Onshore technological solutions

SIEMENS Gamesa
RENEWABLE ENERGY

Innovation drives our business

We are committed to developing efficient products and technological solutions that set new standards in the industry. To that end, the Siemens Gamesa Onshore Technology teams across the world work to continuously evolve the way we design our wind turbines and develop solutions that improve the performance and competitiveness of our products.

Innovation also creates value. That's why we are focused on specific technologies that are going to be key drivers in the market, enabling our customers to bring down their projects' LCoE.


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Segmented blades

The challenge

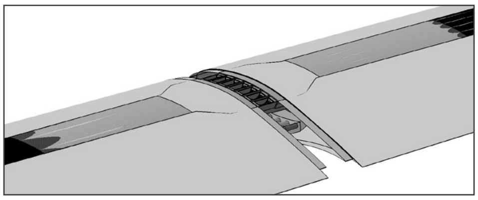
With a wind energy market increasingly requiring larger rotors and more efficient turbines, the length of the blades is expected to become a critical element in many projects with challenging logistics. This circumstance often contributes to an increase in the costs associated with blade production, handling and logistics.

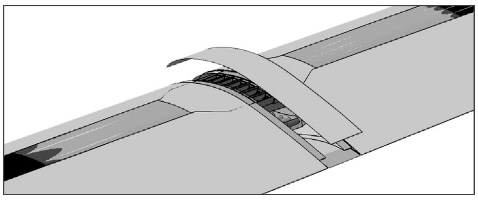
Siemens Gamesa's answer

Our segmented blades will offer solutions that address the cost and weight challenges of large rotors in sites with logistic constraints. Leveraging our know-how and experience in segmented blades, we are developing a technology with improved joints. In addition, our structural designs are based not only on glass fiber-reinforced epoxy, but also on carbon pultruded profiles. These advancements achieve our objective to obtain lighter structures and enhance the manufacturing process. The two segments are manufactured and transported separately and can be assembled on-site, even in extreme conditions.

Main benefits:

- Access to markets with challenging logistics.
- Easy assembly.
- Transportation: no road modification; day/night transportation; standard licenses; simplified harbor and ship storage.





Weak grid solutions

The challenge

With the increasing need to combine wind power with other power generation sources and the installation of wind turbines in weaker grids, turbine functionalities need to be enhanced to guarantee power system stability. Nowadays, weak grids stability issues are mainly due to operational limits and interaction problems, whereas sub-synchronous interaction and high order resonances are the principal challenges from the grid connection perspective.

Siemens Gamesa's answer

Premium Doubly-fed Induction Generators (DFIG) wind turbines rely on the Sub-synchronous Interactions and Resonances Improved Operation (SIRIO) controller, which already addresses these needs effectively.

In addition, grid observability has been enriched providing islanding detection capability and the online estimation of the impedance.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Cold climates

The challenge

Operation of wind turbines in cold climates presents two main challenges: guaranteeing health and safety when the risk of ice throw is high and minimizing the production loss caused by the ice on the turbine blades.

Siemens Gamesa's answer

Our strategy for cold climates addresses both needs through a number of different solutions and allows us to increase the AEP and the availability of our turbines, as well as to extend their range of operation in icing conditions.

Main achievements and lines of development:

- Development of ice assessment tools and icing world maps.
- Development of an ice accretion model and AEP model to estimate the production losses for the specific icing conditions of a site.
- Development of a full blade thermal model to analyze the heat distribution along the blade for the different anti-icing and de-icing solutions.
- Development of smarter ice detection systems for the activation of the anti/de-icing solutions. Ice can be detected by the dedicated external sensors (hardware) and/or by different software algorithms.
- Development of Operation with Ice (OWI) control strategies to adapt the wind turbine to different ice conditions and ice types and to minimize the production losses due to ice. These strategies adjust the turbines' set points to enhance the production by modifying the pitch angle without a significant impact on the loads.
- Development of new anti-icing and de-icing solutions for wind turbine blades:
  - Active solutions (electrically powered).
  - Passive solutions based on advanced coatings and icephobic paints.

