

# Zero Net Energy Case Study Buildings

by Edward Dean, FAIA

BEST Center -1/12/2017

Can “John” Anbarlilar



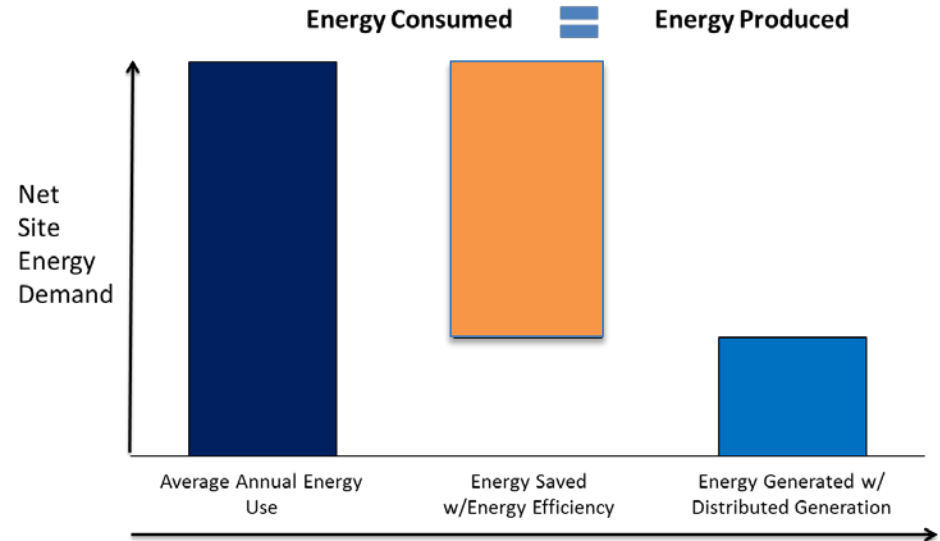
Together, Building  
a Better California



# What is Zero Net Energy (ZNE)?

A highly efficient building that produces as much energy from renewable sources as it consumes over a one year period

- First through high levels of energy efficiency, and then through the addition of clean, on-site renewable power generation, typically solar PV.





# What is Zero Net Energy (ZNE)?

## Many definitions and metrics:

- Site
- Source
- TDV
- ...

**Don't get discouraged by metrics and definitions, the concept is the same!**



# What is Zero Net Energy (ZNE)?

## If you want to read about the details:

- Read ZNE Case Study Buildings Vol.1 Introduction – [Link](#)
- New Buildings Institute (NBI) – Database of buildings, tools, communication kit
- Read DOE’s “A Common Definition for Zero Energy Buildings” – [Link](#)
- International Living Future Institute – Net Zero Energy Certification based on Living Buildings Challenge framework



# Why Zero Net Energy (ZNE)?

## State Policy Framework

- AB 32 Global Warming Solutions Act (2006)
- CPUC Strategic Plan ZNE New Construction Goals (2008) Long Term Energy Efficiency Strategic Plan (2008)
- CEC Integrated Energy Policy Reports (2007-15)
- Executive Order B-18-12 (2012)
- SB 350 (2015)



# California's Goals

## Big Bold Goals

- All new residential construction and all new commercial construction in California will be zero net energy by 2020 and 2030, respectively
- 50% of existing commercial buildings will be retrofit to ZNE by 2030
- All new state buildings and major renovations shall be ZNE (2025)
- 50% of existing state-owned building area by 2025 shall be ZNE



# EUI – Energy Use Intensity

## Energy per square foot per year

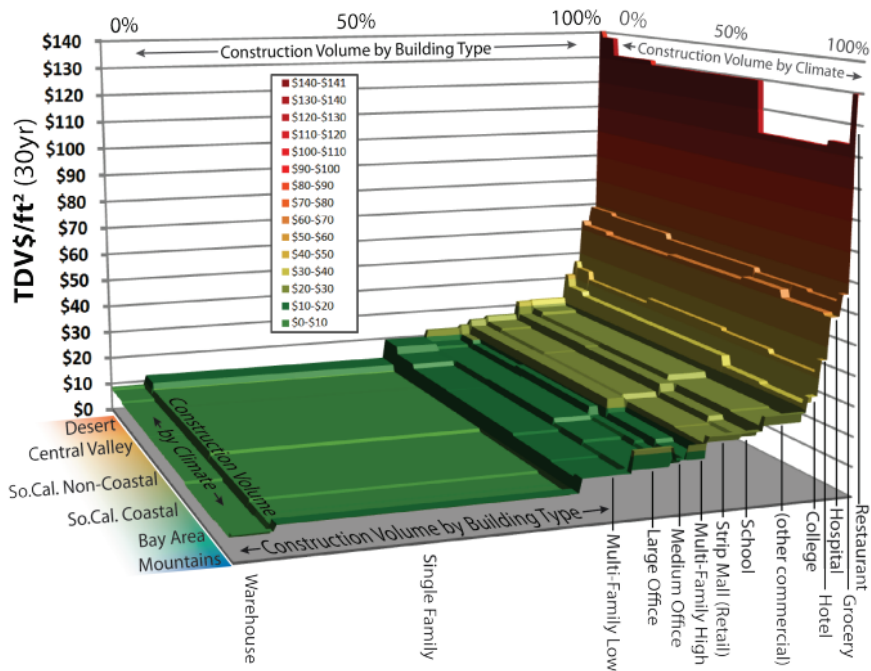
- Total energy consumed by the building in one year (measured in kBtu) by the total gross floor area of the building.
- Energy Star is a great resource for EUI



