DESIGN, ANALYSIS AND REAL TIME IMPLEMENTATION OF SOLAR TREE IN BIHER

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ABSTRACT

Continuous increase in the demand, environmental issues, technology and cost make the biggest driving changes in the centralized generation, transmission and distribution by making use of other non-pollutant energy sources that helps to develop the green energy scenario and also extends it support to the end users and the electric utilities. By increasing the share of energy through renewable helps to overcome the complications in the oldest energy scheme like global warming, deficiency in fossil fuels and depletion in ozone layer etc.., Renewable Energy Sources also called as Distributed Energy Resources like Solar, Wind, Fuel cell, CHP, Small Hydro etc., helps to meet the challenges in the generation of clean energy and also provides imperishable energy future.

Solar is the only abundant and truly free energy resource. Among all the different techniques available to harness solar energy, the most popular and mature technology is the Photovoltaic (PV) conversion of sunlight into electricity. Despite its merits, solar PV technology has issues with the land requirement (specifically in urban areas), capture efficiency and public perception. The concept of solar tree is capable of addressing these problems effectively with elegance. Hence in this project implementation of solar tree in BIHER College is focused.

This project addresses the challenges involved in this technology, the various components of Solar tree, design aspects, applications and also suggests future research direction. This solar tree consists of 10 solar panels, each 10 watts rating fixed at different directions in a Reinforced Steel Pole with 12feet height. The open circuit voltage of each panel is 8.5Volts. This Solar Tree is designed in a decorative manner for lightning a 30Watts LED lamp in the entrance of BIHER university. The energy generated from the panel is sent to the 60Ah lead acid battery for storage purpose. The timer helps to light the lamp automatically. Hope this project gives more awareness about solar energy to the students of our college.

Key words: Solar Tree, LED, Design of Battery.

1. INTRODUCTION

The quest for green, clean and sustainable energy has become one of the biggest challenges for our time, due to the swift exhaustion of conventional fossil fuel, climate change, carbon emission, global warming and forever growing energy demand[1]. The above said issues can be overcome through the utilization of Renewable Energy Sources (RES). Renewable power plant has more advantageous over conventional power plant such as no carbon emission, no photochemical pollution etc., Non Renewable Energies are gone as they cannot be replaced or revitalized. So it is better to prefer renewable energy. It is reliable, plentiful and potentially very cheap. It ever runs out, environmentally beneficial and helps for economic growth.

The different types of RES are Tidal power, Wave power, Solar power, Hydro power, Geothermal power and Biomass. Among these, Solar energy is available everywhere at free of cost. The solar energy consists of light and heat energy from the sun. It is harnessed using various progressing technologies such as Solar Heating, Solar Photo Voltaic, Solar Thermal Electricity, Solar Fuels, Solar Architecture, Artificial Photosynthesis. Out of this, the most popular application of Solar energy is through the Photovoltaic[2]. Solar PV performance is depending on the local climatic condition and availability of solar radiation[3-4]. Solar radiation assessment and estimation is very much useful for proper design of solar energy conversion system. The angle of incidence of sun rays fluctuates throughout the day and over the year. Therefore solar module fixed at a particular angle may not be fully optimized. In addition the installation of solar module occupies much land requirement and creates certain issues especially in land restricted urban areas. Rooftop Solar PV is an attractive choice, but it too has limited space for modules to be arranged in an array. Solar tracking PV system can be designed but they significantly raise the total cost of energy generation as they are costly and need maintenance[5-6]. Therefore to overcome the drawbacks in conventional arrangement of solar modules, a new and promising way to integrate Solar PV into the environment is proposed in this project. Solar PV tree can be one such innovative concept.

The remaining section of the paper is organized as follows: Section 2 presents solar PV panel Modeling. Section 3 formulates the proposed work through block diagram representation. Section 4 depicts the design aspects of the recommended work. Hardware specifications and the corresponding explanations are submitted in section 5. Finally Conclusions are stated in section 6.

2. Mathematical modeling of PV system:

A solar cell is electrical equipment that transforms the light energy straightly into electrical energy through a physical and chemical phenomenon known as Photovoltaic effect. During this effect, electrical characteristics such as current, voltage or resistance differ when revealed to light[7-9].

The current output of the PV module is given by

$$I_{PV} = n_P . I_{Ph} - n_P I_0 \left[e\left(\frac{q(V_{PV} + R_S I_{PV})}{AKTn_s} \right) - 1 \right] - n_P \left(\frac{V_{PV} + R_S I_{PV}}{n_S R_{Sh}} \right) -----(1)$$

Where

Vpv – Array Output Voltage

Ipv– Array Output Current

Rs- Series resistance of the Solar Cell

Rsh-Shunt Resistance of the Solar Cell

Iph is the light generated current

I_0-reverse saturation current

A is dimensionless junction material factor,

*k*is Boltzmann constant

T is the temperature (in Kelvin),

ns – Number of cells connected in series

np- Number of cells connected in parallel

The equivalent circuit and PV Cell characteristics of a solar cell are shown in fig1 and 2.

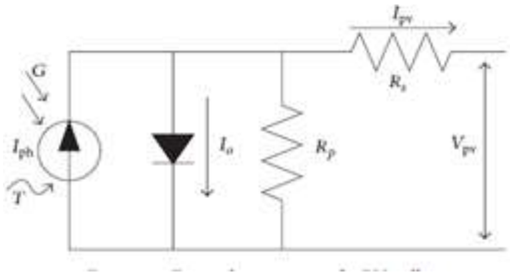

Fig 1 Equivalent Circuit of a PV Cell

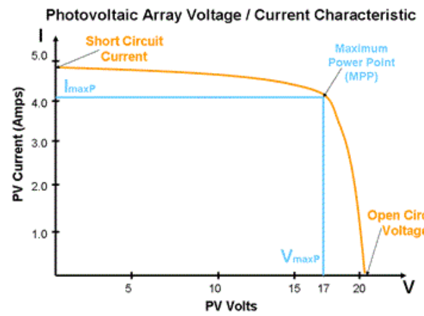

Fig 2 PV Cell Characteristics

3. Proposed Work:

From the review through the introduction, it was identified that single trunk with branches offers more efficiency economically with less cost.Hence in this work the hardware is planned for single trunk with ten number of branches so it offers high reliability. The Block diagram representation is shown in fig 3.

