Chapter 78
Industry 4.0–Based Enterprise Information System for Demand-Side Management and Energy Efficiency

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ABSTRACT

The supply demand gap in energy sector in any country is a major challenge. Demand side management (DSM) and energy efficiency (EE) are the well-known solutions in the short term, and capacity addition is the long-term solution. However, both DSM and EE initiatives require significant investment and logistics if implemented in the traditional approach. The contemporary Industry 4.0 principles can be effectively applied to resolve several issues. This chapter proposes a novel enterprise information system (EIS) by treating the modern power systems as cyber physical system and to manage the processes of DSM and EE. A prototype system is suggested to pave the path for EIS, and the functional characteristics are illustrated with a few data visualizations.

DOI: 10.4018/978-1-7998-8548-1.ch078

INTRODUCTION

Modern power systems are very complex in the sense, they are fed from different forms of renewable energies through micro and smart grids (on the generation side) and supply linear and non-linear loads (at the customer end) through different power network components such as lines, transformers etc. It is normal to see that some of the generation plants are owned and /or operated by different companies, which are also known as independent power producers (IPPs). Both generation plants and customers are geographically wide-spread and values of generation and loads dynamically vary. In other words, there are several electrical parameters such voltages, currents and powers at several different locations and these are continuously changing. In general, utilities may have several different forms of measuring instruments, right from legacy analog equipment (non-smart, cannot communicate) to modern equipment (capable of computing and communicating) that collect data at regular intervals (typically every 15 or 30 minutes) for storage and processing. Over the time, this data gets huge and hence is big-data.

Now, IPPs will have different energy production costs and selling tariffs as specified by power purchase agreements (PPAs). Utilities specify different tariff mechanisms for different customers such as industrial, commercial and domestic. Even Time of Use (ToU) based tariff schemes with four different prices for electrical power in a single day is being implemented in different countries. This measure is part of 'Demand Side Management (DSM)' to influence customer power usage pattern. DSM, in a sense, encourages customers to exercise caution in using the electric power (Khripko, 2017). On the other hand, it is important that electrical loads have good efficiency and are of good quality to ensure they deliver the expected performance at reduced costs. In other words, inefficient or low quality (or equipment not confirming to set quality standards) may consume higher energy to deliver same, expected output and even may cause fire accidents. The aspect of energy efficiency of power apparatus and / or customer appliances is studied under the broad title Energy Efficiency (EE). Though DSM and EE are different in several aspects, in reality both of them depend on each other. In real world setting, electrical load parameters at the customer end are dynamically changing, which need to be measured by meters (Hemapala et al., 2012). However the data as measured by the meters needs to be processed and stored; and then should be made ready for various forms of computations and analysis. Both EE and DSM also require periodical energy audits (Roshan et al., 2014) to develop or to modify the implementation strategies.

Regulatory bodies or organizations specify various quality standards for customer service and even for power network maintenance activities. Both IPPs and power utilities have to follow the specifications set by respective state regulatory bodies. Customer awareness and free flow of information exchange is utmost important. Most regulatory bodies across the world entrust this responsibility to IPPs and utilities.

Different strategies for DSM and EE have been adopted by various power utilities across the world as can be seen from the literature. These strategies depend on various factors including local power tariffs, power network capabilities, and economic status of stakeholders with customers. However, for successful implementation of DSM and/or EE a lot of data (which is authentic) is required be collected and processed from the customers. Big data tools have been recently used in power system monitoring control (Zobba, 2018; Zhou et al., 2016) for various purposes. Several computing architectures (Zhang, 2108) and data analytics have been suggested for composite systems. However, enterprise information systems, or data driven intelligence and analytics specifically for DSM and EE have not been presented in detail.

From the above, it is clear: