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Goldwind Windfarm SCADA Manual

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1. SCOPE

This document defines the functional specification of the standard Goldwind Windfarm SCADA System. Goldwind Windfarm SCADA System is designed according to Goldwind WTG and grid requirements.

Goldwind Windfarm SCADA System adopts C/S and B/S double structure combined mode for design in order to satisfy the application demands of different users under different environments.

The platform implements data processing, storage and publishing through data processing service and data provision service, thus realizing the separation of functions and database system. The data storage can be implemented by selecting different database systems according to users' needs. The central monitoring platform implements the real-time display of each wind turbine data and improves the data acquisition efficiency through front-end services. The platform obtains the real-time detailed status display of the wind turbine selected by implementing independent query mode of each wind turbine as well as realizes the local control of the wind turbine selected by means of command making.

Goldwind Windfarm SCADA System provides functionality at the plant level. A collection of plant can be connected together into Goldwind Windfarm SCADA System. The additional features of the Goldwind Windfarm SCADA System are defined in a separate functional specification.

Goldwind Windfarm SCADA System can be deployed in a number of options. Where these options affect the specification it is indicated in the appropriate section.

2. SYSTEM OVERVIEW

The standard Goldwind Windfarm SCADA System consists of seven different components.
The standard components are :
·Front-end processor service
·Data Process and Provide service
·Data Base service
·Power Control Service
·Web Service
·Workstation
·Data protocol Service
Hardware and Software details of Goldwind Windfarm SCADA System can be found in APPENDIX A.

The System consists of one or more Goldwind servers. These connect to turbines, meteorological masts, substation protection and control system, kiosk-type transformer and other equipments on the project through a Front-end processor.

Database Server is a central Goldwind database where wind turbines data (also substation data, meteorological data etc) is hosted for Workstation or Web service reporting. The database server is

located in a central location and is operated and maintained by Goldwind software service crew. The Database Server is connected to the Goldwind turbines, substation protection and control system and meteorological masts via the LAN.

Workstation is the control and monitoring user interface. Workstation is used by the service crews or customers on site. Workstation is connected to the Goldwind turbines, protection and control system and meteorological masts via the LAN. Workstation also provides data querying and reporting.

Web service is also the control and monitoring user interface. The difference is web service connected to the Internet based on a TCP/IP networks. The SCADA system shall allow transmission of information on the internet via web-server/firewall for public information. It shall be possible for the Network Operator to remotely view data from the SCADA system.

The system is expandable so that several Goldwind servers can be networked together for large projects. A single project can be divided into a number of sites (or phases) to allow for scalability or to reflect geographical distribution of a project. Each module of Goldwind Windfarm SCADA System is flexibly distributed. They can be distributed in different terminals or centrally installed on one or several machines according to the conditions of the wind farm.

A schematic of a typical System is which was shown below. The details of any installation will be project specific.

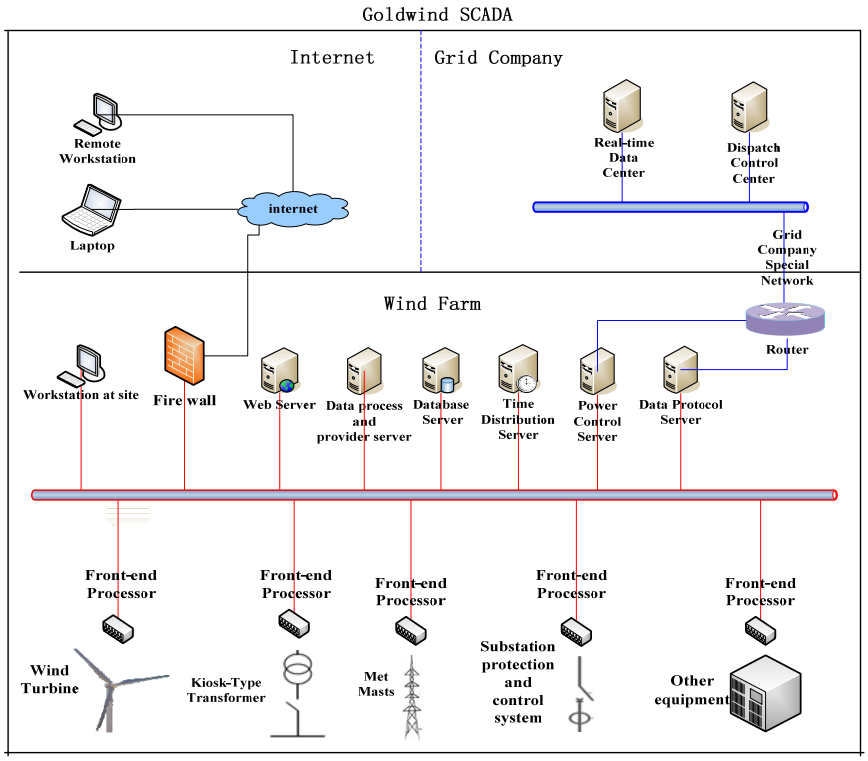


Figure 2.1 system overview

Goldwind Windfarm SCADA System mainly has the following characteristics:

1. Flexible monitoring mode: it cannot only realize single wind farm monitoring but also realize the centralized monitoring of multiple wind farms or the simultaneous implementation of single wind

farm monitoring and multiple wind farm monitoring.

2. Control function interlocking: during the simultaneous monitoring of multiple systems, the control command implements interlocking. After the user of a certain system locks the control, other systems or other users are unable to control. Only after the user of this system unlocks, other systems and other users may implement control.

3. Strong data instantaneity and quick data refresh: under the single wind farm monitoring mode, the data acquisition and refresh are synchronized. The cycle of data refresh may be less than one second. Under the centralized monitoring mode, if the network bandwidth is enough, data acquisition and refresh can also be synchronized. However, if the bandwidth is not enough, the data transmission frequency shall be reduced. The data refresh is slightly lagged behind data acquisition.

4. Two monitoring modes (C/S and B/S): the monitoring platforms in C/S and B/S modes can either run simultaneously or independently. They have same functions, basically consistent interfaces and same data refresh rates.

5. Data transmission mode: compressed transmission mode is adopted for data transmission, which saves the bandwidth. 20Kbit network bandwidth is guaranteed for each wind turbine to realize data remote synchronous refresh with the refresh cycle of approximately one second.

6. Graphic interface: vector graphics are adopted for the main interface and detailed information. They can be zoomed in and out freely.

7. System capacity: each monitoring unit is capable of monitoring at least 200 wind turbines or other devices without influencing data refresh and other performance.

8. Network adaptability: with strong adaptability, the centralized control center and wind farm may adopt VPN tunnel or DVPN and VPDN technologies to realize data interconnection.

9. Display interface: the interface is direct and visualized. The data is displayed to the users mainly in form of graphics. When the user needs to query specific data, he may retrieve the data he concerns through curve.

10. Data storage medium: currently popular databases including SQLSERVER, ORACLE and POSTGRES can be selected to store according to user demand.

11. Data processing upon network communication interruption: during the communication interruption period, the data may be permanently stored locally. However, after recovery of communication, the data can quickly access the database. The data processing may receive more than 3,000 deposited data in communication interruption per second at most.

12. High compatibility: it is compatible with wind turbine or other devices supplied by different manufacturers with different models.

3. SUPPORTED DEVICES

3.1 Wind Turbines

The standard System supports all types of Goldwind wind turbines. It also supports wind turbines of different manufacturers.

Front-end processor which installed inside the turbine main control cabinet communicates directly with each turbine controller. Data is collected from this equipment and sent to the data process server via TCP or UDP.

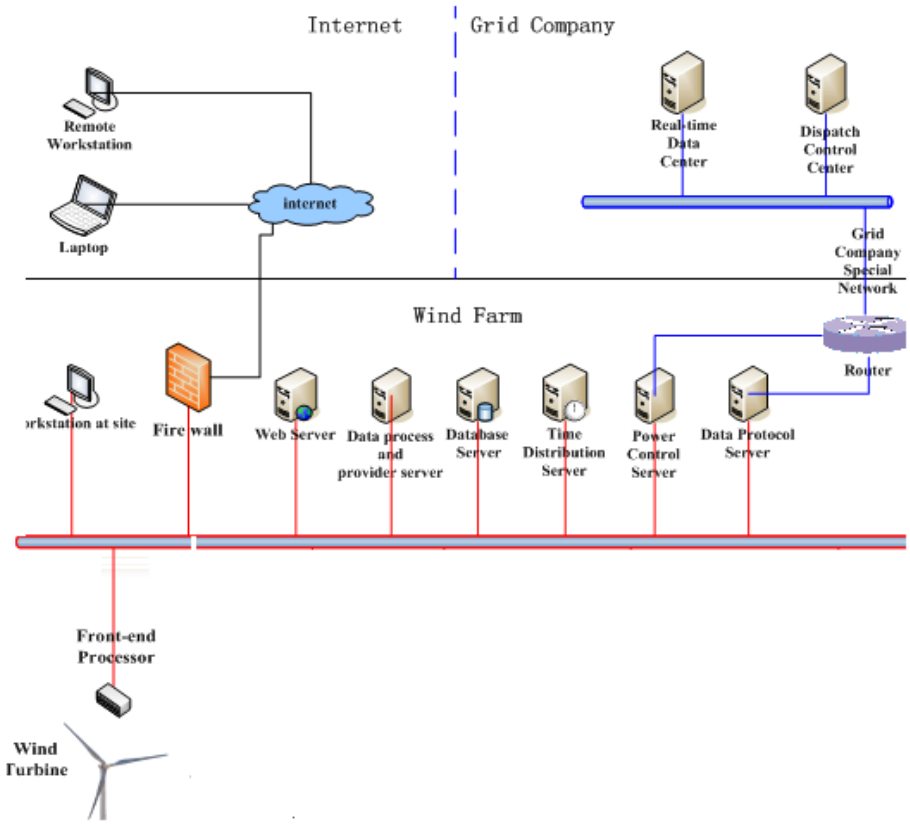


Figure 3.1 Wind turbines communication method in Goldwind Windfarm SCADA System

3.2 Meteorological Mast

Meteorological Masts (Met Masts) are the standard meteorology station installed at wind farms.

Met Masts get power from the nearest turbine and are connected to the wind turbine scada network.

The Front-end processer at the switchgear building communicates directly with Met Mast logger.

The system supports any number of sensors and any number of Met Masts.

More than one interface can be supported per Met Mast, subject to physical limitations of communications ports, such as Modbus Serial RTU (RS232 or RS485), Modbus TCP/IP and OPC interface based on the OPC DA2.0 standard.

10-minute data and daily data are calculated by the data process service and stored at the Database Server.

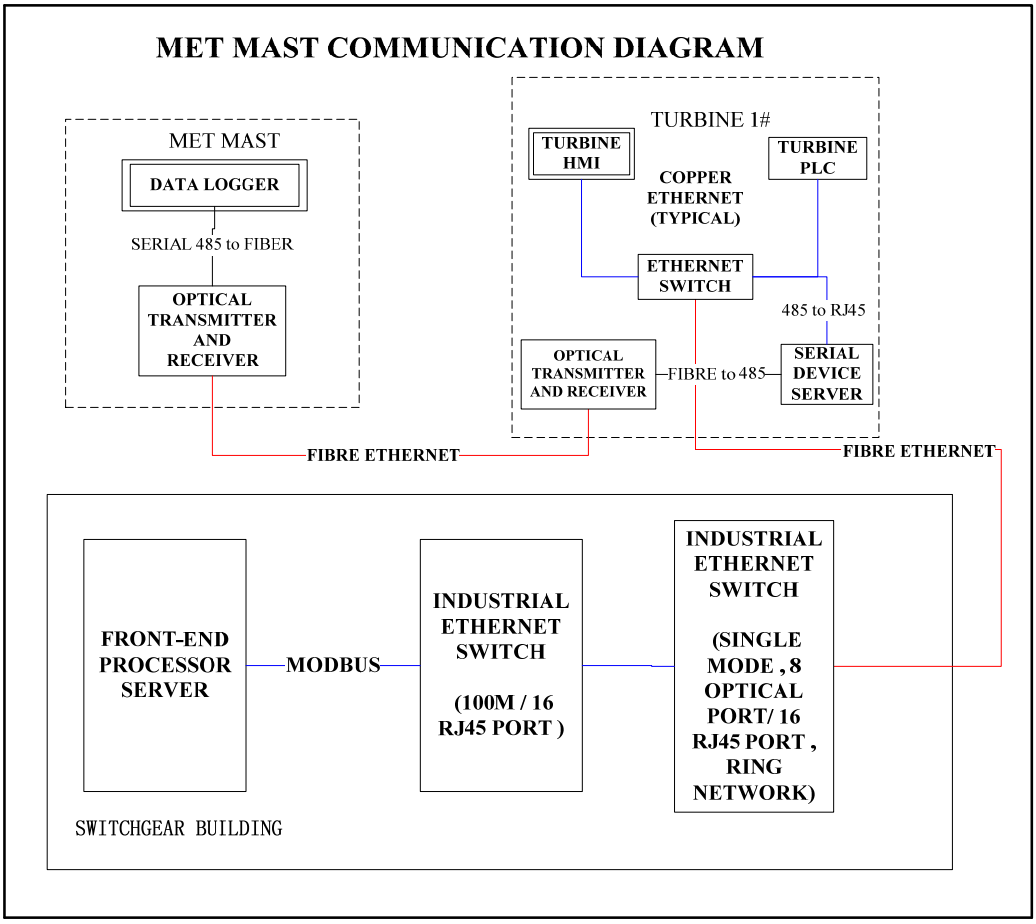


Figure 3.2 Met mast communication diagram

3.3 Substation protection and control system

The system supports collection of data from the substation protection and control system. 10-minute data, daily data and event data are generated by the data process service and stored in the Database Server. This is via the following communication interfaces:

- Modbus Serial RTU (RS232 or RS485)
- Modbus TCP/IP
- CDT protocol interface
- 101 protocol interface(DL/T634.5101-2002)
- 102 protocol interface(DL/T719-2000)
- 104 protocol interface(DL/T634.51041-2002)

Figure 3.3a

Front-end processer communicates with RTU via Ethernet network and use Modbus TCP/IP or 101,102 ,104 protocol.

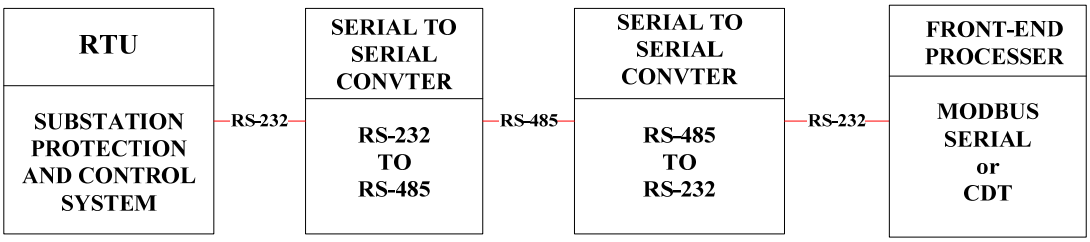


Figure 3.3b

Front-end processor communicates with RTU via serial and use Modbus Serial or CDT protocol.

3.4 Kiosk-Type Transformer

Kiosk-Type transformer data acquisition equipment is additional equipment which needs to be installed in the cabinet at base of the wind turbine.

