

# Sustainable Transit Facilities



**Renée Azerbegi**, CEM, LEED AP  
President, Ambient Energy

**Tom Hootman**, AIA, LEED AP  
Director of Sustainability, RNL

# Agenda

**1. What Makes Transit Facilities Unique?**

**2. What Makes Transit Facilities Green?**

**3. Case Studies**

**4. Green Transit Best Practices**



**What makes transit facilities unique?**





# Sustainable Communities



# Large and Remote Sites

Urban Heat Island, Access to Public Transit, Stormwater





# Industrial Building Construction

Wall and Roof R-Values, Overhead Doors, Durability



# Indoor Environmental Quality

Air Quality, Daylighting





# Energy Historically Daylit





# Energy Daylighting





# Operations

## Fueling Stations, Fuel Tanks, Wash Bays





Energy

Office vs. Maintenance Building Use





# Workplace

A place for people - not just equipment





# Transit Facility Stats

## Transportation LEED Certified Projects (April 2010)

<b>LEED-NC</b>	<b>435</b>
<b>LEED-CS</b>	<b>29</b>
<b>LEED-EB</b>	<b>20</b>
<b>LEED-CI</b>	<b>10</b>
<b>Total</b>	<b>494 (out of 28,062)</b>

# Transit Facility Stats

## California LEED Certified Projects



Gardena Transit Administration Facility  
Gardena Municipal Bus Lines, Gardena,  
LEED NC Silver



MacArthur BART Transit Village MTCP, LLC,  
Oakland, LEED ND 1.0 Pilot Gold



Santa Clarita Transit Maintenance Facility,  
City of Santa Clarita, Santa Clarita, LEED  
NC Gold

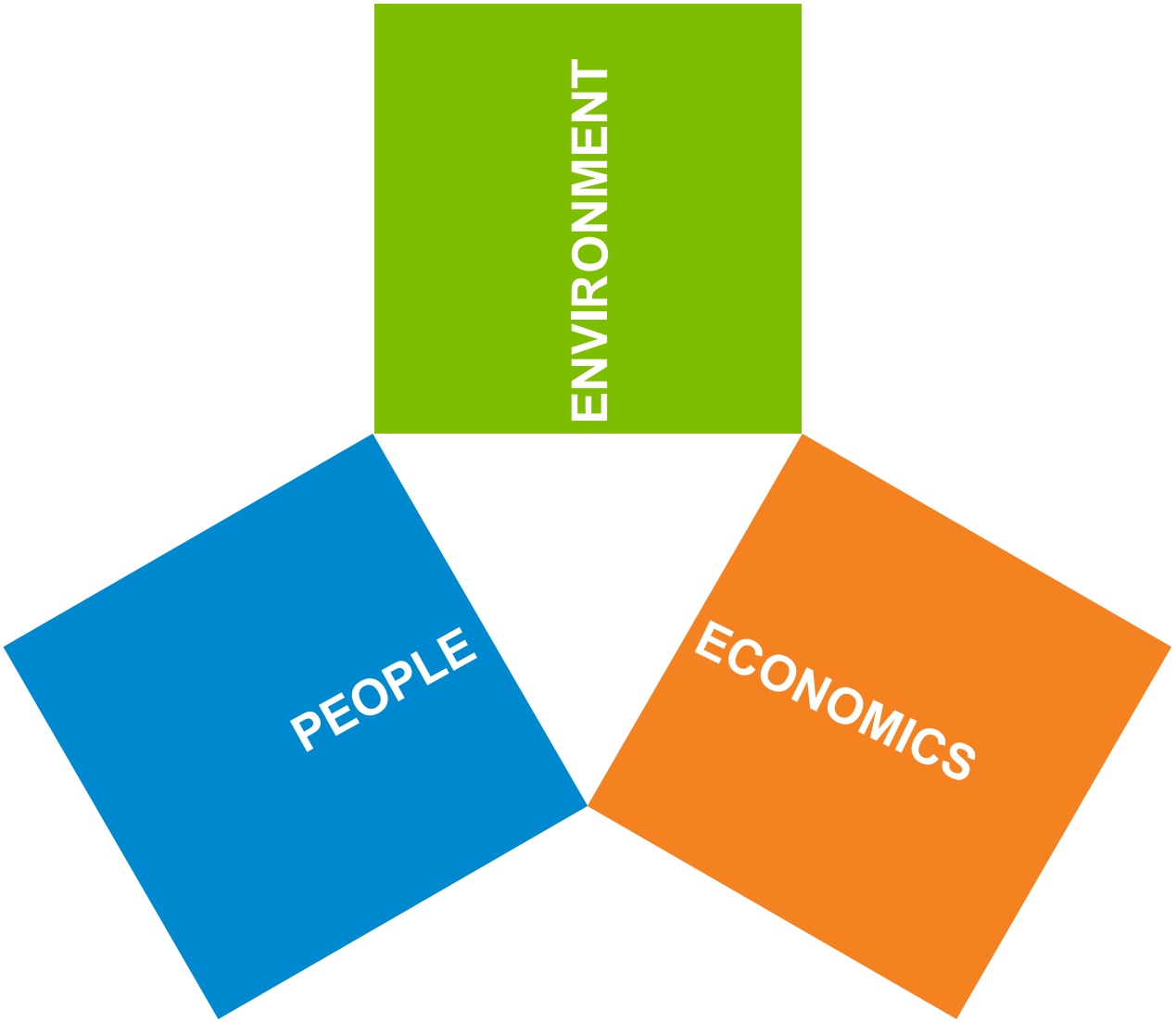
MTA Transportation Building DI, Los  
Angeles County Metropolitan, El Monte,  
LEED NC Gold





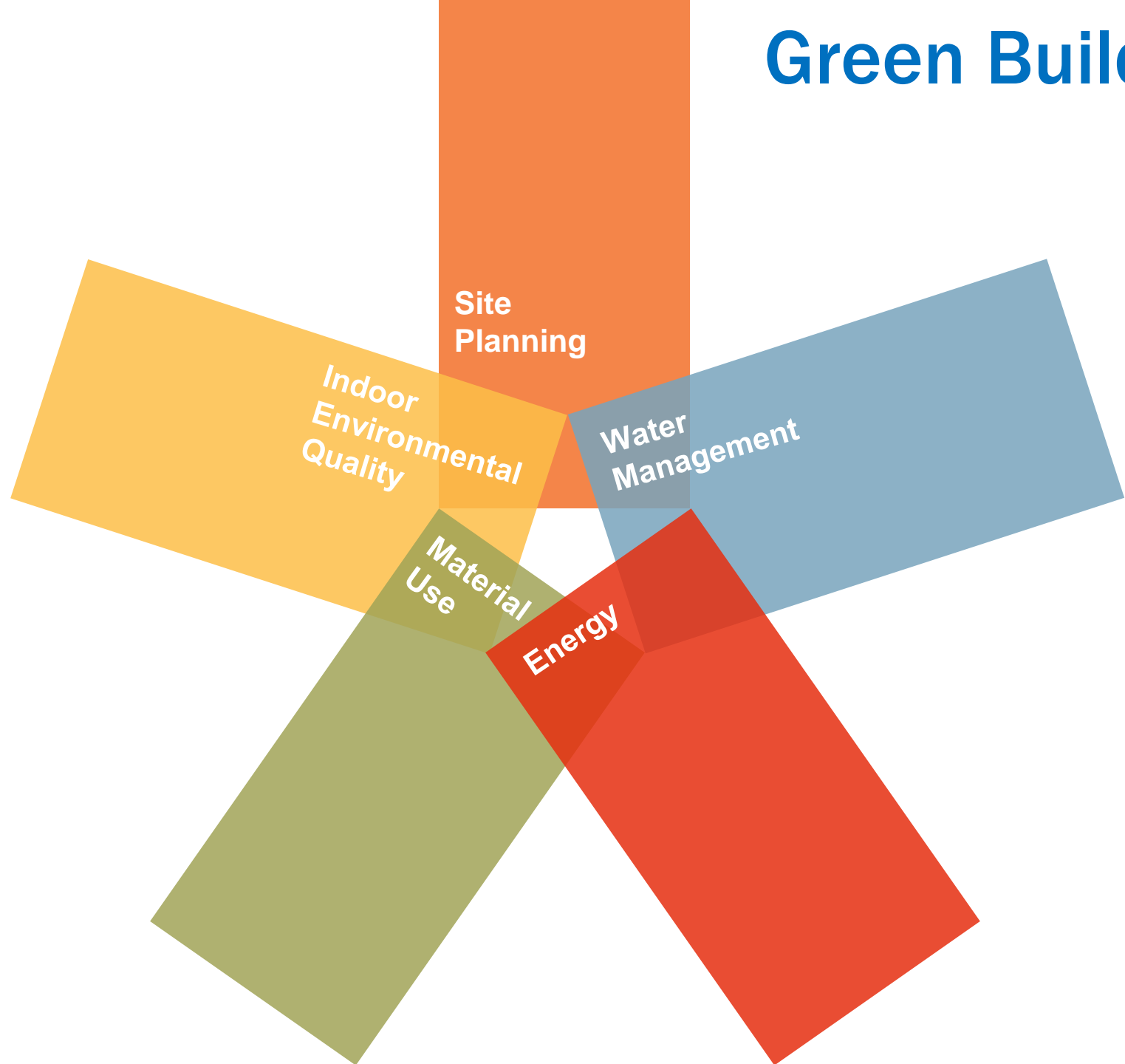
# What makes transit facilities green?

