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ENERCON
ENERGY FOR THE WORLD

# ENERCON WIND TURBINES

## PRODUCT OVERVIEW

330 kW

800–900 kW

2–3 MW

>3 MW

ENERCON
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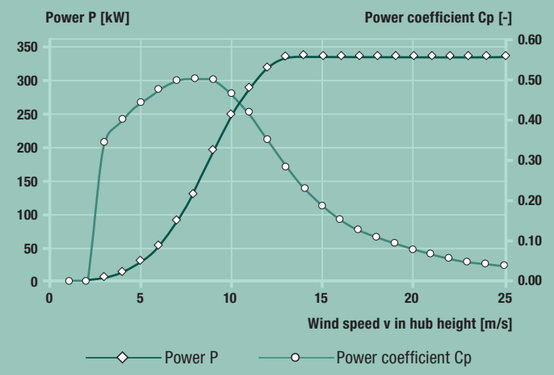
# E33

## 330 kW

## 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 |

$\rho = 1.225\ kg/m^3$

Details – ENERCON power curve – (see last page)

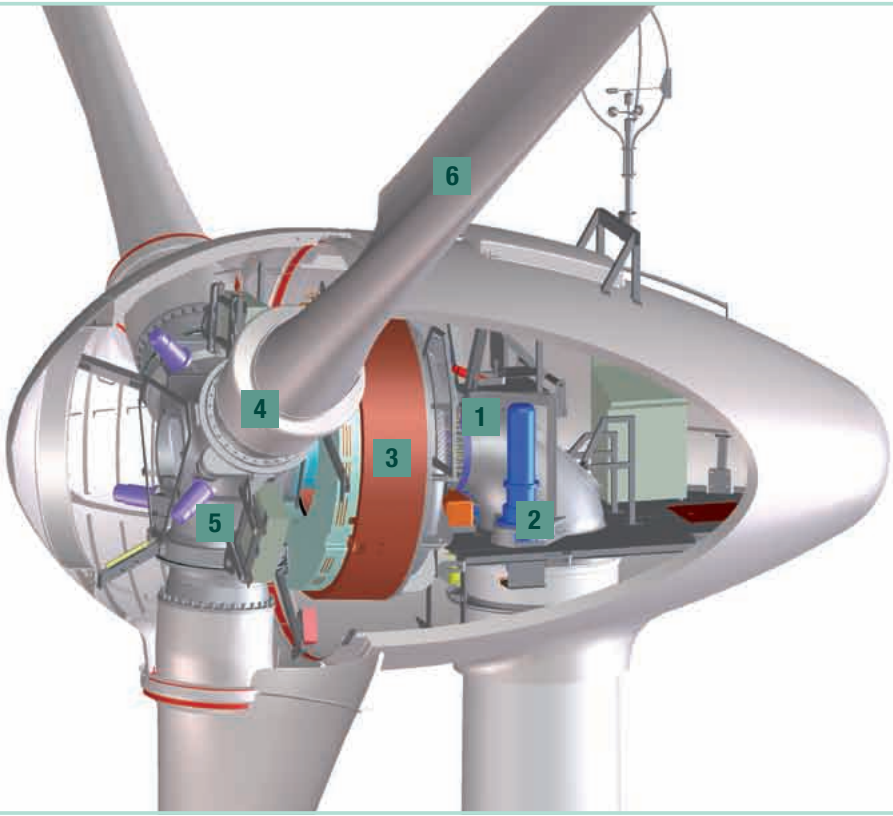


## TECHNICAL SPECIFICATIONS E-33

| | |
|---|---|
| Rated power: | 330 kW |
| Rotor diameter: | 33.4 m |
| Hub height: | 37 m / 44 m / 49 m / 50 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IA and IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 876 $m^2$ |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 18 – 45 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Tapered roller bearing pair |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

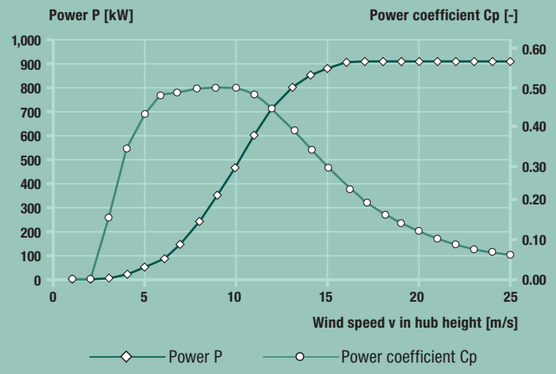



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E44

## 900 kW

## CALCULATED POWER CURVE




| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|---|---|---|
| 1 | 0.0 | 0.00 |
| 2 | 0.0 | 0.00 |
| 3 | 4.0 | 0.16 |
| 4 | 20.0 | 0.34 |
| 5 | 50.0 | 0.43 |
| 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 |

