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June 6, 2017

Ms. Barcy F. McNeal, Secretary
Public Utilities Commission of Ohio
180 E. Broad St., 11th Floor
Columbus, OH 43215-3793

Re: OPSB Case No. 17-1148-EL-BGA
Application for an Amendment to the Black Fork Wind Energy
Certificate Issued in Case No. 10-2865-EL-BGN

Dear Ms. McNeal:

Accompanying this letter are hard and electronic copies of an application by Black Fork Wind Energy, LLC for an amendment to its Certificate of Environmental Compatibility and Public Need issued in Case No. 10-2865-EL-BGN. This amendment seeks to allow the use of the Vestas V110 turbine model with a 2.2 megawatt capacity which has the same physical dimensions as the previously approved Vestas V110 turbine model with a 2.0 megawatt capacity. Black Fork Wind Energy also is requesting an extension of its certificate to January 23, 2020. The original application for an amendment was electronically filed.

In accordance with Rule 4906-2-04 of the Ohio Administrative Code, we make the following declarations:

Name of the applicant:

Black Fork Wind Energy, LLC
a subsidiary of Element Power US, LLC
155 Federal Street, Suite 1200
Boston, MA 02110

Names and location of the facility:

Black Fork Wind Energy Project
Crawford and Richland Counties, Ohio
Auburn, Jackson, Jefferson, Sandusky and Vernon Townships in Crawford County
Plymouth, Sandusky and Sharon Townships in Richland County

Name of authorized representative:

Michael J. Settineri
Vorys, Sater, Seymour and Pease LLP
52 E. Gay Street
Columbus, OH 43215
614-464-5462
mjsettineri@vorys.com

Notarized Statement:

See attached Affidavit of Christopher L. Kopecky
Assistant Corporate Secretary
Black Fork Wind Energy, LLC

Black Fork Wind Energy, LLC is requesting a waiver from the Ohio Power Siting Board Rule 4906-3-11(B)(2)(a)(iii) to allow for newspaper notice of this application.

Very truly yours,

Michael J. Settineri
Vorys, Sater, Seymour and Pease LLP
Attorneys for Black Fork Wind Energy, LLC

MJS/jaw
Enclosure

BEFORE THE OHIO POWER SITING BOARD

In the Matter of the Application of Black Fork Wind Energy, LLC to Amend its Certificate Issued in Case No. 10-2865-EL-BGN	))))	**Case No. 17-1148-EL-BGA**

OFFICER'S AFFIDAVIT

COMMONWEALTH OF MASSACHUSETTS)
) SS:
COUNTY OF SUFFOLK)

Now comes Christopher L. Kopecky, Assistant Corporate Secretary of Black Fork Wind Energy, LLC, having been first duly sworn, declares and states as follows:

1. He is an executive officer in charge of the Black Fork Wind Energy project in Crawford and Richland Counties, Ohio.

2. He has reviewed the Application for a Second Amendment to the Certificate issued in Case No. 10-2865-EL-BGN for the Black Fork Wind Energy project.

3. To the best of his knowledge, the information and statements contained in the Application for a Second Amendment to the Certificate are true and correct and the Application for a Second Amendment to the Certificate is complete.

[signature]
Christopher L. Kopecky
Assistant Corporate Secretary
Black Fork Wind Energy, LLC

Sworn to before me and signed in my presence this 5 day of June 2017.

[signature]
Notary Public
My Commission Expires 5/13/2022

JOANNA M. PERRY
Notary Public
COMMONWEALTH OF MASSACHUSETTS
My Commission Expires
May 13, 2022

BEFORE THE OHIO POWER SITING BOARD

In the Matter of the Application	**)**	
of Black Fork Wind Energy, LLC to	**)**	**Case No. 17-1148-EL-BGA**
Amend the Certificate	**)**	
Issued in Case No. 13-1177-EL-BGN	**)**	

Application to Amend the Black Fork Wind Energy, LLC Certificate

Issued January 23, 2012 in Case No. 10-2865-EL-BGN

June 6, 2017

Introduction

Black Fork Wind Energy, LLC (hereinafter referred to as the "Applicant"), a wholly owned subsidiary of Element Power US, LLC, is certificated to construct the Black Fork Wind Energy Project, a wind-powered electric generation facility to be located in Crawford and Richland Counties, Ohio. The project will consist of up to 91 wind turbines and will have a maximum nameplate capacity of up to 200 MW. Approved turbines for the project consist of the Vestas V100 (1.8 MW) with a total height of 426.5 feet; the GE XLE (1.6 MW) with a total height of 397 feet; and the Siemens SWT-2.3-101 (2.3 MW) with a total height of 494 feet, the Vestas V110 (2.0 MW) turbine using either an 80 meter hub height or 95 meter hub height (maximum height of 492 feet) and the GE 2.3-107 (2.3 MW) turbine with either an 80 meter or 94 meter hub height (maximum height of 483 feet).

The original Application for a certificate of environmental compatibility and public need was filed on March 10, 2011, in Case No. 10-2865-EL-BGN. A Joint Stipulation and Recommendation ("Joint Stipulation") entered into by the Applicant, the Ohio Power Siting Board's Staff and the Ohio Farm Bureau Federation was filed on September 28, 2011. Thereafter, an Amendment to the Joint Stipulation was executed by the same parties and the Crawford County Board of County Commissioners, which included terms related to additional road use conditions. The Board's Staff signed the amendment stating it did not oppose the amendment, and the Board of County Commissioners signed the amendment stating that it did not oppose the Joint Stipulation and supported and recommended adoption of conditions 72 through 80 of the amended Joint Stipulation. Following a hearing, the Board issued an Opinion, Order and Certificate in Case No. 10-2865-EL-BGN on January 23, 2012 (the "Certificate"). On May 24, 2012, certain intervenors appealed the Board's decision to issue a Certificate to the Supreme Court of Ohio. The Court affirmed the Board's decision on December 18, 2013.

On September 12, 2014, the Applicant submitted an application to amend its Certificate in Case No. 14-1591-EL-BGA which included a request to utilize two additional turbine models, the Vestas V110 (2.0 MW) turbine and the GE 2.3-107 (2.3 MW) turbine for this project. The Board approved that application on August 27, 2015 over the objections of certain intervening parties. In addition, on March 24, 2016, the Board approved Black Fork's September 12, 2014 motion to extend the term of the Certificate, from January 23, 2017 to January 23, 2019.

Through this application, the Applicant is proposing a capacity increase to the already approved Vestas V110 turbine model in addition to seeking an additional extension of its Certificate. The V110 turbine is now available in a 2.2 MW version at the same dimensions as the 2.0 MW version, and the Board has approved use of this turbine for other projects (see Case No. 16-1717-EL-BGA). Concurrent with this application, the Applicant seeks to extend its Certificate to January 23, 2020, which would reflect the same three year period of extension that other projects in

Ohio have received. Unless otherwise noted, all information submitted in prior applications remains unchanged and not applicable to this amendment application.

Turbine Model Capacity Increase – Vestas V110 Turbine

The manufacturer of the Vestas V110 turbine has made technological improvements to the turbine, allowing the capacity to increase from 2.0 MW to 2.2 MW. Importantly, the V110 turbine's dimensions including rotor diameter and hub height remain the same. Both turbines will have a 95 meter hub height with a rotor diameter of 110 meters. The 2.2 MW version of the V110 model can be operated at the same operational maximum sound power output as the 2.0 MW version of the V110 model. The only change to the turbine is the use of the V110 turbine at a 2.2 MW capacity in addition to the 2.0 MW design.

Because this application only seeks Board approval for a capacity rating increase (2.0 MW to 2.2 MW for the V110 model), no physical aspects of the approved project are being modified. All approved turbine sites remain unchanged as well as the location of the project's collector substation, access roads and collection lines. The only change is the capacity increase for the V110 model. Of the currently approved turbines, the GE 2.3-107 turbine and the Siemens SWT-2.3-101 turbines have the highest nameplate capacity at 2.3 MW and if selected would result in an 86 turbine project. The turbine with the lowest nameplate capacity remains the GE XLE at 1.6 MW and if selected would result in a 91 turbine project. As with the already approved V110 2.0 MW turbine, selection of the V110 2.2 MW turbine would result in a 91 turbine project.

The below information on the V110 2.2 MW turbine is being submitted in accordance with Board rule 4906-4-03. The only change to the project with the exception of the request to extend the Certificate is the capacity increase from 2.0 MW to 2.2 MW for the V110 turbine model. All other information regarding the project previously submitted to the Board remains unchanged.

General Overview of the V110 2.2 MW Turbine

The V110 2.2 MW turbine represents advancements in Vestas' 2.0 MW platform of turbines. The V110 2.2 MW turbine incorporates technology enhancements that include a 2.2 MW generator along with a 54 meter blade. General information on both the V110 2.0 MW turbine and the V110 2.2 MW turbine is provided in Appendix A (turbine brochures). The benefit of the 2.2 MW turbine is improved energy production, which will lower the cost of energy for the project and improve its competitiveness if the V110 turbine model is utilized.

Comparison Between V110 2.0 MW and 2.2 MW Turbines

The Vestas wind turbines proposed for the Project includes the Vestas V110 – 2.0 MW and now the V110 – 2.2 MW turbines at both 80 and 95 meter hub heights. The use of the 80 meter hub height for the V110 turbine is necessary at 14 turbine locations near an airport (see page 141 of the original Application). If the V110 turbine is selected, the remaining locations will utilize a 95 meter hub height. Importantly, the V110 – 2.0 MW and the V110 – 2.2 MW are physically identical, sharing the same components, tower heights, and rotor diameters; the V110 – 2.0 MW and the V110 – 2.2 MW therefore share the same safety characteristics. The V110 has been field-tested and Type Certified according to the IEC 61400 standard.

The technical specifications for the V110 2.0 MW turbine and the V110 2.2 MW turbine are listed in the below table. Correspondence from the manufacturer confirming that the 2.2 MW turbine and the 2.0 MW turbine are virtually identical, with the exception of nameplate capacity, is attached in Appendix B.

Turbine Detail	**V110 2.0 MW Turbine**	**V110 2.2 MW Turbine**
Rated power	2.0 MW	2.2 MW
Wind class	IIIA (95 meters) and IIIC (80 meters)	S
Rotor diameter	110 meters	110 meters
Swept area	9,503 square meters	9,503 square meters
Gearbox	2 helical stages and 1 planetary stage	2 helical stages and 1 planetary stage
Generator	Doubly fed	Doubly fed
Frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
Hub Height	95 meters	95 meters

Importantly, because the V110 2.0 MW and 2.2 MW turbines have the same rotor diameter and hub height (total tip height of 492 feet), the setback calculation for the V110 turbine model remains the same (541 feet to the nearest property line and 930 feet to the nearest non-participating residential structure). Note, that the Project had applied a 1,250 feet self-imposed setback from residential structures. All turbine locations as currently certificated comply with the self-imposed setback of 1,250 feet. Like the approved V110 2.0 MW turbine and because it has the same overall dimensions, the V110 2.2 MW turbine will satisfy the approved project setbacks. The identical overall dimensions also means that shadow flicker produced by the V110 2.2 MW turbine will be identical to the already approved V110 2.0 MW turbine.

