GE Energy

1.5MW
Wind Turbine

imagination at work

a product of
ecomagination

The industry workhorse

The world needs a reliable, affordable and clean supply of electric power with zero greenhouse gas emissions, which is why GE continues to drive investment in cutting-edge wind turbine technology.

Building on a strong power generation heritage spanning more than a century, our 1.5 MW wind turbine—also known as the industry workhorse—delivers proven performance and reliability, creating more value for our customers.

Our product strategy is focused on results that contribute to our customers' success and wind farm return on investment. Every initiative we pursue bears our uncompromising commitment to quality and product innovation. Our reputation for excellence can be seen in everything we do. GE's commitment to customer value and technology evolution is demonstrated in our ongoing investment in product development. Since entering the wind business in 2002, GE has invested over $850 million in driving reliable and efficient wind technology.

GE 1.5 MW...the most widely used wind turbine in its class

- **12,000+** turbines are in operation worldwide
- **19** countries
- **170+** million operating hours
- **100,000+** GWh produced

Data as of March, 2009

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 Energy Infrastructure—which also includes the Water, Energy Services 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 both ISO 9001:2000 and our Quality Management System, providing our customers with quality assurance backed by the strength of GE. Our wind energy technology centers of excellence in Europe, Asia, and North America, as well as 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 performance and reliability necessary to meet our customers' challenges.

As the cornerstone of GE technology for more than 100 years, our four Global Research Centers are focused on developing breakthrough innovations in the energy industry. 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.

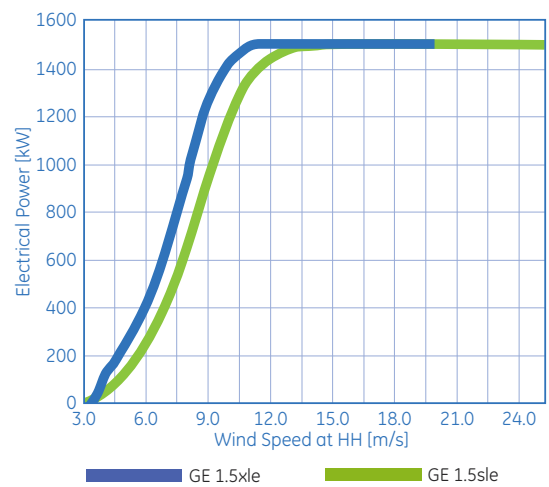
Advancing wind capture performance

As a leading global provider of energy products and services, GE continues to invest in advancing its 1.5 MW wind turbine product platform. With a core focus on enhancing efficiency, reliability, site flexibility and delivering multi-generational product advancements, GE's 1.5 MW wind turbine is the most widely used turbine in its class. Our commitment is to fully understand our customer's needs and respond with new technology enhancements aimed at capturing maximum wind energy to deliver additional return on investment.

Technical data

		1.5sle	1.5xle
Operating Data			
Rated Capacity:		1,500 kW	1,500 kW
Temperature Range: (with Cold Weather Extreme Package)	Operation:	-30°C – +40°C	-30°C – +40°C
	Survival:	-40°C – +50°C	-40°C – +50°C
Cut-in Wind Speed:		3.5 m/s	3.5 m/s
Cut-out Wind Speed (10 min avg.):		25 m/s	20 m/s
Rated Wind Speed:		14 m/s	11.5 m/s
Wind Class — IEC:		IIa (V_{e50} = 55 m/s V_{ave} = 8.5 m/s)	IIIb (V_{e50} = 52.5 m/s V_{ave} = 8.0 m/s)
Electrical Interface			
Frequency		50/60 Hz	50/60 Hz
Voltage		690V	690V
Rotor			
Rotor Diameter:		77 m	82.5 m
Swept Area:		4657 m^2	5346 m^2
Tower			
Hub Heights:		65/80 m	80 m
Power Control		Active Blade Pitch Control	Active Blade Pitch Control

