Continuous training of operations and maintenance personnel can result in better wind turbine performance.

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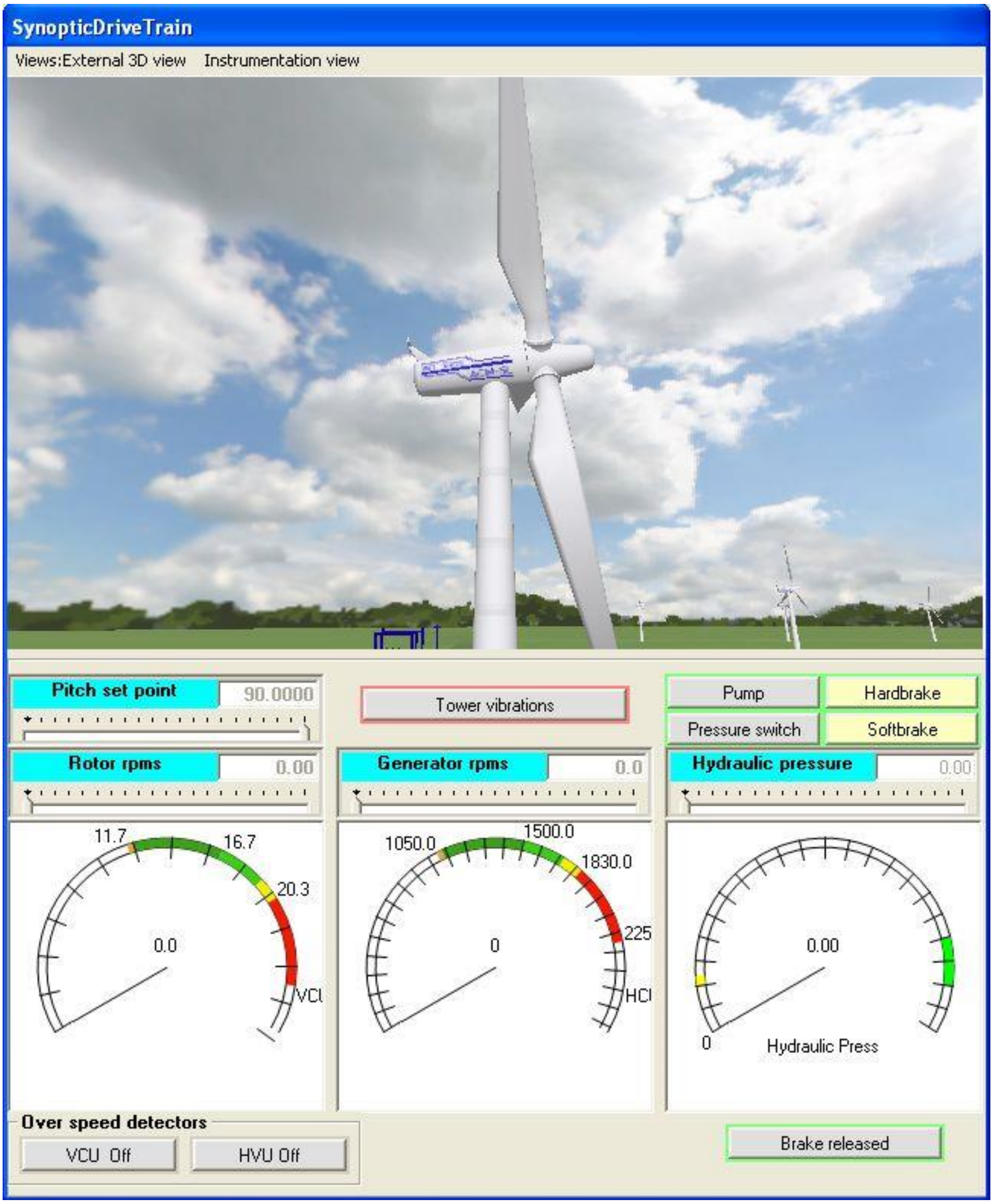
OpEx cost reduction by Informed Maintenance:

Wind farms, as complex production plants, require a complete log of their evolution over time. A full understanding of the causes for each entry in that log is a must for every person involved in its maintenance. So far, that knowledge is available but to a few members of the wind farm owner's team, as the training in the inner behavior of Wind Turbines has been the privilege of a few of them. This is due to the associated costs (OEMs Training costs + travel costs) and the lack of adequate training material. Also, because few OEMs are keen to explain the knowledge about the inner behavior of their machines, protecting it as a highly valued asset.

Fortunately, this is changing, as new approaches address this problem, such as the ones following the field proven Operator Training System (OTS)'s paradigm so common in other industries. This paradigm provides safe and convenient environments where trainees can observe the behavior of Wind Turbines under normal, exceptional (high wind speeds, extreme temperatures, etc.), or faulty situations, without the penalties and costs of going to the field.

