Exploring Solar Charging Station Design for Electric Bicycles

May 2022

A Research Report from the National Center for Sustainable Transportation

Beth Ferguson, University of California, Davis

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16. Abstract

Electric bicycle charging facilities that support active mobility and public transit connectivity can play a significant role in the global transition to low-carbon energy. Design of an electric bicycle solar charging station can combine solar technology, light transportation infrastructure, and civic place-making to provide the public an opportunity to recharge their mobile electronics, e-bikes, or e-scooters. The proposed station design reimagines public space by providing a shaded seating area during the day and a vibrant, LED-lit space at night. Four solar panels and a battery bank extend the station's charging capacity into the night. The goal of this project is to serve as an off-grid energy power supply and environmental information center, with interactive displays of the solar station operation and an LED display of local air quality.

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Beth Ferguson, Department of Design, University of California, Davis

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Introduction

Electric bicycle charging facilities that support active mobility and public transit connectivity can play a significant role in the transition to low-carbon energy. This vital transition will help keep the average temperature rise for the planet below the 1.5–2°C targets identified by the Paris Agreement in 2016 and prevent catastrophic harm to life on our planet.

Electric bike charging infrastructure does not currently exist on the UC Davis campus despite an increase in electric bike ownership in California and the loss of the popular JUMP e-bike share program that was in Davis before the start of the COVID-19 pandemic. A 2021 *New York Times* article reported, “The pandemic bike boom boosted e-bike sales 145 percent from 2019-2020, more than double the rate of classic bikes, according to the market research firm NPD Group.” [6] Public electric bike charging infrastructure could help support college campuses to reduce their dependence on gas vehicles.

This research report explores the design considerations and challenges to installing a solar charging station for electric bikes on the UC Davis campus and beyond. The site placement for this design has been the Cruess Hall courtyard because it is centrally located, south facing and currently under a landscape renovation by Campus Planning. The finished Cruess Hall Solar Charging Station design combines solar technology, transportation infrastructure, and civic placemaking to provide the campus community with an opportunity to recharge their mobile electronics or e-bikes. The station design reimagines public space by providing a shaded seating area during the day and a vibrant, LED-lit space at night. Four solar panels and a battery bank extend the station’s charging capacity after dark. Once built, the station will serve as an off-grid power supply and environmental information center with an interactive display of the solar station operation, data logging, and an LED display of local air quality data.

Solar Charging Station Design Considerations

The solar charging station design process has led to the final proposal of an off-grid system with a footprint of 16 x 12 feet. Figure 1 shows the final solar charging station design that has been custom fit for the UC Davis Cruess Hall courtyard. The charging station will be a solar classroom for research and provide charging for laptops, e-bikes, e-scooters, and wheelchairs. It will have a solar roof canopy, outlets, electrical enclosure for the battery bank, seating, and an air quality sensor with a visual LED display. The bike rack area will use the bikeep smart bike dock (bikeep.com) to provide secure parking and convenient e-bike charging. The project principal investigator Beth Ferguson and collaborator Dallas Swindle successfully installed a similar solar charging station in Austin, Texas for Austin Energy at their Electric Drive Showcase (Appendix A). The project was awarded the 2017 Austin Green Award.

