

# Onshore Aftermarket product catalogue

Jun 2025

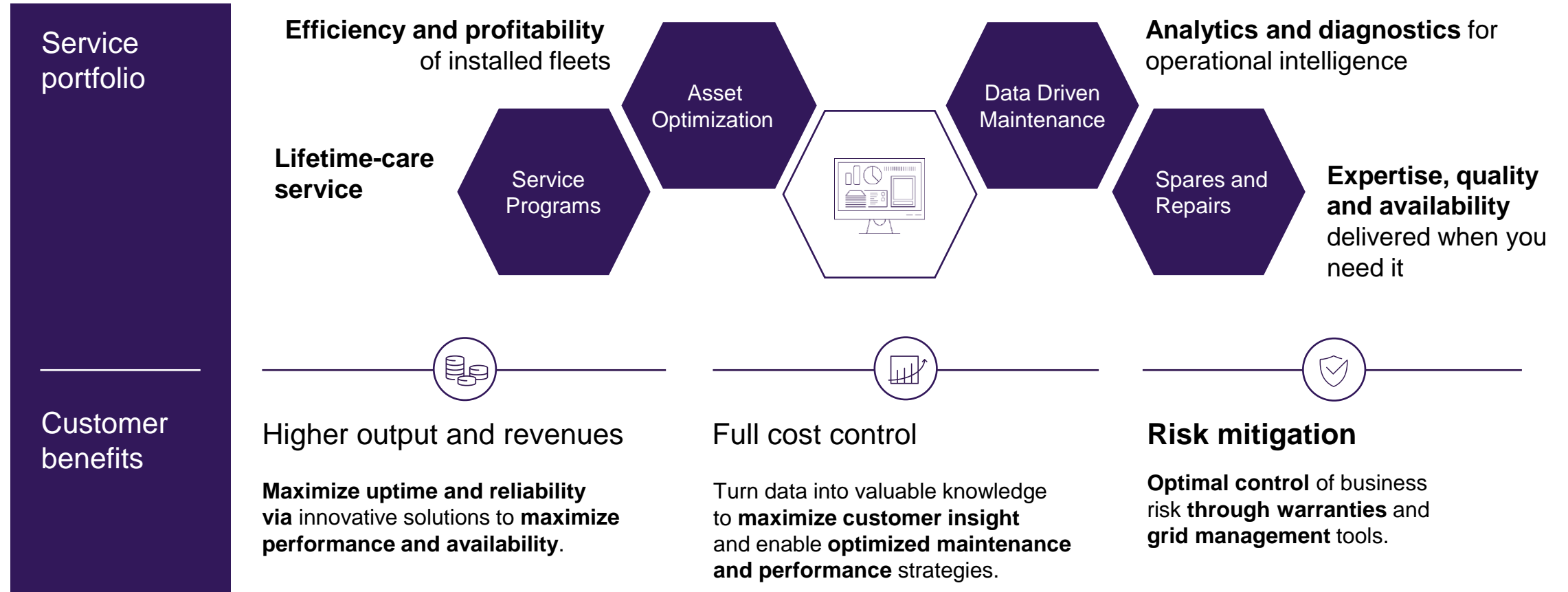
# Wind turbine expertise for superior efficiency

Built on a unique combination of **more than 40 years designing, manufacturing, and operating wind turbines** across the world, Siemens Gamesa's **high-performance aftermarket solutions** deliver enhanced **energy production and operational efficiency** throughout the asset's lifetime.

This is supported by a **comprehensive range of spare parts and repair services**, ensuring **maximum turbine availability and reliable performance**.



# A Reliable One-Stop-Shop for all Your Service Needs



# Stronger together: The Aftermarket Value We Bring to your assets



## Commitment to Your Success

We prioritize your goals and work together to unlock full asset potential.



## Customer-Centric Focus

Your unique requirements drive tailored aftermarket solutions for long-term value.



## Long-Term Partnership


Our experts are with you every step of the way, offering ongoing support, strategic advice, and expertise to drive sustained asset performance.



## Seamless Integration

Aftermarket solutions that can integrate smoothly, minimizing operational disruption.

## We never compromise on safety

Safety is my choice 

### Transparent reporting to drive down our Total Recordable Injury and Lost Time Injury Rates.

- Analysis of trends and areas for improvement.
- Incident investigations to prevent reoccurrence.
- Contractors included in all aspects of our safety performance.

### Proactive control measures and education to deliver improved EHS performance.

- Robust risk assessments to ensure safe operations.
- EHS programs based upon high-risk activities and operational control.
- Real world effective safety training.

# A lifetime partner focused on your success

## Asset Optimization Services to maximize the efficiency and profitability of installed fleets, ensuring reliability for decades



### EnergyUp™ Upgrades

Engineer-driven solutions aimed at increasing energy output.



### Wind Farm Performance Control and Upgrades

Digital and data-driven solutions, including analytics, diagnostics, and SCADA upgrades for operational intelligence and turbine performance enhancement.



### Wind Turbine Improvements

Innovative upgrades to modernize existing turbines.



### Life Extension Program

Monitoring and structural upgrades that support greater control over maintenance expenses and streamline the cost of energy.



### Cybersecurity and Grid Compliance

Supporting improved protection and regulatory compliance.

## Spares and Repairs: comprehensive portfolio across different turbine platforms



### New and Refurbished Parts

**High-quality components** available worldwide.



### Repair and Reconditioning Services

**Expert solutions for both major and minor turbine components**, from electrical parts to gearboxes, generators, and blades.

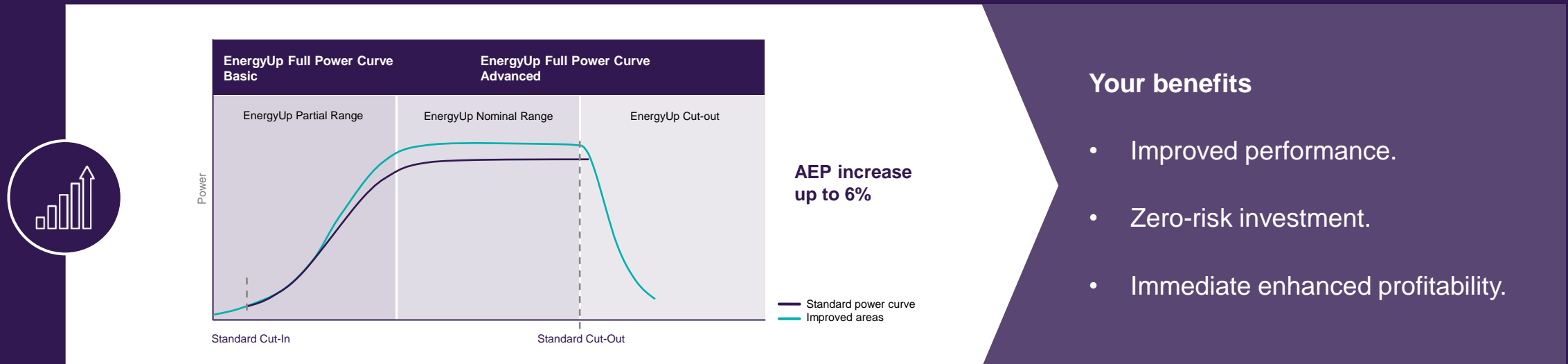
# Asset Optimization

Reliability of installed fleets for decades

# EnergyUp™ Upgrades

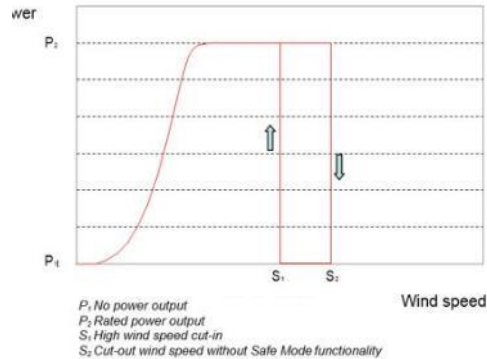
A suite of innovative products designed to **optimize performance and increase the annual energy output of your existing fleet**. Compatible with Siemens, Gamesa, Siemens Gamesa, and Senvion technologies, these products are available individually or as bundled packages.

Each EnergyUp™ solution **enhances specific areas of the power curve, offering greater flexibility and adaptation to site-specific conditions**. With efficient and adaptable solutions, it helps maximize revenue from aging fleets.

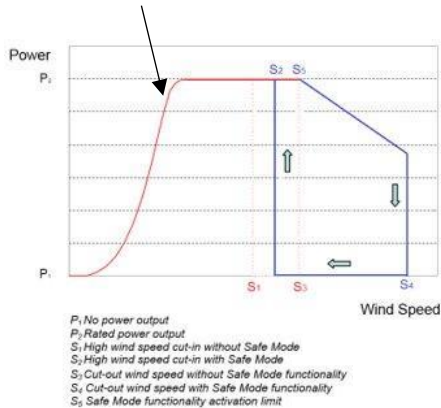


# EnergyUp Cut Out Gamesa technology

Standard high wind speed limits without EnergyUp Cut Out



New high wind speed limits with EnergyUp Cut Out



## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

Designed to maximize performance, this feature increases both the cut-out and restart wind speeds, extending operational time under high-wind conditions.

It also ensures the protection of turbine components when operating beyond the standard cut-out wind speed. Power production and rotor speed are gradually reduced until the EnergyUp Cut-Out wind speed is reached again.

## Benefits

- No upfront cost.
- Pay only for the additional energy produced.
- Increase energy production in high wind conditions.
- Up to 1.5% increase in annual energy production\*.
- Proven increase in energy production.
- Reduction of full stops .
- Benefits from day one.

\* Depends on WTG configuration and WF conditions



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW.  
G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW.

## Compatible products

It can be combined with Full Power Curve Basic and Advanced package to enhance AEP across the entire power curve.

### Fleet experience

Approx. 6,150 MW.

### Installation time

Remote activation 1.5h/WTG.

### Agreement

Will be negotiated on a value-based approach.

### Est. lead time

Approx. 1 week.

# EnergyUp Cut Out Siemens technology

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

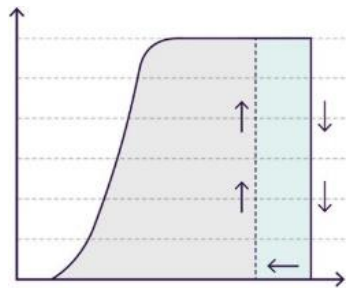
Software feature designed for both onshore and offshore wind turbines, enabling them to capture more wind energy.

During high-wind events, the turbines adjust the pitch angle and rotor speed to reduce loads while maintaining operation. In typical conditions, turbines experience a waiting period after a high-wind shutdown.

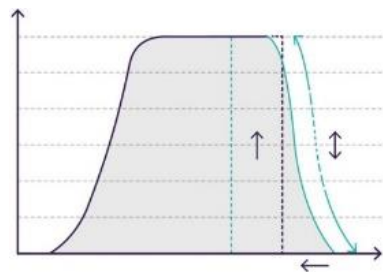
EnergyUp Cut Out feature minimizes this downtime by allowing continued operation at higher wind speeds, reducing unnecessary shutdowns. By preventing abrupt and simultaneous shutdowns, the gradual load-based reduction in power helps stabilize the grid.

## Benefits

- Unlock potential and increase your annual energy production.
- Increase the value of your asset.
- Extend the life-cycle (reduces wear and tear on components due to fewer stops).
- Enhance and stabilize the grid.



Without EnergyUp Cut Out



With EnergyUp Cut Out



AEP



Improved  
performance



Operating  
reliability



Trusted  
partner



Safety

## Applicability

SWT-2.3-93, SWT-2.3-101, SWT-2.3-108, SWT-3.6-107, SWT-2.3-82 VS, SWT-2.3-93, SWT-3.6-120, SWT-3.0-101, SWT-3.0-113, SWT-3.0-108, SWT-3.2-113, SWT-3.2-101, SWT-3.2-108, SWT-3.4-108, SWT-3.4-101.

## Compatible products

It can be combined with EnergyUp Nominal Range and EnergyUp Partial Range function to optimize annual energy production across different segments of the power curve.

## Certificates

Certified for all applicable platforms (DNV-GL for Siemens technology and TÜV-NORD for Senvion technology).

### Fleet experience

> 5,000 WTG ~ 19GW.

### Installation time

Remote activation 1.5 h/WTG.

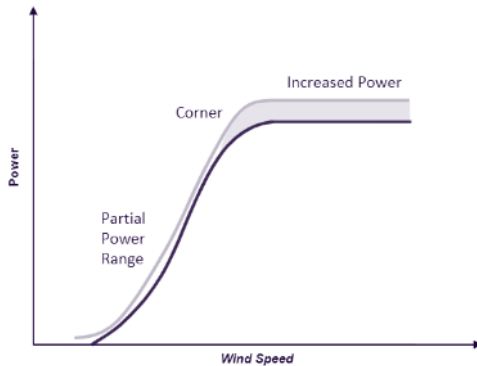
### Payback

Depends on the individual case. E.g. 3-4 years.

### Est. lead time

Approx. 1-2 weeks.

# EnergyUp Full Power Curve Advanced Gamesa technology



\* Compared with a standard power curve and depending on wind and site conditions (G58-850 kW power curve at average wind speed of 7.5 m/sec and wind distribution of  $k=2$ ).

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

EnergyUp Full Power Curve, Advanced is a software and parameter upgrade for the turbine control system, offering the potential for up to a 6%\* increase in AEP by optimizing pitch characteristics through the application of new aeroelastic models.

## Benefit

- No upfront costs.
- Energy production increases by up to 6%, benefits from day one.
- Measurable increase in energy production, demonstrated in a report provided every quarter.
- Transparency on the inputs of the AEP gain calculation as they come from SCADA data.
- Improved performance in low-wind conditions.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

G58-850 kW with PLC Phoenix and TEAM.

### Installation time

Approx. 2 h/WTG.

### Fleet experience

2,800 WTG ~ 4,750 GW previous experience with EnergyUp Full Power Curve, Basic.

### Est. lead time

Approximately 1 month. In some cases, an upgrade to the SCADA or PLC hardware may be required. Lead time is subject to parts availability.

# EnergyUp Full Power Curve Advanced Senvion technology

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

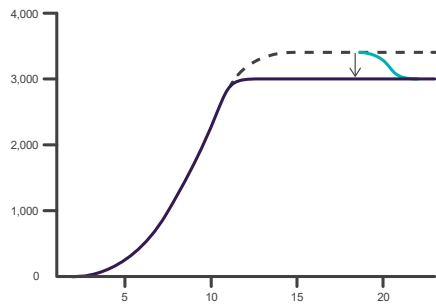
This advanced solution delivers a significant increase in Annual Energy Production (AEP) for the MM82, MM92, and MM100 onshore wind turbines by optimizing torque and rotor speed. This upgrade enhances power output to:

- 2.2 MW for the MM82 and MM92 (50 Hz market).
- 2.15 MW for the MM100 (50 Hz turbines).
- 2.125 MW for the MM82 and MM92 (60 Hz market).

These performance improvements are achieved by refining turbine control logic through a software update, enabling the full potential of the turbine while ensuring safety. Depending on the turbine model and wind farm conditions, the software increases both torque and rotor speed, resulting in an AEP boost of up to 5%.

## Benefits

- Increased profitability.
- Zero risk on your investment.
- No additional hardware needed.
- Smart solution evaluated by a certification body.



**Note:** Only the MM82, MM92 and MM100 turbines equipped with a Bachmann Controller are within the scope of this product.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

MM82, MM92, MM100.

## Compatible products

Compatible with all MM platform products (EnergyUp Partial Range, EnergyUp Full Power Curve Basic, etc.).

### Fleet experience

Already installed in Senvion MM wind turbines.

### Installation time

Fast remote software installation and parameter settings.

### Payback

Depending on factors such as the turbine type and site-specific wind conditions, the actual AEP gain could be up to 5%.

### Est. lead time

Approx. 2.5 months to perform the technical assessment evaluating the site's suitability.

# EnergyUp Full Power Curve Advanced Siemens technology

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

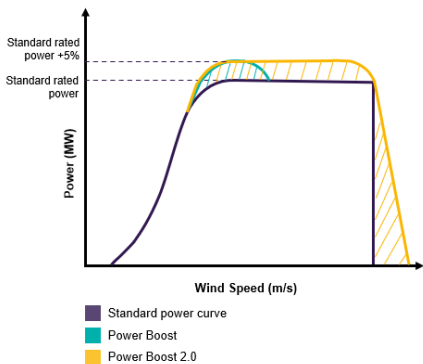
This advanced solution enhances the power production of the Siemens fleet by increasing the standard rated power by up to 5%, depending on site-specific conditions, turbine configuration, and local factors such as wind, temperature, and voltage. The extra energy is produced in the following areas:

- Partial Range.
- Rated Power.
- Cut Out (only for SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93 and SWT-2.625-120).

This is achieved by optimizing the pitch control system in the partial range and, where applicable, extending the wind speed range to capture additional power in high-wind conditions. For turbines that have not been upgraded with EnergyUp Nominal Range, EnergyUp Full Power Curve, Advanced will also increase the revolutions per minute (rpm) along with the rated power.

## Benefits

- Increased annual energy production by up to 3% for turbines not already running EnergyUp Full Power Curve, Advanced.
- Increased power production and improved business case with low risk.
- Measurable and demonstrated output gain.
- Improved AEP at minimized cost while ensuring the integrity of the assets.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

Onshore: SWT-2.3-93, SWT-2.3-101, SWT-2.3-108.

Offshore: SWT-3.6-107, SWT-3.6-120, SWT-4.0-120, SWT-4.0-130, SWT-6.0-154.

## Compatible products

It can be acquired with EnergyUp Partial Range and Cut Out (included for SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93 and SWT-2.625-120) to increase AEP in several areas of the power curve.

### Fleet experience

Approx. 4,500 WTG.

### Installation time

Remote activation 1.5 h/WTG.

### Payback

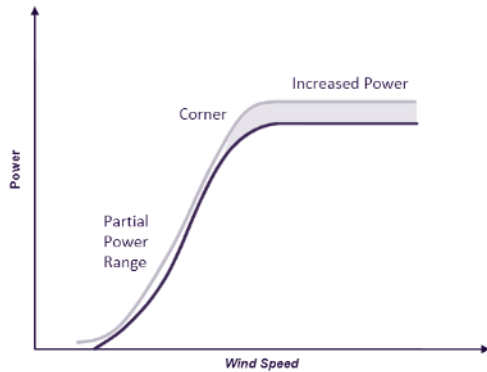
Depends on the individual case.

### Certificate

DNV-GL certification for all applicable platforms.

# EnergyUp Full Power Curve Basic

## Gamesa technology



Models	Power kW	Up to (kW)	Extra power	AEP increase
G52-850 kW G58-850 kW	850	920	8.2%	Up to 5%
G80-2.0 MW G83-2.0 MW G87-2.0 MW G90-2.0 MW	2,000	2,070	3.5%	Up to 5%

Depending on temperature, voltage, reactive power and nominal power increase.

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

EnergyUp Full Power Curve, Basic: an upgrade that transfers state-of-the-art algorithms and strategies to older turbines, enabling them to perform like newer models. This upgrade improves power output across all segments of the power curve: partial range, corner, and nominal range. As a result, it can achieve up to a 5% increase in AEP.

## Benefits

- No upfront costs.
- Energy production increases up to 5%, benefits from day one.
- OEM designed; 3rd party approved.
- Measurable increase in energy production, demonstrated in a report provided every quarter.
- Includes software and if necessary, the needed hardware upgrades.
- Total transparency and access to raw performance data.
- Improved performance in low wind condition.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW.

## Industry validation

Validated by Garrad Hassan\*:

- Turbine integrity is not compromised.
- Modifications will not affect the turbine design life.
- Methodology to calculate energy gain is Garrad Hassan approved.

\* Now part of DNV GL.

## Fleet experience

Approx 5,000 MW.

## Installation time

6-8 h/WTG.

## Est. lead time

Approx. 1 month.

# EnergyUp Full Power Curve Basic

## Senvion technology



AEP



Revenue



Operating  
reliability



Maintenance  
ease



Safety

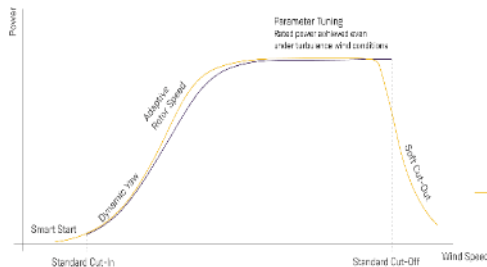
## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

A comprehensive suite of performance-enhancing software features, developed through our advanced data analysis. It includes:

- Smart Start: Optimizes the standard cut-in wind speed based on individual site conditions.
- Dynamic Yaw: Fine-tunes the yaw angle, increasing wind turbine output.
- Adaptive Rotor Speed: Increases rotor speed in the upper partial load range, enabling longer operation at the optimal tip speed ratio and improving rotor efficiency.
- Parameter Tuning: Ensures the turbine reaches its rated power output, even under high-turbulence wind conditions.
- Soft Cut-Out: Instead of a sudden shutdown at the standard cut-out wind speed, the turbine gradually reduces rotational speed and power output, reaching a new, higher maximum cut-out wind speed.



## Benefits

- Increased power output due to the five high-performance features.
- Customized solution thanks to site-specific adjustments.
- Particularly effective for turbines located on complex terrain and with low air density.

## Applicability

3.4M104, MM82, MM92, MM100.

## Customer testimonial

*"We recognized a valuable opportunity to participate in the test program for the new EnergyUp Full Power Curve Basic product and engage in a prototype project. After a seven-month testing period, Siemens Gamesa engineers successfully demonstrated that significant additional yields can be achieved for our customers. Following this successful test, we are confident in recommending EnergyUp Full Power Curve, Basic as an excellent asset for any operator seeking to maximize annual energy production from their wind turbines."*

— Jens Godau, Managing Director, Ingenieurbüro Holst GmbH & Co. KG.

## Fleet experience

Independently validated by TUV Nord and Wind-Consult.

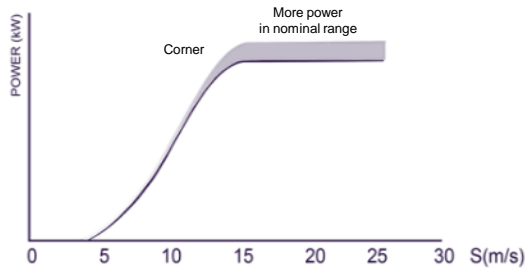
## Installation time

Fast remote software installation and parameter settings. On-site hardware (CPU) change 1.5 hours per turbine, only if required.

## Payback

Depending on factors such as turbine type and site-specific wind regime, the AEP can increase up to 1.5% on average.

# EnergyUp Nominal Range Gamesa technology



Platforms	Original (kW)	Up to (kW)	AEP increase
2.0 MW	2,000	2,070	0.7%-2%
2.1 MW	2,100	2,170	0.7%-2%

Depending on temperature, voltage, reactive power, and nominal power increase.

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

EnergyUp Nominal Range for Gamesa turbines is an upgrade that consists of a transfer of state-of-the-art algorithms and strategies into the old turbines to make them act like new ones.

This improves the maximum power produced in the corner and the nominal part of the power curve, by increasing the maximum torque.

As a result, the wind turbines will be able to generate up to 2% more energy.

## Benefits

- No upfront costs.
- Energy production increased by up to 2%, benefits from day one.
- OEM-designed; third-party approved.
- Measurable increase in energy production, demonstrated in a report provided every quarter.
- Includes the needed software upgrades (incl. SCADA).
- Improved performance in high-wind conditions.



AEP



Operating reliability



Trusted partner



Safety

## Applicability

G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 2.1-114.

## Industry validation

Validated by Garrad Hassan\*:

- Turbine integrity is not compromised.
- Modifications will not affect the turbine design life.

### Fleet experience

More than 400 WTGs, over 800 MW.

### Installation time

Remote activation 1.5 h/WTG.

### Agreement

Will be negotiated on a value-based approach.

### Est. lead time

Approx. 1 week.

\* A Garrad Hassan report has only been released for G97-2.0 MW.

# EnergyUp Nominal Range Siemens technology

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

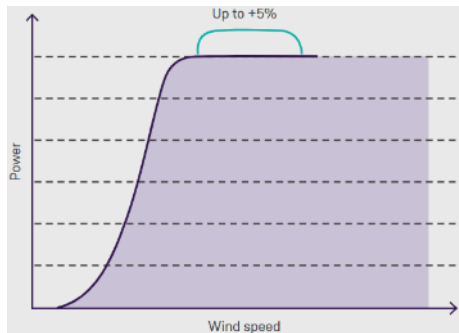
A controller feature that enhances power production by increasing the rated power by 5% under specific operating conditions.