An informed interpretation of the logged incidences of the plant provides additional and, in some cases, crucial information for making decisions on its operation and maintenance, becoming mandatory for the reduction of operational costs.



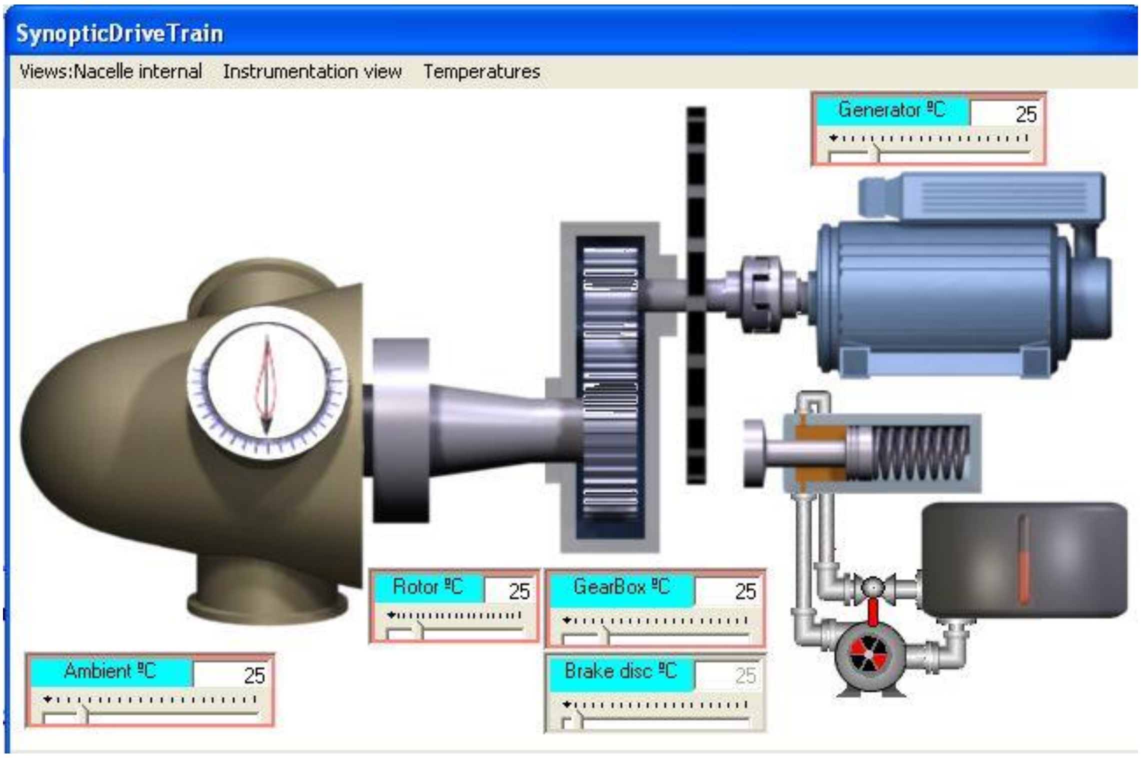
Improved Work Security:

The risks associated with working on Wind Turbines, and other equipment in a Wind Farm, derive not only from being done at heights, but also because of the inherent operational conditions, for example, tight spaces (in the Nacelle, in the Tower), high voltages (electrical panel, transformers), high dissipation elements, moving parts, etc.

To get a perspective of these other conditions, let's consider the case for the electric system (generator + power electronic) with losses of just 1% of the generated power, a reasonably small number. For a 2MW Wind Turbine, that implies 20KW dissipated in those elements; in reality a few times this value. The design of the Wind Turbine includes elements to evacuate that heat outside of the Nacelle: but what happens if those auxiliary elements go out -of-order while you work up in the Nacelle? Chances are you are going to have a hard time. Fortunately, all Wind Turbine elements are supervised by the Wind Turbine Controller: one of the its missions is to inform you about the actual working conditions of all those elements. You should check their status before you climb the tower, but you must know how to interpret all those messages that the Controller may provide to you while you are up there.

Where can you learn about those messages? Certainly, in the Operations manuals; but sequences of events are difficult to explain (to say the least) in those manuals or ppts. What is required is an environment where the trainee may observe different evolutions of all the elements, under realistic conditions, and working unit, not just as sets of islanded subsystems. Again, the OTS paradigm is a viable approach.

“Hands-on” experience is a must for any mechanical or electrical replacement inside the Wind Turbine, but an exact knowledge about the “behavior” of the elements and subsystems in the Wind Turbine is equally required. On top of this, it is a *must* for not compromising *personnel security*.