Sound Power Output Comparison

In addition, both proposed wind turbines can be operated at the same maximum noise level of 106.1 dBA in a standard sound mode (Mode 0) operation using serrated trailing edge technology. Prior preliminary data for the V110 turbine utilized when the Board approved the V110 model in 2015 for this project included a maximum sound power output of 107.5 dBA based on preliminary manufacturer data for a standard blade. The manufacturer has now confirmed a maximum sound power output of 106.1 dBA at standard sound mode (Mode 0) operation using serrated trailing edge blade technology, which the Applicant will utilize if either the Vestas V110 2.0 or 2.2 MW turbine is selected for the project (see correspondence in Appendix B). Also, as stated in the Applicant's application to add the Vestas V110 2.0 turbine in Case No. 14-1591-EL-BGA, the Vestas V110 turbine can be modeled to satisfy Condition 51 of the Certificate (which imposes an operational noise requirement on the project) through a combination of dropping turbines and applying noise reduction technology.

Safety Features

The V110 2.2 MW turbine has the same safety features as the V110 2.0 MW turbine, and will contain safety features as generally described in the project's initial application. These features include sensors that capture outside temperatures, wind speed and direction, and turbine operating parameters such as component temperatures, pressure levels, blade vibrations and positioning. The 2.2 MW turbine also will have the same lightening protection system as the 2.0 MW turbine. Moreover, the Applicant will adhere to Certificate Condition 38, which states that "[t]he applicant shall comply with the turbine manufacturer's most current safety manual and shall maintain a copy of that safety manual in the operation and maintenance O&M building of the facility."

Project Schedule

The Applicant's Certificate permits the construction of a facility currently comprised of up to 91 wind turbines. The original Application estimated the start of construction in March 2012 with an in-service date of December 2012. However, the Project was delayed due to an appeal of the Ohio Power Siting Board's decision to the Supreme Court of Ohio. This litigation hampered Applicant's ability to move forward with the construction for nearly two years. In addition, the Project was delayed due to changes in the energy market in Ohio, including the increased production of natural gas from the Utica and Marcellus shale plays. Because of these delays, the Applicant sought and received an extension of its current certificate to January 23, 2019.

Since submitting that extension request in September, 2014, the Applicant has diligently pursued continued development of the project. Efforts include:

- Renewing lease agreements supporting site control for all 91 approved wind turbine locations;
- Signing new lease and facilities easement agreements;

- Continuing to meet with local officials including the Crawford County Commissioners and the Richland County Commissioners;
- Ordering and commencing manufacturing of a 138-kV transformer for the Project substation, thereby qualifying the Project for the full Production Tax Credit;
- Commencing preliminary design engineering of the Interconnection Facilities under the executed Generator Interconnection Agreement with AEP Transmission and PJM Interconnection LLC; and
- Responding to several renewable energy requests for proposals issued by regional electric utilities and commercial and industrial corporations.

All of these efforts show continued development of the Project under the Certificate with a goal of bringing the Project to commercial operation.

Although the Applicant would like to commence construction as soon as possible, steps remain to bring the Project to the point that physical construction can commence. For example, certain conditions under the Certificate require redesign of certain aspects of the Project that in turn may require additional amendments to the Certificate. Per Condition 12, the collection line system must be redesigned connecting turbines 30 and 44 to turbine 57, considering among other factors better utilization of disturbed areas of this project. Per Condition 30, the Applicant must re-design the underground electric collection lines proposed between turbine sites 16 and 90, to avoid impacts to the woodlot located between these turbines. If amendments are required to comply with these conditions, the Project could incur further delays

Also, as the Applicant noted on page 16 of the original Application, there are many events that can impact the Project schedule, including the complexity of preparing a modern wind energy facility for permitting, construction, financing, off-takes, etc., and the impacts of any such delays can vary widely. Critical delays may have material, adverse effects on Facility financing, including Applicant's ability to procure turbines and other Facility components. Such delays may push the in-service date back.

Assuming no additional litigation over Certificate changes, however, and not taking into account the current litigation at the Supreme Court of Ohio by certain intervenors, construction of the Project could commence at the earliest in the fourth quarter of 2017 with an in-service date of November 2018, as reflected in the below chart.

	Q4 2014	Q1 2015	Q2 2015	Q3 2015	Q4 2015	Q1 2016	Q2 2016	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019
Preparation of Final Design											■	■									
Power Marketing - PPA Negotiation and Execution										■	■	■									
Turbine Supply and EPC Contract Completion													■	■							
Project Construction															■	■	■				
Commercial Operation Date																	■				

Although the Applicant hopes to commence construction in accordance with the above schedule, as noted above the Project faces continued litigation from intervenors with a new appeal pending at the Supreme Court of Ohio (Case No. 2017-0412) on the Board's extension of the Certificate and seeking imposition of the most recent legislative setbacks. Additional uncertainty faces renewable project development in Ohio as a result of pending legislation on Ohio's renewable portfolio requirements. The pending litigation will likely lead to continued delays to the Project and future delays could occur if litigation takes place over any future amendment to the Project. With the current Certificate set to expire in less than two-years and to account for these possible delays, the Applicant seeks to extend the term of the Certificate to January 23, 2020, to allow for continued project development and account for current and future delays that may occur. The Applicant recognizes the Board's well-established practice of granting extensions by motion, however, given the pending litigation over the prior extension grant, the Applicant is requesting the Certificate extension through this application.

Importantly, as with the Board's prior extension of the Certificate term, the same stipulated conditions as to the Project's operation will continue to apply, including conditions on operational noise requirements, setbacks and shadow flicker requirements.

Note, if approved, Black Fork's Certificate aggregate extension will be no more than granted to other similar projects in Ohio. *See e.g. In re Application of Buckeye Wind LLC*, Ohio Power Siting Bd. No. 08-0666-EL-BGN, Entry dated Aug. 25, 2014 (extending by 38 months the certificate to construct a wind-powered electric generation facility); *In re JW Great Lakes Wind, LLC*, Case No. 09-277-EL-BGN, Entry dated Mar. 9, 2015 (extending by 36 months the certificate to construct a wind-powered electric generation facility).

Conclusion

The Applicant appreciates the Board's consideration of this application, which presents only a model capacity increase and a request to extend the term of the certificate. Additional questions about the proposed nameplate capacity increase for the V110 turbine model and the project schedule may be directed to the undersigned counsel or to Bill Behling, Project Manager, Black Fork Wind Energy Project. Given that this amendment presents no physical changes to the facility design, the Applicant requests an expedited ruling on this application.

Respectfully submitted,

/s/ Michael J. Settineri
Michael J. Settineri (0073369)
Stephen M. Howard (0022421)
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Attorneys for Black Fork Wind Energy, LLC

APPENDIX A – TURBINE INFORMATION

2 MW PLATFORM

Wind. It means the world to us.™

Are you looking for the maximum return on **your investment** in wind energy?

Wind energy means the world to us. And we want it to mean the world to our customers, too, by maximising your profits and strengthening the certainty of your investment in wind power.

That's why, together with our partners, we always strive to deliver cost-effective wind technologies, high quality products and first class services throughout the entire value chain. And it's why we put so much emphasis on the reliability, consistency and predictability of our technology.

These aren't idle words. We have over 35 years' experience in wind energy. During that time, we've delivered more than 83 GW of installed capacity and we currently monitor over 33,000 wind turbines across the globe. Tangible proof that Vestas is the right partner to help you realise the full potential of your wind site.

What is the 2 MW platform?
Our 2 MW platform provides industry-leading reliability, serviceability and availability. Durable and dependable, the platform is built on technology that has been proven in the field over more than a decade. The 2 MW platform reduces your costs, minimises the risk of turbine downtime and helps to safeguard your investment.

You can choose from five turbines on the 2 MW platform:
- V90-1.8/2.0 MW® IEC IIA/IEC IIIA
- V100-2.0 MW® IEC IIB
- V110-2.0 MW™ IEC IIIA
- V116-2.0 MW™ IEC IIB
- V120-2.0 MW™ IEC IIIB/IEC S

Each 2 MW turbine incorporates enhancements that improve performance and reliability, reducing your cost of energy. The platform's predictability allows you to forecast confidently, strengthening the business case for investment, while the tried-and-tested design ensures you can produce energy on ultra-low, low, medium and high-wind onshore sites at the lowest possible cost, even in extreme weather conditions.
In addition, remote monitoring and easy servicing keep operational costs at a minimum, while its highly-tested components and power and control systems enhance reliability.

+18,500

Due to the strong performance and reliability of the 2 MW platform, over 18,500 turbines have been installed since 2000.

How does the 2MW platform increase **reliability** and **performance?**

Created with future generations of turbines in mind, the 2 MW platform's single-piece bed frame and strong main bearing housing provide a better foundation for loads. The frame and housing – each made from single-piece castings – work in conjunction to absorb higher loads from the rotor.

Additionally, the housing ensures correct alignment during bearing assembly, making the process accurate and efficient and distributing loads evenly.

A reliable performer

The 2 MW platform is an extremely reliable turbine, which is documented through its strong availability performance. With the newest addition of rotor sizes, the 2 MW platform offers a competitive selection of turbines for all wind segments.

Thoroughly tested

The current 2 MW platform is built on unique knowledge from more than a decade of operational experience. We constantly monitor the majority of the installed 2 MW turbines, providing us with very detailed and invaluable information about how the turbine operates under all kinds of site conditions.

Our quality-control system ensures that each component is produced to design specifications and performs to peak potential at site. We also employ a Six Sigma philosophy and have identified critical manufacturing processes (both in-house and for suppliers). We systematically monitor measurement trends that are critical to quality, locating defects before they occur.

Innovative CoolerTop®

Our exclusive CoolerTop® technology uses the wind's own energy to generate the cooling required, rather than consuming energy from the wind turbine generator. CoolerTop® has no moving parts and requires little maintenance. Furthermore, the absence of cooling fans contributes to turbine efficiency and makes no noise.

Power Optimised Modes increase energy output

The 2 MW platform supports Power Optimised Modes, used to maximise energy production under specific wind and site conditions. Based on a site analysis and under mild wind conditions, the V100-2.0 MW® and V110-2.0 MW® can be uprated up to 2.2 MW - maximising annual energy production.

The 2 MW platform covers a wide range of wind segments enabling you to find the best turbine for your specific site.

WINDCLASSES - IEC

TURBINE TYPE	IEC III (6.0 – 7.5 m/s)	IEC II (7.5 – 8.5 m/s)	IEC I (8.5 – 10.0 m/s)
2 MW TURBINES			
V90-1.8/2.0 MW® IEC IIA/IEC IIIA	Standard IEC conditions	Standard IEC conditions	Site dependent
V100-2.0 MW® IEC IIB		Standard IEC conditions	Site dependent
V110-2.0 MW® IEC IIIA	Standard IEC conditions	Site dependent	
V116-2.0 MW™ IEC IIB	Standard IEC conditions	Standard IEC conditions	
V120-2.0 MW™ IEC IIIB/IEC S	Standard IEC conditions		

■ Standard IEC conditions ■ Site dependent

Low Balance of Plant, installation and transportation costs

At Vestas, we use technology tailored to control loads on specific tower heights. We have applied this principle to the 2 MW platform by reducing both the weight of the turbine and the loads on the tower and foundation. This reduces foundation costs, saving you unnecessary expense.

All 2 MW turbines are easy to transport (by rail, truck or ship) to virtually any site around the world. In terms of weight, height and width, all components comply with local and international standard transportation limits, ensuring you incur no unforeseen costs. In addition, 2 MW turbines are built and maintained using tools and equipment that are standard in the installation and servicing industries – minimising maintenance costs.

