Section 27

Public Safety

Section 27. Public Safety

27.1 State Standards

According to Site Law and the Wind Energy Act, the Applicant will provide evidence that the Project shall be constructed with appropriate setbacks and other considerations to protect the public.

Evidence is needed to demonstrate:

- Appropriate safety setbacks;
- Setbacks from property lines to minimize risks from ice throw, blade shear, etc.;
- Design standards; and
- Fire plans.

27.2 Safety Setbacks

The Project has been sited appropriate distances from non-participating landowners. The closest non-participating landowner's property line is over 1,500 feet away from the nearest turbine. That is over 200% the tip height of the wind turbine and over 150% of the tower height plus the rotor diameter (275 meters or 902 feet).

GE, the turbine manufacturer, recommends a minimum setback for 1.1 times the tip height (215.6 meters or 707.4 feet for the Project) from public use areas, roads, railways, buildings, etc. and 1.1 times the blade length (86.9 meters or 285.1 feet for the Project) from property not owned by Project participants. As the nearest non-participating landowner's property line is over 1,500 feet away from the closest turbine, the Project complies with the manufacturer's recommended setbacks.

See Exhibit 27-1 for the manufacturer's recommended setbacks.

27.3 Setbacks from Property Lines

Pursuant to the Department rules, Chapter 382, § 5, the Department established the minimum setback for generating facilities. The Department requires each wind turbine to be setback from a non-participating property line at 1.5 times the hub height plus the rotor diameter or the minimum local or Land Use Planning Commission standard, whatever is greater.

The Town of Rumford's setback standard for Type 3 wind energy facilities is 1.5 times the turbine height (tip height). Therefore, the State's standard of 1.5 times the hub height plus the rotor diameter is the more stringent standard.

As described in Section 27.3, the closest non-participating landowner's property line is over 1,500 feet away from the nearest turbine, which exceeds the State's setback of 150% of the tower height plus the rotor diameter (150% x 902 feet = 1,353 feet).

See Exhibit 27-2 that depicts the Project setbacks from property lines.

In addition to the locational setbacks, the Project is also separated from public access via a gate. The road that will provide access to the Project site is existing and gated.

27.4 Design Standards

The turbines are certified according to IEC 61400-22 testing and certification scheme in combination with IEC 61400-1 Edition 3 wind turbine design requirements. The wind turbines have a certificate from TUV Nord Group.

See Exhibit 27-3 for the certification.

27.5 Fire Plans

The turbines will be monitored 24x7 during operations. This monitoring will occur through a remote connection. The 24x7 remote monitoring will allow operators to be aware of onsite performance and issues. This includes temperature levels that indicate fire. Each wind turbine is designed to send automated alarms and alter its operations both if it is too cold or too hot. Technical documentation about the fire detection and fire alarm system in the turbines is included as Exhibit 27-4.

In 2022, the Applicant submitted a draft safety plan for review and comment to the Town of Rumford's Code Enforcement Officer and Fire Chief. The Town did not provide substantive changes to the plan. The current draft of that plan is included as Exhibit 27-5.

The Town of Roxbury hosts two operating wind farms and the Applicant will work with the Town of Roxbury to understand the layout, specifications, and health and safety plan for this Project.

As outlined in the health and safety plan, the Project will have fire extinguishers in the base of each tower and at the back of the nacelle. In addition, each service vehicle will have a portable fire extinguisher.

All fire extinguishers shall be:
- Maintained in a fully charged and operable condition,
- Visually inspected each quarter and inspection documented, and undergo a maintenance check each year.

- Kept clear and accessible.

27.7 Other Safety

Lightning

The turbines are designed with lightning protection. The health and safety plan outlines the operating procedures that wind turbine technicians must follow if lightning is detected in the region while they are on site. GE also provides technical data and manuals regarding the lightning protection design for the turbines.

For more on lightning protection, see Exhibit 27-6, Lightning Protection and Technical Description and Data (page 8).

Overspeed

The turbines are also designed to detect and react to overspeed issues. The blades are pitch regulated to control the speed of the rotor. As described in Exhibit 27-6, Technical Description and Data:

"Rotor speed is regulated by a combination of blade pitch angle adjustment and generator/converter torque control. The rotor spins in a clockwise direction under normal operating conditions when viewed from an upwind location.

Full blade pitch angle range is approximately 90 degrees, with the zero degree position being with the blade flat to the prevailing wind. Pitching the blades to a full feather pitch angle of approximately 90 degrees accomplishes aerodynamic braking of the rotor, thus reduces the rotor speed." (Page 6)

And with regard to the Blade Pitch Control System:
"The active pitch controller enables the wind turbine rotor to regulate speed, when above rated wind speed, by allowing the blade to "spill" excess aerodynamic lift. Energy from wind gusts below rated wind speed is captured by allowing the rotor to speed up." (Page 6)

Blade Clearance

Each rotor will be mounted on a 117 meter high tower. Each blade is 79 meters long. The blade clearance from the ground will be 38 meters.

Exhibit 27-1
Manufacturer's Recommended Setbacks

GE Renewable Energy

–Original –

Technical Documentation
Wind Turbine Generator Systems
All Onshore Turbine Types

General Description

Setback Considerations for Wind Turbine Siting

imagination at work

GE Renewable Energy

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www.gerenewableenergy.com

All technical data is subject to change in line with ongoing technical development!

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Table of Contents

1 Introduction

This document provides setback guidance for the siting of wind turbines. This guidance considers potential safety risks associated with wind turbines such as objects (maintenance tools, ice, etc.) directly falling from the wind turbine, unlikely occurrences such as tower collapse and blade failure, and environmental / operational risks such as ice throw. The guidance is general in nature, and is based on the published advice of recognized industry associations. Local codes and other factors may dictate setbacks greater than the guidance in this document. The owner and the developer bear ultimate responsibility to determine whether a wind turbine should be installed at a particular location, and they are encouraged to seek the advice of qualified professionals for siting decisions. It is strongly suggested that wind developers site turbines so that they do not endanger the public.

2 Falling Objects

There is the potential for objects to directly fall from the turbine. The objects may be parts dislodged from the turbine, or dropped objects such as tools. Falling objects create a potential safety risk for anyone who is within close proximity to the turbine, i.e., within approximately a blade length from the turbine.

3 Tower Collapse

In very rare circumstances a tower may collapse due to unstable ground, a violent storm, an extreme earthquake, unpredictable structural fatigue, or other catastrophic events. Tower collapse presents a possible risk to anyone who is within the distance equal to the turbine tip height (hub height plus ½ rotor diameter) from the turbine.

4 Ice Shedding and Ice Throw

As with any structure, wind turbines can accumulate ice under certain atmospheric conditions. A wind turbine may shed accumulated ice due to gravity, and mechanical forces of the rotating blades. Accumulated ice on stationary components such as the tower and nacelle will typically fall directly below the turbine. Ice that has accumulated on the blades will likewise typically fall directly below the turbine, especially during start-up. However, during turbine operation under icing conditions, the mechanical forces of the blades have the potential to throw the ice beyond the immediate area of the turbine.

5 Blade Failure

During operation, there is the remote possibility of turbine blade failure due to fatigue, severe weather, or other events not related to the turbine itself. If one of these events should occur, pieces of the blade may be thrown from the turbine. The pieces may or may not break up in flight, and are expected to behave similarly to ice thrown from the blade. Blade failure presents a possible risk for anyone beyond the immediate area of the turbine.

6 Industry Best Practices

Recognized industry practices suggest the following actions be considered when siting turbines in order to mitigate risk resulting from the hazards listed above:

Place physical and visual warnings such as fences and warning signs as appropriate for the protection of site personnel and the public.

Remotely stop the turbine when ice accumulation is detected by site personnel or other means. Additionally, the wind turbine controller may have the capability to shut down or curtail an individual turbine based on the detection of certain atmospheric conditions or turbine operating characteristics.

Restrict site personnel access to a wind turbine if ice is present on any turbine surface such as the tower, nacelle or blades. If site personnel absolutely must access a turbine with ice accumulation, safety precautions should include but are not limited to remotely shutting down the turbine, yawing the turbine to position the rotor on the side opposite from the tower door, parking vehicles at a safe distance from the turbine, and restarting the turbine remotely when the site is clear. As always, appropriate personnel protective gear must be worn.

7 Setback Considerations

Setback considerations include adjoining population density, usage frequency of adjoining roads, land availability, and proximity to other publicly accessed areas and buildings. Table 1 provides setback guidance for wind turbines given these considerations. GE recommends using the generally accepted guidelines listed in Table 1, in addition to any requirements from local codes or specific direction of the local authorities, when siting wind turbines.

Setback Distance from center of turbine tower	Objects of concern within the setback distance

All turbine sites (blade failure/ice throw):
1.1 x tip height[1], with a minimum setback distance of 170 meters
	- Public use areas
	- Residences
	- Office buildings
	- Public buildings
	- Parking lots
	- Public roads
	  - Moderately or heavily traveled roads if icing is likely
	  - Heavily traveled multi-lane freeways and motorways if icing is not likely
	- Passenger railroads

All turbine sites (tower collapse): 1.1 x tip height[1]	- Public use areas - Residences - Office buildings - Public buildings - Parking lots - Heavily traveled multi-lane freeways and motorways - Sensitive above ground services[2]
All turbine sites (rotor sweep/falling objects): 1.1 x blade length[3]	- Property not owned by wind farm participants[4] - Buildings - Non-building structures - Public and private roads - Railroads - Sensitive above ground services

Table 1: Setback recommendations

The wind turbine buyer should perform a safety review of the proposed turbine location(s). Note that there may be objects of concern within the recommended setback distances that may not create a significant safety risk, but may warrant further analysis. If the location of a particular wind turbine does not meet the Table 1 recommended guidelines, contact GE for guidance, and include the information listed in Table 2 as applicable.

1 The maximum height of any blade tip when the blade is straight up (hub height + ½ rotor diameter).

2 Services that if damaged could result in significant hazard to people or the environment or extended loss of services to a significant population. Examples include pipelines or electrical transmission lines.

3 Use ½ rotor diameter to approximate blade length for this calculation.

4 Property boundaries to vacant areas where there is a remote chance of future development or inhabitancy during the life of the wind farm.

Condition/object within setback circle	Data Required
If icing is likely at the wind turbine site	- Annual number of icing days
Residences	- Number of residences within recommended setback distance - Any abandoned residences within setback distance
For industrial buildings (warehouse/shop)	- Average number of persons-hours in area during shift - Number of work shifts per week - Any abandoned buildings within setback distance
For open industrial areas (storage/parking lot)	- Average number of persons-hours in area during shift - Number of shifts per week. - Any abandoned buildings within setback distance
For sports/assembly areas	- Average number of persons in area per day - Average number of hours occupied per day - Number of days area occupied per week - If area covered, what type of cover
For roads/waterways	- Plot of road/waterway vs. turbine(s) - Average number of vehicles per day - Type of road and speed limit (residential, country, # of lanes, etc.)
For paths/trails (walk, hike, run, bike, ski)	- Plot of paths/trails vs. turbine(s) - Average number # of persons per day by type of presence (walk, hike, etc.) - Flat or uneven/hilly terrain

Table 2: Setback recommendations

Exhibit 27-2
Project Setback Map

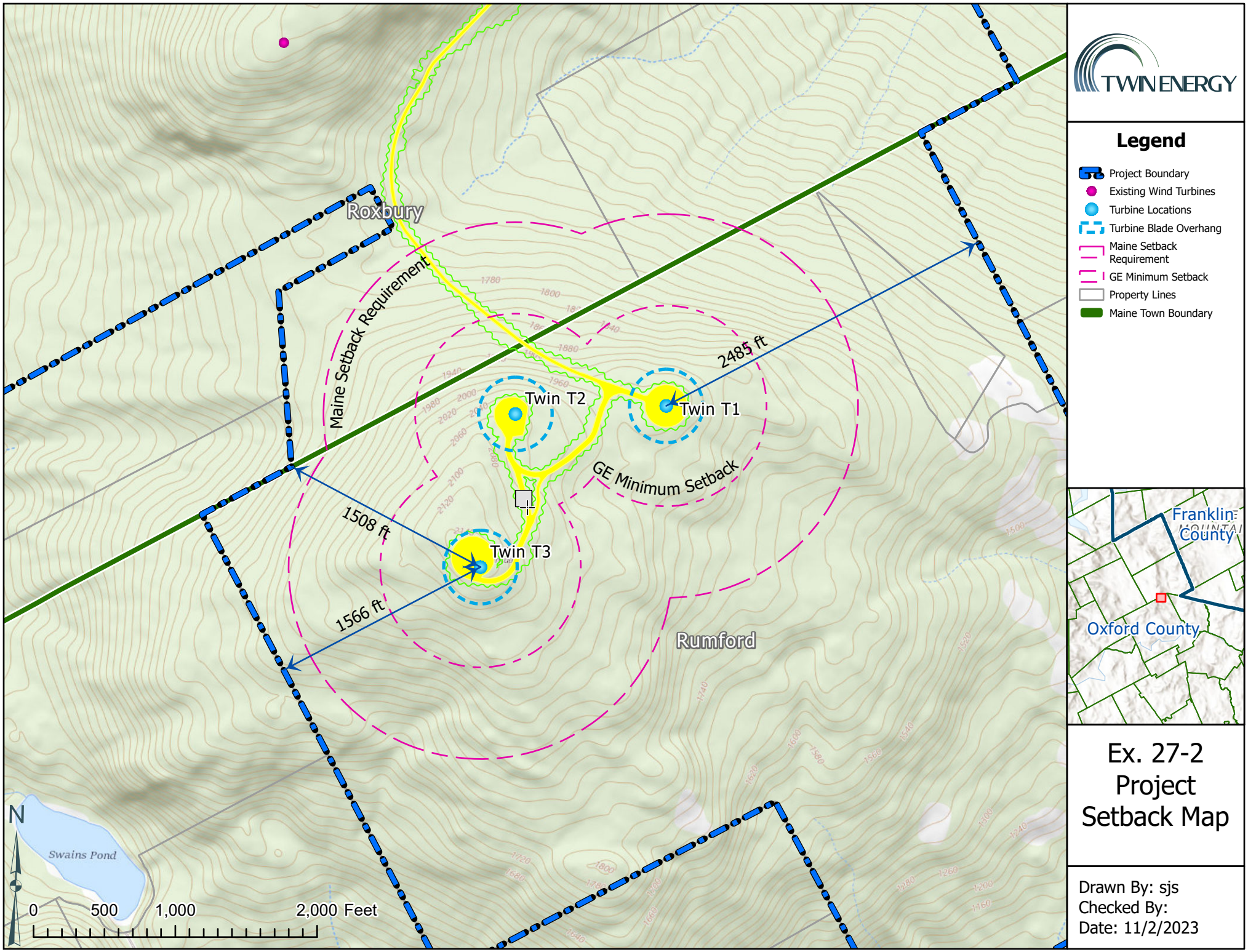
TWIN ENERGY
Legend
Project Boundary
Existing Wind Turbines
Turbine Locations
Turbine Blade Overhang
Maine Setback Requirement
GE Minimum Setback
Property Lines
Maine Town Boundary
Roxbury
Maine Setback Requirement
Twin T2
Twin T1
Twin T3
2485 ft
GE Minimum Setback
1508 ft
1566 ft
Rumford
Swains Pond
N
0
500
1,000
2,000 Feet
Franklin County
Oxford County
Ex. 27-2
Project
Setback Map
Drawn By: sjs
Checked By:
Date: 11/2/2023

Exhibit 27-3
Design Certifications

Type Certificate

Registration no.	**44 220 21850888-TC-IEC-b, Rev. 7**
This Certificate is issued to	GE Wind Energy GmbH Holsterfeld 16 48499 Salzbergen Germany
For the wind turbine	**GE 6.1-158, GE 5.x-158, GE 4.X-158**
WT Class	**IEC S**

This Certificate attests compliance with the below cited certification scheme and standards.

Certification scheme:
IEC 61400-22 "Wind turbines - Part 22: Conformity testing and certification", Edition 1.0, 2010-05
In combination with:
IEC 61400-1 "Wind Turbines - Part 1: Design requirements", Third Edition, 2005-08 and Amendment 1, 2010-10

The wind turbine type is specified on pages 3 - 26 of this Certificate.

Any change in the design, the production and erection or the manufacturer's quality system has to be approved by TÜV NORD CERT GmbH. Without approval this Certificate loses its validity.

