DEVELOPMENT OF A GENERIC WIND FARM SCADA SYSTEM

G J Smith

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Abstract

The aim of the project is to develop a "Generic Wind Farm Supervisory Control and Data Acquisition (SCADA) System" for the wind energy industry. SCADA is a computer-based system that allows local and remote control of basic wind turbine functions and collects data from the wind farm that can be used to analyse and report on the operational performance. As wind farm size, complexity and remoteness of location increase an industry standard SCADA is vitally important to allow effective operation, monitoring, control and reporting.

Turbine manufacturers offer a number of existing systems but these do not always fully meet the needs of wind farm operators and owners. Operators and owners who are involved with more than one turbine supplier end up with a number of incompatible SCADA systems. This causes operational difficulties and makes it hard to compare performance data from different turbines.

This project addresses these issues with the development of a system that will communicate with all turbine types and calculate and store performance data in a consistent way.

A unit called a "Remote Interface Unit" has been developed to communicate directly with the turbine controllers and provide a standard interface to the rest of the SCADA system. It will also have local storage and processing to make the system less dependent on the reliability of the site communications network.

The site communications network is based on an industry-standard protocol (Modbus). The system has been designed so that it can operate on the simplest of networks but will also be able to make use of faster TCP/IP networks when these become cost-effective for wind farm applications.

The system runs on Windows NT and is built from software components using standard, open interfaces (e.g. OPC, ODBC, and Web technology). All user access is through standard Web browsers, allowing multi-user access and simple remote access without any special software.

The system has extensive reporting facilities that allow users to build customised reports from standard, verified options. Reports can be created on demand or can be scheduled and delivered by email. This includes the facility for automatically generating daily, weekly, monthly and annual reports.

Extensive laboratory tests have been carried out and pilot tests have taken place on a commercial wind farm in the UK.

The completed system is available as a commercial product.

Keywords: SCADA, Wind farm, CMS, CMCS

Project Partners

Bonus Energy A/S	Jérôme Hersant Fabriksvej 4 DK-7330 Brande Denmark
Garrad Hassan & Partners	Gordon Smith 2064 Maryhill Road Glasgow G20 0AB Scotland UK
IVPC	Eng. Luigi Boffa IVPC Gestione S.r.l Via Benevento, 50 82025 Montefalcone V.F. (BN) Italy
National Windpower	Dr John Warren Riverside House Meadowbank Furlong Road Bourne End Bucks SL8 5AJ UK

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1. OBJECTIVES

The aim of the project is to develop a "Generic Wind Farm Supervisory Control and Data Acquisition (SCADA) System" for the wind energy industry. A SCADA is a computer-based system that allows local and remote control of basic wind turbine functions and collects data from the wind farm that can be used to analyse and report on the operational performance. As wind farm size, complexity and remoteness of location increase an industry standard SCADA is vitally important to allow effective operation, monitoring, control and reporting.

Turbine manufacturers offer a number of existing systems but these do not always fully meet the needs of wind farm operators and owners. Operators and owners who are involved with more than one turbine supplier end up with a number of incompatible SCADA systems. This causes operational difficulties and makes it hard to compare performance data from different turbines.

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2. TECHNICAL DESCRIPTION

2.1 Site Communications

The SCADA system is required to communicate with different types of turbine. To be able to achieve this a common interface to the turbine is required. This could be implemented at the central computer or at the turbines.

