NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Designing Toward Net Zero/ Low Energy Buildings

Renewable Energy for Tribal Community Development

National Workshop

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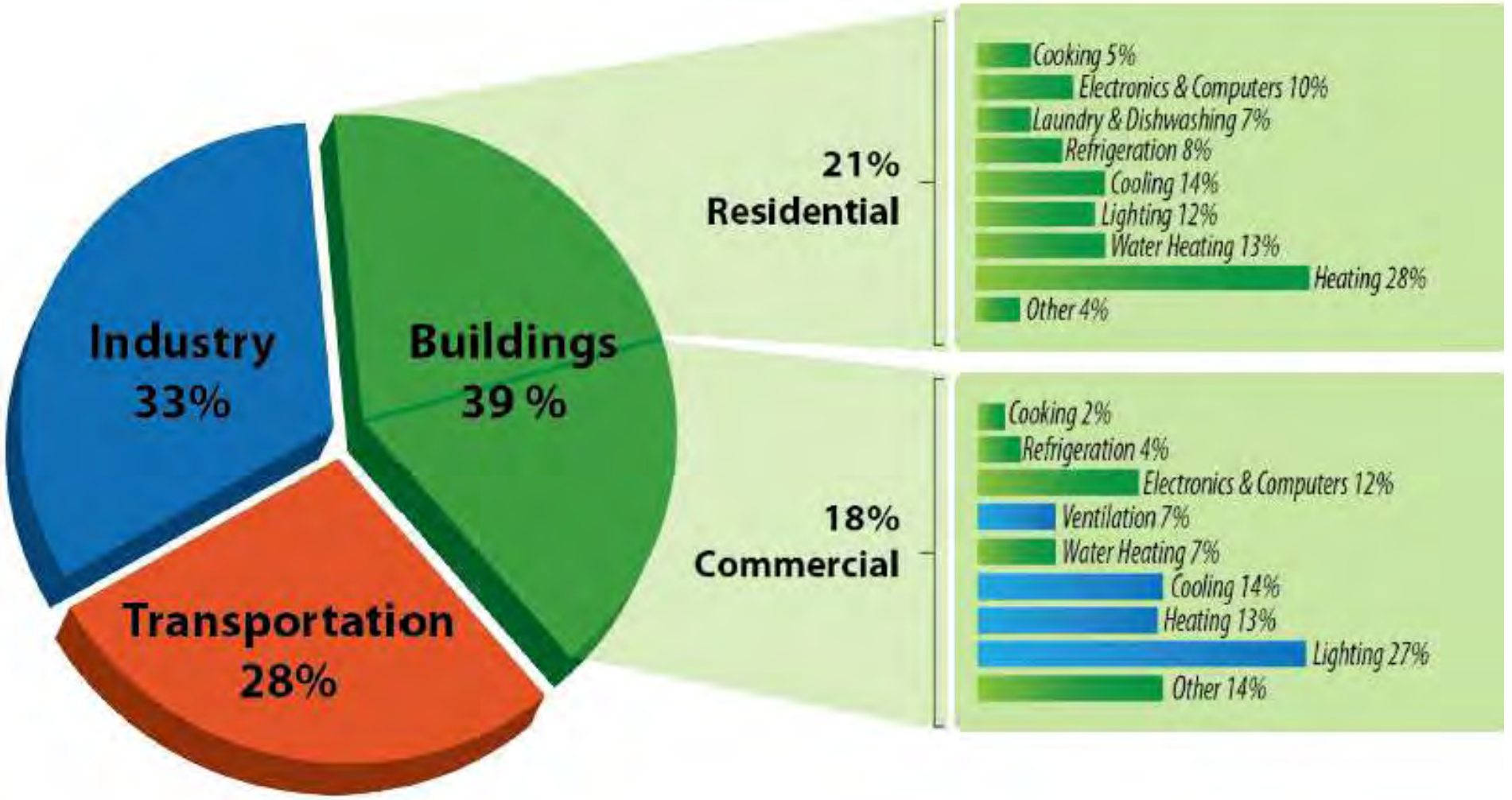
Outline

- Building Energy Consumption in the US
- Commercial Building Energy Consumption
- US Climate Change Policy
- Net Zero Energy Definition
- Net Zero Energy Agency Goals
- BEopt Description and Case Study
- Brief Research Support Facility Discussion

Energy Consumption in the United States

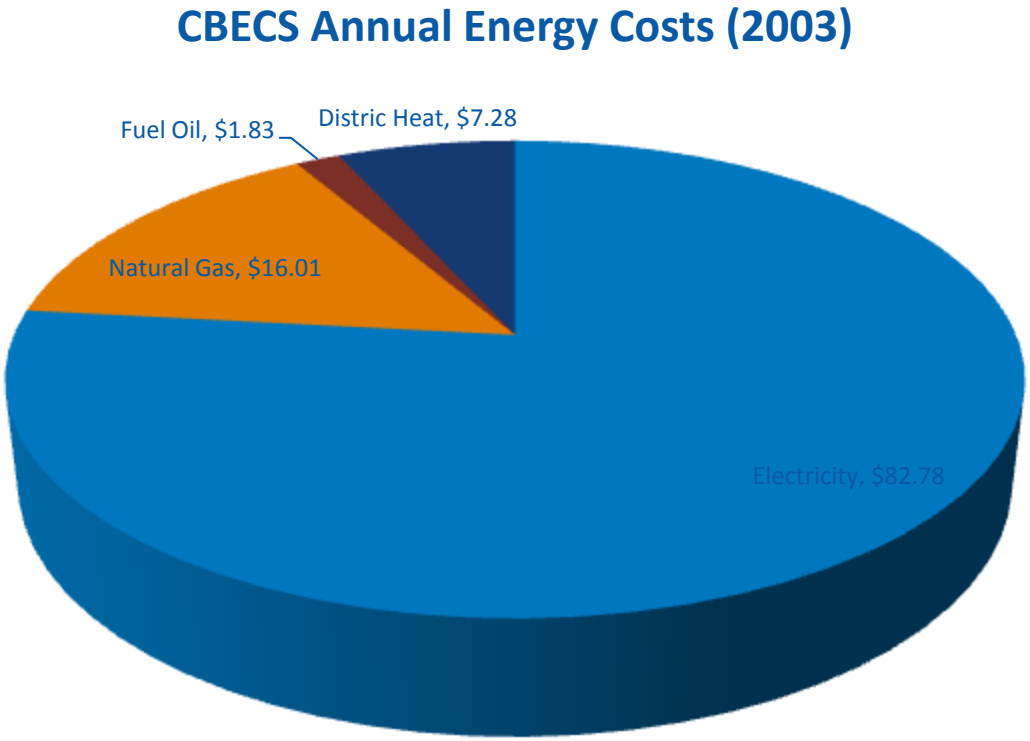


Source: U.S. Department of Energy, Buildings Energy Data Book, 2006

Commercial Buildings Energy Consumption Survey

CBECS 2003 Statistics

- 4,859,000 bldgs
- 71.66 billion ft^2
  - *100.8 billion ft^2 (projected in 2030)*
- 890 billion kwh (elec)
- 1870 billion ft^3 (nat gas)
- 1602 million gal (fuel oil)
- 634 trillion btu (dist heat)
- $107.89 billion/yr

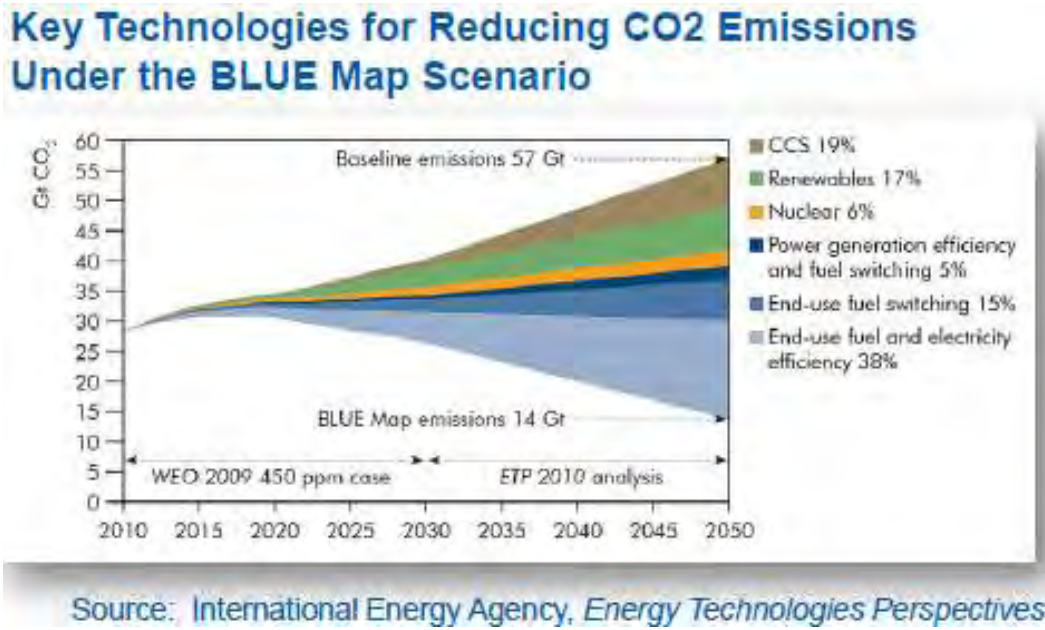


Source: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html

US Climate Change Policy

Target of 80% reduction in GHG emissions by 2050

- Mid term reduction of 45% by 2020



2050 national goal:
Oil use reduced to <15% of current levels,
CO_2 emissions cut by >80%

Net Zero Energy Definition

The U.S. Department of Energy (DOE) has a goal to create the technology and knowledge base for cost-effective zero-energy commercial buildings by 2025.

