Solar District Cup

Project Sponsor:

U.S. Department of Energy

National Renewable Energy Laboratory

Faculty Advisor:

David Trevas

Mechanical Team:

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Daniel McConnell

Project Description: Review

What:

Design a photovoltaic solar energy and storage system for New Mexico State University that maximizes energy offset and financial savings over a 20 year time period [1].

How:

Assume the role of solar energy and storage developer to produce a proposal and analyze electric distribution grid interactions for district use [1].

Importance:

The U.S. is moving more towards renewable energy sources and solar is the most cost effective resource.

Project Updates:

Gained four new electrical engineering team members that will help analyze the transformers, batteries, and panel array.

Project Description: Sponsors

U.S. Department of Energy (DOE)

- Garrett Nilesen
- Shamara Collins

Figure 1: U.S. Department of Energy [2]

National Renewable Energy Laboratory (NREL)

- Sara Farrar
- Travis Lowder
- Joe Simon

Figure 2: National Renewable Energy Laboratory [3]

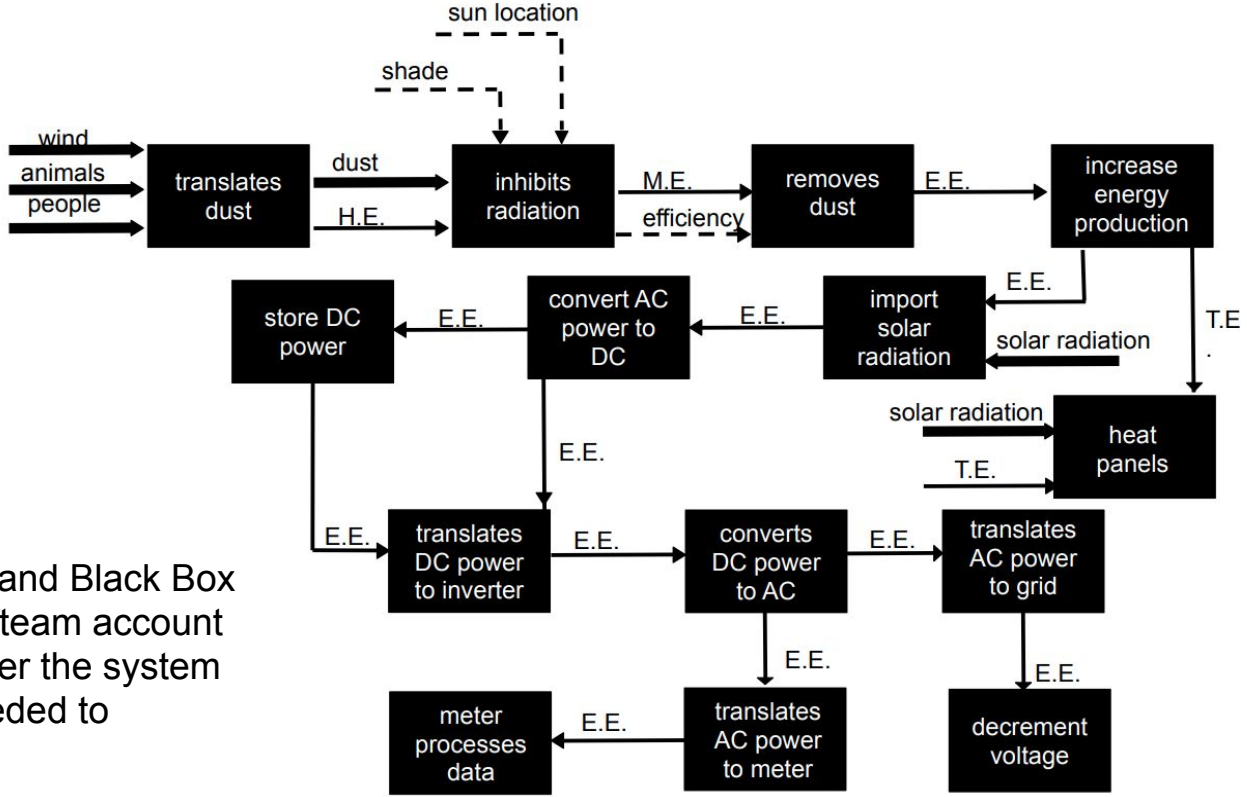
Aurora Solar is providing tools for system design. [1]

Project Description: Black Box Model

Figure 3: Black Box Model of System

The “system” being analyzed is the areas of NMSU considered for solar panel installation. This information was used to account for placement of panels.

