New Challenges in Net Zero Design
July 16, 2014

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The David and Lucile Packard Foundation
New Challenges in Net Zero Design
NBI Webinar | July 16, 2014

Brad Jacobson, AIA, LEED AP BD+C
New Challenges

1. What’s Your EUI?
2. Push the Envelope
3. Count Every Watt
4. Expect the Unexpected
The David & Lucile Packard Foundation
Los Altos, California

Year Completed: 2012
Size: 49,000 SF
Largest Certified Net Zero Energy Building (ILFI)
LEED Platinum certified (2009)
New Challenges in Net Zero Design | 07-16-14

NET ZERO ENERGY
285 kW PV array provides 100% of net annual energy

GREEN STREETS
Rain gardens filter street runoff

PARKING REDUCTION
67 parking spaces meet demand, instead of 160 required by code

SOLAR CONTROL
Layered sunshading, including dynamic blinds, protects southwest exposure

“CALIFORNIA LIVING”
Collaborative central courtyard is focal point and heart of the building

NARROW BUILDING
40’ width maximizes daylighting and natural ventilation

EFFICIENT SYSTEMS
Chilled beams allow 75% reduction in fan energy with 100% outside air delivery

BIOPHILIA
Green roof provides habitat and enhances views from interior

CLIMATE-RESPONSIVE COOLING
Compressor-free cooling tower feeds 50,000 gallon chilled water storage

OPTIMIZED ENVELOPE
Triple-glazed windows; and reduced thermal bridging shrink heating demand

TOWARDS ZERO WATER
Rainwater is captured in a 20,000 gallon cistern, reducing potable water demand by 69%
New Challenges

1. **What’s Your EUI?**
2. **Push the Envelope**
3. **Count Every Watt**
4. **Expect the Unexpected**
Finding the Right Benchmark Data

Row House Annual Primary Energy Use
(All Values Scaled to Green Dorm)

- Average row house primary energy use = 1,750 MMBtu
- Green Dorm primary energy use predicted to be 57% below average existing row house

On-site energy generation offsets all of building primary energy use

Courtesy of Taylor Engineering
Define Peer Group

Select floor area, vintage, and location.

FLOOR AREA
- All sizes
- 0 - 2500 sq. ft.
- 2500 - 15000 sq. ft.
- over 15000 sq. ft.

VINTAGE
- All years
- 1991 - Present
- 1979 - 1990
- 1941 - 1978
- 1901 - 1940
- Pre-1900
- Unknown

LOCATION [MAP]
- All Locations
- Central Coast
- Central Valley
- Desert
- Mountains
- North Coast
- South Coast
- South Inland

Then, select your building types.

OFFICE
- Administration and Management
- Financial/Legal
- Insurance/Real Estate
- Government Services
- Software Development
- Medical/Dental Office
- Assorted/Multi-tenant
- Other Office

WAREHOUSE
- Refrigerated
- Unconditioned Warehouse High Bay
- Unconditioned Warehouse Low Bay
- Conditioned Warehouse High Bay
- Conditioned Warehouse Low Bay

WAREHOUSE (NON-REFRIGERATED)
- Unconditioned Warehouse High Bay
- Unconditioned Warehouse Low Bay
- Conditioned Warehouse High Bay
- Conditioned Warehouse Low Bay

HEALTHCARE
- Hospital
- Nursing Home
- Clinic/Outpatient Care
- Medical/Dental Lab

SCHOOL
- Daytime or Preschool
- Elementary School
- Middle/Secondary School

COLLEGE
- College or University
- Vocational or Trade School

RETAIL
- Department/Varity Store
- Retail Warehouse/Cuts
- Shop in Enclosed Mall
- Shop in Strip Mall
- Auto Sales
- Other Retail Store

OTHER
- Hotel
- Motel
- Resort
- Lodging
- Public Assembly
- Library/Museum
- Conference /Convention Center
- Religious Assembly (Worship only)
- Other Religious Assembly
- Health/Fitness Center
- Theater/Performing Arts
- Community Center
- Other Recreation/Public Assembly
- Miscellaneous
- Gas Station
- Gas with Convenience Store
- Repair (Non-Auto)
- Other Service Shop
- Assembly /Light Mfg.
- Police / Fire Stations
- Post Office
- Other Unlisted Type

