Abstract: The rapid economic development is causing huge stresses in the existing generation, transmission and distribution systems as they are not able to keep pace with the increasing demand. Installation and incorporation of a large number of electrical power generation units with increased capacities to deal with the surging demand has an adverse impact on the environment therefore an efficient Energy Management is imperative. Smart Grid may be the answer to this expected energy crisis and management. Conventional instrumentation has proven inadequate for the purpose of managing the extensive and complex power systems. The electric grid to increase overall system efficiency and reliability. Much of the technology currently in use by the grid is outdated and in many cases unreliable. The smart grid implements a two way communications and also facilitate the two way flow of energy. A smart grid is an intelligent electricity network that integrates the actions of all users connected to it and makes use of advanced information, control, and communications technologies to save energy, reduce cost and increase reliability and transparency. Smart Grid has two major aspects, the smart grid (Generation, transmission and distribution system) on one hand and programmable smart appliances on the other. This review paper presents literature survey conducted on different energy management systems fetching the data from the generation to consumption by using different means and approaches.

The Smart Energy Management System is developed with ability to record, store, and process power consumption data of every major appliance in the house and Industries. The power consumption data is accessible through the Web portal and on handheld devices. Homeowners and Industries can track their power usage by device, room, equipment, Plant or appliance, which helps better regulate power consumption.

In this article, we survey the literature till early 2015 on the enabling technologies for the Smart Grid. Out of three major systems, namely the smart infrastructure system, the smart management system, and the smart protection system, We explore the energy management system (EMS). Again out of various management objectives in smart management system, such as improving energy efficiency, profiling demand, maximizing utility, reducing cost, and controlling emission we explore to integrate home and building energy management systems (HEMS, BEMS), and management.

Keywords:- Smart Grid(SG), energy management system(EMS), Advanced Metering Infrastructure (AMI), Home energy management systems (HEMS), Building energy management systems (BEMS).

I. INTRODUCTION

With the depleting energy resources, enhancing energy security and energy-access, particularly in emerging economies is one of the major challenges that one has to deal with. In addition to managing the existing energy resources, generating power effectively and intelligently is an equally important agenda. Supplementing the establishment of large power plants from conventional energy sources, there is also a need to focus on distributed small scale generation of power particularly from renewable energy sources. Although Distributed Energy Resources (DERs) need additional infrastructure and investment to connect them to the grid, these technologies obviate the need for an expensive transmission system and reduce transmission and distribution (T&D) losses. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a ‘Micro-grid’ [1]. During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the Micro-grid’s load from the disturbance without harming the transmission grid’s integrity. Economic, technology and environmental incentives are changing the face of electricity generation and transmission. Centralized generating facilities are giving way to smaller, more distributed generation partially due to the loss of traditional economies of scale.

Intelligent systems driven by microprocessors and computers need to be employed for online monitoring and control of modern large-scale power systems, in generation, transmission and distribution to overcome the complexities and drawbacks of the conventional instrumentation schemes. These intelligent systems form the basis of the smart grid. The smart grid (generation, transmission and distribution) by itself does not completely solve the problem of the existing demand-supply mismatch. The smart grid needs to be complemented with smart (programmable) appliances at the customer sites to efficiently re-distribute the demand to provide the benefits of lower costs for customers and operational efficiencies for suppliers. Smart Energy Management System need to integrate with Smart grid & Smart Appliances to analyze end to end complex power system data which leads to the reduce power consumption and increase smart grid reliability and efficiency.

The main objective of this paper is to review the work already attempted by various research personnel and provide a consolidated information for management objectives in smart management system, such as improving energy efficiency, profiling demand, maximizing utility, reducing cost, and controlling emission we explore to integrate home and building energy management systems.
Microgrid Energy Management System (MG-EMS) prototype which incorporates software applications that manage sensing data and perform load and generation management. In order to extend the microgrid to a full fledge smart grid prototype, the HEMS, BEMS, renewable energy resources typically PV and BESS can be integrated into the microgrid as shown in Figure 1 below.

II. LITERATURE SURVEY

The literature survey is conducted on different energy management systems fetching the data from the generation to consumption by using different means and approaches. Based on the different papers the smart energy management system (EMS) is studied for our study of Modern Smart Grid architecture. This literature survey forms the basis of our future study on some functions of Smart Grid in a Prototype model using NI LabVIEW, NI DAQ Hardware and NI CompactRIO.

LITERATURE SURVEY ON EMS FOR SMART GRID: Gujar, Mukesh..[1] et al.in this paper has presented the relevance of Smart Mini Grid as well as its existing challenges. It has also briefly pointed out the major initiatives taken by various institutions/industry in the smart mini/micro-grid sectors in India. The main purpose of this paper is to present the design of TERI’s own Smart Mini Grid system which integrated various distributed energy sources such as Solar PV, small wind electric generator Biomass gasifier system, Diesel-Set (DG) and showcase how such implementation can be used in other similar applications for improving the efficiency, reliability and flexibility of the overall system.

Yoshio Ebata [2] et al describes the paper proposes to apply the Intranet technology to SCADA (Supervisory Control and Data Acquisition System) for power system and presents the result of development of the Intranet-Based SCADA trial system. The Intranet-Based SCADA is concerned about real-time performance and reliability of supervisory control. How the trial system resolved these issues is discussed and various measurements at the trial system including picture display time, supervisory control response time and Fail-over times are presented. Real time performance, system cost and maintainability of the Intranet-Based SCADA are evaluated based upon the trail system. And the feature of the Intranet-Based SCADA such as failover between geographically separated servers and capability of supervisory control at night from another control center are discussed. Information security of the Intranet-Based SCADA that should be paid particular attention to is also discussed.

B. Qiu [3] et al describes the World Wide Web (WWW) has become a convenient way to access information on the net because the WWW browser integrates different network services into a common easily accessible user interface. These features coupled with low investment cost are especially suited for accessing information of the SCADA (Supervisory Control and Data Acquisition) system.

Yun Changqin [4] et al The architecture for SCADA/EMS/DMS presented herein makes the system much more extensible, and allows application modules plug-in and play even on line. The architecture adopts client-server computing and is based on “Service Bus” which serves as a middle layer between application modules and operating system, and is responsible for networking the system, codi grating the modules, managing the services provided by the modules, and establishing communication links between the modules for the system.

Gilberto P. Azevedo [5] et al explains in the software development area, as in most fields of the computer industry, new technologies are trumpeted as revolutionary solutions almost daily, just to disappear silently some time later. This was not the case with open-architecture energy management systems (EMS). About 10 years after their conception, they have proven to be a successful technological approach. But this does not mean that all
problems have been solved; in fact, this is a dynamic research area, in continuous evolution and still raising challenges for the near future.

Bin Qiu [6] et al describes the Load shedding takes place as an emergency measure in cases of falling frequency conditions or loss of power generation. Particularly in isolated (island) systems, due to lower inertia and limited reserves, the rate of frequency decay due to loss of generation can be more pronounced. Therefore, a more carefully designed load-shedding scheme is required in an island system than in a large interconnected system.

Rory D. Shaffer [7] explains the rate of change in the utilities industry is rapid and unrelenting. Deregulation has radically altered the environment in which companies operate, leading to fierce competition, major shake-ups in the market structure, and a flurry of mergers and acquisitions.

Lars Grasberg [8] et al describes the traditionally SCADA EMS DMS systems will evolve into concepts containing smaller independently released products. The different products will be adapted to emerging standards and may come from different vendors. There will be the traditional vendor that take full responsibility for the delivery and installation at the customer site and vendors that specialise on one or a few of the different products.

Rochelle A [9] et al describes Restoration of distribution systems is a complicated process, especially after storms, when a large number of outages can occur. Many utilities are implementing Automated Meter Reading (AMR) systems that can aid in the restoration process. This paper presents work done to utilize the capabilities and information provided by a wireless AMR system, including the on-demand read feature, to develop a polling procedure to identify system conditions. It takes advantage of the connection information provided by a utility and the performance of the wireless meter communication systems.

