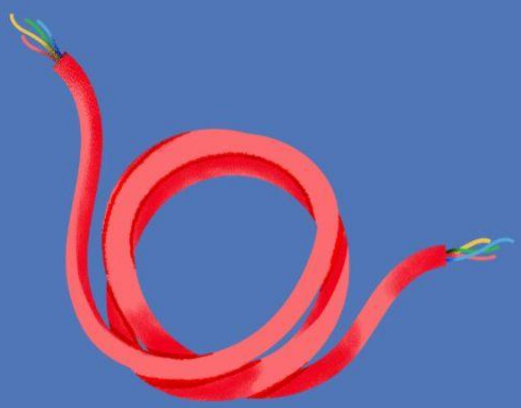
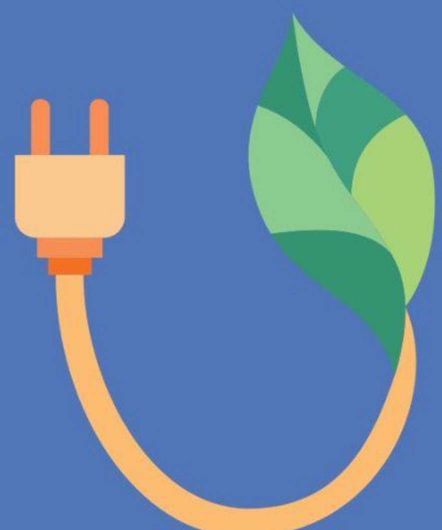
SAR ENERGY TEAM

Final Report





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Stakeholder: Spencer Middleton, UCLA Facilities Management Energy Analyst

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Abstract

This report explores ways to increase effective energy use in UCLA facilities. The university developed the Sustainability Master Plan to promote sustainability and cut emissions, including a 2% reduction in annual energy use. To achieve this goal, Facility Management collaborated with Student Action Research (SAR) to find cheap, easily implemented ways to cut energy use and CO2 emissions through effective Air Handler scheduling. As such, this report explores *How can building occupancy rate data be integrated into UCLA campus building energy management and control plans to increase energy efficiency, produce savings costs and cut C02 emissions?* Through an observational design, our team collected occupancy data that shaped our schedule changes recommendations. We used Facility Mangament's saving costs calculator that produced the CO2 and monetary savings estimates. In addition, the Energy Team spoke with key stakeholders that developed our EDI to ensure the study reflected the views of key facility groups. Results showed a 15 per week cut (annualized at 780 hours) of Air Handler schedules in Perloff could produce a $3,354 annual savings and cut 3,952.92 pounds of CO2. Such savings could have major implications at UCLA. The low cost of schedule adjustments could play a key factor in UCLA's goal to reduce 2% annual energy use. A final deliverable in the form of a 1-page paper providing a recommendation schedule shifts and a simplified version of this report was sent to Facility Management.

Introduction

In 2019, UCLA unveiled a Sustainability Master Plan with ten main subtopics outlining goals encompassing all campus operations. The subtopics of Energy and Buildings have ambitious goals such as reducing campuswide energy use by 2% annually and designing, constructing, and commissioning buildings that outperform California Building Code Energy Efficiency Standards by 30% (UCLA Sustainability, 2019). UCLA has implemented various initiatives in pursuit of its ambitious sustainability goals, such as rapidly increasing the number of Leadership in Energy & Environmental Design (LEED) certified buildings and retrofitting older buildings for energy efficiency. Though these are big improvements, there is still room for growth— UCLA's Campus Energy Facility continues producing 250-gigawatt hours (GWh) annually, enough energy to power almost 188 million homes, while only nine campus buildings participate in energy conservation programs (UCLA Facilities, 2022). There are also avenues of energy conservation the school has not yet examined. One such subject matter is the relationship between building occupancy and energy conservation, which the 2023 SAR Energy Team will explore through the question: *How can building occupancy rate data be integrated into UCLA campus building energy management and control plans to increase energy efficiency, produce financial savings, and cut CO2 emissions?*

Other institutions have already incorporated such a factor into their energy sustainability initiatives, such as the California State University's Systemwide Energy Information System Master Enabling Agreement to inform energy procurement and allocation decisions, and Cornell University's Energy Conservation Initiative. A dozen case studies conducted by the Lawrence Berkeley National Laboratory and the University of Maryland, College Park utilized infrared thermal and video sensors to count how many people entered and left the buildings to supplement existing data provided by building managers. This data was compared to building energy consumption data through a linear regression analysis which found that 10%–40% of the energy can be conserved if building occupancy is factored into facilities' energy plans, saving millions of dollars annually. However, this project and other similar studies were conducted over a year and installed sensor cameras with the intention of keeping them in the buildings long term; due to restrictions on time and policies regarding student confidentiality and installing devices in the building, we opted for different data collection methods (Kim et al., 2017).

Given that UCLA has its own unique building management and energy allocation systems, we cannot use similar studies conducted at other institutions to formulate a hypothesis for our research question and must first collect our own data. Our project purpose is to reveal a comparably low-cost, low-maintenance, adjustable, and easily implementable plan for campus buildings that generates substantial energy and financial savings and adheres with existing campus sustainability plans. Our project will be observational-based rather than experimental as it will be easier to discern correlations between our primary variables, which will be EUI (Energy Usage Index), building occupancy, and the carbon emissions and financial impact from energy expenditures.

Methods

In assessing energy usage and optimal manners of reduction, our team employed a two-part methodology: the first part aimed to observe the change of occupancy over time in Perloff, based on facility scheduling, and the second part aimed to quantify energy costs through CO2 reduction & financial savings.

Observing Occupancy Changes over Time

Our team decided to conduct the data collection process over the period of 2 weeks, from May 3 to May 12. We initiated a preliminary data collection on April 25 collecting data in the morning from 7:00-8:45am that revealed logistical problems relating to data collection. Our team had issues with ineffective data collection as most offices and rooms would not answer inquiries before the actual work day had started. More than expected facility restrictions arose as building managers wanted our team to check in prior to every shift and have a staff attend during the data collection period. This proved difficult as Perloff staff shortage made it difficult to get consistent access. Therefore, we decided to collect data from 7:00 PM-12:00 AM during the two week data collection period.

Data collection was split into different shifts throughout the week with a team member responsible for at least three. Shifts spanned from 7:00-8:30 PM, 8:30-10:00 PM, then 10:00 PM-12:00 AM each day. Therefore, the team had around 30 data collection shifts and data sets. Initially, the team wanted to collect data on all Perloff floors: Floor B, Floor 1, and Floor 2. However, accessibility restrictions prevented collection on Floor 2 that limited the data range.

Occupancy observation was conducted over two weeks, instead of a larger period, to reduce confounding variables that would skew potential schedules changes. Examples of these variables include: finals weeks boosting occupancy or architecture project showcases introducing non-regular Perloff occupancies to the facility.

Data collection consisted of members knocking on every door in each Air Handler (AH) Zone, observing if there were occupancies in rooms & hallways and then inputting in the standardized data collection sheet. AH Zones refer to the area covered by the local HVAC zoning system. HVACs are the “healing and cooling system… used to regulate and redirect air [inside the zone]” (Lennox 2023). In Perloff, there are four AH Zones spread across all three floors: AH-1, AH-2, AH-3, AH-4, AH-5, and AH-6; However, AH-5 & AH-6 were omitted from analysis as they were located as Floor 2 that the team did not have access to. Data collection schedules were dispersed dependent on the AH zone schedules. AH-1 closes at 11:59pm, AH-2 closes at 9:00pm, AH-3 closes at 11:59pm, and AH-4 closes at 9pm.

