PCS-9000
Energy Management System

PCS-9000 Energy Management System (EMS) is a highly specialized, real-time, computer-based supervisory control system designed to assist electric power system operators in monitoring, controlling, managing and optimizing the power grid reliably and efficiently. With hundreds of projects deployed in China and all over the world, PCS-9000 EMS is the state-of-the-art solution for optimal grid analysis and operation in regards to security, quality and economy. It adopts an advanced network management, object-oriented database and visualized cross-platform technology. Furthermore, it provides abundant practical applications to manage the expanding energy system and reduce the operation and maintenance costs, while meeting the present and future's ever-changing business requirements.

PCS-9000 EMS is based on the latest IEC61970 standard, providing a unified application platform for large-scale energy management of power utilities. The applications of PCS-9000 system include SCADA, Automatic Generation Control (AGC), Power Application Software (PAS), Wide Area Measurement System (WAMS), Dispatching Training Simulator (DTS) and Web. It can also be easily integrated with other systems which comply with IEC61970 standard. This is in favor of protecting the existing investments and reducing internal information and function redundancy.
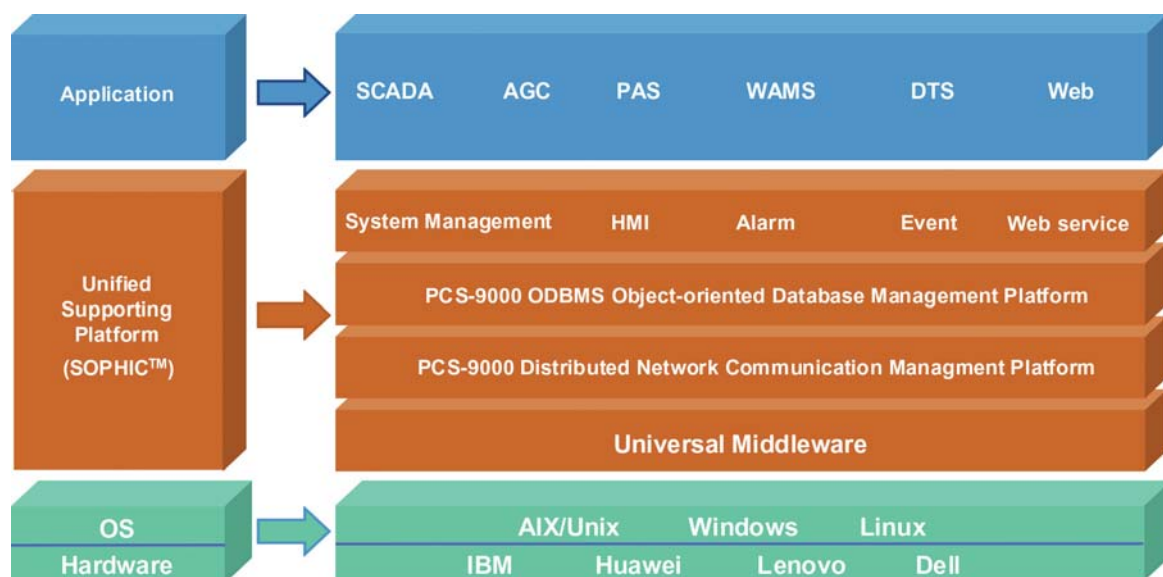

Figure 1 Software architecture of PCS-9000 EMS

Power Grid Monitoring and Control System

Structure

Protection & Control

- Unified Application Supporting Platform
  PCS-9000 unified application supporting platform provides powerful and universal services for applications such as distributed real-time database management, coordinated man-machine interactive interface, transmission of network information, inter-process communication, system management, alarm services and etc. All applications based on this platform are modular designed for easy installation, operation, maintenance and expansion.

- Complete applications
  PCS-9000 EMS provides complete power system applications to improve power system management levels. Moreover, it is expandable to accommodate the future EMS growth.

