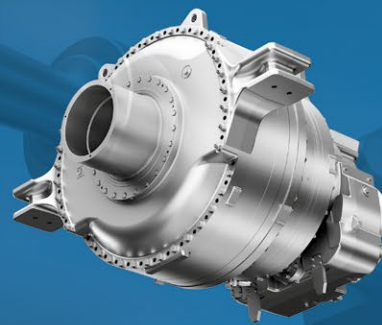
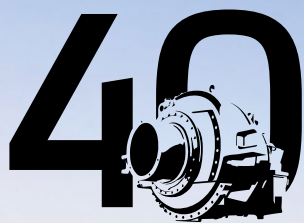


Smart solutions

ZF technology in wind turbines
puts wind energy in motion





YEARS OF INNOVATION
ZF WIND POWER



Wind is on the rise

For centuries, people have used the power of the wind for sailing ships, milling grain and pumping water. Since 1979, wind turbine technology enables us to harness this energy source for generating electricity.

Shaping the future responsibly

A global increase of electricity consumption along with the expected exhaustion of fossil fuel sources are ushering in a new era of environmental awareness that is opening up opportunities for the use of renewable energy sources such as wind power. With more than 70 years of combined experience in wind technology, ZF is determined to support its customers in making wind power the leading renewable energy source for the future.

Integrated technology leaders

ZF Wind Power is a globally established designer, manufacturer, and supplier of advanced gearbox solutions for wind turbines. The company is the result of a successful integration of three technology leaders. The acquisition in 2011 by ZF of the former Hansen Transmissions (one of the major players in wind turbine gearboxes since 1979) has resulted in a winning combination of experience, expertise, efficient production, and innovation.

In 2015 ZF confirmed its strong commitment to the wind power industry again by the acquisition of Bosch Rexroth's wind power activities.

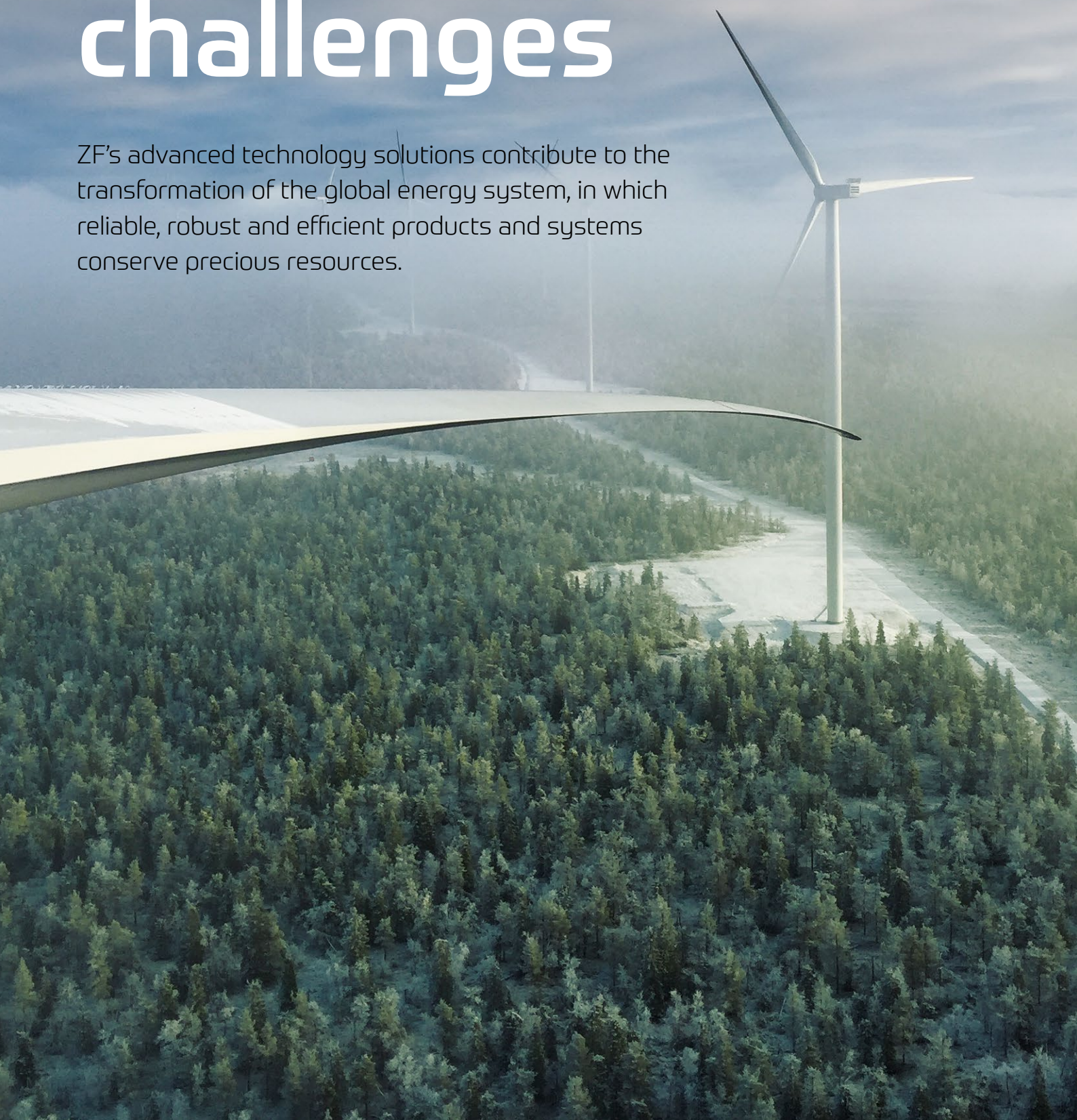
As one of the world leaders in the sector of high precision and high performance gearboxes for wind turbines, ZF Wind Power aims to establish partnerships with customers and suppliers that include design, manufacturing and customer services.

