A Study of Financial Feasibility of Solar Photovoltaic System (SPV): An Investment Analysis Approach

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ABSTRACT

At present, energy sector in India mostly depends on non-renewable energy sources, which generates a considerable amount of carbon footprint. Global warming, environment change and sustainable growth step up the expansion of higher technologies for alternative energy in present scenario. Solar Photo-Voltaic (SPV) became a majorchoice to shift towards carbon free energy supply and it will be emerged as an attractive source of electricity in due course. This paper delves the generated solar energy production by the photovoltaic cells of multi crystalline solar photovoltaic module, used in the campus of department of electrical, CTAE, Udaipur. Various other technical requirements attracting investment includes Rooftop Solar PV Plant or PV modules (panels), mounting structures, batteries, net meter, cables, solar grid inverter and other accessories.

The study discusses a methodology of estimation of various parameters of energy requirement and consumption using SPV. It also attempts to understand its financial feasibility using approach of investment analysis. The paper is an effort for development of an approach for estimation of financial impact on huge investment to be done in SPVs in non-commercial undertakings like Universities which may be helpful in contributing energy consumption but also to provide technical education to the students.

Keywords: Solar Photovoltaic, Capacity Utilization Factor, Photovoltaic Grid, Payback Period

INTRODUCTION TO SOLAR POWER

Solar power is one of the easiest, cleanest and most unswerving forms of renewable power existing in present context. It can be used in numerous forms to supply power at various location of business. Panels of solar-powered photovoltaic (SPV) normally convert the sun's energy into electricity by rousing electrons in silicon cells using the photons transfer mechanism. Solar power is the conversion ofenergy from sunlight into electricity, either by using photovoltaic or circuitously using concentrated solar power. Concentrated solar power systems comprise with lenses by focusing a huge area of sunlight into a small beam. Initially SPV used as common source of electricity for small and medium size projects but in 1980, first saleable concentrated solar power system came in existence Solanki, S.C. (2011).

In India, development of solar power is at nascent stage and increasing by leaps and bounces due to various reasons which include limited non-renewable energy assets, environmental & social impacts, high energy consumption and augmented level of greenhouse gases. Solar photovoltaic system is budding as a significant option due to availability of huge solar resource with least maintenance costs in general. The Government of India has recently uttered its plan to attain 100 GW of solar competency in the nation by 2020 and 40 GW is anticipated to be accomplished by solar power projects. Presently, the cost of solar power system has come down due to various subsidies and schemes offered by the government of India, resulting grid-connected SPVsystemshas become hot especially in sunlight areas of most of the country. Large solar powerstations withhundredsof Megawatts have already installed at various commercial and domestic locations. Due low-carbon emission technology it has emerged as first choice of energy generation tool throughout the India.Various international energy agencies estimated that solar power would contribute about up to 16

percent energy generation in the world by 2050 and soon it will become world fascinating choice of energy. Moreover, solar energy supplied only one percent of worldwide electric energy production and growing at the rate of 33 percent per annum, Fraas and Partain (2010).

Photovoltaic Grid System

A grid-connected PV system consists of solar panels, inverters and mounting structure. They are freely available not only for small residential but also fulfill the requirement of commercial rooftop solar plants. Usually grid-connected SPV system does not includes integrated battery system that is why when conditions are favorable, the system supplies the excess power generated to the utility gird of government and vice-versa.India may face severe electricity scarcity in the near future due to high consumption of power supply. India is expected to require a sustainable growth rate range 8-10 percent over the next twenty years to meet its energy requirement. India receives around 250-300 days of solar energy therefore there will be huge possibilities for generating solar power by utilizing rooftops of government, commercial and domestic premises. So there is need of dissemination of both off grid and on grid design solution to meet its future requirements Baghernejad and Yaghoubi (2011).

Doctrine of Photovoltaic Power System

Solar cell is prepared of the semiconductor manufacturing process. Solar cell absorbs the photon energy when they are exposed of the sunlight and converts energy to electrical energy. This power banter takes place through the photon energy which is transformed into a pair of free electron. Further generated electron and holes split and transmit to the utility via a conductive standard. There are two ways of implanting Solar PV: "Grid Connected" and "Off Grid". In an "Off Grid" system, PV system is completely independent and is disconnected from electricity supply (or electricity distribution company), but in a "Grid Connected" system, PV system is connected to electricity supply or utility grid (or electricity distribution company).

The main difference between the two is storage. In an "Off Grid" system, there is need of batteries to store electricity. But in a "Grid Connected" system, it does not require batteries because whatever electricity is produced through the system; it can be transferred or sold to electricity distribution company (or electricity-supply company). Batteries are a big cost component in the "Off Grid" system which makes the latter expensive Patel, R. A, (2006).

