SOME STUDIES ON SMART GRID TECHNOLOGY WITH PARTICULAR REFERENCE TO INDIAN POWER SYSTEM

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SYNOPSIS

- The electric power system is undergoing a profound change driven by a number of needs,including environmental compliance and energy conservation.Grid reliability,operational efficiencies and customer service become important with aging infrastructure.This paper includes a plan for electric utilities to make their distribution grid a modern one,a smart one,an agile one.Smart Grid solutions,including Distribution Automation,Asset Management,Demand Side Management,Demand Response,Distributed Energy Management and Advanced Metering Infrastructure,allow utilities to identify and correct a number of specific system issues through a single integrated,robust and scalable Smart Grid platform.The paper provides an overview of technologies being deployed and key Smart Grid applications being implemented.

SMART GRID

- A smart grid is an umbrella term that covers modernization of both the transmission and distribution grids.The concept of a smart grid is that of a “digital upgrade” of distribution and long distance transmission grids to both optimize current operations by reducing the losses,as well as open up new markets for alternative energy production.Components of smart grid is shown in FIGURE – 1.

SMART GRID

- SMART GRID CONCEPT RELATES TO ESSENTIALLY COMBINING INFORMATION AND COMMUNICATION TECHNOLOGY WITH POWER TO REALLY OPTIMIZE PERFORMANCE,IMPROVE PRODUCTIVITY,EFFICIENCY,REDUCE OVERALL COSTS AND GET A BETTER HANDLE ON ENERGY RESOURCES.

COMPONENTS OF SMART GRID

- **1.Transmission Automation**
- **2.Distribution Automation**
- **3.Renewable Integration**
- **4.Demand Participation**
- **5.Small appliances / PVEV/ Storage**
- **6.Distributed Generation & Storage**
- **7.Energy Efficiency**
- **8.System operation**

LATEST TECHNOLOGY TO BE USED FOR SMART GRID

- 1) Use of Superconductors for transmission lines, Transformers,
- Generators, HT Cables – Nano materials going to play a major role.
- 2) The sophisticated revenue models they will employ to shape
- customers' behavior.
- 3) Easy-to-install, low-cost sensors to measure energy use with high
- resolution
- 4) Networked power electronics for everything from solid state
- New Technology development opportunities
- lighting to solar micro-inverters
- 5) Grid-scale electricity storage to buffer transients in supply and
- demand
- 6) Electrified-vehicle infrastructure including batteries and charging
- stations (Few MW)
- 7) Universal Remote Control to a Set-top Box which includes Home
- Control
- 8) Fuel Cell

LATEST TECHNOLOGY TO BE USED FOR SMART TECHNOLOGY

- 1) *ANALYTICAL TOOLS*
- System performance monitoring, simulation, and prediction
- Phasor measurement analysis
- Weather prediction and integration
- Ultra-fast load flow analysis
- Market system simulation
- High-speed computing
- 2) Different communication choices Ex.Broadband over power
- New Technology Development opportunities
- line
- 3) Wide-area monitoring system (WAMS)
- 4) Dynamic line rating technology
- 5) Conductor/ compression connector sensor
- 6) Insulation contamination leakage current sensor
- 7) Electronic instrument transformer
- 8) Fault-testing recloser

VARIOUS DOMAINS OF SMART GRID

- • Bulk generation
- • Transmission
- • Distribution
- • Markets
- • Operations
- • Service provider
- • Customer

CHALLENGES TO BE TACKLED WHILE DESIGNING SMART GRID

- **Financial Resources**
- **Government Support**
- **Development of compatible Equipment**
- **Speed of Technology Development**
- **Policy and Regulation to be framed**
- **Cooperation between different entities**

