# NIAGARA REGION WIND FARM
WIND TURBINE SPECIFICATIONS REPORT

File No. 160950269
April 2013

Prepared for:

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# 1.0 Introduction

The purpose of the Wind Turbine Specification Report is to describe the design components, make and model of the turbines proposed for this Project, including noise emission levels. This report should be read in conjunction with the issuance of several other Technical Reports which provide further detail of Project design and operation, construction and decommissioning.

## 1.1 PROJECT OVERVIEW

Niagara Region Wind Corporation (NRWC) is proposing to develop, construct, and operate the 230 Megawatt (MW) Niagara Region Wind Farm (the Project) within the Townships of West Lincoln and Wainfleet and the Town of Lincoln within the Niagara Region and within Haldimand County in Southern Ontario, in response to the Government of Ontario's initiative to promote the development of renewable electricity in the province. Project infrastructure such as collector lines and transmission lines will be sited along the boundaries of the Township of Pelham and Town of Grimsby, but will be sited outside of these municipalities on the opposite side of the road.

The basic components of the Project include 77 wind turbine generators (80 potential locations identified) each with a rated capacity ranging from approximately 2.3 MW to 3.0 MW for a maximum installed nameplate capacity of 230 MW. An overhead and/or underground collection system connects each turbine to one of two transformer substations along a series of 34.5 kilovolt (kV) lines. Turbines are grouped into nine collector circuits that bring power (and data via fibre optic lines) to one of the transformer substations. Voltage is stepped up from 34.5kV to 115kV at each transformer substation by means of a 100 MVA base rated transformer with two stages of cooling (via fans). A 115kV transmission line transports power from each of the two transformer substations north to the tap-in location where the Project is connected to the Hydro One Networks Inc. (HONI) owned transmission line, south of the Queen Elizabeth Way (QEW) in the Town of Lincoln. Power generated from this Project will be conveyed along the existing HONI transmission line to the Beach Transformer Station in Hamilton.

Alternate transmission and collector lines routes have been identified and assessed to provide options during detailed design, the final selection of which route to follow will be confirmed following the consultation process with local distribution companies, agency review and detailed design.

Other Project components include access roads, junction boxes (or pad-mounted disconnect switches) and associated culverts at swales and waterbody crossings. Temporary components during construction may include temporary laydown areas (for storage and staging areas at each turbine location), crane pads or mats, staging areas along access roads, delivery truck turnaround areas, central construction laydown areas and crane paths.

## 1.2 REPORT REQUIREMENTS

This Wind Turbine Specifications Report is one component of the REA Application for the Project, and has been prepared in accordance with Item 13, Table 1 of O. Reg. 359/09 which sets out specific content requirements as provided in **Table 1.1**.

**Table 1.1: Wind Turbine Specifications Report Requirements: O. Reg. 359/09**

| Requirements | Completed | Section Reference |
|---|---|---|
| The make, model, name plate capacity, hub height above grade and rotational speeds. | ✓ | 2.1 |
| The acoustic emissions data, determined and reported in accordance with standard CAN/CSA-C61400-11-07, “Wind Turbine Generator Systems — Part 11: Acoustic Noise Measurement Techniques”, dated October 2007(or equivalent (IEC) standard 61400-11 (edition 2)), including the overall sound power level, measurement uncertainty value, octave-band sound power levels (linear weighted) and tonality and tonal audibility. | ✓ | 2.1 |

# 2.0 Wind Turbines

## 2.1 SPECIFICATIONS

The Project will include 77 ENERCON wind turbine generators (80 potential locations identified) each with a rated capacity ranging from approximately 2.3 MW to 3.0 MW with a maximum installed nameplate capacity of 230 MW.

The selected wind turbine models for the Project are the ENERCON E101 and either the ENERCON E82 or a de-rated ENERCON E101 to achieve the contract capacity of 230 MW. Specifications of the E101 and E82 turbines are summarized below in **Table 2.1** and provided in **Appendix A**.

