UCMERCED

Micro to Macro: Campus Sustainability From the Ground Up

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University of California, Merced

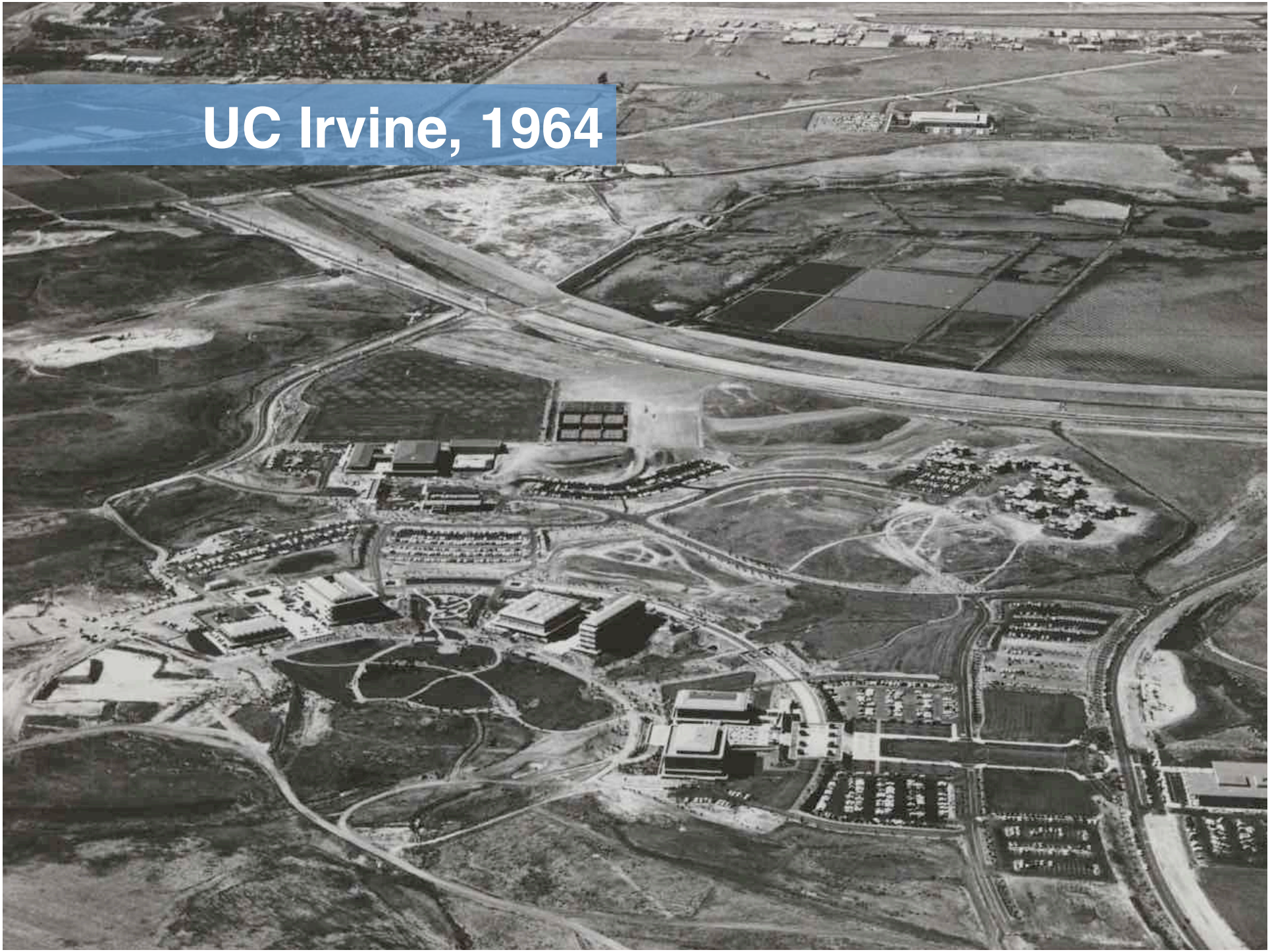
Youngest campus in the UC system

University of California, Berkeley
First Graduating Class, 1873

University of California, Merced
First Graduating Class, 2009

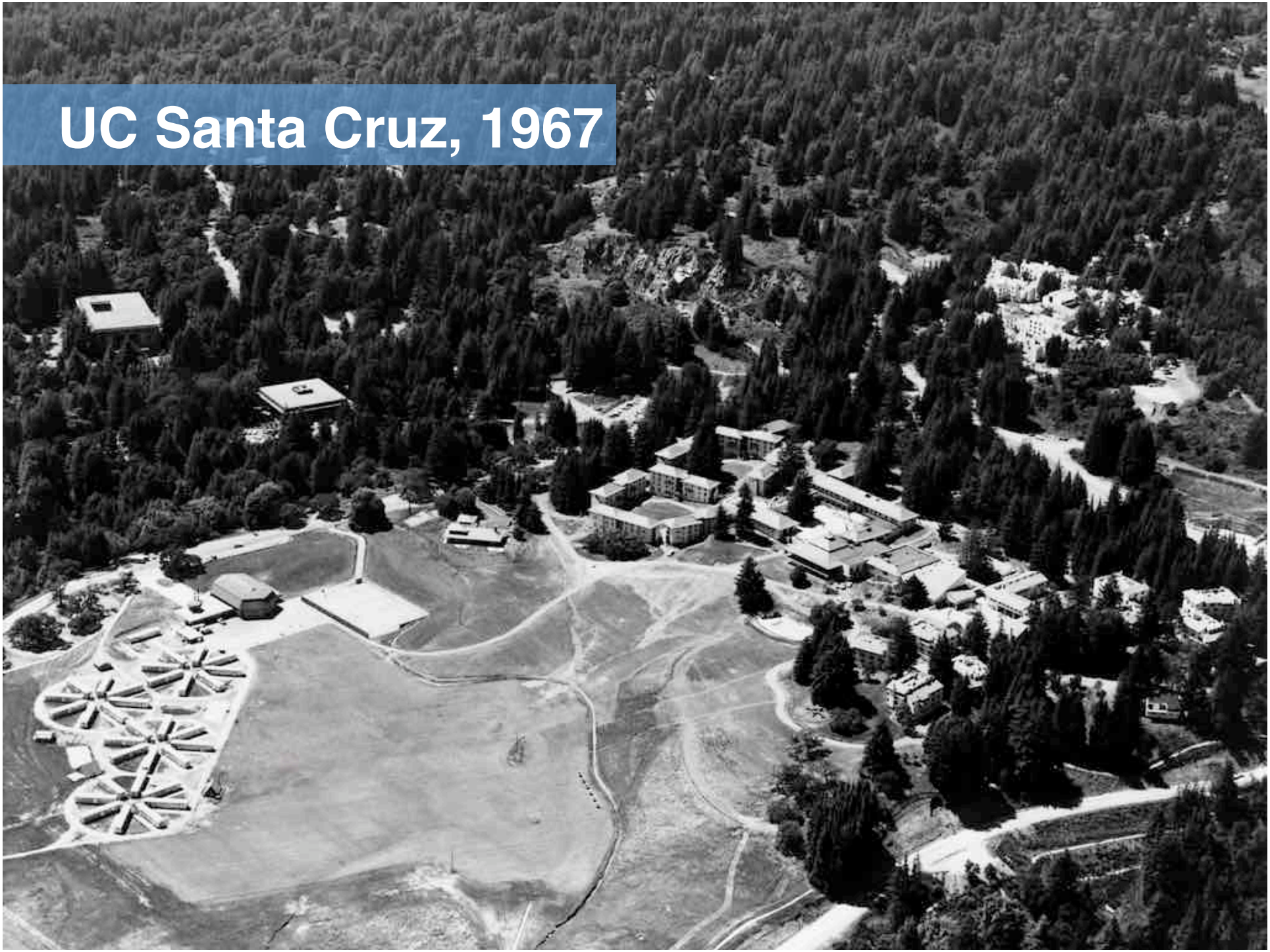
Gold		Water	Baby Boom Tidal Wave						"Tidal Wave II"
Berkeley	UCSF	UCLA	UCSB	UC DAVIS	UC Riverside	UC San Diego	UC Irvine	UC Santa Cruz	UC Merced
1869	1873	1919	1944	1959	1959	1964	1965	1965	2005

