Samsung Renewable Energy Inc. and

Pattern Energy

9 Wind Turbine Specification Report

For

South Kent Wind Project

Samsung Renewable Energy Inc. and
Pattern Energy

10 - Wind Turbine Specifications Report

For

South Kent Wind Project

H335806-0000-07-124-0003
Rev. 2
April 25, 2012

Report Revisions

Section	Report Date: July 19, 2011	Report Date: February 23, 2012 – Revised Content	Report Date: April 25, 2012 – Revised Content
1.1	Samsung Renewable Energy and Pattern Energy (hereinafter referred to as the "Proponent") are jointly proposing to develop the South Kent Wind Project, a 270 MW wind energy project (the "Project"), which will be located within the Municipality of Chatham-Kent in southwestern Ontario.	Samsung Renewable Energy and Pattern Energy (hereinafter referred to as the "Proponent") are jointly proposing to develop the South Kent Wind Project, a 270 MW wind energy project (the "Project"), consisting of approximately 127 operational wind turbines, as well as supporting infrastructure, including access roads, construction and turn around areas, and buried and/or overhead collection/ transmission lines. The collection/transmission line will include approximately a 34 km of 230 kV transmission line and two (2) substations to enable step-up of the voltage from 34.5kV to 230 kV to connect to the Chatham Switching Station (SS). The Project Area is located within the Municipality of Chatham-Kent in southwestern Ontario.	Samsung Renewable Energy and Pattern Energy (hereinafter referred to as the "Proponent") are jointly proposing to develop the South Kent Wind Project, a 270 MW wind energy project (the "Project"), consisting of approximately 124 operational wind turbines, as well as supporting infrastructure, including access roads, construction and turn around areas, and buried and/or overhead collection/transmission lines. The collection/transmission line will include approximately a 34 km of 230 kV transmission line and two (2) substations to enable step-up of the voltage from 34.5kV to 230 kV to connect to the Chatham Switching Station (SS). The Project Area is located within the Municipality of Chatham-Kent in southwestern Ontario.
1.1	The Project is proposed to be 270 MW in size, using Siemens wind turbine technology, supporting infrastructure, including access roads, buried cables, overhead collector lines, a 230 kV transmission line and two (2) substations are required to step-up the voltage from 34.5 kV to 230 kV to enable connection to the Chatham Switching Station (SS).	Paragraph was removed.	

Section	Report Date: July 19, 2011	Report Date: February 23, 2012 – Revised Content	Report Date: April 25, 2012 – Revised Content
1.1	The construction period is estimated to be fifteen to eighteen months in duration, with Project commissioning anticipated in the first quarter of 2013.		The construction period is estimated to be fifteen to eighteen months in duration, with Project commissioning anticipated in the first quarter of 2014.
Table 2.1	Name Plate Capacity: 2.221 MW and 2.126 MW	Name Plate Capacity: 2.221 MW, 2.126 MW, and 1.903 MW	
2	The wind turbine models used on the project will have unit nameplate capacities of 2.221 MW and 2.126 MW and corresponding Sound Power Levels as described in the Noise Report.	The wind turbine models used on the project will have unit nameplate capacities of 2.221 MW, 2.126 MW and 1.903 MW with corresponding Sound Power Levels as described in the Noise Report.	
Appendix B		Addition of Contract Acoustic Emission data for the SWT 2.3-101 Max. Power 1903 kW, Hub Height 99.5 m	

Project Report

April 25, 2012

Samsung Renewable Energy Inc. and Pattern Energy
South Kent Wind Project

Wind Turbine Specifications Report

Table of Contents

1. Introduction

1.1 Background

Samsung Renewable Energy and Pattern Energy (hereinafter referred to as the "Proponent") are jointly proposing to develop the South Kent Wind Project, a 270 MW wind energy project (the "Project"), consisting of approximately 124 operational wind turbines, as well as supporting infrastructure, including access roads, construction and turn around areas, and buried and/or overhead collection/transmission lines. The collection/transmission line will include approximately a 34 km of 230 kV transmission line and two (2) substations to enable step-up of the voltage from 34.5kV to 230 kV to connect to the Chatham Switching Station (SS). The Project Area is located within the Municipality of Chatham-Kent in southwestern Ontario. The Project is located south of Highway 401 between the towns of Tilbury and Ridgetown to the west and east, respectively.

Construction of the Project will commence once the Renewable Energy Approval ("REA") has been obtained. The construction period is estimated to be fifteen to eighteen months in duration, with Project commissioning anticipated in the first quarter of 2014. It is anticipated that the Project will be operational for at least 20 years after which it may be decommissioned if no arrangement for further use is determined.

1.2 Objective and Scope

This Wind Turbine Specifications Report (the "Report") is required as a part of an application for all renewable energy projects that must submit in order to obtain a REA permit under Ontario Regulation (O. Reg.) 359/09, as amended under O. Reg. 521/10 (January 2011) – *Renewable Energy Approvals Under Part V.0.1 of the Act*. This Report provides the specifications of the wind turbine, including make, model, name plate capacity, hub height above grade, rotational speeds and acoustic emissions data in terms of total sound power level for various wind speeds and frequency spectra in terms of octave-band sound power levels.

The Report also functions as a communication tool for Aboriginal, public, agency and municipal consultation. A draft of the Wind Turbine Specifications Report must be made public 60 days prior to the second public consultation meeting in accordance with Section 16 of O. Reg. 359/09 and provided to the Aboriginal communities more than 60 days prior to the second public consultation meeting.

2. Specifications

The Project is a class 4 wind facility (as defined in O. Reg. 359/09) which will consist of Siemens SWT-2.3-101 wind turbines. Table 2.1 provides the total tower height, hub height above grade, blade length/rotor sweep area and rotational speeds. Appendix A contains the technical specifications provided by Siemens. The acoustic emissions data including the sound power level and frequency spectrum in terms of octave-band sound power levels are contained in Appendix B.

Table 2.1 Technical Specifications

Make and Model	Siemens SWT-2.3-101
Name Plate Capacity	2.221 MW, 2.126 MW, and 1.903 MW
Total Tower Height (including blade)	150.0 m
Hub Height above grade	99.5 m
Blade Length	49 m
Rotor Diameter	101 m
Swept Area	8,012 m^2
Rotational Speeds:	6 -16 rpm

The wind turbine models used on the project will have unit nameplate capacities of 2.221 MW, 2.126 MW and 1.903 MW with corresponding Sound Power Levels as described in the Noise Report. Sound Power Level is the noise emission from the turbine.

Appendix A

Siemens Turbine Description and Specifications

Published by and copyright © 2009:
Siemens AG
Energy Sector
Freyeslebenstrasse 1
91058 Erlangen, Germany

Siemens Wind Power A/S
Borupvej 16
7330 Brande, Denmark
www.siemens.com/wind

For more information, please contact
our Customer Support Center.
Phone: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)
E-mail: support.energy@siemens.com

Renewable Energy Division
Order No. E50001-W310-A121-X-4A00
Printed in Germany
Dispo 34804, c4bs No. 7491
61/19716 L WS 04096.

