924	1,075	7.0	13.0	99.2
Mal_24	130	494,269	8,557,743	1,080	7.1	13.2	98.4
Mal_25	130	494,127	8,558,335	1,078	7.1	13.2	96.9
Average				**1,060**	**7.1**	**13.1**	**96.6**
Total						**328.5**	

cc. Coordinate system is UTM Zone 36, datum WGS84.

dd. Wind speed at the location of the turbine, not including wake effects.

ee. Individual turbine output figures include all wind farm losses.

ff. Individual turbine wake loss including all wake effects.

APPENDIX E MONTHLY AND DIURNAL PRODUCTION PROFILES

Choma monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.25	0.21	0.28	0.47	0.47	0.54	0.40	0.40	0.63	0.53	0.45	0.31
0100	0.25	0.21	0.31	0.46	0.45	0.54	0.38	0.42	0.64	0.59	0.48	0.35
0200	0.26	0.22	0.29	0.51	0.45	0.51	0.38	0.44	0.70	0.61	0.45	0.34
0300	0.27	0.21	0.30	0.52	0.49	0.49	0.43	0.48	0.71	0.67	0.47	0.36
0400	0.26	0.22	0.32	0.53	0.50	0.46	0.50	0.52	0.70	0.66	0.50	0.36
0500	0.26	0.23	0.35	0.54	0.52	0.51	0.52	0.53	0.72	0.67	0.49	0.35
0600	0.25	0.24	0.34	0.58	0.57	0.54	0.58	0.59	0.76	0.71	0.45	0.29
0700	0.23	0.18	0.30	0.49	0.54	0.53	0.57	0.61	0.61	0.57	0.40	0.22
0800	0.22	0.18	0.33	0.43	0.37	0.35	0.39	0.44	0.46	0.51	0.41	0.22
0900	0.25	0.20	0.35	0.42	0.36	0.37	0.34	0.37	0.45	0.50	0.36	0.21
1000	0.24	0.18	0.33	0.35	0.30	0.40	0.34	0.32	0.43	0.44	0.27	0.19
1100	0.22	0.14	0.29	0.26	0.23	0.33	0.31	0.26	0.38	0.34	0.20	0.20
1200	0.19	0.12	0.23	0.21	0.18	0.28	0.26	0.22	0.34	0.27	0.18	0.18
1300	0.17	0.13	0.21	0.17	0.15	0.24	0.22	0.18	0.31	0.20	0.18	0.16
1400	0.18	0.12	0.18	0.17	0.14	0.23	0.21	0.16	0.33	0.18	0.21	0.15
1500	0.19	0.10	0.19	0.20	0.17	0.23	0.22	0.16	0.33	0.18	0.22	0.16
1600	0.15	0.10	0.20	0.23	0.19	0.26	0.24	0.18	0.41	0.17	0.23	0.17
1700	0.10	0.10	0.22	0.25	0.27	0.29	0.28	0.24	0.47	0.25	0.22	0.14
1800	0.10	0.10	0.22	0.35	0.51	0.46	0.49	0.35	0.46	0.30	0.24	0.14
1900	0.13	0.13	0.29	0.48	0.58	0.52	0.55	0.49	0.56	0.43	0.28	0.19
2000	0.14	0.17	0.27	0.46	0.53	0.46	0.43	0.45	0.52	0.47	0.30	0.26
2100	0.20	0.20	0.24	0.52	0.51	0.47	0.39	0.39	0.49	0.44	0.33	0.26
2200	0.24	0.19	0.24	0.50	0.50	0.51	0.42	0.35	0.56	0.45	0.39	0.26
2300	0.26	0.19	0.27	0.51	0.50	0.52	0.43	0.31	0.61	0.48	0.42	0.28
All	**4.96**	**4.08**	**6.57**	**9.62**	**9.48**	**10.03**	**9.29**	**8.86**	**12.59**	**10.64**	**8.11**	**5.76**

a. Only wake and hysteresis losses have been included in the calculation

Mwinilunga monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.22	0.14	0.29	0.44	0.68	0.72	0.76	0.69	0.61	0.36	0.24	0.16
0100	0.22	0.15	0.29	0.44	0.69	0.72	0.78	0.71	0.64	0.39	0.26	0.17
0200	0.25	0.17	0.28	0.48	0.71	0.74	0.78	0.74	0.63	0.40	0.28	0.16
0300	0.24	0.20	0.30	0.50	0.69	0.75	0.79	0.74	0.63	0.42	0.30	0.14
0400	0.24	0.21	0.28	0.51	0.69	0.76	0.80	0.75	0.61	0.39	0.30	0.14
0500	0.26	0.23	0.31	0.52	0.70	0.78	0.79	0.74	0.64	0.43	0.30	0.15
0600	0.24	0.19	0.29	0.50	0.68	0.79	0.80	0.74	0.67	0.40	0.31	0.17
0700	0.23	0.19	0.27	0.45	0.66	0.76	0.80	0.72	0.64	0.35	0.25	0.14
0800	0.17	0.15	0.24	0.44	0.49	0.52	0.63	0.61	0.49	0.27	0.19	0.08
0900	0.17	0.16	0.24	0.47	0.50	0.49	0.59	0.58	0.50	0.27	0.19	0.08
1000	0.17	0.17	0.22	0.40	0.43	0.46	0.51	0.47	0.41	0.25	0.16	0.09
1100	0.17	0.17	0.20	0.30	0.33	0.31	0.33	0.33	0.27	0.21	0.18	0.10
1200	0.19	0.18	0.15	0.20	0.26	0.22	0.19	0.23	0.17	0.19	0.17	0.12
1300	0.22	0.16	0.12	0.17	0.21	0.17	0.13	0.17	0.13	0.16	0.13	0.13
1400	0.24	0.20	0.14	0.15	0.19	0.14	0.11	0.15	0.15	0.13	0.11	0.16
1500	0.22	0.16	0.17	0.16	0.19	0.13	0.11	0.15	0.15	0.13	0.14	0.16
1600	0.19	0.12	0.16	0.20	0.21	0.16	0.16	0.19	0.17	0.13	0.11	0.11
1700	0.13	0.12	0.19	0.20	0.23	0.22	0.22	0.25	0.20	0.16	0.12	0.14
1800	0.14	0.11	0.19	0.24	0.36	0.46	0.46	0.41	0.31	0.22	0.11	0.10
1900	0.15	0.09	0.25	0.34	0.53	0.64	0.65	0.63	0.50	0.26	0.17	0.13
2000	0.16	0.13	0.28	0.43	0.64	0.71	0.74	0.66	0.58	0.29	0.18	0.12
2100	0.21	0.12	0.29	0.43	0.68	0.73	0.74	0.68	0.58	0.34	0.20	0.11
2200	0.22	0.15	0.30	0.46	0.64	0.73	0.75	0.68	0.58	0.33	0.25	0.13
2300	0.23	0.14	0.30	0.44	0.65	0.71	0.76	0.68	0.59	0.38	0.21	0.13
All	**4.90**	**3.84**	**5.74**	**8.89**	**12.04**	**12.80**	**13.37**	**12.71**	**10.87**	**6.87**	**4.87**	**3.12**

b. Only wake and hysteresis losses have been included in the calculation

Lusaka monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.19	0.15	0.30	0.44	0.58	0.60	0.50	0.56	0.62	0.49	0.25	0.24
0100	0.19	0.17	0.29	0.46	0.57	0.59	0.50	0.54	0.62	0.52	0.27	0.22
0200	0.18	0.17	0.29	0.47	0.54	0.59	0.51	0.56	0.63	0.54	0.26	0.23
0300	0.17	0.14	0.29	0.48	0.53	0.59	0.50	0.57	0.63	0.54	0.28	0.22
0400	0.19	0.12	0.30	0.51	0.56	0.59	0.51	0.56	0.63	0.55	0.27	0.22
0500	0.21	0.18	0.30	0.52	0.55	0.59	0.52	0.57	0.64	0.55	0.26	0.22
0600	0.22	0.16	0.31	0.48	0.56	0.59	0.54	0.58	0.63	0.54	0.27	0.19
0700	0.20	0.13	0.27	0.42	0.51	0.60	0.54	0.56	0.59	0.46	0.25	0.14
0800	0.19	0.12	0.33	0.45	0.42	0.41	0.39	0.44	0.53	0.48	0.29	0.15
0900	0.20	0.14	0.39	0.55	0.48	0.51	0.47	0.52	0.58	0.48	0.29	0.16
1000	0.18	0.14	0.37	0.53	0.43	0.51	0.48	0.48	0.54	0.43	0.25	0.13
1100	0.17	0.12	0.34	0.45	0.35	0.43	0.39	0.42	0.47	0.33	0.19	0.11
1200	0.16	0.10	0.30	0.36	0.30	0.35	0.31	0.37	0.40	0.24	0.16	0.12
1300	0.12	0.10	0.25	0.27	0.25	0.29	0.25	0.30	0.36	0.22	0.13	0.12
1400	0.12	0.09	0.22	0.25	0.22	0.23	0.21	0.28	0.33	0.20	0.14	0.12
1500	0.13	0.08	0.20	0.20	0.20	0.21	0.20	0.25	0.31	0.21	0.14	0.10
1600	0.13	0.07	0.17	0.20	0.21	0.20	0.22	0.26	0.32	0.19	0.14	0.12
1700	0.08	0.07	0.19	0.22	0.23	0.25	0.26	0.28	0.34	0.21	0.18	0.12
1800	0.08	0.06	0.23	0.35	0.42	0.49	0.46	0.33	0.41	0.26	0.17	0.14
1900	0.11	0.14	0.34	0.46	0.53	0.60	0.57	0.50	0.51	0.36	0.22	0.20
2000	0.13	0.18	0.37	0.51	0.56	0.61	0.58	0.57	0.58	0.44	0.23	0.21
2100	0.15	0.16	0.37	0.51	0.57	0.62	0.58	0.60	0.60	0.46	0.23	0.22
2200	0.18	0.15	0.36	0.47	0.58	0.62	0.56	0.61	0.61	0.45	0.24	0.24
2300	0.18	0.18	0.36	0.45	0.58	0.61	0.54	0.57	0.62	0.48	0.25	0.23
All	**3.84**	**3.14**	**7.12**	**10.01**	**10.71**	**11.69**	**10.56**	**11.27**	**12.47**	**9.62**	**5.38**	**4.18**

c. Only wake and hysteresis losses have been included in the calculation

Mpika monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.14	0.15	0.35	0.52	0.60	0.69	0.64	0.66	0.56	0.50	0.29	0.17
0100	0.13	0.10	0.33	0.55	0.57	0.71	0.65	0.63	0.59	0.51	0.29	0.15
0200	0.15	0.09	0.34	0.54	0.55	0.67	0.64	0.66	0.61	0.44	0.26	0.13
0300	0.13	0.11	0.34	0.53	0.54	0.64	0.63	0.66	0.61	0.45	0.27	0.12
0400	0.12	0.12	0.34	0.53	0.56	0.62	0.63	0.66	0.61	0.43	0.28	0.13
0500	0.12	0.11	0.34	0.47	0.55	0.60	0.62	0.65	0.61	0.41	0.26	0.12
0600	0.11	0.11	0.32	0.45	0.55	0.57	0.61	0.66	0.59	0.38	0.26	0.11
0700	0.07	0.08	0.26	0.46	0.43	0.45	0.52	0.57	0.54	0.30	0.25	0.08
0800	0.08	0.07	0.27	0.47	0.47	0.41	0.46	0.56	0.63	0.37	0.29	0.10
0900	0.08	0.06	0.26	0.43	0.52	0.47	0.53	0.57	0.64	0.37	0.25	0.11
1000	0.11	0.06	0.25	0.35	0.46	0.41	0.45	0.47	0.55	0.32	0.22	0.11
1100	0.10	0.09	0.18	0.28	0.38	0.30	0.35	0.36	0.45	0.29	0.17	0.10
1200	0.12	0.09	0.16	0.27	0.32	0.24	0.29	0.31	0.38	0.28	0.15	0.11
1300	0.13	0.09	0.16	0.27	0.29	0.22	0.26	0.30	0.35	0.29	0.18	0.13
1400	0.14	0.11	0.18	0.26	0.29	0.22	0.26	0.30	0.37	0.33	0.17	0.13
1500	0.10	0.12	0.22	0.28	0.31	0.26	0.27	0.30	0.41	0.35	0.16	0.14
1600	0.11	0.14	0.25	0.31	0.32	0.34	0.33	0.36	0.48	0.36	0.24	0.14
1700	0.16	0.11	0.24	0.34	0.35	0.40	0.38	0.40	0.50	0.39	0.27	0.17
1800	0.15	0.12	0.27	0.40	0.39	0.46	0.45	0.49	0.46	0.45	0.31	0.21
1900	0.15	0.16	0.30	0.41	0.36	0.41	0.46	0.45	0.48	0.47	0.26	0.20
2000	0.17	0.16	0.31	0.41	0.36	0.35	0.48	0.44	0.57	0.49	0.28	0.18
2100	0.18	0.15	0.30	0.48	0.41	0.34	0.51	0.47	0.69	0.58	0.34	0.17
2200	0.15	0.15	0.33	0.54	0.47	0.45	0.56	0.56	0.66	0.59	0.36	0.17
2300	0.14	0.14	0.33	0.57	0.56	0.60	0.59	0.66	0.61	0.52	0.31	0.18
All	**3.02**	**2.69**	**6.63**	**10.12**	**10.62**	**10.84**	**11.60**	**12.16**	**12.95**	**9.86**	**6.12**	**3.40**

