Reliability of Wind Turbines

Experiences of 15 years with 1,500 WTs

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INTRODUCTION

With the rapid expansion of wind energy use in Germany over the past fifteen years, extensive developments in wind turbine technology have taken place. The new technology has achieved such a level of quality, that wind turbines obtain a technical availability of 98 percent.

This means that an average wind turbine (WT) will be inactive for around one week per year for repairs and maintenance. Considering that the WTs operate over years without operating personnel, this average downtime seems short. The paper gives some figures about reliability of wind turbines, failures and downtimes for wind turbines and components.

DATA BASIS

In the framework of the „250 MW Wind“ Programme, ISET is monitoring over 1,500 WTs in operation. Over a period of 15 years now, WTs with a variety of different technical conceptions and installed in different regions in Germany have been included in the programme. So, from these turbines, the experiences of up to 15 operating years are readily available. On average, the participating turbines have completed ten years of operation.

Operators of the supported WTs regularly report to ISET concerning energy yields, maintenance and repairs, and operating costs. In form sheets for maintenance and repair, the operators report on the downtimes caused by malfunctions, the damaged components and - as far as possible - the causes and obvious effects on turbines and operation.

Most of these supported WTs have a rated power below 1 mega-watt. Thus, in the recent years operators of mega-watt WTs where asked quite successfully to contribute to the programme on a voluntary basis. So, experiences of the recent models can be included into the evaluations as well.

Up to now, over 60,000 reports on maintenance and repair have been submitted to ISET. Standardized evaluations are published in the 'Wind Energy Report' [1], which is updated annually.

Break down of Wind Turbines

Usually, WTs are designed to operate for a period of 20 years. But, no final statement can be made yet concerning the actual life expectancy of modern WTs as, until now, no operational experience of such period is available. Changes in reliability with increasing operational age can, however, provide indications of the expected lifetime and the amount of upkeep required. Reliability can be expressed by the number of failures per unit of time, i. e. 'Failure Rate'. In the following, the failure rates of WTs depending on their operational age will be depicted (Fig. 1).

It is clear that the failure rates of the WTs now installed, have almost continually declined in the first operational years. This is true for the older turbines under 500 kW and for the 500/600 kW class. However, the group of mega-watt WTs show a significantly higher failure rate, which also declines by increasing age. But, including now more and more mega-watt WT models of the newest generation, the failure rate in the first year of operation is being reduced.

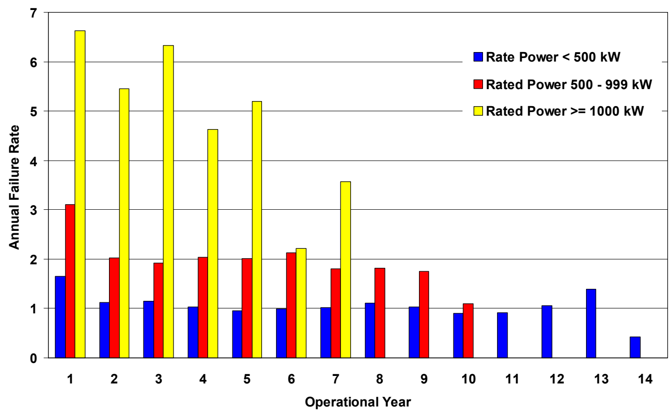

Fig. 1. Frequency of 'failure rate' with increasing operational age

The principal development of failure rates is well known in other technical areas. 'Early failures' often mark the beginning of operation. This phase is generally followed by a longer period of 'random failures', before the failure rate through wear and damage accumulation ('wear-out failures') increases with operational age.

The total life period and the individual phases are naturally distinct for different technical systems. For WTs, hardly any experience is available in this respect. Based on the above evaluations, however, for the WTs under 500kW it can be expected that the failure rate due to 'wear-out failures' does not increase before the 15^{th} year of operation.

MAL-FUNCTIONS OF COMPONENTS

The reported downtimes are caused by both regular maintenance and unforeseen malfunctions. The following evaluations refer only to the latter, which concerned half mechanical and half electrical components. (Fig. 2).

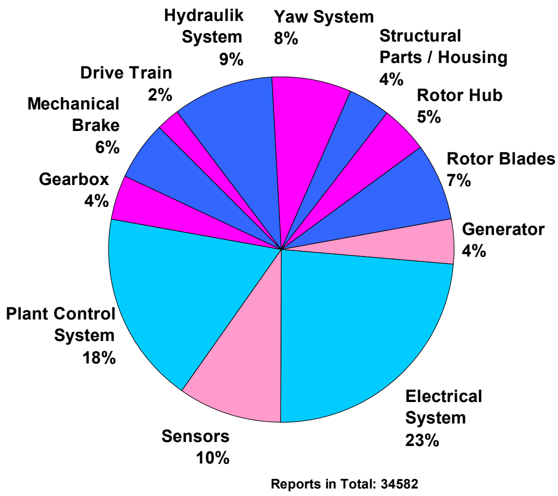

Fig. 2. Share of main components of total number of failures

Besides failure rates, the downtimes of the machines after a failure are an important value to describe the reliability of a machine.

The duration of downtimes, caused by malfunctions, are dependent on necessary repair work, on the availability of replacement parts and on the personnel capacity of service teams. In the past, repairs to generator [2], drive train, hub, gearbox and blades have often caused standstill periods of several weeks.

Taking into account all the reported repair measures now available, the average failure rate and the average downtime per component can be given (Fig. 3). It gets clear, that the downtimes declined in the past five to ten years. So, the high number of failures of some components is now balanced out to a certain extent by short standstill periods. But still, damages of generators, gear boxes, and drive trains are of high relevance due to long downtimes of about one week as an average.

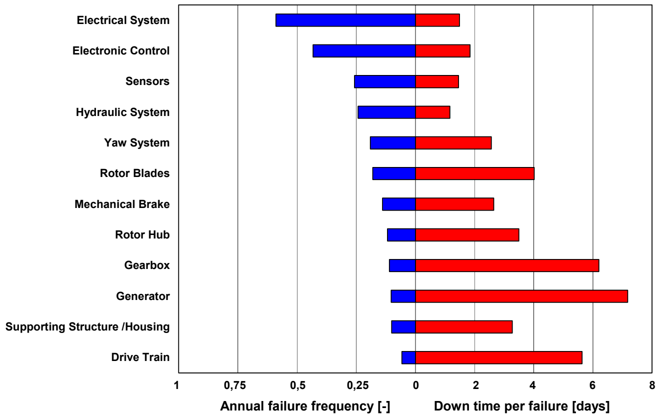

Fig. 3. Failure Frequency and downtimes of components

Conclusion

Wind turbines achieve an excellent technical availability of about 98% on average, although they have to face a high number of malfunctions. It can be assumed that these good availability figures can only be achieved by a high number of service teams who respond to turbine failures within short time. In order to further improve the reliability of WTs, the designers have to better the electric and electronic components. This is particularly true and absolutely necessary in the case of new and large turbines.

References

1. C Ensslin, M Durstewitz, B Hahn, B Lange, K Rohrig (2005) German Wind Energy Report 2005. ISET, Kassel
2. M Durstewitz, R Wengler (1998) Analyses of Generator Failure of Wind Turbines in Germanys ‘250 MW Wind’ Programme, Study. ISET, Kassel