2019

SECC Solar Panels Project Summary

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This project addressed WCU-CAP objective #3.1: "Produce Renewable Energy via Installation of Small-Scale Photovoltaics on Campus." The newly constructed Science & Engineering Center and Commons (SECC) building with dedicated space for an Environmental Health lab, provided an ideal scenario for designing a basic photovoltaic system which can be expanded in the future. The project involves three phases:

- PHASE I – Shade Study
- PHASE II – System Design
- PHASE III – System Installation

In Phase I, graduate and undergraduate students performed a shade study to assess the ideal location and orientation of the solar panels to maximize input. Under the direction of faculty members Lorenzo Cena and Melanie Vile, graduate student Christiana French-Franco in the MPH program and undergraduate student Ciara Goldin in the Environmental Health program were involved in this phase of the study. Annual sun-paths, obstructions on the horizon, and monthly solar access were measured. The results of the study are indicated in Figure 1 where recommendations were made for three ideal locations for the solar array on the roof of the SECC where 99% monthly solar access can be achieved throughout the year.

Phase II involved 5 graduate students in the MPH program: Jayda Toledo, Emily German, William Curley, Jacquelyn Faulkner and Roland Drake. The students performed research on photovoltaic systems, learned the specification of the equipment and helped answer design questions such as charge controller capacity, maximum number of panels and number of batteries that the system can handle, and wattage required by the power inverter to handle laboratory equipment. Each student provided a report of their findings which was reviewed by faculty members. A sample report is provided in Appendix A.

Phase III of the project has been delayed due to construction delays on the SECC building. A contractor has been identified and system installation should begin once the SECC building is near completion. Upon completion, the green roof will showcase the solar panels, a plaque describing the student-design, and a digital controller indicating the amount of energy generated. Inside the SECC building there will be dedicated display monitors which will broadcast live energy production and consumption charts. In the Environmental Health lab, the system will be used to teach students in the Environmental Health program about photovoltaic systems. The battery array and inverters will be displayed for teaching and demonstration purposes in the following courses: ENV102 and ENV435. We anticipate the expansion of the system in the future and the need for ten additional 300-W solar panels. We plan on obtaining external funding from the PA Department of Environmental Protection Education Grants program to purchase the additional solar panels.

