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Analysis on Solar PV based Hybrid Power Solution for Remote Telecom Towers

Jeffy Marin Jose[1], V I Cherian[2]

[1]M.Tech Student, Energy Systems, Amal Jyothi College of Engineering Kanjirappally, jeffymarinjose@gmail.com
[2]Professor, Electrical and Electronics Department, Amal Jyothi College of Engineering Kanjirappally, vicherian@amaljyothi.ac.in

Abstract

Telecommunication is considered as one of the major support services required for the growth and modernization of various economic sectors. The major problem associated with the Telecom Towers is the poor electricity supply that is available, which is tackled by means of Diesel generators (DG). Use of Diesel power leads to an increase in operating cost as well as greenhouse gas emissions. The regulatory authorities are contemplating to curb carbon emissions and rising fuel cost by putting pressure on the operating margins, the use of Renewable energy could be a solution. The commonly used clean energy technologies at the Telecom sites are Solar Photovoltaic (SPV), Wind Turbines, Fuel cells, Biomass power etc. This paper focuses on Telecom sites powered by Solar Photovoltaic (SPV) arrays along with DG and battery. Here the study of a Telecom site powered by hybrid power solution is carried out. The design is done using PVSYST software. The cost analysis of the existing, retrofit and newly proposed site are done manually as well as with the help of HOMER software, which compares the system based on the net present cost, cost of energy and operating cost.

Keywords- Solar Photovoltaic (SPV), Grid, Battery, DG, Base Transceiver Station (BTS), Cost analysis

I. INTRODUCTION

The number of Telecom towers in India approximates to about 7,36,000 this forms the backbone of the Telecom market. These towers consume about 16 billion kWh of electricity per year. Energy saving is considered as a key sustainability focus for the Indian Telecom industry which is especially true for rural areas where energy consumption contributes to 70% of the total network operating cost [1]. Due to the lack of grid, the expenditure on energy acts as a potential barrier to the growth of Telecom industry. That is the teledensity at the rural area is 40% which is about one fourth of the urban teledensity.

A typical State Electricity Board (SEB) power failure in rural India varies from 8-20 hours per day. It is estimated that in India about 70% of Telecom towers are located in rural areas where grid outage is more than 8 hours and about 20% are located in off-grid areas. As these Telecom towers requires 24 hours power supply, tower infrastructure companies are forced to use DGs, batteries etc. Due to the increase in diesel price and concerns regarding rising greenhouse gas emissions the telecom companies are need to focus on better power management ideas.

About 2.6 billion litres of diesel are consumed per year to operate the Telecom towers, which results in the emission about of 7 million metric tonnes of CO_2 [2]. Several efforts such as conversion indoor base transceiver stations (BTS) to outdoor ones, installing energy-efficient equipment and using clean energy sources to power the sites etc are done inorder to optimize energy costs. The use clean energy sources for power production can resolve the three key needs of the Telecom industry, namely: expansion of Telecom infrastructure to off-grid areas; reduction in diesel usage and reduction in carbon emissions. By the use of clean energy technologies the amount of diesel used can be reduced, also the greenhouse gas emission can be reduced. This reduction in the cost of diesel along with the reduction of carbon dioxide emission has attracted the Telecom industry to turn towards green Telecom towers.

The objectives of the paper includes a brief study about the different hybrid power solutions, along with this a cellphone tower power supply system is designed using PVSYST software with SPV as the prime source of power. Also a cost analysis of the site is done by doing a case study so as to find the savings at the site if SPV is used at the site. Initially the site under consideration is powered by DG and battery, as per the client requirement the site is redesigned with SPV as the prime source of power. Along with this a comparison of the conventional system with both the systems - the retrofit system and the newly proposed system is carried out and it is done using the HOMER software.

II. LITERATURE REVIEW

Communication has grown to be an essential factor for socio-economic development. Studies have shown that there is a positive correlation between the penetration of Internet and Mobile Services on the growth of GDP of a country [3]. Considering the telecommunication sector, contribution to GDP is about 3%, the share in energy consumption is about 11% and the energy consumption per unit of GDP is 0.12. It is imperative for the government to recognize the critical role of Telecom in the future growth of the country. As a result of the measures taken by the Government over the years, the Indian Telecom Sector has grown exponentially and has become the second largest network in the world [3].

2.1. Overview of Telecom Industry

The Indian Telecom sector has rapidly grown in the last decade and is still expected to grow steadily. Tele-density, denotes the number of telephones per 100 populations and is an indicator of telecom penetration in the country. Tele-density in the country, which was 73.32% as on April 2013, increased to 75.23 % at the end of March, 2014 [4]. The rural tele-density has increased from 41.05% to 44.01%

during this period urban tele-density, however, has declined of telephone connections increased from 898.02 million in the beginning of the financial year to 933.02 million at the end of March, 2014. During the financial year 2013-14, telephone connections increased every month except in the month of September, 2013.

The cellular phone network comprises of three components mainly: Mobile Switching centre (MSC), Base Station Controller (BSC) and Base transceiver Station (BTS). Any given region is divided into hexagonal cells with BTSs at their centre. A number of BTSs falls under the control of one BSC and a group of BSCs falls under the control of one MSC. The switching and handoffs (when a person moves out of the coverage region of one BTS, the signal is handed off to the next BTS) are handled by the base station controller, which has a group of BTSs under its control. Figure 1 shows the basic diagram of a cell phone network.

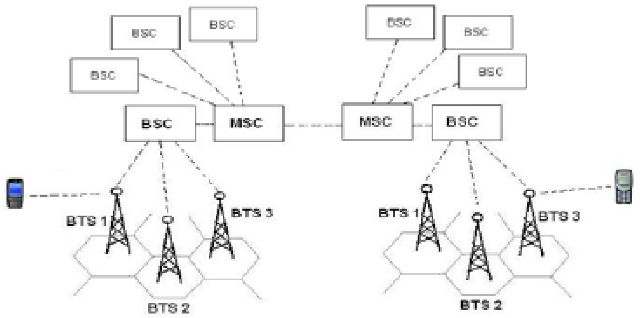

Figure.1. Basic Diagram of a Cell phone Network

BTSs are the biggest consumers of electricity in an outdoor tower site. BTSs are considered as the biggest consumers of electricity in an outdoor tower site [15]. The older generation BTSs (inside BTS) are prone to overheating upon constant usage and needs to be cooled by means of air conditioners. The new BTSs are designed to have higher operating temperatures and outdoor BTSs are preferred inorder to save energy costs.

India imports about 80% of its crude oil and the price of crude is a major component of the production cost of diesel. It is approximated that one litre of diesel produces about 10 kWh of energy but due to conversion processes, only 25-35% of it can be recovered in the form of electricity. The factors that contribute to high diesel cost are transportation cost, pilferage of diesel, inefficient loading, a rise in the price of diesel etc. These factors mentioned above leads to an increase in the amount of diesel consumed by 20-25% this not only impose unnecessary additional cost as higher use of diesel fuel means higher amount of CO_2 and pressures on the operators and but also cause environmental hazards.

2.2. Hybrid Power Solutions

The problems of diesel-power generation like emission of carbon dioxide particulates on the global climate has become a major concern for the environment and this factor has led to the call for the implementation of environmental-friendly green energy solutions [20]. The combination of two or more energy sources is known as Hybrid energy system. The main advantage of hybrid energy from 146.64% to 145.46% during this period. The number system is the enhancement of reliability of the hybrid energy system and cost benefit of the system [12][22].