$\rho$ = 1.225 kg/m³

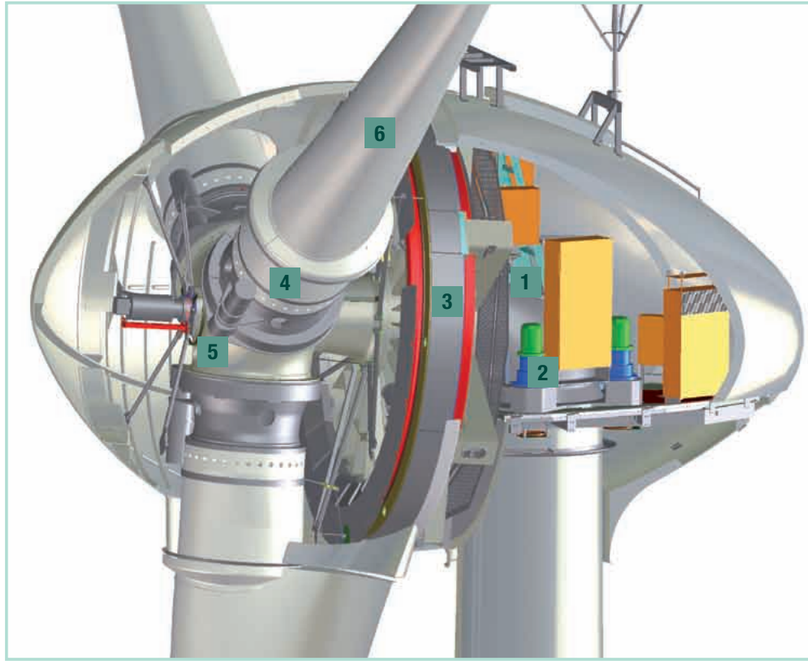
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-44

| | |
|---|---|
| Rated power: | 900 kW |
| Rotor diameter: | 44 m |
| Hub height: | 45 m / 55 m / 65 m |
| Wind class (IEC): | IEC/NVN IA |
| **Turbine concept:** | Gearless, variable speed |
| | Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 1,521 m² |
| Blade material: | GRP (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 12–34 rpm |
| Pitch control: | ENERCON single blade pitch system, one independent pitch system per rotor blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Tapered roller bearing pair |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– 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)

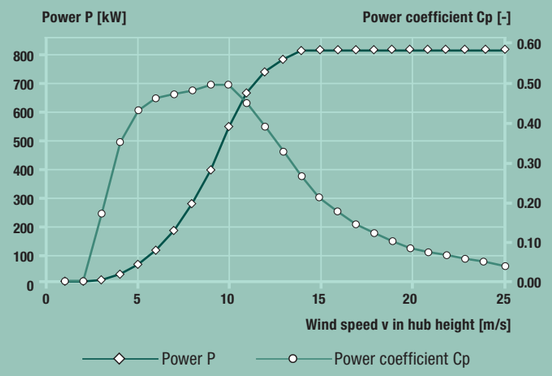



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E48

## 800 kW

## 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 | 0.17 |
| 4 | 25.0 | 0.35 |
| 5 | 60.0 | 0.43 |
| 6 | 110.0 | 0.46 |
| 7 | 180.0 | 0.47 |
| 8 | 275.0 | 0.48 |
| 9 | 400.0 | 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 |

