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Smart Grids & smart grid technologies in India

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Abstract – *Smart grid is one of the trending technological innovation of the modern world, In India, present situation when the electrical industry is facing huge challenges Globally, ranging from a supply-demand gap to rising cost, global warming etc. the solution to reinvent the business is smart grid. Factors that drives for an adaptation of smart grid in India includes the need to reduce commercial & technical losses, resolve the chronic supply-demand gap & finding a revolutionize way for more advanced electricity supply leading to sustainability & high growth economic development goals. It provides real-time monitoring of data collection & remote control of system elements like, smart meters, intelligent devices, power lines, feeder switches, capacitor bank, fault analyzers & other facilities. The paper focus on (a) Current Indian Power Sector; (b) technology & devices used in smart grid; (c) Smart grid challenges; (d) current smart grid status in India.*

Key Words*:* Indian power sector, smart grid technologies in India, smart grids in India, challenges.

1.INTRODUCTION

At present condition(in India) the grids are rapidly running up against its limitations slowly becoming a national challenge, the solution for this is smart grid, it is seeking attention of Central & State policy makers, Business persons & other powerful people, cause in a much less time a smart grid will function more efficiently, resulting in an expected power supply in more affordable price, along with leaving less impact in the environment. Smart Grid Pilot Projects in India is an initiative of Ministry of Power following certain objectives: (1) Increase in Power availability; (2) Reduction of AT&C losses; (3) Reduction in blackouts; (4) Managing load during peak hours; (5) Optimal Utilization of resources for sustainable growth.

1.1 Present power sector of India

Indian company (Power Grid Corporation of India Limited) owns & operates about **1,34,018 cktkms** of transmission lines at 800/765kV, 400kV, 220kV & 132kV EHVAC & +500kV HVDC levels and **214 sub-stations [8].**Also, the transformation capacity ofabout **2,78,862 MVA** as on 31st December 2016. This gigantic transmission network, spread over length and breadth of the country, is consistently maintained at an availability of over 99% [2]. The installed power station capacity in India as of June30, 2016 is shown in table1 [2]. According to the reports it has been observed that the Indian government encourages private producers to reach towards smart grid for a reliable power supply to the consumers end. The Indian power sector spreads in five regional grids to meet the demands, shown on table 2 [2]. These five regional grids are different in energy generation & in consumption. The institutions India Smart Grid Task Force (ISGF) & Indian Smart Grid Forum(ISGF) joined under Ministry of Power, India to set-up an institutional frame for deployment of smart grid projects in India [1,4]. The detailed overview of a smart grid is shown in figure1 & component technologies of smart grid is shown in figure2 [12].

Table -1: Installed Power Station Capacity in India as of June 30, 2016

Installed Power Station Capacity in India as of June 30, 2016

Sector	Thermal (MW)				Nuclear (MW)	Renewable (MW)			Total (MW)
	Coal	Gas	Diesel	Sub-Total Thermal		Hydel	Other Renewable	Sub-Total Renewable	
Central	51,390.00	7,555.33	0.00	55,649.73	5,780.00	11,571.43	0.00	11,571.43	76,296.76
State	64,130.50	7,210.70	363.93	71,705.13	0.00	28,092.00	1,963.81	30,055.81	101,825.93
Private	70,722.38	9,742.60	554.96	81,019.94	0.00	3,120.00	40,885.57	44,005.57	126,383.06
All India	186,242.88	24,508.63	918.89	211,670.40	5,780.00	42,783.43	42,849.38	85,632.81	303,083.21
Percentage	61.45	8.09	0.30	69.84	1.91	14.12	14.14	28.25	100

Table -2: All India (Anticipated) Power Supply Position in FY 2016-17

All India (Anticipated) Power Supply Position in FY 2016-17[27]

Region	Energy			Peak Power		
	Requirement (MU)	Availability (MU)	Surplus(+)/Deficit (-)	Demand (MW)	Supply (MW)	Surplus(+)/Deficit (-)
Northern	357,459	351,009	-1.8%	55,800	54,900	-1.6%
Western	379,087	405,370	+6.9%	51,436	56,715	+10.3%
Southern	310,564	320,944	+3.3%	40,145	44,604	+11.1%
Eastern	151,336	135,713	-10.3 %	21,387	22,440	+4.9%
North-Eastern	16,197	14,858	-8.3%	2,801	2,695	-3.8%
All India	*1,214,642*	*1,227,895*	*+1.1%*	*164,377*	*169,403*	*+2.6%*