Donald J. Marihart [10] explains summary of the different communications technologies available for use or application with EMS/SCADA system projects. All of the various sing the most appropriate communication technology.

B. Stojkovic [11] et al describes the Each EMS (Energy Management System) relies upon the SCADA system that gathers power system data, processes them and issues control commands. Among the all control functions of an EMS, the AGC (Automatic Generation Control) is the most important one. A SCADA system is characterized by geographical spread, a great amount of data, a complexity of belonging equipment, but by a very long period for the finalization and a very high investment costs, too. The long realization period compared with the extremely fast development of the available computer’s hardware and software on the world’s market, coupled with a permanent need for EMS upgrades caused by privatization of electric utility companies and deregulation of the electricity market, coerces some smaller size electric power companies to think in a different manner. This paper describes that manner - a unique control application, developed and implemented at the real power system. The specific feature of this control system is that it is based on the relatively poor set of power system data (around 70 input data), but a very good overall observability is achieved (around 300 output process information).

C.pimpa [12] et al this paper present the type of expert system for controlling the 22kV voltage levels of power system in northern region of Thailand based on the SCADA system. At present, for the operation, the operators have to make decision by their knowledge and experience to control the voltage. This expert system is obtained for alleviation of voltage violation in the day to day of distribution substation in the system and process the data from the SCADA for helping the operator detect buses experiencing abnormal conditions.

Yan Liu [13] et al describes the advances in computer applications and technologies are providing more and more data about the distribution system that can be used for analysis. One new technology is Automated Meter Reading (AMR) systems. AMR systems provide access to the consumption and status of individual customers. This summary outlines research work to incorporate AMR information in outage management. The first technique combines AMR data with SCADA and trouble call data to identify an outage and then uses AMR polling to verify the outage and its level. The second technique provides a way to use AMR to confirm restoration of all customers below an out aged device.

Vikram Janardhan [14] describes on preceding analysis makes clear the impact that the deregulated environment is having on IT systems. The bar has been raised with regard to these systems’ ability to adequately map both market rules and the internal processes of a market participant. Traditional systems like the SCADA and EMS platforms are still an integral part of the overall market participant solution, but the deregulated paradigm has raised the need for a whole new vocabulary to define business management systems.

Zhaoxia Xie [15] explains the Analysis of 162 disturbances from 1979 to 1995 reported by the North American Electric Reliability Council (NERC) indicates the importance of information systems under the regulated and competitive environment. This paper points out the major deficiencies in current communication and information systems and proposes new power system information architecture aimed at correcting these deficiencies. The proposed architecture includes automation and control systems at all levels, from substation control system to independent system operator (ISO) operating center, taking into account the requirements of real-time data, security, availability, scalability, and appropriate Quality of Service (QoS). It uses multiple communication channels employing a wide variety of technologies to transmit real-time operating data and control signals.
Y. Serizawa [16] et al describes a conceptual design for a “Distributed Real-time computer Network Architecture” an architecture that provides seamless, real time, adaptive and secure connections between distributed power system devices, consisting of four functional entities: application programs containing power apparatus information objects with correlated global and local models, sophisticated communications function featuring distributed objects communication and mobile agent communications, IP based transport communication function with QoS control, and network management and security function.

Heike Laqua [17] et al describes Fast ethernet is a suitable candidate for a real-time bus. This has been shown theoretically as well as experimentally. The presented implementation attaches directly to the data link layer and is very efficient. We will implement a second version that attaches to the transport layer, i.e., the user datagram protocol (UDP) that will be less efficient but will allow a communication with devices that do not permit a direct access to the data link layer such as programmable logic controllers. Dedicated W7-X control stations running a real-time operating system will form a gateway between the two networks.

Torsten Cegrell [18] et al explains the power industry is undergoing major changes. Deregulation and a new competitive climates as well as a fast ongoing reorganization have caused an increased demand for effective computer based information systems in utilities. Important systems include SCADA/EMS/DMS/BMS systems, asset management systems, GIS systems, billing systems, call centre systems, traditional groupware and/or intranet solutions etc., to manage the evolution of the total enterprise information system, consisting of all these more or less interconnected complex systems is today a major challenge.

T. Seki [19] et al describes an idea for future EMS/SCADA for power systems application framework, scope, was proposed. The evaluation and verification result with the power failure information delivering prototype system was described.

Yang Ji [20] et al describes the integration of SCADA with AM/FM/GIS with on-line SCADA/AM/FM/GIS just monitor macroscopic run specifically of electric power take into account insulation run state and fault diagnosis situation of electrical equipment, so it has certain limitation. Mean time the classification and function of on-line monitoring system for electrical equipment are discussed in this paper, and a thought is proposed that integrate AM/FM/GIS with on-line monitoring system of electrical equipment. The new integrated system not only comprehensively reflect the run state of electric power system and equipment but also can monitor online insulation state of electrical equipment, so it has quite good economic and practical value.

Warren Wu [21] et al describes a number of advanced visualization tools that are currently in use in several control rooms. The techniques discussed here far exceed the capabilities of tools that use older computer technology and software development methods. Yet, these innovations merely suggest the promise and possibilities the technology holds. Some may argue that the map shown in Figure 1 is rather cluttered, particularly considering that the system it represents is so small. This is a valid argument. The primary intent of that map was to demonstrate some of the many tools a modern visualization engine offers. Furthermore, the map designer must use good judgment in selecting the best combination of tools to use for a display. Ultimately, the users who will use the display should be consulted, perhaps through a formal survey, at each stage of the design to ensure that they agree with and will benefit from the design choices.

J. Oyarzabal [22] et al explains a Micro Grid Management System developed using agent based technologies and its application to the effective management of generation and storage devices connected to a LV network forming a micro grid. The micro grid is defined as a set of generation, storage and load systems electrically connected and complemented by a communication system to enable control actions and follow up surveillance. The effectiveness of the proposed architecture has been tested on laboratory facilities under different micro grid configurations. The performance and scalability issues related to the agent framework have also been considered and verified.

Robert H Mcclanahan [23] describes the article has discussed improvements in cost/benefit and flexibility of both SCADA systems and corporate networks that can be achieved by combining the goals of the two onto a single, multipurpose network based on IP protocols. This allows the cost-justifications for these functions to be taken collectively, making the combined networking project more economically viable. Among these cost/benefit and flexibility improvements are the following: - The convergence of many types of services onto IP-based networks makes it possible to implement a single WAN that can meet most of a utility’s network needs between remote offices, including SCADA.

Wilson Pardi Junior [24] et al describes Object-oriented techniques have been increasingly used during the development of real-time industrial automation systems, both in modelling and simulation frameworks used in problem domain analysis and requirements engineering, as well as for implementing SCADA (Supervisory Control And Data Acquisition) systems. This paper proposes architecture for integrating supervisory tools into object-oriented frameworks for industrial automation applications. The ideas proposed have been implemented and integrated with an object-oriented framework for real-time industrial automation applications. Real case studies have been developed, including the supervisory control of a chemical plant’s prototype and the development of man-machine interfaces for food industry (pork processing plant).
D.P. Buse [25] et al describes a multi agent system on an IP network provides autonomy to each of the constituent parts of an inherently distributed power system.

Nosirev M.B [26] et al explains TINS is a software complex for realtime process control and visualization.

Janez Primozic [27] et al describes control in refrigeration systems. The goal of the article is to support refrigeration systems design and to define optimum parameters which influence refrigerating systems respectively. Basic task in my investigation was also an analysis of present offers and producers of control equipment for refrigeration systems. This equipment can be divided into two segments: the equipment for control simple refrigeration systems which consists of electronic thermostats for controlling elements of refrigeration rooms and miniature microprocessor devices used for controlling smallest compressor aggregates. The advantages of this equipment are its wide consumption, low cost and simple usage. Its disadvantages are inappropriateness for complex refrigeration systems in the sense of increasing COP and electrical energy economizing.