UC Irvine, 1964



UC San Diego, 1965

UC Santa Cruz, 1967



UC Merced, 2005

UC Merced

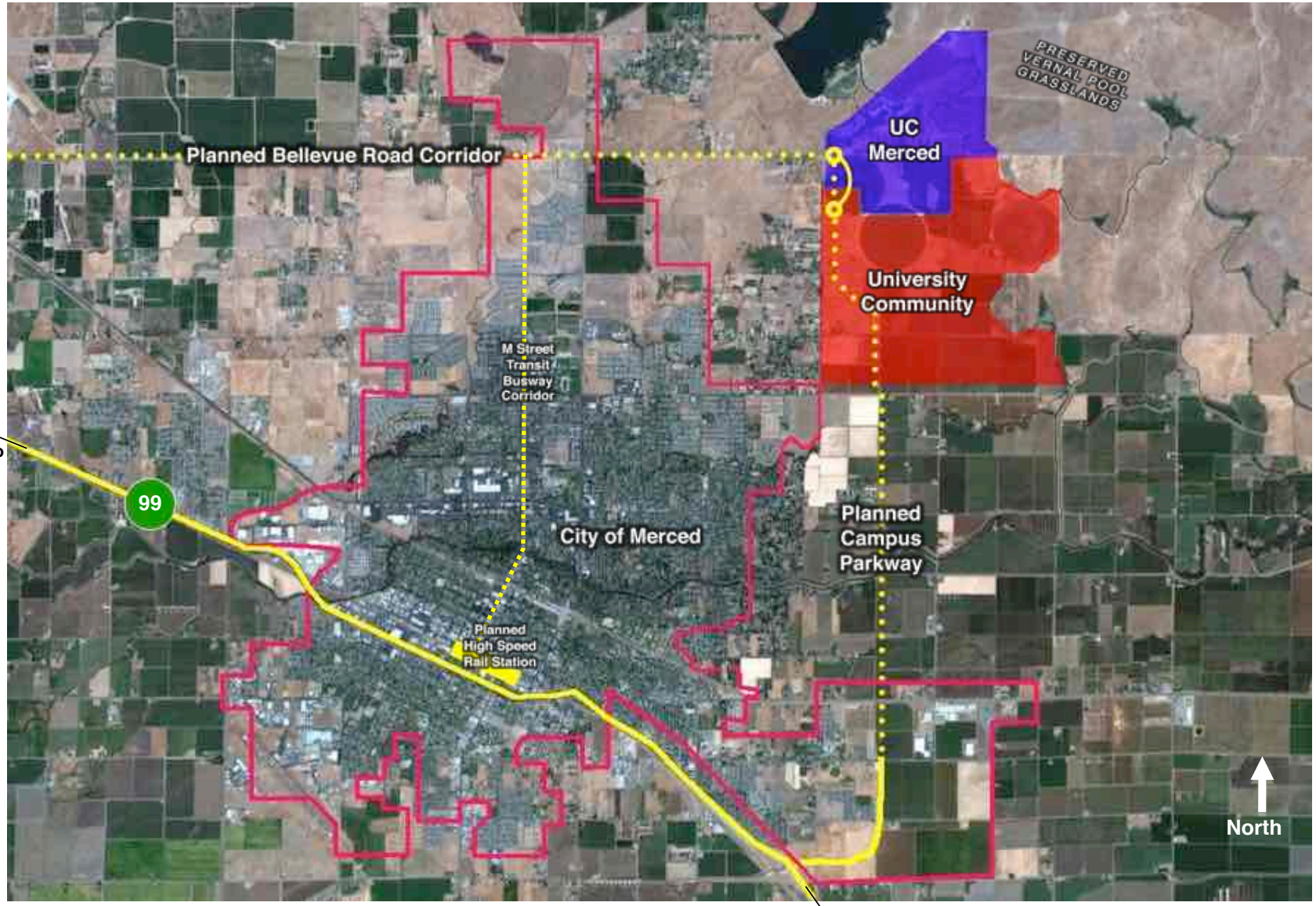
Located in California's fastest growing region

Source: Demographic Research Unit, California Department of Finance. State and County Population Projections by County, by Race/Ethinicity and by Major Age Groups, 2010-2060.

Photos:
Structures of Utility
David Starck Wilson

Campus Construction (2002)

Campus is a greenfield site on city edge



Sacramento
106 miles

Fresno
57 miles

1 mile

Sources: Google Maps, County of Merced, California High Speed Rail Authority

UC Merced's Approach to Sustainability

Integrate land use and cultural context to create memorable places

Design buildings that reduce energy demand

Incorporate energy infrastructure into plans and buildings

Foster involvement from campus community in operations

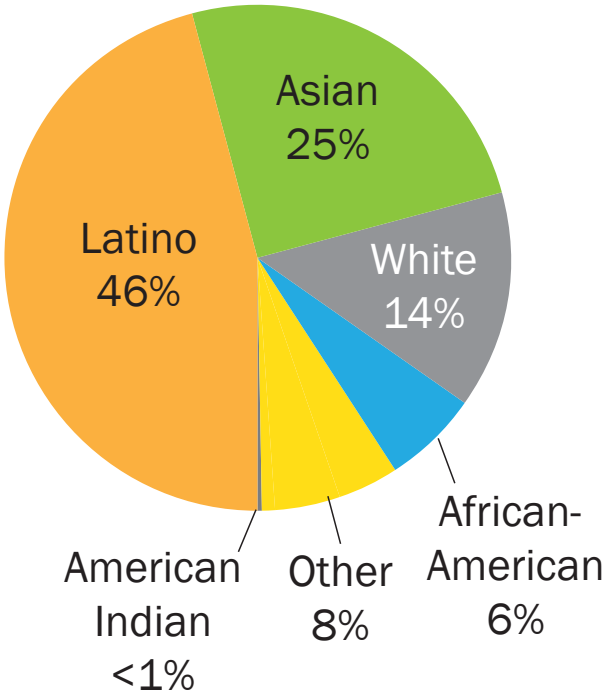
UC Merced has grown to 104 acres

1.4 million gross square feet, 2,000 beds

UC Merced Today
Diverse and growing

- 6,700 Students
- 60% low income
- 62% are from families where neither parent holds a four-year degree
- More than half majoring in STEM fields

UC Merced Undergraduate Diversity

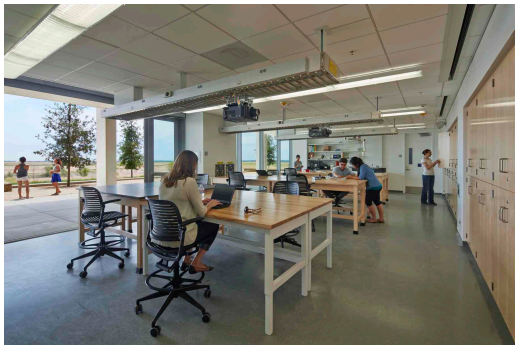


Source: UC Merced Institutional Research and Decision Support, Fall 2013 and Fall 2014,http://ipa.ucmerced.edu/docs/campus%20enrollment/Class%20Level.pdf; http://www.ucmerced.edu/fast-facts - Does not equal 100% due to rounding.
http://ipa.ucmerced.edu/docs/Undergraduates/undergrad%20enrollment%20first%20gen%20status.pdf;

