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GE
Energy

2.5MW
Wind Turbine

a product of
ecomagination™

imagination at work

The evolution of power

Minute by minute, the world is growing. Economic development and increased attention to sustainability mean the world needs a steady supply of cleaner, reliable power. GE continuously stays a step ahead, driving cutting-edge wind turbine technology.

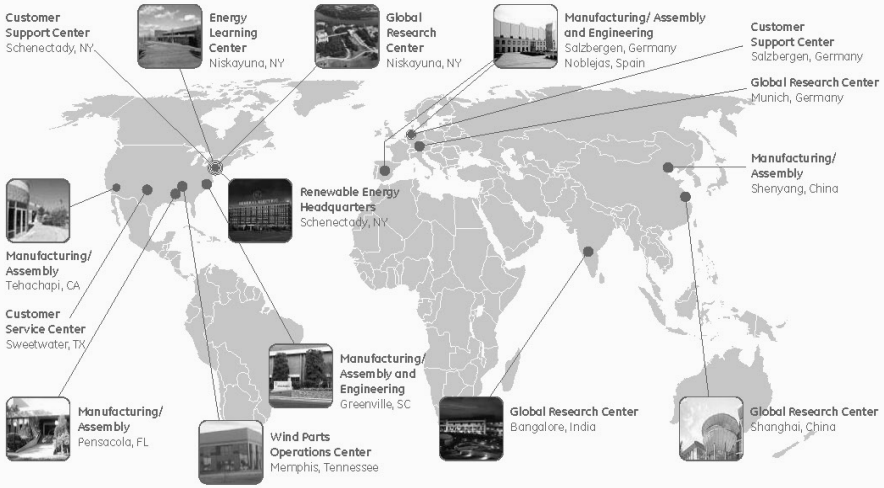
Building on a strong power generation heritage spanning more than a century, the 2.5 MW wind turbine is evolutionary technology based on a unique design strategy. Higher efficiency, increased reliability, maintainability and seamless grid integration make it a powerhouse of precision. In fact, GE's 2.5 MW wind turbine leads the industry by producing the highest annual energy yield in its class, creating more value for our customers.

Drawing on GE's experience of more than 8,500 1.5 MW wind turbines in operation worldwide, the 2.5 MW wind turbine is designed to meet the growing demands of the wind industry. Product evolution is one of the things GE does best and our product strategy is focused on results that contribute to our customers' success. Our reputation for excellence can be seen in everything we do.

Global footprint

GE Energy is one of the world's leading suppliers of power generation and energy delivery technologies—providing comprehensive solutions for coal, oil, natural gas and nuclear energy, renewable resources such as wind, solar and biogas, and other alternative fuels. As a part of GE Infrastructure—which also includes the Water, Transportation, Aviation and Oil & Gas businesses—we have the worldwide resources and experience to help customers meet their needs for cleaner, more reliable and efficient energy.

GE has six wind manufacturing and assembly facilities in Germany, Spain, China and the United States. Our facilities are registered to ISO 9001:2000 and our Quality Management System, which incorporates our rigorous Six Sigma methodologies, provides our customers with quality assurance backed by the strength of GE. We believe wind power will be an integral part of the world energy mix throughout the 21st century and we are committed to helping our customers design and implement energy solutions for their unique energy needs.



The new industry standard

Suitable for a wide variety of sites

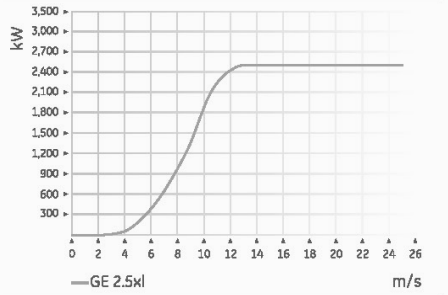
Designed for IEC class II and class III, the 2.5 MW wind turbine can be deployed on over 85% of the sites being developed today. Rated at 2.5 MW, it generates a leading amount of annual energy production and its 100 m rotor also makes it an excellent solution for low wind sites.