This is achieved by proportionally increasing the rotor's rotational speed in line with the power increase. Depending on wind distribution and temperature, the solution can boost annual energy production by up to 2% in offshore environments and up to 1% in onshore environments.

To minimize turbine strain, the solution is only activated when operating conditions fall within predefined limits.

## Benefits

- Increase annual energy production by up to 2%.
- Measurable and demonstrated output gain.
- More power production and improved business case with no risk.
- Highest production benefits for offshore sites.



Illustrative Power Curve for a wind turbine with and without the solution.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

## Applicability

All Siemens technology platforms, with single exceptions.

## Compatible products

It can be combined with the EnergyUp Partial Range Hardware and Cut Out to increase AEP in several areas of the power curve.

## Certificate

DNV-GL certification achieved for all applicable platforms.

### Fleet experience

Approx. 4,500 WTG.

### Installation time

Remote activation 1.5 h/WTG.

### Payback

Depends on the individual case.

### Est. lead time

Approx. 2 weeks.

# EnergyUp Nominal Range Siemens technology



AEP



Revenue



Operating  
reliability



Trusted  
partner



Safety

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

EnergyUp Nominal Range\* delivers a significant increase in AEP by boosting the rated power of turbines to:

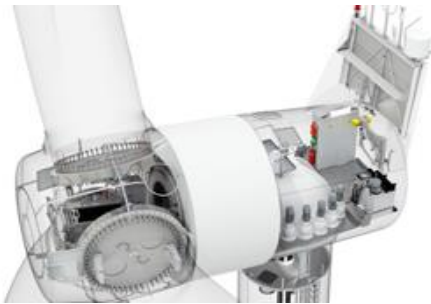
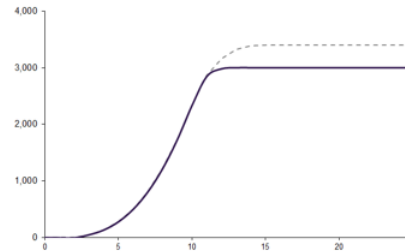
- 3.2 MW for 113-meter rotor diameter turbines.
- 3.2 MW or 3.4 MW for 101-/108-meter rotor diameter turbines.

These updates are achieved by optimizing the turbine control logic through a software update, enabling the full potential of the wind turbine while ensuring full safety guarantees.

Depending on the turbine model, the software increases either torque or both torque and revolutions per minute of the drive train.

## Benefits

- Increased profitability.
- Zero risk investment.
- No additional hardware needed to implement the solution.
- Take advantage of a certified solution that safely increases the maximum power output of wind turbines.



\* Refer to the Applicability section for available models.

## Applicability

SWT-3.0-101, SWT-3.0-113, SWT-3.0-108.

## Compatible products

Compatible with other EnergyUp products.

### Fleet experience

Already running in Siemens Gamesa wind turbines.

### Installation time

Fast remote software installation and parameter settings.

### Payback

Depending on factors such as turbine type and site-specific wind regime, the actual AEP gain could reach up to 5%.

### Est. lead time

Approximately 2.5 months to perform the technical assessment evaluating the site suitability.

Information is subject to change without prior notice.

# EnergyUp Partial Range Gamesa technology

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

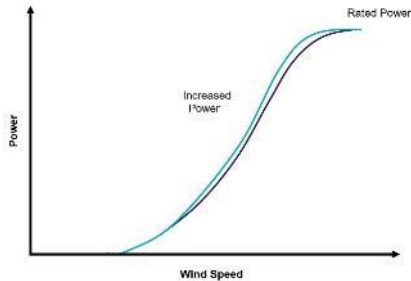
## Solution

A comprehensive software controller tuning that optimizes turbine performance below rated power. A new, improved operational curve is defined using advanced aeroelastic models.

Since the upgrade is implemented in low to medium wind operation zones, load increments are negligible, ensuring full compatibility with Life Extension goals.

## Benefits

- Energy production increases by up to 2% on G52-850 kW and between 2-6% on G58-850 kW (the AEP increase is site – dependent).
- The solution is compatible with lifetime extension program (based on loads envelope).
- OEM-designed and OEM-validated.
- Measurable increase in energy production can be demonstrated by site-specific measurement campaign.
- Improved revenue from day one.



AEP increase (estimates)	
G52-850 kW	G58-850 kW
Up to 2%	Between 2- 6%



AEP



Revenue



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW.

## Combined services

Combine with Life Extension to optimize your aging fleet and energy production increase up to year 30.

## Designer & maintainer

With over 40 years of experience in turbine manufacturing and operational excellence, Siemens Gamesa plays a diverse role as both designers and maintainers, which is key to our successful partnerships.

We have extensive experience in turbine upgrades and improvements for Siemens Gamesa fleets and are here to help you optimize your business case.

## Fleet experience

10,336 WTG ~ 8,786 MW.

## Installation time

4 h/WTG.

## Est. lead time

Regional service will implement the new software during a turbine visit.

# EnergyUp Partial Range Servion technology



AEP



Revenue



Operating reliability



Maintenance ease



Safety

## Challenge

Increase energy production and power output while maintaining safety and turbine longevity.

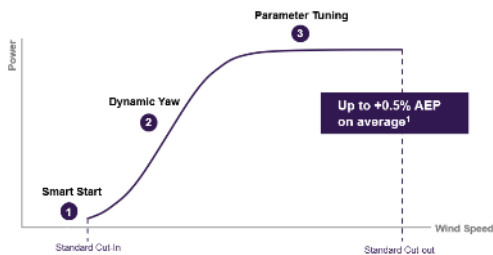
## Solution

An evolution of the AEP solution (formerly known as TCup 1.0), now with an added feature. It increases the partial range area of the power curve and includes the already-developed features:

- Smart Start: Optimizes the standard cut-in wind speed based on individual site conditions.
- Dynamic Yaw: Fine-tunes the yaw angle to increase wind turbine output.
- Parameter Tuning: Ensures the turbine reaches its rated power output, even in high-turbulence wind conditions.

## Benefits

- AEP increased by 0.5%.
- Fully assessed solution.
- No impact on sound level and grid.
- No need to upgrade the controller.



## Applicability

MM82, MM92, MM100, 3.0M122, 3.2M114, 3.2M122, 3.4M104, 3.4M114, 3.4M122, 3.6M140.

## Compatible products

Compatible with OWI, Vortex Generators, etc.

## Field validation

The features have been independently validated by TÜV Nord and Wind Consult as part of EnergyUp Full Power Curve, Basic for Servion fleet (formerly named Turbine Control Upgrade 2.0) validation.

## Fleet experience

Installed on 40 wind turbines.

## Installation time

Fast remote software installation and parameter settings.

## Payback

Depending on factors such as turbine type and site-specific wind regime, the AEP can increase by 0.5%.

# EnergyUp Partial Range Siemens technology

## Challenge

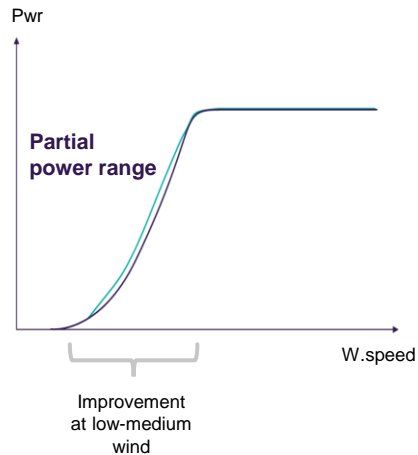
Increase energy production and power output while maintaining safety and turbine longevity.

## Solution

EnergyUp Partial Range is a software and advanced wind turbine control feature designed to provide a site-specific Annual Energy Production (AEP) improvement while ensuring the turbine operates within the design wind class load envelope. It optimizes the partial range area of the power curve by refining the rotational speed and pitch settings.

## Benefit

- Up to a 1% increase AEP (depending on site conditions and configuration).
- Software solution.
- Minimal investment.
- Fast implementation.
- No increase in noise levels.
- Profitability.
- Improved asset value.



AEP



Revenue



Operating  
reliability



Maintenance  
ease



Safety

## Applicability

SG 4.3-120, SG 4.3-130.

## Industry validation

Certification with DNVGL in progress:

- No impact on the grid, loads or noise.
- AEP gains validated for each specific configuration.

### Installation time

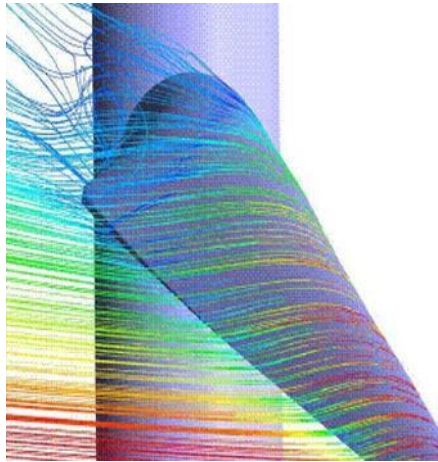
1 h/WTG.

### Est. lead time

Fast remote software  
installation and parameter  
setting.

# EnergyUp Partial Range Hardware

## Your technological route to success



### Challenge

Increase energy production and power output without compromising safety and lifetime expectations of the wind turbine.

### Solution

EnergyUp Partial Range Hardware for Siemens and Senvion fleets includes tailor-made aerodynamic components (Vortex Generators, DinoTail®, and DinoShell®) and controller software features.

The components are strategically placed on the blades to optimize aerodynamics. Once installed, the upgrade allows the turbine to more effectively harness the wind resource, resulting in improved power performance. This improvement is reflected in a new power curve.

Depending on site conditions, the enhanced power curve can lead to an additional 1–3% increase in annual energy production.

### Benefits

- Measurable and demonstrated increase in annual energy production.
- Additional revenue and improved cash flow.
- Shorter overall payback time of the asset.
- Increased value of your asset.



AEP



Improved performance



Operating reliability



Trusted partner



Safety

### Applicability

Siemens: SWT-2.3-82 VS, SWT-2.3-93, SWT-2.3-101.

Senvion: MM82, MM92, 3.0M122, 3.2M114, 3.2M122, 3.4M104, 3.4M114, 3.4M122.

### Compatible products

Can be acquired with EnergyUp Nominal Range and Cut Out for Siemens Fleet and with EnergyUp Full Power Curve for Senvion fleet to increase annual energy production in several areas of the power curve.

### Certificate

Certified by external independent certification bodies for all applicable platforms (E.g., DNV-GL for Siemens technology platforms).

#### Fleet experience

SWT-2.3s: more than 1,800 WTGs up-tower, more than 10,000 WTGs from factory.

#### Installation time

Approx. 2 days per blade for component upgrade.

#### Payback

Depends on the individual case. E.g., 3 years.

#### Est. lead time

Approx. 6 months. Depends on weather and site conditions.

# Wind Farm Performance Control and Upgrades

**Digital and data-driven solutions, including analytics, diagnostics, and SCADA upgrades for operational intelligence and turbine performance enhancement.**



# Blade Integrity Management

## Best care keep your blades healthy

### Challenge

Wind turbines are often located in extreme environments to optimize energy production, but these conditions accelerate blade wear and tear, posing a significant industry challenge.

### Solution

Siemens Gamesa offers the ultimate blade care solution – a comprehensive program to ensure your blades remain in optimal condition throughout their lifetime.

The Inspection module provides recurring blade inspections, offering an up-to-date, structured online overview of blade conditions with actionable insights.

The Repair & Maintenance module ensures expert-supported repair and maintenance, carried out by blade specialists.

### Benefits

- Unique machine learning capabilities built on more than 50.000 blades and more than 20 years of registration of blade data.
- 24/7 accessible overview of blade health of your entire fleet.
- Improved control, stabilized costs, and mitigated AEP reduction through increased predictability of needed repairs and actions, which will influence future wind farm energy production and costs.
- Unique OEM knowledge to secure the health of your blade and optimal turbine performance.



Availability warranty



Cost control



Operating reliability



Trusted partner



Safety

### Applicability

All Onshore and Offshore wind turbines.

### Compatible products

It can be integrated with other blade upgrade products, like PowerEdge Care, to provide a comprehensive and competitive full-scope blade solution.

### One-stop platform

All results, historical data, and reports related to blades will be available on the online platform, giving you easy access to all your data in one place.

#### Fleet experience

2,800 WTG ~  
4,750 GW.

#### Installation time

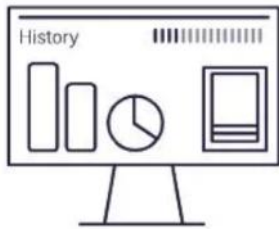
6-8 h/WTG.

#### Est. lead time

Approx. 1 month.

# Communication Manager

## Guardian for data integrity and safety



### Challenge

Wind farms located in remote areas may face data transmission interruptions due to adverse weather conditions or technical issues in the communication infrastructure, which limit operational efficiency and performance.

### Solution

Designed to enhance communication reliability in the event of a lost connection between the SCADA and wind turbines, ensuring smooth operation, data integrity, and overall wind farm efficiency.

It also includes a safety feature that allows remote monitoring while blocking remote commands during emergencies or maintenance, and stores critical data when communication fails, ensuring seamless operation and continued data integrity.

### Benefits

- Ensure data integrity allowing efficient wind farm operation, maximizing uptime and productivity.
- No compromise on safety for workers in the wind turbine, maintaining communication with the turbine while effectively blocking remote commands.



AEP



Operating  
reliability



Security



Safety

### Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW with Phoenix Contact PLC.  
G90-2.0 MW, G97-2.0 MW, G114-2.0 MW, G132-5.0 MW, SG 2.1-114.

### Compatible products

Applicable to both WindNet® PRO Light and Advanced variants, it supports a wider range of remote services and cybersecurity solutions, enabling better diagnostics, enhanced asset protection, and improved regional compliance.

### Est. lead time

Approx. 13 weeks from purchase order to installation.

# Condition Monitoring Blade Bearing When “safety first” really counts

## Challenge

Ensure that the real-time condition of the blade bearings is known with certainty, minimizing operational risk and ensuring reliable production.

## Solution

A reliable and certified solution for Senvion wind turbines to prevent unexpected downtime due to specific deterioration of the blade bearings.

A set of nut cap sensors and an evaluation unit allow fast detection of specific blade bearing deterioration. When a crack in the bore hole of the outer blade bearing ring is detected, the system immediately stops the wind turbine.

Condition Monitoring Blade Bearing continuously monitors the blade bearings 24/7.

## Benefits

- Ensure operational safety of the wind turbines due to the detection of blade bearing cracks at an early stage.
- Risk mitigation versus visual inspection methods.
- Automatic shutdown of the turbine in case of blade bearing cracks.
- Save the costs related to specific blade bearing inspections managed by external companies.
- Avoid wind turbine standstill due to inspection operations.



24/7  
monitoring



Cost  
control



Operating  
reliability



Maintenance  
ease



Safety

## Applicability

MM82, MM92, 3.4M114, 3.4M104, 3.0M122, 3.2M114, 3.6M114, 3.2M122, 3.4M122, 3.6M140, 3.4M140, 3.7M144.

## Certificate

Certified by DNV GL and TÜV Süd.

### Fleet experience

Installed on more than 2,500 wind turbines.

### Installation time

1.5 days (maximum) per wind turbine.

### Payback

This solution becomes cost-effective within approximately three years compared to the estimated operational costs of the recommended inspection regime.

# Main Shaft Integrity Monitoring System

## Challenge

Under certain conditions, including wind variability and operational factors like rotor imbalance or mechanical misalignments, oscillations can lead to the formation of cracks in the main shaft, which may eventually progress to a full fracture.

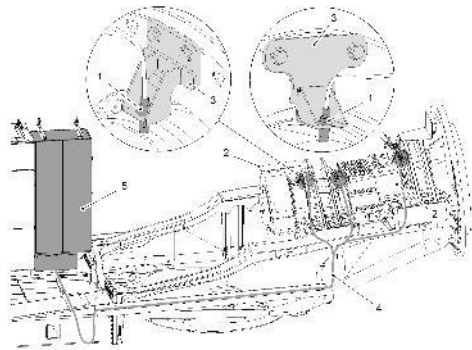
## Solution

Siemens Gamesa has developed and deployed a set of parameters to mitigate the risk of oscillations. As part of this proposal, Siemens Gamesa is introducing the Main Shaft Integrity Monitoring System, designed to automatically detect cracks in the main shaft and safely stop the wind turbine if necessary.

This solution consists of three inductive sensors that continuously monitor the main shaft during operation. These sensors are connected to the PLC and trigger an immediate shutdown of the turbine if a critical threshold is exceeded, preventing further damage.

## Benefits

- **Early Damage Detection & Cost Savings:** Detects cracks early to prevent severe failures, reducing repair costs and downtime.
- **Prevents Catastrophic Failures & Enhances Safety:** Automatically stops the turbine to prevent further damage.
- **Increased Turbine Lifespan & Structural Integrity:** Improves turbine health and frame integrity by preventing damage at critical points, extending the turbine's service life.
- **Predictive Maintenance & Optimized Performance:** Supports proactive maintenance with real-time data, ensuring optimal turbine operation and efficiency



1. Inductive sensors
2. Main shaft guards
3. Supports
4. Cables
5. TOP electrical cabinet



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G97-2.0 MW.

## Related products

Main shaft bearings temperature monitoring.

- Brake pads with thermistors.
- Relocation of the arc sensors.
- Passive fire protection, transformers with fire-resistant blankets.
- Intruder detection.

## Fleet experience

Over 3000 WTG.

## Installation time

Approx. 5 hours with 2 technicians per wind turbine.

## Functional system

Main shaft system.

## Requirements

PLC software update.  
SCADA reconfiguration.

# SMP Vibration Diagnostics Services

## Gamesa technology

### Challenge

Ensure sustainable and profitable energy production, it is crucial to manage your operational expenditures effectively. SMP Services provides the optimal solution for keeping your costs under control.

### Solution

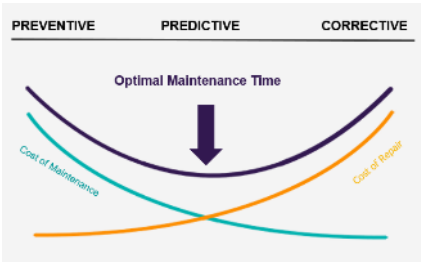
Vibration-based condition monitoring systems are among the most reliable solutions in the wind industry for reducing the levelized cost of energy (LCoE). These systems enable remote monitoring of drivetrain components, utilizing predictive maintenance to balance preventive and corrective strategies, and providing early warnings of potential component failures.

SMP Based Products and Services:

- **Vibration Reports:** Siemens Gamesa vibration specialists will analyze SMP data and generate detailed diagnostic reports.
- **Remote Data Access:** Direct access to the data generated by the SMP system.
- **Firmware Update:** Improvements in noise and signal amplitude, allowing for a better detection rate of failure modes at low frequencies.

### Benefits

- Protect your assets from unexpected downtime by being one step ahead.
- Knowing in advance which tools and parts to bring for a service will improve your first time fix rates.
- The vast knowledge and ability to pinpoint damages in due time before it results in the WTG downtime is how we help reduce costs and increase annual energy production.
- Maintaining your condition monitoring system making sure it is up to date with the latest updates and running smoothly.
- An optional detection guarantee can be combined with the service.



AEP



Operating  
reliability



Maintenance  
ease



Support

### Applicability

G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G128-4.5 MW, G97-2.0 MW, G87-2.0 MW CS, G132-5.0 MW

#### Fleet experience

Over 21,000 WTGs legacy Gamesa have been sold and equipped with SMP systems from factory.

#### Detection Lead times

Predicts component failures up to 3 years in advance enabling optimal planning of serving the wind turbines.

#### Detection Hit rates

90% overall Hit Rate in the target failure modes (gears and bearings).

# TCM Upgrade

## Controlling operational costs



Regulation compliance



Revenue



Operating reliability



Trusted partner

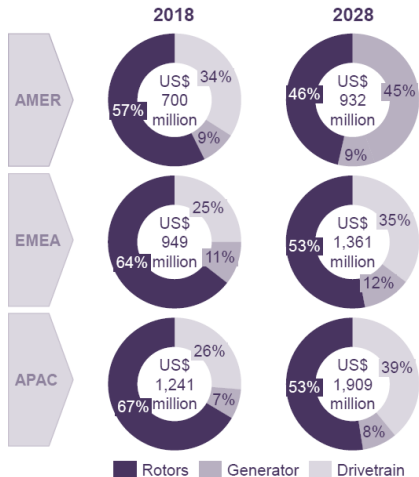


Safety

## Challenge

Maintaining sustainable and profitable energy production requires keeping operational expenditures under control. Reports indicate that wind turbine owners across regions will face an increase in major repairs due to drivetrain component failures, resulting in higher operational costs.

Breakdown of major repairs by component type



## Solution

To help our customers achieve unmatched predictive maintenance capabilities for developing drivetrain component failures, Siemens Gamesa offers the option to upgrade Gamesa turbines equipped with the SMP condition monitoring system. When upgrading the SMP, we retrofit a more advanced system called TCM, which allows our customers to benefit from our high-performance Vibration Diagnostics service. From the TCM system, we leverage Pythia™, our advanced artificial intelligence and machine learning capabilities, to provide early predictions of developing component failures.

## Benefits

- Protect your assets from unexpected downtime by being one step ahead.
- Knowing in advance which tools and parts to bring for a service will improve your first time fix rates.
- The vast knowledge and ability to pinpoint damages in due time before it results in the WTG downtime is how we help reduce costs and increase annual energy production.
- Maintaining your condition monitoring system making sure it is up to date with the latest updates and running smoothly.
- An optional detection guarantee can be combined with the service.

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SWT-1.3-62, SWT-2.0-76, SWT-2.3-82, SWT-3.6-107, SWT-2.3-82 VS, SWT-2.3-93, SWT-3.6-120, SWT-2.3-10, SWT-3.0-101, SWT-3.0-113, SWT-2.3-113, SWT-2.3-108, SWT-4.0-120, SWT-3.0-108, SWT-3.2-113, SWT-3.2-101, SWT-3.2-108, SWT-3.6-130, SWT-2.625-120, SWT-3.15-142, SWT-3.3-130, SWT-3.4-108, SWT-3.4-101, SG 2.1-114, SG 2.6-114, SG 2.6-126, SG 2.1-122, SG 3.4-132, SG 5.0-145 (2.0), SG 2.2-122, SG 2.9-129, SG 5.0-132, SG 6.6-155, SG 6.2-170, SG 2.7-129, SG 4.5-145, SG 3.4-145, SG 6.6-170, SG 3.2-129, SG 4.3-120, SG 4.3-130, SG 4.3-140, SG 7.0-170, SG 5.2-165, SG 5.0-145.

## Flexible service

- |   |  |
|---|--|
| CMS Analysis – active and passive mode:   | CMS Maintenance – active mode:   |
| <ul style="list-style-type: none"> <li>• Health trend reports.</li> <li>• Email notifications.</li> <li>• Actionable advice.</li> </ul> | <ul style="list-style-type: none"> <li>• Software updates.</li> <li>• CMS config, maintenance and reports.</li> <li>• System troubleshooting support.</li> </ul> |

### Fleet experience

20 years of experience with data management of more than 31,000 turbines in over 50 countries.

### Detection Lead times

Predicts component failures up to 3 years in advance enabling optimal planning of serving the wind turbines.

### Detection Hit rates

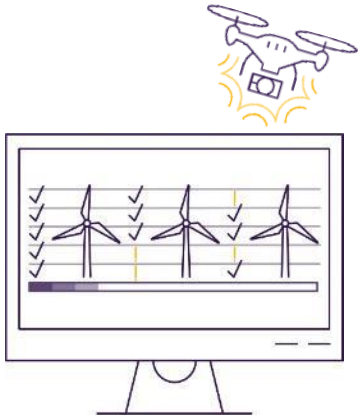
Achieve a 99% detection hit rate across all key drivetrain components, with the option to include a performance guarantee as part of our service.

# Visual Based Asset Integrity

## The future of blade care management

### Challenge

An essential aspect of blade maintenance involves conducting visual inspections to gather insights, where high-quality images and metadata are crucial for assessing overall health and making more efficient blade management decisions.



### Solution

A web-based platform that provides a complete overview of blade conditions and actionable advice, by combining artificial intelligence technology, engineering assessment, and expert knowledge.

With Visual-Based Asset Integrity, we can guarantee high quality in blade inspection data collection, storage, and analysis tools, which is crucial to secure asset integrity.

