Leveraging Knowledge - Teaching + Learning | Research + Practice

CSU Campus as a Living Lab Grants
Project Goal

To create a unique opportunity to partner between faculty and facilities management staff in using the campus as a forum for the exploration of sustainability concepts and theories

Using High-Impact Practices such as...

– Collaborative assignments and projects
– Undergraduate research
– Community-based learning
California State University (CSU) 15 Year Funding
77 days, 18 undergraduates, and 2 professors. One common goal: a more sustainable Cal Poly.

The Living Lab is an ambitious undertaking by the students and faculty of Cal Poly’s College of Architecture and Environmental Design to bring sustainable technologies into a more active and visible role on campus. Students, alongside Architecture professors Barry Williams and Ansar Killings, will oversee the research, design, and installation of a radiant cooling system in the existing Media Lab (05-314) during the course of the Spring 2014 quarter.

PHASE 1: RADIANT COOLING SYSTEM

This quarter we are researching the use of commercial off-the-shelf construction products to create an inexpensive, zero-energy cooling system for climate zones with diurnal temperature shift. By using conventional radiant heating components in combination with solar collector panels, the proposed system will leverage the diurnal temperature shift to control the inside temperature of buildings and thus lower the campus greenhouse gas emissions.
Buildings and Landscapes that Teach

Warren J. Baker Center for Science and Mathematics
Baker Center for Science - Timeline

Phil Bailey, Dean of Science & Math
Project Visionary

Ted Hyman, FAIA, ZGF Architects

President Warren Baker,
Project Advocate

Cal Poly Students, Project Superfans

Facilities Planning, Project Shepherds

Buildings Opens Fall Quarter

Campus as a Living Lab

Antiquated “Spider” Science, remains relative untouched for 40 years

1998
- Programming, Conceptual Design and Project Funding

2003
- Detailed Design and Technical Engineering

2008
- Bid and Construction

Today
- CHESC 2015 | Cal Poly, San Luis Obispo
A Digital Repository
COURSE REDESIGN +
CREATING A LEARNING COMMUNITY
ARCH 207 – Environmental Control Systems
2nd Year Architecture Students

Topics

• Environmental Impact of the Built Environment
• Energy Consumption & Production
• Psychrometrics
• Climate Influences
• Site Analysis
• Heat Transfer | Envelope
• Solar Geometry + Shading
• Passive Heating + Cooling
• Daylighting
• On-site Energy Generation
• Conceptual Modeling
• Climate Change + Adaptation

Lecture (50%)
• Reading
• Lectures
• Open Forums
• Homework (Application)
• Exams

Activities (50%) – Case Study and Studio Application
• Building Performance Analyst Certificate (Extra Credit)
• Case Studies
• Climate Analysis | Responsive Design
• Energy
• Shading
• Passive Heating/Cooling
• Envelope Optimization
Course Learning Objectives

• **Interpret** a Complex Construction Document Set
• **Perform** On-site Field Measurement and Direct Observation
• **Conduct** a Climate Analysis
• **Compare** Design Intent to Real Performance
• **Discuss** Findings
• **Make Recommendations** for Process/Product Improvements
Campus Context

• Learn by Doing Motto
• Polytechnic university
• Rural/Suburban setting
• 3,800 Acres of Constrained Development
• Mediterranean Climate
• Fiscally and Architecturally Conservative
• Enthusiastic Science Dean

Baker Center for Science

Qualitative Ask

• A Defining and Unifying Campus Landmark with Extraordinary Symbolism at Center of Campus
• Exemplary Approaches to Teaching and Learning
• An Inviting and Intriguing Building
• A Building for Now in the Future

Warren J. Baker Center for Science and Mathematics
Baker Center for Science

Quantitative Ask

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Programmatic Space Types

- College of Science and Math Administration & Support
- Chemistry and Biochemistry
- Physics
- Earth and Soil Science
- Interdisciplinary Lecture Hall
- Polymers and Coatings
- Environmental Biotechnology Institute (EBI)
Shading Devices + Daylighting Design

South Elevation
Thermal Comfort

Ave. Max/Min Temperature

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Baker Center - Shading Analysis

The fenestration studied was on the third floor of the Shaler Science Building. Facing thirty degrees east of south, it has a small overhang as a horizontal shading device and is set back within the facade to provide vertical shade, taken out of context, it is not effective as nearly none of the overhanging eaves are covered by the shading protection. However, this window sits within the shade path of the south entrance of the building which provides its own form of vertical shading and makes the window adequately shaded for all but a few hours in August and September.

To create a more efficient system, an overhang could be put on the south entrance to eliminate the form and lower the vertical shading angle and capture a few of those missed hours. Another possible solution is to add adjustable louvers onto the window, generally they are frowned upon because of maintenance and under use, however, the window is located in a classroom space where the concept of an adjustable shading device would be most beneficial to the occupants.
DAYLIGHTING ANALYSIS
Visual | Digital Analysis
Energy Analysis

Figure 3. Section through typical office showing radiant ceiling panels and displacement ventilation. The ceiling panels will be used for heating and possibly cooling if the room loads require additional cooling. The displacement ventilation air will be provided at a minimum of 65°F and will provide a modest amount of cooling on hot days. It will be provided from wall diffusers in the 1st floor lecture classrooms and from ceiling diffusers in the central offices and interaction spaces.

Figure 1: Building rendering from eQuest 3.64.