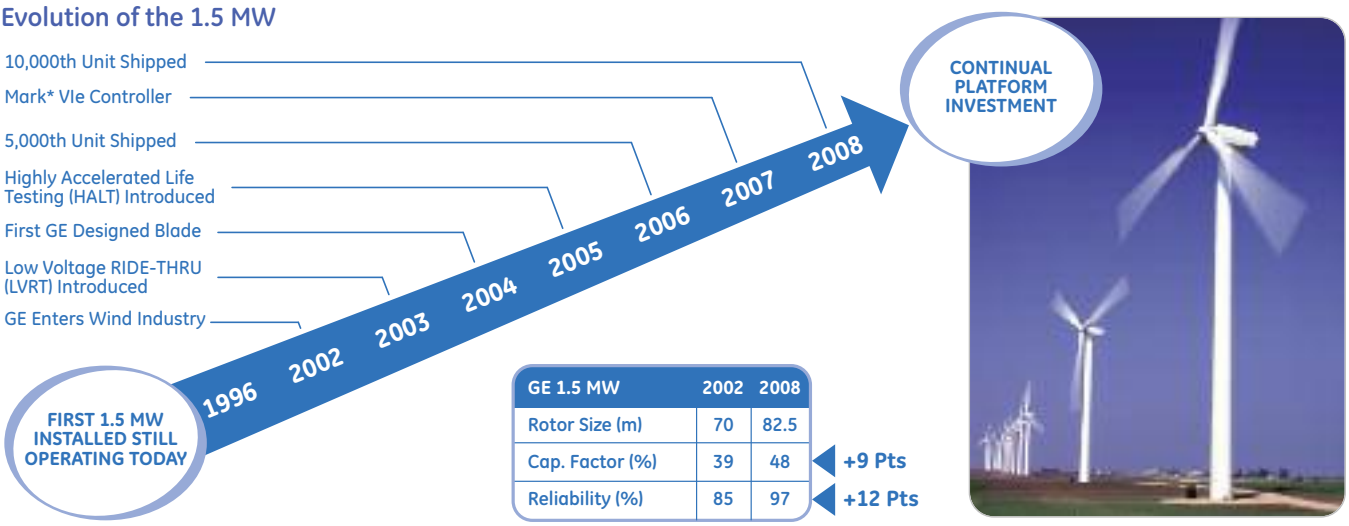
Power curve



1.5sle — *Classic workhorse, an efficient and reliable machine with proven technology*
1.5xle — *Built on the success of the 1.5sle platform, captures more wind energy with 15% greater swept area*

GE's 1.5 MW wind turbine is designed to maximize customer value by providing proven performance and reliability. GE's commitment to customer satisfaction drives our continuous investment in the evolution of the 1.5 MW wind turbine through technological enhancements.

Evolution of the 1.5 MW



GE 1.5 MW	2002	2008
Rotor Size (m)	70	82.5
Cap. Factor (%)	39	48
Reliability (%)	85	97

+9 Pts
+12 Pts

Commitment to continued investment

GE's commitment to investing in technology and increasing customer value is demonstrated with our exciting new customer options for increasing turbine performance, flexibility and reliability.

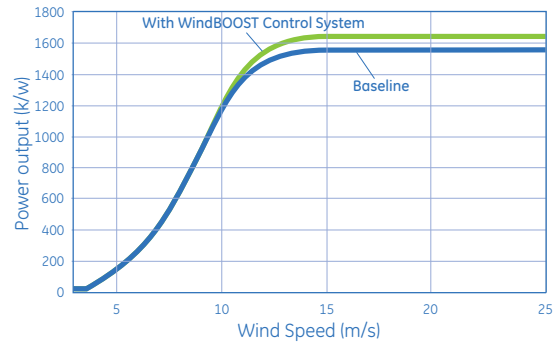
Enhanced performance

WindBOOST* Control System

This exciting new customer option for increasing performance, WindBOOST* control system, is a unique offering in the wind industry and the latest addition to the 1.5 MW product platform. This software upgrade provides:

- Up to 4% increased annual energy production (AEP), resulting in higher return on investment.
- Patent-pending control technology for optimum rotational speed, resulting in increased energy production.
- Remote capability to turn feature on and off at the turbine level.
- Increased power output while maintaining grid stability.

