Zero Net Energy

Here and Now!

A review of progress across multiple markets

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Together, Building
a Better California

Provider Name

American Institute of Architects, San Joaquin Chapter

Course Title

Zero Net Energy Here and Now: Across Many Markets

Speaker Name/s

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AIA
San Joaquin

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Course Description

This presentation details how ZNE is feasible for both residential and non-residential building stocks. It goes over EUI target setting and the relating design process and highlights the importants of continued monitoring post-occupancy. It discusses the role of the utility and the power grid for enabling NZE.

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Learning Objectives

At the end of the this course, participants will be able to:

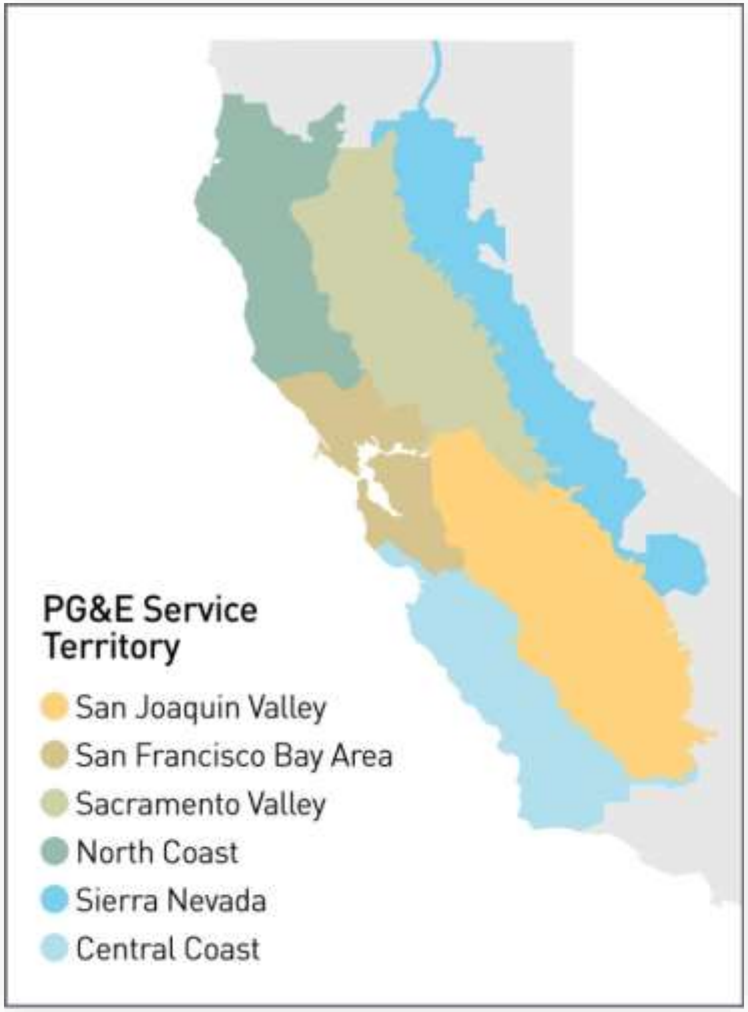
Attendees will walk away with a solid high-level understanding of:

1.Understanding of the basic feasibility of ZNE across both the residential and non-residential building stock.
2.Understadning of EUI tartget-setting and its relation to the design process for ZNE: understanding of the role of monitoring and diagnosis post-occupancy
3.Understanding of the role of the utility and the power grid for enabling ZNE
4.It goes over EUI target setting and the relating design process and highlights the importants of continued monitoring post-occupancy.

Pacific Gas and Electric Company

Our mission:

To safely and reliably deliver clean energy to our customers and communities every single day while building the energy network of tomorrow



PASSIVE THERMAL COMFORT

A Little Review . . . Why "Zero Net Energy"?

AB 32: "The Global Warming Solutions Act" . . . 2006

Chief requirement AB 32—GHG emissions 20% below 1990 levels by 2020

SB 32: An extension and expansion of the AB 32 legislation, 2016

Chief requirement SB 32: GHG emissions 40% below 1990 levels by 2030

Long term goal:

GHG emissions 80% below 1990 levels by 2050

A Little Review . . . Why “Zero Net Energy”?

