Journal of
Electrical & Electronic Systems

Shaheen and Nawaz, J Electr Electron Syst 2016, 5:1
DOI: 10.4172/2332-0796.1000165

Case Report Open Access

Optimization and Cost Benefit Analysis of a Large PV Installation in Delhi

Shaheen H* and Nawaz I

Department of Mechanical Engineering, Jamia Millia Islamia, Delhi, India

Abstract

Acute power crisis in Delhi is stress on the people. Delhi dwellers suffer many problems due to power crisis. Dwellers spent a dark summer in Delhi. Apart from these problem the temperature in summer steadily rising to make their life harder. Presently Delhi has multiple problems, one is already discuss (acute electricity) and second that is storm, more than 10 tower and lines in different parts of the capital got damages. According to centre for science and environment (CSE) says that the domestic sector is the biggest guzzler of electricity in Delhi.

According to newly released report of the Central Electricity Authority (CEA) on load Generation Balance Report 2015-16, Delhi consumes more electricity than the states of others. The household electricity consumption per capita is about 43 units per month against a national average of 25 CEA project Delhi, speak will cross 6,300 MW this year and 12,000 MW by 2012.

While the Delhi govt. plan to reduce its dependence on the NTPC by producing its own power. There are an alternative sources of power generation in short, mid and long term basis. If solar panels be the alternative short term power source, then per unit production cost is a huge barrier in making this technology popular among the mass. But when the people installs roof top, ground solar power plant the cost of installation initially is high. The installation of roof top to get a new electricity connection power utilities. In such a situation, a solar energy rate has been proposed that will cover the solar electricity production cost, alternately called the cost recovery scheme. This rate is near about the maximum per unit rate of energy the government purchases from quick rental plants. Also, different types of solar modules have been compared. This can be a technical support for the city dwellers to who wants to buy solar panels.

Keywords: Solar panel; Battery efficiency; Economic impact; Emission; Environmentally friendly; Roof top photovoltaic; Tilt angle

Introduction

Delhi is situated in northern India with a land area of 1,484 with a population of 25,753,235. The second most populous city and second most populous urban agglomeration in India. The actual power requirement of Delhi is 29,231 MU but the availability of energy in Delhi 29,106 MU. So the deficit of energy is 0.4% [1,2].

Delhi is a state which suffering from significant energy poverty and pervasive electricity deficit. In recent years, Delhi's energy consumption has been increasing at a relative fast rate due to population growth, Metro and economic development. As per the estimates made in the Integrated Energy Policy Report of Planning Commission of India, 2006, if the country is to progress on the path of this sustained GDP growth rate during the next 25 years, it would imply quadrupling of its energy needs over 2003-04 levels with a six-fold increase in the requirement of electricity and a quadrupling in the requirement of crude oil. Delhi at this time suffering many problem such as transportation, pollution, water, residential problem and crime problem etc., (Table 1).

As per Figure 1, Delhi subjected to acute power so for this situation solar PV system is a better option to produce electricity for Delhi dwellers. In this research work, several proposals have been made to keep the PV energy price affordable to the city dwellers [3].

Technical as well as financial have been done on the installation of solar system on the roof-top of high rise building to produce electricity for different type of solar modules and comparing their result, the best one from them have been proposed. The production/installation of solar are high so that we have proposed a solar system that will cover a production cost of solar electricity. Although green energy is costlier compared to utility energy rate, it is not so compared to a small diesel generator frequently used during the time of load shedding [4-6].

Solar Power Calculation

A building has been selected in a highly dense populated area of Delhi city and a solar system is designed to be installed on the unused roof top and parking place. The total number of module used is calculated. The average output and price of the electricity generation by the solar is calculated [7,8].

Site area calculation

Available space area is calculated: The area available for installed a solar system has been calculated as follows:

Available open space for system = The area of stair rooms + Machine room + Meeting room +Parking place +Void area + South wall

Loss area = 5% of available open space, so that area can be calculated for installing solar panel = Available open space - Loose area

Our calculated area was 2787.1 m^2 and effective area of installation is 2,648 m^2.

