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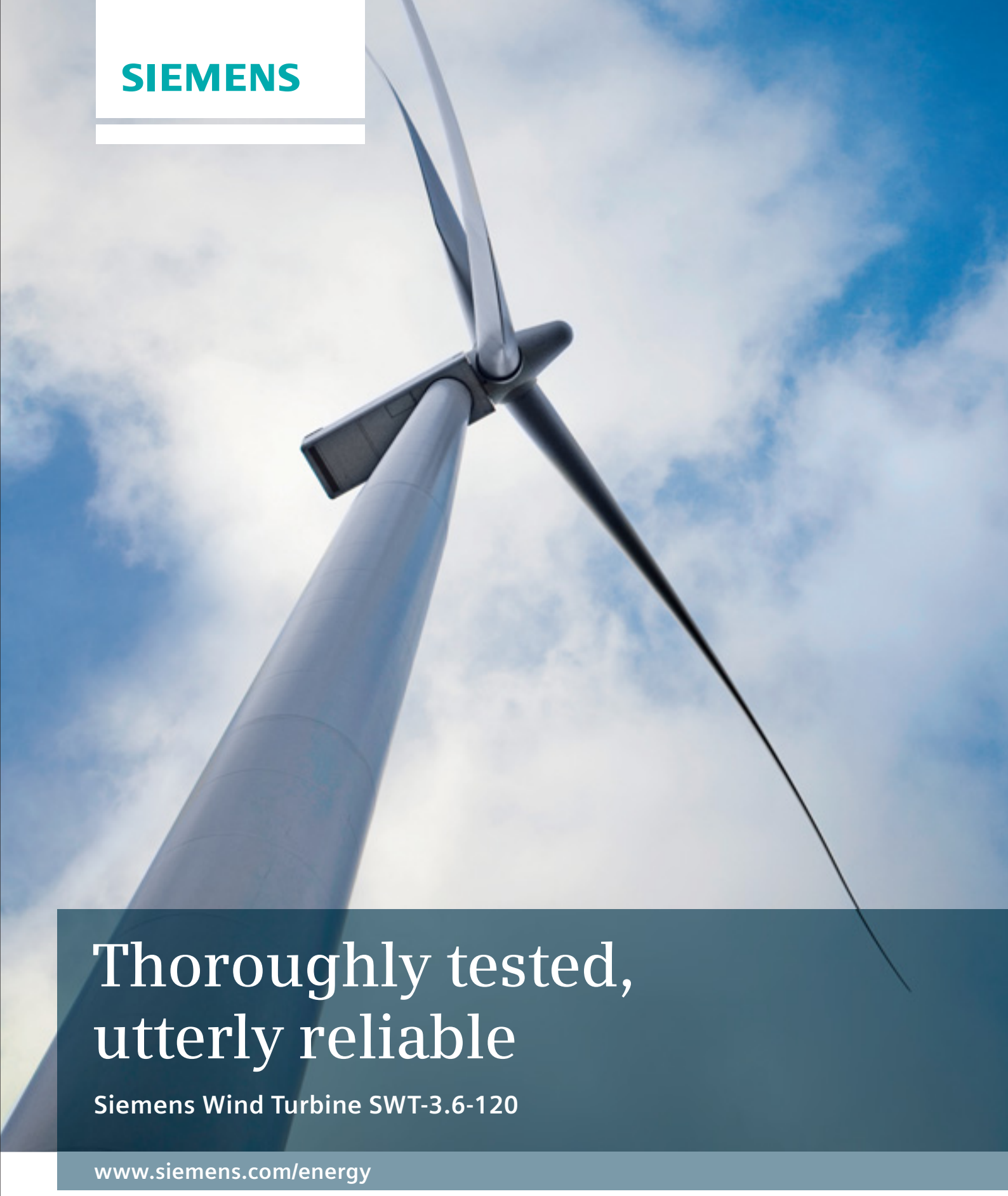

# Thoroughly tested, utterly reliable

## Siemens Wind Turbine SWT-3.6-120

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Answers for energy.

# Global pioneer

In recent times, the world has seen a dramatic increase in the nature and scope of offshore wind power plants. With larger projects heading farther out to sea, the reliability of the wind turbine is paramount.