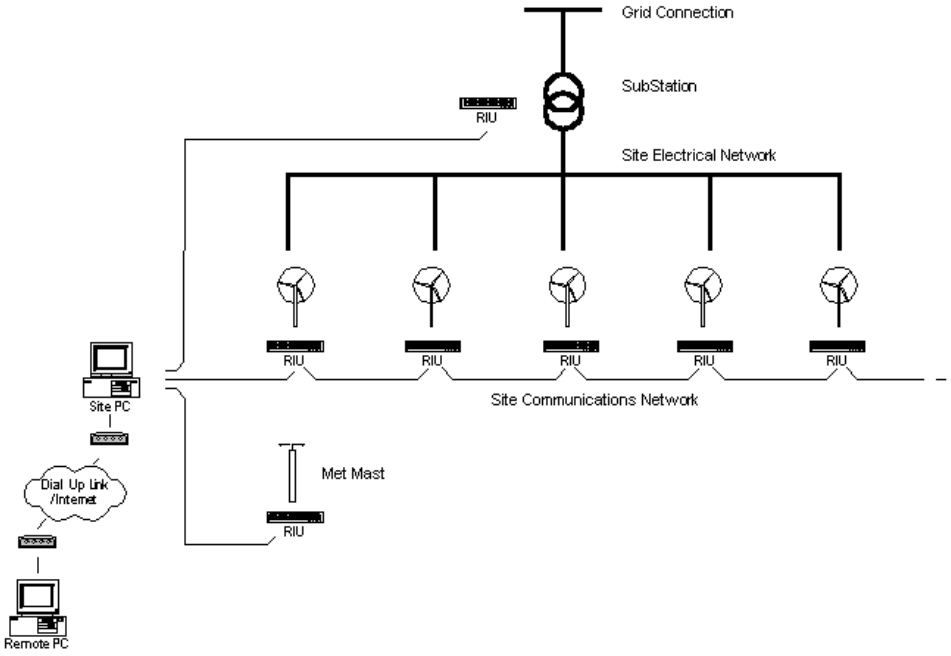
It has been decided that the best approach for the system is to provide for a common interface at the turbines. This is achieved using electronic equipment, called a Remote Interface Unit (RIU), installed at each turbine. It is used to interface to meteorological masts and substations as well as turbines.

The RIU communicates directly with the turbine controller and provides a common interface to the site network and central computer. The advantages of this approach are:

- Data sample rate is independent of the site communications network and depends only on the speed of communication of the turbine controller. The higher sampling rate improves the accuracy of the summary statistics that are produced.
- Processed data can be stored locally in a queue so that no data is lost if the site communications network is temporarily unavailable. When the network is available, the queue is downloaded to the SCADA computer.

- The RIU provides a common interface to the wind farm, allowing different turbines to have the same interface.
- The RIU can provide additional functionality that is not included in the standard turbine controllers. All turbine events can be logged.
- The RIU's can be expanded to provide additional I/O so that additional sensors can be connected to the system. This may include noise monitoring stations and safety and access control equipment.
- Software updates automatically downloaded from the SCADA computer.
- Configuration information downloaded from the SCADA computer.
- Clock automatically corrected to central SCADA computer clock.
- Provision of Crew Present switch.

The arrangement is summarised in the following figure:



A number of solutions for site communications networks were investigated, both master-slave and peer to peer.

It was concluded that the only options for peer-to-peer networks are radio and fibre-optic based Ethernet. There would however be a significant cost penalty of such a solution over a simple master-slave network. Depending on the exact implementation this could be of the order of 2200 euros.

Although a peer-to-peer network will give improved performance and some additional functionality, it is thought that some developers will consider the extra cost is not always justified. The system has therefore been designed to work with a simple master-slave network that can be either a bussed RS485 solution or a fibre-optic ring.

However, it is expected that in the future, there will be many wind farms where the more expensive fibre-optic based Ethernet network option will be used which will allow peer-to-peer operation, particularly offshore. The SCADA system has therefore been designed to be compatible with both types of network.

An Ethernet network is not required by the system but the system can easily be incorporated into an Ethernet network. The main benefits of fitting an Ethernet network for a wind farm are as follows

- Full access to the SCADA system from any turbine
- Ability to easily integrate voice and video communications to the site communications network
- Ease of integration of additional monitoring and balance of plant equipment.

