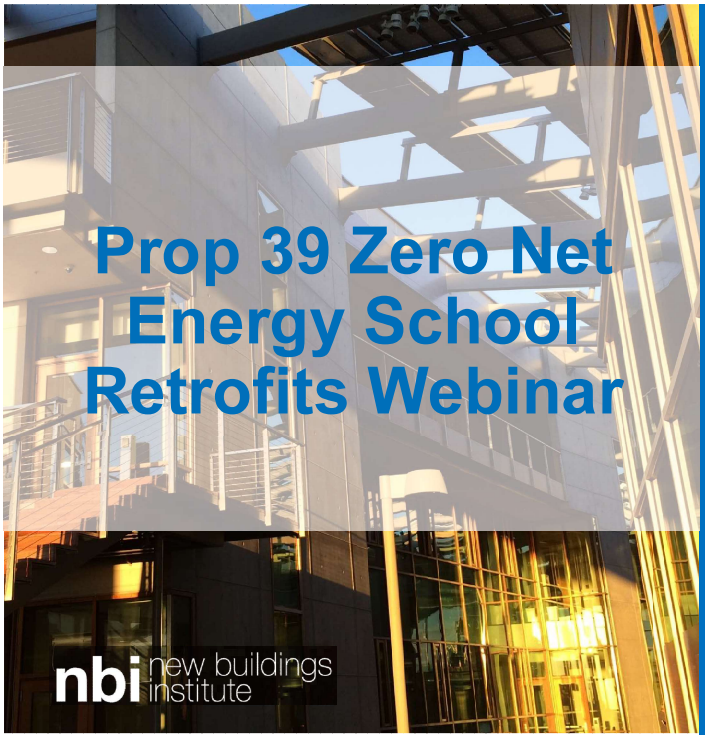

Prop 39 ZNE School Retrofit
Pilot Case Studies
May 31, 2018

New Buildings Institute
Reilly Loveland, Project Analyst

Prop 39 ZNE School Retrofit Pilot Program Workshops

The Prop 39 ZNE Pilot Program s funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, and Southern California Gas Company under the auspices of the California Public Utilities Commission. The California investor-owned utilities are not responsible for the preparation of this presentation, nor do any of them make any representation concerning the quality, accuracy or suitability of the information set forth herein. As the author of this presentation, the New Building Institute is solely responsible for this presentation and its contents.

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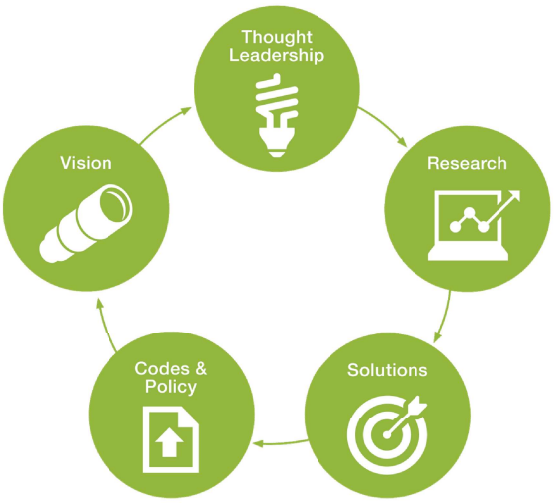
NBI is a national nonprofit working to improve buildings for people and the environment.

Program Areas:

1. *Best practices in new and existing buildings*
2. *Continuous code and policy innovation*
3. *Zero energy leadership and market development*



Learning Objectives

1. Understand how key zero net energy (ZNE) buildings concepts and strategies are implemented through successful case studies of a pilot projects.
2. Learn the benefits of ZNE retrofits beyond energy cost savings and how to communicate the importance of ZNE retrofits beyond cost effectiveness.
3. Learn how ZNE retrofits should be planned and optimized across the whole school district and how to anticipate and overcome the invariable challenges and hurdles in the path of a ZNE retrofit.
4. Learn how ZNE school retrofits and new construction should be coordinated into an integrated design process to optimize building performance, student/teacher performance, and lifecycle cost.

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Introduction to Zero Net Energy

What is a Zero Net Energy Building?

ZNE Source Definition:

A building that produces at least as much energy as it uses in a year when grid-supplied energy (including primary energy for generation, transmission and delivery to the site) is taken into account

Sbrega Health & Science Building | Fall River, MA
Photo Courtesy of Edward Caruso

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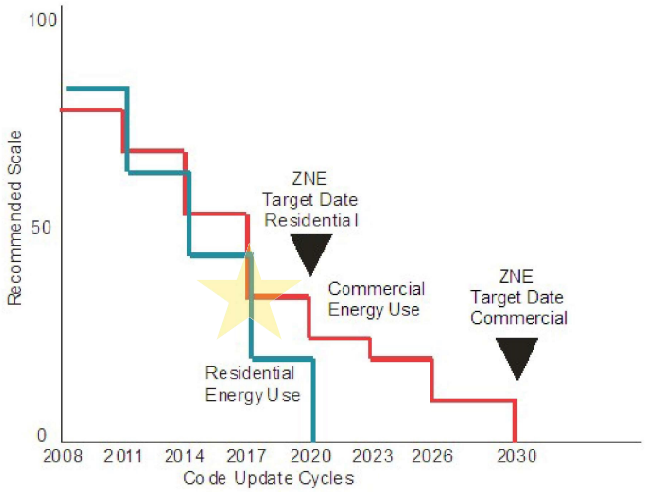
Code Cycles to Net Zero in California



Source: SCE & AEC, 2009

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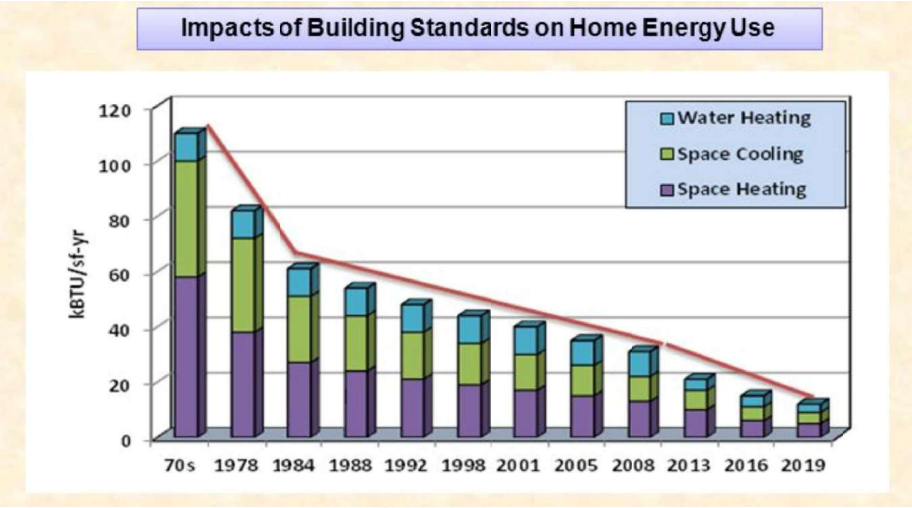
Code Cycles to Net Zero in California



Source: CEC 2016

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Why Zero Net Energy Schools?

