

Gamesa 4.5 MW

Innovating for Reliability

G128-4.5 MW

Gamesa



GLOBAL TECHNOLOGY
EVERLASTING ENERGY

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Innovation & Reliability

Once again, Gamesa has demonstrated that it has the knowledge, experience and resources needed to develop wind turbines capable of extracting maximum power from the wind.

The Spanish company has taken a leap forward in one of its biggest, most ambitious technological challenges to date. Gamesa has designed, developed and manufactured its new generation of wind turbines, the Gamesa 4.5 MW platform.

With this new product platform, Gamesa intends to position itself at the forefront of the multi-megawatt platform segment.

By using assembly equipment and transport methods similar for those used in other Gamesa platforms, the company can provide access of the Gamesa 4.5 MW to a wide variety of sites.

Its innovative modular design and technology ensure maximum reliability and meet the most demanding grid connection regulations and the most restrictive environmental standards.

Gamesa 4.5 MW designed to fully meet all client needs

Offers superior reliability:

- ▶ Nacelle and blades modular design focused on minimizing inactive time.
- ▶ Drive train with no high-speed rotating components.
- ▶ Exhaustive validation and testing plan, as well as the first operational prototype since 2009.

Complies with similar logistics and construction requirements as those of the Gamesa 2.0 MW:

- ▶ Modular design of the nacelle and blades to optimize transport and logistics.
- ▶ The heaviest module weighs less than the weight of a 2-MW nacelle.
- ▶ Gamesa FlexiFit®: The add-on crane attaches to nacelle to simplify and expedite assembly and maintenance.

Optimizes cost of energy (CoE):

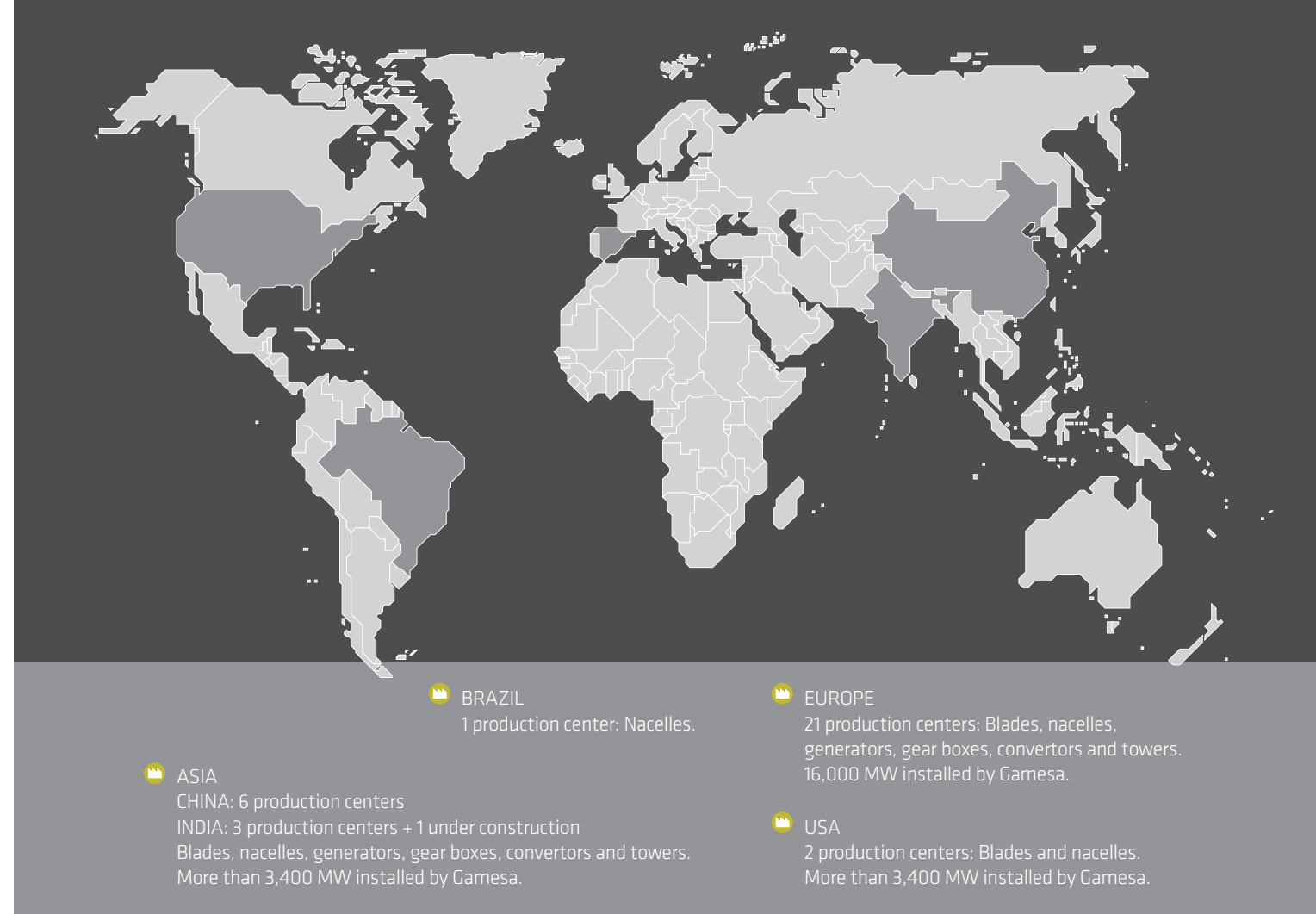
- ▶ Higher production for projects with limited space.
- ▶ Optimization of energetical positions.
- ▶ Potential savings in project civil works.
- ▶ Version with 5.0 MW nominal power available depending on the site.