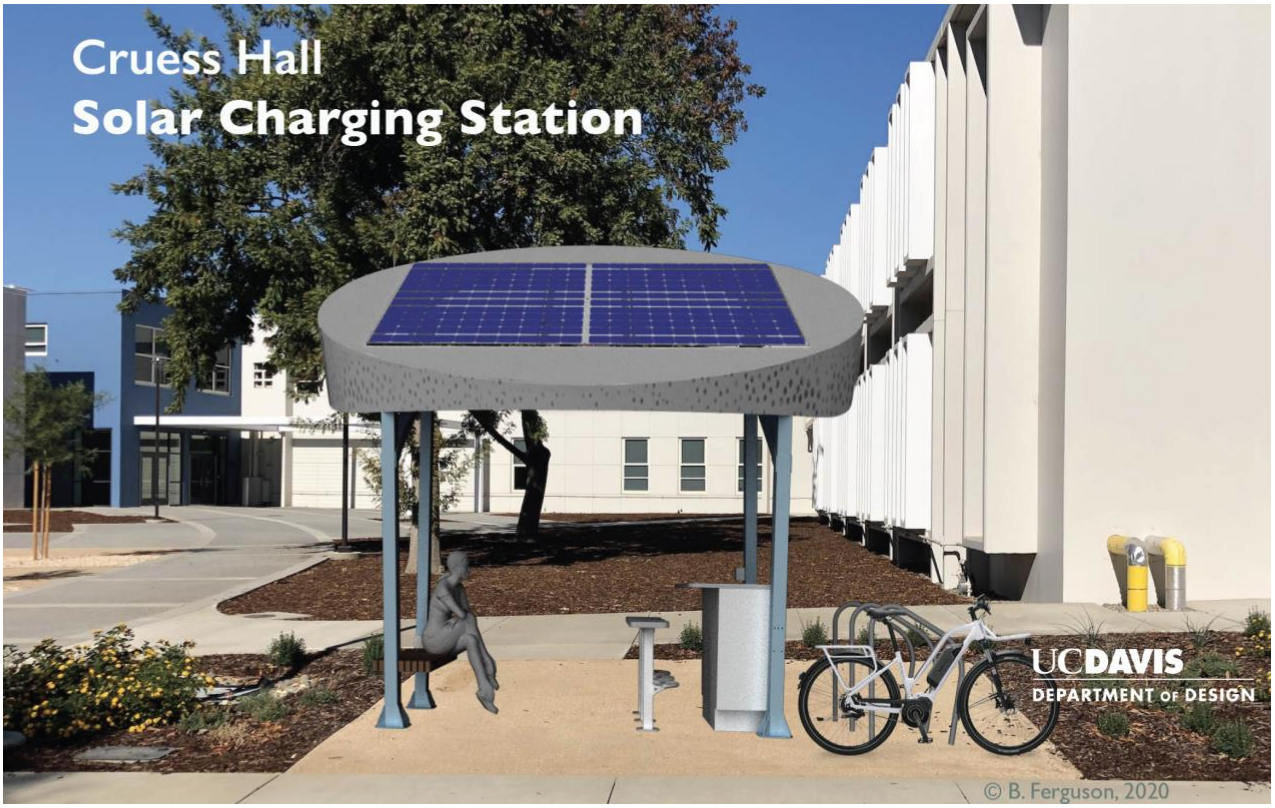

Figure 1. Cruess Hall Solar Charging Station design proposal. Image: © B. Ferguson, 2020

Site Placement

Site placement for a solar charging station in the Northern Hemisphere requires a south facing location free of shade obstacles (trees, buildings) and wheelchair accessibility from the sidewalk. Figure 2 shows the site location at the Cruess Hall courtyard included in the landscape master plan by the UC Davis Campus Planning office. Figure 3 shows an aerial photo of the site taken with a drone camera. The site currently has leveled gravel and will need to have a concrete pad poured at the time of the installation for the structure's poles and underground wire, which will connect the off-grid solar charging station structure and two e-bike racks. The project footprint is 16′ wide by 12′′ deep and 12′-5″ tall.

