GH SCADA

Generic wind farm supervisory control and data acquisition system

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INTRODUCTION

GH SCADA has been designed by Garrad Hassan in collaboration with turbine manufacturers, wind farm operators, wind farm developers and financiers to meet the needs of all parties concerned with wind farm operations, performance analysis and reporting.

Garrad Hassan was established in 1984 and rapidly established itself worldwide as a leading independent consultancy in wind energy. Garrad Hassan has made measurements on a large number of wind turbines using its monitoring system, T-MON, and has experience of wind turbine design, SCADA systems and data analysis from numerous wind farm projects.

This background and skill base allied to Garrad Hassan's completely independent and impartial status means that this is a SCADA system that can be relied on to be totally independent, traceable and transparent in it's operation.

Garrad Hassan staff are available to discuss customer requirements and to design, install and commission a system with the minimum fuss and maximum back up. Garrad Hassan's commitment to wind energy guarantees long term system support.

Key benefits of the system are:

- Completely independent, traceable and transparent in operation. The users specify what they want to see, control, record and report.
- Independent turbine, grid and meteorological station remote interface units providing maximum data integrity.
- Easy remote access requiring only a web browser. No complex software set-ups or dongles required.
- Easily customised to meet the different needs of turbine manufacturers, wind farm developers, wind farm operators, wind farm owners and financiers.
- Operates seamlessly with machines from any wind turbine manufacturer.
- Common graphical interface allowing users to have a common front-end display to all their wind farms.
- Common reporting enabling users to produce reports with the same format for all their wind farms.
- Common format for the database allowing the same data processing to be used for wind farms with different makes of turbine.
- Validated comparison of actual to expected energy and revenue output using wind farm power curve produced by Garrad Hassan WindFarmer the industry-leading software.
- Grid and sub station interface units for control and monitoring of the wind farm electrical system.
- Meteorological station interface units for independent wind speed and meteorological parameter monitoring and analysis.
- Integration of GH Forecaster for real time forecasting of wind farm production (in development).
- Inclusion of condition monitoring in O&M records with input to preventative maintenance (in development).
- Integration of O&M operations into the SCADA system control and database (in development).

