



Mayor Jorge O. Elorza

Leah Bamberger, Director of Sustainability Dilip Shah, Building Energy Advisor

ReP WERPVD

Creating Buildings of the Future



20 % reduction by 2025

Race to Zero















2.3 Million SF of Real Estate in Providence has Joined









Regency Plaza, 10 Memorial Boulevard, Downtown Marriott, Providence Housing Authority

RePowerPVD.com











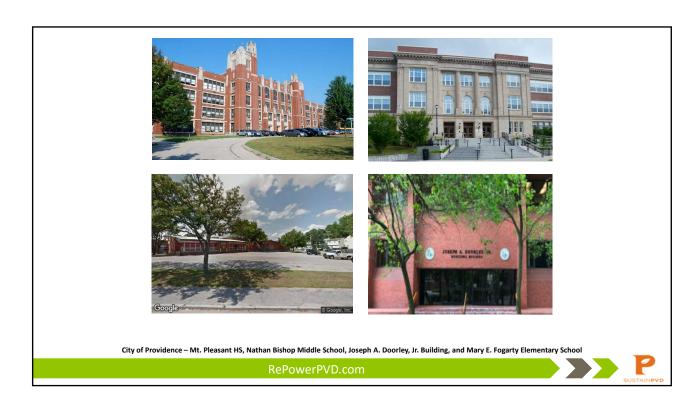


Cornish Associates – Alice Building, Burgess/O'Gorman Building, Kinsley Building, and Smith Building

RePowerPVD.com









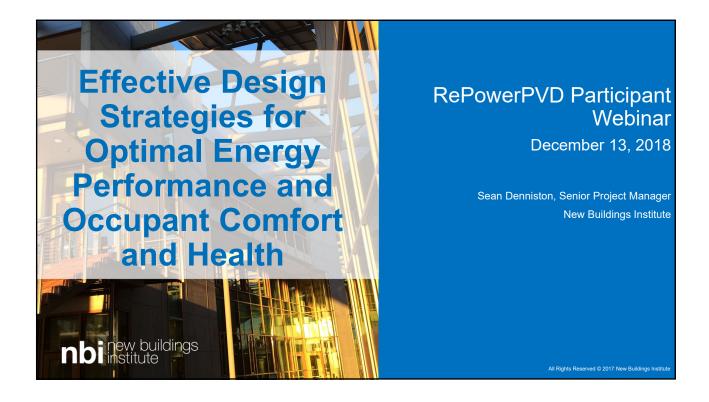
Learn more at RePowerPVD.com

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RePowerPVD.com







Learning Objectives

- 1. Participants will learn how zero energy retrofits and new construction should be coordinated into an integrated design process to optimize building design and performance.
- 2. Participants will gain an understanding of replicable and scalable energy efficiency measures, strategies and policies to get to zero energy across multiple building types.
- Participants will be learn how non energy benefits can increase the long-term cost-effectiveness of a building and improve occupant health and wellness, retention and satisfaction.
- Participants will understand the opportunities occupants have to further increase energy efficiency during day to day operations.







What is New Buildings Institute? (NBI)

NBI makes buildings more efficient. We shape the future with innovation, research, design guidance, and advanced building energy policy.

Technical Expertise:

- · Zero energy leadership and market development
- Best practices in new and existing buildings
- Continuous code and policy innovation





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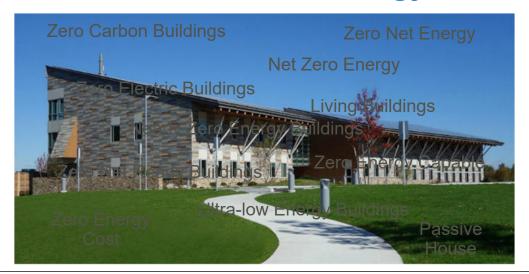
What is Zero Energy







What is Zero Energy



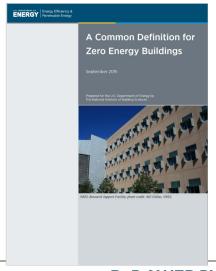


U.S. DOE Definition of Zero Energy

DOE released A Common Definition for Zero Energy Buildings in 2015

An energy-efficient 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).

