Getting to Zero Forum

Oakland, CA
October 10, 2019

About ProspectSV

ProspectSV is a nonprofit cleantech innovation hub focused on advanced mobility and energy solutions for urban communities.
Our Mission

To accelerate the adoption of clean technologies in

- **Advanced Mobility**: Automated, connected, electric, and shared vehicles
- **Energy**: Building Efficiency, Vehicle-to-Grid Integration, Distributed Energy Resources

Energy Demonstration Programs

- Whole Foods ZNE
- CalOp ACE
- REALIZE
The Next First Big Thing: Building Deconstruction / Reuse

Dave Bennink, Director
Building Deconstruction Institute
www.reuseconsulting.com
360-201-6977

RE-USE Consulting
Say “No!” To The Track-Hoe

Sustainable Alternatives to Demolition
Building Deconstruction—Material Salvage—Used Building Material Sales
A Lifetime's Worth of Waste

The EPA states that Americans produce an average of 4.40 pounds of waste/day

That adds up to about 120,000 lbs in 75 years

We are focused on preventing household waste, but what about the house?

Demolition of an average American home is equivalent to a lifetime's worth of waste!

Consider Building Deconstruction and Reuse

Infographic location: www.reuseconsulting.com


Take Buildings Apart, Sell The Parts (energy)
I Feel Bad For You!
1982 Average Energy Consumption per household 115 million BTUs x 80 million housing units = 9.2 trillion BTUs

vs
2009 Average Energy Consumption per household 90 million BTUs x 115 million housing units = 10.35 trillion BTUs

(eia.gov/todayinenergy/detail.php?id=6570)

Trends in Building
Trends in Building

Number of Buildings  | Quality of Materials
↓ ↑

Trends in Building

Number of Buildings  | Quality of Materials  | Ability to Recycle Materials
↓ ↓ ↓
The Cycle of Waste is Accelerating

Decon:

Trying to figure out how (not) to deconstruct a building
Design For Disassembly: Carnegie Mellon’s Solar Home

DFD: Post-Fabs
DFD: From Idea to Reality

RE-USE Consulting
Say “No!” To The Track-Hoe
Sustainable Alternatives to Demolition
Building Deconstruction—Material Salvage—Used Building Material Sales
Retrofitting Existing Municipal Buildings to ZNE: The City of San Diego “ZN3” Project

Kristin Larson, AICP and LEED Green Associate
October 10, 2019

“San Diego ZN3”
Three City of San Diego public libraries are undergoing an integrated demand-side management demonstration to achieve ZNE through cost-effective energy efficiency upgrades, on-site renewable generation, enhanced building automation, pre- & post-installation monitoring, and occupant behavior analysis in order to provide a blueprint that shows ZNE is possible in existing municipal buildings.

Project Summary
ZNE Goals

**California (CPUC Energy Efficiency Strategic Plan)**
- 50% of new major renovations to state buildings will be ZNE by 2025.
- 50% of commercial buildings will be retrofit to ZNE by 2030.

**City of San Diego**
- Reduce energy consumption at municipal facilities by 15% by 2020 and by 25% by 2035.

**SDZN3 Project**
- Achieve ZNE or near-ZNE at three existing libraries.
- Achieve maximum energy efficiency savings through cost-effective demand-side management technology testing and building monitoring.
- Demonstrate the City’s ability to deploy this initiative outside of traditional capital improvement processes.
- Create a replicable blueprint for other municipalities.
**Project ZNE Definition**

"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 Energy Commission'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,"  


CEC equation: \[ \text{Value of modeled energy consumed} - \text{net modeled energy produced} = 0 \]

The project is also evaluating ZNE site and ZNE source results.
Phase 1: Pre-retrofit
1. Perform building energy audits.
2. Identify & install end-use monitoring equipment needs.
3. Collect baseline end-use data.
4. Create energy models.
5. Perform pre-retrofit behavior analysis.
6. Identify, assess & design Energy Conservation Measures (ECMs), including pre-commercial technologies.