L. Shang [28] et al describes large amount data should be collected, transferred and stored for analysing, supervising and controlling the performance of power systems. The capability to compress the power system data is highly desirable. The wavelet transform leads to a new data compression approach. High compression accuracy, high compression quality and good denoising effect can be reached through the wavelet transform. Therefore, the wavelet transform can bring remarkable advantages to all fields in which big amounts of data are processed like fault recording and SCADA/EMS/DMS systems.

Michael C. Cannon [29] et al presented the process of delivering electrical energy may be viewed as similar to many other processes, in that the availability of real time "factory floor" information can improve the quality of the end product, while reducing its cost. The same systems that enable real time monitoring and control of the energy delivery process can also provide real time monitoring of substations equipment. The Electric Power Industry can now access the same type of information its industrial brethren have had for some time, and should consider the implementation of substation monitoring systems for both new and old substations.

J. Amarnath Reddy [30] et al explains the controlling functions in the SCADA EMS system are increasing with the expansion of the power system network as the demand for power increasing. It is difficult to control the functions with the centralized system and rely on a single vendor. This paper introduces the concept of open system and examines one of the distributed hardware configurations for open EMS. The proposed work modelled the above Contingency Analysis procedure for a case study of 6 Bus, II Line network, which was done by a dedicated application server on the pre-specified port.

Xu Hong [31] et al explains the distributed architecture based on Coho DCOM is well supported by Windows platform, and the OPC specification is mainly based on Coho DCOM technology, the distributed data integration using OPC technology is a suitable and acceptable choice. It is easy to design and implement. In our project, the designed Data Engine based on OPC specification has the characteristics of flexibility, upgradeability, openness and interoperability. It has a good performance in speed, efficiency and harmony.

G. L. Kusic [32] et al describes the Transmission line equivalent circuit parameters are often 25% to 30% in error compared to values measured by the SCADA system. These errors cause the economic dispatch to be wrong, and lead to increased costs or incorrect billing. The parameter errors also affect contingency analysis, short circuit analysis; distance relaying, machine stability calculations, transmission planning, and State Estimator Analysis. An economic example is used to demonstrate the effect of transmission line errors. SCADA measurements from several utilities are used to compute the 'real world' value of the transmission line parameters. State Estimation with the estimated parameters is compared to the computations using the theoretical values.

Anjan Bose [33] explains the power grid is not only a network interconnecting generators and loads through a transmission and distribution system, but is overlaid with a communication and control system that enables economic and secure operation. This multi-layered infrastructure has evolved over many decades utilizing new technologies as they have appeared. This evolution has been slow and incremental, as the operation of the power system consisting of vertically integrated utilities has, until recently, changed very little. For example, the monitoring of the grid is still done by SCADA (Supervisory Control and Data Acquisition) systems whose hierarchical design for polling data was appropriate for vertically integrated utilities and whose speed in seconds still reflects the conceptual design of the 1960s.

Mini S. Thomas [34] et al describes the paper reports a state-of-the-art Supervisory Control and Data Acquisition (SCADA) Laboratory facility for power systems at Jamia Millia Islamia, New Delhi, India. It has been designed to function as a research and training center for utilities, faculty members, and students. This paper covers the design, commissioning, and functioning of the SCADA/EMS laboratory facility, based on distributed processing technology. The SCADA laboratory will provide hands on experience to students and practicing engineers and will give them an insight into the contemporary SCADA systems. This lab is the first of its kind to be functional in India.

Bin Hua [35] et al describes this in order to reduce investment, Henan Electric Power Dispatching and Communication Center in China established a set of Henan Dispatcher Training Simulator (HNDTS) base on its exist SCADA/EMS. The general configuration and structure of
HNDTS is introduced. In order to integrated with exist SCADA/EMS, the integration method and technique are proposed. Graph data integration is discussed with emphasis.

Juan García [36] et al describes Use of advanced communication technologies, highly integrated control, and programming platforms drastically increases the performance of industrial control systems. That is the case of Motronic, where the synergistic collaboration between industry and academia has led to an advanced distributed network control system.

To be commercially successful, it needs to have a low cost and to be robust, even if this requirement implies that it is a custom design and not based on previously existing commercial solutions. Use of standards and off-the-shelf products lower development costs, but usually raise production costs. In this paper, we show that, in certain applications, design of a new system from scratch is more advantageous.

A. P. Sakis Meliopoulos [37] et al describes we propose a non-intrusive approach to transformer monitoring, evaluation and dynamic loading using the existing instrumentation infrastructure. The proposed approach is supplemented with visualization and animation software that provide a self-explanatory picture of the operating conditions of the transformer. This approach is very effective and very useful for power system dispatcher. It is believed that it will be a valuable tool for the control center.

The proposed approach and methodology is applicable to any major power system equipment. The real time model can be as detailed as desired. For example, the proposed methodology can be applied to estimate a detailed electrothermal model of a generating unit. This real time model, providing information about the load ability of the generator can be very useful to system dispatchers.

M. Kezunovic [86] et al describes In conclusion, the approach reported in this part of the tutorial has identified a new paradigm for assigning a business value to the data and information produced in the course of processing the energy. Integrating the data and exchanging the information may define several new business opportunities. The approaches of using the data and information may be revisited in the context of the goals of deregulation and more competitive, customer-focused industry. The resulting strategies may offer some new benefits and more efficient and versatile uses of data and information in the future.

S. Cavalieri [38] et al describes an overview on the main features of the CRAFT 1ST 1999-57455 project highlighting the internal architecture and implementation of the GI which is the component in charge to offer to clients a set of services not linked to a specific product and implementation. It was pointed out that the realisation of a Common Interface for the lower level applications in a plant is the main requirement to achieve Vertical and Horizontal Integration.

J. W. Hughes [39] et al explains in 2002, the Consortium to support an Electric Infrastructure to support a Digital Society (CEIDS) launched a project to take the initial steps in developing industry-wide reference architecture for distributed computing and connecting consumers to markets. The results of the project include a set of industry requirements for a variety of advanced applications ranging from wide area measurement and controls to ISO/RTO operations that can reach into consumer facilities and equipment. Through the use of systems engineering methods and advanced notation, the project developed a model of future industry operations that allowed the researchers to align requirements for advanced applications with emerging standards and technology development.

Xiaofeng He [40] et al describes the changing requirements due to privatization and deregulations have created needs for analysing information from different sources within DW. These needs require new high performance solutions represented by the new data warehouse of SCADA/EMS system and its characteristics and structure outlined in the paper. Utilities have started to take advantage of this new technique and many other plans to follow. As the industry gains experience from this new tool new applications will evolve on the SCADA/EMS system.

Felix F. Wu [41] et al describes the paper, we review the functions and architectures of control centres: their past, present, and likely future. The evolving changes in power system operational needs require a distributed control center that is decentralized, integrated, flexible, and open. Presentday control centers are moving in that direction with varying degrees of success.

Jelena Car [42] et al describes the SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. VIEW2 SCADA system, as a modern distributed supervisory-control system, is essential part of Energy Management System (EMS). This paper describes cyber and network security problems in SCADA system as a key role of overall system stability.

Terry Chandler [43] et al describes the technology and Power Monitoring knowledge base has had a very significant impact on AMR and Power monitoring in the past few years. Historically power monitoring systems have been either automated meter reading (AMR) or Power Quality and power usage (PQ) monitoring systems. As the network technology, communication protocols and computing power technology increased the costs have decreased and we are observing a merger of the system capabilities. New AMR systems combine some PQ functions and PQ monitoring systems include AMR functions.

Dean Craig [44] et al describes distribution automation technology has matured to the point where large scale, fully automatic systems are being successfully deployed. The
ENMAX feeder automation project illustrates how a commercially available distributed control system can be applied both strategically and tactically to improve system reliability. Distributed control is a good fit for feeder automation, providing a highly scalable solution with minimal infrastructure requirements.