Given the logistical challenges of offshore projects where even the smallest issue can amplify costs, having technology that works and continues to work under some of the harshest conditions on the planet is crucial.

In the offshore wind industry, Siemens has deservedly earned the reputation for having the most reliable technology, the broadest skill set, the deepest experience, and a name on which the industry can bank.

Siemens is the undisputed market leader when it comes to reliable products for harnessing the power of offshore wind energy. From pioneering the world's first offshore wind power plant at Vindeby (Denmark) in 1991 to the multi-gigawatt wind power plants of tomorrow, products like the SWT-3.6-120 continue to form the basis of a rock-solid technology platform.

# Evolution of the series

Determined to create the right machine for the right application, Siemens has been progressively evolving its wind turbines, creating more powerful generators and larger rotors to give its customers a greater choice of technologies to meet their needs.

With the release of a new 3.6-megawatt wind turbine featuring a 120-meter rotor, Siemens has produced a machine that can generate more power than its predecessor could at similar wind speeds. The SWT-3.6-120 is based on the proven technology of the SWT-3.6-107, which is currently the world's most popular offshore wind turbine.

Basically, the only difference between the two machines' core components is the rotor. The SWT-3.6-120 is equipped with 58.5-meter long rotor blades, giving it a swept area of 11,300 $m^2$ or the equivalent to nearly two football fields. Tests indicate that the new machine will generate approximately 10 percent more electricity in comparison to similar wind turbines.

# World's most tested wind turbine

To ensure that the SWT-3.6-120 is ready for 20 years of ocean life, Siemens put the wind turbine through one of the most rigorous testing schedules on the market. All major components have been through highly accelerated lifetime tests (HALT testing) to withstand the tests of time.

The test regime included tests on the blade, blade bearing, (including raceway and ring life test), generator platform, canopy, yaw bearing, main bearing, main bearing housing, bed frame, yaw system, hub components, and more.

The SWT-3.6-120 has a rugged, conservative structural design, automatic lubrication systems with ample supplies, climate control of the internal environment, and a simple generator system without slip rings that provides exceptional reliability at long service intervals.

### Superior grid compliance

As more wind power enters the grid, there is a greater onus on turbine manufacturers to meet stringent grid stability requirements. The Siemens NetConverter® system used by the SWT-3.6-120 is designed for maximum flexibility in the turbine's response to voltage and frequency variations, fault ride-through capability, and output adjustment. The advanced wind farm control system provides state-of-the-art fleet management.

### Safety first

Safety is at the heart of all Siemens operations. From production to installation, operation, and service, Siemens strives to set the standard in safety. The fail-to-safe capabilities within a turbine, combined with Siemens' superior lightning protection system, are designed to enhance security for the turbine.

### Advanced operations support

Given the logistical challenges associated with servicing wind farms, Siemens has equipped its turbines with a turbine condition monitoring (TCM) system that reduces the need for on-site servicing.

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

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

Using the knowledge gained from monitoring thousands of turbines over the years, Siemens' experts are exceptionally skilled at analyzing and predicting faults within a turbine.

This allows Siemens to proactively plan the service and maintenance of the turbines, as each fault can be categorized and prioritized based on severity. Siemens can then determine the most appropriate course of action to keep the turbine running at its best.

### General components

The following is a brief technical description of the main components of the SWT-3.6-120 wind turbine.

### Rotor

The SWT-3.6-120 rotor is a three-bladed cantilevered construction, mounted upwind of the tower. The power output is controlled by pitch regulation. The rotor speed is variable and is designed to maximize the aerodynamic efficiency.