CPUC Energy Efficiency Strategic Plan, 2008 (updated 2011)

- *All residential new construction shall be ZNE by 2020*
- *All commercial new construction shall by ZNE by 2030*
- *Goals for existing buildings, too*

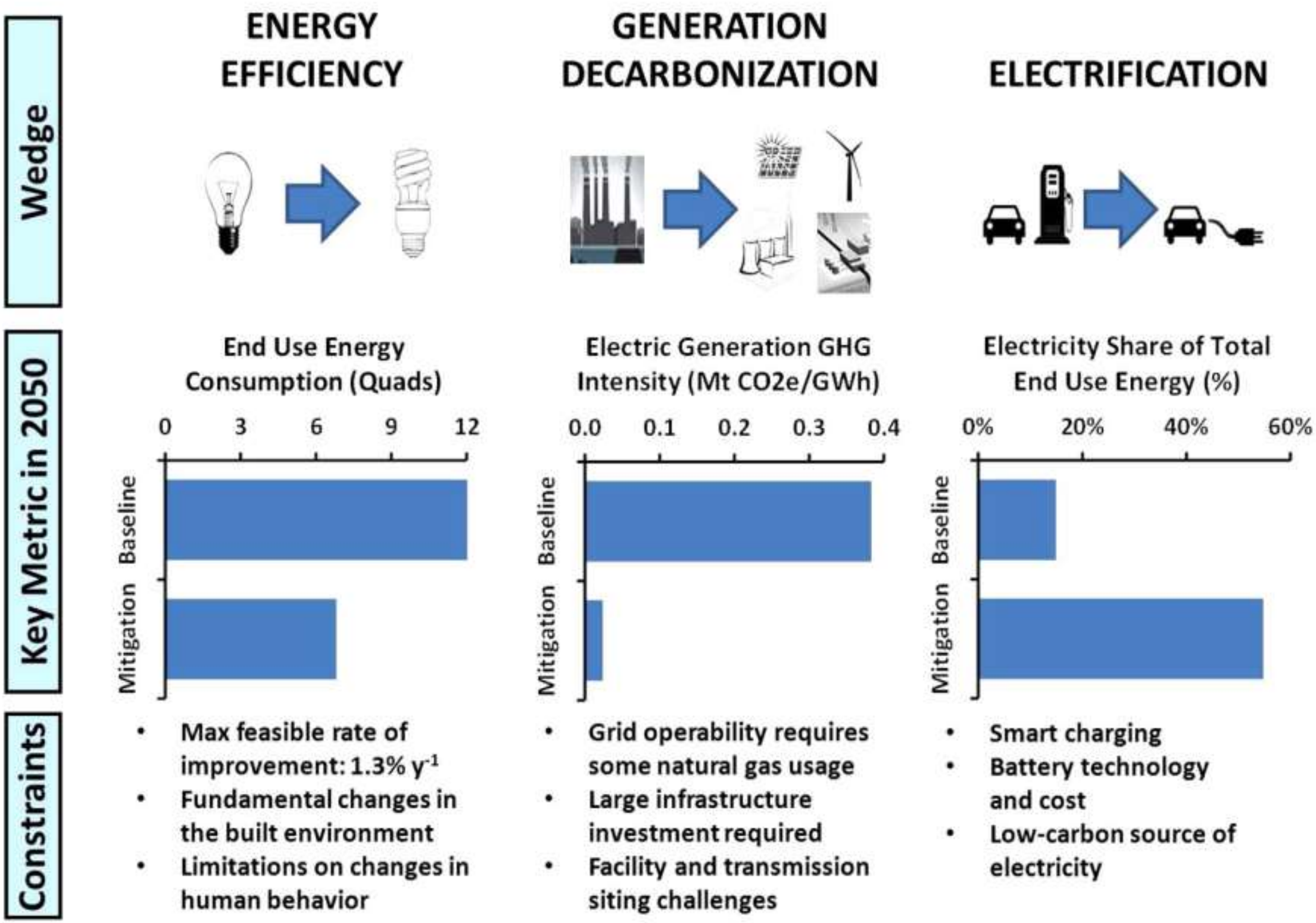
CEC and the IEPR

- *Starting in 2007, the CEC began moving the building standards to achieve ZNE in residential new construction by 2020*
- *2020 code will fall somewhat short of full ZNE; code enhancements will continue in future cycles*

California Air Resources Board

- *Lead agency for implementation*

2012 Science Paper: "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050" (From E3, San Francisco)



What is “Zero Net Energy”?