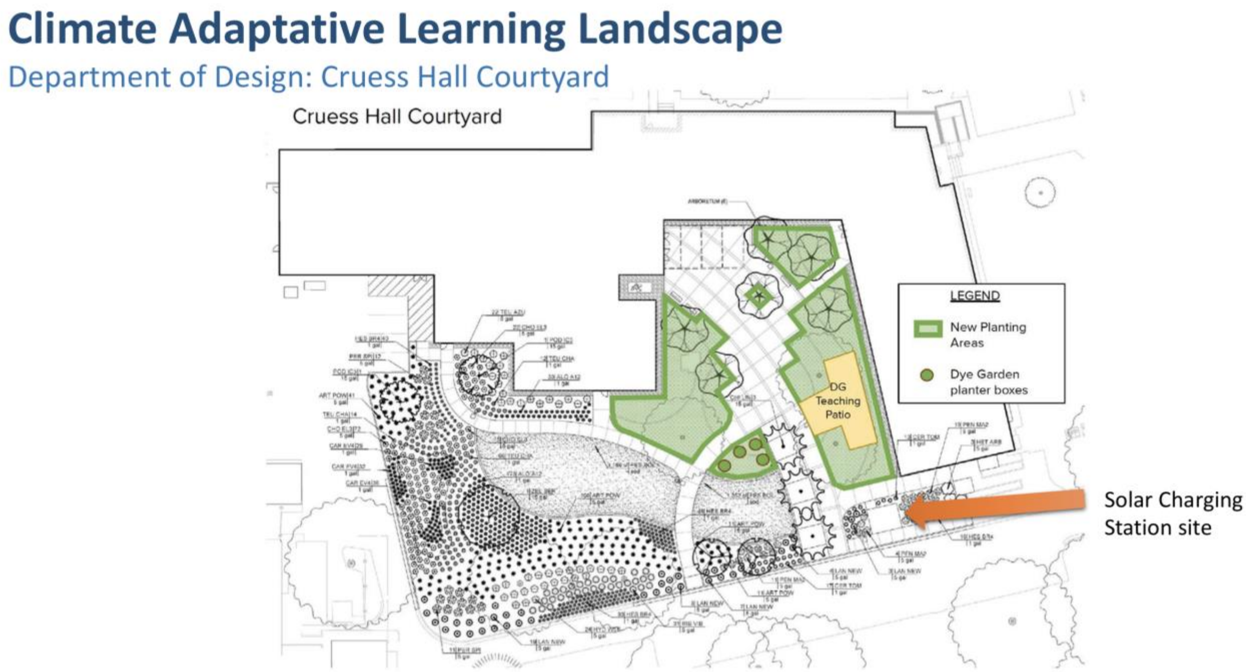

Figure 2. UC Davis Cruess Hall Courtyard. Image: UC Davis Campus Planning

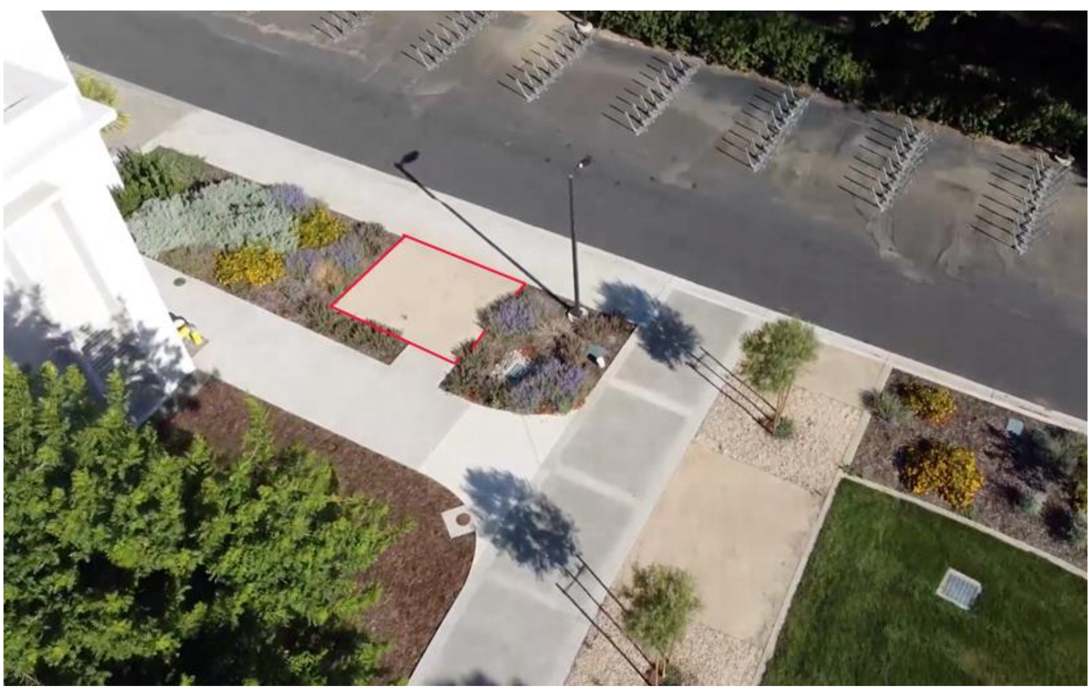

Figure 3. UC Davis Cruess Hall Courtyard aerial photo with the site of the solar charging station marked in red. Image: Tom Maiorana