Pioneering gearbox technology

ZF Wind Power introduced wind power transmissions in 1979. Since then, the company consistently confirmed its pioneering role at the cutting edge of wind power transmission technology. Over four decades now, ZF Wind Power has carved out a reputation as a top tier global supplier of innovative and durable gearboxes to the world's leading gear-driven wind turbine manufacturers.

Addressing key market challenges

ZF's advanced technology solutions contribute to the transformation of the global energy system, in which reliable, robust and efficient products and systems conserve precious resources.



A next-generation gearbox supplier

Renewable energy sources – such as wind – have already reached grid parity in some markets. However, continued technological innovation will be a key factor in developing renewable energy into a low-cost and reliable power source that is able to meet the changing needs of the power generation industry. The objective of all stakeholders in wind energy technology is to take the lead in the reduction of the Levelized Cost Of Electricity among renewable technologies. Flexibility in the supply chain is therefore crucial to supporting wind turbine manufacturers in developing their business globally.

Optimization of grid networks and production of wind energy closer to the location of consumption drive the emergence of new and bigger wind turbines. The development of wind power plants at sea (offshore) increases technology demands. Investments in innovation and technology are critical to sustain wind energy Levelized Cost Of Electricity gains.

With a worldwide installed wind power capacity of almost 600 GW, operational efficiency and availability are crucial for power utilities to profitably exploit their investments. An acknowledged track record of reliable products and the availability of worldwide support for servicing and maintaining wind power plants are crucial criteria in their selection of technology partners.