* Or a campus, community, or portfolio







Site vs. Source Energy

Site: Total energy used on-site (kBtu/sf year)





Site vs. Source Energy

Site: Total energy used on-site (kBtu/sf year)

Example: US Median Office Building EUI





Energy Use Intensity (EUI) =

Annual Energy Use
Square Footage

67 kBtu/ft²/year **Site**





Site vs. Source Energy

Site: Total energy used on-site (kBtu/sf year)

Source: Total upstream energy

required

Energy Use Intensity (EUI) =

Annual Energy Use Square Footage

Example: US Median Office Building EUI



148 kBtu/ft²/year **Source**

67 kBtu/ft²/year **Site**





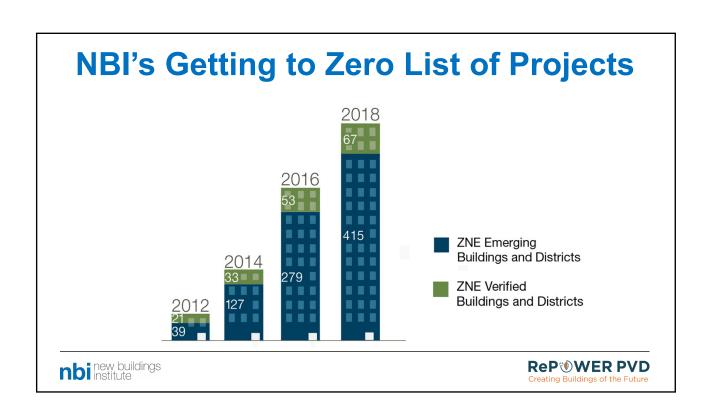
Zero Energy – What is it?

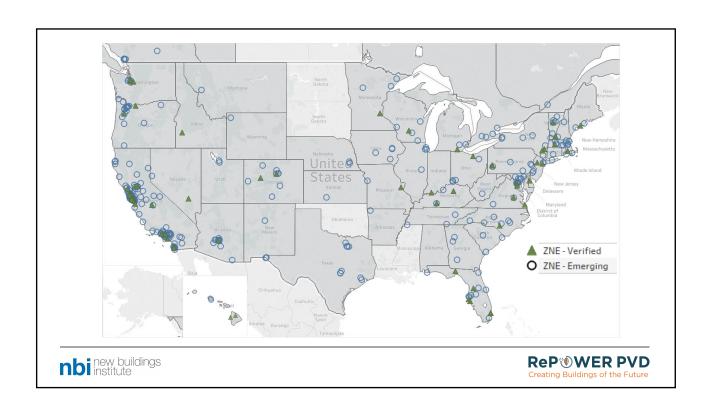


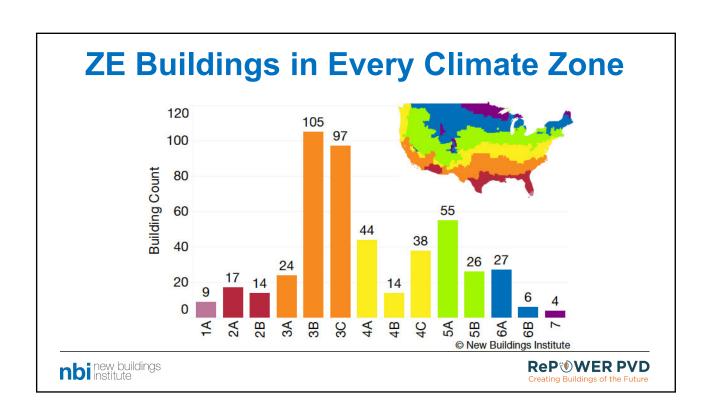
A ZE building is an ultra-efficient building that generates as much energy as it consumes on a net annual basis.