Back to Metrics & Features
DRAW CHART
End Use Breakout - Total Site Energy (kBtu/sf-yr)

Peer Group: 480 buildings

- Heating (5.09)
- Vent (2.74)
- Cooling (5.63)
- Lighting (17.48)
- Service Hot Water (2.27)
- Refrigeration (2.00)
- Motors (0.48)
- Air Compressors (0.25)
- Process (0.00)
- Office Equipment (4.68)
- Miscellaneous (1.59)

Peer Group Information

**Summary**: The Site Energy for typical buildings of the type(s) you've specified is 43.6 kBtu/sf-yr [median value], with a range of 13.8 to 82.3 kBtu/sf-yr [5th to 95th percentiles] for the population. Select “Add a Building” button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes population weights for each building.

**Data Set**: California only (CEUS)

**Location**: California - Central Coast, Central Valley, Desert, Mountains, North Coast, South Coast, South Inland

**Size**: 0 - 25,000 sf, 25,001 - 150,000 sf, Over 150,000 sf

**Vintage**: 1901 through 1940, 1941 through 1978, 1979 through 1990, 1991 through Present, Unknown

**Type**: Administration and Management, Assorted/Multi-Tenant, Financial/Legal, Government Services, Insurance/Real Estate, Medical/Dental Office, Other Office, Software Development
## Packard Energy Tracking Process

### Pre-Design

<table>
<thead>
<tr>
<th>Benchmark Energy Use</th>
<th>51.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIA 2030 Target</td>
<td>20.7</td>
</tr>
<tr>
<td><strong>Project Target</strong></td>
<td><strong>25.8</strong></td>
</tr>
</tbody>
</table>

### Design

| DD Energy Model            | 18.3 |

### Occupancy

| Net First Year Results     | 21.8 |

### Whole Building (kBTU/FT²)

<table>
<thead>
<tr>
<th>HVAC</th>
<th>Hot H₂O</th>
<th>Lighting</th>
<th>Plug Loads</th>
<th>[Other]</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.4</td>
<td>0.0</td>
<td>9.6</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>14.2</td>
<td>0.0</td>
<td>4.8</td>
<td>6.9</td>
<td></td>
</tr>
</tbody>
</table>

### Renewable Energy (kBTU/FT²)

<table>
<thead>
<tr>
<th>PVs</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>-25.8</td>
<td></td>
</tr>
<tr>
<td>-21.9</td>
<td>-0.4</td>
</tr>
<tr>
<td>-26.5</td>
<td></td>
</tr>
</tbody>
</table>

### Energy Use Intensity (kBTU/FT²)

- HVAC
- Lighting
- Plug Loads
- PVs

- 65% reduction from Benchmark Energy Use to Net First Year Results
New Challenges

1. What’s Your EUI?
2. Push the Envelope
3. Count Every Watt
4. Expect the Unexpected
Energy Flow Through the Envelope
Optimizing Wall Assembly Insulation

16" O.C. Framing
24" O.C. Framing

ASSEMBLY 3: A 2"x6" WOOD STUD WALL CAVITY WITH EXTERNAL MINERAL WOOL INSULATION, 16" O.C. WOOD NAILERS, AND WOOD SIDING

Total R-Value:
16" O.C. Framing - R-22.3
24" O.C. Framing - R-24.0

A 5/8" Gypsum Board
B 6" Batt Insulation
C 5/8" Gypsum Board Sheathing
D 1" Mineral Wool Insulation with 16" O.C. Wood Nailer
E 1/2" Air Gap
F 3/4" Wood Siding
TYPICAL FRAMING AT 16" O.C.
3,780 BOARD FEET
Upgrade to High-Performance Windows

+ $75,000  Premium for installed glazing

- $150,000  Eliminate perimeter heating

= $75,000 first cost savings

+ $200,000 in PV system downsizing
Multiple Shading Strategies
New Challenges

1. What’s Your EUI?
2. Push the Envelope
3. Count Every Watt
4. Expect the Unexpected
Plug Load Study

![Image of a plug load study chart showing various appliances and their energy consumption.]

