SCD® Technology

The next generation becomes reality

Vision

Today we all know that fossil energy sources are limited and that the hunger for energy is still growing despite this. Especially new markets like Brazil, China or India have reached a pace of rise in energy demands which will sooner or later lead to unforeseeable consequences for the entire planet. Also the severe incidents in the history of nuclear power plants have demonstrated how absurd the use of this dangerous technology is.

This new century requires new thinking and a powerful vision of efforts that could provide suitable technologies.

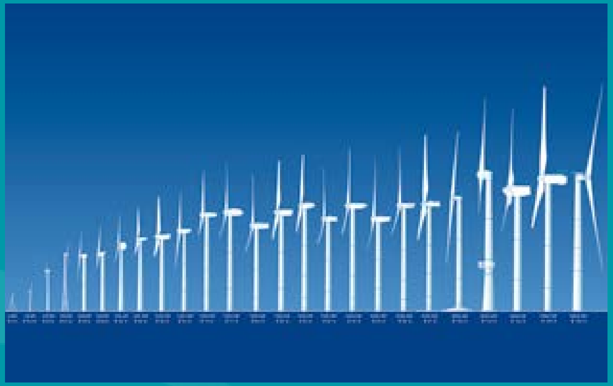
Therefore, a 'next generation' technology must not be developed. The secret is to use available know-how and standards and navigate them to the right direction. All the pieces that make up ideas have to be brought together. Old conventions are to be seen as new challenges and not as restrictive factors. As the German scientist Alexander von Humboldt said, "Kühner als Neues zu entdecken, kann es sein, Bekanntes zu bezweifeln" (It can be more daring to question the known than to investigate the unknown). Experience gained through learning, together with innovative concepts, using state-of-the-art technologies and not being influenced by general market leaders can be seen as one of the ideas behind aerodyn engineering.

A part of the vision of being successful with the disputed two-bladed turbines already became reality with the success of SCD technology. But the vision of setting new standards in the world of wind energy still continues to be the activator on our innovative way to turning the power of nature into the energy that we need. aerodyn engineering's knowledge and experience spur on a high level of motivation to develop always one step ahead of the conventional market. And all that in an environmentally friendly way of treading the blue planet with the respect that it deserves.

In spite of the so-called global market, the production of energy is still a local key factor of success and, consequently, methods must be provided that generate energy with the right equipment for local conditions. Local producibility is one of the roads that lead to using local potential to be as independent as possible of global markets wherever this is possible.

aerodyn engineering with its founder and owner, Sönke Siegfriedsen, is driven by the idea of shaping the future in the right direction.

Background

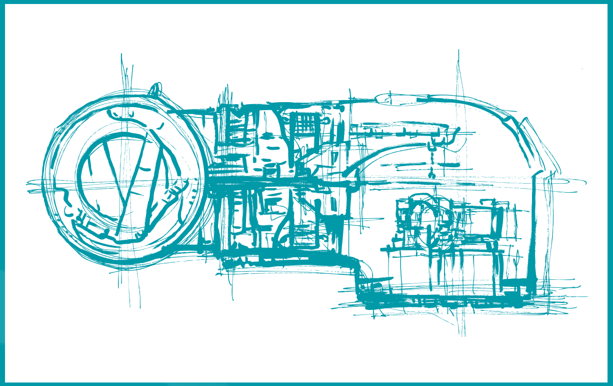


30 years is a long time in the wind energy sector. No wonder that aerodyn Energiesysteme GmbH and especially its founder, Soenke Siegfriedsen, is considered to be a real pioneer of wind energy. As early as 1984, a year after being founded, aerodyn undertook groundbreaking work with the first complete development of a 25 kW wind turbine and its testing in the test field on the North Sea island of Pellworm. This initial project delivered well-founded knowledge about aerodynamic behaviour, mechanical loads and turbine control engineering. Over the following 30 years aerodyn has developed nearly 30 types of wind turbines, from 5 to 6,500 kW, and has worked for companies around the world. Wind turbines designed from aerodyn, or in whose development aerodyn played a significant role, are producing energy on all five continents, with a total number of 26.000, and an installed capacity of around 31,000 MW. That equals 12.3% of the total worldwide installed wind energy capacity. Without any doubt, this figure sets aerodyn apart as the world's leading independent engineering firm for the development of complete wind turbines and single components – and it is clear that many innovative concepts and developments from aerodyn have influenced the current state of the art.

The work carried out by aerodyn's skilled engineering team includes the development of innovative wind turbine concepts, structural dynamics and load calculations, component design, component optimisation, aerodynamic and structural rotor blade design, finite element analysis for cast, welded and fibre composite components, as well as the compilation of complete documentation for manufacturing and certification. Thus, aerodyn offers wind turbine and component manufacturers in all fields of wind-energy engineering comprehensive know-how and services, which allow them to produce even more reliable, better-performing and lower-priced wind turbines. With its high innovative capacity and constant striving for optimisation, the company developed the Multibrid technology in the mid 1990s. This was the starting point for many further developments, all leading the way to the Super Compact Drive (SCD) Technology.


SCD
Technology
THE NEXT GENERATION OF WEC
full-scale model of a 2.5-3.0 MW Onshore-Turbine
conventional WEC
SCD 2.5/3.0
SPECIAL CHARACTERISTICS OF SCD:
ADVANTAGES OF SCD:
designed by aerodyn
aerodyn

Concept



In 1996, aerodyn founder Soenke Siegfriedsen came up with the idea of Multibrid technology. The basis for it was a drive train with a one-stage planetary gear box and a slowly rotating generator, the rotor bearing arrangement within the 1st gear stage as well as the integration of the gear box, the generator and the yaw system in a single housing. That is to say, a design concept that operates without any fast-moving components and protects all sensitive parts within a single housing. The result is reduced wear and a high level of reliability; without doubt a groundbreaking innovation, for which the father of this hybrid solution, Soenke Siegfriedsen, obtained multiple patents and the basic concept of which has since been adapted by many companies. Soenke Siegfriedsen has thus far registered 39 patent families, from which 152 nationalised patents have been granted. In 1999, aerodyn received for this design of the Multibrid technology the IF Award of the Hanover trade fair.

The SCD Technology is a further development of this innovation. The first patent was applied for in 2007. 16 further patents followed in subsequent years. In 2009, the technology received the renowned HUSUM WindEnergy Technology Award at HUSUM WindEnergy, the leading international trade fair for the wind energy sector. The jury's opinion states that the overall design stands for the aim to 'increase the cost-effectiveness of wind turbines, reduce manufacturing, maintenance and repair costs and further improve energy output and reliability.' The underlying idea for the groundbreaking innovation is that the rotor bearing, gear box and generator are arranged linearly with nearly identical diameters and the housings of the components are used for load transfer from the rotor to the tower top.