WindBOOST* Control System
Power Curve Density 1.2 (kg/m^3)



Improved flexibility

Reinforced Tower

GE's investment in a reinforced tower design opens up new potential wind sites for our customers, enabling us to deliver reliable and safe products that meet product and regulatory compliance expectations. GE's reinforced tower sections have the same length and external diameter as the standard GE North American modular system, but are specially built to handle seismic loads.

- Allows wind farms to be located in designated seismic prone areas with good wind resources.
- GE provides an evaluation to determine if the site requires reinforced tower due to seismic activity.

Increased reliability

Condition Based Maintenance (CBM)

GE Energy's integrated Condition Based Maintenance (CBM) system proactively detects impending drive train issues, enabling increased availability and decreased maintenance expenses. Factory or field installed and tested, the CBM solution can improve reliability on a single wind farm or multiple wind farms. GE's CBM allows operators to understand an issue weeks—or even months—in advance. This permits operators to:

- Continue to produce power while parts, crane, and labor are resourced.
- Plan multiple maintenance events with the same resources.
- Reduce or limit the extent of damage to the drivetrain and reduce repair costs.

Leading reliability and availability perform

GE's 1.5 MW wind turbine and services are designed to set the industry standard for product reliability and availability performance. GE's continual investments in technology, established infrastructure, research capabilities and globally recognized business processes allow GE to create and deliver customer value by maximizing energy capture and return on investment. This is evident through our model year performance trend where availability performance significantly improves each year.

GEARBOX

- HALT testing on every design
- Cylindrical roller bearings
- Improved oil filtration, heating and cooling

MAIN SHAFT

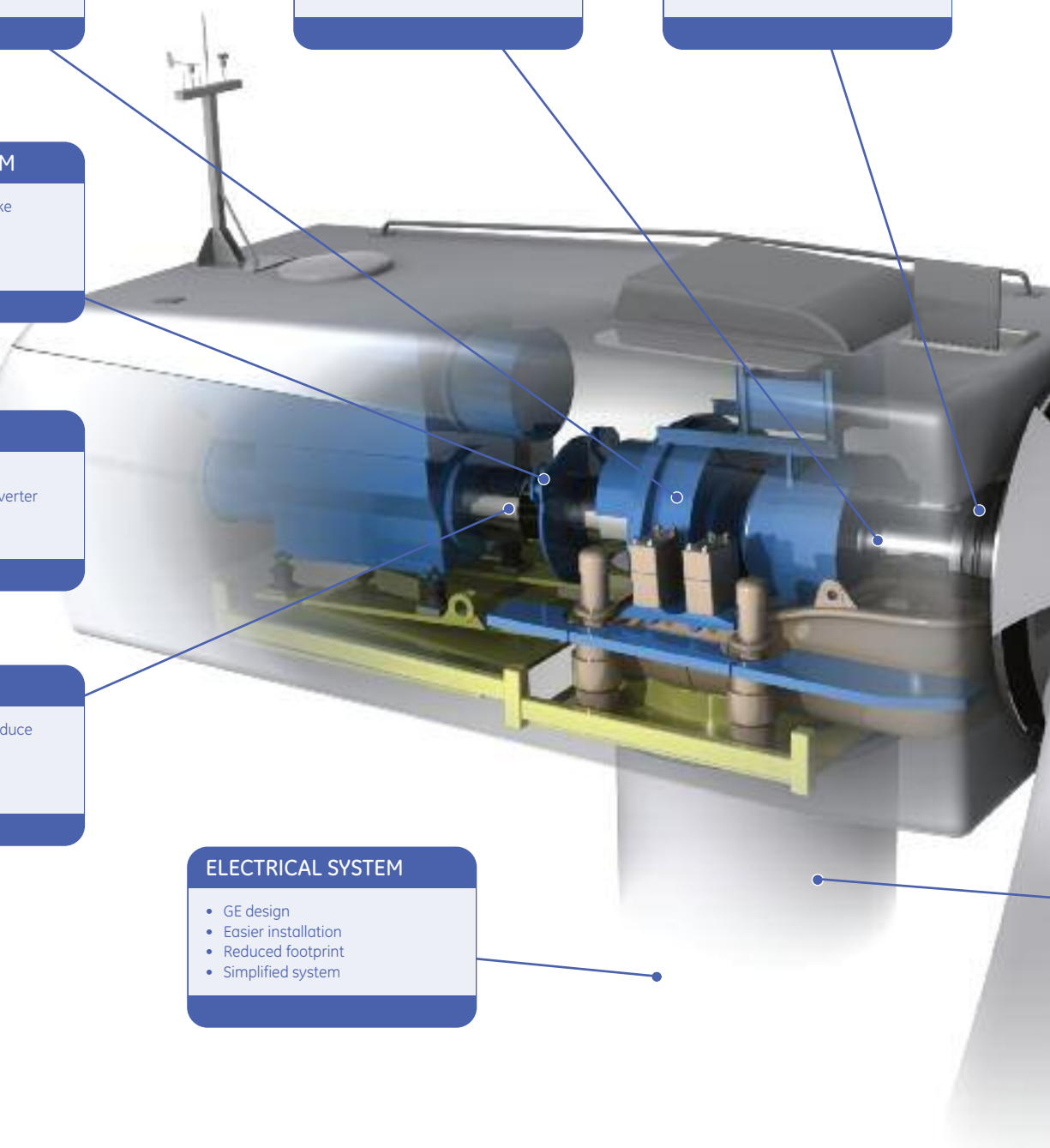
- Material upgrade
- Expanded operating range