Complies with the most demanding grid connection requirements:

- ▶ Gamesa GridMate®: Optimal grid connections due to permanent magnet generator technology + full converter.

Complies with environmental regulations:

- ▶ Reduced visual impact.
- ▶ Noise reduction: Gamesa NRS® system and new aerodynamic blade profile.



Global capacity for production, installation and operation and maintenance

Gamesa is a company specializing in technologies for sustainable energy, mainly wind energy, and is one of the world leaders in the manufacture of wind turbines. Within this sector, Gamesa manages the entire process, from the design, manufacture and installation of wind turbines, to their operation and maintenance.

The over 24,000 MW installed throughout the world is evidence of the excellent performance of Gamesa's wind turbines. This optimum behavior is only possible with a full command of the technology and of the product with all its critical components.

Gamesa has the capacity to design, manufacture, operate and maintain its wind turbines. The tailor-made development of the critical components of its turbines

-from the gearbox to the blades- ensures excellence in the design and the very highest quality standards. At the same time, it permits the shortest delivery times and the fastest technical response during the maintenance period.

Research, Development and Innovation form an integral part of the company's processes and products as well as its tasks and operations all along the supply chain, ensuring customer satisfaction and the search for excellence. In addition to this high ability to innovate, Gamesa also has a remarkable production capacity. From over 30 production centers in Europe, the United States, China, India and Brazil, Gamesa fully controls the production process and attends to the needs of its clients on all five continents, offering its customers the highest quality standards and short customer response times.



Gamesa 4.5 MW:
Maximum annual
production in medium
and low sites

Versatile platform

4.5 MW for low and medium winds

Gamesa has applied design and validation concepts to its new wind turbine development that are only comparable to those used in such demanding industries as the aeronautical industry, where

product reliability must be assured from the first day in operation.

Gamesa 4.5 MW is the result of the evolution of Gamesa technology.

Model	G128-4.5 MW
IEC	IIA
Rated Power	4,500 kW/5,000 kW ⁽¹⁾
Tower Heights	81, 120, 140 m
Type Certificate	✓ ⁽²⁾
Grid connection	✓
Env. / Opt. ⁽³⁾	✓
50 Hz/60 Hz	✓

(1) Availability depending on the site.