# Triple Bottom Line

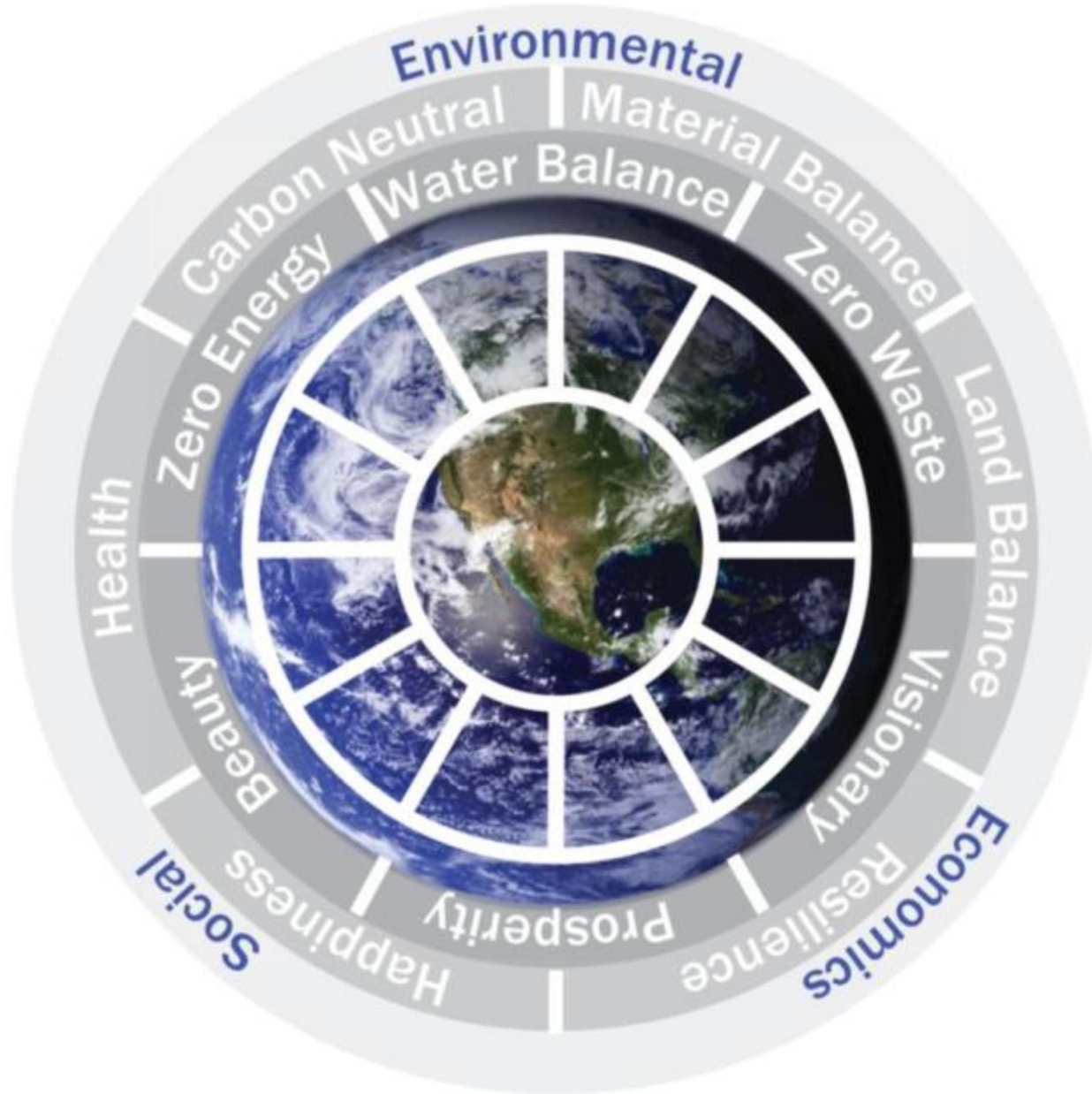




# Green Building



# Design for One Earth





# Establish Performance Based Targets



**Energy**



**Carbon**



**Water**



**Materials / Waste**

# LEED Green Building Rating System



**Sustainable Sites**



**Water Efficiency**



**Energy & Atmosphere**



**Materials & Resources**



**Indoor Environmental Quality**



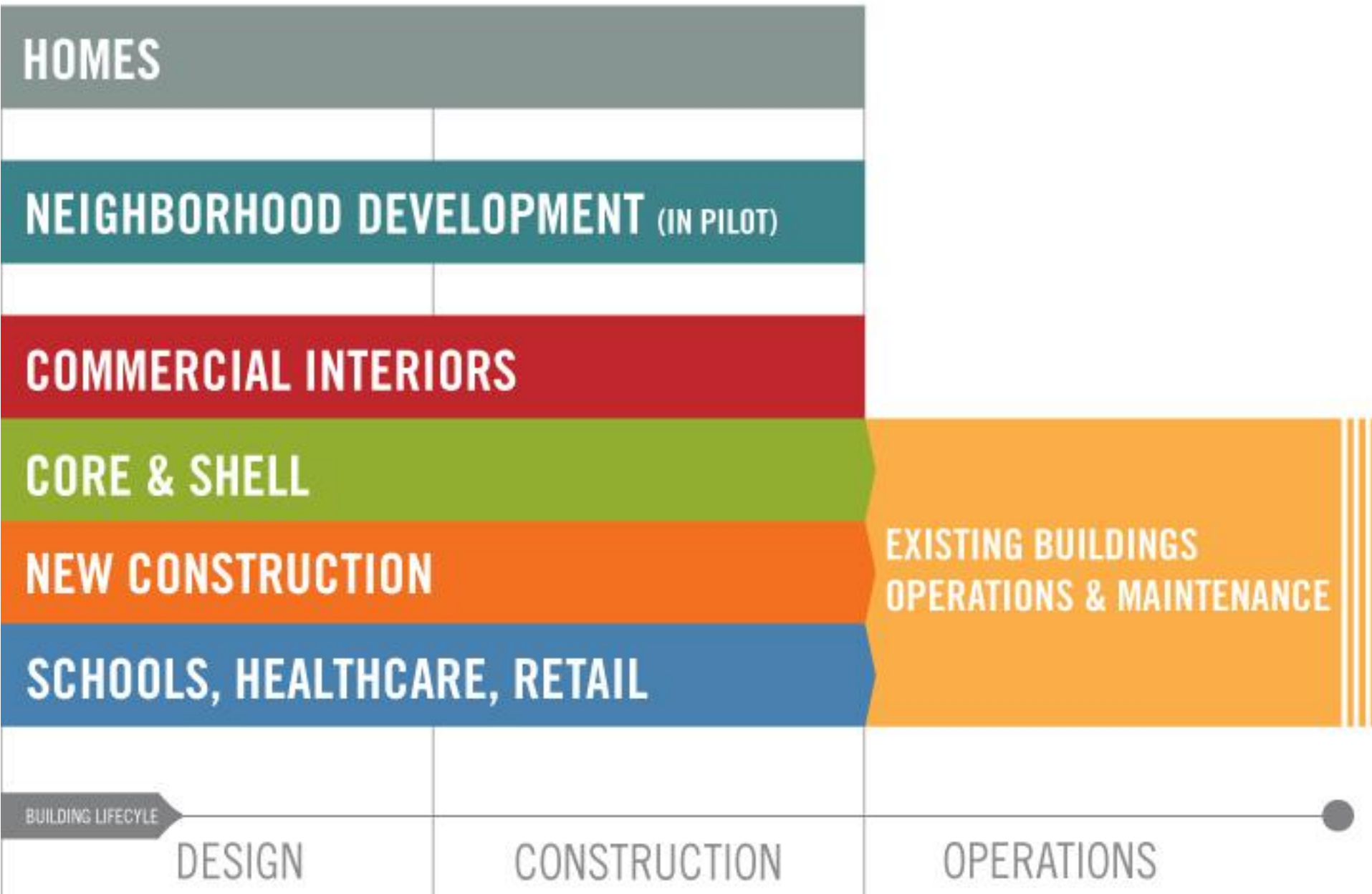
**Innovation in Design**



**Regional Priority**



# LEED Green Building Rating System



# LEED Green Building Rating System





# LEED Green Building Rating System

**1. Holistic Approach**

**2. Performance Based**

**3. Integrated Process**

**4. Third Party Verified**



# California Standards

## Title 24, CALGreen

### 2008 BUILDING ENERGY EFFICIENCY STANDARDS FOR RESIDENTIAL AND NONRESIDENTIAL BUILDINGS

CALIFORNIA  
ENERGY  
COMMISSION

REGULATIONS / STANDARDS



Effective January 1, 2010

December 2008  
CEC-400-2008-001-CMF

Arnold Schwarzenegger  
Governor



# 2008 California Green Building Standards Code

California Code of Regulations  
Title 24, Part 11

California Building  
Standards Commission



EFFECTIVE AUGUST 1, 2009



# Procurement Methods

New Buildings, Major Renovations

## Set Performance Objectives

- LEED
- Energy target
- Other green building targets

## Integrate the Team

- Performance Based Design Build
- Integrated Project Delivery (IPD)
- Award Incentives

