Prop 39 Zero Net Energy School Retrofits Workshop

ZNE Technical Training for Schools & Building Industry Professionals

Tuesday, November 1, 2016
Pasadena Green Schools Conference
Pasadena, CA
The Prop 39 ZNE Pilot Program is 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.
Welcome & Introductions

10:00 – 10:45 a.m.

Introduction to CA ZNE Goals & Policies
Overview of the IOU Prop 39 Zero Net Energy Pilot
Technical Introduction to ZNE – NBI National ZNE Research
Proposition 39: ZNE / Deep Retrofit Pilot for Schools

- D.14-10-046 directs IOUs to design a new deep retrofit and ZNE pilot for K-12 schools and community colleges to be run in conjunction with Prop 39.
- Comprehensive plan that is scalable for the full term of Prop 39.
- Incorporate best practices from other states and jurisdictions.
- IOUs to consult and coordinate with stakeholders: state agencies, schools/CCs, ZNE experts, etc.
NBI Support for Prop 39
ZNE Schools/Deep Retrofit Pilots

- 6 Technical Training Workshops
  (3 in Northern CA, 3 in Southern CA)
- 6 Institutional Trainings
  (3 in Northern CA, 3 in Southern CA)
- 5 ZNE School Case Studies
- Development of Training Materials & Presentations
- ZNE Schools Recognition Program Support (2016)
The ZNE Pilot will provide:

- Design assistance
- Trainings on how to socialize the ZNE concept with stakeholders (e.g. parents, teachers, students, board members)
- Ongoing commissioning and construction inspection
- Training on how to maintain ZNE operations
- Monitoring, verification

And the ZNE Pilot will require:

- Written commitment to the Pilot
- A willingness to design and deeply retrofit an existing building
- A healthy budget
- A willingness to share experiences with other interested schools
Element 1: ZNE Demonstrations

- Small scale, proof-of-concept demonstrations for 13-18 schools statewide.
- The Pilot will focus on existing public school buildings.
- Each IOU will implement the demonstrations independently except SCG who will partner with SCE or PG&E dependent on service territory.
- Support began in 2015 and continue for ~3 years.
- Pilot funds will reflect Prop 39 allocations with the majority (60-80%) dedicated to K-12 schools and the remainder to community colleges.
Round II - Demonstration Projects

Per Utility (Remaining Projects Available):

<table>
<thead>
<tr>
<th>Utility</th>
<th>Projects Available</th>
</tr>
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<tbody>
<tr>
<td>PG&amp;E</td>
<td>2-4</td>
</tr>
<tr>
<td>SCE/SoCalGas</td>
<td>4-6</td>
</tr>
<tr>
<td>SDG&amp;E</td>
<td>2-3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8-13</strong></td>
</tr>
</tbody>
</table>

Per School Type:

<table>
<thead>
<tr>
<th>School Type</th>
<th>Projects Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC</td>
<td>3-5</td>
</tr>
<tr>
<td>K-12</td>
<td>5-8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8-13</strong></td>
</tr>
</tbody>
</table>
Our Agenda

10:00 – 10:45  Welcome & Introductions
10:45 - 11:30  Developing your ZNE Plan and Targeting ZNE
11:30 - 11:40  Break
11:40 - 12:15  Designing to the ZNE Target – Part 1: Design for performance
12:15 - 1:00   Lunch
1:00 – 2:00    Case Study Presentations
2:00 - 2:30    Designing to the ZNE Target – Part 2: Design for Operations
2:30 - 2:45    Break
2:45 - 3:15    Building to the ZNE Design
3:15 - 3:45    Operating to the ZNE Design
3:45 – 4:00    Closing Discussion
ZNE Workshop
Expectations
Zero Net Energy – What is it?

A ZNE building is an ultra-efficient building that generates as much energy as it consumes annually. Also known as Net Zero Energy.
“Big Bold” Goals for ZNE in California

1. All new commercial construction will be ZNE by 2030

2. 50% of existing buildings will be retrofit to ZNE by 2030

3. All new residential construction in California will be ZNE by 2020

The California Efficiency Strategic Plan (Sep 2008)
californiaenergyefficiency.com/docs/EEStrategicPlan.pdf
Foundation of State Policies

Global Warming Solutions Act (2006)

**AB 32**
Reduces statewide greenhouse gas (GHG) emissions to 1990 levels by 2020 and to 20 percent of 1990 levels by 2050.

Energy Efficiency Program for Existing Buildings (2009)

**AB 758**
Requires the Energy Commission to develop and implement a comprehensive program to achieve greater energy savings in the state of California’s existing residential and nonresidential building stock.

Long Term Energy Efficiency Strategic Plan (2008)

State’s first integrated framework—a single roadmap to achieve maximum energy savings across all major groups and sectors.
Leading by Example

California’s Policy for Public Buildings

Executive Order B-18-12 requires state buildings to significantly reduce over the next two decades.

- Any proposed new or major renovation of State buildings larger than 10,000 square feet use clean, on-site power generation, such as solar photovoltaic, solar thermal and wind power generation, and clean back-up power supplies
- 50% of new facilities beginning design after 2020 to be Zero Net Energy.
- 100% of new State buildings & major renovations beginning design after 2025 to be ZNE
Code Cycles to Net Zero in CA

Code Cycles to ZNE, Source: SCE & AEC, 2009
How do you Measure ZNE?

- **Time Dependent Value (TDV)**
- **ZNE Code Building**
- **Energy Use Intensity (EUI)**
Defining & Measuring ZNE

Time Dependent Valuation (TDV): This is the California metric

“A Zero-Net-Energy Code Building is one where the net amount of energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building, at the level of a single “project” seeking development entitlements and building code permits, measured using the CEC’s Time Dependent Valuation metric.”

“A zero-net energy code building meets an energy use intensity value designated in the Building Energy Efficiency Standards by building type and climate zone that reflect best practices for highly efficient buildings.” - IOU Advice Letter to CPUC on Prop 39 ZNE School Pilot
Time Dependent Value of Energy

Close approximation of consumer cost with approximately 10% added for emissions

New Buildings Institute is proud to introduce our Getting to Zero Buildings Database.

The largest database on ZNE buildings in North America and the only database searchable by ZNE Status & Energy Performance

http://newbuildings.org/getting-to-zero-buildings-database
Growth in ZNE Buildings

Growth of ZNE and Ultra-Low Energy Buildings

- ZNE Verified
- ZNE Emerging
- Ultra-Low Energy
Where are ZNE Projects?
Zero Energy Buildings

- 2012: 21 ZNE Verified, 39 ZNE Emerging, 39 Ultra-low Energy
- 2014: 275 ZNE Verified, 106 ZNE Emerging, 53 Ultra-low Energy
- 2016: 44 ZNE Verified, 319 Total

Source: New Buildings Institute | newbuildings.org

2016 Prop 39 ZNE School Retrofit Workshops
ZNE and Ultra-Low Buildings are Possible in Many Building Types Across the US

- Small-Med Commercial Offices
- K-12 Schools
- Large Office Facilities
- Environmental Centers
- Higher Education Institutions
- Government Offices
Who is Aiming for ZNE?

ZNE Building Ownership Type

- Private - Non-profit: 9%
- Private - For-profit: 30%
- Public - Federal: 5%
- Public - State: 10%
- Public - City: 12%
- Private - Multifamily: 12%
- Public - County: 22%

ZNE and Ultra-Low Energy Building Types

- Education: 38%
- Office: 23%
- Other: 21%
- Multifamily: 11%
- Public Assembly: 7%
Schools are Leading

ZNE and Ultra-low Energy Building Types
- Education: 38%
- Office: 23%
- Other: 21%
- Multifamily: 11%
- Public Assembly: 7%

Breakdown of Education Building Types
- Higher Education: 29%
- General Education: 12%

K-12 School Building Count
- K-12 School, Verified: 59%
- Ultralow - Verified: 19
- ZNE - Emerging: 50
Performance By Building Type

Building Performance by Building Type, CBECS 2012

Building Performance by Building Type

2016 Prop 39 ZNE School Retrofit Workshops
ZNE Buildings in Every Climate Zone
Growth in ZNE and Ultra-Low Energy Education Buildings

Growth of ZNE and Ultra-Low Energy Education Buildings

- ZNE Verified
- ZNE Emerging
- Ultra-Low Energy

Building Count


2016 Prop 39 ZNE School Retrofit Workshops
Education Sector Energy Performance: ZNE vs. National Averages

Average Site EUI - Education

- CBECS 2003
- CBECS 2012
- Ultralow - Verified
- ZNE - Verified

EUI (kBtu/sf/yr)
ZNE Performance

Graph showing performance range for ZNE projects. The graph compares the Energy Use Intensity (EUI) of buildings with measured performance data from 2003, 2012, and 2006. The average EUI for these years is indicated:

