
ENERCON
The experience of a multipole wind turbine manufacturer
Nuno Miguel Taveira
ENERCON Sales-Tech. Support

Topics of the presentation

- **Introduction to ENERCON**
- **ENERCON production facilities**
- **First concept of ENERCON wind turbines**
- **Main exchanges in our history:**
  - **New concept of ENERCON wind turbines**
  - **Remote Managment & Comunication system**
  - **New rotor blade design**
  - **Introduction of the concrete tower type**
  - **Customer relation management**
- **Impact on Grid Codes**

ENERCON GmbH - Introduction
Since 1984…

1984 — Founding of ENERCON GmbH

1991 — Development of ENERCON's gearless generator design

1993-1998 — New production facilities in Magdeburg, India, Brazil, as well as serial production of E-30,E-40, E-66 and installation of first desalination plant

2004 — Installation of first E-70 with 2 MW and new rotor blade design

2005 — New precast concrete tower facility in Emden

2006 — Commissioning of E-20 / E-53 prototypes, further development of E-112 to E-126

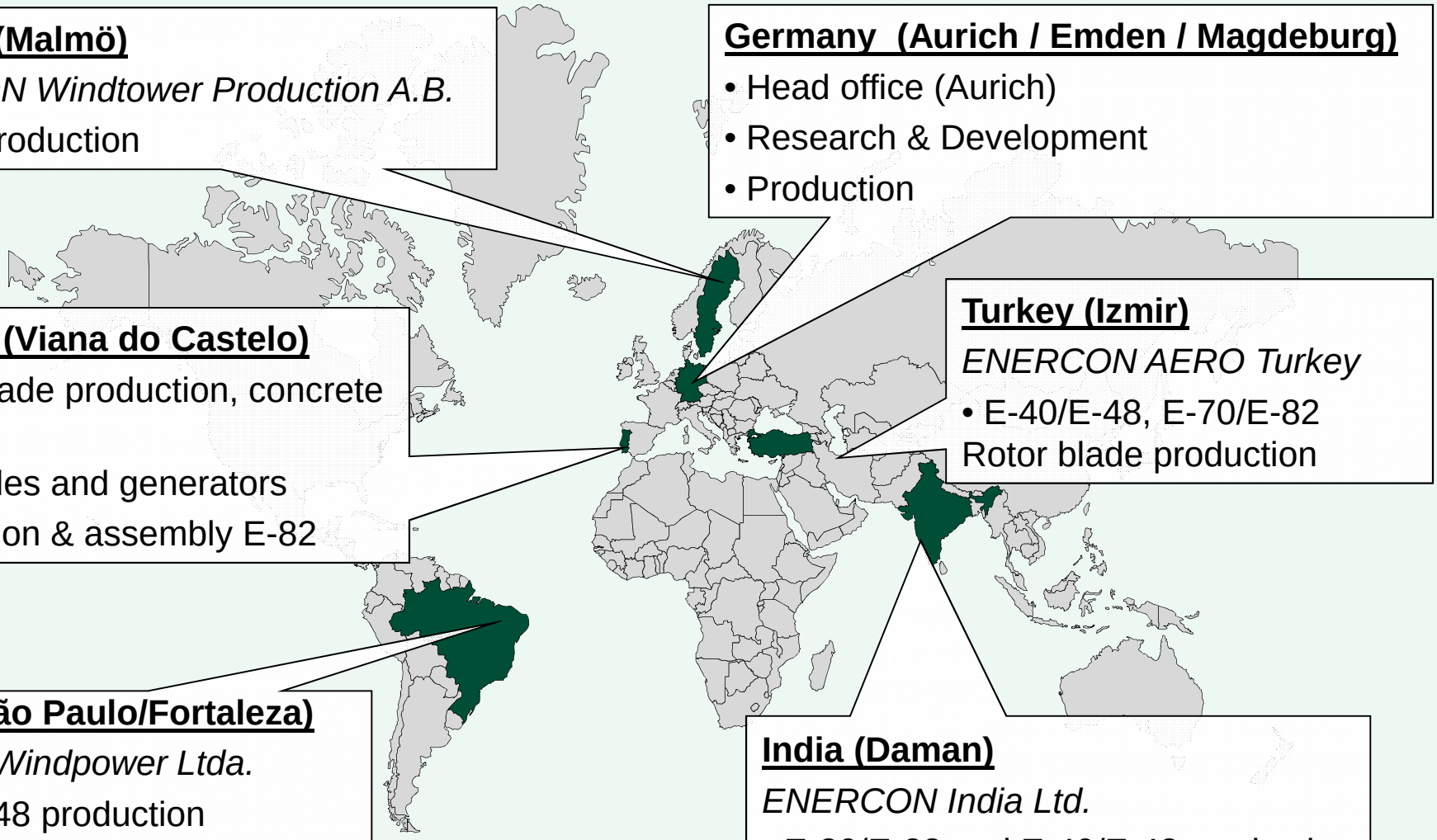
2007 — New production site in Portugal and installation of E-126 (6 MW) prototype

2008 — Launching and christening E-Ship 1

ENERCON
Own experience from serial production

- **Generator**
- **Rotor blades**
- **Hub (mechanical components)**
- **Tower (steel / concrete)**
- **Electronics components**
- **Foundation**
- **Grid connection**

ENERCON production facilities worldwide
Germany/Portugal/Turkey/Sweden/India/Brazil



Sweden (Malmö)

ENERCON Windtower Production A.B.

- Tower production

Germany (Aurich / Emden / Magdeburg)

- Head office (Aurich)
- Research & Development
- Production

Portugal (Viana do Castelo)

- Rotor blade production, concrete towers,
- E-modules and generators
- Production & assembly E-82

Turkey (Izmir)

ENERCON AERO Turkey

- E-40/E-48, E-70/E-82 Rotor blade production

Brazil (São Paulo/Fortaleza)

Wobben Windpower Ltda.

- E-40/E-48 production
- E-70 rotor blade production

India (Daman)

ENERCON India Ltd.