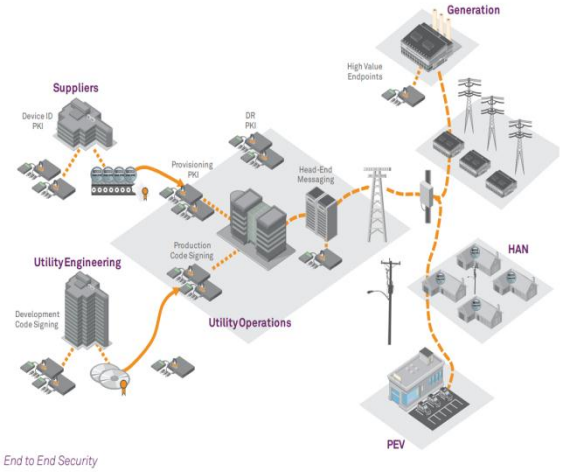

Fig -1: The detailed overview of a smart grid

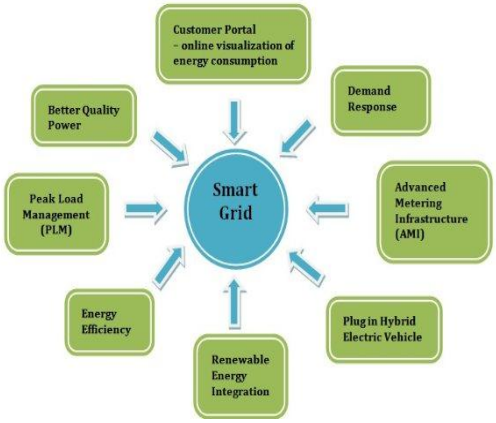

Fig -2: Component technologies of smart grid

There are various technological issues of smart grids in Indian environment such as AMI-AMR developmental framework, communication technology options, home area network, single phase meter, OMS, PLM, demand response, monitoring of power quality etc.

2.AMI-AMR DEVELOPMENT FRAMEWORK

Automatic meter reading (AMR) started as an automated method of collecting basic meter reading data. Subsequently Advanced Metering Infrastructure (AMI) emerged from AMR, evolving from the same technology with the added capability of allowing two way communications with the meter. AMI includes hardware software communications consumer displays and controllers besides meter data management software and supplier business system. Together this enables AMI systems to collect measure and analyze usage [8,1]. The two-way communication further supports communication with multiple metering devices that include gas meters, water meters, electricity meters, or heat meters. Both, government agencies and utilities are today increasingly adopting AMI as part of their smart grid for cities initiatives.

2.1 Components of AMI

smart meters, analytics, in-home display, DCU, last mile connectivity, Head end system, last gasp messaging, MDAS, MDMS [8,1].

2.2 Communication technology options

AMI communication has two divisions namely (LAN)local area network, (WAN) wide area network. The generally adopted communication Technologies are PLCC/GPRS/RF mesh etc.

2.3 AMI communication architecture

AMI working out in Indian context, consists of four major components: smart meters, LAN/WAN communication over PLCC/GPRS/RF mesh, network management system (NMS), home area network supporting [5].

2.4 Home Area Network (HAN)

An ICT (information and communication technology) infrastructure in the home, called home area network (HAN), enables smart management of all digital devices typically found in the home. A HAN can use several connectivity technologies, both wired and wireless, related to the specific subsystems included in the home system[7]. Typical HAN subsystems include PC networks, HVAC systems and alarm/security systems, as well as new types of subsystem related to the emerging smart-grid applications, such as energy management systems, local alternative-energy generation systems (photovoltaic, for example), and vehicle-to-grid systems.A HAN infrastructure can be open and must be interconnected with both the AMI (automatic metering infrastructure) and the Internet through a home gateway in order to enable high-end services.

2.5 Functional requirement of a meter

Smart Meter for an AMI solution supports the regular features as of a standard static meter, it also supports communication interface for data exchange between DCU/HES, also an interface for home energy management including display [11]. The meter has a GPRS modem for a direct connection with NMS for spread out locations, for dense locations meters shall have a RF mesh module working frequency band of 865 to 867 MHz. RF module are also used for home energy management & PLCC are used for high rise building areas [6].