- 2003 CBECs Average Office EUI = 93
- 2012 CBECs Average Office EUI = 78
- 2006 CEUS Average Office EUI = 73

The chart distinguishes between ZNE Verified Buildings, ZNE Emerging Buildings, and Ultra-Low Energy Buildings. The average EUI for ZNE buildings is shown to be 22 kBtu/sf/yr.
Gross EUI Performance Ranges: Education Buildings

- **2003 CBECs Average Education EUI = 83**
- **2012 CBECs Average Education EUI = 69**
- **Average = 19**

- ZNE Verified Education Buildings
- ZNE Emerging Education Buildings
- Ultra-Low Energy Education Buildings

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ZeroNetEnergy

2016 Prop 39 ZNE School Retrofit Workshops
Richardsville Elementary School

Efficiency Measures:

- Ground source heat pump
- DOAS
- CO2 sensors
- Daylighting
- High performance lighting system with controls
- EMS & Energy Dashboard
Common Technologies for Ultra-low Energy

- Ground Source Heat Pumps
- Ventilation: Natural, Dedicated Outdoor Air Systems (DOAS), Demand Control Ventilation (DCV)
- Highly Efficient Thermal Envelope
- Building Orientation & Glazing ratio
- Solar Control - shading
- Daylighting Access and Controls
- Energy Management Systems
- Building Dashboards
- Radiant Heating/Cooling & Chilled Beams
- Plug load Reductions
- Energy Recovery Systems

Redding School for the Arts, CA
Courtesy: Trilogy Architecture Steve Whittaker Photography
Challenges

- Perception of cost
- PV delayed due to cost
- Getting the metering right
- Using meter data correctly
- Projects not occupied or operated as modeled
- Commissioning – new form of ZNE Cx
- Fear of disclosure - ZNE seen as an end-all
California ZNE Watchlist

This CA ZNE Watchlist tracks commercial buildings (including multi-family) based on information gathered by New Buildings Institute (NBI) from multiple sources including designers, owners, utility programs, private and public organizations, articles, e-news, research, and commercial real estate professionals. It serves, along with other available ZNE resources, to support the awareness, acceptance, and adoption of ZNE goals and outcomes throughout California and the nation. Buildings with ultra-low energy performance comparable to ZNE are also included.

The graphics below show the trends in location, type, and size of the ZNE buildings in California.

For more resources: CEC (http://www.energy.ca.gov/1517/energy-efficiency/Zero-Net-Energy-Buildings.html) and NBI (www.newbuildings.org/zero-energy)

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ZNE Buildings in California
# ZNE Schools: Top Five States

<table>
<thead>
<tr>
<th>State</th>
<th>ZNE Verified</th>
<th>ZNE Emerging</th>
<th>Ultra-Low Energy Verified</th>
<th>Grand Total</th>
</tr>
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<tbody>
<tr>
<td>CA</td>
<td>1</td>
<td>18</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>KY</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>9</td>
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<tr>
<td>NC</td>
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<td>7</td>
</tr>
<tr>
<td>TX</td>
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<td>1</td>
<td>6</td>
</tr>
<tr>
<td>SC</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>50</td>
<td>19</td>
<td>78</td>
</tr>
</tbody>
</table>

2016 Prop 39 ZNE School Retrofit Workshops
What Buildings Make Sense for ZNE?

Most Building Types are feasible
- Administrative buildings
- Classrooms
- Service buildings
- Warehouses
- Recreation & environmental centers
- Libraries
- Low occupancy buildings/facilities

Priority Buildings
New school buildings/campuses
- Buildings needing major replacement, big energy hogs, buildings where systems are needing major retrofits
How are Schools Getting to ZNE?

- **Assessment of existing building stock** to find opportunities
- **Capital improvement projects** - Look at pipeline of coming up needed
- **Existing building renewal** - Making major retrofits get to ZNE when significant system or structural upgrades are made
- **Prototype Approach** – Campbell School District targeting 8 ZNE schools
Scaling ZNE

- **ZNE Building** for new and existing facilities – LA Harbor College

- **Campus-wide ZNE** – San Mateo Community College

- **Portfolio-wide Policy Approach** – IUSD, LASD energy and solar investments

- **District Approach** - FortZED
Why ZNE Schools?
Why ZNE Schools?

Why not?! Reverse the argument/conversation - Start from ground up with educating students about ZNE + sustainability - Set an example for ZNE/Env. Leadership - Current path is unsustainable - Need a more financially sustainable route - Also spreading the message to school + broader community - Healthier buildings (e.g., daylighting, or relating to higher test scores) - Schools can be resilient resource centers - Wise use of public funds - Increased savings in operations, brings more money for programs - Showing students what is possible - Demonstrating how schools play a part in meeting state and city goals - Demonstrating good stewardship and leaving a positive legacy for future generations - Students are good advocates with parents - Owner occupied buildings have best payback over long term - Not an unlimited amount of energy - Carbon footprint - Next generation of leaders - Energy savings goes back to programs - Mandate is looming - Next step after LEED - Cost savings - School district as model for community - As a building type, it is ideal – low occupancy, sufficient land, owner-occupied - Greenhouse gas reductions and climate goals - Fiscally responsible with taxpayer dollars - Better financing terms - Education next generation of leaders - Better financing terms - Education next generation of leaders - Increased population, increased need for more schools, will be more cost-effective to build now - Learning/teaching benefits: daylighting enhances student performance and wellbeing, biophilia (connection to nature) - Easier to operate - Maintenance - Energy savings - Retention rates - School as teaching tool - Save planet one building at a time - Necessity - Electricity is expensive - Reinvest savings for other programs - Set a good example for kids - see us doing this - demonstrate leadership - Technology creates a better, more convenient building - Attract and retain students and faculty - Quantitative benefits - Integrate into curriculum - Building awareness - Stay with them whole lives - Change expectations of students - We are doing our part - Better test scores and health
Why ZNE Schools?

- **Innovation & Leadership** - When public sector leads, others will follow. A commitment to zero energy buildings is an important demonstration of leadership and innovation in education.
- **Resiliency** – School facilities often serve as community centers for refuge in times of emergency.
- **Climate & Environmental Sustainability Goals** – Climate Action Plans, State goals, Green Schools Sustainability Roadmap
- **Energy & Cost Savings** mean more financial resources are available to support students, educational programs and facilities
- **Long Term Savings** in efficiency, cost, operations, climate
- **Innovative Educational Approaches** – Experiential Learning
Developing your ZNE Plan & Targeting ZNE

10:45 – 11:30 a.m.

Benchmarking and assessing your existing school building. Setting performance targets: more than just EUI. Making ZNE a part of the designer contract and using the Owners Project Requirements to guide the ZNE process.
Developing your ZNE Plan & Targeting ZNE

KEY TOPICS:

• Developing your **ZNE project plan**
• **Engaging Stakeholders** - ZNE Communication Toolkit
• Project **funding and financing strategies** (benefits of reduced operating budget) (ESCO model)
• **Benchmarking and assessing** existing school facility performance
• **Setting performance targets**: more than just EUI
• Making ZNE a part of the **designer contract**
• Selecting your **project team**
• Owners Project Requirements & the ZNE process
2016 Prop 39 ZNE School Retrofit Workshops

1. Laying the Foundation
2. Orchestrating Resources
3. Developing a ZNE Plan

Zero Net Energy Early Adopters Network

Tools & Resources for ZNE Plans
Assembling the Building Blocks of your ZNE Plan

1. Set your goals & milestones (Worksheet)
2. Backcast how you will get to ZNE (Worksheet)
3. Identify your key stakeholders and communication goals, then map stakeholder interaction (Worksheet)
4. Develop your Communication & Outreach Plan, then engage stakeholders
5. Conduct a gap analysis & create a plan for alignment (Worksheets)
6. Review your current/future building & retrofit plans for ZNE opportunities and develop criteria for prioritizing
Assembling the Building Blocks of your ZNE Plan

7. Identify & conduct any special research/studies needed
8. Select a pilot project
9. Evaluate available delivery method options for best likely ZNE result (Worksheet)
10. Explore alternative financing approaches to help offset costs
11. Create RFQ/RFP that sets clear owner requirements and targets for ZNE
12. Conduct an integrated design process and use proven technologies & design strategies
ZNE Communication Toolkit

1. **ZNE Action Bulletin**
   News, case studies, policy, research, events and trainings

2. **Message Platform**
   Key target audience messages

3. **Intro to ZNE Presentation**
   ZNE What, Why & How

4. **Case Studies**
   California project examples, including design strategies, planning, cost, and lessons learned

