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Smart Grid Roadmap for India

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Abstract: **The idea behind 'Smart Grid Vision for India' is to transform the Indian power sector into a secure, adaptive, sustainable, and digitally enabled ecosystem that provides reliable and quality energy for all with active participation of stakeholders.Realizing the growing importance of Smart Grid technologies in the Indian power sector, very recently Ministry of Power, Government of India on the recommendation of India Smart Grid Task Force (ISGTF) has shortlisted fourteen (14 Nos.) Smart Grid pilot projects that are planned to be executed in power distribution sector in India. As per the 'Smart Grid Roadmap for India', these pilot projects are expected to help technology section guides, develop business cases, policy and regulatory recommendations for larger projects in the next phase, while showcasing the relevance of Smart Grid on different aspects such as, Advanced Metering Infrastructure (AMI), Outage Management System (OMS), Peak Load Management System (PLMS), Renewable Energy (RE) Integration etc. The average estimated cost of each pilot project would be US$ 10 million (approx.) out of which 50% is grant will be provided by Government of India through (budgeted INR 2 Lakh Crores for Smart Grid projects across India under 13th Five-Year Plan) Restructured Accelerated Power Development and Reforms Program (R-APDRP) and rest to be borne either fully by the utility or, shared between the utility and the technology providers.**

Keywords: **Smart grid, distribution losses, AMI (automatic metering infrastructure), virtual power plants, electric vehicles.**

1. INTRODUCTION

Every global driver for Smart Grids applies to India, but India also has additional drivers. The power system in India has roughly doubled in the last decade .With 215 GW of installed capacity with utilities, the Indian power system is now the fourth largest in the world, but per-capita consumption of electricity in India is only one-fourth of the world average. This low consumption level is amplified by the lack of access to electricity to a significant proportion of the population. The potential demand by 2032 is estimated to be as high as 900 GW. India is also pursuing an aggressive renewable generation program .The 12th Five Year Plan target for renewable energy (RE) generation is 36 GW which will increase the current 12 % share of RE (excluding hydro) to 20 % by end of this decade .A power system to this size growing at such pace (8-10 % per year) with an increase share of renewable energy requires smarter systems to manage its efficiency and ensure its stability and reliability.

India has also recently launched a National Mission on Electric Mobility with a target of 6 million electric vehicles (4 million two wheelers and 2 million four wheelers) by 2020. For an efficient rollout of the EV (electric vehicle) program, electrical distribution infrastructure upgrades and smarter systems are required which will control/limit simultaneous charging of hundreds of EVs from the same feeder. Beyond just timing the consumption of power, immediate policy level support is required to build enabling infrastructure to integrate the EVs in the electrical network so that these millions of EVs connected to the power system can be leveraged as virtual power plants (VPP's) that can store energy when there is surplus generation and support the grid during moments of deficit. Vehicle to grid (V2G) technologies are evolving rapidly that can achieve these objectives.

In India, the potential energy demand [1-2] by 2032 is estimated to be as high as 900 GW, out of which the renewable energy potential that can be exploited till 2032 is around 183 GW [3-4]. The twelfth Five Year Plan by Government of India (GoI) target for renewable energy (RE) generation is 36 GW, which will increase the current twelve per cent share of RE (excluding hydro) to twenty per cent by end of this decade [5]. For distribution utilities, Central Electricity Regulatory Commission (CERC) has foreseen Renewable Purchase Obligations (RPOs) mandate of ten per cent of their power-mix by 2015, and thereafter increasing at a rate of one per cent per year till 2020, while the National Action Plan on Climate Change (NAPCC) also aims for fifteen per cent of national generation to be based on renewables by 2020.

The transmission and distribution losses are still very high in the Indian power system and distribution network (aggregate technical & commercial, or AT&C) loss reduction continues to be the top priority of both governments and utilities. Smart grid solutions will help monitor, measure and even control power flows in real time that can contribute to identification of losses and thereby appropriate technical and managerial actions can be taken to arrest the losses.

2. KEY PERFORMANCE INDICATORS FOR DRIVING SMART GRID PILOTS IN INDIA

The major driving factors for implementing Smart Grid pilots for different stakeholders (including Utilities, Consumers,

Government and Regulators) in India [8] are: a) Consumption Monitoring and Detection of Tampering, b) AT&C Loss Reduction and Efficiency Improvements, c) Access to Energy for the Masses, d) Renewable Energy Integration into the Grid, e) Peak Load Management thorough Demand Forecasting, f) System Improvements, and g) Outage Management and Customer Service.