Printed on elementary chlorine-free
bleached paper.

www.siemens.com/energy

The new standard for moderate wind conditions

Siemens Wind Turbine SWT-2.3-101

Answers for energy.

SIEMENS

Your trusted partner

Siemens has been a major driver of innovation in the wind power industry since the early 1980s when wind turbine technology was still in its infancy.

Technology has changed with the times, but Siemens' commitment to providing its customers with proven wind turbine solutions remains the same.

The combination of robust and reliable turbines, highly efficient solutions for power transmission and distribution and a deep understanding of the entire energy market ensures that Siemens will continue to be a leading supplier.

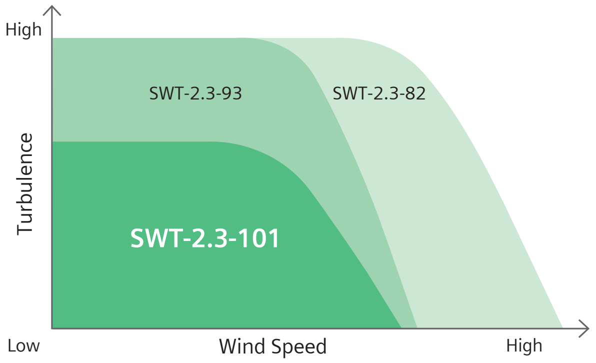
Siemens' record, when it comes to on-time delivery, is impeccable. Long-lasting customer relationships, based on the successful installation of wind turbines, provide for a sound, sustainable and profitable investment.

Drawing on 140 years of experience in the energy sector, a strong focus on renewables and a global network of highly skilled and trained employees, Siemens has proven itself to be a trustworthy and reliable business partner. And will continue to be in the future.

Harvest more energy from sites with moderate wind conditions

The Siemens SWT-2.3-101 turbine is designed to deliver unparalleled performance and reliability, making it especially suited to areas with moderate wind conditions.

Siemens has the right turbines for all wind conditions



The SWT-2.3-101 turbine offers low energy production costs, and joins Siemens' 2.3-MW product family, which has proven availability that is among the highest in the industry. The 101-meter rotor is specifically designed to optimize the energy output in areas with moderate wind conditions. The turbine is also ideal for all types of grid connections in most major markets.

The SWT-2.3-101 is designed to last. The robust and reliable design offers a high yield with low maintenance costs. The turbine is backed by advanced condition monitoring and diagnostics, which constantly examine the turbine. Any change in a turbine's performance is promptly addressed by an experienced after-sales service team either remotely or in the field.

If you desire a better return on investment and superior availability, take a closer look at the SWT-2.3-101 turbine.

Superior performance gives higher yields

Optimum energy at moderate wind conditions

Harvesting more energy
The SWT-2.3-101 wind turbine is designed to increase the energy returns from sites with moderate wind conditions. Advanced blade technology also allows for quieter operation. The B49 blade with a rotor diameter of 101 meters and pitch regulation optimizes power output and increases control over the energy output.

High availability
Currently, the Siemens fleet of 2.3-MW wind turbines sets the industry standard for availability. The SWT-2.3-101 will build on the reputation for reliability that the market has come to expect from a Siemens Wind turbine.

High yield with minimal maintenance
Siemens optimizes the return on investment in its wind turbines through intelligent maintenance that ensures the turbine to deliver high yield with low operational costs.

The rugged structural design, combined with an automatic lubrication system, internal climate control and a generator system without slip rings contributes to exceptional reliability. The innovative design of the SWT-2.3-101 allows for longer service intervals.

Superior grid compliance
The Siemens NetConverter® system is designed for maximum flexibility in the turbine's response to voltage and frequency variations, fault ride-through capability and output adjustment. The advanced wind farm control system provides state-of-the-art fleet management.

Proven track record
Siemens has a proven track record of providing reliable turbines that last. The world's first offshore wind farm in Vindeby, Denmark, was installed in 1991 and is still fully operational. In California, Siemens installed over 1,100 turbines between 1983 and 1990, with 97% still in operation today. Siemens takes its commitment to reliability seriously and prides itself on the long lifespan that its turbines have demonstrated.

No compromise on reliability

SWT-2.3-101: Newest member of the extremely reliable product family

Designed for life
Siemens turbines are designed to last. The robust design of the SWT-2.3-101 allows for trouble-free output throughout the complete lifecycle of the turbine.

The blades are made of fiberglass-reinforced epoxy in Siemens' proprietary IntegralBlade® manufacturing process. The blades are cast in one piece in a closed process, which eliminates the traditional weaknesses found at glue joints in other manufacturers' blades. Like the turbine itself, the blades are designed to last.

Climate control within the turbine protects vital equipment from the outside environment. The turbine also offers controlled-wear strategies for critical components, which results in a further reduction of maintenance costs.

Safety first
Safety is at the heart of all Siemens operations. From production to installation, operation and service, Siemens strives to set the standard in safety.

The fail-to-safe capabilities within a turbine, combined with Siemens' superior lightning protection system, are designed to enhance security for the turbine.

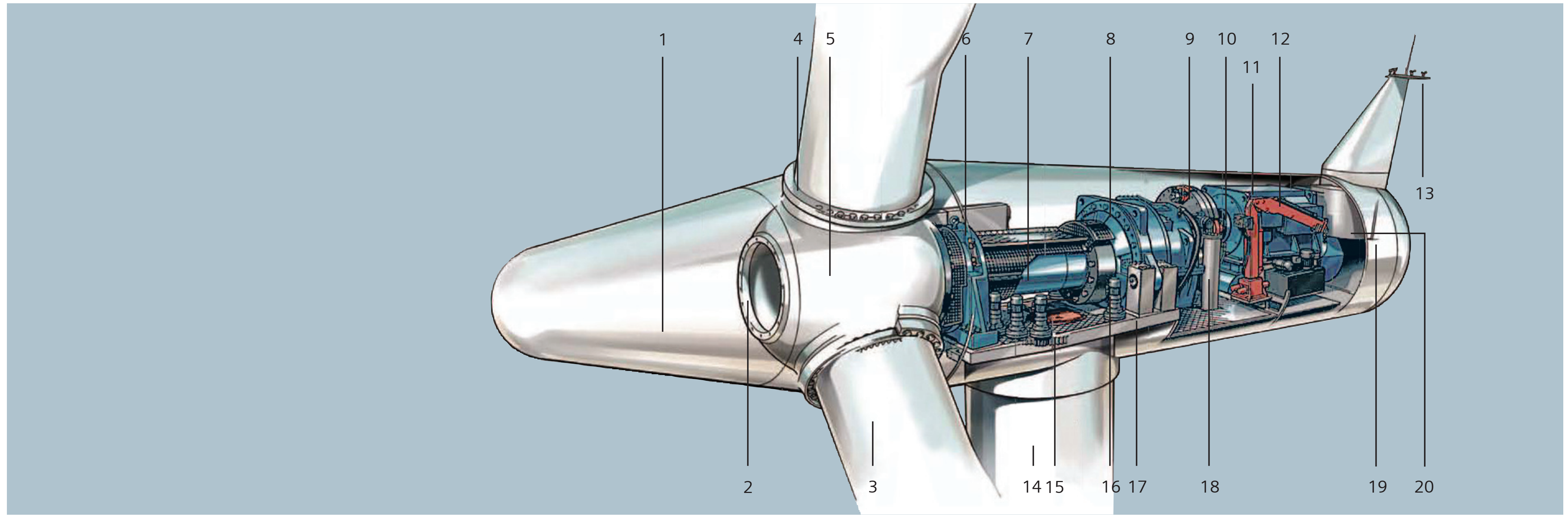
Advanced operations support
Given the logistical challenges associated with servicing wind farms, Siemens has equipped its turbines with a Turbine Condition Monitoring (TCM) system that reduces the need for on-site servicing.

