

**Bender participating in**  
 FRAUNHOFER INNOVATION CLUSTER  
 "POWER ELECTRONICS FOR REGENERATIVE ENERGY SUPPLY"



## Answers for tomorrow

**As a long-standing member** of standardization organizations, Bender is now also participating in a larger research cooperation encompassing industry, science and research, contributing its specialist know-how towards jointly managing the challenges of the electric future. The goal of the Fraunhofer Innovation Cluster is to find answers to the issue of how the power electronics in wind turbines can be made less fault-prone, more efficient and less expensive.

The Fraunhofer Society sees one of its key tasks in transferring new scientific knowledge into innovations that benefit the economy and society. Under the "Pact for Research and Innovation", the Fraunhofer Society has taken on the task of devising Innovation Clusters and turning them into practical reality. The primary purpose of the Innovation Clusters is to contribute to the further development of already existing strengths. Cooperations of this kind set themselves clear targets and pool the specific capabilities of business enterprises, universities, non-university research partners and the Fraunhofer Institutes (see Fig. 1).



**Fig. 1:** Innovation cluster involving universities, Fraunhofer institutes and industrial partners

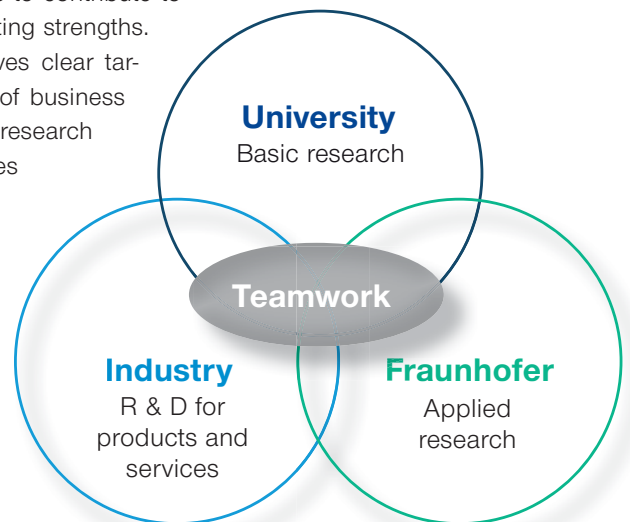
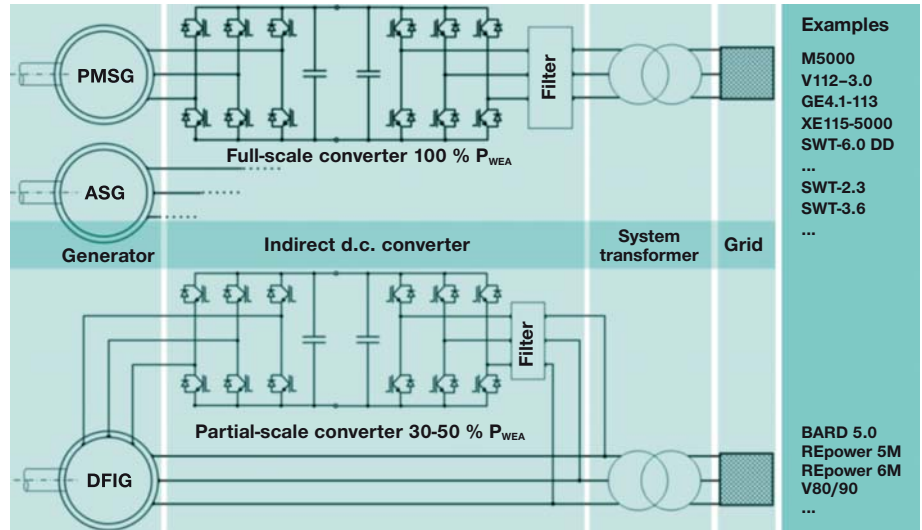




Fig. 2: Connection of wind turbines to the power grid at mains frequency.



▶▶▶ The collaboration leads to pooling and further development of the knowledge and skills of the parties involved and to better coordination of their activities. The close involvement of the university partners also ensures that the most up-to-date research results can also be consistently incorporated.

### The energy question

The worldwide growth in energy demand, the finite nature of conventional energy sources and the increasing warming of the climate make rapid progress towards sustainable energy supply and efficient energy use essential. A central role in this process will be played by the renewable energies. In the development of the renewable energies, the use of wind as an energy source will play a central role in the move towards an economically viable and climate-compatible energy supply.

In the last ten years, assisted by the public funding provided through Germany's Renewable Energies Law ("EEG"), the use of regenerative energy in Germany has experienced a huge development. Wind turbines in particular, with a total installed capacity of 31 GW, already cover a significant share of energy consumption in Germany, namely 11% (figures for the end of 2012). Wind energy currently supports around 100,000 jobs throughout Germany. In particular for the German economy, therefore, the further development of regenerative energy use is a strategic investment for the future.