d. Only wake and hysteresis losses have been included in the calculation

Chanka monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.12	0.15	0.12	0.35	0.43	0.49	0.44	0.49	0.57	0.47	0.26	0.20
0100	0.11	0.13	0.13	0.34	0.48	0.48	0.45	0.54	0.60	0.44	0.25	0.16
0200	0.11	0.12	0.12	0.35	0.54	0.53	0.51	0.60	0.63	0.43	0.26	0.15
0300	0.13	0.10	0.11	0.36	0.54	0.57	0.57	0.62	0.67	0.43	0.25	0.16
0400	0.14	0.11	0.12	0.35	0.55	0.57	0.60	0.60	0.66	0.41	0.24	0.14
0500	0.13	0.13	0.12	0.35	0.55	0.54	0.60	0.59	0.66	0.36	0.21	0.15
0600	0.10	0.08	0.11	0.33	0.50	0.52	0.58	0.56	0.61	0.31	0.15	0.14
0700	0.07	0.05	0.09	0.30	0.44	0.42	0.51	0.51	0.58	0.32	0.16	0.12
0800	0.08	0.06	0.11	0.35	0.51	0.43	0.49	0.58	0.67	0.33	0.18	0.13
0900	0.09	0.05	0.11	0.37	0.53	0.48	0.51	0.65	0.70	0.36	0.22	0.13
1000	0.11	0.05	0.13	0.38	0.53	0.55	0.52	0.64	0.69	0.40	0.25	0.12
1100	0.11	0.05	0.12	0.37	0.52	0.53	0.49	0.58	0.61	0.42	0.25	0.11
1200	0.16	0.06	0.13	0.40	0.51	0.44	0.43	0.50	0.53	0.38	0.25	0.10
1300	0.13	0.07	0.12	0.38	0.48	0.37	0.38	0.43	0.45	0.35	0.27	0.16
1400	0.16	0.12	0.12	0.38	0.47	0.35	0.35	0.42	0.44	0.34	0.31	0.17
1500	0.13	0.10	0.15	0.39	0.47	0.35	0.36	0.43	0.48	0.42	0.32	0.22
1600	0.14	0.10	0.19	0.41	0.47	0.39	0.42	0.51	0.59	0.54	0.37	0.24
1700	0.09	0.08	0.15	0.40	0.47	0.41	0.47	0.53	0.64	0.63	0.43	0.17
1800	0.11	0.11	0.17	0.40	0.49	0.48	0.45	0.49	0.58	0.58	0.42	0.15
1900	0.10	0.18	0.15	0.41	0.43	0.49	0.42	0.48	0.55	0.53	0.37	0.15
2000	0.09	0.17	0.16	0.41	0.41	0.48	0.46	0.54	0.55	0.54	0.39	0.18
2100	0.13	0.15	0.17	0.43	0.44	0.43	0.45	0.56	0.59	0.54	0.35	0.21
2200	0.12	0.14	0.17	0.38	0.46	0.45	0.41	0.54	0.57	0.56	0.31	0.20
2300	0.11	0.15	0.16	0.37	0.43	0.46	0.42	0.50	0.57	0.50	0.28	0.19
All	**2.79**	**2.52**	**3.21**	**8.95**	**11.66**	**11.23**	**11.29**	**12.91**	**14.20**	**10.59**	**6.76**	**3.86**

e. Only wake and hysteresis losses have been included in the calculation

Petauke monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.17	0.13	0.39	0.47	0.41	0.56	0.61	0.69	0.57	0.63	0.29	0.22
0100	0.20	0.11	0.37	0.47	0.39	0.51	0.63	0.58	0.57	0.55	0.26	0.21
0200	0.17	0.12	0.35	0.44	0.42	0.49	0.57	0.60	0.57	0.53	0.27	0.20
0300	0.18	0.13	0.36	0.40	0.43	0.48	0.49	0.57	0.59	0.54	0.34	0.17
0400	0.19	0.15	0.33	0.40	0.40	0.49	0.47	0.51	0.60	0.51	0.34	0.20
0500	0.18	0.11	0.32	0.40	0.42	0.50	0.51	0.51	0.62	0.52	0.37	0.19
0600	0.15	0.09	0.31	0.40	0.38	0.49	0.49	0.52	0.61	0.53	0.39	0.17
0700	0.07	0.06	0.26	0.32	0.30	0.41	0.46	0.46	0.47	0.50	0.35	0.16
0800	0.07	0.08	0.34	0.37	0.33	0.31	0.40	0.51	0.49	0.64	0.30	0.19
0900	0.08	0.08	0.37	0.35	0.31	0.33	0.48	0.51	0.57	0.60	0.25	0.17
1000	0.13	0.05	0.30	0.30	0.24	0.27	0.39	0.45	0.53	0.47	0.23	0.15
1100	0.14	0.06	0.25	0.22	0.18	0.22	0.25	0.36	0.44	0.38	0.22	0.14
1200	0.15	0.06	0.21	0.16	0.15	0.18	0.19	0.29	0.38	0.33	0.15	0.11
1300	0.12	0.06	0.20	0.16	0.13	0.15	0.19	0.26	0.37	0.29	0.14	0.12
1400	0.14	0.07	0.15	0.14	0.13	0.15	0.20	0.24	0.34	0.30	0.13	0.12
1500	0.14	0.08	0.19	0.17	0.13	0.19	0.20	0.23	0.36	0.29	0.15	0.12
1600	0.13	0.08	0.22	0.20	0.17	0.23	0.25	0.26	0.43	0.30	0.23	0.15
1700	0.13	0.09	0.25	0.24	0.25	0.33	0.33	0.34	0.47	0.37	0.29	0.17
1800	0.18	0.14	0.35	0.39	0.41	0.56	0.52	0.50	0.61	0.44	0.37	0.23
1900	0.23	0.17	0.42	0.52	0.48	0.64	0.69	0.67	0.73	0.61	0.46	0.27
2000	0.21	0.13	0.47	0.52	0.50	0.64	0.73	0.69	0.71	0.71	0.45	0.28
2100	0.19	0.13	0.50	0.51	0.48	0.69	0.71	0.74	0.67	0.69	0.39	0.25
2200	0.15	0.10	0.45	0.46	0.49	0.66	0.70	0.77	0.67	0.71	0.30	0.22
2300	0.15	0.11	0.40	0.48	0.45	0.63	0.67	0.76	0.62	0.71	0.29	0.24
All	**3.65**	**2.38**	**7.74**	**8.49**	**7.96**	**10.09**	**11.13**	**12.04**	**12.98**	**12.12**	**6.96**	**4.47**

f. Only wake and hysteresis losses have been included in the calculation

Mansa monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.17	0.14	0.32	0.55	0.66	0.68	0.71	0.64	0.67	0.34	0.25	0.15
0100	0.18	0.13	0.29	0.51	0.71	0.70	0.73	0.65	0.67	0.32	0.26	0.15
0200	0.18	0.14	0.28	0.50	0.67	0.69	0.71	0.67	0.59	0.33	0.21	0.15
0300	0.19	0.12	0.23	0.47	0.67	0.69	0.71	0.63	0.56	0.35	0.26	0.15
0400	0.18	0.16	0.21	0.46	0.63	0.67	0.69	0.64	0.56	0.35	0.23	0.14
0500	0.16	0.17	0.21	0.46	0.61	0.66	0.66	0.65	0.57	0.38	0.21	0.12
0600	0.14	0.14	0.20	0.43	0.61	0.64	0.69	0.63	0.57	0.34	0.23	0.12
0700	0.09	0.11	0.16	0.41	0.46	0.54	0.62	0.54	0.44	0.27	0.19	0.07
0800	0.08	0.06	0.21	0.50	0.50	0.46	0.45	0.47	0.52	0.33	0.22	0.07
0900	0.08	0.06	0.27	0.52	0.59	0.53	0.57	0.59	0.61	0.35	0.19	0.07
1000	0.09	0.05	0.26	0.49	0.52	0.45	0.57	0.58	0.57	0.30	0.18	0.06
1100	0.08	0.04	0.19	0.41	0.43	0.35	0.46	0.49	0.45	0.23	0.15	0.06
1200	0.06	0.06	0.17	0.34	0.35	0.27	0.36	0.40	0.37	0.19	0.11	0.07
1300	0.08	0.08	0.16	0.31	0.32	0.22	0.30	0.34	0.33	0.15	0.10	0.09
1400	0.09	0.08	0.15	0.27	0.30	0.23	0.28	0.31	0.33	0.15	0.10	0.12
1500	0.12	0.11	0.17	0.28	0.34	0.21	0.29	0.30	0.38	0.22	0.16	0.12
1600	0.12	0.13	0.16	0.26	0.38	0.24	0.31	0.34	0.42	0.29	0.13	0.12
1700	0.16	0.16	0.18	0.28	0.34	0.28	0.33	0.34	0.43	0.32	0.15	0.09
1800	0.14	0.15	0.22	0.36	0.48	0.52	0.49	0.50	0.51	0.34	0.14	0.09
1900	0.15	0.13	0.27	0.45	0.59	0.62	0.58	0.65	0.58	0.40	0.20	0.13
2000	0.15	0.10	0.31	0.49	0.59	0.66	0.59	0.64	0.56	0.41	0.22	0.12
2100	0.17	0.12	0.33	0.47	0.60	0.63	0.62	0.58	0.60	0.39	0.24	0.14
2200	0.18	0.14	0.34	0.49	0.66	0.64	0.63	0.61	0.64	0.38	0.25	0.15
2300	0.18	0.14	0.35	0.55	0.65	0.64	0.66	0.64	0.69	0.37	0.24	0.15
All	**3.17**	**2.74**	**5.64**	**10.27**	**12.64**	**12.22**	**13.01**	**12.82**	**12.63**	**7.51**	**4.64**	**2.70**