The 2.5 MW wind turbine also excels on sites that are constrained by environmental regulations. For example, the optional noise-reduced power operation modes accommodate noise restrictions while simultaneously maintaining a high energy yield.

The 2.5 MW wind turbine can be equipped with various towers resulting in hub heights of 100 m, 85 m and 75 m, meeting potential tip height constraints and maximizing energy yield.

Technical Data	2.5xl
Operating data	
• Rated capacity:	2.500 kW
• Cut-in wind speed:	3,5 m/s
• Cut-out wind speed:	25 m/s
• Rated wind speed:	12,5 m/s
• Wind Class - IEC:	IIIa, IIb
Rotor	
• Number of rotor blades:	3
• Rotor diameter:	100 m
• Swept area:	7854 m2
Tower	
• Hub heights:	75 m, 85 m, 100 m

Power Curve



Higher efficiency

The 2.5 MW wind turbine is equipped with a permanent magnet generator, ensuring high efficiency even at low wind speeds. Compared to a conventional doubly-fed system, the efficiency in the partial load range is remarkably higher, resulting in increased revenues for wind power producers. Employing magnets instead of copper coils in the generator rotor reduces electrical losses in the generator and current flow through the rotating parts of the generator. The brushless system also simplifies maintenance activities.

Optimal maintainability

The interior of the nacelle is designed to optimize maintainability and ergonomics for the maintenance crew. It provides an environment that facilitates safe and efficient maintenance and inspection work.

Automatic lubrication systems for the grease-lubricated bearings are used to accommodate for a 12-month maintenance interval under normal operating conditions. Not only does this minimize turbine down-time and provide the opportunity to avoid maintenance in the windiest seasons, it also provides the operator of remote sites with the opportunity to plan for maintenance in the season that the turbine is most accessible.

The optional elevator and climb-assist facilitate ergonomically optimal operations and maintenance of the turbine, enabling people to visit more wind turbines per day. This improves availability and reduces the size of the labor force required to operate a wind plant.

Reliability by design

With technology centers of excellence in the United States, Europe, India and China, our teams of engineers and scientists use Six Sigma methodology, coupled with the latest computational modeling and power electronic analysis tools, to manufacture wind turbines with the reliability, efficiency and maintainability necessary to meet the challenges our customers face in today's energy environment.

GE's commitment to customer value and technology evolution is demonstrated by our ongoing investment in product development. Since entering the wind business in 2002, GE has invested over $750 million in driving reliability and efficient wind technology.

