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Evacuation of electricity generated through conventional means is by itself a challenging aspect of the power sector, add to this the addition of renewable energy into the mix and there is no telling the kind of chaos this may cause. Smart grids may be the way forward here.

Smart grid is an evolving set of various technologies, especially information and communication technologies, working together to improve the present grid. Being an evolving technology, it is difficult to define it. A number of renowned organisations working towards the development of smart grid have defined it as an electricity network that can intelligently integrate the actions of all users connected to it, in order to efficiently deliver sustainable, economic and secure electricity supplies. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to better facilitate the connection and operation of generators of all sizes and technologies; allow consumers to play a part in optimising the operation of the system; provide consumers with greater information and choice of supply; significantly reduce the environmental impact of the whole electricity supply system; and deliver enhanced levels of reliability and security of supply.

Smart Grid Functionality

The present electricity grid delivers electricity from points of generation to consumers through two primary systems. The transmission system brings electricity from power plants to distribution substations, while the distribution system delivers electricity from distribution substations to consumers.

A smart grid would allow new large-scale, renewable-energy projects to connect to the grid. On the distribution side, the smart grid would integrate new digital technology into local electricity distribution networks that would help manage the demand that appliances and other end-use equipment place on the grid at key times of the day, improve the efficiency of electricity distribution within local networks, and provide better information about electricity use in homes, businesses, and public institutions.

The smart grid will also provide the pricing and control system to flexibly integrate new distributed energy resources, e.g. solar panels, energy storage devices, and electric vehicles, close to the point of demand. Users could charge up their plug-in cars at

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night to later feed that power back into the grid as their cars are parked at work or at home during the day.

In general, working of smart grid technology can be understood by grouping into following key areas: integrated communications, sensing and measurement-smart meters, phase measurement units, advanced components-superconductivity, advanced control and pricing mechanism-real time pricing, distributed generation-feed-in tariff, renewable energy resources, energy storage, electric vehicles.

The smart grid vision involves a uniformly integrated communication system with the present power system. Present communication systems have evolved over a period of time and lack uniformity and thus interoperability. The communication system shall be a two-way system where the load can be controlled remotely from a control centre and also read the real time power consumption of the load. To enable this real time monitoring, advanced devices like smart sensors, smart meters and phase measurement units will be required to be integrated in the smart grid system. It would enable quick fault detection and analysis of the system, thus increasing reliability. The real time-monitoring and control will enable a market dependent pricing mechanism and thus a deregulated market. Also, consumers would be able to feed power back into the grid and earn according to the feed-in tariff. All these will help in reducing the peak demand and the country´s dependence on fossil fuel energy. The next stage envisaged is incorporation of advanced technologies like superconductivity in the transmission network to increase the efficiency of the system.

India Connect

With a growth rate of around 8 per cent GDP, India´s energy demand is expected to increase three times in the coming 10 years, out of which 2/3rd would be carried by the grid. To enable a similar growth for the coming years, India needs a major revamp of the ageing electricity system from the transmission to the distribution. Presently, the Indian electricity system faces a number of challenges like shortage of power, power theft, poor access to electricity in rural areas, huge losses in the grid, inefficient power consumption and poor reliability. The present grid system needs a major revamp to address all these challenges. It needs investment in several areas: increasing generation capacity, improving grid efficiencies and rural electrification. A

smart grid is supposed to be the solution to all these challenges and in fact essential for India´s energy security in the future.

In the XIIth plan, the Government has proposed to invest around USD 86.4 billion to upgrade the present electricity system. It has been done through various programs like Revised Accelerated Power Development and Reform Program (RAPDRP), Jawaharlal Nehru National Solar Mission, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). With such a huge investment, India has an opportunity to leapfrog into the latest smart grid technologies as it has done in other sectors like telecommunications.