- The next evolution in sustainable, high performance buildings
- Cost avoidance from utility bills to classroom
- Create comfortable and productive environment for teachers and students
- Provide hands-on, tangible learning opportunities for 21st century skills
- Make schools and communities stronger, resilient and energy independent

Hood River School District Science Building | Hood River, OR
Photo Courtesy of Opsis Architecture

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Benefits of High Performance Schools

- Occupants in ventilated spaces with low CO2 and low volatile organic compounds (VOCs) had improved scores in crisis response, information usage, and strategy ranging from 100 to 300%.[1]
- Students in daylit environments showed a 20-26% improvement on test scores compared to traditionally lit environments[2].
- Students with operable windows progressed 7-8% faster than those without operable windows[2].
- Students with the most daylighting performed 7-18% better in math and reading than those without[2].
- Students exposed to daylight attended school 3.2 to 3.810 more days per year[3]

Discovery Elementary School | Arlington, VA
Photo Courtesy of VMDO Architects

1. Bako-Biró, Zs., Kochhar, N., Clements-Croome, D.J., Awbi, H.B. & Williams, M. (2007, January). Ventilation Rates in Schools and Learning Performance. https://www.researchgate.net/publication
2. Heshong Mahone Group. (1999, August 20). Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance. http://h-m-g.com/downloads/Daylighting/schools.pdf
3. Healthy Schools Network, Inc. (2012) Daylighting. http://www.healthyschools.org/downloads/Daylighting.pdf

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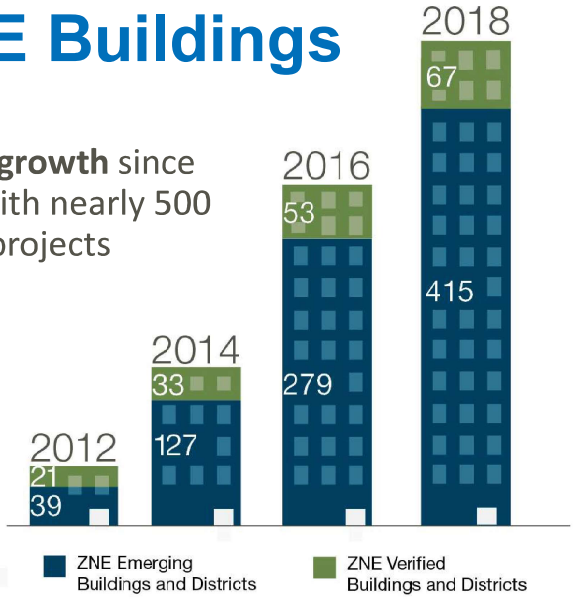
2018 List of ZNE Buildings

700% growth since 2012 with nearly 500 projects



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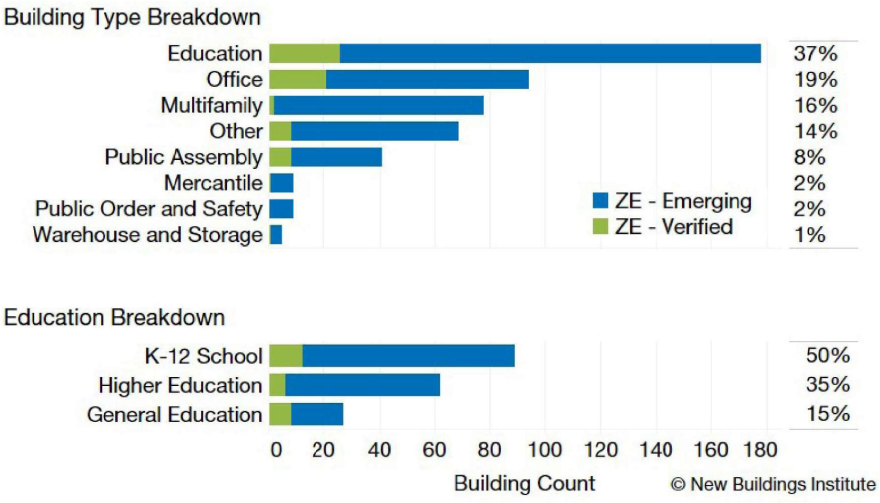
Schools are Leading in ZNE



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ZNE and Ultra-Low Energy in Education

K-12 Schools

Community Colleges

Higher Education

Libraries

Science Centers

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Path to Zero Net Energy Schools:

Redding School for the Arts | Redding, CA
Photo Courtesy: TRILOGY Architecture

While ZE is a realistic end game, the path to sustainable, zero energy schools is a process that will take time to accomplish.

School districts can start now with benchmarking, energy targets, policies, plans and practices on the path to zero.

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Steps to Success in Sustainable Design

Kathleen Grimm School, PS 62 | New York, NY
Photo Courtesy: James Ewing

- Get Stakeholder Support
- Make a Commitment
- Use an Integrated Design Process
- Set Energy Targets
- Design and Construct To The Target
- Optimize Operations
- Measure and Verify

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Prop 39 ZNE Pilot Overview

Prop 39 Public Schools ZNE Pilot, IOUs

Core Idea: Create an "adjunct" pilot to Prop 39 focused on ZNE

- **Demonstrate the technical feasibility of ZNE retrofits** in public K-14 schools statewide
  - Implement 12-14 total ZNE retrofit projects statewide
  - Use expert technical consultants to develop projects
  - Choose geographically, demographically diverse schools to work with

- **Provide training, recognition and communication**: Disseminate lessons learned regarding the technical design process and the implementation process broadly throughout the state
  - Technical and Institutional Training
  - Recognition Events
  - Publications

Prop 39 ZNE Pilot Main Components

Main components:

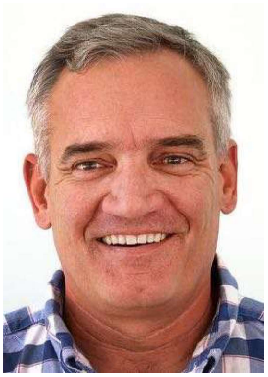
1. ***Design Development.***
2. ***Construction and Construction Inspections.***
3. ***Equipment and System "Buy Down."***
4. ***Ongoing Performance Monitoring.***

Status Update of IOU Pilot

- **Training:** We have teamed up with the New Buildings Institute to deliver many training sessions statewide, both technical and institutional, with more to come
- **School Projects**: About 12 ZNE retrofit projects are underway throughout the state; these will complete mainly in 2018
- **Energy Performance Targets:** We find that a site energy target of about 20 kBtu/square foot/year is commonly feasible for many schools; savings in the range of 30-40% is a typical savings range
- **Common Measures**: We find many similarities in the measures identified for implementation across many schools
- **Bulk Procurement Opportunity**: There appear to be opportunities for statewide or regional "bulk procurement" of common measures (tubular skylights, heat pumps)

Meet our Presenters!

Alexis Karolides
Sustainability Practice Leader | Point Energy Innovations
Newcastle Elementary School Retrofit



Dave Houghton
Owner | Avila Partners
Los Osos Middle School Retrofit

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David Houghton PE

May 31, 2018

Los Osos Middle School ZNE Project

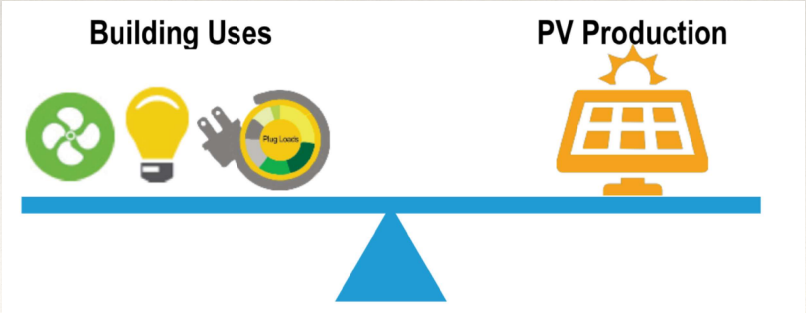
nbi new buildings institute
celebrating 20 YEARS

avila partners

ecos™ research

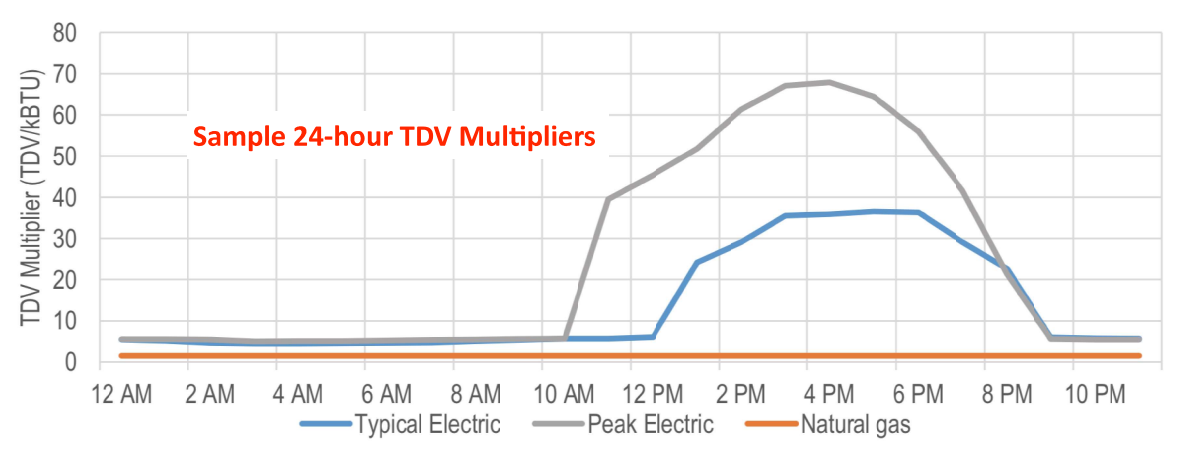
ZNE Concepts

- Energy efficiency first
- Target: Energy Use Intensity (EUI) **20–30 kBtu/ft2-y**
- Solar PV to offset annual energy
- Gas use can be handled by over-producing electricity
- California uses Time-Dependent Valuation (TDV)



