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# SECURE AND RELIABLE POWER SUPPLY WITH CHALLENGES- SMART GRID

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**Abstract-** Smart Grid implementations will certainly increase the quantity, quality and use of information available from advanced sensing, computing and communications hardware as well as software. There is virtually universal agreement that it is necessary to upgrade the electric grid to increase overall system efficiency and reliability. Many technologies currently in use by the grid is outdated and in many cases unreliable. The reliance on old technology leads to inefficient systems, costing unnecessary money to the utilities, consumers and taxpayers. To upgrade the grid and to operate an improved grid will require significant dependence on distributed intelligence and broadband communication capabilities. The access and communications capabilities require the latest in security technology which are reliable for extremely large, wide-area communications networks. This paper discusses features, reasons of development, barriers and their solutions for a smart grid system.

***Keywords-*** *smart grid, smart meters, cyber security.*

## I. INTRODUCTION

Over the past few years, the electric power industry, state and federal regulators, government agencies, and academics have been grappling with how to best update the aging electric power infrastructure. The general consensus is that the updated grid not only must secure the future reliability of the power system in light of the ever increasing demand for electricity, but it also must operate with greater efficiency overall.

The term smart grid has been in use since at least 2005, when it appeared in the article "Toward A Smart Grid" by Amin and Wollenberg. The term had been used previously and may date as far back as 1998. There are many smart grid definitions, some functional, some technological, and some benefits-oriented. A common element to most definitions is the application of digital processing and communications to the power grid, making data flow and information management central to the smart grid. Various capabilities result from the deeply integrated use of digital technology with power grids and integration of the new grid information flows into utility processes and systems is one of the key issues in the design of smart grids. Electric utilities are classified in three classes of transformations. Firstly improvement of infrastructure which is known as strong grid; secondly, addition of the digital layer which is the essence of the smart grid; and finally, business process transformation which is necessary to capitalize on the investments in smart technology. Many modernization work has been going on for the modernization of electric grid, especially substation and distribution automation, is now included in the general concept of the smart grid, but additional capabilities are evolving as well. Smart Grid uses computer hardware and software, sensors, telecommunication equipment and services to:

- ✓ Helps the customer to manage consumption and use electricity wisely.
- ✓ Enables customer to respond to utility that help minimize the period of surpluses, bottlenecks, and outages.
- ✓ Helps utilities in improving their performance and controlling costs by timely availability of information.

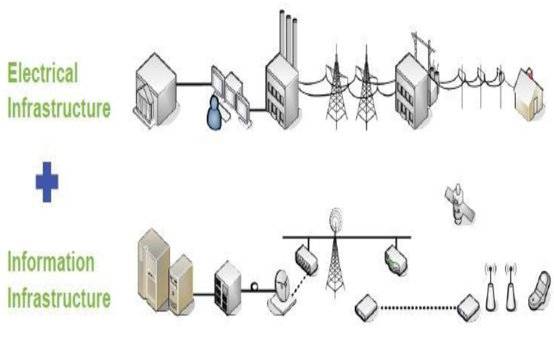


**Figure.1. Smart Grid Infrastructure**

Thus Smart Grids associates customer to electricity by an information rich network. And also it provides utilities with valuable operational information that helps them to improve efficiency. In a layman's term Smart Grid is an efficient combination of electrical infrastructure and information technology as shown in figure 1

Smart grid (SG) is envisioned to take advantage of all available modern technologies in transforming the current grid to one that functions more intelligently to facilitate:

- Better situational awareness and operator assistance.
- Autonomous control actions to enhance reliability by increasing resiliency against component failures and natural disasters and by eliminating or minimizing frequency and magnitude of power outages subject to regulatory policies, operating requirements, equipment limitations and customer preferences. Such control actions can be more responsive than human operator actions.
- Efficiency enhancement by maximizing asset utilization.
- Resiliency against malicious attacks by virtue of better physical and IT security protocols.
- Integration of renewable resources including solar, wind, and various types of energy storage. Such integration may occur at any location in the grid ranging from the retail consumer premises to centralized plants. This will help in addressing environmental concerns and offer a genuine path toward global sustainability by adopting "green" technologies including electric transportation.
- Real-time communication between the consumer and utility so that end-users can actively participate and tailor their energy consumption based on individual preferences (price, environmental concerns, etc.).
- Improved market efficiency through innovative solutions for product types (energy, ancillary services, risks, etc.) available to market participants of all types and sizes.
- Higher quality of service – free of voltage sags and spikes as well as other disturbances and interruptions –to power an increasingly digital economy.