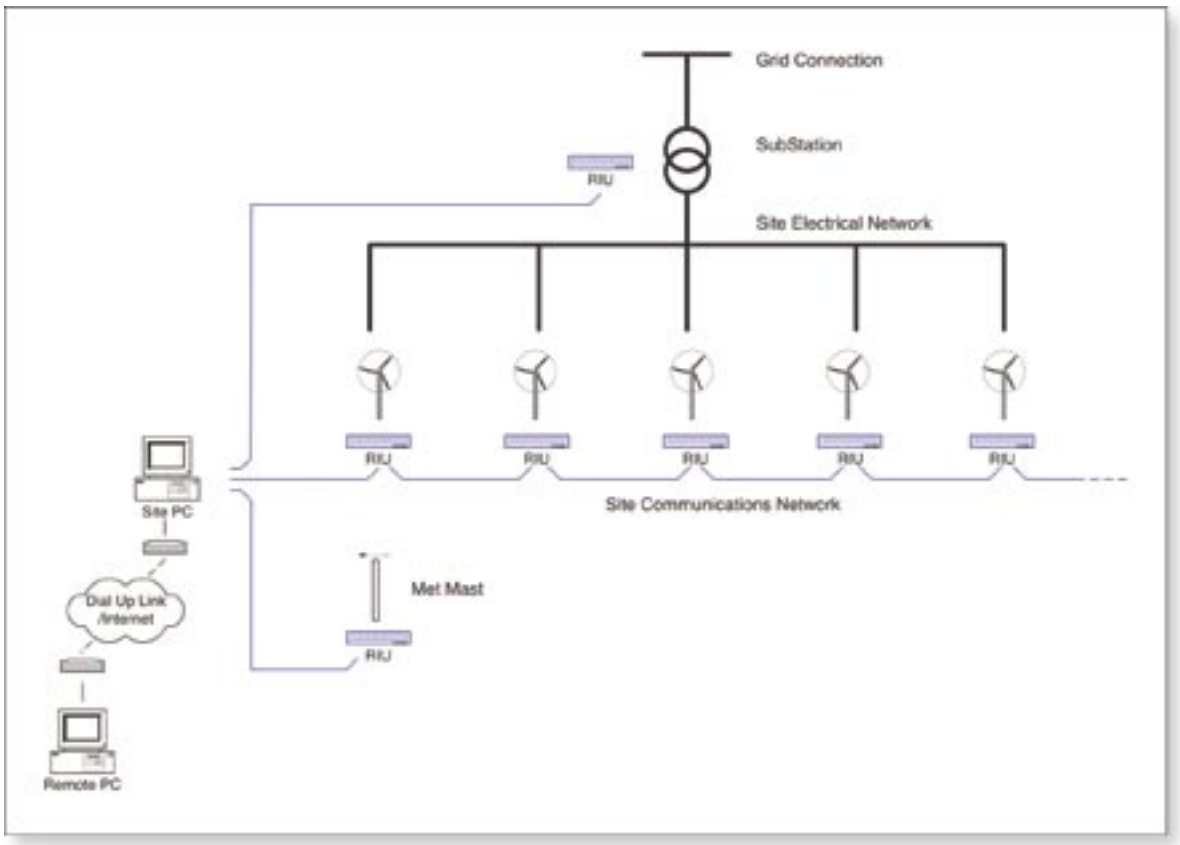
SYSTEM OVERVIEW

The system consists of a central SCADA computer connected to each turbine, meteorological station and grid station remote interface unit (RIU) using a site network as shown below. The system is expandable so that several SCADA computers can be networked together for large wind farms. There is no limit to the number of turbines that can be monitored with the system.

Remote Interface Units

A key feature of the system is the Remote Interface Unit (RIU) at each turbine, meteorological station and grid station. In the turbines these units are connected between the turbine controller and the site communications network. They have local processing and storage and provide the following benefits:

- 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 or SCADA computer are temporarily unavailable for up to two weeks. 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 RIUs 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 are automatically downloaded from the SCADA computer.
- Configuration information is downloaded from the SCADA computer.
- Clock automatically corrected to central SCADA computer clock.
- Provision of Crew Present switch.



Site communications network

The site communications network is based on Modbus an industry standard protocol. It can operate on the simplest of networks but will be able to use the faster TCP/IP networks when these become cost effective for wind farm use.

The SCADA computer system runs on Windows NT and is built from software components using standard open interfaces (OPC, OBDC and web technology).

Local and remote access

All local and remote user access is through standard web browsers allowing multi-user access and easy remote access.

Local users can access the system through a web browser on the SCADA PC or on any other networked PC.

Remote users can access the system from any PC with a modem and web browser (Internet Explorer, Netscape Navigator) without requiring any extra software or dongles.

Remote alerts

The system can be configured to alert staff via mobile phone, pager, fax or email if any part of the wind farm requires attention.

This feature can be configured to operate continuously for unmanned sites or only during certain times of day as required.

Security

Security is based on standard NT security and can be customised to meet the requirements of particular sites. The following groups are defined:

- View real time status only.
- View real time status and allow commands.
- View real time status and access historical data.
- View real time status, allow commands and access historical data.
- View real time status, allow commands, access historical data and set-up configuration access.
- Full system administration access.

Time base and date formats

Time and date formats have been chosen to eliminate confusion arising from different time zones, summer/winter changes and different country display formats.

- All time stamps apply to the end of a period.
- All time stamps are stored as UTC, regardless of local time setting used.
- All times are displayed with the time zone to which they apply.
- All dates are entered and displayed in the form "dd mmm yyyy", e.g. 13 Sep 2000.

Data back up

Full data back up facilities are provided based on CD ROM or tape drives as appropriate.

SYSTEM FUNCTIONS

Control commands

GH SCADA allows local or remote control of individual turbines or groups of turbines.

System configuration allows for any number of userdefined groups of turbines.

In addition a number of predefined groups are automatically created:

- All turbines on site.
- All turbines connected to a grid circuit.
- All turbines connected to a particular PC.
- All turbines connected to a particular communications port.

The following commands can be issued to turbines either individually or to a predefined group of turbines:

- Release to Run.
- Stop.
- Reset.

