SMART GRID

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Overview

The Smart Grid is the integration of Electrical & Digital Technologies, Information and communication which facilitates integration of business processes and systems to yield real measurable value across the power delivery chain. It is an intelligent future electricity system that connects all supply, grid and demand elements through a communication system. Smart grid delivers electricity to consumers using two-way digital technology that enable the efficient management of consumers, efficient use of the grid to identify and correct supply-demand imbalances.

Smart Grid solutions enable utilities to increase energy productivity and power reliability while allowing the customers to manage the usage and costs through real time information exchange. It impacts all the components of the power system like Generation, Transmission and Distribution.

Typical components of a Smart Grid system

Smart Power Meters:

Smart Power meters include a two way communication between consumers and power providers. These are used for billing data collection, detect outages and dispatch repair crews to correct location faster. Smart power meters often hold a close link between smart substation and smart distribution.

Smart Substations:

Smart substations include the monitoring and control of critical and non-critical operational data such as power factor performance, security, and breaker, transformer and battery status.

Smart distribution:

Smart grid is self-healing, self-balancing and self-optimizing. It includes superconducting cables for long-distance transmission, and automated monitoring and analysis tools capable of detecting or even predicting cable and other failures based on real-time data on weather.

Smart generation:

Smart Grid helps power generation resources to optimize energy production, and to automatically maintain voltage, frequency and power factor standards based on feedback from multiple points in the grid. Smart grid provides universal access to affordable, low-carbon electrical power generation and storage.

Power generation is likely to move towards more renewable and distributed generation. Changes in a distribution system include greater automation and switching, allowing for more physical control over which lines are opened or closed. Smart systems also allow better use of variable capacitor banks or static VAR compensators, automatic reclosers .,etc.

On the Transmission front the most striking change would be the use of phasor measurement units (PMUs), which can precisely measure the state of a power grid. It can accurately measure the state of the system through improvement in measurement, communication and analysis techniques.

One of the important components of smart grids is smart metering. The older smart meters allowed automated meter reading, which evolved into advanced metering infrastructure where the meter not only measures, stores, and communicates loads and other power statistics in real time, but it can also be a point for control and signalling to consumers and their devices for load control.

A smart grid will exhibit seven key characteristics:

Self-healing and resilient:

Smart grid system performs real time self-assessment to detect, analyse and respond to subnormal grid conditions. Through integrated automation, it has a ability to self heal by restoring grid components of the network. It will remain resilient, minimizing the consequences and speeding up the time to service restoration. It increases the reliability, efficiency and security of the grid and avoids the inconvenience and expense of interruptions.

Asset optimization and operational efficiency:

A smart grid will enable better asset utilization from generation to the consumer end points. It will enable condition and performance based maintenance. Smart grids will also improve efficiency through reduction in technical and non-technical line losses.

Enable demand response:

Extending the smart grid within the home, consumer appliances and devices can be controlled remotely, allowing for demand response. In the event of peak in demand, a central system operator would potentially be able to control both the amount of power generation feeding into the system and the amount of demand drawing from the system.

Integration of advanced and low-carbon technologies:

A smart grid will exhibit "plug and play" scalable and interoperable capabilities. It permits a higher transmission and distribution system penetration of renewable generation, distributed generation and energy storage .It allows the society to optimize the use of low-carbon energy sources, support the efforts to reduce the carbon intensity and minimize the collective environmental footprint. Smarter Grid helps the customers to lower the carbon footprints, without having to compromise on the lifestyle, usage requirements.

Power quality: A smart grid will have high quality of power and reduces the occurrence of distortions of power supply. As the load demands increase on an exponential path, there would be power quality degradation, in turn requiring distributed monitoring and proactive mediation. •

Market empowerment:

A smart grid will provide greater transparency and availability of energy market information. It will enable more efficient, automated management of market parameters, such as changes of capacity, and enable a plethora of new products and services. New sources of supply and enhanced control of demand will expand markets and bring together buyers and sellers and remove inefficiencies. It will shift the utility from a commodity provider to a service provider.