5. **ZNE Companion Guide/Fact Sheets**
   General info, key audiences messages

[www.newbuildings.org/zne-communications-toolkit](http://www.newbuildings.org/zne-communications-toolkit)
ZERO NET ENERGY BUILDINGS BACKCASTING TIMELINE

ENVELOPE

HVAC

LIGHTING

SPACE PLANNING

FINANCE - STRATEGIES + OPPORTUNITIES

PROCESS - PLANNING, CONTRACTING, DESIGN

PEOPLE - STAKEHOLDER ENGAGEMENT, EDUCATION + OUTREACH

2015 GOALS

2020 GOALS

2030 GOALS

BUILDING SCALE

© New Buildings Institute, 2015
Developing your ZNE Plan & Targeting ZNE

- Project funding and financing strategies
- Life-Cycle Cost Analysis
- Budget Guidelines
Fundraising & Financing Strategies

1. Utility Program Support - Savings By Design
2. Pilot Research Program
3. Technology Demonstrations
4. Use an Upgradable Design Strategy (e.g. Redding School for the Arts)
5. External Grant Funding
6. District Approach to Energy (FortZED)
7. Solar Financing District (e.g. PACE)
8. Prop 39 funding for schools
9. Prototypical Design for replication of standard buildings (Campbell School District’s 8 new schools)

10. Reduction of operation costs = increased capital project budgets

11. Power purchase agreements (PPAs)

12. Energy Service Companies (ESCo)

13. Emerging Tech programs through utilities

14. Urban development tools (if they are in local government redevelopment area)

15. FEMA or hazard mitigation financing for resiliency planning and critical building upgrades
Life Cycle Cost Analysis - LCCA

What is the full price of a building?

Life Cycle Cost =
Net Present Value of:

- First Costs (hard and soft)
- Utility Costs
- Ongoing Maintenance
- Repair/Replacement
- Residual Value
### 5.1 ENERGY LIFE CYCLE COST SPREADSHEET

**PROJECT DATA**

- **Facility Name**: (Enter Facility Name)
- **Alt. No.**: (Enter Alternative Number)
- **Description**: (Enter Description)
- **Analyst’s Name**: (Enter Analyst’s Name)

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<tr>
<th>Enter 1 or 0 for each fuel type.</th>
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<tbody>
<tr>
<td>1 = Yes</td>
<td>2.0%</td>
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<tr>
<td>0 = No</td>
<td>2.0%</td>
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<tr>
<td><strong>IOU Electricity Source</strong></td>
<td>1.0%</td>
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<tr>
<td><strong>POU Electricity Source</strong></td>
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<tr>
<td><strong>Natural Gas Fuel?</strong></td>
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<tr>
<td><strong>Propane Fuel?</strong></td>
<td>1.0%</td>
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<tr>
<td><strong>Oil Fuel?</strong></td>
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**DISCOUNT & ESCALATION**

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<tr>
<td>2016-2045</td>
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<table>
<thead>
<tr>
<th>(Investor Owned Utility)</th>
<th>(Publicly Owned Utility)</th>
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<tbody>
<tr>
<td>Natural Gas</td>
<td>Natural Gas</td>
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<tr>
<td>2.0%</td>
<td>2.0%</td>
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<table>
<thead>
<tr>
<th>And other fossil fuels</th>
<th>2.0%</th>
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<tbody>
<tr>
<td>2016-2025</td>
<td>2.0%</td>
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<tr>
<td>2017-2026</td>
<td>2.0%</td>
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<table>
<thead>
<tr>
<th>Maintenance</th>
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<tbody>
<tr>
<td>2005-2040</td>
<td>2.0%</td>
</tr>
<tr>
<td>Inflation (Nominal, not used)</td>
<td>3.0%</td>
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<table>
<thead>
<tr>
<th><strong>ANNUAL REAL CASH FLOWS</strong></th>
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<tr>
<td>$3,312,886 = 30-year LCC</td>
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</tbody>
</table>

**Instructions**:

1. C14. C18 plug in 1 if true, 0 if false
2. C14. If electric utility is privately owned enter 1
3. C15. If electric utility is publicly owned (e.g. PUD, municipality, rural electric utility) enter 1
4. C16. If natural gas escalation factors are desired enter 1
5. C17. If propane fuel is used enter 1
6. C18. If oil fuel is used enter 1
7. A29: Enter first analysis year
8. B29: Estimated construction cost would be the differential cost between the subject systems. (Including overhead & profit, tax, design fees, etc.) (If this was the least cost baseline system, the construction cost would be zero.)
9. C29. "Annual Maint Cost" includes boiler water and cooling tower water treatment, air filter changes, lubrication, spot replacement of lamps and ballasts, luminaire cleaning, boiler tune-up, condenser cleaning, controls calibration, and other routine maintenance.
10. E27. "Annual Gas Costs" (or other heating fuel). Apply current utility rate structure to monthly consumption from the building computer model. Enter first year dollar total in this cell.

8. A30. "Fire Safety"
Budget Guidelines for Net Zero Energy Projects

- **Life-cycle value**: Seek long-term, life-cycle value and budget for quality and performance, keeping in mind that net zero energy buildings are all about exemplary energy performance and value.

- **Selection and pricing**: Project team selection and pricing methods used for the project are as important as the budget for overall cost control. (The pros and cons of selection and pricing methods are addressed later in this chapter.)

- **Soft costs**: It is important to budget for additional soft costs, which include the effort and investment in smart design required during the front end of the design phase. Along with the investment in smart design comes the investment in a more rigorous energy modeling process. The additional soft costs also fund participation of all project delivery team members, to ensure an integrated project delivery.

- **Renewable energy**: Consider the cost of renewable energy systems as a separate investment from the construction cost. They can be a sizable investment, but one that virtually buys the future energy for the building up front. In this sense, it is also a financial investment and should be analyzed as such. (Refer to Chapter 9 for more on financial analysis of renewable energy systems.)
“The prevailing industry perception is that zero energy is cost prohibitive and suitable only for showcase projects with atypical, large budgets; however, there is mounting evidence that zero energy can, in many cases, be achieved within typical construction budgets.”
"The perception is that green schools cost more than conventional schools, but Evergreen understands that investing in sustainable design technologies now is actually a fiscally responsible strategy."

- Assistant Superintendent Kathy Gomez
George V. Leyva Middle School Administration Building

PROFILE DATA

- K-12 School Building
- Evergreen Elementary School District
- San Jose, CA
- Climate Zone 4
- 9,200 ft² New Construction
- Completed in June 2011
- $640/ft²
Developing your ZNE Plan & Targeting ZNE

Benchmarking and assessing existing school facility performance

• Starting with Energy Star Portfolio Manager/CEUS: how CA schools perform
• Understanding energy end uses (using FirstView) and opportunities for EE upgrades
• Determining the technical potential of your facility
Benchmarking Existing Facilities: How CA Schools Perform

Comparison K-12 EUIs from Two Data Sources:

- CBECES (K-12) = 58.2 kBtu/sf/yr
  Nationwide Median, released 2003
- CEUS (K-12) = 41.4 kBtu/sf/yr
  CA Specific Average, released 2006

ZNE Threshold: Approx EUI = 20-25 kBtu/sf/yr
Benchmarking Existing Facilities: How CA Schools Perform

Example from analysis with NBI’s FirstView®

![Graph showing EUI (kBtu/SF) comparison for different categories: This Building, CBECs Median, CEUS Average. The values are 26, 58, and 41 respectively.]
Benchmarking Existing Facilities: Understanding Energy End Uses

Detailed average end uses (CEUS – site visits)

- **Heating, Cooling, Ventilation** = Envelope & HVAC Equip.
- **Lighting, Plugs, Cooking, Refrigeration** = Interior Equipment
- **All Usage** = Controls & Occupants
Benchmarking Existing Facilities: Understanding Energy End Uses

Energy usage by end use: CEUS averages

- Combined to four basic categories

![Bar chart showing energy usage by end use: Space Heat (12), Cooling (6), Thermal Baseload (7), Electric Baseload (17).]
Benchmarking Existing Facilities: Understanding Energy End Uses

Example: FirstView analysis of a CA Prop 39 ZNE Retrofit Pilot Candidate School:

![Chart showing Energy Use Intensity (EUI) in kBtu/SF for Space Heat, Cooling, Thermal Baseload, and Electric Baseload with values 4, 6, 0, and 17 respectively.]
FirstView:

Energy Signature by End Use

![Energy Signature by End Use Diagram]

- **DESIGN AND CONSTRUCTION**
- **OPERATIONS & CONTROLS**
- **TENANTS & OCCUPANTS**
Trending allows owners to observe performance patterns over time. Paired with the collection of key indicators such as occupancy/vacancy, operational changes and system modifications, the FirstView tool’s energy signatures can track changes in performance.
FirstView: Portfolio Analysis