Wheelchair Accessibility and Traffic Flow

The design team followed the California Building Code, Chapter 11 section B2010 to make sure that a person in a wheelchair would have a similar experience to a person not in a wheelchair when using the solar charging station. Figure 4 (Plan View Section A) shows that the center area of the station is 4’5½” to allow for easy wheelchair entry and turning. The floor plan has a 3’ x 4’ wheelchair resting location next to a companion bench and power outlet for both electric wheelchair and mobile device charging. The station also includes table seating with three stools and one spot reserved for a wheelchair (size 2’6” x 2’3”). The height of the table is 2’9” and allows for a person in a wheelchair to be able to reach the power outlet on the table. Figure 5 shows a traffic flow diagram for people, wheelchairs, and e-bikes. Site drainage and additional LED night lighting has also been a careful consideration.

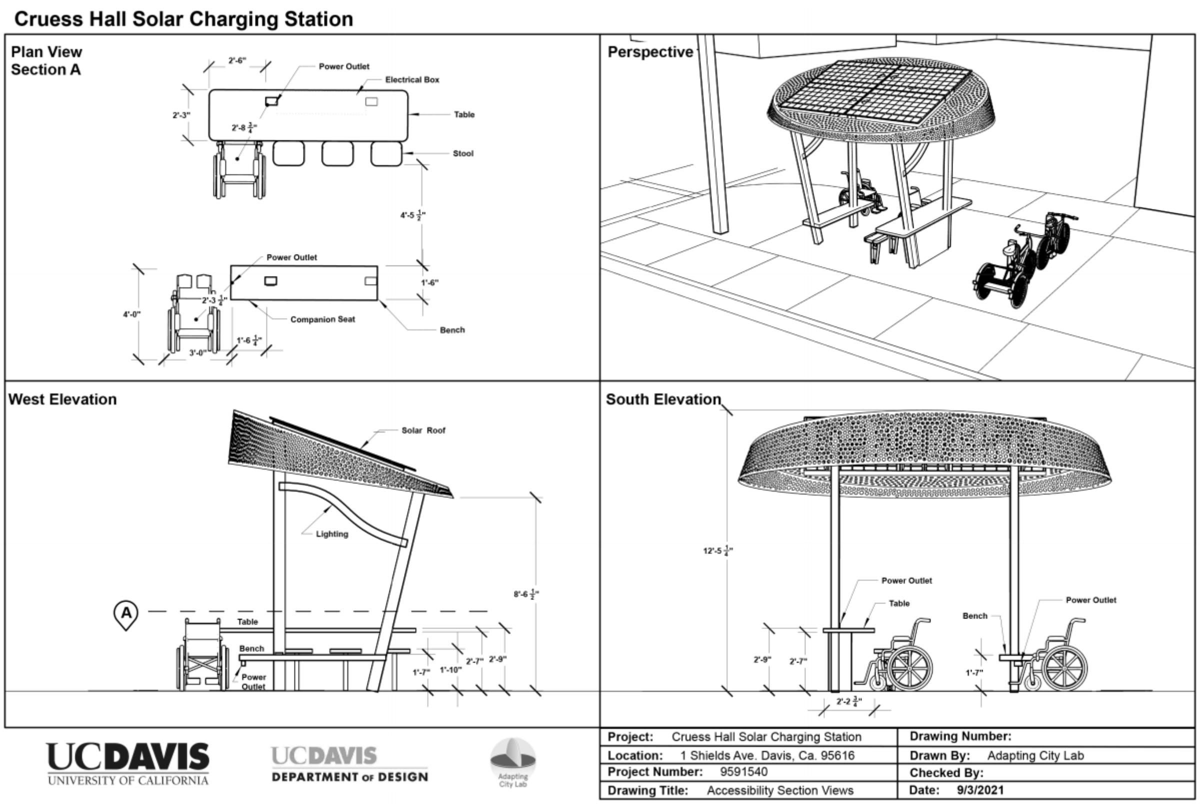

Figure 4. Solar Charging Station Accessibility Plan. Image: © B. Ferguson, D. Swindle, 2021