Fig Block Diagrammatic View of Proposed Work

4. Design Aspects of Solar Tree

The design aspects of solar tree is discussed under the following categories

1. Determination of power consumption demands
2. Size of the PV modules
3. Battery sizing
4. Charge controller sizing

4.1 Determination of Power Consumption Demand:

The first step in designing a solar PV system is to find out the total power and energy consumption of all loads that need to be supplied by the solar PV system as follows:

4.1.1 Calculation of total Watt-hours per day for each appliance used.

Add the Watt-hours needed for all appliances together to get the total Watt- hours per day which must be delivered to the appliances.

$$\boldsymbol{Total\ Appliance\ Use = (30W * 6\ hours = 180\ Wh/day) ------(2)}$$

4.1.2 Calculation of total Watt-hours per day needed from the PV modules.

Multiply the total appliances Watt-hours per day × 1.4(the energy lost in the system) to get the total Watt-hours per day which must be provided by the panels.

$$\boldsymbol{Total\ PV\ Panels\ Energy\ Needed = 180 * 1.4 = \frac{252Wh}{day} -------- (3)}$$

4.2 Size of the PV Modules

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt(Wp) produced depends on size of the PV module and climate of site location. We have to consider "panel generation factor" which is different in each site location. For Thailand, the panel generation factor is 3.43. To determine the sizing of PV modules, calculate as follows:

4.2.1 Calculation of the total Watt-peak rating needed for PV modules

Divide the total Watt-hours per day needed from the PV modules (from item 1.2) by 3 to get the total Watt-peak rating needed for the PV panels needed to operate the appliances.

$$\boldsymbol{Total\ Watt\ Power = \frac{252}{3} ------(4)}$$

Panel capacity = 84Wp

4.2.2 Calculation of the number of PV panels for the system

Divide the answer obtained in item 2.1 by the rated output Watt-peak of the pvmodules available to you. Increase any fractional part of result to next highest full number and that will be the number of PV psnels. If more PV modules are installed, the system will perform betterand battery life will be improved. If fewer PV modules are used. The system may not work at all during cloudy periods and battery life will be shortened.

$$\boldsymbol{Number\ of\ PV\ Panels\ needed = \frac{84}{10} watt\ Power ----(5)}$$

$$\boldsymbol{= 8.4\ Modules \approx 8\ Modeules}$$

5. Battery Sizing:

The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculation as follows:

Step1: Calculate total Watt-hours per day used by appliances.

Step2: Divide the total Watt-hours per day used by 0.85 for battery loss.

Step3: Divide the answer obtained in step2 by 0.8 for depth of discharge.

Step4: Divide the answer obtained in step3 by the nominal battery voltage.

Step5: Multiply the answer obtained in step4 with days of autonomy (The number of days that you need the system to operate when there is no power produced by PV panels) to get the required Ampere-hours capacity of deep-cycle battery.

$$\boldsymbol{Capacity} = \frac{(\boldsymbol{Total\ Watt - HourDays * Autonomydays})}{(\boldsymbol{0.86 * 0.8 * 4.5 * Nominal\ Battery\ Voltage})} \boldsymbol{---(6)}$$

$$\boldsymbol{Total\ Appliance\ use} = (\boldsymbol{30\ watts * 6hours}) \boldsymbol{----(7)}$$

$$\boldsymbol{Nominal\ Battery\ Voltage = 12\ volts}$$

$$\boldsymbol{Days\ no.of\ autonmy = 1\ day}$$

$$\boldsymbol{Battery\ Capacity} = \frac{(\boldsymbol{180watt * 6\ hours}) * \boldsymbol{1}}{(\boldsymbol{0.85 * 0.8 * 4.5 * 12})}$$

= 39.21 Ah

Total Ampere-hours required is 39.21Ah

So the battery should be rated 12v 39.21Ah for 1day autonomy.

6. Hardware Specifications:

The hardware details of implemented solar tree are discussed in the below table1.

Table 1Hardware Parameters with Ratings

S.no	System Parameters	Ratings
1	PV Panel	
	Each panel Power	10 watts
	Open Circuit Voltage(Voc)	8.5 volts
	Short Circuit Current(Isc)	1.18 Amps
	Number of Panels	10
2	Battery	
	Battery Bank	60Ah
	Type of Battery	Lead Acid Battery
3	Load	
	LED Lamp	30 watts
4	Pole	
	Reinforced Steel	12 feet

5. CONCLUSION

With land always being a precious and scarce resources for human activities, the solar tree concept can be s suitable solution for urban areas with less open spaces. Hence in this project successfully a solar PV tree is designed and implemented in BIHER Engineering College to lighten a LED of 30watts. From the design and implementation of the PV tree the following key inferences are drawn.

1. PV tree is more effective than the traditional land based system in terms of sunlight captures throughout the day.
2. The impact of grazing angles of solar irradiation is less on the solar tree.
3. PV tree satisfies today's most pressing social, cultural and environmental demands with very less land footprint compared to land based PV system.
4. PV tree design can become a model of green technology and opens up a wide range of research applications in PV industry market.

6. REFERENCES

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