Washington State Department of Enterprise Services

ZNE Workshop

Alexi Miller, Senior Project Manager
Webly Bowles, Project Manager
Lauren McCloy, Senior Policy Advisor, Energy, Office of Governor Jay Inslee
Chuck Murray, Washington State Department of Commerce

May 8, 2018

Agenda

9:00 am – 9:10 am Welcome and Introductions
9:10 am – 9:20 am Workshop Objectives and Expectations
9:20 am – 9:30 am Intro to ZNE Buildings: National, Regional and WA Status of ZNE
9:30 am – 10:00 am The Process of Getting to ZNE
10:00 am – 10:20 am Case Study: Issaquah Fire Station 72 and King County International Airport Terminal Building
10:20 am – 10:30 am BREAK!
10:30 am – 11:00 am Deep Dive into ZNE: Common Measures & Strategies
11:00 am – 11:45 am Activity: Incorporating WA ZNE Goals into the Process
11:45 am – 12:00 am Wrap Up, Review of Available Resources and Closing
Welcome & Introductions

- Lauren McCloy, Senior Policy Advisor, Energy, Office of Governor Jay Inslee
- Chuck Murray, Washington State Department of Commerce
- Alexi Miller, Senior Project Manager, New Buildings Institute

Expectations

- What are you expecting to take away at the end of day?
- What areas of ZNE are challenging?
Purpose & Learning Objectives

Purpose: Executive Order 18-01 requires new Executive Agency buildings to be Zero Net Energy (ZNE) or Zero Net Energy Capable (ZNE-C). This workshop is to give State Agency project managers the tools they need to meet this requirement.

Learning Objectives:
• Describe the concept of ZNE buildings and explain emerging trends identified in research on ZNE.
• Learn energy efficiency technologies for design and construction teams to meet ZNE goals.
• Incorporate ZNE considerations into the building delivery process.
• Identify and avoid common factors that create ZNE challenges.

nbi: the virtuous cycle

NBI is a national nonprofit working to improve buildings for people and the environment. We drive research, uncover solutions, and advance industry practices and policies that deliver positive change in the built environment.

Program Areas:
1. Innovation and best practices for new and existing buildings and programs
2. Continuous code and policy advancement
3. Leadership in Zero Energy buildings and market development
Introduction to ZNE Buildings: The status of national and regional ZNE

Alexi Miller, Senior Project Manager, NBI

Zero Net Energy – The Name Game
Zero Net Energy – The Name Game
What is a Zero Net Energy Building?

A Zero Net Energy (ZNE) building* is highly energy efficiency and meets >100% of its annual energy from renewables.

- **Energy** = All energy (electric, gas, steam, liquid fuel etc.) consumed on site
- **Net** = One year or more of on-site renewable energy production minus energy use
- **Verified** = A year of more of documented performance at net zero
- **Emerging** = not yet a year or more of data (may be on a path to ZE)
- **EUI** = Energy Use Intensity in kBtu/sf/yr - metric of energy performance.

*Also known as Net Zero Energy (NZE), Zero Energy (ZE), or Zero Energy Building (ZEB)

Definitions

DOE released A Common Definition for Zero Energy Buildings in September 2015

• Zero Energy Building (ZEB):
  An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.
Site vs. Source Energy

**Site:** Total energy used on-site

**Source:** Total upstream energy required

\[
\text{Annual Energy Use} \quad \frac{\text{Square Footage}}{} = \text{Energy Use Intensity}
\]

Example: US Median Office Building EUI

- **Source:** 150 kBtu/ft²/yr
- **Site:** 67 kBtu/ft²/yr

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**Zero Net Energy Projects**

Alexi Miller, Senior Project Manager, NBI
Zero Energy Building Growth

Graph showing the growth of zero energy buildings over time.

Zero Energy Building Area Growth

Graph showing the growth of zero energy building area over time.
Trending Toward Larger Buildings

• More than 40% of all buildings and **88% of the total floor space of ZE Emerging buildings are 50,000 sf or larger.**
National ZNE Building Ownership

Completion Year

Building Count

- Private - For-profit
- Public - County
- Public - City
- Public - State
- Private - Non-profit
- Private - Multifamily
- Public - Federal

National ZNE Building Types

Building Type Breakdown

- Education: 37%
- Office: 19%
- Multifamily: 16%
- Other: 14%
- Public Assembly: 8%
- Mercantile: 2%
- Public Order and Safety: 2%
- Warehouse and Storage: 1%

Education Breakdown

- K-12 School: 50%
- Higher Education: 35%
- General Education: 15%
ZNE Buildings in Every Climate Zone

Putting Performance into Perspective

ZE Verified buildings on average use **60% less energy** than comparable existing U.S. commercial buildings and 46% less than new buildings under one of the most stringent U.S. base code (CA Title 24).
The Process of Getting to ZNE

Alexi Miller, Senior Project Manager, NBI
Webly Bowles, Project Manager, NBI

Strategic ZNE Process

- Engage Stakeholders
- Assess Performance
- The Cost of Zero
- Project Planning
- Select Team and Set Goals
- Design to the Target
  - Passive
  - Envelop
  - Lighting
  - Space Conditioning and Ventilation
  - Plug Loads
  - Onsite Energy Generation
- Continue Design through Operation
- Verify ZNE Through Ongoing Monitoring
Engage Stakeholders

• Map stakeholders:
  • Who are the stakeholders?
  • What are their drivers?
  • What are the key messages?
• Share case studies, fact sheets, and other ZNE materials
• Attend webinars and trainings
• Identify resources to support your efforts
  • Consumer Energy’s Zero Net Energy Pilot Program
  • NBI Getting to Zero Project Guide
• Visit a ZNE building!
## Stakeholder Mapping

### Six Key Messages for Communicating ZE:

1. **ZERO ENERGY:** Zero energy (ZE) schools are low energy buildings coupled with a steady generation resource. A school achieves zero when the one exceeds the energy used over the year. Schools are easy to learn hubs to educate others.

