Greenbuilding Initiatives

High Performance Design

Presented by:

Fred Andreas AIA LEED AP

UNiT design studio

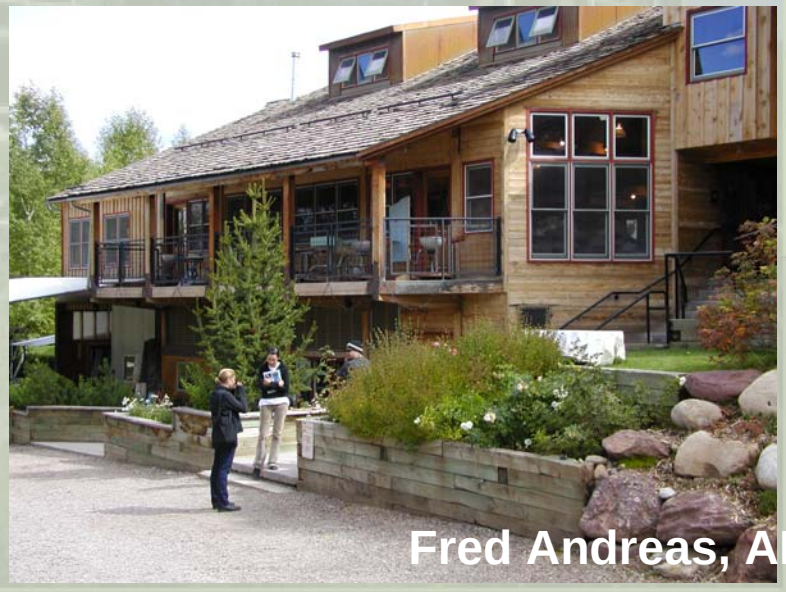
sustainable urban design and architecture

Beyond LEED To High Performance
Passive Heating, Cooling and Lighting

Advanced Greenbuilding Studio Projects
College of Architecture and Planning

USGBC EGB Winners, 2005 – 2008
National Honor Winner, USGBC 2006
Top Award All Studio Design Competition 2009
Outstanding Research & Creative Activity Award, UCD 2009

Greenbuilding Design



2008

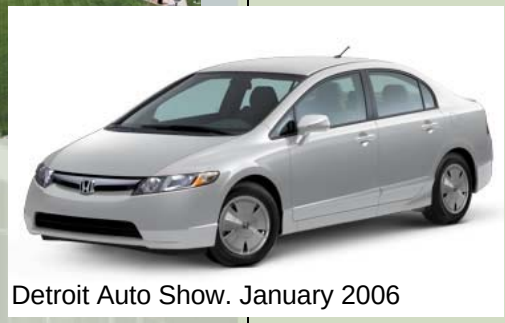
Fred Andreas, AIA, LEED AP

UNiT
design studio
sustainable urban design and architecture

What is Green Design?

- Gas-electric hybrid automobiles
- Sustainable energy
- Sustainable buildings
- LEED Certified Buildings
- High Performance Standards
- High Architectural Design
- Preservation
- Ecologic & climatic design
- Urban, and community design
- Expensive??

CH2M HILL. LEED Silver.
Englewood CO



Detroit Auto Show. January 2006

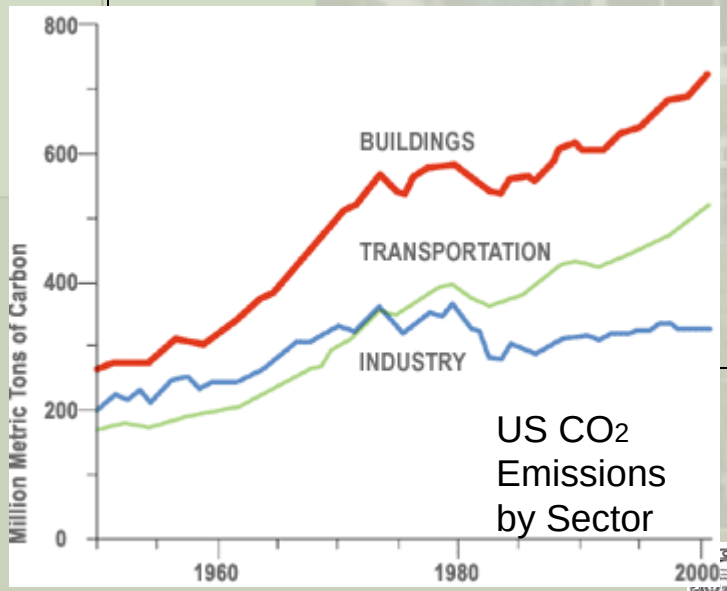
William McDonough. LEED Platinum.
Herman Miller Headquarters. Zeeland MI

Alberici Corporate Headquarters. LEED Platinum. St. Louis MO

What is Green Design?

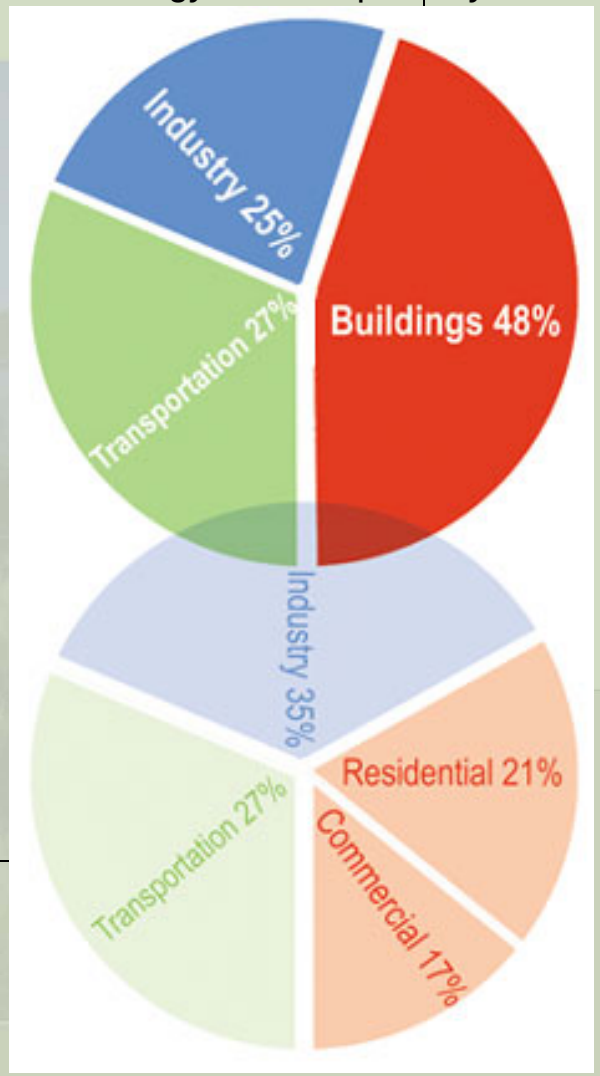
- **Global Warming Crisis**
- **Carbon Loading Crisis**
- **Energy and Water Crisis**
- **Buildings = 48% of Total US Energy**
- **Buildings = 78% of Electrical Energy**
- **Sustainability is Achievable**
- **LEED Ratings**