Provided that valid Component Certificates of the Rotor Blades are available, this Certificate is valid until: 2027-01-30 (First issue: 2022-01-31)

(under the condition of regular maintenance according to chapter 6.5.2 of IEC 61400-22)

DAkkS Deutsche Akkreditierungsstelle D-ZE-12007-01-02

Essen, 2023-06-23

TÜV NORD CERT GmbH
Certification Body, Wind Energy
Am TÜV 1 | 45307 Essen
email: windenergy@tuev-nord.de

Dr. F. Messer

Form P20-F-2005, Rev.07 /05.23

TÜV ®

THE CERTIFICATE IS BASED ON THE FOLLOWING REFERENCE DOCUMENTS:

Conformity Statements:

TÜV NORD	44 220 19711611-TDB-IEC	Design Basis	Rev. 7	2023-01-12
TÜV NORD	44 220 21850888-D-IEC-b	Design Evaluation	Rev. 8	2023-06-23
TÜV NORD	44 220 19288026-M-IEC	Manufacturing Evaluation	Rev. 12	2023-03-17
TÜV NORD	44 220 19288026-T-IEC	Type Testing	Rev. 4	2022-03-31
TÜV NORD	44 220 21554772-CC-IEC	Component Certificate for LM77.4P3 **(valid until 2026-12-09)**	Rev. 1	2022-06-20
TÜV NORD	44 220 21884831-CC-IEC	Component Certificate for LM77.4P6 / IMS **(valid until 2026-12-09)**	Rev. 0	2021-12-10

Final Evaluation Report:

TÜV NORD	8118 850 888-20 E II	GE6.1-158, GE5.x-158, GE4.x-158 (60Hz)	Rev. 8	2023-06-23

WIND TURBINE TYPE SPECIFICATION:

Machine parameters:

Model	GE6.1-158, GE5.x-158, GE4.x-158
Type	Horizontal axis wind turbine with variable rotor speed
Wind turbine manufacturer and country	GE Wind Energy GmbH, Germany
Power regulation	Independent electromechanical pitch system for each blade
Variable Rating Concept	Torque and Thrust based
Rotor diameter	158 m
Rotor orientation	Upwind
Number of rotor blades	3
Rotor tilt	4°
Cone angle	5°
IEC WT class	S
Operating wind speed range Vin – Vout	3 – 25 m/s (reduced power mode above V_{HWSNR})
Operating range rotational speed	6 – 12 rpm
Lightning protection class	Protection class 1 as per IEC 61400-24
Software version	see Control & Safety System

Electrical network conditions:

Normal supply voltage and range	33 kV, 34.5 kV ± 10%
Normal supply frequency and range	60 Hz ± 3 Hz
Voltage imbalance	4%
Maximum duration of electrical power network outages	no information
Number of electrical network outages	290/ year

Other environmental conditions:

Normal climate conditions (STW)	
Operational temperature range	-15°C - +40°C (Start: - 10°C, derated above 35°C)
Survival temperature range	-20°C - +50°C
Cold climate conditions (CWE)	
Operational temperature range	-30°C - +40°C (Start: - 10°C, derated above 35°C and below -15°C)
Survival temperature range	-40°C - +50°C
Air density	see table below
Relative humidity of the air	up to 95%
Solar radiation	1000 W/m2
Ice conditions	STW: No ice considered CWE: see table below
Earthquake model and parameters	not considered

Wind turbine configurations:

Configuration	1 (PRD 68)	2 (PRD 69)	3 (PRD 35)	4 (PRD 136)
Max Rated Power	5530 kW	5530 kW	5530 kW	6130 kW
Variable Rating	possible variable rating from 5530 kW down to 4500 kW	possible variable rating from 5530 kW down to 4500 kW	possible variable rating from 5530 kW down to 4500 kW	possible variable rating from 6130 kW down to 4830 kW
Hub Height	107.4 m	125.4 m	101 m	125.4 m
Frequency	60 Hz	60 Hz	60 Hz	60 Hz
Rated wind speed	11.55 m/s	11.55 m/s	11.55 m/s	12 m/s
Rated rpm	9.7 rpm	10.1 rpm	10.1 rpm	10.1 rpm
IEC WT class	S	S	S	S
Design Lifetime WT	20 years(4)	25 years(3,4)	25 years(3,4)	25 years(3,4)
I_{ref}	Specific turbulence profile(2)	Specific turbulence profile(2)	Specific turbulence profile(2)	Specific turbulence profile(2)
V_{ave}	9.5 m/s(1)	9.6 m/s(1)	10.2 m/s(1)	7.2 m/s(1)
V_{ref}	28.0 m/s	28.0 m/s	36.4 m/s	40 m/s
V_{e50}	39.2 m/s	39.2 m/s	50.96 m/s	56 m/s
Mean inflow	0.3°	2.7°	6.9°	2.7°
Air density	1.156 kg/m³	1.138 kg/m³	1.104 kg/m³	1.096 kg/m³
Climate	STW	STW	STW	STW
Ice conditions	none	none	none	none
V_{HWSNR}	15 m/s	15 m/s	15 m/s	18 m/s

Configuration	5 (PRD 142)	6 (PRD 169)	7 (PRD 153)
Max Rated Power	6130 kW	6130 kW	6130 kW
Variable Rating	possible variable rating from 6130 kW down to 4830 kW	possible variable rating from 6130 kW down to 4830 kW	possible variable rating from 6130 kW down to 4990 kW
Hub Height	101 m	117 m	101 m
Frequency	60 Hz	60 Hz	60 Hz
Rated wind speed	12 m/s	11.55 m/s	12 m/s
Rated rpm	10.1 rpm	10.1 rpm	10.1 rpm
IEC WT class	S	S	S
Design Lifetime WT	25 years[3,4]	20 years	25 years[3,5]
I_{ref}	Specific turbulence profile[2]	Specific turbulence profile[2]	Specific turbulence profile[2]
V_{ave}	7.2 m/s[1]	7.9 m/s	7.25 m/s
V_{ref}	40 m/s	39.9 m/s	39.9 m/s
V_{e50}	56 m/s	55.86 m/s	55.86 m/s
Mean inflow	6.9°	1.6°	0.7°
Air density	1.104 kg/m³	1.089 kg/m³	1.103 kg/m³
Climate	STW	STW / CWE	STW/CWE
Icing conditions	none	168 hours/year	168 hours/year
V_{HWSNR}	18 m/s	18 m/s	18 m/s

[1]Reported V_{ave} corresponds to the value used for Extreme Loads. For Fatigue Loads, refer to corresponding evaluation report in the Design Evaluation Conformity Statement

[2]Details available in loads evaluation report in the Design Evaluation Conformity Statement

[3]Design lifetime of components relevant for operation of safety functions: 20 years, replacement required to continue

[4]Design lifetime pitch drive: 15 years when equipped with LM77.4P3 blades or LM77.4P6 blades

[5]Design lifetime pitch drive: 20 years when equipped with LM77.4P3 blades

MAJOR COMPONENTS:

Manufacturing site(s) for hub and nacelle assembly:	(1) GE GE Wind Energy, Salzbergen, Germany (2) GE Wind Energy Equipment Manufacturing (Shenyang), China (3) GE Energia Renováveis Ltda, Camaçari, Brazil
Nacelle cover	
Designed by:	GE Renewable Energy
GE Part no.: 450W4798G002 (Brackets)	450W4473G001 (Cover)
Alternative	
GE Part no.:	450W4473G003 (Cover) 450W4798G004 (Brackets)
Alternative	
GE Part no.:	451W6589G001 (Cover) 450W4798G004 (Brackets)
Alternative	
GE Part no.:	453W0897G001 (Cover) 450W4798G004 (Brackets)
Alternative	
GE Part no.:	450W4473G004 (Cover) 450W4798G005 (Brackets)
Alternative	
GE Part no.:	453W5175G001 (Cover) 450W4798G005 (Brackets)
Blade	
For configurations 1-6	
Designed by:	LM Wind Power Group
Designation:	LM77.4P3 Gen A
Material:	E-glass and carbon fibre reinforced polyester
Blade length:	77.491 m
Number of blades:	3
Drawing no.:	DR-09345/A6, Rev. A6
GE PN (root group):	451W4184G001-G018 454W9440G001 454W7941G001-G005

GE PN (tip group):	451W4182G001-G014 455W0060G001 454W9251G001-G012
Specification:	BS-01170/A5, Rev. A5
Attachments:	Vortex Generators / Serrations / LNTE T-spoilers / Stiffner plate

Alternative for configurations 1-7

Designed by:	LM Wind Power Group
Designation:	LM77.4P3 Gen B
Material:	E-glass and carbon fibre reinforced polyester
Blade length:	77.491 m
Number of blades:	3
Drawing no.:	DR-09345/A6, Rev. A6
GE PN (root group):	454W3270G001-G012 454W9440G002 454W9248G001-G012
GE PN (tip group):	451W4182G001-G014 455W0060G001 454W9251G001-G012
Specification:	BS-01170/A5, Rev. A5
Attachments:	Vortex Generators / Serrations / LNTE T-spoilers / Stiffner plate

Alternative for configurations 1-6

Designed by:	LM Wind Power Group
Designation:	LM77.4P6 with IMS
Material:	E-glass and carbon fibre reinforced polyester
Blade length:	77.491 m
Number of blades:	3
Drawing no.:	DR-15590/A4, Rev. A4
GE PN:	452W3948G001 452W3948G002
Specification:	BS-01369/A2, Rev. A2
Attachments:	Vortex Generators / Serrations / LNTE T-spoilers / Stiffner plate

Alternative for configurations 1-6

Designed by:	LM Wind Power Group
Designation:	LM77.4P6 without IMS
Material:	E-glass and carbon fibre reinforced polyester
Blade length:	77.491 m
Number of blades:	3

Drawing no.:	DR-15590/A4, Rev. A4
GE PN:	452W8900G001-G004 454W5940G001-G005 454W9316G001-G002
Specification:	BS-01510/A2, Rev. A2
Attachments:	Vortex Generators / Serrations / LNTE T-spoilers / Stiffner plate
Manufacturer/Site:	LM Wind Power A/S All manufacturing sites covered by same global Manufacturing process and ISO9001 certificate DK01262

Blade bearing

Type:	Ball bearing slewing ring
Designed by:	GE Renewable Energy
Designation:	448W4841G001/G002
Drawing no.:	448W4841, Rev. A, dated 2020-01-08
Manufacturer/Site:	(1) Tianma (Chengdu) Precision Machinery Co. Ltd., Chengdu, P.R. China (2) Shilla Brazil Industria de Rolament de Giro Ltda, Tiete, Brazil (3) SKF do Brazil Ltda, Cajamar, Brazil

Alternative

Designed by:	GE Renewable Energy
GE Part no.:	452W1372G001 453W6327G001
Drawing no.:	452W1372, Rev. C, dated 2022-01-10 453W6327, Rev. -, dated 2021-10-25
Manufacturer/Site:	(1) Shilla Brazil Industria de Rolament de Giro Ltda, Tiete, Brazil (2) SKF do Brazil Ltda, Cajamar, Brazil (3) Liebherr Components GmbH, Biberach, Germany (4) Tianma (Chengdu) Precision Machinery Co. Ltd., Chengdu, P.R. China

Alternative

Designed by:	GE Renewable Energy
GE Part no.:	453W1204G001
Drawing no.:	453W1204, Rev. A, dated 2022-04-12
Manufacturer/Site:	(1) SKF do Brazil Ltda, Cajamar, Brazil (2) Liebherr Components GmbH, Biberach, Germany (3) Shilla Brazil Industria de Rolament de

		Giro Ltda, Tiete, Brazil (4) Tianma (Chengdu) Precision Machinery Co. Ltd., Chengdu, P.R. China

Pitch Motor

Designed by:	AMD /Nidec
GE Part no.:	448W0101P001
GE VSPN:	448W3984P001
Designation:	1175.291.1256

Pitch drive

Type:	3-stage planetary gearbox
Designed by:	Bonfiglioli Trasmital
Designation:	2T709T3157A02
Drawing no.:	I7090T012600, Rev. D, dated 2019-02-01
GE Part no.:	446W6974P001
GE VSPN:	446W6973P001
Manufacturer/Site:	(1) Bonfiglioli Riduttori S.p.A., Bologna, Italy

Alternative

Designed by:	Liebherr Components Biberach GmbH
Designation:	DAT 350/2491 V2 (12805547)
Drawing no.:	268 491 3000 99 2, Rev.02, dated 2019-10-14
GE Part no.:	446W6974P001
GE VSPN:	448W3394P001
Manufacturer/Site:	(1) Liebherr Machinery (Dalian) Co., Ltd., China (2) Liebherr Components GmbH, Biberach, Germany

Alternative

Designed by:	SEW Eurodrive Brasil
Designation:	PW022
Drawing no.:	2422 433 2.30.1, Rev.00, dated 2019-06-08
GE Part no.:	446W6974P001
GE VSPN:	449W7381P001
Manufacturer/Site:	(1) Sew-Eurodrive Brasil Ltda, Indaiatuba, Brazil

Alternative

Designed by:	NGC
Designation:	FDX104E-01-00R3
Drawing no.:	FDX104E-01-00R3, Rev. B, dated 2020-06-18
GE Part no.:	446W6974P001
GE VSPN:	451W2061P001
Manufacturer/Site:	(1) Nanjing High Speed & Accurate Gear, Nanjing, China

Pitch lock

Type:	Blade Locking Device
Designed by:	GE Renewable Energy
GE Part no.:	449W5494
Drawing no.:	449W5494, Rev. -, dated 2019-08-22

Hub

Type:	Cast
Designed by:	GE Renewable Energy
Designed by:	GE Renewable Energy
Material:	acc. to spec. B50WE001
GE Part no.:	449W9972G001 (serial, standard) 450W0325G001/G003 (Serial. IMS) 451W4185G001/G003 454W5903G001
Drawing no. (machining):	449W9972, Rev. -, dated 2020-01-31 450W0325, Rev. -, dated 2020-01-31 451W4185, Rev. A, dated 2021-10-12 454W5903, Rev. -, dated 2022-06-08
Drawing no. (casting):	449W9971, Rev. -, dated 2019-11-15
Manufacturer/Site:	(1) Jiangsu FAW Foundry Co. Ltd, Wuxi, Jiangsu, P.R. China (2) Himile Mechanical Science and Technology Co. Ltd, Shandong, P.R. China (3) Stepan ind de Maquinas e Motoresl, Campinas, Brazil (4) Emalto Industria Mecanica Ltda, Timoteo, Brazil (5) Emalto Usinagem e Tratamento Anticorrosivo Ltda, Santand do Paraiso, Brazil (6) Jiangsu Sinojit Wind Energy Technology Co. Ltd., Jiangyin City, P.R. China

Main shaft

Type:	Forged
Designed by:	GE Renewable Energy
Material:	34CrNiMo6, WTG-113 acc. to spec.
GE Part no.:	450W3625G001/G002
Drawing no.:	450W3625, Rev. -, dated 2020-06-10
Manufacturer/Site:	(1) Tongyu Heavy Industry Co. Ltd, Yucheng City, P.R. China (2) Jinlei Technology Co. Ltd., Laiwu City, Shandong, P.R. China (3) Mecanizados Tar, S.L., Arrona-Zestoa, Spain

Main bearing

Type:	Spherical roller bearing
Designed by:	NTN Bearing Corporation of America
GE Part no.:	448W2212P001
Designation:	5MX4-240/1120BPX3V4S30
Drawing no.:	19-01937, Rev. -, dated 2019-03-15
Manufacturer/Site:	(1) NTN Houdatsushimizu Corporation, Ishikawa, Japan (2) NTN Waelzlager Europa GmbH, Erkrath, Germany

Alternative

Designed by:	Schaeffler Technologies AG & Co. KG
GE Part no.:	448W2212P001
Designation:	F-623433.03.PRL-WPO-J48BB
Drawing no.:	EDD F-623433.03.PRL-WPO-J48BB 000, Rev. AE, dated 2019-03-21
Manufacturer/Site:	(1) Schaeffler Technologies AG & Co. KG, Schweinfurt, Germany (2) Schaeffler Technologies AG & Co. KG, Brasov, Romania

Low Speed Coupling

Type:	Shrink disc
Designed by:	Stüwe GmbH & Co KG
GE Part no.:	446W5714P001
GE VSPN:	449W0153P001
Designation:	HSD 890-23-2
Main Drawing no.:	HSD 890-23-2, Rev. 1, dated 2018-01-31
Manufacturer/Site:	(1) Stüwe GmbH and Co. KG, Hattingen, Germany

Alternative

Designed by:	Rexnord Tollok
GE Part no.:	446W5714P001
GE VSPN:	449W0156P001
Designation:	TLK622 890x1310 Y2360
Main Drawing no.:	Y2360, Rev. -, dated 2018-01-29
Manufacturer/Site:	(1) Rexnord Tollok S.r.l., Masi Torello, Italy

Alternative

Designed by:	Luoyang Haozhi Machinery Co.,Ltd
GE Part no.:	446W5714P001
GE VSPN:	449W0155P001
Designation:	FN890-23B

Main Drawing no.:	446W5714P001 (FN890-23B), Rev. 2, dated 2019-01-21
Manufacturer/Site:	(1) Luoyang Haozhi Machinery Co. Ltd., Luoyang, P.R. China

Alternative

Designed by:	SIT S.p.A
GE Part no.:	446W5714P001
GE VSPN:	449W0154P001
Designation:	SIT-LOCK 14 4.8/5.3-158
Main Drawing no.:	300320/10/CL, Rev. -, dated 2021-10-01
Manufacturer/Site:	(1) SIT S.p.A., Cusago, Italy

Gearbox

Type:	planetary helical gearbox
Designed by:	ZF Wind Power Antwerpen
GE Part no.:	451W6174P003 451W6174P005 451W6174P007
GE VSPN:	451W6175P001 (Hydac Pump / Filter) 451W6175P003 (Hydra Specma Pump /Filter) 451W6175P005 (P001 + Planet Brg. Sensor) 451W6175P007 (P003 + Planet Brg. Sensor) 451W6175P009 (P001 + Housing Modification) 451W6175P011 (P003 + Housing Modification)
Designation:	EH0941A-0X2 (JB-Version)
Gear ratio:	142.86
Main drawing no.:	097-EH0941A021, Rev. A, dated 2021-06-17
Sectional drawing no.:	098-EH0941A021, Rev. A, dated 2020-06-23
Manufacturer/Site:	(1) ZF Wind Power Antwerpen N.V. Lommel, Belgium (2) ZF Wind Power Coimbatore pvt. Ltd., Coimbatore, India

Alternative

Type:	planetary helical gearbox
Designed by:	ZF Wind Power Antwerpen
GE Part no.:	451W6174P011
GE VSPN:	451W6177P001 (Hydac Pump / Filter) 451W6177P003 (Hydra Specma Pump / Filter)
Designation:	EH0941B-0X2 (TRB-Version)
Gear ratio:	142.86
Main drawing no.:	097-EH0941A021, Rev. A, dated 2021-06-17
Sectional drawing no.:	098-EH0941B011, Rev. A, undated
Manufacturer/Site:	(1) ZF Wind Power Antwerpen N.V. Lommel, Belgium

	(2) ZF Wind Power Coimbatore pvt. Ltd., Coimbatore, India

Alternative

Type:	planetary helical gearbox
Designed by:	Moventas Gears Oy
GE Part no.:	451W6174P001
GE VSPN:	451W6176P001 (Hydac Pump + Hydac Filter) 451W6176P003 (Hydac Pump + Agro-Hytos Fil.)
Designation:	PPH-5700
Gear ratio:	143.079
Main drawing no.:	GDRM107213, Rev. B, dated 2019-09-09
Sectional drawing no.:	GDRM105685, Rev. -, dated 2018-04-11
Manufacturer /Site:	(1) Moventas Gearx Oy, Jyväskylä, Karkkila, Finland

Alternative for configurations 4, 5, 6, 7

Type:	planetary helical gearbox
Designed by:	ZF Wind Power Antwerpen
GE Part no.:	451W0528P003 453W3938P001
GE VSPN:	451W0529P001 (Hydac Pump + Filter) 453W3946P001 (Hydac Pump + Filter) 451W0529P003 (Hydra Specma Pump + Filter) 453W3946P003 (Hydra Specma Pump + Filter)
Designation:	EH0941A-004 EH0941A-014
Gear ratio:	142.86
Main drawing no.:	097-EH0941A003, Rev. A, undated
Sectional drawing no.:	098-EH0941A003, Rev. A, undated
Manufacturer/Site:	(1) ZF Wind Power Antwerpen N.V. Lommel, Belgium (2) ZF Wind Power Coimbatore pvt. Ltd., Coimbatore, India