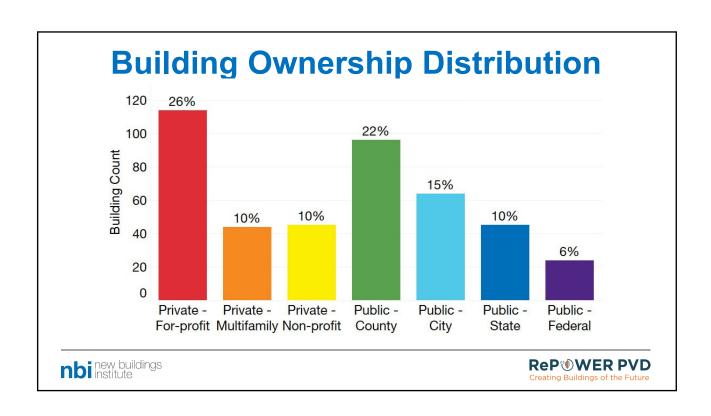


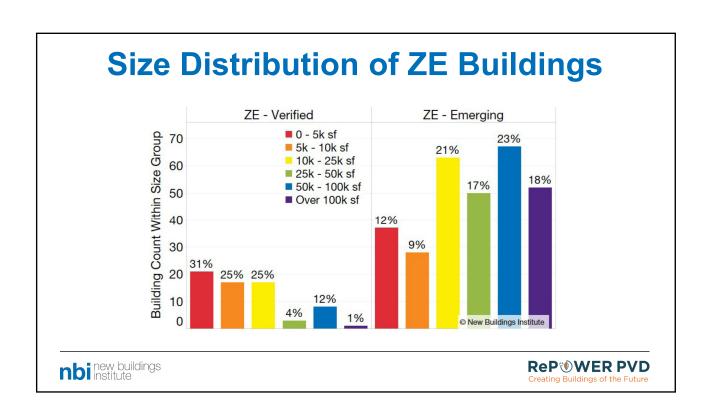


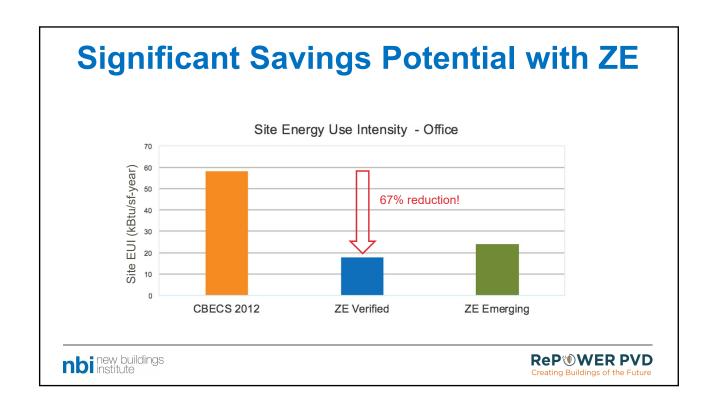


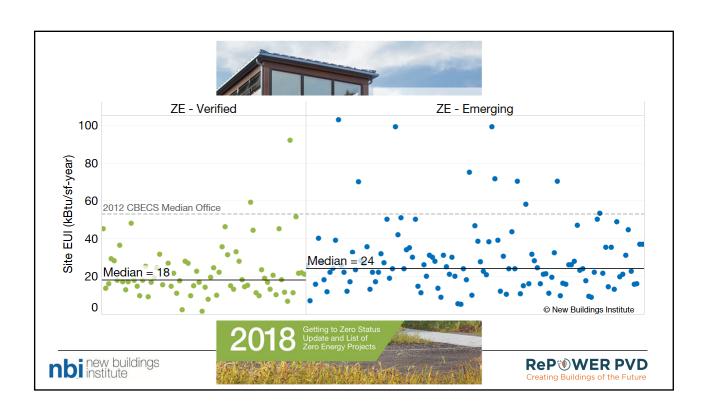


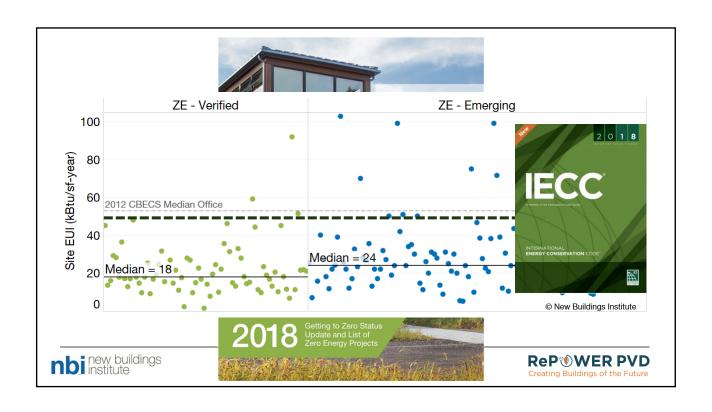


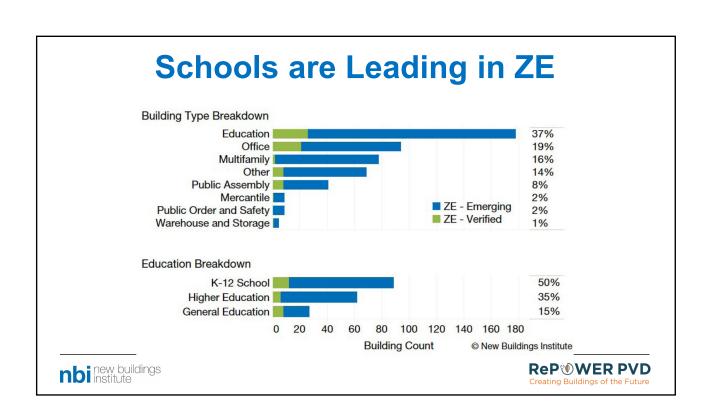


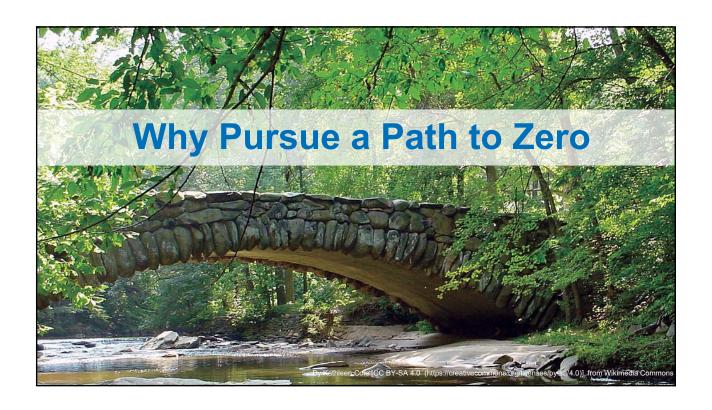












Non-Energy Benefits

3 - 30 - 300



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Non-Energy Benefits

3 - 30 - 300

Energy



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Non-Energy Benefits

3 - 30 - 300

Rent



Non-Energy Benefits

3 - 30 - <u>300</u> Payroll

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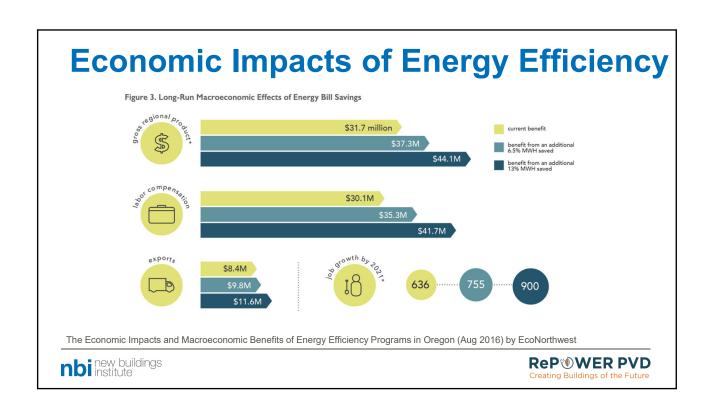
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Non-Energy Benefits

3 - 30 - <u>300</u>

100% = 1%

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Health Benefits

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



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Productivity Benefits of 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.

Health, Wellbeing & Productivity in Offices
The next dapter for green building Suprander 2814

Health, Wellbeing and Productivity in Offices: The Next Chapter for Green Building





Done Right By Planet and People: The Business Case for Health and Well Being in Green Buildings - Key Findings

- Companies save money by occupying a green building that benefits people
- Employees prefer green buildings that make them feel healthier and more productive
- A building's asset value increases the greener and healthier it is





Why Zero Energy Schools?