# Existing Facilities

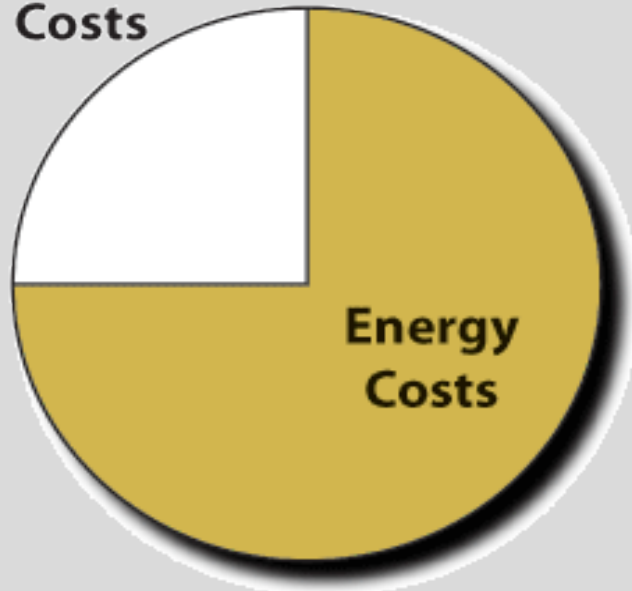
## Energy Audits / Retrocommissioning

- Walk thru audit
- Detailed audit
- Retro or Re-commissioning
- Sustainability audit



# Existing Facilities Performance Contracting

**Maintenance  
Costs**



**Prior to Performance  
Contracting**

**Maintenance  
Costs**



**After Performance  
Contracting**

**Energy savings typically 15 – 30%**



# Existing Facilities

## ENERGY STAR and LEED EBOM

ALLIANCE  
CENTER  
1536 WYNKOOP

- ENERGY STAR : energy bills, ventilation, lighting
- LEED-EBOM: utility bills, policies, procedures, maintenance, grounds, janitorial



**DSIRE**  
Database of State Incentives for Renewables & Efficiency

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

North Carolina Solar Center

IREC

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**DSIRE SOLAR**

Thumbnail image showing the DSIRE SOLAR interface with a map of the United States.



## CALIFORNIA

### Incentives/Policies for Renewables & Efficiency



[See Federal Incentives](#)



[See All Summaries](#)



[See Residential Incentives Only](#)

## Resources

Summary Maps

Summary Tables

Library

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What's New?

## Financial Incentives

### Green Building Incentive

- [Marin County - Green Building Incentive Program](#)
- [San Bernardino County - Green Building Incentive](#)
- [San Diego County - Green Building Program](#)
- [Santa Monica - Building Permit Fee Waiver for Solar Projects](#)
- [Santa Monica - Expedited Permitting for Green Buildings](#)

### Industry Recruitment/Support

- [Sales Tax Exemption for Alternative Energy Manufacturing Equipment](#)

### Leasing Program

- [Santa Clara Water & Sewer - Solar Water Heating Program](#)

### Local Loan Program

- [Palm Desert - Energy Independence Program](#)
- [San Francisco - GreenFinanceSF](#)
- [Sonoma County - Energy Independence Program](#)

# ARRA Opportunities

www.recovery.ca.gov



Search California Recovery

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California will receive billions in Recovery Act funds to repair and improve our state's transportation system, create jobs and stimulate economic growth. California will receive funds to rebuild and repair highways, local streets and roads, as well as numerous transit projects. California is also eligible to apply for billions in competitive funding for high speed and intercity rail, surface transportation projects, aviation and AMTRAK, new starts, transit, ferries and other programs; California is positioning itself to receive a large portion of funds for high speed rail, which will supplement the \$10 billion voters approved in November 2008 to jumpstart high speed rail, create jobs and clean up the environment in California.

Governor Schwarzenegger is a strong advocate for infrastructure investment as it is one of the best ways to create and sustain jobs, stimulate economic development, and leave a legacy to support the financial well-being of the generations to come.

## Transportation Funds Distribution Graph



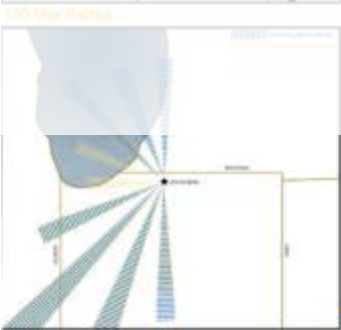
**Note:** The above dollar amounts are in millions. The above graph depicts a snapshot of the distribution of federal recovery funds allocated to the state of California. The actual dollar amounts will vary as recovery dollars move from an estimate by the Federal Government to the actual amount awarded to California and eventually made available to

## Related Agencies

- [California Department of Transportation \(Caltrans\)](#)
- [United States Department of Transportation](#)
- [Federal Aviation Administration \(FAA\)](#)
- [Federal Highway Administration \(FHWA\)](#)
- [Federal Railroad Administration \(FRA\)](#)
- [Federal Transit Administration \(FTA\)](#)

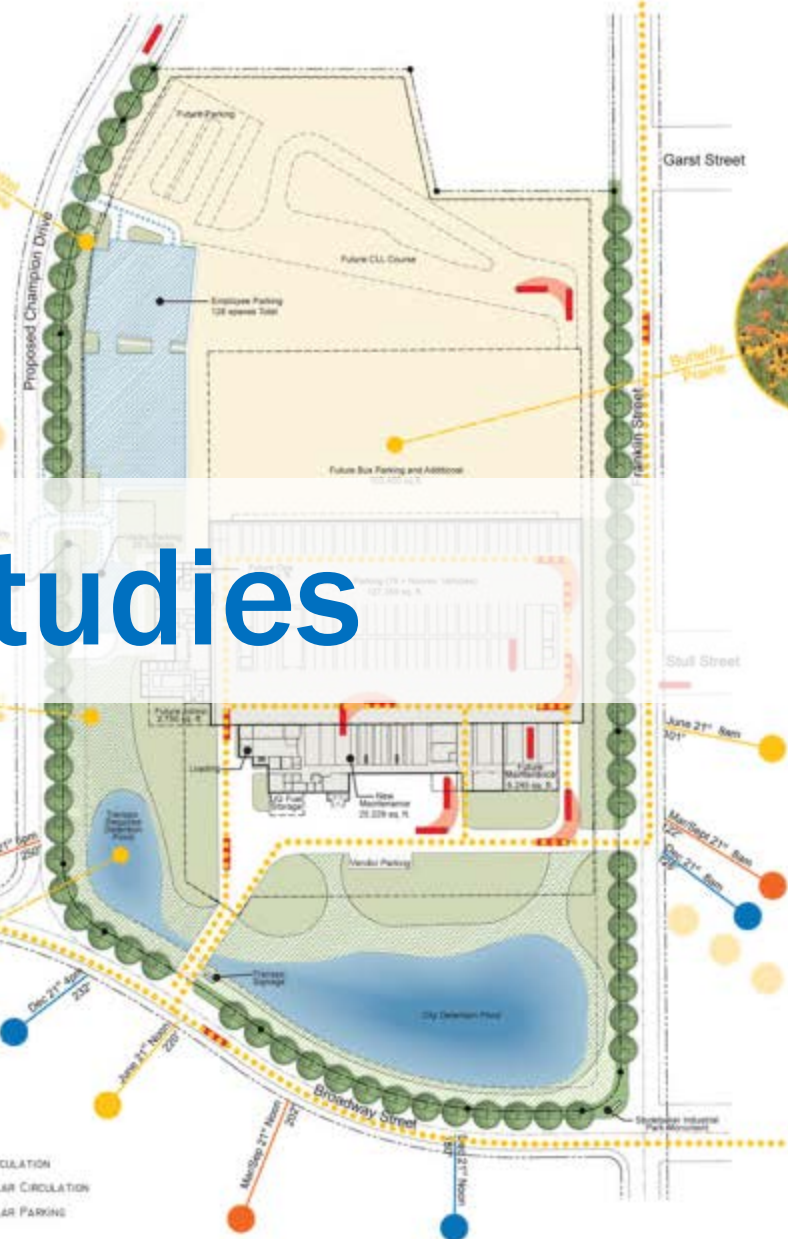
SUSTAINABILITY

# Case Studies



LEED Gold  
50% Greenhouse Gas Reduction  
50% Energy Use Reduction  
50% Water Conservation  
50% Local Sourcing