2. **LOWER OPERATING COSTS:** K-12 schools spend $8 billion on energy, oil, computers and textbooks combined. Schools built to ZE performance costs and the revenue reduce to the school budgets to the volatility of shifting energy prices.

3. **INCREASED STUDENT PERFORMANCE:** Occupants of ZE schools are student performance, increased attendance, better occupant health satisfaction and retention.

4. **EDUCATIONAL BENEFITS:** ZE schools are living laboratories, simulating the demands of the real world. Occupants in ZE schools can provide additional energy-saving teaching tool for students, DBM programs, and teachers. This and other knowledge results in a cleaner, safer, and technology is surrounding students and faculty to take leadership roles in their own learning needs.

5. **RESILIENCY:** ZE schools are more resilient in severe weather events, having a lower risk for the community during emergencies since the building energy is reduced and remain functional to provide light and space in the event of a natural disaster.

6. **GETTING TO ZERO:** While “ZE” is the end game for building sustainability, it takes time to accomplish. School districts can start now on this path to ZE.

### Stakeholders and Drivers

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Board</td>
<td>Mission: Excellence in education for every child every day by focusing on quality instruction, educational outcomes, healthy school buildings, and enhancing a culture of excellence.</td>
</tr>
<tr>
<td>Superintendent &amp; Assistant Superintendent</td>
<td>Mission: To instill students to engage in meaningful learning in a safe and nurturing environment that embraces diversity. Challenge students to be ethical, productive members of the community.</td>
</tr>
<tr>
<td>Capital Projects &amp; Planning Department</td>
<td>Mission: To support the School District missions, Facilities Planning provides professional services to the Board, the Administration and to other departments within the District. The goal is to provide safe, student, faculty, staff and public with a safe, comfortable and functional learning environment.</td>
</tr>
</tbody>
</table>

### Priority 1

- Educate all the participants.
- Foster teamwork for an integrated design process.
  - Diminish adversity
- Agreeing on energy target and other sustainability goals.
  - Get goal “buy-in”
- Brainstorm potential technologies and strategies to achieve target.
  - Identify synergies
  - Document decisions
Energy Targets

- Set an EUI early.
- Identify EUI per market and climate zone.

Assess Performance
Assessment

- Collect energy consumption
  - 2-3 years
- Benchmark use against
  - CBECS
- Energy Use Intensity - kBtu/sf/yr (EUI)
- Tools:
  - ENERGY STAR Portfolio Manager
  - Online data tracking
  - Excel

Benchmarking
Benchmarking

EUI = 186
Good? Bad? Ugly?

Santa Rosa State Building

Remote Assessment Example: FirstView
Identify Top Candidates

High thermal baseload
High heating use

High electric baseload
High Ventilation/Cooling Load
Portfolio Prioritization

Building Energy Use Intensity (EUI) and Total Energy Usage by End-Use
Prioritize the Opportunities

Successful Retrofits
Start with the Right Building

Hybrid
30% Improvement = 73 MPG – OR – 88 Gallons per Year

Old Pick-up
30% Improvement = 17 MPG – OR – 375 Gallons per Year

Assessment

• Individual Building Assessments:
  • **Physical**: Envelope, structural analysis, electrical
    • ID strengths and weaknesses in existing building systems
  • **Site analysis**: other site opportunities: temperature, wind, solar access
  • **Occupant interviews**: of facility managers and operators: ID known issues and possible solutions
Assessment

Table 5: Top Candidates for Further Investigation (Retro-commissioning and Retrofit)

<table>
<thead>
<tr>
<th>Building</th>
<th>Building Type</th>
<th>Size, ft²</th>
<th>EUI, kBtu/ft²/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building 1</td>
<td>Office</td>
<td>32,500</td>
<td>86</td>
</tr>
<tr>
<td>Building 2</td>
<td>Senior Care Community</td>
<td>12,122</td>
<td>154</td>
</tr>
<tr>
<td>Building 3</td>
<td>Office</td>
<td>52,200</td>
<td>83</td>
</tr>
<tr>
<td>Building 4</td>
<td>Police Station</td>
<td>73,000</td>
<td>89</td>
</tr>
</tbody>
</table>

Building 2

- Very energy intensive building, especially when compared to other senior centers.
- High thermal baseload for this building – Savings in hot water usage likely.
- The majority of the energy use goes towards heating – heating efficiency should be prioritized

ASHRAE Energy Audits

What's involved with each level?

<table>
<thead>
<tr>
<th>Type of Audit</th>
<th>Highlights</th>
</tr>
</thead>
</table>
| Level 1       | Rapid Assessment of building energy systems  
Building energy benchmark  
High-level definition of energy system optimization opportunities  
Outline applicable incentive programs |
| Level 2       | Detailed building survey of systems and operations  
Breakdown of energy source and end use  
Identification of energy-efficiency measures (EEMs) for each energy system  
Range of savings and costs for the EEMs  
Spotlight on operational discrepancies  
Outlining priorities for limited resources, next steps, and identification of EEMs requiring more thorough data collection and data analysis (Level 3) |
| Level 3       | Longer-term data collection and analysis  
Whole-building computer simulation calibrated with field data  
Accurate modeling of EEMs and power/energy response  
Bid-level construction cost estimating  
Investment-grade, decision-making support |
Matching Strengths & Weaknesses

Single Pane Window

No Insulation

Beaumont Middle School, Portland, OR

Matching Strengths & Weaknesses

Natural Ventilation & Daylighting

Thermal Mass

Beaumont Middle School, Portland, OR
Lifecycle Opportunities

- Recognize trigger points in building lifecycle and operational practices.
- Plan for opportunities for efficiency improvements:
  - As-is – no planned capital improvements.
  - Plan in Place – regular maintenance plan, equipment regularly assessed and upgraded.
  - Major Renovation – large-scale changes, often structural, with multiple system changes providing opportunities for deeper savings. The solution sets and timing of delivery must match the trigger points.

