Haiti Transitional Home: Solar Panel System Design

Kasey R Hetzel
California Polytechnic State University
San Luis Obispo, California

Haiti is located in a region with optimal access to the sun's rays, but not enough resources to make use of them. While the country is known for its limited access to electricity and unreliable power quality, it has the potential to become a renewable energy powerhouse. Providing a safe place for families to reunite under one roof, that runs solely on solar power is the ultimate goal of this project. Not only designing the most efficient system, but finding which products are available in country, and which products would be more cost effective to ship internationally was the intent of this project. After calculating the 3000 Watt electrical load of the Transitional Home, the results came to a 48 volt system with 12 X 215 Watt Solar Panels, a 70 Amp MPPT Charging Controller, 8 X 12 Volt AGM Batteries, and a 3000 Watt Power Inverter.

Keywords: renewable energy, solar power, resources, electrical load

Introduction

In Haiti, it is common for struggling parents to give their children up to orphanages with the idea that those institutions would provide better lives for their children. As a result, an overwhelming 80% of 'orphans' actually have loving, living parents. To help with this ongoing issue, a partnership was made with the non-profit organization, Friends and Family Community Connection (FFCC). The author has volunteered with FFCC for six years and travelled to Haiti with them twice where a school and orphanage were built, water filters installed, and medical clinics were held.

Figure 1: Children living at Shepherd's House Ministries

The project was chosen to help design the first of multiple "Transitional Homes" at Shepherd's House Ministries, the orphanage that was built during previous trips several years ago. The transitional homes will be a space for parents to not only be reunited with their child but also receive support in finding jobs to get them back on their feet. Studies have shown that when children are with their loved ones in a stable environment, more opportunities arise for them to flourish, which is the ultimate goal of these homes. This project, while “transitional,” will offer a long term solution that will shift the orphanage dynamic in Haiti.

Design

Working with an architect major at Cal Poly to help come up with the design and rendering of the transitional home, work on the solar design started. The home will be 1200 SF, including 2 bedrooms, 1 bathroom, an office, a living room, and a kitchen. The foundation of the building will be slab on grade, with concrete masonry walls, and metal roofing panels. This is the cheapest, and most structurally effective form of building in Haiti.

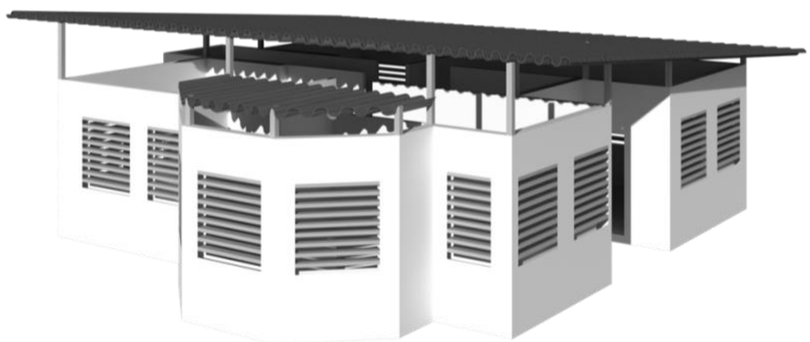


Figure 2: Transitional Home Design

After coming up with the house design, the next step was finding the maximum energy consumption that the house will use. To determine the load, all of the appliances and other systems that consume power in the house were analyzed. From there, the wattage of each appliance was needed to determine the maximum load that the Transitional Home demands.

The breakdown of the electricity load is as follows:

- 1 Refrigerator : 1000 Watts
- 1 Microwave: 1000 Watts
- 1 Blender: 450 Watts
- 5 Ceiling Fans: 265 Watts
- 10 LED Ceiling Lights: 76 Watts
- 1 Radio: 30 Watts
- 1 Television: 69 Watts

Calculations

The maximum load of the house was rounded up to 3000 Watts. The voltage of the DC system was chosen by first narrowing down the options of the industry standard (24V and 48V). By doing a simple calculation of Wattage/Voltage, the Amperage was determined. In this case, choosing 48 Volts feeds a lower amperage than choosing a 24 V system, allowing for the cable size and components such as the charging controller and power inverter to be more accessible and affordable. The solar panels will provide energy directly to the house for 10 hours of the day while the sun is out, and the batteries will provide energy for the remaining 14 hours. To determine the amount of batteries needed to sustain 14 hours of power, the Amp Hours that each product will draw was calculated.