### Benefits

- Support efficient repair and maintenance decisions.
- Automated blade condition assessment process to allow delivery of highly accurate AI digital reports within 12 hours.
- Transparency in the whole process, from data upload to recommendation based on findings and severity level.
- Access to our team of blade experts to support you with key knowledge.



Availability



Revenue



Maintenance ease



Trusted partner

### Applicability

All types of blades and platforms.

### Compatible products

For those striving for the best care for blades, Siemens Gamesa offers an end-to-end blade service solution: Blade Integrity Management.

### Future aspects

Currently, VBAI is optimized and geared solely to cover the external surface of blades, but it has been designed with an eye to the future.

Siemens Gamesa plan to have this platform include image-capturing inspections for all components, e.g., internal blade inspection, gearbox, and other major components.

That will make it the go-to platform for all asset inspection and maintenance management, accessible anywhere from any device.

### Fleet experience

3,600 users are already using the platform.

### Installation time

Only when inspection is conducted.

### Est. lead time

Within 48 h.

### Storage facility

Microsoft Azure: unlimited storage capacity in the cloud (user pays by volume).

# Weather and Energy Forecasting

## Efficiency & performance to the next level

### Challenge

The safety of technicians and integrity of the assets can be threatened without precise weather and marine forecasting. In addition, such forecasts are essential for successful energy market participation.

### Solution

This solution offers customers services based on a forecasting modelling system which provides short, medium, and long-term weather and marine data forecasts to ensure the safety of people and assets, as well as power generation forecasting to optimize production in wind, solar, and hybrid plants located all around the world.

Operators are provided with 10-days-ahead deterministic forecasts based on accurate multi-model weather and marine forecasting methodology and physical and statistical downscaling. Data is accessible via an application programming interface (API) or through an [application \(MyWeather&Energy\)](#), available in [the customer operational web portal \(MyOperations\)](#) hosted by Siemens Gamesa and accessible through the internet.

### Benefits

- Delivers unique energy, marine, and meteorological forecasting insights to wind and hybrid power plant owners, ensuring safety, efficiency, accuracy, and risk control.
- Enables smarter maintenance scheduling and enhancements of planning, resources, and turbine availability.
- Improves AEP and revenue capture in energy wholesale markets.
- Enables compliance with network codes (e.g., where sharing of a generation forecast with the network operator is mandatory).



Value of energy



Increase revenue



Operating reliability



Trusted partner



Safety

### Applicability

Available for all wind farms and all platforms.

#### Fleet experience

WEF is the cornerstone of all O&M activities at Siemens Gamesa:

- Over 15 years of experience.
- +145 GW modeled.
- +3,000 wind farms around the world.

#### Est. Lead Time

- Standard forecast: 1 week.
- Customized forecast: 3 weeks incl. specific forecasting model development.

**Note:** MyWeather&Energy is currently not integrated into MyOperations. Until its integration, users can access the application via Siemens Gamesa's development portal, Dojo. Once MyWeather&Energy becomes part of MyOperations, this process will be streamlined. There are no functional limitations in the current setup.

# WindNet® PRO Upgrade

## Maintain control over your wind farm

### Challenge

A robust and reliable SCADA system is essential for maximizing power plant performance. The risks of centralized systems become critical when outdated, leading to issues such as server failures or loss of wind farm control.

### Solution

WindNet® PRO Upgrade enables you to optimize operational performance and wind asset management. It has been designed to be able to adapt to the current grid and minimum cybersecurity requirements.

**Available in two variants, Light and Advanced**, includes the exchange and upgrade of:

- Server hardware.
- Operating system.
- Application software.
- Network equipment.
- UPS and power supply.
- Grid measurement equipment (optional).

### Benefits

- Minimized risk of breakdown.
- Advanced power plant performance with extended environmental control capabilities.
- More accurate system to comply with the grid requirements.
- Enhanced power plant cybersecurity.
- Improved SCADA support from the Siemens Gamesa team.
- Key to secure appropriate control, component monitoring, remote services, and overall mitigation of failures.



AEP



Operating  
reliability



Maintenance  
ease



Security

### Applicability

G42-600 kW, G44-600 kW, G47-660 kW, G66-1650 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G87-2.0 MW CS, G90-2.0 MW, G97-2.0 MW, G128-4.5 MW, G132-5.0 MW.

### Compatible products

With WindNet® PRO Upgrade, the system can be supported with a range of remote services and cybersecurity solutions, enabling better diagnostics and enhanced protection of your assets while allowing better compliance regionally.

#### Risk of not upgrading

Outdated SCADA hardware increases the risk of failure, which can result in production stops.

#### Est. lead time

Approx. 13 weeks from purchase order to installation.

# WPS3 Upgrade

## Maintain control over your wind farm

### Challenge

Reliable control and supervision of wind farm assets is important in order to ensure a sustainable power supply to the grid and for collecting valuable data from the wind farm.

### Solution

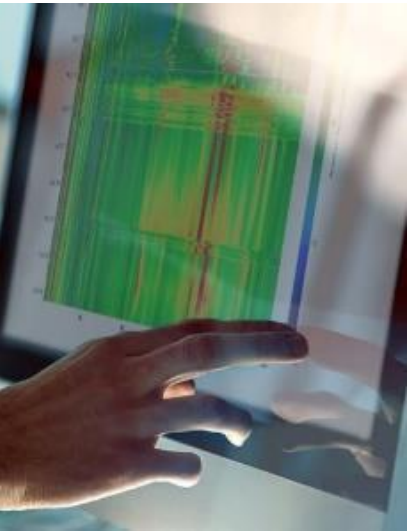
Replacing existing hardware and securing the latest version available:

- WPS3 Upgrade, Server Upgrade: Upgrade of individual server components.
- WPS3 Upgrade, Standard: Upgrade of all substation SCADA equipment, panel and physical servers.
- WPS3 Upgrade, VSI-SA<sup>1</sup>: Upgrade of all substation SCADA equipment, panel, and virtualization of the SCADA on a single server.
- WPS3 Upgrade, VSI-HA<sup>2</sup>: Upgrade of all substation SCADA equipment, panel, and virtualization of the SCADA on multiple servers.

The wind farm controller will be upgraded with the stand-alone HPPP or with the high availability HPPP (optional feature).

### Benefits

- Update to the supported OS – Windows 19.
- Update to the newest SCADA version of WPS3.
- Enable a more accurate system to comply with the grid code requirements.
- Key to secure appropriate control, component monitoring, remote services, and overall mitigation of failures.
- Enhanced power plant cybersecurity and opens up the possibility of acquiring cybersecurity solutions.



1. VSI-SA: Virtualized Server Infrastructure – Stand Alone.

2. VSI-HA: Virtualized Server Infrastructure – High Availability.



AEP



Operating  
reliability



Maintenance  
ease



Security

### Applicability

Siemens technologies.

### Compatible products

This product supports SCADA with a range of remote services and cybersecurity solutions, offering improved diagnostics, enhanced asset protection, and better regional compliance. Upgrading to a virtualized WPS3 server infrastructure also ensures hardware compatibility with MySite360<sup>®</sup>, Siemens Gamesa's next-generation power plant solution, enabling a seamless migration.

#### Risk of not upgrading

Outdated SCADA hardware increases the risk of failure, which can result in production stops.

#### Est. lead time

From PO to installation is approx. 6 months.

#### Network

Network segmentation and improved stability.

# Remote Services

Wind turbines are often located in remote areas, **making access challenging**. With remote diagnostics, we can **minimize** service visits – and even resolve issues remotely – **while ensuring** reliability by detecting potential errors before they escalate.

Proactivity is the most effective approach to **preventing** damage and ensuring optimal performance. Siemens Gamesa provides a single point of entry for Remote Services, which can be **customized** into tailor-made solutions to meet your specific needs.



## Products included

- 24/7 Alarm Response
- Vibration Diagnostics
- Troubleshooting Support
- ICS Software Updates

## Your benefits

- Reduces downtime and optimizes production by fast remote response.
- Improves onsite first-time fix rates by analytics and advices to site.
- Optimizes maintenance strategy, reduce risk and operational expenditure by predictive methods.

# 24/7 Alarm Response, Reset

## Turning insights into smarter wind power



### Challenge

Wind turbine failure and downtime can compromise profitability and be very costly.

### Solution

24/7 Alarm Response, Reset means that our employees are on duty 24 hours a day, 7 days a week to monitor and reset alarms. Ensuring early detection of failure and fast response with remote resetting of turbines and real-time notification to site.

Based on many years of advances monitoring of turbines we apply continuously improving knowledge-based alarm rules to detect alarms and to perform alarm management.

### Benefits

- Average response time of local alarms: Approx. 4 minutes for turbine alarms.
- Reduced downtime and optimized production thanks to fast remote response.
- Approx. 85%\* of turbine alarms can be solved remotely without calling out technicians.
- Siemens Gamesa saves more than 2,000 turbine visits per month thanks to its remote response and alarm reset capabilities.
- Statistics and alarm response reports are continuously shared to provide full transparency.



AEP



Cost reduction



Operating reliability



Trusted partner



Support

### Applicability

It is available for all Siemens Gamesa technologies.

### Compatible products

It is recommended to combine Alarm Response Services with other remote service solutions to optimize operation and maintenance costs and further increase AEP.

Remote Services\*: Troubleshooting Support, ICS Software Update, Vibration Diagnostic and Cyber Security.

#### Fleet experience

More than 32,000 wind turbines are globally monitored.

#### Est. lead time

Within 2 weeks, without hardware deployment.

\* Some Remote Services for Servion are currently under development.

# ICS Software Updates

## OEM expertise to optimize your operation



### Challenge

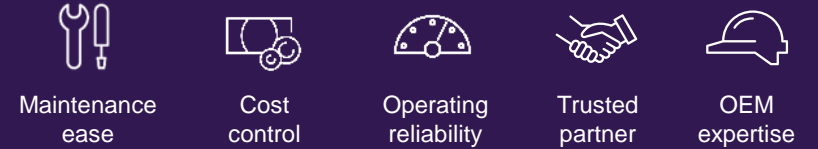
Updating the wind farms software to ensure compatibility of different hardware and software functionalities and the full support of the latest control strategy to ensure stable energy production.

### Solution

ICS Software Updates as a service provides our customers with a new software version package as soon as a new relevant software version has been released for the site. The relevant changes from old to new software package include information on alarm, type selection, and design values. Software packages are bundled to ensure dependencies are considered. Existing software functionalities are optimized or changed to improve the existing control strategies and enable stable energy production over the lifetime of the asset.

### Benefits

- Our strong OEM expertise and know-how to ensure optimum operation of your asset with a stable software version.
- Software packages are bundled to ensure dependencies are considered.
- Existing software functionalities are optimized or changed.
- Improvements to existing control and monitoring strategies to enable stable energy production over the lifetime of your asset.



### Applicability

All Siemens models.

### Compatible products

Combined with our Cyber Security Services and Troubleshooting Support provides a comprehensive solution, ensuring your wind farm is running efficiently with a secure software package.

### Added service value

As an OEM, Siemens Gamesa has the capability to provide you with the most recently developed ICS Software Updates. For you to benefit from the latest improvements to the wind turbine and wind farm software strategy.

#### Fleet experience

20 years of experience with software updates on more than 31,000 turbines in the aftermarket.

#### Est. lead time

Dependent on the existing connection to the site, between 2 – 4 weeks.

# Troubleshooting Support Benefit from OEM expertise

## Challenge

Maintaining wind farms in an efficient way is complex and can be difficult when you do not have the right expertise. It requires knowledge.

## Solution

This solution provides you with remote support in resolving specific identified incidents. Our service is flexible and adapted to your needs:

- **Troubleshooting Support, Reactive:** upon your request, Siemens Gamesa will provide you with high-value technical support.
- **Troubleshooting Support, Proactive:** on top of what is provided in Reactive option, you will benefit from Siemens Gamesa proactive advice allowing earlier detection of incidents that could lead to future failures, avoiding production losses.

## Benefits

- Our strong OEM expertise and know-how.
- Flexible offerings customized to your needs.
- Assistance to resolve specific identified incidents and avoid production losses, resulting in maximizing the revenue of your wind farm.
- A full systematic fleet support structure in place with a well-defined escalation process.
- Regular and systematic communication on the progress of your request, providing transparency.



OEM  
expertise



Revenue



Operating  
reliability



Trusted  
partner



AEP

## Applicability

- Reactive and Proactive options are available for all Siemens Gamesa technologies.
- Reactive option is available for Servion technology.

## Compatible products

Combined with our other Remote Services provides comprehensive solutions, ensuring your wind farm profitability.

### Fleet experience

77 GW under  
service onshore  
and offshore.

### Est. lead time

As an OEM, Siemens Gamesa has the capability to provide you with added-value remote technical support to maintain your wind farms in an efficient way.

Even with a self-performing strategy, you will benefit from our OEM knowledge and expertise.

# Vibration Diagnostics

## Predicting the future



AEP



Cost reduction



Operating reliability



Support



Maintenance

## Challenge

Reports show that wind turbine owners will experience a vast increase in major repairs due to drivetrain component failures, causing an increase in operational expenditures. The solution keep your costs under control.

## Solution

A market-leading condition monitoring solution, enabling early detection of drivetrain component failures. The service is flexible and can be tailored to meet specific requirements.

### CMS Analysis – Active and Passive mode:

- Health trend reports.
- Email notifications.
- Actionable advice.
- Data Access.

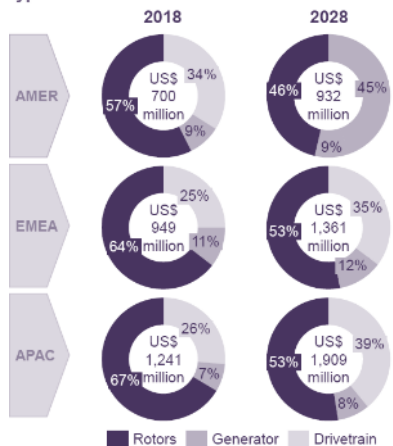
### CMS Maintenance – added service scope on Active mode:

- Software updates.
- CMS configuration, maintenance, and reports.
- System troubleshooting support.

## Benefits

- Converting unplanned- into planned service activities.
- Early detection of developing component failures makes it possible to:
  - Transform major crane events into up-tower repair tasks.
  - Refurbishing parts instead making a complete change.
  - Savings on manpower, parts and crane hire.
  - Limiting the need for having many parts on stock improving inventory costs and cashflow.

Breakdown of major repairs by component type



## Applicability

Turbines equipped with a TCM system.

## Added service value

As an OEM, we are capable of offering a complete range of connected services. Through the Siemens Gamesa online shop, you can easily order the parts needed to support component exchanges. Our global network of local teams allows us to provide quick assistance with any onsite repair tasks you may require.

## Machine learning

More than 600 TB of vibration feeding algorithms, which continuously improve over time in turning data into better outcomes for the customer.

## Fleet experience

20 years of experience with data management of more than 31,000 turbines in over 50 countries.

## Detection hit rates

Providing an overall detection hit rate of 99% on all key drivetrain components.

## Detection lead times

Predicts component failures up to three years in advance, enabling optimal planning for servicing of the wind turbines.

# Wind turbine Improvements

As part of our commitment to the sustained performance and efficiency of installed fleets, Siemens Gamesa has developed a comprehensive **catalog of turbine upgrades and modifications**. Leveraging our OEM knowledge and operational expertise, we aim to meet the evolving needs of wind energy production.

Our upgrades **enhance performance, reduce downtime, and extend turbine lifecycles, ensuring optimized operations, streamlines maintenance, and increased reliability.**

Our solutions for **Siemens, Gamesa** and **Senvion** turbines cover:



**Mechanical  
upgrades**



**Hydraulic system  
retrofits**



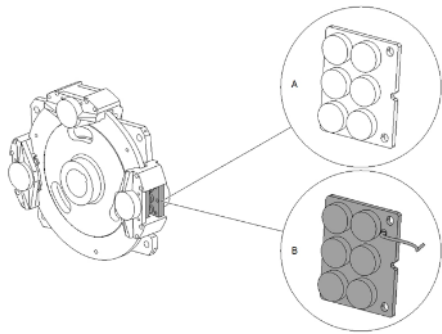
**Safety  
enhancements**



**Asset Protection  
and Security**

# Asset Protection Kits

## Brake pads with thermistors



A- Brake pads without thermistor  
B- Brake pads with thermistor

### Challenge

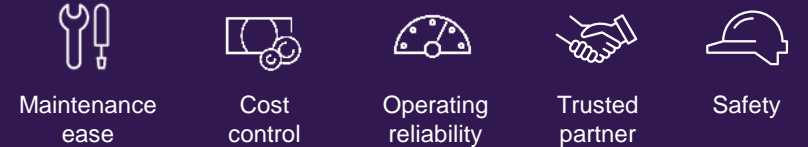
Fire can occur due to different component failures inside the turbine. At Siemens Gamesa, safety is a priority, and we are continuously working on new solutions and upgrades to keep your asset operating safely and protected against fire incidents.

### Solution

Brake calipers can get stuck, making contact with the brake disk, which will cause a temperature rise or even produce sparks. A simple upgrade and installation of brake pads with thermistors on all three brake calipers can keep your turbine protected from high brake temperatures. In the event of a temperature rise in the brake calipers, this will be detected by the thermistors, which immediately send a signal to the PLC, and the wind turbine will be stopped in a controlled manner.

### Benefit

- Reinforces the vigilance over the braking system.
- Prevention of overheating in the mechanical brake thanks to monitoring of the system.
- Increased safety and reliability in the mechanical brake system.
- Improved monitoring of the condition of the mechanical brake pads.



### Applicability

G47-660 kW, G80-2.0 MW, G83-2.0 MW, G87 S -2.0 MW, G90-2.0 MW, G97-2.0 MW.

### Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of your wind farm.

### Requirements

PLC software update.  
SCADA reconfiguration.

#### Installation time

Approx. 4 hours with 2 technicians per wind turbine.

#### Functional system

High-speed coupling and mechanical brake.

# Asset Protection Kits Intruder Detection

## Challenge

Wind turbine performance can be affected by the intentional efforts of others, especially thieves and vandals. They will effectively diminish the potential of the project during and after construction, as costly repairs and replacements must be made.

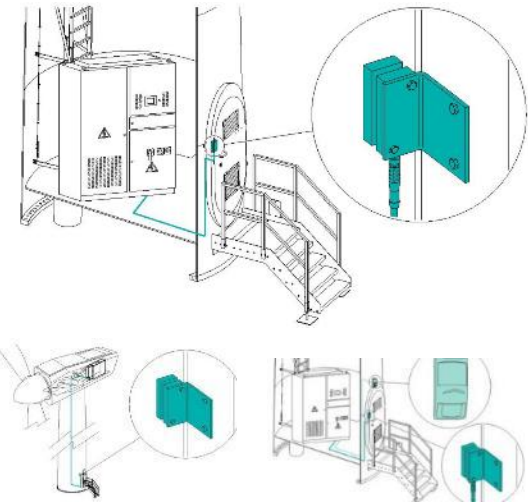
## Solution

To secure your asset against unauthorized access, Siemens Gamesa offers you Intruder Detection.

Through installation of a magnetic sensor and optionally a volumetric sensor connected to the SCADA system, notifications will be triggered when someone is trying to enter the turbine. When the system is triggered, it identifies legitimate access to the turbine once the technician confirms the authorized access on the touch screen.

## Benefit

- Reduction in downtimes and non-productive time: minimizing turbine damage.
- Enhanced wind turbine security.
- Control of access to the wind turbine, to prevent unauthorized and thereby increase protection against theft.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G47-660 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87 S -2.0 MW, G90-2.0 MW, G97-2.0 MW.

## Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

## Requirements

PLC software update.  
SCADA reconfiguration.

### Fleet experience

More than 100 wind turbines.

### Functional system

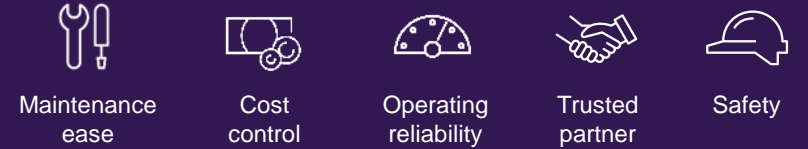
Electrical cabinets.

### Installation time

- Approx. 6 hours with 2 technicians for G47-660 kW, G52-850 kW, G58-850 kW.
- Approx. 8 hours with 2 technicians for the other models.

# Asset Protection Kits

## Passive fire protection, brake disk



### Challenge

Fires in wind turbines are one of the most catastrophic accidents that can occur and result in structural damages or, in the worst-case scenario, total loss of the turbine.

### Solution

A protective fabric of fireproof material has been designed which completely covers the metal guard of the brake system and prevents the emission of sparks through any openings in the closures of the metal guard that already exist in the wind turbine.

This solution is based on the replacement of the original brake disk guard and the installation of a new safeguard design (mechanical brake and high-speed shaft) to improve the enclosure.

In the event of an emergency brake sequence, this new design retains the sparks that could appear when the brake disk is activated at high rotor speeds.

### Benefit

- Reduction of operating and maintenance costs.
- Increased service life.
- Fire prevention due to the improved closing mechanism of the new guards that retain the sparks produced when the brake disk engages.

### Applicability

G47-660 kW, G52-850 kW, G58-850 kW.

### Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

### Requirements

No requirements.

#### Fleet experience

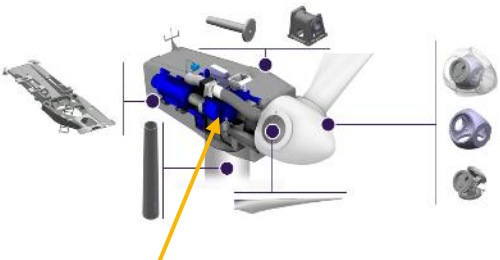
3,000 wind turbines worldwide.

#### Installation time

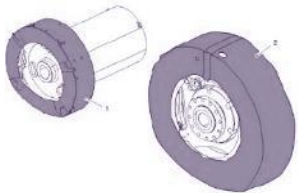
Approx. 3.5 hours with 2 technicians (per WTG).

#### Functional system

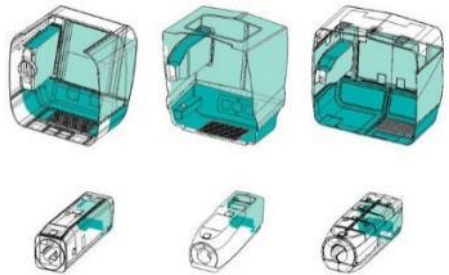
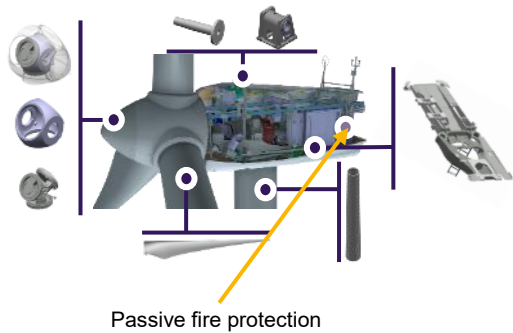
High-speed coupling and mechanical brake.



Passive fire protection



# Asset Protection Kits. Passive fire protection, transformers with fire-resistant blankets



## Challenge

Fires in wind turbines are one of the most catastrophic accidents that can occur and result in structural damages or, in the worst-case scenario, total loss of the turbine.

## Solution

The protection consists of the installation of fire-resistant panels in the transformer compartment. Separation of the transformer from the nacelle fiber is ensured using highly fire-resistant material.

## Benefit

- Separation of the transformer from the nacelle fiber using highly fire-resistant material.
- Improvement of the fire hazard protection in the wind turbine.
- Reduction of operating and maintenance costs.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87 S -2.0 MW, G90-2.0 MW, G97-2.0 MW with some limitations, SG 2.1-114 with some limitations.

## Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

## Requirements

No requirements.

### Fleet experience

More than 2,000 wind turbines worldwide.

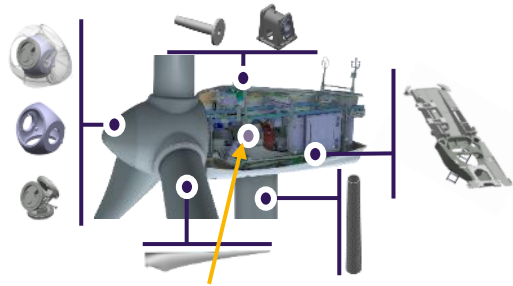
### Installation time

Approx. 8 hours with 4 technicians.

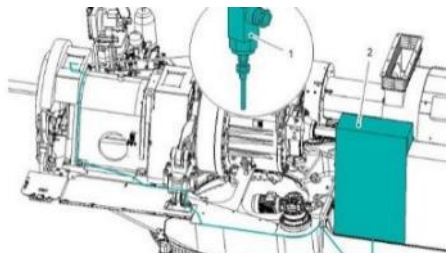
### Functional system

Nacelle.