---

Major Renovation – 30-50 Years
Lifecycle Opportunities

HVAC Replacement – 15-20 Years

Lifecycle Opportunities

Lighting Retrofit – 5-7 Years
Lifecycle Opportunities

Lease Renewal– 2-5 Years

Lifecycle Opportunities

Real Estate Transactions
Financing & Incentives

- ZNE projects do not need to cost more than a code compliant building!
  - (But they can...)
- Start early with ZNE goal
- Identify potential funding sources:
  - Utility incentive programs
  - Bond funding
  - External grant funding
  - Solar financing district
  - Pilot programs
  - Upgradable design strategy
  - Technology demonstrations
WA Financing Options

• Tax credits and incentives
  • Energy-Efficient Commercial Buildings Tax Deduction
  • Local Utilities

• Grants
  • WA State Dept. of Commerce Clean Energy Fund
  • WA State Dept. of Commerce Energy Efficiency & Solar Grants
  • Community Energy Efficiency Program (CEEP)
  • County Based Programs

• Power Purchase Agreement (PPA)

Costs of ZNE Buildings

Total Building Cost for select ZNE Verified Buildings (n=29)
“The prevailing industry perception is that zero energy is cost prohibitive and suitable only for showcase projects with atypical, large budgets; however, there is mounting evidence that zero energy can, in many cases, be achieved within typical construction budgets.”

Cost Analysis

• What is the real cost of a building?
  Life Cycle Cost = Net Present Value of:
  - First Costs (hard and soft)
  - Utility Costs
  - Ongoing Maintenance
  - Repair/Replacement
  - Residual Value

2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Set an Energy Target

The largest database on ZNE buildings in North America and the only database searchable by ZNE Status & Energy Performance

http://newbuildings.org/getting-to-zero-buildings-database
EUI Scatter Plot

- 2003 CBECS Average Office EUI = 93
- 2012 CBECS Average Office EUI = 78
- 2006 CEUS Average Office = 73
- Median = 28
- Median = 28

Figure 10 – Statewide Technically Feasible EUIs without Solar (TDV5) distributed by Projected 2020 Construction Volume
Set Your Energy Target

- Begin by defining your energy target and solar budget.

Select Team and Set Goals
Request for Proposals & Qualifications (RFPs & RFQs)

- Define desired team
- Engage team from design through operations
- Energy modeler to inform the design
- Building commissioner
- Controls integration

Integrated Design Process

- Align project vision and goals early
- Review scenarios early to achieve consensus
- Streamline the design process
- Active and ongoing collaboration
- Additional communication
- Reduce revisions and change orders
Selecting Your Project Team

- Define your ZNE targets and incorporate into RFP guidelines

- Qualifications:
  - ZNE experience, or not?
  - EUI of previously designs
    - Predicted and actual
  - Previous sustainable project goals

- Pre-bid and pre-construction conferences

Owner’s Project Requirements

Owners Project Requirements (OPR)
- How should the building perform?

Define Basis of Design (BOD)
- Energy targets
- Operating targets
  - Operating hours
  - Temperature set points
Integrating the ZNE Team

Non-Energy Benefits
Non-Energy Benefits

NEBs
• Productivity
• Health
• Absenteeism
• Safety
• Maintenance
• Financial

Average Staff vs. Facility Costs ($/sf/month)

Staff costs:
• Salary and benefits
• Recruitment
• Staff retention
• Absenteeism

Goal: Keep the staff productive

2004 data provided by Carnegie Mellon University’s Center for Building Performance and Diagnostics

Health Benefits

• Higher outdoor ventilation rates
• Temperature control
• Low-VOC
• Low-CO₂

Better cognitive function
Health Benefits

Productivity in Green Buildings
• Reduced Absenteeism
• Lower staff turnover
• Less medical complaints and costs
• Less physical environment complaints
• Self reported attitudes via perception studies
• Low concentrations of CO2 and pollutants and high ventilation rates can lead to 8-11% productivity improvement.

Source: JLL

Non-Energy Benefits

3 - 30 - 300

Source: JLL
Non-Energy Benefits

3 - 30 - 300

Energy

Source: JLL

Non-Energy Benefits

3 - 30 - 300

Rent

Source: JLL
Non-Energy Benefits

3 - 30 - 300

Payroll

Source: JLL

Non-Energy Benefits

3 - 30 - 300

100% = 1%

Source: JLL
Case Studies:
Issaquah Fire Station 72
and
King County International Airport Terminal Building
Shawn Oram, Director of Engineering and Design, Ecotope

BREAK!
Return at 10:30
Deep Dive into ZNE: Common Measures and Strategies
Alexi Miller, Senior Project Manager, NBI
Webly Bowles, Project Manager, NBI

Design to the Target
AGENDA

Background

Barriers to Delivering Net Zero Energy

Case Study #1: Issaquah Fire Station 72

Case Study #2: King County Regional Airport
ECOTOPE
Transformation of the building industry to energy efficient carbon neutral buildings

ECOTOPE
Green Building Rated Projects

- 1 project | Living Building Projects
- 25 projects | LEED Platinum Rated
- 100+ projects | LEED, ESDS, Green Globes Rated

