Solar District Cup

Individual Analysis II

Daniel McConnell

2019-2020

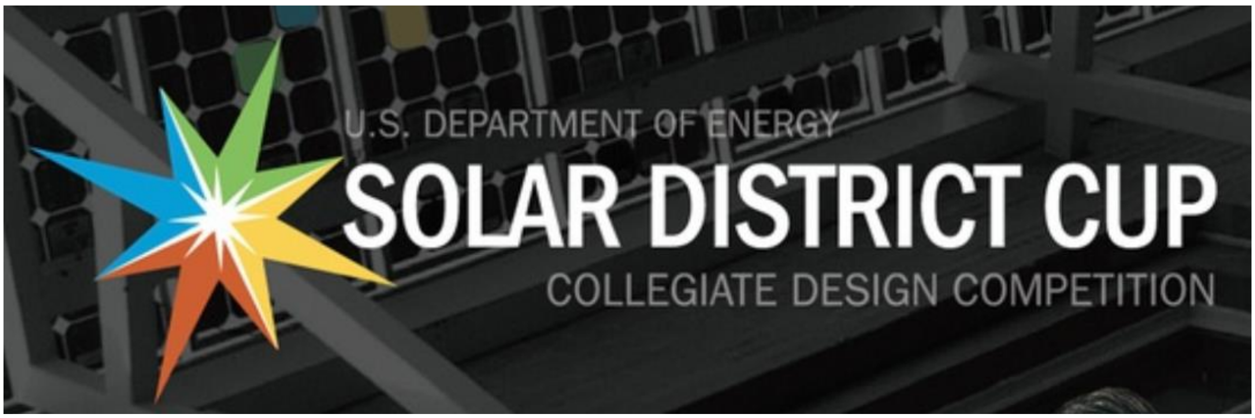

Figure 1: Solar District Cup Collegiate Design Competition

Project Sponsor: U.S. Department of Energy and National Renewable Energy Laboratory
Faculty Advisor: Dr. David Trevas
Instructor: Dr. Sarah Oman

Introduction

This year a competition is being held for the design of a solar generation system in three different districts. The NAU capstone team was assigned the New Mexico State University (NMSU) district for design. The goal of the project is to design a solar generation system within the boundaries of the district defined that maximizes the energy offset while also being the most financially viable. One problem the team is working on is modeling the creative design that is required for the competition. The team has decided to use Hantiles on Hadley Hall at NMSU so replicate the Spanish clay tile style of the building while also being solar. Solar Spanish tiles are very new to the market and so modelling them in the system advisory model or Aurora Solar is not possible, so I plan to analyze the energy production and cost of putting these panels on the Hadley Hall building.

Assumptions

There are several assumptions that are used in this analysis. The first is the dimensions of Hadley Hall, Aurora Solar was used to model the building getting the dimensions of the roof shown below in figures 2 and 3.

