Case study on Smart Grid Technology for India

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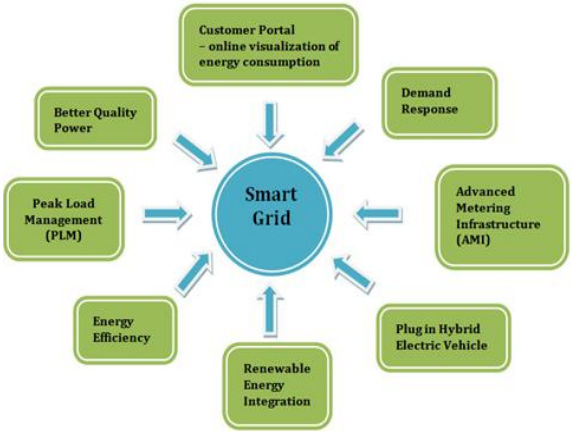
***Abstract*- The growing demand of electricity with the requirement of latest developments in the grids of power network proposes the need for the creation of smart grids. A smart grid is the integration of information and communication technology with the existing power network making the two way communication possible in the generation, transmission & distribution sectors between the utilities and customers by employing the use of smart devices. This paper presents a vision of smart grid development in India. The road map, highlights and development plans envisaged by the India Smart Grid Task Force for smart grid in India are discussed in the paper. Every power grid has three functional components generation, transmission & distribution. A smart grid should employ smart control centers, smart transmission network and smart distribution systems. The development is based on the optimal use of natural resources, integration of grids, creating and enhancing smart infrastructure of generation, transmission & distribution technology. This work is an effort to investigate all the developments related to smart grid in reference to India. The developments for creating smart grid in India are multifactorial in nature but major concerns are to electrify rural sector of India which is yet deprived from electrification.**

Index terms- Renewable Energy, Transmission and Distribution, Time of Demand

INTRODUCTION

A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via two-way digital communication. Smart Grid will enable to manage and measure all power flow across the system continuously. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce energy consumption and cost, and maximize the transparency and reliability of the energy supply chain.

Smart grids are electricity networks that can efficiently integrate the behaviors and actions of users connected to it – generators, consumers and those that do both – in order to develop an economically efficient, sustainable power system with low losses and high quality and security of supply and safety. From this perspective, a smart grid can be considered as a smart electricity system,



Which encompasses both the electric grid and the users connected to it, and includes both technical and non-technical building blocks.

Smart grid technologies are vital to meeting India's vast and growing electricity needs. We need an Indian smart grid model that can engage our country's particular operating conditions and address our top challenges: curbing power losses, and enhancing access to reliable, quality power for the common citizen. In the face of rising citizen expectations and demand, smart grid technologies offer India the tools needed to engage and overcome these challenges.

A. Benefits:

- Improve reliability of supply to all consumers – no power cuts.
- Help identify and reduce outages
- Better quality power– no more voltage stabilizers
- Users friendly and transparent interface with utilities
- Enables online visualization of energy consumption at consumer level.

- Provide options for renewable generation integration to grid
- Options for prepaid connection
- Reduce meter reading errors
- Better control over electricity bills by utilizing Time of Use (ToU)/ Time of Day (ToD) Tariff
- Reduction of Aggregate Technical & Commercial (AT & C) loss
- Save energy by intelligently controlling loads such as street lights

B. From Traditional Grid to Future Grid

The power grid is a complex marvel of engineering that has had a profound impact on society. One reason alternating current (AC) power grids are complex is because they are always balancing supply and demand in real time, continuously. Unlike the internet, one cannot “retransmit" or “slow down" during congestion. This traditional grid is now evolving to become smart, or rather smarter, driven by an intersection of digital technology and the use of renewable energy (RE). How we manage this transition will determine not just our supply mix of fuels but the fundamental nature of the grid and the relationships among its stakeholders.

No longer should we think of power flows as one-way, from generation to transmission to distribution to consumers. Consumers who set up their own solar panels can now become producers (“prosumers"), and they can also voluntarily adapt their loads— if given a signal or incentive. In the old days, demand was the main aspect that varied by consumers’ unilateral actions, such as by time of day or season, and the grid always needed sufficient generation capability to meet any anticipated demand (plus a margin). That’s expensive.

Our entire power system (pre-future grid) is based on averages and a lot of cross-subsidization. It is precisely the richer and larger consumers—who overpay and keep the system afloat—who will be the first to put up solar panels, and exit the grid. In reality, today’s RE is opportunistic RE (use it when you can), so they won’t exit entirely but come back to the grid during the evening peak period. This raises the grid costs further, prompting more people to reduce their grid usage. Dubbed the “utility death spiral", this is a risk that is fast approaching.