# Technical Feasibility of ZNE in CA

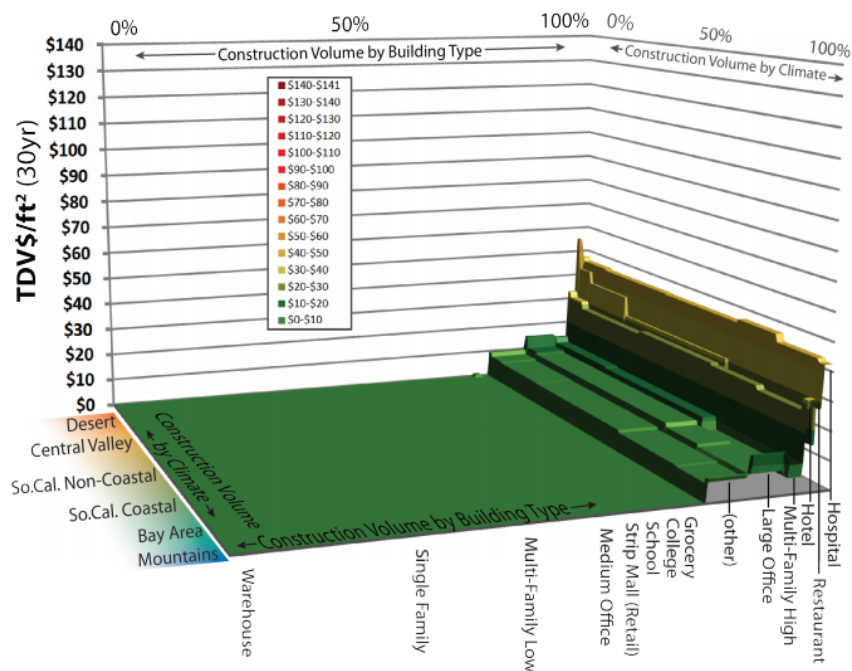
## without Solar

Figure 10 – Statewide Technically Feasible EUIs without Solar (TDV\$) distributed by Projected 2020 Construction Volume



## with Solar

Figure 11 – Statewide Technically Feasible Net-EUIs with Solar (TDV\$) by Projected 2020 Construction Volume



From "The Technical Feasibility of Zero Net Energy Buildings in California" by ARUP

[http://www.energydataweb.com/cpucfiles/pdadocs/904/california\\_zne\\_technical\\_feasibility\\_report\\_final.pdf](http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf)





# What is Zero Net Energy (ZNE)?

## A Distinction to make:

- **ZNE Design**
- **ZNE Performance**



# Zero Net Energy Case Study Buildings

## Zero Net Energy Case Study Buildings

Volume 1

Written by  
Edward Dean, FAIA  
Bernheim + Dean, Inc.

Foreword by  
Peter Turnbull  
Principal, Commercial Buildings,  
Pacific Gas and Electric Company

*Note: This is a low-resolution version of this book, designed to be viewed on a computer screen only. It is not suitable for a printed copy.*

September 2014

## Zero Net Energy Case Study Buildings

Volume 2

Written by  
Edward Dean, FAIA  
Bernheim + Dean, Inc.

Foreword by  
Peter Turnbull  
Principal, Commercial Buildings,  
Pacific Gas and Electric Company

*Note: This is a low-resolution version of this book, designed to be viewed on a computer screen only. It is not suitable for a printed copy.*

April 2016



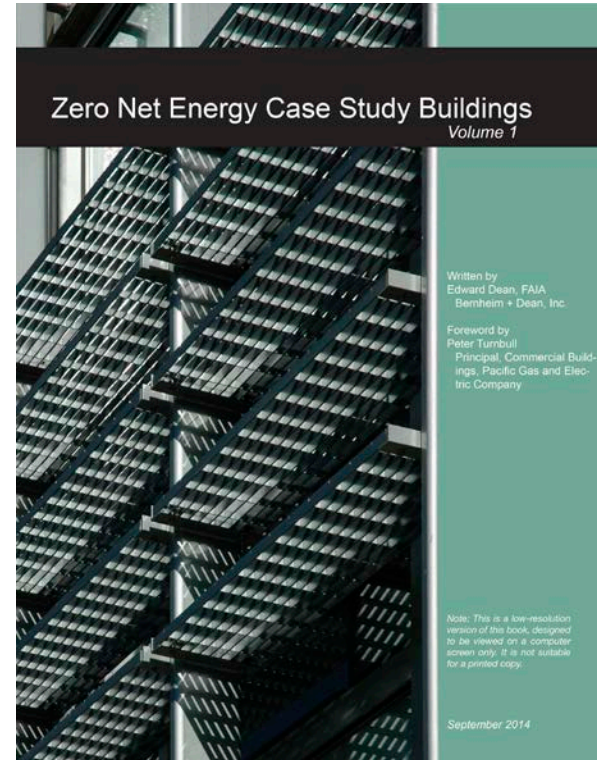
# Zero Net Energy Case Study Buildings by Edward Dean, FAIA

## Case Studies in Volume 1:

- Packard Foundation Office Building
- Stevens Library at Sacred Heart Schools
- IDeAS Office Building
- Watsonville Water Resources Center
- Science and Engineering Building at UC Merced
- Classroom and Office Building at UC Merced

**FREE** to download at <http://bit.ly/2a6J6v4>

Order a print copy on Amazon.com, sold at cost





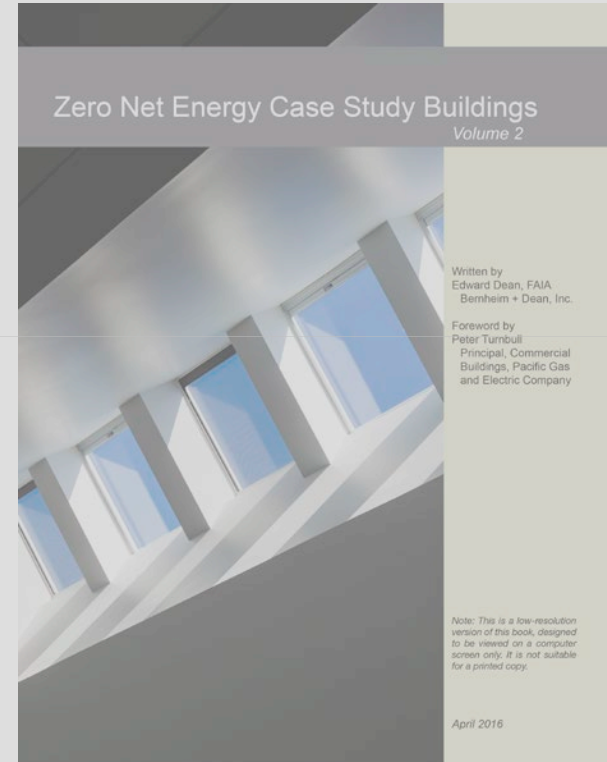
# Zero Net Energy Case Study Buildings by Edward Dean, FAIA

## Case Studies in Volume 2:

- DPR Construction Office Building
- IBEW-NECA JATC Training Facility
- Speculative Office Building at 435 Indio Way
- West Berkeley Branch Library
- The Exploratorium Science Museum

**FREE** to download at <http://bit.ly/29VOVwx>

Order a print copy on Amazon.com, sold at cost





# Zero Net Energy Case Study Buildings

	Building Type	Location	Climate Zone	Floor Area (sf)
DPR Construction San Francisco Office	Office	San Francisco, CA	CA CZ 3 Marine	20,020
435 Indio Way Speculative Office Building	Office	Sunnyvale, CA	CA CZ 4 Marine	31,759
IBEW-NECA JTAC Training Facility	Classroom / Office	San Leandro, CA	CA CZ 3 Marine	45,000