Different hybrid power systems available are:

i. Photovoltaic-Battery-Diesel Systems

In these systems the prime source of power is SPV, if SPV power is less, then the required power is provided by battery and if the battery depth of discharge (DOD) is reached then the power is provided by the DG. These systems are used in those places where there is deficiency of grid [1][11][13].

ii. Wind-diesel Hybrid Systems

Wind energy is one of the renewable power option for remote areas. Utilization of wind energy provides reduction in fuel consumption, whereas the diesel genset assures the reliability of power supply. A wind turbine installed in an area with a good wind resource can produce energy cost-effectively [16][17]. High penetration wind-diesel system has three types of operating conditions: Diesel Only (DO), Wind Diesel (WD) and Wind Only (WO) [23].

iii. Photovoltaic-Grid-Battery-Diesel Hybrid Systems

This system mainly consists of four components namely PV, grid, diesel and battery. In these systems the required power is provided by the SPV system, when deficit of power from SPV power, grid provides the supply , if grid not available then the supply is provided by the battery and if the battery limits are reached then DG provides the required power. Grid is the cheapest source of electricity. But in rural India the load shedding hours varies from 8 to 10 hours, hence cannot be relied upon [9].

iv. Photovoltaic-Battery-LPG Hybrid Systems

LPG system (full-time LPG generator) is used in stand-alone remote applications too. It consists on portable engine driven by LPG (liquefied petroleum gas). LPG would be a good choice because it is less pollutant than gasoline or diesel, easily to buy, store and transport. These systems are used for low power application. Here instead of DG there is a portable engine driven by LPG [18]. The prime source of power is the SPV, if SPV power is less then power is provided by the battery and if that goes less then it is powered by LPG driven engine.

The design of the hybrid system is done using the PVSYST software. PVSYST V5.0 is a PC software package for the study, sizing and data analysis of complete PV systems. It deals with grid-connected, stand-alone, pumping and DC-grid (public transport) PV systems and includes extensive meteo and PV systems components databases, as well as general solar energy tools [26]. The analysis of the hybrid system is done using HOMER. The techno-economical study of the hybrid systems are done by using HOMER [22]. Here the comparison is done based on the net present cost, levelized cost of energy and operating cost.

III. DESCRIPTION OF THE SYSTEM

Figure 2 depicts the existing power solution at the site. These are powered by grid, DG and battery in normal cases. In many cases there is a lack of grid supply as such even in areas where grid connection exists the site has to be powered by DG sets. The extensive usage of DGs leads to amount of CO_2 and other GHG emission [7]. The greenhouse gases are responsible for global warming [6]. They are cost effective and reliable [8].

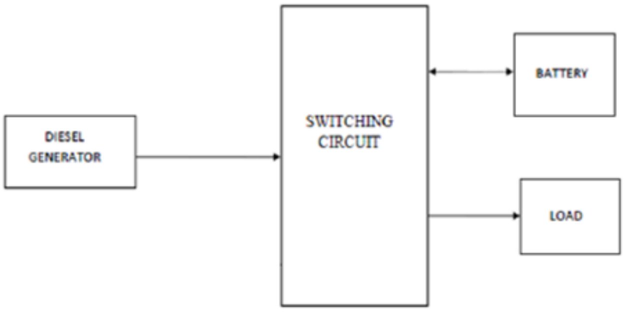

Figure.2. Existing Power Supply at the site

Figure 3 shows the load curve at the site as on 29/05/2015.

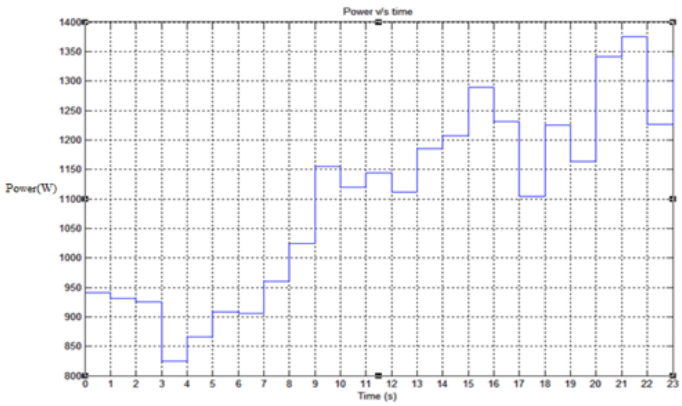

Figure.3. Load Curve at the site

Table.1. Load Requirements at the site

Major load	840 W for 24 hours
Other load	400 W for 15 hours
Total load	840 x 24+400x15 = 26.16 kWh