Definition: A net zero-energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies.

Net Zero Energy Goals

California Zero Net Energy Action Plan - The California Energy Commission has launched a program to achieve net zero energy use for residential construction by 2020 and commercial buildings by 2030

Federal Building Standards - In October 2009 Executive Order EO 13514 requires that any building designs started after 2020 be capable of achieving net zero energy by 2030.

Net Zero Energy Definition

Net Zero Site Energy **-** A site ZEB produces at least as much energy as it uses in a year, when accounted for at the site.

Net Zero Source Energy **-** A source ZEB produces at least as much energy as it uses in a year, when accounted for at the source.

Net Zero Energy Costs **-** In a cost ZEB, the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

Net Zero Energy Emissions **-** A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources.

Renewable Energy Options

Renewable Energy Generated Onsite

PV, Wind, Biogass, SHW, CSP, Hydro, etc

Renewable Energy Generated Offsite

Woody Biomass, LFG, PV, Wind, etc

Purchased Renewable Energy Credits

The Vision.....

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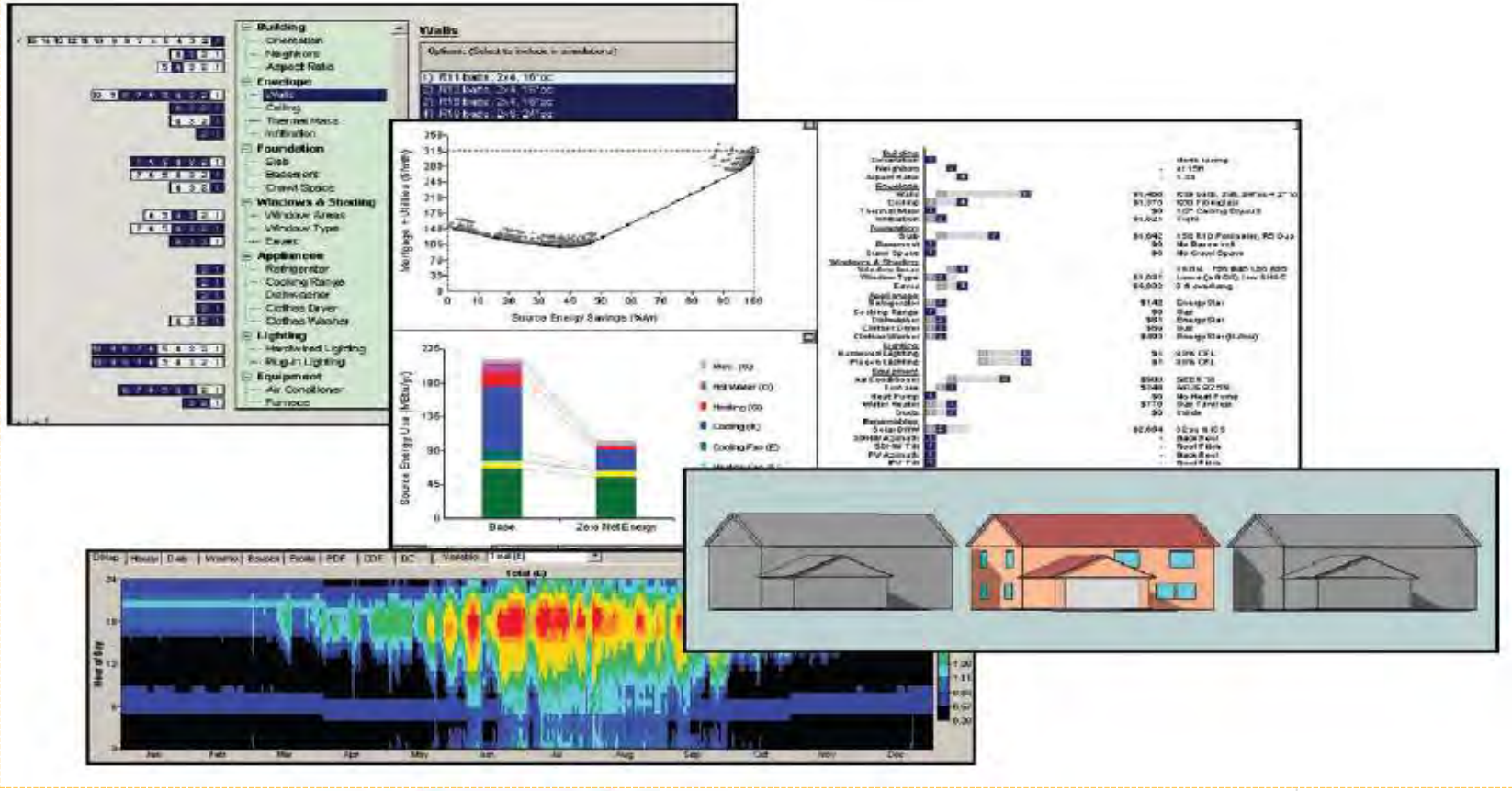
Sustainable Design + Energy Efficiency + Renewable Energy =

A Net Zero Energy Development

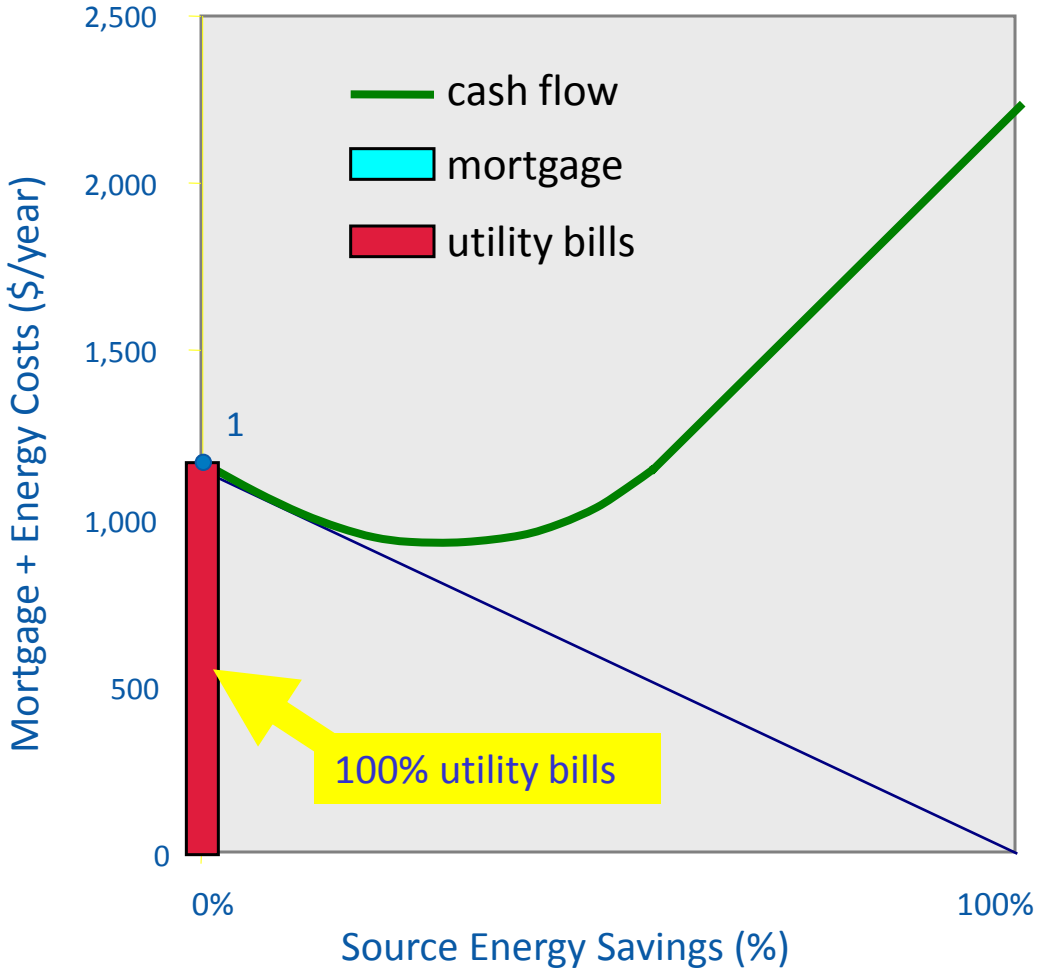
Achieving NZE through Energy Modeling

BEopt™ software program description

–The BEopt™ software is designed to identify optimal building designs at various energy-savings levels on the path to zero net energy