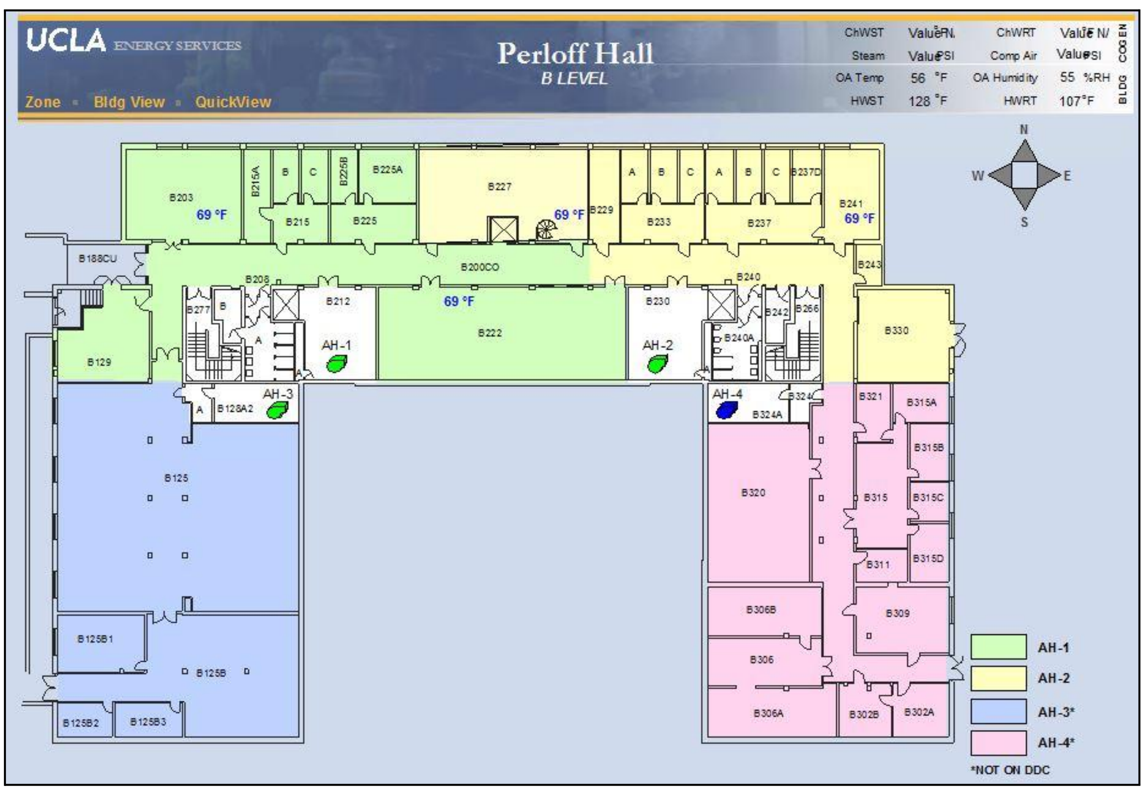
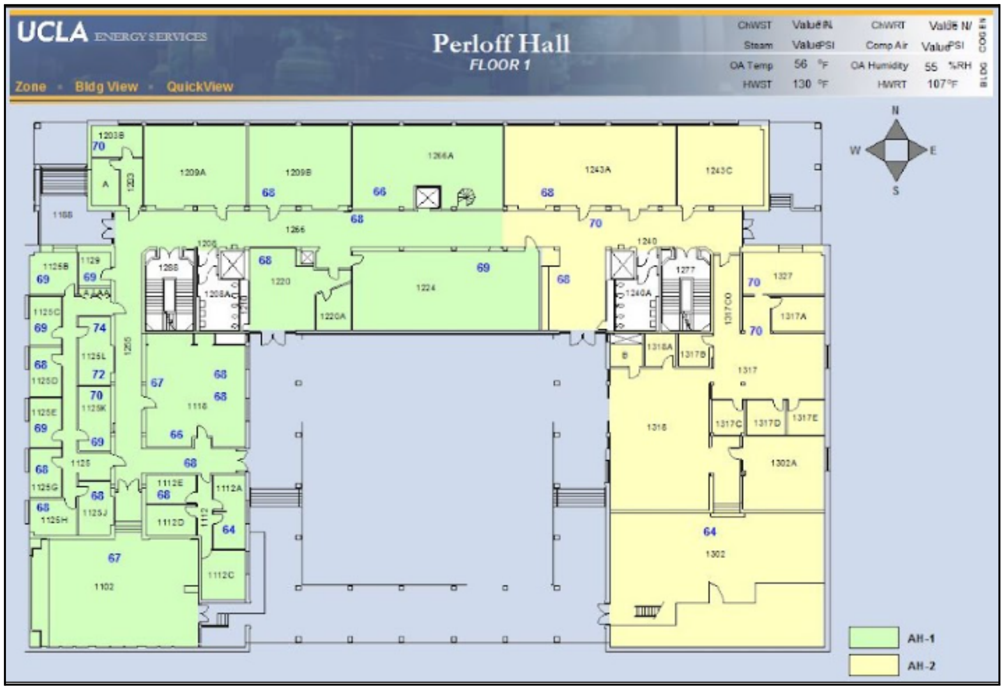