Table 1 shows the approximate load calculation at the site. The total load requirement is about 26.160 kWh. On account of all these problems associated with the existing power system, a system is proposed with SPV powering the Telecom sites, along with this grid, battery and DG are also used to provide a reliable and continuous power supply [1]. Here the load is assumed to be constant. Figure 4 shows the proposed power supply system at the site.

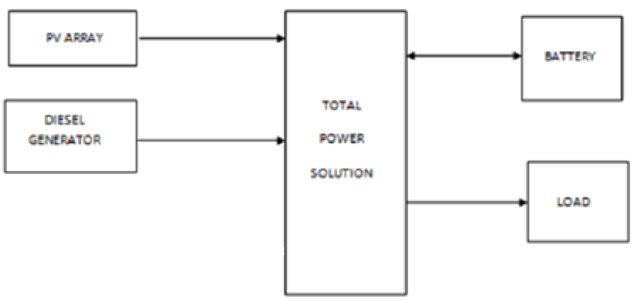

Figure.4. Proposed power supply system at the site

The proposed system can be of either two types: a retrofit one or it can be a new system with a reduced DG capacity. Considering the retrofit system, here in the site DG and battery already exist along with that a SPV system is suggested. The suggested SPV system has a capacity of 5.76 kW and this is capable of supplying the load requirement and does the battery charging. The retrofit system has the following specifications. The SPV system has a capacity of 5.76 kW, 240 W panel is used, a total of 24 panels are used. The DG at the site has a capacity of 10 kVA and has a battery capacity of 621 Ah.

The newly proposed system at the site has a reduced DG capacity. This can be considered only in those cases where a new telecom tower is constructed, as existing telecom towers will be always powered. The SPV system proposed at the site has the same capacity as mentioned above and the battery bank is also the same. The only difference in the above case is that the DG capacity is reduced. The optimum case is obtained by doing an optimisation using HOMER software [21].

IV. DESIGN AND ANALYSIS OF THE SYSTEM

Designing is done with the help of software named PVSYST. The outdoor ground-based mobile phone tower situated in Gazipur, Bihar, contains one base transceiver station (BTS). The objective of the project was to demonstrate the effectiveness of a Solar Photovoltaic system along with a DG customized for grid deficit Telecom sites.

3.1. Design of the system using PVSYST

This retrofit system mainly includes a SPV system integrated into the existing site where a DG and battery already exist. The DG set has a capacity of 10 kVA and the battery capacity is about 621 Ah. Before the installation of SPV system, based on a manual calculation, the daily consumption of diesel at the site is around 11.89 litres per day and the diesel consumption in a year is calculated as 4340 litres per year approximately and the cost of diesel for a year is approximated as Rs. 2,17,000. Also the CO_2 emission is about 11,284 kg of CO_2 per year.

In the design part, initially the location details are entered into the user interface and thereby the site location is generated. The number of PV modules and the number of battery units are generated by the system. Inorder to power a load of 26.160 kWh, the system proposes a 5.76 kW system. In the case of retrofit system, the SPV system produces about 7580 kWh of electricity and DG produces around 3300 kWh of electricity per year. The total amount of diesel required is about 1503.8 litres/year and the diesel consumption per day is 4.12 litres/day. The cost of diesel for a year is approximated as Rs.75,190. Also the CO_2 emission is about 3909.88 kg of CO_2.