Buildings with Data Centers

Buildings with Labs

Steep Heating Slopes
FirstView: Portfolio Analysis

Seattle 2030 District Portfolio Analysis (NBI, 2014)

Top Performers

Heating Opportunity

Thermal Baseload Opportunity

High Electric Baseload (Data Centers)
Benchmarking Existing Facilities: Determining Technical Potential

1. Remote analytics for retrofit prioritization

2. Full energy audit with recommendations

3. Prioritize and select retrofit EE measures
Developing your ZNE Plan & Targeting ZNE

The Energy Loading Order
## Two ZNE Building Typologies

<table>
<thead>
<tr>
<th>Renewable-Oriented</th>
<th>Efficiency-Oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimally to moderately sensitive to the grid</td>
<td>Highly grid-integrated and responsive</td>
</tr>
<tr>
<td>Higher gross energy use</td>
<td>Lower gross energy use</td>
</tr>
<tr>
<td>Higher renewable generation</td>
<td>Lower renewable generation</td>
</tr>
</tbody>
</table>

**Active Strategies Focus:**
- Mechanical HVAC Systems, Thermal Storage, Night Flush with Fans, Demand Response

**Passive Strategies Focus:**
- Daylighting, Building Orientation, High Insulation Levels, Passive HVAC, Built-In Shading
Developing your ZNE Plan & Targeting ZNE

Establishing your solar and energy budget

© 2014 - The Miller Hull Partnership, LLP
Developing your ZNE Plan & Targeting ZNE

Defining your EUI Target:

1. Define cost effective EEMs from Audit
2. Define your operating schedule compared to annual renewable energy generation
3. Develop iterative energy model (include TDV)
4. Understand PV feasibility
5. Determine solar budget
(Example) ZNE Retrofit Energy Efficiency Measures (EEM)

<table>
<thead>
<tr>
<th>Measure 1: Reduced Building Equipment Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy 1a. Receptacle Controls</td>
</tr>
<tr>
<td>Strategy 1b. Plug Load Management</td>
</tr>
<tr>
<td>Strategy 1c. Plug Load Equipment</td>
</tr>
<tr>
<td>Measure 2: Heating and Cooling Strategies</td>
</tr>
<tr>
<td>Strategy 2a. Dedicated Outdoor Air System (DOAS)</td>
</tr>
<tr>
<td>Strategy 2b. HVAC Zone Control</td>
</tr>
<tr>
<td>Measure 3: Improved Overall Building Envelope Performance</td>
</tr>
<tr>
<td>Strategy 3a. Thermal Load Intensity</td>
</tr>
<tr>
<td>Strategy 3b. Air Infiltration Testing</td>
</tr>
<tr>
<td>Measure 4: Reduced Lighting Energy</td>
</tr>
<tr>
<td>Strategy 4a. Luminaire Level Lighting Control</td>
</tr>
<tr>
<td>Strategy 4b. Interior LPDs and Exterior Lighting Efficacies Based on Solid-state Lighting</td>
</tr>
</tbody>
</table>
Jeffrey Trail Middle School & Irvine Unified School District

PROFILE DATA
- New Middle School
- Irvine Unified School District
- Irvine, CA
- 73,178 ft²
- Climate zone 8
PEOPLE, POLICY & PROCESS

- CHPS High Performance schools resolution
- Irvine pursued a district-wide approach to energy efficiency
- Bonded for solar on all schools
- Power Purchase Agreement (PPA) to fund solar
- Capital outlay=$0
IUSD set energy-wise guidelines to help make its heating, ventilation, and air conditioning systems (HVAC) more efficient. The District also issued conservation mandates for lighting, thermostat settings, classroom and office equipment, and a variety of other areas. These measures are intended to reduce district-wide electrical usage by 15 percent.
“We have developed our own fifth and sixth grade curriculum that lets students learn about a variety of types of renewable energy. We discuss the pros and cons of different types of renewable energy. We are hearing that kids are more aware of things like conservation, recycling, and global warming. And the community appreciates the nonpartisan way we present the education.”

– Mark Sontag, UC Irvine Energy Consultant
DESIGN STRATEGIES & EFFICIENCY MEASURES

• Solar photovoltaics above parking canopies
• Daylighting
• Pyramid skylights
• Lighting controls
• Single building design for energy efficiency
• Whole Building Commissioning
Jeffrey Trail Middle School & Irvine Unified School District

Systems commissioning included:
Ductwork, air door, zone damper terminal, building automation system, packaged gas/electric units, exhaust fans, make-up air units, fan coil/outdoor condensing units, domestic hot water heaters and associated circulating pumps and controls, lighting controls, and occupancy sensors.
Jeffrey Trail Middle School & Irvine Unified School District

METRICS

- Verified Ultra-Low Energy Performance

\[ 29 - 12 = 17 \]
RESULTS & SUCCESSES

- CHPS Verified School
- Leadership in energy efficiency and operations district-wide
- Solar installed on 27 sites
- Long term cost savings of $5-11 million - puts more resources back into student programs
Georgina Blach Intermediate School

PROFILE DATA

- Los Altos, CA
- 75,000 ft² Existing Building Modernization
- Ultra-Low Energy Middle school
- Climate zone 4
- Completed in 2003
- $180/ft²
DESIGN STRATEGIES & EFFICIENCY MEASURES

• Re-use of existing structure
• Large north facing façade for indirect daylight
• BAS controls artificial lighting levels
• Natural ventilation
DESIGN STRATEGIES & EFFICIENCY MEASURES

• Automatic sensors modulate direct/indirect lighting to harvest daylighting
• Stack ventilation reduces active cooling
• Right sized mechanical equipment increases efficiency and reduces capital costs
Developing your ZNE Plan & Targeting ZNE

CHPS, LEED and other green goals
Developing your ZNE Plan & Targeting ZNE

Making ZNE a Part of the Designer Contract:

- Developing RFP language
- Defining scopes of work
  - Design through operations
  - Energy modeling
  - ZNE Commissioning
  - Controls integration
Request for Proposals & Qualifications (RFPs & RFQs)

RFP Guidelines for Net Zero Energy Projects

- Establish net zero energy as one of the key project objectives.
- Set an annual energy use target appropriate for the net zero energy objective.
- Clarify whether or not on-site renewable energy systems will be part of the RFP; in either case, consider how they will be coordinated with building design and construction.
- Provide a well-crafted project definition, one that takes into account the opportunities and challenges of net zero energy.
- If a separate RFQ is not used prior to the RFP, integrate the guidelines for RFQs stated in the previous RFQ section.
- Establish the selection process and delivery method in support of forming a trust-based, integrated delivery team, whose members are aligned with the project objectives.

Net Zero Energy Design: Tom Hootman
Developing your ZNE Plan & Targeting ZNE

Selecting your project team:

- Pre-bid and pre-construction conferences, project team interviews
Developing your ZNE Plan & Targeting ZNE

Using the Owners Project Requirements to guide the ZNE process:

• Defining Owner’s Project Requirements (OPR)
• Establishing the Basis of Design (BoD) (the design team approach)
Example OPR Table of Contents

Owner’s Project Requirements (OPR)

17.1 Introduction
17.2 Owner Requirements Covered Elsewhere
17.3 Project-Specific Design Goals
17.4 Occupancy & Use
17.5 Sustainability and Energy Efficiency
17.6 Building Site
17.7 Transportation & Parking
17.8 Building Envelope
17.9 Indoor Environmental Quality
17.10 Emergency or Backup Power
17.11 Telecommunications and A/V Systems
17.12 Security
17.13 Hazardous Materials
17.14 Furnishings & Equipment
17.15 Commissioning, Inspection, and Q.A.
17.16 Construction Completion & Turnover
17.17 Operation & Maintenance
17.18 Owner Training
17.19 Post-Occupancy and Warranty

NOTE to PM/Author: Enter the project # in the footer, left side... delete this + other notes-to-author

17.1 INTRODUCTION

Along with the other sections of this Facilities Program, this Owner’s Project Requirements (OPR) document outlines functional requirements of the project and expectations of how the facility and its systems will be used and operated. The OPR is required for LEED certification of the project, but also serves three broader vital purposes:
Developing your ZNE Plan & Targeting ZNE

Questions & Answers
Break

11:30 – 11:40 p.m.
Designing to the ZNE Target
Part 1: Design for performance

11:40 a.m. - 12:15 p.m.