The Path to Zero Net Energy



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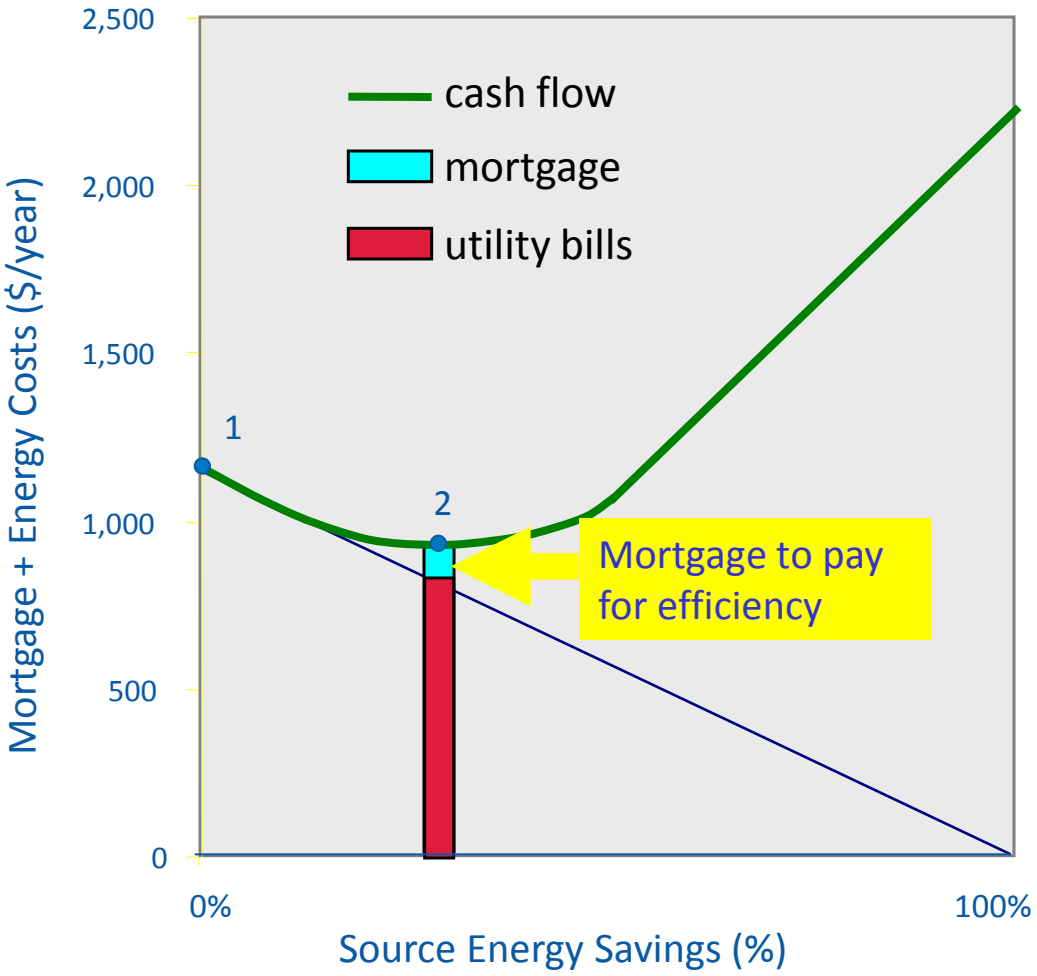

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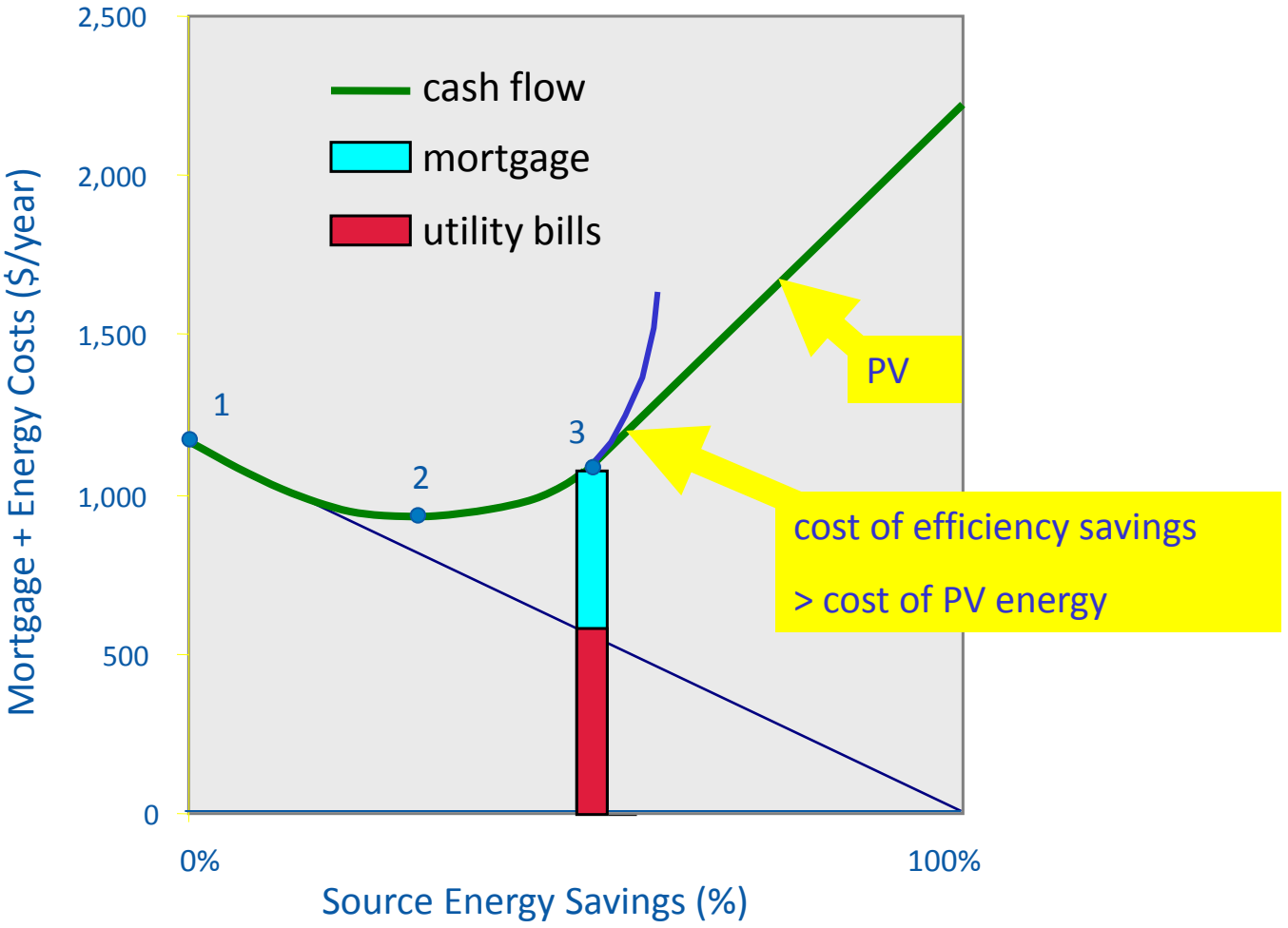

