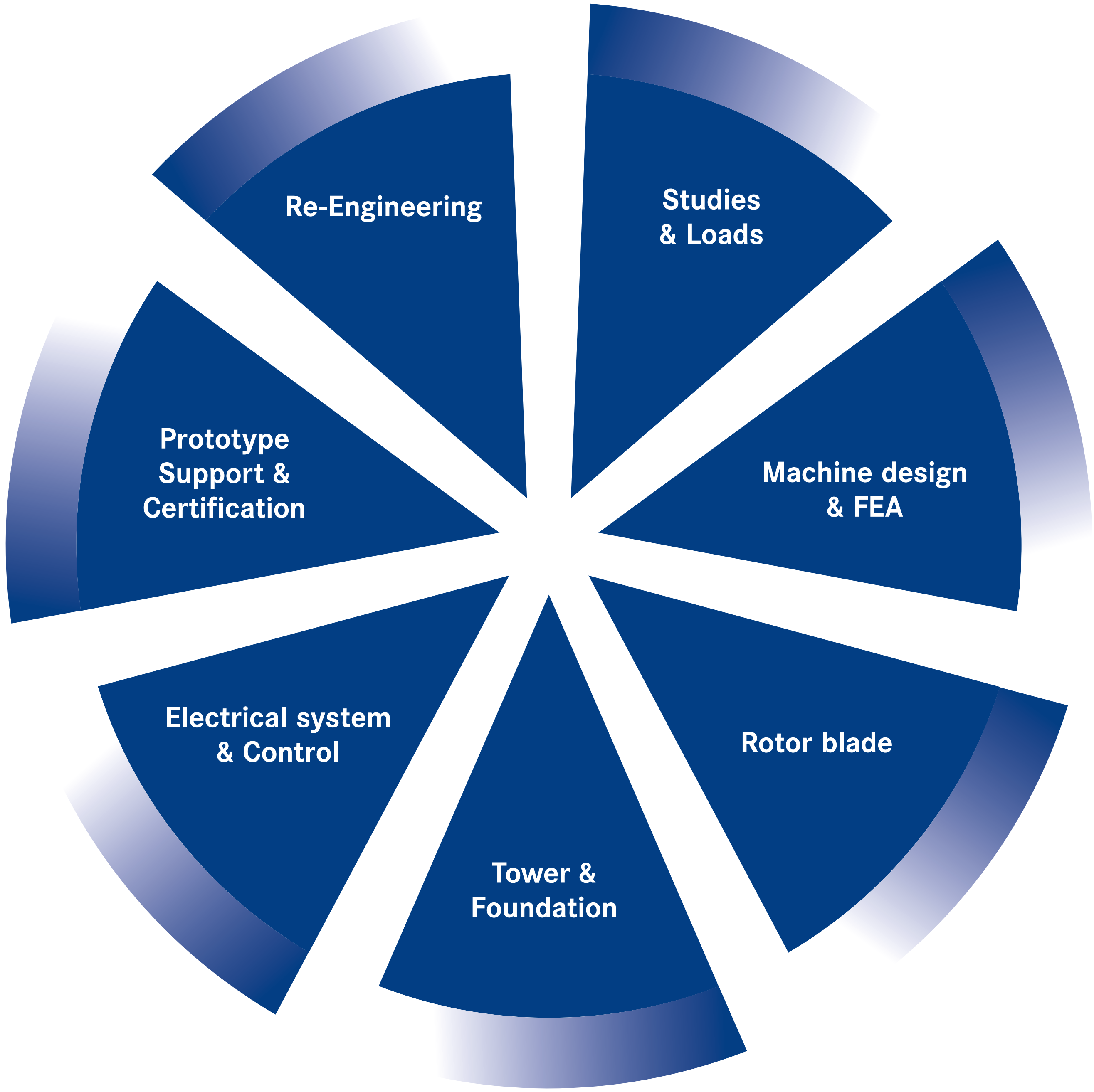
AEROVIDE

AEROVIDE services

Customer-specific overall developments and individual engineering service

WE PROVIDE WIND TECHNOLOGY

AEROVIDE, your full service provider for wind energy projects



Our full range of services covers all the fields of work required for the development of new wind turbines and makes us the only independent "full service provider". Fewer interfaces and clear responsibilities alleviate the development effort and reduce the development risk for our customers.

Customers can build up their wind energy know-how through custom training programmes which AEROVIDE offers as part of a longer-term cooperation. The development engineers of our customers are given training in specific topics in these programmes.