Gearbox support

Type:	Cast part
Designed by:	GE Renewable Energy
GE Part no.:	451W2612G001 Material: SSDI class C acc. to spec. A50WE053
Main drawing no. (machining):	451W2612, Rev. B, dated 2021-06-01
Main drawing no. (casting):	451W4798, Rev. -, dated 2020-07-30

Gearbox Elastomer Bearing

Type:	Elastomer bearing
Designed by:	ESM Energie- und Schwingungstechnik Mitsch GmbH
GE Part no.:	449W5051P001 (Serial)
Designation:	UB17_001_02
Main drawing no.:	UB17_001_02, Rev. -, dated 2019-07-30

Generator Elastomer Bearing

Type:	Genearator isolation mount
Designed by:	ESM Energie- und Schwingungstechnik Mitsch GmbH
GE Part no.:	448W9164P001
Designation:	ML01_003_44
Main drawing no.:	ML01_003_44_KD, dated 2019-03-15

Generator coupling

Type:	Friction clutch
Designed by:	Flender GmbH
GE Part no.:	449W3630P001/P002
GE VSPN:	449W3633P001
Designation:	ARV-4 KZR 570-4
Main drawing no.:	A5E47722315A_AB, Rev.002, dated 2020-04-21
Manufacturer/Site:	(1) Flender GmbH, Bocholt, Germany

Alternative

Type:	Friction clutch
Designed by:	KTR-Group
GE Part no.:	449W3630P002
GE VSPN:	449W3632P002
Designation:	RADEX-N 220 NANA 4 special
Main drawing no.:	M 809751, Rev. 0, dated 2020-07-13
Manufacturer/Site:	(1) KTR Kupplungstechnik GmbH, Rheine, Germany

Rotor brake

Type:	Hydraulic braking system
Designed by:	KTR Group
GE Part no.:	449W3580P001 (Serial)
GE VSPN:	449W3583P001 (Serial)
Designation:	KTR-STOP YAW M C-40
Number of brakes:	1
Position:	High speed shaft
Drawing no.:	M 777412, Rev.1, dated 2019-08-16

Manufacturer/Site:	(1) KTR Brake Systems GmbH, Schloss Holte Stukenbrock, Germany

Alternative

Designed by:	Svendborg Brakes
GE Part no.:	449W3580P001 449W3258P001
GE VSPN:	449W2412P001 449W3259P001
Designation:	BSAB90 / CB90R
Number of brakes:	1 Position: High speed shaft
Drawing no.:	490-6914-801, Rev. A, dated 2019-04-04 490-6909-801, Rev. A, dated 2020-03-03
Manufacturer/Site:	(1) Svendborg Brakes A/S, Vejstrup, Denmark (2) Altra Industrial Motion do Brasil S.A., Cotia, Brazil (3) Svendborg Brakes (Shanghai), Shanghai, China

Alternative

Designed by:	Antec
GE Part no.:	449W3580P001
GE VSPN:	451W2168P001
Designation:	HE-2-90/110
Number of brakes:	1
Position:	High speed shaft
Drawing no.:	20.104.587, Rev. J, dated 2020-09-23
Manufacturer/Site:	(1) Antec Eolica Fabricavao e Comercio de Freios Ltda, Camacari, Brazil

Low Speed
Rotor Lock Disc

Type:	Manual rotor lock disc
Designed by:	GE Renewable Energy
GE Part no.:	448W2972P001
Drawing no.:	448W2972, Rev.-, dated 2019-01-04
Manufacturer/Site:	(1) Shandong Weiteng Machine Co Ltd., Weifang, Shandong, China (2) Energy Hardware Holdings, LLC (Shanghai Aerotech), P.R. China (3) Liyang Flying Industry Co. Ltd., Liyang City, Jiangsu Province, P.R. China (4) Wheels India Limited, Chennai, India

Low Speed
Rotor Lock Pin

For configurations 1-3

Type:	Manual Rotor Lock Pin
Designed by:	Svendborg Brakes A/S
GE Part no.:	448W4722P001
GE VSPN:	448W4730P001
Drawing no.:	490-6366-802, Rev.-, dated 2018-05-04
Manufacturer/Site:	(1) Svendborg Brakes A/S,Vejstrup,Denmark (2) Svendborg Brakes Shanghai Co. Ltd., Shanghai, China (3) Altra Industrial Motio do Brasil, Cotia, Brazil

Alternative for configurations 1-3

Designed by:	KTR Group
GE Part no.:	448W4722P001
GE VSPN:	448W4731P001
Designation:	KTR-STOP RL M-B-355-214 (740101)
Drawing no.:	740101, Rev. 0, dated 2018-09-12
Manufacturer/Site:	(1) KTR Brake Systems GmbH, Schloss Holte Stukenbrock, Germany

Alternative

Designed by:	GE Renewable Energy
GE Part no.:	451W7440G001 453W4704G001
Drawing no.:	451W7440, Rev. -, dated 2020-09-16 453W4704, Rev. -, dated 2021-09-17
Manufacturer/Site:	(1) Svendborg Brakes A/S, Vejstrup,Denmark (2) Altra Industrial Motio do Brasil, Cotia, Brazil (3) Svendborg Brakes (Shanghai) Co. Ltd, Shanghai, China (4) CSIC Heisheng Technology Co Ltd., Yichang, China (5) Dellner Bubenzer Germany Wind GmbH, Dorsten, Germany (6) Antec Eolica Fabricacao e Comercio de Freios Ltda., Camacari, Brazil (7) KTR Brake Systems GmbH, Schloss Holte Stukenbrock, Germany

High Speed
Rotor Lock

Type:	Manual rotor lock

Designed by:	GE Renewable Energy
GE Part no.:	448W2230G001
Main Drawing no.:	448W2230, Rev.-, dated 2018-10-17
Manufacturer/Site:	(1) Duomo Euroservices S.L., Santiago, Toledo, Spain (2) Shenyang Sunny Lion Equipment Co. Ltd., Shenyang, China (3) Dalian E & T., Development Zone, Jingshang Mould Co., Ltd., Dalian, China (4) Energy Hardware Holdings, LLC (Shanghai Aerotech), P.R.China

Bolted Connection Hub-Main Shaft

Type:	Double-row bolted connection
Designed by:	GE Renewable Energy
GE Part no.:	450W9911G001
Drawing no.:	451W1408, Rev. -, dated 2020-06-03

Main frame

Type:	Cast
Designed by:	GE Renewable Energy
GE Part no.:	450W8034G001 452W9306G001 452W7091G001 453W7241G001 454W0334G001
Material:	SSDI class C acc. to spec. A50WE053
Main Drawing no. (machining):	450W8034, Rev. B, dated 2020-12-02 452W9306, Rev. -, dated 2021-05-17 452W7091, Rev. -, dated 2021-03-19 453W7241, Rev. A, dated 2022-03-04 454W0334, Rev. -, dated 2022-01-28
Main Drawing no. (casting):	450W8033, Rev. -, dated 2020-06-02 453W7240, Rev. -, dated 2021-11-18
Manufacturer/Site:	(1) Jiangsu Sinojit Wind Energy Technology Co. Ltd, Jiangsu, P.R. China (2) Jiangsu FAW Foundry Co. Ltd, Wuxi, Jiangsu, P.R. China (3) GE Energias Renovaveis Ltda, Brazil (4) Himile Mechanical Science and Technology Co. Ltd, Shandong, P.R. China (5) Emalto Usinagem e Tratamento Anticorrosivo Ltda, Santand do Paraiso, Brazil

Pillow Block

Type:	Cast
Designed by:	GE Renewable Energy
GE Part no.:	451W4791G001 452W7093G001 453W7242G001
Material:	SSDI class C acc. to spec. A50WE053
Main Drawing no. (machining):	451W4791, Rev. A, dated 2020-12-02 452W7093, Rev. -, dated 2021-03-19 453W7242, Rev.-, dated 2022-03-07
Main Drawing no. (casting):	452W1636, Rev. -, dated 2020-11-27
Manufacturer/Site:	(1) Wuxi Rhester Machinery Co. Ltd., Wuxi, Jiangsu, China (2) Jiangsu Sinojit Wind Energy Technology Co. Ltd, Jiangsu, China (3) Himile Mechanical Science and Technology Co. Ltd, Shandong, P.R. China (4) Shandong Weiteng Machine Co. Ltd., Weifang, Shandong, P.R. China (5) Baettr Lem A/S, Lem, Denmark

Generator frame

Type:	Welded part
Designed by:	GE Renewable Energy
GE Part no.:	452W4085G001
Material:	S355J2 or ASTM A572 Grade 50 (steel)
Main Drawing no. (fabrication):	452W4084, Rev. -, dated 2021-02-04
Main Drawing no. (machining):	452W4085, Rev. -, dated 2021-02-05
Manufacturer/Site:	(1) Liyang Flying Industry Co. Ltd. Jiangsu Province, P.R. China (2) Himile Mechanical Science and Technology, Shandong, P.R. China (3) Painco Industria e Comercio S/A, rio das Pedras, Brazil (4) Wuxi Rhester Machinery Co. Ltd., Wuxi, Jiangsu, China (5) ATES CELIK INSAAT TAAHHÜT PROJE MÜH. SAN. CE TIC A.S., BERGAMA / IZMIR, Turkey

Alternative

Designed by:	GE Renewable Energy
GE Part no.:	453W0577G001 453W3848G001
Material:	S355J2 or ASTM A572 Grade 50 (steel)
Main Drawing no. (fabrication):	452W4084, Rev. A, dated 2021-03-18

		453W3847, Rev. A, dated 2021-10-14
	Main Drawing no. (machining):	453W0577, Rev. -, dated 2021-06-23 453W3848, Rev. A, dated 2021-10-14
	Manufacturer/Site:	see above
Yaw system		
	Type:	Active, yaw bearing slewing ring with 4 active yaw drives and 20 hydraulic brakes
Yaw drive		
	Type:	4 stage planetary gearbox
	Designed by:	Bonfiglioli Transmital
	GE Part no.:	449W3493P001
	GE VSPN:	449W3495P001
	Designation:	714T4 (JB00004586)
	Drawing no.:	I7140T012700, Rev. -, dated 2019-05-23
	Manufacturer/Site:	(1) Bonfiglioli Riduttori S.p.A., Bologna, Italy
	Manufacturer motor:	Bonfiglioli
	Designation motor:	BN132MB 6
	Alternative	
	Designed by:	SEW Eurodrive Brasil
	GE Part no.:	449W3493P001 452W6636P001
	GE VSPN:	450W1703P001/P002 452W7635P001
	Designation:	PW067 / PW067L
	Drawing no.:	2422 441 3.30.1, Rev.00, dated 2019-07-08 2422 441 5.30.1, Rev.00, dated 2020-08-31
	Manufacturer/Site:	(1) Sew-Eurodrive Brasil Ltda., Indaiatuba, Brazil
	Manufacturer motor:	SEW Eurodrive
	Designation motor:	DRN132M6
	Alternative	
	Designed by:	NGC
	GE Part no.:	449W3493P001 452W6636P001
	GE VSPN:	449W8163P001/P002
	NGC PN:	110200000326 / 110200000328
	Drawing no.:	SYW07A010101 / SYW07A010301, Rev. A, dated 2020-09-10
	Manufacturer/Site:	(1) Nanjing High Speed & Accurate Gear, Nanjing, China
	Manufacturer motor:	LEGO / Marathon
	Designation motor:	AKEJ132M2-6H / LEB 132MD-6

Alternative

Designed by:	Liebherr Components Biberach GmbH
GE Part no.:	449W3493P001 452W6636P001
GE VSPN:	450W7982P001
Designation:	DAT 450/3462-4MA0 (13401783)
Drawing no.:	368 462 4000 99 0, Rev. 08, dated 2021-01-26
Manufacturer/Site:	(1) Liebherr Components GmbH, Biberach, Germany (2) Liebherr Machinery (Dalian) Co., Ltd., P.R. China
Manufacturer motor:	LEGO
Designation motor:	AKEJ132M2-6H

Yaw bearing

Type:	Ball bearing slewing ring
Designed by:	GE Renewable Energy
Designation:	448W3840G001 449W9228G001 454W8188G001
Drawing no.:	448W3840, Rev. -, dated 2018-11-21 449W9228, Rev. -, dated 2021-01-26 454W8188, Rev. -, dated 2022-07-25
Manufacturer/Site:	(1) Tianma (Chengdu) Precision Machinery Co. Ltd., Chengdu, P.R. China (2) CS Bearing Co. Ltd., Kyoungnam, Korea (3) Shilla Corporation, Cheonan-si, Chungnam, South Korea (4) Shilla Brazil Industria de Rolament de Giro Ltda, Tiete, Brazil (5) SKF do Brazil Ltda, Cajamar, Brazil (6) Changzhou Shilla Machinery Manufacturing Co. Ltd., Changzhou, China

Yaw brakes

Type:	Yaw brake
Designed by:	JHS Jungblut GmbH & Co.KG
GE Part no.:	446W7576P001
GE VSPN:	446W7577P001
Designation:	JHS-08-1x100
Drawing no.:	VA002274, Rev. D, dated 2018-09-06
Manufacturer/Site:	(1) Dellner Bubenzer Germany Wind GmbH, Dorsten, Germany (2) KTR Brake Systems GmbH, Schloss Holte Stukenbrock, Germany

Passive Cooler

Type:	passive cooler with plate heat exchanger
Designed by:	Ymer Technology
GE PN Cooler:	452W0376P001
	453W1497P001
	453W4029P001
	453W6400P001
Designation cooler:	3000x1274x63
GE PN Heat Exchanger:	452W0379P001
	454W0579P001
Designation Heat Exchanger:	840x394x450 – 1071.0491
GE Drawing Cooler no.:	450W8866, Rev. -, dated 2020-11-09
	453W1944, Rev. -, dated 2021-07-26
	453W4314, Rev. -, dated 2021-09-13
GE Drawing Heat Exchanger:	452W1013, Rev. -, dated 2020-11-17

Hydraulic system

Type:	Hydraulic system
Designed by:	HAWE-Hydraulik
GE Part no.:	447W8054P001 (STW)
	449W3384P001 (CWE)
GE VSPN:	448W3498P001 (STW)
	453W5827P001 (STW)
	449W3391P001 (CWE)
	453W5828P001 (CWE)
Designation:	17-111-H-01-00 (8801 0270-00) (STW)
	17-111-H-02-00/UL (8801 1646-00) (STW)
	17-111-H-01-01 (8801 0506-00) (CWE)
	17-111-H-02-01 (8801 1645-00 (CWE)
Main drawing no.:	00_DE-D00018518, Rev. 00 (STW)
	00_DE-D00071337, Rev. 00 (STW)
	00_DE-D00025855, Rev. 00 (CWE)
	00_DE-D00071343, Rev. 00 (CWE)
Circuit Diagram no.:	00_DE-D00018005, Rev. 01 (STW)
	00_DE-D00067395, Rev. 00 (STW)
	00_DE-D00024437, Rev. 01 (CWE)
	00_DE-D00067394, Rev. 00 (CWE)

Alternative

Type:	Hydraulic system
Designed by:	Svendborg Brakes
GE Part no.:	447W8054P001 (STW)
	449W3384P001 (CWE)
GE VSPN:	449W2454P001 (STW)
	449W3392P001 (CWE)
Designation:	1110-0027-801 (STW)

	1110-0027-802 (CWE)
Main Drawing no.:	1110-0027-801, Rev. -, dated 2019-03-22 (STW)
	1110-0027-802, Rev. -, dated 2019-10-31 (CWE)
Circuit Diagram no.:	1110-0027-601, Rev.C, dated 2019-04-25 (STW)
	1110-0027-602, Rev. -, dated 2019-11-05 (CWE)

Alternative

Type:	Hydraulic system
Designed by:	Hine S.A.
GE Part no.:	447W8054P001 (STW)
GE VSPN:	452W3416P001 (STW)
Designation:	HR002761
Main Drawing no.:	B1-9216, Rev. F, dated 2021-11-08 (STW)
Circuit Diagram no.:	B1-11259, Rev. -, dated 2021-03-30 (STW)

Generator

for configurations 1-3

Type:	Asynchronous doubly-fed induction
Designed by:	Indar
GE Part no.:	448W9503P004
GE VSPN:	448W9505P002
Designation:	NAR710G6B60NS2 (3002045)
Rated power:	5733 kW
Rated frequency:	60 Hz
Rated speed:	1444 rpm
Rated voltage:	6000 V (stator)
Insulation class:	F
Degree of protection:	IP34 (generator)
	IP23 (slip ring)
Manufacturer/Site:	(1) Indar Electric S.L., Beasain, Gipuzkoa, Spain

Alternative for configurations 4-7

Type:	Asynchronous doubly-fed induction
Designed by:	Indar
GE Part no.:	452W6597P002
GE VSPN:	452W1605P002
Designation:	NAR710G6SB60N
Rated power:	5733 / 6049 / 6357 kW
Rated frequency:	60 Hz
Rated speed:	1444 rpm
Rated voltage:	6000 V (stator)
Insulation class:	F
Degree of protection:	IP34 (generator)
	IP23 (slip ring)
Manufacturer/Site:	(1) Indar Electric S.L., Beasain, Gipuzkoa,

		Spain
	Alternative for configurations 1-7	
	Type:	Asynchronous doubly-fed induction
	Designed by:	Winergy
	GE Part no.:	452W6597P002
	GE VSPN:	447W9924P003
	Designation:	W1G53000345
	Rated power:	6357 kW
	Rated frequency:	60 Hz
	Rated speed:	1444 rpm
	Rated voltage:	6000 V (stator) 489 V (rotor)
	Rated current:	510 A (stator) 1532 A (rotor)
	Insulation class:	F
	Degree of protection:	IP34 (generator) IP23 (slip ring)
	Manufacturer/Site:	(1) Siemens d.o.o. Belgrade, Subotica, Serbia
Converter		
	Designed by:	GE Power Conversion
	Designation:	151X1258KA01SA03
	GE Part no.:	448W0372P003
	Power:	4.5 to 6.1 MW
	Rated voltage (grid side):	690 V AC
	Rated current (grid side):	1050 A
	Rated voltage (machine side):	0 to 825 V AC
	Rated current (machine side):	2400 A
	Degree of protection:	IP 21 (cabinet) IP 41 (bridge cabinet) IP 22 (filter and inductor cabinet) IP 21 (AC entry cabinet)
	Manufacturer/Site:	(1) GE Power and Water, Hai Phong City, Vietnam (2) GE Shenyang, Liaoning, P.R. China (3) Jabil do Brasil Industria Electroeletronica Ltda, Betim, Brazil
Transformer		
	Type:	dry type
	Designed by:	Hainan Jinpan Smart Technology (JST)
	Rated power:	6228 kVA
	Degree of protection:	IP 00 (degree not yet defined)
	Location:	Inside nacelle
	Manufacturer/Site:	(1) Hainan Jinpan Electric Co. Ltd. (JST),