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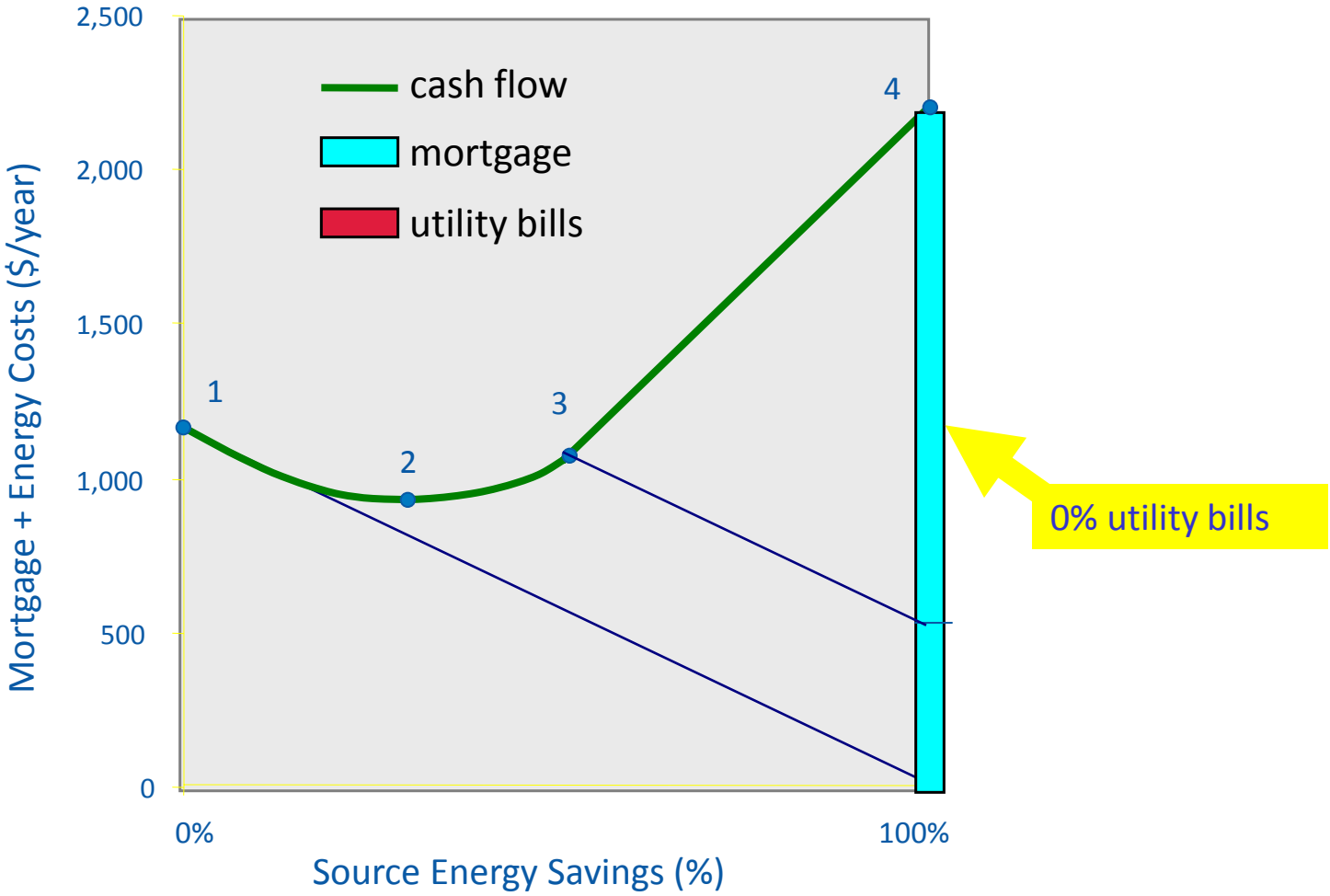

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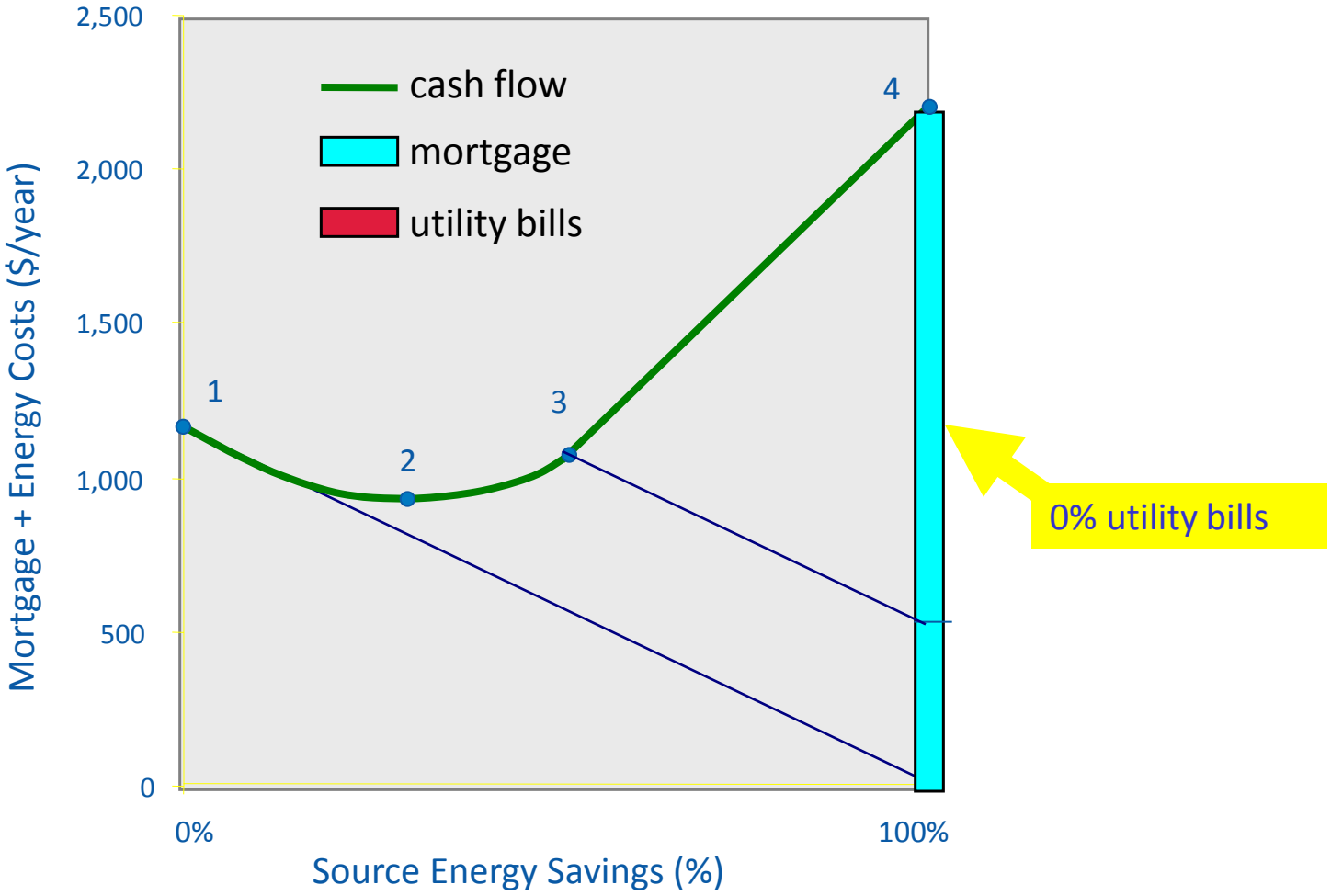