Each transformer interface needs a transformer data acquisition device and several lightning-protection devices.

The device receives analog signals of box-type transformer, and converts analog signals into digital signals.

Equipment Specification:

- AI (Analog Input)

Channel Number: 5 Differential Input
Resolution: 16 bits
I/O Mode: Current
Input Range: 4~20mA

- DI (Digital Input) ,DO (Digital Output)

Channel Number: 12
I/O Mode: Digital input or digital output can be configured by software

- Temperature Input

Channel Number: 3 RTD Input
Resolution: 16 bits
I/O Mode: RTD (Resistance Temperature Detector)
Input Range: PT-100

- LAN

Ethernet Network: 1*10/100Mbps, RJ45
Protection: 1.5KV Magneto-Isolation Protection

Protocol: Modbus/TCP，TCP/IP，UDP，DHCP，Bootp，HTTP

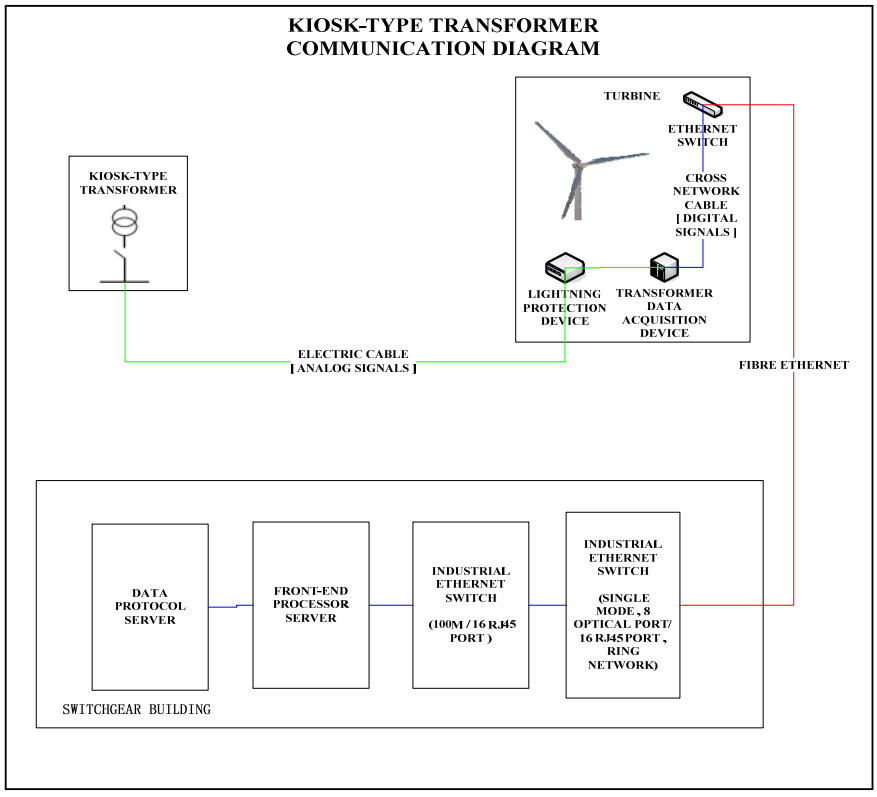
- Power Supply Requirement

Power Input：Standard 24VDC，12 ~ 36 VDC

Kiosk-Type Transformer Data Acquisition Device

3.5 Other equipments

The system supports collection of data from other equipments. It is the client's responsibility to provide details of the interface for any specific projects and to provide any software and licenses required for the interfaces.



4. ENVIRONMENTAL CONDITIONS

Servers :

. Operating Temperature: 10ºC to 35ºC (50ºF to 95ºF)

- Storage Temperature: -40ºC to 65ºC (-40ºF to 149ºF)
- Operating Relative Humidity: 20% to 80% non-condensing (non-condensing twmax=29°C)
- Storage Relative Humidity: 5% to 95% non-condensing (twmax=38°C)
- Maximum Humidity Gradient: 10% per hour, operational and non-operational conditions
- Operating Vibration: 0.25 G at 3 Hz to 200 Hz for 15 minutes
- Storage Vibration: 1.54 Grms Random Vibration at 10 Hz to 250 Hz for 15 minutes
- Operating Shock: 1 shock pulse of 31 G for up to 2 ms
- Storage Shock: 6 shock pulses of 71 G for up to 2 ms
- Operating Altitude: -15.2 m to 10,668 m (-50 ft to 35,000 ft)
- Storage Altitude: -15.2 m to 10,668 m (-50 ft to 35,000 ft)

5. SITE NETWORK COMPATIBILITY

The System uses Ethernet for communications between the central System server and the Front-end Processors.

The System requires a 100 Mb/s RJ45, F/UTP Ethernet connection adjacent to each server and each Front-end Processor.

The network infrastructure between the servers and Front-end Processors is not part of the standard

6. DATA COLLECTION

6.1 Real-time data

The SCADA system can acquire operating data in real time from all wind farm and ancillary system instruments and controllers including:

- Wind Turbine Generator controllers (WTG) – wind turbine and generator data in accordance with the IEC61400-25-2 information model.
- Met Masts – weather data in accordance with the IEC61400-25-2 information model.
- Substation Protection and Control Systems – power transmission and protection data in accordance with the IEC61850-7-3 information model.

All data acquired is time stamped.

The system stores all the real-time data as a zipped SQLLite file. A new file is created for each turbine, met mast and substation every day.

This data can be viewed on site and remotely at an update rate of once every three seconds. The real-time data can be exported to third-party software, such as Excel.

The standard system provides six-month storage on the server. More server disk space can be added to prolong real-time data storage time.

Users can back up the real-time data files to other storage media if required.

6.2 Statistical Data

The analogue signals are processed at 10-minute intervals.

Statistics are produced from the data processing including: mean values, min and max values.

Incremental counters such as kWh and kVArh production, maintenance time and system OK time counters are stored as incremental counts.

The attached is the requirement specification of data exchange between TSS947 Substation SCADA and Goldwind SCADA. It includes the requirements of transmission medium, protocol, services and data point list.

6.3 Event Data

If any turbine is switched off or has a fault, an event can be generated to flag this.

Event data includes: turbine status change data, turbine fault data.

Priority Alarming: The software provides a priority alarming system, such that each alarm may be assigned a priority by the user and each priority shall have a unique display message.

An alarm notification system can be provided which alerts operation/maintenance staff if any part of the wind farm requires attention via sms and also has the capability of notifying the relevant people via email.

Event data is kept online for the duration of the project.

6.4 Daily Data

Statistical data is aggregated to create daily statistics at the end of each day. Daily data is kept online for the duration of the project.

6.5 Power Curve data

Power output and wind speed data is obtained and used to generate the power curve.

Power curve data is kept online for the duration of the project.

7. TIME SYNCHRONISATION

The System stores all internal time stamps in UTC time.

The system is set to run at a specified GMT offset. All day boundaries are based on this GMT offset.

The server times are synchronized with an external GPS Satellite Timing Synchronization System. GPS or radio based time sources can be included on a per project basis but are not part of the standard system.

Front-end Processor times are synchronized to the server.

8. DATABASE

The database contains data structures with selected essential meta data, project specific information and operational data being produced by the turbine controllers at site, being Goldwind turbines, Met masts and Substation protection and control system. All data apart from the zipped high resolution data files (zipped SQLLite files) are stored in a MS SQL Server database.

The data structures in this document are maintained and continuously developed upon by the SCADA Development team at Goldwind.

Goldwind reserves the right to make any modifications to the data structures without any prior notice. Modifications include and is not limited to changes in table structures, data types, naming conventions etc.

9. USER INTERFACE

The SCADA system provides graphical user interfaces (GUIs) for the use of the wind farm operators, and by other users of the system. The GUIs conform to contemporary standards for display appearance, resolution and usability. The GUIs provide a hierarchy of displays arranged in a logical arrangement.

Remote user access is through a standard web browser allowing multi-user access. Remote users can access the system from any PC with a Web Browser and Internet access.

Local users can access the system through a standard Web Browser on any locally networked PC or install a windows application program.All access is password protected.

Open wind farm central monitoring platform program, and then the system login interface will be displayed as follows:

Figure 9 login interface

Enter correct user's name, password and identifying code and click "Log in". Then, you can log in the system

9.1 Authority and security

Goldwind Windfarm SCADA System is of very high safety. Since the centralized control mode is adopted, the data transmission may be carried out by means of Internet. This system adopts encryption algorithm to encrypt the data transmission in order to guarantee data security during transmission process.

If this platform system is only used inside one wind form, the function of encrypted data transmission may not be used. As for the users of the system, different authorities can be assigned. The user may only operate authorized function modules, which may guarantee the security of some important data. Meanwhile, the system will record detailed operation log for the operation carried out by each user who logs in the system, which is helpful for accountability tracing and various evaluation processes in the later stage.

9.2 Wind Farm Overview

Main information interface is the first interface after the user logs in the system. The information of the whole wind farm can be browsed in this interface.

The main interface displays the data concerned in the whole wind form in form of curve. The time period displayed by each curve can be freely defined (e.g. mean wind velocity, total power, etc. of the whole wind farm). The user may see the trends of the whole wind farm at any time. The quantity displayed can be freely defined. See the following diagram:

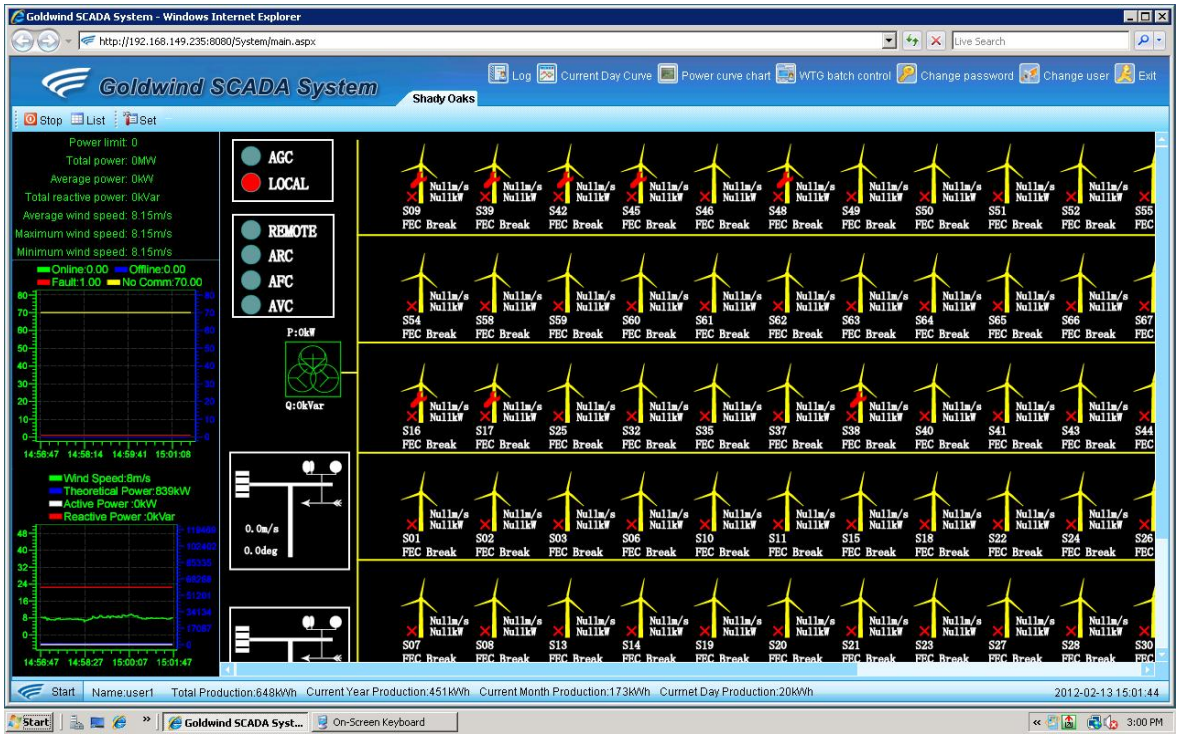


Figure 9.2 wind farm overview

The statuses of the wind turbine are displayed by using different colors. The user may tell the

current statuses of the turbine according to the colors displayed like communication interruption, failure and whether it is synchronization or running with limited power.

9.2.1 Start/stop monitoring

Users can start or stop monitoring by clicking start/stop button on the webpage. (seen figure 9.2.1)

Figure 9.2.1 start/stop button

9.2.2 List/Graphic view

The main information interface of the monitoring platform has 2 display methods: graphic view and list view. They can be conveniently switched according to relevant demand. Users can change view by clicking list/graphics button on the webpage. (seen figure 9.2.2)

Figure 9.2.2 list/graphics button

List View of Wind Farm: The wind farm can be viewed in tabular form and the information for turbines is configurable.

Information available for each turbine includes: turbine name, turbine status, wind speed, active power, reactive power, frequency, power factor, production, and operating time etc.

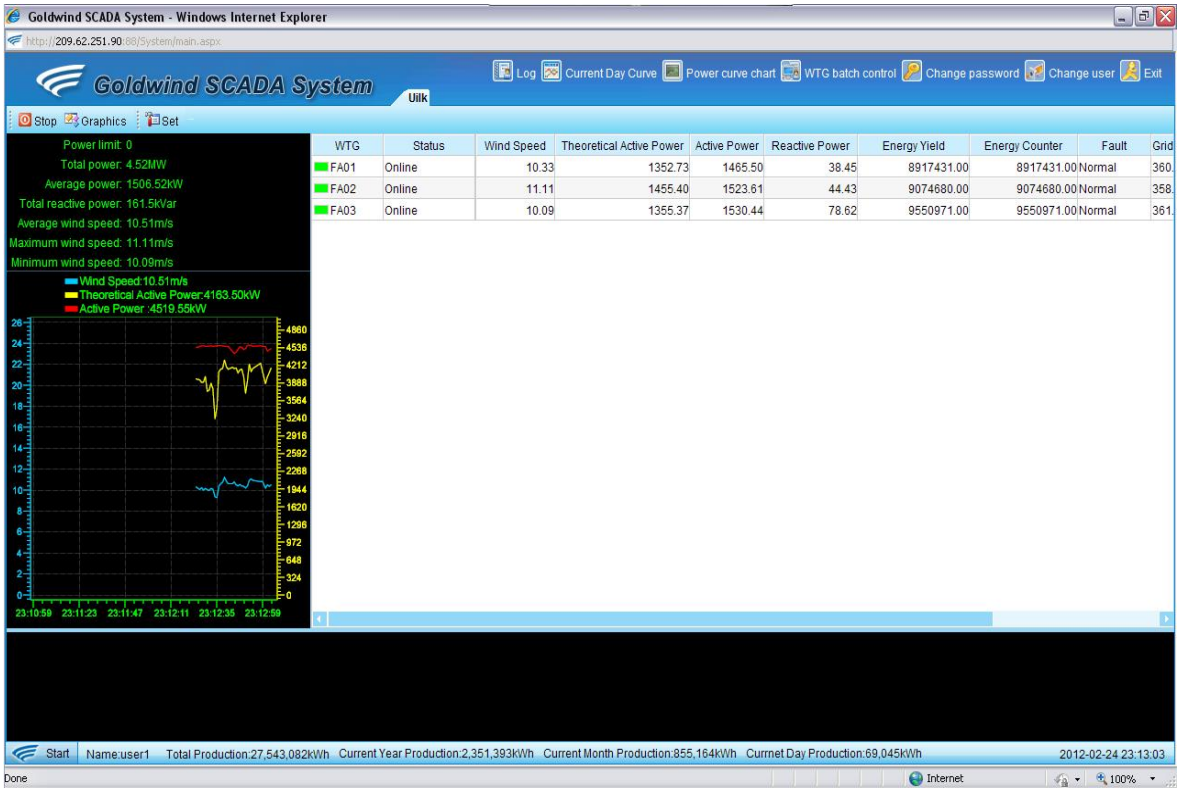


Figure 9.2.2a list view

Information is which was shown on list view could be customize by users . Seen '9.2.3 set operating parameters'

Graphics View of Wind Farm: This view shows an icon for each turbine, meteorological mast and substation on the wind farm. Status is indicated via a color wind turbine icon.

