Challenge for the future

Intelligent fire detection in wind power plants

AUTHOR: DIPL.-BETRIEBSWIRT MANUEL PELAZAS

Fig. 1: Fire in a 2 megawatt wind power station after a lightning stroke in 2004 (Source: HDI-Gerling)

The development of wind energy

The generation of electric power through wind energy has gradually increased over the last 20 years in consideration of the global warming and the limited resources of fossil fuels and due to the related public promotion of renewable energies.

More and more nations and governments recognize the importance of this renewable energy. In 2009, more than 158,505 megawatt wind power were generated globally according to the German Wind Energy Association (BWE Bundesverband WindEnergie e.V.) which has the world's largest data collection about the use of wind power. Bearing in mind the annual global new construction as per the 2010 mid-year result of BWE, about 38,000 megawatt will be added to this so that an annual total of some 196,300 megawatt is estimated by the association for 2010.

Europe is the world's leading region when it comes to installed capacity

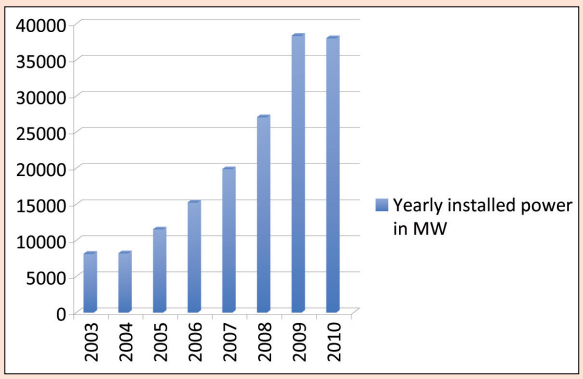

Fig. 2: Annual estimate on installed wind power worldwide (Source: BWE 2010)

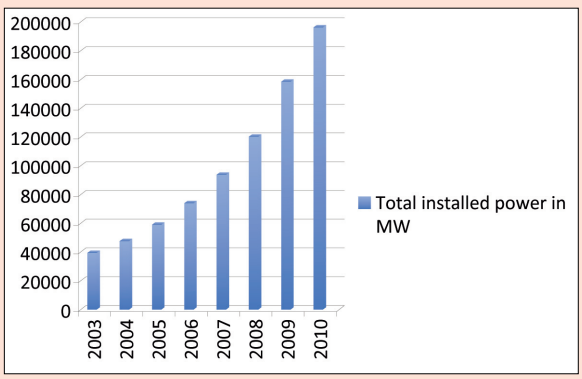

Fig. 3: Total estimate on installed wind power worldwide (Source: BWE 2010)

(approx. 75,000 megawatt), followed by Asia (approx. 40,000 megawatt) and North America (approx. 39,000 megawatt). Analyzed by country, the USA have approx. 35,000 MW installed, followed by Germany with about 25,000 MW, China with up to 25,000 MW, Spain with up to 20,000 MW and last but not least India with approx. 10,000 MW. For the first time in more than a decade, the US took over the number one position from Germany.

Both the US and the emerging markets of China and India appreciate this alternative type of energy and have pushed the installation of new wind power plants over the past years. In 2009, China has erected new wind generators with up to 13,000 MW and the USA added some 10,000 MW, with the latter corresponding to the power needed to provide 2.4 million homes with electricity or three large nuclear power plants (acc. to the AWEA American Wind Energy Association). The European leaders Spain, with approx. 2,500 MW, and Germany, with approx. 2,000 MW, rank next and are followed by the potential Asian Pacific leader India, with some 1,300 MW. According to the WWEA World Wind Energy Association the trend continued that wind capacity doubles every three years.

To identify why wind power is so important globally, its useful to look at a few more figures from Germany, as this country is constantly investing about 2 billion EUR on a year-by-year basis. The 2009 quota of the German capital investment in wind power technology was around 6% compared with 94% of global investment.

After energy generation with biomass, wind power takes second place among the most important alternative energy supplies in Germany, with hydroelectric power coming in third place. Wind energy accounts for 7.58 % of total power consumption in Germany and considerably contributes to reducing the carbon dioxide output.