Data analysis capabilities, Predictive Maintenance:

Wind Turbines are robust production plants on themselves, designed to be left in the field and to produce electric energy without requiring any action from any external agent. Wind Farms add additional features to Wind Turbines (reactive power compensation, overall management, etc.), complementing them with additional elements (FACTs, Substations, etc.), and management capabilities through specific SCADA systems.

Data collected by the SCADA system in a Wind Farm is received from the Wind Turbines and from the additional elements on the Wind Farm. This information constitutes the basic one for all the financial, maintenance, logistics, etc., aspects of the Wind Farm operation.

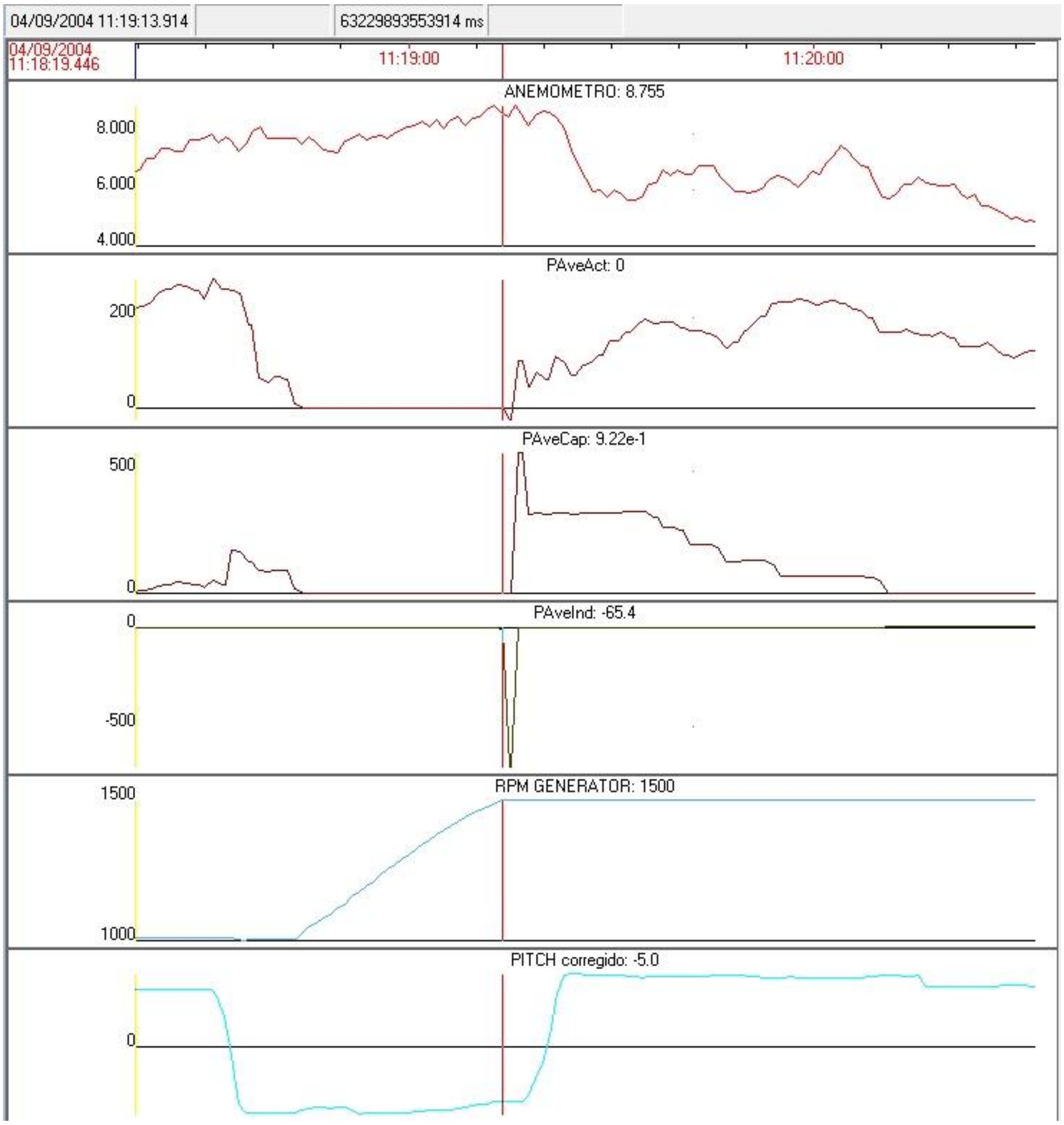
Unfortunately, not all the data inside the Wind Turbine are transmitted to the Wind Farm SCADA; typically, only management data are sent, at 10 minute intervals. This information is enough to cope with the financial statements of the operation of the plant but fall short when you need to dig into the root causes of many problems that may arise inside a Wind Turbine.

