Advance Technics, Challenges and Developments in Smart Grid System

S.Ganesh Kumaran, S.Singaravelu, K.Vivekanandan

***Abstract*—Smart grid is emerging power system technologies with ensured reliability, efficiency, security and interoperability. This extensive system has many features on transmission and distribution facing a lot of challenges on the constraints like integrated communication system, advance measuring and sensing system, advance control methods, advance grid components, advance interface and decision support. This paper gives about the techniques, challenges, developments on the key strategies mentioned above and based on the literary surveys made..**

***Index Terms*— smart gird control techniques, challenges, developments, integrated communication, grid control, grid components, grid system support.**

I. INTRODUCTION

The smart grid is a planned nationwide network that uses information technology to deliver electricity efficiently, reliably, and securely. It also called "electricity with brain", enables a two way communication, two way flows of Energy and information. It has some of attractive features. Unlike the existing grid, smart grids have the capability of self monitoring, self healing, pervasive control and adaptive islanding, enhanced interoperability. The self healing concept briefly given by Schneider *et al.* [36] and the interoperability concept and its impact on SG given by Sortomme *et al.*[1].

Smart grid system which integrates the different form of Distributed Energy Resources (DER) to optimize the Energy as produced and delivered effectively given by Moreno et al.[39] Conejo *et al.* [27] talks about the Demand Response (DR) which enables peak sharing, Profile shaping with exclusive control and maintenance by keeping a good power quality. Integrated communication system through many technologies like Distributed Automations System (DAS) given by Mc.Granaghan *et al.*[17], Advanced Metering Infrastructure (AMI) given by Hart *et al.*[9], which makes the greater communication between utility, consumer and operators. Cyber Secured communication through many soft technologies like data supervisory control and Energy Management System (EMS). The demand profile shaping, peak sharing which optimize the cost of generation and also increase the consumers by attractive variation real time pricing technologies. Very important aspect of these integrated renewable / distributed energy resources is it reduces the Carbon Emission (CO_2) unlike that of the existing fossil fuel based generating system.

Manuscript received October, 2013.

Mr.S.Ganesh kumaran, Assistant Professor, Department of EEE, Arunai Engineering College, Affiliated to Anna University, Tamilnadu, India.

Dr. S.Singaravelu, Professor, Department of EEE, Annamalai University Tamilnadu, India.

Mr.K.Vivekanandan, PG Scholar, Department of EEE, Arunai Engineering College, Affiliated to Anna University, Tamilnadu, India.

II. OVERVIEW

The Fig.1 shows the overview of Smart Grid (SG) techniques, challenges and the developments under the key strategies.

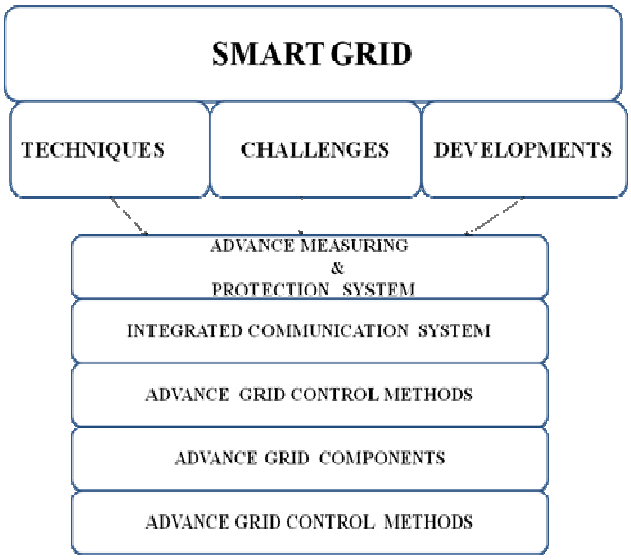

Fig.1 Smart Gird Overview

The smart grid establishes its growth widely with its attracting features Fig.2 shows the road map on world wide SGs by Information Clearing house [42].

Fig.2 The Road Map By Information Clearing House

The SG based on distributed energy resources and its effective utility Fig.3 by Worldwide Distributed Energy Resources (WWDER) The energy report [43] shows the different energy resource and its contributions. SGs have many associated models with it among these Fig.4 shows the widely accepted model made by National Institute of Standards and Technology (NIST) [41].

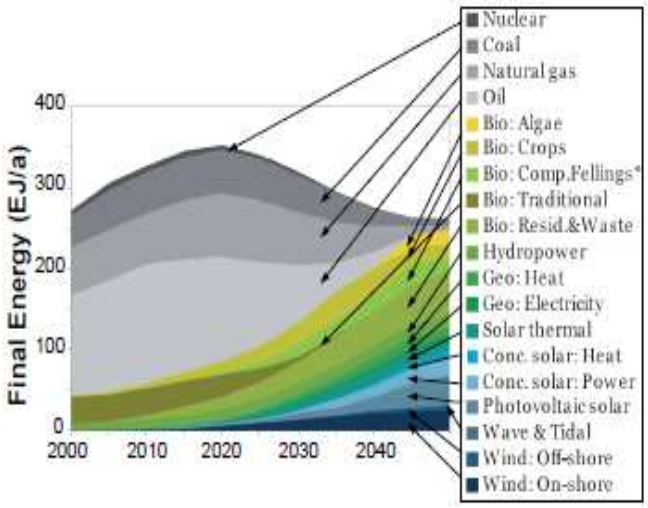

Fig.3 Worldwide Distributed Energy Resources

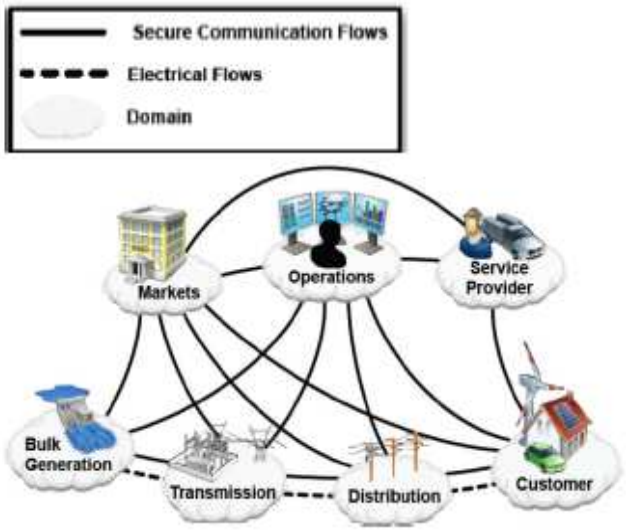

Fig.4 NIST Conceptual Model

A modern smart gird system which utilizes advance techniques as follows.

