Campus as a Living Laboratory:

A Study of Place

California State University, Chico

Interim Report

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Campus as a Living Lab Grant Program: A Study of Place

PROJECT OBJECTIVE:

Our overarching curricular goal is to engage students in the implementation of our campus climate action plan (CAP), having them assist in the development of strategies toward achieving campus climate neutrality. This effort will encourage the collaboration and exchange of information between students, faculty and operations professionals, building knowledge bridges, sharing expertise and fiscal realities. There are three principle objectives in this proposal:

- To illustrate the connectivity between energy consumption and greenhouse gas emissions by integrating real-time energy consumption data into the sustainability pathway curriculum.
- To establish a campus based web accessible energy management tool that is scalable and usefully for campus energy operations.
- To raise the energy consumption awareness of building occupants and foster dialogue between academics and facilities management about conservation measures.

CAMPUS AS A LIVING LABORATORY DEVELOPMENT:

During the spring of 2014, Marie Patterson, Luis Caraballo and James Pushnik worked with Lucid Technologies representatives Kayla Mahoney and Cole Schoolland to establish the connection of real-time energy dashboard to monitor four campus buildings: Holt Hall, Physical Sciences, Tehama Hall and O'Connell Technology Center. These buildings represent infrastructure from the 1960's (Holt and Physical Sciences) and more recent construction from the 1980's and 1990's (Tehama and O'Connell). During the same period and continuing into the Fall semester of 2014, David Brown, Eric Willard and James Pushnik began preparation of new instructional materials and modifications to the Natural Sciences capstone of the General

Education Sustainability Studies Pathway (GEOS 330). The instructional modules will use the energy dashboard and building surveys to gain a deeper understanding of the patterns and magnitudes of electricity and water consumption in those buildings. Modified versions of these exercises will also be applicable to lower division courses, ENVL 105, GEOS 130 and NSCI 105.

CURRICULAR INNOVATIONS:

Electricity Use on Campus and in the Four Buildings

In GEOS 330, students will be more directly engaged with facilities professionals and the Institute for Sustainable Development personnel to foster a more in depth understanding of current campus operational approaches, the GHG accounting methodologies utilized to collect the data and explore the challenges associated with meeting the goals of Campus Climate Action Plan. During the first weeks of the course, as a pre-assessment, students will be assigned the task of listing all the different uses of electricity, both indoors and outdoors, on campus. A specific emphasis will be placed on the four campus buildings in the monitoring study. To frame the study, the campus Sustainability Coordinator will present an overview relating energy consumption to greenhouse gas emission and climate change. A Pacific Gas & Electric (PG&E) representative will review electricity supplies in California from a regional and local perspective. The Facilities and Management Services staff has been invited to present on campus electricity use and management. Campus infrastructure will be reviewed, including electricity obtained from PG&E and onsite generation.

Electricity consumption by individual campus and student electronic equipment will be measured using Kill-A-Watt meters. Electricity conservation technologies identified in the introductory lectures and activities will be examined to estimate savings and return-on-investment if their use is expanded. To synthesize their perspectives on campus electricity consumption and conservation efforts, current and potential, they will be assigned the task of

compiling the present conservation methods being employed on campus and qualitatively assessing their effectiveness. To communicate their findings, they will generate a website summarizing their results using Blackboard or other simple web authoring tools.

EXAMPLE OF CLASSROOM ASSIGNMENTS (*To be further modified after website launch and testing)*

Monitoring Campus Building Electricity Consumption Patterns Assignment

Exercise Goal

The learning objective of these exercises is to determine if there are behavioral changes that the building occupants could make to reduce power consumption and the associated greenhouse gas emissions.

Background: Campus as a Living Laboratory

In the following exercises you will utilize a web based energy dashboard and hand-held energy meters to gain an appreciation the energy consumption in four campus buildings: Holt Hall, Physical Sciences, O'Connell Technology Center and Tehama Hall. An energy dashboard is a graphical interface that will allow you to directly access and compare the energy consumption of the four campus buildings for electrical performance from several different perspectives, including total daily kilowatt (kW) building usage, on a per person (kW/person) or a building per square footage basis (kW/ft^2). Additionally, you will also be able to examine a single building or compare buildings on different time scales, hourly averages, daily or monthly. The dashboard will also allow you to convert the kWh usage within a building to tons of $CO_{2\,eq}$ (the emissions associated with that level of power consumption) or to economic cost basis (dollars spent).

The web interface will appear similar to the image below. You will be able to access the electricity consumption profile for each of the buildings by clicking on the link to that building.

buildingOS

Facilities & Meters at California State University, Chico

Holt Hall O'Connell Tehama Hall Physical Sciences

Technology Center

The data you collect from the Lucid Energy Dashboard will be used to quantitatively examine electricity use patterns within the four buildings, both daily, weekly, monthly, and annually. Time series plots of electricity use will be developed by your group to examine large- and small-scale variability in electricity demand. Student groups will be assigned the task of looking for patterns or events of use at particular times of day or days of the week.