$\rho$ = 1.225 kg/m³

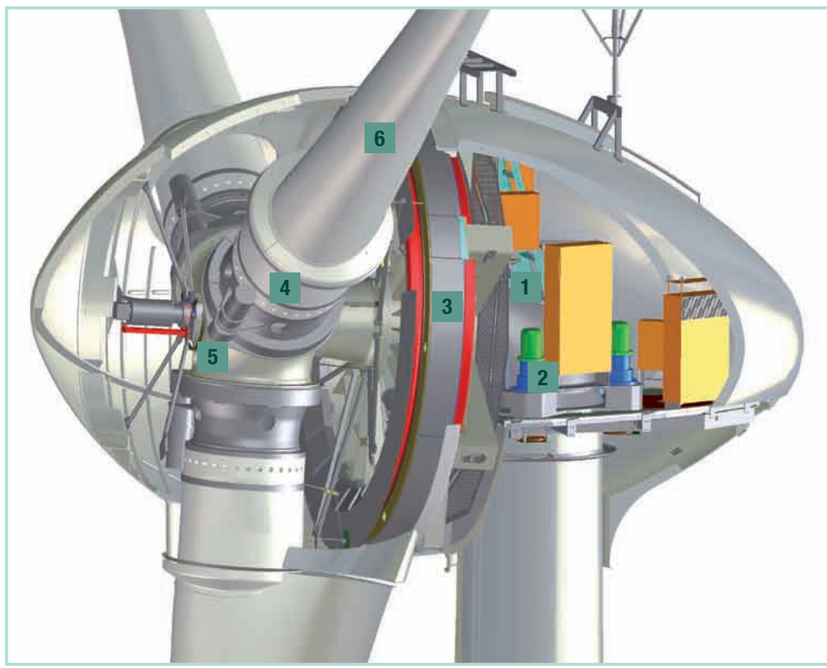
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-48

| | |
|---|---|
| Rated power: | 800 kW |
| Rotor diameter: | 48 m |
| Hub height: | 50 m / 60 m / 75 m / 76 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 1,810 m² |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 16 – 31 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Tapered roller bearing pair |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

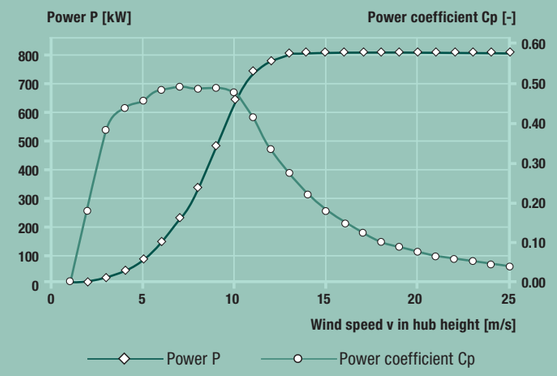



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E53

## 800 kW

## 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 |

$\rho$ = 1.225 kg/m³

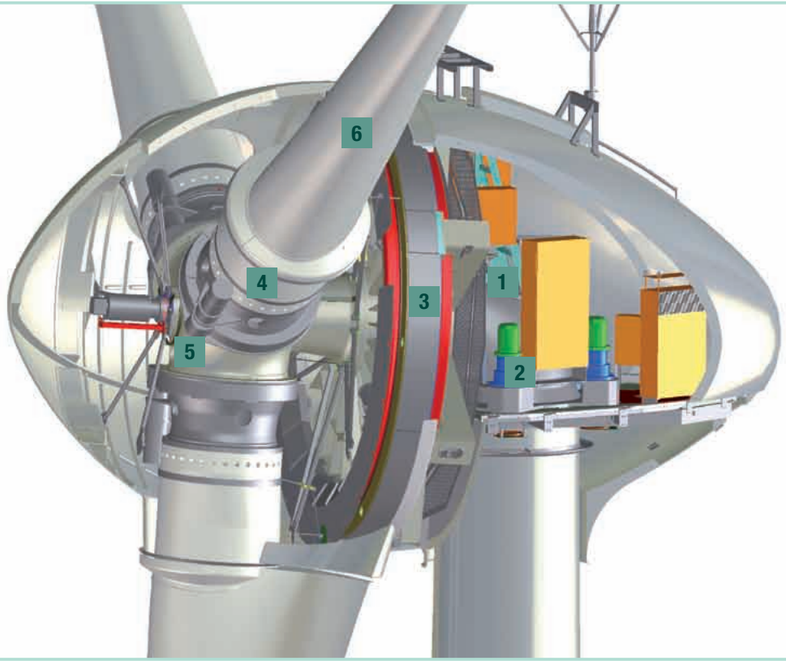
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-53

| | |
|---|---|
| Rated power: | 800 kW |
| Rotor diameter: | 52.9 m |
| Hub height: | 60 m / 73 m / 75 m |
| Wind zone (DIBt): | WZ II exp |
| Wind class (IEC): | IEC/NVN Class S |
| | ($v_{av}$ = 7.5 m/s, $v_{ext}$ = 57 m/s) |
| **Turbine concept:** | Gearless, variable speed |
| | Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 2,198 m² |
| Blade material: | GRP (epoxy resin); |
| | integrated lightning protection |
| Rotational speed: | Variable, 12–28.3 rpm |
| Pitch control: | ENERCON single blade pitch system, |
| | one independent pitch system per rotor |
| | blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Tapered roller bearing pair |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power 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)