(1) Integrated communication.
This includes wired, wireless [11] technologies, fiber optic and radio communication system with its techniques, challenges and developments.

(2) Advanced measuring and sensing system and protection system.
This includes different metering, sensing devices with its techniques, challenges and developments.

(3) Improved grid control methods.
This includes DAS, Phasor Measurement Unit (PMU) etc with its techniques, challenges and developments.

(4) Advance grid components.
This includes Distributed Energy Resources (DER), Automatic Metering Reading (AMR) and Energy Management Systems (EMS), DR unit with its techniques, challenges and developments.

(5) Advance interface and decision support.

This includes Home Area Network (HAN), Wide Area Network (WAN), Meter Data Management Systems (MDMS) by Ibars *et al*. [29], Electric Hybrid Vehicle (EHV) etc with its techniques, challenges and developments.

III. ADVANCED MEASURING, SENSING AND PROTECTION SYSTEM

A. Techniques:

Fig.5 shows the general overview of the measuring and protection system based on techniques challenges and developments.

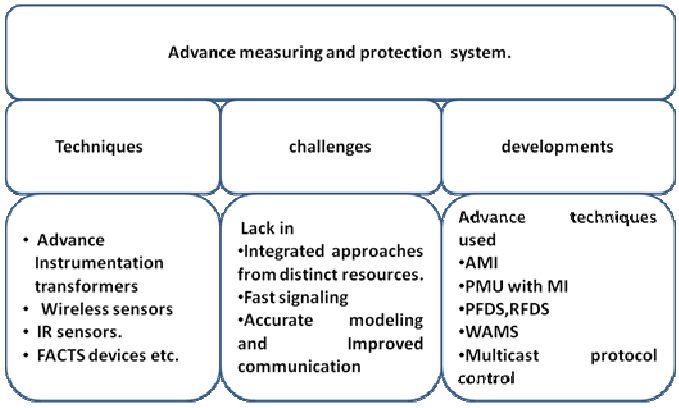

Fig.5 The Overview Of Advance Measuring And Protection System

The Fig 6. Shows the world wide usage of smart meters [45] and its growth during the year and its scope on future.

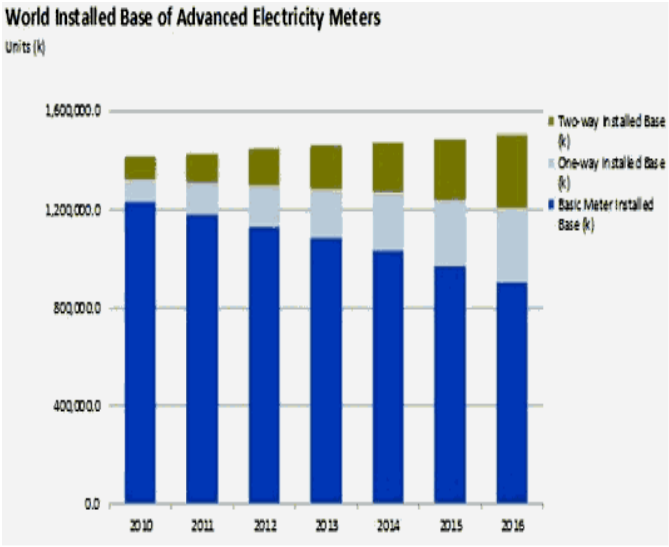

Fig.6 World Installed Base Of Advanced Electricity Meters

North American Electrical Reliability Corporation (NERC), Power System Relaying Committee (PSRC), Institute of Electrical and Electronics Engineers (IEEE) reliable organizations develops many standards , set of rules and design and implementations on protection, remedial actions available in western interconnection[7], Energy Independence and Security Act of 2007[2].

R. Leon *et al.* [10] [11] explained about Wireless Intelligent System Sensors (WISS) which used to access of data's reliably in time. These are comes under many technologies radio briefly given by Britz, Deep *et al*. [20] [21], Infra Red (IR), web based powers system monitoring. Back setter's technology for operating the sensors. Advance instrumentation transformers fiber optic and Current Transformer (CT), Potential Transformer (PT).Transformer monitoring system which helps in dynamic measurements of

temperature current sophisticated monitoring, Load Tap Changer (LTC) saving oil, gases discharge measurements. Circuit Breakers (CB), cables, battery charging explained by Elbakush *et al*. [40] also real time monitoring system and its measurements. Advance protection explained by D´an *et al.* [33] system with intelligent electronics devices. relays with wide range of operating conditions with new technologies with International Electro technical Commission (IEC) 61850 standards. Overman *et al.* [38] talks about Advance over head line protection system that senses create operating pulses in time significantly reduce the fault current and voltage sags on the faulted line. that sense power system operating conditions perform calculations the risk and access to the grid. Waveform analysis that senses traveling current waves from the fault locations which helps to identify and clear fault locations and island. DONUT advance measuring platform for real time data acquisition system. Wide area protection real time data measurements and improved communication based on PMU. Wide Area Measurement Systems (WAMS) synchronize the data's and stream data's in real time basis with Phasor Data Concentrator (PDC) by Armenia *et al.* [12] and PMU. Radio Frequency Identification Devices (RFID) given by Ghassemi et al.[23]is a code type technology for security, portion of electromagnetic spectrum are used to transmit the signals. Distributed series impedance devices on each tower can measure the sag, temperature, dynamic ratings .Differential Global Positioning Systems (GPS) also used Visual Basic (VB) based grand line program. Partial Detection Online with Localization (PDOL) system locates the partial discharge location in time from the complete Medium Voltage (MV) cable system.

