

GE Renewable Energy

# Onshore Wind Services



[www.gerenewableenergy.com](http://www.gerenewableenergy.com)

## TABLE OF CONTENTS:

3	Operate and Maintain
3	Turbine Maintenance
7	Asset and Park Management
8	Enhance and Optimize
8	Wind PowerUp* Services
10	Digital Wind Farm
10	Flexible Services Offerings

GE's onshore wind services team provides customers with lifecycle solutions that are customizable to meet their desired outcomes and risk profiles. With our advanced technology, a wide breadth of offerings and world-class field service expertise, we deliver service performance excellence.

Today, GE is investing in the power of the industrial internet, utilizing big data & analytics at both the farm and fleet level to optimize existing assets. More energy production and greater reliability means more revenue from your windfarms. At GE, our wind services team is committed to making sure your turbines run better tomorrow, than they do today.

## GE can operate your wind farm...

GE is your ally in simplifying your fleet operations. As a leading wind turbine manufacturer, with over 10 years of operating experience and technical knowledge, no one knows your turbines better. GE provides technical expertise and engineered solutions supporting smart maintenance and repairs while prioritizing lifecycle costs and guaranteed availability. In turn, we simplify your fleet operations and manage your portfolio to your metrics and risk appetite.

## Planned Maintenance

Applying industry leading expertise and experience to routinely service your turbines and keep them online, resulting in superior fleet performance.

## The GE Advantage

### Highly trained Service Technicians who know turbine technology inside & out

~1,200 hours of training per Wind Field Service Technician, with 600+ technicians on our team

### Technical expertise with data driven insights

Preventive maintenance procedures based on 10+ years of root cause analysis

### Industry leading troubleshooting practices

Solutions engineered with lifecycle mindset

## Unplanned Maintenance

Applying robust methods to monitor, troubleshoot and inspect your turbines, boosting uptime and lifecycle production.

### Drivetrain

- With advanced sensors and analytics, we can troubleshoot obstacles uptower, offering an array of gearbox and generator remanufacturing options in addition to fixed rotor gearbox replacement to reduce crane requirements

### Blades

- Our experience allows for uptower repairs and upgrades, including surface and structural repairs
- Single blade exchange and optimized blade bearing exchange with reduced crane requirements

### Converter and controls

- Advanced troubleshooting
- Remanufactured control cards to latest revision

# GE can maintain your turbines...

A suite of offerings to keep your turbines online and running at capacity

At GE, we apply technical expertise and rigor to keep your turbines online by servicing major systems within the turbine to avoid potential downtime and under performance. This is all backed by data driven insights, which enable us to drive down your O&M costs through intelligent monitoring. We have developed specialized upgrades, repairs, and exchange techniques to ensure superior turbine performance, through unique detection and diagnostic capabilities.

## Parts Plans

Availability of parts is critical to keep your wind farms running smoothly. GE's Wind Parts Center of Excellence provides a full range of offerings to support your preferred level of service. From maintenance kits and wear and tear flow parts to gearboxes and blades, our team gets you what you need. Our forecasting capability, driven by fleet-wide parts consumption data configuration and management knowledge, can even help to predict what you may need.

## PulsePOINT\*

PulsePOINT Services is GE's way of monitoring the internal heartbeat of your turbines. Data is only as powerful as the analytics powering it and the power of PulsePOINT empowers GE to detect anomalies before they even become a challenge, enabling more predictive maintenance and avoiding costly failures. The result is reduced unplanned downtime, higher availability, and increased long-term reliability of your wind fleet and overall lifecycle. As we keep learning more from our fleet, PulsePOINT will continue to teach us how to best serve our customers.

## Remote Operations Center

Driving down O&M costs through intelligent monitoring ... getting your turbines back online quickly and safely.

GE's customer support and remote operations centers in Schenectady, New York and Salzbergen, Germany provide continuous monitoring and diagnostics services 24-hours a day, 365 days a year. GE Service Technicians care for your fleet around the clock providing remote troubleshooting and technical support to quickly get turbines back online. An on-site SCADA system connected to each wind turbine's control system enables our technicians to constantly track key operating parameters and detect abnormal conditions. They can then troubleshoot or reset the turbines right from their chair in the remote location, in real-time.



