University of Nebraska-Lincoln District Solar Photovoltaic Technical and Economic Feasibility Analysis

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U.S. DEPARTMENT OF EMERGY
SOLAR DISTRICT CUP
COLLEGIATE DESIGN COMPETITION

ILLINOIS STATE UNIVERSITY
Illinois' first public university.

UNIVERSITY OF Nebraska Lincoln

INTRODUCTION

The Solar District Cup (SDC) Challenges multidisciplinary student teams to design and model solar photovoltaic (PV) energy systems for a district, encouraging them to engage in the engineering, urban planning, and financing aspects of solar arrays. The SDC is directed by the National Renewable Energy Laboratory (NREL) and is funded by the U.S. Department of Energy (DOE).

Over the past year, the competition team at ISU has modeled the solar systems, financials, and distribution of 13 buildings on the University of Nebraska –Lincoln campus, following NREL and DOE guidelines to present our efforts at an industry conference on April 25-26, 2021.

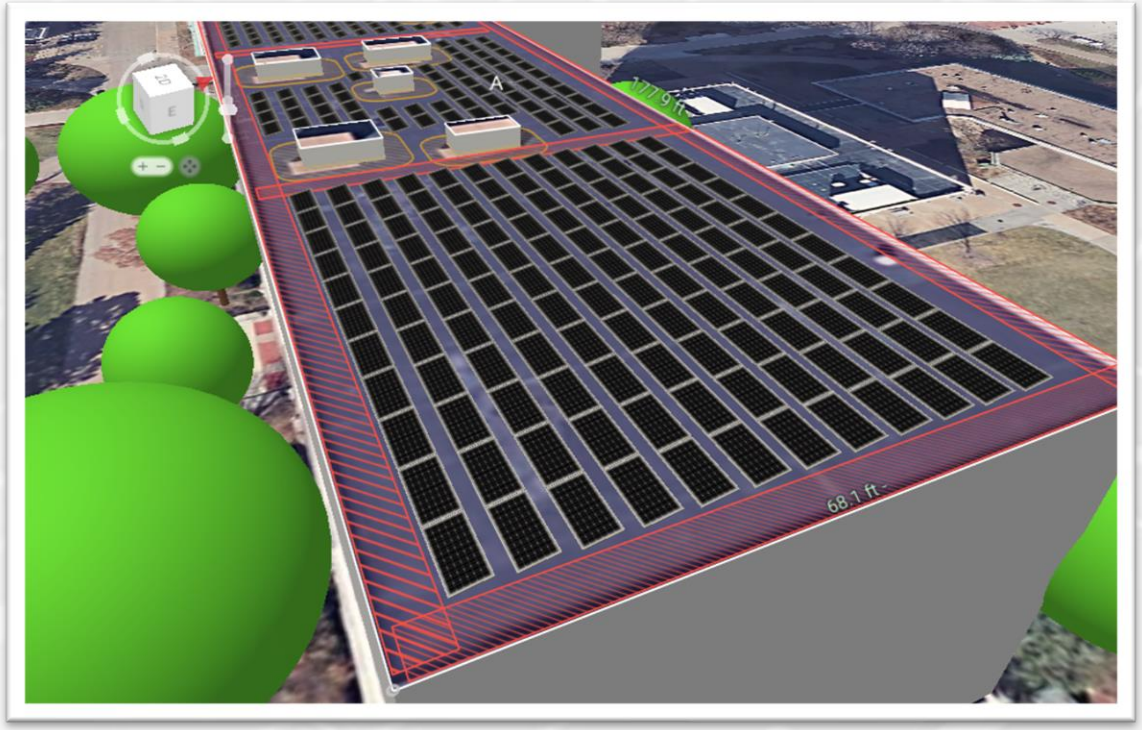


Figure 1: Burnett Hall, Astronergy Modules at 10° tilt and 180° orientation, designed in Aurora.

OBJECTIVE

- These systems will integrate solar photovoltaic (PV) technology across a collection of large buildings on the UNL's City and East campus. The Animal Science Solar Array (Figure 2) will feature a battery storage system that supports a 30% critical load totaling $2,000,000 USD worth of assets.
- The financial analyses will be financed through Power Purchase Agreements (PPA) to eliminate large upfront investments by the university. This PPA must have an attractive Internal Rate of Return (IRR) for investors, along with a $/kWh less than traditional utility rates.
- The systems' distribution will perform at an optimal voltage and not cause any negative impacts on the transformers or electric grid.