In December 2009, a total number of 21,164 wind power plants was recorded. Approx. 1,000 plants are erected annually. Particularly efficient types have been used in recent years which paves the way for more continuous growth. More than 45,000 kilowatt-hours were clocked in 2009, and the potential of today's existing plants lies far beyond this. However, due to years with below-average wind levels, this potential has not yet been fully exploited.

Wind energy is also an important job engine for the economy

About 100,000 people from 550,000 acc. to the WWEA (Wold Wind Energy Association) are occupied with the planning, construction and operation of wind power plants in Germany – more than in the national coal mining industry. Wind energy actually provides the majority of the 250,000 new jobs created in the field of renewable energies in Germany. By 2020, the wind power industry will have created approximately 120,000 jobs in the country of the European leader in wind energy. And the GWEC (Global Wind Energy Council) estimates that by the end of this decade the wind industry will offer 2,2 million jobs worldwide.

Currently, the German wind power industry consumes about 750,000 tons of steel per annum; almost three times as much as the national shipbuilding industry.

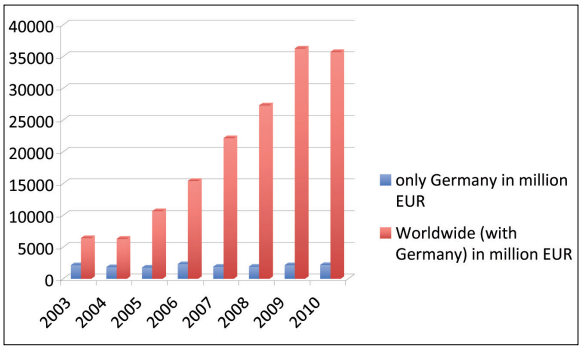

Fig. 4: Capital investment in new wind power plants (Source: BWE 2010)

Wind power "Made in Germany" is the world champion in this economic sector. Domestic manufacturers and suppliers dominate 30% of the world market for wind power plants, and the export business is increasingly becoming the most important pillar of the German wind industry. Almost 75% of the German plants and components are shipped abroad, which means an added value of about 7 billion euros for domestic suppliers (1.65 billion EUR in the domestic market and 4.7 billion EUR in the foreign markets).

Generally, the wind industry has been far better off during the financial crisis than the German mechanical and plant engineering industry. The world market took a breather in 2009 before growth rates of up to ten percent are expected to materialize again in 2010. The international markets are in good