In the case of a retrofit system, there exists a DG of capacity 10 kVA, while for the new system; the DG capacity is reduced to 3 kVA. This is in accordance with the optimization done using HOMER software. The SPV system produces about 7630 kWh of electricity and DG produces around 2900 kWh of electricity per year. The total amount of diesel required is about 1317.65 litres/year and the diesel consumption per day is 3.61 litres/day. The cost of diesel for a year is approximated as Rs. 65, 883. Also the CO_2 emission is about 3425.50 kg of CO_2.

Figure 5 shows the simulation result obtained from PVSYST for retrofit system showing the available energy, energy need of the user and the energy supplied to the user. Figure 6 shows the simulation result obtained from PVSYST for new system showing the available energy, energy need of the user and the energy supplied to the user.

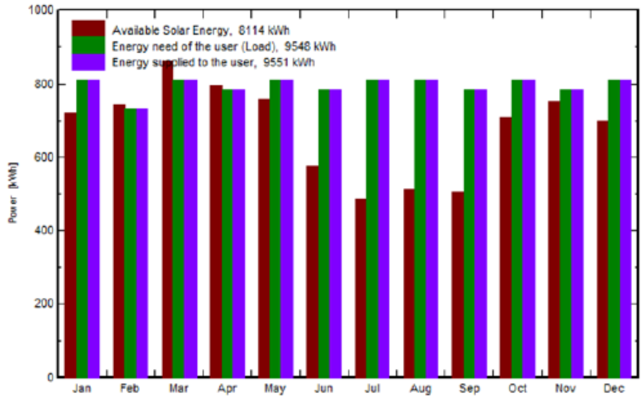

Figure.5. Graph obtained from PVSYST for retrofit system

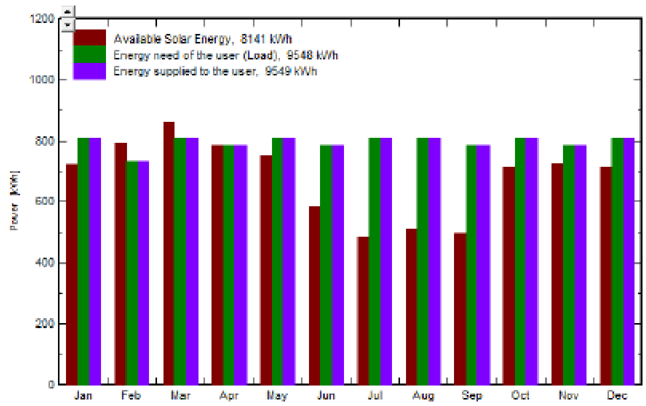

Figure.6. Graph obtained from PVSYST for retrofit system

3.2. Design of the system using HOMER

The three systems namely conventional DG-Battery system, Retrofit system with 10 kVA DG set and new system with reduced DG capacity are simulated using HOMER. Inputs data for this software includes electrical loads, renewable components data like PV specification, wind turbine models, types of batteries and converters, capital costs of components, replacement cost, maintenance and operation costs, fuels cost, renewable resources data like solar radiations and monthly average wind speeds [24]. HOMER performs numbers of hourly simulation to ensure the best possible matching between the loads. Here the details regarding the Solar PV, battery, diesel generator etc are inputted.

V. RESULTS AND DISCUSSIONS

Based on the simulation using HOMER, a comparison between the conventional DG-Battery system, DG-Battery system with retrofit SPV and a newly proposed PV-DG-Battery system with reduced capacity of DG are done. Figure 7 shows the graph for conventional DG-Battery system as on 29/05/2015. Here the battery charges and discharges twice a day. The battery is charged from the DG set.