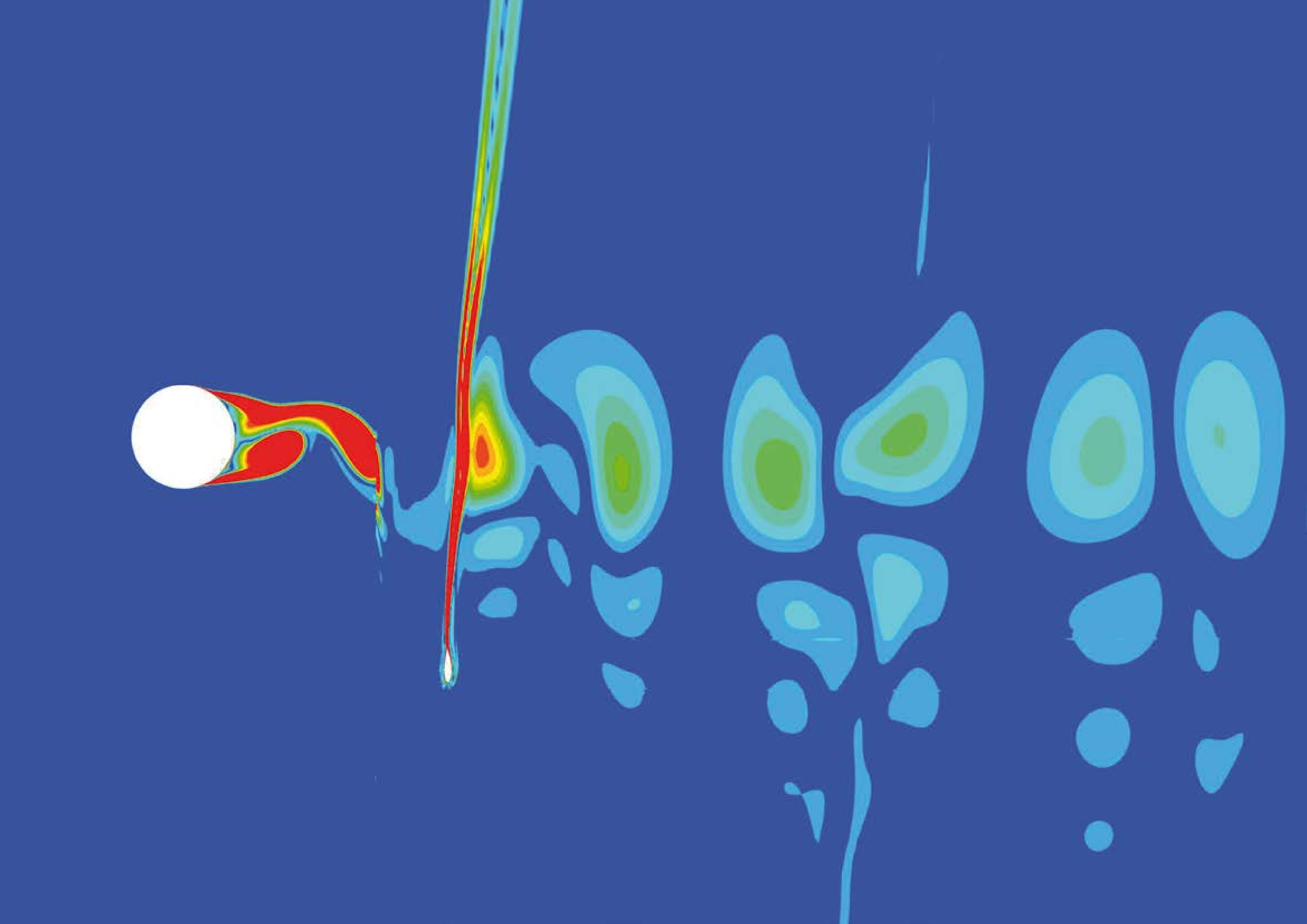
In the SCD, the first of the two gear stages is integrated directly into the main bearing of the rotor. This saves space. In case of the SCD Technology, the extremely compact and small drive train leads to an optimal load transfer and, in consideration of all costs incurred, to particularly cost-effective power generation.

Two-bladed rotor

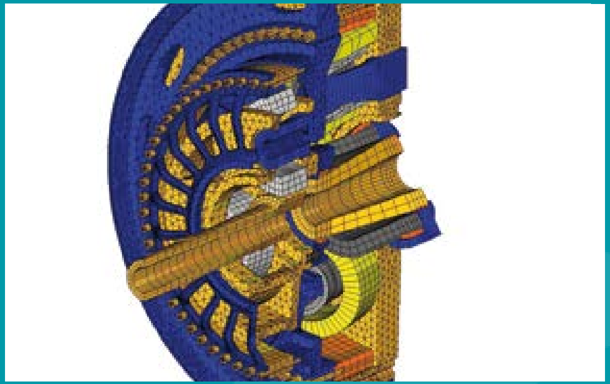
Two-bladed rotors have a very long history. The advantages of a two-bladed rotor were recognized already some decades ago. Back in the 50s of the last century, Prof. Huetter in particular broke ground in the development of future-oriented rotor systems. This work greatly influenced further development in the 70s in Germany, USA and Sweden. In the 70s and 80s a number of 2-3 MW research systems with a rotor diameter of 80-100 m were installed. Some of them were not particularly successful like GROWIAN in Germany, but projects in the USA and Sweden as well were very successful, with the systems producing energy on a reliable basis for more than 20 years. This made it possible to gather much experience and many dimensional results. But acceptance of these systems never materialised because of the visual impact and the slightly higher noise level.

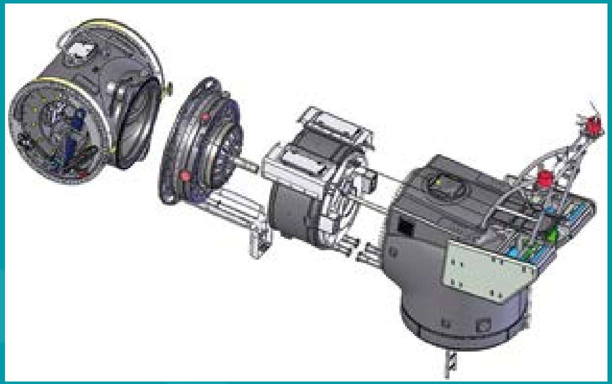
At aerodyn, experience in this field began with the thesis of Sönke Siegfriedsen in 1979 when he developed and built a 500 W two-bladed wind turbine and installed and operated it on the roof of the university. In 1984, a wind turbine with a diameter of 12.5 m and 30 kW was tested with extensive measuring equipment on the Pellworm test field. The dimensional results were incorporated into the drawing up of the first IEC and GL guidelines. Furthermore, these practical findings were extremely important for verification and revision of the calculation applications at aerodyn. In the period that followed, 100, 500 and 1200 kW wind turbines were developed at aerodyn. Extensive experience in the design of two-bladed rotors at aerodyn grew out of these developments and was integrated into the calculation software.

