Energy Management System (EMS)

Energy management is the process of monitoring, coordinating and controlling thegeneration, transmission and distribution of electrical energy. It is performed at centers called ‘system control centers’, by a computer system called Energy Management System (EMS). Data acquisition and remote control is performed by the computer system called SCADA, which forms the front end of EMS. The EMS communicates with generating, transmission and distribution systems through SCADA systems.

Energy management system consists of energy management, AGC, Security control, SCADA, load management as shown in figure.

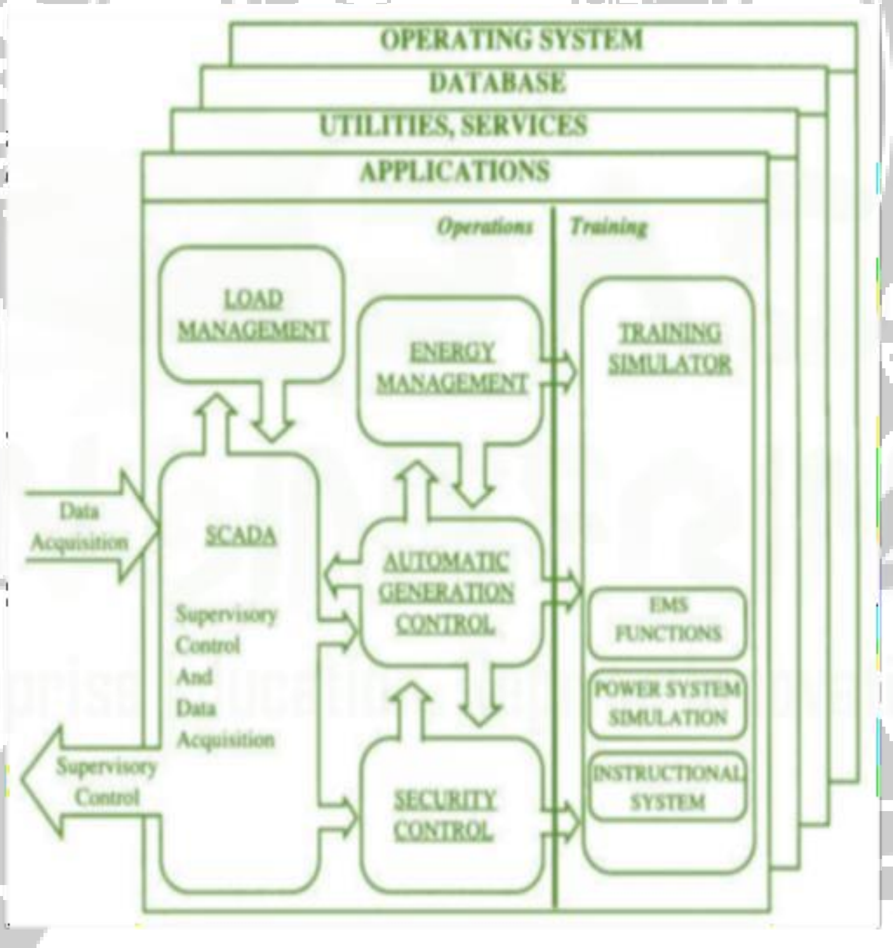

Fig. Energy Management System

Energy Management

Automatic generation control and economic dispatch minimize the production cost ad transmission cost. Commit the number of units to be operated to minimize the cost and schedule hydro-thermal plants properly have come under energy management.

The functions of energy management systems are:

System load forecasting – Hourly energy, 1 to 7 days
Unit commitment – 1 to 7 days.
Fuel scheduling to plants.
Hydro-thermal scheduling – up to 7 days.
MW interchanges evaluation
Transmission loss minimization.
Maintenance scheduling.
Production cost calculation.

Load Management – Carried out at Distribution Control Centre

Remote terminal unit (RTU) installed at distribution substations, can provide status and measurements for distribution substation. RTU can monitor switches, interrupters, control voltage, customer meter reading, etc.