# Commonalities

## Emerging storyline:

- **Integrated Design Process (IDP):**
  - Among design disciplines & general contractor
- **Master Systems Integrator:**
  - Coordinate operational controls
  - Monitoring Cx
  - Handholding during the first year of operations
- **Life Cycle Cost Assessment**
  - Based on performance expectations, maintenance costs, added value of a high performance space





# DPR Construction Office Building San Francisco, CA

Photo: Drew Kelly



# DPR Construction Office Building San Francisco, CA

**Building Type:** Office

**Location:** San Francisco, CA

**Gross Floor Area:** 24,010 gsf  
(including tenant space of 4,000 gsf)

**Occupied:** May 2014

**Energy Modeling Software:**  
OpenStudio 1.4

**Modeled EUI (Site):**  
25.8 kBtu/sf-year

**Measured EUI (Site):**  
22.4 kBtu/sf-year (May 2014 —  
June 2015)

**On-Site Renewable Energy**

**System Installed:**  
118 kW (DC) Solar PV

**Measured On-Site Energy  
Production (Electric):**  
157,000 kWh/year  
26.8 kBtu/sf-year (May 2014 —  
June 2015)

**Measured Solar Thermal  
Production:**  
3,400 kWh/year  
0.6 kBtu/sf-year (May 2014 —  
June 2015)

**Design Team**

*Architect:* FME Architecture +  
Design, San Francisco, CA

*Structural Engineer:* Paradigm,  
San Francisco, CA

*Mechanical/Electrical/Plumbing  
Systems Design and Energy  
Analyst:* Integral Group, Oak-  
land, CA

*Lighting Design:*  
DPR Construction

*Commissioning Agent:*  
Integral Group, Oakland, CA

*Master System Integrator:*  
Honeywell

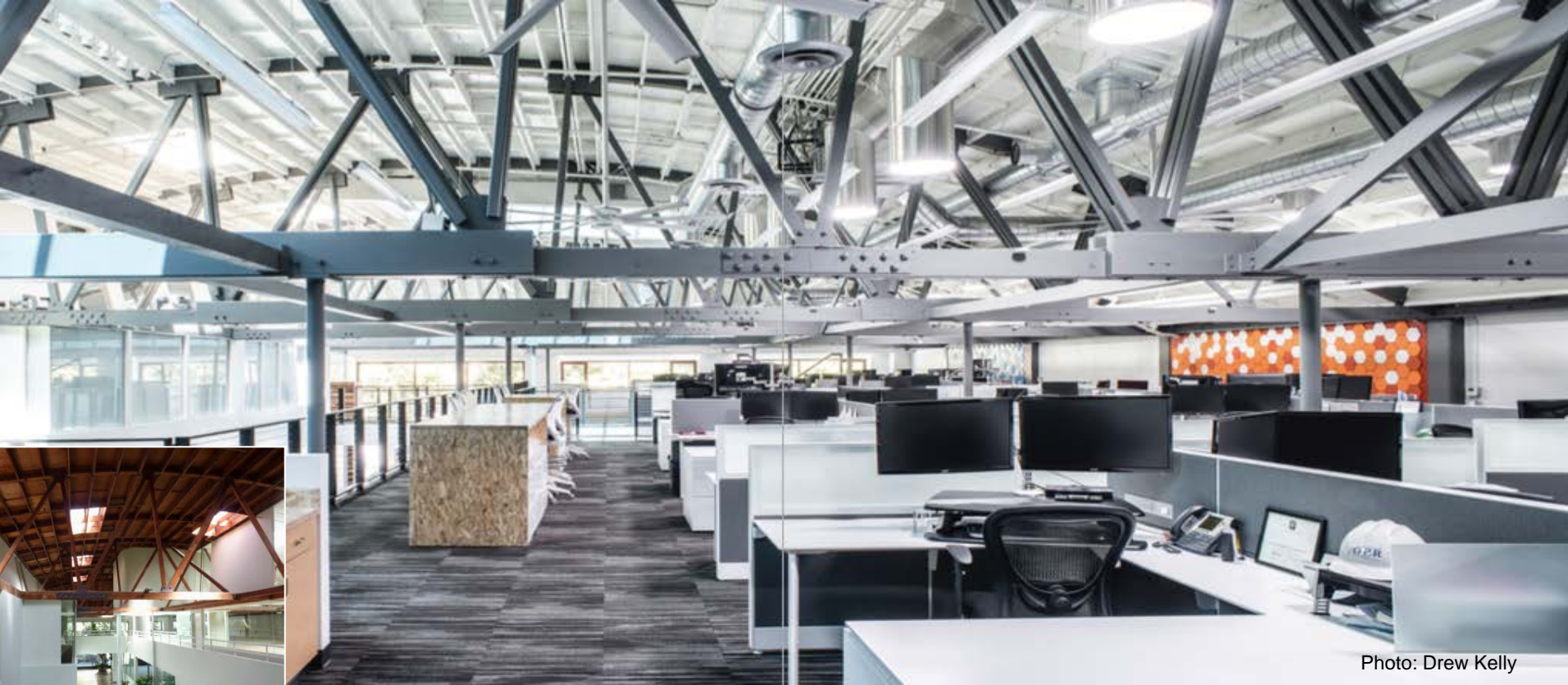
**General Contractor**

DPR Construction





# DPR Construction Office Building San Francisco, CA





# DPR Construction Office Building San Francisco, CA

- **Building Envelope:**
  - Spray foam roof insulation, R-24
- **Daylighting:**
  - Existing large skylights (electrochromic glass)
  - Tubular daylighting, residential manual skylights
- **Natural Ventilation:**
  - Landlocked
  - Night flushing might have been helpful



# DPR Construction Office Building San Francisco, CA

- **Heating, Ventilating & Cooling:**
  - Single air-source heat pump → VRF HVAC
  - Large Fans
  - 4 Dedicated outside air system (DOAS) units w/ air-to-air
  - Solar thermal DHW
- **Plug Loads:**
  - Plug load management software
  - “Kill Switch”
- **Building Control Systems:**
  - 11 different control systems integrated.