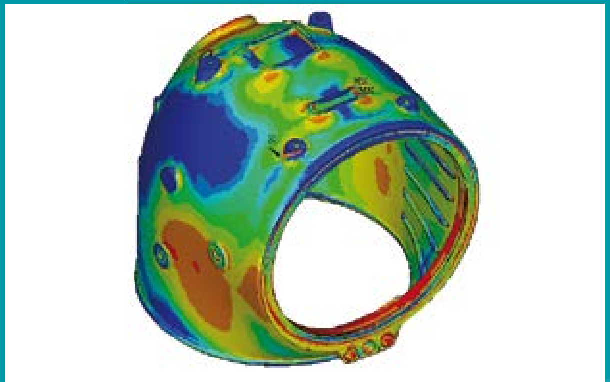
The advantages of two-bladed rotors are for a start the much lighter rotor weight of approx. 70% that of a comparable three-bladed rotor, less torque and consequently a smaller gearbox, the hub design is simpler to produce, there are only two pitch systems and above all there is a noticeable drop in assembly, transport, installation and maintenance expenses. Especially offshore applications are simplified due to the only one turbine lifting stroke. For regions with tropical cyclones, the ultimate loads can be reduced considerably through the horizontal parking position. Furthermore, this parking position makes it possible to install a helicopter landing pad.



Design





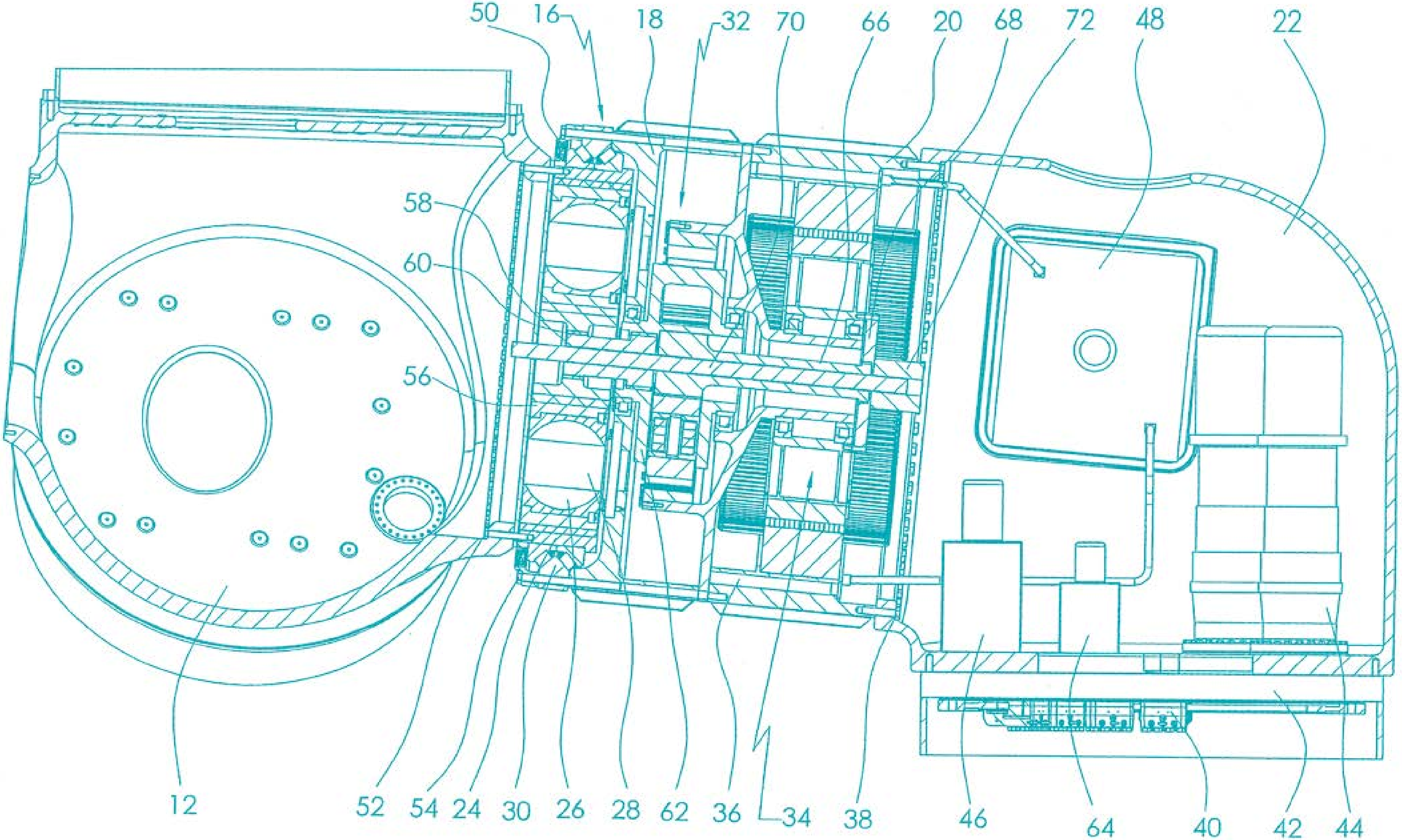


A clearly visible unique feature of the SCD Technology is the use of two-blade technology. The first two – blade wind turbine with a relevant capacity made by aerodyn dates back to the mid 1980s already. When this turbine was designed, a consistent effort was made to avoid anything superfluous. It had to be as compact as possible. The philosophy for the extremely compact turbines and the entire design made in Germany was to 'reduce to the max'. This was achieved with a wind turbine that fulfils the functions of load bearing and external housing and does not therefore contain main frame or housings. The result is a compact turbine that achieves its 3.0 MW output with a transport length of barely 7.8 metres. The tower head mass of the 3.0 MW turbine is approximately 108 t. The 6.0 MW SCD weighs around 308 t and the 8.0 MW around 395 t.

All components have been designed by aerodyn and its partners to interact as well as possible and have been optimised using the most recent methods. The four main components include the hub, the gear box with the rotor bearing, the generator and the head carrier, which is where all other components are housed. Modern simulation programs are used to create a clear picture of component loads. Using these data, superfluous mass could be eliminated and after all, less material also means reduced component and transport costs. The interaction between the rotor blade and the tower wake was calculated precisely using the CFD program. The rectifier section has been installed into the head carrier and the grid-side inverter into the tower base. The inverter complies with all network codes and is also suitable for 50- and 60-hertz grids.

The gear box of the SCD Technology contains a flexpin bearing in which the gear wheels sit on flexible bolts. The advantage is that any movement caused by occurring forces can be compensated. The generator has been designed to be a robust synchronous 16-pole machine with permanent magnets.