Tilt angle calculation

When we adjust the tilt angle in such a way that it get the highest amount of solar radiation. So that panel efficiency is optimize. We can

***Corresponding author:** Shaheen H, Department of Mechanical Engineering, Jamia Millia Islamia, Delhi, India, Tel: 91-7417728627; E-mail: Shasan39@gmail.com

Received August 16, 2015; **Accepted** December 30, 2015; **Published** January 01, 2016

Citation: Shaheen H, Nawaz I (2016) Optimization and Cost Benefit Analysis of a Large PV Installation in Delhi. J Electr Electron Syst 5: 165. doi:10.4172/2332-0796.1000165

Delhi	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	2014-15
Peak Demand(MW)	4418	5358	5533	6006	5589	4882	4570	3408	4271	4405	3847	3589	6006
Peak Availability(MW)	4418	5338	5533	5925	5507	4882	4570	3408	4271	4405	3847	3589	5925
Surplus(+)/Deficit(-) (MW)	0	-20	0	-81	-82	0	0	0	0	0	0	0	-81
(%)	0.0	-0.4	0.0	-1.3	-1.5	0.0	-1.8	0.0	-0.1	0.0	0.0	0.0	-1.3

Table 1: Month-wise power supply position of Delhi during the year 2014-15(in terms of peak demand).

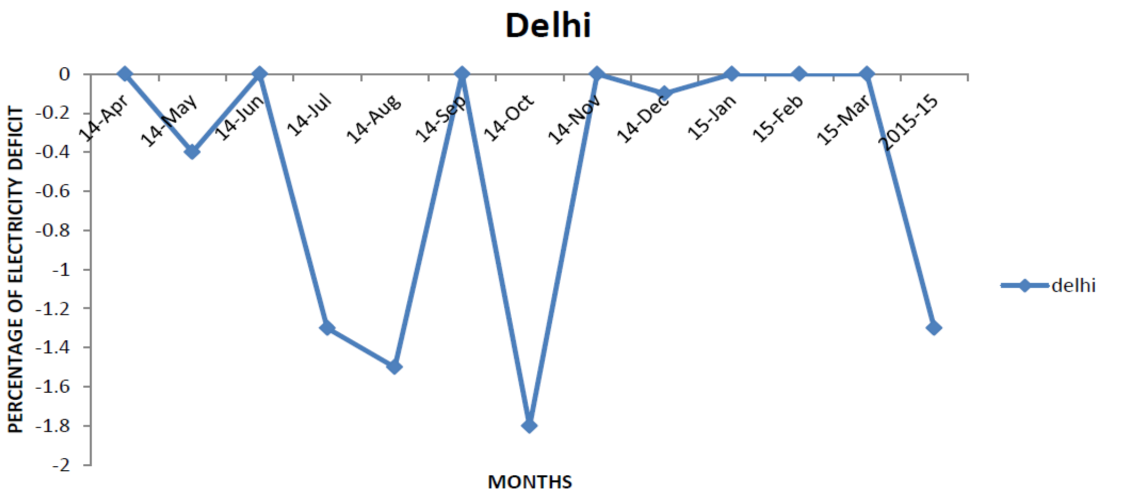

Figure 1: Shows Electricity Reduction in Delhi.

adjust the tilt angle as per requirement or each seasonal. But is a very complicated and costly process. So to reduce this problem we adjust the fix angle to get most energy the whole year. Formula [2] can be used for calculating the tilt angle,

$$\beta = 0.76 \times \phi + 3.1^{o} \quad (1)$$

Where ϕ = geographic latitude (Delhi is situated). So the optimum tilt angle for this region is

$$\beta = 0.76 \times 28.38^{o} + 3.1 = 24.67^{o}$$

Row distance calculation

One of the boundary conditions for the installation and performance of PV modules is to determine the correct distance between two consecutive arrays. To avoid excessive shadowing, the arrays have to be spaced apart by a distance, d in relation to the module width, a [2]:

$$d/a = \cos\beta + \sin\beta/\tan\varepsilon \quad (2)$$

$$\text{and, } \varepsilon = 90^{o} - \delta - \phi \quad (3)$$

Where, ε = shadowing angle, and δ = ecliptic angle = 23.5° [4].

