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Evaluation of Smart Grid Technologies Based on Decision Support Systems

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ABSTRACT

The smart grid complements the deficit in traditional electrical energy such as the pollution issues that come with certain energy resources such as fossil fuels and nuclear energy. Many literature discusses various technologies but very few talk about the implementation of the smart grid and its considerations to be implemented, the assessment of the power system with the communication network put into play, how to optimize technological schemes with economic and political constraints put into consideration and many other considerations. Governments across the globe and related organizations such as utility companies are eager to assess the cost and advantages of new technological mechanisms scientifically as opposed to decision making with no scientific base. Decision Support System is a system of information that is interfaced with computers to support the making of decisions in operations, management, and planning for assessing the technologies. This is an important tool because it helps the decision-makers with scientific evidence needed. The main objective of this project is to point out the technologies that help in the processing of data and information and also the mechanisms that will enhance the decision support systems that are used for the assessment of the indices of the smart grid technology for future investments. To begin with, this project introduces the smart grid together with its features and technologies for clarification of the benefits of using the smart grid such as safety, efficiency, reliability, economics, environment, and security. Understanding how power system business and how it operates is key because it affects the communication network model. This project gives a detailed report of what the smart grid needs for simulation following the operation and power system business. Furthermore, the smart grid involves some monitoring system and communication system that helps to better understand management on the demand side so that its impact on the power system can be reviewed. Load shedding strategies are helping the power system from crumbling and keep the grid in a complete form to an extent. Soon, many countries and organizations have set goals to reduce the contribution of the emission of greenhouse gas. For example, the United Kingdom is planning to produce about 27% of its energy from renewable energy resources by 2030.

Keywords: Smart Grid, Technologies, Decision and Support Systems.

INTRODUCTION

There has been a significant growth of large industry and commerce which has brought the need for more power supply which in turn has created an energy supply deficit and pollution issues due to the power demand generated from fossil fuels. Smart grids have come into play to solve some of these issues in both developing and developed countries. Smart grids have more advanced construction, the best algorithms, and creative frameworks that are being enhanced [1]. The smart grid concept has been modeled for quite some time now such that a lot of power organizations across the globe are focused on explaining its functionality and its technical applications. Different countries and regions develop smart grids according to what best suits them, such as energy distribution and consumption. In addition, climate, industrial and commercial, etc. For example, people in Europe are inclined to develop renewable energy and distributed energy (distributed generation) systems whereas in the United States, the implementation of a

smart grid is more of smart metering and demand response. The Chinese state grid Corporation wants to develop a strong and robust smart grid for High Voltage, Direct Current (HVDC), and Flexible AC Transmission Systems (FACTS) for transmission of electric power from west china which is rich in energy to east china. The difference between the smart grid and the traditional grid is that the smart grid deploys communication networks which are much more critical. Electricity delivery systems now incorporate a lot of computerized control, monitoring, and automatic operations from remote which form a two-way communication system link between power plants and the consumers such as domestic, industrial, commercial and agricultural. Furthermore, power systems can now share information with other systems such as petroleum, natural gas dispatch systems, weather forecast, and so on. The penetration levels of renewable energy resources such as wind energy, solar and demand response have become high and the effect of weather on the power system plays a significant role. Information exchange between the weather forecast and power systems is made possible using mechanisms such as the Load forecasting mechanism. Power economic dispatch and design of the right demand response or load shedding scheme for the prevention of loads from drawing too much energy from the grid may be as a result of accurate short term load forecasting. Long term load forecasting on the other hand helps to plan better for optimized allocation of energy. It is a gradual process of replacing the old power system elements with new computer-based elements in order to achieve the smart grid. Thus, the planning process for the smart grid does not only puts the effects of creative technology into consideration but also appreciates the diversity of the stakeholders' interest. To make correct and responsible decisions, carrying out a cost analysis may be the best way to go. Constructing a Decision Support System is one of the best and effective ways of estimating the cost of the technologies and implementation of smart grids. The decision support system is an information system that is based on the interaction of computers to support planning using decision making, management, and operations of the grid.