The drivers for smart grid for different stakeholders in India

- Utilities

1. Reduction of T&D losses in all utilities to 15 % or below
2. Peak load management –multiple options
3. Reduction in power purchase cost
4. Better asset management
5. Increased grid visibility
6. Self-healing grid
7. Renewable integration

- Customers

1. Improve reliability of supply to all customers –no power cuts, no more DG sets and inverters
2. Improve quality of supply – no more voltage stabilizers
3. User friendly and transparent interface with utilities
4. Increased choices for consumers, including green power

- Government and regulators :

1. Satisfied customers
2. Financially sound utilities
3. Tariff neutral system upgrade and modernization
4. Reduction in carbon and other pollutant emissions and emission intensity

It is evident that the far-reaching goals of the power system can be enabled by smart grids which can help improve the efficiency and optimize performance within the Indian power sector.

3. TECHNO-ECONOMIC ANALYSIS OF DIFFERENT ASPECTS OF SMART GRID

In view of the growing importance and relevance for smart grids in India, ministry of power (MoP) has taken early steps for the development and adoption of smart grid technologies. In 2010 MoP constituted the India Smart Grid Task Force (ISGTF), an inter-ministerial body and the India Smart Grid Forum (ISGF).Both ISGTF and ISGF have been functional for over a year and have laid the foundations for building smart grids in India. Some important measures taken by MoP so far are:

- Formulation of 14 smart grid pilot projects to be undertaken by distribution utilities in various states. Fifty percent of the cost of these projects will be given as a grant by MoP and rest to be borne by distribution utilities, states or other stakeholders. These initial set of projects are expected to help with technology selection and establish the business case and regulatory environment for implementing larger smart grid projects in the future.
- Indigenous development of low cost smart meters for mass roll –out for volume consumers. The specifications are being formulated and the strategy for implementation is nearing finalization.
- Development of the India Smart Grid Knowledge portal, which is expected to serve as an expected collaboration and knowledge dissemination platform for all stakeholders involved in smart grid developments including consumers.

4. SMART GRID VISION FOR INDIA

"Transform the Indian power sector into a secure, adaptive, sustainable and digitally enabled ecosystem by 2027 that provides reliable and quality energy for all with active participation of stakeholders".

In order to achieve this vision, stakeholders shall undertake:

DISTRIBUTION

1. Appropriate policies and programs to provide access for electricity for all with lifeline supply (to be defined) by 2015, electrification of 100% households by 2017 and 24x7 quality supply on demand to all citizens by 2027.

2. Integrated technology trails through a set of smart grid pilot projects by 2015 ; and based on outcome of the pilots, full rollout of smart grids in pilot project areas by 2017 in urban areas (to be defined) by 2022 and nationwide by 2027.

3. Completion of existing complementary or building block projects and then including planning for integration of such systems into future smart grid deployments.

4. Availability of an indigenous smart meter by 2014. AMI rollout for all customers with load greater than 20 KW by 2017, with load greater than 10 KW by 2022 and for all customers with load greater than 2 KW by 2027 by deploying smart meters and necessary IT and communication infrastructure for the same.

5. Working with other stakeholders, building for National Optical Fiber Network by connecting all the 2, 50, 000 Gram Panchayats in the country by optical fiber cable

and including the telecom link at the nearest 33/11 KV substation to support smart grid in distribution by 2015.

6. Enabling programs and projects in distribution utilities to reduce AT & C losses to below 15 percent by 2017, below 12 percent by 2022 and below 10 percent by 2027.
7. Conversion of existing distribution substations to GIS (gas insulated substation) based substations in metro cities in a phased manner for better control and unlocking the substation land for other purposes.
8. Formulation of effective customer outreach and communication programs for active involvement of customers in the smart grid implementations.
9. Development of utility specific strategic road map(s) for implementation of smart grid technologies across the utility. Required business process reengineering, change management and capacity building programs to be initiated by 2014.
10. Development of microgrids, storage option, virtual power plants (VPP), vehicle to grid (V2G), solar to grid (PV2G), and building to grid (B2G) technologies in order to manage peak demand, optimal use installed capacity and reduce load shedding and black-outs.
11. Mandatory roof top solar power generation for large establishments with connecting load more than 20 KW.
12. EV charging facilities should be created in all parking lots institutional buildings, apartment blocks etc.; and quick / fast charging facilities to be built in the fuel stations.
13. Microgrids in 200 villages by 2017 and 1000 villages by 2022 to ensure minimum 8 hrs. of electric supply.
14. 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.
15. Improvement in power quality and quantum across the board.

