A REVIEW ON DESIGN AND COST ANALYSIS ON HYBRID POWER SOLUTION FOR REMOTE TELECOM TOWERS

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Abstract— Telecommunications has been recognized as one of the prime support services needed for rapid growth and modernization of various sectors of economy. The problem of poor electricity supply is experienced at the Telecom service which is tackled by using Diesel generators (DG). Diesel power, besides increasing operating cost also causes emission of greenhouse gas. With regulatory authorities contemplating to curb carbon emissions and rising liquid fuel cost putting pressure on operating margins, renewable energy could prove to be an attractive option for Telecom sector. The clean energy technologies such as solar photovoltaic (SPV), wind turbines, biomass power, fuel cells have undergone trials at Telecom sites. This paper emphasis on Telecom sites powered by Solar Photovoltaic (SPV) arrays along with DG, grid and battery. Here the study of a hybrid power solution at a Telecom site is carried out. The design is done using PVSYST software. Along with this, cost analysis of the particular site is also done.

Index Terms—Solar Photovoltaic (SPV), Grid, Battery, DG, Base Transceiver Station (BTS), Cost analysis

I. INTRODUCTION

India has 7,36,654 Telecom towers which forms the backbone of its Telecom market. These towers require about 16.5 billion kWh of electrical energy per annum. Energy saving is a key sustainability focus for the Indian Telecom industry today [1]. This is especially true in rural areas where energy consumption contributes to 70% of the total network operating cost. In urban areas, the energy cost for network operation ranges between 15-30% [2]. This expenditure on energy as a result of the lack of grid availability highlights a potential barrier to Telecom industry growth, especially regarding the expansion of rural teledensity which sits at 40.81% is about one fourth of the teledensity in urban areas.

As the Telecom networks requires 2 hours power supply, due to an unreliable electrical power grid, tower infrastructure companies use Diesel Generators (DGs), batteries and a variety of power management equipment to back-up the grid and ensure network availability. The growing cost of energy due to increasing diesel prices and concerns over rising greenhouse emissions have caused tower infrastructure companies to focus on better power management methods. Annually more than 2.6 billion litres of diesel are consumed to operate Telecom towers, resulting in the emission of 7 million metric tonnes of CO_2 [2].

Due to the deregulation of diesel prices and the need to reduce carbon emissions, it has become imperative for the industry to evaluate all alternative options. Of which clean energy sources for power has the potential to resolve the three key needs of the Telecom industry, namely: reduction in diesel usage; expansion of Telecom infrastructure to off-grid areas; and reduction in carbon emissions; in order to improve network operation and to reduce energy costs. While clean energy technologies such as solar photovoltaic, windturbines, biomass power and fuel cells have undergone trials at Telecom sites, the majority of these trials have been with solar photovoltaic technology.

The objectives of this paper are to conduct a brief study about the different hybrid power solutions, along with the designing of a cell phone tower power supply system using PVSYST software with SPV as the prime source of power. Here a cost analysis of the site is done by doing a case study inorder to find the savings at the site if SPV is used in a remote Telecom power supply system. 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.

II. LITERATURE REVIEW

A. *OVERVIEW*

The telecommunication sector is at the helm of this growth story. The growth of Telecom industry is vital to the sustenance of the extraordinary growth rate of India. The Indian Telecom sector is one industry, which has rapidly grown in the last decade and is still expected to grow steadily. As on May 31st 2012, India's urban teledensity was about four times that of rural, where rural teledensity is about 40.21% as shown in figure 1.