## II. FEATURES OF SMART GRID

***1) Reliability :*** The smart grid will make use of technologies that improve fault detection and allow self-healing of the network without the intervention of technicians. This will ensure more reliable supply of electricity, and reduced vulnerability to natural disasters or attack. Initial power lines in the grid were built using a radial model, later connectivity was guaranteed via multiple routes, referred to as a network structure. However, this created a new problem: if the current flow or related effects across the network exceed the limits of any particular network element, it could fail and the current would be shunted to other network elements, which eventually may fail also, causing a domino effect.

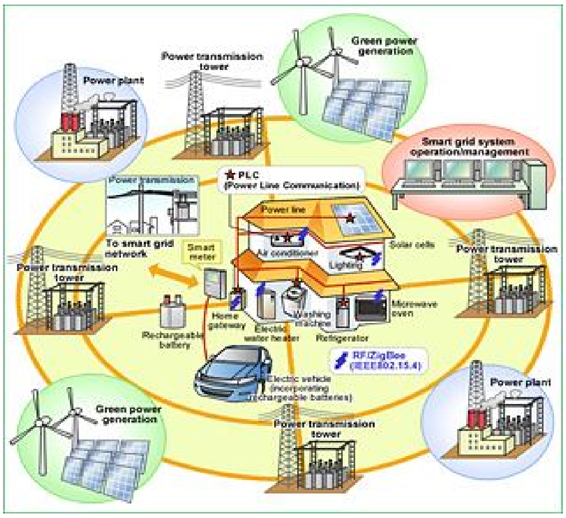


**Fig.2. Overview of Smart grid**

***2) Flexibility in network topology :*** Classic grids were designed for one-way flow of electricity, but if a local sub-network generates more power than it is consuming, the reverse flow can raise safety and reliability issues. A smart grid aims to manage these situations. Next-generation transmission and distribution infrastructure will be better able to handle possible bidirectional energy flows, allowing for distributed generation such as from photovoltaic panels on building roofs, but also the use of fuel cells, charging to/from the batteries of electric cars, wind turbines, pumped hydroelectric power and other sources.

***3) Efficiency :*** Numerous contributions to overall improvement of the efficiency of energy infrastructure is anticipated from the deployment of smart grid technology, in particular including demand-side management, for example turning off air conditioners during short-term spikes in electricity price. The overall effect is less redundancy in transmission and distribution lines, and greater utilisation of generators, leading to lower power prices.

***4) Load adjustment:*** The total load connected to the power grid can vary significantly over time. Although the total load is the sum of many individual choices of the clients, the overall load is not a stable, slow varying, average power consumption. Imagine the increment of the load if a popular television program starts and millions of televisions will draw current instantly. Traditionally, to respond to a rapid increase in power consumption, faster than the start-up time of a large generator, some spare generators are put on a dissipative standby mode. A smart grid may warn all individual television sets, or another larger customer, to reduce the load temporarily (to allow time to start up a larger generator) or continuously (in the case of limited resources). Using mathematical prediction algorithms it is possible to predict how many standby generators need to be used, to reach a certain failure rate. In the traditional grid, the failure rate can only be reduced at the cost of more standby generators. In a smart grid, the load reduction by even a small portion of the clients may eliminate the problem.

***5) Peak leveling and time of use pricing:*** To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used. It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overloads. An example would be a utility reducing the usage of a group of electric vehicle charging stations. To motivate them to cut back use and perform what is called peak curtailment or peak leveling, prices of electricity are increased during high demand periods, and decreased during low demand periods. It is thought that consumers and businesses will tend to consume less during high demand periods if it is possible for consumers and consumer devices to be aware of the high price premium for using electricity at peak periods. This could mean making trade-offs such as cooking dinner at 8 pm instead of 5 pm. When businesses and consumers see a direct economic benefit of using energy at off-peak times become more energy efficient, the theory is that they will include energy cost of operation into their consumer device and building construction decisions. According to proponents of smart grid plans, this will reduce the amount of spinning reserve that electric utilities have to keep on stand-by, as the load curve will level itself through a combination of "invisible hand" free-market capitalism and central control of a large number of devices by power management services that pay consumers a portion of the peak power saved by turning their devices off.

***6) Sustainability :*** The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage. Current network infrastructure is not built to allow for many distributed feed-in points, and typically even if some feed-in is allowed at the local (distribution) level; the transmission-level infrastructure cannot accommodate it. Rapid fluctuations in distributed generation, such as due to cloudy or gusty weather, present significant challenges to power engineers who need to ensure stable power levels through varying the output of the more controllable generators such as gas turbines and hydroelectric generators. Smart grid technology is a necessary condition for very large amounts of renewable electricity on the grid for this reason.

