GovEnergy
www.govenergy.gov
· August 15-18, 2010 · Dallas, Texas ·
· Dallas Convention Center ·


# Design by Metric – An NREL case study

*John Nangle - NREL*

# Acknowledgements

Nancy Carlisle, AIA
Director – Integrated Applications Office
National Renewable Energy Laboratory
nancy.carlisle@nrel.gov

ShantiPless, LEED AP
Senior Research Engineer – Advanced Commercial Buildings Research Group
National Renewable Energy Laboratory
shanti.pless@nrel.gov

Philip Macey, AIA
Director - Science and Technology
RNL

# Outline

- Zero Energy Building Background
- Research Support Facility at NREL
- References and Links

Nation's primary EE/RE R&D Laboratory

Mission: Advancing DOE and National Energy Goals

Renewable Energy Research

Renewable Fuels & Transportation

Strategic Energy Analysis

Integrated Systems Engineering

GovEnergy
www.govenergy.gov

# Background: Zero Energy Buildings

Energy Independence and Security Act of 2007 (EISA 2007)

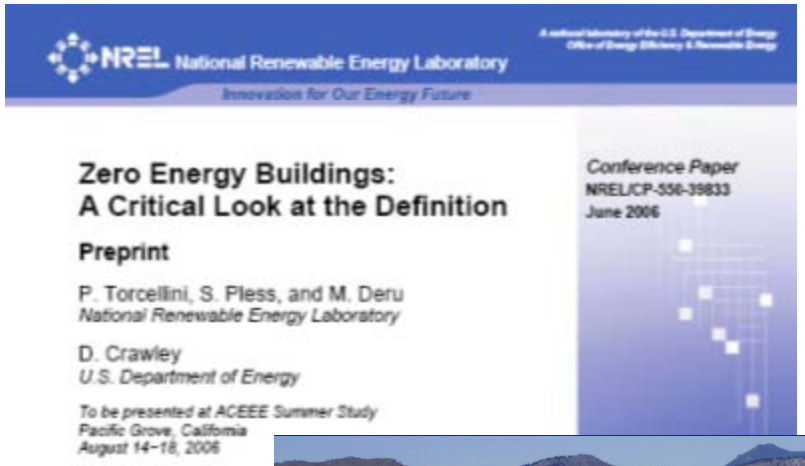
Net-Zero Energy Commercial Buildings Initiative

- Net-zero for all new commercial buildings by 2030
- Net-zero for 50% of US Commercial Buildings by 2040
- Net-zero for all US Commercial Buildings by 2050

# DEFINITIONS OF NZEB'S

1. ZEB:A Net Zero Site Energy
2. ZEB:B Net Zero Source Energy
3. ZEB:C Net Zero Emissions
4. ZEB:D Net Zero Energy Cost

The Definition used WILL impact the ZEB design strategies!


NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

Zero Energy Buildings:
A Critical Look at the Definition

Preprint

P. Torcellini, S. Pless, and M. Deru
National Renewable Energy Laboratory

D. Crawley
U.S. Department of Energy

To be presented at ACEEE Summer Study
Pacific Grove, California
August 14–18, 2006

Conference Paper
NREL/CP-550-39833
June 2006


*This rendering shows the proposed orientation of the National Renewable Energy Laboratory Research Support Facilities.*

## Getting to Net Zero

**By Drury Crawley, Ph.D.,** Member ASHRAE; **Shanti Pless,** Associate Member ASHRAE; and **Paul Torcellini, Ph.D., P.E.,** Member ASHRAE

As the futurist Stewart Brand observed, "Every building is a forecast. Every forecast is wrong." Making forecasts progressively less wrong over time—specifically, forecasts about high-performance buildings—is the purpose of the U.S. Department of Energy's (DOE) Zero Energy Buildings Database. The intent of this article is to provide an overview of the DOE's efforts toward realizing cost-effective net zero energy buildings (NZEBs).

The vision of NZEBs is compelling. These highly energy-efficient buildings will use, over the course of a year, renewable technology to produce as much energy as they consume from the grid. Building owners and tenants stand to realize attractive returns on their NZEB investments while reducing carbon footprints. And, while today's buildings are our nation's highest energy-consuming and carbon-emitting sector, with NZEBs, our nation can gain a network of clean domestic energy assets.

Yet, how realistic is this vision? How close do NZEBs come to realizing their design goals? How much does it cost to design and build a net zero energy building? Thanks to data being provided voluntarily by building owners in the Zero Energy Buildings Database, we now have some early insight into these questions and into the drivers of net zero energy performance.