It does not have to be an overall development. Depending on your project, you can naturally also select single service packages from the whole range on offer. AEROVIDE offers you customized engineering services for every task .

Overall developments

The focus at AEROVIDE is on overall developments, where we support our customers during all phases of the project, from the initial concept studies right up to certification of the new wind turbines. We have experience in all drive train technologies like conventional concepts, direct drives or hybrid drives.

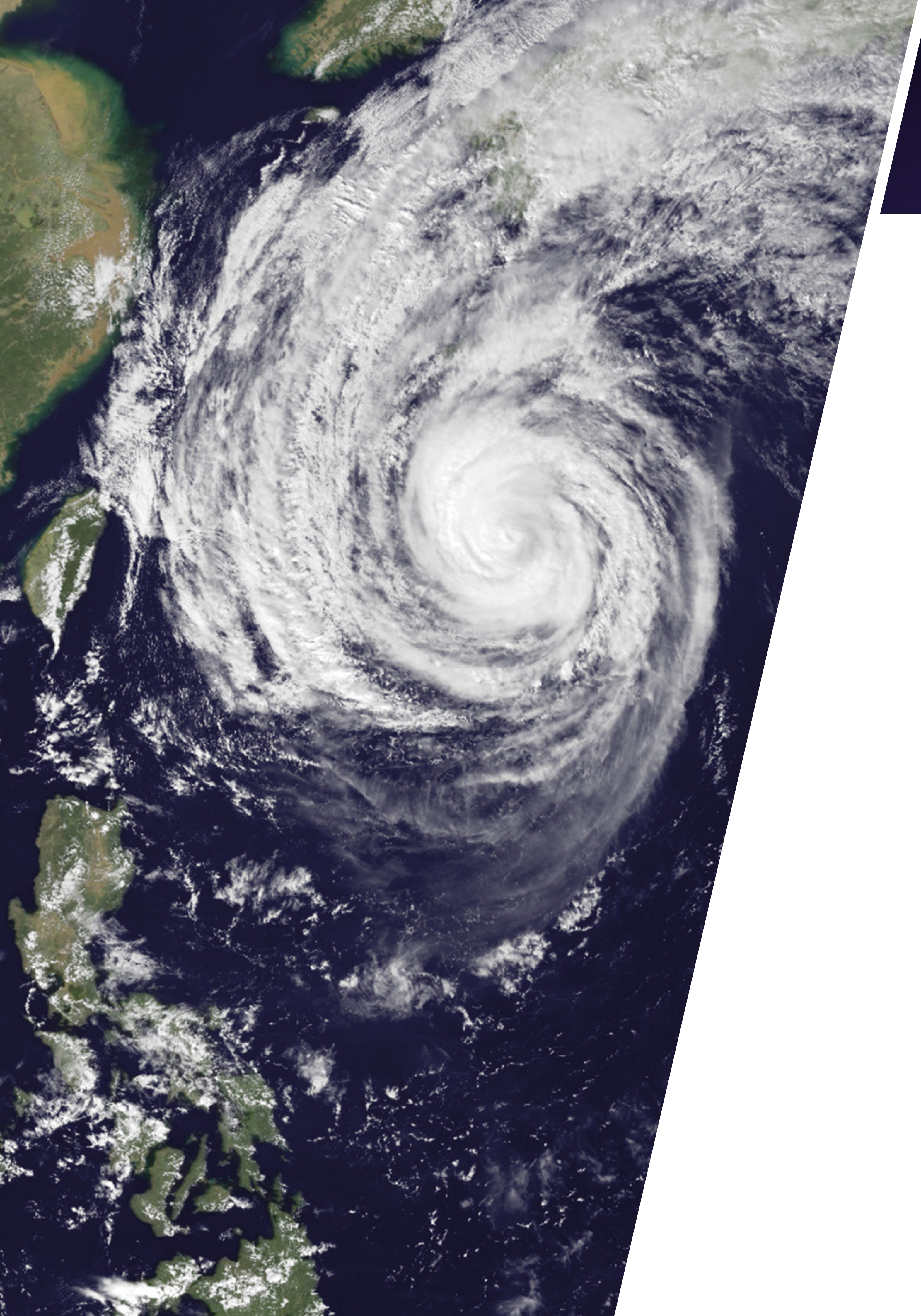
Our revolutionary developments result from the close and proven interaction of all work areas and departments, the software tools which are constantly developed further, the commitment of our qualified staff and many years of experience in the branch. Different turbine concepts ranging between 5 kW and 10 MW have been implemented in the last 37 years.

