



# *Energy Internet of the Future*

India's hunger for electricity can be satiated through smart grids that integrate renewable sources of energy such as solar and wind. However, certain challenges will need to be addressed even as the country – one of the world's fastest growing economies – readies itself to leapfrog to the next level in power revolution.

India's energy sector made global headlines in May 2017 when at a reverse auction in Rajasthan, each of the independent power producers, Phelan Energy and Avaada Power, offered to charge Rs 2.62 (¢4) per kilowatt-hour (kWh) for electricity generated from a solar energy park in the desert state. What is even more significant is the fact that the tariff surpassed the previous low of Rs 3.15 (¢5) per kWh submitted just a month earlier in April!

With such steep fall witnessed in

the per unit price of solar energy, the country suspended plans to build nearly 14 GW of coal-fired power stations. Experts aver that at a time when solar power in India is cheaper than fossil fuel-generated power, there is a need to ensure that its benefits are widely available. They point out that this is best done through a rapid, yet systematic rollout of the smart grid, also often termed as the 'energy Internet of the future.'

A conventional grid comprises power lines, transformers and

infrastructure that transport electricity from power plants to end users. Being unidirectional, the traditional electricity grid of alternating current (AC) is forever required to adjust to supply-and-demand fluctuations in real time. And, as the demand is entirely driven by consumers' requirement over different time periods, the grid requires sufficient generation capability to fulfil any spikes. But, with the implementation of digital solutions and increasing use of renewable energy, the world is



moving towards the era of smart grids. Thus, the flow of electricity can no longer be simplistically defined as generation, transmission and distribution. Users with their own solar panels can now also become prosumers (producers and consumers) of electricity.

## INTELLIGENT GRIDS

In a telephone interview to **SOLAR TODAY**, Reji Pillai, President, India Smart Grid Forum (ISGF) and Chairman, Global Smart Grid Federation (GSGF), said, "There are net metering policies in all 29 states and seven union territories in India, and theoretically every consumer in India can be a prosumer. With constantly increasing prices of conventional power from the grid and steeply falling prices of PV panels, many consumers are finding it economically viable to have rooftop systems." However, he added that distribution utilities are yet to provide connections to a large number of such potential prosumers.

Moreover, growing use of renewable energy will result in electricity grids becoming highly interactive. They will intervene to seek a reduction in demand from consumers during peak hours. Traditionally, in case of electricity, Indian electric utilities have relied on load shedding to avoid an all-out crash in the distribution system to meet shortage during peak hours. Rather than resorting to drastic power cuts, a smart grid can reduce supply so that consumers can operate at least basic electrical appliances such as lights and fan.

**Anurag Garg, Vice President, Solar and Energy Storage, Schneider Electric India** told **SOLAR TODAY**, "Through the integration of renewable energy, smart grid technology is making significant contribution to overall grid operations. With emphasis on non-conventional energy sources, especially solar power, the role of smart grid technologies has become all the more critical to ensure stability of power supply, tackle fluctuations and allow smooth



Smart grid technologies allow smooth integration of conventional and renewable power generation.

integration of conventional and renewable power generation. The presence of smart grid also helps in streamlining the distributed solar power generation using rooftop solar arrays to feed electricity into the grid during daylight hours in order to meet the peak in demand." With integration of solar energy, which is only expected to rise as more solar plants become operational, it is imperative for a country like India to continue to focus on grid planning for the future. This has led to the next round of innovation and development of a new generation of grid architectures.

In view of certain other technological disruptions taking place, Pillai asserted, "The bitcoin and blockchain is going to change the entire energy value chain. Anybody will be able to sell (electricity) from anywhere in the world." He cited the example of a primary school in a low-income community in South Africa whose electric supply is remotely funded by Boston-based donors using bitcoins.

## NEED FOR SMART GRIDS

Some industry insiders like **Francois Vazille, Japan & Asia Pacific (JAPAC), Oracle Utilities**, however, caution that

since renewable energy sources might prove to be inadequate in meeting the entire demand, traditional power plants would still be required. "It will be crazy to venture into very big renewable energy projects at this stage. The projects will evolve as we embark on new solar and wind smart grids step-by-step and understand the requirements in terms of electricity generation and demand, and what needs to be done with our existing plants. We are going to learn as we go."

But others like Pillai reject this line of argument on the ground that it is more suited to developed Western economies where consumers have enjoyed 24-hour electricity for the past several generations. "Even today one-fourth of our population is neither connected to the electricity grid nor do those connected to the grid get 24 x 7 electricity supply. Therefore, we need not wait for such a natural evolution. We should embrace the emerging technologies and leapfrog," he asserted.

The federal government is also looking at making all public transports and personal vehicles electric by 2030. Energy Efficiency Services Ltd (EESL), a joint venture between public sector enterprises and the Ministry of Power,

## INDIA'S R&amp;D PROGRAMME ON SMART GRIDS

India's Department of Science & Technology (DST) has funded around Rs 3 billion (\$46.5 million) towards research and development (R&D) on smart grids. Indian academic institutions, including Indian Institute of Technology (IIT), Indian Institute of Science (IISc), and private industries have been engaged in R&D on the concept. Some of the DST-funded projects undertaken by the academic institutions are in advanced stages of completion. These projects include national as well as bilateral programmes with other countries such as the US, UK and Netherlands.

**Advanced metering infrastructure**

Advanced Metering Infrastructure (AMI) facilitates monitoring and measurement of consumer information and control through smart metres installed at customer premises. It supports bidirectional flow of information between consumers and utility control centres through communication modes such as General Packet Radio Service (GPRS) and Power Line Communication and Radio Frequency (RF). Smart metres will also enable time of use (TOU) and critical peak pricing (CPP) or real-time pricing (RTP) rate metering for demand response.