Project Description: Functional Model



Functional Model and Black Box model helped the team account for what could enter the system and things we needed to account for.

Figure 4: Functional Model of System

Concept Generation: Location (1)

New Mexico State University

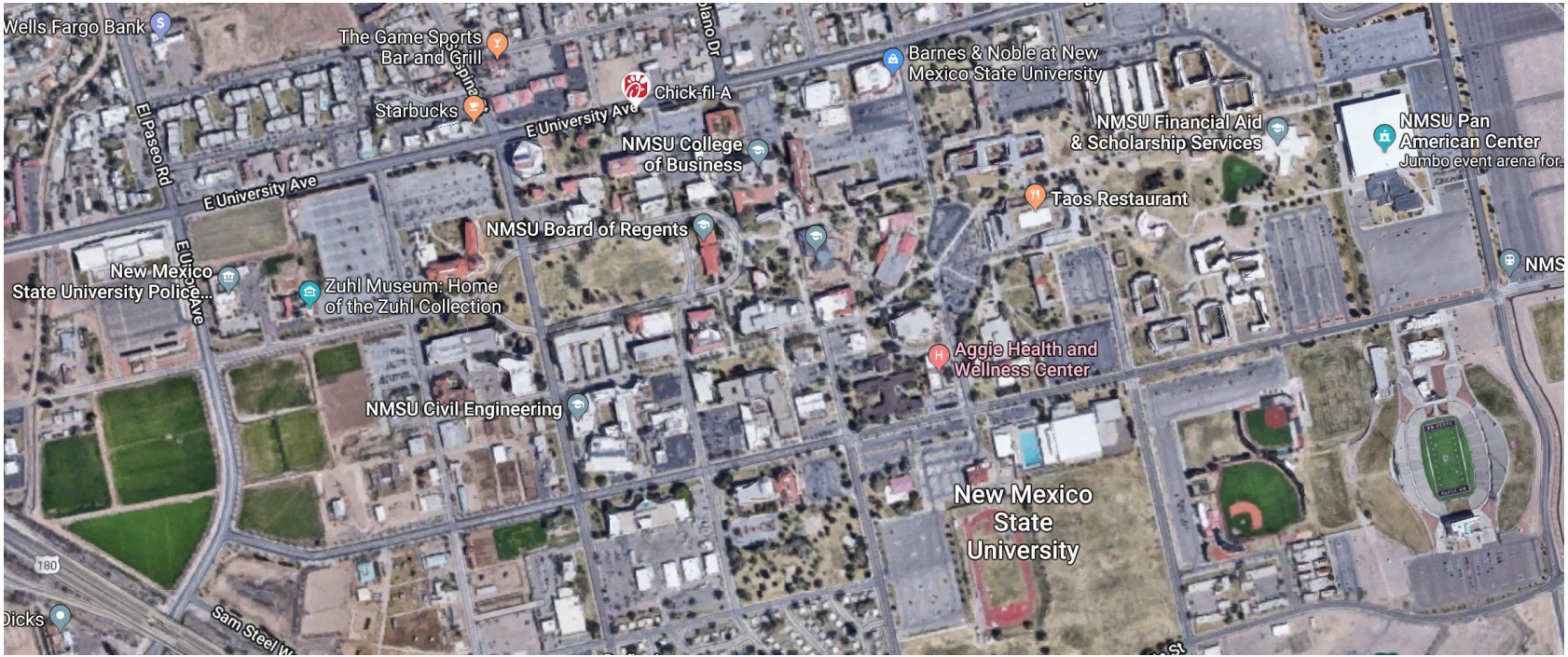


Figure 5: New Mexico State University [1]

Concept Generation: Location (2)

Given 3 different areas for Solar Development

1. Between S Locust St and S Espina St.
2. Land east of campus adjacent to the Geothermal Substation
3. “Horseshoe” Quad and Hadley Hall

Figure 6: NMSU corridor for solar development [1]

Figure 7: Ground space available, east of NMSU campus [1]

Figure 8: The Horseshoe Quad and Hadley Hall [1]

Concept Generation: Overview (3)

Location 1: Between S Locust St and S Espina St.