LAUSD ZNE Prototype Classroom, designed by Swift Lee
Designing to the ZNE Target
Part 1: Design for performance

KEY TOPICS:

• Using Case Studies as a Guide
• Implementing an integrated design process
• Optimizing existing building features
• A design focus on energy conservation and efficiency
• Getting to ZNE with renewables and grid-friendly technologies
Designing to the ZNE Target
Part 1: Design for performance

Using Case Studies as a Guide: *The technologies and design approaches that have a proven track record in ZNE projects, including daylighting, radiant heating/cooling, lighting controls, plug load controls, LEDs and beyond*

**New Prop 39 Case Studies:**
- Berkeley West Branch Library (Net Positive NC)
- Georgina Blach Middle School, Los Altos (Ultra-low Retrofit)
- George V. Leyva Middle School (Emerging ZNE)
- City College of San Francisco (Ultra-Low Energy)
- Jeffrey Trail Middle School, Irvine (Ultra-Low Energy)
Designing to the ZNE Target
Part 1: Design for performance

Using Case Studies as a Guide: More CA Examples

• Stevens Library at Sacred Heart Elementary (ZNE Verified)
• Redding School for the Arts (Emerging ZNE)
• Marin Country Day School (Ultra-Low Energy)
• Solano School (Emerging ZNE)
• Blackford (Emerging ZNE as part of Campbell SD’s 8 new ZNE schools)
• La Escuelita (OUSD) – (Emerging ZNE)
Designing to the ZNE Target
Part 1: Design for performance

Implementing an integrated design process:
ZNE Workshop
ZNE Workshop: Team Building

- Sets green building **goals**
- Identifies **strategies**
- Develops an **action plan**
ZNE Workshop: Outcomes

- Vested stakeholders
- Consensus
- Guiding Principles
- An action plan
- A report for reference
Designing to the ZNE Target
Part 1: Design for performance

Optimizing existing building features:
Designing to the ZNE Target
Part 1: Design for performance

ZNE design strategies: Passive design approaches and designing for OFF
- Lighting and daylighting controls
- Occupancy/vacancy sensors
- Plug load controls
Integrated Daylighting and Occupancy Controls

• Lighting can reach 20% of energy use
• School hours are optimal
• Cut lighting energy use by half

Source: Boora Architects
Source: http://www.srgpartnership.com/
Integrated Daylighting and Occupancy Controls

Redding School for the Arts, CA
Courtesy: Trilogy Architecture
Steve Whittaker Photography
Integrated Daylighting and Occupancy Controls

IDeAsZ² Office Building  San Jose, CA
City College San Francisco (CCSF)
City College San Francisco (CCSF)

PROFILE DATA

- Community College
- San Francisco, CA
- 102,000 ft²
- Climate zone 3
- Completed in summer 2010
- LEED Gold
- $460/ft²
RESULTS & SUCCESSES

• Ground source central plant will serve up to 5 other buildings

• One of the largest modern buildings fully reliant on natural ventilation
Common ZNE Technologies

High Efficiency Technologies
- Ground source heat pump
- Radiant heating and cooling
- Condensing Boilers, Furnaces, etc.
- Demand control Ventilation
- Energy Recovery
- Variable Refrigerant Flow (VRF)
- Daylighting Controls
- LED Lighting
- Energy Star Equipment

Energy Generation
- Solar PV
- Solar Thermal
- Biogas
- Biomass
- Wind
- Combined Heat & Power

Operations and Occupancy
- Intelligent controls (scheduling, sensing, metering, etc.)
- Occupant engagement and training
- Energy Displays (i.e. Dashboards)
Gas Technologies

- Condensing Furnace
  - Up to 98% efficiency
- Tankless Water Heating
  - On demand use
- Energy Star Appliances

Source: https://www.precisionheatac.com/
Source: http://www.faucetdepot.com/
ZNE Retrofit Actions

What systems present a challenge for you?
# ZNE Retrofit Actions

<table>
<thead>
<tr>
<th>Low intervention:</th>
<th>Medium intervention:</th>
<th>High intervention:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Remote Audit</td>
<td>• Lighting/Daylighting</td>
<td>• HVAC System Switching</td>
</tr>
<tr>
<td>• Retro-commissioning</td>
<td>• HVAC Equipment Upgrades</td>
<td>• Envelope Upgrade</td>
</tr>
<tr>
<td>• Controls: Building Tuning</td>
<td>• Controls: System Upgrade</td>
<td>• Window Replacement</td>
</tr>
<tr>
<td>• Plug Load Savings/Policy</td>
<td>• Opportunistic Envelope Insulation</td>
<td>• Renewable Energy System</td>
</tr>
<tr>
<td>• Operator and Occupant Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Infiltration Reduction Measures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Designing to the ZNE Target
Part 1: Design for performance

Developing a grid friendly building
Renewable Energy Integration

- The Final step
- Solar most common
- Size as feasible
Designing to the ZNE Target
Part 1: Design for performance

Questions & Answers
Lunch Break

12:15 – 1:00 p.m.
Case Study Presentations

1:00 – 2:00 p.m.
Stevens Library case study: ZNE evolution and lessons learned

Pauline Souza
WRNS Studio
psouza@wrnsstudio.com
• Est. 2005
• 135 Staff
• Offices in San Francisco, Honolulu and New York
• 45 Design Awards
• 52 LEED APs
• 4 Net Zero Energy Projects
• 1% Pro Bono Commitment
• AIA 2030 Signaturory
Sacred Heart Schools Lower and Middle School, Atherton CA
450 students
Low budget Y2009
Fast Paced: 9 mo. design, 14 mo. construction
Sacred Heart Schools Lower and Middle School, Atherton CA
14 miles from ocean. 4 miles from bay
K – 8 Education
Previously a girls boarding school in 1898

Now a K-8 school, a high school, and a retirement home
- Interested client with inspiring mission statement
- Amazingly creative design team –
- Wonderful program
Starts with the vision and mission

- educate children to become exceptional leaders

work in partnership with students, parents, and other community members to educate the whole child in a nurturing environment and empower each student to become a contributing member and responsible participant in our changing world.
Limited dollars - $250 - $300/sf – approximately 20% less than the current construction dollar

No green
Reduced EUI for all buildings
CBECs for Schools: 69 EUI
63 acres plus

Local code requirements:
  2 year storm
  accommodate a 25 year storm for 48 hours

Permeability of soils – coefficient less than $10^{-8}$ cm/sec
Clay Soils – hydraulic soil group “D”
c) The Town requires stormwater detention for the purpose of reducing peak flows to downstream creeks and channels. Stormwater detention is required for projects that create or replace greater than 5,000 square feet impervious surface, with no credit given for existing impervious surface that is removed. Stormwater detention shall be based on storing 2-inches of rainfall over the proposed impervious area. The peak release rate shall be the 48-hour inflow volume over a 36 to 48-hour period. A higher rate of release is allowed if the calculated orifice size would be less than 1 inch diameter for a gravity release or less than that pumped by a 1/3 horsepower pumping unit, in which case, these minimum sizes are acceptable. Storage is required in all portions of the Town and within the Atherton Channel Drainage District. Detentions basins may discharge to groundwater, gravity flow to the Town storm drain system, which includes gutter flow if no storm drain line is present, or be pumped to the Town storm drain system.

d) Percolation from detention ponds is allowed only if a Geotechnical Report shows that there will be at least a 10-foot separation from the groundwater table and that percolating water will not seep onto other properties. Raising the groundwater table by seepage is accepted. If the bottom of the storage basin is within 10 feet of the groundwater table or affects seepage to other properties, a low permeability barrier designed to mitigate the effects of the seepage is required. Infiltration devices shall be located at least 100 feet away from water supply wells.