- **Green Building = High Design**

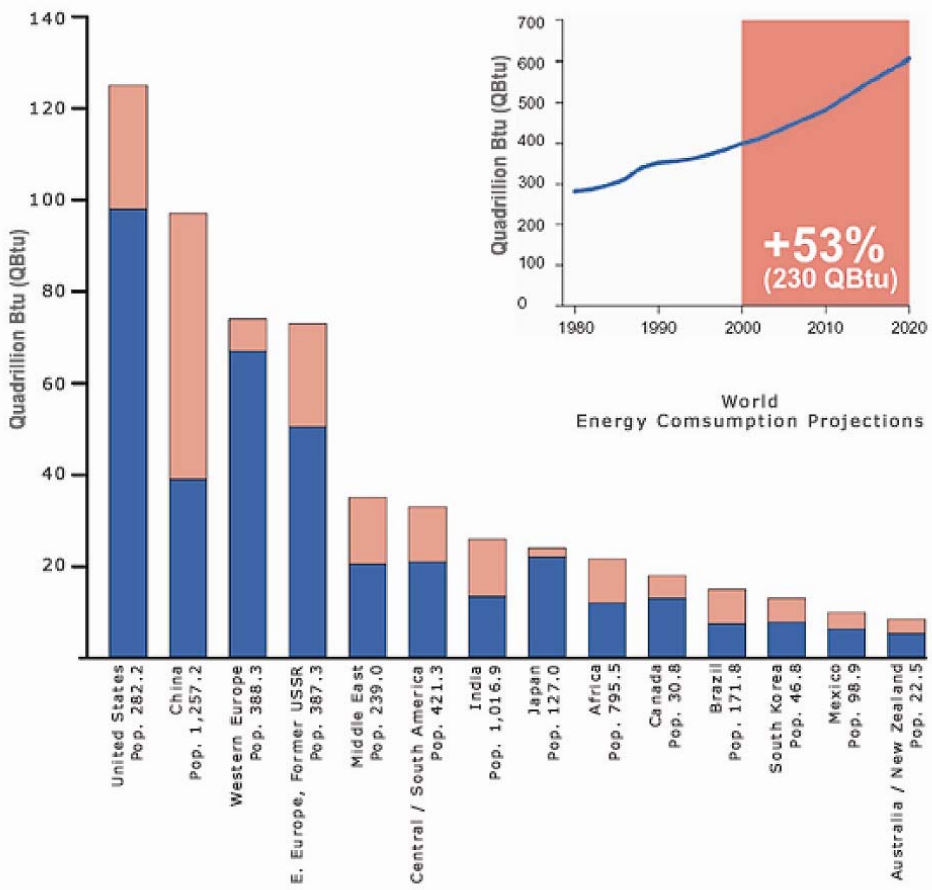


US CO_2 Emissions by Sector

US Energy Consumption by Sector



Country / Region Energy Consumption Projections



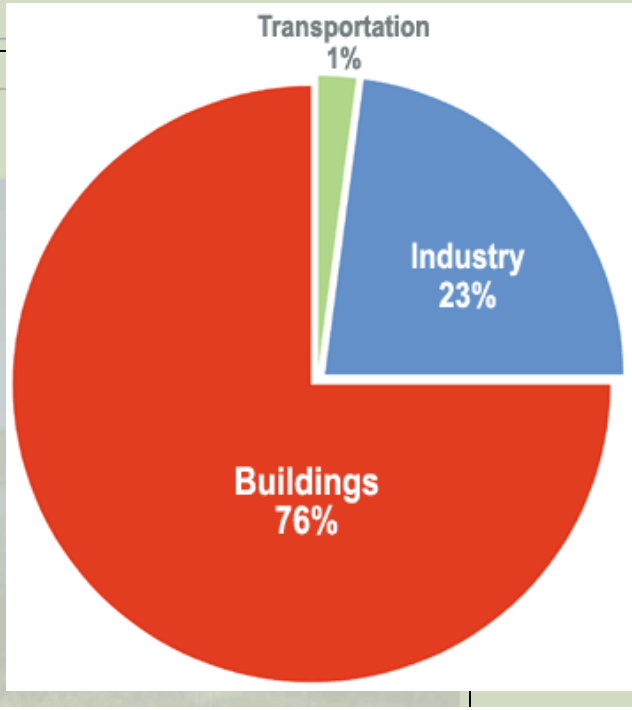
World
Energy Comsumption Projections

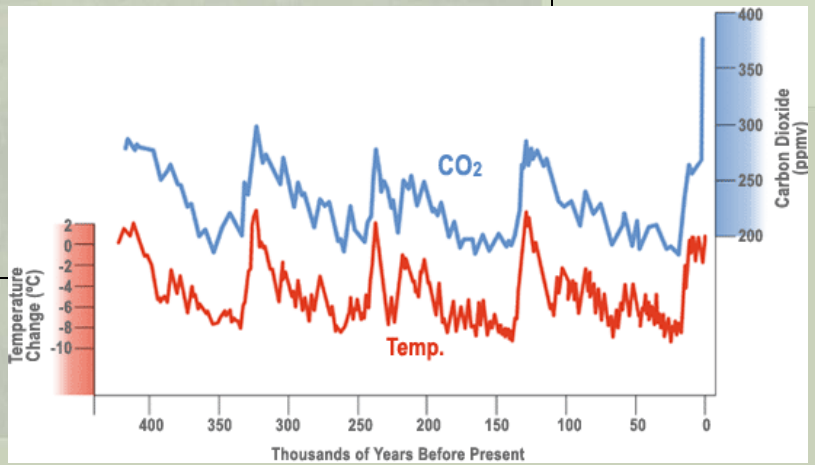
COMPARATIVE CHART KEY

Projected Annual Energy Consumption (2020)

Annual Energy Consumption (2000)

2000 Population Numbers are in Millions



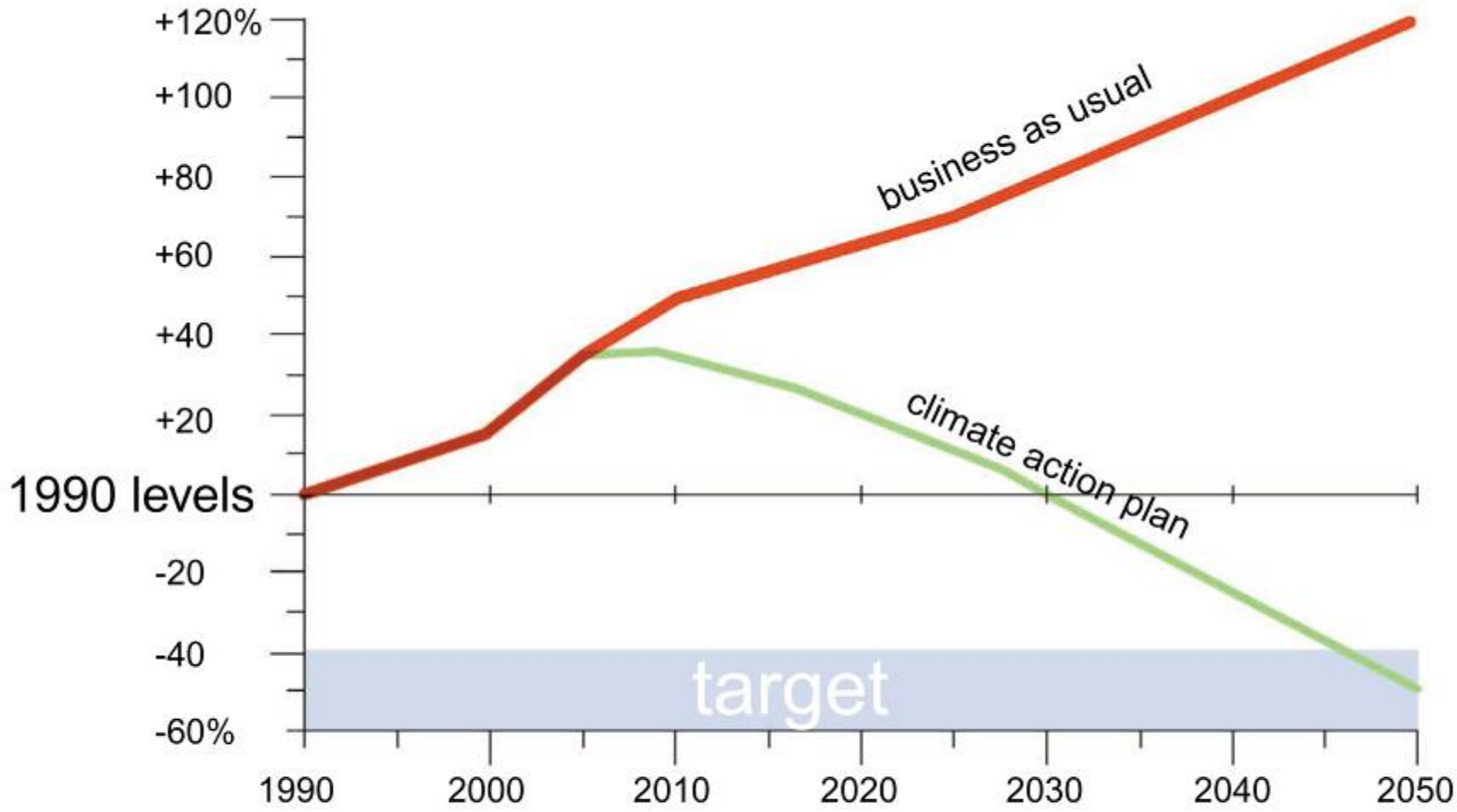


The 2030 Challenge…
ZNE and ZNC by the year 2030!

AIA's carbon emission reduction targets

By 2010…New & Renovated Buildings
A Minimum of 50% Reduction

2012 – 60%
2015 – 70%
2020 – 80%
2025 – 90%



U.S. Building Sector CO2 Emissions

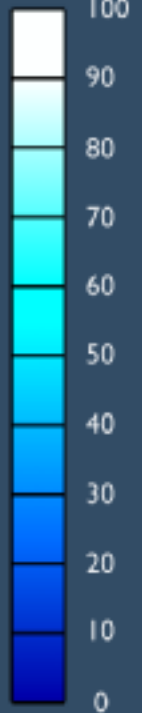
Source: Maz (Assumes a 15% embodied energy reduction in the construction of new buildings)

