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# **Survey of Commercially Available SCADA Data Analysis Tools for Wind Turbine Health Monitoring**

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## **Survey of Commercially Available SCADA Data Analysis Tools for Wind Turbine Health Monitoring**

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### **Confidentiality**

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### **Previous Versions**

The first survey completed was initially prepared by Bindi Chen (Durham University School of Engineering and Computing Sciences). The document has been further revised by D. Zappalá (Durham University School of Engineering and Computing Sciences) who added information gathered at European Wind Energy Conference 2011 held in Brussels, Belgium, from 14<sup>th</sup> to 17<sup>th</sup> of March 2011, at the European Wind Energy Conference 2012 held in Copenhagen, Denmark, from 16<sup>th</sup> to 19<sup>th</sup> of April 2012 and at the European Wind Energy Conference 2013 held in Vienna, Austria, from 4<sup>th</sup> to 7<sup>th</sup> February 2013.

This document contains 14 (fourteen) pages including the cover page.

### **Abstract**

By analysing data from the Signal Conditioning and Data Acquisition (SCADA) systems fitted to wind turbines (WT) their manufacturers, Operators and other experts are able to monitor and improve WT performance.

This survey summarises and describes the current commercially available SCADA systems and associated analysis tools for monitoring WTs and optimising their performance.

The main information is gathered from papers and internet with the help of partners in the UK EPSRC Supergen Wind and EU FP7 ReliaWind Consortia. The document contains also information contributed by D. Zappalá obtained at European Wind Energy Conference 2011, at European Wind Energy Conference 2012 and at European Wind Energy Conference 2013.



**Survey of Commercially Available  
SCADA Data Analysis Tools for Wind  
Turbine Health Monitoring**

**Revised: 26th May 2014  
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## **Contents**

Confidentiality.....	2
Previous Versions.....	2
Abstract.....	2
Contents.....	3
1. Introduction .....	4
2. SCADA Data .....	4
3. Commercially Available SCADA Data Analysis Tools.....	4
4. Conclusions .....	12
5. References .....	12



## **1. Introduction**

A Wind Farm's existing Supervisory Control and Data Acquisition (SCADA) data stream is a valuable resource, which can be monitored by WT manufacturers, Operators and other experts to monitor and optimise wind turbine (WT) maintenance. In order to conduct an efficient SCADA data analysis, Data Analysis Tools are required.

This survey discusses commercially available SCADA Data Analysis Tools which are currently being applied in the WT Industry. The main information is gathered from papers and internet with the help of in the UK EPSRC Supergen Wind and EU FP7 ReliaWind Consortia. Information has been also collected from interaction with SCADA system manufacturers, WT manufacturers and product brochures at European Wind Energy Association (EWEA) Conference 2011 and EWEA Conference 2012.

## **2. SCADA Data**

SCADA systems are a standard installation in large WTs and wind farms their data being collected from individual WT controllers. According to Zaher et al. [1], the SCADA system assesses the status of the WT and its sub-systems using sensors fitted to the WT, such as anemometers, thermocouples and switches. The signals from these instruments are monitored and recorded at a low data rate, usually at 10 minute intervals. The SCADA data shows a snapshot of the WT operating condition [2] at 10 minute intervals. Many large WTs are now also fitted with Condition Monitoring Systems (CMS), which monitor sensors associated with the rotating drive train, such as accelerometers, proximeters and oil particle counters. The CMS is normally separate from the SCADA system and collects data at much higher data rates, although some Operators provide connections between CMS and the WT controller to give the SCADA system some view of CMS outputs.

A separate survey on CMS has been prepared by Supergen Wind on WT CMS systems [2].

By analysing SCADA data, we are able to observe the relationship between different signals, and hence deduce the health of a WT's components. It would prove beneficial, from the perspective of utility companies, if SCADA data could be analysed and interpreted automatically to support the Operators in identifying defects.

## **3. Commercially Available SCADA Data Analysis Tools**

Table 1 provides a summary of the available SCADA Data Analysis Tools based on information collected from internet and from interaction with SCADA system manufacturers, WT manufacturers and product brochures at EWEA 2011, EWEA2012 and EWEA2013.



## Survey of Commercially Available SCADA Data Analysis Tools for Wind Turbine Health Monitoring

Revised: 26th May 2014  
Revisers: DZ, CJC, PJT

It should be noted that the Table is as accurate as possible at the time of writing but may not be definitive. The products in Table 1 are arranged alphabetically by product name. A quick summary of Table 1 shows that:

- 6 products are developed by WT Manufacturers (2, 5, 6, 8, 18 and 19)
- 5 products are developed by Renewable Energy Consultancies (9, 13, 16, 22 and 25)
- 10 products are developed by Industrial Software Companies (1, 3, 4, 10, 11, 15, 20, 21, 23 and 24)
- 1 product is developed by a WT Operating Company (17)
- 3 products are developed by an Electrical Equipment Provider (7, 12, 14)
- 1 product is a demonstration platform developed by the American Center for Intelligent Maintenance Systems (IMS) (26)

Among these 26 products, Enercon SCADA System (5) and Gamesa WindNet (6) are examples of Wind Farm Cluster Management Systems [3]. Both provide a framework for data acquisition, remote monitoring, open/closed loop control, and data analysis for both individual WTs and wind farms. Enercon SCADA System was launched in 1998 and is now used in conjunction with more than 11,000 WTs. Gamesa WindNet consists of a wide area network (WAN) system for wind farms connected to an operational centre [3].

GE – HMI/SCADA – iFIX 5.1 (8) was developed by General Electric Co. (GE), also a WT Manufacturer. It is ideally suited for complex SCADA applications. The software also enables faster, better intelligent control and visibility of wind farm operations.

Kenersys CASCADA (2), VestasOnline Business SCADA (21) and Alstom WindAccess (22) are customisable SCADA systems also developed by WT Manufacturers. CASCADA's open-source approach allows customers to service the turbines with external partners or enables them to do all the operation and maintenance work on their own. VestasOnline Business SCADA provides easy monitoring and control of individual turbines, groups of turbines and the entire plant. In WindAccess the remotely collected data can be used to establish benchmarks and identify irregularities allowing timely intervention to avoid unplanned outages or secondary damage.

GH SCADA (9), OneView SCADA system (13), SgurrTREND (16), WindHelm Portfolio Manager (22) and Wind Turbine In-Service (25) were developed by renewable energy consultancies in collaboration with WT manufacturers, wind farm Operators, developers and financiers to meet the needs of all those involved in wind farm operation, analysis and reporting.

CONCERTO (4) is not specialized for SCADA data analysis. It is a generic data post-processing tool focusing on quick and intuitive signal analysis, validation, correlation and reporting for any kind of acquired data. Gray and Watson used it to perform analysis of WT SCADA data in [30].



## **Survey of Commercially Available SCADA Data Analysis Tools for Wind Turbine Health Monitoring**

**Revised:** 26th May 2014  
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SIMAP (17) is based on artificial intelligence techniques. The new and positive aspects of this predictive maintenance methodology have been tested on WTs. SIMAP has been applied to a wind farm owned by a Spanish Wind Energy Company called Molinos del Ebro, S.A.

INGESYS Wind IT (12) was developed by IngeTeam, an electrical equipment provider. The system aims to integrate wind power plants into a single system and then optimize wind-farm management. INGENSYS Wind IT also provides an advanced reporting service for power curve analysis, faults, alarms and customer reports.

Gateway System (7) was developed by another electrical equipment provider called Mita-Teknik. It is a PC-based software package, designed to collect, handle, analyse and illustrate the data from the Wind Turbine Controller with simple graphics and text. Operational parameters are recorded alongside with vibration signals/spectra and fully integrated into Gateway SCADA system.

PROZA NET (14) is the modular and multi-user SCADA system for control, monitoring and management of wind turbines presented by KONCAR, one of the biggest industrial companies in Croatia.

The other products – BaxEnergy WindPower Dashboard (1), CitectSCADA (3), ICONICS for Renewable Energy (10), InduSoft Wind Power (11), reSCADA (15), MATRIKON Wind Asset Monitoring Solution (20), WindCapture (21), Wind SCADA Pack for Renewable Energy (23) and Wind Systems (24) were developed by industrial software companies. These integrated SCADA systems aim to provide reliable, flexible and high performance applications for WT automation, monitoring and control.