Stop and Release to Run commands are ignored if there is a crew at the turbine. Any commands issued locally at a turbine will override the SCADA system if there is a crew present. If there are no crew present, commands from the SCADA system will override the current turbine setting.

Commands to groups of turbines can optionally be staggered.

Command requests are queued so that if there are no communications to the turbine when the command is issued, it will be applied when communications return.

The system can implement auto control of the turbines. This allows automatic implementation of any constraints on wind farm operation (e.g. network restrictions, noise restrictions, time of day restrictions). A standard DLL interface is provided and the user can either implement the required control function or Garrad Hassan can provide a DLL to meet user requirements.

On line data viewing

The user is able to monitor the wind farm current status through either a graphical user interface (GUI) showing a map based representation of the wind farm or a series of tables summarising turbine, meteorological station and grid station status.

The GUI provides a top-level view of the wind farm with facilities to link to particular groups or units. Units are represented by icons identifying the unit type and name and conveying the equipment status as the user scans the wind farm. The screen incorporates a geographical map as a backdrop showing contours, vegetation, buildings and roads etc.

Commands are instantly available on selecting a unit or group of units from the map.

Direct links are available from the GUI icons to the corresponding tabular summary screens.

A single top level tabular screen shows the complete site status at a glance. Clearly defined areas of the screen show turbines, meteorological stations, grid stations and current events. The turbine status shows turbines on line, faulted, stopped, crew present, power and energy outputs. The meteorological status shows the site mean wind speed, direction, temperature, pressure and air density. The grid status shows the grid power and energy output for the wind farm, site electrical loss and overall production efficiency.

Current site events are clearly shown with event code, event description, response status and times.

Links are highlighted to detailed information screens on individual turbines, meteorological stations and grid stations.

The user has a choice between a ‘snapshot’ screen and a ‘dynamic’ screen. A snapshot screen shows the status of each unit on the wind farm at the time the screen was requested. A dynamic screen continuously updates the information from the wind farm while the screen is in view. At all times 10-minute average data values are stored in the working database for further analysis.

Configuration information for any unit on the wind farm can be easily accessed and displayed.

Reports, analysis and database functions

Ten-minute performance data and all event data are stored in an industry standard relational database. Any ODBC 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.

Reports

The 'Reports' function gives access to powerful reports, analysis and database functions built into GH SCADA. They provide extensive analysis and viewing functions for statistical and event data. Reports are built up using easy to follow 'Report Definition Forms'. When finished they can either be viewed immediately or stored as 'Predefined Reports' for later use. They can be stored either in the 'System' box where they are available to all users or in the 'User' box where they are only available to the defined user.

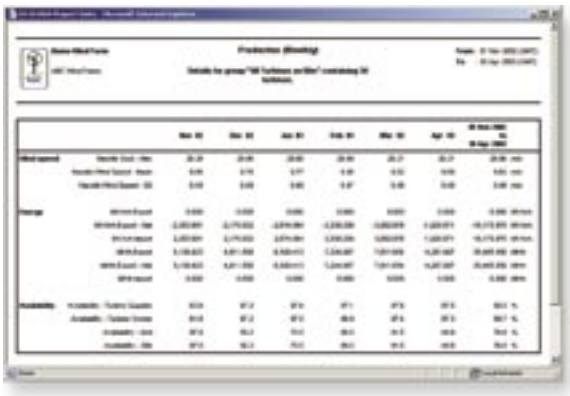
'Predefined Reports' are fully defined and produced at the click of a button, emailed to recipients at predefined times or stored in a file. This means custom reports are delivered automatically at the end of the specified time period.

Energy production

The actual, expected and planned energy production for individual turbines, groups of turbines or the whole wind farm for any time period to date is available.

Expected energy output is calculated using the wind farm power curve produced by the 'WindFarmer' code, the industry leading validated wind farm performance prediction software.

Energy lost during periods of downtime according to wind speed and warranted power curve may also be determined.