Fulfilling our ambition

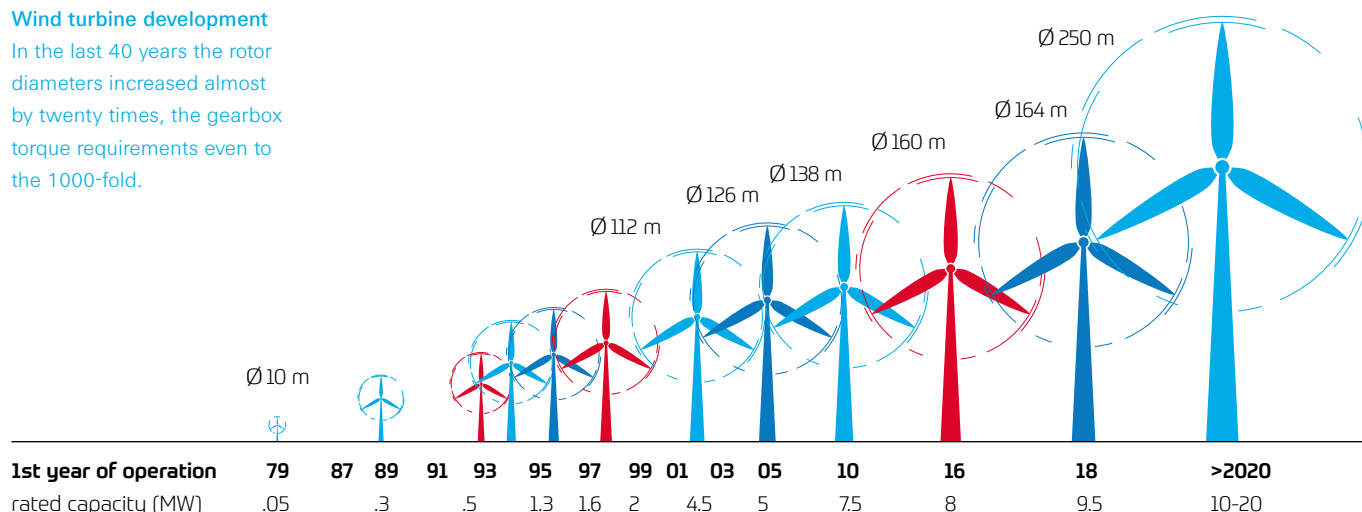
ZF is determined to be the leading supplier in geared solutions for wind turbines and is committed to succeed in making wind power the most attractive energy source in the future.

With state-of-the-art manufacturing plants and worldwide service locations, ZF is dedicated to delivering advanced gearbox solutions and services on a global scale, meeting the individual needs of the global wind energy market. The company has a global footprint with manufacturing and service centers in Europe, China, India and the US.

Customer satisfaction with products and services provided by ZF is the topmost objective in all company activities. In its close cooperation with international customers, ZF integrates the best services in the product cycle, ranging from development and consultancy to aftermarket service. Proximity to international customers is of great significance to ZF.

Wind turbine development

In the last 40 years the rotor diameters increased almost by twenty times, the gearbox torque requirements even to the 1000-fold.



Leading wind turbine gearbox technology

ZF Wind Power is a globally established designer, manufacturer and supplier of reliable and advanced gearbox solutions for multi-MW wind turbines with power capacities ranging up to 9.5 MW.





A proven track record

Producing multi-megawatt gearboxes efficiently in serial production with a consistent high level of quality and reliability requires excellence in sourcing, manufacturing, logistics, assembly and testing. Since ZF Wind Power first entered the wind turbine market in 1979, its manufacturing plants have shipped more than 65,000 gearboxes powering more than 120,000 MW of installed wind capacity all over the globe.

Performing critical activities in-house allows the company to have full control over quality at all stages of production. ZF believes this is an essential prerequisite to delivering the high-quality serial products with constant performance characteristics required by the world's leading wind turbine manufacturers. ZF Wind Power's 13.2 MW dynamic gearbox test rig in Belgium is one of the world's largest test facilities of its kind keeping up with the continuously increasing power of wind turbine output in the market. By means of this test rig, ZF Wind Power is able

to test gearboxes under representative wind turbine loading conditions. With ZF's dynamic bearing test rig, the company has one of the most advanced facilities of its kind to test real-size bearings in their actual arrangement as built in the gearbox, under representative wind turbine loading and environmental conditions. The flexible test rig design reproduces the same shaft and housing deflection as the real gearbox and enables the verification of bearing behavior and loadability of bearing assemblies.