Phase 2: Construction
7. Select installation contractors.
8. Apply for permits.
10. Notify library occupants and patrons.
11. Install ECMs.
12. Perform Commissioning (Cx) & Retrocommissioning (RCx).
13. Integrate new & existing systems into building management system.

Phase 3: Post-retrofit
14. Collect 12 months of measurement and verification data.
15. Educate & train facility operators.
17. Evaluate project results and benefits.

ASHRAE Audit Findings

Valencia Park/Malcolm X Library
ZNE Verified (Public...)
Pre-Retrofit EUI Comparison (kBtu/ft²)
EUI 45

Serra Mesa-Kearny Mesa Library
Valencia Park/Malcolm X...
EUI 71

Point Loma/Hervey Library
CBECS (Public...)
EUI 65
Path to ZNE (Energy Conservation Measures)

<table>
<thead>
<tr>
<th>Energy Conservation Measure</th>
<th>Electricity Savings (kWh/yr.)</th>
<th>Total Energy Savings (kBtu/yr.)</th>
<th>Electricity Savings ($)</th>
<th>Peak Demand Savings (kW)</th>
<th>Est. Installation Costs* ($)</th>
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<tbody>
<tr>
<td>Lighting Retrofit</td>
<td>160,662</td>
<td>548,179</td>
<td>21,864</td>
<td>39.1</td>
<td>580,927</td>
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<td>Lighting Controls</td>
<td>24,528</td>
<td>83,690</td>
<td>2,908</td>
<td>6.5</td>
<td>150,000</td>
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<tr>
<td>HVAC Controls + Tridium Building Automation</td>
<td>38,813</td>
<td>135,365</td>
<td>7,124</td>
<td>33.3</td>
<td>195,000</td>
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<td>Plug Load Optimization: BERTBrain Plug Load Manager**</td>
<td>14,002</td>
<td>47,775</td>
<td>1485</td>
<td>4.3</td>
<td>10,000</td>
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<tr>
<td>Building Envelope: Window Film and Weatherization</td>
<td>1,699</td>
<td>6,090</td>
<td>274</td>
<td>0.7</td>
<td>7,000</td>
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<tr>
<td>TOTAL</td>
<td>239,704</td>
<td>821,099</td>
<td>33,655</td>
<td>83.9</td>
<td>942,027</td>
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</tbody>
</table>

* Does not include design, energy modeling and construction management costs
** Pre-commercial technology
Pre- & Post- Retrofit + PV EUI Comparison (kBtu/ft$^2$)

- **Serra Mesa-Kearny Mesa**: 65 EUI, 138.69 kW PV System, 15,626 sq. ft, Pre-retrofit
- **Valencia Park/Malcolm X**: 45 EUI, 138.69 kW PV System, 26,328 sq. ft, Pre-retrofit
- **Point Loma/Hervey**: 71 EUI, 84.42 kW PV System, 22,480 sq. ft, Pre-retrofit

Next Steps

- **Fall 2019 – Winter 2020** - - - Construction!
- **Spring 2020 – Spring 2021** - - - 12 Months Measurement & Verification
- **Spring 2021** - - - Final Report!

Check out project updates and resources at [www.energycenter.org/sdzn3](http://www.energycenter.org/sdzn3)
Lessons Learned for Future Existing Building ZNE Projects

• Know and stick to your ZNE definition.
• Know your delta to ZNE.
• Conduct pre-retrofit submetered monitoring.
• Isolate energy reductions by end-use to achieve maximum savings.
• Identify the right energy modeling tool for the project & perform additive modeling.
• Cyber security requirements - especially for public projects - will affect building automation decisions.
• Lighting upgrades and building controls are cost-effective ECMs for existing buildings but many emerging technologies are still cost-prohibitive.
• Best Practice: Perform 12 months of post-retrofit monitoring (don’t just rely on “ZNE design” to call it ZNE).
• Be adaptable and be prepared to learn new things. 😊

Additional Research Value of this Project

• Showcases a public, private and nonprofit partnership.
  ➢ Tested and implemented integrated project delivery and contracting.
• Retrofits existing buildings with unique building characteristics & approx. 10,000 visitors per month.
• Tests pre-commercial plug load management devices that are integrated into building management systems.
• Provides pre- and post-retrofit behavior surveys.
• Conducts knowledge transfer activities.
• All being done to create a blueprint for local governments!
Follow the Project