The Controller inside each Wind Turbine monitors key signals (wind speed, Nacelle orientation, electric panel, generator status, etc.), but they are not transmitted to the SCADA. Sometimes a data logger with higher time resolution (1 second or better), installed in the Wind Turbine, is a useful tool to investigate the root causes for difficult to pinpoint problems, such as intermittent ones.

For other applications, such as analysis of the bearings and the gearbox, a very high rate data logger is used, such as the ones used for Predictive Maintenance.

All these data ask for specific and specialized analysis tools in order to obtain the maximum knowledge from them. In turn this additional knowledge will lead to better maintenance decisions at better schedules.

Proficiency with data analysis tools is also required for the personnel involved in the maintenance, operation and management of the Wind Farm.

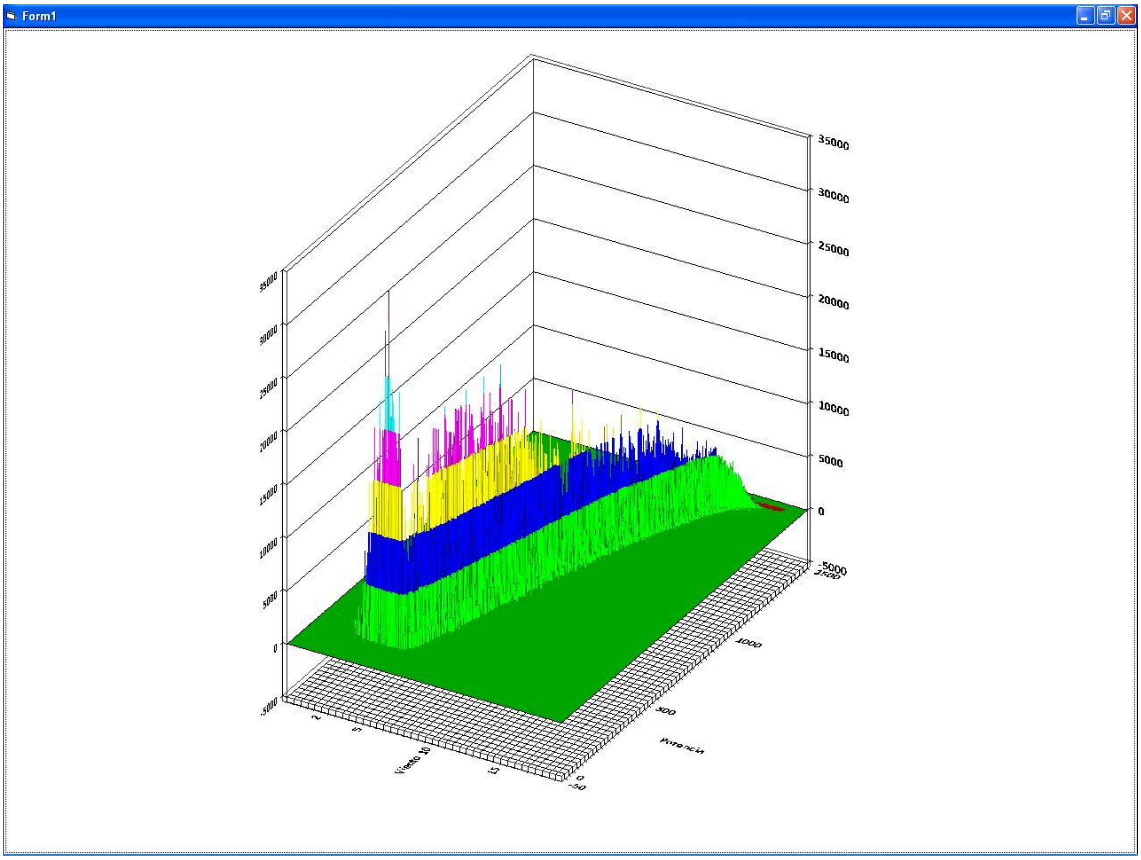


Internal Training Capabilities – Corporate Universities:

As the adequate maintenance and operations of the Wind Farm demands a savvy team, so it demands for tools to spread that knowledge across the organization, and to keep that knowledge updated. A practical approach is to organize them around a repository from where that knowledge can be spread out across the organization, at the appropriate levels.

The feedback from operations in the plant should have a path to this knowledge system, so they can be studied, and eventually new solution patterns be discovered, and used to enhance it.

To spread out the appropriate information for each Maintenance, Operations and Management personnel level, the system should provide ad hoc channels, from direct access, to *eLearning* channels, to Operator Training Systems feed with actual plant conditions.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