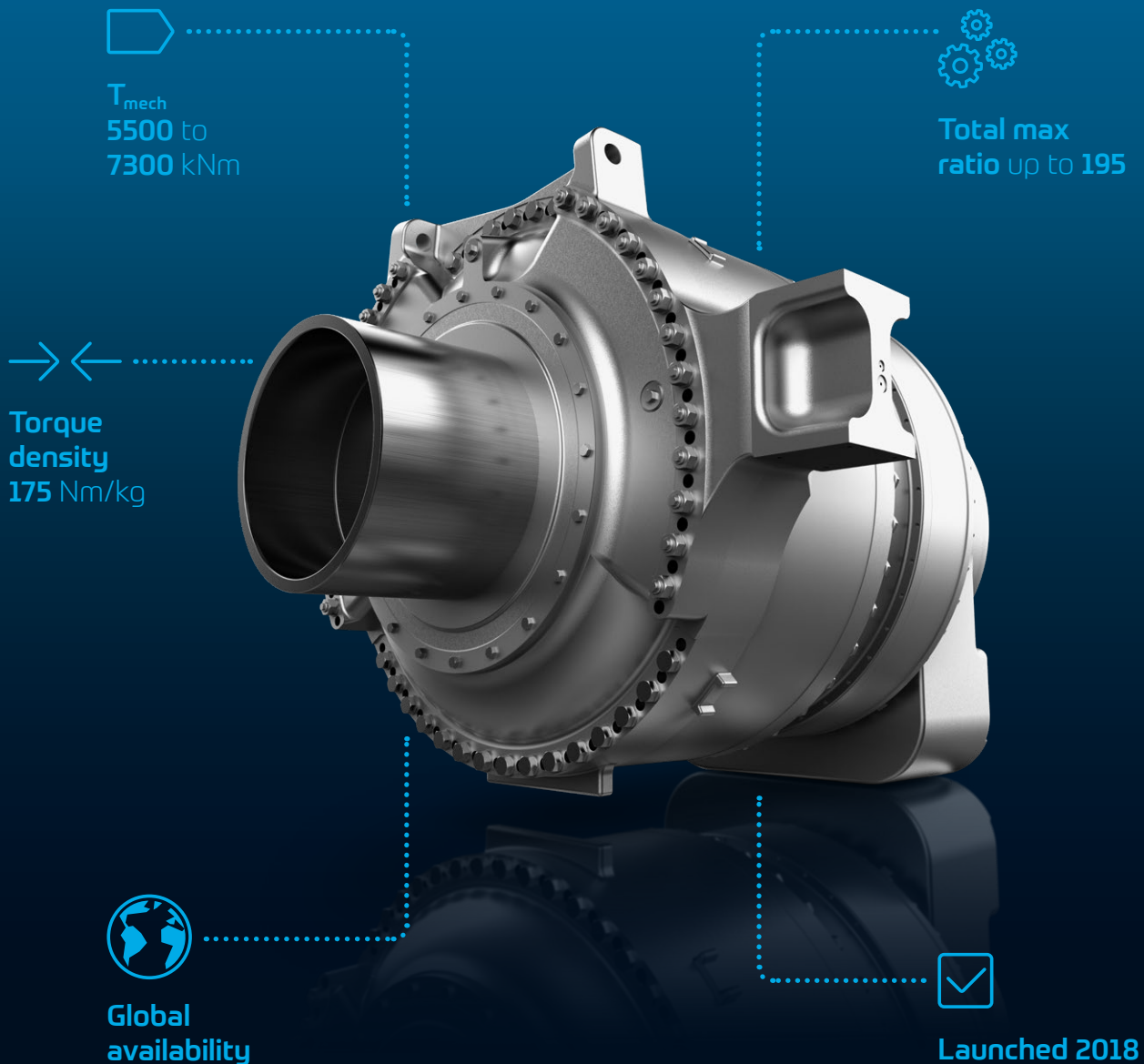
ZF's "Design Operational Robustness Test" philosophy – DORoTe – is used to assess the robustness of a new gearbox design with respect to the operational conditions as specified by the customer. This test philosophy takes principles of highly accelerated life testing (HALT) one step further by incorporating dynamics and transients of wind turbine applications.