From eq. (1), (2) and (3), ε = 41.8°

Determining the total load of building

Design solar photovoltaic system

SPV design in a 3 steps

Step 1: Load Estimate, power, converter Rating, system voltage decision.

The available area for install the solar system in the building is 2,648 m^2 (Figure 2 and Table 2).

Total load =503.36 Kw

Assume we take 4 hr, energy supplied.

Load in kWh= 503.36 × 4 = 2013.44 kWh

Note: Total number of load does not run continuous, if we take 70% use load. This term 70% is called load factor.

Actual load = 2013.44 kWh × 0.7 = 1409.408 kWh.

Energy supplied to the Inverter every day

The available efficiency of the inverter is in the range of 0.90 to 0.97%. If we choose the inverter efficiency 0.94%, then the energy supplied to the input end of the inverter should be adjust accordingly.

Input energy of the inverter = 1409.408 kWh/0.94

=1499.37 kWh.

System voltage determination: The photo voltaic output voltage is specified as 15-16 V at standard conditions, actual voltage at operationing conditions and after all other voltage drops becomes 12 V. Therefore, we say solar panels are available for 12 V and in multiplies of 12, (12 V, 24 V, 36 V, 48 V etc.,). I study on for all 4 cases of voltage: 12 V, 24 V, 36 V, 48 V.

Steps 2: Sizing the batteries:

How many batteries and what A-hr. capacity, we have to consider battery parameters like,

- Depth of Discharge (DOD)
- Operating voltage of battery and it‟s A-hr. capacity
- Number of day of autonomy (how many cloudy days without sunshine you want to consider may be 2,3,4) Normally batteries with

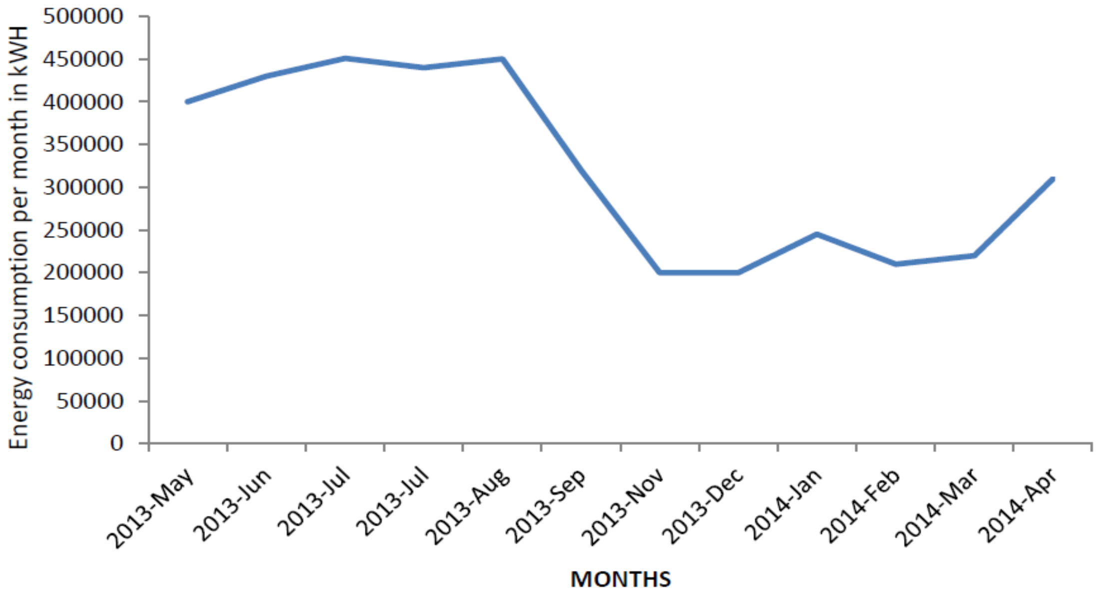

Figure 2: Energy consumption.