Vestas Online® Business

All Vestas wind turbines benefit from Vestas Online® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for modern wind power plants. This flexible system includes an extensive range of monitoring and management functions to control your wind power plant in the same way as a conventional power plant. Vestas Online® Business enables you to optimise production levels, monitor performance, and produce detailed, tailored reports from anywhere in the world. The system's power plant controller provides active and reactive power regulation, power ramping and voltage control.

24/7 remote surveillance with VMP Global® and Vestas Online® Business

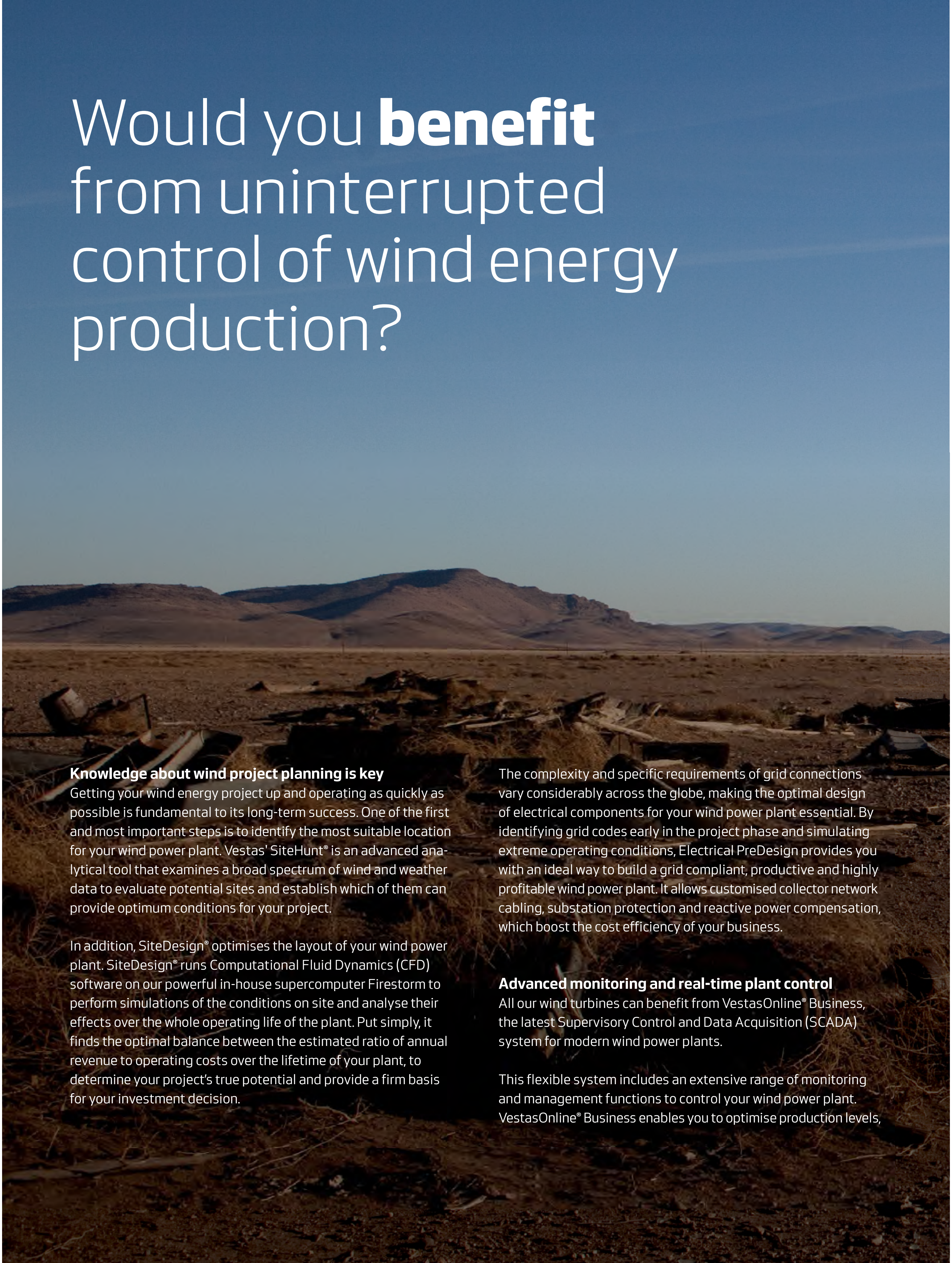
To reduce the cost of energy, the 2 MW platform is equipped with VMP Global®, our latest turbine control and operation software. Developed to run this latest generation of turbines, VMP Global®, combined with Vestas Online® Business, automatically manages the turbine 24/7 and ensures maximum power generation. The application also monitors and troubleshoots the turbines – both onsite and remotely – saving further expense on servicing.

Designed for serviceability

Service is facilitated by the overall design of the 2 MW platform and components are specifically positioned for easy access.

Options available for the 2 MW platform

- Power Optimised Modes up to 2.2 MW (Available for V100-2.0 MW® and V110-2.0 MW®)
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™



Would you **benefit** from uninterrupted control of wind energy production?

Knowledge about wind project planning is key
Getting your wind energy project up and operating as quickly as possible is fundamental to its long-term success. One of the first and most important steps is to identify the most suitable location for your wind power plant. Vestas' SiteHunt® is an advanced analytical tool that examines a broad spectrum of wind and weather data to evaluate potential sites and establish which of them can provide optimum conditions for your project.

In addition, SiteDesign® optimises the layout of your wind power plant. SiteDesign® runs Computational Fluid Dynamics (CFD) software on our powerful in-house supercomputer Firestorm to perform simulations of the conditions on site and analyse their effects over the whole operating life of the plant. Put simply, it finds the optimal balance between the estimated ratio of annual revenue to operating costs over the lifetime of your plant, to determine your project's true potential and provide a firm basis for your investment decision.

The complexity and specific requirements of grid connections vary considerably across the globe, making the optimal design of electrical components for your wind power plant essential. By identifying grid codes early in the project phase and simulating extreme operating conditions, Electrical PreDesign provides you with an ideal way to build a grid compliant, productive and highly profitable wind power plant. It allows customised collector network cabling, substation protection and reactive power compensation, which boost the cost efficiency of your business.

Advanced monitoring and real-time plant control
All our wind turbines can benefit from VestasOnline® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for modern wind power plants.

This flexible system includes an extensive range of monitoring and management functions to control your wind power plant. VestasOnline® Business enables you to optimise production levels,

+33,000

The Vestas Performance and Diagnostics Centre monitors more than 33,000 turbines worldwide. We use this information to continually develop and improve our products and services.

monitor performance and produce detailed, tailored reports from anywhere in the world. The VestasOnline® Power Plant Controller offers scalability and fast, reliable real-time control and features customisable configuration, allowing you to implement any control concept needed to meet local grid requirements.

Surveillance, maintenance and service

Operating a large wind power plant calls for efficient management strategies to ensure uninterrupted power production and to control operational expenses. We offer 24/7 monitoring, performance reporting and predictive maintenance systems to improve turbine performance and availability. Predicting faults in advance is essential, helping to avoid costly emergency repairs and unscheduled interruptions to energy production.

Our Condition Monitoring System (CMS) assesses the status of the turbines by analysing vibration signals. For example, by measuring the vibration of the drive train, it can detect faults at an early stage and monitor any damage. This information allows pre-emptive maintenance to be carried out before the component fails, reducing repair costs and production loss.

Additionally, our Active Output Management® (AOM) concept provides detailed plans and long term agreements for service and maintenance, online monitoring, optimisation and troubleshooting. It is possible to get a full scope contract, combining your turbines' state-of-the-art technology with guaranteed time or energy-based availability performance targets, thereby creating a solid base for your power plant investment. The Active Output Management® agreement provides you with long term and financial operational peace of mind for your business case.


Vestas

V90-1.8/2.0 MW®
IEC IIA/IEC IIIA
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	1,800/2,000 kW
Cut-in wind speed	4 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IIA/IEC IIIA

Standard operating temperature range from -20°C* to 40°C

SOUND POWER

Maximum	104 dB*

* Noise modes available

ROTOR

Rotor diameter	90 m
Swept area	6,362 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Generator type	4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	80 m (IEC IIA), 95 m (IEC IIA), and 105 m (IEC IIA)

NACELLE DIMENSIONS

Height for transport	4 m
Height installed (incl. CoolerTop®)	5.4 m
Length	10.4 m
Width	3.5 m

HUB DIMENSIONS

Max. transport height	3.4 m
Max. transport width	4 m
Max. transport length	4.2 m

BLADE DIMENSIONS

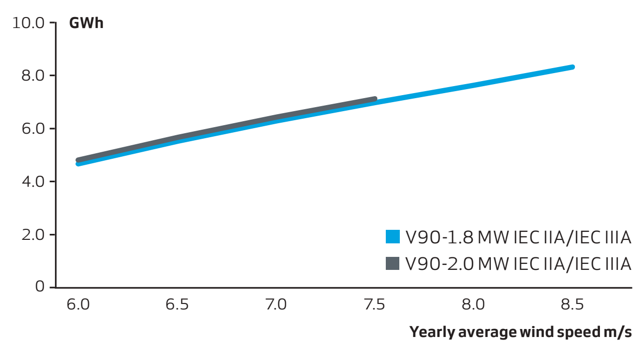
Length	44 m
Max. chord	3.9 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor = 2,
Standard air density = 1.225, wind speed at hub height

V100-2.0 MW®
IEC IIB
Facts & figures

POWER REGULATION Pitch regulated with variable speed

OPERATING DATA

Rated power	2,000 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	22 m/s
Re cut-in wind speed	20 m/s
Wind class	IEC IIB

Standard operating temperature range from -20°C* to 45°C

SOUND POWER

Maximum	105 dB*

* Noise modes available

ROTOR

Rotor diameter	100 m
Swept area	7,854 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Generator type	4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	80 m (IEC IIB) and 95 m (IEC IIB)

NACELLE DIMENSIONS

Height for transport	4 m
Height installed (incl. CoolerTop®)	5.4 m
Length	10.4 m
Width	3.5 m

HUB DIMENSIONS

Max. transport height	3.4 m
Max. transport width	4 m
Max. transport length	4.2 m

BLADE DIMENSIONS

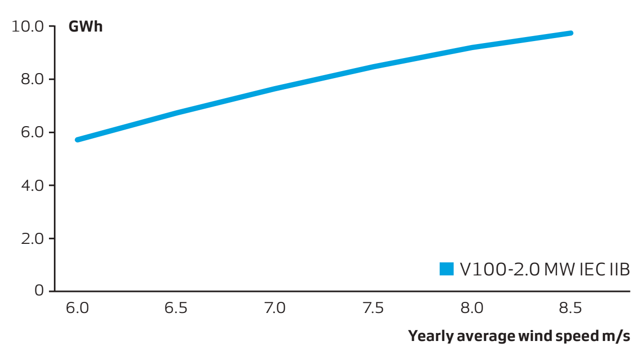
Length	49 m
Max. chord	3.9 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- Power Optimised Modes up to 2.2 MW (site specfic)
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2,
Standard air density = 1.225, wind speed at hub height

V110-2.0 MW® IEC IIIA Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	2,000 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	21 m/s
Re cut-in wind speed	18 m/s
Wind class	IEC IIIA