Salzbergen, Germany



Schenectady, New York

**10,500** turbines monitored and operated globally

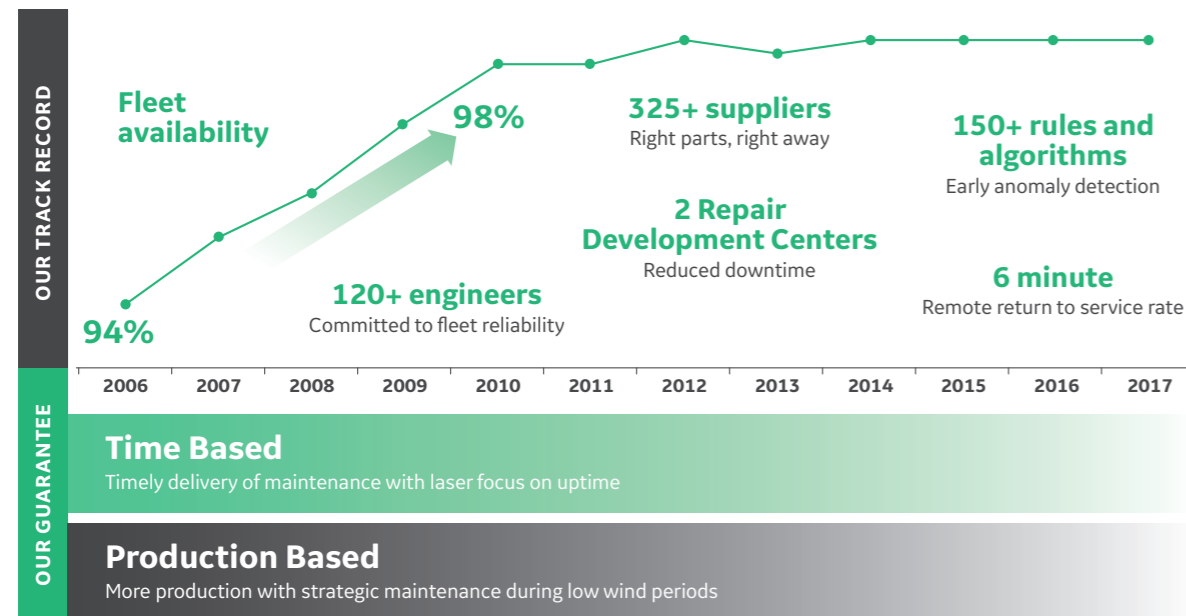
**6 minute** average return to service for faulted turbines

**>25TB** of data analyzed a day across the fleet

## Availability

Throughout our rich history in wind GE has maintained industry leading fleet availability of 98%, delivering more output and more money to our customers. At GE, we strive to develop the best people, processes, and technologies, all of which have resulted in a fleet running at 98%+ availability.

Our success and confidence in our technology has led us to develop a set of availability guarantees that are directly aligned to your project economics and designed to reduce project risk.



## Beyond the GE Fleet

GE's Universal Fleet Solutions (UFS) platform was created to provide a broad spectrum of services to support the wind industry beyond the GE fleet. The UFS platform uses the knowledge gained from servicing a fleet of over 30,000 turbines to support your fleet long-term with:

- **The right products** for your fleet, sites, and individual turbines
- **Service solutions** to run your wind farm efficiently
- **Technology investments** to position wind as a mainstream power source

## Asset Management and Park Management

One point of contact, simplifying the operations of your portfolio to help you meet your profitability metrics