LEED Platinum  
50% Greenhouse Gas Reduction  
50% Energy Use Reduction  
50% Water Conservation  
50% Local Sourcing



- BUS CIRCULATION
- VEHICULAR CIRCULATION
- VEHICULAR PARKING



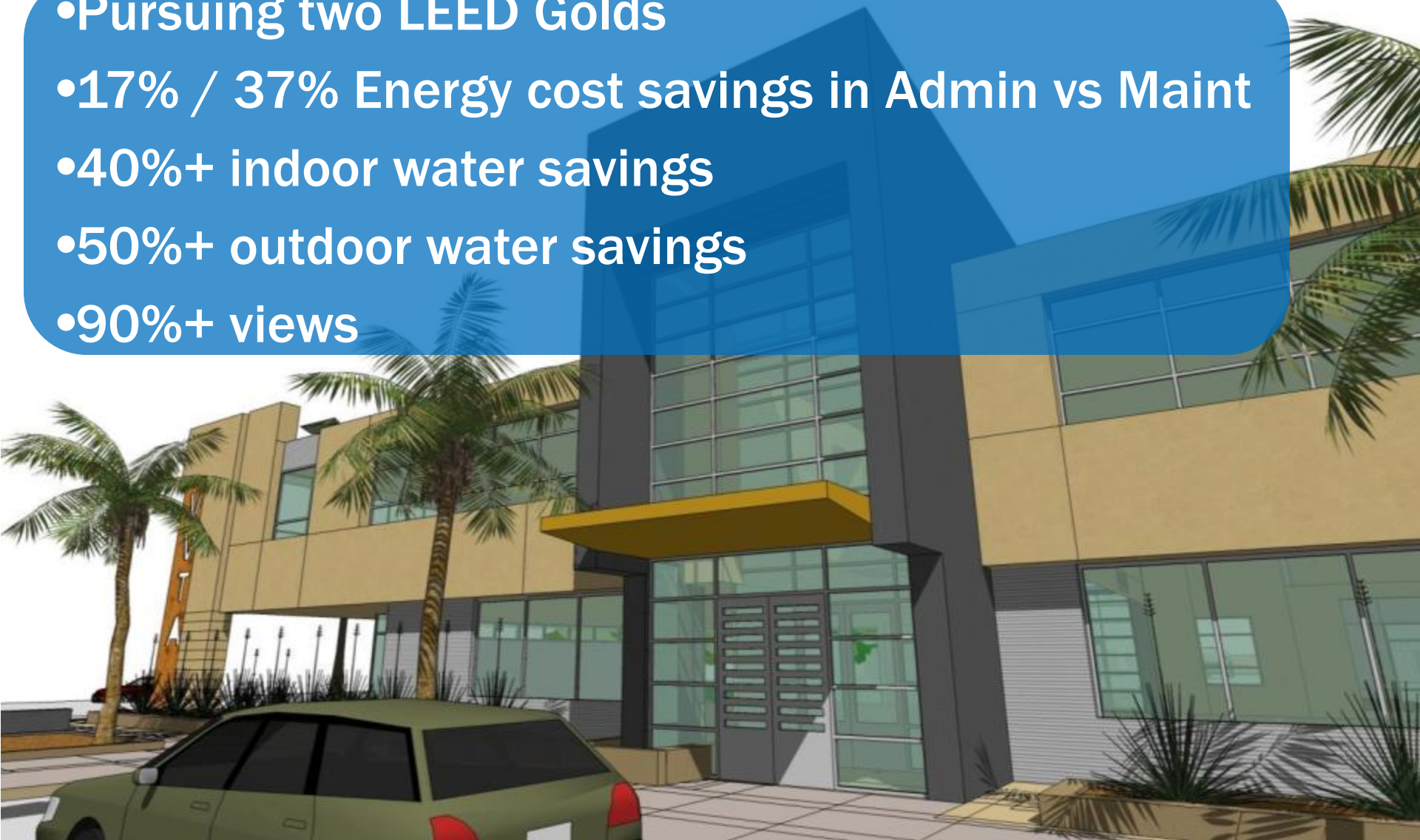
VVTA

Hesperia, CA


Bus Administration, Operations, and Maintenance Facility



- Pursuing two LEED Golds
- 17% / 37% Energy cost savings in Admin vs Maint
- 40%+ indoor water savings
- 50%+ outdoor water savings
- 90%+ views





- 
- An architectural rendering of a modern, multi-story building complex. The buildings feature large windows and flat roofs. The surrounding landscape includes numerous palm trees and other xeric plants. A bus is visible on a road to the right of the building. The scene is set against a clear sky.
- Underfloor air distribution
  - 1 MW photovoltaic system
  - Stormwater management
  - Native and xeric plants



# Central Platte Campus

Denver, CO

Public Works Fleet Maintenance facility and Office/Warehouse



# Central Platte Campus

Denver, CO

- Pursuing 2 LEED Golds
- 35% / 41%+energy cost savings in Shop-Warehouse vs Fleet-Maint.
- 40%/50%+ indoor/outdoor water usage savings
- 95%+ construction waste recycling



# Central Platte Campus

Denver, CO



- Photovoltaics through a PPA
- Sawtooth roof design
- Evaporative cooling (no refrigerants)
- Heat recovery



# TRANSPO

## South Bend, IN

Bus Administration, Operations, and Maintenance Facility



# TRANSPO

South Bend, IN



- Pursuing LEED Platinum
- 28% energy savings
- 30%+ water use reduction
- 75%+ construction waste diversion

# TRANSP0

South Bend, IN

- Ground source heat pumps
- Radiant slabs
- Brownfield remediation
- Bioremediation of stormwater
- Super insulated envelope



# East Valley Bus Maintenance

Tempe, AZ

Bus Operations, and Maintenance Facility



# East Valley Bus Maintenance

Tempe, AZ

- **LEED-NC Gold** (Office and Maintenance)
- **98% Construction waste diversion**
- **53% Energy savings**
- **30%+ Water use reduction**



# East Valley Bus Maintenance

Tempe, AZ

- Underfloor air delivery
- Daylighting / clerestories / sensors
- Dual flush WC / waterless urinals
- Operable windows
- Bus parking shade canopies



# LA Metro Division 13

Los Angeles, CA

Bus Operations, and Maintenance Facility





# LA Metro Division 13


Los Angeles, CA

- Pursuing LEED Gold
- 50%+ Irrigation water reduction
- 30%+ water use reduction
- High indoor environmental quality



# LA Metro Division 13

Los Angeles, CA

- 
- Green roof
  - Rainwater harvesting
  - Public transportation access
  - BIPV on façade
  - Public use green fueling station