Continuous monitoring of turbines allows for the discovery of small faults before they become major problems.

The TCM system continuously checks the external and internal condition of the wind turbine. Twenty-four hours a day, seven days a week precise measurements are taken of vibrations in the gearbox, the generator and the main shaft bearings. The system instantly detects deviations from normal operating conditions.

Using the knowledge gained from monitoring thousands of turbines over the years, Siemens' experts are exceptionally skilled at analyzing and predicting faults within a turbine. This allows Siemens to proactively plan the service and maintenance of the turbines as each fault can be categorized and prioritized based on the severity of the fault. Siemens can then determine the most appropriate course of action to keep the turbine running at its best.

Technical specifications

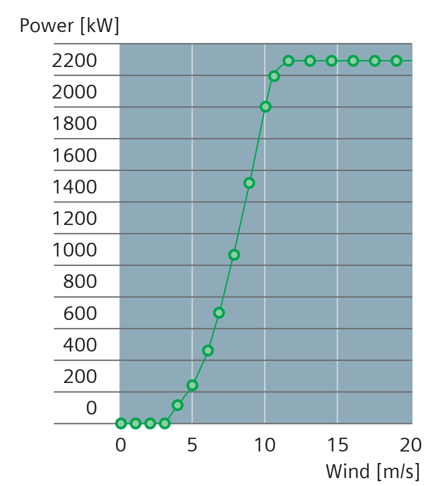


Rotor	
Diameter	101 m
Swept area	8,000 m²
Rotor speed	6-16 rpm
Power regulation	Pitch regulation with variable speed
Blades	
Type	B49
Length	49 m
Aerodynamic brake	
Type	Full-span pitching
Activation	Active, hydraulic
Transmission system	
Gearbox type	3-stage planetary/helical
Gearbox ratio	1:91
Gearbox oil filtering	Inline and offline
Gearbox cooling	Separate oil cooler
Oil volume	Approximately 400 l
Mechanical brake	
Type	Hydraulic disc brake

Generator	
Type	Asynchronous
Nominal power	2,300 kW
Voltage	690 V
Cooling system	Integrated heat exchanger
Yaw system	
Type	Active
Monitoring system	
SCADA system	WebWPS
Remote control	Full turbine control
Tower	
Type	Cylindrical and/or tapered tubular
Hub height	80 m or site-specific
Operational data	
Cut-in wind speed	3-4 m/s
Rated power at	12-13 m/s
Cut-out wind speed	25 m/s
Maximum 3 s gust	55 m/s (standard version)
	60 m/s (IEC version)
Weights	
Rotor	62 tons
Nacelle	82 tons
Tower for 80-m hub height	162 tons

Sales power curve

The calculated power curve data are valid for standard conditions of 15 degrees Celsius air temperature, 1013 hPa air pressure and 1.225 kg/m³ air density, clean rotor blades and horizontal, undisturbed air flow. The calculated curve data are preliminary.



Nacelle arrangement

1. Spinner
2. Spinner bracket
3. Blade
4. Pitch bearing
5. Rotor hub
6. Main bearing
7. Main shaft
8. Gearbox
9. Brake disc
10. Coupling
11. Generator
12. Service crane
13. Meteorological sensors
14. Tower
15. Yaw ring
16. Yaw gear
17. Nacelle bedplate
18. Oil filter
19. Canopy
20. Generator fan

Siemens Wind Turbines Lightning Protection

These specifications are valid for all Siemens Wind Turbines of 1.3 MW and upwards. The lightning protection aims at ensuring protection from the effects of direct and nearby strikes. Even though a 100 percent protection from lightning cannot be assured, the Siemens protection system has shown extremely good performance in wind turbine applications all over the world.

Design Basis
The overall design basis refers to the standard IEC/TR 61400-24:2002 'Wind turbine generator systems - Part 24 Lightning Protection' and the standards for building technology IEC 62305-1-4 ED 1.0:2006, lightning protection level I.

Blades
The blades are protected with a dedicated protection system. Each blade has lightning receptors fitted close to the tip and, for blade lengths from 40m and up, at other locations along the blade. The receptors project slightly above the blade surface on both sides. A flexible integrated metal conductor located inside the blade provides the conduction path from the receptor to the hub.

Hub
The hub casting is used as a natural bonding conductor to the main shaft. Electrical and hydraulic equipment located inside the hub is completely protected by the Faraday cage of the hub itself.

Main Shaft and Bearing
Lightning currents from the blades are discharged through a pick-up system located at the rotor side of the main bearing. Each pick-up can each carry a level I lightning (corresponding to current of 200 kA 10/350μs) and is backed up by at least two other pick-ups.

Nacelle
The nacelle canopy is fabricated in steel plate and acts as a Faraday cage. It provides very good natural bonding and protection of the machinery inside the nacelle. All components protruding from the nacelle are protected to LPZ2 (Lightning Protection Zone 2) either directly or by surge arrestors.

Gearbox and Other Equipment
The gearbox and other equipment in the nacelle are grounded by natural bonding points and this protection is backed up by metal conductors shorting to ground.

Yaw System
A pick-up system provides ground connection from the tower to the nacelle.

Tower
The steel tower acts as a natural bonding part providing conduction from the nacelle to the earth. The wind turbine earthing system must be connected to a completing earthing system provided by the Purchaser. The maximum recommended earth resistance for a single turbine is 10 Ohms. If an earth resistance of maximum 10 Ohms cannot be achieved e.g. due to soil conditions, Siemens should be contacted for further advice. Please also refer to Siemens Wind Power earth termination document.

Electrical System
Surge arrestors in the main supply and communication connections by fibre optical cables provide protection from effects of nearby strikes. The power supply of the control system is based on a UPS that gives a clean electrical environment for all computers and electronics. The Faraday cages of the hub, nacelle and tower provide LPZ2 for all energy containing components inside, i.e. lubrication, electrical and hydraulic systems. All signalling cabling is shielded, signal cables and power cables are separated, and all cubicles/connection boxes are made of metal and fitted with dedicated bonding.