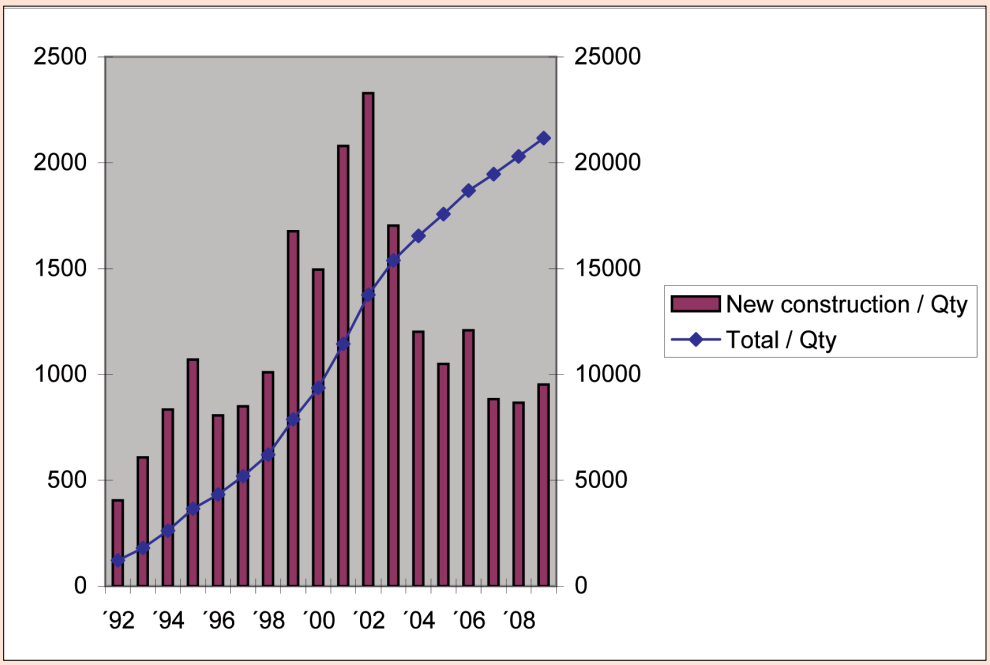

Fig. 5: The number of new wind power plants in relation to the cumulative figure for Germany (Source: BWE 2010)

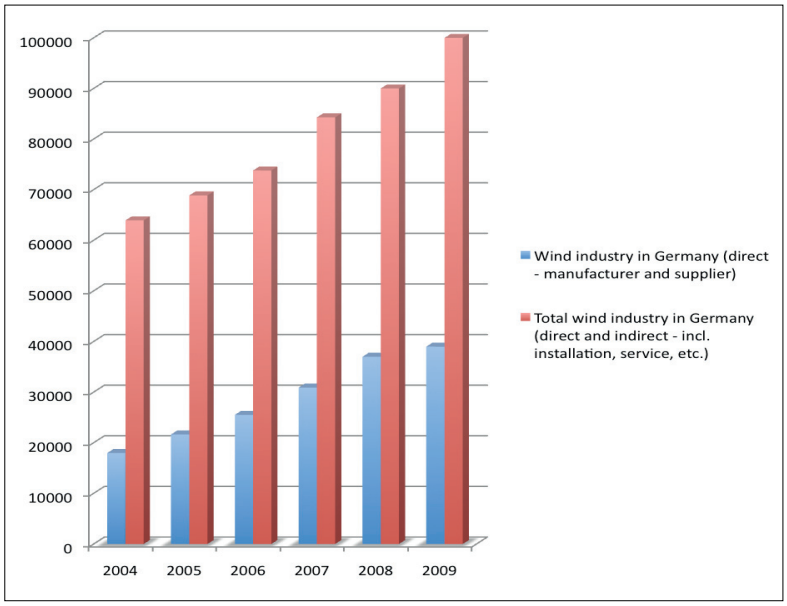

Fig. 6: Employees in the German wind industry (Source: BWE 2010)

shape and financing of reasonable projects is solid.

Wind energy will generate even more power through planned and already realized offshore wind parks. Since the wind blows stronger and more consistently over the sea, the energy output of wind power plants located offshore lies about 40% above those ashore. Therefore, offshore wind parks will considerably contribute to the energy supply in the coming years, like Germany's first offshore wind farm "Alpha ventus" (also known as BORKUM WEST, located in the North Sea approximately 45 km north of the island of Borkum, Germany) with 12 wind power stations each generating 5 MW. The annual electricity Alpha ventus is expected to generate in the future is equal to the consumption of 50,000 households.

The German Federal Government's offshore strategy assumes that a wind power performance of 25,000 mega watt will be realized offshore by the year 2030. Combined with the wind parks ashore, 25% of the overall electricity in Germany could then be generated by wind power alone.

Discussion about the fire protection of wind power plants

In order to reach this objective, plant-specific fire protection in wind power plants needs to be considered. Through the increasing prevalence of wind power stations, the wind power plant manufacturers have enlarged the installations concerning height and efficiency, which in turn has led to an enormous increase in capital investment.

Condition Monitoring Systems (also called CMS) are offered to prevent mechanical damage. In this context, the state of the wind power plant is permanently or regularly monitored by measuring and analyzing the crucial components and units. The monitoring system forwards the processed data to the operating staff for them to initiate a controlled disconnection in the event of a failure with the aim to minimize consequential damage. Current calculations assume that approx. 2% of wind power plants are equipped with such a system.