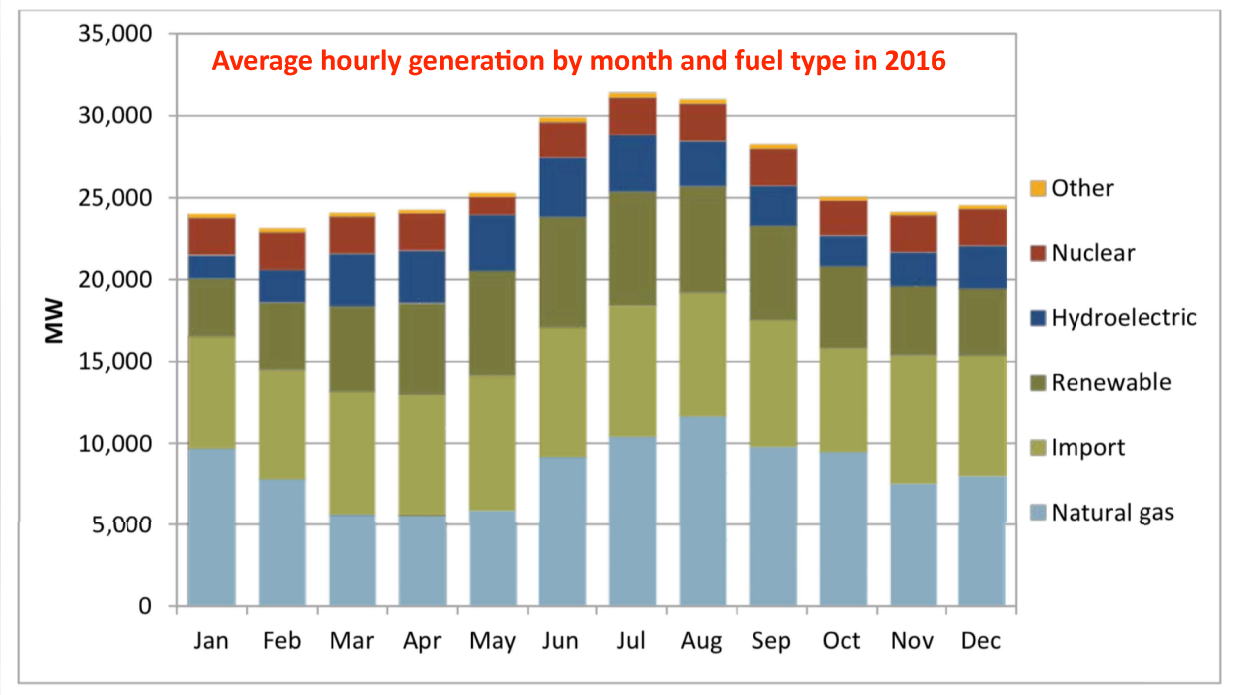
Time-Dependent Valuation

- Not all kWh are created equal!
- TDV stands in for *source energy* (vs site energy)



Source: Integral LOMS Energy Modeling Report

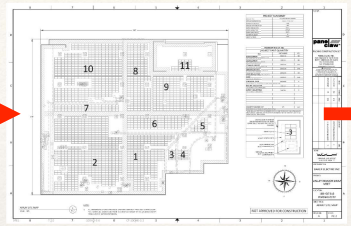
CA Electricity Mix



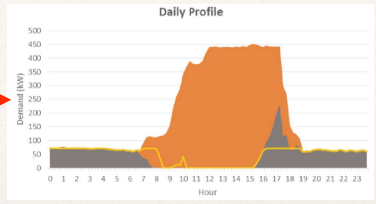
Source: CAISO Annual Report 2016

Solar roof above vs energy use below

335W PV Panel
18.0 W/ft2 (DC)



Deployed on roof
6.3 W/ft2 (DC)



Annual energy
10.4 kWh/ft2-y

Annual "EPI"
35.6 kBtu/ft2-y

Pre-retrofit
50 kBtu/ft2-y

Post-retrofit
30 kBtu/ft2-y

✓

Taller Buildings—
Lower EUI and/or
PV over parking, etc.

Energy Use Intensity Averages

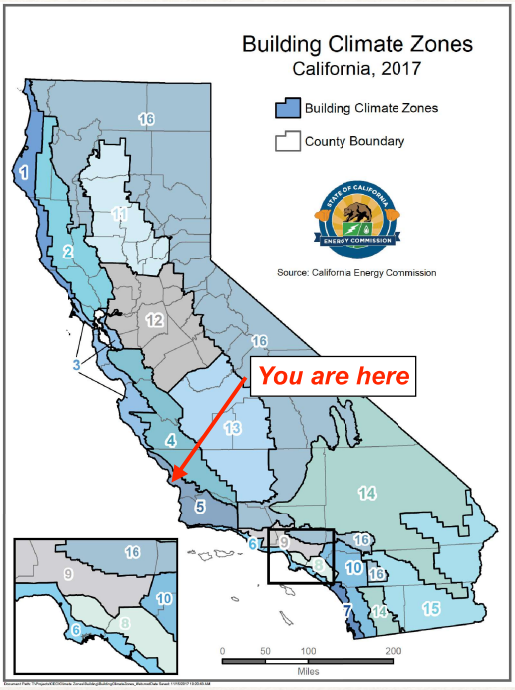
K-12 School	58
College/University	131
Convenience Store	193
Fast Food Rest	384
Hospital	197
Hotel	73
Senior Care	126
Office	67
Retail-Strip Mall	94
Warehouse—non-refr	20
Warehouse—refr	126

All Values in kBtu/ft2-y

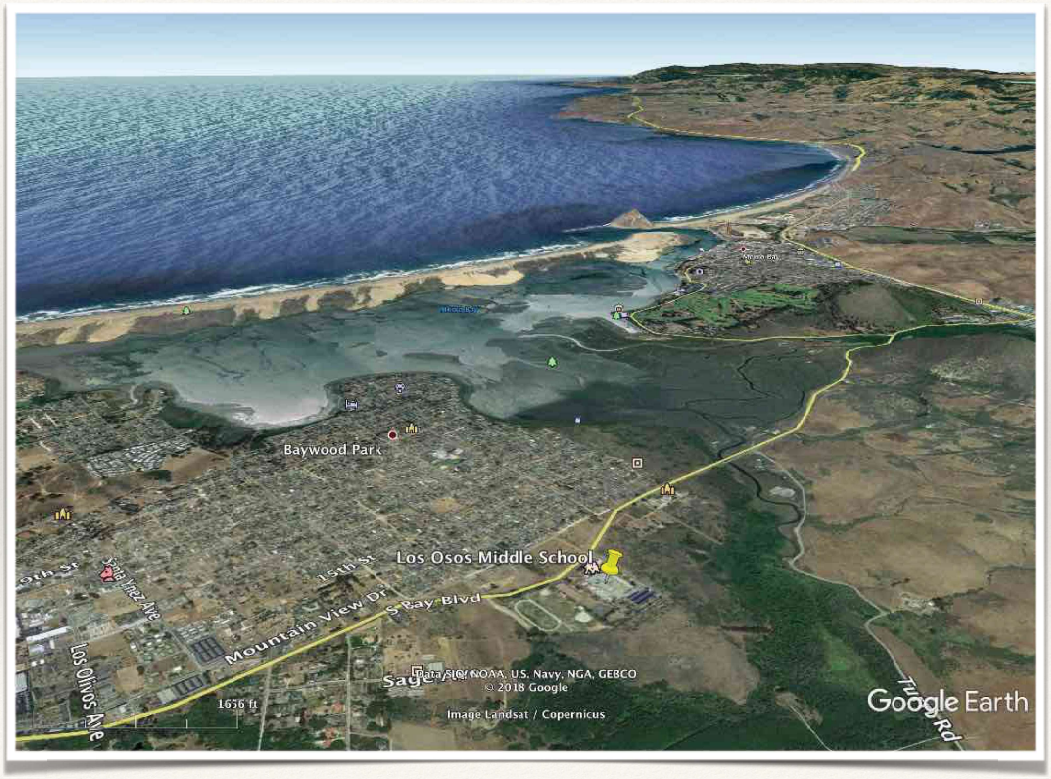
Source: US DOE Commercial Building Energy Consumption Survey (CBECS) 2016

