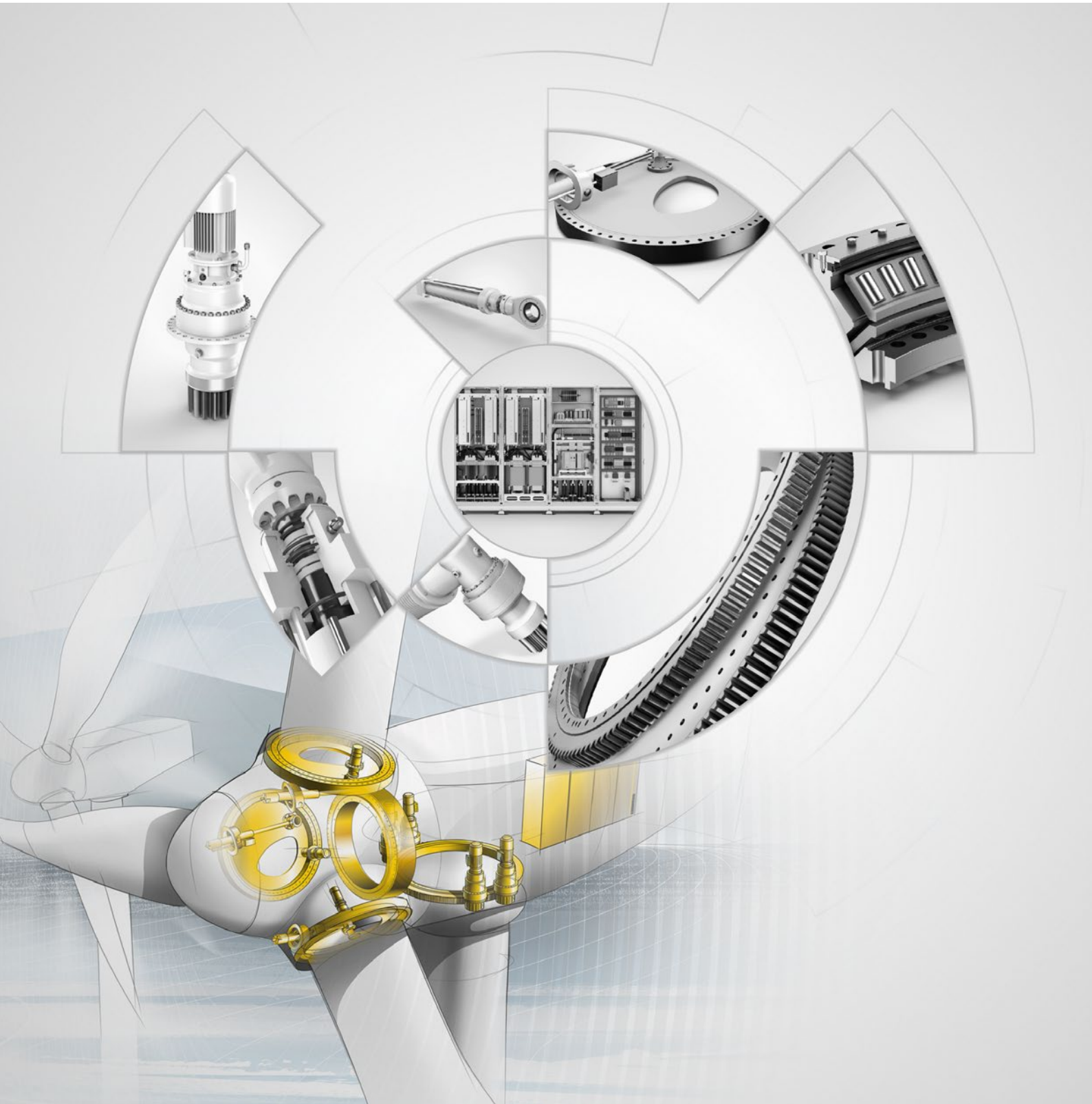


System and Technology Expertise

Solutions for Wind Energy



LIEBHERR

A strong partner for the wind industry





As a strong partner for the wind industry, Liebherr offers the ideal solution for various requirements ranging from individual components used for turbines to excavators, concrete technology, mobile cranes, tower cranes and offshore cranes used not only to erect turbines but to construct entire wind farms. Liebherr works together with virtually all well-known turbine manufacturers and to date has supplied components for thousands of wind turbines. The product portfolio covers components for 800 kW installations up to solutions for multi-megawatt turbines for offshore wind farms.

Advantages

Liebherr is the only manufacturer worldwide who is not only able to supply individual components such as slewing bearings, slewing drives, electric motors, hydraulic cylinders and frequency converter systems but is also able to supply hydraulic and electromechanical pitch systems and electromechanical yaw systems for wind turbines. With a global footprint, Liebherr is furthermore

able to support in assembly-line set-ups where local content requirements are specified or simply due to cost advantages. An important element of the cooperation with customers from all over the world is the applied application-specific engineering necessary for adapting and matching the individual components to each other.

Wide product range

Slewing bearings, drives, electric motors, hydraulic cylinders and frequency converter systems – everything from one source

