Cost Benefit Analysis of 10kW off Grid Solar Power Plant

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Abstract— The demand for energy is increasing day by day globally. To overcome the problem of energy scarcity solar energy promises to be the best solution without significant increase of the carbon footprint of the atmosphere. The sun emits more than 10,000 times energy than it is required on the earth to fulfill the needs the solar energy has many applications for heating up water to generate electricity .in this study the use photovoltaic systems will be investigated for powering a domestic / commercial load of 10kw. The components design and installing of a solar photovoltaic system is influenced by the electrical equipment to be powered different equipment requires different voltage current and power these variables ultimately determine the design and the choice of the other components of the system. In this study the advantages and disadvantages of using solar photovoltaic will be explored. Generally the major advantages of using renewable energy are to reduce annual energy costs reduced environmental impact since renewable energy technologies usually produce little to no pollutants during their operation and increased sustainability as a result of fewer pollutants.

Keywords: Solar Power Plant, Photovoltaic, Generation, Cost

I. INTRODUCTION

India is one of the countries with the largest production of energy from renewable sources. As of 2019, 35% of India's installed electricity generation capacity is from renewable sources, generating 17% of total electricity in the country. The country is aiming for even more ambitious target of 57% of the total electricity capacity from renewable sources by 2027. According to 2027 blueprint, India aims to have 275 GW from renewable energy, 72 GW of hydroelectricity, 15 GW of nuclear energy and nearly 100 GW from "other zero emission" sources.In the quarter ending September 2019, India's total renewable electricity capacity (including large hydro) was 130.68 GW. This represents 35.7% of the total installed electricity generation capacity in the country, which is around 366 GW. As of October 2019, of the 175 GW interim target, 83 GW is already operational, 29 is under installation, 30 GW is under bidding, and remaining 43 GW is under planning.175 GW interim target is 100 GW of solar, 60 GW of wind, 10 GW of bio mass and 5 GW of small hydro. As of 2019, 35% total power production comes from renewable energy, 13% or 45.399 GW of the total fromall sources comes from large hydro projects,10% or 36,686.82 GW of the total from all sources from wind power which is fourth-largest in the world, 8% or 9.1 GW of total power from all sources from Biomass power from biomass combustion, biomass gasification and bagasse cogeneration. India was the first country in the world to set up a ministry of non-conventional energy resources, Ministry of New and Renewable (MNRE), In the early 1980's and its public sector undertakings the Solar Energy Corporation of India is responsible for the development of solar energy industry in India.

Hydroelectricity is administered separately by the ministry of power and not included in MNRE targets.

II. SYSTEM MODEL

A. *Solar PV module/Solar Panel:*

The term solar panel is used normally for a photo-voltaic (PV) module. A PV module is an assembly of photo-voltaic cells mounted in a frame work for installation. PV cells use sunlight as a source of energy and generate direct current electricity. A collection of PV modules is called a PV panel and a system of panels is called an array. These are high efficiency mono-crystalline solar cells. Standard solar panel price list is shown in Table 1

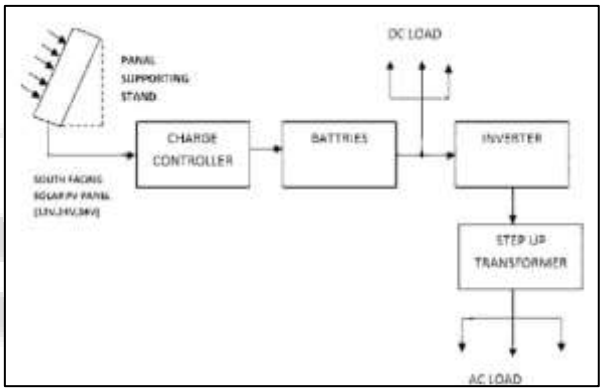

Fig. 1: Photovoltaic Power Generation

Model	Price(Rs)	Per watt(Rs)
Solar Panel 100 Watt	3300	33
Solar Panel 150 Watt	4950	33
Solar Panel 250 Watt	8000	32
Solar Panel 270 Watt	8640	32
Solar Panel 315 Watt	8112	26
Solar Panel 320 Watt	8320	26
Solar Panel 330 Watt	8580	26

