

McKinsey on **Electric Power and Natural Gas**



Perspectives on electric power and natural gas

Number 1,
Winter 2008

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How to operate and maintain wind assets

Superior O&M practices are critical to achieving optimal profitability of wind farms and can increase return to shareholders by 20 percent.

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and Nuno Santos**

The wind industry has traditionally believed that value creation is concentrated in manufacturing and wind farm development: since once a wind farm is up and running, turbine performance is generally above 93 to 94 percent availability,¹ and cash flows will be stable and predictable.

Our research, however, suggests that operations and maintenance (O&M) can play an important role in maximizing the returns of existing assets and increasing revenues from existing wind farms. Depending on existing levels of performance, improved O&M could account for nearly a 20 percent increase in the equity internal rate of return (IRR) (Exhibit 1). Companies that identify and systematically capture this potential could then develop a key competitive advantage in the industry.

There are three key levers that allow improvements of wind farm O&M:

Availability. A 3 percent increase in the operation of a wind farm's turbines, to reach an ambitious but achievable 98 to 99 percent target, can yield a 1.2 percent increase in IRR.

Efficiency.² A 2 percent improvement, to reach up to 99 percent, can produce a 0.8 percent higher IRR.

O&M costs. The improvement potential varies significantly, but a 10 percent reduction would mean 0.8 percent higher IRR.

Availability: Do not forget small failures

Of the different ways of calculating availability, we have chosen "energy availability," which compares the actual production of a given turbine with the total potential production if it were always available. This definition excludes unavailability in periods with no wind that has no impact on wind park output.

Although availability levels of 95 to 96 percent are common in the industry, perfor-

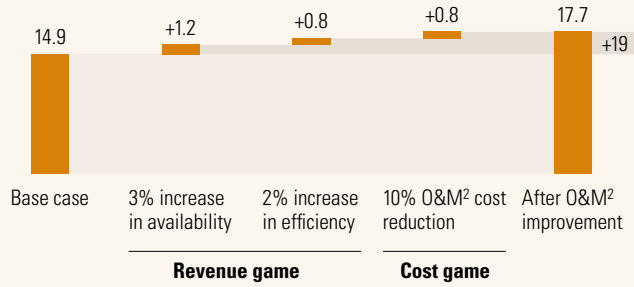
¹ Availability measures the percentage of time a turbine is ready to produce electricity.

² Efficiency measures the power generated by a turbine as a percentage of the theoretical output specified by the OEM.

Exhibit 1
O&M practices could deliver extra returns

There is significant potential to increase revenues and reduce costs at an existing wind farm.

Equity IRR¹ of a wind project, %



¹Internal rate of return.

²Operations and maintenance.

mance typically varies widely. In practice, only one-quarter of wind parks operate above 98.5 percent availability, demonstrating that such a level of performance is achievable. More than 40 percent, however, are below 97 percent and some parks as low as 92 percent, creating significant potential for improvement.

This inconsistency in performance is unrelated to the age of the park or the manufacturer. It is critical then to understand the most common causes of this unavailability.

Large component failures can typically take two to eight weeks or even longer to repair or replace, especially in the current tight market. Component lead time, in fact, represents more than 80 to 90 percent of total downtime.

Small failures are frequently the most common cause of unavailability. Although each individual failure has limited impact, they occur frequently and are therefore disruptive. Most of this unavailability is due to a small number of distinct causes (usually fewer than 10 in number) in each individual wind park.

The first step for managers is therefore to identify the specific local reasons for unavailability. Once such a diagnostic is performed across a wind park's portfolio, it is possible to identify ways to significantly reduce it and increase power output accordingly. There are a number of different ways of optimizing output:

Eliminating root causes of underperformance begins with identifying the issues that are causing the greatest loss of output. In one park we studied, high temperatures in turbine transformers were causing most of the unavailability. Replacing them was too expensive, but increasing mechanical ventilation inside the tower proved extremely effective.

Optimizing preventive maintenance begins with reviewing on a regular basis which components are failing and why. Preventive maintenance needs to be adapted based on experience and failure statistics.

Optimizing logistics of components begins with having an optimal stock of components available. An installed base of around

75 components (even less if critical components take more than two to three weeks to arrive) already justifies having a specific stock of components that can be delivered and installed within days (Exhibit 2).