Both wind turbine models have been assessed with two hub height options (124m and 135m) in the REA application to provide operational flexibility. Final selection between the turbine models and hub heights will be determined during detailed design. The E101 turbine has higher sound emissions and a larger blade length than the E82. As a result, for the Technical Studies such as the **Natural Heritage Assessment / Environmental Impact Study**, **Water Body and Water Body Assessment Report**, **Stage 1 and 2 Archaeological Assessments**, **Protected Properties Assessment** and **Heritage Impact Assessment**, all turbines are assumed to be E101 turbines to account for the worst case scenario for feature setbacks and identification of potential negative impacts.

Some specific wind turbine model and hub height constraints have been identified through the Noise Assessment Report. Operational flexibility will not be provided for nine turbines which will have a hub height of 135m (T18, T36, T45, T46, T47, T53, T55, T60 and T74). Three of these nine turbines (T36, T46 and T53) will also be either E82 turbines or de-rated E101 turbines, the selection of which will be determined during detailed design on condition that the final selection meets the noise emission limits highlighted in the Noise Assessment Report. Additional information with respect to the sound power level for the ENERCON E101 and E82 turbines are provided in the **Noise Assessment Report** (**Appendix C** of the **Design and Operations Report** provided under separate cover).

**Table 2.1: Enercon E101 & E82 – Wind Turbine Specifications**

| | | |
|---|---|---|
| Manufacturer | ENERCON | ENERCON |
| Model | E101 | E82 |
| Name plate capacity (MW) | 3 MW | 2.3 MW |
| Hub height above grade | 124 m or 135 m * | 135 m |
| Blade length | 48.6 m | 38.8 m |
| Rotor diameter | 101 m | 82 m |
| Rotor sweep area | 8,012 $m^2$ | 5,281 $m^2$ |
| Nominal revolutions (rotational speed) | 4 – 14.5 rpm | 6 – 18 rpm |

| **Table 2.1: Enercon E101 & E82 – Wind Turbine Specifications** | | |
|---|---|---|
| Cut-in and cut-off wind speeds | 2.5 m/s (cut-in)<br>28 – 34 m/s (cut-out) | 2.5 m/s (cut-in)<br>28 – 34 m/s (cut-out) |
| Frequency | 50 Hz or 60 Hz | 50 Hz or 60 Hz |
| Sound Power Levels (Maximum Power for entire operation wind speed from cut in to cut off) | 104.8 dBA | 103.3 dBA |
| Tonal Audibility | $\Delta L_{a,k} \leq 2$ dB | $\Delta L_{a,k} < 2$ dB |

* The hub height will be confirmed during detailed design and therefore both options have been carried through the REA assessment.

Operation of wind turbines between cut-in and cut-off wind speeds will generate noise. Appendix C of the **Noise Assessment Report** includes a Summary of the Test Report from Kotter Consulting Engineers for the E-101 3.0 MW turbine and E-82 2.3 MW turbine (German) demonstrating that the sound power level at 95% of the rated power is 104.8 dBA and 103.3 dBA respectively. Noise emissions are assessed in the **Noise Assessment Report**, **Appendix C** in the **Design and Operation Report**.

## 2.2 WIND TURBINE COMPONENTS

Each wind turbine consists of the following key components, each of which are further described in the Design and Operations Report and Project Description Report. These components are similar for the E101 turbine, E82 turbine and de-rated E101 turbine.

- Reinforced concrete tower foundation;
- 21 concrete tower sections for the 124 m hub height tower (or 24 concrete tower sections for the 135 m hub height tower);
- 3 steel tower sections;
- Nacelle (comprised of electrical generator and housing);
- Three rotor blades;
- Hub (the structure to where the blades attach);
- Power converter;
- Step-up transformer; and
- Electrical wiring and grounding.

The tower is supported by a concrete foundation, approximately 5 m deep and 25 m wide with piles as required, depending upon subsurface conditions. The specific size and design of each foundation will be confirmed following geotechnical investigations to be completed at each turbine location.

The towers consist of separate, pre-fabricated concrete segments produced in two or three half shells to allow for transportation. After assembly, the segments are linked to each other as inseparable units by means of pre-stressing tendons inside the tower that are connected to the foundation. Three tubular steel tower sections at the top of the turbine are erected and bolted together on top of the precast concrete tower sections.