In concept, a Zero Net Energy building produces as much energy, from renewables, as it consumes over a year. Simple!

However: There are multiple ways of measuring energy and energy performance: Site? Source? TDV?

What the consumer should know: ***Achieving ZNE by any credible definition will yield a great building with low operating costs***

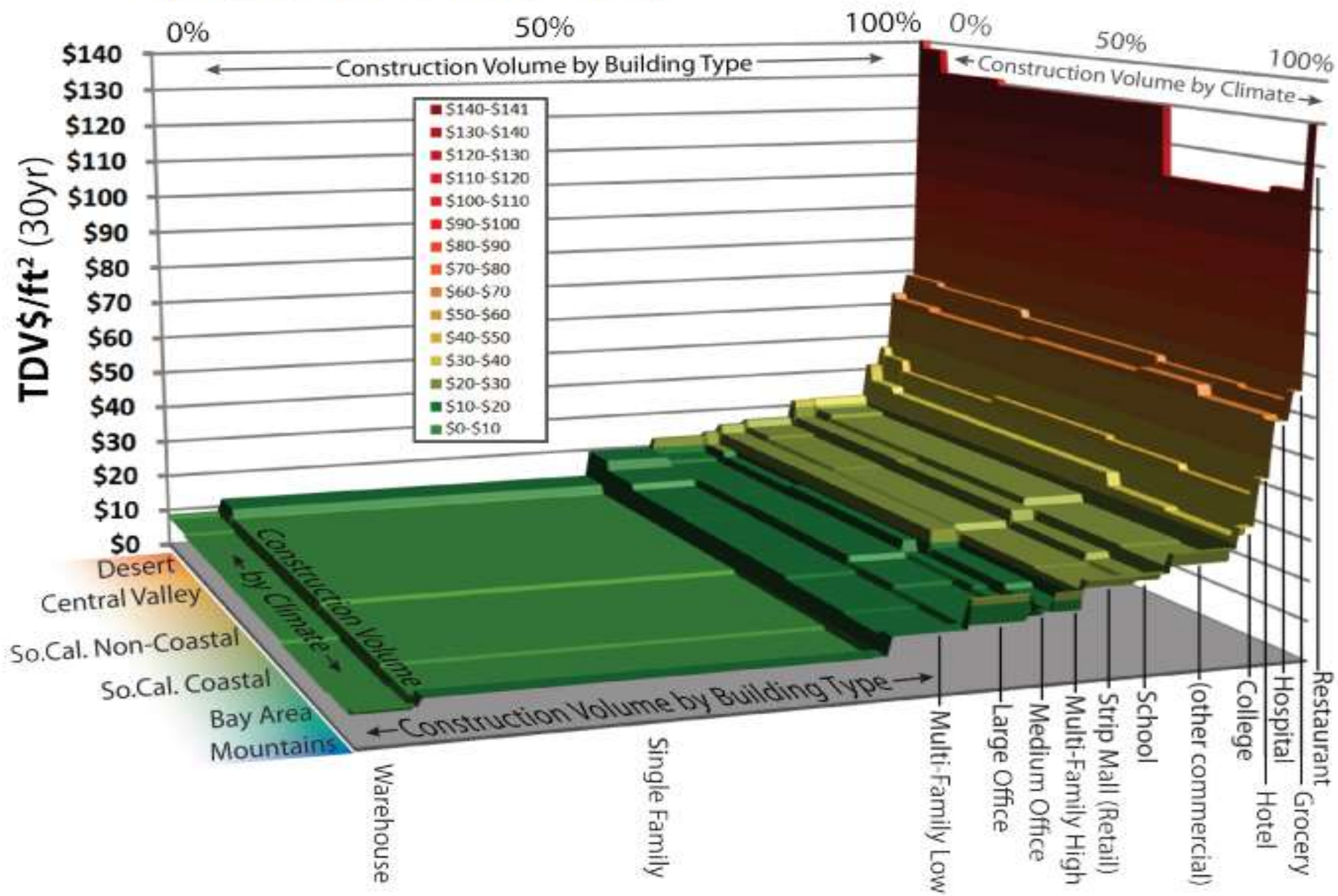
It will mean low energy bills, but not “zero” energy bills