B. Challenges

Reliability and security of power infrastructures required according to National Infrastructure Advisory Council (NIAC) with deduced disruption. Integrated approaches for handling all distinct resources and its data's, valid model required with flexibility in the dynamic conditions. These will ensure reliability and power quality. Improved performance metrics will derive utility investments, fast signaling approaches required for good services, both are cost-effective. Accurate system models for different system with legitimate communication protocol and taxonomies to be arrived meld models required for wide range data's and should be validated. Improve communications required to meet the industries, factories, domestic areas etc .wide range of communication needed. Lack in public, utility communication to be reduced. Cost effective optimized solution models to be created with referred to a good standard.

C. Developments:

PMU with Mutual Information (MI) will enhance the communication of distinct systems helpful in DER, DR utility efficiently a self calibrating, discriminating algorithm will be helpful. Fault Diagnosis Schemes (FDS) are used for determining the performance, improvements and deteriorated system and its impact can reduces the outages. Online monitoring scheme [33] for periodic measurements of voltages, current, frequency with a standard database. Robust state estimation algorithms can detect malicious data while monitoring real time system. Multicast protocol control will help demand response, Wide Area Measurement (WAM), substation, protection and control. Multicast model of different Vehicle to Grid (V2G) given by Clement, Hutson *et. al* [26] [28]batches at a time instead of individual V2G, a one signature verification (UBAPV2G). A fault steady state component –based method for identifying fault branch, helps in forming Protection Correlation Region (PCR), analyzing network before and after occurrence of fault with Fault Clearing Factor (FCF), PMU placement.

IV. INTEGRATED COMMUNICATION

A. Techniques:

The Fig.7 shows the integrated communication with the required techniques and its challenges and its improvements.

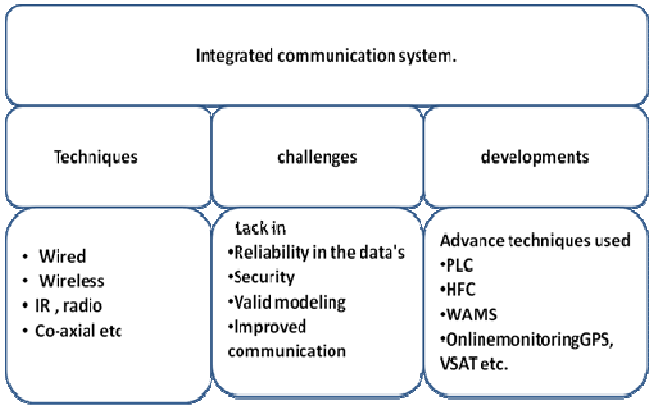

Fig.7 The Overview Of Integrated Communication

Fig.8 shows the intelligent scheduling utility network and its coalition all over the world.

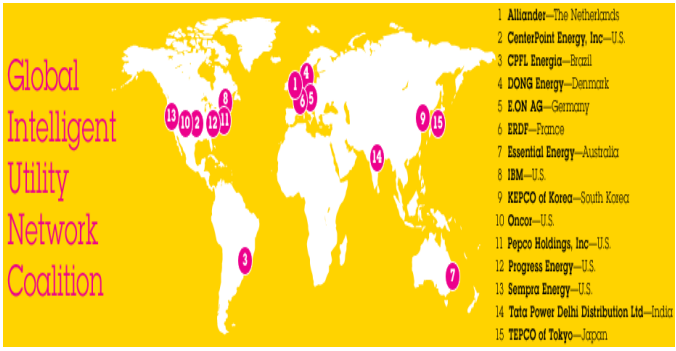

Fig.8 The Intelligent Scheduling Utility Network

Power Line Communication system (PLC) Barmada, Corripio *et al*. [14] [15] used for one way communication provides centralized load control, peak shaving. N.Bressan gives the requirement of wireless [11] sensor communication network HAN includes with zigbee application used for monitoring, home and commercial building automation. Programming Logic Control (PLC) [14] will enables the determination of exact position of faults located on SG network. Supports grid control [38] initiatives as load shedding. Narrow band PLC used for low speed applications like Automatic Meter Reading (AMR) supports communication interfaces. Hybrid Fiber Coax (HFC) cables used for voice, data, and video transmission from head end or central office to an optical node serving a neighborhood. Asymmetric Digital Subscriber Line / Digital Subscriber Line (ADSL/DSL) uses twisted pair coaxial cable high speed data communication. Wireless Fidelity Internet (WIFI) using

wireless Hochgraf, Akyol *et al.* [18][19] broad band network technology which uses IEEE 802.11x standards. Utilized for small distance communication, expensive. Wimax also used for more than 100meter.upto 30miles uses IEEE802.16 standards. Zigbee suites for high level communication protocols using small low power digital radio signals based network. IEEE8002.15. its main driver for HAN networks. And Investor Owned Utilities (IOUs) uses zigbee as HAN standards. Fiber To The Home (FFTH) broad fiber optic Gungor *et al.* [16] [17] connection uses Passive Optical Network (PON) technology require less electronic devices for measuring and controlling. Radio Frequency Identifications (RFID) [20] [21] identifies any things/living beings contact in the system by the use of electromagnetic or electrostatic coupling in the Radio Frequency (RF) portion of the electromagnetic spectrum. Cellular [18] [19] SMS functions can be applied to provide low-cost substation automation for monitor and controlling purpose. PMU concept explained by Best *et al*. [13] optimization and their infrastructure used for state estimation problems. Broad band over Power Line (BPL) communications allows digital data communication by using modulated high frequency radio waves. Intelligent managing tools will help for managing loads, sharing, efficiently reduces the cost of maintenances and cost of productivity.

B. Challenges

There is a need of multi physic approach since subsystems are tightly interconnected cannot be simulated easily. There is a need to support of multi disciplinary approach from different aspects like control, power flow and communication to get perfect completion. Dynamic and reconFigurable model required to meet the challenges of update. High level graphic visualization to support system since analysis needs a different visualization for a system. The uncertainty propagation required in the various sources, design depends on static and dynamic state estimation.