- E-30/E-33 and E-40/E-48 production

ENERCON production facilities worldwide
Germany/Portugal/Turkey/Sweden/India/Brazil

Rotor blade production
8 facilities worldwide

Generator production
5 facilities worldwide

Electronics
4 facilities worldwide

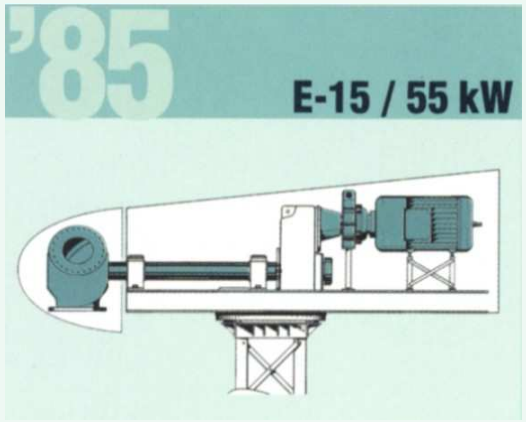
Tower production
5 facilities worldwide

Assembly
5 facilities worldwide

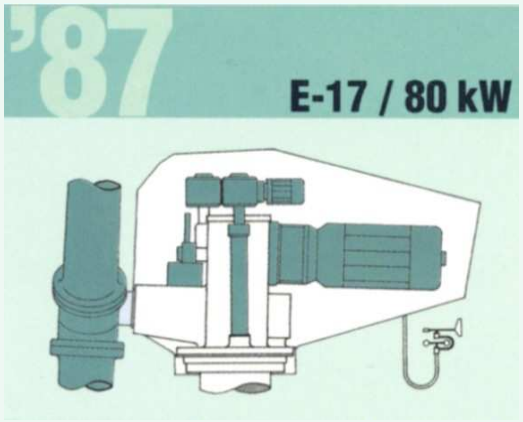
Total production area
approx. 450.000 m2
(from 2008)

= approx. 47 SOCCER PITCHES

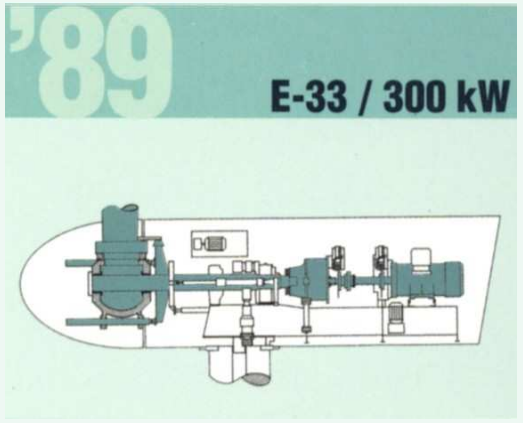
ENERCON technology
ENERCON old concept on E15 / E17 / E32



- Variable speed
- 1985 - 1989: 45 units



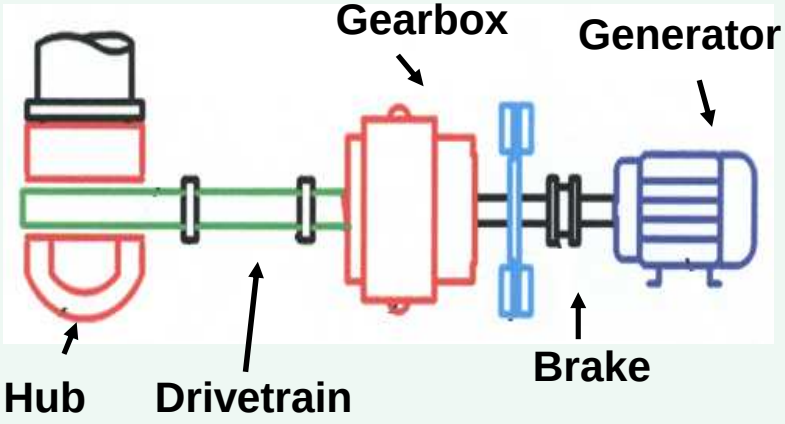
- Variable speed
- Compact design
- 1987- 1994: 156 units