***7) Market-enabling*** The smart grid allows for systematic communication between suppliers and consumers and permits both the suppliers and the consumers to be more flexible and sophisticated in their operational strategies. Only the critical loads will need to pay the peak energy prices, and consumers will be able to be more strategic in when they use energy. Generators with greater flexibility will be able to sell energy strategically for maximum profit, whereas inflexible generators such as base-load steam turbines and wind turbines will receive a varying tariff based on the level of demand and the status of the other generators currently operating. The overall effect is a signal that awards energy efficiency and energy consumption that is sensitive the time-varying limitations of the supply. At the domestic level, appliances with a degree of energy storage or thermal mass (such as refrigerators, heat banks, and heat pumps) will be well placed to 'play' the market at seek to minimize energy cost by adapting demand to the lower-cost energy support periods.

***8) Platform for advanced services*:** As with other industries, use of robust two-way communications, advanced sensors and distributed computing technology will improve the efficiency, reliability and safety of power delivery and use. It also opens up the potential for entirely new services or improvements on existing ones, such as fire monitoring and alarms that can shut off power, make phone calls to emergency services, etc.

## III. REASONS OF DEVELOPMENT OF SMART GRID

There are two reasons to create a national smart grid. First, today's grid needs to be upgraded because it is aging, inadequate and outdated in many respects like investment is needed to improve its material condition, ensure adequate capacity exists and enable it to address the 21st-century power supply challenges. Secondly, the benefits of the smart grid are substantial.

***1) Environmental Impact* :-** Smart Grid development is happening at a very fast pace because of the broad interest of policy makers and utilities in decreasing the adverse effect that energy usage has on the environment. Smart Grids uses technology to drive efficiencies in transmission, distribution and consumption. As a result, fewer generating plants, fewer transmission and distribution assets are required in order to provide the growing demand of electricity. With the possible expectation of wind farm sprawl, landscape preservation is one of the evident benefits. Since maximum generation today results in emission of greenhouse gas, Smart Grids reduces air pollution and plays a significant role in fighting global climate change issue. Smart Grids has the capability to accommodate technical difficulties of integrating renewable resources like wind and solar to the grid, providing further reduction in greenhouse gas emissions.

***2) Costs :-*** The ability to bypass the cost of the plant and grid development is a major advantage to both the utilities and customers. And Smart Grids will not reduce funds expansion, of course; therefore huge investments are required in order to setup a link between the customers and the Smart Grid. Further with the aid of Smart Grids less generating units would be required in order to fulfill the energy demand of the growing population and cost of setting up more and more plants can be deferred. At that point of time, more emphasis will be on overall development of T&D efficiency based on demand response, load control, and many other Smart Grid technologies. Energy efficiency would be the second priority in order to save cost with reference to the customers. With timely and detailed information provided by Smart Grids, customers would be encouraged to limit waste, adopt energy-efficient building standards and invest more and more in energy efficient appliances.

***3) Utility Operations*** **:-** Smart Grids can assist the utilities, as the principal focus of the utilities is to improve business processes. Many utilities have an extensive list of projects that they would like to fund in order to improve the customer service or to ease workforce's burden of repetitive work. Calculating Smart Grid benefits by the cost/benefit analysis it puts emphasis in favor of the change and can also significantly decrease settlement periods. Similarly, Smart Grid provides customers with real time information and encourages them to do online payments, thus lowering billing costs. Utilities can include these cost and service improvement in the list of Smart Grid benefits.

***4) Theft Control :-*** This is not an issue in developed countries like US, but in developing countries like India, where people have a little insight of the grid and higher poverty rate, power theft is quite common. With development of Smart Grid, power theft can be controlled to a greater extent, thereby improving the efficiency of our distribution system. Thus grids will provide higher quality and reliable power supply, and there will be fewer blackouts.

## IV. BARRIERS IN IMPLEMENTATION OF SMART GRID

***1) Policy and regulation :-*** The current policy and regulatory frameworks were typically designed to deal with the existing networks and utilities. To some extent the existing model has encouraged competition in generation and supply of power but is unable to promote clean energy supplies. With the move towards smart grids, the prevailing policy and regulatory frameworks must evolve in order to encourage incentives for investment. The new frameworks will need to match the interests of the consumers with the utilities and suppliers to ensure that the collective goals are achieved at the lowest cost to the consumers.

Generally, governments set policy whereas regulators monitor the implementation in order to protect the consumers and seeks to avoid market exploitation. Over the last two decades, the trend of liberalized market structure in various parts of the world has focused the attention of policy-makers on empowering competition and consumer choice. The regulatory models have evolved to become more and more effective to avoid market abuse and to regulate the rates of return.

***2) Business Scenario :*** Two fundamental challenges in business are namely : **High capital and operating costs** in which capital and operating costs include large fixed costs linked to the chronic communications network. Secondly, **Benefits are constrained by the regulatory framework** in the other words we can say during calculating the benefits, organizations tend to be conservative in what they can gather as cash benefits to the shareholders. Regulators are required tofollow such policies and regulations in place which could provide benefits for both to the utilities and the consumers. On the budget point of view there is the fact that smart technologies are expensive to implement .