C. Developments:

Satellite explained by Deep *et al* [22] technology used for accurate positioning , precise timing through remote monitoring system obtained by GPs, Very Small Aperture Terminal (VSAT), Low Earth Orbiting Satellite (LEOS) The service reliability, power quality is improved by proper communication infrastructure reduced outages and block outs ease awareness of consumers. Effective communication gives real time ensured data helps in transmission, consumption of power with price consideration and also helps in decision making to replace worn out parts of the system. Reduces the losses in power transfer, carbon emission by improved communication. Improved asset data's, greater reliability reduces the cost. Wireless Token Ring Protocol (WTRP) is distributed protocol gives flexible in the control networks used for protection systems. Integrated security frame given by Cho *et al*.[32] work handled by physical and logical security systems for real times support and scheduling.

V. ADVANCED CONTROL METHODS

A. Techniques:

The Fig.9 shows the advance control system and the techniques used, challenges, developments associated with it.

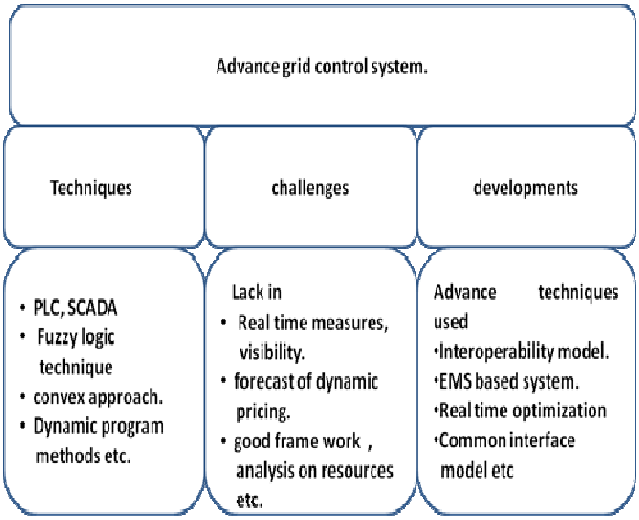

Fig.9 The Overview Of Advance Grid Control Methods

Fig. 10 shows the energy management system spread all over the world and its growth.

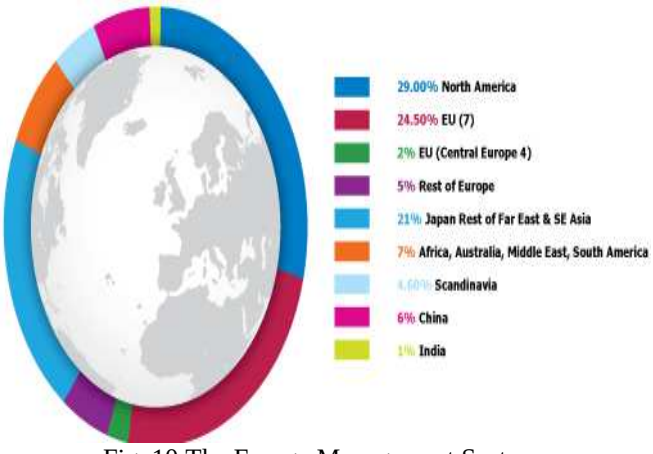

Fig. 10 The Energy Management System

The major constraints on control is the ease of access points to give a reliable solutions, there were many methods of deducing the complexity of finding solutions with large number of nodes. Islanding used when a section of the grid loads and DER made it being grid-connected to operating independent of the grid.

Barmada,Corripio *et al.*[14][15]gives bout Supervisory Control And Data Acquisition (SCADA) supervisory controls has integrated features that provide short term load forecasting, advance interface and load management. Fuzzy logic is set of fuzzy theory with its approximate reasoning apart from the classical predicate logic. The program based optimization techniques plays a major role in minimizing cost of generation and consumer utilization with a good operable solutions. Convex optimization. , details given by Kallitsis *et al.* [24] problem are focused to optimize the cost of utility, generation, delay operation cost. The dynamic programming ,the stochastic approach gives real time solution for time varying systems given by Anderson *et al.* [25]method which gives the optimal and possible interconnections between load and source points reduce the size of the problems these methods can legitimately gives good day to day solutions on daily load forecasting. The advance automation of systems that yields attractive control on integrated communications Substation Automation (SA), Distribution Automation (DA),

uses integrated communications with smart sensors gives a real time monitoring to fix malfunction and deduce the outages in time. Distribution Intelligent Control System (DICS) with its capability to perform parallel communication with number of independent systems improves Self healing [36] of the system and awareness to the operators. GRID SAT is a flexible power grid communication architecture that provides power grid data's with a common platform instantly to utilities, brokers, end users , participants Wide Area Management System (WAMS) used for monitoring power grid performance and provides quality data's and analytical tools for the operators. these are in service in the west.

B. Challenges

Although many advance techniques gives the reliable control on the system and gives ease way of handling issues to the operators there were many technical challenges always there. The lack in real-time measurement and visibility of non-generation resources. The lack in the best data handling system with availability of real time and ensured data to make efficient control in system. For modeling and analysis the valuation, poor concentration on modeling methods for load forecasting dynamic pricing, a bit reluctance on the acceptance of results under uncertainty which lead to poor decision making. Determination of appropriate technologies to be used on the utility management system lack in consistency and credibility. There is no specified or consolidated framework that enables a good mapping of resources and theirs need for optimized techniques to meet the interoperability challenges.

C. Developments:

A protocol based frame work to determine the best method for energy management and control system to be used its been accepted as effective one. More developed technologies to meet a good optimization dispatch of loads to obtain a real time business solution with DER. SCADA/EMS Energy Management Systems (EMS) system nowadays gives a secure fire wall conFiguration between operational and administrative parts for reliable control and utilization of data's. Sortomme *et al.* [1] gives about the interoperability concept improves the ability of diverse system together to perform co-operative tasks, exchange information effectively. The Common Information Model (CIM) can also be used to represent the node-break level information ease way of representing off line bus branch model, exchange of information. Insulation Displacement Connector (IDC) based optimal hedging model gives an optimal solution on distribution network given by Caldon *et al.*[5] helps in decision of risk , price based on work load uncertainty. Real time optimization two stage model for calculation of voltages, phase angle variation using Newton Type Algorithm (NTA), Lest Square Approximation (LSA) based on instantaneous power frequency at low sampling rate.