The assumptions are as follows:

- Refrigerator: 7 hours; drawing 20.8 Amps = 145.6 Amp Hours
- Microwave: 0.5 hours; drawing 20.8 Amps = 10.4 Amp Hours
- Ceiling fans: 2 fans for 14 hours; drawing 1.3 Amps each = 26.4 Amp Hours
- Lights: 2 lights for 14 hours; drawing 0.2 Amps each = 5.6 Amp Hours
- TV: 3 hours; drawing 1.4 Amps = 4.2 Amp Hours
- Radio: 2 hours; drawing 0.6 Amps = 1.2 Amp Hours

The Transitional Home is assumed to draw 194 Amp Hours during the 14 hours that the house is relying on the battery power.

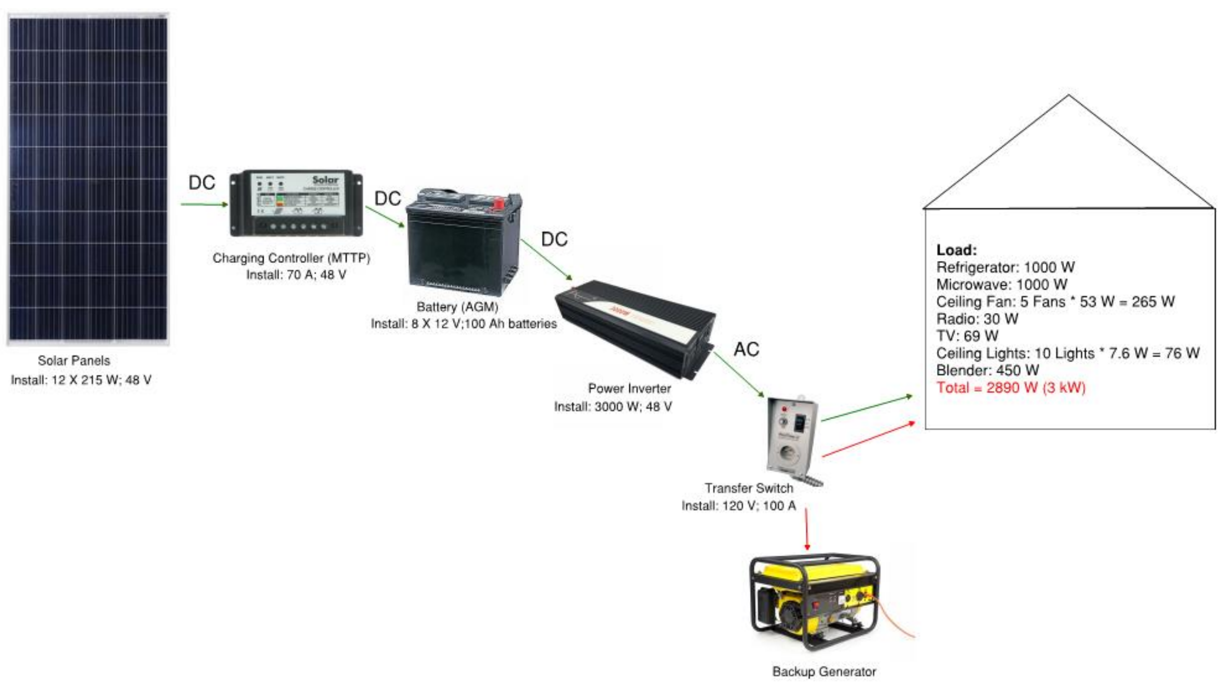


Figure 3: Solar Panel System Diagram

Methodology

The solar panel system was designed to serve a 3 Kilowatt house. This is an off-grid system, so the storage of solar power in batteries is critical for the use of electricity when the solar panels are not generating energy during the night time. The system was designed to 48 Volts, meaning that this 3 kilowatt demand will require a minimum of 63 Amps. These will be Lead Acid - Absorbent Glass Mat (AGM) Batteries, chosen because they are easily accessible and replaceable, while also being more cost effective than lithium ion batteries. To ensure the maximum lifespan and performance of the batteries, a 70 Amp charging controller must be installed to prevent overcharging and overvoltage. Another assumption made was the amount of sun hours Haiti will feed the solar panels on a daily basis. Given the close proximity to the equator, 10 hours was a fair assumption. To meet the 3 kilowatt demand of the transitional home, 12 – 215 Watt Solar Panels must be installed releasing 48 Volts. Solar panels produce Direct Current (DC) electricity, while the household devices use Alternating Current (AC) electricity. To convert the electricity from DC to AC, a 3000 Watt, 48 Volt inverter must be installed to fit the maximum load of the house (See Appendix A).

