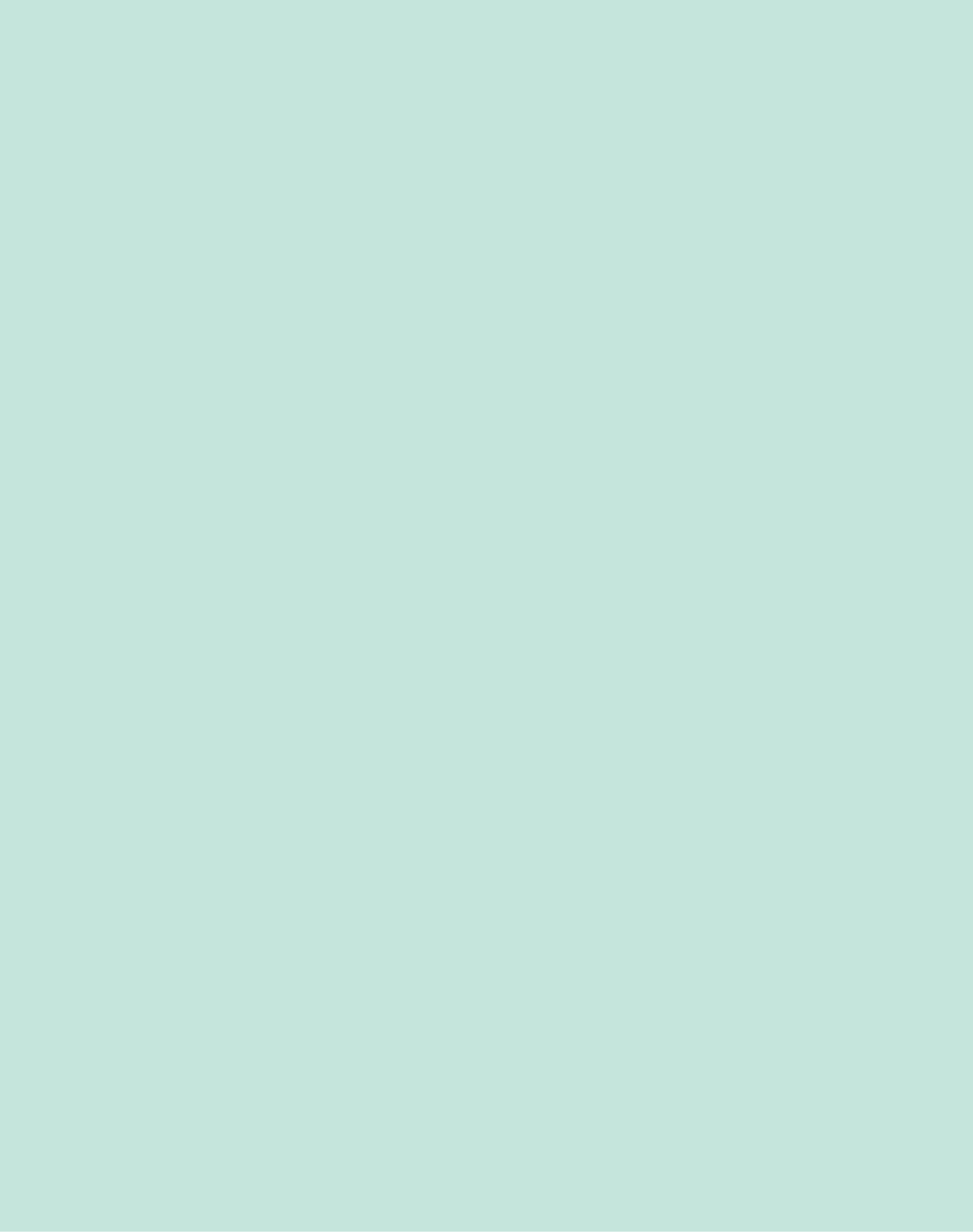


Annexe B2

Les éoliennes Enercon – La gamme de produits : E-33, E-44, E-48, E-53, E-70, E-82



Sales

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Phone +49 4941 92 70 · Fax +49 4941 92 71 09
vertrieb@enercon.de