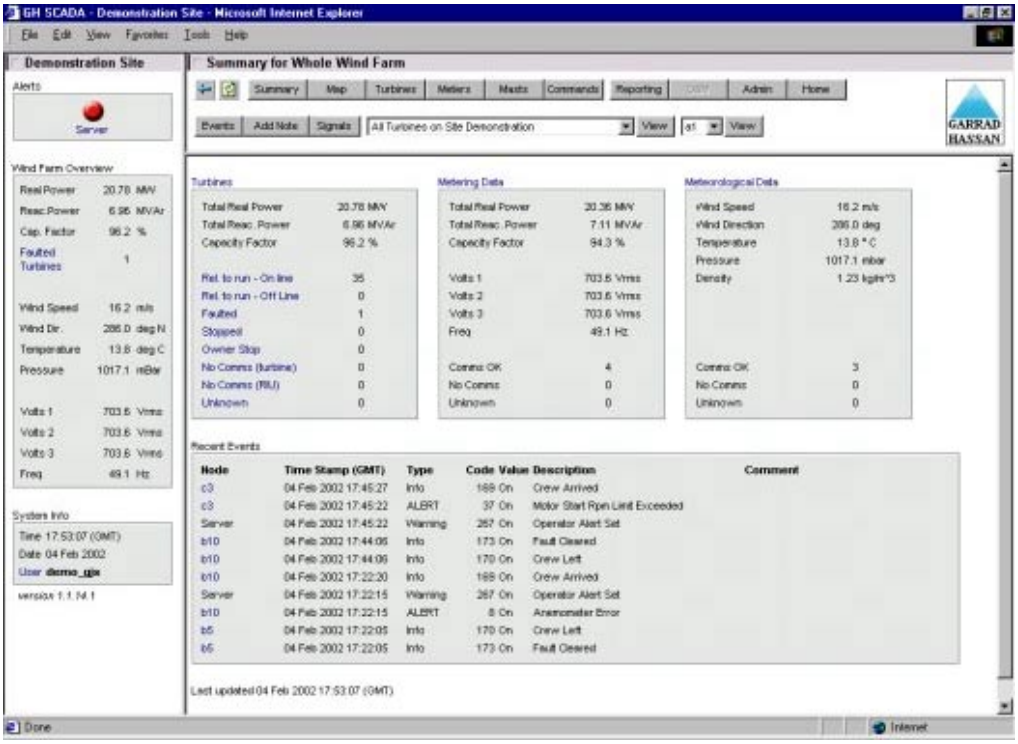
2.2 User Interface

The system needs to be used by a number of users and from a number of locations at the same time. The user interface is based on a standard web browser that will allow multi-user access from different computers.

This approach also has the benefit that it allows users to access the system from any computer with a minimal amount of software and without the need for dongles.

Remote access by dial-up link or over the internet is very straightforward and requires no further software beyond a standard web browser.

The following screen shot shows the summary page from the user interface.



