ATS
Leading of Integration

Wind SCADA & PPC

Wind Plant Monitoring & Control Solution

A Strategic Partner of

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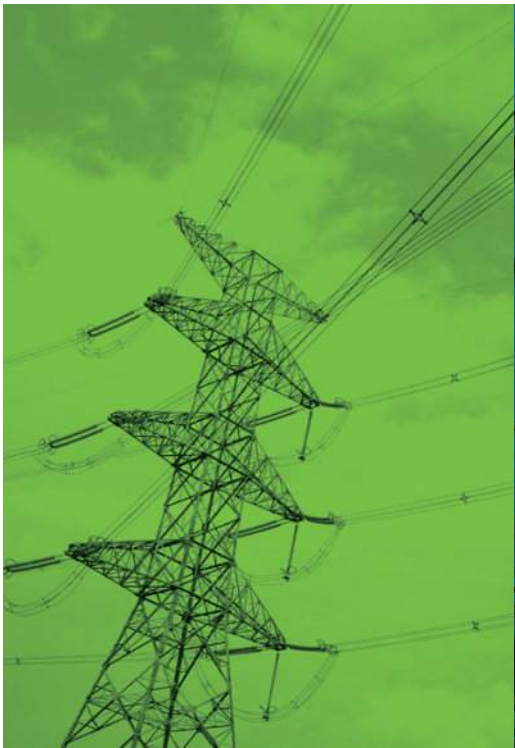
TAKAOKA TOKO CO., LTD.



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A. Product Overview

Our Wind SCADA & PPC System offers full control and supervision functions for the entire wind park and individual wind turbines. This can be performed remotely from a computer in the control room of the wind park or integrated in the control system of related sub-station.

Wind SCADA & PPC System can perform all data acquisition, monitoring and control functions on power plants. All necessary information concerning process behavior, instrument and integrity controller, sequential control and alarm function shall be immediately available at the operation consoles.

Our Solution for Wind SCADA & PPC fully supports both national and international grid codes, thus enabling grid-compliant feed-in from wind systems at high-voltage levels world-wide. The high performance system provides a wide range of features for active and reactive power control, which guarantees grid stability - in fact manufacturer independent. Modularity and scalability allow for customized plant control and provide the flexibility needed to meet the needs of the high diversity of grid connection require-ments. The Human-Machine Interface (HMI) visualizes all measured values locally and in real time, and allows for technical operation management of wind power plants on site.

In order to ensure operational reliability for the wind power plant, the Wind SCADA & PPC System is also built with high availability by using a single-fault-tolerant design for the centralized components and important devices and redundant configuration.

ADVANTAGES

- Compliance with national and international grid codes.
- High flexibility in system design in accordance with wind system technology.
- High compatibility thanks to interface and protocol variety.
- Ability to connect with and control Wind Turbine Generator (WTG) from various vendors such as Vestas, GE Energy, Siemens, Suzlon, etc.
- Reduction of commissioning and maintenance cost of the plants.
- Availability of Wind Power Generation forecast data.

MAIN FEATURES

- Provide full features of Wind SCADA & PPC system for data acquisition, monitoring and control of wind plant in accordance with national and international grid codes.
- Modular, scalable architecture and manufacturer independent, suitable for controlling wind power plant with wind turbine from different vendors.
- De facto Historical Information System (HIS) in popular use world-wide.
- Multi-protocol speaking: Modbus Serial/TCP, IEC61850, SEL Fast-Message, DNP3, IEC 62056/IEC61107, IEC-60870-5-104,... (can be extended upon users' requests).
- System sizing support over 2000 IEDs, controller and monitor, and can handle up to 256,000 datapoints.
- User-friendly graphic interface allowing operators to perform their tasks with minimal computer knowledge and reducing "start-up" time.
- Ready for future utility interface bus integration.

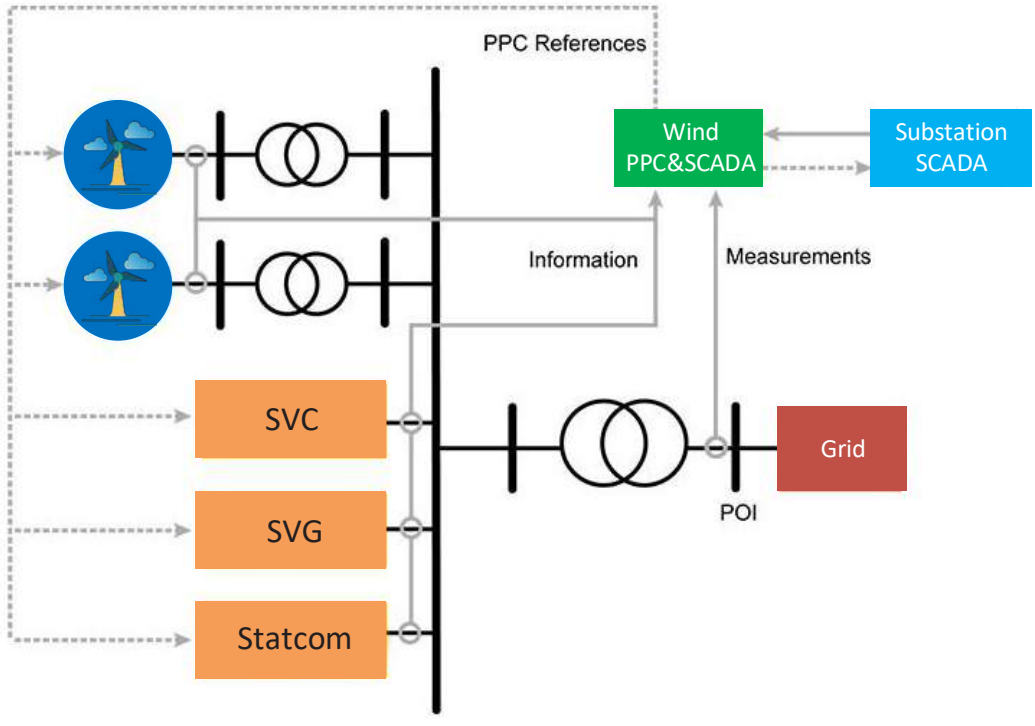


Figure 1. Overview of Wind SCADA & PPC System

1. HARDWARE STRUCTURE

Wind SCADA & PPC system is located in the central control room to perform monitoring and control on all equipment in the entire wind power plant and substation. In addition, the system's data processing function creates a complete database for operational management:

- At operator control room:
  - Redundant Wind Power Plant Controller (WPPC) with Human - Machine Interface function (HMI) for data acquisition, data processing, monitoring and control of the entire wind power plant.
  - Historian Server for historical database storage, processing, management, as well as data mining, analytical and system operation optimizing applications. Web service is provided for access and monitoring from client site with cyber security. The server is also integrated with application software supporting operator in system evaluation, analysis, reporting, and maintenance.
  - Ethernet switch for communication system linked with Control Center Room network and WTG network system.
  - Satellite-Synchronized Clock for time synchronization of all equipment in the Wind SCADA & PPC system.
  - All servers and ethernet switches are manufactured according to industrial standards with open architecture, networking capability and standard protocols compatibility, ensuring that any single device failure shall not affect the monitoring and control process of the power plant.
- Multi-meter installed at substation to collect measurement data (U/I/P/Q/Pf/F) at POI; provide data input for Wind PPC system.

SCADA signals of wind power plant will be integrated into Substation SCADA Gateway servers and connect to SCADA systems at the Load Dispatching Centers (such as NLDC, RLDC, etc.)

Note:

- Hardware system and hardware connection at Wind farm is not under the scope of this solution.

- ATS also provide integrated solution with a single system to monitor and control of all equipment not only in the wind power plant but also in substation. This configuration is highly recommended.

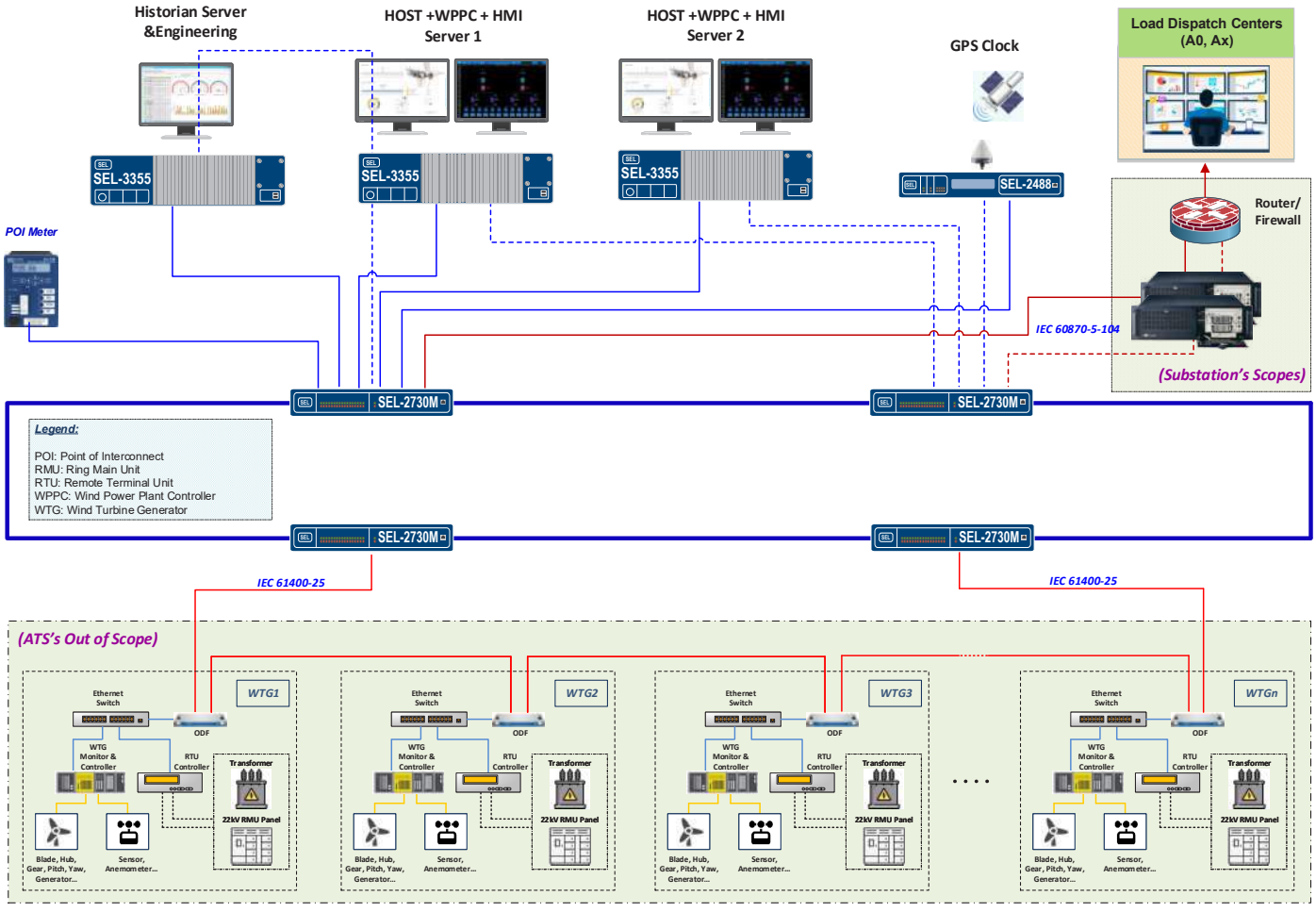


Figure 2. Wind SCADA & PPC Hardware System

B. Technical Highlights

2. SOFTWARE DESCRIPTION

2.1. Software Architecture

The Wind SCADA & PPC System is provided with data acquisition, processing, presentation and storage functions to be performed at the power plant. The primary data acquisition, control and processing tasks shall be performed via the redundant power plant control and Host Servers with appropriate protocol via the Ethernet LAN or dedicated serial communication system.

Main software modules of the Wind SCADA & PPC system include:

- **Standard modules:**
  - Data Acquisition (DA)
  - Real-time Database (RTDB)
  - Time-series Historical Information System (HIS)
  - Wind Power Plant Control (WPPC)
  - Human – Machine Interface (HMI)
- **Advanced modules:**
  - HIS applications (Web-based monitoring and report)
  - Renewable Energy Generation Forecast (RFG)

2.2. Supported Communication Protocol

Supported communication protocols include:

- Modbus Serial/TCP
- IEC 61850, SEL Fast Message, DNP3, etc
- IEC 60870-5-101/104
- OPC
- etc

2.3. System Sizing

The Wind SCADA&PPC system can support over **2.000** IEDs, controllers and monitors, and up to **256.000** data points. This capacity can meet all requirements of any wind plant and can be extend- ed in the future without having to upgrade any of the control system components.

