DESIGNING OF A PHOTOVOLTAIC SYSTEM

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ABSTRACT

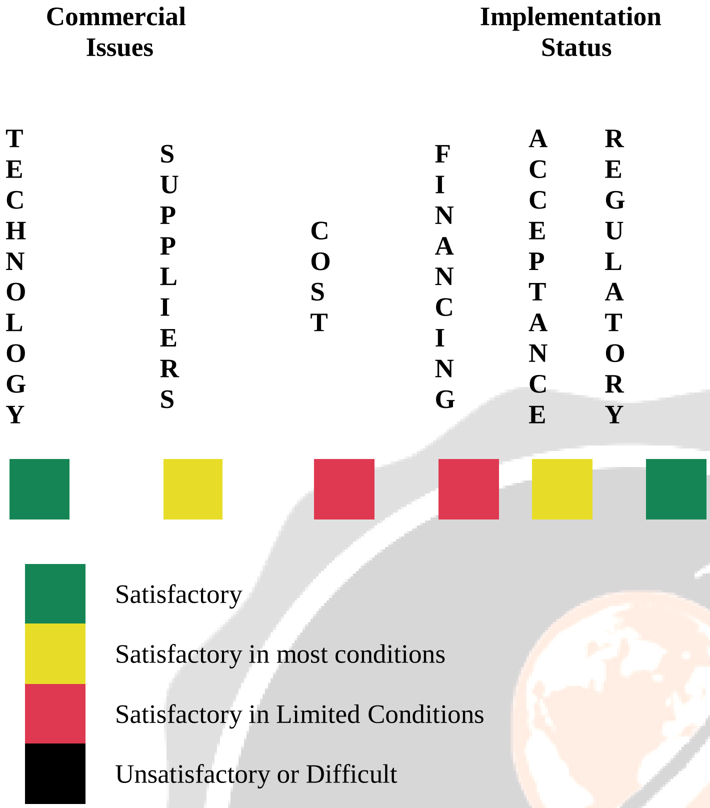
Photovoltaic systems acts in an amazingly useful way. They react to light by transforming part of it into electricity. This conversion is novel and unique, since it have no moving parts to wear out, Contain no fluids or gases that can leak out, Consume no fuel ,Have a rapid response, operate at moderate temperature, Produce no pollution ,Require little maintenance, are modular permitting a wide range of solar-electric applications, have a relatively high conversion efficiency giving the highest overall conversion efficiency from electricity, have wide power-handling capabilities, have a high power-to-weight ratio, are amenable to on-site installation. Clearly PV has an appealing range of characteristics. This paper deals with the understanding of PV systems and their designing.

Keywords- *Photovoltaic system, inverters, controllers, photovoltaic cells.*

1. INTRODUCTION

The word “photovoltaic” is the combination of two terms – “photo” means light and “voltaic” means voltage. The technology used in photovoltaic (PV) systems is well-developed and there are improvements and modifications occurring regularly, primarily in production processes. The systems are quite consistent and have been well tested in space and terrestrial applications. Reliable and well tested PV subsystem components are greatly improved but installation and equipment selection generally requires engineering for each application. In recent years many more installers have been trained and new companies have sprung up in many areas. However they are still not common everywhere, either due to legal constraints, low interest in the technology, or lack of trained installers. Overall system costs are greatly affected by installation and subsystem costs, as well as any available local, state, or federal return programs. With inexpert local suppliers or subcontractors, this expense will govern the system’s cost, thousands of dollars can be spent on setting up a residential PV system for the complete electrical needs of a home. The most important strategy for use of PVs as the electrical power source for a residence is reducing the need for electricity. Refrigerators, air conditioners, electric water heaters, electric ranges, electric dryers, and clothes washers are large users of electricity. Highly energy conserving alternatives and gas appliances are available to greatly reduce electrical loads.

Here it is represented through different colors the issues related to PV system. The commercial status and implantation issues are represented very clearly. Four colors used are red, yellow, green and black. Green color indicated the satisfactory service. Yellow color represents the satisfactory service under most of the conditions. Red color indicated that the PV system works satisfactorily under some conditions only. While the black color represent the total unsatisfactory service of PV system. Here we can see there is no black color indication that clearly shows that PV system in no case has unsatisfactory service.



2. PROACHES FOR USING PVS

There are two approaches 1) Stand alone 2) Grid interface. **Stand-alone system** requires batteries to store power for the time when the sun is not shining. They do not use electric utility power. **Grid-interface or grid-tied system** uses power from the central utility when needed and supplies surplus home-generated power back to the utility. It is often termed as “parallel” system by the utility.