- E-33
- E-44
- E-48
- E-53
- E-70
- E-82

ENERCON WIND TURBINES

PRODUCT OVERVIEW

E33



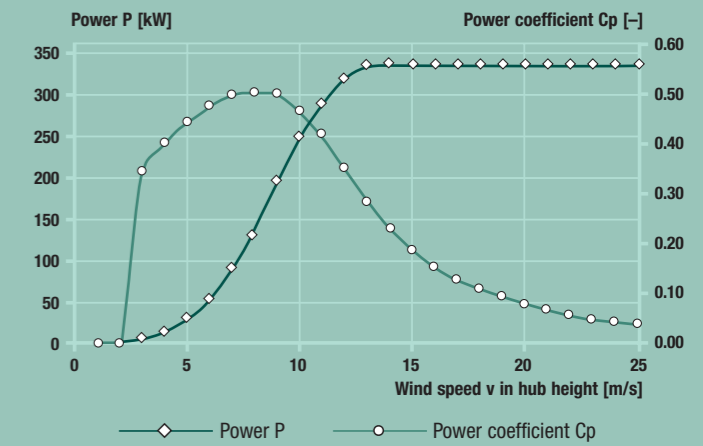
ENERCON's E-33 wind turbine makes it economically feasible to realise wind energy projects even at sites difficult to access. Their modular design allows for convenient container transport by ship and truck as well as efficient installation using one regular-sized lifting crane.

TECHNICAL DATA

| | |
|-----------------------------------|---|
| Rated power: | 330 kW |
| Rotor diameter: | 33.4 m |
| Hub height: | 36 m – 50 m |
| Wind class (IEC): | IEC/NVN I and IEC/NVN II (depending on hub height) |
| Turbine concept: | Gearless, variable speed, variable pitch control |
| Rotor | |
| Type: | Upwind rotor with active pitch control |
| Direction of rotation: | Clockwise |
| Number of blades: | 3 |
| Swept area: | 876 m ² |
| Blade material: | Fibreglass (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 18 – 45 rpm |
| Pitch control: | ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply |
| Drive train with generator | |
| Hub: | Rigid |
| Main bearings: | Single-row cylindrical roller bearings |
| Generator: | ENERCON direct-drive synchronous annular generator |
| Grid feeding: | ENERCON converter |
| Braking systems: | – 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock |
| Yaw control: | Active via adjustment gears, load-dependent damping |
| Cut-out wind speed: | 28 – 34 m/s (with ENERCON storm control) |
| Remote monitoring: | ENERCON SCADA |

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 0.0 | 0.00 |
| 3 | 5.0 | 0.35 |
| 4 | 13.7 | 0.40 |
| 5 | 30.0 | 0.45 |
| 6 | 55.0 | 0.47 |
| 7 | 92.0 | 0.50 |
| 8 | 138.0 | 0.50 |
| 9 | 196.0 | 0.50 |
| 10 | 250.0 | 0.47 |
| 11 | 292.8 | 0.41 |
| 12 | 320.0 | 0.35 |
| 13 | 335.0 | 0.28 |
| 14 | 335.0 | 0.23 |
| 15 | 335.0 | 0.18 |
| 16 | 335.0 | 0.15 |
| 17 | 335.0 | 0.13 |
| 18 | 335.0 | 0.11 |
| 19 | 335.0 | 0.09 |
| 20 | 335.0 | 0.08 |
| 21 | 335.0 | 0.07 |
| 22 | 335.0 | 0.06 |
| 23 | 335.0 | 0.05 |
| 24 | 335.0 | 0.05 |
| 25 | 335.0 | 0.04 |

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E44



Developed as a strong-wind system for the international market, the E-44 wind turbine sets the benchmark in the medium power range. As all other ENERCON wind turbines, the E-44 is also provided with ENERCON's efficient rotor blade design. With a rated power of 900 kW, maximum use is made of prevailing winds at strong wind sites.