ASHRAE AWARDS

<table>
<thead>
<tr>
<th>EUI (kBtu/sf/yr)</th>
<th>Project</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Stackhouse Apartments</td>
<td>2016</td>
</tr>
<tr>
<td>19</td>
<td>Rice Fergus Miller Office</td>
<td>2013</td>
</tr>
<tr>
<td>23</td>
<td>Eastside Fire Station 72</td>
<td>2013</td>
</tr>
<tr>
<td>32</td>
<td>Maritime Heritage Building PT</td>
<td>2011</td>
</tr>
<tr>
<td>26</td>
<td>King County Housing Authority</td>
<td>2014</td>
</tr>
<tr>
<td>35</td>
<td>Bellevue Youth Theater</td>
<td>2018</td>
</tr>
<tr>
<td>14</td>
<td>Westside School</td>
<td>2018</td>
</tr>
</tbody>
</table>
REGIONAL GOALS

2030 Washington State Energy Code should represent 70% savings over 2006 code

2050 Washington State to be Carbon Neutral

WASHINGTON STATE CO2 EMISSIONS

2030 Washington State Energy Code should represent 70% savings over 2006 code

2050 Washington State to be Carbon Neutral

Total 2011 GHG emissions: 91.7 Million Metric Tons CO₂e
SEATTLE IS A HEATING CLIMATE
1. Separate Ventilation from Heating & Cooling
   Dedicated Outdoor Air System with Energy Recovery

2. Turn Off Heating & Cooling Equipment
   When Not in Use
   Zoned heating and cooling equipment
   Cycling on load

3. Right-size Equipment
   Limit ventilation volumes and HVAC equipment sizing to 130% of ASHRAE standards and load calculations

ENERGY MEASURE IMPACTS IN SEATTLE
KING COUNTY REGIONAL AIRPORT

Terminal Building
HVAC Retrofit

KING COUNTY REGIONAL AIRPORT

Terminal Building Retrofit (Boeing Field)

22,000 Square Foot Airport

Newly Upgraded Envelope in 2002

Kept the Same Multi-Zone HVAC System

EUI of 168 kBTU/sf/yr
KING COUNTY REGIONAL AIRPORT
Terminal Building Retrofit (Boeing Field)

Existing Building’s Team

Investment Grade Audit

Level 3 ASHRAE Audit
Billing Analysis
Calibrated Energy Model
Measure Analysis
Delivered Savings
Play Owner’s Rep Role

KING COUNTY REGIONAL AIRPORT
Terminal Building Retrofit (Boeing Field)

OLD: All-in One HVAC Multi-Zone System

NEW: Energy Recovery Ventilation and Variable Refrigerant Flow (VRF) Heat Pumps
KING COUNTY REGIONAL AIRPORT
Terminal Building Retrofit (Boeing Field)

Before & After Energy Use

Energy Use Reduction
- Gas: 99%
- Electric: 39%
- Total: 70%

Terminal Building Retrofit (Boeing Field)

Boeing Field by the Numbers

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric (kWh/yr)</td>
<td>630,000</td>
<td>378,000</td>
</tr>
<tr>
<td>Gas (therms/yr)</td>
<td>24,000</td>
<td>168</td>
</tr>
<tr>
<td>EUI (kBtu/sf/yr)</td>
<td>168</td>
<td>51</td>
</tr>
<tr>
<td>CO2 Emissions (lbs/yr)</td>
<td>281,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Project Delivery – Energy Savings Performance Contracting (ESPC)

HVAC Replacement - $29/sf (HVAC - $640,000)

Operating Cost Savings - $39,500/year

Carbon Neutral Airport
Plan for Successful Retrofit

1. Set aside capital improvement money
2. Schedule improvements based on expected lifespan of equipment
3. Select replacement systems based on goals of organization over next 20-years (Low energy, Carbon Neutral)
4. Perform replacement work before equipment failure

NET ZERO ENERGY
ISSAQUAH FIRE STATION 72

New Construction Building
DESIGN GOALS - ISSAQUAH FIRE STATION 72
New Construction Building

- Building Size 11,000 SF
- Site Size ½ Acre
- Two-story
- No use of fossil fuels
- Meets 2030 challenge through 2020
- Zero Net energy by 2030
- LEED Platinum

BENCHMARKING FIRE STATION 73
New Construction Building

Benchmarking Fire Station 73 – Issaquah, WA
Audit Findings

- 24/7 Occupancy
- Most Stations run systems assuming full occupancy (20+ occup) 24/7, typically only 4-5 people on average/shift.
- High Bay Engine space use a lot of energy when HVAC is fan coil or air heating.
- All Lights are mostly on.
- Wet Gear Rooms typically high outdoor air exchange
- Simultaneous Heating/Cooling loads exist
- Firefighters don’t turn anything off (lights/plugs)
- High DHW Load (laundry and showers)
LOAD REDUCTION STRATEGIES
New Construction Building

Reduce Peak Cooling Loads (1000 SF/Ton)
- Super Insulate
- Build Tight
- Energy Recovery Ventilation
- Low SHGC Glass
- Reduce West Glass
- Low LPD Lights
- Design for Off™

<table>
<thead>
<tr>
<th>Typical</th>
<th>FS 72</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF/Ton</td>
<td>400</td>
</tr>
<tr>
<td>Peak Tons</td>
<td>28</td>
</tr>
<tr>
<td>Bores</td>
<td>24</td>
</tr>
<tr>
<td>Cost/Ton</td>
<td>$15,000</td>
</tr>
<tr>
<td>Total Geo Costs</td>
<td>$360,000</td>
</tr>
</tbody>
</table>

$240,000 to use towards load reduction strategies

NET ZERO ISSAQUAH FIRE STATION 72
New Construction Building

Only 8 geo bores easily fit in parking lot. 1 ton per 1,140 SF for Heating and Cooling.
NET ZERO ISSAQUAH FIRE STATION 72
New Construction Building

