Green Energy: A Perspective for Indian Rural Telecom

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Received 26 September 2011; Accepted: 7 October 2011

Abstract

This paper presents the current scenario of energy availability in a typical rural telecom system and proposes green energy utilization in rural telecom sector in India. The paper discusses the renewable energy source as the best alternative for rural telecom to supply the required load at any given time. The technical suitability and financial viability of using green energy sources to meet energy demands is also discussed.

Keywords: telecom passive infrastructure, sharing, renewable energy source.

Notation

AC DB	Alternating Current Distribution Board
BTS	Base Transceiver Station
DDG	Decentralized Distribution Generation
CAPEX	Capital Expenditure
GHG	Green House Gas
MPPT	Maximum Power Point Tracking
OPEX	Operation Expenditure
SMPS	Switch Mode Power Supply
SPV	Solar Photo Voltaic

Journal of Green Engineering, Vol. 2, 103–114.

VRLA	Valve-Regulated Lead – Acid
WTG	Wind Turbine Generator

1 Introduction

In India many of the rural areas lying remotely from the grid, have a high potential of renewable energy with solar energy being the most abundant. Certain areas especially along the eastern and western coast have substantial levels of wind energy that can be harnessed for electrification. Therefore, in such areas solar and wind energy based hybrid system can be used to harness both the forms of energy. There is reluctance for use of renewable energy mainly due to the relatively high cost associated with the energy conversion technologies.

The telecom networks are expanding and lot of initiatives have been taken in several ways to increase the Tele-density and broadband penetration on urban as well as rural part of the country. Telecom initiatives in rural India face problems due to the dismal state of rural electrification. The rural areas have been facing specific problems of power for quite some time. In most of the rural areas conventional grid power is not available and in some cases the grid is far away. Furthermore, wherever the grid supply is available the power quality is poor and erratic. The poor power quality is mainly due to supply interruption, sudden change in voltage, under-voltage, over-voltage, voltage fluctuation, etc. The poor power quality causes data loss and data errors in communication network equipments.

As availability of quality power in the rural areas is not assured, batteries are used as power back-up which keep an un-interrupted power supply for the desired period. Two of the most common alternate power solutions are diesel generator and inverter-battery systems. While supply, storage, cost of diesel and the resulting pollution (noise and environmental) pose major hurdles in operating diesel generator sets, low voltage and intermittent supply of electricity render inverter batteries ineffective.

There are about 5,88,000 mobile Base Transceiver Stations (BTS) towers in the country and each BTS is having 15–20 KVA diesel generators as power back-up. One liter diesel emits 2.68 kg of CO_2. More than two billion liters diesel is being consumed every year in mobile tower stations generating 10 million tons of carbon. Some state notifications have been issued banning installation and operation of diesel generator at mobile towers in order to curb air and noise pollution.

The low load factor of rural areas which has a negative influence on plant operating cost and high transmission losses make it less cost effective to supply them from grid. This being the power situation, the Decentralized Distribution Generation (DDG) renewable energy sources to power telecommunication network become the best alternative despite having comparatively high installation cost and is a solution for green energy. This can address the technical challenges of energy sustainability, reliability and power conditioning along with the environmental impact.

Converting solar energy into electricity could be the answer to the mounting power problems. Solar radiations represent the earth's most abundant energy source. The perennial source of solar energy provides unlimited supply and it has no negative impact on the environment. Its suitability for decentralized applications and its environment-friendly nature make it an attractive option to supplement the energy supply from other sources. In India the annual global solar radiation is about 5 KWhr/sqm. per day with about 2300–3200 hours of sunshine per year. If we could install Solar Photovoltaic Cells much of the rural telephone exchange power needs could be met, adequately cutting down harmful greenhouse gases. 1 Kwp SPV generates around 4–4.5 units (KWhr) per day.

Wind energy is another viable option. The Wind Turbine Generator is designed for optimal operation at a wind speed of 10–14 m/s. The Turbine Generator starts at a cut-in speed of 3–3.5 m/s and generates power at speeds of 4.5 m/s and above. In India the best wind speed is available during monsoons from May to September and low wind speed during November to March. The annual national average wind speed considered is 5–6 m/s. Wherever an average wind speed of 4.5 m/s and above is available, this is also an attractive option to supplement the energy supply. 1 KW WTG generates around 3 units (KWhr) per day.