Donald G [45] et al explains as it is intuitive that this is the time to interconnect existing and new communicating devices. It can be justified from safety, operations and maintenance viewpoints. IEDs, HMIs, touch panels, PLCs, SCADA, DCS, communications devices, and protocols are evolving daily, and hence, application engineers must remain informed of modern advances in these areas. Although the details presented above will change, fundamental concepts will not change. With a straightforward, common-sense approach, it is time to advance the industrial substation into the world of smart interactive communications.

C. Gaspar [46] et al describes the SMI++ framework is a powerful tool which, while merging the concepts of object modelling, finite state machines and rule-based reasoning, allows the implementation of homogeneous, integrated and fully automated control systems. Its inherent capabilities of distribution and scalability over large sets of heterogeneous platforms make it extremely well-suited to control very large applications. Yung-Hui Liu [39] et al explains some improvement works, including expansion of the grounding monitoring system composing analytical software will integrate in the next step. Detection and reduction of the grounding noise and electromagnetic noise will be the main work in the future.

Ray Klump [47] et al explains the ways to highlight threats to power system security by displaying data from phaser measurement units (PMUs) and SCADA data sources simultaneously. SCADA measurements provide a picture of the steady-state health of the system, whereas PMUs capture the faster variations that may indicate small signal stability problems. The software system described in this system gathers SCADA and PMU data and displays them on a geographic map of the system. The system uses contour plots to show the variation of a measurement with location, even when adjacent measurement points are widely spread.

Miller, Ann [48] et al describes the protection of critical infrastructure systems is a hotly debated topic. The very label “critical infrastructure” implies that these systems are important, and they are: they support our everyday lives, from the water and food in our homes to our physical and financial welfare.

Eric Byres [49] et al explains the use of firewalls between business and process control networks is often suggested as an ideal solution for plant floor cyber security. But research shows that few firewalls are properly configured and that many control system security incidents bypass the firewall. If firewalls are to be effective, guidance on how to deploy them in industrial settings is badly needed. The authors conducted a survey exploring the state of the art in industrial firewall deployment. Based on the survey results, four firewalls were configured, using one open-source and three commercial firewall products, and subjected to extensive analysis and testing. While the results indicate that commercial and open-source firewalls can be successfully used, the study also shows important differences between the configuration of firewalls in industrial and IT settings.

S. M. Dragojlovic [50] et al describes the Very minor number of the information system for power distribution on south-east Europe and underdeveloped countries has technical information system, business information system; geographic information system, billing system and accounting system unite into unique information system. Working on developing into this power distribution system is very hard; they have small information for their system. Our information system can be solution for many power distribution systems.

Thumanoo Paukatong [51] et al describes the in-house EGAT-SCADA provides us a useful tool for monitoring the transmission system. To display the power system network, three applications work together. RTDB serves the data accessing process for other applications. The advantage comes from the design to suit with the actual need of EGAT. The disadvantage is caused by the limitation in knowledge. However, this in-house development provides us a great opportunity to learn and enhance capability and knowledge. Moreover, the handicaps have been acknowledged and planned to be alleviated in the future.

A. Kalam [52] et al describes briefly outlined and explained the network securities vulnerability issues involves in SCADA and EMS. Several remedial actions to be taken to increase the security of SCADA network have also been presented. The complex architecture, interconnected nature and extreme sensitivity of SCADA mandate that utility organizations have a comprehensive plan for assessing and mitigating potential online vulnerabilities and threats.

Nuno Malheiro [53] et al describes the stresses the importance of online fault diagnosis in power transmission networks. Fault diagnosis can add support for decisions of the operator for service restoration. Other addressed issues are the problems of using a real SCADA system as an information source. These problems can be temporal, non-monotonic and of incomplete information. Architecture has been designed to provide decision support to Control Center operators, overcoming the problems of the SCADA. The SPARSE II system is presented in this paper as an implementation of the architecture and is installed in the Control Center of the Portuguese Power Transmission Network, integrated with the Siemens SINAUT Spectrum SCADA.

Andrew Golder [54] et al presents a remote data acquisition and control system that will allow students and researchers to perform an experiment using power systems hardware from any location with an active internet connection. There are four main components for this system: first, the power
systems hardware necessary to perform the experiment; second, digital control and data acquisition hardware; third, a software system composed of a server and client module that communicate data and control signals over the internet; and fourth, a safety system to protect local hardware and software systems from damage. This paper will focus on the development of the software system which allows for remote access.

Joao M. G. Figueiredo [55] et al. Houses are becoming intelligent in our days. It is expected that in the near future the instrumentation and automation solutions that have been entering in our cars, in the last decade, are going to expand into the house market. The future intelligent house is a system that interacts with its inhabitants showing information about the system state, alarm occurrences and making suggestions to overcome emerging problems. In this paper a two-level hierarchical control strategy is applied to an intelligent house. The developed control architecture is based on an industrial PLC network that is managed by a SCADA supervisor system. The first control loop is managed locally by each PLC, controlling its own process. Tests on a prototype are presented in this paper and the experiments show the capability of this two-level hierarchical control strategy to monitor and control intelligent houses, preventing accidents and improving home comfort.

B. Stojkovic [56] et al explains each EMS (Energy Management System) relies upon the SCADA system, which is characterized by a complexity of belonging HW & SW as well as the high costs. To preserve previous investments in a SCADA infrastructure, but to assure your SCADA/EMS system to "hold a step" with the innovations in this field, it's a good idea to build your system in a manner to be open for future changes and upgrades. It can be achieved by using open development tools, capable to provide low-cost, long lasting upgrades that can be performed from inside the Power Company.

Yang Haijing [57] et al explains the flexible SCADA in this paper is the enlargement and development of traditional SCADA, widens the data origination, and enriches data foundation of Power Advanced Software. Compared with the traditional SCADA, it has the following peculiarities: The broad data source it not only can collect the normal state information of power grid, but also dynamic data and fault data of power grid, and make possible to monitor and control in dynamic proceedings and analyse the fault element after the fault. Having the function of data management and intelligent analysis in substation.

Chun-Lien Su [88] et al describes a value-based economic evaluation method for DA was proposed in this paper to evaluate the Tai-Chung DA project. This method takes customer interruption costs into account in the benefit analysis and uses the present worth analysis to perform the project economic evaluation. The FDIR function appears to be most cost-effective; the distribution analysis and customer management functions may not be cost-justified based on quantifiable benefits, but may be justified if the intangible benefits are of concern. The methodology, used to find the candidate feeders for further feeder automation extension and determine the number of switch for a feeder, is also proposed in this paper. The study results have indicated that the implementation of the feeder automation is suitable for the feeders with the high values of feeder failure rate, feeder load, and feeder length. The industrial customers and overhead feeders are preferable for implementing feeder automation.

Zhihong Liu [59] et al describes To sump up, the power distribution automatic system in the Yangjiaping Power Supply Bureau builds a “digital network” by utilizing advanced computer technology. It can be used for realtime and direct mastery of the information of power network system and assisting personnel in service management and decision, for the purpose of performing effective and scientific management for power network, improving management quality and operating efficiency, reducing operation cost and ensuring the reliability of power supply.

Davidson, Euan M., et al [60] et al explains these reports on the use of multi-agent system technology to automate the management and analysis of SCADA and digital fault recorder (DFR) data. The multi-agent system, entitled Protection Engineering Diagnostic Agents (PEDA), integrates legacy intelligent systems that analyse SCADA and DFR data to provide data management and online diagnostic information to protection engineers. Since November 2004, PEDA agents have been intelligently interpreting and managing data online at a transmission system operator in the U.K. As the results presented in this paper demonstrate, PEDA supports protection engineers by providing access to interpreted power systems data via the corporate intranet within minutes of the data being received. In this paper, the authors discuss their experience of developing a multi-agent system that is robust enough for continual online use within the power industry. The use of existing agent development toolsets and standards is also discussed.