A further specific feature is the single blade pitching by the hydraulic cylinder.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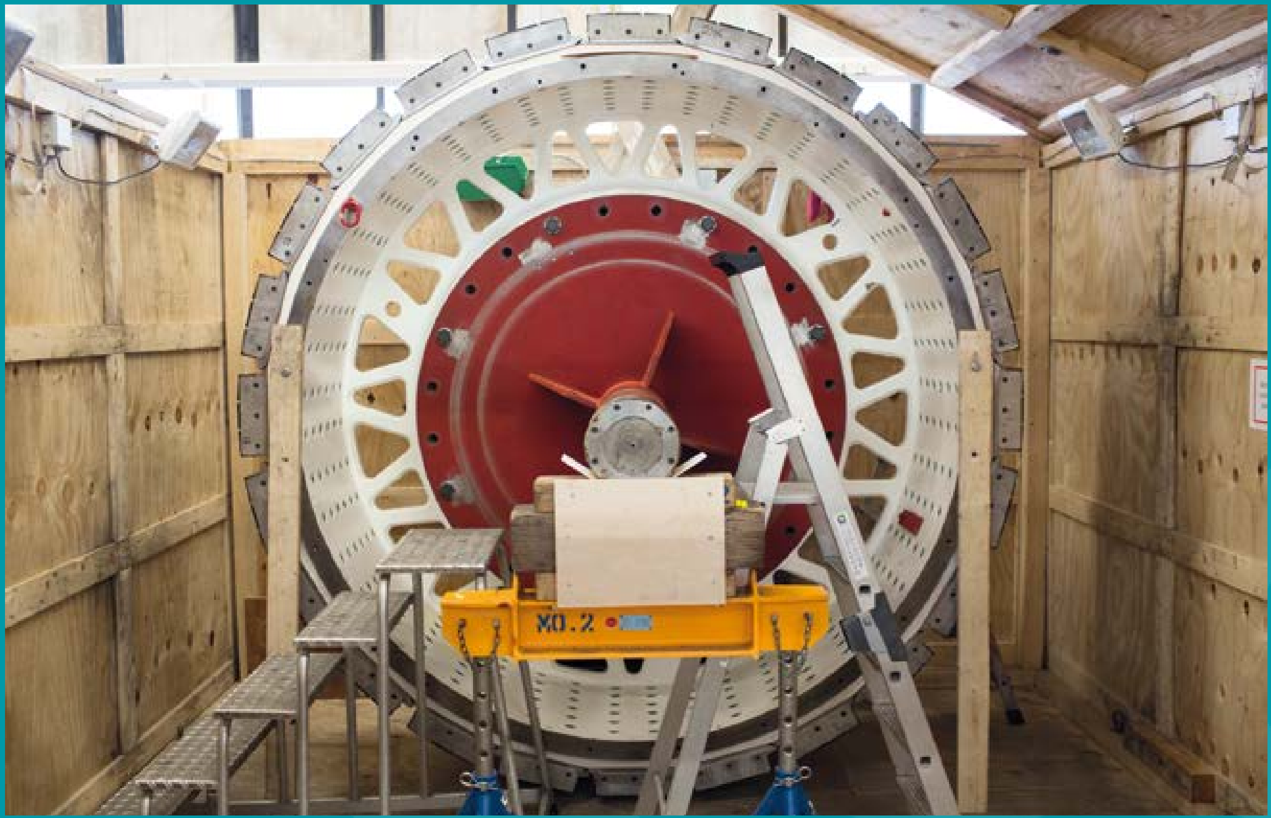
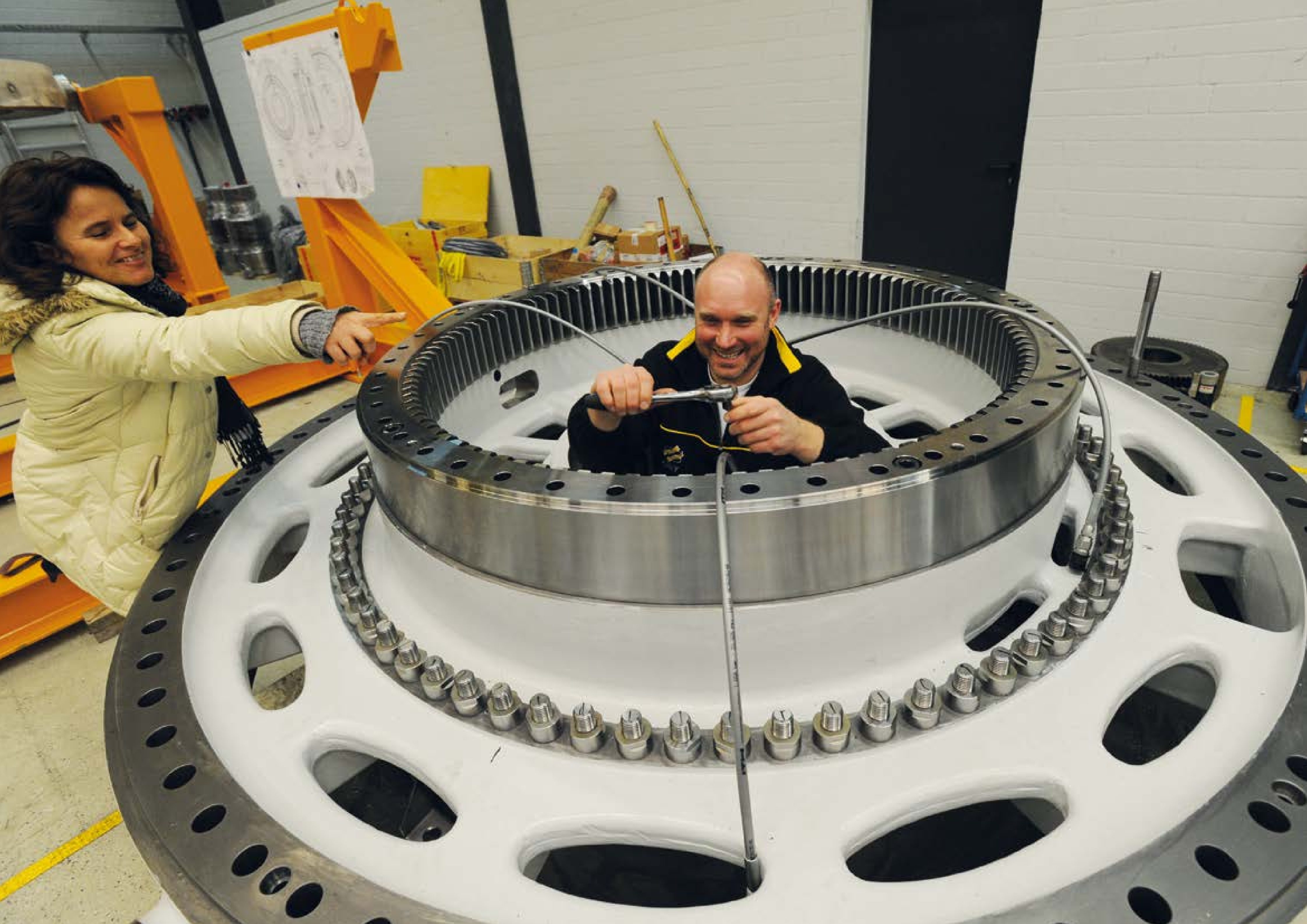
Patents

Patents are required to protect the unique features of such an innovative and unparalleled conception like that of SCD technology from unwarranted copying. The basic patent application was filed back in 2007 and is granted in numerous countries in America, Europe, Asia and Australia. Parallel to the development of the entire turbine technology, a great number of other patent applications have also been filed. These applications concern all the components: rotor blade, hub, gearbox, generator, hydraulics, control system and helicopter landing pad. All these applications do not rest with their German applications but have moved on further into the worldwide process of PCT application. Thus 16 patent families of SCD technology now cover together more than 100 nationalized patents or applications. This provides excellent protection of SCD core components in the main countries that today and also in future are interesting for the use of wind energy. The right of use of these patents will be granted to the licensee as part of a licensing agreement for the production of SCD so that the licensee has sole right to this technology in the area covered by this license.