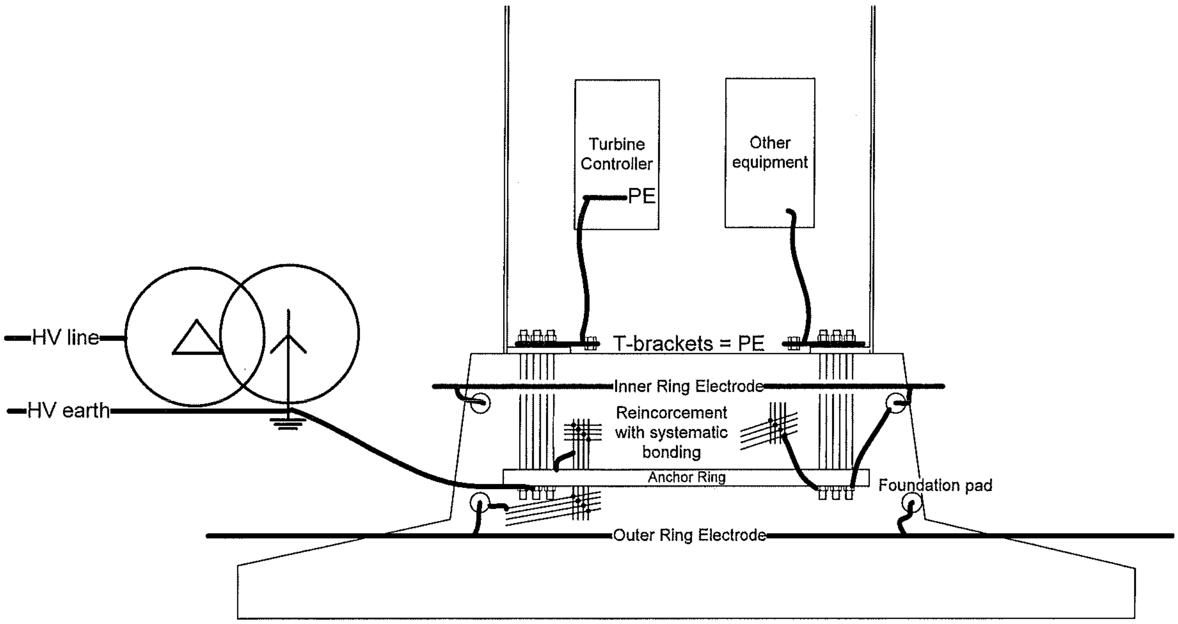
Siemens Wind Turbines
Earth Termination System

General
Siemens wind turbines are equipped with an equipotential bonding and down-conductor system designed in accordance with IEC 60364-5-54 and IEC 62305-3. This system must be connected to an earthing system in the foundation provided by the Employer. The maximum recommended earthing resistance for a single turbine is 10 Ohms. If an earthing resistance of less than 10 Ohms cannot be achieved with a standard earthing system, e.g. due to soil conditions, please refer to IEC 62305-3 or contact Siemens Wind Power for further advice.

Requirements for Earthing System
Figure 1 depicts a principle drawing for a wind turbine earthing system and its connection to the tower. The turbine tower acts as the main bonding and down conductor system ("natural down conductor" according to IEC62305-3) of the wind turbine.

The earthing system of the wind turbine foundation consists of several components, e.g. concrete reinforcement, ring electrodes, stainless steel outlets, anchor ring and connection clamps. The electrical connection between tower and earthing system is realized via the foundation bolts. At four places evenly distributed around the tower, three foundation bolts must be electrically connected to the tower for the purpose of conducting fault and lightning currents to earth. The electrical connection can be realized by removing the tower paint before installing the respective bolt nuts. In order to connect electrical equipment, e.g. the power unit, to the down-conductor system, the tower is equipped with PE pads (Protective Earth pads). Depending on the tower type, different kinds of PE pads can be used. In older towers, welded nuts can very often be found directly on the tower wall; see right hand side of figure 2. In later towers, these welded nuts are replaced by T-brackets (see left hand side of figure 2), which will be directly mounted to the foundation bolts that have been selected for earth connection. The cross section area of any T-bracket or the like (see figure 2) has to fulfill the minimum requirements with respect to the electrical equipment connected to it. Furthermore, there must be no paint between the tower and the T-bracket. In case the tower flange is completely painted, the paint has to be removed at the bolts.

The reinforcement in the foundation shall be systematically bonded using clamp connections. Furthermore, all metal parts in the foundation shall be bonded by clamp connections to the reinforcement. The same applies to the ring electrodes. All earthing system conductors, e.g. ring electrodes, shall be selected with at least 50 mm^2 bare copper wires. Similar metal works with a conductive cross section that corresponds to at least 50 mm^2 copper are also an option. In the latter case, caution to corrosion should be taken when selecting materials.



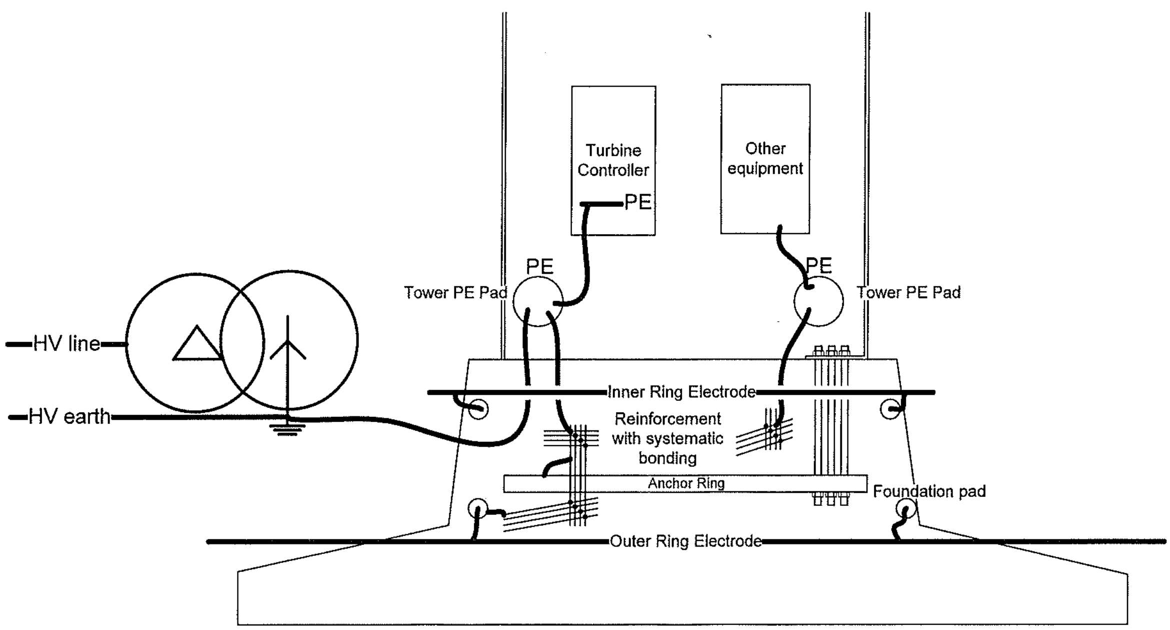


Figure 1: Principle drawings of SWP earthing system. (PE is an acronym for Protection Earth). In the upper drawing, T-brackets on the foundation bolts are used as PE pads. In the lower picture, welded nuts on the tower wall are used as PE pads.