TRANSMISSION

Development of a reliable, secure, 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) for the entire transmission system. Installation of a larger no. 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 and synchrophasor data by 2017.

50, 000 Kms of OPGW (optical ground wire) cable to be installed 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 percent by 2017 and below 2.5 percent by 2022.

Implement power system enhancements to facilitate evacuation and integration of 30 GW renewable capacities by 2017, 80 GW by 2022, and 130 GW by 2027(consulted with MNRE (Ministry of Renewable Energy) and MoP (Ministry of Power).

5. DEPLOYING SMART GRID MATURITY MODEL WITH POLICIES AND REGULATIONS

These demonstration projects by the private utility companies required to be followed by those responsible utilities as a mature role model [9] while implementing Smart Grid pilots in their respective areas to leverage the benefits of the Smart Grid technologies for up-scaling their distribution business, as well as they can assess those detailed gap analysis on affected domains, identify metrics for tracking effectiveness of Smart Grid deployment, and periodic monitoring of progress through objective evaluation of metrics and identifying relevant actions by following SEI's Smart Grid Maturity Model (SGMM).

POLICIES, STANDARDS AND REGULATIONS

1. Establishment of CERT (Central Electricity Regulatory Tribunal) / distribution and finalization of norms for cyber security (including audit) of distribution systems by 2014.
2. Policies for grid/interconnection of captive/consumers generation facilities (including renewables) wherever technically feasible; policies for roof-top solar; and policies for peaking power stations.
3. Policies supporting improved tariffs such as dynamic tariffs, variable tariffs etc., including demand response programs, starting with bulk consumers by 2014, and extending to all 3-phase (or otherwise defined consumers) by 2022.
4. Policies for public infrastructure including EV charging facilities by 2015 and for DR (Demand Response) ready appliances by 2020.
5. Development of appropriate standards for smart grid development in India; and active involvement of Indian experts in international bodies engaged in smart grids standards development.

6. OTHER ISSUES

1. Tariff mechanism, new energy products, energy options and programs to encourage participation of customers in the energy markets that make them producers and consumers.

2. Create an effective information exchange platform that can be shared by all market participants, including consumers in real time which will lead to the development of energy markets.

3. 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 as well as export of smart grid know-how, products and services.

7. THE NEAR TERM AND LONG TERM TARGETS

12TH Plan (2012-2017)

- Reduction of transmission losses (greater than 66 kV) to below 3%.
- Reduction of AT&C losses in all distribution utilities to below 15%.
- Augmentation of control centers and data centers for all states to cater to deployment of smart grid.
- Reduction in power cuts; 24 hrs. availability of power at principal cities, 22 hrs. for all towns and lifeline supply to all by 2015.
- Grid connection of all consumer end generation facilities where feasible.
- Development of indigenous smart meter.
- Total renewable integration of 30 GW; and EV trials, 2% EV penetration.
- Compulsory roof-top PV and energy efficient building code for new government offices and group housing projects by 2014.
- Development of microgrids in 200 villages.
- EV charging station in urban areas.
- Improvement in power quality.
- GIS substation/automation of substations in all metros.
- Implementation of dynamic tariff.
- Tariff mechanism for small roof-top solar PVs.
- Energy Efficiency Programs for lighting in metros and state capitals.
- Standards development for smart grids including EVs and its charging infrastructure.
- Strengthening of EHV System.
- Strengthening of fiber optic communication system.
- 1200 kV UHVAC testing and simulation studies.
- Research and development, training and capacity building. 10 % utility technical, personnel to be trained in smart grid technologies.
- Customer outreach and participation.
- Sustainability initiatives.
- SG (Smart Grid) pilots, full SG rollout in pilot project cities.
- Development of 5 smart cities.
- Establishment of Smart Grid Test bed and Smart Grid Knowledge center.