### Blades

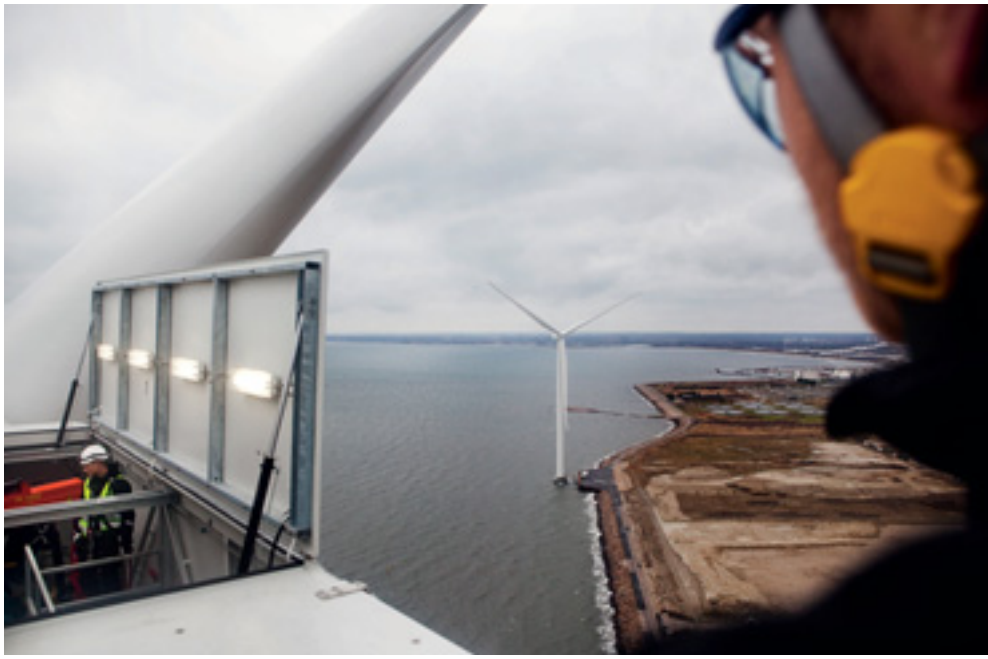
The B58 blades are made of fiberglass-reinforced epoxy in Siemens' proprietary IntegralBlade® manufacturing process. In this process, the blades are cast in one piece to eliminate weaker areas at glue joints. The blades are mounted on pitch bearings and can be feathered 80 degrees for shutdown purposes. Each blade has its own independent pitching mechanism capable of feathering the blade under any operating condition. The blade pitch arrangement allows for optimization of the power output throughout the operating range, and the blades are feathered during standstill to minimize wind loads.

### Rotor hub

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

### Main shaft and bearing

The main shaft is forged in alloy steel and is hollow to facilitate the transfer of power and signals to the blade pitching system. The main shaft is supported by two self-aligning, double spherical roller bearings that are shrunk onto the main shaft. The bearings are grease lubricated and feature labyrinth seals.



### Gearbox

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

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

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

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

### Generator

The generator is a fully-enclosed, asynchronous generator. It has a squirrel-cage rotor without slip-rings. The generator rotor construction and stator winding are designed for high efficiency at partial loads. The generator is protected with thermal switches and analogue temperature measurement sensors.

It is fitted with a separate thermostat-controlled ventilation arrangement. Air is recirculated internally in the generator and heat is transferred through an air-to-air heat exchanger that separates the internal environment in the generator from the ambient air.

### Mechanical brake

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

### Yaw system

The yaw bearing is an internally geared ball bearing fitted with a hydraulic disc brake. Six electric planetary gear motors drive the yawing.

### Tower

The SWT-3.6-120 wind turbine is mounted on a tapered, tubular steel tower. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and internal electric lighting.


### Controller

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

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

### SCADA

The SWT-3.6-120 wind turbine is equipped with the Siemens WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard Internet Web browser. The status views present information such as electrical and mechanical data, operation and fault status, meteorological data, and grid station data.

### Turbine condition monitoring

In addition to the Siemens WebWPS SCADA system, the SWT-3.6-120 wind turbine is equipped with the unique Siemens TCM® condition monitoring system. This system monitors the vibration level of the main components and compares the actual vibration spectra with a set of established reference spectra. Result review, detailed analysis, and reprogramming can all be carried out using a standard Web browser.

### Operation systems

The wind turbine operates automatically. It is self-starting when the wind speed reaches an average of about 3 to 5 m/s (about 10 mph). The output increases approximately linearly with the wind speed until the wind speed reaches 12 to 13 m/s (about 30 mph). At this point, the power is regulated at rated power.

