Getting to Zero: The 2014 Status Update
Thank You to Our Sponsors!
Today’s Topics

1. How Many Are There?
2. Energy Performance
   
   Attendee Polling and Q & A

3. Technologies, Strategies & Cost
4. Closing
   
   Q & A
Ralph DiNola, Executive Director

ZERO NET ENERGY
DISRUPTIVE INNOVATION
Building The Capacity To Increase Net Zero Construction

The net zero building movement (where buildings produce as much or more energy than they consume) remains a nascent phenomenon. As of this time last year, the U.S. Green Building Council grew the number of buildings that tracks energy performance – had recognized only 62 buildings as net zero structures, but these exceeded 15,000 square feet.

The concept of net zero buildings is still in its infancy, but it is gaining traction. The Bullitt Center is a six-story, 50,000 square-foot building that is utilizing never-before-seen technology to be the most sustainable building ever built.
Zero Net Energy

Defined...

Zero Net Energy buildings are buildings with greatly reduced energy load such that, averaged over a year, 100% of the buildings energy use can be met with onsite renewable energy technologies. Also known as Net Zero Energy.
Disruptive Innovation

Clayton Christensen
Professor of Business Administration, Harvard Graduate School of Business Administration

Published 1997
Disruptive Innovation

A disruptive innovation is an innovation that helps create a new market and value network, and eventually goes on to disrupt an existing market and value network (over a few years or decades), displacing an earlier technology.

1804
Richard Trevithick
Penydarren Ironworks
Merthyr Tydfil, Wales
1830
*Tom Thumb*
Peter Cooper
1880 In the ten-year period prior to 1880, some 40,000 miles of railroad were built, bringing the total network up to 93,267 miles. In 1880, every state and territory was provided with railway transportation. A second line of railroads to the Pacific was nearing completion, and other transcontinental railroads were under construction. Railway development was exerting a powerful influence upon immigration and agricultural and industrial growth throughout the country.
1876

Acoustic Telegraph
Alexander Graham Bell
1973

*Mobile Telephone*

Dr. Martin Cooper
2000
BedZED
2012
zHome

z-home.org
Jerry Brown's Tough-Love California Miracle

The 75-year-old governor rescued the Golden State from financial ruin - and is reshaping a national progressive agenda
Governor Brown’s Zero Net Energy Goals

California has set a bold course to achieve statewide Zero Net Energy (ZNE) in the next two decades:

- All new residential construction will be ZNE by 2020 in California
- All new commercial construction will be ZNE by 2030
- 50% of existing commercial buildings in California will be retrofitted to ZNE by 2030
2014 Getting to Zero Status Update

A look at the projects, policies and programs driving zero net energy performance in commercial buildings.

David and Lucile Packard Foundation, Los Altos, California

nbi new buildings institute

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Massachusetts Zero Net Energy Buildings Task Force

Governor Patrick’s Zero Net Energy Buildings (ZNEB) Task Force, made up of energy and building industry professionals, released Getting to Zero sub in March 2009. The report outlines 44 policy recommendations for new and existing buildings in the commercial and residential sectors. The Task Force’s recommendations are designed to move the Commonwealth toward ZNEB construction by 2030. They fall into four broad categories:

1. Establishment of minimum performance standards based on energy use per sq/ft
2. Energy use benchmarking of all buildings
3. Incentives to help address regulatory and financial barriers
4. Workforce development and public education initiatives

Several policy actions are currently underway to advance zero net energy buildings:
Amy Cortese, Senior Program Manager

HOW MANY ARE THERE?
Zero Net Energy (ZNE) Definitions

- **ZNE Verified** - buildings (or districts) have been documented to have met, over the course of a year, all net energy use through onsite renewables.

- **ZNE Emerging** - buildings (or districts) have a publically stated goal of ZNE but do not yet meet the definition of ZNE verified.