Figure 6: NMSU corridor for solar development [1]

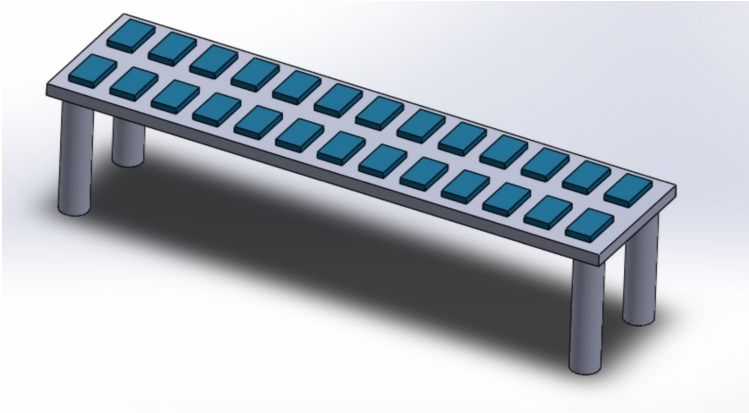


Figure 9: Solar paneled parking shade

Advantages: shaded parking, avoids issues with structural integrity of roofs

Disadvantages: must pay for structure to be built and maintenance is difficult

Concept Generation: Overview (4)

Location 2: Land east of campus, next to the Geothermal Substation

Figure 7: Ground space available, east of NMSU campus [1]

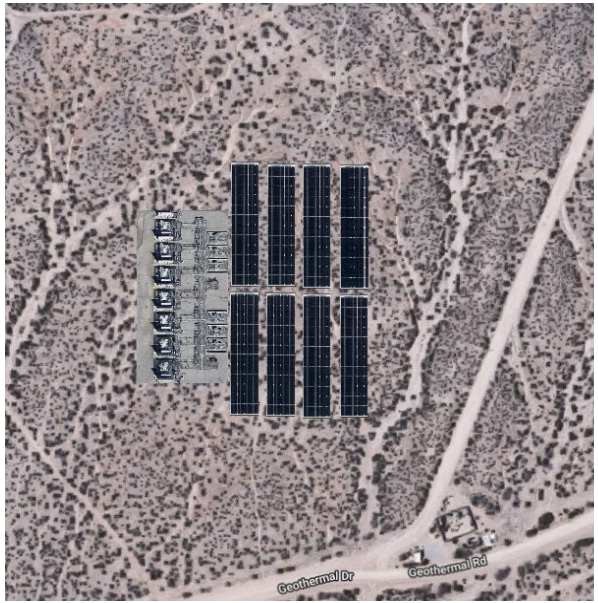


Figure 10: Sun Tracking Solar Development

Advantages:
high power output, minimal human interaction, and easily accessible

Disadvantages:
high installation cost, disturbs wildlife, and higher power loss due to energy translation to campus

Concept Generation: Overview (5)

Location 3: The Horseshoe Quad and Hadley Hall

Advantages: easy installation and does not obstruct the quad

Disadvantages: lower power output and accessibility

Figure 8: The Horseshoe Quad and Hadley Hall [1]

Figure 11: Solar street light

Concept Evaluation: Decision Matrix

Table 1. Decision Matrix

	Weight	Jett Hall	American Center	Science Hall	Zuhl Library	Parking Shade	Streetlight	Trash Can	Bench Awning	Dirt Lot - Fixed	Dirt Lot - Solar Tracking	Dirt Lot - Concentrated	Branson Hall Library
Intallation Price	4	3	1	3	4	1	4	1	3	2	2	1	3
Net Energy Produced (kWh)	5	4	5	2	1	3	1	1	1	4	5	5	2
Aesthetics	2	5	5	5	5	5	4	5	5	2	2	2	5
Safety	4	3	3	3	3	4	5	5	4	4	4	1	3
Maintenance	3	2	1	3	4	2	3	5	4	2	2	1	3
Accessibility	3	4	4	3	4	3	1	5	4	5	5	5	5
Ethics	3	5	5	5	5	5	5	5	5	3	3	3	5
Lifespan	3	5	5	5	5	5	4	4	5	5	5	5	5
Distance from Distribution	2	3	3	5	5	3	3	3	3	2	2	2	4
Dust Accumulation	2	4	5	4	4	3	5	3	3	1	1	1	4
Weighted Sum > 100		116	112	110	115	102	104	108	109	99	104	85	114

Because it is more than one design being considered, the decision matrix evaluated concepts and eliminated the concepts with the lowest cumulative weighted points as opposed to narrowing the selection down to one design.

