ISES Solar Charging Station

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Concept Generation and Selection

Document

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1.0 INTRODUCTION

Our project is sponsored by Dr. Thomas Acker. He is the director of Institute for Sustainable Energy Solution in Northern Arizona University. ISES has in possession of multiple solar photovoltaic modules that can be installed on structure to charge small electronic devices. The goal of our project is to design a solar charging station to charge electronic devices. The two main subsections to the solar charging station are the control system and the display system. We will generate several concepts for the two systems and make decision matrixes to select a best concept.

2.0 Control Systems

There are three different types of control systems that are covered by solar energy. These are the off grid battery based control system, the grid tie only control system, and the grid tie with battery backup control system. Each of these systems have their own advantages and disadvantages. There are also various components that are incorporated with each system. The different components involved for each of the systems are defined in the subsequent sections.

Charge Controller

Since the brighter the sunlight, the more voltage the solar cells produce, the excessive voltage could damage the batteries. A charge controller is used to maintain the proper charging voltage on the batteries. As the input voltage from the solar array rises, the charge controller regulates the charge to the batteries preventing any over charging

Battery

They store the electrical power in the form of a chemical reaction. Without storage you would only have power when the sun is shining or the generator is running.

- RV or Marine type deep cycle batteries

Suitable for only very small systems, they can be used but do not really have the capacity for continuous service with many charge/discharge cycles for many years.

- Flooded

Lead acid batteries that have caps to add water. Many manufacturers make these types for Solar Energy use. They are reasonably priced and work well for many years. All flooded batteries release gas when charged and should not be used indoors.

- Sealed gel batteries

Will not release gas during the charging process like flooded batteries do. This is a big advantage because it allows the batteries to maintain a more constant temperature and perform better.

- Absorbed Glass Mat batteries

Best available for Solar Power use. They are leak/spill proof, do not out gas when charging, and have superior performance. They have all the advantages of the sealed gel types and are higher quality, maintain voltage better, self-discharge slower, and last longer.

Inventers

The Power Inverters the heart of the system. It makes 220 volts AC from the 12 volts DC stored in the batteries. It can also charge the batteries if connected to a generator or the AC line. For 12v applications an inverter is not required. An inverter should only be required when it is necessary to convert the 12v input to power a 220v standard application [1].

Solar Array Combiner

The solar array combiner takes the wires from several solar panels and combines them into one main feed. Breakers and fuses, however, need to be purchased separately. There are two types of wiring combiners:

- Wires from panel junction blocks connected to terminal blocks.
- MC connecters which need an MC extender cable and cut in half to transition to array combiner junctions from panel wiring.

There are combiner boxes using MC connectors that plug in, but availability is scarce and very expensive. Nearly all combiners require fuses, not breakers to meet electrical and safety codes [2].

Ground Fault Protector

A ground fault is an undesirable condition of current flowing through the grounding conductor. This is caused by an unintentional electrical connection between current-carrying conductor in PV system and the equipment grounding conductor. The ground fault protection device is used to reduce the risk of fire hazard associated with ground fault [3].

DC/AC Disconnect Switch

The DC disconnect switch interrupts DC current between modules before reaching the inverter. Sizing is done by multiplying the number of PV modules that are connected in series with the open circuit voltage. The AC disconnect switch separates the inverter from the electrical grid. Sizing is done by multiplying the number of PV strings connected in parallel by the short circuit current [4].

Battery Control System

This system has advantages and disadvantages that occur as a result of its components. The advantages don’t have an equal amount to the disadvantages.

Advantages

- This system is inexpensive
- This system does not have as many components as the other two systems.

Disadvantages

- This system has energy losses from batteries that are not in operation
- This system requires battery replacement over time

Grid Tie Control System

This system has mostly different components from the off grid battery based control system. This system connects only to the grid and allows for power to be pulled from the grid and also gives power while the solar panels are in operation.