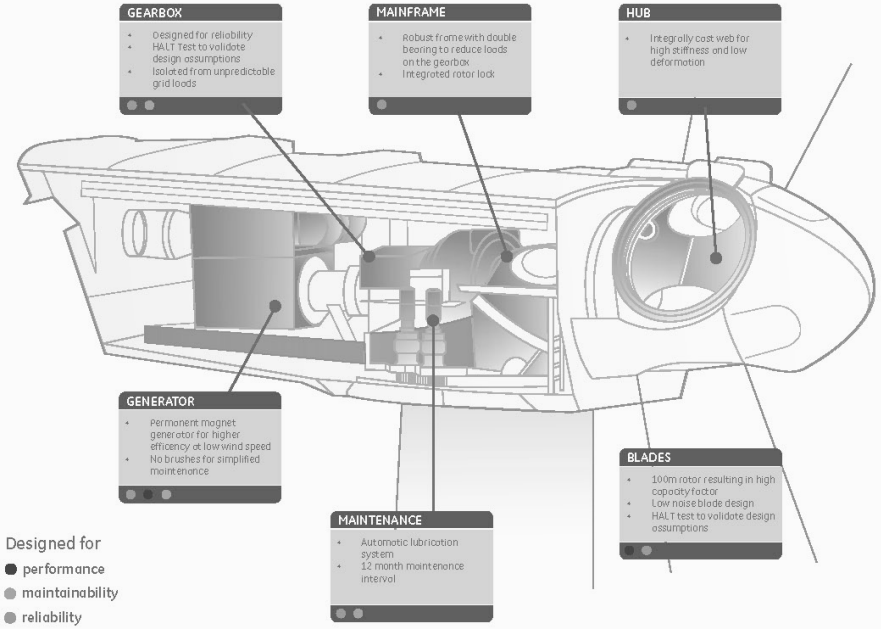
Advancing technology

A double-bearing main shaft minimizes gearbox thrust and bending loads by transmitting loads through the bedplate to the tower. The gearbox is only subjected to torque loading which is controlled by the wind turbine through the converter, resulting in less severe and better predictable loads than in conventional drivetrain designs.

The double-bearing main shaft also improves overall drivetrain reliability and improves gearbox lifetime predictability. Additionally, a full power converter separates the generator and gearbox from the grid, allowing them to remain essentially unaffected by transient grid loads. This unique system design results in robust and reliable power conversion.

The main bearings remain well lubricated even under severe conditions due to grease lubrication, which unlike oil, requires no heating at low ambient temperatures in order to keep its lubricating properties.

The hub design contains an integrally cast web in the blade root opening, providing high stiffness to the hub assembly. Higher stiffness results in less deflection of the hub, and therefore less loads on the components mounted to the hub. Consequently, stresses on the pitch bearing and pitch drive are reduced significantly when compared to conventional designs.



The 2.5 MW wind turbine is designed according to our Design for Reliability (DFR) methodology.

DFR starts with the definition of reliability goals and the environmental conditions in which the wind turbine components must operate. The reliability targets are then broken down to component level models that are developed to predict reliability.

A key step in the DFR process is validating design assumptions on both component levels and system levels. Different types of testing are used for validation, including climate chamber testing, compliance testing and Highly Accelerated Life Testing (HALT). HALT testing is a very efficient tool to flush-out design flaws rapidly. In the test, components are subjected to loads of the entire design life, but in a very short time frame.

The next step is field validation. The 2.5 MW design was validated with more than four years and 500,000 hours of operating experience. After extensive field validation, one turbine was decommissioned so that our engineers could teardown and inspect all of the major components.

The last step of the DFR methodolgy is production auditing. Where validation is focused on ensuring that the design is free of flaws, the production audit is focused on ensuring that each unit is delivered with consistent quality by understanding the impact of manufacturing variability.

DFR COMMON STEPS	TESTING & EVALUATION
1 GOAL SETTING	SHOP TESTING
2 SYSTEM MODELING	FIELD TESTING
3 DESIGN AND PREDICTION	ACCELERATED TESTING
4 TESTING AND EVALUATION	COMPLIANCE TESTING
5 PRODUCT AUDIT	

Technological expertise:

GE Infrastructure

Energy

- Controls, materials, technology
- Fulfillment & logistics capability
- Efficient supply chain management

