Sustainable Buildings: Pauley Pavilion

Final Report: Spring 2017

Adam Gushansky Anne Youngdahl Ileana Callejas Shannon Cavanaugh Erick Ocampo-Ramos Chu Young Woo Stakeholder: Todd Lynch; Principal Project Planner, UCLA Capital Programs

Sustainability Action Research

Introduction And Background



Introduction

The goal of the Sustainable Buildings: Pauley Pavilion team was to gather the materials necessary in order to initiate the recertification process for Pauley Pavilion under the LEED (Leadership in Energy and Environmental Design) version 4 standards for Building Operations and Maintenance (O&M). This effort was in support of our intent to improve energy efficiency and sustainability of Pauley Pavilion and other existing buildings.

We began the process by reviewing the credits that Pauley Pavilion earned when it was certified at the LEED Gold level under version 2.2 standards for New Construction (NC). Based on this review, we compiled a list of information and documentation that is necessary to demonstrate Pauley's adherence to O&M requirements. We then transitioned to the data acquisition phase by reaching out to our stakeholder Todd Lynch, Principal Project Planner for UCLA Capital Programs, as well as Katie Zeller, Sustainability Coordinator for UCLA Recreation Sport Venues and Event Operations, and others in Facilities Management. Collected data included the building's utility records, which we analyzed to begin demonstrating fulfilment of LEED requirements or identifying necessary improvements to reach recertification eligibility. We also organized the utility data using the Energy Star Portfolio Manager tool put forth by the Environmental Protection Agency (EPA) in order to evaluate the building's Energy Use Intensity (EUI), among other metrics.

Based on these analyses and other documentation collected, we evaluated the various earnable credits set forth in the LEED standards and provided recommendations as to which credits should be pursued in recertification efforts. Accompanying our recommendations were listed knowledge gaps and assumptions that we made in our evaluation, as well as the documentation we have compiled thus far, so that the project can move forward in the future. To help further support the project's continuation, we applied to The Green Initiative Fund (TGIF) and received a grant to cover the registration and review costs of the LEED certification. Additionally, in an effort to share the importance of building sustainability with the campus at large, we reached out to the UCLA campus through flier distribution in residential buildings, and poster presentations at events such as the Earth Day Fair and the Green Gala.

Because so much of people's time is spent in buildings, we hope that the recertification of Pauley can serve as a precedent for pursuing LEED O&M certifications for other buildings on campus, and that, as a major event venue, Pauley Pavilion can serve as a focal point for campus and community sustainability.

Background

Precedents and Context

Multiple Sustainability Action Research (SAR) teams have previously tackled issues of energy sustainability and green buildings at UCLA. The 2012 LEED Assessment Action Research Team worked with our current stakeholder Todd Lynch to raise campus-wide awareness of LEED certification milestones and the importance of sustainable buildings through methods such as educational posted panels (Bains, Josephson, et al. 2012). This project's education measures had a special focus on depicting how LEED certification is pertinent to UCLA and the University of California's sustainability goals. The 2014 Green Buildings team focused on gathering and compiling documentation to streamline the LEED certification process of residential buildings on campus (Hirashiki, Lai, et al. 2014). In continuing with this precedent, we as the 2017 Sustainable Buildings: Pauley Pavilion team broadened our original focus on the energy efficiency aspect of LEED in order to examine Pauley Pavilion through the complete set of LEED standards for Existing Buildings: Operations and Maintenance in comparison to its former New Construction certification. This project uses Pauley Pavilion as a case study to take a broader look at expanding UCLA's focus on sustainable buildings.

A Need for LEED EBOM

There are about 30 LEED-registered buildings across UCLA. Most of these buildings have been certified under LEED-New Construction and these efforts have been vital in upholding the vision of sustainability on campus. On the other hand, there is a lacking effort in certifying LEED-Existing Buildings (EB). Improving existing buildings often allows for a smaller carbon footprint and overall resource strain in comparison to constructing a new, start-of-the-art facility. new construction. Applying for LEED-EB certification also helps ensure that the facility is being operated in accordance with practices outlined when the managing entity applied for accreditation under NC. Altogether, there is sufficient motivation to actively pursue LEED accreditation at Pauley Pavilion and other existing buildings on campus.