VI. GRID COMPONENTS

A. Techniques:

The Fig.11 shows the advance gird components and its techniques, challenges and developments associated with it.Fig.12 show the management tools and its impact on a management system. Fig.13 shows the increasing utility of renewable energy resources worldwide.

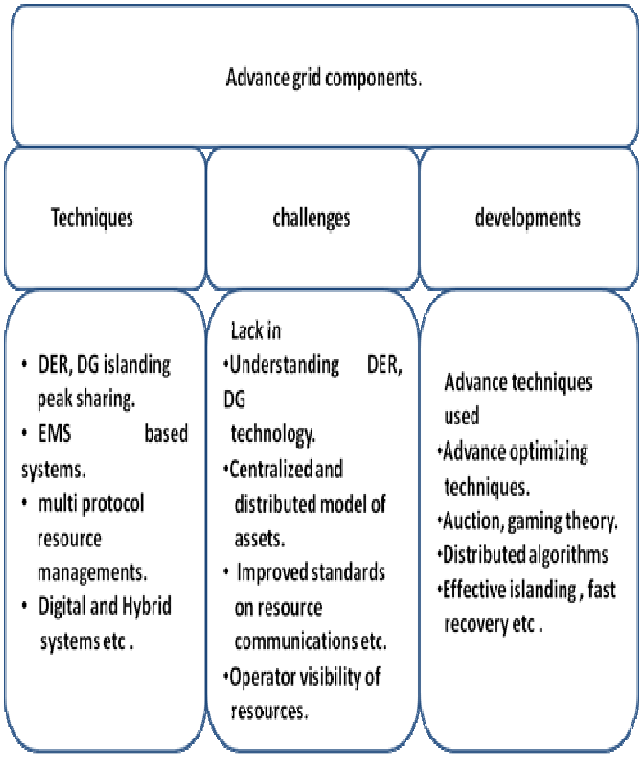

Fig.11 The Overview Of Advance Grid Components

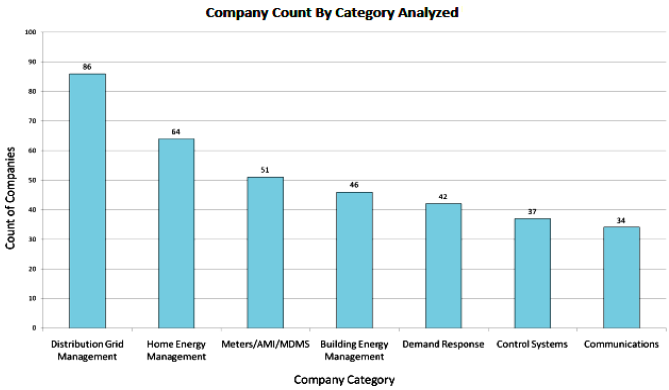

Fig.12 The Management Tools And Its Impacts

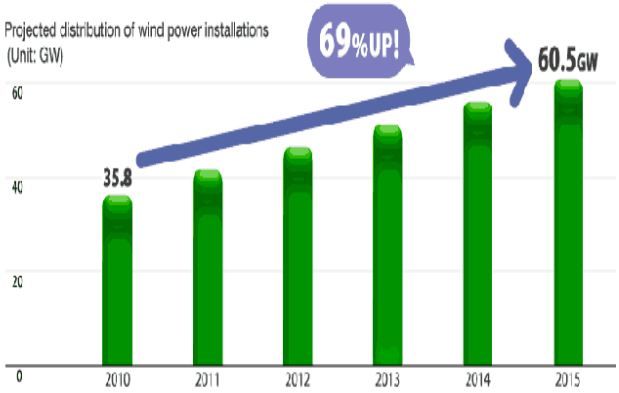

Fig.13 Utility Of Renewable Energy Resources Worldwide

The SG has a massive infrastructure which utilizes number of Energy resources called DER. which relies on disparate technologies which has its own condition, capacity and interoperability. The Distributed Generation (DG) given by International Energy Agency [4] succeeded in SG system which meets out the challenges of demand sharing; peak

sharing with effective utilization of DER with intelligent optimization techniques has a greater impact on reducing the cost of generation, flexible Energy management system. Decentralized agent-based control has greater solutions using Multi Agent System (MAS) improved viability and capability of smart grid Interoperability [1] concepts increase the coordination of individual systems, effective communications to perform task. DR strategy used for load shaping reduces overloading given by Chertkov et al.[34] improves the distribution transformer utilization, delays the upgrading of transformers on high EV penetrations. Wide Area Monitoring and Control system (WAMC) proposed load shedding scheme estimates frequency instability, magnitude of disturbance in real time formulation through dynamic voltage stability criterion with Voltage Stability Risk Index (VSRI). Small Autonomous Hybrid Power Systems (SAHPS) uses renewable resources effectively, economically by optimizing size. The digital grid termed as large grids are divided into smaller grids connected asynchronously can accept the no renewable power, cascaded outages, power flows etc.

B. Challenges

A complete understanding of regulation and policy impact on DER , DG technology integration required for getting adequate data's, quantitative analysis for regulatory practices has a effective impact on economic models and cost benefits. Caldon *et al.* [5] described about the Advance control system required for distribution networks enables real time awareness and gives automated response allows flexibility in operator decision. Centralized and distributed models to be found for scaling of assets, its coordination .the associated challenge is the security and privacy. The deployment of DER to maximize the efficiency and power quality have a level of lack in standard communication and protocol controls accessibility models for analysis . Improvement required in standards to integrate all devices communication, functionality implementing advance technologies to ensure secure communications explained by Bobba et al.[8] at low cost. The data management need an increased concentration with the deployed datagiven by Cai et al.[35] from the billions of sensors has its impact of deduced focus on DER integration.