- **ZNE Projects** – the sum of the ZNE Verified and ZNE Emerging projects

- **Ultra-Low Energy Verified** – measured data documents energy performance dramatically better than the industry average
Number of Projects from 2012 to 2014

- **2012**
  - ZNE Verified Buildings and Districts: 21
  - ZNE Emerging Buildings and Districts: 39
  - Ultra-low Energy Buildings: 39

- **2014**
  - ZNE Verified Buildings and Districts: 33
  - ZNE Emerging Buildings and Districts: 127
  - Ultra-low Energy Buildings: 53

(2012 report used label “ZNE-Capable”)
# 2014 List of Zero Net Energy Verified Buildings

<table>
<thead>
<tr>
<th>Year Completed</th>
<th>Name</th>
<th>Location</th>
<th>State</th>
<th>Building Type</th>
<th>Size (sf)</th>
<th>Total Building Actual EUI</th>
<th>Site Renewable EUI</th>
<th>Net Building EUI</th>
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<th>Building Type</th>
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new buildings institute

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Energy Use Index of ZNE Buildings

![Bar chart showing energy use index (EUI) comparison between CBECS Average (91) and ZNE Average (21), with a 77% reduction.](image-url)
Existing Building Renovation

- Renovations: 24%
- New Construction: 76%
Where Are They?

Number of ZNE Verified Buildings

States with ZNE Emerging or Verified Buildings
## Number of Buildings by State

<table>
<thead>
<tr>
<th>State</th>
<th>ZNE Verified</th>
<th>ZNE Emerging</th>
<th>Total ZNE Projects</th>
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*NBI © 2014*
18 ZNE Districts

- Campus: 8
- Military: 8
- National Historic Site & Campus: 1
- Neighborhood Mixed Use: 1
Anna Maria Historic Green Village
Ownership Type

- Public: 67%
- Private: 26%
- Non-profits: 7%
Overall Trends

- ZNE is achievable in a wide variety of regions and climate zones
- ZNE works for many building types and sizes
- ZNE is achievable during existing buildings renovations
- Private sector is increasingly embracing ZNE
- ZNE districts are a growing trend
- Large proportion ZNE buildings are in the educational sector
The Promise of Data

What’s my EUI?

Attribution: newspaper.li/matrix
Challenges

- Data Gathering
- PV delayed due to cost
- Getting the metering right
- Fear of disclosure – we did not meet our goal!

Attribution: blog.modernmechanix.com
In this Study

– **ZNE Verified** - buildings (or districts) have been documented to have met, over the course of a year, all net energy use through onsite renewables.

– **ZNE Emerging** - buildings (or districts) have a publically stated goal of ZNE but do not yet meet the definition of ZNE verified.

– **ZNE Projects** – the sum of the ZNE Verified and ZNE Emerging projects

– **Ultra Low Energy Verified** – measured data documents energy performance dramatically better than the industry average
Project Dataset

ZNE Verified

All: 33

Measured Performance Dataset

9 of 127

All: 53

ZNE Emerging

Ultra-Low Energy

NBI © 2014
Performance Range (all projects w/ MP data)

National CBECS average for Commercial Buildings

Avg. EUI 21

n=95
Performance Range - Offices

Measured EUI of Offices

- ZNE Verified Office
- ZNE Verified Office Retrofit
- ZNE Emerging Office Retrofit
- Ultra-low Energy Office
- Ultra-low Energy Office Retrofit

Average for all Verified Office Buildings

EUI (kBTu/sf/yr)

100
90
80
70
60
50
40
30
20
10
0

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

NBI © 2014
DPR Construction San Diego

- San Diego, CA
- 24,500 SF
- Office
- LEED NC Platinum
- ILFI Zero Energy Building Certified
- Callison Architecture
- DPR Construction, Owner, Design/Builder

Photo: DPR Construction
Efficiency Measures:
- Natural ventilation
- Daylighting
- Roof monitors
- Efficient HVAC
- Solatubes and high performance lighting
- 64 kW PV
Performance Range - Education