2.6 Outage Management System(OMS)

An outage management system is a computer system used by operators of electric distribution systems to assist in restoration of power [8]. OMS manage unscheduled and scheduled outages of distribution infrastructure like Distribution Transformers (DTs), HT/LT feeders etc. It collects and coordinates information about outages including customer calls and report the operator for taking corrective actions through crew management and remote control enabling customer satisfaction, improve System Availability and Reliability.

2.7 Peak Load Management(PLM)

PLM means economic reduction of electrical energy demand during peak generation period, which includes managing of peak load through DSM/DR techniques[14]. It is a process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load, it also allows utilities to reduce demand for electricity during peak usage resulting in cost reduction by eliminating the need for peaking power plants.

2.7 Demand Response(DR)

DR provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives [9].

2.8 Monitoring of Power Quality

Power quality involves voltage, frequency & waveform, good power quality can be defined as a steady supply voltage that stays within the prescribed range, steady A.C. frequency close to the rated value, and smooth voltage curve waveform, leading to reduction in losses, improving quality of the power supply resulting in customer satisfaction & increase in the company's profit [10,12].

3.KEY CHALLENGES FOR SMART GRID

There are several challenges during the execution & post execution of the smart grid pilot project like transition of legacy equipment/system, lack of standard & interoperability, policy & regulatory framework, lack of awareness, cyber security & data privacy etc.[13], the government should encourage financially & technically for development of smart grid standards including pilot models, for the expected key benefits from these projects like lowering of peak demand, differed capital investment by avoiding network capacity cost, reduction in outage duration & outage restoration costs, increased efficiency of network & empowerment of consumers .

4. SMART GRID PILOT PROJECTS IN INDIA

Ministry of power has allocated 14 smart grid pilot projects that will be implemented by state-owned distribution utilities in India under restricted accelerated power development & reforms program initiative for distribution reforms[2,3]. The List of 14 pilot projects are as follows:

4.1 ASSAM POWER DISTRIBUTION COMPANY LIMITED (APDCL), GUWAHATI DISTRIBUTION REGION

The pilot project covers 15,000 consumers involving 90MUs of input energy. APDCL is in the process IT implementation under R-APDRP & SCADA/DMS implementation is also to be taken up shortly, APDCL has also proposed the functionality of PLM using industrial & residential AMI, integration of distributed system & OMS. Making it beneficial for increasing availability of energy during peak time, reduction in AT&C losses, reduction in interest payments due to deferred capital investment in sub-transmission networks. The project costs Rs.29.94 Cr.

4.2 Andhra Pradesh Central Power Distribution Company Limited (APCPDCL), Jeedimetla Industrial Area

The proposed project area is covered under RAPDRP scheme; DAS, IT & SCADA shall be implemented. The functionalities of PLM, power quality & OMS are proposed by implementation of AMI. Making it beneficial in reducing AT&C losses, reduced purchase of high cost power at peak hours. The cost of the project is Rs.41.82 Cr.

4.3 Maharashtra State Electricity Distribution Corporation Limited (MSEDCL), Baramati Town

Project proposes covering 25,629 consumers with a mix of residential, commercial & industrial consumers & input energy of 261.6MU. the functionality of OMS is proposed by implementing AMI for residential & industrial consumers. In addition, MSEDCL has proposed to leverage AMI for remote connected/disconnected of consumers, monitoring the consumption patterns, tamper detection, control load monitoring, load curtailment program, i.e. reduced power supply instead of no power scenarios, etc. Making it beneficial in reducing AT&C losses, improving reliability parameters. The project costs Rs.28.21 Cr.

4.4. Chhattisgarh State Power Distribution Company Limited (CSPDCL), Siltara-Urla area of Raipur District.

The project includes installing smart meters at 508 HT&LT industrial consumer's premises including 140 smart meters for expected load growth during the implementation. The area has around 2140.86MU input energy consumption. The functionality of PLM is proposed by implementing AMI for industrial consumers. Providing benefits by reducing distribution T&D losses, reducing peak load consumption through shifting of peak load demand by saving UI charges.

4.5. Himachal Pradesh State Electricity Board Limited (HPSEB), Industrial town of kalaAmb

The project covers 650 consumers & have an annual input energy of 533MUs. The functionality of PLM & OMS is proposed by implementing AMI for industrial consumers, providing benefits like shifting peak load, reduction in penalties & outages. Total cost of the project is Rs 17.84Cr.

