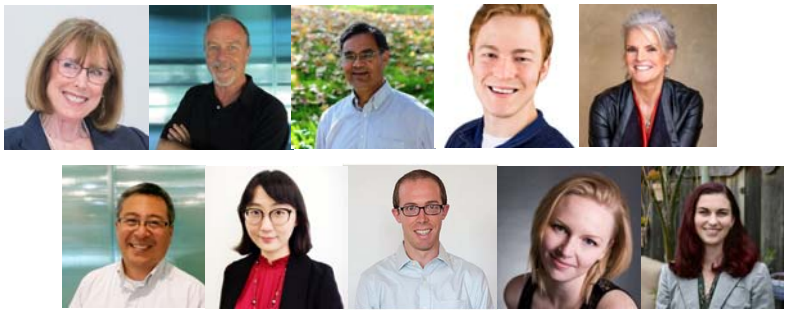
Getting to Zero Forum

Oakland, CA
October 10, 2019

PROSPECT Silicon Valley

About ProspectSV



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

PROSPECT Silicon Valley

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

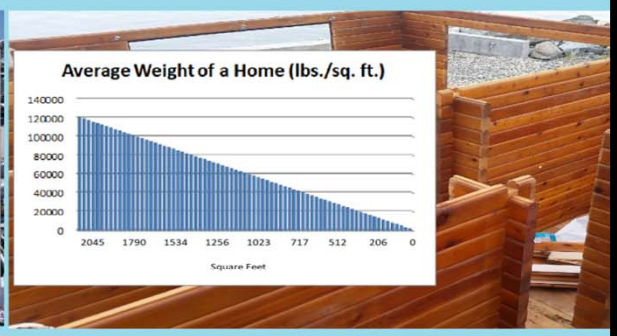
CalOp ACE

REALIZE

The ~~Next~~ First Big Thing: Building Deconstruction / Reuse

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

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

The average American home over the last 50 yrs. is 2000 sq ft + weighs about 60 pounds/sq ft

That adds up to about 120,000 lbs per home

RE-USE Consulting

Infographic location: www.reuseconsulting.com

https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/

https://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf

Take Buildings Apart, Sell The Parts (energy)

I Feel Bad For You!

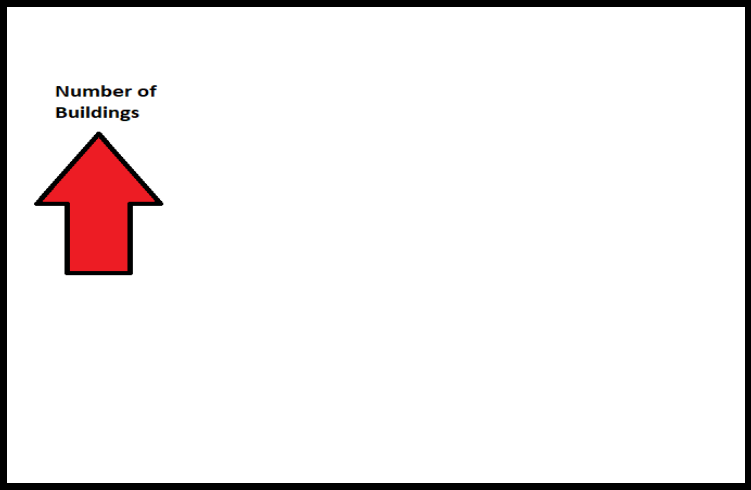
1982 Average Energy Consumption per household 115 million BTUs x 80 million housing units = 9.2 trillion BTUs

vs

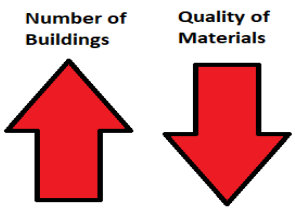
2009 Average Energy Consumption per household 90 million BTUs x 115 million housing units = 10.35 trillion BTUs