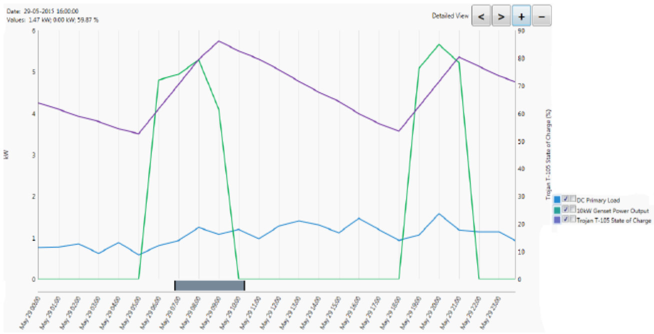

Figure.7. Graph obtained from HOMER for conventional system

Figure 8 shows the graph for Retrofit system with 10 kVA DG set as on 29/05/2015. Here the battery discharges only once in a day. Here the battery is charged from the PV, also at times from the diesel generator.

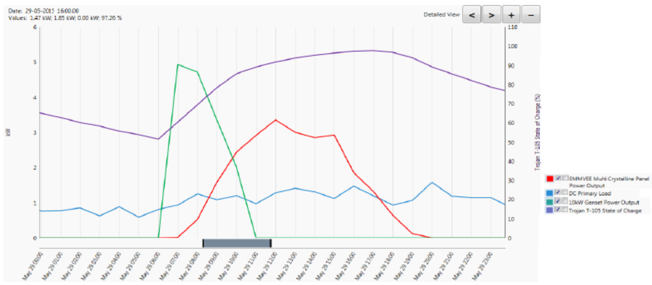

Figure.8. Graph obtained from HOMER for retrofit system

Figure 9 shows the graph for newly proposed system with 3 kVA as on 29/05/2015. Here the battery discharges only once in a day. Here the battery is charged from the PV, also at times from the diesel generator.

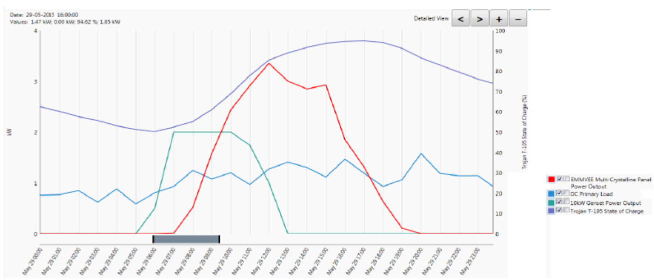

Figure.9. Graph obtained from HOMER for new system

Economics play an integral role both in HOMER's simulation process, wherein it operates the system so as to minimize total net present cost and in its optimization process, wherein it searches for the system configuration with the lowest total net present cost. Renewable and non renewable energy sources typically have dramatically different cost characteristics [28]. HOMER uses the total net present cost (NPC) to represent the life-cycle cost of a system. The three systems are compared based on the Net Present cost (NPC), Levelized cost of energy (LCOE) and Operating cost. Table 2 shows the comparison between the three systems.

Table.2. Comparison between three systems

System	NPC (Rs.)	LCOE (Rs.)	Operating Cost (Rs.)
DG-Battery	57,46,959	35.075	2,90,269
Retrofit System (10 kVA DG set)	32,55,194	19.867	1,32,116
Proposed System (3 kVA DG set)	30,94,567	18.89	1,16,074

VI. CONCLUSION

Given the current scenario, renewable energy appears to be a prudent solution for powering the Telecom towers. It is clear that as the energy demand of the Telecom sector grows, the supply of renewable energy must also keep pace. The most commonly used renewable energy source for BTS sites is Solar Photovoltaic Systems.

The given site has been studied and a design for the same by using PVSYST for both the retrofit system with SPV system of 5.76 kW and for the newly proposed system with reduced DG capacity has been done. Along with this the three systems were analyzed and compared using the HOMER.