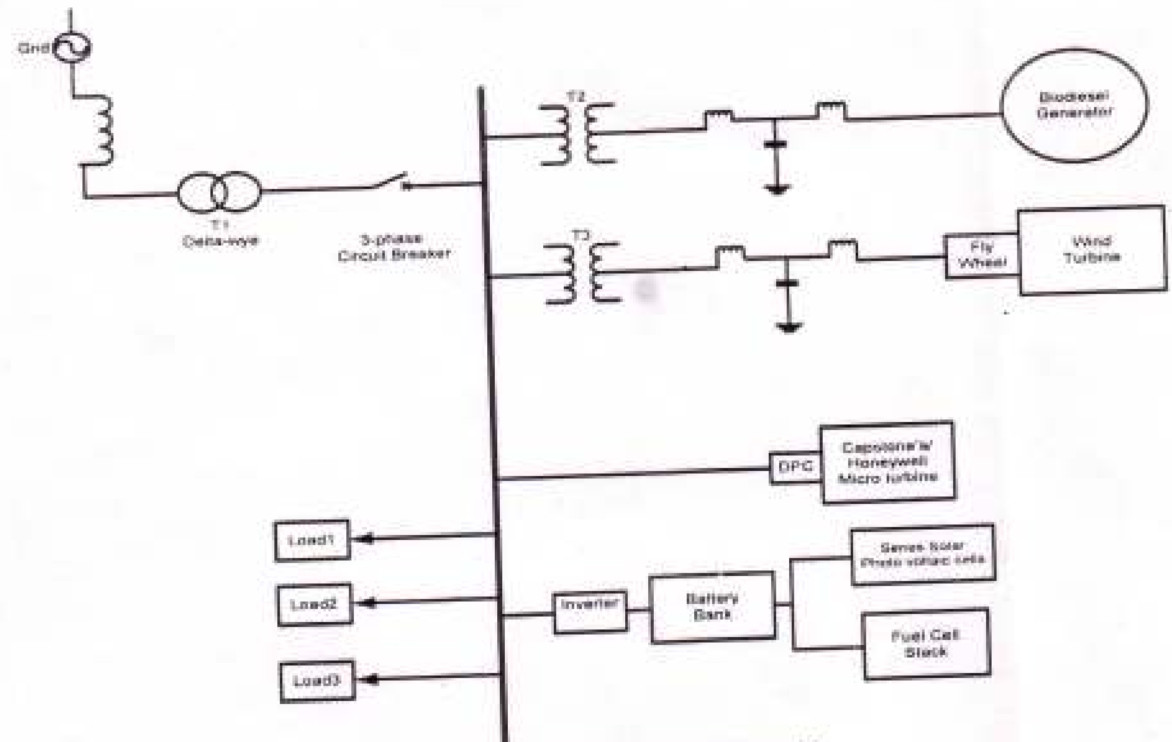

Fig 1: Basic Architecture of Microgrid

MAJOR DRIVING FORCES TO MODERNISE CURRENT POWER GRID

- * Increasing reliability,efficiency and safety of the power grid;
- * Enabling decentralized power generation so homes can be both an energy client and supplier (provide consumers with interactive tool to manage energy usage);
- * Flexibility of power consumption at the clients side to allow supplier selection (enables distributed generation,solar,wind,biomass);
- *Increase GDP by creating more new green-collar energy jobs related to renewable energy industry manufacturing,plu-in electric vehicles,solar panel and wind turbine generation,energy consumption construction.

SALIENT FEATURES OF SMART GRID

- * Self healing :- The grid has the ability to rapidly detect,analyze,respond and restore from disturbances;
- * Tolerant to attack : The grid should be resilient to physical and cyber security attacks;
- * Provide quality power required by users;
- * Accommodate various generation options,including green power;
- * Allow competitive electricity markets;
- * Use IT for monitoring and minimize O & M costs;
- * Empower the consumer and incorporate consumer equipment and behaviour in operation and design of the grid.

