Embry-Riddle Aeronautical University

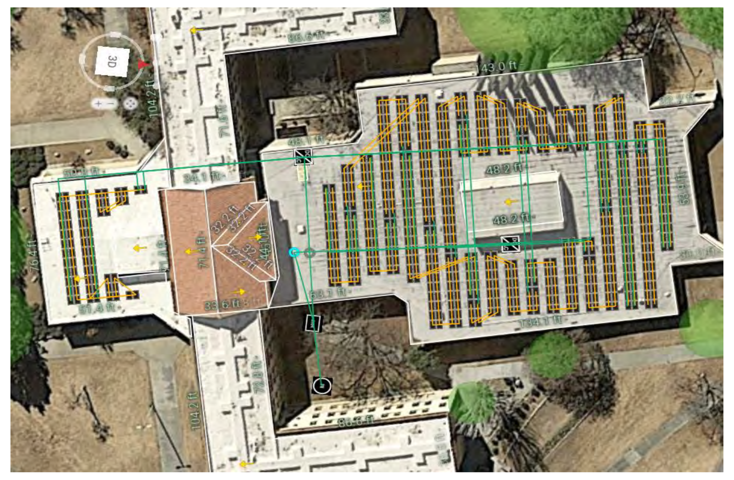
Mechanical Engineering

Discovery Day 2020

U.S. Department of Energy Competition: Solar District Cup

Project Requirements

The U.S. Department of Energy (DOE) is challenging groups to create a photovoltaic (PV) solar energy system for a district; districts are assigned to teams of their selection. The DOE provided constraint areas, the building load profiles in 15-minute intervals for 10 buildings on the campus for the year 2018, size and length of distribution wires, electric utility rate schedule, and a master plan for the district. The above picture gives an overhead view of the project working area for NMSU, along with a 29-acre open field zone for the construction of ground mounted solar panels (top left), we were assigned a block of the campus' main buildings (named on the bottom center), and a request for a creative design to be placed on or near the chancellors building (top right) are to be included in the design.



LIDAR (Terrain)

Irradiance Model

Designing the System

To design the PV system, a software tool called Aurora solar was utilized for the project. Using the software's built in Lidar function to model the height of the buildings and the location of obstructions such as trees and other buildings, we were able to locate where the solar cells could physically be placed. Then the Irradiance Model was generated to demonstrate what areas the solar panels will be effective and what areas were receiving less than ideal sunlight throughout the year. Referencing the Irradiance Model figure, the darker the area is on the rooftop, the less effective a panels placed in that location would be due to the lack of sunlight throughout portions of the day and year.

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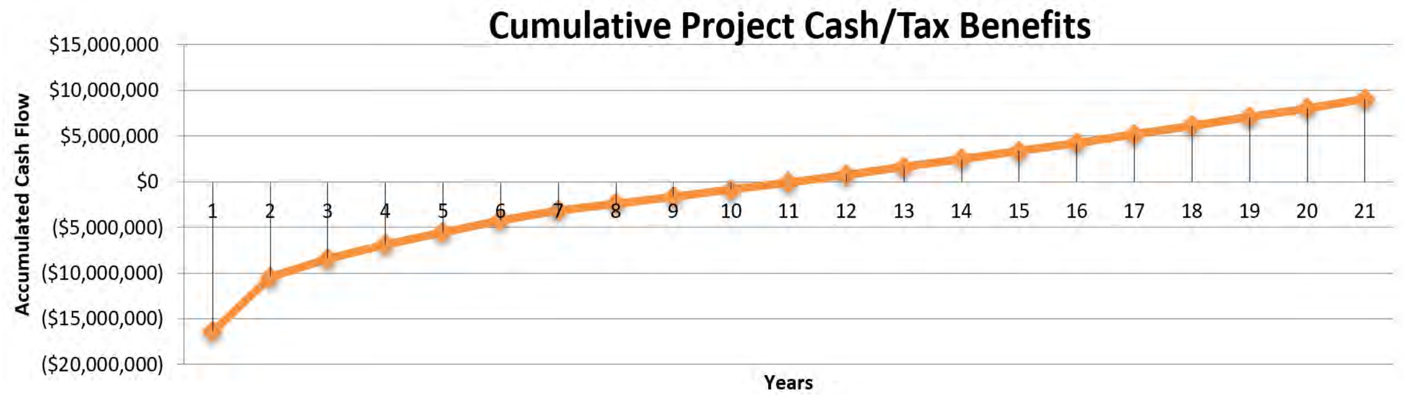
Abstract