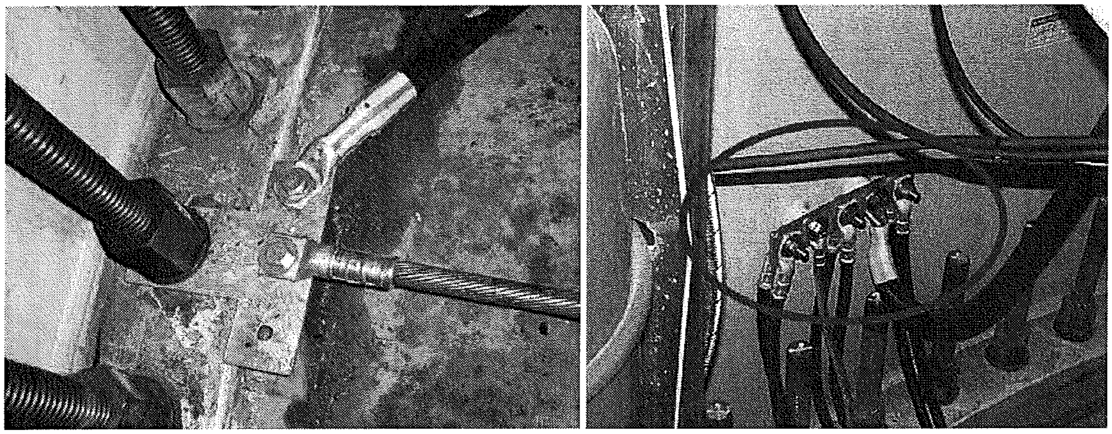


Figure 2: Example of different types of PE pads to be found in Siemens wind turbine towers.

Connection between Electrical Systems and the Earthing System
The star point earthing system of the transformer LV windings must be connected to the wind turbine earthing system by means of a PE conductor that has to be connected to the PE pads in the tower. The cross section of the PE conductor must be in accordance with local requirements and the type of protection installed. Irrespective of other requirements the cross section of the PE conductor must be at least half the cross section of the phase conductors.

High voltage cables connecting the wind turbine to a power grid shall be shielded and connected to the turbine earthing system. For onshore projects, a bare copper conductor of at least $50mm^2$ shall be placed along all cable ducts and be connected to the earthing system of the turbine. The principle is depicted in figure 1.

Onshore Foundations
For onshore turbines the earthing system must include at least one inner earth ring electrode with a diameter of between 1 and 2 m larger than the tower bottom diameter, and one outer ring electrode with a diameter of inner ring plus 3-8 m. The inner ring electrode shall be installed in a depth of 0.4-0.5 m, and the outer ring at a depth of 0.8-1.0 m. Ring electrodes shall be covered with low conductivity material such as large grade gravel etc. The ring electrodes shall be connected with at least four equidistant radials connected to mounting pad outlets on the foundation. The outlets shall be corrosion resistant (e.g. stainless steel) and shall be bonded to the reinforcement.

Monopole and Jacket Foundation for Offshore Turbines
If foundation is of monopole or jacket type, surface to surface between transition piece and tower shall be metal-to-metal. In case a transition piece is not used, the connection between the respective foundation type and the tower has to be metal-to-metal.

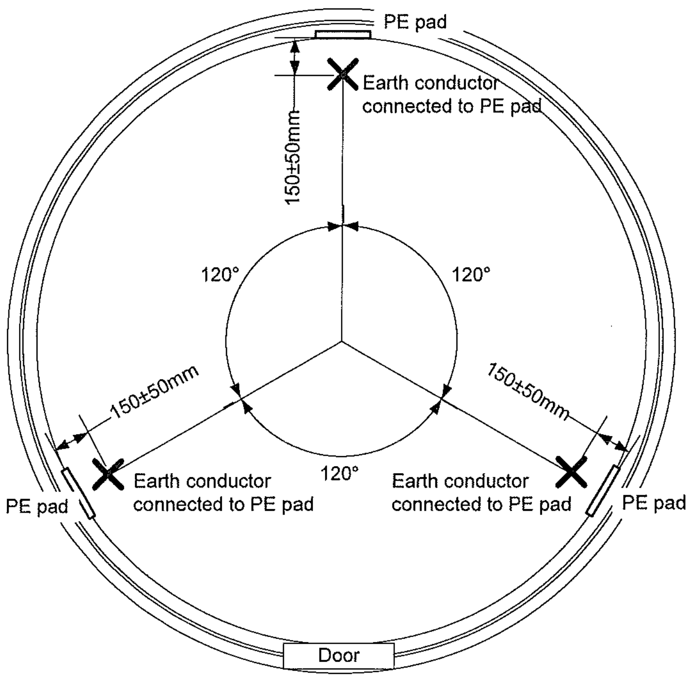


Figure 3: Position of earth wire connection for Tower PE Pads

Offshore Gravitation Foundation
The tower is connected to the foundation with an M16 SS bolt welded to a steel plate cast in the foundation concrete such that it is in flush with its top side. To the plate bottom side are welded three 400 mm Ø10 mm stainless steel rods, each attached to an outer re-bar iron. The kit is installed at four positions around the bottom flange perimeter.

The reinforcement is connected in meshes of approximately 3-5 m, in the periphery closest to the sea, see figure 4 and 5.

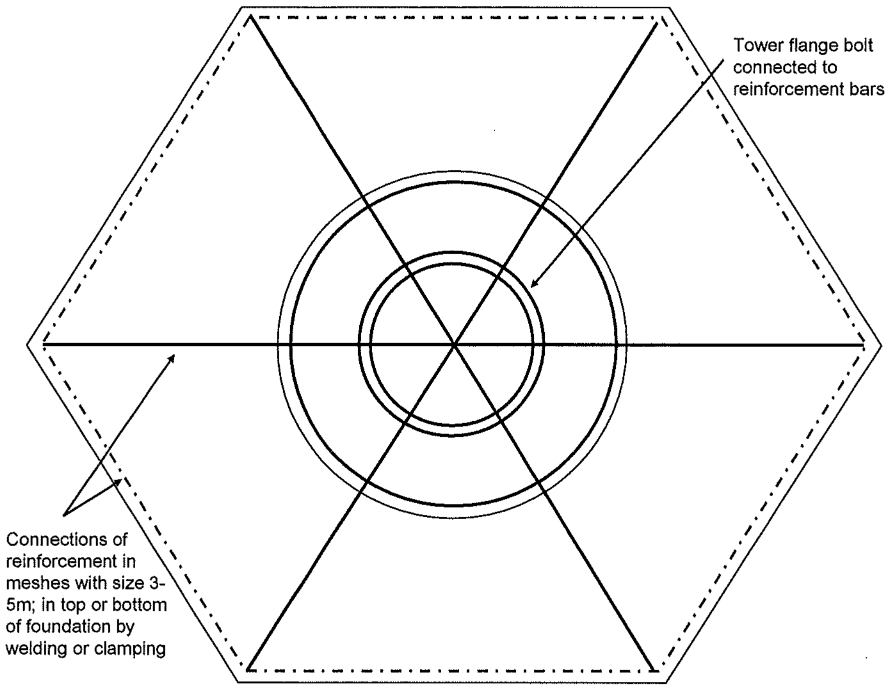


Figure 4: Principle drawing of offshore gravitation foundation reinforcement and earthing.