Recent SCADA solutions, as (7), (25), can be adapted and fully integrated with commercial available conventional vibration-based CMSs using standard protocols. This unified plant operations' view allows a broad and complete analysis of the turbine's conditions by considering signals of the controller network as well as condition monitoring signals.

In some cases the SCADA product developer offers also service contracts for SCADA systems beyond the manufacturer service and warranty. They usually include hardware audit, system specific maintenance plan, monthly check of the SCADA system and 24/7 online support. Examples are ABS Wind Turbine In-Service (25), SCADA International OneView SCADA system (13) and several others.

The Wind Turbine Prognostics and Health Management (26) demonstration platform has been developed by the American Center for Intelligent Maintenance Systems (IMS) for asset health information by intelligent interpretation of SCADA measurements. It features wind turbine modelling for predictive maintenance and a multiregime prognostics approach to handle the various the wind turbine under various highly dynamic operating conditions.

**Table 1: Table of commercially available SCADA Data Analysis Tools**

Ref	Product and Company Information			Product Details	
	Product Name	Company	Country of Origin	Description	Main Function
1	BaxEnergy WindPower Dashboard [4]	BaxEnergy GmbH	Germany	Offers an extensive and comprehensive customization for full integration of SCADA system applications and SCADA Software.	Real-time data acquisition and visualization, alarm analytics and data reporting
2	CASCADA [5]	Kenersys	Germany	Turbine control and visualisation in one system, applicable in a large number of control hardware solutions. Access to CASCADA possible from the control room or mobile devices. First "Open Source Solution" in the wind industry.	Smooth data integration via SQL Database and individually customisable reports, alarms and availability calculations.
3	CitectSCADA [6]	Schneider Electric Pty. Ltd.	Australia	CitectSCADA is a reliable, flexible and high performance system for any industrial automation monitoring and control application.	Graphical process visualization, superior alarm management, built-in reporting, and powerful analysis tools.
4	CONCERTO [7]	AVL	Austria	A commercially available analysis and post-processing system capable of handling large quantities of data.	One tool for manifold applications, all data post-processing tasks within one tool, advanced data management
5	ENERCON SCADA system [8]	ENERCON	USA	The Enercon SCADA System is used for data acquisition, remote monitoring, open-loop and closed-loop control for both individual WT and wind farms. It enables the customer and Enercon Service to monitor the operating state and to analyse saved operating data.	Requesting status data, storing operating data, wind farm communication and loop control of the wind farm.
6	Gamesa WindNet [9]	Gamesa	Spain	The WindNet SCADA system in a wind farm is configured with a basic hardware and software platform based on Windows technology. The user interface is an easy to use SCADA application with specific options for optimal supervision and control of a wind farm including devices like WTs, meteorological masts and a substation.	Supervision and control of WTs, meteorological masts. Alarm and warning management, report generation and user management.