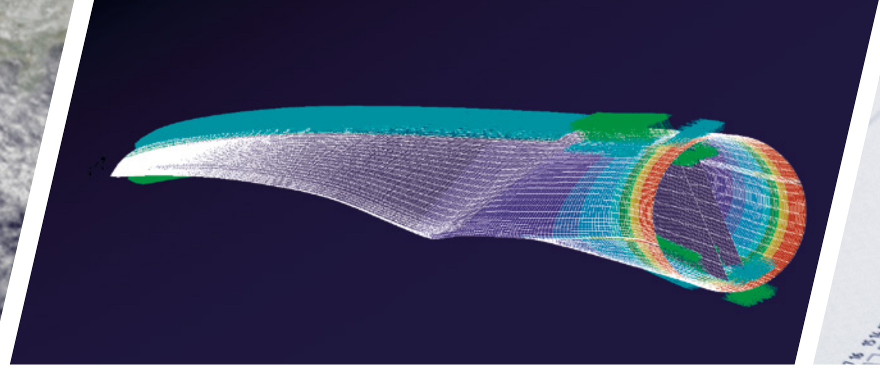
Support and supervision of the assembly process as well as installation and commissioning of the prototype of your new turbine model round off AEROVIDE range of services. This way we ensure that you have consistent project management and continuous support down-the-line from the initial concept drafts up to the certified wind turbine.

The development process at AEROVIDE is broken down into the following five steps:

The technical documentation that results from the development activity includes the following documents:

- Design reports, drawings and specifications for structural components
- Purchase component specifications
- Assembly drawings & parts lists
- Single part drawings
- Manuals for assembly, installation and commissioning
- Electrical wiring diagram and control system software





Load simulation

During its long service life, a wind turbine is exposed to extremely high dynamic loads. Determination of these loads and of the resulting stress and strain on the structure is the starting point for wind turbine developments which are safe to operate. Load case simulation and preparation of the required documentation ready for certification are standard procedures at AEROVIDE. Load case simulations are performed for all required international standards such as GL guideline or IEC-61400 standard.

AEROVIDE uses aeroFlex and HAWC2 for load case simulations. aeroFlex was the result of ongoing in-house customization of the tried-and-tested FLEX5 code. aeroFlex has an easy-to-use graphical user interface for input of the wind turbine data as well as extensive routines for analysis and processing of the generated load time series. HAWC2 is a very general and flexible multibody simulation code developed by the University of Denmark. HAWC2 is nowadays used for all new onshore and offshore wind turbine projects at AEROVIDE. Our own developed pre- and post-processor aeroHALO creates the simulation environment for HAWC2, manages and writes input parameter files for the simulation and monitors the HAWC2 executable. aeroHalo provides a user friendly graphical user interface (GUI) for setting up Design Load Cases, External Conditions and Simulation Parameters. A newly developed, DNV-GL approved wind model enables to simulate the wind loads under typhoon conditions. Only this simulation can assure the structural integrity of wind turbines in typhoon risk areas.

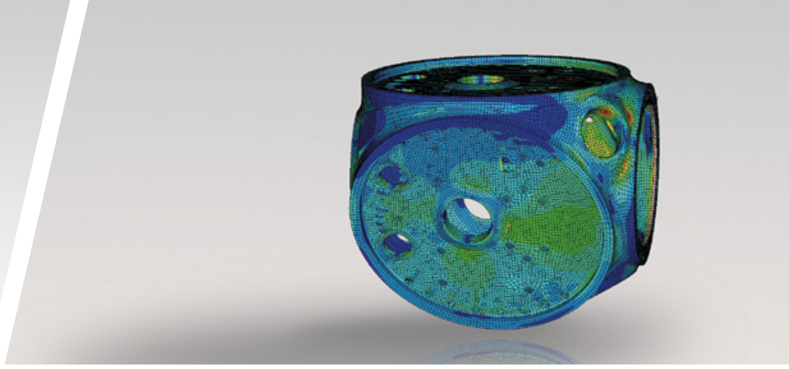
Rotorblade design

The aerodynamic design of the rotor blade of a wind turbine influences the performance and energy yield of the wind turbine significantly and is therefore key know-how for successful wind turbine design projects. Careful optimization of the rotor blades is therefore closely linked to the efficiency of the wind turbine.