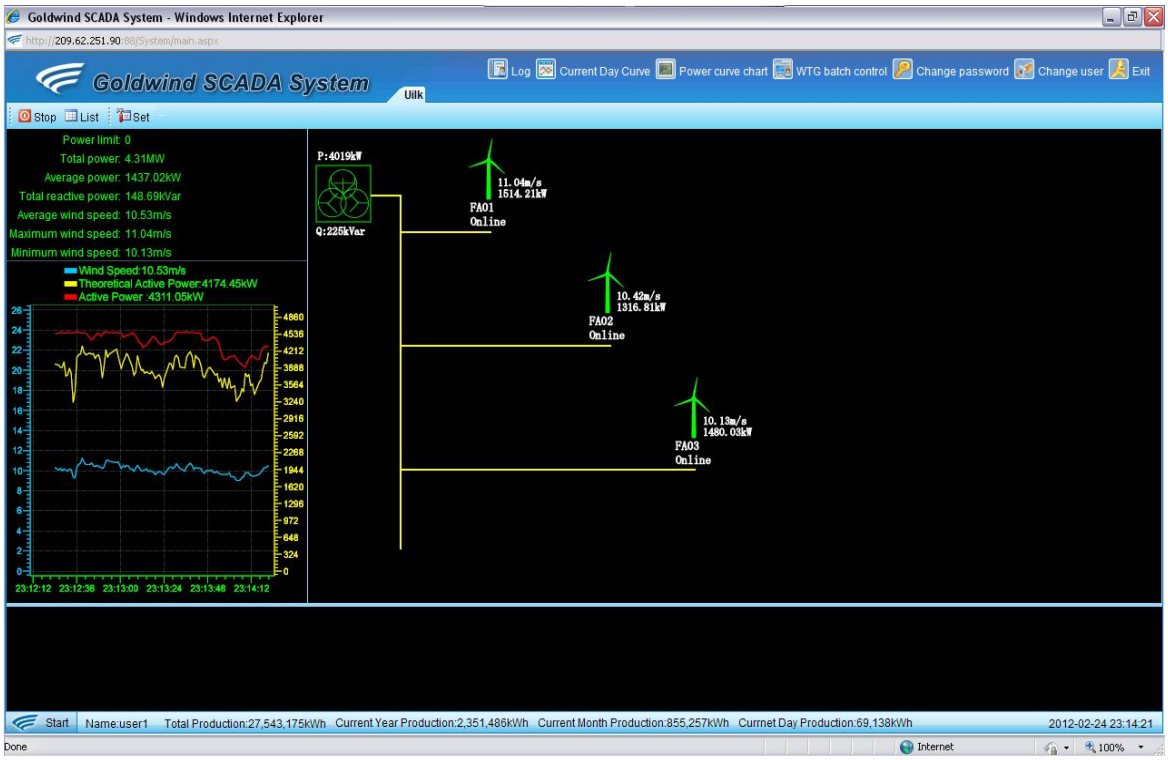


Figure 9.2.2b graphics view

9.2.3 Set operating parameters

Users can set operating parameters by clicking set button on the webpage. (seen figure 9.2.3). Operating parameters consists general setting, chart setting and list setting.

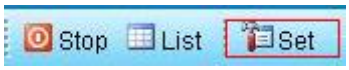


Figure 9.2.3 operating parameters setting

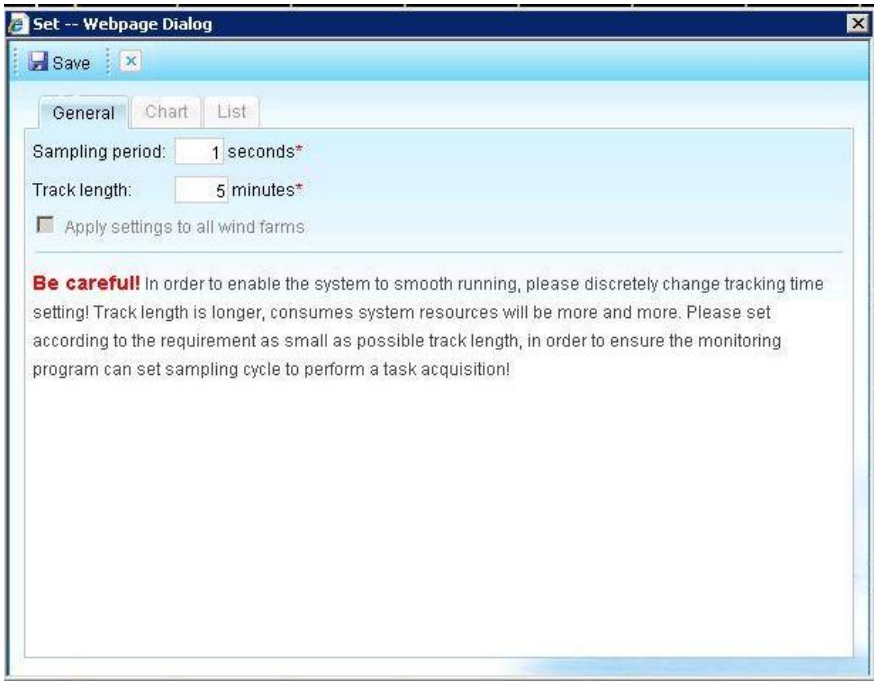


Figure 9.2.3a General setting

The data refreshes every second on site and every 1-5 second(s) remotely. The remote refresh rate

depends on the internet connection speed of the web server at the wind farm. Users can set sampling period and track length on this webpage dialog. Click save button to save settings.

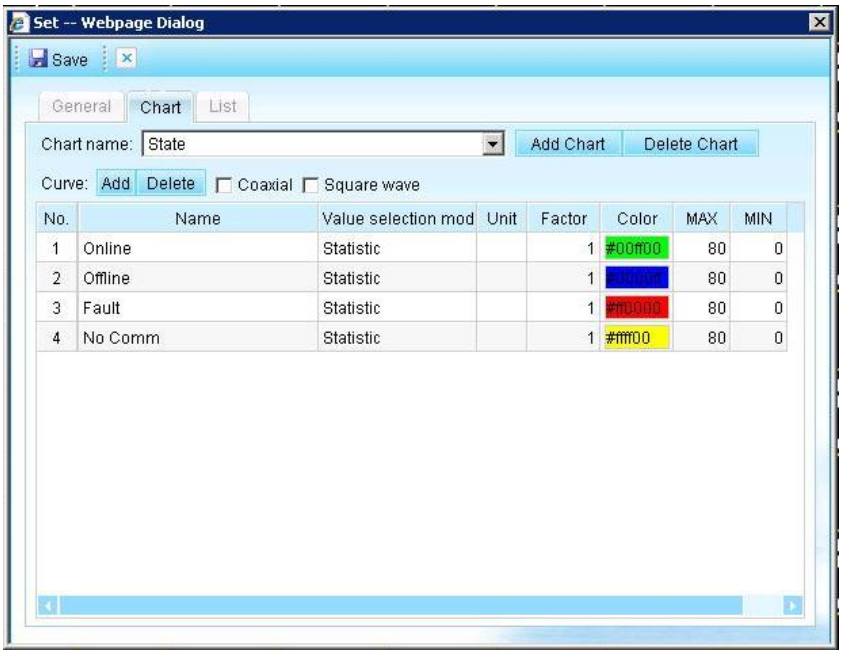


Figure 9.2.3b Chart setting

Chart setting allow users to add or delete charts on the webpage. Users also can add or delete curves on the webpage. Click save button to save settings.

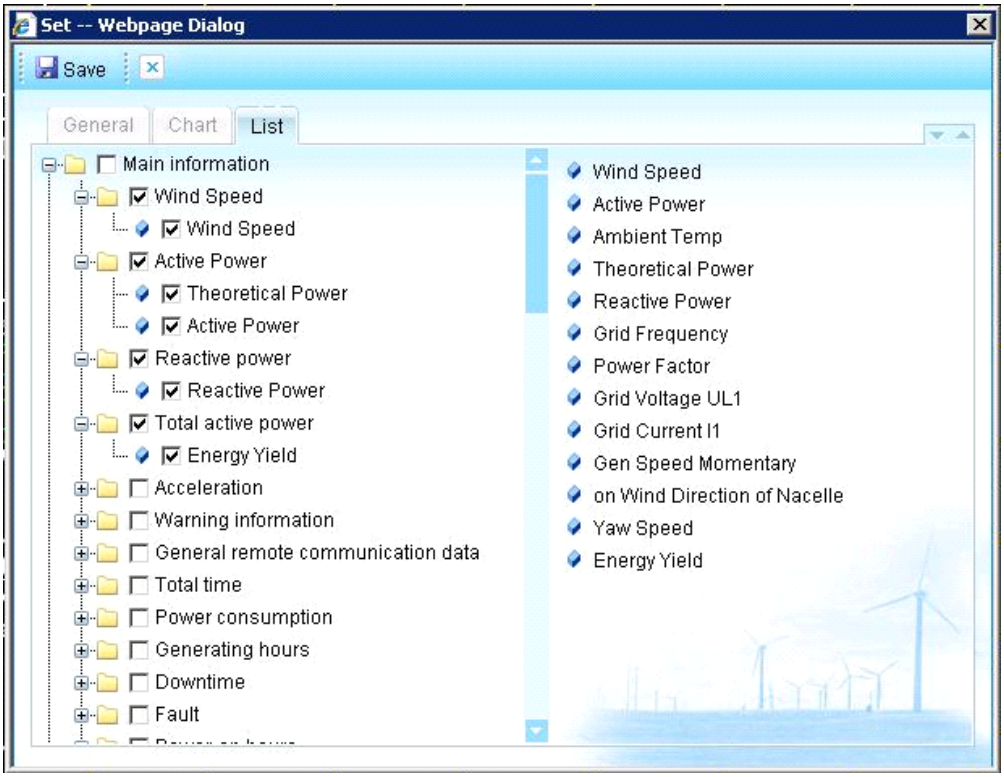


Figure 9.2.3c list setting

List setting is used to customize users data requirements which was shown on webpage of list view. Select check-marked box to pick data needed. Then click save button to save settings.

9.2.4 Failure and warning display window

The operation condition of each wind turbine can be timely and directly understood through “Failure and warning display window” at the bottom of the main interface. The failure and warning associated information amount can be set. If the associated information amount is set, the set information amount will be displayed when failure or warning is reported to facilitate the judgment and search of reasons. See the following diagram:

Figure 9.2.4 Failure and warning display window

9.2.5 Shortcut buttons for frequently used functions

Goldwind Windfarm SCADA System offers shortcuts buttons for frequently used functions. Users can access these functions by clicking the shortcut buttons which was shown on the webpage.

Figure 9.2.5 shortcut buttons

The shortcut buttons are:

·Log

·Current Day Curve

·Power curve chart

·WTG batch control

·Change password

·Change user

·Exit

The function of each button will be shown in the later chapters.

9.3 Detailed information of wind turbine

9.3.1 Real-time data

Double click wind turbine icon on the webpage to check the wind turbine with detailed information. Enter the wind turbine detailed information display page as which was shown in the following diagram

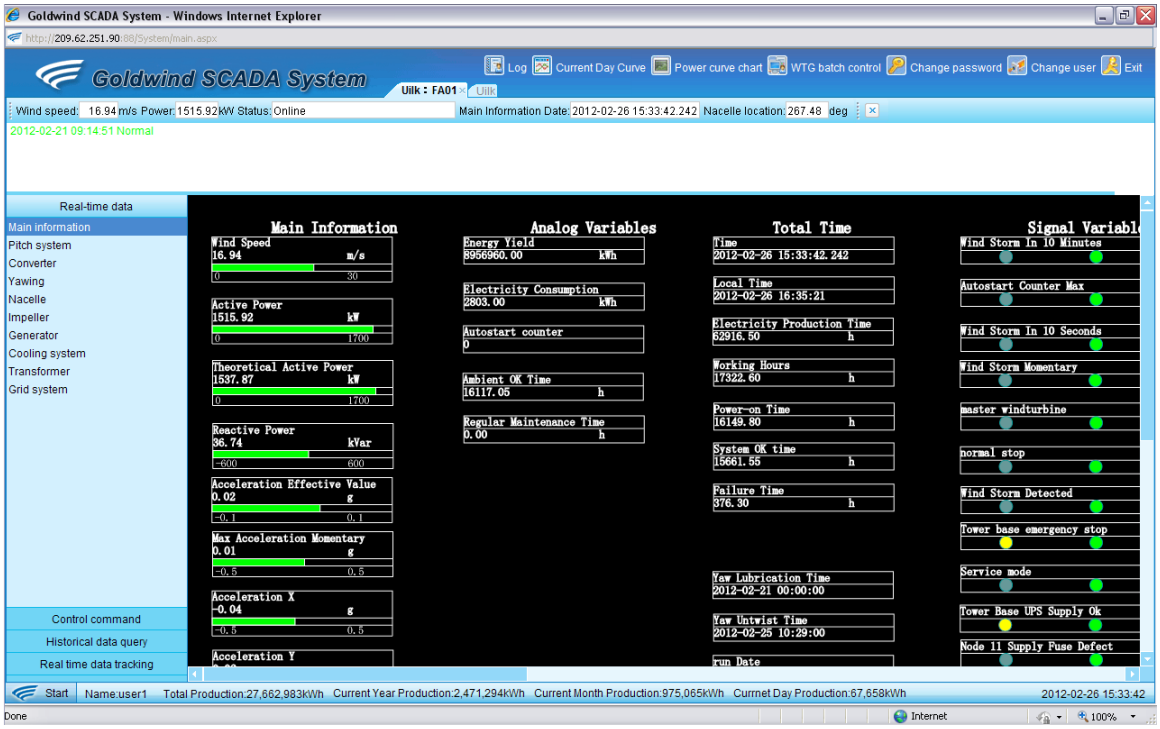


Figure 9.3.1 detail information of wind turbine

The top side of this webpage is wind turbine operation status recording. It records wind turbine's operation status, includes production, start, stop, stand still, fault, FEC break etc.