REVIEW OF LITERATURE

Maheshwari, H., & Jain, K. (2017) outlined the financial feasibility of SPV installed at IIT, Roorkee, India. They studied payback period, discounted rate of return and net cumulative cash flow from the system along with computation of carbon credit. The system produced 32, 86, 605 k Wh electricity in a year with 20.6 percent capacity utilization factor. According to CERC (2013) the total project cost of solar PV system includes PV modules cost (40.9%), land cost (2.1%), additional module cost (1.2%), civil and general works(11.9%), mounting structures (13.2%), power conditioning units (7.5%), evacuation cost (13.2%) and preliminary& pre-operativeexpensescost(10%).Themajorassistanceofallowingtherightofuse to one's rooftop would generate a source of returns in prospect to the owner. The average rental value varies in different locations.

Patel, (2006) studied that the separate solar power technology is a first-rate explanation for remote areas where utilities amenities are not economical to runto install owed to higher installation. Similarly, Engine, (2013) found that separate structure can be further classified into common direct current application bus or common alternative current device. Erratic character of renewable resources can be somewhat overcome by integration of the various resources into most favorable mishmash so as to make the system becomes more consistent. The potency of one alternative can overcome the disadvantage of the other source during a given period of time

Dalwadi et al. (2011) propounded that the conservative method for controlling the whole hybrid power system. There was a power electronics converter which is used for utmost energy take out from solar power system and wind power possessions as well. Moreover, new controlling techniques help to remove the power fluctuations which are generally caused by the unpredictability of the renewable power resource.

ECREHSB, (2007) studied that PV modules provide reliable but dependent energy at the point of use because its uses depend upon sufficient exposure of sunlight. In the form of rooftop solar PV system, it is increasingly being used in offices, colleges and homes for electricity to replace utility power line of government. PV cells,

in panels, convert free daylight into electricity, but they are expensive to install and can take many years to achieve payback. PV is definitely cost saving power source with low maintenance especially in remote areas where grid connection is costly. The several benefits of SPV system are: no fuel requirements, modular design, reliability of PV modules, easy to maintain, long life, national economic benefits, environmentally benign REIHRD (2011).

RESEARCH METHODOLOGY

This study presents a reliable methodology to analyze the energy generation from solar PV system and process to grid. The outcome shows vital information to select the SPV system for particular College of Engineering and Technology, Udaipur. Calculated power output is framed with the monthly generation for the whole year from installed power plants. The study comprises of literature review, stakeholder consultation and followed by financial analysis of the system in general. Primary and secondary data collected from the College of Engineering and Technology i.e. how much electricity is required and how much is generated from the installed panel for given period of time and finally cost analysis has also been done in the study. Sample unit is department of electrical whereas sampling method is convenience.

OBJECTIVE

To study of financial feasibility of solar photovoltaic power system with an investment analysis approach.

DATA ANALYSIS AND INTERPRETATION

Technical Requirement of 100kW System:

Each Grid-Connected Solar Photovoltaic System will have following ranges:

Table 1: Technical Requirement of 100kW System

Particular	Capacity
Photovoltaic Module	100 Kw
Module capacity	250 kwp
Number of Panels	400 nos.
Solar PCU (Inverter)	100 KW
Area	600-1000 sq mtr

Sources: www.aliensolar.com

Average Output Generation:
- 400 Units per day
- 12000 Units per month
- 144000 Units per year.

Price: Rs. 49, 99,000 (+ GST 5%)

Instruments require for grid connected SPV are as follows:
- SPV array
- GI support structure
- Grid connected inverter
- Net meter
- Some protection device and cables

Financial Feasibility of Solar PhotovoltaicSystem

The cost of rooftop solar system depends on the system size (1 kW, 25 kW, 100 kW etc), system type (on-grid, off-grid, hybrid etc), autonomy needed (1 Hr, 4 Hr, 24 Hr etc), location and also on the quality of the products and services.

On-Grid Rooftop Solar System

Where to Use: Power cut is less than 2 Hr a day on average, peak load is 5 kVA or more, want to reduce electricity bill. It is suitable for residential, commercial and industrial purpose where the electricity consumption is above 500 Units (kWh) per month.