Learn more about the ZF portfolio in the field of wind energy technology.

SHIFT is ZF Wind Power's new modular platform. While using standardized building blocks, the platform offers more flexibility in terms of gearbox development and next generation turbine concepts, consequently reducing our customers' Levelized Cost of Energy.

SH/FT **6k**





Delivering modular gearbox solutions

With a long tradition of innovation, ZF Wind Power differentiates itself in the marketplace by means of quality and reliability in advanced solutions for different concepts used by its customers in their markets: Integrated, Conventional, High Speed and Medium Speed. Traditionally, wind gearboxes have been designed for a specific turbine development. In the current era of wind auction systems, market demands are rapidly changing in terms of pace of introduction of new turbine variants and thus flexibility in development to meet shorter time to market. As such gearbox volumes per specific turbine design are limited. As a gearbox manufacturer ZF responds to these demands with the 'SHIFT' concept, representing a paradigm shift to a modular platform, which helps wind turbine manufacturers to reduce cost of wind energy drastically.

The 'SHIFT' concept facilitates faster steps towards future wind turbine designs

- at lower cost
- with reduced time-to-market
- and with more potential for the future than initially required by the customers

This modular platform offers high flexibility in adapting wind turbine designs to changing market requirements. ZF believes that innovations in both technology and policy will accelerate the reduction of Levelized Cost Of Energy to fully realize the shift to renewable energy.

Covering all torque ranges

ZF bundled its experience in high-torque applications and reliable wind gearbox technology to create a new wind gearbox platform that covers the dynamics of the wind market, safeguard specific customer requirements, and reduces time-to-market significantly.

The new modular designs help turbine manufacturers reduce business uncertainties and life cycle costs by:

- Allowing maximum use of the latest technological developments and optimized designs, processes and supply chain to scale power density, while reducing the Cost Of Energy.
- Enabling upgrades of the mechanical torque, while covering a broad range of gearbox-generator combinations in terms of gearbox ratios. ZF is developing powerful platforms beyond current market requirements.
- Keeping the gear unit outer dimensions identical across the full torque range – eliminating the need for major drive-train/nacelle re-designs during the turbine platform lifetime.

