Senvion service.

Performance leveraged.

SENVION
wind energy solutions

Senvion service for performance.
Maximizing yield, minimizing Levelized Cost of Energy.

The quality of our service is your gain in productivity.

Senvion is one of the world's foremost manufacturers of wind turbines with over 25 years of experience in service and maintenance. And perhaps the most important lesson we have learned along the way is this: when our customers buy a Senvion turbine, what they are really buying is performance and availability. That is where Senvion service comes in – because optimizing performance and lowering LCoE (Levelized Cost of Energy) does not stop with the purchase of a Senvion turbine. Our service is designed to meet diverse customer requirements, ensure high availability over the entire life cycle and reduce downtime due to maintenance and repairs. With 80 % of our fleet serviced by Senvion, it would seem that most customers feel we have succeeded.

As good as our word.

Senvion service scores high on customer satisfaction, because they know they can rely on it to deliver tangible business benefits. With Senvion, there is no cap on the cost of repairs or transport of major components. Plus: our contracts are flexible to meet diverse customer requirements and our Integrated Service Packages (ISPs) provide a care-free answer to the service and maintenance of wind farms.

Benefits of our ISPs include:

- Guaranteed high availability of onshore and offshore turbines
- Extended scope of service compared to industry standards (incl. converter and transformer)
- Over entire lifetime of turbine
  – no exclusion of single components
  – no increasing replacement costs

Our premium service sets standards to support your growth.

We continuously improve our service activities and technology to better maximize the profitability of your wind farm. This is reflected in several ways: first, by our decentralized service structure which enables rapid repairs and maintenance. Second, by our full-service Integrated Service Packages (ISPs) which provide complete cost control for service and maintenance as well as an insurance against loss of output or availability. And finally, in the extended scope of our service which includes:

- 24/7 monitoring by our Turbine Control Center (TCC)
- Service performance continuously measured by KPI's
- 80 % of faults solved within one day
- High-tech infrastructure with high security standards

Senvion service concept.
The four pillars of performance.

Four for more.

Senvion service unlocks the full potential of your wind farm. We have created a four-pillar system to ensure optimized performance and minimized Levelized Cost of Energy (LCoE). Our service concept for monitoring, maintaining, regaining and enhancing performance will make sure you get the most out of your wind farm: more performance and efficiency, more output and yield, more uptime and revenue.

Monitor performance

Monitoring is the first pillar of performance and forms the basis for all other services. After all, you need to know how you are doing before you can improve. The latest monitoring technologies allow both you and Senvion to oversee individual turbine performance, create reports and assess overall output at any time. Fast detection means that problems can be addressed quickly, resulting in less downtime.

Maintain performance

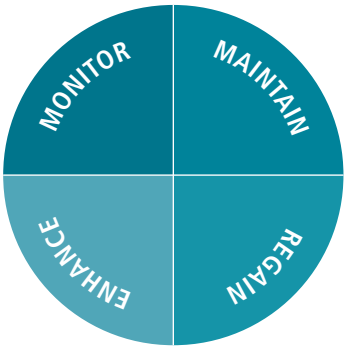
Regular maintenance is the second pillar of performance and delivers tangible results. Our trained service teams carry out scheduled maintenance during low-wind periods. This increases product lifespan and minimizes loss of output due to technical faults and damage. It can also improve long-term availability and increase annual output. All of which translates into a reduction of LCoE.

Regain performance

Regaining performance is the third pillar of performance. While the vast majority of problems can be solved remotely by the staff of our Turbine Control Center (TCC), the decentralized structure of our service means that our own local repair teams can rapidly respond to those problems that need on-site attention. This minimizes downtime caused by technical failures, resulting in higher output and ultimately lower LCoE.

Enhance performance

Enhancement is the fourth pillar of performance. At Senvion, we never stop looking for ways to improve. Which is why we have developed a modular series of hardware and software products to increase output and efficiency. These enhancements add value to your investment over the entire lifetime of the turbine. Plus: all monitoring and maintenance data is collected and analyzed at the Senvion TCC to continuously improve our current technology and develop next-generation products.



Senvion service contracts and modules.
Packing performance into service.

ISPs: Integrated Service Packages.

Peak performance, zero hassle.

The scope of the service offered by Senvion can be flexibly adapted to suit our customers' needs. However, based on over 25 years of experience, we have combined the first three modules of Senvion service in two Integrated Service Packages (ISPs) which enable you to take full advantage of the Senvion service concept. With complete cost control and no cap on repairs, replacement of major technical components and guaranteed availability / output, our ISPs are a simple, worry-free way to put your investment on a sure footing.

Monitor performance

At Senvion's Turbine Control Center (TCC), approx. 5,500 wind turbines around the world are monitored 24/7. A dedicated team of over 80 experts in lifecycle engineering uses the resulting wealth of data to drive continuous and next-generation product improvements in close cooperation with the staff of our TCC.

- Monitoring, analysis and diagnostics for approx. 5,500 wind turbines worldwide
- Vibration-based condition monitoring (CMS) of turbines available
- Close cooperation between TCC / product development / life cycle engineering
- SCADA Access and Wind Farm Management are tools suitable for wind farms up to 250 units and enable integration into higher level SCADA Systems and communication with other software systems via interfaces e. g. IEC 61400-25

Maintain performance

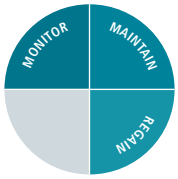
The breadth and depth of our experience translates into outstanding service expertise. We cover every aspect of maintenance, using trained technicians to provide highly-efficient and fast service that is optimally geared to your requirements.

- Regular, comprehensive maintenance of all major components
- Refill consumables and replace parts subject to wear and tear
- Highly-qualified service technicians
- Quick response time due to decentralized service structure
- Nacelles designed for easy servicing
- Senvion-trained third-party service providers to meet peaks in demand

Regain performance

Senvion wind turbines are renowned for their reliability. Of the occasional problems that turn up, 80 % are resolved remotely. If onsite-repairs are necessary, the staff of our TCC provide highly-trained service teams with a briefing to effect fast repairs. Even in case of major component replacements, well-organized logistics ensure fast repairs. So while we cannot promise that nothing will ever break, we can promise you this: it will not stay broken for long.