Haikou, P.R. China
(2) JST Power Equipment Inc., Nogales, Mexico

GE Part no.	GE VSPN	Supplier Designation	Rated voltage (HV)
452W0495P001 452W0495P003	452W0496P001 452W0496P003	316010893001 316010913001	33-34.5 kV
452W0495P002	452W0496P002	316010903001	34.5 kV

Medium voltage Switchgear

Manufacturer:	Schneider Electric
Designation:	DVCAS 38.5 (operation from -30°C to 40°C)
Rated voltage:	38.5 kV
Rated current:	630 A
Location:	Inside tower
Manufacturer/Site:	(1) Schneider Electric, Libourne, France (2) Schneider Electric, Stezzano, Italy (3) Schneider Electric, Mungia, Spain

Alternative

Manufacturer:	Schneider Electric
Designation:	RM6 (operation from -25°C to 45°C)
Rated voltage:	24 kV
Rated current:	630 A
Location:	Inside tower
Manufacturer/Site:	see above

Alternative

Manufacturer:	Schneider Electric
Designation:	Flusarc (operation from -25°C to 55°C)
Rated voltage:	36 kV
Rated current:	630 A
Location:	Inside tower
Manufacturer/Site:	see above

Alternative

Manufacturer:	Ormazabal
Designation:	cgm.3 (operation from -30°C to 40 °C)
Rated voltage:	38 kV
Rated current:	600 A
Location:	Inside tower
Manufacturer/Site:	(1) Ormazabal, Igorre, Spain

		(2) Ormazabal do Brasil,Sao Paulo, Brazil
	Alternative	
	Manufacturer:	ABB
	Designation:	SafePlus 36 (operation from -25°C to 40°C)
	Rated voltage:	36 / 40.5 kV
	Rated current:	630 A
	Location:	Inside tower
	Manufacturer/Site:	(1) ABB, Skien, Norway (2) ABB Eletrificacao Ltda, Sorocaba, Brazil
Tower HH107.4 **(Conf. 1)**		
	Type:	Tubular steel tower
	Designed by:	GE Renewable Energy
	Sections:	5
	Length:	104.785 m
	Main drawing no.:	447W2844, Rev. B
	Foundation specification:	Foundation_Load_Drawing_5.5-158_60Hz_107.4mHH_PRD068_EN_r01
Tower HH125.4 **(Conf. 2, 4)**		
	Type:	Tubular steel tower
	Designed by:	GE Renewable Energy
	Sections:	5
	Length:	122.705 m
	Main drawing no.:	449W9393, Rev. - 451W1779, Rev. A (alternative) 451W2505, Rev. - (alternative)
	Foundation specification:	(1) Foundation_Load_Drawing_5.5-158_60Hz_125.4mHH _PRD069_EN_r01 (2) Foundation_Load_Drawing_6.1-158_60Hz_125.4mHH_PRD136_EN_r02
Tower HH101 **(Conf. 3, 5)**		
	Type:	Tubular steel tower
	Designed by:	GE Renewable Energy
	Sections:	4
	Length:	98.345 m
	Main drawing no.:	449W5216, Rev. -
	Foundation specification:	(1) Foundation_Load_Drawing_5.5-158_60Hz_101mHH_PRD035_EN_r01 (2) Foundation_Load_Drawing_6.1-158_60Hz_101mHH_PRD142_EN_r01

Tower HH101
(Conf. 7)

Type:	Tubular steel tower
Designed by:	GE Renewable Energy
Sections:	4
Length:	98.345 m
Main drawing no.:	452W7380, Rev. -, dated: 2022-07-13
Foundation specification:	(1) Foundation_Load_Drawing_6.1-158_60Hz_101mHH_PRD153_EN_r01

Tower HH117
(Conf. 6)

Type:	Tubular steel tower
Designed by:	GE Renewable Energy
Sections:	5
Length:	114.305 m
Main drawing no.:	452W3871, Rev. -, dated: 2021-09-13
Foundation specification:	(1) Foundation_Load_Drawing_6.1-158_60Hz_117mHH_PRD169_EN_r01

All Towers

Manufacturers/Sites:	(1) Torres Eolicas do Nordeste SA, Jacobina, Brazil (2) Ventower Industries, Monroe, Michigan, USA (3) GRI Tower Brazil Estruturas Metalicas S.A., Cabo de Santo Agostinho, Brazil

Manuals

see Evaluation Reports on Safety System and Manuals
For the Rotor Blade LM77.4P3: see manuals BM-00207/A8 and SI-00922/B9

Control and safety system

Designed by:	GE Renewable Energy
Hardware:	Mark VIe
Software:	V5.7.5

Note:
Please refer to the mentioned evaluation reports for revision control of drawings/documents, detailed drawings, detailed design documents and other requirements and conditions.

– End of Certificate –

Exhibit 27-4
Fire Detection and Fire Alarm Manual

GE Renewable Energy

- Original Document -

Technical Documentation
Wind Turbine Generator Systems
Cypress Platform 50/60Hz

Fire Detection and Fire Alarm

Rev. 01a - Doc-0081242 - EN 2020-04-23

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Table of Contents

Document Revision Table

Rev.	Date (YYYY/MM/DD)	Affected Pages	Change Description
01	2020/04/22	-	New Document.
01a	2020/04/23	1	CHANGED Cover photo

1 Introduction

This document describes the fire detection and fire alarm systems for GE wind turbines of Cypress Platform.

2 Description of Fire Detection and Fire Alarm

The Buyer may select fire detection and fire alarm system which monitors sensitive areas of the wind turbine (machine head, transformer enclosure) using smoke detection and flame detection devices.

When the system detects a fire, it activates an acoustic and visual alarm signal and sends a shutdown command to the turbine controller to stop the unit and all fans. Status information is sent via the SCADA system to the Seller's service organization and a safety status event will be saved in the windfarm SCADA server. In cases where the status information needs to be sent via the SCADA system to the Buyer or another automated message is needed, the Buyer must provide project-specific clarification. The Buyer can send a message to the fire department.

The sensors and detectors are installed in the wind turbine as follows:

Item	Machine Head	Tower Base (tubular tower)	Tower Base (hybrid tower)	Transformer Enclosure in the Nacelle
Smoke detector	x	-	-	x
IR-flame sensor	-	-	-	x
Acoustic / visual alarm	x	x	x	x
Alarm deactivation	x	-	-	-
Manual call point	x	-	-	-

The detectors listed in the table above monitor the open areas of the machine head and down tower and do not provide monitoring inside individual electrical cabinets.

The controller unit of fire detection system is connected to the WTG controller and provides following signals:

Signal	Signal type	WTG controller action
Device failure	Status message	Send warning message via SCADA
Sensor failure	Status message	Send warning message via SCADA
Fire detected	Alarm message	Send alarm message via SCADA WTG shut down and stop of WTG fans

Exhibit 27-5
Health and Safety Plan

TWIN ENERGY

18.3 MW Wind Project
Fire, Health, and Safety Plan

November 2, 2023

Prepared By:

Sumul Shah
sumul@palmcap.com | 781.389.4671

Table of Contents

1 Introduction

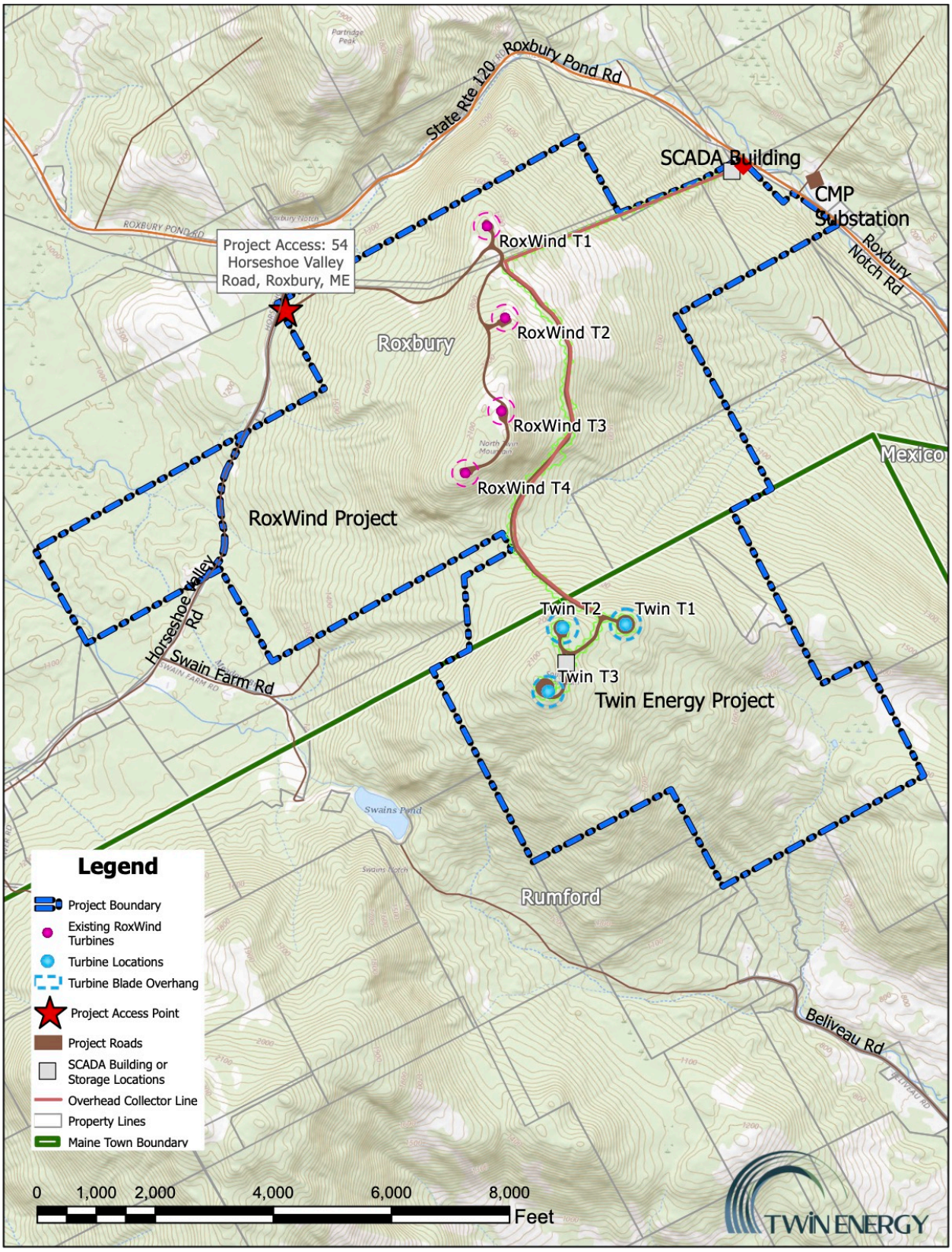
This Fire Protection and Emergency Response Plan (Plan) presents general health and safety considerations and minimum requirements associated with the Twin Energy Project (Project) but does not include Fire Department specific additional requirements or procedures. The Plan may be amended or revised as project activities or conditions change or when supplemental information becomes available. All project employees as well as emergency responders are to be familiar with contents of this Plan.

1.1 Project Information and Description

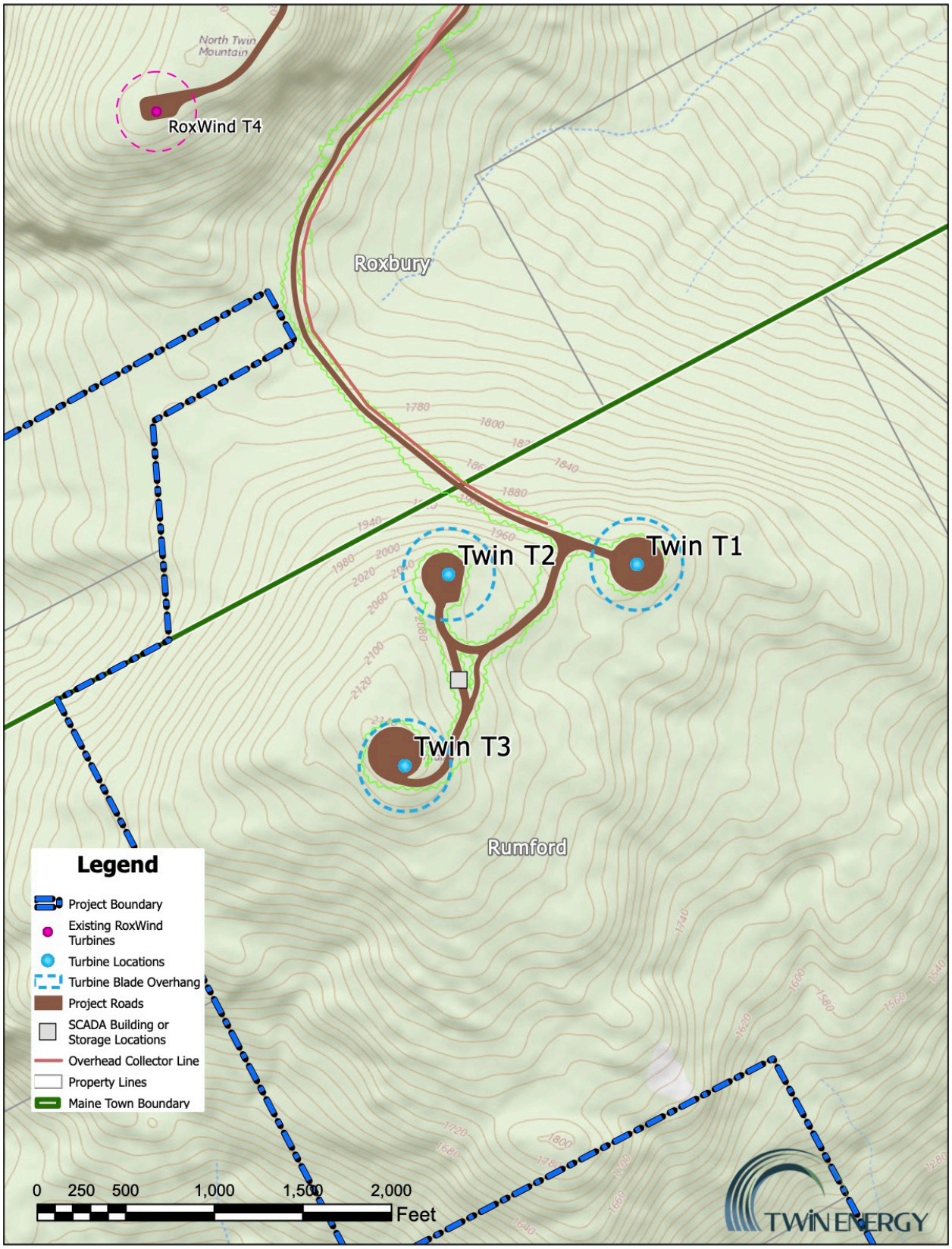
Project Description:	The Project consists of three (3) 6.1 MW General Electric wind turbines located on South Twin Mountain in the town of Rumford, Maine. The access road and the collector line are proposed to extend from the existing RoxWind Project in Roxbury, Maine, southerly to South Twin Mountain in Rumford. The installed capacity of the Project is expected to be 18.3 Megawatts. It is important to note, primary access to the site originates along **Horseshoe Valley Road in Roxbury**.
Project Owners:	**Twin Energy LLC**
Project Manager:	Palmer Management Corporation 13 Elm Street, Suite 200 Cohasset, MA 02025
Site Access and description:	The wind turbines are located on South Twin Mountain in Rumford, Maine. From the entrance at 54 Horseshoe Valley Road in Roxbury, Maine, a gravel road leads through forested land up to North Twin. From North Twin, a gravel road connects the two towns and leads to the Twin Energy project in Rumford. See maps in Section 1.2 for further details. The site is heavily wooded with mountainous terrain.
Fire Prevention	**Rumford Fire Department** Town of Rumford 151 Congress St Rumford, Maine 04276

