

Brochure

Generators for wind power

Proven generators – reliable power



We provide motors, generators and mechanical power transmission products, services and expertise to save energy and improve customers' processes over the total life cycle of our products, and beyond.

Over 30 000 wind generators in 30 years

ABB is the world's leading supplier of motors and generators. We have been manufacturing these products since 1889, and today we have 45 plants in 13 different countries employing 15 000 people. We supply motors and generators for a full range of industrial, marine and power generation applications. Our product portfolio extends up to 70 MW and 15 kV.

Wind power

ABB has supplied more than 30 000 generators over the last 30 years to leading wind turbine customers all over the world. We have solutions for all the main drivetrain concepts from direct drive to medium and high speed, and we supply generators and converters in perfectly matched packages. We have been the leader in permanent magnet (PM) technology since its introduction for large motors in the 1990's.

Our global organization with its network of local service centers enables us to provide fast response to our customers, minimizing downtime and maximizing power production. By partnering with us, turbine manufacturers can ensure they remain on schedule and within budget, especially when introducing new products.

Quality built in

We manufacture high quality motors and generators that offer the best performance and highest efficiency combined with the lowest O&M costs. Our technology leadership is built on innovation, consistent investments in R&D and more than 6 000 engineers and researchers working with 70 universities around the world.

Quality is built into our design, manufacturing processes and the materials and components we use. We source our purchases from reliable suppliers only, and we perform thorough testing in all phases of manufacturing. In addition to our own quality programs, using tools like Failure Mode and Effect Analysis (FMEA), we follow the ISO 9001 and 14001 standards, and the quality systems in place at our global manufacturing facilities have also been verified by end users and leading turbine manufactures.

Offshore expertise

ABB has a long track record in manufacturing high quality marine and offshore motors and generators. Today, our production totals around 50 000 units per year. Our solutions meet the highest marine requirements and are certified to major classification standards like DNV and GL.

In offshore wind power, proven ABB generators offer the highest efficiency and reliability. In fact, the majority of the offshore turbines now operating rely on ABB generators. These are mostly high speed squirrel cage and doubly-fed (DF), but also medium speed PMGs, in the 2, 3 and 5 MW class. We have supplied generators for projects ranging from Vindeby (1991), the world's first offshore turbine, to Hyvind, the world's first floating turbine; and from Middelgrunden (2000), the first large offshore park, to the 600 MW London Array I wind farm (due for completion in 2012).

1 2-speed generator | 2 Doubly-fed generator | 3 Medium speed permanent magnet generator



ABB – your reliable partner with solutions for

Selecting your electrical drivetrain

The main concepts are doubly-fed (DF) and full converter (FC), using gearless low speed or geared medium or high speed generator solutions. There is no single optimum solution and the ideal choice will always be 'a perfect compromise' chosen according to market factors and wind conditions.

The most obvious technical criteria are high system efficiency, for maximum kWh production, combined with small size and low weight, for low foundation and logistics costs. Reliability means availability, and it is realized by using proven components. Grid code compliance must be backed by simulations and full-scale testing. Overall success depends on working with partners who have the necessary know how and experience to develop a system in a short, but realistic, time-to-market.

The generator and gear solution must be designed together for an optimal speed that delivers the best system performance. The design of the generator and converter must be closely

coordinated to produce a perfectly integrated package for full electrical system compatibility. The goal is continuous maximum production of kWh with the lowest O&M cost and a long lifetime. Decisions made at the design stage will also influence serviceability, exchangeability and O&M costs throughout the turbine's lifetime – ie, they will affect the life cycle profit of the wind park. By contrast, the initial investment cost is not particularly significant for the end user.

