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Review Paper

Financial analysis of PV installations in rural India

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Abstract

Acute power crisis in rural India is stress on the people. Hence use of renewable energy is the way to a sustainable future. Photovoltaic technology, one of the cleanest and greenest sources of electricity, has attracted many types of customers with different federal initiatives and incentives. This paper presents study of variability of investment value through different economic performance metrics and compares the PV technology with conventional power generation costs. This study critically defines the cost benefit economic parameters for adopting photovoltaic technology/traditional technology through benefit cost ratio, net present value, profitability index and internal rate of return analysis. Real time case study of Bidal village (Tal-Man; Dist- Satara) demonstrates the applicability of proposed analysis.

Keywords: PV system, CBA, NPV, IRR.

Introduction

Renewable energy sources such as biomass, geothermal, wind and solar represent a feasible alternative to traditional fossil fuels in terms of reduced impact on environment as well as benefit of their renewable ability. Even they are not subjected to depletion.

There has been a substantial increase in the rising costs of energy production and distribution, regardless of the energy generation techniques used. The initial cost of installation and revenues in high scale and low scale PV projects, non-price project parameters and standard business models of traditional power generation have affected the PV economics. This has been regarded as one of the major challenges that impede the adoption of photovoltaic energy technologies.

An extensive but intensive literature survey to the existing body of knowledge pertaining to energy investment and its cost benefit analysis reveals that studies related to decision making factors such as the B/C ratio, risk analysis of initial investment and net present value for adopting photovoltaic technology or traditional power generation methods are lacking[1].

Literature Review: For the engineering project of a large scale PVGS, the economic analysis should be performed to evaluate the profitability to ensure the investment cost can be recovered over the life cycle. The classical profitability analysis has been performed on PVGS[2,3]. In[4], it is concluded that the main factors affecting the PVGS deployment are the initial capital cost of the system, the feed-in tariff, and the capital cost subsidization rate.

Roque A. et.al.[5] presented the economic aspects of a hybrid system with solar energy and wind energy production. Two economic indices of the NPV and the PBY are applied for the financial analysis for the PV system projects by considering the cash inflows and the life-cycle expenses[6,7].

Table-1: List of Abbreviations.

Abbreviation	Description
B/C	Benefit Cost Ratio
NPV	Net Present Value
PVGS	Photo Voltaic Grid System
PBY	Pay Back Year

Economic and Financial Evaluation

Benefit- Cost Model: The benefit–cost analysis (BCA) is decision making model to estimate the expenditures and revenue of alternatives that satisfy cash flows and operations for a venture. The benefits and costs in this analysis are expressed in monetary terms so as to calculate the overall project cost which includes the installation cost, operational cost and the future maintenance cost and benefits. These cost variations occur at different time periods in the project and can be expressed in terms of the NPV.

Different parameters such as payback period, net present value, internal rate of return, profitability index and benefit cost ratio can be considered to critically evaluate the economics of photovoltaic technology over on-grid electricity.

Cost of Off-Grid Solar System: In this case, solar system term is used for solar street lightning in Bidal village. Load calculation details are given in Table-2.

Table-2: Load Calculation.

Name of institute	Name of electricity appliance	No	Power rating (in Watt)	Usage/day	Watt-hr/day
Rooms in school and GP	Light	31 (LED bulbs)	8	5 hr/day	1240
	Fan	6	50	6 hr/day	1800
	Computer	3	100	6 hr/day	1800
GP	Street lights	20	20	12 hr/day	4800
Total					9640

The cost of installing a solar system is primarily dependent on the system size which in this case is 9.64 kW. The system size determines the number of solar modules based on the available roof space for installation.

The racking system is generally made of high strength stainless steel, galvanized steel or aluminum alloys. The construction cost of solar systems is one expensive component in this configuration.

Basic system Input Parameters and their approximate costing: These parameters are given in Table-3 and Table-4.

Table-3: Basic System Input Parameters.

System Parameters			
			Units
VARIABLE	Photovoltaic power capacity	9640	W
	Maximum Power/Module	250	W
	No. of Modules	39	No
	Lifetime Warranty	20	Year

Table-4: Approximate Costing of System.

Description of item	Quantity	Cost
PV panel	39	2,89,575/-
Poles	20	6,151/-
Battery	13	2,08,000/-
Inverter	1	1,43,500/-
Installation charges		30,000/-
Total	6,77,226/-	

Hence total initial cost required for off-grid solar lightning system is around 6.8 lakhs for Bidal village.

Cost of On Grid Conventional Energy System: Conventional systems derive their energy through non-renewable sources. They are still the most dependent source of electricity in residential and commercial setups. They are presumed to be relatively cheaper as compared to various other renewable sources of energy such as solar, wind, geothermal and biogas.

For calculation of overall costing of conventional system, Average cost of supply is considered as 7.74 Rs/Kwh (Source: MSEDCL). Maintenance charge details are also calculated from MSEDCL manual.

Table-5: Overall Cost and benefits of Solar Vs Conventional system.

Overall Costs		
Different systems giving same power output ~ 9640Wh	Solar system	Conventional
Cost of Installation + Construction + Balance of system	6,72,226	38,850
Annual Maintenance Charges (Approx)	5000	1800
Total Expenses	6,77,226/-	87800/-
Overall Benefits		
Annual Power savings after solar installation	1,44,000/-	0

Power savings calculation is based on number of batteries that store the solar energy and uses whenever required.

Benefit Inflows Vs On-Grid Power Cost: The benefit inflows are an outcome of solar energy produced and state's utility energy prices on an annual basis. Cash inflows are directly dependent on the savings received after commissioning solar systems throughout its lifetime. After recouping the benefits of the system, end customers benefit from the cash inflows at an expected rate of 10% every year.