# Asset Protection Kits. PT100-Main shaft bearings temperature monitoring



Main bearing temperature monitoring



## Challenge

Fires in wind turbines are one of the most catastrophic accidents that can occur and result in structural damages or, in the worst-case scenario, total loss of the turbine.

## Solution

In order to identify temperature increases that could lead to problems for the integrity of the wind turbine, it is possible to install a temperature sensor in the main bearing.

The temperature is measured and monitored by the control system, which can stop the turbine if unsafe conditions are detected. The temperature and any error due to unsafe working condition of the main bearing are reported to the SCADA and control center.

## Benefit

- Reduction of operation and maintenance costs.
- Reduction of damages to the main shaft bearings and reduction of incidents.
- Extension of the useful life of the main shaft bearings.
- Reduction in downtime and non-productive time.
- Increased reliability of the main shaft system.
- Easy and fast recognition of the trip circuit that has acted.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G47-660 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87 S -2.0 MW, G90-2.0 MW, G97-2.0 MW with some limitations, SG 2.1-114 with some limitations.

## Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

## Requirements

PLC software update.  
SCADA reconfiguration.

### Installation time

- Approx. 7 hours with 2 technicians for 660 kW turbine (per WTG).
- Approx. 6 hours with 2 technicians for 850 kW turbines (per WTG).
- Approx. 2 hours with 2 technicians for 2.0 MW turbines (per WTG).
- Approx. 2.5 hours with 2 technicians for 2.1 MW turbines (per WTG).

### Functional system

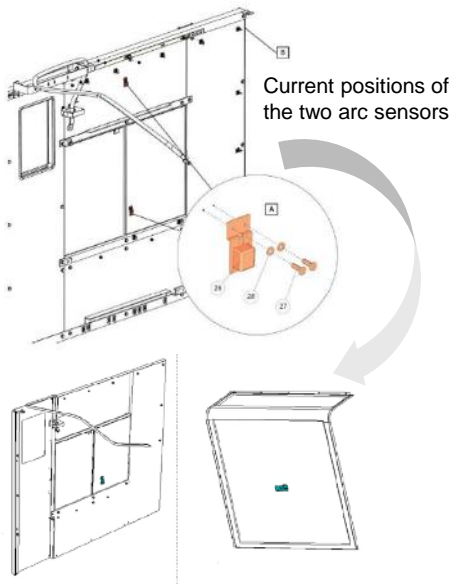
Main shaft system.

### Fleet experience

More than 2,000 wind turbines worldwide.

# Asset Protection Kits

## Relocation of the arc sensors



### Challenge

Fires in wind turbines are one of the most catastrophic accidents that can occur and result in structural damages or, in the worst-case scenario, total loss of the turbine.

### Solution

The rear area between the transformer and the nacelle wall is poorly protected since it has no electric arc detection device directly installed and because the device is on the wall.

The solution of relocation of the arc sensors and connection of the ground meshes has been designed in order to avoid possible incidences of false shots and to better protect the rear area of the transformer compartment. The implementation of the relocation of the arc sensors and connection can take place during the next preventive or corrective maintenance.

### Benefit

- Reduction of operating and maintenance costs.
- Improved protection of the whole transformer cabin.
- Reduction of false trips and reduction in downtimes and thus reduced non-productive time.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

### Applicability

G80-2.0 MW, G83-2.0 MW, G87 S -2.0 MW, G90-2.0 MW, G97-2.0 MW with some limitations.

### Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

### Requirements

No requirements.

#### Fleet experience

6,030 wind turbines worldwide.

#### Installation time

Approx. 8 hours with 2 technicians.

#### Functional system

Electrical cabinets.

# Asset Protection Kits

## Smoke detection system

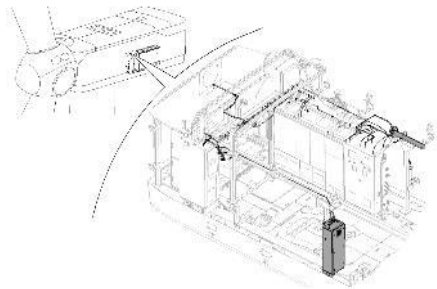


Figure 1: Installation of a smoke sensor and updating of the smoke system wiring

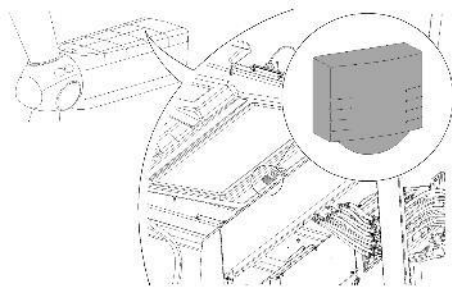


Figure 2: Smoke sensor in the nacelle

### Challenge

Detecting fires early, particularly in remote and harsh environments where smoke or fire can spread rapidly, is a significant challenge for turbine owners. Without effective smoke detection systems, timely identification of fire risks in time becomes difficult, endangering personnel and equipment at risk and increasing the potential for substantial damage, downtime, and safety concerns.

### Solution

Siemens Gamesa has developed a fire detection and warning system for wind turbines, featuring multiple smoke sensors installed within the tower and strategically placed acoustic alarms placed in both the nacelle and on the ground. When smoke is detected by any of the sensors, a sound alarm is immediately triggered, and the high voltage switchgear is opened to mitigate further risks. This system significantly improves safety in high-risk areas by reducing evacuation time for personnel in the nacelle and allowing two workers to safely operate on intermediate platforms during a fire.

### Benefits

- **Enhanced Safety:** The system enables early smoke detection and quick alarms, ensuring faster evacuation and reducing injury risk in case of fire.
- The system ensures regulatory compliance with fire detection and emergency response regulations for wind turbines.
- Early fire detection helps safeguard personnel and turbine equipment from fire damage.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

### Applicability

G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 2.1-114, SG 3.4-132, SG 3.4-145, 3.4M114, 3.4M104, 3.0M122, 3.2M114, 3.6M114, 3.2M122, 3.4M122, 3.6M140, 3.4M140, 3.7M144.

### Related products

This solution is part of an Asset Protection Kit which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

#### Installation time

- Smoke detection installation:  
8 hours x 2 technicians
- SG3X SADEI mod:  
5 hours x 2 technicians

#### Fleet experience

Installed in +450 turbines.

#### Functional system

General.

# Asset Protection Kits

## Software thermal event protection



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

### Challenge

Fires in wind turbines are one of the most catastrophic accidents that can occur and result in structural damages or, in the worst-case scenario, total loss of the turbine. Fortunately, cost-effective fire suppression technology can help to mitigate risks.

### Solution

Years of registration and investigation of thermal events have made it possible for Siemens Gamesa to develop a system to prevent and protect wind turbines from thermal events.

Software Thermal Event Protection is controlling software that includes several improvements to reduce the risk of fire caused by pitch problems and brake activation in the G5X wind turbine. By applying new control strategies, you can prevent and protect the wind turbine when any dangerous sequence is detected, which makes it possible to react before it is too late.

### Benefit

- Keep your wind turbines safe and mitigate risk of thermal events.
- Protect your asset and ensure a profitable business.
- Easy to install and maintenance can be carried out during low-wind periods.

### Applicability

G52-850 kW, G58-850 kW.

### Related products

This solution is part of an Asset Protection Kit, which consists of a set of protection upgrades to keep your turbine safe and ensure high availability of the wind farm.

### Requirements

PLC software update.  
SCADA reconfiguration.

#### Fleet experience

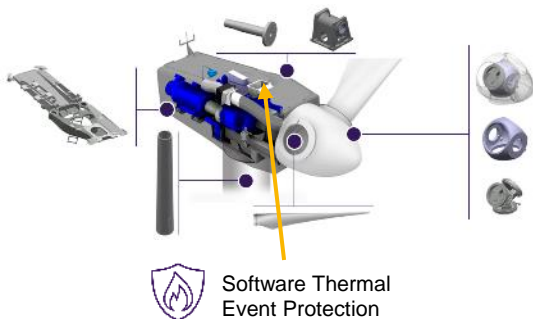
380 wind turbines.

#### Installation time

3-4h per wind turbine.

#### Functional system

PLC software.



Software Thermal Event Protection

# Automatic Lubrication System

## Minimize maintenance downtime



### Challenge

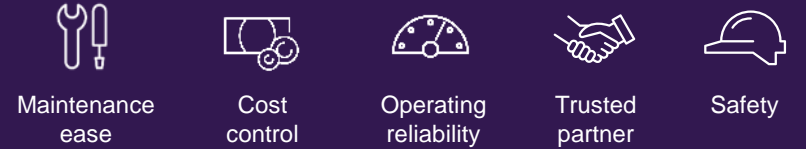
Manual lubrication during scheduled maintenance has several disadvantages: longer downtime, over- or under-lubrication, and even missed points that can affect component performance and potentially cause damage. After years of analysis and research, Siemens Gamesa introduces Automatic Lubrication Systems – a breakthrough for turbine improvement.

### Solution

This optimization of the six-month maintenance consists in several technical upgrades focused primarily on the yaw system that will in essence transform manual lubricating operations into automatic ones. They will be integrated and controlled by the wind turbines PLC, which mean that the equipment can be controlled and supervised remotely. The tasks is now reduced to refilling the grease tanks once a year.

### Benefits

- 50% reduction in wind turbine stop time, by removal of the six months maintenance.
- Improving the reliability of the system.
- Proved and tested system.
- It extends the service life of the yaw system thanks to greater protection against wear, even with vibrations.
- Greater turbine flexibility due to excellent grease distribution.



### Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 3.4-132.

### Requirements

- To reach yearly maintenance:
- Generator's bearing grease type change.
  - Yaw automatic lubrication system assembly.

### Payback

Depends on the individual case. E.g., 3-5 years.

#### Fleet experience

Already installed on serial production. Not yet installed on older windfarms.

#### Installation time

Approx. 1.5 days.

#### Est. lead time

8 weeks.

# Aviation Lights Beacon System Replacement

## Challenge

Depending on regional standards, especially in Germany, or specific country regulations, various types of beacons are available.

## Solution

Siemens Gamesa proposes the installation of a new beacon model that allows for pre-configuration to adapt to different regulations. The task consists of the replacement of the obsolete Orga beacon models with an alternative:

- Orga L550.
- Saprem.
- Obelux.

All new homologated beacons have integrated control of the blinking frequency, light sensor, and GPS synchronization, so they are completely autonomous.

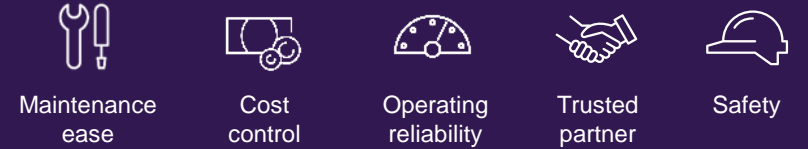
## Benefits

- Improved signage on wind farm.
- Increased safety in the wind turbine thanks to optimum signage.
- Operating ease.
- Increased reliability of the signage system.



Figure 1: Elements of the beacon system

- A. Beacon
- B. Signage GPS
- C. Beacon control cabinet
- D. UPS electrical cabinet



## Applicability

G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.

## Requirements

Power converters of the applicable turbine models.  
Connection of the system to the PLC control.

### Fleet experience

More than 180 wind turbines.

### Installation time

- Saprem or Obelux beacon: 5 hours x 2 technicians.
- Orga L550 beacon: 7–10 hours x 2 technicians.

### Functional system

Beacon.

# Aviation Lights on Demand Ready for the new AVV requirements



Regulation  
compliance



Revenue



Operating  
reliability



Trusted  
partner



Safety

## Challenge

To improve public acceptance of wind energy in Germany, the new Energy Collection Act (EnSaG) requires on-demand activation of aviation light systems when an aircraft approaches wind turbines at night (known as BNK). This requirement affects both new and existing wind turbines.

## Solution

Aviation Lights on Demand supports all existing technologies for the detection of aircraft (primary radar, passive radar, or transponder). Each of these technologies ensures that the aviation lights of the wind turbines are only activated at night when an aircraft is within 4 kilometers air space of each turbine.

Through integration of this product with any of these technologies, the wind turbine aviation lights are automatically controlled and include signal processing interface, infrared lights, and an uninterruptible power supply (UPS) covering at least 16 hours, to comply with the new regulation.

## Benefits

- Robust and fully integrated design.
- Compatible with signals from a range of aircraft detection technologies.
- Compatible for combining with neighboring wind farms.
- Installation and commissioning by Siemens Gamesa.



## Applicability

Onshore: SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.4-101, SWT-3.4-108, SG 4.3-120.  
Offshore: All offshore turbines up to SG 8.0-167.

## Compatible products

The maintenance is covered by existing Siemens Gamesa service contracts.

## Customer testimonial

*"The Aviation Lights on Demand and the on-demand lighting system, represents an important building block for us as local operators, in that a maximum switch-off time of the obstruction warning light is really appreciated by residents. We promised our local communities' swift implementation and Siemens Gamesa was a great help in achieving it. We are pleased that the project with the transponder system is now finalized and is even a world first."*

— Eike Schuldt (General Manager of the Neuengoers-Weede citizen wind farm).

## Fleet experience

More than 210 wind turbines.

## Installation time

Approx. 1 day per wind turbine in normal weather conditions.

Information is subject to change without prior notice.

# Brake Chopper

## Challenge

Adhering to local grid code regulations is essential to avoid penalties and ensure uninterrupted operation. As compliance requirements become increasingly stringent, retrofittable solutions are vital for wind farm operators. One effective solution is the Brake Chopper system, which was not originally standard in many 2.0 MW wind turbine generators. This critical feature can now be retrofitted to enhance performance and align with updated grid standards.

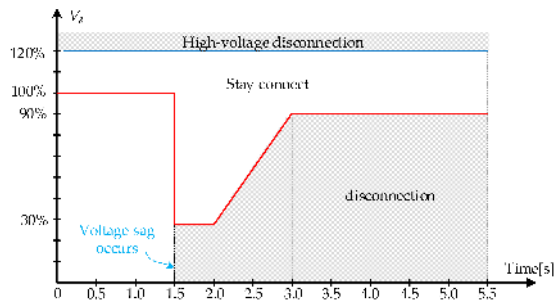


Figure 1: Low Voltage Ride Through

## Solution

Siemens Gamesa offers the installation of the ABRU-20R Unit (ABB Brake Chopper Unit) in the DTC converters of its 2.0 MW wind turbine models — G80-2.0 MW; G83-2.0 MW; G87-2.0 MW; G90-2.0 MW — when required. This Brake Chopper system, integrated into the converter cabinets, enhances the Low Voltage Ride Through (LVRT) performance of these turbines.

## Benefits

- **Ensuring compliance with grid code regulations** — especially those related to Low Voltage Ride Through (LVRT) performance.
- During faults such as voltage dips or blackouts, turbines cannot feed energy into the grid, but the rotor still generates kinetic energy. Without proper control, this can stress or damage components. **The Brake Chopper safely dissipates the excess, reducing loads, protecting the system, and maintaining stability.**



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW  
G83-2.0 MW  
G87-2.0 MW  
G90-2.0 MW

## Related products

- FG008 change and KM52 installation.

### Fleet experience

Installed in +200 turbines.

### Installation time

5 hours x 2 technicians.

### Functional system

Electrical cabinet.

# Cold Climate, Operation With Ice

## Don't let your assets freeze



AEP



Availability



Operating reliability



Maintenance ease

## Challenge

Ice buildup reduces aerodynamic performance and can cause the turbine to stall. Many wind farm owners also report significant AEP losses due to icing.

## Solution

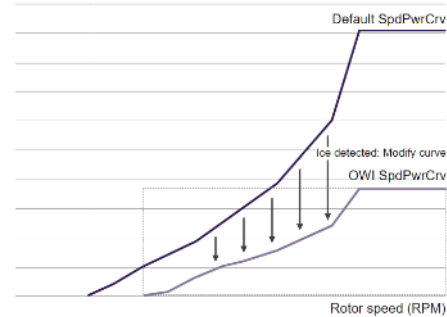
Operation with Ice (OWI) is a controller software feature based on intelligent pitch control that optimizes performance in icy conditions. Once the measured power drops below a certain level, the OWI feature is activated:

- The rotational speed is recovered in order to reduce ice accumulation, avoid stalling, and stabilize energy production (not for Senvion technology).
- The blade pitch angles are adjusted to optimize aerodynamic performance and continue operation, preventing further ice accumulation.

## Benefits

- Early sensing of ice accumulation through the detection of power loss and a cut-in speed that is higher than expected.
- Facilitated cut-in and the reduced likelihood of stalling due to ice through the recovery of rotor speed.
- Optimized performance for increased production under icy conditions.
- Increased availability by reducing downtime due to ice.

Speed power curve change  
Active power (kW)



## Applicability\*

Siemens: SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93, SWT-2.625-120, SWT-2.3-113, SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.15-142, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.3-130, SWT-3.4-101, SWT-3.4-108, SWT-3.6-130.  
Gamesa: G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW (standard configuration with Phoenix controller).  
Senvion: MM82, MM92, MM100, 3.0M104, 3.2M114, 3.2M122, 3.0M122, 3.4M104, 3.4M114, 3.4M122, 3.4M140, 3.6M114, 3.6M140, 6.2M126, 6.2M152.  
ON Siemens Gamesa: SG 2.7-129, SG 3.2-129, SG 4.3-120, SG 4.3-130.

## Payback

Depending on site conditions and the turbine and blade type, Operation with Ice can potentially increase the AEP.

### Fleet experience

Installed in more than 2,000 turbines in the combined Siemens Gamesa fleet.

### Installation time

The installation can be performed remotely or locally in approximately 1 to 1.5 hours per wind turbine.

\* Due to local regulation, Operation With Ice is not allowed in Germany, Belgium, and Austria.

# Cold Climate, Rotor Blade Ice Detection

## Don't let your assets freeze



AEP



Revenue



Operating  
reliability



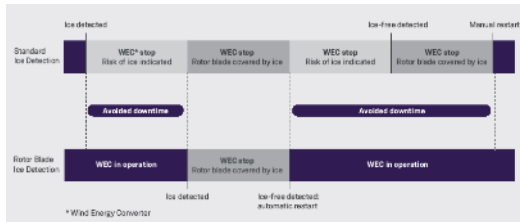
Trusted  
partner



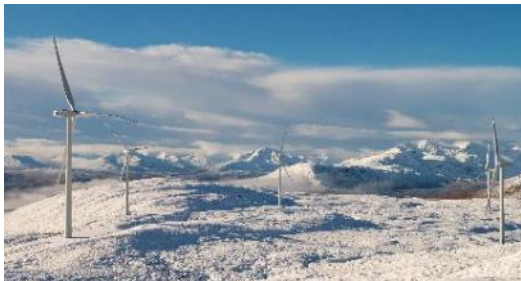
Safety

## Challenge

Accumulation of ice on the blade reduces the aerodynamic performance, which can lead to the turbine stopping, resulting in a substantial AEP loss. Ice can also pose a hazard for the surrounding area.



Longer operating times in comparison to standard ice detection system



## Solution

The Rotor Blade Ice Detection system for Senvion wind turbines provides immediate and reliable detection of ice on the blades during both operation and standstill.

Each blade is individually monitored using a fiber-optic sensor, and if ice accumulation reaches a critical level, the system halts the turbine. Once conditions improve, the turbine can automatically restart. These advanced fiber-optic sensors can detect ice buildup as small as 10 kg per blade. Compared to standard ice detection systems, this technology maximizes turbine performance in icy conditions, enabling longer and safer operation.

## Benefits

- Increased turbine availability by reducing downtime due to icing.
- More accurate detection of ice and automatic restart of the wind turbine, no visual inspection needed.
- Optimized performance by increasing the AEP in icy conditions.

## Applicability

MM82, MM92, MM100 (excluding MM70).  
3.0M122, 3.2M114, 3.2M122, 3.4M104, 3.4M114, 3.4M122, 3.6M140, 3.6M114.

## Payback

Depending on factors such as turbine type and site-specific icing conditions, it can potentially increase the AEP by between 0.5% and 2%.

### Fleet experience

Installed on more than 250 wind turbines.

### Installation time

In normal weather conditions (above 5°C), the installation takes approximately 1 day per wind turbine.

# Control System Improvement

## Hardware & software turbine improvement



### Challenge

Keep wind turbines up to date and ensure they benefit from new knowledge and experience is essential for maximizing energy production.

### Solution

A regulation improvement which consist of a complete upgrade of the control system (PLC) for the Gamesa 700 kW wind turbine.

Installing these features requires replacing certain components of the wind turbine control hardware (PLC, I/O, etc.) and upgrading the control software (PLC, CCU, and HMI) to support the new Siemens Gamesa 700 kW controller.

### Benefits

- General optimization of wind turbine regulation algorithms (MRA\* feature).
- Maximize energy availability – reduction of alarms triggered by overspeed.
- Increase of annual energy production (MRA feature).
- Improve maintainability.
- Avoid regularity penalties (related to reactive power generation).



Increased  
AEP



Maintenance  
ease



Operating  
reliability



Trusted  
partner



Safety

### Applicability

G47-660 kW.

### Optional features

- MRA\*: Improved Regulation Algorithm.
- SW Reactive Optimized.
- SW Ice Operation.
- SW LPTC (power limitation by component temperature).

#### Fleet experience

New PLC IC3 has  
already been  
installed in 340  
turbines.

#### Installation time

1 day per WTG  
and 2 technicians  
(SCADA tasks are  
not included).

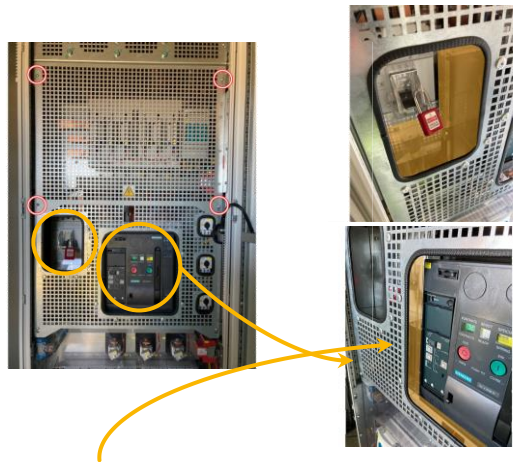
#### Functional system

PLC.

\* MRA = Regulation improvement including AEP increase.

# Converter Cabinet Safety Guards

## Safety improvement



**Solution:** installation of safety guards in Q3 and Q10 isolations

### Challenge

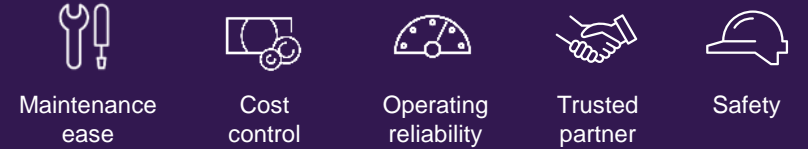
Tools and lock-out devices can fall inside the converter cabinet when performing maintenance operations. This creates a risk of creating arc flash which can lead to damage in the cabinet and safety hazard for the personnel.

### Solution

Installation of polycarbonate safety guards designed by Siemens Gamesa in the Q3 and Q10 isolations in the converter cabinet, to prevent tools from falling inside the cabinet.

### Benefits

- Increased safety.
- Reduction of arc flash risk leading to damage in the converter.



### Applicability

Senvion MM82, MM92 and MM100.

### Requirements

Woodward CSC4 converter.

#### Fleet experience

More than 5,300 wind turbines worldwide.

#### Installation time

Approx. 2 hours with 2 technicians.

#### Functional system

Electrical cabinets.

# Converter Door Safety improvement

## Challenge

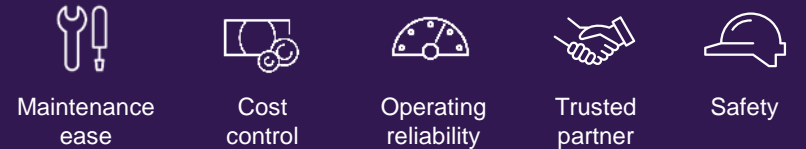
If the arc flash protection device is disabled (with Q1 and UPS turned off) and Q1 is operated, there will be no fast disconnection during an arc event. This leads to a high Category 4 arc rating.