Consequently, particular importance is attached to the design of the blade geometry which is characterized by aerodynamic profile, twist and chord distribution. With this in mind, AEROVIDE has developed applications designed especially for these tasks.

The load-bearing structure of the rotor blades is designed after the blade geometry has been decided on and the loads have been determined. And state-of-the art, fibre-reinforced composite materials are used for the blades. The structural design is created at AEROVIDE using the aeroBlade software tool combined with a detailed calculation using FEA. AEROVIDE uses GEMO, a preprocessor developed in-house, for an efficient and mainly automated design of the complex finite element model. Our detailed documentation of the rotor blade development results for the certification process and the extensive support for the certification process is a requirement for an efficient certification process for the complete wind turbine design.

In addition, AEROVIDE supplies all the information that is needed for the manufacturing of the master plug and main mould of the rotor blade. Customers are then able to produce the main mould themselves or to subcontract its production. If requested, AEROVIDE specialists can supervise the construction of the rotor blade prototype and the static blade test, giving their advice and support. By doing so, AEROVIDE provides all the information required for setting up one's own rotor blade production.



Design of machine components

For more than thirty years, customers have been benefiting from the competence of the AEROVIDE team in the design of cost-optimized drive trains and components. A wide variety of designs has been covered, ranging from conventional detached drive trains, direct drive systems over to hybrid type drive trains.

Many different types of pitch and yaw systems with hydraulic and electrical drives have been realized in various wind turbine design projects. The use of the latest calculation methods in aeroComp, an AEROVIDE software development, guarantees optimal component design. Because many components of a wind turbine design are dimensioned by fatigue loads, AEROVIDE has made big efforts to develop sophisticated fatigue analysis methods based on time series calculations for all structural components.

The design and integration of all machine components with all its interactions between component suppliers, designer and customer plays an important role for a successful wind turbine design project. AEROVIDE has longstanding and continuous experience in the management of the interaction between customer, component suppliers, certifying institutions and the design team. This has been proven a key issue for the successful conclusion of wind turbine projects and short time-to-market.

Finite-Element-Analysis (FEA)

At AEROVIDE, all relevant structural components of a wind turbine undergo finite element simulation, in most cases ANSYS™ software is used.

Hence the stresses and deformations of the components are known at a very early stage of the design process and can be optimized within the project deadlines.

Usually, the CAD geometry of the component is converted into a standardized data format and imported into the FEA software. Afterwards, the behaviour of the structure is investigated under extreme and fatigue loading.

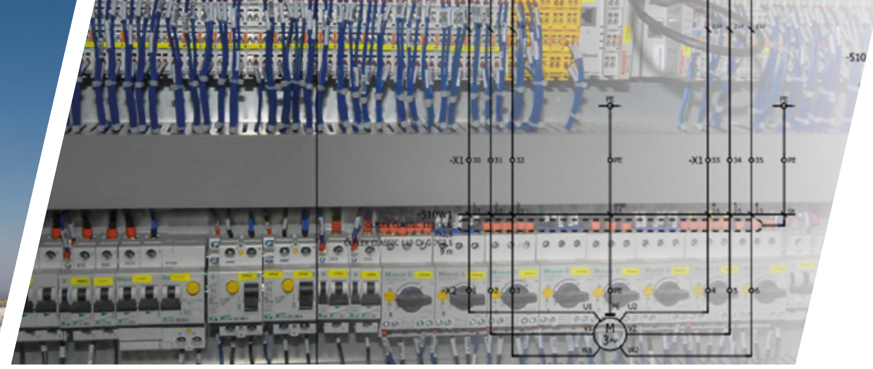
For fatigue calculation, AEROVIDE has developed in-house software tools. The components are subjected to the full load time series that runs the whole time a wind turbine is in operation. This permits quite a good estimation of the component lifetime and makes further mass and cost optimization possible.

Of course, optimization is not just done by experience and guessing; in fact, AEROVIDE has at its disposal a variety of optimization software, partly programmed in-house, partly purchased externally, for example altair Optistruct™.

It should be emphasized that AEROVIDE applies FEA also to the design of composite components such as rotor blades and nacelle covers. Very detailed knowledge of the stress and strain level in each composite layer as well as a good prediction of interfiber failure lead to remarkable weight and cost savings for the composite parts.