System mindset and know-how

One system - one contact

Wide product range

Pitch systems

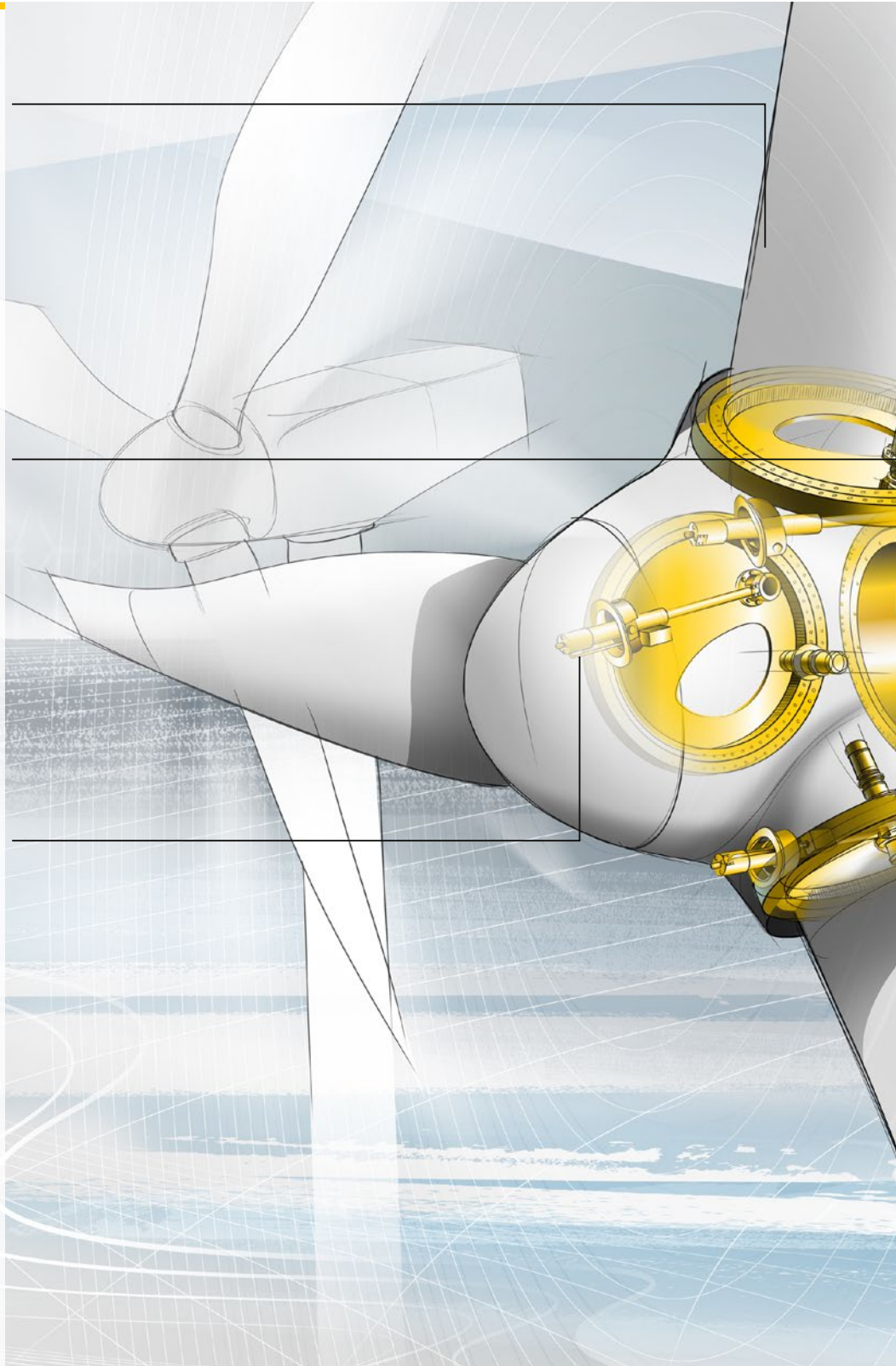
- Well-engineered mechanical systems for rotor blade adjustment produced by Liebherr
- Precise positioning of rotor blades for maximum energy yield

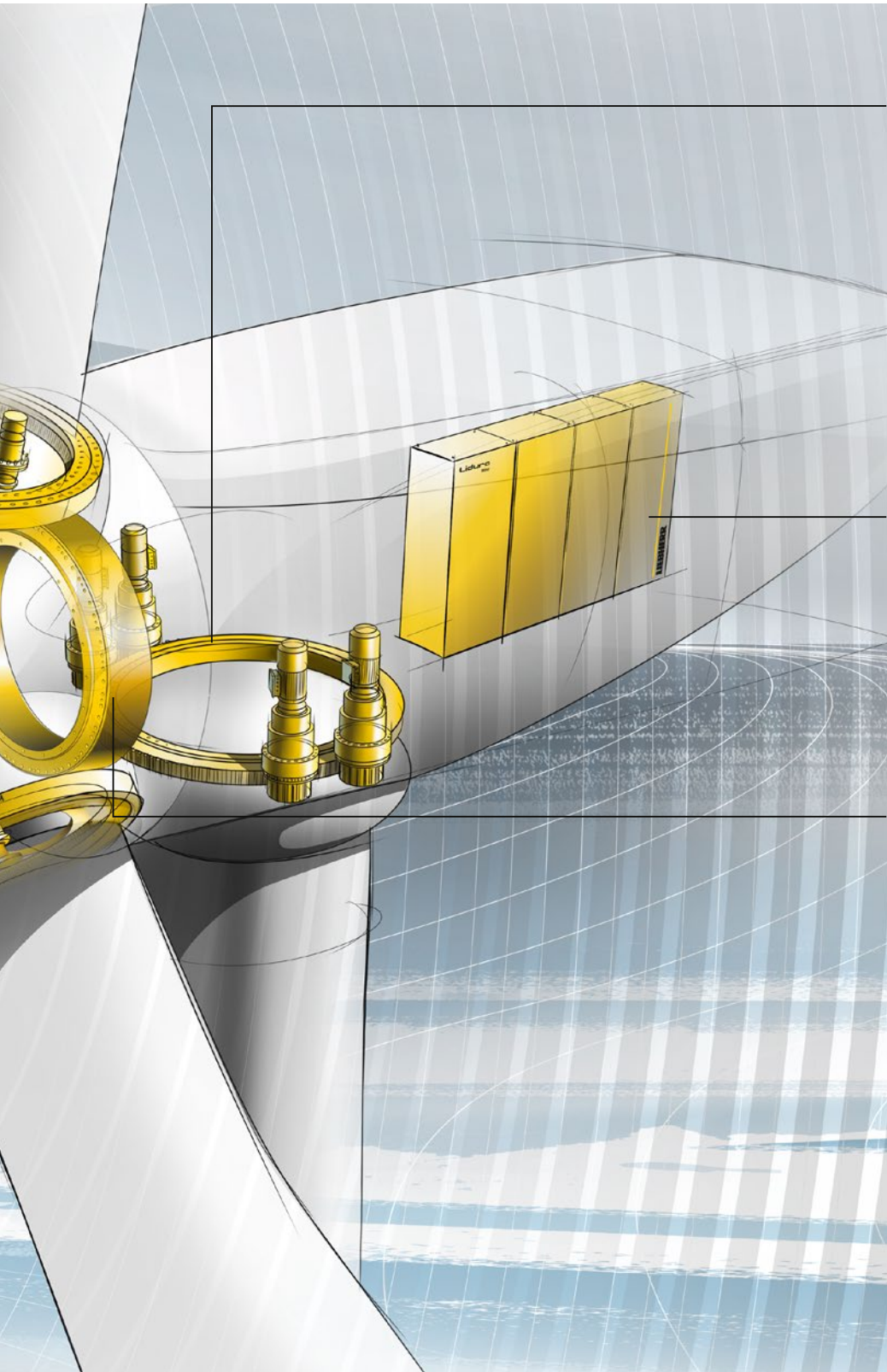
Electric pitch systems

Pitch system based on 3-4 stage planetary gearboxes with electric motor, which drives a geared slewing bearing

Hydraulic pitch systems

All-in-one solution based on hydraulic cylinders, hydraulic power unit, hydraulic manifolds, control system as well as accumulators and gearless slewing bearing for adjusting the rotor blade position.