II. POWER SECTOR ANALYSIS

The population of India is 1,326,801,576 as of March 2017, while occupying 3.287 million km² surface area. The utility electricity sector in India has a National Grid with an installed capacity of 326.8 GW (as of 31 March 2017) (Figure 3). The country’s power installed capacity as on 31st March 2017 and energy consumption during April 2016-March 2017 have been 326.8 GW and 1114.41 TWh, respectively, During the fiscal year 2016-17, the gross electricity generated by utilities in India was 1159.835 Billion Units, whereas the per capita electricity consumption in the year (2015-16) was 1,075 kWh [1]. The country’s energy mix has been gradually increasing with a share of oil, coal, gas, nuclear power and hydro power. The transmission & distribution losses during the year 2014-15 (provisional) including commercial losses were about 22.77%1. The target on distribution utilities is to reduce the Aggregate Technical and Commercial (AT&C) losses below 15% by 2017, below 12% by 2022, and below 10% by 2027, transmission utilities to reduce transmission losses to below 4% by 2017 and below 3.5% by 2022 in the country2

- Indian power sector has had eventful developments in not only generation and transmission capacity addition, but also from the distribution reforms aspect. The sector witnessed 9.6% growth in installed capacity with an addition of 28,788 MW.
- The major growth of 47.5% was witnessed in renewable capacity addition reaching to 57,260 MW. The renewable sector achieved grid parity or even surpassed conventional sector tariffs with competitive bid discovered prices of Rs 2.44 per unit for solar and Rs 3.46 per unit for wind power projects. All these developments

lead to improvement in the power supply situation with 0.7% energy deficit and 1.6% peak deficit during FY17 as compared to 2.1% energy deficit and 3.2% peak deficit last year.

- Distribution reforms through Ujwal Discom Assurance Yojana (UDAY) have resulted in Discom savings of around Rs 120 billion with issuance of UDAY bonds worth Rs 2.32 trillion. However, even after implementation of the UDAY scheme the situation at SEBs will only improve if they take tariff hikes. While some states have taken tariff hikes recently, many states have yet not taken the same on account of political pressures. Increase in tariff hike does not bode well with the political parties as it takes a toll on their vote bank.
- Further, these SEBs had aggregate technical and commercial losses of 24.6% in 2013-14. And this ratio hasn't improved significantly since then. This means that a major portion of the power that is used is not paid for. Unless these issues are addressed, the situation at the SEBs is not going to change drastically even after implementation of UDAY.
- In further development for making coal allocation more transparent, Scheme for Harnessing and Allocating Koyala (Coal) (SHAKTI) was launched through which allocation of linkages for power sector shall be based on auction of linkages or through Power Purchase Agreement (PPA) based on competitive bidding of tariffs except for the State and the Central Power Generating companies, and the exceptions provided in Tariff Policy, 2016. Coal drawal will be permitted against valid Long Term PPAs and to be concluded Medium Term PPAs. The sector also witnessed emphasis on transparency through various web/mobile applications and digitization of competitive bidding through MSTC platform for short and medium term power procurement.
- Government's thrust on renewable energy with core focus on solar power dominated the power sector in the fiscal year 2017. Government has laid an ambitious plan to add 100 Gigawatt (GW) of solar power by 2022. However, solar power tariffs continue to trade at levels higher than thermal power tariffs. Tariffs in some of the agreements that State Electricity Boards (SEBs) have signed with renewable developers are as high as Rs 7 per unit. Burdened with a huge pile of losses, the SEBs are increasingly shifting to purchase cheaper power from the power exchanges wherein the spot price is hovering somewhere around Rs 2.41 per unit. This puts into jeopardy the massive renewable projects that are scheduled to come up going forward. Solar power offtake is already seeing curtailment in the state of Rajasthan and Tamil Nadu.
- Average transmission and distribution losses (T&D) exceed 25% of total power generation. India's T&D losses are almost 2.5 times the world average. The T&D losses are due to variety of reasons viz., substantial energy sold at low voltage, sparsely distributed loads over large rural areas, inadequate investment in distribution system, improper billing, and high pilferage.
- Lack of coal supply was a major hurdle in the power sector till some time back. Majority of power generation takes place through thermal power plants which uses coal as its raw material. However, with e-coal auctions coming in the picture, this problem seems to have been resolved considerably. Major players in the generation space were sitting on sufficient inventories of coal as at the end of the previous fiscal year.
- Presently, major concern for the power generators is the off-take of electricity. Power generators sell power to SEBs or DISCOMs. SEBs are facing financial crisis and are suffering losses to the extent of Rs 700 billion annually. The SEBs do not have enough resources to purchase power from the generators. Hence a situation has risen wherein there is excess of power but no takers for the same.

III. SMART GRIDS – CHALLENGES FOR INDIA

- High rate of growth in power sector is needed to support economic growth and employment generation Estimated demand by 2032 is 900 GW – almost quadrupling the existing capacity
- Present the per capita consumption is one--fourth of the world average!

- 79 Million households yet to be electrified (2011 census)
- To address the above challenges, the Indian power system is expected to grow 8-10% per annum for next several decades - managing a rapidly growing power system of this size requires smarter systems
- India is pursuing one of world's largest grid connected renewable energy programs
- Integration of such renewable resources require smarter systems
- India launched the National Electric Mobility Mission with a target of 6 million EVs by 2020 • Successful rollout of EVs with required smarter systems
- Reduction of T&D losses continues to be top priority of both Government and utilities
- Smart grid technologies will increase visibility and control of power flows in in real time

Developed nations with reliable electric grids are investing in smart metering, data communications and advanced IT systems and analytics, tools for forecasting, scheduling and dispatching to further their smart grid journey…developing countries like India need to invest in both strengthening the electrical network as well as adding communications, IT and automation systems to build a strong and smart grid

IV. SMART GRID VISION FOR INDIA

Transform the Indian power sector into a secure, adapPve, sustainable and digitally enabled ecosystem that provides reliable and quality energy for all with acPve parPcipaPon of stakeholders

A National Smart Grid Mission will be launched soon that will have the overall responsibility to bring all stakeholders for successful implementation of the policies and programs envisaged under this Roadmap.

A. Smart Grid Roadmap: Distribution

- Appropriate policies and programs to provide access for electricity for all
- Uninterrupted life line supply (8 hours/day minimum) by 2015
- Electrification of 100% households by 2017
- 24x7 quality supply on demand to all citizens by 2027
- Integrated technology trials through a set of smart grid pilot projects by 2015
- Based on outcome of the pilots, full rollout of smart grids in pilot project areas by 2017; in major urban areas by 2022 and nationwide by 2027
- Completion of existing complementary or building block projects such as R--APDRP
- Planning for integration of such systems into future smart grid deployments 4. Availability of an indigenous low cost smart meter by 2014
- AMI roll out for all customers in a phased manner based on size of connection (and geography and utility business case)
- Starting with consumers with load ti20 KW by 2017, 3--phase connections by 2022 and all consumers by 2027
- Development of innovative and sustainable financing/business models for smart meter roll outs 5.Working with other stakeholders, building of National Optical Fibre Network by connecting all the 2,50,000 Gram Panchayats in the country by Optical Fibre Cable and including the telecom
- link at the nearest 33/11 kV substation to support smart grid in distribution by 2017
- Enabling programs and projects in distribution utilities to reduce AT&C losses • Below 15% by 2017, below 12% by 2022, and below 10% by 2027
- Conversion of existing EHV sub stations in all urban areas and sub transmission and medium voltage substations in metro cities to advanced (such as) Gas Insulated Substations (GIS) in a phased manner through innovative financing models
- Development of Microgrids, storage options, virtual power plants (VPP), vehicle to grid (V2G), solar to grid (PV2G), and building to grid (B2G) technologies in order to manage peak demand, optimally use installed capacity and eliminate load shedding and black-outs
- Push for mandated roof top solar power generation for large establishments with connected load ti20kW
- EV charging facilities should be created in all parking lots, institutional buildings, apartment

blocks etc; and quick/fast charging facilities to be built in fuel stations and at strategic locations on highways

- Microgrids in 1,000 villages/industrial parks/commercial hubs by 2017 and 10,000 villages/ industrial parks/commercial hubs by 2022 Can island from main grids during peak hours
- Optimally balancing different sources of generation through efficient scheduling and dispatch of distributed energy resources (including captive plants in the near term) with the goal of long term energy sustainability
- Improvement in power quality and quantum across the board

B. Smart Grid Roadmap: Transmission

- Development of a reliable, secure and resilient grid supported by a strong communication infrastructure that enables greater visibility and control of efficient power flow between all sources of production and consumption by 2027
- Implementation of Wide Area Monitoring System (WAMS, using Phasor Measurement Units, or PMUs) for the entire transmission system
- Installation of a larger number of PMUs on the transmission network by 2017 or sooner, as guided by the results of initial deployments
- Indigenization of WAMS technology and PMU development and development of custom made analytics for synchrophasor data by 2017
- Sepng up of Renewable Energy Monitoring Centres (REMCs) and Energy Storage Systems to facilitate grid integration of renewable generation
- Installation of 50,000 km of optical fibre ground wire (OPGW) over transmission lines by the year 2017 to support implementation of smart grid technologies
- Enabling programs and projects in transmission utilities to reduce transmission losses to below 3.5% by 2017 and below 2.5% by 2022
- Implement power system enhancements to facilitate evacuation and integration of 30 GW renewable capacity by 2017, 80 GW by 2022, and 130 GW by 2027, or as mutually agreed between MoP and MNRE