TECHNICAL DATA

Rated power: 900 kW
 Rotor diameter: 44 m
 Hub height: 45 m / 55 m
 Wind class (IEC): IEC/NVN I A
Turbine concept: Gearless, variable speed, variable pitch control

Rotor

Type: Upwind rotor with active pitch control
 Direction of rotation: Clockwise
 Number of blades: 3
 Swept area: 1,521 m²
 Blade material: Fibreglass (epoxy resin); integrated lightning protection
 Rotational speed: Variable, 12–34 rpm
 Pitch control: ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply

Drive train with generator

Hub: Rigid
 Main bearings: Single-row cylindrical roller bearings
 Generator: ENERCON direct-drive synchronous annular generator

Grid feeding: ENERCON converter

Braking systems: – 3 independent blade pitch systems with emergency supply
 – Rotor brake
 – Rotor lock

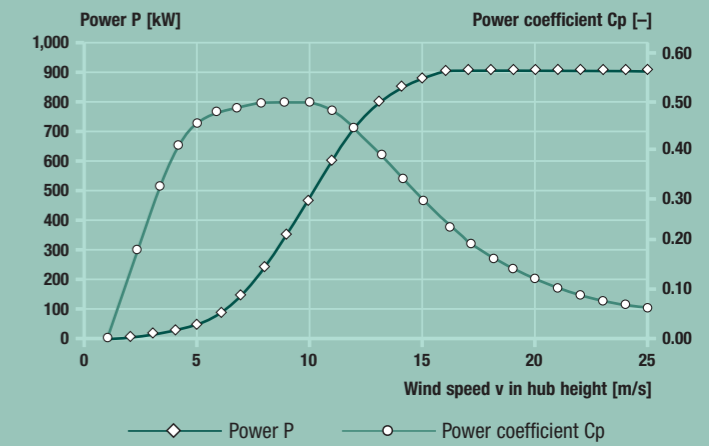
Yaw control: Active via adjustment gears, load-dependent damping

Cut-out wind speed: 28–34 m/s (with ENERCON storm control)

Remote monitoring: ENERCON SCADA

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 1.4 | 0.19 |
| 3 | 8.0 | 0.32 |
| 4 | 24.5 | 0.41 |
| 5 | 53.0 | 0.46 |
| 6 | 96.0 | 0.48 |
| 7 | 156.0 | 0.49 |
| 8 | 238.0 | 0.50 |
| 9 | 340.0 | 0.50 |
| 10 | 466.0 | 0.50 |
| 11 | 600.0 | 0.48 |
| 12 | 710.0 | 0.44 |
| 13 | 790.0 | 0.39 |
| 14 | 850.0 | 0.33 |
| 15 | 880.0 | 0.28 |
| 16 | 905.0 | 0.24 |
| 17 | 910.0 | 0.20 |
| 18 | 910.0 | 0.17 |
| 19 | 910.0 | 0.14 |
| 20 | 910.0 | 0.12 |
| 21 | 910.0 | 0.11 |
| 22 | 910.0 | 0.09 |
| 23 | 910.0 | 0.08 |
| 24 | 910.0 | 0.07 |
| 25 | 910.0 | 0.06 |

ρ = 1,225 kg/m³

Details – ENERCON power curve – (see last page)

E48



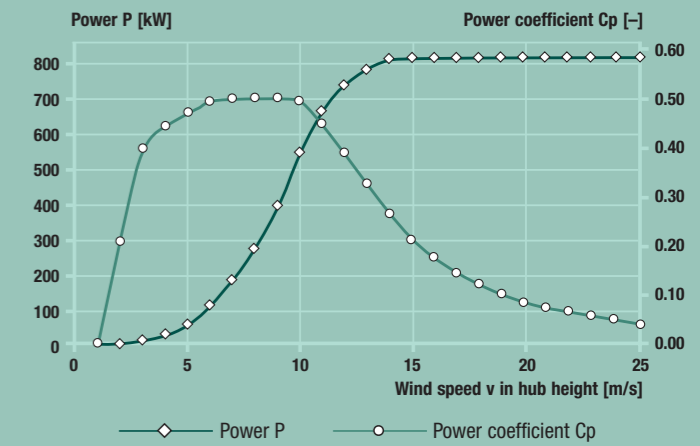
ENERCON's E-48 wind turbine is yet another success story in the company's medium class power range. With a rated power of 800 kW and a sophisticated rotor blade design, the E-48 wind turbine is the most profitable system within its class. Together with a choice of different tower versions up to 76 m, the E-48 offers an economically sound solution to complex sites worldwide.