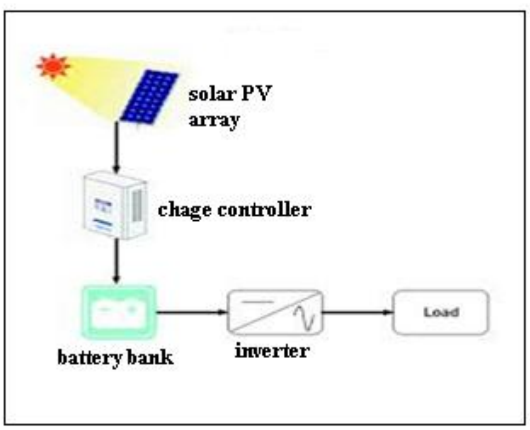


Fig1: Stand Alone System

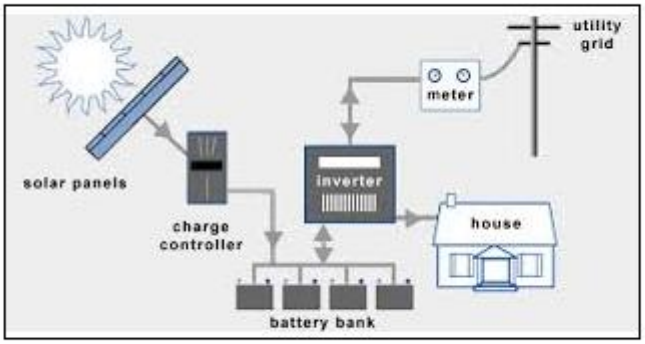


FIG 2: Grid –Tie system

3. DESIGNING A PV SYSTEM

3.1. CALCULATE THE ELECTRICAL LOAD

The uses of energy in a home in three categories

1. Thermal energy requirement for heating living spaces, water, and cooking

2. Electrical loads (lighting, appliance and equipment operation)

3. Refrigeration for air conditioning and food preservation.

A worksheet to calculate the size of a residential PV system is presented here

Magnitude	Electrical device	Usage in Hrs	Wattage	Total Daily WH used
				X 1.1
				X 1.1
				X 1.1
				X 1.1
		Daily Energy Use		

Wattage is usually listed on the electric appliance. If not, multiply the voltage times the amperage to obtain wattage. See the labels for the appliance/equipment to get this information. Steps:

1. List the appliances, lighting, and equipment that will be operated.

2. Mark the appliances that will operate on DC.

3. Enter the quantity of appliances, estimated hours of daily use, and their respective wattage.

4.Multiply the quantity times the hours of daily use times the wattage and enter into the Total Daily Watt Hours used column for each appliance. For each appliance that is not DC, multiply the Total Daily Watt Hours Used amount by 1.1 and enter that amount in the column. Add the Total Daily Watt Hours Used to get a total Daily Energy Use. If batteries are used to store the PV generated power, multiply the "Daily Energy Use" total by 1.25 to account for battery inefficiencies. The final total is the amount of power that PVs need to provide to accomplish operation of the listed appliances for one day.

3.2.Size the PV System

Different size PV panels will produce different amounts of power. The rated output wattage of the panel is the amount of watts the panel will create in one hour of direct sun. For our area, multiply the rated wattage by 5.1 to get the average amount produced in one day. The 5.1 factor is the viable operating hours per day and accounts for the fact that there will be more sun available in the summer and less in the winter.

3.3 PV Subsystems – Inverters, Controllers, and Wiring

1. **INVERTERS-**Conventional electric appliances and equipment and utility-supplied power use alternating current (AC) power and PV systems produce direct current (DC) power. Inverters are required to convert the power from the PVs from DC to AC. Recently produced inverters are reliable and efficient. They are also a major cost for the project. For practical reasons, including electrical code compliance and financing, it is beneficial to have a conventional (AC) electrical distribution system in the house. This will permit the use of appliances, equipment, and lighting that is commonly available.

2. **CHARGE CONTROLLERS-** Regulate the voltage entering batteries to avoid overcharging the batteries. They are available in different capacities and must be selected to match the system. They prevent losses of power back through the panels at night.

3. **WIRING-** Some direct current (DC) equipment may be desirable to operate in a home. DC appliances and equipment, although initially more costly than their AC counterparts, will use less power to operate. In some cases, such as pumps, the DC motors are much more efficient. When DC wiring is going to be used in a home, a heavier wire is required. Generally, #10 wires is best for direct current applications but larger wire may be necessary if the wire runs are quite long. Electrical code requirements will apply to PV installations in regards to having fused disconnects, load centers, and proper grounding. Inverted power (AC) is wired normally as per code.