Aviation

Aerodynamic and aero-acoustic modeling expertise

Rail

Gearbox and power converter technologies

GE Global Research

- Energy conversion
- Material sciences
- Smart grids

Optimized wind power plant performance

Electrical system design

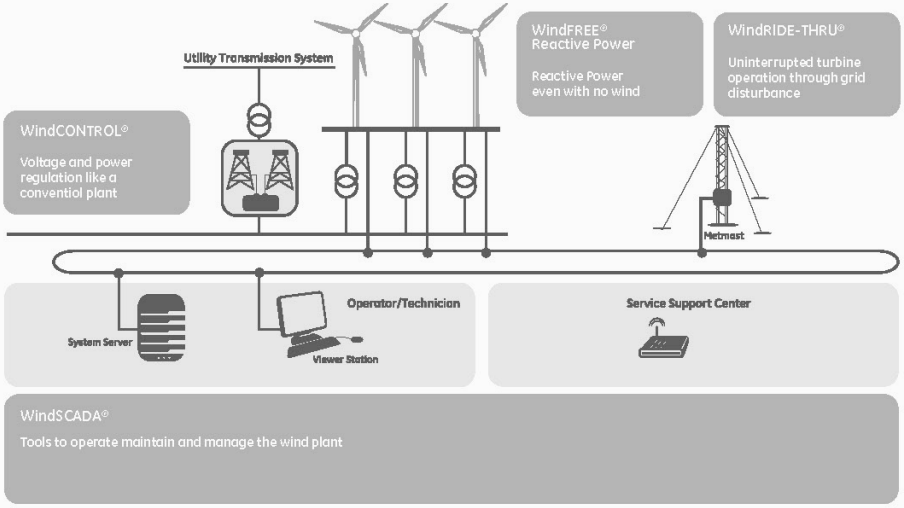
The electrical system design of the 2.5 MW wind turbine consists of a permanent magnet generator and full power conversion. In the lower tower section, the power module efficiently converts the energy from the permanent magnet generator into power that provides frequency and voltage control required by transmission system operators. The integration of the converter and transformer down tower, rather than the nacelle, ensures that vibration loads do not affect the reliability of the power electronics. The converter cooling system has been designed to minimize moving parts for reliability and features passive coolers that use the same wind that powers the turbine.

Seamless grid integration

Wind turbine performance is a critical issue in light of increasingly stringent grid requirements. GE's unrivaled experience in power generation makes us the industry leader in grid connection. By providing a sophisticated set of grid-friendly benefits similar to conventional power plants, GE's unique integrated suite of controls and electronics take your wind power station to the frontline of performance and seamless grid integration.

The full-size power converter concept is an important technical advantage to reduce grid constraints and to maximize the connectable MW capacity at the network. GE technology can support the grid through reactive power supply and with the WindCONTROL® system, it can be operated similar to a conventional power plant.

With the WindFREE® Reactive Power feature, the 2.5 MW wind turbine can generate reactive power even when the wind is not blowing. Consequently, it reduces the need for additional VAR-generating equipment, thus minimizing investments in electrical infrastructure.



Feature	Description	Benefits
WindRIDE-THRU® Turbine Operation System	Uninterrupted turbine operation through grid disturbances Offered in two standard packages: • Low Voltage Ride Through • Zero Voltage Ride Through	Meets present and emerging transmission reliability standards similar to those demanded of thermal generators
WindCONTROL® Power Regulation System	Voltage and power regulation like a conventional power plant	Provides frequency droop and power ramp limiters to help stabilize power system frequency Reduces BOP costs
WindFREE Reactive Power® System	Provides reactive power even with no wind	Provides smooth fast voltage regulation by delivering controlled reactive power through all operating conditions Eliminates the need for grid reinforcements specifically designed for no-wind conditions, and may allow for more economic commitment of other generating resources that will enhance grid security
WindSCADA® System	Tools to operate, maintain and manage the wind power plant	Intuitive operation and maintenance control Secure user-access

World-class customer service

GE's wind turbine fleet is one of the fastest growing and best-run fleets in the world. Utilizing our decades of experience in product services in the power generation industry, GE provides state of the art solutions to ensure optimal performance for your wind plant.

24x7 Customer Support

GE's customer support centers in Europe and the Americas provide remote monitoring and troubleshooting for our installed fleet of wind turbines around the world, 24 hours a day, 365 days a year. The customer support centers are able to quickly perform remote resets for over 250 turbine faults. It is one of the most effective ways to ensure continuous monitoring and fault resets of your wind assets by qualified technology experts.

Technical skills and in-depth product knowledge

GE's wind customer support centers have dedicated teams to dispatch for troubleshooting, repair and maintenance, available 24 hours a day, 365 days a year. This model assures wide coverage of large wind turbine fleets without compromising technical skills or quality.

GE taps into our extensive product knowledge for timely resolution of many issues. All turbine faults are investigated using a structured technical process, which is then escalated as necessary. We also use feedback from this process in product development.

Operations and maintenance support

Driven by a highly skilled work force and the operating knowledge of over 8,500 1.5 MW wind turbines, GE offers a wide range of services tailored to the operation and maintenance needs of your wind assets. Our offerings range from technical advisory services, transactional services and remote operations to full on-site operations support, including availability guarantees.