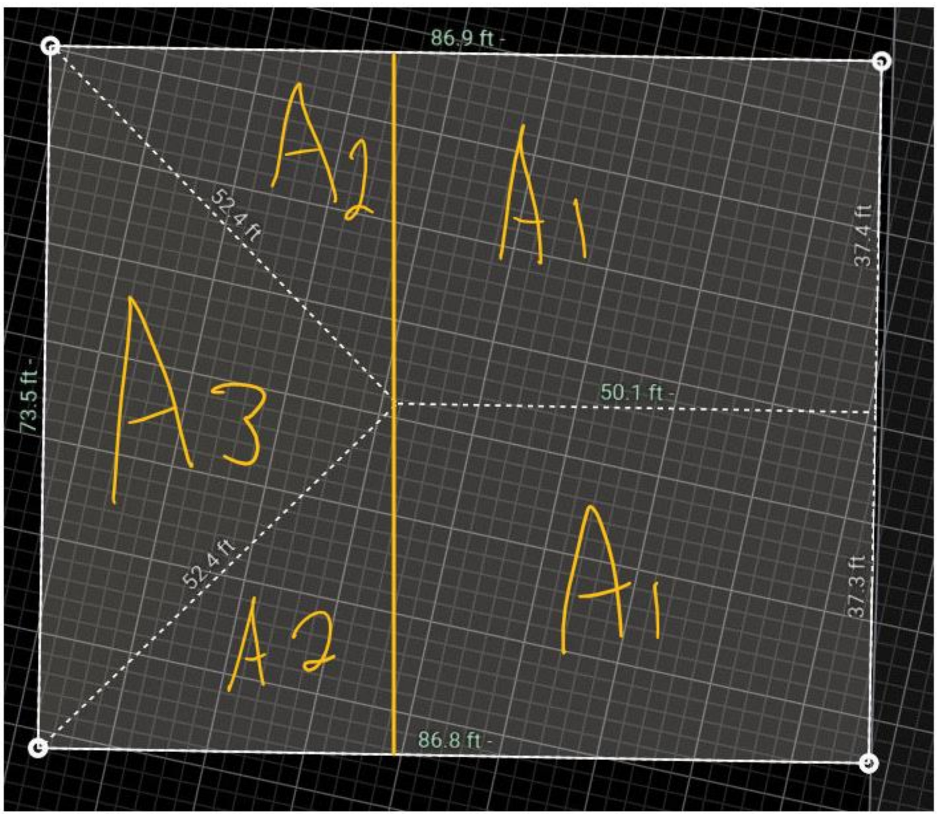

Figure 2: Hadley Hall roof 1

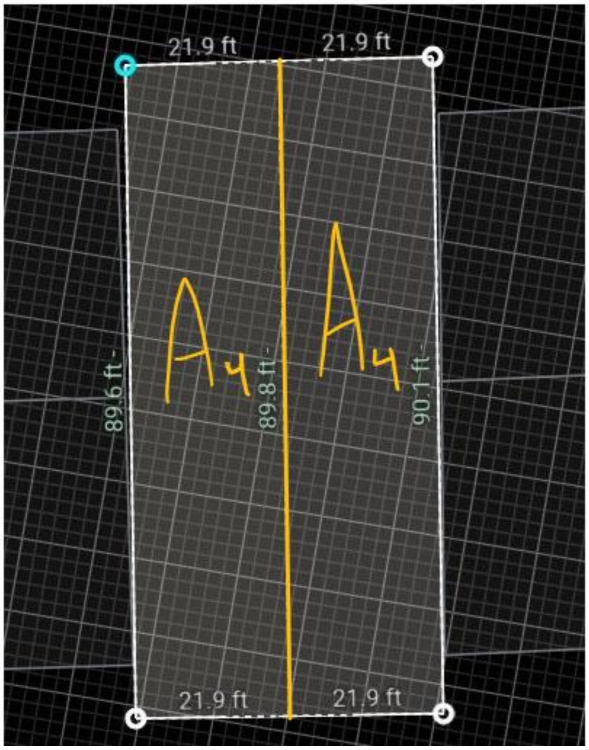

Figure 3: Hadley Hall roof 2

Figure 2 shows the western structure of the building and figure 3 shows the center structure of the building. The eastern structure was assumed to have the same dimensions as the western. Other assumptions made were the price and power of the Hantiles, the average hours of sunlight per day in New Mexico, and the construction loan interest rate. The cost of the Hantiles was assumed to be $185.5 and the power per area was assumed to be 105 W/m^2 [1] [2]. The average hours of sunlight per day was assumed to be 6.77 hours/day [3]. Lastly, the construction loan interest rate was assumed to be 5% [4].

Equations Used

The equations that were used in this analysis included equations for calculating the area of the roof, the annual energy production of the Hantiles, and the total cost of the project after 20 years. The first equations are quite simple, the area of a rectangle

$$A = L * W \tag{1}$$

Where A is the Area, L is the length, and W is the width of the rectangle. The next equation was the area of a tringle shown below.

$$A = 0.5 * L * W \tag{2}$$

For the annual energy production an equation was taken from energy sage shown in equation 3 below [5].

$$P * \frac{h}{day} * \frac{day}{year} = \frac{P}{year} \tag{3}$$

Where P is the total power of the system and h is the hours of sunlight. Lastly an equation was used to find the total cost after 20 years.

$$TC = \sum LAi * (1 + I) - Si \tag{3}$$

In this equation TC is the total cost of the system after 20 years, LAi is the loan amount each year, I is the interest rate, and Si is the savings each year.

Results

After performing this economic analysis, it was found that the total cost of the system after 20 years would be $1,046,799 highlighted in yellow in table 1 below. Seeing that the original cost of the project is about $500,000, the interest on the loan accumulates faster than the system can pay it off. This shows that the project is not financially viable on its own. This is not surprising because the cost of electricity for the campus is very low and the cost to buy and install the Hantiles is very expensive. The team expected this design to lose money, but the team wanted to know the cost of the project upfront and the energy production to be used in the financial model provided by the competition holders. The average annual energy production is 406,813 kWh and the initial cost of the project is $506,517.

Table 1: Results of Calculations

A1 (ft^2)	1871.235	Average Cost of electricity NMSU ($/kWh)	0.011547	Loan Amount	$ 506,517
A2 (ft^2)	687.225			Interest Rate for loan	0.05
A3 (ft^2)	1350.5625			Loan payments yearly	
A4 (ft^2)	1971				
Atotal (ft^2)	16876.965	Year	Money Saved that year	Loan total	
Atotal (m^2)	1568	1	$ 4,697.47	$ 506,517	
		2	$ 4,673.98	$ 527,145.14	
Price of tiles($/m^2)	185.5	3	$ 4,650.61	$ 548,828.42	
		4	$ 4,627.36	$ 571,619.22	
Total Cost of tiles ($)	$ 290,849	5	$ 4,604.22	$ 595,572.83	
		6	$ 4,581.20	$ 620,747.24	
Power (W/m^2)	105	7	$ 4,558.30	$ 647,203.40	
		8	$ 4,535.51	$ 675,005.28	
Total size of system (W)	164632	9	$ 4,512.83	$ 704,220.04	
		10	$ 4,490.26	$ 734,918.21	
Cost of installation ($/W)	1.31	11	$ 4,467.81	$ 767,173.86	
		12	$ 4,445.47	$ 801,064.74	
Cost to install system	215667.4895	13	$ 4,423.25	$ 836,672.50	
		14	$ 4,401.13	$ 874,082.88	
Total cost of system	$ 506,517	15	$ 4,379.12	$ 913,385.90	
		16	$ 4,357.23	$ 954,676.07	
Average sunlight hours per day	6.77	17	$ 4,335.44	$ 998,052.64	
		18	$ 4,313.76	$ 1,043,619.83	
Average production per day (Wh/day)	1114556.415	19	$ 4,292.20	$ 1,091,487.06	
Average production per year (kWh/year)	406813.0915	20	$ 4,270.73	$ 1,141,769.22	
				$ 1,194,586.94	
		Resale price	$ 58,169.86		
				Total Cost after 20 years	
		Total Money Saved	$ 147,787.75	$ 1,046,799.19	

Conclusions/Recommendations

This economic analysis shows how the Hantile design would perform by itself, and the results show that the project would lose the company money. Another analysis should be done using data from all the designs in order to see if the project would be financially viable. The team may not choose to use the Hantiles because they are not efficient and cost a high price. This new data will be discussed with the team and a decision made soon.

References

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