O&M Optimisation and Smart Grids

Strategies for increasing the profitability of wind energy

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The costs and benefits associated with the Operation and Maintenance (O&M) of wind turbines during the complete life cycle have an important impact on overall profitability. Techniques such as condition monitoring, assessment of failure rates and proactive maintenance are commonly used to reduce the risk of failure and unplanned repairs. Furthermore wind farm operators are increasingly motivated to investigate and exploit opportunities to increase the energy yield of their turbines through performance upgrades. The coordinated application of such techniques across multiple sites and for large numbers of turbines requires a high level of information transparency, automatic data processing and intelligent decision making based on an understanding of the trade-offs that exist between maximum performance and reliability. Smart Grids acting not only as a network between distributed energy sources but also enhancing information transfer will contribute to the effectiveness of such techniques.

In the following article several key the issues relating to the optimisation of the availability and performance of wind turbines are introduced. Within the context of Smart Grids, it is shown that techniques exist that will increasingly support operators in optimising the profitability of their wind farms.

Maximising availability and energy yield

The requirement to maximise the operational availability of wind turbines is already well recognized. Techniques such the use of weather prognostics to support maintenance scheduling and sophisticated management of spare parts, tools and manpower are typical. Multiple information sources (e.g. maintenance plans, SCADA data logs, service records...) are combined and used as a basis to plan field activities. Supported by efficient software and database tools, the modern wind farm operator can identify and diagnose developing problems and react quickly and effectively.

In addition to ensuring that turbines are always available when wind conditions allow power production, the operator strives to maximize the energy yield from running machines. Such optimisation requires that the turbine alignment (pitch, yaw) is correct, blade condition is good, control systems are correctly parameterised and so on. Operators are increasingly recognising the need to investigate such issues and intervene where improvements can be made.

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Performance versus Durability

Simultaneously maximizing turbine availability and energy yield can be somewhat contradictory. Increased turbine performance implies an increase in the duration and number of high load events. Such high loading often correlates strongly with increased failure rates for various damage mechanisms. For example it is commonly accepted that failure rates of gearboxes correlate strongly with the duration spend at high power operation and/ or the extent of wind turbulence. Increasing the power output of turbines may lead to more frequent or earlier wear-out, hence reducing overall availability. The proper assessment of such trade-offs requires a detailed understanding of the mechanisms that cause the components and sub-systems of a turbine to fail, as well as the relationship with the applied loads and operational environment.

Smart Grids & Virtual Power Plants

The task of increasing the profitability of wind energy is complex. However, opportunities do exist, particularly within the context of the modern renewable energy market. In order to counteract the challenges associated with a distributed and variable energy supply (e.g. demand/supply matching, grid frequency control, power quality requirements) there is a trend towards collaborative energy supply, with multiple decentralized providers combining their anticipated energy production and selling such packages to the grid, including some margin to avoid the risk of underproduction. In particular in the German market the development of “Virtual Power Plants” is increasing momentum following the amendment of the Renewable Energy Act in 2012. Such developments are synonymous with the drive towards increasingly advanced transmission systems, or “Smart Grids”, capable of not only electricity transfer but also measuring and communicating demand and supply side variations.

Operating Reserve

In view of such developments, the rules dictating the goals of the turbine operator are changing. It is no longer a given that all turbines should operate at the maximum possible power and for the maximum possible time. Rather the goal is to provide the grid with a reliable, stable and predictable energy supply. This change provides the operator with additional degrees of freedom in the planning and execution of maintenance activities. In cases where the maximum energy production is limited to a level below that which would be possible given available wind conditions, the operator may choose to shut down individual turbines altogether, or operate a large number of machines at reduced power set points. This approach is similar to the “operating reserve” strategy practiced by the operators of centralised power stations.

Protective Operation

As mentioned above, relationships may be defined between the load history and the failure probability of a given turbine. Software tools developed by Uptime Engineering support the efficient processing of available data logs for the calculation of indicators such as *current failure probability* and *remaining useful life* for each turbine and its sub-systems. Given such techniques, it is not necessary to assign at random the turbines to be used as operating reserve. Rather the operator may apply a risk-based approach, choosing to reduce the load on units that have accumulated the most damage due to past operation. Essentially this is a protective operation approach; in the long term all turbines in the available fleet contribute as part of a "load sharing scheme" and on average the failure rate of the fleet is reduced.

Smart Maintenance

Such a reduction in failure rates results in reduced unplanned downtime and reduced maintenance costs. Further savings may be achieved if the information transparency provided by interconnected energy providers is extended to include inputs relevant to maintenance planning.

The grouping of large numbers of turbines to form virtual power plants provides exciting opportunities for maintenance optimisation at the overall plant level. Detailed maintenance schedules from all members of a virtual power plant collaboration may be shared and managed centrally. Each member is automatically provided with recommendations defining the time window within which specific maintenance may be carried out on specific units. The strategy is designed to ensure that the overall energy supply of the virtual power plant matches an agreed target level, whilst at the same time providing members with adequate opportunity to carry out repairs.

Weather Prognosis

The success of such centralised scheduling activities depends strongly on the availability of accurate prognosis of short and medium term weather conditions. This is required both for the definition of overall production targets as well as the scheduling of maintenance activities. Currently the majority of operators procure weather prognosis data from one or more centralised meteorological centres and apply correction factors to yield the best possible prediction at the specific location of the operating units.

Research performed by Uptime Engineering has shown that effective weather prognosis may be performed using meteorological data such as wind speeds, air pressure and temperatures measured either by on-site meteorological masts or at the turbines themselves (i.e. using SCADA logs). Such measurements are site relevant (requiring no transformation via correlation methods) and readily available in large quantities. Within a virtual power plant, measurements from many geographical locations (e.g. from each turbine) may be combined and used to track current and future weather trends.

Enabling the Energy Revolution

The success of distributed energy providers such as wind turbines in competing with centralized, conventional power plants depend on several key enablers. Security and quality of supply must be consistent with the grid infrastructure and the cost of energy must be driven down by maximised availability and performance. The recent trends towards the development of Smart Grids and interconnected systems with centralised management, supported by modern information technology are already making an important contribution. Enhanced by techniques such as protective operation, smart maintenance and localised weather prognostics, modern wind farms are well placed to make a vital contribution to the energy revolution.