# El Monte Station

El Monte, CA

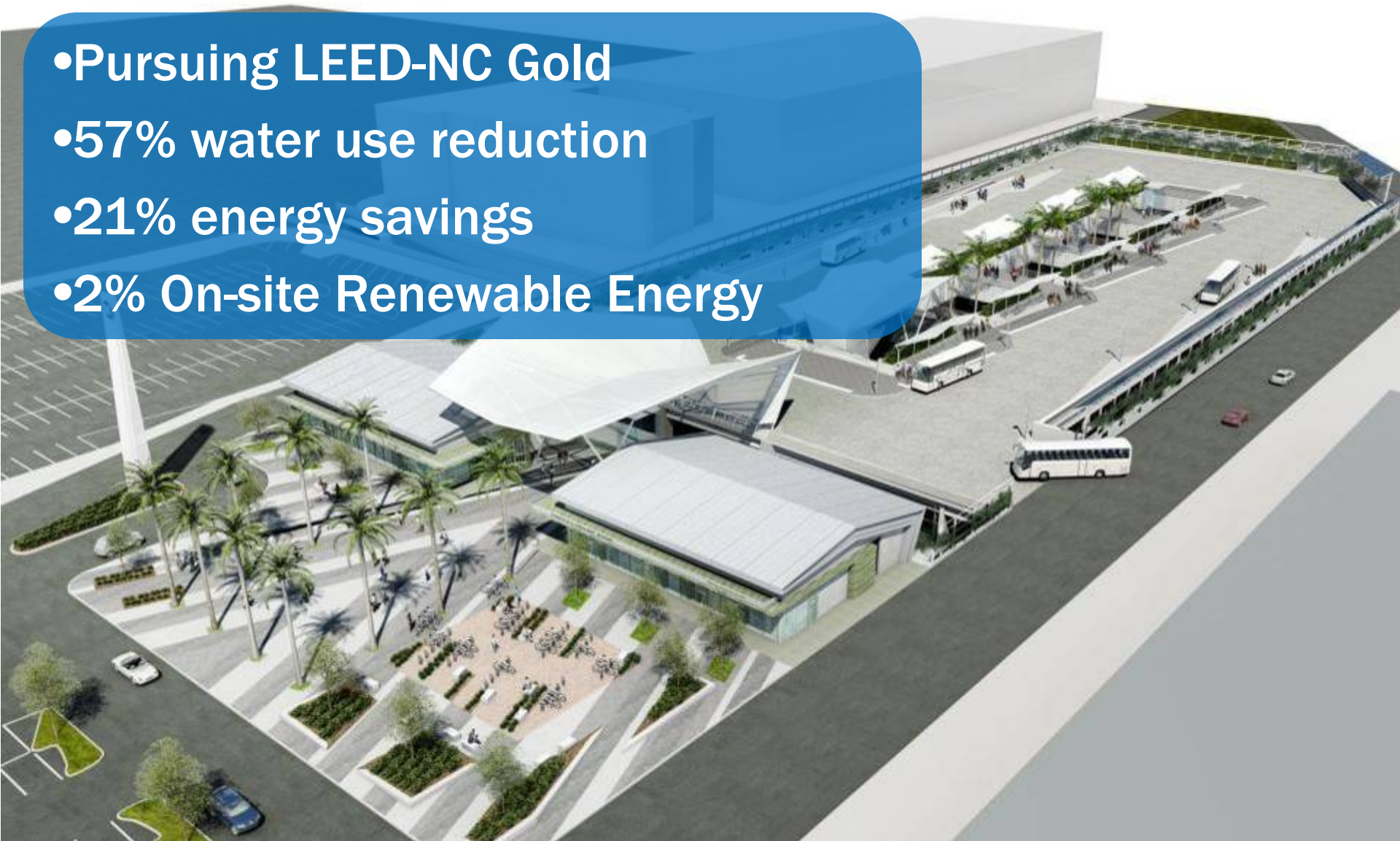
Bus Station



# El Monte Station

El Monte, CA

- Pursuing LEED-NC Gold
- 57% water use reduction
- 21% energy savings
- 2% On-site Renewable Energy





# El Monte Station

El Monte, CA

- Maximize open space (25%)
- Water efficient landscaping
- Vegetated walls for sound control
- Cool roofs / High albedo paving