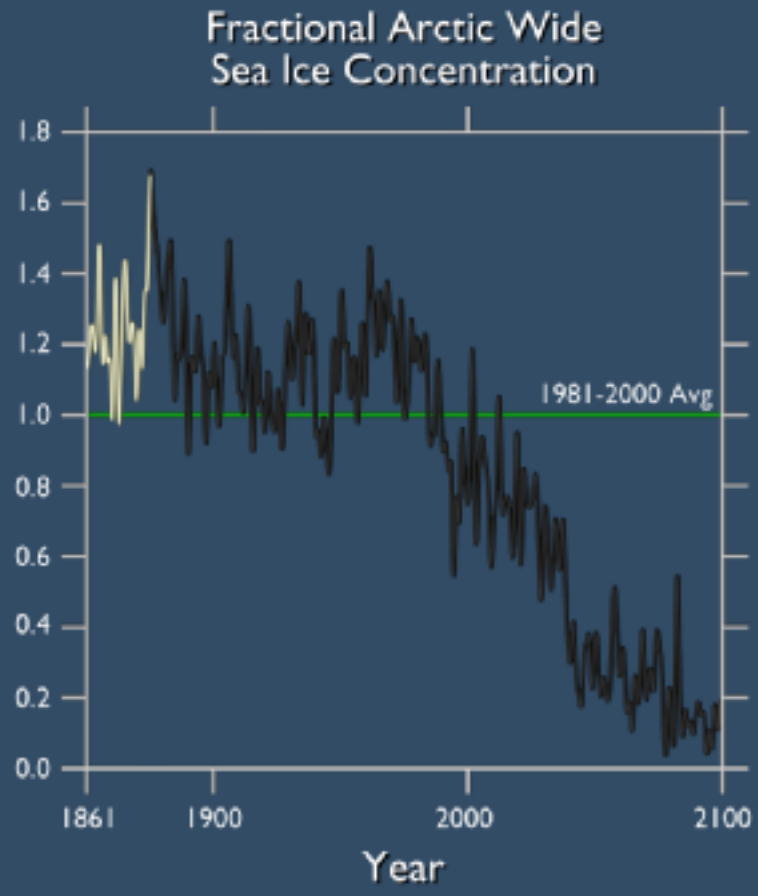
Source: Ed Mazria, Architecture2030

NOAA GFDL CM2.1 Model Simulation: SRES A1B Scenario

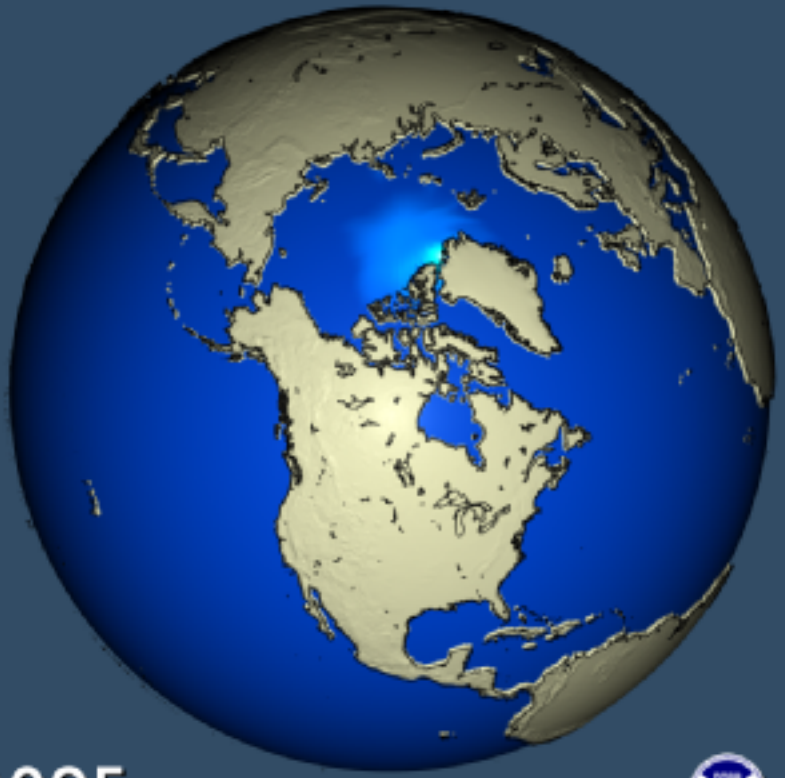
1885

Aug Sept Oct Avg Sea Ice Concentration



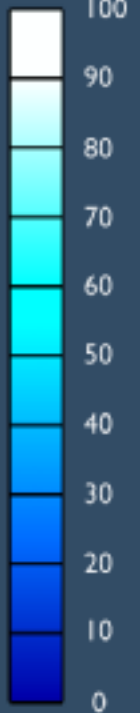


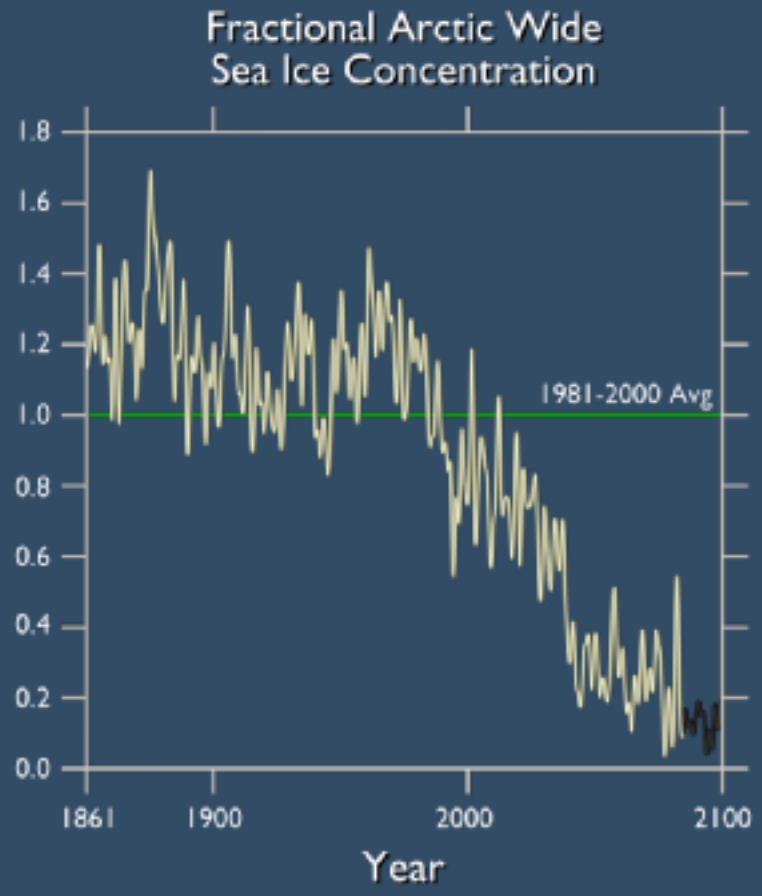
NOAA GFDL CM2.1 Model Simulation: SRES A1B Scenario