THE BASIC REQUIREMENTS OF SMRT GRID

- * Dynamic,fast response to varying supply demand situations;
- * Preparation of old grids to the era of alternate energy and energy efficiency;
- * Constant monitoring and communication all around the electric grid;
- * Establishment of dynamic energy markets and optimal revenue patterns to generators and utilities;
- * Improving the overall efficiency of the network through better management of resources,thus reducing the effect on the environment;
- * Improving the operational efficiency of utilities.This aspect is not to be under estimated,just changing the way utilities measure power and do billing can yield tremendous benefits;
- * And last but not least,probably the foremost is to improve the stability of the electrical system under any adverse conditions.

GREEN HOUSE GAS POLICY

- Smart grid is an aggregate term for a set of related technologies on which government has invited the attention.Demand side management enabling grid connection of distributed generation,power with photovoltaic arrays,small wind turbines,micro hydros or even combined heat power generators in buildings incorporating grid energy storage for distributed generation, load balancing and eliminating or containing failures such as widespread power grid cascading failures.The increased efficiency and reliability of the smart grid is expected to save consumers money,fuel,import of conventional energy resources and help reduce CO2 emissions.Increase GDP by creating more new green collar worker energy jobs related to renewable energy industry manufacturing,plug-in electric vehicles,solar panel and wind turbine generation,energy conservation construction.

OVERVIEW OF SMART GRID TECHNOLOGY

- * Detect and address emerging problems before they impact service;
- * Respond to local and system-wide inputs and know much more without broader system problems;
- * Incorporate extensive measurements,rapid communications and feedback controls that quickly return the system to a stable state after interruptions or disturbances;
- * Automatically adapt protective systems to accommodate changing system conditions;
- * Reroute power flows,change load patterns,improve voltage profiles and take other corrective steps within seconds of detecting a problem;
- * Enable loads and distributed resources to participate in operations;
- * Be a grid that is self-healing and adaptive,interactive with consumers and markets,more secure from attacks,accommodate all generation and storage options,accommodate bidirectional energy flow for net metering and predictive rather than just reacting to emergencies.

STEPS TO BE TAKEN FOR UNIFICATION OF SMART GRID

- * Integration of new technology/new type of generation at generation level;
- * Integration of new technology in transmission system;
- * Smart way of managing the transmission system;
- * Integration of new & smart technology at distribution level;
- * Smart way of using the electricity.

DRIVERS FOR SMART GRID

- The global movement towards smart grid is driven by improving operational efficiency,enhanced customer satisfaction,improvement in energy efficiency and environmental impact.These are elaborated below :
- Operational efficiency : Increase operational productivity,reduce capital and operating costs,improvement physical/cyber security.
- Efficient energy use : Optimize usuage,meet growing demand,enhance utilization of existing assets.
- Customer satisfaction : Improve reliability matrix,empower consumer to control energy usuage,stronger communications.
- Environmental aspects : Reduce GHG emissions with utility,give more environmental options to consumer,adhere to regulatory mandates.
- The key functional elements which are required to meet the challenges are described in FIGURE -2.