- 80 % of faults resolved remotely
- Fast repairs for minimal downtime
- Highly-trained service technicians
- Excellent communication between TCC and service teams
- Decentralized service structure ensures
  - local availability of components
  - proximity of service teams



ISP-T

Time-based Integrated Service Package (ISP-T). Because uptime is money.

The ISP-T includes all maintenance and repair work to ensure your wind farm is technically capable of operation and protects your investment by providing compensation if your turbines are operational for less than the guaranteed time of technical availability.

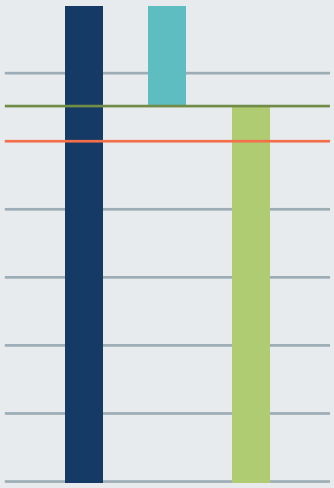
ISP-E

Energy-based Integrated Service Package (ISP-E). Because power is money.

The ISP-E covers all monitoring, maintenance and repair services to minimize downtime and maximize performance and safeguards your investment by providing compensation if the annual output of your wind farm falls below the guaranteed potential output.

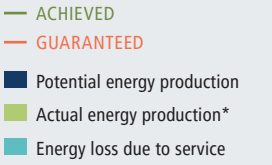
The Senvion ISP-T availability guarantee.

Customers receive compensation if availability falls below the guaranteed level. The guaranteed availability includes time for maintenance, retrofits and inspection.



More power to you!

This guarantee is based on the potential output. If the actually achieved energy production is below the guaranteed level, full compensation is paid by Senvion.



*Loss of output caused by customer not taken into account

Senvion will be happy to advise you so you can choose the ISP that works best for you.

Benefits of the Integrated Service Packages.

- No-hassle, care-free operation
- Complete cost control for maintenance and repair
- No cap on repair and replacement of major components
- Compensation for lost output / availability
- Availability / output guarantee strengthens your business case

Offshore service.
Optimized solutions for each customer.

Customers who opt for the offshore full-service contract will be placing all their turbine maintenance and repair work into our capable hands. Needless to say, you can also choose a customized solution to match your specific requirements.

Offshore full-service contract

The offshore full-service contract covers everything you need to ensure your turbines produce the highest possible energy output. Turbines are monitored 24/7 by our Turbine Control Center and a dedicated site management takes care of both scheduled and unscheduled services with local service technicians. This service package covers all required personnel, onshore and offshore logistics as well as spare parts and consumables. When combined with a time-based or production-based guarantee, the Senvion Offshore full-service contract delivers a complete, carefree package.

Customized service contract

Senvion is always happy to discuss any custom-made solution for a specific service agreement. For example, sometimes the customer wants to provide the offshore logistics or facilities to achieve an optimal utilization and to bring down the overall costs. Customers who want to do the maintenance and services of the turbines on their own can be assisted by Senvion with the help of mixed teams. In this case, customer technicians work together with Senvion technicians and receive on-the-job training – the best preparation for taking over the maintenance of the turbines on their own. Here's how we can support your project to optimize the Levelized Cost of Energy.

Excellent level of quality and experience

- More than 10 years of experience in offshore service
- Successful installation of several offshore parks
- More than 140 turbines of 5M/6M fleet under service contract

Unrivaled commitment to our customers

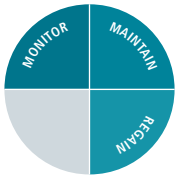
- Strong and supportive organization
- High availability, providing business case certainty
- Turbines are monitored 24/7 by our Turbine Control Center
- Service performance is continuously measured using KPIs
- High-tech infrastructure with high security standards

Outstanding scope and level of service

- No cap on repair obligations
- Offshore full-service contract excludes no components
- Continuous technical improvement
- Asset optimization over lifecycle

Nacelles designed to facilitate maintenance

- Spacious nacelle design for ergonomic and reliable service
- Convenient, all-weather access to the hub from within the nacelle
- Easy access to all important components
- All rotating components have covers for safe service
- Complete and easy disassembly within the turbine



Benefits and features of Senvion ISPs and standard maintenance agreement at a glance.

Module	Standard maintenance	Integrated Service Packages (ISP-T / ISP-E)	Offshore full-service contract
Monitor performance			
Remote monitoring (24/7)	Included	Included	Included
SCADA Access	Included	Included	Included
Senvion condition monitoring	Optional	Included*	Included
Maintain performance			
Regular maintenance	Included	Included	Included
Consumables	Included	Included	Included
Maintenance protocols	Included	Included	Included
Regain performance			
Remote troubleshooting	Optional	Included	Included
On-site repairs	Optional	Included	Included
Spare parts exchange	Optional	Included	Included
Large component exchange	Optional	Included	Included
Documentation of on-site repairs	Optional	Included	Included
Optimization modules			
Service hotline (TCC, local service manager)	Included	Included	Included
SCADA solutions	Optional	Included	Included
Gearbox inspection via endoscopy	Optional	Optional	Optional
Blade inspection	Optional	Optional	Included
Testing and maintenance of safety functions by an independent expert	Optional	Optional	Optional
Offshore logistics (vessels, helicopters, jack-up barges)	—	—	Included
Statutory inspections	—	—	Included

*Optional with ISP-T

Enhance performance.
Boost your output.

Turbocharge your turbines.

While the first three modules of the Senvion service concept ensure that your wind farm achieves and maintains its full potential, the fourth pillar is all about extending that potential and boosting performance.