g. Only wake and hysteresis losses have been included in the calculation

Malawi monthly and diurnal production matrix

Hour	Energy Production [a] [%]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	0.18	0.07	0.27	0.35	0.42	0.60	0.56	0.62	0.62	0.65	0.30	0.22
0100	0.16	0.10	0.28	0.34	0.44	0.61	0.62	0.64	0.64	0.63	0.29	0.24
0200	0.12	0.10	0.28	0.42	0.49	0.58	0.64	0.68	0.64	0.60	0.28	0.20
0300	0.11	0.09	0.22	0.37	0.53	0.59	0.65	0.66	0.60	0.59	0.30	0.20
0400	0.16	0.08	0.27	0.38	0.47	0.58	0.57	0.63	0.59	0.58	0.30	0.22
0500	0.11	0.09	0.26	0.36	0.43	0.59	0.58	0.63	0.58	0.55	0.29	0.21
0600	0.09	0.10	0.24	0.34	0.45	0.57	0.50	0.62	0.59	0.48	0.29	0.17
0700	0.07	0.07	0.22	0.26	0.28	0.36	0.32	0.46	0.41	0.47	0.34	0.14
0800	0.10	0.08	0.25	0.35	0.36	0.27	0.24	0.49	0.47	0.63	0.40	0.20
0900	0.11	0.08	0.23	0.40	0.42	0.33	0.34	0.59	0.61	0.59	0.38	0.22
1000	0.11	0.08	0.18	0.33	0.39	0.32	0.34	0.48	0.56	0.53	0.32	0.17
1100	0.11	0.06	0.13	0.26	0.30	0.21	0.24	0.40	0.49	0.48	0.28	0.18
1200	0.14	0.06	0.12	0.20	0.23	0.15	0.19	0.32	0.44	0.46	0.26	0.15
1300	0.16	0.07	0.12	0.22	0.20	0.13	0.17	0.28	0.42	0.44	0.24	0.18
1400	0.16	0.10	0.10	0.19	0.18	0.13	0.16	0.27	0.43	0.46	0.29	0.16
1500	0.18	0.15	0.12	0.22	0.20	0.13	0.17	0.31	0.47	0.50	0.35	0.21
1600	0.13	0.07	0.11	0.25	0.23	0.15	0.18	0.28	0.50	0.60	0.43	0.26
1700	0.13	0.11	0.15	0.24	0.26	0.20	0.21	0.30	0.52	0.67	0.46	0.18
1800	0.15	0.12	0.19	0.34	0.47	0.44	0.47	0.54	0.62	0.62	0.41	0.18
1900	0.17	0.18	0.27	0.40	0.55	0.64	0.69	0.70	0.75	0.69	0.37	0.23
2000	0.21	0.17	0.30	0.32	0.52	0.51	0.62	0.69	0.73	0.66	0.34	0.28
2100	0.21	0.18	0.29	0.34	0.47	0.47	0.55	0.62	0.64	0.67	0.31	0.30
2200	0.21	0.15	0.27	0.39	0.40	0.54	0.52	0.53	0.56	0.68	0.33	0.24
2300	0.23	0.11	0.28	0.35	0.39	0.58	0.53	0.54	0.60	0.68	0.25	0.22
All	**3.50**	**2.48**	**5.18**	**7.62**	**9.08**	**9.68**	**10.04**	**12.27**	**13.46**	**13.91**	**7.83**	**4.96**

h. Only wake and hysteresis losses have been included in the calculation

APPENDIX F UNCERTAINTY ANALYSIS

Uncertainty in the projected energy output for the Choma site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	10.2		3.4%	
Long-term measurement height wind regime	30.5		10.0%	
Vertical extrapolation	21.0		6.9%	
Spatial extrapolation	11.9		3.9%	
Loss factors	5.3		1.7%	
Inter-annual variability	36.5		12.0%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**56.0**	**42.9**	**18.4%**	**14.1%**

Uncertainty in the projected energy output for the Mwinilunga site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	8.8		2.8%	
Long-term measurement height wind regime	18.6		5.8%	
Vertical extrapolation	23.3		7.3%	
Spatial extrapolation	13.0		4.1%	
Loss factors	5.1		1.6%	
Inter-annual variability	31.7		10.0%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**49.0**	**36.8**	**15.4%**	**11.6%**

Uncertainty in the projected energy output for the Lusaka site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	10.3		2.6%	
Long-term measurement height wind regime	21.9		5.5%	
Vertical extrapolation	27.2		6.9%	
Spatial extrapolation	15.2		3.8%	
Loss factors	5.4		1.4%	
Inter-annual variability	37.2		9.4%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**56.9**	**41.9**	**14.4%**	**10.6%**

Uncertainty in the projected energy output for the Mpika site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	10.9		3.4%	
Long-term measurement height wind regime	22.6		7.1%	
Vertical extrapolation	22.4		7.0%	
Spatial extrapolation	12.6		4.0%	
Loss factors	4.6		1.4%	
Inter-annual variability	38.5		12.1%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**54.3**	**38.2**	**17.0%**	**11.9%**

Uncertainty in the projected energy output for the Chanka site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	11.2		3.2%	
Long-term measurement height wind regime	23.7		6.9%	
Vertical extrapolation	23.4		6.8%	
Spatial extrapolation	23.1		6.7%	
Loss factors	4.7		1.4%	
Inter-annual variability	40.5		11.8%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**60.5**	**44.3**	**17.6%**	**12.9%**

Uncertainty in the projected energy output for the Petauke site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	10.0		3.3%	
Long-term measurement height wind regime	21.0		6.9%	
Vertical extrapolation	26.4		8.7%	
Spatial extrapolation	20.5		6.8%	
Loss factors	5.2		1.7%	
Inter-annual variability	35.8		11.8%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**56.0**	**42.7**	**18.5%**	**14.1%**

Uncertainty in the projected energy output for the Mansa site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	9.5		2.9%	
Long-term measurement height wind regime	20.1		6.1%	
Vertical extrapolation	25.3		7.7%	
Spatial extrapolation	16.9		5.1%	
Loss factors	4.5		1.4%	
Inter-annual variability	34.2		10.4%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**53.1**	**40.1**	**16.1%**	**12.1%**

Uncertainty in the projected energy output for the Malawi site

Source of uncertainty/variability	[GWh/annum]		Equivalent standard deviation [%]	
Measurement accuracy	10.2		3.1%	
Long-term measurement height wind regime	21.5		6.5%	
Vertical extrapolation	26.9		8.2%	
Spatial extrapolation	18.0		5.5%	
Loss factors	4.8		1.5%	
Inter-annual variability	36.9		11.2%	
Future period under consideration	*1 year*	*10 year*	*1 year*	*10 year*
Overall energy uncertainty	**56.3**	**42.8**	**17.1%**	**13.0%**

APPENDIX G SITE CONDITIONS

Table G-1 Predicted profiles of design equivalent turbulence intensity at the Choma site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Cho _01	Cho _02	Cho _03	Cho _04	Cho _05	Cho _06	Cho _07	Cho _08	Cho _09	Cho _10	Cho _11	Cho _12	Cho _13	Cho _14	Cho _15	Cho _16	Cho _17	*A*	*B*	*C*
3	36.4	35.6	35.7	35.8	36.2	36.7	36.5	35.4	36.5	36.7	36.9	36.7	35.5	36.3	35.8	35.6	36.3	*41.9*	*36.6*	*31.4*
4	30.9	29.5	29.7	30.0	30.3	31.1	30.9	29.2	30.9	31.2	31.4	31.1	29.2	30.7	29.9	29.6	30.8	*34.4*	*30.1*	*25.8*
5	26.9	24.9	25.4	25.8	26.0	26.8	26.6	24.5	26.7	27.1	27.2	26.8	24.5	26.4	25.5	25.2	26.6	*29.9*	*26.2*	*22.4*
6	24.0	21.6	22.3	22.9	22.9	23.9	23.6	21.1	23.7	24.2	24.3	23.9	21.0	23.5	22.3	22.0	23.8	*26.9*	*23.6*	*20.2*
7	21.7	19.0	19.8	20.8	20.5	21.5	21.3	18.4	21.4	21.9	22.1	21.6	18.2	21.2	19.8	19.4	21.5	*24.8*	*21.7*	*18.6*
8	**20.1**	**17.2**	**18.1**	**19.2**	**18.9**	**19.8**	**19.7**	**16.5**	**19.7**	**20.3**	**20.4**	**19.9**	**16.3**	**19.5**	**18.2**	**17.6**	**19.9**	*23.2*	*20.3*	*17.4*
9	**18.4**	**16.1**	**16.4**	**17.6**	**17.2**	**18.2**	**18.1**	**15.1**	**18.1**	**18.7**	**18.9**	**18.4**	**14.7**	**18.0**	**16.5**	**16.0**	**18.4**	*22.0*	*19.2*	*16.5*
10	**16.4**	**14.4**	**14.7**	**15.9**	**15.5**	**16.5**	**16.3**	**13.4**	**16.4**	**16.8**	**17.1**	**16.7**	**13.0**	**16.3**	**14.6**	**14.4**	**16.6**	*21.0*	*18.3*	*15.7*
11	**14.4**	**12.5**	**12.9**	**14.1**	**13.7**	**14.6**	**14.4**	**11.8**	**14.4**	**14.8**	**15.1**	**14.7**	**11.6**	**14.6**	**12.8**	**12.7**	**14.7**	*20.1*	*17.6*	*15.1*
12	**12.8**	**11.3**	**11.3**	**12.3**	**12.0**	**12.7**	**12.6**	**10.5**	**12.5**	**13.0**	**13.2**	**12.8**	**10.3**	**12.7**	**11.4**	**11.2**	**12.8**	*19.5*	*17.0*	*14.6*
13	**11.3**	**10.1**	**9.9**	**10.8**	**10.7**	**11.3**	**11.1**	**9.3**	**11.0**	**11.5**	**11.7**	**11.3**	**9.0**	**11.1**	**10.1**	**10.1**	**11.3**	*18.9*	*16.5*	*14.2*
14	**10.0**	**9.8**	**8.7**	**9.6**	**9.5**	**10.1**	**10.0**	**8.7**	**9.8**	**10.2**	**10.5**	**10.2**	**8.1**	**10.0**	**8.9**	**9.2**	**10.1**	*18.4*	*16.1*	*13.8*
15	**9.1**	**9.6**	**7.8**	**8.7**	**8.5**	**9.3**	**9.4**	**8.4**	**9.3**	**9.6**	**9.9**	**9.8**	**7.6**	**9.3**	**8.2**	**8.3**	**9.4**	*18.0*	*15.7*	*13.5*
16	8.0	8.7	7.4	8.1	7.9	9.1	9.1	7.7	9.2	9.2	9.5	9.5	7.1	9.2	7.8	7.7	9.2	*17.6*	*15.4*	*13.2*
17	6.6	7.1	7.7	8.1	8.2	10.0	9.8	7.4	9.7	9.4	9.8	10.0	8.2	10.0	7.4	7.3	9.8	*17.3*	*15.1*	*13.0*
18	8.5	9.0	9.4	9.4	9.6	10.7	10.8	9.6	8.5	8.4	8.6	8.8	7.7	11.6	9.5	9.3	10.3	*17.0*	*14.9*	*12.7*
19	11.1	10.6	11.8	11.7	11.3	11.3	11.6	11.8	10.4	10.4	11.1	11.1	10.4	11.9	11.3	11.8	10.9	*16.7*	*14.6*	*12.5*
20	11.7	11.7	11.5	11.5	11.7	11.9	11.7	11.9	11.5	11.5	11.7	11.7	11.9	11.9	11.9	11.9	12.1	*16.5*	*14.4*	*12.4*
21	11.6	11.6	11.4	11.4	11.6	11.7	11.6	11.7	11.4	11.4	11.6	11.6	11.7	11.7	11.7	11.7	11.9	*16.3*	*14.2*	*12.2*
22	-	11.2	11.1	11.1	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Cho _18	**Cho _19**	**Cho _20**	**Cho _21**	**Cho _22**	**Cho _23**	**Cho _24**	**Cho _25**	***A***	***B***	***C***
3	35.3	35.5	36.0	35.8	35.2	35.1	36.1	35.3	*41.9*	*36.6*	*31.4*
4	29.2	29.6	30.3	30.0	29.2	29.1	30.3	29.3	*34.4*	*30.1*	*25.8*
5	24.5	25.4	26.2	25.7	24.6	24.6	26.2	24.8	*29.9*	*26.2*	*22.4*
6	21.1	22.2	23.2	22.6	21.1	21.1	23.3	21.6	*26.9*	*23.6*	*20.2*
7	18.3	19.8	21.0	20.2	18.3	18.3	20.9	18.9	*24.8*	*21.7*	*18.6*
8	**16.5**	**18.1**	**19.4**	**18.6**	**16.3**	**16.3**	**19.4**	**17.1**	*23.2*	*20.3*	*17.4*
9	**15.0**	**16.5**	**17.9**	**17.0**	**14.5**	**14.5**	**17.7**	**15.8**	*22.0*	*19.2*	*16.5*
10	**13.3**	**15.0**	**16.3**	**15.5**	**12.9**	**12.7**	**15.8**	**14.1**	*21.0*	*18.3*	*15.7*
11	**11.8**	**13.5**	**14.6**	**13.9**	**11.5**	**11.2**	**13.8**	**12.4**	*20.1*	*17.6*	*15.1*
12	**10.5**	**12.1**	**13.0**	**12.4**	**10.1**	**9.9**	**12.2**	**11.0**	*19.5*	*17.0*	*14.6*
13	**9.2**	**10.8**	**11.5**	**11.1**	**8.9**	**8.7**	**11.0**	**10.0**	*18.9*	*16.5*	*14.2*
14	**8.5**	**9.6**	**10.3**	**9.9**	**7.8**	**7.8**	**9.8**	**9.3**	*18.4*	*16.1*	*13.8*
15	**8.2**	**8.7**	**9.4**	**9.0**	**7.0**	**7.2**	**8.9**	**8.9**	*18.0*	*15.7*	*13.5*
16	7.6	8.4	9.2	8.7	7.0	6.8	8.4	8.2	*17.6*	*15.4*	*13.2*
17	7.8	8.7	9.6	9.0	7.7	6.7	6.7	6.6	*17.3*	*15.1*	*13.0*
18	8.8	9.6	10.8	9.8	9.5	8.9	8.7	8.7	*17.0*	*14.9*	*12.7*
19	11.0	10.5	10.5	10.5	11.0	11.1	10.4	10.5	*16.7*	*14.6*	*12.5*
20	12.1	11.5	12.5	12.3	12.6	11.8	11.4	11.5	*16.5*	*14.4*	*12.4*
21	11.7	11.4	12.2	12.1	12.4	11.6	11.2	11.4	*16.3*	*14.2*	*12.2*
22	-	11.1	11.1	11.9	-	11.7	11.1	11.2	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to 0.2V_{ref} to 0.4V_{ref}, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass A limits within 0.2V_{ref} to 0.4V_{ref} are shown in red font.*