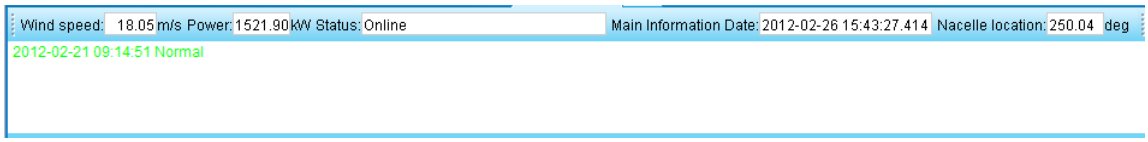


Figure 9.3.1a operation status window

The left side of this webpage is Information tree of wind turbine. The information tree includes main information, patch system, converter, yawing, nacelle, rotor, generator, cooling system, transformer and grid system. Users can get data from each system by clicking each item, also can get signal variables information of each system.

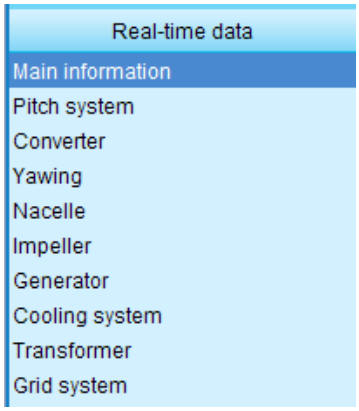


Figure 9.3.1b Information tree of wind turbine

In the middle of this webpage is Detailed information display area. The content displayed based on users' selection from Information tree of wind turbine on the left side.

Figure 9.3.1c Detailed information display area

Left side on the bottom of this webpage is control command, historical data query, real time data tracking, these functions will be shown in the later chapter.

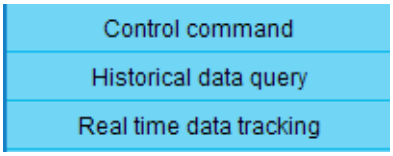
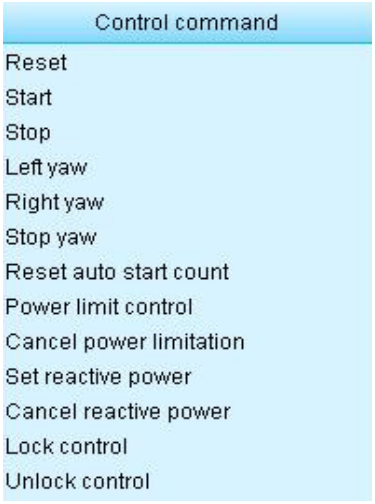


Figure 9.3.1d other functions

9.3.2 Control command

Double click wind turbine icon on the webpage, go to the left side on the bottom of the webpage, choose 'control command' to open wind turbine control command window.



9.3.2 control command window

Click relevant commands to sent the control commands to the equipment including reset, start, stop, left yaw, right yaw, stop yaw, reset auto start count, power limit control, cancel power limitation, set reactive power, cancel reactive power, lock control, unlock control. The following diagram displays the operation of reset control.

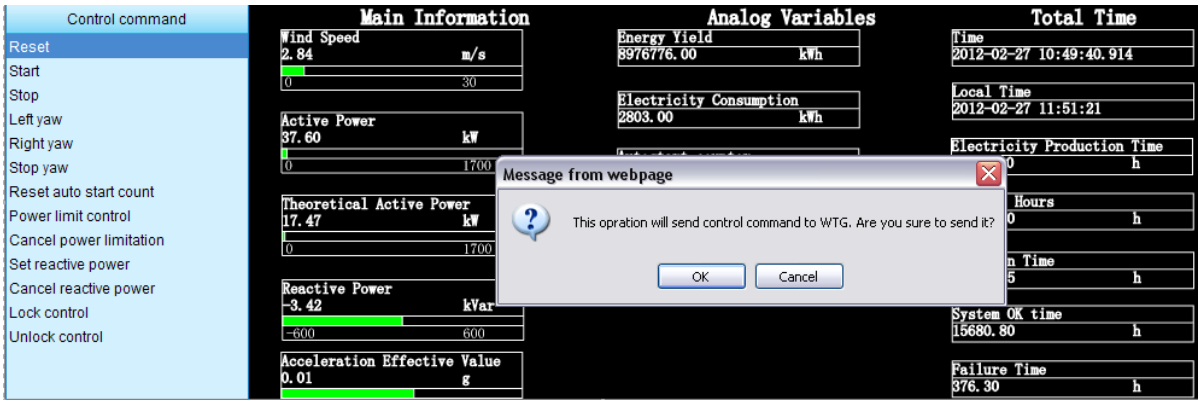


Figure 9.3.2a reset command

Click OK to reset wind turbine, click cancel to cancel reset.

9.3.3 Historical data query

Data storage can be classified to real-time data storage, ten-minute data storage, and daily data storage. The query can be carried out from the abovementioned three data types.The ten-minute interval data is saved in the database for more than one year. The user may set the saving time, and the principle of first-in first-out (FIFO) is adopted. The real-time data can be permanently saved in the files. The daily interval data can be permanently saved in the database. The real-time data is permanently saved in the hard disk of the server in form of file. When the hard disk has insufficient space, the user may backup the data to other mediums. All data queries are unfolded in form of curve and data. The graphics are mainly focused on. The graphics can be zoomed in and out. The query results will be exported to Excel table.

Double click wind turbine icon on the webpage, go to the left side on the bottom of the webpage, choose 'historical data query' to open wind turbine historical data query window.

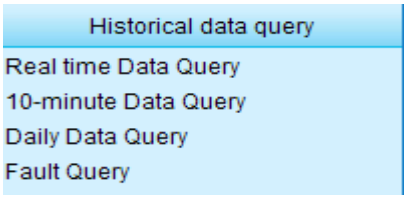


Figure 9.3.3 historical data query

In the menu of “Historical data query”, the query of real-time data, ten-minute data, daily data and historical failure can be carried out.

The operation is the same as the operation of relevant menu in “Start-Data query report”. Please refer to “Data query-Real-time data query”, “Data query-Ten-minute data query”, “Data query-Daily data query”, and “Data query-Historical failure query” for detailed introduction.

9.3.4 Real-time data tracking

Double click wind turbine icon on the webpage, go to the left side on the bottom of the webpage, choose 'real-time data tracking' to open wind turbine real-time data tracking window.

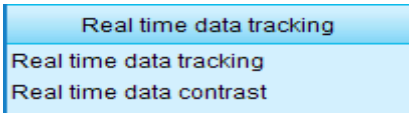


Figure 9.3.4 real-time data tracking

Select equipment, amount to the queried, same vertical axis comparison, etc. and click the button of “Query”. Then, the real-time data tracing conforming to the query condition will be displayed. See the following diagram.

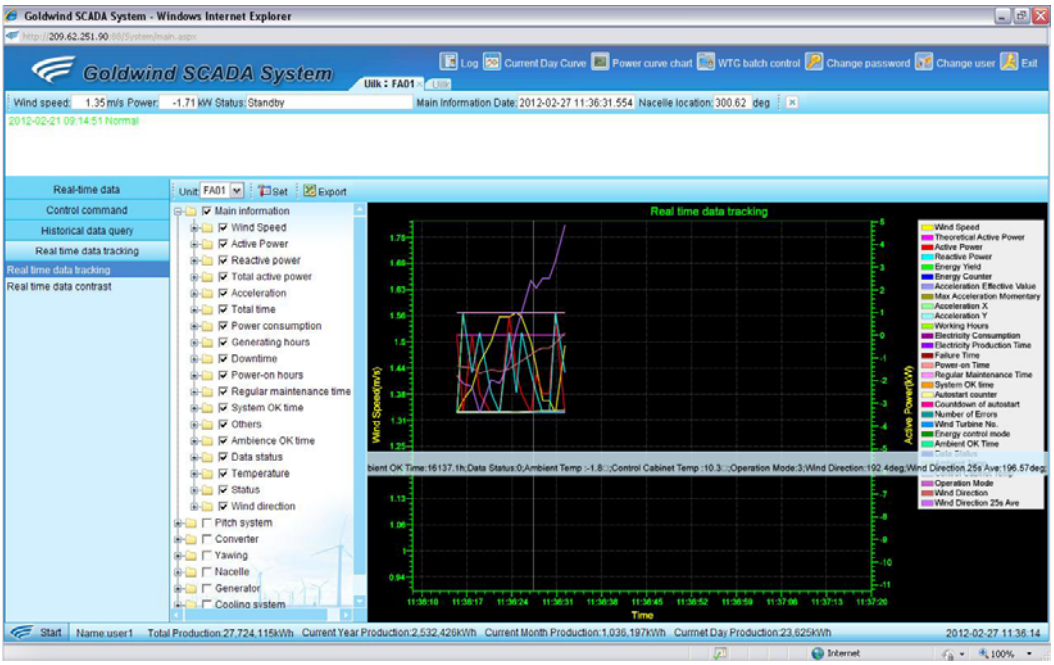


Figure 9.3.4a real-time data tracking

Click Export button to export data to Excel.

Figure 9.3.4b export button

Click set button to set real-time data tracking parameters. It includes Track length settings and screen settings.

Figure 9.3.4c set parameters window

Fill propriety track length and sampling period, click save to save settings.

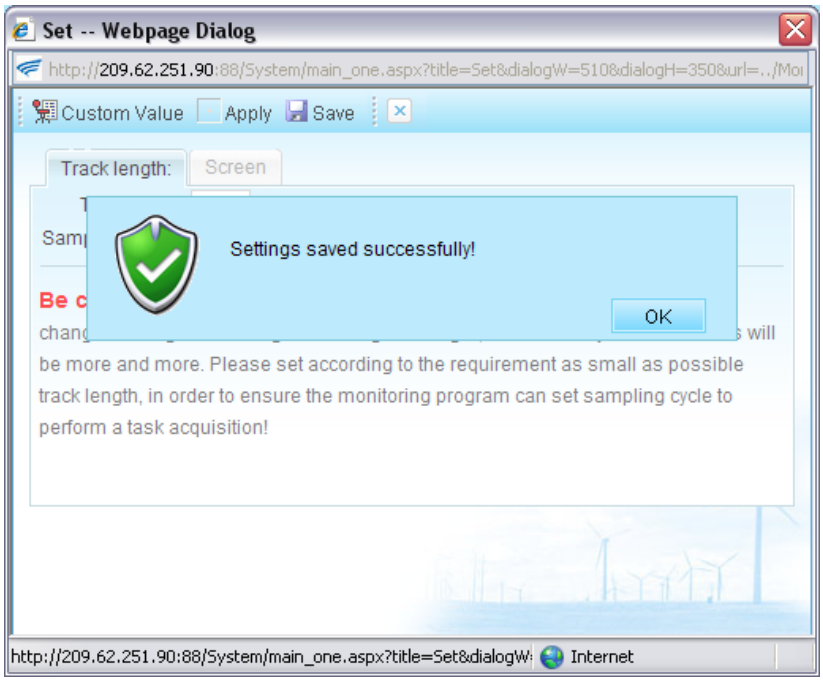


Figure 9.3.4d save settings

Double click wind turbine icon on the webpage, go to the left side on the bottom of the webpage, choose 'real-time data comparison' to open wind turbine real-time data comparison window.

Select “Real-time data comparison” to query and set query conditions like comparison quantity and compared wind turbine. Click “Query”, and then the real-time data comparison results conforming to the conditions are displayed. See the following diagram.

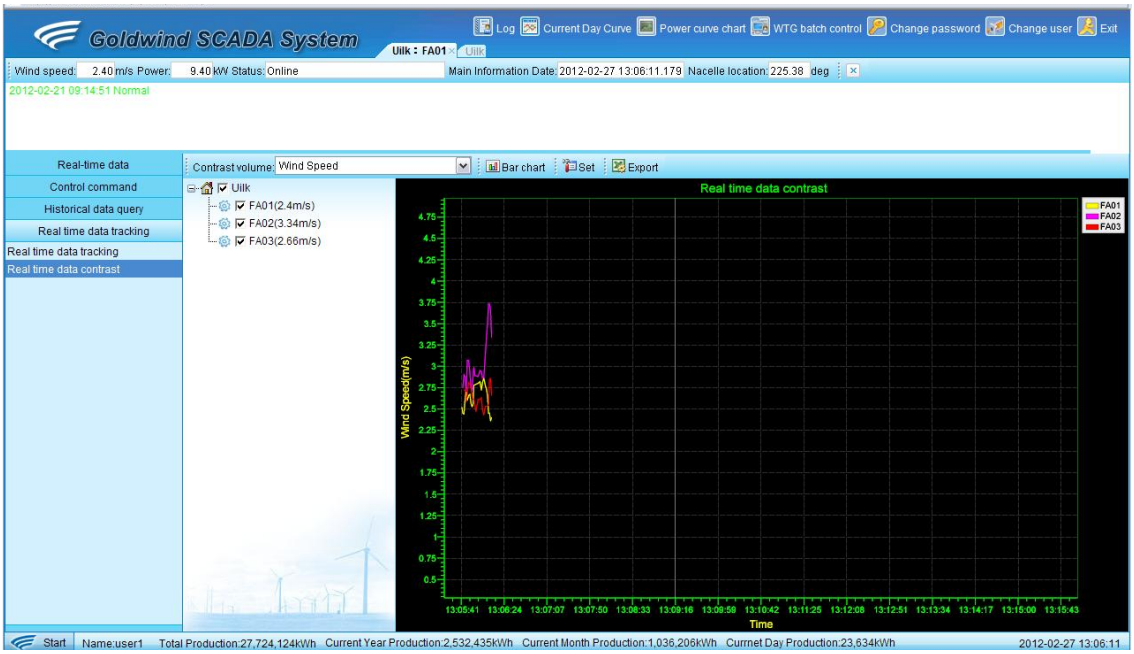


Figure 9.3.4e real-time data comparison

Click the line chart/bar chart button to switch view.

Figure 9.3.4f line chart/bar chart view

Click set button to set parameters. The operation is the same as the operation of setting parameters in chapter 9.3.3. Please refer to 9.3.3 see more details.

Figure 9.3.4g set button

Click Export button to export data to Excel.

Figure 9.3.4h export button

9.4 Data query

In the menu of data query, statistic data query, historical status query, historical failure query, real-time data query, ten-minute data query, daily data query, data query of wind farm, query of loss of electric quantity of wind turbine, equipment information query of wind farm, query of power changing rate of wind farm, event action log query, user operation record query and latest data time query are available.

Click “Start-Data query report” to display menus available for query as shown in the following diagram:

Figure 9.4.1 data query report

Data query report offers information query below:

·Status query
·Fault query
·Event log query
·Event and fault timestamp query
·Real-time data query
·10-minute data query
·Daily data query
·Wind farm data query
·Wind farm output query
·User operation record query
·Latest data time query
·Equipment information query
·Static data query

9.4.1 Status query

Status query is a function which can provide single wind turbine status during a certain period of time.

Click “Start-Data query report-status query” to query wind turbine status.

Figure 9.4.1 status query

Users can select a wind turbine from left side of the webpage, then select start&end time on the top of the webpage, wind turbine status will be displayed in main display area, on the bottom of the webpage, there are text descriptions about state time, status code, status duration(s), duration description and WTG status.

9.4.2 Fault query

Fault query is a function which can provide single wind turbine fault(s) during a certain period of time. It includes fault statistics query and fault details query.

Click “Start-Data query report-fault query” to query wind turbine fault(s).

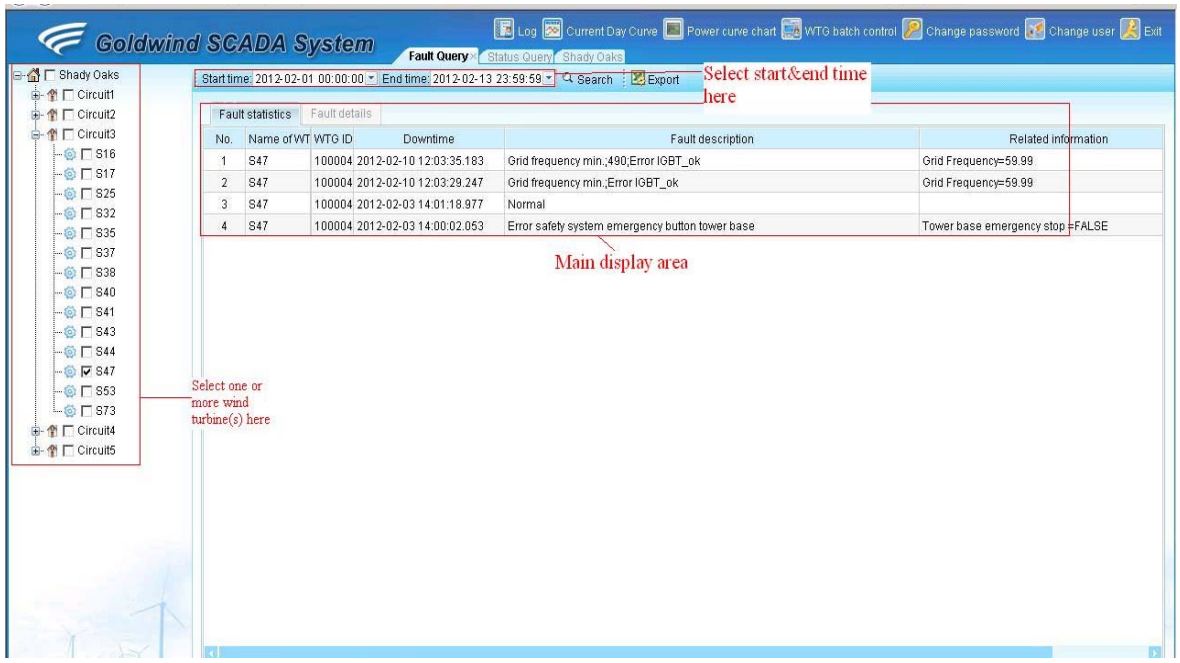


Figure 9.4.2 fault query

Users can select one or more wind turbine(s) from left side of the webpage, then select start&end time from the top of the webpage, click search to display. Number, name of WTG, WTG ID, downtime, fault description and related information will be displayed in main display area.

If faults displayed more than one page, go to the bottom, right side of the webpage, click 'next' to the next page, click 'previ' to the pervious page.

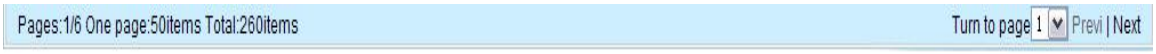
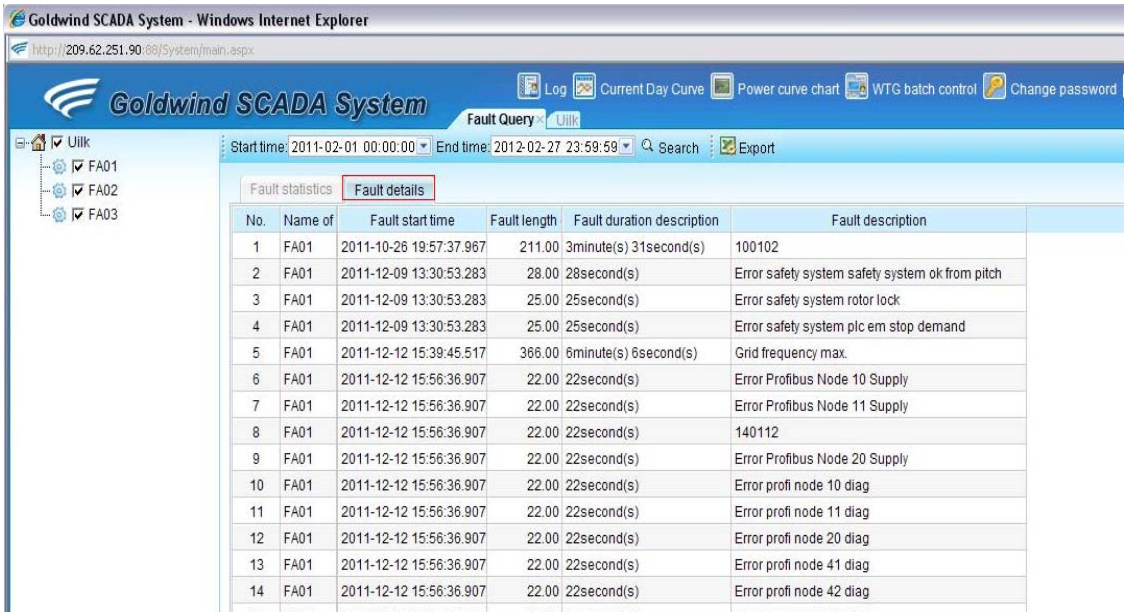


Figure 9.4.2a fault query

Click 'Fault Details' tab on the top of the webpage to display fault details.



No.	Name of	Fault start time	Fault length	Fault duration description	Fault description
1	FA01	2011-10-26 19:57:37.967	211.00	3minute(s) 31second(s)	100102
2	FA01	2011-12-09 13:30:53.283	28.00	28second(s)	Error safety system safety system ok from pitch
3	FA01	2011-12-09 13:30:53.283	25.00	25second(s)	Error safety system rotor lock
4	FA01	2011-12-09 13:30:53.283	25.00	25second(s)	Error safety system plc em stop demand
5	FA01	2011-12-12 15:39:45.517	366.00	6minute(s) 6second(s)	Grid frequency max.
6	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error Profibus Node 10 Supply
7	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error Profibus Node 11 Supply
8	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	140112
9	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error Profibus Node 20 Supply
10	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error profi node 10 diag
11	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error profi node 11 diag
12	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error profi node 20 diag
13	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error profi node 41 diag
14	FA01	2011-12-12 15:56:36.907	22.00	22second(s)	Error profi node 42 diag

Figure 9.4.2b fault details

Number, name of fault, fault start time, fault length, fault duration description and fault description displayed on fault details tab.

Users also can export all data to excel by clicking export button on the webpage.

9.4.3 Event log query

Event log query is a function which can provide event log of a wind turbine during a certain period of time.

Click “Start-Data query report-Event log query” to query event logs.

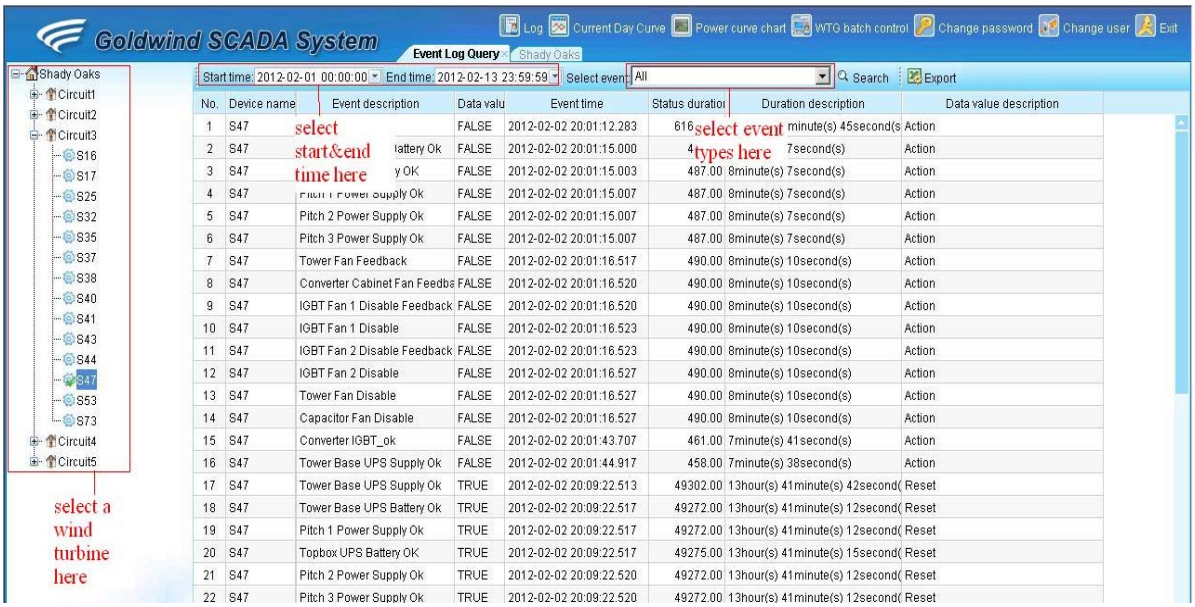


Figure 9.4.3 event log query

Number,device name, event description, data value, event time, status duration, duration description and data value description will be displayed on event log query tab.

Users also can export all data to excel by clicking export button on the webpage.

9.4.4 Event and fault timestamp query

Event and fault timestamp query offers user a quick way to query when fault happened and event occurred.

Click “Start-Data query report-Event and fault timestamp query” to query event and fault timestamp.

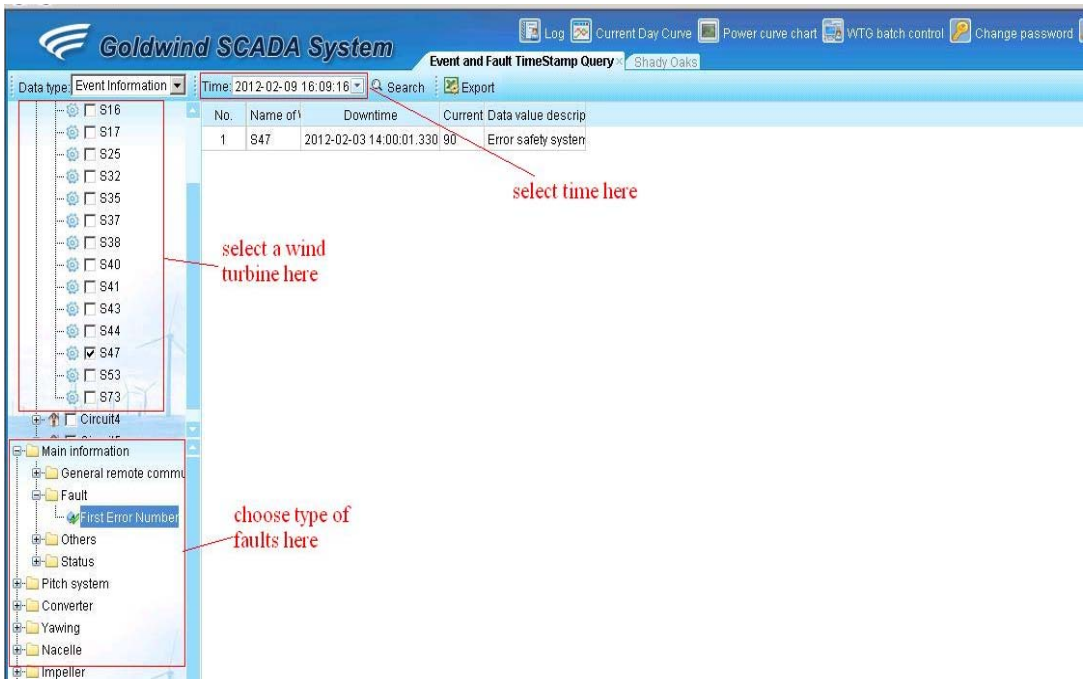


Figure 9.4.4 event and fault timestamp query

Number, name of WTG, downtime, current value, data value description will be displayed on the event and fault timestamp tab.

Users also can export all data to excel by clicking export button on the webpage.

9.4.5 Real-time data query

Real-time data query is a function which can provide real-time data query of each wind turbine in a certain period of time. Users can select real-time data they need to form to a report or for data analysis. Information refreshing rate of all real-time data: <=5s.

Click “Start-Data query report-Event log query” to query event logsClick “Start-Data query report-Event log query” to query event logs.

Figure 9.4.5 real-time data query

Main display area displayed data by graphic, text description area displayed data by text.

Users also can export all data to excel by clicking export button on the webpage.

9.4.6 10-minute data query

10-minute data query is a function which can provide 10-minute data query of each wind turbine in a certain period of time.

Click “Start-Data query report-10-minute data query” to query 10-minute data.

Figure 9.4.6 10-minute data query

Users can pick data they concerned to analysis or form to a report. 10-minute data was stored in database server. Make sure communication works well between database server and web service server/workstation before we do this query.

Graphic will be displayed in main display area, text description will be shown in text description area. Users also can export all data to excel by clicking export button on the webpage.

9.4.7 Daily data query

Daily data query is a function which can provide daily data query of each wind turbine in a certain period of time.

Click “Start-Data query report-Daily data query” to query daily data.

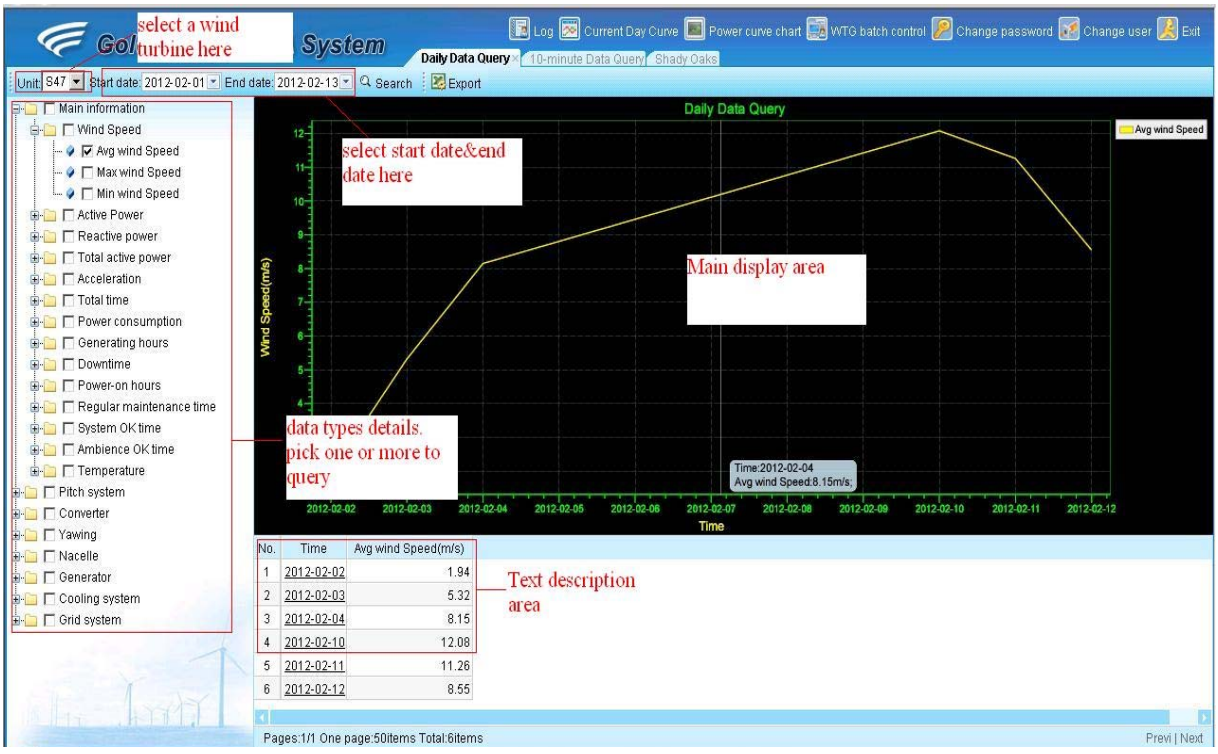


Figure 9.4.7 daily data query

Graphic will be displayed in main display area, text description will be shown in text description area. Users also can export all data to excel by clicking export button on the webpage.

