

Innovative wind power all over the world



LM Glasfiber



LM Glasfiber develops and manufactures blades for both small onshore wind turbines and the large turbines in off-shore wind farms. We supply blades for wind turbine projects all over the world, working in close collaboration with our customers.

We have one common goal, which we share with our customers: to utilise wind energy profitably and with maximum operational reliability. Our strategy is based on innovation at all stages: in the development of ideas, research, design, manufacture, testing, and delivery – in collaboration with both customers and end users.

The results speak for themselves. Our goal is to offer the shortest development time and the best quality on the market. It is therefore no surprise that LM Glasfiber blades are mounted on more than one in three wind turbines throughout the world.

LM Glasfiber is prepared for the future. We have production, sales and service facilities in Asia, North America and Northern and Southern Europe and develop technology and products with new capabilities to monitor operations, protect against lightning strike and ensure maximum energy production.

Technological competence in an international perspective

LM Glasfiber is the world's leading supplier of rotor solutions for wind turbines, and the only supplier that operates on a global basis. We focus on research, product and process development, quality assurance and a high level of service for our customers. As a result, we have become the market leader with a short development time, very reliable delivery schedules and high quality measured in terms of operating efficiency and price per kWh.

LM Glasfiber blades are characterised by excellent quality that is based on our extensive knowledge of aerodynamics, composite materials and production technologies. LM Glasfiber has a large, specialised development department with the industry's most comprehensive body of knowledge and experience about blade development, moulding and manufacture.

In addition, LM Glasfiber possesses unique experience with all sorts of tests, from nanoscale materials testing to the

full-scale testing of complete wind turbine blades. We have more than 50 years' experience with product development in the field of composite technology.

Preferred working partner

LM Glasfiber was one of the pioneers in the development of modern wind turbine blades. Since then, our constant focus on innovation has had a significant influence on development within this industry.

LM Glasfiber has therefore now become an important working partner for both turbine manufacturers and end users:

We supply high-performance blades that provide twenty years of service life, manufactured using advanced, patented technology.

We have production, sales and service companies in Asia, North America and Northern and Southern Europe that ensure prompt, efficient delivery and quality service all over the world, regardless of

the wind and climate conditions at the particular erection site.

We have considerable experience based on the more than 86,000 wind turbine blades we have supplied since 1978, corresponding to more than one in three such blades in the entire world.

All these factors combine to ensure quality and peace of mind for our customers and to provide LM Glasfiber with a sound basis for expanding its position as the world's leading supplier of rotor solutions for wind turbines.



Manufacturing and service facilities



Blades designed to match the turbine

We develop solutions that are customised to meet each individual customer's specific projects and requirements. We work together with the customer to create a rotor solution that dovetails perfectly with other wind turbine components, thus ensuring maximum output.

The blades are designed to match the specific conditions at each erection site, whether in a high or low wind area or in arctic or desert locations. LM Glasfiber is a market leader within the development of rotor solutions for offshore wind turbines – a demanding environment due to the aggressive influence of the sea and the need for minimal maintenance.

LM Glasfiber has a wide range of products, comprising more than thirty different types of blades in sizes that vary from 13 metres to more than 60 metres. We can therefore supply blades for all sizes of wind turbines, right up to the largest and most modern multi-MW wind turbines for offshore use.

Our range comprises blades that can be adjusted for pitch as well as stall and active stall, and wind turbines with either constant or variable speed of rotation.

High quality and additional equipment

LM Glasfiber blades are known for their high quality, which is ensured at all stages of the process, from materials and design via moulding and manufacture to delivery and service. Our quality standards results in a minimum of twenty years of service life, safe operation and high performance. Easy maintenance is yet another benefit.

LM Lightning Protection provides the best-documented protection against lightning currently available. We have carried out numerous tests in the world's most advanced high voltage laboratories and can document the efficiency of the LM Glasfiber lightning protection system. A range of other special equipment, such as Vortex Generators Stall Strips and Flaps, is also available in order to increase blade performance.

LM Glasfiber blades blend in with nature. Intensive development efforts have resulted in the reduction of blade noise by more than 50%. As a result, LM Glasfiber blades are among the world's quietest blades, while the absence of shine on the surface of the blades minimises light reflection.

Towards new goals

The intensive product development work conducted by LM Glasfiber sets new standards for the industry in terms of ever larger and more efficient wind turbines. LM BladeMonitoring, for monitoring and optimising blades in terms of the amounts of energy produced, and the new large blades for multi-MW turbines are examples of products that have set new standards.