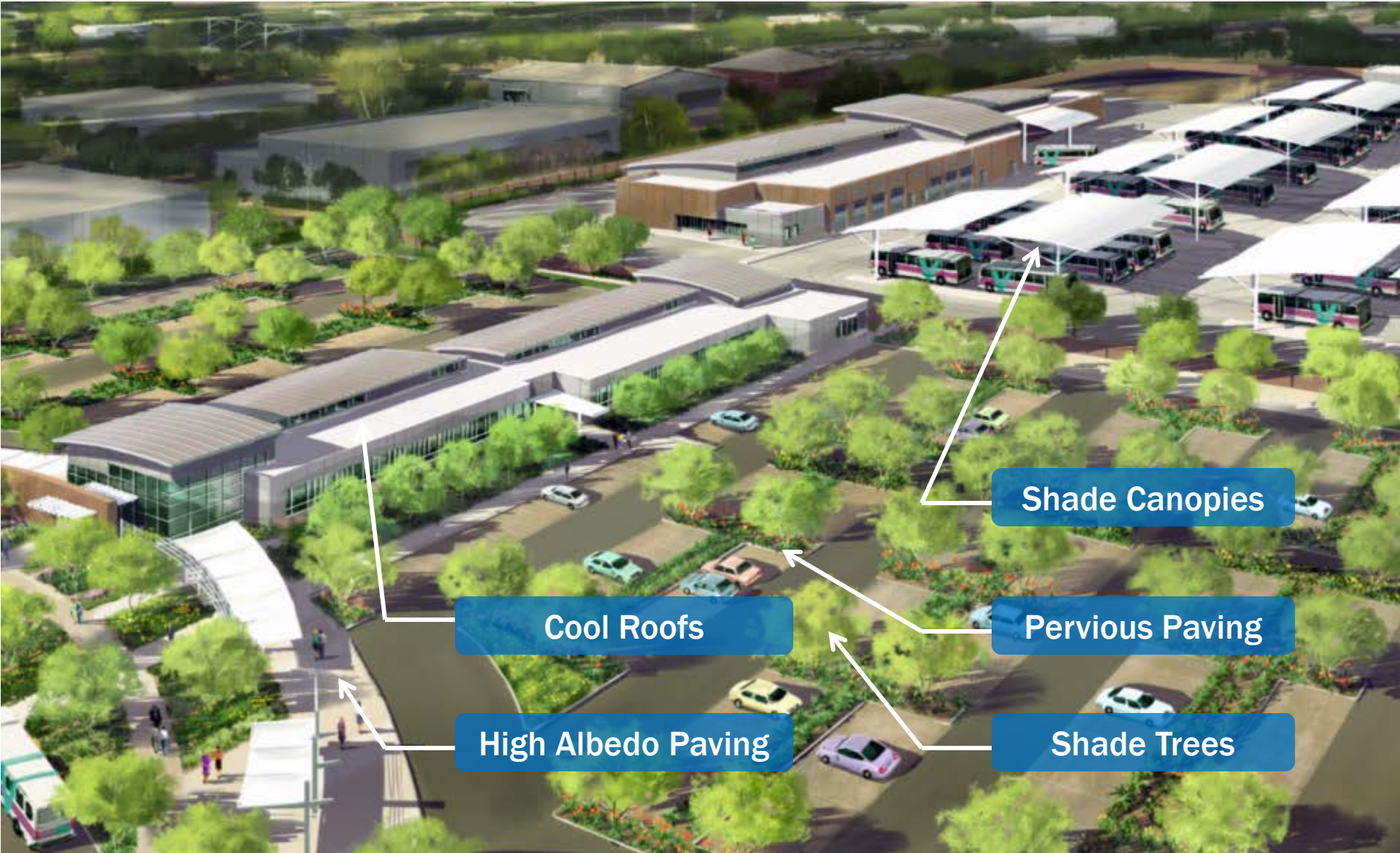
# Green Transit Best Practices





# Urban Heat Island

Cool Roofs, High Albedo Paving, Shading, Vegetation



Shade Canopies

Cool Roofs

Pervious Paving

High Albedo Paving

Shade Trees



# Stormwater Management

## Bioswales, Constructed Wetlands, On-site Retention





# Stormwater Management

Rainwater Harvest, Green Roof, Pervious Paving



# Water

## Low Flow Fixtures, Water Re-use, Wash Bays



Source: InterClean



Source: Caroma



# Green Materials

Recycled, Regional. Low Emitting, Certified Wood

- Recycled Content
- Regional Material
- Certified Wood
- Low VOC finishes



# Building Materials Research

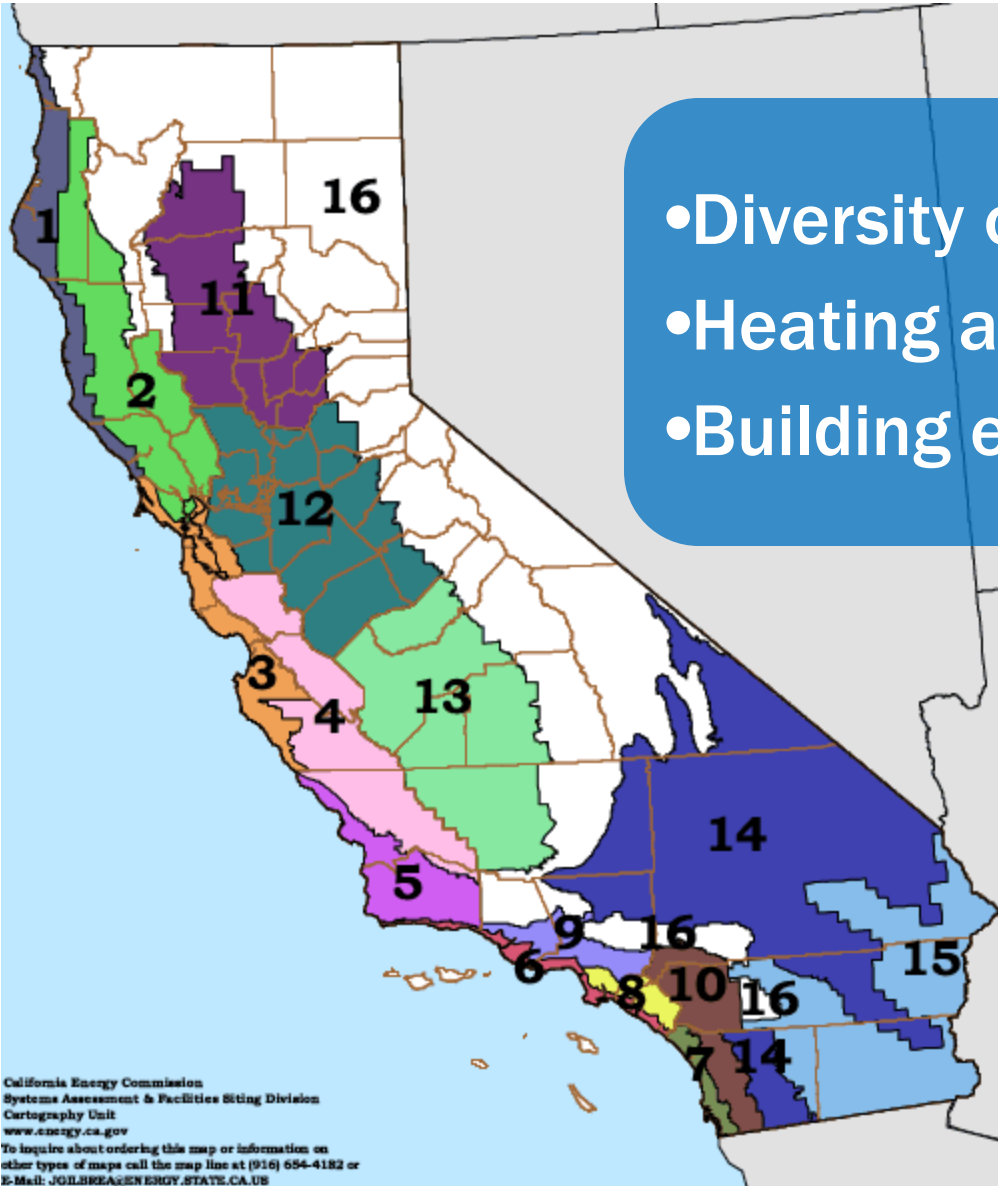
<b>Central Platte Campus</b> 4/16/2009 <b>LEED GOALS:</b> RECYCLED CONTENT: 10-20% REGIONAL MATERIALS: 20% RAPIDLY RENEWABLE: Up to 2.5% CERTIFIED WOOD: 50% (of total wood) LOW-EMITTING: All WATER EFFICIENCY: 30% ENERGY EFFICIENCY: 28%		RECYCLED CONTENT	REGIONAL	RAPIDLY RENEWABLE	CERTIFIED WOOD	LOW-EMITTING	EFFICIENCY	<b>WHOLE BUILDING CHECKLIST</b>  <b>SUSTAINABLE PROPERTIES</b>
<b>SITE</b>	PAVING- ASPHALT	X	X				Regional and recycled content materials to be given preference.	
	PAVING- CONCRETE	X	X				20% flyash by weight in concrete. Recycled aggregate: up to 100% (Confirm with structural engineer). Source regionally.	
	PAVING- DECOMPOSED GRANITE - CRUSH FINES		X				Products available regionally to be given preference.	
	EROSION CONTROL	X	X	X			Regional and recycled content products to be given preference. Rapidly renewable products to be given preference when available regionally.	
	SITE FURNISHINGS- GENERAL	X					Highest recycled content to be given preference.	
	SITE FURNISHINGS- BIKE RACK	X					67-75% recycled content. Highest recycled content to be given preference.	



# Energy

## California's Climate

- Diversity of climate conditions
- Heating and cooling systems
- Building envelope strategies



# Energy

## Energy Usage Index

### Average Site EUI

(kBtu/sf/year)

**Vehicle Maintenance Buildings 27 to 101**

**Office Buildings 58 to 143**

**Storage Buildings 16 to 60**

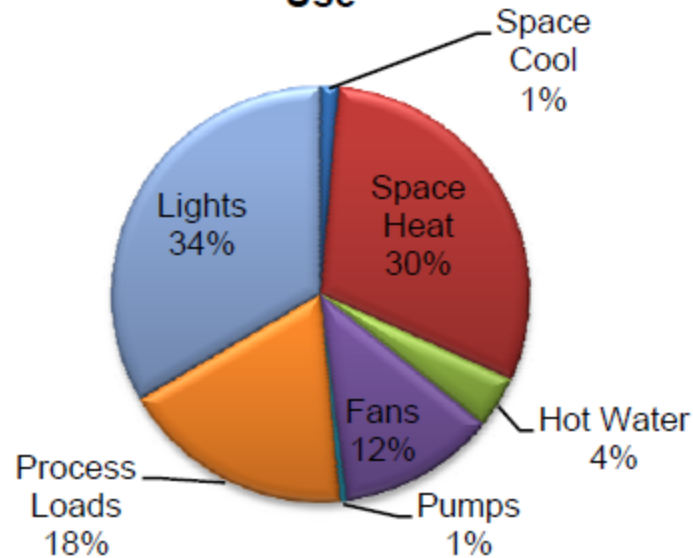




# Energy

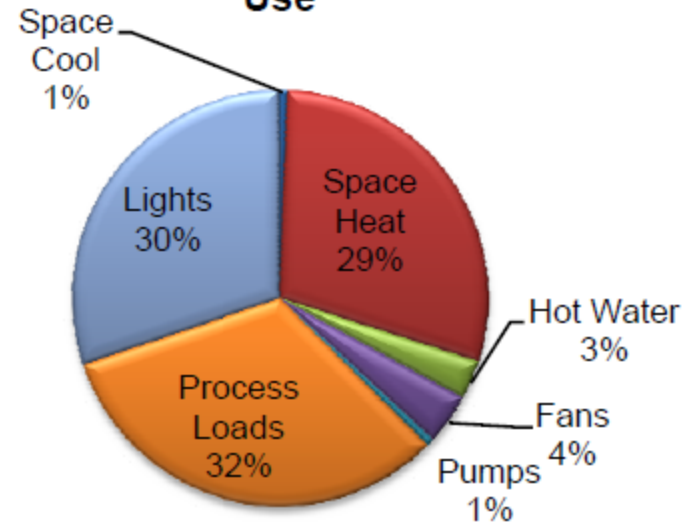
## Office vs. Maintenance Building Use

**Design Case Energy Usage By End Use**



Admin/Operations Building  
65 kBtu/sf/yr

**Design Case Energy Usage By End Use**



vs. Maintenance Building  
120 kBtu/sf/yr



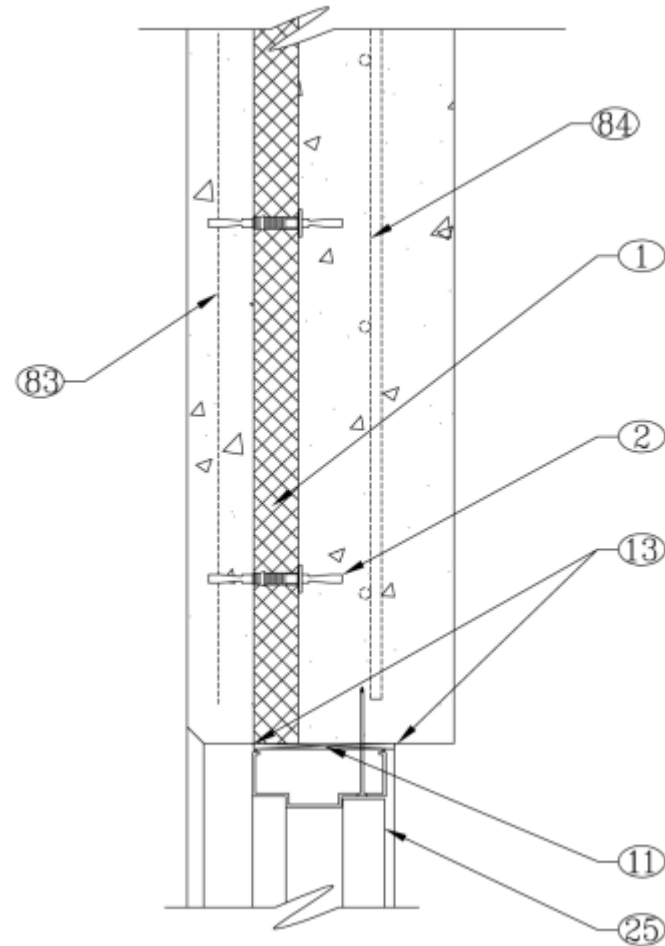
# Energy Energy Modeling

- Select lowest life cycle measures
- Optimize building prior to building footprint
- Select major mechanical systems

EEM	Initial Cost	Life Cycle Cost (PV)	% Change
E1 Daylighting Based Lighting Control	\$12,450	\$1,015,998	10.4%
E2 Occupancy Based Lighting Control	\$9,000	\$1,081,891	4.6%
M1 Evaporative Cooling	\$20,400	\$1,090,746	3.9%
Design Case	\$0	\$1,134,475	0.0%
A1d Shading: Boardroom	\$4,320	\$1,138,414	-0.3%
A2a Wall Insulation	\$11,512	\$1,138,562	-0.4%
A2b Roof Insulation	\$26,406	\$1,154,168	-1.7%
A3a Glazing: Solarban 70 XL	\$22,995	\$1,154,607	-1.8%