Figure 1: Perloff Floor B, AH-1, AH-2, AH-3, AH-4



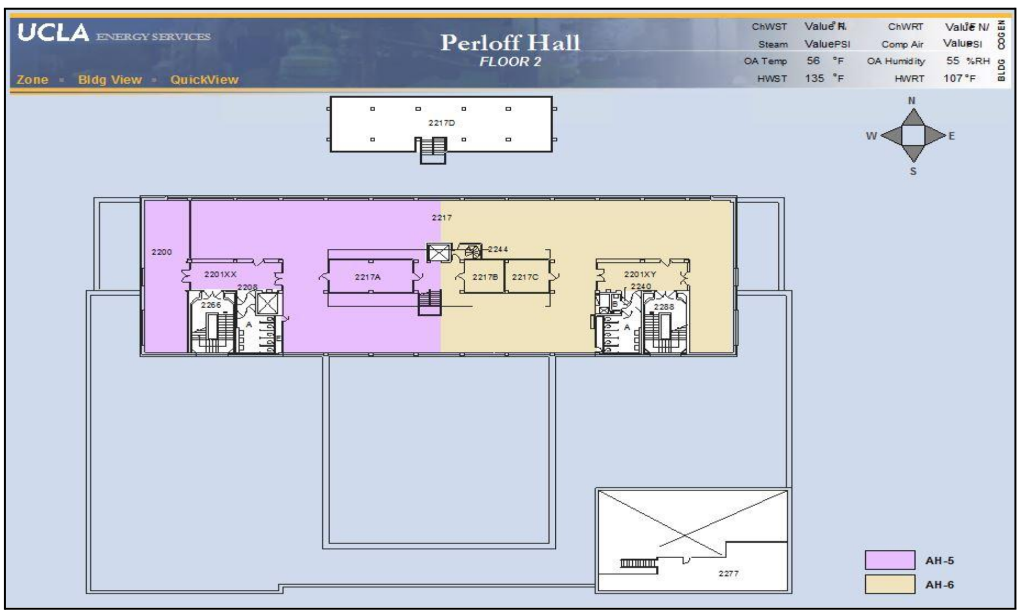


Figure 2: Perloff Floor 1, AH-1, AH-2

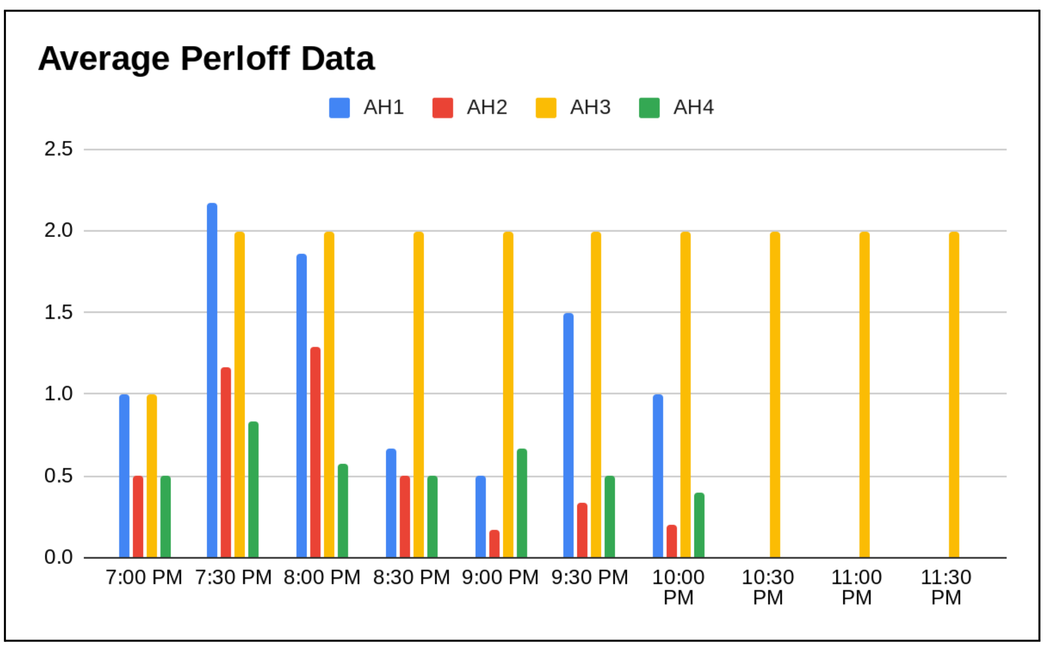
Figure 3: Perloff Floor 2, AH-5, AH-6

After collecting the occupancy data, the team consolidated all observed occupancies and categorized by 30 minute staggered periods such as: 7:30pm, 8:00pm, 8:30pm. The changes in occupancy were then visualized through a bar graph for each day such as: May 3, May 4, and May 5.

Perloff May 11				
	AH1	AH2	AH3	AH4
7:30 PM	4	5	2	1
8:00 PM	4	5	2	1
8:30 PM	1	3	2	1
8:40 PM	2	0	2	1
9:00 PM	0	0	2	1
9:30 PM	2	0	2	1
10:00 PM	0	0	2	1
10:30 PM	0	0	2	0

Figure 4: Occupancy Observation May 11, 2023 7:30-10:30 pm

Finally, the data were consolidated and categorized by each day and hour of observation to make a bar graph that visualized the average changes over time throughout each round of data collection. Based on these average occupancy counts, the team developed the recommended Air Handler schedules changes.



Graph 1: Average Perloff Occupancies, 7:00pm-11:30pm

The Energy Team received a Saving Cost Calculator from our stakeholder, Spencer Middelton that produced a financial and C02 saving estimate. To produce the financial saving estimate, the team changed the occupied hours of the normal operations column. This calculates the annual energy produced from each air handler zone. However, due to Perloff accessibility issues, only AH-1, AH-2, AH-3, and AH-4 were considered. All other columns remained the same as our stakeholder set up. Modifications then produce a net annual savings.

BUILDING ENERGY CALCULATOR

BLDG: Perloff
DATE: June 12, 2023

			Based on 70% of design.			NORMAL OPERATION					ENERGY OPERATION								
						OCCUPIED HOURS / day				ANNUAL ENERGY	OCCUPIED HOURS / day				VENTILATION HOURS				ANNUAL ENERGY
UNIT	SERVING	FUNCTION	CFM	100% OA 1 = YES	RECIRC 1 = YES	M-F	SAT	SUN	HOURS		M-F	SAT	SUN	HOURS	M-F	SAT	SUN	HOURS	
AH-1			14,840		1	17	7.5	7.5	5,200	22,083	15	7.5	7.5	4,680	0	0	0	0	19,875
AH-2			15,400		1	14	7	7	4,368	19,250	13	7	7	4,108	0	0	0	0	18,104
AH-3			2,590		1	22	7	7	6,448	4,779	22	7	7	6,448	0	0	0	0	4,779
AH-4			3,360		1	14	7.5	7.5	4,420	4,250	14	7.5	7.5	4,420	0	0	0	0	4,250
AH-5			7,000		1	18	7.5	7.5	5,460	10,938	18	7.5	7.5	5,460	0	0	0	0	10,938
AH-6			5,950		1	7.5	7.5	7.5	2,730	4,648	7.5	7.5	7.5	2,730	0	0	0	0	4,648
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0

ENERGY RATES
SYSTEM $ per CFM per YEAR
$3.75 100 % OUTSIDE AIR
$2.50 RECIRCULATED AIR
$1.25 VENTILATION MODE

TOTAL CFM.. 49,140
TOTAL ANNUAL COST.. $65,948
TOTAL OPERATING HOURS.. 28,626
LESS RESCHEDULED COST.. $62,594
NET ANNUAL SAVINGS.. $3,354

TOTAL RESCHEDULED COST.. $62,594
27,846 0
TOTAL RESCHEDULED HOURS.. 27,846
REDUCED OPERATING HOURS.. 3%

Difference in hours 780

Figure 5: Financial Saving Cost Calculator

For the CO2 saving costs, the team inputs the “hours saved” in the recommended schedule. The calculator annualized the hours saved and calculated the energy saving use of each different energy type and its measurement: Electricity (Kilowatt/hour), Chilled Water (kilo

British Thermal Unit/hour), and Steam (pounds/fan runtime). The calculator then produced the total annual CO_2 saving estimate.

Challenges

Building upon the progress we made in the winter quarter, our team encountered new challenges during the preparation stage and data collection process. During the preparation phase, we faced communication issues when attempting to engage with certain building coordinators. Although we were only able to conduct the actual data collection process in the Perloff Building, our original plan encompassed three buildings: Perloff, Campbell, and Kaufman Hall. However, when we attempted to contact the building coordinators from Campbell and Kaufman, we found their contact information to be outdated. Despite our proactive efforts to overcome this obstacle through stakeholder engagement and site visits, we were still unable to secure these two buildings for our research. Our group adapted to this change in the data collection plan by deciding to focus solely on the Perloff Building. This shift in strategy proved to be a positive turning point for our team. Considering the time constraints and the vast amount of data required for thorough analysis, and with only six group members, focusing on one building emerged as a more feasible option. This allowed our team to dedicate more time to comprehensive data collection over a two-week period, resulting in an exhaustive analysis of the Perloff Building. Moreover, our research on the Perloff Building can serve as a foundation for potential future SAR energy teams.

