Prop 39 Zero Net Energy School Retrofits Workshop

A Technical Deep Dive into ZNE School Retrofits
May 25, 2017

New Buildings Institute
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Prop 39 ZNE School Retrofit Workshops

The Prop 39 ZNE Pilot Program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, and Southern California Gas Company under the auspices of the California Public Utilities Commission. The California investor-owned utilities are not responsible for the preparation of this presentation, nor do any of them make any representation concerning the quality, accuracy or suitability of the information set forth herein. As the author of this presentation, the New Building Institute is solely responsible for this presentation and its contents.
Welcome & Introductions
Workshop Agenda

8:00 a.m. – 8:15 a.m.  Welcome, Expectations & Agenda
8:15 a.m. – 8:35 a.m.  Introduction: Zero Net Energy & Prop 39
8:35 a.m. – 9:45 a.m.  Process: ZNE Versus a Typical Project
   Prop 39 Case Study: Performance Targets, Project Process & Ensuring Project Delivery
   Alexis Karolides, Point Energy Innovations
9:45 a.m. – 10:00 a.m.  Break
10:00 a.m. – 11:15 a.m.  Technologies: Opportunities in ZNE Retrofits
   Prop 39 Case Study: Design Approaches, Technologies, Occupant Engagement & Lessons Learned
   Alexis Karolides, Point Energy Innovations
11:15 a.m. – 11:45 a.m.  Activity: Benchmarking & Prioritization to Achieve ZNE
11:45 a.m. – 12:00 a.m.  Closing Discussion
Goals & Expectations
NBI is a national nonprofit working to improve buildings for people and the environment.

Program Areas:
1. Best practices in new and existing buildings
2. Continuous code and policy innovation
3. Zero net energy leadership and market development
Introduction to Zero Net Energy & Prop 39 ZNE Pilot Program
Introduction to Zero Net Energy (ZNE)
What is Zero Net Energy (ZNE)?

- ZNE Verified Buildings and Districts
- ZNE Emerging Buildings and Districts
- Ultra-low Energy Buildings

2012:
- 21 ZNE Verified
- 39 ZNE Emerging
- 39 Ultra-low Energy

2014:
- 33 ZNE Verified
- 127 ZNE Emerging
- 53 Ultra-low Energy

2016:
- 53 ZNE Verified
- 279 ZNE Emerging
- 62 Ultra-low Energy

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Why ZNE Schools?

• The next evolution in sustainable, high performance buildings

• Redirect money from utility bills to classroom

• Comfortable and productive environment for working, learning and living

• Provides hands-on, tangible learning opportunities for 21st century skills

• Makes schools and communities stronger, resilient and energy independent
ZNE is Gaining Momentum!

Growth of ZNE and Ultra-Low Energy Buildings

- ZNE Verified
- ZNE Emerging
- Ultra-Low Energy

Building Count

©2017, New Buildings Institute
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

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Area</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leslie Shao-ming Sun Field Station at Jasper Ridge Biological Preserve</td>
<td>Woodside, CA</td>
<td>13,197</td>
<td>3</td>
</tr>
<tr>
<td>Adam Joseph Lewis Center for Environmental Studies--Oberlin College</td>
<td>Oberlin, OH</td>
<td>13,595</td>
<td>-11</td>
</tr>
<tr>
<td>Omega Center for Sustainable Living</td>
<td>Rhinebeck, NY</td>
<td>6,200</td>
<td>-8</td>
</tr>
<tr>
<td>Plano Elementary School</td>
<td>Bowling Green, KY</td>
<td>81,149</td>
<td>26</td>
</tr>
</tbody>
</table>
Where are ZNE Projects?

Number of ZNE Verified Buildings

States and Provinces with ZNE Emerging or Verified Buildings (44)
ZNE Buildings in Every Climate Zone
ZNE Buildings in California
# ZNE Schools: Top Five States

<table>
<thead>
<tr>
<th>State</th>
<th>ZE Verified</th>
<th>ZE Emerging</th>
<th>Ultra-Low Energy Verified</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>2</td>
<td>23</td>
<td>6</td>
<td>27</td>
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<tr>
<td>KY</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>9</td>
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<tr>
<td>NC</td>
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<td>SC</td>
<td>0</td>
<td>5</td>
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<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>55</td>
<td>19</td>
<td>84</td>
</tr>
</tbody>
</table>
“Big Bold” Goals for ZNE in California