A Hybrid Wind-Solar System for rural exchanges can make an ideal alternative in areas where a wind velocity of 5–6 m/s is available. Solar-wind power generations are clear and non-polluting, and they also complement each other. During the period of bright sun-light the solar energy is utilized for charging the batteries, creating enough energy reserve to be drawn during night, while the wind turbine produce most of the energy during monsoon when solar-power generation is minimum. Thus the hybrid combination uses the best of both means and can provide quality, stable power supply for sustainable development in rural areas.

This paper is organized as follows. Section 2 introduces a typical power distribution system of cellular BTS system. The energy consumption scen-

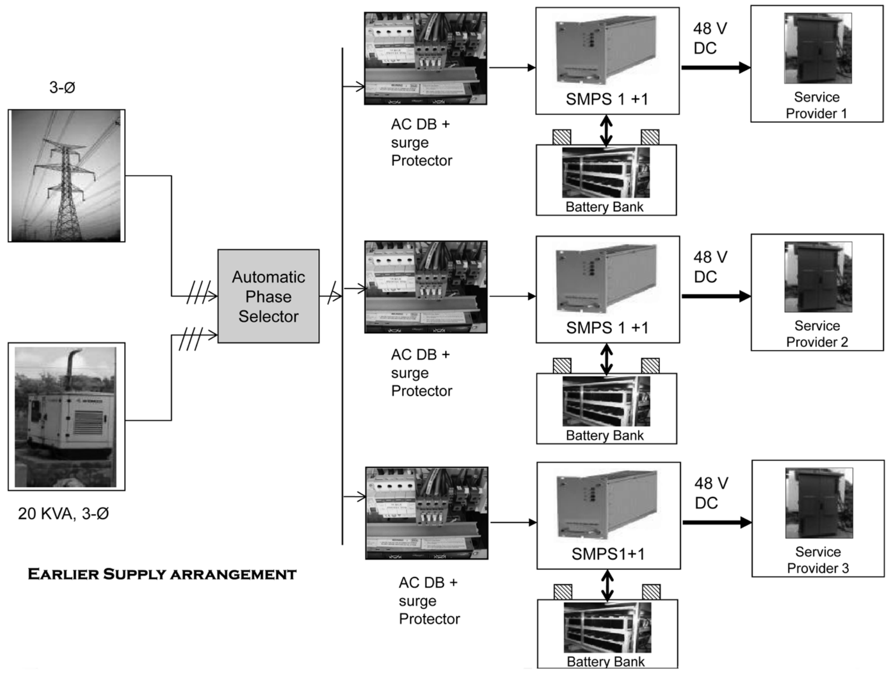

Figure 1 Schematic diagram of the existing power distribution arrangement.

ario and carbon foot prints are discussed in Section 3. The methodology of passive infrastructure sharing with renewable energy sources are discussed in Section 4. As a sample case the study of two pilot projects for green energy solutions in rural telecom sector and analysis are in Section 5. Discussions are stated in Section 6 and the conclusions are presented in Section 7.

2 Typical Power Distribution Arrangement of Cellular BTS System

In a typical cellular telecom system a BTS site infrastructure is being shared by multiple operators (service providers). Figure 1 shows the present arrangements of the service providers installing separate SMPS & storage battery along with their BTS equipment and sharing common AC power source.

3 Energy Consumption Scenario and Carbon Footprints

A significant amount of energy today is wasted by not having appropriate base stations sleep mechanisms in place. Maximum load scenario is a rather rare case in typical network deployment. Most of the time the network infrastructure is operated with sub-optimal energy efficiency leading to a significant waste of energy. Thus power efficiency of base station component has significant further improvement potential. The power variation of the output of power amplifier cause impedance variation resulting in an antenna mismatch and thereby power wastage of the overall system.

Today running cellular networks has been designed to maximize coverage area. Energy efficiency has not yet played a prime role. There exist no methodologies to evaluate the energy efficiency of cellular network. Communication efficiency energy indeed presents an alarming bottleneck in telecommunications network. Operators need to reduce the CAPEX as well as OPEX and carbon emission. The challenge lies in reducing the overall downlink energy consumption without sacrificing the target of Quality of Service (QoS).

It is felt essential to have, optimal load sizing, reduction in power losses, accurate data on BTS load pattern & potential renewable energy sources in rural area, before deciding the use of renewable energy sources for rural BTS applications. For the purpose of this study, two types of renewable energy sources considered were PV solar and wind energy to carry out technical feasibility, financial viability & economic analysis study.

