A STANDALONE SOLAR SYSTEM

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Abstract - *Energy crisis has become a serious issue for the developing countries across Asia and Africa, nowadays. Compared to the other developing countries, India has a greater demand for power since it is the country with the second highest population in the world. This might be an alarming indication that our present existing energy resources are starting to run out, which has very serious and disturbing consequences on the global quality of life as well as the global economy. Therefore, we have tried to access the theoretical and technical viability of a standalone PV (photovoltaic) system for base stations located in areas where it is not efficient to run power transmission lines or have alternative generation like diesel generator. This paper aims to work out on optimum sizing of the standalone PV system for BTS in rural area having a fixed D.C load.*

***Key Words*: base-transceiver system (BTS), non-conventional energy source, photovoltaic system, solar panel**

1. INTRODUCTION

Energy saving is a key focus for the Indian Telecom Industry today. This is especially true in rural areas where energy consumption contributes to 70% of the total network operating costs (OPEX). In urban areas, the energy costs for network operating ranges between 15-30% [1]. It is estimated that in India almost 70% of telecom towers are located in areas with more than eight hours of grid outage and almost 20% are located in off-grid areas.[2] This uncertainty in power has compelled the providers to use diesel generators to ensure a continuous supply of power. Annually more than 2.6 billion litres of diesel is consumed to operate telecom towers, resulting in the emission of 7 million metric tons of CO2. Given the deregulation of diesel prices and the need to reduce CO2 emission, it has become imperative for the industry to evaluate all alternative options in order to improve network operations and to reduce energy costs. The best way to harvest the sun's power is the photovoltaic technology. Stand alone photovoltaic system is a way to electrify remote areas, giving power to BTS (base-transceiver system) stations and increasing trend in rise in prices of petroleum products. India, with its excellent irradiance has the opportunity to exploit PV solar power to meet the challenges coming from the DG sets of onsite power generation. Coupled with a battery back-up i.e. Stand-alone PV system are a viable exciting alternative to reduce the correlation between power costs and total operating expenditures, thereby providing sustainable and reliable strategic solution to the fuel problem. While the capital expenditure (CAPEX) to implement a PV system is greater than setting up DG sets, this is more than offset through a reduction in operating expenditure (OPEX).

The table given below provides facts about solar radiation in India-

Table-1: Parameters and their availability in INDIA

PARAMETERS	AVAILABILITY
DAILY AVERAGE ENERGY INCIDENTS	4-7 kWhr/m^2
SOLAR POWER DENSITY ACROSS INDIA	Refer to solar map of India (Fig. 1)
DURATION OF QUALITY SUNSHINE PER DAY	Approximately 5 hours
NUMBER OF DAYS WITH QUALITY SUNSHINE	300

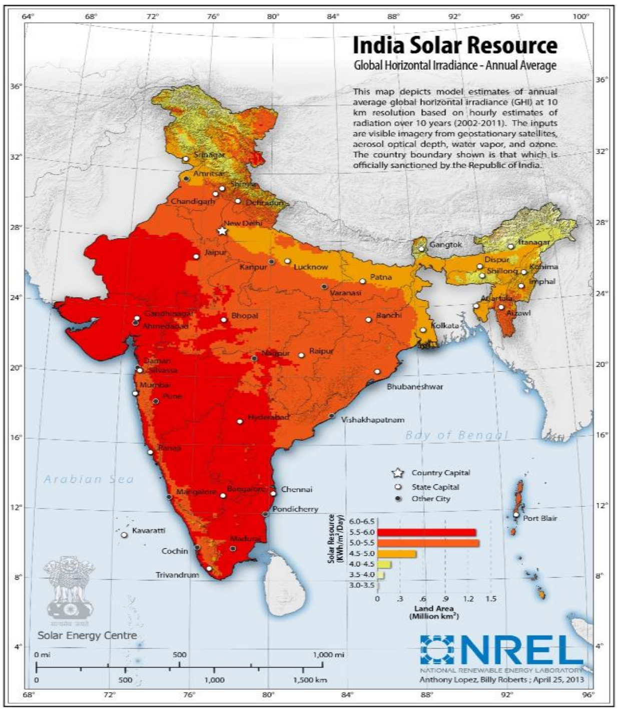


Fig -1 Solar map of INDIA (copied from Google)

2. OPPORTUNITIES AND CHALLENGES OF SOLAR PV TECHNOLOGY ADOPTION IN THE INDIAN TELECOM INDUSTRY:

Advantages of adopting solar energy in INDIA:

1) This is an inexhaustible source of energy and the best replacement to other non-renewable energies in India.