9.4.8 Wind farm data query

Wind farm data query is a function which can provide data query of each circuit in a certain period of time.

Click “Start-Data query report-wind farm data query” to query circuit data.

Figure 9.4.8 wind farm data query

All information displayed by graphic/list view, graphic will be displayed in main display area, list will be shown in text description area. Wind farm data query offers three types of statistical data, ten-mins data, hourly data and daily data. Users can pick up a circuit and a type of data to query. Users also can set parameters by clicking set button on the webpage.

Users also can export all data to excel by clicking export button on the webpage.

9.4.9 Wind farm output query

Wind farm output query is a function which users can query theoretical power and real power of each wind turbine.

Click “Start-Data query report-Wind farm output query” to query theoretical power and real power.

Figure 9.4.9 wind farm output query

Wind farm output query allow users to query and compare theoretical power and real power of each wind turbine.

Users also can export all data to excel by clicking export button on the webpage.

9.4.10 User operation record query

User operation record query is a function which can provide user operation record query. It offers query for central monitor(C/S), central monitor (B/S), energy management platform, OPC server and external system.

Click “Start-Data query report-User operation record query” to query user operation record(s).

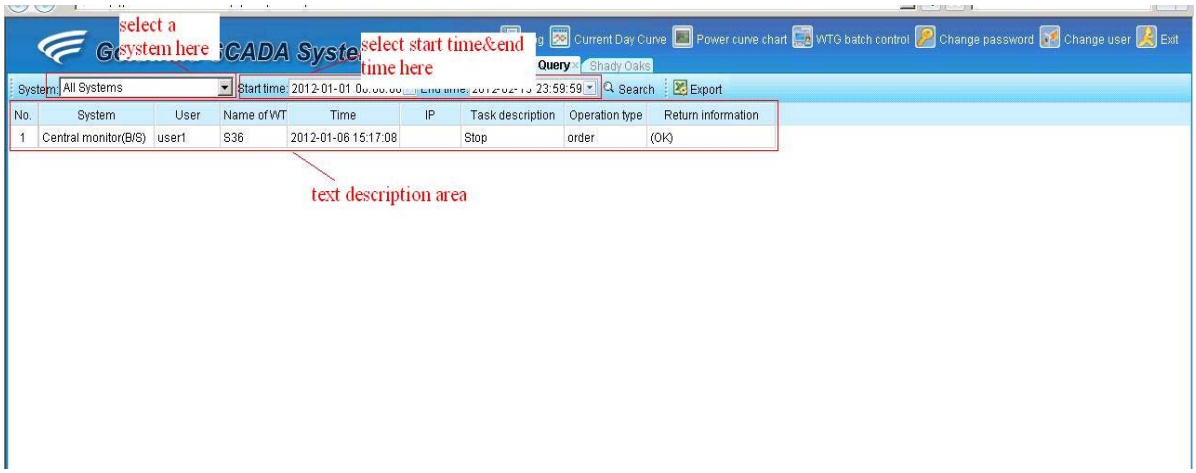


Figure 9.4.10 user operation record query

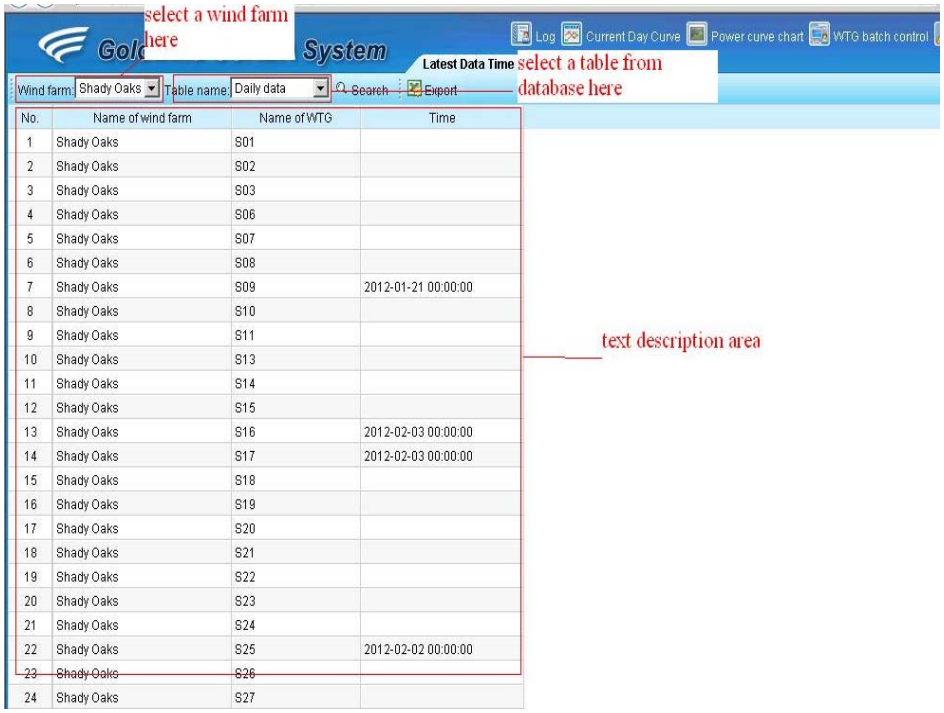
Number, system, user, name of WTG, time, ip, task description, operation type and return information will be displayed in text description area.

Users also can export all data to excel by clicking export button on the webpage.

9.4.11 Latest data time query

Latest data time query allow users to query latest data time in database, it would help users to figure out communication issues and data issues.

Click “Start-Data query report-Latest data time query” to query latest data time.



No.	Name of wind farm	Name of WTG	Time
1	Shady Oaks	S01	
2	Shady Oaks	S02	
3	Shady Oaks	S03	
4	Shady Oaks	S06	
5	Shady Oaks	S07	
6	Shady Oaks	S08	
7	Shady Oaks	S09	2012-01-21 00:00:00
8	Shady Oaks	S10	
9	Shady Oaks	S11	
10	Shady Oaks	S13	
11	Shady Oaks	S14	
12	Shady Oaks	S15	
13	Shady Oaks	S16	2012-02-03 00:00:00
14	Shady Oaks	S17	2012-02-03 00:00:00
15	Shady Oaks	S18	
16	Shady Oaks	S19	
17	Shady Oaks	S20	
18	Shady Oaks	S21	
19	Shady Oaks	S22	
20	Shady Oaks	S23	
21	Shady Oaks	S24	
22	Shady Oaks	S25	2012-02-02 00:00:00
23	Shady Oaks	S26	
24	Shady Oaks	S27	

Figure 9.4.11 latest data time query

Latest data time query could be used on communication trouble shooting. When communication between database server and front-end processor was break down, database could not get data from front-end processor, users can figure out when the fault occurred by querying latest data time. Sometimes when some data issues occurred, users also could figure out problems quickly by querying latest data time.

Users also can export all data to excel by clicking export button on the webpage.

9.4.12 Equipment information query

Equipment information query could get some basic information about front-end processor and PLC. It includes Front-end computer time contrast, PLC time contrast, front version contrast, PLC versions information contrast, front ini configuration contrast, front disk remaining space contrast and front CPU contrast.

Click “Start-Data query report-Latest data time query” to query latest data time.

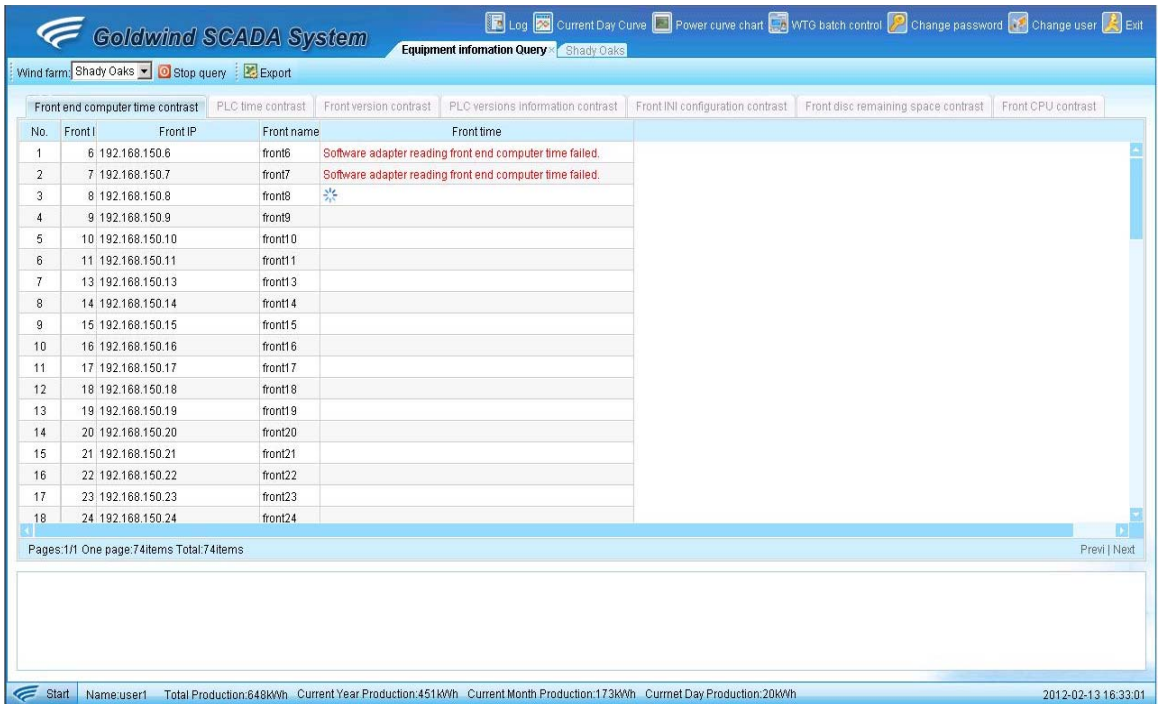


Figure 9.4.12 equipment information query—front-end computer time contrast

Users can switch equipment information by click the tab.

Users also can export all data to excel by clicking export button on the webpage.

9.4.13 Static data query

Static data query provides tables query in database. It includes 'wind farm information', 'information of WTG, substation and anemometer tower', 'Front-setting computer information' and 'port information list'.

Click "Start-Data query report-Static data query" to query static data.

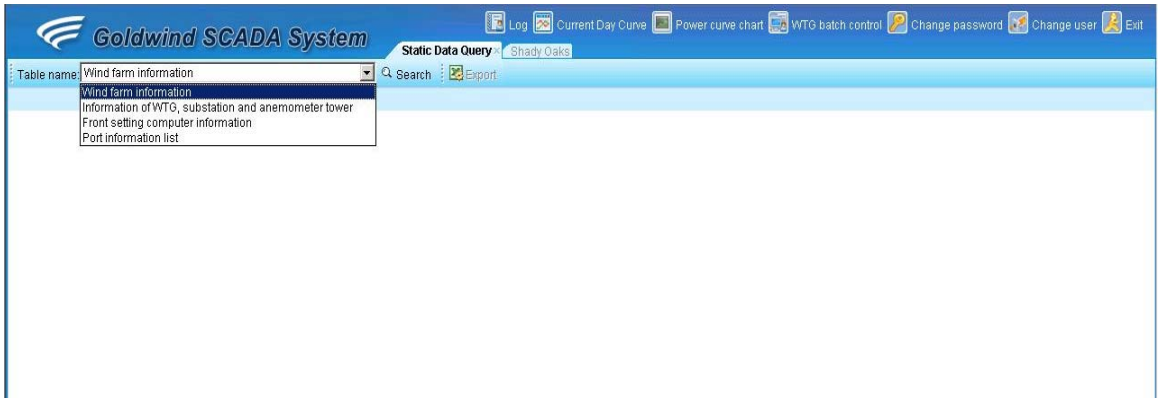


Figure 9.4.13 static data query

Users also can export all data to excel by clicking export button on the webpage.

9.5 Statistical analysis

Statistical analysis offers professional data analyzing for wind farm and wind turbine evaluation. Data analyzing can be displayed by graphic view or list view. For example, users can evaluate wind

turbine performance in a certain period of time by status statistic querying. Status statistic includes WTG status, status code, occurrence frequency, status durations and duration description, users can analysis data and evaluate if wind turbine works well during selected period of time.

Click ”Start-Data Statistic Report” to access statistical analysis function.

Figure 9.5 data statistic report

In the menu of Data Statistic Report, it includes status statistic, fault statistic, fault classified statistic, event data statistic, 10-minute data statistic, daily data statistic, output summary, WTG cumulate statistic, wind farm lost production statistic, main fault statistic, power change rate query.

The operation of ‘data statistic report’ almost the same as ‘data query’, seen ‘9.4 data query’.

9.6 data comparison

Goldwind Windfarm SCADA System offers data comparison functions. It includes substation data comparison and historical data relation comparison. In the menu of historical data relation comparison, it includes real time data relation comparison, 10-minute data comparison and wind farm data comparison.

Data comparison is for further data analysis, like data correlation between different wind turbines or different variables. For example, substation data comparison offers users a way to compare wind turbines active power with circuit data collected from substation device.

Click ”Start-Substation data comparison” and “Start-Historical data relation comparison” to access statistical analysis function.