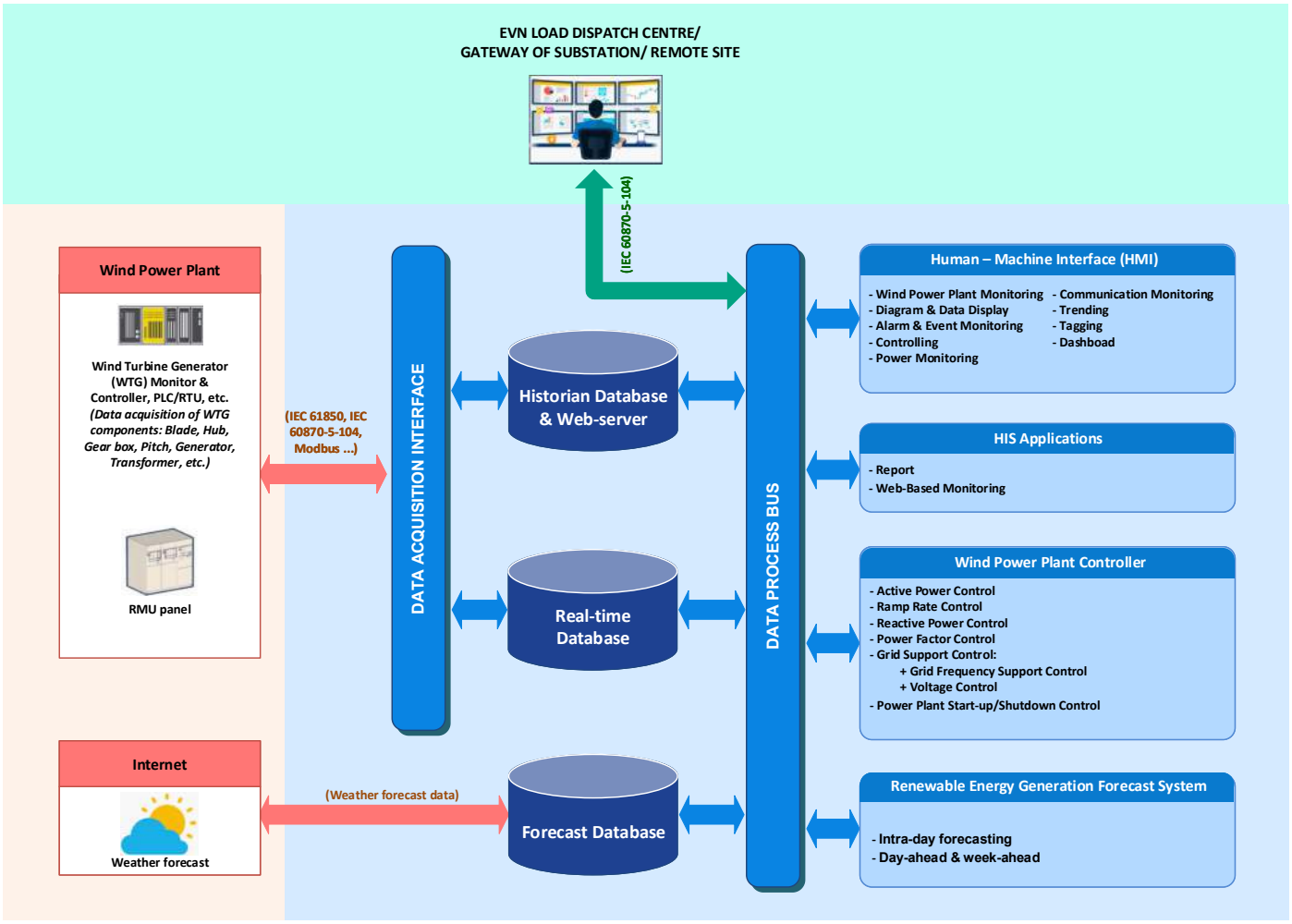


Figure 3. Wind SCADA & PPC Software System

2.4. Standard Software Modules

2.4.1. Data Acquisition (DA)

DA shall perform data filtering, data conversion and data processing locally at the Substation and Wind Farm. A local data repository is built up at Host Computers for on-line and historical data. The connection to the existing SCADA system uses IEC60870-5-104 protocol for data exchange and interoperation between WPP and SCADA/EMS of EVN-Load Dispatch Centre or the DCS of WPP.

DA module supports the following types of data processing:

- Scanned Analog Data
- Scanned Status Data
- Scanned Accumulator Data
- Calculated Analog Data
- Calculated Status Data
- Non-telemeter Data
- Database

Data acquisition from main wind power plant devices:

- WTGs, including rotor, transmission, generator, converter, nacelle, yaw system, etc.
- MV transformer and RMU panel
- Meteorological station
- HV transformer
- HV bay and MV switchgear bay

2.4.2. Real-time Database (RTDB)

Real-time database management with ability to process unlimited data points, to collect data at substation and wind farm level or processing level from IEDs such as WTG controller, relays, BCUs, IO device, etc. Data will be processed and converted to archive form and allowed to covert in accordance with user requirements.
The database processing provides the necessary conditions and functions to define, store, modify, and access unlimited chosen data points that are processed and archived by the Wind SCADA & PPC applications. Data types includes static, fixed, dynamic, real-time, and historical data.

2.4.3. Time-series Historical Information System (HIS)

Smart Historical Information System (SmartHIS™) developed by ATS is used for the historical repository of all information coming from the wind power plant operation, generated under normal operating conditions or during disturbances. The SmartHIS™ is designed with the client-server architecture, non-SQL database technology, Time-series data archiving to collect, process, store, manage and retrieve data.

Benefits of Historical Information System:

- **Data Infrastructure base for advanced applications**, such as Energy Generation Forecast.
- **Massive scalability and performance**: the database can be scaled to support millions of devices or time series data points in continuous flow and perform real-time analysis.
- **Reduced downtime**: the architecture of a database that is built for time series data ensures that data is always available even in the event of network partitions or hardware failures.
- **Lower costs**: Fast and easy scaling using commodity hardware reduces the operational and hardware costs of scaling up or down.
- **Improved business decisions**: analyze data in real time and make faster and more accurate adjustments for energy consumption, device maintenance, infrastructure changes, or other important decisions that impact the business.