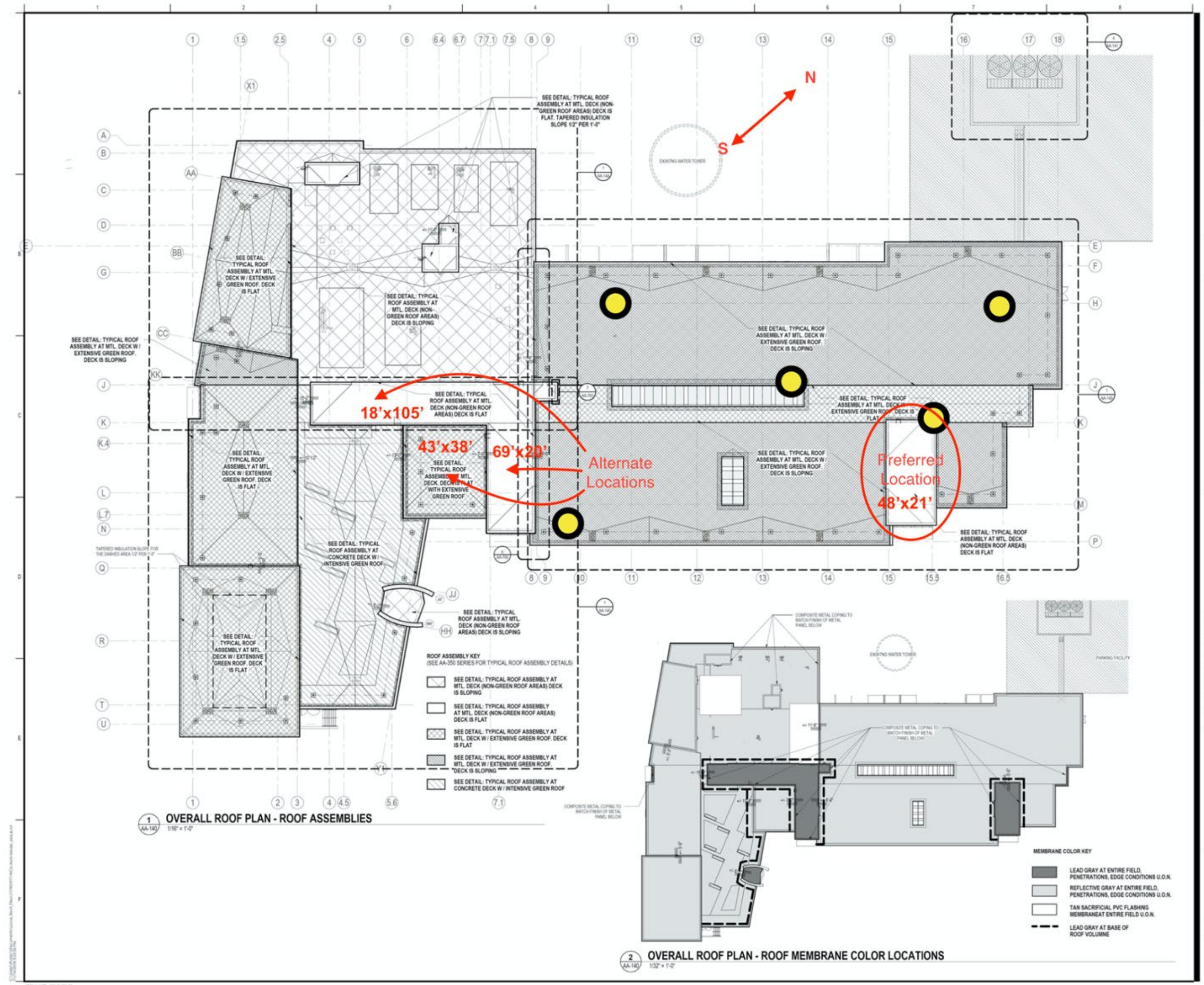
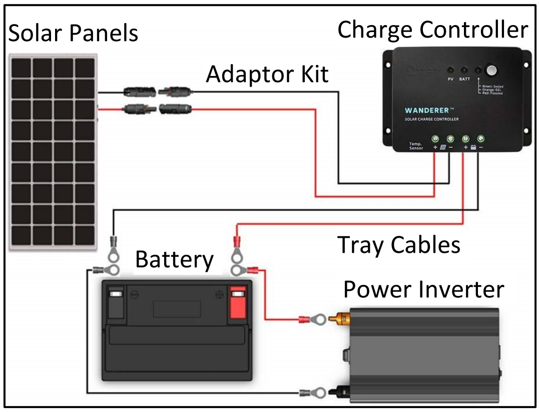


Figure 1. Roof plan of SECC building on WCU campus and ideal location of solar arrays as result of the shade study performed in Phase I.

APPENDIX A – Sample Student Report of PHASE II

Basic components of a solar energy system:



Based on the specifications provided for the charge controller, find the maximum capacity of the system, i.e., how many panels and batteries the system can handle. Your task is to do research on photovoltaic systems, learn the basics and help answer the questions below. The specifications and manuals for the existing components are available on D2L.

Existing system components:

Solar Panels:
Renogy RNG-300D
300W, 24 V

Charge Controller:
Renogy Rover 100A

Batteries:
2 Renogy 12 V 200 Ah
1 Renogy 12 V 100 Ah

Inverter:
WZRELB RBP100012VCRT
1000W 12V 120V Pure Sine Wave Solar Power

Questions

- What is the Maximum charge controller capacity?

  The maximum charge controller capacity is 100A

- How many Watts can it handle on 24V panels?

The maximum Watts the charge controller can handle using 24V panels is 2600W.

- How many 24V solar panels can it handle?

  The maximum number of 24V solar panels the charge controller can handle is eight.

- How many batteries can we charge simultaneously with this controller?

  This charge controller can handle up to 48V battery bank. Therefore, this controller can simultaneously charge four 12V batteries connected in series. If batteries were connected in parallel, the voltage would remain 12V and the system would be limited by the Ah demand of the batteries which varies depending on the battery used (100Ah or 200Ah).