The technical analysis involves the study of BTS load characteristic, optimal renewable system design and sizing of storage battery capacity for the BTS demand to be met any time. The economic analysis entails on evaluation of CAPEX, OPEX and financial viability in comparison to other options such as grid supply, diesel generator set. Further for proper renewable energy source design an analysis of relationship between the energy source and rural BTS load is essential taking into consideration the availability, size of the storage battery to meet the rural BTS demand of 24×7.

In India the average per subscriber CO_2 emission is high when compared to the international average of 8 kg of CO_2 emission per subscriber. Diesel generators are commonly used as alternate power solutions in the telecom sector which is one of the major contributors of Green House Gas (GHG) emissions and emits CO_2 on account of BTS towers alone.

Reduction of GHG emissions through efficient and sound technologies is necessary for long term sustainable development in the sector. As there is vast potential for carbon emission reduction, efforts are needed for reduction of carbon foot prints in the telecom sector.

The objective of the study was for utilization of natural solar power, optimization of fuel consumption with minimum diesel generator set running hours and reduction in Operational Expenditure (OPEX) in an eco-friendly atmosphere. For the purpose of study of potential renewable energy sources in rural areas 20 pilot projects (SPV and SPV – wind hybrid) were undertaken one in each state of India.

4 Methodology

For the purpose of study considering the optimal load requirement of BTS and the concept of sharing of passive infrastructure, SPV array of 10 KWp and 5 KW Wind turbine generator has been designed with common storage battery of 2500 AH VRLA Gel type (taking into consideration one day autonomy), common SMPS and DC distribution panel. The passive infrastructure i.e. land, cellular tower, hybrid power supply (grid, diesel generator, solar and wind), SMPS and storage battery in the present scheme is common and the DC power shared by more than one operators for meeting the load demand of BTS switch. Figure 2 shows the arrangements of sharing passive infrastructure by service providers.

5 Study Area

Project 1: Shreepati Nagar, Sundarban, West Bengal

Shreepati Nagar known as Sunderban covering an area of 4,110 km^2 is a vast delta of Bay of Bengal located 180 km from Kolkatta, in the Eastern state of West Bengal (India). The Cellular Tower is shared by three service providers Reliance, BSNL and Vodafone. The average energy consumption of the three service providers is about 50 units per day. There is no grid power supply available for powering the Cellular Tower BTS. A 20 KVA diesel generator set was operating 16 hours a day for supply of power to the Cellular Towers consuming 1320 litres diesel and emitting 3537 Kg of Carbon per month. With a renewable energy source, solar powering the BTS, a substantial reduction in diesel generator operating hours has been achieved resulting in savings as shown below:

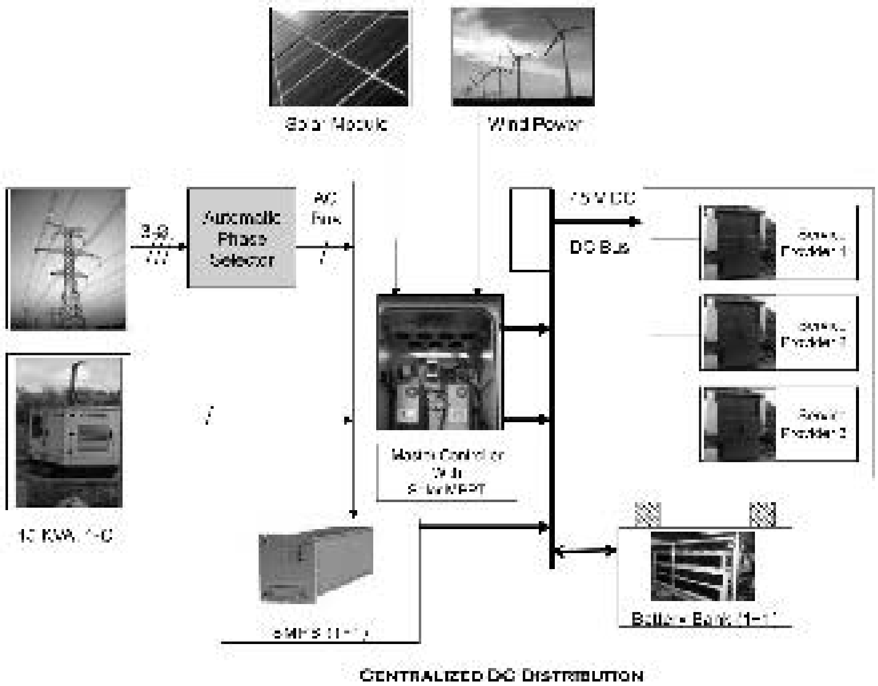

Figure 2 Passive infrastructure sharing with renewable energy sources.