California Climate & HVAC Trends

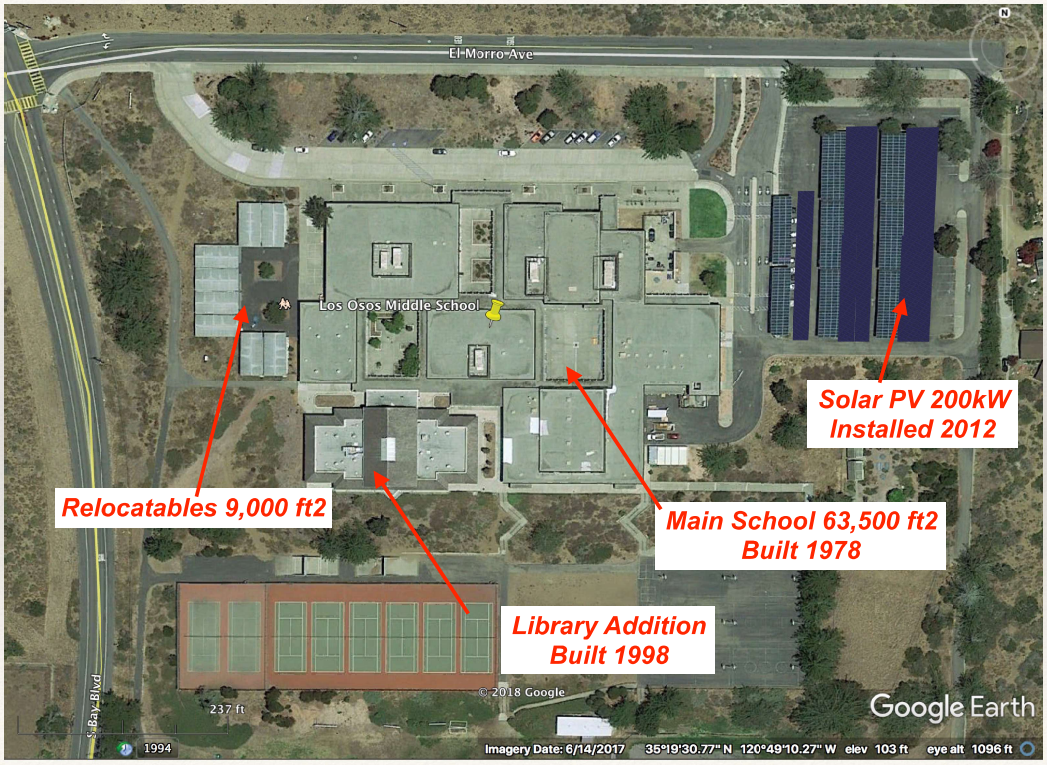
- Our climate is very mild (Zone 5)
- Yet, more cooling is being installed
- Yet, runtime is relatively low
- More refrigerant-based systems (VRF, VRV)
- Heat pumps for heating, cooling, and water heating
- Passive strategies work great in coastal climate zones



Los Osos Middle School

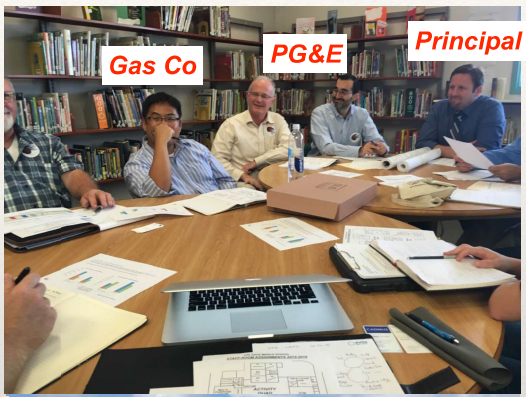


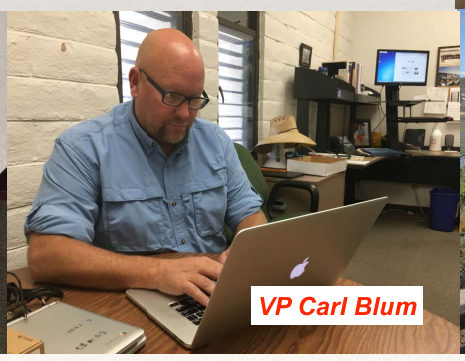
LOMS Overview



Design, Modeling, Meetings

- Two on-site meetings, several phone meetings
- Consultants: utility co, modeling, Measurement & Verification (M&V)
- School District: Principal, VP, electricians, maintenance staff





LOMS ZNE Recipe

- Reduce EUI from 35 kBtu/ft2-y to 27 kBtu/ft2-y
- Existing 200KW Solar PV offsets remaining energy use (on a TDV Basis)
- Proposition 39 funded soft costs, capital buy-down

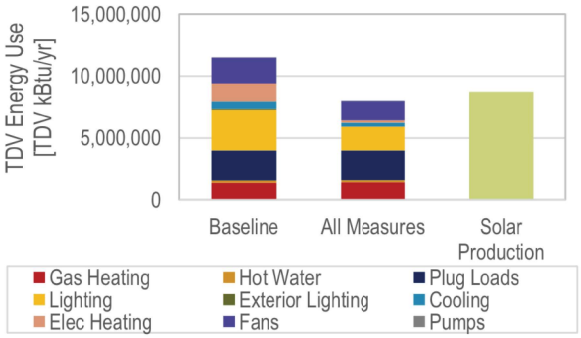


Figure 2. TDV Energy

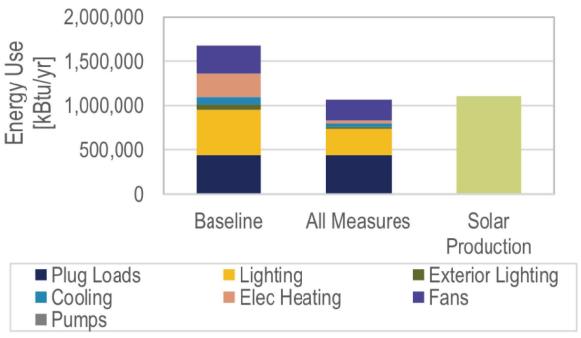
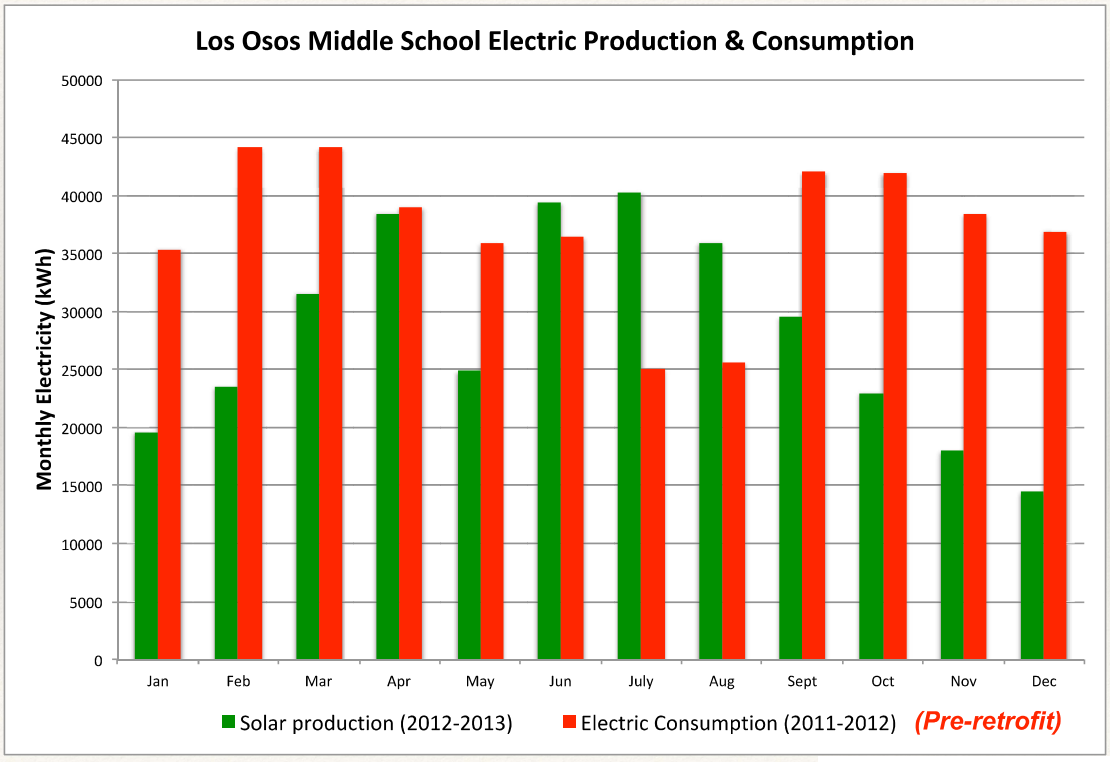