However, a CMS is neither able to detect a fire nor able to extinguish it. The percentage of fire detection systems in wind power plants is estimated at the same level. Hence, some 98% of the wind power plants have no fire alarm system at all, i.e. 33.4 billion EUR of capital investment worldwide is not 24/7 protected against fire.

Underestimation of risks in wind power stations

Both the fire load and fire risks in wind power plants were underestimated in the past. The central components of a wind power plant are mainly found in the cramped nacelle.

All of these units are located in minimal space, e.g. gears, generators, transformers, brakes and switch cabinets. They are surrounded by plastics for the nacelle housing and/or for insulation, oils and lubricants for the gears, brakes and transformers. Additional fire loads are the thickly packed wiring harnesses and maintenance and cleaning materials, sometimes even not properly stored.

Other risks are the unmanned operation as well as the missing connection to central management systems.

What are the typical causes of a fire outbreak in wind power plants?

The most frequently mentioned causes of fire in wind power plants are lightning strikes, defective lightning conductors in particular,

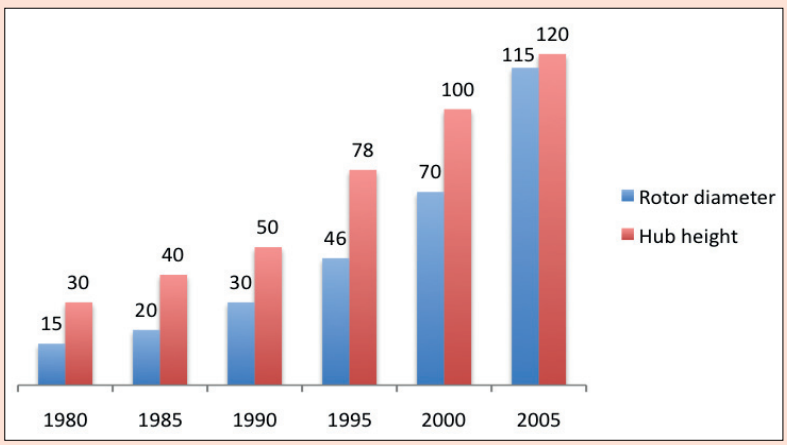

Fig. 7: Hazardous height, Progression of windmills in meter, (Source: Allianz & BWE 2007)

overheated electronics due to overload and short-circuits, machinery breakage due to material fatigue, additional dangers in the form of heated surfaces, e.g. through the mechanical emergency brake which leads to flying firebrands in the nacelle, if coverings are missing, and/or inadequately lubricated generator and gear bearings.

Another risk factor is the height of the construction. The diagram (Fig. 4) clearly shows the tremendous increase in hub heights and rotor diameters over the last thirty years. The trend has continued over the past five years: the plants have been growing to record heights. Due to extreme hub heights, the standard turntable ladders of the local fire departments, usually with a working height of 20-40 m, can no longer be used to extinguish a fire at the top of a wind power plant and/or a burning rotor. The local fire departments often do not even know the location of the wind power plants, especially since they can be quite remote and are difficult to access, which leads to long response times by the fire fighters. To prevent the fire fighters from being injured by burning parts falling down and/or a rotor burning out of control, or by bare high voltage cables in the wind power plants, those in command will always resort to a controlled burning process.

In summary, fire departments reach their limits when it comes to these plants. A disaster is almost always about to happen!

The controlled burning of a wind power plant is therefore explicitly recommended by the German Fire Department Association (DFV Deutscher Feuerwehr Verband) and the Hanseatic Fire Department Accident Insurance, Bureau Prevention (Hanseatische Feuerwehr-Unfallkasse, Abteilung Prävention). Thus, an investment risk arises from the wind power plant fire damage.

Controlled burning is a decision justified for the above-mentioned safety reasons. For the owner, however, this mostly means total loss with serious consequential damage, e.g. crop loss (e.g. damaged agricultural plants & fruits) and the disposal cost of the destroyed wind turbine.