Courtesy of Integral Group
Computer Monitor Energy Use

![Graph showing energy usage comparison between current and recommended monitors.](chart.png)

**Current Energy Usage - Monitors**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Current</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP LP2465 PC Monitors (Current)</td>
<td>15,700</td>
<td>6,400</td>
</tr>
<tr>
<td>121 Lenovo L2440x Monitors + Power Strip Occupancy Sensors (Recommended)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Specifications**

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>HP LP2465</td>
<td>Lenovo L2440x</td>
</tr>
<tr>
<td><strong>Screen Size</strong></td>
<td>24” LCD</td>
<td>24” LCD</td>
</tr>
<tr>
<td><strong>Brightness</strong></td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td><strong>Contrast Ratio</strong></td>
<td>1000:1</td>
<td>1000:1</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>1920 x 1200</td>
<td>1900 x 1200</td>
</tr>
<tr>
<td><strong>Bulb Type</strong></td>
<td>CCFL</td>
<td>LED</td>
</tr>
</tbody>
</table>

**Energy Usage Per Unit**

<table>
<thead>
<tr>
<th>State</th>
<th>Current (W)</th>
<th>Recommended (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On</strong></td>
<td>65</td>
<td>28</td>
</tr>
<tr>
<td><strong>Standby</strong></td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Used w/ Occupancy Sensor?</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Avg. Plug Load (W)</strong></td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td><strong>Annual Consumption (kWh)</strong></td>
<td>134</td>
<td>56</td>
</tr>
</tbody>
</table>

**Current Monitor:** HP LP2465 24"

**Recommended Monitor:** Lenovo L2440x 24"

Courtesy of Integral Group
Filtered Water Cooler Energy Use

Daily Power Usage of Current Water Cooler (Innowave 270)

- 1000W On
- 80W Sleep

Current Water Cooler: Innowave 270

Recommended: GE Merlin Reverse Osmosis System

Annual Energy Consumption - Water Coolers

- 4 Innowave 270 Water Coolers (Current)
- 4 GE Merlin Reverse Osmosis Systems + Remote Chillers
- 4 GE Merlin Reverse Osmosis Systems (Recommended)

- 20,100 kWh/year
- 1,200 kWh/year
- 0 kWh/year

95% Reduction
100% Reduction

Courtesy of Integral Group
Plug Loads Annual Energy Consumption

- Current consumption vs. recommended reduction
- 58% reduction
- Courtesy of Integral Group
Estimated Annual Energy Use

- **54% reduction**
- **65% reduction**

- **Packard Baseline Energy Model**
- **Packard "Efficient" Energy Model**
- **Packard "Zero Energy" Model**

- Electric Car Charging Stations
- Lighting
- HVAC
- Plug Loads
New Challenges

1. What’s Your EUI?
2. Push the Envelope
3. Count Every Watt
4. Expect the Unexpected
Energy Performance, Two Ways

- Equipment
- Lighting Use
- Schedule
- Controls
- Maintenance
- Commissioning
- Heating 16%
- Cooling 17%
- Hot Water 2%
- Lighting 32%
- Ventilation 12%
- Miscellaneous 5%
- Plug Loads 16%
- Orientation
- Insulation
- Glass type
- System selection
A “Real Energy” Model

Courtesy of Integral Group

New Challenges in Net Zero Design | 07-16-14
Energy Data

Baseline Model Monthly Energy Use

KWh/month

Area Lights
Task Lights
Misc. Equip.
Ext. Usage
Pumps & Aux.
Vent. Fans
Hot Water
HP Supp.
Space Heat
Refrigeration
Heat Reject.
Space Cool

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Design Model Monthly Energy Use

- Energy Data

- kWh/month

- Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec

- Area Lights
- Task Lights
- Misc. Equip.
- Ext. Usage
- Pumps & Aux.
- Vent. Fans
- Hot Water
- HP Supp.
- Space Heat
- Refrigeration
- Heat Reject.
- Space Cool
Energy Data: Less Cooling than Predicted

June

July

- Unknown
- Area Lights
- Task Lights
- Misc. Equip.
- Ext. Usage
- Pumps & Aux.
- Vent. Fans
- Hot Water
- HP Supp.
- Space Heat
- Refrigeration
- Heat Reject.
- Space Cool
Year One Results

