

NREL Commercial Buildings Research



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**NREL Commercial
Buildings Research
Group**

**Boulder Green Building
Guild Conference**

Boulder, CO

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Advanced Commercial Building Research

www1.eere.energy.gov/buildings

- Commercial Building Energy Alliances (CBEA)
- Commercial Building Partnerships (CBP)
- Net Zero Energy Buildings (ZEB)
 - DOE's Net Zero Energy Commercial Building's Initiative
- Technical Support Documents & Advanced Energy Design Guides

- Benchmark Models
- HVAC Test Facility
- Opt-E-Plus
- EnergyPlus
- Open Studio



The Future of Zero Energy Buildings

- The DOE Net-Zero Energy Commercial Building Initiative aims to achieve marketable net-zero energy commercial buildings by 2025
 - Buildings consume 40% of US energy (70% electricity) – electricity use predicted to increase 50% by 2025 under BAU
- ASHRAE Vision 2020
- AIA 2030 Challenge
- California Public Utilities Commission ZEB Action Plan
 - All new residential ZEB by 2020
 - All new commercial ZEB by 2030
- EU ZEB requirement by 2019
 - International Energy Agency ZEB Definitions Task
- All Federal Buildings ZEB by 2030
 - October 2009 Executive Order
 - Beginning in 2020 all new Federal buildings that enter the planning process are designed to achieve zero-net-energy by 2030

www.commercialbuildings.energy.gov

Guiding Concepts

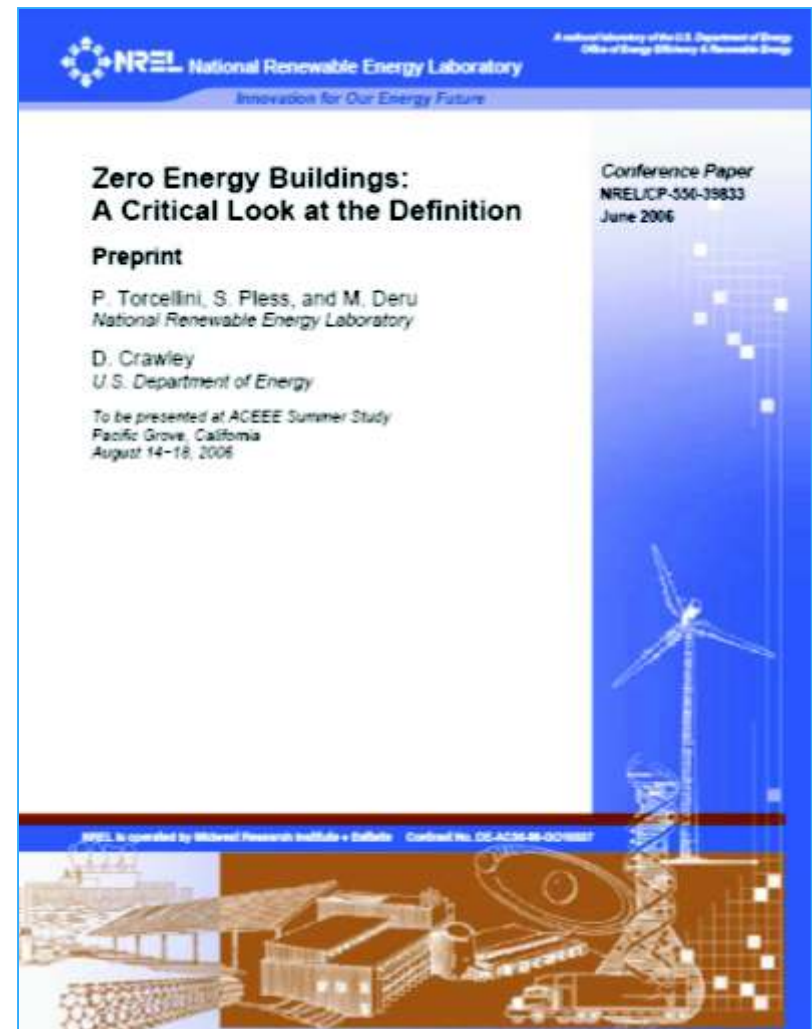
- Buildings can meet all of their energy needs from renewable sources
- Demand side first, then supply side
- Net zero using grid for energy balance
- Prioritize renewable energy options
 - Within Footprint
 - On-site
- Lots of Room for Interpretation...

Definitions of NZEB's

- Net Zero Site Energy
- Net Zero Source Energy
- Net Zero Emissions
- Net Zero Energy Cost

Boundaries and metrics

The Definition used WILL impact the ZEB design strategies!