During the actual data collection stage, our team faced some alterations in our initial plan regarding data collection method and schedules. While doing research, our team discovered that past occupancy data collection research projects utilized technology such as thermal sensors and security cameras in order to save time and improve occupancy count accuracy. However, consultation with our stakeholder revealed that such methods raised concerns of privacy over the students being recorded through such technology, and also included cost barriers to purchase and operate such technology, which not all buildings had, and also logistical restrictions as the cameras available were only accessible to actual building employees. Thus, after hearing about these difficulties, we decided upon collecting empirical data through visiting the Perloff building ourselves in alternating shifts, spanning the entire building schedule throughout each week.

Furthermore, we encountered difficulties during data collection in the Perloff Building. One such issue was that we were prohibited from accessing the second floor, which was exclusively designated for architecture students. As a result, our data collection was confined to the remaining three floors. We adjusted to this limitation by concentrating our efforts on these accessible floors. In addition, we found that several rooms, mostly faculty offices, were locked from the inside starting at 7:00 PM, often with faculty or students working within. We addressed this challenge by knocking on every door and either inquiring about the number of occupants in each room or listening at the door to estimate the number of individuals present.

Results

Our results began with a series of interviews, from which we collected important qualitative data. We used this to develop and begin our data collection process. We applied the collected data to generate scheduling changes for Perloff. Every piece of data we collected was essential to our project and gave us new insight into the operations of UCLA facilities.

Qualitative Data

The first step of our project was to understand the complex energy systems and facilities of UCLA. Our stakeholder, Spencer Middleton, set up a meeting with our team and Robert Striff, the Director of Energy Services. This was a casual information-gathering meeting, in which we learned how buildings differ in funding, and how they use different types of energy. There are state-funded buildings, recharge buildings that can charge businesses for their expenses, and student-fee buildings that are funded by students' tuition. Of these buildings, Mr. Striff advised we choose state-funded buildings because the savings created from reducing energy in those buildings can go into the school in another way. Also, we would have full access to the energy data for state-funded buildings, and the other building types have more complicated finances and energy data. Mr. Striff also informed us of the different types of energy used: electric, chilled water, steam, and gas. The chilled water is used for cooling the buildings and the steam is used for heating the buildings. This meeting was very informative and helped immensely in starting our project.

The next informal meeting we had was with Christian Tsouras, the Head of Building Automation. In this meeting, Mr. Tsouras helped us further understand the HVAC zoning, in that there are some buildings in which the entire floor plan's temperature is controlled at once, while others have zoning in which certain areas or rooms can have dual temperatures. This more specific zoning helps us create quadrants for our sampling in the future. Mr. Tsouras also informed us that we can bring our findings to him and he can easily implement changes to the building automation.

Most recently, we talked with Justin Wisor, the Director of Custodial and Grounds. Justin informed us when custodial workers are in the buildings, which aids us in determining the building peak and least busy usage hours in terms of occupancy. There are two shifts, one in the morning until 1:30 pm, and one in the evening from 5:30 pm - 2 am. Mr. Wisor also communicated that when there are custodial workers in the building there should not be any rapid temperature changes so it is not too hot for them. This information is incorporated into our final deliverable. We will be combining all of the information we gathered through conversing with these experienced stakeholders throughout the UCLA administration with the data that our stakeholder provided.

Building-Specific Data

The other data we have gathered so far is building-specific. The data is specific to Perloff and includes the number and location of air handlers, as well as the regions they control and their schedules. As pictured below, there are six air handlers that control different zones within Perloff. For our study, we used this information to determine where we would observe occupancy. For our deliverable, this helped us determine the level of specificity for our scheduling recommendations.

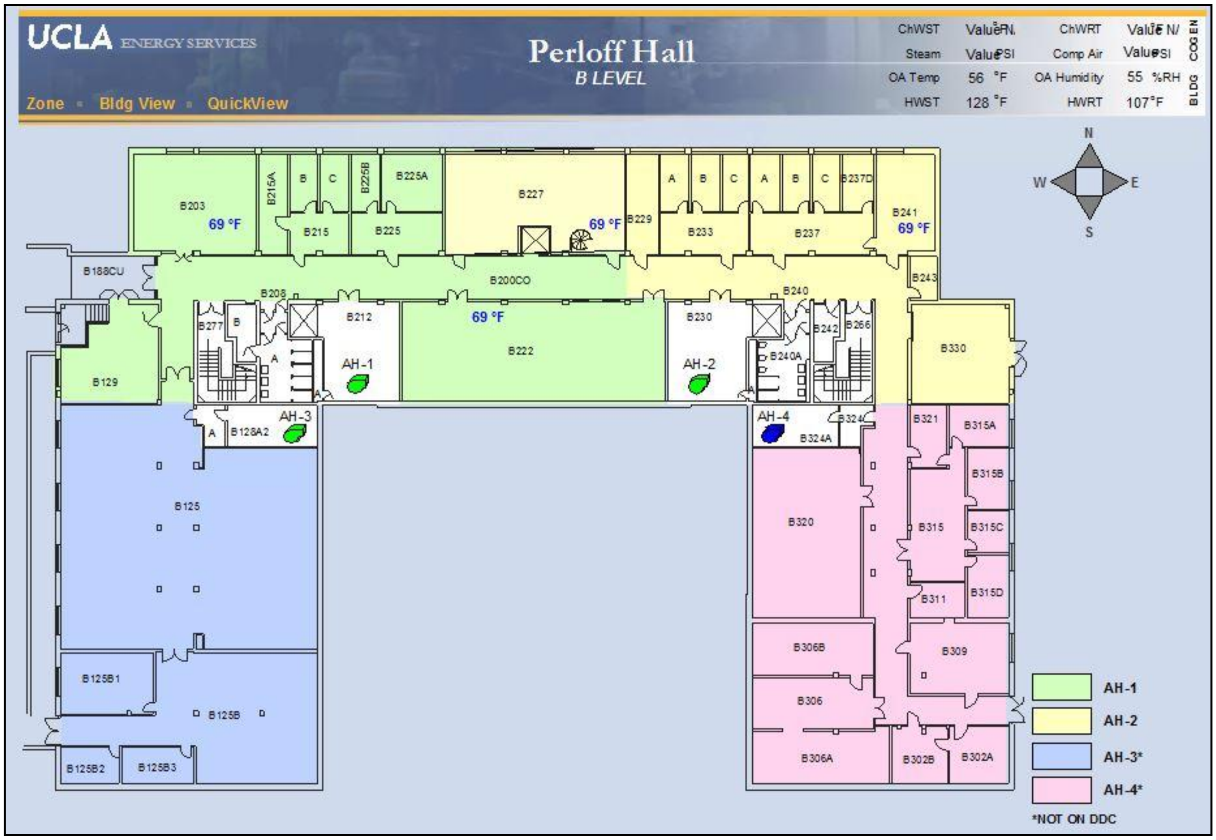


Figure 6: The Air Handler in Perloff

Figure 1 (also pictured in the "Methods" section): Perloff Floor B, AH-1, AH-2, AH-3, AH-4

We also have the schedules of the Perloff air handlers. There is one schedule for weekdays and another for Saturdays and Sundays. These schedules are pictured below. We observed occupancy before and after the end times listed here for weekdays. We chose not to collect data on weekends because the schedules for weekends are adequately succinct. Our recommendations to our stakeholder will detail whether or not these weekday end times can be adjusted.