The difference between SQL and Non-SQL database is summarized per table 1 below:

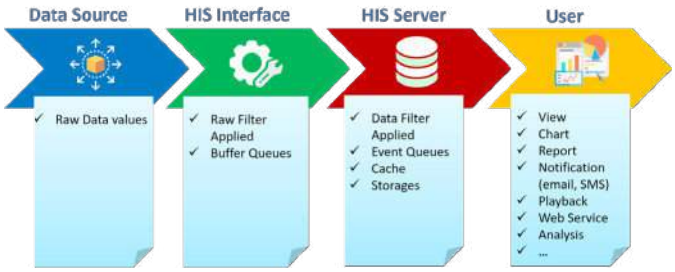


Figure 4. SmartHIS™ System Overview

SQL Database	No-SQL Database
Use predefined schemas to determine the structure of data. A change in the structure would be both difficult and disruptive to whole system.	Has dynamic schema for unstructured data. Data can be stored in various ways, with additional fields can be added in later on.
Data tables have complex relation, therefore data reading and writing processing is not fast.	Data structure allows for retrieval of all information on specific item in a single query. Data reading and writing can be done faster than SQL Database.
Sequence data query. Performance is slow.	Ad-hoc data query. Fast access to historical data at a timestamp.
Built on the idea of "one size fit all". When the database gets larger, reading and writing performance is slower and also requires larger hard disk volume for storage.	Built on the idea of "one size does not fit all". When database becomes larger, data can be stored on different partitions.
Consistent with the static data which has specific structure and relationship.	Data stored with key-value structure, suitable for time series data type.

Table 1. Comparison between SQL and No-SQL Database

B. Technical Highlights

2.4.4. Wind Power Plant Control (WPPC)

Wind Power Plant Controller (WPPC) is an intelligent vendor-independent system for dynamic wind power plant control and grid code compliance, customizable to satisfy any grid requirement while ensuring interoperability with plant SCADA systems.

Our solution is suitable for controlling wind power plant with WTG from different vendors (such as Vestas, GE Energy, Siemens, Suzlon, etc.) for both of onshore and offshore WTG. The wind plant controller will be implemented at plant-level logic and utilized closed-loop control schemes. Real-time commands will be sent to each WTG via industrial protocols such as Modbus RTU/TCP, IEC 61850, IEC 60870-5-104, etc... to achieve fast and reliable regulation of wind power plant generation.

Main WPPC functions:

- Active Power Control: Keep output at fixed commanded Set- point or react to curtailment commands by operator and the Load dispatching center. Ensure that output of wind power plant does not exceed specified limit.
- Ramp rate control: Limit change to ramp rate to avoid causing system instability at grid connection point.
- Reactive Power Control: Used to keep the plant at a specific reactive power output.
- WPPC can control SVG/SVC/Statcom with priority mode to optimize the plant's ability to absorb or generate reactive power.
- Power Factor Control: Allow the plant to maintain a desirable power factor at the point of connection.
- Grid support control:
  - Grid frequency support control: Automatically regulate the active power delivered based on the instantaneous frequency deviation of the Grid.
  - Voltage Control: Allows the plant to dynamically provide reactive power support, based on system voltage.
- Power plant start-up/shutdown:
  - If a planned outage is needed, operations should be able to take the plant offline in a controlled manner. Similarly, after an outage period, the plant's re-start needs to be performed smoothly.
  - When a shutdown request is provided along with required confirmation, the active power of plant will ramp generation down all the way to 0MW. Inverters will then be stopped. Likewise, when a startup command is issued, each WTG will be started and ramped up to the plant level setpoint.
  - Operator can configure automatic start-up for power plant at set time. When WTG detect wind speed to be higher than cut-in speed, the WTG will start. WTG will stop when wind speed is higher than cut-out speed.

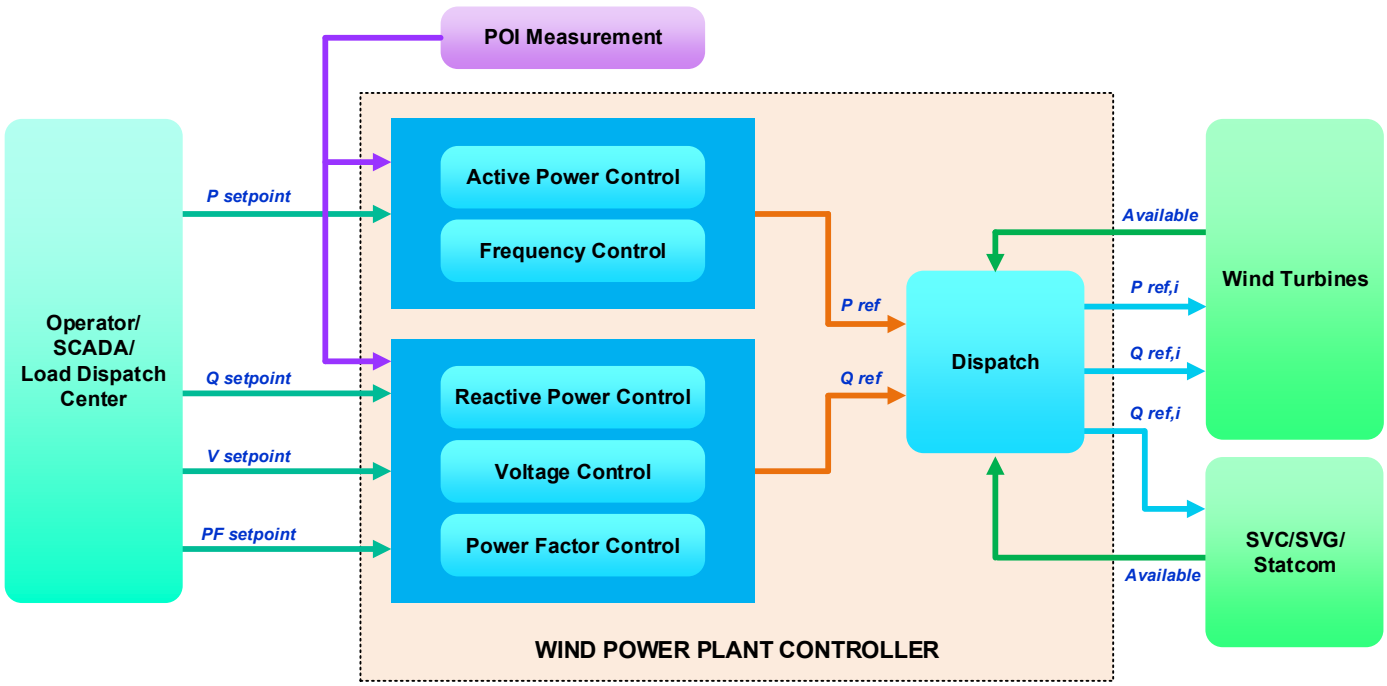


Figure 5. Wind Power Plant Control Function Block Diagram

The interface of the Wind Power Plant shall be integrated in the HMI of the Wind SCADA & PPC System.