Similar Projects

There are about 30 LEED-registered buildings across UCLA. Most of these buildings have been certified under LEED-New Construction and these efforts have been vital in upholding the vision of sustainability on campus. On the other hand, there is a lacking effort in certifying LEED-Existing Buildings (EB). Improving existing buildings often allows for a smaller carbon footprint and overall resource strain in comparison to constructing a new, start-of-the-art facility. new construction. Applying for LEED-EB certification also helps ensure that the facility is being operated in accordance with practices outlined when the managing entity applied for accreditation under NC. Altogether, there is sufficient motivation to actively pursue LEED accreditation at Pauley Pavilion and other existing buildings on campus.



Aside from the basic knowledge of LEED's association with green buildings, our team started this project with a clean slate. The first few weeks of Winter Quarter were spent learning about the LEED framework. Pauley Pavilion had been certified under LEED v2.2 for NC in 2012 following its major renovation. LEED certification expires after five years; if Pauley did not move to renew its certification under LEED v4 O&M, it would have had to apply for LEED certification as a new building, which is a far more laborious and expensive process.

After our initial meetings with Professor Lynch, we established our central goal of recertifying Pauley Pavilion under LEED v4 O&M. Our first step was to reconcile the LEED v2.2 NC standards and the LEED v4 O&M standards by making a spreadsheet that outlined their respective similarities and differences. In doing so, we found that a few credits overlapped; however, the overwhelming majority of them were either new credits not listed in the NC standards, or modified credits with different requirements. Generally, these differences could be attributed to the observation that NC focused more on the construction process, location, materials, and the overall physical attributes of the building, whereas O&M was centered around operations and sustainable policies.

Professor Lynch also recommended that we familiarize ourselves with Energy Star Portfolio Manager, which is an online platform created by the U.S. Environmental Protection Agency that helps track the energy and resource usage of a given building. The tool uses information from energy, water and waste management utility bills to calculate a score and corresponding energy use intensity (EUI). These scores are helpful in comparing a facility's energy usage to other, similar buildings that are registered on Portfolio Manager.

Our next step was analyzing Pauley Pavilion's utility records. With the help of Todd Lynch and Katie Zeller, we reached out to Spencer Middleton from UCLA Facilities Management to provide us with these documents, which included data from four electricity meters, one chilled water meter, a steam consumption meter and four water meters, for the period starting in January of 2015 and ending in August of 2016. We were then able to input this data into the Portfolio Manager.

Metrics Summary						
Metric	Dec 2015 (Energy / Baseline)	Apr 2016 (Energy Current)	Change			
ENERGY STAR score (1-100)	Not Available	Not Available	N/A			
Source EUI (kBtu/ft ²)	97.2	95.3	-1.9(-2.0%)			
Site EUI (kBtu/ft ²)	31.0	30.4	-0.6(-1.9%)			
Energy Cost (\$)	216,451.71	212,772.11	-3679.60(-1.7%)			
Total GHG Emissions (Metric Tons CO2e)	634.4	622.1	-12.3(-1.9%)			
Water Use (All Water Sources) (kgal)	2,797.7	3,072.2	274.5(9.8%)			
Total Waste (Disposed and Diverted) (Tons)	58.79	58.79	0.00(0.0%)			

Figure 1: Metric summary derived from Energy Star Portfolio Manager. Data spans from January 2015 - August 2016.

Portfolio Manager calculates the energy usage of a building by assessing both the site's EUI, and the energy source EUI. Pauley's site EUI is 30.7 kBtu/ft2, which is lower than the national median of 45.3 kBtu/ft2 for indoor arenas (a 25% improvement). But for the source EUI, Pauley checks in at 96.25 kBtu/ft2, which is higher than the national median of 85.1 kBtu/ft2. This contrast likely stems from the fact that Pauley's electricity intake was described as being purchased from the electrical grid. In reality, only a portion of Pauley's electricity comes from the grid; the rest is provided by UCLA's cogeneration plant, which is far more efficient than a traditional natural gas-powered plant and uses relatively cleaner fuels, including biogas. As a result, Pauley's actual source EUI is expected to be lower than what is seen in Figure 1. One knowledge gap associated with this finding is that the EUI is impacted by building occupancy, and we are unsure of the accuracy of our occupancy estimate. Determining and inputting a verified occupancy estimate to accompany the utility records data is an essential next step for the project.