- Cost avoidance from utility bills to classroom
- Create comfortable and productive environment for teachers and students
- Provide hands-on, tangible learning opportunities for 21st century skills
- Make communities stronger, resilient and energy independent



lood River School District Science Building | Hood River, O Photo Courtesy of Opsis Architectur





Benefits of High Performance Schools

- Occupants in ventilated spaces with low CO2 and low volatile organic compounds (VOCs) had improved scores in crisis response, information usage, and strategy ranging from 100 to 300%.¹
- Students in daylit environments showed a 20-26% improvement on test scores compared to traditionally lit environments².
- Students with operable windows progressed 7-8% faster than those without operable windows².
- Students with the most daylighting performed 7-18% better in math and reading than those without².
- Students exposed to daylight attended school 3.2 to 3.810 more days per year³







Discovery Elementary School | Arlington, VA Photo Courtesy of VMDO Architects





High Performance Schools Fast Facts!

Did you know that the classroom environment can affect a child's academic progress over a year by as much as

25%'

65%



Reduction in asthma cases among elementary students when school indoor environment quality improves.^a **3**%



Reduction in teacher turnover in green schools - saving US\$4 per square foot over a 20 year period.³

20%



Faster progression in math in schools with good daylighting.4

26%



Faster progression in reading in schools with good daylighting.⁴

10%



Increase in overall performance in schools with good daylighting.4

Barett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2012, October 03). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning Meng, Y., Babey, S. H., & Wolstein, J. (2012). Ashtma-Related School Absenteeism and School Concentration of Low-Income Students in California. Katz, G. (2005). Genering America's Schools: Ossia and Benefits. Credit: World GBC







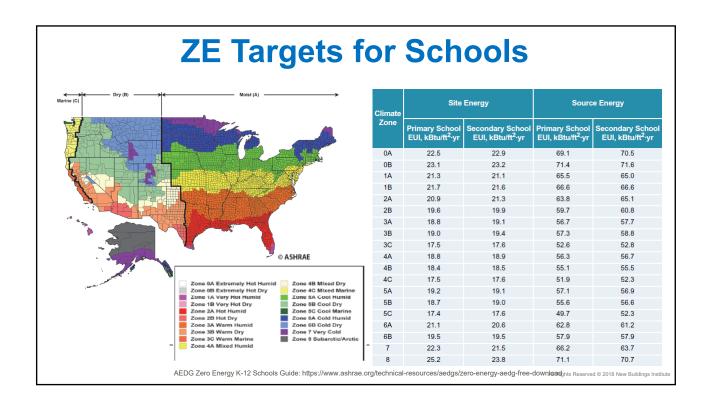
Strategic Process to Get to Zero

- Stakeholder Awareness
- Select Team
- Integrated Design / Pre-design
- Building Prioritization
- Energy Goals and Targets
- · Finance and Incentives
- · Design and Construction
- Project Hand Off
- Operation and Maintenance
- Measurement and Verification



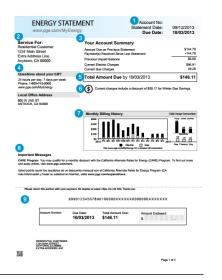
Paul W. Crowley East Bay Met Campus | Newport, RI RGB Architects





Benchmarking

- Collect energy consumption
 - 2-3 years
- Benchmark use against
 - CBECS, CEUS, other schools in district
- Useful tools include :
 - ENERGY STAR Portfolio Manager
 - Online data tracking
 - · School Dude & Others
 - Excel





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



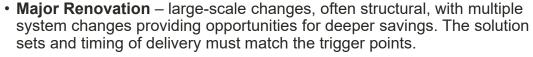
Watson Center for Information Technology