Table 1: Solar Panel Price List

B. *Power Conditioning Unit/Inverter*

A solar inverter is a type of electrical converter which converts the DC (direct current) into a utility frequency AC (alternating current).It is very important part of as shown in Table

Model	VOLT/PHASE	Price
500VA Solar Inverter	12 V/1 Phase	3,500
850VA Solar Inverter	12 V/1 Phase	4,900
1100VA Solar Inverter	12 V/1 Phase	6,000
1500VA Solar Inverter	24 V/1 Phase	7,000
2KVA Solar Inverter	24 V/1 Phase	11,000
3.5KVA Solar Inverter	48 V/1 Phase	21,000
5.5KVA Solar Inverter	96 V/1 Phase	45,000

7.5KVA Solar Inverter	120 V/1 Phase	59,000
10KVA Solar Inverter	120 V/1 Phase	85,000

Table 2: Off-Grid Solar Inverter Price List

C. Cables:

All cables have been designed to minimize losses and ensure optimal operation at high temperatures. Specifications of the cable are:

Parameters	Specifications
Type	XLPE/PVC-Armored & Unarmored
Material	Copper / Aluminum
Standard	IS 5831
Conductor class	IEC 60228 class5
Short circuit temperature	250 C
Protection	IP 65

Table 3: Specifications of the cable

D. Array Junction Box:

Combined boxes are usually used on both DC and AC side of PV power plant. The specification is shown in Table 4.4

Combined boxes	Specification
Material	Thermoplastic/ Metal sheet
Type	Dust, Vermin and water proof
Hardware	SS304
Cable gland	Thermoplastic
Protection	IP 65

Table 4: Specifications of Array Junction Box

E. Battery

Solar batteries are designed for used in solar systems are built to last longer Lead acid batteries are mainly used as an energy storage for solar battery banks. Solar batteries are rated according to their voltage, ampere hours (AH). Solar batteries are specially designed for optimum performance, very long life, high reliability.

Capacity	Model	Weight (Kg)	Price (Rs)
Solar Battery 20 AH	12v/20Ah	15	2,700
Solar Battery 40 AH	12v/40Ah	26	3,600
Solar Battery 75 AH	12v/75Ah	38	5,900
Solar Battery 80 AH	12v/80Ah	41	6,300
Solar Battery 100 AH	12v/100Ah	56	7,800
Solar Battery 120 AH	12v/120Ah	61	8,700
Solar Battery 150 AH	12v/150Ah	65	11,750
Solar Battery 200 AH	12v/200Ah	73	12,750

Table 5: Solar Battery Price List

Cost analysis for 10 KW off-Grid Solar PV Roof-Top System
The cost on the 10 KW off grid with solar PV rooftop system is calculated as follows:-

F. Solar PV panel cost:

Cost of 330 W rooftop solar PV panel =Rs. 8580/-
Number of solar PV panels required = 30
Cost of 10 KW rooftop solar PV panels =
Rs. 8580/- * 30(nos.) = Rs. 2,57,400/-
Cost of Off-Grid Solar Inverter Voltage per phase=120 V
Size of inverter= 10 KVA …… (1.1)
From (1.1)
Total cost for 3 phase inverter= Rs. 85,000/- …..(1.2)

G. Cost of Solar Battery:

Capacity of battery = 200AH
Model of battery = 12 V/ 200 AH
Total battery cost for 12 V/ 200 AH= Rs 12,750…. (2.1)
Number of batteries required for 120 V, 10 KVA inverter
=10 * 12V= 10 …..(2.2)
From 2.1 and 2.2
Total cost for battery set up
= Rs12750/- * 10(nos.)= Rs. 1,27,500/- (2.3)

H. Cost of Solar Roof-Top System without auxiliary:

Cost of 10 kw rooftop solar PV panels = Rs 2,57,400/-
Total cost for 3 phase inverter = Rs 85,000/-
From (2.1)
Total cost for battery set up=Rs. 12750/-*10(nos.)
= Rs 1,27,500/- …..(3.1)

I. Overall cost of solar roof-top system without auxiliary: = Rs 4,69,900/- …….(4.1)

Cost of auxiliary components used in off-grid solar roof-top power plant
Costs of wires, fuses, switches @ 20% of overall cost = Rs 4,69,900/-*0.2 =Rs 93,980/- .....(4.2)
From (4.1) and (4.2)
Net cost of whole setup with auxiliary cost = Rs 4,69,900/- + Rs 93,980/- =Rs 5,63,880/- .....(4.3)

