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RENEWABLE GENERATION PLANT COMMUNICATIONS

By

SIDDHARTH BABURAO ROKADE

BALU LAHU UGALE

MAHARASHTRA ELECTRICITY REGULATORY COMMISSION

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SUMMARY

India is the sixth largest power consumer in the World and third largest in Asia. In the above context the contribution of renewable energy sources would play major role to cater with growing demand in the scene of diminishing resources of fossil fuels. The pressure of global warming and the carbon emission is also the driving factor in the fast development and industrialization in India.

The Renewable energy potential and its exploration is always being a challenging task with the technological, economical and geographical constraints. One of the biggest issues in the present Indian power scenario in the ABT regime is the measurement of renewable energy in the integrated grid. The scheduling of power and commercial aspects are stuck with various regulators in India due to the metering and communication constraints in the renewable energy exploration. The basic thrust to write this Paper is to evaluate cost effective measures to enable the metering and data communication facilitation in Indian off shore renewable energy generation plants.

KEYWORDS

LPRF: Low power radio frequency.
GSM: Global System for mobile communication.
CDMA: code division multiple access.
PLCC: power line carrier communications.
FEMS: Financial energy management system.
CMS: consumer monitoring System.
AMI: Advance metering interface.
RF: Radio Frequency.
DDG: Decentralised distributed generation.

* MERC, 12th Floor, Centre No.1, World trade centre, Cuffe parade, Colaba, Mumbai-400005
Fax: + 91 022 22163966 e-mail: siddharth.rokade@merc.gov.in

1. INTRODUCTION

There are various issues like climate change, depleting level of fossil fuel resources and growing energy demand which are on the top concern of the nation which are therefore, growing interest all over the world in renewable energy resources. Since most renewable energy Sources are dispersed and scattered in nature, it is a challenging task to integrate the renewable energy resources into the power grid infrastructure.
Basically the electricity grid is designed to transmit and distribute electricity generated by conventional power plants. The electricity generally flows from the generation sources to the load area, but in case of the renewable energy plants have less capacity, and are installed in a Dispersed manner at different locations. The measurement and the metering is the big issue of such scattered energy resourses.These has great impact on the technical as well as the commercial operation of the integrated grid operations.

Communication systems plays crucial role in the integrated grid operations. These are the backbone of the smart grid technologies which are driving the forces for grid integration of renewable energy resources. Two-way communications are the fundamental infrastructure that is essential for proper integration of data of distributed energy generation.

There are various components of the integrated grid operations which are meters, sensors, Potential transformers, current transformers, relays which are monitored and observed for their support which enable important decision support systems and applications, such as Supervisory Control and Data Acquisition (SCADA),Financial Energy Management System (FEMS), Consumer monitoring system (CMS). These applications are important and crucial in monitoring, operating, and protecting both renewable energy generators and power systems. There are several communication options available for the grid integration of renewable energy resources.
These options are Radio frequency (RF), power line carrier communications (PLCC), telephone wire line communication, fiber optics and various hybrid mixes of technologies. There are always arguments and debates in the sector questioning the emergence of the communication standards and choice of appropriate technology. Since distribution utilities always need to have a control over all the applications which are attached with their distribution networks, where as the generators are always concern about the capital cost and other expenses/.The generators are always keen to keep it minimum. There are various issues like commercial viability of the smart grid applications, issues of bandwidth, latency, reliability, security, scalability and cost will continue to dominate debate. The commercial mechanism, distinguished characteristics of power system and the embedded decentralized distributed generation (DDG) in integrated electric grid poses new challenges to the communication systems for grid integration of renewable energy resources.

2. RENEWABLE ENERGY SOURSES

The various renewable energy Generation Technologies are available in India

a) Solar Photovoltaic Generation.

b) Concentrated solar power /solar thermal power Generation.
c) Mini hydro/Micro-hydro Power Generation
d) Wind Energy.
e) Bio –mass Energy/Baggage based Generation.
f) Municipal Sewage waste Based Generation.

Contribution of Renewable to Indian Power Sector
As per the latest report of CEA the renewable contribution is around 25856 MW as on dated 30.11.2012.It may noted that the contribution is around 12%.