Yaw systems

- Depending on the specific system design, comprising of up to twelve or more high-performance planetary gearboxes which drive a slewing bearing
- Alignment and supply of entire system, including electric motors, by Liebherr
- Various bearing and ring designs

Frequency converter system

- Liquid cooled full-scale converter
- High power density
- Completely closed converter cabinets
- Maximum safety, durability and efficiency

Main bearing

- Moment bearings for 2MW turbines and upwards
- Validated on internal test rig
- Design types: Double-row tapered roller bearings or triple-row roller bearings

Slewing bearings

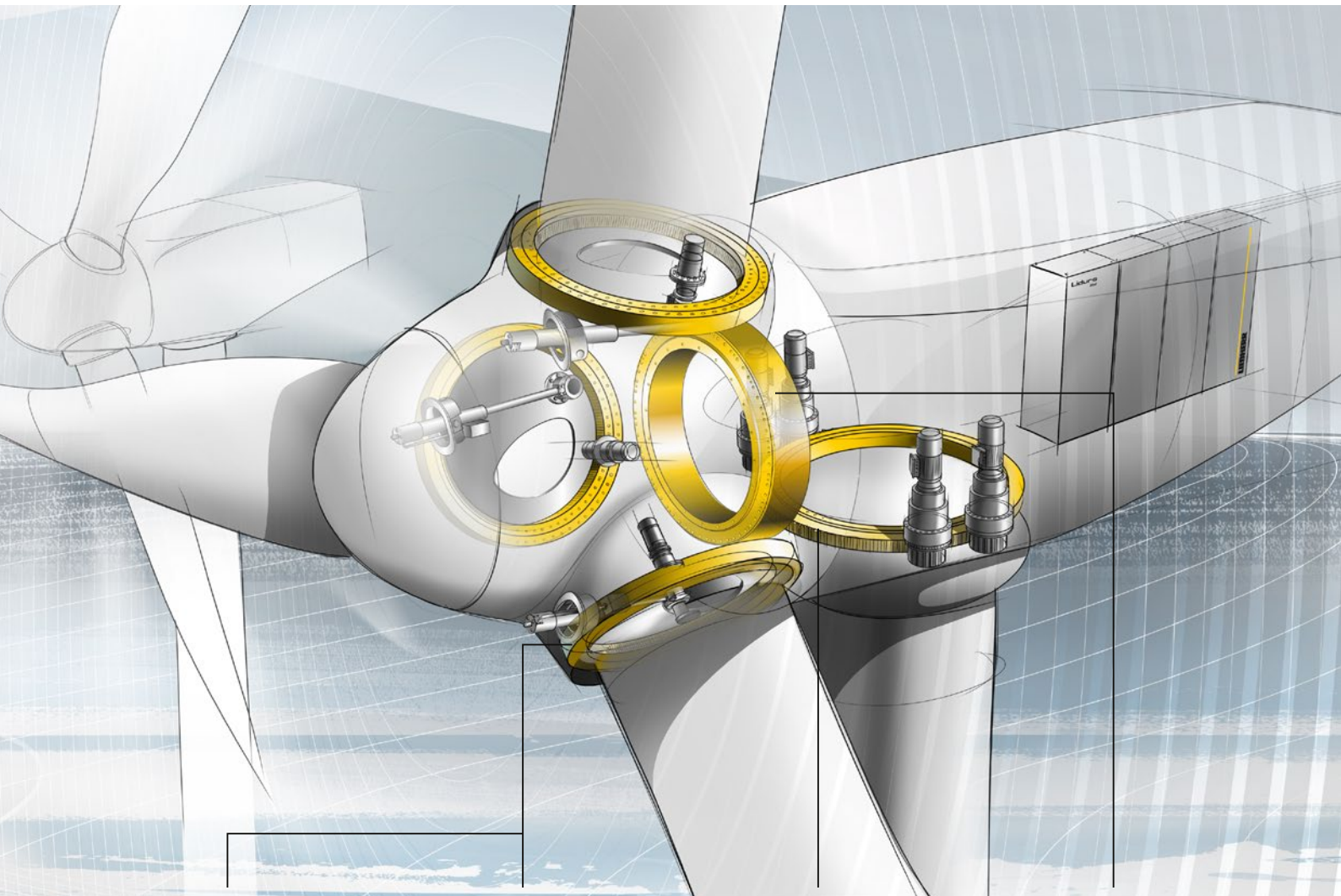
- Diameter up to 9.5 m
- Blade, yaw and main bearings for 2 MW turbines and upwards
- Gear rings for yaw adjustment
- Durable seals
- Application-optimized raceway design



Liebherr slewing bearings for wind turbines are used in rotor blade and yaw adjustment as well as in the main bearing of the rotor. Our solutions for these applications are diverse: **Double-row four-point bearings, triple-row roller bearings, tapered roller bearings and geared rings.**

Liebherr is your development partner for all bearings. Through continuous development and expansion of our portfolio, we are the leading manufacturer of the latest generation of blade bearings with regard to roller bearings. In order to meet our high quality standards, bearings by Liebherr are validated through life time tests on both internally and externally test benches and by field tests.

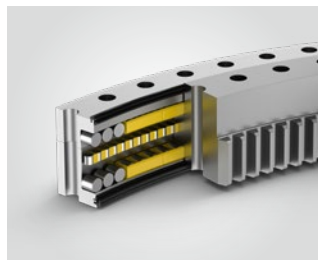
Application expertise and diversity



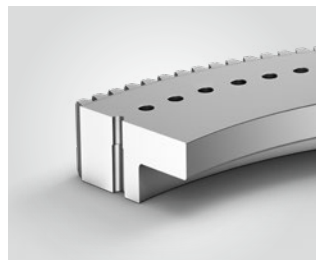
Bearing designs for wind turbines:



Single-row and double-row four-point bearings
for blade and yaw bearings



Triple-row roller bearings
for blade, yaw and main bearings



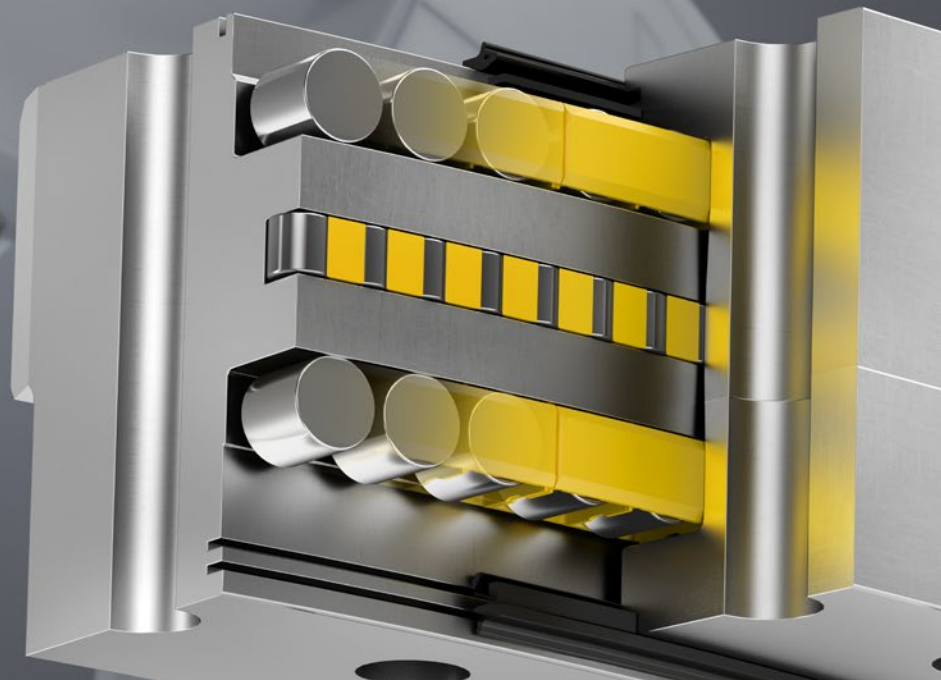
Gear rings
for yaw adjustment



Double-row tapered roller bearing
for main bearings

Pitch bearings

- Higher load capacity per diameter (increasing C, iso)
- Lower turning resistance
- Higher bearing stiffness
- Weight and cost reduction



The future of the blade bearing

Wind turbines are growing steadily in an effort to attain higher energy yields. The options of adapting existing designs to the growing dimensions and more demanding load profiles are limited, however – particularly in regard to rotor blade bearings. Therefore, in addition to the current single-row and double-row four-point bearings, Liebherr now also offers triple-row roller bearings for pitch systems. This highly increases the potential in terms of dimensioning and load capacity.

Option 1

Reduced blade root diameter with consistent blade length

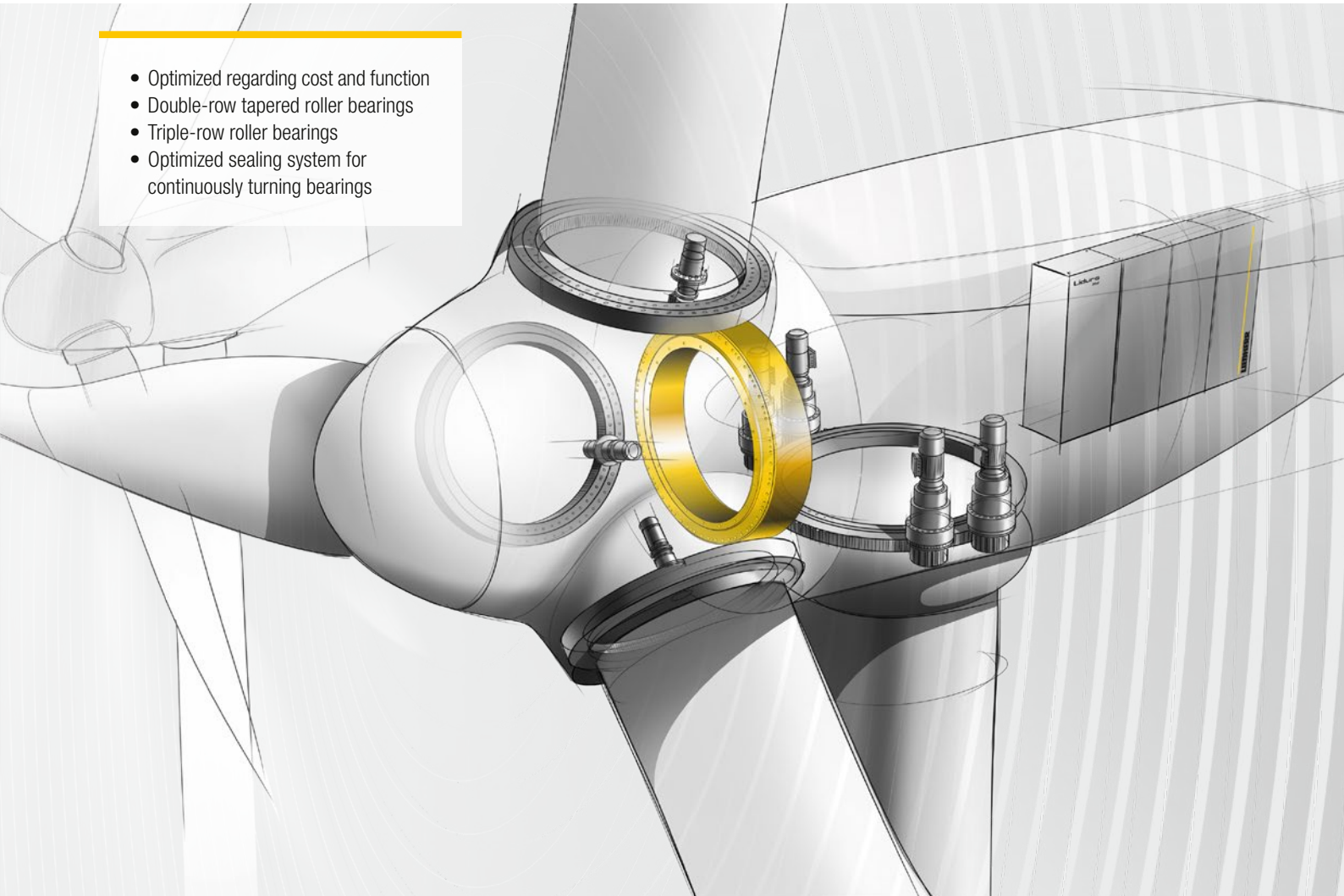
Option 2

Longer blades with same bolt diameter



Main bearings

- Optimized regarding cost and function
- Double-row tapered roller bearings
- Triple-row roller bearings
- Optimized sealing system for continuously turning bearings



Main bearings by Liebherr

Based on 30 years of experience in the wind sector, Liebherr offers main bearings for wind turbines ranging from 2MW and upwards.