Based on the comparison between the conventional DG - Battery system and retrofitted system with SPV system, the DG run hours are reduced from 2431 hours per year to 945 hours per year, the diesel consumption is reduced from 4405.10 litres per year to 1,556.70 litres per year, thereby the CO_2 emissions are also reduced from 11,600 kg per year to 4,099.30 kg per year. Also the value of NPC, LCOE and operating cost are much less than the conventional system.

On comparing the conventional DG – Battery system and the newly proposed system with reduced DG capacity, the DG run hours are reduced from 2431 hours per year to 2135 hours per year, the diesel consumption is reduced from 4405.10 litres per year to 1301 litres per year, thereby the CO2 emissions are also reduced from 11,600 kg per year to 3425.90 kg per year. Along with this the NPC, LCOE and Operating cost are reduced, and are also less when compared to the retrofitted system. But the diesel consumption is higher in the case of new system. This system would be advisable if the telecom site is a newly established one with same load profile.

REFERENCES

[1]M. W. Quashem Bin, M. A. Kawser , ‘‘Application of PV-Battery-Fossil Fuel Hybrid System for Remote Telecom Operation in Bangladesh’’, 2nd International Conference on Green Energy Technology (ICGET), pp.116-120, 2014.

[2]G. Venu, C. Mrinmoy, Energy Alternative India [EAI], Greenpeace India, Enabling Green Talking, August 2012, http://www. greenpeace.org/ India/ Global/ India/ report Enabling-Clean-Talking. pdf, Mar 30, 2014.

[3]T. Kaushlendra, \Energy Efficiency in Green Telecom", Indo-European Dialogue on ICT Standards and Emerging Technologies, pp. 1 - 5, 2014.

[4]Annual Report - Telecom Regulatory Authority of India, Department of Telecommunication, Ministry of Communications and Information Technology, Government of India, 2013-2014, http://www.dot.gov.in /sites /default/les/AR.pdf, Jun 7, 2015.

[5]Tata Teleservices Limited, Green Energy Initiatives : Gaps & Opportunities, http://www.lse.ac.uk /intranet / Careers And Vacancies / careersService/ Internships/ TataISES/Presentations%20and%20reports/CherylMohReport.pdf, Mar 15, 2014.

[6]Intelligent energy, Green Solutions for Telecom Towers: PartII,SolarPhotovoltaicApplicationsJuly2013,http://www.intelligentenergy.com/media/uploads/green solutions for telecom towers part 2.pdf, Feb 20, 2014.

[7]A. Mohammed, P. Jagadeesh, K. Tamer, E. Wilfried, “A Review of Process and Operational System Control of Hybrid Photovoltaic/Diesel Generator Systems”, Renewable and Sustainable Energy, **3**(4), pp.436-446, 2014.

[8]N. Pandiarajan, M. Ranganath, , “Mathematical Modeling of Photovoltaic Module with Simulink", International Conference on Electrical Energy Systems (ICEES), pp.314-319, 2011.

[9]R. Sebastin, R. Pea-Alzola , “Study and Simulation of a Battery based Energy Storage System for Wind Diesel Hybrid Systems", IEEE International Energy Conference and Exhibition (ENERGYCON), pp.563 - 568, 2012.

[10]H. Ibrahim, J. Lefebvre, J. F. Methot, J. S. Deschenes , “Numerical Modeling Wind-Diesel Hybrid System: Overview of the Requirements, Models and Software Tools", IEEE Conference on Electrical Power and Energy(EPEC), pp.23- 28, 2011.

[11]S. Vicente, O. Emilio, “Hybrid Powering System for Stand-Alone Remote Telecom Applications", 22nd International Conference on Telecommunications Energy Conference (INTELEC), pp.311-316, 2000.

[12]L. J. Olatomiwa, S. Mekhilef, A. S. N. Huda, “Optimal Sizing of Hybrid Energy System for a Remote Telecom Tower: A Case Study in Nigeria", IEEE Conference on Energy Conversion (CENCON), 3(1), pp.243-247, 2014.