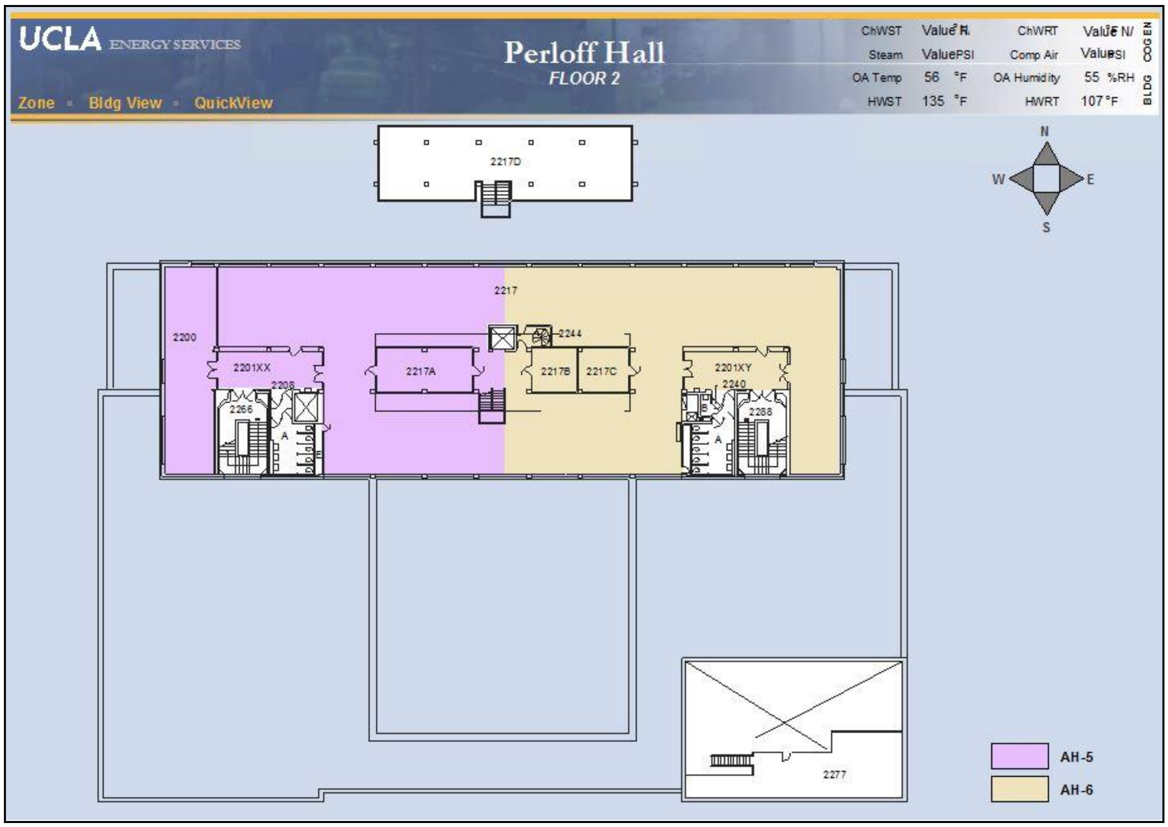
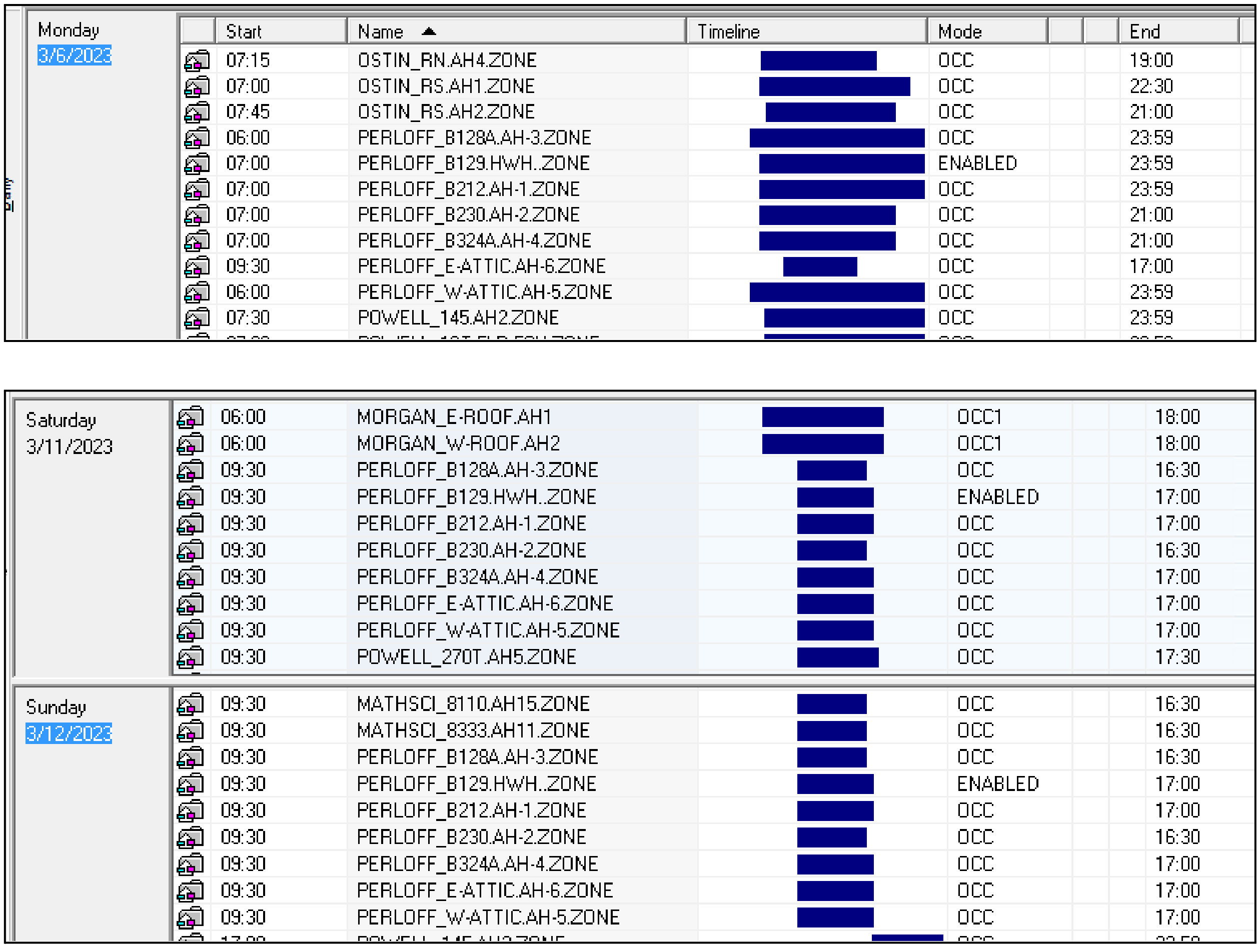


