EMS LECTURE 1: INTRODUCTION

1. Introduction:

Electrical Energy Management System (EEMS) widely refers to a computer system which is designed specifically for the automated control and monitoring of electric power and utility system. The scope may span from a load dispatch center to a group of power networks. Most of these energy management systems also provide decision making facilities for operator in the operation and control in real time. The data obtained from such actions are used to train operators in a control center and for performing engineering studies for futuristic actions like planning, optimization and maintenance scheduling, etc. on a frequent basis and to produce trend analysis and annual consumption forecasts.

Energy Management System (EMS) is a collection of computerized tools used to monitor, control, and optimize the performance of generation and transmission systems. This intelligent energy management software control system is designed to reduce energy consumption, improve the utilization of the system, increase reliability, and predict electrical system performance as well as optimize energy usage to reduce cost. Energy Management System applications use real-time data such as frequency, actual generation, tie-line load flows, and plant units' controller status to provide system changes. Energy Management System had its origin in the need for electric utility companies to operate their generators as economically as possible. To operate the system as economically as possible required that the characteristics of all generating units be available in one location so that the most efficient units could be dispatched properly along with the less efficient. In addition, there was a requirement that the on/off scheduling of generating units be done in an efficient manner as well. Energy management systems can also provide metering, sub metering, and monitoring functions that allow facility and building managers to gather data and insight that allows them to make more informed decisions about energy activities across their sites.

1.1 EMS in Power Systems:

Electrical energy management systems (EMS) are an important function for the reliable and efficient operation of power systems. EMS is related to the real time monitoring, operation and control of a power system. The information from the power system is read through Remote Terminal Units (RTUs), an integral part of SCADA to an EMS or Energy Control Centre (ECC). EMS consists of both hardware and software. Hardware part of EMS consists of RTU, Intelligent Electronic Device (IED), Protection, Computer networking, .etc. Software part of EMS consists of Application programs for network analysis of power systems. In EMS, application programs are run in a real time as well as extended real time environment to keep the power system in a secure operating state. Now-days, EMS is an integral part of any power system. It is used as a part of Substation Automation System (SAS), Demand Side Management (DSM), Protection, and Distribution Management Systems (DMS) for renewable energy and so-on. In the next few years, EMS-DMA will change the role of power systems, monitoring and control.

An energy management system (EMS) is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system. The monitor and control functions are known as Supervisory Control and Data Acquisition (SCADA), followed by several on-line application functions. Energy Management Software (EMS) is a general term referring to a variety of energy-related software applications which may provide utility bill tracking, real-time metering and lighting control systems, building simulation and modeling, carbon and sustainability reporting , demand response, and/or energy audits. Managing energy can require a system of systems approach.

1.2 Objectives:

There are primary and secondary objectives of energy management system. The primary objectives are related to the security and stability of the system, while the secondary objectives relate to the

Primary Objectives: Security and Stability of the system
Secondary Objectives: Economic Operation and Control
Tertiary Objectives: Optimization, Operational Planning and Maintenance Scheduling

1.2.1 Primary Objectives:

1. Maintaining the power system in a secure and stable operating state by continuously monitoring the power flowing in the lines and voltage magnitudes at the buses.
2. Maintaining the frequency within allowable limits.
3. Maintaining the tie-line power close to the scheduled values.

1.2.2 Secondary Objectives:

1. Economic Operation of the power systems through real time dispatch and Control.
2. Optimal control of the power system using both preventive and corrective control actions.
3. Real time Economic Dispatch through real power and reactive power control

1.2.3 Tertiary Objectives:

1. Optimization of the power system for normal and abnormal operating scenarios.
2. Optimal control of the power system by appropriate using both preventive and corrective control actions
3. Maintenance scheduling of generation and transmission systems.

The three objectives are executed at different levels by the operator in a control centre.
While the first objective is automatic or closed loop control without the intervention of the operator, the secondary and tertiary are performed with the aid of the operator.
In energy management systems, voltage magnitudes and power flows over the lines are continuously monitored through SCADA, to check for violations. The violations in voltage are addressed by preventive control actions, while the power flow violations are addressed by means of corrective actions. The tie line power flows at scheduled values will be maintained by adjusting the MW outputs of the AGC generators so as to accommodate fluctuating load demands.

The energy management software application will also calculate the required parameters to optimize the operation of the generation units under energy management action. EMS is a computer-based Operation and Control System. It is used in mentoring and controlling the

system in real time. It receives large amount of information from power Systems through SCADA. It selectively uses Information from SCADA for computation and analysis. It Send back 'important control signals' to the System through SCADA.