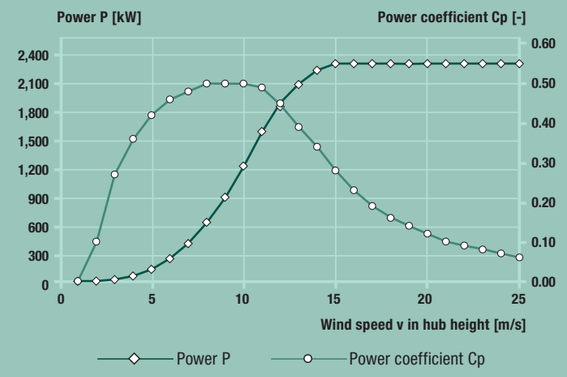



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E70

## 2,300 kW

## 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 |

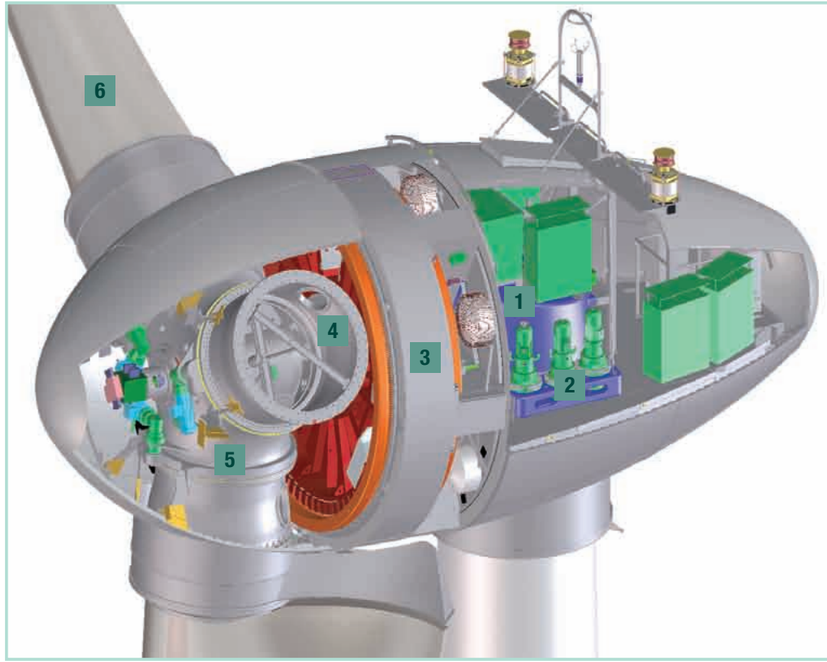
$\rho$ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-70 E4

| | |
|---|---|
| Rated power: | 2,300 kW |
| Rotor diameter: | 71 m |
| Hub height: | 57 m / 64 m / 85 m / 98 m / 113 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IA and IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 3,959 m² |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 6 – 21.5 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Double-row tapered/cylindrical roller bearings |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

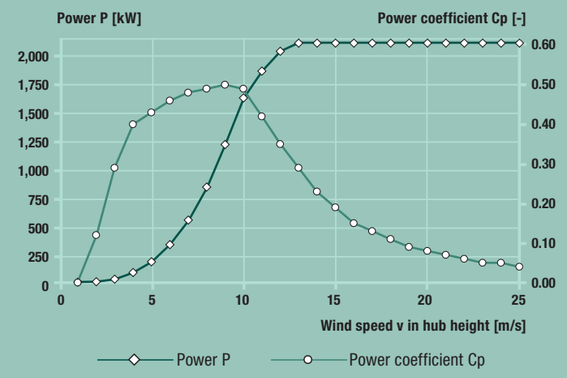



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E82

## 2,000 kW

## 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 | 1.580.0 | 0.49 |
| 11 | 1.810.0 | 0.42 |
| 12 | 1.980.0 | 0.35 |
| 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 kg/m³