Figure 3. Site Electricity

Source: Integral LOMS Energy Modeling Report

LOMS Electricity



Source: SLCUSD Billing Data

LOMS Baseline Energy Use

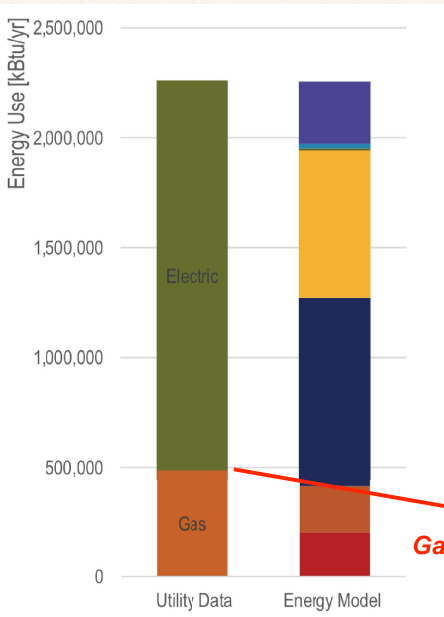


Figure 1. Site Energy

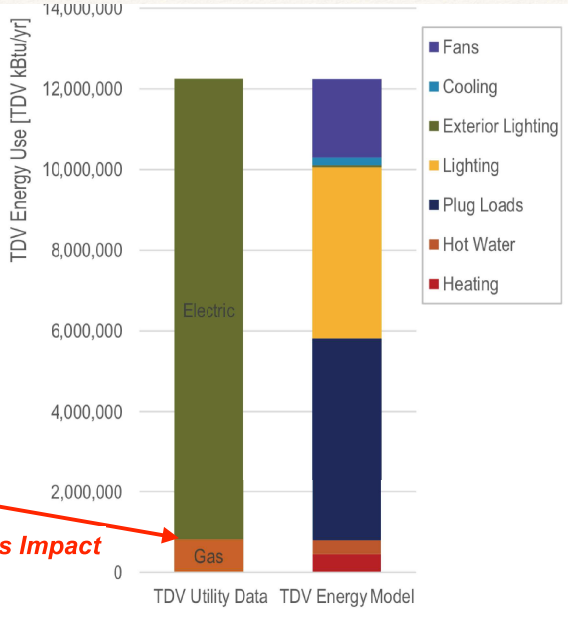


Figure 2. TDV Energy

One result of using a TDV energy metric is that the gas energy savings is less impactful than electric energy savings. Notice how the natural gas use makes up 21% of the Site Energy use, but only 6.6 % of the TDV Energy Use.

Source: Integral LOMS Energy Modeling Report

Energy Efficiency Measures

- Indoor Lighting
- Outdoor Lighting
- New Relo Heat Pumps
- Condensing water heaters
- Asstd controls

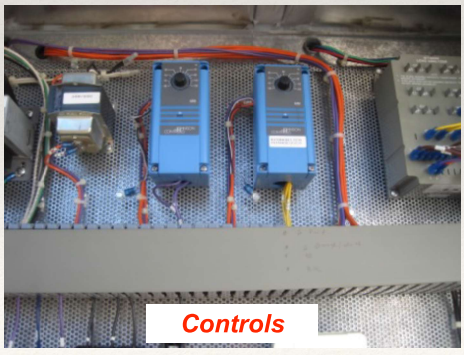
Measures *not* selected

- Envelope upgrades (insulation, glazing, etc.)
  payback way too long—mild climate
- AHU retrofits
  existing units in great shape
- Daylighting
  requires roof penetration, heavy construction, downtime
- DDC controls
  District developing standards for controls
- Plug load improvements/controls
  Prop 39 won't buy computers, copiers, etc.
- Kitchen equipment upgrades
  Low runtime, costly upgrades, long payback

Rooftop HVAC Units

- Custom units in great shape
- Economizers, heating, no a/c
- Low efficiency, but better-built than most new equipment
- Decision: Keep 'em!


RTUs


Controls


OA dampers

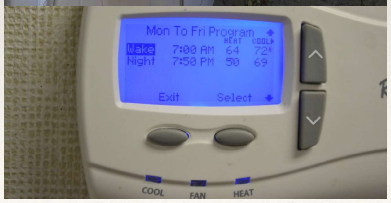

Zone dampers

Furnaces

- Residential-scale units
- Non-condensing (low effcy)
- Mix of vintages
- Low runtime = long payback
- Decision: Keep ‘em!

Relocatable Heat Pumps

- 2 of 8 units already retrofitted
- Higher-effcy units available, decent payback
- Decision: Upgrade!



Water Heating

- Low-efficiency NG tank-style water heaters (6)
- Large (1M+Btu/h) low-effcy boiler for locker room showers
- Decision: Upgrade!

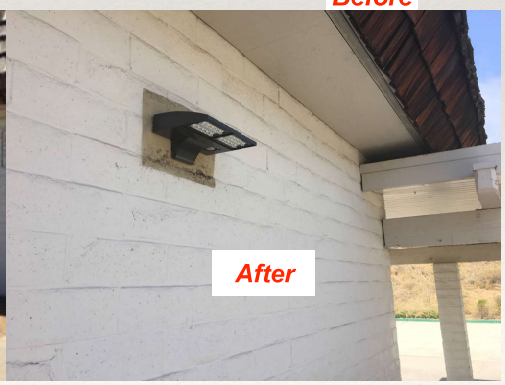
Lighting—Classroom Fluorescents

- Biggest single category of retrofit
- All new LED fixtures with wireless zoning/dimming
- Lighting power density reduced from 1.05 to ≈0.40 W/ft2

Lighting—Outdoor

- Mix of metal halide & sodium lamps
- All retrofitted to LED
- Built-in photocells & occupancy sensors
- Saves energy, but not demand