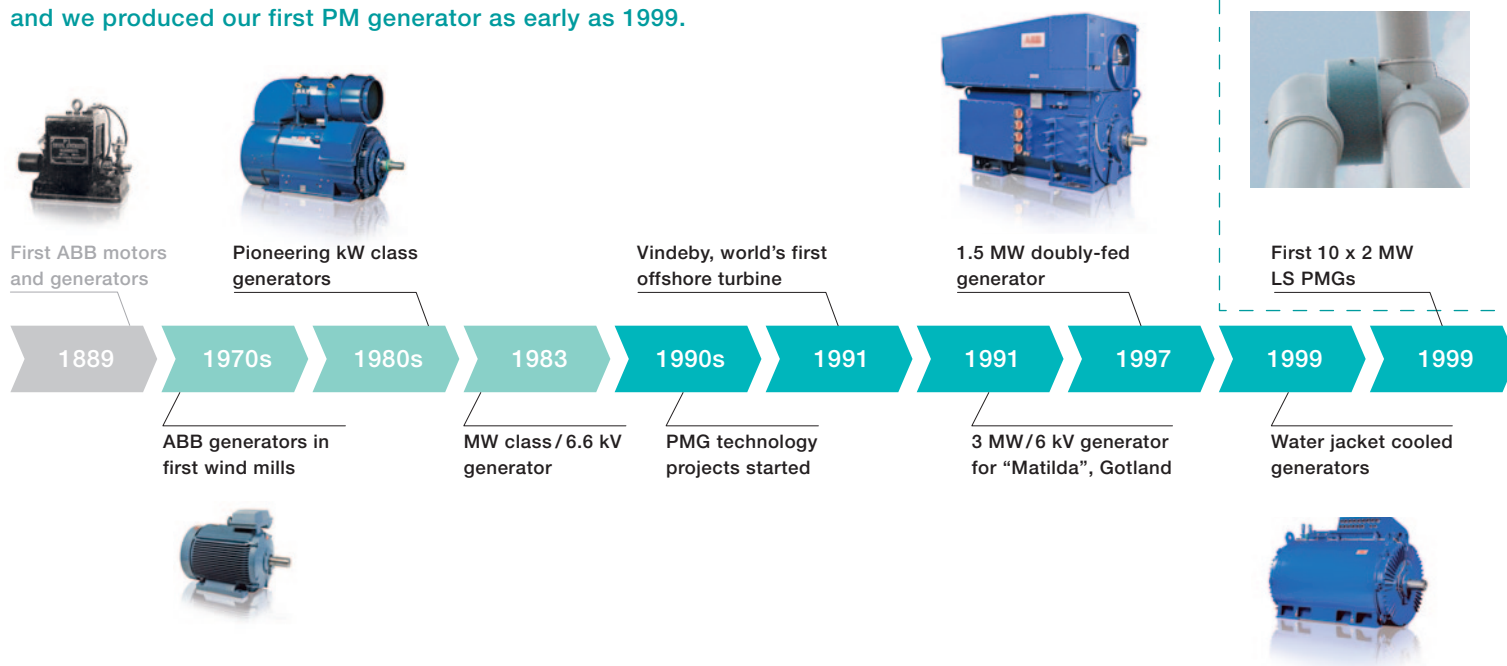
Proven ABB solutions

Low speed direct drive

ABB low speed direct drive (DD) permanent magnet generators have been running since 1999. Direct drive turbines provide good system efficiency, even though the large ring generators themselves deliver only modest efficiency. The efficiency of a PMG DD system is especially good in low wind areas because there are no gear losses, and up to 3 MW the size of the turbine is fairly manageable. With no gear the low nominal speed and high energy of the wind turning the long blades

More than three decades of wind technology leadership

We have been building megawatt class doubly-fed generators since 1997, and we produced our first PM generator as early as 1999.



all main drivetrain concepts

creates high torques. To cope with these forces, a heavy, large diameter, multi-pole generator construction must be used. This requires large amounts of steel, copper and magnet material, which increases the foundation, crane and logistics costs. There are also technical challenges like the need to realize a very narrow air gap between a large diameter rotor and stator in a construction that is subject to bending by wind loads.