***3) Technology maturity and delivery risk :*** Technology is one of the essential constituents of Smart Grid which include a broad range of hardware, software and communication technologies. In some cases, the technology is well developed; however, in many areas the technologies are still at a very initial stage of development and are yet to be developed to a significant level. As the technologies advances, it will reduce the delivery risk; but till then risk factor have to be included in the business situation.

## V. SOLUTION TO OVERCOME THE BARRIRES

By building the right economic environment for the private sector investment and focusing more broadly about the way that social value cases are created and presented implementation would become much easier. By analyzing these solutions in bigger environments i.e. in cities, the entire industry will learn what it takes to implement smart grids successfully and will result in developing an industry that is set to boom in the coming periods.

***1) Forming Political and Economic Frameworks*** Policy makers and regulators have to implement a framework which optimally spread the risk over the whole value chain i.e. to guard the investors from risk and to yield the result at lower cost to the customers. They have to form a robust incentive model in order to attract more and more private investment. Also rate of return should be based on the output generated. Rewards and penalty mechanism should be considered in order to monitor the performance of the utilities and to encourage them to deliver the outcomes in the most efficient manner.

***2) Achieving greater efficiency in energy delivery :*** Smart Grid Technology should consider building greater efficiency into the energy system which would result in reduction of losses, peak load demand and thereby decreasing generation as well as consumption of energy. New regulatory framework which incentivizes utilities for reducing the technical losses would help utilities to perform more efficiently.

***3) Enabling distributed generation and storage :*** Smart grids will change where, when and how energy is produced. Each household and business will be empowered to become a micro-generator. Onsite photovoltaic panels and small-scale wind turbines are the predominant examples; developing resources consist of geothermal, biomass, hydrogen fuel cells, plug-in hybrid electric vehicles and batteries. As the cost of traditional energy sources continues to rise and the cost of distributed generation technologies falls, the economic situation for this evolution will build.

***4) Increasing Awareness on Smart Grids :*** There is an imperative need to make the society and the policy makers aware about the capabilities of a Smart Grid. The main step is to form a perfect, universal description on the common principles of a smart grid. Beyond agreement on a characterization, the matter also needs to be debated more holistically as a true enabler to the low-carbon economy, rather than as an investment decision to be taken within the meeting room of distinct utilities. The importance of consumer education is not to be under estimated. The formation of user-friendly and state-of-the-art products and services will play a significant role in convincing the society about Smart Grids. Also the utilities are required to scrutinize the major challenges in implementation of Smart Grid and their impact on their business model and operations.

***5) Skills and Knowledge :*** Successful implementation of the smart grid will require a large number of highly skilled engineers and managers mainly those who are trained to work on transmission and distribution networks. As a result to on-job training and employees development will be vital across the industry. Simultaneously, there is a requirement for investment in the development of relevant undergraduate, postgraduate and vocational training to make sure the availability of a suitable workforce for the future. The investment in T&D should not be limited and neither in research and knowledge development, which would be essential for the development of this sector.

***6) Cyber security Risks and Data Privacy Issues :*** Smart Grid success depends on the successful handling of two major IT issues first namely Security secondly, Integration and data handling . With increase in computers and communication networks comes the increased threat of cyber-attack. The Government should look into this matter because consumer’s consumption data can be misused by the utilities and the third party. Utilities have to give assurance to the consumers that their valuable information is handled by authorized party in ethical manner. The government has to adopt high standard level in order to withstand cyber-attacks.

**Table: 1**

**Grid-Interactive Renewable Power -11$^{th}$ Plan (2007-2012)**

| Program Component | Physical Target for 11$^{th}$ Plan(MW) |
|---|---|
| Wind | 10500 |
| Small Hydro | 1400 |
| Biomass power | 1200 |
| Co-generation | 500 |
| Urban Waste to energy | 200 |
| Industrial waste to energy | 200 |

## VI. CONCLUSION

In this paper an attempt has been made to focus on the key challenges in implementing the Smart Grid with possible solution. In most of the advanced countries utilities have made major achievements in terms of productivity, reliability and efficiency through the use of Smart Grid technology. Indian utilities are still lagging far behind when compared to other countries. Today their main focus is on providing energy at reasonable price but soon the day will come when the utilities will be focusing on encompassing sustainable use and environmental improvement into their agendas and Smart Grids will play a vital role to help utilities in accomplishing this mission. So, the utilities will need to invest heavily in new hardware, software, business process development and staff training. Further there would be high investment in home area networks and smart appliances by the customers. Right set of policies and regulations has to be follow. In addition to these benefits it would play important role in addressing global issues like energy security and climate change.

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