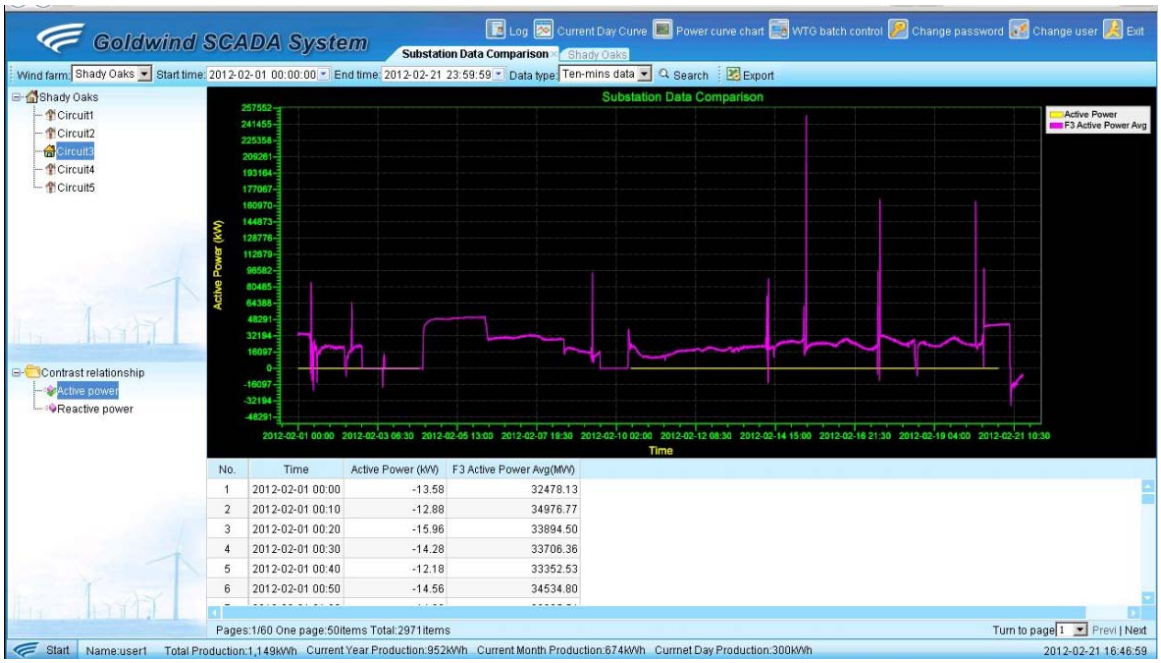


Figure 9.6.1 data comparison

The operation of ‘data comparison’ almost the same as ‘data query’, seen ‘9.4 data query’.

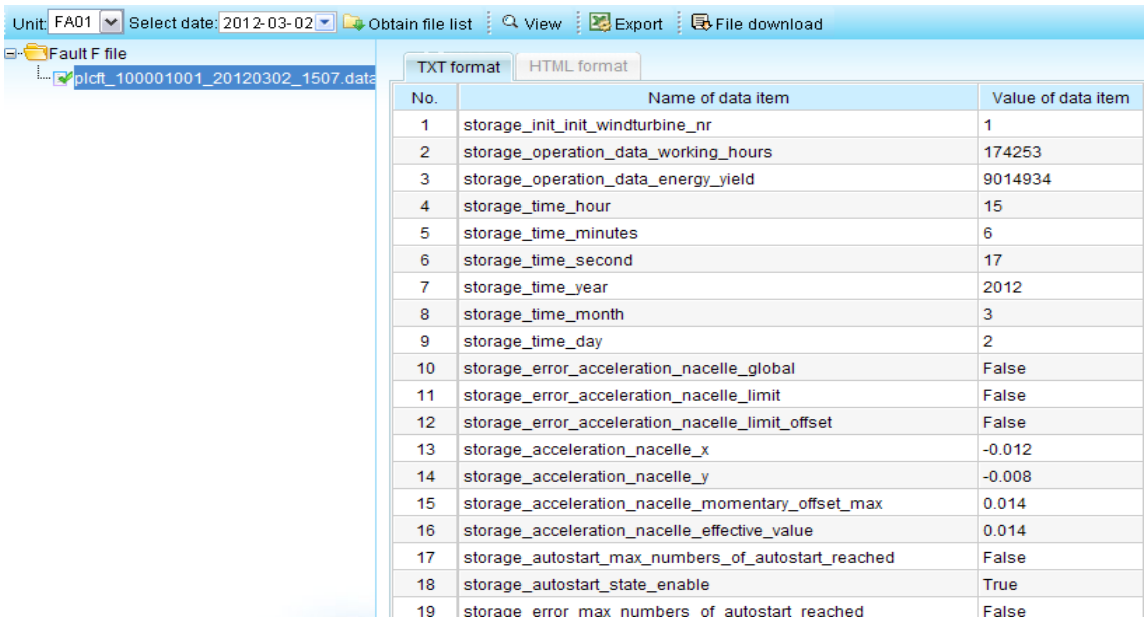
9.7 File data browse

Goldwind Windfarm SCADA System has file data browse function. Files include real time data file, 10-minute data file, fault data file, fault B file, fault M file and data M file.

Click ”Start-File Data Browse” to access file data browse function.

Real time data file & 10-minute data file offer users a good way to query data details if they need. Real time data file recorded every 6s data of wind turbine. 10-minute data file recorded every 10 minutes data of wind turbines.

Fault data file, fault B file, fault M file recorded wind turbine fault information. Experienced engineer could figure out what is the fault and how to deal with it by checking these fault files. It would be better if you read fault files before you begin your trouble shooting.



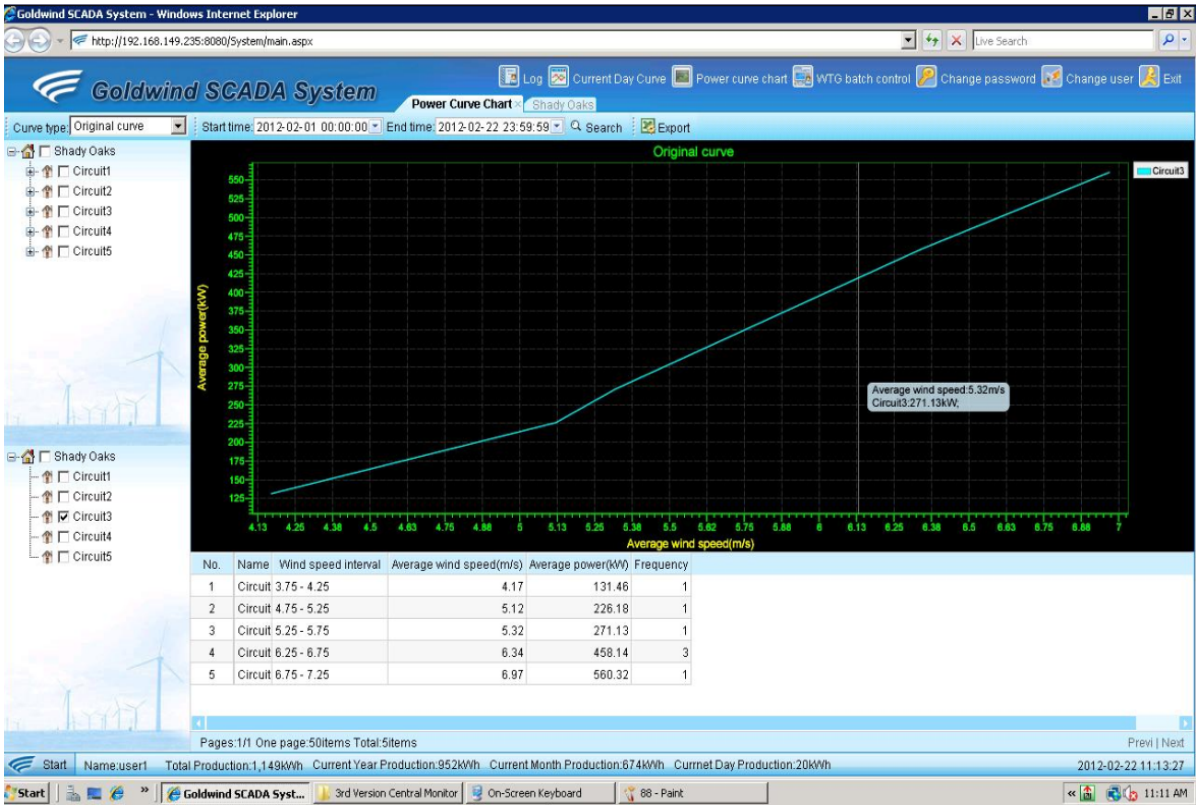
No.	Name of data item	Value of data item
1	storage_init_init_windturbine_nr	1
2	storage_operation_data_working_hours	174253
3	storage_operation_data_energy_yield	9014934
4	storage_time_hour	15
5	storage_time_minutes	6
6	storage_time_second	17
7	storage_time_year	2012
8	storage_time_month	3
9	storage_time_day	2
10	storage_error_acceleration_nacelle_global	False
11	storage_error_acceleration_nacelle_limit	False
12	storage_error_acceleration_nacelle_limit_offset	False
13	storage_acceleration_nacelle_x	-0.012
14	storage_acceleration_nacelle_y	-0.008
15	storage_acceleration_nacelle_momentary_offset_max	0.014
16	storage_acceleration_nacelle_effective_value	0.014
17	storage_autostart_max_numbers_of_autostart_reached	False
18	storage_autostart_state_enable	True
19	storage_error_max_numbers_of_autostart_reached	False

Figure 9.7.1 fault F file

Fault M file created by PLC, data in fault M file should be as same as statistic table in the database. Users can compare data in fault M file and database to figure out if we get some data issues.

9.8 Graph Analysis

Click ”Start-Graph Analysis” to access graph analysis function. Graph analysis includes power curve chart, wind frequency chart, WTG fault analysis and event analysis.



No.	Name	Wind speed interval	Average wind speed(m/s)	Average power(kW)	Frequency
1	Circuit	3.75 - 4.25	4.17	131.46	1
2	Circuit	4.75 - 5.25	5.12	226.18	1
3	Circuit	5.25 - 5.75	5.32	271.13	1
4	Circuit	6.25 - 6.75	6.34	458.14	3
5	Circuit	6.75 - 7.25	6.97	560.32	1

Figure 9.8.1 power curve chart-original curve

For example, power curve chart offers users one or more turbines power curve. Users can select curve type from left top side of the webpage to query. Curve types are: Original curve, correction

curve, comparison curve and analyze curve.

9.9 Wind Farm Control

Click ”Start-wind farm control” to access wind farm control function.

Wind farm control allows users to batch control wind turbines.

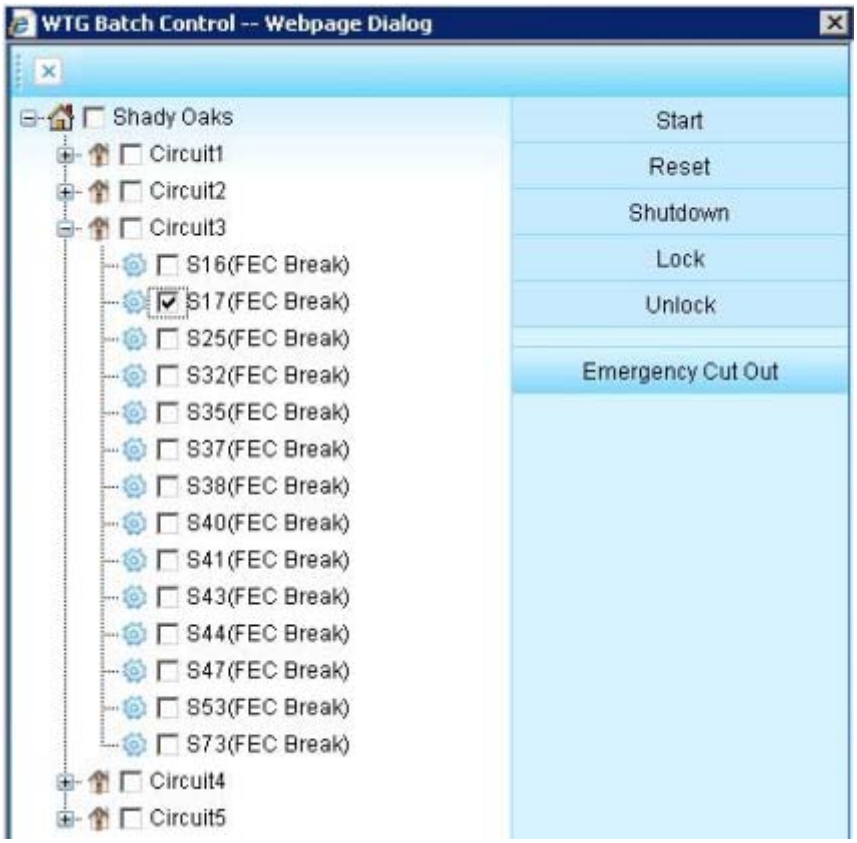


Figure 9.9.1 WTG batch control

Users can pick turbines they want and send batch control commands.

‘Energy control parameter modify’ allow users to set energy control parameter for Energy Management Platform control wind turbines.

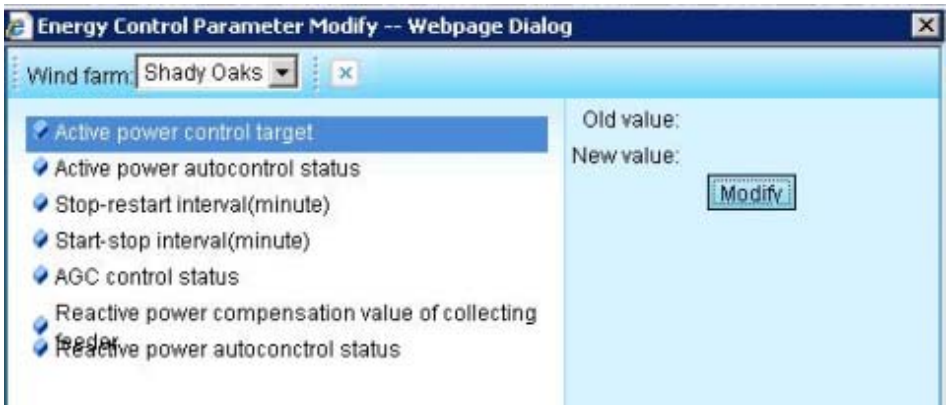


Figure 9.9.2 energy control parameter modify

9.10 Help

Click ”Start-Help” to get legend information and company information.

10. REMOTE ACCESS

Internet access to the system is required for remote access to the system and also for Goldwind warranty support.

Users should allow remote access to web service server. The setting steps are following:
Right click computer-properties

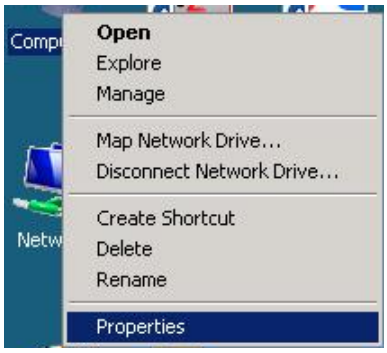


Figure 10.1

1. Click ‘Remote settings’

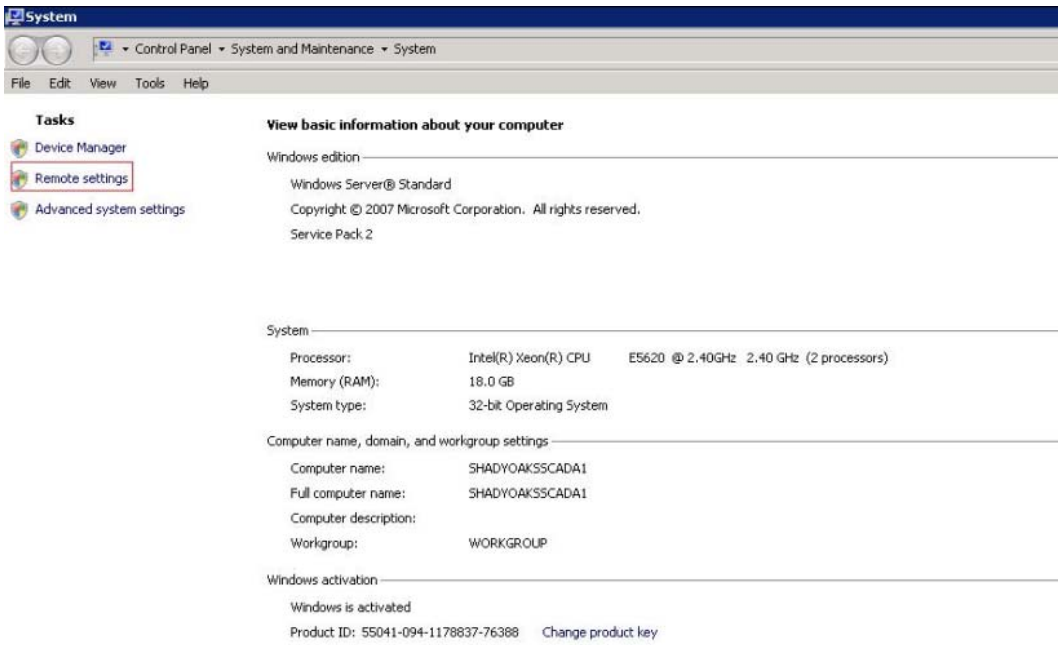


Figure 10.2

Select ‘Allow connections from computers running any version of Remote Desktop (less secure).