From the decision matrix, the team decided to rule out fixed solar panels and concentrated solar panels in the dirt lot off of campus as potential panel systems.

Concept Evaluation: SAM

Jett hall building, highest score on decision matrix

- Large area, on campus,
- Large flat roof
- No adjacent obstructions
- Used system advisory model to estimate production [4]

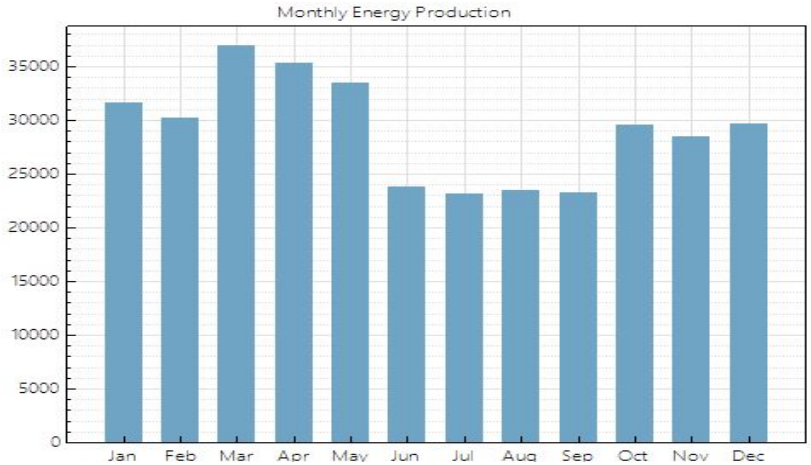


Figure 12: Monthly energy production of the Jett Hall Building

- Tested 1000m^2 area
- Polycrystalline cells
- MPPT inverter

Figure 13: Jett Hall with proposed solar panel layout

Concept Evaluation: SAM

- Lots of open space
- SAM with same panels and inverters
- Solar tracking
- 2000m^2 area

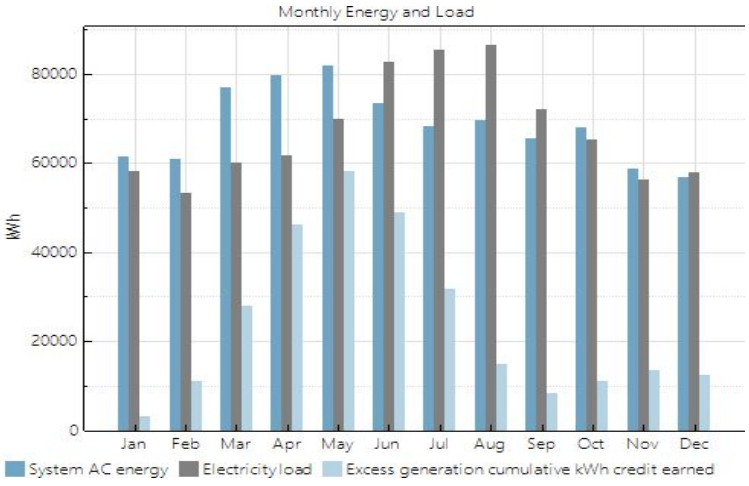


Figure 14. Desert Concept Monthly Energy and Load

- Will need to level
- 3 mile transportation distance
- Is there wildlife?
- Need to connect to grid

Figure 10: Sun Tracking Solar Development

Concept Evaluation: Customer Requirements

Dirt lot should create enough energy production for the entire campus

- Solar tracking can increase our production by up to 30% [4]
- Minimizes inverter losses with MPPT
- Accounting for peaks
- Battery storage solution

Dirt Lot alone meets the three primary customer requirements:

1. Only uses PV cells and batteries
2. Offsets annual energy and power consumption
3. Financial savings over 20 years

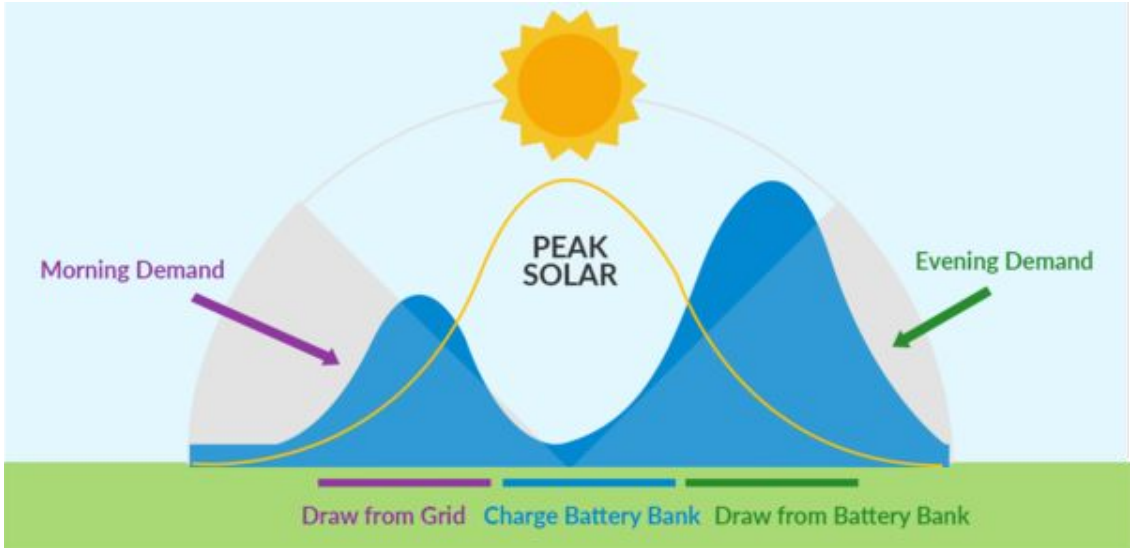


Fig.15. Peak Solar vs Demand [5]

Budget Planning: Tentative BOM

Table 2: Costs of Solar Panels of Jett Hall

Cost for Jett Hall						
	Uint Cost	# of Units	Total Cost			Cost
Panels	$ 110.23	693	$76,388.70		Permit	$24,007.88
Inverters	$ 3,637.56	6	$21,825.34		Land	$ -
					Labor	$30,555.48
					Installer overhead	$21,825.34
					Balance of Equipment	$65,476.03
	Tax	$ 7,527.91			Contingency	$ 8,642.84
	Total Cost	**$256,249.52**				

Budget Planning: Tentative BOM

Table 3: Costs of Solar Farm on Open Land

Cost for Solar Farm on Open Land						
	Uint Cost	# of Units	Total Cost			Cost
Panels	$ 110.23	1404	$154,761.52		Permit	$ 48,639.40
Inverters	$22,108.79	2	$ 44,217.58		Land	$ -
					Labor	$ 61,904.61
					Installer overhead	$309,523.03
					Balance of Equipment	$132,652.73
	Tax	$ 24,494.59			Contingency	$ 28,122.38
	Total Cost	**$804,315.84**				

Budget Planning: Budget

Available Dollars: TBD

Anticipated Expenses: $4095 + taxes

- Travel
  - **Driving**
    - Flagstaff, Az to Phoenix, Az $50
    - Phoenix, Az to Flagstaff, Az $50
  - **Flights**
    - Phoenix, Az to Atlanta, Ga
      - 8 Tickets @ $365 each + taxes
  - **Hotel**
    - Atlanta, GA
      - 2 Nights, 4 Rooms @ $1000 total

Potential Prototyping: $75

Expenses to Date: $0

Resulting Balance: TBD

Works Cited

[1] Herox, "Solar District Cup," HeroX, 2019. [Online]. Available: https://www.herox.com/SolarDistrictCup. [Accessed 13 09 2019].

[2] GroupNIRE, "DOE-LOGO-WHITE," GroupNIRE, 2017. [Online]. Available: https://groupnire.com/home/doe-logo-white/. [Accessed 17 September 2019].

[3] NREL, "About NREL," NREL, 2018. [Online]. Available: https://www.nrel.gov/about/. [Accessed 17 September 2019].

[4] National Renewable Energy Laboratory, "Systam Advisor Model," National Renewable Energy Laboratory, 2019. [Online]. Available: https://sam.nrel.gov/. [Accessed 16 September 2019].

[5] C. Morris, "TESLA ENERGY: HERE'S WHY GRID STORAGE WILL BE HUGE - ON BOTH SIDES OF THE METER," Evannex, 29 August 2017. [Online]. Available: https://evannex.com/blogs/news/why-grid-storage-will-be-huge-on-both-sides-of-the-meter. [Accessed 10 October 2019].

Questions?