Efficiency: Make “hidden” potential visible

Efficiency is measured by the amount of power generated by an operating turbine compared with the theoretical output it should provide according to OEM specifications. Measuring efficiency is less obvious than availability, since it is not a visible variable. Some turbines produce systematically less than the average. This does not necessarily mean they are not working properly, as wind is not always uniform within a specific site but indicates it is worth further investigation.

The first step is to analyze the power curve for suspect turbines. This curve represents power generated at different wind speeds and allows for comparison with the theo-

retical performance specified by the OEM. If the two curves do not match, there is potential for improvement. Lost production in the range of 10 to 20 percent is common in underperforming turbines.

The causes of turbine inefficiency can vary significantly, including the following:

Vane malfunction often causes improper orientation of the turbine. Any deviation from the wind direction means part of the wind power is lost and production is lower than it should be. Exhibit 3 shows power curves before and after replacing a vane.

Dirty blades that contain dust or other material can prevent the wind force from being transmitted appropriately to the blades and the generator, resulting in lower output.

O&M costs: Choose the best operating model

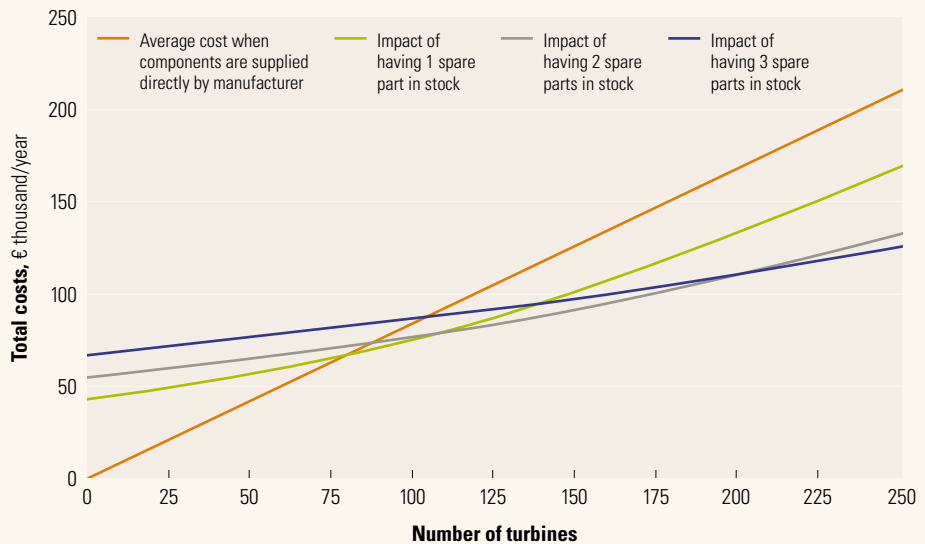
Wind turbine equipment represents around 80 percent of the total investment in a wind

Exhibit 2

The impact of improved logistics

Having a specific stock of components available can significantly improve performance.

Impact an in-stock component has on resolution time



park, but when total life cycle costs are considered, this share falls to about 60 percent—with O&M accounting for 15 to 20 percent. More important, it is the only driver of costs that can be addressed after construction of the wind park.

Developing the most appropriate O&M model is critical. Typically when a developer purchases wind turbines from a manufacturer, the contract usually includes a full O&M service agreement that guarantees the level of performance for a certain period, typically three to five years. Such a contract is important to guarantee the quality of the turbines and their installation. After the period of guarantee expires, the owner needs to decide between the following different possible models:

Renewal of the existing full O&M outsourcing agreement, ideally with a certain guarantee over performance.

Completely internal O&M, including its own teams to conduct all maintenance activities.

A hybrid model, in which the owner performs certain tasks while subcontracting others to third parties.

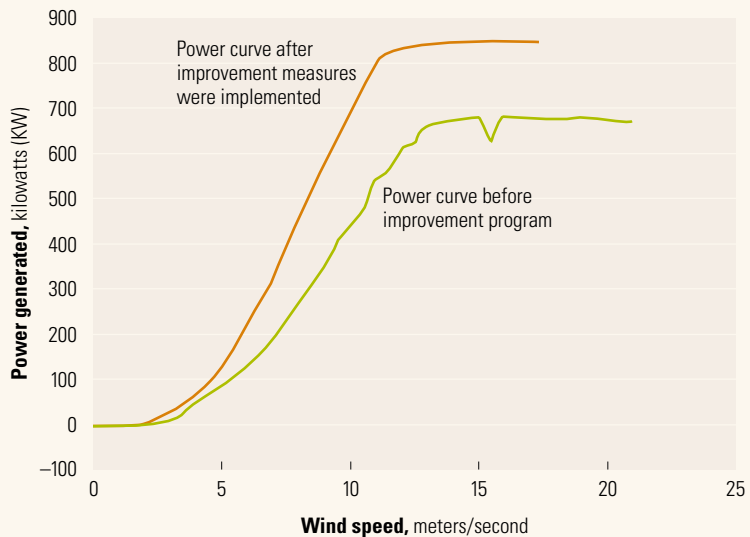
The best model could depend on the size of the wind portfolio, the type of company (for example, financial players seldom have the capabilities to conduct O&M internally), and the appetite for risk. In any case, it is critical to ensure a close collaboration between the wind park owner and the service provider to ensure a proactive approach in addressing underperformance.