S. No	Particulars	Description	Cost (Rs)
1.	Solar Panel in Watt	330 W	8580/-
2.	Solar Panels	30 nos.	-
3.	Cost of Solar PV Panels	10 KW	2,57,400/-
4.	Off Grid Solar Inverter	10 KVA/120V	85,000/-
5.	Solar Battery	10 No.s (200 AH/12V)	1,27,500/-
6.	Auxilliary components	Junction Box, DC &AC Cables, Fasteners ,Crimping Tool,Earthing Kit, L.A	93,980/-
7.	Space req.	1000 sq feet	-
8.	Total Cost	10 KW Off-Grid Solar System	5,63,880/-

Note: No Subsidy is offered by govt. on Off Grid Solar Power System.

Table 6: Summary of Specifications/Calculations for 10 KWoff-grid roof-top solar system

Recommended Load	Load	Back-up Time
* 8 LED Lights + 8 Fans + 2 A.C (2 ton) + Fridge+ 1 TV + Washing Machine + 1 Cooler	8000 watt	6 Hours
* 12 LED Lights + 6 Fans + 2 AC (2 ton) + Cooler+ Fridge+ 1 TV	6000 watt	8 Hours
* 12 LEDs + 10 Fans + Fridge+ 1 TV+ Washing Machine +1 Cooler	3000 watt	12 Hours

Table 7: Recommended load on 10 kw off-grid solar system

J. Generation per month

Rating of PV=10 kW ..... (5.1)

Generation per day (on an average)= 40 units ..... (5.2)

From (5.2)

Generation per month = 40*30 = 1200units ..... (5.3)

Generation per year = 1200*12=14400 units ..... (5.4)

K. Total annual cost saving after installation of PV system

Average monthly saving on energy bill = 1200(units)*7 (avg. unit cost) =Rs.8400/- ..... (6.1)

Average annual saving on energy bill = Rs.8400 * 12 = Rs.100,800/- ..... (6.2)

L. Pay-back period calculation

Pay –back period =A/B ..... (7.1)

Where A= total cost of PV system with all auxiliary equipment.

From (6.1)

B=total annual cost saving after installation of PV system.

From (7.1)

Pay-back period= Rs.5,63880/- Rs.100,800 = 5.6 (Appx. 5 years 6 months) ..... (7.2)

III. Result and Discussion

Estimation of cost analysis for 10KW off- grid connected solar rooftop power plant has been done in Chapter 4. Net results are summarized below:-

- Cost of 10 kw rooftop solar PV panels = Rs 8580/- *30(nos.) = Rs 2,57,400/
- Total cost for 3 phase inverter = Rs 85,000/-
- Total cost for battery set up = Rs12750/-*10(nos.) = Rs 1,27,500/-
- Overall cost of solar roof-top system without auxillary = Rs 4,69,900/-
- Costs of wires, fuses, switches @ 20% of overall cost = Rs(4,69,900*0.2)/- =Rs 93,980/-
- Net cost of whole setup with auxiliary cost = Rs(4,69,900 + 93,980)/- =Rs 5,63,880/-
- Generation per day (on an average) =40 units
- Generation per month =40*30= 1200units
- Generation per year = 1200*12=14400 units
- Average monthly saving on energy bill = 1200(units) * 7 (avg. unit cost) =Rs 8400/-
- Average annual saving on energy bill = Rs 8400 * 12 = Rs 100,800/-
- Pay –back period= Rs 5,63,880/ Rs 100,800 = 5.6 (Appx. 5 years 6 months)

IV. Conclusions

The cost-benefit analysis for 10 KW off- grid connected solar roof top power plant is based on the area of installation and the system is capable of supplying power to load during day and night time. After installation of system consuming electricity cost is reduced. However battery backup, provides supply to night and cloud time. Shade free roof-top required is around 1000 sq. m. It is concluded that overall cost for 10 KW Off-Grid Roof-Top Solar PV system is Rs. 5,63,880/- and pay-back period is around 5 years 6 months. The cost-benefit analysis has been done for 10 KW Off-Grid Solar PV System. It can be used to large scale solar PV roof top power plants in future.

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