The tower supports the nacelle, which houses the main components of the wind turbine (comprised of electrical generator and housing). The nacelle cover is made of aluminum and is accessible from the tower via a hatch in the base frame.

Inside the base of each tower a step-up transformer transforms the power to a standard operating power line voltage (i.e. 400 V to 34.5 kV). A converter converts the power from direct current to alternating current in the tower base.

The 101 m diameter rotor consists of three blades and a hub. The blade design requires a strong structure to face high wind loads but also lightweight construction to minimize the load transmission to the nacelle. The blades for the E101 and E82 turbines are 48.6 m and 38.8 m in length, respectively. The pitch of the blades is adjustable, allowing maximum energy input from the wind and also acting as a braking system.

Electrical wiring includes cabling, which runs down the turbine tower to the transformer, converter and switchgear located at the base of the tower. From the switchgear, the 34.5 kV collection system transmits power from the turbines to one of two transformer substations.

The blades will be equipped with a blade de-icing system that detects conditions for potential ice formation and heats the blades to prevent the buildup of ice during winter operation. In addition, the controls of the turbine will detect if ice has accumulated on the blades during extreme weather events and will shut down operation. Wind turbine operation would not resume until the ice has melted.

Turbines would be lit with navigation lights on the top of the nacelles in accordance with Transport Canada Regulations and Standards as described in the Design and Operations Report.

# 3.0 Closure

The Niagara Region Wind Farm Wind Turbines Specifications Report has been prepared by Stantec Consulting Ltd. for Niagara Region Wind Corporation in accordance with Item 13, Table 1 of O. Reg. 359/09. Information compiled in this report has been provided in association with ENERCON, with additional support from Hatch Ltd., PCL Construction Ltd., and the Niagara Region Wind Corporation.

This report has been prepared by Stantec for the sole benefit of Niagara Region Wind Corporation, and may not be used by any third party without the express written consent of Niagara Region Wind Corporation. The data presented in this report are in accordance with Stantec's understanding of the Project as it was presented at the time of reporting.

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# 4.0 References

Ontario Ministry of the Environment (MOE). 2012. Technical Guide to Renewable Energy Approvals, as amended.

O. Reg. 359/09. 2012. Ontario Regulation 359/09 made under the Environmental Protection Act, Renewable Energy Approvals Under Part V.0.1 of the Act, as amended by O. Reg. 333/12 on November 2, 2012.

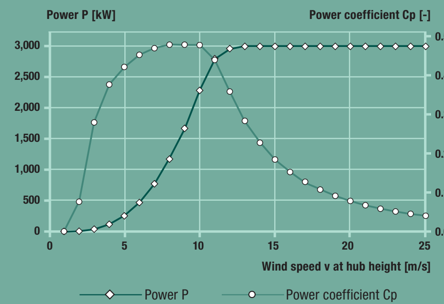
# Appendix A

## Turbine Specifications from Manufacturer

# 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

For more information on the ENERCON power curve, please see the 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 |
| **WEC concept:** | Gearless, variable speed<br>Single blade adjustment |