- Optimized sealing systems
- Oil- and grease-lubricated version

In-house main bearing test bench

- Max. bending moment: 8,000 kNm
- Max. radial force: 2,000 kNm



Planetary gearboxes

- Extended oil change intervals
- Certified HALT
- Complete development support
- Extensive application know-how



Reliability and precise positioning are the crucial factors for the rotor blade and yaw adjustment drives. Liebherr offers multistage planetary gearboxes for the rotor blade adjustment. If required by the installation constraints, they can also be fitted with an angled increment. Three- to four-stage planetary gearboxes are usually used for yaw adjustment. Up to twelve or more yaw drives per yaw system are installed to transmit the high torques encountered in wind turbines in the multi-megawatt class.

High power density under high dynamic loads

Reliability and availability

Yaw adjustment and pitch drives are based on tried-and-tested technology. Their high reliability and availability are the result of a variety of intelligent design solutions, such as special sealing concepts, corrosion protection systems, as well as optimised anti-friction bearings and gearing.

Optimum use of installation space

The integral design of Liebherr gearboxes allow compact shapes and an optimum power to weight ratio.

Pitch drives

A distinction is made between the three main designs: With short output shaft, with long output shaft or alternatively as bevel gear.



High-quality design

Liebherr planetary gearboxes boast a very high-quality design. For instance, the planetary supports are forged and the case-hardened output pinions have ground involute gearing. Meshing errors are also avoided with a very rigid mounting of the one-piece output shaft.

Compatible electric motors

As a system supplier, Liebherr offers electric motors with power between 1.1 and 11 kW for the gearboxes. The larger motors from 11 kW are developed and also produced by Liebherr.

Yaw drives

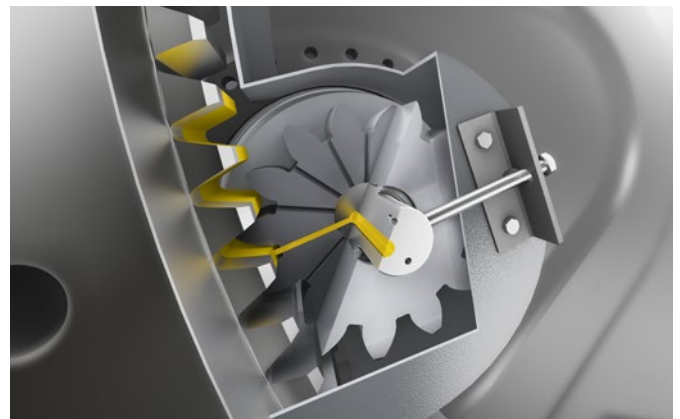
The high-performance yaw drives are also designed with short or long output shafts.



Direct lubrication

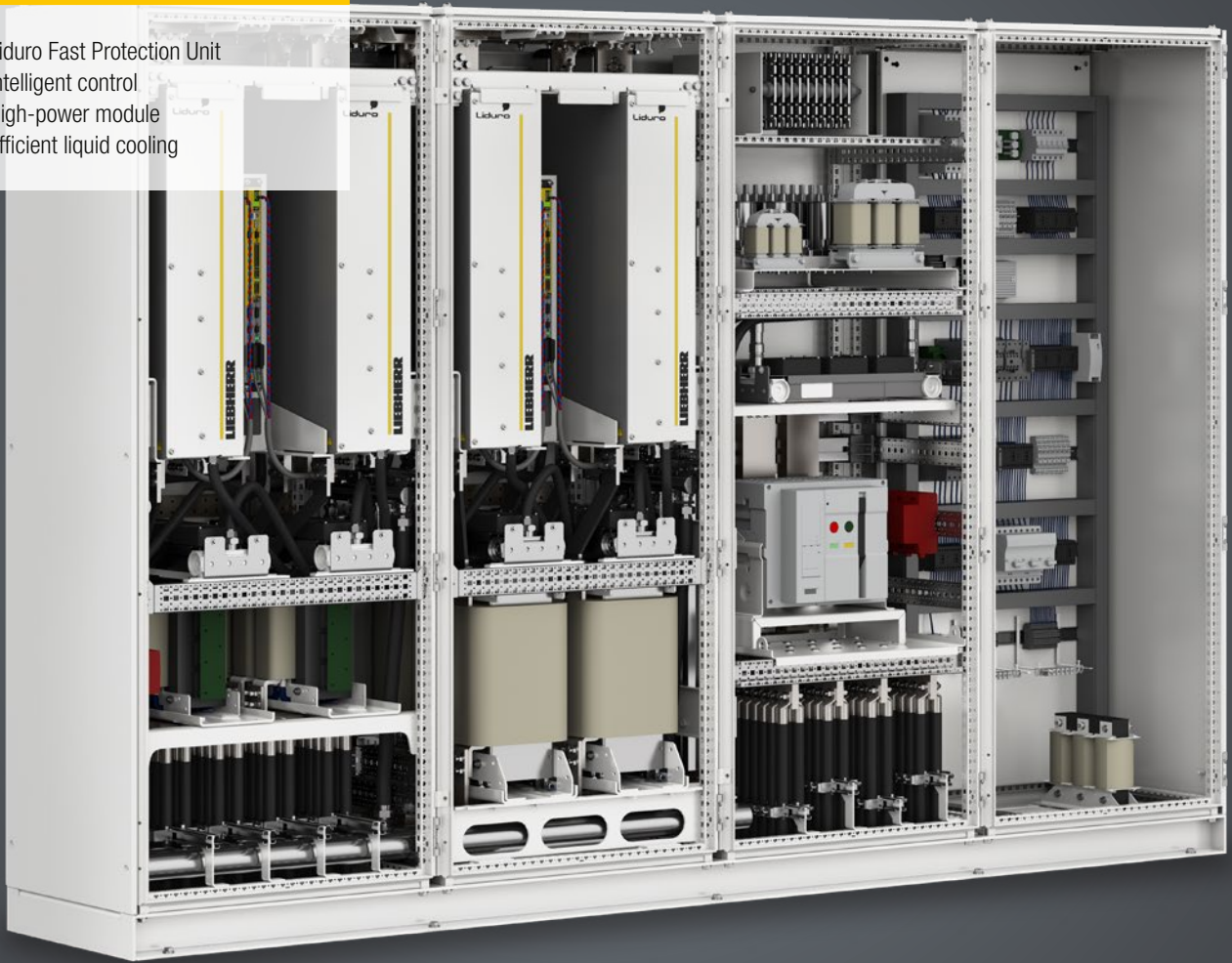
The integrated lubrication system

Due to small oscillations of the rotor blade angle and a resulting displacement of the lubrication at the tooth engagement there can be a high wear of 0° tooth pairs. With the implementation of an integrated solution, the integrated lubrication system inside the gear pinion however, the 0° tooth engagement is optimally lubricated without the need of a lubrication run.