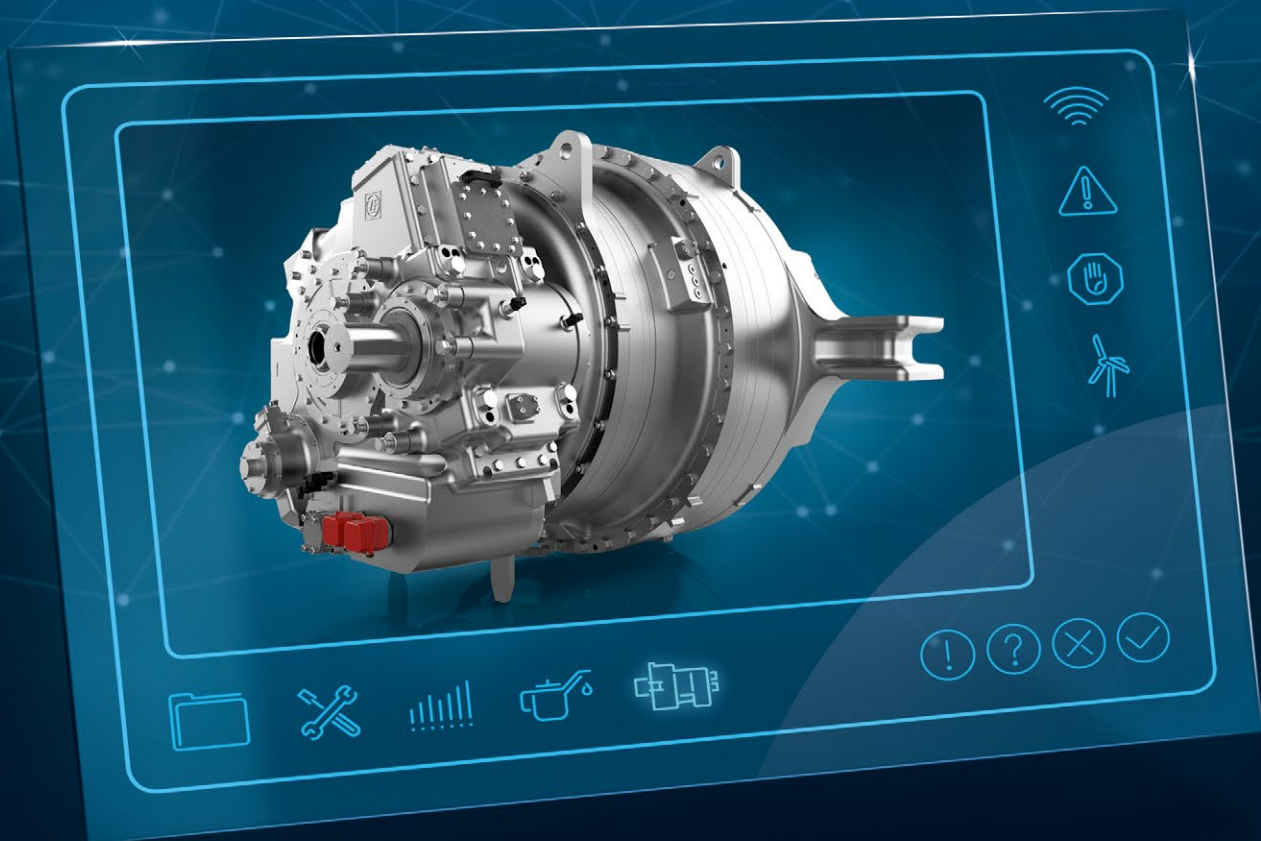
Digitalization

Continuously innovating, ZF's pioneering 'Services powered by Analytics' will help reduce the levelized cost of energy. Digital solutions integrated with ZF's high performance mechanical systems will bring new opportunities to optimize the energy yield and decrease the operational cost of wind farms.

DATA ANALYTICS

LIFE CYCLE ANALYTICS

GEARBOX EXPERTISE



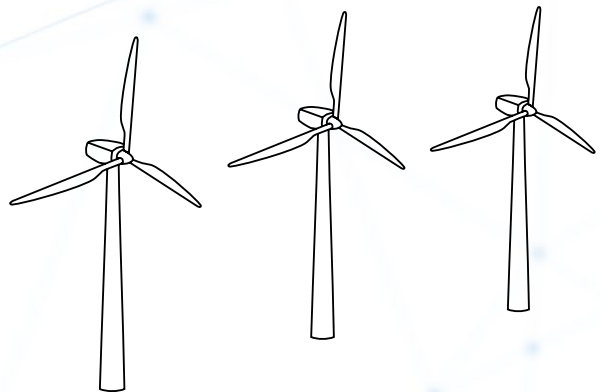
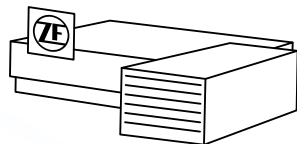
Digital services driving O&M decisions

ZF's 'Services powered by Analytics' offering is a key driver for the optimization of Operations and Maintenance of wind turbines.