ZEB Renewable Energy Supply Option Hierarchy

ZEB Classifications	Option Number	ZEB Supply-Side Options	Examples
	0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, ground source heat pumps, etc.
On-Site Supply Options			
ZEB:A	1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
ZEB:B	2	Use renewable energy sources available at the building site and connected to the building electrical or hot water distribution system	PV, solar hot water, low-impact hydro, and wind located on parking lots, adjacent open space, etc, but not on the building. RE output directly connected to building systems.
Off-Site Supply Options			
ZEB:C	3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.
ZEB:D	4	Purchase certified off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options, as certified by programs such as Green-E. Hydroelectric is sometimes considered.

Zero Energy Buildings Database

First US Database of Net-Zero Energy Buildings:

http://www.eere.energy.gov/buildings/commercial_initiative/zero_energy_projects.html

	Picture	Name	Owner	Location	Building Type	Floor Area (ft ²)	Annual Purchased Energy (kBtu/ft ²)
<input type="checkbox"/>		Aldo Leopold Legacy Center	The Aldo Leopold Foundation, Inc.	Baraboo, WI	Commercial office; Interpretive Center	11,900	-2.02
<input type="checkbox"/>		Audubon Center at Debs Park	The National Audubon Society	Los Angeles, CA	Recreation; Interpretive Center; Park	5,020	
<input type="checkbox"/>		Challenger's Tennis Club	Whittier Foundation	Los Angeles, CA	Recreation	3,500	-0.0955
<input type="checkbox"/>		Environmental Tech. Center, Sonoma State	Sonoma State University	Rohnert Park, CA	Higher education; Laboratory	2,200	-1.47
<input type="checkbox"/>		Hawaii Gateway Energy Center	Natural Energy Laboratory of Hawaii Authority (NELHA)	Kaunakakai, HI	Commercial office; Interpretive Center; Assembly; Other	3,600	-3.46
<input type="checkbox"/>		Oberlin College Lewis Center	Oberlin College	Oberlin, OH	Higher education; Library; Assembly; Campus	13,600	-4.23
<input type="checkbox"/>		Science House	Science Museum of Minnesota	St. Paul, MN	Interpretive Center	1,530	0

7 project(s)

- Enter your own ZEB projects, even for as-designed examples
- Update with monitored data after first year of operation

Design Strategies for ZEB...

- Maximize space efficiency
- Envelope and orientation to reduce loads
 - Well insulated roofs, walls, floors, windows (with shading)
- Envelope and orientation to meet loads
 - Daylighting
 - Passive solar heating, Trombe walls
 - Natural ventilation
- Lighting design to match daylighting
- Plug loads
 - Design vs. owner loads
- Climate specific HVAC designed for the remaining loads
- Commissioning (making sure the building works)
- Metering and evaluation
- Make it simple
- Site specific renewable generation
 - within footprint, site, off-site
- Small amounts of RECs

ZEB Examples- Generation within Footprint (ZEB:A)

Site, Source, Emissions ZEB within Footprint

- Science House
- IDeAs Z² Design Facility
- Aldo Leopold Legacy Center
- Hawaii Gateway Energy Center



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Photograph by David Wakely



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Used by permission of
Science Museum of Minnesota

ZEB Examples- Generation within Site (ZEB:B)

Site, Source, Emissions ZEB within Site

–Measured

Oberlin College Lewis Center

–13,600 ft² , 1 ½ floors

•~35 kBtu/ft² Site EUI, 50% savings

•160 kW PV

•100 kW in parking lot



NREL Pix #10860

NREL Research Support Facility Current Design: Site, Source, Cost, Emissions ZEB:B



Images Used by Permission of RNL Design

ZEB procurement

- Design-Bid-Build
- Construction Manager at Risk
- Design-Build
 - Prescriptive-Based
 - **Performance-Based**
 - RFP specifies project goals
 - Fixed, firm price
 - Energy goals built into contract
 - Substantiation required

Setting Goals

- Measurable goals are better
- From bad to good...
 - I want a green building
 - Design a LEED <rating> building
 - Design a building to use 30% less energy than ASHRAE 90.1-2004
 - Design a building to use less than 25,000 BTU/sqft
 - Design a [NET] ZERO ENERGY BUILDING
- Influencing purchasing decision—the owner

Project Goals

- 742 people
- 220,000 ft²
- 25 kBtu/ft²
- 50% energy savings
- \$250/ft²
- LEED Platinum
- Replicable
 - process
 - technologies
 - cost
- Site, source, carbon, cost ZEB:B
 - Includes plugs loads and datacenter
- Design/Build Process with required energy goals



NREL Pix #16865

Replicable - Cost

- \$64 million total design/build contract
 - Excludes site work and infrastructure
 - Includes interiors and furniture
- \$262 / SF Construction cost
 - ~30/ft² for PV if we purchased unsubsidized
 - Working on a full project cost
 - What will it take to build this building somewhere else?
- Comparable cost with other government office building projects in the region
- Third party owned PV
- Keep it simple
 - No curved walls, prototypes
 - Optimize glazing
- Require net zero and demand side EUI at the beginning
 - Put it in the contract!