2) Solar energy is environment friendly. When in use, it does not release CO2 and other gases, which pollute the air. Hence it is very suitable for India, India being one of the most polluted countries of the world.

3) Solar energy can be used for variety of purposes like as heating, drying, cooking or electricity, which is suitable for the rural areas in India. It can also be used in cars, planes, large powerboats, satellites, calculators and many more such items, just apt for the urban population.

4) Solar power is inexhaustible. In an energy deficient country like India, where power generation is costly, solar energy is the best alternate means of power generation.

5) We don't need a power or gas grid to get solar energy. A solar energy system can be installed anywhere. Solar panels can be easily placed in houses. Hence, it is quite inexpensive compared to other sources of energy.

Disadvantages of Solar Energy in India:

1) We cannot generate energy during the nighttime with solar energy. Also during daytime, the weather may be cloudy or rainy, with little or no sun radiation. Hence, this makes solar energy panels less reliable as a solution.

2) Only those areas that receive good amount of sunlight are suitable for producing solar energy.

3) Solar panels also require inverters and storage batteries to convert direct electricity to alternating electricity to generate electricity. While installing a solar panel is quite cheap, installing other equipment becomes expensive.

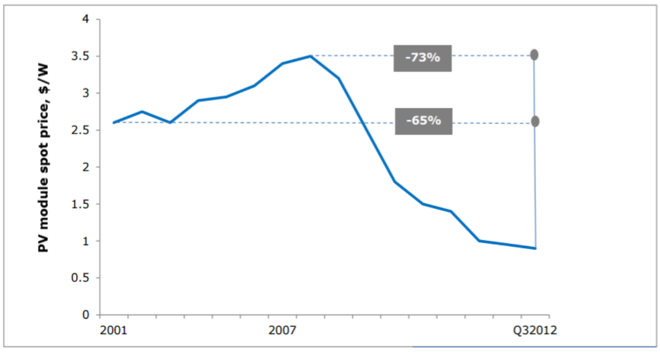


Chart-1 Price trend of solar Photo-voltaic modules, 2001 to 2012

4) The land space required to install a solar plant with solar panel is quite large and that land space remains occupied for many years altogether and cannot be used for other purposes.

5) Energy production is quite low compared to other forms of energy.

6) Solar panels require considerable maintenance as they are fragile and can be easily damaged. So extra expenses are incurred as additional insurance costs.

Solar Energy Power in India: Future

In solar energy sector, many large projects have been proposed in India. Thar Desert has some of India's best solar power projects, estimated to generate 700 to 2,100 GW. On March 1st, 2014, the then Chief Minister of Gujarat, Narendra Modi, inaugurated at Diken in Neemuch district of Madhya Pradesh, India's biggest solar power plant. The Jawaharlal Nehru National Solar Mission (JNNSM) launched by the Centre is targeting 20,000 MW of solar energy power by 2022 Gujarat's pioneering solar power policy aims at 1,000 MW of solar energy generation. In July 2009, a $19 billion solar power plan was unveiled which projected to produce 20 GW of solar power by 2020. About 66 MW is installed for various applications in the rural area, amounting to be used in solar lanterns, street lighting systems and solar water pumps, etc.

3. GOVERNMENT POLICIES

The Indian governments new policy direction provides incentives for using renewable energy in one hand and decreasing subsidies on petroleum fuels and a move towards market pricing in this regard.

The Ministry of Renewable Energy has issued Guidelines for off-grid and De-centralized solar Applications under the Jawaharlal Nehru Solar Mission. This provides capital subsidy up to 30% of capital cost for such systems. Alternatively, there is an offer of soft loans at 5% interest rate subsidized by IREDA for these projects.