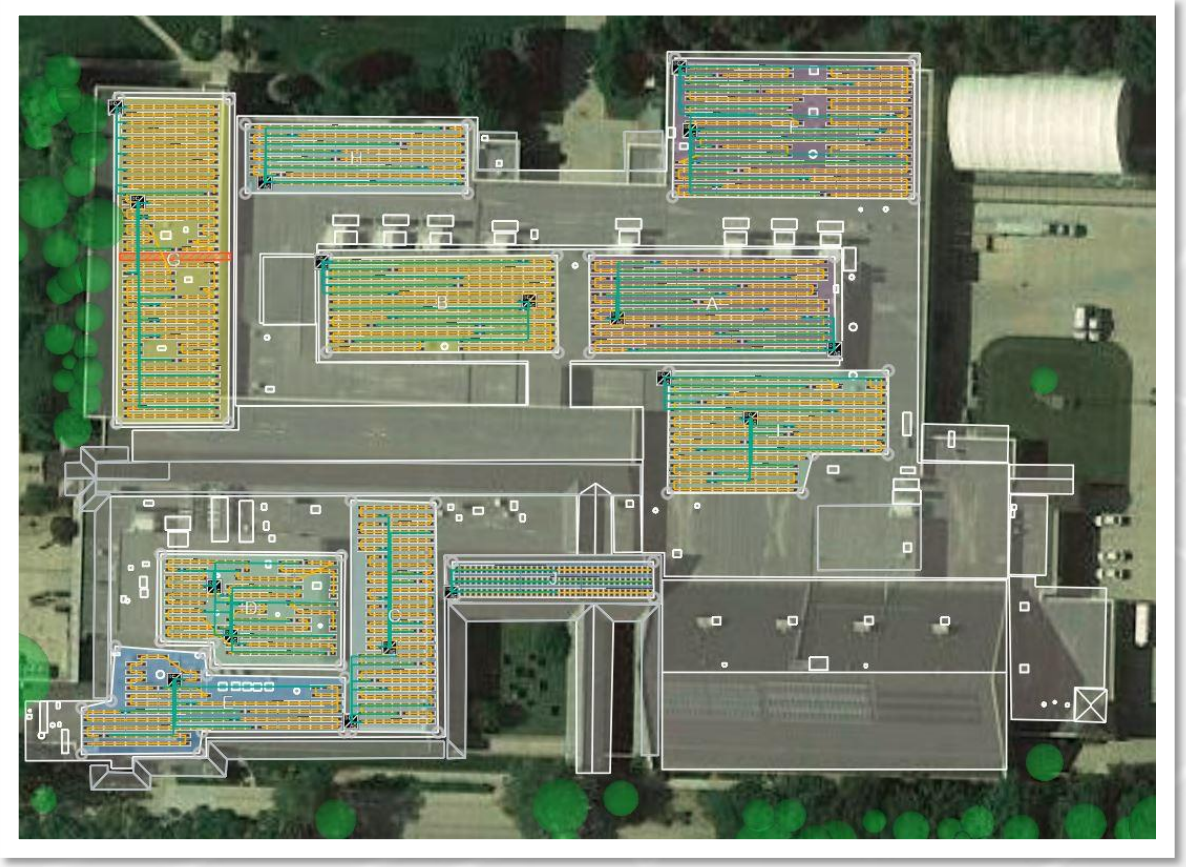


Figure 2: Animal Science Building with battery storage designed in Aurora and ReOpt Lite

METHODOLOGY: DESIGN

Roof (11 systems): 10° tilt, 18-inch row spacing, 0.5-inch module spacing

Carport (4 systems): 10° tilt, 2-foot row spacing, 0.5-inch module spacing

Agrivoltaic (1 system): 45° tilt, 20-foot row spacing, 0.5-inch module spacing, 15% field coverage density, (2) 10-foot, (1) 8-foot racking height.

Created in Aurora & Helioscope solar design software.