Stanley. A. Klein [61] explains addresses development of an open source toolkit for constructing secure, next generation (based on IEC-61850 and related standards), and SCADA systems for control of electric power transmission, distribution, and distributed generation. The toolkit will include basic SCADA and control center components. It can be used in a variety of ways such as building a starter SCADA for small utilities, providing local control at a distributed generation facility, and others.

Paulo S [62] et al describes the SCADA (Supervisory Control and Data Acquisition) systems play an important role in industrial process. In the past, these used to be stand-alone models, with closed architecture, proprietary protocols and no external connectivity. Nowadays, SCADA rely on wide connectivity and open systems and are connected to corporate intranets and to the Internet for improve efficiency and productivity. SCADA networks connected to corporate networks brought some new security.
related challenges. This paper presents an overview of the security aspects of this interconnection.

Kun Xiao [63] et al describes the focus of this paper is on vulnerabilities which exist in Supervisory Control and Data Acquisition (SCADA) systems. Cyber attacks targeting weaknesses in these systems can seriously degrade the survivability of a critical system. Detailed here is a non-intrusive approach for improving the survivability of these systems without interruption of their normal process flow. In a typical SCADA system, unsafe conditions are avoided by including interlocking logic code on the base system. This prevents conflicting operations from starting at inappropriate times, and provides corrective action or graceful shut-down of the system when a potentially unsafe condition is detected. The workflow will then contain functional and survivability knowledge of the underlying system. Failures induced by the introduction of malicious logic will be predicted by simulating the fault in the workflow. Modelling these modes of failure will be valuable in implementing damage control. This model is event driven and conducts simulation externally, hence does not interfere with normal functionality of the underlying systems.

Antonio Moreno [64] et al describes the Outage Management System (OMS) is one of the main components of a Distribution Management System (DMS). This research work has focused on outage location and service restoration, which are the main functions of outage management system. An efficient outage location method could dramatically reduce the outage duration and costs. Thus, a fast and accurate outage management system would be very important. Metering technologies and communications systems have advanced to enable the development of Automated Meter Reading (AMR) Systems. Outage management is one area where the AMR system can be very valuable. However, more information than the AMRs provide is necessary to locate an outage accurately. For this purpose an algorithm that makes efficient use information available from the distribution supervisory control and data acquisition (SCADA) and power line communication based AMR systems to locate the more probable outage sources has been developed. The algorithm also allows constructing a tree model of a distribution network from a data input table.

Ahmed Helmy [65] et al describes the Electrical energy consumers are demanding better customer service, higher power quality, higher energy measurement accuracy and more timely data. Utility companies all over the world are being forced to find solutions giving greater information on the population’s power consumption. The Automatic Meter Reading system (AMR) is one of the ways in which utilities are go-getting to achieve these goals. Power lines are one of the communication mediums used in the AMR system.

Hak-Man Kim [66] et al describes Cyber security problems of SCADA network of critical infrastructures such as electric power, gas and oil are very important against cyber attack and terrorism. Recently, research efforts to solve the problems have been progressed throughout the world. In this paper, flexible key distribution scheme is suggested for SCADA network using Multi-Agent System.

Hyun Sang Cho [67] presents energy management has become one of the emerging services in the area of residential network service. A smart meter is the most essential component of advanced metering infrastructure (AMI) that connects the home energy management system of individual residences and a smart grid that optimizes the production, distribution, and consumption of electric power. Power strip type smart meters can be used to not only monitor but also control the electric power consumption at individual power outlet ports in the power outlet directly. They can be used to control and effectively reduce standby power consumption by the application of the direct power supply control. However, the SMPT cannot be used to determine the location of appliances when the connections among SMPTs form a tree structure. In this study, we develop a mathematical model of cascade connections among SMPTs and propose a solution for obtaining the location information of the tree structure. The proposed method helps realize real applications of the SMPT for providing activity based context-aware home network services and energy management services.

Coalton Bennett [68] describes the variety of real world AMI smart meter networking scenarios. We examine the network performance as a function the following parameters: the size of the network, node scheduling, and polling interval (period) under normal conditions. Then we introduce malevolent agents to the network to demonstrate the effects of their actions. Although there are several inherent security related issues involving wireless network the most relevant and attacks to launch against the de facto networking protocols used by AMI smart meters is a black hole attack. Focusing on the black hole attack we demonstrate, through simulations, how to avoid these attacks by creating dedicated paths between the source (smart meter) and the sink collecting the information (access point). In addition to this, we simulate a network of nodes that use a hybrid routing protocol when time sensitive data is needed in order to ensure that outages do not occur due to excess demand.

Kwok Cheung [69] et al describes the vision of Smart Dispatch in the context of control center’s operations in the evolving smart grid environment. In particular, a new generation dispatch system to cope with the increasing uncertainties being introduced by distributed energy resources is proposed. The proposed dispatch system will provide a better holistic and forward-looking view of system conditions and generation patterns and help system operators to make better decisions. Such features are deemed critical for the success of efficient power system operations in the near future.

Valeriy Vyatkin [70] et al explains the an intelligent control architecture for the Smart Grid is proposed which combines two recently developed industrial standards. The utility network is modelled as IEC 61850 - compliant logical
nodes, embedded in an IEC 61499 distributed automation framework. We make the case that an incremental approach is required for the transition to the Energy Web by bringing intelligence down to the level of substation automation devices to enrich the applications that can be created using interoperable Smart Grid devices. Using Matlab-based simulation environment we demonstrate that the collaborative environment achieves self-healing through simple fault location and power restoration.

Jorge Arinez [71] et al explains that there are many types of Energy Management Systems (EMS) that may be found in the industrial, commercial, and residential sectors. These systems range from the largest and most complex ones found in power generation and industrial plants down to the smallest and simple systems utilized by the residential consumer of energy. Independent of the magnitude and sophistication of the application, each type of EMS has its own unique requirements depending on the user’s needs. The focus of this paper is on those EMS found in manufacturing plants. Traditionally, manufacturing firms have lacked complex energy monitoring and control systems when compared to the ones frequently found in electrical generating plants. This paper reviews the current technology level of EMS found in manufacturing firms and typical approaches to improving energy efficiency. The paper also provides a motivating mathematical example illustrating interdependencies that exist amongst multiple manufacturing domains that relate to energy consumption. Finally, various scenarios are presented describing the requirements for a highly integrated EMS capable of providing manufacturing plants with new efficiency and conservation opportunities. Such integration requirements will be better aligned with the goals of Smart Grid technologies compared to what is achievable with the system architecture of today’s manufacturing-based EMS.

Vincent J. Forte [72] explains many electric utilities are investigating or implementing a Smart Grid, which is expected to be the new industry platform. This is a work in progress for the industry and thus it is in the industry’s interest to discuss not only specific achievements but also the vision for this new platform. In this way industry norms for Smart Grid can be developed in an efficient and collective manner. This paper described National Grid’s vision for Smart Grid in its franchise area. It also described achievements to date with the self healing (DA) portion of the Smart Grid. Finally it described the manner that National Grid is implementing its vision including a proof of concept process and pilot location considerations.

Victor M. Zavala [73] et al explains we have presented an integrative study of weather forecasting, uncertainty quantification, and optimization based operations to analyse the economic impacts of adopting advanced weather forecasting systems at different operational levels of the power grid. Our studies suggest that costs and power losses can be reduced by incorporating accurate forecasts. In addition, our model validation studies indicate that WRF forecasts significantly outperform those obtained with empirical models, especially for medium- and long-term horizons.

Gary A. McNaughton, P.E [74] et al describes the interaction of customer network equipment and utility operations is an area of growing interest in the industry. There is significant potential for customers to be able to make energy choices that better suit their needs, both financially and to support societal goals important to them, such as those related to encouraging renewable generation or reducing carbon emissions. This paper discusses a potential structure for handling enterprise integration in utility operations and discusses steps that the Multi Speak Initiative is taking to develop standardized data objects and services to support these needs.