Trends

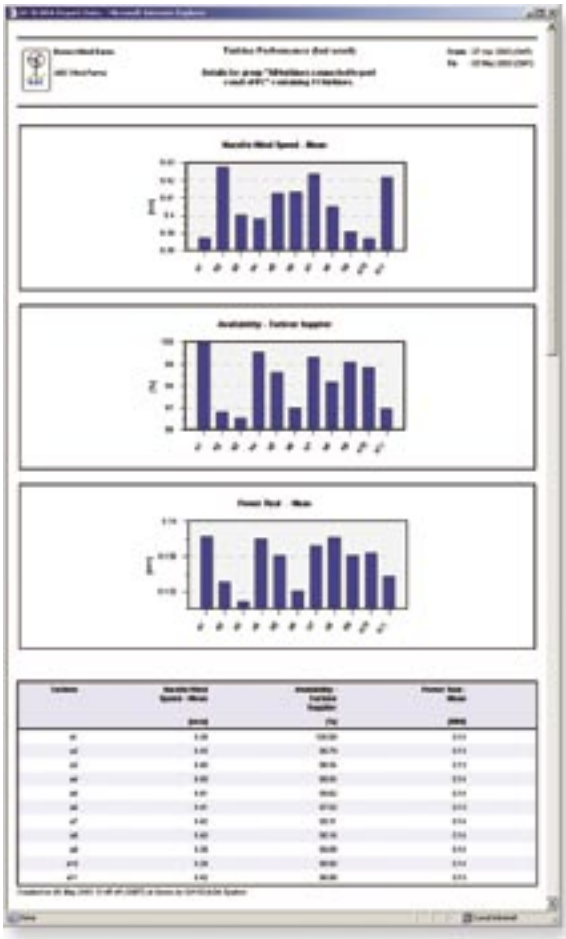
Compare time series data for any selected signal from turbines, metering stations and meteorological masts.

Database

'Database Forms' are pre-set forms and queries to allow the user full access to the database without having to transfer data outside the program.

The user may browse the ten-minute data and events database and show the events for any unit for any time period. The system allows the user complete freedom in browsing the database but the more common selections are catered for in drop down menus.

View turbine and wind farm event data with options to, select turbine or group of turbines, include events from grid stations, meteorological stations and servers, select time range and list all events or show totals only.

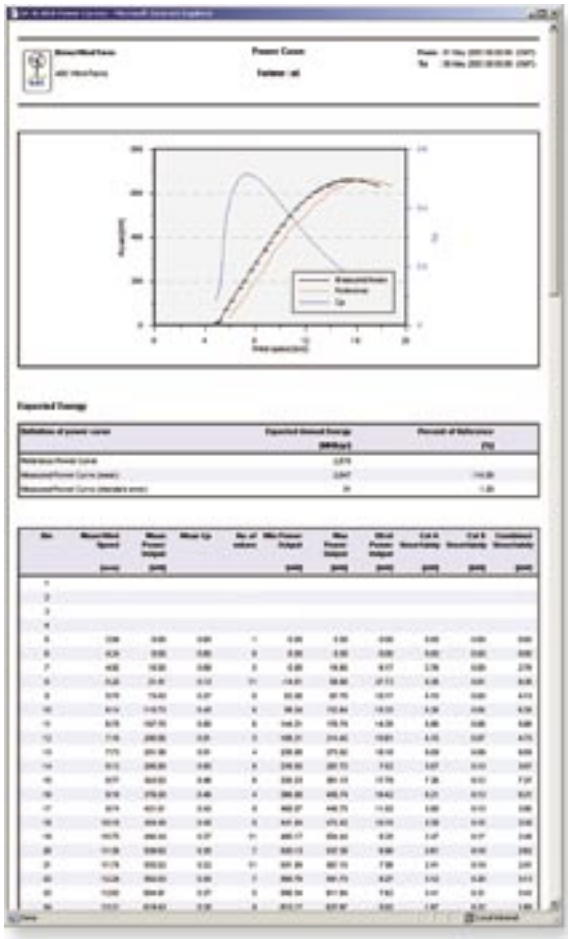


Power curves

Power curves may be created for any user selectable date range with a selectable wind speed bin size and choice of binned or scatter data.

Power Curves are generated according to the IEC 61400-12 Standard and include the following options:

- Application of speed-up factors.
- Standard error analysis.
- Air density correction: to specified value based on measured temperature and pressure data, record by record based on measured temperature and pressure data or average correction for period.
- Wind direction exclusion sectors.
- Exclusion of records where icing occurred.
- Filtering of data based on:
  - minimum sample rates.
  - minimum number of readings.
  - record length.