If percolation is used, the Geotechnical Report shall verify that all soils to the groundwater level will percolate at the minimum rate recommended for design.
Inherited approach
Need to capture water from larger campus – 9 acres of stormwater
Tight Construction Budget

First solution was an 80” dia. Pipe

Hancor Perforated Pipe system
100% of storm water and used, project water discharge must be managed onsite to feed the project’s internal water demands or released onto adjacent sites for management through acceptable natural time-scale surface flow, groundwater recharge, agricultural use or adjacent property needs.
Stormwater cleansed through landscape based natural treatment – meets C3 regulatory requirements

Stormwater flow rates are reduced through maximized pervious paving and Increased landscape – calculate and prove
• With Sherwood, New Strategy for Stormwater Management of the Site through multiple city agency discussions and calculations

• Capturing the runoff from the new campus PLUS the contributing 9 acre run off from the south part of campus in distributed areas

• Make it a Teaching Opportunity
Pervious paving at courtyard and entry areas
Bioswales and retention areas
Flow through planters serve as seating
Flow through planters serve as waiting seating at front of campus
Connecting art and science
the change in the place you usually sit, here the sound of the rushing water
Experience how it changes
Notice how the water doesn’t puddle
Collection from all sinks to GREYWATER filtration system and to landscape and Library toilets

Use of RAINWATER for potable uses

Library Demand:
  2 lavatory sinks, 1 service sink, 2 water fountains
  113 gallons a day
  33,750 gallons per year
  Max Flow: 4 gpm

Greywater and Rainwater reuse
K-8 Lower and Middle School Campus
10 Acres – L-3 transect
85,000 sf

Reduced EUI for all buildings:
- Assembly/ Theater: 31.7 kbtu/sf yr (vs 41.1)
- Library: 27 kbtu/sf yr (vs 42.4)
- Classrooms: 23.4 kbtu/sf yr (vs 36.6)
- Admin/ Chapel/ Classrooms: 25.1 kbtu/sf yr (vs 41.1)

CBECS for Schools: 42.4 EUI
Stevens Library 6,300 square feet – target: low energy at low cost

Living Building Challenge – Net Zero Energy
Petal Recognition target – Water and Energy
LEED Platinum submission
PGE Net Zero Pilot Project
PGE Monograph with Edward Dean
Zero-Net Energy in California Schools – A Case Study and more

LeyVa Middle School ZNE+E Administration Building (2012)
Learning Objectives:

- Learn an approach to introducing ZNE to schools
- Understand the technical aspects of ZNE
- A glimpse into the future of “Net Zero” thinking
"ROADBLOCKS"

"We have to focus on un-met needs like classrooms and technology"
“ROAD BLOCKS”

“We have our District Standards. We can’t maintain a fancy EMS”
“ROADBLOCKS”

“We just can’t afford it. We have to save money”
“We save money everyday thanks to the investment in high quality design from the beginning”
“OPPORTUNITIES”

“We have a safe and healthy learning environment in which students, teachers and staff thrive together”
<table>
<thead>
<tr>
<th>Biophilic Pattern</th>
<th>Stress Reduction</th>
<th>Cognitive Performance</th>
<th>Emotion, Mood &amp; Preference</th>
</tr>
</thead>
</table>

Reference: 14 Patterns of Biophilic Design, Terrapin Bright Green LLC, 2014
DEVELOPING A NEW APPROACH:
TRADITIONAL APPROACH

Educational Program Planning → Conceptual Design → High Performance Systems Design → Documentation & Construction

Discover Performance Outcomes “beat T-24 by...”
Integrated Design Is...

“a collaborative method for designing buildings which emphasizes the development of a holistic design”
DEVELOPING A NEW APPROACH:
INTEGRATED APPROACH

Educational Program Planning

Identify and Commit to Performance Outcomes (ZNE)

Integrated Design

Test & Evaluate

Documentation & Construction

Test & Evaluate
PROJECT BUDGETING:

“Tunneling through the cost barrier”
Case Study: LeyVa Middle School Administrative Office Building

“Conventional” Project?
Un-Conventional Project?
OUTCOMES:

• Technical Intentions
  – Reduce Cooling loads
  – Reduce Lighting loads
  – Reduce Electrical demand
  – Eliminate Gas fired equipment
  – Zero Net Energy and Emissions

• Architectural Intentions
  – Define a new welcoming image and entry gateway to the school
  – Light, Space, and Fresh Air
Daylight Analysis

Daylight Factor

Contour Range: 0.0 - 60.0 %
In Stages of: 1.0 %

A-A. SECTION AT CLERICAL AREA

B. SECTION PERSPECTIVE AT CLERICAL AREA

Lobby / Clerical Design Recommendations

Consider extending this wall up to the roof and using a slit daylight for balanced daylighting to space.

Extend roof overhang to give a 50 to 60 cut-off angle to provide adequate summertime heat gain control.

West facing glazing should be avoided to avoid excessive winter peak loads.

As an alternative to the slit window approach, a series of walling skylights and daylighting design is recommended to provide daylight to both the open clerical space and enclosed offices in the corridor.

There will be winter hours where direct sunlight will be a glare issue for clerical desks. Fabric roller shades or other daylighting redirection will need to be considered.
Energy Modeling

- **Energy Pro 4.4**
  - CA Accepted Compliance Software
  - Best Modeling Solution for this Project

- **E Pro Equivalent to ASHRAE 90.1**
  - Based on DOE2 algorithms
  - LEED accepted E Pro for Modeling
Energy Modeling

- T24 Compliance
  - 41% Better than CA Energy Code Compliance
  - Obtained thru Integrated Design of Envelope, Mechanical, and Lighting Systems
Energy Strategies

Envelope

- Greater than R30 Roof Insulation
- R19 Wall Insulation
- Dual Pane Low-e Glazing
- Window shading
Energy Strategies

- Electrical
  - High Efficiency Lighting
  - Daylighting
Energy Strategies

- Mechanical

  - Variable Refrigerant Flow (VRF) System in Administration Areas
  - High Efficiency Displacement Ventilation (DV) Single Zone VAV Heat Pump in Work Room
  - Energy Management System (EMS)
Energy Strategies

Variable Refrigerant Flow (VRF)

- Energy transfer using refrigerant instead of central fans uses less fan energy
- Allows simultaneous heating and cooling between zones with little compressor power
- Variable speed compressors match changing building loads and provide high part load efficiency
- Superior Zone Temperature Control, zones are not over cooled or heated
Energy Strategies

Displacement Ventilation

Heat Pump

– Use of higher supply air temperature (65°F) allows extended economizer operation
– Low velocity = low static = low fan power = low sound
– Heat pump operation allows heating with solar power
– Variable air supply volume reduces fan energy
Particle trace graphic

Note how cool air delivered from diffusers at low velocity drops to floor and rises up around the occupant heat load at the tables providing room set point.
Temperature slice graphic in z direction

Note stratification of air with cool air at diffusers, room set point temperature air at occupants at tables, and warm air above the occupants.
Energy Modeling

• Compliance vs. Actual
  – Compliance run uses code defined baseline model
  – Non-compliant run needed to calculate actual energy use
  – Redefine occupancy schedules
  – Redefine daylight lighting power levels
Energy Modeling

- Estimated Annual Consumption
Photovoltaic Technologies

38.4kW
Energy Modeling

Monthly Average Electric Production

38.4kW Photovoltaic System
Energy Modeling

- Net Monthly Consumption/Production
Lighting: High Efficiency

The diagram illustrates the efficiency of various lighting types, with "Incandescent" being the least efficient at 14, and "Instant Start T-8 lamp" being the most efficient at 102. Other types include Low Voltage Halogen (16), Line Voltage Halogen (22), LED (60), Standard Metal Halide (65), Compact fluorescent (66), Pulse Start Metal Halide (77), Standard T-12 (79), High Pressure Sodium (85), Standard T-8 (86), T-5 High Output (88), Program Start T-8 lamp (97), Standard T-5 (98), and Instant Start T-8 lamp (102).
IMPORTANCE OF USER BEHAVIOR

Typical Building
- Plug Loads: 25%
- HVAC: 40%
- Lighting: 35%

Efficient HVAC & Lighting
- Plug Loads: 55%
- HVAC: 30%
- Lighting: 15%

Net Zero Building
- Plug Loads: 45%
- HVAC: 35%
- Lighting: 20%
LEVYA MIDDLE SCHOOL POWER MONITORING DIAGRAM

- **PGE Main**
- **ION8600 (FORM 9S) SOCKET METER INSTALLED IN DUAL PG&E METERING SOCKET AT UTILITY MAIN**
- **SWITCHBOARD MSB**
- **BELDEN 9841 2 WIRE MODBUS COMMS**
- **POWERLOGIC HIGH DENSITY METERING (HDM) ENCLOSURES WITH PM750 POWER METERS METERING 21 TOTAL LOADS ON SWITCHBOARD MSB**
- **ETHERNET CABLE TYPICAL CAT 5E / CAT 6 TO 3RD PARTY ENERGY KIOSK**

[Diagram showing the power monitoring system setup]
Energy Kiosk PV System Dashboards
Energy Modeling?