Functions

- Supervisory Control and Data Acquisition (SCADA)
  SCADA is a specific application framed on the unified application supporting platform and the most basic application of the EMS system. It is mainly used to implement the high performance acquisition and supervisory control function of real-time data.

  The following functions are provided:
  - Data Processing
    The data processing module is used for data acquisition, da-

tabase updating and generation of corresponding alarm and events. In normal operation, SCADA acquires system data from front-end applications and communication services. During post disturbance review (PDR), SCADA receives data from the PDR controller.

- Control and Regulation
  SCADA control and regulation functions refer to the remote control of breaker status, changing of transformer tape position, switchover of capacitors and regulation of generator outputs. Specific program logic is integrated to avoid mal- operations during control and regulation so as to ensure operation reliability.

- Sequence of Events (SOE)
  When a fault occurs in the power grid, PCS-9000 SCADA acquires general fault signals, CB closing/opening signals, protection operation signals, etc. After SOE records are received, PCS-9000 EMS organizes these events in sequence, displays them on the LCD display, prints and stores as historical data in the database.

- Data Calculation and Statistics Assessment
  Considering system real-time performance and its implementation, PCS-9000 provides data calculation functions in each application, including standard and customized calculations.

- Trending
  NR provides aggregates trending data from substation devices and presents them in a clear visual format that is fully customizable to facilitate quick identification of
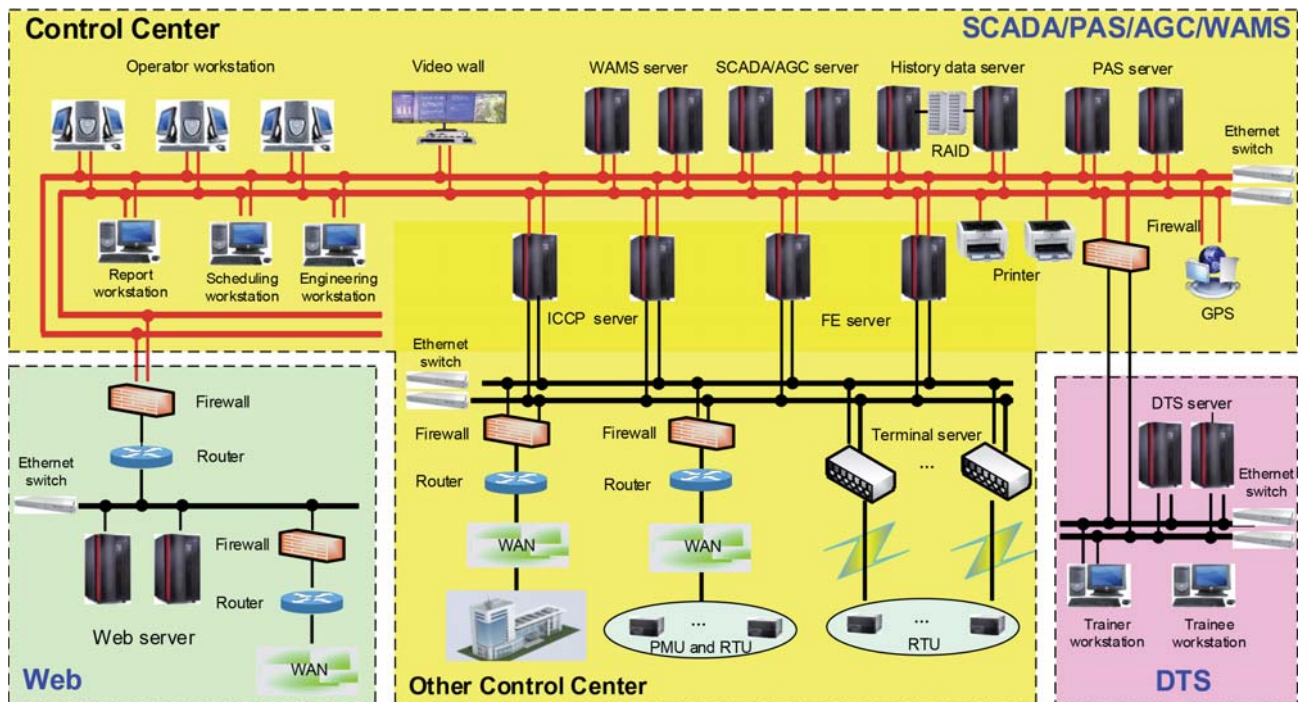