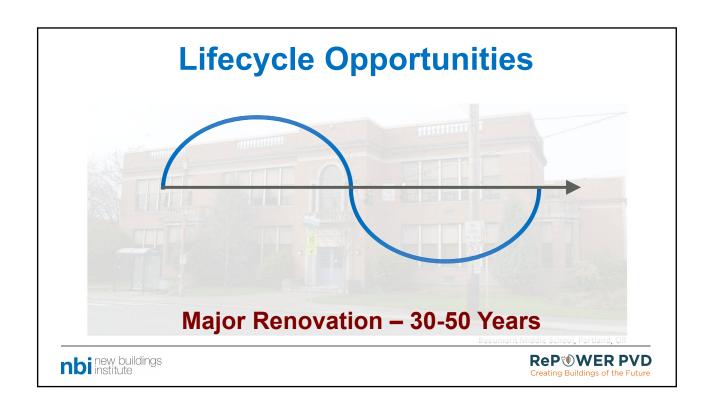
Lifecycle Opportunities

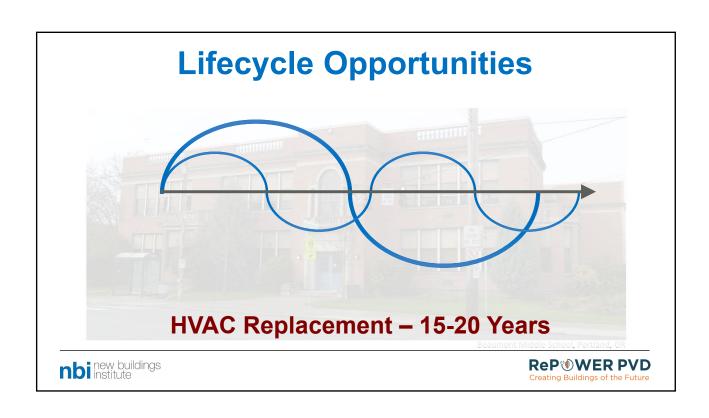
- Recognize trigger points in building lifecycle and operational practices
- Plan for efficiency improvements:
 - **As-is** no planned capital improvements.
 - Plan in Place regular maintenance plan, equipment regularly assessed and upgraded.