Advantages

- This system can be used anytime during the day
- Extra energy goes into the grid to save money

Disadvantages

- This system does not work at night during power failure
- Money cannot be saved while the system is in use at night

Grid Tie with Battery Backup Control System

This system is a combination of the off grid battery based control system and the grid tie control system. This makes the amount of components that are required to operate the system to be higher than that of the other two systems. This increases the cost of the total system.

Advantages

- This system can still be used during a power outage.

Disadvantages

- This system becomes complicated when trying to get everything to work properly.
- Battery replacement must be considered with this system.
- The amount of components in this system increases the cost to higher than the other two systems.

3.0 Display System

There are three possible systems that could be used to display the power readings:

- Pre-programed
- Team programed
- Tablets

The advantages and disadvantages of each display is discussed in the following section.

Pre-programed display

A Pre-programmed display is an option designed especially for displaying information from the PV panels. Most of these display packages include everything that is required to display the information such as power monitors, transmitters, and the program to interpret the data.

Advantages

- Variety of interactive displays
- Most appealing display

Disadvantages

- Price

Team programmed display

A team programed display is a display where the team buys all the components separately, assembles them, and then programs the system. While this system is cheap to construct, it also requires programming knowledge. Each component must be compatible with one another for the system to work together.

Advantages

- Cheapest
- Less power consumption

Disadvantages

- Requires time to program
- Display is limited to simplistic designs

Tablets display

For a tablet display, the team will purchase a tablet and design specified applications to display the power readings. This option is allows for a more interactive display but still requires programming knowledge. There is no assembly of the display components, making the design less complicated.

Advantages

- Appealing display

Disadvantages

- Specialized application programing
- Expensive

4.0 Design Selection

Below, Table 1 describes how the team determined appropriate weights for each design criteria pertaining to the control system. An overview of what each criteria means is outlined below.

- Cost- How expensive the system is
- Efficiency- Power savings
- Simplicity- How easy the system is to build
- Reliability- Operates under various circumstances
- Environmentally friendly- How the design impacts the environment
- Customization- The various features of the display
- Man Hours- The amount of time required
- Adaptability- How compatible the system is

Table 1- Control system weighting (Scale: 1-POOR, 5-BEST)

Criteria	Cost	Efficiency	Simplicity	Reliability	Environmentally friendly	Total	Weighted Value
Cost	x	0	1	0	0	1	0.10
Efficiency	1	x	1	0	1	3	0.30
Simplicity	0	0	x	0	1	1	0.10
Reliability	1	1	1	x	1	4	0.40
Environmental friendly	1	0	0	0	x	1	0.10

Table 2 outlines the weighted values for the display system.

Table 2 - Display weighting (Scale: 1-POOR, 5-BEST)

Criteria	Cost	Reliability	Customization	Man hours	Adaptability	Total	Weighted Value
Cost	x	0	0.5	0	0	0.5	0.05
Reliability	1	X	1	1	1	4.0	0.40
Customization	0.5	0	x	1	0	1.5	0.15
Man hours	1	0	0	x	0	1.0	0.10
Adaptability	1	0	1	1	x	3.0	0.30

Table 3 below describes the decision matrix for solar control systems and each criteria is graded from 1 to 5 where 5 is best and 1 is worst.

Table 3: Decision matrix for solar control systems

Decision Criteria	Decision Criteria Weights	Grid Only	Battery Only	Grid with Battery Backup
Cost	0.10	3	4	2
Efficiency	0.30	5	3	4
Simplicity	0.10	3	4	2
Reliability	0.40	5	3	4
Environmentally Friendly	0.10	4	2	2
Total		4.5	3.1	3.4

From Table 3, we decided to choose the grid only option for our design. This is largely in part to the efficiency and reliability of the system compared to the other options. Since energy is lost in batteries, sending the electricity straight into the grid is more efficient. Also, if the system is connected to the grid, then the system will always be functional.

Table 4 below describes the decision matrix for the display options and each criteria is graded from 1 to 5 where 5 is best and 1 is worst.