About the Libraries
Get Project Updates
Upcoming Presentations

Visit EnergyCenter.org/SDZN

RECIPE FOR NET ZERO ADAPTIVE RE-USE
SMITHGROUP SUSTAINABILITY MILESTONES

1993
U.S. Green Building Council founder

1998
First LEED Silver certification for a building

2006
Living Building Challenge recognized

2009
Living Building Challenge certified

2010
First LEED Platinum certification for a building

2012
First LEED Platinum certification for energy efficiency

2013
First LEED Platinum certification for water efficiency

2015
First LEED Platinum certification for materials

2016
First LEED Platinum certification for indoor air quality

2018
First LEED Platinum certification for social performance

Sacramento San Diego Phoenix San Francisco

DPR NATIONAL NET ZERO PORTFOLIO

2003
DPR LEED Silver
Sacramento Office was the first privately owned LEED certified building in California's Central Valley.

2010
DPR's San Diego office was the first commercial building to achieve both LEED-NC Platinum and net-zero energy status in San Diego.

2013
DPR's LEED-NC Platinum Phoenix office became the largest building in the world to achieve Net-Zero Energy Building certification from the International Living Future Institute.

2016
DPR's San Francisco office became the first certified net-zero energy commercial building in San Francisco.

Sacramento
San Diego
Phoenix
San Francisco
DPR NATIONAL NET ZERO PORTFOLIO

2016
DPR opened its net-zero energy design Washington, DC office in Reston, Virginia and became DPR’s first WELL certified building

2019
DPR opens its net-zero, LEED Platinum building. It is targeted to be the first WELL certified office in Austin

2019
The New Sacramento Office is DPR’s first ILFI Petal Certified building with Net Positive Energy. Also targeting LEED Platinum & WELL Certification.

2019
DPR opens its net-zero, LEED Platinum building. It is targeted to be the first WELL certified office in Austin

GETTING TO ZERO FORUM 2019

DPR NET ZERO ENERGY RECIPE


GETTING TO ZERO FORUM 2019
BEFORE / AFTER

GETTING TO ZERO FORUM 2019

NATURAL VENTILATION

Stack Ventilation/Thermal Chimneys

Operable Window Configuration

Wind Catchers

GETTING TO ZERO FORUM 2019
ENERGY EFFICIENCY MEASURES ANALYSIS

Recommended “Bundle”
- Roof: R-30 roof insulation
- Maximum 0.64 w/sf interior lighting
- Automatic daylighting control
- Exterior lighting: 30% Reduction (1.0 kW)
- Plug loads consistent with DPR San Diego
- VRF or heat pump to temper OA
- Natural Ventilation

Results
- 135,000 kWh/yr consumption
- Site EUI of 30 kBTU/sf-yr
- 100 kW DC for ZNE (including 10% Buffer)
- Reduced consumption by 60,000 kWh/yr & PV by 43 kW DC relative to Base Design.
ENERGY EFFICIENCY MEASURES ANALYSIS

CONTRIBUTING FEATURES IN REDUCTION

- Thermal labyrinth ventilation system (TLVS) to pre-condition air
- Energy recovery ventilator (ERV) to further pre-condition air
- Variable Flow Temperature (VRT) HVAC system
- Ventilation decoupling from VRT system
- Lighting power density (LPD) 0.35 w/sf
- No vampire switch: self-sensing with daylight harvesting, local dimming, local occupancy sensors tied into lighting & plug load
- New R-30 roof
- Dual-pane low-e glazing with thermally broken frames
- Future infrastructure setup for peak demand shaving when market ready

NET POSITIVE ENERGY

REVEAL.
1. Air Enters Exterior Louver
2. Moves Through 1st Half
3. Moves Through 2nd Half
4. Moves Up Internal Shaft
5. Is Further Conditioned by HVAC System

Ave Pre-Cooling During Summer Days | w/ Night Flush | During Peak Summer Days (105 °F) | Ave Pre-Heating During Winter Days

