WES18 COMPLETE DESCRIPTION

INTRODUCTION

The WES18 is a modern two bladed, high performance, reliable 80 kW midsize wind turbine with a rotor diameter of 18 meters. The mechanical part of the WES18 was designed in 1983, the electrical part has been redesigned in 2005. WES18 turbines are manufactured and exported by WES in the Netherlands. WES18 wind turbines are sold, installed and maintained all over the world by a global network of certified and trained dealers.

WES30 MAIN CHARACTERISTICS

- With 6,5 m/s wind, more than 193.000 kWh/year,
- Over 750 units installed around the world.
- High reliability.
- High life expectancy, more than 20 years.
- Lattice or tubular towers, in different heights.
- Standard 40 foot container transport.
- Low mechanical loads on blades, gearbox and tower.
- Mechanical passive blade pitch and active yaw.
- Little maintenance needed.
- Easy installation.
- Ideal for hard to reach, remote locations.
- PLC and IPC controlled
- Advanced AC/DC/AC IGBT control cabinet.
- Frequency wind diesel control (patented).
- Internet monitoring.

WES18 ELECTRICAL SYSTEMS

WES18 CONTROLLER

The control of the WES18 is based on a Industrial PC or IPC. This IPC based system acts like a PLC and has I/O modules in the control cabinet and a remote I/O unit in the nacelle.

All sensors in the nacelle, switches, relays and the converter are wired to the I/O modules in the control cabinet. The IPC also runs an internal Ethernet LAN which connects the IPC to the I/O modules, the converter and the local control panel.

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The control panel is located on the control cabinet door for friendly user interface. The screen shows the actual wind speed, wind direction, rotor-speed and the generated power. It also provides the cumulative kWh production and the historical data. Using the buttons on the control panel, parameters controlling the behaviour of the system can be changed. Some of these parameters can be set remotely over the Internet as well.

The controller and the electrical system are 'fail-safe' designed, which means that in case of a failure the turbine goes in a safe position.

The IPC logs detailed information about any failure. WES18 turbines are connected to the Internet. System log files, status reports, wind speed, the actual and cumulated performance can be monitored remotely. Each turbine can have its own URL, login and password and can be reached through any Internet browser.

IGBT controller and IPC

WES18 ELECTRICAL

Electrical energy is generated by the generator in the nacelle of the WES18. Cables run from the generator to the control cabinet. The flexible cable loop in the top of the tower is protected from twisting by an anti-twist sensor. When the nacelle has made 3 complete rotations in one direction the control system orders the yaw system to unwind the cables by turning the nacelle 3 times in the other direction.

The control cabinet is positioned in a shed nearby the tower. For safety reasons you have to be able to see the turbine reacting when operating the control panel on the control cabinet door.

The advanced IGBT technology makes the WES18 a relatively easy wind turbine to connect to any kind of grid. Local regulations can make that some components or security devices have to be adapted. Your WES dealer is aware of the specific regulations and restriction from your local electricity company.

WES18 GRID CONNECTION

The type of grid that is available, the cost price for electricity and the availability of a feed-in tariff define what the best way is to connect your turbine to the grid. There are 3 ways to connect your WES18 wind turbine to the grid:

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Directly into the grid	Behind the meter	Hybrid (wind/diesel)
Electricity generated with a WES18 wind turbine can be sold back to the grid at an agreed feed in tariff. Once your WES18 is installed an approved kWh measurement device will measure the electrical energy that is exported into the grid.The measured amount of energy multiplied by the price per kWh is what will be paid back for energy production or will be deducted from your regular electricity bill.	WES18 wind turbines can be used to reduce own energy import. The produced electricity is not measured and / or bought by the electricity company but is used directly for own consumption. This type of configuration is called "behind the meter". Behind the meter installations are interesting in those situations where electricity consumption is high and the feed in tariff is low compared to the purchase price of electrical energy.	WES18 Hybrid turbines offer a full integration with diesel generated power. When diesel engines are used to drive generators and generate electricity economics change completely. Prices per kWh increase dramatically. When wind is available the WES18 can reduce your energy costs in a spectacular way.