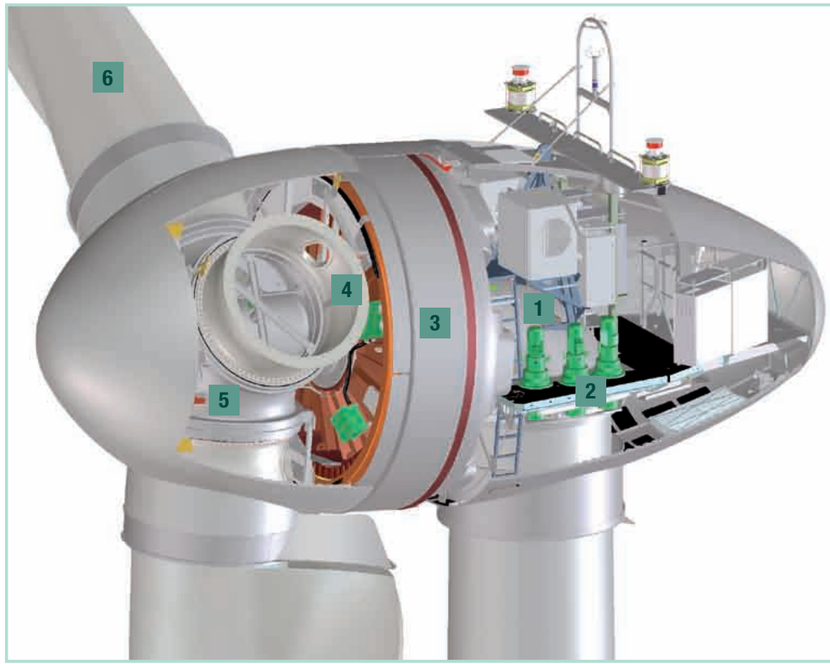
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-82 E2

| | |
|---|---|
| Rated power: | 2,000 kW |
| Rotor diameter: | 82 m |
| Hub height: | 78 m / 85 m / 98 m / 108 m / 138 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 5,281 m² |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 6 – 18 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Double-row tapered/cylindrical roller bearings |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

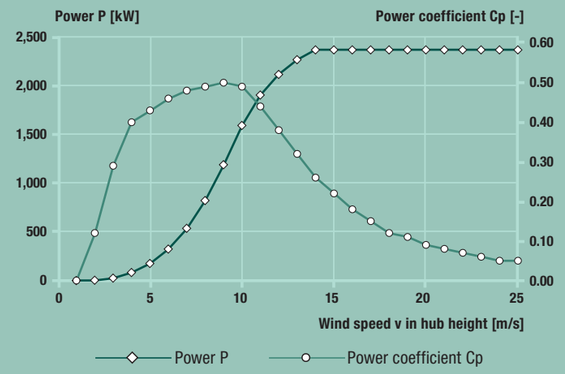



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E82

## 2,300 kW

## 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 | 1,580.0 | 0.49 |
| 11 | 1,890.0 | 0.44 |
| 12 | 2,100.0 | 0.38 |
| 13 | 2,250.0 | 0.32 |
| 14 | 2,350.0 | 0.26 |
| 15 | 2,350.0 | 0.22 |
| 16 | 2,350.0 | 0.18 |
| 17 | 2,350.0 | 0.15 |
| 18 | 2,350.0 | 0.12 |
| 19 | 2,350.0 | 0.11 |
| 20 | 2,350.0 | 0.09 |
| 21 | 2,350.0 | 0.08 |
| 22 | 2,350.0 | 0.07 |
| 23 | 2,350.0 | 0.06 |
| 24 | 2,350.0 | 0.05 |
| 25 | 2,350.0 | 0.05 |

$\rho$ = 1.225 kg/m³

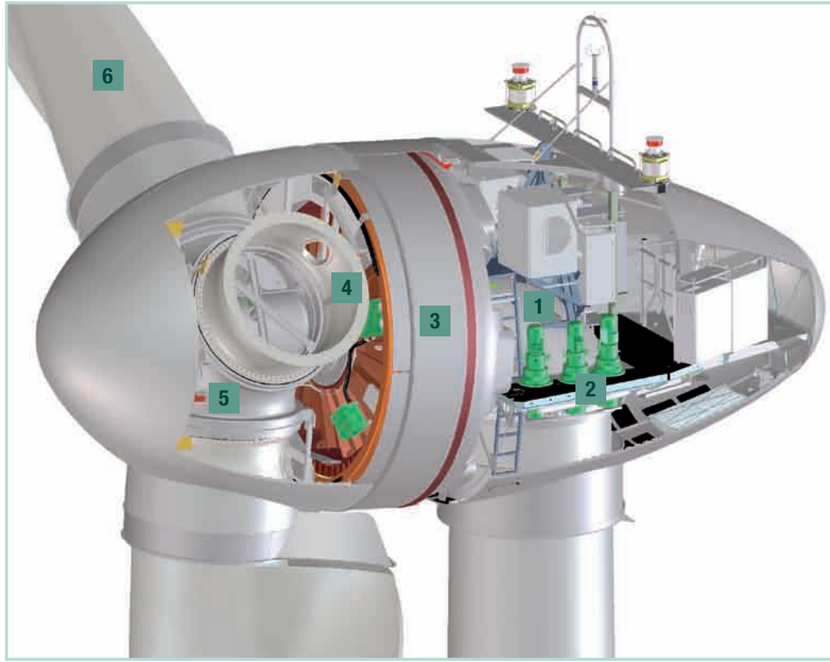
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-82 E2

| | |
|---|---|
| Rated power: | 2,300 kW |
| Rotor diameter: | 82 m |
| Hub height: | 78 m / 85 m / 98 m / 108 m / 138 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 5,281 m² |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 6 – 18 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Double-row tapered/cylindrical roller bearings |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