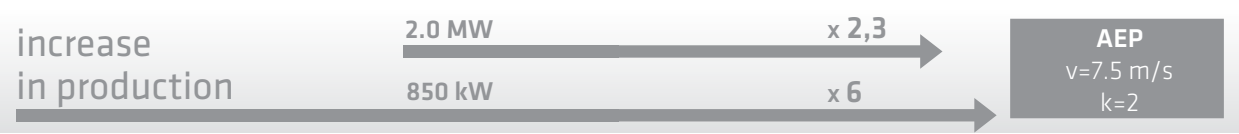
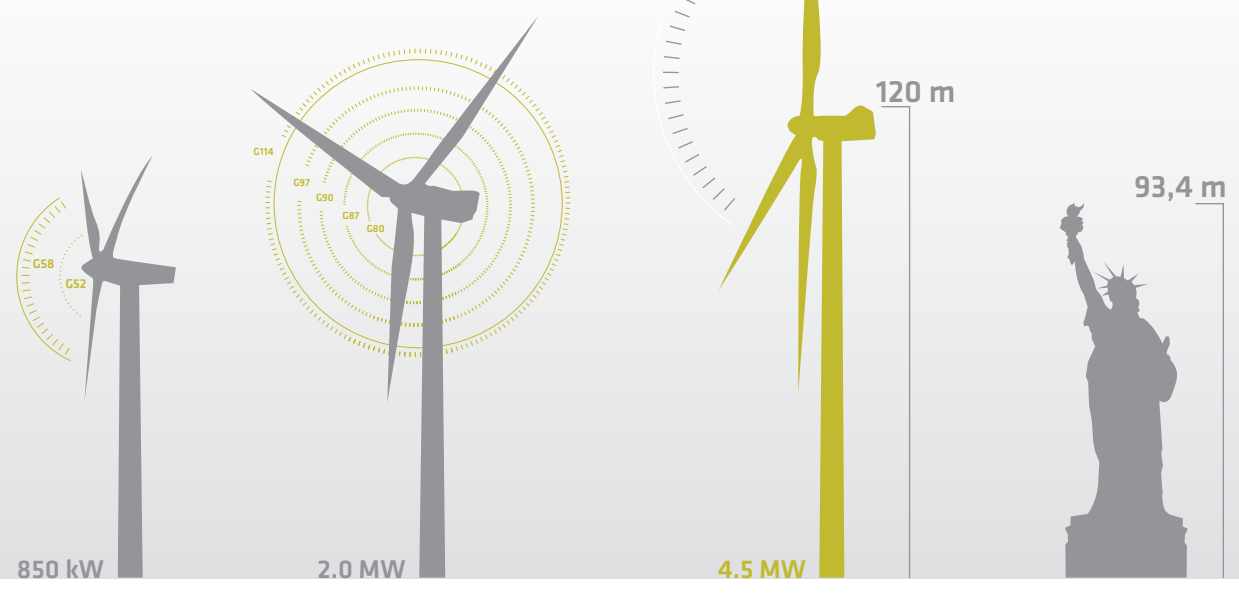
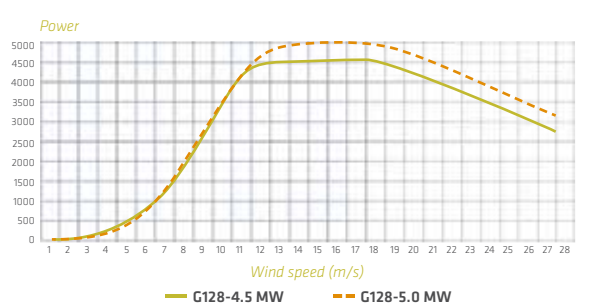
(2) For 60 Hz available only Design Certificate.

(3) Different versions and optional kits are available to adapt machinery to high or low temperatures and saline or dust environments.

Greater size for greater production

Improved lay-out
optimizes energetical positions.

Maximum production
for sites with limited space.