Amit Aggarwal [75] describes need for a Smart Grid if we were to deliver on the requirements of electric generation, distribution, and usage in the future. We have shown that Smart Grids build on the technologies of sensing, communication, and control. We have postulated a medium size distribution network and computed the bandwidth requirements of the communication facilities in the grid. Based on the assumptions we have used, we can already foresee needs for communicating at 100Mbps and above even for a moderate size distribution system.

J. Wang [76] et al describes the Calls to improve customer participation as a key element of smart grids have reinvigorated interest in demand side features such as distributed generation, on-site storage and demand response. In the context of deregulated market structures, these features can improve flexibility of demand, but at the cost of added uncertainty. Therefore, how to implement these features under deregulated power markets is worth consideration. To address the problems induced by the demand side participation features together with deregulated electricity markets, this paper presents a new bidding mechanism, which uses Price Elasticity Matrices (PEM) to model the concerned features. Three typical traditional bidding mechanisms are reviewed and compared with the proposed bidding mechanism. Multiple benefits induced are shown by numerical examples in a day-ahead wholesale electricity pool under real time pricing.

Farrokh Rahimi [77] et al describes the demand Response (DR) is an important ingredient of the emerging Smart Grid paradigm. Although much of the DR emerging under Smart Grid is targeted at the distribution level, DR programs are regarded as important elements for reliable and economic operation of the transmission system and the wholesale markets. In the context of Energy and Ancillary Service markets facilitated by the ISOs / RTOs, DR programs may be broadly classified as market-based or reliability based depending on the conditions under which DR is deployed: The former provide for DR vis-à-vis economic signals, while the latter are generally triggered under emergency conditions.

M. B. Lively [78] explains the Smart Grid includes automatic responses to events on the grid, responses such as
demand side management, the operation of storage devices, and the control of reactive power sources. Many of these actions will involve one party obtaining automated assistance from another party, often in a fraction of a second, and generally in time periods shorter than the settlement periods of conventional ISO auctions. Wide Open Load Following (WOLF) is a short interval formulary auction for unscheduled flows of electricity that produces short run marginal cost prices.

Albert Molderink [79] et al explains Increasing energy prices and the greenhouse effect lead to more awareness of energy efficiency of electricity supply. During the last years, a lot of technologies have been developed to improve this efficiency. Next to large scale technologies such as wind turbine parks, domestic technologies are developed. These domestic technologies can be divided in 1) Distributed Generation (DG), 2) Energy Storage and 3) Demand Side Load Management. Control algorithms optimizing a combination of these techniques can raise the energy reduction potential of the individual techniques.

M. Kezunovic [80] explains Substation automation has critical role in power systems. Substations are responsible for protection, control and monitoring functions that allow robust routing of power from generators to loads through a complex network of transmission lines. With the latest technology development, many intelligent electronic devices (IEDs) available in substations today are capable of performing enhanced functionalities new functionalities that go well beyond what the traditional substation automation solutions have provided.

Lucie Copin [81] presents here our contribution on designing data warehouse architectural models for massive and heterogeneous data, to be integrated in a multi-building intelligent energy management platform. Although a lot of work has been done on the subject, present tools and techniques still do not cover all the challenges we face when confronted to real time energy-related data management. This paper presents an overview of the related research work on data streams, data warehousing and ETL (Extract Transform Load) processes. ETL data exceptions will be our main point of focus. This critical subject has been rather left aside in research works.

A.R. Metke [82] describes to upgrade the electric grid to increase overall system efficiency and reliability. Much of the technology currently in use by the grid is outdated and in many cases unreliable. There have been three major blackouts in the past ten years. The reliance on old technology leads to inefficient systems, costing unnecessary money to the utilities, consumers, and taxpayers. This paper discusses key security technologies for a smart grid system, including public key infrastructures and trusted computing.

Nthonto [83] describes study focused on smart energy management using advanced metering infrastructure (AMI). The paper digs into AMI communication standards understood and proposed by power utilities and regulators. Furthermore, the paper discusses a study of different AMI communication networks architectures designed by various proprietors and compares these system architectures with requirements stated by utilities and regulators. Standardisation and collaboration is important to ensure interworking of equipment from heterogeneous manufacturers. Applying standardised principles in design of interfacing and communication technologies used to interconnect the AMI components promotes interworking of systems. For a system to be classified as an AMI system, it must meet certain functional requirements. It should provide a two-way communication between the utility and the consumer. It should have built in automatic configuration and control. The system should run over a communication network. AMI meters have connect/disconnect functions, and quality of supply reporting system. Other services AMI systems support are load control switch for load limiting capability, fault reporting system, and tamper detection for revenue protection. At control level, load management system and vending management systems are included. This paper reports on different proprietary architectures and analyses them in terms of functional requirements and need for standardisation. The AMI system communication network architectures are compared with standards defined by utilities in countries such as South Africa, China and the United States of America.

T. Sauter [84] describes Smart grids heavily depend on communication in order to coordinate the generation, distribution, and consumption of energy—even more so if distributed power plants based on renewable energies are taken into account. Given the variety of communication partners, a heterogeneous network infrastructure consisting of IP-based and suitable field-level networks is the most appropriate solution. This paper investigates such a two-tier infrastructure and possible field-level networks with particular attention to metering and supervisory control and data acquisition applications. For the problem of network integration, a combination of gateway and tunneling solutions is proposed which allows a semitransparent end-to-end connection between application servers and field nodes. Nevertheless, it is shown that the communication architecture is versatile enough to serve as a generic solution for smart grids.

Z. Ming-Yue [85] describes the decision to construct the smart grids around China, the power line communications (PLC) on the low-voltage (LV) distribution networks have become one of the potential technologies to commute the information between the end users and the power provider. In order to provide communications services with different priorities under the smart grids environment, it is a must to design a completely new PLC system with variable information rate, which means understanding of the LV PLC channel characteristics become vital. This paper presents the measurement results of channel properties of LV PLC systems after giving a general overview of the topologies for the typical LV distribution networks in China. The testing results show that the main reason influencing the reliable communication of high-speed data of power line is the attenuation of the high-frequency signal, which exhibits more obviously in the branch of power line.
It is almost impossible to use the frequency range from 10 to 20 MHz for the reliable communications from distribution transformer to end user, so it must be solved with the aid of such means as the repeater and the modulation schemes. Considering the signal's attenuation, the lower frequency range from 2 to 10 MHz is more suitable for the high-speed data access system. Based on the general topologies of the LV distribution networks, a new method with the help of the reflection matrix based on the multi conductor transmission line theory is proposed to model the channel transfer functions, taking into account of the source inner impedance matrix. The simulation results fit the measured data quite well and verify the feasibility of the proposed modeling scheme.

Gao, Cheng, and M. A. Redfern [86] have reviewed Smart metering technologies. Smart meter has the capability to realize the real-time voltage measurement and communication between the consumers and network controllers. The actual network status is observed, measured, reported and analyzed by smart metering technologies. The voltage control signals are issued to various voltage control devices such as OLTC to solve the voltage problems like overvoltage and undervoltage across the whole networks. Therefore, a more flexible and coordinated voltage control is performed in a Smart Grid to provide an improved power quality to consumers. They concluded that the number of sensors on a Smart Grid will be considerably greater than that found on existing power systems. The high speed of data sensing and communications through wireless communication systems will make the grid real smart. The smart metering can provide the necessary voltage information from both the suppliers system and consumer sites to provide near-real-time control.

The voltage control method may well change in the future as the control needs to be more flexible and smarter. However, with a high penetration of DG in Smart Grid, the impact on the voltage control is significant and making it more difficult to control steady state voltages. Meanwhile, the concepts of Smart Grids and Smart Metering offer the potential opportunities to improve the voltage control in the distribution network. The potential use of the data communication system as part of an OLTC voltage control strategy is going to be used to solve the voltage problems caused by DG. The smart metering can provide the necessary voltage information from all the monitors to the master control centre within a short time period to establish a near real-time control. The coordination of OLTC voltage control using Automatic Voltage Control Strategy and data wireless communication systems in smart metering is the basis for a new approach for high performance voltage control.