- 3.5°F
- 7°F
- 14°F
- 12°F
PV - SOLATUBE
FOUR UNIQUE USES/INSTALLATIONS OF PV

BEFORE / AFTER
ALL NATURAL LIGHT: SOLATUBES AND ENLARGED GLAZING
**Daylighting**

- Rooftop solar tube fixtures (Solatubes)
- Rooftop daylight harvesting light wells
- Daylight and Views Strategy, Utilizing Glass Fronts for all Conference Rooms
- Window Glass, Minimize Glare, and Radiant Heat from Direct Sunlight
- White countertop surfaces, and acoustical ceiling clouds to extend daylight further into space

**Energy**

- High efficiency and LED fixtures
- Low Energy or Energy Star Equipment
- Single Extra Wide Monitors ILO Dual Monitors at Workstations
- WELL Circadian Lighting and Visual Balance
## NET ZERO STRATEGIES

### Energy Consumption Awareness

<table>
<thead>
<tr>
<th>Strategy</th>
<th>DPR San Francisco</th>
<th>DPR Phoenix</th>
<th>DPR Washington DC</th>
<th>DPR Sacramento</th>
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</thead>
<tbody>
<tr>
<td>Energy End-Use Measurement Submeters</td>
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<tr>
<td>Building Energy Use Dashboard Display (Lucid Designs)</td>
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<tr>
<td>Occupant Plug Load Management &amp; Measurement System</td>
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### Onsite Renewable Energy Generation

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<tr>
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<tbody>
<tr>
<td>Rooftop Photovoltaic (PV) Solar Array</td>
<td>●</td>
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<tr>
<td>Rooftop Solar Water Heating Array</td>
<td>●</td>
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<tr>
<td>Shaded Parking Photovoltaic (PV) Solar Array</td>
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<tr>
<td>Onsite Battery Backup for Resiliency</td>
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### Design

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<th>Strategy</th>
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<th>DPR Washington DC</th>
<th>DPR Sacramento</th>
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</thead>
<tbody>
<tr>
<td>Extensive energy Modeling</td>
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<td></td>
<td></td>
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<tr>
<td>3rd Party HVAC/Electrical Consultant</td>
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</table>

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## NET ZERO STRATEGIES

### Controls and Building Management

<table>
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<tr>
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<th>DPR Washington DC</th>
<th>DPR Sacramento</th>
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</thead>
<tbody>
<tr>
<td>Passive Infra-Red Occupancy Controls</td>
<td>●</td>
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<tr>
<td>Time Controls and Shut-Offs</td>
<td>●</td>
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<tr>
<td>Integrated Building Management System</td>
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<tr>
<td>Non-Occupied Energy Circuit Shut-Off – Phantom Load Management Switch</td>
<td>●</td>
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</table>

### HVAC

<table>
<thead>
<tr>
<th>Strategy</th>
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<th>DPR Phoenix</th>
<th>DPR Washington DC</th>
<th>DPR Sacramento</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated Outdoor Air System w/ Water Source Heat Pump/Heat Recovery Chiller &amp; Fan Powered Terminal Units served by a four pipe system.</td>
<td>●</td>
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<tr>
<td>Utilization of Several Energy Efficient Heating/Cooling Radiant Sails</td>
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<tr>
<td>Set Points Established on Dew-point, Not Just Temp.</td>
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<tr>
<td>Simultaneous Energy Recovery from Hot and Cold Water Loops Design - Collaborative Process</td>
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<tr>
<td>Thermal Labyrinth – Collaborative Process</td>
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### NET ZERO STRATEGIES