Table 2: Cost of on-Grid Rooftop Solar System

System Size	System Cost	Cost/Watt
1 kW	Rs 82,000	Rs 82
5 kW	Rs 3,85,000	Rs 77
10 kW	Rs 6,20,000	Rs 62
15 kW	Rs 9,00,000	Rs 60
20 kW	Rs 12,20,000	Rs 61
25 kW	Rs 14,50,000	Rs 58
50 kW	Rs 26,50,000	Rs 53
100 kW	Rs 50,00,000	Rs 50
250 kW	Rs 1,25,00,000	Rs 50
500 kW	Rs 2,40,00,000	Rs 48
1000 kW	Rs 4,60,00,000	Rs 46

Sources: www.aliensolar.com

The department of electrical at CTAE connected with regular grid electricity. Approximate average electricity consumption of the department is 1, 05,000 kWh p.a.

The most efficient solar technologyisrooftop solarplant becauseitis easy touse at groundlevelland or roofforinstallation. Therefore, fixedsolarPVgridconnected systemwithouttrackinghasusedintherooftopsof thecampus.Thetotalnumber of modules is 370 having a total capacity of 92.50 KWp (table3).

Table 3: PV Modules Installed on Different Buildings in CTAE

S. No.	Roof of Different Building Blocks	Capacity (Wp)	Quantity	Total (kWp)
1.	Department of Electrical	250	370	92.50

Sources: CTAE

Table 4 outlines the components and data used description of each solar module installed in the campus. Whereas figure 4 below give a view of actual location of the module or PV system which has been installed on the roof of department of electrical, CTAE.

Table 4: Details of a PV Module

S. N	Components	Data Used
1	System type	Solar Photovoltaic Grid connect System
2	Type of module	Multi Crystalline silicon solar photovoltaic module
3	Module size (L*W*H)	1667 mm *1000 mm * 30 mm
4	Series Cells (No's)	60
5	Module efficiency (%)	13.8
6	Single solar panel output	250Wp
7	Solar Array capacity	100 kWp(0.100MW)
8	Life Span	25 years

Sources: Department of renewable energy engineering, CTAE

Amount of Actual Energy Generation

The net installed capacity is planned to be 92.5 kWp (0.0925MW) but this is only a yardstick and cannot be measured as the authentic output for a given location. The actual energy generation from the installed SPV depends upon various factors. If talk about external factors which are not controllable includes quality of air mass, availability of sunny days, solar radiation, day temperatures etc. The reasons which are within the control of a solar developer that includes plant location, panel efficiency, orientation of the roof, quality of installed equipment and operational and maintenance activities (http://www.solarmango.com/faq/5; Mukherjee & Ghosh, 2009).

Solar energy generation can be calculated in the campus based on a module which is having 60 cells of each size 1667 mm × 1000 mm. The module efficiency is 13.80% with a life span of 25 years.

The output power is as follows:

Taking into consideration, the area of the module having 60 cells = 1667 mm × 1000 mm = 1.667m2. The average solar radiation in the campus is 6.02 kWh/ m2 in a day.

Power output = Efficiency × average rate of solar radiation × area

= 0.138 × 6.02 × 1.667 kWh/day

= 1.385 kWh/day

If 300 clear days are there in a year, the energy production is 1.385 × 300 kWh/year = 415.50 kWh/year

Total no of modules = 370 (Table 3)

Total power production in a year = 370 × 415.50 kWh/year

= 153735kWh / year

= 153.735MWh / year

During twenty five years, the power output of the module = 25 × 415.50 kWh

= 10387.50kWh

= 10.3875MWh

Capacity Utilization Factor

To know the performance of solar power plant the best method is available is capacity utilization factor (CUF) which depicts that the fraction of concrete energy generated in given period of time to the highest theoretical likely generation of the system (CERC, 2011). The standard notation for calculating CUF is as shown below:

Capacity Utilization Factor (CUF) in%= Energy measured (MWh) ×100

300 × 24 × installed capacity of the plant

= (1.53 × 100) / (300×24× 0.092)

= 153/662 = 23.11%

Calculation of Pay Back Period

The payback period is the most popular and widely recognized traditional method of evaluating capital expenditure proposals. It is the length of time required to recover the initial cost of the project. It is an expression of how long it will take to recover the initial outlay on an investment from its cash flow returns. PBP can be calculated as follows:

Pay Back Period = Initial Investment for a project / Net Cash Inflow per Period

The benchmark cost of a solar power project is INR 50, 00,000 (app.) with GST and subsidy given by government. The prevailing unit cost of electricity in campus is (INR 7).

