Pathways to Net Zero Outcomes

Mark Frankel
April 28, 2016
Number of ZNE Projects—2012 to 2016

2012: 21
2013: 39
2014: 127
2015: 275
2016: 44

NBI New Buildings Institute
Building Toward Energy Efficiency
January 2014

NBI Featured Project
Built Foundation Cascadia Center
Building Toward Energy Efficiency
January 2014

Most Popular
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center

Most Recent
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center

Featured Views
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center
- Built Foundation Cascadia Center

Resources:
The Building Toward Energy Efficiency website offers case studies, tools, and resources for designers and builders.

Courtesy of New Buildings Institute | newbuildings.org
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
40 States with ZNE Buildings
Building Size

- over 100k sf
- 50k-100k sf
- 25k-50k sf
- 10k-25k sf
- 5k-10k sf
- 1k-5k sf

ZNE Verified
ZNE Emerging

n=109

new buildings institute
Existing Building Renovation

- New Construction: 76%
- Renovations: 24%

nbi new buildings institute
Net Zero Spec Office

435 Indio
RMW Architects
Code and Policy Goals

IBEW Local 595 Training Center, CA
Aggressive Code/Performance Goals are Widely Adopted

- 2030 Challenge
- 2030 Commitment
- CA Big Bold Goals
- Carbon Neutral Cities Alliance/Urban Sustainable Directors Network
- Federal, State, and City Jurisdictions
- Paris Accord
- GSA
Standard 90.1 Stringency Trend
Technical Progress by Component

- Lighting Interior
- Power Density
- Envelope Heat Transfer (UA)
- Cooling Equipment
- Heating Equipment
- ASHRAE 90.1 Overall

Normalized Energy Use (1975 = 100)

- Vector required to reach net zero goal in 2030
- Projections after 2015 at same rate as 2004 to 2013
Mechanical Systems: Relative Cooling Efficiency

- Conventional: 7.5 kBtu/kWh
- Direct Evap.: 20 kBtu/kWh
- Passive Evap.: 88 kBtu/kWh
Regulated vs. Unregulated Loads
(conceptual relationship as codes evolve)
Energy End Use by Building Type (new buildings in the Pacific Northwest)
Weighted End Use Energy (across building types)

Data from the Pacific Northwest
Renewables offset load to achieve goal.
OPTIMIZING project costs and PV

Increasing Efficiency

Cost

Optimization Curve
Building Operating Cost
Construction Budget
NPV Energy Savings
Cost of PV
Net Zero Cost vs. Performance

This scatter plot compares the construction cost premium (as a percentage of the base) against the advanced building EUIs (kBtu/sf) for different types and locations. The data is sourced from the New Buildings Institute (NBI) in 2015.
OPTIMIZING project costs and PV

Cost

Increasing Efficiency

Construction Budget
Optimization Curve
Cost of PV
Cost of PV-low
Range of Outcome

- 90-75
- 90.1-1989
- 90.1-2001
- 90.1-2004
- 90.1-2007 (IECC 2009)
- 90.1-2010 (IECC 2012)

NBI 2015

Year 2000 Baseline
- A2030 Goals
- Code Stringency

Energy Use Index (1975 Use=100)
Use Good Ingredients

Create a Good Meal
Design vs Operation

- Single-Fixture Task-ambient (task light provides ambient)
- All building lighting on occupancy sensors
- Private offices 50% auto-on with occupancy sensors, all lights auto-off

Title 24 2005 Baseline 1.18 W/SF
Connected Load 0.83 W/SF
Controls Credit 0.66 W/SF

Courtesy of Glumac
Components of energy outcomes

- Tenant Behavior
- Operating Characteristics
- Design Components

Energy Use

- 2000
- 2010
- 2020
- 2030
Outcome-Based Codes
(Energy Performance Outcome Policy)
Outcome Project Examples

• Edith Green Wendell Wyatt Federal Building; Portland -SERA
• George Deukmejian Courthouse, Long Beach –AECOM/Clark
• Federal Center South; Seattle -ZGF
City of Seattle: Outcome Code Pathway
Demonstrate EUI of 40 or less within 3 years of building completion

City of Vancouver, BC: Annual Thermal Energy Demand Intensity (TEDI)
Envelope/Infiltration-driven heating load limits (Similar to Passive House)
IGCC Language

• **Section 612, Outcome-Based Pathway Requirements**
  
  612.1 Outcome-based requirements. Compliance for buildings and their sites to be designed on an outcome basis shall be determined by actual measurement of all energy being used once the building and the energy using elements associated with the building site are in full operation...

