The Photovoltaic Energy System for the MSU Sustainable House

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RESEARCH

A photovoltaic (PV) energy system, which includes both panels and associated hardware, allows direct conversion of sunlight to usable electrical power. Sunlight consists of small energy packets called photons. When photons strike the PV panels, electrons are dislodged that create both current and voltage. The voltage and current together provide the electrical power that can be used to meet building demands normally met by the conventional power grid (Figure 1).

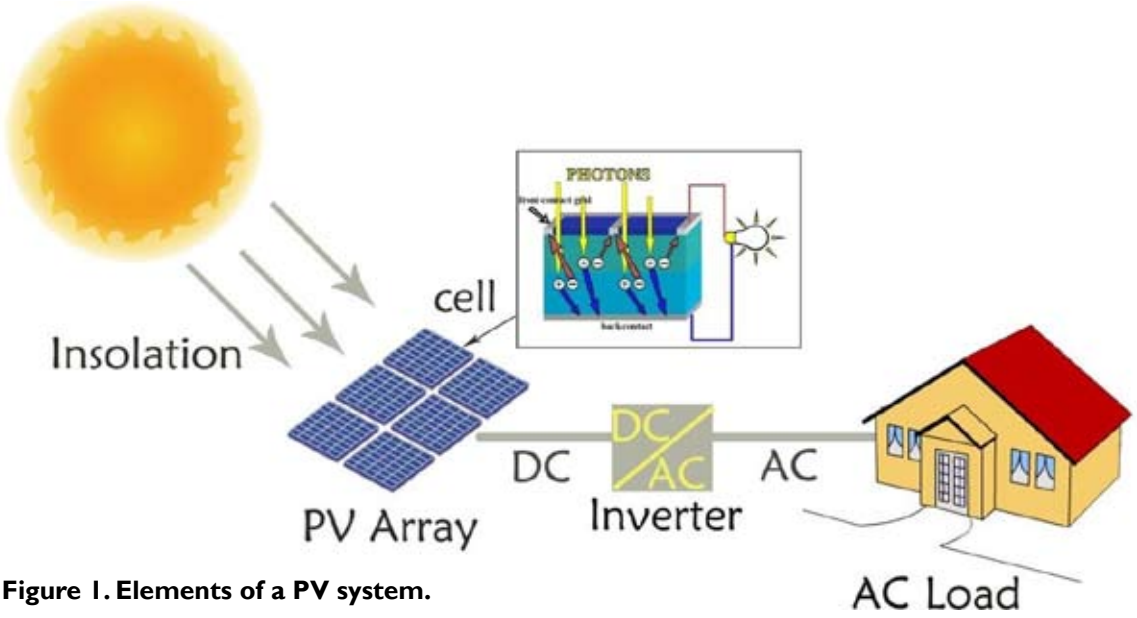


Figure 1. Elements of a PV system.

Production of electrical power by PV has been less attractive than other technologies due to its high up-front costs and long pay back times. Rising energy costs, concern over the production of greenhouse gases by conventional power production methods, and steadily dropping production costs appear to indicate that PV power will play an important role in the energy mix of the future. The Tennessee Valley Authority (the principal power source for much of the US Southeast) has recognized the increasing importance of PV among the "green" technologies. They are currently promoting its adoption through the TVA "Green Switch" program. Producers of PV power, once accepted into the program, are paid 15 cents per kWh of energy produced (compared to the current residential use rate of 6.75 cents per kWh). The TVA pays this premium in order to encourage introduction of residential and commercial building scale PV systems into the SE United States, where green technology use has lagged behind much of the rest of the country.

The designers of the Mississippi State University "Sustainable House" recognized the growing importance of PV power production and wanted such a system to be a component of the finished complex. To this end, Sarah Duffy (senior Biological Engineering student) and her advisor, Dr. Thomas Cathcart (professor of Biological Engineering) were recruited to design and oversee the implementation of PV power as part of the project.

