# Operating Conditions of Wind Turbine Nacelles

An expanding industry with ever-growing demands for larger turbines and more extreme installation conditions is creating increasing strain for those working to operate and maintain these systems, especially when it comes to the all-important nacelles. Today's industry is responding with new and interesting technology to handle not only accessibility and safety issues, but also ease of repair and cost effectiveness.

Most wind turbines are located in areas that can be hard to get to or that are remote. Depending on the time of year and climate in the area of the wind turbine, environmental conditions can make it difficult to maintain or operate a wind turbine as well. Not only that, but given that the nacelle is hard to reach because of its vertical height, it can be both physically daunting and expensive to visit for maintenance workers. Lowering the costs for maintenance and operations is an increasing priority to both manufacturers and wind turbine owners.

There have been great advances in technology to help lower the costs of maintenance in wind turbines, not least of which is the use of online monitoring systems which help to predict operation and maintenance requirements and also any potential failures in a wind turbine.

There are also many improvements being made with 5+ MW wind turbines that prove to be both reliable and cost effective. Superconducting generators are the new innovations that accompany a direct drive system for 5+ MW wind turbines. There is no need for a gearbox in direct drive systems which eliminate some of the failures in reliability in other wind turbine versions.[i] The larger a turbine is the more complex components and innovative technology is needed for it to work appropriately.

The challenges are truly great, but industry is really rising up with ideas and concepts that will prove to help bring the wind energy sector into the coming decades stronger and more lean than every before.

**The Importance of Thermal Management in Wind Turbine Nacelles**

Wind turbines, especially those that are offshore, are continuing to rise in capacity. And that means an increase of heat generation – a problem that can mean the death of a turbine, or significantly reduced power output if not properly managed.


Assembled 2.3-MW nacelle (Siemens website)

Obviously, as a wind turbine produces energy it also produces heat, so one of the primarily concerns with larger turbines is how to properly manage the additional heat that accumulates in the nacelle.

Heat management was already a problem for 5 MW turbines, but with plans for 6 MW, 10 MW and even 20 MW wind turbines in the near future comes an increased need for thermal management systems. After all, the larger the nacelle, the more likely it is to generate heat, especially when enclosed in a very small space. In order for any wind turbine to function properly thermal management needs to be a large component of the system.

Thermal management in itself is necessary to prevent damage to components, but another issue for heat generation is the resulting power losses that can occur as a result of a heat build-up. Any power loss can greatly dig into the profitability of a turbine, so mitigating such risks is extremely important, especially given that an incurred power loss of 3% to 5% may require a thermal management system that would have to drive away hundreds of kW of heat.[ii]

To add to the complications of heat management, offshore wind turbines pose additional challenges. Thermal problems are time-sensitive, but given that it can take time to get to an offshore turbine – especially one in deep waters – significant damage to nacelle components can occur if maintenance crews cannot get there in time. More damage will incur on the system the longer it takes workers to remedy a problem.

In the past, cooling systems in wind turbines have offered a low entry cost solution involving air coolers, but unfortunately these same systems are becoming increasingly hard to implement in larger turbines. Additionally, these past cooling systems prove impractical with new and larger turbines because the thermal capacity of air makes it impossible to propel enough air over the motor or even the converter to maintain proper temperatures.[iii]

An alternative to conventional air coolers is the water-cooled system. These, however, pose their own problems, one of which is the size of the equipment. In order to keep a larger wind turbine cool with water, components need to be spread out in order to adequately cool the extra loads of heat. This can require a lot of space.

Another potential problem with using water-cooling systems is the dangers it poses if there would be a leak in the system. Leaks can contribute to electrical system interruptions, corrosion, and other problems inside the nacelle, which would naturally damage other components and reduce the functionality of the turbine.

Additionally, with water-cooled systems, the climate surrounding the area of the turbine should also be taken into consideration. Where temperatures drop below freezing, water cooling can become a problem since ice won't generally flow through a system like water will.

A new and innovative technology being used by Parker Hannifin Precision Cooling Systems is evaporative cooling. This company has developed a non-conductive and non-corrosive refrigerant/coolant. This coolant evaporates when it comes in contact with hot components and does so in a very efficient close-loop system. This solution could solve many of the thermal management problems of larger nacelles, including water freezing issues, leakage issues, and so forth.

### Why Electromagnetic Shielding is Important For Wind Turbines

Not only do wind turbines transfer energy, but they can also transmit electromagnetic interference (EMI). This happens namely through three known mechanisms which are diffraction, scattering or reflection and field effects. Wind turbines also transmit EMI in the form of lightning strikes. Not surprisingly, when struck by lightning, a nacelle's control systems can be severely compromised if not properly protected. This is of special concern for the pitch control system contained within the nacelle.[iv]

Protecting wind turbines against EMI is extremely important and is usually handled through electromagnetic shielding. This protects both the electronic circuits and the control systems against EMI.