Measured EUIs of Educational Buildings

Average for all verified Education buildings

- ZNE Verified
- ZNE Emerging
- Ultra-low Energy

CBECs Education Average

NBI © 2014
Richardsville Elementary School

- Bowling Green, KY
- 72,300 SF
- Education K-12
- Completed in 2010
- LEED Gold
- $206/SF
- Warren County Public Schools
- Sherman Carter Barnhart, Architect
- CMTA, Mechanical and Electrical

Photo: Sherman Carter Barnhart
Richardsville Elementary School

Efficiency Measures:
- Ground source heat pump
- DOAS
- CO2 sensors
- Daylighting
- High performance lighting system with controls
- EMS & Energy Dashboard

Photo: Sherman Carter Barnhart
# Richardsville Elementary School

## Richardsville Energy MWh Summary

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<th>MWh Generated</th>
<th>MWh Difference</th>
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<td>(6.8)</td>
</tr>
<tr>
<td>4/16/2012</td>
<td>29.6</td>
<td>35.3</td>
<td>(5.5)</td>
</tr>
<tr>
<td>3/15/2012</td>
<td>30.6</td>
<td>31.9</td>
<td>(1.3)</td>
</tr>
<tr>
<td>2/14/2012</td>
<td>33.8</td>
<td>19.5</td>
<td>14.3</td>
</tr>
<tr>
<td>1/16/2012</td>
<td>26.0</td>
<td>14.9</td>
<td>11.1</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>396</strong></td>
<td><strong>443.8</strong></td>
<td><strong>(47.8)</strong></td>
</tr>
</tbody>
</table>
Measured Performance Trends

- *Ultra-low Energy* buildings strengthens data set
- ZNE Verified Bldgs. had an avg. EUI of 21 – provide helpful targets
- *Emerging* projects are on the path to Zero – sometimes takes more than a year
- Good insight on technologies and practices
Polling

SHARE YOUR OPINION
Cathy Higgins, Research Director

TECHNOLOGIES, STRATEGIES & COSTS
Design
Bullitt Center Energy Budget

Typical Seattle Office Building

Bullitt Foundation

Courtesy: PAE Consulting Engineers
Bullitt Center Solar Budget

Typical U.S. Building
EUI = 92
64,000 sf of PV

High Performance Building
EUI = 32
26,000 sf of PV

ZNE. Building
EUI = 16
14,000 sf of PV

Courtesy: PAE Consulting Engineers
Packard Building Energy Model

CA Title 24
EUI = 50

54% reduction
65% reduction

24 - 28 = -4

BUILDING'S TOTAL EUI
RENEWABLE PRODUCTION EUI
BUILDING'S NET EUI

kWhs/sf/yr
kBtu/sf/yr

Packard Baseline Energy Model
Packard “Efficient” Energy Model
Packard “Zero Energy” Model

Electric Car Charging Stations
Lighting
HVAC
Plug Loads

Courtesy: EHDD
Passive First

West Façade: Edith Green, Wendell Wyatt
Federal Bldg. Portland, OR

Shading reduces the heat gain on the building minimizing the energy needed for cooling.

- **West Façade**
  - Reeds provide avg. 50% shading

- **South & East Facades**
  - Combination vertical + horizontal shades

- **North Facade**
  - No shading

Courtesy: SERA Architects
Comparison – Daylight Autonomy (%)

Floor 1

NBI and IDL Daylight Pattern Guide – Online
## Kentucky

6 high performance schools
3 Net Zero
1 Firm

<table>
<thead>
<tr>
<th>Net Zero Energy</th>
<th>Operational</th>
<th>Geothermal HVAC</th>
<th>Lighting Controls</th>
<th>ICF Walls</th>
<th>Daylighting</th>
<th>Photovoltaics</th>
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<tbody>
<tr>
<td>Locust Trace - ZNE</td>
<td>2012 New</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Richardsville - ZNE</td>
<td>2010 New</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Turkey Foot Middle - ZNE</td>
<td>2010 New</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Flaherty Primary</td>
<td>2012 New</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td></td>
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<tr>
<td>Bistrow Elementary</td>
<td>2011 New</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Foster Heights Elementary</td>
<td>2012 Renovation</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Putney Field House, VT