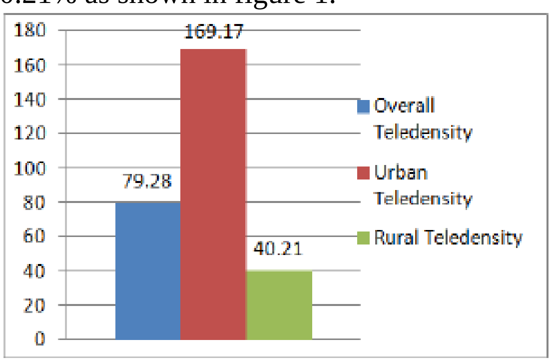

Figure.1 Teledensity [2]

The cellular phone network consists, primarily, of three components: mobile switching centers (MSC), base station controllers (BSC) and base transceiver stations (BTS). Any region is divided into hexagonal cells with BTSs at their centre. Several BTSs fall under the control of one BSC and a group of BSCs fall under the control of one MSC [3]. The BTS is located at the centre of the hexagonal cells of each region. A mobile switching centre (MSC) handles the switching among various base station controllers (BSCs). BTSs are the biggest consumers of electricity in an outdoor tower site. The older generation BTSs was prone to overheating on constant usage and was cooled inside shelters by air conditioners. Air conditioners, especially the older ones, are high consumers of electricity. This doubled the load of an indoor BTS. The new BTSs have higher operating temperatures and outdoor sites are preferred to save energy costs. Lack of a developed national grid network is a major cause for power-supply snags to the Telecom towers. This has led to the use of Diesel generators at the site.

Diesel is a regulated commodity in India, that is, the Government of India sets a ceiling on the selling price of the fossil fuel [4]. India imports 80 per cent of its crude oil and the price of crude is a major component of the production cost of diesel. It is important to mention here that the Telecom industry is the single largest consumer of diesel after the Indian railways and probably the biggest beneficiary of the subsidy that is given to users of fossil fuels. A litre of diesel produces about 10 kWh of energy but due to conversion processes, only 25 - 35 per cent of it can be recovered in the form of electricity. The factors that contribute to high diesel cost are pilferage of diesel, inefficient loading, transportation cost, rise in the price of diesel etc.

B. *EXISTING POWER SOLUTION AT THE SITE*

The existing power solution at the site is depicted in the Figure 2. In normal case the sites are powered by grid, DG and battery. As mentioned in the above section grid is not available. Even in areas connected to the grid, the power supply can be unstable and expensive [6]. Though the primary establishment cost is not very high for DG. Extensive use of DGs has big adversary environment effects as higher use of diesel fuel means higher 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].

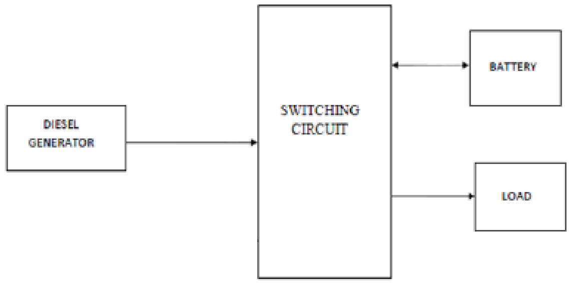

Figure 2. Existing Power Solution at the site

Typically these sites are backed-up by a 15KVA to 25KVA generator sets depending on the number of shared BTS systems and battery capacity installed. Even a typical 15KVA generator set consumes nearly 2.0 litres of diesel very hour for a single operator base station. Oversized DGs

are being used at sites operating at very low load factors which results in excessive fuel consumption. The DG is turned on when the grid fails at conventional sites to primarily drive the oversized air conditioners at the shelter. DG is a very expensive source of power as compared to the grid [11]. The load requirement at the site is 840W for 24 hours for Base Transceiver Station (BTS) and for other uses it is 400W for 15 hours. The diesel consumption, cost and CO_2 emissions are calculated below for the case when DG supplies the system.

Total cost = Capital cost + Running cost + Maintenance cost

= Rs.4, 40,000 + Rs.2,73,420 + Rs.10,000

= **Rs.7, 23,420**

1litre of diesel produces about 2.6kg of CO_2. DG consumes about 4340 litres of diesel per year.

CO_2 emissions for a year = **11,284 kg of CO_2**.

C. *HYBRID POWER SOLUTIONS*

The adverse effects 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. The combination of two or more energy sources is known as Hybrid energy system. The main advantage of hybrid energy system is the enhancement of reliability of the hybrid energy system and cost benefit of the system [10].