- Installed Capacity -215000 MW
- Thermal-68%
- Hydro-18%
- Nuclear-2%
- Renewable-12%
- Peak Demand -135000MW
- Per Capita Consumption-880kwh

3. Communication Technologies

New communication technology1 brought high expectations and a great deal of sophistication into the business world. Business managers were thrilled by promises of efficiency, effectiveness and innovation that would overcome barriers in time and geography. At the same time, however, many early adopters of electronic market systems experienced bitter failures. There are various techniques for the present communication which are prevailing in the power sector

a) Communication system of lower-bandwidth access networks,
b) Fiber optics,
c) Digital microwave radio are usually the technologies for backbone,
d) Copper twisted-pair wire lines,
e) power line communications,
f) Wireless systems.

A. Power Line Communications

The Power line communications (PLCs) are using the existing electrical wires to transport data. PLC Can be used in several important applications in the transmission and distribution system. These applications may be broadband Internet access, indoor wired local area networks, utility metering and control, real-time pricing, distributed energy generation, etc.

The main feature of the PLC is that it allows communication signals to travel on the same wires of the transmission or the distribution network that carry electricity with different level of frequencies. These waves are transported at higher frequency. However, since power line cables are often unshielded and thus become both a source and a victim of electromagnetic interference (EMI).Financially the PLC module is expensive than a wireless module, such
As ZigBee, Because of its cost effectiveness the PLC generally used at higher level of transmission voltages. These are not affordable at lower distribution voltage levels.

B. Local Area Networks
A leading standard for the wireless home network communications is ZigBee. The Zigbee Smart Energy standard builds on top of the ZigBee Home Automation (HAN) standard. HAN

Provides a framework to automatically control lighting, refrigerator, Air Conditioners, and other appliances at home. ZigBee Smart Energy provides a framework to connect HAN devices with smart meters and other such devices. This will enable the energy utility to directly communicate with the end consumers of energy.

Wi-Fi is often used as a synonym for wireless local area network (WLAN) technologies. Wi-Fi became a standard for laptops and subsequently phones due to its high speed network. The distribution utilities can use the Wi-Fi network but they are more power consuming, hence need to be used very cost effectively.

C. Wireless Wide Area Networks

Public cell phone carriers have great interest in using wireless wide area networks to connect Household smart meters directly with the utility's systems. A major advantage of this approach is the reduction of the costs. However, since public wireless cellular networks are not specialized in machine-to-machine area, some requirements in utilities may not be met by cellular networks.

D. Hybrid of the different Communication Systems

Without a framework the proper mix or hybrid standards for communications, it would be very tough task to integrate renewable energy sources into the grid. Since the potential standards landscape is very large and complex, hybrid standards adoption is challenging. Many utilities and trying to address these issues through their experimental efforts.

Wind energy has become an increasingly significant portion of the generation mix. Large scale Wind farms are normally integrated into power distribution *networks* so that the generated Electric power can be delivered to load centers in remote locations. Small scale wind farms can be integrated into power *distribution* networks to meet local demands. Because of high variability and intermittency, wind farm operations become a great challenge to power systems. Communication systems are fundamental infrastructure that transmits measured information and control signals between wind farms and power systems. Well-designed communication Systems can better explore the wind potentials and facilitate farm controls, helping shaving peak load and providing voltage support for power systems. Any deficiency in communication systems could compromise the system observability and controllability, which would negatively impact system security, reliability, and safety.

Present Communication Channels & protocols in RE Indian Scene

1. LPRF
2. GSM Technologies in smart metering
3. CDMA Technologies in smart metering

Future Scope for evaluation of Communication Technologies in Renewable Energy

Worldwide various smart metering projects have been implemented using both GPRS and PLCC technologies.PLCC implementation needs high quality power cable infrastructure which is yet to be tested in India, while GPRS may require greater provisioning and service qualities from various service providers.

The basic issues need to be addressed are as

a) Cost effectiveness of the technology
b) Integration of data
c) Centralized control and monitoring of data

d) Security issues
e) Services and applications of the integrated communication channel

Cost effectiveness of the Technology:

By using cost analysis In particular, it looks at three major sources of transaction costs: transaction asset specificity, behavioral uncertainty and environmental uncertainty. Consequently, it is pertinent that asset specificity is the major factor to be considered in the adoption of new communication technology to the power sectors utilities.
The power sectors utilities can ensure leverage the telecom sector's expertise to enable comprehensive end to end solutions for effective communication channels for data transfer and measurement of renewable energy generation. This will also help to reduce their capital as well as operational cost.

