2021 Onsite Photovoltaic Analysis for Montana State University

Bozeman, MT

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MSU Engineering and Utilities

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EXECUTIVE SUMMARY

Alternative energy is critical to the electrification goals of Montana State University (MSU) as it pursues the new climate action plan and net neutrality goals. This project undertook an analysis of photovoltaic (PV) solar arrays within the boundaries of the MSU campus; it is expanding upon a couple of other previous analyses of solar efficacy. The goals of this project were to determine the challenges and opportunities associated with solar PV in the winter climate, to explore dual-use opportunities for solar arrays, and to learn more about what makes a solar project successful.

Through structured interviews of key MSU stakeholders, and through research of crucial topics, this project developed a set of recommendations for future solar projects that would benefit the MSU campus and the Bozeman community. Project recommendations were divided into scope 1 projects that will change direct campus emissions, and scope projects that will influence other cultural habits and reduce indirect emissions.

It was determined that the Brick Breeden Fieldhouse parking lot, as well as the MSU Holding Pond were ideal candidates for scope 1 solar installations while not compromising the usage of any space on campus. Furthermore, these projects have the potential to improve these spaces for the MSU community. In terms of scope 3 projects, it was determined that solar bus stops, walkways, sidewalks, and compactors have the potential to not only improve the usability of campus, but also generate energy and awareness for sustainability on the MSU campus. Overall, investing in these projects will improve MSU campus while also improving our precious environment.

PROJECT DESCRIPTION

Background

As Montana State University (MSU) continues to advocate for more sustainable operations, electrification and increased low carbon site generation are necessary to achieve net zero emissions. While MSU campus has small solar photovoltaic (PV) arrays[1] (Norm Asbjornson, Jabs, SUB[2], etc.), there is still an immense opportunity to expand this across campus. Alternative energy will be key to achieve the MSU carbon neutrality goals as natural gas infrastructure is removed.

First, in 2018 MSU Engineering & Utilities completed a preliminary assessment of campus via student work.[3] This analysis identified rooftops across campus where photovoltaic arrays could be placed along with an in depth financial and technical analysis of solar panel options. This report concluded that only rooftops designed with solar in mind are feasible options for future installment without significant retrofitting; this includes Jake Jabs Hall, Yellowstone Hall, and any new construction. Similarly, Beartooth lighting and design conducted a solar PV analysis in June 2021. This report determined that a façade array on the South side of the garage would be economically ineffectual, while a rooftop array would be feasible and generate nearly 1 MW.

In concurrence with the current revision of the MSU climate action plan, there is opportunity to expand upon this initial study. Through initial conversation and review of the previous study, areas of interest include the parking garage, the large area parking lots behind the Brick Breeden Fieldhouse, and the outer campus walking paths. However, the initial study uncovered many questions that remain, including how to connect large PV arrays to the MSU electrical grid, financial mechanisms to fund larger projects, how to install covered parking PV in winter climates, and what additional areas of campus could be utilized.

Finally, the installation of solar on campus has the unique opportunity to influence the culture of MSU students. As other greenhouse gas (GHG) initiatives are proposed, solar installments provide the visible proof of a reduction in emissions; this artifact has the potential to bring more attention to invisible mechanisms of climate change. As MSU continues to push for more sustainable operations, analysis of PV options on campus is crucial to the success of the electrification movement.

The primary research question for this project was as follows: what are the challenges and opportunities associated with the installation of covered parking in the MSU winter climate? Supplemental questions include: 1) What are the issues with utilizing PV to serve dual purposes on campus (i.e. covered parking, walkways, solar sidewalks, etc.), and 2) What factors influence economic, functional, cultural, and safety associated with PV systems?

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[1] https://www.montana.edu/sustainability/programs_and_projects/leed_certified_buildings.html
[2] https://www.montana.edu/pdc/archive/2012/sub-solar-array-installation.html
[3] Unpublished work available from author; Aaron Juntunen, MSU – Bozeman Photovoltaic Study, Summer 2018; Email: Aaronjuntunen@montana.edu

Stakeholder Needs Analysis

This project, if successful, will help to evaluate the most prudent PV locations and applications. First, MSU Engineering and Utilities will directly benefit from the expansion of the preliminary PV report and possible next steps. In particular, Duke Elliot and Megan Sterl oversaw this project and provided the key questions that Engineering and Utilities wanted to see answered.