Thanks to our highly focused, intensified product development processes, we are always able to supply the blades our customers require regardless of size and specific features.





Making sure the blades produce maximum energy

Customers and end users place ever-increasing demands on blade solutions in terms of technology, quality and size. The goal is to achieve and combine operationally reliable solutions and high output. We therefore work closely with our customers at all stages of research, design, development and manufacture.

Originally, the design and manufacture of glass fibre wind turbine blades were a question of general engineering and production skills. The dramatic size of the new types of blades, the size of the wind farms and the quality requirements to offshore wind farms have now combined to alter this.

LM Glasfiber focuses on innovation in all the processes involved, from the very birth of the ideas via research, development and test to the manufacture of the actual blade. It is a key part of the overall LM Glasfiber strategy to create breakthroughs in design, materials and processes so as to make our blades more

competitive, more durable, and more reliable when in operation.

The challenge is to maintain short development and production times for the individual type of blade and at the same time prevent the higher technology content from increasing delivery times. LM Glasfiber aims at developing composite materials and methods in which glass fibre materials are used in combination with other materials, resulting in a very low price per kWh and maximum operational reliability.

Wind turbine engine

The blades are the engines of the wind turbine. LM Glasfiber therefore constantly focuses on increasing the amount of energy that the blades can produce, in order to reduce the overall cost of wind power.

LM Glasfiber has been the leader in wind turbine blade development for decades. We undertake comprehensive research

and development work in fields that include aerodynamics, blade construction, materials and manufacturing processes.

This work extends from the development of new profiles that allow the production of lighter, cheaper blades to the design and construction of the large new wind turbine rotors of the future for offshore use. We also work on improvements in areas that include blade noise, vibration dampening, aerodynamics, the monitoring of de-icing and lightning protection. The end results are solutions and technologies that improve the efficiency of the blades and ensure maximum service life for both wind turbines and blades.

Technological know-how

LM Glasfiber develops new materials and processes in close collaboration with suppliers and technical institutes. The knowledge we acquire from this makes it possible to open up new opportunities within modern blade construction.

The work we have done on blade design and process technology means that the redesigned blades have an increased output and a weight reduced by more than 10%. In addition, we have managed to cut production costs and improve quality. Today, LM Glasfiber blades for serial production are produced solely by use of vacuum infusion. This enables us to achieve a better, more consistent product quality and a much better work environment compared with the previous solutions.

FutureBlade is LM Glasfiber's answer to the technological challenges that the new multi-MW blades present. The FutureBlade technology optimises the entire design and production chain in blade production and extracts maximum benefits from standard materials and well-known processes. FutureBlade makes it possible to manufacture even very large blades with a low weight and a guaranteed high quality and long service life.

The FutureBlade technology plays an important role in the design process

when we manufacture large blades using a combination of glass fibre and carbon fibre. Carbon fibre is stiffer and stronger than glass fibre but more expensive. The FutureBlade technology allows us to design blades with the best possible blend of carbon and glass fibre.

Excellent safety and output

The service life of a wind turbine blade, which is set at a minimum of twenty years, presupposes a careful choice of materials. We achieve a high level of safety by using LM Glasfiber's thoroughly tested blade root design and lightning protection.

The LM Glasfiber lightning protection system is the first on the market to provide documented level 1 lightning protection according to the international CEI/IEC standards, corresponding to a 98% degree of protection against all lightning strikes.

The aerodynamic efficiency of the blade can be optimised for each individual wind turbine and the wind conditions at the erection site. These adjustments are made using a range of special aerodynamic

accessories, including vortex generators that can improve the wind turbine's power production by as much as 4–6%.

Analysis and design

The development work at LM Glasfiber is based on advanced analysis and design tools. Today, some of these tools provide valuable links between blade construction, moulding and blade testing. The result is shorter development time and a high degree of precision and reliability.

This highly focused development process has increased wind turbine efficiency year after year. The development work is set to continue in the form of ongoing improvements to the blades, wind turbine control systems, gear units and generator – both separately and in combination. LM Glasfiber development activities therefore mean that we work closely with both our customers and a large number of technical institutes, universities and specialist knowledge centres throughout the world









Always in close contact with the customers

LM Glasfiber produces more than just wind turbine blades. We actually develop and produce 20 per cent of the entire wind turbine, in close collaboration with our customers. By working with LM Glasfiber, our customers gain access to the wind energy industry's most comprehensive body of know-how and experience related to blade technology. This makes us an attractive working partner and adviser.