- **Benchmark**
  - Plug Loads
  - Lighting
  - HVAC
  - 51.7 Net Energy

- **Design Prediction**
  - +3.6 Net Energy

- **YR 1 - Measured**
  - +4.7 Net Energy
Getting to Net Zero

July 16, 2014

PRESENTED BY:
Paul Schwer, PE, LEED AP – President
Scott Bevan, PE, LEED AP – Associate Principal
Discussion Topics

PV in Utility Networks

Real Plug Load Reduction

Green Leases

Heating and Cooling People Not Buildings
PV

The Workhorse
The earth receives more energy from the sun in just one hour than the whole world uses in a year. *

*solarbuzz.com
Solar Resource

Array Tilt = Latitude

- **Los Angeles**: 652 kBtu/Sf/Yr
- **San Francisco**: 631 kBtu/Sf/Yr
- **Seattle**: 435 kBtu/Sf/Yr
- **Phoenix**: 760 kBtu/Sf/Yr
- **New York**: 528 Kbtu/Sf/Yr
- **Atlanta**: 604 kBTU/sf/yr
- **Denver**: 649 kBtu/Sf/Yr
- **Houston**: 559 kBtu/Sf/Yr
- **Miami**: 614 kBtu/Sf/Yr

**kWh/m²/day**
- 6.78
- 6.00
- 5.00
- 4.00
- 3.00
- 2.19
First Cost Trend

Average Price of PV
Energy Storage
Making it Happen
Net Zero Energy

Energy Use | Solar Budget

- Energy Surplus
- Solar Energy Harvest
- Energy Deficit

Building Energy Use

Energy (kWh)
Utility Grids
Grid
Radial
Grid
Spot Network
Grid

Area Network

Transformer

Network Protector
• Reverse power flow not permitted in downtown network.
• 100 kW buffer required by utility.
• Lost PV production between 15-20%.

Portland
Downtown Network
Edith Green-Wendell Wyatt
Photovoltaic Systems Interconnected onto Secondary Network Distribution Systems – Success Stories

Mike Coddington, Ben Kroposki, and Tom Basso
National Renewable Energy Laboratory

Kevin Lynn
Sentechn, Inc.

Dan Sammon
Consolidated Edison of New York, Inc.

Mohammad Vaziri
Pacific Gas and Electric Company

Tom Yohn
Xcel Energy
PV Array

Minimize Array Size
PV Array

Dynamically Controlled Inverters
Net Electricity

Typical Occupied and Unoccupied Days

- Energy (kWh)
- PV Available
- PV Used (kW)
- Building Demand (kW)

Friday
Saturday
Opportunity Lost

More Than 35% of Possible Production Lost

Monthly Estimated PV Available and PV Captured

Energy (kWh)

Month

- PV Available
- PV Captured
Seattle
Downtown Network

Downtown Network
Elliott Bay
Lake Union
Lake Washington
The Power Plant
Net Zero Energy
Energy Use | Solar Budget

Solar Energy Production
Energy Surplus
Energy Deficit
Building Energy Use
Grasshopper
Scheme 2 - TILTED ROOF ARRAY (15 deg tilt @ Back):

- ROOF (5 deg West) = 7,258sf = 123,000 kWh/yr
- ROOF (15 deg Southeast) = 4,240sf = 73,000 kWh/yr
- SOUTHEAST WALL = 750sf = 9,000 kWh/yr
- SOUTH WALL = 4,015sf = 50,000 kWh/yr (3,500 kWh/yr/row)

Total: 255,000 kWh/yr (+9K v. BASE)
Net Zero Energy - PV

Scheme III

Scheme 3 - TILTED ROOF ARRAY (25 deg tilt @ Back):

- ROOF (5 deg West) = 7,258sf = 123,000 kWh/yr
- ROOF (25 deg Southeast) = 4,514sf = 80,000 kWh/yr
- SOUTHEAST WALL = 750sf = 9,000 kWh/yr
- SOUTH WALL = 4,015sf = 50,000 kWh/yr (3,500kWh/yr/row)

Total: 262,000 kWh/yr (+18K v. BASE)
Net Zero Energy in Seattle
Energy Use + Solar Budget

- Average Building (Energy Star Score = 50): 92 kBtu/sf/year
- Seattle Energy Code Building: 52 kBtu/sf/year
- LEED Platinum Building (19 Energy Credits): 32 kBtu/sf/year
- PV Budget: 200,000 kW
- Proposed Building: 229,000 kW