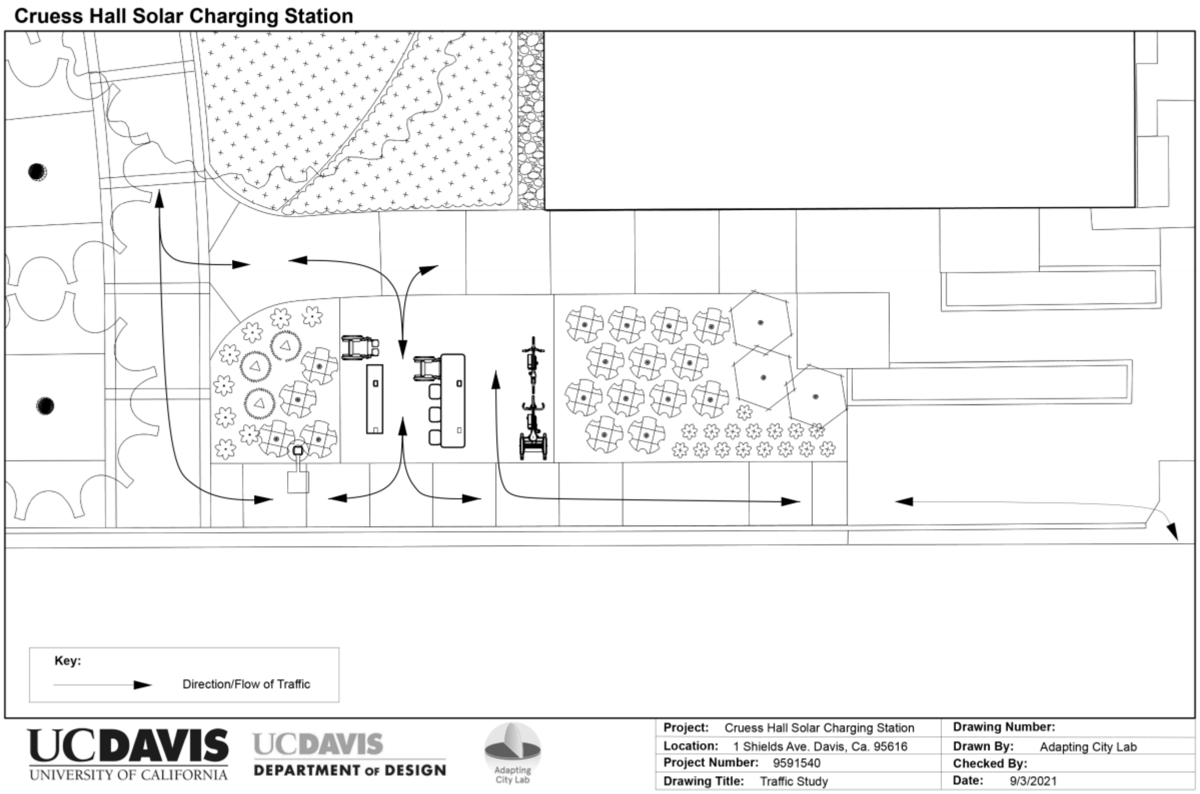

Figure 5. Solar Charging Station Traffic Study image. Image: © B. Ferguson, D. Swindle, 2021

Charging Capacity

The goal of an off-grid solar electronics system is to be able to charge two electric bikes or wheelchairs at a time, multiple times a day. Figure 6 shows the solar equipment needed for this project: solar panel, charge controller, battery, inverter, meter, load (outlets). These items will be installed in an electrical enclosure box that is under the table. The design team chose four Lumos Solar panels (290 watts each) or 1160-watt array and an inverter, charge controller, and battery system from Victron Energy. An outdoor rated touch screen will display the system's dashboard to users using VictronConnect software and a Raspberry Pi microprocessor.