KEY ENERGY EFFICIENCY MEASURES

- Super Insulation
- Radiant floor heating and cooling distribution
- Ground source heat pump
- Heat recovery ventilation
- Operable windows for natural ventilation
- Solar hot water preheat
- Daylighting controls
- Occupancy controls for lights and non-critical plug loads
- Occupant feedback (dashboard)
- Solar PV panels
- Induction cooking equipment
- Energy Star appliances
- Low flow plumbing fixtures

RENEWABLES

6 EUI
25 kW Solar PV
6.6 kW Solar Hot Water
**Net Zero Issaquah Fire Station 72**

*New Construction Building*

### Fire-Station Costs/Performance

<table>
<thead>
<tr>
<th>Fire Station</th>
<th>Total Cost ($/sf)</th>
<th>EUI (kbtu/sf/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issaquah FS 72</td>
<td>$349</td>
<td>23</td>
</tr>
<tr>
<td>Seattle FS 30</td>
<td>$688</td>
<td>90</td>
</tr>
<tr>
<td>Seattle FS 20</td>
<td>$1,020</td>
<td>117</td>
</tr>
<tr>
<td>Seattle FS 22</td>
<td>$944</td>
<td>30</td>
</tr>
<tr>
<td>Seattle FS 32</td>
<td>$725</td>
<td>65</td>
</tr>
</tbody>
</table>

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**Thank You**

Shawn Oram, P.E., LEED AP  
Director of Engineering and Design  
shawn@ecotope.com  
206.596.4703
Deep Dive into ZNE: Common Measures and Strategies
Alexi Miller, Senior Project Manager, NBI
Webly Bowles, Project Manager, NBI

Design to the Target
Common ZNE Design Technologies and Strategies

- Highly Efficient and Sealed Thermal Envelope
- Building Orientation and Glazing ratio
- Thermal Energy Storage
- Phase Change Material
- Daylighting Access and Controls
- Advanced Ventilation: Natural, Dedicated Outdoor Air Systems (DOAS), Demand Control Ventilation (DCV)
- Ground Source and CO2 Heat Pumps
- Night Flush
- Radiant Heating/ Cooling
- Evaporative Cooling
- Ceiling Fans
- Fiber Optics
- Energy Recovery Systems
- Energy Generation and storage
- Plug load Reductions and Controls
- Energy Management Systems
- Design for “Off”
- Programmatic Zoning
- Sequence of Operations
- Direct Current Equipment

Zero Net Energy and Modeling

Design Process

- Programming
- Conceptual Design
- Schematic Design
- Design Development
- Construction Documents
- Bidding
- Construction

Courtesy: http://www.bazzani.com
Zero Net Energy and Modeling

Design Process

• Programming
• Conceptual Design
• Schematic Design
• Design Development
• Construction Documents
• Bidding
• Construction
Zero Net Energy and Modeling

Design Process
• Programming
• Conceptual Design
• Schematic Design
• Design Development
• Construction Documents
• Bidding
• Construction
Iterative Energy Modeling

• During Programming & Conceptual Design:
  • Evaluate: Orientation, window to wall ratio, massing, etc.

• Schematic Design through Construction
  • Evaluate efficiency options
  • Compare with LCCA

Passive Strategies
Design Strategies: Efficient Systems

- Lighting
- Space Conditioning
- Ventilation Loads

Passive Before Active Systems

- Orientation
- Massing
- Shading
- Natural Ventilation
- Daylighting
Passive Daylight First

West façade: Edith Green, Wendell Wyatt
Federal Bldg, Portland, OR

Courtesy: SERA Architects
Passive Ventilation First

- Cross ventilation
  - Move air across deep spaces
- Stack ventilation
  - Air enters low, warms, and rises
- Night flushing to cool
- Combine with active systems

Daylighting Opportunities

![ANNUAL ELECTRIC USE IN OFFICE BUILDINGS](image)

- Lighting 39%
- Office Equipment 15%
- Ventilation 9%
- Space Cooling 14%
- Space Heating 5%
- Other 18%

EIA, 2003 Commercial Buildings Energy Consumption Survey
Daylighting Opportunities

- Space layout impacts
- Daylight needs to be controlled for comfort
  - Light shelves
  - Exterior shades
  - Interior shades
- Surface color and texture impacts
Envelope Upgrade Potential

- Air Sealing
- Insulation
- Windows
- Reflective Surfaces

Building Envelope

- Install continuous air barriers and adequately seal penetrations to minimize leakage
  - Continuous air barrier
    - Reduce temperature changes
    - Control outside air
    - Minimize moisture changes
  - Retrofit Option: Storm windows have been proven to reduce whole-building infiltration by 5.7% to 8.6%
Building Envelope

- Review construction details and revise to avoid thermal bridging
  - Reduce heat transfers
  - Review details for materials that penetrate the thermal envelope

Source: BC Hydro

---

Building Envelope

- Review construction details and revise to avoid thermal bridging
  - Reduce heat transfers
  - Review details for materials that penetrate the thermal envelope

Source: Yourhome.gov.au
# Building Envelope

<table>
<thead>
<tr>
<th>Location</th>
<th>Code U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A - Miami</td>
<td>0.077</td>
</tr>
<tr>
<td>2B - Phoenix</td>
<td>0.064</td>
</tr>
<tr>
<td>4C - Portland</td>
<td>0.064</td>
</tr>
<tr>
<td>5A - Boston</td>
<td>0.064</td>
</tr>
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</table>

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<table>
<thead>
<tr>
<th>Location</th>
<th>Code U-Factor</th>
<th>Effective U-Factor</th>
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</thead>
<tbody>
<tr>
<td>1A - Miami</td>
<td>0.077</td>
<td>0.199</td>
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<tr>
<td>2B - Phoenix</td>
<td>0.064</td>
<td>0.186</td>
</tr>
<tr>
<td>4C - Portland</td>
<td>0.064</td>
<td>0.145</td>
</tr>
<tr>
<td>5A - Boston</td>
<td>0.064</td>
<td>0.145</td>
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</table>
Building Envelope

• Loss of building performance with actual wall u factor.