It is Really About the Details

- Combinations of 1000's of little things that cause buildings to use energy
- Conceptually, zero-energy buildings can be done
 - fail on the details
 - and the replication...
- Difference between expectations and actual operation?
- ZEB is a challenge! Work needed to:
 - understand cost effective pathways to zero
 - Plug loads efficiency measures
 - Address daily and seasonal mismatch with the grid
- Optimize efficiency measures
 - 50%-70% Energy Savings
- Optimize available renewable energy generation options
 - Weighted toward technologies available within footprint
 - “Dedicated” to the building
 - Require energy efficiency to reach ZEB

Ending Thoughts...

- Zero is Possible
- Zero takes a coordinated effort with the owner (and all user groups), architect, builder, and the engineering
- The little things make the difference in getting to zero
 - as you get to zero, little is significant
 - Thermal breaks
 - 4 W/phone!
- The owner needs to set measurable goals and communicate these goals to the design team
 - \$ incentive helps too
- The solution is not bigger supplies
- How can we reduce plug loads?

Thanks!

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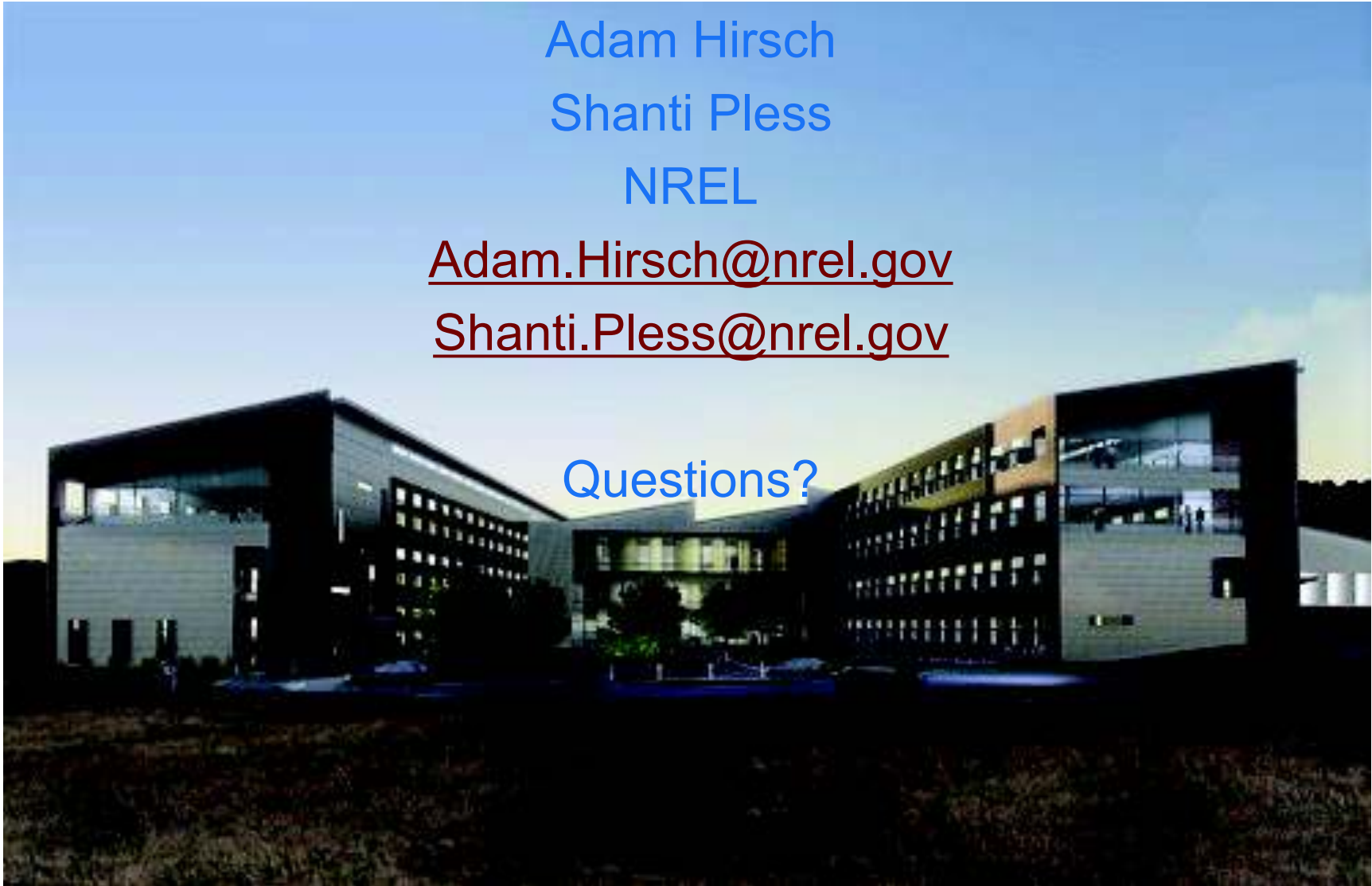
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Questions?



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