Per the Portfolio Manager summary, Pauley Pavilion's energy usage decreased from 2015 to 2016, which suggests increased efficiency, and possibly decreased demand. Water consumption, on the other hand, increased from 2015 to 2016. After receiving the utility records, our team delegated specific meters and energy resources for analysis. Unfortunately, the data that we received lacked units for some of the values. Specifically, we noticed that readings for two of the water meter readings were lower than the readings of the other two water meters by two to three orders of magnitude. We suspect that this was due to these measurements being made in gallons instead of in hundred cubic-feet. These assumptions were supported by Spencer Middleton.

	Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft ²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison	
Entertainment/Public Assembly			Indoor Arena	85.1	45.3	CBECS - Public Assembly	
			Race Track				
		Stadium	Stadium (Closed)				
	Entertainment/Public		Stadium (Open)				
			Other - Stadium				
		Other	Aquarium				
			Bar/Nightclub				
			Casino				
			Zoo				
			Other - Entertainment/Public Assembly				

Figure 2: U.S national median reference values for all Portfolio Manager property types

Our work extended beyond data analysis. We sought to conduct an energy audit of Pauley Pavilion in collaboration with the Southern California Gas Company. With the help of Katie Zeller, we scheduled a meeting with Michael Kung from SoCal Gas, who walked us through the process of securing an audit, and the associated costs. We learned that SoCal Gas was willing to conduct an audit if that meant that they would receive a reasonable assurance that UCLA would offer a subsequent project for them to execute; understandably, Katie and Todd Lynch were unwilling to make this kind of commitment.

Instead, Katie scheduled a walkthrough of Pauley Pavilion for our team to be led by Kevin Winder from UCLA Facilities Management, and one of Pauley's building managers in charge of Pauley's HVAC operations. The walkthrough was instrumental in our team's process of learning about Pauley Pavilion's steam and chilled water consumption, and it was an opportunity for us to gain a better understanding of the data in the utility records. For instance, we noticed that consumption of steam, which is normally used for heating, was higher in the summer months, as was chilled water consumption. Intuitively, Pauley Pavilion should require very little heating over the summer; however, we learned from Kevin Winder that steam is also used in the building as a condensate-control measure. In order to prevent condensate from forming on the arena floor, steam is used to direct moisture away from the floor. Warmer air can also hold more moisture. This process is necessary to allow athletes to practice at any time of day. The last thing UCLA needs is for a basketball player to slip and pull a leg muscle.

Kevin also gave us a sneak peak of the mechanical room, which housed many of the meters we analyzed in the utility records. Despite the room's miserable humidity and blistering temperature, we took our time in cross-checking meter data with our numerical analysis. The aforementioned discrepancy between the water meters still persisted at the time, and unfortunately units were not labeled on the meters (won't someone think of the units!). Fortunately, Kevin suspected we were right in assuming water consumption units were not uniform between the different meters.

Around the same time, our team developed an application to submit to the Grant Committee of The Green Initiative Fund. We requested a shade over \$10,000 to cover LEED registration costs for Pauley Pavilion as well as a certification review fee that would be paid out once all of the certification documents have been submitted. Admittedly, our request was seen as a tough sell, given that LEED certification alone did not guarantee sustainable building improvements. Our pitch was centered around the idea of LEED certification driving these improvements. The certification process entails taking scores of measurements in energy use and other aspects of sustainability, and this data can empower entities like UCLA Recreation and Capital Programs to suggest improvements. Without these insights, the default method of "business as usual" would prevent measurements from being carried out in the first place. This is why it was so important for our team to secure this funding. The Committee agreed, and we were granted the full amount that we requested. Just a few weeks later, Pauley Pavilion was registered as an official LEED project.

As student supporters of LEED, we felt an additional obligation to promote our work to the campus community. To this end, we held a booth at UCLA's annual Earth Day Fair along with our fellow Sustainability Action Research (SAR) teams. Under the balmy sun, we managed to introduce the concept of LEED to many passerby, and even play some Jenga Trivia. For every correct answer to questions about building sustainability, a block was placed on top of the Jenga tower. By the end, there were some fairly impressive structures.