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

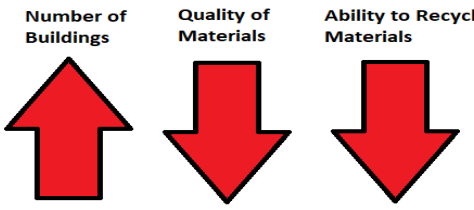
Trends in Building



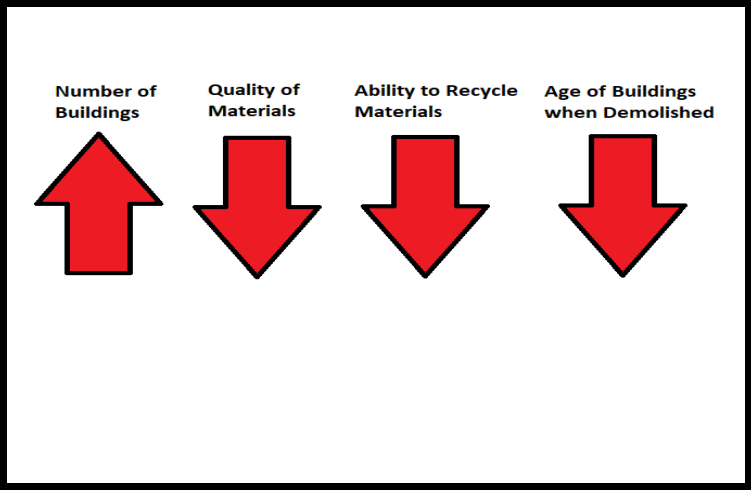
Trends in Building



Trends in Building

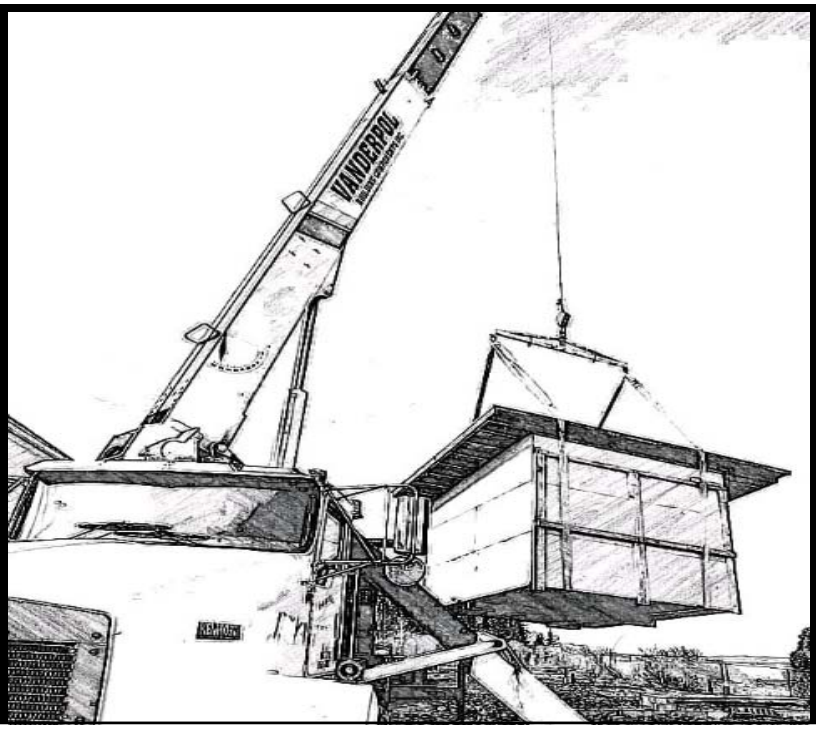


The Cycle of Waste is Accelerating



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

Center for Sustainable Energy™

"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

Project Sites

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 Team

Funder

Center for Sustainable Energy™

Prime

The City of SAN DIEGO

Site Host & Sponsor

SDGE A Sempra Energy utility

Emerging Technologies

MAZZETTI

Design and Construction

SAN DIEGO GREEN BUILDING COUNCIL

Education and Outreach

ABM Building Value

Baseline Monitoring & Lighting Upgrades

CLIMATEC MERGING BUILDINGS & TECHNOLOGY

HVAC Controls & Building Automation Upgrades

lucid

Data Visualization

BERT

Plug Load Management

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," (2013 Energy Commission Integrated Energy Policy Report, CEC)

CEC equation: [Value of modeled energy consumed] – [net modeled energy produced] = ≤0

The project is also evaluating ZNE site and ZNE source results.

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Getting to Zero

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.
9. Procure equipment.
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.
16. Complete post-retrofit occupant behavior analysis.
17. Evaluate project results and benefits.

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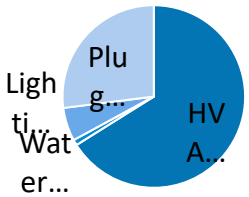
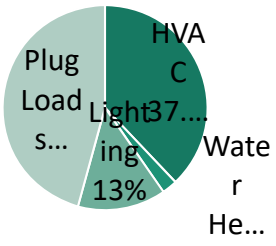
ASHRAE Audit Findings

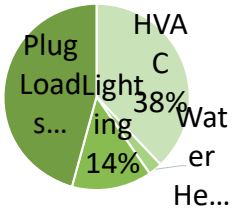
kBtu by End Use



Valencia Park/Malcolm X Library

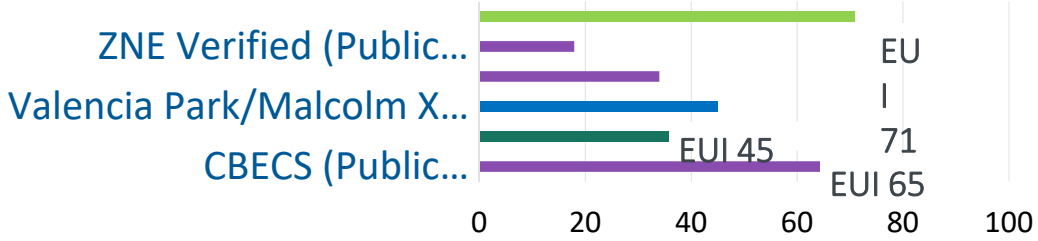


Serra Mesa-Kearny Mesa Library



Point Loma/Hervey Library

Pre-Retrofit EUI Comparison (kBtu/ft^2)



Integrated Demand-Side Management and Solar PV

HVAC Controls

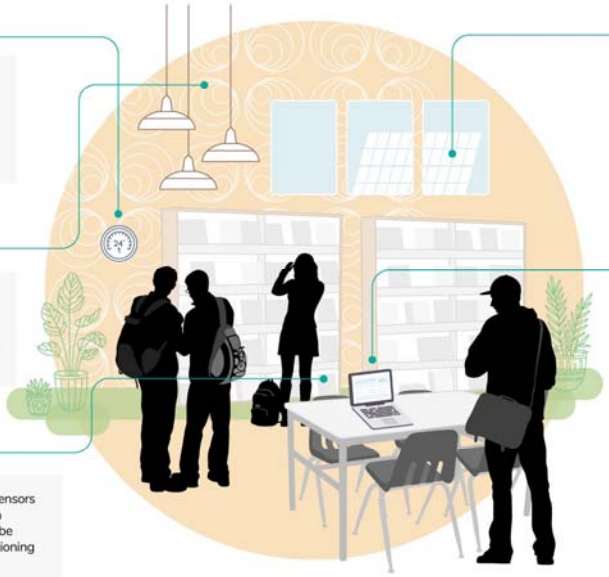
Heating, ventilation and air conditioning (HVAC) controls include sensing and control devices that compare and adjust the actual temperature and air flow to a target state. Automatic setback thermostats program this process, providing both comfort and convenience without using unnecessary energy.

LED Lighting and Lighting Controls

Light-emitting diode (LED) products are more versatile, last longer and are 90% percent more efficient than incandescent lightbulbs. LEDs work by passing an electrical current through a microchip, which illuminates the tiny light sources, resulting in visible light.

Energy End-use Monitoring Equipment

Energy end-use monitoring systems are measurement sensors that track energy consumption patterns of a building at a granular level. The installed sensors allow energy use to be broken down between heating, ventilation and air conditioning (HVAC), lighting, office equipment and other usages.



Solar photovoltaic

Solar photovoltaic (PV) systems, also referred to as solar electric systems, capture sunlight energy and convert it into electricity. PV systems can be used to power everything in your home from lights and appliances to an electric vehicle.