2.3 Database and Reporting

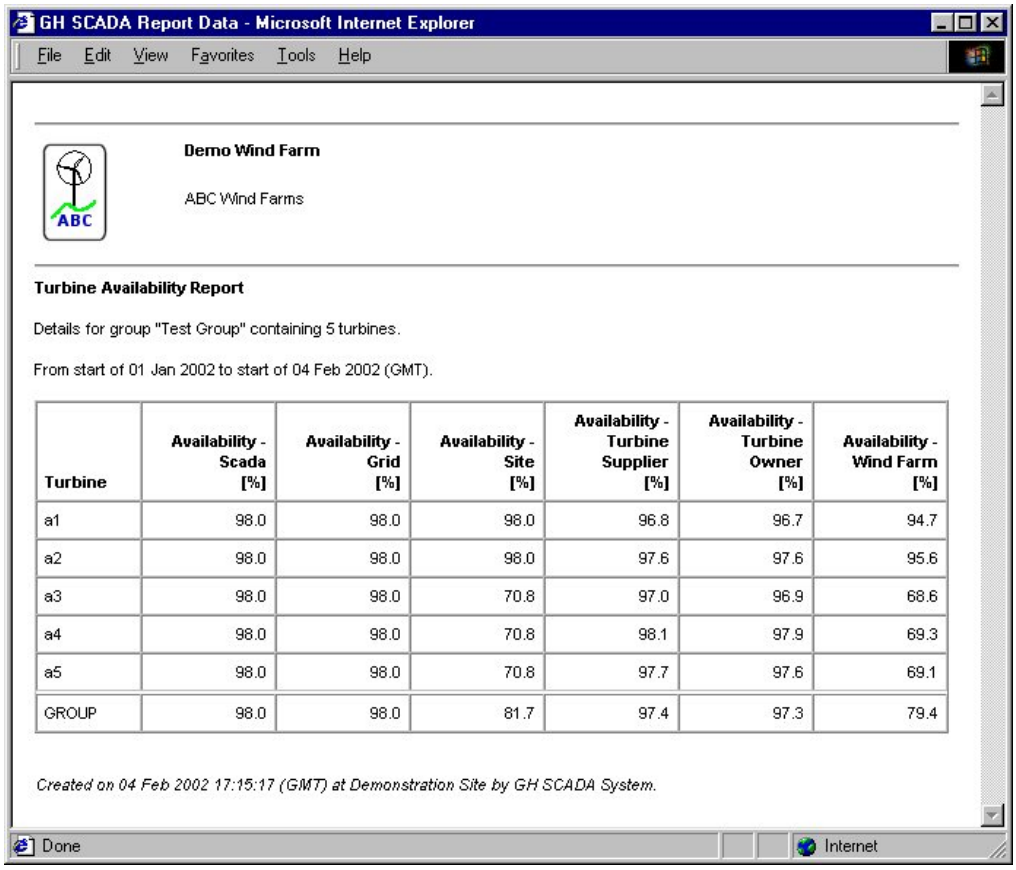
Ten-minute performance data and all event data are stored in an industry standard relational database. Any ODBC (Open Database Connectivity) compliant database can be used. The data is time stamped when received at the server and a record of the number of readings used to calculate all statistics is maintained. This ensures complete traceability of stored and edited data.

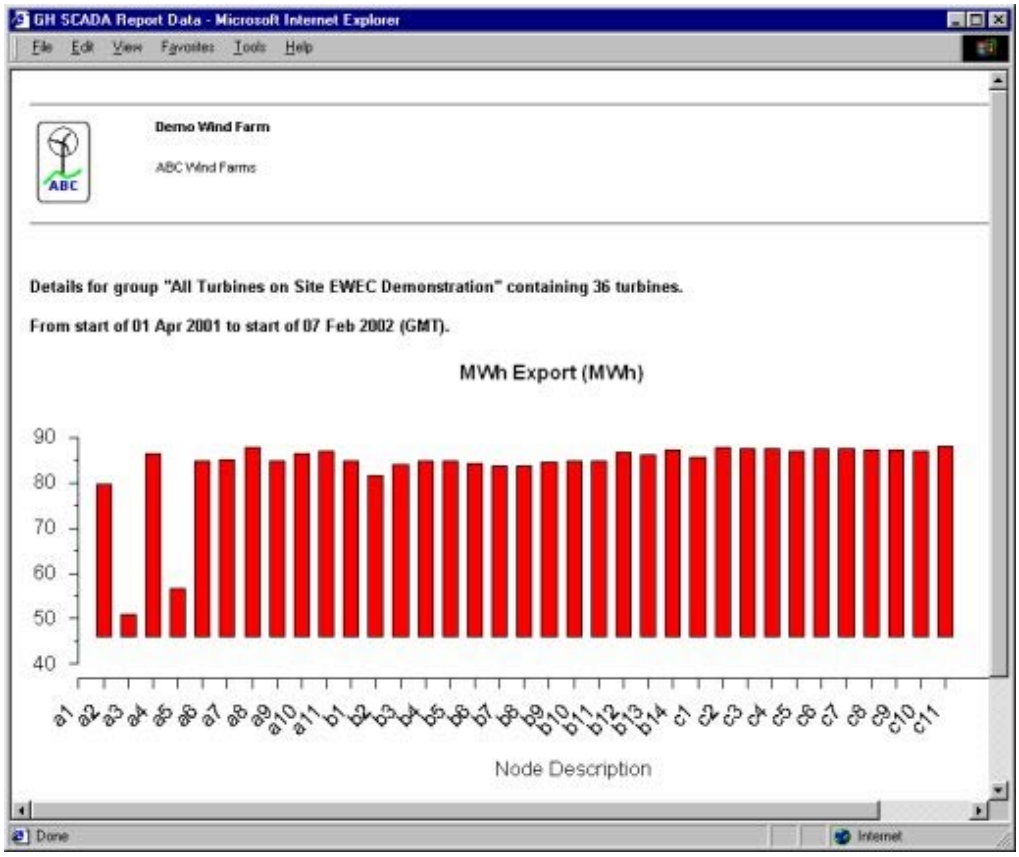
The system was tested with Microsoft Access and Microsoft SQL Server.