To be added to the above are the tremendously high costs for a new plant, which in turn depend on different factors, e.g. rotor model, tower construction, type of generator, type of foundation, infrastructure and licensing procedure. The acquisition costs for one 1,500 kilowatt plant may amount to approx. 1.5 million euros. The costs for offshore plants are even higher because of the special location. One 5 MW offshore wind power plant costs some 5.0 million euros.

Downtimes of wind power plants due to damage represent a massive loss of profit for the operator and/or investor. Usually, the investor has to write off the object completely and cannot expect to build a new plant within short time due to the required new planning and building permission. In the event of minor fires, recommissioning may be jeopardized by extremely long delivery times of spare parts (approx. 9-16 months).

Moreover, operators and investors risk further loss of reputation with every fire, especially since wind power is already criticized in many regions due to its effects on the fauna, the noise pollution of the neighboring housing estates and the destruction of the landscape.

Fire protection concept for wind power plants

The risk can be minimized, if a corresponding fire protection concept is designed. The German Insurance Federation (GDV Gesamtverband der Deutschen Versicherungswirtschaft e.V.) and GL Germanischer Lloyd published a guideline for fire protection in wind power plants. This was due to the increase of incidents over the last years and the discovery that the degree of importance currently attached to plant-specific fire protection in particular was only minimal in this industry. The fire protection concept for wind power plants was published as document "VdS 3523" in summer 2008. The guideline is mandatory for individual plants as well as for on- and offshore wind parks to be built. In the case of already existing wind power plants it is recommended to adjust fire protection measures in conformity with this systematic guideline.

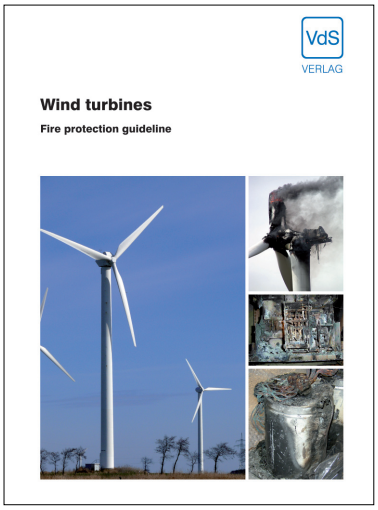

Fig. 8: GDV/GL fire protection guideline for wind power plants, VdS 3523

Section 5.2 "Fire detection and fire fighting" of the VdS 3523 guideline distinguishes between area monitoring and installation monitoring in wind power plants:

AREA MONITORING = monitoring of nacelle and tower area in which the wind power plant's technology is located as well as external transformer stations and substations. False floors, ceiling voids or similar are to be included in the fire load. The VdS 2095 guideline must be considered in planning and installation.

An indispensable complement to the area protection is INSTALLATION MONITORING = monitoring of equipment and related parts that are operated in a housing either totally enclosed or forced-air cooled, or operated in rooms with high air exchange rates, e.g. switch boards and converter cabinets. For both area and equipment monitoring, fire detectors using the SMOKE parameter are most suitable.

The guideline explicitly states that the suitability of a fire detector generally depends on the intended use which needs to be checked individually. One factor which deserves special attention is the optimum

The author of this article, ***Dipl.-Betriebswirt Manuel Pelazas,*** is International Sales Support Manager with Novar GmbH Neuss/Germany, known for its Esser by Honeywell brand.

Contact: manuel.pelazas @honeywell.com

fire detection and limitation of false alarms. The guideline helps to clearly select the suitable fire detectors for wind power plant applications.

Automatic early fire detection in wind power plants is only useful if the following reactions are to be triggered:

❏ Fire detection with forwarding of alarms to a permanently staffed location
❏ Shutdown of the wind power plant and complete separation from power supply
❏ Triggering of extinguishing system for area and installation protection with two-detector dependency (Type B) / (according to DIN 0833 Part -1/2, Dated: September 2009).

This VdS requirement clarifies that aspirating smoke detection systems for the corresponding wind power plant protection classes also have to be designed with two-detector dependency (Type B).