<table>
<thead>
<tr>
<th>Location</th>
<th>Low-Rise</th>
<th>Mid-Rise</th>
<th>High-Rise</th>
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<tbody>
<tr>
<td>1A - Miami</td>
<td>-0.5%</td>
<td>-0.3%</td>
<td>-2.3%</td>
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<tr>
<td>2B - Phoenix</td>
<td>-1.4%</td>
<td>-0.8%</td>
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<td>4C - Portland</td>
<td>-2.9%</td>
<td>-0.4%</td>
<td>-2.5%</td>
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<td>5A - Boston</td>
<td>-2.7%</td>
<td>-0.5%</td>
<td>-3.5%</td>
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</table>

Interior Lighting
Interior and Site Lighting

• Select 100% LEDs.

Daylighting Controls

• Interior Lighting Controls
  • The most efficient lamp is one that isn’t in use
Daylighting Controls

• Interior Lighting Controls
  • The most efficient lamp is one that isn’t in use

Daylighting Controls

• Occupancy Controls
Daylighting Controls

• Occupancy Controls

• Occupancy Control:
  • Automatic On/Off

• Vacancy Control:
  • Manual on / Automatic Off
Daylighting Controls

- Occupancy Control:
  - Automatic On/Off
- Vacancy Control:
  - Manual on / Automatic Off

Space Conditioning and Ventilation
Space Conditioning and Ventilation

- HVAC systems offer great opportunities for efficiency.

Seattle HVAC Opportunities
- Heat recovery and airtightness are important
- VAV is important due to the ability to reheat with the air conditioning system for dehumidification.

Separate Ventilation from Conditioning

Separate ventilation from conditioning
- Space conditioning and ventilation responsible for 60% of the total energy load in conventional offices

Radiant heating/cooling with dedicated outside air systems (DOAS):
- Panels or surface layer easier to install in existing buildings
- Increased thermal comfort
- Best suited for mild climates
Space Conditioning and Ventilation

Heat Recovery Ventilation:
• Transfers energy between the supply and exhaust airstreams.

Energy Recovery Ventilation:
• Transfers both sensible and latent heat.
• Can significantly reduce RTU compressor and/or furnace run time.
• Balances ventilation.

Energy Recovery Ventilation

Energy Recovery Ventilation:
• Recover energy (heating/cooling) from exhaust air
• Can significantly reduce RTU compressor and/or furnace run time

NBI Resources:
• ERV User Guide
• ERV Calculator
System Controls

• Building Automated System (BAS)
Controls:
  • Systems:
    • Windows, shading, HVAC, lighting, security, PV, other equipment, and appliances.
  • Sensors:
    • Air temperature, humidity, solar intensity, daylight, wind, occupancy, vacancy, scheduled hours.
• Controls integrator to program all systems
  • Integrate early
  • Identify reporting characteristics

Plugs Loads

[Image of a power strip with various plugs]
Plug Load Controls

• Plug loads can be 50% of total energy use
• More devices and occupant-driven misc. loads
• More efficient regulated loads (Lights, HVAC, Water Heat…)
• Most ZNE buildings (64%) use plug load controls or monitoring

Plug Load Control Strategies

• Power management for computers, monitors, copiers, and printers
  • Automated switching
  • Desk lamp vacancy sensors
  • Receptacle switches
  • Scheduled evening “off”
• Office policies
  • Procurement
  • Monitor sleep mode policy
  • Involvement & education
Designing Controls

Advice from Building Operators:

- Select leading technologies for high performance
- Design for "Off"
- User friendly and intuitive
- Consistent across an institution
- Integrate the controls contractor
- Optimize settings and strategies
- Check for interferences
- Meter and monitor then track and share actual performance

Onsite Energy Generation
Estimating PV

Backcast to create a solar budget
• What is the maximum area of PV you could have?
• How much energy would this generate?
• How does this compare with your anticipated energy consumption?
• Does the building need to be more efficient?
• Does the cost justify the savings?

Maximum Energy Generation + Energy Consumption = ZNE Potential

Estimating PV

Develop a solar budget:
• Info needed:
  • Location, available area, shading…
  • NREL's PV Watts® Calculator
    • Estimates energy production and annual energy cost saved
  • Google Project Sunroof
  • Bioclimatic analysis

<table>
<thead>
<tr>
<th>Month</th>
<th>Solar Radiation (kWh/m²/day)</th>
<th>AC Energy (kWh)</th>
<th>Energy Value ($)</th>
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<td>January</td>
<td>3.91</td>
<td>4,141</td>
<td>462</td>
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<tr>
<td>February</td>
<td>4.61</td>
<td>4,416</td>
<td>606</td>
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<td>March</td>
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<td>April</td>
<td>6.01</td>
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<tr>
<td>May</td>
<td>6.49</td>
<td>6,205</td>
<td>10,271</td>
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<tr>
<td>June</td>
<td>6.85</td>
<td>6,572</td>
<td>10,598</td>
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<tr>
<td>July</td>
<td>7.08</td>
<td>7,124</td>
<td>11,488</td>
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<tr>
<td>August</td>
<td>6.68</td>
<td>7,028</td>
<td>13,133</td>
</tr>
<tr>
<td>September</td>
<td>6.09</td>
<td>5,884</td>
<td>996</td>
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<tr>
<td>October</td>
<td>5.10</td>
<td>5,581</td>
<td>844</td>
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<tr>
<td>November</td>
<td>4.28</td>
<td>5,086</td>
<td>896</td>
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<tr>
<td>December</td>
<td>3.78</td>
<td>3,973</td>
<td>608</td>
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<tr>
<td><strong>Annual</strong></td>
<td><strong>5.55</strong></td>
<td><strong>67,027</strong></td>
<td><strong>$ 10,806</strong></td>
</tr>
</tbody>
</table>