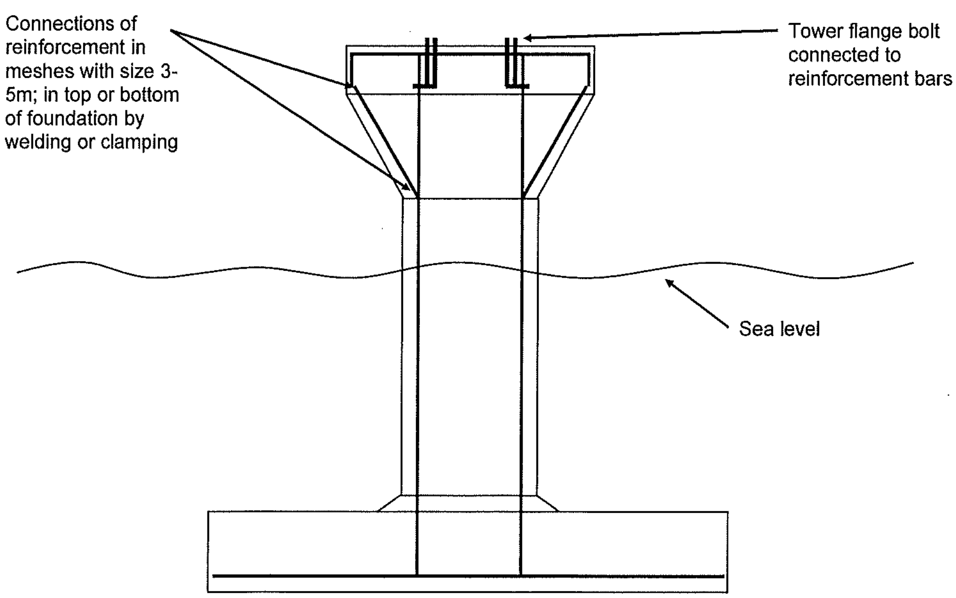


Figure 5: Schematic depiction of offshore gravitation foundation and tower connection.

SWT-2.3-101 Technical Specifications

Rotor
Type .... 3-bladed, horizontal axis
Position .... Upwind
Diameter.......... 101 m
Swept area.......... 8000 m²
Synchronous rotor speed..... 6-16 rpm
Power regulation .... Pitch regulation with variable speed
Rotor tilt.......... 6 degrees

Blade
Type .... Self-supporting
Blade length .... 49 m
Root chord.......... 3.4 m
Aerodynamic profile .... NACA63.xxx, FFAxxx, SWPxxx
Material .... GRE
Surface gloss .... Semi-mat, < 30 / ISO2813
Surface colour.......... Light grey, RAL 7035

Aerodynamic Brake
Type .... Full span pitching
Activation.......... Active, hydraulic

Load-Supporting Parts
Hub .... Nodular cast iron
Main bearing .... Spherical roller bearing
Main shaft.......... Alloy steel
Nacelle bed plate .... Steel

Transmission System
Coupling hub - shaft.......... Flange
Coupling shaft – gearbox ..... Shrink disc
Gearbox type.......... 3-stage planetary/helical
Gearbox ratio .... 1 : 91
Gearbox lubrication .... Splash / forced lubrication
Oil volume .... Approx. 400 l
Gearbox oil filtering .... Inline and offline
Gearbox cooling.......... Separate oil cooler
Gearbox designation .... PEAB 4456 (Winergy) or EH851 (Hansen)
Coupling gear - generator .... Double flexible coupling

Mechanical Brake
Type .... Hydraulic disc brake
Position .... High speed shaft
Number of callipers 2

Canopy
Type.......... Totally enclosed
Material.......... Steel
Surface gloss .... Semi gloss, 30-50, ISO2813
Colour .... Light grey, RAL 7035

Generator
Type.......... Asynchronous
Nominal power.......... 2300 kW
Protection.......... IP 54
Cooling .... Integrated heat exchanger
Insulation class .... F

Grid Terminals (LV)
Nominal power.......... 2300 kW
Voltage .... 690 V
Frequency.......... 50 Hz or 60 Hz

Yaw System
Type.......... Active
Yaw bearing.......... Externally geared slewring
Yaw drive.......... Eight electric gear motors with frequency converter
Yaw brake.......... Passive friction brake

Controller
Type.......... Microprocessor
SCADA system.......... WPS via modem
Controller designation.......... KK WTC 3.0
Controller manufacturer........ KK Electronic A/S

Tower
Type.......... Cylindrical and/or tapered tubular
Hub height .... 80 m or site specific
Corrosion protection .... Painted
Surface gloss .... Semi gloss, 30-50, ISO2813
Colour .... Light grey, RAL 7035

Operational Data
Cut-in wind speed. .... 4 m/s
Nominal power at.......... 12-13 m/s
Cut-out wind speed .... 25 m/s
Maximum 3 s gust.......... 59.5 m/s (IEC version)

Weights (approximately)
Rotor.......... 62,000 kg
Nacelle.......... 82,000 kg
Tower for 80 m hub height.... 162,000 kg

Siemens Wind Power A/S reserves the right to change the above specifications without previous notice.

SWT-2.3-101, 60 Hz Application Electrical Specifications Americas

Generator

Type	Asynchronous
Nominal power	2300kW
Speed range	600 - 1800 rpm
Nominal voltage	750V @ 1550 rpm
Nominal current	2070 A
Frequency	16,5 - 60 Hz
Protection	IP 54

Generator Protection

Insulation class	F
Winding temperatures	2 x 3 PT100 sensors
Bearing temperatures	1 PT100 at each bearing
Bearing insulation	Insulation at both bearings
Grounding brush	On drive end

Generator Cooling

Cooling system	Air to air
Ventilation	Shaft mounted fan
Ventilation type	Centrifugal
External flow direction	From D-end to N-end
Control parameter	Winding temperature

Frequency Converter

Operation	4Q Full scale converter
Switching	PWM
Switching frequency	1250/2500 Hz
Cooling	Liquid

Power Factor at 690 V and Nominal Grid Conditions

Power factor correction	Frequency converter control
Power factor range	0.9 cap. to 0.9 ind. at nominal balanced voltage

Main circuit protection

Short circuit protection	Circuit breaker
Surge protection per phase Imax (8/20 μs)	30 kA

Peak Power Levels

10 min average	100 % of nominal
30 sec average	104 % of nominal

Grid Requirements

Nominal grid frequency	60 Hz
Minimum voltage	90 % of nominal
Maximum voltage	110 % of nominal
Minimum frequency	95 % of nominal
Maximum frequency	103 % of nominal
Maximum current asym.	5%
Max 1 s. short circuit level at controller's grid Terminals (690 V)	40 kA
Min. 1 s short circuit level at controller's grid terminals (690 V)	5 x Pn
Grid error numbers	Max. 300 per year

Power Consumption from Grid (approximately)

At stand-by	5.0 kW, 9kVAR
At stand-by, yawing	9.6 kW, 9kVAR
Before cut-out (60 s)	18 kW
After cut-out (600 s)	18 kW

Earthing Requirements

Earth system	Acc. To IEC62305-3 ED 1.0:2006
Depth electrodes	Min. 2 pcs 50 mm2 Cu, 120° separation
Inner ring electrode	50 mm2 Cu 1 m from tower
Outer ring electrode	50 mm2 Cu min. 10 m from tower
Foundation reinforcement	Must be connected to earth electrodes
Foundation terminals	Min. 6 stainless pads in two levels corresponding to ring electrodes, separated at 120°
HV connection	HV cable shield shall be connected to earthing system
Cable tray conductor	Min. 50 mm2 bare Cu parallel to HV cable

Transformer Requirements

Transformer impedance requirement	6 %
Secondary voltage	690 V
Vector group	Dyn 11 (star point earthed)

Siemens Wind Power A/S reserves the right to change the specifications without previous notice
All data are subject to tolerances in accordance with IEC.

