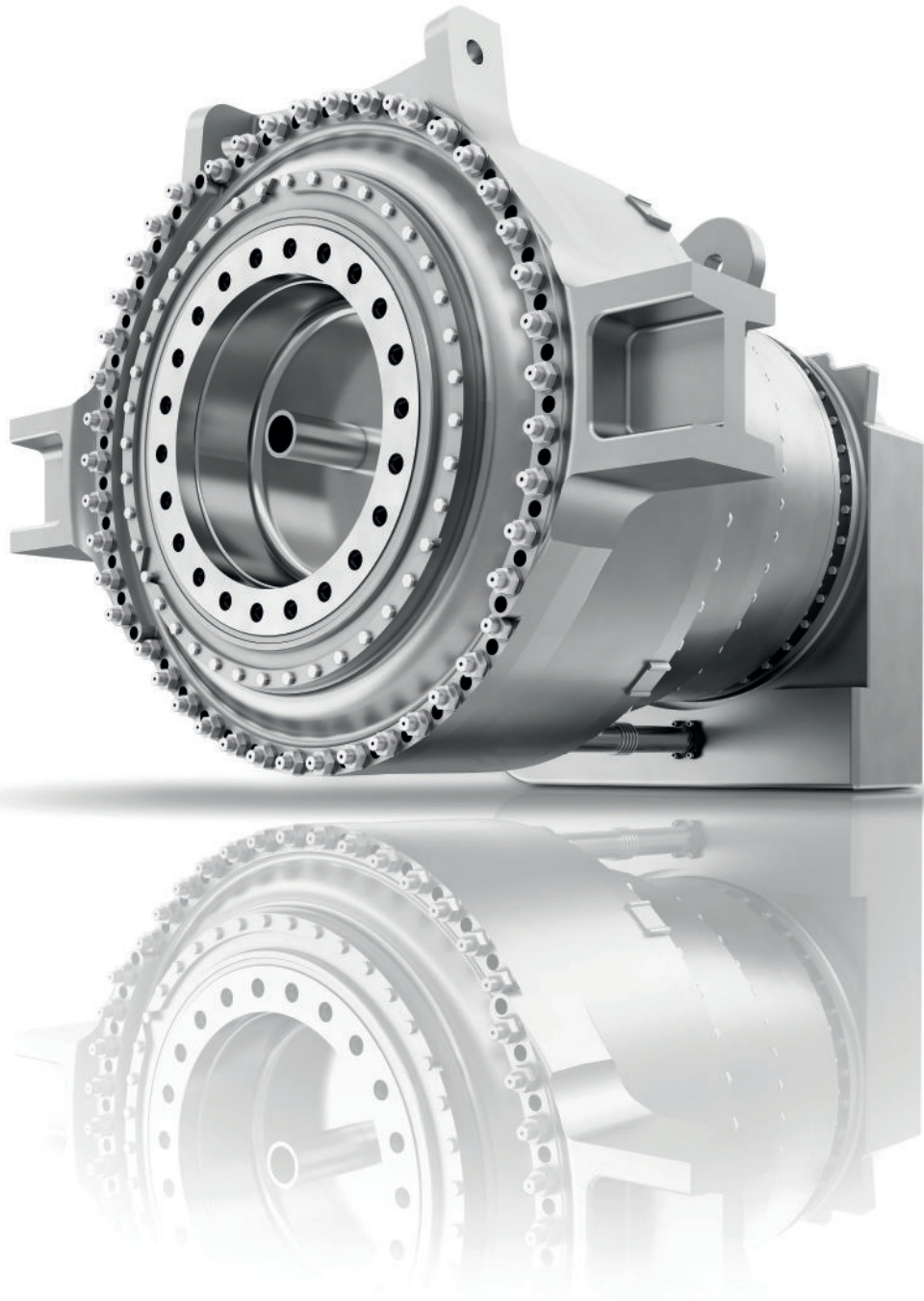


Competitive gearboxes: electrification at high speed



SHIFT 7k - To achieve an overall ratio of 200Nm/kg, the 7k variant comes with 4 stages in total, of which the first 2 stages are equipped with a higher number of planets than its 4k and 6k predecessors.

With the launch of the SHIFT platform four years ago, ZF Wind Power changed the wind gearbox market in terms of flexibility, product lifetime and competition. Thanks to a design based on standardized building blocks, the platform offers high flexibility in gearbox development for next-generation turbine concepts. Currently, the platform has been extended with two new members: SHIFT 3k to the lower end of the torque scale and SHIFT 7k at the high end. Together with the 4k and 6k variants, the SHIFT platform contributes to the lowest levelized cost of energy in all wind areas.