C. Smart Grid Roadmap: Policy, Standards and Regulations

- Formulation of effective customer outreach and communication programs
- Development of state/utility specific strategic roadmap(s) by 2014 for Smart Grid deployments
- Required business process reengineering, change management and capacity building programs to be initiated by 2014
- Policies for grid-interconnection of consumer generation facilities (including renewable) where feasible
- Policies for roof-top solar, net-metering/feed-in tariff as well as peaking power by 2014
- Policies supporting improved tariffs such as dynamic tariffs, variable tariffs, etc., including demand response programs
- Bulk consumers by 2014; extending to all 3-phase (or otherwise defined) consumers by 2017 5. Policies created by 2014 for implementing energy efficiency in public infrastructure and EV
- charging facilities starting by 2015 and Demand Response ready appliances by 2017
- Finalization of frameworks for cyber security assessment, audit and certification of utilities by 2013
- Development of business models to create alternate revenue streams by leveraging the Smart Grid infrastructure to offer other services (security solutions, water metering, traffic solutions etc) to municipalities, state governments and other agencies

- Build upon the results of smart grid pilot projects and recommend appropriate changes conducive to smart grid development in Acts/Plans/etc. by end of 2015
- Development of 1st set of Indian Smart Grid Standards by 2014
- Active involvement of Indian experts in international SG development bodies

D. Smart Grid Roadmap: Other Initiatives

- Tariff mechanisms, new energy products, energy options and programs to encourage participation of customers in the energy markets that make them "Prosumers" – producers and consumers – by 2017
- Create an effective information exchange platform that can be shared by all market participants, including Prosumers, in real time which will lead to the development of new and enhanced energy markets
- Investment in research and development, training and capacity building programs for creation of adequate resource pools for developing and implementing smart grid technologies in India - can also become a global leader and exporter of smart grid know-how, products and services

National Smart Grid Mission (NSGM)
Phase I: Ministry of Power approval for National Smart Grid Mission (March 2014)
Preparation of NSGM framework and cabinet note under progress
NSGM will have a Steering Commilee chaired by the Minister of Power, an Executive Commilee chaired by Secretary-- Power, a Technical Commilee chaired by Chairperson of Central Electricity Authority, and a Mission Directorate. There will be NSGM PMUs in all states

Phase II: National Smart Grid Mission (by mid 2014)
Launch of NSGM with its own resources and funding mechanism that will bring national level support from other Ministries, Institutions, and the State Governments
NSGM will formulate detailed blueprint that would cover specific programs and projects in different utilities in each state and estimate the capital outlays and budgetary support
NSGM will coordinate with state governments, utilities and other stakeholders for rollout of smart grid projects and monitor project implementation
NSGM will coordinate development of standards, technically feasible and economically sustainable business models relevant to the Indian context

Smart Grid Pilot Projects in India

- 14 Smart Grid Pilot projects have been approved for different distribution utilities last year by Ministry of Power (MoP), Govt of India (GoI).
- These projects will be part funded by MoP (50% project cost as grant from GoI). Combined costs of these projects are about US$ 80 million
- These projects will be in execution mode early 2014 – presently in RFP stage • Most projects involve 20,000 or more customers
- These pilots are expected to help technology section guides and business case developments for larger projects in the next phase
- Many large utilities (in large states) could not apply for the first set of projects. So another set of larger and more integrated projects will be formulated soon
- Last mile connectivity is the major challenge in smart grid applications – and these field trials to determine the most appropriate communication solutions

VII. CONCLUSION

The deployment of smart grid technology will result in transforming the present grid into a marvel with many benefits as indicated and there will be improvement in two way interaction between consumer and utility.
The smart grid pilot would provide an opportunity to consumers to use electricity in an efficient way, participate in and make available incentives, including becoming a power source by opting to install roof top solar or photovoltaics (PV).Indian electricity sector has witnessed tremendous growth in its energy demand, generation capacity, transmission and distribution networks. Keeping pace with the recent technological advancements, it is deploying new types of devices and ICT infrastructure, adopting new monitoring, control and energy management tools, and aiming at fast deployment of smart grid concepts at distribution as well as transmission level.

Electricity, being a concurrent subject in India, both central government and state governments are responsible for its growth, operation and control. The central government frames overall regulations whereas each provincial (state) government formulates their policies within the overall regulatory framework.

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