Our next LEED roadshow stop was at UCLA's annual Green Gala. The Gala presented an opportunity for us to communicate our work to a more environmentally focused audience that was more in-tune with LEED and building sustainability. Here, our team was afforded the chance to explain our project at a more technical level. We were also granted a pleasant surprise at the awards ceremony when our team was awarded Student Research Project of the Year! The final component of our outreach efforts entailed promoting energy and water conservation to students living on campus. With the help of Sustainability Manager Emma Sorrell and Joshua O'Connor of UCLA Residential Life, we created and distributed fliers to students in order to enhance conservation efforts.

The latter half of Spring Quarter was dedicated to fulfilling our early promise and final deliverable: a LEED certification attainment model for Pauley Pavilion. As soon as we realized that a full review and certification of Pauley Pavilion as a LEED building was not a six-month endeavor, we shifted our expectations toward setting up the next team--be it another SAR team or UCLA Capital Programs--to efficiently carry out the certification process.

We constructed two versions of an attainment model. The first was a text-heavy document that provided team recommendations and staff time estimates to attain each credit for Pauley Pavilion under LEED v4 for Building Operations and Maintenance. Each estimate was supplemented with a list of assumptions and knowledge gaps to elucidate our methodology and provide a specified list of required actions. The second aspect of our model was a spreadsheet that visualized our recommendations and categorized the credits to illustrate which must be fulfilled to attain the different LEED rating levels of Certified, Silver, Gold, and Platinum. We categorized the credits in the order of least to greatest estimated time or money required to obtain one point. For credits that had a range of available points, we made a "points to attempt" recommendation which can be found in parentheses in the "Points Available" column.

Despite being laden with assumptions and hampered by knowledge gaps, the attainment model established a useful benchmark which a subsequent team can effectively build on. We also recommend the next team to conduct a sensitivity analysis, which would provide a much-needed range of cost estimations to fulfill various credits. A snippet of the spreadsheet can be found below (Figure 3). To streamline the continuation of this project, we also compiled a list of documents relevant to Pauley's LEED certification that were gathered over the course of the year and shared this list with Todd Lynch.

Credit Name	Points Available (Recommended Points to Attempt)	Required Cost or Time Estimate	Points per Hour of Staff Time*	Certified (40–49 points)	Silver (50-59 points)	Gold (60-79 points)	Platinum (80+ points)**
Location and Transportation							
Alternative Transportation	1-15 (8)	5-25 hours of staff time	0.533	x			
Sustainable Sites							
Site Management Policy	prerequisite	6-8 hours of staff time	-	х			
Site DevelopmentProtect or Restore Habitat	1-2 (1)	\$11,000	0.0018			x	
Rainwater Management	2-3 (3)	10 hours of staff time	0.3	x			
Heat Island Reduction	2	1 hour of staff time	2	х			
Light Pollution Reduction	1	20 hours of staff time or cost of fixtures shields and installation	0.05		x		
Site Management	1	3-10 hours of staff time	0.154	х			
Site Improvement Plan	1	6-8 hours of staff time	0.143	х			
Joint Use of Facilities	1	N/A	N/A				
Water Efficiency							
Indoor Water Use Reduction	prerequisite	6-8 hours of staff time	-	х			
Building-Level Water Metering	prerequisite	N/A	-	х			
Outdoor Water Use Reduction	1-2	N/A	N/A				
Indoor Water Use Reduction	1-5 (5)	1-3 hours of staff time	1	x			
Cooling Tower Water Use	2-3 (0)	N/A	N/A				
Water Metering	2	5 hours of staff time	0.4	х			

Figure 3: LEED v4 O&M certification attainment model for Pauley Pavilion. Since several credits lacked sufficient data to provide an estimate, most credits fell under the "Certified" attainment column.

and Discussion

Results



Results and Discussion

Utility Records Analysis

Spencer Middleton, Energy Analyst with UCLA Facilities, provided us with utility records for Pauley Pavilion's consumption of chilled water, electricity, steam, potable water, and monthly number of cooling and heating degree days. The data also contained monthly campus rates by resource, as well as meter locations. In our spreadsheet, we made two bar graphs for each utility—one for consumption and one for cost. We made segmented bar graphs to demonstrate consumption for resources with multiple installed meters. Shown below are the graphs depicting overall consumption by resource. We also created line graphs to relate temperature, chilled water, and steam to the amount of cooling and heating degree days. Steam and chilled water usage displayed sinusoidal activity with peaks occurring during the summer months. These peaks were especially prominent in steam consumption. The electricity consumption also showed this pattern, but at a much greater cyclical rate (one to three months as opposed to seasonal). Degree days were, for the most part, inversely related to the average temperature.