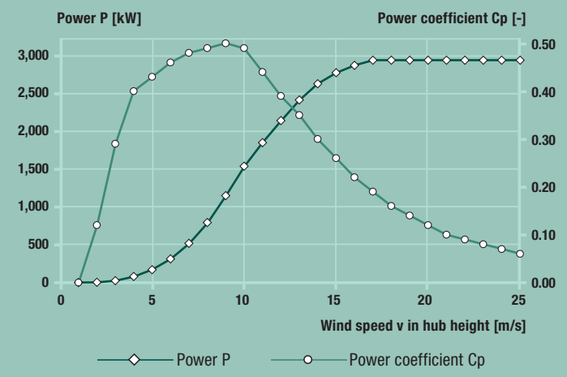



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E82

## 3,000 kW

## 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 | 1,580.0 | 0.49 |
| 11 | 1,900.0 | 0.44 |
| 12 | 2,200.0 | 0.39 |
| 13 | 2,480.0 | 0.35 |
| 14 | 2,700.0 | 0.30 |
| 15 | 2,850.0 | 0.26 |
| 16 | 2,950.0 | 0.22 |
| 17 | 3,020.0 | 0.19 |
| 18 | 3,020.0 | 0.16 |
| 19 | 3,020.0 | 0.14 |
| 20 | 3,020.0 | 0.12 |
| 21 | 3,020.0 | 0.10 |
| 22 | 3,020.0 | 0.09 |
| 23 | 3,020.0 | 0.08 |
| 24 | 3,020.0 | 0.07 |
| 25 | 3,020.0 | 0.06 |

$\rho$ = 1.225 kg/m³

Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-82 E3

| | |
|---|---|
| Rated power: | 3,000 kW |
| Rotor diameter: | 82 m |
| Hub height: | 78 m / 85 m / 98 m / 108 m / 138 m |
| Wind class (IEC): | IEC/NVN IA and IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed |
| | Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 5,281 m² |
| Blade material: | GRP (epoxy resin); integrated lightning protection |
| Rotational speed: | Variable, 6–18.5 rpm |
| Pitch control: | ENERCON single blade pitch system, one independent pitch system per rotor blade with allocated emergency supply |
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Double-row tapered/cylindrical roller bearings |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– 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 |

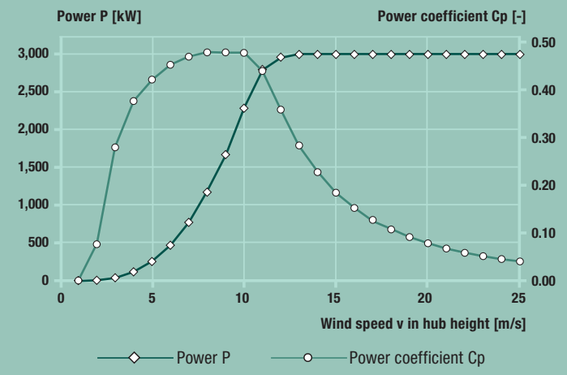
*Details – ENERCON Storm Control – (see last page)


1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E101

## 3,000 kW

## CALCULATED POWER CURVE




| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|---|---|---|
| 1 | 0.0 | 0.000 |
| 2 | 3.0 | 0.076 |
| 3 | 37.0 | 0.279 |
| 4 | 118.0 | 0.376 |
| 5 | 258.0 | 0.421 |
| 6 | 479.0 | 0.452 |
| 7 | 790.0 | 0.469 |
| 8 | 1,200.0 | 0.478 |
| 9 | 1,710.0 | 0.478 |
| 10 | 2,340.0 | 0.477 |
| 11 | 2,867.0 | 0.439 |
| 12 | 3,034.0 | 0.358 |
| 13 | 3,050.0 | 0.283 |
| 14 | 3,050.0 | 0.227 |
| 15 | 3,050.0 | 0.184 |
| 16 | 3,050.0 | 0.152 |
| 17 | 3,050.0 | 0.127 |
| 18 | 3,050.0 | 0.107 |
| 19 | 3,050.0 | 0.091 |
| 20 | 3,050.0 | 0.078 |
| 21 | 3,050.0 | 0.067 |
| 22 | 3,050.0 | 0.058 |
| 23 | 3,050.0 | 0.051 |
| 24 | 3,050.0 | 0.045 |
| 25 | 3,050.0 | 0.040 |