# DPR Construction Office Building San Francisco, CA



Photo: Ted Van Der Linden

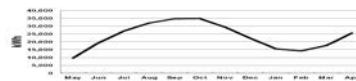
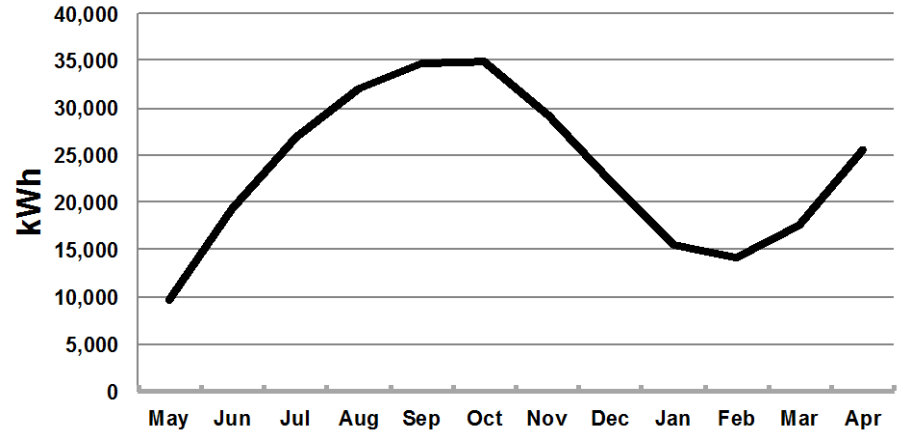
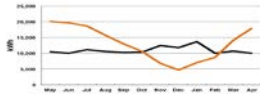
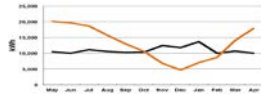
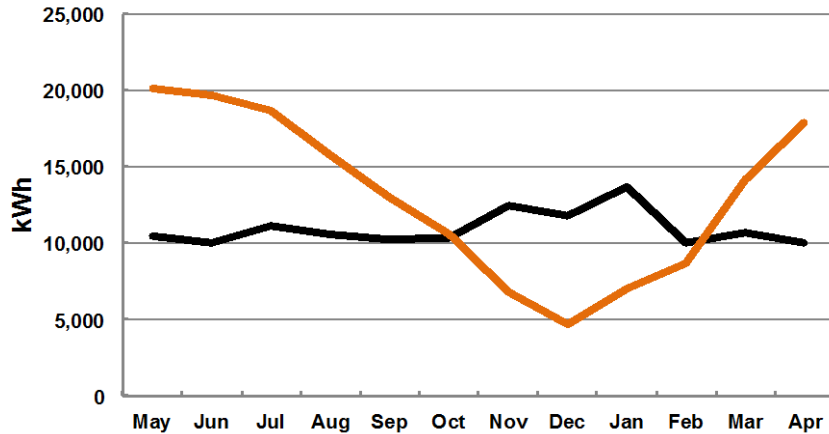


Photo: Ted Van Der Linden



# DPR Construction Office Building May 2014 – April 2015

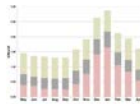
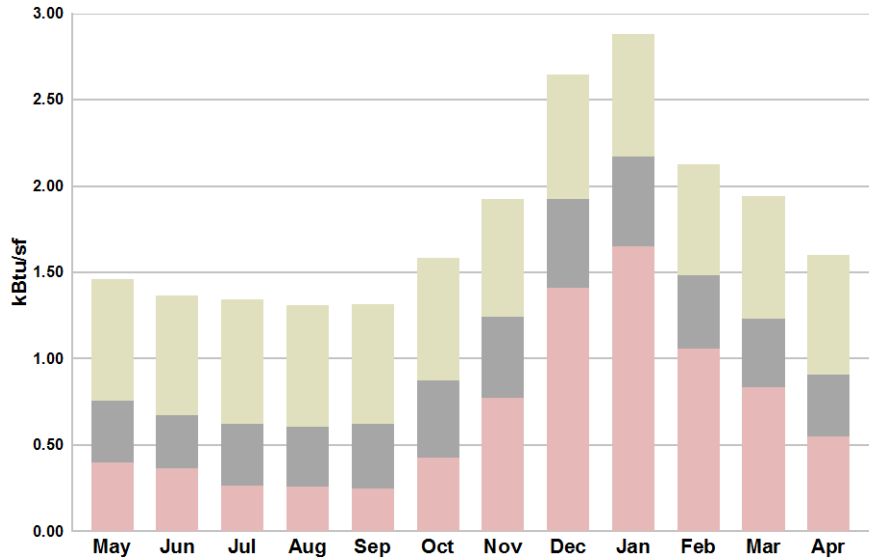
Measured Site Energy	kBtu/sf/yr
Consumption	22.4
Production	26.8





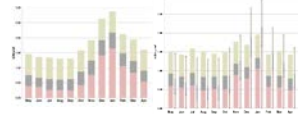
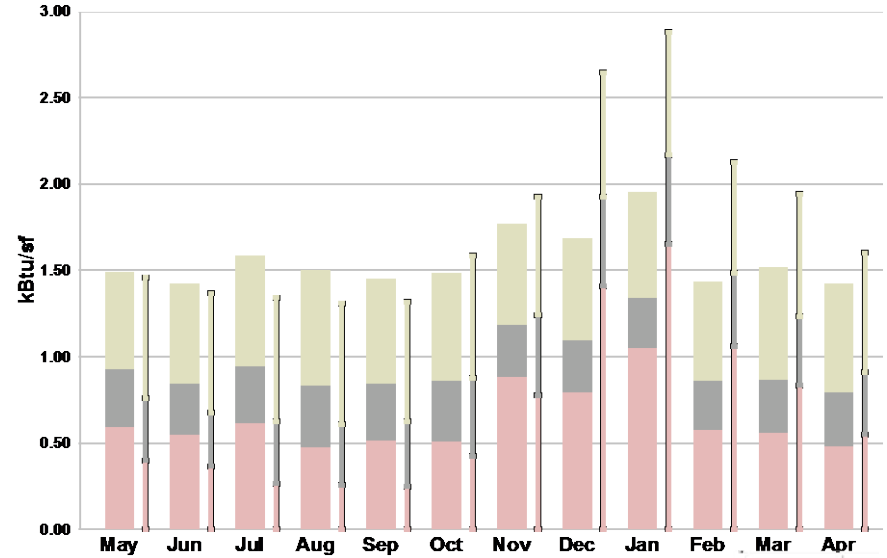
# DPR Construction Office Building May 2014 – April 2015