Table G-2 Predicted profiles of design equivalent turbulence intensity at the Mwinilunga site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Mwi _01	Mwi _02	Mwi _03	Mwi _04	Mwi _05	Mwi _06	Mwi _07	Mwi _08	Mwi _09	Mwi _10	Mwi _11	Mwi _12	Mwi _13	Mwi _14	Mwi _15	Mwi _16	Mwi _17	*A*	*B*	*C*
3	34.7	34.0	34.8	34.6	34.5	34.4	34.6	33.4	34.1	34.2	33.3	34.3	34.7	33.8	33.7	33.8	33.4	*41.9*	*36.6*	*31.4*
4	30.0	29.1	30.4	30.1	30.0	30.0	29.6	28.5	29.2	29.6	28.4	29.3	29.7	28.7	29.0	28.9	28.4	*34.4*	*30.1*	*25.8*
5	26.6	25.8	27.3	27.0	26.8	26.8	26.0	24.8	25.7	26.1	24.8	25.7	26.2	25.0	25.7	25.4	24.8	*29.9*	*26.2*	*22.4*
6	23.9	23.1	24.9	24.5	24.4	24.3	23.1	21.8	23.0	23.3	21.9	22.9	23.4	22.0	23.2	22.6	21.8	*26.9*	*23.6*	*20.2*
7	22.2	21.2	23.4	22.9	22.8	22.6	21.2	19.5	21.1	21.4	19.7	21.0	21.4	19.6	21.4	20.7	19.5	*24.8*	*21.7*	*18.6*
8	**20.5**	**19.5**	**21.8**	**21.4**	**21.2**	**21.0**	**19.3**	**17.6**	**19.4**	**19.7**	**17.8**	**19.3**	**19.7**	**17.7**	**19.9**	**19.0**	**17.6**	*23.2*	*20.3*	*17.4*
9	**18.8**	**18.0**	**20.0**	**19.5**	**19.4**	**19.2**	**17.5**	**16.0**	**17.6**	**17.9**	**16.1**	**17.6**	**18.0**	**16.0**	**18.1**	**17.3**	**16.0**	*22.0*	*19.2*	*16.5*
10	**16.6**	**15.8**	**17.3**	**16.7**	**16.8**	**16.6**	**15.0**	**13.7**	**15.2**	**15.6**	**13.9**	**15.1**	**15.4**	**13.3**	**15.4**	**14.9**	**13.7**	*21.0*	*18.3*	*15.7*
11	**14.1**	**13.2**	**14.4**	**13.9**	**14.0**	**13.9**	**12.1**	**11.1**	**12.5**	**13.0**	**11.5**	**12.4**	**12.7**	**10.5**	**12.5**	**12.2**	**11.3**	*20.1*	*17.6*	*15.1*
12	**12.1**	**11.1**	**12.3**	**11.8**	**12.0**	**12.0**	**9.8**	**8.9**	**10.4**	**10.8**	**9.5**	**10.4**	**10.5**	**8.1**	**10.1**	**9.8**	**9.4**	*19.5*	*17.0*	*14.6*
13	**10.9**	**9.9**	**11.0**	**10.7**	**10.9**	**10.9**	**8.1**	**7.2**	**9.0**	**9.3**	**7.9**	**9.0**	**9.1**	**7.1**	**8.6**	**8.3**	**8.2**	*18.9*	*16.5*	*14.2*
14	**10.1**	**9.4**	**10.4**	**10.0**	**10.2**	**10.0**	**7.9**	**6.6**	**8.5**	**8.5**	**7.0**	**8.5**	**8.6**	**7.1**	**7.7**	**7.6**	**7.7**	*18.4*	*16.1*	*13.8*
15	**9.4**	**8.9**	**9.4**	**9.2**	**9.6**	**9.8**	**7.9**	**6.6**	**8.6**	**8.4**	**7.5**	**8.4**	**8.3**	**7.1**	**7.9**	**7.7**	**7.2**	*18.0*	*15.7*	*13.5*
16	9.4	9.7	9.4	9.3	9.7	9.7	9.3	8.3	9.9	9.4	9.0	9.3	9.1	8.6	8.6	9.1	8.7	*17.6*	*15.4*	*13.2*
17	9.8	11.0	9.5	9.6	9.9	10.0	10.1	9.9	11.2	10.7	10.5	10.5	10.3	9.8	9.7	10.9	10.2	*17.3*	*15.1*	*13.0*
18	10.4	12.2	9.9	10.2	10.6	11.0	11.2	10.9	11.8	11.5	11.4	11.2	11.1	11.0	10.9	11.9	11.4	*17.0*	*14.9*	*12.7*
19	11.3	12.6	11.2	11.3	11.4	11.5	11.7	10.9	11.5	11.4	11.5	11.5	11.5	11.5	11.4	-	10.8	*16.7*	*14.6*	*12.5*
20	11.1	-	11.1	11.0	11.0	11.0	-	-	-	-	-	-	-	-	11.0	-	-	*16.5*	*14.4*	*12.4*
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Mwi _18	**Mwi _19**	**Mwi _20**	**Mwi _21**	**Mwi _22**	**Mwi _23**	**Mwi _24**	**Mwi _25**	***A***	***B***	***C***
3	34.2	34.4	34.6	34.8	34.7	34.9	34.3	34.0	*41.9*	*36.6*	*31.4*
4	29.2	29.5	29.6	29.9	29.7	29.9	29.5	28.8	*34.4*	*30.1*	*25.8*
5	25.6	25.9	25.8	26.1	26.1	26.3	25.9	25.1	*29.9*	*26.2*	*22.4*
6	22.7	23.1	23.0	23.3	23.3	23.5	23.1	22.1	*26.9*	*23.6*	*20.2*
7	20.5	21.0	20.8	21.2	21.3	21.6	20.9	19.8	*24.8*	*21.7*	*18.6*
8	**18.6**	**19.0**	**18.8**	**19.2**	**19.6**	**19.9**	**19.0**	**18.0**	*23.2*	*20.3*	*17.4*
9	**16.6**	**17.1**	**16.9**	**17.3**	**17.7**	**17.7**	**17.1**	**16.2**	*22.0*	*19.2*	*16.5*
10	**14.1**	**14.7**	**14.3**	**14.6**	**14.9**	**14.8**	**14.6**	**13.8**	*21.0*	*18.3*	*15.7*
11	**11.6**	**12.3**	**11.8**	**11.8**	**12.0**	**11.9**	**11.9**	**11.5**	*20.1*	*17.6*	*15.1*
12	**9.7**	**10.4**	**9.7**	**9.6**	**9.6**	**9.8**	**9.8**	**9.7**	*19.5*	*17.0*	*14.6*
13	**8.7**	**9.0**	**8.5**	**8.4**	**8.1**	**8.6**	**8.5**	**8.5**	*18.9*	*16.5*	*14.2*
14	**8.0**	**8.1**	**7.9**	**8.1**	**7.8**	**8.1**	**7.7**	**7.6**	*18.4*	*16.1*	*13.8*
15	**8.1**	**8.5**	**8.7**	**9.0**	**8.3**	**8.7**	**7.3**	**7.2**	*18.0*	*15.7*	*13.5*
16	9.2	9.1	9.1	9.7	9.8	9.6	8.6	8.9	*17.6*	*15.4*	*13.2*
17	10.2	9.9	9.6	10.6	10.9	10.7	10.1	10.3	*17.3*	*15.1*	*13.0*
18	11.4	11.0	10.6	11.9	11.9	12.0	11.3	11.8	*17.0*	*14.9*	*12.7*
19	11.6	11.5	11.4	-	-	-	11.7	-	*16.7*	*14.6*	*12.5*
20	-	-	-	-	-	-	-	-	*16.5*	*14.4*	*12.4*
21	-	-	-	-	-	-	-	-	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Table G-3 Predicted profiles of design equivalent turbulence intensity at the Lusaka site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Lus_01	Lus_02	Lus_03	Lus_04	Lus_05	Lus_06	Lus_07	Lus_08	Lus_09	Lus_10	Lus_11	Lus_12	Lus_13	Lus_14	Lus_15	Lus_16	Lus_17	*A*	*B*	*C*
3	34.0	34.5	34.3	34.8	34.5	34.2	34.3	35.1	34.8	35.1	35.1	34.3	34.5	34.9	35.0	34.3	34.9	*41.9*	*36.6*	*31.4*
4	29.9	30.4	29.8	30.6	30.1	29.8	29.9	30.9	30.6	31.0	30.9	29.9	30.2	30.6	30.6	29.9	30.5	*34.4*	*30.1*	*25.8*
5	26.2	26.7	26.0	26.9	26.4	26.0	26.1	27.2	27.0	27.5	27.1	26.1	26.6	26.9	26.8	26.2	26.8	*29.9*	*26.2*	*22.4*
6	23.9	24.3	23.3	24.6	23.8	23.4	23.4	24.9	24.4	25.2	24.8	23.4	24.0	24.5	24.1	23.5	24.2	*26.9*	*23.6*	*20.2*
7	21.7	22.1	20.9	22.4	21.5	21.2	21.1	22.7	22.1	23.3	22.5	21.1	21.9	22.1	21.8	21.2	22.0	*24.8*	*21.7*	*18.6*
8	**19.8**	**20.1**	**18.9**	**20.4**	**19.5**	**19.1**	**19.1**	**20.7**	**20.1**	**21.6**	**20.4**	**19.0**	**20.2**	**20.1**	**19.7**	**19.1**	**20.1**	*23.2*	*20.3*	*17.4*
9	**17.7**	**18.0**	**16.8**	**18.3**	**17.4**	**17.0**	**17.0**	**18.5**	**17.8**	**19.8**	**18.2**	**16.9**	**18.3**	**17.9**	**17.5**	**16.9**	**18.1**	*22.0*	*19.2*	*16.5*
10	**15.4**	**15.7**	**14.5**	**15.9**	**15.1**	**14.7**	**14.8**	**16.1**	**15.4**	**17.7**	**15.9**	**14.7**	**16.2**	**15.5**	**15.2**	**14.7**	**16.0**	*21.0*	*18.3*	*15.7*
11	**13.0**	**13.2**	**12.1**	**13.4**	**12.7**	**12.4**	**12.5**	**13.5**	**13.0**	**15.5**	**13.3**	**12.4**	**14.0**	**13.0**	**12.8**	**12.3**	**13.8**	*20.1*	*17.6*	*15.1*
12	**11.0**	**11.2**	**10.2**	**11.3**	**10.6**	**10.3**	**10.3**	**11.4**	**10.9**	**13.6**	**11.2**	**10.4**	**12.0**	**11.0**	**10.7**	**10.2**	**11.9**	*19.5*	*17.0*	*14.6*
13	**9.5**	**9.6**	**8.6**	**9.8**	**9.0**	**8.7**	**8.9**	**9.7**	**9.2**	**12.0**	**9.5**	**8.7**	**10.5**	**9.3**	**9.1**	**8.6**	**10.4**	*18.9*	*16.5*	*14.2*
14	**8.2**	**8.3**	**7.2**	**8.6**	**7.6**	**7.4**	**7.6**	**8.4**	**7.7**	**10.5**	**8.2**	**7.3**	**9.1**	**8.0**	**7.8**	**7.2**	**9.1**	*18.4*	*16.1*	*13.8*
15	**7.1**	**7.1**	**6.2**	**7.4**	**6.4**	**6.2**	**6.5**	**7.2**	**6.5**	**9.4**	**6.9**	**6.1**	**8.1**	**6.9**	**6.6**	**6.3**	**8.0**	*18.0*	*15.7*	*13.5*
16	6.7	6.7	5.9	6.9	6.0	5.9	6.0	7.0	6.1	8.6	6.7	5.7	7.4	6.8	5.8	5.9	7.3	*17.6*	*15.4*	*13.2*
17	6.8	6.8	5.8	7.0	6.0	6.0	5.8	7.1	5.9	8.0	6.7	5.6	6.9	6.6	5.7	5.8	6.8	*17.3*	*15.1*	*13.0*
18	6.6	6.6	5.6	6.6	5.9	5.8	5.7	6.5	5.8	7.1	6.2	5.7	6.3	6.0	5.7	5.6	6.2	*17.0*	*14.9*	*12.7*
19	5.5	5.5	4.5	5.0	5.0	5.0	4.9	4.8	4.9	5.6	4.9	4.9	5.2	4.9	4.9	4.8	5.0	*16.7*	*14.6*	*12.5*
20	7.4	7.1	8.2	6.2	5.8	7.4	7.5	7.5	7.3	7.4	7.3	7.3	8.2	7.5	7.3	7.6	7.6	*16.5*	*14.4*	*12.4*
21	11.9	11.8	11.8	11.7	10.4	10.4	10.4	11.7	10.4	11.7	10.4	10.4	10.4	10.4	10.4	11.7	11.7	*16.3*	*14.2*	*12.2*
22	11.7	11.7	11.7	11.6	11.5	11.5	11.5	11.6	11.5	11.6	11.5	11.5	11.5	11.5	11.5	11.6	11.6	*16.1*	*14.1*	*12.1*
23	11.7	11.7	-	11.5	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								IEC 61400-1 Ed3 Turbine Subclass		
	Lus_18	Lus_19	Lus_20	Lus_21	Lus_22	Lus_23	Lus_24	Lus_25	*A*	*B*	*C*
3	34.1	34.9	35.2	34.2	34.6	35.1	35.1	34.1	*41.9*	*36.6*	*31.4*
4	29.6	30.6	30.9	29.6	30.2	30.9	30.7	29.5	*34.4*	*30.1*	*25.8*
5	25.8	26.9	27.2	25.9	26.6	27.1	27.0	25.7	*29.9*	*26.2*	*22.4*
6	23.1	24.5	24.6	23.2	24.0	24.7	24.5	23.0	*26.9*	*23.6*	*20.2*
7	20.7	22.2	22.3	20.9	21.8	22.4	22.2	20.7	*24.8*	*21.7*	*18.6*
8	**18.8**	**20.1**	**20.2**	**19.0**	**19.6**	**20.4**	**20.1**	**18.8**	*23.2*	*20.3*	*17.4*
9	**16.7**	**17.9**	**18.0**	**16.9**	**17.3**	**18.2**	**17.9**	**16.8**	*22.0*	*19.2*	*16.5*
10	**14.5**	**15.6**	**15.6**	**14.8**	**14.9**	**15.8**	**15.5**	**14.6**	*21.0*	*18.3*	*15.7*
11	**12.1**	**13.1**	**13.1**	**12.5**	**12.5**	**13.3**	**13.0**	**12.3**	*20.1*	*17.6*	*15.1*
12	**10.1**	**11.0**	**11.0**	**10.4**	**10.4**	**11.3**	**10.9**	**10.4**	*19.5*	*17.0*	*14.6*
13	**8.6**	**9.5**	**9.5**	**8.8**	**8.7**	**9.7**	**9.2**	**8.8**	*18.9*	*16.5*	*14.2*
14	**7.1**	**8.1**	**8.1**	**7.3**	**7.4**	**8.2**	**7.8**	**7.4**	*18.4*	*16.1*	*13.8*
15	**6.3**	**7.0**	**6.9**	**6.4**	**6.3**	**7.1**	**6.7**	**6.3**	*18.0*	*15.7*	*13.5*
16	5.9	6.8	6.3	5.9	6.2	7.0	6.5	5.9	*17.6*	*15.4*	*13.2*
17	5.7	6.7	6.1	5.6	6.1	6.7	6.2	5.7	*17.3*	*15.1*	*13.0*
18	5.6	6.0	5.8	5.7	5.7	6.0	5.7	5.6	*17.0*	*14.9*	*12.7*
19	4.8	4.9	4.8	5.0	6.3	5.7	5.0	5.3	*16.7*	*14.6*	*12.5*
20	6.6	7.5	7.5	7.4	8.5	8.9	8.2	8.9	*16.5*	*14.4*	*12.4*
21	11.7	11.7	11.7	10.4	11.7	11.7	10.4	11.7	*16.3*	*14.2*	*12.2*
22	11.6	11.6	11.6	11.5	11.6	11.6	11.5	11.6	*16.1*	*14.1*	*12.1*
23	11.5	11.4	11.4	11.4	11.4	11.4	11.4	11.4	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Table G-4 Predicted profiles of design equivalent turbulence intensity at the Mpika site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Mpi_01	Mpi_02	Mpi_03	Mpi_04	Mpi_05	Mpi_06	Mpi_07	Mpi_08	Mpi_09	Mpi_10	Mpi_11	Mpi_12	Mpi_13	Mpi_14	Mpi_15	Mpi_16	Mpi_17	*A*	*B*	*C*
3	31.6	32.1	32.3	32.2	32.0	31.9	32.1	32.6	32.4	32.0	32.2	32.7	32.1	32.3	32.3	32.4	32.6	*41.9*	*36.6*	*31.4*
4	27.5	28.0	28.2	28.2	27.9	27.8	28.0	28.5	28.3	27.8	28.2	28.6	28.0	28.3	28.2	28.4	28.5	*34.4*	*30.1*	*25.8*
5	24.3	24.9	25.0	25.0	24.7	24.5	24.7	25.2	24.9	24.5	24.8	25.3	24.8	25.0	24.8	25.1	25.2	*29.9*	*26.2*	*22.4*
6	21.8	22.6	22.6	22.7	22.3	22.0	22.3	22.7	22.4	22.0	22.3	22.8	22.4	22.5	22.2	22.5	22.7	*26.9*	*23.6*	*20.2*
7	19.2	20.2	20.2	20.4	19.9	19.4	19.8	20.2	19.7	19.3	19.8	20.3	19.9	19.9	19.6	20.0	20.1	*24.8*	*21.7*	*18.6*
8	**16.9**	**18.1**	**18.1**	**18.5**	**17.8**	**17.1**	**17.7**	**18.1**	**17.4**	**17.0**	**17.5**	**17.9**	**17.8**	**17.5**	**17.1**	**17.6**	**17.7**	*23.2*	*20.3*	*17.4*
9	**15.1**	**16.5**	**16.3**	**16.8**	**16.1**	**15.3**	**16.0**	**16.3**	**15.4**	**15.1**	**15.4**	**15.9**	**16.1**	**15.5**	**15.1**	**15.6**	**15.7**	*22.0*	*19.2*	*16.5*
10	**13.7**	**15.0**	**14.8**	**15.4**	**14.6**	**13.8**	**14.4**	**14.7**	**13.9**	**13.6**	**13.9**	**14.3**	**14.8**	**14.0**	**13.7**	**14.0**	**14.1**	*21.0*	*18.3*	*15.7*
11	**12.7**	**13.8**	**13.5**	**14.2**	**13.4**	**12.7**	**13.2**	**13.3**	**12.9**	**12.7**	**12.8**	**13.1**	**13.7**	**12.9**	**12.7**	**12.8**	**12.9**	*20.1*	*17.6*	*15.1*
12	**12.0**	**12.9**	**12.5**	**13.1**	**12.4**	**11.9**	**12.1**	**12.3**	**12.1**	**11.9**	**11.9**	**12.2**	**12.7**	**12.1**	**12.0**	**12.0**	**12.1**	*19.5*	*17.0*	*14.6*
13	**12.2**	**12.7**	**12.4**	**12.7**	**12.3**	**12.0**	**12.2**	**12.3**	**12.2**	**12.0**	**12.0**	**12.1**	**12.5**	**12.2**	**12.0**	**11.9**	**11.8**	*18.9*	*16.5*	*14.2*
14	**12.2**	**12.6**	**12.4**	**12.5**	**12.3**	**12.1**	**12.3**	**12.3**	**12.2**	**12.1**	**12.1**	**12.1**	**12.5**	**12.2**	**12.1**	**11.9**	**11.9**	*18.4*	*16.1*	*13.8*
15	**12.2**	**12.2**	**12.0**	**12.2**	**11.9**	**11.8**	**11.8**	**12.0**	**11.8**	**11.8**	**11.8**	**11.8**	**12.1**	**12.0**	**11.8**	**11.8**	**11.7**	*18.0*	*15.7*	*13.5*
16	13.3	13.2	13.2	12.9	13.1	13.3	13.6	13.6	13.5	13.2	13.0	13.4	13.5	13.5	13.2	12.7	12.7	*17.6*	*15.4*	*13.2*
17	12.9	12.9	12.9	12.9	12.9	12.9	13.2	13.2	13.1	13.0	12.9	13.0	13.1	13.1	13.0	12.9	13.0	*17.3*	*15.1*	*13.0*
18	12.8	12.4	12.5	12.4	12.5	12.6	13.3	13.9	14.2	13.1	12.8	13.9	12.8	13.7	13.3	12.9	13.3	*17.0*	*14.9*	*12.7*
19	13.1	12.7	13.0	12.8	12.6	12.5	12.5	13.3	13.1	12.8	13.4	13.7	13.0	13.6	13.1	13.9	13.2	*16.7*	*14.6*	*12.5*
20	12.3	12.7	12.8	12.7	12.5	12.3	12.4	12.4	12.4	12.5	13.8	12.7	13.1	13.3	12.6	13.6	12.6	*16.5*	*14.4*	*12.4*
21	12.0	12.5	12.5	12.5	12.3	12.2	12.3	12.2	12.2	12.5	13.7	12.6	13.1	13.3	12.5	13.9	12.7	*16.3*	*14.2*	*12.2*
22	11.9	12.4	12.4	12.4	12.2	-	12.2	12.4	12.4	12.4	13.6	12.5	13.0	13.1	12.4	13.7	12.6	*16.1*	*14.1*	*12.1*
23	11.8	12.3	12.3	12.3	12.1	11.9	12.1	12.3	12.3	12.3	13.5	12.4	12.8	13.0	12.3	13.6	12.5	*15.9*	*13.9*	*11.9*
24	11.7	12.1	12.1	12.1	12.0	11.8	12.0	12.1	12.2	12.2	13.4	12.3	12.7	12.9	12.2	12.8	12.3	*15.7*	*13.8*	*11.8*
25	11.6	11.6	11.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Mpi_ 18	Mpi_ 19	Mpi_ 20	Mpi_ 21	Mpi_ 22	Mpi_ 23	Mpi_ 24	Mpi_ 25	*A*	*B*	*C*
3	32.4	31.6	31.8	32.2	32.3	32.6	32.7	31.8	*41.9*	*36.6*	*31.4*
4	28.3	27.4	27.9	28.2	28.2	28.6	28.7	27.6	*34.4*	*30.1*	*25.8*
5	24.9	24.1	24.6	25.0	25.0	25.4	25.5	24.3	*29.9*	*26.2*	*22.4*
6	22.3	21.5	22.2	22.5	22.5	22.9	23.0	21.8	*26.9*	*23.6*	*20.2*
7	19.6	18.7	19.7	20.0	20.0	20.5	20.5	19.0	*24.8*	*21.7*	*18.6*
8	**17.3**	**16.2**	**17.4**	**17.7**	**17.7**	**18.3**	**18.2**	**16.5**	*23.2*	*20.3*	*17.4*
9	**15.2**	**14.3**	**15.6**	**15.8**	**15.8**	**16.4**	**16.3**	**14.6**	*22.0*	*19.2*	*16.5*
10	**13.7**	**13.1**	**14.1**	**14.2**	**14.2**	**14.7**	**14.7**	**13.4**	*21.0*	*18.3*	*15.7*
11	**12.7**	**12.5**	**13.0**	**13.1**	**13.1**	**13.4**	**13.4**	**12.7**	*20.1*	*17.6*	*15.1*
12	**12.0**	**11.9**	**12.3**	**12.3**	**12.2**	**12.4**	**12.4**	**12.0**	*19.5*	*17.0*	*14.6*
13	**11.9**	**12.0**	**12.4**	**12.3**	**12.3**	**12.3**	**12.3**	**12.2**	*18.9*	*16.5*	*14.2*
14	**12.0**	**12.1**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.2**	*18.4*	*16.1*	*13.8*
15	**11.8**	**11.8**	**12.3**	**12.1**	**12.1**	**12.1**	**12.1**	**12.2**	*18.0*	*15.7*	*13.5*
16	12.8	12.9	13.6	13.6	13.6	13.4	13.4	13.5	*17.6*	*15.4*	*13.2*
17	12.9	12.8	13.3	13.3	13.3	13.3	13.3	12.9	*17.3*	*15.1*	*13.0*
18	13.2	12.7	13.9	14.1	14.0	13.5	13.4	12.5	*17.0*	*14.9*	*12.7*
19	13.7	12.8	13.7	13.5	13.5	13.8	13.7	12.5	*16.7*	*14.6*	*12.5*
20	12.9	12.6	13.4	13.3	13.3	13.6	13.5	12.4	*16.5*	*14.4*	*12.4*
21	13.2	12.9	13.5	13.1	13.1	13.5	13.3	12.3	*16.3*	*14.2*	*12.2*
22	13.5	12.8	13.3	12.8	12.9	13.3	13.1	12.2	*16.1*	*14.1*	*12.1*
23	13.4	12.6	13.2	12.7	12.8	13.2	13.0	12.1	*15.9*	*13.9*	*11.9*
24	12.2	-	13.5	12.8	12.8	13.1	13.0	12.0	*15.7*	*13.8*	*11.8*
25	-	-	-	13.6	13.6	13.9	13.8	11.6	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font.*
Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.