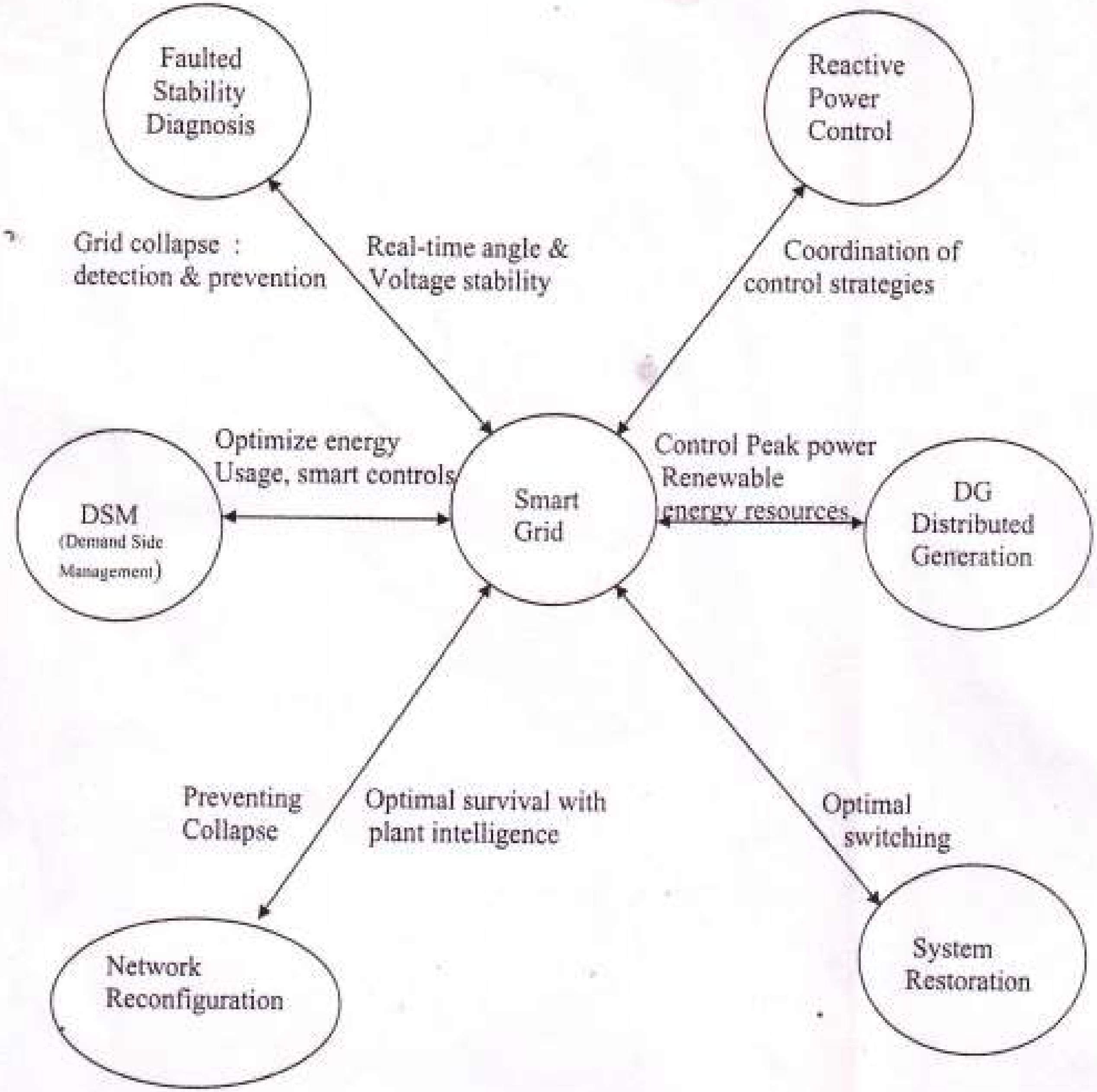

Fig 2 : Functionality of smart grid

MAJOR CHALLENGES TO BE FACED WHILE DESIGNING SMART GRID TECHNOLOGY

- Challenges are present in system planning,policies,metering,communication etc.A few major challenges to be faced are as folloews :
- System planning level : Too many decision makers,opposition to new plants and lines,lack of predictive real-time system controls,inadequate focus on supply-side reliability solutions,proper tax incentives for predictive real-time system,time-dependent controls,pricing information and tax incentives for demand side management(DSM) technologies.
- Energy selling level : Public resistance to deregulation,lack of consumer participation in DSM,environmental incentives/penalties to be addressed,consumer access to pricing information to enable DSM technology.
- Technology level : Communication bit falls for real-time management of grid,optimal power flow control,automatic meter reading,reduction in energy consumption by use of improved technology,harnessing alternate energy sources and feeding the grid from them,energy storage devices,innovation in smart sensors and automation.