UC Merced has a distinct design vocabulary inspired by its place and time

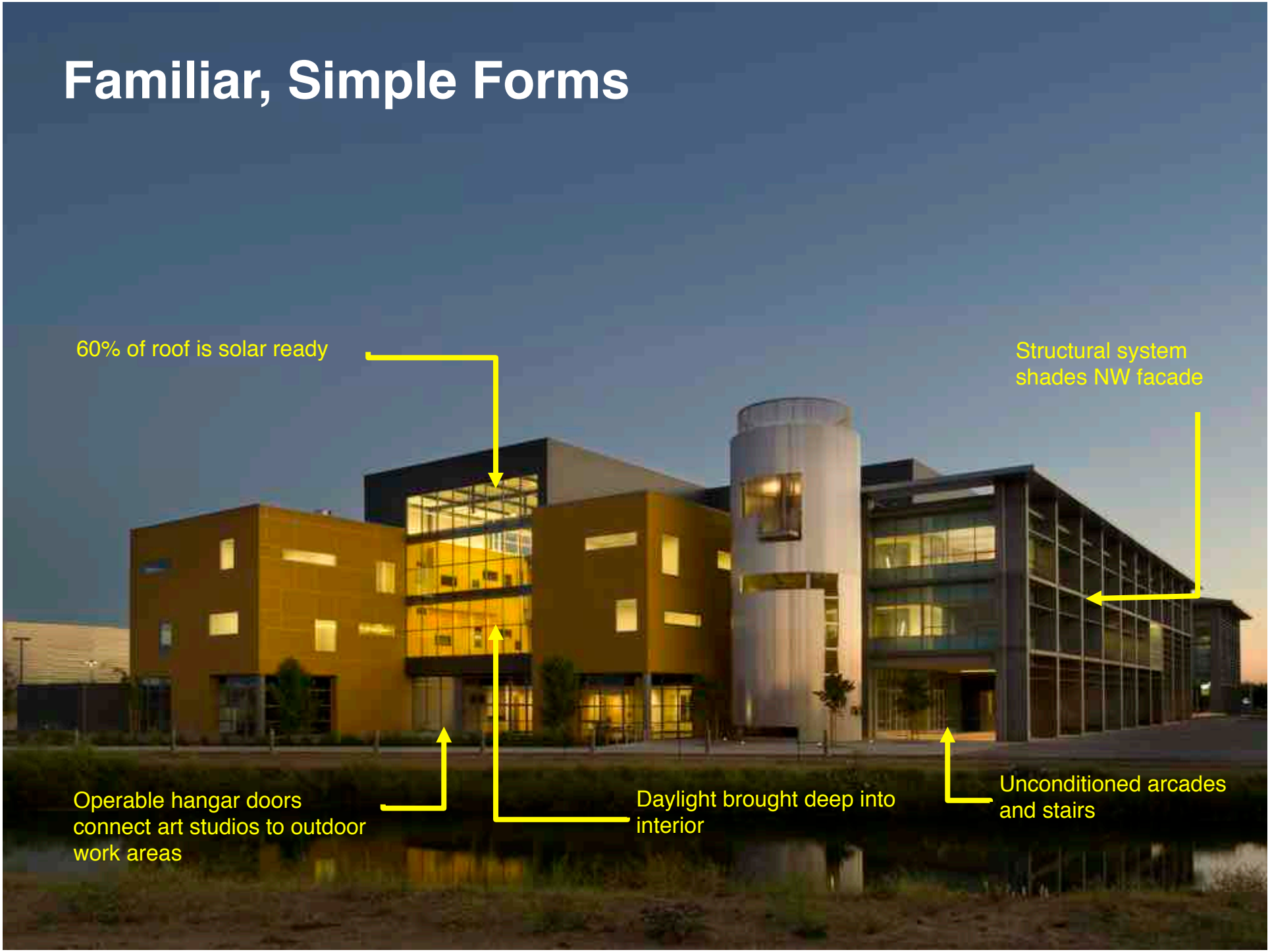
Glass, concrete, stucco and steel

Inspired by simple forms derived from the region's architecturally underappreciated buildings