Standard operating temperature range from -20°C* to 45°C

SOUND POWER

Maximum	107.6 dB*

* Noise modes available

ROTOR

Rotor diameter	110 m
Swept area	9,503 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Generator type	4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	75 m (IECIIIA), 80 m (IEC IIIA), 95 m (IEC IIIA/IEC IIIB), 110 m (IEC IIIB), 120 m (IEC IIIB) and 125 m (IEC IIIB)

NACELLE DIMENSIONS

Height for transport	4 m
Height installed (incl. CoolerTop®)	5.4 m
Length	10.4 m
Width	3.5 m

HUB DIMENSIONS

Max. transport height	3.4 m
Max. transport width	4 m
Max. transport length	4.2 m

BLADE DIMENSIONS

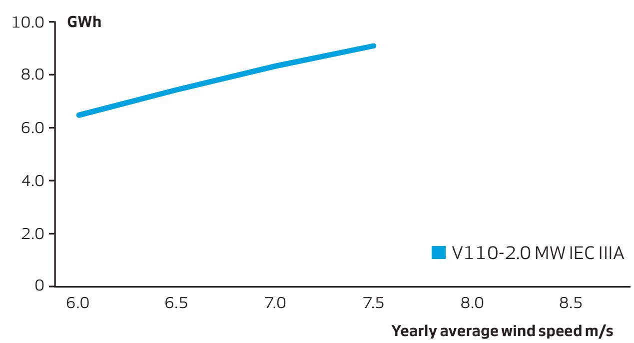
Length	54 m
Max. chord	3.9 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- Power Optimised Modes up to 2.2 MW (site specific)
- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2,
Standard air density = 1.225, wind speed at hub height

V116-2.0 MW™ IEC IIB Facts & figures

POWER REGULATION Pitch regulated with variable speed

OPERATING DATA

Rated power	2,000 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	20 m/s
Re cut-in wind speed	18 m/s
Wind class	IEC IIB

Standard operating temperature range from -20°C* to 45°C

SOUND POWER

Maximum	109.5 dB*

* Serrated trailing edges available to reduce sound power level

ROTOR

Rotor diameter	116 m
Swept area	10,568 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Generator type	4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	Site and country specific

NACELLE DIMENSIONS

Height for transport	4 m
Height installed (incl. CoolerTop®)	5.4 m
Length	10.4 m
Width	3.5 m

HUB DIMENSIONS

Max. transport height	3.6 m
Max. transport width	4 m
Max. transport length	4.2 m

BLADE DIMENSIONS

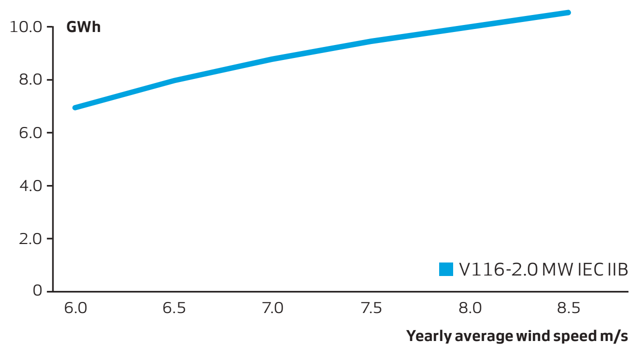
Length	57 m
Max. chord	3.9 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2,
Standard air density = 1.225, wind speed at hub height

V120-2.0 MW™ IEC IIIB/IEC S
Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	2,000 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	18 m/s
Re cut-in wind speed	16 m/s
Wind class	IEC IIIB/IEC S

Standard operating temperature range from -20°C* to 45°C

SOUND POWER

Maximum	110.5 dB*

* Serrated trailing edges available to reduce sound power level

ROTOR

Rotor diameter	120 m
Swept area	11,310 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Generator type	4-pole (50 Hz)/6-pole (60 Hz) doubly fed generator, slip rings

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	Site and country specific

NACELLE DIMENSIONS

Height for transport	4 m
Height installed (incl. CoolerTop®)	5.4 m
Length	10.4 m
Width	3.5 m

HUB DIMENSIONS

Max. transport height	3.6 m
Max. transport width	4 m
Max. transport length	4.2 m

BLADE DIMENSIONS

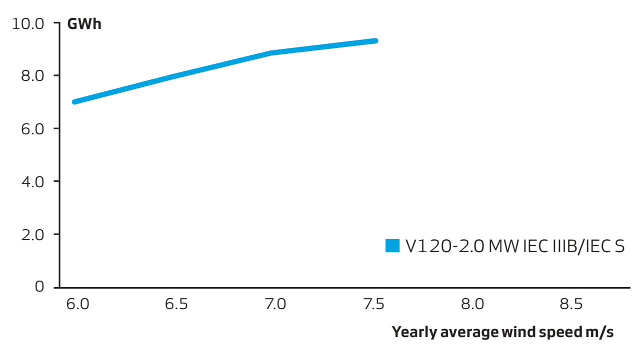
Length	59 m
Max. chord	3.9 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- Condition Monitoring System
- Vestas Ice Detection
- Smoke Detection
- Shadow Detection
- Low Temperature Operation to -30°C
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2,
Standard air density = 1.225, wind speed at hub height

Ensuring Business Case Certainty.

Our business depends on your success. We are commited to delivering maximum certainty on the revenue and costs of your wind farm.

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General specification

2.0/2.2MW V100/110 50/60Hz

Vestas Wind Systems A/S · Hedeager 42 · 8200 Aarhus N · Denmark · www.vestas.com

Table of contents

1 Abbreviations and technical terms 4
2 General description 5
3 Safety 5
3.1 Access 5
3.2 Escape 6
3.3 Rooms/working areas 6
3.4 Climbing facilities 6
3.5 Moving parts, guards, and blocking devices 6
3.6 Lighting 6
3.7 Emergency stop buttons 6
3.8 Power disconnection 6
3.9 Fire protection/first aid 6
3.10 Warning signs 7
3.11 Manuals and warnings 7
4 Type approvals 7
5 Operational envelope and performance guidelines 7
5.1 Climate and site conditions 8
5.1.1 Complex terrain 8
5.1.2 Altitude 9
5.1.3 Wind farm layout 9
5.2 Operational envelope (temperature and wind) 9
5.3 Operational envelope (grid connection) 11
5.4 Reactive power capability 13
5.4.1 Standard P/Q Charts 13
5.4.2 Site specific P/Q Chart 15
5.5 Fault ride through 16
5.5.1 OVRT 17
5.6 Reactive current contribution 17
5.6.1 Symmetrical reactive current contribution 17
5.6.2 Asymmetrical reactive current contribution 18
5.6.3 Sub synchronous resonance protection 18
5.7 Active and reactive power control 19
5.8 Voltage control 19
5.9 Frequency control 19
5.10 High voltage connection 19
5.10.1 Transformer 19
5.10.2 HV Switchgear 20
5.11 Main contributors to own consumption 22
6 Drawings 23
6.1 Structural design – illustration of outer dimensions 23
6.2 Structural design (side-view drawing) 24
6.3 Turbine protection systems 24
6.3.1 Braking concept 24
6.4 Overspeed protection 24
6.5 EMC system 24
6.6 Lightning protection system 25
6.7 Earthing 25
7 Environment 25
7.1 Chemicals 25
8 General reservations, notes, and disclaimers 26
9 Appendices 27
9.1 Design codes – structural design 27

9.2 Design codes – mechanical equipment 27
9.3 Design codes – electrical equipment 27
9.4 Design codes – I/O network system 28
9.5 Design codes – EMC system 28
9.6 Design codes – lightning protection 29
9.7 Design codes – earthing 29
9.8 Operational envelope conditions for power curve (at hub height) 30
9.9 Power curves, C_t values, and sound power levels 30

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See general reservations, notes, and disclaimers to this general specification in section General reservations, notes, and disclaimers, p. 26.

1 Abbreviations and technical terms

Abbreviation	Explanation
AEP	Annual Energy Production
EMC	Electromagnetic Compatibility
HH	Hub Height
HV	High Voltage
LPS	Lightning Protection System
MASL	Meters Above Sea Level
MW	Megawatt
OH&S	Occupational Health & Safety
OVRT	Over Voltage Ride-Through
pu	Per unit
rpm	Revolutions per minute
SSR-P	Sub Synchronous Resonance Protection
UVRT	Under Voltage Ride-Through

Table 1-1: Abbreviations

Term	Explanation
None	

Table 1-2: Explanation of terms

2 General description

The Vestas 2.0MW series wind turbine is a pitch-regulated upwind turbine with active yaw, gearbox and a three-blade rotor. The turbine is available in two rotor diameters 100 or 110m with a generator rated at 2.0 or 2.2MW. The turbine utilises a microprocessor pitch control system called OptiTip® and the OptiSpeed™ (variable speed) feature. With these features, the wind turbine is able to operate the rotor at variable speed (rpm), helping to maintain output at or near rated power.

Rotor	Rating [MW]	Wind Class [IEC]	Hub Height [m]	
			50Hz	60Hz
V100	2.0	IIB	75, 80, 95	80, 95
		IIC	80	80
	2.2	S	75, 80, 95	80, 95
V110	2.0	IIIA	75, 95	80, 95
	2.0	IIIB	95, 110, 120, 125	95, 110
	2.0	IIIC	80	80
	2.2	S	75, 80, 95 110, 120, 125	80, 95

Table 2-1: Turbine variants and tower heights

3 Safety

The safety specifications in this safety section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and Buyer's agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, (c) conducting all appropriate safety training and education and (d) reading and understanding all safety-related manuals and instructions. See section 3.11 Manuals and warnings for additional guidance.

3.1 Access

Access to the turbine from the outside is through the bottom of the tower. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is controlled with a lock. Unauthorised access to electrical switchboards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

3.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch.

The hatch in the roof can be opened from both the inside and the outside.

Escape from the service lift is by ladder.

3.3 Rooms/working areas

The tower and nacelle are equipped with connection points for electrical tools for service and maintenance of the turbine.

3.4 Climbing facilities

A ladder with a fall arrest system (rigid rail or wire system) is installed through the tower.

There are anchor points in the tower, nacelle, hub, and on the roof for attaching a full-body harness (fall arrest equipment).

Over the crane hatch there is an anchor point for the emergency descent equipment.

3.5 Moving parts, guards, and blocking devices

Moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

It is possible to block the pitch of the cylinder with mechanical tools in the hub.

3.6 Lighting

The turbine is equipped with light in tower, nacelle, and hub.

There is emergency light in case of the loss of electrical power.

3.7 Emergency stop buttons

There are emergency stop buttons in the nacelle and in the bottom of the tower.

3.8 Power disconnection

The turbine is designed to allow for disconnection from all its power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and in the bottom of the tower.

3.9 Fire protection/first aid

A CO_2 (recommended) or ABC fire extinguisher and first aid kit must be available in the nacelle during all service and maintenance activities. A fire blanket must be available nearby for all those activities for which the respective work instruction requires it.

3.10 Warning signs

Additional warning signs inside or on the turbine must be reviewed before operating or servicing the turbine.

3.11 Manuals and warnings

The Vestas Corporate OH&S Manual and manuals for operation, maintenance, and service of the turbine provide additional safety rules and information for operating, servicing, or maintaining the turbine.