Technical Feasibility in new construction: at this point, a settled issue for years

Technical Feasibility of ZNE in CA

without Solar

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

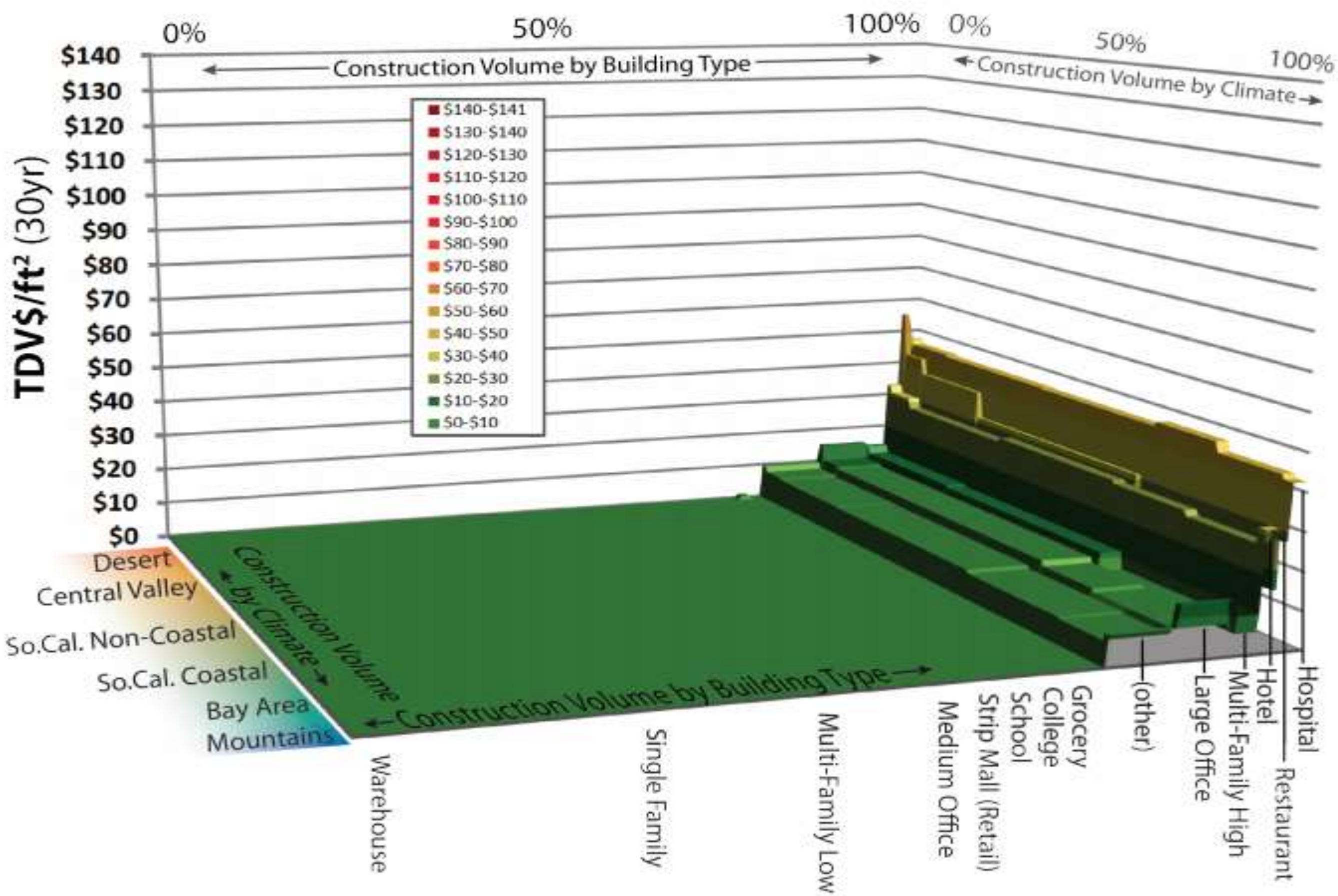


From "The Technical Feasibility of Zero Net Energy Buildings in California" by ARUP
http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