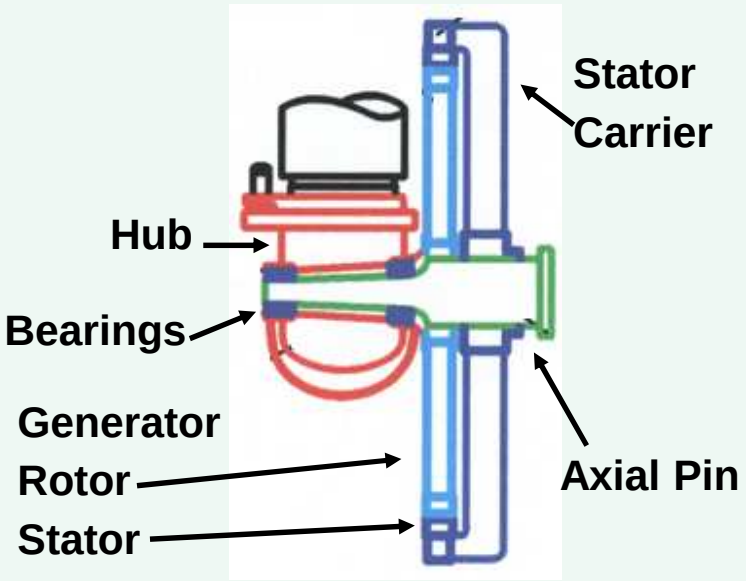


- Variable speed
- Pitch regulation
- 1989- 1993: 187 units

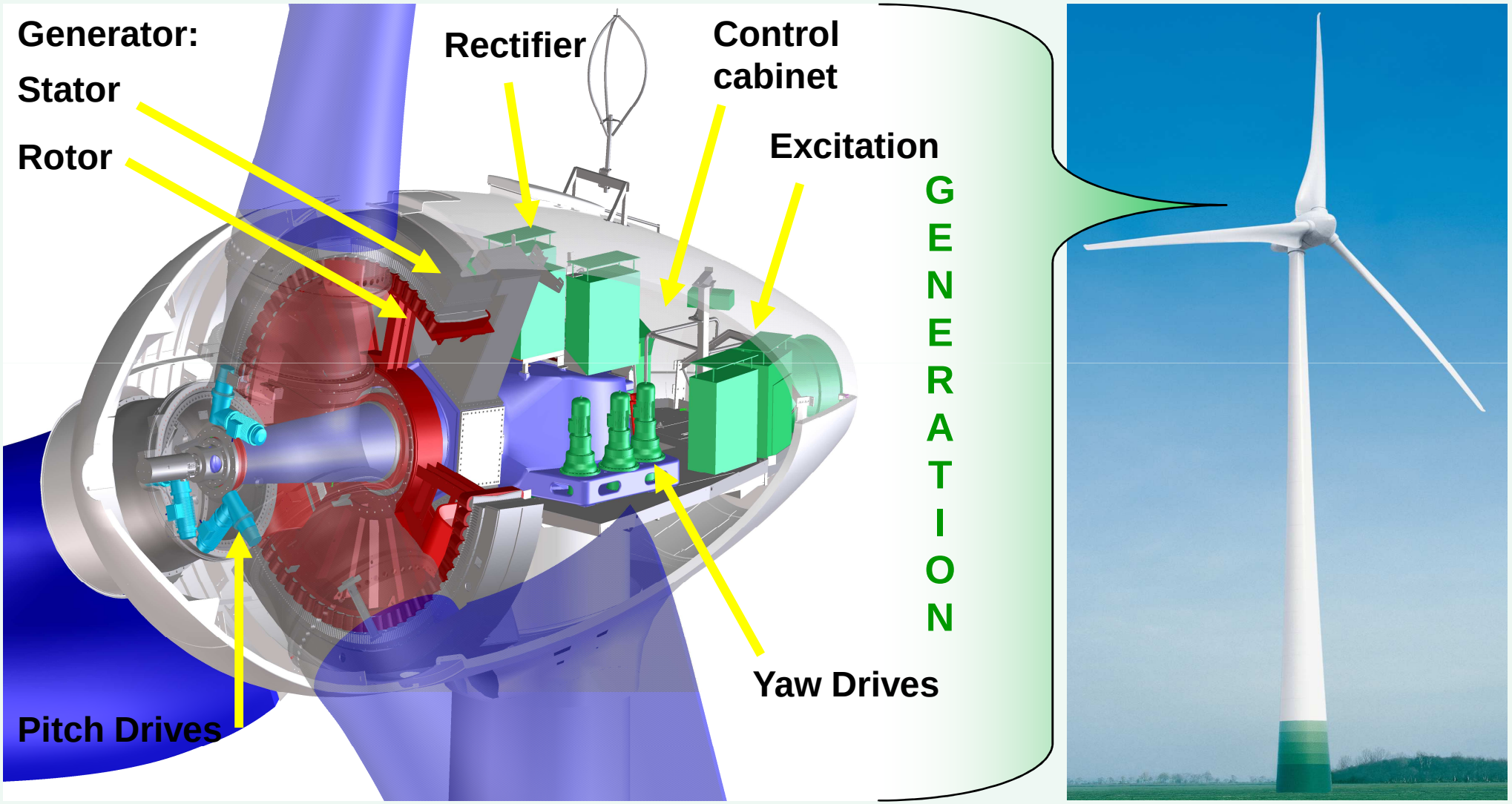
ENERCON's target:

- **Create one realiable and robust wind turbine concept that can be easilly**
  - **increase the power output**
  - **everytime updated with the most demandings Grid Codes**
- **New concept of Wind turbine: direct drive, no gearbox and own generator project**