The Data

Annual Average (3 years): 312K kbtu
\[=34.9 \text{ kbtu/sf-yr} \]
(Predicted: 18)

Underestimated
- HVAC use by 851%
- Lighting use by 55%

Plug loads were right on

PV system producing \(~30\%\) more than predicted
SOME ERRORS TO AVOID

• Allowing Energy Monitoring Systems and Energy Data Dashboards to be “Value-engineered” out of the project

• Lack of organizational capacity and institutional memory for new technology

• Improper or insufficient Commissioning and follow-through

• Allowing Critical Envelope enhancements and to be “Value-engineered” out of the project, like high performance glazing and insulation

Developed by J. Diffenderfer, Aedis Architects, and A. Sung, Greenbank Associates
CAMPUS NET ZERO ENERGY

IF THE AVAILABLE SPACE ON THE ROOFS IS COVERED IN HIGH EFFICIENCY PV PANELS, THE SITE AVERAGE ENERGY UTILIZATION INTENSITY TO ACHIEVE NZE IS:

\[\text{EUI} = 30 \text{ KBTU/SF/YEAR}\]

THIS GOAL IS ACHIEVABLE BY UTILIZING SELECT DESIGN STRATEGIES I

IF ALL DESIGN STRATEGIES DEVELOPED BY THE AEDIS-INTEGRAL TEAM ARE IMPLEMENTED TO ACHIEVE CAMPUS LOW ENERGY POTENTIAL:

\[\text{EUI} = 23 \text{ KBTU/SF/YEAR}\]
Zero-Net Energy in California Schools – A Case Study and more

LeyVa Middle School ZNE+E Administration Building (2012)
envelope
Wall Assembly and Roof Assembly

- **WALL R 12.5**
  - 3/4” Brick Veneer
  - 3/4” Exterior Plaster
  - 1/2” Rigid plus 1/2” shear board/ 1” Rigid
  - 6” metal studs at 24” oc with R19
  - Could go 1” more of rigid to R 17

- **ROOF – R 27**
  - TPO Roofing
  - 2” rigid
  - 1-1/2” metal decking
  - R-40 insulation
• Change in assembly - Wood would have been R20 with same assembly (vs R12.5)
Displacement Ventilation through Air to air heat pump system with Indirect direct evaporative cooling
Maximized panels on roof area
170 panels @ 250 w/panel – 40 kw sized 15% over
Flat panels vs tilted resulted in a 13% reduction - required for city planning requirement
Stir the pot.
Infuse with inspiration and poetry.
Embrace the psychology of the end game.
Lead the market forward.
Create models for the future.

Achieve the Living Building Challenge®
Stevens Library at Sacred Heart Schools
Solar Photovoltaic System Performance

- Energy Use (Building)
- Energy Production (PV System)

Cumulative Net Energy Performance
- Net Energy Production
- Net Zero
PV predicted at 50832 kWh
PV measured 56,811 kWh

**Production vs Consumption**

- PV Production
- Measured Energy Consumption

KWh

January, February, March, April, May, June, July, August, September, October, November, December
Table 1: Measured Energy Use (kWh) by End Use

*Months when heating system had fault conditions requiring auxiliary heating. Heating system has since been fixed by the manufacturer.

### Mechanical

<table>
<thead>
<tr>
<th></th>
<th>Measured</th>
<th>Modeled</th>
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<tbody>
<tr>
<td>Dec</td>
<td>1,773.9</td>
<td>2018</td>
</tr>
<tr>
<td>Jan</td>
<td>4,442.5</td>
<td>1,914.0</td>
</tr>
<tr>
<td>Feb</td>
<td>4,457.6</td>
<td>1,283.0</td>
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<tr>
<td>Mar</td>
<td>2,032.1</td>
<td>1,115.0</td>
</tr>
<tr>
<td>Apr</td>
<td>1,040.7</td>
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highs & lows
Better tracking
Constant communication
lighting

Daylight modeling and People modeling
37% predicted
4% actual
Approximately 8000 kWh difference
modeling site and plugs
Equest 3.64
Greywater added approximately 3000 kWh to the actual metering data – not originally expected. EUI of 16.1 or 13.2 if not including greywater.

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Stevens Library at Sacred Heart Schools
Modeled Annual Energy Use

- DHW: 19%
- Ventilation: 5%
- Plug Load: 21%
- Lighting: 37%
- Heating: 14%
- Cooling: 4%

Modeled Energy Use
50 MWhr per Year
Modeled EUI = 27.0

Stevens Library at Sacred Heart Schools
Measured Annual Energy Use

- DHW: 0%
- Gray/Rain Water System Pumps: 10%
- Ventilation: 22%
- Plug Load: 20%
- Lighting: 4%
- Cooling: 11%
- Heating: 33%

Measured Energy Use
31.1 MWhr per Year
Actual EUI = 18.9
how much
PV predicted at 50832 kWh
PV measured 56811 kWh
Demand measured 24394 kWh

Production vs Consumption

PV Production
Measured Energy Consumption
170 panels @ 250 w/panel – 40 kw sized 15% over covers graywater system, 4,408 kwh
Too much?
Too Good?
people
highs
DO YOU KNOW...

...where the rain goes when it falls?

DO YOU KNOW...

...what’s on the roof of the library?

1 panel = 633 iPhones
Proud to be GREEN.
Momentum moving forward
SHS Stevens Library
Sacred Heart Schools

6300 sf library; 83,000 sf school; 6 acre site
Independent School
LOW construction budget - y2009
LOW - Moderate fees - y2009

LOW interest in driving sustainability through project
FAST paced Design and Construction (9 mo. design; 14 mo. build)

Pursued Net Zero Water
LEED Platinum targeted
Net Zero Energy Certified through ILFI
Designing to the ZNE Target
Part 2: Design for Operations

2:00 - 2:30 p.m.

Defining the elements that need to be put into a building in order to enable ZNE operation
Designing to the ZNE Target
Part 2: Design for Operations

Integrating operations team into the design process

Design Team → Construction Team → Operations & Maintenance Team
Designing to the ZNE Target
Part 2: Design for Operations

Developing a ZNE operations framework:
• Select technologies appropriate to operators and occupants
• Provide tools and resources
• Develop facilities operations plans
Designing to the ZNE Target
Part 2: Design for Operations

KEY TOPICS

• Building automation and controls integration
• Integrating operations into the design process
• Developing a ZNE operations framework: technologies, tools and facilities operations planning
Designing to the ZNE Target
Part 2: Design for Operations

ZNE design strategies: Building automation and controls, and controls integration

Architecture
Designing to the ZNE Target
Part 2: Design for Operations

Building automation and controls integration

Many decisions to make:
• System type
• Points controlled
• Integration between systems
• Simplicity vs complexity

Despite all the choices…

Just make it work.
Designing to the ZNE Target
Part 2: Design for Operations

Building automation and controls integration

Making It All Work Together: Key Points

- Plan for Measurement and Verification
- Beware of Value Engineering!
- Controls considered from design through operation
  - Controls Integrator contracted 1 year post occupancy
- Design controls for real-world use
  - Keep the Operators and Occupants in mind
Controls

- User-friendly/intuitive
- Over-rides contribute to the confusion
- Consistent - across an institution if possible
- Organized
Designing to the ZNE Target
Part 2: Design for Operation

You can’t improve what you don’t measure

Measurement and verification of building performance

• Standardized Protocol: IPMVP

Design for Measurability

• Submetering & Electrical Circuits
• Controls: Data Trending
• Make sure you can use measured data to improve performance!

Image credit: EVO
Designing to the ZNE Target
Part 1: Design for performance

Plug load performance – selecting energy efficient plug load equipment

Plug Load Best Practices Guide
Managing Your Office Equipment Plug Load

Guide to Energy Savings
Plug loads can be managed through low- and no-cost measures that are relatively straightforward to implement.

This Guide shows how simple changes can cut costs and save energy in offices.

 Courtesy of PAE Consulting Engineers
Designing to the ZNE Target
Part 1: Design for performance
Focus on Operations and Occupancy
Operator & Occupant Engagement
Operator & Occupant Engagement

- Monitor energy consumption wirelessly.
- Be rewarded for efficient energy habits.
- Control outlets and compare to others.
- Set timers & powerdown min/max
- Set goals, chart progress, & compare with coworkers

eMetric by Jason Deperro

2016 Prop 39 ZNE School Retrofit Workshops
Designing to the ZNE Target
Part 2: Design for Operations

Questions & Answers
Break

2:30 – 2:45 p.m.
Building to the ZNE Design

2:45- 3:15 p.m.

Ensuring that a ZNE design becomes a ZNE building, from selecting contractors, construction and commissioning, to fine-tuning
Building to the ZNE Design

KEY TOPICS

• Construction delivery methods
• Integrating ZNE strategies and technologies into the school facility
• ZNE commissioning: ensuring ZNE performance
• Beginning M&V, controls integration and setting up systems for successful operations
West Berkeley Public Library

PROFILE DATA
- New Public Library
- Verified ZNE/Net Positive Performance
- Dense urban setting
- Berkeley, CA
- ~9,500 ft$^2$
- Climate zone 3
- Completed: Dec. 2013
- $585/ft^2$
West Berkeley Public Library

METRICS

• Over 50% savings beyond Title 24
• Net Positive
West Berkeley Public Library

CHALLENGES & LESSONS LEARNED

Skylights:
• Operable skylight controls were difficult to get to communicate with building management system (BMS)
• Value engineering exercise had removed integral blinds- added back during construction
CHALLENGES & LESSONS LEARNED

Daylighting:

• Operable skylight controls were difficult to communicate with building management system. Value engineering exercise had removed integral blinds - added back during construction.