Medium speed – new semi-integrated solution

ABB medium speed (MS) PMGs provide over 98% efficiency, which is the highest in the market. This compact, lower speed design offers a proven way to reduce top head mass without compromising reliability. The nominal speed influences the size of the generator and can be selected between 100 and 500 rpm using a single or two-stage gear. There are two main ways to implement the MS solution.

Fully integrated type: the gearbox and generator share the same frame, bearings and shaft, enabling a very compact solution with low weight. In this design ABB has proven

products since 2000 and 1, 3 and 5 MW generators have been supplied.

Semi-integrated type: the separate generator and gear are only partly integrated via a flange connection. This enables additional benefits like easy dismounting for servicing and low lifting weights. It also offers savings in tower and foundation costs, and allows the use of serial produced and individually tested plug-in units. At present generators up to 7 MW are being realized with leading OEMs.

High speed – the mainstream solution

There are three proven high speed (HS) generator types: squirrel cage, doubly-fed and PM. High speed is the leading solution both on land and at sea. The combination of HS drivetrain and full converter concept using ABB PM generators ensures the best kWh production and the smallest size and weight, and it also enables easy manufacturing and logistics. Using small, standard components results in a fast time-to-market for new turbines. Most of the ABB generators in use around the world today are HS types.

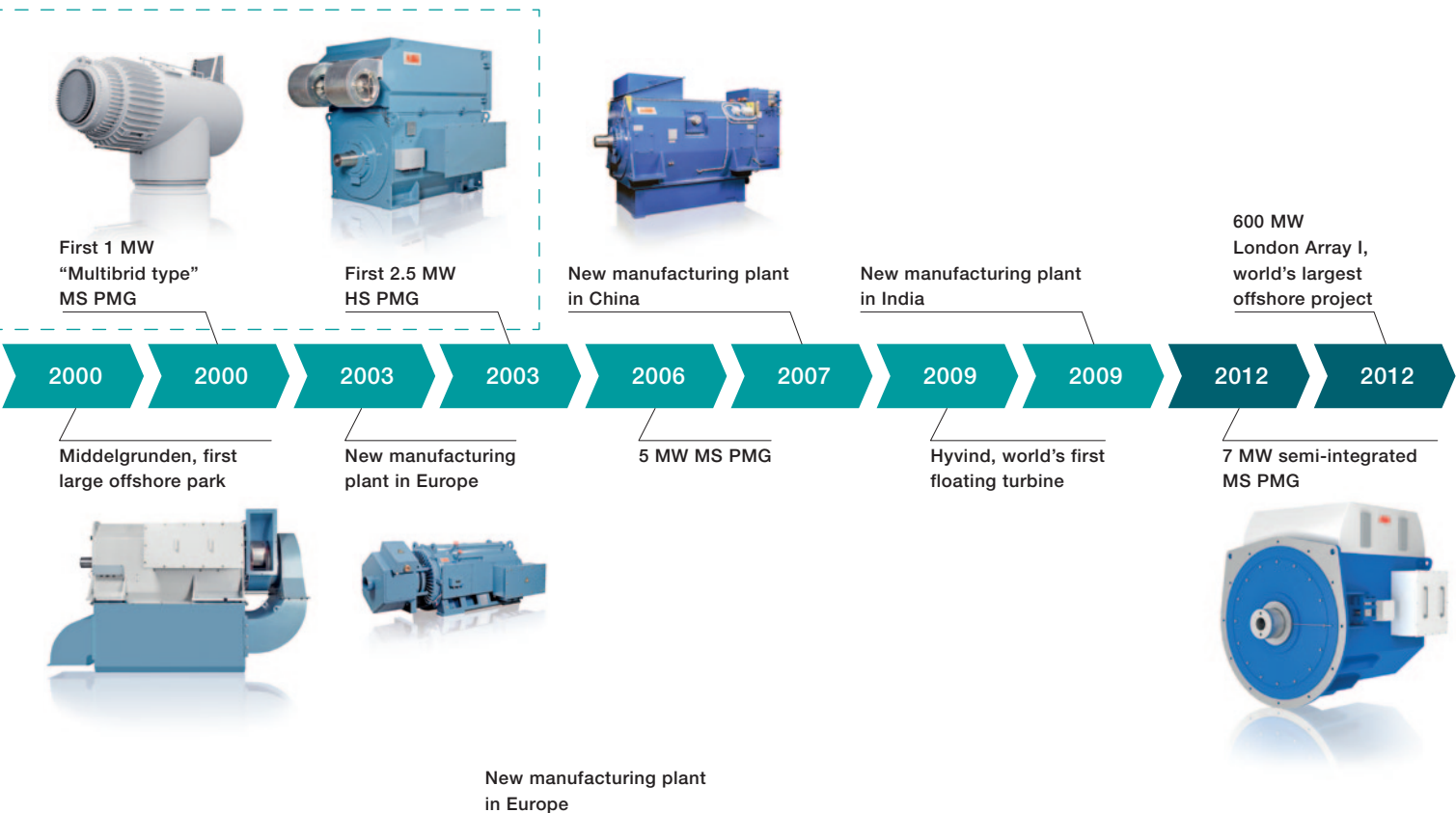


ABB generators are designed and built for th

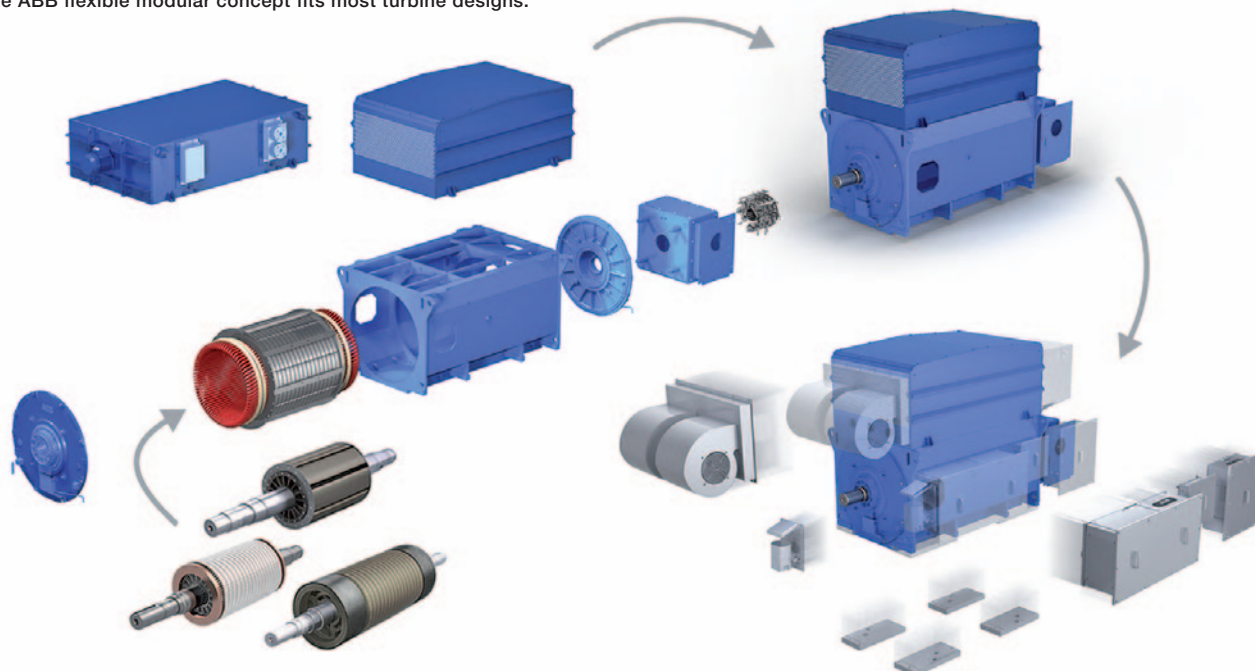
At ABB reliability is based on the know-how and experience we have accumulated in 120 years of working with demanding industrial, marine and power applications. Quality is built into our products through our proven design and manufacturing processes, and through the first-class components that we use. Our special areas of expertise are winding and insulation systems, PM technology and advanced rotor and slip ring constructions.