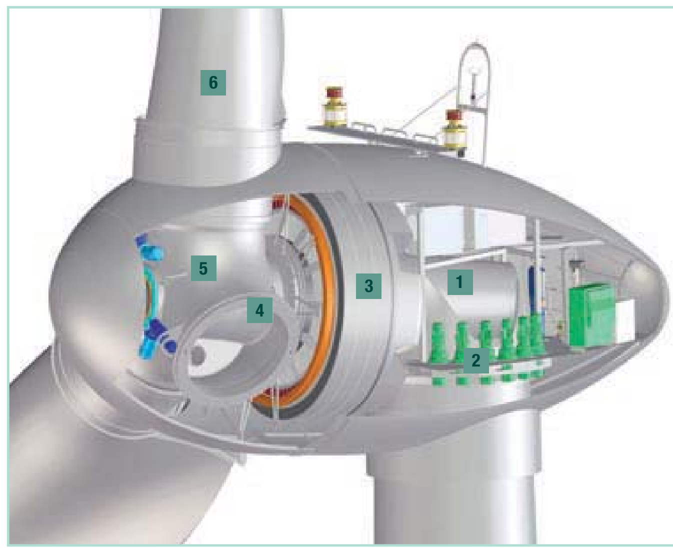
**Rotor**

| | |
|---|---|
| Type: | Upwind rotor with active pitch control |
| Rotational direction: | Clockwise |
| No. of blades: | 3 |
| Swept area: | 8,012 m² |
| Blade material: | GRP (epoxy resin);<br>Built-in lightning protection |
| Rotational speed: | Variable, 4 – 14.5 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 feed:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock, latching (15°) |
| **Yaw system:** | Active via yaw gear, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s<br>(with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

*For more information on the ENERCON storm control feature, please see the last page.




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

# WIND ENERGY CONVERTER CHARACTERISTICS E-101

| **Rotor** | |
|---|---|
| Type | E-101 |
| Rotor diameter | 101 m |
| Swept area | 8012 $m^2$ |
| Power regulation | Pitch |
| RPM | 4 –14,5 $min^{-1}$ |
| Cut in wind | 2,5 m/s |
| Cut out wind | 28 – 34 m/s |
| Survival wind speed | 59,5 m/s |

| **Gear Box** | |
|---|---|
| Not applicable | No gearbox |

| **Blades** | |
|---|---|
| Manufacturer | ENERCON |
| Blade length | 48,5 m |
| Material | GRP (Epoxy) |
| Lightning protection | included |

| **Generator** | |
|---|---|
| Manufacturer | ENERCON |
| Nominal Power | 3000 kW |
| Type (model) | Synchronous, direct-drive ringgenerator |
| Protection classification | IP 23 |
| Insulation class | F |

| **Yaw System** | |
|---|---|
| Type | electrical motors |
| Yaw control | Active (based on wind vane signal) |
| Yaw rate | 0,5°/sec |

| **Controller** | |
|---|---|
| Manufacturer | ENERCON |
| Type | microprocessor |
| Grid connection | Via ENERCON inverter |
| Remote communication | ENERCON Remote Monitoring System |
| UPS | included |

| **Braking System** | |
|---|---|
| Aerodynamic brake | - three independent blade pitch systems with emergency supply<br>- rotor brake<br>- rotor lock, locking at 30° |

| **Tower** | | | |
|---|---|---|---|
| Hub heights | 99 m | 135 m | |
| Tower | Prefab concrete | Prefab concrete | |
| Design Wind Class | **IIA** | **IIA** | |

*Sources: Design Assessment*



| | | | |
|---|---|---|---|
| Created/Date: | M. Lüninghöner | Checked: | AH/09/2009 |
| Dpt.: | SL_HB | Approved: | SL_HB_WEC Characteristics_E-101_Rev001_eng-eng.doc |
| Revision: | 001/31.03.2010 | Reference : | |

KÖTTER CONSULTING ENGINEERS

## Vorläufiger Auszug aus dem Prüfbericht

**Stammblatt "Geräusche", entsprechend den *"Technischen Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"***

Rev. 18 vom 01 Februar 2008 (Herausgeber: Fördergesellschaft Windenergie e.V. Stresemannplatz 4, D-24103 Kiel)

Auszug aus dem Prüfbericht 213121-01.01
zur Schallemission einer Windenergieanlage vom Typ E-101

| Allgemeine Angaben | | Technische Daten (Herstellerangaben) | |
|---|---|---|---|
| Anlagenhersteller | Enercon GmbH | Nennleistung (Generator): | 3.0 (3.25) MW |
| Seriennummer: | 1010002 | Rotordurchmesser: | 101 m |
| WEA-Standort (ca.): | 49733 Haren | Nabenhöhe über Grund: | 99 m |
| Standortkoordinaten: | RW: 25.76.214 | Turmbauart: | Beton |
| | HW: 58.59.856 | Leistungsregelung: | Pitch |
| **Ergänzende Daten zum Rotor (Herstellerangaben)** | | **Ergänzende Daten zu Getriebe und Generator (Herstellerangaben)** | |
| Rotorblatthersteller | Enercon | Getriebehersteller | entfällt |
| Typenbezeichnung Blatt: | E-101-1 | Typenbezeichnung Getriebe: | entfällt |
| Blatteinstellwinkel: | variabel | Generatorhersteller | Enercon |
| Rotorblattanzahl: | 3 | Typenbezeichnung Generator: | G-101/30-G2 |
| Rotordrehzahlbereich: | 5 - 14,7 U/min | Generatornenndrehzahl: | 14,7 U/min |