Parts offerings

GE has utilized the extensive Parts and Refurbishment experience of its Energy Services business to establish a global center of excellence for wind parts operations. The wind parts resources are aligned to provide a full range of offerings for all types of parts and refurbishment needs, including routine maintenance kits, consumables and flow parts, and key capital parts such as gearboxes and blades.

With the launch of our 24/7 parts call center, and the development of online ordering tools, we are increasing the channels that our wind plant operators can utilize to order required wind turbine parts, including emergency requests for down-turbine needs.

For wind plant operators looking for additional benefits that a contractual parts relationship with GE can offer, the wind parts team has developed tailored offerings that can provide ongoing inventory-level support and parts lead-time guarantees. One of the exciting advantages of a GE wind parts and refurbishment program is membership to the capital parts pool, providing a priority access to often hard-to-source capital parts.

Long-Term Asset Management Support

GE is your reliable partner as we strive to build long-term relationships with asset managers. Utilizing our strengths, we can provide parts solutions, field technician and customer training and a wide range of specialized services to complement local on-site capabilities.

Project execution

GE understands that grid compatibility, site flexibility, and on-time delivery are critical to the economics of a wind project. For that reason, the 2.5 MW wind turbine has been engineered for ease of integration and delivery to a wide range of locations.

Our global project management and fulfillment expertise offer customers on-time delivery and schedule certainty. Regardless of where wind turbine components are delivered, GE's integrated logistics team retains ownership and responsibility for this critical step. Utilizing the GE Energy Power Answer Center, our engineering and supply chain teams are ready to respond to any technical, mechanical or electrical questions that may arise.

As one of the world's largest power plant system providers, GE is uniquely positioned to provide customers with full-service project management solutions.

With offices in North America, Europe, and Asia, our world-class Power Plant Systems division utilizes decades of fulfillment expertise in project management, logistics, plant start-up and integration from Gas Turbine, Combined Cycle, Hydro, and Aero plants.

Environmental Health and Safety, a GE commitment

Maintaining high Environmental Health and Safety (EHS) standards is more than simply a good business practice; it is a fundamental responsibility to our employees, customers, contractors, and the environment we all share.

GE is committed to maintaining a safe work environment. We incorporate these values into every product, service and process, driving EHS processes to the highest standards.

Powering the world...responsibly.

