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Abstract

Universities across the United States are generating goals to be more sustainable and carbon neutral. The energy used in existing buildings on campus amount to a large volume of greenhouse emissions and must be reduced to help achieve neutrality goals. Strategic Energy Master Plans are instrumental to support these goals through the development of recommendations to reduce energy. Calculating the energy use intensity for existing buildings, a main component of a Strategic Energy Master Plan, can help the campus understand where energy is being used the most. With this information the highest energy consuming buildings can be the focus of renovations to improve energy efficiency to reduce emissions. This study evaluated existing building energy use at California State University, Chico and made energy efficiency recommendations on 12 campus buildings. The information was also used to identify where the campus may fall short of their neutrality goals and provided additional recommendations to meet them.

Overview

California State University, Chico (Chico State) has had the goal to be carbon neutral by 2030 since they joined the President Climate Commitment in 2007 (Chico State, 2021). As the second oldest campus in the California State University System and with over 3,352,457 square feet of buildings, including seven historical buildings over 85 years old, Chico State buildings use a large amount of energy. With the aging buildings and the energy needed to heat, cool, light and power the building space, how can Chico State achieve their carbon neutrality goal?

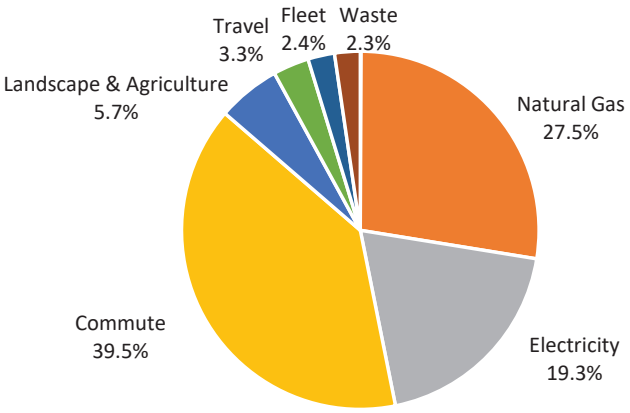
To aid in planning, Chico State updated their Climate Action Plan (CAP) in 2020 (Chico State, 2021) that provides recommendations on how to achieve neutrality by 2030 for all emission types. In order to implement the CAP, some of the measures require greater detail from an energy management perspective. This is where a Strategic Energy Master Plan (SEMP) is beneficial as it is specific to managing and reducing energy usage to meet a desired goal (Association of Energy Engineers, 2020). The two plans complement each other to provide guidance and recommendations to implement for all emission sources (Patterson, 2021).

Greenhouse gas emissions are measured in metric tons of carbon dioxide equivalent (MTeCO2). In 2017-2018 Chico State greenhouse gas emissions were 20,867 MTeCO2, and Figure 1 shows the emissions breakdown per category. The SEMP and this research focus on natural gas and electricity emissions. Natural gas emissions were 5,733 MTeCO2 or 27.5%, and electricity were 4,025 MTeCO2

or 19.3%, equating to 9,758 MTeCO2, or 46.8% of total campus emissions.

Figure 1

Campus emissions 2017-2018.



According to the California Coalition for Adequate School Housing (CASH) calculating the Energy Use Intensity (EUI) for the campus and individual buildings is one of the first steps in understanding where energy is being used across campus (CASH, 2009). EUI is calculated as an energy use per square foot per year, typically in BTU/SF, which allows electricity, natural gas, and other energy sources to be converted to one whole number. The EUI allows a campus to benchmark its energy use and compare individual buildings against the benchmark to determine higher and lower energy use buildings. By prioritizing the higher energy buildings for renovation, it will conserve the most energy and bring down the EUI average in a shorter amount of time. Annual energy consumption and square footage of buildings was required for the calculations and was received from Chico State's campus energy manager through their energy management system. This paper focuses on the research associated with evaluating the energy in existing buildings to understand if the campus will meet their targeted goals and make recommendations to achieve neutrality by 2030.

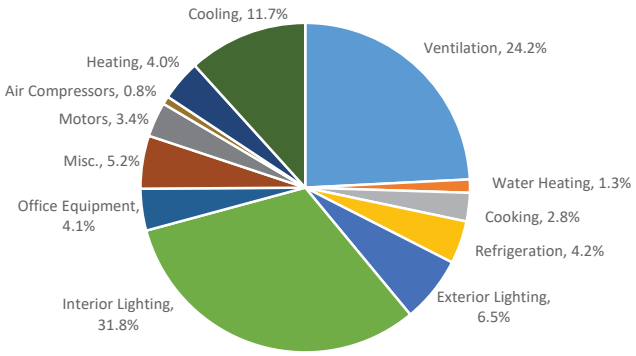
Research Methods

This research replicates the methods developed by CASH to benchmark the electricity use of the existing buildings on campus. The steps included compiling annual energy data, establishing an energy average or benchmark, identifying which buildings are performing more or less efficiently than others and then performing audits to make recommendations for renovations for those buildings (CASH, 2009). Using the 12-month electricity data and square footage, the campus average EUI was calculated and used to determine the baseline energy consumption. The next step was to calculate the EUI for each building on campus using the same data set. The resulting data was sorted by highest to lowest EUI to determine which buildings used the most energy.

Buildings that exceeded the baseline average energy use were audited for energy and energy conservation measures (ECM's) were developed. Based on the ECM estimated energy savings per building, emission reductions were calculated. Figure 2 from the California Energy Commission (CEC) shows how energy is used for a typical college campus in PG&E's service territory (CEC, 2006). ECM's typically consist of recommendations on similar categories like heating, cooling, lighting and office equipment. After existing building energy and emissions were calculated, the results were analyzed to determine where the campus is in terms of meeting carbon neutral goals. If goals were met, then the campus is on

Figure 2

College electricity use for PG&E service area.



track to meet their sustainability goal. If goals were not met, then additional recommendations must be proposed to meet neutrality goals.