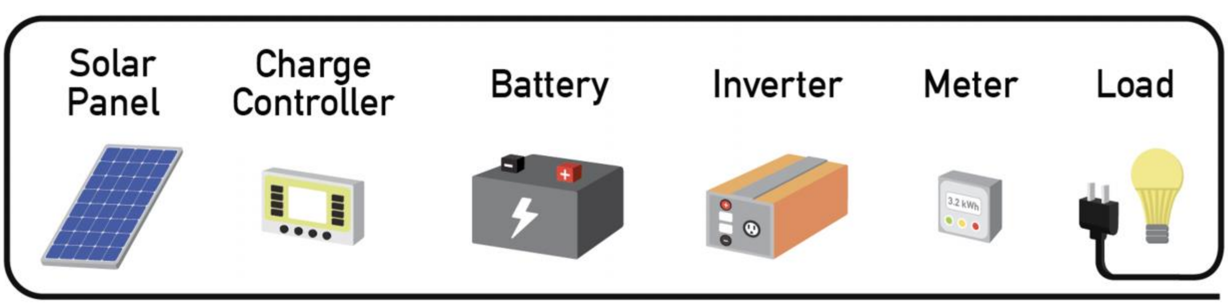

Figure 6. Solar charging station equipment. Image: © B. Ferguson, J. Wattimena, 2021

Data Collection

A shade study was done at the Cruess Hall courtyard site where the solar charging station will be located. An electronic instrument, the Solmetric SunEye 210, was used to measure any potential shade around the solar roof during 12 months of the year. The solar panels will be at a 38° angle and face south. Figure 7 shows the instrument in use at the courtyard calibrated to Davis, CA. Figure 8 shows the study results projected by the Solmetric SunEye 210 device: the average annual solar access is 90%, the May-Oct solar access is 96%, and the Nov-April solar access, 77%. The solar access is reduced in the winter because the sun is lower in the sky and the shade cast during this time by the trees to the far south of the site. Overall, this is an excellent site with modest winter shade coverage.