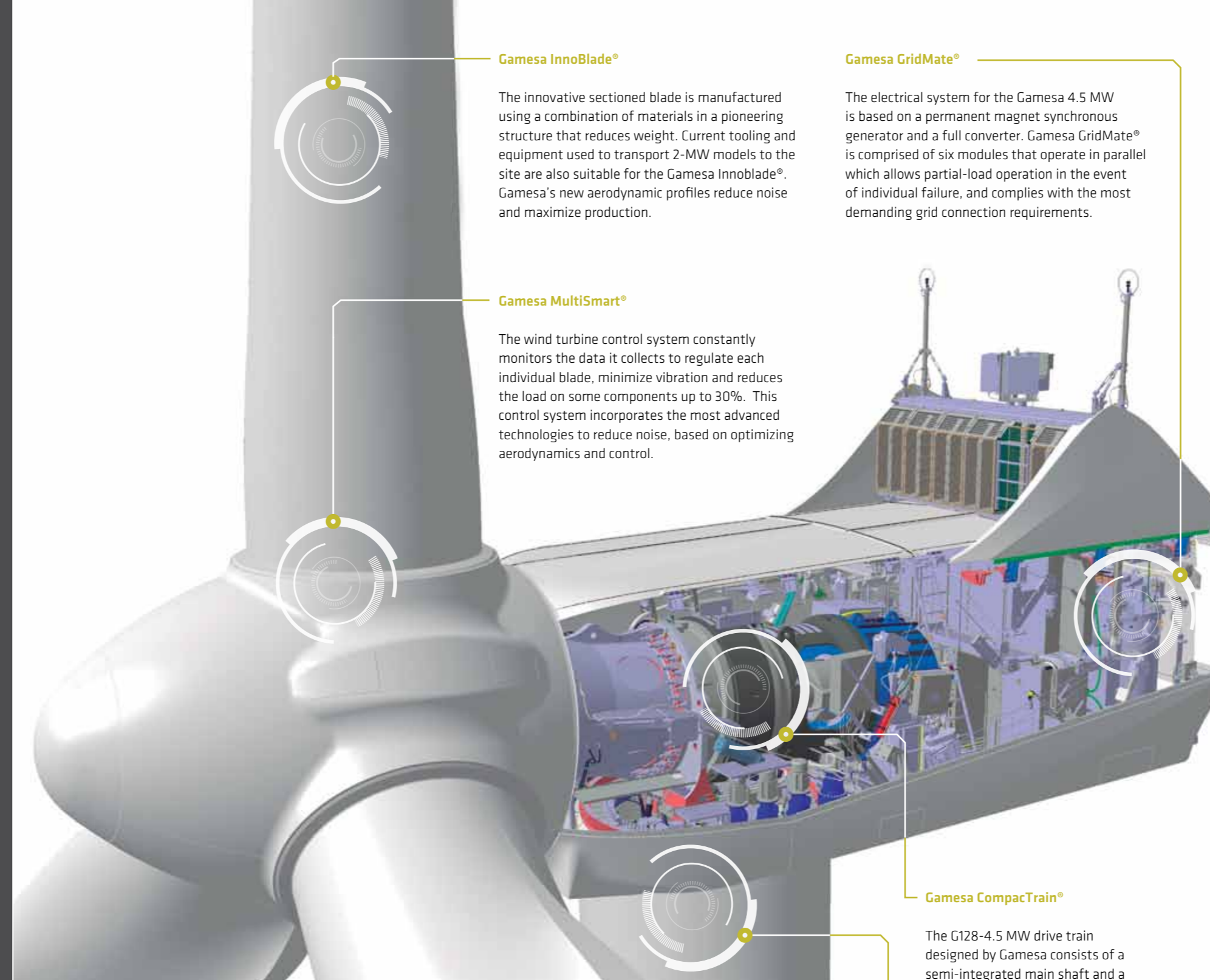




An exceptionally reliable wind turbine,
the result of Gamesa's evolution in technology

Advantages of the Gamesa 4.5 MW platform

- ▶ Individual pitch and multivariable control minimize weight, loads and noise.
- ▶ Sectional blade for easy transport and installation.
- ▶ Compact, high-performance drive train reduces mechanical stress.
- ▶ Permanent magnet synchronous generator and full converter technology that allow the most demanding grid code requirements to be met.
- ▶ Modular design of the nacelle and blades for maximum reliability and easy assembly and maintenance.
- ▶ Add-on crane attaches to nacelle for assisting in the assembly and maintenance of the main modules.
- ▶ Aerodynamic blade design and the Gamesa NRS® control system minimize noise emissions.
- ▶ Gamesa WindNet®: the advanced SCADA technology for online wind farm control and monitoring.
- ▶ Gamesa SMP System: system for predictive maintenance.