Table G-5 Predicted profiles of design equivalent turbulence intensity at the Chanka site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Cha_01	Cha_02	Cha_03	Cha_04	Cha_05	Cha_06	Cha_07	Cha_08	Cha_09	Cha_10	Cha_11	Cha_12	Cha_13	Cha_14	Cha_15	Cha_16	Cha_17	*A*	*B*	*C*
3	30.4	32.5	32.6	31.1	31.7	31.1	31.8	31.5	31.9	30.8	31.7	32.5	32.8	31.7	32.0	32.6	31.6	*41.9*	*36.6*	*31.4*
4	25.3	28.2	28.3	26.5	27.0	26.3	27.2	27.0	27.6	26.3	27.5	28.3	28.6	27.2	27.1	28.0	27.0	*34.4*	*30.1*	*25.8*
5	22.1	25.4	25.5	23.4	24.0	22.9	24.3	24.1	24.7	23.2	25.0	25.6	25.9	24.2	24.3	25.0	23.8	*29.9*	*26.2*	*22.4*
6	20.1	23.4	23.5	21.5	21.9	21.1	22.3	22.2	22.8	21.4	23.1	23.7	24.0	22.4	22.2	23.0	22.0	*26.9*	*23.6*	*20.2*
7	18.2	20.9	21.4	20.0	19.8	19.3	20.0	20.4	20.9	19.7	20.7	21.7	21.8	20.7	20.2	21.1	20.2	*24.8*	*21.7*	*18.6*
8	**16.8**	**18.7**	**19.1**	**18.1**	**18.1**	**17.9**	**18.0**	**18.6**	**19.2**	**18.3**	**18.6**	**19.8**	**19.9**	**19.1**	**18.4**	**19.4**	**18.8**	*23.2*	*20.3*	*17.4*
9	**15.7**	**16.8**	**17.2**	**16.6**	**16.6**	**16.5**	**16.3**	**17.0**	**17.6**	**16.9**	**16.5**	**18.0**	**18.0**	**17.5**	**17.1**	**17.9**	**17.4**	*22.0*	*19.2*	*16.5*
10	**14.9**	**15.5**	**15.6**	**15.4**	**15.5**	**15.4**	**15.1**	**15.7**	**16.2**	**15.7**	**15.0**	**16.3**	**16.4**	**16.1**	**15.6**	**16.3**	**16.0**	*21.0*	*18.3*	*15.7*
11	**14.4**	**14.6**	**14.7**	**14.5**	**14.6**	**14.6**	**14.4**	**14.6**	**15.0**	**14.7**	**14.2**	**15.0**	**15.1**	**15.0**	**14.6**	**15.1**	**14.9**	*20.1*	*17.6*	*15.1*
12	**14.1**	**14.2**	**14.1**	**14.0**	**14.2**	**14.1**	**14.0**	**14.0**	**14.3**	**14.2**	**13.8**	**14.3**	**14.3**	**14.3**	**14.2**	**14.4**	**14.3**	*19.5*	*17.0*	*14.6*
13	**14.2**	**14.2**	**14.0**	**13.9**	**14.2**	**14.1**	**14.0**	**13.8**	**14.1**	**14.0**	**13.7**	**14.0**	**14.1**	**14.2**	**14.2**	**14.3**	**14.2**	*18.9*	*16.5*	*14.2*
14	**14.5**	**14.5**	**14.2**	**14.1**	**14.4**	**14.2**	**14.2**	**13.9**	**14.2**	**14.1**	**13.9**	**14.1**	**14.3**	**14.3**	**14.4**	**14.5**	**14.3**	*18.4*	*16.1*	*13.8*
15	**15.7**	**15.7**	**15.2**	**15.1**	**15.6**	**15.2**	**15.2**	**14.7**	**15.0**	**15.0**	**14.7**	**15.0**	**15.2**	**15.3**	**15.6**	**15.6**	**15.2**	*18.0*	*15.7*	*13.5*
16	16.8	17.3	16.8	16.7	17.1	16.6	16.7	16.1	16.5	16.4	16.1	16.4	16.5	16.7	17.0	17.0	16.5	*17.6*	*15.4*	*13.2*
17	16.0	17.0	16.1	16.1	17.0	16.2	17.0	16.2	16.4	16.3	16.3	16.4	16.4	16.3	16.0	16.1	16.2	*17.3*	*15.1*	*13.0*
18	13.7	14.9	13.8	14.0	16.0	14.2	15.6	14.1	14.4	13.9	13.9	13.9	13.9	13.7	13.8	13.8	13.9	*17.0*	*14.9*	*12.7*
19	13.4	14.6	13.7	13.3	14.4	13.2	15.0	13.2	13.6	13.4	13.4	13.4	13.4	13.4	13.7	13.7	13.4	*16.7*	*14.6*	*12.5*
20	13.3	14.5	13.5	13.3	14.6	13.1	14.8	13.1	13.4	13.3	13.3	13.3	13.3	13.3	13.5	13.5	13.3	*16.5*	*14.4*	*12.4*
21	13.1	14.5	-	12.9	14.3	13.0	14.5	12.9	13.3	12.9	13.1	12.9	13.1	13.1	-	-	13.1	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Cha_18	Cha_19	Cha_20	Cha_21	Cha_22	Cha_23	Cha_24	Cha_25	*A*	*B*	*C*
3	30.3	31.6	31.1	30.2	29.7	30.8	32.1	31.1	*41.9*	*36.6*	*31.4*
4	25.3	26.6	26.3	25.4	24.6	26.4	27.7	26.5	*34.4*	*30.1*	*25.8*
5	21.8	23.2	23.0	22.1	21.1	23.7	24.7	23.3	*29.9*	*26.2*	*22.4*
6	19.8	20.9	20.8	20.1	19.3	21.7	22.7	21.5	*26.9*	*23.6*	*20.2*
7	18.0	19.2	19.1	18.2	17.6	19.7	20.8	19.8	*24.8*	*21.7*	*18.6*
8	**16.7**	**17.9**	**17.7**	**16.7**	**16.4**	**17.9**	**19.1**	**18.4**	*23.2*	*20.3*	*17.4*
9	**15.5**	**16.5**	**16.4**	**15.5**	**15.3**	**16.4**	**17.6**	**17.1**	*22.0*	*19.2*	*16.5*
10	**14.9**	**15.6**	**15.5**	**14.7**	**14.7**	**15.2**	**16.2**	**15.9**	*21.0*	*18.3*	*15.7*
11	**14.4**	**14.7**	**14.6**	**14.2**	**14.2**	**14.3**	**15.0**	**15.0**	*20.1*	*17.6*	*15.1*
12	**14.1**	**14.4**	**14.4**	**13.9**	**14.0**	**13.9**	**14.5**	**14.5**	*19.5*	*17.0*	*14.6*
13	**14.2**	**14.3**	**14.2**	**13.8**	**14.0**	**13.9**	**14.4**	**14.4**	*18.9*	*16.5*	*14.2*
14	**14.5**	**14.7**	**14.6**	**14.0**	**14.1**	**14.0**	**14.7**	**14.7**	*18.4*	*16.1*	*13.8*
15	**15.6**	**16.0**	**15.8**	**14.9**	**15.1**	**14.9**	**15.7**	**15.8**	*18.0*	*15.7*	*13.5*
16	16.7	17.6	17.4	16.2	16.4	16.1	17.2	17.3	*17.6*	*15.4*	*13.2*
17	16.0	17.4	17.4	16.3	16.2	15.7	16.3	16.4	*17.3*	*15.1*	*13.0*
18	13.6	15.9	15.9	14.7	14.1	15.1	14.2	13.7	*17.0*	*14.9*	*12.7*
19	13.4	15.9	15.8	13.9	13.2	13.6	13.2	13.4	*16.7*	*14.6*	*12.5*
20	13.3	15.5	15.5	13.7	13.1	12.5	13.1	13.3	*16.5*	*14.4*	*12.4*
21	12.9	15.2	15.1	13.5	12.9	12.3	12.9	12.9	*16.3*	*14.2*	*12.2*
22	-	-	-	13.8	-	12.2	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to 0.2V_{ref} to 0.4V_{ref}, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass A limits within 0.2V_{ref} to 0.4V_{ref} are shown in red font.*