LM Glasfiber has the industry's largest and most flexible production capacity, with facilities in each of the most important wind energy markets. Our customers benefit in terms of economical solutions, reliable delivery and good service.

Global production in local markets

Being close to all the important markets allows us to be both flexible and efficient. We can use the Group's extensive international capacity to manufacture the majority of LM Glasfiber blades close to the markets where they are in demand. This means that we can ensure our cus-

tomers prompt, on-time delivery and excellent service.

It is very important to our customers and suppliers that we are able to organise and control the supply chain. Our goal is to combine global production with agreements with local suppliers. We aim at ensuring a high degree of reliability as regards to availability, shorter delivery times, lower costs, more flexible deliveries and a consistently high quality. All things being equal, this gives LM Glasfiber customers an important competitive edge.

High quality on all markets

LM Glasfiber provides comprehensive, consistent global production and excellent service. The Group's activities comprise ongoing service of blades, in order to ensure extended service lives and a consistently high output, and repairs and maintenance of blades on all types of wind turbines.

LM Glasfiber established its position on the world market in the 1980s. Today, LM Glasfiber blades operate on all the continents of the world. The head office at Lunderskov in Denmark coordinates the activities undertaken in the production and sales companies in Asia, North America and Northern and Southern Europe.

Our global production and service are based on extensive technology transfer and quality assurance, certified in accordance with ISO9001. This certification means that the customer has a guarantee that we meet laid-down quality standards and supply solutions whose quality is consistent throughout the world.

Credibility based on decades of experience

Experience is the foundation on which we develop and manufacture quality products. LM Glasfiber has developed and manufactured wind turbine blades for more than twenty-five years and thus acquired extensive knowledge and experience about all aspects of blade production, from design, choice of materials, moulding, manufacture of prototypes and testing to series production, shipping and service.

As befitting our position as a highly specialised order-producing supplier, LM Glasfiber currently employs a staff of more than one hundred people in our R&D organisation. This makes us the blade producer with the most extensive specialist knowledge in the world. Beside 3D-CAD project teams we have expert engineers specializing in material and process technology, aero-elastic calculation, geometric design, structural design, testing of materials and components and testing in blades in full scale. We have also developed blade features

including lightning protection and blade monitoring systems.

In order to consolidate our leading position within blade technology and manufacture, we are committed to maintaining the knowledge and competence base we currently possess and extending it still further.

Industry pioneers

LM Glasfiber began working with glass fibre material and the use of its many properties and applications as early as 1953. Product and process development have been the focus of attention at LM Glasfiber ever since. As a result, the company today has very broad knowledge and experience of production and process technology in relation to composite materials and their application. This process technology is one of the main reasons that LM Glasfiber is so competitive today, and that the company is able to undertake large-scale production of high-quality blades at low cost.

Quality gives peace of mind

A wind turbine is a major investment. It has to function optimally – all the time and throughout its entire service life. LM Glasfiber has the competence and the capacity to guarantee high quality series production. This can only be accomplished with the efforts of committed staff who share the company's fundamental values: responsibility, initiative and forward thinking.

We undertake a series of concrete initiatives that all reflect our position as the industry's leading blade manufacturer. All blades are accompanied by extensive documentation that accounts for all the control inspections undertaken during the manufacturing process, and we also undertake thorough final checks upon completion of the product.

Our ISO 9001:2000 quality assurance system is certified by DNV and testing and approval of the blades are carried out in collaboration with the Risø National





Laboratory, DNV and Germanischer Lloyd and in accordance with strict industry guidelines.

Accredited testing

Quality assurance and accredited testing
An important part of quality assurance is related to materials testing. LM Glasfiber has developed a so-called Non Destructive Testing programme, consisting of infrared scanning and documentation of the glue joint that binds the upper and lower parts of the blade, ultrasound scanning of the carbon fibre axle in stall-regulated blades as well as static and dynamic testing in test beds and all prototypes.

LM Glasfiber has conducted both static and dynamic full-scale testing of a large number of blades over the last twenty-five years. This testing comprises extensive simulation of the loads to which the blades are exposed in a worst-case scenario. We carry out an accelerated test that corresponds to twenty years of operation.

LM Glasfiber is the only blade manufacturer that is accredited to test blades in accordance with DS/ISO/IEC 17025. The testing is carried out using our seven complete test installations. At the same time, we have improved the LM Glasfiber quality assurance system and the documentation of the testing procedures by introducing infrared scanning of all manufactured blades.