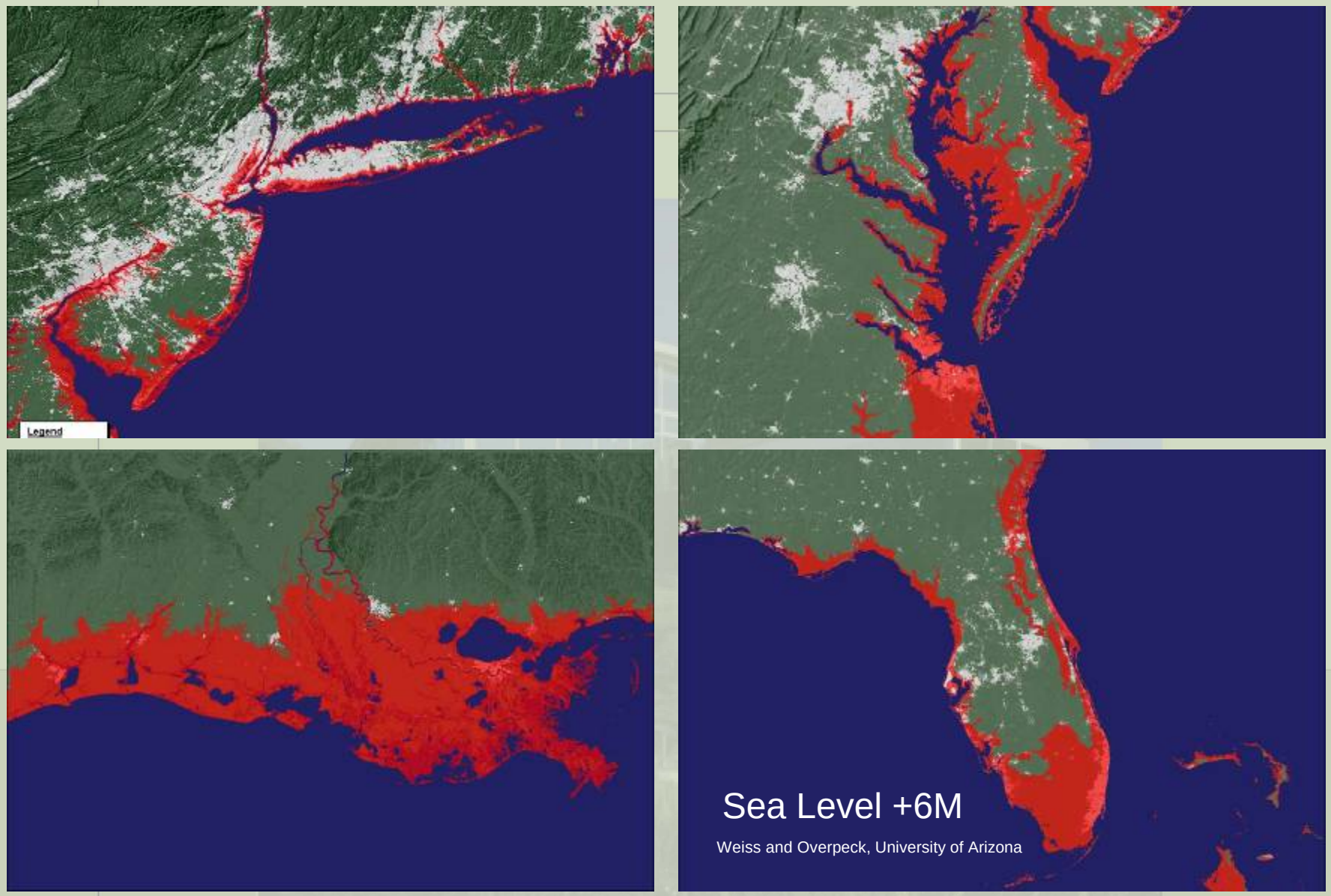


2085

Aug Sept Oct Avg Sea Ice Concentration

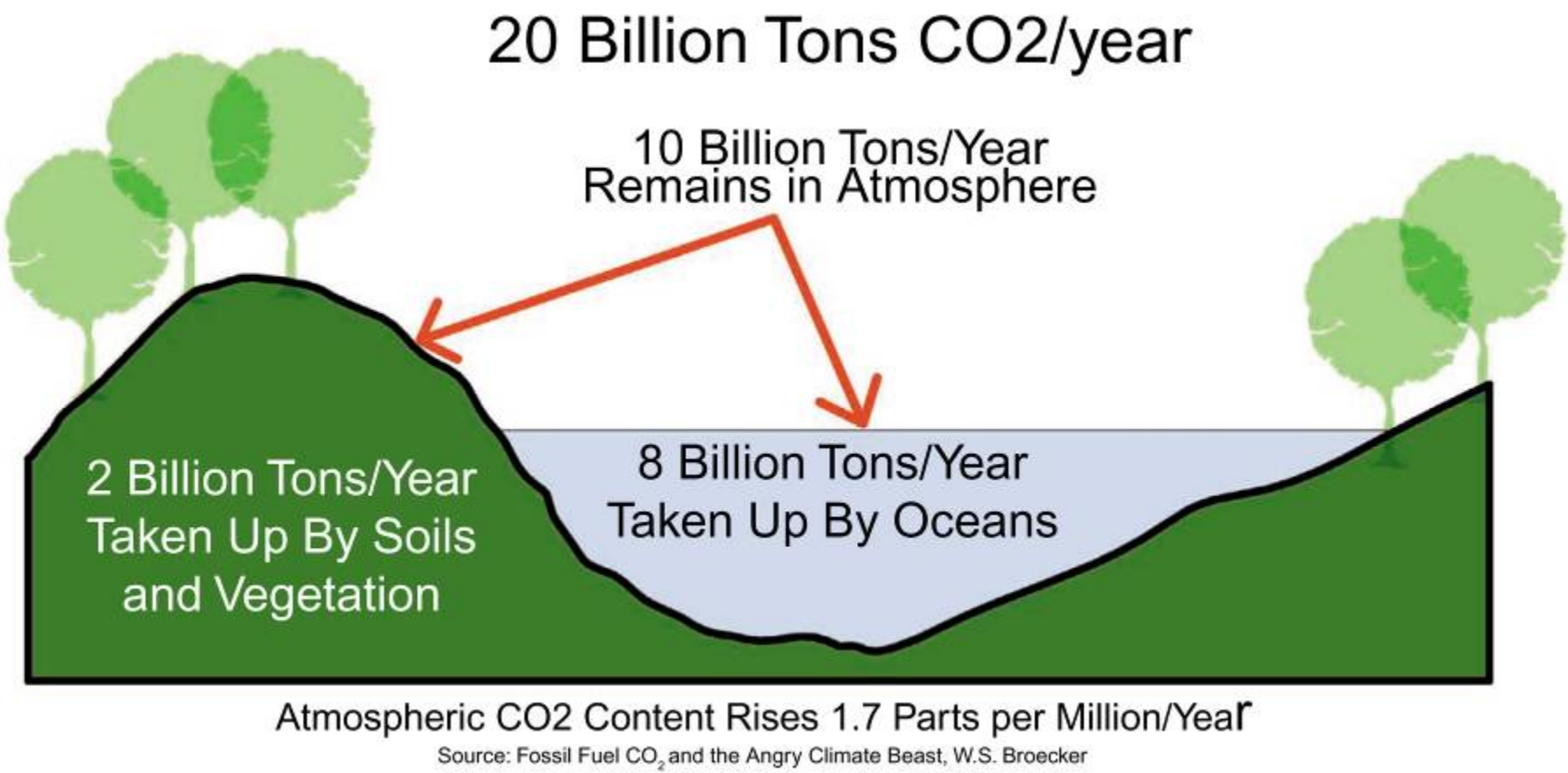


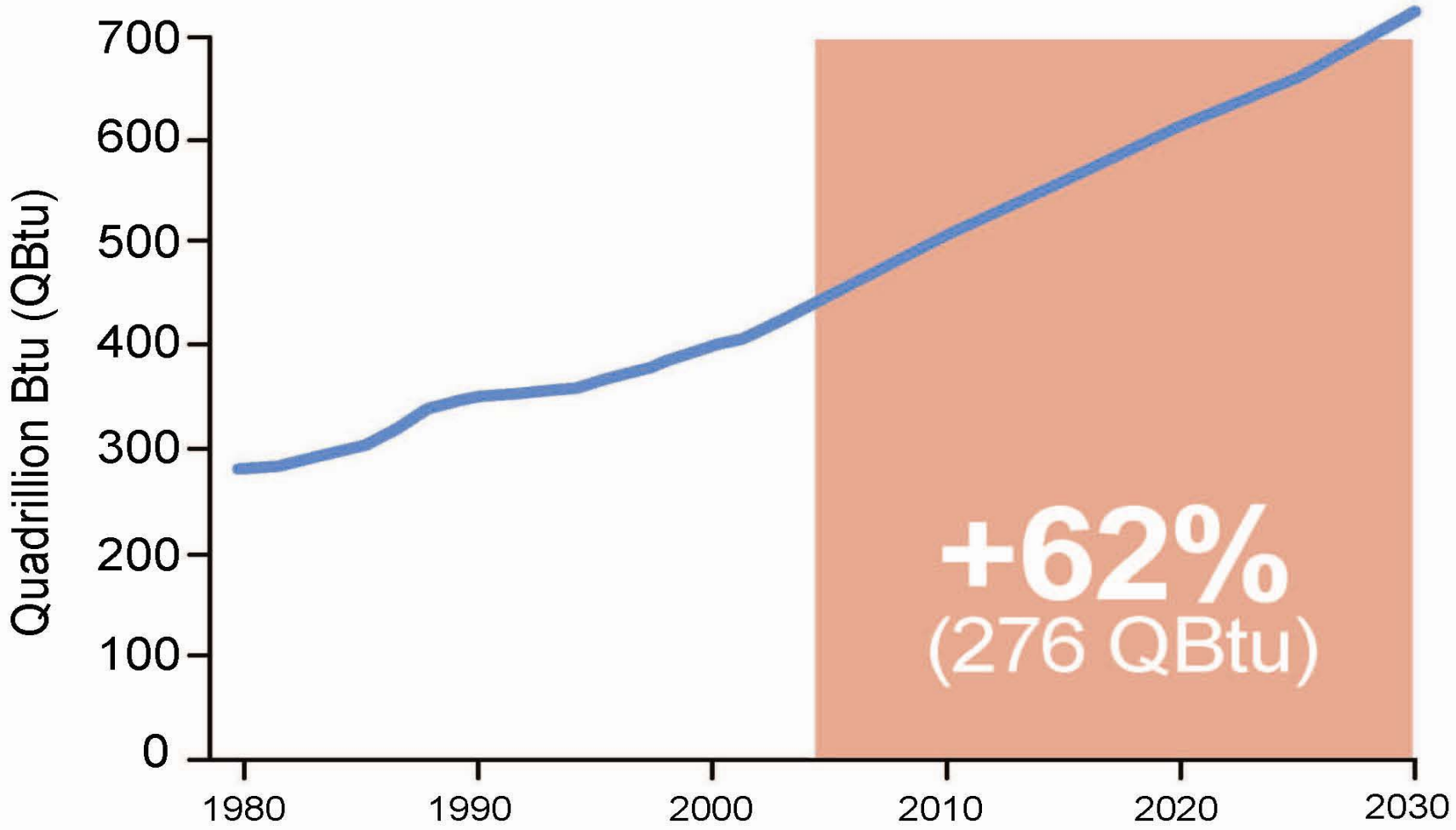




Source: Weiss and Overpeck, University of Arizona

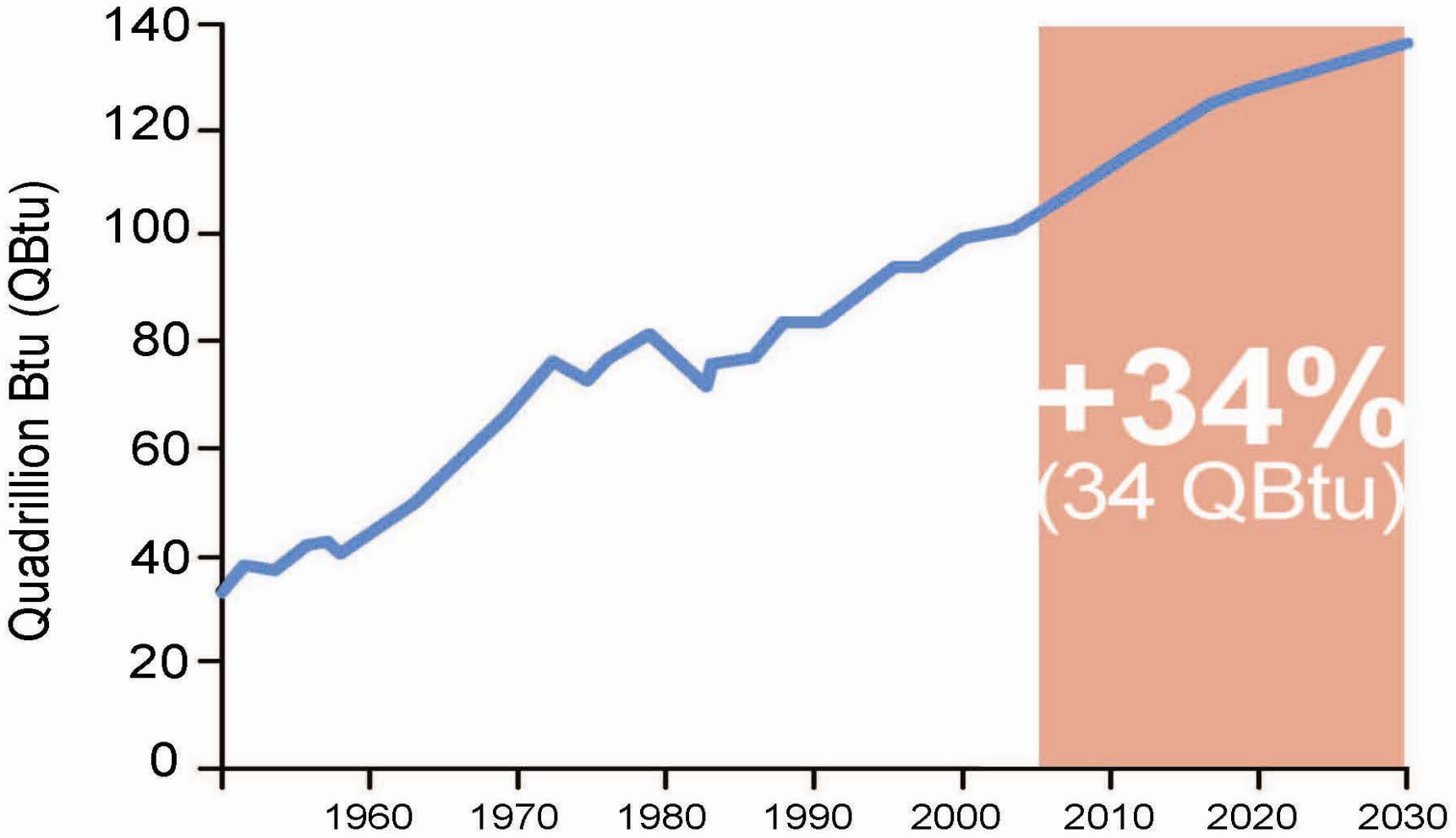
The U.S. holds less than 5% of the world's population, but produces nearly 23% of global carbon emissions.