Frequency converter systems

- Liduro Fast Protection Unit
- Intelligent control
- High-power module
- Efficient liquid cooling



Liebherr has developed the liquid-cooled Liduro power electronic modules especially for reliable operation, for harsh environmental conditions in onshore and offshore wind turbines. The power electronic modules are installed in completely closed cabinet units. Together with the coordinated additional components, they form an extremely reliable converter system and reveal a very wide performance range in the smallest footprint. The newly developed and unique Liduro Fast Protection System not only provides operating safety, but also increases the availability of the system in total. In addition, a highly efficient integrated cooling system enables maximum energy conversion with maximum service life of all components. The system is virtually maintenance-free. As for placement, it can be installed both in the nacelle and at the tower base - in-line or back-to-back.

Highest power density with small installation volume

Efficiency and service life

Selected components optimized for operation of the converter system achieve a very high efficiency at maximum power. The liquid cooling allows for very high performance at low power consumption per installation volume. Since there are no fans needed for cooling the converter cabinet, the converter systems are fully self contained, so they are almost maintenance free and low noise. Door fans and filter mats do not have to be changed, as is usually the case with air-cooled systems. This makes an operation, both, at very high and low ambient temperatures possible. Also dust, oily air or humidity cannot penetrate the cabinets. Corrosion and high temperature load changes are avoided. This increases the service life of the converters. Power enhancements without changing the size of the cabinet are possible by a simple exchange of internal components. This reduces the development effort for the different wind turbine types.

Safety and quality

The control and protection system monitors all processes inside and outside the frequency converter system with high precision and reacts to unforeseen errors within a few milliseconds. This isolates possible sources of error as quickly as possible and prevents damage to plant components or persons. The integrated condition monitoring also offers reliable component analysis and information for wind turbine operators before the protection systems are triggered. The reliable components enable for wind turbines a long service life with as low maintenance as possible. Selective main filters allow operation even at weak grids. Finally, the operating status of the system can be proved and analyzed via remote diagnosis on a regular basis.

Highly efficient

The liquid cooling system is a special developed system, to achieve maximum lifetime and smallest installation room.



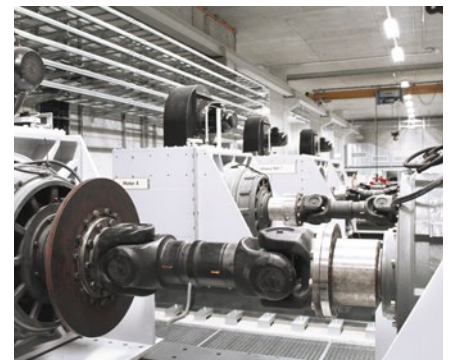
Intelligent control

The custom developed control system enables fast, precise control processes and reliable protective functions.



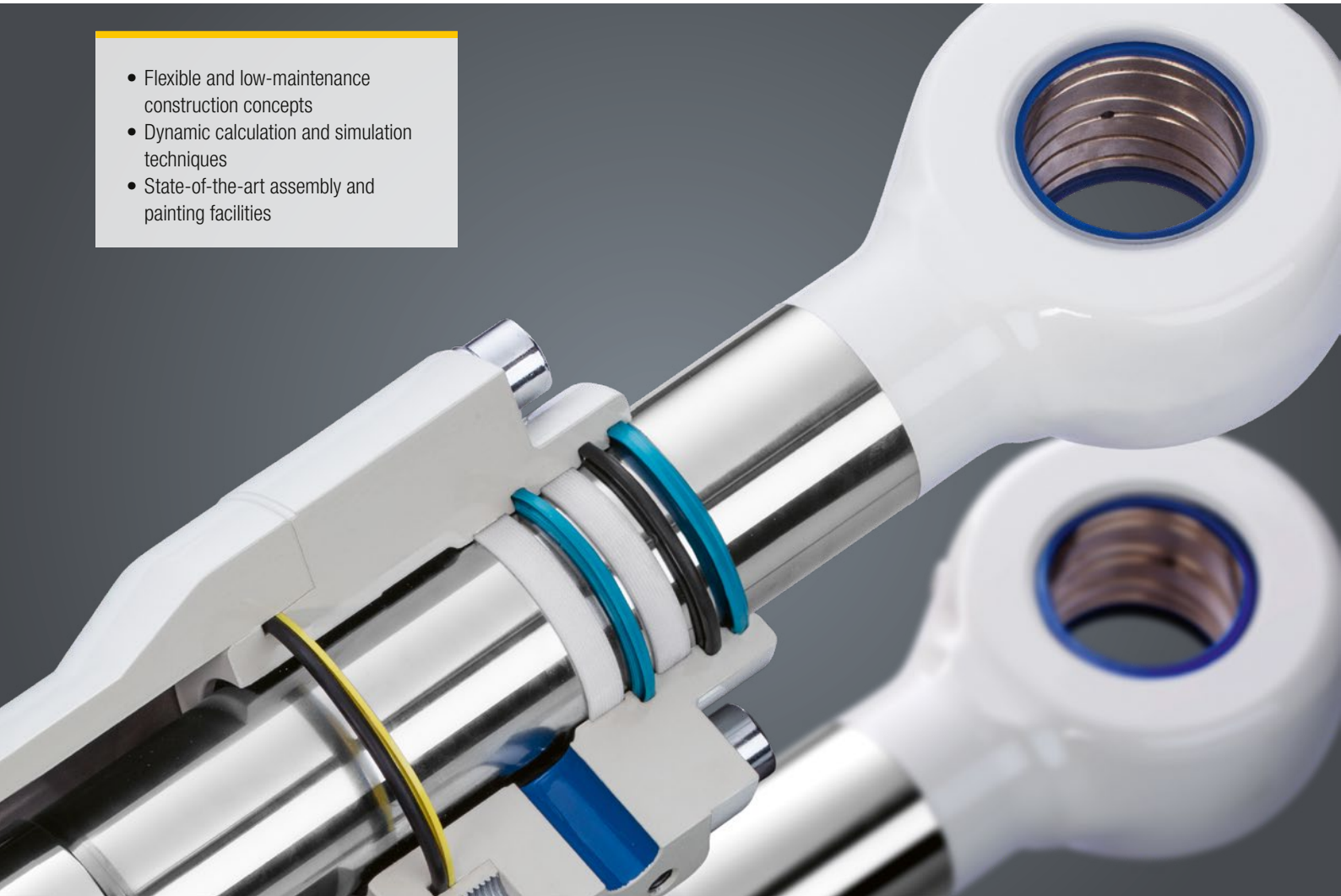
High durability

All components of the system are subjected to extensive test and quality assurance procedures.