Foundations

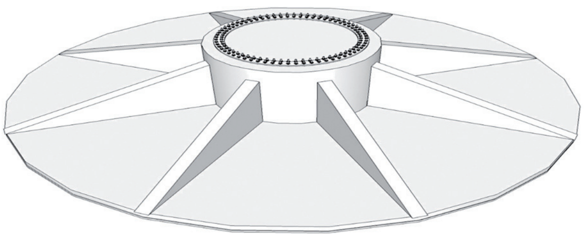
The challenge

The optimization of the foundation design, which normally accounts for 7-9% of the total CAPEX, is key in most of the projects as it significantly affects the business case.

Siemens Gamesa's answer

We have been offering breakthrough foundation designs and technologies in real wind farms for years. We continue setting the path for next-generation solutions through cost-effective technologies and helping our customers to reach their profitability goals through:

- Different foundation typologies concepts to improve LCoE: 8walls, shallow, pile, rock anchor, pre-cast, uplift, soil improvement, etc., with extensive site experience.
- In-house technological projects to develop foundation concepts, new materials and methodologies to add value for the projects.
- Advanced calculation methodologies to get maximum accurate performance.
- Complete support in all project phases: conceptual definition, detailed calculation, support to certification and execution.

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Control strategies

The challenge

The increasing size of wind turbines has an important impact on power production. Bigger blades harvest more energy and higher hub heights have become very popular due to the demand of higher power production opportunities in specific sites characterized by low- to medium-wind speeds.

The choice of rotor diameter and tower height is based on a trade-off between energy production and cost of construction to enhance Levelized Cost of Energy (LCoE). For this reason, research on structural designs, control strategies and materials able to stand up the loads increase associated to longer blades is especially interesting to guarantee the structural integrity of these wind turbines.

Additionally, material alleviation is also needed to achieve tall tower cost-efficient designs leading to very flexible (soft-soft) tower solutions which can significantly reduce production costs.

Siemens Gamesa's answer

We are actively working on control strategies and sensor technologies with the objective to push back the limitations associated with turbines with longer blades and taller towers. This involves ensuring an appropriate dynamic response of the turbine in every site and in every specific position.

Robust control systems

Siemens Gamesa Advanced Robust Control is able to ensure good levels of control performance while actively mitigating loads in the wind turbine components, making feasible wind turbines with large rotors and tall and flexible towers. Siemens Gamesa Advanced Robust Control takes into account the real coupling in soft-soft tower configurations and considers the non-linearities of the system to make a multivariable robust control synthesis. The multivariable robust control algorithms not only mitigate component loads and guarantee the integrity of the structural components of the wind turbine, but also regulate the electrical power production with great accuracy.

We have successfully designed multivariable and multi-objective advanced control algorithms that guarantee good levels of control performance while actively mitigating loads in the turbine components.

These control strategies have been successfully tested in hardware-in-the-loop simulation environment and in a real prototype built for this purpose.

Control auto-tuning for site adaptation

We are testing new control auto-tuning strategies that automatically detect any issue related to the site and environmental conditions (e.g. dirt, ice) or the blade (e.g. erosion on the blade profiles) with a significant impact on the production. In these cases, the control strategy is adapted to bring the turbine back to normal operation and optimize AEP in such conditions.

Auto-tuning control strategies are also used to monitor vibrations and reduce them, specifically for the following components:

- Drive train natural mode: adaptive drive train damping algorithm.
- First fore-aft tower natural mode: adaptive active tower damping algorithm.
- 1P resonance mode: Individual Pitch Offset detection (IPO) algorithm will be included to detect and remove possible aerodynamic imbalances.

In addition, AEP monitoring, IPO and Goertzel algorithms have already been designed and implemented to measure amplitude and phase of the studied frequencies. These three strategies are in the final validation phase in a prototype and are the basis of the auto-tuning developments.

Sensors and monitoring challenges for LCoE reduction

Over the last years we have developed sensor and monitoring alternatives to reduce the LCoE both by increasing the AEP and by mitigating the structural loads to reduce the material costs. Our technical developments in this area are:

- Characterization and business case analysis of alternative wind sensors with the installation and testing of Lidar and nose cone sensors in a prototype.
- Analysis of an alternative sensorless technology for the accurate measurement of the generator rotational speed and acceleration signal to improve the response of the generator speed-based control loops.
- Monitoring of loads by means of the tower accelerometers to design control algorithms that mitigate the structural loads under certain wind conditions.
- Development of Lidar-based control algorithms that improve control performance to increase AEP and reduce fatigue and extreme loads.