Leistungskurve: Leistungskennlinie E101 3 MW OM I (berechnet) der Enercon GmbH zur E-101 vom 05.07.2012

| | Referenzpunkt: Normierte Windgeschwindigkeit in 10 m Höhe | Referenzpunkt: Elektrische Wirkleistung | Schallemissions-Parameter | Bemerkungen |
|---|---|---|---|---|
| Schallleistungs-Pegel $L_{WA,P}$ | 6 $ms^{-1}$ | 1.414 kW | 103,6 dB(A) | |
| | 7 $ms^{-1}$ | 2.077 kW | 104,3 dB(A) | |
| | 8 $ms^{-1}$ | 2.751 kW | 104,7 dB(A) | |
| | 9 $ms^{-1}$ | 2.987 kW | 104,6 dB(A) | |
| | 10 $ms^{-1}$ | 3.050 kW | -- dB(A) | (2) |
| | *8,3 $ms^{-1}$* | *2.850 kW* | *104,8 dB(A)* | *(1)* |
| Tonzuschlag für den Nahbereich $K_{TN}$ | 6 $ms^{-1}$ | 1.414 kW | 0 dB bei 116 Hz | |
| | 7 $ms^{-1}$ | 2.077 kW | 0 dB | |
| | 8 $ms^{-1}$ | 2.751 kW | 0 dB | |
| | 9 $ms^{-1}$ | 2.987 kW | 0 dB | |
| | 10 $ms^{-1}$ | 3.050 kW | -- dB | (2) |
| | *8,3 $ms^{-1}$* | *2.850 kW* | *0 dB* | *(1)* |
| Impulszuschlag für den Nahbereich $K_{IN}$ | 6 $ms^{-1}$ | 1.414 kW | 0 dB | |
| | 7 $ms^{-1}$ | 2.077 kW | 0 dB | |
| | 8 $ms^{-1}$ | 2.751 kW | 0 dB | |
| | 9 $ms^{-1}$ | 2.987 kW | 0 dB | |
| | 10 $ms^{-1}$ | 3.050 kW | -- dB | (2) |
| | *8,3 $ms^{-1}$* | *2.850 kW* | *0 dB* | *(1)* |

**Terz-Schallleistungspegel** für $v_s$ = 8,3 $ms^{-1}$ in dB(A) entsprechend dem maximalen Schallleistungspegel

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,max}$ | 78,8 | 82,1 | 82,7 | 84,4 | 88,4 | 86,7 | 90,0 | 94,8 | 95,0 | 95,6 | 96,3 | 96,2 |
| Frequenz | 800 | 1.000 | 1.250 | 1.600 | 2.000 | 2.500 | 3.150 | 4.000 | 5.000 | 6.300 | 8.000 | 10.000 |
| $L_{WA,P,max}$ | 95,0 | 93,3 | 91,5 | 90,4 | 86,6 | 85,4 | 83,7 | 80,8 | 75,8 | 69,7* | 67,1** | 65,5** |

**Oktav-Schallleistungspegel** für $v_s$ = 8,3 $ms^{-1}$ in dB(A) entsprechend dem maximalen Schallleistungspegel

| Frequenz | 63 | 125 | 250 | 500 | 1.000 | 2.000 | 4.000 | 8.000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,max}$ | 86,3 | 91,6 | 98,6 | 100,8 | 98,3 | 92,8 | 85,9 | 73,3** |

Dieser Auszug aus dem Prüfbericht gilt nur in Verbindung mit der Herstellerbescheinigung vom 13.03.2013.