## Modeled Performance



Modeled EUI: 25.8 kBtu/sf/yr

## Measured Performance



Measured EUI: 22.4 kBtu/sf/yr





# 435 Indio Way Speculative Office Building Sunnyvale, CA



Photo: RMW Architects

Photo: Bruce Damonte



# 435 Indio Way Speculative Office Building Sunnyvale, CA

**Building Type:** Office

**Location:** Sunnyvale, CA

**Gross Floor Area:** 31,759 gsf

**Occupied:** May 2014

**Energy Modeling Software:**  
EnergyPlus 7.2

**Modeled EUI (Site):**  
21.2 kBtu/sf-year

**Measured EUI (Site):**  
13.5 kBtu/sf-year (Oct 2014 —  
Sept 2015)

**On-Site Renewable Energy  
System Installed:**  
113.2 kW (DC) Solar PV

**Measured On-Site Energy  
Production:**  
266,000 kWh/year  
28.6 kBtu/sf-year (Oct 2014 —  
Sept 2015)

**Measured Solar Thermal  
Production:**  
500 kWh/year  
0.1 kBtu/sf-year (May 2014 —  
June 2015)

## **Client/Developer**

Sharp Development Company

## **Owner**

Huettig & Schromm, Inc.

## **Design Team**

*Architect:* RMW Architects, San  
Jose, CA

*Structural Engineer:* SEI (Struc-  
tural Engineers Inc)

*Mechanical/Electrical Engineer:*  
Integral Group, Oakland, CA

*Lighting Design:* Integral Group,  
Oakland, CA

*Master System Integrator:*  
Intertie Automation

## **General Contractor**

Hillhouse Construction Company





# 435 Indio Way Speculative Office Building Sunnyvale, CA

- **Building Envelope:**
  - 5-5/8" Rigid Insulation, roof insulation
  - Double electrochromic glazing
- **Daylighting:**
  - Unique south-facing skylight w/ light-diffusing film
- **Natural Ventilation:**
  - Skylights are automatically opened for night flush
  - Operable perimeter windows, high density spaces on the perimeter.



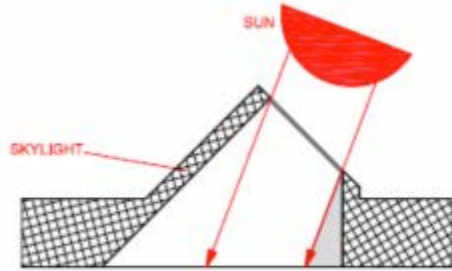
# 435 Indio Way Speculative Office Building Sunnyvale, CA



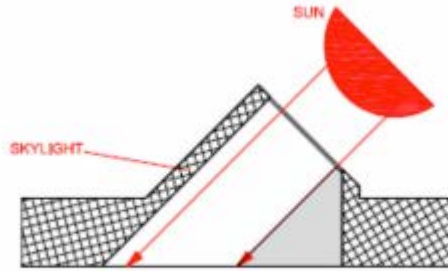
Photo: Bruce Damonte



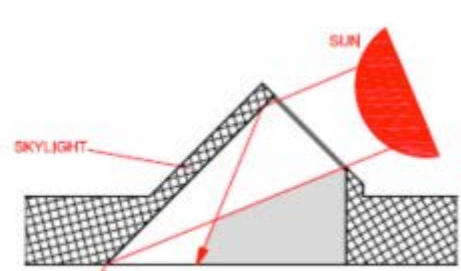
# 435 Indio Way Speculative Office Building Sunnyvale, CA



SEASONAL SUN ANGLE  
DIAGRAM JUNE 21 12 PM



SEASONAL SUN ANGLE  
DIAGRAM SEPT 21 12 PM



SEASONAL SUN ANGLE  
DIAGRAM DEC 21 12 PM

Diagram: Integral Group



Photo: Bruce Damonte



# 435 Indio Way Speculative Office Building Sunnyvale, CA

- **Heating, Ventilating & Cooling:**
  - Air Source heat-pumps as a back-up heating cooling to passive systems.
  - Large ceiling fans
  - Mixed-mode
- **Plug Loads:**
  - User feedback
- **Building Control Systems:**
  - Master System Integrator: part of design-build team, sequence of operations.





# 435 Indio Way Speculative Office Building Sunnyvale, CA

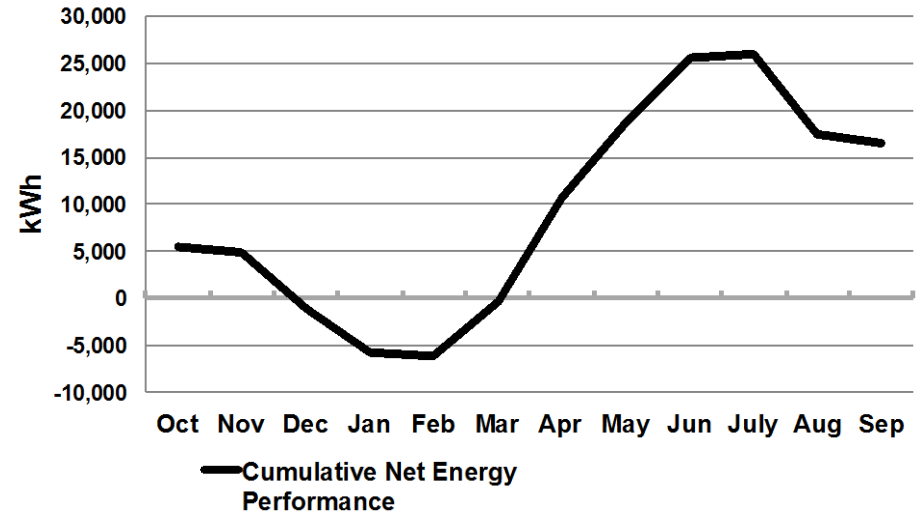
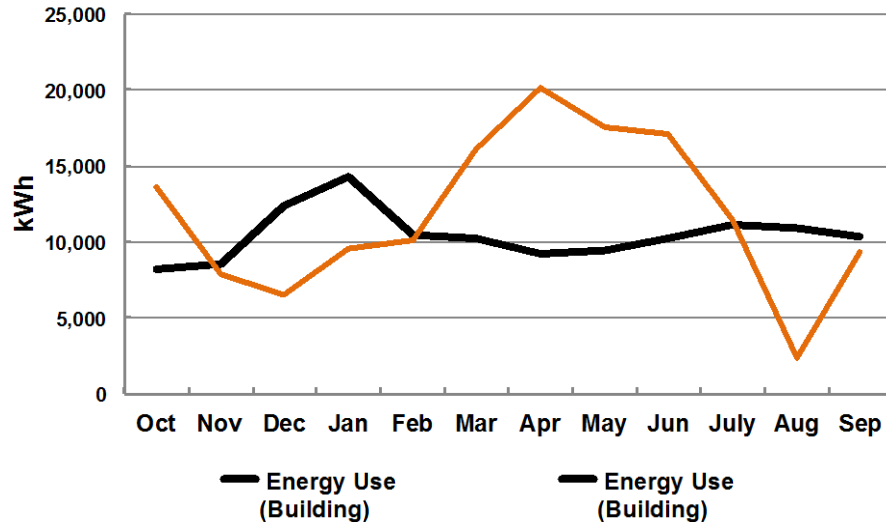