´Smart grids have emerged as a key enabling infrastructure to develop smart solutions to resolve India´s energy woes. Smart grids are also crucial to some of Indian government´s key projects: 100 Smart Cities, 175 GW of renewable energy by 2022, 40% Renewable energy by 2030, electric vehicles (to combat air pollution) and smart meters amongst others. We are looking forward to experience sharing from utilities, policy makers and technology companies on deployment of large smart grid projects in North America, Western Europe, Japan, South Korea etc. which will be fruitful for stakeholders in India for planning and rollout of smart grid projects,ö according to Reji Kumar Pillai, India Smart Grid Forum President.

Global Appeal

Power sector globally is at the threshold of a paradigm shift - from centralised generation we are fast moving to an era of distributed generation and smart grids - increasing share of generation resource being added at the distribution grid. Governments of various Countries are implementing Smart Grid projects by giving grants and incentives. The table below indicates the spending on Smart Grid demonstration projects in various countries during 2008-2014:

According to the India Smart Grid Forum (ISGF), which has compiled summary of 68 projects across the world, it is observed that most successful projects were implemented in public private partnership (PPP). The Government grants varied from 25 per cent to 50 per cent and utilities and technology companies contributed to the rest of project cost. Many projects had active participation of academia which was mostly funded through Government grants. Transparent selection process was followed in which Government agencies invited call for proposals. Utilities partnered

with technology companies and academia and submitted detailed project proposals which were evaluated by committees of experts and projects were allotted purely on the basis of the merits. Frameworks for monitoring of project implementation and evaluation of results were also observed in most cases.

Smart Grids for Renew

Traditionally, integration of small-scale or micro grid renewable energy sources into a regular grid causes glitches. These include voltage fluctuations and harmonic distortions, which require synchronisation of the sources with the grid. Smart grid, on the other hand, optimises these problems by preventing outages and allowing consumers to manage energy usage. This technology enables various options to add energy to the grid at transmission and distribution levels through distributed generation and storage. Hence, smart grid technology can be most suitably applied here. In other words, a smart grid makes better use of renewable energy resources.

The electric power grid is one of the most complex interconnected networks and is actually smart. It is going through a massive change especially with the penetration of renewables and distributed power. With the rapid technology development in the areas of communication and software, there is an opportunity to make the grid smarter and get more out of the existing grid in terms of improved reliability and efficiency, embracing renewables and reduced emissions. India provides a wide range of opportunities for smart grid players and the growth is expected at a fast pace. This ranges right from generation, transmission, distribution to the end users.

On the generation side, with the ambitious plan to have 175 GW of renewables in India by 2022, there is a tremendous opportunity for smart grid players to make an impact. Developing technologies by which the grid can handle this level of penetration by managing the intermittency of power will become very critical.

On the transmission side, technologies that can help power system operators with the situational awareness of the grid, i.e., how much margin we have in the grid before experiencing problems, would be vital. Sensing, Communication, Analytics and Controls technologies would play a major role in this area. Technologies such as big data analytics, improved visualization, advanced communication infrastructure and fast & reliable control systems design can play a major role in improved situational

awareness at a wide area level and allow for more efficient and reliable operation of the grid at all levels - the key goal of the smart grid framework. Distribution sector is probably seen to be the highest growing sector. Given India´s needs to improve ATC losses, and the government focus in enabling this, along with increasing penetration of solar energy makes distribution the key growth area. Automation technologies that can restore power much faster to consumers, identification and isolation of fault areas and effectively managing the distribution operations would be essential.

Besides, India has a huge rural population that have limited or no access to electricity. There is a great opportunity for micro-grids here. Technologies that can integrate various locally available energy resources and be able to operate the small grid reliably would gain lot of importance over the next few years. Inherently, transformation of such a complex and large scale system, with the technical and regulatory ramifications will happen in a phased manner. The key is to anticipate the value creation potential of smart grid technologies in tomorrow´s grid, and to develop technology that can be adopted by the key players.

Renewables integration brings with it challenges in both planning and operation. Wind and solar fluctuation patterns are totally different from each other. A smart grid should be able to dispatch conventional generation resources at the system level fast enough and in the most optimal way to maintain load-generation balance and mitigate grid frequency variation. Also, forecasting applications will be needed to predict the generation patterns of wind and solar plants and facilitate decisions in power system operation.