Building Automation Systems

A building automation system (BAS) allows for the centralized control and monitoring of mechanical and electrical equipment, resulting in improved overall efficiency, lower operating costs and increased safety. BAS controls are usually implemented in large-scale projects with extensive mechanical and electrical systems that would be difficult to coordinate manually.

Path to ZNE (Energy Conservation Measures)

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

* Does not include design, energy modeling and construction management costs

** Pre-commercial technology

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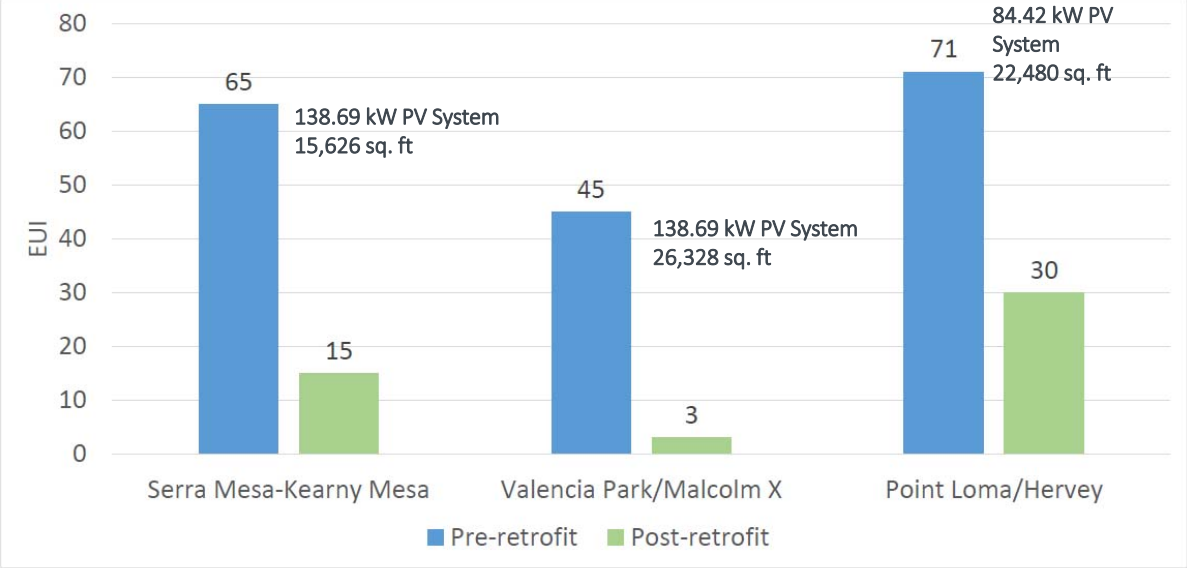
Pre- & Post- Retrofit + PV EUI Comparison (kBtu/ft^2)



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

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

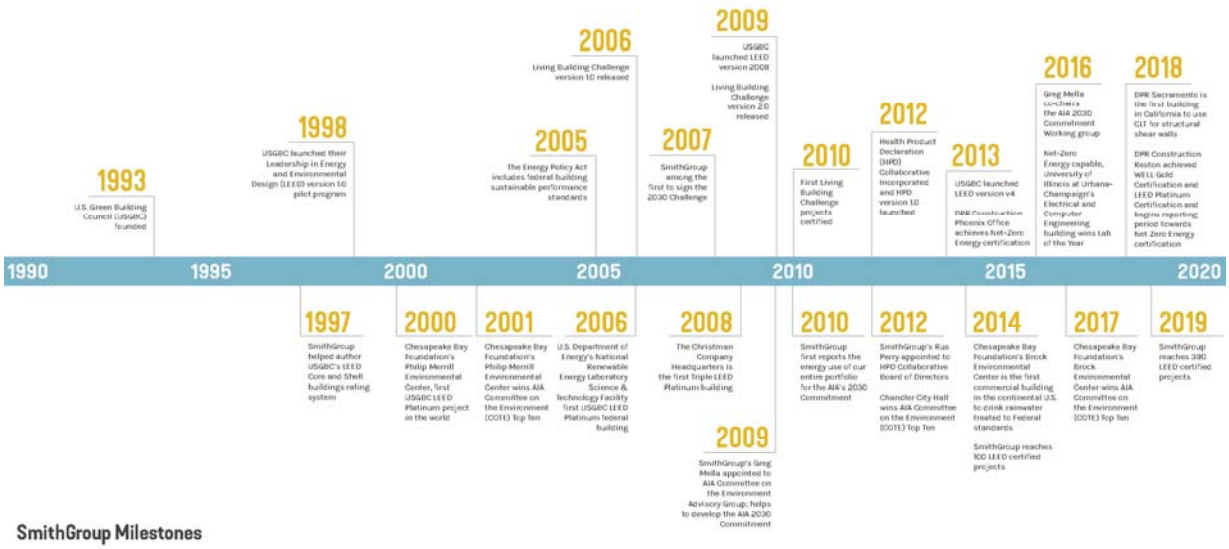
About the Libraries

Get Project Updates

Upcoming Presentations

Visit
EnergyCenter.org/SDZN3

SMITHGROUP SUSTAINABILITY MILESTONES



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DPR NATIONAL NET ZERO PORTFOLIO

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

Sacramento

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

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

Phoenix

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

San Francisco

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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

Washington, DC

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

Austin, TX

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

Sacramento, CA

???
Next great thing to be designed/built for a better future in a town near you!

Anytown, USA

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DPR NET ZERO ENERGY RECIPE

Net-Zero Energy features, clockwise from top left: **1**. Rooftop photovoltaics **2**. Solatubes **3**. Expansive windows **4**. Rooftop solar thermal water heating system **5**. Solar chimney **6**. LED lighting **7**. AER-DEC sink / ultra low flush plumbing fixtures **8**. Living walls with live plants **9**. Building performance monitoring **10**. Big Ass fans **11**. Vampire shutoff switch **12**. Operable windows and roll-up doors for fresh air and natural light