Wake Adapt®

The challenge

The wind field inside a wake is characterized by reduced wind speed and higher turbulence than in free wind flow. As a consequence, when compared to a neighbor wind turbine in free wind conditions, a wind turbine operating inside a wake generates less energy and suffers higher loads. The development of solutions that minimize the losses due to the wake effects is key to increasing the wind farm energy yield.

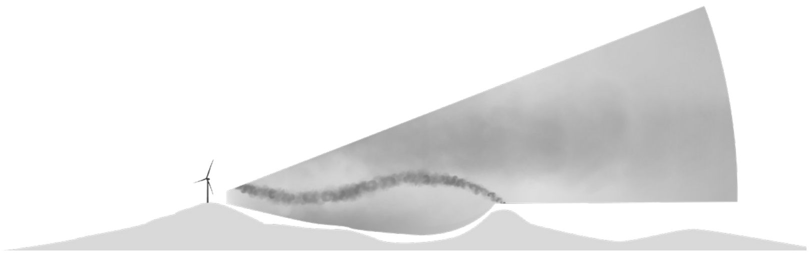
Siemens Gamesa's answer

Our technology efforts are focused on the development of wind farm wake control strategies. The intelligent management of key variables such as wind direction, wind speed and turbulence intensity enables us to:

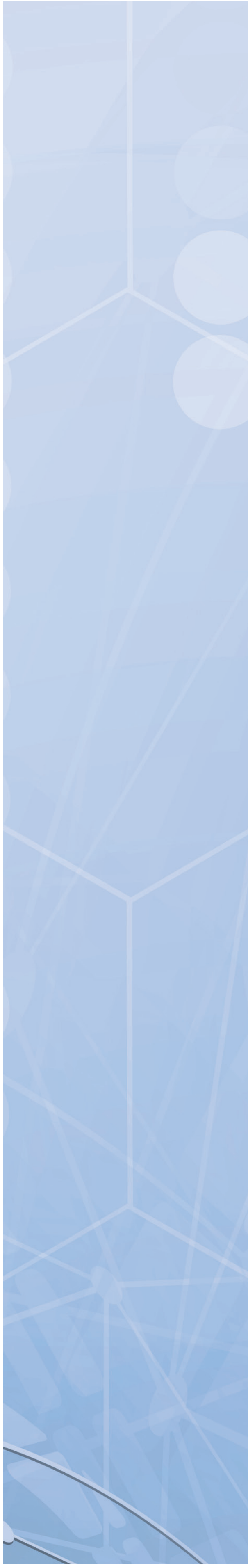
- Identify the wind turbines that generate wakes with significant impact on downstream turbines.
- Send specific commands to each of them for:
  - Yaw steering to deflect the wake, so that the downstream wind turbines work in better wind conditions.

  These commands also have a positive impact on the energy production of the downstream wind turbines.

In onshore projects, complex terrains make this strategy a lot more challenging, as it represents a speed-accuracy trade-off between model fidelity and computational speed. For this reason, we typically adopt a two-layer solution designed to deliver a combination of model-based and real time supervision/ fine-tuning control actions.



Cybersecurity



The challenge

Every wind power plant relies on a cyberinfrastructure (HW/SW) that manages and stores protected information potentially exposed to new vulnerabilities. Wind Power Plants (WPP) owners are increasingly demanding cybersecurity measures, not only to protect their installations against the thread of cyberattacks and, as a consequence, to ensure the availability of their assets, but also to comply with specific legislation requirements.

Siemens Gamesa's answer

Product and Solution Security (PSS) is Siemens Gamesa's response to the demand of cybersecurity measures applied to the product and solutions we supply. We acknowledge how important it is to protect assets and data, as well as secure the stability of power production, and we invest heavily in human resources and competences to improve our capabilities and better serve our customers.

A vital aspect of this protection is safeguarding the operational technology control system that is used to manage and monitor our wind turbines. We are fully committed in supporting WPP owners by implementing a variety of solutions within different cybersecurity domains/areas:

- Protection of sensitive data at rest and in transit.
- Identity management to grant access only to the authorized people.
- Network security through segmentation and data filtering.
- Endpoint protection through managed antimalware solutions.
- Asset configuration management.
- Managed disaster recovery solutions.

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