Senvion has developed a series of performance-enhancing hardware and software technologies to further reduce downtime, deliver a higher return on investment and lower LCoE. Each feature can achieve an increase in Annual Energy Production (AEP). They are modular and easily retrofittable so you can choose the feature which delivers the highest increase in output based on site-specific conditions or combine them to benefit from the aggregate increase in AEP.

Senvion service – enhance performance.

- Service and maintenance covered by our full-service packages
- Can be used independently or combined to maximize AEP
- Easily retrofittable to existing turbines

Vortex Generators

Vortex Generators are aerodynamic devices fitted to the rotor blades of wind turbines to prevent airflow separation and thus increase lift. The increase in lift achieved by Vortex Generators correlates to an increase in AEP.

Rotor Blade Ice Detection

The Senvion Rotor Blade Ice Detection system uses fiber-optic sensors, mounted in the rotor blades to reliably and accurately assess whether blades are iced over. This feature eliminates the risks from ice throw and enables your turbines to operate longer and start up again sooner, thus reducing downtime.

Benefits of Rotor Blade Ice Detection

- Reduced downtime thanks to reliable ice detection
- Automatic restart – no visual inspection required
- Individual monitoring of each blade during operation and during standstill

Turbine Control Upgrade

The Turbine Control Upgrade is a bundle of performance-enhancing software products, derived from our data analysis activities and comprises the following features:

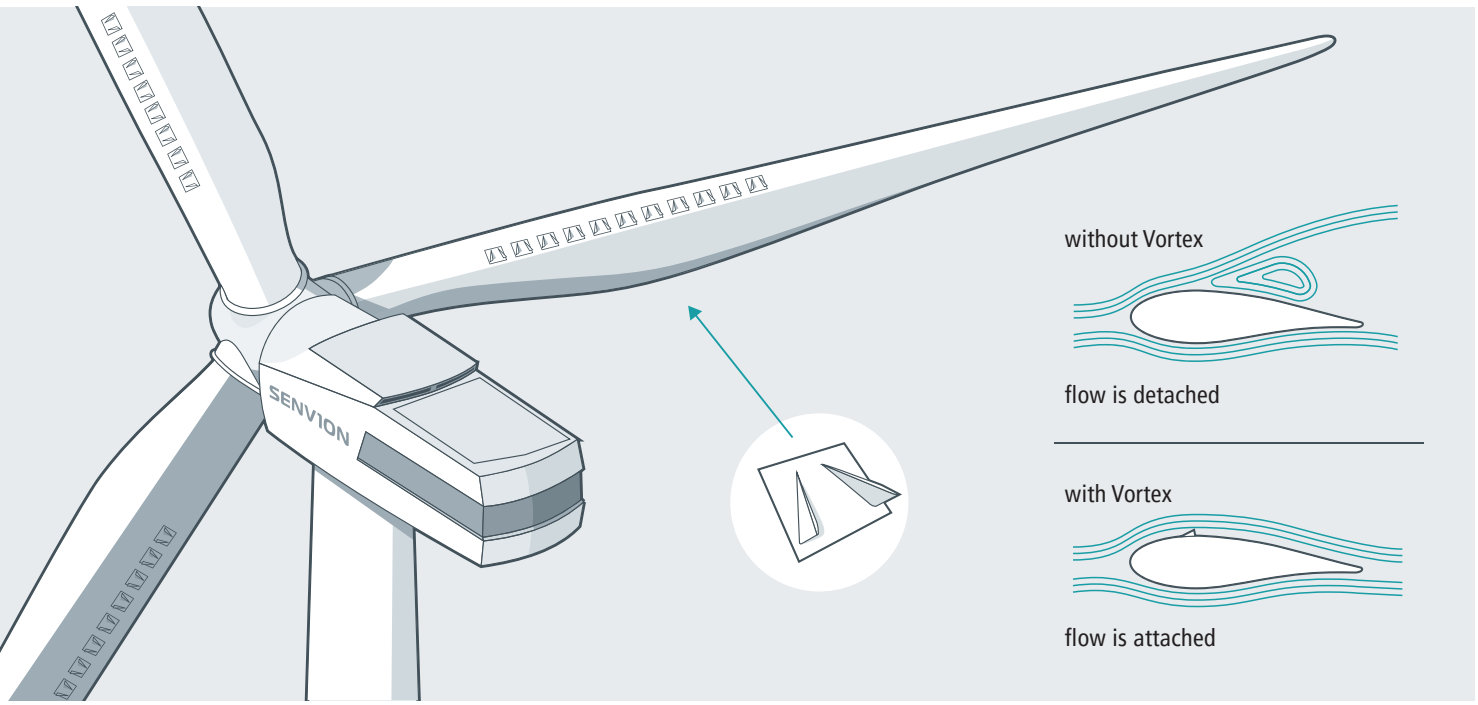
- **Dynamic Yaw** improves the angle by which the turbine is allowed to point out of the wind, thus increasing AEP and reducing loads on the turbine
- **Smart Turbine Start** uses a self-learning algorithm to find the optimal start-up wind speed at a given site

Advanced Monitoring Service*

Advanced Monitoring Service unlocks the hidden potential of your turbine by the statistical analysis of big data. Smart algorithms and the analysis activity by Senvion specialists uncover underperformance caused, for example, by sensor errors and turbine misalignment by comparing the individual turbine results to the performance of the entire Senvion fleet.

* The complete service is not available in the US.

Vortex Generators.
Give your blades a lift.



Put a new spin on aerodynamics.

The efficiency of wind turbine rotor blades is decreased when flow separation from the blade occurs. Senvion Vortex Generators are fin-shaped aerodynamic devices which optimize airflow. They significantly reduce the occurrence of flow separation, stalling of the blade and increase lift and thus output. Vortex Generators are glued onto the rotor blade, are easily and quickly retrofittable and can achieve a significant increase in Annual Energy Production (AEP).

Benefits of Vortex Generators.