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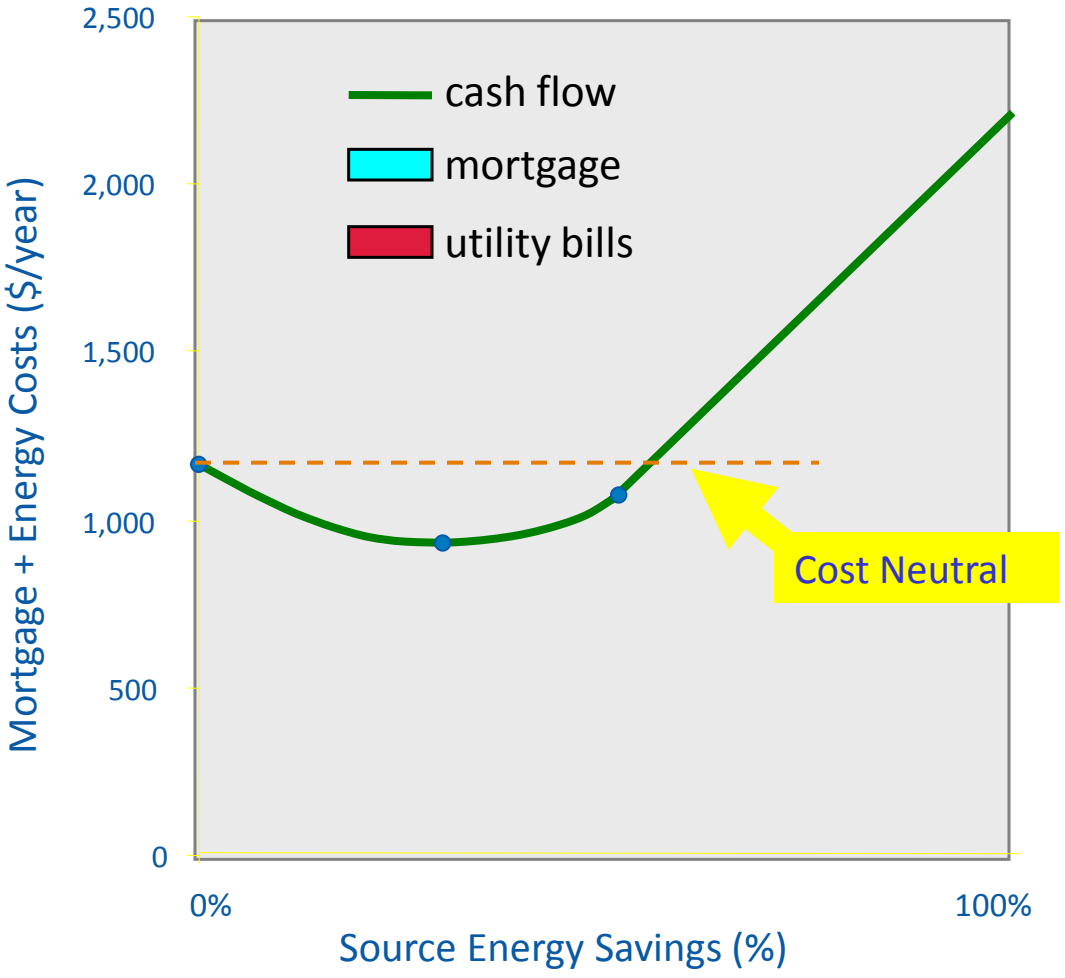

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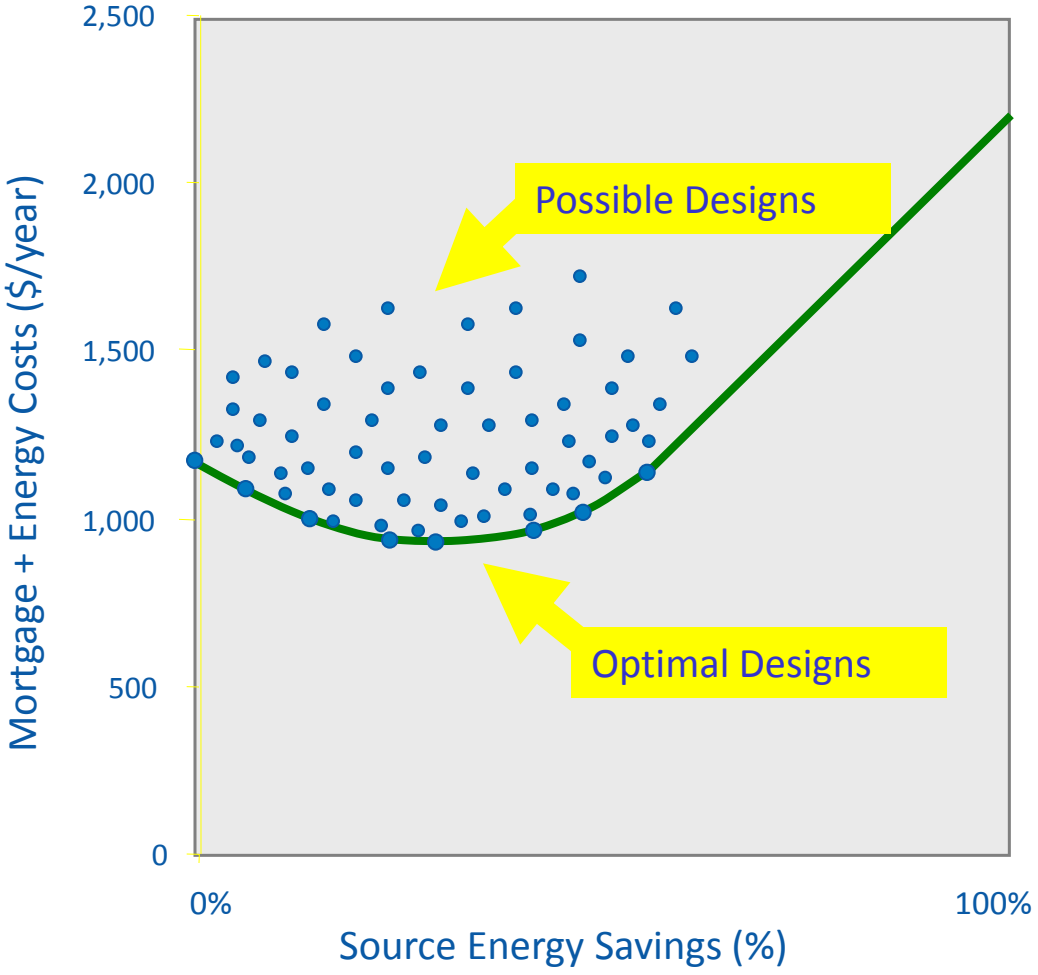


Josephine Commons Project

- The Paradigm project is a pilot venture for innovative, sustainable, affordable housing which will inform the design and construction of a future 153-unit, low income and senior housing development on a nearby 14 acre site. The project consists of one duplex unit and one single family unit on an urban infill lot situated between a residential neighborhood and industrial park in Lafayette, CO.
- Modular construction and efficient design provided lower construction costs, which allowed the owner to invest in higher performance materials and renewable energy features.