The functions

1. Data acquisition
2. Monitoring, sectionalizing switches and create circuit configuration
3. Feeder switch control and preparing distribution map
4. Preparation of switching orders
5. Customer meter reading
6. Load management
7. Fault location and circuit topology configuration
8. Service restoration
9. Power factor and voltage control
10. Implementation time dependent pricing

11. Circuit continuity analysis.

12. To control customer load through appliance switching and indirectly through voltage control

Power System Data Acquisition and Control

- A SCADA system consists of a master station that communicates with remote terminal units (RTUs) for the purpose of allowing operators to observe and controlphysical plants.
- Generating plants and transmission substations certainly justify RTUs, and their installation is becoming more common in distribution substations as costs decrease. RTUs transmit device status and measurements to, and receive control commands and set point data from, the master station.
- Communication is generally via dedicated circuits operating in the range of 600 to 4800 bits/s with the RTU responding to periodic requests initiated from the master station (polling) every 2 to 10 s, depending on the criticality of the data.
- The traditional functions of SCADA systems are summarized:

✓ Data acquisition: Provides telemetered measurements and status information tooperator.

✓ Supervisory control: Allows operator to remotely control devices, e.g., open andclose circuit breakers. A "select before operate" procedure is used for greater safety.

✓ Tagging: Identifies a device as subject to specific operating restrictions andprevents unauthorized operation.

✓ Alarms: Inform operator of unplanned events and undesirable operating conditions. Alarms are sorted by criticality, area of responsibility, and chronology.
Acknowledgment may be required

✓ Logging: Logs all operator entry, all alarms, and selected information.

✓ Load shed: Provides both automatic and operator-initiated tripping of load in response to system emergencies.

✓ Trending: Plots measurements on selected time scales.

Energy Management

Since the master station is critical to power system operations, its functions are generally distributed among several computer systems depending on specificdesign. A dual computer system configured in primary and standby modes is mostcommon. SCADA functions are listed below without stating which computer has specific responsibility.

- Manage communication circuit configuration
- Downline load RTU files
- Maintain scan tables and perform polling
- Check and correct message
- Detect status and measurement changes
- Monitor abnormal and out-of-limit conditions
- Log and time-tag sequence of events
- Detect and annunciate alarms
- Respond to operator requests to:
  - Display information
  - Enter data
  - Execute control action
  - Acknowledge alarms Transmit control action to RTUs
- Inhibit unauthorized actions
- Maintain historical files
- Log events and prepare reports
- Perform load shedding

Automatic Generation Control

- Automatic generation control (AGC) consists of two major and several minor functions that operate online in real time to adjust the generation against load at minimum cost.
- The major functions are load frequency control and economic dispatch, each

of which is described below.

- The minor functions are reserve monitoring, which assures enough reserve on the system; interchange scheduling, which initiates and completes scheduled interchanges; and other similar monitoring and recording functions.
- **Load Frequency Control**

Load frequency control (LFC) has to achieve three primary objectives, which are stated below in priority order:

1. To maintain frequency at the scheduled value
2. To maintain net power interchanges with neighboring control areas at thescheduled values
3. To maintain power allocation among units at economically desired values.

The first and second objectives are met by monitoring an error signal, called area control error (ACE), which is a combination of net interchange error and frequency error and represents the power imbalance between generation and loadat any instant.

- This ACE must be filtered or smoothed such that excessive and random changes in ACE are not translated into control action.
- Since these excessive changes are different for different systems, the filter parameters have to be tuned specifically for each control area.
- The filtered ACE is then used to obtain the proportional plus integral control signal
- This control signal is modified by limiters, dead bands, and gain constants that aretuned to the particular system.
- This control signal is then divided among the generating units under control by using participation factors to obtain unit control errors (UCE).
- These participation factors may be proportional to the inverse of the second derivative of the cost of unit generation so that the units would be loaded according to their costs, thus meeting the third objective.
- However, cost may not be the only consideration because the different units mayhave different response rates and it may be necessary to move the faster generators more to obtain an acceptable response.

- The UCEs are then sent to the various units under control and the generating units monitored to see that the corrections take place.
- This control action is repeated every 2 to 6 s. In spite of the integral control, errors in frequency and net interchange do tend to accumulate over time.
- These time errors and accumulated interchange errors have to be corrected by adjusting the controller settings according to procedures agreed upon by the whole interconnection.
- These accumulated errors as well as ACE serve as performance measures forLFC.
- The main philosophy in the design of LFC is that each system should follow its own load very closely during normal operation, while during emergencies; each system should contribute according to its relative size in the interconnection without regard to the locality of the emergency.
- Thus, the most important factor in obtaining good control of a system is its inherent capability of following its own load.
- This is guaranteed if the system has adequate regulation margin as well as adequate response capability.