Discussion of Results

After receiving information from Chico State, it was determined that some buildings did not have energy sub-

metering in place to provide natural gas data for individual building consumption. Also, several buildings did not have 12 months of accurate electricity data. Based on this, several buildings were removed from the study and the EUI was modified to only calculate electricity per square foot (kWh/SF). After this there was a total of 44 buildings in this study. The total annual electricity for campus was 29,061,121 kWh, with total square footage of 3,352,457 SF, calculating an av-

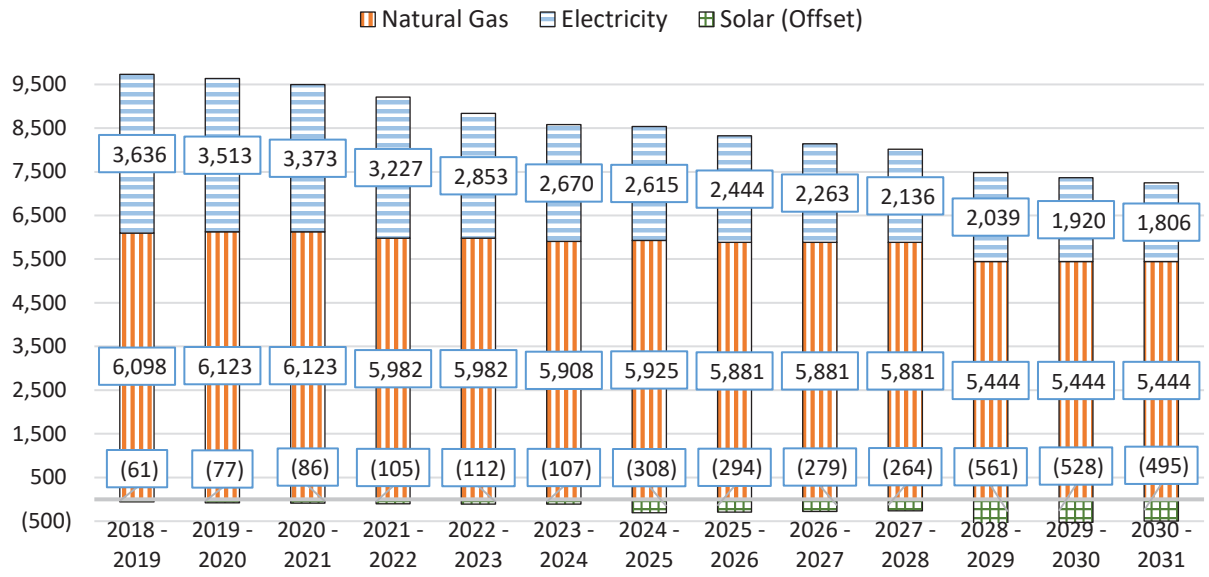
Table 1

Highest electrical EUI buildings at Chico State.

Campus Building	Annual Electricity (kWh)	Building Size (SF)	EUI (kWh/SF)	Annual Electricity ($)
Gateway Science Museum	1,121,669	9,656	116.16	$ 174,531
Butte Station	61,744	1,212	50.94	$ 9,607
O'Connell Technology Center	1,431,156	75,683	18.91	$ 222,687
Nettleton Stadium	130,397	8,364	15.59	$ 20,289
Langdon Engineering Center	677,473	58,249	11.63	$ 105,414
Bell Memorial Union & Bookstore	1,454,319	133,677	10.88	$ 226,292
Holt Hall	1,393,789	130,850	10.65	$ 216,873
Selvester's Cafe	92,692	9,388	9.87	$ 14,422
Wildcat Recreation Center	1,050,103	109,000	9.63	$ 163,396
Meriam Library	2,560,401	269,018	9.52	$ 398,398
TOTAL	**9,973,743**	**805,097**		**$ 1,551,909**

Figure 3

Emission forecasts incorporating ECM recommendations and Master Plan.



erage EUI of 8.67 kWh/SF. Building EUI was calculated and when the buildings were sorted to determine higher energy use, there was a total of 12 buildings above the average. Two buildings were removed from the list as they were found to be in the recently updated Master Plan to be demolished and rebuilt by 2030.

The remaining 10 buildings are shown in Table 1 with the highest EUI at the top. These buildings totaled 9,973,743 kWh or 34.3% of campus kWh use, and 1,284 MTeCO2, which is 13.2% of campus emissions. ECM recommendations included LED lighting upgrades, additional lighting controls, occupancy sensors and HVAC upgrades for each building. By incorporating the recommended ECM's for the 10 buildings, the campus could reduce electricity by 3,216,075 kWh, or $537,480 per year.

Based on the calculations and results of this research and SEMP, Chico State will be short of their carbon neutral goal. Figure 3 forecasts the emissions for the campus as a result of the recommendations from this study. In order to achieve this goal, the campus needs to maximize solar installations, or other renewable energy, in order to offset the remaining campus energy use. Additionally, natural gas is seen to continue to be the largest generation of emissions. How the university uses natural gas to heat buildings will be another primary factor in determining the speed at which carbon neutrality is possible and is a future research topic.

With the SEMP and CAP, Chico State has taken the first step in generating a plan to achieve their desired goal of being carbon neutral. Implementation is the next phase and will help reinforce Chico State as a continued leader in sustainability.

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