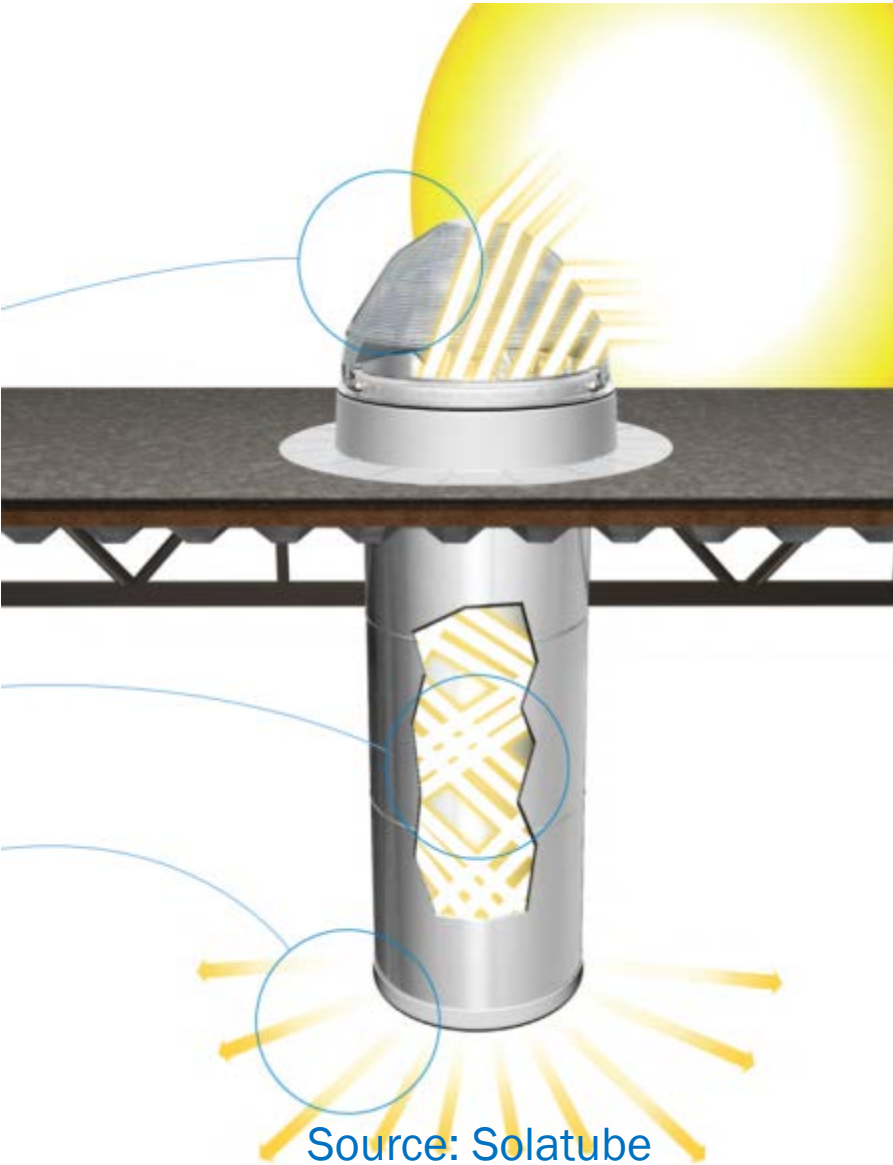
## Building Envelope and Insulation

Wall Type	Total R-Value
Baseline steel framed	11.9
Insulated stud wall	19.1
Un-insulated tilt up wall	1.7
Insulated tilt up wall	13.1





# Energy Daylighting



Source: Sunoptics

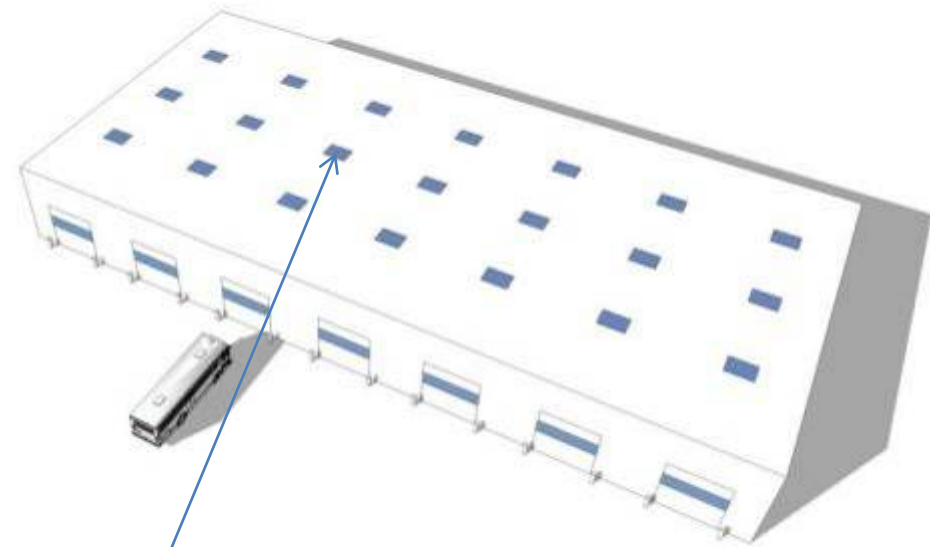
## Daylighting, Lighting and Controls

- Glazed bay doors
- Photosensors
- Multiple switches per bay
- Glazing per orientation and height

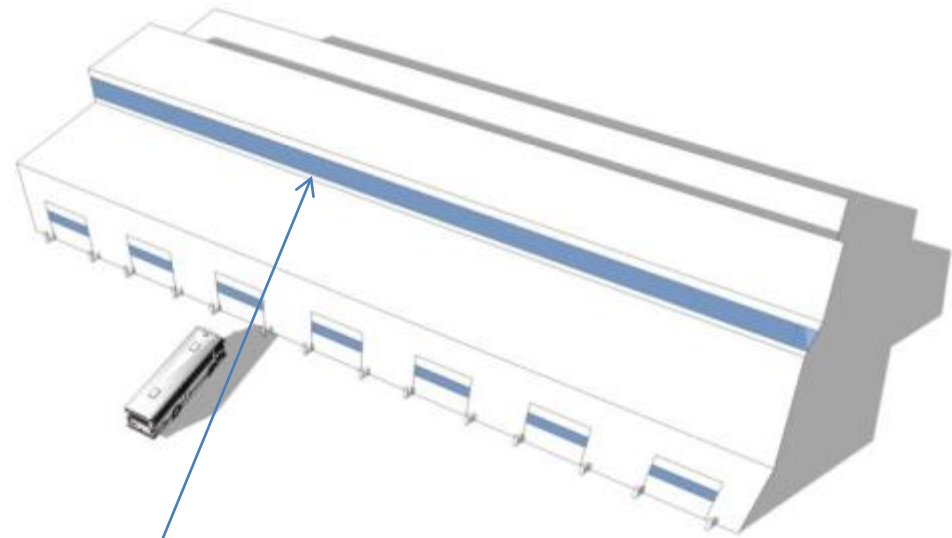




# Energy Daylighting



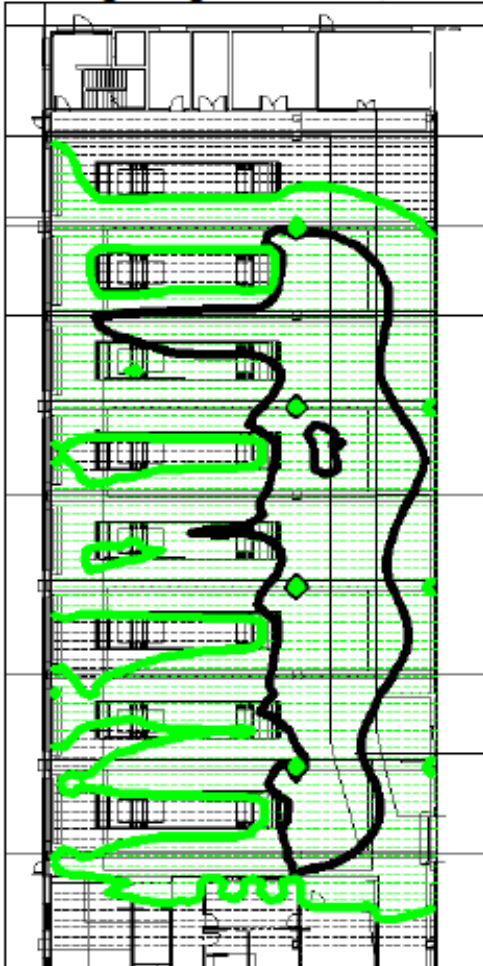
**Skylights or Solatubes**



**Clerestory / Roof Monitors**

# Energy Daylighting Modeling

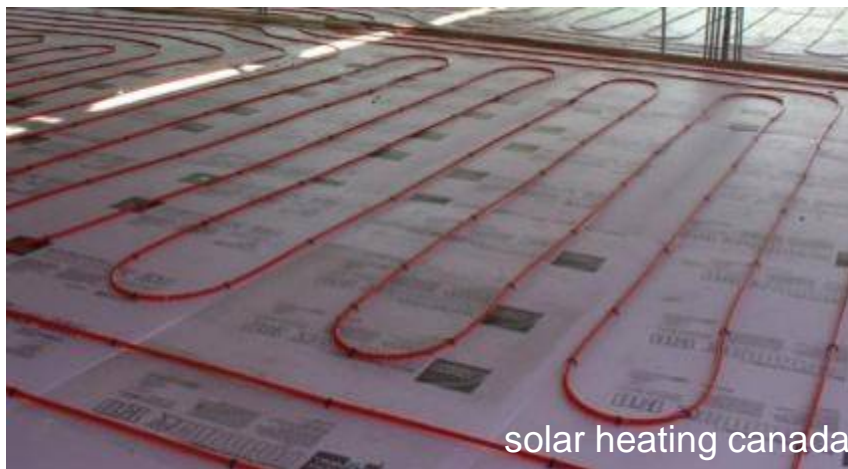
Image 15. Maintenance Bays, Horizontal Footcandles at 2.5' AFF, March 21, Noon, Clerestory and roof monitor glazing Tvis at 0.70, diffuse glazing in roof monitors