The Smart Grid

Organizations, research institutions, and governments across the world have conceptualized, expanded, and developed the smart grid. There is no standard definition of the smart grid, so far, as things stand, each country seems to have a different concept and definition of the smart grid. For example, the Chinese are aiming at establishing a robust smart system from generation to utilization, this includes transmission and distribution. In the UK, the definition of the smart grid is within the distribution network. So far, a lot of publishers focus on defining the features of the smart grid or the kind of technology that is involved in the smart grid. For planning and operations, some new issues that have never occurred on the conventional power system also need to be considered as a way of understanding the smart grid. For example, one would ask a question like, what is the most efficient way of operating the system with the increasing number of consumers getting involved in the power system? Another question would be, in the event of a cyber-attack in the communication channel, how will the smart grid detect this kind of attack and how will it defend the network from damage?

Customer Side Systems (CSS)

Customer side systems are employed to help regulate energy consumption at different usage levels such as commercial level, industrial level, service level, and residential level. There are four aspects that are involved in the customer side systems [2] and these are:

1. Energy management systems
2. Energy storage devices
3. Intelligent electronic devices
4. Distributed generations

On displays in homes such as smart appliances, energy dashboards, and load storage employment can cause a high rise in the profit of energy efficiency and have a reduced peak demand. The demand response is a situation where the end-use customers reduce their electricity consumption as a response to

the power grids' requirements, indices of economics from a wholesale market with the competition or retail rates. Both responses from the customer, either manual or automated, price-responsive appliances, and thermostats are connected to the Energy Management System or controlled by a signal from the company or the operating system [2].

Electric Vehicle Charging and Discharging

The demand for electricity vehicles' charging infrastructure can be regulated through charging and discharging. Electric vehicles charging and discharging has four operational modes and these are Grid to vehicles (G2V), vehicles to grid (V2G), storage to vehicles (S2V), and vehicles to storage (V2S). Vehicles operate as moving storage constituents of the grid because of the rise in penetration of the demand response and constant change in the pricing. In the event where the EV is fully charged and the grid is subjected to peak demand, the EV will discharge to the grid or maybe a home storage device as a backup for residential consumption. The storage devices will charge the EV when the grid is subjected to peak demand for everyday utilization. This implies that the EV will charge from the power grid when the grid is subjected to low energy demand and the price of electricity is low.

System Monitoring

Intelligent monitoring system is associated with functions such as analysis of videos, behavior recognition and business intelligence. The computer vision (CV) artificial intelligence (AI) is used to aggregate data and information from the video analysis to create a close map link from the images to the description of the event. Behavior recognition has the function of analyzing, monitoring and sounding the alarm. The most crucial part in intelligent systems is Business intelligence which is as a provider for key video business for users. There is a hierarch in which the intelligent technologies are deployed in the network including equipment and software to accomplish the integration of information and scheduling through a management system platform. [3] Realized the three main issues of capturing data. Firstly, raw data the quantities were very large for the engineers to deal with, then secondly, it was very hard to obtain meaningful information from conditional monitoring of data because there was no understanding of plant item and its health all the time. And lastly, the life span of an item was not easy to estimate from its health as this was not always apparent. The architecture proposed was an agent-based system in which each module had a self-contained functional software. The exchange of information and co-operation amid the independent modules has been implemented through a regiment Agent Communication Language (ACL). A literature review on the condition monitoring techniques for the power generator, transformer and an inductive motor was used as reference [4]. The authors discovered that a paperback conditional monitoring system needs signal processing and Artificial Intelligence as its main elements for evolving into the next generation of condition monitoring which has high levels of reliability, sensitivity, accuracy and intelligence. [5] Shows the monitoring applications improvement by incorporating spatial and temporal features of data and information. There are two new monitoring functions that have been portrayed in this project to illustrate how the smart grid technologies can help to locate faults more accurately. The Intelligent Electronic Devices (IEDs) together with Digital Protective Relays (DPRs) plus Digital Fault Recorders (DFRs) have synchronization to a GPS clock that links to absolute time. Translucent granting of time and space in IEDs in a common infrastructure, needs exchange of information and incorporation of data, is the trend in the future functionality of monitoring. A lot of technological fields including industry, traffic, clinics, geography and agriculture have used intelligent condition monitoring. Communication technology has improved such that over the last decade, it has been suggested for monitoring based on the web. A rationed out intelligent monitoring system using 3G network was suggested