- Increase in AEP
- Based on tried and tested aerospace technology
- Service and maintenance included in ISPs
- Developed in-house by Senvion for optimal effectiveness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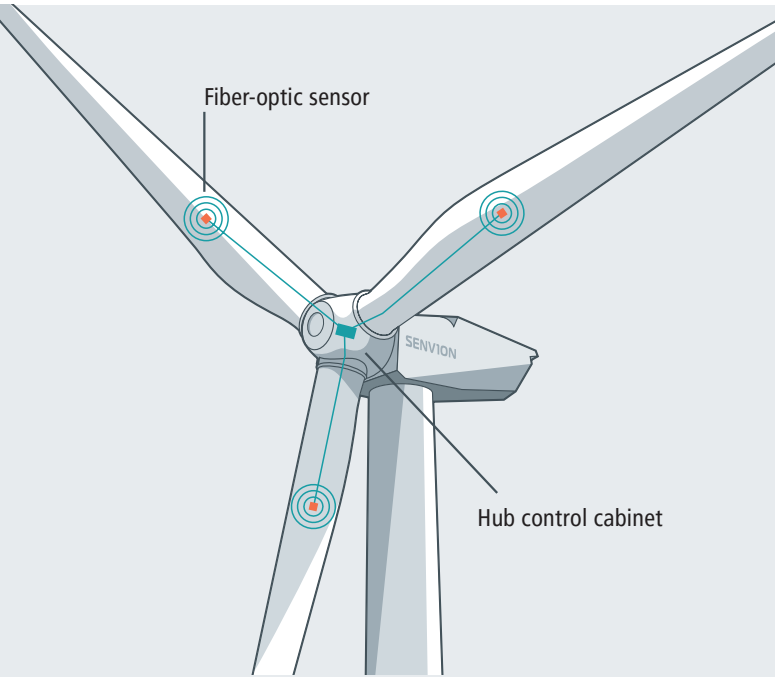
Rotor Blade Ice Detection.
Put downtime on ice.



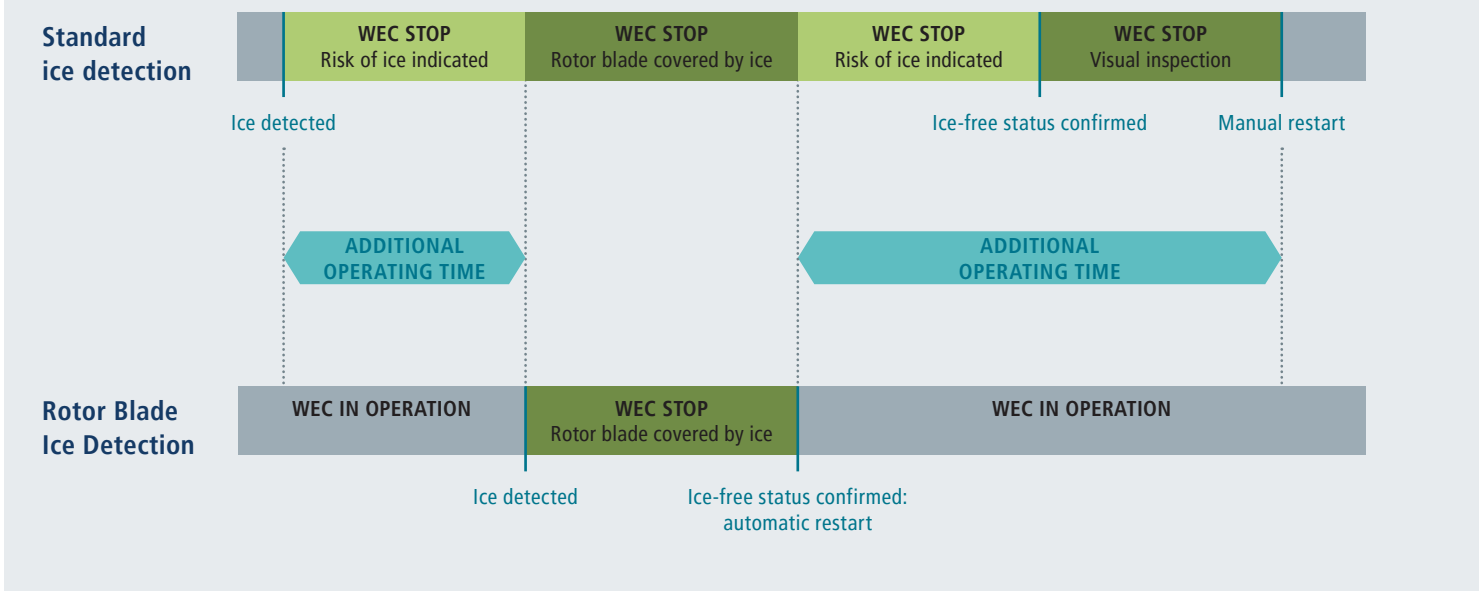
Benefits of Rotor Blade Ice Detection.

- Reliable ice detection on the rotor blade reduces downtime
- Individual monitoring of each blade both during operation as well as at a standstill
- Automatic restart after ice-free status is confirmed
- Reduced risk of damage and injury due to ice throw in the turbine's vicinity
- No visual inspection required for restart
- No increased risk of lightning strikes thanks to optical sensors (glass fiber)

Put a freeze on downtime and maintenance.

Ice accretion on wind turbine rotor blades is a problem for two reasons. Firstly, there is a risk of damage and injury: depending on rotor speed and hub height, shards of ice can be thrown a considerable distance when the ice detaches itself from the rotor blades. Secondly, to eliminate the first problem, turbines have to be shut down, which results in lost revenue.

The crucial question therefore is: is there ice build-up? And if so, when is the rotor blade ice-free again? That is where Senvion Rotor Blade Ice Detection comes in. It reliably detects the presence of ice on the blades, and automatically starts up the turbine when the rotor is ice-free with no visual inspection required for the restart. Ultimately, that means lower maintenance costs, more uptime and more output.

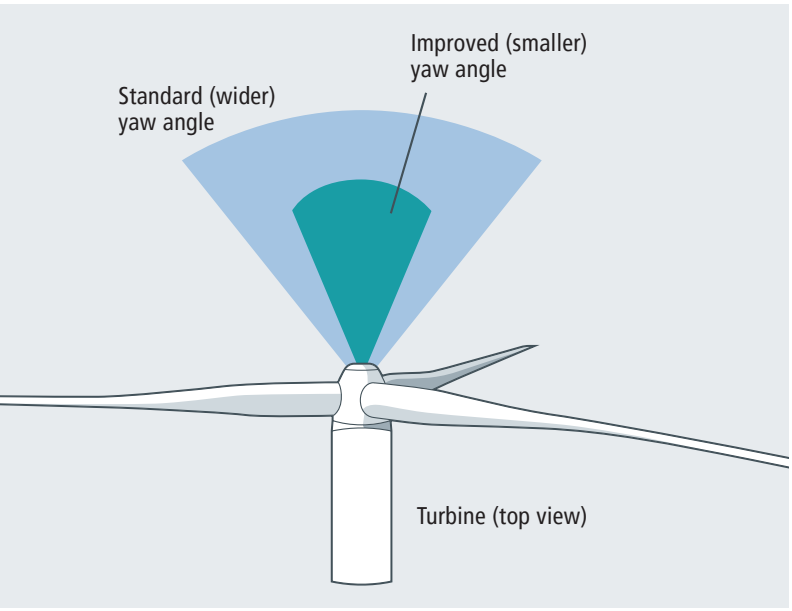


Don't think twice about ice.

Senvion's Rotor Blade Ice Detection uses fiber-optic sensors mounted on the rotor blades. These sensors measure the natural frequency inside the rotor blade which changes when ice accretion occurs. The resulting data is used to determine the thickness of the ice on the rotor blade. This technology offers two key advantages over standard ice detection systems: firstly, the point at which a turbine needs to be shut down – and the time when it can be restarted – can be determined more precisely. Secondly – following consultation with the competent licensing authorities – visual inspection before restart may be omitted and the turbine can restart automatically. As a result, downtime and manpower cost can be reduced.

The above timeline visualizes the reduction in downtime achieved by Rotor Blade Ice Detection. Standard ice detection relies on comparing wind speeds measured with an unheated cup anemometer and a heated ultrasonic anemometer at the nacelle. While this system is a suitable method for ice detection, it is less precise and turbines will be shut down when there is a risk of ice accretion even when they could still be safely operated. Rotor Blade Ice Detection avoids downtime both before and after turbine shut-down as turbines can run for longer and can be started up sooner.

Turbine Control Upgrade.
A bundle of performance-improving features.



Dynamic Yaw.

Small angle – big output.

A wind turbine produces the maximum output when its rotor faces directly into the wind. If the angle between the plane of the rotor and the wind is not perpendicular, the swept area of the rotor is decreased and less electricity is generated. So we have come up with a way to ensure our turbines' rotors point as closely as possible into the wind for as much of the time as possible. Because the smaller the angle, the greater the output.

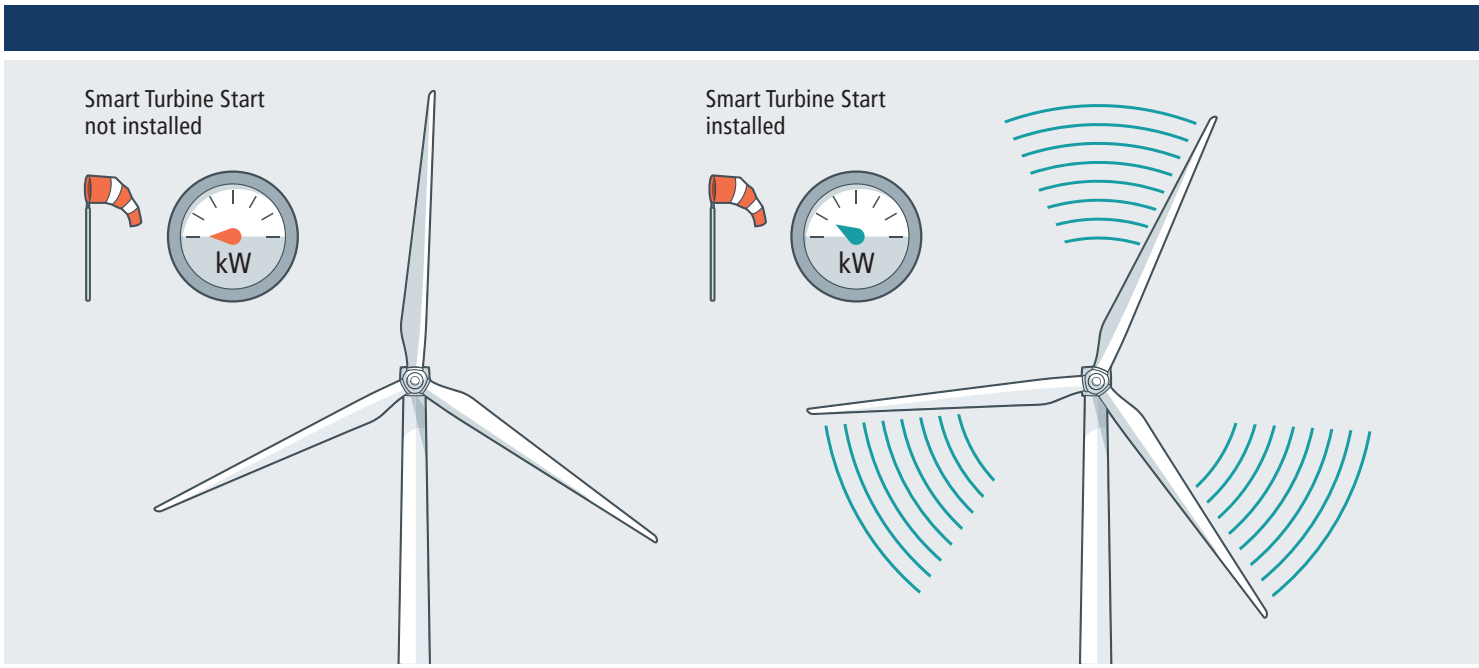
Ideally, the rotor of a wind turbine would point directly into the wind at all times. But this would require constant adjustment of the turbine and would lead to its increased energy consumption, thus reducing the gain in output.