4 Type approvals

The turbine will be type-certified according to the certification standards listed below:

- IEC 61400-22

5 Operational envelope and performance guidelines

Actual climate and site conditions have many variables and must be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

The turbine can be equipped with different power generation components depending on the region which may influence the performance of the turbine. Consult Vestas Wind Systems for further details.

NOTE As evaluation of climate and site conditions is complex, it is necessary to consult Vestas for every project.

5.1 Climate and site conditions

Values refer to hub height and as determined by the sensors and control system of the turbine.

Extreme design parameters				
	V100		**V110**	
	2MW	**2.2MW**	**2MW**	**2.2MW**
	IEC IIB	**IEC S**	**IEC IIIA**	**IEC S**
Ambient temperature range (standard turbine)	-30° to +50°C	-30° to +50°C	-30° to +50°C	-30° to +50°C
Ambient temperature interval (low temperature turbine)	-40° to +50°C	-40° to +50°C	-40° to +50°C	-40° to +50°C
Ambient temperature interval (Special temperature variant)	-5° to +50°C	-5° to +50°C	-5° to +50°C	-5° to +50°C
Extreme wind speed (10-minute average)	42.5 m/s	42.5 m/s	37.5 m/s	37.5 m/s
Survival wind speed (3-second gust)	59.5 m/s	59.5 m/s	52.5 m/s	52.5 m/s

Table 5-1: Extreme design parameters

Average design parameters				
	V100		**V110**	
	2MW	**2.2MW**	**2MW**	**2.2MW**
	IEC IIB	**IEC S**	**IEC IIIA**	**IEC S**
Annual average wind speed	8.5 m/s	7.5 m/s	7.5 m/s	6.5 m/s
Form factor, c	2.0	2.2	2.0	2.0
Turbulence intensity according to IEC 61400-1:2005, including wind farm turbulence (@15 m/s – 90% quartile)	16%	16%	18%	18%
Wind shear	0.20	0.20	0.20	0.20
Inflow angle (vertical)	8°	8°	8°	8°

Table 5-2: Average design parameters

5.1.1 Complex terrain

Classification of complex terrain according to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex, appropriate measures are to be included in the site assessment.

5.1.2 Altitude

The 2.0MW variants of the turbine are designed for use at altitudes up to 1.500 metres above sea level as standard. The 2.2MW variants are restricted in altitude according to Figure 5-2.

With altitudes above 1.500 metres, special considerations must be taken regarding for example HV installations and cooling performance. Consult Vestas for further information.

5.1.3 Wind farm layout

Turbine spacing is to be evaluated site-specifically. Spacing below three rotor diameters (2D) may require sector-wise curtailment.

5.2 Operational envelope (temperature and wind)

Values refer to hub height and are determined by the sensors and control system of the turbine.

Operational envelope (temperature and wind)				
	V100		V110	
	2MW	2.2MW	2MW	2.2MW
	IEC IIB	IEC S	IEC IIIA	IEC S
Ambient temperature interval (standard temperature turbine)	-20° to +45°C[1]	-20° to +45°C[1]	-20° to +45°C[1]	-20° to +45°C[1]
Ambient temperature interval (low temperature turbine)[1]	-30° to +45°C[1]	-30° to +45°C[1]	-30° to +45°C[1]	-30° to +45°C[1]
Ambient temperature interval (Special temperature turbine)	0° to +45°C[1]	0° to +45°C[1]	0° to +45°C[1]	0° to +45°C[1]
Cut-in (10 minute average)	3 m/s	3 m/s	3 m/s	3 m/s
Cut-out (10 minute average)	22 m/s	22 m/s	22[2] m/s	20 m/s
Re-cut in (10 minute average)	20 m/s	20 m/s	20[2] m/s	18 m/s

Table 5-3: Operational envelope (temperature and wind)

NOTE Turbines will de-rate the power according to the coolings system selected for the specific product. See Figure 5-2

[1] Limitation in high temperature performance will apply according to Figure 5-1: Temperature variants

[2] The turbine will keep 2.0MW rating to 20m/s and de-rate power for wind speeds above

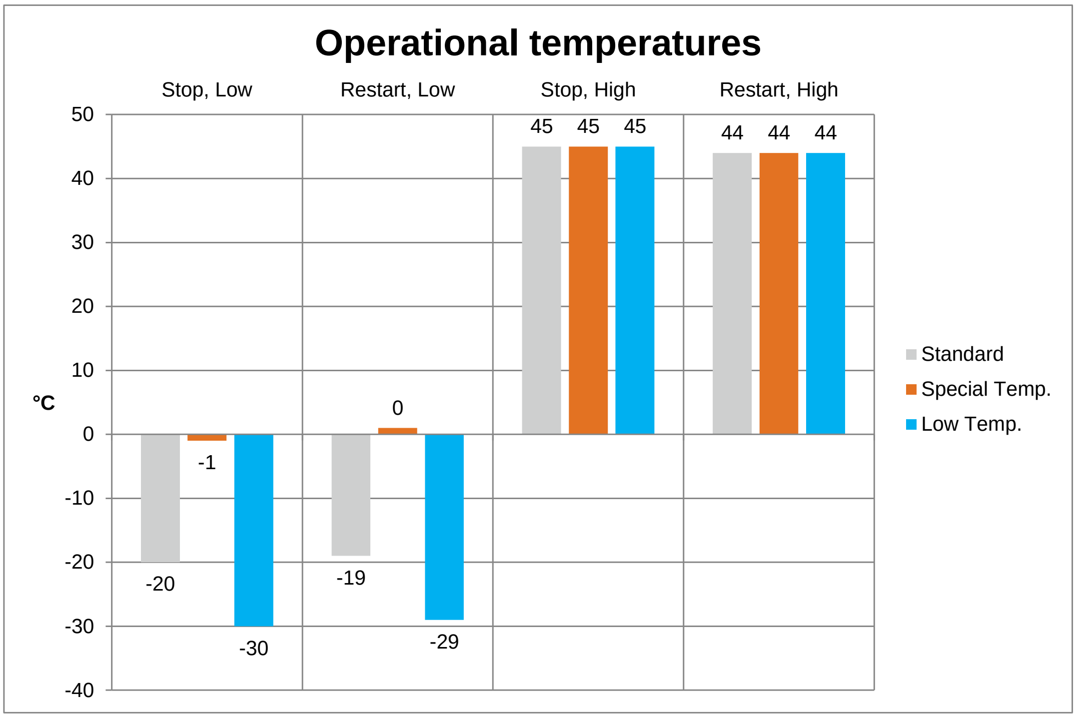

Figure 5-1: Temperature variants

NOTE The special temperature variant is designed for use in stable warm climates. Consult Vestas for specific climate conditions for the special temperature variant.

Restart temperature is where the turbine will initiate the start-up; not resume production.

The turbine can be equipped with different Coolertop variants which are suited for different climate conditions:

Coolertop 30 is suited for turbines sited in relative low temperature areas or where there is no or a limited correlation between high temperature and high wind speeds.

Coolertop 40 is suited for turbines sited in high temperature areas where there is a correlation between high temperatures and high wind speed.

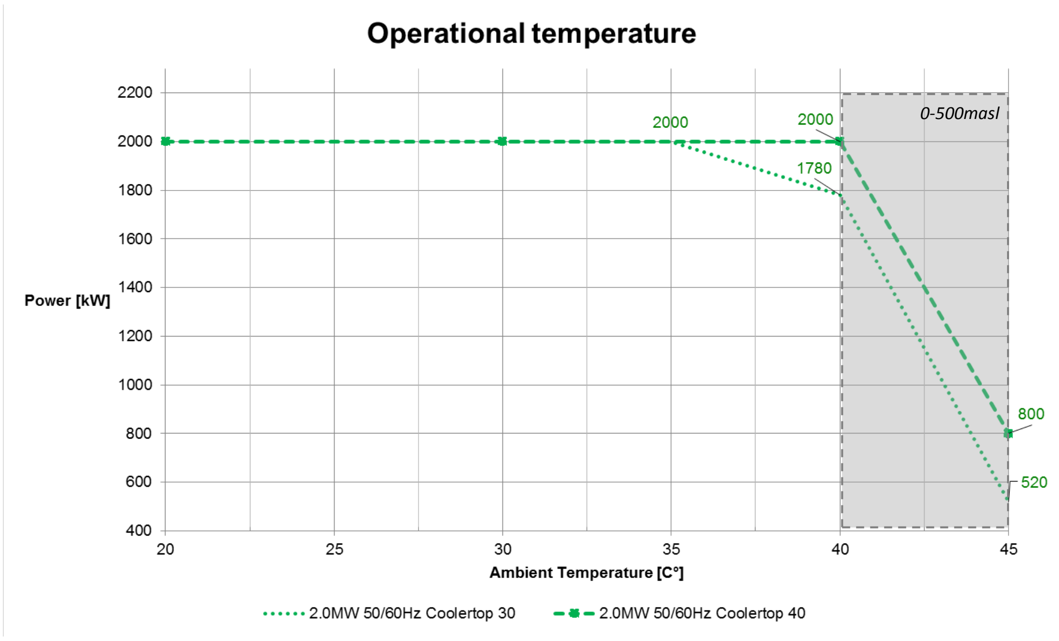

Figure 5-2: Temperature and de-rate curves 2.0MW. 0 to 1.500masl

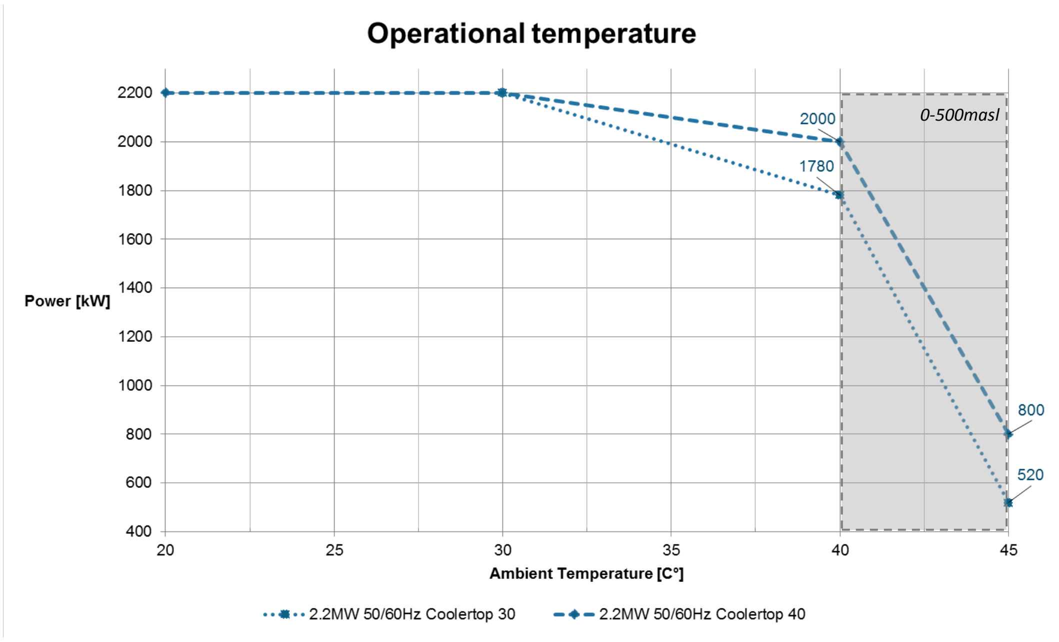

Figure 5-3: Temperature and de-rate curves 2.2MW. 0 to 1.500masl

5.3 Operational envelope (grid connection)

Operational envelope (grid connection)		
Nominal phase voltage	$[U_{NP}]$	480 V (Grid inverter) 690 V (Stator)
Nominal frequency	$[f_N]$	50 / 60Hz

Operational envelope (grid connection)	
Maximum frequency gradient	±4 Hz/sec.
Maximum negative sequence voltage	3% *(connection)* 2% *(operation)*
Minimum required short circuit ratio at turbine HV connection	3[3]
Maximum short circuit current contribution	4.0 pu *(peak short-circuit current)* 1.5 pu *(steady-state short-circuit current)*

Table 5-4: Operational envelope (grid connection)

[3] For SCR below 3 the WTG default parameter settings may need modifications. Consult Vestas for further information.