Moslehi, Khosrow, and Ranjit Kumar[87] critically reviewed the reliability impactsof major smart grid resources such as renewables, demand response, storage. They observed that an ideal mix of these resources leads to a flatter net demand that eventually accentuates reliability issues further. An architectural framework is proposed to serve as a concrete representation of such common vision to facilitate the design, development, and gridwide integration of various components as well as the emergence of standards and protocols needed for a smart grid. This architecture supports a multitude of fail-proof geographically and temporally coordinated hierarchical monitoring and control actions over time scales ranging from milliseconds to operational planning horizon. This high performance infrastructure can be thought of as a “super EMS” consisting of a network of networks.

Salehi, V.,[88] et al. have the objective to apply the concept of real time analysis of a smart grid and implementation it on a smart grid test-bed in the Energy System Research Laboratories to enhance the power system testing and validation scheme. This hardware/software based system includes implementation of control strategies for generating stations, as well as power transfer to loads in a laboratory scale reaching to 35 kilowatts, monitoring all system parameters and controlling various components developed in this setup. Laboratory experiments and their analysis give to understand the concepts of power system engineering fundamentals and the required demonstrations needed for smart grid implementation in the real world. This laboratory-based smart grid and its real-time operation analysis capability provide a platform for investigation of the most challenging aspects of actual real world power system and its operation in real time.

Fang, Xi,[89] et al in this article have surveyed the literature till 2011 on the enabling technologies for the Smart Grid. We explore three major systems, namely the smart infrastructure system, the smart management system, and the smart protection system. They have proposed possible future directions in each system. Specifically, for the smart infrastructure system, we explore the smart energy subsystem, the smart information subsystem, and the smart communication subsystem. For the smart management system, we explore various management objectives, such as improving energy efficiency, profiling demand, maximizing utility, reducing cost, and controlling emission. For the smart management system, most of the existing works aim to improve energy efficiency, demand profile, utility, cost, and emission, based on the smart infrastructure by using optimization, machine learning, and game theory. We believe that within the advanced infrastructure framework of SG, more and more new management services and applications would emerge and eventually revolutionize consumers’ daily lives.

Cheah, P. H.,[90] et al. have presented a web-based consumer energy portal (CEP) and home energy management system (HEMS) developed in Laboratory for Clean Energy Research (LaCER), School of Electrical & Electronic Engineering in Nanyang Technological University (NTU). The CEP developed will be deployed in NTU campus to provide home users at staff quarters with improved energy services such as electricity billing, outage detection and notification, metering information and energy analysis via websites, distributed generation (DG) aggregation for market participation, home energy management system (HEMS), Time of Use (ToU) pricing
scheme selection and demand response management (DRM). A ZigBee based HEMS has been developed with NI-LabVIEW software to take advantage of the CEP. With the CEP and HEMS, home users can manage their energy consumption wisely based on ToU pricing and increase in energy efficiency with the help of the DRM function. Simulation studies were done with the historical data collected from the smart meters installed at staff quarters to show the impact of implementing load shifting technique and incorporating distributed energy resources (DERs) such as Solar Photovoltaic (PV) system and battery storage system (BEES) for non contestable consumers in NTU. The CEP and HEMS proposed in this paper are able to provide a better electricity service. Better energy management will result in energy saving as well as increase in efficiency. Through the CEP, consumers are able to understand their energy use and electricity bill better and with the help of HEMS, consumers are able to control their energy usage and reduce their energy cost.

Fan, Zhong[91] et al. have presented an overview of the unique challenges and opportunities posed by smart grid communications, e.g. interoperability, new infrastructure requirements, scalability, demand response, security and privacy. The success of future smart grid depends heavily on the communication infrastructure, devices, and enabling services and software. They mentioned that it to be very desirable to have a single set of standards defining the interfaces, communications and data exchange formats for smart metering and smart grids in Europe. Although the roadmap of worldwide smart grid deployment is still not clear, it is almost certain that the future intelligent energy network empowered by advanced ICT technology will not only be as big as the current Internet, but also change people’s lives in a fundamental way similar to the Internet. As communication is an underpinning technology for this huge development, we envisage that smart grids will be an exciting research area for communication engineers for many years to come.

Rahimi-Eichi, Habiballah,[92] et al. discussed the Need for Energy Storage in the Smart Grid in their article. One of the major components in the smart grid is the energy storage which needs to satisfy several power and energy density criteria based on the characteristics of the application. For different applications, including short-term and long-term power support, various types of energy storage from flywheels to numerous battery chemistries are employed. The Battery Management System (BMS) not only actively controls the functions of the storage device to maximize its life, efficiency, and safety but also provides accurate estimations energy management system (EMS) unit. The EMS [6]–[8] is a unit in the smart grid, and also in EVs, that minimizes the cost involved in energy production, storage, distribution, plant maintenance, and operations, while maximizing lifetime, reliability, and safety. The performance of the EMS is only as accurate as the data provided by the BMS about the battery’s SOC, remaining useful life (RUL), round-trip efficiency, etc.

Gungor, V. Cagri,[93] et al. overviewed the issues related to the smart grid architecture from the perspective of potential applications and the communications requirements needed for ensuring performance, flexible operation, reliability and economics.

Lee, Wookwon[94] in this paper presented a small-scale prototype system of wireless networks and design details of the prototype system with a specific application to a Smart Grid system in mind. The author has presented a small-scale prototype system of wireless networks applicable to Home Area Networks for the Smart Grid. In this project, the teams successfully configured two types of utility meters and the wireless devices in order to deliver the usage data from the utility meters to a remote monitoring center. A GUI using LabVIEW for the remote monitoring center was successfully created. The objectives of this project are 1) to develop power- and water metering subsystems that collect usage data and 2) to develop a software-based graphical user interface (GUI) for a remote monitoring center. The GUI at the remote monitoring center is implemented on a Windows 7-based computer using LabVIEW as a design tool and collects and displays the usage of water and electricity at the target spots. The physical communication link between the wireless communication device and the GUI is realized in two different modes of operation: Ethernet-based and USB-based.

Mehmi, Sandeep,[95] et al has discussed Inadequate infrastructure network, storage and compute servers availability towards challenge for accomplishing the SG vision in India. The unprecedented advantages: ubiquitous computing, on demand self-service, scalability, pay-per-use model has made cloud computing, a potential to be integrated with SG. The SG cloud proposed by the authors has capability to reduce generation operation costs, defer generation capital investments, reduce equipment failures, reduce distribution maintenance costs, reduce distribution operations costs, reduce electricity theft, reduce electricity losses, reduce electricity cost to consumers, reduce major outages, reduce restoration costs and reduce SOx NOx emissions. Though cloud computing relieves the burden of upfront cost and maintenance cost of the data centers, it also relinquishes the owner's control on data. Outsourcing the data brings confidentiality, integrity, availability, accountability and privacy issues that may be exploited by attackers.

Khan, Muhammad Faisal,[96] et al. are of the opinion that Smart Metering Infrastructure can help in addressing the energy deficit as well as effectively support the energy management. This paper focused on a roadmap for smart metering deployment for Indian smart grid and describes the AMI technologies, Interoperability standards for AMI, and features of smart grid pilot projects in India with deployment functionalities/technologies and deliverables of pilot projects. This paper also discussed emerging technologies like Internet of Things and their utilization for smart metering infrastructure and gives the details of open protocol standard stack for smart metering. It also provides valuable information and research inputs for the
development of the new products/technology solutions for smart metering infrastructure utilizing the emerging technologies.