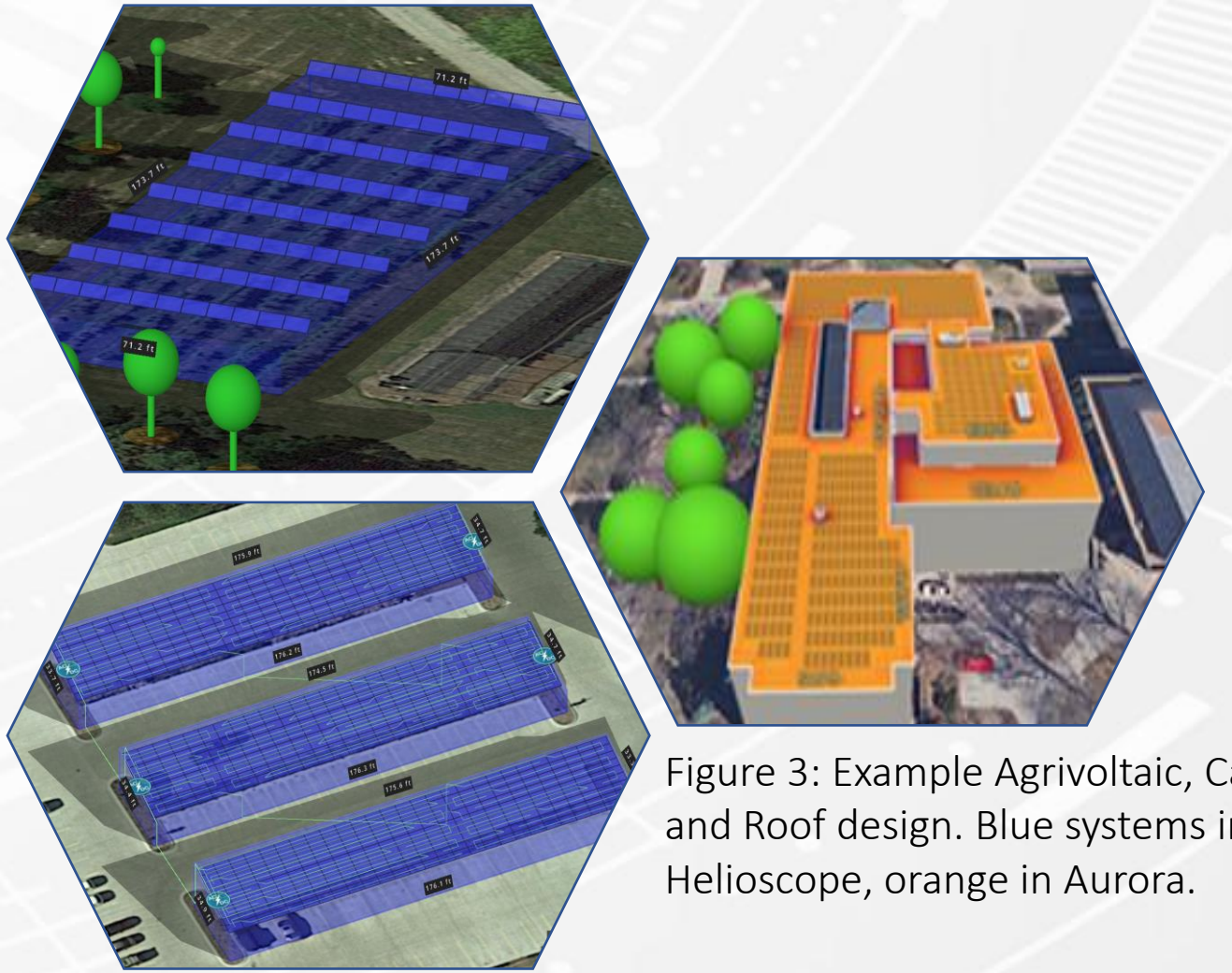


Figure 3: Example Agrivoltaic, Carport and Roof design. Blue systems in Helioscope, orange in Aurora.

METHODOLOGY: FINANCIAL

Baseline assumptions for the financial analyses are as follows:

- Utility price of $.15 per kWh
- $0 property tax
- Sales tax already expressed
- 27% corporate tax rate
- Developer margin is 10%
- PV life is 30 years
- PPA life is 20 years
- System degradation is .5%
- Inflation is 2%

(Solar District Cup Rules. 2020)

Building	$/kWh	IRR%	$/kWh*	IRR%*
Animal Science Building	$0.080	8%	$0.076	7.47%
Barkley Memorial	$0.087	8%	$0.083	7.49%
College of Dentistry	$0.074	8%	$0.070	7.48%
CY Thompson Library	$0.075	8%	$0.072	7.51%
Forestry Carport	$0.069	8%	$0.066	7.46%
KCR Carport	$0.072	8%	$0.069	7.47%
Agrivoltaics (LAW)	$0.067	8%	$0.064	7.47%
Nebraska East Union	$0.089	8%	$0.085	7.48%
Plants Science Hall	$0.073	8%	$0.070	7.49%
Andrews Hall	$0.080	8%	$0.076	7.42%
Burnett Hall	$0.079	8%	$0.076	7.58%
Louise Pound Hall	$0.077	8%	$0.074	7.46%
Love Library	$0.080	8%	$0.077	7.49%