Table G-6 Predicted profiles of design equivalent turbulence intensity at the Petauke site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Pet_ 01	Pet_ 02	Pet_ 03	Pet_ 04	Pet_ 05	Pet_ 06	Pet_ 07	Pet_ 08	Pet_ 09	Pet_ 10	Pet_ 11	Pet_ 12	Pet_ 13	Pet_ 14	Pet_ 15	Pet_ 16	Pet_ 17	*A*	*B*	*C*
3	33.2	33.3	33.7	32.4	32.1	32.7	33.1	33.2	32.5	34.1	34.6	32.5	35.0	33.0	35.0	34.1	33.2	*41.9*	*36.6*	*31.4*
4	28.3	28.5	29.3	27.8	27.4	27.8	28.2	28.5	27.6	29.6	30.2	27.8	30.8	28.4	30.6	29.5	28.3	*34.4*	*30.1*	*25.8*
5	24.0	24.3	25.7	24.1	23.8	23.7	24.1	24.5	23.5	25.8	26.4	24.1	27.3	24.8	26.8	25.4	24.1	*29.9*	*26.2*	*22.4*
6	20.4	20.9	22.8	20.9	20.7	20.1	20.6	21.2	20.1	22.7	23.3	20.9	24.3	21.9	23.7	22.2	20.6	*26.9*	*23.6*	*20.2*
7	17.5	18.4	20.4	18.3	18.2	17.2	17.9	18.6	17.2	20.1	20.8	18.4	21.9	19.7	21.1	19.7	17.8	*24.8*	*21.7*	*18.6*
8	**15.3**	**16.9**	**18.5**	**16.0**	**16.4**	**15.0**	**16.1**	**16.6**	**15.0**	**18.0**	**18.8**	**16.4**	**19.9**	**18.1**	**19.1**	**17.8**	**15.6**	*23.2*	*20.3*	*17.4*
9	**13.8**	**15.8**	**16.9**	**14.2**	**15.1**	**13.6**	**14.8**	**15.1**	**13.5**	**16.5**	**17.3**	**15.1**	**18.3**	**16.6**	**17.7**	**16.4**	**14.1**	*22.0*	*19.2*	*16.5*
10	**12.8**	**14.7**	**15.5**	**12.8**	**14.0**	**12.6**	**13.7**	**13.9**	**12.4**	**15.0**	**15.8**	**13.8**	**16.7**	**15.2**	**16.0**	**14.7**	**13.0**	*21.0*	*18.3*	*15.7*
11	**12.1**	**13.6**	**14.3**	**11.9**	**12.8**	**12.1**	**12.9**	**12.9**	**11.7**	**13.7**	**14.3**	**12.4**	**15.2**	**13.8**	**14.6**	**13.4**	**12.1**	*20.1*	*17.6*	*15.1*
12	**12.1**	**13.0**	**13.5**	**11.2**	**11.9**	**11.9**	**12.4**	**12.4**	**11.3**	**12.7**	**13.0**	**11.5**	**13.9**	**12.8**	**13.2**	**12.5**	**11.6**	*19.5*	*17.0*	*14.6*
13	**12.2**	**12.8**	**13.1**	**11.1**	**11.3**	**12.1**	**12.2**	**12.3**	**11.3**	**12.1**	**12.3**	**11.1**	**13.1**	**12.4**	**12.5**	**11.9**	**11.5**	*18.9*	*16.5*	*14.2*
14	**13.0**	**13.4**	**13.4**	**11.2**	**11.0**	**12.8**	**12.6**	**12.7**	**11.4**	**12.1**	**12.0**	**10.9**	**12.7**	**12.0**	**12.4**	**11.9**	**11.8**	*18.4*	*16.1*	*13.8*
15	**13.9**	**14.2**	**14.1**	**11.8**	**11.1**	**13.7**	**13.5**	**13.5**	**12.2**	**12.8**	**12.6**	**11.1**	**13.4**	**12.2**	**13.2**	**12.3**	**12.5**	*18.0*	*15.7*	*13.5*
16	14.1	14.4	14.2	12.6	11.7	13.9	13.9	14.0	13.0	13.4	13.0	11.9	13.7	12.8	13.0	13.1	13.2	*17.6*	*15.4*	*13.2*
17	15.1	15.0	15.0	13.0	12.4	14.6	14.1	14.3	13.2	13.5	13.3	12.6	13.6	13.4	13.6	13.6	13.5	*17.3*	*15.1*	*13.0*
18	13.1	13.4	13.7	13.5	12.5	13.2	14.5	14.1	14.0	13.9	13.6	12.9	14.1	13.6	13.6	13.6	14.1	*17.0*	*14.9*	*12.7*
19	13.5	12.4	12.5	13.4	13.0	13.0	12.2	12.2	12.9	12.9	13.8	13.3	13.6	14.2	13.3	13.8	13.0	*16.7*	*14.6*	*12.5*
20	11.6	11.9	12.2	11.6	12.7	11.7	11.8	12.0	11.7	11.7	11.7	12.4	11.9	12.3	11.6	12.1	12.0	*16.5*	*14.4*	*12.4*
21	11.4	11.7	-	11.5	11.0	11.2	11.7	-	11.7	11.7	12.7	11.7	11.7	12.7	-	11.3	12.6	*16.3*	*14.2*	*12.2*
22	-	-	-	11.1	-	11.1	-	-	-	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Pet_ 18	**Pet_ 19**	**Pet_ 20**	**Pet_ 21**	**Pet_ 22**	**Pet_ 23**	**Pet_ 24**	**Pet_ 25**	***A***	***B***	***C***
3	33.2	34.3	36.0	35.1	34.8	34.8	34.3	32.6	*41.9*	*36.6*	*31.4*
4	28.3	30.3	31.6	30.6	30.2	30.1	29.8	27.9	*34.4*	*30.1*	*25.8*
5	24.1	26.9	27.6	26.5	26.1	25.9	26.0	23.9	*29.9*	*26.2*	*22.4*
6	20.8	24.0	24.5	23.4	23.0	22.7	22.9	20.6	*26.9*	*23.6*	*20.2*
7	18.2	21.7	22.0	20.9	20.5	20.1	20.7	17.9	*24.8*	*21.7*	*18.6*
8	**16.3**	**19.6**	**20.1**	**19.0**	**18.8**	**18.3**	**19.0**	**15.9**	*23.2*	*20.3*	*17.4*
9	**14.8**	**17.9**	**18.6**	**17.6**	**17.4**	**17.0**	**17.6**	**14.3**	*22.0*	*19.2*	*16.5*
10	**13.6**	**16.2**	**16.8**	**15.7**	**15.8**	**15.4**	**15.9**	**13.0**	*21.0*	*18.3*	*15.7*
11	**12.6**	**14.6**	**15.0**	**14.1**	**14.2**	**13.9**	**14.3**	**12.2**	*20.1*	*17.6*	*15.1*
12	**12.0**	**13.3**	**13.6**	**12.8**	**12.9**	**12.7**	**13.0**	**11.6**	*19.5*	*17.0*	*14.6*
13	**11.9**	**12.3**	**12.6**	**11.9**	**12.1**	**12.2**	**12.4**	**11.5**	*18.9*	*16.5*	*14.2*
14	**12.1**	**11.8**	**12.9**	**11.9**	**11.9**	**12.2**	**12.3**	**11.6**	*18.4*	*16.1*	*13.8*
15	**12.7**	**12.0**	**12.1**	**11.9**	**12.4**	**13.2**	**12.8**	**12.2**	*18.0*	*15.7*	*13.5*
16	13.4	12.5	13.1	12.9	12.8	13.4	13.4	12.9	*17.6*	*15.4*	*13.2*
17	13.5	12.6	13.3	13.2	13.2	13.6	13.5	13.1	*17.3*	*15.1*	*13.0*
18	14.3	12.8	13.3	13.1	13.5	14.2	14.2	13.9	*17.0*	*14.9*	*12.7*
19	13.1	13.2	13.7	13.5	13.7	12.7	12.6	13.4	*16.7*	*14.6*	*12.5*
20	12.0	12.9	12.3	12.1	11.8	12.1	12.1	12.5	*16.5*	*14.4*	*12.4*
21	-	11.2	11.3	11.1	11.3	12.4	-	11.8	*16.3*	*14.2*	*12.2*
22	-	11.2	-	-	-	-	-	11.4	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Table G-7 Predicted profiles of design equivalent turbulence intensity at the Mansa site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Man _01	Man _02	Man _03	Man _04	Man _05	Man _06	Man _07	Man _08	Man _09	Man _10	Man _11	Man _12	Man _13	Man _14	Man _15	Man _16	Man _17	*A*	*B*	*C*
3	33.6	33.8	32.1	33.3	33.9	33.8	33.8	33.8	33.4	33.5	33.7	33.6	33.8	33.7	32.0	33.1	33.9	*41.9*	*36.6*	*31.4*
4	29.5	29.6	27.7	29.0	29.6	29.5	29.5	29.5	29.1	29.2	29.5	29.3	29.5	29.4	27.6	28.9	29.7	*34.4*	*30.1*	*25.8*
5	26.3	26.5	24.4	25.7	26.3	26.2	26.2	26.3	26.0	26.0	26.2	25.9	26.2	26.2	24.2	25.6	26.3	*29.9*	*26.2*	*22.4*
6	23.8	24.0	22.1	23.0	23.7	23.7	23.8	23.9	23.6	23.5	23.7	23.5	23.8	23.8	21.8	23.1	23.9	*26.9*	*23.6*	*20.2*
7	21.7	21.8	20.1	20.8	21.5	21.4	21.6	21.7	21.5	21.4	21.5	21.3	21.5	21.6	19.8	20.9	21.6	*24.8*	*21.7*	*18.6*
8	**20.0**	**20.2**	**18.8**	**18.7**	**19.6**	**19.5**	**19.8**	**20.0**	**19.9**	**19.6**	**19.6**	**19.5**	**19.7**	**20.0**	**18.2**	**18.9**	**19.8**	*23.2*	*20.3*	*17.4*
9	**18.1**	**18.2**	**17.1**	**16.6**	**17.4**	**17.4**	**17.6**	**18.0**	**18.0**	**17.6**	**17.5**	**17.4**	**17.5**	**17.9**	**16.5**	**16.9**	**17.7**	*22.0*	*19.2*	*16.5*
10	**16.1**	**16.2**	**15.1**	**14.8**	**15.4**	**15.3**	**15.5**	**15.8**	**15.8**	**15.6**	**15.4**	**15.2**	**15.4**	**15.8**	**14.5**	**14.9**	**15.5**	*21.0*	*18.3*	*15.7*
11	**13.7**	**13.9**	**12.8**	**12.7**	**13.2**	**13.2**	**13.4**	**13.8**	**13.7**	**13.4**	**13.2**	**13.2**	**13.3**	**13.7**	**12.4**	**12.8**	**13.4**	*20.1*	*17.6*	*15.1*
12	**11.6**	**11.7**	**11.2**	**10.9**	**11.2**	**11.3**	**11.5**	**11.7**	**11.6**	**11.3**	**11.3**	**11.3**	**11.3**	**11.6**	**10.7**	**11.0**	**11.4**	*19.5*	*17.0*	*14.6*
13	**9.8**	**9.9**	**9.6**	**9.4**	**9.8**	**9.9**	**9.9**	**10.0**	**9.8**	**9.8**	**9.8**	**9.9**	**9.8**	**10.0**	**9.5**	**9.5**	**10.0**	*18.9*	*16.5*	*14.2*
14	**8.8**	**8.8**	**8.9**	**8.2**	**8.9**	**8.8**	**9.0**	**9.1**	**9.1**	**8.6**	**8.6**	**8.8**	**8.7**	**8.9**	**8.5**	**8.0**	**8.9**	*18.4*	*16.1*	*13.8*
15	**8.3**	**8.2**	**7.8**	**8.7**	**8.7**	**8.4**	**8.4**	**8.4**	**8.0**	**7.9**	**8.1**	**8.1**	**8.4**	**8.3**	**7.7**	**8.4**	**8.6**	*18.0*	*15.7*	*13.5*
16	9.3	8.8	8.0	10.1	10.0	9.3	9.2	9.1	8.2	8.6	8.9	8.9	9.2	8.9	8.2	9.4	9.5	*17.6*	*15.4*	*13.2*
17	10.2	10.6	9.5	11.2	11.0	11.1	11.0	10.8	9.4	10.0	10.7	10.5	11.0	10.2	9.1	11.5	11.4	*17.3*	*15.1*	*13.0*
18	10.7	10.5	10.3	11.1	10.6	10.5	11.3	11.0	10.4	10.4	10.2	10.9	10.6	10.8	10.3	11.5	11.0	*17.0*	*14.9*	*12.7*
19	12.5	11.9	12.0	12.9	13.0	12.3	12.0	12.0	11.4	11.9	11.9	12.3	12.6	12.7	12.2	12.5	12.7	*16.7*	*14.6*	*12.5*
20	12.0	12.4	12.1	12.1	12.5	12.8	13.3	13.2	12.7	12.4	12.7	12.7	12.5	12.2	11.8	12.4	12.8	*16.5*	*14.4*	*12.4*
21	11.0	11.0	11.2	11.0	10.9	10.8	11.2	11.1	11.5	11.4	10.8	11.5	11.6	13.4	11.7	13.0	10.9	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	11.3	-	10.5	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Man _18	**Man _19**	**Man _20**	**Man _21**	**Man _22**	**Man _23**	**Man _24**	**Man _25**	***A***	***B***	***C***
3	32.2	32.8	33.3	33.4	31.8	32.7	33.3	33.6	*41.9*	*36.6*	*31.4*
4	27.8	28.6	29.3	29.3	27.5	28.3	29.0	29.5	*34.4*	*30.1*	*25.8*
5	24.4	25.5	26.2	26.1	24.1	24.9	25.6	26.2	*29.9*	*26.2*	*22.4*
6	22.0	23.0	23.8	23.8	21.7	22.2	23.0	23.6	*26.9*	*23.6*	*20.2*
7	20.0	20.9	21.8	21.7	19.7	20.0	20.9	21.4	*24.8*	*21.7*	*18.6*
8	**18.4**	**19.3**	**20.1**	**20.0**	**18.3**	**18.2**	**19.3**	**19.8**	*23.2*	*20.3*	*17.4*
9	**16.5**	**17.4**	**18.4**	**18.2**	**16.6**	**16.2**	**17.3**	**17.8**	*22.0*	*19.2*	*16.5*
10	**14.5**	**15.5**	**16.3**	**16.1**	**14.7**	**14.4**	**15.3**	**15.8**	*21.0*	*18.3*	*15.7*
11	**12.5**	**13.5**	**14.0**	**13.8**	**12.5**	**12.4**	**13.1**	**13.5**	*20.1*	*17.6*	*15.1*
12	**10.8**	**11.5**	**12.2**	**12.0**	**10.9**	**10.5**	**11.1**	**11.3**	*19.5*	*17.0*	*14.6*
13	**9.6**	**9.7**	**10.3**	**10.2**	**9.6**	**9.0**	**9.4**	**9.6**	*18.9*	*16.5*	*14.2*
14	**8.7**	**8.3**	**9.0**	**9.0**	**8.7**	**8.1**	**8.6**	**8.6**	*18.4*	*16.1*	*13.8*
15	**7.9**	**8.0**	**7.9**	**7.9**	**7.9**	**8.4**	**8.4**	**8.5**	*18.0*	*15.7*	*13.5*
16	8.5	8.4	8.3	8.4	8.4	10.0	9.7	9.9	*17.6*	*15.4*	*13.2*
17	9.2	10.0	9.8	9.7	9.2	10.5	10.5	10.2	*17.3*	*15.1*	*13.0*
18	9.6	10.3	10.2	11.0	10.2	11.8	11.8	11.1	*17.0*	*14.9*	*12.7*
19	12.4	11.9	11.8	12.2	12.6	12.9	12.8	13.1	*16.7*	*14.6*	*12.5*
20	12.1	11.9	12.1	12.3	11.7	11.5	11.8	11.3	*16.5*	*14.4*	*12.4*
21	11.0	12.4	11.4	12.5	11.7	-	-	11.1	*16.3*	*14.2*	*12.2*
22	-	-	13.2	13.3	11.2	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in ***bold*** *font. Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Table G-8 Predicted profiles of design equivalent turbulence intensity at the Malawi site for a Generic 4 MW wind turbine at a hub height of 130 m