MAIN BEARING

- Increased bearing robustness

SOFT BRAKE SYSTEM

- Hydraulic secondary brake



CONTROL

- GE Mark VIe controller
- Integrated pitch and converter diagnostics

COUPLING

- Slip coupling design to reduce gearbox loads

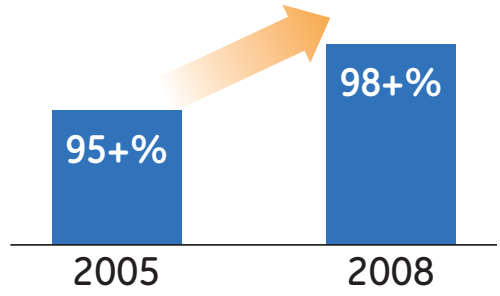
ELECTRICAL SYSTEM

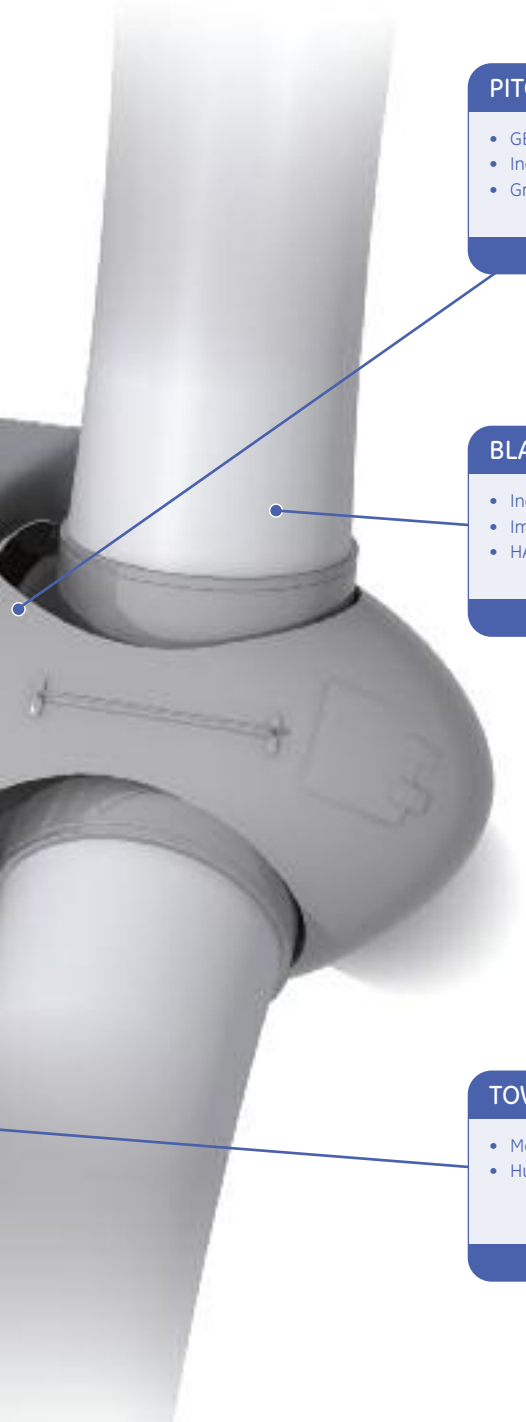
- GE design
- Easier installation
- Reduced footprint
- Simplified system

ance

Delivering reliability through advanced technology
To optimize turbine reliability and availability, GE focuses on reducing the number of downtime faults, and providing faster Return-to-Service (RTS). Our rigorous design and testing process—including specialized 20-year fatigue testing and Highly Accelerated Life Testing (HALT)—reflects our ongoing investment in key turbine components.

1.5 model year availability





PITCH
- GE designed pitch electronics
- Increased pitch drive robustness
- Greater torque

BLADES
- Includes GE designs
- Improved capacity factor
- HALT testing

TOWER
- Modular tower system
- Hub height flexibility

Technological expertise

GE Infrastructure

Energy
- Controls, materials, power electronics
- Fulfillment and logistics capability
- Efficient supply chain management