At first we were perplexed as to why steam usage increased in the summer months, but while on our tour of Pauley Pavilion, Kevin informed us that chilled water and steam must be used in conjunction with one another in order to prevent excess condensation from damaging the arena's wooden floor. This interaction with a maintenance representative provided the team with an enriching experience by giving meaning to the utility data beyond the numbers.

We then took a look at all of the utilities together, in terms of both cost and usage. Chilled water, electricity, and steam data were all converted to kilo British thermal units (kBtu). This unit is inapplicable to water consumption. For total energy consumed by resource, chilled water towers over electricity and steam; chilled water and electricity dominate overall cost. Surprisingly, total costs for water came in well under our expectations. This finding lends to the notion that water as a resource is underpriced in California. As a result, there is less of an incentive to pursue water efficiency improvements.

Results and Discussion

Utility Records Analysis







Cooling Degree Days vs. Chilled Water



Total Energy Consumption by Resource (Jan '15 - Aug '16)





Water Consumption



Cooling Degree Days vs. Average Temperature



Total Utilities Cost by Resource (Jan '15 - Aug '16)



Note: The two water meters with the lowest values were converted from HCF to gallons.

Results and Discussion

Attainment Model

Following the utility records analysis, we shifted focus to our LEED certification attainment model. To build such a model, we first had to establish a degree of familiarity with Pauley Pavilion's initial LEED certification under NC. For this purpose, Todd Lynch provided us with two key documents: Pauley Pavilion's Final LEED Scorecard for NC and LEED v4 Standards for Building Operations and Maintenance. The LEED scorecard contained a brief description of all the prerequisites and credits associated with Pauley Pavilion's LEED Gold certification under LEED v2.2 and whether they were earned or denied. We compared current LEED v4 O&M standards with the LEED scorecard associated with Pauley Pavilion's recent renovation and identified prerequisites and credits that overlapped. This allowed us to shift focus from credits that were likely already met to more-demanding new or modified credits and prerequisites. Our task also required that we immerse ourselves in the details of current LEED requirements. LEED v4 O&M is divided into 6 main categories: Location & Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Air Quality. In order to facilitate data collection we delegated specific prerequisites and credits to each team member.

The final attainment model unveiled several key findings. The first was that, at this time, it serves as a useful starting point, but nothing beyond that. Between the lack of sufficient documentation and inexperience with fulfilling the credits, the model can be characterized as a best guess and a head start. This conclusion is not meant to deprecate our work in the slightest -- in fact, this legwork is necessary to allow the next team to jump head-first into credit analysis and attainment. We are wholly satisfied with setting the table.

Furthermore, our model supported several of our hypotheses. The overwhelming majority of the credits analyzed could be achieved with student or staff time-- without a high infusion of capital for improvement projects. All of the prerequisites appear especially within reach, and we are confident that Pauley Pavilion can attain at least "Certified" status with minimal effort. Combining insights from our attainment model with the utility records analysis, it is also evident that Pauley Pavilion sources its energy sustainably from the cogeneration plant and that its electricity consumption efficiency rates well in comparison to similar buildings. The greatest area for improvement is water efficiency. Kevin Winder of UCLA Facilities posed the idea of collecting runoff from Parking Lot 8 and repurposing it for use in Pauley Pavilion. As much as we like the sustainability aspect of a project like this, the relatively low cost of purchasing water relative to other utilities would surely be a limiting factor.



Challenges and Difficulties

We have been fortunate to avoid any major setbacks throughout our work on this project, but certain challenges have arisen for which we had to use our creativity and problem-solving skills to overcome. At the onset of our research, we found ourselves entering an area of study that we were largely unfamiliar with. Because we had little preexisting knowledge about energy efficiency or the LEED framework, our background research and initial literature review were slightly daunting and overwhelming at first. We were unsure about where to start background research of a topic so broad, but we found that by researching general information about LEED, we were left with questions that guided the rest of our research. By asking a lot of questions and using our stakeholder as a resource for confusing topics, we were able to amass substantial background knowledge about our subject.