1. All new commercial construction will be ZNE by 2030

2. 50% of existing commercial buildings will be retrofit to ZNE by 2030

3. All new residential construction in California will be ZNE by 2020

The California Efficiency Strategic Plan (Sep 2008): californiaenergyefficiency.com/docs/EEStrategicPlan.pdf
## Foundation of State Policies

<table>
<thead>
<tr>
<th>Act</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global Warming Solutions Act (2006)</strong></td>
<td>AB 32 Reduces statewide greenhouse gas (GHG) emissions to 1990 levels by 2020 and to 20 percent of 1990 levels by 2050.</td>
</tr>
<tr>
<td><strong>Energy Efficiency Program for Existing Buildings (2009)</strong></td>
<td>AB 758 Requires the Energy Commission to develop and implement a comprehensive program to achieve greater energy savings in the state of California’s existing residential and nonresidential building stock.</td>
</tr>
<tr>
<td><strong>Long Term Energy Efficiency Strategic Plan (2008)</strong></td>
<td>State’s first integrated framework—a single roadmap to achieve maximum energy savings across all major groups and sectors.</td>
</tr>
</tbody>
</table>
### Leading by Example

**California’s Policy for Public Buildings**

Executive Order B-18-12 requires state buildings to significantly reduce over the next two decades.

- Any proposed new or major renovation of State buildings larger than 10,000 square feet use clean, on-site power generation, such as solar photovoltaic, solar thermal and wind power generation, and clean back-up power supplies

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<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>50% of new facilities beginning design after 2020 to be Zero Net Energy.</td>
</tr>
<tr>
<td></td>
<td>100% of new State buildings &amp; major renovations beginning design after 2025 to be ZNE</td>
</tr>
</tbody>
</table>

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Code Cycles to Net Zero in CA
What is ZNE in CA?

- **Time Dependent Value (TDV) = ZNE Code Building**

- **Energy Use Intensity (EUI) by Site or Source**

  **ZNE Site**: The building produces at least as much energy as it uses in a year, when grid-supplied energy is accounted for at the site boundary.

  **ZNE Source**: A building that produces at least as much energy as it uses in a year, when grid-supplied energy is accounted for at the source (including primary energy for generation, transmission, and delivery to the site).

- **Definitions may vary…**
  
  The common theme: efficiency before renewables

*This graph represents ZNE site energy usage*
ZNE and Ultra-Low Buildings are Possible in Many Building Types

- Small-Med Commercial Offices
- K-12 Schools
- Large Office Facilities
- Environmental Centers
- Higher Education Institutions
- Government Offices
Schools are Leading
Growth in ZNE and Ultra-Low Energy Education Buildings

Growth of ZNE and Ultra-Low Energy Education Buildings

- ZNE Verified
- ZNE Emerging
- Ultra-Low Energy

Building Count

<table>
<thead>
<tr>
<th>Year</th>
<th>ZNE Verified</th>
<th>ZNE Emerging</th>
<th>Ultra-Low Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
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<td>2014</td>
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<td>2015</td>
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<td></td>
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<tr>
<td>2016</td>
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</tbody>
</table>
Why Schools?

Why not?! Reverse the argument/conversation - Start from ground up with educating students about ZNE + sustainability - Set an example for ZNE/Env. Leadership - Current path is unsustainable - Need a more financially sustainable route - Also spreading the message to school + broader community - Healthier buildings (e.g., daylighting, or relating to higher test scores) - Schools can be resilient resource centers - Wise use of public funds - Increased savings in operations, brings more money for programs - Showing students what is possible - Demonstrating how schools play a part in meeting state and city goals - Demonstrating good stewardship and leaving a positive legacy for future generations - Students are good advocates with parents - Owner occupied buildings have best payback over long term - Not an unlimited amount of energy - Carbon footprint - Next generation of leaders - Energy savings goes back to programs - Mandate is looming - Next step after LEED - Cost savings - School district as model for community - As a building type, it is ideal – low occupancy, sufficient land, owner-occupied - Greenhouse gas reductions and climate goals - Fiscally responsible with taxpayer dollars - Better financing terms - Education next generation of leaders - Better financing terms - Education next generation of leaders - Increased population, increased need for more schools, will be more cost-effective to build now - Learning/teaching benefits: daylighting enhances student performance and wellbeing, biophilia (connection to nature) - Easier to operate - Maintenance - Energy savings - Retention rates - School as teaching tool - Save planet one building at a time - Necessity - Electricity is expensive - Reinvest savings for other programs - Set a good example for kids - see us doing this - demonstrate leadership - Technology creates a better, more convenient building - Attract and retain students and faculty - Quantitative benefits - Integrate into curriculum - Building awareness - Stay with them whole lives - Change expectations of students - We are doing our part - Better test scores and health
Introduction to Prop 39 ZNE Pilot Program
Process: ZNE versus a Typical Project
Gain Support for your ZNE Vision