EMS has different names, namely 1) ECC: Energy Control Centre, 2) Load Dispatch Centre, 3) DSM: Demand side Management, 4) DMS: Distribution Management System, etc.. The main functions of these are to operate the power systems in real time.

2. **Evolution of EMS:**

The evolution of EMS has a long past. It has started with control centers in 1960s to fully developed energy management systems

1960 – Termed as Control Centre's (CC)

These control centers were initially termed a load dispatch centres. The important task was to control the power generation and load demand as to match the generation with load demand. Even today, the term load dispatch centre's are widely used in various state electricity boards as well as energy control centre's.

1970 – Energy Control Centre's.

Here the main task was to control the energy rather than the power. Here energy monitoring is of main concern the matching of energy of power demand from that of power generation is of main concern.

1990 – Energy Management Systems (EMS)

In EMS, the main task was to manage the energy through various techniques like load management (LM), demand side management (DSM), distribution management systems (DMS). EMS are computer based programs hat perform both computational tasks as well as decision making tasks so as to assist the operator for real time operation and control.

Evolution of SCADA:

The evolution of SCADA started with monitoring and data acquisition systems plants followed by control. These have been used prior to EMS. The main tasks of SCADA were to continuously measure and monitor parameters for checking limit violations and to ensure reliable and safe operation of the system being controlled. The earlier tasks of SCADA were mostly monitoring with gradual control tasks coming into picture.

It becomes more beneficial when EMS and SCADA are used together

3. Functions and Benefits of EMS:

The important benefits of an EMS can be addresses as the following functions:

Control functions:

1. Real time monitoring and control functions.
2. Automatic Control and automation of a power system like Automated interfaces and electronic tagging
3. Efficient automatic generation control and load frequency control.
4. Optimal automatic generation control across multiple areas
5. Tie -line control.

Operating functions

1. Economic and optimal Operation of the generating system.
2. Efficient operator Decision Making Improved quality of supply

Optimization functions

1. Optimal utilization of the transmission network
2. Power scheduling interchange between areas.
3. Optimal allocation of resources
4. Immediate overview of the power generation, interchanges and reserves

Planning functions

1. Improved quality of supply and system reliability

2. Forecasting of loads and load patterns
3. Generation scheduling based on load forecast and trading schedules
4. Maintaining reserves and committed transactions
5. Calculation of fuel consumption, production costs and emissions

4. EMS Architecture:

Figure 1.1 shows the main important entities of power systems, EMS and SCADA. EMS and SCADA are two important entities in the real time monitoring, operation control of power systems. The flow of Power and information between the three modules can be observed. While Power (unidirectional) flows from Power Systems through SCADA to EMS. Information flow (bi directional) SCADA forms the interface between Power Systems and EMS. The power system data, both continuous and discrete, is collected by SCADA and selectively sent to the EMS. EMS is a computerized control of power systems consisting of several application programs which are run / executed by the operator so as to maintain the power system in a secure and table operating state. EMS consists of several programs interconnected in a particular fashion so as to obtain the solution in real time.

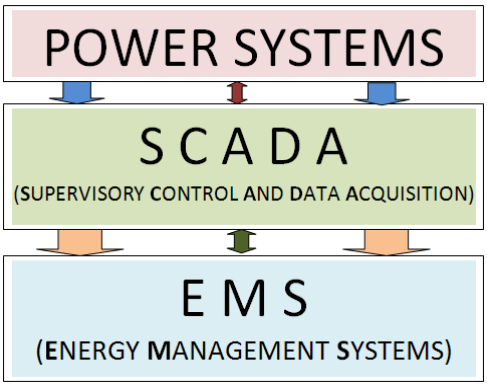

Fig 1.1 Power and Information flow between Power systems, SCADA and EMS.

Figure 1.2 shows the components in EMS-SCADA. Power Systems contain generators, transformers, transmission lines, different loads to industry and consumers. SCADA consists mostly of hardware components, which measure the quantities (Voltage, current, power, etc..)

from various meters. SCADA consists of collection of information from meters distributed throughout the area through Remote Terminal Units (RTUS).