## Solution

Converter Door is an extended handle adapter that can be positioned on the outside of the cabinet door. The technician does not need to open the cabinet to turn on Q1. The door remains closed while Q1 is in operation. This massively improves staff safety, as the technician is not directly exposed to any potential arc levels. In addition, the door of the cabinet is adjusted to accept LoTo. When Q1 is used for disconnecting the working area, the Q1 handle, and the cabinet door can be secured with standard LoTo equipment. Additional labels on the front door provide guidance to show the new Q1 operation and LoTo procedure.

## Benefits

- Increased personnel safety during operation.
- Minimized potential for arc flash occurrence.
- Safer work environment.
- Universal common solution for all versions.
- Simple and efficient.



## Applicability

3.4M114, 3.0M122, 3.2M114, 3.6M114, 3.4M104, 3.2M122, 3.4M122, 3.6M140, 3.4M140, 3.7M144.

## Turbine improvement

Within a comprehensive catalog of smaller upgrades available for purchase, you'll find solutions to optimize your fleet's operation and reduce repair costs. The catalog also includes other solutions, such as the following:

- Asset Protection Upgrades.
- Lightning Protection.
- Control System Improvement.
- Automatic Lubrication Systems.
- Detection of Loose Object.
- Pitch Cylinder Leakage Reconduction.
- Beacon System Replacement.

### Installation time

Approx. 5 h/WTG.

### Converter type

Woodward converter  
CW3300RP21.x.

Reach out to your local Siemens Gamesa contact for more information.

# Cooling Performance Enhancements for ABB Generator

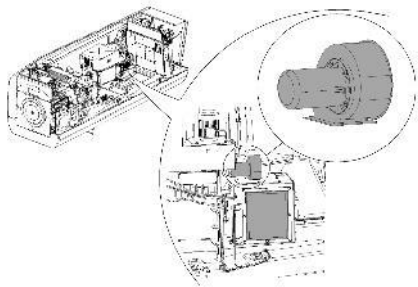


Figure 1: Replacement of the ventilation system of the Generator

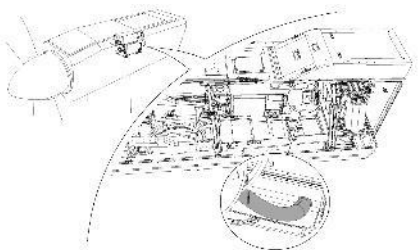


Figure 2: Replacement of the ring body outlet pipe

## Challenge

The ventilation system of the ABB AMK500L4A generators may not meet Siemens Gamesa requirements, affecting cooling efficiency. Additionally, the cooling outlet pipe of the ring body may lack the necessary resistance to handle potential thermal issues, risking overheating and reduced performance.

## Solution

Siemens Gamesa solution involves replacing the existing ventilation system of the ABB AMK500L4A generators with a more suitable model, including the installation of a centrifugal motor fan on the upper left corner of the ring body (Figure 1) to enhance cooling performance. Additionally, the cooling outlet pipe of the generator's ring body will be replaced with a more durable pipe to better resist thermal stress. The routing of the pipe will also be modified, connecting the end of the pipe to the outside of the nacelle (Figure 2), ensuring optimal thermal management.

## Benefits

- Improved air flow and cooling performance reduce maintenance while extending generator system's lifespan.
- Modifying the pipe routing to connect to the outside of the nacelle improves heat dissipation, preventing excessive temperatures and ensuring stable operation.
- Improved maintenance efficiency.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW.

## Related products

Maintenance Optimization.

## Requirements

Hardware update.

### Installation time

- Generator solution: 4 hours x 2 technicians.
- Outlet pipe solution: 2 hours x 2 technicians.

### Fleet experience

Installed in +350 turbines.

### Functional system

Generator.

# Detection of Loose Objects



Figure 1: Detection of Loose Objects extension board

## Challenge

Loose objects in the hub of the turbine may cause serious mechanical, electrical, or hydraulic damage to the turbine and in the worst case may cause structural damage to the blade construction.

## Solution

Siemens Gamesa engineering has developed a microphone to be installed in the A6 cabinet (located in the hub) to prevent damage caused by a loose object.

Detection of Loose Objects (DLO) is a feature capturing the sound in the hub of the turbine. It consists of an extension board, which has a microphone installed capturing dissonances in the sound. If the DLO system detects a change in the sound in the hub, an alarm is set to stop the turbine to eliminate further damage.

## Benefits

- Minimizing risk of loose objects in the hub of the turbine.
- Preventing mechanical, electrical, and hydraulic damage to the turbine.
- Cost savings from reduced man hours and downtime of the turbine.



Maintenance ease



Cost control



Operating reliability



Safety

## Applicability

SWT-2.3-101, SWT-2.3-108, SWT-2.3-93 with a WTC-3 controller.

### Fleet experience

More than 3,000 wind turbines.

### Installation time

Approximately 1 hour downtime of each turbine (the mounting is done on-site).

# Direct Drive (DD) Generator Bypass Application

## Challenge

In cases where waiting times for replacing a failed DD generator are prolonged, it can result in extended downtime and production losses.

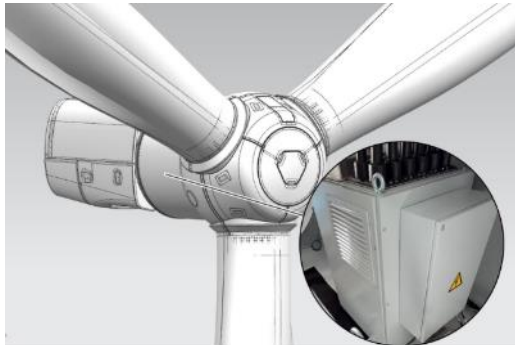
## Solution

To restore a failed DD generator to operational and profitable status, an on-site repair solution called the 'Bypass Application' can be implemented. This solution is particularly useful when there are extended lead times before the generator can be replaced. The Bypass Application is a repair method designed for DD generators, which keeps failed units operational by isolating the malfunctioning section of the component. This allows the generator to resume operation, with reduced performance.

## Benefit

The Bypass Application allows failed units to remain operational with reduced production capacity until a full down-tower replacement can be completed, minimizing production losses caused by generator failures.

Once implemented, the wind turbine can operate at a reduced capacity, maintaining at least 50% of its nominal production capacity. The exact capacity will be determined after a site test.



Trusted partner



Cost control



Operating reliability



Safety

## Applicability

SWT-2.3-113, SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.4-101, SWT-3.4-108, SWT-3.15-142, SWT-3.3-130, SWT-3.6-107, SWT-3.6-130, SWT-6.0-154, SG 7.0-154, SG 8.0-154, SG 8.0-167.

### Fleet experience

+30 turbines with Bypass Applications successfully installed.

### Installation time

Approx. 3 days with 2 technicians (per wind turbine)\*.

\* The exact installation time depends on the number of coil heads to be cut off, weather conditions, and other on-site conditions.

# FG008 Change and KM052 installation

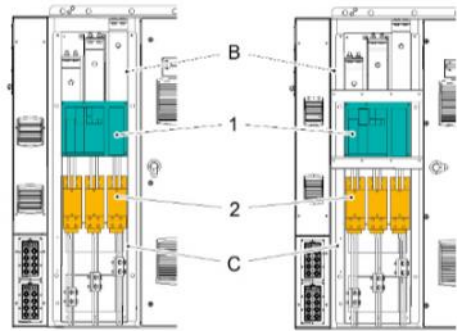


Figure1: Location of circuit breaker FG008 and stator contactor KM52E in the top electrical cabinet

- 1. Circuit breaker switch FG008
- 2. Stator contactor KM52E
- B. Top electrical cabinet compartment B
- C. Top electrical cabinet compartment C

## Challenge

FG008 carries out coupling and decoupling maneuvers for G8X wind turbines to the grid. By year's end, it has affected an elevated number of maneuvers, leading to a reduced service life of the FG008 breaker.

## Solution

To avoid this, the solution consist of:

- The replacement of the current circuit breaker FG008 model with an assembly consisting of a fixed FG008 plus a power contactor.
- The installation of the KM52E stator contactor, responsible for coupling and disconnection maneuvers, allowing for this change to the FG008 and, consequently, reducing the number of FG008 maneuvers, extending the breaker's useful life.

## Benefits

- Reduction of the number of operations of circuit breaker FG008.
- Increase in the service life of circuit breaker FG008.
- Reduction of operation and maintenance costs.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW.

## Requirements

Converter: DFM model 50Hz

- Ingeteam V3.0.
- Ingeteam V3.1.
- Ingeteam V3.2 (The detailed solution depends on Ingeteam's metal fabrication supplier: Himel or Hercor).

### Fleet experience

200 wind turbines.

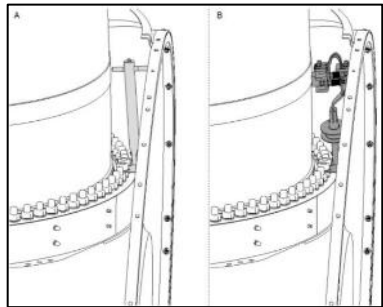
### Installation time

11 hours x 2 technicians.

### Functional system

Electrical cabinets.

# Lightning Protection System Contact LTS (Hammer)



A. Existing standard lightning protection system  
 B. New contact Lightning Transmission System (LTS)

## Challenge

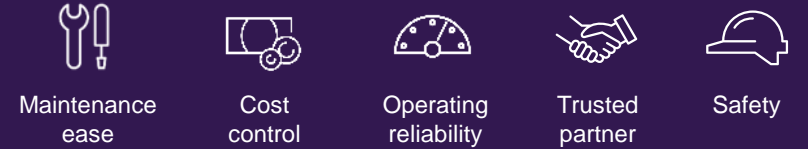
In regions of large static electricity concentration, especially during storms, the transfer of static discharge from the blade to the nacelle is sometimes not optimal. The result can be an alarm notification, leading to unnecessary turbine stoppage.

## Solution

This modification improves the flow of static discharge between the blade and nacelle and reduces the number of alarms. The existing lightning protection system is replaced with a new contact Lightning Transmission System (LTS), which transmits the discharges from the lightning through a contact circuit. The aim is to enable improved control of the air gap and prevent high electrostatic charges. The contact LTS has two circuits: One for the static electricity, which connects the blade plate using a contact bush with the blade bearing, and the second for the lightning that is based on a gap between the blade plate and the blade side comb and between the gutter ring and the gutter ring side comb.

## Benefit

- Productivity improvements.
- Reduction of number of alarms linked to electrostatic discharge.
- Reduction of wind turbine shutdown times.



## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 2.1-114, SG 2.1-122, SG 2.6-114, SG 3.4-132, SG 3.4-145.

## Requirements

No PLC update required.  
 No SCADA update required.  
 Installation of 3 devices per WTG, one per blade.

## Related products

Diverter strips and lightning receptor improvement.  
 Lightning rod ("Omega").  
 Flash Lightning Detection.

### Fleet experience

200 wind turbines worldwide.

### Installation time

For all applicable platforms: 8 hours x 2 technicians.

### Functional system

Lightning Protection System (LPS) – Blade bearings.

# Lightning Protection System Diverter Strips & Lightning Receptors

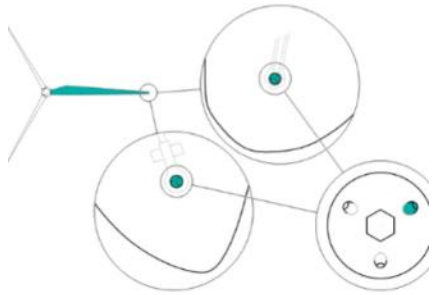


Figure 1: General location of the receptor bolts (blade tips)

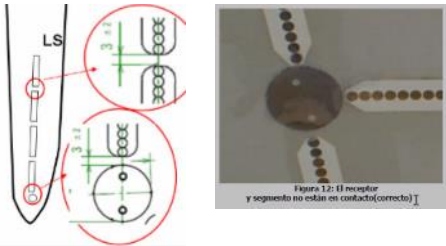


Figure 2: Diverter strips

## Challenge

Wind turbine blades are subject to lightning strikes, which may result in severe damages to the blade structure. According to NASA data, lightning strikes around 40 times globally every second.

## Solution

It can be crucial to have an optimized solution to protect the blade against damages due to strikes of lightning. Especially in areas with a high likelihood of lightning strikes. To improve protection, Siemens Gamesa proposes two small design upgrades:

- Bigger receptor bolts or additional receptor bolts, depending on the turbine model.
- Diverter strip installation for guiding the lightning strikes to the receptor bolts.

## Benefit

- Reduction of operating and maintenance costs:
  - Reduction of blade damage caused by lightning.
  - Reduction of damage to the lightning protection system.
  - Reduction of electrical discharges caused by lightning.
- Increased reliability of the turbine's lightning protection system.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.

## Requirements

No PLC update required.  
No SCADA update required.  
External crane may be needed.

## Related products

Contact Lightning Transmission System ("Hammer").  
Lightning rod ("Omega").  
Flash Lightning Detection.

### Installation time

- Diverter strips (all applicable models, except G97-2.0 MW): 5 hours x 2 technicians.
- Receptor bolts (all applicable models, except G97-2.0 MW): 5 hours x 2 technicians.
- G97-2.0 MW, all: 26 hours x 3 technicians.

### Functional system

Lightning Protection System (LPS) – Blades.

### Fleet experience

67 wind turbines worldwide.

# Lightning Protection System Lightning Rod (Omega)

## Challenge

Potential impact on the functionality of the omega-shaped lightning rod. Turbine integrity would be at risk of lightning strikes, and, eventually, due to corrosion, the elements could detach from the welding bead and fall to the ground.

## Solution

Installation of the new omega-shaped lightning rod designed to prevent breakage due to the vibrations of the nacelle and with the proper anti-corrosive surface treatment. In addition, the lightning rod is isolated from the stainless-steel fastening elements that fasten it to the mast to prevent galvanic corrosion. It includes the replacement of the current omega-shaped lightning rods, anemometer, and wind vane bolted joints.

## Benefit

- Increased reliability of the lightning rod.
- Improved stability compared to previous lightning rod: Prevents the lightning rod, wind vane, and anemometer from detaching.
- Extension of lightning rod service life.
- Reduction of maintenance costs.
- Compatible with highly corrosive environments.

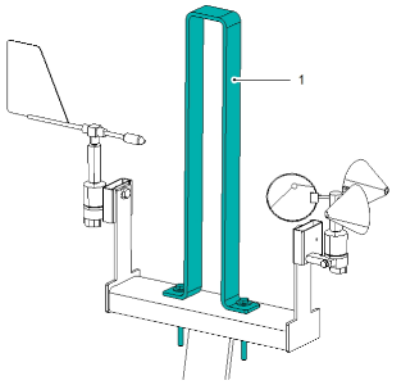


Figure 1: Detailed view of new lightning rod (1) on the upper support of the anemometer



Maintenance  
ease



Cost  
control



Operating  
reliability



Trusted  
partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 2.6-114.

## Requirements

No PLC update required.  
No SCADA update required.

## Related products

Diverter strips and lightning receptor improvement.  
Contact Lightning Transmission System ("Hammer").  
Flash Lightning Detection.

### Installation time

- All applicable models, except SG 2.6-114: 5 hours x 2 technicians.
- SG 2.6-114: 2.25 hours x 2 technicians.

### Fleet experience

170 wind turbines worldwide.

### Functional system

Lightning Protection System (LPS) – Anemometer.

# Main Frame Reinforcement 660 kW

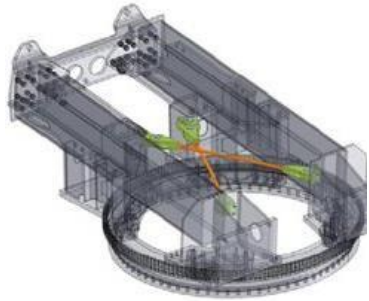


Figure 1: Preventive solution – assembling cross braces

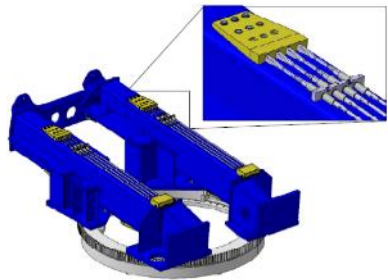


Figure 2: Corrective solution – assembling lengthwise braces

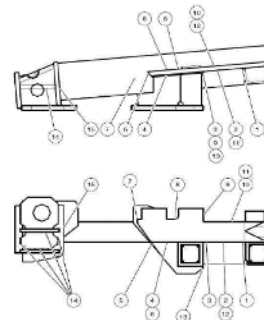
## Challenge

Historically, the appearance of cracks at different points of G47-660 kW turbines' frame has been recorded. Two of the most sensitive points are 5 and 7.

## Solution

Based on our experience, we recommend repairing any cracks detected on the frame, either through welding or by installing bolted reinforcements.

Depending on the crack length, and if it exceeds critical values, we propose both preventive and corrective solutions to prevent further crack propagation and the appearance of new cracks (see Figures 1 and 2).



## Benefits

- Increase the integrity of the frame.
- Increase service life of the wind turbine.
- Modification of the load path on the frame, with the subsequent inhibition of new cracks at points 5 and 7.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G47-660 kW.

## Requirements

No PLC update.  
No SCADA update.

## Related products

Life Extension program.  
Procedure for repairing the frame.

### Fleet experience

- Preventive solution: 240 turbines.
- Corrective solution: 50 turbines.

### Installation time

- Preventive solution: 8 hours x 2 technicians.
- Corrective solution: 16 hours x 2 technicians.

### Functional system

Frame system.

# Main Frame Reinforcement 2 MW

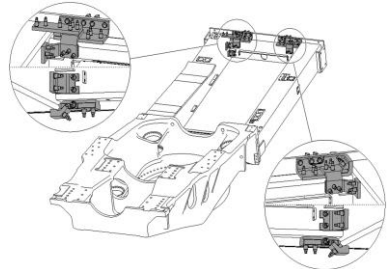


Figure 1: Preventive solution – assembling reinforcements

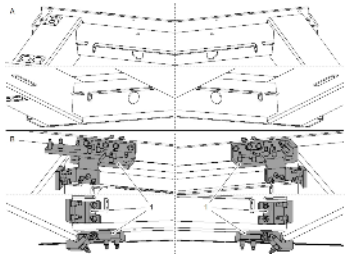


Figure 2: Before and after installing the reinforcements on the rear frame

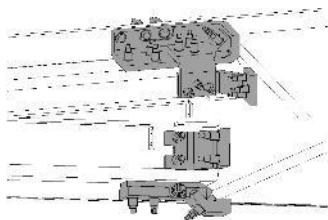


Figure 3: Detail of the reinforcements

## Challenge

The main frame in 2 MW turbines, backbone of the turbine's operation, faces structural fatigue and load distribution challenges due to prolonged operational stresses and evolving site conditions. Under certain conditions this structural fatigue may cause cracks in the main frame and in the welds between the longitudinal and transversal beams of the rear frame. This could lead to progressive damage, compromising the integrity of the structure.

## Solution

Integrate durable materials and proven techniques that modify the load path, setting a new standard in main frame reliability. This tailored engineering solution involves welding or installing bolted reinforcements when cracks are detected. Depending on crack length and whether it exceeds critical thresholds, a preventive or corrective approach is recommended to inhibit propagation and prevent future cracks, ensuring long-term structural integrity.

## Benefits

- **Comprehensive structural care** thanks to a holistic approach that assesses the main frame's condition and determines the most efficient actions to ensure its integrity and durability.
- **Increase service life** of the wind turbine.
- **Reinforcement of the load path on the rear frame**, with the subsequent inhibition of new cracks.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW and G97-2.0 MW.

## Related products

Life Extension program.

## Requirements

Hardware.

### Fleet experience

- Preventive solution: +450 turbines.
- Corrective solution: +90 turbines.

### Installation time

- Preventive solution: 4 hours x 2 technicians.
- Corrective solution: 8 hours x 2 technicians.

### Functional system

Frame system.

# Metal-Shield Ambient Temperature Sensors

## Challenge

Siemens Gamesa has developed an improved shielding solution for ambient temperature sensors inside the nacelle to enhance measurement accuracy. This upgrade reduces the impact of electrical noise from nacelle electronics and external factors like weather conditions and dirt accumulation. By ensuring more reliable sensor readings, this solution helps optimize turbine performance and control strategies.

## Solution

To enhance temperature measurement accuracy inside the nacelle, the existing PT100 sensors are replaced with ambient temperature sensors featuring a metal shield on the conductor. This shielding effectively minimizes the impact of electrical noise generated by nacelle electronics, reducing the risk of erroneous readings. Additionally, by properly grounding the sensor screens to the PLC's ground terminal, electromagnetic interference is further mitigated, ensuring more stable and reliable temperature data for optimized turbine performance and control strategies.

## Benefits

- **Improved measurement accuracy** thanks to the reduction of electrical noise interference.
- **Optimized turbine performance:** more reliable data enables better control strategies leading to improved operational efficiency.

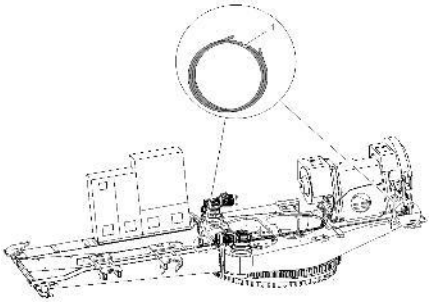


Figure 1: Location of the ambient temperature sensors in the nacelle

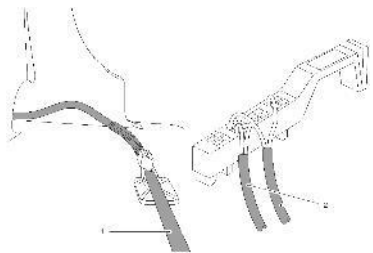


Figure 2: New temperature sensors with mesh.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW.

## Requirements

No PLC update.  
No SCADA update.

### Fleet experience

Installed in +150 turbines.

### Installation time

6 hours x 2 technicians.

### Functional system

Control.

# Noise Reduction DinoTails and Serrations



Figure 1: Blade without DinoTails or serrations



Figure 2: Blade with DinoTails or serrations

## Challenge

Customers with Gamesa wind farms located near residential areas or environmentally sensitive zones must comply with strict noise regulations, and exceeding these limits can result in operational restrictions, curtailment or penalties.

## Solution

Siemens Gamesa offers DinoTails for G90-2.0 MW and G97-2.0 MW turbines and serrations for Servion turbines equipped with RE and LM blades, specifically designed to reduce noise in sensitive locations. By incorporating trailing-edge DinoTails or serrations at the rotor blade tip region, these modifications optimize airflow at the trailing-edge separation point of laminar flow, effectively lowering sound power levels. Available in various sizes, the solution effectively minimizes noise emissions, making them ideal for noise-sensitive areas and reducing environmental noise pollution.

## Benefits

- Noise Regulation Compliance, particularly in noise-sensitive or environmentally protected areas. Noise level reduction up to 1.5 dB<sub>A</sub>.
- Minimized Environmental Disruption, ensuring turbines operate with minimal disturbance to the surrounding environment.
- Operational Flexibility: Enables turbines to perform at full capacity without exceeding noise limits, avoiding potential operational restrictions or curtailment.



Maintenance  
ease



Cost  
control



Operating  
reliability



Trusted  
partner



Safety

## Applicability

G90-2.0 MW, G97-2.0 MW, 3.2M114, 3.4M114, 3.4M104, 3.4M122, MM92, MM82, MM100.

## Related products

EnergyUp Partial Range, Hardware.

## Requirements

No PLC update.  
No SCADA update.

### Fleet experience

Installed in +90  
Gamesa turbines  
and +80 Servion  
turbines.

### Installation time

- 30 hours x 2 technicians for Gamesa turbines.
- 19 hours x 3 technicians for Servion turbines.

### Functional system

Blades.

# Overspeed Guard System (OGS) Protection

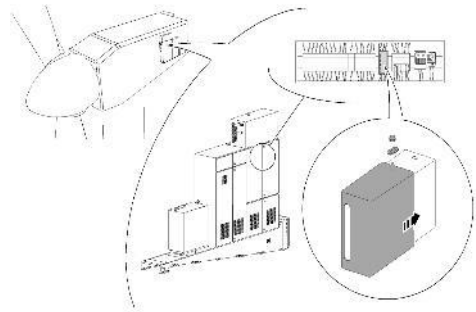


Figure 1: Installation of a Faraday box to protect the overspeed guard system

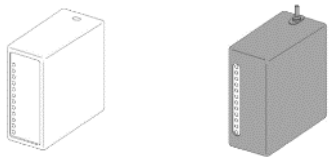


Figure 2: Before and after installing a Faraday box to protect the OGS in the Top electrical cabinet

## Challenge

Undesired electrical noise within the top electrical cabinets of Siemens Gamesa Electric may interfere with the performance of the overspeed guard system (OGS), causing false turbine shutdowns. These disruptions can lead to unintended stops and power losses, negatively impacting the turbine's efficiency and availability.