The next stakeholder is MSU Facilities Services. The installation of solar would directly impact the ecosystem of campus, the snow removal needs, and the maintenance needs. Facilities was included in the decision-making process by determining their goals and vision for the campus. Other direct stakeholders included the solar installers, lighting installers, and the designers of the solar arrays. MSU engineering and utilities had an independent consultant that investigated solar installations on the parking garage that was consulted to determine their findings.

Non-primary stakeholders include the students, faculty, and staff of the university. Solar PV could serve as a visual symbol for the sustainability efforts of campus, and it can influence sustainability action in the MSU community.

PROJECT DEVELOPMENT

Methods

This primary objective of this project will be to undertake a preliminary analysis of possible solar installations on MSU campus. This analysis will allow MSU facilities and engineering to know where solar PV arrays would be the most beneficial for the university. The second objective is to determine the optimal solar configurations and mounting to withstand the Montana climate. These two objectives will paint a clearer picture on where and what is possible for solar PV on the MSU campus.

First, a series of interviews was conducted with key stakeholders on the MSU campus and in the Bozeman community. The interviews include:

- EJ Hook, Director of MSU Facilities & Services
- Candace Mastel, MSU Campus Planner
- Andy Moore, President of Beartooth Lighting Design
- Dr. Todd Keiser, Department Head for Electrical & Computer Engineering
- Duke Elliot, Resource Conservation Specialist
- Megan Sterl, Engineering & Utilities Manger

Each interview consisted of a conversation around the primary research question with questions tailored to the expertise of each interviewee. Detailed notes (appendix A) were taken throughout the 30 – 45 minute interviews)

Next, analysis of similar universities and related institutions (i.e. municipalities) was utilized to address operational concerns in winter conditions and determine where solar has been utilized as a cultural artifact. The universities that were investigated include:

- University of Alaska, Fairbanks,
- Colorado State University, Fort Collins
- University of Idaho, Moscow
- Utah State University, Logan
- University of Wyoming, Laramie
- Colorado University, Boulder

These universities were chosen because they are all land grant universities (with the exception of CU Boulder) in the Northwest United States that experience similar climate conditions. This was supplemented with discoveries from other municipalities and universities that are pushing the boundaries of solar application:

- Utrecht, Netherlands
- Sandpoint, Idaho
- Healdsburg, California

Finally, research was conducted on up-and-coming technologies that are making solar more of an energy reality in the world.

The recommendations for this project will be split into two categories: Scope1/2, and Scope 3. Scope 1/2 refers to the direct and indirect electricity emissions that the university has direct control over. Scope 3 refers to all other indirect emissions that the university has influence over. This allows projects to be distinguished in their goal and implementation.

Constraints

This project was constrained by the following assumptions:

- The recommendations for this project pertain only to the main electricity grid of the MSU campus.
- The research was primarily exploratory and qualitative.
- Financial feasibility investigated as a go/no-go analysis; further analysis will have to be done to determine funding sources.
- The findings of the 2018 Solar Report and the 2021 Beartooth Lighting Report were used as a framework on what has already been researched and are not superseded by any recommendations in this report

Finally, this project was conducted over a period of 6 weeks and therefore will require further analysis.

RESULTS & ANALYSIS

Interviews

Each of the interviews (Appendix A) revealed some key aspects of how to achieve more solar installations on the MSU campus. The key points from each interview are as follows:

Winter Applications

Solar PV is challenging in the winter environment due to the extra maintenance and planning. However, Andy Moore shared some new technology (described below) that can be utilized to melt snow off the solar panels; this makes rooftop solar in the winter climate more of a possibility. Additionally, the conversation with EJ Hook identified that solar could be used in parking lots and on walkways to decrease snow removal and the consequent slip/trip liability. Finally, Andy Moore recommended the System Advisor Model from NREL with has a free PVWatts modeling application which can model shading, panel angle, weather patterns, and snow coverage. This allows an array to be quickly evaluated.