7	Gateway System [10]	Mita-Teknik	Denmark	Gateway is a PC-based software package, designed to collect, handle, analyse and illustrate the data from the controller with simple graphics and text. Operational parameters are recorded alongside with vibration signals/spectra and fully integrated into Gateway SCADA system.	Data collection and reporting, user-friendly operation, life time data, CMS Algorithm Toolbox for diagnostic analysis. Instant alarm notification. Approx 5000 – 8000 variables covering different production classes.
8	GE – HMI/SCADA – iFIX 5.1 [11]	GE (General Electric Co.)	USA	iFIX is a superior proven real time information management and SCADA solution. It is open, flexible and scalable which includes impressive next-generation visualizations, a reliable control engine, a powerful built in historian and more.	Real-time data management and control, information analysis.
9	GH SCADA [12]	GL Garrad Hassan	Germany	GH SCADA has been designed by Garrad Hassan in collaboration with WT manufacturers, wind farm Operators, developers and financiers to meet the needs of all those involved in wind farm operation, analysis and reporting.	Remote control of individual WT. Online data viewing. Reports & Analysis
10	ICONICS for Renewable Energy [13]	ICONICS Inc.	USA	Provide portals for complete operations, including energy analytics, data histories and reports, geo SCADA with meteorological updates.	Portals for complete operations, data histories and reports, geo SCADA with meteorological updates.
11	InduSoft Wind Power solutions [14]	InduSoft	USA	InduSoft Web Studio software brings you a powerful HMI/SCADA package that can monitor and adjust any operating set point in the controller or PLC.	WT monitoring, maintenance assistance, and control room.
12	INGESYS Wind IT [15]	IngeTeam	Spain	INGESYS Wind IT makes it possible to completely integrate all the wind power plants into a single system. It provides advanced reporting services.	Advanced reporting, client/server architecture, standard protocols and formats.
13	OneView SCADA system [16]	SCADA International	Denmark	SCADA International is a subcontractor which provides specialized SCADA consultancy services both for wind power plant customers and wind turbine manufactures, with services from commissioning of SCADA systems, project execution from sign of project to final handover and solutions to specific customer's requirements. It offers service contracts for SCADA systems beyond the manufacturer service and warranty.	Data collection, interface for viewing the data, advanced reporting tool, Web access, 8 standard reports (production, performance, availability, alarm, power curve, production graph, wind rose and raw data) and trend curves.
14	PROZA NET [17]	KONČAR	Croatia	Modular and multi-user system for control, monitoring and management of wind turbines. It enables supervisory control and execution of advanced functions (EMS, DMS, GMS) in real-time. Availability calculation, adjustable in accordance with	Remote monitoring of wind turbine data such as temperatures, pitch and yaw, frequency converter and

				owner/product contract, real-time trend view, power curve calculation, wind rose log, event log & history, alarm log & history and power distribution.	generator excitation, greasing and hydraulic brakes, vibration, cooling and heating, weather station and grid.
15	reSCADA [18]	Kinetic Automation Pty. Ltd.	USA	Targeting and specializing in Renewable Energy industries. Will save time, effort and cost in developing HMI/SCADA.	Office 2007 GUI style, Data visualization, diary and mapping tools.
16	SgurrTREND [19]	SgurrEnergy	UK	SgurrEnergy provide a variety of wind monitoring solutions to evaluate the wind resource potential at your prospective wind farm site, offering a one stop shop for all mast services from planning application, data collection and mast decommissioning to wind analysis services for energy yield prediction, project layout and design services.	Wind monitoring, process and archive the data, and reporting services.
17	SIMAP [20]	Molinos del Ebro, S.A.	Spain	SIMAP is based on artificial intelligence techniques. It is able to create and dynamically adapt a maintenance calendar for the WT that is monitoring. The new and positive aspects of this predictive maintenance methodology have been tested in WTs.	Continuous collection of data, continuous processing information, failure risk forecasting, and dynamical maintenance scheduling
18	VestasOnline Business SCADA [21]	Vestas	Denmark	Power Plant Server continuously collects data from all the components and stores it in a central database. Data processed in the server and fed to the standard Operator interface through a local network, a wide area network or a dial-in connection. Communication Network uses fibre-optic cables to allow communication between the server, clients, turbines, substations and the other units making up the wind power plant.	Monitoring and control of individual turbines, groups of turbines and the entire plant. Operator interface used to view current and historical power plant data. Advanced power plant regulation technology. Customisable with different types of interfaces.
19	WindAccess [22]	ALSTOM	Spain	Modular web-based tool. Remote access to wind turbine data such as generated power, rotor rpm, electrical data, temperature of main components, mechanical sensors status, wind conditions and wind turbine status. Wind farm masts and substation equipment integration. Full support of Alstom wind farm experts. Performance optimisation of an individual wind turbine or the whole wind farm in real time Remotely collected data used to establish benchmarks and identify irregularities to allow timely intervention avoiding unplanned outages or secondary damage.	Alarm and warning management. Event and Condition-Based Maintenance (ECBM) system combines planned maintenance with input from CMS and SCADA system. Appropriate schedule calculated taking into consideration weather forecasts, availability of spare parts and tools, as well as access and elevation logistics.