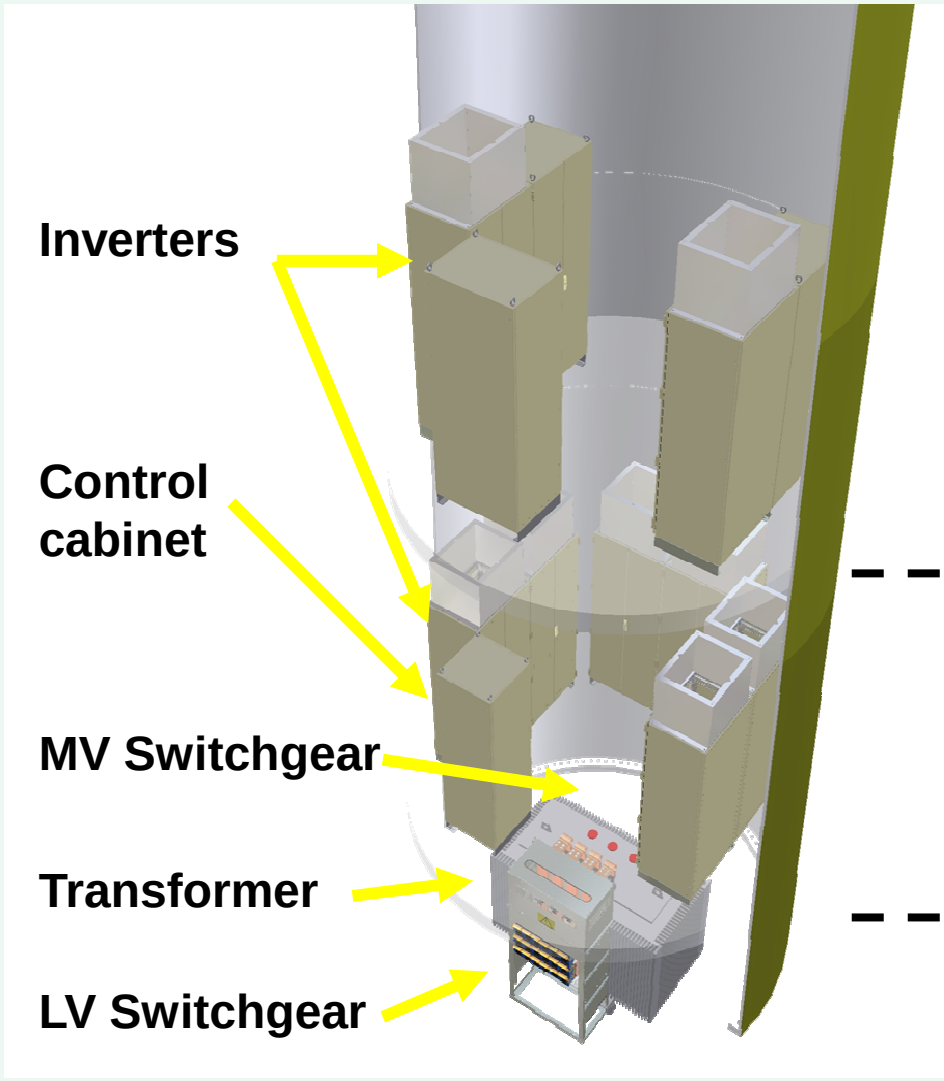




Main exchanges
Wind turbine concept (I): Gearless drive and variable speed



Main exchanges
Wind turbine concept (I): Full scale power electronics

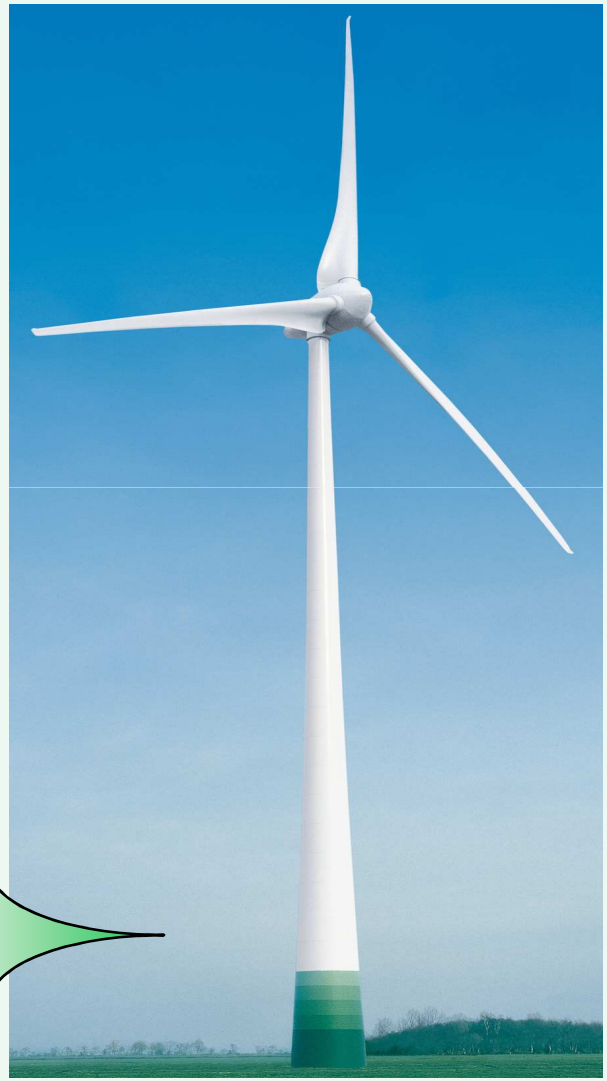


Level 2

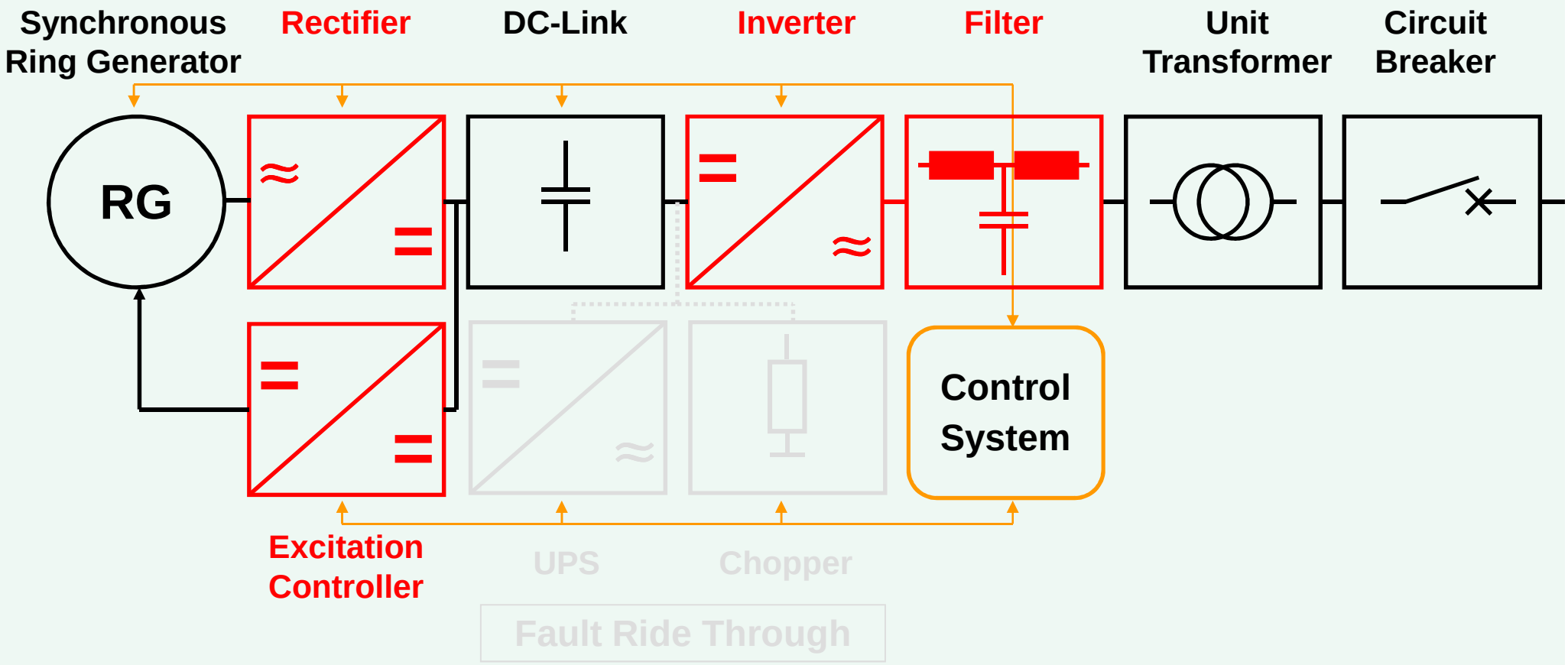
Level 1

Level 0

CONVERSION



Main exchanges
Wind turbine concept (I): Block diagram

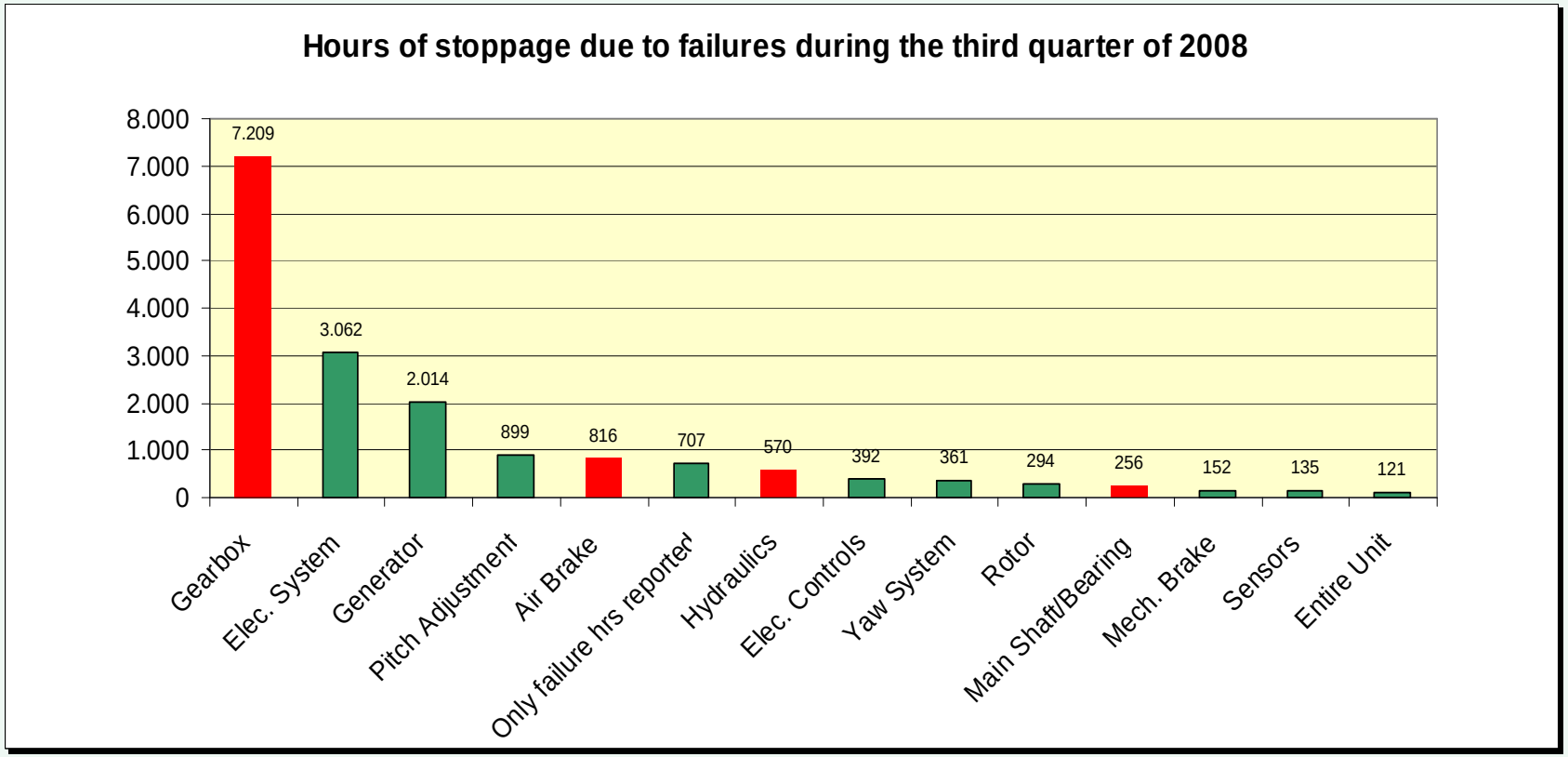


The power electronic devices play a major role in the actual ENERCON wind energy converters.

Main exchanges
Wind turbine concept (I): Advantages

- ✓ **Direct Drive Concept**
  No Gearbox
- ✓ **Variable speed operation**
- ✓ **Slow machine rotation means low wear**
- ✓ **Low machine stress due to high level of speed variability**
- ✓ **Yield-optimised blade design and WEC control**
- ✓ **High hub heights for increased steady yield**