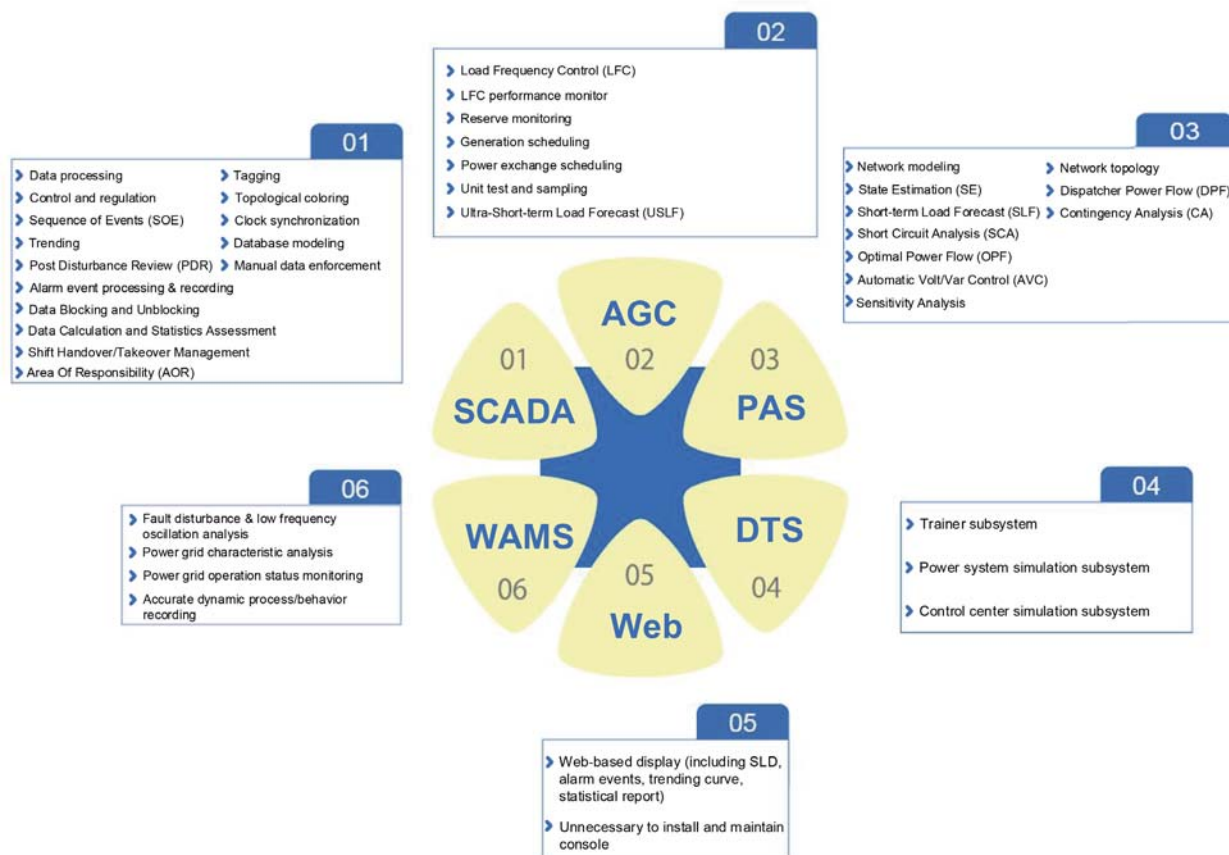Figure 2 Typical system structure diagram of PCS-9000 EMS

Figure 3 Main functions of PCS-9000 EMS

potential issues or to assist in problem analysis. Customizable curve with selectable colors, gridlines and scaling, real-time & historical curve displays, dynamic trending, XY plots are provided.