Production – Generator



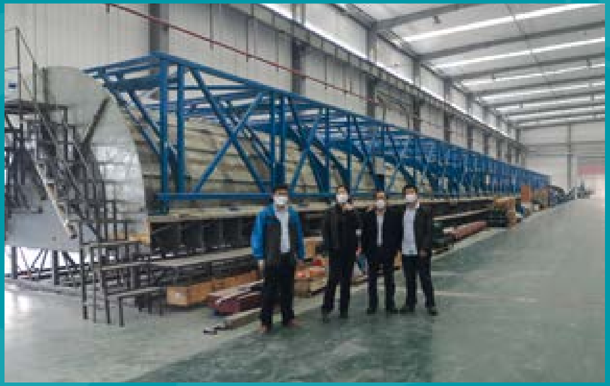
A long history in the designing of generators qualified an experienced partner to develop a compact, efficient and robust generator together with aerodyn engineering. Focus has been on optimized manufacturing with fewer parts for easy assembly, for robust field use and an almost maintenance-free lifetime. The permanently excited air-cooled synchronous generator with its proven concept is screwed directly to the gearbox housing and forms the compact drive train unit. No need for time-consuming adjustments at all. The stator is equipped with the coil and the rotor is equipped with permanent magnets. It is entirely up to the licensee to decide whether to be independent of the world market of generator suppliers or to use in-house capacities or to develop in-house production. He can take exactly the road he needs. The entire documentation set for the supplier as well as the aerodyn engineering support team can qualify or support the proven process - regardless of whether in-house manufacturing is planned or not.



Production – Gearbox

Sometimes simplicity is the key to more robustness. Easily said - but difficult to achieve. Innovating gearbox engineers have succeeded in creating a compact and reliable gearbox. Impressively shown in a GL behaviour test and in the meantime in onshore and offshore field use. The aerodyn engineering two-stage planetary gearbox with its integrated main bearing has been designed using only a limited number of parts for optimized robustness. New manufacturing technologies and high-end surfaces made this possible. No adjustments are required for integration with the generator to become the drive train. A licensee can decide to manufacture and assemble in-house depending on the know-how and potential that is available or to commission a partner with the assembly. Due to the unique design a highly qualified gearbox manufacturer is not required. It is part of aerodyn's concept to work worldwide with motivated and qualified firms in the mechanical engineering industry. aerodyn engineers can support or qualify those suppliers to set up a production process that suits the supplier needs as well as in-house production. In any case, the entire process for all components in the hands of the licensee is independent of the market. Thus more flexibility is the result which in turn means costs can be controlled.

Production – Blade

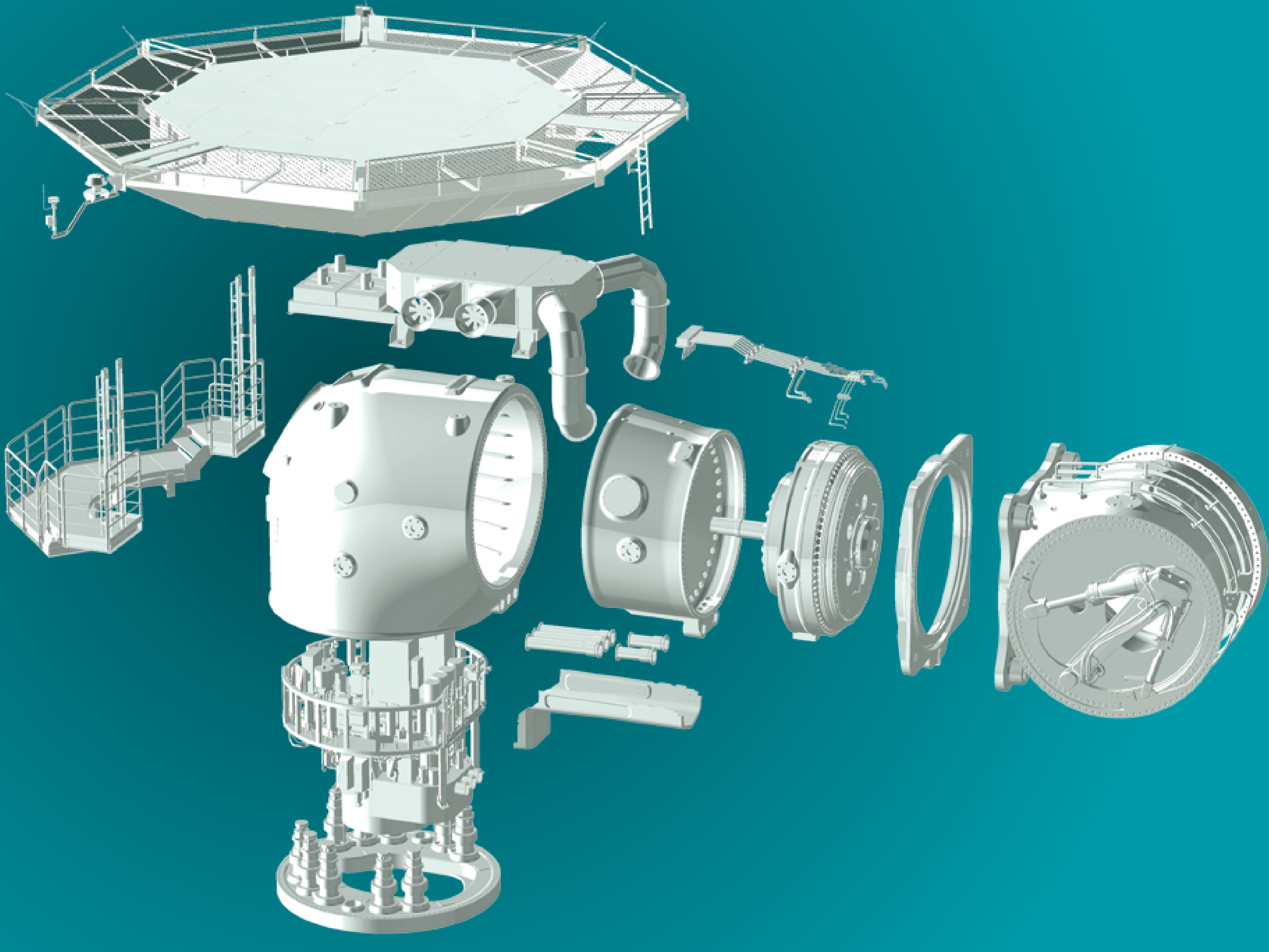


SCD blades reflect more than 30 years experience in the design of blades and the in-depth knowledge of leading blade engineers has made it possible to develop these blades not only for optimal efficiency but also to design them for a cost-effective production.