SWT-2.3-101
Technical Description

General
The following is a brief technical description of the main components of the SWT-2.3-101 wind turbine.

Rotor
The SWT-2.3-101 rotor is a three-bladed cantilevered construction, mounted upwind of the tower. The power output is controlled by pitch regulation. The rotor speed is variable and is designed to maximize the aerodynamic efficiency.

Blades
The B49 blades are made of fibreglass-reinforced epoxy in Siemens' proprietary IntegralBlade® manufacturing process. In this process the blades are cast in one piece to eliminate weaker areas at glue joints. The blades are mounted on pitch bearings and can be feathered 80 degrees for shutdown purposes. Each blade has its own independent pitching mechanism capable of feathering the blade under any operating condition. The blade pitch arrangement allows for optimization of the power output throughout the operating range, and the blades are feathered during standstill to minimize wind loads.

Rotor Hub
The rotor hub is cast in nodular cast iron and is fitted to the main shaft with a flange connection. The hub is sufficiently large to provide a comfortable working environment for two service technicians during maintenance of blade roots and pitch bearings from inside the structure.

Main Shaft and Bearing
The main shaft is forged in alloy steel and is hollow to facilitate the transfer of power and signals to the blade pitching system. The main shaft is supported by a self-aligning double spherical roller bearing which is shrunk onto the main shaft.

Gearbox
The gearbox is a custom-built three-stage planetary-helical design. The first high torque stage is of a helical planetary design. The two high-speed stages are of a normal helical design and provide the offset of the high speed shaft that is needed to allow passage of power and control signals to the pitch systems.

The gearbox is shaft-mounted and the main shaft torque is transferred to the gearbox by a shrink disk connection. The gearbox is supported on the nacelle with flexible rubber bushings.

The gearbox is fitted with an oil conditioning system. All bearings are lubricated with oil fed directly from a large in-line filter and is cleaned by an off-line filter unit.

The gearbox is fitted with sensors for monitoring temperature, oil pressure and vibration levels.

Generator
The generator is a fully enclosed asynchronous generator. The generator has a squirrel-cage rotor without slip-rings. The generator rotor construction and stator winding are designed for high efficiency at partial loads.

The generator is protected with thermal switches and analogue temperature measurement sensors. The generator is fitted with a separate thermostat-controlled ventilation arrangement. Air is re-circulated internally in the generator and heat is transferred through an air-to-air heat exchanger that separates the internal environment in the generator from the ambient air.

Mechanical Brake
The mechanical brake is fitted to the gearbox high-speed shaft and has two hydraulic calipers.

Yaw System
The yaw bearing is an externally geared ring with a friction bearing. Eight electric planetary gear motors drive the yawing.

Tower
The SWT-2.3-101 wind turbine is mounted on a tapered tubular steel tower. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and internal electric lighting.

Controller
The wind turbine controller is a microprocessor-based industrial controller. The controller is complete with switchgear and protection devices. It is self-diagnosing and has a keyboard and display for easy readout of status and for adjustment of settings.

The NetConverter® power conversion system allows generator operation at variable speed, frequency and voltage while supplying power at constant frequency and voltage to the MV transformer. The power conversion system is a modular arrangement for easy maintenance and is water cooled.

SCADA
The SWT-2.3-101wind turbine is equipped with the Siemens WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard internet web browser. The status views present information including electrical and mechanical data, operation and fault status, meteorological data and grid station data.

Turbine Condition Monitoring
In addition to the Siemens WebWPS SCADA system, the SWT-2.3-101 wind turbine is equipped with the unique Siemens TCM condition monitoring system. This system monitors the vibration level of the main components and compares the actual vibration spectra with a set of established reference spectra. Result review, detailed analysis and reprogramming can all be carried out using a standard web browser.

Operation Systems
The wind turbine operates automatically. It is self-starting when the wind speed reaches an average about 3 to 5 m/s. The output increases approximately linearly with the wind speed until the wind speed reaches 11 to 12 m/s. At this point, the power is regulated at rated power.

If the average wind speed exceeds the maximum operational limit of 25 m/s, the wind turbine is shut down by feathering of the blades. When the average wind speed drops back below the restart average wind speed, the systems reset automatically.

Siemens Wind Power A/S reserves the right to change the above specifications without previous notice.

SWT-2.3-101
Design Climatic Conditions

The design climatic conditions are the boundary conditions at which the turbine can be applied without supplementary design review. Applications of the wind turbine in more severe conditions may be possible, depending upon the overall circumstances. A project site-specific review requires the completion by the Client of the “Project Climatic Conditions” form.

Subject	ID	Issue	Unit	Value
1. Wind, operation	1.1	Wind definitions	-	IEC 61400-1 Ed3
	1.2	IEC class	-	IIB
	1.3	Air density, ρ	kg/m^3	1.225
	1.4	Mean wind speed, v_{ave}	m/s	8.5
	1.5	Weibull scale parameter, A	m/s	9.6
	1.6	Weibull shape parameter, k	-	2
	1.7	Wind shear exponent, α	-	0.20
	1.8	Mean turbulence intensity at 15 m/s, I_{ref}	-	0.14
	1.9	Standard deviation of wind direction	Deg	7.5
	1.10	Maximum flow inclination,	Deg	8
	1.11	Minimum turbine spacing, in rows	D	3
	1.12	Minimum turbine spacing, between rows	D	5
2. Wind, extreme	2.1	Wind definitions		IEC 61400-1 Ed3
	2.2	Air density, ρ	kg/m^3	1.225
	2.3	Maximum hub height 10 min.wind, V_{ref}	m/s	42.5
	2.4	Maximum 3 s gust in hub height, V_{e50}	m/s	59.5
	2.5	Maximum hub height power law index, α	-	0.11
3. Temperature	3.1	Temperature definitions	-	IEC 61400-1 Ed3
	3.2	Minimum temperature at 2 m, stand-still, $T_{min,s}$	Deg.C	-20
	3.3	Minimum temperature at 2 m, operation, $T_{min,o}$	Deg.C	-10
	3.4	Maximum temperature at 2 m, operation, $T_{max,o}$	Deg.C	35
	3.5	Maximum temperature at 2 m, stand-still, $T_{max,s}$	Deg.C	45
4. Corrosion	4.1	Corrosion definitions	-	ISO 12944
	4.2	External corrosion class	-	C3
	4.3	Internal corrosion class	-	C2
	4.4	Internal climate control	-	Yes
5. Lightning	5.1	Lightning definitions	-	IEC 62305-1
	5.2	Lightning protection level (LPL) acc to IEC 62305	-	LPL 1
6. Dust	6.1	Dust definitions	-	-
	6.2	Dust conditions, ground level	-	Normal DK
	6.3	Dust conditions, hub height	-	Normal DK
7. Hail	7.1	Maximum hail diameter	mm	20
	7.2	Maximum hail falling speed	m/s	20
8. Ice	8.1	Ice definitions	-	IEC 61400-1 Ed3
	8.2	Ice conditions		Normal DK
9. Trees	9.1	If the height of trees within 500m of any turbine location height exceeds 1/3 of H – D/2 where H is the hub height and D is the rotor diameter then restrictions may apply. Please contact Siemens for information on the maximum allowable tree height with respect to the site and the turbine type.		