=Energy generation per year x cost of a unit

= 153735 kWh x 07 = Rs. 1076145

= 50, 00,000/ 1076145

= 4.64 years

CONCLUSION

The PV systems technology is a form of renewable energy production which is rapidly developing in India. Most of the primary energy comes from non-renewable resources which are limited in nature whereas energy generation from SPV does not emit green house gases compared with fossil fuels. Thus, SPV helps in reducing carbon footprint in the environment and provide opportunities to gain carbon credits. The paper attempts a methodology for the economic feasibility i.e. payback period of SPV plant. Initial investments of the SPV and the annual cash inflow have been calculated. The generation of actual solar energy by the PV module is equivalent to the product of module capacity, the average rate of solar radiation and cell area. The campus located in the western part of the country and exposes to extensive intensity of solar radiation. The average insolation value of solar energy in the campus is 6.02 kWh/m2/day. The rooftop solar PV plant having 370 modules and each module has 60 cells having a total capacity of 0.0925 MW. The computations of the carbon credit earned by solar grid connect system for the campus as per the norms of the Kyoto Protocol and the amount of CO_2 generated as per the guidelines of the International panel of climate change (IPCC) has also been carried out.

The following conclusions have been drawn from the above analysis:

- Technical requirement of a rooftop solar PV plant are PV modules (panels), solar grid inverter, mounting structures, batteries, net meter, cables and other accessories.

- Usually average output generation of 100 KW is about 400 Units per Day, 12000 Units per month, 144000 units per year that cost around 50 lacs after subsidies.

- The system is generating 153735 kWh/year electricity at 23.11 percent capacity utilization factor.

- The simple payback period is analyzed with help of total investment after subsidy.

- Energy generation per year multiplied by cost of a unit i.e. 153735 kWh with Rs. 7 per unit lead to 4.64 years of payback period which is very low in term of recovering entire cost of the whole PV installation.

- The solar PV systems help in reducing the carbon emissions and enhance the carbon credits. Besides,

solar energy is energy supplied by nature – it is thus free and abundant. Solar energy can be made available almost anywhere there is sunlight.

The outcome of study will be path finder to SPV developers, academician, industrial persons, big institutions. Further, its recommendations will be transformed into action because installation cost of solar plant is a one-time investment but in long run it will be beneficial for every stakeholder.

Future Scope

In India, the scope of solar energy is very momentous due to great exposure of sunlight. Solar radiation in the country is almost available throughout the year, which amounts to 2,500 hours of sunshine. Moreover, payback period of PV plant is also very short so it can be used in every walk of energy life.

REFERENCES

1. Baghernejad, A. & Yaghoubi, M. (2011). Exergoeconomic Analysis And Optimization of An Integrated Solar Combined Cycle System (Isccs) Using Genetic Algorithm. Energy Conversion And Management,52:2193–2203.

2. Cerc (Central Electricity Regulatory Commission), 2014. Performance Of Solar Power Plants in India.

3. Dalwadi, P., Shrinet, Mehta, C. And Shah, P. (2011). Optimization of Solar-Wind Hybrid System For Distributed Generation, Proc. Nirma University International Conference on Engineering (Nuicone 11), Ieee Press, Pp. 1-4, Doi: 10.1109/Nuicone.2011.6153300

4. Ecrehsb (Energy Conservation And Renewable Energy for Householders and Small Businesses), 2007. Directorate of Environment and Regeneration, Local Planning Services, Issue:2.

5. Engine, M. (2013). Sizing And Simulation of PV-Wind Hybrid Power System, *International Journal of Photo Energy*, 1(10), Doi:10.1155/2013/217526.

6. Fraas, L., & Larry P. (2010). Solar Cells and Their Applications, Second Edition, Wiley, ISBN978-0-470-44633-1,Section10.2.

7. Maheshwari, H., & Jain, K. (2017). Financial Viability of Solar Photovoltaic System: A Case Study, *International Journal of Civil Engineering and Technology*, 8(11), 180-190.

8. Mnre (Ministry of New And Renewable Energy), 2012. Phase II.

9. Mukherjee, S. and Ghosh, P.B., (2009). Estimation of Carbon Credit And Direct Carbon Footprint By Solar Photovoltaic Cells In West Bengal, India. *International Journal of Low Carbon Technology*, 4:42–51.

10. Patel, R. A. (2006). Wind And Solar Power Systems," Taylor And Francis, New York, Edition2.

11. Reihrd (Renewable Energy for India's Human Resource Development), 2011. Renewable Energy Occasional Paper Series. url:www.Climateparl.Net.

12. Solanki, S.C. (2011). Solar Photovoltaic, Fundamentals, Technologies and Applications, PHI Learning Private Limited, New Delhi.

13. Solarbuzz.Com, www.Solarbuzz.Com

14. Url: Http://Www.Solarmango.Com/Faq/5 (Last Accessed Jan 09,2018)

15. Http://Www.Nwwindandsolar.Com/Solar-Power-In-Seattle-And-The-Northwest/How-Do-Solar-Systems-Produce-Energy/ Retrieved On 12 Sept,2018.