- 83% Savings
- 16
Building Envelope
Daylighting
Bullitt Center
HVAC System Overview
Reducing Plug Loads

2007

20" CFL-LCD
75 watts

20" CFL-LCD
75 watts

100 watts

250 watts
Reducing Plug Loads

2009

22” CFL-LCD: 40 watts
22” CFL-LCD: 40 watts

80 watts

160 watts
Reducing Plug Loads

22” LED-LCD
14 watts

22” LED-LCD
14 watts

14 watts

42 watts
Reducing Plug Loads

2013

56 watts
Commercial Lease Agreement

This Lease agreement is made on this _____ day of _________ (Month), _____ (Year) by and between:

__________________________________________ (hereinafter “Landlord”)

AND

__________________________________________ (hereinafter “Tenant”).

In consideration for the shared promises and agreements contained herein, and for other good and valuable consideration, the parties hereby agree as follows:

1. The Landlord leases to the Tenant, and the Tenant rents from the Landlord the following stated property:

__________________________________________

2. The tenure of the Lease shall be for ________________ beginning ________________ and ending ________________.

3. The Tenant shall pay to Landlord as rent $ ________________ per year in equal monthly installments of $ ________________ payable in advance ___________________.

4. This Lease is subject to all present, prospective, taxes affecting the property.

5. Tenant shall use and occupy the building only as a ___________________ (Tenant Rental Status) subject at all times to the approval of the Landlord.

6. The Tenant shall not make any amendments, additions or improvements to the building without the prior written permission of the Landlord.

7. The property owner, at his own cost, shall equip the following utilities or facilities for the benefit of the occupant:

__________________________________________

8. The leaseholder, at his own cost, shall provide the following:

__________________________________________

9. The leaseholder shall purchase at his own cost public liability insurance in the amount of $ ________________ as well as fire and exposure insurance in the amount of $ ________________ for the property and shall provide satisfactory proof thereof to the property-owner and shall continue same in force and effect throughout the Lease period hereof.
Financial Considerations

Market Rate Lease Rates – Seattle Class A

Class A ($/sf)

- Triple Net Lease: ~$30-40
- Operating Cost: ~$10
Financial Considerations

Direct Construction Costs

$350 / SF
Includes city infrastructure improvements and costs associated with the PV array.

$265 / SF
Does not include PV, water system, or city infrastructure improvements.
How’s Bullitt Doing?

Energy production 5% more than predicted

Building energy use 15% less than predicted
How’s Bullitt Doing?

Predicted EUI: **16** | First Year EUI: **10** | After PV EUI: **-10**

Bullitt Center Performance

Actual 2/20/14

- Electric Consumption, kWh
- SCL Power Used
- Savings over Baseline
- PV Exported to SCL
- PV Used by Bullitt
- Est. Code Baseline
- Bullitt Building Use
- Proposed Tenant Building
- SCL Net Meter - SVC 4
How Public Policy Can Help
Living Building Challenge

Seattle Living Building Pilot Ordinance
• 10 foot building height bonus
• Additional height for PV and “rooftop features” (skylights)
• Elimination of on site commercial loading berth

Term Permit
• PV over right-of-way
• Greywater infiltration in right-of-way
Rocky Mountain Institute Headquarters
REINVENTING FIRE
BOLD BUSINESS SOLUTIONS FOR THE NEW ENERGY ERA

AMORY B. LOVINS AND ROCKY MOUNTAIN INSTITUTE

"A wise, detailed, and comprehensive blueprint" — President Bill Clinton

FOREWORDS BY
MARVIN ODUM, PRESIDENT, SHELL OIL COMPANY
JOHN W. ROWE, CHAIRMAN AND CEO, EXELON CORPORATION
### Reinventing Fire: Bold Business Solutions for the New Energy Era

This table (except the RMI Column) is from a Book entitled "Re-inventing Fire: Bold Business Solutions for the New Energy Era" by Amory Lovins (2011). It is Table 3.3-2 "Benchmarking a New U.S. Office Building". (p. 108). These targets were developed by the Rocky Mountain Institute and are typical of a new midsize -to-large Class A office in an average US climate like the Mid-Atlantic states.