- **Stakeholder mapping:**
  - Who are the stakeholders?
  - What are their drivers?
  - What are the key messages?
- Share case studies, fact sheets and other ZE materials
- Attend webinars and trainings
- **Identify sources to support your efforts**
  - Prop 39 & California IOU’s
  - NBI Getting to Zero Project Guide
- Visit a ZE school!
The Building as an Opportunity for Education

- **Schools** are about **educating students** and not about running facilities!

- **Use daily building operations as educational opportunities.**

- **Hands on learning** opportunities increase **student performance** and **lesson retention**.

- Adapts students to a knowledge-based **technologically advanced society**.

- Students grasp **21st century skills** like teamwork, research gathering, time management, information synthesizing, independence and utilizing high tech tools.

- **Schools house the next generation of environmental leaders.**
Next Generation Science Standards & Skills

- Analyzing and Interpreting Data
  Engineering Design and Human Impacts
  Energy

- Influence of Science, Engineering, and Technology on Society and the Natural World
  Engineering Design

- ESS3.C: Human Impacts on Earth Systems
  Human Impacts

- Science Addresses Questions About the Natural and Material World
  Human Impacts

- Constructing Explanations and Designing Solutions
  Energy

- Engaging in Argument from Evidence
  Energy

- ETS1.B: Developing Possible Solutions
  Energy

... among others!
Selecting Your Project Team

• Define your ZNE targets and incorporate into RFP guidelines

• During interviews ask about ZNE experience
  • NBI has a list of questions to consider

• Pre-bid and pre-construction conferences

• Clarify how renewables will be addressed
Building Benchmarking, Prioritization & Assessment

- Benchmark energy use & establish your energy target
- Review the Development Pipeline: Can be at the building, district or portfolio level
- Perform initial evaluations:
  - Do they have good access for solar?
  - What is a typical energy target for this building?
  - Are there any unusual circumstances that make this building a bad candidate for ZE?
- Evaluate timeline in respect to school board meetings, bond planning, etc.
Benchmarking Existing Facilities: How CA Schools Perform

• Comparison K-12 EUIs from Two Data Sources:
  • CBECs (K-12) = 58.2 kBtu/sf/yr
    • Nationwide Median, released 2003
  • CEUS (K-12) = 41.4 kBtu/sf/yr
    • CA Specific Average, released 2006

• ZNE Threshold: Approx. EUI = 20-25 kBtu/sf/yr
Performance Range (all projects w/ measured performance data)

Average EUI 21
Performance Range - Education

Measured EUs of Educational Buildings

Average for all verified Education buildings 24.5 EUI

EUI (kBtu/ft²/yr)

Education-Higher

Education-K-12

ZNE Verified
ZNE Emerging
Ultra-low Energy
FirstView Analysis of Building Performance

- High thermal baseload
- High heating use
- High electric baseload
- High Ventilation/Cooling Load

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Define your ZNE Target

Defining your EUI:

1. Define **cost effective** EEMs from Audit
2. Develop iterative energy model
3. Define your operating schedule compared to annual renewable energy generation
4. Understand **PV feasibility**
5. Determine solar budget
(Example) ZNE Retrofit Energy Efficiency Measures (EEM)

<table>
<thead>
<tr>
<th>Measure 1: Reduced Building Equipment Energy Use</th>
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<tbody>
<tr>
<td>Strategy 1a. Receptacle Controls</td>
</tr>
<tr>
<td>Strategy 1b. Plug Load Management</td>
</tr>
<tr>
<td>Strategy 1c. Plug Load Equipment</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Measure 2: Heating and Cooling Strategies</th>
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</thead>
<tbody>
<tr>
<td>Strategy 2a. Dedicated Outdoor Air System (DOAS)</td>
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<tr>
<td>Strategy 2b. HVAC Zone Control</td>
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</table>