1.2 Project Site Plan and Evacuation Routes

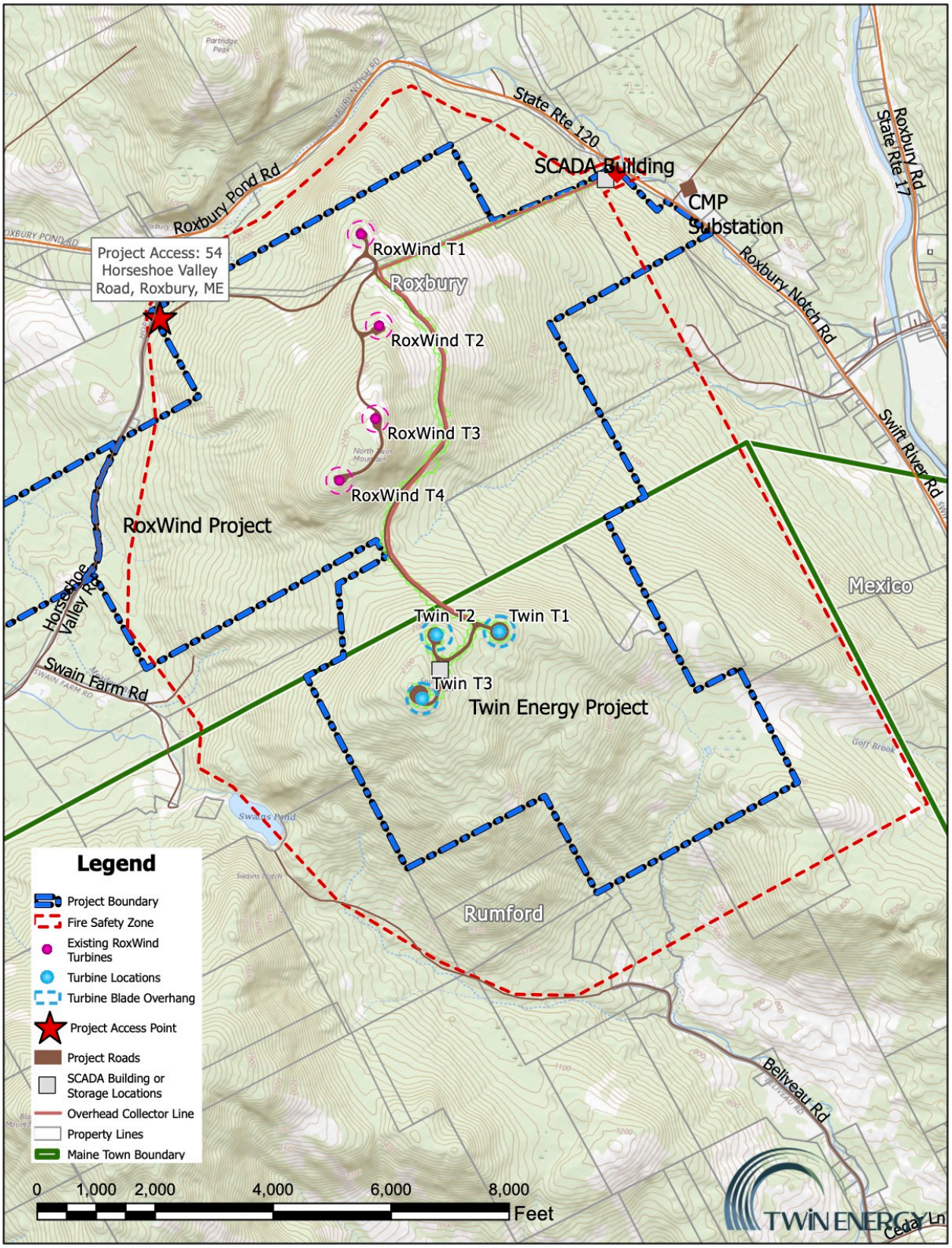
1.2.1 Project Overview Map



1.2.2 Turbine Designation Map



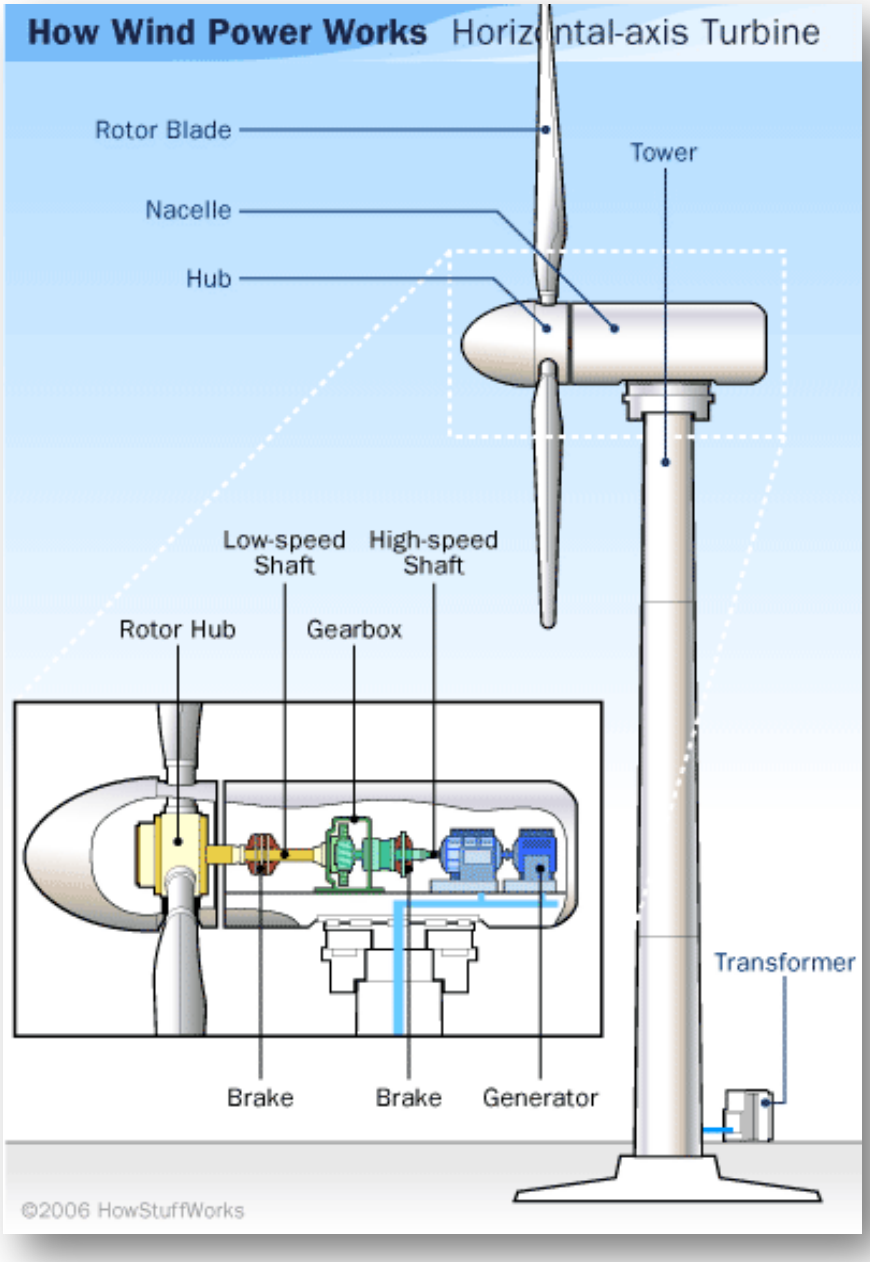
1.2.3 Recommended Fire Safe Zone



During a fire incident the actual fire safe zone is to be determined by the Fire Department Incident commander. Twin Energy will support the Fire Department in its efforts to establish a safe perimeter.

1.3 Wind Turbine Orientation

When working around a wind turbine, it is helpful to understand the basic components of a wind turbine so that conditions can be described properly to emergency response personnel. The following is a diagram[1] indicating the key components of a wind turbine:



[1] For the Project, the transformer is inside each tower and is not accessible or visible from outside the turbine.

2 Health and Safety Plan for Turbine Hazards

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. Emergency Services, project staff and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. Emergency Services, project staff and subcontractors who do not understand any of these provisions should contact their supervisor for clarification.

2.1 General Turbine Safety

Follow all applicable and site-specific Health and Safety Plans, Accident Prevention Plans, Fire Protection Procedures, and Environmental Regulations when working on the Project. Particular requirements shall be followed when working inside the wind turbine, both down-tower and within the nacelle. The nacelle is the up-tower housing that contains all of the generating components in a wind turbine, including the generator, gearbox, drive train, and brake assembly.

Follow and update applicable Activity Hazard Analysis (AHA) that directly pertains to wind turbine operations. Work on the wind turbine must always be performed prudently and carefully. All personnel must be equipped with personal protection equipment (PPE), first aid kits, communication devices (radios or cell phones), and have proper training. All technicians' skills must be ascertained before starting any work and all personnel must be qualified to perform work on the turbine. Task specific AHA should be prepared before performing any work on the turbine. When working in the turbine or climbing the turbine, the "buddy system" must be utilized for safety.

2.1.1 Personal Protective Equipment (PPE)

Each person who climbs the tower must use an approved and inspected safety harness, fall protection, safety climbing aids, and adequate safety equipment specific to the turbine being accessed.

Tower Climbing and Tower/Nacelle Work Safety Equipment and PPE:

- ☐ Full body safety harness specific to climbing and turbine work, rated for the user's size and weight.
- ☐ Slides or clips specific for the turbine ladder fall protection system.
- ☐ Safety climbing helmet with locking chin strap and head lamp.
- ☐ Protective clothing and gloves for protection against injuries and the effects of oils and greases.
- ☐ Protective gloves for climbing and working on the turbine.
- ☐ Proper clothing for the work conditions/temperature.
- ☐ Steel toe safety boots with electrical safety rating.
- ☐ Hearing protection (ear plugs or earmuffs) as needed.

Tower Base and outside working area of the Turbine PPE:

- A safety helmet or hard hat.
- Steel toe safety boots (with an electrical safety rating if performing energized electrical work).
- Hearing protection (ear plugs or earmuffs) as needed.
- Proper clothing for the work conditions/temperature.

2.1.2 Mechanical/Rotating Dangers

Personnel must tie back long hair and not wear loose clothing or jewelry.

Be aware of your surroundings at all times.

Keep machine guards in place at all times unless equipment is properly locked out.

2.1.3 Falling Objects Inside and Outside the Wind Turbine

There are personnel and equipment falling hazards when climbing and working inside the turbine. Keep all hatchways closed when not in use and be aware of your surroundings. Do not carry tools or equipment while climbing. Use the tower utility winch system for bringing equipment and tools up and down from the nacelle. Maintain a tower section between personnel when climbing to minimize the risk of falling objects onto personnel below. In order to protect personnel against falling objects, do not access the danger area around the outside base of the turbine without proper PPE and always be aware of your surroundings.

2.1.4 Working at Heights

Working at heights may be required during operation and maintenance of the Project. Prevention and control of hazards associated with working at heights include:

- Implementation of a fall protection program to include regular testing for structural integrity and training for personnel in climbing techniques.
- When working above 6 feet, fall protection system(s) must be used 100% of the time.
- The fall protection system(s) should be appropriate for the tower structure and movements including ascent, descent, and point to point.
- Ensure that equipment is properly rated and maintained, including PPE appropriately sized per user.
- Secure all tools operated at heights with a secondary safety strap.
- Remove all obstructions prior to work.
- Avoid maintenance work during poor weather conditions.

Work in or around the turbines requires at least two personnel to be present as a safety precaution. Any work within the hub requires a minimum of three project personnel to be at the tower. One person must remain at ground level and one person must remain in the nacelle while the third person enters the hub to perform work or inspection.

No work is anticipated to be performed inside the turbine blades. However, if working inside the blades becomes necessary, it would require a Confined Space Entry (CSE) and personnel trained in CSE.

For additional information regarding working at heights, consult Section 2.3.7.

2.1.5 Electrical Dangers

Only qualified and properly trained individuals shall perform electrical work in the turbine. Before opening a high voltage electrical cabinet or before working with any interconnected components, the wind turbine must be in a voltage-free state (de-energized). Always observe the following five safety rules in the specified order to ensure that a voltage-free state has been achieved.

1. Disconnect completely.
   - Make sure that the part on which work is to be carried out is disconnected from all sources of supply.
2. Secure it against unexpected re-connection and utilize Lock out/Tag Out (LOTO).
   - All switching devices that have been used to disconnect the electrical installation for the work activity must be secured against re-connection preferably by locking the operating mechanism, commonly referred to as Lock out/Tag out or LOTO.
   - Parts of the electrical installation still remaining charged after complete disconnection of the electrical installation, for example capacitors and cables, shall be discharged using suitable devices.
3. Verify that the turbine is in a voltage-free state (de-energized).
   - The dead condition must be verified on all equipment at or as near as practicable to the work location.
   - Utilize proper equipment (multi-meter, etc.) to verify that the device being worked on is in a voltage-free state.
4. Carry out grounding and short-circuiting as necessary (capacitors, etc.).
5. Provide protection against adjacent live parts.
   - If there are parts of an electrical installation in the vicinity of the work location that cannot be de-energized, special additional precautions are necessary and must be taken before work starts.

2.1.6 Pressurized Hydraulic Oil

The maximum operating pressure of the hydraulic system must be observed. Excess pressure exerts extreme loads on pressure carrying parts and the system; this can cause the hydraulic system to rupture. Be aware of hydraulic oil under pressure. Block and bleed pressure in the system before working on the hydraulics. Follow LOTO procedures when working on the hydraulic systems.

2.1.7 Severe Weather Conditions

The wind turbine must not be accessed during heavy winds and thunder/lightning storms. Monitor weather conditions prior to and during all work activities in or around the wind turbine. Climb down the wind turbine and exit immediately if a storm starts while you are working in or

around the tower or nacelle. Tornados, lightning, or other threatening weather conditions will result in an immediate shut down of maintenance operations and evacuation of personnel. When lightning is observed, the site operations manager shall shut the maintenance operations down for a minimum of 30 minutes between strikes. At a minimum, maintenance operations will be shut down for the period of the storm passing **plus an additional 30 minutes** prior to any up-tower work resuming.

2.1.8 Safety Chain/Emergency Stops

Personnel must be aware of the locations and the proper use of all emergencies stops when working in or around the wind turbine.
The safety chain is triggered by:

- Emergency stop button at the tower base (at the cabinet).
- Emergency stop button in the nacelle (at the nacelle cabinet).
- Over speed control switch (for rotational speed).
- Vibration sensors (on the main frame).
- Working position switch for blade pitch.
- Brake signal.
- Twist protection.

2.1.9 Emergency Exit

There are three emergency exit locations:

- The main exit is located in the base of the tower. This exit is accessible on the bottom deck of the tower and is the primary method of egress for the turbine.
- There is an emergency exit located in the nacelle and is to only be used in emergencies.
- There is a secondary emergency exit located in the hub. As this is the most technically complicated exit of the three options, this exit should only be used when required by the type of emergency.

Injured personnel can be rescued from the nacelle using ascent/descent type safety equipment (such as a Tractel). Project technicians are regularly trained on proper procedures to use the two up-tower emergency exits.

2.1.10 Public Access

Safety issues may arise with unauthorized public access to the wind turbine.
Prevention and control measures to manage public access include:

- Maintain safety, hazard, and emergency contact information on public information boards.
- Gate preventing unnecessary vehicle access.

2.2 Hazard Communication

This Written Communication Program explains how Twin Energy LLC meets the requirements of the federal Occupational Safety and Health Administration's hazard communication standard

(29CFR 1926.59). It spells out how this company will obtain and use material safety data sheets, inventory and maintain labels on chemical substances, and train employees and contract workers on the hazards of chemicals they are likely to encounter on the job. During the maintenance and operations of the wind turbines, Twin Energy will designate a Site Safety & Health Officer (SSHO). It is the responsibility of the SSHO to ensure that this communications plan is executed.

The turbine's operator is responsible for providing copies of this program.

2.2.1 Pollution Control Policy

The monitoring of activities that have the potential to cause pollution and the detection of emissions from these activities is the responsibility of the SSHO. The following procedures will be continually followed by personnel at the Project site:

1. Refueling of any equipment or machinery will be done with the utmost care to prevent spillage. In the event that a spill does take place, the individual performing the refueling will immediately clean up the material spilled using the onsite spill kit and report the incident to the SSHO. The SSHO will inspect the site to ensure all material has been recovered and properly containerized for disposal. SSHO will also determine the volume of the spilled material and if the incident warrants additional reporting.

2. Hydraulic line breaks or leaks shall be attended to in the same manner as refueling spills above. Hydraulic equipment will be inspected on a daily basis when working onsite and leaks will be reported to the equipment owner for immediate repair. Leaking equipment will be dead lined and not allowed to operate on the turbine site. This includes turbine equipment as well as delivery equipment such as truck mounted cranes and small truck carried forklifts.

3. Other equipment within the Project site will be inspected regularly. This may include the nacelle and storage containers that may be operating or remaining in place and contain hazardous material within the boundaries of the turbine area. Leaks detected in such items will be contained and reported to SSHO for coordination of repairs and disposal of the spilled material.

4. Clean-up of any other spilled materials such as paint, adhesives, lubricants, oils or other commonly used products will be accomplished quickly and in accordance with the material's Material Safety and Data Sheet (MSDS). All such spills and clean up actions will be reported to the SSHO for review and further action if required.

2.2.2 List of Hazardous Chemicals; Material Safety and Data Sheets

At the Project site, a binder will be maintained containing a master list of all hazardous chemicals used. Called the Master Chemical List (MCL), this hazardous chemical list is updated whenever

new chemicals are received at the project site. The hazardous substances may include paint, adhesives, lubricants, oils, refrigerant, etc.

No new hazardous chemical substances may be purchased or brought into this facility unless the SSHO is informed in advance and such hazardous substance is subsequently recorded in the MCL.

To comply with the hazard communication standard, the SSHO maintains a library of MSDS for chemicals used in the Project. The MSDS consist of a fully completed OSHA form 174 or equivalent. Receiving, storing, maintaining and controlling MSDS will be administered and supervised by the SSHO. The MSDS library location will be provided prior to commencing Project operations.

2.2.3 Labels, Labeling and Warnings

The SSHO will ensure that all chemicals used in the Project are properly labeled. SSHO will verify that the identifying information and other data on the label correspond with the information on the MSDS for that hazardous chemical. Labels on incoming containers of chemicals may not be removed or defaced, however, containers into which an employee transfers hazardous chemicals for his or her own immediate use do not require labeling.

Labels, tags or markings on containers will list at least:

- The identity of the hazardous chemicals as listed on the MSDS.
- Appropriate hazard warnings to help employees protect themselves from the hazards of the substance.
- Labels provided by chemical manufacturers, distributors and importers must list the name and address of the manufacturer, importer or other person responsible for the chemical and from whom more information about the chemical can be obtained.

2.2.4 Training for Working with Hazardous Substances

Employees who work with or may be exposed to hazardous chemicals will be trained on safe use of those substances. Additional training will be provided whenever a new hazard is introduced into the work area. The training will consist of visual and/or printed handouts about hazard communication about MSDS and related information. This will include hazard communication standards, and the content and location of this written program and the hazardous chemicals. Detection, presence or release of hazardous chemicals including appearance and odor and use of monitoring and control measures will be discussed in training sessions. The sessions will also cover an explanation of the operation of the hazard communication program. This will include the means and use of labels and materials safety data sheets, information about worker's rights

under the hazard communication program, and how to obtain and use appropriate and/or additional hazard information.

2.3 Other General Hazards

2.3.1 General Practices and Housekeeping

- Site work should be performed during daylight hours whenever possible.
- Good housekeeping must be maintained at all times in all Project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- Never leave electrical cords lying on the ground or with an end plugged into an outlet.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.

2.3.2 Shipping and Transportation of Chemical Products

Chemicals brought to the Project site might be defined as hazardous materials by the U.S. Department of Transportation. All staff who ship the materials or transport them by road must receive training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff.

2.3.3 Lifting

- Back injuries are the leading cause of disabling work; most back injuries are the result of improper lifting techniques or overexertion. Office or field tasks and activities involving manual lifting are to be identified and a program implemented to assist employees to mitigate the risks associated with manual lifting.
- When possible, the task should be modified to minimize manual lifting hazards.
- Using mechanical lifting devices are the preferred means of lifting heavy objects such as forklifts; cranes, hoists, and rigging; hand trucks; and trolleys.
- Personnel shall seek assistance when performing manual lifting tasks that appear beyond their physical capabilities.