Shielding devices are of course important, but it's also important to install filter applications. Filter applications will allow data and power to be shared between electric circuits/electronic devices to their operator and environment without interference from an EMI.

Siemens Global has developed EMI shielding and protection specifically for wind turbines, most of which is aimed at preventing damage from lightning strikes. For the nacelle specifically, Siemens has developed a fabricated 5 mm steel plate that acts as a Faraday cage.[v] This canopy protects the meteorological instruments towards the back of the nacelle. Instruments receive additional protection from a separate lightning rod system that is held far above the components to ensure safety.

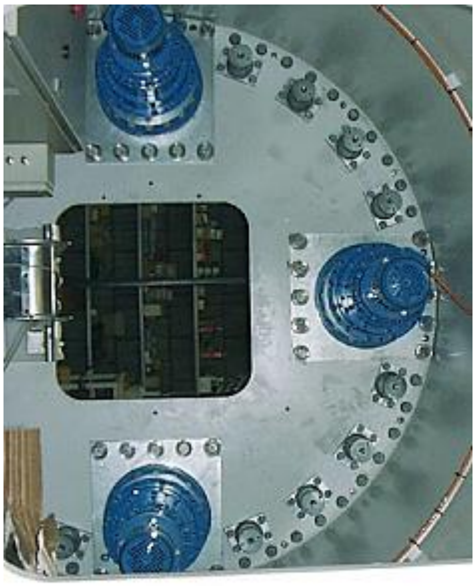
The turbine controller is also protected by surge protection devices.[vi] These devices are specifically designed and installed with a mechanical overload protection so that in the case of a direct lightning strike, they will not explode.[vii] This provides additional protection for any electronic components within the nacelle.

In addition to the above innovations, most wind turbines today are making use of grounding systems to protect all components of the nacelle, including all metal parts such as the cabinet doors and DIN rails. The grounded components act as a conductor from the nacelle to a controller on the Earth's surface. The connection on the Earth's surface uses a heavy bonding foundation or a direct coupling monopile foundation.[viii]

### Innovations in Yaw Systems for Easier Maintenance

Responsible for turning the nacelle in the direction of the wind, yaw systems also experience problems that require maintenance and repair, especially given the large wind loads and the increased weight of nacelles. To address this problem, many companies are working on improvements.

For instance, the Italian industrial group, Bonfiglioli, is coming out with a new slimmer yaw control system for wind turbines. Bonfiglioli's aim is for a 20% shorter and 8% less hefty model.[ix] This slimmer yaw system will also have a multi-stage motor, with a simpler nacelle connection and a parking brake. This design incorporates all these features and also 11% fewer components.[x]



Yaw System (Americas Wind Energy Inc.)

It will also utilize a drive that consists of high specification electric gearbox and motor to enhance the torque in order to keep the nose of the turbine facing prevailing winds.[xi] The system is designed specifically for those wind turbines that range between 1.5 to 3.5 MW. Bonfiglioli is targeting markets in both northwest Europe and South America.[xii] These new innovations in yaw systems produce a more reliable product that is highly efficient.

**The Need For Dehumidification Systems in Nacelles**

Moisture is another of the biggest dangers to a wind turbine operation over the years. Given the huge investment in wind turbines that are designed to last for decades, it's important not to ignore dehumidification, even if it seems as though it is a minor issue.

The company Cotes worked with Siemens Wind Power to help install dehumidification systems for the Nysted Offshore Wind Farm, which is a wind farm about 10 km from land in the south eastern tip of Denmark.[xiii] Two Cotes CR80B dehumidifiers were installed in each turbine with 72 wind turbines encompassing the wind farm.[xiv] The purpose of using two dehumidifiers for each turbine was to supplement standard measures of corrosion protection.

The dehumidifiers would remove moisture from the flow of air around both the transformer unit and the turbine machinery. The second would do the same for the electrical cabinets, which contain electronic equipment and sensitive electrical equipment. Together these two dehumidifiers will reduce wear on the turbine nacelles and other components and lengthen the usable life of these machines. They may also increase power production, given that a corrosion that results from high humidity can negatively impact components, driving down overall energy generation capabilities.

**Lower Maintenance Wind Energy with Higher Functioning Nacelles and Components**

Wind turbines are complex machines, and to run smoothly and without incident they need components that are built to stand the test of time under harsh, demanding conditions. The increased capacity of these machines combined with the more extreme nature of their installations creates even more pressure for the components to function without problem for as long as possible in order to reduce operational maintenance requirements. Today's innovative industry is working on these challenges as you can see. More innovations are sure to come.

Images via: Siemens (Figure 1) and Americas Wind Energy, Inc. (Figure 2)

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