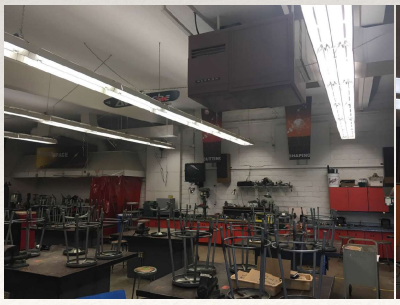
Before



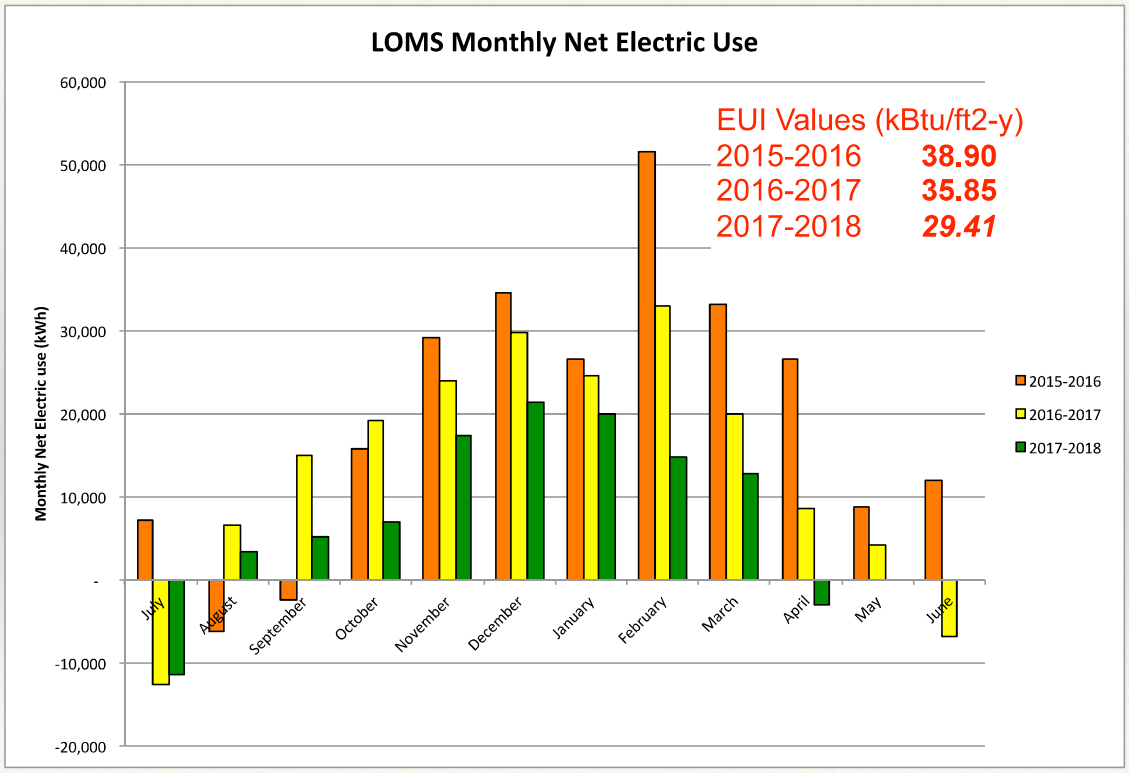
After

Odds & Ends

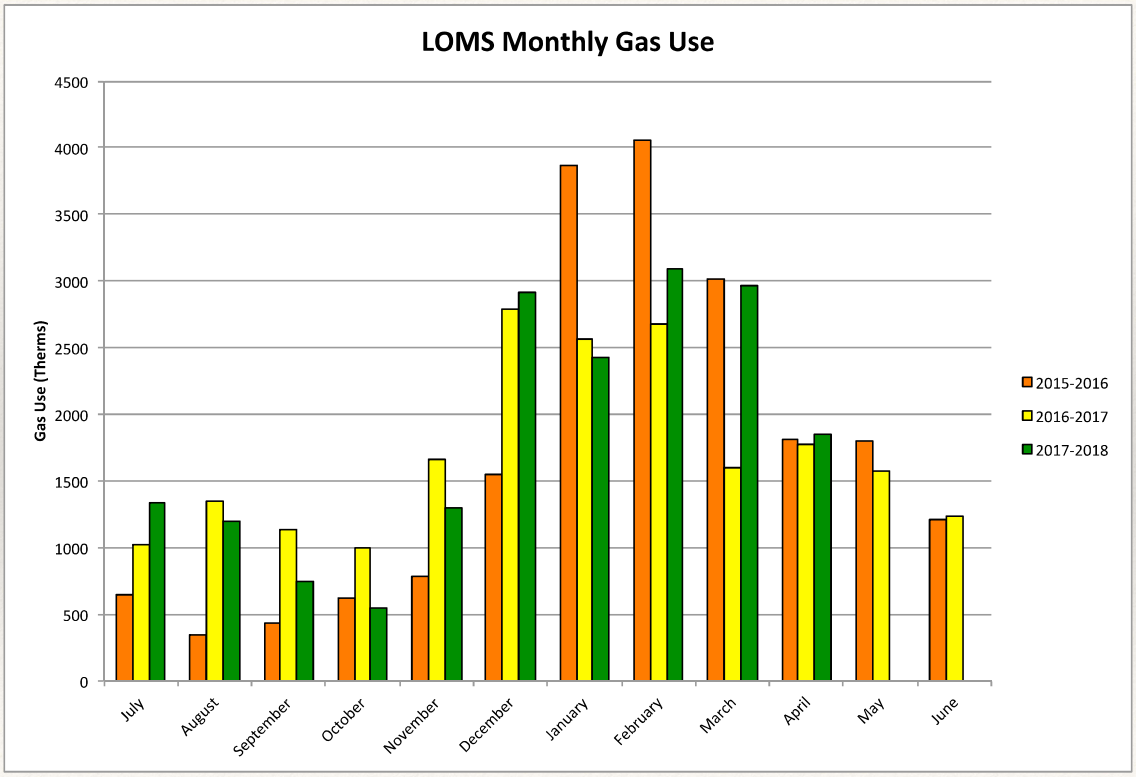
- Commercial Kitchen—most equipment not used
  Decision: Leave it
- Server room—split system a/c
  Decision: turn up T-stat
- Special light fixtures: shops, MPR
  Decision: custom retrofits



Updated Electric Use



Updated Gas Use



LOMS ZNE Project Credits

- California Energy Commission Proposition 39 (The Clean Energy Jobs Act)
- Pacific Gas & Electric Company—Electric Utility
- The Gas Company—Gas Utility
- Integral Group—Lead consultant/energy modeling
- Cadmus Group—Measurement & Verification
- Thoma Electric—Lighting retrofits
- All Systems Heating & Air—HVAC retrofits
- Avila Partners—Owner's Rep

Dave Houghton • 970-209-1216 • dave@avilapartners.com

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Zero Net Energy School Pilot

Process, Outcomes & Lessons Learned from the Newcastle Case Study

Presented by Alexis Karolides, AIA May 31, 2018

POINTENERGY INNOVATIONS

Zero Energy: a path to a better school

Process

District plan

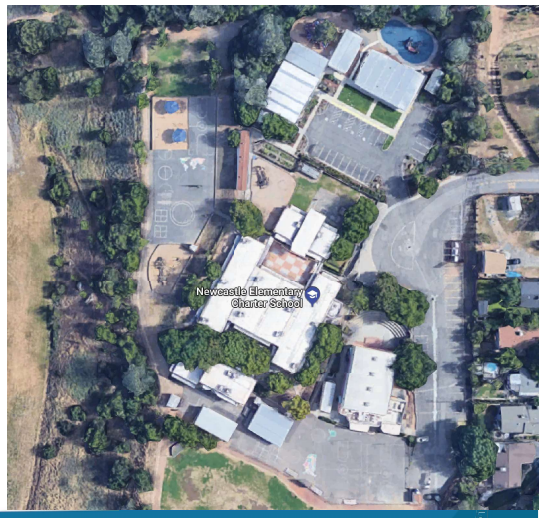
School evaluation for ZNE

Analysis & design

Implementation & monitoring

Prioritize ZNE sites across the whole district

- Need for better comfort, daylight, etc.
- Savings potential
- Alignment with scheduled replacements & renovations (equipment, roofs)
- Schools with a *practical* ability to site PV
- Funding



Evaluate the school

- Goals, funding & implementation strategy
- On site PV siting & capacity
- Base case model; EUI needed for ZNE
- Improvements & maintenance planned or needed
- Preferences: active or passive; maintenance team needs
- Local requirements: local labor? Inspector or code requirements?

Evaluate efficiency opportunities

- Daylighting / lighting - undoing the 1970's
- Building envelope
- HVAC replacement schedule
- Portables - condition of lighting & Bard units
- BMS / Occupancy sensors? Are lights/HVAC left on?