### Key technology for the future

Power electronics has evolved into a key technology of the 21st century. Power-electronic frequency converters can also be found today in nearly all modern wind turbines. As the link between the generator and the system transformer, the purpose of the power electronics is to enable the wind turbines to connect up to the power grid at the mains frequency (cf. Fig. 2). As well as exacting demands to be met by the quality of the current fed into the

grid and to ensure the provision of reactive power in normal operation, there are detailed requirements on how a wind turbine must behave dynamically in the event of grid malfunctions in order to exert a stabilizing influence on the grid.

### Research and development

The Innovation Cluster “Power Electronics for Regenerative Power Supply” is aimed at the development of power electronic systems for regenerative energies in particular for use in existing and future wind turbines so as to make them less fault-prone, more efficient and less expensive. As initial R&D activities on the part of the Innovation Cluster, two lead projects are being pursued in the German federal states of Schleswig-Holstein and Lower Saxony:

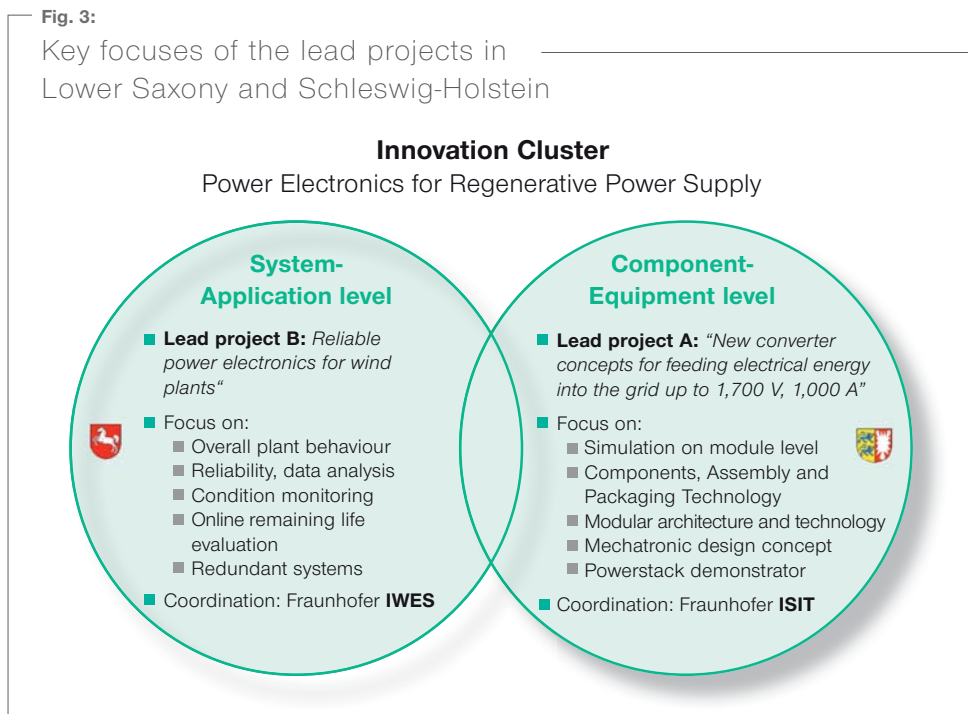
As a company working the field of measuring technology and condition monitoring, Bender’s involvement in Lead Project B (Innovation Cluster Lower Saxony), “Reliable power electronics for wind turbines”, is especially important for the skills and technical know-how it can provide in the area of condition monitoring.

One of the major challenges is that the power electronic components, which are of such central importance for the functioning of wind turbines, are increasingly dominating the fault statistics. Recent studies<sup>1</sup> have shown that while gearbox faults accounted



Fig. 3:

Key focuses of the lead projects in Lower Saxony and Schleswig-Holstein

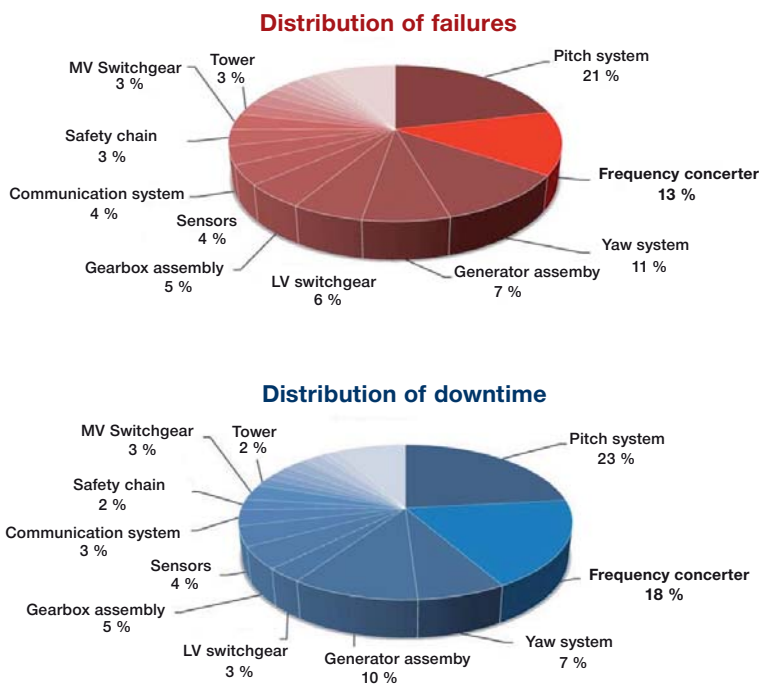


<sup>1)</sup> M. Wilkinson, B. Hendriks: Report on Wind Turbine Reliability Profiles, »Reliawind« project report, Deliverable D.1.3, 2011

▶▶▶ for a share of only around 5% of breakdowns, around three times as many breakdowns and no less than 18% of all damage-related downtimes were due to the frequency converter system (see Fig. 4).

**FIG. 4:** Share of various plant components in total failure frequency (top) and downtimes (bottom);

Data: [Reliawind-Projektbericht Wilkinson and Hendriks (2011)]



### Electrical faults as a cost driver

Therefore, faults affecting the power electronic components of wind turbines, and especially the converters, are a significant cost driver during the plant's operational life in terms of both the repair and/or replacement costs and also, in many cases, the resulting yield losses. And even more serious than in the case of land-based wind farms is the negative impact on system availability, and hence on earnings, of offshore wind farms. Here, the average downtime until repair tends to be markedly longer due to the restrictions on accessibility caused by the ambient environmental conditions.

Initial investigations confirm that the frequent failure of converter systems in wind turbines is both a manufacturer problem and a general topological problem<sup>2</sup>. However, analysing the causes is a complex process and is rendered more difficult by the often severe damage to the power modules.

### Currently no monitoring of electrical systems

At the present time, condition monitoring systems (CMS) for the early detection of faults are generally only used in wind turbines for monitoring the mechanical drivetrain components (e.g. gearbox, clutch, brake or rotor shaft). These systems frequently help to prevent serious damage, knock-on damage and lengthy downtimes. However, there are no comparable systems available for the electronic components in wind turbines. These components therefore tend to fail suddenly, quite often accompanied by an explosion and hence the associated risk of total loss through fire. The additional condition monitoring of electronic components could sharply reduce the financial effects

<sup>2)</sup> K. Fischer, T. Stalin, H. Ramberg, T. Thiringer, J. Wenske, R. Karlsson: Investigation of converter failure in wind turbines, »Confail«-Projektbericht, Elforsk Nr. 12:58, Stockholm, November 2012

of unforeseen damage and, in conjunction with coordinated preventive servicing and maintenance strategies, minimize the number of such events.

**In light of these facts, the following objectives have been defined for the Lower Saxony-based Lead Project B “Reliable power electronics for wind turbines”:**

- Investigation and identification of relevant causes of failure and failure mechanisms, and development of solutions to improve reliability
- Development of approaches for the early detection of changes of condition in power electronic components
- Understanding of the real environmental conditions and dynamic loads on frequency converters and the development of a basic specification specifically for wind turbine converters.

**The work under Lead Project B is broken down into the following work packages:**

- Analysis of causes of failure, and enhancement of reliability
- Condition monitoring and preventive maintenance
- Development and validation of models
- Development of innovative fault-tolerant system concepts.

We at Bender are proud to be involved in such an important and path-breaking research project, the results of which will benefit the industry as a whole and strengthen its technical market leadership in the field of wind energy and potentially expand it still further. ■

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## ALL PARTNERS CURRENTLY PARTICIPATING IN THE CONSORTIUM:

### Science/Research:

- Leibniz Universität Hannover, Institut für Antriebssysteme und Leistungselektronik (IAL)
- Fraunhofer ISIT
- Fraunhofer IWES

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- FeCon GmbH
- Gothaer Allgemeine Versicherung AG
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- juwi Operations & Maintenance GmbH
- Leine Linde Systems GmbH
- PNE WIND AG
- SSB Wind Systems GmbH
- SEMIKRON International GmbH
- Suzlon Energy GmbH
- Vattenfall R&D
- Woodward Kempen GmbH
- wpd AG
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