- Post Disturbance Review (PDR)
  PCS-9000 PDR records power grid operation conditions before/after disturbance to facilitate power grid analysis and research.

- Alarm Event Processing & Recording
  Alarm events are usually caused by status changes of the power grid abnormal conditions of PCS-9000 EMS system. Grid events and EMS system events can be separately processed, recorded, stored and printed.

- Data Blocking and Unblocking
  Data blocking function is used to prohibit particular data processing, data acquisition, alarm processing and report printout. Blocked data can also be unblocked.

- Tagging
  Tagging is used to prevent inadvertent control operations on devices. The operator can place/remove tags on equipment and configure the effective duration. Corresponding alarm signal can be issued whenever a tag is placed or

removed. Before a control operation is executed, corresponding tags will be checked automatically.

- Topological Coloring
  The topological coloring module identifies real-time system wiring configuration and colors up equipment in different states according to the network connection and the state of CB/DS/ES.

- Shift Handover/Takeover Management
  By shift handover/takeover management software, details of shift handover/takeover can be recorded and stored.

- Clock Synchronization
  PCS-9000 EMS provides GPS clock synchronization for all computers/devices in the system.

- Database Modeling
  Database modeling provides a visual and convenient graph-model-database integration modeling tool. Therefore, single line diagram (SLD), power grid model and database records can be generated simultaneously.

- Manual Data Enforcement
  PCS-9000 supports manual enforcement for measurements and binary inputs, i.e.: the displayed value of measurements

and binary inputs can be configured by the user.

- Area Of Responsibility (AOR)

  With development of power grid, it is necessary to divide resources into various areas of responsibility to ensure flexible management. With AOR tool, various areas of responsibility can be defined and managed, and the alarm signals of each AOR can be acknowledged separately. AOR tool can also be applied in staff/device/equipment management.

- Automatic Generation Control (AGC)

  AGC optimizes and controls the use of generation resources to meet regulatory standard and contractual requirements.

  - Load Frequency Control (LFC)

    LFC is implemented by the data processing module, basic power tracking module, power distribution regulating module and power plant controller module.

  - LFC Performance Monitor

    LFC performance monitor is activated during each AGC execution period to evaluate AGC control behavior. It calculates area performance indicators and unit performance indicators.

  - Reserve Monitoring

    During reserve monitoring period, capacities are calculated, and response speeds are supervised. The reserve capacity value required by a specified area can be configured via the interface, and an alarm will be sent out when reserve capacities are insufficient.

  - Generation Scheduling

    The generation scheduling function is used to arrange basic power schedule, output reduction schedule and fuel consumption schedule for generators.

  - Power Exchange Scheduling

    The power exchange scheduling function is used to arrange various transaction contracts and obtain regional power exchange plans.

  - Unit Test and Sampling

    The unit test and sampling function is used to perform unit commissioning for AGC units. During the test, the start/end time, unit output, unit load increment/decrement rate and etc will be recorded automatically.

  - Ultra-Short-term Load Forecast (USLF)

    USLF serves to forecast loads for the next hour by using the linear extrapolation method. Error analysis can be performed at any time during load forecast. All forecast results and error results can be displayed in curve and tabulation.

- Power Application Software (PAS)

  PAS is designed to enhance system safety and economical operation. It analyzes the power system operating status and helps dispatchers to understand operation status of the system.