Design in the right order

- ***People*** *first, then*
- ***Reduce*** loads
- Optimize ***design***
- Optimize ***equipment***
  (target deferred maintenance)
- *Then* add ***PV*** for ZNE

Design

(for people)

Daylight benefits people

Daylight* can provide the light level & color spectrum that benefits our circadian rhythm, avoids “blue light hazard,” and avoids social jet lag, which is associated with poor school performance, obesity, & ADHD

--Robert Soler, Chief Science and Technology Officer, Bios

*Note: Melanopic light can also be provided by *daylight-tuned* electric LED’s

Design ***glare-free*** daylighting (that won't be covered up)

Students in daylit schools progress 20-25% faster on test scores (Heshong Mahone, PG&E Daylighting Study 2002)

Restore daylight

Avoid glare

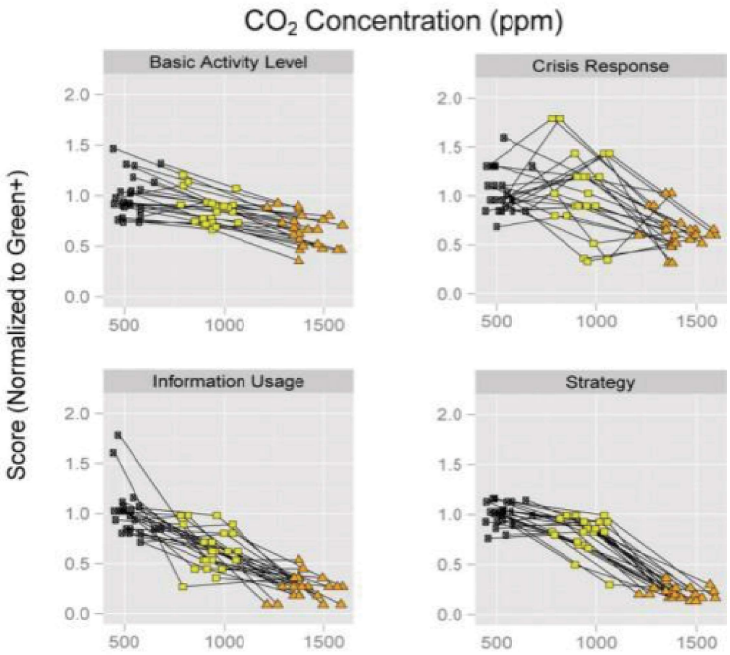
Without covering up the windows!

Avoid drowsiness with ventilation!

High CO2 levels reduce cognitive function up to 300%

CO2-controlled "LEED level" ventilation can improve both energy efficiency and air quality

--Allen et al (2015), Harvard Study



Design ***quiet*** ventilation

(that will be run)

"The HVAC [standard Bard unit] is so loud, I heat the classroom before school starts, but then I just leave it off when I'm teaching."

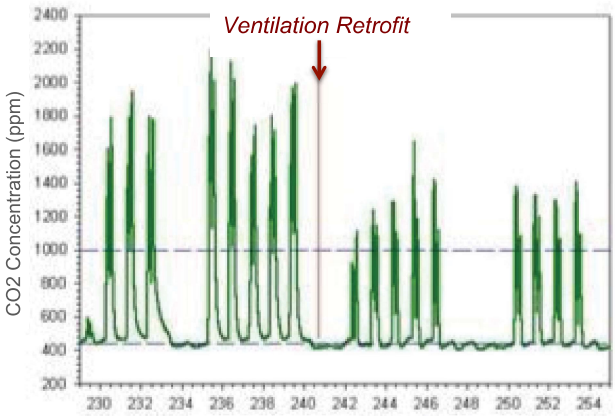
--OUSD teacher, 2016

HVAC provides 15 cfm/person required by law, only when heating, cooling, or manually running fans. Teachers struggling to teach over noisy HVAC sometimes preferred to suffer in a hot, cold, stuffy room.

--LBNL Study, 2002

HVAC should be optimally efficient (*and quiet)*, ideally with energy recovery

CO2 Level before & after new HVAC w/ERV



--Florida Portable Classroom Study (1999)

Technologies in PG&E ZNE Retrofits






Address “temporary” classrooms

Inefficient, noisy units have quiet efficient versions

Add affordable skylighting

Many schools are one- or two- story

Replace interior lamps & exterior fixtures with LEDs

Ideally use ***daylight tuned*** LEDs

Replacing interior fixtures is more costly than replacing lamps only, and triggers T24 controls upgrades

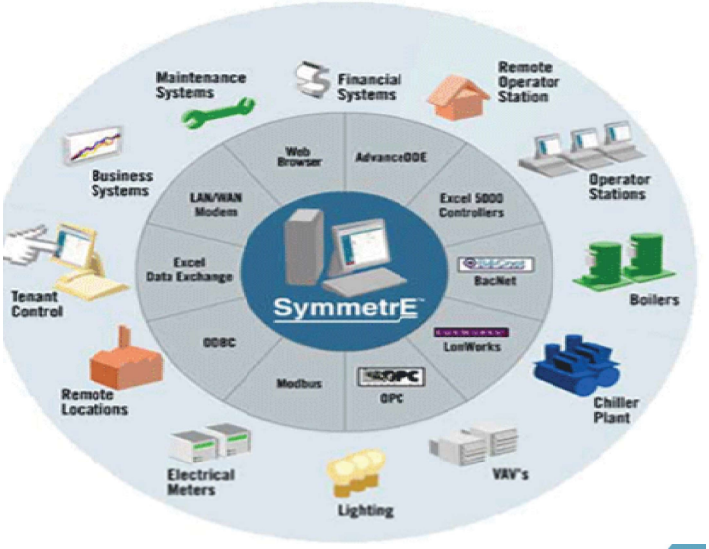
Identify deferred maintenance & ***upgrade*** HVAC

Equipment replacement may not meet SIR unless unit is at the end of its useful life anyway

More efficient HVAC may be heavier – may need custom tall aluminum air handlers to meet weight limits

BMS

Helps maintenance staff find malfunctioning HVAC, and HVAC that is left on!



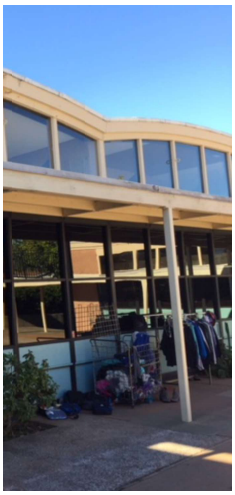
Other people's money, your carbon-free energy!

Many finance methods such as PACE, ESCO, 3rd party PPA, or finance-to-own

Target practical PV locations

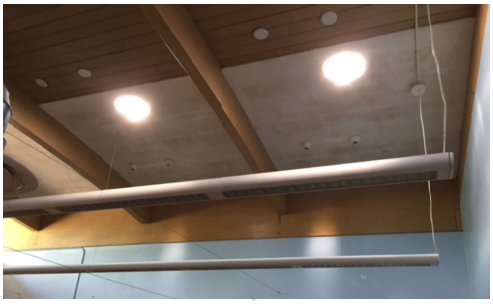
- Rooftop PV requires 20-yr roof warranty; maybe structural review
- Target schools with new roofs for adding PV
- Canopy PV *may* be cheaper

Outcome: Newcastle Elementary: 32% energy savings



What could possibly go wrong?

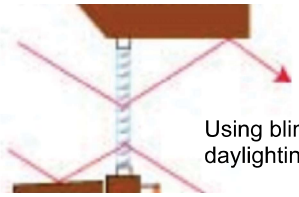
- Complicated state approvals (got time?)
- Asbestos? Lead? Conflicting retrofit?
- Local contractor shortage, high prevailing wages?
- Efficient rooftop HVAC unit is too heavy?
- Oops – they don't like the look of Solatubes, and they're
  - Too costly
  - Too bright for presentations but can't shut-off
  - Can't afford electric light dimming--lights have to be on/off so Solatubes have to provide 100% light
  - In asbestos
  - In tighter beam spacing than expected
  - Conflicting with another retrofit



Engage occupants

- Test non-dimmable Solatubes and lights
- Monitor end use - add visual display!
- Use CO2 sensors; adequately ventilate
- Use of blinds to redirect, not block out daylight
- Visuals for planning
- Manual & training for staff
- Teaching opportunities for students!

Ecobee Smart Thermostat has logging capability for temperature and setpoint settings



Using blinds for daylighting

Lessons Learned (Planning)

- Plan across the whole district
- Ensure *practicality* of onsite solar array (or, why not offsite . . . ?)
- Troubleshoot ahead (school staff interview checklist; backup plans)
- Use imagery, site visits & conference calls with other schools (for Solatube installations, etc.)
- It's not the standard audit, ZNE pushes the envelope!