We have also improved our material and component testing programmes and work with leading research centres to define new standards for testing methods for the materials used in blade production.

Blade construction and production processes are other areas that are the focus of ongoing improvements. As the size of the blades increases, increased automation of the production processes results in improved efficiency and contributes to a high, well-documented level of quality.



Strategy for future growth on global markets

LM Glasfiber's mission is clear: we will live up to our position as market leader by passing on the advantages of a high degree of specialisation, technical know-how, global presence and large-scale production to our customers.

We wish to strengthen our core competences both in terms of technology and in innovative areas such as materials, processes, blade design and testing and in logistics and service. We also wish to keep up with global market growth and continue to establish local production and service facilities in the most important wind energy markets.

Values as competence

LM Glasfiber's values are an important asset for the decisions we make and the actions we take on a day-to-day basis. We use our staff policy, management and control to ensure that our staff feel involved, understand the company's goals and adhere to our three fundamental values: responsibility, initiative and forward thinking.

We use these values when recruiting new staff members by exploring candidates' attitudes to the three values. These values are also an integral part of our management training and staff appraisals.

Values

LM Glasfiber has three values that form the basis of our day-to-day decisions and actions. These values govern the way we relate to customers, suppliers, business partners, colleagues, shareholders, public authorities and organisations.

Responsibility

We are responsible to our surroundings, our customers and ourselves. We do our best to give customers and end users the best possible solutions and service. We are cooperative and prepared to promptly solve any problems that might arise.

Initiative

We are open to new ideas and creative suggestions and prepared to try new approaches. We suggest new work methods and procedures in order to become more efficient and productive. We accept challenges and help bridge the gap between projects and processes. We are curious and pursue opportunities that will provide our customers with better, cheaper solutions.

Forward thinking

We are forward thinking, look out for opportunities and use them to the benefit of our customers and ourselves. We great emphasis priority on technological development and specialisation. We have a long-term strategy to ensure the stable development of the company and of new innovative products that increase our customers' competitive edge.

Blades for the wind turbines of the future

The wind energy of the future will be generated by increasingly large and more and more cost-effective wind turbines, and by large offshore wind farms. LM Glasfiber is prepared to face the challenges and trends of the future.

We can now undertake series production of the largest blades on the market, and we have considerable expertise within the field of blade technology. LM Glasfiber blades were mounted, for example, on the Danish offshore wind farms at Middelgrunden off Copenhagen, at Yttre Stengrund in the Baltic Sea off the south of Sweden and for the wind farm at Ijselmeer in the Netherlands. LM Glasfiber blades have also been operating for more than ten years at the Vindeby offshore wind farm in the southwestern part of the Baltic Sea.

The offshore wind farms of the future will be even bigger and present many new challenges. First of all, we have to produce larger blades that are designed for the special conditions at sea and that require only

a minimum of maintenance. Service of blades mounted on offshore wind turbines is expensive, and LM Glasfiber therefore focuses on producing blades with high performance and a long service life.

LM Glasfiber will remain at the forefront with solutions and technology that meet these requirements. One example is LM BladeMonitoring, which helps create the intelligent wind turbine blades of the future. Such technology is increasingly incorporated in blades on multi-MW wind turbines and large onshore or offshore wind farms, typically in blades 40 metres and more in length. LM BladeMonitoring electronically monitors critical parameters such as load, temperature, cracking and lightning strikes. This makes it possible to fine-tune the load on the individual blade, and the technology can also be incorporated into the systems controlling the turbine's operation.

The customers who invest in intelligent wind turbine blades rather than the tradi-

tional blades gain a number of advantages. It becomes easier to plan the necessary service and maintenance and to optimise the turbine's energy production.

Another example is the FutureBlade technology, which we use to manufacture large blades for the next generation of multi-MW wind turbines used offshore. This FutureBlade technology comprises an advanced design concept that includes new materials, tools and production processes.

Our ambition is to create new opportunities within modern blade construction. Using our experience, resources and capacity, and in close collaboration with the wind turbine manufacturers, we wish to contribute to making it even cheaper to produce electricity using wind power.

This is the only way to ensure that wind power becomes an increasingly competitive energy source – for the benefit of both our customers and the environment.



www.lmglasfiber.com

LM Glasfiber

Rolles Møllevvej 1
DK-6640 Lunderskov
Denmark

Tel +45 79 84 00 00
Fax+45 79 84 00 01

www.lmglasfiber.com
info@lmglasfiber.com