State-of-the-art analytics combine data from gearbox manufacturing and life cycle monitoring with advanced reliability models and gearbox expertise to enable spare parts optimization and a fast return to operation, increasing availability and output of turbines. Using data from the existing SCADA system, no additional hardware is needed to start experiencing the benefits of ZF's digital services.

DIGITAL BIRTH CERTIFICATE

DATA PLATFORMS



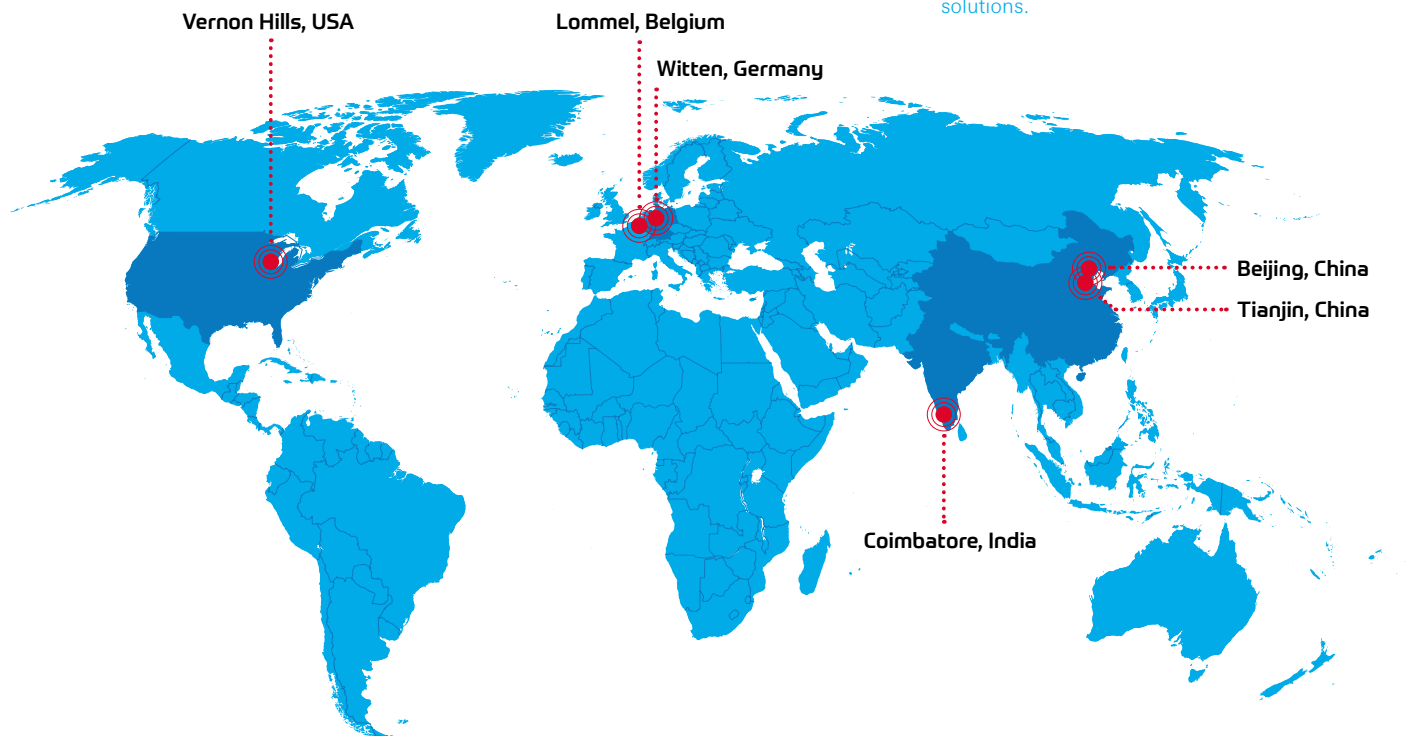
Having accurate data available for every stakeholder is key for efficient Operations and Maintenance. The Digital Birth Certificate and Life Cycle Monitoring provided with ZF's 'Services powered by Analytics' are available in a cloud-platform for staff in the field and in the office. Better and easily accessible data allows to increase the turbine performance and availability, to reduce the operational expenditures and enable life time extensions.