Induction Diffuser Cooling
- Lower amount of outside air used to meet ventilation requirements
- Smaller air handler and ducts
- Lower energy use due to lower volume of outside air to cool
- Lower reheat requirement uses less energy

Figure 4. Section through typical lab showing induction diffuser/chilled beam application.
Metered Vs Modeled Annual Energy Use

Total Energy Use

- Metered Total Energy (kBtu)
- Modeled Total Energy (kBtu)
Campus as a Living Lab II: Daylighting

In San Luis Obispo, the sun will display at its highest at 2:48 minutes after 12:00 pm clock time.

Measurements taken:

Clock time: 4:45 pm
Solar time: 3:11 pm

IESNA Standards

Shared Office Space: 50 footcandles = 538 lux

From our personal experience and the experience of the students in the space, the fenestration seemed to work successfully. However, when you look at the results from the lux meter application many portions of the space seem to have inefficient light or way too much light. When an average is taken, the value is 966 lux which is below the IESNA standards. However, the reflectance of the various surfaces of the chairs and tables in the space tend to bring light farther into the space, so when physically there, it feels very comfortable. Furthermore, other times during the day or the year the lux value may very well meet or exceed the standard.

To prevent glare and veiling reflections a simple solution would be automated shading devices. These devices would have the ability to automatically adjust to prevent glare when the sun is coming directly into the space, but open when there is indirect sun for light. These shading devices would need to be located on the exterior form of the space because the room became slightly overheated later in the day after extended direct sunlight. The exterior shading devices block both light and heat, unlike interior shading which only blocks light.
# 2-Hour Shading Calendar

**Example: A House in San Luis Obispo**

- **< 65°**  Closed  **Balance Point Temperature = 65°**
- **65° to 74°**  Open
- **> 75°**  Closed  **Change-over Temperature = 75°**

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**Shading Calendar + Sun Path Diagram**

**San Luis Obispo**  36° N Sun Path Diagram

June 22 - December 21
LEED + Sustainability Analysis

Sustainability Strategies
The Baker Center exemplifies flexibility, sustainability, and efficiency in its design. Cal Poly students will be inspired by the respect for the environment, energy, and natural resources demonstrated in the building's design and construction and will be able to monitor resource utilization through visual real-time displays.

Forest Stewardship Council Certified Wood
The laboratory casework is certified by FSC. This ensures the sustainable logging of trees and use of plantation grown wood.

Green Roofs
Intensive and extensive roof gardens mitigate the building temperature, increase the lifespan of the roof, create new wildlife habitat, and mitigate stormwater runoff volume.
Daylighting

First Floor

Second Floor

Third Floor

Fourth Floor

Fifth Floor
Assessment Design

• Direct Methods
  – Assignments
  – Tests
  – New applications of knowledge

• Indirect
  – Self-evaluation surveys (pre and post)
  – Focus groups
Sample Student Feedback

- **Room 111**: Shown in plan as one office space. Permanent walls were built to divided space into three different office spaces.

- **Room 209**: Wall partition built to create corner office space. Wall partition blocks the occupancy sensors so lights turn off with people still occupying space.

- **Room 209B**: In the evening light, the room’s sensors shut lights off.

- **Rooms 304ABC, 306ABC, 404, 405, 406...**: Room overheats in the afternoon/evenings (+80F)

- **Room 542**: The lights in the entryway to room have no visible controls so lights can’t be turned on/off. May be wired with hallway lights?

- **Rooms 604, 605, and 606**: Room overheats in the afternoon/evenings (+80F)

- Some faculty have added film (aluminum foil) over windows in an effort to reduce overheating / glare

- Blinds are often left down and in one case blackout curtains were added (laser lab)

Using the new IES daylighting autonomy standard (300 lux – 3000 lux), 37% of the SF of regularly occupied space meets the threshold. HOWEVER, under the previous standard 73% of the regularly occupied square footage meets the threshold (1000 – 5000 lux).

I think that it would accurate to say that a majority of the regularly occupied space are adequately daylit, however space use practices tend to conflict with maximizing the benefits of this resource. Teaching labs would benefit from strategies such as automated blinds that reset between courses based on measured light levels, etc. The manual blinds tend to get moved to one spot and then stay there due to course turnover and transient instructors.
Exit Survey – Student Responses

• After we studied the Baker Science Center and looked in depth at how to shade windows I took what we learned and implemented that into my own project. I added shading devices to the windows I had in my own building and tried to right size them for my project.

• Just being aware of these strategies should allow us to create a more suitable environment for future generations, and allow us to soften the impact of previously very wasteful practices in our field. I feel as though incorporating these practices into our projects are not only a great start to our introduction into the field, but also a start of finally realizing that these practices shouldn't be supplemental to the overall process, but rather already incorporated into the design process.
Comprehensive Course Redesign

• More lead time and adding longitudinal studies
• More buy-in from teaching faculty + facilities
• More learning outcomes assessment
• Need better data management (security, file sizes and types)
Future Partnerships

• Digital Commons @ Cal Poly
• Design, Construction and Campus Teams
• PowerSave Green Campus
• Green Schools
• Autodesk BPAC
• STEM educators
• Other faculty (e.g., environmental psychology)
Cal Poly, SLO Team

Margot McDonald, AIA, NCARB, LEED AP BD+C
Stacey White, AIA, LEED AP BD+C
Clare Olsen, RA
Jeff Landreth, PE
with Ted Hyman, FAIA, ZGF Architects
and research assistants Lisa Hayden and Katie Worden
and the students of ARCH 207!