Power curves may be generated using nacelle or any meteorological station wind speed signal. It is possible to apply user specified corrections to nacelle anemometer readings to obtain the free stream wind speed.

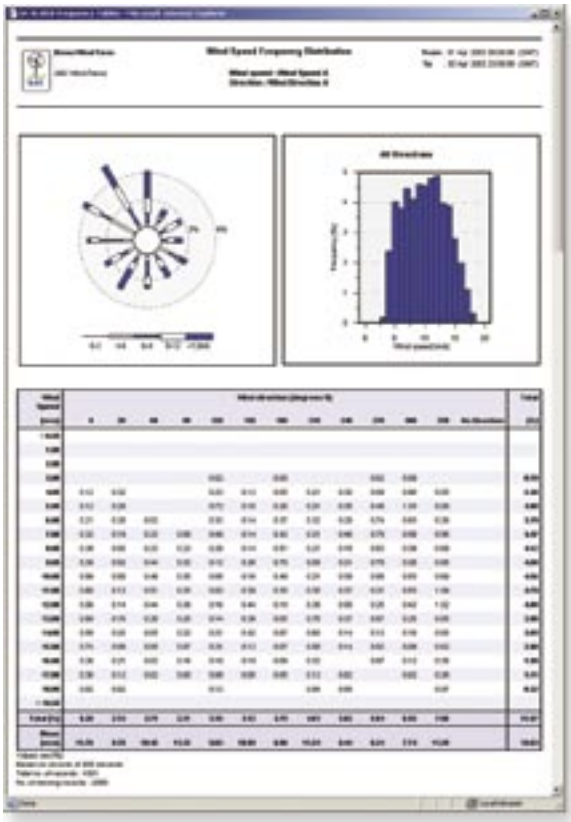
Power curves can be either shown immediately or queued for delivery by email at a later date. Facilities are also provided to queue a batch of Power Curves reports for groups of turbines.

Meteorological data

Meteorological data may be analysed according to wind speeds, wind direction, turbulence, temperature, pressure, density and other data from any installed sensors. This includes frequency distributions, wind rose and analysis of mean, maximum, minimum and standard deviation data.

Distributions can be created over any user selectable date range with a selectable bin size and choices of binned or scatter data. They may be generated from any meteorological station or nacelle anemometer with optional correction of nacelle wind speeds.

Results can either be shown immediately or queued for delivery by email.



Availability

Availability calculations are made on definitions that are generic, transparent, unambiguous and based on realistic measurements. All turbine time is recorded and assigned to fifteen mutually exclusive categories as shown in the table below. The availability may be calculated over any time period.

Default calculations are supplied with the system. In addition the user may define their own availability calculations based on the addition and division of these time categories.

Availability category	Time	Status
No SCADA	T1	The SCADA system is out of operation.
Force majeure	T2	Force Majeure condition exists on the wind farm.
No comms	T3	The SCADA communications system is functioning correctly but no data communication is available from the turbine controller.
On line	T4	Turbine generator on line.
Grid limits stop	T5	The grid is outside agreed operational limits.
Ambient temperature stop	T6	The wind farm ambient temperature is outside the agreed turbine operational limits.
Off line wind in limits	T7	Turbine is released to run and wind is within limits but turbine generator is off line. This may be due to turbine operations such as cable unwinds and generator changes.
Off line wind out limits	T8	Turbine is released to run but generator is off line due to wind conditions being outside the operational limits.
Fault stop wind in limits	T9	Turbine is stopped with a turbine fault requiring operator intervention. Wind is within operational limits.
Fault stop wind out limits	T10	Turbine is stopped with a turbine fault requiring operator intervention. Wind is outside operational limits.
Maintenance stop wind out limits	T12	Turbine is stopped for scheduled or unscheduled maintenance while the wind is outside operational limits.
Operator stop wind in limits	T13	Turbine is stopped by operator command while the wind is within operational limits.
Operator stop wind out limits	T14	Turbine is stopped by operator command while the wind is outside operational limits.
Constraint stop	T15	Turbine is stopped for operational constraints (time of day, noise etc). May be manual or pre-programmed.