If the average wind speed exceeds the maximum operational limit of 25 m/s (about 56 mph), the wind turbine is shut down by feathering the blades. When the average wind speed drops back below the restart average wind speed, the systems reset automatically.

**Nacelle arrangement**

1. Spinner
2. Blade
3. Pitch bearing
4. Rotor hub
5. Main bearing
6. Main shaft
7. Gearbox
8. Service crane
9. Brake disc
10. Coupling
11. Generator
12. Yaw gear
13. Tower
14. Yaw ring
15. Generator fan
16. Canopy

# Technical specifications

| Rotor | |
|---|---|
| Type | 3-bladed, horizontal axis |
| Position | Upwind |
| Diameter | 120 m |
| Swept area | 11,300 m² |
| Nominal rotor speed | 5–13 rpm |
| Power regulation | Pitch regulation with variable speed |
| Rotor tilt | 6 degrees |

| Blades | |
|---|---|
| Type | B58 |
| Blade length | 58.5 m |
| Root chord | 4.2 m |
| Aerodynamic profile | NACA63.xxx, FFAxxx |
| Material | GRE |
| Surface gloss | Semi-matte, < 30 / ISO2813 |
| Surface color | Light grey, RAL 7035 |

| Aerodynamic brake | |
|---|---|
| Type | Full span pitching |
| Activation | Active, hydraulic |

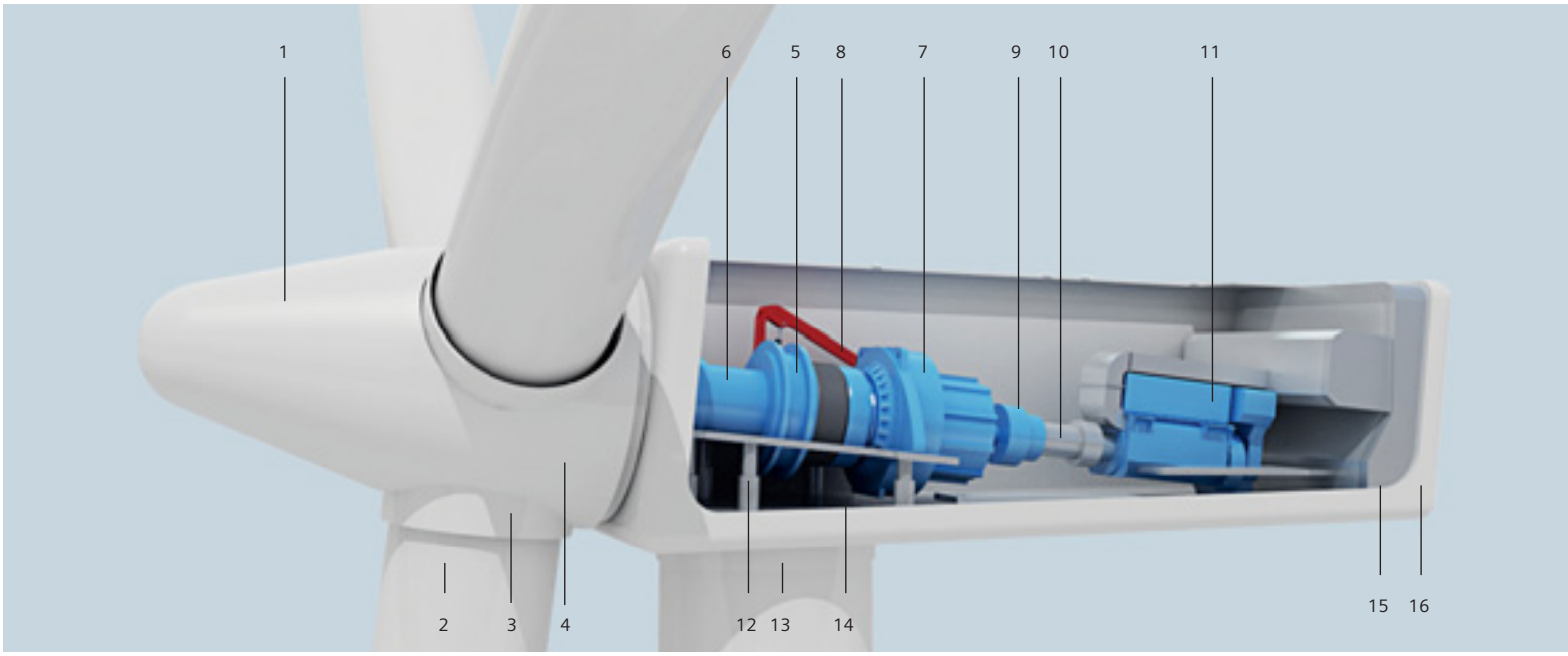
| Load-supporting parts | |
|---|---|
| Hub | Nodular cast iron |
| Main bearings | Spherical roller bearings |
| Main shaft | Alloy steel |
| Nacelle bed plate | Cast iron |