Technical Feasibility of ZNE in CA

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

PG&E Activities

Production Builder Demonstration

Partnership with 7 Production Builders

- Expert technical consulting—"no stone left unturned" analysis of options
- Incremental cost buy-down of EEMs compared to BAU
- Determine how to influence future offerings
- Collect and evaluate monitoring data

Key Question: Can "Zero" be achieved at an acceptable cost?

Blu Homes

- 1,869 sf (~175 m^2)
- 3 Bedrooms

Lessons, H4H San Joaquin

It is possible to build to ZNE at no incremental cost!

- **It's about *tradeoffs* and *design innovation*:**
- **Better framing techniques (framing factor 0.13 instead of 0.25—less wood, labor, waste)**
- **Mechanical systems: located to minimize ducting and piping runs**
- **2 x 6 studs on 24": deeper cavity for more insulation without weakening the structure**
- **HVAC: smaller and more compact due to reduced building loads**

PG&E Activities

Production Builder Demonstration

Partnership with 7 Production Builders

- Covers 25% of California builder market
- Different climate zones & customer profiles
- Occupancy starting March 2016
- Detailed design assistance for energy performance goals

Pulte Home Corporation

- #3 Builder in the Nation
- 2,344 sf (~215 m^2)
- 4 Bedrooms

Summing it Up

Production Builder Demonstration Lessons

To reach zero: set the target at zero, work with a reliable modeler, build according to design

Emphasis: reduce the load, reduce the load, reduce the load. Then add renewables.

Reported incremental costs: Zero to a few thousand dollars (on houses which sell for up to $600K+

The owner gets a better, sturdier home:

- Stronger and more resilient
- Better thermal comfort
- Better indoor air quality

The energy costs will not be zero but will be low

What's Next? Existing Homes

The Challenge of Retrofits

EPIC Program (CEC) . . . Many projects, one very important one involves the retrofit of a 60 unit low-income apartment complex in Fresno to ZNE

Feasibility "At Scale"

ZNE becomes truly feasible at scale when it can be accomplished by way of skilled, routine professional practice in design and construction with little or no incremental cost compared to typical alternatives and considered at the whole building level.

Commercial Examples . . .

Packard Foundation,
Los Altos Hill, CA

A Few Words about "How" ZNE is Done

Process—save half of the energy compared to BAU

- Set the target (to Zero)
- Design to the target
- Build to the design (no "de"-value engineering
- Monitor, diagnose, correct

Reasonable site energy targets: 18 to 30 kBtu/ft2/yr for most typical building stock

A Few Words about "How" ZNE is Done

Technologies

- Building shell insulation and thermal mass
  - Thicker walls (with more and better insulation)
  - Better windows
- Natural ventilation (reduce or eliminate air conditioning)
- Radiant heating and cooling (high mass, don't "blow air")
- Daylighting—up to 75% savings
  - Apertures (skylights, windows, clerestories)
  - Controls (turn off light when available daylight is adequate)
- High efficiency equipment
  - LED lighting
  - High efficiency HVAC
  - High efficiency water heaters
- Control systems that reduce and eliminate waste (plug load controls)

435 Indio Way Speculative Office Building
San Leandro, CA

Photo: RMW Architects

Photo: Bruce Damonte

PASSIVE THERMAL COMFORT

A Few Numbers . . .

Lighting Example

Typical office building lighting load (CEUS):

Approximate lighting load, current code:

Measured lighting loads in ZNE buildings:

A Few Numbers . . .