The Solar District Cup is a two-semester design competition sponsored by the U.S. Dept. of Energy. For this competition, teams from across the nation are tasked with designing the most efficient and cost-effective solar plus storage system for a unique district case. The Embry Riddle team was tasked with designing such a system for New Mexico State University (NMSU) in Las Cruses, NM. During the first semester, the team's primary focus was on selecting the photovoltaic panels and equipment used, placing/wiring that equipment across the campus, and developing a plan that would finish construction of the system within 6-months. For this second semester our focus has been on how to incorporate an energy storage system that will allow NMSU to lower their daily peak demand charges without affecting the 6-month construction period, and, per the competition requirements, ensure that the entire project will be fully paid back within 25 years. Our results showcase our proposed design, with a focus on the benefits associated with installing such a system.

Finance

SAM Financial Analysis Model and Excel that is provided by NREL were used to analyze the cost and payback period

- Utilizes a 20 year Power Purchase Agreement
- NMSU is tax exempt
- System inflation is 2% per year and degradation is 0.5% per year
- Payback of the photovoltaic (PV) system complete in 11 years
- Total installation cost of the PV system is $14,103,375

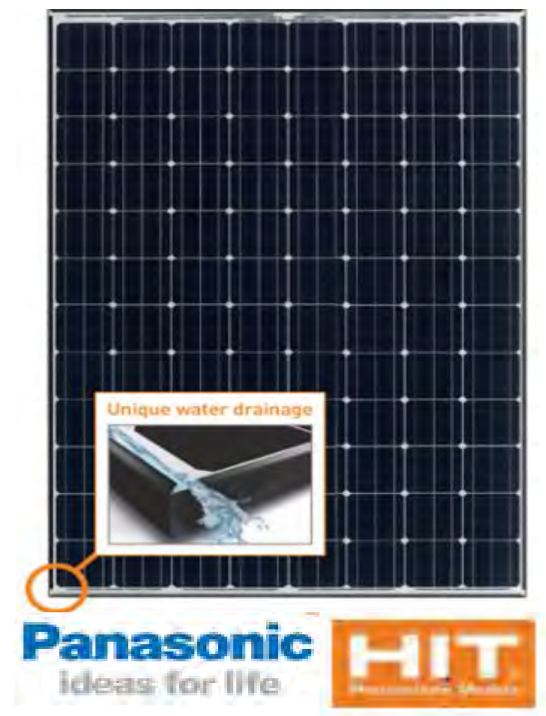


Development Plan

- Acquire State Building and Reroof Permit
- Acquire any Special Permits
- Valid license issued by CID (Construction Industries Division)

Building Area Selection

- Available Roof/Ground Area
- Distance to Energy Receiving Building
- Minimal shadowing area
- Satisfy the electrical loads requirement