World Energy Consumption Projections

Source: U.S. Energy Information Agency Statistics Center

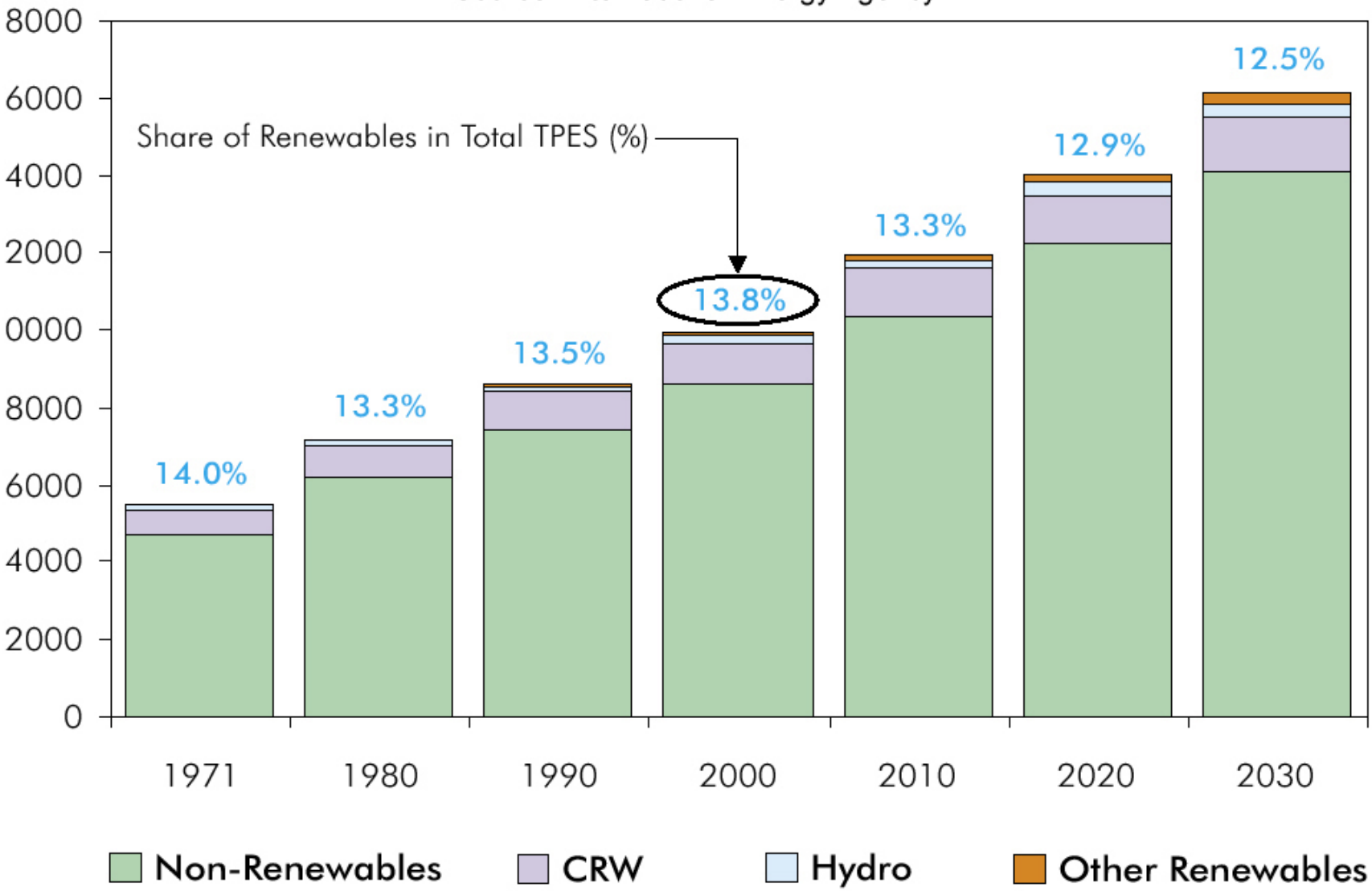


U.S. Energy Consumption Projections

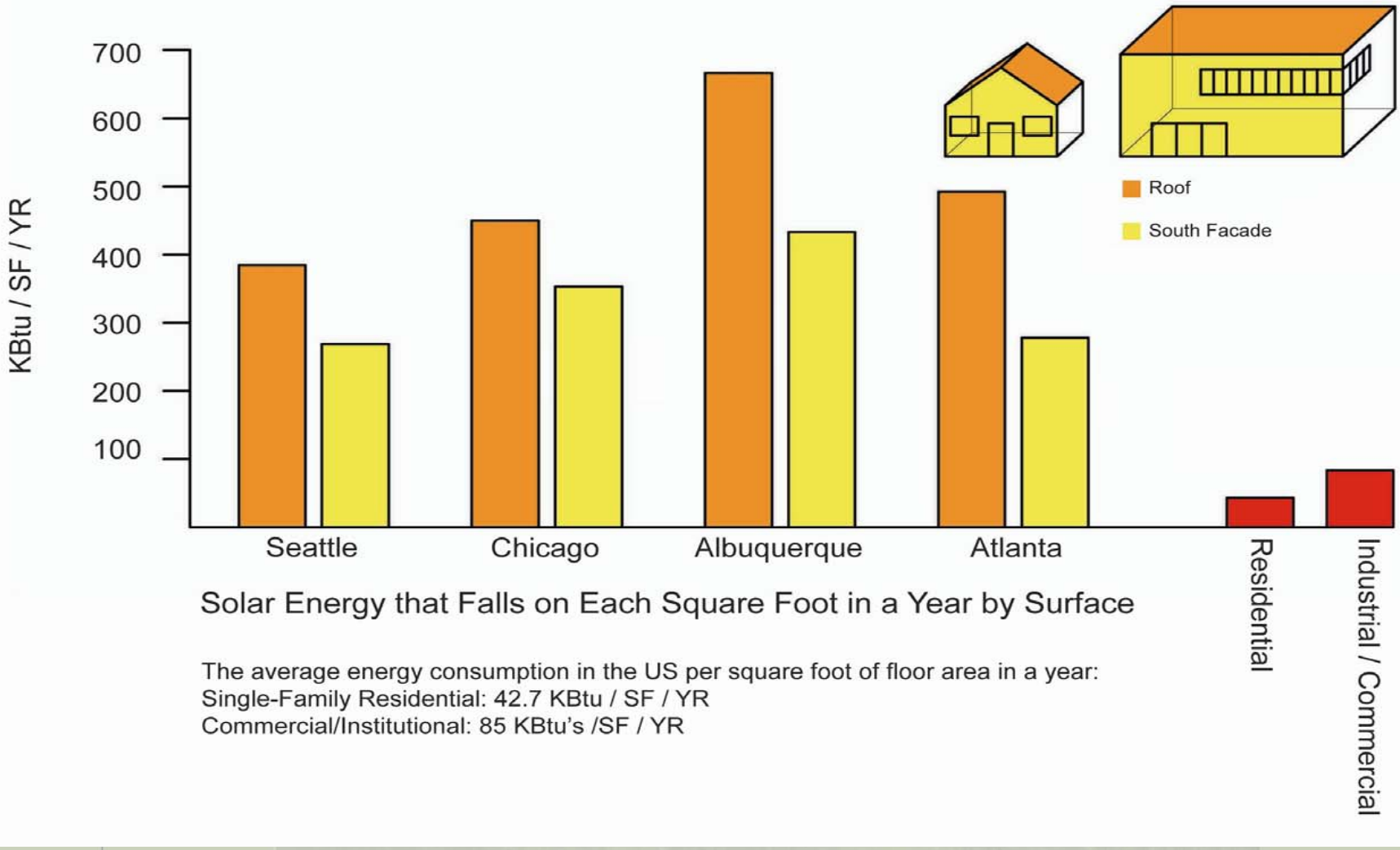
Source: U.S. Energy Information Agency Statistics Center

World Total Primary Energy Supply

Source: International Energy Agency



CRW = Combustible Renewables & Waste

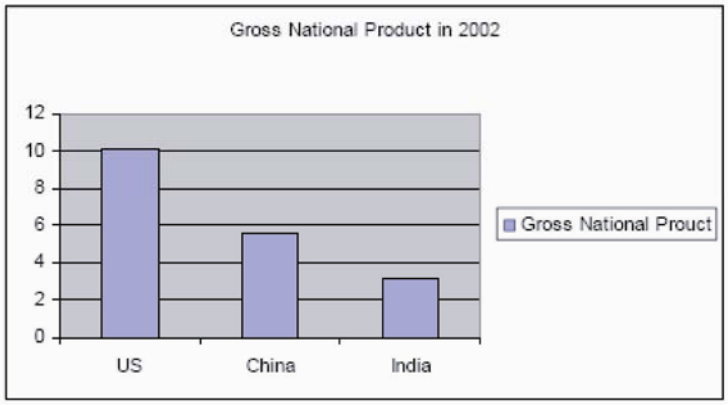


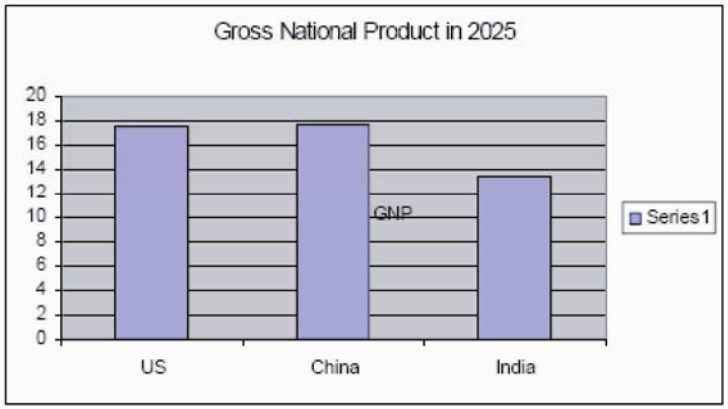
Solar Energy that Falls on Each Square Foot in a Year by Surface

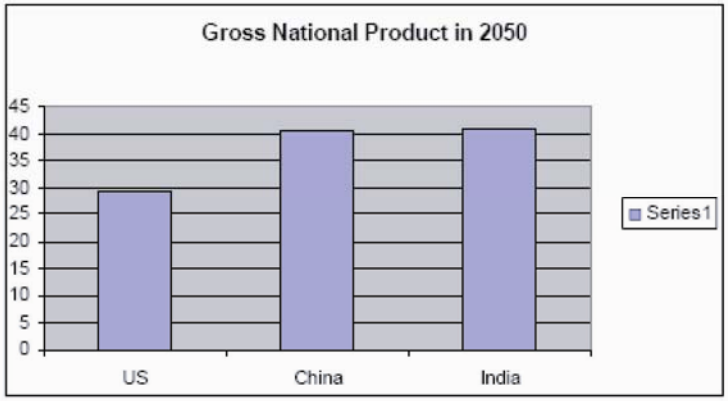
The average energy consumption in the US per square foot of floor area in a year:
Single-Family Residential: 42.7 KBtu / SF / YR
Commercial/Institutional: 85 KBtu's /SF / YR

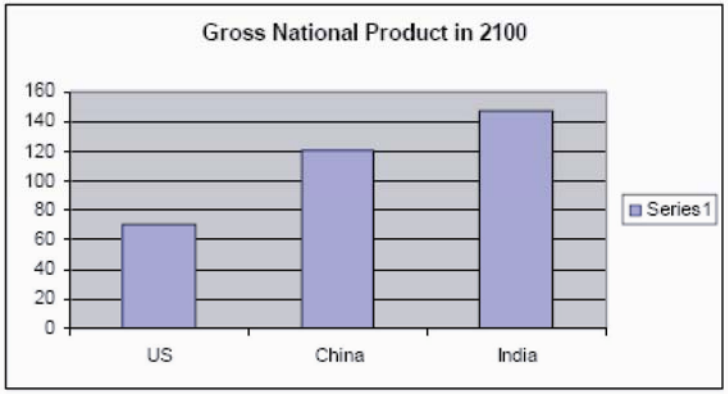
Source: Ed Mazria, Architecture2030

Projections of the Gross National Product for the US, China, and India









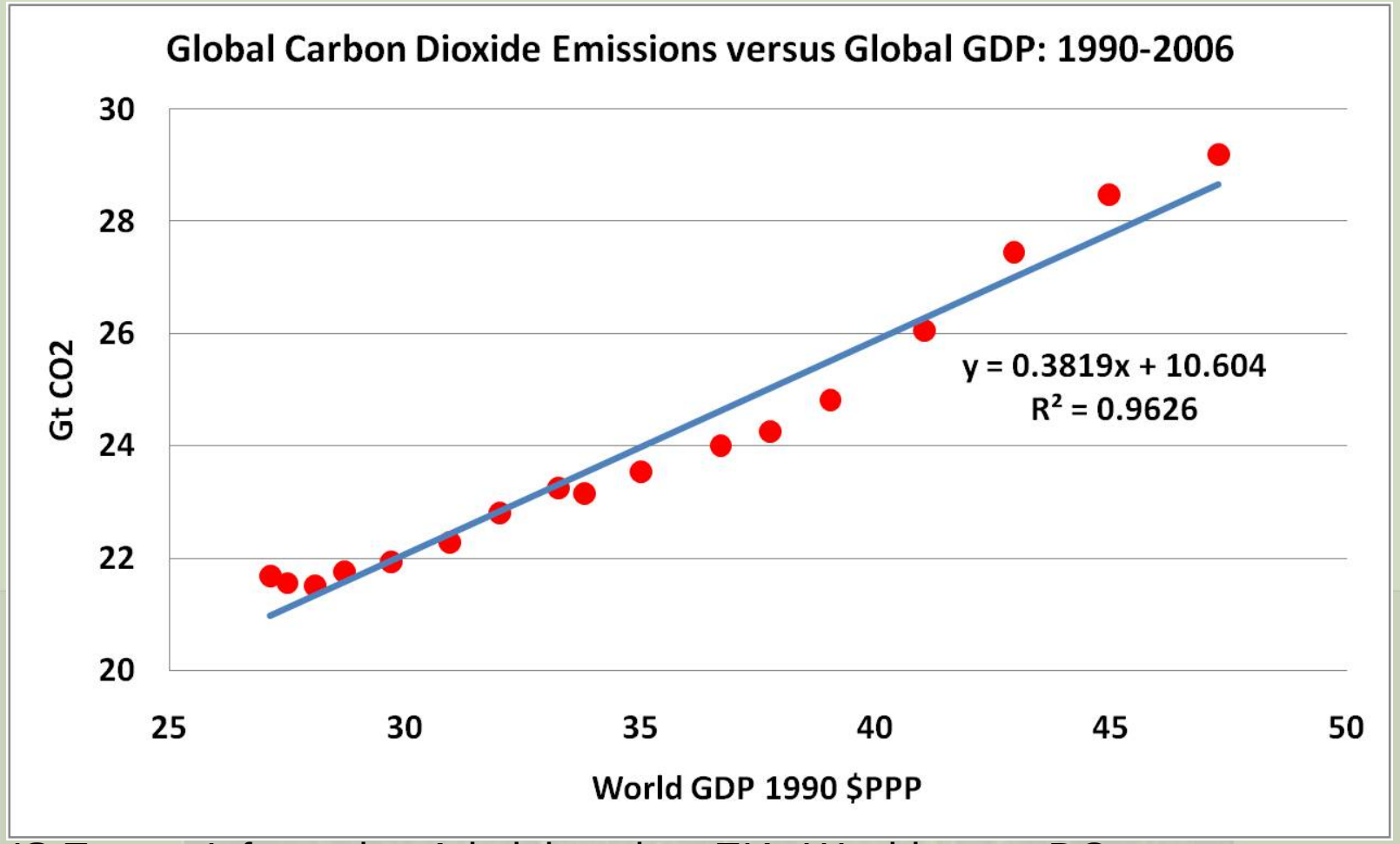
National Emitted CO_2 Level = 280ppm **Current Emitted CO_2 Level = 380ppm** **2 Times Natural Carbon Level = 550ppm**