ASSET MANAGEMENT Comprehensive planning and execution, prioritizing holistic farm performance	PARK MANAGEMENT Effectively lead site operations and maintenance
<p><b>Operating Plan</b></p> <ul style="list-style-type: none"> <li>• Cost modeling and efficiency identification</li> <li>• Budgeting, bookkeeping, reporting</li> <li>• Interfacing with community, grid operator, insurance, warranty and contractors</li> </ul> <p><b>NERC Compliance Support</b></p> <ul style="list-style-type: none"> <li>• NERC 693 and Critical Infrastructure Protection v5 standard regulations</li> </ul>	<p><b>Electrical Balance of Plant</b></p> <ul style="list-style-type: none"> <li>• Substation maintenance, remote monitoring, and troubleshooting</li> <li>• Padmount Transformers</li> <li>• Transmission Lines</li> </ul> <p><b>Balance of Plant</b></p> <ul style="list-style-type: none"> <li>• Civil Maintenance</li> <li>• Facility Services Management</li> <li>• 3rd Party Contract Management</li> <li>• EHS Management</li> <li>• IT Infrastructure</li> </ul>



# GE can enhance and optimize your fleet ...

## Wind PowerUp\* Services

A results based, customized, Predix-enabled platform, created to increase the annual energy production (AEP) of your wind farm by up to 10%.

### Technical Differentiation

When the PowerUp platform is activated for your fleet, GE's Predix software performs a complete historical analysis of each asset's configuration, performance, and operational history along with the environmental conditions of the site. After establishing a baseline for each turbine, GE's Predix software will determine the potential increase in annual energy production using lifecycle analytics on a model of your asset and site. Now that your turbines are connected to the industrial Internet new asset performance management capabilities are unlocked, enabling real time enhancements of wind farm production levels to turbine-specific environmental, operational, and economic conditions.

### Commercial Innovation

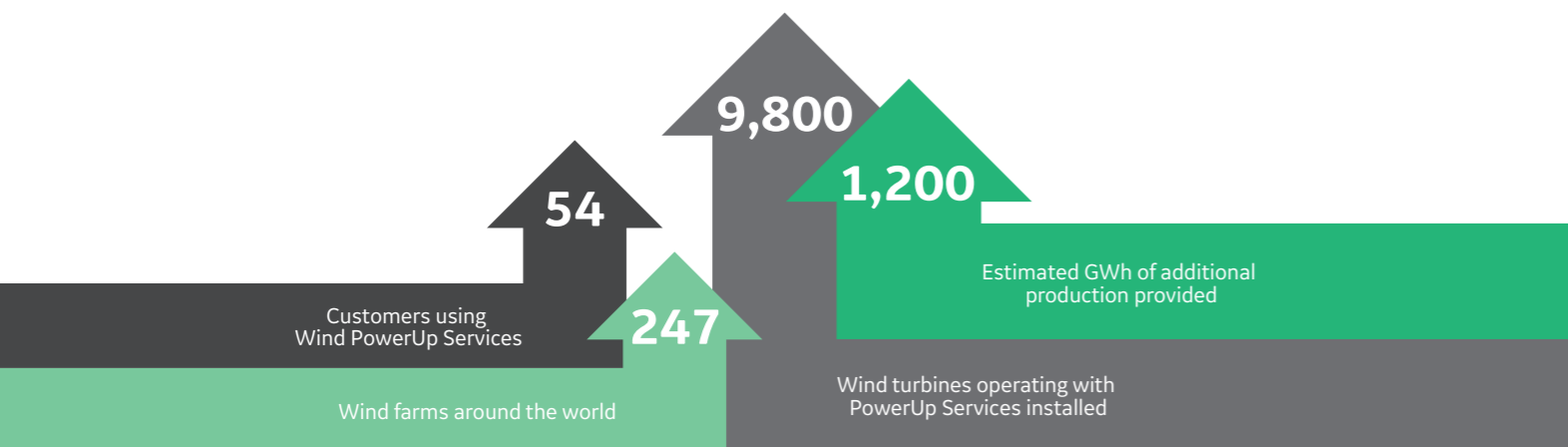
The PowerUp platform is a lifecycle asset performance offering available for new or existing Flexible Service Agreements that continues to increase a wind farm's AEP as new GE technologies are introduced. PowerUp is a flexible, outcome-based, commercial offering (OPEX, CAPEX) that allows wind farm operators to pay only for validated performance improvements.