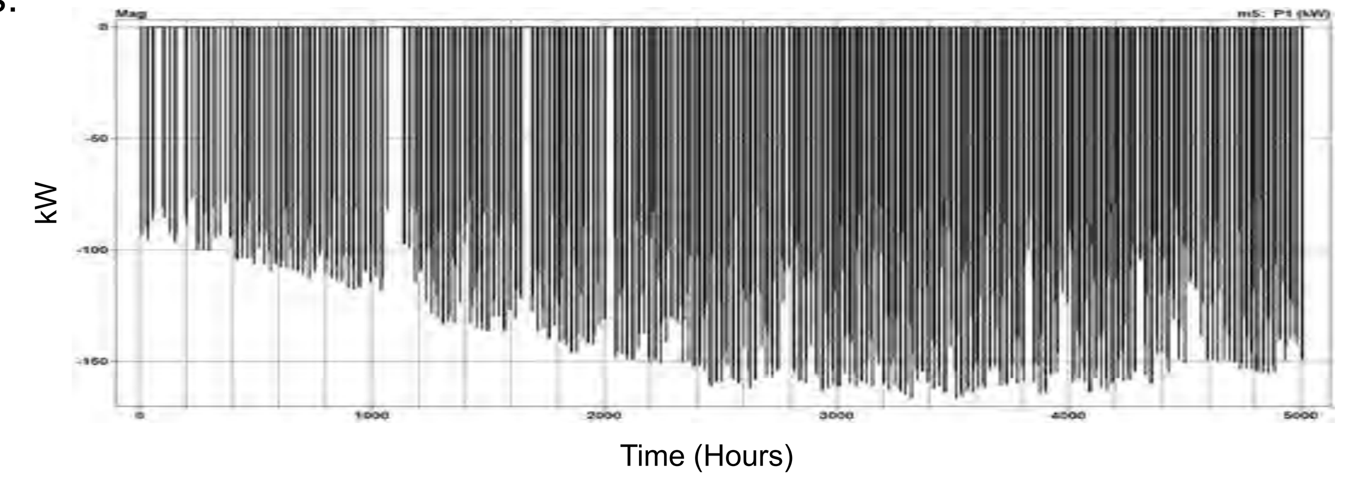


Equipment Selection

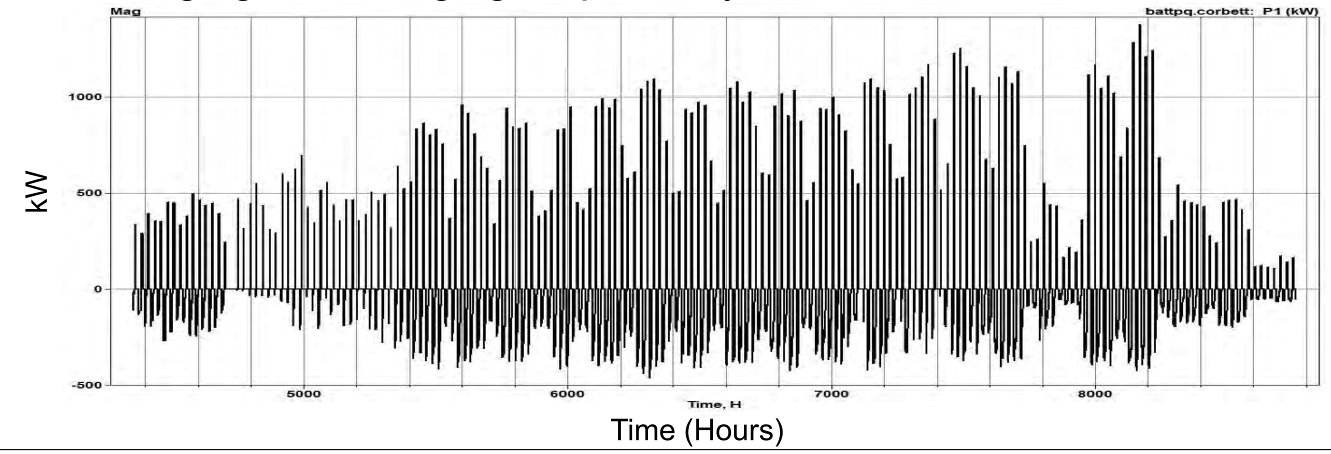
Prioritizing different factors contributing to the efficiency, cost, and performance of the design the following components were chosen. For the PV system, the Panasonic HIT N330 was selected throughout the design. The high panel efficiency and low degradation would provide a high energy output for the lifetime of the system as there is an expected useful life of 30 years. The goal of this system is to be efficient and have a low difference between performance in the first year and the final year of the PV system; end of useful life. For the Energy Storage System, the EOS Aurora 100|300 & 1000|4000 (kW | kWh) series of zinc-hybrid cathode batteries were selected. The relative low cost and high on-demand power output make this an acceptable option given the need for replacement in 14 years. The goal of this system is to lower the daily peak demand charges by storing energy for use at high demand periods.

System Evaluation

OpenDSS is a simulation tool used to estimate the impacts of the PV system connected to an electric utility power distribution system in terms of voltage, power and current. In order to verify if the system can receive such loads in specified areas, the simulation tool incorporates elements such as are wires, transformers, and solar panels in its calculation. The overall purpose is to demonstrate if there are system overloads on the grid from designing a PV system along with the predefined substation system. The below graph shows the power production of the designed PV system for 8 months.



In addition to this, the same evaluations were conducted on the battery to evaluate its performance. The below graph shows the power (KW) of one of the storage systems in the open field over 6 months; the negative and positive power values indicate that the battery is discharging and charging respectively.



U.S. Department of Energy

U.S. Department of Energy Solar District Cup Collegiate Design Competition

NREL National Renewable Energy Laboratory