C. Developments:

Computations on load composition rate, Total Harmonic Distortion (THD) measured on Point of Common Coupling (PCC) based with new Distortion power quality indices (DPI). A tool to reduce the computation by data mining. Given by Chen *et al.* [37] technique, SAX method to reduce the dimensionality of data base by identifying hidden patterns. By gaming theory an agent based functional approach both network and Energy [39] markets can be integrated and coordinated by optimally allocating resources. To evaluate the sizing, placement of D.G an improved multi –objective Harmony Search (HS) algorithm used on radial distribution system. A methodology of relay settings on dependability and security performance indices reduce nuisance tripping of large DG A high speed area EPS given by IEEE. P2030/D7.0 draft guide [3] can reclose the disconnected, the islanded DG's in time called effective island protection. The Low Carbon Zones (LCZ) are set to follow the Decentralized short term changes by DG and centralized long term changes by Sub Station (SS) On Load Tap Changer (OLTC)'s. For future smart grid Vickrey-Clarke-Groves (VCG) mechanism for Demand Side Management (DSM) maximize the utility of all users, minimizes the cost of power generation.

Fully distributed algorithm for multi-area state estimation in grid system compared with existing hierarchy algorithm. Convergence compared with centralized state estimation results. The utilization of reactive power from DG by electronic interface which acts as a network level Volt Ampere Rating (VAR) controller. The relay trip characteristics are updated in time to clear the faults, islands on distribution given by Lasseter *et al.* [6] system governed by load detection algorithms. For nonlinear system performance identifying difficulties are overcome by Field Programmable Analog Array (FPAA) apart from the digital iterative techniques quickly and accurately. Optimum sizing method through Small Autonomous Hybrid Power Systems (SAHPS) to utilize the renewable resources efficiently and economically. Mining, analyzing, and managing the data can deliver meaningful and actionable information for model inference and state-based control.

VII. INTERFACE AND DECISION SUPPORT

A. Techniques:

The Fig. 14 shows the interface and decision support with its techniques, challenges and development associated with it.

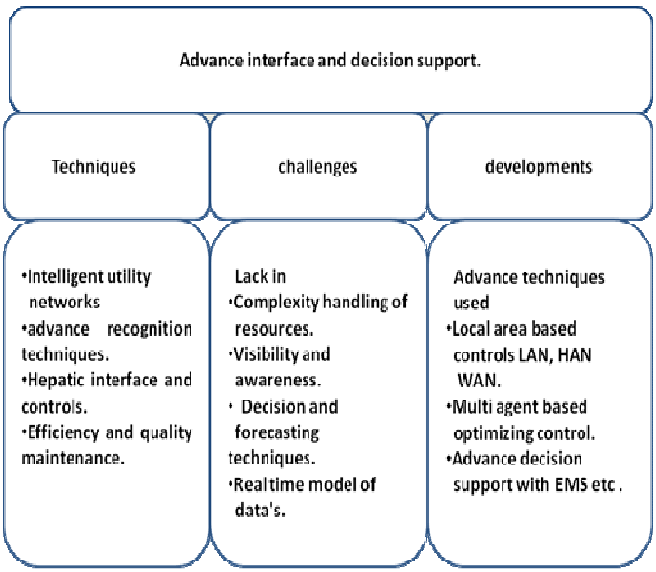

Fig.14 The Overview Of Advance Interface And Decision Support

Fig.15 shows the intelligent utility network for good visibility and awareness on both utility and consumers.

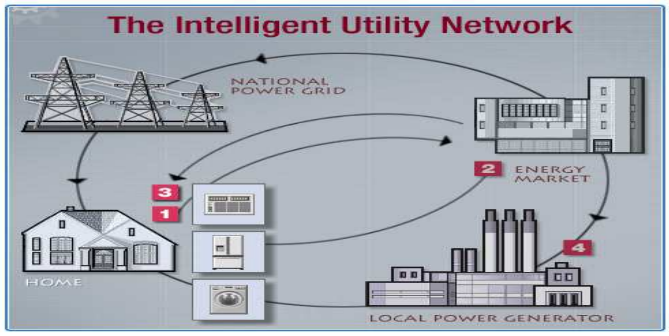

Fig.15 the intelligent utility network

Geographic Information and Services (GIS) provides geographic information's for any networks or platform. Which used for visualization and analyzing the assets for easy management by using a spatial network connectivity data base and GIS mapping software Advance speech recognizing systems composed of three functions as capturing , translating(digital signals), recognizing through algorithms for consumer support Amit Jain et al[44] gives about the prepaid metering.

Hepatica interfaces for control inputs through hand movements, lets us to generate control inputs through hand movements these systems are used for sensing and provide 3D virtual objects with respect to the shape, weight, surface textures and temperature. Advance pattern recognized for intruder detection, forgery, and biometrics. Real time 3D visualization for simulation analysis and decision support.
Virtual machines self operating environment for isolation of system that provides prevention of cross corruption and security.

Intelligent user interfaces makes the system as intelligent active and personalized collaborator. Region Of Stability Existence (ROSE) region of stability existence will utilize directly SCADA and Performance Measuring Device (PMD) provides 2D interface to operators with essential data's secured operating regions considering the constraints voltage, thermal limits, flow gate. Online transient stability monitor uses fast fault screening to determine the most serious fault.

B. Challenges:

The flexible system with objective of flexibility in the aspects of utilization of demand and network analysis. Clement explained about the domestic appliances part in SG Established communication protocols gives large number of data's but there is always a undefined data exchange rules, application lack persists. Tools and decision support given by Anderson *et al.* [31] have to give improved visibility, situational awareness to the operator for enhanced observation; computational analysis will lead to better decision support and forecasting profile. Performance metrics should be effective consensus among stake holders and policy makers. Operational and planning models not resolving the production, balancing, planning by Han *et al.* [30]. Commercial models need to access the dynamic operation and performance. Choice of EV estimated by mixed logic model depends on consumer preferences which determine their marginal willingness for payment.