California State and CSU system guidelines will be reviewed investigated and compared with student perceptions and preferences on how much lighting is optimal. The quantity of electricity used for lighting will be investigated by students as they inventory lighting in select rooms and then attempt to estimate aggregate use by rooms, floors, common areas, outdoor lighting, and the whole building. After hours lighting use will be investigated using simple data loggers and light sensors. In the Dashboard assignments, you will analyze electricity use, costs, and CO2 emissions. Assessment targets will include demonstrated student understanding of key energy terms such as energy, power, kilowatts, kilowatt-hours, wattage, and others.

Patterns of Electricity Consumption

The quantity and timing of electricity use will be compared among the four buildings. Heating, ventilation, and air conditioning (HVAC) energy use will be considered using available data from FMS. Energy use in a non-science building (Tehama Hall) will be compared with the engineering and science building (O'Connell, Holt, and Physical Sciences).

During the instructor defined data collection periods (daily, weekly or monthly), you will be asked to keep a log of the buildings assigned to your group and record the values in the table below.

Building monitored		
Measurement	**Observed value**	**Comment**
Date and Time		
Current rate of total electricity consumption now (kW)		
Rate of electricity consumption yesterday at this time yesterday (kW)		
$CO_{2\ eq.}$ emitted during this observation period (lbs. CO_2)		
Dollars spent on electricity during this observation period ($)		
Aggregated electricity consumption over a the past week		

As a weekly assignment your group should meet and compile your individual observations and collectively write a short summary analysis of the data, indicating peak and off-peak energy consumption times, per capita use consumption, $CO_{2\ eq}$ emission and financial costs. To

communicate you findings, you will generate a website summarizing their results using the course Blackboard site or other simple web authoring tools.

Capstone Assignment

As a capstone exercise your group will present summative analyses of your groups' findings, along with actionable recommendations of behavioral changes that would reduce energy consumption of the individual buildings and an overall strategy for reduction across campus.

Your final report should address the following question in your final reports.

1) How and why do the daily patterns of electricity consumption within a building differ between days or times of day? What is occurring in the different building during the peak and low-points of energy consumption?
2) What are similarities and difference between in the various buildings? How do the different types of activities (classes or laboratories) within those building influence the energy consumption patterns?
3) How responsive are these observed changes to the external conditions (outside temperature, heating degree day, or cooling degree day) on a daily timeframe versus monthly basis? Explain what you think is the driving factor behind the observed variations?
4) Based on your observations, propose at least three behavioral activities that could be taken to reduce electricity consumption in these four buildings? Do you think your proposed behavioral changes could be applied campus-wide?
5) Which of the metrics that you collected (kWh, $Co_{2\ eq}$, or $) did you find most interesting and most motivating to create your proposed behavioral changes?

ASSIGNMENT ASSESSMENT

The capstone report will be evaluated using the following rubric:

Assessment Rubric: Capstone Project

Indicator	Semester Milestones 4 3 2			Baseline Knowledge 1
Define Problem	Demonstrates the ability to insightfully define the energy consumption problem, using relevant and scientific evidence	Demonstrates the ability to define the energy consumption problem, using relevant information	Demonstrates the ability to define the energy consumption problem, but use superficial evidence	Demonstrates lack of understanding of the problems associated with energy consumption
Existing knowledge and Research	Synthesizes in-depth information from relevant resources and from various points of view	Uses in-depth information from relevant resources from various points of view	Uses information from relevant resources and from limited points of view	Uses information from irrelevant resources and from narrow points of view
Identify Strategies	Identifies several approaches for solving the energy consumption problem that implementable within the assignment context	Identifies one or more approaches for solving the energy consumption problem having reasonable application within the assignment context	Identifies one approach for solving the energy consumption problem but having limited application within the assignment context	Identifies one approach for solving the energy consumption problem that does not apply within the assignment context
Analysis	Organizes dashboard energy data, revealing insightful patterns and differences in the buildings energy consumption	Organizes dashboard energy data, revealing important patterns in the buildings energy consumption	Organizes dashboard energy data, but does not reveal important patterns in the buildings energy consumption	List dashboard energy data, that is unorganized or unrelated to the buildings energy consumption
Propose Solutions	Proposes one of more solutions that demonstrates a deep comprehension of the energy consumption pattern and are designed to address the specific issue	Proposes one or more solutions that demonstrates comprehension of the energy consumption pattern and are in general designed to address the issue	Proposes an "off – the- shelf" solution rather than one designed to meet the specific problem	Proposes solutions that are difficult to evaluate in the context of the assignment
Evaluate Alternative Solutions	Evaluation of potential alternative solutions is detailed and includes insightful quantitative examination of the feasibility of the solutions	Evaluation of potential alternative solutions is adequate and includes examination of the feasibility of the solutions	Evaluation of potential alternative solutions is brief and lacks examination of the feasibility of the solutions	Evaluation of potential alternative solutions is superficial and cursory
Limitations and Implications	Insightfully discusses limitations and implications that are supported	Discusses relevant limitations and implications that are supported	Presents relevant limitations and implications that are supported	Presents limitations and implications but are unsupported

CURRENT STATUS:

The Building OS website is not currently user accessible because of concerns over internet security issues and campus facilities operations. These concerns are presently being addressed with the implementation of a new firewall protocol on the dedicated server. The website should be available for testing in the next couple of weeks and ready for classroom implementation at the start of the spring semester.