No.of equipment	W(Watt)	%
5 PAC (packed air condition)	289.5(TR)	57.5
82 lighting (CFL/LED/Tube light)	40.5	8.04
971 Celling fans	72.833	14.46
50 Chiller	37.5	7.49
50 Water pump	18.75	3.72
20 Exhaust fan	15	2.97
20 Fridge (310 Ltrs)	7.98	1.58
23 Fridge (165 Ltrs)	2.3	0.456
50 Computer	15	2.98
35 Monitors	3.2	0.695
20 Printer	0.5	0.0993
Total	503.36	100%

Table 2: Total load The available area for install the solar system in the building is 2,648m^2.

DOD 60-80% are available for the PV system. Batteries are available for 12 V and different A-hr., 50 A-hr., 100 A-hr., 150 A-hr., etc. for my calculation I choose 12 V - 150 A-H-hr. batteries.

If we take DOD value as 0.7

Required charge capacity= 1499.37 kWh/12 V=124,947.5 A-hr. (For 12 V) (4)

No of batteries required =124,947/150 0.7=1190

- For 3 days autonomy (no sunshine):
- No. of batteries =1190 × 3 = 3570

Required charge capacity =1499370 W-hr. / 24 V = 62,473.75 A-hr. (For…24 V) (5)

- No. of batteries required = 62,473.75 A-hr. / 150 × 0.7 = 595 batteries
- Actual no. of batteries required (as battery voltage is 12 V) =1190 batteries
- For 3 days autonomy

No. of batteries = 1190 × 3 = 3570

Required charge capacity =1499370 W-hr. / 36 V= 31,236.875 A-hr. (For 36 V) (6)

No. of batteries required 31,236.875 / 150 × 0.7 = 397 batteries

Actual no. of batteries required (As battery voltage is 36 V) = 397 × 3 = 1191 batteries.

For 3 days autonomy:

No. of batteries = 1191 × 3 = 3573

Required charge capacity = 1499370 W-hr. / 48 V = 31,236.875 A-hr. (For 48 V) (7)

No. of batteries required =31,236.875 / 150 × 0.7 = 298 batteries

Actual no. of batteries required (as batteries voltage is 12 V) = 1190 batteries

For 3 days autonomy (no sunshine):1190 × 3 = 3570

Steps 3: Sizing the solar array

The panel with specification 220 W, at 16 V standard conditions. This panel produce 220/16 = 13.75 Amps.

Actual operating conditions of these solar panels are: 12 V, 13.5 Amps.

The PV panels are connected to the battery. The efficiency of the battery depends on the type of the battery; normally 0.80-0.90.

We take battery efficiency as 0.85. And the efficiency of the controller circuit (of the battery as 0.90).

Then the solar array has to generate = 1499370 = W-hr./0.85; 0.90=1,959,960 W-hr. every day.

Again, we will calculated for 4 option of system voltage: 12 V, 24 V, 36 V and 48 V

If the array voltage is 12 V, it needs to generated 1959.960 kWh/12 V=163,330 A-hr.

Assuming good sunshine of 6 hr. most of the days, the solar array has to generate:

163,330 A-hr. / 6 hr = 27,221.67 Amps.

27,221 Amps / 13.75 Amps = 1980 solar panel (as each produces 13.75 Amps.)

For 12 V PV system No. of panels required =1980

For 12 V PV system No. of batteries required = 3570

If the array voltage is 24 V (two panels connected in series),

It needs to generated 1,959,960 W-hr. / 24 V = 81665 A-hr.

Assuming good sunshine of 6 hr. most of the days, the solar array has to generate;

81665 A-hr 8/ 6 hr. =13610.8 Amps.

13610.8 Amps / 13.75 = 990 solar panels (as each produces 13.75 Amps.)

For 24 V PV system No. of panels required = 990 × 2 = 1980.

For 24 V PV system No. of batteries required = 3570

If array voltage is 36 V (three panels connected in series connection),

It needs to generated 1,959,960 W-hr. / 36 V = 54,443 A-hr.