No.	Items	DG Set	SPV with DG Set	Savings
1.	20 KVA DG set running	16 hours/day	2 hours/day	14 hours/day
2.	Fuel consumption (2.75 litres/hour)	1320 litres/month INR 52800per month	165 litres/month INR 6600 per month	1065 litres/month (Rs. 46,200 per month) **Rs 5,54,400 per annum**
3.	Carbon emission	3537 kg/month	442 kg/month	3095 kg/month **37140 kg/annum**

Project 2: Shivarampura, District Tumkur, Karnataka

Shivarampura, District Tumkur, is around 150 km from Bangalore in the Southern state of Karnataka (India). The Cellular Tower is shared by three service providers Airtel, BSNL and Vodafone. The average energy consumption of the three service providers is about 74 units per day. Grid power supply is also available for powering the Cellular Tower BTS. A 20 KVA diesel generator set was operating 10 hours a day for supply of power

Figure 3 SPV system at Cellular BTS site, Shreepati Nagar, Sunderban, West Bengal, India.

to the Cellular Towers consuming 865 litres diesel and emitting 2318 kg of carbon per month. With a renewable energy source, hybrid solar and wind powering the BTS, a substantial reduction in diesel generator operating hours has been achieved, resulting in savings as given below:

No.	Items	Before	After with Solar-Wind Hybrid System	Savings
1.	20 KVA DG set running	1022 units/month	448 units/month	574 units/month
2.	Fuel consumption (2.75 litres/hour)	865 litres/month Rs. 34626 per month	231 litres Rs. 9260 per month	634 litres/month **Rs. 25366 per month**
3.	Carbon emission	2318 kg/month	619 kg/month	20387 kg/annum
4.	Grid supply	1209 units/month Rs. 8003 per month	547 units/month Rs. 3607 per month	662 units/month **Rs. 4396 per month**
5.	Total savings			Rs. 29762 per month **Rs. 3,57,144 per annum**

Figure 4 Solar-wind hybrid system at Cellular BTS site Shivarampura, Tumkur, Karnataka, India.

6 Discussion

Out of the total power requirement of 50 units of the Cellular BTS site shared by three operators, 10 KWp SPV module supplementing approximately 40 units (KWhr) daily and the balance 10 units is met from diesel generator set. In project 1, the Sunderban Site being an off grid site, the total power requirement was earlier met from 20 KVA DF set operating for 16 hours per day. With the supplement of renewable solar energy the generating running hours has been brought to 2 hours per day. This has resulted into substantial saving of diesel of approximately 1065 litres per month and reduction in carbon emission of 3095 kg per month.

In project 2, the Shivarampura site, the solar-wind hybrid system has resulted in reduction in grid supply of 662 units per month, saving of diesel of approximately 634 litres per month and reduction in carbon emission of 1669 kg per month.

Sharing of passive infrastructure has resulted into savings of both CAPEX as well OPEX. With the sharing of cellular towers by more than one operator the number of tower requirement in a geographical area has been reduced.

With the sharing of passive infrastructure by the service providers i.e. generator/grid supply, SMPS, battery, DC distribution panel, energy saving of 30% has been achieved.

Converting solar energy into electricity is an answer to the mounting problem in rural areas for the cellular BTS. Its suitability for decentralized application and environment friendly nature make it an attractive option to supplement the energy supply for cellular BTS. Installation of SPV cells the problem of telecom initiative in rural areas can be effectively addressed and cutting down harmful green house gases.

7 Conclusion

1. Green energy solutions to power rural telecom BTS is the best alternative.
2. The renewable energy source powering cellular BTS is found to be technically feasible and financially viable.
3. Payback period from the cost analysis of DG operated system vs. 10 KWp SPV system is approximately 3–4 years.
4. Sharing of the passive infrastructure, i.e. land, cellular tower, power back-up (grid, diesel generator, solar and wind), SMPS and storage battery in a BTS site having more than one operator has resulted in significant cost and 30% energy savings. For new operators this will result in faster roll out of network.
5. Reduction of Green House Gas (GHG) emissions due to a substantial reduction in diesel generator operating hours and savings of fossil fuel as well, without sacrificing the QoS.
6. Currently deployed base stations are commonly designed so as to accommodate the traffic demand at peak time. Cell traffic load notably varies during the day. Most of the time, the wireless system is moderately loaded, i.e. cellular networks exhibit highly dynamic traffic fluctuations. The transceiver should enable dynamic power management in order to keep active only the necessary modules during sleep mode. The energy wastage occurs during low load situations. These load variations can be effectively exploited to reduce network energy consumption.