C. Developments

The complexity in handling with large resources requires computational approaches like meta-heuristic approach as Particle Swarm Optimization (PSO) to solve scheduling Electrical Vehicle (EV and DR) and optimization problem. Trip distance, trip shifting DR programs can have significance of EV and to make it to participate in DR events. The Average System Availability Index (ASAI) gives us the ratio of customer service per hour availability to customer service per hour demand help full for the operator. Local area based controller for power system oscillation damping and handle the complex, stochastic and time varying power systems. The proposed authentication AP3 scheme with HAN meets security challenge on V2G networks. There is a need for quality monitoring and protection with power quality, while using V2G low cost triangular based neural network based monitoring scheme. Multi agent based optimizing control and Graphical User Interface (GUI) based platform will provide flexibility on control of integrated system. Price threshold is determined by stochastic dynamic programming helps on consumers. WAMS-based multiple High Voltage Direct Current (HVDC) damping control system is proposed will enhance the damping of certain inter area modes. Damping, calculations of results. Interconnection protocols reduce operation error and increases system security. Advance decision support using EMS and DR integration with data will improve decision logic. A new measurement required for collection of data's, verified and simulate all modeled approach of different resources.

VIII.CONCLUSION

The communication technologies on smart grid have used number of techniques such as wireless [11] and wired communication technologies, and the end-to-end communication management. SG systems aim to improve energy efficiency, demand profile, utility, cost, and emission, based on the smart infrastructure by using optimization, machine learning, and game theory realize more powerful mechanisms to defend against attacks and handle failures, but on the other hand, opens up many new vulnerabilities four perspectives: practical deployments and projects, infrastructure, management system, and protection system.
The result was not satisfactory is that Xcel failed to perform a thorough cost-benefit analysis before the initiative begins. Therefore, although SG itself is an encouraging and promising technology, we still need to carefully design blueprints of SG projects. SG is a complex system of systems, resulting in complicated interactions among energy, information, and communication subsystems. The evolution of the SG infrastructure may ask for more experienced information and communication technology sectors to be involved. Ultimate objectives are related to energy efficiency improvement, supply and demand balance, emission control, operation cost reduction, and utility maximization. One of the important management objectives in SG is reducing *CO*2 emission. The electric utilities desire to provide services to minimize costs or maximize profits. Therefore, they may tend to neglect security and privacy, and long-term system reliability new technologies into SG, we should also assess the possible risk introduced. SG will lead to a more environmentally sound future, better power supply services, and eventually revolutionize our daily lives.

REFERENCES

[1] E. Sortomme, S. S. Venkata, and J. Mitra, "Micro grid protection using communication-assisted digital relays, " IEEE Trans. Power Del., 2010, 25(4):2789–2796.
[2] The Congress of the United States. Energy Independence and Security Act of 2007, an Act of the Congress of the United States of America Publ. December 2007,L. No. 110-140, H.R. 6.
[3] IEEE. P2030/D7.0 draft guide for Smart Grid interoperability of energy technology and information technology operation with the electric power system EPS), and end-use applications and loads. 2011.
[4] International Energy Agency. Distributed generation in liberalized electricity markets 2002.
[5] R. Caldon, A. R. Patria, and R. Turri, "Optimal control of a distribution system with a virtual power plant," Bulk Power System Dynamics and Control Conference, 2004,pages 278–284,.
[6] R. H. Lasseter, "Smart distribution: Coupled micro grids," Proc. IEEE, 2011, 99(6):1074–1082.