## Solution

To mitigate the impact of electrical noise, a Faraday box is installed around the overspeed guard system (OGS). This protective enclosure works by shielding the OGS from electromagnetic interference, effectively blocking external electrical noise. By preventing disruptions, the Faraday box enhances the reliability of the OGS, ensuring consistent performance, reducing false turbine shutdowns, and improving overall turbine efficiency and availability.

## Benefits

- Improved reliability: Installing a Faraday box shields the OGS from electrical noise, ensuring consistent performance.
- Enhanced efficiency: Reduces false turbine shutdowns, improving turbine uptime and overall system stability.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW, SG 3.4-132.

## Requirements

Hardware update.

### Fleet experience

Installed in +250 turbines.

### Installation time

2 hours x 2 technicians.

### Functional system

Control.

# Pitch Control Cylinder Support Replacement

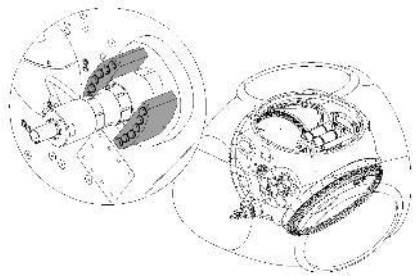


Figure 1: Location pitch cylinder and its supports

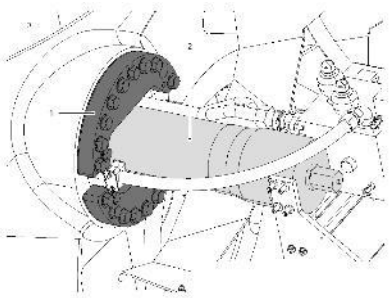


Figure 2: Location of the supports of the pitch control cylinders.

## Challenge

Optimal wind turbine performance depends on precise pitch control to adjust blade angles and maximize energy production. However, under certain wind conditions, looseness in the hollow shaft of the pitch control system can lead to excessive wear in the friction bushings mounted on the supports of the pitch control cylinders. This accelerated wear affects pitch actuator operation, compromising system performance and long-term reliability.

## Solution

The solution involves replacing the existing supports with upgraded versions. The new supports incorporate friction bushings better suited to the operation of the pitch control cylinder. This enhancement improves durability and performance, reducing excessive wear. The replacement can be efficiently carried out during a scheduled maintenance task.

## Benefits

- **Extended Component Lifespan:** Reduction wear on pitch control cylinders and supports, enhances long-term reliability.
- **Optimized Pitch System Performance:** Ensures smoother and more precise blade angle adjustments.
- **Reduced Maintenance Needs:** Minimizes unplanned interventions and associated downtime.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW.

## Related products

Life Extension Program.

## Requirements

- No PLC update.
- No SCADA update.

### Fleet experience

Installed in +150 turbines.

### Installation time

6 hours x 2 technicians.

### Functional system

Pitch system.

# Pitch Control Reinforcement Double Flange

## Challenge

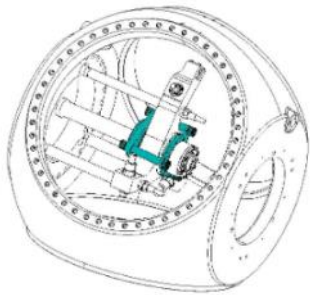
Eradicate the known problem of hollow shaft bolt breakages. This improvement is highly recommended to prevent the breakage of the bolted joint between the hollow shaft and the star in the pitch control system.

## Solution

A double flange solution is designed to reduce the load that is currently passing through the hollow shaft bolts and to avoid the hollow shaft going out from the traverse. With the new design, the loads are transmitted from the traverse to the hollow shaft through the new components and a shrink disk located in one of the flanges.

## Benefits

- Avoiding the repair of the assembly (dismounting the rotor).
- Reduction of operating and maintenance costs:
  - Reduction of damage in the bolted joint between the hollow shaft and the star.
  - Reduction of damage to the pitch control system.
  - Reduction of alarms related to the pitch control system.
- Extension of the service life of the bolted joint between the hollow shaft and the star.
- Increased pitch control system reliability.



Detailed view of the double flange system in the pitch control system



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G52-850 kW, G58-850 kW.

## Requirements

Has been validated by Garrad Hassan\*:

- Turbine integrity is not compromised.
- Modifications will not affect the turbine design life.
- Methodology to calculate energy gain is Garrad Hassan approved.

### Fleet experience

550 wind turbines.

### Installation time

8 hours × 2 technicians.

### Functional system

Hydraulic and pitch system.

\* Now part of DNV GL.

# Pitch Cylinder Leakage Reconduction

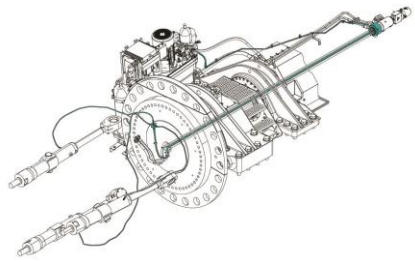
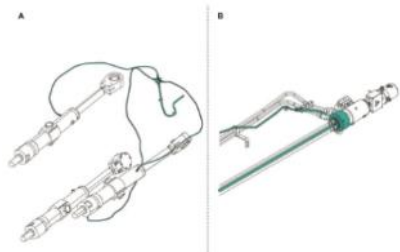


Figure1: New routing of the drainage circuit on the pitch control system cylinders



A. New hub elements  
B. New nacelle elements

## Challenge

Initially, the drainage of the cylinders was directed toward the hub's leak tank. This tank is equipped with a level sensor that triggers the 212 alarm, prompting the system to prepare the tool for drainage before restarting the wind turbine. Access to the inside of the rotor is dependent on certain wind speeds, which results in prolonged downtime and reduced availability.

## Solution

The proposal solution is to redirect the drainage of each cylinder from the bushing tank to the hydraulic group tank in order to reduce the triggering of the hub leak alarm (212), and therefore the loss of availability caused by this triggering. Given the different configurations of the turbine, the list of materials and assembly of the solution differs.

## Benefits

- Reduction of operating and maintenance costs: Avoids the local resetting of alarm 212.
- Increased wind turbine availability: Avoids the triggering of alarm 212 (detection of full leak tank in hub) and turbine stoppage.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.

## Requirements

No PLC update.  
No SCADA update.

## Related products

Replacement of mechanical protection from the valve block.

### Fleet experience

300 wind turbines worldwide.

### Installation time

8 hours x 2 technicians.

### Functional system

Hydraulic and pitch system.

# PowerEdge® Care

## Safeguard the leading edge for life



AEP



Availability



Operating  
reliability



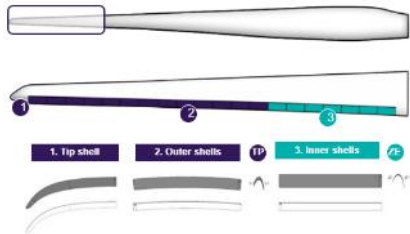
Maintenance  
ease



Safety

### Challenge

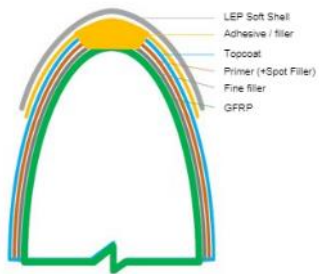
Leading-edge erosion is an increasing challenge impacting the cost of operations and increasing service intervals.



### Solution

Precast polyurethane protective shells installed on the blades leading edge and complemented with vortex generators; DNV-GL-certified:

- Site-specific solution length based on environmental assessment of erosion development.
- Optimized application method as liquid adhesive is used as glue, filler, and edge sealer, minimizing installation downtime.
- It is normally installed up-tower by rope access; alternative methods are available.



### Benefits

- Safeguard the blades leading edge for life from weather conditions (rain, hail, sand ...); one-time remedy.
- PowerEdge® Care provides a long-term AEP upside of up to 1% compared to repeating repairs of eroding blades.
- PowerEdge® Care allows a flexible and site-specific approach to blade maintenance.
- The cost of the solution is independent of the erosion level of the leading edge.

### Applicability

Available for all Siemens wind turbines.

### Compatible products

Bundled with BIM provides a competitive full-coverage blade solution.

### Payback

In case of more than two repeating repairs over the lifetime of the wind turbine it could optimize blade repair, maintenance and downtime.

#### Fleet experience

More than 1,000 meters installed on Siemens Gamesa and other OEMs onshore and offshore wind turbines.

#### Installation time

In normal weather conditions, the installation takes approximately one day per blade, depending on the length of PowerEdge® Care to be installed.

# Root Anchoring Solution (RAS)



## Challenge

Exposure to sustained oil and grease contamination is a potential risk for the mechanical properties of the cast inserts in the root end. A combination of several factors can lead to incidents with loose inserts in LM blades liberated from G97 turbines due to the embedded inserts coming loose.

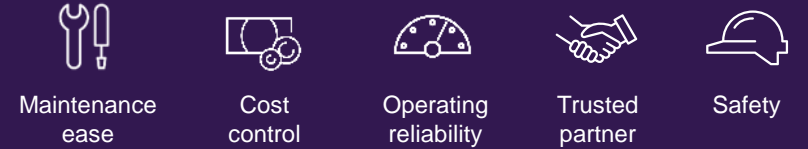
## Solution

The Root Anchoring Solution (RAS) can be performed following a wobbling inspection and test of movement within the blade root once the corresponding thresholds are reached. The RAS consists of retrofitting the damaged inserts in the root area by creating a sandwich structure of the root-laminate faces, inner and outer, bolted with washers to join the plates on the blade's root-laminates to the blade inserts.

RAS requires special maintenance to inspect the components every 12 months to ensure the safest performance of the solution.

## Benefit

The RAS improves the mechanical connection of the root inserts of the LM blades by increasing the load-carrying capacity of the embedded metallic mounting inserts. This helps prevent the mounting inserts slipping out when the blade is in operation. The RAS up-tower method reduces the repair costs and turbine downtimes compared to down-tower blade repair and/or modification works.



## Applicability

G97-2.0 MW with LM47.6 blades.

## Installation method

Up-tower without the need for cranes or complex machinery, so the blade can remain in its position at the hub while RAS is performed.

## Patent application

Status "pending".

### Installation time

77\* hours per blade and 3 technicians.

### Functional system

Blades.

\* Estimated mean duration of the task for a standard repair of 21 inserts located in the same shell.

# TCM Upgrade

## Challenge

Existing turbines with legacy systems lack the advanced capabilities of vibration-based condition monitoring, limiting remote and automatic drivetrain monitoring. The SMP system requires operators to rely heavily on technician visits, with manual downloads and analysis of excessive vibrations, increasing the risk of delayed failure detection and costly repairs. Without early issue detection, turbines are more vulnerable to performance degradation, directly impacting operational efficiency and raising the levelized cost of energy (LCoE).

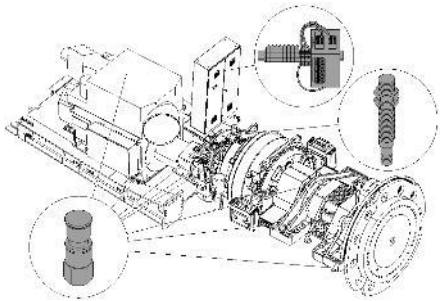


Figure 1: Location of the TCM unit and the sensors in a wind turbine. 2 MW example

## Solution

To enhance predictive maintenance capabilities, the TCM upgrade involves the strategic installation of a network of sensors along the drivetrain to monitor key components such as the main shaft bearing, gearbox and generator. These sensors continuously gather vibration data and transmit it to the TCM unit located in the control cabinet. Integrated with the Programmable Logic Controller (PLC), the TCM system analyzes this data to detect early signs of potential failures, enabling proactive maintenance and minimizing unplanned downtime.

## Benefits

- **Earlier issue detection:** TCM improves predictive maintenance with real-time data analysis, replacing the previous system's reliance on manual inspections and reactive maintenance.
- **Cost Efficiency and Productivity improvements:** early issue detection, allowing repair operations to be scheduled more efficiently during low wind windows, reducing downtimes and non-productive time.



Maintenance ease



Cost control



Operating reliability



Trusted partner



Safety

## Applicability

G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW, SG 2.1-114, SG 2.1-122, SG 2.6-114, SG 2.6-126, SG 3.4-132, SG 3.4-145.

## Related products

Life Time Extension.

## Requirements

PLC update.  
SCADA update.

### Fleet experience

Installed in more than 250 turbines.

### Installation time

8 hours x 2 technicians.

### Functional system

Drive train.

# Wildlife Protection Bat Environmental solutions



## Challenge

Minimize risk to bats while ensuring compliance with local regulations for your wind farms.

## Solution

The Wildlife Protection Bat System controls the operation of individual wind turbines based on the specific requirements of each site. The system halts turbine activity upon detecting bats near the wind farm.

Turbines pause only when all configured conditions (such as calendar settings, wind direction sectors, temperature, light levels, etc.) are met. If condition changes, the algorithm considering the configured hysteresis values, will prompt the paused turbines to resume operation.

## Benefits

- Compliance with local regulations.
- Allowing extended operation windows due to improved control.
- Ensuring the optimum energy production with greater local acceptance.



Regulation compliance



Customized solution



Revenue



Partnership

## Applicability

- Sector, Calendar, Temperature and Light configurations: SGIPE 2.3, WindNet, WindNet® PRO, WPS2, WPS3.
- Humidity, Rain sensor, External signal integration: WindNet® PRO.

## Compatible products

Can be acquired with other Siemens Gamesa environmental solutions to ensure compliance with local regulations and enhance operational capabilities, ultimately increasing energy production.

## Installation time

Depends on site.

# Wildlife Protection Bat Rain Sensor integration feature

## Challenge

Minimize risk to bats while ensuring compliance with local regulations and minimizing turbine's stoppages due to bats, resulting in higher energy production for the wind farms.

## Solution

The Wildlife Protection Bat System with rain sensor integration provides a more precise control over individual wind turbine operations during rain events. The rain sensor integration ensures that turbines stop only when it is not raining, thereby reducing curtailment periods.

The solution includes:

- Configuration of the bat protection module in the Environmental Management tool integrated into the SCADA system.
- Development of an algorithm to manage stoppages due to bat presence, taking rain conditions into account.
- Configuration of network and communication devices to enable connection of the rain sensor\*.
- SCADA adaptation to ensure proper operation, including updates as necessary.
- Customer acceptance testing.

## Benefits

- Enhanced bat protection: Ensures turbines stop only when bat activity is highly probable, minimizing collision risks.
- Optimized energy production: Smart curtailment reduces unnecessary shutdowns, balancing energy output and wildlife safety.
- Reliable data logging: Consistent logs ensure transparency and support analysis.

\* Device, installation and configuration is in the scope of the operator.



Regulation  
compliance



Customized  
solution



Revenue



Partnership

## Applicability

WindNet® PRO.

## Compatible products

Can be acquired with other Siemens Gamesa environmental solutions to ensure compliance with local regulations and enhance operational capabilities, ultimately increasing energy production.

## Installation time

Depends on site.

# Wildlife Protection Bird Environmental solutions

## Challenge

Minimize risk to birds while ensuring compliance with local regulations for your wind farms.

## Solution

The Wildlife Protection Bird system detects flying birds in flight in real-time and executes programmed actions to minimize bird mortality from wind farm operations.

The system pauses wind turbines when birds are detected near the wind farm, provided the configured conditions are met. This functionality is enabled by two types of sensors, which can be integrated either individually or together into the control system:

- **Bird detector:** the turbines linked to the sensor will be paused when birds are detected.
- **Visibility sensor:** the turbines linked to the sensor will be paused when low visibility is detected during the periods specified in the configuration calendar.

## Benefits

- Compliance with local regulations.
- Allowing extended operation windows due to improved control.
- Ensuring the optimum energy production with greater local acceptance.



Regulation compliance



Customized solution



Revenue



Partnership

## Applicability

WindNet® PRO, WPS2, WPS3.

## Compatible products

It can be acquired with other Siemens Gamesa environmental solutions to ensure compliance with local regulations and enhance operational capabilities, ultimately increasing energy production.

## Installation time

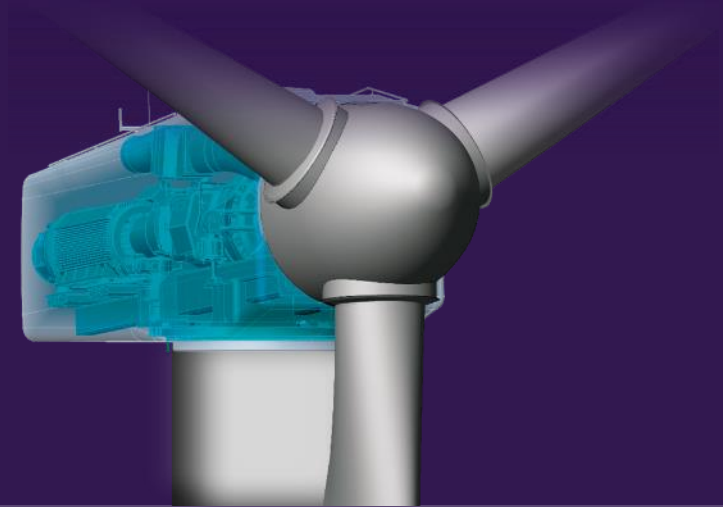
Depends on site.

# Life Extension

## More life, more revenue

Owners of aging turbines face challenges with reliability, performance, and rising operations and maintenance (O&M) costs. Advances in reliability-centered maintenance and reconditioning programs allow for extending the design life of wind turbines, often enhancing their performance.

Siemens Gamesa offers Life Extension services for up to 10 additional years for various turbine models. Through on-site inspections, critical component upgrades, and leveraging decades of OEM and maintenance expertise, we ensure continuous energy production while managing risks and controlling O&M costs.



### **Life Extension, adding up to 10 years of income**

Incorporate a Life Extension program into regular maintenance for wind turbines surpassing their design life.

Siemens Gamesa will conduct a comprehensive, site-specific study to determine necessary inspections and upgrades for an additional 10 years of operation.

# Life Extension. Your trusted partner for Asset Safety, Health and Performance



Revenue



Availability



Operating reliability



Partnership



Safety

## Challenge

Wind turbines typically reach the end of their design life around year 20, which often leads to increased O&M costs and a negative impact on the business case.

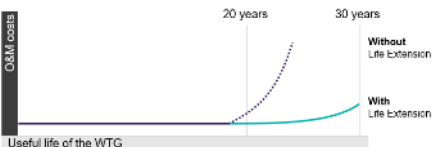
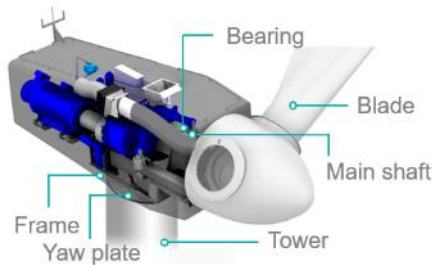
## Solution

The Life Extension program involves a detailed site analysis of key components. By combining load calculations with operational data, it delivers an accurate assessment of the mechanical components' lifespan, projecting up to 10 additional years. This program also provides a customized maintenance strategy tailored to your site's needs, enabling the wind farm to operate beyond design lifetime.

- Actions to be taken at the beginning of the extended period.
- Preventive inspection plan (starting year and frequency).
- Preliminary proposal for design modifications, upgrades, or reinforcement.

## Benefit

- Ensuring 10 more years of additional revenue and increasing the net asset value.
- Low-cost alternative to repowering with mitigated risk.
- Full control of operational expenditures over the remaining life of the wind turbines.



## Applicability

Gamesa: G47-660 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.  
 Siemens: SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93, SWT-2.3-113, SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.15-142, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.3-130, SWT-3.4-101, SWT-3.4-108, SG 4.3-130, SG 4.3-120.  
 Senvion: MM82, MM92, MM100.

## Compatible products

It is possible to combine with other Siemens Gamesa solutions to optimize O&M costs and/or further increase the AEP.

### Fleet experience

Experience in carrying out studies since 2014 on 5,259 wind turbines.

### Est. Lead time

Depends on site.

### Recommended

For all Siemens Gamesa wind turbines and technologies.

# Life Extension Maintenance Strategy Report



Cost control



Knowledge



Insight



Partnership



Customized solution

## Challenge

Wind turbines typically reach the end of their design life around year 20, which often leads to increased O&M costs and a negative impact on the business case.

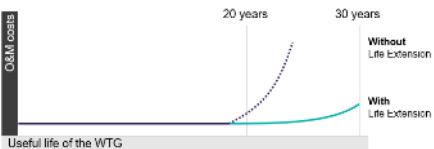
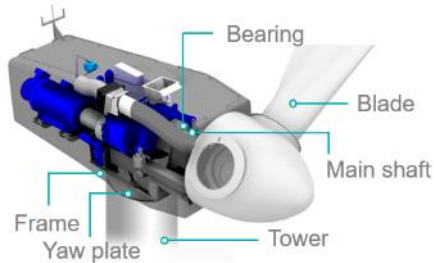
## Solution

Life Extension Maintenance Strategy Report is a comprehensive report based on the key component study that combines site-specific conditions and fatigue load calculations with operational experience to carry out a precise assessment of the mechanical components. It provides you with a site-tailored maintenance strategy necessary to operate the wind farm for up to 10 more years:

- Actions to be taken at the beginning of the extended period.
- Preventive inspections plan for the life extension period (starting year and frequency).
- Preliminary proposal for design modifications, upgrades, or reinforcement to be implemented in the wind turbines.

## Benefit

- Best partner of choice to gain up to 10 years of additional revenue.
- Supports you in gaining full control of operational expenditures over the remaining life of the asset.
- Advantages from unique OEM knowledge to support your maintenance strategy.
- Helps you make better-informed decisions on financing, asset sales, upgrading, or repowering.



## Applicability

Gamesa: G47-660 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.  
 Siemens: SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93, SWT-2.3-113, SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.15-142, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.3-130, SWT-3.4-101, SWT-3.4-108, SG 4.3-130, SG 4.3-120.  
 Senvion: MM82, MM92, MM100.

## Compatible products

It is possible to combine with other Siemens Gamesa solutions to optimize O&M costs and/or further increase the AEP.

## Track Record

Experience in carrying out studies since 2014 on 5,259 wind turbines.

### Fleet experience and Inspection

Experience in carrying out studies since 2014 on 5,259 wind turbines.

### Est. Lead time

Depends on site.

### Repair

Benefit from our vast OEM knowledge and secure optimal repair of your turbines.

### Upgrade

Choose a variety of upgrade solutions and optimize your investment.

### Recommended

For all Siemens Gamesa wind turbines reaching year 20.

# Life Extension Site Fatigue Load Assessment



Cost control



Knowledge



Operating reliability



Insight



Safety

## Challenge

Wind turbines typically reach the end of their design life around year 20, which often results in increased O&M costs and a negative business case. To continue operating the wind farm beyond design lifetime, it is essential to assess the estimated life expectancy of the main components.

## Solution

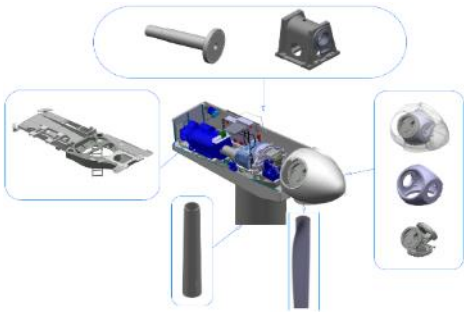
It combines turbine-specific data (design, operational history, etc.) and site-specific conditions (wind data, climate data, SCADA data, etc.) to calculate the loads beyond the extended period.

Comparing the site-specific loads and design loads over next 10 years indicates whether the turbine has enough fatigue load capacity to withstand the loads in the additional time. This makes it possible to determine:

- If the site-specific loads for over 10 years beyond the designed lifetime are below the design loads.
- Which components of each turbine can last up to 30 years.

## Benefit

- Use the lifetime expectation of the structural elements to determine future possibilities and make better-informed decisions on financing, asset sales, and repowering.



Load path/control system, wind turbine G58-850 kW

## Applicability

Gamesa: G47-660 kW, G52-850 kW, G58-850 kW, G80-2.0 MW, G83-2.0 MW, G87-2.0 MW, G90-2.0 MW, G97-2.0 MW.  
Siemens: SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93, SWT-2.3-113, SWT-3.0-101, SWT-3.0-108, SWT-3.0-113, SWT-3.15-142, SWT-3.2-101, SWT-3.2-108, SWT-3.2-113, SWT-3.3-130, SWT-3.4-101, SWT-3.4-108, SG 4.3-130, SG 4.3-120.  
Senvion: MM82, MM92, MM100.