* Dynamic voltage or power factor, reactive power regulation of the WPP at the point of interconnection (POI) to Grid support.
* Active power output control with fixed setpoint or curtailment command of the wind plant when required so that it does not exceed operator's specified limit.
* Frequency control to lower plant output in case of over-frequency situation or increase plant output (if possible) in case of under-frequency.
* Start-up and shut-down control of whole power plant.

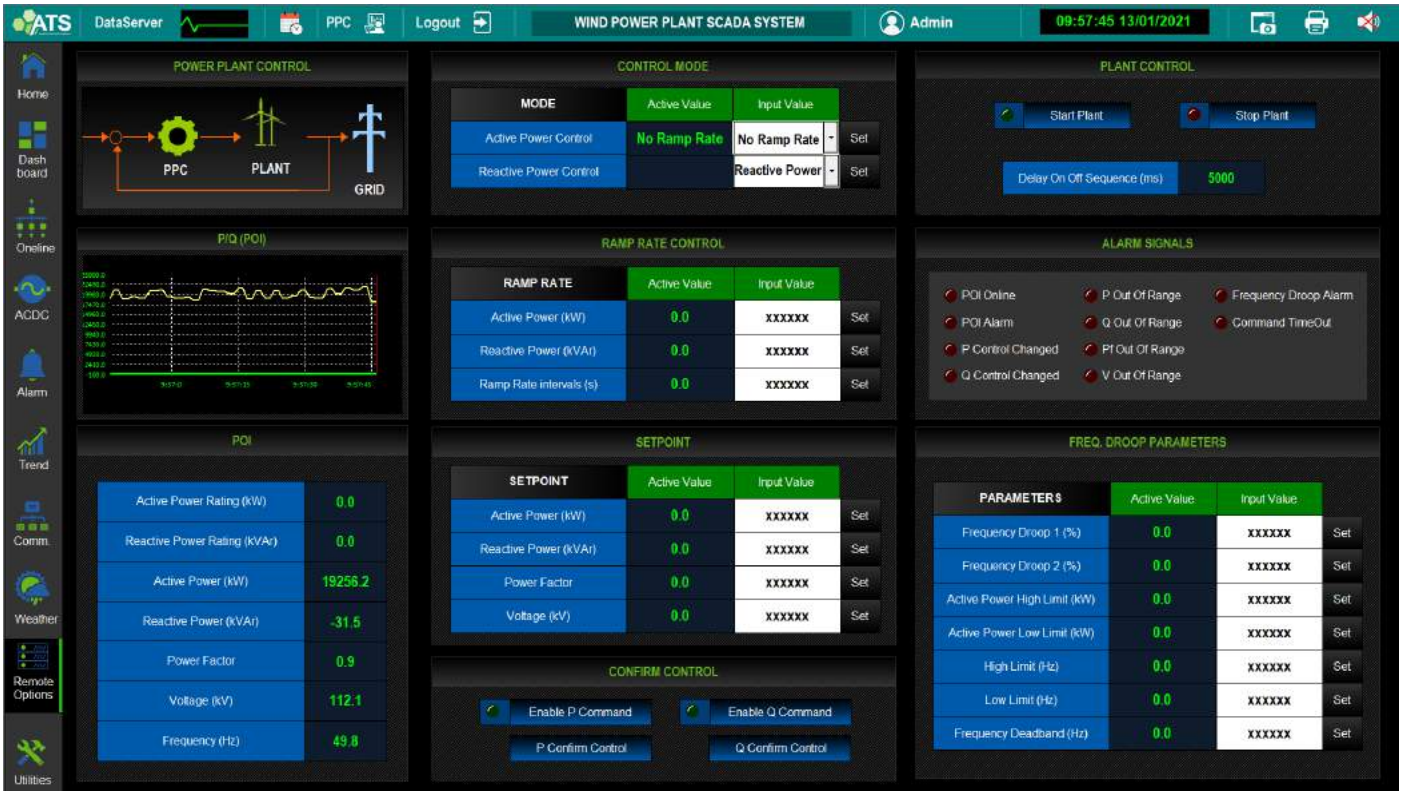
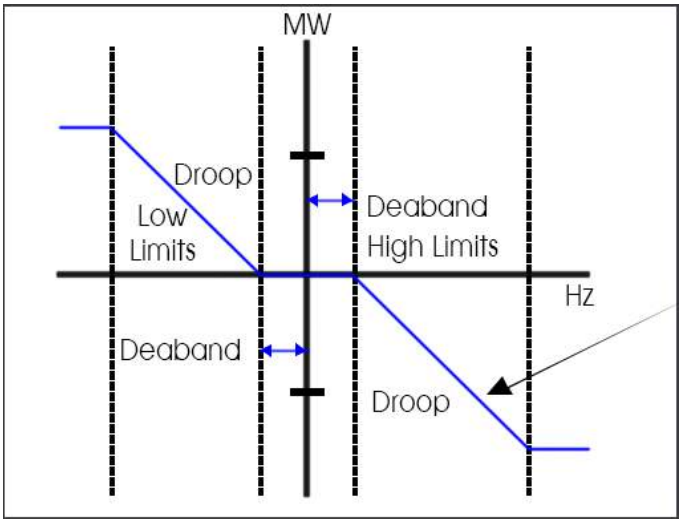


Figure 6. Power Plant Control Screen



Droop Frequency Control Characteristic

B. Technical Highlights

2.4.5. Human-Machine Interface (HMI)

Human-Machine Interface can be understood as communication path between user and monitoring & controlling programs of the Wind SCADA & PPC System as well as other applications. User interfaces allow for simple and user-friendly monitoring and controlling of all primary device in power plant, with access to data storage. At central control room, the operator can perform all supervisory functions on the Wind Plant such as Power Plant and/or Substation monitoring, Wind Power Plant Controller, etc.