Just as important, we now have an influential community of industry leaders who are committed to pushing the boundaries of building performance and sharing the results. As part of the Net-Zero Energy Commercial Building Initiative, authorized by Congress in the Energy

**About the Authors**

**Drury Crawley, Ph.D.,** leads the commercial buildings team for the U.S. Department of Energy's Office of Building Technologies. **Shanti Pless** is energy efficiency research engineer and **Paul Torcellini, Ph.D., P.E.,** is group manager of the commercial buildings research group at the National Renewable Energy Laboratory in Golden, Colo.



GovEnergy
www.govenergy.gov

# Zero Energy Buildings

**ZEB:A - Net Zero Site Energy**
Site produces as much energy as it uses annually.

**ZEB:B - Net Zero Source Energy**
The facility generates the same amount of energy as is used, including the energy used to transport the energy to the building.

**ZEB:C - Net Zero Energy Costs**
The amount of money paid by the building owner to the utility for energy and energy services equals the amount paid to the building owner by the utility for exported energy.

**ZEB:D - Net Zero Energy Emissions**
The building produces (or purchases) enough emissions-free energy to offset emissions for all energy used annually.

GovEnergy
www.govenergy.gov

# ZEB:A - NET ZERO SITE ENERGY

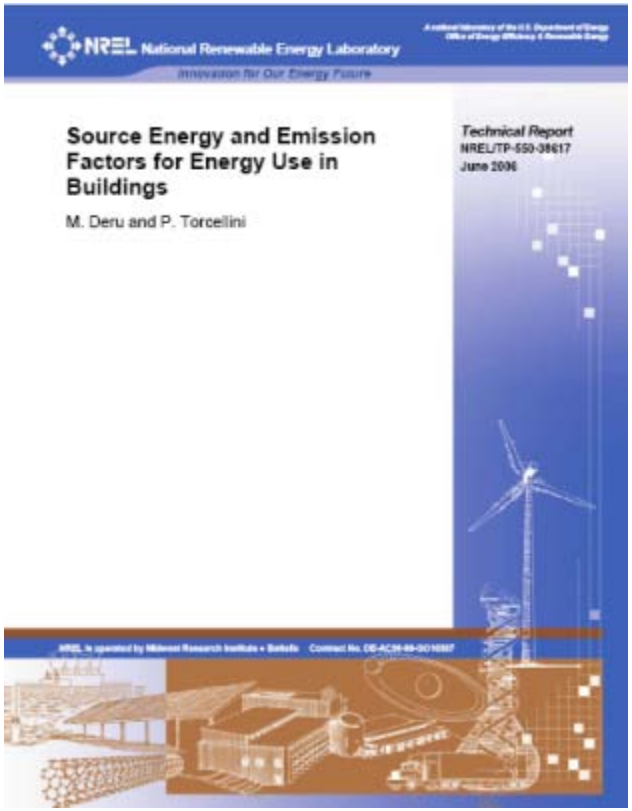
- Measured at the interface of the building to the utility (point of sale)
- Easy to measure/verify (vested interest in having the right number)
- Encourages energy efficient designs at the building level
- What is the “site?” Building footprint or property

GovEnergy
www.govenergy.gov

# ZEB:B - NET ZERO SOURCE ENERGY

- Calculated with current energy use and and source factors
- Has a grid (more global) impact
- Daily and seasonal dependencies
    - impacts on fuel use and delivery
- Regional (non climatic) dependencies
    - Availability of energy (fuel) source
- May not require a strong focus on building efficiency

Example: Biomass boiler at NREL



# ZEB:C - NET ZERO ENERGY COST

- (Also) based on site measurements
- Easy to verify
- Demand component
- High regional variations
- Highly dependent on rate structures
- Subject to cost volatility
- Cannot do this on a large scale (Who would pay the utility?)

GovEnergy
www.govenergy.gov

# ZEB:D - NET ZERO EMISSIONS

- Also based on site numbers, typically with national or regional multipliers based on generation location (eGRID)
- Understand carbon cycles of biofuels
- Same issues as source
- Carbon reductions becoming more of a driving force

GovEnergy 2010

GovEnergy
www.govenergy.gov

# Zero Energy Buildings: An Example

# Research Support Facility

**"Raise the national standard for high-performance commercial buildings and effectively transfer this knowledge to other"**

- DOE Expectations letter

- **Create a "national showcase" -**
  - demonstrate how high-performance buildings can be aesthetically compelling, acquired at competitive first-cost and life-cycle cost, and through integrated design, can reduce performance risks to the owner, constructor and financier

# RSF - Program

**MISSION CRITICAL:**
- Attain Safe Work Performance/Safe Design Practices
- LEED™ Platinum
- ENERGY STAR First, unless other system out performs

**HIGHLY DESIRABLE:**
- Up to 800 Staff Capacity
- 25 kBTU/sf/year
- Architectural Integrity
- Honor "Future Staff" Needs
- Measurable ASHRAE 90.1-50% plus
- Support culture and amenities
- Expandable building
- Ergonomics
- Flexible workspace
- 6 Other..