DISTRIBUTED ENERGY RESOURCES (DER)

- DER"s are small sources of generation and/or storage that are connected to the distribution system.A smart grid has the potential to have large and flexible sources of DER's to include solar photovoltaics,wind turbines,micro turbines,fuel cells and battery storage.An extension would result in an Intelligent Distributed Autonomous Power Systems(IDAPS),to include 'normal operation' and 'outage mode operation'.The characteristics are :
- Intelligent : IDAPS performs DSM based on price,secures critical loads,sheds loads of low priority and allows for locally available power to be shared within a community.
- Distributed : DER's are dispersed and communicate through a common IP protocol.
- Autonomous : IDAPS disconnects itself from the local distribution utility and operates autonomously to maintain integrity of the system.
- Here,the distribution system begins to resemble a small transmission system and has to consider non-radial power flow and increased fault current duty.Thus it can be seen that the evolution of a smart grid is still a long way off,from what has been conceptualized.

SUGGESTIVE MEASURES TO BE TAKEN FOR MOVING FORWARD TO A SMART GRID

- * Suggestions for DSM to selectively curtail delinquent customers/neighbourhoods;
- * Improve service for consistently paying customers;
- * Increased use of renewables;
- * Sophisticated metering i.e Smart Meter;
- * Introduction of Availability Based Tariffs(ABT).

DESIRED FUNCTIONALITIES OF SMART GRID

- * Self-healing;
- * High reliability and power quality;
- * Resistant to cyber attacks;
- * Accommodates a wide variety of distributed generation and storage options;
- * Optimizes asset utilization;
- * Minimizes operations and maintenance expenses.

GUIDING PRINCIPLE TO BE FOLLOWED FOR DEVELOPMENT OF SMART GRID

- INDIGENOUS MODEL TO BE DEVELOPED TO COMPETE WITH REQUIRED HARDWARE EQUIPMENTS LOCAL PRODUCTION AND SKILL DEVELOPMENT THROUGH TRAINING FOR MAINTENANCE.
- FOCUS ON ADDRESSING THE PROBLEM OF POWER SHORTAGE.
- FOCUS ON THEFT PREVENTION AND LOSS REDUCTION.
- ACCESS OF POWER TO RURAL AREAS TO THE POOR.
- DEVELOP ALTERNATIVE SOURCES OF POWER AND ENHANCE RELIABILITY OF POWER TO URBAN AREAS.
- AFFORDABLE AND SUSTAINABLE POWER PRODUCTION.

DESIGN CRITERIA OF SMART GRID

- * Increasing use of clean DER;
- * Establishing a significant amount of DSM & Demand side response capability with direct consumer communication;
- * Replacing over build reliability methodologies with distribution and sub-station automation approaches;
- * Maximizing utilization of the existing delivery infrastructure;
- * Adding physical and IT security systems to protect critical infrastructure.

FIXED DEVICES REQUIRED FOR IMPLEMENTATION OF SMART GRID TECHNOLOGY

- The smart grid has a lot to do with decentralization i.e distributed generation and storage,distribution system automation and optimization,customer involvement and interaction,plug in hybrid electric vehicles (PHEV) and even micro grids.That means that it will be necessary to have more intelligence and control beyond generation and transmission throughout the distribution grid and all the way to the retail consumer's side of the meter.This will involve few fixed devices like :
- Supervisory control and data acquisition (SCADA) devices and distribution automation (DA) devices;
- Automatic meter reading (AMR) devices and smart meters;
- Retail premises monitoring and control systems and energy management systems (EMS) and
- Emerging technologies for monitoring and control,both for electric utilities and for consumers.