Lessons Learned (Design)

- ZNE retrofits can uncover dramatic unmetered inefficiency
- Plan needed for 30% “portable” classrooms (need IAQ, acoustics daylight, efficiency; yet meet DSA)
- Many retrofits can’t compete based on SIR
  - SIR of replacing light fixtures (and triggering T24) can’t compete with re-lamping
  - Many IEQ retrofits (quieter Bards, daylight) may not compete on SIR alone
  - High efficiency HVAC may not meet SIR unless due for replacement anyway
  - Heavier (more efficient) HVAC units trigger structural review (try customizing)
  - Heat pumps can cost-effectively replace aging boilers (except CEC favors gas over electric)
- Overworked maintenance staff favor time- and energy saving of BMS
- User training is essential to reap the *energy* benefit of daylighting

Thank You

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ZNE Resources

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2018 Proposition 39 ZNE School Trainings

Workshops

Delivering The Winning Pitch: Making the Business Case for ZNE Schools
June 26, 9 AM-12 PM
East Bay AIA, Oakland, CA

Inefficiency is Old School: A Technical Deep Dive Into ZNE School Retrofits
October 30, 1-5 PM
Pasadena, CA

Webinars

Dreaming the Future: How Zero Net Energy Design Can Transform the School Environment
June 13, 11 AM-12 PM

More webinars coming soon! Check back at: https://newbuildings.org/proposition-39-trainings/

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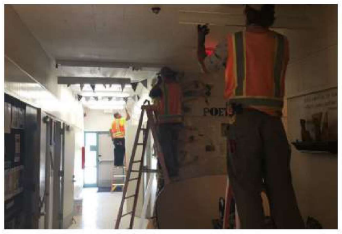
NBI Prop 39 Retrofit Case Studies



COMMERCIAL

BUILDING TYPE: K-12 SCHOOL

LOS OSOS MIDDLE SCHOOL

LOS OSOS, CA

VIEW CASE STUDY

COMMERCIAL

BUILDING TYPE: K-12 SCHOOL

NEWCASTLE ELEMENTARY SCHOOL

NEWCASTLE, CA

VIEW CASE STUDY

COMMERCIAL

BUILDING TYPE: K-12 SCHOOL

GARDEN GROVE UNIFIED SCHOOL DISTRICT

GARDEN GROVE, CA

VIEW CASE STUDY

https://gettingtozeroforum.org/schools/

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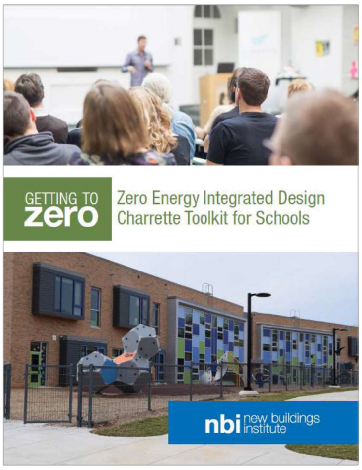
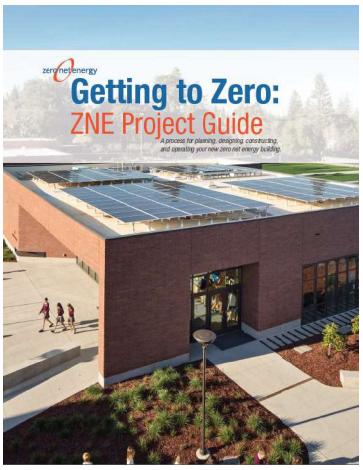
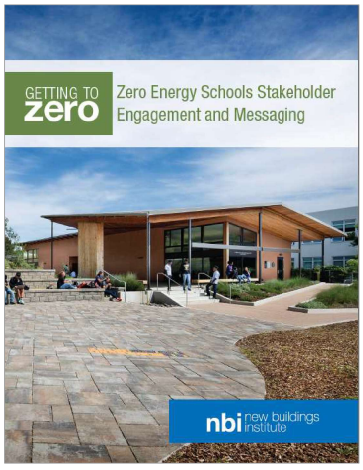
Tools for Zero Energy Schools







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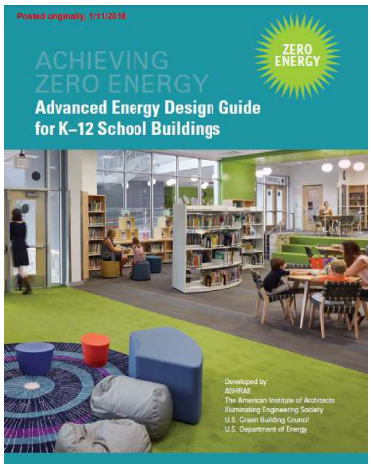
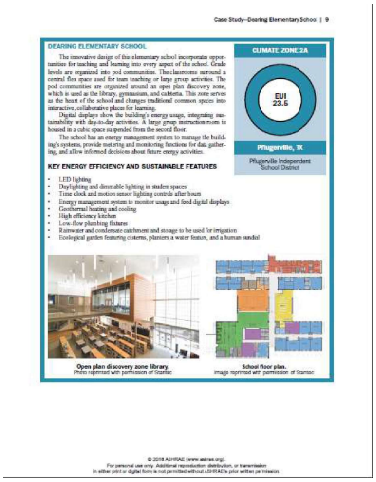
AEDG Zero Energy K-12 Schools Guide





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Getting to Zero Resources HUB

https://gettingtozeroforum.org/zero-energy-schools-resources/

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Additional Resources

- **Energy Star Portfolio Manager:** https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager
- **NEEP High Performance Schools:** http://www.neep.org/initiatives/energy-efficient-buildings/high-performance-schools
- **Collaborative for High Performance Schools (CHPS) Criteria:** http://www.chps.net/dev/Drupal/node/212
- **Green Ribbon Schools:** https://www2.ed.gov/programs/green-ribbon-schools/index.html
- **NCEF School Buildings Assessment Methods:** http://www.ncef.org/pubs/sanoffassess.pdf
- **U.S. DOE Zero Energy School Accelerator:** www.zeroenergy.org
- **NREL Technical Feasibility for K-12 Schools:** http://www.nrel.gov/docs/fy17osti/67233.pdf
- **DOE Toolkit: K-12 Solutions for Building Energy Excellence:** https://betterbuildingsinitiative.energy.gov/toolkits/k-12-solutions-building-energy-excellence

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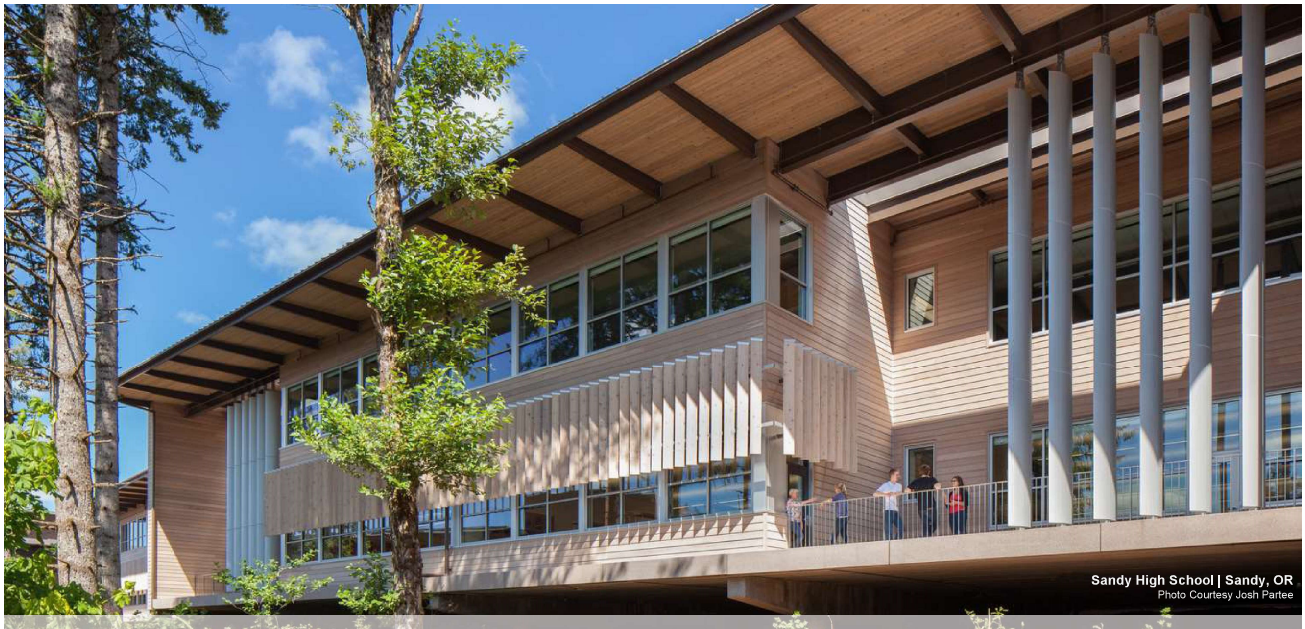

Thank You!

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