Design – based on thousands of type test results

ABB has created a unique design tool incorporating our vast experience and actual measured data from thousands of type tests covering all industrial sectors. This tool provides the precise calculated data we need to build the best generators. We use advanced design methods such as 3D and FEM (finite element method) simulation to mechanical, electrical and thermal optimization. FEM simulations also help us to efficiently reduce vibration and mechanical noise during the design phase.

Our electrical design know how enables us to build generators with the highest efficiency. Having low losses, less cooling fan power is needed, noise levels are also reduced and low running temperatures eliminate shutdowns caused by bearing overheating. Our grid friendly generators feature low Total Harmonic Distortion (THD) values, minimizing additional losses, overheating, vibration and electrical noise. The generator designs incorporate 30 years of converter expertise.

The ABB flexible modular concept fits most turbine designs.



e best life cycle performance

Manufacturing – quality built in

The heavy duty frame is designed with FEM tools, resulting in a stiff construction with very low vibration levels. The stator core is laminated using high grade electrical steel plates for high efficiency. We have patented rotor designs for high overspeed withstand that use special winding end support rings and reliable magnet fixing.

Winding and insulation know how is one of ABB's special areas of expertise, proven in tens of thousands of machines. We use reliable class F high voltage insulation technology, because in demanding wind applications this gives greater flexibility to withstand the thermal movements of the winding without the formation of cracks. Our advanced insulation and vacuum pressure impregnation systems maximize operational lifetime and enable a high momentary overload capacity.

The bearing construction design is important for a long lifetime. In high speed types we use pre-loaded bearings for accurate, smooth and silent operation and the massive brass cage is a factory standard. Converter applications give rise to bearing currents, but our expertise in proven bearing end shield insulation systems enables us to avoid the bearing damage these currents could otherwise cause.

All ABB generators are tested for the highest operational performance values, and thorough testing is undertaken in all phases of manufacturing. For example every low voltage winding coil is separately tested with medium voltage before

being installed in the stator. A final comprehensive test is carried out on all generators before shipment to the customer. We also undertake accelerated product lifetime testing.

Leader in PM technology for two decades

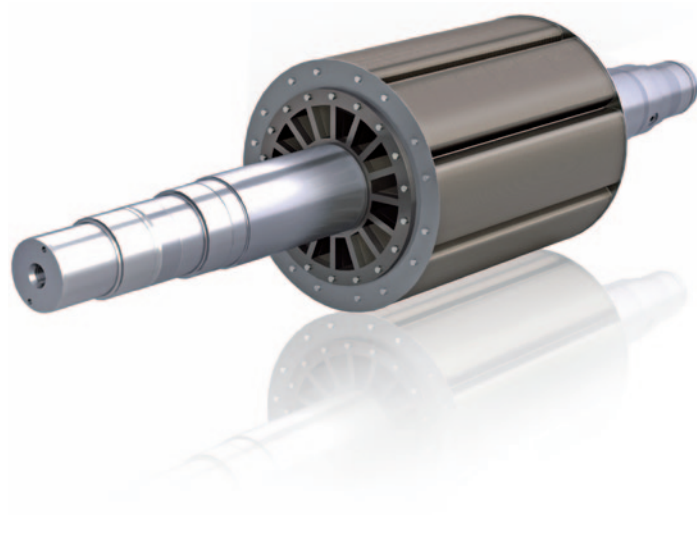
We have been developing PM technology for different motor and generator applications since the 1990s. Our reliable PM generators are designed for the highest fatigue and peak loads, ensuring continuous operation and a long lifetime, as well as low noise levels.