In general, the following steps must be practiced when planning and performing manual lifts: assess the situation before you lift, ask for assistance if needed, ensure good lifting and body positioning practices, ensure good carrying and setting down practices.

2.3.4 Fire Extinguishers

- When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet of the crew.
- One fire extinguisher must travel in the crew vehicle.
- All fire extinguishers must be:
  - Maintained in a fully charged and operable condition,
  - Visually inspected each quarter and inspection documented, and undergo a maintenance check each year.
  - Kept clear and accessible.

2.3.5 Other Fire Prevention

- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in fire resistant, covered containers until removed from the site.
- Flammable/combustible liquids must be kept and stored in approved containers and storage cabinets.

2.3.6 Electrical

- Only qualified personnel are permitted to work on energized electrical systems.
- Only authorized personnel are permitted to enter high-voltage areas.
- Do not tamper with electrical wiring and equipment unless qualified to do so.
- All electrical wiring and equipment must be considered energized until LOTO procedures are implemented.
- Inspect electrical equipment, power tools, and extension cords for damage prior to use.
- Do not use defective electrical equipment; remove from service.
- All temporary wiring, including extension cords and electrical power tools, must have ground fault circuit interrupters (GFCIs) installed.
- Extension cords must be:
  - Equipped with third-wire grounding.
  - Covered, elevated, or protected from damage when passing through work areas.
  - Protected from pinching if routed through doorways.
  - Not fastened with staples, hung from nails, or suspended with wire.
  - Use only extension cords that have been visually inspected prior to use.
- Electrical power tools and equipment must be effectively grounded or double insulated Underwriters Laboratories, Inc. (UL) approved.
- Operate and maintain electric power tools and equipment according to manufacturers' instructions.
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet from overhead power lines for voltages of 50 kV or less, and 10 feet plus ½ inch for every 1 kV over 50 kV.

- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

2.3.7 Portable Generator Hazards

Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.

- NEVER use a generator indoors or in similarly enclosed or partially enclosed spaces. Generators can produce high levels of CO very quickly. **Remember that you cannot smell or see CO.**
- If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. CO can rapidly lead to full incapacitation and death.
- If you experience serious symptoms, get medical attention immediately. Inform project staff that CO poisoning is suspected. If you experienced symptoms while indoors, have someone call the fire department to determine when it is safe to re-enter the building.
- Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.
- Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.
- Plug appliances directly into the generator. Or use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.
- Most generators come with GFCI. Test the GFCI daily to determine whether they are working.
- If the generator is not equipped with GFCI protected circuits plug a portable GFCI into the generator and plug appliances, tools and lights into the portable GFCI.
- Never store fuel near the generator or near any sources of ignition.
- Before refueling the generator turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

2.3.8 Fall Protection

- Fall protection systems must be used to eliminate fall hazards when performing construction activities at a height of 6 feet or greater.
- Staff exposed to fall hazards must complete a fall protection training course and receive site-specific fall protection training. Do not use fall protection systems that you have not been trained to use.
- A Project fall protection evaluation, or similar evaluation, must be completed for each event.

- A competent person shall inspect and oversee the use of fall protection systems. Follow all requirements established by the competent person for the use and limitation of fall protection systems.
- Qualified personnel shall oversee the use of lifelines.
- Only one person shall be attached to each vertical lifeline.
- Remain within the guardrail system when provided. Leaning over or stepping across a guardrail system is not permitted.
- Do not stand on objects (boxes, buckets, bricks, blocks, etc.) or ladders to increase working height on top of platforms protected by guardrails.
- Inspect personal fall arrest systems prior to each use. Do not use damaged fall protection systems at any time, or for any reason.
- Set-up personal fall arrest systems so that you can neither free-fall more than 6 feet or contact any lower level.
- Only attach personal fall arrest systems to anchorage points capable of supporting at least 5,000 pounds (lbs.).
- Use fall protection equipment for fall protection only and not to hoist materials.
- Do not use personal fall arrest systems that have been subjected to impact loading.

2.3.9 Lifts

- Only authorized and trained personnel are permitted to operate aerial lifts or forklifts.
- Inspect forklifts or aerial lifts and test lift controls prior to use. Reverse alarm must be in working order.
- Wear a full body harness with lanyard attached to the boom or platform.
- Do not attach lanyard to any adjacent structures or equipment while working from an aerial lift.
- Stand firmly on the floor of the platform and do not sit or climb on the railings of the platform or use planks, ladders, or other devices to increase working height.
- Remain in the platform at all times and do not leave the platform to climb to adjacent structures.
- Position lifts on firm, level surfaces, when possible, with the brakes set.
- Use wheel chocks on inclines.
- If outriggers are provided, position on solid surfaces or cribbing.
- Maintain safe clearance distances between overhead power lines and any part of the aerial lift or conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet from overhead power lines for voltages of 50 kV or less, and 10 feet plus ½ inch for every 1 kV over 50 kV.
- Do not exceed the boom and basket load limits.
- Do not use lifts as cranes, unless specifically designed and approved by the lift manufacturer.
- Do not work or stand below lift operations.

- Do not use aerial lifts when winds exceed 30 miles per hour (mph) or as directed by operations manual.

2.3.10 Rigging

- All rigging equipment shall be used only for its intended purpose, inspected by a competent person prior to use, and shall not be loaded in excess of its capacity rating.
- Defective rigging shall be removed from service.
- Tag lines shall be attached to every load being lifted by a crane.
- No modification or addition that could affect the capacity and/or safe operation of the equipment shall be made without the manufacturer's written approval.
- All rigging equipment shall be load tested at least annually by a competent person and documented.
- Special hoisting devices, slings, chokers, hooks, clamps, or other lifting accessories shall be marked to indicate the safe working loads and shall be proof tested prior to initial use to 125% of their rated load.
- Wire rope shall not be used if, in any length of eight diameters, the total number of visible broken wires exceeds 10% of the total number of wires, or if the rope shows other signs of excessive wear, corrosion, or defect.
- Synthetic web slings shall be immediately removed from service if any of the following conditions are present:
    - acid or caustic burns;
    - melting or charring of any part of the sling surface;
    - snags, punctures, tears or cuts; broken or worn stitches;
    - distortion of fittings;
    - discoloration or rotting;
    - red warning line showing.
- Never use makeshift hooks, links or other fasteners. Job or shop hooks and links, or makeshift fasteners, formed from bolts, rods, or other such attachments, shall not be used.
- Alloy steel chains shall have permanently affixed identification stating size, grade, rated capacity and reach.
- Shackles and hooks shall be constructed of forged alloy steel with the identifiable load rating on the shackle or hook.
- Rigging shall not be pulled from under a load when the load is resting on the rigging.
- Place sling(s) in center bowl of hook.
- When attaching slings to the load hoist hook, corners and sharp edges should be "packed" to prevent cutting or damaging the rope or slings.
- Never use nylon, polyester, or polypropylene web slings, or web slings with aluminum fittings where fumes, vapors, sprays, mists or liquids of acids, caustics or phenolics are present.

- Natural and synthetic fiber rope slings, except for wet frozen slings, may be used in a temperature range form from minus 20º F to plus 180º F without decreasing the working load limit. For operations outside this temperature range, and for wet frozen slings, the sling manufacturer's recommendations shall be followed.
- When used for eye splices, the U-bolt shall be installed so that the "U" section is in contact with the dead end of the rope.

2.3.11 Gasoline

In addition to the readily apparent physical hazards created by improperly stored gasoline including fire and explosion, skin exposure to gasoline can cause dermatitis. Inhalation exposure can cause eye, nose, and throat irritation. Exposure can cause dizziness, headache, fatigue, and vomiting. Ingesting gasoline is very dangerous and can lead to pulmonary edema and death.

2.3.12 Heat Stress

To prevent heat related injury:

- Drink 16 ounces of water before beginning work. Water maintained at 50°F to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).
- Observe one another for signs of heat stress. Persons who experience signs of heat syncope, heat rash, or heat cramps should consult the SSHO to avoid progression of heat-related illness.

2.3.13 Cold Stress

To prevent cold related injury:

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in cool weather.
- Persons who experience initial signs of immersion foot, frostbite, or hypothermia should cease work activities immediately and consult their supervisor to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.
- Even in cold weather, continue consuming water to prevent dehydration.

2.3.14 General Exposure

- Wear sturdy footwear appropriate for site activities.
- Observe work area for tripping hazards; be alert.

- Carry a cellular phone or radio.
- Should a physical condition develop or appear to develop with site personnel, seek medical attention.
- Be careful to avoid exposure to bees. Bee and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic.
- Blisters most commonly occur on the feet, especially if someone uses inappropriate socks, wet socks or boots, or boots that do not fit or are not broken in. Preventing blisters is the most important first aid: if someone feels a "hot spot" starting (from friction between the skin and the boot) stop immediately and do something about it
- Nosebleeds more commonly occur in cold than in hot weather because of the very dry air. If someone gets a nosebleed, try to stop the bleeding by pinching the nostrils with your fingers.
- Headaches result from many different things: dehydration, sunlight, tension, etc. You can best treat the headache by treating the cause if you know it. Also take aspirin, acetaminophen (e.g., Tylenol), or ibuprofen (e.g., Advil), drink water, eat a little, and, if possible, take a rest break.
- Fainting results from loss of blood from the brain and is best treated by lowering the head in relation to the heart. If someone feels faint, have him or her sit down, or lie down (on a sleeping pad or some other insulation, if possible) until feeling better.
- Take the time to wash cuts and scrapes with soap and water, or an antiseptic towelette. Cleaning the wound immediately will help prevent infection.
- If someone experiences muscle cramps, have him or her sit or lie down and relax. Massage and stretch the sore muscle slowly, gently, and carefully. Have him or her drink water, eat a little, and start again slowly.
- If the sprain is minor, the victim may be able to walk with little or no assistance, otherwise seek medical attention immediately.

If any medical conditions are suspected to occur or to be occurring, DO NOT ASCEND THE TOWER.

3 Emergency Notification Procedure

In the event of an emergency, first follow the notification procedure listed below. Then follow the procedures listed below pertaining to the type of emergency.

3.1 Notification Procedure

All emergency situations should immediately be reported. The following five-step Emergency Notification Procedure should be used:

1. Notify 911 Immediately

- Give the site name, address, and directions to the operator.

2. Describe the type of emergency situation and provide pertinent details.

Typically, the categories include:

- Medical Emergency
- Fire
- Construction Emergency
  - Equipment Failure
  - Hazardous Spillage
  - Turbine Structural Failure
  - Power Failure
- Extreme Weather Conditions
  - Thunderstorm/Electrical Storm
  - Extreme High Winds
  - Severe Hail
  - Snow/Ice Storm
- Transport Incident
  - Passenger Vehicle
  - Heavy Hauler
  - Aircraft Impact
- Extreme Site Conditions
  - Flood
  - Earthquake
- Act of Sabotage/Vandalism
  - Act of Terrorist
  - Bomb Threat

When describing personnel involved, indicate the numbers affected and the following initial assessment:

a. Fatality
b. Major Illness (e.g., heart attack, not breathing, unconscious, etc.)
c. Major Injury (e.g., broken bone, loss of limb, severe cuts/bleeding, etc.)
d. Minor Injury (e.g., twisted ankle, foreign body in eyes, minor cuts, etc.)
e. Bite/Sting (e.g., snake, scorpion, spider, etc.)
f. Weather Effect (e.g., effects of heat, sun, cold, wind chill, lightning strike, etc.)
g. Incident Type (e.g., fall, crush, vehicle crash, fire, electric shock, etc.)

3. **Location**
Give the operator the location of the emergency, by referring to the Twin Energy Project at South Twin Mountain in the town of Rumford, Maine , access from Horseshoe Valley Road, Roxbury. Indicate the turbine or turbines involved in the incident. Let the operator know whether casualties are in the open, trapped in a vehicle or site equipment, or at height within a turbine.

4. **Shut the Turbine Down or Notify Twin Energy**
Shut the turbine down immediately. Otherwise, contact a Twin Energy representative (a full list of emergency contacts is provided in the Appendix to this Plan). Twin Energy personnel can check remotely that the turbines have been stopped.

5. **Coordinate**
If the emergency involves injury to personnel, stay with the injured person if safe to do so until emergency personnel arrive on the scene. If there are no injuries involved, move away from the turbines, and meet with first responders at the nearest access points shown in Section 1 of this Plan. Coordinate with emergency personnel and first responders and escort them to the location of the emergency. Assist injured personnel in getting to the nearest hospital as indicated in the Appendix.

3.2 Post-Incident Review of Response Procedure

Following an emergency response incident, Twin Energy will hold a meeting with all relevant project personnel and emergency response providers to review how successfully the Plan was implemented. Following this review, actions may be taken to correct any deficiencies, either by improved communication or modification of the Plan.

4 Emergency Procedures

4.1 Fire Emergency

In the event of a fire, stop the wind turbine immediately (emergency stop button), exit immediately, and alert medical and fire services immediately (Rumford Fire Department).
Emergency Phone Numbers:

- Emergency Services: 911
- Rumford Fire Department: (207) 364-2901
- Roxbury Fire Department: (207) 364-5298

In the event of a fire and if you cannot descend the tower using the internal ladder safely, you can descend from the nacelle or hub using the "rope-down" devices.

- Personnel should be trained and qualified to use the "rope-down" device before performing any up-tower work in the turbine.
- The "rope-down" technique should be used as a last resort for exiting.
- The turbine is equipped with manual fire extinguishers:
  - One fire extinguisher in the tower base at the entrance.
  - One fire extinguisher in the back of the nacelle.

4.1.1 Fire Department Response

In the event of a fire, firefighters should not enter the turbine unless there is a concern for the health and safety of personnel working in the turbine. The Fire Department Incident Commander will decide on how to mitigate any emergency it is called to with/and or technical assistance from any Twin Energy employee or subcontractor as deemed necessary.

4.1.2 Fire Hazard Safety Zone

In the event of a fire, the public and facility personnel should be kept a minimum distance away from the base of the turbines. Fire response personnel will make a determination on maintaining a safe perimeter around the turbines. The map in Section 1 depicts potential recommended safe zones around the turbines in the event of fire.

4.2 Blade Icing/Ice Throw and Rotor/Blade Unbalanced Condition

Ice can build up on the rotor blades at certain air-streams and climate conditions. The additional weight may lead to an unbalance of the rotor/blade assembly. The appearance of ice and unbalanced condition is detected by the control system and the wind turbine should shut down automatically. The turbine will not restart until the control system deems the turbine safe to start itself.

There is a danger of falling ice outside the wind turbine during certain climate conditions. Personnel should be aware of these conditions and aware of their surroundings at all times.

4.3 Severe Weather Conditions

Severe weather conditions, particularly gusting high wind speed and electrical storms, have a pronounced effect on the operation of wind turbines. Records will be kept of prevailing weather conditions daily and periodically throughout the day weather forecast updates will be reviewed and assessed to ensure the safe continuity of work, while ensuring that weather sensitive activity is only commenced on the understanding that existing or imminent weather conditions will not exceed the risk assessed for that activity. In any event, due diligence should be proactive with routine observation by all concerned about obvious local changing atmospheric conditions that could indicate deteriorating weather conditions.

The turbine manufacturers have recommendations in the turbine installation manuals that specify maximum wind speeds that are allowed for:

Item	Maximum Wind Speed
Working at height inside a turbine	20 m/s
Working at height external to the turbine	14 – 20 m/s
Working with a locked rotor	14 m/s

With regard to atmospheric electrical activity, tall metal structures like wind turbines and heavy lifting cranes are prone to attract such activity until such time as suitable grounding is in place. In the event of local electrical storms or thunderstorms, all turbine locations should be evacuated, and site personnel seek safety in the cab of their vehicle at least 400 feet from the turbine location until such time as the storm has passed or abated.

4.4 Emergency within a Turbine

In the event that an incident occurs at height within a turbine, Emergency Services should be made aware of the need for specialized recovery equipment and techniques to enable injured personnel to be removed to safety. Twin Energy and/or the wind turbine manufacturer will have available such equipment and trained personnel to support and assist the Emergency Services in such a recovery.

Emergency response equipment will be stored in the turbine supplier's office and shall be transported to the appropriate turbine in case of an emergency incident.

4.5 Natural Disasters

Natural disasters like earthquakes and flash floods may occur without warning. In such cases, it is important that the site be evacuated with all possible haste. All site personnel should move away from the location of the event and get to a safe distance location. It is essential that personnel remain calm and do not panic.

Once personnel are in a safe location, Emergency Notification Procedures should be enacted.

4.6 Acts of Sabotage or Terrorism

With the advent of potentially increased levels of terrorist activity in the United States, it has become essential that all personnel consider the implications to the health and safety of the public should a terrorist attack occur in the workplace. Acts of terrorism, vandalism or sabotage by their nature frequently come without warning and require that Emergency Notification Procedures be enacted.

The primary concerns are threatened bombing attacks and the potential for chemical or biological attack. The local Police Department has law enforcement authority over the site and is responsible for assuming control of response actions.

4.7 Bomb Threat Procedure

In the event that a bomb threat call is received, the main objective is to record every word of the threat message accurately and obtain as much information as possible from the caller. To this end, the following questions should be asked:

- When will the bomb go off?
- Where is the bomb?
- What type of bomb is it?
- What does it look like?
- When was it put there?
- Why are you doing this?
- Who are you?

While talking to the person, try to determine:

- The gender of the caller.
- The style of speech.
- The accent and mannerisms of the caller.
- Listen for background noises that could be helpful to an investigator.

After receiving the call, the recipient will then follow the emergency notification procedure in Section 3 and ensure the immediate evacuation of the area of the bomb's supposed location and the surrounding areas.

4.8 Chemical and Biological Threat

It is difficult to have a contingency Plan that takes into consideration all the possibilities that avoid the consequences of a chemical or biological attack. However, should a warning or threat be issued, the identical procedure should be applied as that used for a bomb threat. Leaving the

area is even more imperative. Keeping your body covered as far as possible to avoid any skin contact with the threatened substance is a priority. Cover your nose and mouth to avoid inhalation.

In the event that a letter or parcel is suspected of spreading a noxious medium, all site personnel shall vigilantly examine any such suspicious or unsolicited deliveries. If there are doubts about the content of a letter or parcel, and if the sender's address and the postmark do not match, the item should be treated as suspect, and the authorities contacted to examine the piece under controlled conditions.

DO NOT APPROACH, TOUCH, OR ATTEMPT TO REMOVE ANY SUSPICIOUS OBJECT OR DEVICE.

