

Wind farm owners, operators and financial backers have traditionally relied upon availability numbers as the best way to predict the amount of power and revenue a given project will produce over its lifetime. Yet a cursory survey of turbine vendors and industry consultants reveals enormous discrepancies concerning the calculation of availability.

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Mean Time Between Faults

The Hidden Factor in Turbine Unavailability

While most vendors promote availability in the 97 to 98% range for their machines, and most investors have come to expect that, a recent analysis by Garrad Hassan discovered that levels of true availability are a percentage point or two below that level. Furthermore, turbines operating in North America average in the 94 to 95% range.

One factor that has not been adequately discussed in relation to these divergent statistics is the role played by Mean Time Between Faults (MTBF or MTBF) in distorting these numbers. The fact is that the wind industry as a whole gets away with unacceptable levels of MTBF. Some of these faults are even excused by existing definitions of availability and so do not count in the availability calculations.

This paper discusses availability and the

role played by MTBF in holding availability numbers down, and suggests an industry consensus towards widespread sharing of MTBF data as a necessary prerequisite to the wind sector assuming its role as an integral part of the energy mainstream.

Disparate Availabilities

Garrad Hassan (GH) probably provides the best clarification of availability in a recent paper entitled 'Understanding availability trends of operating wind farms'. It covers the difference between turbine availability and wind farm system availability.

- **Turbine availability:** This is centred upon a specific turbine and is the number most frequently cited in contractual warranties. It typically excludes downtime on the grid, major catastrophic events or weather

patterns, routine scheduled maintenance (of up to 120 hours per year in some cases – 1.4% of total annual availability) and even retrofits of major components such as gears, blades and generators. The way each vendor adds up turbine availability varies widely across the industry.

- **Wind system availability:** In this, most downtime counts against availability except perhaps shutdowns due to high winds or cable unwinds (i.e. system availability is basically the amount of hours the turbines were available to operate over the total amount of hours in a given time period). System availability is always lower than turbine availability.

According to the Garrad Hassan paper, there has been a tendency to overpredict availability levels. In the USA, for instance, the actual availability average is only 94.1%. Yet most customers expect 97% and most contracts stipulate such numbers. The data indicate that these figures are lowered by the presence of larger turbines of more recent designs and therefore not yet fully proven technology. Older proven designs in the sub-megawatt range have higher availability but are less productive on a dollars per megawatt of capacity basis. Turbines in the megawatt-plus range, on the other hand, still tend to be overcoming teething issues and so have lower availability. GH calculations put sub-megawatt models in the 96–97% range, while megawatt-plus sizes remain in the 94% range. By year three of operation, though, the megawatt-plus category moves up to almost 96%, demonstrating the growing maturity of newer technology.





Fault Conditions

Faults occur on turbines for a variety of reasons. There are anywhere from 100 to 300 faults identified per machine. These might be temperature related due to oil, air or bearing issues, or pressure related – oil pressure in the gearbox, for example. Other fault conditions concern too high or low a voltage or current, high or low winds that are beyond operating parameters, pitch rate and grid stability. High load faults

due to vibration protection alarms or a rotor overspeed condition, for instance, cause a turbine to fault.

Thresholds for these faults are set for the turbine. When they are exceeded, the machine is automatically turned off. While some matters are purely routine and the turbine merely needs to be reset, it has become a bad habit in the industry to simply hit reset almost every time a fault occurs. Certainly, this keeps availability rates higher – but only in the short term. Underlying any one of these fault conditions could be a more serious situation that threatens the long-term functioning and productivity of the unit.

Take the case of a temperature fault on a hot day. While it may simply be caused by excessive ambient temperatures, failure to investigate could mask an underlying issue. If the operator lets the turbine cool down and then hits reset, he/she could be making a grave error. We can use the analogy of a car driving through Death Valley with radiator problems: perhaps you could make the journey by stopping every hour to let the car cool down and then filling up the radiator each time, but clearly

there is something seriously wrong. Battery voltage systems are another area where faults are frequently ignored – a fault tends to show up, for instance, when the battery voltage is too low. As this is rarely going to cause any immediate problems, it is almost standard practice to reset the machine immediately. Yet, if you restart the turbine with little or no battery voltage remaining and a grid event occurs, you could be faced with the catastrophic failure of that machine.

Another factor to take into account is the damage that can be done by constantly stopping and starting a turbine. This is typically not included in the design criteria for the machine. If the reset button is being hit continually in order to bolster availability statistics, damage can be done due to inordinate numbers of starts and stops causing undue wear and tear.

Furthermore, cascading damage can be done to neighbouring systems. A problem ignored in one area, after all, can lead to failures in adjacent systems. Collateral damage is a possibility if faults are not investigated and dealt with appropriately.

Obviously, the customer and the utility demand a high degree of availability. Unfortunately, this is often interpreted as a way to mean that ‘routine’ fault conditions should be bypassed. If this is carried out on a continuous basis, mechanical issues could curtail long-term operational effectiveness.