The make or buy decision lies in the hands of the manufacturer. Full guarantee is given for a complete and verified documentation set for the entire blade process – from tooling to the final quality document, no matter whether the licensee decides on an in-house production or whether he decides to purchase the blades on the world market. Whatever the case is, aerodyn specialists can qualify or support the production steps to guarantee smooth processes and to identify issues before they become expensive or critical.

Production – Hydraulic

The entire hydraulic system has been developed by aerodyn engineering supported by a supplier with more than 50 years of experience. This system is the core unit inside the head carrier of the SCD turbine. As such it provides the hydraulic oil pressure for the yaw brake system, for the rotor brake system, for the rotor lock system and sends hydraulic power through a rotary unit to the pitch hydraulic distribution unit inside the rotor hub. Also part of this complex unit is the lubrication oil unit which supplies filtered oil at the defined pressure and at the required volume flow to the gearbox and to the generator bearing unit. Depressurized oil flows back into the tank of the hydraulic station and is restored to the required conditions in terms of temperature and cleanliness. It has been already tested fully at the supplier's site for efficient integration and final workshop commissioning, meaning that no further adjustments during assembly and commissioning are required. During workshop integration, the two separate oil tanks need only be filled up and connected to all interfaces.

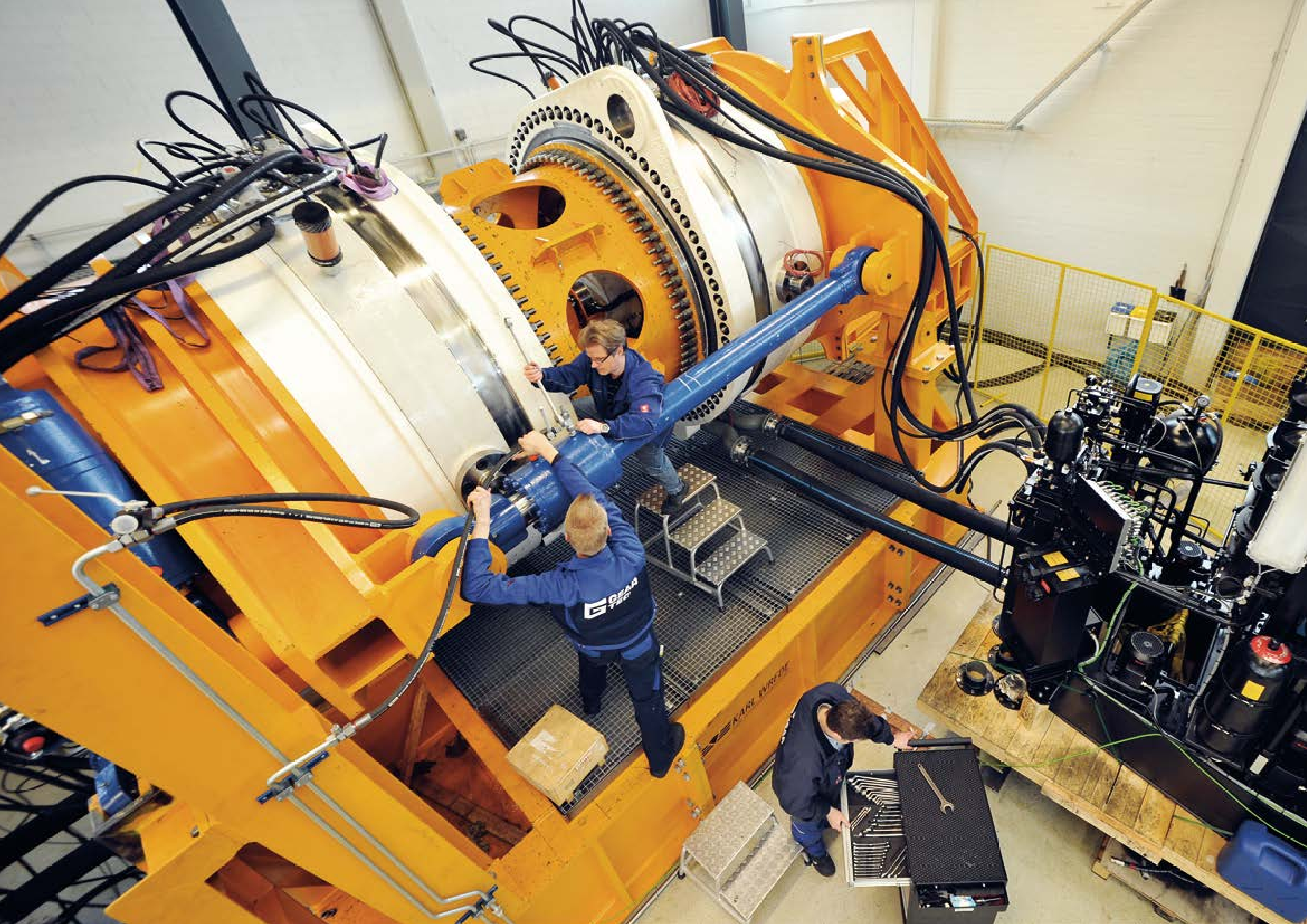


Assembly

The main components of the SCD prototype have been assembled in Germany and Switzerland by qualified specialist personnel. This is also where incoming goods controls have been carried out and where test records accompanying assembly have been created.

The assembly of components can, however, take place anywhere in the world. It is only necessary to have suitably large workshops and special tools, well-trained qualified personnel and the documentation from aerodyn. A licensee of aerodyn will receive plans for assembly workshops for various production quantities, drawings of assembly equipment and assembly instructions as well as test records, which are to be completed during assembly and countersigned. The documentation also describes the optimal course of assembly. For the assembly of the turbine, aerodyn recommends the setting up of four assembly lines: one for the hub, one for the gear box, one for the generator and one for the head carrier. During the sub-assembly of components, detail tests be carried out, for example on the gearbox, generator, yaw system and electrical equipment. If it is necessary, the experts from aerodyn can provide appropriate training and support for the assembly on site.

Due to the compact construction and the limited number of components, only little time is required for the assembly of the SCD wind turbine. The SCD turbine also fulfils all requirements for a problem-free and quick series assembly. The complete wind turbine can be assembled in a respective assembly workshop, including the mounting of the hub and all components as well as the installation of all electrical cabling. Thereafter, the turbine is ready for a full load test.