- Optimize glazing type
- Optimize shading devices
- Optimize photosensors
- Optimize daylight strategy

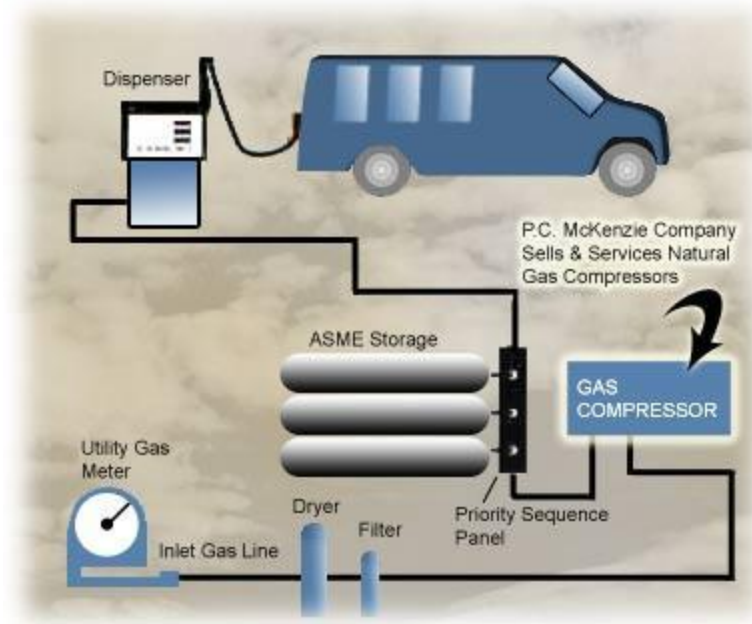
Image 29. March 21, 6pm, looking west





- Destratification fans
- Air quality sensors
- Radiant heating /condensing boilers
- Heat recovery
- Evaporative cooling





- Low emitting alt fuel vehicles
- CNG energy management
- Biobased fuels
- Parking for alt vehicles

# Energy

## Maintenance Processes

Energy Model	
Daily Occupancy	Hours Occupied
5	4AM-1PM M-Sa
2	5:30AM-8PM M-Su
5	5PM-2AM M-Sa
6	7AM-5PM M-Sa
2	7AM-5PM M-Sa
1	7AM-5PM M-Sa
1	7AM-5PM M-Sa
1	7AM-5PM M-Sa
1	7AM-5PM M-Sa
1	7AM-5PM M-Sa
2	7AM-7PM M-Sa
1	7AM-7PM M-Sa
2	8AM-8PM Su
5	10AM-7PM M-Sa
8	8PM-5:30AM M-Su
<b>Total 43</b>	

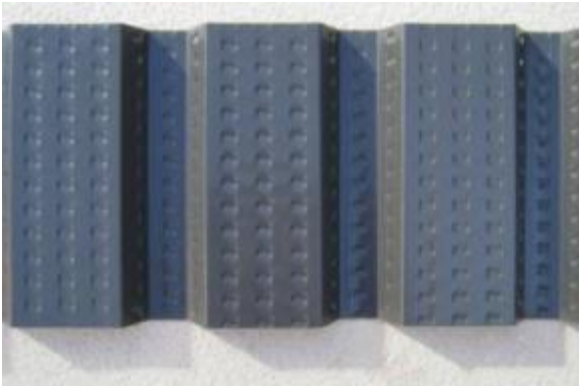
Maintenance Design Group

- Highest efficient motors
- Variable speed drives
- Scheduling equipment



# Renewable Energy

## Transpired Solar Collector



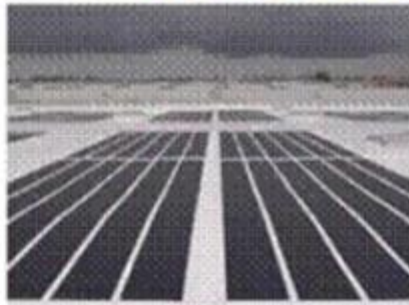
Source: Solarwall





# Renewable Energy

## Photovoltaic

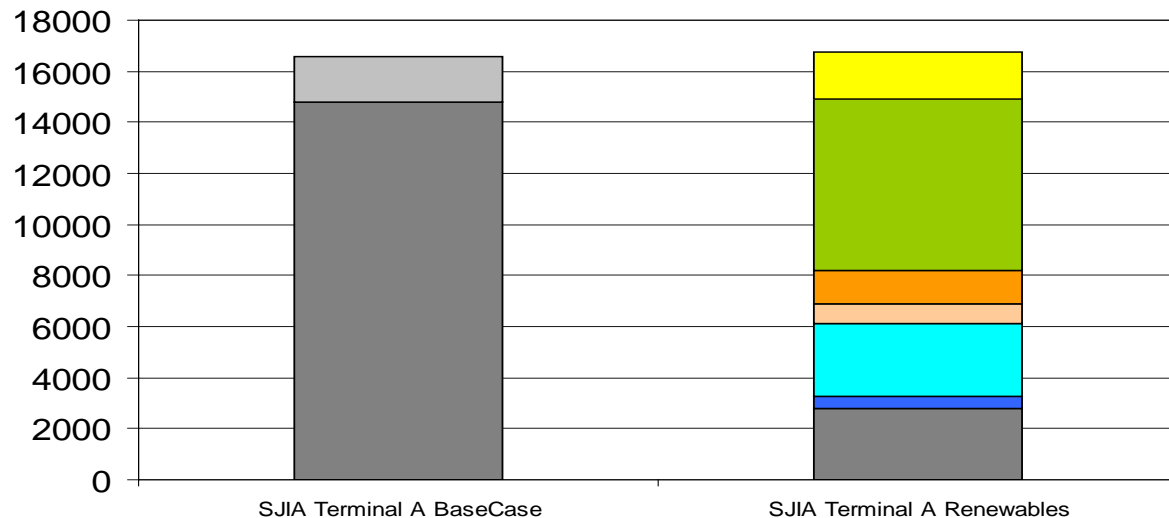
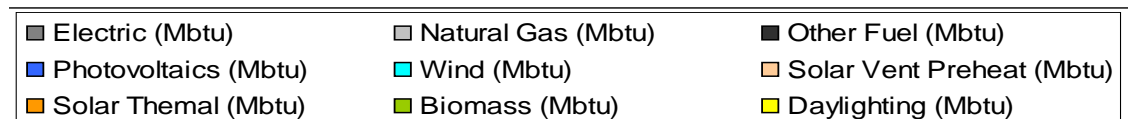


# Renewable Energy

## Renewable Energy Analysis

- Select renewables appropriate for the load
- Identify alt. funding sources
- Select the lowest life cycle

	"closed loop" evacuated tube solar water heating schematic with tank	"recirculation loop" evacuated tube solar water heating schematic without tank
Initial Cost (\$)	\$424,981	\$148,677
Utility Incentive (\$)	0	0
Tax Credit (\$)	0	0
Cost to SJIA after Incentives (\$)	\$424,981	\$148,677
Utility Cost Savings (\$/year)	\$44,653.00	\$17,918.75
O&M Cost (\$/year)	\$1,062.45	\$371.69
Internal Rate of Return	10.26%	11.80%
Simple Payback Period	9.7	8.5
Life Cycle Savings	\$78,262.00	\$156,817.24
Savings to Investment Ratio	1.1	2.1



# Zero Energy Buildings

Low Energy and Renewable Energy



=



**ZEBs produce as much energy as they consume over the course of a year.**



# Thank You!



**Renée Azerbegi**, CEM, LEED AP  
President, Ambient Energy

[www.ambient-e.com](http://www.ambient-e.com)

[renee@ambient-e.com](mailto:renee@ambient-e.com)

**Tom Hootman**, AIA, LEED AP  
Director of Sustainability, RNL

[www.rnldesign.com](http://www.rnldesign.com)

[tom.hootman@rnldesign.com](mailto:tom.hootman@rnldesign.com)