## Compatible products

It is possible to upgrade with a Life Extension Maintenance Strategy Report, which provides a site-specific maintenance strategy. This includes a list of necessary repairs, inspections, and upgrades required to operate the wind farm for up to 30 years.

### Fleet experience

Experience in carrying out studies since 2014 on 5,259 wind turbines.

### Est. Lead time

Depends on site.

### Recommended

For all Siemens Gamesa wind turbines reaching year 20.

# Cybersecurity Excellence for Secure and Resilient Wind Operations

**As cyber threats become more sophisticated, ensuring the security of wind assets is more critical than ever. Siemens Gamesa provides robust security measures, real-time monitoring, and rapid response capabilities to safeguard customer assets, ensuring their continuous and secure operation.**

Our ISO 27001 certification validates that Siemens Gamesa's Information Security Management System (ISMS) adheres to best-in-class security practices. This certification ensures the implementation of a comprehensive cybersecurity framework designed to mitigate risks and protect sensitive information, meeting the highest international standards

# Advanced Endpoint Protection

## Guard your asset against unwanted guests



AEP



Operating  
reliability



Support



Safety

### Challenge

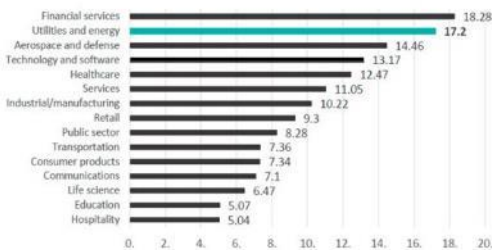
Cyberattacks cost an average of \$17.2 M per targeted organization in the energy sector. To keep control over the system, park operation and prevent sensitive data being compromised, a strong cybersecurity service is critical during the whole lifetime of a SCADA system.

### Solution

To support our customers in protecting critical assets and securing the stability of power production, Siemens Gamesa has created Advanced Endpoint Protection.

This solution combines traditional antivirus protection with advanced threat protection to prevent wind farm SCADA Endpoints from being compromised by known and unknown threats – and may even prevent zero-day attacks. Malicious files are identified and flagged to a central Siemens Gamesa team, available 24/7/365. The Advanced Endpoint Protection service includes 24/7/365 Incident Handling, in case something goes wrong.

Global annual costs caused by cyber crime (\$M)\*



A single day's outage at a 100 MW windfarm = \$50-100K in lost revenue



### Benefits

- Daily scans of attack surfaces without compromising system and network performance.
- Event notifications are clearly categorized and provided to the customer with actionable advice depending on the severity of the detection.
- Active monitoring for malicious files and suspicious behavior to identify and report to the central Siemens Gamesa team, available 24/7/365.
- Central management, action and reporting done by our dedicated security incident management task force team.

### In scope

WPS3 (OS 2012 – OS 2019).  
WindNet® PRO (OS 2016 – 2019).

### Compatible products

If the SCADA systems are not supported by these offerings a SCADA, Upgrade makes it possible.

### Compliance

Support our customers in protecting their assets and being compliant with regulatory legislations such as NIS, NERC and CIP.

#### Fleet experience

As an OEM and system supplier with an extensive fleet we have in-depth knowledge on the systems architecture.

#### WTG downtime

Securing your assets are safely guarded against cyber warfare limits the risk of attacks and unplanned downtime.

# Patch Management

## Guard your asset against unwanted guests



AEP



Operating  
reliability



Support



Safety

## Challenge

Cyberattacks cost an average of \$17.2 M per targeted organization in the energy sector. To keep control over the system, park operation and prevent sensitive data being compromised, a strong cybersecurity service is critical during the whole lifetime of a SCADA system.

## Solution

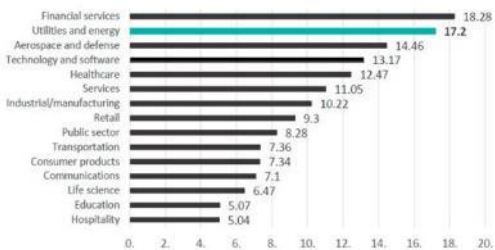
To support our customers in protecting critical assets and securing the stability of power production, Siemens Gamesa has created Patch Management.

**Patch Management** is a preventive activity to protect the system against known cybersecurity threats. The solution identifies available security patches and manages the process of testing and patching (deploying security updates) on the windfarm SCADA Endpoints.

## Benefits

- Adds an important layer to endpoint protection improving overall security.
- Patch management provided by the OEM system supplier gives the advantage of verified/customized patches to ensure no unnecessary interruption of operations, downtime and lost energy production.
- Providing the customer with action plans to ensure a lean coordination of patching activities proving our OEM knowledge of wind farm operations to ensure less impact on production downtime.

Global annual costs caused by cyber crime (\$M)\*



A single day's outage at a 100 MW windfarm = \$50-100K in lost revenue



## Applicability

WindNet® PRO (OS 2016 – 2019).  
WPS3 OS 2019.

## Compatible products

If the SCADA systems are not supported by these offerings, a SCADA Upgrade makes it possible.

## Compliance

Support our customers in protecting their assets and being compliant with regulatory legislations such as NIS, NERC and CIP.

### Fleet experience

As an OEM and system supplier with an extensive fleet we have in-depth knowledge on the systems architecture.

### WTG downtime

Securing your assets are safely guarded against cyber warfare limits the risk of attacks and unplanned downtime.

# Backup & Restore

## Maintain high level of cybersecurity



### Challenge

Cybersecurity is critical at all stages of a SCADA system daily operation and maintenance activities.

### Solution

Backup & Restore creates and store copies of data that can be used to protect the SCADA solution against data loss or system corruption.

Build on existing capabilities to implement basic backup and restore capabilities. The basic backup and restore capabilities could be extended based on market demand.

### Benefits

- Support cybersecurity.
- Meet local cybersecurity legislation.
- No impact on normal operation of the site when doing backups.
- Backup is performed remotely.



AEP  
control



Operating  
reliability



Maintenance  
ease



Cyber  
security

### Applicability

All Gamesa site with WindNet® PRO installed.

### Compatible products

Siemens Gamesa offers a range of cybersecurity solutions to protect customer sites from cyber risks. We provide two essential services to ensure a minimum level of security for wind farms: Advanced Endpoint Protection and Patch Management. To enhance security or comply with legal requirements, we recommend bundling these services with Network Security and Backup and Restore.



### Est. lead time

Approx. 1 month from  
purchase order to  
installation

# Cybersecurity Health Check

## Checking your cybersecurity capabilities

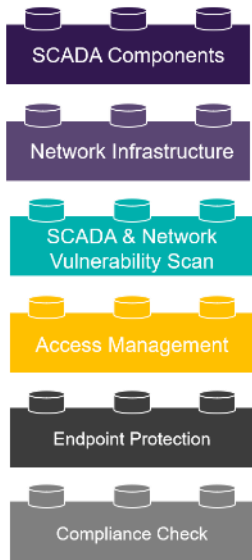


Figure 1. Cyber pillars of the assessment

### Challenge

As the energy sector becomes more critical to society, it is becoming increasingly important to protect this critical infrastructure against cyberattacks. Local authorities wish to mitigate this risk and have started to increasingly enforce regulatory stipulations that energy providers must comply with making operations more challenging and complex.

### Solution

To support our customers' understanding of how their assets are protected, Siemens Gamesa has developed a Cybersecurity Health Check. This product is a preventive activity that aims to provide our customers with insights into their current security level. It gives recommendations on actions to take with the aim of improving security and outlines actions required to improve compliance. This is achieved by our consultants, who perform a detailed assessment (Figure1) of the entire site infrastructure and review compliance with best practice cybersecurity standards. Once the assessment is completed, the customer will receive a complete overview.

### Benefits

- Recommendations for improving compliance.
- Gaining a complete overview of the site's cybersecurity levels.
- Understanding the risk of your site being exposed to cyberattacks and the costs associated with cybercrime.



AEP



Operating reliability



Support



Safety

### Applicability

WPS3.  
WindNet® PRO.

### Complementary solutions

A range of cybersecurity products, such as Advanced Endpoint Protection, Patch Management and SCADA Upgrades, are offered to support improved security of your assets.

### Compliance

Providing guidance towards achieving compliance with cybersecurity standards.

#### Fleet experience

As an OEM and system supplier with an extensive fleet, we have in-depth knowledge of the systems' architecture.

#### WTG downtime

Enabling awareness of the current security level of your assets to limit the risk of cyberattacks, reducing the risk of unplanned downtime.

#### Est. lead time

Approximately 1 to 2 months, depending on remote accessibility.

# Network Security

## Maintain high level of cybersecurity

### Challenge

Cybersecurity is critical at all stages of a SCADA system daily operation and maintenance activities.

### Solution

The installation of firewalls provides an additional layer of security to safeguard the network infrastructure of the wind farm against potential cyber threats and unauthorized access. Installing advanced firewalls and switches can offer fast detection and response capabilities to potential cyber threats, minimizing downtime and mitigating the impact of potential security incidents.

### Benefits

- Support cybersecurity.
- Meet local cybersecurity legislation.
- Segmented network design improving the incident handling to only the affected segments to keep the rest in operation.
- No impact on operation of the site.
- Remote management.



AEP  
control



Operating  
reliability



Maintenance  
ease



Cyber  
security

### Applicability

All Gamesa site with WindNet® PRO installed.

### Compatible products

Siemens Gamesa offers a range of cybersecurity solutions to protect customer sites from cyber risks. We provide two essential services to ensure a minimum level of security for wind farms: Advanced Endpoint Protection and Patch Management. To enhance security or comply with legal requirements, we recommend bundling these services with Network Security and Backup and Restore.



### Est. lead time

Approx. 1 month from  
purchase order to  
installation

# Grid Compliance

As wind energy capacity grows, wind asset owners are increasingly required to contribute to national grid stability, adhering to progressively stricter grid codes while managing the integration of wind assets.

Siemens Gamesa offers essential upgrades to ensure your wind farms remain compliant with these grid codes, including high/low voltage ride-through, reactive power in the absence of wind, and inertial response.

## Grid management services

- Production forecasting
- Active power control
- Multi-grid release mode
- Frequency response
- Dispatching center



# Grid Ancillary Services

## aFRR Down

### Challenge

The number of Variable Renewable Energy Sources is growing fast and with it also the volatility on the energy generation in the grid. Grid Operators require more sources of power generation flexibility for stabilizing the grids.

### Solution

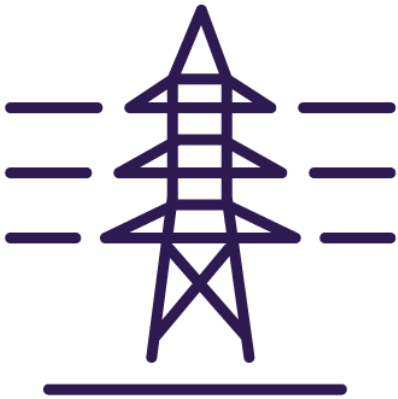
aFRR Downwards (Automatic Frequency Restoration Reserve) is an ancillary service that is activated through a signal from the balancing responsible party or the transmission system operator. The response time is rather fast: Full activation of the reserved capacity needs to happen in accordance with a predefined ramp rate within a few minutes.

Siemens Gamesa implements:

- Data exchange with the energy trader to provide all data necessary for market bidding and capacity reservation.
- Correct wind farm behavior (curtailment) when capacity is reserved and activated through an activation signal from TSO.

### Benefit

- Power producers can use the same hardware (wind farm) for achieving up to 20% higher revenues at minimal to no risk.
- Increase value of wind farm.
- Reduce risk of penalties.
- Immediate payback/breakeven.



New revenues



Small investment



Operating reliability



Partnership

### Applicability

All platforms with MySite360 or WPS3.

### Compatible products

Compatibility with other wind-farm or turbine features like WakeAdapt or EnergyUp Nominal Range.

#### Fleet experience

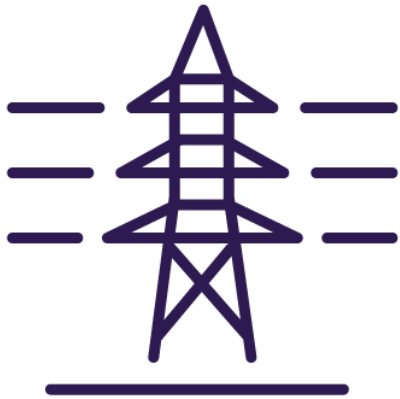
Sold to 4 Sites, piloted on 1 sites successfully.

#### Est. Lead time

6 months (including pre-qualification).

# Grid Ancillary Services

## FCR-D Down



### Challenge

The number of Variable Renewable Energy Sources is growing fast and with it the volatility on the energy generation in the grid. Grid Operators require more sources of power generation flexibility for stabilizing the grids.

### Solution

FCR-D Downwards (Frequency Containment Reserve for Disturbances) is an ancillary service, a so-called primary control reserve. It activates when a frequency event leads to an over frequency above e.g. 50.1 Hz. The response is fast and acts within seconds to keep the frequency within the required frequency bands.

Siemens Gamesa provides the team and organizational setup to implement and maintain the required hard- and software changes. The team also supports with pre-qualification, monitors the technical market requirements and provides grid expert support during the term of the service contract.

### Benefit

- Power producers can use the same hardware (wind farm) for achieving up to 20% higher revenues at minimal to no risk
- Increase value of wind farm
- Reduce risk of penalties
- Immediate payback/breakeven



New revenues



Small investment



Operating reliability



Partnership

### Applicability

All platforms with MySite360 or WPS3.

### Compatible products

Compatibility with other wind-farm or turbine features like WakeAdapt or EnergyUp Nominal Range.

#### Fleet experience

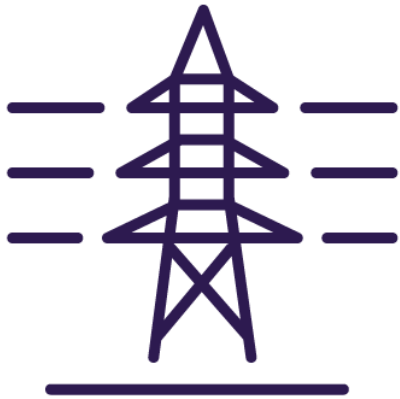
Sold to 17 sites, 3 successfully prequalified and 10 in implementation.

#### Est. Lead time

6 months (including pre-qualification).

# Grid Ancillary Services

## mFRR Down



### Challenge

The number of Variable Renewable Energy Sources is growing fast and with it also the volatility on the energy generation in the grid. Grid Operators require more sources of power generation flexibility for stabilizing the grids.

### Solution

mFRR Downwards (Manual Frequency Restoration Reserve) is an ancillary service that is activated through a signal from the balancing responsible party. The response time is rather slow: Full activation of the reserved capacity needs to happen in accordance with a predefined ramp rate within a 15-45 minutes.

Siemens Gamesa implements:

- Data exchange with the energy trader to provide all data necessary for market bidding and capacity reservation.
- Correct wind farm behavior (curtailment) when capacity is reserved and activated.

### Benefit

- Power producers can use the same hardware (wind farm) for achieving up to 20% higher revenues at minimal to no risk.
- Increase value of wind farm.
- Reduce risk of penalties.
- Immediate payback/breakeven.



New revenues



Small investment



Operating reliability



Partnership

### Applicability

All platforms with MySite360 or WPS3.

### Compatible products

Compatibility with other wind-farm or turbine features like WakeAdapt or EnergyUp Nominal Range.

#### Fleet experience

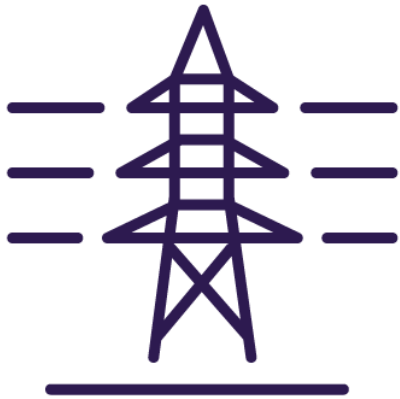
Sold to 2 Sites, piloted on 1 sites successfully.

#### Est. Lead time

6 months (including pre-qualification).

# Grid Flexibility Services

## Automatic Power Reduction System



### Challenge

Wind Farms in Spain are suffering from curtailment by Red Eléctrica Española (REE), Spain's grid operator. They look for way to avoid such curtailment to avoid losses in energy production and revenues.

### Solution

Wind farms can avoid preventive curtailment if they prove their ability to quickly curtail at the request of REE. This Automatic Power Reduction System – called SRAP (*Sistema de reducción automática de potencia*) – is a centralized approach in Spain to quickly activate negative balancing energy without introducing a complex market system yet.

Siemens Gamesa implements data reception from REE / Dispatch Control Center and ensures that the wind farm curtails according to the signal received. Our experts supports with homologation and provide quick assistance in case of grid-related issues during operation. The Siemens Gamesa Remote Monitoring and Control Centers monitor the correct behavior of the service and initiate immediate action in case of any alerts.

### Benefit

- Avoid preventive curtailment and revenue losses.



New revenues



Small investment



Operating reliability



Partnership

### Applicability

All platforms with WindNetPro.

### Compatible products

Compatibility with other wind-farm or turbine features like WakeAdapt or EnergyUp Nominal Range.

#### Fleet experience

Sold to 8 Sites, 2 sites successfully prequalified, 6 sites in implementation.

#### Est. Lead time

6 months (including homologation).

# Grid Model Update

## Challenge

In today's dynamic energy landscape, maintaining seamless wind park operations while adapting to evolving grid requirements is a real challenge. Frequent software and hardware updates are essential for efficiency but can lead to misalignment and operational disruptions, causing costly downtime and compliance issues.

## Solution

An effective energy management system is necessary for a whole grid and similarly for a power plant (park). Sophisticated Grid Models is an invaluable asset to ensure efficient operation and proper configuration of the entire park. Some software and hardware components (wind turbine and power plant control) needs to be updated regularly. These updates can have a potential negative impact on the operation of the park due to misalignment in the configuration. As a turbine manufacture, we can ensure that the park is behaving as desired and catch unwanted behavior in simulations before they go life in the real grid.

## Benefits

- Increase confidence in park compliance.
- All grid models are tested and benchmarked.
- Enable park improvement: AEP increase and loss reduction.
- Siemens Gamesa consults customer with the right configuration and model.
- Customized solutions and models that fit grid regulations.
- Models are available in all common simulation environments.



Customized solutions



Operating reliability



Trusted partner



Safety

## Applicability

All Siemens Gamesa technologies.  
Release 1 scope: SWT-2.3-101, SWT-2.3-108, SWT-2.3-82 VS, SWT-2.3-93, SWT-2.625-120, SG 6.0-154, SG 7.0-154, SG 8.0-154, SG 8.0-167.

## Compatible products

Compatibility with other wind-farm or turbine features like WakeAdapt or EnergyUp Nominal Range.

## Industry validation





Models are benchmarked with older models in several test cases.

### Fleet experience

Over 100 models delivered after Turbine Supply Agreement.

### Est. Lead time

Depends on model: between 4-20 weeks.

Simulation Environment	Short Description
DigSilent PowerFactory models 	Dynamic Simulations, with a rough timestep; see slides below.
PSS/E 	Dynamic Simulations, with a rough timestep; see slides below.
PSCAD 	Electro Magnetic Simulations for detailed simulations
TSAT 	Dynamic Simulations, with a rough timestep; see slides below.

# Spares

# The importance of spare parts in wind turbine operations

In wind turbine operations, **spare parts management is more than just logistics—it's a strategic priority.** Operators face constant pressure to ensure part availability, control costs, and minimize downtime, all while keeping turbines running at peak performance.

## Key challenges faced by wind farm operators



**Unplanned  
downtime**



**High-cost  
emergency  
replacements**



**Availability  
and lead  
times**



**Supply chain  
uncertainty**

A well-structured spare parts program **secures access to essential components when and where they're needed**—boosting reliability, reducing repair costs, and protecting the long-term performance and profitability of wind assets

# Key considerations for spare parts sourcing

When sourcing spare parts for wind turbines, the following factors are critical for making informed decisions:



**Price**

Ensuring cost-effectiveness without compromising on the quality and reliability of the parts.



**Lead times**

Minimizing delays by relying in the right partner.



**Quality of service**

Securing customer support, warranties and technical assistance.



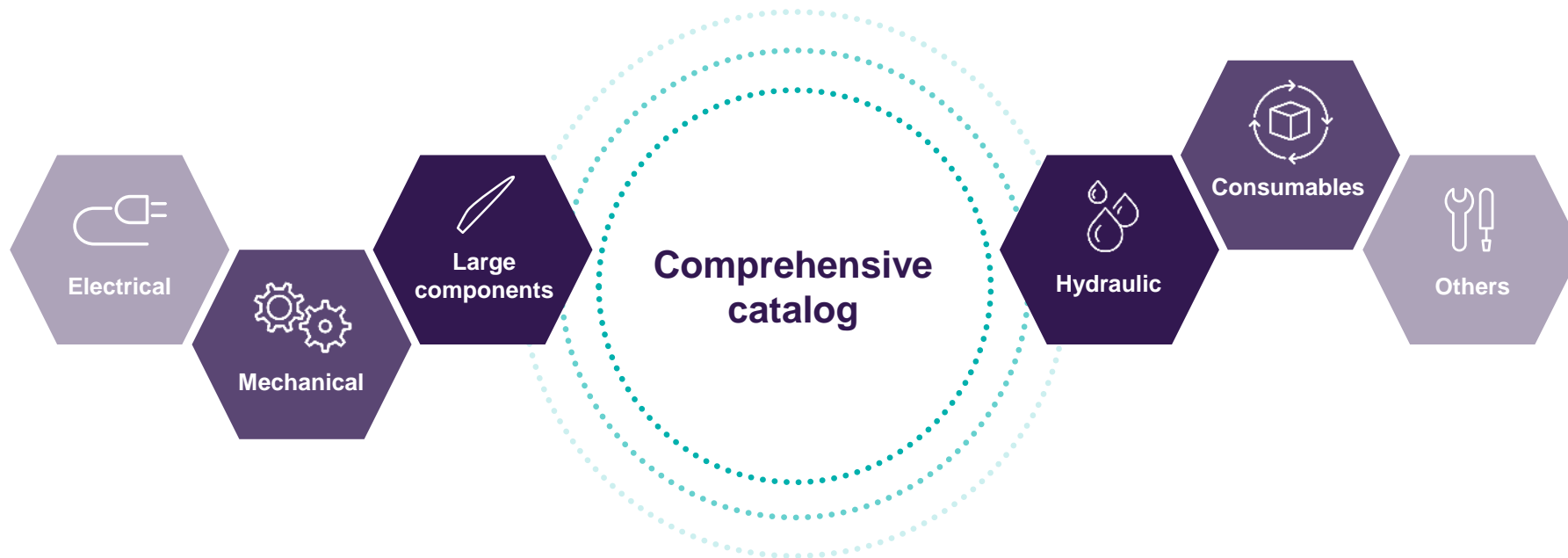
**Reliability**

High quality parts that support performance.

**The right part at the right time is the key to performance**

# Your go-to partner for wind turbine spare parts

From seamless spare parts management to in-depth technical support, **having a trusted partner by your side means meeting the diverse needs of your business.** Whether you are looking for reliable spare parts or specialized solutions we are committed to delivering the expertise and support you need to drive success.



To ensure continued and safe operation of your wind turbine Siemens Gamesa offers a comprehensive catalog of high-quality new and refurbished spare parts, available when and where you need them, at competitive prices

# Refurbished spare parts: a sustainable alternative

As wind power grows, so does the need for spare parts and repairs. The spare parts industry has a significant role in sustainability, particularly in minimizing CO<sub>2</sub> emissions and reducing environmental impacts.

**Refurbished parts provide a cost-effective, sustainable solution without compromising on performance, offering long-term value while reducing environmental impact:**



## Cost-effective solution

Providing high-quality, budget-friendly alternative, offering significant savings without compromising performance.



## Guaranteed quality and performance

Meeting highest standards and third-party certifications refurbished parts are tested to like-New Standards to perform as new components.



## Quick Availability

Faster readiness, reducing lead times to keep turbines operational with minimal downtime.



## Complete warranty coverage

Peace of mind with our warranties ensuring long-term protection against the unexpected.