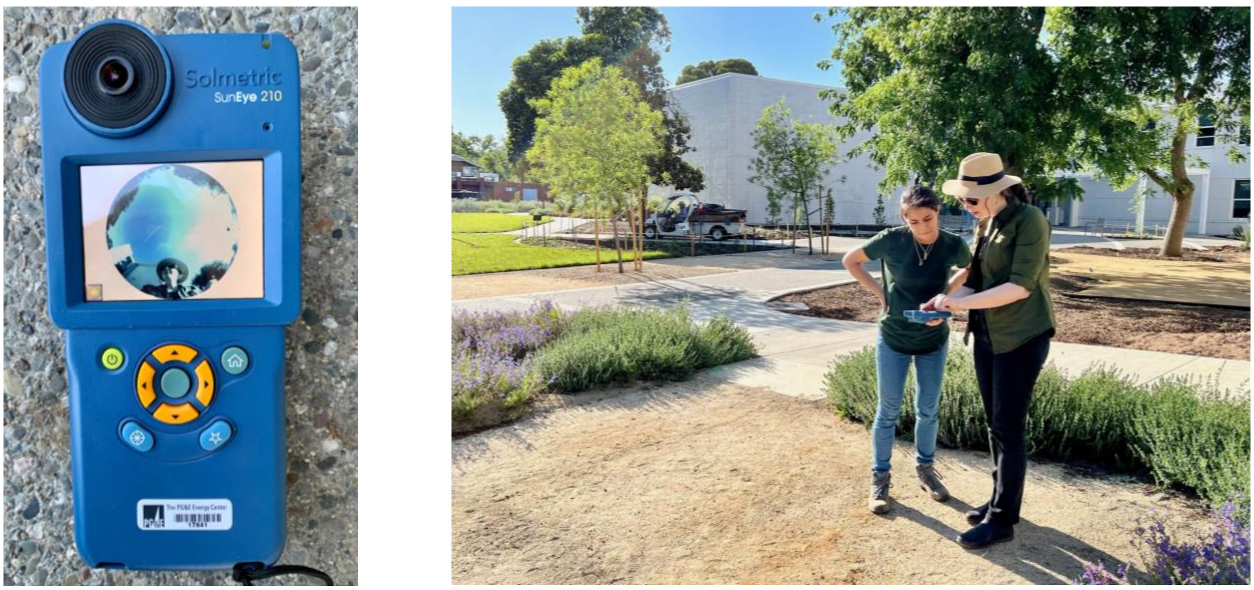

Figure 7. Solmetric SunEye Used at the Cruess Hall Courtyard

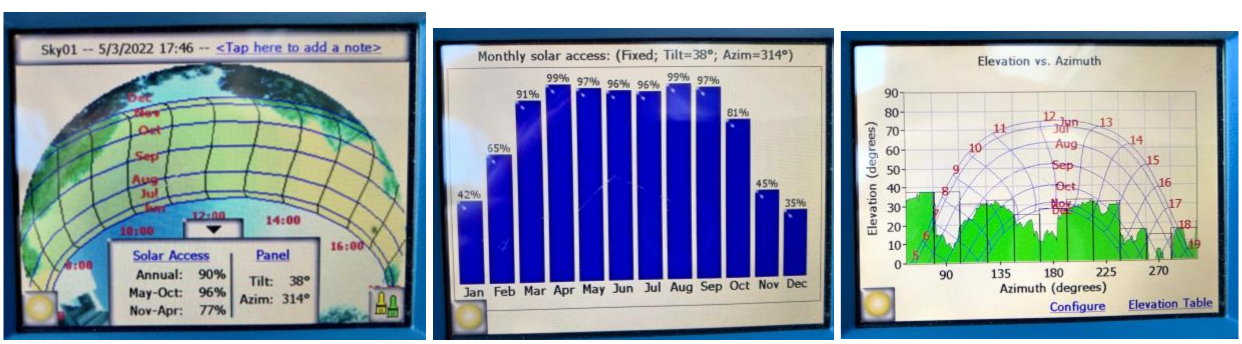

Figure 8. Screen shots from the Solmetric SunEye 210 showing the solar access yearly projection charts and shade coverage.

Solar Energy

Future research opportunities with this project will emerge after the station installation is complete. The VictronConnect App (https://www.victronenergy.com/panel-systems-remote-monitoring/victronconnect) that comes with the solar inverter and battery system selected will allow for remote monitoring and data logging of the solar energy collected and stored and the outlet load used.

Air Quality Sensor Kit

The Purple Air sensor (www2.purpleair.com) was chosen to use with the station because it will allow for data collection of the local air quality index (AQI) for $PM_{2.5}$,—a measurement of the concentration in the air of fine particulate matter (measuring 2.5 µm or less in width). This system was also chosen because of the low cost ($250) and its open-source features. LED lights on the station will display Green (0-49 AQI $PM_{2.5}$), Yellow (50-99 AQI $PM_{2.5}$), Orange (100-149), Red (150-199), Purple (200-299), and Maroon (300+). Student research assistant David Haddad built a prototype for this project using the Purple Air sensor with the parts listed in Table 1. Figure 6 shows the purple air sensor and map when tested at the UC Davis West Village site.

Table 1. Charging Station air sensor prototype part list

Part Name	Function	Link
MAP PurpleAir	web map	https://www.purpleair.com/map
JSON PurpleAir	air sensor	https://www.purpleair.com/json
Rasberry Pi	microprocessor	https://www.adafruit.com/product/3058
LED Strip	full color lights	https://www.adafruit.com/product/1138?length=1