Through our preliminary research, we found that LEED is a multifaceted system with a scope much larger than energy. We found it challenging to formulate research questions and goals solely focused on energy, so we evaluated what we wanted our research project to encompass and decided to change the name of our team. Although energy is a big factor in the efficiency of buildings, our project goals depended on many other factors such as water use and utility metering, which are all aspects of sustainable buildings. Thus, we became Sustainable Buildings: Pauley Pavilion.

As we began the data collection process, we found that much of the initial data we sought (such as utility data) already existed, but we depended on others to access it. At times, we felt powerless in our efforts to make the process as straightforward as possible. We found that by communicating well with the people helping us gather data and by being organized and specific about which data we needed, we were able to gather the data for analysis in a timely manner. This hurdle presented itself again as we began to develop our attainment model, and we soon realized that more information was needed for an objective analysis of each credit's cost. This lack of complete information took effect for most credits in the model. Our solution was to include two sections noting "Knowledge Gaps" and "Assumptions" for each credit in order to guide further research.

One minor disappointment for our team was the inability to conduct an energy audit of Pauley Pavilion, which would have provided further insight into the operating performance of the facility. We learned that performing an energy audit is much easier said than done. Audits cannot be completed by students independently, and require extensive support from a third party like a utility company. To perform an ASHRAE Level 2 energy audit for Pauley Pavilion which fulfils requirements for LEED certification, our cost estimate ranges from \$75,000 to \$100,000. While this audit would provide detailed data about the building's efficiency, our initial utility analysis suggested that Pauley's electricity usage scored well, and that the audit would not be cost-effective. While we chose not to pursue the ASHRAE energy audit this year, we recommend that a future team explore less expensive energy audit options through UCLA Facilities Management or other student-based projects to monitor energy usage.





Conclusion

Monitoring the energy consumption and sustainability of existing buildings at UCLA is a crucial component of campus sustainability. Maximizing the efficiency of existing infrastructure is often more cost- and energy-efficient than erecting new buildings. At this time, there is not yet an ongoing policy in place at UCLA for examining and certifying existing buildings. Therefore, certification under Building Operations and Maintenance standards goes above and beyond UC policy requirements. Examining existing buildings can also help set precedents for management policies that create a stepping stone for expanding certification to other buildings on campus, or integrating building management with other sustainability initiatives. Certification for existing buildings requires careful review, evaluation, and documentation of ongoing processes in energy and water consumption, as well as waste recovery, purchasing, and cleaning. All of these facets are supported by campus practices and policies, but a systematic comparison back to design goals is less common, and highly valuable. Checking meter data and benchmarking our buildings can help identify anomalies or opportunities for improvements via repairs, operations, or campaigns informing occupant behaviors. Hopefully, the methodology, experiences, and lessons learned in Pauley Pavilion's re-certification process can set a precedent for a system that can both be continually maintained, and help facilitate other energy audits and LEED O&M certifications for other buildings on campus.

As the project moves forward, the next steps in completing the LEED re-certification process include leveraging the attainment model to decide which credits to pursue, combining analysis of utility records with other documentation to determine future projects, and submitting the required documentation to complete the certification review process. With funding from The Green Initiative Fund (TGIF), a portal has been opened with USGBC LEED online, which will allow those working on the project in the future to begin uploading the documentation and information required for LEED review. The Sustainable Buildings: Pauley Pavilion team recommends that Sustainability Action Research (SAR) enlist a team for the 2017-2018 school year to assist in this process and submit the project for review by June 2018 using the remaining TGIF funding. This team would research each credit more closely and attempt to fill the knowledge gaps highlighted in the attainment model. Once it is determined which credits will be pursued for recertification, documents and information required for each credit will need to be drafted and uploaded to the online portal. Much of this work will be feasible for students to complete with the guidance of an expert, but some work will need to be completed by professionals and/or consultants as highlighted in the "Assumptions" sections of the attainment model. If SAR does not continue involvement with the project, a group from Capitol Programs or related parties will be responsible for completing the recertification process.

