Educational

Northern Power® 100 General Description

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PURPOSE

The purpose of this document is to provide a general description for the Northern Power 100 wind turbine that is intended for public use.

TURBINE ARCHITECTURE

The Northern Power 100 wind turbine incorporates technology that is often only found on much larger turbines. The Northern Power 100 wind turbine has the following components:

- Three bladed, stall controlled, upwind rotor with rigid hub
- Direct drive permanent magnet synchronous generator
- IGBT-based full power converter allowing variable speed generator operation and compliance with the UL 1741 utility interconnection standard
- Redundant rotor braking: dual mechanical brakes plus an electrodynamic brake
- System controller and power converter located in nacelle
- Active yaw drive system with friction damping
- Steel tube monopole tower

An exploded view of the Northern Power 100 wind turbine is shown in Figure 1.

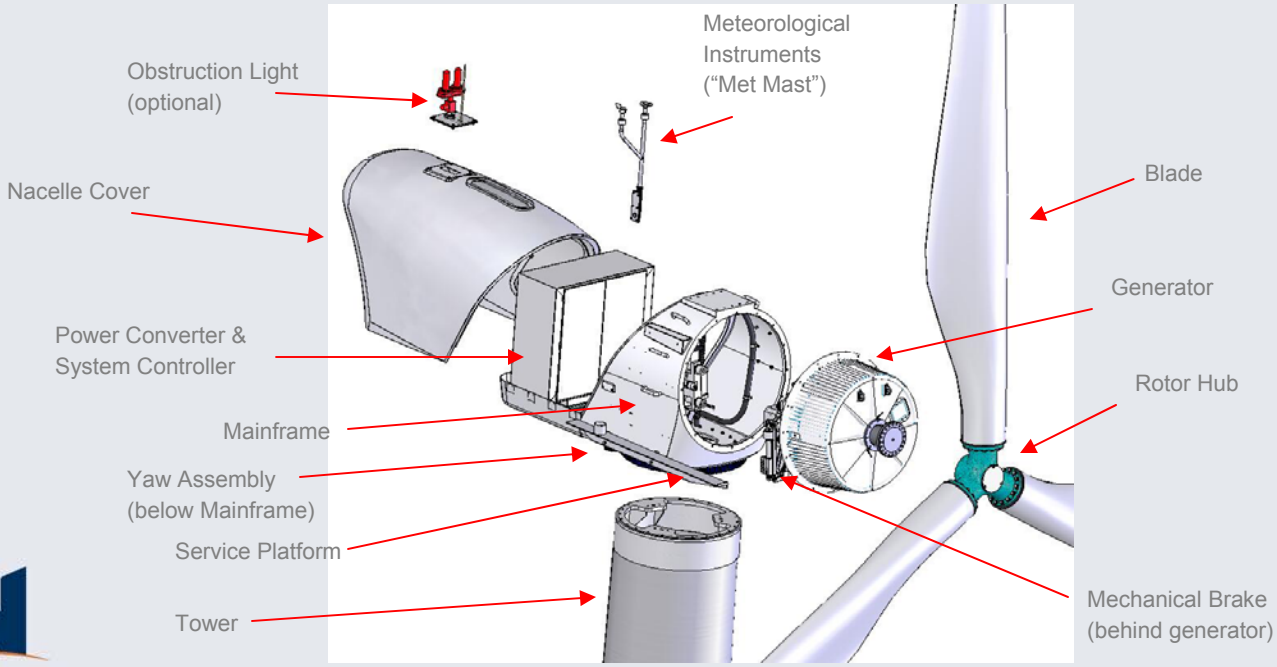

Figure 1 Key Northern Power 100 Turbine Components

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MAJOR SYSTEM FUNCTIONS

The **ROTOR** converts the aerodynamic energy in the wind to mechanical shaft torque. It also provides a lightning path from the blade tips to the main shaft.

The **GENERATOR** converts the mechanical shaft power to electrical power at variable frequency, and provides the reaction torque to the rotor.

The **FULL POWER CONVERTER** converts the variable frequency generator output to constant frequency for feeding into the grid.

The **SYSTEM CONTROLLER** manages the normal operation of the wind turbine. The system controller is integrated into the power converter cabinet.

The **SAFETY CHAIN** is activated when the machine exceeds its normal operating limits, and takes the machine to a safe state.

The **NACELLE** performs several functions:

- The mainframe subsystem carries the mechanical rotor loads to the yaw system
- The yaw subsystem orients the machine into the wind and transfers mechanical loads to the tower.
- The nacelle cover protects the interior components (brake system, converter, yaw drive)
- The met mast collects wind data for turbine control and monitoring

The **TOWER** holds the machine up high in the windstream and brings the mechanical loads to the foundation

The **TRANSFORMER** converts the converter output voltage to grid voltage.

The **FOUNDATION** transmits the tower base loads to the earth, and provides a path (conduit) for the electrical service, and contains features to accomplish system grounding.