[13]R. Langella, G. Margiotta, D. Proto, A. Testa, “Hybrid PV-Diesel Stand Alone System Sizing for Remote Microgrids", IEEE International Energy Conference and Exhibition (ENERGYCON), pp.475-482, 2012.

[14]P. O. Akuon, “Optimized Hybrid Green Power Model for Remote Telecom Sites", IEEE International Power Engineering Society Conference and Exposition in Africa (PowerAfrica), pp.1-5, 2012.

[15]M. R. Chethana , C. Kavitha, , "A Survey of Green Base Stations in Cellular Networks", International Journal of Computer Networks and Wireless Communications (IJCNWC) , 2(2), pp.232-236, 2012.

[16]C. A. Shahriar, R. Vishwajit, A. Shakila , "Renewable Energy Usage in the Telecommunication Sector of Bangladesh: Prospect and Progress", 1st International Conference on Developments in Renewable Energy Technology (ICDRET), pp.1-5, 2009.

[17]B. Mangu, K. Kiran Kumar, B. G. Fernandes, "A Novel Grid Interactive Hybrid Power Supply System for Telecom Application", Annual IEEE India Conference (INDICON), pp.1-5, 2011.

[18]S. Narayanamurthy, S. Ramdaspalli, A. Jhunjhunwala, B. Ramamurthi, "Rural base station powering ", IEEE National Conference on Communications (NCC), pp. 1 - 5, 2012.

[19]A. Soufi, A. Chermitti, Z. Allam, M. M. Bouzaki, "Design and Simulation of Dairy Farm Photovoltaic System for a Rural Area in Tlemcen, Algeria", Journal of Engineering Science and Technology Review, 7 (3), pp. 133 - 136, 2014.

[20]Geetha P., "A Case Study of Solar Powered Cellular Base Stations", Master's Thesis, Energy Systems, Department of Technology, University of Gavle, 2009.

[21]G. Paul, L. Peter, Micro power System Modelling with HOMER, National Renewable Energy Laboratory, USA, pp. 379 - 417, 2006.

[22]L. Olatomiwa, S. Mekhilef, A. S. N. Huda, K. Sanusi, "Techno-economic analysis of hybrid PV diesel battery and PV wind diesel battery power systems for mobile BTS: the way forward for rural development", Energy Science and Engineering, pp. 1 - 15, 2015.

[23]A. Shiroudi, R. Rashidi, G. B. Gharehpetian, S. A. Mousavifar, A. Akbari, "Simulation and optimization of photovoltaic-wind-battery hybrid energy system in Taleghan-Iran using homer software", Renewable and Sustainable Energy, pp. 1 - 11, 2012.

[24]S. Ajay , S. Anand , K. Manish, "Homer Optimization Based Solar PV; Wind Energy and Diesel Generator Based Hybrid System", International Journal of Soft Computing and Engineering (IJSCE), **3**(1), pp. 199 - 204, 2013.

[25]P. Anchal, K. Manish, A. Naveen, "Optimization of Hybrid System using HOMER", International Journal of Advanced Technology and Engineering Research (IJATER), **4**(4), pp. 56 - 59, 2014.

[26]A. M. Raees, K. Fahimullah, "Cellular Base Station Powered by Hybrid Energy Options ", Power and Energy Engineering Conference (APPEEC), pp. 35 - 39, 2015.

[27]A. H. Mohammed, N. Rosdiadee, I. Mahamod, "Energy optimization of hybrid off-grid system for remote telecommunication base station deployment in Modelling with Malaysia", Journal on Wireless Communication and Networking SPRINGER, pp. 1 - 15, 2015.

[28]A.V. Ani, N. V. Nzeako, "Potentials of Optimized Hybrid System in Powering Off-Grid Macro Base Transmitter Station Site", International Journal of Renewable Energy Research, **3**(4), pp. 861 - 871, 2013.