Customer inclusion:

A smart grid involves consumers by engaging them as active participants in the electricity market. It will help empower utilities to match evolving consumer expectation and deliver greater visibility and choice in energy purchasing. It will generate demand, for cost-saving and energy-saving products. Smart grids will help educate the average consumer, foster innovation in new energy management services and reduce the costs and environmental impact of the delivery of electricity.

Smart Grid and Environment:

The energy conservation and improvements in end-use efficiency enabled by the smart grid reduce half of the emissions. Environmental improvements can be obtained by managing the peak load through demand response rather than spinning reserves. It can reduce T&D losses by 30%. Smart grid system gives a continuous feed back on electricity use, which enables the consumers to adjust the usage in response to pricing and consumption and thereby reduce annual CO_2 emissions. Optimised use of existing generation, transmission and distribution through this system reduces the new infrastructure constructions.

Key characteristics of Smart Grid

INTELLIGENT ON THE EDGES
- DISTRIBUTED ARCHITECTURE, EMBEDDED SENSORS & MONITORS, INTERACTIVE

ADAPTIVE, FLEXIBLE , RELIABLE, SECURE, RESILIENT
- SELF HEALING, SELF CONFIGURING, ISLANDING, PLUG & PLAY

INTERCONNECTED, INTEROPERABLE
- INTEGRATES SEAMLESSLY, OPEN STANDARDS, DISTRIBUTED GENERATION

PARTICIPATIVE
- DEMAND/CUSTOMER PARTICIPATION

DYNAMIC
- REAL TIME INFORMATION FLOW, DISTRIBUTION AUTOMATION, MOBILE COMPUTING

HIGH SPEED REAL TIME COMMUNICATION IN MULTIPLE DIRECTIONS
- NET METERING, REMOTE CONNECT/DISCONNECT, REAL-TIME PRICING OPTIONS

LOW COST
- OPTIMIZES NETWORK ASSET UTILIZATION

CLEAN & GREEN
- RENEWABLES INTEGRATION, ENERGY EFFICIENCY

Source: Infosys report on Smart Grid

Engineering Economics and Financial Benefits of Smart Grid

The smart grid presents a wide range of potential benefits, which include

- Optimizing the value of existing production and transmission capacity
- Incorporating more renewable energy
- Improvements in energy efficiency
- Broader penetration and use of energy storage options
- Reducing carbon emissions by increasing system, load and delivery efficiencies
- Improving power quality
- Improving a utility's power reliability, operational performance, asset management and overall productivity.
- Promoting energy independence.

The primary benefits include lower operating and maintenance costs, lower peak demand, increased reliability and power quality, reductions in carbon emissions, expansion of access to electricity and lower energy costs from fuel switching and home automation. Smart grids through demand response and load management reduces the per unit production cost. By reducing the peak demand, a smart grid can reduce the need for additional transmission lines and distribution investments. It also reduces the Operations & Maintenance costs by eliminating the unneeded field trips, reduce consumer outage and high bill calls. Industrial and commercial consumers

Challenges for Smart Grid

Several challenges present themselves for smart grid development

Financial resources: The self-healing characteristic of grid is good, particularly if it includes societal benefits. But regulators will require extensive proof before authorizing major investments based heavily on societal benefits.

Government support: The industry may not have the financial capacity to fund new technologies without the aid of government. The utility industry is capital-intensive, but has been sustaining exorbitant losses due to thefts and subsidization.

Compatible equipment: Some older equipment must be replaced as it cannot be compatible with smart grid technologies. This may present a problem for utilities and regulators as keeping equipment beyond its depreciated life minimizes the capital cost to consumers.

Lack of policy and regulation: No defined standards and guidelines exist for the regulation of smart grid initiatives in most of the countries.

Capacity to absorb advanced technology: Most of the distribution companies have limited experience with basic information and communications technology and, as a result, they have weak internal skills to manage critical component of smart grids.