As do all of the components of the Sustainable House, the PV system will be used for both demonstration and research. The system has been designed to offset much of the expected power

requirements of the house under normal use. Additionally, the system includes components that will allow each one-kilowatt block to be metered and adjusted independently. This will allow the designers of the house to investigate:

•the importance of routine panel cleaning in long term power production; and

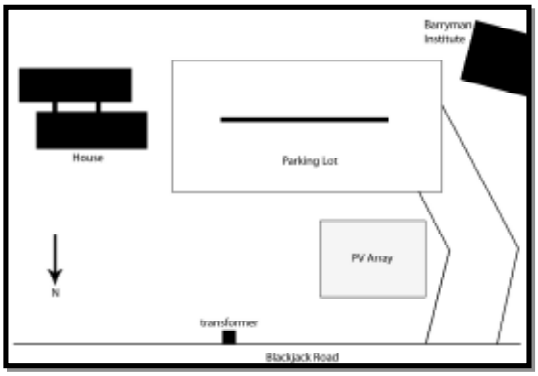
•the utility of bi-annual panel tilt angle adjustments to enhance annual power production.

These are basic maintenance and management issues that have not been addressed in the Southeast US and will be helpful as this technology becomes more widely used.

The PV system design and component selection process is now complete and ready to be sent out for bid. Notable accomplishments in the last quarter include:

•Listing of power and energy requirements for the house.
•System size to meet most of projected demand (4 kW).
•Components selected to meet performance and safety criteria.
•Array size (twenty 200 W panels).
•Site for array (just to the NE of the house).
•Array mounting hardware (adjustable).
•System price (approximately $32,000).
•Source of funding (School of Architecture and the Wood Products Laboratory).
•Arrangements for net metering equivalent.
•Potential vendors (1 selected, one yet to be decided; this is for bidding purposes).

The Tennessee Valley Authority (TVA) has officially accepted this system as a green switch participant. Power from this system will be fed directly to the grid and compensation will be 15 cents per kWh. The sustainable house will be billed at a rate of 6.75 cents per kWh. The Sustainable House is the first site to partner with local provider 4-County Electric under the auspices of the TVA program.



Areal view of lot

Location of PV array from driveway

Figure 2. Location of proposed system.

Siting of the system is illustrated in Figure 2. Criteria for site selection were good exposure to the southern sky and proximity to the Sustainable House. The proposed site meets both criteria.

Figure 3 shows a partial list of the system components. Installation will be done by a certified contractor and will meet TVA and National Electrical Code requirements. The monitoring equipment will include 4 meters for each 1 kW block of the 4 kW system.

- 4 kW system
- 20 200W solar panels
  - Each panel measures 3' x 5.5'
  - Total area of 15' x 22' in closest "square" configuration
- Ground mount
  - approximately 5' above ground
- Adjustable- tilt racks
- Sine wave inverter
- Monitoring equipment
- Fenced enclosure

Figure 3. System components (partial list).

Figure 4 shows projected annual electrical power production for the proposed system under a variety of tilt regimes. The larger values, found in the column labeled "ABE Clear Sky Model" are based on clear sky atmospheric conditions and do not take into account cloud cover. This model was implemented at MSU as a tool to determine the effects of panel direction and line of sight issues on system performance. The right most column is system performance based on the National Renewable Energy Laboratory's PV model that takes into account average cloud cover effects on energy production. The area of the proposed array is 30.67 m2, indicating that projected power production will meet approximately half to 80 percent of the electrical power needs of the Sustainable House.

	Model	PVWatts Estimate
Fixed 0°	2201	1649
Fixed 20°	2488.9	1807
Fixed 32.33°*	2538.9	1821
Bi-annual 15° tilt adjustment	2619.4	n/a

Figure 4. Projected power production by the PV system.

ADDITIONAL READING:

Melby, Pete & Tom Cathcart. Regenerative Design Techniques. Wiley & Sons. 2002.

Masters, GM. Renewable and Efficient Electric Power Systems. Wiley & Sons. 2004.

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The MSU Southern Climatic Housing Research Team is a collaborative effort involving Architecture, Civil Engineering, Electrical Engineering, Forest Products, Landscape Architecture, and Mechanical Engineering. The MSU Southern Climatic Housing Research Team is affiliated with the Coalition for Advanced Wood Structures (CAWS) as a partnership with the USDA Forest Service, Forest Products Laboratory in Madison, Wisconsin. CAWS is a partnership between universities, industry and government to advance research for wood structures related to residential, non-residential and transportation uses.

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