Gamesa InnoBlade®

The innovative sectioned blade is manufactured using a combination of materials in a pioneering structure that reduces weight. Current tooling and equipment used to transport 2-MW models to the site are also suitable for the Gamesa InnoBlade®. Gamesa's new aerodynamic profiles reduce noise and maximize production.

Gamesa MultiSmart®

The wind turbine control system constantly monitors the data it collects to regulate each individual blade, minimize vibration and reduces the load on some components up to 30%. This control system incorporates the most advanced technologies to reduce noise, based on optimizing aerodynamics and control.

Gamesa GridMate®

The electrical system for the Gamesa 4.5 MW is based on a permanent magnet synchronous generator and a full converter. Gamesa GridMate® is comprised of six modules that operate in parallel which allows partial-load operation in the event of individual failure, and complies with the most demanding grid connection requirements.

Gamesa CompactTrain®

The G128-4.5 MW drive train designed by Gamesa consists of a semi-integrated main shaft and a 2-stage gearbox with mid-speed range output. This integrated design makes the unit more compact, with fewer components. Furthermore, elimination of high-speed rotating mechanical components and use of the mid-range speed output improves the turbine reliability.

Gamesa WindGrabber™

This is a concrete/steel hybrid tower designed for the Gamesa 4.5 MW platform. The hybrid tower achieves the lowest costs for tall tower heights.

Technology developed entirely by Gamesa

State-of-the-art wind turbine design and development

Gamesa FlexiFit®

Add-on crane, coupled to nacelle, capable of assembling the main modules.

Gamesa FlexiFit® is used for on-site assembly and servicing of large components. Its main advantage is that it is coupled to the nacelle and requires no additional external structure. In many situations, it is an alternative to the use of heavy cranes. It requires no special means of transport to be moved and consists of several modules assembled at ground level. Once Gamesa FlexiFit® is fixed to the nacelle, the main components of the wind turbine can be raised and lowered.





Gamesa 4.5 MW

Reliability brought about through a thorough program of validation checks and tests

This goal has been achieved because of an ambitious validation and testing program that has allowed the Gamesa 4.5 MW to start operating at maximum availability right from the outset:

- ▶ More than 600 tests on components of the various wind turbines in the Gamesa 4.5 MW platform were carried out at 100 certified laboratories in the United States, Japan and Europe.
- ▶ More than 190 functional and/or integration tests performed at the Wind Turbine Test Laboratory (LEA) at the National Renewable Energy Centre (CENER, Spain), one of the most highly qualified international technology centers specializing in applied research, development and promotion of renewable energies.
- ▶ More than 300,000 hours of validation and test engineering.

This extensive validation and development program has taken over 6 years. It was designed to test each component and system under real life operating conditions, in controlled environments in order to verify these components will function under the most demanding conditions.



Lower assembly and logistics cost

One of the key advantages of the Gamesa 4.5 MW platform is its compliance with the logistics and construction requirements of the Gamesa 2.0 MW platform. The modular design of the nacelle and blades of the Gamesa 4.5 MW means that the heaviest module does not exceed the total weight of the Gamesa 2.0 MW platform, which makes it just as easy to transport and assemble as a 2.0-MW wind turbine.

The Gamesa InnoBlade® segmented blade, patented by Gamesa, can be transported by road with no need for additional resources other than those already used for the Gamesa 2.0 MW wind turbine. The longest module is no more than 35 meters long. Furthermore, lifting the nacelle is the final step in the assembly requiring a heavy-tonnage crane. The remaining modules only require the help of a small auxiliary crane for assembly.

Simple maintenance cuts stoppage times

Predictive maintenance system

The Gamesa SMP-12, the predictive maintenance system is an essential tool for advanced detection of potential deterioration or faults in the main wind-turbine components.

Gamesa SMP-12 is the result of an analysis of a large number of wind turbines to identify the essential requirements with which a predictive maintenance system must comply:

- ▶ Continuous control of critical wind turbine components.
- ▶ Signal processing and alarm detection capacity.
- ▶ Integration in Gamesa Windnet®.
- ▶ Easy installation and maintenance.
- ▶ Low cost.