For more information, please visit
www.ge-energy.com/wind

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V90-3.0 MW

Exceptional performance and
reliability at high-wind-speed sites

vestas.com

Vestas

WE DELIVER
ON THE PROMISE
OF WIND POWER

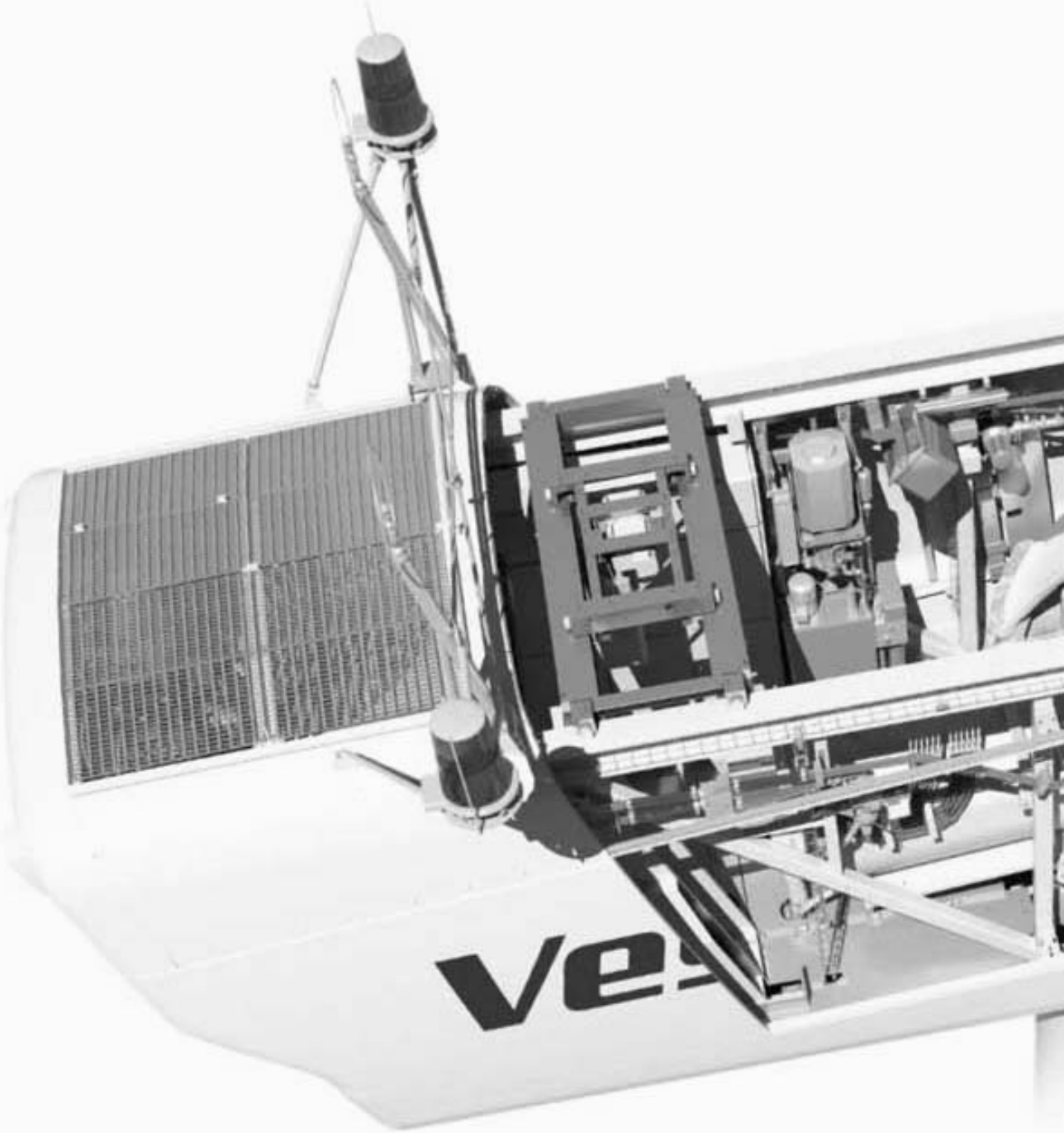
SUPERIOR YIELD AT HIGH-WIND-SPEED SITES

High standards for weight and performance
The V90-3.0 MW is a compact, high-performance turbine designed to deliver optimal yield at high-wind-speed sites (IEC IA) and medium-wind-speed sites (IEC IIA).

Designed for both onshore and offshore sites, it's built on a well-tested and reliable design platform – and few other turbines can match it when it comes to performance.

Thanks to its light-weight tower and blades, along with the high-efficiency integrated drive train, the V90-3.0 MW sets the standard for low-weight performance.

The market has responded very favourably, and Vestas has installed more than 1,100 V90-3.0 MW turbines since the launch in 2003.



GROUNDBREAKING DESIGN AND EASY MAINTENANCE

3x44 meters of cutting edge

The V90-3.0 MW features revolutionary blades that are made from carbon fibre and other lightweight materials. Even though these blades sweep a 27% greater area than V80 blades, their weight is virtually the same. What's more, the shape of the blades has been refined to deliver the greatest possible output while minimising the load on the turbine.

The shape also makes these blades less sensitive to dirt, providing better performance at sites affected by salt, insects or other particles in the air.

Innovative solutions for lubrication

The V90-3.0 MW offers a number of features that boost reliability and serviceability, including innovative solutions for lubricating key components such as the blade-bearing system and the yaw system.