Dual-use Suggestions

The interviews yielded compelling suggestions for the dual-use application of solar:

- Covered porticos in front of Lewis, Traphagen, Herrick, etc. (EJ Hook)
- Covered bike parking with e-bike/technology charging capabilities (EJ Hook, Todd Kasier)
- Covered walkways on busy pathways (EJ Hook)
- Covered bus stops with heated seats, charging capabilities, and wifi hotspots (Todd Kaiser)
- Solar sidewalks that can heat stairs, handicap ramps, North side of buildings (EJ Hook, Candace Mastel)
- Covered parking with a more expensive parking pass (Candace Mastel)

Implementation Suggestions

Several of the interviews provided suggestions for the implementation of ideas. To preface, Candace Mastel mentioned that if a building or structure was not planned with solar in mind, retrofitting is more of a superfluous cost. Therefore, planning is key to the future of solar projects. A first implementation idea in the same interview was to find a common denominator for solar projects; a project must not only generate power but meet the usability/aesthetic/ideals of MSU leadership. Second, Dr. Todd Kaiser suggested that smaller Scope 3 solar projects could be designed by Electrical Engineering capstone teams; capstone has already been used to design microgrid solutions. Overall, implementation will hinge on not only the availability of money, but also the support of the campus community. Refer to the implementation section below for final recommendations.

Research

Solar PV technology has advanced significantly in the last couple of years. While there isn't the large-scale adoption in the United States that we see in Europe and Asia, it is becoming a prudent option for energy electrification. Research was done on technologies that can make solar more useful in a campus and winter environment, and on the progress of other similar universities and municipalities.

New Technologies & Applications

Several technologies have arisen in the past couple of years that allow solar to be used in more compact spaces and in the winter climate. As these technologies develop, it becomes more of a reality for MSU to invest in solar PV.

First, the company KEI solar designed solar panels that can transfer energy in reverse to melt snow off the panels. Utilizing a programmable logic controller and sensors, the solar panel can melt all snow within 30-120 minutes and promptly return to energy production.[4] This allows solar panels to be placed on flat rooves with less maintenance, less snow load on the building structure, and more energy efficiency. Therefore, these panels make solar energy production a reality in Bozeman.

Second, solar concentrators are gaining traction in the PV arena. The efficiency of a standard solar PV panel is between 15% and 20%[5]. Concentrated PV, on the other hand, can almost double this efficiency. While there are many different companies, one is the Barcelona-based company Rawlemon. Rawlemon uses optics to concentrate the solar energy through a large lens onto a more concentrated solar cell.[6] This technology allows solar to be placed in more compact areas rather than having large arrays to generate the same amount of energy. Concentrated PV would a good candidate for smaller walls and rooftops on the MSU campus. However, Dr. Todd Kaiser suggested that the maintenance may not be worth the extra efficiency.

Third, solar sidewalks are a technology gaining traction around the world. Utrecht, Netherlands just unveiled the world's longest solar powered cycling path at 330 meters.[7] Similarly, Thompson Rivers University in British Columbia has been working on a solar sidewalk project since 2017. This project, called the Solar Compass, has undergone several winters, and it provides energy for the university sustainability office.[8] Moreover, there is experimentation with solar sidewalk in the United States in Sandpoint, Idaho. A company named Solar Roadways is

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[4] Solar, KEI. (2021). Commercial Flat Roof Designed with Safety in Mind. https://keisolar.com/hain-commercial-flat-roof/

[5] https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/

[6] https://rawlemon.com

[7] Furtula, Aleksandar. (2021)/. Road to future: Dutch province unveils solar bicycle path. https://apnews.com/article/technology-europe-business-environment-and-nature-9f9a06fe6fbe9f4c6c5b8edfb274f43d

[8] Mehta, Michael. (2020). Solar Compass Project. http://solarcompass.blogspot.com/?view=magazine

working to build a solar sidewalk that will be heated and can communicate via LEDs[9]; a livestream of the Sandpoint town square array is visible here.

Finally, floating solar has also become more feasible with the first large installations going online. In one instance, Healdsburg, CA installed a 5 MW floating PV array on their wastewater pond. This installation reduces algae blooms, water evaporation, and generates energy.[10] Floating solar, however, is still possible in winter climates. In China's Bayan County, they installed a 500-kW array in a lake that freezes for 4 months out of the year (Figure 1); extra considerations needed to be made for snow loading and ice compression.[11]

Figure 1: Floating Solar Installation in Bayan County, China

Universities

To put MSU in context, other municipalities and universities were investigated to determine what solar projects are feasible.