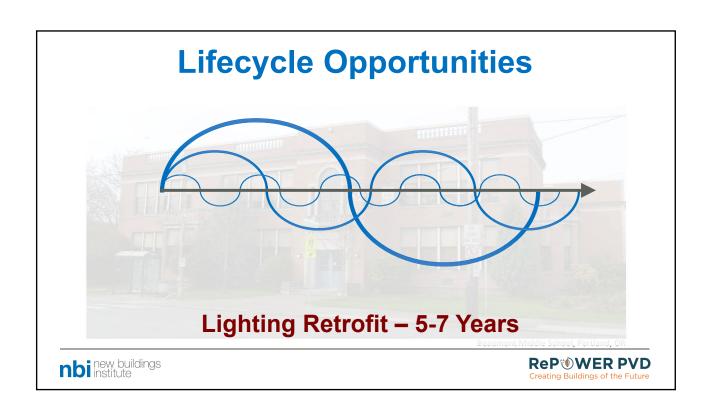




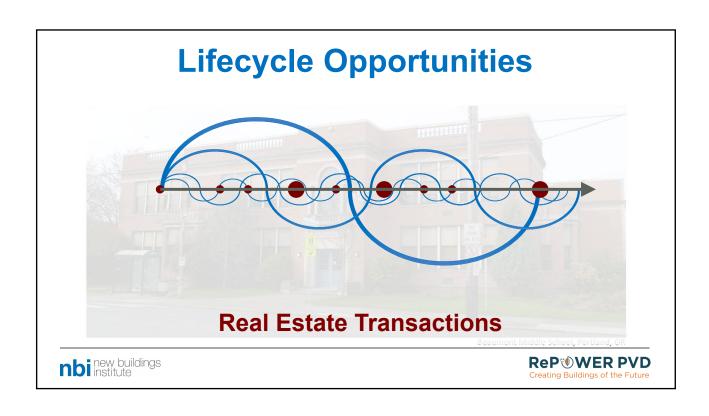


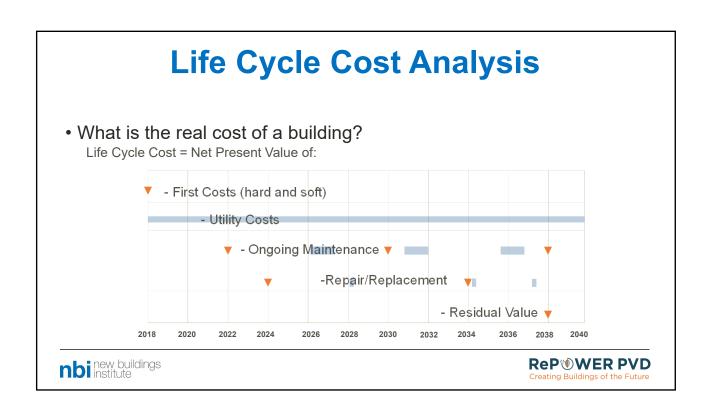












Zero Energy Design Charrette

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



Getting to Zero:
ZNE Integrated Design
Charrette Toolkit







Common Measures and Strategies

- Passive Measures
- Envelope and Air Tightness
- Space Conditioning (separate from ventilation)
- Interior Lighting
- Hot Water Distribution
- Plug Load Management
- Onsite Renewable Energy
- Electric Vehicle Charging
- Battery Storage



Kathleen Grimm School PS 16 | New York City



Design: Passive First







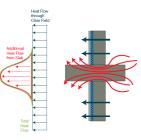


Design: Passive First









Window to Wall Ratio

Thermal Performance

Infiltration

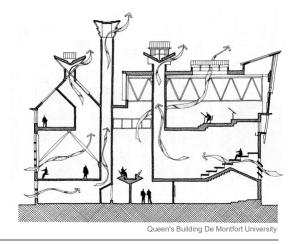
Thermal Bridges





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

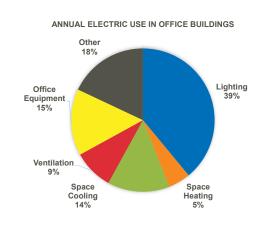


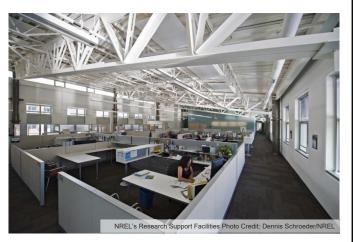






Daylighting Opportunities





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



owa Utilities Board Office of Consumer Advocate

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Interior and Site Lighting

- Select 100% LEDs.
- Controls: The most efficient lamp is one that isn't in use.









Building Envelope

- Design around effective R Value
- Be relentless about air sealing
- · Conduct blower door testing
- · Continuous air barriers and penetration sealing
 - · Minimize leakage
 - Reduce temperature changes
 - · Control outside air
 - Minimize moisture changes
- Reduce number of mullions and increase glass size



Source: VMDO



Space Conditioning and Ventilation

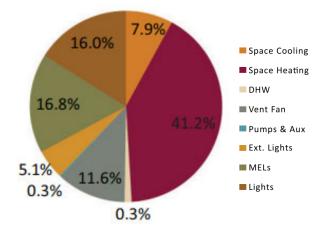
HVAC systems offer great opportunities for efficiency.

RI HVAC Opportunities

- Heat recovery
- Airtightness
- VAV reheat with AC for dehumidification

Less Important:

· Data center and plug loads, lighting



Sensitivity Analysis: Chicago Energy by End Use





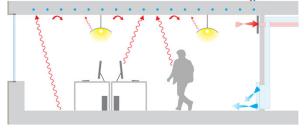
Separate Ventilation from Conditioning

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



©Center for the Built Environment at UC Berkeley, ©Caroline karmann



Advanced Water Heating

	Individual Electric	Individual Gas	Central Electric	Central Gas
	0.92 UEF	0.60 UEF / 0.91 UEF	2.03 UEF	0.80 Et
Energy STAR	2.0 UEF	0.64* UEF / 0.87* UEF	2.2 UEF	0.90 Et
Best in Class	3.5 UEF	0.83 UEF / 0.96 UEF	3.5 UEF	0.97 Et



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Advanced Water Heating

Water Heater Type	Input Rating	Required Efficiency	Customer Discount
Storage Water Heaters	< 75 Mbtuh	Energy Factor ≥ 0.67 or Uniform Energy Factor ≥ 0.68	\$50/unit
	≥ 75 Mbtuh	Thermal Efficiency ≥ 90%	\$2.00/Mbtuh
Tankless Water Heaters	< 200 Mbtuh	Energy Factor ≥ 0.82 or Uniform Energy Factor ≥ 0.81	\$0.25/Mbtuh
	< 200 Mbtuh	Energy Factor ≥ 0.90 or Uniform Energy Factor ≥ 0.89	\$1.00/Mbtuh
Volume Water	≥ 75 Mbtuh	Thermal Efficiency ≥ 85%	\$0.50/Mbtuh
Heaters	≥ 75 Mbtuh	Thermal Efficiency ≥ 92%	\$2.00/Mbtuh
Indirect Water Heaters	N/A	N/A	\$200/unit