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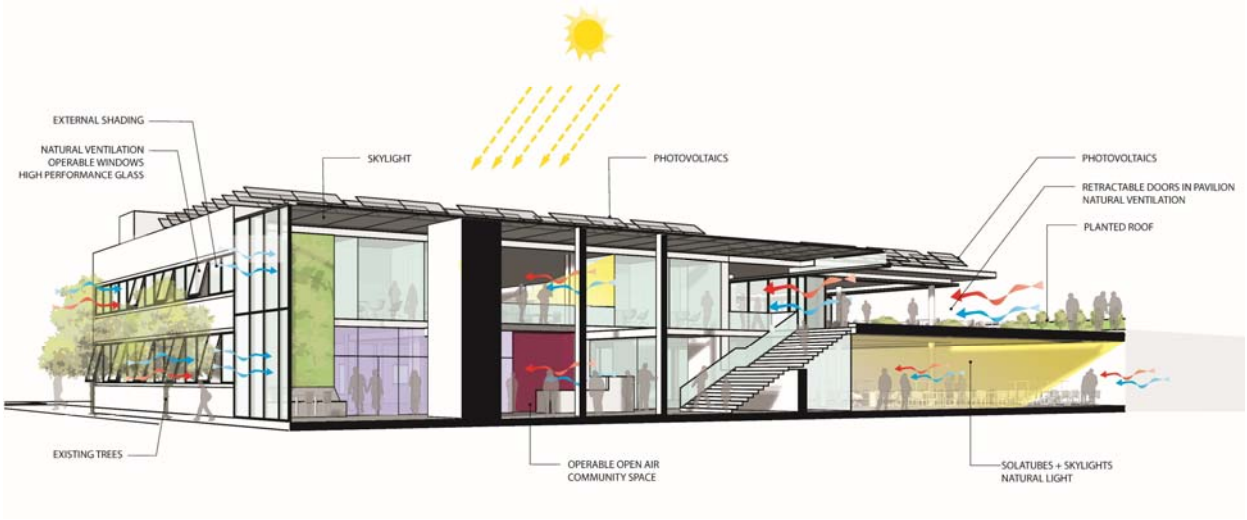
DPR SACRAMENTO STRATEGIES



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DPR SACRAMENTO STRATEGIES

1. **Existing Trees** - Trees preserved, used for shading interior
2. **Solar Tubes** - Tubular skylights were installed on the new and old roofs to maximize filtered daylight reducing reliance on artificial lighting.
3. **Operable Windows with High-Performance Glazing** - all glazing in existing building replaced to high performance
4. **Exterior Sun-Shading**
5. **Vegetated Roof and shaded roof terrace** - A new rooftop terrace creates a parklike space for work or respite.
6. **Retractable Wall/ Door**
7. **Mass Timber Construction Addition** - This low-carbon, low-toxin material creates a sleek, serene environment and improves indoor air quality. First use of CLT shear walls in CA.
8. **Adaptive Reuse of Existing Building** - A 1940s era building, once a vehicle testing facility, has been converted in a model of efficiency and community resilience.
9. **Seed Wall**
10. **Thermal Labyrinth** - Ventilation system conditions the building by drawing outdoor air through a concrete maze located in the existing basement. Through heat exchange with the ground, outdoor air is pre-cooled and pre-heated in the summer and winter seasons, respectively.
11. **Red/Green Light Indictor Operable Windows**-indicator lights are controlled by the BMS and will leverage public data from the air quality sensors installed at California's Air Quality Board building which is located within 1 mile of the project.
12. **New Communicating Stair** - to encourage active design/ connection to community
13. **Lucid Dashboard** - DPR can view, compare and share energy and water use data in real-time. Staff can assess energy consumption rates and adjust practices, as required, encouraging employees to actively participate in maintaining the building's functionality.
14. **Photovoltaics** -new photovoltaic panels were integrated in a-typical locations--above the rooftop terrace, existing/ new roof and carport, offsetting all operational energy on a annual basis resulting in a net-positive energy facility.
15. **Rightsized & Flexible Workspace** - DPR's agile workspace reflects its family-like culture, rightsized to flexibly accommodate employees that spend more time at job sites than in the office and to encourage collaboration.
16. **Biophilia** – From exposed woodgrain panels, to sculptural 'grow columns,' a seed wall, abundant plantings, and oversized sliding windows, the design creates a soothing environment that brings users closer to nature.
17. **Certifications** - The project is targeting LEED Platinum (Interior) and Gold (Core+Shell) certification, WELL v2, REVEAL, fitwel, Energy Star, and ILFI's Zero-Net Energy certification.

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BEFORE / AFTER

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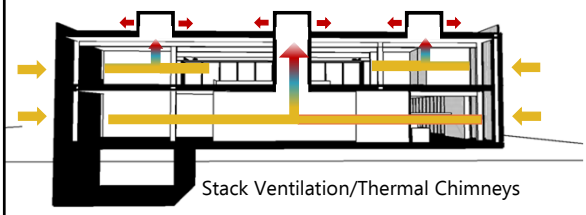
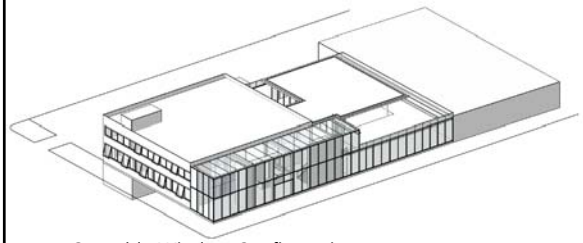
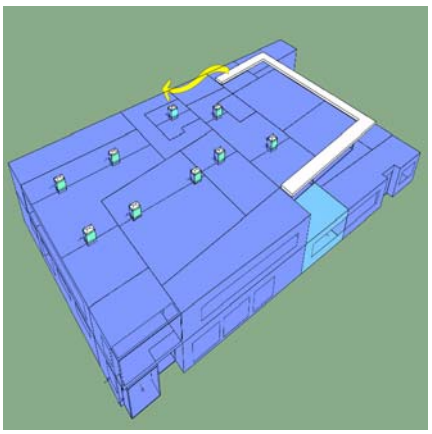
NATURAL VENTILATION