**IF POSSIBLE:**
- Net Zero/Design approach
- 6 Other..

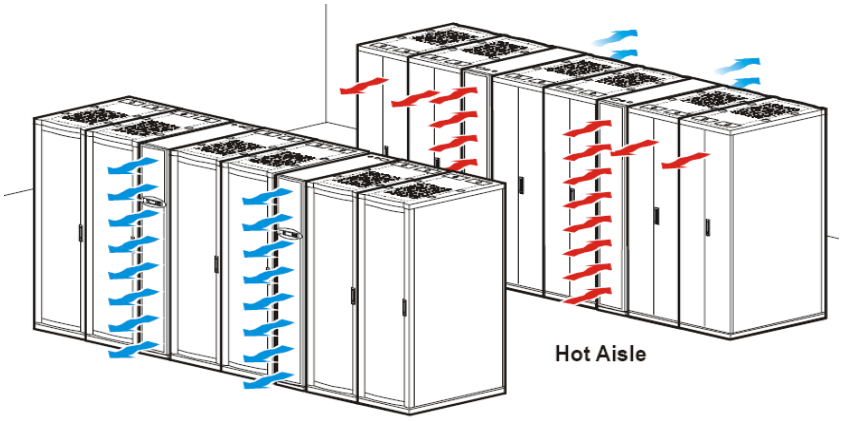
# RSF: Problem Statement

- 800 people
- 220,000 $ft^2$
- 25 kBtu/$ft^2$
- LEED Platinum +
- 50% energy savings
- \$259/$ft^2$
- Replicable
    - process
    - technologies
    - cost
- Site, source, carbon, cost ZEB
    - Includes plug loads and datacenter
- Design/Build Process with required energy goals