The system is designed to minimize corrective operations. Gamesa SMP system consists of a device located in the nacelle and a data-processing center, capable of processing and providing useful data about the condition of critical mechanical wind-turbine components.

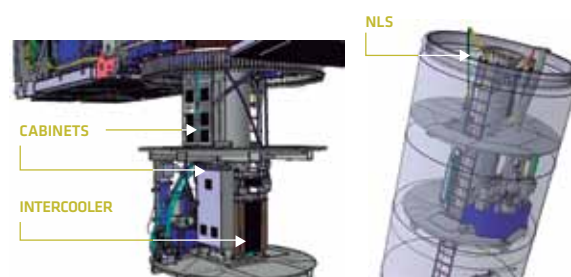
The Gamesa 4.5 MW has also been designed to take platform maintainability to a higher level by incorporating elements that optimize preventive and corrective maintenance.

Preventive maintenance

- ▶ RCM (Reliability Centered Maintenance): This reduces the time spent on preventive maintenance tasks.
- ▶ Automatic lubrication system.

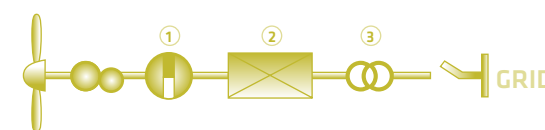
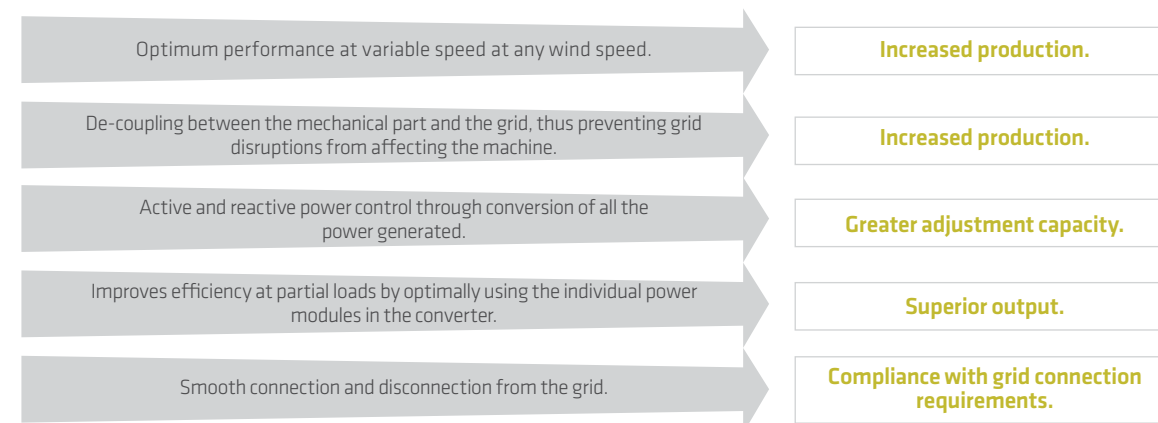
Corrective maintenance:

- ▶ NLS (Nacelle Lower Structure): Nacelle lower structure allowing more space for servicing tasks to be performed.
- ▶ Easier replacement of large components: there is no need to disassemble the rotor to change the Gamesa CompacTrain®.



Optimum grid connection

The Gamesa GridMate® is the solution for the Gamesa 4.5 MW platform that assures optimum grid connection. The system uses a permanent magnet synchronous generator with independent modules and a full frequency converter. This solution allows the most demanding grid code connection requirements to be met.



1. Multi-pole synchronous **GENERATOR** with six independent modules in parallel.
2. **CONVERTER** with six independent modules and built-in automatic circuit breaker.
3. **TRANSFORMER** with multiple grid voltage connection options.

Range of power factor: 0.9 cap / 0.9 ind
 Support of OV voltage-drop: YES
 Injection of reactive current: YES
 Adjustment of active, reactive, frequency and voltage: YES, with Scada WindNet®

128

ROTOR

Diameter	128 m
Swept area	12,868 m ²

BLADES

Number of blades	3
Length	62.5 m
Material	Organic matrix composite reinforced with fiber glass or carbon fiber

TOWER

Type	Conical tubular concrete and steel tower
Height	81, 120, 140 m

GEAR BOX

Type	2-stage planetary gearbox
Ratio	1:37.88

GENERATOR

Type	Permanent magnet synchronous generator with independent modules in parallel
Nominal power	4,500 kW/5,000 kW*
Voltage	690 V AC
Frequency	50 Hz / 60 Hz
Protection class	IP 54
Rotation speed	448 rpm
Power factor	0.9 CAP - 0.9 IND **

* Availability depending on the site.