#### HVAC

<table>
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<tr>
<th>Strategy</th>
<th>San Francisco</th>
<th>Phoenix</th>
<th>Washington DC</th>
<th>Sacramento</th>
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<tr>
<td>Expanded Occupancy Thermal Comfort</td>
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<tr>
<td>Enhanced air circulation – High Volume, Low velocity ceiling fans (Big Ass Fans)</td>
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<tr>
<td>Passive ventilation</td>
<td>●</td>
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<tr>
<td>Evaporative Cooling – Shower Towers</td>
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<tr>
<td>Natural Ventilation – Operable Windows and Rooftop Monitors – Solar Chimney</td>
<td></td>
<td>●</td>
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<tr>
<td>Exterior Window Shading / Treatments – Green Screens</td>
<td></td>
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<tr>
<td>Indoor Landscaping (Biophilia)</td>
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<td>●</td>
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</table>
Current State of Deep Energy Retrofits

- We can do them, but... they take
  - A lot of **TIME**
  - A lot of **MONEY**
  - A lot of **EFFORT**
  - A lot of **PEOPLE**
  - A lot of **COORDINATION**
  - A lot...
  - A lot...
  - A lot...
Current State of Deep Energy Retrofits

LIWP Projects Average Energy Savings: 42%, with some projects achieving ZNE and close to ZNE (80%+)

Typical Project Timeline: 1-2 years from initial outreach to construction completion.

Average Incentive Contribution: $3500-$4000/unit
Average Total Project Cost: $7600/unit

Deep Energy Savings LIWP Project Example

PROPERTY INFORMATION
- Located in McLean, CA; built in 1995
- 52 units, 57,189 sq. ft.
- Existing DHW: Unitary gas non-condensing tank - switched to heat pump water heaters
- Existing HVAC: Unitary gas forced air furnace with A/C - switched to inverter driven heat pumps

SCOPE OF WORK
- Energy Efficiency
  - Heat Pump Water Heaters (electrification scope)
  - Inverter Drive Heat Pumps (electrification scope)
  - Ductwork Asealing
  - Attic Air Sealing and Insulation
  - New ENERGY STAR Washing Machines and Refrigerators
  - Dual Pane Windows
  - Comprehensive LED Upgrade
  - Low-Flow Aerators and Showerheads
- Renewable Energy
  - 37.3 kW solar PV array, 90% allocated to tenant meters

MONTHLY ENERGY USE
- Projected Solar PV
- Natural Gas
- Electricity

79% Energy Savings
83% Utility Cost Savings
Piecemeal Retrofits

The Solution
ENERGIESPRONG: A MODEL OF INSPIRATION

Core offering: A net zero carbon retrofit bundle that is 1) affordable, 2) attractive, 3) ensures energy performance, and 4) can be delivered in less than two weeks.

- **QUALITY**: Net-zero energy homes with long performance warranties
- **NON-INTRUSIVE**: Refurbishment within a week to 10 days
- **AFFORDABLE**: Financeable through energy cost savings
- **LOOK & FEEL**: Attractive and comfortable homes

FACADE PANELS: A VARIETY OF SOLUTIONS
FACADE INSTALLATION SITE PRE-WORK

RENO LUTION PROJ ECT
Packaged Mechanical Systems

- Designed, configured, assembled offsite
- Delivered on skids
- Final product

Mechanical Systems

- PV Inverter
- Heat Pump (for DHW and space heating)
- Control Board and Thermostat
- Plumbing (behind control board and ducting)
- DHW Tank
- ERV
FACTORY ZERO INTEGRATED CLIMATE ENERGY MODULE (iCEM)

PERFORMANCE MONITORING STRUCTURE
Concepts to Adapt from Energiesprong Model

• **Design** - develop scalable systems, focusing on unitized yet customizable panels

• **Building science** - improve on building science while also embracing Dutch spirit of learning through implementation

• **Foster innovation** - Develop multiple solution types

• **Tenant engagement** - set expectations on total delivery time and collaborate with tenants during planning phase

---

Project Steps

**Technical Solutions**
- Building Characterization/Typology
- Emerging Technology Assessment
- Development of Retrofit Packages
- Prototype/Constructability Testing
- Demonstration Projects (design, install, QA/commissioning, EM&V) of industrialized retrofit packages

**Market Solutions**
- Market Characterization
- Stakeholder Convening’s
- Business Plan
- Energy Plan
- Financing Tools
- Market Scaling
- Aggregated Demand
- Technology Transfer
Thank You!
Andy Brooks
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abrooks@aea.us.org