PV Watts for LONG BEACH, CA

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Case Study: Solar Budget

Bullitt Center
• 16 EUI target is driven by the 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

On-site Energy Generation

• Maximum PV efficiency:
  • Shade-free
  • Tilted toward the sun or tracking
• DC equipment
• Ownership
  • Ownership
  • Lease - PPA
• Solar ready

Credit: AGL Solar Energy (CC-SA-3.0)
On-site Energy Storage

• Store the energy generated
• Off-set peak electric use
• Schedule peak electric rates to pull from battery
• Integrate electric vehicle battery into storage and drawdown

Credit: AGL Solar Energy (CC-SA-3.0)
Complementary Elements of ZEBs

www.newbuildings.org/gridoptimal

Continue Design Through Operations
Common Operations and Occupancy Technologies and Strategies

- Occupant Engagement and Training
- Energy Displays (i.e., Dashboards)
- Green Leases
- Purchasing Policies
- Service Contracts
- Ongoing Energy Tracking
- System Calibration
- Sensor Evaluation
- Ongoing Commissioning
- Demand Response
- Load Shifting Software

Continue Design to Operations

- **Design** with O&M in mind
- **Operate** with design in mind
  - Develop O&M training manual and program
    - Include equipment specifications
    - Coordinate with OPR
    - Energy evaluation
- **Train** building engineers
  - Coordinate with commissioning agent
  - Building automation system review
  - ZNE as part of job performance
Commissioning

- Commissioning links design, construction, and operations.
- Ensures that a building is delivered according to the OPR.
- Cost effective for energy savings.
- Commissioned buildings operate more efficiently, are more comfortable, and have lower operations and maintenance costs.
- Commissioning Agent to help train owners and occupants to properly use the systems for maximum efficiency.

Engage Operations

- **Engage** operations team and occupants on design and O&M strategies
  - Form a green team
  - Share anticipated ZNE performance
  - Provide real time energy use feedback
  - Integrate ZNE into facilities staff job descriptions
Verify ZNE through Ongoing Monitoring and Certification

Measurability

- Submeter for meterability
  - Systems and electrical circuits
    - HVAC, lighting, plug loads, hot water, etc.
  - Controls: data trending
  - Use measured data to improve performance!
- Measurement and verification (M&V) of building performance
  - Standardized Protocol: IPMVP
Building Dashboard Systems

• Meter and track energy use
• Review to identify abnormalities
• Share data

Verification and Ongoing Monitoring

• Track and maintain performance
  • Address efficiencies at the building cycles
  • Schedule regular ZNE performance check in meetings
  • Develop a facilities plan
• Benchmark to the target
Verify Performance

ZNE Certification

- Certification program:
  - International Living Future Institute
  - New Buildings Institute
  - One year of energy data

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Spread the Word

• Create and share case studies
• Hold an open house
• Conduct building tour to inspire others
• Present at conferences
• Submit to the NBI Registry
• Get listed on ZE Watchlist

Overview: Strategic ZNE Process

• Engage Stakeholders
• Assess Performance
• The Cost of Zero
• Project Planning
• Select Team and Set Goals

• Design to the Target
  • Passive
  • Envelop
  • Lighting
  • Space Conditioning and Ventilation
  • Plug Loads
  • Onsite Energy Generation

• Continue Design through Operation
• Verify ZNE Through Ongoing Monitoring
Activity: Incorporating WA ZNE Goals into the Process

Capital Development & ZNE

- Incorporate the ZNE process into the typical DES capital project development process.

  Master Planning
  Program need identified “we need a building”
  Predesign funding request
  Predesign
  Design budget request
  Design
  Construction budget request
  Construction
  Occupancy
Capital Development & ZNE

- Incorporate the ZNE process into the typical DES capital project development process.

- Questions:
  - What additional actions need to be included to be a ZNE project?
  - Who needs to be involved?
  - When do the new actions need to be incorporated?
  - What information needed?

ZNE Tools & Resources Wrap up & Closing

Alexi Miller, Senior Project Manager, NBI
ZNE Project Guide

Getting to Zero: ZNE Project Guide outlines ZNE changes from traditional process those differences and provides a framework for planning any ZNE project.

• Resources
• Checklists
• Worksheets
ZNE Communication Toolkit Contents

- Message Platform
  - Key target audience messages
- ZNE Companion Guide/Fact Sheets
  - General info, key audiences messages
- Case Studies
  - California project examples, including design strategies, planning, cost, and lessons learned
- Intro to ZNE Presentation
  - ZNE What, Why & How

www.newbuildings.org/zne-communications-toolkit

ZNE & Ultra-Low Energy Case Studies

- CPUC Case Study Briefs & NBI ZNE Case Studies
  http://newbuildings.org/case-studies-zne-projects
- PG&E Case Studies
- NBI Registry http://newbuildings.org/share
- Getting to Zero Database
  http://newbuildings.org/getting-to-zero-buildings-database
Be Counted!

- NBI is seeking North America’s most advanced energy efficiency commercial projects including zero and ultra-low energy projects.
- Designers, engineers, architects, building owners and operators are invited to enter their commercial projects.
- Buildings, once vetted, will be categorized and published in a list spotlighting zero energy and ultra-low energy buildings to be released this fall.
- Leading owners, builders and designers will be honored at the 2019 Forum.