• Skylight blinds have solar cell - self powered and automatic.
CHALLENGES & LESSONS LEARNED

Natural Ventilation:

- Interior of chimney has to be lined with acoustic board
- Provide for access to service and maintain
- CFD studies were worth it. Minimal comfort issues – most addressed during commissioning
KEY LESSONS

• Extensive Bioclimatic Studies & Energy Modeling are Critical
• Anticipate Changes in Technology – be ZNE Aware
• Design & Define Performance Criteria for Design/Build Systems – PV/ Solar
• Commissioning – Data, Performance, Metrics – Stay the Course.
Building to the ZNE Design

Construction delivery methods:

• Design – Bid – Build
• Design – Build
• Guaranteed Maximum Price
• Integrated Project Delivery
• Energy Savings Performance Contract (ESPC)
Owner contracts with separate entities for both the design and construction of a project. There are three main sequential phases to the design–bid–build delivery method:

- The design phase
- The bidding (or tender) phase
- The construction phase
Design–build

Design and construction services are **contracted by a single entity** known as the design–builder or design–build contractor.
Guaranteed Maximum Price

Also known as GMP, Not-To-Exceed Price

A cost-type contract or **open-book** contract costs incurred plus a fixed fee subject to a ceiling price.

The **contractor is responsible for cost overruns**, unless the GMP has been increased via formal change order as a result of added scope by client.
Integrated Project Delivery (IPD)

Collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

Eight main sequential phases to the integrated project delivery method:
- conceptualization phase [expanded programming]
- criteria design phase [expanded schematic design]
- detailed design phase [expanded design development]
- implementation documents phase [construction documents]
- agency review phase
- buyout phase
- construction phase
- closeout phase
- facilities management
**Integrated Project Delivery (IPD)**

- **Figure 2:** Traditional vs. Integrated Project Team Structure

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[https://buildings.lbl.gov/sites/all/files/lbnl-6130e.pdf](https://buildings.lbl.gov/sites/all/files/lbnl-6130e.pdf)
Energy Savings Performance Contract (ESPC)

- Energy savings performance contracts (ESPCs): Procure energy savings / facility improvements with no up-front capital costs
- An ESPC is a partnership between an owner and an energy service company (ESCO)
Building to the ZNE Target

Integrating ZNE strategies and technologies into the school facility:

• Insulation
• Glazing
• Lighting and Daylighting
• HVAC
• Controls
Building to the ZNE Target
Building to the ZNE Target
Building to the ZNE Target

ZNE commissioning: ensuring ZNE performance

Design
- OPR + BoD
- HVAC Selection
- EMS Design + SoO
- Request Submittals + O&Ms

Construction
- Design Review + Cx Specs
- Review Submittals
- Prepare PFATs + FATs
- Cx Kickoff Meeting
- IT Installation

Operations
- Owner Training
- Cx Report
- Systems Manual
- Bldg. O+M Review
- HVAC Startup
- Implement PFATs
- EMS Wiring Check
- EMS Startup
- TAB
- Execute FATs
- Bldg. O+M Review
Who is involved in Commissioning?

- Architect
- MEP Engineer
- Commissioning Authority
- Owner/PM
- General Contractor
- MEP Contractor
- TAB Contractor
- Controls Contractor
Begin the commissioning process early during the design process and execute additional activities after systems performance verification is completed.
ZNE Commissioning

Implement Commissioning Activities:

1. Conduct commission Design Review of the Owner's Project Requirements (OPR), Basis of Design (BOD), and design documents

2. Review contractor submittals concurrently with A/E reviews

3. Develop a systems operations manual

4. Verify that training requirements for operations personnel and building occupants are completed.

5. Review building operation within 10 months of substantial completion with O&M staff and occupants.
Building to the ZNE Design

Questions & Answers
Operating to the ZNE Design

3:15 - 3:45 p.m.

Operating to the ZNE Target:
Taking ZNE Design to ZNE Reality
Operating to the ZNE Target: Taking ZNE Design to ZNE Reality

KEY TOPICS:

• Bridging from design to operations: Integrating the design team into ongoing operations
• Operator training and occupant engagement
• Purchasing equipment: A focus on minimizing plug loads
• Monitoring and diagnostics
• Maintenance and ongoing commissioning: ensuring persistence in performance
Operational Strategies: End of Construction

Features that can be delivered/required in the construction contract/process

- Acceptance Testing (incl., economizers, controls, feedback systems etc)
- Infiltration Testing/Air Barrier Commissioning
- Metering/Meterability
- Equipment Fault Detection and Diagnostics (FDD) Capabilities
- Updated OPR
- Operations guide
- Maintenance schedule
- As-Built Drawings
Building Operation: Post Construction

- Tenants
- Design
- Operation
- Staffing Controls Maintenance Commissioning
- Computers and Equipment Schedule Habits
- Layout Integration Installation Components and Features
Operating to the ZNE Target: 
Taking ZNE Design to ZNE Reality

Initiation and Training to start building operation on the right track:

- Owner Orientation
- Operator Training
- Metering and Feedback Plan
- Equipment Purchase Standards for Fit-out
- Occupant Training
- Maintenance Plan
Operating to the ZNE Target: Taking ZNE Design to ZNE Reality

Maintaining long-term building operation:
- Resource Conservation Manager
- Tenant engagement
- Plug Load Management
- Retro Commissioning Plan
- Performance Data Review
- Equipment purchase guidelines
- On-going operator training/support
- Disclosure
- Operator feedback
- Tenant feedback
- Public feedback
ZNE Exercise:

Turn to your neighbor and discuss: What are the most important elements for operations going forward?
Existing ZNE & Ultra-Low Energy Case Studies

- CPUC Case Study Briefs & NBI ZNE Case Studies
  http://newbuildings.org/case-studies-zne-projects

- PG&E Case Studies

- NBI Registry
  http://newbuildings.org/share

- Getting to Zero Database
  http://newbuildings.org/getting-to-zero-buildings-database

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**BACON STREET OFFICES**

The Bacon Street Office project is a 4,500 SF retrofit of a single-story, 1960’s-era auto repair shop into a high performance office for the firm ARCHITECTS hannah garrison wex. Through creative design strategies, renewable energy generation and with support from local utilities, including the Savings by Design program, this project has achieved zero net energy goals. In fact, this project is so energy efficient it returns power to the grid.

**Planning & Design Approach**

- Start early and use an integrated design process
- Define goals and benefits
- Structure fees to provide more research and design iterations
- Stay flexible and iterative with the design process

**Energy Efficiency Strategies and Features**

**Daylighting**

A wall of windows along the public street side of the building provides daylight and views of a landscaped parking court with native vegetation and canopy trees. This light is balanced with top lighting from diffuse skylights at the back of the space to reduce glare, reflection walls, blinds, and task lighting.

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ZNE Technology Application Guides

LUMINAIRE LEVEL LIGHTING CONTROL

INDIRECT EVAPORATIVE COOLING

RADIANT HEATING AND COOLING + DEDICATED OUTDOOR AIR SYSTEMS

http://newbuildings.org/zero-energy
5 GREAT NEW TOOLS FOR ZNE BUILDINGS

1 ZNE Message Platform
Key messages for target audiences on the what and why of ZNE.

2 “Intro to ZNE” Presentation
Customizable powerpoint presentation provides an overview of California’s goals and policies for ZNE, key strategies, and case study examples.

3 ZNE Companion Guide/Fact Sheets
Collection of FAQs, resources, design strategies, and key messages for designers, commercial building owners, policymakers, and decisionmakers of schools and public buildings.

4 Case Studies: ZNE & Ultra-Low Energy Buildings
Read about ZNE and ultra-low energy building examples, including design strategies, costs, and lessons learned.

5 ZNE Action Bulletin
Sign up for our quarterly e-newsletter for updates on ZNE news, events, trainings, case studies, planning, policy, and research. To sign up, or to get more info about the toolkit, email heather@newbuildings.org.

www.newbuildings.org/zne-communications-toolkit
"The business case for making the building net zero energy is that it will not just lower our energy bill, but it also will allow us to put those savings straight back to the top line of our operations budget for maintaining programs for kids."

– Assistant Superintendent Kathy Gomez
Closing Discussion

3:45 - 4:00
Share your Feedback

Take the Feedback Survey:
www.surveymonkey.com/r/ZNESchoolsTraining12
Prop 39 ZNE School Retrofit Workshops

Thank you!

For more information, contact:

Ralph DiNola, Ralph@newbuildings.org
Heather Flint Chatto, heather@newbuildings.org