- ✓ **Full scale power electronics for power plant capabilities**
- ✓ **FACTS Capabilities meet the most advanced grid codes and connection requirements**

Off-times of Wind Turbines in Germany
Data from failures in the components

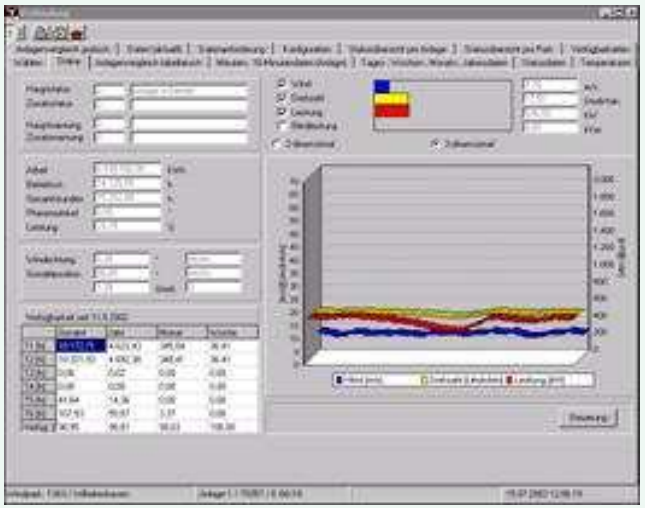


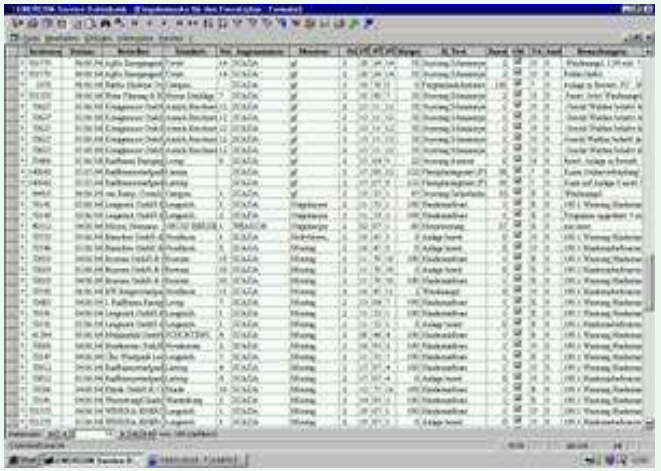
Source: Windstats Newsletter. Autumn 2008. Vol. 21, No. 4

Can be expect ~50% less down-time due to failures with ENERCON turbines!

The ENERCON SCADA SYSTEM:

- Developed by ENERCON was launched in 1998
- Used in more than 13,000 wind turbines worldwide.
- Data acquisition, remote monitoring, and open-loop and closed-loop control for wind farms.
- It enables the customer and ENERCON Service to monitor the operating state and to analyse stored operating data.
- Authorised users may use it to modify the operating parameters of the wind turbines and the grid connection