Different hybrid power systems available are:

i. Photovoltaic/Battery/Diesel/ systems

In these systems the prime importance is given to SPV, if SPV power is less then power is provide by battery and if the battery limits are reached then the power is provided by the DG. These systems are used in those places where there is deficiency of grid [6]. In this hybrid system, there are four main components to be considered-PV modules, generators, batteries and converter.

ii. Wind diesel hybrid systems

Wind energy is one the renewable power supply options for remote areas. Utilization of wind energy provides reduction of 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 [7]. High penetration wind-diesel system has three types of operating conditions: Diesel Only (DO), Wind Diesel (WD) and Wind Only (WO).

iii. Photovoltaic/Grid/Battery/Diesel Hybrid Systems

This system mainly consists four components namely PV, grid, diesel, 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 rely [8].

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 [10]. 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.

III. PROPOSED SYSTEM

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]. Figure 3 shows the block diagram of the proposed system.

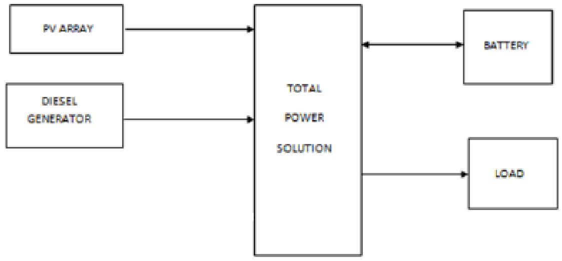

Figure 3. Proposed power solution at the site [1]

Here the load is assumed to be constant. The Telecom towers mainly have two loads namely: Base Transceiver Station (BTS) and the link. The function of BTS is to provide communication between the tower and the mobile. For this purpose some amount of power is consumed. As per the requirement of the client, a system with SPV, Battery and DG is proposed. As mentioned in the literature survey, the site is not equipped with grid supply, hence these three sources contributes to the power supply. Based on the load profile at the site, a suitable system has been proposed. Figure 4 shows the load details of the site on 29/05/2015.

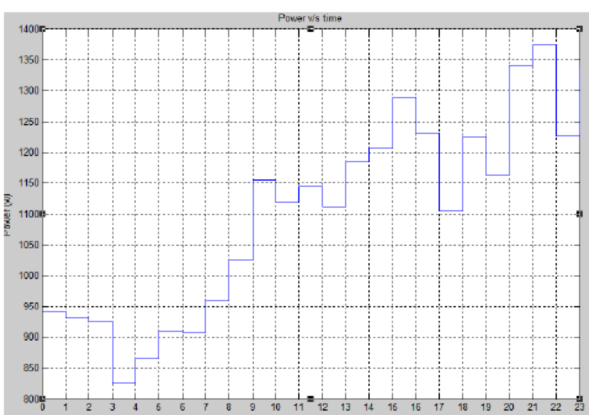

Figure 4 Load Profile of the site on 29/05/2015

IV. DESIGN AND SIMULATION

Inorder to get a clear picture about the design of a Solar Photovoltaic system at the BTS site, a case study is done. The design part is done with the help of PVSYST software and the simulation part is done with the help of MATLAB. 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.

A. *DESIGN OF THE SPV SYSTEM*

PVSYST V5.0 is a PC software package for the study, sizing and data analysis of complete SPV systems. It deals with grid-connected, stand-alone, pumping and DC-grid (public transport) SPV systems, and includes extensive meteo and SPV systems components databases, as well as general solar energy tools. This software is geared to the needs of architects, engineers, researchers educational training. For stand-alone systems this tool allows to size the required SPV power and battery capacity, given the load profile and the probability that the user will not be satisfied ("Loss of Load" LOL probability, or equivalently the desired "solar fraction"). Table 4 shows the location details of the site under consideration.

Table 1. Location Details

Geographic location	**Place** : Gazipur **State** : Bihar
Latitude	25.1°N
Longitude	86.7°E
Altitude	111 m
Time zone	5.3
Site type	Outdoor
Number of BTS	1
BTS load	0.84 kW

There were two sources of electricity and a DG system the location. Grid electricity was available for only for about 1 hour and the tower was powered by a 10 kVA DG set for 24 hours. The total energy consumption per day is 26.160kWh. The DG used at the site is of 10 kVA, Eicher make, and cost is approximately Rs. 4,40,000.