Consumer education:

The two critical and often overlooked components of smart grid implementations are

a) Sufficient marketing analysis and product design to optimize the likelihood to use the new technology

b) Education, communication and public relations program aimed at creating an understanding of smart grids, the associated benefits and the potential implementation issues.

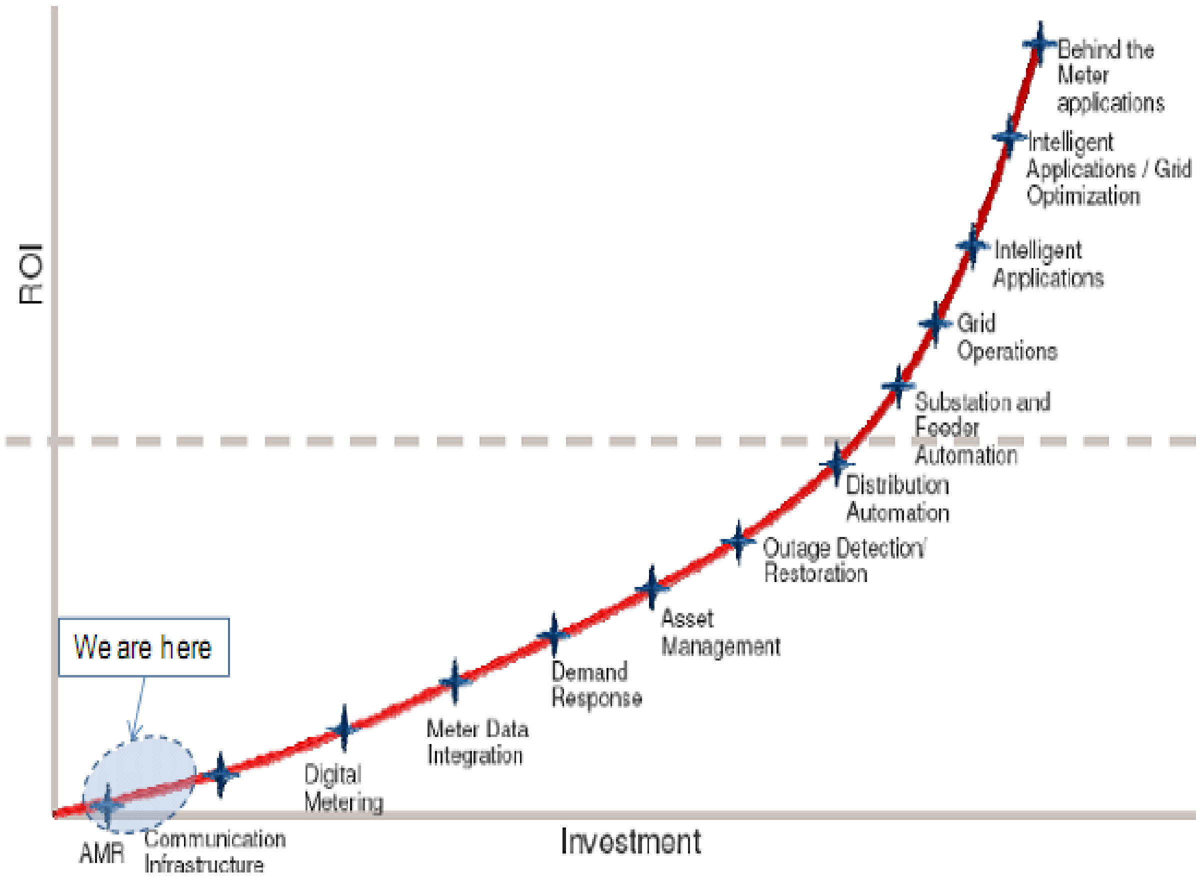
Cost assessment: Costs could be higher than projected because the standards and protocols needed to design and operate an advanced metering infrastructure are still in a state of flux. Thus, investments made now, before the standards are settled, have a higher risk of obsolescence. Failure to include estimates of the costs for the control equipment customers will install to automate their response to time-differentiated pricing could put smart grid investments at risk.