Table 4: Decision matrix for the display options

Decision Criteria	Decision Criteria Weights	Pre-Programmed	Team Programmed	Tablet
Cost	0.05	3	4	3
Reliability	0.40	4	3	2
Customization	0.15	4	5	2
Man Hours	0.10	5	2	2
Adaptability	0.30	4	4	1
Total		4.05	3.55	1.75

Based on Table 4, we decided to choose the pre-programed display for our system. While a pre-programmed system can potentially be expensive, the benefits from this system outweigh the cost. Since this system is on the market, it has been through various tests ensuring product reliability. In addition, the man hours required to program the team programmed system and the tablet vastly outweighs that of the pre-programmed. This will allow for more time to be spent on other aspects of the project.

5.0 Gantt Chart

For Gantt chart see Appendix A. The group has finished the preliminary design phase and we have established our specifications per our sponsor's vision. The next phase for the project is to create AutoCAD design for the control system and decide the specific design elements that will make the system efficient, effective, and aesthetically pleasing. As soon as the design is created, the team will survey students for the aesthesis and the practicality of the system. While surveying, we will simultaneously be testing the solar panels for their energy output and their efficiency.

6.0 Conclusion

For the solar charging station there are two main components that have multiple design decisions to be made. Those components are the display system and the control system. Due to the previously demonstrated decision matrices, the solar changing stations will be most efficient in terms of cost, technology, and time while incorporating a pre-programmed display system. This system will also easily incorporate all of the components our sponsor has requested, such as a power produced output and potentially a "money saved" feature. For the power connection (control system), the group has decided on a grid-tie control system. This system is reliable and will save the university more money compared to the battery storage and mixed grid-battery system. The next step in the process is to take the selected control and display systems and create representations in 3D modeling software.

References

[1] Solarflex, "Solar Panel Technical Information Guidelines," World Focus, 2007.

[2] Northern Arizona Wind & Sun, "Solar Array Combiners", www.solar-electric.com/solar-combiner-boxes.html, October 25, 2013.

[3] Berdner, J., Mync, P., "PV System Ground Faults", Solar Pro: 2.5, August/September 2009

[4] Civic Solar, "Sizing for DC Disconnect for Solar PV Systems", www.civicsolar.com/resource/sizing-acdc-disconnect-solar-pv-systems, October 25, 2013.

Appendix A

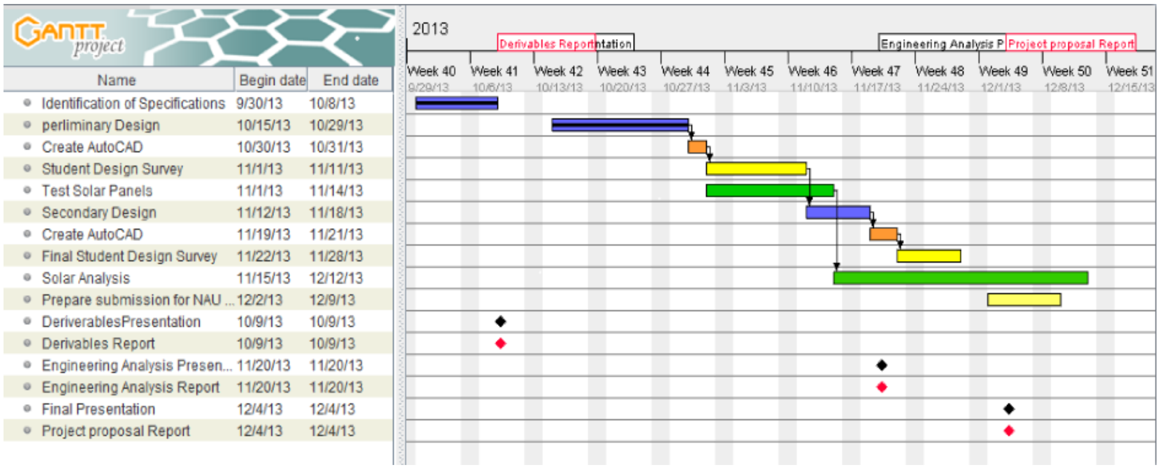

Figure 1: Project progress