TECHNICAL DATA

| | |
|-----------------------------------|---|
| Rated power: | 800 kW |
| Rotor diameter: | 48 m |
| Hub height: | 50 m – 76 m |
| Wind class (IEC): | IEC/NVN II |
| Turbine concept: | Gearless, variable speed, variable pitch control |
| Rotor | |
| Type: | Upwind rotor with active pitch control |
| Direction of rotation: | Clockwise |
| Number of blades: | 3 |
| Swept area: | 1,810 m ² |
| Blade material: | Fibreglass (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 16 – 30 rpm |
| Pitch control: | ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply |
| Drive train with generator | |
| Hub: | Rigid |
| Main bearings: | Single-row cylindrical roller bearings |
| Generator: | ENERCON direct-drive synchronous annular generator |
| Grid feeding: | ENERCON converter |
| Braking systems: | – 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock |
| Yaw control: | Active via adjustment gears, load-dependent damping |
| Cut-out wind speed: | 28 – 34 m/s (with ENERCON storm control) |
| Remote monitoring: | ENERCON SCADA |

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 2.0 | 0.23 |
| 3 | 12.0 | 0.40 |
| 4 | 32.0 | 0.45 |
| 5 | 66.0 | 0.48 |
| 6 | 120.0 | 0.50 |
| 7 | 191.0 | 0.50 |
| 8 | 284.0 | 0.50 |
| 9 | 405.0 | 0.50 |
| 10 | 555.0 | 0.50 |
| 11 | 671.0 | 0.45 |
| 12 | 750.0 | 0.39 |
| 13 | 790.0 | 0.32 |
| 14 | 810.0 | 0.27 |
| 15 | 810.0 | 0.22 |
| 16 | 810.0 | 0.18 |
| 17 | 810.0 | 0.15 |
| 18 | 810.0 | 0.13 |
| 19 | 810.0 | 0.11 |
| 20 | 810.0 | 0.09 |
| 21 | 810.0 | 0.08 |
| 22 | 810.0 | 0.07 |
| 23 | 810.0 | 0.06 |
| 24 | 810.0 | 0.05 |
| 25 | 810.0 | 0.05 |

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E53



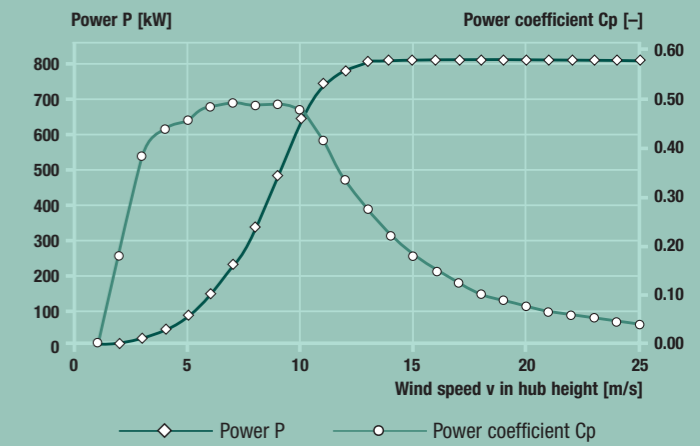
Developed for sites with medium wind speeds, the ENERCON E-53 wind turbine's expanded rotor diameter and newly designed rotor blades guarantee maximum yield even at low wind speeds.

TECHNICAL DATA

| | |
|-----------------------------------|---|
| Rated power: | 800 kW |
| Rotor diameter: | 52.9 m |
| Hub height: | 60 m / 73 m |
| Wind class (IEC): | IEC/NVN S ($v_{av} = 7.5$ m/s, $v_{ext} = 57$ m/s) |
| Turbine concept: | Gearless, variable speed, variable pitch control |
| Rotor | |
| Type: | Upwind rotor with active pitch control |
| Direction of rotation: | Clockwise |
| Number of blades: | 3 |
| Swept area: | 2,198 m ² |
| Blade material: | Fibreglass (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 12–29 rpm |
| Pitch control: | ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply |
| Drive train with generator | |
| Hub: | Rigid |
| Main bearings: | Single-row cylindrical roller bearings |
| Generator: | ENERCON direct-drive synchronous annular generator |
| Grid feeding: | ENERCON converter |
| Braking systems: | – 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock |
| Yaw control: | Active via adjustment gears, load-dependent damping |
| Cut-out wind speed: | 28–34 m/s (with ENERCON storm control) |
| Remote monitoring: | ENERCON SCADA |