NARRATIVE

Josephine Commons Project

BEopt – Model Inputs

Hardwired Lighting
100% CFL per Energy Star

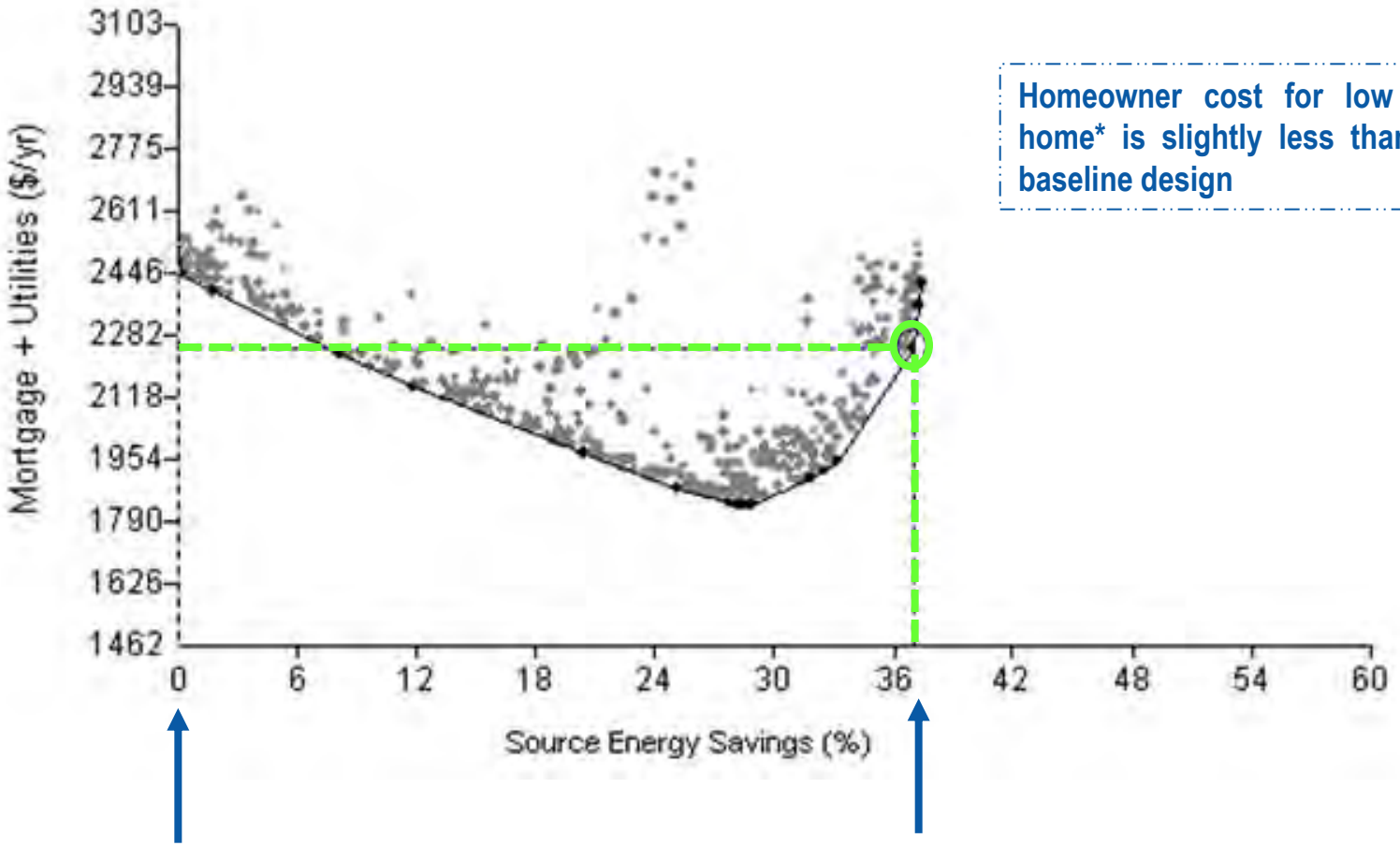
Air Conditioner
No AC

Furnace
AFUE 80%

Domestic Hot Water
Standard Electric

Paradigm Project Baseline Design	
Characteristic	**Performance Value**
Orientation	North North East (210 deg)
Aspect Ratio	1.5 (44 ft x 29.5 ft)
Thermostat	Non-Programmable
Ventilation Rate	100% of ASHRAE 62.2
Natural Ventilation	BA Benchmark
Wall R Value	R - 25
Roof R Value	R - 50
Infiltration	ELA 0.85 ft^2
Foundation R Value	R - 22
Window Area	Front (76 ft^2), Back (140 ft^2), Left (15 ft^2), Right (72 ft^2)
Window Type	Double Paned (U value = 0.447, SHGC = 0.547)
Appliances	Energy Star
Hardwired Lighting	100% CFL
Furnace	AFUE 80%
Mechanical Ventilation	Bathroom Exhaust
Domestic Hot Water	Standard Electric

Maximum Efficiency and Savings



Homeowner cost for low energy home* is slightly less than BCHA baseline design

BCHA Baseline Design

**Low energy home uses 63% less energy than a typical mid 1990's home

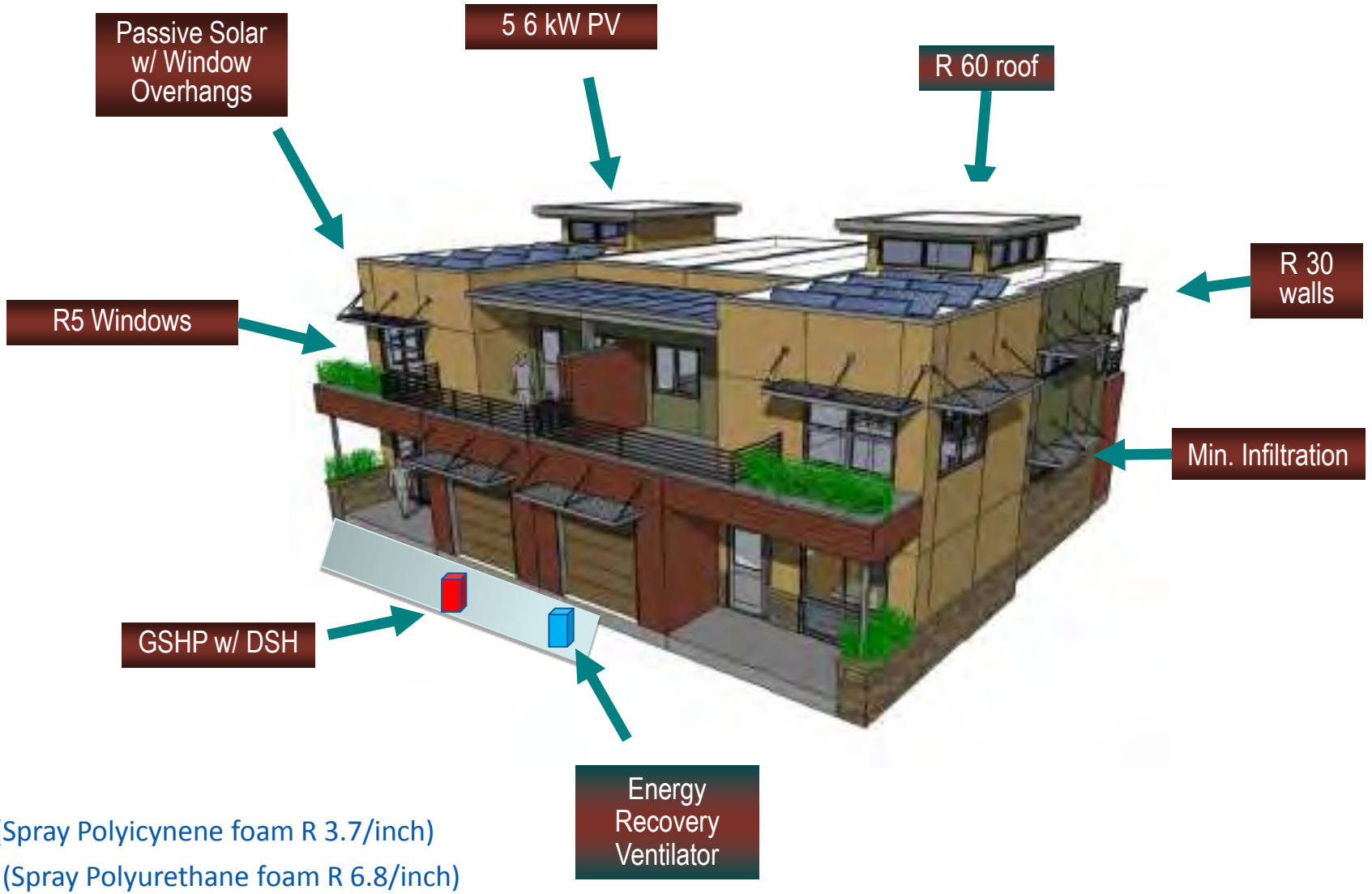
Beopt – Max. Eff and Savings Cost

Group Name	Category Name	Delta Capital Cost (Present Value)	Current Option Name	Ref Option Name
Building				
	Heating Set Point	$100	71 F w/ setback 65 F (wkdy)	71 F
Envelope				
	Infiltration	$1,886	Tightest	Tighter
Windows & Shading				
	Window Areas	$0	BCHA Duplex 1 Reduced West Gl	BCHA Duplex 1
	Eaves	$0	3 ft overhang	
Lg. Appliances				
	Refrigerator	$142	EnergyStar	Standard
	Cooking Range	($35)	Gas	Electric
	Dishwasher	$94	EnergyStar	Standard
	Clothes Dryer	$59	Gas	Electric
	Clothes Washer	$493	EnergyStar (H-Axis) - Cold Only	Standard (V-Axis)
Equipment				
	Furnace	$1,919	AFUE 96%	AFUE 80%
	Mechanical Ventilation	$3,667	Balanced Energy-Recovery Ventilator	Upgraded Bathroom Exhaust
	Water Heater	$431	Gas Tankless	Electric Standard
Total Capital Cost (Present Value)		$8,756		

Paradigm Pilot Project

- Well insulated building envelope
- Passive Solar Design
- Natural Day-lighting
- CFL lighting
- High Performance Windows
- Energy Star Appliances
- Balanced ERV
- High Eff HVAC
- Onsite RE

Josephine Commons Final Design



Icynene (Spray Polyicynene foam R 3.7/inch)