| Transmission system | |
|---|---|
| Coupling hub – shaft | Flange |
| Coupling shaft – gearbox | Shrink disc |
| Gearbox type | 3-stage planetary/helical |
| Gearbox ratio | 1:119 |
| Gearbox lubrication | Forced lubrication |
| Oil volume | Approx. 750 l |
| Gearbox cooling | Separate oil cooler |
| Gearbox designation | PZAB 3540 |
| Gearbox manufacturer | Winergy AG |
| Coupling gear – generator | Double-flexible coupling |

| Mechanical brake | |
|---|---|
| Type | Hydraulic disc brake |
| Position | High-speed shaft |
| Number of calipers | 2 |

| Generator | |
|---|---|
| Type | Asynchronous |
| Nominal power | 3,600 kW |
| Protection | IP 54 |
| Cooling | Integrated heat exchanger |
| Insulation class | F |

| Canopy | |
|---|---|
| Type | Totally enclosed |
| Material | Steel/aluminium |
| Surface gloss | Semi-gloss, 30–50, ISO2813 |
| Color | Light grey, RAL 7035 |




| Yaw system | |
|---|---|
| Type | Active |
| Yaw bearing | Internally-geared ball bearing |
| Yaw drive | Six electric gear motors |
| Yaw brake | Active friction brake |

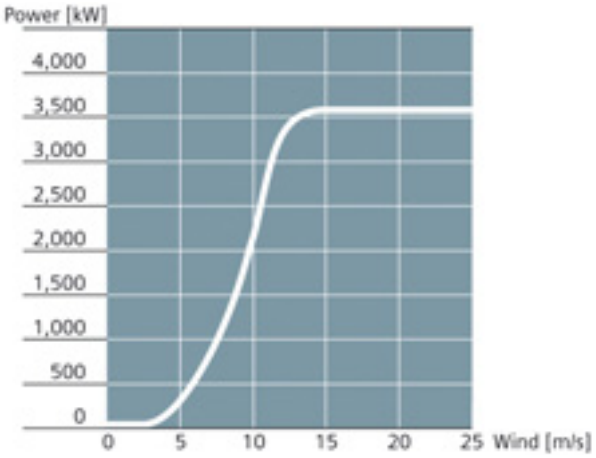
| Controller | |
|---|---|
| Type | Microprocessor |
| SCADA system | WebWPS |
| Controller designation | WTC 3 |

| Tower | |
|---|---|
| Type | Cylindrical and/or tapered tubular |
| Hub height | 90 m or site-specific |
| Corrosion protection | Painted |
| Surface gloss | Semi-gloss, 30–50, ISO-2813 |
| Color | Light grey, RAL 7035 |

| Operational data | |
|---|---|
| Cut-in wind speed | 3–5 m/s |
| Nominal power at | 12–13 m/s |
| Cut-out wind speed | 25 m/s |
| Maximum 3 s gust | 70 m/s (IEC version) |

| Weights (approximately) | |
|---|---|
| Rotor | 100,000 kg |
| Nacelle | 125,000 kg |
| Tower for 90 m hub height | Site-specific |

**Sales power curve**
The power curve data are valid for standard conditions of 15° Celsius air temperature, 1,013 mBar air pressure, and 1.225 kg/m³ air density, clean rotor blades, and horizontal, undisturbed airflow.



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