Generator and converter disconnecting values		
	50Hz	**60Hz**
Frequency is above [Hz] for 0.2 Seconds	53 Hz	63,6Hz
Frequency is below [Hz] for 0.2 Seconds	47 Hz	56,4Hz

Table 5-5: Generator and converter disconnecting values

NOTE Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

5.4 Reactive power capability

5.4.1 Standard P/Q Charts

The standard turbine has a reactive power capability dependent on power rating as illustrated in Figure 5-4 and Figure 5-5. Special reactive power charts can be enabled per site specific evaluation as shown in Figure 5-6.

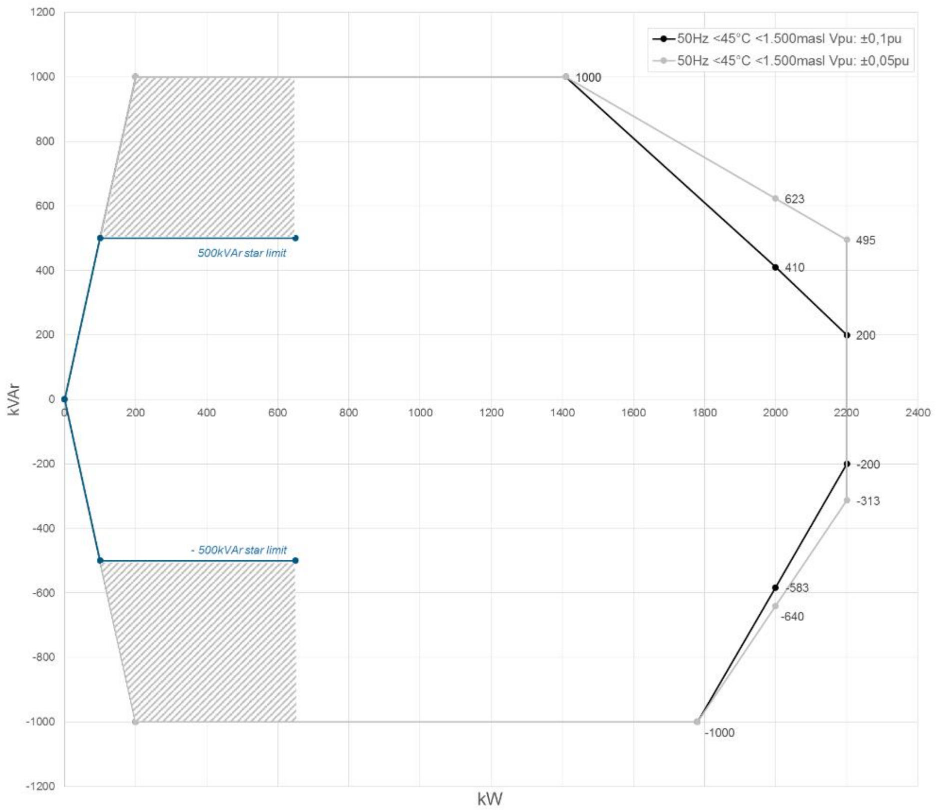

Figure 5-4: Reactive power capability for 2.0/2.2MW 50Hz

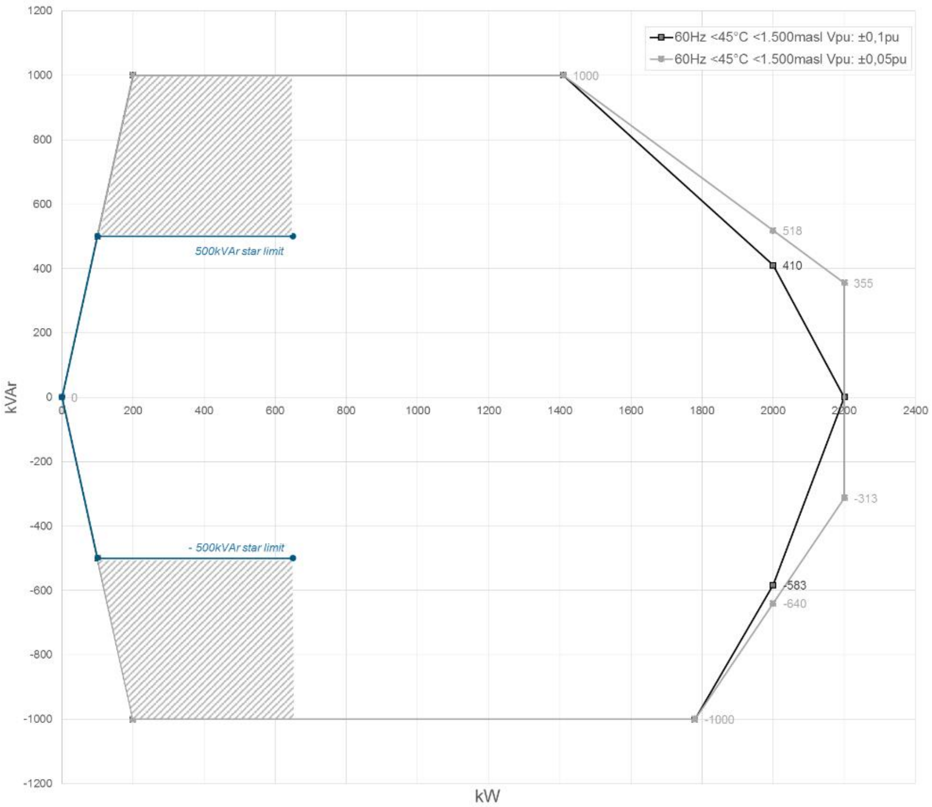

Figure 5-5: Reactive power capability for 2.0/2.2MW 60Hz

5.4.2 Site specific P/Q Chart

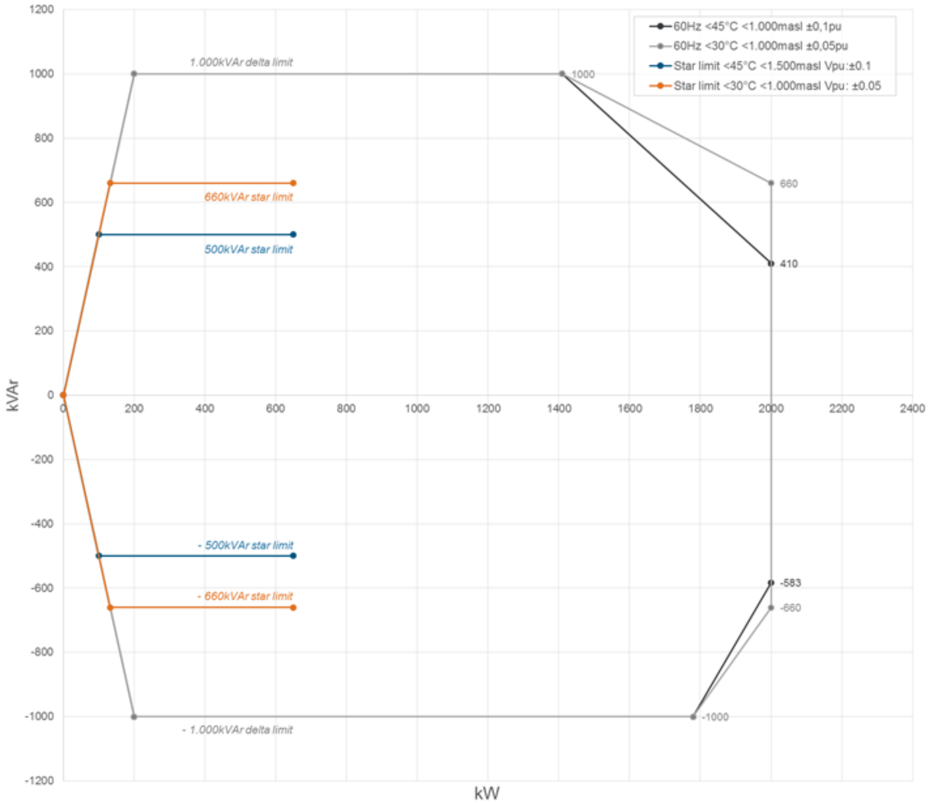

Figure 5-6: Reactive power capability for site specific 2.0MW 60Hz

- *Alternative climatic conditions can be approved within envelope specified in* Figure 5-7
- *The Q capability is only applicable for turbines running in Voltage control mode. For Q controlled operation consult Vestas for further information.*
- *The turbine shall be equipped with 2.300kVA HV transformer type*
- *The turbine shall be equipped with a Coolertop 40.*

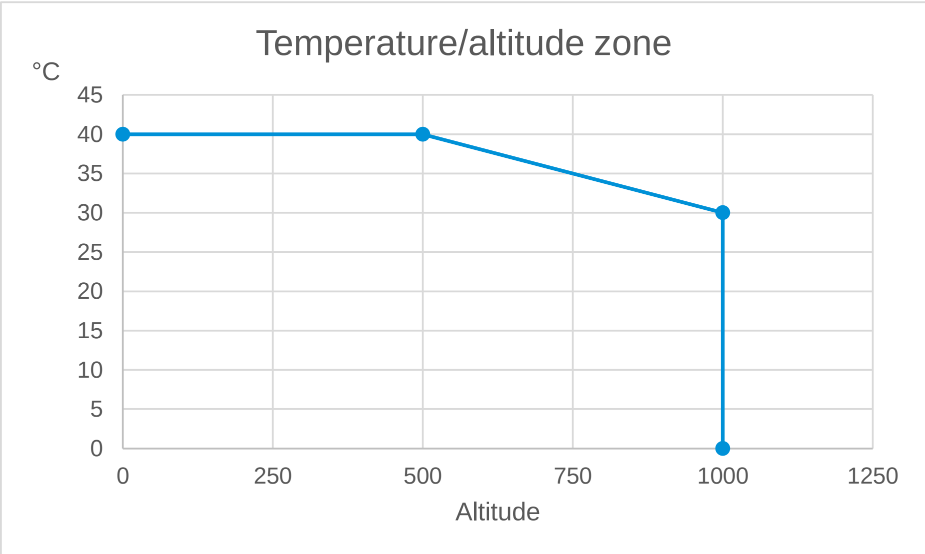

Figure 5-7: Climatic envelope

NOTE The above reactive power capability charts applies to the low-voltage side of the HV transformer. The turbine maximises active power or reactive power depending selected settings.

5.4.3 Reactive power in standstill

The turbine can as an option provide reactive power supply when it is not producing active power to the grid due to low wind speeds.