A solar Photovoltaic system was installed at the site, as such it bears a major portion of the load. When there is a shortage in the power produced from the SPV system, the DG acts as a back-up generator and produces the power. Design of the photovoltaic system is done using software named PVSYST. As the number of units required is 26.160 kWh, it is possible to find the array capacity with this value. Taking the average number of hours of sunshine as 4.5, the array capacity can be calculate as 26.160/4.5 = 5.8kW approximately. Here 240W panels Si-poly panels are being used. The panel manufacturers are EMMVEE Diamond 240. The number of panels required can be calculated as 24.

Battery is provided for back up. It is used to power the BTS, when the solar power is not available basically during night time. The number of units is 26.160kWh and the operating voltage is 48V. A simple calculation to find out the battery capacity,
Battery capacity = Voltage x Ampere hour rating
Therefore battery capacity is 545 Ah (approximately).Figure 5 shows the PVSYST design of the required system. On calculating the cost, i.e, total cost for the proposed system is equal to the sum of the capital cost in installing the SPV system plus the DG cost along with the maintenance cost.

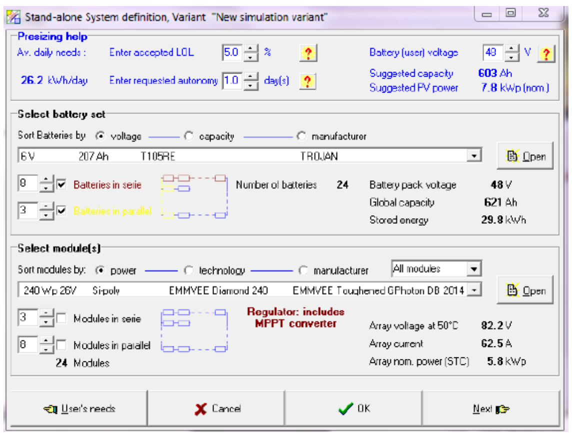

Figure 5 System Design in PVSYST

Total cost = Capital cost + Running cost + Maintenance cost
= Rs.11, 68,317 + Rs.94, 739.4 + Rs.13, 000
= **Rs.12, 76,056.4**

Diesel cost without SPV installed = Rs. 2, 73,420
Diesel cost with SPV installed = Rs. 94,739.40
Savings in diesel price in a year = Rs. 2, 73,420 - Rs.94,739.4= **Rs. 1, 78,680.6**

Litres of diesel consumed without SPV (per yr) = 4340 l/yr
Litres of diesel consumed with SPV (per yr) = 1503.80 l/yr
Savings in diesel consumed = **2836.2 l/yr**

As the diesel consumption is reduced, the CO_2 emissions are also reduced. The CO_2 emissions got reduced to about 3909.88 kg of CO_2 per year. As such the total reduction CO_2 emissions in a year is about 7374.12 kg of CO_2. The initial cost of investment for the Solar Photovoltaic system is high but on comparing it with the savings in future it is more economical than employing a DG set at the site.

B. *SIMULATIONS FROM PVSYST*

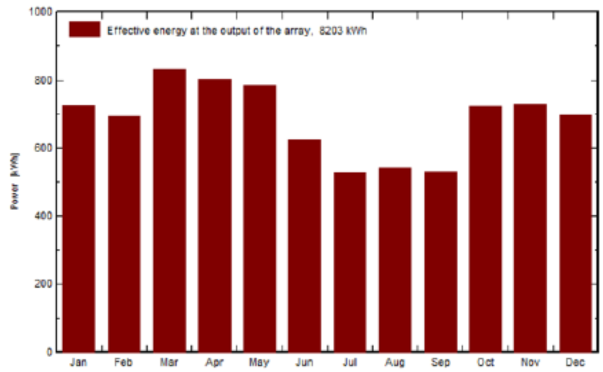

Figure 6. Effective energy at the output of the array

The figure 6 shows the effective output of the SPV array. The effective output is high in the month of March. Hence the working of generator can be stopped during the month of March and the fuel consumption is much reduced.

