

University of Delaware
Department of Electrical and Computer Engineering
ELEG620: Solar Electric Systems
Photovoltaic System Design Project

The goal of this project is to specify, design, implement and test a simple, stand-alone photovoltaic system. Working in groups, you will:

- Decide on a load and design goal for your system;
- Write a system design program and optimize your particular design for a selected location and then for Delaware;
- Implement, trouble shoot and test the PV system.

System Specification

The first step in the design of your system is to determine the type and size of the system. You are given substantial latitude in choosing the load to be powered, the location of the load, the design goals of system, but you must be able to justify the system. The load should be one which can be implemented, or at least useful information obtained as an approximation to your design load, using 200Ws of solar panels. Existing loads which we have include a water pump, refrigerator, and fluorescent lighting.

Before starting on the design, come up with a set of design goals. These include addressing trade-offs such as the reliability required, the availability, etc. Then you should do a rough calculation to see if these criteria seem feasible. For example, if your design comes out to a 5 kW system for a light bulb for a residence because you specified 99.99% availability and reliability, you may need to re-think your design criteria.

Design of the photovoltaic system

The design of the photovoltaic system involves writing a program which: (1) calculates the power produced by the photovoltaic module based on incident solar radiation (from TMY data) as a function of module tilt and azimuth angle; (2) determines how much energy reaches the battery and load and analyzes the energy flows in your system; and (3) calculates performance evaluation parameters. Since you will also need to calculate lifecycle costs (and they are often a performance evaluation parameter anyway), you may want to include this in your program. However, you can do these separately as well – your groups choice. Acceptable programming formats are MATLAB, C++, Java and Excel.

The program should include calculations that are used to design and analyze your photovoltaic system. This program should include at a minimum:

- The ability to change the tilt and azimuth angle of your array.
- Change the location for the solar array.
- Specify a load for every hour of the year, and determine yearly total and average load.
- Calculate energy flows and system performance parameters for a given number of panels and battery capacity.
- Correctly account for series and parallel connection of ideal PV modules and batteries (i.e., no mismatch).
- Correctly adjust the number of panels and batteries if the system voltage is changed.
- Determine the average, minimum and maximum BSOC.

- Determine relevant performance parameters for the system (I recommend having the performance parameters for each month of the year as well as yearly).
- Include one “advanced” effect. You may select which effect you include. A list of possible advanced effects includes:
 - Non-constant inverter efficiency
 - Effect of temperature on the array power
 - Non-constant battery voltage
 - Effect of mismatch losses in calculating the array power.
 - Calculation of TMY data from world radiation data sets.

Based on your program, you must write up in your report:

- The array size and battery size which best meets your system goals and how you decided this was the optimum.
- Justification of why this is the optimum design. This includes analysis of the performance parameters and well as a sensitivity analysis.
- Lifecycle cost of the system.
- Other necessary system specifications, including: inverter size, charge controller current, which other components the system needs.
- Description of your program, showing approach taken, electronic copy of source code, and outputs of your program.

System Implementation

Your system will be implemented using solar panels on the roof of DuPont Hall. For the system implementation, you need to re-run your design to account for the fixed tilt of the roof and the location (use Wilmington DE solar radiation data). You may also need to change the size of the load. You will then hook up your system and analyze the results to determine the performance of your system and how well it matched your predicted performance.

You should aim to take data over one week and analyze the data a system performance, and then analyze for system performance and loss mechanisms.

Data Sources

Solar radiation data. In order to perform accurate calculations, particularly for battery sizing, you will need to solar radiation data sets for your location. The US data is available to all; the location of the site from which it is obtained is: http://rredc.nrel.gov/solar/old_data/nsrdb/. The TMY2 data files and manual are at: http://rredc.nrel.gov/solar/old_data/nsrdb/tmy2/ .

Worldwide data is a little harder to come by. The site <http://wrdc-mgo.nrel.gov/> is a link to the World Radiation Data Center. However, this data is not in TMY or similar format. For the purpose of this project, you may assume that the data for a year is equivalent to the TMY data.

Module and Battery Information. You should get an idea of the modules and batteries, and include these in your report. You may find information on panels at: <http://www.solarbuzz.com/solarindex/CellManufacturers.htm> and <http://www.solarbuzz.com/solarindex/ModuleManufacturers.htm> . A more manageable site (though with relatively limited selection) is <http://www.gaiam.com/retail/SolarLiving> . There are many other sites available, and you may use any, as long as it has the price, maximum power point current and voltage and you tell me what the site is. These sites also have battery information

Assessment

Each person will be given an assessment for the overall project based on the following:

- 65%: The overall grade of the written final report. The overall report marking consists of:
 - 10% System Plan
 - 35% System Design
 - 30% System Implementation and Measurement
 - 25% System Analysis
- 25% Oral Presentation. Each person in the group will be responsible for one section of the oral report, and will be graded individually on this section.
- 10% Peer Assessment: Each person in the group will be required to fill out a peer assessment table. This is handed in for each person INDIVIDUALLY and is not shown to other members of the group. Each person receives the aggregate from other team members. Problems with individuals in groups should be brought to the attention Prof. Honsberg two weeks before the final report is handed. I will address these issues and attempt to provide opportunity to rectify the problems.