**Die Angaben ersetzen nicht den o. g. Prüfbericht (insbesondere bei Schallimmissionsprognosen).**

Bemerkungen:
- (1) Die normierte Windgeschwindigkeit von $v_s$ = 8,3 $ms^{-1}$ entspricht 95 % der Nennleistung.
- (2) Witterungsbedingt keine Daten vorhanden
- * Abstand zwischen Anlagengeräusch und Fremdgeräusch < 6 dB, Pegelkorrektur um 1,3 dB
- ** Abstand zwischen Anlagengeräusch und Fremdgeräusch < 3 dB, keine Pegelkorrektur

Gemessen durch: KÖTTER Consulting Engineers GmbH & Co. KG

Datum: 13.03.2013 — i. V. Dipl.-Ing. Oliver Bunk — i. A. Matthias Humpohl, B. Sc.

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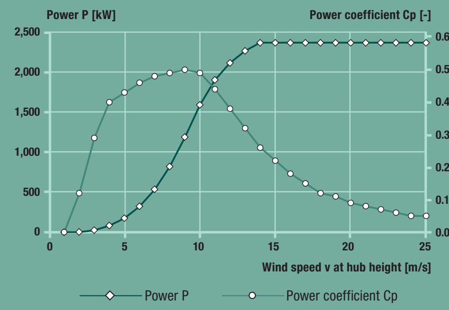
# E82

## 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 |

ρ = 1.225 kg/m³

For more information on the ENERCON power curve, please see the 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 |
| **WEC 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>Built-in lightning protection |
| Rotational speed: | Variable, 6 – 18 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 feed:** | ENERCON inverter |
| **Brake systems:** | – 3 independent pitch control systems with emergency power supply<br>– Rotor brake<br>– Rotor lock |
| **Yaw system:** | Active via yaw gear, load-dependent damping |
| **Cut-out wind speed:** | 28 – 34 m/s (with ENERCON storm control*) |
| **Remote monitoring:** | ENERCON SCADA |

* For more information on the ENERCON storm control feature, please see the last page.


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

# WIND ENERGY CONVERTER CHARACTERISTICS

## E-82 E2 2.3MW

| Rotor | |
|---|---|
| Type | E82 E2 |
| Rotor diameter | 82 m |
| Swept area | 5281 $m^2$ |
| Power regulation | Pitch |
| RPM | 6 –18 $min^{-1}$ |
| Cut in wind | 2,5 m/s |
| Cut out wind | 28 – 34 m/s |
| Survival wind speed | 59,5 m/s |

| Gear Box | |
|---|---|
| Not applicable | No gearbox |

| Blades | |
|---|---|
| Manufacturer | ENERCON |
| Blade length | 38,8 m |
| Material | GRP (Epoxy) |
| Lightning protection | included |

| Generator | |
|---|---|
| Manufacturer | ENERCON |
| Nominal Power | 2300 kW |
| Type (model) | Synchronous, direct-drive ringgenerator |
| Protection classification | IP 23 |
| Insulation class | F |

| Yaw System | |
|---|---|
| Type | 6 electrical motors |
| Yaw control | Active (based on wind vane signal) |
| Yaw rate | 0,5°/sec |

| Controller | |
|---|---|
| Manufacturer | ENERCON |
| Type | microprocessor |
| Grid connection | Via ENERCON inverter |
| Remote communication | ENERCON Remote Monitoring System |
| UPS | included |

| Braking System | |
|---|---|
| Aerodynamic brake | - three independent blade pitch systems with emergency supply<br>- rotor brake<br>- rotor lock, locking at 30° |

| **Tower** | | | | | |
|---|---|---|---|---|---|
| Hub heights | 78 m | 85 m | 98 m | 108 m | 138 m |
| Tower | Steel (4 + FS) | Steel + Prefab concrete (2 + 15) | Steel + Prefab concrete (2 + 18) | Steel + Prefab concrete (2 + 21) | Steel + Prefab concrete (2 + 21) |
| Design Wind Class | **II** | **II** | **II** | **II** | **II** |

| **Weights** | |
|---|---|
| Nacelle, excl. Rotor and hub | Approx. 18 to |
| Rotor incl. Hub/Main pin | Approx. 55 to |
| Generator | Approx. 62 to |
| **Total Weight** | **Approx. 135 to** |