ALTERNATIVE ENERGY SOURCES

- a) SOLAR POWER :
- b) FUEL CELLS :
- c) PHOTO VOLTAIC (PV) CELLS :
- d) WIND TURBINES :
- e) BIODIESEL GENERATOR :
- f) MICRO TURBINE :

SUGGESTIVE MEASURES TO BE TAKEN FOR INDIA

- **Enlighten all stake holder about global developments.**
- **Insist and mandate to procure equipment based on open standards.**
- **Work with National & International bodies compling Smart Grid concepts.**
- **Standardise software / Hardware devices based on International standards (Meter to Control Room) -**
- **No proprietary.**
- **Implement the best security standards.**
- **Software standarisation in distribution sector based on IEC 61968 / 61970 (EMS).**
- **Measures to be taken for few pilot projects covering large area as in other countries.**
- **Action to be taken for replacement of equipments not suitable for integration purposes.**

CONCLUSIONS

- The evolution of smart grid is still in its nascent stage.The entire power society is busy now in understanding & developing smart power grid system which is no longer a theme of future.
- Some of the utilities are progressive and have come forward to implement new technologies in their network for getting hands on experience and would like to be the first to use latest technology,where as many utilities are still looking forward to share the experiences gained by the others before implementing the new devices/technologies in their networks (deferred risk and higher development costs).
- Some of the technologies may be improving the system reliability and increasing the life of the equipment/system,however not providing the direct monitory benefit to the utility,do not get much attention as a mind set.
- Off-setting the peak demand by renewable generation,plugging hybrid vehicles for charging during off-peak load duration.

CONCLUSIONS

- With smart communication between end user and the service/power provider,power consumption can be optimized.The customer is ignorant about the status of grid overloading,cost of the power at any instant of time in order to schedule its consumption to optimal use.
- At the moment it is difficult to access or predict the contribution of smart grid technology to the Nations's energy efficiency applicable for the present grid and there may be other variables too.
- In the coming years,many distribution systems will not resemble the distribution systems of today.These systems will have advanced metering,robust communications capability,extensive automation and distributed generation.Through the integrated use of these technologies,smart grids will be able to operate,provide high degree of reliability and power quality.
- There will also be muti-directional power flow possible,increased equipment utilization and more importantly,the customers will be offered a variety of services possibly at lower costs.

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- There will also be muti-directional power flow possible,increased equipment utilization and more importantly,the customers will be offered a variety of services possibly at lower costs.
- Intelligent or Smart grids,the vision unfolded,would soon becomes a reality in a couple of years.Increasing energy demands,depletion of natural resources,effect of carbon emissions,need for a sustainable environment together with changing life styles requiring increased automation,make smart grids an inevitable option of the future.
- The only viable way to realize an extensive smart grid is to develop a vision for the ultimate design of a smart grid and then make short term decisions that incrementally transform existing distribution systems into this future vision.Within a utility culture of annual budget cycles and hard-to-change standards,this is a tall order.What is needed now is an effort to develop an integrated vision for smart grid,and strong leadership to ingrain this vision on the people who are ultimately responsible to make it happen.

CONCLUSIONS

- We are at the genesis of a worldwide overhaul in the way electric power is generated,distributed and consumed.It will take a decade or two for this whole transition to take place,but the seeds are being sown now.Hence,this market represents many opportunities to penetrate the ecosystem both by exploiting adjacencies as well as exploring new areas.Fundamental to this revolution is an understanding of how to measure and control voltage,current,power,energy – whether on the load side,generation side or in distribution.An understanding of alternate energy (especially Solar PV),which is very closely tied to energy efficiency markets is essential.
- The industry will need very sophisticated analytical tools to ensure that coming generations of grid design are safe.These are available in other domains and need to be retargeted to the electrical world.
- The major power quality events which are delineating the electrical transmission efficiency can be eliminated using micro grid as a perfect solution.Even voltages and frequencies can be uniformed by adding power electronic interfaces to each component of a micro grid.Micro grid with its unique features is the only alternative to large UPS,SMPS systems used as a solution for sensitive load problem in the IT,electronic component manufacturing industries.Micro grid also can be a well established approach to provide electricity to remote areas of our country.

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