- Network Modeling

  PCS-9000 network modeling is designed for building the network database of the power system, which is the foundation of all network analysis applications and the Dispatcher Training Simulator (DTS).

- Network Topology

  PCS-9000 network topology function identifies system wiring configuration according to interconnection relations of electric elements in the power grid and CB/DS/ES states. Moreover, state of equipments with different colors can be indicated.

- State Estimation (SE)

  SE is used to assess the states of real-time measurements according to the information of system connectivity.

- Dispatcher Power Flow (DPF)

  DPF can be used to perform power flow studies that include loss of power system equipment, changes in generation, changes in bus load and any other changes in system (e.g.: load, generation, interchange and voltages).

- Short-term Load Forecast (SLF)

  SLF is used to forecast the hourly, half-hourly or quarter-hourly future load in one day or one week based on the historical loads and weather data. Both overall system loads and regional loads can be forecasted.

- Contingency Analysis (CA)

  CA provides analysis for the steady-state security of the power system by applying assumed contingencies.

- Short Circuit Analysis (SCA)

  SCA enables dispatcher to evaluate whether CB breaking capacity is adequate under assumed contingencies applied to the real-time/study conditions. Single-phase/2-phase/3-phase faults can be simulated. Short circuit fault, broken conductor fault, complicated faults can also be simulated.

- Optimal Power Flow (OPF)

  OPF serves to optimize the security and economy of power system operation. PCS-9000 OPF can recommend control actions that can move the power system from a particular operation status to optimized operation status.

- Automatic Volt/Var Control (AVC)

  AVC function offers centralized decision and multi-level coordination to achieve automatic volt/var control.

- Sensitivity Analysis

  During power system operation, equipment state change will influence relevant equipment. With application of PCS-9000 sensitivity analysis, the following influences can be estimated: line active power change upon variation of gen-

erator active power output, bus voltage change upon tap position change and etc.

- Wide Area Measurement System (WAMS)
  By application of WAMS, dynamic behaviors of power grid can be monitored, considerable economic/social benefits can be achieved. Moreover, WAMS provides fault disturbance and low frequency oscillation analysis, power grid characteristic analysis, power grid operation status monitoring and accurate dynamic process/behavior recording.

- Dispatcher Training Simulator (DTS)
  DTS provides training capability that realistically simulates the power system and interacts with the trainee. DTS can simulate normal/emergency/faulty status and restoration process of the power grid. Therefore, DTS enables trainees to study normal operation, fault treatment and system restoration in a dispatching environment similar to scenarios in actual control center.

  - Trainer Subsystem
    Trainer subsystem consists of 3 parts: preparations for training, control and supervision during training and post-training treatment. It is used to complete preparation of training data, monitor and control training process, display or print training reports and dynamic curves, etc.

  - Power System Simulation Subsystem
    Power system simulation subsystem considers changes of load and frequency after disturbances. It can also simulate the operations of protection and automation devices when a fault occurs.

  - Control Center Simulation Subsystem
    Control center simulation subsystem can replicate the complete functionality of SCADA system, but the data acquisition functionality is simulated. All the operations available in real system can be simulated in the subsystem.

- Web
  PCS-9000 provides web-based delivery of SLD (Single Line Diagram) and other applications (e.g.: real-time/history alarm events and trending curve display, statistical report retrieval).

  Single line diagrams are treated as SVG (Scalable Vector Graphics) files, they can be generated from existing displays automatically, i.e.: manual intervention is not required.

  Moreover, it is unnecessary to install and maintain consoles for PCS-9000 web-based browser.