in monitoring the well-being of the railway bridges [6]. Monitoring systems can also be used for clinical purposes for artificial heart monitoring [7]. The Chinese use monitoring for their medicine using temperature and humidity intelligent monitoring through ZigBee wireless networks was suggested in [8].

Requirements for a Decision Support System

A standard Decision Support System includes various scientific aspects such as technologies of simulation, computer science, software programming and perceptive science and so on. There are three kinds of problems associated with decision making and these are structured, unstructured and semi-structured. For structured, the issues can be resolved using standard solution methods by clearly stating the procedures for making a making a decision. There are no specified challenges in the unstructured and the decision procedures are followed one time only. Optimization in semi-structured problems is not guaranteed in as much as the decision making procedures are specified. The DSS is different depending on the level of the business companies and organizations. Three distinctive levels are involved in organizations. Firstly, there is strategic planning, which includes long term policy planning, which is used for governing the acquisition of resources, usage and disposition. Then secondly, the management control makes sure that the resources are acquired and optimized in order to accomplish the objectives of the organization. And lastly, operation control makes sure that there is progress [9,10].

Functionalities of the DSS

Generally, as earlier mentioned, the DSS is project-oriented and its functionality is determined by the architecture of the system. Using various architectures, the functionalities of the DSS are summarized as follows:

- Obtaining, management and providing the organization with exterior information associated with decision questions in areas such as policy, technology, market, economy, society and environment.
- Obtaining, management and giving the organization intramural information associated with decision questions in areas such as the capabilities of production, order requests, storage status and the finance.
- Obtaining, management and giving feedback of each option of decision performance like processing of contracts, plan for supplying material and implementing the production.
- Has the capacity to store data and manage mathematical models closely linked to decision making.
- Has the capacity to store and provide frequent usage of mathematical methodologies and algorithms such as linear programming, regression analysis and models of computational intelligence
- Has the capacity to aggregate and modify data easily including modeling and algorithms.
- Has a flexible way of gathering, processing, forecasting and analyzing data through representation and methodologies.
- Provides a platform for interaction between man and machine as well as the graphic output functionality. Also, there is capacity to meet the request of random probability distribution of data queries to give answers to questions such as "what...if..." and so on.
- Gives a platform for data communication so that the data required can be gathered, processed and transferred to the user in time.

CONCLUSION

A lot of advanced technologies, creative architectures, and paperback algorithms have been deployed into the existing electrical power systems for improved energy efficiency and accomplish resource allocation optimization and ultimately make the grid "smart". Two-way communication systems'

deployment is one of the distinctive mark of the smart grid. The smart can gather and transfer monitored data from the power system elements to operators of the system using the smart grid monitoring system and form a two-way communication system via the grid power plant and the end user of electricity. The smart grid implementation is a gradual process to substitute the conventional power systems' elements built on the basis of existing systems and building brand new systems which would be very costly. Smart grid planning involves not only the consideration of these creative technologies but also respecting the interest of all the stakeholders involved. Decision making requires to be executed to analyze each smart grid component and its cost before investment and consequently deploying into the real grid. Considering the above mentioned issues, this project surveys an overall monitoring and communication structure. Information optimization is one the key strategies to obtain the benefits of the smart grid. The architecture of decision support systems has been surveyed and the new trend for decision support system was outlined out for future research. The large penetration of advanced technologies such as renewable energy resources and communication technology incorporated in the power system, has brought new challenges such as instability, reliability and security issues have become critical than when it was the traditional grid. Reliability indices and stability scenarios illustrate the physical insight of the system provide a decision making plan and cost benefit analysis.

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