<table>
<thead>
<tr>
<th>Measured Energy Stats</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 10 = 0</td>
</tr>
<tr>
<td>Building's Total EUI</td>
</tr>
<tr>
<td>Renewable Production EUI</td>
</tr>
<tr>
<td>Building's Net EUI</td>
</tr>
</tbody>
</table>

Courtesy: Putney School
IBEW Local 595 Training Center, CA

Courtesy: Chad Zeimendorf
VanDusen Botanical Garden Visitor Centre, BC. Photo: Nic Lehoux / Architect: Perkins+Will

Technologies
IBEW Local 595 Training Center, CA

Courtesy: Chad Zeimendorf
Technologies used at Locust Trace AgriScience, KY

Courtesy: CMTA Engineering and USGBC KY Chapter
Decoupling Space Conditioning from Ventilation
Integrated Daylighting and Occupancy Controls

Redding School for the Arts, CA
Courtesy: Trilogy Architecture
Steve Whittaker Photography
Bullitt Center, Seattle WA

Courtesy: Denis Hayes, Bullitt Foundation
Irresistible Stair

Courtesy: Denis Hayes, Bullitt Foundation
Bullitt Center Modeled Energy Use 16 EUI

Courtesy: PAE Consulting Engineers
Reduce Plug Loads
Plug Load Strategies

- VOIP Phones: 2 Watts
- LED Task Light: 6 Watts
- 24” LCD Monitor: 18 Watts
- Laptop: 30 Watts
- Shared Printers: 100 Watts
- Load Sensing Power Strip

- Std. Phones: 15 Watts
- Fluorescent Task Light: 35 Watts
- 24” LCD Monitor: 50 Watts
- Desktop Computer: 300 Watts
- Personal Printer: 460 Watts
- Personal Space Heater: 1500 Watts

Courtesy T. Hootman RNL Design, S. Pleiss NREL
Monitoring for ‘Energy Red Flags’ at TD Bank

**January 2012 Energy Consumption Analysis**

<table>
<thead>
<tr>
<th>Description</th>
<th>Metered</th>
<th>Modeled</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Building Consumption</td>
<td>KWH 9,993</td>
<td>KWH 8,650</td>
<td>1,343</td>
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<tr>
<td>Plug Load</td>
<td>KWH 2,083</td>
<td>KWH 2,078</td>
<td>5</td>
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<tr>
<td>HVAC</td>
<td>KWH 1,760</td>
<td>KWH 1,740</td>
<td>20</td>
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<tr>
<td>Water Heater</td>
<td>KWH 32</td>
<td>KWH 492</td>
<td>460</td>
</tr>
<tr>
<td>Exterior Lighting</td>
<td>KWH 2,828</td>
<td>KWH 2,630</td>
<td>198</td>
</tr>
<tr>
<td>Interior Lighting</td>
<td>KWH 885</td>
<td>KWH 1,027</td>
<td>137</td>
</tr>
</tbody>
</table>

*49% over modeled projection*

*29% over modeled projection*

**Photo Courtesy of Turner Construction**
**Graph: TD Bank – Dave Del Rossi**
Feedback and Dashboards

Total Electricity Production vs. Consumption
Kilowatt-hours of electricity produced last year

Solar Production
120,493 Kilowatt-hours

Total Consumption
102,864 Kilowatt-hours

15% PERFORMANCE NOW

Select a Timescale
Select a Unit Equivalent
Learn More

Introduction Electricity Solar Electric Water Natural Gas Comparison Green Features Weather

Courtesy: DPR Construction
Characterizing Cost
Rice Fergus Miller Office

- Bremerton, WA
- 39,000 SF
- LEED Platinum
- Office
- Renovation
- $109/SF
- Completed in 2011
- Renewables being staged
Cost Impacts of an Upgrade to High Performance Windows

+ $75,000  Premium for installed glazing
- $150,000  Eliminate perimeter heating

= $75,000 first cost savings

Courtesy: EHDD
Cost = Choices

Glass Curtain Wall
- More expensive
- Less efficient
- Pretty?