$\rho$ = 1.225 kg/m³

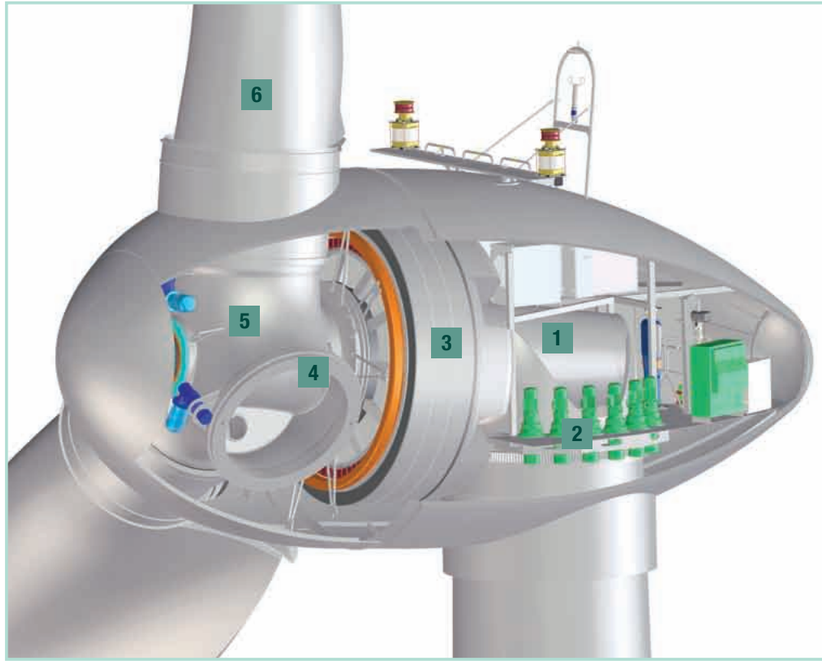
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-101

| | |
|---|---|
| Rated power: | 3,000 kW |
| Rotor diameter: | 101 m |
| Hub height: | 99 m / 135 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IIA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 7,854 m² |
| Blade material: | GRP (epoxy resin);<br>integrated lightning protection |
| Rotational speed: | Variable, 4–14.5 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |

| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Double-row tapered/cylindrical roller bearings |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock, 15° latching |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28–34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)

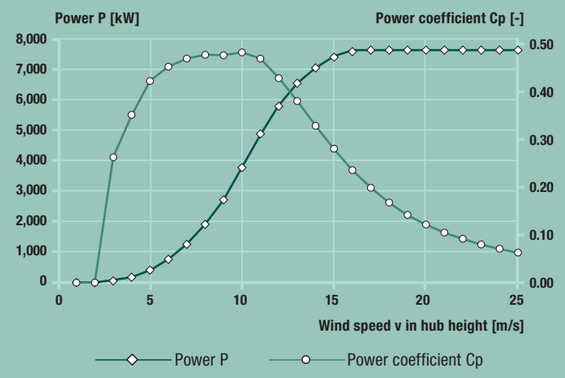



1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

# E126

## 7,500 kW

## CALCULATED POWER CURVE




| Wind [m/s] | Power P [kW] | Power coefficient Cp [-] |
|---|---|---|
| 1 | 0.0 | 0.000 |
| 2 | 0.0 | 0.000 |
| 3 | 55.0 | 0.263 |
| 4 | 175.0 | 0.352 |
| 5 | 410.0 | 0.423 |
| 6 | 760.0 | 0.453 |
| 7 | 1,250.0 | 0.470 |
| 8 | 1,900.0 | 0.478 |
| 9 | 2,700.0 | 0.477 |
| 10 | 3,750.0 | 0.483 |
| 11 | 4,850.0 | 0.470 |
| 12 | 5,750.0 | 0.429 |
| 13 | 6,500.0 | 0.381 |
| 14 | 7,000.0 | 0.329 |
| 15 | 7,350.0 | 0.281 |
| 16 | 7,500.0 | 0.236 |
| 17 | 7,580.0 | 0.199 |
| 18 | 7,580.0 | 0.168 |
| 19 | 7,580.0 | 0.142 |
| 20 | 7,580.0 | 0.122 |
| 21 | 7,580.0 | 0.105 |
| 22 | 7,580.0 | 0.092 |
| 23 | 7,580.0 | 0.080 |
| 24 | 7,580.0 | 0.071 |
| 25 | 7,580.0 | 0.063 |