Controls

- User-friendly/intuitive
- Over-rides contribute to the confusion
- Consistent across an institution if possible





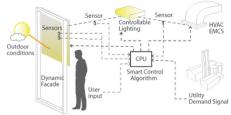






System Controls

- 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



Courtesy of Steve Selkowitz, LBL

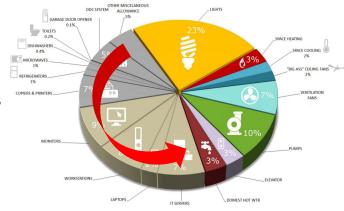




Plug Load Controls

- Modern office: increase in miscellaneous loads
- Plug loads can be 50% of total energy use in an ZE building
- More efficient regulated loads (Lights, HVAC, H2O Heating)
- Most ZE buildings (64%) use plug load controls, controlled outlets, monitoring

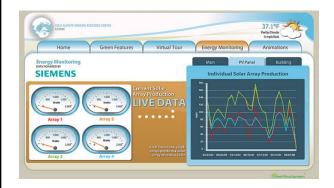






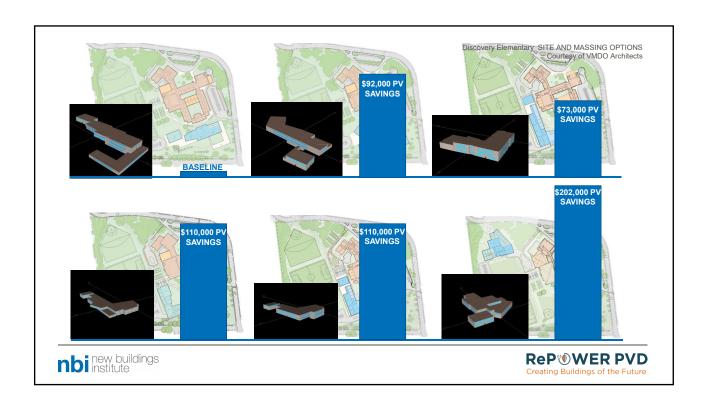


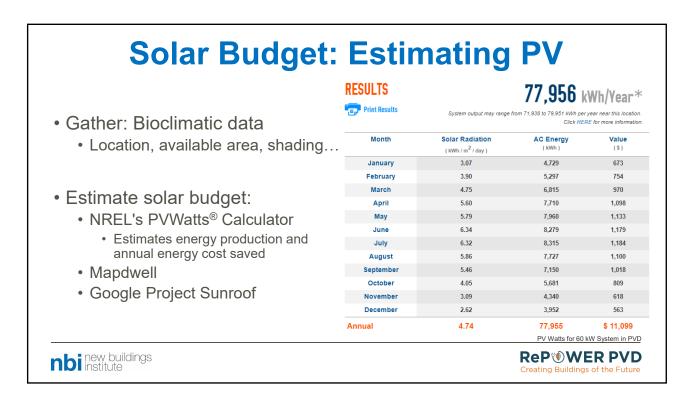
Integrating Operations











Take a Strategic Approach

- Clarify sustainability and energy (EUI) goals
- Consider comfort & health first (thermal, acoustic, lighting, views)
- Align with building lifecycle opportunities
- Use energy modeling as a design tool
- Start with load reduction
- Then optimize mechanical design
- Then optimize mechanical equipment
- Then consider PVs and renewables







ZE Tools & Resources

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- ZE Case Studies
 http://newbuildings.org/case-studies-ZE-projects
- http://energydesignresources.com/resources/publ ications/case-studies/case-studies-zne-nonresidential-buildings.aspx
- NBI Registry http://newbuildings.org/share
- Getting to Zero Database http://newbuildings.org/getting-to-zero-buildings-database