** Power factor at output terminals of the wind turbine on the low voltage side before entering the transformer, at the rated grid voltage.





C/ Ciudad de la Innovación, 9-11
31621 Sarriguren (Spain)
Tel: +34 948 771 000
Fax: +34 948 165 039
info@gamesacorp.com
www.gamesacorp.com

AUSTRALIA

Level 13, 167 Macquarie Street,
Sydney NSW 2000
Tel: +61 (2) 8667 3000

BRAZIL

Rua Hungria 1240, 3º A
Jd. Europa, CEP 01455-000
São Paulo (SP)
Tel: +5511 3096 4444

BULGARIA

53-55 Totleben Blvd.
Sofia 1606
Tel: +359 2 805 7173
Fax: +359 2 805 7001

CHILE

Av. Apoquindo, 3.600
9th floor, 904
Las Condes - Santiago
Tel: +56 2 446 8485

CHINA

23/F, Tower 1,
Beijing Prosper Center No. 5
Guanghua Road,
Chaoyang District,
Beijing 100020
Tel: +86 10 5789 0899
Fax: +86 10 5761 1996

EGYPT

3, 218 St. Degla,
Maadi, Cairo
Tel: +20 225 211 048
Fax: +20 225 211 282

FRANCE

Parc Mail,
Bâtiment G
6 Allée Irène Joliot-Curie
69791 Saint Priest Cedex
Tel: +33 (0) 4 72 79 49 39

GREECE

23 Adrianou str,
11525 Neo Psychiko, Athens
Tel: +30 21067 48947
Fax: +30 21067 20167

INDIA

The Futura IT Park, B-Block, 8th Floor
334, Rajiv Gandhi Salai
Sholinganallur, Chennai - 600 119
Tel: +91 44 3924 2424
sales.india@gamesacorp.com

ITALY

Via Pio Emanuelli 1
00143 Rome
Tel: +39 0645543650
Fax: +39 0645553974

MEXICO

Torre Diana, Piso 14
Av. Pº de la Reforma 389
Colonia Cuahatemoc
06500 Mexico DF
Tel: +52 55 5533 0810

MOROCCO

Immeuble Office Building
Angle Boulevard Mohamed V et
Rue Victor Hugo
2º Etage Apt. Nº21
90000 Tanger
Tel: +212 539 94 61 14
Fax: +212 539 94 59 69

POLAND

Ul. Galaktyczna 30A
80-299 Gdansk
Tel: +48 58 766 62 62
Fax: +48 58 766 62 99
poland.wind@gamesacorp.com

ROMANIA

169A Calea Floreasca Street,
Building A, 4th Floor,
office no 2069, Sector 1
014459 Bucharest
Tel: +40 318 21 24
Fax: +40 318 60 21 00

SINGAPORE

3 Temasek Avenue
Centennial Tower - Level 34
Singapore 039190
Tel: +65 6549 7763
Fax: +65 6549 7011

SOUTH AFRICA

The Colosseum
1st Floor Century Way, Foyer 3
Century City
7441 Cape Town
Tel: +27 0 215260300
Fax: +27 0 215260311

SWEDEN, FINLAND & NORWAY

Solna Strandväg 78
171 54 Solna
Tel: +46 (0) 8 5052 00 00
Fax: +46 (0) 8 5052 10 10

TURKEY

Astoria
Buyukdere Cad. No. 127 Kule A, Kat 10
Esentepe
Istanbul 34394
Tel: +90 212 340 76 00

UNITED KINGDOM

25 Napier Place
Wardpark North
Cumbernauld G68 0LL
Tel: +44 1236724890

UNITED STATES

1150 Northbrook Drive
Trevose, PA 19053
Tel: +1 215 710 3100
Fax: +1 215 741 4048