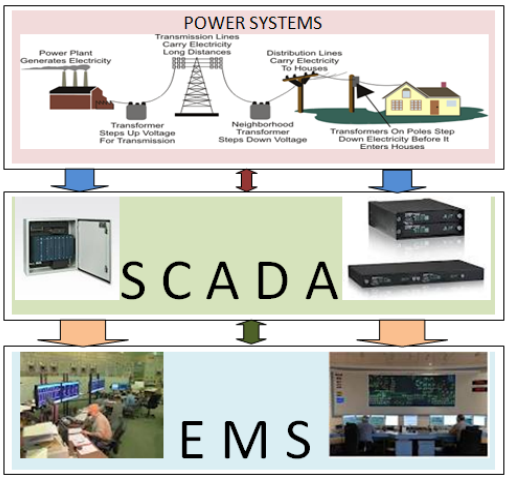

Fig 1.2 Components of EMS/SCADA

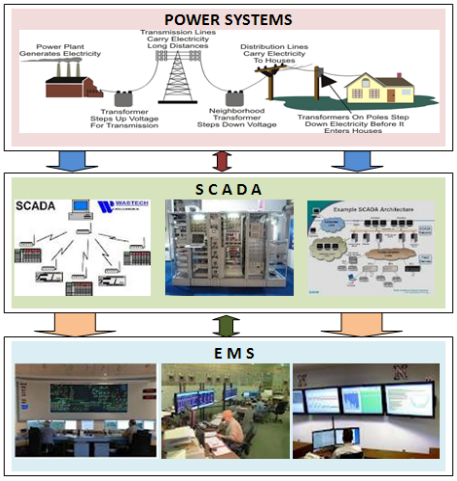

Fig 1.3 Structure of EMS SCADA

5. Practical EMS

Figure 1.4 shows the actual implementation of Power System Model, SCADA AND EMS in a laboratory environment. The power system model consists of scaled down components of three phase generators, transformers, transmission lines and loads. The SCADA modules consist essentially of hardware for measurement monitoring, control and protection of the power systems. SCADA monitors information from the power system through PT, CT, etc., collects data and sends them to the EMS. Both Analog (continuous) data and digital (discrete) information are collected by the Remote Terminal Units (RTU). EMS consists of a network of computers or work stations which perform computational tasks for decision making

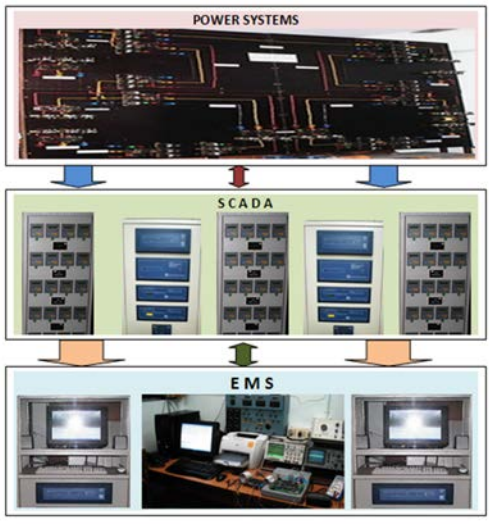

Fig 1.4.Practical EMS- SCADA System.

in real time operation and control. Both On-line and Off-Line functions can be performed in an EMS. The operators in an EMS send signals to the power system through SCADA. On line functions include mainly closed loop control functions like automatic generating control (AGC), load frequency control (LFC), voltage reactive power control (volt-var control). Open loop functions like Economic Dispatch and Operator load flow, state estimation, security assessment, etc are also performed in real time as on line functions.

6. Working of EMS:

The important working of an EMS is given below

1. Real time monitoring and control over the whole distribution network.
2. Enhanced customer service through a complete outage management package including trouble call taking, fault localization and restoration as well as outage statistics and customer notification.
3. Efficient work order handling via the built-in work management tools.
4. Better crew and resource management including support for crew scheduling and tracking, dispatching and assignments as well as follow-up and reports.
5. Optimal network utilization using the State Estimator functionality for optimal feeder reconfiguration and loss minimization in balanced networks
6. Better support for all reporting with retrieval of historical data archived in a data warehouse

Summary:

This section provides an introduction to Energy Management Systems and its evolution. The important objectives of EMS and the architecture for control and operation of a power system are presented. The subsequent chapters provide the various detailed operations in an EMS.

Important References for further reading:

1. Edmund Handschien “Energy Management Systems” book by

2. Steve Doty and Wayne C Turner, Energy Management Handbook, Eighth Edition, , Farimont Press, Nov 2012.
3. Energy Management Systems "http://www.alstom.com/grid/products-and-services/market-solutions/Energy-management-systems/",
4. Aman, S. ; Simmhan, Y. ; Prasanna, V.K. "Energy management systems: state of the art and emerging trends", IEEE Communications Magazine, Vol. 50, No 1, 2013, pp. 114-119.
5. Dusi, B. ; Schultz, R. "Energy management and efficiency — A systems approach|", IEEE Cement Industry Technical Conference, pp 1-8, 2012.
6. Saina Amam, Yogesg S and Prasanna, V. K. " Energy Management Systems: State of the art and Emerging Trends", IEEE Communications Magazine, Jan 2013, pp. 112-119.