Because regulations, grants, feed-in tariff and the price of electricity can change over time it is important to be able to change the way you are paid for the energy produced by your WES18. Changes between all 3 types off connections are possible. The installation change from one configuration to another is simple and takes little time.

Electricity companies all over the world are comfortable buying energy generated with WES18 wind turbines for a number of reasons, including:

Maximum power limitation.

The maximum power output of the WES18 can be limited through settings in the IPC control system. This can be useful when your local grid is not yet strong enough to support the maximum power generated by your WES18. Your WES dealer can adjust or remove the limitation on maximum power output of your WES18 once the grid has been improved and is strong enough to support the full power output.

Power factor improvement.

The WES18 control cabinet is able to influence the power factor of your grid. Through settings in the IGBT convertors the power factor can be moved in both directions. Besides generating electrical energy the WES18 is able to improve the quality of your grid.

Shut down during grid failure (anti islanding UK G59).

When the grid voltage or frequency are out of tolerances or when a grid black-out occurs the WES18 will shut down automatically within tens of milliseconds.

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Remote access through the Internet.
WES18 turbines can be monitored and operated from a distance.

Future connections.
Your WES18 wind turbine will generate electrical energy in the same way for 20 years or more. The environment in which it will deliver its energy will change over time. Your WES18 is ready to deal with any change and will always be able to deliver its energy in the way that is most beneficial for you.

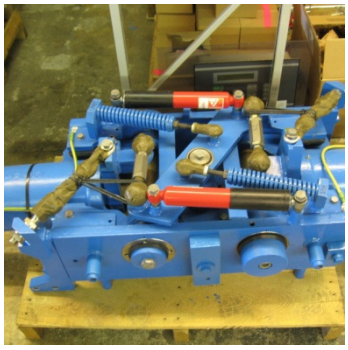
Your WES dealer is aware of local situations and can calculate for you how much will be paid for electricity generated with your WES18 or how much will be saved. Your local WES dealer will inform you when changes in regulations or laws have impact on the way you are compensated for electricity generated with your WES18.

WES18 GENERATOR
The generator is a 4-pole a-synchronous generator, nominal power of the generator is 80 kW. The generator is totally enclosed fan cooled and therefore this generator is **maintenance free.**

The choice for a a-synchronous generator is key in the WES18 design. Fluctuations in wind speed are absorbed by rotor and generator frequency. Fluctuations in wind speed do not cause fluctuations in loads on blades, gearbox or tower. This is the main reason why the WES18 has a long live expectancy and needs little maintenance. The combination of an a-synchronous generator and IGBT technology allows the WES18 to deliver electricity in weak or small grids.

WES18 MECHANICAL SYSTEMS

WES18 ROTOR
The rotor of the WES18 is equipped with two blades and is characterised by the flexible (hinged) way of mounting the blades and the passive blade-angle adjustment. The possibility for the blades to hinge over a small angle has the advantage that the load on the construction will be less. This way of mounting the blades is similar to the teetering hub construction but has the additional advantage that the blades can hinge independently. This allows for a lighter construction.



The operating principle is described as follows:

The pressure of the wind pushes the blades in the direction of the main shaft. Due to the hinges in the rotor hub, the actual position of the blades will be slightly backward. Instead of a disc perpendicular to the main shaft,

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the rotating blades will form a cone with the hub being top. The rotation of the rotor causes centrifugal forces on the blades, forcing the blades to stretch out and come forward to a position more perpendicular to the main shaft. Mentioned opposite forces will come to an equilibrium. Bending moments and forces on the rotor-hub and main shaft are being reduced considerably by this design.

The passive blade-angle adjustment affects the blade-angle. The blade-angle is a major aspect with regard to the efficiency of the rotor and consequently for the generated power.
Rotating the blades around a pitch-shaft can alter the pitch. The blade-angles of both blades are always kept equal by means of a synchronisation mechanism located in the rotor hub.