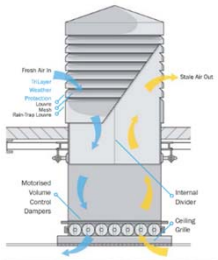


Stack Ventilation/Thermal Chimneys



Operable Window Configuration





Wind Catchers

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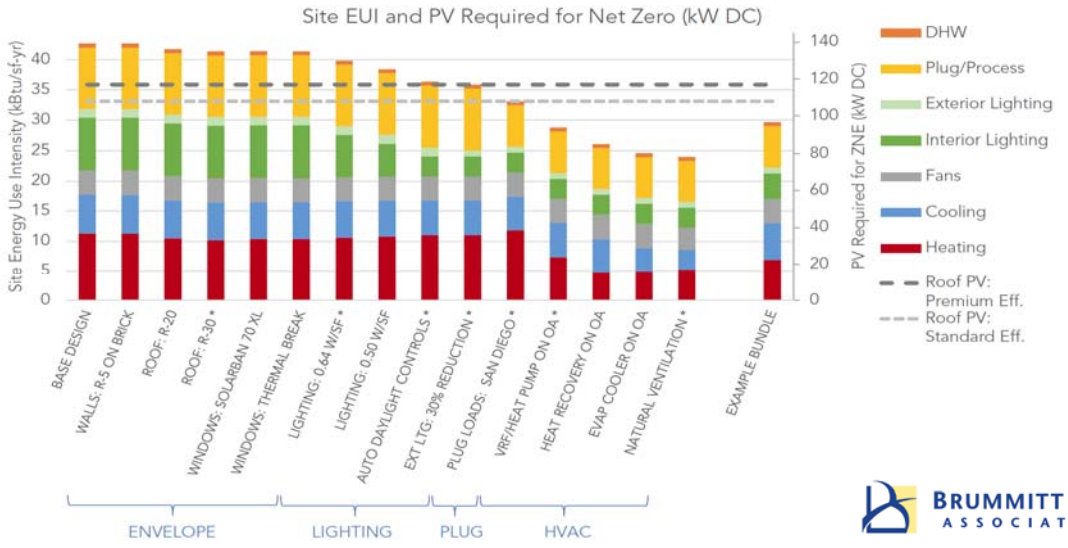
ENERGY EFFICIENCY MEASURES ANALYSIS



BRUMMITT ENERGY ASSOCIATES INC

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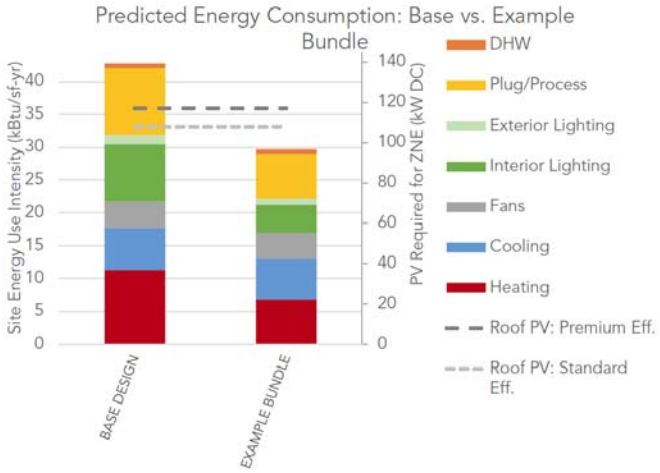
ENERGY EFFICIENCY MEASURES ANALYSIS

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.



BRUMMITT ENERGY ASSOCIATES INC

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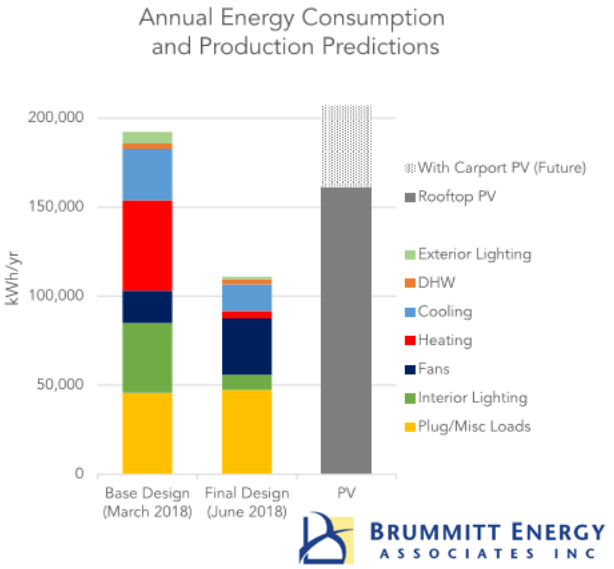
ENERGY EFFICIENCY MEASURES ANALYSIS

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



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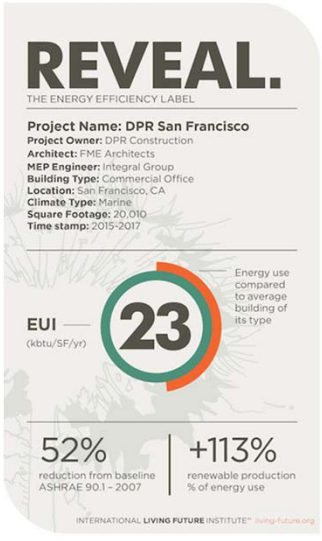
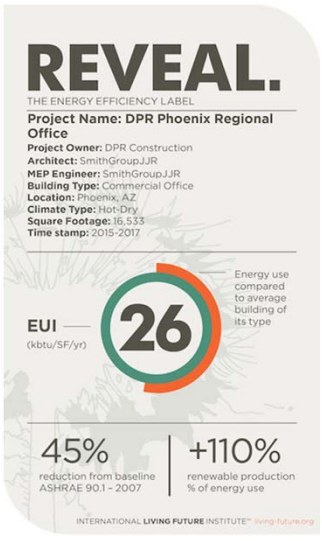
NET POSITIVE ENERGY

REVEAL





Project Name: DPR Sacramento
Project Owner: DPR Construction
Architect: SmithGroup
Mechanical Engineer: Lawson Mechanical
Electrical Engineer: Evergreen Innovation Group
Building Type: Commercial Office
Location: Sacramento, CA
Climate Type: Marine
Square Footage: 34,508
Time Stamp: 2020-2022