Appendix

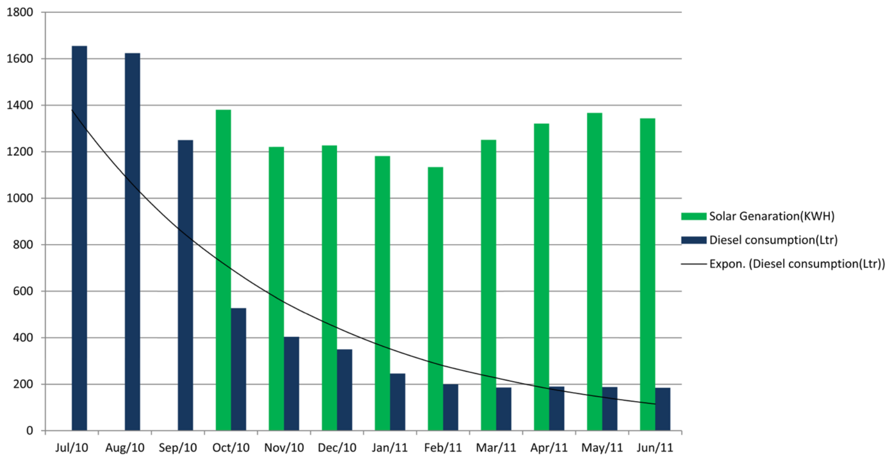

Figure 5 Trend of monthly reduction of diesel consumption and increase in solar generation.

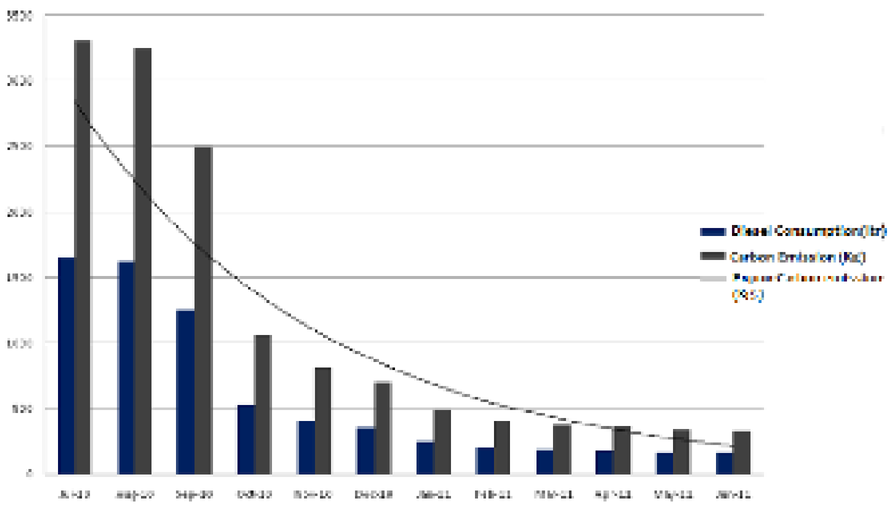

Figure 6 Monthly trend in reduction of diesel consumption and carbon emission.

Acknowledgments

The author wishes to gratefully acknowledge the Universal Service Obligation Fund (USOF), Department of Telecommunication and Ministry of New & Renewable Energy, Government of India for supporting the project. The author also wishes to thank Bharat Sanchar Nigam Limited (BSNL) for the execution of 20 pilot projects.

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Biography

Shri. Panigrahi is an Electrical Engineer from National Institute of Technology, Rourkela, India. Worked for a brief period of two years in BHEL as commissioning engineer of 210 MW thermal power station before joining the Department of Telecommunication, Ministry of Communications & IT, in 1979. In the Department of Telecom he worked in various capacities in planning, design, installation of telecom infrastructure. He is responsible for standardization of electromechanical products and the introduction of the concept of energy conservation/efficiency in the department which resulted in substantial energy savings. He is also responsible for the introduction of Green Energy in rural telephony in India. Dr. Panigrahi is a recipient of an Award from Hon'ble President of India in appreciation of the achievements in the field of energy conservation. He has written papers on standardization, climatic change, energy efficiency & conservation, effects of EMF radiation on health from mobile towers/hand-sets, e-waste management, innovative institutions, etc. Presently he is working as Senior Deputy Director General in Department of Telecommunication, Government of India.