Literature Study:

a) Primary data collection and study
   First of all various papers on the renewable energy generation were studied to know the practical issues related with them. The embedded energy generation has several issues.
b) Secondary data collection and study
   The data of various solar as well as wind farms was collected to make analysis. Most of the time it is very big issue to recollect the status of the renewable power plants as a scheduled power availability. It is the big issue that the wind and solar power cannot be predicted early and hence scheduling is the big issue.
c) Sample field visit at off shore wind farms in Maharashtra and analysis thereof
   The wind mills situated at Sinner and Bhagur in Nasik district were selected for field visit. These wind mills are situated in the western belt of the Sinner Taluka, in Nasik district of the Maharashtra. All these wind mills are connected at 33 KV level in MSEDCL Thangaon substation. The meters are installed at MSEDCL substation as well as the mill ends. The real time data is not available in this case. The conventional methods of the metering are being used. Another field visit was at suragana taluka where the wind farms are connected to MSEDCL networks.
d) Visit to SLDC to see the communication protocols and limitations thereof.
   The field visit at Maharashtra state load dispatch centre at Kalva was also proved to be help full while driving out various issues regarding the renewable power generation. The real time data monitoring through the SCADA system as well as the Concept of PMU (Phasor measurement Unit) data is also has the improved information to the system operator.
e) Study of Integrated grid communication of Maharashtra and western region.
   And Study of role Regulators to enhance the smart grid concept.
   The Smart grid pilot project is being implemented in Baramati district of the Maharashtra.

R-APDRP PART-A solutions are implemented in Baramati Town,R-APDRP infrastructure is being erected in the Part-B at Baramati Town which is suitable for Smart Grid Pilot Project .Industrial area is developing in the surrounding Baramati towwn. Co-Generation power is being generated in the Baramati Area. Many sugar factories are interested in Co-Generation.

1)	Annual energy input (Last financial year)	MU	261.6
2)	Population (as per 2001 census)	No.	51,334
	Area of Coverage	Sq. kM	50
	Total Number of consumers	Numbers	25,629
	Peak Demand of the Last Fiscal	MW	23.06
	Average Demand of the Last Fiscal	MW	21.80
	Location of Project Area (Town)	Name	BARAMATI

Some of the new technologies which are introduced:

a) Smart metering technologies for R&C Consumers
b) Introduction of SCADA as well as integration of SCADA data with IT systems.
c) Introduction of DCUs and FRTUs
d) Motorization of all feeder breakers and RMU's.
e) Introduction of communication technologies like GPRS/CDMA/RF in metering environment with common protocol Near real time analytics technologies for meter analytics as well as near real time event insights coming from SCADA systems
f) Outage Management Systems SCADA is to be introduced
g) All feeder breakers, RMUs will have to be motorized.
h) All DTs will have to be provided with Smart Meters.
i) DCUs and FRTUs need to be provided.
j) All consumers will have to be provided with Smart Meters
k) Common protocol is to be provided for Meter as well as for DCU
l) Communication facility such as GPRS/CDMA/RF is to be provided
m) With the introduction of Automated Metering Infrastructure and Outage Management several technology led new processes will be introduced Remote connect/ disconnect for various purposes like initial connection, payment not made, payment made after disconnection, fraud detection etc
n) This process will bring down the operational cost and also will increase operational efficiency
o) Monitor the consumption pattern at customer level and also use this data in suggesting Energy Conservation measures at the consumer level with real time data. This consumption pattern will also be very useful data for demand forecasting and management
p) AMI based Tamper detection will become more real time

q) AMI system will create a new process of identifying the sanctioned load v/s actual load of consumers.

r) Use of AMI and near real time analytics, MSEDCL will introduce better methods of demand forecasting

F) Trend Analysis of Renewable energy Generation and regulatory support.

Maharashtra Electricity Regulatory Commission has already introduced Time of Day (TOD) tariff way back in 2000. AMI will also introduce capabilities to understand the profiles of consumer's and therefore help in introducing energy conservation measures.

Study of present Communication channels and protocols in Indian RE Scene

LPRF:

Low power radio frequency meters are installed as part of the smart metering options in some of the projects, but these are very limited range in few meters only. The actual online data is not possible in this option.

GSM:

Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA). both offering their own set of technology standards and competitively evolving. GSM is the world's most widely used mobile system standard and is currently in use in more than 200 countries across five continents. By the end of this decade, GSM is forecast to be the most .used technology, commanding two thirds of the global mobile market. It is Crossed three billion mobile subscribers in the world.

CDMA:

CDMA is a proprietary standard designed by Qualcomm, USA and is more concentrated in the Americas as well as Korea, Japan and Australia. CDMA2000 is the current 3G standard and is an extension of the initial IS-95 standard of Qualcomm. There has been a steady growth in the CDMA subscriber levels.