45%
Reduction from baseline ASHRAE 90.1 - 2007

+107%
Renewable production % of energy use

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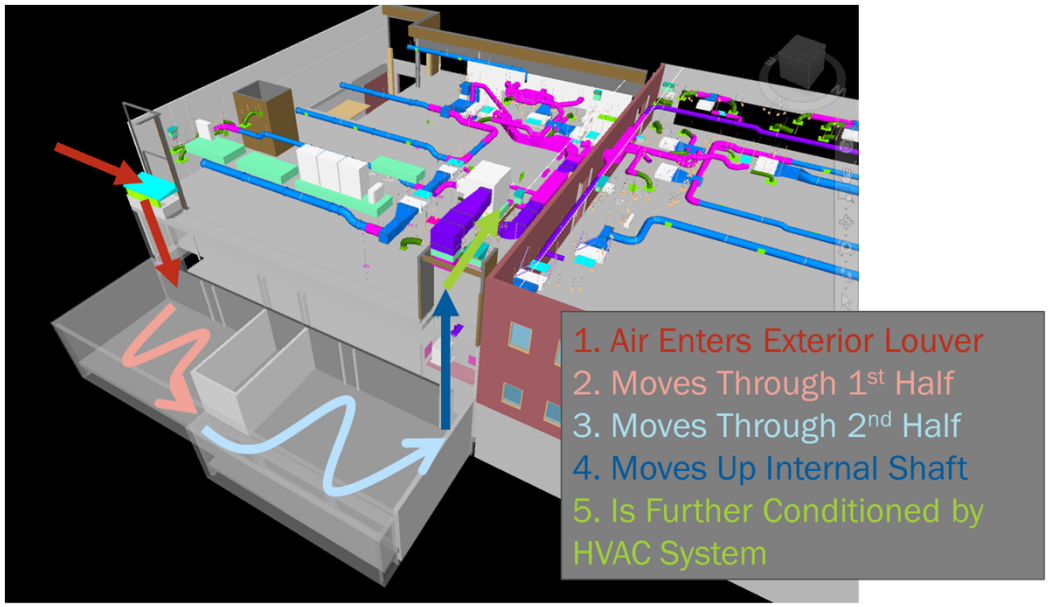
THERMAL LABYRINTH



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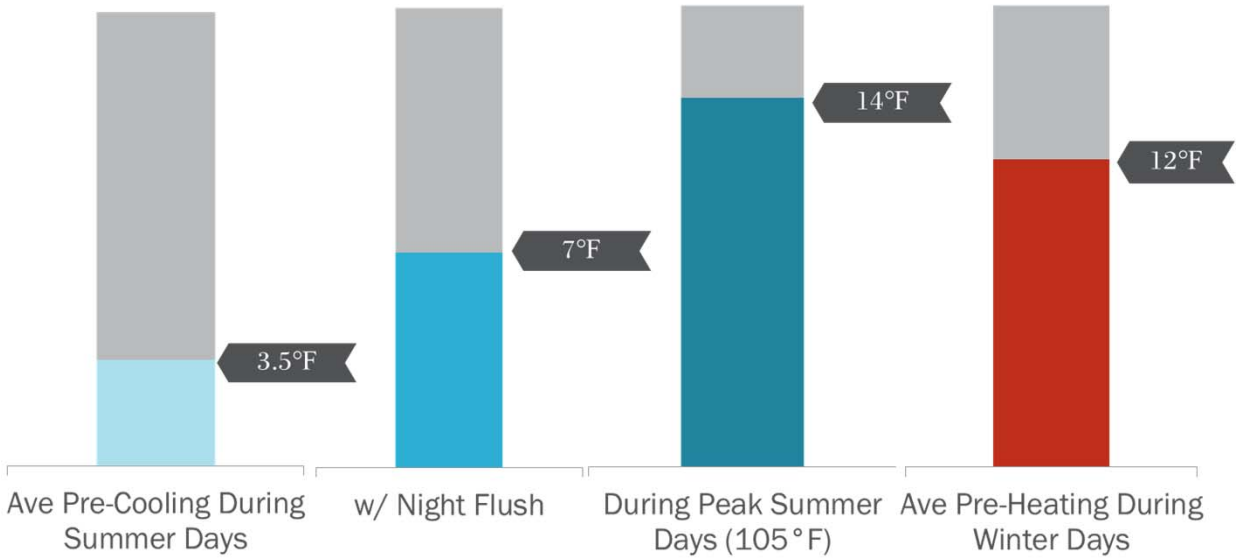
THERMAL LABYRINTH



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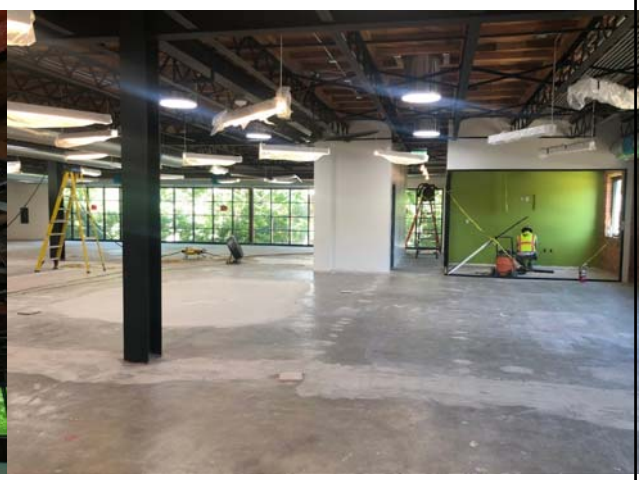
PV – SOLATUBE

FOUR UNIQUE USES/ INSTALLATIONS OF PV

BEFORE / AFTER

ALL NATURAL LIGHT: SOLATUBES AND ENLARGED GLAZING



MASS TIMBER

CARBON ESTIMATOR

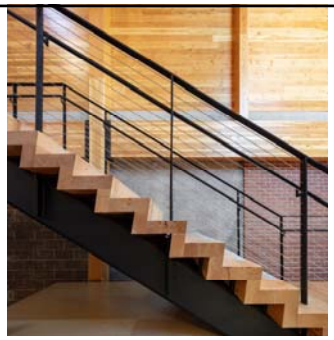
RESULTS

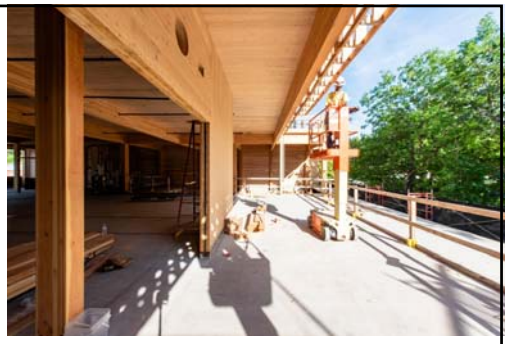
- Volume of wood products used: 70 cubic meters (2,432 cubic feet)
- U.S. and Canadian forests grow this much wood in: 12 seconds
- Carbon stored in the wood: 55 metric tons of carbon dioxide
- Avoided greenhouse gas emissions: 115 metric tons of carbon dioxide
- Total potential carbon benefit: 170 metric tons of carbon dioxide