Figure 3: Perloff Floor 2, AH-5, AH-6



Day	Start	Name	Timeline	Mode	End
Monday 3/6/2023	07:15	OSTIN_RN.AH4.ZONE		OCC	19:00
	07:00	OSTIN_RS.AH1.ZONE		OCC	22:30
	07:45	OSTIN_RS.AH2.ZONE		OCC	21:00
	06:00	PERLOFF_B128A.AH-3.ZONE		OCC	23:59
	07:00	PERLOFF_B129.HWH..ZONE		ENABLED	23:59
	07:00	PERLOFF_B212.AH-1.ZONE		OCC	23:59
	07:00	PERLOFF_B230.AH-2.ZONE		OCC	21:00
	07:00	PERLOFF_B324A.AH-4.ZONE		OCC	21:00
	09:30	PERLOFF_E-ATTIC.AH-6.ZONE		OCC	17:00
	06:00	PERLOFF_W-ATTIC.AH-5.ZONE		OCC	23:59
	07:30	POWELL_145.AH2.ZONE		OCC	23:59

Day	Start	Name	Timeline	Mode	End
Saturday 3/11/2023	06:00	MORGAN_E-ROOF.AH1		OCC1	18:00
	06:00	MORGAN_W-ROOF.AH2		OCC1	18:00
	09:30	PERLOFF_B128A.AH-3.ZONE		OCC	16:30
	09:30	PERLOFF_B129.HWH..ZONE		ENABLED	17:00
	09:30	PERLOFF_B212.AH-1.ZONE		OCC	17:00
	09:30	PERLOFF_B230.AH-2.ZONE		OCC	16:30
	09:30	PERLOFF_B324A.AH-4.ZONE		OCC	17:00
	09:30	PERLOFF_E-ATTIC.AH-6.ZONE		OCC	17:00
	09:30	PERLOFF_W-ATTIC.AH-5.ZONE		OCC	17:00
	09:30	POWELL_270T.AH5.ZONE		OCC	17:30
Sunday 3/12/2023	09:30	MATHSCI_8110.AH15.ZONE		OCC	16:30
	09:30	MATHSCI_8333.AH11.ZONE		OCC	16:30
	09:30	PERLOFF_B128A.AH-3.ZONE		OCC	16:30
	09:30	PERLOFF_B129.HWH..ZONE		ENABLED	17:00
	09:30	PERLOFF_B212.AH-1.ZONE		OCC	17:00
	09:30	PERLOFF_B230.AH-2.ZONE		OCC	16:30
	09:30	PERLOFF_B324A.AH-4.ZONE		OCC	17:00
	09:30	PERLOFF_E-ATTIC.AH-6.ZONE		OCC	17:00
	09:30	PERLOFF_W-ATTIC.AH-5.ZONE		OCC	17:00

Figure 7: Air Handler Zone Schedules

Quantitative Data

Occupancy Data

The analysis of occupancy patterns in the Perloff building revealed important insights into the usage of different air handler zones. By collecting data over a week and observing the number of people present in each zone at various times, we were able to identify trends and draw meaningful conclusions.

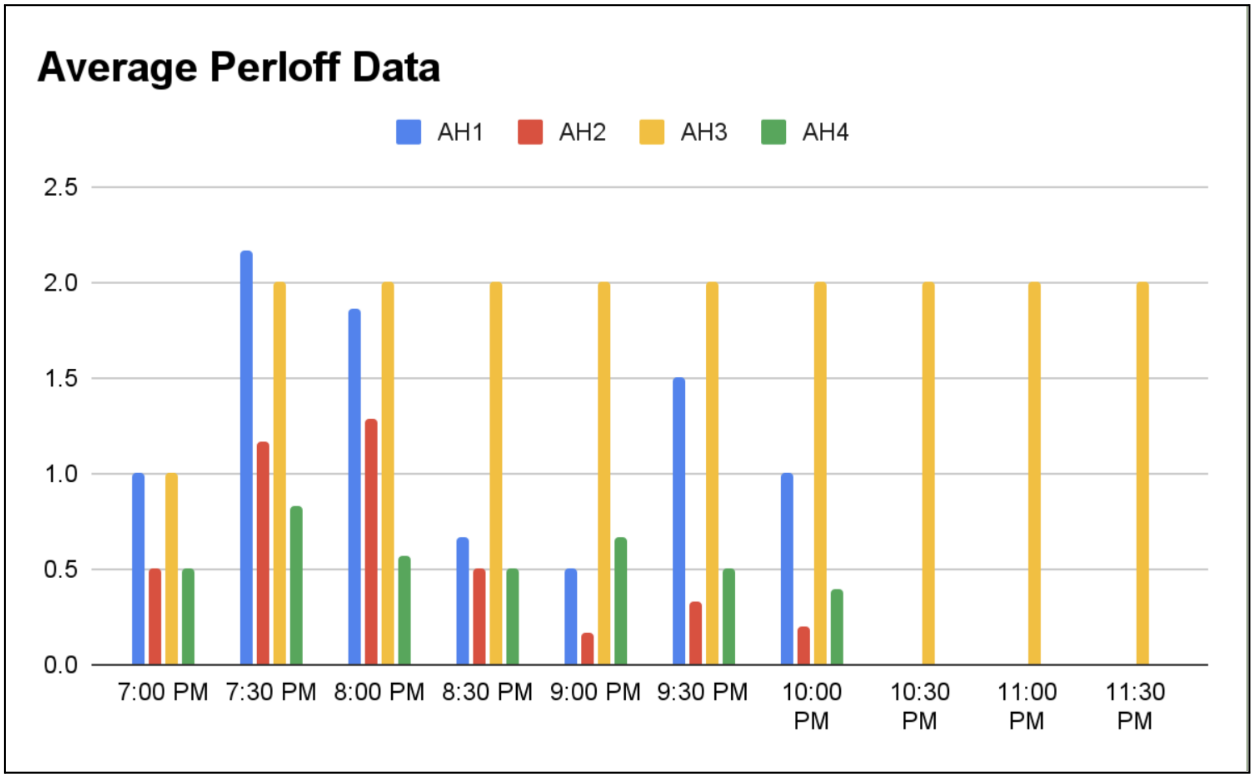
We began by utilizing building-specific information, such as the number and location of air handlers, their respective control regions, and schedules. This data allowed us to select the areas where we would observe occupancy and gather relevant information for our study. To capture occupancy levels, we conducted regularly scheduled door-to-door visits during nighttime hours (see *Methods* for more). This approach enabled us to identify when and where people were present in the building. The data collected during these visits was recorded into a spreadsheet, forming our analysis's basis.

The data was processed and transformed into a consolidated format, representing the number of individuals present in each air handler zone at specific times. We converted the hourly data into this format to facilitate a comprehensive analysis of occupancy patterns. This spreadsheet pictured below shows the template we inserted our data into, separated by floor and room because that is how we collected the data, but as we analyzed this information we grouped each point by Air Handler. The full record of our collected data can be found in the spreadsheet linked in Appendix C.

Perloff May x xx:xxpm		B Level								Floor 1			
AH1	0	AH1	Y/N	AH2	Y/N	AH3	Y/N	AH4	Y/N	AH1	Y/N	AH2	Y/N
B203		B203		B227		B125		B321		1102		1243A	
B212		B212		B229		B128		B315		1112		1243B	
B215		B215		B230			Shop Rooms ^	B311		1112A		1243C	
B225		B225		B233				B309		1112C		1327	
B222		B222		B237				B302		1112D		1317	
1102				B241				B306		1112E		1318	
1112				B243				B320		1118		1302	
1112A				B330				B324		1125A-L			
1112C										1125AA			
1112D										1255			
1112E										1129			
1118										1203A			
1125A-L										1203B			
1125AA										1209A			
1255										1209B			
1129										1220			
1203										1224			
1203A										1266			
1203B													
1209A													
1209B													
1220													
1224													
1266													
AH2	0												
B227													

Figure 8: Data Collection Template

The data was processed and transformed into a consolidated format, representing the number of individuals present in each air handler zone at specific times. We made graphs representing the occupancy for each night over time, then merged every day into one complete graph.