SWT-2.3-101, 60 Hz Application Electrical Specifications Americas

Generator

Type	Asynchronous
Nominal power	2300kW
Speed range	600 - 1800 rpm
Nominal voltage	750V @ 1550 rpm
Nominal current	2070 A
Frequency	16,5 - 60 Hz
Protection	IP 54

Generator Protection

Insulation class	F
Winding temperatures	2 x 3 PT100 sensors
Bearing temperatures	1 PT100 at each bearing
Bearing insulation	Insulation at both bearings
Grounding brush	On drive end

Generator Cooling

Cooling system	Air to air
Ventilation	Shaft mounted fan
Ventilation type	Centrifugal
External flow direction	From D-end to N-end
Control parameter	Winding temperature

Frequency Converter

Operation	4Q Full scale converter
Switching	PWM
Switching frequency	1250/2500 Hz
Cooling	Liquid

Power Factor at 690 V and Nominal Grid Conditions

Power factor correction	Frequency converter control
Power factor range	0.9 cap. to 0.9 ind. at nominal balanced voltage

Main circuit protection

Short circuit protection	Circuit breaker
Surge protection per phase Imax (8/20 µs)	30 kA

Peak Power Levels

10 min average	100 % of nominal
30 sec average	104 % of nominal

Grid Requirements

Nominal grid frequency	60 Hz
Minimum voltage	90 % of nominal
Maximum voltage	110 % of nominal
Minimum frequency	95 % of nominal
Maximum frequency	103 % of nominal
Maximum current asym.	5%
Max 1 s. short circuit level at controller's grid Terminals (690 V)	40 kA
Min. 1 s short circuit level at controller's grid terminals (690 V)	5 x Pn
Grid error numbers	Max. 300 per year

Power Consumption from Grid (approximately)

At stand-by	5.0 kW, 9kVAR
At stand-by, yawing	9.6 kW, 9kVAR
Before cut-out (60 s)	18 kW
After cut-out (600 s)	18 kW

Earthing Requirements

Earth system	Acc. To IEC62305-3 ED 1.0:2006
Depth electrodes	Min. 2 pcs 50 mm2 Cu, 120° separation
Inner ring electrode	50 mm2 Cu 1 m from tower
Outer ring electrode	50 mm2 Cu min. 10 m from tower
Foundation reinforcement	Must be connected to earth electrodes
Foundation terminals	Min. 6 stainless pads in two levels corresponding to ring electrodes, separated at 120°
HV connection	HV cable shield shall be connected to earthing system
Cable tray conductor	Min. 50 mm2 bare Cu parallel to HV cable

Transformer Requirements

Transformer impedance requirement	6 %
Secondary voltage	690 V
Vector group	Dyn 11 (star point earthed)

Siemens Wind Power A/S reserves the right to change the specifications without previous notice
All data are subject to tolerances in accordance with IEC.

Appendix B

Siemens Acoustic Emission Data

SWT-2.221-101 Low Noise, Hub Height 99.5 m Acoustic Emission

Sound Power Levels

The warranted sound power levels are presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 1.661 m as described in the IEC code. The sound power levels (Lwa) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	4	5	6	7	8	9	10	11	12	Up to cut-out
Sound Power Level	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0

Table 1: Noise emission, Lwa [dB(A) re 1 pW]

Typical Octave Band

Typical, not warranted octave band spectra are tabulated below for 6 and 8 m/s referenced to 10 m height.

Octave band, centre frequency [Hz]	63	125	250	500	1000	2000	4000	8000
Sound Power Level	82.6	93.8	97.0	99.5	99.6	97.1	89.3	84.9

Table 2: Typical octave band for 6 m/s

Octave band, centre frequency [Hz]	63	125	250	500	1000	2000	4000	8000
Sound Power Level	82.4	93.0	96.0	99.8	100.1	96.5	89.6	85.7

Table 3: Typical octave band for 8 m/s

SWT-2.126-101 Low Noise, Hub Height 99.5 m Acoustic Emission

Sound Power Levels

The warranted sound power levels are presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 1.800 m as described in the IEC code. The sound power levels (Lwa) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Sound Power Level	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0

Table 1: Noise emission, Lwa [dB(A) re 1 pW]

Typical Octave Band

Typical, not warranted octave band spectra are tabulated below for 6 and 8 m/s referenced to 10 m height.

Octave band, centre frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound Power Level	83.1	94.1	96.6	97.8	97.9	96.5	88.4	84.0

Table 2: Typical octave band for 6 m/s

Octave band, centre frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound Power Level	82.2	92.5	94.8	98.5	99.1	95.5	89.0	85.1

Table 3: Typical octave band for 8 m/s

SWT-2.3-101, Max. Power 1903 kW
Contract Acoustic Emission, Hub Height 99.5 m

Sound Power Levels
The warranted sound power level is presented with reference to the code IEC 61400-11:2002 with amendment 1 dated 2006-05 based on a hub height of 99.5 m and a roughness length of 0.05 m as described in the IEC code. The sound power levels (L_{WA}) presented are valid for the corresponding wind speeds referenced to a height of 10 m above ground level.

Wind speed [m/s]	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Up to cut-out**
Sound power level	91.4	95.5	99.0	101.5	102.0	102.0	102.0	102.0	102.0	102.0	102.0

Table 1: Noise emission, L_{WA} [dB(A) re 1 pW]

Octave Band
Octave band spectra are tabulated below for 6 and 8 m/s referenced to 10 m height.

Octave band, centre frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound power level	83.4	93.3	94.5	93.7	94.4	94.7	87.3	83.5

Table 2: Octave band for 6 m/s, L_{WA} [dB(A) re 1 pW]

Octave band, centre frequency [Hz]	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Sound power level	82.1	91.8	92.5	95.8	97.2	93.7	88.1	84.3

Table 3: Octave band for 8 m/s, L_{WA} [dB(A) re 1 pW]

Suite 500, 4342 Queen Street
Niagara Falls, Ontario, Canada L2E 7J7
Tel 905 374 5200 ◆ Fax 905 374 1157

HATCH™

Suite 500, 4342 Queen Street
Niagara Falls, Ontario, Canada L2E 7J7
Tel 905 374 5200 ◆ Fax 905 374 1157