[7] European Smart Grids Technology Platform. Vision and strategy for Europe's electricity networks of the future, http://www.smartgrids.eu/documents/vision.pdf. 2006.
[8] R. B. Bobba, K. M. Rogers, Q. Wang, H. Khurana, K. Nahrstedt, and T. J. Overbye, "Detecting false data injection attacks on DC state estimation," the First Workshop on Secure Control Systems10, 2010, pages 1–9.
[9] D. G. Hart," Using AMI to realize the smart grid. IEEE Power and Energy Society General Meeting 2008, " Conversion and Delivery of Electrical Energy in the 21st Century, 2008,pages 1–2.
[10] R. Leon, V. Vittal, and G. Manimaran," Application of sensor network for secure electric energy infrastructure," IEEE Trans. Power Del., 2007 22(2):1021–1028.
[11] N. Bressan, L. Bazzaco, N. Bui, P. Casari, L. Vangelista, and M. Zorzi, "The deployment of a smart monitoring system using wireless sensors and actuators networks," IEEE SmartGridComm'10, 2010 ,pages 49–54.
[12] A. Armenia and J. H. Chow, "A flexible phasor data concentrator design leveraging existing software technologies," IEEE Trans. Smart Grid, 2010, 1(1):73–81.
[13] R. J. Best, D. J. Morrow, D. M. Laverty, and P. A Crossley," Synchro phasor broadcast over Internet protocol for distributed generator synchronization," IEEE Trans. Power Del, 2010,25(4):2835–2841.
[14] S. Barmada, A. Musolino, M. Raugi, R. Rizzo, and M. Tucci," A wavelet based method for the analysis of impulsive noise due to switch commutations in power line communication (PLC) systems', IEEE Trans. Smart Grid, 2011, 2(1):92–101.
[15] F. J. C. Corripio, J. A. C. Arrabal, L. D. del R´ıo, and J. T. E. Munoz. "Analysis of the cyclic short-term variation of indoor power line channels," IEEE J. Sel. Areas Commun, 2006, 24(7):1327–1338.
[16] V. C. Gungor and F. C. Lambert," A survey on communication networks for electric system automation, "Computer Networks, 2006,50(7):877–897.
[17] M. McGranaghan and F. Goodman, "Technical and system requirements for advanced distribution automation", 18th International Conference and Exhibition on Electricity Distribution, 2005, pages 1–5.
[18] C. Hochgraf, R. Tripathi, and S. Herzberg, "Smart grid charger for electric vehicles using existing cellular networks and sms text messages," IEEE SmartGridComm'10, 2010, pages 167–172.
[19] B. Akyol, H. Kirkham, S. Clements, and M. Hadley," A survey of wireless communications for the electric power system," Prepared for the U.S. Department of Energy, 2010.
[20] D. M. Britz and R. R. Miller,"Mesh free space optical systems: A method to improve broadband neighborhood area network backhaul," Local & Metropolitan Area Networks, 2007. LANMAN 2007, 15th IEEE Workshop on , June 2007 37 - 42.
[21] IEEE Workshop on Local & Metropolitan Area Networks, 2007, pages 37– 42.
[22] D. Deep, B. R. Petersen, and J. Meng, "Smart microcontrollerbased iridium satellite-communication architecture for a remote renewable energy source," IEEE Trans. Power Del, 2009, 24(4):1869–1875.
[23] A. Ghassemi, S. Bavarian, and L. Lampe, "Cognitive radio for smart grid communications," IEEE SmartGridComm'10, 2010 , pages 297–302,.
[24] M. G. Kallitsis, G. Michailidis, and M. Devetsikiotis," A framework for optimizing measurement-based power distribution under communication network constraints," IEEE SmartGridComm'10, 2010,pages 185–190,.
[25] R. N. Anderson, A. Boulanger, W. B. Powell, and W. Scott, "Adaptive stochastic control for the smart grid. Proc," IEEE 2011, 99(6):1098 – 1115.
[26] K. Clement, E. Haesen, and J. Driesen, "Coordinated charging of multiple plug-in hybrid electric vehicles in residential distribution grids," IEEE PSCE'09, pages 1–7.
[27] A. J. Conejo, J. M. Morales, and L. Baringo," Real-time demand response model. IEEE Trans. Smart Grid," 2010,1(3):236–242.
[28] Hutson, G. K. Venayagamoorthy, and K. A. Corzine, "Intelligent scheduling of hybrid and electric vehicle storage capacity in a parking lot for profit maximization in grid power transactions," IEEE Energy2030, 2008,pages 1–8.
[29] C. Ibars, M. Navarro, and L. Giupponi," Distributed demand management in smart grid with a congestion game," IEEE SmartGridComm'10, 2001pages 495–500.
[30] J. Han and M. Piette, "Solutions for summer electric power shortages: Demand response and its applications in air conditioning and refrigeration systems. Refrigeration," Air Conditioning and Electric Power Machinery, 2008,29(1):1–4.
[31] R. Anderson and S. Fuloria,"Who controls the off switch?," IEEE SmartGridComm'10, 2010 ,pages 96–101.
[32] H. S. Cho, T. Yamazaki, and M. Hahn, "Aero: Extraction of user's activities from electric power consumption data," IEEE Trans. Consum. Electron. ,2010, 56(3):2011–2018.
[33] G. D´an and H. Sandberg, "Stealth attacks and protection schemes for state estimators in power systems," IEEE SmartGridComm'10, 2010 ,pages 214–219,.
[34] M. Chertkov, F. Pan, and M. G. Stepanov, "Predicting failures in power grids: The case of static overloads," IEEE Trans. Smart Grid, 20112(1):162– 172,.
[35] Y. Cai, M.-Y. Chow, W. Lu, and L. Li, "Statistical feature selection from massive data in distribution fault diagnosis," IEEE Trans. Power Syst., 2010, 25(2):642–648.
[36] Li, C.-C. Liu, and K. P. Schneider, "Controlled partitioning of a power network considering real and reactive power balance," IEEE Trans. Smart Grid, 2010 ,1(3):261–269.
[37] J. Chen, W. Li, A. Lau, J. Cao, and K. Wang," Automated load curve data cleansing in power system," IEEE Trans. Smart Grid, 2010,1(2):213– 221.
[38] T. M. Overman and R. W. Sackman, "High assurance smart grid: Smart grid control systems communications architecture," IEEE SmartGrid- Comm'10,2010, pages 19–24.
[39] R. Moreno, G. Strbac, F. Porrua, S. Mocarquer, B. Bezerra," Making room for the boom," IEEE Power & Energy Magazine -2010,8 (5) 36.
[40] E. Elbakush and A. M. Sharaf, "A Hybrid FACTS PV-Smart Grid (V2G) Battery Charging Scheme," international jouranal of advanced renewable energy research ,2012, Vol. 1, Issue. 10, pp. 560-572.
[41] National Institute of Standards and Technology. NIST framework and roadmap for smart grid interoperability standards, release 1.0, http://www.nist.gov/public/ affairs/releases/upload/smart grid interoperability final.pdf. January 2010.
[42] roadmap Smart Grid InformationClearinghouse. http://www.sgiclearinghouse.org.
[43] WWF. The energy report, http://wwf.panda.org/what we do/ footprint/climate carbon energy/energy solutions/renewable energy/ sustainable energy report/. 2010.
[44] Amit Jain1, Mohnish Bagree,"A prepaid meter using mobile communication," international jouranal of engineering,science and technology, 2011, Vol. 3, No. 3,pp. 160-166.
[45] http://www.smartenergyuniverse.com/ami/11198-global-smart-electricity-meter-installed-base-to-double-by-2016
[46] http://www.global.tdk.com/ir/tdk_at_a_glance/strategy/st03.htm
[47] http://m.smartplanet.com/blog/smart-takes/275-billion-to-be-spent-on-smart-grid-in-2010-report-says/11099
[48] .http://www.memoori.com/portfolio/the-smart-building-to-smart-grid-interface-business/
[49] .http://www.ibm.com/smarterplanet/za/en/smart_grid/ideas/index.htm

S.Ganesh kumaarn received Bachelor of Technology in Electrical and Electronics Engineering in 2008, Master of Engineering in Power System Engineering in 2011 from Annamalai University, Annamalainagar, Tamilnadu, India. He is currently pursing Ph.D degree in the Department of Electrical Engineering, Annamalai University. He is Assistant Professor in the Electrical Engineering department at Arunai Engineering College. His research interests are in Smart Grid, Power Systems, and wind/Solar energy applications.

S. Singaravelu received Bachelor of Engineering in Electrical and Electronics Engineering in 1990, Master of Engineering in Power System Engineering in 1992 and Ph.D in 2007 from Annamalai University, Annamalainagar, Tamilnadu, India. He is Professor in the Department of Electrical Engineering at Annamalai University. His research interests are in Smart Grid power electronics, power systems, electrical machines, wind/solar energy applications and high voltage DC transmission.

K.Vivekanandan received Bachelor of Engineering in Electrical and Electronics Engineering in 2006; He is currently pursing Master of Engineering in Power Electronics and Drives in the Department of Electrical and Electronics Engineering, Arunai Engineering College. His research interests are in Smart Grid and power electronics.