The pressure on the blades causes a force, which intends to reduce the projected area: increasing the blade-angle. A spring is installed to withstand this force. Wind speeds less than 13 m/s will not affect the blade-angle: it will remain in its most favourable position. The nominal power output of the turbine is limited to 80 kW by means of the power electronics system. Wind speeds above 13 m/s will increase of the rotor speed since the generator does not absorb the extra power produced by the rotor. However, due to the increased speed and forces at this point, the passive blade-angle adjustment is activated since these forces will exceed the above-mentioned spring forces. An increased blade angle will reduce the efficiency of the blades. Consequently the rotor speed is reduced. This procedure constitutes the first safety system of the WES18 wind turbine.

WES18 BLADES

The blades are made of carbon-fibre reinforced epoxy. Due to this material composition the blades are light, strong and flexible. They have a taper wise form and a slightly twisted chord. The length is 7.8 metres. This design has been tested thoroughly both under static and dynamic loads.

WES18 HUB-FRAME

The hub-frame is the connection point of the blades to the main shaft. In the frame the synchronisation mechanism and the blade-hinges for flexible mounting of the blades are located. By means of a flanged connection the hub-frame is mounted to the main shaft; being the low speed shaft of the gearbox.

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WES18 GEARBOX

The gearbox increases the rotor speed. In two stages a ratio of 1:20 is obtained between the rotor speed and the out-coming shaft from the gearbox. Therefore the out-coming shaft, and consequently the generator, will have an effective working range between approximately

1200 and 2400 rounds per minute. The gearbox is provided with a low speed shaft and bearings. A built-in radial bearing and an attached radial/axial bearing allow the rotor to be mounted directly to the gearbox. The high-speed shaft is connected to the generator by means of a flexible coupling. Further, the gearbox is equipped with a brake that prevents the rotor from turning backwards. When the turbine is yawed 120^0 out of the wind, the rotor will have the intention to rotate backward. The above-mentioned brake will be activated and the rotor will stand still. The same procedure is followed during a shut down the turbine. For maintenance the rotor can be locked.

WES18 YAW SYSTEM

The yaw-system turns the position of the nacelle in order to place the rotor in the right position: in the wind or, if required, out of the wind. Contactors control the yaw-system. In case of a grid failure, which causes malfunctioning of the installation, the yaw-motor is directly connected to the generator. The turbine will yaw out of the wind all by itself. In order to avoid that the moments and forces of the rotor, which are passed through to the nacelle, are projected on the yaw-system four friction brakes are mounted. Furthermore a flexible coupling is mounted between the worm-wheel reduction and the pinion in view of its dampening and shock-absorbing properties.

WES18 NACELLE

The nacelle is that part of the turbine that is placed on top of the tower. A yaw bearing allows the nacelle to turn along the horizontal plane. The base plate of the nacelle is made of painted steel, on which the gearbox, generator, yaw-system and part of the control equipment are mounted.

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WES18 TOWER

The tower consists of three cylindrical parts, mounted to each other by means of a flanged connection. If a heavy lifting crane is not available, or the terrain does not allow access, a specially designed lattice tower can be used.

The standard total height of the tower is 30 metres 18, 24 and 39 meter towers are optional. The tower has an external ascent, and is provided with a steel cable parallel to the ladder in order to connect the fall-protection gear of the maintenance engineer as a safety measure. The tower is made of hot dip galvanised steel.

WES18 FOUNDATION

The detailed design of the foundation depends on the local situation with regard to the strength and composition of the soil. In case of insufficient support, the foundation should be piled. In all cases an anchor of anchor-bolts is bedded into the concrete. The electrical- and control cables are led away through a pipe, which goes from the centre of the anchor to one of the sides of the foundation. Alternatively a one-pole-foundation (steel tube piled in the soil) is possible in cases where the soil allows this.