13th Plan (2017-2022)

- Reduction of transmission losses (greater than 66 kV) to below 3%.
- Reduction of AT&C losses to below 12% in all utilities.
- Improvement in power quality.
- Electrification of all households by 2020.
- Nationwide AMI rollout for customers greater than 10 KW loads.
- Total renewable integration of 80 GW; 5% EV penetration.
- Development of microgrids in total 1000 villages.
- EV charging station.
- GIS substations/automation of substations in all state capitals and principle cities.
- Energy efficiency programs for all lighting in urban areas.
- Standards development for smart infrastructure (SEZ), buildings, roads/bridges, parking lots, malls and smart cities.
- UHV and EHV strengthening.
- Research and developments; training and capacity building, 25% utility technical personnel to be trained in smart grid technologies.
- Export of smart grid products solution and services to overseas.
- Customer outreach and participation.
- Smart Grid rollout in urban areas.
- Development of 25 smart cities.

14th Plan (2022-2027)

- Reduction of AT&C losses to below 10% in all utilities.
- Stable 24×7 power supply to all categories of consumers all across the country.
- Choice of electricity supplier (open access) to all consumers.
- Nationwide AMI roll-out for customers.
- Total renewable integration of 130 GW; 10% EV penetration.
- Development of microgrids in 5000 villages.
- Development of 50 smart cities.
- Energy efficiency programs for all lighting across nation.
- Export of SG products, solution and services to overseas.
- Active participations of “prosumers (producer and consumers)”.
- SG rollout nationwide.

8. NEXT STEPS

1. Discussions with stakeholders for the implementation of the roadmap.

2. Intuitional framework for smart grid development.

There is a need for a strong institution that can drive smart grid development in India. One designated entity should be made responsible for the smart grid roadmap including implementation roadmaps, technology, selection, guidelines, standards guidelines, capacity building programs, etc. Government of India has also recently launched a

National Mission for Electric Mobility (NMEM) with a target of six million electric vehicles by 2020 [6-7]. In India, a power system of this size growing at such pace (8-10 per cent per year) with an increased share of renewable energy requires smarter systems to manage it efficiently and ensure its stability and reliability

There can be two approaches here: strengthen the existing institution or create a new institution. Existing institutions are India Smart Grid Task Force (ISGTF) and India Smart Grid Forum (ISGF). While ISGTF s an interministerial task force with representatives from various ministries and government institutions with a small secretariat housed in Powergrid Corporation of India, ISGF is a public-private partnership body registered as a cooperative society. Both these bodies currently lack the organizational and financial strength to take up the above responsibilities and also lack authority. ISGTF can be strengthened with a permanent secretariat with larger no. of staff who will work exclusively. ISGTF can assign some tasks on selective basis to ISGF which could leverage the vast knowledge of its members. ISGTF should have broader powers in taking decisions in matters related to smart grid developments.

In the second approach an entirely new entity may be created along similar lines to the national mission for Electric Mobility recently launched by Ministry of Heavy Industry. A National Smart Grid Mission (NSGM) may be formulated and establish a national council for smart grids (NCSG). The council may be made up of members from central and state utilities, academic institutions, regulators and standards institutions. The council shall be supported by a National Board for Smart Grids (NBSG) under the Ministry of Power (MoP). The NCSG shall formulate the NSGM, which shall define the short, medium and long term action plan for implementation for smart grids in India. The action plan shall be recognized as a national objective and be included as part of the national planning process and thereby receiving adequate funding to carry out the work detailed in the action plan. The council shall work closely with all industry stakeholders and through a process of consultation will conclude all transverse issues related to: standards, regulation and policy, engineering design, process methodologies, and technology selection etc. The council/respective bodies may be given statutory powers to approve the necessary rules and regulations.

9. CONCLUSION AND WAY FORWARD

As an immediate way forward, there is a need for a strong institutional framework that can drive Smart Grid development in India. To begin with, ISGTF needs to be supported by the permanent, independent members including industry experts in respective areas on deputation from different entities, and with the whole-time engagement of appropriate man-power who will work exclusively for Smart Grid deployment in India. In order to effectively implement the goals conceived in the Smart Grid Vision and Roadmap for India, there should be unanimity in launching a National Smart Grid Mission (NSGM) for India, may be targeted by the end of 2014.

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