UGA PV SYSTEM DEMONSTRATION PROJECT

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Sustainable Building Design

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1. PROJECT DESCRIPTION

The University of Georgia is instituting a photovoltaic system on the roof of the University Bookstore. This project will contribute electricity to the university grid and act as a demonstration project for students and visitors. The demonstration aspect of this project is what we are focusing on; we are proposing inverters along with a display to educate the public on the benefits and features of the new PV system. There are several factors that need to be considered to ensure successful communication. Our project will examine the following:

SITING: The placement of the inverters, a key aspect of the PV system, must account for both educational and technical factors. A main objective of the PV system is to display the system as an educational tool. To effectively communicate the basics of solar power to students, the system must be placed in an area of high traffic with easy visibility. Safety and technical considerations should be addressed.

SIGNAGE: There must be concise, coherent images to explain the process to laypeople. Some text will be included on the signs. The signs will explain the system design and components of the system.

ELECTRICAL SPECIFICATION: A brief description of the system has been included to convey important aspects, such as parts and specifications. Basic information will be pulled from this data to include in the display. This section will also include the design process known as string sizing. This procedure will lead allow us to determine additional wiring for the system that has not yet been specified.

PROJECTED ENERGY MODELING: To communicate the basics of solar energy, we feel it is necessary to address topics such as energy and power. By predicting both power and long term energy output, future data can be compared to baseline predictions. The displays will incorporate system power ratings, as well as projected energy goals.

2. SITING

FIGURE 1: PROPOSED SITE FOR PANELS AND INVERTERS

FIGURE 2: CONCEPTUAL VIEW OF PANELS[1]

We have focused on a site on the southwest corner of the University Bookstore, just west of the main entrance (figures 1 and 2). This is an optimal site for a number of reasons.

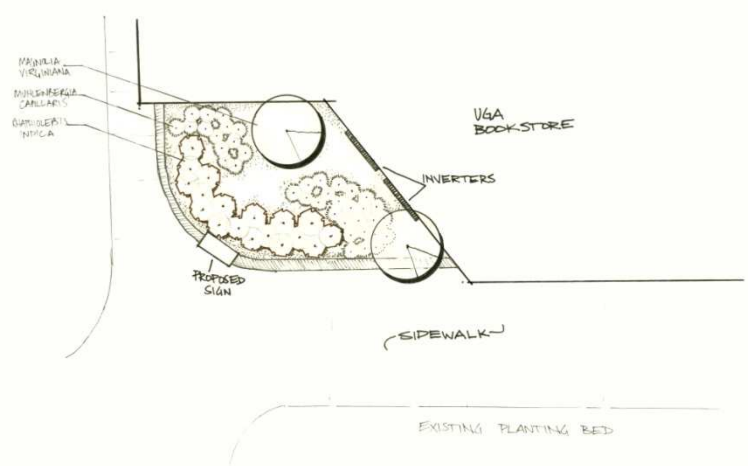
-PROXIMITY TO SOLAR PANELS AND ELECTRICAL PANEL: The selected site is between the solar panel and the bookstore electrical panel, creating a short distance to each. This minimizes the amount of power loss associated with low voltage DC wiring.

-VISIBILITY: The site is on a main thoroughfare between Lumpkin Street, the bookstore, the Tate Center, and Sanford Stadium. This provides an excellent opportunity for public viewing. There is an elevated walkway above the site which allows people to see the entire system from above: the solar panels, the inverters, and the wiring leading to the power box. By placing all components of the system in such a public location, thousands of students will have the opportunity to view the complete workings of solar energy.

-SAFETY: The exterior building wall, upon which the inverters will be mounted, is set back from the walking path by 10'. There is a 4' tall retaining wall creating a barrier between the path and the space that will house the inverters. This will keep the public at a safe distance from the inverters. Warning signs should also be used to keep the public back from the inverters.

-DISPLAY: The retaining wall is a natural fit for an educational display; if signs are placed atop it, they are at a natural level for adults and teens to read. Signs can also be placed on the elevated walkway to explain the components of the system to people from above. Plantings can be done in the space in front of the inverters for aesthetic purposes, and to create shade for the system during peak afternoon heat. Figure 3 is an example of what can be placed in the area: we propose Indian Hawthorne and Muhly Grass in the foreground, which stays consistent with other plantings on campus. These plants are low to the ground, not obstructing views of the inverters. Two Bay Leaf Magnolias can be placed closer to the building to provide the necessary shade for the inverters. These trees have a relatively thin profile to allow easy viewing of the inverters.