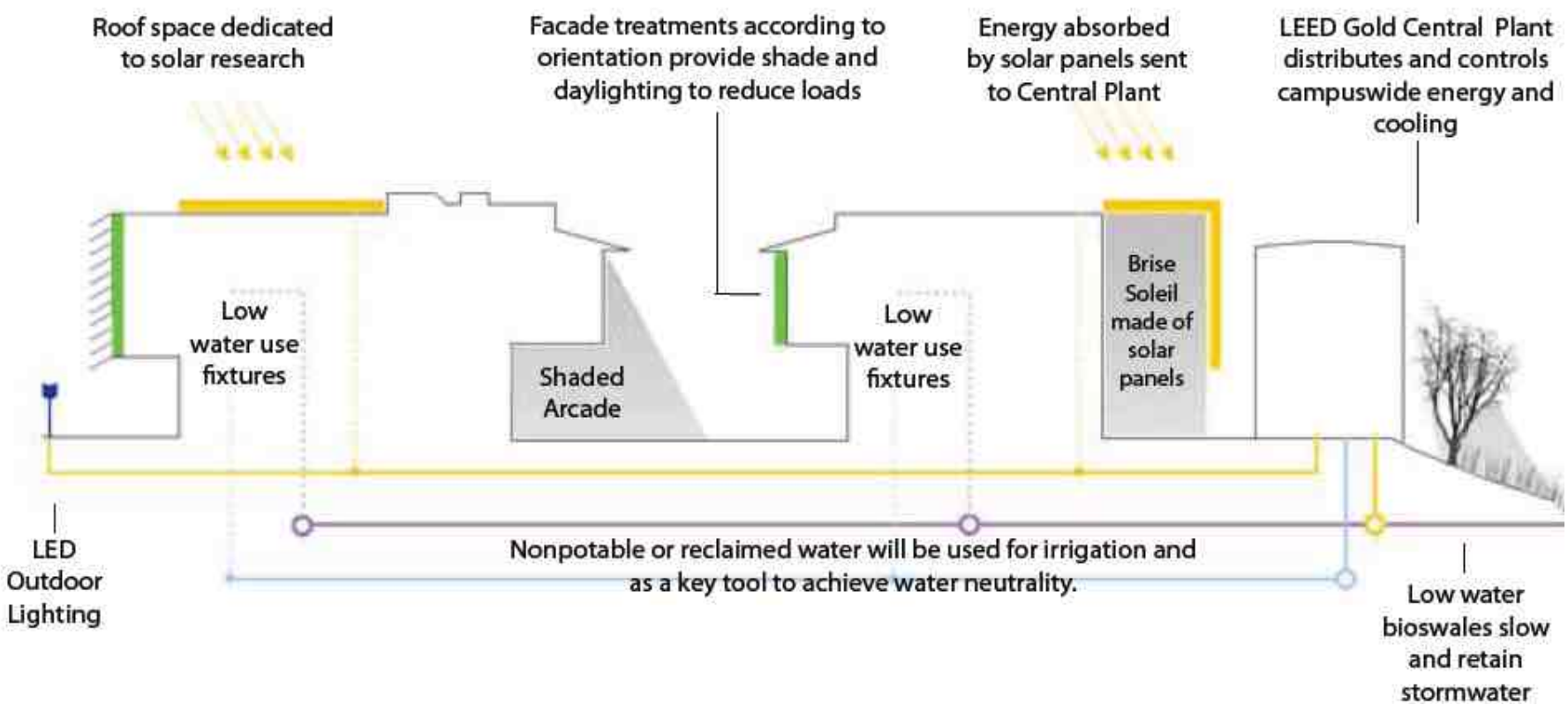



Cafe

Familiar, Simple Forms

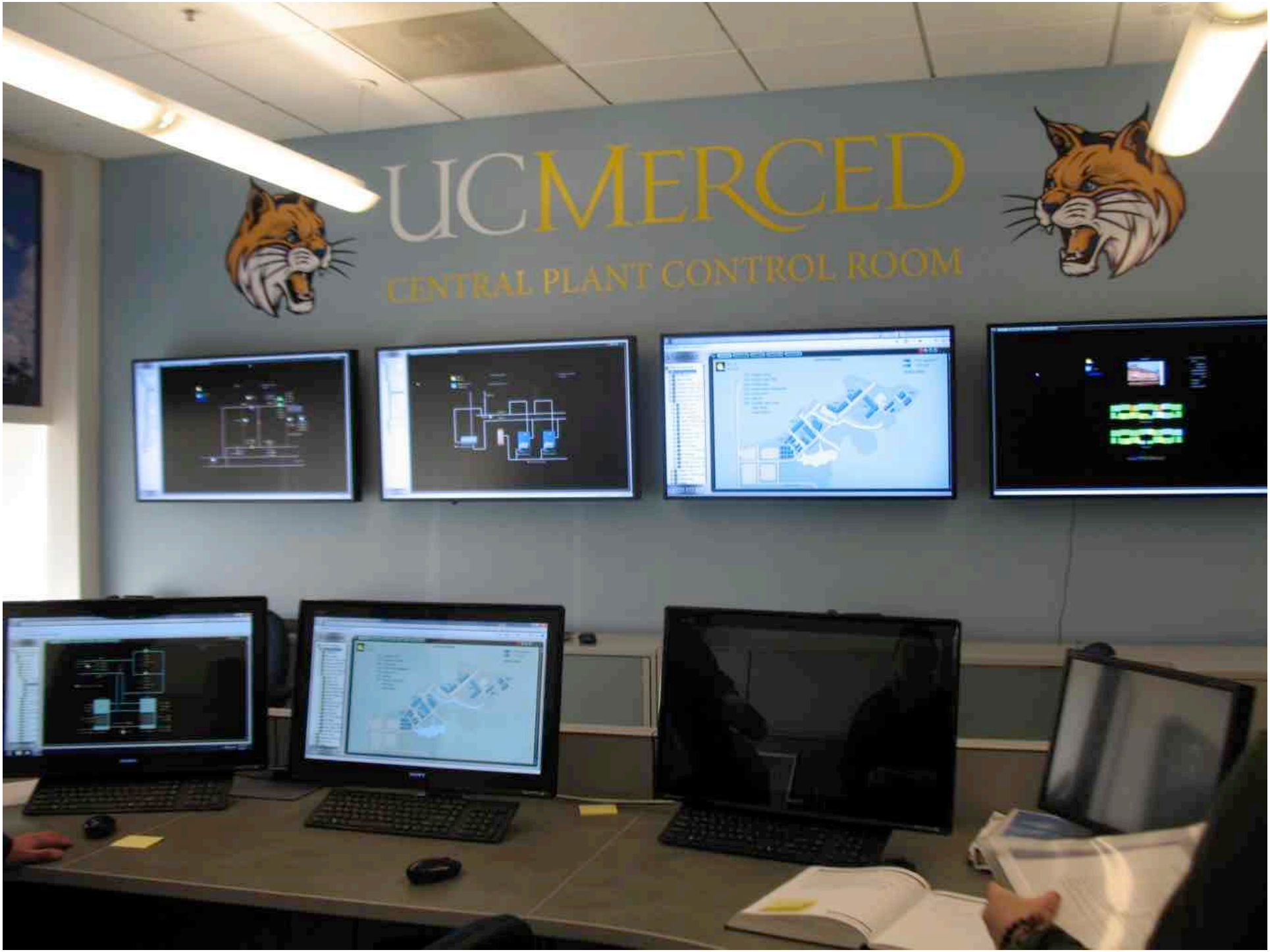


The campus is networked for efficiency



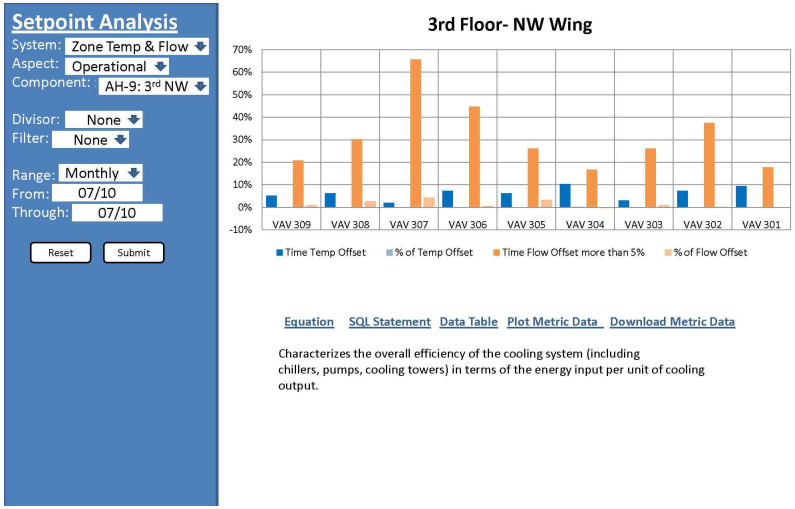
Central Plant

UC Merced Utility Tunnel

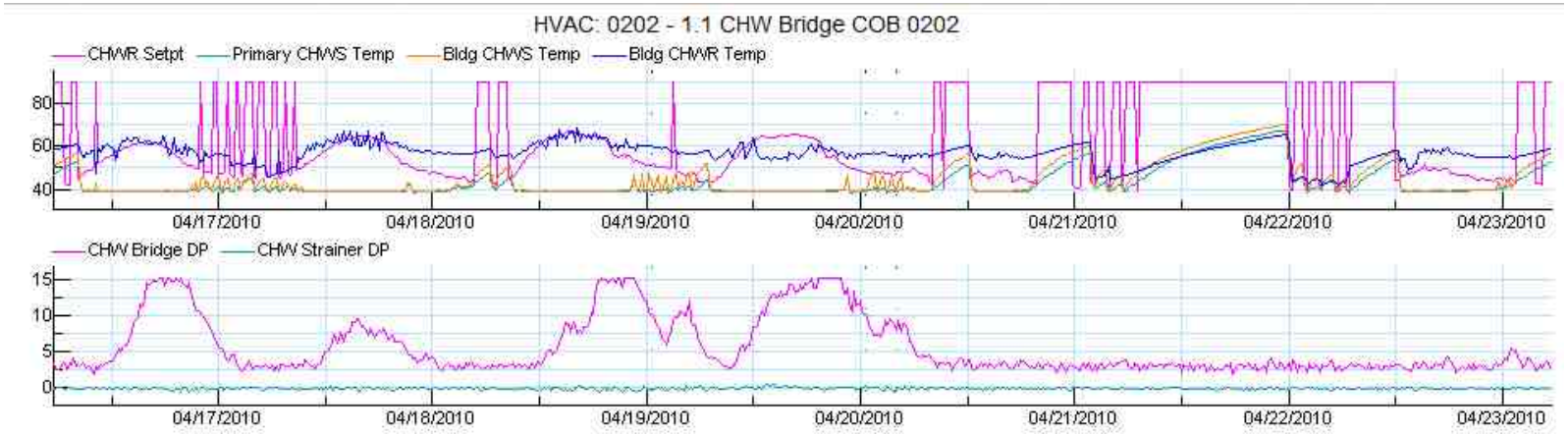

UCMERCED
CENTRAL PLANT CONTROL ROOM

Building Maintenance through data

Campus Building Energy Performance Platform



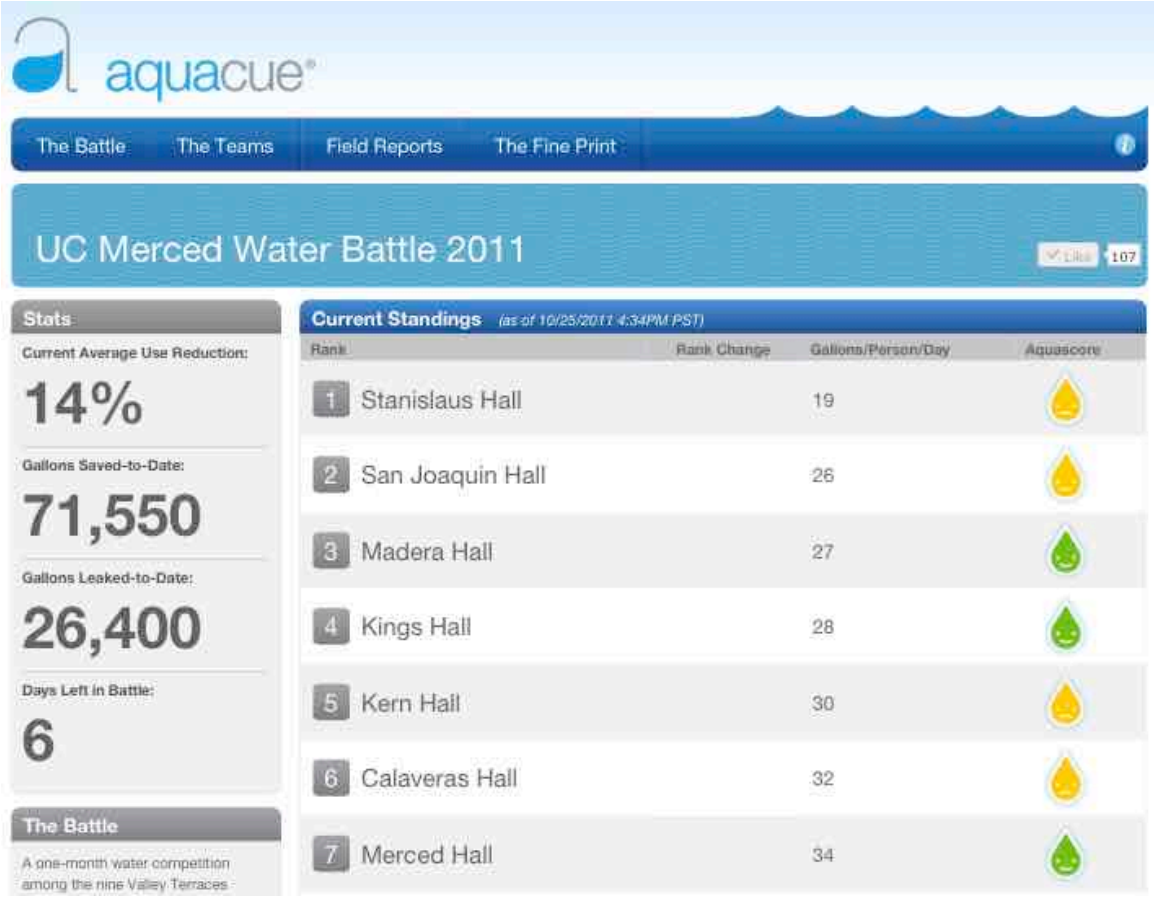
- **Today**: Campus has extensive effort to capture and collect building data
- **Goal**: To quantify portion of building performance and return on investment attributable to maintenance, verify performance and aid troubleshooting



For more detail, visit: http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/uc_merced_case_study.pdf and http://labs21.lbl.gov/DPM/Assets/Campus-right-sizing.pdf and https://newbuildings.org/wp-content/uploads/2015/11/UCM-SE1_CaseStudy_07_111.pdf

Nurturing a Data Gathering Culture

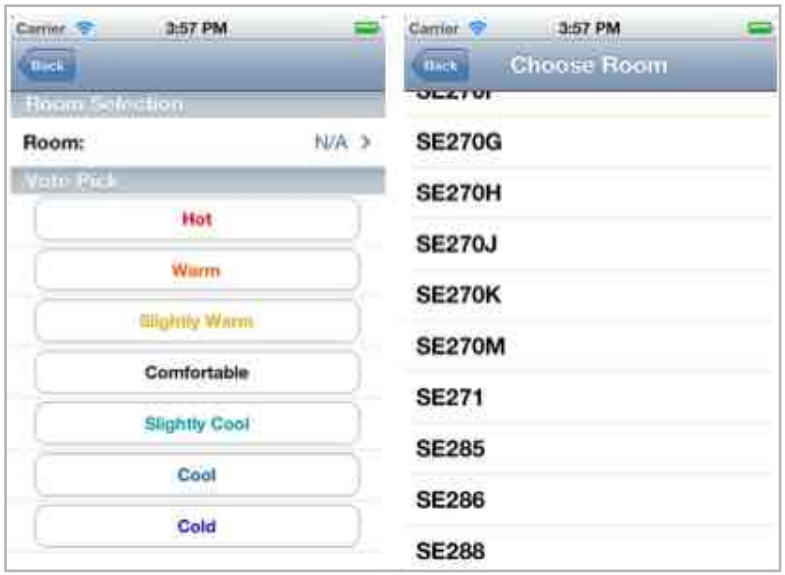
Pushing conservation through behavior

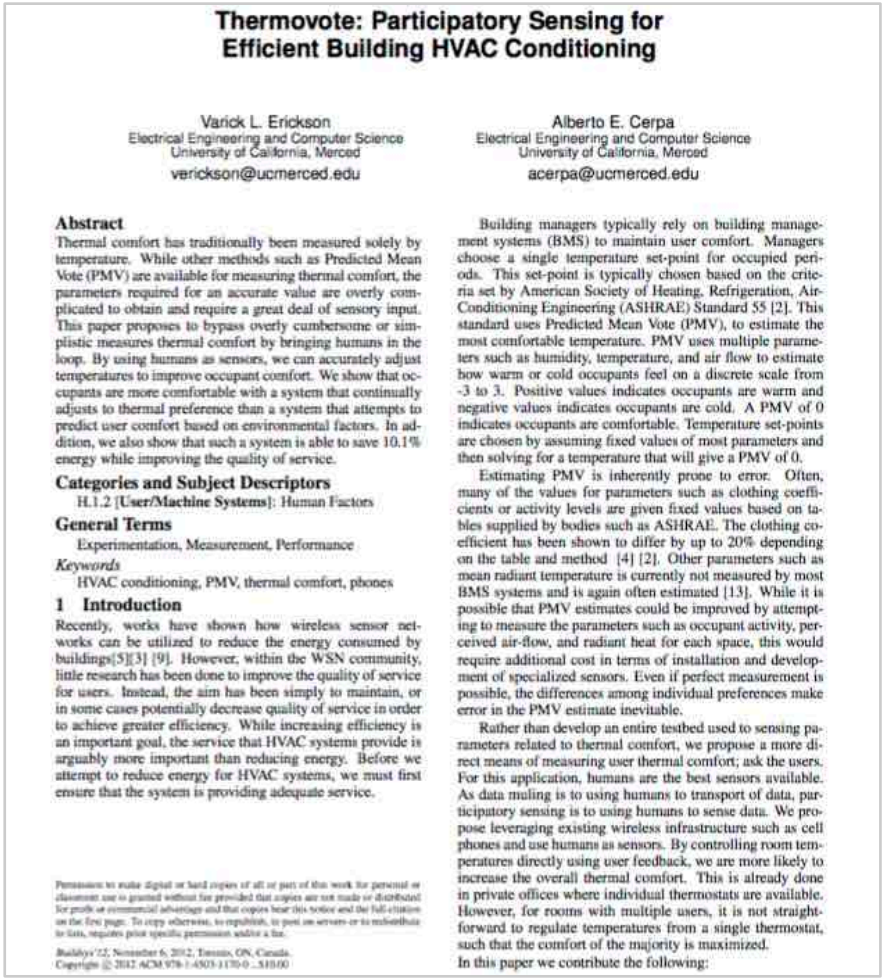


Source: “Students Clash in Month-Long Battle to Save Water” http://www.ucmerced.edu/news/2011/students-clash-month-long-battle-save-water

Blending Data Gathering with the Academy

Thermovote – Crowd sourced climate control





Thermovote: Participatory Sensing for Efficient Building HVAC Conditioning

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Abstract

Thermal comfort has traditionally been measured solely by temperature. While other methods such as Predicted Mean Vote (PMV) are available for measuring thermal comfort, the parameters required for an accurate value are overly complicated to obtain and require a great deal of sensory input. This paper proposes to bypass overly cumbersome or simplistic measures thermal comfort by bringing humans in the loop. By using humans as sensors, we can accurately adjust temperatures to improve occupant comfort. We show that occupants are more comfortable with a system that continually adjusts to thermal preference than a system that attempts to predict user comfort based on environmental factors. In addition, we also show that such a system is able to save 10.1% energy while improving the quality of service.