All of our turbines have factory-preset angles of deviation and delay before intervention, calculated for a range of different turbines and reflect an average of wind conditions at various sites.

These standard settings deliver excellent performance, but – especially at low wind-speed sites – they can be further optimized to generate higher output. And that is what our Dynamic Yaw software does.

Benefits of Dynamic Yaw.

- Increased power output despite increased yawing
- Reduction of loads thanks to improved rotor alignment
- Optimized yaw angle increases Annual Energy Production (AEP)
- Particularly effective for turbines located on easy and medium-complex terrain



Smart Turbine Start.

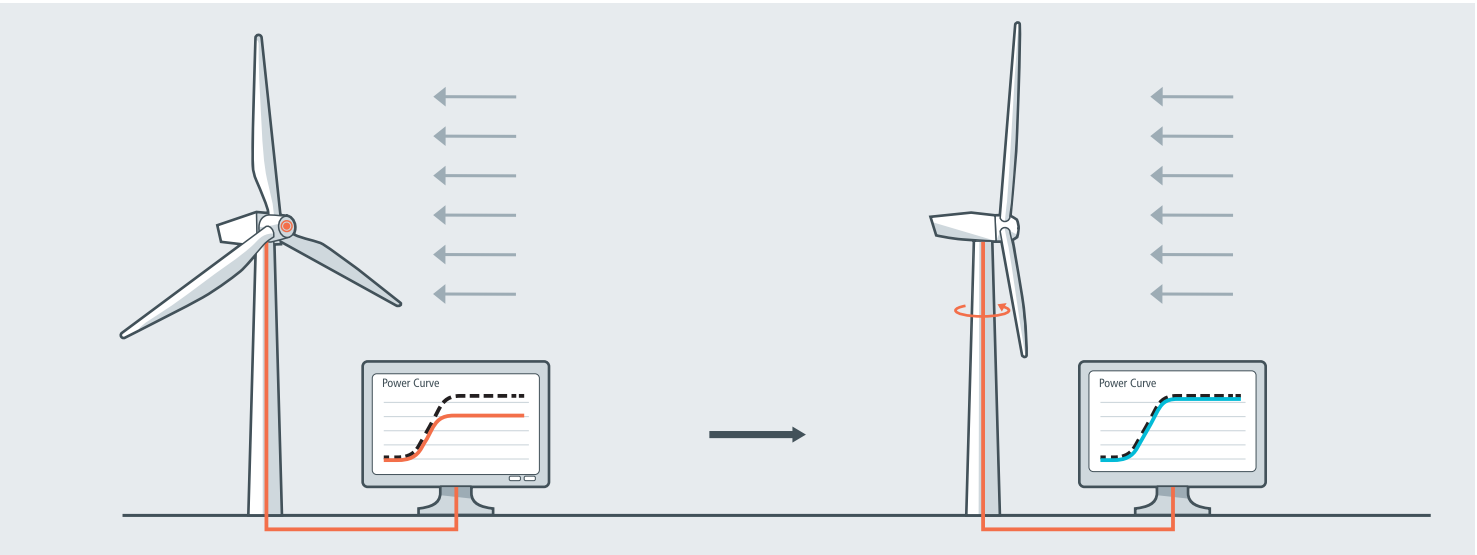
Off to a good start.

The standard cut-in wind speed of Senvion turbines is set at 3 m/s or 3.5 m/s depending on the type of turbine. Actually, this is the standard start-up speed for virtually all wind turbines in the industry and for a very good reason: it has been clearly established to be as close to optimal as any standard parameter can be. Of course, our engineers were not satisfied with that. They argued, 'If you cannot improve the standard setting, why not improve the setting for individual sites?' And so they did. They programmed an algorithm which is fed with SCADA data and optimizes start-up settings to reflect individual site conditions. This enables harvesting of wind energy at wind speeds below the standard cut-in speed and reduces idle time, both of which result in an increase of AEP.

Benefits of Smart Turbine Start.

- Reduced idle time increases output at low wind speeds
- Site-specific adjustment of start-up speed based on smart algorithms

Advanced Monitoring Service*.
Unlock the potential of your turbine.



Key to optimized performance: understanding the data.