An extensive set of reporting and database query tools has been developed which allow users to quickly and easily assess the wind farm's performance.

Reports can be presented immediately in the users browser or can be automatically sent by the system by email. Facilities are provided for reports to be automatically generated on a daily, weekly, monthly or annual basis.

Some sample reports are shown below.


GH SCADA Report Data - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Demo Wind Farm
ABC Wind Farms
Turbine Availability Report
Details for group "Test Group" containing 5 turbines.
From start of 01 Jan 2002 to start of 04 Feb 2002 (GMT).
Turbine | Availability - Scada [%] | Availability - Grid [%] | Availability - Site [%] | Availability - Turbine Supplier [%] | Availability - Turbine Owner [%] | Availability - Wind Farm [%]
a1 | 98.0 | 98.0 | 98.0 | 96.8 | 96.7 | 94.7
a2 | 98.0 | 98.0 | 98.0 | 97.6 | 97.6 | 95.6
a3 | 98.0 | 98.0 | 70.8 | 97.0 | 96.9 | 68.6
a4 | 98.0 | 98.0 | 70.8 | 98.1 | 97.9 | 69.3
a5 | 98.0 | 98.0 | 70.8 | 97.7 | 97.6 | 69.1
GROUP | 98.0 | 98.0 | 81.7 | 97.4 | 97.3 | 79.4
Created on 04 Feb 2002 17:15:17 (GMT) at Demonstration Site by GH SCADA System.
Done
Internet


GH SCADA Report Data - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Demo Wind Farm
ABC Wind Farms
Details for group "All Turbines on Site EWEC Demonstration" containing 36 turbines.
From start of 01 Apr 2001 to start of 07 Feb 2002 (GMT).
MWh Export (MWh)
90
80
70
60
50
40
a1 a2 a3 a4 a5 a6 a7 a8 a9 a10 a11 b1 b2 b3 b4 b5 b6 b7 b8 b9 b10 b11 b12 b13 b14 c1 c2 c3 c4 c5 c6 c7 c8 c9 c10 c11
Node Description
Done
Internet

3. RESULTS AND CONCLUSIONS

The system has been implemented and a fully functioning demonstration system is available on the web.

The design of the system has allowed the main objectives of the project to be met, i.e. a system which has the following features

- Can be connected to a number of a number of different turbine types
- Can be used with a simple master/slave site communications network or over TCP/IP network.
- Improved data collection which is independent of site communications network speed and availability.
- Common user interface for different turbine types
- Standard, user configurable reporting for different turbine types
- Easy remote access requiring only a Web Browser. No complex software set-ups or dongles required

Extensive office based tests have been carried out with simulated turbines to test system loading, database capacity and reporting functions.

Preliminary tests have been carried out at Carno, a commercial wind farm in Wales owned by National Wind Power and consisting of 56 Bonus 600 kW wind turbines. The system was connected to one on the turbines on the site and correct operation confirmed over a 2 week period.

Carno Wind Farm (picture courtesy of National Wind Power Ltd.)