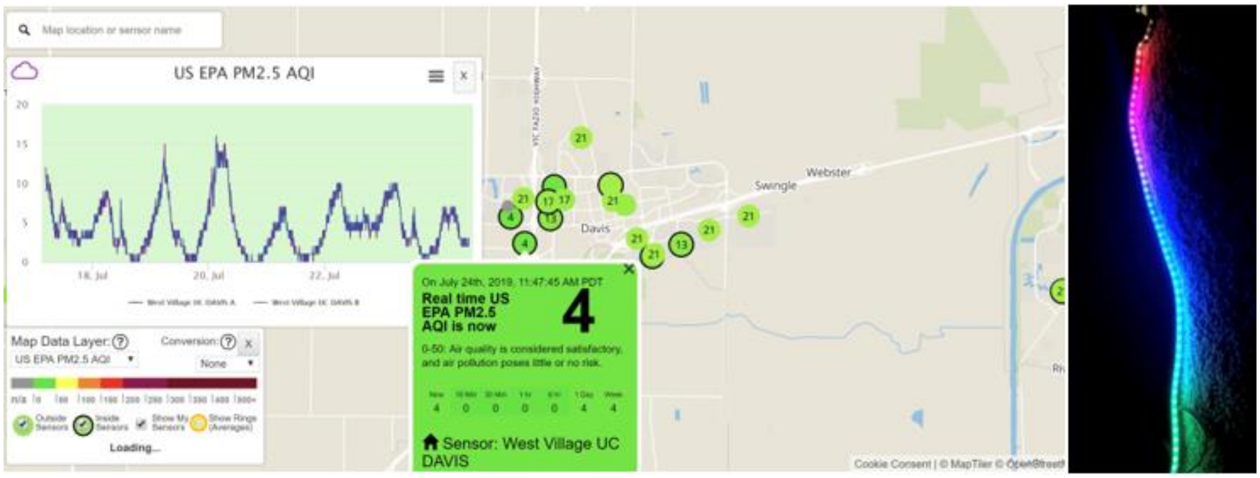

Figure 9. PurpleAir website dashboard showing the UC Davis West Village sensor: AQI PM2.5 = 4 (green). The image on the right shows the programable colored LEDs on the sensor. (https://www.purpleair.com/map)

Discussion

Challenges

The original goal of this project was to use a pre-existing solar charging station on the UC Davis campus to collect charging data from the JUMP e-bike share program in Davis, CA. The solar charging station that was available from a previous project at Stanford University did not meet the UC Davis campus outdoor structure code requirements. The project focus changed to the design of a new solar charging station that would meet the campus building code requirements. The project team planned to work with the JUMP e-bike share program to solar charge their e-bikes that once circulated on the UC Davis campus and in Davis, CA. The JUMP vendor (Lime) discontinued their fleet service at the start of the COVID-19 pandemic and they have not reinstated the service, despite its popularity with students and community members.

The budget for this project increased due to costs associated with building a permanent structure on the UC Davis campus with a solar roof, battery bank, furniture, and bike charging system. Additional grants have been awarded to build the newly designed solar charging station from the 3 Revolutions Future Mobility Program, the Hellman Fellows Fund, the UC Davis Green Initiative Fund, the UC Placemaking Initiative, and the UC Davis Department of Design. A project of this scale requires considerable resources, especially for completing the fabrication and installation phase. The plan is to build the structure in the new Design Department Makerspace after it has been permitted by campus, and then to install it on the designated site at the Cruess Hall Courtyard

Permitting

This project is currently under a design review phase with the UC Davis Design and Construction Management office. The University of California has not previously built e-bike solar charging stations, though they have provided EV charging stations on most of their campuses. This project provides an opportunity for innovative infrastructure for lighter EV charging systems as the market growth in personal ownership of electric bikes and scooters increases.

Conclusion

Electric bicycle charging facilities that support active mobility and public transit connectivity can make a significant contribution to limiting global warming and should designed for. Such facilities may also serve broader purposes of allowing people to gather and to charge portable electronic devices. As such, they should be accessible to wheelchairs.

The process to design an electric bicycle, scooter, and wheelchair solar charging station has taken careful consideration regarding the many steps required to install a permanent structure on the UC Davis campus. When finished, it will be the first solar charging station for light electric vehicles with hopes to streamline this process for similar University of California projects in the future. Sustainable transportation infrastructure and data collection is crucial as we look for ways to provide alternatives to private automobiles.

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Appendix A

Figure 10. The Electric Drive Solar Kiosk, designed by Beth Ferguson, Dallas Swindle, Austin, TX, 2017