- Cyber Security
  With the development of energy management system, cyber security becomes more and more important. Conforming to relevant international standards (e.g.: NERC-CIP, ISO27001 and etc.), PCS-9000 provides panoramic cyber security solution with excellent performance. Strong 2-factor authentication, Single Sign-On (SSO), Role-Based Access Control (RBAC), network security zones & encryption, necessary security hardening and etc. are integrated in this solution.
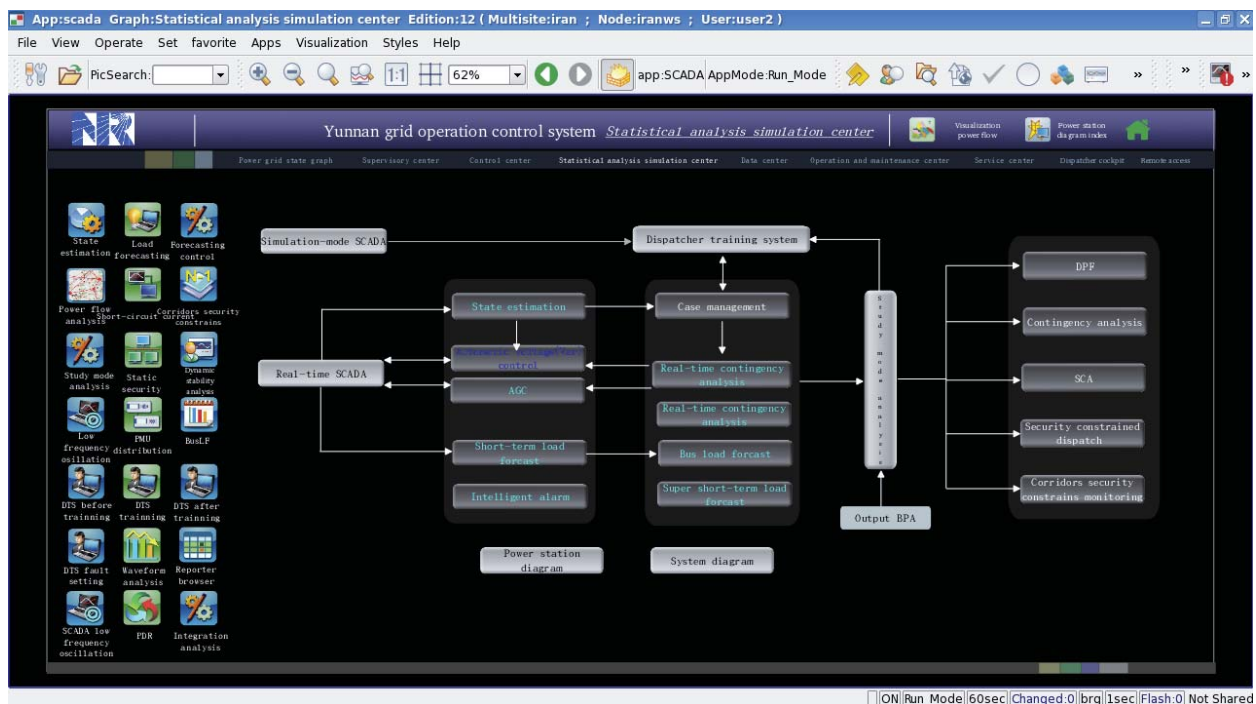

Figure 4 Typical diagram 1 of PCS-9000 EMS

Power Grid Monitoring and Control System

Moreover, PCS-9000 has passed security test performed by Experiment and Verification Center of SGEPRI (State Grid Electric Power Research Institute).

Features

- Unified Application Supporting Platform
PCS-9000 EMS provides an autonomously developed software integration platform: complying with the latest international standards, adopting the latest computer technologies and utilizing object-oriented real-time database modeling.

- Customized System Configurations
All functions of PCS-9000 EMS adopt modular design. Users can freely select required application modules to build their own application system. It is ensured that when a new application module is added, other operating functions will not be affected.

- Easy Interoperation
From the unified application supporting platform to all power system applications, PCS-9000 EMS fully complies with IEC61970 standard.

- Flexible Distributed Data Acquisition
The independent acquisition application can be distributed to suit the communication infrastructure. It supports all of the available protocols including international standard protocols, multiple industry standard protocols, proprietary communication protocols. Additional protocols can be easily implemented and loaded online without downtime.