The solar panel system includes:

- Solar Panels: 12 X 215 Watt
- Overload Breaker: 70 Amp
- Charging Controller (MPPT): 70 Amp
- Batteries (AGM): 8 X 12 Volt; 100 Amp hours
- Power Inverter (Pure Sine Wave): 3000 Watt; 48 Volt
- Transfer Switch: 120 Volt; 100 Amp
- Backup Generator (Manual Transfer)

Product Breakdown

Construction material costs in Haiti are more expensive than in the United States. When choosing the products to use in this solar panel system, it was necessary to do a cost analysis of materials in Haiti and materials from the United States to build the most effective system.

Material Cost Breakdown

Material	Purchased In Haiti	Imported
Solar Panels	$2933.00	$2200.00
Charging Controller	$605.00	$589.05
Batteries (12)	$2868.00	$2807.00
Power Inverter	$1165.00	$348.00

Purchasing the solar panels in Haiti limits the number of options and products to choose from. Although the cost of these panels are more expensive, it would be more effective to purchase them in country rather than importing them due to their size and weight. There are also options to purchase panels in bulk, which drops the unit price.

It is important to size power inverters correctly to optimize the solar panel system efficiency. The primary job of an inverter is to convert Direct Current power that the solar panels generate into Alternating Current power needed for the appliances in the house. A pure sine inverter as opposed to a modified sine inverter is necessary for optimal performance of most modern electronics (Solar Choice, 2019). The sizing 3000 W, 48 V inverter is more particular than standard inverter sizes. In order to avoid oversizing and overspending, it is recommended to import this inverter from out of country.

In choosing a charging controller for the batteries, there are options between a Pulse Width Modulation (PWM) and a Maximum Power Point Tracking (MPPT) controller. The PWM controller slowly lowers the amount of power applied to the batteries as the batteries get closer to fully charged, allowing the batteries to be fully charged with less stress on the battery. The MPPT controllers are more sophisticated and look at the output of the panels and compare it to the battery voltage. The controller then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to the best voltage to get maximum amps into the battery. This allows the charge voltage to be kept at an optimal level while the time required to fully charge the batteries is reduced, enhancing the use of the solar panel system. MPPT controllers also offer an increase in charging efficiency by up to 30% (Northern Arizona Wind & Sun, 2019). MPPT controllers are available in various sizes in Haiti, and would be more effective to purchase in country.

There are several battery types that can be used to store solar energy, the two most popular being Lead Acid and Lithium Ion. When comparing the two types, the three factors that were taken into consideration were cost, efficiency, and accessibility. Lithium Ion batteries have an advantage over Lead Acid batteries in that they do not suffer from deficit cycling. This is when the batteries cannot be fully charged before being discharged again the next day. The efficiency of the average lead acid battery is about 80%, while a Lithium Ion battery is around 95% (Northern Arizona Wind & Sun, 2019). Although the Lithium Ion batteries are more efficient, they are far more expensive and less accessible than the Lead Acid - Absorbent Glass Mat (AGM) Batteries. The Lead Acid Batteries store power efficiently, do not require any maintenance, and are easily replaceable. For these reasons, purchasing the AGM batteries in country to use in the solar panel system is the superior option.