Competitive design raising the torque density bar above 200Nm/kg

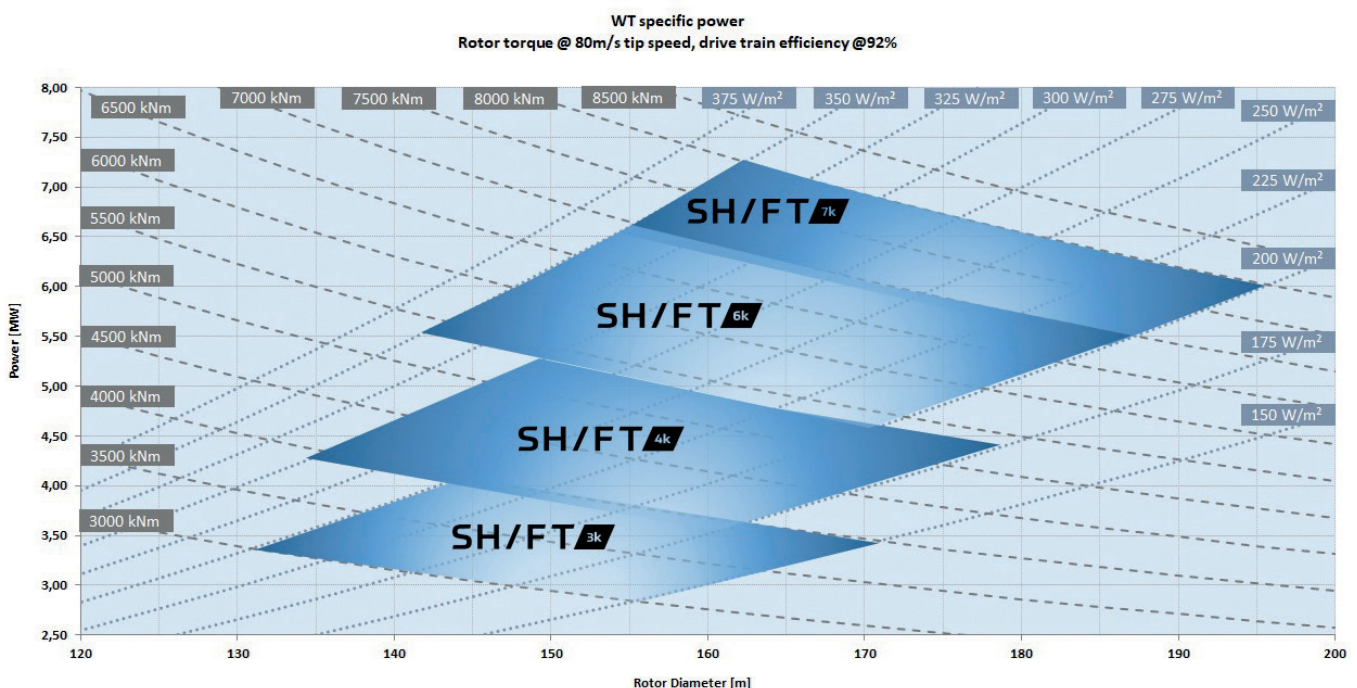
During its 40 years of activity in the wind market, ZF Wind Power has shipped 150 GW of gearboxes worldwide, of which 75% of today's shipments are based on the modular platform design. With a torque range of 2000-8000 kNm, all onshore and offshore wind sites can be covered. Where the SHIFT 7k variant with a maximal torque up to 8000kNm addresses the high power and high output onshore segments as well as dedicated offshore markets, the SHIFT 3k variant was added to the product family specifically to cover the demand in view of low to very low wind sites to boost annual energy production. With this broad torque range, ZF Wind Power SHIFT gearboxes enable cost-efficient turbine designs for all

markets with a wind power density starting from 125W/m² up to 500W/m².