In PM generators the rotor uses the powerful and carefully selected NdFeB magnets in place of the windings. This eliminates the need for separate excitation – and the associated losses – enabling high power intensity and high efficiency, especially at partial loads.

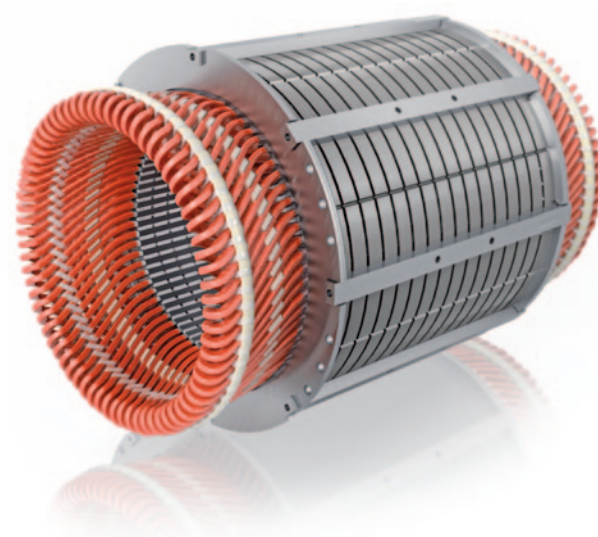
ABB's extensive experience in magnetic circuit design enables us to use optimized magnet geometry for each low, medium and high speed case to achieve the highest efficiency. Proven magnet fastening methods and special corrosion protective magnet modules enable trouble-free operation and long lifetimes. The correct dimensioning and low operating temperatures of our generators prevent demagnetization, even during grid fault situations.

We have developed standard product platforms, enabling us to build reliable, cost-efficient solutions for different turbine types. Our proven PM generators offer maximum annual production of kWh with the lowest lifetime costs.

Patented HS PM rotor



Robust stator construction



Proven ABB generators for leading wind turb

ABB has proven solutions for both doubly-fed (DF) and full converter (FC) concepts. We make all synchronous PM types from direct drive to medium and high speed. Powers range from 1 to 8 MW in low and medium voltage (with ratings up to 20 MW and 15 kV available).

Asynchronous generators since the 1980s – pioneering wind power

Asynchronous generators can be used in fixed speed, doubly-fed and also full converter concepts. They are normally high speed types.

Squirrel cage generators – straightforward and robust

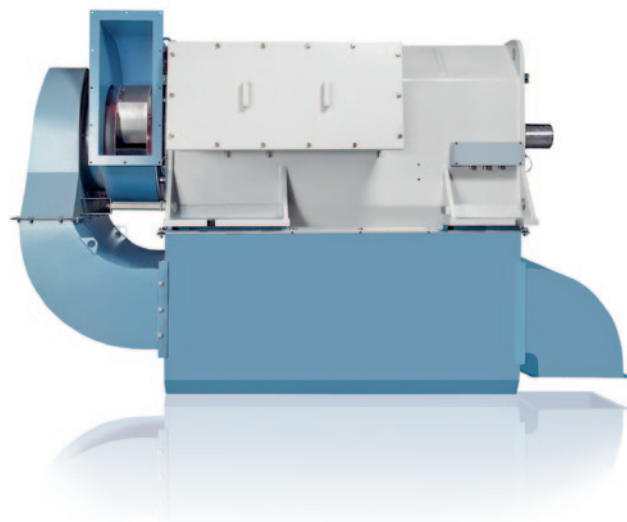
These generators are used in the conventional fixed speed stall concept with the generator directly coupled to the grid. They can also be used in the full converter concept.

- Powers up to 7 MW, with higher powers available
- Typical rated speed between 1000 and 1500 rpm
- Voltages from 690 to 3300 V and more

Doubly-fed, semi-variable speed generators since 1997 – economical and grid friendly

This is a mainstream pitch concept where the rotor windings also feed power to the grid via a small converter. It is an economical, grid friendly way to obtain variable speed and produce reactive power, and to increase the energy yield. ABB has over 50 years of experience in asynchronous wound rotor slip ring motors.