On the other hand, due to the deregulated price of petrol and diesel, there is a sharp increase in the price of diesel. These policies create a strong incentive for BTS operators to move to solar power.

Though government subsidies, lower interest rates on loans and the significant reduction in solar panel prices are encouraging, there are more challenges that need to be addressed including optimal solution design, seamless integration with other renewable energy.

4. PROPOSED MODEL

Firstly, the individual components of photovoltaic systems are modelled with mathematical expressions. Secondly, two criteria in terms of cost systems compared DG sets with SAVS and power reliability are investigated. Finally, PV solar power for telecom BTS in India is studied.

Optimum Design of PV system For BTS in Remote Areas:
In remote areas, where electric utility is not available, photovoltaic (PV) stand-alone system using storage batteries represents a good solution although it is costly. It is also possible to have a hybrid stand-alone system using diesel generators combined with PV system to supply BTS stations in remote areas. All BTS powered by 48V D.C. PV solar systems require two important units PV solar modules and batteries as back up at night. PV solar modules lifetime is 20-25 years. Although PV system long lifetime makes the choice of PV stand-alone system favourable for storage; the short lifetime of storage battery increases the cost. So economic solution may be hybrid of PV and diesel generator.

The location where batteries are stored should be designed to minimize fluctuations in battery temperature. For these applications, the design temperature is assured to be 25°C. The battery storage system is designed to improve the necessary electrical energy for a period equivalent to 7 days without any sunshine.

The maximum fraction of capacity that can be withdrawn from the battery as specified by the designer. For this application, the allowable depth of discharge is 0.8. The required battery capacity is calculated by first multiplying the total ampere-hour per day by the days of storage required and then dividing this number by the allowable depth of discharge limit. Total ampere-hour per day:

Total electrical load (BTS) = 4 KW
Total energy demand per day = 4KW X24 hours
Now, total ampere-hour per day = Total energy demand per day /battery bus voltage
= (4 KW X 24 hours) /50 V
= 1920 AH
Required battery capacity = (Total AH per day X Number of days for storage)/(Depth of discharge allowable)
= (1920 AH X 7)/0.8
= 16,800 AH

Once the required number of ampere-hours been determined, batteries or battery cells can be selected using manufacturer's information.

Excide 6E 120-13 industrial grade batteries were selected for this application because of their long cycle life and rugged construction.

From the Excide battery specification sheet, it is observed that Excide 6E 120-13's capacity is 808 ampere-hours for a 5 day rate.

Since, battery capacity may vary with the rate of discharge; the ampere-hour capacity that corresponds to the required days of storage should be used. The number of batteries or battery cells needed to provide the required battery capacity by the ampere-hour capacity of the selected battery.
For this application,
The number of batteries in parallel = (Required battery capacity)/(AH capacity of the selected battery)
= (16,800 AH)/(808 AH)
= 21 (round up from 20.79)
The number of batteries needed to provide the necessary D.C. system voltage is determined by dividing the battery bus-voltage by the selected battery or battery cell voltage (taken from manufacturer's information)
For this application,
Battery cell voltage = 12V
Battery bus voltage = 50V
Therefore, the number of batteries in series = 50/12 = 5 (rounded up from 4.16)
Multiplying the number batteries in parallel by the number of batteries in series determines the total number of batteries needed = 21 X 5 = 105
In addition, the total rated capacity of selected batteries is determined by multiplying the number of batteries in parallel by the ampere-hour capacity of the selected battery. i.e. 21X 808AH = 16,968 A-H.
Based on the selected batteries, the KWH is determined by first multiplying the total ampere-hour capacity by the battery bus voltage and then dividing this number by 1000.
= (16,968 AH X 50 Volt)/1000
= 848.4 kWh

PHOTOVOLTAIC ARRAY SIZING:
The array is sized to meet the average daily load requirement for the month or season of the year with the lowest ratio daily insulation to the daily load. Knowing the insulation available and the power output requirement, the array can be sized using module specifications supplied by manufactures. Using module power output and daily insulation (in peak sum hours), the energy (watt-hours or ampere-hours) delivered by PV module for an average day can be determined. Then, knowing the requirements of the load and the output of a single module, the array can be sized.