Assuming good voltage of 6 hr. most of the days, the solar array has to generate;

54,443 A-hr / 6 hr. = 9,074 Amps

9,074 Amps / 13.75 Amps = 660 solar panels (as each produces 13.75 Amps.)

For 36 V PV system No. of panels required = 660 × 3 = 1980

For 36 V PV system No. of batteries required = 3573

If the array voltage is 48 V (four panels connected in series)

It needs to generate 1,959,960 W-hr. / 48 V = 40,832.25 A-hr.

Assuming good voltage of 6 hr. most of the days, the solar array has to generate:

40,832.5 A-hr / 6 hr = 6,805.4 Amps

6,805 Amps / 13.75 Amps = 495 solar panels (as each produces 13.75 Amps.)

For 48 V PV system no of panels required = 495 × 4 = 1980

For 48 V PV system no. of batteries required = 3570

Solar panel area required for this load

Area of each panel 4.5 × 2 = 9

1980 × 9 = 17820

The best design in the study chosen is SPV system with 12 V 220 Watt solar panel and 3570 No. of 12 V -150 A-hr. batteries.

Solar panel system

Specification

- Peak power generation per panel; 220 Wp

Types of Solar Panel	η (%)	Average Output(kW)	Annual Energy Production(kWh)
Monocrystalline	15.6	6.112	26,747
Polycrystalline	13.5	5.501	24,072
Thin Film	11.1	4.676	20,461

Table 3: Calculated Efficiencies and Average Output Power for Different Types of Solar Panels.

- Number of panel needs 1980
- Dimension of each panel: 2 feet feet
- Life 25 years
- % degradation every 10 yr.: 8-9%

Batteries

Specifications

- Total capacity: 12 V – 100 Ah
- Number of batteries: 3570
- Life: 6-7 years
- Warranty; 5 years with 8 years maintenance contract
- Cost: 27-41%

7. Inverter

Specifications

- Sine wave in inverter 0.9 kW
- Cost 50%

Conclusion

By the calculation and study of SPV (solar photovoltaic system) in building we find that we reduce the power load which take from any other energy resources and use renewable and non-polluted energy (Table 3). It is available in an abundantly amount. By using solar system we consumed an environmental and eco –friendly energy. As per we know that in a Delhi no hydraulic system and geo- thermal system and thermal energy produce a more quantity of carbon dioxide, hydrogen sulphide, and other component of nitrogen oxide. We already know that Delhi is a high dense city so electricity consumption in a Delhi is high and Government does not fulfil criteria of energy demand. So it is very important to initiate the renewable energy used. So by study of solar photovoltaic system we conclude that installing charge of SPV is high and it is not available 24 hr so by using batteries we use this energy in autonomy day and in the night. In SPV field more research is necessary which reduce the starting cost of SPV. When cost is reduced then it is a very useful because it is more in quantity. It is easily available and environmental friendly. It is not harmful for worker and human. It does not smoke and not required any extra site. It installed in roof, open area car parking, etc.,

Reference

1. Roy P, Arafat Y, Upama MB, Hoque A (2012) Technical and Financial Aspects of Solar PV System for City Dwellers of Bangladesh Where Green Energy Installation is Mandatory to Get Utility Power Supply, 7th International Conference on Electrical and Computer Engineering, Bangladesh.
2. Berger AG, Hoffmann V (2005) Photovoltaic Solar Energy Generation, Springer-Verlag Berlin Germany.
3. Aki H (2007) The penetration of micro CHP in residential dwellings in Japan, in Proc. IEEE-PES Gen. Meet: 1-4.

4. Nyeng P, Østergaard J (2011) Information and communications systems for control-by-price of distributed energy resources and flexible demand, IEEE Trans. Smart Grid 2: 334-341.

5. (2011) Electro Solar Power Ltd. website on PV Module.

6. (2011) HOMER, Software for Micro Power Optimization Modeling.

7. (2011) The GREENZU homepage on Solar Inverter.

8. Aziz S, Chowdhury SA, Al-Hammad H (2009) Marketing and Financing of Solar Home Systems in Bangladesh: Assessment of Success, International Conference on the developments in Renewable Energy (ICDRET): 34-37.