The key operational challenges in the form of frequency response and increased power swings are met by enabling smart grid technologies that can be deployed at the solar or wind farm; or by having controls at the transmission level. At the wind/solar farm level, improved frequency droop response, secondary frequency response and controlled inertial response are key enablers. Other technologies such as synchrophasor measurements could enable better visibility of the grids at very high frequencies. At the transmission level, control solutions need to be developed to improve damping of power swings introduced due to renewable power variation.

Energy Storage is another technology that has promise. Integration of storage into the grid has the potential for directly impacting the overall variability introduced by renewables. Demand response technologies that can vary the load fast enough to accommodate intermittency of renewables at a system level can also be explored. Each of these has their own advantages and challenges for mass deployment. However, each of this would have to work in a cohesive ôsmartö mode, to enable grid stabilisation.

Besides, smart grid technologies are very much relevant to micro grids. A micro-grid is a very challenging power system configuration in terms of operation and control, more so when it includes renewable power. The key requirements of a micro grid would be to be able to supply grid quality power, 24x7. This is not an easy task because the grid would be weak. The sensitivity of the system to small disturbances such as renewable power variation within seconds is higher compared to a larger conventional grid. The system is closer to the stability margin and can be subjected to higher variations in frequency. Real time energy management becomes a key to enable to stable micro grid. Other critical technology is fast communication between the resources and the micro-grid controller and the appropriate control knobs to help mitigate the challenges encountered in micro-grid operation. An example is the coordination of load control within the micro-grid to respond to large variations in frequency and frequency rate of change to prevent large frequency excursion. Since in a low inertia micro-grid, the variations in frequency (and in fact most other system states) are large, fast acting controls are key to mitigating these issues.

The key driver is the need for reliable electricity in India to enhance our economy. To enable faster implementation of smart grids, there is a need for various stakeholders (Utilities, Policy makers, technology developers, R&D institutions and consumers) to get together chalk out a plan where they can jointly contribute and take accountability for successful demonstration and deployment of smart grids. The govt should increase the focus on R&D in this area and enforce strict milestones in development of smart grids. India can be lead this transformation driving innovation and deployment of smart grids that can then be leveraged across the world. Smart grids have the potential to explode in a fashion similar to mobile phone networks in India.

Conclusion

One of the key benefits that facilities can get form smart grid is the improved efficiency and reliability of the grid. As the grid becomes more intelligent and smart, it will automatically self assess its reliability during changing circumstances and will adopt itself accordingly. This enhanced and improved functionality will result into greater reliability and certainty for consumer which includes both commercial as well as the mass consumers of India, subsequently it will also result in an improved power quality and fewer power cut and shortage especially during peak time.

One of the prime essence of a smart grid is to seamlessly interconnect different fuel cells, renewable sources, micro turbines and other distributed-generation system at all levels. This includes advancement in dealing with principle challenges of bi-directional power flow on distribution systems, along with support of innovations related to energy storage. All of these innovations will enhance in stabilising renewable energy fluctuations even in different weather condition A smart grid provides power utilities with digital intelligence to the power system network. Smart grid is often called as ´energy internet´. The technology employed while using smart grids with renewable energy are not different than usual technology.

It comes with smart metering techniques, digital sensors, and intelligent control systems with analytical tools which enable the two-way flow of energy from power to plug to be automated, monitored and controlled.

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India is aggressively venturing into renewable energy resources like wind and solar. With such unpredictable energy sources feeding the grid, it is necessary to have a grid that is highly adaptive (both in terms of supply and demand). A good electric supply is

one of the key infrastructure requirements to support overall development; hence, the opportunities for building smart grids in India are immense.

TAGS Smart grid, Technologies, Electricity, Renewable energy, Smart grid, Distribution, Energy storage, Electric vehicles, GDP, Transmission, Grid system, RAPDRP, RGGVY, Smart Cities, Infrastructure, Reji Kumar Pillai, India Smart Grid Forum, Generation, ISGF, PPP, smart grid technology, R&D

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