Photo: Bruce Damonte



# 435 Indio Way Speculative Office Building October 2014 – September 2015

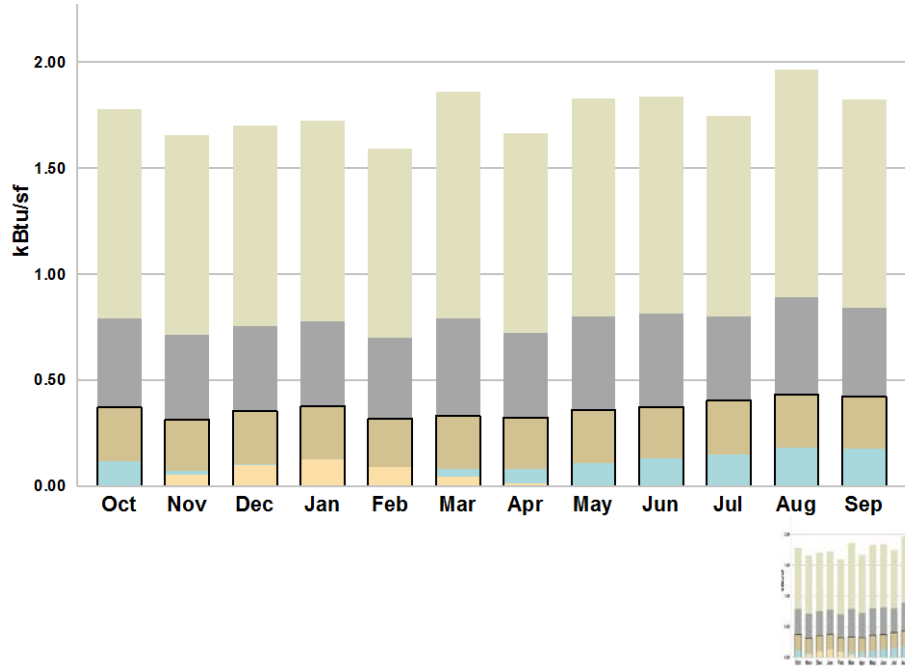
Measured Site Energy	kBtu/sf/yr
Consumption	13.5
Production	15.2





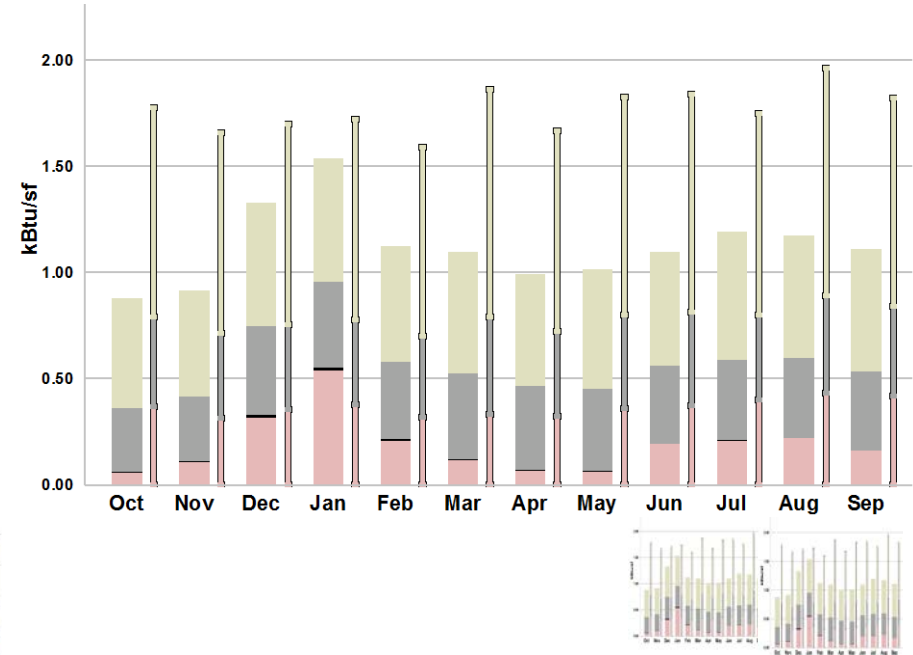
# 435 Indio Way Speculative Office Building October 2014 – September 2015

## Modeled Performance



Modeled EUI: 21.2 kBtu/sf/yr

## Measured Performance



Measured EUI: 13.5 kBtu/sf/yr



# IBEW Joint Apprenticeship and Training Facility San Leandro, CA



Photo: FCGA Architects

Photo: Chad Ziemendorf





# IBEW Joint Apprenticeship and Training Facility San Leandro, CA

**Building Type:** Classroom / Office

**Location:** San Leandro, CA

**Gross Floor Area:** 45,000 gsf

**Occupied:** June 2013

**Energy Modeling Software:**  
eQuest 3.63

**Modeled EUI (Site):**  
18.0 kBtu/sf-year

**Measured EUI (Site):**  
16.3 kBtu/sf-year (July 2014—  
June 2015)

**On-Site Renewable Energy  
System Installed:**

154 kW (DC) Solar PV-flat panel

12 kW (DC) Solar PV-tracking

12 kW (DC) Wind Turbines

**Measured On-Site Energy  
Production:**

267,500 kWh/year

20.3 kBtu/sf-year

**Solar Thermal Production:**  
Not measured.

## **Owner/Client**

IBEW Local 595 / National Electrical Contractors Association—  
Northern California Chapter

## **Design Team**

*Architect:* FCGA Architects,  
Dublin, CA

*Structural Engineer:* Belden  
Inc., Pleasanton, CA

*Mechanical/Electrical/Plumbing  
Engineer:* Belden Inc, Pleasanton,  
CA

*Sustainability Consultant (Energy  
Modeling):* EBS Consultants,  
San Francisco, CA

*Landscape Architect:* Gates &  
Associates, San Ramon, CA

*Master System Integrator:*  
Energy Etc, Union City, CA

## **General Contractor**

Novo Construction Company



# IBEW Joint Apprenticeship and Training Facility San Leandro, CA

- **Building Envelope:**
  - Roof insulation, code level, R-19
- **Daylighting:**
  - Roof monitors, solving solar structural problem
- **Natural Ventilation:**
  - Computational Fluid Dynamics (CFD)
  - “Free cooling” only not for min. fresh air requirements.