### The Value of PowerUp

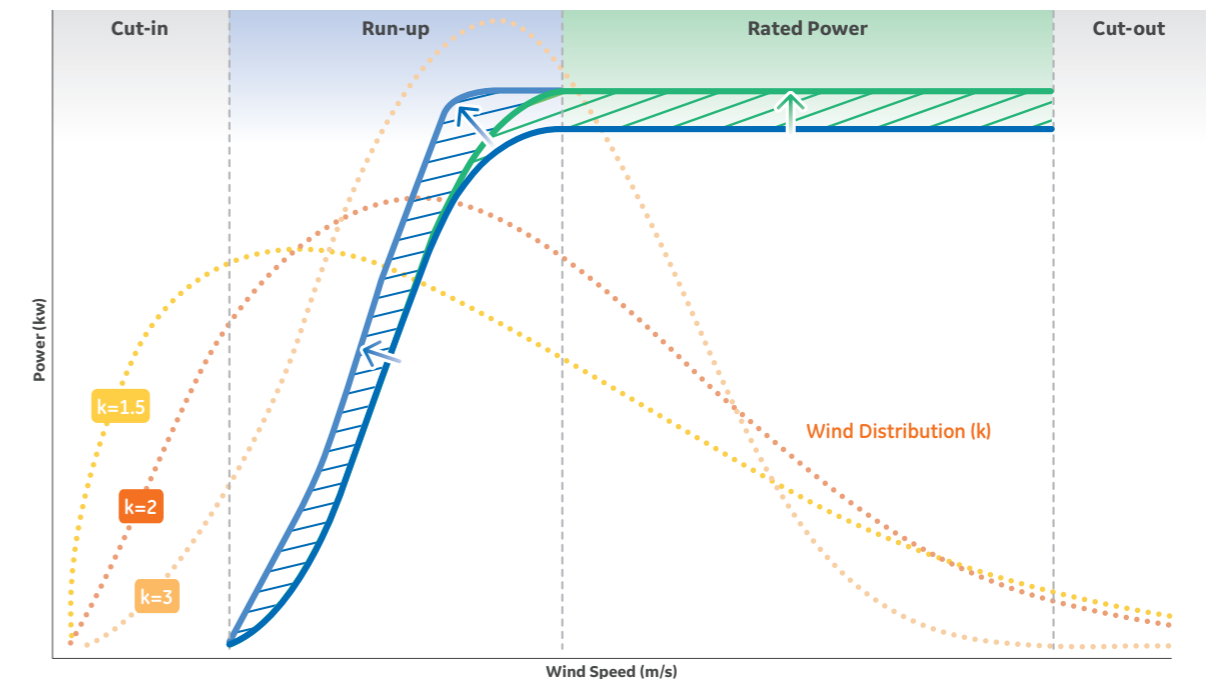
*"The PowerUp system offers a great chance for owners like us who are investing literally billions of dollars in this market to try and get more production out of existing assets. GE took a lot of risk out of this for us."*

- Patrick Woodson, CEO, E.ON Climate & Renewables

Our customers determine our success, and PowerUp enables us to align directly to customer outcomes, delivering reliable performance gains over the lifetime of your fleet.



## PowerUp Platform performance curve



The PowerUp platform uses a suite of performance dials and levers to fine tune a wind turbine's operation and help enhance its energy production, resulting in a customized solution that seeks to increase annual energy production.

### Speed

The rate at which the drivetrain moves, measured in rotations per minute (rpm). Speed (balanced with torque) directly affects bearing rotations, gear rotations, generator voltage and blade noise.

### Yaw

The position of the turbine nacelle as it relates to the wind direction. Nacelle yaw position directly impacts the energy yield and mechanical loads.

### Torque

The torsional force that flows through the drivetrain, measured in Newton-meters. Torque, balanced with speed, directly affects bearing thrust, gear contact stress and generator current.

### Aerodynamics

The efficiency of a blade configuration to extract energy from the wind, as measured by the rotor coefficient of power (Cp). Efficiency is directly affected by the blade profile, surface finish, lift and drag. The maximum theoretical value for efficiency is 59%, also known as the Betz limit.