Categories and Subject Descriptors

H.1.2 [**User/Machine Systems**]: Human Factors

General Terms

Experimentation, Measurement, Performance

Keywords

HVAC conditioning, PMV, thermal comfort, phones

1 Introduction

Recently, works have shown how wireless sensor networks can be utilized to reduce the energy consumed by buildings[5][3] [9]. However, within the WSN community, little research has been done to improve the quality of service for users. Instead, the aim has been simply to maintain, or in some cases potentially decrease quality of service in order to achieve greater efficiency. While increasing efficiency is an important goal, the service that HVAC systems provide is arguably more important than reducing energy. Before we attempt to reduce energy for HVAC systems, we must first ensure that the system is providing adequate service.

Building managers typically rely on building management systems (BMS) to maintain user comfort. Managers choose a single temperature set-point for occupied periods. This set-point is typically chosen based on the criteria set by American Society of Heating, Refrigeration, Air-Conditioning Engineering (ASHRAE) Standard 55 [2]. This standard uses Predicted Mean Vote (PMV), to estimate the most comfortable temperature. PMV uses multiple parameters such as humidity, temperature, and air flow to estimate how warm or cold occupants feel on a discrete scale from -3 to 3. Positive values indicates occupants are warm and negative values indicates occupants are cold. A PMV of 0 indicates occupants are comfortable. Temperature set-points are chosen by assuming fixed values of most parameters and then solving for a temperature that will give a PMV of 0.

Estimating PMV is inherently prone to error. Often, many of the values for parameters such as clothing coefficients or activity levels are given fixed values based on tables supplied by bodies such as ASHRAE. The clothing coefficient has been shown to differ by up to 20% depending on the table and method [4] [2]. Other parameters such as mean radiant temperature is currently not measured by most BMS systems and is again often estimated [13]. While it is possible that PMV estimates could be improved by attempting to measure the parameters such as occupant activity, perceived air-flow, and radiant heat for each space, this would require additional cost in terms of installation and development of specialized sensors. Even if perfect measurement is possible, the differences among individual preferences make error in the PMV estimate inevitable.

Rather than develop an entire testbed used to sensing parameters related to thermal comfort, we propose a more direct means of measuring user thermal comfort; ask the users. For this application, humans are the best sensors available. As data muling is to using humans to transport of data, participatory sensing is to using humans to sense data. We propose leveraging existing wireless infrastructure such as cell phones and use humans as sensors. By controlling room temperatures directly using user feedback, we are more likely to increase the overall thermal comfort. This is already done in private offices where individual thermostats are available. However, for rooms with multiple users, it is not straightforward to regulate temperatures from a single thermostat, such that the comfort of the majority is maximized.

In this paper we contribute the following:

BuildSys'12, November 6, 2012, Toronto, ON, Canada.

Source:

"Thermovote: Participatory Sensing for Efficient Building HVAC Conditioning"

http://www.andes.ucmerced.edu/papers/Erickson12a.pdf

The 2020 Project

Planning for a campus of 10,000 students

- Add physical capacity to grow to 10,000 students
- Compact Development Footprint
- Mixed-use, long term approach to design and sustainable buildings
- Academic, Student Life, Infrastructure

Construction scheduled for 2016, Completion by 2020

Our challenge

Ensuring lifecycle costs are predictable over the long term

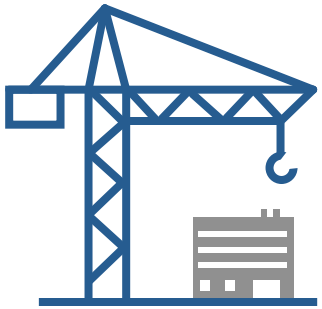
UC Merced's buildings are brand new, sustainable and state of the art...

Every building at UC Merced is **LEED Gold or Platinum**

... ***but*** UC Merced needs a long term strategy to avoid accumulating a backlog of deferred maintenance

Deferred Maintenance has historically been a challenge on UC campuses

How the 2020 Project will work

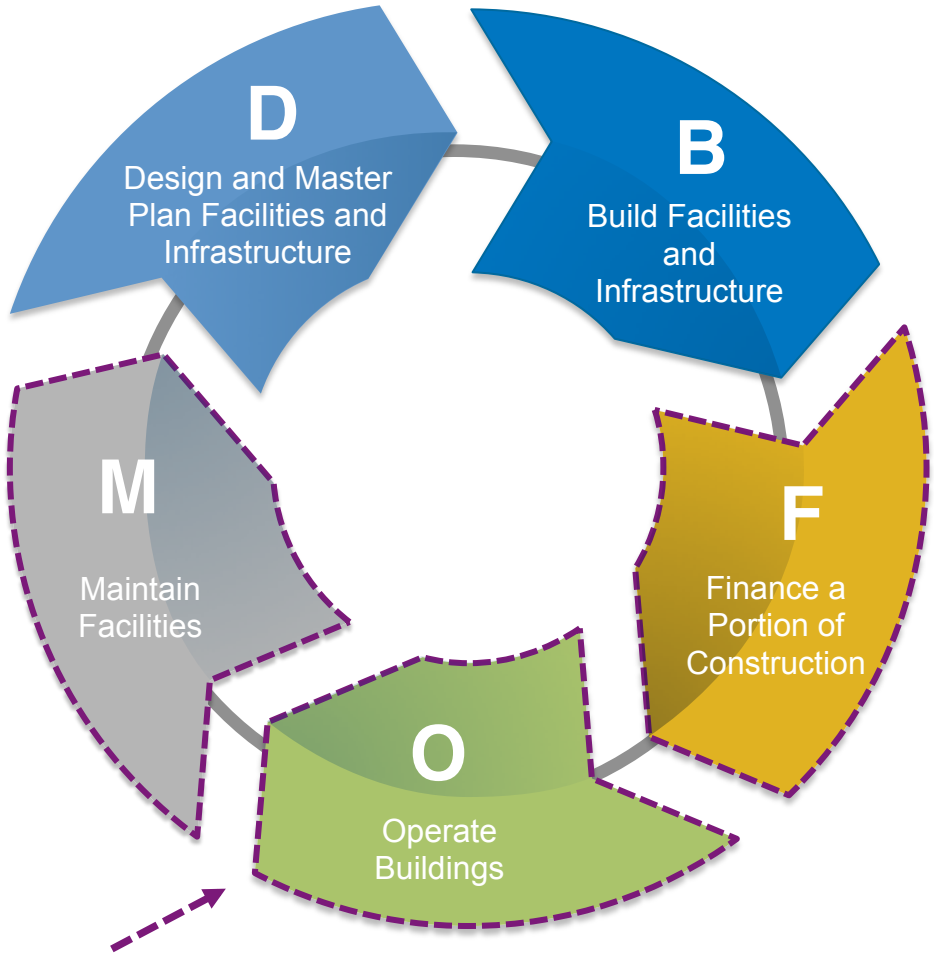


UC and a Developer jointly finance the design and construction of multiple facilities at UC Merced.

The Developer maintains major building systems for 35 years in exchange for availability payments subject to performance.

At the end of the contract, the developer turns over maintenance of the well-maintained buildings to UC Merced.