Ultimately, the optimal combination of detector types needs to be identified by specialized planners for every individual object . Undoubtedly, extinguishing plays a major role in the detection process in wind power plants.

Basically, it is possible to monitor equipment, such as switch cabinet rooms, switch cabinets and central substations in wind power plants, with point-type & line smoke detectors as well as with intelligent smoke detectors.

Extreme operating conditions for the plant-specific fire detection

The environmental conditions in a wind power plant can be very extreme for fire detectors. Wind power plants are a demanding site of operation for fire detectors due to the heavily fluctuating and aggressive environmental conditions. The operational conditions are influenced by different factors, e.g. by

❏ variation in temperature, by direct sun light in the nacelle
❏ permanent change of air exchange and air currents,
❏ strong/regular vibrations caused by the rotor blades, winds and/or waves,
❏ oil drippings from the gear and hydraulics systems,
❏ dust and exhaust due to the installation height
❏ high humidity rates due to the wind power plants construction and location
❏ high level of humidity and high concentration of salt, especially with offshore plants

The environmental conditions in larger plants are automatically controlled in the nacelle but this is not standard. Due to rapidly changing weather conditions and intense sunlight, condensation may occur in the machine cabin. In this environment fire detectors must be able to safely identify disturbances and false variables yet at the same time reliably detect an incipient fire for a quick automatic extinguishing to be triggered and damages as well as operation disruption to be minimized.

Fig. 9: Instruction how to select fire detectors for area and equipment monitoring in wind power plants (Source: VdS 3523, table 3, page 16)

Type of detector	Smoke detector			Heat detector (index "R" according to DIN EN 54-5)		Flame detector		Multi-sensor smoke detector	
	Point-shaped	Multi-point-shaped	Linear	Point-shaped	Linear	IR	UV	Smoke and heat	Smoke and CO
Room/Installation	Scattered light	Aspirating	Light beam						
Nacelle with transformer, including hub and raised floors	-	+	-	-	-	-	-	-	-
Central electric power substation, switch cabinet rooms	+	+	+	+	+	-	-	+	+
Tower base/platform with available installations, if applicable	-	+	-	+	-	-	-	-	-
Switchgear cabinets	+	+	-	-	-	-	-	+	-
Hydraulic systems	-	+	-	+	-	-	-	-	-
Transformer	-	+	-	Buchholz relay		-	-	-	-

+ basically suitable - not likely suitable

The data in this table refers to the basic suitability of several types of detectors with respect to functionality and general application conditions in the respective area of the wind turbine's system; it serves as orientation guide and does not replace the required proof of suitability as well as the object-specific technical planning by appropriate specialist planners, e.g., VdS-approved installers. Type-specific characteristics of wind turbines and fire detection systems have to be taken into account after consulting with the insurer (e.g., Engineering department), VdS Schadenverhütung GmbH (VdS loss prevention) as well as the certifying body for wind turbines, if applicable (for more information see also VdS guidelines for the planning and installation of fire detection systems).

The O2T detection principle has proven its value in these extreme usage conditions.

Intelligent fire detection to prevent fire loss and consequential damage

For reliable and early fire detection and/or to avoid false alarms in wind power plants, the usage of intelligent multisensor fire detectors is recommended, especially if the sensors are to detect not only smoke and heat but also vapor disturbance variables in adverse environmental conditions.

The O2T is such a multisensor detector capable of early recognizing fires and providing reliable protection from disturbances and false variables by using the two-angle-technology according to the forwards and backwards scattering principle and an additional heat detector. Unlike traditional detectors using the scattered light principle, the O2T detector distinguishes between different signal patterns typical for fires by using its multisensor technology plus a comparison of patterns to fire characteristics. Thus, it can distinctly analyze different particles in its measuring chamber. The fire detector optimally adjusts to the rough environmental conditions of this application through optional parameterization, intelligent recognition, rejection of transient signals, and the integrated drift compensation.

This type of intelligent fire detector has repeatedly proven itself in practical applications, among them the world's highest wind power plant in Laasow/Germany in the south of Brandenburg. This plant was completed in September 2006, and is considered to be the prototype of off-shore wind parks in the North Sea.