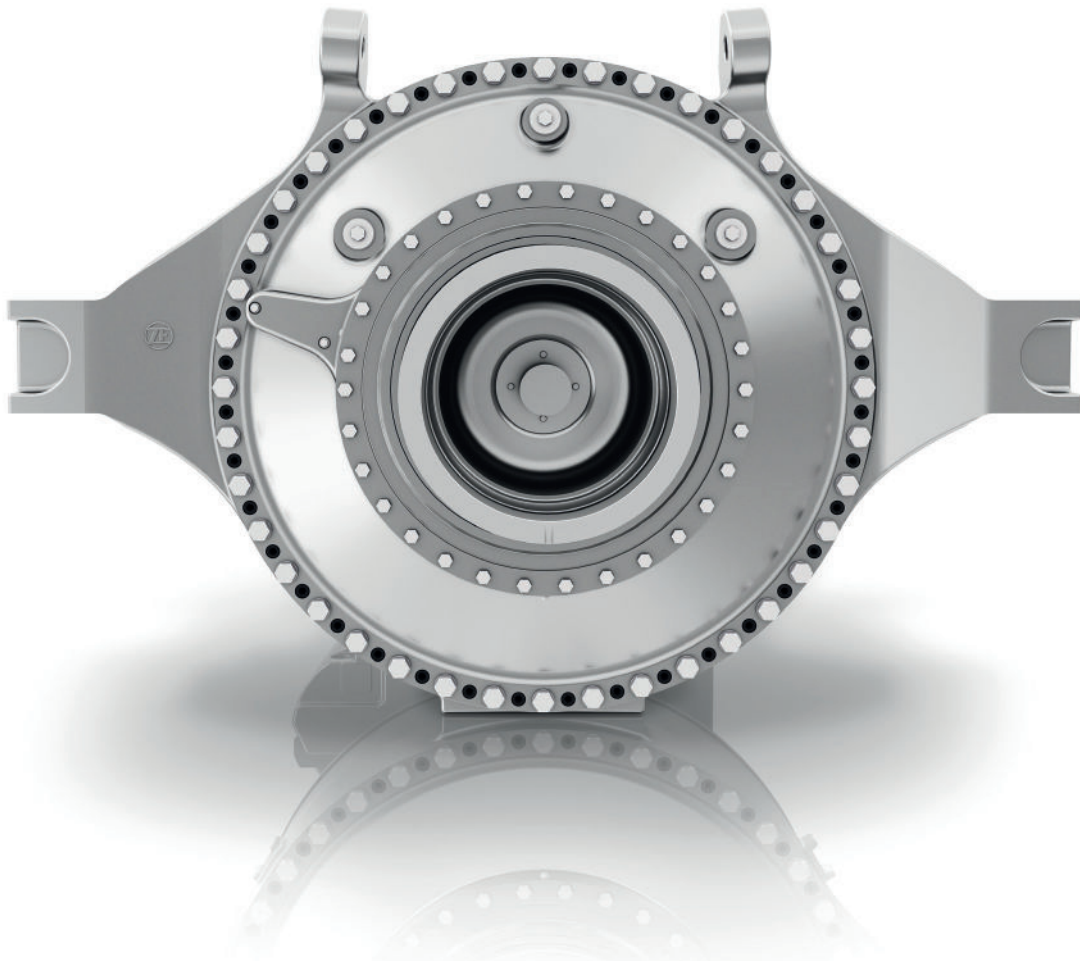
In terms of torque density, the 3k and 7k siblings in the product family clearly raise the bar in their segments, with the 7k even surpassing the 200Nm/kg mark. This step-up in torque density was made possible by continuously advancing the state-of-the-art in gearbox components and materials. To achieve an overall ratio of 200, the 7k variant comes with 4 stages in total, of which the first 2 stages are equipped with a higher number of planets than its 4k and 6k predecessors. Optimization of load sharing in these multi-planet stages is the 'fine art' of gearbox design combined with selective assembly of components in the assembly process.

Full flexibility to cover all wind markets

Overall, the SHIFT platform offers a modular and upgradeable gearbox design that enables wind turbine manufacturers to choose from multiple gearbox variants over the lifetime of a wind turbine platform, including a broad range of rotor-size, generators and ratio combinations. With the pre-designed and pre-validated gearbox variants, the platform offers lowest powertrain development cost over the turbine platform lifetime as well as shortest time-to-market for any turbine upgrade. Turbine manufacturers can select the best fit gearbox variant from the platform in consideration of site-specific loads. Even mixing variants within a single wind park is possible.



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SHIFT 3k - The SHIFT 3k variant was added to the product family specifically to cover the demand in view of low to very low wind sites to boost annual energy production

The re-use of gearbox building blocks simplifies service operations, thereby reducing maintenance cost, whilst offering potential for future turbine power upgrades of the installed base. As such, SHIFT gives our customers the confidence to adopt forward pricing when participating in auction biddings.

Reliable operations backed up by data intelligence

As gearboxes are critical components in the reliable operation of wind turbines, ZF Wind Power takes a leading stance in supporting their customers with operations and maintenance planning based on data analytics. SHIFT gearboxes can be delivered with a cloud-based analytics solution that takes in general performance information from the wind turbine (SCADA system) and combines it with signals from condition monitoring systems - vibration, temperature and amount of oil particles – that generate an alarm when threshold values are reached.

State-of-the-art analytics and machine learning algorithms are also applied to both operational and historical data. In combination with their expertise from

manufacturing and servicing gearboxes over 40 years, ZF Wind Power is able to provide dedicated recommendations per gearbox to optimize spare parts inventory and plan maintenance intervals, preferably during low production periods, such that the highest availability of the turbine can be guaranteed.

Pathways to an electrified world

The introduction of the SHIFT gearbox

platform four years ago clearly marked a leap in gearbox development strategy in tune with market needs. With the introduction of the SHIFT 3k and SHIFT 7k, the modular gearbox platform is further synchronized with evolving wind turbine platform requirements. In doing so, ZF Wind Power delivers on its commitment to making wind energy one of the most cost-efficient renewable energy sources powering the global energy shift.

ZF Wind Power

With more than 150 GW of globally installed wind energy, ZF Wind Power is a reliable partner, supplying major manufacturers of gear-driven wind turbines with a gearbox output range up to 10 MW power capacity and serving all key wind power segments.

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

With state-of-the-art manufacturing plants and worldwide service locations, ZF Wind Power is dedicated to delivering advanced gearbox solutions and services on a global scale, meeting the individual needs of the global wind market.

With headquarters in Belgium, the company has a global footprint with manufacturing and service presence in Europe, China, India and the US.

As a continuous innovator, ZF anticipates the trend towards intelligent systems by enabling performance optimization of the overall wind turbine.

www.zf.com/windpower