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On Some Aspects of Photovoltaic System

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ABSTRACT

Now a days in view of the world energy crisis attention has been focused on non-conventional energy sources. Among the well known non conventional energy sources the photovoltaic technology (solar energy) has emerged as the most fast evolving renewable energy technology. Continuous advances in photovoltaic have reduced the expenses of solar energy sources reduced by about one order of magnitude in the last 20 years. In the present article an attempt has been made to critically analyze the cost of photovoltaic technology by considering different ways to minimize it. It is concluded that photovoltaic industry has shown dramatic drops in module price since 2008 and with the continuous advancement of photovoltaic technology it is expected that the cost will be reduced further.

Keywords: Phase locked loop, Photovoltaics , Power Grid and Life Cycle Costing.

1. INTRODUCTION

The rising energy need of human being has forced the mankind to look for alternative energy sources. Therefore, a significant research is going on in the area of renewable energy sources. The characteristics of renewable energy sources such as photovoltaic, bio fuel and wind and their grid integration have widely been studied. Among all the other non-conventional sources solar PV technology has emerged as one of the most matured and fast evolving renewable energy technology and it is expected that it will play a major role in the future global electricity generation mix. Solar energy is free and most available natural resource in many parts of the world.

In a year the sun can provide the earth with 15000 times more energy than the atomic and fuel energy actually needed during the year. Even if solar energy is free and abundant still photovoltaic technology represents only around 0.04% of the fuel share of world's total primary energy supply [1]. Continuous advances in PV have reduced the price which has fallen down to about a tenth in the last 20 years. In the present work the evaluation of the cost of the PV technology has been considered in details. In case of non-conventional sources such as photovoltaic technology only installation costs are required whereas in case of conventional sources apart from the used electricity costs such as monthly variable cost (MVC), electricity surcharges are needed to be paid. The PV technology is drawing more attention than other non-conventional sources not only because of worldwide environmental concern but also of its mass energy production capability and eco-friendly non-polluting nature [2].

Again there are several factors that affect the PV system cost and feasibility. Photovoltaic systems have been used as standalone & grid connected PV system since 1990's [3]. The mass production first started in the year 2000.With the use of earlier technology PV systems output directly depends on direct sunlight, hence almost 10-25% of the energy used to get lost. With the advancement of technology like maximum power point tracking (MPPT), phase locked loop (PLL) and static compensator (STATCOM) are used to increase the efficiency and synchronize the photovoltaic system with the power grid. MPPT trackers achieve the efficiency for constant output by monitoring the panels towards the sun ray. Implementation of nano scale components [4] in photovoltaic cells is a way to reduce various limitations by controlling the energy band gap by providing flexibility and inter-changeability. It also enhances the effective optical path and significantly decreases the probability of charge recombination. Introduction of nano scale components also increases the surface to volume ratio which in turn increases the solar irradiation intake capability which results in enhancement of power generation capability. Other advancements in PV cell include introduction of thin-filament solar cell, organic solar cell, dye synthesized solar cell and silicon based solar cell.

2. METHODOLOGY

The possible ways that can be implemented to minimize the cost of PV system are:

1) Grid connection [5]: The most advantageous economic prospective about grid connected PV system is that it doesn't need battery and hence reduces initial capital cost. As per load consuming point of view grid connected systems use smaller PV arrays than stand-alone systems.

2) Solar resource: Source to a PV panel is free i.e sun's ray. Solar resource will not affect capital costs but the availability of solar energy does affect the cost of producing energy, hence the payback period for the investment. Location is considered the second important factor affecting PV system cost performance. It can have influence on shading patterns, soiling, operating temperature and solar resource variations.

3) Stand alone system [6]: Unlike a grid connection system stand alone system also has advantages. Stand alone system tend to become feasible in locations which are far from electrical distribution networks. Grid extensions can cost thousands of dollars per mile of transmission line.

4) BOS (tracking): BOS (Balance of system) is the most important aspect in a PV system. To balance the PV system various components are used. It has been estimated that cost of those components represent 30-50% of the total cost of a PV system. Local safety codes or regulations can require additional balance of system costs for the installation.

5) Types of installation, mounting, size and space: Flat roofs are preferred more both commercially and industrially to maximize flat room utilization and to lower mounting expenses. Retrofit installations for previously made unplanned building tend to be more expensive than those planned for new buildings. Large scale PV systems tend to be less expensive on a per watt basis. Stand-alone system tends to be smaller or used for smaller loads. Grid- tied systems tend to be larger because they provide lower capital costs and energy costs for larger loads.

6) Module technology: Module technology determines the total area needed to install the system. Modules accounts for 40-50 % of total system cost. Less area per watt is desired to maximize roof or land use.

7) Energy use and cost: The size of the system is mostly dependent on energy use, solar resource and component efficiency. Photovoltaic system can be cost competitive in locations with high energy prices and net metering programs.

3. MATHEMATICAL COST ESTIMATION

Mathematical cost estimation includes estimation of life cycle costing (LCC) of the whole Photovoltaic system.

$$LCC = Cost_{Installed} + Cost_{Maintenance} + Cost_{Energy} + Cost_{Replace} - RV_{Panels} - RV_{inverter}$$

Where,
$Cost_{Installed}$ = Cost to installing the system.
$Cost_{Maintenance}$ = Present Value of maintenance cost.
$Cost_{Energy}$ = The cost of energy
$Cost_{Replace}$ = Replacement cost of inverters and other power electronic devices used.
RV_{Panels} = Residual value of the panels.
$RV_{inverter}$ = Residual value of the inverters

4. RESULT AND DISCUSSION

The purchase of a PV system represents an expenditure of capital resources at a given time with the expectation of benefits in the form of electric energy delivered over the technical life of the system. Thus, the operation of a PV system involves a cash flow over several years, and an economical assessment requires measurement of both outflows, such as purchase and maintenance costs, and inflows, such as the value of electricity produced and/or the salvage value (cheaper bill) due to the local consumption of the energy produced [7]. The recent estimated PV cost has been explained in Table 1.

The most policy relevant aspects of our findings relate to the customer value of solar (VOS), which reflects the present value of all incentives and electricity bill saving over the life time of a system. Those areas with a higher customer VOS also tend to have higher priced PV systems. The present work shows that for low priced PV systems a higher customer VOS can actually yield even-lower prices.

5. TABLE

Table 1: Recent estimated PV installation cost

Components	Cost (INR)
Photovoltaic modules	5565126
Power conditioning unit	1207044
Cables	174903
Total	6947074.68
Total/kW_p	359021.83
Total/kW_p without PV mod.	71418.20

6. CONCLUSION

The assumption that PV is expensive is therefore relative to the solar resource and utility energy prices in a location. The PV industry has shown dramatic drops in module price since 2008. With the advancement of technology PV system has reached a notable point of efficiency hence most of the research is going on to decrease the cost, so cost estimation is an important factor for consideration.

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