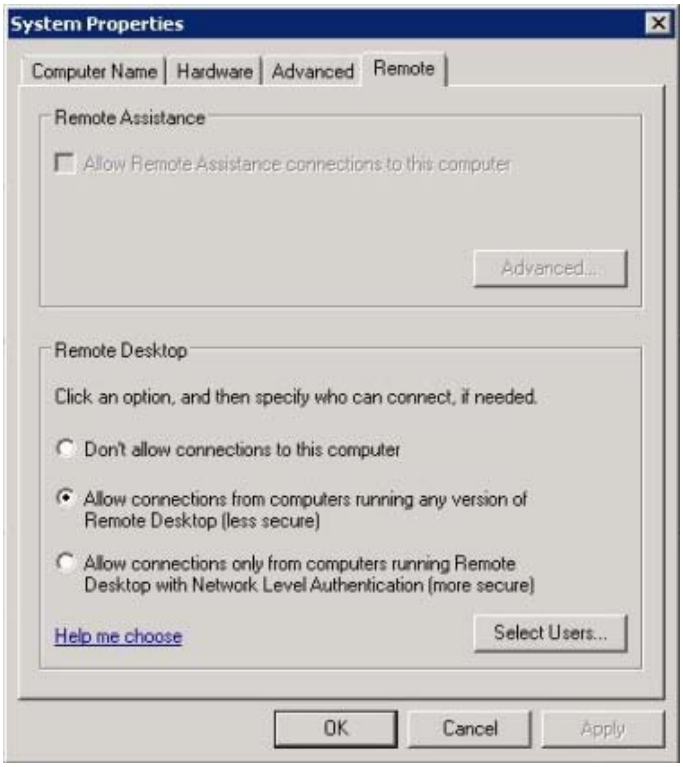


Figure 10.3

The internet access itself does not form part of the System.

11. SECURITY

Security is based on standard Windows security groups. Users are given access to different parts of the system by membership of a group.

Users can be given access to system functions by membership of the following groups:

Role	Purpose
Administrator	Allow administration of the system, intended for use by administrators of the wind farm.
Manager	Wind Farm monitoring and reporting
Operator	Wind Farm monitoring control and reporting
Engineer	Wind Farm system support and maintenance

12. DATA BACKUP

Backups of the SQL Server recorded data on the System server are made during a certain period of time by the System and stored in a specified location on the System server.

The System server comes with appropriate backup devices installed – a data backup server.

Goldwind provides a script to backup all data required to rebuild the system to the backup device on a daily basis.

It is the responsibility of the site administrator to plan and implement an appropriate off-line storage procedure.

13. SYSTEM REDUNDANCY

The System is designed around achieving maximum data coverage and quality.

Data collection is independent of server and network availability between the server and Front-end processor. The Front-end Processor continues to collect and process data whilst powered up even if the network is lost, and will automatically transfer the data to the Data Process and Provider Server later when the communications are resumed.

The standard System does not include any server redundancy but various options are available and can be reviewed on a per project basis.

14. SYSTEM EVENTS

System created events include the following:

- Main System service restart
- Front-end processor Configuration change
- Front-end processor start
- Front-end processor stop
- Front-end processor restart
- Front-end processor time correction
- Turbine communications loss (after a configurable time period)
- Logger communications loss (after a configurable time period)
- Turbine status
- Turbine fault
- Crew present/service mode
- Turbine release to run
- Turbine stop
- Auto Control stops
- Auto Control starts
- User's action list (Stop, restart, yaw, lock, unlock etc.)
- User configuration changes

15. POWER REGULATION

Wind farm power regulation gathers grid data from the interconnection point. This information is acquired via the substation protection and control system.

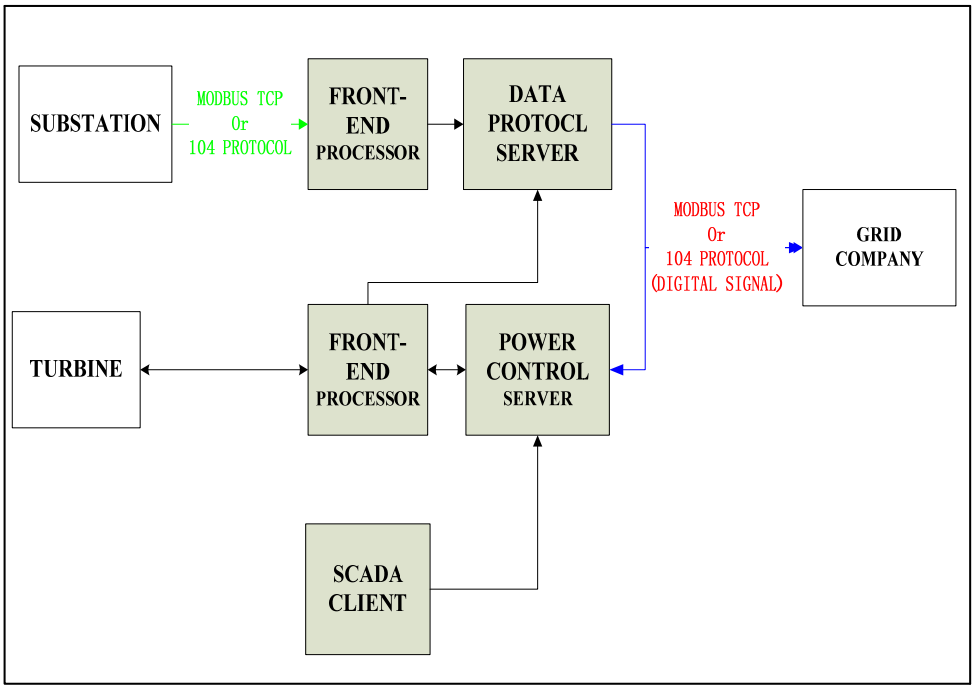


Figure 15.1 power regulation Schematic

The power control service retrieves real-time data from all the turbines and uses this together with the grid data from the substation to regulate the entire wind farm.

The data protocol service sends grid data and turbine data to the grid company real-time data center.

The power control service receives regulation commands from grid company dispatch control center and SCADA client.

The power control service executes the respective proprietary regulation strategy.

The following interfaces are supported by the SCADA system:

- OPC interface based on the OPC DA2.0 standard
- Modbus Serial RTU (RS232 or RS485)
- Modbus (modbustcp)
- CDT protocol interface
- 101 protocol interface(DL/T634.5101-2002)
  IEC 60870-5-101 [IEC101] is a standard for power system monitoring, control & associated communications for telecontrol, teleprotection, and associated telecommunications for electric power systems. This is completely compatible with IEC 60870-5-1 to IEC 60870-5-5 standards and uses standard asynchronous serial tele-control channel interface between DTE and DCE. The standard is suitable for multiple configurations like point-to-point, star, multidropped etc.

- 103 protocol interface(DL/T719-2000)
  IEC 60870-5-103 [IEC103] is a standard for power system control and associated communications. It defines a companion standard that enables interoperability between

protection equipment and devices of a control system in a substation. Devices complying with this standard can send information using two methods for data transfer - either using the explicitly specified application service data units (ASDU) or using generic services for transmission of all the possible information. The standard supports some specific protection functions and provides the vendor a facility to incorporate its own protective functions on private data ranges.

- 104 protocol interface(DL/T634.51041-2002)
  IEC 60870-5-104 (IEC 104) protocol is an extension of IEC 101 protocol with changes in transport, network, link & physical layer services to suit the complete network access. The standard uses an open TCP/IP interface to network to have connectivity to the LAN (Local Area Network) and routers with different facility (ISDN, X.25, Frame relay etc) can be used to connect to the WAN (Wide Area Network). Application layer of IEC 104 is preserved in the same way as that of IEC 101 with some of the data types and facilities not used. There are two separate link layers defined in the standard, which is suitable for data transfer over Ethernet & serial line (PPP - Point-to-Point Protocol). The control field data of IEC104 contains various types of mechanisms for effective handling of network data synchronisation

15.1 Active Power Regulation

Active power regulation controls active power output at wind turbines by receiving a set point automatically or manually. Grid company commands are automatically received and dispatched to each turbine to control the wind farm active power output. Users can manually control wind farm active power by inputting active power regulation commands.

In some cases it might be necessary to reduce the active power beyond the minimum control level of the each turbine (500kW). In this situation one or more turbines will be stopped and set points dispatched to remaining turbines to achieve the desired active power set point.

Users can set the WTG to be involved in active power control. All regulation inputs are logged, which makes it possible to trace who is responsible for user generated active power commands.

General description of active power control

Process:
Receive the grid company command via Modbus or 101,103,104 (*setpoint*)
Step 1: Retrieve active power of interconnection point. If active power is greater than *setpoint*, go to step 2, else go to step 3.

Step 2: If the active power can be reduced to *setpoint* via turbines pitch control, the system calculates how many turbines are required to control pitch, and then sends pitch control commands to respective turbines.

If the active power cannot be reduced to *setpoint* via turbines pitch control alone, the system calculates the turbines that need pitch control as well as how many turbines should be stopped in order to achieve the *setpoint*. The pitch control and stop commands are sent to respective

turbines.

Step 3: If any turbines are already in pitch control mode, go to step 4, else go to step 5.

Step 4: The system calculate the expected output after releasing turbines from pitch control mode. (The expected output is calculated via current wind speed and power curve.)

If expected output is greater than the *setpoint*, the system calculates how many turbines are required to stop pitch control, and then sends command to those turbines.

If expected output is less-than the *setpoint*, the system calculates how many turbines to stop pitch control and how many turbines should additionally start up in order to increase active power to the *setpoint*.

The system sends stop pitch control and start up commands to respective turbines.

Step 5: The system calculates how many turbines are required to start up in order to increase active power to the *setpoint*, and then sends start up commands to respective turbines.
Step1 to step 5 is a cycle that takes about 45 seconds.

As the wind speed continuously changes, the cycle may need to run two or three times to reach the *setpoint.*

15.2 Reactive power regulation

Reactive power regulation controls reactive power generated at each wind turbine by dispatching set points either automatically or manually.

Each WTG can be set to a default control algorithm:

- Reactive power automatic control mode. (controls reactive power on the transmission line at the low-voltage side of substation to zero by issuing reactive power set points to the WTGs)
- Reactive power zero control mode (WTG exports no reactive power).

All reactive power regulation inputs are logged, which makes it possible to trace who is responsible for user generated commands.

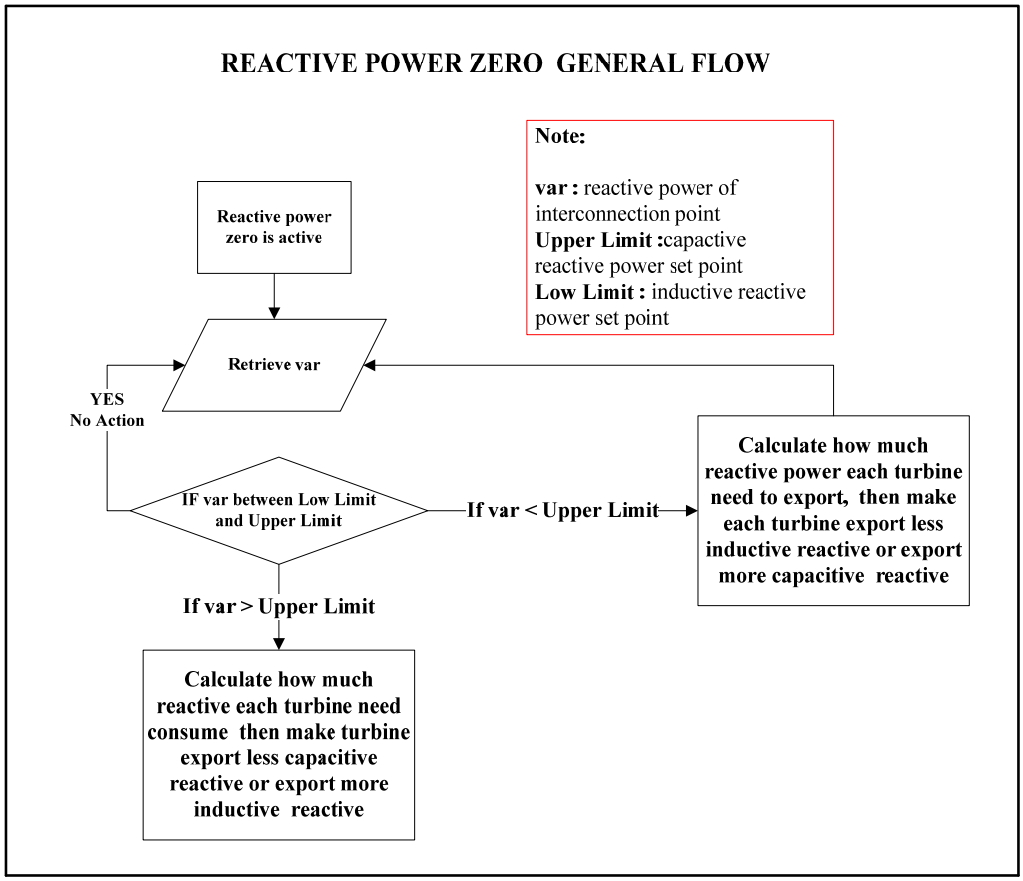


Figure 15.2 reactive power zero general flow

16. SITE SPECIFIC MONITORING AND CONTROL

The System can be configured to deal with a variety of site specific monitoring and control

requirements. The system includes tools to allow mapping of signals between OPC servers which allows for most requirements to be met. Configuration of these tools and provision of any additional Server provides real-time data from the turbines, met masts and substation to third-party software, such as sending data to Grid Company real-time data center .It communicates with third-party software directly via respective proprietary communication protocol.

17. NETWORK

For each wind farm which needs to be incorporated into the Goldwind data collection network following Internet broadband connection information need to be provide by to Goldwind by the customer:

Public Static IP address details
Default gateway details

Goldwind will then decide on an IP range relevant for the wind farm size.
The Goldwind Windfarm SCADA Network is located in the following IP scope: 192.168.0.0
For more information regarding the IP addresses assigned for each project please see Appendix B.