### Pitch

The position of the blade on the turbine that determines the aerodynamic efficiency of the rotor. Pitch directly affects the energy yield, mechanical loads, and thrust through the drivetrain.

### Turbine Controls

The brain of the wind turbine. Wind turbine controls manage the interaction between the components, the environment and the operator to produce reliable energy.

# Digital Wind Farm

## Turning insights into better, faster decision-making

GE's Digital Wind Farm is a comprehensive hardware & software solution comprised of GE's customizable 2 and 3MW wind turbine products, a predictive analytics software platform, and performance optimization controls technology that, over the course of a wind farm's life, can improve its energy output by up to 20%.

The Digital Wind Farm optimizes turbine performance and equipment life through the use of Predix\*, a predictive analytics software platform. Predix provides a digital infrastructure for your wind farm, enabling you to collect, visualize and analyze unit & site level data. Through the constant collection of real time data—weather, component messages, service reports, performance of similar models in GE's fleets—a predictive model is built and the data collected is turned into actionable insights. This model can perform advanced planning, such as forecasting a 'plan of the day' for turbine operation, determining a highly efficient strategy to execute planned maintenance activities, and providing warnings about upcoming unplanned maintenance events, all of which ultimately generates more output and revenue for the customer.

# Flexible Services

## Fully customizable services offerings to meet your needs

## Focused on Lifecycle Value

Our Flexible Service Offerings focus on lifecycle value—aiming to deliver the lowest cost on a \$/MWh basis. A GE service agreement is a relationship with our customers aimed and continuously enhancing lifecycle performance for your fleet. It's all about delivering low cost energy and GE is positioned to help you improve energy production and reduce operating costs over the life of your assets. Simply put, we know how to deliver results in an uncertain world.

## Flexing to Customer Needs

What do we mean by flexible? We mean aligned to our customers' desired outcomes:

- **Flexible pricing** – from fixed fee to variable fee to revenue sharing
- **Flexible term** – from five years to end-of-life to life extension solutions
- **Flexible scope** – from planned to unplanned maintenance to asset and operations optimization (and everything in between)

# The GE Advantage

GE service agreements are based on over a decade of technical leadership in the wind industry. But they also benefit from more than a century of GE power plant experience and capabilities in areas such as condition monitoring, regulatory compliance, and plant engineering.

- Engineering expertise
- Customized performance upgrades for your fleet
- Early issue detection
- Regulatory expertise
- Software and analytics

## GE's Flexible Service Offerings:

ATTRIBUTE	PRODUCT FEATURE	EXPANDED SERVICE ESA	FULL SERVICE FSA	OPERATIONS SERVICE OSA
<b>Enhanced Performance</b>	Wind PowerUp Services Platform	Standard	Optional	Optional
<b>Operations Solutions</b>	Asset Management • Operating plan, NERC support	Standard	Optional	Optional
	Park Management • Site operations, eBOP, BOP	Standard	Optional	Optional
<b>Unplanned Maintenance</b>	Customizable unplanned coverage • Full scope • Major components • Minor components	Standard	Standard	Optional
	Availability guarantee	Standard	Optional	Optional
	Manual resets and troubleshooting	Standard	Optional	Optional
<b>Planned Maintenance</b>	Parts management	Standard	Optional	Optional
	Preventive maintenance	Standard	Optional	Optional
	Routine maintenance	Standard	Optional	Optional
<b>Monitoring and Diagnostics</b>	Remote monitoring and resets	Standard	Optional	Optional
	PulsePOINT* Services	Standard	Optional	Lite
	Data analytics and reporting	Standard	Optional	Optional
	Technical advisory support	Standard	Optional	Optional

Lite: SCADA-based anomaly detection. ■ Standard for service level ■ Optional for service level

TORQUE

# PROVEN, RELIABLE WIND ENERGY SOLUTIONS YESTERDAY, TODAY AND TOMORROW.

[www.gerenewableenergy.com](http://www.gerenewableenergy.com)

DIGITAL WIND FARM

WindSCADA™

CONNECTED MACHINE

INDUSTRIAL INTER



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GEA31819C (05/2017)