Graph 1: Average Perloff Occupancies, 7:00pm-11:30pm

This total graph of all of our data points shows a consistent downward trend in occupancy before 10:00 PM, indicating that the majority of individuals had left the building by that time. However, one exception was observed in air handler 3, the wood shop area, which exhibited ongoing activity during later hours. Using this information and the timetable of the current air handler schedule we produced to recommend certain changes in the automation schedule to better reflect the occupancy we observed.

Building Hours and Reduction

Based on these results, we proposed specific recommendations to optimize the scheduling of air handlers. AH1 and AH2, which control the largest zones, would be shifted to turn off earlier, considering the lack of occupancy during those hours. The original schedule is shown to the left and the proposed changed schedule is shown to the right.

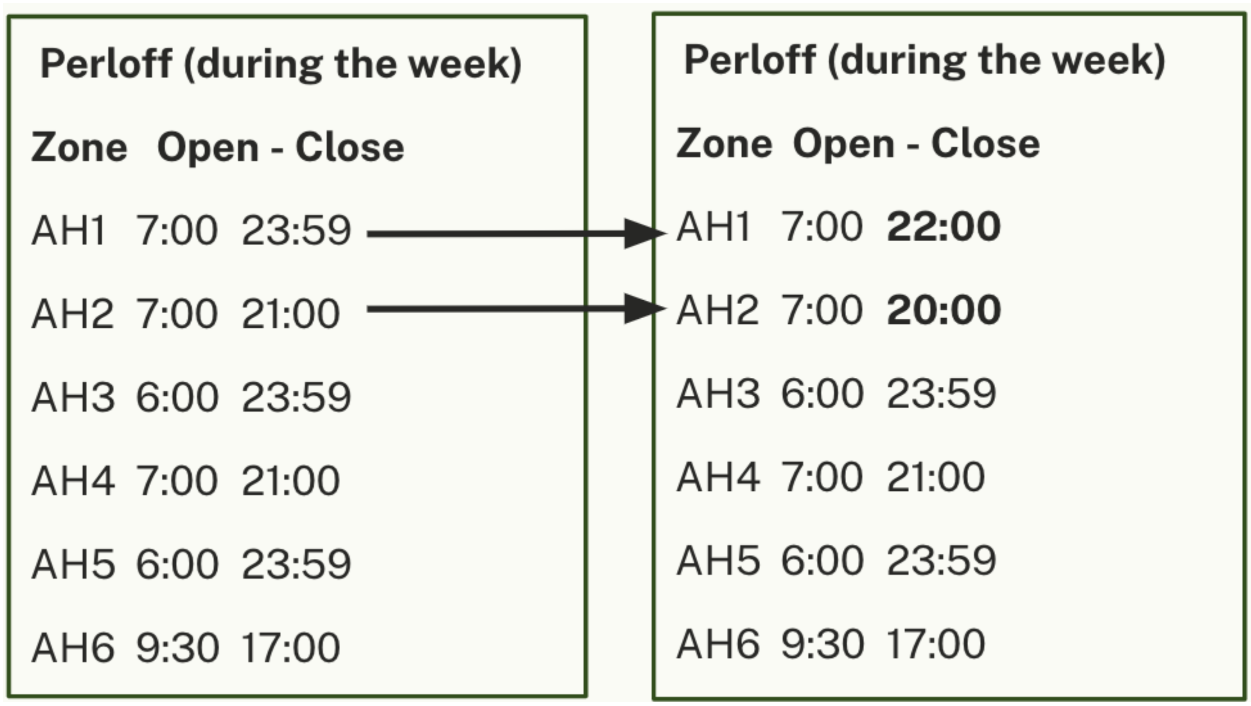


Figure 9: Recommended Air Handler Zones Schedule Changes

As shown in our converged datasheet there is no occupancy at all over the entire week in air handler zone 1 so it was easy to recommend a reduction in hours for that zone. Air handler 2 on the other hand was already automated to shut off at 21:00 (9:00 pm) and we are suggesting pushing that back to shut off at 20:00 (8:00 pm). Though this may seem controversial we have justified this suggestion based on the following observations:

- Minimal occupancy after 8 pm: Our analysis indicated that there was consistently minimal occupancy in air handler zone 2 after 8 pm, with an average of approximately 0.5 individuals present. This average shows that it is more likely than not that there will be no individuals in this zone at these hours. Because the zone is predominantly vacant during this time, it is feasible to adjust the shutdown time earlier.

- Empty classrooms: Another significant factor influencing our recommendation is that the classrooms within this zone were consistently empty during the observed period. With no classes in session, the only occupants in this area were typically limited to a single person working in an office. This observation reinforces the notion that the zone experiences minimal activity after 8 pm.

By advancing the shutdown time of air handler zone 2 to 20:00 (8:00 pm), we can align the energy usage with the actual occupancy patterns, optimizing the efficiency of the building's operations. This adjustment takes into account the consistently low occupancy levels and the absence of classroom activities during that time. Implementing this change will contribute to energy savings, which results in financial savings and carbon emission reductions, as outlined in our previous analysis.

Furthermore, it is worth noting that our recommendation is based on a thorough analysis of the collected data, aiming to strike a balance between energy conservation and maintaining a comfortable environment for the occupants. The proposed adjustment in operating hours reflects an evidence-based approach toward sustainability and optimization in Perloff. By reducing the operating time of these air handlers by three hours on weekdays, a total of 15 hours could be saved weekly, resulting in a substantial reduction of 780 hours annually.

Financial and Energy Savings

Our stakeholder provided a spreadsheet calculator (linked in Appendix B) in which we could submit our proposed schedule into the saving cost calculator. This calculation produced the monetary savings and emission reductions that result from reductions in energy usage. The impact of our proposed adjustment extends beyond energy savings. By implementing these changes, we estimated a reduction of approximately 3,952.92 pounds of carbon dioxide emissions and a net cost reduction of $3,354. These figures highlight the environmental and financial benefits that can be achieved through targeted scheduling modifications.