- Powers up to 6 MW, with higher powers available
- Typical rated speed between 1000 and 1500 rpm
- Voltages from 690 to 3300 V and more



ine manufacturers

Synchronous PM generators since 1999 – high efficiency and small size

The full converter concept totally separates the generator from grid disturbances. It offers the best performance, advanced grid compliance and full control during grid transients. Combined with PM technology it enables higher efficiencies, especially in low wind conditions at partial load. Reliable ABB PM generators are built for the highest fatigue and peak loads. ABB produces all three PM solutions from direct drive to high speed.

Low speed PM generators (LS PMG) since 1999

ABB LS direct drive PMGs form a structurally integrated unit with the wind turbine. Inner and outer rotor designs are available.

- Powers up to 3 MW, with higher powers available
- Typical rated speed between 14 and 30 rpm
- Voltages from 690 to 3300 V and more

Medium speed PM generators (MS PMG) since 2000

Compact MS PMGs represent a reliable slower speed solution. ABB offers the highest efficiencies: over 98% at full load, and even at only 20% load the figure is still 98%. We make both fully and semi-integrated types, for single or 2-stage geared systems. Proven ABB MS PMGs offer small size and weight to reduce top head mass. A modern 7 MW MS PMG with a nominal speed of around 400 rpm can be about 3 meters in diameter and weigh under 30 000 kg.

- Powers up to 7 MW, with higher powers available
- Typical rated speed between 100 and 500 rpm
- Voltages from 690 to 3300 V and more

High speed PM generators (HS PMG) since 2003

ABB's HS PMGs provide high power from the smallest frame size, with high efficiency over the whole speed range. They offer turbine OEMs a fast-track route from DF to the benefits of the full converter (FC) concept without extensive re-engineering.

- Powers up to 7 MW, with higher powers available
- Typical rated speed between 1000 and 2000 rpm
- Voltages from 690 to 3300 V and more



Generating better profitability for owners and operators

ABB supports customers' efforts to maximize their profitability by supplying products that deliver efficiency, availability and a low cost of energy (CoE). Our proven products are built for advanced grid code compliance and high power quality. They offer reliable operation at the highest peak and fatigue loads.

We design generators and converters for integration into perfectly matched packages which enable full system compatibility without compromising reliability.

Balancing investment and operating costs

The focus for wind turbine owners is on maximizing power production from the wind, in combination with low operation and maintenance costs and a long lifetime. Component costs are much less significant for turbine owners, as their involvement spans 20 years or more. It therefore makes sense to select components that will deliver high efficiency and reliability, rather than trying to minimize component costs.

ABB generators achieve the highest efficiencies in the market with lower running temperatures for continuous uninterrupted energy production and long lifetimes. The highest annual kWh production together with low maintenance costs results in the best life cycle profit (LCP) and low cost of ownership.

ABB services

We offer a complete portfolio of services to help ensure continuous, optimized kWh production and reduced turbine downtime. Our services include a fast, efficient spare parts logistics system, and advanced preventive and predictive maintenance solutions.

We also help to keep your wind turbine operational by offering repair services and replacement generators for ABB and many other generator brands.

Wherever you are located in the world we can provide rapid response through our network of service centers, which are backed by our global R&D resources.