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 2.0 | 0.19 |
| 3 | 14.0 | 0.39 |
| 4 | 38.0 | 0.44 |
| 5 | 77.0 | 0.46 |
| 6 | 141.0 | 0.48 |
| 7 | 228.0 | 0.49 |
| 8 | 336.0 | 0.49 |
| 9 | 480.0 | 0.49 |
| 10 | 645.0 | 0.48 |
| 11 | 744.0 | 0.42 |
| 12 | 780.0 | 0.34 |
| 13 | 810.0 | 0.27 |
| 14 | 810.0 | 0.22 |
| 15 | 810.0 | 0.18 |
| 16 | 810.0 | 0.15 |
| 17 | 810.0 | 0.12 |
| 18 | 810.0 | 0.10 |
| 19 | 810.0 | 0.09 |
| 20 | 810.0 | 0.08 |
| 21 | 810.0 | 0.06 |
| 22 | 810.0 | 0.06 |
| 23 | 810.0 | 0.05 |
| 24 | 810.0 | 0.04 |
| 25 | 810.0 | 0.04 |

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E70



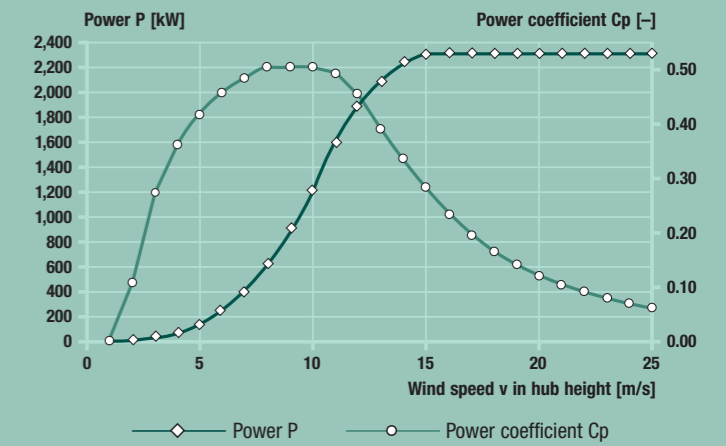
With the E-70 wind turbine ENERCON continues its longstanding reputation for reliability in the 2 MW class. Especially suitable for sites with high wind speeds, the E-70 wind turbine – with 2.3 MW rated power and numerous steel and precast concrete tower versions – is designed to ensure maximum yield in the upper power range.

TECHNICAL DATA

| | |
|-----------------------------------|---|
| Rated power: | 2,300 kW |
| Rotor diameter: | 71 m |
| Hub height: | 64 m – 113 m |
| Wind class (IEC): | IEC/NVN I and IEC/NVN II (depending on hub height) |
| Turbine concept: | Gearless, variable speed, variable pitch control |
| Rotor | |
| Type: | Upwind rotor with active pitch control |
| Direction of rotation: | Clockwise |
| Number of blades: | 3 |
| Swept area: | 3,959 m ² |
| Blade material: | Fibreglass (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 6–21.5 rpm |
| Pitch control: | ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply |
| Drive train with generator | |
| Hub: | Rigid |
| Main bearings: | Dual-row tapered/single-row cylindrical roller bearings |
| Generator: | ENERCON direct-drive synchronous annular generator |
| Grid feeding: | ENERCON converter |
| Braking systems: | – 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock |
| Yaw control: | Active via adjustment gears, load-dependent damping |
| Cut-out wind speed: | 28–34 m/s (with ENERCON storm control) |
| Remote monitoring: | ENERCON SCADA |

Details – ENERCON Storm Control – (see last page)