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]																	*IEC 61400-1 Ed3 Turbine Subclass*		
	Mal_01	Mal_02	Mal_03	Mal_04	Mal_05	Mal_06	Mal_07	Mal_08	Mal_09	Mal_10	Mal_11	Mal_12	Mal_13	Mal_14	Mal_15	Mal_16	Mal_17	*A*	*B*	*C*
3	32.6	32.9	32.9	32.9	33.5	34.0	33.9	33.1	33.2	33.4	33.7	33.0	32.8	33.8	33.3	32.5	32.7	*41.9*	*36.6*	*31.4*
4	27.8	28.2	28.3	28.3	29.2	29.5	29.1	28.5	28.5	28.5	29.1	28.5	28.2	29.2	28.8	27.9	28.1	*34.4*	*30.1*	*25.8*
5	24.1	24.5	24.8	24.6	26.0	26.0	25.4	24.9	24.7	24.8	25.4	24.9	24.6	25.6	25.2	24.4	24.4	*29.9*	*26.2*	*22.4*
6	21.4	21.9	22.4	22.1	23.7	23.5	22.7	22.3	22.0	22.1	22.9	22.4	21.9	23.0	22.8	22.0	21.7	*26.9*	*23.6*	*20.2*
7	19.2	19.7	20.6	20.1	22.1	21.6	20.3	20.4	19.6	19.8	20.8	20.4	19.8	21.0	20.8	20.2	19.4	*24.8*	*21.7*	*18.6*
8	**17.0**	**17.7**	**18.9**	**18.2**	**20.6**	**19.9**	**18.1**	**18.5**	**17.4**	**17.7**	**18.9**	**18.6**	**17.7**	**19.2**	**19.0**	**18.5**	**17.3**	*23.2*	*20.3*	*17.4*
9	**15.1**	**15.9**	**17.3**	**16.4**	**18.9**	**18.2**	**15.9**	**16.8**	**15.2**	**15.7**	**17.0**	**16.8**	**15.7**	**17.3**	**17.2**	**16.8**	**15.2**	*22.0*	*19.2*	*16.5*
10	**13.1**	**13.9**	**15.4**	**14.5**	**17.1**	**16.4**	**13.8**	**14.6**	**13.2**	**13.6**	**14.8**	**14.6**	**13.7**	**15.2**	**15.1**	**14.9**	**13.2**	*21.0*	*18.3*	*15.7*
11	**11.2**	**11.9**	**13.3**	**12.5**	**15.2**	**14.4**	**11.8**	**12.6**	**11.3**	**11.5**	**12.7**	**12.6**	**11.7**	**13.0**	**13.0**	**12.8**	**11.3**	*20.1*	*17.6*	*15.1*
12	**9.4**	**10.1**	**11.3**	**10.6**	**13.4**	**12.6**	**10.1**	**10.9**	**9.4**	**9.8**	**10.9**	**10.8**	**9.9**	**11.2**	**11.2**	**10.7**	**9.5**	*19.5*	*17.0*	*14.6*
13	**8.1**	**8.6**	**9.7**	**9.2**	**12.0**	**11.3**	**8.8**	**9.4**	**8.2**	**8.6**	**9.5**	**9.4**	**8.7**	**9.9**	**9.8**	**9.2**	**8.2**	*18.9*	*16.5*	*14.2*
14	**7.1**	**7.5**	**8.4**	**8.1**	**10.9**	**10.2**	**7.8**	**8.2**	**7.1**	**7.6**	**8.3**	**8.2**	**7.8**	**8.7**	**8.5**	**7.9**	**7.2**	*18.4*	*16.1*	*13.8*
15	**6.6**	**7.0**	**8.0**	**7.6**	**10.1**	**9.5**	**7.3**	**7.8**	**6.4**	**7.0**	**8.0**	**7.9**	**7.3**	**8.3**	**8.3**	**7.3**	**6.5**	*18.0*	*15.7*	*13.5*
16	7.8	7.8	8.6	8.2	10.1	9.6	7.9	7.9	7.9	7.9	8.4	8.3	7.9	8.7	8.5	8.2	7.5	*17.6*	*15.4*	*13.2*
17	10.1	9.8	10.4	10.1	11.0	10.9	10.0	9.6	10.5	10.0	10.1	10.3	9.8	10.1	10.3	10.4	9.9	*17.3*	*15.1*	*13.0*
18	11.8	11.6	11.9	11.6	12.5	12.0	12.2	11.6	12.0	12.1	12.1	11.9	11.7	12.2	11.9	12.1	11.7	*17.0*	*14.9*	*12.7*
19	14.0	13.2	12.8	12.7	12.5	12.4	14.6	12.4	12.5	14.6	14.0	12.4	13.3	14.0	12.4	12.5	12.6	*16.7*	*14.6*	*12.5*
20	12.2	12.2	12.3	12.3	12.3	12.3	15.0	12.3	12.3	14.3	14.3	12.2	14.3	14.7	12.2	12.2	12.5	*16.5*	*14.4*	*12.4*
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in ***bold*** *font. Turbulence intensities that exceed subclass B limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.*