- HMI is designed for monitoring and control of the entire Wind Power Plant and/or Substation.
- HMI will be able to perform all essential activities from a few displays, so that the users do not have to do a great deal of switching between displays to accomplish their work.
- Regardless of the design chosen, a common "look and feel" is established for all displays. To accomplish this, a widely-used Graphical User Interface (GUI) standard is applied.
- HMI can immediately notify by light and sound indication corresponding to events of operators or primary devices.
- Operators can implement every control tasks excluding automatic controlling functions. All message or warning signals will be unlimited and follow time sequence. All signals of operation process will be collected and continuously alerted to operator on Alarm screen.

(1). User Access Management

The HMI provides user access management function with interface, include:

- Manage username and password.
- Manage appropriate priority level of each user.
- Assign username with all activities after login to the system.
- Add new user, update, delete existing user by administration personnel.

(2). Monitoring

a) General monitoring

The HMI screens display general information of plant, including plant dashboard and single line diagram (Figure 7-8).

Figure 7. Power Plant Dashboard

Display plant dashboard with current generation parameters and 10 minute average (3-phase currents, voltage, active power, reactive power, power factor and frequency, etc.); total plant energy generated daily, weekly and monthly; current weather parameters, etc

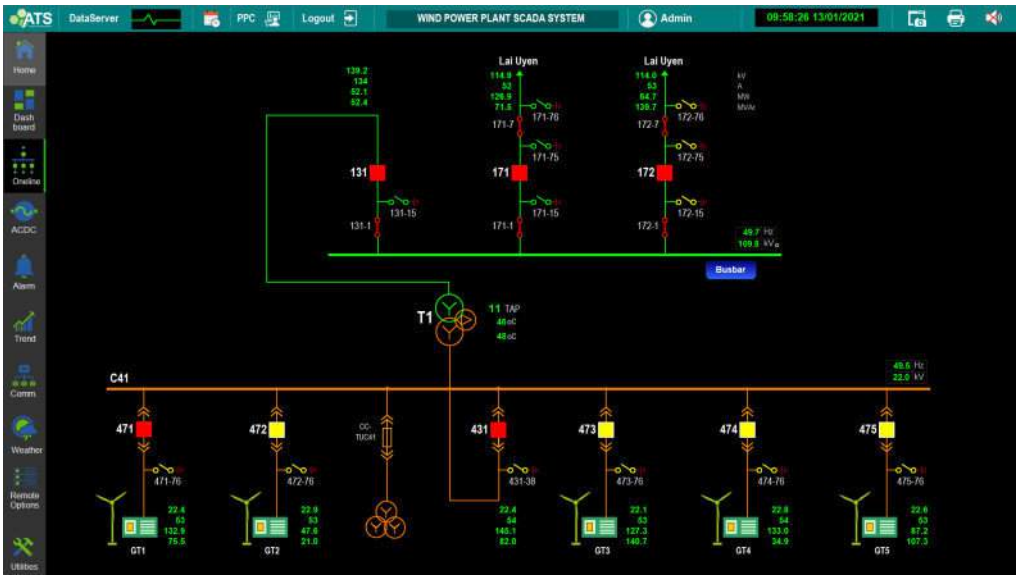


Figure 8. Wind Power Plant Single Line Diagram

Display wind power plant single diagram with main devices and operation parameters include HV Transformer, HV Switchgear, MV Switchgear, WTG, etc.

b) Wind power plant monitoring

Besides an overall view on operation of the entire plant, operation parameters of wind turbine are also monitored in detail (Figure 9-14).

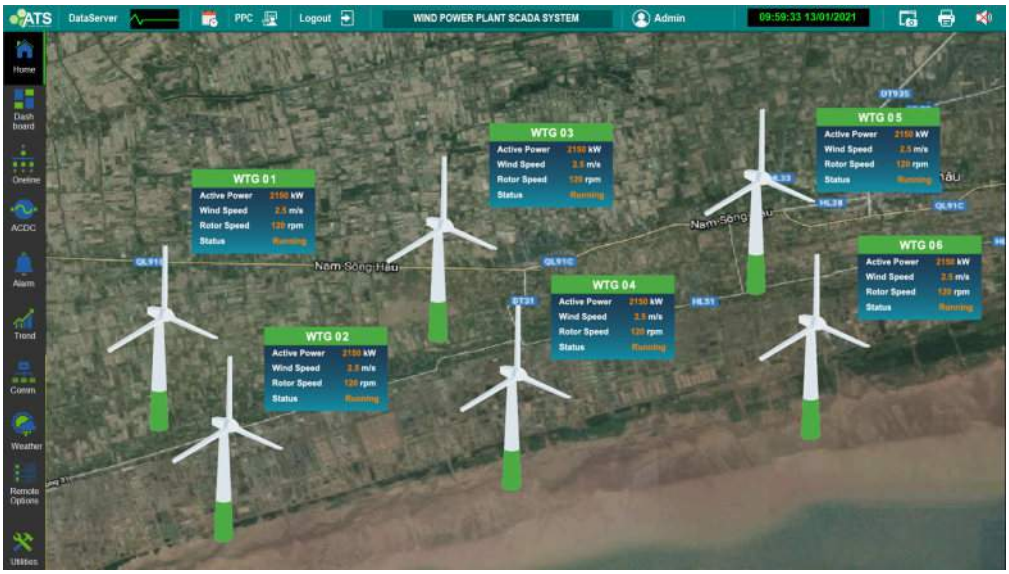


Figure 9. Overview of WPP

Display an overview of Wind Power Plant with WTG location and main parameters such as WTG status and meters including active power, rotor speed, wind speed, etc.

Figure 10. Weather Conditions Display

Display current value and 10-minute average value of weather conditions such as density, wind direction, wind speed ambient temperature, atmospheric pressure, humidity, etc.