Safety first and easy maintenance
Like all Vestas turbines, the V90-3.0 MW is designed for safe, convenient installation and maintenance. The improved nacelle design leaves more space in the nacelle, where rotating parts are shielded, and all components are positioned to minimise service time and manpower.

Service and maintenance can be carried out using standard tools and equipment, but Vestas has also developed special equipment and methods that reduce service time and costs.

Next-generation control system
The V90-3.0 MW is equipped with the latest turbine control and operation software, a state-of-the-art modular software platform developed to run the next generation of Vestas turbines. This software ensures reliable, automatic management of the V90-3.0 MW around the clock.

The Vestas service department also uses this software for monitoring the wind turbines and troubleshooting problems on site and remotely.

THOROUGHLY TESTED TO ENSURE HIGH AVAILABILITY

Thoroughly tested technology ensures stable revenue
The V90-3.0 MW features a rugged 6-gear yaw system and a 50 Hz/60 Hz 4-pole asynchronous generator. But what really sets this turbine apart is the well-tested integrated drive train, which eliminates the need for a traditional main shaft.

Finally, the V90-3.0 MW is designed around a large number of standard components that several suppliers can provide.

Flexible grid integration and stable output
Vestas turbines such as the V90-3.0 MW are designed to make your wind power plant fully compliant with applicable grid codes at the point of common coupling.

How this is achieved may differ from country to country, but in general, our advanced grid compliance system provides active and reactive power regulation, frequency regulation and fault ride-through capabilities to support grid levels and stability in the event of disturbances.

Can be installed virtually anywhere
The V90-3.0 MW is designed for fast, easy transport by truck, barge or rail to virtually any site in the world.

The weight, height and width of all components are designed to accommodate local and international transport limits.

OPTIONS AND ADVANTAGES FOR A PROFITABLE PLANT

Special options
The V90-3.0 MW is available with a number of special options that can be ordered as desired. These options include:

- Condition monitoring system
- VestasOnline®, Compact or Business
- Switchgear
- Aviation markings on the blades
- Aviation lights
- Company logo
- Ice detection system
- Low temperature package allowing operation in temperatures as low as -30°C.

Towering advantages
When we designed the tower for the V90-3.0 MW, we invented a completely new turbine tower design. One new approach was to fasten components such as ladders to the tower wall using magnets instead of weldings.

We also use stronger steel and have reduced the weight considerably, while also reducing fatigue and extreme loads.

Project management for effective plants
The better your turbines fit your wind site, the more profitable your plant will be. That's why Vestas offers to take on project management from the initial wind measurements to complete installation of the wind power plant.

More than 30 years of international experience and local expertise enable us to complete:

- Wind and site studies
- Designing the wind power project
- Selecting wind turbine types
- Installing the wind farm
- Servicing and maintenance throughout the turbine's service life
- Monitoring and remote troubleshooting

Vestas

VESTAS TAKES CARE OF YOUR INVESTMENT ROUND THE CLOCK

Verified component lifetime

At our Vestas Technology R&D testing centres, engineering experts and technicians use state-of-the-art testing methods to ensure that all components and systems meet our standards for safety, performance and reliability throughout the turbine's 20-year service life.

These tests push the components beyond their specifications. One method is known as Highly Accelerated Life Testing, where some of the testing is conducted in a HALT chamber. Extreme fluctuations in temperatures combined with heavy vibrations is just one of the stress tests the components are subjected to here. This enables Vestas to eliminate design flaws long before the turbines reach the market.

Surveillance 24/7/365

Our surveillance services are manned 24/7 all year round to provide real-time surveillance, remote troubleshooting and other services. These services can also detect potential errors and disruptions before they occur, as data from your turbines is gathered and analysed. This enables us to prepare a plan for preventative maintenance, saving you from unexpected production stops and costly downtime.

Vestas has service centres around the globe and we are able to cover your every need, from simple cleaning and planned maintenance to emergency call-outs and on-site inventories customised for your turbines.