Cyber security and data privacy: Digital communication networks and more granular and frequent information on consumption patterns raise concerns in cyber-insecurity and potential for misuse of private data.

Stages in evolution of Smart Grid

	Elementary stage	Evolutionary stage	Fully Integrated smart grid
Metering	▪ Largely manual metering ▪ Some automated meters for large industrial users	▪ 100% Smart meters with automated meter reading and real time displays	▪ Advanced meters allowing real time rate changes and remote on/off capability
Transmission Grid	▪ Zero automation in transmission lines, switches and substations	▪ Ongoing automation of HV systems and substations	▪ Full automation of HV systems and substations ▪ All switches and flows remotely controlled
Distribution network	▪ Zero automation of distribution network including substations & circuit breakers ▪ Manual fault localization	▪ Partly automated switches & circuit breakers along MV lines for fault identification ▪ Manual LV grid	▪ Fully, remotely automated distribution network with remote sensing and voltage control capability
Integration	▪ Basic communication between grid components ▪ Limited ability to control dispatch	▪ Online monitoring of flows in transmission grid and ability to balance system	▪ Total integration of supply and usage of electricity ▪ Ability to control dispatch and usage remotely

Smart Grid Technology implementation curve



Source: GPBullhound report

Smart Grid for India

India's electrical grids are one of the weakest electric grids in the World, the opportunities for improvement are enormous. According to Ministry of Power, India's transmission and distribution losses are among the highest in the world, averaging 24% of total electricity production, with some states as high as 62%. When other losses such as energy theft are taken into account the total, average losses are as high as 50%.

For India to maintain its economic growth there is an urgent need to build a modern, intelligent grid. To provide a stable environment in electric infrastructure through fixing the fundamental problems, an intelligent Smart grid is needed for the country. Without this, India will not be able to keep pace with the growing electricity needs of its industries, and will fail to create the required environment for growth.

Smart grid, a system that can provide uninterrupted electricity to consumers across India, even in remote locations, while eliminating wastage of power units and therefore tripping-is is the best solution

Ministry of Power in India has taken a task of mission “Electricity for All” by 2012. India now has the fifth largest Electricity grid in the world and the world’s third largest Transmission & Distribution network. However, the demand from increased economic activities and the rising living standard of population has led to a situation where the supply of energy falls short of the demand. The existing power deficit and a rising demand coupled with country’s commitment to provide access to electricity for all has necessitated a large scale capacity addition program.

In India POWER GRID is in the forefront of technology initiative for Smart grid. Power grid has taken lead in implementing several new technologies, such as HVDC or Flexible AC Transmission (FACT) Systems in the transmission sector of country. It has a plan to introduce 800KV HVDC and 1200KV AC transmission lines. These initiatives led to formation of National grid which is connected to regional grids. Power grid aimed at deploying Smart Grid Technology in transmission system, as a step towards realizing modern smart grid which is essential in managing increased share of energy from natural resources without unduly impacting the reliability of the Grid.

India has been actively introducing IT in power. Distribution sector has implemented projects under APDRP programme of Government of India for several states. Ministry of Power through R-APDRP assigned IT consultants to each state utility and included modern technology in the management of the Smart Grid to consumers.

Current Indian Scenario

Smart Grid for Transmission Network in India

- Power Grid Corp – operation of the national grid
- Growing at 40% CAGR
- Aggressive deployment of Phasor Measurement Units (PMUs)
- Northern grid – already installed 4 PMUs, 20 more in progress
- Western grid – 25 PMUs
- Eastern grid – 70-80 PMUs
- Functioning wholesale electricity trading markets on commodity exchanges
- Low volumes, ~5% of electricity traded on exchanges
- Lot of research activity related to PMUs in universities
- Optimal placement of PMUs
- Dynamic State Estimation
- Control schemes, Software for data visualization,