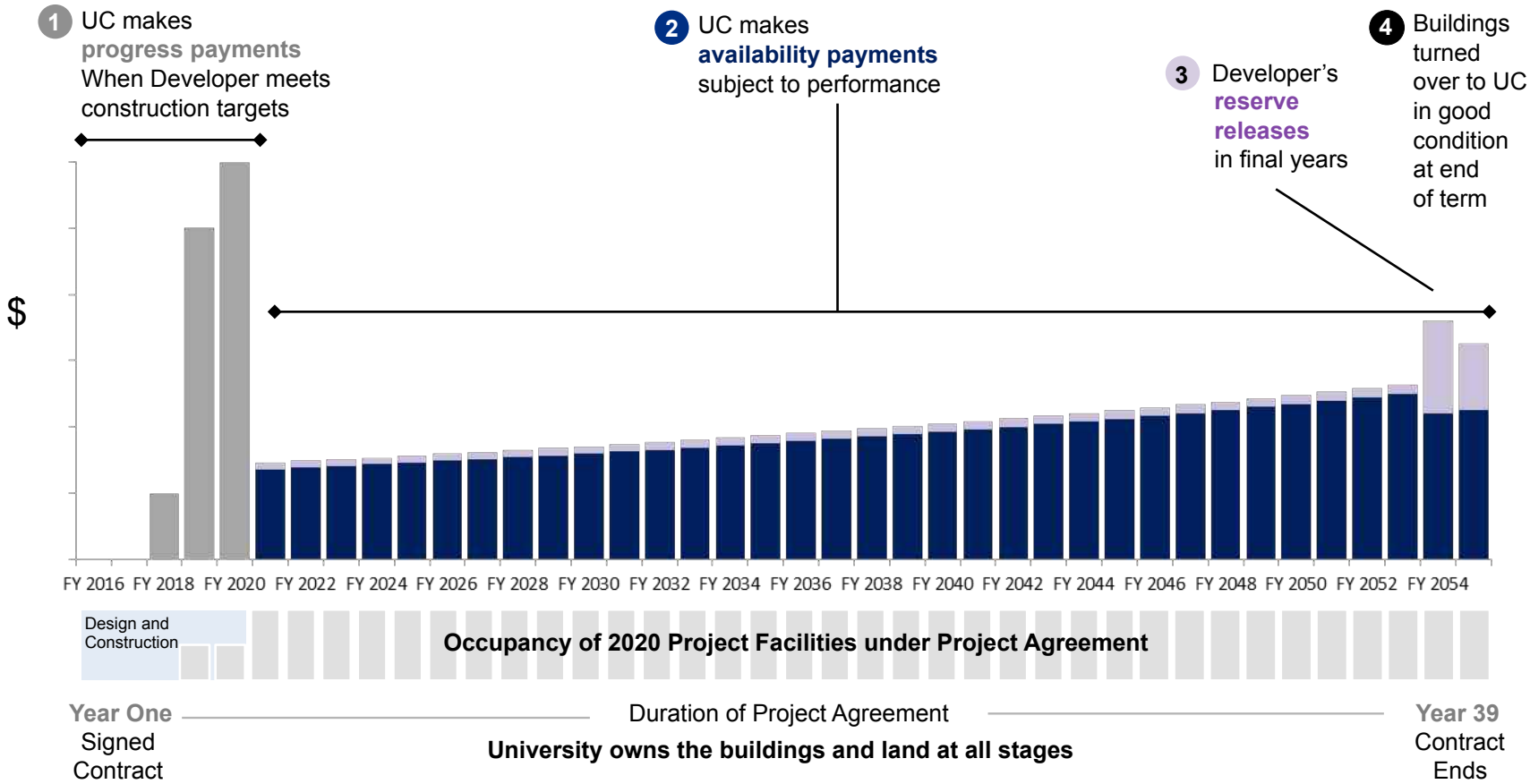
Strategy bundles all project elements into a single, coordinated delivery



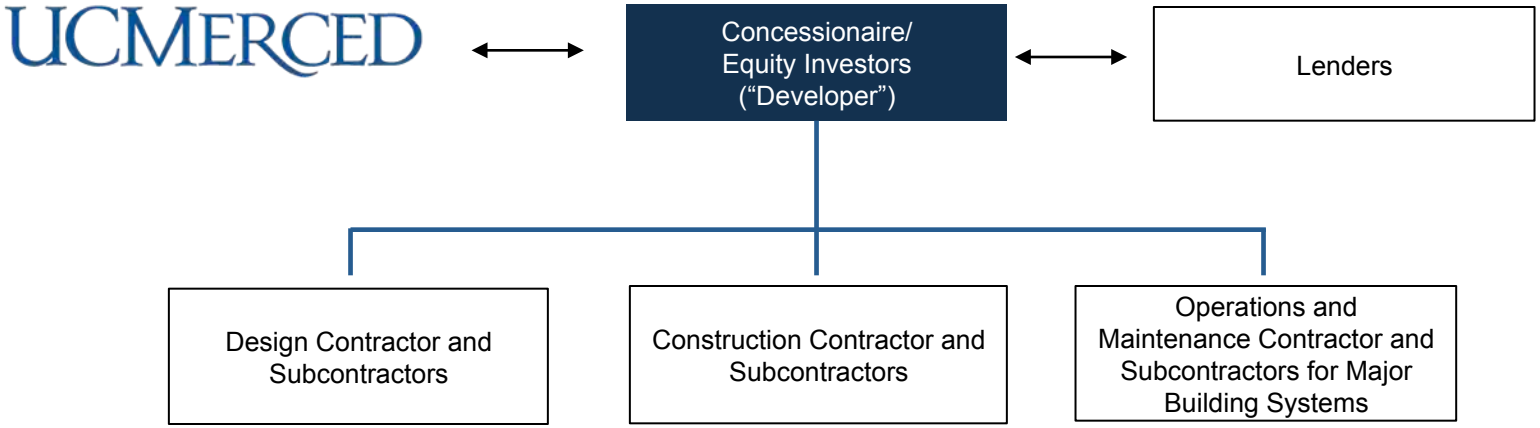
Finance, operations and maintenance risks are shared by University and Developer

- **Creates link** between design and construction of facilities and long-term maintenance
- **Holds the Developer accountable for performance** over life of the asset
- **Incorporates life-cycle financial plan** within affordability constraints established by the University
- **Addresses future obligations** for capital maintenance
- **Creates competition** for all Project elements
- **Manages certain risk elements** to enable campus to focus on core teaching, research and public service missions

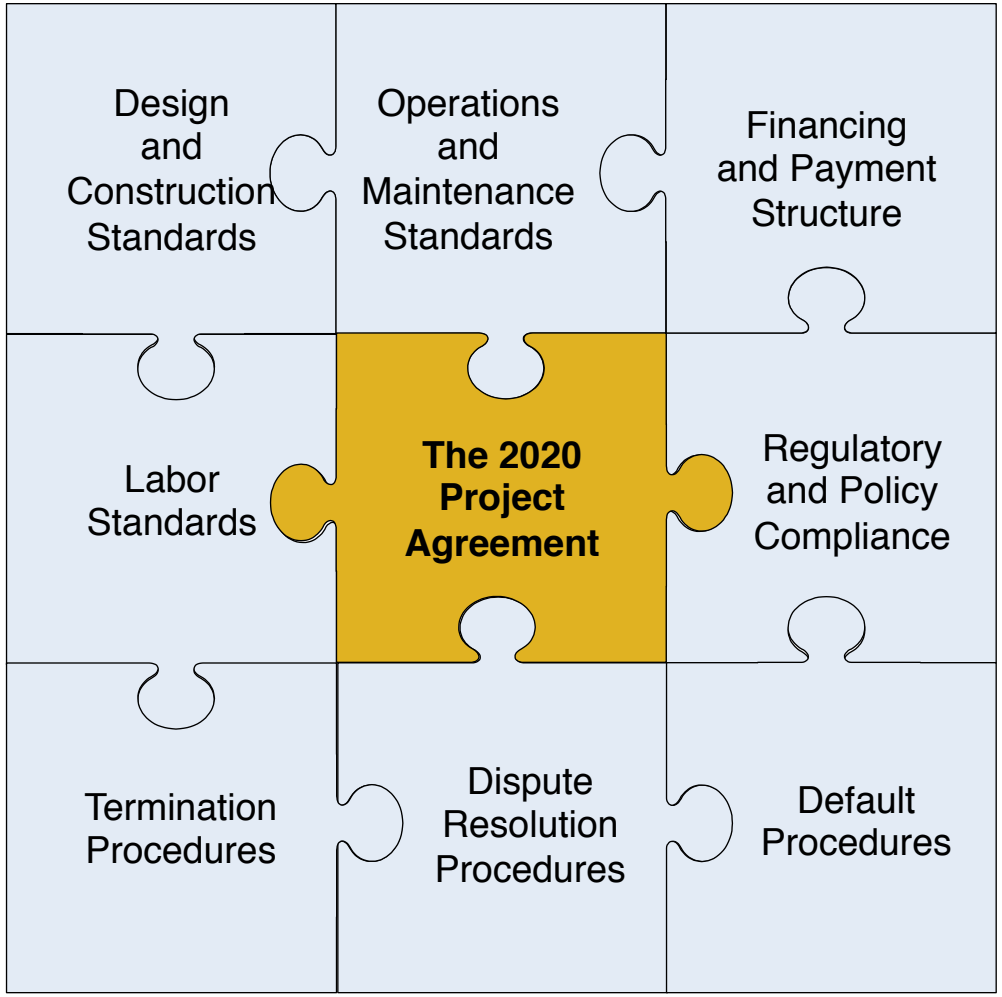
How the payment mechanism works



The campus will enter into a Project Agreement with a “concessionaire” comprised of the equity members of the team (the “Developer”)