Let the design month be December:
To calculate the battery round trip efficiency a factor between 0. 70 to 0.85 is used to estimate battery round trip efficiency. For this application, 0.85 is used because the battery selected is relatively efficient and because a significant percentage of the energy is used during daylight hours.

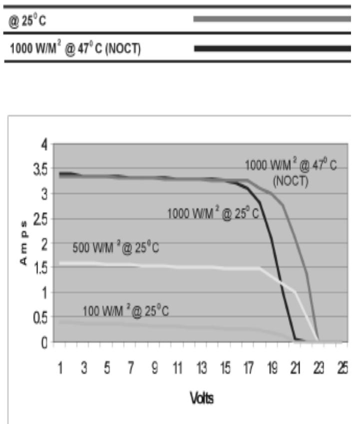
The watt-hours required by the load are adjusted (upwards) because batteries are less than 100% efficient. Dividing the total energy demand per day (A) by the battery round trip efficiency (B) gives the required array output per day. (A/B) = 96000Wh/0.85 = 112,941 watt-hours per day

To calculate the design operating voltage for each module and acceptable module output current, Siemens solar m55 modules are used.

Power Specifications*	
Model	M55
Power (typical +/- 10%)	53.0 Watts
Current (typical at load)	3.05 Amps
Voltage (typical at load)	17.4 Volts
Short Circuit Current (typical)	3.27 Amps
Oopen Circuit Voltage (typical)	2.18 Volts
Physical Characteristics	
Length	50.9 in/1293 mm
Width	13 in/330 mm
Depth	1.4 in/36 mm
Weight	12.6 lb/5.7 kg

*Power specifications are at standard test conditions of: 1000 W/M², 25° C cell temperature and spectrum of 1.5 air mass.

Performance Characteristics



The IV curve (current vs. Voltage) above demonstrates typical power response to various light levels at 25° C cell temperature, and at the NOCT (Normal Cell Operating Temperature), 47° C.

From the Siemens solar M55 modules specification, the maximum power voltage at STC = 17.4 Volts.
So, the desired operating voltage of each module = 17.4 X 0.85 (Depth of discharge allowable)
= 14.80 Volts
From the manufacturer's data sheet shows the nominal power output at 1000W/m2 and 25°C is 53.0 Watts.
Therefore, the guaranteed power output = 53.0 X 90% = 47.7
Peak sun hours for the proposed location in December is 3.8 hours. The amount of energy produced by the array per day during the worst month is determined by multiplying the selected PV power output at STC by the peak sun hours at design tilt = 47.7 X 3.8 = 181 Whr. Also, A de-rating factor 0.90 (for moderate climate and non- critical application) is used in this application to determine the module energy output at operating temperature. Multiplying the de-rating factor by the energy output module establishes an average energy out from one module = 0.90 X 181 Whr = 163 Whr. Again, Dividing the required output per day by the module energy output at operating temperature determines the number of modules required to meet the energy requirements = 1133 KWh/163 Whr = 113,000/163 = 693 modules. Dividing battery bus voltage by module design operating voltage 48 Volts/14.8 = 3.24 = 4 (round to next higher integer). Therefore, Number of strings in parallel = 693/4 = 173.25 = 174.
Number of modules to be purchased:- 174 X 4 = 696 modules. This rated module output in watts as stated by the manufacturers. PV modules are usual priced in terms of the rated module output. The Siemen solar M55's rated module power is 53. Finally, multiplying the number of modules to be purchased by nominal rated module output determines the nominal rated array output = 696 modules X 53 Watts = 36.888 Kw

5. CONCLUSION

Stand alone photo-voltaic system is recognized a viable solution to energies rural off- grid applications. In this paper, we have tried to summarize the optimal sizing of standalone PV system for a given telecom application (BTS), also, reviewing the mathematical model of a cell, a module and a PV array for a BTS load (D.C) located in remote and hilly area.

FUTURE SCOPE

The work discussed in this paper may be extended to BTS site at remote areas having A.C loads along with D.C loads by introducing a proper sized inverter. Furthermore, a hybrid system comprising a diesel- generator set with the existing stand-alone system may be a suggestion for better performance of the desired load.

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BIOGRAPHIES

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