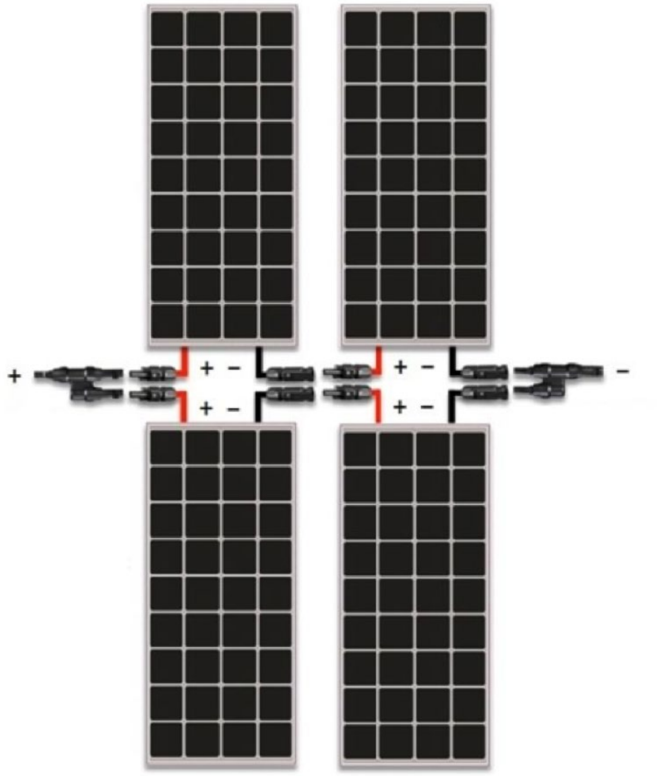
- What should be the wattage of the power inverter necessary to power refrigerators, air compressors and oven (this would be comparable to powering modern kitchen appliances) E.g., is 1,000W sufficient or should we use a 5,000 or 10,000W inverter?

  The wattage of the power inverter necessary to power refrigerators, air compressors, and an oven would need to be greater than 1,000W, preferably 10,000W. Pure Sine Wave Solar Power Inverter provides 1000W continuous power with 2000W surge power. The average refrigerator requires 1,000W continuous with 2000W surge. Therefore, this invertor would be overwhelmed if any energy were drawn from this system. To accommodate the continuous draw and surge potential of multiple large appliances, a 10,000W inverter would be required.

- How should the panels be connected together? Series, or parallel? Provide schematic drawings.

  If all four 24V 300W solar panels were connected in series, the total open circuit voltage of the system would be 4x39.82V= 159.28. This exceeds the charge controllers maximum solar input voltage of 140 VDC at -25°C. To maximize the amount of energy captured by the solar panels without overworking the charge controller the panels should be connected in series/parallel. Connecting two panels in series to generate two strings that are then connected in parallel generates a solar array of 48V. Since the MPPT charge controller is used, the input voltage is okay to exceed the battery banks charge needs without harming the life or functionality of the battery.

Figure 1: Solar Panel Array Design in Series-Parallel



- How should the batteries be connected together? Series or parallel, provide schematic drawings. The answer to this question may be found in the instruction manual of the power inverter.

  With the charge controller listed above, the batteries should be connected in series-parallel format. The general guide for solar charge controllers is that the charge controller Amps rating should be equivalent to 10-20% of the battery array Ah rating. If all three batteries were to be connected in parallel, the voltage for the battery system would be 12V with a capacity of 500 Ah. While the 100A rating of the charge controller does fall within the desired range, the total voltage of the battery system would be only 12V, which result in a great loss of energy when operating with a 24V solar array. If the batteries were connected in parallel, system would have a 36V battery system with a capacity of 200 Ah. An additional consideration is the need of the lab. If the intentions are to run heavier appliances with a higher watt-hour need (such as air compressors, refrigerators, etc.), it would be desirable to have a 24V or higher system, as long as the estimated amp-hours match the battery configuration. Assuming the regular use of one appliance, the batteries should be configured in series-parallel. Two 12V 200Ah batteries will be connected in series, which will be connected in parallel to the 12V 100Ah battery. This will allow for 24V 300Ah battery bank which is better for powering larger appliances.

Figure 2: Battery Bank Design in Series Parallel