Datta, Alekhya,[97] et al. have underlined the present scenario of those selected Smart Grid pilots in India, including proposed state-of-the-art Technology Integration, Consumer Coverage (Base), and Key Performance Indicators (KPIs). This study will also capture the Carnegie Mellon’s Software Engineering Institute (SEI) Smart Grid Maturity Model (SGMM), developed by the Global Intelligent Utility Network Coalition (GIUNC) as a management tool, towards the Smart Grid transformation to assess the performance (including, current status) of those utilities responsible for pilot demonstrations and provide necessary recommendations to use this framework for establishing future strategies and work plans as pertain to Smart Grid implementations in the country. The purpose of this research will further emphasize on the progress of applicable Smart Grid interoperability and standards relevant to the Indian context, development of indigenous low-cost smart solutions, gap analysis and appropriate changes conducive to the deployment of Smart Grid pilot projects, and discussion on National Smart Grid Mission (NSGM) in India.

Song, Xujiang,[98] et al. have included an optimised technical design of a smart grid electricity use monitor and a more efficient algorithm for data collection, processing and presentation for professional users. The benefit of having such an efficient design is that users can process and utilise data among terminals and networks in an appropriate and effective manner, and thus increase the utilisation rate of electrical power and quickly detect power network faults. In addition, the optimised data processing and forecasting algorithms employed by this electricity monitor will guarantee a more precise data analysis and will result in an optimised decision-making process at the generation terminal. In particular, the models developed or improved in this use monitor include: the power demand forecasting model, operational status estimation model, thermal model, capacity model of oil-immersed transformers and an enhanced early warning mechanism based on these innovative models. All these models are beneficial for making a robust EMS.

El-Kanj Baitie, Hania, and Tarek Selmi[99] recommended that intelligent interfaces be linked and connected to the PV system to empower the grid with ability to handle two-way flows of power and communication. This implementation is required and will permit the seamless integration of solar technologies in high-penetration developments. In this paper, the authors aimed at reviewing the smart grid characteristics in the light of integrating renewable energy. In accordance, a wide research is conducted in the market to check the availability of different transformerless inverters that are compatible with solar PV applications. Following, a comparison between the features of selected inverters and those of smart grid is obtained. Consequently, a detailed description as well as the simulation of the designed transformerless inverter is demonstrated in this paper.

Rasoul, Mohammad,[100] et al have aim to reduce consumers cost and Reduce Fossil Fuel consumption in a smart grid with smart houses which are equipped with Electrical Hybrid Vehicles (PHEVs), and also to reduce load peak in consumption peak hours and to reduce application of fossil fuels. In the present paper, a new optimization method based on demand management was presented in order to reduce cost, load peak and PHEV charging coordination using a game theory and non-cooperative game. Based on this game, to achieve Nash equilibrium system, each user to reduce its cost should inevitably charge its car in low consumption hours and save the electricity in battery during day using his solar cell, and utilize the energy saved by solar cell and PHEV at peak consumption hours at a time.

S. Deilami,[101] et al, have proposed a management solution to improve voltage profile in smart networks. In this plan, the proposed management algorithm has utilized different valuations of electricity in different hours of a day. This forces users to charge their machines at initial hours of a day. Its another way of involving the consumers to participate in the EMS.

Pereira, R.,[102] et al have developed an energy management system with integration of smart meters for electricity consumers in a smart grid context. The integration of two types of smart meters (SM) were developed: (i) consumer owned SM and (ii) distributor owned SM. The consumer owned SM runs over a wireless platform – ZigBee protocol and the distributor owned SM uses the wired environment – ModBus protocol. The SM were connected to a SCADA system (Supervisory Control And Data Acquisition) which supervises a network of Programmable Logic Controllers (PLC). The SCADA system/PLC network integrates different types of information coming from several technologies present in modern buildings.

Charly, Atheena,[103] et al have, in this paper, suggested development of a low-cost and flexible GSM - ZigBee based energy management controller which implements demand side management at consumer level. Each home has to be installed with this controller which communicates with the utility through GSM. Major power consuming devices in home are to be installed with local controllers which control the operation of each appliance. ZigBee communication is established between the energy management controller and local controllers. Upon receiving command from Utility, the energy management controller implements load control and shifting of loads to off peak times according to the consumer preference and automatic control of loads based on the energy consumption data received from energy meter is also implemented. Graphical User interface (GUI) is developed at the utility level for easing distant control from the utility side. Control is also provided from the mobile phone of the house owner.
Arboleya, Pablo,[104] et al This paper includes a new concept for making a building self reliant by integrating in Micro-Grids(MGs) with zero grid-impact so improving the MG efficiency. These aims are shown to be achievable with an intelligent system, based on a dc/ac converter connected to the building point of coupling with the main grid. This system can provide active and reactive power services also including a dc link where storage, generation, and loads can be installed. The whole building worked as a two coordinated small MG or as a dispatchable load or generator.

Mahmood, A.,[105] et al have proposed a home energy management (HEM) scheme based on appliances coordination for future smart grids. This scheme is based on communication among home appliances, a central energy management unit (EMU), smart meter and the storage unit inside home. A wireless sensor home area network (WSHAN) using ZigBee protocol is employed for relaying messages among different entities involved in our proposed HEM scheme. The performance of WSHAN is analyzed with respect to different networking properties. HEM implementation will lead to socially and economically beneficial environment by addressing the consumers’ and utilities concerns. Increased savings, better peak load management and reduction in peak to average ratio are some of the benefits achieved by proposed scheme. Appropriate use of HEMs in a system integrated with distributed resources along with appliances co-ordination and dynamic pricing scheme provides the optimized solutions for energy management issues in smart grids as confirmed by simulation results.

Tushar, Wayes,[106] et al have explained the benefits of distributed energy resources in an energy management scheme for a smart community consisting of a large number of residential units (RUs) and a shared facility controller (SFC). The authors have proposed a suitable system model in which can facilitate the considered energy management between the SFC, RUs, and the grid through a Stackelberg game.

MAIN OBJECTIVE: The main objective of this paper is to review the work already attempted by various research personnel and provide a consolidated information for management objectives in smart management system, such as improving energy efficiency, profiling demand, maximizing utility, reducing cost, and controlling emission we explore to integrate home and building energy management systems (HEMS, BEMS), solar PV technology, and energy storage with the microgrid. The power consumption data is accessible to the consumers through the Web portal and on handheld devices so that they can track their power usage by device, room, equipment, Plant or appliance, which helps better regulate power consumption. The key is to decide whether the demand is off-peak, midpeak or on-peak dynamically and relay this information to smart appliances of select customer groups based on available supply. Integration of home and building energy management systems (HEMS, BEMS), solar PV technology, and energy storage with the microgrid is also discussed in this paper.

III. SUMMARY

A detailed literature review of nearly 100 odd papers from International and national journals clearly indicates that, it is worthwhile and high time to carry out research work on energy management of our present power system. Improvement in smart grid as a whole, the advancement in its constituent parts like smart meter, distributed generation, communication system (ICT) is essential. Various methods ranging from structural modification of grid and its components to the use of mathematical tools and advanced artificial intelligence based algorithms can used for improving the performance of smart grid. Various management objectives in smart management system, such as improving energy efficiency, profiling demand, maximizing utility, reducing cost, and controlling emission has been discussed. Proper management of various DG will be the key to success of future Smart Grid EMS.
The authors believe that there is an ample opportunity to explore the integration of home and building energy management systems (HEMS, BEMS), solar PV technology, and energy storage with the microgrid.

The above literature clearly concludes that for improvement in smart grid as a whole, the advancement in its constituent parts like smart meter, distributed generation, communication system (ICT) is essential along with proper EMS. Various methods ranging from structural modification of grid and its components to the use of mathematical tools and advanced artificial intelligence based algorithms can be used for improving the performance of smart grid. Less cost and simpler design with minimum maintenance are the requirements of SG on which future research can be carried out. Thus using better and advanced method in each of the above mentioned fields will surely result in a highly secure and reliable smart grid which will be capable to meet future energy demand efficiently.

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