CALCULATED POWER CURVE



| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 2.0 | 0.10 |
| 3 | 18.0 | 0.27 |
| 4 | 56.0 | 0.36 |
| 5 | 127.0 | 0.42 |
| 6 | 240.0 | 0.46 |
| 7 | 400.0 | 0.48 |
| 8 | 626.0 | 0.50 |
| 9 | 892.0 | 0.50 |
| 10 | 1,223.0 | 0.50 |
| 11 | 1,590.0 | 0.49 |
| 12 | 1,900.0 | 0.45 |
| 13 | 2,080.0 | 0.39 |
| 14 | 2,230.0 | 0.34 |
| 15 | 2,300.0 | 0.28 |
| 16 | 2,310.0 | 0.23 |
| 17 | 2,310.0 | 0.19 |
| 18 | 2,310.0 | 0.16 |
| 19 | 2,310.0 | 0.14 |
| 20 | 2,310.0 | 0.12 |
| 21 | 2,310.0 | 0.10 |
| 22 | 2,310.0 | 0.09 |
| 23 | 2,310.0 | 0.08 |
| 24 | 2,310.0 | 0.07 |
| 25 | 2,310.0 | 0.06 |

ρ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

E82



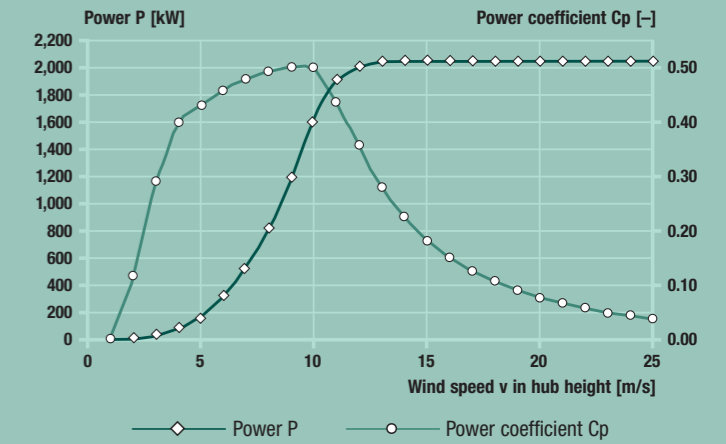
Specially designed for medium wind speeds, the ENERCON E-82 wind turbine – with the new rotor blade design and tower versions up to 138 m hub height – guarantees excellent yields in the 2 MW category, even at inland sites.

TECHNICAL DATA

| | |
|-----------------------------------|---|
| Rated power: | 2,000 kW |
| Rotor diameter: | 82 m |
| Hub height: | 78 m – 138 m |
| Wind class (IEC): | IEC/NVN II |
| Turbine concept: | Gearless, variable speed, variable pitch control |
| Rotor | |
| Type: | Upwind rotor with active pitch control |
| Direction of rotation: | Clockwise |
| Number of blades: | 3 |
| Swept area: | 5,281 m ² |
| Blade material: | Fibreglass (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 6–19.5 rpm |
| Pitch control: | ENERCON blade pitch system, one independent pitching system per rotor blade with allocated emergency supply |
| Drive train with generator | |
| Hub: | Rigid |
| Main bearings: | Dual-row tapered/single-row cylindrical roller bearings |
| Generator: | ENERCON direct-drive synchronous annular generator |
| Grid feeding: | ENERCON converter |
| Braking systems: | – 3 independent blade pitch systems with emergency supply – Rotor brake – Rotor lock |
| Yaw control: | Active via adjustment gears, load-dependent damping |
| Cut-out wind speed: | 28–34 m/s (with ENERCON storm control) |
| Remote monitoring: | ENERCON SCADA |

Details – ENERCON Storm Control – (see last page)