Yearly Increase of Emitted CO_2 = 2 ppm/year **Total Amount of Emitted CO_2 = 25 GIGATONS / year**

GNP Charts and Statistics courtesy of Jeffrey Sachs, UN Advisor

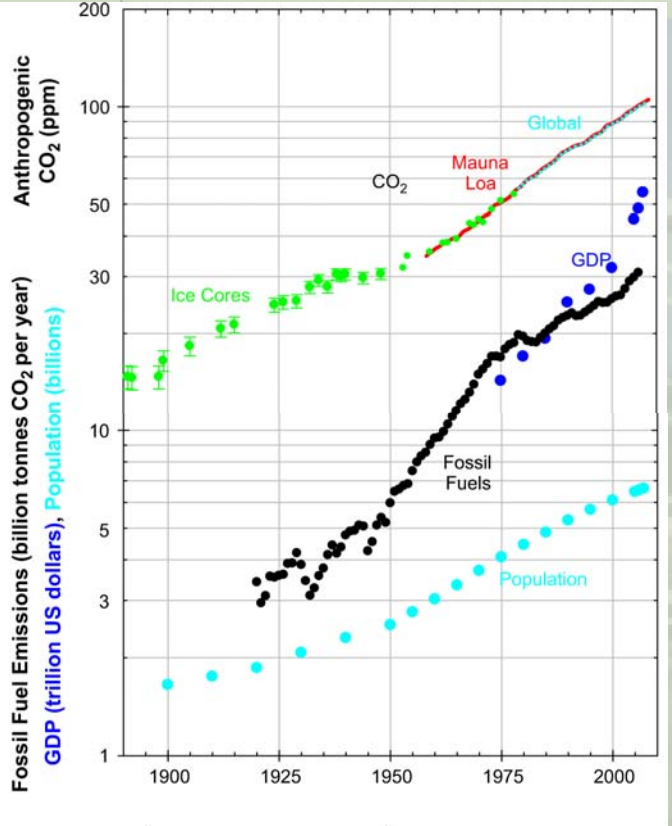
CO2 vs. GDP

Worldwide % Increase Ratio

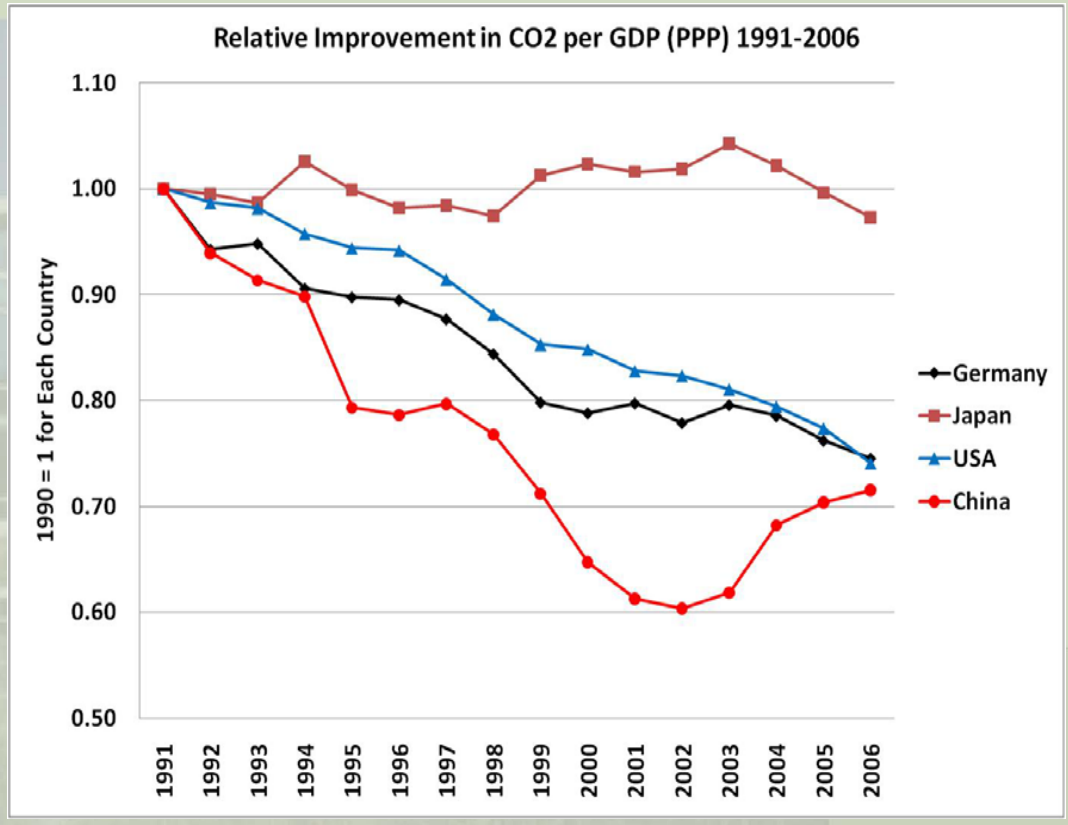


US Energy Information Administration, EIA, Washington, DC

CO2 vs. GDP
Worldwide % Changes

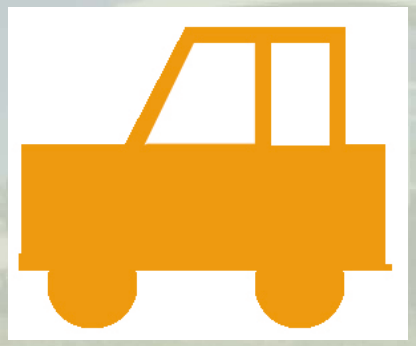


NOAA



http://thebreakthrough.org/

INDUSTRY
25%

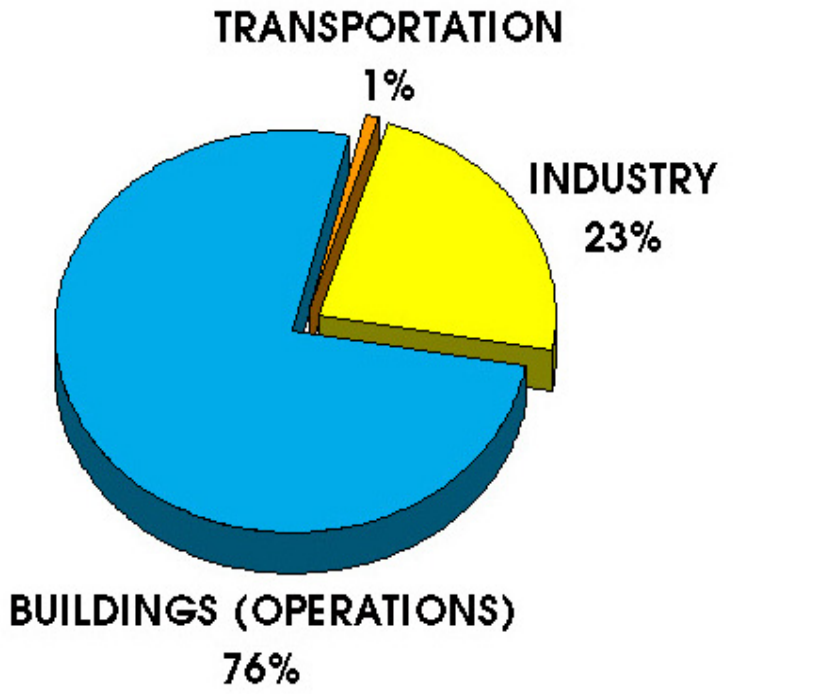


TRANSPORTATION
27%

BUILDINGS
48%

U.S. ENERGY CONSUMPTION

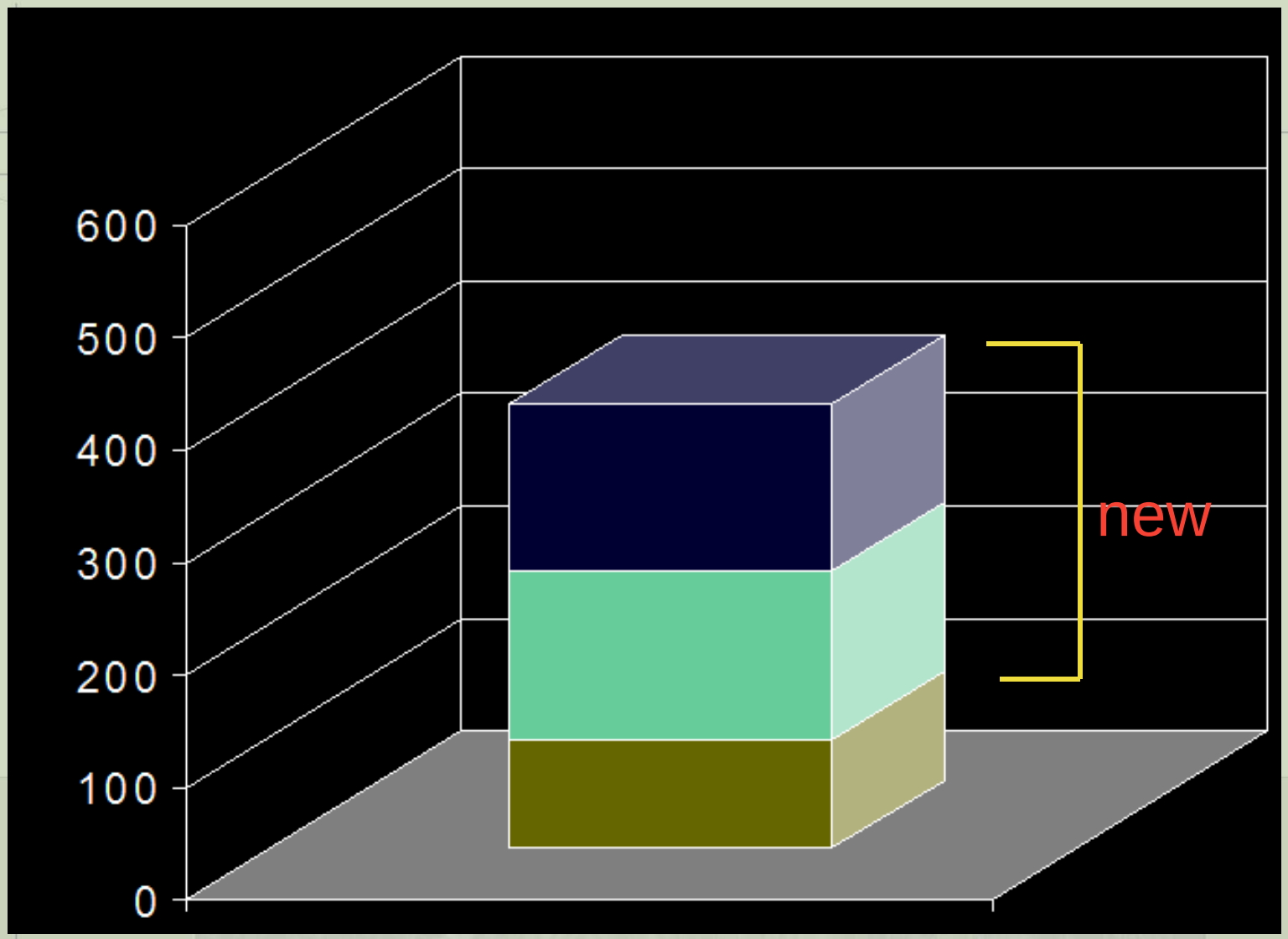
Source: Energy Information Administration Statistics and Pew Climate Report



U.S. ELECTRICITY CONSUMPTION

Source: Energy Information Administration Statistics

Building design, construction, materials and operation…..
consume more energy than any other part of the US economy!



B SF

2035

source: architecture 2030

High Performance Standards
Greenbuilding Design

- **LEED Certified, Silver, Gold and Platinum & alternates**
- **2030 Challenge, ZNE and ZNC within 23 years**
- **2010 Imperative, High Performance Standards in Schools**
- **2025 Denver, Greenprint Denver**
- **Colorado's SB 051 & HB 147, High Performance Standards**