Lighting Example

Typical office building lighting load (CEUS): ~4 kWh/sf/yr

Approximate lighting load, current code: ~2+ kWh/sf/yr

Measured lighting loads in ZNE buildings: ~1 kWh/sf/yr

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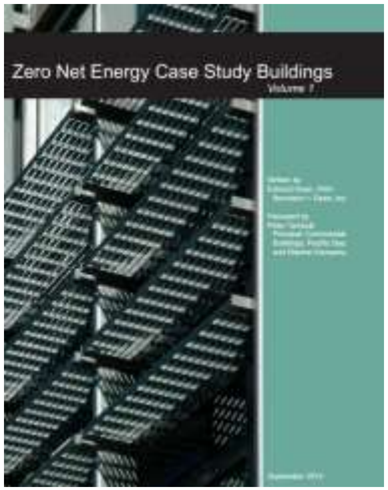
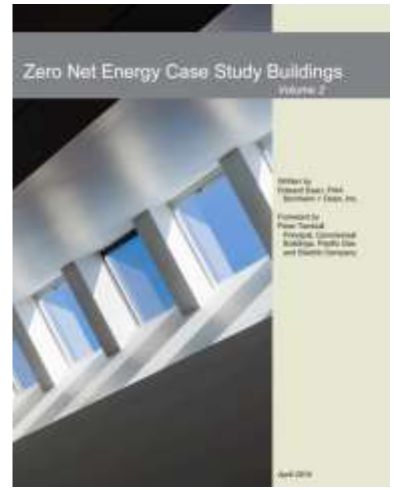
Zero Net Energy Case Study Buildings

Zero Net Energy Case Study Buildings Written 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

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

Schools . . .

Statewide “Adjunct” Program for ZNE in Prop 39

About 12-14 retrofits of public schools statewide

Many “types” and climate zones represented

Typically start with 25-40 kBtu/ft2/yr

Typicially get to 15-22 kBtu/ft2/yr

Training and outreach included in the program

Newcastle, CA

Basic Facts
Newcastle, CA (CZ 12)
1950s construction
31,536 sf

Site EUI (kBtu/sf)
Baseline: 21-25
ZNE Package: 13-16
PV required for Source ZNE: 108 kW (w/ 20% +)

Project Team
School Consultants: ABM
Design: Point Energy with Stok
Monitoring: Davis Energy Group

Schedule

✓	Site visit	9/18/2015
✓	ZNE package	finalized
•	Monitoring	installed 8/18/2016
✓	Construction: Lighting	Summer/Fall 2016
✓	Construction: HVAC	Spring 2017
	Construction: Daylighting and PV	expected summer 2017, due 8/31/2017

Recommended ZNE Package
updated 5/6/16

EEM #	Energy Efficiency Measure (EEM)	Cost	Electricity savings (kWh/yr)	Gas savings (thrm/yr)	kBtu savings /yr	20-yr NPV	SIR	EUI (kBTU/sf)
6	Combined classroom daylighting (no dimmers) and interior/exterior LEDs	$200,195	73,900	-48	252,200	$121,600	1.62	21
10	High efficiency HVAC for gym	$52,200	4,092	11	15,062	$1,687	1.03	28
11	Building Energy Management System (BMS) (savings estimated not modeled)	$129,900	11,500	85	39,100	-$81,400	0.36	27
12	Sealing and Caulking (savings not modeled)	$0	>0	N/A	>0	>0	>0	N/A
13	Replace five EER-8.7 BARD HVAC units with EER-14.5 BARD HVAC units	$73,145	3,100	--	8,817	-$11,231	0.84	28
	TOTALS	$455,440	92,592	48	315,179	$30,656	1.07	18
	Solar PV (108 kW array producing 150,400 kWh/yr; incl. 20% safety factor)	$411,331	147,677	--	503,875	$122,258	1.3	--
P2	Package 2 with Solar PV	$866,771	240,269	--	819,054	$152,914	1.18	--

Oakland, CA

Basic Facts
Oakland, CA (CZ 3)
1977 construction
25,000 sf

Site EUI (kBtu/sf)
Baseline: 29
ZNE Package: 20
PV required for Source ZNE: 88 kW

Project Team
School Consultants: N/A
Design: Point Energy with Stok
Monitoring: Davis Energy Group

Schedule

✓	Site visit	9/16/2015
•	ZNE package	*Package 4 preferred, awaiting bids and Board approval*
•	Monitoring	*draft in progress*
	Construction	EEMs est 2017, PV 2018