Last but not least, the finite element analysis at AEROVIDE also includes fracture mechanics, especially the prediction of crack behavior in metallic components.

Of course, all relevant FEA results are part of the documentation package for the customer and the certifying institution.



Tower and foundation

The tower of a wind turbine is a mainstay on two accounts. Not only does it bear all of the loads but it also has a decisive influence on the costs and overall dynamics of a wind turbine.

The loads which are used for the tower static and fatigue analysis are the result of the wind turbine load simulations. All tower design analyses and required documentation are prepared by AEROVIDE in compliance with national and international standards. The foundation is designed working closely with consulting engineers from the field of civil engineering who have years of experience in wind energy. Both, the tower and the foundation design, have significant influence on the load simulation results which makes it necessary to perform wind turbine simulation and tower analysis interactively in several design loops.

AEROVIDE uses aeroTower for tower design, a software tool for tower design developed by AEROVIDE. Structural tower analysis and fatigue analysis using load time series for the tower wall and bolt connections as well as buckling analysis for the tower wall are run with this software. All calculations and documentation of the process comply with the valid national and international standards.

Electrical engineering and control technology

Electrical engineering and control technology round off the “full service provider” package offered by AEROVIDE. As a result, AEROVIDE can ensure the smooth interplay of all elements in the wind turbine; interface issues caused by unclear management responsibilities are avoided.

At AEROVIDE, the electrical engineering comprises the specification of the pitch system, generator, inverter and transformer, taking into account all the requirements from the turbine design and in close coordination with the component suppliers. When all electric interfaces are coordinated, AEROVIDE draws up the complete circuit diagram of the wind turbine and the layout of the electric cabinets.

AEROVIDE has a sophisticated control system software which has proved itself over the years in a great number of projects. The source code of the software can be customized and optimized to meet each project requirement.

Prototype support

AEROVIDE takes the turbine concept and customer requirements into account when creating concepts for the assembly hall together with production specialists as the basis for further detailed implementation planning. The customer is supported by our qualified and experienced members of staff during workshop assembly of the mechanical and electrical components, workshop commissioning and prototype commissioning at the site. An important aspect in prototype support is the implementation of the safety regulations and processes for assembly, installation and commissioning that were defined during the design stage.

On demand, AEROVIDE will also design the necessary production tools and produce assembly manuals.

This ensures a smooth and safe procedure from the first assembly steps up to the automatic mode of the prototype.

Training and know-how transfer

In combination with an overall development project of a wind turbine, we offer our customers support when needed to build up their general knowledge of wind energy and know-how on the design of wind turbines. The training and know-how transfer package is customized to the needs of each customer and covers all fields, going from the basics of wind energy up to design methods for wind turbines.

The know-how transfer package can also consist of training in and use of AEROVIDE's own aeroFlex, aeroHalo, aeroBlade, aeroTower and aeroComp software packages. Through this know-how transfer, we make it possible for our customers to undertake further developments of their own or even to develop new wind turbines.

Please contact us so we can set up the optimal know-how transfer package for your needs.

Offshore technology

As early as 1996 the AEROVIDE team recognized the importance of offshore wind energy in future power supply and pressed ahead with initial studies and patent applications for the Multibrid technology. The revolutionary concept optimized for offshore use plus a rated power of 5 MW which was considered spectacular then set a new standard in wind energy. The innovative feature of the Multibrid drive train concept is a system consisting of a single-stage planetary gearbox combined with a medium speed generator.

This first successful offshore project was followed by three other offshore developments from 5 MW to 10 MW. This makes AEROVIDE the leading engineering firm in offshore wind energy, with a total of four offshore developments giving it the world's biggest background experience.

Other engineering services

Constant optimization and further development of existing technologies play a major role in the long-term success of wind energy. For that reason, AEROVIDE supports manufacturers, operators, maintenance companies and consultancy firms in finding solutions to the many different issues which can occur during the service life of a wind turbine. Besides overall developments and the services already described, AEROVIDE offers its support in the following areas:

- Further development and optimization of existing turbine platforms through bigger diameters or by increasing the hub heights.
- Site-specific load calculations
- Qualification of new component suppliers
- Site-specific tower and foundation designs
- Design reviews, due diligence, re-engineering and elaboration of upgrade measures for existing wind turbines
- Remaining lifetime analyses
- Modernization of the system control and visualization
- Evaluation of operational data, error analysis, planning and design of improvement measures
- Recertification in compliance with new guidelines or following re-engineering.

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