Wall
- Less expensive
- More efficient
- Good for hanging things

Courtesy: Energy & Resource Solutions
NREL Research Support Facility (RSF)
222,000 sf   $260/sf   EUI = 35

Courtesy: T. Hootman, RNL, S. Pleiss, NREL
NREL RSF Building compared to others

Courtesy: T. Hootman, RNL, S. Pleiss, NREL
Data Source: Design Build Institute of America (DBIA) database
Capping the Project

Courtesy: CMTA Consulting Engineers
PV cost trend makes ZNE accessible

Source: P. Mints, Navigant Solar Services Program, 2011
NBI Case Study Examples

Case Study Info:

- Size, use, climate, age
- Owner & design firm
- Energy Use Targets
- Energy Use Actual
- Technologies
- Business Rationale
- Lessons Learned
- Cost info if available
Cost Study Coming

Statistical Analysis and Case Studies

Types of buildings:
• community centers
• k-12 schools
• office buildings – low-rise
• wet labs
Ultra-low Energy Strategies

- 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 Recover Systems

NASA Sustainability Base, CA
Courtesy: Cesar Rubio Photography, McDonough & Partners
The Big Picture

- Set the zero net energy goal and build the team
- Go Passive first: optimize passive design solutions
- Invest in the envelope and glazing
- Get control of lighting and HVAC with integrated control strategies
- Separate ventilation from space conditioning
- Prioritize People: occupants and operators drive energy use

✓ Zero Net Energy is achievable through readily available technologies and design.

✓ Price range is broad and less about zero than choices. Cost can be at or approaching standard budgets.
Share Your ZNE and Exemplary Commercial Building Project

Momentum is growing for zero-net energy (ZNE) buildings as well as buildings that demonstrate superior energy efficiency. We want to hear about your project!

NBI is updating its current list of zero-net energy (ZNE) verified buildings and creating a registry to track and share information about these projects. We are looking for owners and design teams to submit measured energy use information on commercial building projects that have achieved zero-net energy performance or have been designed with the intention of achieving ZNE. In addition, we are looking for buildings that are exemplary in terms of energy performance, but either through lack of onsite renewable energy sources or for other reasons were unable to achieve ZNE. Initially, three possible categories of classification include:

- **Zero-net energy buildings** produce as much clean, renewable energy on-site as they consume over the course of a year.
- **Zero-net energy capable buildings** are exemplary buildings that achieve the levels of efficiency comparable to a ZNE project, but don’t have onsite renewables meeting all the energy needs.
- **Emerging buildings** are structures that don’t yet have a year of measured data to share.

**Why Share?**

Document your building’s true energy performance. LEED and other certification programs validate buildings based on the expected energy performance of the design plans. NBI’s high performance buildings registry highlights projects that have accomplished ultra-low or zero-net energy performance based on a review of at least 12-months of measured energy use data. If you don’t have a year of data yet, no problem, register your project and we’ll put it on our ‘emerging’ list based on your target.

Gain publicity for your project. ZNE and other exemplary projects will be highlighted in NBI information including the 2013 list of verified ZNE projects and status update on ZNE costs and features (see Getting to Zero 2012 Status Update). This list is published annually and promoted to all major...
Questions & Answers

David and Lucille Packard Foundation Building
Courtesy: EHDD
Join Us for Our Next Webinar

Policies and Programs to Advance ZNE

Energy policy at the state and local level can accelerate ZNE actions, and make major contributions to carbon reductions. NBI and NASEO will review some of the key policies currently in play, and provide specific examples of where policies are influencing market activities.

Join us February 19th at 10:00 Pacific / 1:00 Eastern
A link to registration will be in the follow-up email all registrants will receive
Learn more about NBI

http://newbuildings.org/support
Links and resources

http://newbuildings.org/zero-energy

- Link to the report
- Interactive map
- Case Studies
- Graphics used in the report
- Resources and Q&A