Comprehensive ABB offer for wind turbines and parks

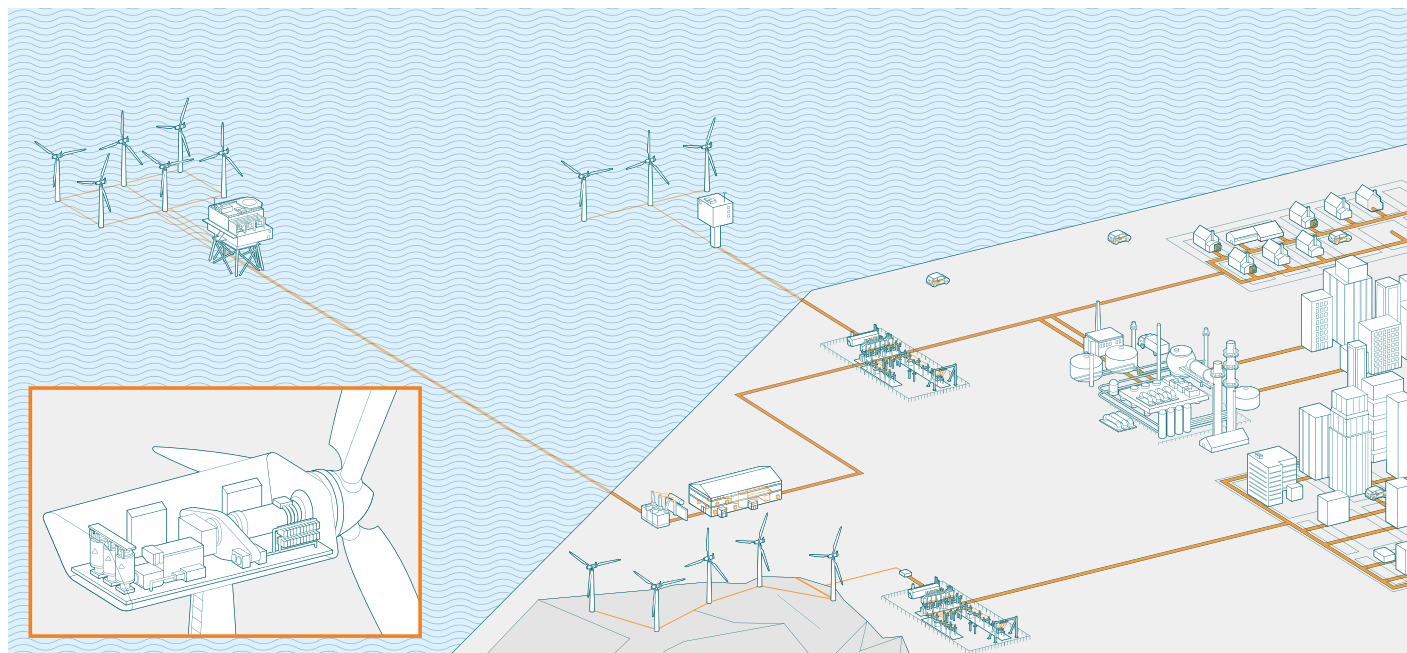


ABB is the largest worldwide supplier of electrical products and solutions for wind turbines and parks. We are the market and technology leader in generators, converters, motors, circuit breakers, contactors, and transformers. We have supplied a number of turn-key wind park grid connections and High Voltage DC transmission systems for distant offshore plants.

We are an experienced system supplier in electrical infrastructure. Our offering ranges from feasibility studies to power T&D projects using proven products and systems.

The new predictive maintenance solution ABB MACHsense-R is suitable for all wind power generator brands. This solution continuously monitors and immediately analyzes key parameters related to the condition of the cage rotor and bearings, and it also addresses temperature issues. ABB MACHsense-R avoids false alarms by monitoring key parameters rather than overall values. It can be used with all generator brands.

ABB products are used throughout turbine subsystems and entire wind parks.

Our products ensure efficient and safe power production in all turbine subsystems, from the generator to the grid.

The generator and converter form the heart and brains of the electrical drivetrain system, which also includes the stator, contactor and breaker.

The turbine control and protection system is based on PLCs for safe operation.

Motors and drives enable reliable operation of the yaw and blade pitch system, as well as the hydraulic and cooling systems.

Our offering includes electrical protection and disconnect systems and lightning protection.

ABB grid connection systems connect the wind power plant's internal network to the grid through the transformer and switchgear.

Grid connection products enable the distribution of the generated power from the turbines to the wind power plant's internal collection network and HVDC transmission to land.

Contact us

www.abb.com/motors&generators

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