MSU is currently in the middle of the pack for solar PV installations. Universities like Colorado State University (CSU) and Utah State University (USU) have made large strides with rooftop and ground mount installations. CSU already has 6.8 MW of solar on campus and recently

[9] Varinsky, Dana. (2016). Snow-melting solar roads are being tested publicly for the first time in the US. https://www.businessinsider.com/solar-road-panels-first-public-test-2016-10
[10] Graham, Andrew. (2021). Healdsburg debuts biggest floating solar farm in nation. https://www.pressdemocrat.com/article/news/healdsburg-debuts-biggest-floating-solar-farm-in-nation-if-not-for-long/
[11] Bellini, Emiliano. (2021) What happens to floating PV when the water surface freezes. https://www.pv-magazine.com/2021/01/15/what-happens-to-floating-pv-when-the-water-surface-freezes/

signed a contract with Namaste Solar for an additional 10 MW of energy.[12] Similarly, USU has several rooftop solar installations for a total of 0.5 MW.[13] University of Alaska Fairbanks (UAF) is like MSU with solar installations in 2012, 2014, and 2015, but with more recent focus on LED conversions and efficiency. However, UAF was the only college researched that had an alternate solar technology with solar compacters.[14] On the other hand, the University of Wyoming[15] and University of Idaho[16] have very little or are working on their first solar installation.

The common theme among these land grant universities was a focus on reducing Scope 1 emissions and generating power rather than smaller dual-use projects.

Several municipalities in the United States have also been pushing the boundaries of solar. Similar to CSU, CU Boulder installed a 100-kW solar carport (Figure 2) in 2009 that can charge electrical vehicles.[17]

Figure 2: CU Boulder Solar Carport

[12] Gorman, Mark. (2021). Colorado State University to double solar production with Namasté Solar project. https://solarbuildermag.com/news/colorado-state-university-to-double-solar-production-with-namaste-solar-project/

[13] https://sustainability.usu.edu/sustainability-council/energy/renewables

[14] https://www.uaf.edu/sustainability/pastprojects.php

[15] https://www.uwyo.edu/sustainability/sustainability-tour/

[16] https://www.uidaho.edu/current-students/sustainability-center/solar-energy-initiative

[17] Energy, Solarado. (2009) CU Boulder 100kW Solar Carport. https://www.energysage.com/project/6776/cu-boulder-100-kw-solar-carport/

FINAL RECOMMENDATIONS

Scope 1 Projects

Solar PV can increase power generation to meet the growing needs of grid electrification. As seen at other universities, solar can decrease scope 1 direct emissions as well as decrease reliance on purchased scope 2 electricity. A couple of locations were identified as viable locations for future solar installations on MSU campus.

Brick Breeden Fieldhouse Parking Lot

The Brick Breeden lot (Figure 3) is an excellent candidate for covered parking as it is unshaded and a permanent parking location. The large portion of the lot has the ability for 19 rows of solar PV panels that are up to 450' in length. Additionally, covered parking could preliminarily be tested in rows 6 and 12 to ensure that snow removal and maintenance are not a primary concern. Additional work will have to be done to determine the angle of these panels and the structural design to account for snow removal equipment.

With standard parking spaces that are 9' wide and 18' long, these leaves $450' * 18' * 19\ rows = 153900ft^2$ of usable space. With 60-cell solar panels dimension 5.4'x3.25'[18], the parking lot can fit 8768 panels. Using a PVWatts model, the maximum energy generated with a 250 W nameplate capacity[19], 15-degree tilt, 180-degree azimuth, 0% shading, and 15% snow would be 1,169 kWh/kW (Table 1).

Table 1: Energy statistics from PVWatts

Metric	Value
Annual energy (year 1)	2,561,456 kWh
Capacity factor (year 1)	13.3%
Energy yield (year 1)	1,169 kWh/kW

[18] Residential solar panel size: https://us.sunpower.com/how-many-solar-panels-do-you-need-panel-size-and-output-factors
[19] Capacity assumed from: https://us.sunpower.com/how-many-solar-panels-do-you-need-panel-size-and-output-factors

Figure 3: Brick Breeden Parking Lot Dimensions

MSU Holding Pond

The MSU holding pond would be a great candidate for a floating solar application. For example, if the 370'x200' holding pond (Figure 4) was covered by 60-cell solar panels dimension 5.4'x3.25', PVWatts models an energy yield of 840 kWh/kW and an annual energy of 885,192 kW (Table 2). This is assuming each panel has a 250-Watt nameplate capacity, 0-degree tilt, 180-degree azimuth, 0% shading, and 30% snow coverage. While additional calculations and design are necessary to account for freezing and snow coverage, this poses an opportunity for MSU to use the pond for multiple purposes.