Test

How good a technology really is only becomes clear under real conditions. In order to be able to closely test and verify behaviour, functioning and design data, aerodyn has developed its own gear box test stand.

The gear box is tested using the so-called back-to-back procedure with maximum torque, more than 3.0 MW output and correspondingly high torques. The test stand is equipped with comprehensive measurement technology to determine the deformation and load distribution, temperature and vibrations as well as the degree of efficiency. The test stand also has the ability to apply the bending moments of the rotor to the gear box.

The simulation of a realistic environment is the endurance test for the SCD turbine. Under the supervision of a certification institute, the gear box is disassembled after the test in order to determine the typical running-in behaviour and the effect on the gearing. This testing could also verify the effectiveness of the flexpins as proved by the outstanding attestation of the certification institute.

In the test of the entire turbine, also supervised by a certification institute, the drive has been tested over 24 hours at an output of up to 3.0 MW. This operational test closely examines the interaction of every component and tests their functional performance.

The certification institute's overall assessment of the entire SCD Technology was also excellent. Which is no wonder, as all of design data were either confirmed or topped. The successfulness of the tests is illustrated by one figure: the load distribution factor for the gear wheels is an incredible 1.01. Furthermore, these excellent values have already been confirmed multiple times. In China as well, the SCD has passed comprehensive tests with flying colours. It goes without saying that every SCD turbine assembled is first comprehensively tested and inspected. All experiences from the 3MW testing are basis for design and testing of all following SCD products like 6 or 8MW.


中国华电

Erection

The advantages of the compact and lightweight design of SCD turbines are of course also clear during transport. The 3.0 MW turbine has a transport length, including the hub, of a length 7.8 m, a width of 3.2 m and a height of 3.8 m. The tower head mass, including the rotor blades, is 108 t. This makes it the lightest wind turbine in its size class available on the market. Lightweight components are not only simpler to transport, they also shorten assembly times.

The erection of a SCD turbine takes less than a day and requires no more than a handful of personnel. Both blades of the wind turbine as well as the hub can be mounted onto the turbine on the ground while the tower is erected alongside. All electrical and hydraulic connections can also be put in place and tested on the ground. First, the inverter and the control system are installed into the lower section of the tower. This is followed by the mounting of the three-piece tower including the lift cage. The final step is the placement of the nacelle and the rotor with the blades onto the tower top in a single lifting procedure. A single crane is required for the erection. Unlike with many other turbines with three blades, a second crane for turning the rotor in the air is not required. Assembly is short and simple for offshore turbines as well. It is significantly shorter and simpler than that of any three-blade wind turbine on the market. And, after all, less time means reduced costs.

The fact that even the worst conditions cannot affect this speedy process was demonstrated by the erection of the prototype in Urumqi in northwestern China, where the weather was dominated by high wind speeds and very cold temperatures.

Especially the offshore erection will be fundamentally influenced by this easy way of erection.


中国华

Projects

There are several wind turbine versions of the SCD technology for different climate zone and for offshore conditions. The differences between these versions lie in the details of cooling and pre-heating systems. In the offshore turbine a special casing of the tower and the nacelle is used. Every component has a special coating in order to ensure long-term protection against corrosion. Furthermore, motors, sensors and actuators as well as electronic components are designed to be redundant. The failure of a small component therefore does not require that a repair team be immediately dispatched to the wind turbine in order to exchange components.

Depending on regional wind conditions, the SCD 3.0 MW is provided with varying rotor diameters. The selection includes 100 m for type class IIa+, 110 m for type class IIIa and more. Standard tower height is 85 m. Other heights are available – depending on regional conditions and requirements – and can be designed for specific locations.

The 6.0 MW SCD Technology particularly shows its strengths offshore as well as in areas threatened by tropical cyclones. A special method of operation has been implemented for those areas, which reduces loads and with that increases the safety in the event of tropical storms. This is achieved by allowing the turbine to react quickly to the changes of wind direction – among others because as a downwind turbine it passively aligns itself in wind direction and because of the horizontal parking position of the rotor. The targeted horizontal parking of the rotor significantly reduces extreme loads and, as a result, the tower and foundation weight. This is effective even under the heaviest typhoon conditions and thereby also reduces the load on the entire machine. On the one hand, it increases the probability of survival and on the other hand, it makes the presence of wind turbines in typhoon areas possible in the first place.

Offshore

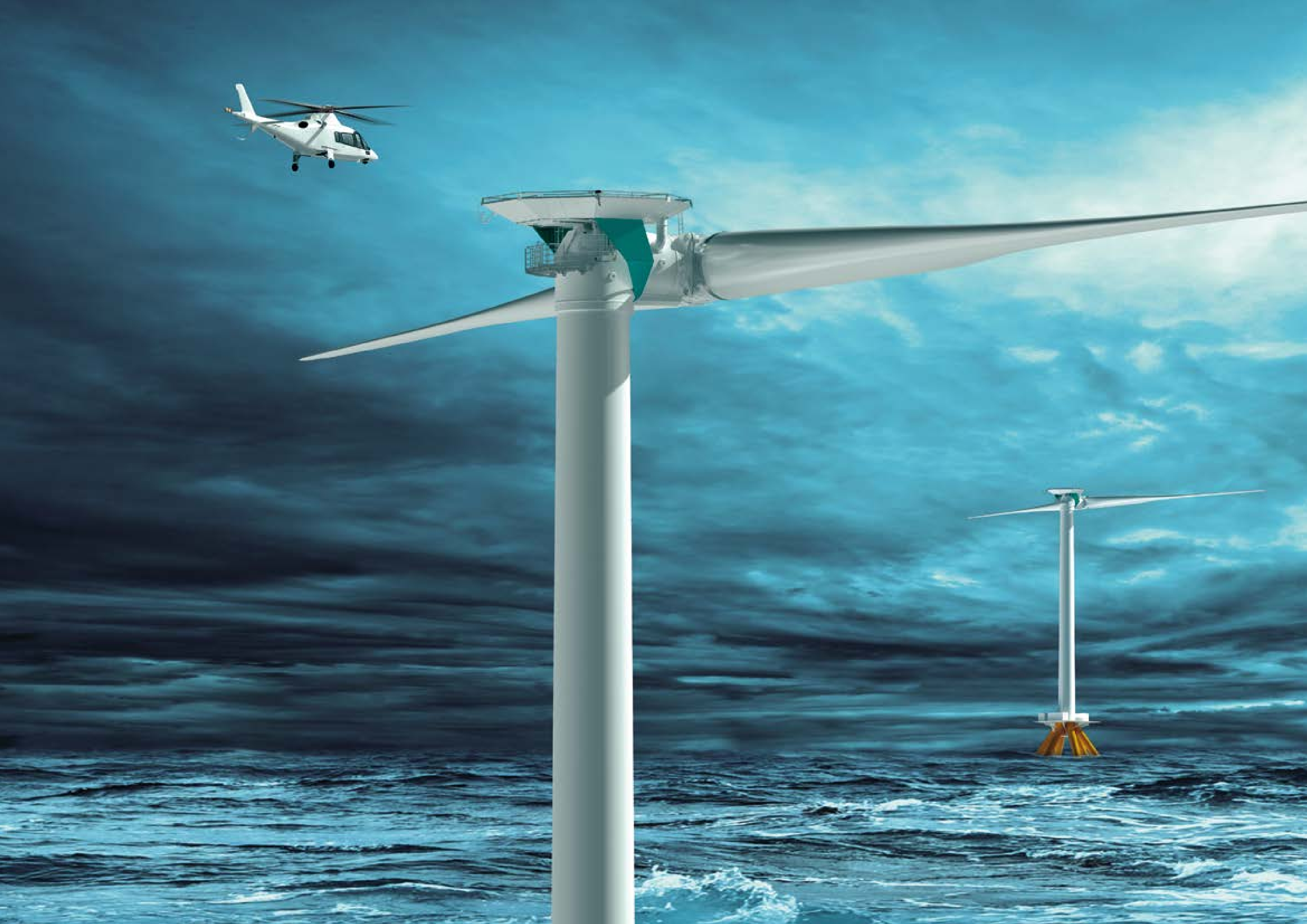
The 6.0 MW SCD Technology particularly fulfils all the requirements of challenging offshore use. The assembly of the entire machine head including the hub and both blades takes place in harbour. It is then possible to transport the turbine together with installed blades, since they pass through any lock. The following erection at sea takes place in a single lift onto the tower. This simple concept reduces both the costs and the efforts of the erection team or the number of personnel required on site, respectively.

