Solar Photovoltaic System Design Process For the Theological College of Zimbabwe

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Introduction

The Solar PV team (Figure 1) designs and implements solar power systems in developing countries where power is inaccessible or unreliable. A lack of power can hinder the work done by facilities such as medical clinics, churches, or schools.

This poster describes the basic steps in designing a Solar Power system, including load analysis, component selection, and installation layout design. Specific examples from the design for our most recent client are included.

Figure 1: The Solar PV team in Spring 2013

Client

The Theological College of Zimbabwe (Figures 2& 4) is located just outside Bulawayo, Zimbabwe. The power grid in Zimbabwe is unreliable; shutting down as many as 40 times each week. A solar photovoltaic system is being designed for the Theological College of Zimbabwe (TCZ) to power their library and computer lab. Installation is planned for May 2015.

Figure 2: TCZ Location in Africa

More information about TCZ can be found at tczonline.com.

Design Steps

- The first step in the design process is to analyze power usage and decide the appropriate size of the system. This is done through a Load Analysis which calculates the required production of energy, measured in kilowatt-hours per day (kWh/day).
- Next the basic system type must be determined. Some systems are tied into the power grid while others are not.
- Then system components (Figure 3) are chosen, including solar panels, a charge controller, batteries, an inverter, and a back-up power source if desired.
  - Solar Panels convert energy from sunlight to electricity. The wattage of the panels is chosen based on the required battery charging time.

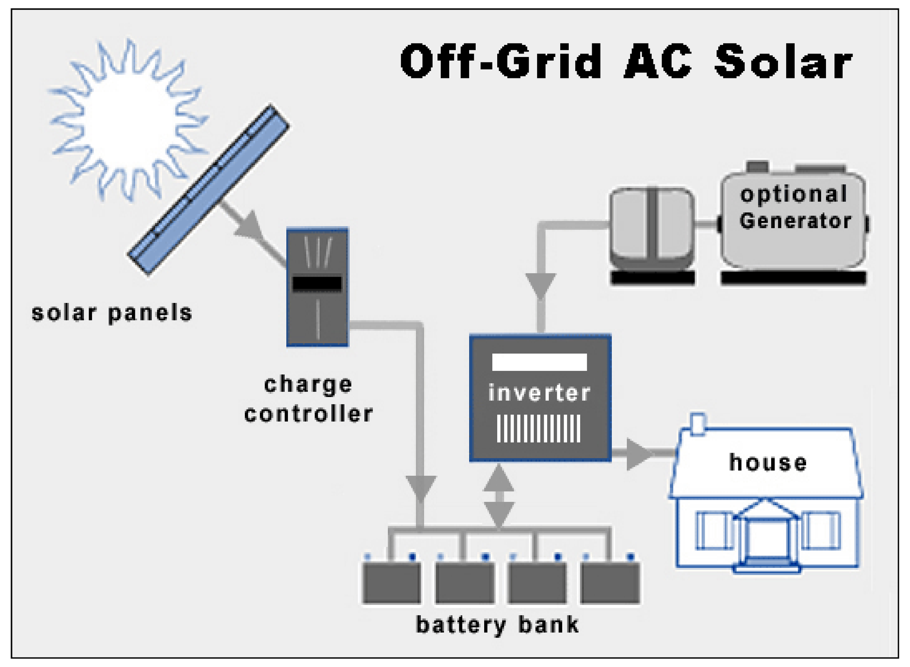

Figure 3: Diagram of a Simple Off-Grid Solar Installation

  - Batteries store the energy from the panels for later use at night or when the loads require more power than produced by the panels. Batteries are chosen based on the kWh/day needed by the loads.
  - The Charge Controller monitors and supplies energy to recharge the batteries. It is chosen to be compatible with the solar panels and batteries.
  - The Inverter converts the DC electricity from the panels and batteries to AC for use by electronic devices. Inverters are chosen based on the loads and the battery voltage.
  - The Generator (Figure 3) shows that a back-up power source, such as a generator or power grid, can be incorporated into the system.
  - An important component for large scale systems (not shown in Figure 3) is a MATE which controls and monitors the whole system.
- After the components are chosen, the system layout must be determined.
  - The Solar Panels must be placed where they will not be shaded. Placement of the panels is determined after conducting a shade analysis which accounts for shading from nearby trees and other objects at all times of the year.
  - The Charge Controller, Batteries, MATE and Inverter should be located as close together as possible to minimize the power loss due to resistance of connecting wires. It is suggested that the Charge Controller, MATE and Inverter be mounted on a wall for easy access.

Example: Theological College of Zimbabwe

- The Load Analysis of TCZ's computer lab and library revealed that they use 41 kwh/day.
- To charge the batteries, we chose to use 24 panels of 280 W each. Collectively, the system will produce approximately 6.7 kW.
- The system will use twenty 12 volt batteries in a 48 volt battery bank which will provide the 1050 Amp-hours needed by the loads.
- A reliable Charge Controller brand, Outback, makes a charge controller which can handle the voltages from the batteries and panels. Two of these will be used for this system.
- Based on the loads, we chose to use two Outback 3 kW inverters.
- TCZ does have a back-up generator and can connect to the power grid. The MATE will decide when to use the different energy sources (from highest to lowest priority): Solar Panels, Power Grid, Batteries, and Generator.

Figure 4: The Theological College of Zimbabwe

Conclusions

While Solar PV is a mature technology, each application requires a custom designed system. In this work we have been able to design a solar power system for TCZ which will provide students with reliable, cost effective power to facilitate their studies.

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