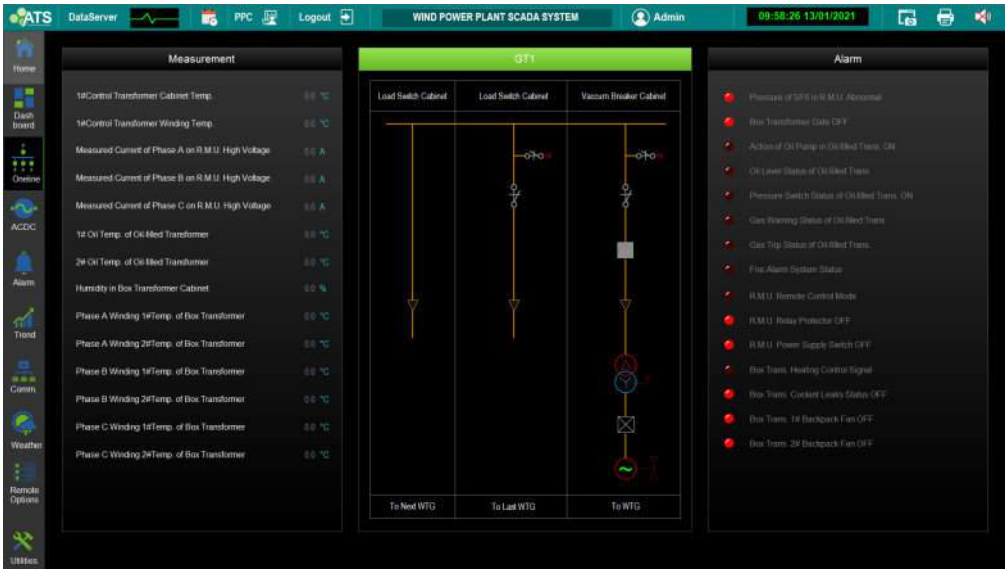


Figure 11. RMU Monitoring

Display operation parameter, status signal, alarm and protection signal of RMU panel devices such as circuit breaker, load break switch, etc.

B. Technical Highlights

Figure 12. WTG Monitoring

Display operation parameters, measurement data with instantaneous value and 10-minute average value, status signal, alarm and protection signal of each WTG. Remote control function each WTG (if available).

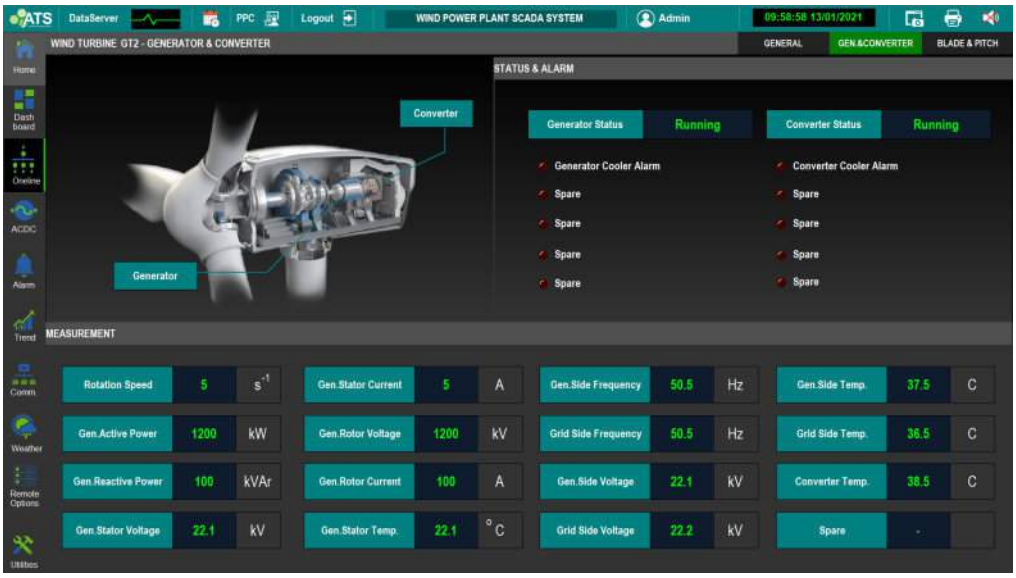


Figure 13. WTG Component Monitoring

Display operation parameters, status signal, alarm and protection signal of each component of WTG as Blade & Pitch, Rotor, Gearbox, Generator, Yaw system, Brake system, etc.

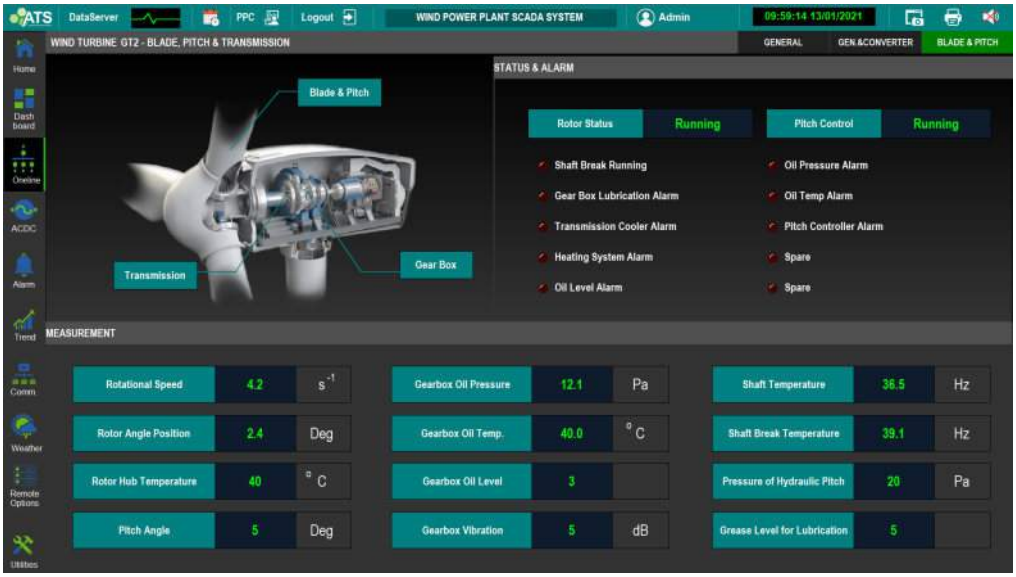


Figure 14. Other WTG Component Monitoring

c) Substation Monitoring

When Wind SCADA & PPC System is integrated with Substation Control System, the system provides the ability to monitor and control the operation of the entire plant and substation from one single system, thus facilitate operators' works and optimize resource used.