Table 2: Energy Statistics from PVWatts

Metric	Value
Annual energy (year 1)	885,192 kWh
Capacity factor (year 1)	9.6%
Energy yield (year 1)	840 kWh/kW

Figure 4: MSU Holding Pond Measurements

Scope 3 Projects

In addition to power generation, solar PV can be used for dual purposes on campus and can influence a change in our sustainability culture; this would indirectly cause a decrease in scope 3 emissions. Solar panels have the unique advantage of being visible to all the students, staff, faculty, and community members that visit the MSU campus. They can therefore be utilized to start a culture that is willing to support the less visible (yet equally necessary) alternative energy projects. Additionally, they can be used for dual purposes to improve the usability of campus, charge electric vehicles, decrease snow removal, and many other applications. Several projects were identified as potential Scope 3 leverage points.

- Solar Covered Bus Stations
    - Location: In front of the SUB, 11th street, in front of North/South Hedges, etc.
- Solar Covered Walkways & Porticos

    - Location: an additional project would have to be done to identify critical pathways
    - Andy Moore recommended covered walkways along Grant street because it will have to be rebuilt after the current gym construction process
- Solar Sidewalks
    - Location: In front of Montana Hall, Rendezvous, along 11th street (i.e. areas with low shading and high traffic)
- Solar Bike Infrastructure
    - Location: behind south Hedges, Langford, Cobleigh, South side of Norm Asbjornson.
- Solar Compactors
    - Location: along the university mall, outside of Miller/Rendezvous

Implementation

Large Projects

Larger scope 1 projects will have to gain funding through significant grants or investments. However, smaller scope 3 projects have the potential to improve visibility for alternative energy and thus garner more support for the less attractive large instalments. Therefore, a focus on small solar projects and visible solar PV should be done before projects that are more expensive and receive less attention.

Small Projects

For the smaller scope 3 projects, there are several implementation routes.

1. ASMSU: Discuss the project and benefits and allow the student government to fundraise and support the project.
2. Capstone
    a. Hardware and electrical configurations can be done through the electrical engineering department. For example, a solar bus station could be designed and configured by an undergraduate team.
    b. Structural solutions can be developed through a civil engineering capstone
    c. Critical path and optimal layouts can be determined by industrial and management systems undergraduates.

For dual use projects such as covered walkways, Engineering & Utilities can partner with Facilities & Services to split costs as the project will generate a return for both.

Future Enquiry

For many of these projects to be implemented, more research will need to be conducted to determine technical and financial feasibility. Projects that could further this research include:[20]

- Analysis of critical walking paths on campus to determine where covered walkways would be the most effective
- Structural analysis of PV mounting configurations that do not interfere with snow removal
    - Cantilevered systems
    - Snow melting panels
- Analysis of the cost savings from a solar powered electrical MSU fleet
- Investigation on the most effective way to fundraise for alternative energy projects via research of other college campuses
    - How have other campuses raised money for solar? Through facilities, engineering, crowdfunding, other methods?

[20] Some of the recommendations already discuss future work

APPENDIX

A. Interview transcripts

EJ Hook
MSU Director of Facilities & Services

- Are there any existing areas of campus that could be made more usable by a solar installation (covered walkways, bike racks, solar sidewalks, etc.)?

Covered porticos on Lewis, Traphagen, Herrick; could keep grit and sand further away from the building. Some of these projects have to be run through the historic building.

- Level 1: working on better loading configurations for roofs so that there is no melted heat loss.

Covered bike parking:
We'd be better off doing larger areas at once. We need a bigger array to make a difference.
Locations: South side of Norm, West of Cobleigh, Green space between Hamilton/Roberts/Wilson, Roskie on the east side, West side of the hedges (extend off of the current in hedges. Include bike fixing stations underneath the coverings.

Covered walkways:
Small connects between buildings: Barnard to SUB, library to Reed
Problem: snow offloading onto the main walkway, the poles need to be designed so that snow removal machines can move under.