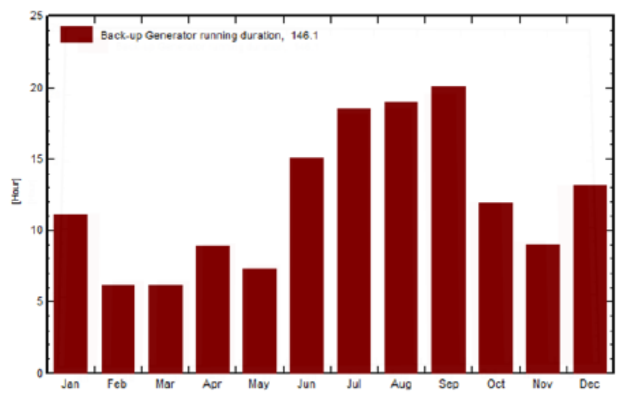

Figure 7. Back-up generator running duration

The figure 7 shows the running hours of a DG. The running of the back-up generator is more in June, July, August etc. During September most of the power is obtained from the DG and diesel consumption is more in the month of September compared to the other months. As the diesel consumption is more, more amount of carbon emissions are given out during this month.

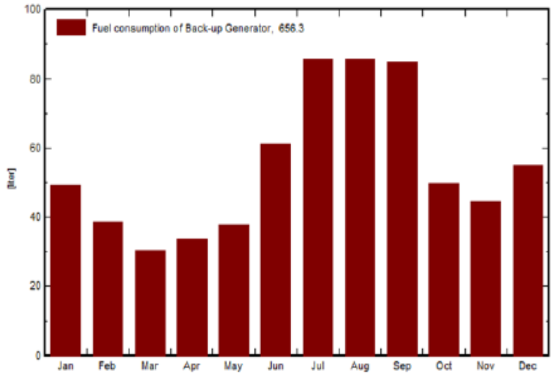

Figure 8. Fuel Consumption of Back-up generator

The figure 8 mentions the fuel consumption of the back- up generator. On comparing it with the DG running hours, it is clear that, it is high during June, July, August, September etc.

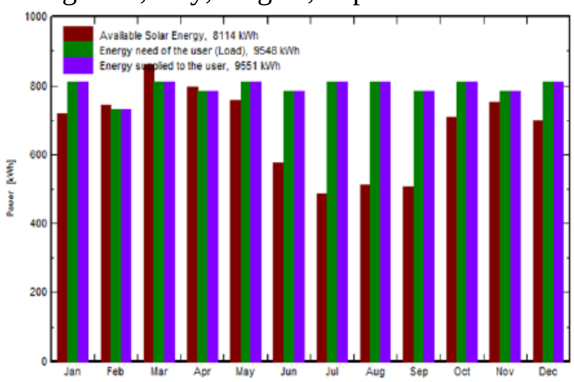

Figure 9. Energy required and supplied

Figure 9 shows the available solar energy, the requirement of the user (load end), and also the energy supplied to user. That is here the available solar energy or radiation is 8114 kWh. The energy requirement of the user (load) is 9548 kWh and the energy that is supplied to the user is 9551 kWh, this power is the sum of the powers coming from the solar photovoltaic system and the back-up generator. With the help of these graphs the input and output radiation incident can be easily found out. Also the contribution of the back-up generator to the power supply can be easily analysed.

V. CONCLUSION

The Telecom sector in India holds one of the keys to reaching our climate goals. It is clear that as the energy demand of the Telecom sector grows, the supply of renewable energy must also keep pace. Given the current scenario, renewable energy appears to be a prudent solution for powering the Telecom towers. The most commonly used renewable energy source for BTS sites is Solar Photovoltaic Systems. On the basis of the case study, it is possible to conclude that there is a great reduction in the amount of diesel consumed (in litres), also reduction in the cost, which results in the savings.

1. Savings in Diesel cost → Rs. 1,78,680.6
2. Savings in Diesel consumed → 2836.2 litres/year

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