Distribution Infrastructure in India

- Reform of the distribution sector identified as a key need by the government.
- APDRP, R-APDRP – Reducing AT&C losses a key focus
- Open-Access for the distribution network to foster competition
- Laws against theft - better enforcement, better communication
- Privatization & Franchising of distribution network
- Demand Side Management – especially in agricultural sector
- Rationalization of tariffs and removal of cross-subsidies.
- High Penetration of Distributed Energy Resources
- Many customer segments taking things in their own hands - Industrial centres, Software Export ones (SEZs) have their own captive generation
- Large residential complexes usually have near-100% power back-up through captive generation
- Small residential customers have a high penetration of distributed energy resources - Diesel-generators
- Battery-Inverter packs – peak-load shifting and load management

Ongoing Smart Grid Activities

- APDRP, R-APDRP initiative for distribution reform (AT&C focus)
- DRUM India – Distribution Reform Upgrade, Management
- Four pilot sites (North Delhi, Bangalore, Gujarat, Maharashtra)
- Smart Grid Vision for India
- Smart Grid Task Force – Headed by Sam Pitroda
- BESCOM project – Bangalore – Integration of renewable and distributed energy resources into the grid
- KEPCO project in Kerala India - $10 Billion initiative for Smart-Grid
- L&T and Telvent project – Maharashtra – Distribution Management System roll-out
- Housing – Rabirashmi Abasan housing project – Kolkata (2008). First instance of net-metering in India from roof-top Solar
- SA Habitat and Valence Energy – Hyderabad (2009) .
- Distributed generation via roof-top solar for 40% in a micro-grid

For complete implementation of Smart Grid our country needs a national vision and a flexible plan. India needs to build on the R-APDRP program and use it to improve service quality. It needs to identify and implement smart grid concepts that reinforce the operational efficiency of discoms. Conduct customer and marketing surveys to develop a more refined understanding of customer satisfaction, and analyses to develop a better understanding of demand and consumption. India needs to develop policies and regulations to create receptive environment for smart grids, by encouraging innovation, establishing standards for interoperability, and allowing market-oriented and entrepreneurial solutions.

Barriers for Smart Grid Implementation in India

In India there is no proven commercial viability for large scale smart grid roll outs and there is no coordinated road map for Smart grid deployment. Also the State owned transmission and distribution companies have poor financial health. There is very low awareness of technological developments and benefits in the utility sector. These are some of the hurdles or barriers for Smart grid implementation in India.