<table>
<thead>
<tr>
<th>DESIGN TARGET</th>
<th>UNITS</th>
<th>EXISTING (U.S.)</th>
<th>BETTER</th>
<th>BEST PRACTICE</th>
<th>RMI BUILDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivered energy intensity</td>
<td>kBTU/sf-y</td>
<td>90</td>
<td>40-60</td>
<td>&lt;30</td>
<td>Targeting 19</td>
</tr>
<tr>
<td>Lighting power density: connected load</td>
<td>W/sf</td>
<td>1.5</td>
<td>0.8</td>
<td>0.4-0.6</td>
<td>Targeting 0.7</td>
</tr>
<tr>
<td>Lighting power density: as-used net of controls</td>
<td>W/sf</td>
<td>1.5</td>
<td>0.6</td>
<td>0.1-0.3</td>
<td>Targeting 0.1</td>
</tr>
<tr>
<td>Installed computers/appliances/tasklighting</td>
<td>W/sf</td>
<td>4-6</td>
<td>1-2</td>
<td>&lt;0.5</td>
<td>1.6 installed (0.5 operating)</td>
</tr>
<tr>
<td>Glazing R-value (center of glass)</td>
<td>sf-F°-h/BTU</td>
<td>1-2</td>
<td>6-10</td>
<td>≥20</td>
<td>11</td>
</tr>
<tr>
<td>Window R-value (including frame)</td>
<td>sf-F°-h/BTU</td>
<td>1</td>
<td>3</td>
<td>7-8</td>
<td>8</td>
</tr>
<tr>
<td>Glazing spectral selectivity*</td>
<td>kₑ = Tᵥ/SC</td>
<td>1.0</td>
<td>1.2</td>
<td>&gt;2.0</td>
<td>Mostly PV, 0.8, 0.2</td>
</tr>
<tr>
<td>Roof solar absorbance and infrared emittance</td>
<td>α, ε</td>
<td>0.8, 0.2</td>
<td>0.4, 0.4</td>
<td>0.08, 0.97</td>
<td>0.6 AC/hr at 50 Pa (~0.2cfm/sf equivalent)</td>
</tr>
<tr>
<td>Whole-building airtightness</td>
<td>cfm/sf @ 0.3&quot; w.g.</td>
<td>1</td>
<td>0</td>
<td>&lt;0.25</td>
<td>1500-2000 sf/ton</td>
</tr>
<tr>
<td>Installed mechanical cooling</td>
<td>sf/ton</td>
<td>250-350</td>
<td>500-600</td>
<td>1,200-1,400+</td>
<td>1.1</td>
</tr>
<tr>
<td>Cooling design-hour efficiency**</td>
<td>kW/ton</td>
<td>1.9</td>
<td>1.2-1.5</td>
<td>&lt;0.6</td>
<td>Minimal</td>
</tr>
<tr>
<td>Level of installed perimeter heating</td>
<td>-</td>
<td>extensive</td>
<td>minimal</td>
<td>none</td>
<td></td>
</tr>
</tbody>
</table>

* A measure of how well the glazing lets in light without heat

** Whole system, including pumps, fans, and cooling towers as well as chillers

| ADDITIONAL DESIGN TARGET ITEMS (not included in original RMI table) | | | | |
|---------------------------------------------------------------------|---|---|---|
| Wall R-value                                                        | sf-F°-h/BTU | R-40 |
| Roof R-value                                                        | sf-F°-h/BTU | R-60 |
| Wall to window ratio                                                | %            | >30% |
| Heat recovery effectiveness                                         | %            | > 75% operating |
| Installed mechanical heating                                         | BTU/h-sf     | Target 8 BTU/h-sf |
Phase Changing Materials
Personal Comfort System
Hyper-Chair
Beyond Net Zero
In the Rocky Mountains

1 Parking Space 9x18’

==

PV Production 1.6 kW

==

EV Travel 30 miles/day
Bullitt Center Equivalent Buildings

% of Roof Area to Achieve Net Zero

<table>
<thead>
<tr>
<th>City</th>
<th>Roof % Needed for Net Zero</th>
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kBtu/sf/year
Getting to Zero

2014 Getting to Zero Status Update: A look at the projects, policies and programs driving zero net energy performance in commercial buildings

Conclusion

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