Learn more and register at: newbuildings.org/project-registry

Thank You!

Alexi Miller
Senior Project Manager, NBI
alexi@newbuildings.org

Webly Bowles
Project Manager, NBI
webly@newbuildings.org
Master Planning
- Ask the question
- How much will it cost?
- Operational budget
- Separated from capital budget
- LCCA is challenged
- (Legislative Service Request)
- (Cabinets Office)

Program need identified
- "We need a building"
- Ask the question
- Include the questions
- Program that needs
- Pre-requirement
- Study of the user
- Research grade
- Admin buy-in of
- Concept
- Identifying team
- Conduct interviews & workshops

Pre-design funding request
- Space costs (C-100)
- Code compliance
- Energy modeling
- BPR funding
- Feasibility
- NCE opportunities

Pre-design
- CHARRETE
- Energy modeling
- Space planning
- Add on projects
- Capable (tbd)
- Needs clarification
- C-100

Design budget request
- Capable (tbd)
- Needs clarification
- C-100

Design
- (Add information here)
- (Add on projects)
- Capable (tbd)
- Needs clarification

Construction budget request
- (Add on projects)
- Capable (tbd)

Construction
- (Add on projects)
- Capable (tbd)

Occupancy
- (Add on projects)
- Capable (tbd)
Master Planning
Program need identified
"we need a building"

Predesign funding request

Pre-design

Design budget request

Design

Construction budget request

Construction

Occupancy

Adequate Funding for 
Maintenance and 
Operations

Systems Training

Replacement with new 
technology

Resource Containment

WAF - Individual Melting

Site Conditions
- Bldg Orig.
- Use + Occup. Over Time

Eng Rsp Use + Target

* Funding for Integrated Master Plan - Proc. + Fac.

Long Term Strategy.

LEG SU

Port for ZNE

Mech/El/TL/CT/Sec/Prog.

STAKEHOLDER

Buy In

for ZNE

Doc 1/15/15

Doc 1/3/15
Master Planning
Program need identified
  “we need a building”
  - Research
  - OPR
  - BOD
  - 27% BASE BUDGET for Redesign
  - Lab Case Studies
  - Possible Other Resource Funds

Predesign

Predesign funding request

Design
Design budget request

Construction
Construction budget request

Occupancy
Master Planning

Ask the question: how much realistic energy performance?

Goal of NZE - drill down to existing & #203;

PM & Owner Ed.

Operating budget is separate from capital budget.

LECA is challenged.

Legislative solution needed?

Governor’s Office...

Program need identified

“we need a building”

Close the question:

Include for operations:

Program that meet

CPM requirements:

Research grants

Admin buy in of concept:

Identifying team needs:

Central graphics & software

Predesign funding request

True costs (5-10%)

Construction escalation?

Energy incentives

PPR funding?

Feasibility

NZE opportunities
<table>
<thead>
<tr>
<th>Pre-design</th>
<th>Design budget request</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHARRETTE</strong></td>
<td>Add consultants req'd?</td>
<td>Capable firms?</td>
</tr>
<tr>
<td>Energy models</td>
<td>Add on projects that realize add savings (capable)</td>
<td></td>
</tr>
<tr>
<td>Identifying firms that are capable</td>
<td></td>
<td></td>
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<tr>
<td>Variety w/ MP</td>
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<tr>
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<td>Occupancy</td>
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<td>Add on for add project (capable)</td>
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<tr>
<td>DES</td>
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</tr>
</tbody>
</table>
**6 Year Plan**

- OFM
- FPMT Input
- Baseline info
  - Full Service leases
    - (not data available)
  - Do energy
  - What is required - portfolio manager
    - Can we require this?
  - Yes, we think so.
  - Analyze baseline
  - Identify Dogs

**Space Request**

- Include energy
  - US Policy Goals
  - Target EUI level
  - Daylighting
  - Air changes/hour

- Engage OFM in
  - Including energy criteria
  - In MPD

**Initiate**
Define/Charter
Market/Solicitation

State goals:
"An EUI of \( \leq xx \) would be advantageous to the agency."
Include energy in scoring.
Offer levels of performance with different costs per sq. ft.
How do you control it if you don’t pay for it??
(Energy)

Negotiate

Green Leases -
savings for energy passed on to agency.
Changes in LSR -
- daylighting metrics
- performance metrics

How do we make it advantageous to lessee to build ZNE or even better than code?

Design

# Will take more time.
# Need in house expertise.
# More collaboration with lessors architects.

How do we deal with Existing buildings?
Most buildings we lease are existing.
Execute Lease Construction

Commissioning required for leased buildings.

Closeout

6-year planning ongoing reporting for baseline
Master Planning

Program need identified
“we need a building”

Predesign funding request

* FUNDING

SITE CONDITIONS
- BLDG ORT.
- USE ≠ OCCP. OVER TIME

ENERGY USE ≠ TARGET

* FUNDING FOR INTEGRATED MASTER PLANS PED, FAC.

LONG TERM STRATEGY.

DOC + DSHS
STAKEHOLDER Continued

PORT FOR ZNE

Mech/Elec SYS
CUSTODY TYPE/BUY
SECURITY/PROG.

STAKEHOLDER BUY-IN FOR ZNE

HL REQ
TEAM ASSEMBLY
<table>
<thead>
<tr>
<th>Construction budget request</th>
<th>Construction</th>
<th>Occupancy</th>
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<tr>
<td>Adequate Funding for</td>
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<td>Replacement with new</td>
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<td>technology</td>
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<td>EXP = Individual Metering</td>
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