Conclusion

This year, the Sustainable Buildings: Pauley Pavilion team has had remarkable success in our educational, research, and outreach goals. We feel confident with the progress that has been made in two quarters of research, and that we have laid the groundwork for a future team to complete the project and re-certify Pauley Pavilion. We could not have achieved all of this without the unwavering support of our stakeholder Todd Lynch and the countless hours he has spent answering our questions and gathering information for us. We are also extremely grateful to those have helped us gather data and information including Katie Zeller, Jesse Escobar, and Spencer Middleton. Our sincerest thanks also go out to the Sustainability Action Research leadership group, which includes Carl Maida, Cully Nordby, Mochi Li, Austin Park, and Gabby Merino, as well as the incredible support of the broader SAR community and the UCLA Institute of the Environment and Sustainability. We could not have been successful without the support of this extensive network and the strong presence of sustainability and environmentalism at UCLA.

References

Bains, Jasneet, Claire Josephson, Melissa Grace Klose, Amy Sen, Tiffany Tran, and Edgar Vargas. "LEED Assessment Action Research Team Final Report." (2012) n. pag. UCLA IoES. UCLA IoES, 2012. Web. 22 Mar. 2017.

(n.d.). In ENERGY STAR Portfolio Manager. Retrieved from https://portfoliomanager.energystar.gov/.

- Hampton, Jessica, Sean Murphy, Lauren Dickenson, Charlie Falconer, Corey Roth, and Megan Vyenielo. "Zero Waste Pauley Action Research Team Final Report." (2013). n. pag. UCLA IoES. UCLA IoES, 2013. Web. 22 Mar. 2017. https://www.ioes.ucla.edu/wpcontent/uploads/ZeroWastePauleyFinalreport.pdf>.
- Hirashiki, Claire, Danh Lai, Justin Brandt, Elizabeth Roswell, and Alexandra Stream. "Green Buildings Final Report Spring 2014." (2014). n. pag. UCLA IoES. UCLA IoES, 2014. Web. 22 Mar. 2017. https://www.ioes.ucla.edu/wpcontent/uploads/greenbuildings_final_report.pdf>.

Jacques, Kiley. "In the Leed." USGBC+. U.S. Green Buildings Council, 2014. Web. 22 Mar. 2017. http://plus.usgbc.org/in-the-leed/

"Maples Pavilion." Sustainable Stanford - Stanford University. N.p., n.d. Web. 28 Jan. 2017. http://sustainable.stanford.edu/buildings/09-300

- "Member Benefits." Green Sports Alliance. Green Sports Alliance, 2017. Web. 22 Mar. 2017. http://greensportsalliance.org/members-benefits/>.
- Sandler, Mike. "LEED-EB For the Public Affairs Building." (2008) Web. 24 Mar. 2017 http://mikesandler.org/docs/LEED-EB-SPA-BLDGReport.pdf
- Sandler, Mike. "LEED-EB at the Public Affairs Building Water Efficiency: Toilets, Urinals, and Faucets" (2008) Web. 24 2017 http://mikesandler.org/docs/LEEDEB-WaterEff.pdf>
- "The difference between source and site energy." ENERGY STAR Buildings and Plants | ENERGY STAR. N.p., n.d. Web. 24 Mar, 2017 <https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand metrics/difference>
- U.S. Energy Use Intensity by Property Type (2016, March). In ENERGY STAR Portfolio Manager. Retrieved June 6, 2017.
- U.S. Green Building Council. "LEED v4 for Building Operations and Maintenance." USGBC, 1 July 2016. Web. 25 Jan. 2017. http://www.usgbc.org/sites/default/files/LEED%20v4%20EBOM_07.01.16_current.pdf
- What is energy use intensity (EUI)?. (n.d.). In Energy Star. Retrieved June 11, 2017, from https://www.energystar.gov/buildings/facility-owners-andmanagers/existing-buildings/use-portfolio-manager/understand metrics/what-energy
- Young, Talia, Katie Zeller, Rachel Chung, Kimberly Mak, Peilun Sun, and Rich Mylin. "Zero Waste Pauley Final Report Spring 2014." (2014): n.pag. UCLA IoES. UCLA IoES, 2014. Web. 25 Jan. 2017. https://www.ioes.ucla.edu/wpcontent/uploads/Pauley_final_report.pdf>.
- "Zero Waste at Ohio Stadium." OhioStateBuckeyes.com :: The Ohio State University Official Athletic Site. N.p., n.d. Web. 28 Jan. 2017.

<http://www.ohiostatebuckeyes.com/facilities/zero-waste-ohio-stadium.html>