GPRS Communication Channel:

GPRS (General Packet Radio Service) is protocols designed for high-quality data, multimedia, streaming audio/ video and broadcast type services with data rates as high as 2Mbps. These heavily rely on complimentary high-speed, low-power and ultra-compact RF equipment both at the base station and the receiving set.

SCADA:

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. These systems encompass the transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the central host and the operator terminals. A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that a leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. These systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or very complex, such as a system that monitors all the

activity in a nuclear power plant or the activity of a municipal water system. Traditionally, SCADA systems have made use of the Public Switched Network (PSN) for monitoring purposes. Today many systems are monitored using the infrastructure of the corporate Local Area Network (LAN)/Wide Area Network (WAN).Wireless technologies are now being widely deployed for purposes of monitoring.

SCADA systems consist of:

1. One or more field data interface devices, usually RTUs, or PLCs, which interface to field sensing devices and local control switchboxes and valve actuators.
2. A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite, etc., or any combination of these.
3. A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU)
4. A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the communications system, and monitor and control remotely located field data interface devices.

PMU – (Phasor Monitoring Unit)

A device which measures the electrical waves on an electricity grid, using a common time source for synchronization. Time synchronization allows synchronized real-time measurements of multiple remote measurement points on the grid. In power engineering, these are also commonly referred to as synchrophasors and are considered one of the most important measuring devices in the future of power systems.

Evaluation of international as well as Indian Communication channels for feasibility in Indian power context.

We study various communication channel used for the data communication in the renewable energy sources in India. It is very pertinent aspect which needs to address is that the provision for capital expenditure required for the metering and data communication in renewable energy plants .Presently there is no regulatory or legal provision found which would mandate the upcoming renewable power generation plants. As discussed earlier many of the embedded plants are connected to the distribution or transmission system are having traditional energy meters which would send the cumulative consumption data at the end of the billing cycle .The readings are either taken by manually or by the AMR,but these are not the desirable things in the integrated power system.

In this study we evaluated the capital requirement of the various renewable energy generation plants as well as the cost of the communication channels to be implemented.

The capital requirement for the renewable generation plants as benchmarks are as below,

a) Solar Photovoltaic Generation :8 Crores/MW
b) Concentrated solar power /solar thermal power Generation:12 Crores/MW
c) Mini hydro/Micro-hydro Power Generation:5.77 Crores/MW
d) Wind Energy: 5.4Crores /MW

e) Bio –mass Energy/Baggage based Generation:4.71 Crores/MW
f) Municipal Sewage waste Based Generation: 4.64 Crores/MW

The Capital cost of Communication channel and operating expenses are also studied for various data Communication technologies. We found that the PLC module is expensive than a wireless module. Further these are not affordable at lower distribution voltage levels. The various entrepreneurs installing wind mills and solar PV plants is either using the conventional energy meters or some cases they are using the GPS technology. The wind mills installed in Maharashtra by M/S. Suzlon energy limited have installed the GPS based communication channel to monitor their real time generation data.
With reference to our study we found that the proper mix of GPS and SCADA system will ensure the cost effective technology for the dispersed renewable energy generation. The same methodology can be adopted for the decentralized distributed generation plants.

Setting up a hypothesis:

The power sectors utilities can ensure leverage the telecom sector's expertise to enable comprehensive end to end solutions for effective communication channels for data transfer and measurement of renewable energy generation. This will also help to reduce their capital as well as operational cost.

Hypothesis testing:
The hypothesis tested on the basis of the Capital cost, operating cost, reliability, adequacy of the infrastructure and the rate of data transfer. The overall project cost was also considered while doing the analysis.

Recommendations:

1. There is need of the Regulatory framework and policy intervention in the renewable plant generation communication so as to the integration of the renewable energy sources will be achieved.
2. There is also need of Regulatory framework and policy intervention to develop the grid connectivity and metering protocol with the voltage levels.
3. The small project at distinct places can easily adopt the GPS/GSM Technology for the data communication.
4. The scheme of the communication may be designed depending upon the grid connectivity and voltage level of the grid connectivity.
5. The larger projects may adopt the PMU/SCADA systems for the communication.

Conclusion :
The power sectors utilities can ensure leverage the telecom sector's expertise to enable comprehensive end to end solutions for effective communication channels for data transfer and measurement of renewable energy generation. This will also help to reduce their capital as well as operational cost.

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