BLADES AND ROTOR

The fixed-pitch fiberglass reinforced polyester (FRP) blades capture the wind and turn the rotor shaft. The blade has an advanced root design, which is suitable for low temperature operation, and integral lightning protection is provided. The rotor hub is a Y-shaped design with an integral shaft mounting flange. Power limiting and control is achieved using an advanced stall control technology. In a stall controlled turbine, the captured power is a complex function of the blade design, wind speed and rotor speed. The Northern Power 100 regulates the generator speed through use of the power converter which results in the control of the rotor speed and thus the output power to the grid.

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GENERATOR

The generator is an advanced permanent magnet generator with passive air-cooling via the exposed generator housing. The generator housing contains the bearing mounts for the generator mainshaft, which serves as the rotor mainshaft in this integrated design configuration. The generator includes an automatic bearing greasing system which allows for extended service intervals. When the greasing system requires service, it is readily performed from within the nacelle.

MAIN SHAFT BRAKE ASSEMBLY

The Northern Power 100 uses a main shaft braking system consisting of two caliper brakes which can be motor applied for normal braking and are fail safe in emergency conditions. The braking system is readily serviced from within the nacelle. In addition to the two mechanical brakes, the turbine includes an electrodynamic brake that is incorporated into the power converter. The turbine may be stopped under any circumstance by using any two of the three brakes.

MAINFRAME AND NACELLE

The Northern Power 100 mainframe is the main structural element of the tower top assembly, transmitting the rotor loads from the main shaft and bearings to the tower. The mainframe includes external service platforms for access to the rotor hub and blades.

The nacelle housing is fabricated from fiberglass reinforced polyester (FRP). The nacelle is sized so that it can be shipped virtually assembled in a standard ISO container. The design includes an integral skylight window and a removable side hatch for access to the external service platforms.

Mounted off of the side of the nacelle is the “met mast” which contains the meteorological instruments that measure the wind speed and yaw error. An optional obstruction light (FAA Light) is also mounted on the nacelle’s top.

YAW ASSEMBLY

The Northern Power 100 uses an active yaw drive system to orient the turbine into the wind. A gear motor mounted to the turbine bedplate drives against the integral bull gear and slew ring which is attached to the tower in order to yaw the turbine. A yaw error sensor mounted on the met mast provides the input to the yaw control system. A proprietary friction system provides constant yaw friction to minimize low amplitude vibration of the nacelle.

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FULL POWER CONVERTER AND CONTROLS ASSEMBLY

The full power converter assembly is located in the nacelle and includes the Northern Power 100 system controller, the power converter and the electrodynamic brake system. The system controller autonomously controls the turbine and has an Ethernet-based Modbus-TCP interface for remote monitoring and supervisory control. The power converter interfaces the generator with the grid and consists of an active rectifier and inverter. The electrodynamic brake system uses the generator, power converter and an air-cooled, resistive load bank.

Control switches are present both on the power converter in the nacelle and on the electrical junction box at the tower base. These controls allow the turbine to be placed in a safe service state and include an emergency stop. The nacelle control switches also include manual yaw and brake controls.

The Northern Power 100 power converter uses an advanced IGBT-based technology to convert the varying output of the generator to the constant frequency and voltage required by the grid. This conversion is performed in two steps. The first conversion changes the generator's varying output to a dc voltage. The second conversion produces the constant frequency and amplitude for delivery to the grid. The turbine's grid output meets the IEEE 519 harmonic standard so no additional filtering is required.

Because of this double conversion process, adding a Northern Power 100 turbine to the grid is different than adding a traditional wind turbine in this power class because the power converter isolates the generator from the grid. Traditionally, wind turbines are directly-connected induction generators which require utility coordination due to their reactive current needs and large fault current characteristics. To the grid, the Northern Power 100 appears as an inverter, with no reactive current requirements and a very small fault current characteristic. The Northern Power 100 is designed to meet the UL 1741 grid interconnection standard and presently is in the process of certification to this standard. The UL1741 certification is expected in the first quarter of 2009. Therefore, the Northern Power 100 does not present the traditional interconnection issues of other wind turbines.

Because of its power converter interface, the Northern Power 100 can be configured to supply reactive power to the grid, even at times when it is not generating real power.

TOWER

The standard Northern Power 100 tower is a multi-section, tapered tubular steel tower. Access is gained through a door located at the tower base. An electrical junction box that contains the power and control connection points; a fused, lockable power disconnect and a basic control interface to secure the turbine for service is installed in the tower base. Access to the nacelle is provided by an internal ladder equipped with a fall restraint system.

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FOUNDATION

The foundation for the Northern Power 100 typically falls into two broad categories: concrete pad or pile type. The foundation design is site specific because of soil conditions and other factors. The customer must provide a foundation design based on loads and key dimensions provided by Northern Power.

TRANSFORMER

One transformer per Northern Power 100 is required for connecting the turbine with the utility system. The transformer is not supplied or installed by Northern Power. This transformer is used to match the NPS 100 output voltage to the local utility voltage and to manage the safety and power quality of the electrical interface.

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