EQUIVALENT TO…

- 33 cars off the road for a year
- Energy to operate 14 homes for a year

*Source: WoodWorks Wood Products Council





DPR CONSTRUCTION SMITHGROUP

NET ZERO STRATEGIES

		DPR San Francisco	DPR Phoenix	DPR Washington DC	DPR Sacramento
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				●

DPR CONSTRUCTION SMITHGROUP

NET ZERO STRATEGIES

		DPR San Francisco	DPR Phoenix	DPR Washington DC	DPR Sacramento
Energy Consumption Awareness	Energy End-Use Measurement Submeters	●	●	●	●
	Building Energy Use Dashboard Display (Lucid Designs)	●	●	●	●
	Occupant Plug Load Management & Measurement System	●		●	●
Onsite Renewable Energy Generation	Rooftop Photovoltaic (PV) Solar Array	●	●	●	●
	Rooftop Solar Water Heating Array	●		●	
	Shaded Parking Photovoltaic (PV) Solar Array		●		●
	Onsite Battery Backup for Resiliency				●
Design	Extensive energy Modeling			●	●
	3rd Party HVAC/Electrical Consultant			●	●

DPR CONSTRUCTION SMITHGROUP

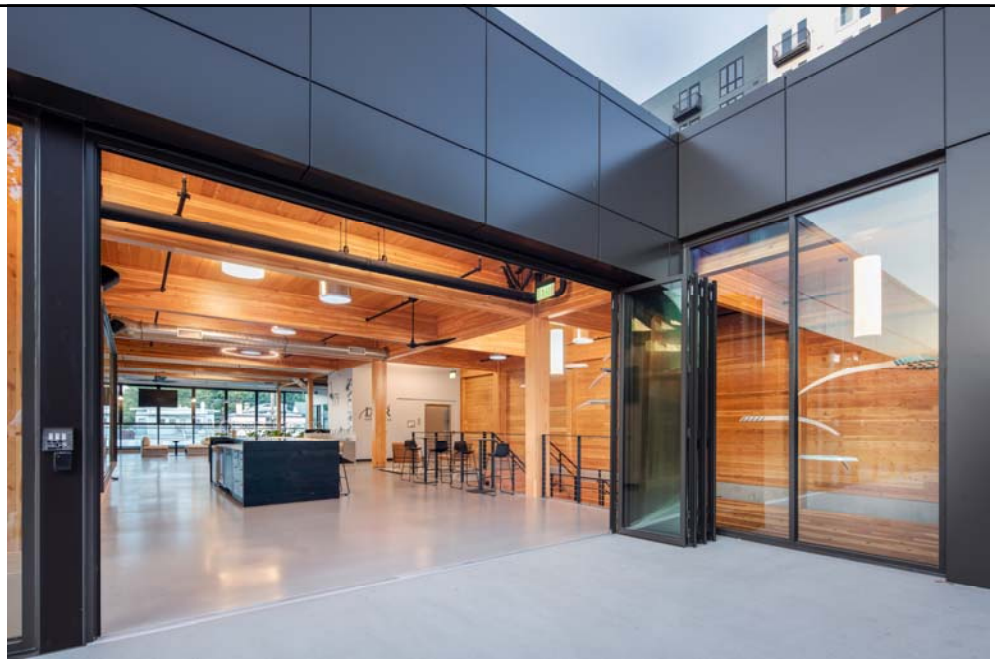
NET ZERO STRATEGIES

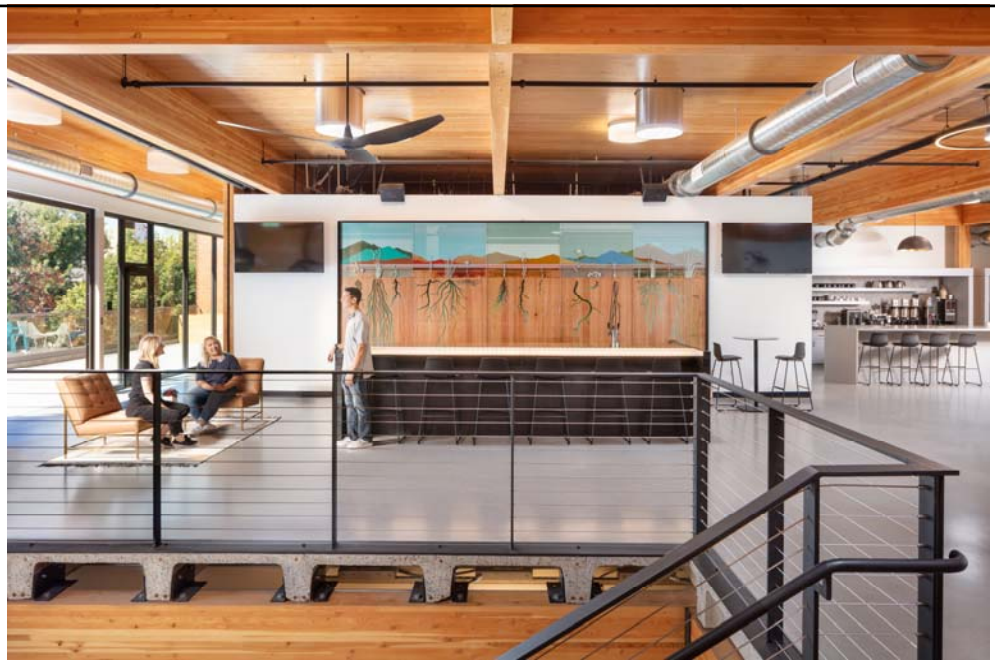
		DPR San Francisco	DPR Phoenix	DPR Washington DC	DPR Sacramento
Controls and Building Management	Passive Infra-Red Occupancy Controls	●	●	●	●
	Time Controls and Shut-Offs	●	●	●	●
	Integrated Building Management System	●	●	●	●
	Non-Occupied Energy Circuit Shut-Off – Phantom Load Management Switch	●	●	●	●
HVAC	Dedicated Outdoor Air System w/ Water Source Heat Pump/Heat Recovery Chiller & Fan Powered Terminal Units served by a four pipe system.			●	●
	Utilization of Several Energy Efficient Heating/Cooling Radiant Sails			●	
	Set Points Established on Dew-point, Not Just Temp.			●	
	Simultaneous Energy Recovery from Hot and Cold Water Loops Design - Collaborative Process			●	
	Thermal Labyrinth – Collaborative Process				●