Approximately 1,400 four-person households can be supplied with the current efficiency of the 2.5 MW plant. With its hub height of 160 meters and rotor of 90 meters, it has a total height of 205 meters. For comparison: Germany's second highest church, the Cologne Cathedral, is 157.38 meters high.

The following equipment is installed in the Laasow wind power plant FL2500:
6x IQ8Quad O2T detectors, 1x aspirating smoke detection system, 2x line heat detectors and 1x extinguishing system.

The number of detectors required depends on the type of wind power plant, but considering what was used in Laasow/Germany and the number of wind power plants in Germany (21,164 plants as of 31 December 2009 according to BWE), there are still some 20,740 wind power plants (about 98%) being operated without an early warning fire alarm system in Germany.

Fire detectors are indispensable for the future of wind power as a source of energy

The usage of wind energy has established itself, both nationally and internationally, as an important factor in the field of renewable energies. Wind power technology is much in demand. Due to the global competition, the wind power plant technology is going to bring about further innovative developments with respect to efficiency and/or performance increase and the related output of the wind power plants, e.g. through more efficient ways of construction, more aerodynamic rotors, more powerful gears, generators, brakes etc.

Since experience has shown that a fire can arise at any time and that the related damage may be serious, fire detectors for such plants are indispensable. By using intelligent smoke detectors for early fire detection in wind power plants, wind power can be secured for the next generations.

List of references

❏ Wind turbines – fire protection guideline, VdS 3523 : 2008-07 (01), VdS Schadenverhütung Verlag, Köln-Germany

❏ Erneuerbare Energien: Gesamtüberblick über den technologischen Entwicklungsstand und das technische Gefährdungspotenzial, Abschlussbericht der Projektgruppe „Erneuerbare Energien" der Technischen Versicherer im GDV, Stand März 2008, Gesamtverband der Deutschen Versicherer

❏ GL Wind-Leitfaden – Zertifizierung von Brandschutzsystemen für Windenergieanlagen (WEA), Revision 2, 28.01.2009, Germanischer Lloyd

❏ Unerwartete Kräfte – DER SPIEGEL 34/2007 vom 20.08.2007, S. 42

❏ Statistiken vom Bundesverband WindEnergie e. V., www.wind-energie.de

Fig. 10: Wind power plant FL2500 with 2.5 megawatt power (Source: plant photo Fuhrländer)

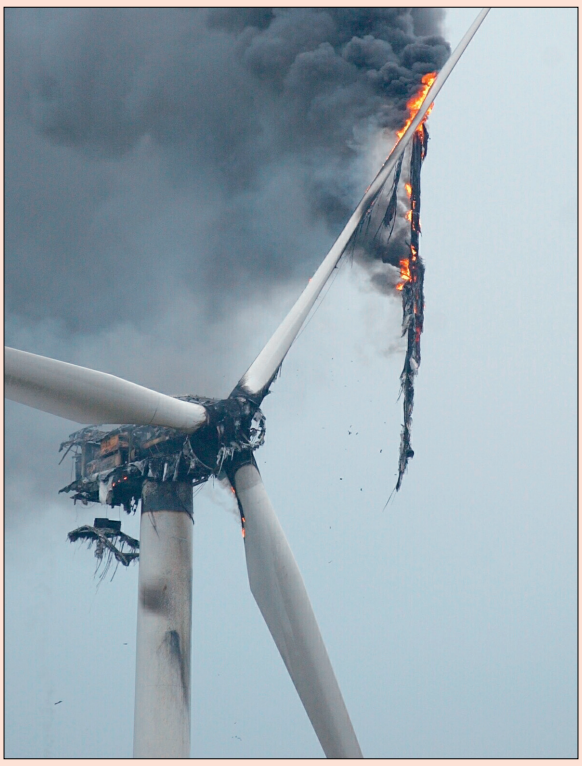

Fig. 11: Without an automatically operating fire alarm system a wind generator cannot be saved in the event of a fire