20	Wind Asset Monitoring Solution [23]	Matrikon	Canada	The solution bridges the gap between instrumentation and management systems, to enable operational excellence by retrieving and better managing data not readily accessible.	Monitor and manage all remote assets, leverage and integrate with SCADA and CMS.
21	WindCapture [24]	SCADA Solutions	Canada	WindCapture is a SCADA software package used for monitoring, controlling and data collection and reporting for WT generators. It was designed and tailored to the demands of manufacturers, Operators, developers and maintenance managers of wind energy project and facilities.	Real-time data reporting with the highest degree of accuracy. Advanced GUI.
22	WindHelm Portfolio Manager [25]	GL Garrad Hassan	Germany	WindHelm Portfolio Manager provides a single platform for the monitoring, optimisation and control of any combination of operational turbines, farms and portfolios. It gives owners and Operators uniform access to, and analysis of, their SCADA data, facilitating intelligent operational decisions.	Instant access to "near real time" data via a single user interface accessible from any web browser; broad range of summary and detailed operational reports; taxonomy from the RELIAWIND project included as standard; ability to send event alerts and status messages.
23	Wind SCADA Pack for Renewable Energy [26]	ICONICS	USA	Wind SCADA Pack allows users to create 2D and 3D GEO SCADA visualisation and reports with integrated real-time and historical geographical terrain maps, enabling a quick overview of multiple operations and plants located anywhere in the world. From one unified console wind park Operators, engineers, and maintenance workers can monitor and control their entire operations.	Real-time turbine information, as wind speed, wind direction, power, blade position, temperature and vibration, are instantly data logged, visualized and analyzed. Users can receive weather information, power generated from turbines, react to alarm conditions and schedule maintenance.
24	Wind Systems [27]	SmartSignal	USA	SmartSignal analyses in real time data and detects and notifies wind farms of impending problems, allowing owners to focus on fixing problems early and efficiently.	Model maintenance, monitoring services, and predictive diagnostics.
25	Wind Turbine In-Service [28]	ABS Consulting	USA	The data gathered from inspections, vibration sensors and the SCADA system provide an overview of the wind farm and turbine conditions. The SCADA data allows monitoring wind farm assets in real-time, by also integrating historical and current data.	Regular diagnostics, Dynamic performance reports, Key performance indicators, Fleet-wide analysis, Forecasts and Schedules, and Asset benchmarking.

26	Wind Turbine Prognostics and Health Management (WT-PHM) demonstration platform [29]	American Center for Intelligent Maintenance Systems (IMS)	USA	Wind-turbine behavioural tools including routines for feature extraction, health assessment, and fault diagnostics. Results displayed in visualization tools for degradation assessment and monitoring. Multiregime prognostics approach to handle the wind turbine under various highly dynamic operating conditions	Wind turbine modelling for predictive maintenance. Platform implemented as a Watchdog Agent-based software platform. Hardware and instrumentation obtained using existing National Instruments tools.
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## **4. Conclusions**

From this survey we conclude that:

- There is a wide variety of commercial SCADA systems and SCADA Data Analysis Tools available to the Wind Industry;
- Most of the commercially available SCADA Data Analysis Tools are able to analyse real-time data;
- The performance analysis techniques used in SCADA Data Analysis Tools vary from tailored statistical methods to the use of artificial intelligence;
- Successful SCADA Data Analysis Tools provide cluster management for Wind Farms. They provide a framework for data acquisition, alarm management, reporting & analysis, production forecasting and meteorological updates;
- Some built-in diagnostics techniques are able to diagnose the component failure of WT;
- Some SCADA Data Analysis Tools are beginning to be fully integrated by Operators with commercially available CMSs;
- Recently proposed SCADA systems feature wind turbine modelling, with diagnostic and prognostic models for wind farm predictive maintenance.

Finally, it should be noted that the development of SCADA Data Analysis Tools is aimed to provide a reliable, flexible and high performance for WT automation monitoring and control. The industry is already noting the importance of operational parameters such as load and speed and so techniques may begin to adapt further to the WT environment leading to more reliable WT diagnostics solution [2].

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**Survey of Commercially Available  
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