Some wind owners are opting for the hybrid model. Depending on the importance of the different activities along its O&M value chain for maximizing turbines output and their capabilities, these players

Exhibit 3

The impact of inefficiency

Deviation from the wind direction means power is lost and turbine efficiency reduced.



choose which activity to insource. In-house activities could include O&M intelligence (data analysis, failure prioritization, and root cause analysis) and maintenance planning (when and in which components to conduct preventive maintenance). Neither of these activities requires huge resources but both are critical to maximize output.

Other activities, such as spare-parts management or the dispatching of field crews, are partially outsourced—but under strict specifications from the owner. Finally, labor-intensive field activities, which represent a significant level of complexity in people management, are subcontracted.

During the initial phase, it is useful to create a lean team that is in charge of rolling out the continuous-improvement process across all the wind parks

This is a challenging model because it requires solid execution, since there is no guarantee on performance, and it is more difficult to access an OEM's resources. But when the total costs of this new model are compared against renewal proposals for full O&M contracts, they could be 20 to 40 percent cheaper.

The challenge:
Continuous improvement

Capturing the full financial potential of improved O&M along the three dimensions of availability, efficiency, and costs requires applying principles similar to those in lean manufacturing. It is especially important to create the appropriate operating and IT tools that allow continuous performance tracking, as well as promote a mind-set of continuous improvement. From a techni-

cal point of view, the levers themselves are reasonably straightforward. Creating the conditions for a systematic approach to identifying waste and eliminating it is more complex, and involves the following:

Establishing the correct management information system (MIS). This system requires ensuring that all data generated by the SCADA system³ is continuously registered, that any work conducted in the wind park is codified and stored in central databases, and that reports are automatically generated to identify underperformance and root causes of failure. This process is best conducted through a remote control center that centralizes information from and allows real-time monitoring of turbine alarms so that issues can then be solved either remotely or by sending crews onto the field.

Developing a culture focused on O&M improvement. Companies must create clearly defined roles so that all elements of the organization work in a coordinated fashion to identify and resolve issues. During the initial phase, it is useful to create a lean team that is in charge of rolling out the continuous-improvement process across all the wind parks. This team should include a number of change agents put in charge of training wind park managers in lean techniques and in helping them conduct an initial performance review. Together with site managers, technical staff, and OEM personnel, they are also in charge of defining improvement levers. Focus on continuous improvement should go beyond operations and maintenance and should include all areas of the organization. For example, purchasing should incorporate input from failure analysis to improve turbine specifications and OEM selection. Additionally, it is

³Supervisory control and data acquisition system.

important to ensure the right key performance indicators (KPI) are measured and tracked and that objectives and incentives reflect them properly.

Ensuring appropriate mind-sets and behavior is the key success factor in any continuous-improvement program of this kind. This objective is likely to be a challenge in a geographically dispersed organization. Factors that contribute to creating the right attitude include ensuring that a clear message is sent from top management about the importance of O&M, investing in training staff, and celebrating and rewarding improvement.

Significant opportunities exist to optimize wind park operations and maintenance, providing a significant boost to internal rates of return. Availability and efficiency can be improved through a systematic approach that requires a rigorous analysis of performance and the elimination of root causes of failures. Although not particularly complicated or capital intensive, the challenges of setting up the right systems and motivating the organization to sustain continuous-improvement in O&M should not be underestimated. Establishing a continuous-improvement culture requires a very proactive attitude and cooperation with key stakeholders like turbine manufacturers and O&M suppliers. It is, however, an opportunity to maximize revenue, reduce costs, and gain advantage as the industry becomes increasingly competitive. ●

The authors would like to thank Paul Kolter, Johannes Lüneborg, and Luis Troyano for their contributions to this article.

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