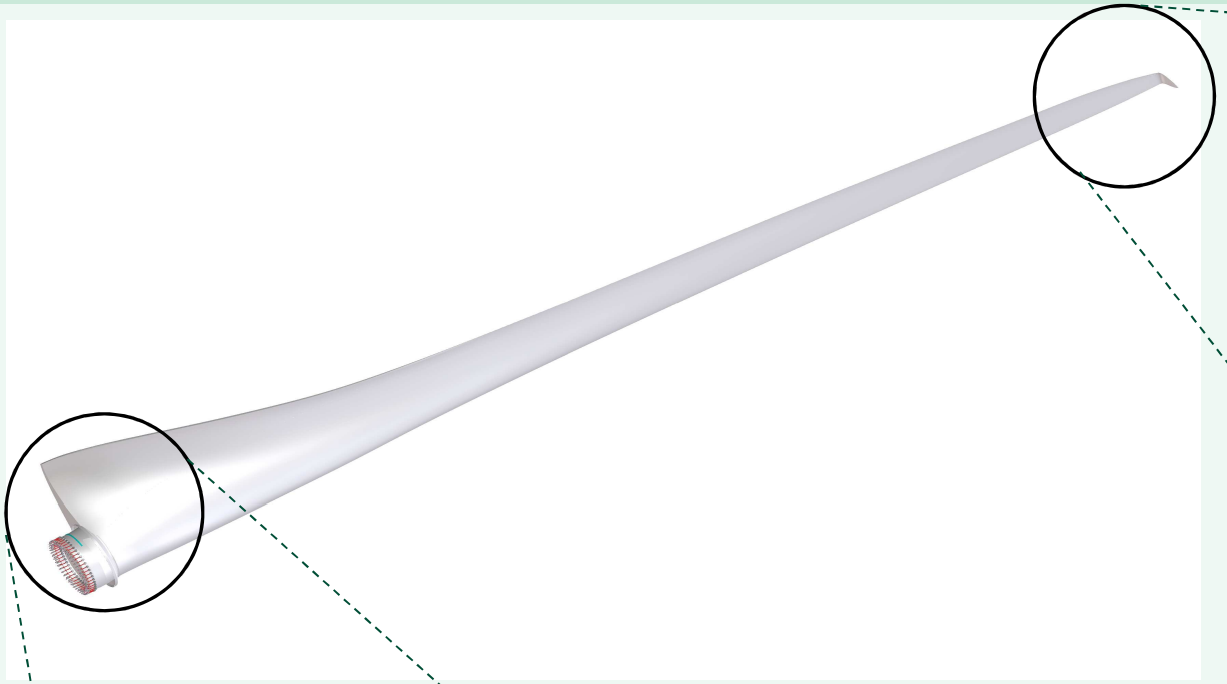




Improvements in the last years:

- Fibre-optics cabling instead of copper cables;
- OPC interface with LINUX OS (reliable and more user-friendly);
- SCADA Interfaces with different protocols used by customers and System operators (connection to dispatch centers);

Main exchanges
New blade design (III)



- ✓ **Higher efficiency due to the modified blade design:**
  - ✓ **The wind turbines reach a maximum Cp of 0.516 (51.6%) (highest Cp ever measured)**
- ✓ **Less noise emission due to optimised blade tips**
- ✓ **Longer service life due to reduced stress**
- ✓ **Transport facilitated due to streamlined blade design**

- ✓ **Production features: Vacuum infusion and sandwich technique**

Main exchanges
Introduction of concrete tower type (IV)

Installation inside concrete towers

- Higher tower heights compared to a steel tower;
- Less vibrations and oscillations as the steel tower and as a result slightly higher energy yield;
- Smoother running of the wind turbine, no drone (resonating body);
- No corrosion effects;
- Less maintenance;
- Less dependance on the steel;
- Higher availability due to more ENERCON production facilities;

Main exchanges
Customer Relation Managment (V)

Concept of **partnership** Customer-ENERCON Service during the time life of the Wind Turbines means:

ENERCON PartnerKonzept (EPK)

- **ENERCON guarantee of at least 97 % technical availability of the Wind Farm;**
- **Profit-oriented cost structure (calculable operating costs);**
- **Term of contract up to 15 years;**
- **Remote control (24 h) by ENERCON SCADA;**
- **Predictive Maintenance (Visual, Electric and Greasing);**
- **Unscheduled maintenance (Faults);**
- **Reparation**;
- **Maintenance and Repairs only done by ENERCON Service teams;**

More than 90% of the O&M contracts are EPK contracts (full maintenance)!

Customer Relation Managment (V)