Hub height wind speed [m/s]	Design equivalent turbulence intensity for individual turbine [%]								*IEC 61400-1 Ed3 Turbine Subclass*		
	Mal_ 18	**Mal_ 19**	**Mal_ 20**	**Mal_ 21**	**Mal_ 22**	**Mal_ 23**	**Mal_ 24**	**Mal_ 25**	***A***	***B***	***C***
3	33.2	34.1	32.8	33.3	33.9	32.8	32.9	32.8	*41.9*	*36.6*	*31.4*
4	28.6	29.6	28.9	28.8	29.6	28.1	28.2	28.5	*34.4*	*30.1*	*25.8*
5	25.0	26.0	25.7	25.2	26.4	24.4	24.6	25.1	*29.9*	*26.2*	*22.4*
6	22.3	23.6	23.7	22.6	24.1	21.7	22.1	23.0	*26.9*	*23.6*	*20.2*
7	20.1	21.6	22.3	20.3	22.4	19.4	20.0	21.5	*24.8*	*21.7*	*18.6*
8	**18.1**	**19.9**	**21.1**	**18.1**	**20.9**	**17.2**	**18.0**	**20.1**	*23.2*	*20.3*	*17.4*
9	**16.0**	**18.1**	**19.7**	**16.0**	**19.3**	**15.1**	**16.2**	**18.6**	*22.0*	*19.2*	*16.5*
10	**13.9**	**15.9**	**17.9**	**13.9**	**17.4**	**13.1**	**14.2**	**16.7**	*21.0*	*18.3*	*15.7*
11	**11.7**	**13.7**	**15.9**	**12.1**	**15.5**	**11.1**	**12.2**	**14.5**	*20.1*	*17.6*	*15.1*
12	**10.2**	**11.9**	**13.8**	**10.2**	**13.6**	**9.2**	**10.3**	**12.4**	*19.5*	*17.0*	*14.6*
13	**9.0**	**10.5**	**12.1**	**9.0**	**12.3**	**8.0**	**8.9**	**10.7**	*18.9*	*16.5*	*14.2*
14	**8.0**	**9.2**	**10.7**	**8.1**	**11.2**	**7.0**	**7.7**	**9.3**	*18.4*	*16.1*	*13.8*
15	**7.5**	**8.8**	**9.7**	**7.4**	**10.6**	**6.9**	**7.3**	**8.7**	*18.0*	*15.7*	*13.5*
16	8.0	9.0	9.6	8.1	10.9	8.4	8.2	9.1	*17.6*	*15.4*	*13.2*
17	9.7	10.3	10.7	10.6	12.2	10.9	10.4	10.6	*17.3*	*15.1*	*13.0*
18	12.0	11.9	11.9	12.0	13.5	12.2	11.8	11.8	*17.0*	*14.9*	*12.7*
19	14.4	13.6	12.1	12.4	12.6	13.1	13.1	11.8	*16.7*	*14.6*	*12.5*
20	15.0	14.7	12.2	12.2	12.4	12.8	13.3	12.3	*16.5*	*14.4*	*12.4*
21	-	-	-	-	-	-	-	-	*16.3*	*14.2*	*12.2*
22	-	-	-	-	-	-	-	-	*16.1*	*14.1*	*12.1*
23	-	-	-	-	-	-	-	-	*15.9*	*13.9*	*11.9*
24	-	-	-	-	-	-	-	-	*15.7*	*13.8*	*11.8*
25	-	-	-	-	-	-	-	-	*15.6*	*13.6*	*11.7*

*Note: The wind speed range corresponding to $0.2V_{ref}$ to $0.4V_{ref}$, for IEC Class II is shown in **bold** font.*
Turbulence intensities that exceed subclass A limits within $0.2V_{ref}$ to $0.4V_{ref}$ are shown in red font.

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