Reactive power support below cut-in wind speeds		
	Reactive power [±kVAr]	Max ambient temperature [°C]
Coolertop 30°C	150	35
Coolertop 40°C	200	43

Table 5-6: Reactive power supply below cut-in wind speed.

NOTE The reactive power capability in standstill/idle will not follow the ramp rates specified Figure 5-9 and Table 5-9.

The turbines will not supply reactive power when switching between standstill/idle and operation.

5.5 Fault ride through

The turbine is equipped with a reinforced converter system in order to gain better control of the generator during grid faults. The turbine control system continues to run during grid faults.

The pitch system is optimised to keep the turbine within normal speed conditions, and the generator speed is accelerated in order to store rotational energy and be able to resume normal power production faster after a fault and keep mechanical stress on the turbine at a minimum.

The turbine is designed to stay connected during grid disturbances within the UVRT curve in Figure 5-8, p. 17.

Power recovery time	
Power recovery to 90% of pre-fault level	Maximum 2 seconds

Table 5-7: Power recovery time

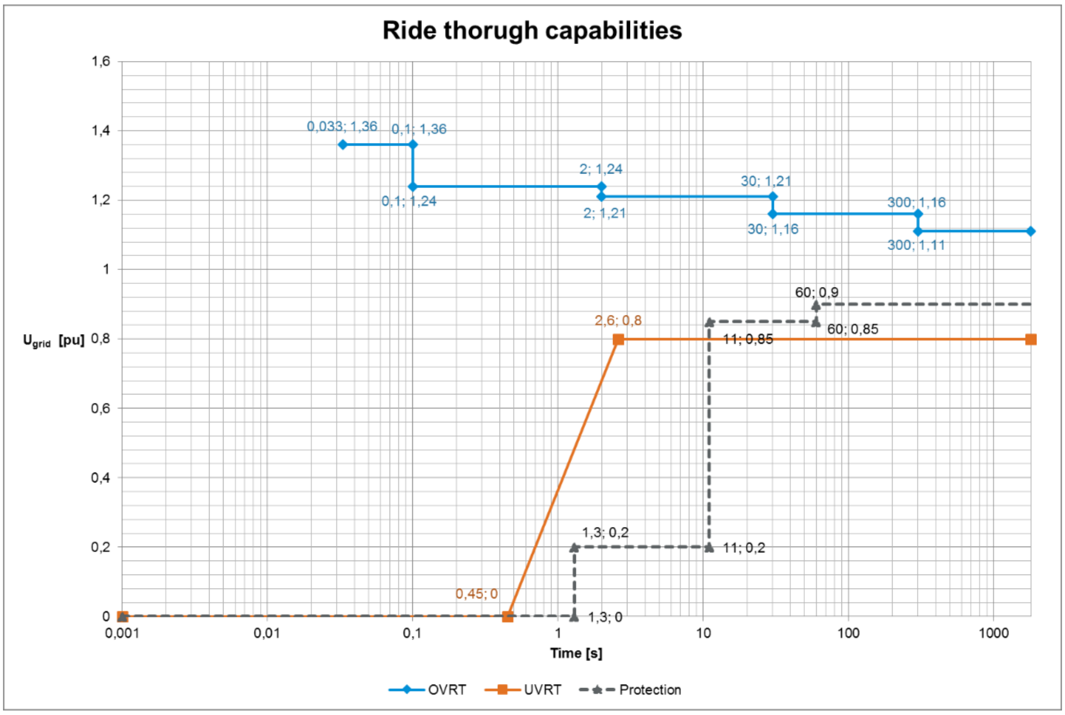

Figure 5-8: OVRT, UVRT and Protection curves for symmetrical and asymmetrical faults where U_{grid} represents grid voltage values. Linear interpolation can be assumed between all points in the UVRT curve.

The turbine stays connected when the values are above UVRT (and protection) and below OVRT. The UVRT curve is only active when the turbine is supplying power.

5.5.1 OVRT

The turbine is able to run with voltage levels above nominal within restricted time intervals.

The generator and the converter will be disconnected if the voltage level exceeds the OVRT curve shown in Figure 5-8.

5.6 Reactive current contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

5.6.1 Symmetrical reactive current contribution

During symmetrical voltage dips the wind farm will inject reactive current to support the grid voltage. The reactive current injected is a function of the voltage measured at the low voltage side of the WTG transformer.

The default value gives a reactive current part of 1 p.u. of the nominal WTG current. Figure 5-9 indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level.

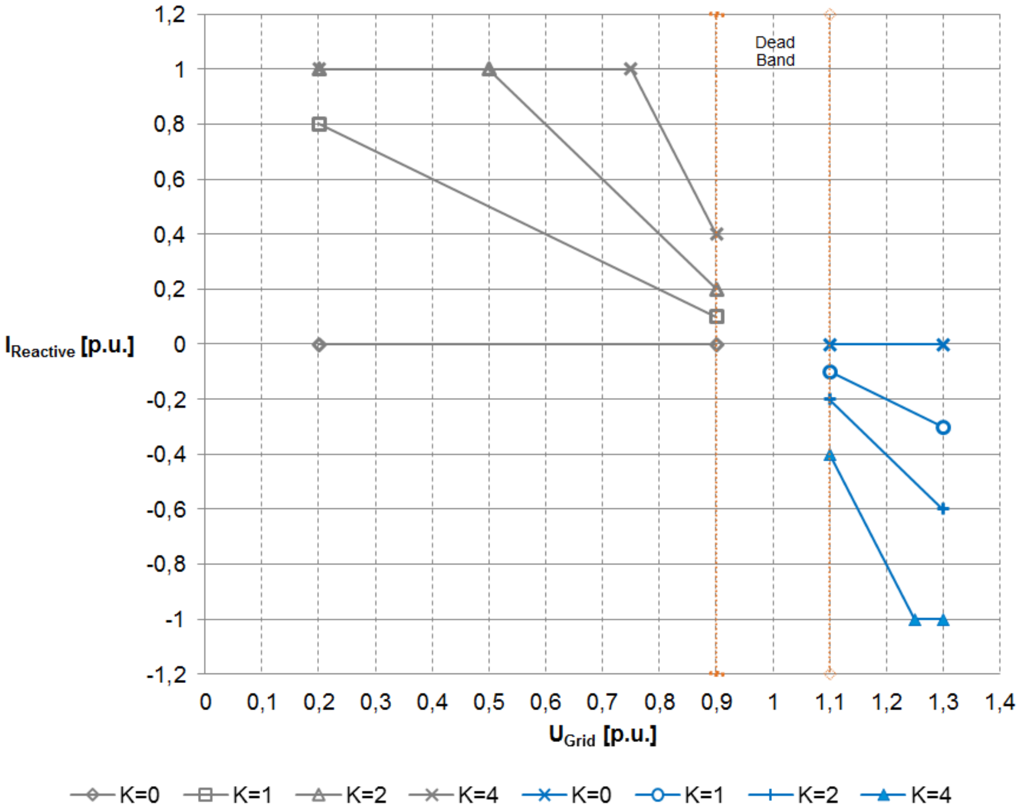

Figure 5-9: Reactive current contribution

Slope (K-factor), offset and dead band can be set freely to fulfil requirements to UVRT current injection.

5.6.2 Asymmetrical reactive current contribution

Current reference values are controlled during asymmetrical faults to ensure ride through.

5.6.3 Sub synchronous resonance protection

Turbine is equipped with fast-acting protection to shield the converter, generator and drivetrain from excessive voltages, currents and torques due to sub-synchronous resonance (SSR) caused by interaction between the turbine and the series-capacitor-compensated transmission lines. The generator and converter will be disconnected upon SSR detection by the turbine controller, according to Table 5-8: SSR protection time. SSR protections availability is depending on grid conditions at the specific sites.

SSR protection time	
Generator and converter disconnect	Maximum 100ms (including breaker response time)

Table 5-8: SSR protection time

5.7 Active and reactive power control

The turbine is designed for control of active and reactive power by means of the VestasOnline® SCADA system.

Maximum ramp rates for external control	
Active power[4]	0.1 pu/sec
Reactive power[4]	2.5 pu/sec

Table 5-9: Maximum ramp rates for external control data

Active power restriction	
Technical minimum	400kW

Table 5-10: Minimum active power output

5.8 Voltage control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

5.9 Frequency control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency).

Dead band and slope for the frequency control function are configurable.

5.10 High voltage connection

5.10.1 Transformer

The step-up HV transformer is located in a separate locked room in the back of the nacelle.

The transformer is a three-phase, two-winding, dry-type transformer that is self-extinguishing. The windings are delta-connected on the high-voltage side unless otherwise specified.

The transformer comes in different versions depending on the market where it is intended to be installed.

- The transformer is as default designed according to IEC standards for both 50 Hz and 60Hz versions.

[4] Limitations in duration of a power ramp may apply.

- For turbines installed in Member States of the European Union, it is required to fulfil the Eco design regulation No 548/2014 set by the European Commission.

5.10.2 HV Switchgear

Vestas delivers a gas insulated switchgear which is installed in the bottom of the tower as an integrated part of the turbine. Its controls are integrated with the turbine safety system which monitors the condition of the switchgear and high voltage safety related devices in the turbine. This ensures all protection devices are fully operational whenever high voltage components in the turbine are energised. The earthing switch of the circuit breaker contains a trapped-key interlock system with its counterpart installed on the access door to the transformer room in order to avoid unauthorized access to the transformer room during live condition.

The switchgear is available in two variants with increasing features – see *Table 5-11 - HV switchgear variants and features*. Beside the increase in features, the switchgear can be configured depending on the number of grid cables planned to enter the individual turbine. The design of the switchgear solution is optimized such grid cables can be connected to the switchgear even before the tower is installed and still maintain its protection toward weather conditions and internal condensation due to a gas tight packing.

The switchgear is available in an IEC version and in an IEEE version. The IEEE version is however only available in the highest voltage class.

HV Switchgear		
Variant	**Basic**	**Streamline**
IEC standards	○	⊙
IEEE standards	⊙	○
Vacuum circuit breaker panel	⊙	⊙
Overcurrent, short-circuit and earth fault protection	⊙	⊙
Disconnector / earthing switch in circuit breaker panel	⊙	⊙
Voltage Presence Indicator System for circuit breaker	⊙	⊙
Voltage Presence Indicator System for grid cables	⊙	⊙
Double grid cable connection	⊙	⊙
Triple grid cable connection	⊙	○
Preconfigured relay settings	⊙	⊙
Turbine safety system integration	⊙	⊙
Redundant trip coil circuits	⊙	⊙
Trip coil supervision	⊙	⊙
Pendant remote control from outside of tower (Option via ground controller)	⊙	⊙
Sequential energisation	⊙	⊙
Reclose blocking function	⊙	⊙
Heating elements	⊙	⊙
Trapped-key interlock system for circuit breaker panel	⊙	⊙
UPS power back-up for protection circuits	⊙	⊙
Motor operation of circuit breaker	⊙	⊙
Cable panel for grid cables (configurable)	○	⊙
Switch disconnector panels for grid cables – max three panels (configurable)	○	⊙
Earthing switch for grid cables	○	⊙
Internal arc classification	○	⊙
Supervision on MCB’s	○	⊙

Table 5-11 - HV switchgear variants and features

5.11 Main contributors to own consumption

The consumption of electrical power by the wind turbine is defined as consumption when the wind turbine is not producing energy (generator is not connected to the grid). This is defined in the control system as Production Generator (zero).