  ...Buildings and building sites complying with this section shall also comply with the IECC. Compliance shall be based on a determination of actual energy use in accordance with this section.

  ‘Post-Occupancy Verification Permit’
Portfolio Evaluation

Hood River Middle School
Photo: Michael Mathers
City Portfolio Approach

• Portfolio Benchmarking
• City Engagement
• Analysis and Prioritization
• SEMP
• Integration in City Policy
• Tool for On-Going Performance Tracking and Management
• Project Financing Plan
• Implement Upgrades
Building Life-Cycle Opportunities

Design → Operate → Demolish

Design → Upgrade → Operate → RCx → Major Remodel → Demolish
The EUI Report allows you to instantly identify underperforming buildings and departments. Using the powerful filters below, you can easily compare building performance across the portfolio and identify trends year over year.

- **Portfolio Average EUI**
- **Portfolio Year over Year average**
- **Building Year over Year EUI**

The Portfolio Resource Plot provides insights into yearly aggregated resource use trends. The default view is a stacked bar chart that citizen yearly portfolio resource use broken down by building type or department. Mousing over enables quick insights into how much of a given resource each department has consumed in a given year.

- **Properties**
FirstView®

An honest look at building performance
Simple Inputs for Deep Insight

- **Inputs:**
  - 1 year of monthly utility bills
    - All fuels – electric, gas, other
  - Basic Building Info:
    - Location
    - Building size
    - Building type

- **Automatic disaggregation of end uses into:**
  - Heating
  - Cooling
  - Thermal baseload (gas/steam)
  - Electric baseload
**Energy Signature Diagnostics**

FirstView automates diagnostics based on specific patterns in the energy signature.

<table>
<thead>
<tr>
<th>Diagnostic Category</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupant Load</td>
<td>Low</td>
</tr>
<tr>
<td>Heating Impact of Shell and Ventilation</td>
<td>Typical</td>
</tr>
<tr>
<td>Cooling Efficiency</td>
<td>Good</td>
</tr>
<tr>
<td>Control Inefficiencies</td>
<td>Moderate</td>
</tr>
<tr>
<td>Reheat</td>
<td>None</td>
</tr>
<tr>
<td>Gas Baseload</td>
<td>High</td>
</tr>
</tbody>
</table>

![Energy Signature by End Use](image)

- **DESIGN AND CONSTRUCTION**
- **OPERATIONS & CONTROLS**
- **TENANTS & OCCUPANTS**
## Portfolio Diagnostics: Prioritization

<table>
<thead>
<tr>
<th>Building #</th>
<th>Areas to Investigate</th>
</tr>
</thead>
<tbody>
<tr>
<td>xxxxx</td>
<td>Heating Equipment &amp; Controls, Ventilation Rates &amp; Schedules, Infiltration</td>
</tr>
<tr>
<td>xxxxx</td>
<td>Heating Equipment &amp; Controls, Ventilation Rates &amp; Schedules, Infiltration</td>
</tr>
<tr>
<td>xxxxx</td>
<td>Domestic Hot Water Setpoint &amp; Recirculation, Steam Reheat, Steam Traps</td>
</tr>
<tr>
<td>xxxxx</td>
<td>Domestic Hot Water Setpoint &amp; Recirculation, Gas Reheat, Gas Process Load</td>
</tr>
<tr>
<td>xxxxx</td>
<td>Plug Loads, Lighting Power Density, Lighting Controls, 24 Hour Fan Operation</td>
</tr>
</tbody>
</table>
EUI by End Use

Portfolio Analysis
(NBI, 2014)
Comparing Building Performance at the Leading Edge

**zEPI**  
Zero Energy Performance Index
Some Opportunities

• Market uptake on ZNE is broadening
• Cities are leading on energy/climate policy
• Codes are moving aggressively, but are running out of scope
• Operations and occupancy are major opportunity areas for energy performance
• Building performance data is influencing performance outcomes
• Energy Performance Outcome policies (outcome-based codes) are starting to get traction conceptually
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