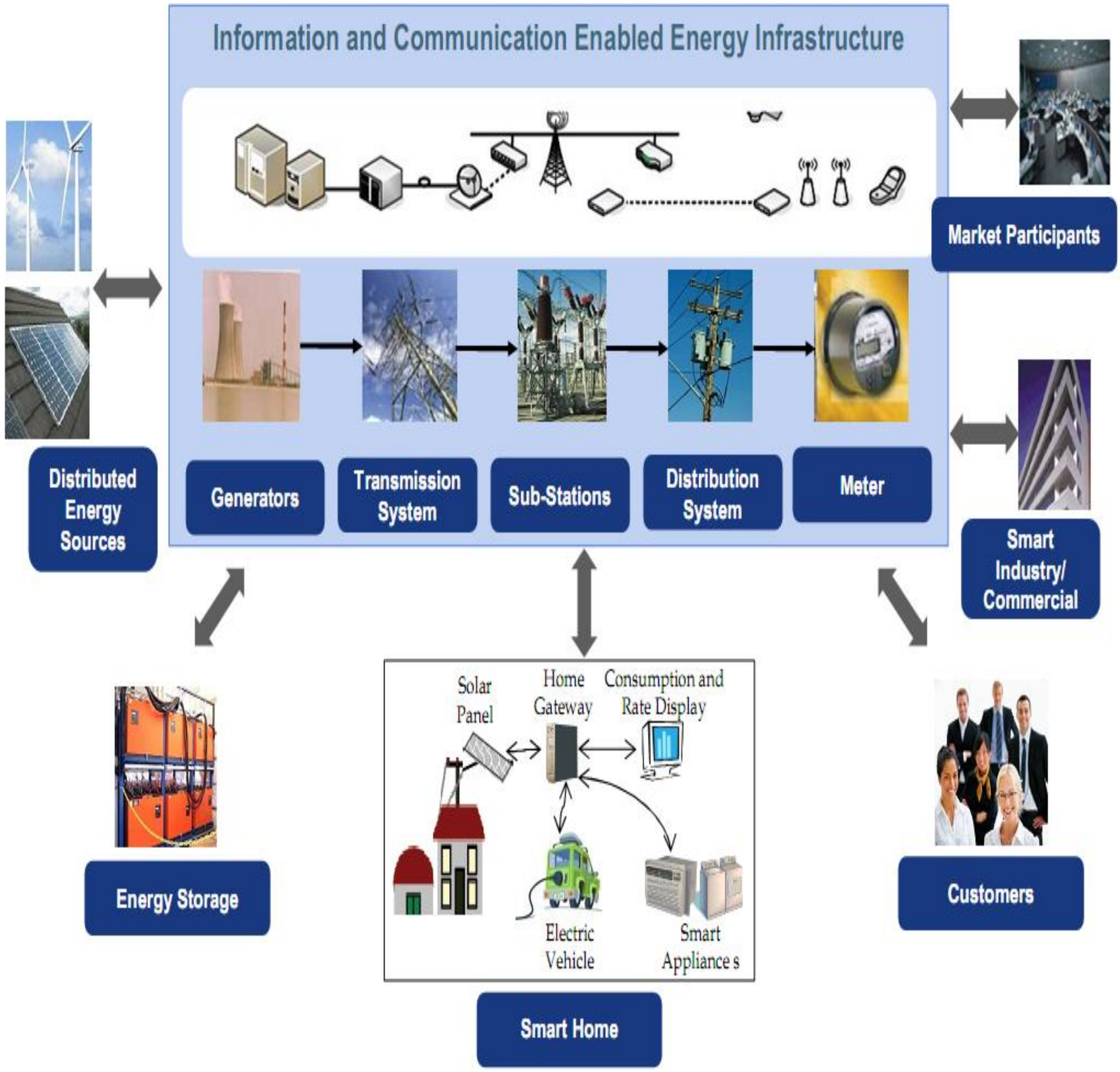
As bulk amount of power in the country is owned and operated by government of India, the major push for smart grid implementation should come from them. Since most of India's utilities find it difficult to invest funds on their own for smart grid initiatives, they will have to depend on the allocation of funds from the central government for smart grid deployment. The central government will also need to take the initiatives required to ensure that central and state regulatory bodies respond proactively in terms of developing regulations suitable to enable a smart grid. Restructured Accelerated Power Development and Reform Programme is an area regulators should assess and respond to in preface to any smart grid development. CEA can play a key role in coordinating the efforts for interoperability and standards for smart grids, in addition to its major role in planning and monitoring the country's power projects.

Twenty-one smart grid players are on the list of empanelled consultants for R-APDRP. They are of varying skills, sizes, and backgrounds. The empanelment process used for R-APDRP has certain advantages and disadvantages. If India's utilities are to take an active part in designing and implementing IT and smart grid projects, they must acquire the skills they need to take over their projects' operation and maintenance, as vendors assistance will only be rendered for a short period of time.

Conclusion

In 21st century, if India dreams to emerge out as a developed nation, energy efficiency and energy conservation integrated with IT infrastructure is required to be implemented. Smart Grids is one such option which can drive India an inch closer to be a developed nation and achieve energy security. Energy Automation will also play a vital role in achieving the targets. The trend of Smart Grid in US had turned out to be a huge success. The country's economy has improved drastically after implementation and power losses have been reduced to around 12-15% in US.

Complete Flow-Chart of Smart Grid System



Source: Infosys report

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