5 Training

All Project employees as well as emergency responders are to be familiar with these standard operating procedures and the contents of this Plan.

5.1 Project Personnel Training

All Project personnel are required to review the procedures contained in this plan at the start of their assignment to the Project and on an annual basis. All on site personnel and personnel involved with the remote monitoring of the facility are required to be given a copy of this Plan.

5.2 Fire Department Training

Twin Energy will provide an on-site orientation to Rumford and Roxbury Fire Department personnel regarding the orientation of the turbines and the policies and procedures in this Plan. All personnel attending the training will be provided with an orientation of the turbine and the general safety procedures outlined in this Plan.

5.3 Training Drills

Twin Energy will conduct annual drills on site to review the procedures outlined in this manual and to discuss emergency response procedures. Rumford and Roxbury Fire Department and Emergency Services personnel will be invited to participate in the training drills.

6 Appendix A: Emergency Contact Information

6.1 Twin Energy Emergency Contact Calling Sequence During Operations

This page must be posted at the base of all towers, inside all nacelles and at the facility entrance during turbine operations. This contact information page will be updated prior to commercial operations.

1st	**In the event of an emergency, first call 911**
2nd	**Palmer Capital Corporation** **Sumul Shah** **sumul@palmcap.com** **(781) 389-4671**
3rd	**Palmer Capital Corporation** **Lindsay Deane-Mayer** **lindsay@palmcap.com** **(781)383-3200**

6.2 Twin Energy Emergency Contact Calling Sequence During Construction

This page must be posted at the base of all towers, inside all nacelles and at the facility entrance during facility construction. This contact information page will be updated prior to the start of construction.

1st	**In the event of an emergency, first call 911**
2nd	**Palmer Capital Corporation** **Sumul Shah** **(781) 3894671**
3rd	**Palmer Capital Corporation** **Lindsay Deane-Mayer** **(781)383-3200**
4th	**Turbine Owner Emergency Contact** **Sumul Shah** **(781) 389-4671**

6.3 Emergency Service Providers

Rumford Fire Department
Address: 151 Congress St, Rumford, ME 04276
Emergencies: 911
Non-emergencies: (207) 364-2901

Rumford Police Department
Address: 150 River St, Rumford, ME 04276
Emergencies: 911
Non-emergencies: (207) 364-4516

Roxbury Fire Department
Address: 1095 Roxbury Road, Roxbury, Maine 04275
Emergencies: 911
Non-emergencies: (207) 364-5298

Mexico Police Department
Address: 3 Recreation Drive, Mexico, Maine 04257
Emergencies: 911
Non-emergencies: (207) 364-5686

Hospital
Rumford Hospital
Address: 420 Franklin St, Rumford, ME 04276
Phone: (207) 369-1000

Spill Reports—National Response Center
Emergencies: 911
Non-emergencies: 800-424-8802
Poison Center: 800-222-1222

Ambulance Service
Med-Care Ambulance
Address: 290 Highland Terrace, Mexico, ME 04257
Emergencies: 911
Phone: (207) 364-8748

6.4 Other Useful Contacts

Center for Disease Control (CDC)
http://www.cdc.gov/

Environmental Protection Agency
http://www.epa.gov/

National Response Center to report Toxic Chemical and Oil Spills
http://www.nrc.uscg.mil/nrchp.html

Poisons Control Center
http://www.aapcc.org/

Maine Dept of Health and Human Services
www.maine.gov/dhhs/

Maine Department of Environmental Protection (DEP)
www.maine.gov/dep/

ME DEP, Spill Hotline
Oil Spills - 800.482.0777
Hazardous Materials - 800.452.4664
DEP Regional Offices (Augusta) - 207.287.7688
Maine Emergency Management Agency - 207.624.4400

Department of Homeland Security
http://www.dhs.gov/dhspublic/

Federal Bureau of Investigation (FBI)
http://www.fbi.gov/

Federal Emergency Management Agency (FEMA)
http://www.fema.gov/

United States Postal Service
http://www.usps.com/

Occupational Safety and Health Admin (OSHA)
http://www.osha.gov/

NH Department of Labor, Safety and Training Division
http://www.nh.gov/labor/inspection/safety-training.htm

Exhibit 27-6
Technical Description and Data
Lightning Protection

GE Renewable Energy

- Original Document -

Technical Documentation
Wind Turbine Generator Systems
Cypress 158 - 50/60Hz

Technical Description and Data

Rev. 08 - Doc-0075288 - EN 2021-11-19

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Table of Contents

Document Revision Table

Rev.	Date (YYYY/MM/DD)	Affected Pages	Change Description
06	2020-08-10	7	ADDED new HHs.
		11	EDITED section 2.11.
		13	ADDED Cypress 158m rotor the dimensional details in Section 4.
		14	EDITED section 3.1.
		15	MODIFIED section 4.
07	2021-06-17	5, 10, 12	ADDED information on 5.8/6.1 uprate
		8	UPDATED Section 2.12 Nacelle
		5, 12, 13	ADDED 117 m tower information
08	2021-11-19	14	MODIFIED section 2.2 UPDATED Table 5 CHANGED values for B1, D1, D4 and new on the list B3 and B4 UPDATED table chapter 3 table 1 UPDATED CW Temperature range chapter 3.1 table 3

1 Introduction

This document summarizes the technical description and specifications of the Cypress 158 wind turbine.

2 Technical Description of the Wind Turbine and Major Components

The Cypress -158 is a three-bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 158 meters. The turbine rotor and nacelle are mounted on top of:

- a tubular steel tower with a hub height of 96 m
- a tubular steel tower with a hub height of 101 m (config supports 5.8/6.1)
- a tubular steel tower with a hub height of 107.4 m
- a tubular steel tower with a hub height of 117 m (config supports 5.8/6.1)
- a tubular steel tower with a hub height of 120.9 m (config supports 5.8/6.1)
- a tubular steel tower with a hub height of 125.4 m (config supports 5.8/6.1)
- a tubular steel tower with a hub height of 141 m
- a concrete hybrid tower with a hub height of 150 m
- a tubular steel tower with a hub height of 151 m
- a concrete hybrid tower with a hub height of 161 m

The Cypress 158 turbine, available with these ratings: 4.2/4.5/4.8/5.0/5.2/5.3/ 5.5/5.8/6.1 employs active yaw control (designed to steer the wind turbine with respect to the wind direction), active blade pitch control (to regulate turbine rotor speed) and a variable speed generator with a power electronic converter system.

The Cypress -158 turbine features a modular drive train design where the major drive train components, including main shaft bearing, gearbox, generator and yaw drives, are attached to a bedplate.

The increased ratings 5.8 and 6.1 are available for the listed configuration except for 96m, 107.4m, 141m and 150m. These configurations and others may be added on demand

2.1 Rotor

Rotor speed is regulated by a combination of blade pitch angle adjustment and generator/converter torque control. The rotor spins in a clockwise direction under normal operating conditions when viewed from an upwind location.

Full blade pitch angle range is approximately 90 degrees, with the zero degree position being with the blade flat to the prevailing wind. Pitching the blades to a full feather pitch angle of approximately 90 degrees accomplishes aerodynamic braking of the rotor, thus reduces the rotor speed.

2.2 Blades

There are three logistics optimized rotor blades used on the Cypress -158 wind turbine. Optionally, the blades can be equipped with Leading Edge Protection.

In order to optimize noise emissions, the rotor blades are equipped with Low-Noise-Trailing-Edges (LNTEs) at the pressure side of the blade's rear edge. LNTEs are thin jagged plastic strips. The rotor blades of the Cypress -158 are equipped with these strips at the factory.

Fig. 1: LNTEs at the wind turbine rotor blade

Blade Split

To ease transportation of blade, GE developed a solution using a split blade which has transportation requirements comparable to 137 m product. The two parts of the blade are connected using a mechanical connection which has been extensively tested. The blade is also available in one piece; for turbines equipped with the Ice Mitigation System it is always one piece.

2.3 Blade Pitch Control System

The rotor utilizes a pitch system to provide adjustment of the blade pitch angle during operation.

The active pitch controller enables the wind turbine rotor to regulate speed, when above rated wind speed, by allowing the blade to "spill" excess aerodynamic lift. Energy from wind gusts below rated wind speed is captured by allowing the rotor to speed up.

Independent back up is provided to drive each blade in order to feather the blades and shut down the wind turbine in the event of a grid line outage or other fault. By having all three blades outfitted with independent pitch systems, redundancy of individual blade aerodynamic braking capability is provided.

2.4 Hub

The hub is used to connect the three rotor blades to the turbine main shaft. The hub also houses the blade pitch system and is mounted directly to the main shaft. To carry out maintenance work, the hub can be entered through one of three hatches at the area close to the nacelle roof.

2.5 Gearbox

The gearbox in the wind turbine is designed to transmit torsional power between the low-rpm turbine rotor and high-rpm electric generator. The gearbox is a multi-stage planetary/helical design. The gearbox is mounted to the wind turbine bedplate. The gearbox mounting is designed to reduce vibration and noise transfer to the bedplate. The gearbox is lubricated by a forced, cooled lubrication system and a filter assist to maintain oil cleanliness.

2.6 Bearings

The blade pitch bearing is designed to allow the blade to pitch about a span-wise pitch axis. The inner race of the blade pitch bearing is outfitted with a blade drive gear that enables the blade to pitch.

The spherical roller main bearing supports and aligns the main shaft to the main gearbox and is absorbing radial and axial loads from the rotor.

2.7 Brake System

The blade pitch system acts as the main braking system for the wind turbine. Braking under normal operating conditions is accomplished by feathering the blades out of the wind. Only two feathered rotor blades are required to decelerate the rotor safely into idling mode, and each rotor blade has its own backup to drive the blade in the event of a grid line loss.

2.8 Generator

The generator is a doubly fed induction generator. It is mounted to the generator frame with a mounting designed to reduce vibration and noise transfer to machine.

2.9 Gearbox/Generator Coupling

To protect the drive train from excessive torque loads, a special coupling including a torque-limiting device is provided between the generator and gearbox output shaft.

2.10 Yaw System

A bearing positioned between the nacelle and tower facilitates yaw motion. Yaw drives mesh with the gear of the yaw bearing and steer the wind turbine to track the wind in yaw. The yaw drive system contains an automatic yaw brake. This brake engages when the yaw drive is not operating and prevents the yaw drives from being loaded due to turbulent wind conditions.

The controller activates the yaw drives to align the nacelle to the wind direction based on the wind vane sensor mounted on the top of the nacelle.

The wind turbine records nacelle yaw position following excessive rotation in one direction, the controller automatically brings the rotor to a complete stop, untwists the internal cables, and restarts the wind turbine.

2.11 Tower

The wind turbine is mounted on top of a tubular steel tower (or a hybrid tower). Access to the turbine is through a door at the base of the tower. Internal service platforms and interior lighting is included. A ladder provides access to the nacelle and also supports a fall arrest safety system.

Optional climb assist or service lifts are available upon request.

2.12 Nacelle

The nacelle houses the main components of the wind turbine generator. Access from the tower into the nacelle is through the bottom of the nacelle. The nacelle is ventilated and illuminated by electric lights. A hatch provides access to the blades and hub. The nacelle enclosure floor is designed to collect liquids (e.g. oil, grease) in cases of leakage with a safety factor of 1.5. Such capability has been proven by a test.

2.13 Wind Sensor and Lightning Rod

An ultrasonic wind sensor and lightning rod are mounted on top of the nacelle housing. Access is accomplished through the hatch in the nacelle.

2.14 Lightning Protection (according to IEC 61400-24 Level I)

The rotor blades are equipped with lightning receptors mounted in the blade. The turbine is grounded and shielded to protect against lightning; however, lightning is an unpredictable force of nature and it is possible that a lightning strike could damage various components notwithstanding the lightning protection employed in the wind turbine.

2.15 Wind Turbine Control System

The wind turbine can be controlled locally. Control signals can also be sent from a remote computer via a Supervisory Control and Data Acquisition System (SCADA), with local lockout capability provided at the turbine controller.

Service switches at the tower top prevent service personnel at the bottom of the tower from operating certain systems of the turbine while service personnel are in the nacelle. To override any wind turbine operation, emergency-stop buttons located in the tower base and in the nacelle can be activated to stop the turbine in the event of an emergency.

2.16 Power Converter

The wind turbine uses a power converter system that consists of a converter on the rotor side, a DC intermediate circuit, and a power inverter on the grid side.

The converter system consists of a power module and the associated electrical equipment.

2.17 Transformer and Medium Voltage Switch Gear

Transformer

The 3 winding transformer is located at the rear of the nacelle. The transformer is a dry type transformer supporting medium voltage range of 10 - 35 kV range. The transformer is completely separated from the rest of machine head. The transformer is in GE scope, a pad mounted variant is not available.

Medium Voltage Switchgear

The medium voltage switchgear is mounted in the tower entry area.

3 Technical Data for the Cypress-158

Turbine	4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1 158
Rated output [MW]	4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1
Rotor diameter [m]	158
Number of blades	3
Swept area [m^2]	19607
Rotational direction (viewed from an upwind location)	Clockwise
Maximum speed of the blade tips [m/s]	4.2-4.8MW 50Hz - 74.5 m/s 4.8-6.1MW 50Hz - 82.0 m/s 4.8-6.1MW 60Hz - 83.6 m/s
Orientation	Upwind
Speed regulation	Pitch control
Aerodynamic brake	Full feathering
Color of outer components	RAL 7035 (light grey) and RAL 7023 (concrete grey, for concrete sections of hybrid tower only)
Reflection degree/Gloss degree Steel tower	30 - 60 gloss units measured at 60° as per ISO 2813
Reflection degree/Gloss degree Rotor blades, Nacelle, Hub	60 - 80 gloss units measured at 60° as per ISO 2813
Reflection degree/Gloss degree Hybrid Tower	Concrete gray (similar RAL 7023); gloss matte

Table 1: Technical data Cypress-158 wind turbine

Atmospheric corrosion protection (corrosion categories as defined by ISO 12944 2:1998)	
Tower Shell Coating internal/external	C-2/C-3 (standard)/ C-4/C-5 (enhanced)
Tower Flange Bolts (TFB) internal/external	C-4/C-4 (standard) / C-4/C-4 (enhanced)
Tower Mechanical Fasteners and internals internal/external	C-3/C-3 (standard) / C-3/C-5 (enhanced)
Hub internal/external	C-5/C-5
Nacelle & Hub Fasteners internal/external	C-3/C-5
Automatic Lubrication System, Yaw Drive Bolts internal	C-3
Pitch Motor, Pitch Gearbox internal	C-4
Main Shaft, Pillow Block, Gearbox internal	C-4
Bedplate, Generator Frame internal	C-5

Table 2: Atmospheric corrosion protection

3.1 Operational Limits

Turbine	4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1-158
Hub height	96 m tubular steel tower (only 50Hz) 101 m tubular steel tower (50/60Hz) 107.4 m tubular steel tower (only 60Hz) 117 m tubular steel tower (only 60Hz) 120.9 m tubular steel tower (only 50Hz) 125.4 m tubular steel (only 60Hz) 141 m tubular steel tower (only 50Hz) 150 m hybrid tower (only 50Hz) 151 tubular steel tower (only 50Hz) 161 m hybrid tower (only 50Hz)
Wind turbine design standard	* IEC 61400-1, Ed. 3 ** DIBt 2012
Height above sea level	Maximum 1000 m with the maximum standard operational temperature of up to +40 °C. Above 1000 m, the maximum operational temperature is reduced per DIN IEC 60034 1 (e.g., maximum operational temperature reduced up to +30 °C at 2000 m). For installations above 1000 m isolation distances of medium voltage terminals must also be re-evaluated. De-rated operation additionally driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Hot Weather High Altitude and the Grid Interconnection documentation.
Standard Weather Option (STW)	Operation from -15 °C up to +40 °C. De-rated operation driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Hot Weather High Altitude and Grid Interconnection documentation. Survival temperature of -20 °C to +50 °C without the grid. Survival means turbine not in operation including the heat transfer system due to lack of energy supply by the grid.
Cold Weather Option (CW)	Operation from -30 °C up to +40 °C. De-rated operation driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Cold Weather Options, Hot Weather High Altitiude and Grid Interconnection documentation. Survive extreme temperature of -40 °C to +50 °C without the grid. Survive means: turbine not in operation including the heat transfer system due to lack of energy supply by the grid.
Wind class	IEC S + WZ (S)

Table 3: Operational limits

3.2 Cypress Overview Drawing and Dimensions

This document presents an overview of the relevant dimensions for the wind energy turbine with 158 m rotor diameter.

The table shown below fits to the GE drawing 450W1333.