- **ASHRAE 189, the new baseline**
- **Land-use planning and transportation**
- **Water conservation standards**

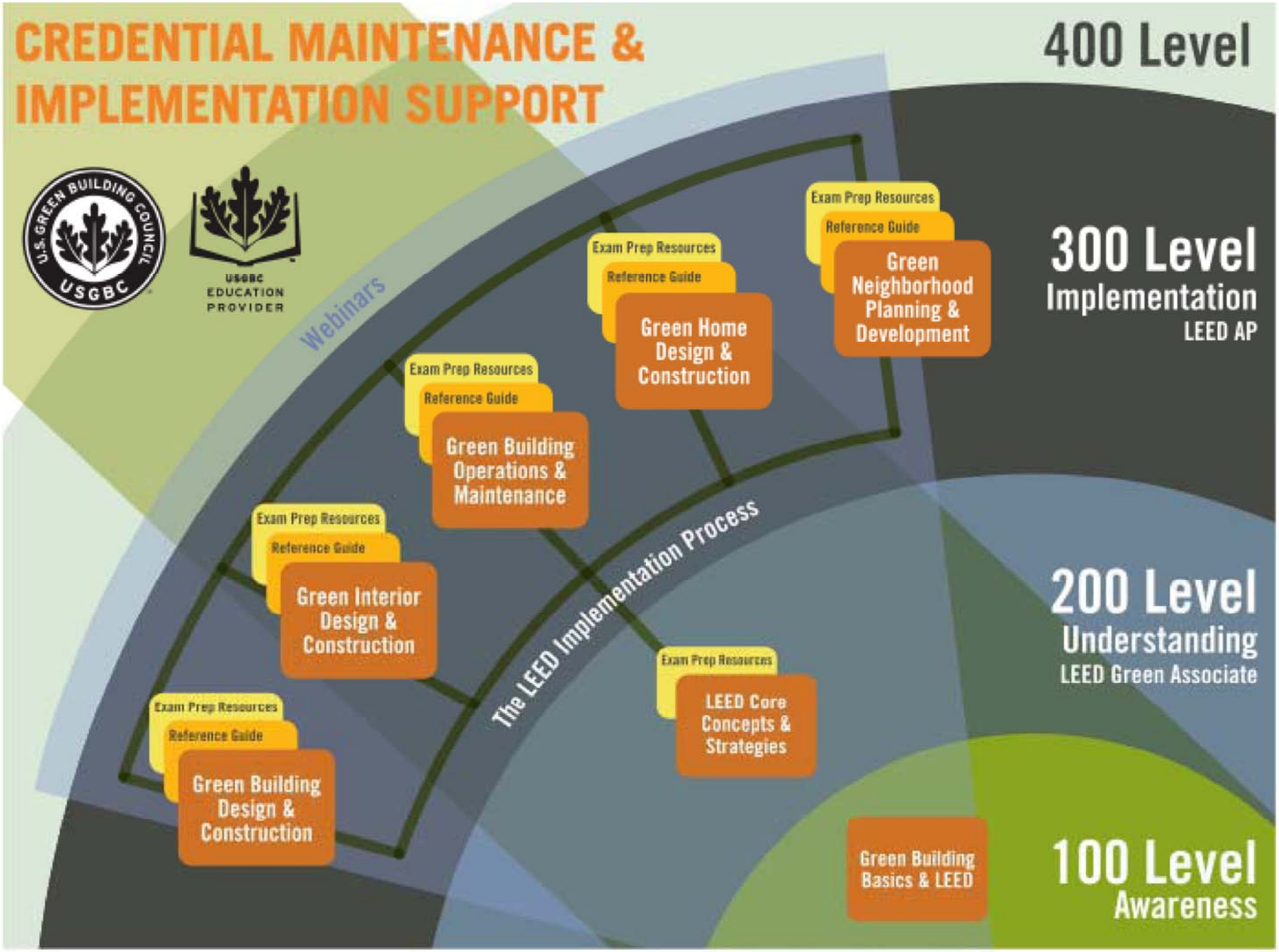
High Performance Strategies
Greenbuilding Design

- **ZNE and ZNC achieved through…**

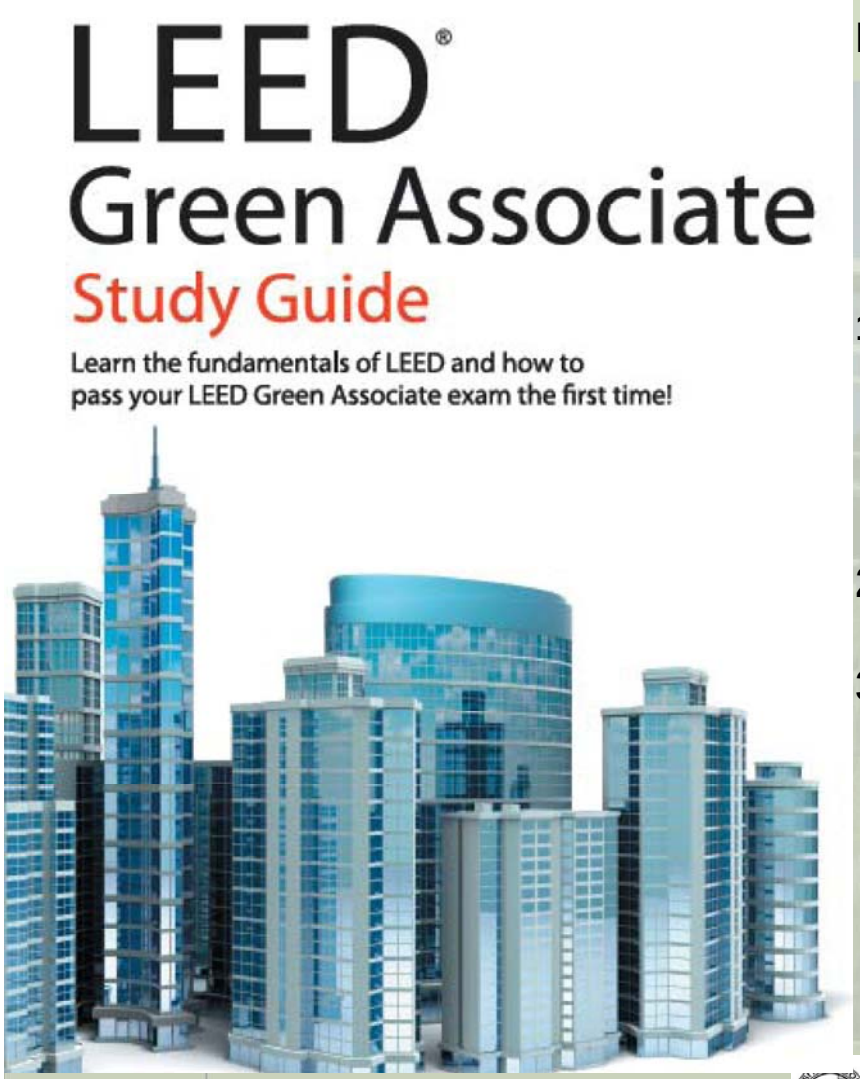
- **Zero Net Energy, Zero Net Carbon**
- **Currently achieving 75% efficiencies**
- **High Performance Building Skins**
- **High Performance HVAC Strategies**
- **Passive Heating, Cooling and Lighting**
- **Renewable Energy, BIPV and BAWT**

Introduction to the New LEED System Version 3.0 - 2009

NEW LEED CREDENTIALS


CREDENTIAL MAINTENANCE & IMPLEMENTATION SUPPORT
400 Level
300 Level
Implementation
LEED AP
200 Level
Understanding
LEED Green Associate
100 Level
Awareness
USGBC EDUCATION PROVIDER
Webinars
The LEED Implementation Process
Exam Prep Resources
Reference Guide
Green Neighborhood Planning & Development
Green Home Design & Construction
Green Building Operations & Maintenance
Green Interior Design & Construction
LEED Core Concepts & Strategies
Green Building Design & Construction
Green Building Basics & LEED

green building
EDUCATION SERVICES
www.greenexamprep.com



How do I achieve eligibility for the LEED Green Associate exam?