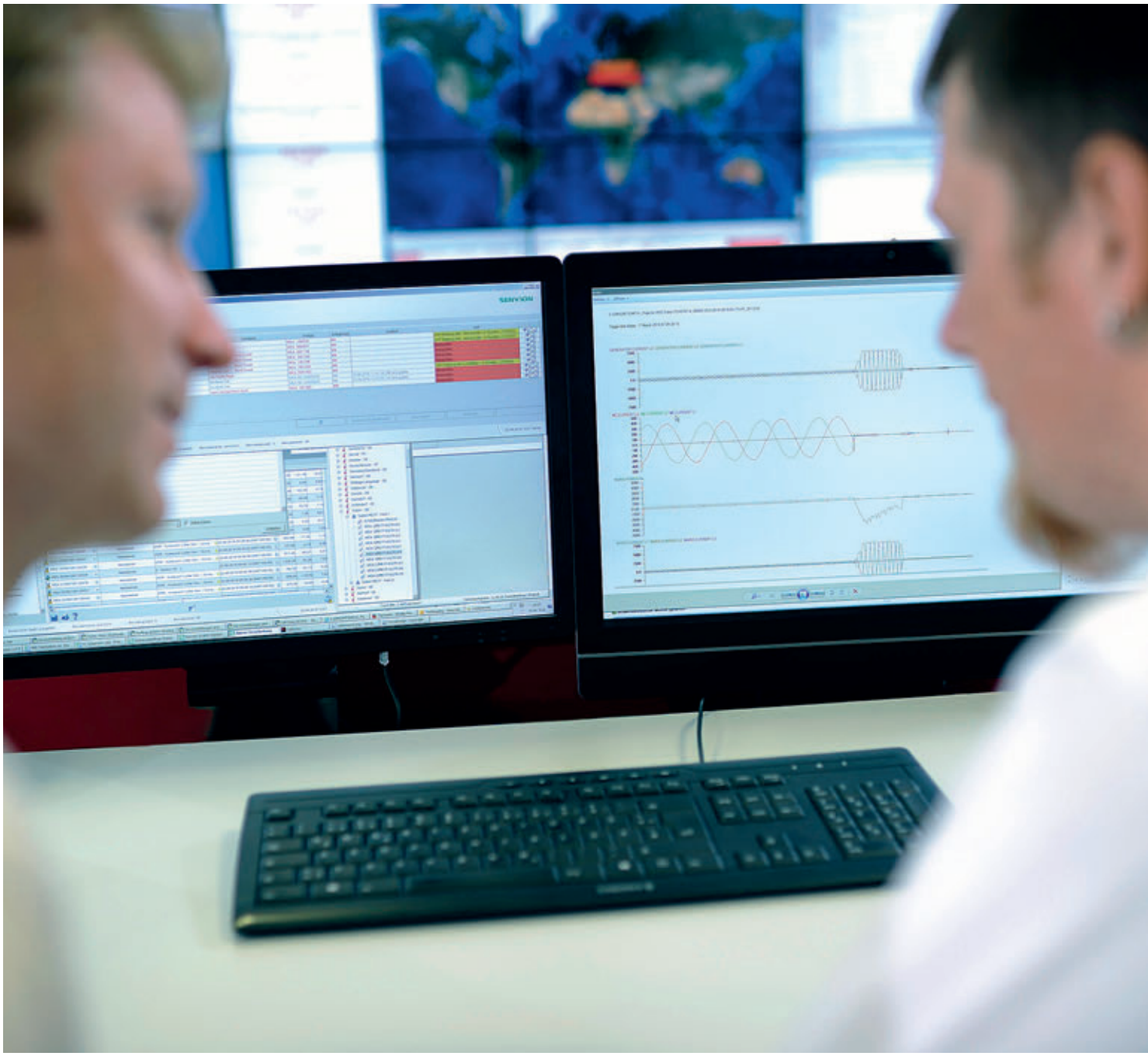
For a wind farm to deliver maximum yield, each individual turbine needs to perform to its full potential. This raises several questions: what is a turbine's full potential under given atmospheric conditions? How can I find out if a turbine is not performing to expectations and how can this be corrected quickly? Using the latest data analyzing tools, our Turbine Control Center is now able to unlock a turbine's performance potential remotely. The TCC uses statistical analysis and automatic pattern recognition of SCADA data from the entire Senvion fleet to evaluate every Turbine individually. The results of this analysis can be used to detect if a turbine operates below the expected output and also to detect critical sensor errors which may lead to downtime.

Senvion specialists assess the performance data of turbines identified by the software and initiate on-site repairs when necessary. Sensor errors (e.g. of the temperature sensor) can deliver false values and cause the turbine to shut down, thus increasing downtime. Some of the biggest losses in potential output occur because of turbine misalignment, which Advanced Monitoring Service can swiftly detect. With a several percent increase in AEP, understanding – and using – your turbine data clearly pays off.

Benefits of Advanced Monitoring Service*.

- Increase in AEP
- 24/7 individual Advanced Monitoring Service
- Re-parameterization of turbines initiated by Senvion specialists
- Detection of turbine underperformance based on SCADA data from entire Senvion fleet
- Prevention of turbine misalignment due to faulty wind direction indicator
- Prevention of turbine shutdowns thanks to early detection of critical sensor errors – e.g. indicated overheating as a result of a faulty temperature sensor
- Continuous evaluation and monthly reports of individual turbine performance

* The complete service is not available in the US.



Senvion
around the world.

AUSTRALIA
- Goulbourn
- Mt Mercer
- Portland
- Tarwin Lower
- Wendouree

AUSTRIA
- Ernstbrunn

BELGIUM
- Houthalen
- Oostende

CANADA
- Jonquière
- Kitchener
- Murdochville
- Saint Irène
- St-Luc de Bellechasse
- St-Paul-de-la-Croix
- West Kelowna

FRANCE
- Bretagne
- Champagne-Ablis
- Champagne-Vallant
- Lesquin
- Est-Lorraine
- Frevent
- Joinville
- Langres
- Lislet
- Meuse
- Normandie
- Picardie
- Poitou-Charentes
- Sud Carcassonne

GERMANY
- Aachen
- Alsleben
- Averlak
- Bremen
- Dresden-Langebrück
- Eberswalde
- Ellwangen
- Enge Sande
- Erfurt
- Hannover
- Helgoland
- Hooksiel
- Husum
- Lübeck
- Norden-Norddeich
- Ostrohe
- Pasewalk
- Recklinghausen
- Rostock
- Schleswig
- Simmern
- Wittstock

INDIA
- Mumbai

ITALY
- Ariano Irpino
- Foggia
- Maida
- Mazara del Vallo
- S. Stefano Di Camastra