FIGURE 3: PROPOSED PLANTING DESIGN



3. SIGNAGE

In order to explain the system to students and the public, signs will be placed in key locations that explain solar power in general as well as UGA’s specific system. Several groups are working on this idea/component. We will focus on explaining the system from a technical aspect (i.e. system components). We propose placing two signs in the general vicinity of the system.

The first sign, figure 4, would be placed in front of the inverter site, mounted along the retaining wall outside of the bookstore. This would provide a clear view of the electrical workings of the system. It would explain the path electricity takes from the solar panels to the bookstore electrical panel.

The second sign, figure 5, would be placed on walkway between the Tate Center and the MLC. Its location provides a clear view of both the solar panels and the inverters. It provides details on UGA's system and solar energy as a whole.

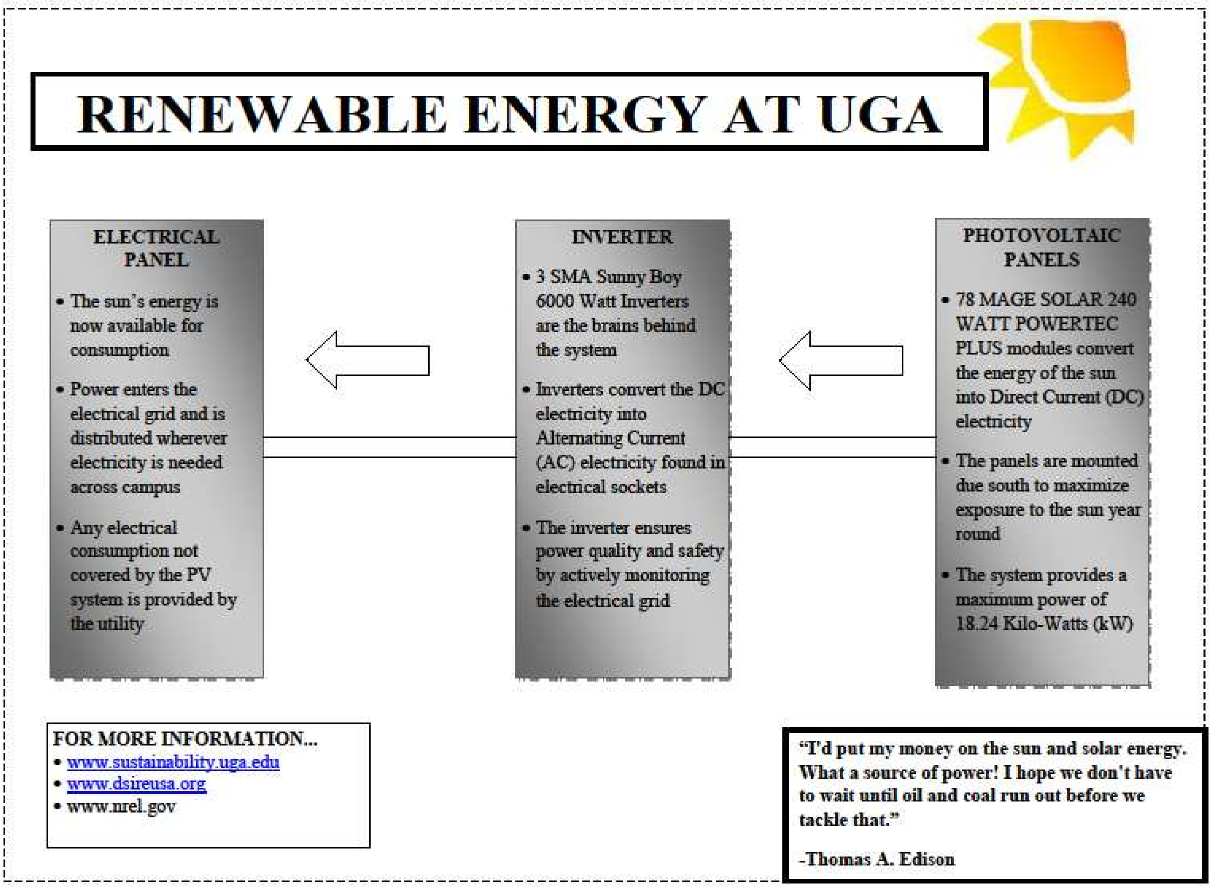


FIGURE 4: RETAINING WALL DISPLAY

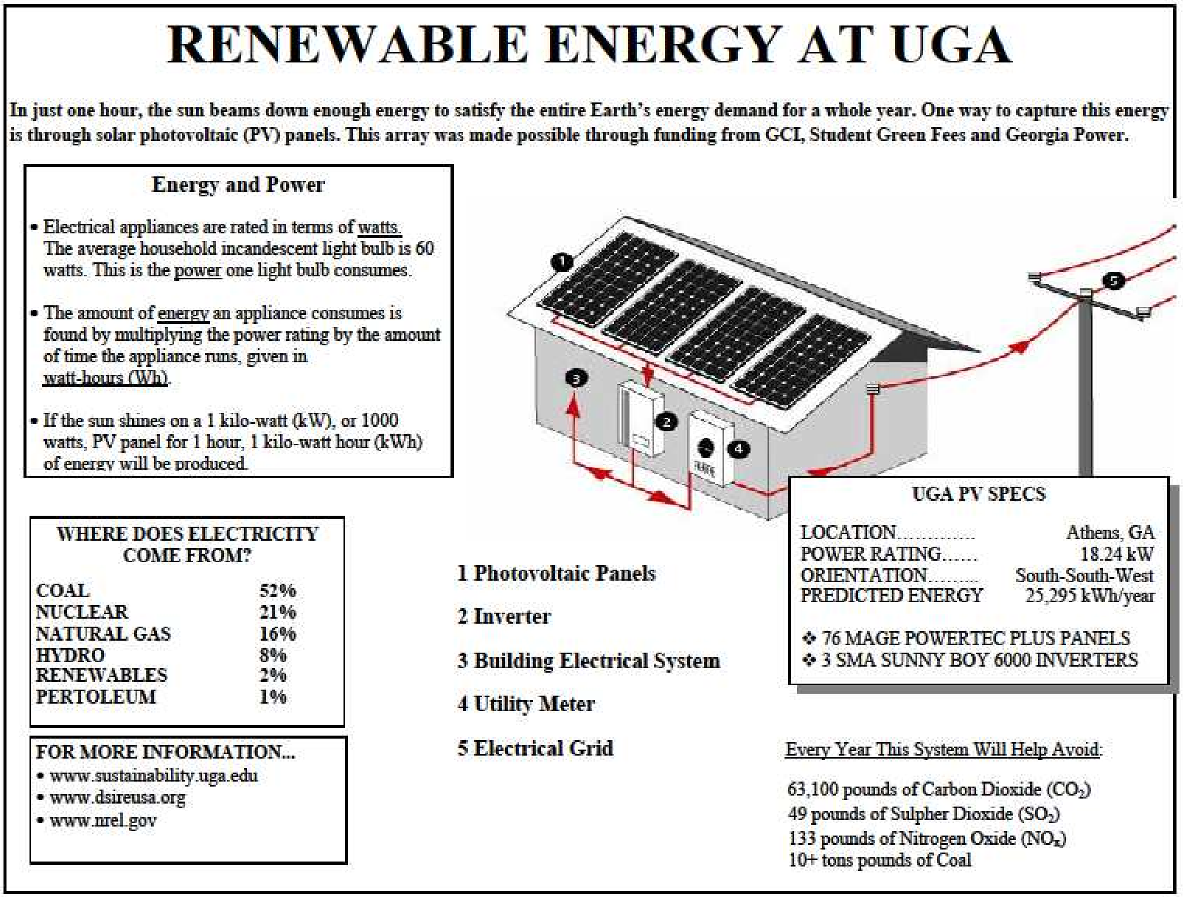


FIGURE 5: BRIDGE DISPLAY

4. ELECTRICAL SPECIFICATIONS

The photovoltaic system to be installed at UGA has a maximum DC power rating of 18.24 Kilo-Watts[1]. The electrical components of the system will include the following: solar panels, DC wiring, DC disconnect, inverters, AC disconnect, AC wiring, utility/load interconnect. The university has purchased the inverter and PV panels. There will be a total of 76 MAGE POWERTEC PLUS 240 PV panels (figure 7)[2]. Each panel produces at maximum power of 240 watts, at a maximum of 30.4 V (V_{MP}). There will be 3 SMA 6000 inverters (figure 6)[4]. The inverters have a maximum DC power input of 7500 watts.

The design of the inverters/panel interface, know as string sizing, is paramount to the performance of the system. Essentially, the number of panels that can be connected to an inverter is determined by the voltage range of the inverter. For the SMA 6000, the voltage range is 250 – 480 V. SMA (the inverter manufacturer) provides an online tool for string sizing[5]. After inputting data such as panel type/rating, inverter type and climate data, the program specifies how to connect the panels. The results of the process are as follows (see fig 8 for a diagram):

- Inverter 1: 2 Strings, 12 panels/string
- Inverter 2: 2 Strings, 11 panels/string
- Inverter 3: 3 Strings, 10 panels/string

Each inverter contains a function known as maximum power-point tracking. This function enables the inverter to optimize the performance of the panels it is connected to. It will optimize the performance according to the lowest performing panel in the string. For this reason, it is suggested that the panels be grouped in strings according to shading factors. If no shading is present, grouping the panels from east to west will be the most efficient design.