GovEnergy
www.govenergy.gov

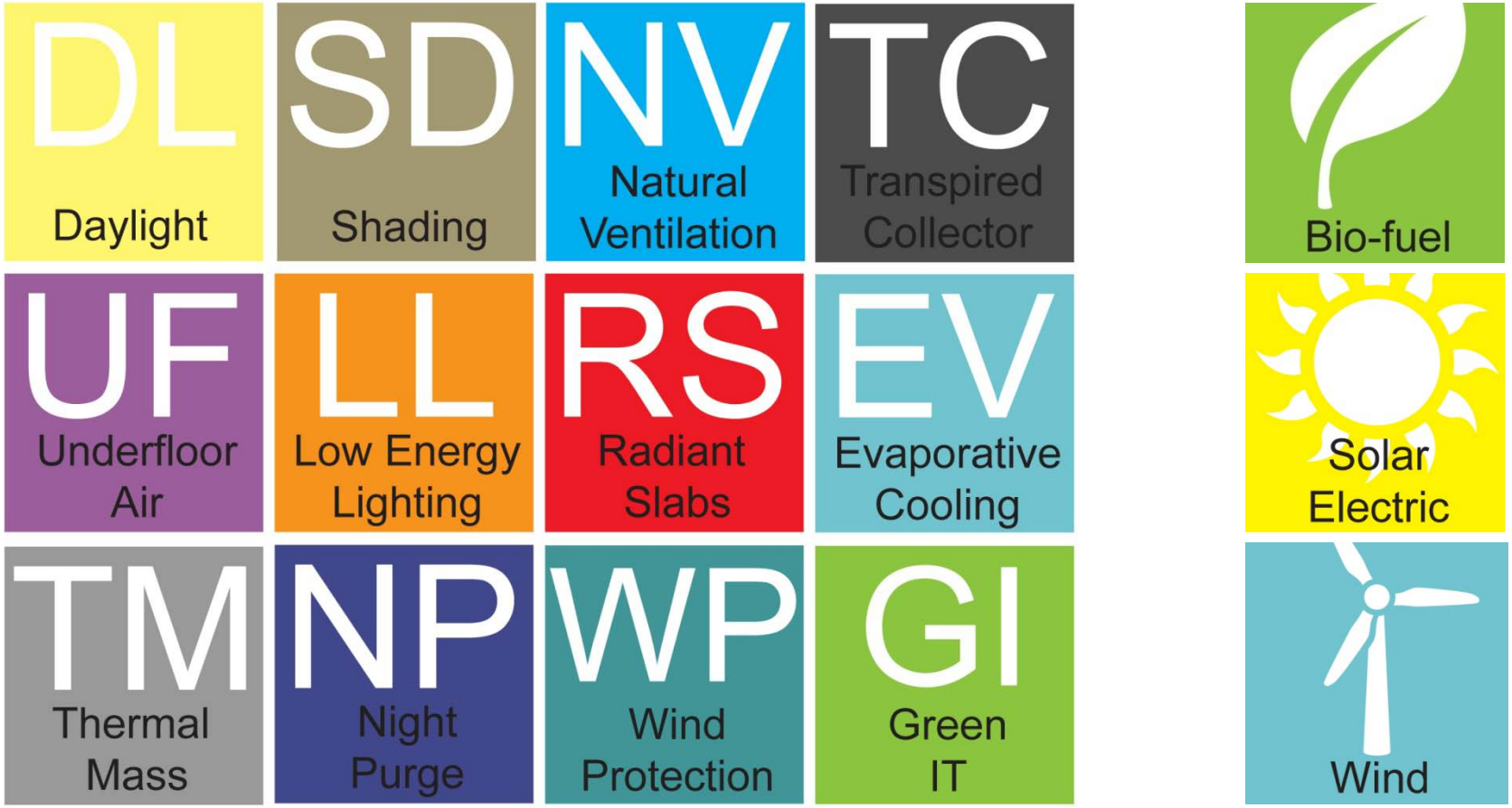
# RSF: Problem Statement

- Pro-rate for full NREL Data Center
  - RFP requires 65W/RSF occupant 24/7/365 in energy model
  - Final 35.1 kBtu/ft2 includes additional 378 NREL employees portion of data center
  - Incentives design team to take advantage of waste heat from data center