<table>
<thead>
<tr>
<th>Measure 3: Improved Overall Building Envelope Performance</th>
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</thead>
<tbody>
<tr>
<td>Strategy 3a. Thermal Load Intensity</td>
</tr>
<tr>
<td>Strategy 3b. Air Infiltration Testing</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure 4: Reduced Lighting Energy</th>
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<tbody>
<tr>
<td>Strategy 4a. Luminaire Level Lighting Control</td>
</tr>
<tr>
<td>Strategy 4b. Interior LPDs and Exterior Lighting Efficacies Based on Solid-state Lighting</td>
</tr>
</tbody>
</table>
Establishing your ZNE Target

• Set your targets **beyond** “xx% better than”
• Future proofing – beyond code
• Also use other programs to establish energy targets or set goals
  • CHPS
  • LEED
# Benchmarking & Target Setting

## Table 29. Energy Intensity Values for Zero Energy Schools

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Representative City</th>
<th>Primary School</th>
<th>Secondary School</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>Site Energy</td>
<td>Source Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(kBtu/ft²·yr)</td>
<td>(kBtu/ft²·yr)</td>
</tr>
<tr>
<td>1A</td>
<td>Miami, FL</td>
<td>25.9</td>
<td>76.4</td>
</tr>
<tr>
<td>2A</td>
<td>Houston, TX</td>
<td>24.3</td>
<td>71.1</td>
</tr>
<tr>
<td>2B</td>
<td>Phoenix, AZ</td>
<td>24.7</td>
<td>72.5</td>
</tr>
<tr>
<td>3A</td>
<td>Memphis, TN</td>
<td>23.8</td>
<td>69.0</td>
</tr>
<tr>
<td>3B</td>
<td>El Paso, TX</td>
<td>23.4</td>
<td>67.8</td>
</tr>
<tr>
<td>3C</td>
<td>San Francisco, CA</td>
<td>21.6</td>
<td>61.9</td>
</tr>
<tr>
<td>4A</td>
<td>Baltimore, MD</td>
<td>23.5</td>
<td>67.6</td>
</tr>
<tr>
<td>4B</td>
<td>Albuquerque, NM</td>
<td>23.1</td>
<td>66.6</td>
</tr>
<tr>
<td>4C</td>
<td>Salem, OR</td>
<td>22.4</td>
<td>64.2</td>
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<td>Chicago, IL</td>
<td>24.3</td>
<td>69.9</td>
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<td>Burlington, VT</td>
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<td>70.1</td>
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<td>25.9</td>
<td>74.1</td>
</tr>
<tr>
<td>8</td>
<td>Fairbanks, AL</td>
<td>28.7</td>
<td>82.5</td>
</tr>
</tbody>
</table>
Set your Target

Begin by defining your energy target and solar budget
Contract to Achieve the Target

Make “Getting to Zero” Part of the Contract:

• Integrate into RFP language
• Define scopes of work
  • Engage team for design through operations
  • Use “shoebox” energy modeling to inform the design
  • Include net zero building commissioning
  • Include controls integration
• Define critical path schedule
Request for Proposals & Qualifications (RFPs & RFQs)

RFP Guidelines for Net Zero Energy Projects

- Establish net zero energy as one of the key project objectives.
- Set an annual energy use target appropriate for the net zero energy objective.
- Clarify whether or not on-site renewable energy systems will be part of the RFP; in either case, consider how they will be coordinated with building design and construction.
- Provide a well-crafted project definition, one that takes into account the opportunities and challenges of net zero energy.
- If a separate RFQ is not used prior to the RFP, integrate the guidelines for RFQs stated in the previous RFQ section.
- Establish the selection process and delivery method in support of forming a trust-based, integrated delivery team, whose members are aligned with the project objectives.
Integrated Design & Early Charrettes

Integrated design and charrettes help facilitate:

1. Clear & Continuous Communication
2. Rigorous attention to detail
3. Active collaboration among all team members throughout all phases of the project

NBI Charrette Toolkit:
- Charrette Checklist & Materials List
- Sample Agendas
- Presentation Template
- And more!

http://www.wbdg.org/design-objectives/aesthetics/engage-integrated-design-process

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Use the Owners Project Requirements to guide the ZNE process:

- Define Owner’s Project Requirements (OPR)
- Establish the Basis of Design (BoD) (the design team approach)
Example OPR’s

**SFUSD PROJECT REQUIREMENTS**

May 1, 2017

**STRATEGY**

The District has many opportunities to improve the carbon footprint of its buildings:

- **BOND PROJECTS:** ballot-approved funding for new construction & major renovations provides the best opportunity for deep energy retrofits.