WES18 TECHNICAL SPECIFICATIONS

WES18 GENERAL	
Supplier / manufacturer	WES BV
Life expectancy	More than 20 years
Service / maintenance	Twice a year
Nominal power	80 kW
Cut - in wind speed	2.7 m/sec. (6.7 mph)
Cut - out wind speed	25 m/sec. (56 mph)
Nominal wind speed	12,5 m / sec. (29 mph)
Survival wind speed	60 m/sec.
Fast passive power regulation	Pitching (blade angle adjustment)
Active power regulation	Fully variable back – to – back IGBT system.
Noise emission at 8 m / sec	Less than 45 dBa at 100 meter
Operating temperatures	From – 20^{o}C up to + 40^{0}C

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Grid voltage	400V ± 10%
Grid frequency	50/60Hz ± 3 Hz
Connection	3 phase + neutral
Specific power	315 W/m2

WES18 Applied standards	
Degree of protection	IP55
Standards	NEN1010 (electrical); EN50308 (safety); EN6096 (wind turbines); UL1741 (anti islanding); UKG59 (anti islanding); IIEC61346-2000 (cabinet)
CE mark	Yes

WES18 Electrical	
Grid voltage	400 V ± 10%
Grid Frequency	50 / 60 Hz ± 3 Hz (suitable for poor grids)
# Phases	3 + N
Specific power	315 W / m2
Convertor type	Back – to – back IGBT convertor

WES18 ROTOR	
Number of blades	2
Diameter	18 m
Rotor position	Upwind
Direction	Clockwise
Angle of the main shaft	7° with horizon
Swept area	254 m2
Speed	Variable 60 – 120 rpm
Power regulation	Passive: blade-angle adjustment
Min. Blade - angle	1.0
Flapping - angle	180° – 164°

WES18 BLADES	
Blade length	7,8 meter
Weight one blade	100 kg
Chord	500 – 1,200 mm
Twist	5°
Mounted	Flexible

WES18 GEARBOX	
Brand	Flender (= part of Siemens)
Number of stages	2
Weight	700 kg (incl. oil)

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Ratio	1: 20

WES18 GENERATOR	
Brand	ABB
Type	A - synchronous
Nominal ouput	80 kW
Number of poles	3
Number of phases	3 + N
Nominal voltage	230/400 V
Frequency	Variable 40 - 80 Hz
Weight	455kg
Protection	IP 55

WES18 GRID-CONNECTION	
Converter	Back-to-Back
Converter principle	AC - DC – AC
Power supply	400 V / 50 or 60 Hz (± 3 Hz) / 3 phase + neutral (deviating voltage and frequency are available as an option)

WES18 TOWER	
Type	Tubular
Number of sections	2, 3 or 4 sections
Hub height	18m, 24 m 30m or 39 m
Material	Steel
Location ladder	External
Type	Lattice
Hub height	32 m
Material	Hot dip galvanized steel, four legged.
Location ladder	External

WES18 CONTROLLER	
Control by	IPC (Beckhoff)
Remote monitoring & control	Yes
Data logging	Optional

WES18 YAW-SYSTEM	
Yaw system	Active
Signal from	Wind vane
Driven by	Electro motor with worm-wheel reduction.
Power yaw-motor	0,55 kW
Yaw speed	1.2°/sec.

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Yaw bearing	Crown-bearing, externally geared
Yaw breaks	Constant friction break; 4 pcs.

WES18 SAFETY	
First safety system	Passive blade pitch
Activated by:	• rotor speed (110 rpm)
Second safety system	Yawing out of the wind
Activated by:	• rotor speed (>120 rpm) • excessive vibrations • failure anemometer • failure wind vane • failure in IPC • grid Failure • other failures
Blocking system	
Rotor blocking system	Pin in high speed shaft; for service purposes.
Activation	Manual

WES18 WEIGHTS	
Rotor incl. blades	900 kg
Nacelle excl. rotor	3000 kg
Control cabinet	350 kg
Tower	10.000 kg (30 m tower)

WES18 MATERIAL SPECIFICATIONS	
Blades	Carbon and glass fibre reinforced epoxy.
Nacelle / rotor	Steel
Covers	Polyester
Tower	Hot dip galvanised steel.
Foundation	Concrete block with steel anchor.