4.6. Punjab State Power Corporation Limited, Tech-II sub-division, SAS Nagar

The functionality of PLM is proposed by implementing AMI in the project area for 9818 residential & industrial consumers. The area is around 60MU input energy, providing benefits in reduced AT&C losses, reduced peak load consumption, reduced cost of billing. Total cost of the project is Rs. 10.11Cr.

4.7. Rajasthan-Jaipur Vidyut Vitaran Nigam Limited (JVVNL), Sanganer Sub Division, Jaipur city

Project proposes covering 34,752 consumers & distribution system off 651 DTs. The area has around 148.12MU input energy. The functional PLM is proposed by AMI for residential & industrial consumers. Functionalities of OMS with SCADA & distributed generation from renewable sources, benefiting by reducing AT&C losses. Reduced peak load consumption, Reduced line outages & DT failures. Total Project costs Rs. 33.38Cr.

4.8 West Bengal State Electricity Distribution Company Limited, SiliguriTown, Darjeeling

The project proposes to take up four numbers of 11KV feeders for implementation of Smart Grid covering 4404 consumers. The area has 42MUinput energy consumption.

Functionalities of AT&C loss reduction & PLM using AMIfor residential & industrial consumers. Total project cost:-Rs 7.3Cr.

4.9Chamundeshwari Electricity Supply Corporation Limited (CESC), Additional City Division, Mysore

Project involves 21,824 consumers with a good mix of residential, commercial, industrial consumers including 512 irrigation pumps covering over 14 feeders & 473 distribution transformers & accounting input energy of 151.89MU. Benefiting a reduction in AT&C losses, shifting load during peak hours, reducing meter reading cost. Total Project Costs:-Rs 32.59 Cr.

4.10 Tripura State Electricity Corporation Limited (TSECL), Electrical Division No.1, of Agartala town

The pilot project covers46,071 number of consumers, the project area is under RAPDRP scheme for IT implementation & system strengthening, making benefits in reduced distribution losses & peak load consumption. Total cost of the project: - Rs24.08Cr.

4.11. Kerala State Electricity Board Limited (KSEB)

Project is proposed for around 25078 LT industrial consumers of selected distribution section in Kerala. The input energy for the total scheme area is mentioned as 2108MUs & for LT industrial consumers is 376MUs. Part of this area is covered under RAPDRP scheme, benefiting in reduction of AT&C losses, tampers, thefts, short assessment etc. total project costs:-Rs 27.58 Cr.

4.12. Electricity Department, Government of Pondicherry, Division 1 of Pondicherry

Project proposes covering 87031 number of consumers with dominant being domestic consumers (79%). The area has around 367MU input energy consumption. the proposed covered area comes under RAPDRP scheme for IT implementation & system strengthening. Benefiting in reduction in distribution losses, increasing revenue collection efficiency. Total project cost: -Rs 46.11 Cr.

4.13. Uttar Gujrat Vij Company Limited (UGVCL), Naroda of Sabarmati Circle

Project proposes covering 20,524 consumers in Naroda& 18,898 agricultural unmetered consumers in Deesa-II division accounting for input energy of around 1700MU, benefiting in reduction in AT&C losses, reducing the rates of failures, reducing in number of outages. Total Project Cost:-Rs.48.78Cr.

4.14. Uttar Haryana Bijli Vitaran Nigam(UHBVN), Panipat City Subdivision

The pilot project covers 31,914 consumers & distribution system of 531DTs. The area has around 131.8MU input energy consumption. The proposed area is covered under RAPDRP scheme for IT implementation, benefiting in reduction of AT&C losses, reduced peak load consumption. Total project cost: -Rs.20.07Cr.

5. CONCLUSION

With the implementation of Smart Grid Technology in Power Sector, the government & regulators, utilities, vendors & consumers will receive certain benefits, like:- government will have the opportunity for GDP uplift & green-collar job creation, effective carbon abatement investment options, security & reliability of energy supply improved, creation of low carbon regulatory frameworks accelerated; vendors will have an opportunity to collaborate with other participants in the value chain to gain market access, an opportunity to create new products or machines etc. to have economic growth & a social status; the consumers will have a greater choice between energy providers, product & services, greater transparency & control over energy consumption etc. The smart grid projects are the modern technology which is revolutionizing & beneficial for all.

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