Conclusion

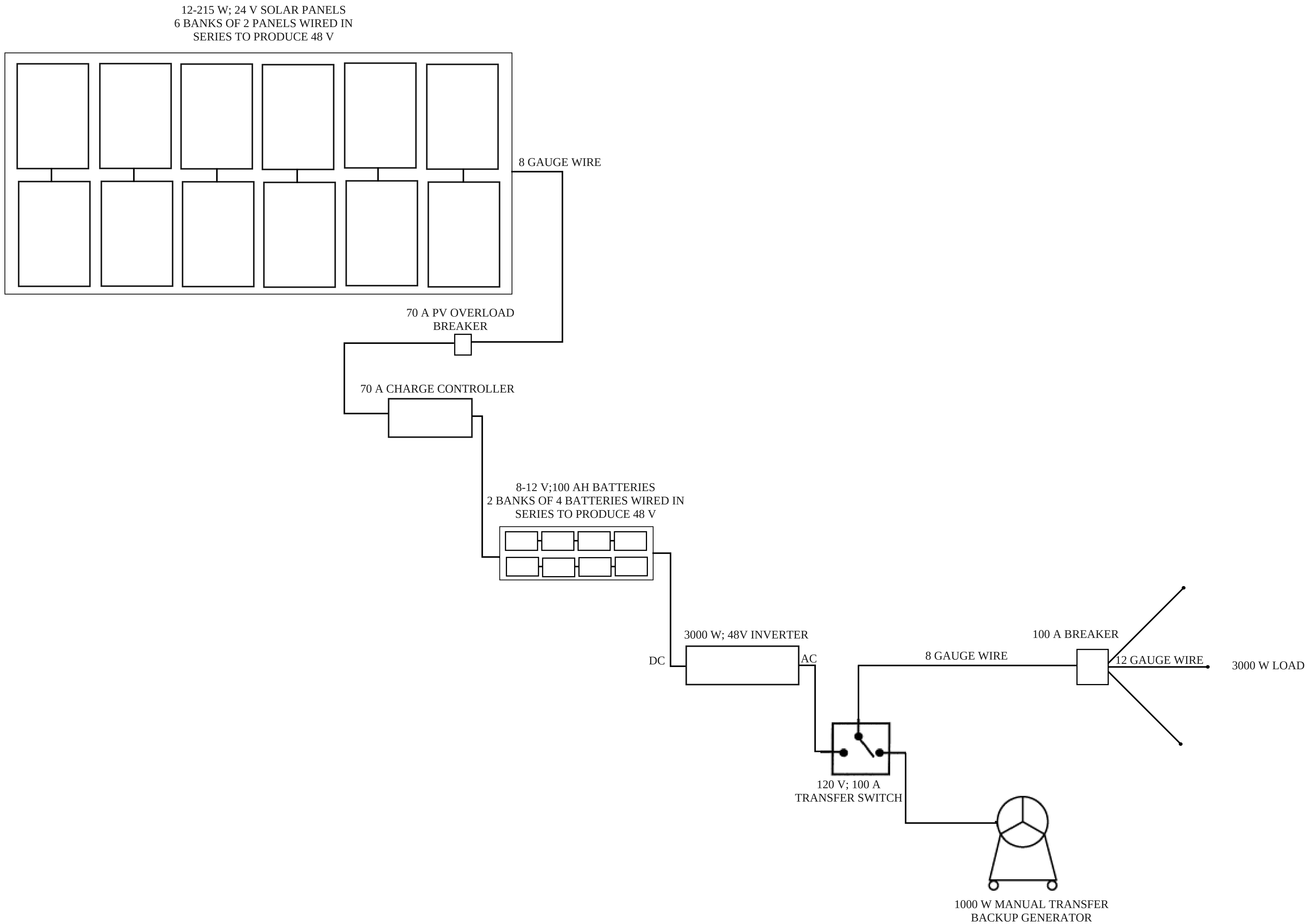
Expanding and improving access to electricity in Haiti is an ongoing process. Roughly 38% of Haitians have access to electricity, and even those with access, still experience frequent blackouts and unreliable power quality as stated by (Helping U.S. Companies Export, 2019). The potential for solar energy in Haiti is boundless, and has the opportunity to increase the countries resiliency, and promote prosperity. Designing a solar panel system that is self-sustaining, reliable, and efficient is the ultimate goal of this project. Giving families that reside in the transitional home access to reliable power is one of the many factors that will instill confidence and provide the resources they need to create a secure and stable future.

References

Helping U.S. Companies Export. Haiti Country Commercial Guide: Haiti - Energy. https://www.export.gov/article?id=Haiti-Energy (accessed May 6, 2019).

Solar Choice. Sizing inverters to optimize solar panel system efficiency. https://www.solarchoice.net.au/blog/optimizing-solar-panel-system-efficiency-through-inverter-sizing/(accessed May 8, 2019).

Northern Arizona Wind & Sun. What is Lithium Battery Technology? https://www.solar-electric.com/learning-center/batteries-and-charging/lithium-battery-technology.html(accessed May 15, 2019).



Transitional Home

Kasey Hetzel

CAL POLY SLO

DESIGNED BY: KH

SHEET TITLE:

SOLAR PANEL
SINGLE LINE
SCHEMATIC

Appendix
A