Description		Dimension for hub height in [m]									
		96 m (tubular steel tower)	101 m (tubular steel tower)	107.4 m (tubular steel tower 60Hz only)	117m (tubular steel tower 60Hz only)	120.9 m (tubular steel tower)	125.4 m (tubular steel tower 60Hz only)	141 m (tubular steel tower)	150 m (hybrid tower)	151 m (tubular steel tower)	161 m (hybrid tower)
Hub height [m]	A2	96	101	107.4	117	120.9	125.4	141	150	151	161
Total height [m]	A3	175	180	186.4	196	199.9	204.4	220	229	230	240
Height upper daylight identification (only when required) [m]	A4	-	60	60	-	60	60	60	60	-	60
Height lower daylight identification (only when required) [m]	A5	-	40	40	-	40	40	40	40	-	40
Top of soil to top of foundation EU [m]	A6	1.3	1.3		-	1.3			1.51		1.31
Top of soil to top of foundation Australia [m]	A6	0.2	0.2		-	0.2			-		-
Top of soil to top of foundation Australia & North America [m]	A6	0.745	0.745	0.745	0.745	-	0.745	-	-		-
Height aviation light [m]	A7	100 ∓1	105 ∓1	111.7 ∓1	-	125 ∓1	129 ∓1	145 ∓1	154 ∓1		165 ∓1
Foundation diameter [m]	B2	22	22	20-25	20-25	25.8	20-25	25.8	23.5 and 25		23.5 and 25
Distance aviation lights (only when required) [m]	C1		52.5 ∓4	52.5 ∓4	-	62.5 ∓4	62.5 ∓4	72.5 ∓4	77 ∓4		82.5 ∓4
Tower bottom diameter [m]	C7	4.3	4.3	4.3	4.56	4.3	4.3	5.0	7.9	5.3	8.5

Table 4: Description

General information for all hub heights		
Description	**Parameter**	**Dimension**
Rotor diameter	A1	158 m
Longest chord	A8	4.0 m
Chord at 90% rotor radius	A9	1.35 m
Aviation light spacing on machine head	B1	~ 4.4 m
Blade tip distance in ideal position	C2	9.55 m
Blade tip distance in operation position	C3	5.55 m
Blade tip distance in ideal position	C4	20.48 m
Blade tip distance in operation position	C5	16.53 m
Tower top diameter	C6	3.7 m
Nacelle length (incl. ventilation outlets)	D1	~ 12.8 m (~ 13.2 m)
Distance from Yaw Bearing to Centre line crossing	D2	1.38 m
Aviation marking stripe width	D3	2 m
Nacelle height	D4	~ 3.8 m
Distance tower center - hub center	D5	4.17 m
Overhang	D6	4.18 m
Distance tower top - hub center	D7	1.92 m
Tilt drivetrain	D8	4°
cone angle	D9	85°
Eccentricity area in idle	B3	20314,95 m^2
Eccentricity area in operation	B4	19989,58 m^2

Table 5: General information for all hub heights

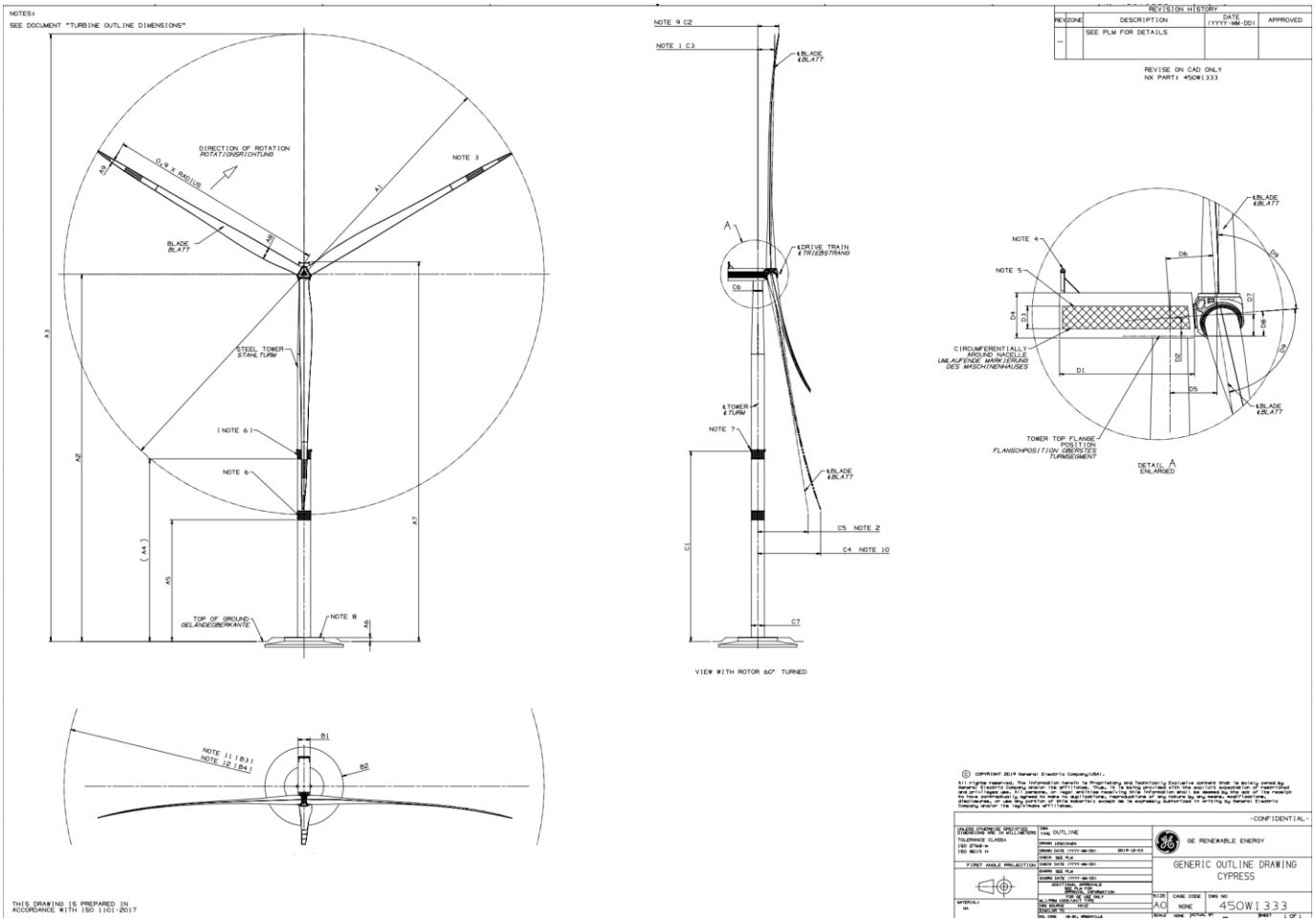

Figure 2: Generic outline drawing Cypress 450W1333

Please note that generic outline drawing 450W1333 is attached to this file as a separate document.

GE Renewable Energy

- Original Document -

Technical Documentation
Wind Turbine Generator Systems
Cypress Platform - 50/60Hz

Lightning Protection

Lightning Protection Zone Concept

Rev. 06a - Doc-0073537 - EN 2020-05-04

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Table of Contents

Document Revision Table

Rev.	Date (YYYY/MM/DD)	Affected Pages	Change Description
06	2020/04/16	7	ADDED new Figure in Section 6 Surge Voltage Protection of the Turbine Electrical System
		9	EDITED text in Section 7.3 Discharge from the Rotor Hub
		10	EDITED text in Section 8.2 Grounding System of the Base Frame
		10	EDITED text in Section 8.3 Grounding System of the Generator and the Gearbox
06a	2020/05/04	-	INCLUDED all Cypress models
		9	MODIFIED Section 7.1 Paragraph 2.

1 General

The lightning protection for Cypress wind turbine generators has been designed to protection level 1 according to IEC 61400-24.

Lightning protection on the MV side by means of surge arrestors or other devices is solely in customer scope as the wind farm grid lay-out defines the required hardware.

This document is applicable for all Cypress turbines

1.1 Requirements

An EMC lightning protection zone concept was prepared in order to specify the lightning protection measures of the wind turbine. The necessity for protective measures was examined proceeding from a risk assessment which considered the following causes of damage:

- Electric shock
- Physical damage and
- Malfunctions in electrical and electronic systems as a result of overvoltage

and which also considered potential types of damage such as:

- The loss of human life
- The loss of services
- The loss of irreplaceable cultural assets and
- Economic losses

1.2 Specification of the Protection Zones

The lightning protection measures in the wind turbine were planned and executed on the basis of an EMC-oriented lightning protection zone concept. This means that the overall wind turbine is divided into different **protection zones** after the lightning protection class has been specified. The zones have the task of reducing conducted disturbance variables and disturbance fields to specified limit values. The requirements of the higher protection zone are to be complied with at the transitions between two protection zones.

1.3 Implementation

Lightning protection class 0_A is selected for areas in which objects are exposed to direct lightning strikes and therefore have to conduct the full lightning current. These areas are:

- rotor blades
- rotor hub
- nacelle enclosure
- the outside of the tower

Lightning protection class 0_B. is selected for areas in which objects are not exposed to direct lightning strikes, but in which an undamped electromagnetic field occurs, e.g. the anemometry equipment located on the nacelle.

Lightning protection zone 1 applies for areas in which objects are not exposed to direct lightning strikes and in which the currents in all components within this zone are reduced in comparison with zones 0_A and 0_B. The electromagnetic field can also be damped in this zone, depending on the screening. These areas are:

- inside of the tower
- inside of control cabinets in the nacelle

Lightning protection zone 2 is a zone in which supplementary screening measures for a further reduction in the interference level have been implemented. This applies to the areas in the control cabinets located in the tubular steel tower.

The lightning protection systems in the wind turbine have the task of diverting the lightning currents arising from inevitable lightning strikes as well as the energy contained in the lightning to ground in a controlled manner.

The interference effects of the high current, which has an extreme broadband frequency, are reduced to appropriate levels by screening. The overvoltages that arise in the electrical equipment are rendered harmless by lightning arresters or surge arresters.

2 Foundation Ground Connection

The function of the ground connection is to divert the lightning current to ground across the largest possible area. The higher the resistance between the foundation ground connection and the surrounding ground, the higher the voltage of the ground connection against the surrounding ground potential and thus against the feeders entering the tower.

Of particular importance during a lightning strike is not just the resistance of the earthing system, but also its inductance. As a lightning current contains many high frequency components, these interact with any earthing system inductance to produce very high transient impedances. As such, an earthing system that is installed using horizontal electrodes over approximately 50 m in length may have a very low earth resistance but could have a high transient impedance. If, for example, 60 m of additional horizontal electrode is required it would be better to use multiple electrodes of shorter lengths instead of one long conductor.

If the voltage between the feeders and the tower potential is too high owing to an excessive ground resistance, flashover or arcing may occur between the feeder and the parts connected to the tower, e.g. control cabinet housings.

The Buyer is responsible for the grounding design and installation requirements, and must encompass the minimum requirements specified in the separately provided GE documents for foundation design and detailing recommendations.

3 Protection of the Tower

The tower has been designed as a tubular steel tower or as a hybrid tower, tubular steel with steel reinforced concrete part, and is therefore suitable for discharging the lightning current. The electrical equipment in the tower is inside a Faraday cage and is therefore protected from direct lightning effects.

4 Protection of the Control Cables

The control cables used for the transmission of serial data are twisted pairs. Control signal lines 24 V DC to 1 A are wired in 24-core cables with overall shielding.

5 Cables and Lead Wires at the Intersecting Points of the Lightning Protection Zones

The cables and lead wires are provided with surge voltage and overcurrent protection components at the intersecting points of the lightning protection zones.

6 Surge Voltage Protection of the Turbine Electrical System

The installation of the surge protection and the transformer inside the power distribution panel is designed to achieve an equipotential bonding in the event of a lightning strike. Arresting devices capable of conducting lightning currents and with a protection level characteristic of I_B. (10/350): 50 kA are used on the low-voltage bus bar.

The surge voltage protection in the MVSG is generally needed but it is not in the scope of GE.

Figure 1 displays an example of a 3-field MVSG. The MVSG could also be a different configuration, e.g. 2-field version.

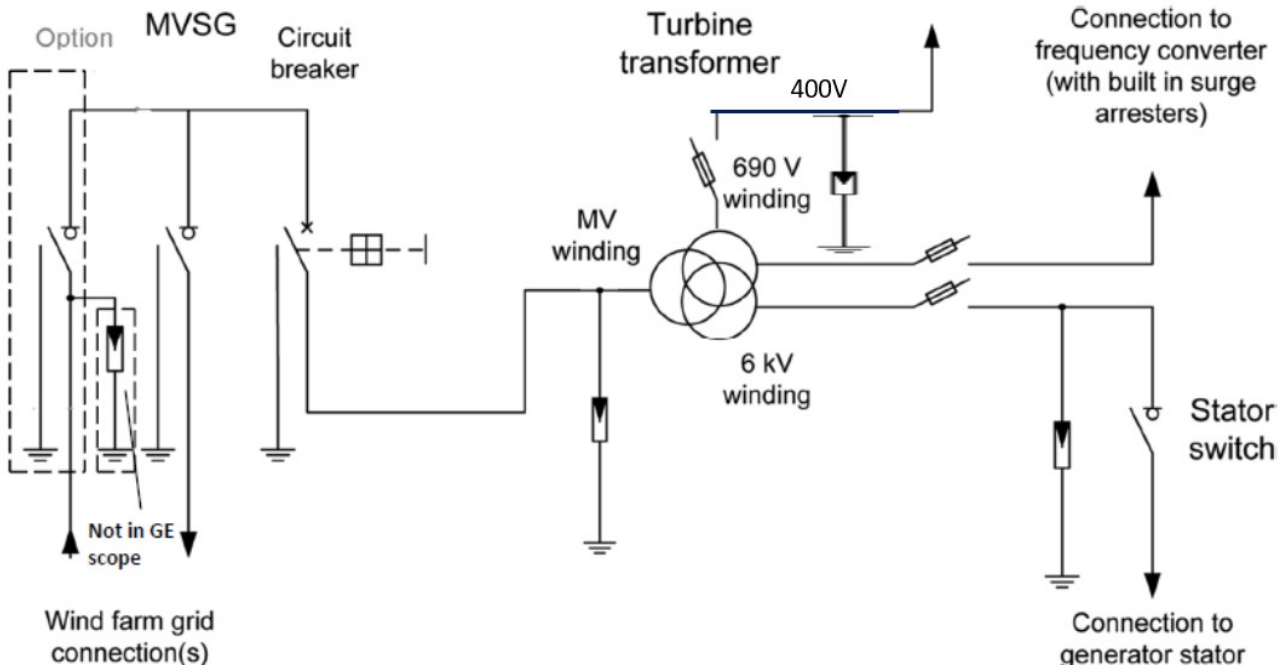

Figure 1: Surge voltage protection of the turbine electrical system

7 Rotors

7.1 Discharges from the Rotor Blades

The rotor blades are Lightning Protection Level 1 (LPL) and to protect against a 10 MJ/Ohm and 300 Coulombs lightning strike. Air termination receptors located on the blade surface have been arranged such that they minimize lightning strike damage in accordance with IEC61400-24 Edition 2010.

The air termination network is connected to a central down conductor cable from the tip to the root of the blade. The Lightning Protection System (LPS) is configured with one receptor located at the tip of the blade, and four pairs of receptors (one each on the pressure side and on the suction side) distributed over the blade to cover the area with the highest lightning strike attachment probability.

7.2 Protection of the Rotor Blade Adjustment Equipment

The rotor hub is made of cast material which makes up the greater part of the screening, and screens the installations against direct strokes and magnetic fields caused by lightning currents which have been caught in the rotor blade. The openings to the rotor blades are closed by the special steel housings of the axis adjustment control cabinets, which also form a screening. The housings have a large-surface, conductive connection to the rotor hub by means of U-beams, and thus, offer only a negligible resistance to high-frequency currents.

7.3 Discharge from the Rotor Hub

The hub consists of ductile cast iron and is an arresting device, which is capable of conducting lightning currents. The lightning current is conducted away from the hub to the base frame via the rotor shaft and the carbon-brush with spark gaps dischargers mounted on the rotor shaft (tested to lightning protection class I). The current is discharged from the base frame to the tower via the yaw bearing, which is capable of conducting lightning currents. The grounding cables are not the main lightning current path.

8 Protection of the Nacelle against a Direct Strike

8.1 Enclosure of the Nacelle

The nacelle is made of glass-fiber reinforced plastic.

8.2 Grounding System of the Base Frame

The base frame is connected to the tower base via grounding cables and equipotential bonding strips. Main Lightning currents path is the tower via the tower via the yaw bearing, which is capable of conducting lightning currents.

8.3 Grounding System of the Generator and the Gearbox

The generator and the gearbox are insulated to each other via an insulated coupling device. Grounding is effected via copper grounding strips.

8.4 Wind Speed Measurement Equipment

Discharge from Wind Sensors

The wind speed measurement equipment on the nacelle is protected by an air-termination rod. This lightning rod is connected to the base frame of the nacelle.

9 Protection of all Components in the WTGS against Damage

All electrical equipment within the wind turbine is protected against the effects of a direct lightning strike and is located in lightning protection zones 1, 2 or 3.

The transition from lightning protection zone 0 (direct lightning effect) to lightning protection zone 1 is situated at the inlet of the feeder cables from the transformer station to the low-voltage distribution in the tower.

Arresting devices which are capable of conducting lightning currents and which have a protection level characteristic I_B (10/350): 50 kA are used at this point. These arresting devices are able to limit surge voltages within the control cabinet to a voltage of 1.5 kV. However, this is not sufficient for all the electric equipment in the low voltage section.

For this reason, surge voltage protectors with a protection level characteristic of I_B (8/20) at 15 kA are installed decoupled from the lightning arresters. These are capable of limiting the arising surge voltage to 1 kV. In accordance with the manufacturer's specifications, all components used can cope with this surge voltage against ground. Components arranged downstream of these surge arresters are situated in lightning protection zone 2.

Sensitive electronic components are located in the devices used in the control cabinet (SPC or UPS). They are protected against surge voltages by appropriate input circuitry, by inductive or optical type galvanic decoupling or by surge arresters in the respective power supply units (lightning protection zone 3). Inductive capacitive interference is prevented by the electrical isolation and screening of the feeders and signal lines. The PLC and UPS are provided with a metal housing to protect against interference.

10 Equipotential Bonding

The medium-voltage transformer, the main cabinet, the low-voltage distribution and the medium voltage circuit breaker as well as the converter and the generator box are all connected to the frame.

Equipotential bonding is effected via several equipotential bonding strips. The transformer, medium-voltage control cabinet and converter are connected on equipotential bonding strips. In general all cabinets are connected to the overall grounding system.

The equipotential bonding strips are potentially joined to the potential of the machine frame.

11 Discharge of the Lightning Currents

If a lightning discharge takes place via a rotor blade of the wind turbine generator system, the lightning current flows to the blade root via a receptor of the blade and then via the conductor in the rotor blade. From here, the current flows to the hub via the prestressed bearing, which is capable of conducting lightning currents.

The lightning current is conducted from the rotor shaft to the base frame of the turbine via carbon brushes which are capable of conducting lightning currents. The main bearing is protected from the high lightning currents by this means.

The lightning current flows from the base frame to the tower via the yaw bearing which is also prestressed and capable of carrying lightning currents. Partial lightning currents can be discharged to the tower base in parallel via the protective earth cables of the generator which are connected to the base frame via the equipotential bonding in the nacelle.

The steel tower is connected to the equipotential bonding strip in the area of the tower base.
From here, the lightning current flows to the foundation or the ring ground connection of the wind turbine generator system.

Lightning discharges which take place via the lightning rod are conducted to the base frame. From here the current takes the same route as a discharge to a rotor blade.

12 Applied Standards

The following standards and guidelines were taken as a basis for the design of the lightning protection of the wind turbine generator system:

IEC 62305-1:2010	Protection against Lightning - Part 1: General Principles
IEC 62305-2:2010	Protection against Lightning - Part 2: Risk Management
IEC 62305-3:2010	Protection against Lightning - Part 3: Physical Damage to Structures and Life Hazard
IEC 62305-4:2010	Protection against Lightning - Part 4: Electrical and Electronic Systems within Structures
IEC 61400-24, Edition 1.0 2010 06	Wind turbine generator systems, lightning protection for wind turbine generator systems