$\rho$ = 1.225 kg/m³

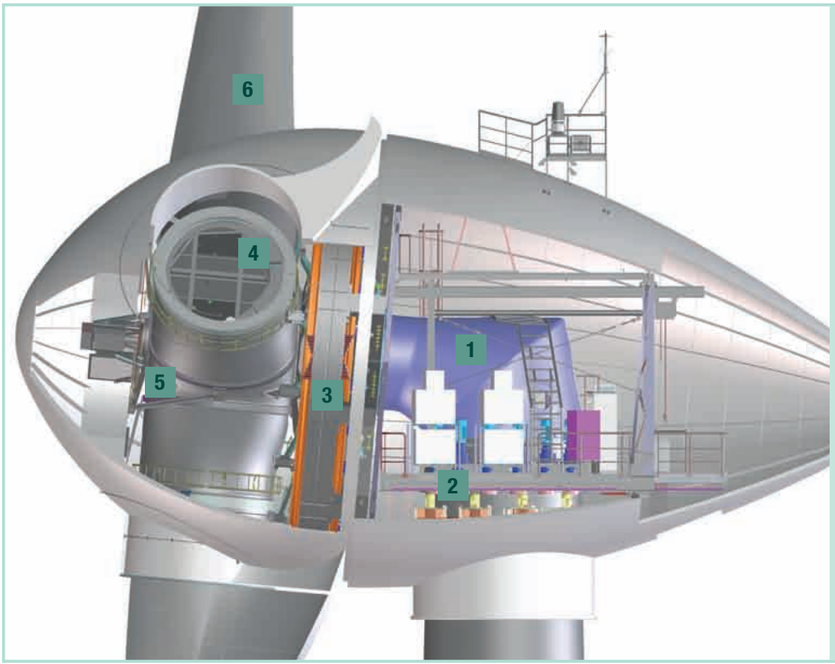
Details – ENERCON power curve – (see last page)

## TECHNICAL SPECIFICATIONS E-126

| | |
|---|---|
| Rated power: | 7,500 kW |
| Rotor diameter: | 127 m |
| Hub height: | 135 m |
| Wind zone (DIBt): | WZ III |
| Wind class (IEC): | IEC/NVN IA |
| **Turbine concept:** | Gearless, variable speed<br>Single blade adjustment |
| **Rotor** | |
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 12,668 m² |
| Blade material: | GRP (epoxy resin) / GRP;<br>GRP (epoxy resin) / steel;<br>integrated lightning protection |
| Rotational speed: | Variable, 5 – 11.7 rpm |
| Pitch control: | ENERCON single blade pitch system,<br>one independent pitch system per rotor<br>blade with allocated emergency supply |

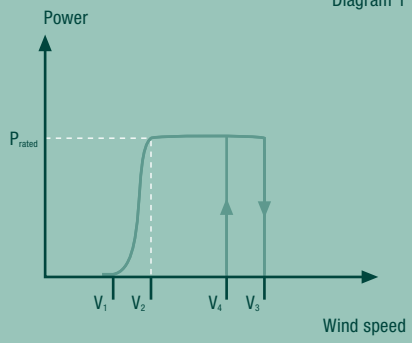
| | |
|---|---|
| **Drive train with generator** | |
| Hub: | Rigid |
| Main bearing: | Single-row tapered roller bearing |
| Generator: | ENERCON direct-drive annular generator |
| **Grid feeding:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake |
| **Yaw control:** | Active via adjustment gears, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*Details – ENERCON Storm Control – (see last page)



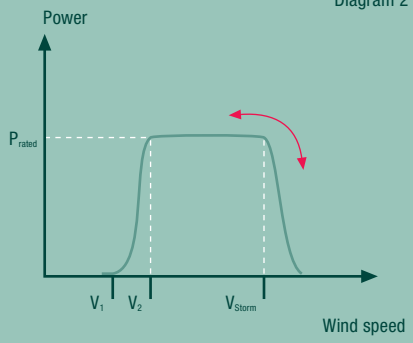

1 Main carrier
2 Yaw drive
3 Annular generator
4 Blade adapter
5 Rotor hub
6 Rotor blade

Diagram 1




*Power curve of a wind turbine without ENERCON storm control*

Diagram 2




*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 taking 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; socalled 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.