Solar sidewalks:
28 miles of sidewalk on campus; 8 miles of road. Can you take the solar energy and use it as a heating element? Most of the snows are 2 inches are less. The problem is the North side of the buildings, but they also don't receive as much sun (solar might not be best option). Well placed and strategic application of solar sidewalk could reduce injuries and snow-related fall costs; would need to identify the high-risk spots (like security lighting). Identify the primary pathways on campus.
Could try to put an electric roadway on Grant after all of the construction is done.

How can we push the envelope to improve snow removal? Could we use solar installations like this to charge EV's

Covered parking lots:
How to we angle the panels for optimal snow removal? Is there a way to cover the entire drive lane?

Questions:

- Are there any examples in snow country where someone installed solar?
- Where are some areas we could centralize bike parking?

- What would the payback be for facilities projects given snow offsets?

Follow-up
What are some of the cost numbers for snow removal?

Andy Moore
Beartooth Lighting

High voltage one line diagram for campus – ask for from Duke

Refer to the parking garage solar report as a draft

Grant street would be a great opportunity to install covered solar when the building projects are done.

Download System Advisor Model from NREL.
- **Start project**
- **PVWatts**
- **No financial model**
- **Download weather file for Bozeman**
- **Determine shading value via an ecotex shading model via an architecture student.**
- **Snow would be about 15% for a 90-degree array**

Use this software to get simple feedback and use as a go/no-go project

Look at solar concentrators from a watts per square meter perspective

Reach out to RawLemon to see if they have any installations in the United States

Look into solar sidewalk installments in the United States and potential manufacturers. Reach out to facilities and see what their feedback is

Look into tracking technology as a learning opportunity for campus. Could make panels much more efficient. Would work in front of the SUB in an open area with a lower wind load. Potentially doubles output and takes solar off the ground.

Another resource for system architecture: SMA out of Germany in Inverter and battery market.

Candace Mastel
MSU Campus Planner

It is less easy to retrofit buildings for solar, much easier to plan ahead to put solar on rooftops; it comes down to efficient planning.

Bike shelters would be tricky to involve solar if we only use the solar to power lighting or something small like charging. Solar and covered bike parking are one of the first things to be taken out of a project on campus due to the cost per square foot; the trick will be finding the investment potential to fund these smaller projects.

Question: How do you bring funding to the table to fund these extracurricular projects such as solar? How can we use our endowment to be directed toward sustainably minded projects?

Handicap ramps, stairs, how do you make accessibility services have more easy maintenance with something like a heated or solar sidewalk. Where are the high use areas?

What if covered solar parking had a slightly more expensive pass? It would pay for itself in terms of energy and infrastructure costs.

How do we make solar so doable that people can't say no? Where is the common denominator?

To do: what is the common denominator for making solar sexy and adapatable?

Duke Elliott & Megan Sterl
MSU Engineering & Utilities

Peak load is about 8-9 MW. The steamplant generates 1 MW and the rest is purchased from NorthWest Energy. 50 million kwh is the usage of power; the cogen capability is 4% of this total usage.

What would it take to get the campus electrical system to handle a larger electrical load?

Before we can put more solar on campus, we need non-export controls on the MSU system. Rooftop doesn't require any modification to the system. Ground mount solar could work with the current system. A more complex scenario would involve battery storage.

Possible areas for solar:

Rooftops and parking lots: closer to the current electrical grid so they are easier to install.

Question to research: When solar is put in a parking lot, how do they build the structures so that people don't damage them?

What would the bandwidth be for dual use solar on campus?
Funding
Process: must get authority to use money for these extraneous projects; all of these have different timelines so it's tricky to get projects started. Finding $10,000 is simple but funding larger projects is difficult.
The tradeoffs also get difficult when it is over $50,000, other projects take precedents.

Question: price per square foot for sidewalk solar?

Dr. Todd Kaiser
Electrical & Computer Engineering Department Head

Covered bus stops: heated seats, wireless hotspots

Covered bike racks with a battery bank for e-bikes

Covered picnic benches and outdoor seating for study areas

Concentrated PV: the maintenance might not be worth the extra costs; mechanical systems have extra moving parts.

Where is the data for the Norm array, would this data be available for teaching purposes?

Could any of the engineering departments fund a solar project?

- Could have something as a capstone project? We'd have to write a proposal to the department to determine feasibility.
- Capstone projects have already been done looking at the engineering complex and one of the dorms.
- Charging station for e-bikes, power banks, etc.

Would need project ideas by mid-August for Fall and mid-December for Spring for capstone