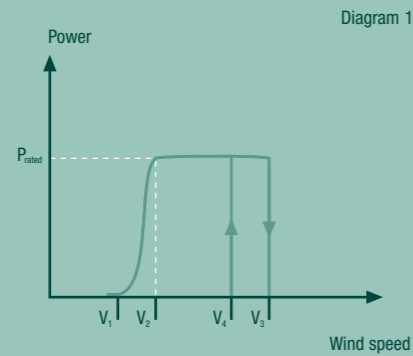
CALCULATED POWER CURVE



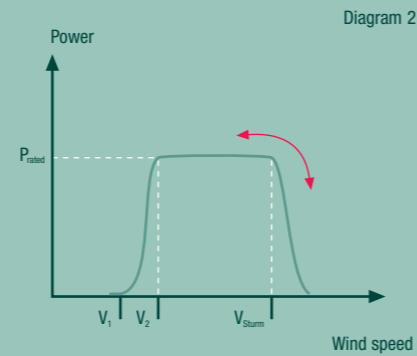
| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|------------|--------------|--------------------------|
| 1 | 0.0 | 0.00 |
| 2 | 3.0 | 0.12 |
| 3 | 25.0 | 0.29 |
| 4 | 82.0 | 0.40 |
| 5 | 174.0 | 0.43 |
| 6 | 321.0 | 0.46 |
| 7 | 532.0 | 0.48 |
| 8 | 815.0 | 0.49 |
| 9 | 1,180.0 | 0.50 |
| 10 | 1,612.0 | 0.50 |
| 11 | 1,890.0 | 0.44 |
| 12 | 2,000.0 | 0.36 |
| 13 | 2,050.0 | 0.29 |
| 14 | 2,050.0 | 0.23 |
| 15 | 2,050.0 | 0.19 |
| 16 | 2,050.0 | 0.15 |
| 17 | 2,050.0 | 0.13 |
| 18 | 2,050.0 | 0.11 |
| 19 | 2,050.0 | 0.09 |
| 20 | 2,050.0 | 0.08 |
| 21 | 2,050.0 | 0.07 |
| 22 | 2,050.0 | 0.06 |
| 23 | 2,050.0 | 0.05 |
| 24 | 2,050.0 | 0.05 |
| 25 | 2,050.0 | 0.04 |

$\rho = 1.225 \text{ kg/m}^3$

Details – ENERCON power curve – (see last page)



Power curve of a wind turbine without ENERCON storm control



Power curve of a wind turbine with ENERCON storm control

ENERCON POWER CURVES

According to current standards at power curve measurement certain parameters such as turbulence intensity are not taken into consideration. The results are deviating measurements on the same type of wind turbine at different locations. Also when comparing yield using power curve measurements from different types of wind turbines, a clear picture cannot be obtained unless all measurement parameters are taken into consideration.

So in order to calculate power yield forecasts for its wind turbines, ENERCON does not use power curve measurements but calculated power curves.

These are based on the following:

- several different power curve measurements for the respective wind turbine type taken by accredited institutes with documented evidence of these measurements on the respective power curve certificates; or results from other turbine types if measurements have not yet begun or are still in progress
- average turbulence intensity 12 %
- standard air density – 1.225 kg/m³
- realistic assumptions concerning anemometer behaviour
- wind turbine operation with ENERCON's storm control feature which enables operation without shutdown at high wind speeds.

Thus the power curves for ENERCON wind turbines provide highly reliable and realistic calculations for expected energy yield according to the wind conditions at the respective site.

DESCRIPTION WIND CLASSES

IEC I $V_{av} = 10$ m/s
 $V_{ext} = 70$ m/s

IEC II $V_{av} = 8.5$ m/s
 $V_{ext} = 59.5$ m/s

IEC S V_{av} and V_{ext} to be determined by the manufacturer

ENERCON STORM CONTROL

ENERCON wind turbines are operated with a special storm control feature. This system enables reduced turbine operation in the event of extremely high wind speeds, and prevents the otherwise frequent shutdowns and resulting yield losses.

Power curve without ENERCON storm control

The diagram 1 shows that the wind turbine stops at a defined shutdown speed V_3 . The reason being that a specified maximum wind speed has been exceeded. In the case of a wind turbine without storm control this, for example, occurs at a wind speed of 25 m/s within the 20 second mean. The wind turbine only starts up again when the average wind speed drops below the shutdown speed or a possibly even lower restart speed (V_4 in the diagram; so-called strong wind hysteresis). In gusty wind conditions there may be a longer delay, which means that considerable yield losses are incurred.

Power curve with ENERCON storm control

The power curve diagram with ENERCON storm control (diagram 2) demonstrates that the wind turbine does not shut down automatically when a certain wind speed V_{storm} is exceeded, but merely reduces the power output by lowering the rotational speed. This is achieved by turning the rotor blades slightly out of the wind. Once the wind speed drops, the blades turn back into the wind, and the turbine immediately resumes operation at full power. Yield-reducing shutdown and start-up procedures are thus avoided.



TRADEMARK NOTE

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