The MTBF measurement would indicate this situation, and is a good metric to track and improve.

Energy Industry Standards

If a large gas turbine faults, the lights in the neighbourhood will dim. This is not the case with wind turbines, even those in the 1 to 3MW range. The reasoning goes, therefore, that the faulting of one or two wind turbines is not a significant concern. But multiply that by a few dozen turbines in a large project and the impact becomes noticeable.

The situation is not assisted by permissiveness with regards to grid

interconnection by wind farms. The North American Energy Reliability Corporation (NERC), which sets standards for reliability, polices the grid behaviour of nuclear, gas, hydro and even geothermal power generation, but not wind. This could well be contributing to the huge gap facing wind – gas turbines fault maybe four or five times per year compared to hundreds of faults per year for the average wind turbine. This is measured by the MTBFault or MTBF statistic, which represents the number of faults divided by hours.

At Clipper, for example, on the 2.5MW turbine platform, we noticed fault conditions every 20 or 30 hours on average in the early days of our Liberty technology. We have developed a downtime tracking tool based on the NERC’s Equivalent Forced Outage Rate (EFOR) measurement of unit reliability. By working conscientiously on this issue, by May 2009 we had increased the average MTBF to over 100 hours for the Clipper fleet. These improvements were achieved using quality assurance processes such as Six Sigma in tandem with Root Cause Analysis (RCA) to really solve the underlying causes of fault conditions. In addition, tools were put in place to gather data and analyse it to determine the primary reasons for faults on each machine, each wind farm and our fleet as a whole.

For example, an over-temperature problem was discovered with a power converter at the base of the tower due to its relatively high fault count. While overheating might be normal in Palm Springs on a hot day, this was on Lake Erie at only 75°F (24°C). An RCA found the cause, proposed corrective measures, validated them through prototyping and testing, and led to a better cooling system being added across the fleet as a retrofit. This improved cooling system is now part of all new Clipper turbines installed.

If the operator at Lake Erie had reset the unit that may have cranked up availability in the short term. But a more thorough approach by Clipper has brought a 200% gain in MTBF in less than a year. The immediate goal is to push MTBF to 200 hours

with the ultimate goal of achieving 750 hours. This is not an unreasonable goal. Another established wind manufacturer embarked upon a similar programme a couple of years ago and has pushed MTBF up to 175 hours.

However, a major barrier stands in the way. Almost no-one in the industry is willing to discuss MTBF figures. This closed door policy means ultimately that change will come slowly. Yet it is totally within our power to push MTBF up to acceptable levels in the range of 750 hours (one fault per month approximately) – if we work together, and help each other increase reliability to unprecedented levels.

With the USA having gone through a record year of wind energy deployment and the world as a whole installing more wind turbines year after year, issues such as MTBF have to be confronted. By accepting NERC standards, demanding they be made applicable to wind generation and then working with utilities and energy providers to achieve the desired levels of reliability and availability, wind can move forward with confidence and take its rightful place in the energy mainstream.

Best Practices and Lessons Learned from Conventional Turbo-Machinery

Wind energy has derived several best practices and lessons learned from the operations and maintenance of traditional turbo-machinery. This includes but is not limited to real-time performance monitoring and optimisation, fault recognition, Environmental Health and Safety (EHS) provisions such as lock out-tag out protocol, and the use of Supervisory Control and Data Acquisition (SCADA) systems for power plant control and data acquisition.

In addition, most wind turbine power plant equipment suppliers and operators have implemented remote centralised monitoring and diagnostic centres (RMDC) to efficiently manage power plant performance and track warranty obligations. This approach has been used extensively by conventional turbo-machinery operators in the past and has proved to be very cost-effective.

Another best practice from conventional turbo-machinery is the use of condition based monitoring (CBM) systems to provide real-time and trend vibration data and oil contamination levels from gearboxes and generators. Although still in their infancy in terms of widespread utilisation in wind energy, CBM systems are gaining traction as a useful tool to optimise preventative maintenance strategies needed to lower the overall operations and maintenance cost for wind power plants. ■

Biography of the Author

Mr Christenson brings 27 years of product development experience to Clipper Windpower. After joining the wind energy industry in 1994, Mr Christenson has made a major contribution to the design and development of several utility scale wind turbine models ranging in size from 750kW to 3.6MW. Mr Christenson held positions of Director and Vice President of Engineering at Enron Wind and its predecessor Zond prior to the acquisition by General Electric in 2002 and his appointment to Chief Engineer.



During his tenure at GE Energy, Mr Christenson’s technology team leadership enabled rapid growth and GE Energy’s Wind business unit became one of the world’s leading wind turbine suppliers through the introduction of GE’s advanced 1.5MW and 2.5 multi-megawatt product lines. Mr Christenson has received a US Department of Energy R&D Partnership Award for his contribution to the advancement of wind power technology and holds several US patents.

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