Fully committed to life cycle service and customer satisfaction

Profit with ZF from a strong, global partnership and enhanced multi-brand full service for wind turbine gearboxes and drive trains enabling you to successfully stand your ground amongst the competition.



With state-of-the-art manufacturing plants and worldwide service locations, ZF offers a global footprint to deliver advanced gearbox solutions.



Customer satisfaction with the products and services provided by ZF is the topmost objective in all its activities. The company offers services into the complete product cycle, from development and consultancy to aftermarket service. Proximity to international customers is of great significance to ZF.

ZF Wind Power currently operates with state-of-the-art manufacturing plants in all key regions so that ZF Wind Power is best positioned to serve its customers.

As a service partner, ZF links extensive technical know-how with an intense sense of responsibility for the customer's business over the entire product life cycle. Clients can rely on more than 70 years of cumulative experience and the expertise of more than 65,000 wind turbine gearboxes on the market.

ZF understands the customer's need for total reliability for maximum productivity. ZF offers fast and individual solutions for both ZF and non-ZF mechanical drive train repair and service thereby meeting the highest standards. To ensure economical operation of wind turbines, the highest degree of availability must be guaranteed. This is a ZF aftermarket specialty with its committed, fast-reacting on-site support and flexible spare parts service.

To avoid unnecessary risks and lower the cost of electricity, proper maintenance and service throughout the complete service life is indispensable: quick, flexible, and reliable service delivery. With modern production and service locations for wind turbine gearboxes in Belgium, Germany, India, China, and the U.S., ZF Wind Power supports its customers as a strong partner on all continents, onshore and offshore.

As a further evolution in service, ZF Wind Power sees an important role for connecting devices to actively control gearbox performance and monitor health status during operation, as well as new methods to reduce service operational expenses.

Gearbox performance monitoring will open new possibilities relating to gearbox performance and enable remote based engineering advice and up-tower interventions preventing gearbox exchange. Engineering know-how of the installed base in combination with predictive analytics are used for root cause analysis, correct component assessment and needed re-work in order to reach the lowest possible repair cost for each repair level.

The ZF Group

Shaping the future responsibly

ZF Friedrichshafen is a global leader in driveline, chassis and safety technology and its broad portfolio of products and services is advancing mobility in the automobile, truck and industrial technology sectors. Specializing in highly efficient driveline technologies, ZF has expanded into urban mobility solutions which help protect all road users. With its intelligent mechanical systems that combine innovative automotive components and advanced digital technology, ZF is allowing vehicles to see, think and act.

The company is playing a major role in implementing key technologies that are shaping the megatrends of efficiency, safety and autonomous driving in the global automotive industry. Its engineers are currently working on the next generation of advanced safety systems to help enable autonomous driving for both cars and trucks.

ZF focuses on highly efficient driveline solutions with products for E-Mobility and develops solutions for urban mobility and assistance for vulnerable road users. We work on autonomous and remote driving technology for trucks to make the transportation of goods more efficient and safe.

ZF has a global workforce of around 146,000 employees with approximately 230 locations in some 40 countries. In 2017, ZF achieved sales of €36.4 billion. The company supports sustainable business practices and believes in the importance of corporate social responsibility. It annually invests about six percent of its sales in research & development – ensuring continued success through the design and engineering of innovative technologies. ZF is one of the largest automotive suppliers worldwide.



Get a new or
better view of ZF
– a technology-
based company.

WHAT'S NEXT?

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