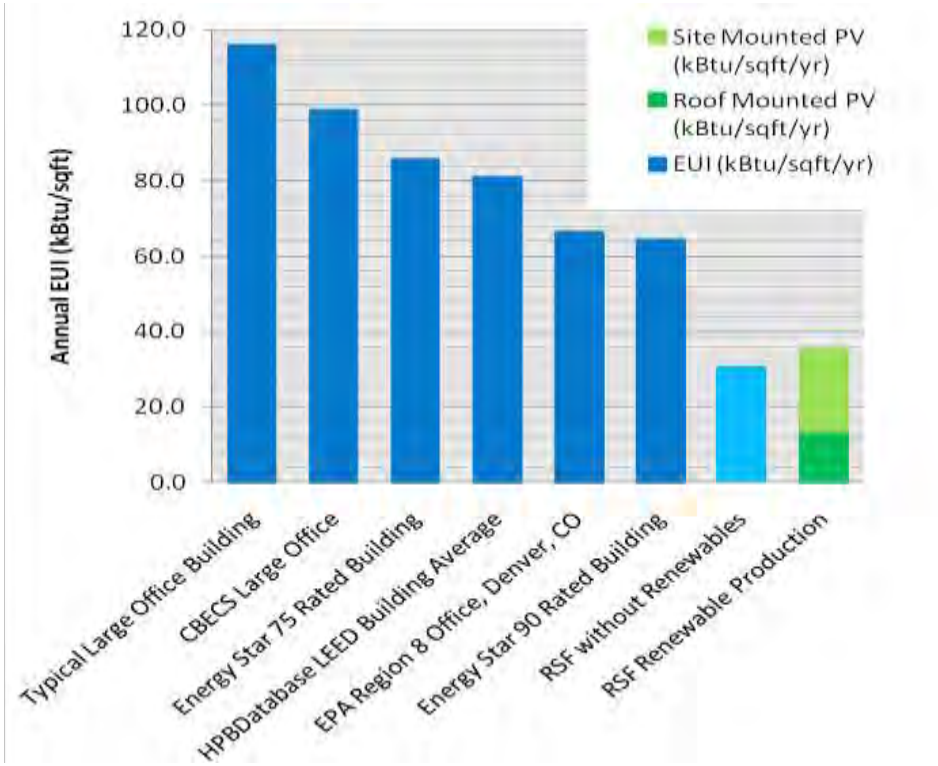
Insulstar (Spray Polyurethane foam R 6.8/inch)

DOE/NREL RSF: Project Goals

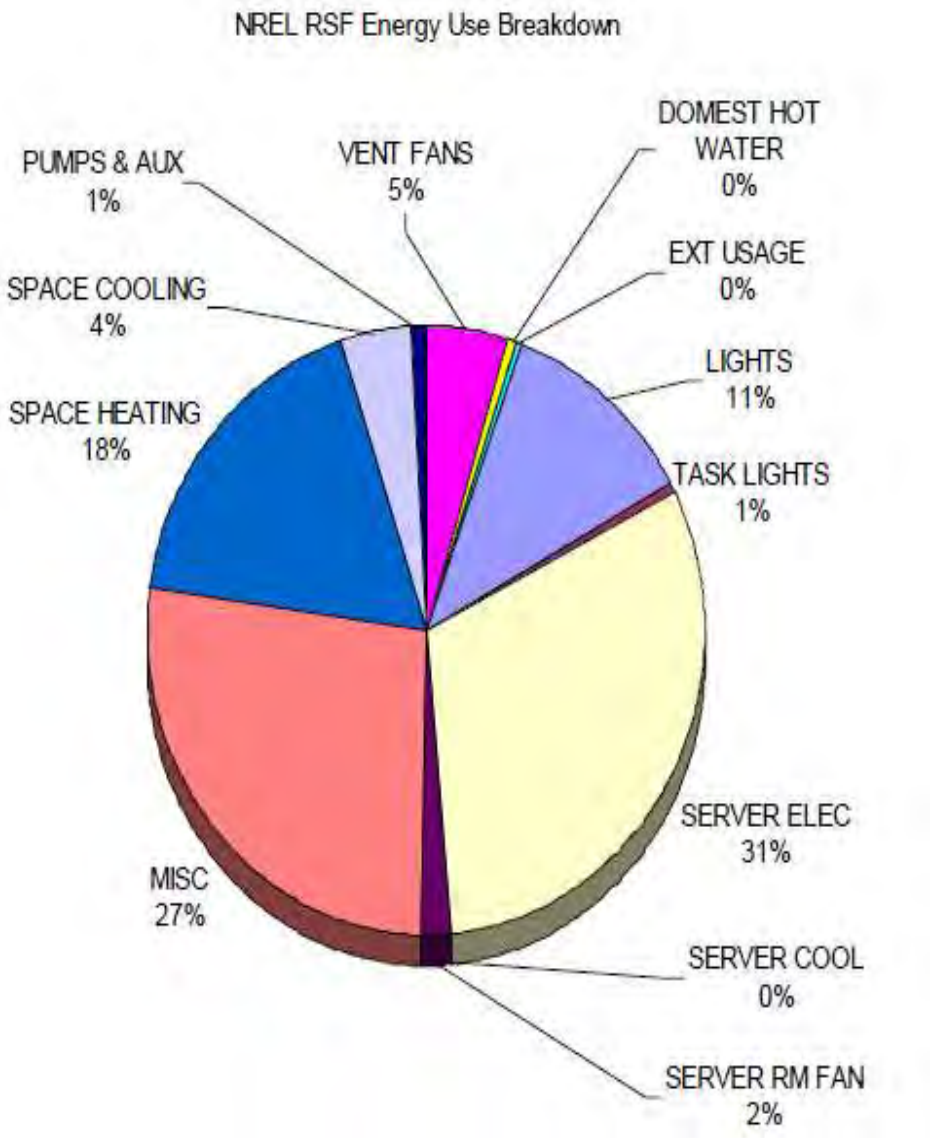
- 800+ people in DOE office space on NREL's campus
- 220,000 ft^2
- Design/Build Process with required energy goals
  - 25 kBtu/ft^2
  - 50% energy savings
  - LEED Platinum
- Replicable
  - process
  - technologies
  - cost
- Site, source, carbon, cost ZEB:B
  - Includes plugs loads and datacenter
- Firm fixed price of ~$64 million
  - $259/$ft^2$ construction cost (not including $27/$ft^2$ for PV)
- Open first phase June 10, 2010

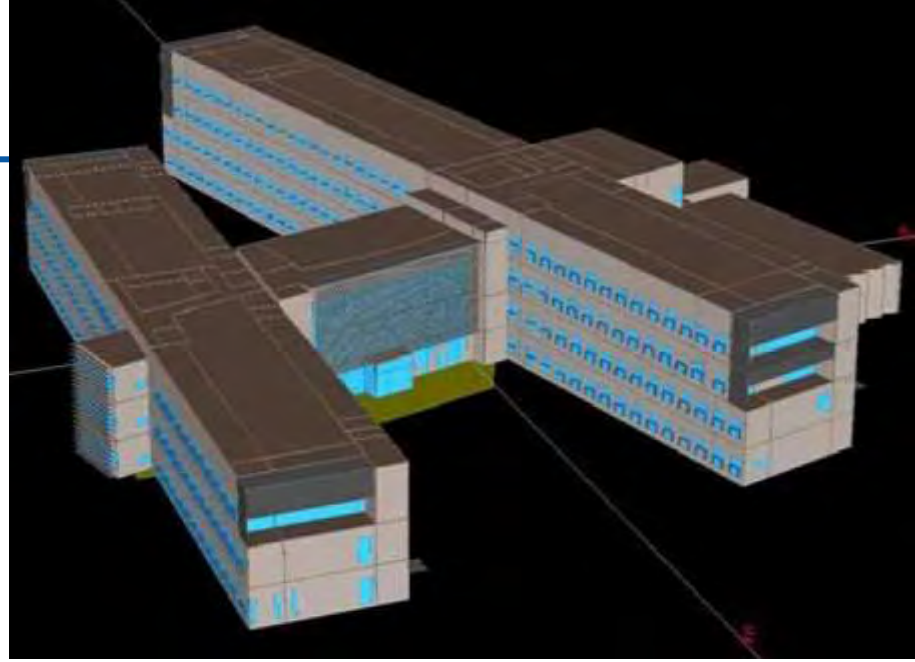
Design Requirements

- 25 kBtu/ft^2/yr for standard office space occupant density and datacenter loads
- Normalized up to 35.1 kBtu/ft^2/yr for better space efficiency and to account for full data center load