The following components have the largest influence on the power consumption of the wind turbine:

Main contributors to own consumption	
Hydraulic motor	20 kW
Yaw motors 6 x 1.75 kW	10.5 kW
Oil heating 3 x 0.76 kW	2.3 kW
Air heaters (2 x 6 kW)	12 kW
Oil pump for gearbox lubrication	5.0 kW
Generator fans (included in generator efficiency)	7.0 kW
Average of measured no-load loss of the HV transformer	4.0 kW

Table 5-12: Own consumption data

6 Drawings

6.1 Structural design – illustration of outer dimensions

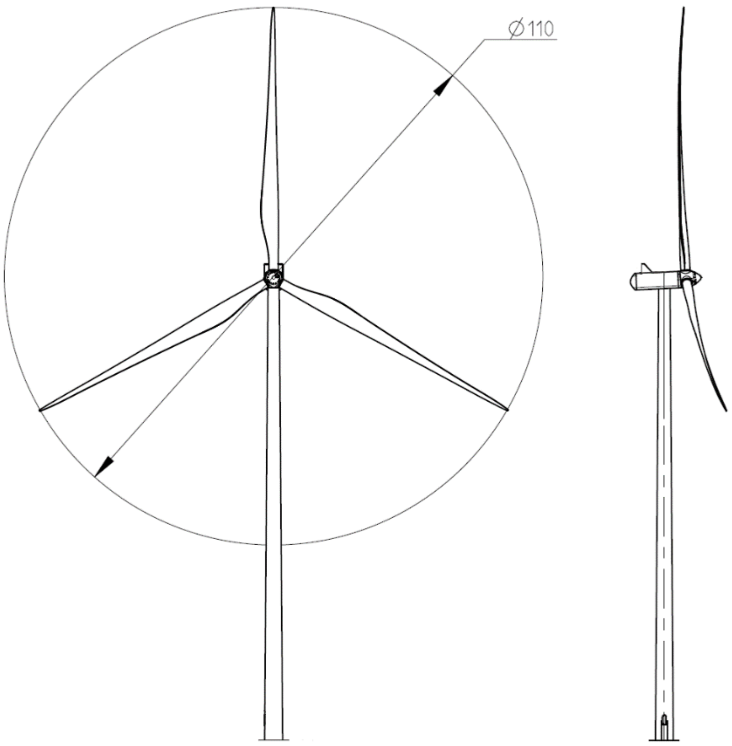

Figure 6-1: Illustration of outer dimensions for a V110 turbine

6.2 Structural design (side-view drawing)

Figure 6-2: Side-view drawing

6.3 Turbine protection systems

6.3.1 Braking concept

The main brake on the turbine is aerodynamic. Braking the turbine is done by feathering the three blades. During emergency stop all three blades will feather simultaneously to full end stop, thereby slowing the rotor speed.

In addition there is a mechanical disc brake on the high-speed shaft of the gearbox. The mechanical brake is only used as a parking brake and when activating the emergency stop push buttons.

6.4 Overspeed protection

The generator rpm and the main shaft rpm are registered by inductive sensors and calculated by the wind turbine controller to protect against overspeed and rotating errors.

In addition, the turbine is equipped with a safety PLC, an independent computer module that measures the rotor rpm. In case of an overspeed situation, the safety PLC activates the emergency feathered position (full feathering) of the three blades independently of the turbine controller.

6.5 EMC system

The turbine and related equipment must fulfil the EU EMC-directive with later amendments:

- European Parliament Council directive 2004/108/EC of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
- The EMC-directive with later amendments.

6.6 Lightning protection system

The LPS consists of three main parts.

- Lightning receptors.
- Down conducting system.
- Earthing system.

NOTE The LPS is designed according to IEC standards.

6.7 Earthing

The Vestas Earthing System is based on foundation earthing.

Document 0000-3388 ‘Vestas Earthing System’ contains the list of documents pertaining to the Vestas Earthing System.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements may require additional measures.

7 Environment

7.1 Chemicals

Chemicals used in the turbine are evaluated according to the Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2004.

- Anti-freeze liquid to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

8 General reservations, notes, and disclaimers

-
- The general specification document here described applies to the present design of the 2.0MW wind turbine series. Updated versions of the wind turbine, which may be manufactured in the future, may have a general specification document that differs from these general specifications. In the event that Vestas supplies an updated version of the wind turbine, Vestas will provide updated general specification applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with little variation in frequency.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- The estimated power curve for the different estimated noise levels (sound power levels) is for wind speeds at 10 minute average value at hub height and perpendicular to the rotor plane.
- All listed start/stop parameters (for example wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements, and codes of standards.
- This document, ‘General Specifications’, is not an offer for sale, and does not contain any guarantee, warranty, and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty, and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

9 Appendices

9.1 Design codes – structural design

The structural design has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – structural design	
Nacelle and hub	IEC 61400-1:2005 EN 50308 ANSI/ASSE Z359.1-2007
Bed frame	IEC 61400-1:2005
Tower	IEC 61400-1:2005 Eurocode 3

Table 9-1: Structural design codes

9.2 Design codes – mechanical equipment

The mechanical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – mechanical equipment	
Gear	Designed in accordance with rules in ISO 81400-4
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12, 22 and 23) DEFU R25 ISO 2813

Table 9-2: Mechanical equipment design codes

9.3 Design codes – electrical equipment

The electrical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – electrical equipment	
High-voltage AC circuit breakers	IEC 60056
High-voltage testing techniques	IEC 60060
Power capacitors	IEC 60831
Insulating bushings for AC voltage above 1 kV	IEC 60137
Insulation coordination	BS EN 60071
AC disconnectors and earth switches	BS EN 60129

Design codes – electrical equipment	
Current transformers	IEC 60185
Voltage transformers	IEC 60186
High-voltage switches	IEC 60265
Disconnectors and fuses	IEC 60269
Flame retardant standard for MV cables	IEC 60332
Transformer	IEC 60076-11
Generator	IEC 60034
Specification for sulphur hexafluoride for electrical equipment	IEC 60376
Rotating electrical machines	IEC 34
Dimensions and output ratings for rotating electrical machines	IEC 72 and IEC 72A
Classification of insulation, materials for electrical machinery	IEC 85
Safety of machinery – electrical equipment of machines	IEC 60204-1

Table 9-3: Electrical equipment design codes

9.4 Design codes – I/O network system

The distributed I/O network system has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – I/O network system	
Salt mist test	IEC 60068-2-52
Damp head, cyclic	IEC 60068-2-30
Vibration sinus	IEC 60068-2-6
Cold	IEC 60068-2-1
Enclosure	IEC 60529
Damp head, steady state	IEC 60068-2-56
Vibration random	IEC 60068-2-64
Dry heat	IEC 60068-2-2
Temperature shock	IEC 60068-2-14
Free fall	IEC 60068-2-32

Table 9-4: I/O network system design codes

9.5 Design codes – EMC system

To fulfil EMC requirements the design must be as recommended for lightning protection. See section 9.6 Design codes – lightning , p. 29.

Design codes – EMC system	
Designed according to	IEC 61400-1: 2005
Further robustness requirements according to	TPS 901795

Table 9-5: EMC system design codes

9.6 Design codes – lightning protection

The LPS is designed according to lightning protection level I:

Design codes – lightning protection	
Designed according to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non-harmonized standard and technically normative documents	IEC/TR 61400-24:2010

Table 9-6: Lightning protection design codes

9.7 Design codes – earthing

The Vestas Earthing System design is based on and complies with the following international standards and guidelines:

- IEC 62305-1 Ed. 1.0: Protection against lightning – Part 1: General principles.
- IEC 62305-3 Ed. 1.0: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- IEC 62305-4 Ed. 1.0: Protection against lightning – Part 4: Electrical and electronic systems within structures.
- IEC/TR 61400-24. First edition. 2002-07. Wind turbine generator systems – Part 24: Lightning protection.
- IEC 60364-5-54. Second edition 2002-06. Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.

9.8 Operational envelope conditions for power curve (at hub height)

Conditions for power curve (at hub height)	
Wind shear	0.00-0.30 (10 minute average)
Turbulence intensity	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/snow on blades	No
Leading edge	No damage
Terrain	IEC 61400-12-1
Inflow angle (vertical)	0 ±2°

Table 9-7: Conditions for power curve

9.9 Power curves, C_t values, and sound power levels

Power curve, C_t values and sound power levels for noise modes are defined in separate performance specifications for each variant. The documents will reference this General Specification to ensure correct traceability between performance data sheet and the General Specification.

The turbine can be equipped with different power generation components depending on the region which may influence the performance of the turbine. Consult Vestas Wind Systems for further details.

The Performance Specifications are listed below:

Performance specifications	Number
V100-2.0MW 50/60Hz	0062-4192
V100-2.2MW 50/60Hz	0062-4193
V110-2.0MW 50/60Hz	0062-4194
V110-2.2MW 50/60Hz	0062-4195

Table 9-8: Performance specifications

APPENDIX B – MANUFACTUER LETTERS

Confidential

Memorandum

Date: April 10, 2017

To: Bill Behling, Director of Development, U.S. East, Capital Power

From: Technical Sales North America, Vestas-American Wind Technology, Inc.

Pages: 1 of 1

Re: V110-2.0 and V110-2.2

The V110-2.0 MW and the V110-2.2 MW are physically identical, sharing the same components, tower heights, and rotor diameters; the V110-2.0 MW and the V110-2.2 MW therefore share the same safety characteristics. The V110, both at 2.0 and 2.2 nameplates, has been field-tested and Type Certified according to the IEC 61400 standard. OPSB previously approved increasing the nameplate of the V110-2.0 to 2.2 at Scioto Ridge.

Please direct any questions or comments to Chelsea Stone, casea@vestas.com, and Gabe Garbarino, gagab@vestas.com.

Confidential

Memorandum

Date: May 8, 2017

To: Bill Behling, Business Development Manager, Capital Power

From: Technical Sales North America, Vestas-American Wind Technology, Inc.

Pages: 1 of 1

Re: Sound Power Level of the V110-2.2 in Noise Mode 0

Please see the table below for the maximum sound output at wind speed at hub height for standard blades and for blades with serrated trailing edges (STE).

Sound Power Level at Hub Height		
Measurement standard:	IEC 61400-11 3rd edition. 2012	
Max. turbulence at 10m height:	16%	
Inflow angle (vertical):	0 ± 2^{o}	
Air density:	1.225 kg/m^3	
Wind shear:	0.0-0.4 (10 minute average)	
Wind speed at Hub Height (m/s)	**dBA (standard blade)**	**dBA (with optional STE)**
3.0	95.5	95.5
4.0	96.4	96.1
5.0	97.9	97.3
6.0	101.9	100.9
7.0	103.9	102.6
8.0	106.4	104.8
9.0	107.6	106.0
10.0	107.7	106.1
11.0	107.7	106.1
12.0	107.7	106.1
13.0	107.7	106.1
14.0	107.7	106.1
15.0	107.7	106.1
16.0	107.7	106.1
17.0	107.7	106.1
18.0	107.7	106.1
19.0	107.7	106.1
20.0	107.7	106.1

Please direct any questions or comments to Chelsea Stone, casea@vestas.com, and Gabe Garbarino, gagab@vestas.com.

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