Hydraulic cylinders

- Flexible and low-maintenance construction concepts
- Dynamic calculation and simulation techniques
- State-of-the-art assembly and painting facilities



Since 1958, the Liebherr Group has been developing and producing hydraulic cylinders at the main site in Kirchdorf an der Iller. The product portfolio ranges from highly durable hydraulic cylinders for dynamic applications, large heavy-duty cylinders and suspensions to lightweight and special cylinders. Liebherr benefits from its vast experience also in the development of cylinders for wind turbines.

Precise and reliable work under demanding conditions

Longlife and high availability

Liebherr hydraulic cylinders achieve maximum efficiency in non-stop operation thanks to a flexible design which is adapted to the respective application - for example as a tie rod cylinder. The sealing systems are designed to withstand continuous vibrations and high-frequency short stroke operations with low friction and are leak-free. Liebherr cylinders are suitable for both onshore and offshore applications. There is a wide range of special piston rod coatings and cylinder paintings available for optimal corrosion protection.

Development and quality

State-of-the-art analysis and simulation methods are used during the development stage. These methods provide information about the material behaviour and the vibration resistance in realistic operating conditions, thus allowing the right material and sealing to be selected. In order to demonstrate the service life of several decades, hydraulic cylinders for wind turbines are subject to high-speed endurance tests at special test benches. State-of-the-art assembly and painting equipment with a high degree of automation also ensure process stability at all times and the ability to react flexibly to changes in customer requirements.

Furthermore, Liebherr meets its own high quality requirements through continuous material testing, as well as continuous process monitoring. The acceptance of hydraulic cylinders is possible through various classification bodies, for example the DNV Type Approval.

From the individual product to the complete system

In addition to the individual hydraulic cylinders, Liebherr also offers its customers complete hydraulic systems from a single source. Customised hydraulic power units and piston accumulator systems are developed and produced in-house for this purpose. Matching control and valve units round off the range as a system supplier.

Designed to suit the requirements

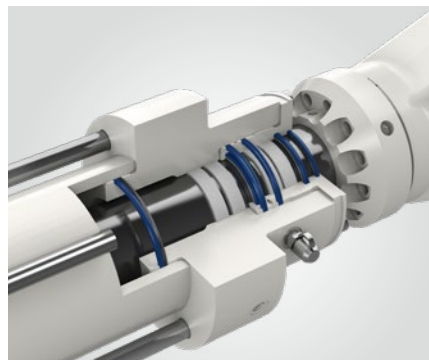
Customer-specific and flexible design concepts allow worldwide availability and service.

Low-maintenance design

Already in the development phase, the components are designed for minimum maintenance and the simplest service conditions in use.

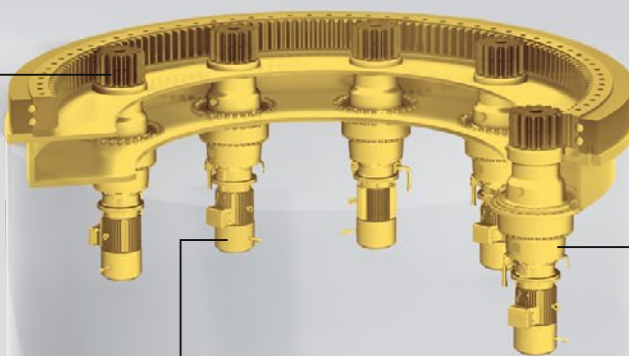
Various design options

The cylinders can also be optionally equipped with various sensors, cushionings as well as specific interfaces and hydraulic connections.

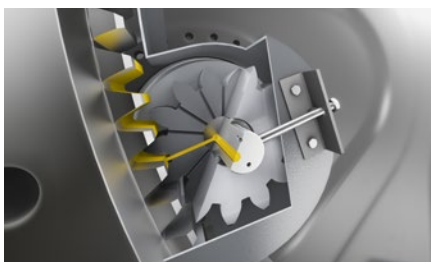


System mindset and know-how

- Modularization based on standard components
- Wide range of configuration options
- Optimized value chain - more flexibility