# IBEW Joint Apprenticeship and Training Facility San Leandro, CA

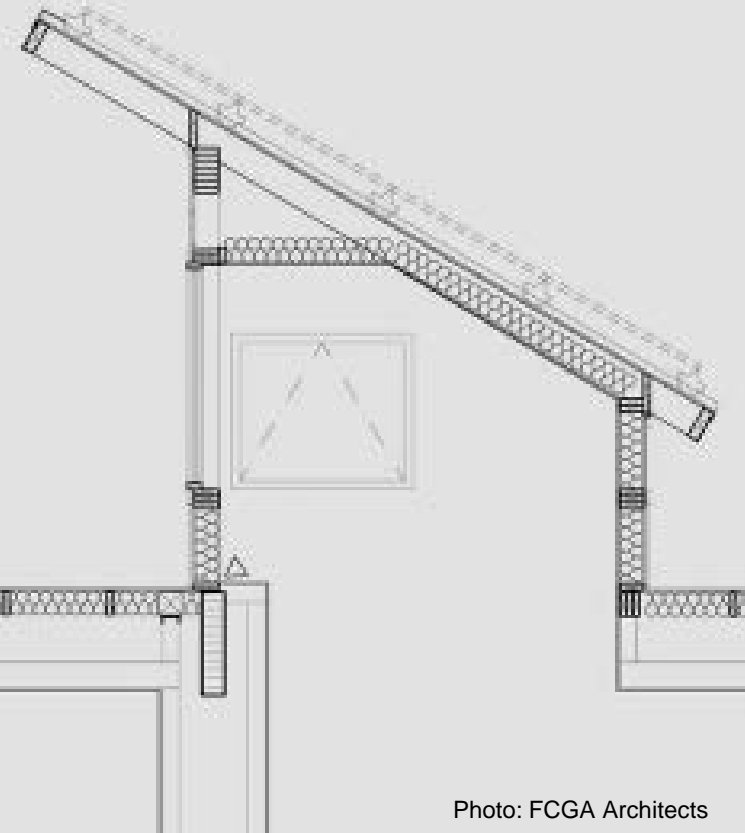


Photo: FCGA Architects



Photo: Chad Ziemendorf



# IBEW Joint Apprenticeship and Training Facility San Leandro, CA

- **Heating, Ventilating & Cooling:**
  - Simultaneous heating & cooling → VRF HVAC
  - Central condensing & local fan coils
  - Fresh air at local fan coils
  - Standalone Solar thermal DHW
- **Plug Loads:**
  - New computers more cost effective than more PV
- **Building Control Systems:**
  - Master System Integrator: sequence of operations, controls Cx, data collection and performance monitoring.



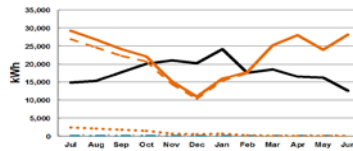
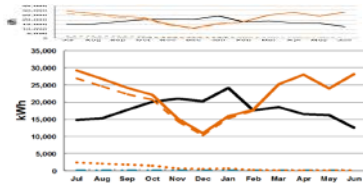
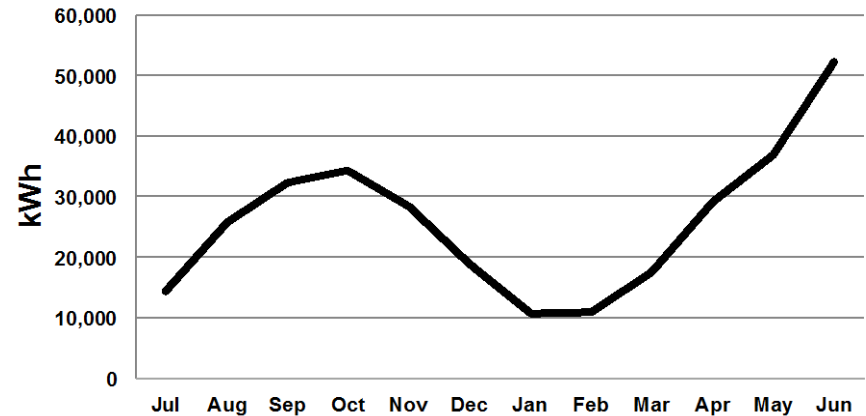
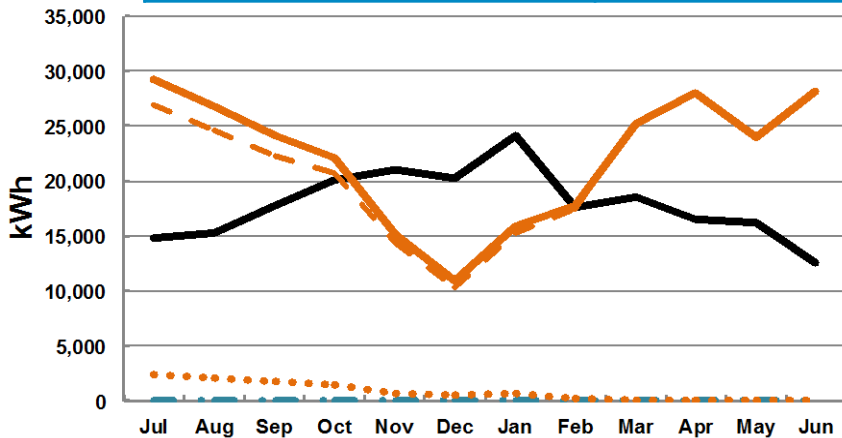
# IBEW Joint Apprenticeship and Training Facility San Leandro, CA