- High Data Consistency
The core technology of support platform is an autonomously developed object-oriented real-time database. Using our autonomously developed real-time database management system, new applications can be easily expanded and data synchronization in different nodes can be ensured reliably.

- Convenient Maintenance with Security
PCS-9000 EMS provides offline maintenance and disturbance-free online loading functions for various application databases. After an application database at the maintenance node is modified, strict verification and testing must be carried out before reloading it. Therefore, pressure of maintenance personnel can be reduced, and security & continuity of system operation can be ensured.

- Easy Expandability and Progressive Upgrading
PCS-9000 system frame is easily expandable due to its distributed modularization structure, which utilizes Enterprise Service Bus (ESB) based on Service-Oriented Architecture (SOA).
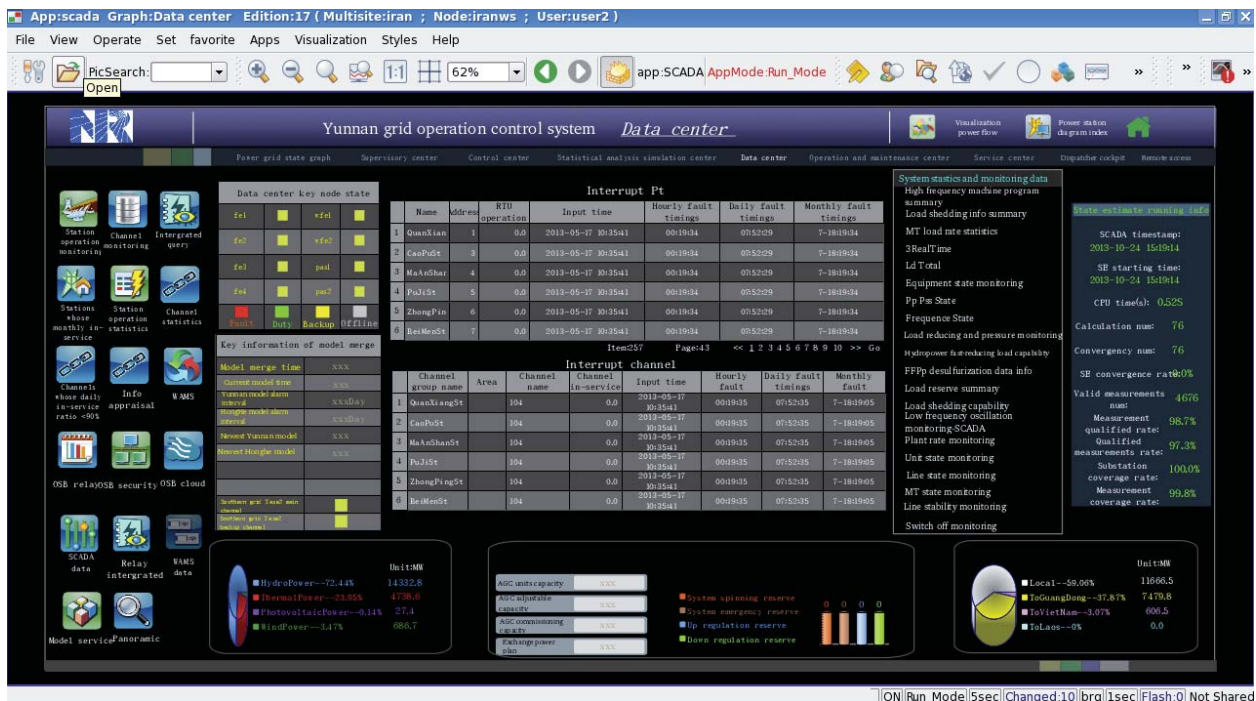

Figure 5 Typical diagram 2 of PCS-9000 EMS