*Sources: Design Assessment, Manufacturers Certificate*

KÖTTER CONSULTING ENGINEERS

## Summary of Test Report
## (Measured hub height of 108 m) /1/

**Basic sheet "Geräusche" (*Noise*), according to the**
**"Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"**
***(Technical Guidelines for Wind Energy Converters, Part 1: Determination of sound emission values)***

Rev. 18 of February 1, 2008 (Editor: Fördergesellschaft Windenergie e.V. Stresemannplatz 4, D-24103 Kiel)

Extract of Test Report 209244-04.01 IEC
on noise emission of wind energy converter of type E-82 E2

| **General Data** | | **Technical Data (manufacturer's specifications)** | |
|---|---|---|---|
| Manufacturer of WEC: | Enercon GmbH | Rated power (generator): | 2.300 kW |
| Serial number: | 82679 | Diameter of rotor: | 82 m |
| Location of WEC (ca.): | 26629 Großefehn | Hub height above ground: | 108 m |
| Geographic co-ordinates: | GK longitude: 34.15.287 | Type of tower: | conical tube tower |
| | GK latitude: 59.14.701 | Power control: | Pitch |
| **Complementary rotor data (manufacturer's specifications)** | | **Complementary data of gear unit and generator (manufacturer's specifications)** | |
| Manufacturer of rotor blade: | Enercon | Manufacturer of gear unit: | not applicable |
| Type of rotor blade: | E-82 E2 | Type of gear unit: | not applicable |
| Blade setting angle: | variable | Manufacturer of generator: | Enercon |
| Number of rotor blades: | 3 | Type of generator: | E-82 E2 |
| Rotor speed range: | 6 to 18 r.p.m. (mode OM I) | Generator speed range: | 6 to 18 r.p.m. (mode OM I) |

Calculated Performance Chart ENERCON E-82 E2; calculated by ENERCON (Rev. 3.0)

| | **Reference Point** | | **Noise emission parameters** | **Observations** |
|---|---|---|---|---|
| | standardized wind speed in 10 m height | true electrical power | | |
| sound power level $L_{WA,P}$ | 5 $ms^{-1}$ | 579 kW | 96.4 dB(A) | |
| | 6 $ms^{-1}$ | 1,089 kW | 100.6 dB(A) | |
| | 7 $ms^{-1}$ | 1,612 kW | 102.5 dB(A) | |
| | 8 $ms^{-1}$ | 2,032 kW | 103.2 dB(A) | |
| | 9 $ms^{-1}$ | 2,255 kW | 103.3 dB(A) | |
| | 10 $ms^{-1}$ | 2,300 kW | 102.9 dB(A) | |
| tonal audibility $\Delta L_{a,k}$ | 5 $ms^{-1}$ | kW | - 2.7 dB | |
| | 6 $ms^{-1}$ | kW | <- 3.0 dB | |
| | 7 $ms^{-1}$ | kW | - 1.8 dB | |
| | 8 $ms^{-1}$ | kW | - 0.7 dB | |
| | 9 $ms^{-1}$ | kW | 0.2 dB | |
| | 10 $ms^{-1}$ | kW | - 0.4 dB | |
| impulse adjustment for small distances $K_{IN}$ | 5 $ms^{-1}$ | kW | 0 dB | |
| | 6 $ms^{-1}$ | kW | 0 dB | |
| | 7 $ms^{-1}$ | kW | 0 dB | |
| | 8 $ms^{-1}$ | kW | 0 dB | |
| | 9 $ms^{-1}$ | kW | 0 dB | |
| | 10 $ms^{-1}$ | kW | 0 dB | |

**Third-octave band sound power level** for $v_s$ = 5 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 74.1 | 76.5* | 80.0 | 85.6 | 82.2 | 81.7 | 81.9 | 83.7 | 85.6 | 85.1 | 85.5 | 87.6 |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 86.9 | 86.2 | 84.8 | 82.4 | 78.8 | 75.3 | 70.6 | 65.5 | 60.3* | 60.3* | 63.0 | 70.3 |

**Octave band sound power level** for $v_s$ = 5 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 82.3 | 88.3 | 88.8 | 91.0 | 90.8 | 84.5 | 72.1 | 71.4 |