**Peak load management**

Peak load management refers to controlling the demand and matching it with the available supply at the instant of peak. For power availability and volume of shortage, peak load management function shall take inputs from supervisory control and detection acquisition (SCADA) or energy management system (EMS). Based on the shortage, the peak management function shall run algorithms considering various constraints and priorities pre-defined on the basis of customer profile by System Integrator (SI) in association with the employer or utility personnel, and suggest the recommended options. The approach shall be to avoid tripping of feeders for load shedding and manage peak load either by load curtailment through AMI or by price incentives or disincentives in the form of TOU pricing.

**Power quality management**

Power quality management addresses events like voltage

flickering (sags or swells), unbalanced phase voltages and harmonic distorted supply. This will facilitate efficient and reliable operation of the power system, reduce losses, improve customer satisfaction and minimise equipment (utility or consumer) failures. Power quality management shall include voltage or volt-ampere reactive (var) control, load balancing, harmonics control, etc.

**Outage management**

Outage management system (OMS) manages unscheduled distribution infrastructure like distribution transformers (DT), high-tension (HT), low-tension (LT) feeders, etc. It collects and coordinates information about outages, including customer calls and reports to the operator for taking corrective actions through crew management and remote control, enabling customer satisfaction and improvement in system availability and reliability.

**Micro grids**

A micro grid is an integrated energy and communication system consisting of interconnected loads and distributed energy resources (DER), which mainly operates in standalone mode or in parallel with the grid, in case of emergency. Micro grid generation resources include micro turbines, wind, solar, fuel cells or other energy sources. Ability of the micro grid to isolate from a larger network ensures highly reliable electric power to consumers.

**Distributed generation**

Distributed generation involves development and implementation of new and innovative technology solutions related to plug-in hybrid (PHEV) and electric vehicles (EV), wind, photovoltaics and other distributed generation technologies, systems and solutions supporting flexibility of interaction with customers, energy use or exchange, demand and loss management, management of transactions, pricing and billing, etc.

*Source: India Country Report, Dept of Science & Technology, Ministry of Science & Technology, Govt of India, June 2017*

has already completed the formalities for procurement of 10,000 electric vehicles from the country's largest automaker, Tata Motors.

Elaborating on the plan in his spanking office in Noida on Delhi's outskirts, **Saurabh Kumar, Managing Director, EESL** remarked, "Half a million cars are estimated to be used by the government. We would like to replace them in a phased manner. This will create an ecosystem that attracts global manufactures to set up facilities here, battery manufacturers and charging station establishments." Initially, car batteries will be

replenished at charging stations located inside government buildings.

**DYNAMIC TARIFF MECHANISM**

The conventional grid is largely based on a system of cross-subsidisation where certain categories of consumers such as commercial establishments pay extra to sustain the electric utility. In the scenario that is now emerging, they will be the ones who will be migrating to renewable energy.

Summarising the scenario, a 2014 post by the Vermont-based not-for-profit organisation Clean Energy Group

noted, "Solar + storage systems will soon reach cost parity with grid-purchased electricity, thus presenting the first serious challenge to the centralised utility model. Customers, the theory goes, will soon be able to cut the cord that has bound them to traditional utilities, opting instead to self-generate using cheap photovoltaics (PV) with batteries to regulate intermittent output and carry them through cloudy spells. Factors such as the plummeting cost of solar panels, the imminent increased production and decreased cost of electric vehicle batteries that can be





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used in stationary applications have combined to create a perfect storm in terms of technology.”

This has raised the spectre of ‘utility death spiral,’ where an increasing number of consumers either substantially reduce or completely stop depending on the conventional grid. With more people self-generating electricity, utilities will be forced to seek higher tariffs from a shrinking consumer base.

**Rahul Tongia, Brookings India Fellow and Founding Technical Advisor to India’s Smart Grid Task Force**, recommended in a June 2017 article published in the business daily, Mint, “To fix this problem, we have to stop treating all units of power the same. Similar to how we sell a basket of assorted fruits (say Rs 5 per kilo or kilowatt-hour) that includes mangoes, bananas, lychees and other fruits, different options of supply that include differences in costs, availability, predictability, ramping

rates, etc should be included to the cost basket. Blending and selling at average masks the marginal costs, which is where there is scope for improvement.”

Therefore, in a price-sensitive market like India, this can be avoided by the demand response being addressed by time of day (ToD) mechanism of dynamic pricing. Effective ToD mechanism will not only provide a fillip to demand response but also serve to buttress the renewable energy revolution.

Schneider’s Garg added, “In order to capture more value from renewable resources, it is essential to devise cost-effective methods for new transmission or grid upgrades. This will further improve the viability of projects and enhance the overall investment climate.” He opined that in the era of smart cities, smart grids are going to play a critical role in infrastructure development.

In anticipation of the market

demand, makers of renewable energy equipment have started putting their latest offerings in the market.

Schneider Electric’s EcoStruxure Grid, an interoperable, IoT-enabled system architecture and platform is targeted at several verticals, including the grid market and Distribution System Operators (DSO). Its digital architecture leverages advancements in IoT, mobility, sensing, cloud computing, analytics and cyber security. The firm claims the product can save as much as 30 per cent of energy through end-to-end integration.

Smart grids imply a 360-degree transformation in the way electricity is generated and consumed. In a rapidly growing economy like India, successful integration of renewable sources of energy in a smart grid can help expand access to electricity to its over 1.32 billion citizens.

- MANISH PANT