GovEnergy
www.govenergy.gov

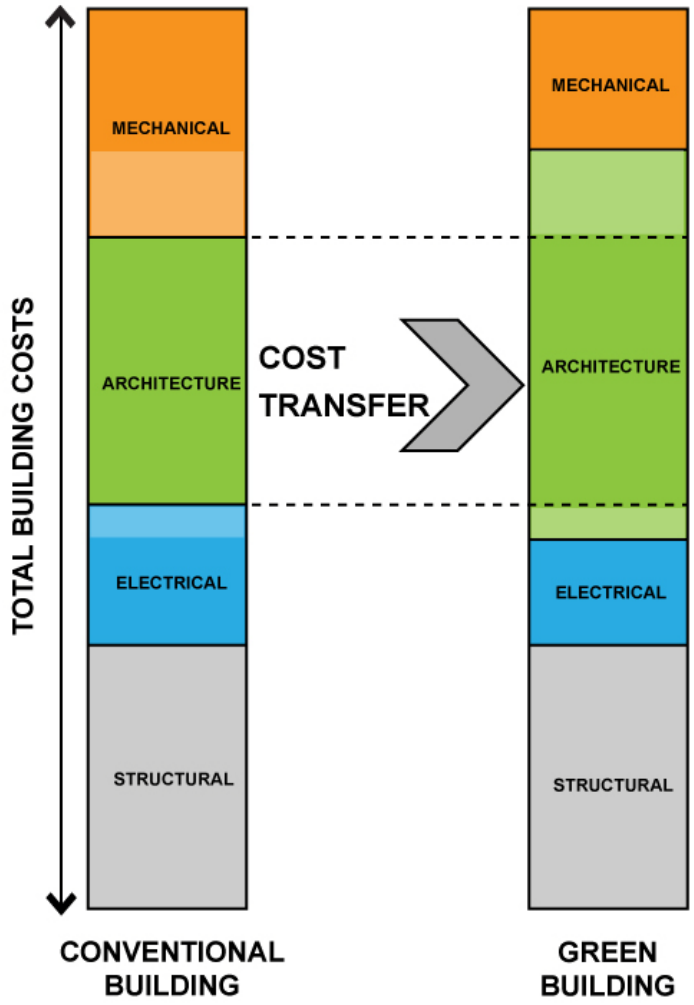
# Zero Energy Strategies



# Integrated Design

## Cost Transfer

Transfer costs from mechanical and electrical systems to building architecture

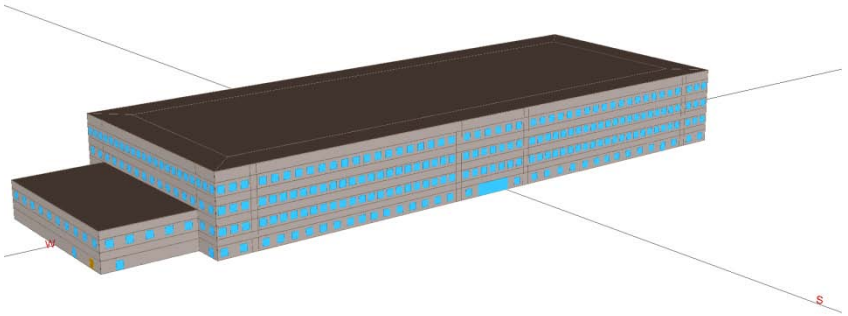



GovEnergy
www.govenergy.gov

# Integrated Design

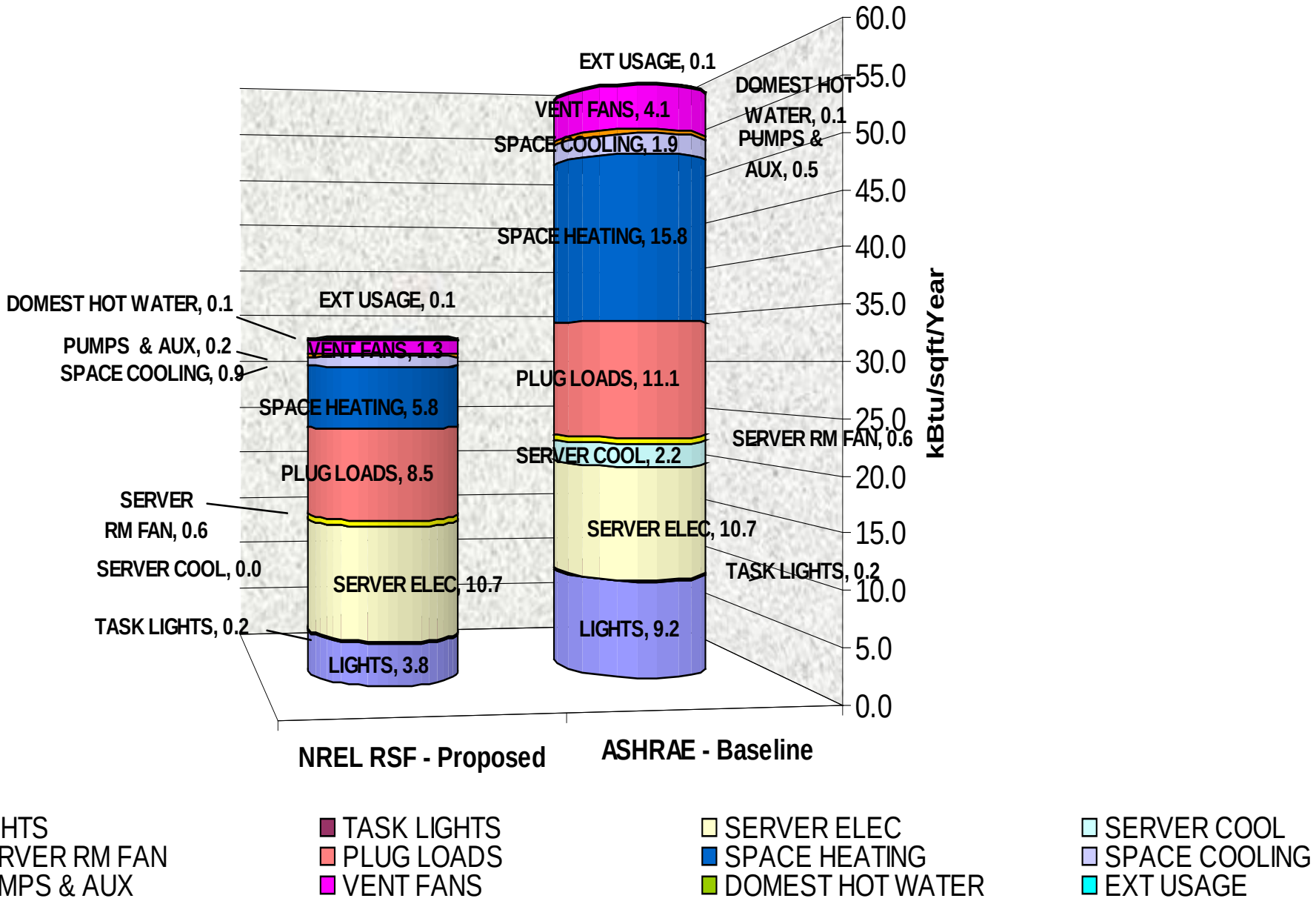
## Design Simulations

- Energy modeling
- Daylight modeling
- Natural ventilation modeling
- Thermal mass modeling
- And all must meet the Cost Model