BWE (German Wind Association) – service survey customer satisfaction

Results of the 2008 survey on service

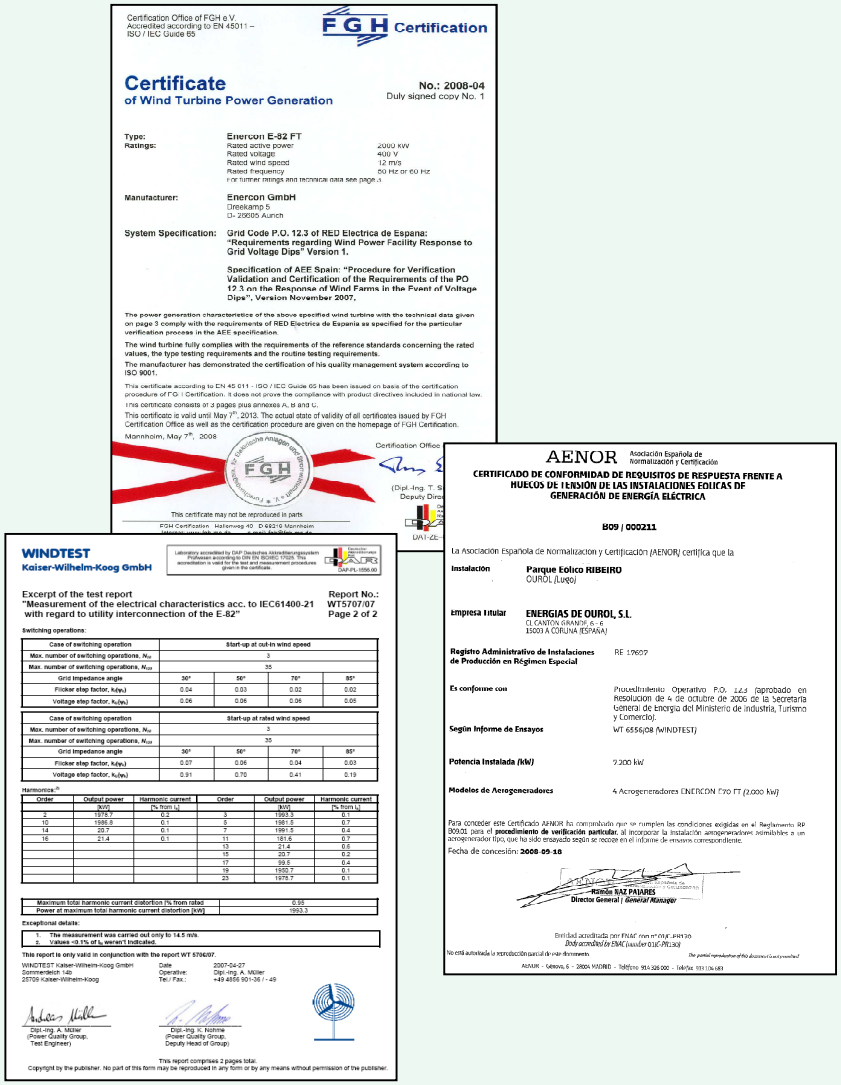
Manufacturer		Enercon			Repower Systems			Vestas			Nordex			Siemens			GE Energy		
Overall score	**100%**	**Good (1.82)**			**Satisfactory (2.65)**			**Satisfactory (3.07)**			**Satisfactory (3.43)**			**Satisfactory (3.43)**			**Adequate (3.54)**		
Basis Questionnaires		246			17			130			33			34			49		
		26	45	175	8	6	3	5	16	109	3	3	27	1	5	24	2	4	43
Number of turbines		738			37			571			86			108			191		
		82	182	474	22	7	8	33	78	460	9	10	67	4	14	80	9	29	153
	Weighting	W	<6	≥6	W	<6	≥6	W	<6	≥6	W	<6	≥6	W	<6	≥6	W	<6	≥6
Routine maintenance	33.3%	Good (1.98)			Satisfactory (2.65)			Satisfactory (2.77)			Satisfactory (3.06)			Satisfactory (3.23)			Satisfactory (3.06)		
Previous year		2.06			2.43			3.31			2.89			3.15			3.20		
1. Scheduling and appointments		1.88	1.82	1.87	3.88	1.83	2.00	3.80	2.81	2.94	2.33	3.33	2.89	3.00	4.60	2.63	2.50	3.00	2.79
2. Quality of work performed		1.73	1.44	1.50	2.88	1.83	1.67	2.00	2.20	2.53	2.67	3.00	2.93	1.00	3.60	2.79	2.50	3.00	2.84
3. Feedback regarding maintenance (Activity reports, protocols)		2.42	2.42	2.46	3.13	2.00	2.67	2.80	2.44	2.87	2.67	2.67	2.67	2.00	4.00	3.04	3.00	3.25	3.00
4. Satisfaction with cost-performance ratio		2.32	2.36	2.02	3.38	2.33	2.33	2.00	2.73	2.91	2.33	3.33	4.00	2.00	5.60	4.46	3.00	4.25	3.53
Unscheduled corrective maintenance or repairs	33.3%	Good (1.80)			Satisfactory (2.69)			Satisfactory (2.83)			Satisfactory (3.03)			Satisfactory (3.29)			Satisfactory (3.13)		
Previous year		1.89			2.53			3.26			2.99			3.09			3.18		
5. Accessibility of service team		1.96	1.78	1.49	3.63	2.00	2.00	2.40	2.81	2.89	2.67	2.00	2.22	2.00	4.00	2.79	2.00	2.50	2.28
6. Speed of repairs of parts critical for operation		1.73	1.38	1.43	3.63	2.17	1.67	2.20	2.88	3.05	3.00	3.67	3.22	1.00	4.60	3.42	2.00	2.75	3.26
7. Speed of repairs of other parts		1.81	1.53	1.68	3.38	2.17	2.33	2.40	2.81	3.09	3.00	3.33	3.59	1.00	4.80	3.63	2.50	3.00	3.77
8. Quality of work performed		1.73	1.47	1.56	3.00	1.83	1.67	2.20	2.44	2.51	2.33	3.33	2.93	2.00	3.40	2.96	2.00	3.00	2.86
9. Feedback regarding work performed (Activity reports, protocols)		2.42	2.36	2.41	3.00	2.00	2.67	2.40	2.44	2.65	2.67	2.33	2.85	2.00	4.00	3.13	3.00	2.75	2.72
10. Satisfaction with cost-performance ratio		2.32	2.40	2.01	3.50	2.33	2.33	2.00	2.63	3.07	2.33	3.33	3.63	2.00	5.20	4.54	3.00	4.25	4.14
Extra services	33.3%	Good (1.68)			Satisfactory (2.62)			Adequate (3.62)			Adequate (4.19)			Adequate (3.76)			Adequate (4.43)		
Previous year		1.81			2.68			3.93			3.68			3.83			4.13		
11. Discretionary improvements (updates, etc.)		1.85	1.64	1.54	2.88	2.17	2.33	3.20	2.69	3.26	3.33	4.33	4.42	2.00	4.40	3.67	2.50	4.50	4.57
12. Willingness to meet costs		1.85	1.86	1.73	3.25	2.20	2.33	3.60	3.93	4.08	3.67	3.33	4.19	2.00	5.60	4.08	3.00	4.75	4.40

Source: New Energy magazine. April 2009. No. 2

Impact on the grid codes
ENERCON technology

ENERCON wind energy technology for efficient power feed

- ✓ Intelligent and flexible grid management system;
  - ✓ **Active power control**
  - ✓ **Wide voltage and frequency ranges;**
  - ✓ **Power-frequency control**
  - ✓ **Reactive power managment**
- ✓ ENERCON first company to obtain certification for WECs with power plant properties
  - ✓ **Support to the grid during short circuits, bottlenecks and other grid faults;**
- ✓ WEC and Grid connection monitoring through ENERCON SCADA;



Certification Office of FGH e.V.
Accredited according to EN 45011 – ISO / IEC Guide 65

FGH Certification

Certificate
of Wind Turbine Power Generation

No.: 2008-04
Duly signed copy No. 1

Type: Enercon E-82 FT
Ratings: Rated active power 2000 kW
Rated voltage 400 V
Rated wind speed 12 m/s
Rated frequency 50 Hz or 60 Hz

Manufacturer: Enercon GmbH
Dreekamp 5
D- 26605 Aurich

System Specification: Grid Code P.O. 12.3 of REE Electrica de Espana: "Requirements regarding Wind Power Facility Response to Grid Voltage Dips" Version 1.

Specification of AEE Spain: "Procedure for Verification Validation and Certification of the Requirements of the PO 12.3 on the Response of Wind Farms in the Event of Voltage Dips", Version November 2007.

The power generation characteristics of the above specified wind turbine with the technical data given on page 3 comply with the requirements of REE Electrica de Espania as specified for the particular verification process in the AEE specification.

The wind turbine fully complies with the requirements of the reference standards concerning the rated values, the type testing requirements and the routine testing requirements.

The manufacturer has demonstrated the certification of his quality management system according to ISO 9001.

This certificate according to EN 45 011 - ISO / IEC Guide 65 has been issued on basis of the certification procedure of FGH Certification. It does not prove the compliance with product directives included in national law.