DPR CONSTRUCTION SMITHGROUP

NET ZERO STRATEGIES

		DPR San Francisco	DPR Phoenix	DPR Washington DC	DPR Sacramento
HVAC	Expanded Occupancy Thermal Comfort	●			●
	Enhanced air circulation – High Volume, Low velocity ceiling fans (Big Ass Fans)	●			●
	Passive ventilation	●			●
	Evaporative Cooling – Shower Towers		●		
	Natural Ventilation – Operable Windows and Rooftop Monitors – Solar Chimney		●		●
	Exterior Window Shading / Treatments – Green Screens		●	●	●
	Indoor Landscaping (Biophilia)	●	●	●	●





ASSOCIATION FOR ENERGY AFFORDABILITY INC.

REALIZE: CalRetro

Mass Deployment Model for ZNC Retrofits of Low-income Multifamily Buildings

Andy Brooks
Direct, West Coast Operations
Association for Energy Affordability
October, 2019

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

79% Energy Savings

83% Utility Cost Savings

PROPERTY INFORMATION

- Located in McFarland, CA; built in 1995
- 52 units, 57,716 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

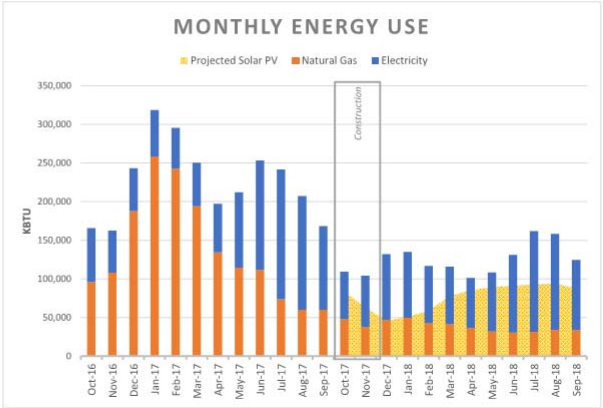
SCOPE OF WORK

Energy Efficiency

- Heat Pump Water Heaters (electrification scope)
- Inverter Drive Heat Pumps (electrification scope)
- Ductwork Aerosealing
- 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

- 171.2 kW solar PV array, 90% allocated to tenant meters



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

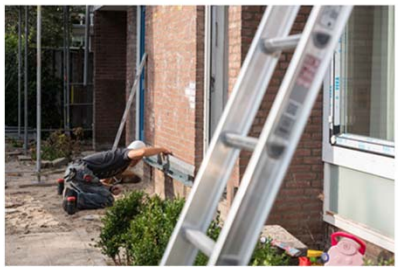
LOOK & FEEL

Attractive and comfortable homes

FACADE PANELS: A VARIETY OF SOLUTIONS

FACADE INSTALLATION SITE PRE-WORK






RENOLUTION PROJECT





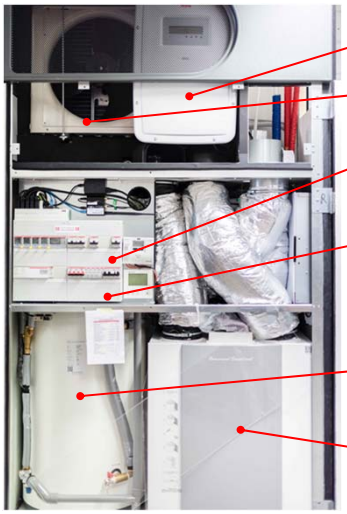
Packaged Mechanical Systems

Designed, configured, assembled offsite

Delivered on skids

Final product

Mechanical Systems



PV Inverter

Heat Pump (for DHW and space heating)

Control Board and Thermostat

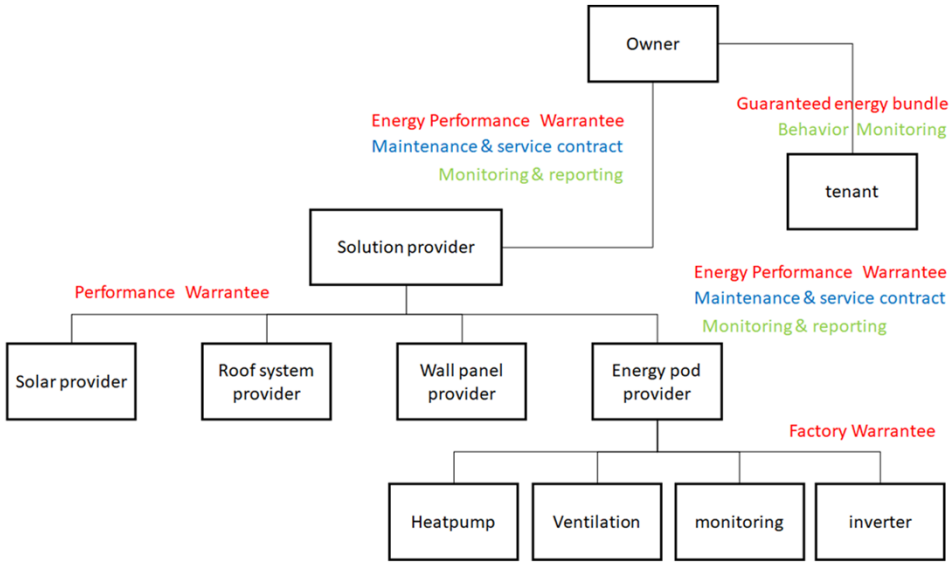
Plumbing (behind control board and ducting)

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

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Thank You!

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