Figure 15. Transformer Monitoring

Display operation signal of HV transformer such as tap position, temperature, alarm and protection signal, etc.

Figure 16. Bay Monitoring

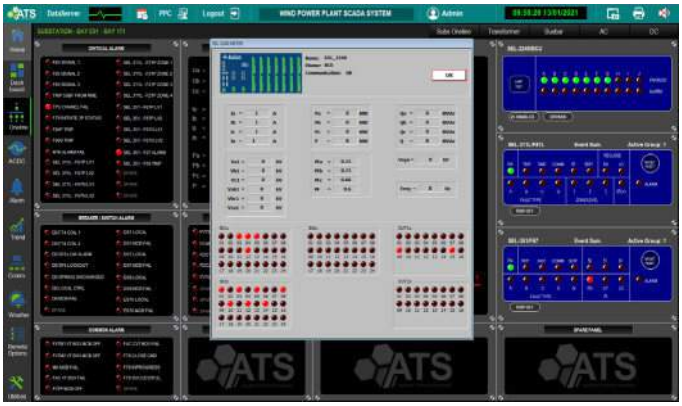


Figure 17. IEDs Monitoring

Figure 18. SCADA Channel Status and Control

Figure 19. Auxiliary Power Supply Monitoring

B. Technical Highlights

(3). Supervisory Control

Supervisory control commands entered at the Opera- tor's request, via tabular and graphic displays, will be processed by the SCADA & WPPC and sent to the BCU, relay, PLC/RTU only after the command has been validated. The control sequence is predicated on "select and check before operate (SBO)" philosophy to ensure operation security.

The supervisory control is designed with lock-out tripping functions to ensure safety and accuracy in the control process. Lock-out tripping functions is showed when IEDs/Controllable devices have interlocks or when operators select device for control via logic warning and alarm pop-up.

(4). Alarm Processing

The monitoring of alarms coming from the equipment operation is of high importance for the operation of substation and Wind Farm, especially during significant events such as total or partial system outages. An event is defined as any change in the substation operation. An alarm is a subgroup of events. Any unsolicited status change or violation of any allowable limits of the power system variables shall initiate an alarm.

(5). Trending

The Wind SCADA & PPC System shall incorporate trending functionality. It shall be possible to represent trends both from historical data, using the information stored in the HIS, and with real-time data.

(6). Tagging

Tagging of the circuit breakers and disconnector switches for maintenance, hot line work or automatic re-closing is an important part of the Wind SCADA & PPC System design criteria. This will be accomplished by using a latch in the redundant Relay & BCU. Once set, the latch provides an indication to all remote systems, Host computers and on the local Relay & BCU display indicating the breaker was tagged out. The Wind SCADA & PPC System typically uses four different types of tags: Red, Yellow, Orange, and Blue.

The Tagging function also allows the user to enter the following tag information:

- Job/Permit Number
- Date
- Purpose
- "Tagged by" and "Tagged for" Information

Figure 20. Operation Trending

Figure 21. Equipment Tagging

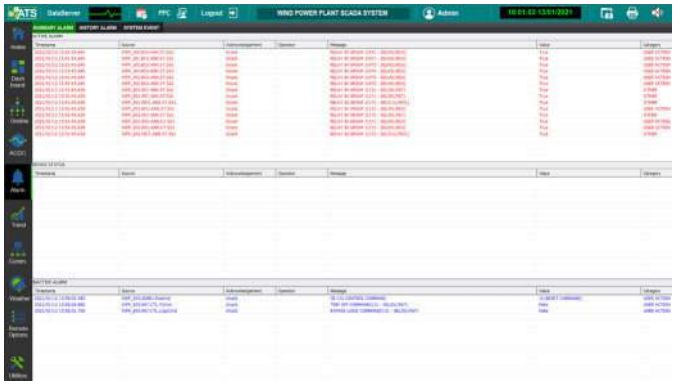


Figure 22. Alarm Presentation

(7). Communication Monitoring and Diagnostic

The following communications monitoring and diagnosis functions shall be provided.

- *Communications Monitoring:*
  - Interactive access to the parameters of the communication links database
  - Maintenance of the data links elements in the same database
  - Monitor on all operational status of Network devices including switches, computers and IED ports
  - Failure detection and recovery management
  - Graphic display of statuses and activities of communication devices
- *Channel and Interface Diagnostics* - including channels selection, diagnostic message generation, establishment of communication sessions with other elements, and presentation of information displays.

2.5. Advanced Software Modules

2.5.1. HIS Applications

(1). Report and Operation Log-Book

The system will be able to create the following reports:

- On-line reports on failed status of analog devices, update on real-time measured date, etc.
- Off-line reports by historical data storage features of SQL.

The operational diary will be recorded 24 hours/ day. Time duration can be selected for view and printing.

- Power consumption, total active power and reactive power of generator units, incoming transformer bay and transformer bay in the substation.
- Load status, minimum, maximum load current, active power, reactive power of line feeders.
- Maximum and minimum voltage of busbar.

Figure 23. Web-Based Monitoring

(2). Web-based Monitoring Subsystem and Web server

This subsystem can allow external users to retrieve real-time data and historical data at wind power plant or remote site (with secure authorization). The benefit of web-based monitoring system includes:

- Able to connect to multiple data sources
- Ensure reliability and security
- Allows for connection from multiple users at the same time
- HIS data will be available for display in tabular, graphic, chart and gausses
- Any quality code, tag, timestamp or data value stored for any HIS data value will be displayable
- Allows for display of any calculated data value
- Allows for display of any report in real-time mode and historical mode
- User can download and print report to local computer (Microsoft Excel format or PDF format). Parameter of any chart via can be downloaded in Excel format
- Provides Chart function for customizing data viewer by line-chart. Supports data analytics and evaluation of operation parameter of wind power plant.

2.5.2 Renewable Energy Generation Forecast Option

The Wind SCADA & PPC System can provide Renewable energy generation forecast function to predict output of wind power plant on basis of historical and real-time data collected from SCADA controller system on each turbine, augmented with weather prediction data. Based on this information, Grid operators can request power generation companies to provide proposed amount of power output that can be made available in the next period (hour, day, week, etc.), upon which Grid operator can plan appropriate schedule for wind plants that can better match power generation with load demand.

Forecast results will be given in graph, Excel tables, etc, convenient for use in evaluating, analyzing and also reporting results.

Figure 24. Generation Forecast

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