

# Technical description

## General design

The SWT-2.3-93 wind turbine is an upgraded version of the standard SWT-2.3-82 machine and includes the new B45 blade, a rotor diameter of 93 m, and hence a 25 percent increase of the swept area relative to the standard version of the SWT-2.3-82 wind turbine.

## Rotor

The SWT-2.3-93 turbine has a three-bladed rotor with pitch regulation for power output optimization and control. The rotor speed is variable in order to maximize the aerodynamic efficiency, and speed compliance during power regulation minimizes the dynamic loads on the transmission system.

## Blades

The B45 blades are made of fiberglass-reinforced epoxy in Siemens' proprietary IntegralBlade® manufacturing process. In this process, the blades are cast in one piece, leaving no weak points at glue joints and providing optimum quality. The aerodynamic design represents state-of-the-art wind turbine technology, and the structural design has special Siemens safety factors over and above all normal industry and customer requirements.

## Rotor hub

The rotor hub is cast in nodular cast iron and is fitted to the main shaft with a flange connection. The hub is large enough to provide a comfortable working environment inside the structure for two service technicians during maintenance of bolt connections and pitch bearings.

## Blade pitch system

The blade pitch arrangement is used to optimize and regulate power output through the operating range. The blades are feathered to minimize wind loads during standstill under extreme wind conditions.

## Main shaft and bearing

The main shaft is forged in alloy steel and is hollow for the transfer of power and

signals to the blade pitching system. The main shaft is supported by a self-aligning double spherical roller bearing, grease lubricated from an automatic lubrication system. The bearing seals are maintenance-free labyrinth seals.

## Gearbox

The gearbox is a custom-built, three-stage planetary-helical design. The planetary-helical, high-torque stage provides a compact high-performance construction. The intermediary and high-speed stages are normal helical stages arranged with an offset of the high-speed shaft and thus allowing passage of power and control signals to the pitch systems. The gearbox is equipped with large-capacity cooling and filtering systems that ensure optimum operating conditions.

## Generator

The generator is a fully-enclosed asynchronous machine with squirrel-cage rotor, which does not require slip rings. The generator rotor construction and stator windings are specially designed for high efficiency at partial loads. The generator is internally ventilated and cooled with an air-to-air heat exchanger.

## Mechanical brake

The mechanical brake represents the secondary safety system of the turbine. It is fitted to the gearbox high-speed shaft and has two hydraulic calipers.

## Yaw system

The yaw bearing is an externally geared ring with a friction bearing. Eight electric planetary gear motors drive the yawing. The yaw gear motors are fitted with brakes, assisting the passive friction of the bearing for stable maintenance of the yaw position.

## Controller

A standard industrial computer is the basis of the turbine controller. The controller is self-diagnosing and includes a keyboard and display for easy status readout and adjustment of settings.

## Power conversion

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

## Tower

The SWT-2.3-93 turbine is mounted on a tapered tubular steel tower. The tower can be fitted with a personnel hoist as an option.

## Operation

The wind turbine operates automatically, self-starting when the wind reaches an average speed of about 3 - 5 m/s. During operation below rated power, the pitch angle and rotor speed are continuously adjusted to maximize the aerodynamic efficiency. Rated power is reached at a wind speed of about 13 - 14 m/s, and at higher wind speeds the output is regulated at rated power. Speed compliance during power regulation minimizes the dynamic loads on the transmission system. If the average wind speed exceeds the maximum operational limit of 25 m/s, the turbine is shut down by feathering of the blades. When the wind drops back below the restart speed, the safety systems reset automatically.

## Remote control

The SWT-2.3-93 turbine is equipped with the unique WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard Internet Web browser. The status views present electrical and mechanical data, operation and fault status, meteorological data and grid station data. Primary level users can be granted access to any of the server's features, including full control over the turbines.

# Technical specifications

|                            |                                      |                          |  |
|----------------------------|--------------------------------------|--------------------------|--|
| <b>Rotor</b>               |                                      | <b>Generator</b>         |  |
| Diameter                   | 93 m                                 | Type                     | Asynchronous   |
| Swept area                 | 6,800 m <sup>2</sup>                 | Nominal power            | 2,300 kW   |
| Rotor speed                | 6-16 rpm                             | Voltage                  | 690 V  |
| Power regulation           | Pitch regulation with variable speed | Cooling system           | Integrated heat exchanger                                |
| <b>Blades</b>              |                                      | <b>Yaw system</b>        |  |
| Type                       | B45                                  | Type                     | Active   |
| Length                     | 45 m                                 | <b>Monitoring system</b> |  |
| <b>Aerodynamic brake</b>   |                                      | SCADA system             | WebWPS   |
| Type                       | Full span pitch                      | Remote control           | Full turbine control                                     |
| Activation                 | Hydraulic, fail-safe                 | <b>Tower</b>             |  |
| <b>Transmission system</b> |                                      | Type                     | Cylindrical and/or tapered tubular                       |
| Gearbox type               | 3-stage planetary/helical            | Hub height               | 60 m, 80 m or site-specific                              |
| Gearbox ratio              | 1:91                                 | <b>Operational data</b>  |  |
| Gearbox oil filtering      | Inline and offline                   | Cut-in wind speed        | 4 m/s  |
| Gearbox cooling            | Separate oil cooler                  | Nominal power at         | 13-14 m/s  |
| Oil volume                 | Approx. 400 l                        | Cut-out wind speed       | 25 m/s   |
| <b>Mechanical brake</b>    |                                      | Maximum 2 s gust         | 55 m/s (standard version)<br>60-80 m/s (special version) |
| Type                       | Fail-safe disc brake                 | <b>Weights</b>           |  |
|                            |                                      | Rotor                    | 60 tons  |
|                            |                                      | Nacelle                  | 82 tons  |
|                            |                                      | Tower                    | Site-specific  |

## Sales power curve