3.4. MOUNTING PV PANELS

PV arrays must be placed to receive the most sunlight. At our latitude (Austin, TX), a 45-degree slope to the panels with a south orientation is considered to be best. However, in recent years this has been modified. It is now considered better to orient the panels toward the sun's position at 4pm to 5pm, when electricity demands are often at peak.

A steeper slope will help balance the shorter winter day by bringing the panels closer to perpendicular to the lower winter sun. There are many ways to mount the panels – fixed, fixed with adjustable tilt angles, manual tracking, passive tracking, and active trackers. All of these mounting approaches can be placed on the ground or on a roof except for some active trackers which are pole mounted and thus more suited for a ground mount. Fixed mounts are the cheapest and lowest energy producing mounting systems. A metal frame suited for outdoor conditions is best. PV panels will substantially outlive the best wood racks. The fixed mount with adjustable tilt angles and manual tracking mounts will require manually changing the angle of the PV panels either several times a day (manual tracking) and/or seasonal adjustments to keep the panels as close to perpendicular as possible to the sun (tilt angle adjustments).

Trackers are useful if the site is appropriate. There needs to be no obstacles in the east and west direction that will block the sun since the trackers will orient the PV panels to face the sun from early morning to late afternoon. Passive trackers are typically Freon activated to track the sun from east to west only (there is no automatic tilt angle change). Active trackers draw a very small amount of power from the PV panels (as low as one watt) and mechanically track from east to west and adjust to the proper tilt angle. The passive trackers will increase the panels output from 40-50%. Active trackers will improve panel output by as much as 60%. However, it is important to realize that the largest gains for the trackers occurs during the longest days of summer. There are not large gains in the winter

Fig 3: PV Panels

3.5. BATTERIES

Batteries are the best method of storing energy from a PV system for the periods when the sun is not shining. (This is for stand-alone or non -grid connected systems.) The information from calculating the daily load will be needed for determining the battery sizing.

3.6 STEPS FOR SIZING THE BATTERY BANK:

1. Divide the "Daily Energy Use" (derived from using the Chart) by the voltage of the battery (typically 12 volts). The result is amp-hours which is the common manner of measuring battery capacity. For example, if the "Daily Energy Use" is 2,000 (watt-hours), divide 2,000 by 12 to get 167 (amp-hours).
2. Multiply the daily amp-hours by the number of days that you want to have power in storage in case the sun is not shining adequately. Three to five days is recommended. For this example, we will choose four days. Multiply 167 amp-hours per day times 4 days to get 668 amp-hours.
3. Batteries should not be discharged excessively. A deep cycle lead-acid battery (the main battery option) will last longest if it is discharged only 50%. By dividing the total amp-hours from Step 2 (668) by .50, the optimal battery capacity is determined; 668/.50 = 1336 amp-hours at 12 volts.

3.7. PHOTOVOLTAIC CELLS

Semiconductor material, typically silicon, is used in thin wafers or ribbons in most commercially available cells. One side of the semiconductor material has a positive charge and the other side is negatively charged. Sunlight hitting the positive side will activate the negative side electrons and produce an electrical current.

1. CRYSTALLINE SILICON

Crystalline cells have been in service the longest and exhibit outstanding longevity. Cells developed almost 40 years ago are still operating and most manufacturers offer 10-year or longer warranties on crystalline cells. There are two sub-categories of crystalline cells – single crystal and polycrystalline. They both perform similarly. The efficiency of crystalline cells is around 13%.

2. AMORPHOUS SILICON

Amorphous silicon is a recent technology for solar cells. It is cheaper to produce and offers greater flexibility, but their efficiency is half of the crystalline cells and they will degrade with use. These types of cells will produce power in low light situations. This technology is expected to improve application possibilities far exceeding crystalline technology. Currently, the best choice for solar cells will be the crystalline variety.

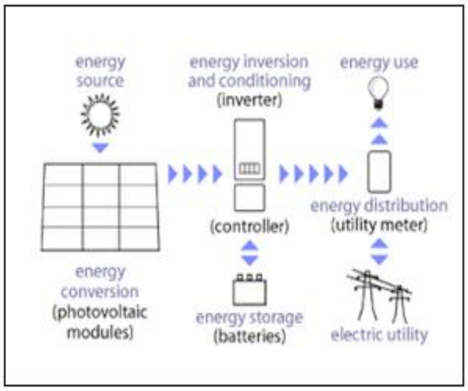


FIG 4: Flow diagram of PV system

4. CONCLUSION

The designing of Photovoltaic (PV) systems is discussed in detail in the paper. The step by step approach of designing each and every unit of PV system and its installation is discussed very clearly. Also commercial status and implementation issues can be examined very clearly from the paper.

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