**Third-octave band sound power level** for $v_s$ = 6 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 78.2** | 79.1* | 82.2 | 85.2 | 87.4 | 84.3 | 85.0 | 87.3 | 88.7 | 88.5* | 89.5* | 93.2 |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 91.7 | 91.5 | 89.9 | 87.1 | 83.0 | 79.4 | 74.4 | 69.0 | 63.5 | 64.4 | 67.4 | 74.3 |

**Octave band sound power level** for $v_s$ = 6 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 84.9* | 90.6 | 92.0 | 95.7 | 95.9 | 89.0 | 75.8 | 75.4 |

**Third-octave band sound power level** for $v_s$ = 7 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 78.6** | 79.8 | 82.7 | 84.8 | 90.8 | 86.2 | 86.0 | 89.7 | 91.0 | 92.5 | 91.7 | 93.9 |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 93.4 | 93.3 | 91.8 | 89.2 | 85.8 | 81.9 | 77.0 | 72.2 | 66.1 | 65.3 | 66.8 | 72.8 |

**Octave band sound power level** for $v_s$ = 7 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 85.5* | 92.8 | 94.2 | 97.6 | 97.7 | 91.4 | 78.5 | 74.4 |

**Third-octave band sound power level** for $v_s$ = 8 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 77.4* | 80.4 | 83.1 | 84.9 | 91.2 | 86.6 | 86.3 | 90.4 | 91.4 | 92.9 | 92.1* | 94.8 |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 94.2 | 94.1 | 92.6 | 90.1 | 86.7 | 82.7 | 77.8 | 73.3 | 67.7 | 65.8 | 66.6 | 71.4 |

**Octave band sound power level** for $v_s$ = 8 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 85.6 | 93.2 | 94.6 | 98.2 | 98.5 | 92.2 | 79.4 | 73.4 |

**Third-octave band sound power level** for $v_s$ = 9 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 78.5 | 81.4 | 83.9 | 85.7 | 92.6 | 88.2 | 86.4 | 90.2 | 90.7 | 91.8 | 91.5* | 93.9 |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 94.0 | 94.4 | 93.4 | 91.5 | 88.4 | 84.6 | 79.9 | 75.4 | 69.3 | 65.5* | 66.4 | 71.5 |

**Octave band sound power level** for $v_s$ = 9 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 86.6 | 94.6 | 94.3 | 97.3* | 98.7 | 93.8 | 81.5 | 73.4 |

**Third-octave band sound power level** for $v_s$ = 10 $ms^{-1}$ in dB(A)

| Frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 78.8 | 81.7 | 84.5 | 86.3 | 92.4 | 88.5 | 86.4 | 89.8 | 90.0* | 91.2 | 90.9* | 92.7* |
| Frequency | 800 | 1,000 | 1,250 | 1,600 | 2,000 | 2,500 | 3,150 | 4,000 | 5,000 | 6,300 | 8,000 | 10,000 |
| $L_{WA,P}$ | 93.3 | 93.9 | 93.3 | 91.5 | 88.8 | 85.2 | 80.7 | 76.5 | 71.9 | 70.4 | 68.5 | 71.8 |

**Octave band sound power level** for $v_s$ = 10 $ms^{-1}$ in dB(A)

| Frequency | 63 | 125 | 250 | 500 | 1,000 | 2,000 | 4,000 | 8,000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P}$ | 87.0 | 94.6 | 93.7 | 96.5* | 98.3 | 94.0 | 82.5 | 75.2 |

This summary of the test report is valid only in combination with the certification of the manufacturer of 03/05/2010.

**These specifications do not replace the test report mentioned above (particularly for noise immission predictions).**

Observations: * Difference between working and background noise < 6 dB, correction by 1.3 dB

** Difference between working and background noise < 3 dB, values shall not be presented

/1/ Wind turbine generator systems – Part 11: Acoustic noise; measurement techniques (IEC 61400-11:2002 and A1:2006); German version DIN EN 61400-11:2007

Measured by: KÖTTER Consulting Engineers
- Rheine -

Date: 08/02/2010

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