FIGURE 6: SMA 6000[4]

FIGURE 7: MAGE POWERTEC PLUS 240 [2]

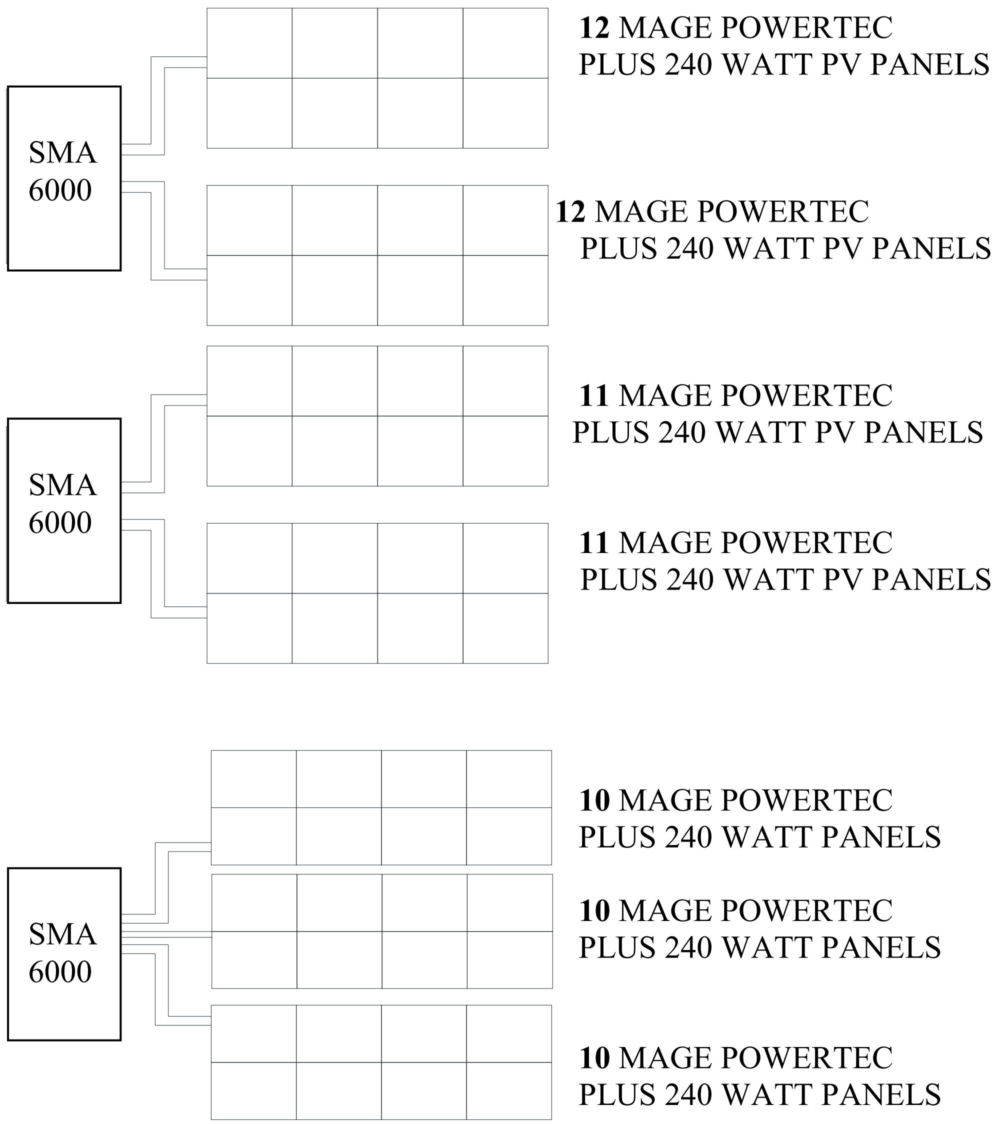


FIGURE 8: STRING SIZING

5. ENERGY PRODUCTION ANALYSIS

The National Renewable Energy Laboratory (NREL) offers an online program called PV Watts[3]. By inputting system parameters such as location, system size, inverter type, etc. the program uses NASA climate data to predict the useful AC energy output of a system. Energy prediction is an important aspect of a successful PV system. By making a baseline prediction, performance can be measured when future data is in place. This model also serves to provide data for the display. It will allow us to communicate how much energy generated by a system in this location. It shows the relationship between system output and system size, location, tilt, orientation, etc. Table 1 summarizes the input variables and the results.