BUILDING ENERGY CALCULATOR

BLDG	Perloff																		
DATE	June 10, 2023		Based on 70% of design.	100% OA 1 = YES	RECIRC 1 = YES	NORMAL OPERATION					ENERGY OPERATION								
						OCCUPIED HOURS / day				ANNUAL ENERGY	OCCUPIED HOURS / day				VENTILATION HOURS				ANNUAL ENERGY
UNIT	SERVING	FUNCTION	CFM			M-F	SAT	SUN	HOURS		M-F	SAT	SUN	HOURS	M-F	SAT	SUN	HOURS	
AH-1			14,840		1	17	7.5	7.5	5,200	22,083	15	7.5	7.5	4,680	0	0	0	0	19,875
AH-2			15,400		1	14	7	7	4,368	19,250	13	7	7	4,108	0	0	0	0	18,104
AH-3			2,590		1	22	7	7	6,448	4,779	22	7	7	6,448	0	0	0	0	4,779
AH-4			3,360		1	14	7.5	7.5	4,420	4,250	14	7.5	7.5	4,420	0	0	0	0	4,250
AH-5			7,000		1	18	7.5	7.5	5,460	10,938	18	7.5	7.5	5,460	0	0	0	0	10,938
AH-6			5,950		1	7.5	7.5	7.5	2,730	4,648	7.5	7.5	7.5	2,730	0	0	0	0	4,648
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
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									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0
									0	0				0				0	0

TOTAL CFM.. 49,140

TOTAL ANNUAL COST.. $65,948

TOTAL RESCHEDULED COST.. $62,594

ENERGY RATES

SYSTEM $ per CFM per YEAR

TOTAL OPERATING HOURS.. 28,626

27,846 0

$3.75 100 % OUTSIDE AIR

LESS RESCHEDULED COST.. $62,594

TOTAL RESCHEDULED HOURS.. 27,846

$2.50 RECIRCULATED AIR

NET ANNUAL SAVINGS.. $3,354

REDUCED OPERATING HOURS.. 3%

$1.25 VENTILATION MODE

Difference in hours 780

	Electricity	Chilled Water	Steam		
	kWh/hour of fan runtime	kBtu/hour of fan runtime	lbs/hour of fan runtime	Hours saved/week	Hours saved/year
AH-1	7.27	0.0120	9.82	10	520
AH-2	7.27	0.0120	10.19	5	260
AH-3	1.09	0.0018	11.43	0	0
AH-4	1.94	0.0032	8.34	0	0
AH-5	2.98	0.0049	13.90	0	0
AH-6	2.98	0.0049	11.81	0	0

Electricity	Chilled Water	Steam				
kWh saved	kBtu saved	lbs saved	lbs CO2e from ELE	lbs CO2e from CHW	lbs CO2e from STM	Total annual CO2e savings
3,782.22	6.22	5,107.10	2,034.46	192.29	403.46	2,630.21
1,891.11	3.11	2,649.91	1,017.23	96.14	209.34	1,322.72
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
						3,952.92

Figure 5: Financial Saving Cost Calculator

Figure 10: CO2 Saving Cost Calculator

The valuations utilized the energy rates per cubic foot per minute and the air ventilation costs of recirculated air. Using the different costs of these modes and the area that each air handler occupies, the calculator found the amount of savings for our proposed schedule change to be $3,354. A similar calculation was done for finding the energy savings using the change in the number of hours the HVAC would be running and the amount of area each air handler covered in that time. This calculation revealed 3,952.92 pounds of carbon dioxide emissions would be saved by implementing our reduction in hours.

Analysis

As noted in our challenges section, there were certain limitations to our data collection. There were architecture students in the shop area throughout the night, all of the air handler 3, and in the studio area. This resulted in only truly being able to analyze the data from air handlers zones 1, 2, and 4, of which air handlers 2 and 4 both ended at 9 pm, rendering it more difficult to cut back on hours in these areas because they already reflected times similar to the occupancy.

Though not all of our statistics collected were used to reduce the air handler times, this information is still incredibly valuable to the automation department, as it provides a paper trail of reasoning and data for why the automaton is scheduled at certain times.

Final Deliverable

For our final deliverable, our stakeholder requested a report detailing the methods used and significant findings, for which we will send this report. He also requested a one-page outline to be used for research at other facilities, to show that our research is standardized and able to be repeated. This one-page report is attached in Appendix A.

Our deliverables can be used to replicate our study. With the replication of this research, energy savings can be found across the UCLA campus. The methods we used are simple enough to be repeated, but thorough enough to come to reliable findings. We also will be distributing this information to our other interviewees, Justin Wisor, Robert Striff, and Christian Tsouras, so that they can distribute the information to their respective networks. If we make our findings easily accessible and widespread, then it will be much easier for our stakeholder and UCLA Facilities to enact sustainable changes using our data and suggestions.

Discussion

Our project helped us gain substantially more insight and transparency into exactly how UCLA Facilities Management oversees campus building energy usage; our team learned how to leverage HVAC zoning, an often overlooked and underutilized factor, for targeted building energy management. Without adding any additional expenditures and simply refining energy schedules to better match building occupancy, our plan is able to reduce tons of carbon emissions and save thousands of dollars, even for Perloff, a building that has already been refined under the Smart HVAC Scheduling Program. Thus, we hope to apply this low cost, low commitment method of reducing energy and emissions to other buildings across campus. To maximize impact, we will prioritize buildings that are not already partaking in the Facilities Management Smart HVAC Scheduling Program and those already with LEED Certifications. We will hope to direct more focus on refining the schedules of North Campus buildings, particularly buildings with buildings with wide variability of usage and occupancy rates. We intentionally avoid South Campus laboratories and research centers which require adherence to strict energy and lighting schedules to prevent interference with research experiments, and also because we learned through stakeholder interviews that North Campus building schedules and facilities are not as updated in comparison to buildings on South Campus. Our methodology demonstrates that as long as we are able to keep campus building energy schedules up to date and intuitive to occupancy changes, thousands of dollars can be saved annually and tons of carbon emissions reduced. Our plan also has a long-term adaptability advantage, following a model that can last indefinitely as it only requires building schedule adjustments. Above all, this can be done without interfering student and faculty usage of the buildings at all and without requiring additional expenditures, equipment, or other resources, making occupancy-based building energy scheduling an optimal method of increasing campus sustainability and energy efficiency. This plan will help UCLA make progress towards its universitywide sustainability goals, such as the Green Buildings and Climate & Energy sectors of the UCLA Sustainability Master Plan and the UC Carbon Neutrality Initiative.

We plan on and also advise future SAR Energy Teams to continue building relationships with stakeholders within UCLA Facilities Management in order to implement our energy-saving occupancy methodology. Additionally in an interview with Facilities Management Project Manager Christian Tsouras, Tsouras mentioned how in the future he would like to see Facilities Management consolidate campus buildings schedule changes and schedule change requests into a living document that is easy to reference and modify. Thus, if time permits, we hope that future teams can find an optimal method of consolidating pre-existing building occupancy and scheduling data into such a database, and propose methods on using this living document to integrate occupancy-based schedule changes into daily building operations. Currently, workers must go out of their way to submit schedule change requests, and some are also unaware of the process— if an efficient method to document and act upon these schedule change requests is integrated into daily operations, it will become much easier for the department to keep HVAC schedules updated without extra effort exerted for data collection and research as the database should already include such information.

Furthermore, Equity, Diversity, and Inclusion (EDI) represents a key factor of consideration in order to improve UCLA Facilities Management's working environment. Throughout project research and interviews, we have discovered that facilities members like janitorial and systems control staff have been excluded from crucial building management decision making, such as deciding upon energy schedules and room temperatures. Moving forward, we are committed to reducing the vertical hierarchy often associated with bureaucratic offices, and hope future teams can also advocate to include everyone's perspectives and lived experiences into these important conversations that will impact the work environment of all Facilities Management employees.

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Appendix A

UCLA Facilities Occupancy Analysis Guidelines

This link contains our one-page deliverable requested by our stakeholder. It contains a short walk-through of our methods for research replication.

Appendix B

HVAC Savings Estimator_Perloff - FINAL.xlsx

This link contains the calculation spreadsheet used to quantify energy, emission, and financial savings that result from scheduling changes. This calculator works only for Perloff.

Appendix C

Data Collection

This link goes to the spreadsheet used for data collection. It contains all of the data collected from Perloff.

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