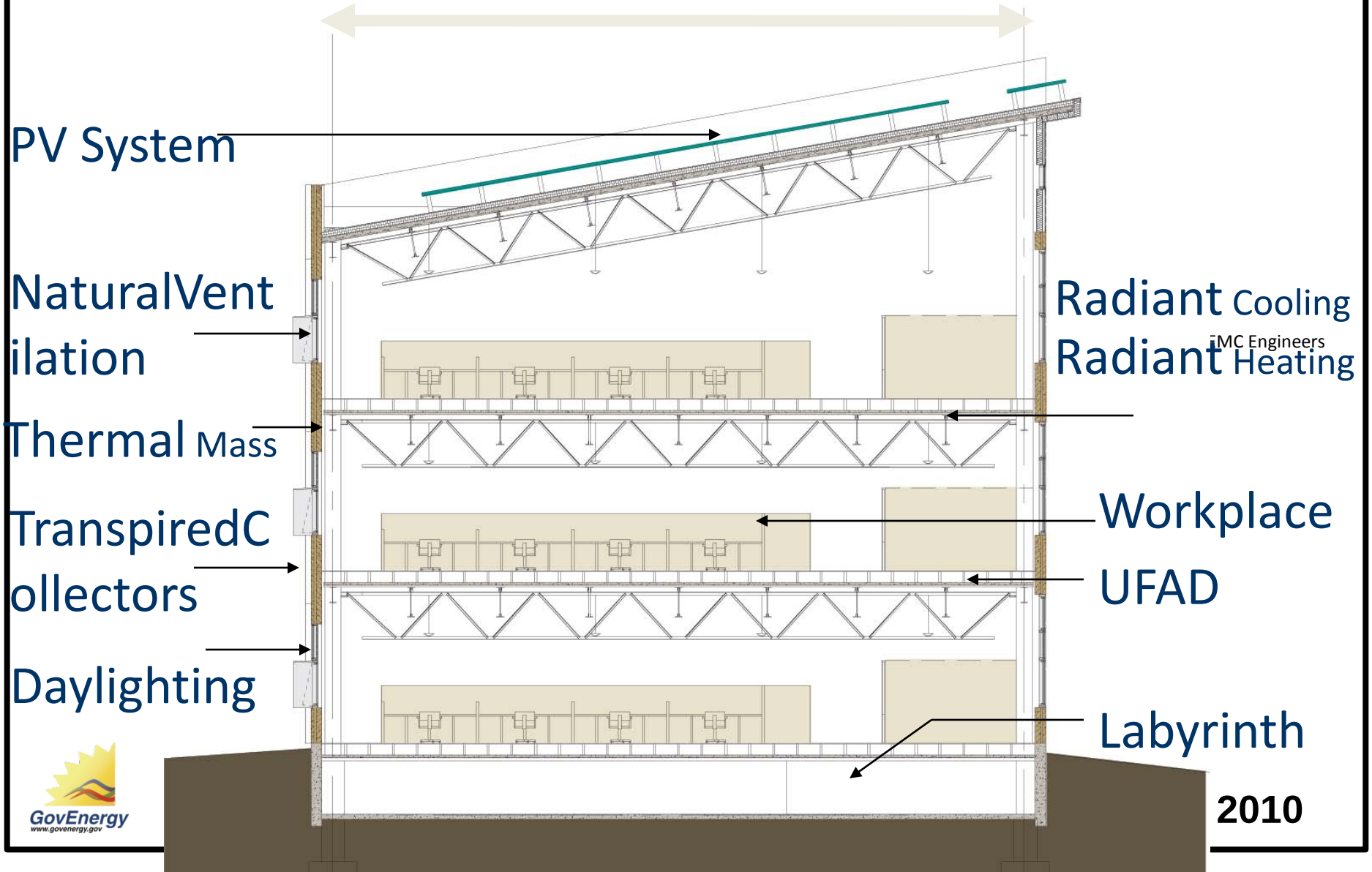


Credit: EMC Engineers

# NREL RSF Annual Energy Consumption Comparison



# The Section

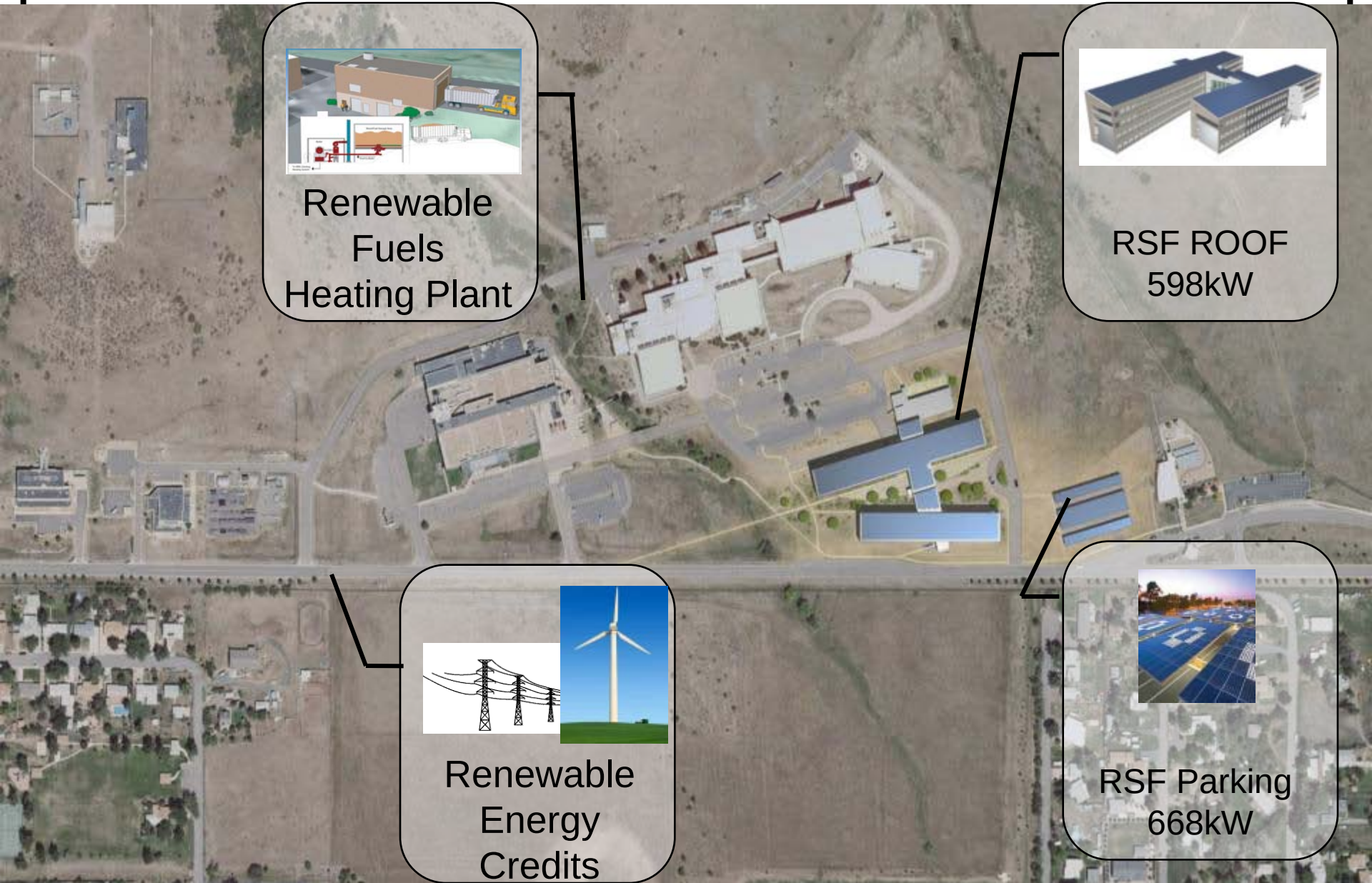

60’
PV System
NaturalVentilation
Thermal Mass
TranspiredCollectors
Daylighting
Radiant Cooling
Radiant Heating
Workplace
UFAD
Labyrinth

# ZEB RENEWABLE HIERARCHY

- 0. Energy efficiency
  - Daylighting, CHP, passive solar
- 1. Footprint supply options
  - Building mounted PV or wind
- 2. Site supply options
  - Parking lot PV or wind
- 3. Imported supply options
  - Wood chips, ethanol
- 4. Purchase of renewable credits