# IBEW-NECA JATC Training Facility July 2014 – June 2015

Measured Site Energy	kBtu/sf/yr
Consumption	16.3
Production	20.3



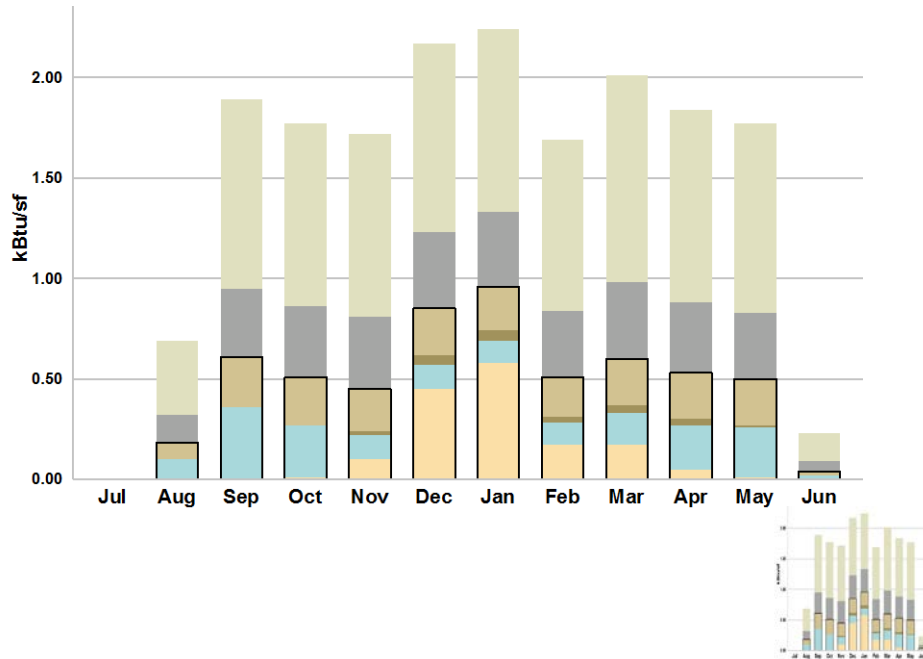
**— Cumulative Net Energy Performance**



# IBEW-NECA JATC Training Facility

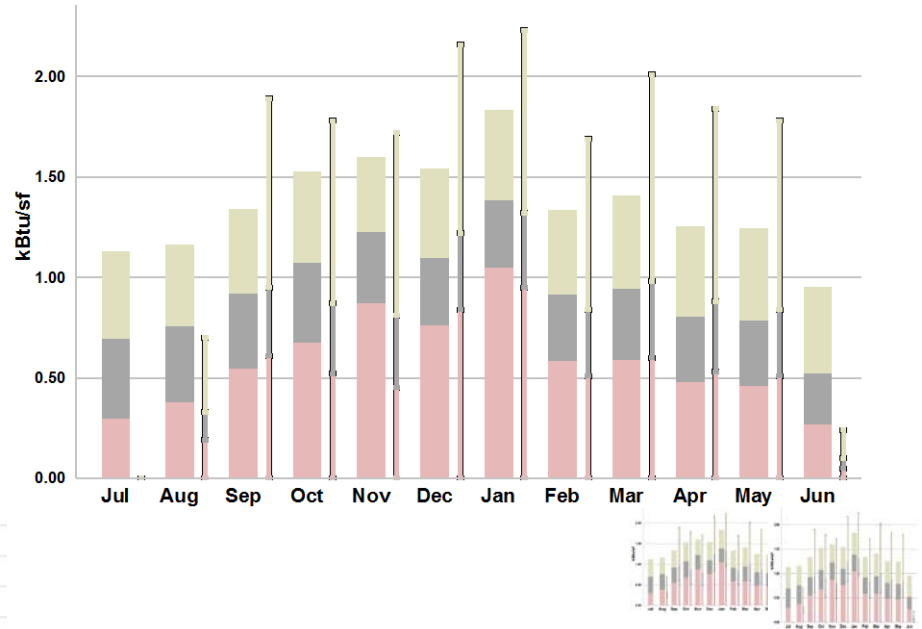
## July 2014 – June 2015

### Modeled Performance



Modeled EUI: 18.0 kBtu/sf/yr

### Measured Performance



Measured EUI: 16.5 kBtu/sf/yr





# Future Opportunities

## Occupant Behavior – West Village in Davis, CA

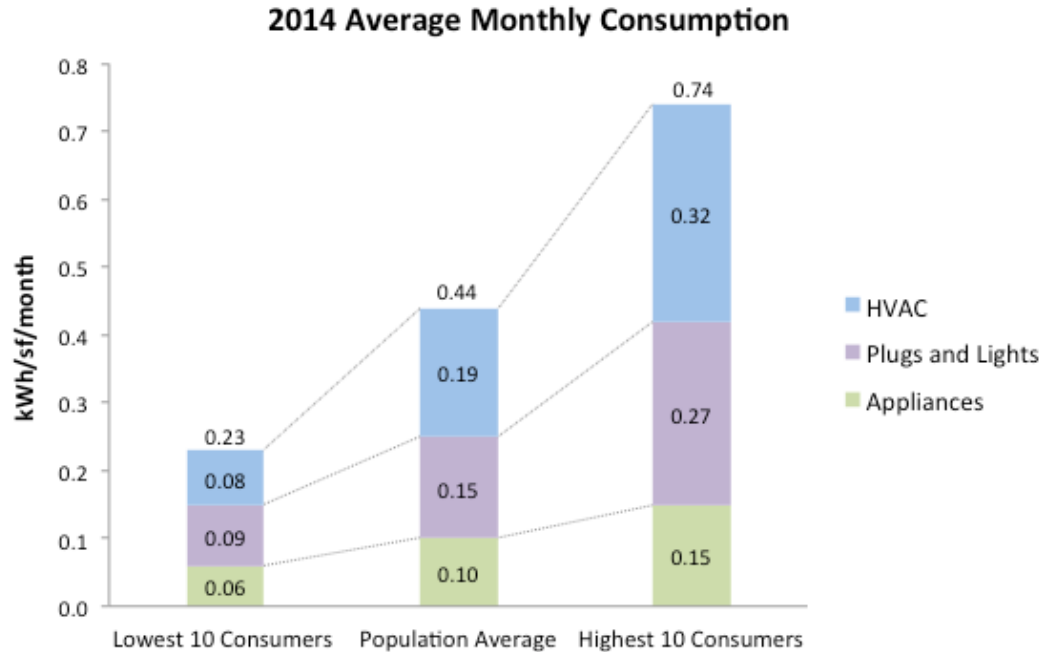


Chart by Resource Refocus





## Also check-out:

**For Design and Operations:**

[www.pge.com/training](http://www.pge.com/training)

**For Design Only:**

[www.energydesignresources.com](http://www.energydesignresources.com)

[www. energycodeace.com/](http://www.energycodeace.com/)

# Thank you

Can “John” Anbarlilar  
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Feel free to find me on LinkedIn