Energy Modeling



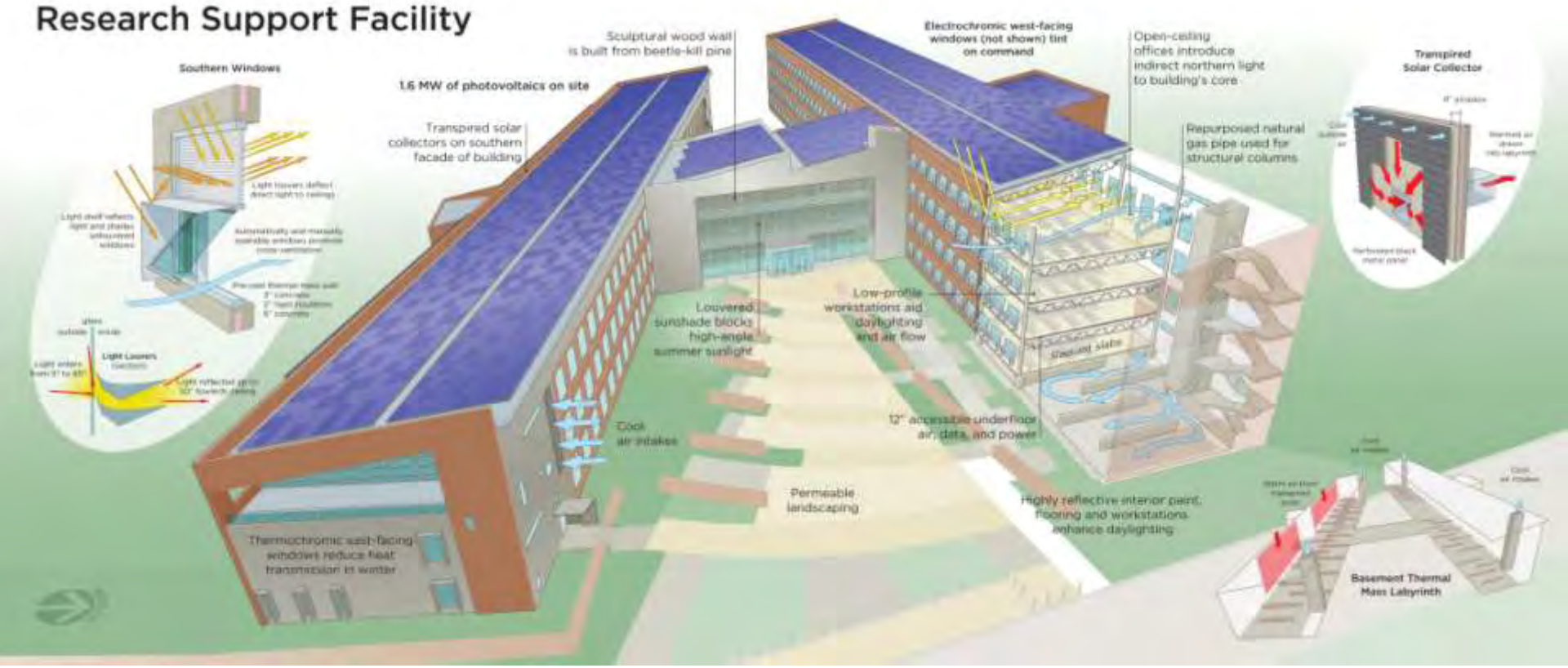


End Use	kBtu/ft2
Lights	3.85
Task Lights	0.19
Data Center	10.60
Data Center Cooling	0.01
Data Center Fans	0.55
Office Plug Loads	9.16
Space Heating	6.11
Space Cooling	1.42
Pumps	0.27
Ventilation Fans	1.61
Domestic Hot Water	0.13
Exterior Lights	0.12

Key Design Strategies

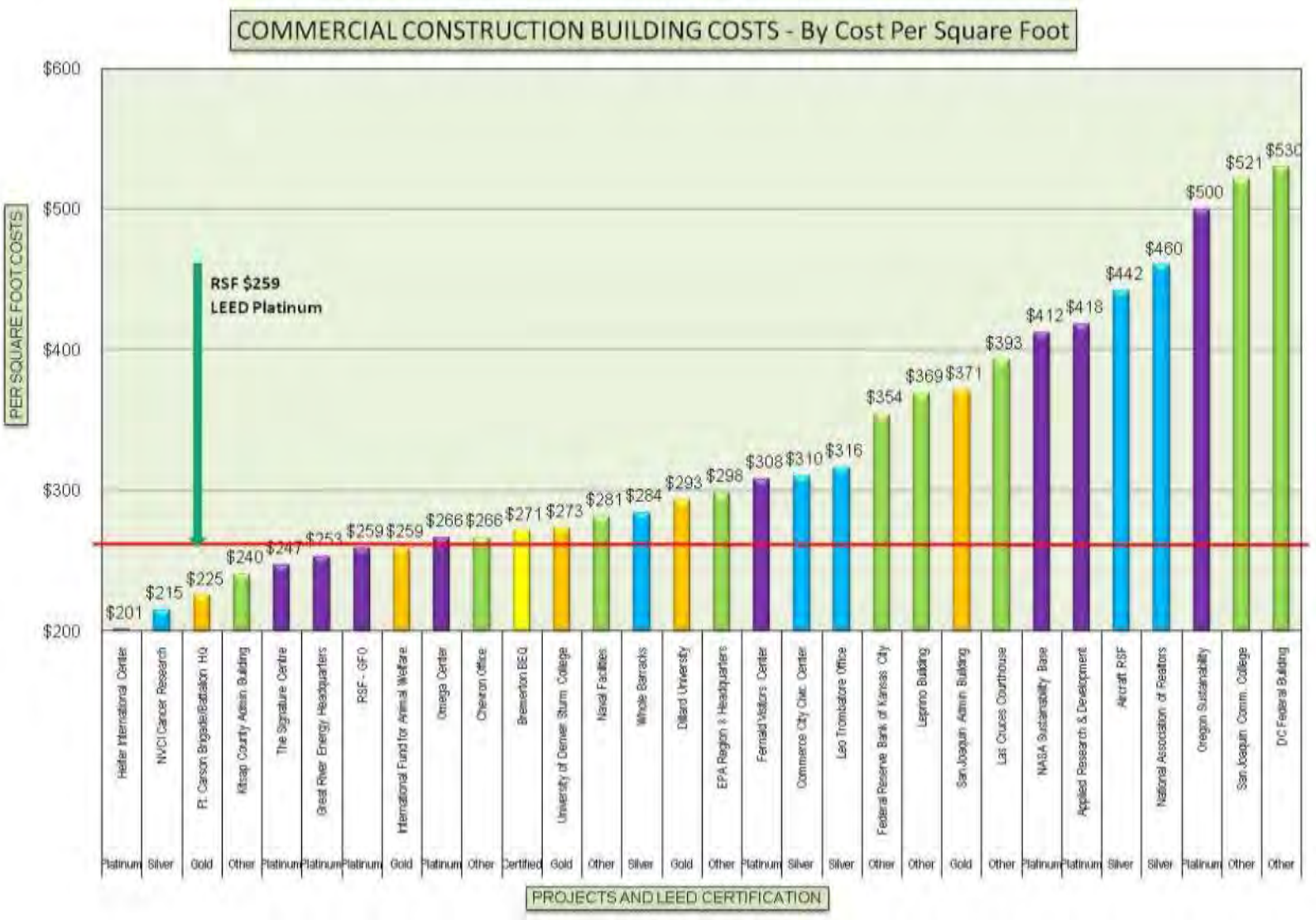
1. Optimal orientation and office space layout
2. Fully daylit office wings with high performance electrical lighting
3. Continuous insulation precast wall panels with thermal mass
4. Operable windows for natural ventilation
5. Radiant heating and cooling
6. Outdoor air preheating
   - Transpired solar collector
   - Datacenter waste heat
   - Exhaust air energy recovery
   - Crawl space thermal storage
7. Aggressive plug load control strategies
8. Data center outdoor air economizer with hot aisle containment
9. Roof top and parking lot based PV

Research Support Facility



RSF Net-Zero Boundary

RSF Cost Effectiveness



Net Zero Energy Design Process

1. Set Energy Use Performance Goals based on LCCA
    1. Typically 50% to 65% savings over ASHRAE 90.1 or IECC (residential)
    2. ASHRAE advanced energy design guides http://www.ashrae.org/technology/page/938
    3. BEopt - http://www.nrel.gov/buildings/energy_analysis.html
2. Calculate cost effectiveness of meeting residual loads with onsite renewable energy
3. If site energy can't be met within site boundary, purchase renewable energy offsets

Local Net Zero Energy Community Projects

- PrairieStar Project

http://www.prairiestarcolorado.com/

- FortZED

http://fortzed.com/

- South Lincoln Re-Development

http://www.denverhousing.org/development/SouthLincoln/Pages/default.aspx

- GEOS

http://discovergeos.com/index.php

- Solar Row Boulder

http://www.treehugger.com/files/2007/09/solar_row_susta.php

Contact Information

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