Higher the system size (kW), higher is the amount for cash inflows throughout the life period of system.

Payback Period: The solar panel payback period is a calculation that estimates how long it will take to "break even" on solar energy investment. Increased utility electricity rates and lower equipment costs can make it easier and less expensive to own.

To calculate solar panel payback period, one need to determine the *combined costs* and *annual benefits* of on-going solar. Following information explains it clearly: i. Gross cost of solar panel system, ii. Value of up-front financial incentives, iii. Average monthly electricity use, iv. Estimated electricity generation.

Payback Period Calculation: Steps involved in calculation: First step is to determine combined costs: Subtract the value of up-front incentives and rebates from the gross cost of your solar panel system. Second step is to determine annual benefits: Sum up your annual financial benefits, including avoided electricity costs and any additional incentives.

Third step to divide your combined costs by your annual financial benefits: The result will be the number of years it will take for you to achieve payback. Every month of savings after that point in time should be counted as a financial gain. As per above calculation, let us consider total investment as Rs.6, 80,000/-

Average monthly electricity bill of school, street lights and Grampanchyat office in Bidal village is Rs.10, 000/-. Hence annual electricity bill will be Rs.1, 20,000/-.

Payback period = Net investment/ Net earnings
= 6, 80,000/1, 20,000
= 5.67 years.

Hence payback period of solar system in Bidal village will be around 6 years and after that period every year saving will be financial gain.

Study of Net Present Value: The concept of net present value suffices the interrelation between the cash inflows and cash outflows of a project. The main objective of this economic characteristic is to quantify the projected profit margins and sustainability of the project. The net present value of any venture is based on four critical components such as initial investment, cash flows, discount rate and time period of the project. The discount rate is the rate of return which an end customer expects out of the project monthly or annually.

NPV= Future Value / $(1+i)^n$
If NPV > 0 then 'Accept Project'
If NPV < 0 then 'Reject Project'

Table-6: Conventional Street light Vs Solar Poles.

Parameter	Solar Street light	Conventional Street light
Lighting Efficiency	LED lights also have longer lifespan with more than 80,000 working hours	This type ranges from 10,000-15,000 working hours with much higher failure rate
Initial Investment	2-3 times higher compared to traditional street lights	Much lesser compared to solar
Installation cost	Installation easier than conventional	In remote areas, difficult to install and maintain
Life Span	LED bulbs has life span of more than 10 years	Sodium bulbs have a life span of 5 years
Maintenance	Almost 70% less comparing traditional sodium or metal halide lights.	Requires periodic maintenance.

Conclusion

In this paper, study of PV technology and conventional system is carried out and comparison proves that use of LED solar panels is more feasible for sustainable environment. Also economic analysis of solar system is performed using payback period and net present value method and study shows that it takes 6 years to recover capital investment. This study shows that dependency on on-grid conventional systems will reduce to 75-80% after solar installations and solar power is more cost-effective than "regular" or standard electricity.

References

1. Drury E., Denholm P. and Margolis R. (2011). The impact of different economic performances metrics on the perceived value of solar photovoltaics. Technical Report NREL/TP-6A20-52197

2. Chabot B. (1998). From costs to prices: economic analysis of photovoltaic energy and services. *Progress in photovoltaics: research and applications*, 6(1), 55-68.

3. Nofuentes G., Aguilera J. and Muñoz F.J. (2002). Tools for the profitability analysis of grid-connected photovoltaics. *Progress in Photovoltaics: Research and Applications*, 10(8), 555-570.

4. Swider D.J., Beurskens L., Davidson S., Twidell J., Pyrko J., Prüggler W. and Skema R. (2008). Conditions and costs for renewables electricity grid connection: Examples in Europe. *Renewable energy*, 33(8), 1832-1842.

5. Roque A., Fontes N., Maia J., Casimiro C. and Sousa D.M. (2009). Economic aspects of a domestic micro-generation

system. In 2009 6th International Conference on the European Energy Market, 1-6. IEEE.

6. Talavera D.L., Nofuentes G., Aguilera J. and Fuentes M. (2007). Tables for the estimation of the internal rate of return of photovoltaic grid-connected systems. *Renewable and sustainable energy reviews*, 11(3), 447-466.

7. Nofuentes G., Aguilera J., Rus C. and Santiago R.L. (2003). A short assessment on the profitability of PV grid-connected systems using classical investment project analysis. In 3rd World Conference on Photovoltaic Energy Conversion, 2003, IEEE, 3, 2632-2635.

8. Lin C.H., Hsieh W.L., Chen C.S., Hsu C.T., Ku T.T. and Tsai C.T. (2011). Financial analysis of a large-scale photovoltaic system and its impact on distribution feeders. *IEEE Transactions on Industry Applications*, 47(4), 1884-1891.

9. Kaldellis J.K. and Gavras Jh. J. (2010). The Economic Viability of Commercial Wind Plants in Greece: A Completed Sensitivity Analysis. *Energy Policy*, 28(8), 509-517.

10. Roberts B.P. and Sandberg C. (2011). The role of energy storage in development of smart grids. *Proceedings of the IEEE*, 99(6), 1139-1144.

11. Mohsenian-Rad A.H. and Leon-Garcia A. (2010). Optimal residential load control with price prediction in real-time electricity pricing environments. *IEEE Trans. Smart Grid*, 1(2), 120-133.

12. Raziei S.A. and Mohscnian-Had H. (2013). Optimal demand response capacity of automatic lighting control. In 2013 IEEE PES Innovative Smart Grid Technologies Conference (ISGT), 1-6, IEEE.