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Designing a Solar PV System for Tree 4 Hope

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Our Team

The Solar Photovoltaics (PV) team designs and installs solar electricity systems in developing countries where power is less reliable, non-existent, or very expensive. Starting in 2020, the Solar PV team began collaborating with Tree 4 Hope—a non-profit organization that partners with the Hogar Miguel Magone (HMM) Orphanage near Guatemala City, Guatemala. Over the past year, the team has designed a solar system to be installed at the orphanage which will provide them with a cleaner and cheaper source of electricity. Thus far, the overall 5 kW solar panel system design including lead-acid batteries has been completed. Key components of the system consisting of the system controller, two charge controllers and the inverter have been programmed and tested, by substituting them in to existing element modules of the solar lab system, in preparation for installation in Guatemala. This poster details the progress accomplished this year in the design, testing, and programming of the Solar PV system including design considerations and communication with in-country suppliers, for installation at the orphanage during May of this year.

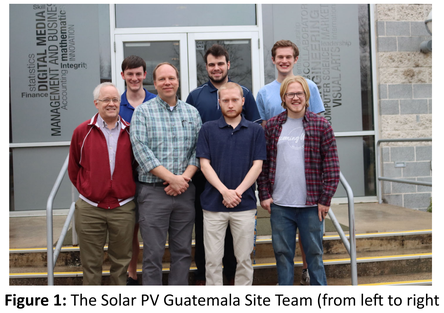

Figure 1: The Solar PV Guatemala Site Team (from left to right and back to front—Michael S., Christian P., Josh G., Harold U., Andy E., Noah R., Jonas K.)

Our Partner

The orphanage that Tree 4 Hope has partnered with ministers to many children through providing food, clothing, and hospitality to them. Additionally, since COVID-19 the HMM orphanage has also served as a makeshift school for the children. In partnering with HMM orphanage, Tree 4 Hope aids in sourcing the needed funds to operate the orphanage. In an effort to be better stewards of the money that is donated to the orphanage ways to reduce the cost of operation have been explored and utilizing solar power has been determined to be one such way to do so.

Our Partner's Need

The HMM orphanage receives power from the local Guatemalan grid. With the cost of electricity being high in Guatemala and the grid being occasionally unreliable, Tree 4 Hope and the orphanage have expressed interest in the benefits that a Solar PV system could provide for them. In an effort to help offset electrical bills, use a cleaner source of energy, and provide a more reliable source of power at the orphanage, the Solar PV team has designed a system for installation later this year.

Design Methodology

In order to design a proper Solar PV system for our partner, we had to follow a list of steps. A summarized version of these steps are described below:

- First, we estimated that by the orphanage's daily power usage, a 5 kW Solar PV system would need to be designed. We were able to determine that a 5 kW system would be sufficient by looking at the specifications of the appliances that the orphanage wanted to be powered by the Solar PV system, in addition to detailed descriptions of how, when, and how often they are being used.
- Next, as we were working with a small nonprofit charitable organization, that operates off of donations, we knew our budget wouldn't be limitless. Tree 4 Hope provided us their budget and we had to optimize a Solar PV system to work within the bounds outlined for us.
- Then, we had to request details of the orphanage's building plan (Figure 2). This is how we assessed our physical limitations of our design— where could we fit a system within their home that would be most optimal: lockable and inaccessible by the children of the orphanage as high voltages have the potential to kill, adequate ventilation so that the equipment doesn't overheat, and a place large enough to mount all of the equipment. We also needed to extrapolate with satellite imagery if the Solar PV system of their needs would even fit on their rooftop, which thankfully it will.
- Furthermore, we had to realize the differences in pricing and accessibility of certain equipment we were looking to buy for our system. In Guatemala, not everything that we originally were looking to purchase was available— and even if it was, it may have been far more expensive than it would be here in the very competitive American electronic goods market. Hence, we had to buy some materials locally in the United States, such as the power inverter and battery controllers. This also affected our budget as we had to adjust our design to compensate for the availability of certain components in Guatemala.
- We are in communication with multiple in country vendors. This will dictate what exactly the specifications of the system will be. However, we will adjust the components needed to ensure they will be acceptable to our partner.
- We also will look into optimizing some of their current lighting fixtures and making them more efficient, such as replacing old, inefficient incandescent bulbs with modern LED bulbs that use only a fraction of the power the old ones required.
- As the batteries are a very expensive part of the system, we will set them up to act depleted far above where they are actually totally discharged. A physical power "throw" switch will adjust between the Solar PV/battery bank system versus mains power.

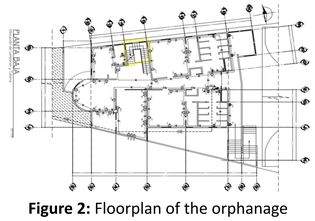

Figure 2: Floorplan of the orphanage

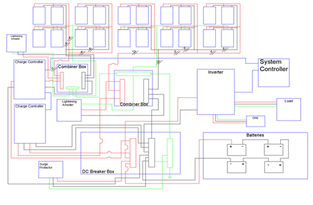

Figure 3: System Wiring Schematic

System Layout

There will be sixteen 330 watt solar panels on the roof of the building in strings of two. With this amount of panels on an average solar day they should be able to produce at least 5 kilowatts. The orphanage has a flat roof so installation and orientation of the panels should be simple, especially compared to previous installations conducted by the Solar PV team (Figure 4). The panels can be positioned nearly parallel to the horizon since the orphanage is at a point on earth that is much closer to the equator than we are in Grantham, Pennsylvania. However a slight angle will need to be added to allow for rainwater to flow off of them (Figure 5).The rest of the equipment will be mounted in a small spare room set aside by our partner underneath a stairway inside the building (Figure 6). This room was chosen intentionally as it can be secured to prevent undesired access and to help avoid accidental injury.

Figure 5: Panel Incline Mounting

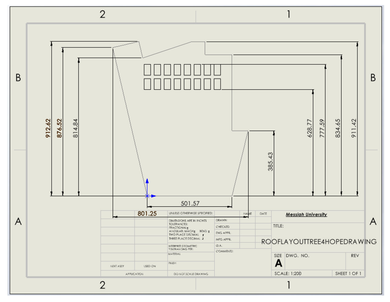

Figure 4: Solar Panel Layout

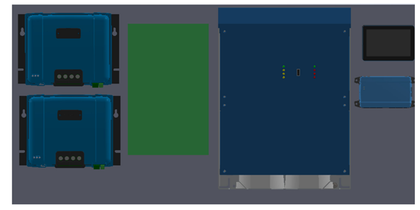

Figure 6: Control Panel Layout

Conclusions

The Solar PV team looks forward to traveling to Guatemala in May-June 2022 to install the Solar PV system and interact with the staff and children of the HMM orphanage. We are eager to see the impact it has on the mission of Tree 4 Hope and the day to day operation of the HMM orphanage.

Acknowledgements

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