**Sustainability in action – Refurbishing reduces waste and extends the life of materials, contributing to a circular economy and reducing carbon footprint**

# Global presence: always close to our customers

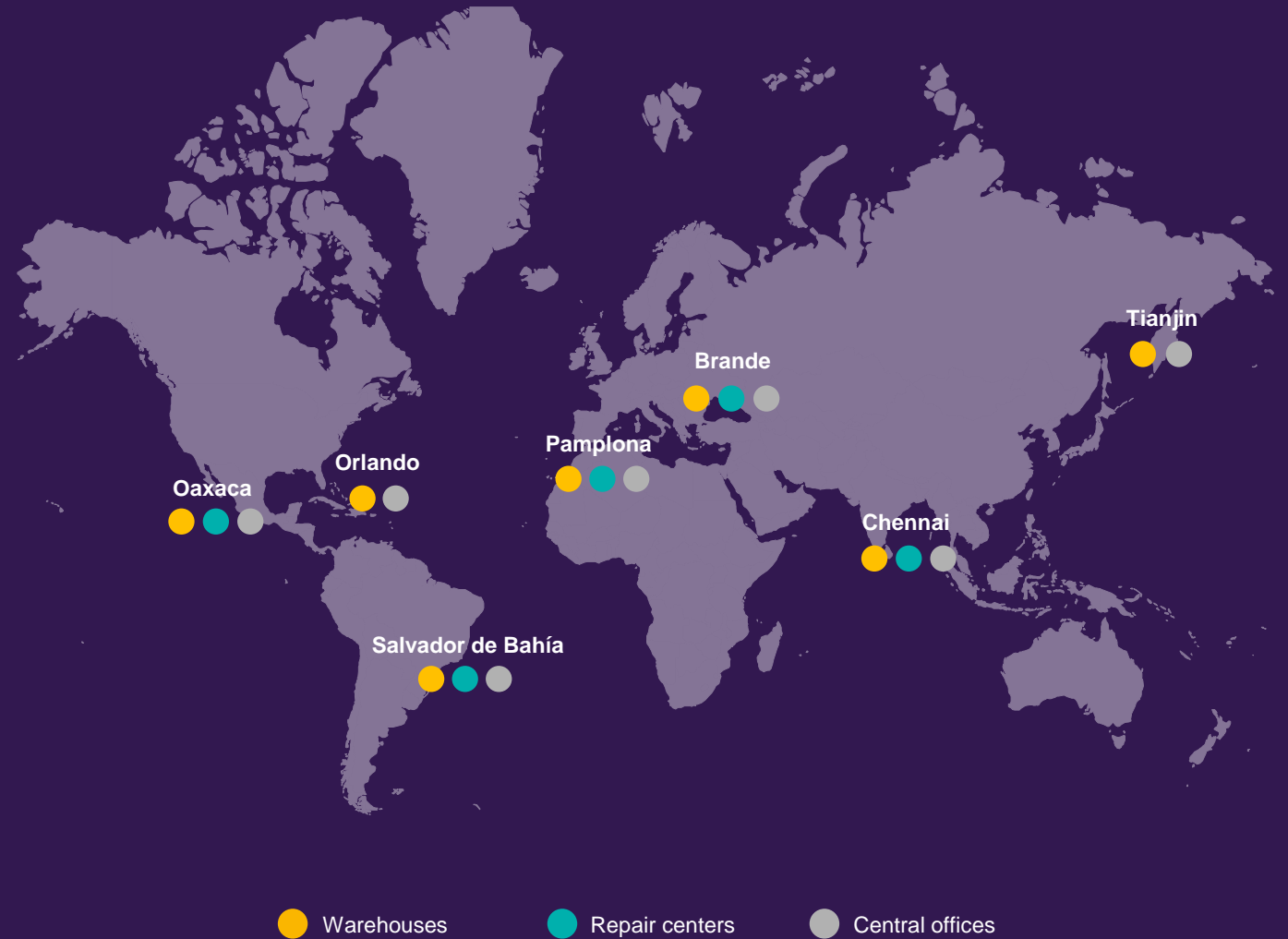


## +20\* warehouses

20 Distribution centers

5 Repair centers

7 Central offices



\* 2 central and +20 regional warehouses.  
Figures as of CY25Q1.

# Seamless spare parts management

Defining the optimal investment in spare parts aligned with your operational needs is essential. Our experts collaborate with you to develop **customized forecasting capabilities and tailored spare parts solutions** to meet our customer's unique operational needs.

Our reinforced supply chain combines global scale with local agility, ensuring on-time delivery and efficient support wherever you operate.



## The benefits of signing a spare parts frame agreement

- **Guaranteed availability** – Your defined spares list ready when and where you need it.
- **Premium lead times** – Prioritized access to critical components.
- **Cost predictability** – Tailored pricing and long-term agreement to help manage budgets effectively.
- **Operational efficiency** – Streamlined procurement and inventory management reducing administrative workload.
- **Risk mitigation** – Minimize the impact of supply chain disruption with strategic stock planning.

# Siemens Gamesa Shop: online parts procurement

Shop over +20,000\* parts online. With a Siemens Gamesa Shop account, you can quickly find and purchase parts. Count on our high-quality new or refurbished parts and our shop support team to keep your assets running so you can focus on what matters most.

## Siemens Gamesa Shop: online parts procurement



**Direct access**



**Agile response  
time**



**Tailored  
customer  
pricing**



**Single site for  
orders and  
information  
source**



**Related  
products to  
current  
selection**

**Full digital access to the spares catalog enabling transparency and reliability from the start**

\* Market dependant.

# Repairs

# Inspections and repairs to expect the unexpected

**Unexpected issues can arise at any time** – but with our inspections, repair and performance optimization, you can stay ahead. We help you **detect risks early, adapt quickly** and keep your fleet reliable, efficient and ready for the long term.

Here's our **commitment** delivered **when** and **where** you need it:



## Expert talent & customer focus

Skilled professionals with a deep understanding of your assets and a commitment to minimizing downtime.



## Advanced diagnostics & predictive technology

Leveraging in AI, IoT, and data analytics to detect issues before they escalate.



## Supply chain resilience

Ensuring critical components and parts are available when needed to avoid delays.



## Efficient logistics & rapid deployment

Getting the right parts and teams to the right place at the right time.

**Global coverage and flexible solutions: reliable maintenance no matter where your turbines are located**

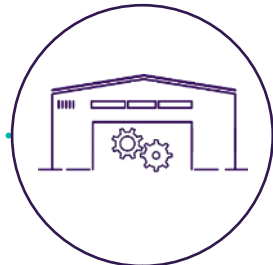
# Our comprehensive and modular repair services

With over 40 years of service and engineering excellence, Siemens Gamesa offers complete turnkey repair solutions – or you can simply choose the service you need.

In addition to our repair services, the Siemens Gamesa Life Extension program offers a site-specific maintenance strategy to help you operate your wind farm for up to ten more years – unlocking additional revenue and supporting a more sustainable, circular economy.



Flexible transport for diverse service tasks.



Repair and Reconditioning Services for minor and major components.



Highly skilled and trained technicians to inspect, repair, or replace components on-site, including special tools.



Uptower repair service. Major and minor components.

# Repairs and inspections to expect the unexpected

**Expert repair and reconditioning services for all components**, cost effective and timely repairs or component replacements: a structured, end-to-end approach to handling failures, unplanned outages or deviations in performance—aimed at restoring optimal operation while addressing root causes and preventing recurrence.



## Minor correctives

Advanced diagnostics and agile repair capabilities.



## Major components inspections

Inspection technology and analytics to monitor critical components health, ensuring early detection and minimal downtime.



## Major correctives

**On-site or at repair centers**, effectively managing all needed activity to have your turbine back to production ensuring minimal disruption.

**With global coverage and flexible solutions, from worldwide repair centers to on-site or uptower services, Siemens Gamesa ensures reliable and long-term turbine performance wherever you are**

# Beyond repair: corrective management that boosts asset reliability

**Expert repair and reconditioning services for all components**, cost effective and timely repairs or component replacements: it's not just about fixing issues—it's about responding quickly and precisely to unplanned failures, restoring performance, strengthening long-term reliability, resilience and prevention.



## Rapid response

- Fast deployment of teams and parts.
- Aligned support across functions.



## Engineering excellence

- Root cause verified.
- Certified methods for lasting results.



## Full transparency

- Regular updates.
- Final report with insights and next recommended steps.



## Value recovery

- Downtime and losses reduced.
- Insights and next recommended steps.

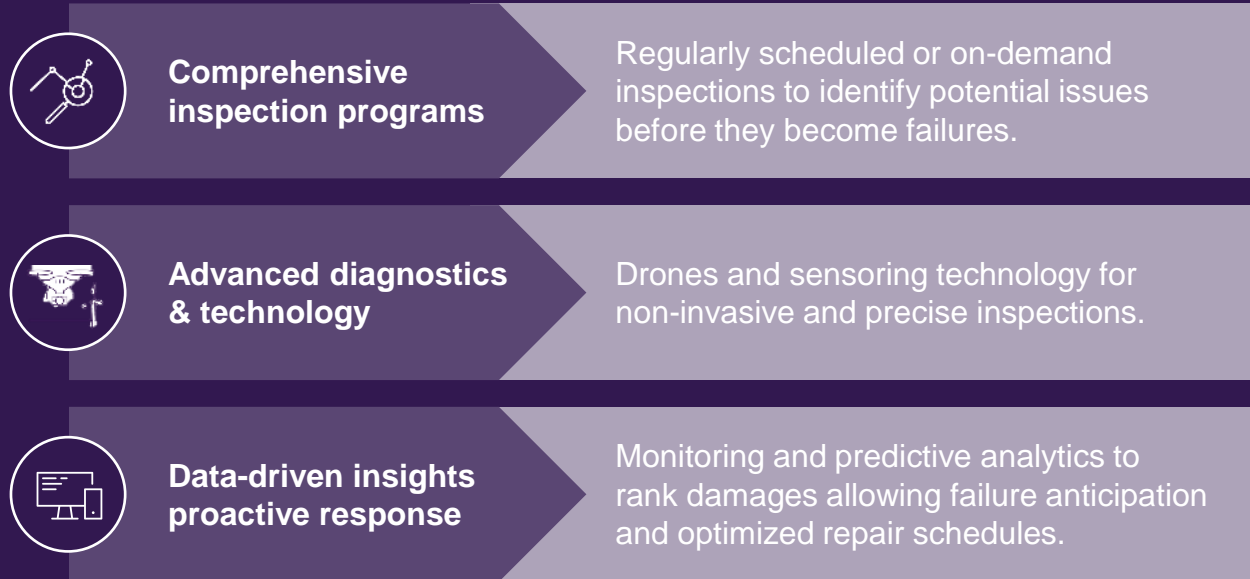
**With a proactive approach to every repair, we turn challenges into opportunities for strengthening your asset's performance and ensuring long-term operational success**

# Wind turbine inspections

## The proactivity that secures performance

Keeping maintenance costs under control requires **proactivity**. Regular inspections and accurate condition assessment enable timely responses and support efficient operations and intervention planning when needed.

**Effective inspections must be quick, safe and efficient to avoid unnecessary downtime.**



# Repair and Reconditioning services

## Benefits for your business

Siemens  
Gamesa  
gives  
you



Improved  
and reliable  
components

Precise and  
accurate  
diagnostics

Reduced  
O&M costs

Higher  
availability

Transition to  
a circular  
economy and  
sustainability

Proven  
engineering  
enhancements

More energy  
production

Efficient  
repair process  
management

Fast  
turnaround  
time

Extended  
warranties

# Cost-effective repairing alternatives to your fleet

Repairing instead of replacing reduces costs and ensures faster recovery times and minimal disruptions. Our **flexible repair solutions** are designed to address **issues swiftly, restoring components to full functionality** while keeping your turbines operating at peak efficiency.



## On-site

Repairing right in your windfarm is the most cost-efficient solution, that is why we keep on developing uptower and on-site solutions that offer you flexibility, cost savings, shorter lead times and minimized downtime.



## Repair centers

Siemens Gamesa Repair Centers specialize in the restoration, refurbishment, and upgrading of wind turbine components. Using advanced diagnostics, certified repair processes, and rigorous quality testing, these centers ensure that refurbished parts meet the same high standards as new components.

**Global coverage and flexible solutions no matter where your turbines are located,  
safeguarding performance for the long term**

# Comprehensive and value-added Repair and Reconditioning portfolio



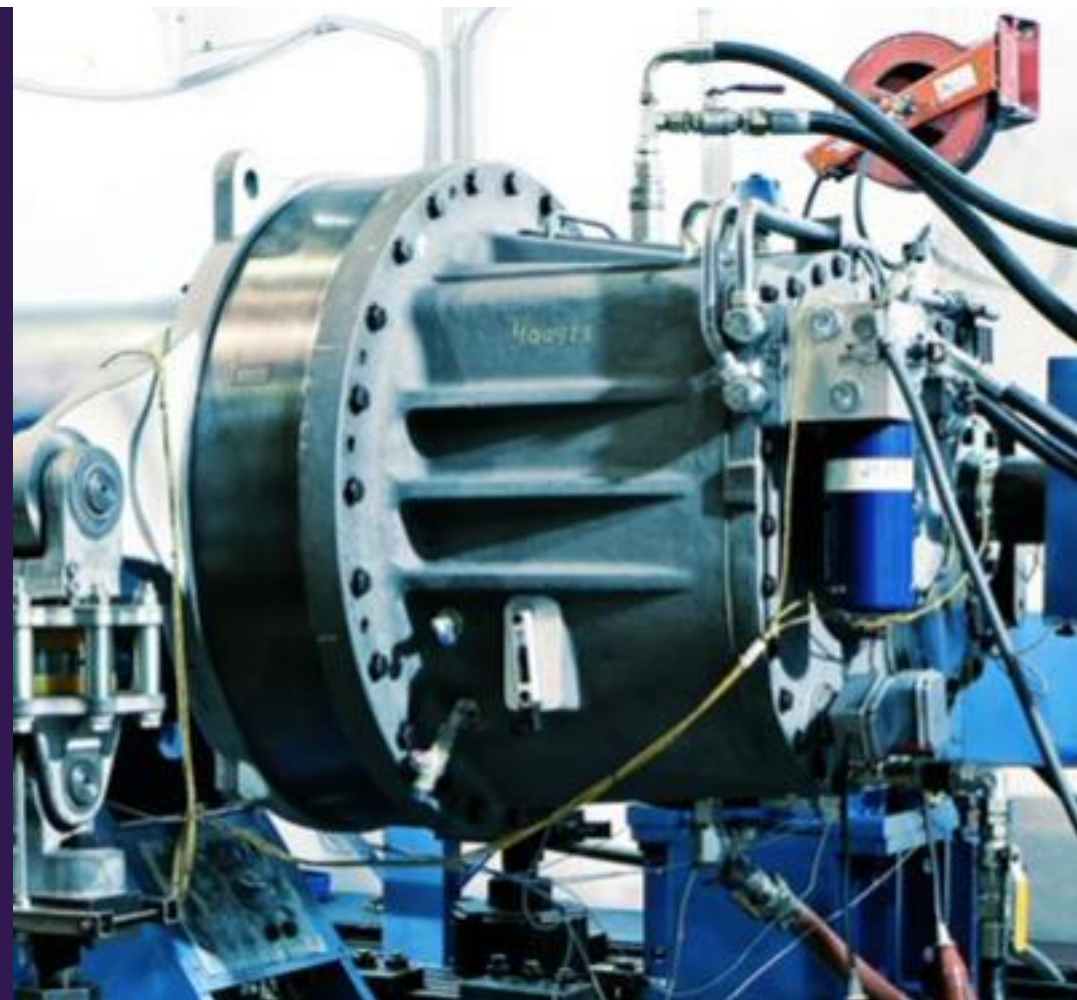
**Major components**  
+650 unique references



**Minor components**  
+500 unique references



Available for components of onshore and multibrand fleets



# Uptower Repair Services: save costs and time

What makes the uptower repair unique is that **there is no crane, and no component transportation or heavy load transport needed**. This state-of-the-art solution repairs your wind turbine in a fast and cost-efficient way. Siemens Gamesa can perform uptower repairs for preventive and corrective maintenance.



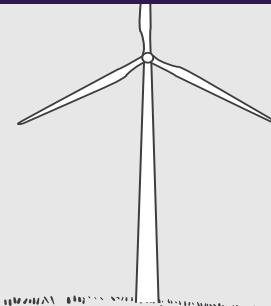
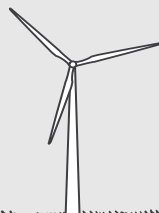
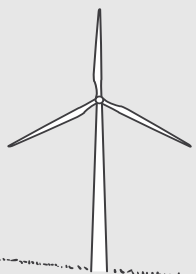
## Preventive maintenance

By monitoring the condition of the major components, early failure forecasts can be identified, and impacted parts can be exchanged before the gearbox fails. The turbine downtimes are reduced to a minimum.



## Corrective maintenance

If the wind turbine is stopped due to a failure of the gearbox, our experts will exchange the impacted parts uptower in a time- and cost-efficient way.



# Siemens Gamesa Repair Centers: certified quality, safety and sustainability

Siemens Gamesa Repair Centers are certified with:

- ISO 9001** Quality management system.
- ISO 14001** Environmental management system.
- ISO 45001** Occupational health and safety management system.

Ensuring that our refurbished components meet—or exceed—the highest industry standards, providing you with reliable performance in a demanding market.



Global footprint and local expertise ensuring faster turnaround times and reduced shipping costs

# In-house analysis ensuring improved performance of the repaired component

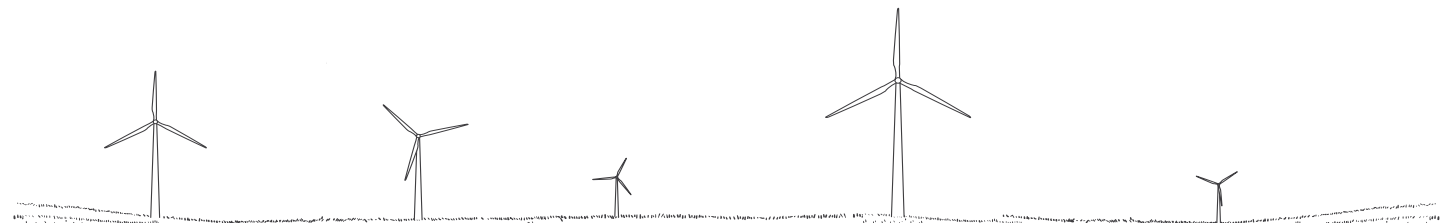


Ensuring long-lasting performance with certified repairs

Our technical team performs an in-depth analysis and collaborates with our suppliers to ensure that during a repair or reconditioning process, component quality and reliability are increased beyond that of the original standard.

Our highly specialized technical team perform **in-house root cause analysis**.

These advanced investigations enable us to boost performance and prevent future damage or failures for the repaired components.



# What are the options for component exchange programs?



## Swap\*

- Swap solution is an efficient choice, ensuring higher availability of your wind turbine.
- With this option, on an as-needed basis, the failed component is shipped to one of the Siemens Gamesa repair centers for diagnosis.
- Meanwhile, you receive an immediate replacement of the part, ensuring reduced downtime of your asset.

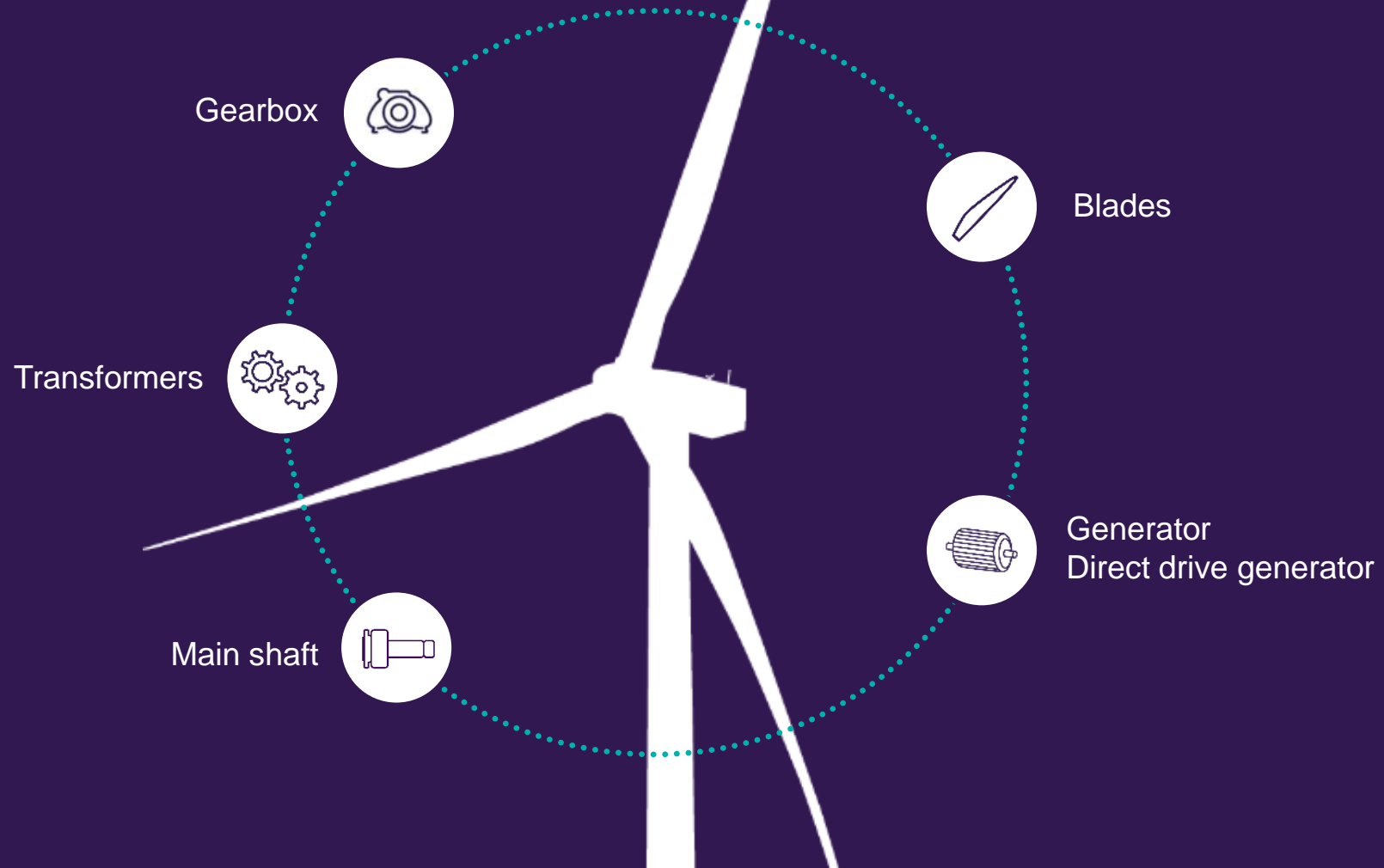


## Repair

- Repair solution is a cost-efficient way to get your wind turbine back in operation.
- In this case, the failed component is sent to one of the Siemens Gamesa repair centers for diagnostics, and a repair estimate and the lead time are provided.
- You can then determine how to proceed.

\* Major components: available for Gamesa, Siemens and Servion turbines.

# Major-component categories



# How do we repair and recondition major components?



## Reception

- Packing conditions are analyzed to improve packing and logistics processes.



## Diagnostics

- Disassembly and analysis of components to consider every sub-component.
- Identification of specific failure, along with any ancillary issues or potential issues.



## Repair, testing, upgrades

- Strictest quality standards during the repair process.
- Material and design upgrades may be recommended to boost performance and prevent future failure.



## Quality assurance

- Component match certificate, ensuring it fits with the turbine.
- Results for all critical operations are measured, recorded, and compiled into part- and customer-specific reports.

**Major-component rigorous and high-quality four-phase process**

# Our best-in-class quality improvement service for your major components

Siemens Gamesa provides a quality improvement service for major components. Our engineering excellence enables us to offer this service for components of Siemens Gamesa and multibrand fleets.

When required, our global team of experienced engineers will redesign the component to refurbish, enhancing its effectiveness by taking advantage of:

- Modern manufacturing processes.
- Tackling design issues to make it more reliable.

These enhancements significantly reduce component failure rate, keep repair costs down, and ultimately increase energy production of your assets, no matter the age, no matter the make.



# Thank you

# Disclaimer

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The information given in this document only contains general descriptions and/or performance features, which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

# Contact us

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## Head quarters

Parque Tecnológico de Bizkaia – Edif. 222

48170 Zamudio

Spain

[comercial\\_consultas@siemensgamesa.com](mailto:comercial_consultas@siemensgamesa.com)

**[siemensgamesa.com](https://www.siemensgamesa.com)**