Asset management and operation risk mitigation
Your wind turbines have to be maintained with great care to avoid exposing your investment to unnecessary risks. And that is exactly what Active Output Management (AOM) is designed to ensure – that you get the greatest possible return on your investment in a Vestas wind turbine.

AOM provides a number of advantages, such as detailed plans for service and maintenance, online monitoring, optimization and troubleshooting, and a competitive insurance optimisation.

We even offer a full availability guarantee, where Vestas pays compensation if the turbine fails to meet the agreed availability targets.

TECHNICAL DATA FOR V90-3.0 MW

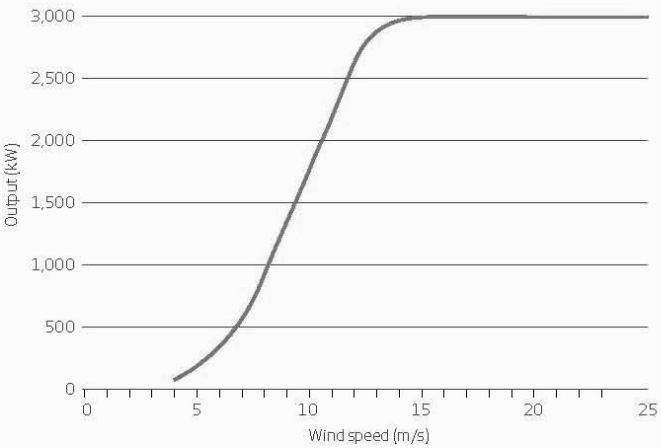
Power regulation	pitch regulated with variable speed
Operating data	
Rated power	3,000 kW
Cut-in wind speed	3.5 m/s
Rated wind speed	15 m/s
Cut-out wind speed	25 m/s
Wind Class - IEC	IEC IA (high wind) and IEC IIA (medium wind)
Operating temperature range	standard range -20°C to 40°C. low temperature option -30°C to 40°C
Sound power (10 m above ground, hub height 80 m, standard air density 1,225 kg/m³)	
4 m/s	97.9 dB(A)
5 m/s	100.9 dB(A)
6 m/s	104.2 dB(A)
7 m/s	106.1 dB(A)
8 m/s	107.0 dB(A)
9 m/s	106.9 dB(A)
Rotor	
Rotor diameter	90 m
Swept area	6,362 m²
Nominal revolutions	16.1 rpm
Operational interval	8.6 - 18.4 rpm
Air brake	full blade feathering with three pitch cylinders
Tower	
Type	tubular steel tower
Hub heights	80 m and 90 m (IEC IA) 105 m (IEC IIA)
Electrical	
Frequency	50 Hz/60 Hz
Generator type	4-pole asynchronous with variable speed
Gearbox	
Type	two planetary stages and one helical stage

Main dimensions

Blade	
Length	44 m
Max. chord	3.5 m
Weight	6,700 kg
Nacelle	
Height for transport	4 m
Length	9.65 m
Width	3.65 m (3.85 m installed)
Weight	70 metric tonnes
Hub incl. nose cone	
Diameter	3.6 m
Max. width	4.2 m
Length	4.4 m
Weight	22 metric tonnes
Tower	
80 m (IEC IA)	
Weight (50 Hz)	145 metric tonnes
Weight (60 Hz)	155 metric tonnes
90 m (IEC IA)	
Weight (50 Hz)	205 metric tonnes
105 m (IEC IIA)	
Weight (50 Hz/60 Hz)	255 metric tonnes
Offshore	site specific towers

Power curve V90-3.0 MW

Noise reduced sound power modes are available.



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No. 1 in Modern Energy

The world needs ever-greater supplies of clean, sustainable energy. Modern energy that promotes sustainable development and greater prosperity for all our planet's inhabitants. Vestas wind turbines are already generating more than 60 million MWh of electricity every year – enough to power all of Spain, for example - and we are ready to go even further.

After more than 30 years, Vestas continues to pioneer the wind energy business, with technological breakthroughs that have transformed our industry. The V90-3.0 MW turbine is an important step forward for modern energy.

No. 1 in Modern Energy

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