Recommended ZNE Package

updated 3/9/17

Energy Efficiency Measure (EEM)	Cost	Electricity savings (kWh/yr)	Gas savings (thrm/yr)	kBtu savings /yr	NPV	SIR	EUI	% site energy reduction
Delamp CR Lighting fixtures and replace lamps with LED Equiv	$112,714	29,615	-198	81,237	$14,347	1.19	25.4	11%
Install ECM motors in Classrooms	$42,750	10,857	9	37,944	$3,319	1.13	27.1	5%
Install ECM motors in unit heaters	$30,828	11,607	53	44,903	$7,508	1.31	26.9	6%
Install smart thermostats	$13,894	0	120	11,950	-$8,732	0.39	28.2	2%
Daylighting in mixed use space	$19,000	6,053	22	22,853	$15,279	1.90	27.7	3%
Replace Bard HVAC units with new high efficiency Bard units	$15,818	2,046	0	6,981	$1,380	1.14	28.4	1%
Daylighting in classrooms	$104,310	12,785	-157	27,922	-$1,963	1.03	27.5	4%
P4 total	**$339,314**	**67,702**	**-141**	**216,932**	**-$6,417**	**1.03**	**20.1**	**30%**
88 kW PV	$461,120	131,499	0	448,693	$44,772	1.10		62%
P4 with 88 kW PV	$800,434	199,201	-141	665,634	$55,321	1.07	20.1	92%

Los Altos, CA

Basic Facts

Los Altos, CA (CZ 3)

Project Team

School Consultants: Gelfand Partners

Design: Integral Group

Monitoring: Cadmus Group

Site EUI (kBtu/sf)

Baseline: 33.3

ZNE Package: 19.7-20.9

PV required for Source ZNE: 110 kW

Schedule

✓	Site visit	10/13/2015
✓	ZNE package	finalized
•	Monitoring	11/21/2016, updates 2/21/2017
	Construction	Winter-Summer 2017

updated 2/13/17

			Site Energy Results				Source Energy Results			
		Site EUI	Peak Demand Savings	Electricity Savings	Natural Gas Savings	Total Energy Savings	Peak Demand Savings	Electricity Savings	Natural Gas Savings	Total Energy Savings
EEM #	ZNE Measure	(kBtu/sf)	(kW)	(kWh/yr)	(therms/yr)	(kBtu/yr)	(kW)	(kWh/yr)	(therms/yr)	(kBtu/yr)
Baseline	Baseline	33.3	$0	0	0	$0	0	0	0	0
Proposed EEMs 1a, 1b, 1c, & 1d	Replace existing package air handler units with new heat pump system, full lighting retrofit, install daylighting controls, replace skylights	20.9	$23	48,400	1,700	$335,100	72	152,500	1,900	710,300
Proposed + EEM 2	Reduce infiltration	20.3	25	52,800	1,700	350,200	79	166,300	1,900	757,400
Proposed + EEM 3	Install ceiling fans for expanded thermal comf	20.1	23	54,300	1,700	355,300	72	171,000	1,900	773,500
Proposed + EEM 4	Install Energy Star classroom and kitchen equi	19.8	26	57,000	1,700	364,500	83	179,600	1,900	802,800
Proposed + EEM 5	Replace facade glazing	20.6	23	50,500	1,700	342,300	73	159,100	1,900	732,800
Proposed + EEM 6	Upgrade to high efficiency heat pumps	19.8	45	56,600	1,700	363,100	142	178,300	1,900	798,400
Proposed + EEM 7	Implement natural ventilation strategies	20.3	23	53,100	1,700	351,200	73	167,300	1,900	760,800
Proposed + EEM 8	Implement night purge strategies	19.7	22	57,500	1,700	366,200	71	181,100	1,900	807,900

Richardsville Elementary (Kentucky)

- Owner – Warren County Schools
- Building Occupied – 2010
- 72,285 sf, 500 students
- Total Construction Cost - $14,927,000
- Total Cost/sf - $206.50
- Solar PV Size – 348 kW
- Energy Consumption – 18 kBtu/sf yr

cmta

NET ZERO ENGINEERING

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Thank you!

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This concludes The American Institute ofArchitects
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