“The Project Agreement” is the performance based tool we are using to deliver the project



Key Terms

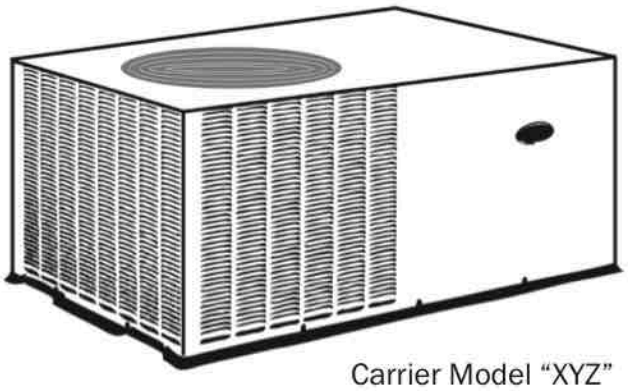
- Developer’s obligation to design, build, finance, operate and maintain major building systems for a term of 39 years
- LEED Gold Minimums
- Energy usage
- Water Budgets
- Daylighting requirements
- Groundwater reduction targets
- Delivery dates for all facilities
- Detailed campus review of design and construction to ensure compliance with the contract terms
- Penalties for performance failure and a “non-compliance” points scheme that lead to progressive remedies up to and including default and termination
- Energy Incentives
- Handback conditions and reserves

Traditional Procurement vs. 2020 Project

UC Merced is using a long-term, performance based framework for every element of the campus

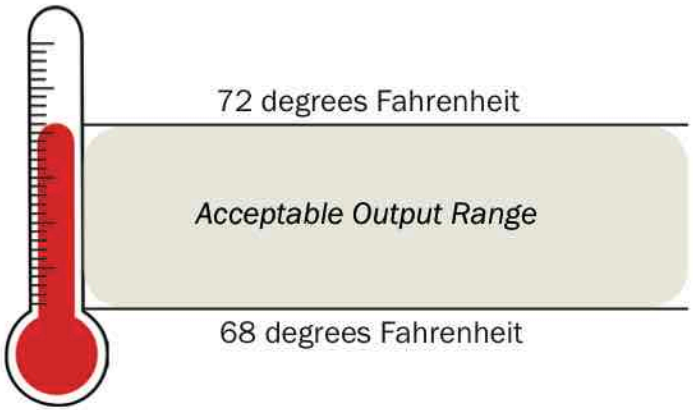
Inputs in a Traditional Procurement

"Cooling to the building must be provided by Carrier Model "XYZ" heat pump with a cooling capacity of "ZZ" tons."

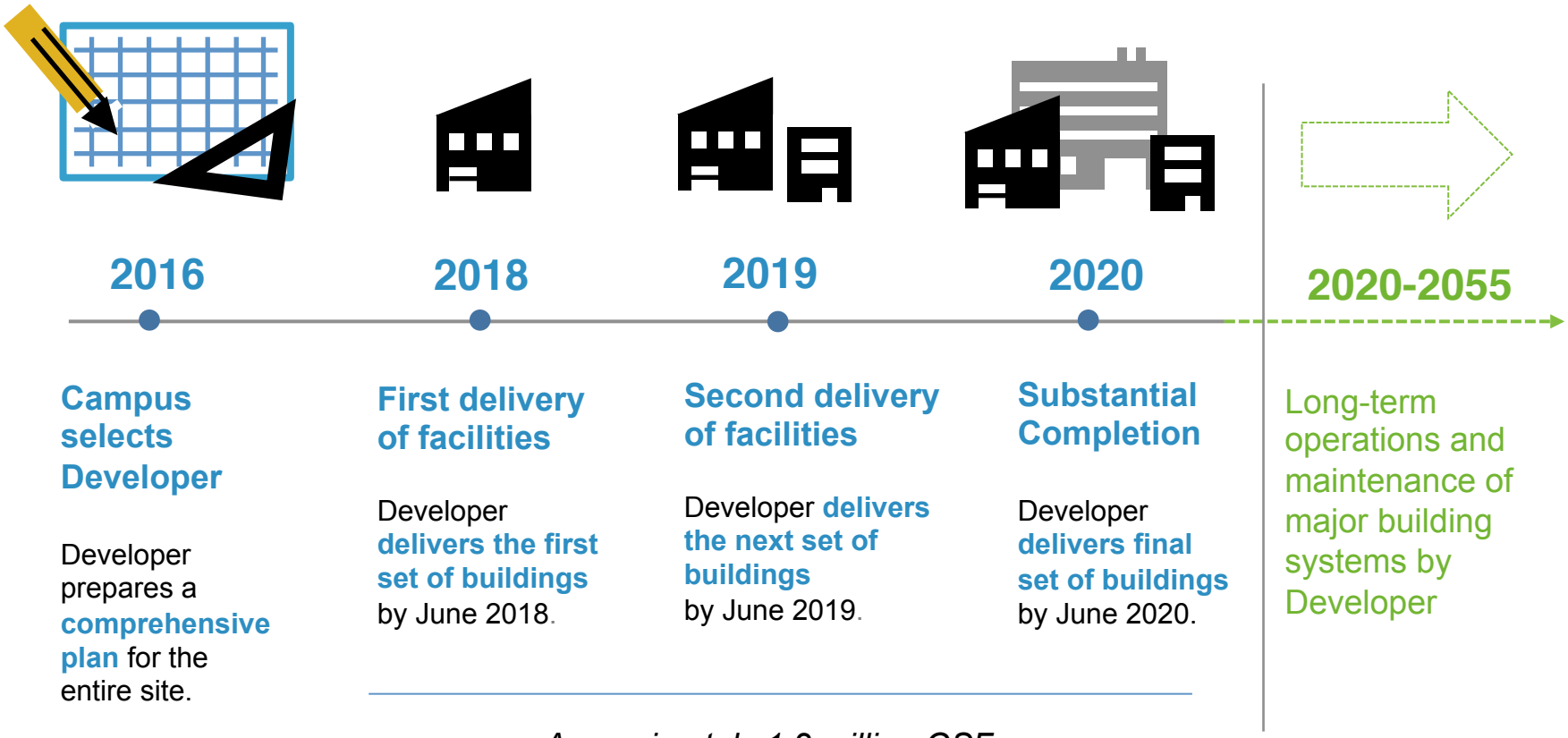


Outputs in a Public-Private Partnership Procurement

"The temperature of the occupied portions of the building shall not be lower than 68 degrees Fahrenheit and not higher than 72 degrees Fahrenheit, 97% of the time that the building is open to occupants."



Proposed Phasing of the 2020 Project



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Lessons Learned

- **Set clear**, achievable design and operations **goals**
- **Acting holistically** about long-range financial condition can help set priorities
- **Make sustainability a key element** of the competitive process
- Better suited for **large scale projects** that can capture economies of scale for infrastructure


http://2020project.ucmerced.edu
2020 Project + Master Plan