NETHERLANDS
- Nijkerk

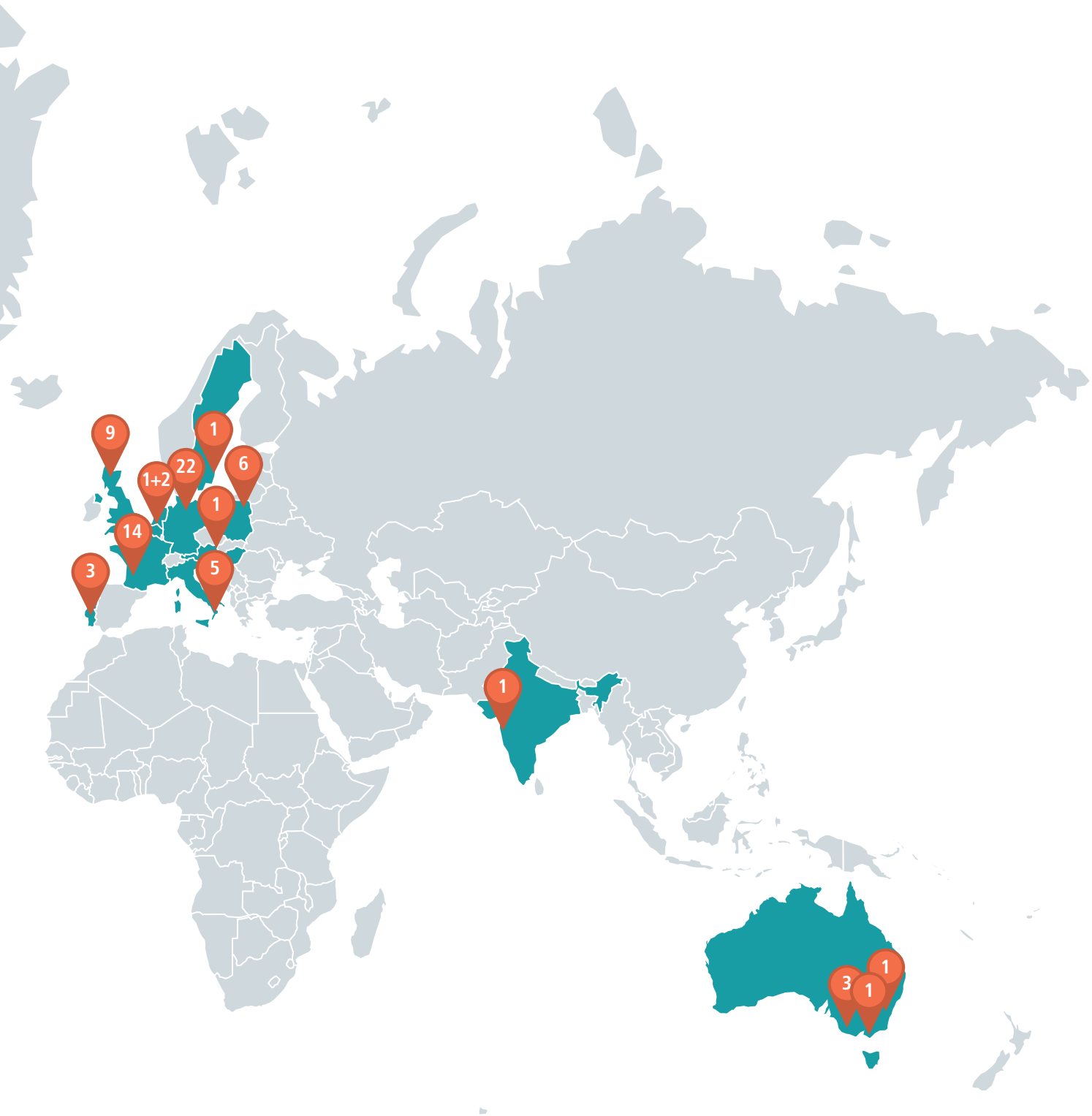
POLAND
- Dąbrowa
- Gościno
- Nowy Staw
- Rymanów
- Rzeszow
- Szymanovice

PORTUGAL
- Moimenta
- Oliveira de Frades
- Torres Vedras

SWEDEN
- Bromölla

UK
- Barrow-Ormonde
- Dalswinton
- East Yorks
- Hirwaun
- Inverness
- Livingston
- Peterborough
- Preston
- Tyne on Wear

USA
- Calumet, OK
- Goldendale, WA
- Healy, AK
- Hermiston, OR
- Hornell, NY
- Luverne, MN
- McBain, MI
- Meyersdale, PA
- Rio Vista, CA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Our references.
Expertise, backed by experience.

Operator:
WES energy GmbH

Type of contract:
ISP-T

Number of wind turbines:
11

Type of wind farm:
MD70, MM92, 3.2M114, 3.4M104

Total MW installed within wind farm:
27.4 MW

Total GWh produced per year:
approx. 41 GWh per year

St. Michaelisdonn, Germany

In 1995, WES energy GmbH was one of our first clients. In the course of 20 years, we have delivered 137 turbines producing over 190 MW to WES energy GmbH, including several prototypes. Throughout that time, the business relationship has been characterized by a spirit of cooperation in service and innovation.

Operator:
Engie SA

Type of contract:
ISP-E

Number of wind turbines:
39

Type of wind farm:
MM92

Total MW installed within wind farm:
78 MW

Total GWh produced per year:
approx. 182 GWh per year

Les Hauts Pays, France

Engie SA has been a customer of Senvion since 2005. In 2010 they decided to place service and maintenance completely in the hands of Senvion by signing a full service contract. In 2015 Engie SA changed their existing contract into 7-year, energy-based Integrated Service Package contract with a dedicated staff of 6 for this specific wind farm.

Operator:
Ingenieurbüro Teut & Phase 5 GmbH & Co. KG

Type of contract:
ISP-T

Number of wind turbines:
3

Type of wind farm:
3.2M114

Total MW installed within wind farm:
9.6 MW

Total GWh produced per year:
approx. 29 GWh per year

Kahnsdorf, Germany

The cooperation between Senvion and Ingenieurbüro Teut & Phase 5 GmbH & Co. KG – a member of the German Wind Energy Association, Berlin-Brandenburg – goes back 10 years. It all started with two MD77 turbines (hub height 61.5 m) and has grown to 29 turbines, including many innovative products such as the prototype steel tower in Landin and the Vortex Generator test project in Lindenberg.

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