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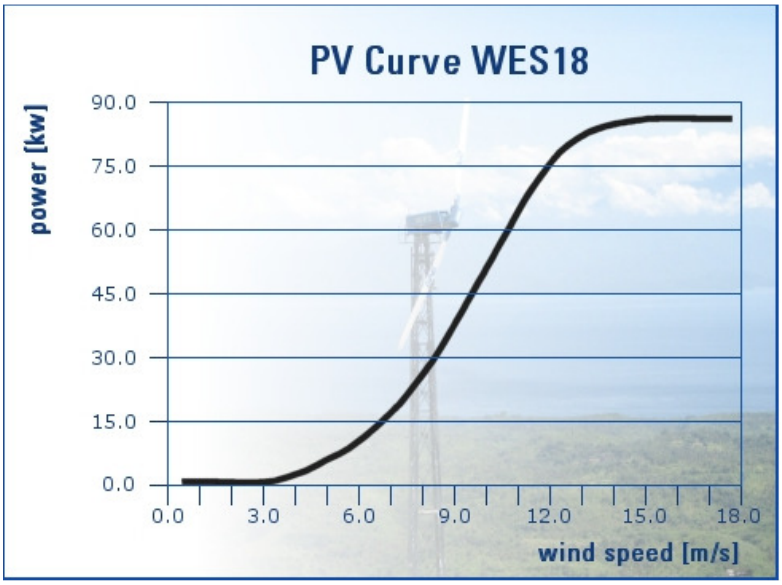
WES318 measured power curve.

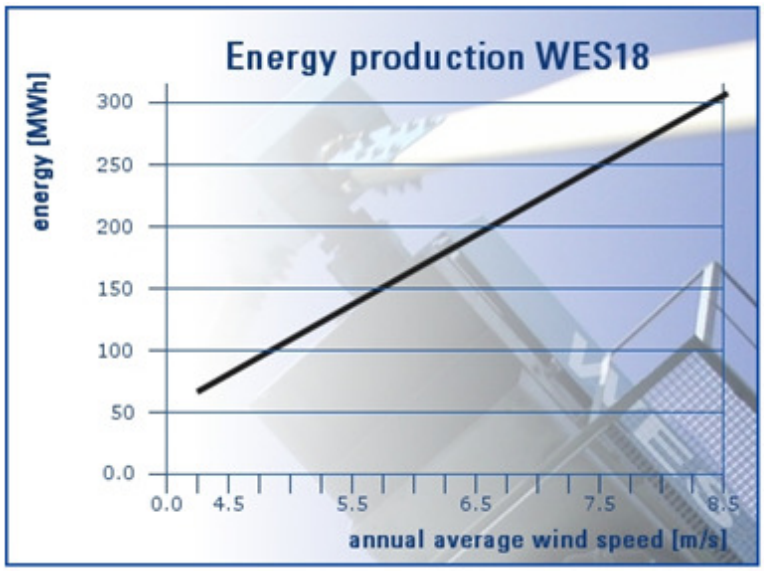
The curve data are valid for standard atmospheric conditions of 15° C air temperature, 1013 mbar air pressure and 1.225 kg/m³ air density, clean rotor blades and horizontal undisturbed air flow.



Wind speed [m / s]	Power [kW]
2,7	cut - in
3	0,8
4	2,9
5	6
6	11
7	17,7
8	27,7
9	39,2
10	51,4
11	63,8
12	74,2
13	79,9
14	82,2
15 - 25	83

WES18 measured annual production.

The annual energy production data for different annual mean wind speeds at hub height are calculated from the above power curve data assuming a Rayleigh wind speed distribution, K=2 and 100% availability and no reductions due array losses, grid losses, or other external factors effecting the production.



Wind speed [m / s]	Energy [MWh]
4	52
5	102
6	161
7	224
8	284
9	341
more than 9	more than 341

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