Station Identification	
City:	Athens
State:	Georgia
Latitude:	33.95° N
Longitude:	83.32° W
Elevation:	244 m
PV System Specifications	
DC Rating:	18.2 kW
DC to AC Derate Factor:	0.800
AC Rating:	14.6 kW
Array Type:	Fixed Tilt
Array Tilt:	34.0°
Array Azimuth:	170.0°
Energy Specifications	
Cost of Electricity:	7 ¢/kWh

TABLE 1: PV WATTS ENERGY ANALYSIS

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.66	1613	112.9
2	4.73	1881	131.7
3	5.38	2300	161.0
4	5.84	2387	167.1
5	5.72	2332	163.2
6	5.72	2202	154.1
7	5.72	2258	158.1
8	5.60	2222	155.5
9	5.29	2067	144.7
10	5.47	2293	160.5
11	4.31	1787	125.1
12	3.76	1651	115.6
Year	5.10	24992	$1749.44

6. RECOMMENDATIONS

Our final recommendations for this project are as follows:

1. To maximize the educational potential of the system, the inverters will be placed in a location based on three key factors. First, the location must be in a high traffic area. Second, the inverters as well as the viewers must be protected. Finally the location should minimize distance from the solar panels to the inverters. We recommend placing the inverters on the south-southwest wall of the bookstore. It is on a raised dais putting the system out of normal walking areas but prominently displaying the system. By planting trees and shrubs on the dais the location will look nice and the temperature around the inverters will be reduced. Further shade can be provided by placing a wall mounted roof over the inverters.
2. To explain solar power to students, we have designed two signs to be placed around the system. The first sign explains the electrical components of the system (figure 4). This sign will be mounted on the retaining wall in front of the inverters. The second sign depicts solar power in general and explains the benefits of UGA's system (figure 5). This sign could be placed on the bridge connecting the Tate Center and the Student Learning Center.
3. To ensure maximum power-point tracking from each inverter, we advise the following string sizing (see figure 8):
    - Inverter 1: 2 Strings, 12 panels/string (365 V_{MP})
    - Inverter 2: 2 Strings, 11 panels/string (334 V_{MP})
    - Inverter 3: 3 Strings, 10 panels/string (304 V_{MP})

4. We feel the best way to display the system is through a website. By placing a link on UGA's web page and on the signs, far more detail could be provided on the system. This could include the data monitoring software visual. A more thorough explanation of the details of solar power, external references and data monitoring could be provided and far more people could be reached.

LIST OF FIGURES

References

[1]University of Georgia Office of Sustainability

[2] ***MAGE SOLAR POWERTEC PLUS***. MAGE SOLAR USA Web. 01 Dec. 2011. <http://web.magesolar.de/us/products/mono-and-polycry.stalline-modules.html>.

[3]**PVWATTS** *Renewable Resource Data Center (RReDC) Home Page*. National Renewable Energy Laboratory (NREL). Web. 01 Dec. 2011. <http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/>.

[4]**SUNNY BOY 6000** *SMA America, LLC* Web. 01 Dec. 2011. <http://www.sma-america.com/en_US/products/grid-tied-inverters/sunny-boy/sunny-boy-5000-us-6000-us-7000-us-8000-us.html>.

[5]**SUNNY DESIGN** Version 1.57. SMA America.

PERSONAL STATEMENTS OF WORK

ANDREW SPATZ:

Ben and I worked together to determine the best site for the project. We researched other projects similar in scope to this one to find what some of the main concerns were when installing a PV system, especially one that is used for demonstration purposes. Once we determined these constraints, we visited the site before settling on the proposed location. I have worked to develop signage that will be easy to read and that can communicate the ideas we are trying to get across. I also drafted a planting plan for the area surrounding the inverters, which will provide shade and cooler temperatures during the day.

BEN SLEISTER:

My role in our team has been to explain the technical aspects of PV systems. The first step I preformed was a prediction of energy output for the system via the online program PV Watts. This data can be used to estimate payback time as well as used in the future for comparison of expected vs actual results. Next I compiled a list of the pertinent electrical components of the system. This information will later be used on the signs that explain the system. Both Andrew and I helped select a site to place the inverters. I took pictures of the site to include in the report. After compiling the necessary data, I created the two signs shown in the report. The final aspect I preformed was string sizing. I downloaded the program Sunny Design, offered online from SMA. This program allowed me to size the number of solar panels that could be connected to each individual inverter in series and parallel configurations.