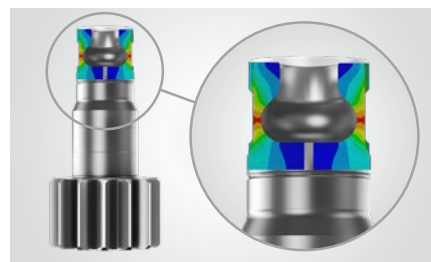
Integrated lubrication system



Electric brake system



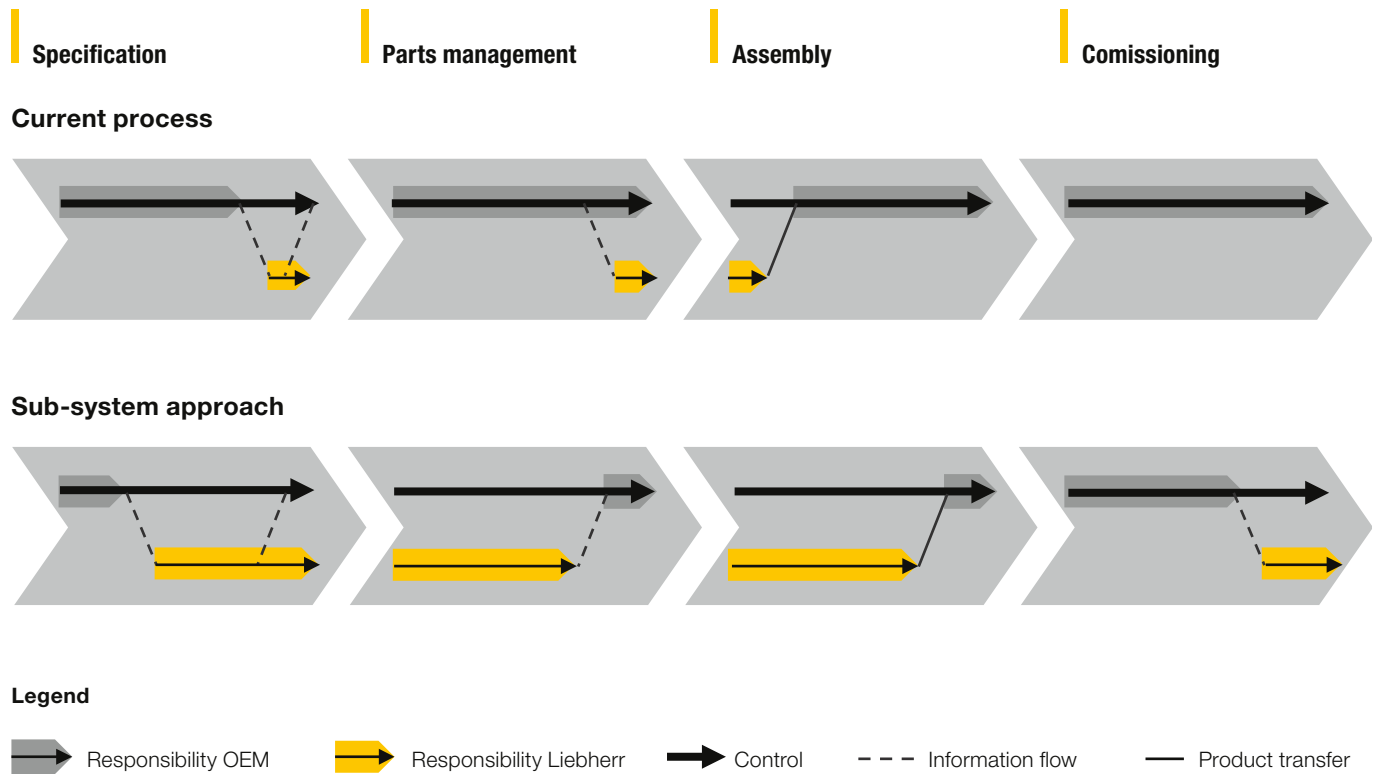
Overload protection



Flexibility on a new level: The yaw module concept is one example how to enable application-specific, cost-optimized modularization based on standard products without geometric restrictions. Hub and nacelle assemblies could also be optimized based on a sub-system approach. How could your company benefit from sub-system approach from Liebherr?

The sub-system approach

The implementation of a sub-system as a ready-to-install module enables processes to be simplified and resource locations to be optimized along the entire value chain.



Specification

One general sub-system specification instead of individual specifications for each component.

Parts management

Module management instead of individual management for each integrated component.

Assembly

- No specific production line required
- Functionality test is performed by Liebherr
- The module is delivered on site, ready for installation

Commissioning

- Easy access for service work
- One system - one contact

A strong partner for the wind industry

Liebherr has one of the most diverse portfolios of all suppliers for the wind turbine industry. From the gear cutting machine by which the demanding blade and yaw bearings are machined, to the onshore and offshore cranes, excavators and concrete mixers used during construction of wind farms. Liebherr is a reliable partner for the wind industry at all times.

Liebherr concrete mixing plants

Liebherr concrete mixing plants ensure that the required concrete for tower elements and foundation for modern wind power plants is available in high quality.

Tower cranes

For the construction of wind turbines with hub heights above 110 m in low wind areas, Liebherr has developed special tower cranes.

Mobile cranes

For ever more powerful systems and increasingly taller towers Liebherr develops performance-optimized mobile cranes and jib systems for particularly high loads.





Mobile harbour and ship cranes

Mobile harbour and ship cranes by Liebherr transport and load heavy wind power components e.g. onto ships, jack-up vessels, low loaders or freight wagons.

Gearing cutting and automation solutions

Slewing bearings for rotor blade and yaw adjustment are manufactured on high-precision Liebherr gear machines. With automation systems by Liebherr, rotor blades can be processed economically.

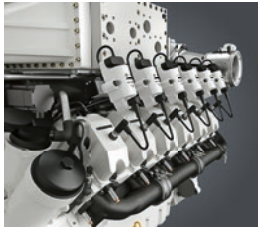
Crawler cranes

Liebherr offers crawler cranes in different performance classes, which are used in the construction of wind power plants.

Key components for wind turbines

With slewing bearings, drives, electric motors, hydraulic cylinders and frequency converter systems Liebherr supplies the entire product range for the electromechanical and hydraulic blade and yaw adjustment in wind turbines. In addition, Liebherr now supplies main bearings and full frequency converter systems for 2MW turbines and upwards.

Liebherr Components



Gas engines



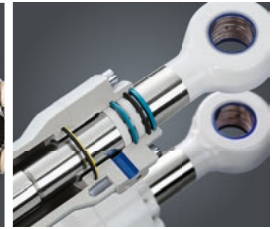
Diesel engines



Fuel injection systems



Axial piston hydraulics



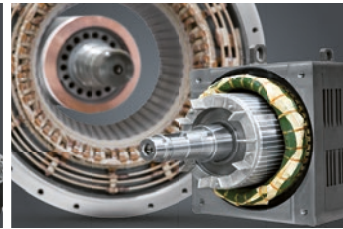
Hydraulic cylinders



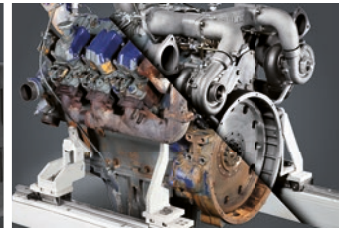
Slewing bearings



Gearboxes and winches



Electric machines



Remanufacturing



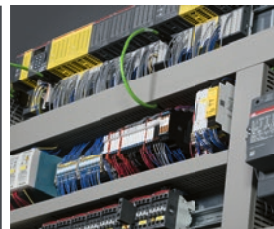
Human-machine interfaces and gateways



Control electronics and sensor technology



Power electronics



Control cabinets



Software

From A to Z – the components division of the Liebherr Group offers a broad range of solutions in the area of mechanical, hydraulic, electric and electronic drive system and control technology. The efficient components and systems are produced at a total of ten production sites around the world to the highest standards of quality. Central contact persons for all product lines are available to our customers at Liebherr-

Components AG and the regional sales and distribution branches.

Liebherr is your partner for joint success: from the product idea to development, manufacture and commissioning right through to customer service solutions like remanufacturing.

components.liebherr.com