The offshore version of the SCD Technology especially demonstrates its stability through the use of a further innovative concept: it is hermetically enclosed and has a closed cooling concept with an air-air heat exchanger. This prevents the penetration of salt and the resulting corrosion.

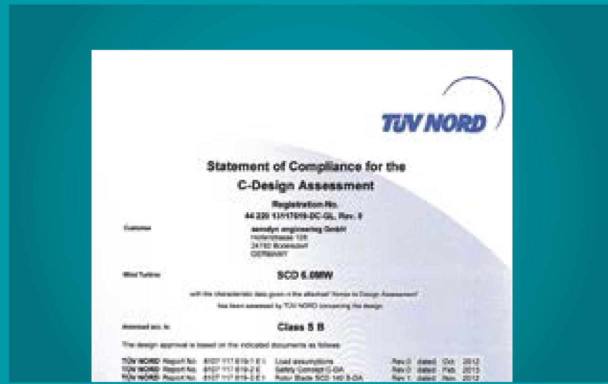
A significant characteristic of the SCD Technology is its use of redundant components, which guarantees a high level of reliability. For example, the 6.0 MW machine includes not two, but three 3.0 MW inverters. So in case one inverter has a defect, the turbine can produce further with full power output. These increase the economics of the turbine.

Hydraulic pumps and other components are also integrated in surplus. In the event of damage, a defective unit can simply be switched over to a functional one and the turbine produces further energy.

The SCD turbine naturally features remote maintenance and remote control. Video surveillance is also provided, as is a conditioning monitoring system for early detection of defects. Any irregularities that occur are immediately reported to the central control unit with a corresponding interpretation. The warning is accompanied by a recommendation how to deal with the fault. If something does require maintenance on site, personnel and replacement parts can be brought to the wind turbine by air using the installed helicopter landing platform.



Certification



A certification institute supervises the development phase to guarantee the quality of the construction, design and calculation while still in the design process. During this process, the requirements for the documentation are agreed upon and set. These documents include: concept description, load calculations, all tensile strengths of all load-transmitting elements, drawings of all components, functional verification of safety-relevant components, manuals for assembly, installation, operation and maintenance. Furthermore, the certifier must accompany the blade and gearbox test in order for the A-Design Assessment to be issued. Not only that, an expert from the certification institute must accompany commissioning of the prototype and confirm that it was done in compliance with the submitted documents. For SCD wind turbines, all documents are inspected and confirmed by Germanischer Lloyd or TÜV Nord (German Association for Technical Inspection) using their own comparative calculations. This entire process gives us the assurance that the whole design was conducted in compliance with the state-of-the-art and the conditions of the guidelines. This is rounded off by the handover of the Design Assessment certificate.


SCD 3.0 MW
SCD 6.0 MW
SCD 8.0 MW

Products – Technical data

Type class	TCIIIA (onshore)	TCIIB (offshore)	TCIB + (offshore)
Rated power	**3.000 kW**	**6.000 kW**	**8.000 kW**
Principle	Upwind	downwind	downwind
Power control	Pitch controlled regulated	Pitch controlled regulated	Pitch controlled regulated
Cut-in wind speed	3 m/s	3 m/s	3,5 m/s
Cut-out wind speed	20 m/s	22 m/s	25 m/s
Nominal rotor speed	17,1 min^{-1}	13,6 min^{-1}	11,5 min^{-1}
Tower			
Hub height	85 m (or site specific)	100 m (or site specific)	100 m (or site specific)
Tower design	conical steel tube	conical steel tube	conical steel tube
Turbine head			
Turbine head mass incl. Rotor with blades	108 t	308 t	395 t
Turbine head size (l * w * h)	7,8 m * 3,2 m * 3,8 m	11,7 m * 4,5 m * 5,3 m	12,2 m * 4,5 m * 5,7 m
Tilt angle	5°	0°	0°
Rotor			
Cone angle blade to blade	0°	9 °	7 °
Rotor diameter	110 m	140 m	168 m
Rotor blades	2	2	2
Rotor locking mechanism	2 hydraulic bolts	4 hydraulic bolts	4 hydraulic bolts
Pitch system Pitch system			
Pitch actuating mechanism	2 Hydraulic Cylinders per blade	2 Hydraulic Cylinders per blade	2 Hydraulic Cylinders per blade
Drive Train			
Gear box	2-stage planetary gear box	2-stage planetary gear box	2-stage planetary gear box
Generator	Permanent magnet synchronous generator	Permanent magnet synchronous generator	electrical exited synchronous generator
Generator speed	410 min^{-1}	315 min^{-1}	308 min^{-1}
Yaw system			
Yaw drive system	4 x gear boxes with electric motor	10 gear boxes with hydraulic motor	10 gear boxes with hydraulic motor
Yaw brake system	12 x hydraulically applied active brakes	18 x hydraulically applied active brakes	18 x hydraulically applied active brakes
Electric system			
Converter system	Full converter	Full converter, redundant 9 MW	Full converter
Controller	Siemens PLC	Siemens PLC	Siemens PLC

SCD-Technology
One Step Ahead

aerodyn engineering gmbh
Hollerstraße 122 · 24782 Büdelsdorf · Germany

phone: +49 - 43 31 - 4 37 07 34
fax: +49 - 43 31 - 4 37 08 85

email: info@aerodyn-engineering.com
www.scd-technology.com