This certificate consists of 3 pages plus annexes A, B and C.

This certificate is valid until May 7th, 2013. The actual state of validity of all certificates issued by FGH Certification Office as well as the certification procedure are given on the homepage of FGH Certification.

Mannheim, May 7th, 2008

Certification Office

This certificate may not be reproduced in parts

FGH Certification · Hallenweg 40 · D-68219 Mannheim

WINDTEST
Kaiser-Wilhelm-Koog GmbH

Excerpt of the test report
"Measurement of the electrical characteristics acc. to IEC61400-21 with regard to utility interconnection of the E-82"

Report No.: WT5707/07
Page 2 of 2

Switching operations:

Case of switching operation	Start-up at cut-in wind speed			
Max. number of switching operations, N_{10}	3			
Max. number of switching operations, N_{120}	35			
Grid impedance angle	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0.04	0.03	0.02	0.02
Voltage step factor, $k_u(\psi_k)$	0.06	0.06	0.06	0.06

Case of switching operation	Start-up at rated wind speed			
Max. number of switching operations, N_{10}	3			
Max. number of switching operations, N_{120}	35			
Grid impedance angle	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0.07	0.06	0.04	0.03
Voltage step factor, $k_u(\psi_k)$	0.91	0.70	0.41	0.19

Harmonics:

Order	Output power [kW]	Harmonic current [% from I_N]	Order	Output power [kW]	Harmonic current [% from I_N]
2	1978.7	0.2	3	1993.3	0.1
10	1986.8	0.1	5	1981.5	0.7
14	20.7	0.1	7	1991.5	0.4
16	21.4	0.1	11	181.6	0.7
			13	21.4	0.6
			15	20.7	0.2
			17	99.6	0.4
			19	1950.7	0.1
			23	1978.7	0.1

Maximum total harmonic current distortion [% from rated]	0.95
Power at maximum total harmonic current distortion [kW]	1993.3

Exceptional details:

1. The measurement was carried out only to 14.5 m/s.
2. Values <0.1% of I_N weren't indicated.

This report is only valid in conjunction with the report WT 5706/07.

WINDTEST Kaiser-Wilhelm-Koog GmbH
Sommerdeich 14b
25709 Kaiser-Wilhelm-Koog

Date: 2007-04-27
Operative: Dipl.-Ing. A. Müller
Tel./ Fax.: +49 4856 901-36 / -49

Dipl.-Ing. A. Müller
(Power Quality Group, Test Engineer)

Dipl.-Ing. H. Nomme
(Power Quality Group, Deputy Head of Group)

This report comprises 2 pages total.

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AENOR Asociación Española de Normalización y Certificación

CERTIFICADO DE CONFORMIDAD DE REQUISITOS DE RESPUESTA FRENTE A HUECOS DE TENSIÓN DE LAS INSTALACIONES EÓLICAS DE GENERACIÓN DE ENERGÍA ELÉCTRICA

B09 / 000211

La Asociación Española de Normalización y Certificación (AENOR) certifica que la

Instalación: Parque Eólico RIBEIRO
OUROL (Lugo)

Empresa titular: ENERGIAS DE OUROL, S.L.
CL CANTON GRANDE, 6 - 6
15003 A CORUÑA (ESPAÑA)

Registro Administrativo de Instalaciones de Producción en Régimen Especial: RE 17607

Es conforme con: Procedimiento Operativo P.O. 12.3 (aprobado en Resolución de 4 de octubre de 2006 de la Secretaría General de Energía del Ministerio de Industria, Turismo y Comercio).

Según Informe de Ensayos: WT 6556/08 (WINDTEST)

Potencia Instalada (kW): 9.200 kW

Modelos de Aerogeneradores: 4 Aerogeneradores ENERCON E70 FT (2.000 kW)

Para conceder este Certificado AENOR ha comprobado que se cumplen las condiciones exigidas en el Reglamento RP B09.01 para el **procedimiento de verificación particular**, al incorporar la instalación aerogeneradores asimilables a un aerogenerador tipo, que ha sido ensayado según se recoge en el informe de ensayos correspondiente.

Fecha de concesión: **2008-05-16**

Ramón RAZ PAJARES
Director General / General Manager

Entidad acreditada por ENAC con nº OVC-ER126
Body accredited by ENAC (number OVC-ER126)

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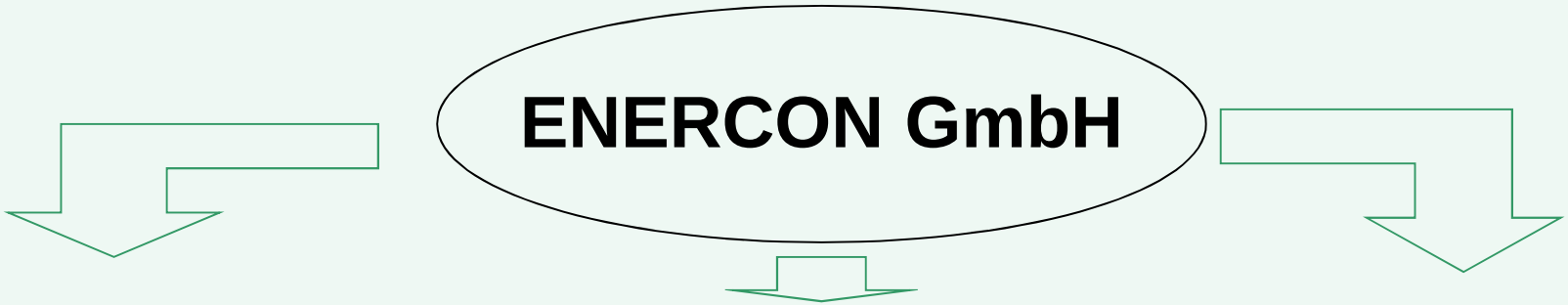
AENOR - Génova, 6 - 28004 MADRID - Teléfono 914 326 000 - Telefax 913 104 033

ENERCON's Overview



Planning:

- Site planning
- Planning permission process
- Grid codes
- Feasibility & financing

Production:

- Rotor blades
- Generator
- Hub, main carrier, etc.
- Tower (steel / concrete)
- Electronic components

Installation period and service:

- Transport and installation
- Access roads
- Foundation
- Grid connection
- Maintenance & repair

- ✓ Expert consulting & customer care
- ✓ Highly qualified employees
- ✓ Years of experience

- ✓ High quality
- ✓ Minimized supplier risk
- ✓ Engineering & development

- ✓ Logistics & installation
- ✓ Long-term partnership
- ✓ Customer-oriented service


Thanks for your attention!