- **MONITORING:** post-occupancy commissioning and energy monitoring can identify opportunities to adjust operation to meet design intent.

- **OPERATIONS & SHARED SAVINGS:** preventative maintenance, energy and water monitoring, and engagement of users preventing energy and water usage at buildings age.

- **FACILITIES PROJECTS:** major repairs and deferred maintenance projects provide an opportunity to improve energy and water efficiency.

These SFUSD Owner’s Project Requirements were created to assist design teams in supporting the District’s ambitious zero carbon goals. The following pages describe the process for incorporating ZNE-ready design into new buildings, bond modernizations, and facilities projects. In summary:

- **New Buildings:** will be designed to achieve an Energy Use Intensity (EUI) of 40 BTU/sf/ly in.

- **SFUSD’s preferred strategies for achieving such exemplary energy efficiency are outlined in the ZNE District for K-12 Schools document.**

- **Bond Modernizations:** will focus on improvements to the lighting, systems and building envelope as outlined in SFUSD Assessment commissioned by the District for every project prior to the design phase. These assessments will also look for opportunities to improve heating and ventilation systems; but these items will generally be included in future bonds unless broken equipment necessitates earlier action.

- **Facilities Projects:** generally have limited scope and will support ZNE goals by upgrading building elements as they wear out. In such cases, the ZNE Building Advisor and Green Design Standards will inform the design and selection of materials and equipment for these projects.

**PROCESS**

- **New Buildings:** ensuring that the District’s energy targets are met in new construction projects requires a rigorous design process, better construction techniques, and attention to quality control. To ensure the best possible outcome on each and every project, SFUSD requires architects to incorporate the following elements into the process of creating new buildings:

  - **CHARGE:** All projects will commence with an architectural design charrette specifically focused on identifying the strategies and systems necessary for meeting the EUI performance goal. At a minimum, the Project Manager, Sustainability Office, Buildings & Grounds Design Team, Commissioning Agent, and Electrical/MEP/Mechanical/HVAC consultants will attend.

  - **ENERGY MODELING:** Building form, massing, orientation, and roof layout (among other design parameters) have a significant impact on energy usage and solar energy production. Therefore, design decisions shall be evaluated against a consistently refined energy model from the earliest stages of a project. In this way, project architects will have more opportunities for course correction should site conditions or non-energy parameters make achievement of ZNE goals difficult.

  - **COMMISSIONING:** Commissioning agents hired by the District will be brought into the design process early on and follow each project through design, construction, and post-occupancy to ensure that design intent is achieved as outlined in this document and reflected in the District’s Design (SDD). The Commissioning Plan will include design review, construction inspections, functional testing, development of a maintenance manual, and systems training (see Commissioning Procedures in the 2016 Bond Program Procedures – Standards Book).

  - **First ZNE Projects:** SFUSD is in the process of designing its first new ZNE building at Claire Lilienthal School on Divisadero St. The building will house the middle school program of this historic school and replaced eight existing bargains. The second ZNE project is a K-828 supported modernization of Galileo Elementary on Telegraph Hill. The utility is particularly interested in identifying design solutions in the constrained urban environment.
Design to the Target

Building automation and controls integration

Making It All Work Together: Key Points

• Use the **Owners Project Requirements (OPR’s)** to guide the ZNE process
• Plan for Measurement and Verification
• Beware of Value Engineering!
• Controls considered from design through operation
• Keep the Operators and Occupants in mind
Controls

• User-friendly/intuitive
• Over-rides contribute to the confusion
• Consistent – across an institution if possible
• Organized
Common Technologies for ZNE and Ultra-low Energy

- Building Orientation, Window to Wall Ratio, and Glazing Location/Optimization
- Highly Efficient Thermal Envelope
- Ventilation: Natural, Dedicated Outdoor Air Systems (DOAS), Demand Control Ventilation (DCV)
- Conditioning: Ground Source, Radiant, Chilled Beams
- Controls Integration
- Daylighting Access and Controls
- Solar and Glare Control - shading
- Energy Recovery Systems
- Plug Load Reductions
- Energy Management Systems
- Building Dashboards
Part 1: ZNE Retrofit Process
Alexis Karolides
Sustainability Practice Leader, Point Energy Innovations