Having successfully implemented the interface to the Bonus turbine, interfaces to other turbine types are now being developed.

The web demo is driven by a real-time wind farm simulator and provides fully functioning user interface and reporting facilities.

4. EXPLOITATION PLANS AND ANTICIPATED BENEFITS

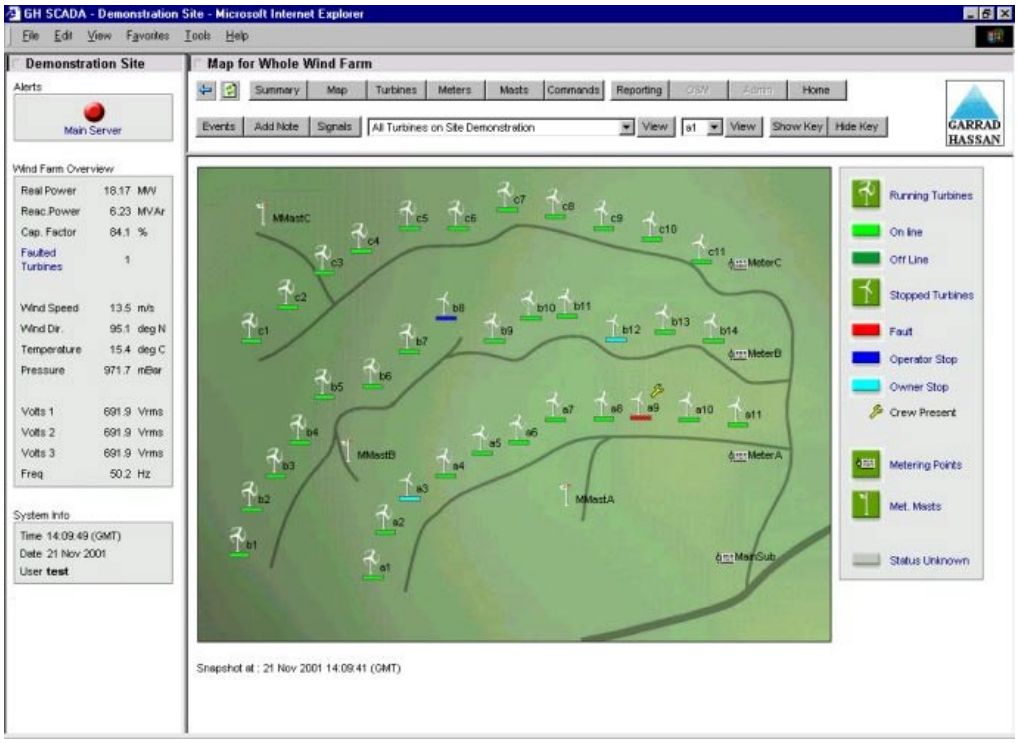
The project has developed a generic SCADA system with integrated facilities for O&M procedures that will enable the cost of energy from wind farms to be reduced. Operational data provided by the SCADA system will lead directly to improved maintenance scheduling of wind farms, better machine and farm performance, and contribute to improvements to machine components.

The key deliverable is the developed generic wind farm SCADA system. This will be of interest to all of the project partners for future wind farms.

The project is of strategic importance for GH because of the company's aim to extend its machine monitoring product range and services. The SCADA system will be a natural extension to the company's T-MON system that is widely used within the industry for performance and load measurements. GH plans to market the system vigorously to all wind farm developers and manufacturers. GH plans to extend immediately the number of different turbines to which the system can interface to cover all the major commercial manufacturers. Discussions with other wind turbine manufacturers have been very encouraging with a number agreeing to provide the protocols for their wind turbines and the remainder considering the matter.

5. DEMONSTRATION SYSTEM

The following figure shows a screen shot of the map page from the final system.



Information on the system can be found at:

http://www.garradhassan.com/scada/home.htm

A fully functioning demonstration system is also available on the web. Details can be found at:

http://www.garradhassan.com/scada/scada_demo.htm