Aviation

Aerodynamic and aero-acoustic modeling expertise

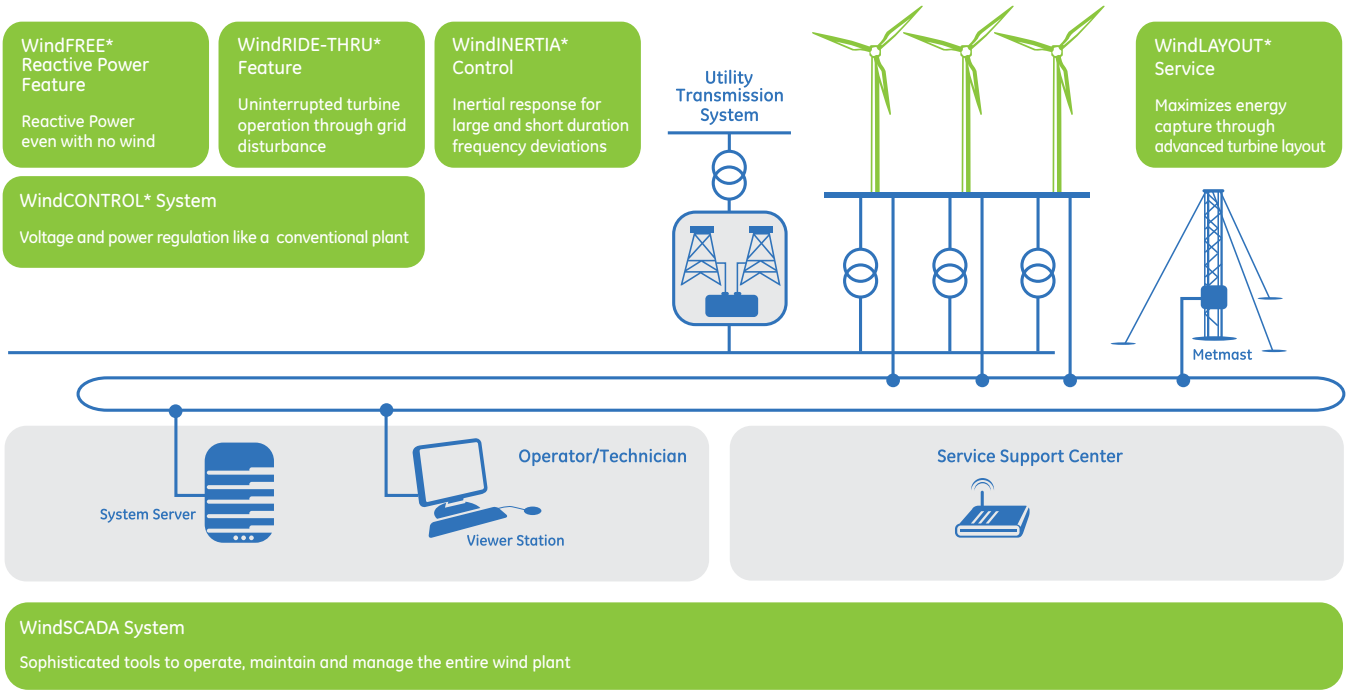
Rail

Gearbox and drive train technologies

GE Global Research
- Energy conversion
- Material sciences
- Smart grids

Optimized wind power plant performance

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 patented integrated suite of controls and electronics take your wind power plant to the frontline of performance and seamless grid integration.



FEATURE	DESCRIPTION	BENEFITS
WindCONTROL* System	Voltage and power regulation like a conventional power plant	Ability to supply and regulate reactive and active power to the grid Additional features include power frequency droop, power ramp rate limiters and integrated capacitor/reactor bank control
WindFREE* Reactive Power Feature	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
WindRIDE-THRU* Feature	Low voltage, zero voltage and high voltage ride-through of grid disturbances	Uninterrupted turbine operation through grid disturbances Meets present and emerging transmission reliability standards
WindINERTIA* Control	Provides temporary boost in power for under-frequency grid events	Provides inertial response capability to wind turbines that is similar to conventional synchronous generators without additional hardware
WindLAYOUT* Service	Service to optimize turbine layout for a site	Opportunity to increase annual energy production for a site
WindSCADA System	Tools to operate, maintain and manage wind power plant	Real-time data visualization, reporting on historical data, alarm management and secure user access

Project execution

GE understands that grid compatibility, site flexibility, and on-time delivery are critical to the economics of a wind project. That's why the 1.5 MW wind turbine has been engineered for ease of integration and delivery to a wide range of locations, including those with challenging site conditions.

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 Global Projects Organization utilizes decades of fulfillment expertise in project management, logistics, plant start-up and integration from Gas Turbine, Combined Cycle, Hydro, and Aero plants.

Here are some examples of how GE has worked with customers to solve project challenges and maximize their value through on-time delivery and advanced logistic capabilities:

Challenge:
Site with late grid availability due to project location change

GE's solution:
Pre-commissioning service: GE can bring portable generators on site and pre-commission turbines even without back feed power

Customer benefit:
Faster commissioning once grid became available

Challenge:
Project site with difficult geographic access

GE's solution:
Well-choreographed team with challenging terrain transportation expertise

Customer benefit:
More site flexibility; schedule target met

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 ensures 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 12,000 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 (877-956-3778), 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 in the capital parts pool, with a priority access to often hard-to-source capital parts.

Conversions, Modifications and Uprates (CM&U)

Continuous technological improvements are key for GE to be a world leader in the wind industry. Our CM&U offerings utilize the new technology developments in the 1.5 MW platforms to improve the performance of existing assets. These offerings are designed to improve reliability and availability, and increase turbine output and improve grid integration.

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.

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
or contact your GE Energy sales representative at
800-821-2222

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