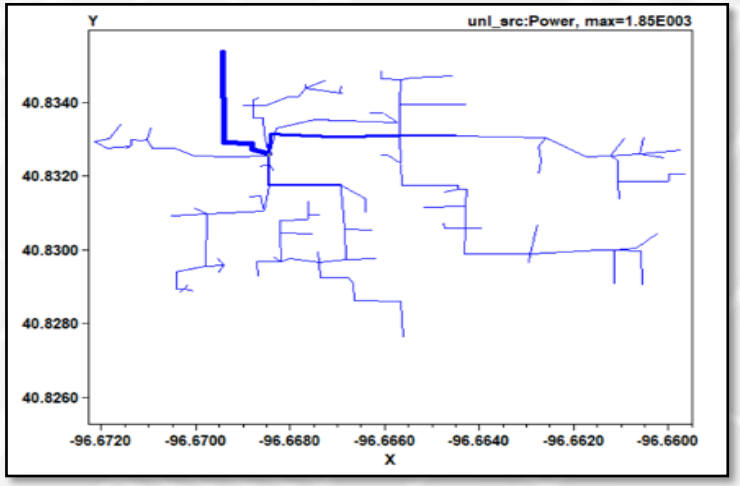
Figure 4: First two columns show values at $1 NPV, second two columns show values at max IRR. (Lord, C. 2020)

METHODOLOGY: DISTRIBUTION

Analyses were performed on all proposed designs for the UNL East Campus utilizing OpenDSS software. We coded the PV systems to incorporate their loads into the UNL distribution system. The studies examined:

- System size, DC/AC ratio, and battery storage solutions
- Systems' voltage loads at transformers connections
- Implementation of smart controls and solutions

Figure 5: Heat map for the baseline simulation of the UNL distribution system.



(Latif, A. 2021)

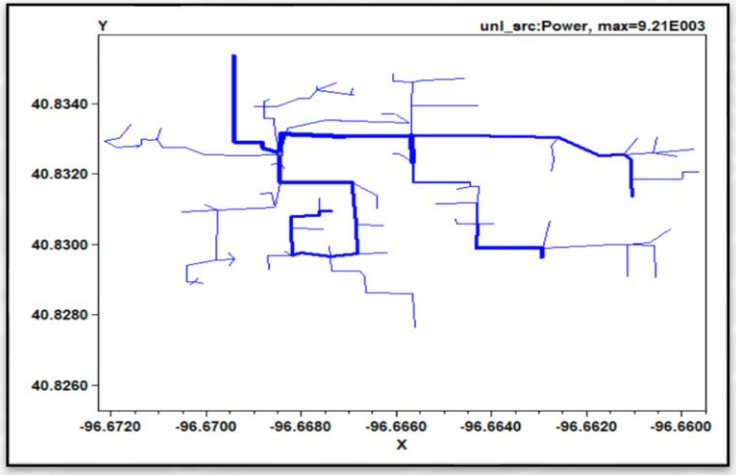


Figure 6: Baseline simulation of UNL's distribution heat map displaying transmission lines and nodes.

RESULTS

Building	System Size (kW)	Production/Year (kWh)	Energy Offset %	NPV of Customer Savings
Animal Science Complex	806.2	1,112,160	19.7%	$1,080,585
Barkley Memorial	141.3	162,778	33.3%	$145,925
College of Dentistry	604.8	878,369	36.3%	$911,517
CY Thompson Library	179.4	250,733	32.0%	$256,962
Forestry Carport	134.3	196,973	88.5%	$215,439
KCR Carport	55.5	80,520	64.9%	$85,211
Agrivoltaics(LAW)	387.6	589,125	48.6%	$654,908
Nebraska East Union	201.7	228,061	23.6%	$203,900
Plant Science Hall	385.4	557,461	37.8%	$582,586
Andrews Hall	110.6	141,474	47.0%	$138,006
Burnett Hall	122.8	156,678	40.0%	$156,853
Louise Pound Hall	181.3	238,410	76.0%	$255,942
Love Library	438.4	553,454	24.0%	$534,773

CONCLUSION

Energy & Emission Offset

The yearly energy consumption of all the given buildings combined equates to 24,528,851 kWh or 24.5 GWh. Our designs produce 5,146,196 kWh or 5.1 GWh per year. Our designs will offset 17% of the yearly consumption and emissions for UNL. This will save UNL $251,430.35 at NPV annually while offsetting 3,535 tons of carbon emissions annually (US EPA, 2021).

Fossil Fuel Offset

411,695.68 gal of oil

38,493,546.1 ft^3 natural gas

5,660,815.6 lbs of coal

(EIA, 2021)

REFERENCES

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