GovEnergy
www.govenergy.gov

# RSF Renewables





Renewable Fuels Heating Plant



RSF ROOF 598kW



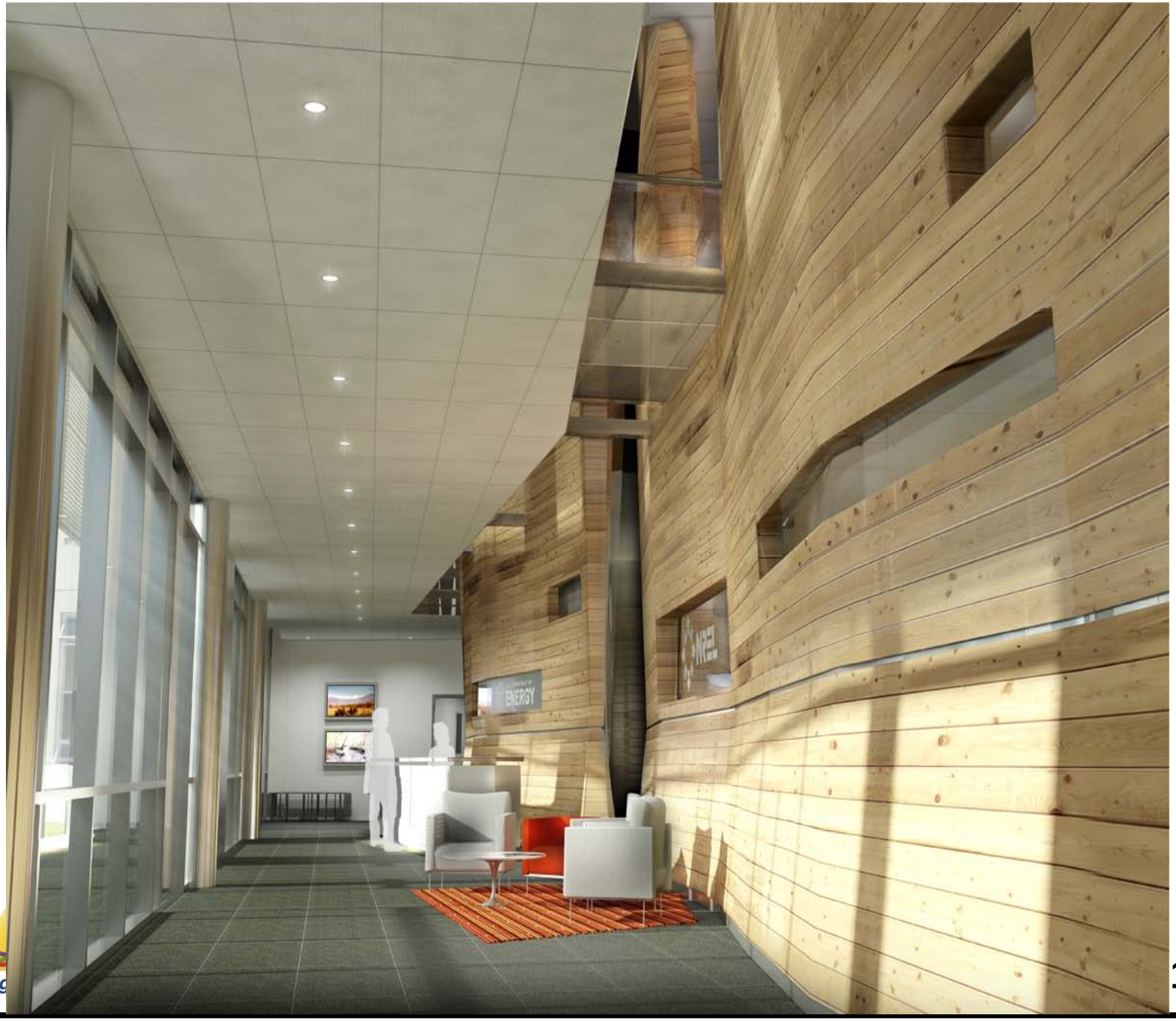
Renewable Energy Credits



RSF Parking 668kW

# Replicable Cost

- $57.5 Million construction cost
- Includes site work
- Includes interiors and all furniture
- 218,000 SF
- $262 / SF


ENERGY

# References and Links

- DOE Building Technologies Program
  - http://www1.eere.energy.gov/buildings
- Zero Energy Buildings: A Critical Look at the Definition
  - http://www.nrel.gov/docs/fy06osti/39833.pdf
- Research Support Facility
  - http://www.nrel.gov/sustainable_nrel/rsf.html
- Sustainable NREL
  - http://www.nrel.gov/sustainable_nrel/
- NREL RSF Video
  - http://www.youtube.com/user/NRELPR#p/u/2/43dT66mhh0c

# *Questions?*

**John Nangle**

National Renewable Energy Laboratory

Integrated Applications Office

303-384-7377

john.nangle@nrel.gov