GBCI's Green Associate Candidate Handbook requires LEED GA candidates to have done **one of the following** in order to be eligible to sit for the Green Associate exam:

1. **Attended an education program that addresses green building principles.** ***Any of USGBC's workshops or online courses satisfy this requirement.***

2. **Worked in support of a LEED-registered project.**

3. **Worked in a sustainable field of work.**

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How do I become a LEED AP?

1. **Pass the LEED Green Associate exam.**

2. **Work on one LEED-registered project in the last 3 years.**

3. **Pass 1 of the 5 LEED Specialty Exams.**

LEED Reference Guide for Green Building Design and Construction
For the Design, Construction and Major Renovations of Commercial and Institutional Buildings Including Core & Shell and K–12 School Projects
2009 Edition

UNiT

project boundary is the portion of the project site that is submitted for LEED certification and must be used consistently across all Sustainable Sites prerequisites and credits.

CREDIT	TITLE	NC	SCHOOLS	CS
SS Prerequisite 1	Construction Activity Pollution Prevention	Required	Required	Required
SS Prerequisite 2	Environmental Site Assessment	NA	Required	NA
SS Credit 1	Site Selection	1 point	1 point	1 point
SS Credit 2	Development Density and Community Connectivity	5 points	4 points	5 points
SS Credit 3	Brownfield Redevelopment	1 point	1 point	1 point
SS Credit 4.1	Alternative Transportation—Public Transportation Access	6 points	4 points	6 points
SS Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1 point	1 point	2 points
SS Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3 points	2 points	3 points
SS Credit 4.4	Alternative Transportation—Parking Capacity	2 points	2 points	2 points
SS Credit 5.1	Site Development—Protect or Restore Habitat	1 point	1 point	1 point
SS Credit 5.2	Site Development—Maximize Open Space	1 point	1 point	1 point
SS Credit 6.1	Stormwater Design—Quantity Control	1 point	1 point	1 point
SS Credit 6.2	Stormwater Design—Quality Control	1 point	1 point	1 point
SS Credit 7.1	Heat Island Effect—Nonroof	1 point	1 point	1 point
SS Credit 7.2	Heat Island Effect—Roof	1 point	1 point	1 point
SS Credit 8	Light Pollution Reduction	1 point	1 point	1 point
SS Credit 9	Tenant Design and Construction Guidelines	NA	NA	1 point
SS Credit 9	Site Master Plan	NA	1 point	NA
SS Credit 10	Joint Use of Facilities	NA	1 point	NA

ALTERNATIVE TRANSPORTATION—LOW-EMITTING AND FUEL-EFFICIENT VEHICLES

SS CREDIT 4.3

	NC	SCHOOLS	CS
Credit	SS Credit 4.3	SS Credit 4.3	SS Credit 4.3
Points	3 points	2 points	3 points

Intent

To reduce pollution and land development impacts from automobile use.

Requirements

distributed.

ALTERNATIVE TRANSPORTATION—PUBLIC TRANSPORTATION ACCESS

	NC	SCHOOLS	CS
Credit	SS Credit 4.1	SS Credit 4.1	SS Credit 4.1
Points	6 points	4 points	6 points

Intent

To reduce pollution and land development impacts from automobile use.

Requirements

NC, SCHOOLS & CS

OPTION 1. Rail Station Proximity

Locate the project within 1/2-mile walking distance (measured from a main building entrance) of an existing or planned and funded commuter rail, light rail or subway station.

OR

OPTION 2. Bus Stop Proximity

Locate the project within 1/4-mile walking distance (measured from a main building entrance) of 1 or more stops for 2 or more public, campus, or private bus lines usable by building occupants.

SCHOOLS Additional Requirement

A school bus system may count as 1 of these lines.

OR

SCHOOLS

OPTION 3. Pedestrian Access

Show that the project school has an attendance boundary such that at least 80% of students live within no more than 3/4-mile walking distance for grades 8 and below, and 1 1/2-mile walking distance for grades 9 and above. In addition, locate the project on a site that allows pedestrian access to the site from all residential neighborhoods that house the planned student population.

ALL OPTIONS

For all options (Options 1, 2, and 3 for Schools), provide dedicated walking or biking lanes to the transit lines that extend from the school building at least to the end of the school property in 2 or more directions without any barriers (e.g., fences) on school property.

LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS

For Public Use and Display
LEED 2009 for New Construction and Major Renovations Rating System
USGBC Member Approved November 2008

LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS PROJECT CHECKLIST

Sustainable Sites		26 Possible Points
☑ Prerequisite 1	Construction Activity Pollution Prevention	Required
☐ Credit 1	Site Selection	1
☐ Credit 2	Development Density and Community Connectivity	5
☐ Credit 3	Brownfield Redevelopment	1
☐ Credit 4.1	Alternative Transportation—Public Transportation Access	6
☐ Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
☐ Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
☐ Credit 4.4	Alternative Transportation—Parking Capacity	2
☐ Credit 5.1	Site Development—Protect or Restore Habitat	1
☐ Credit 5.2	Site Development—Maximize Open Space	1
☐ Credit 6.1	Stormwater Design—Quantity Control	1
☐ Credit 6.2	Stormwater Design—Quality Control	1
☐ Credit 7.1	Heat Island Effect—Nonroof	1
☐ Credit 7.2	Heat Island Effect—Roof	1
☐ Credit 8	Light Pollution Reduction	1

Water Efficiency		10 Possible Points
☑ Prerequisite 1	Water Use Reduction	Required
☐ Credit 1	Water Efficient Landscaping	2-4
☐ Credit 2	Innovative Wastewater Technologies	2
☐ Credit 3	Water Use Reduction	2-4

Energy and Atmosphere		35 Possible Points
☑ Prerequisite 1	Fundamental Commissioning of Building Energy Systems	Required
☑ Prerequisite 2	Minimum Energy Performance	Required
☑ Prerequisite 3	Fundamental Refrigerant Management	Required
☐ Credit 1	Optimize Energy Performance	1–19
☐ Credit 2	On-site Renewable Energy	1–7
☐ Credit 3	Enhanced Commissioning	2
☐ Credit 4	Enhanced Refrigerant Management	2
☐ Credit 5	Measurement and Verification	3
☐ Credit 6	Green Power	2

Materials and Resources		14 Possible Points
☑ Prerequisite 1	Storage and Collection of Recyclables	Required
☐ Credit 1.1	Building Reuse—Maintain Existing Walls, Floors and Roof	1-3
☐ Credit 1.2	Building Reuse—Maintain Existing Interior Nonstructural Elements	1
☐ Credit 2	Construction Waste Management	1-2
☐ Credit 3	Materials Reuse	1-2
☐ Credit 4	Recycled Content	1-2

LEED 2009 for New Construction and Major Renovation
Project Scorecard

Project Name:
Project Address:

Yes	?	No			
			SUSTAINABLE SITES		**26 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	**Required**
			Credit 1	**Site Selection**	**1**
			Credit 2	**Development Density and Community Connectivity**	**5**
			Credit 3	**Brownfield Redevelopment**	**1**
			Credit 4.1	**Alternative Transportation -** Public Transportation Access	**6**
			Credit 4.2	**Alternative Transportation -** Bicycle Storage and Changing Rooms	**1**
			Credit 4.3	**Alternative Transportation -** Low-Emitting and Fuel-Efficient Vehicles	**3**
			Credit 4.4	**Alternative Transportation -** Parking Capacity	**2**
			Credit 5.1	**Site Development -** Protect or Restore Habitat	**1**
			Credit 5.2	**Site Development -** Maximize Open Space	**1**
			Credit 6.1	**Stormwater Design -** Quantity Control	**1**
			Credit 6.2	**Stormwater Design -** Quality Control	**1**
			Credit 7.1	**Heat Island Effect -** Nonroof	**1**
			Credit 7.2	**Heat Island Effect -** Roof	**1**
			Credit 8	**Light Pollution Reduction**	**1**
Yes	?	No			
			WATER EFFICIENCY		**10 Points**
					4
Y			Prereq 1	**Water Use Reduction**	**Required**
			Credit 1	**Water Efficient Landscaping**	**2 to 4**
				Reduce by 50%	2
				No Potable Water Use or Irrigation	4
			Credit 2	**Innovative Wastewater Technologies**	**2**
			Credit 3	**Water Use Reduction**	**2 to 4**
				Reduce by 30%	2
				Reduce by 35%	3
				Reduce by 40%	4
			ENERGY & ATMOSPHERE		**35 Points**
Y			Prereq 1	**Fundamental Commissioning of Building Energy Systems**	**Required**
Y			Prereq 2	**Minimum Energy Performance**	**Required**
Y			Prereq 3	**Fundamental Refrigerant Management**	**Required**
			Credit 1	**Optimize Energy Performance**	**1 to 19**
				Improve by 12% for New Buildings or 8% for Existing Building Renovations	1
				Improve by 14% for New Buildings or 10% for Existing Building Renovations	2
				Improve by 16% for New Buildings or 12% for Existing Building Renovations	3
				Improve by 18% for New Buildings or 14% for Existing Building Renovations	4
				Improve by 20% for New Buildings or 16% for Existing Building Renovations	5
				Improve by 22% for New Buildings or 18% for Existing Building Renovations	6
				Improve by 24% for New Buildings or 20% for Existing Building Renovations	7
				Improve by 26% for New Buildings or 22% for Existing Building Renovations	8
				Improve by 28% for New Buildings or 24% for Existing Building Renovations	9
				Improve by 30% for New Buildings or 26% for Existing Building Renovations	10
				Improve by 32% for New Buildings or 28% for Existing Building Renovations	11
				Improve by 34% for New Buildings or 30% for Existing Building Renovations	12
				Improve by 36% for New Buildings or 32% for Existing Building Renovations	13
				Improve by 38% for New Buildings or 34% for Existing Building Renovations	14
				Improve by 40% for New Buildings or 36% for Existing Building Renovations	15
				Improve by 42% for New Buildings or 38% for Existing Building Renovations	16
				Improve by 44% for New Buildings or 40% for Existing Building Renovations	17
				Improve by 46% for New Buildings or 42% for Existing Building Renovations	18
				Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19
			Credit 2	**On-Site Renewable Energy**	**1 to 7**
				1% Renewable Energy	1
				3% Renewable Energy	2
				5% Renewable Energy	3
				7% Renewable Energy	4
				9% Renewable Energy	5
				11% Renewable Energy	6
				13% Renewable Energy	7
			Credit 3	**Enhanced Commissioning**	**2**
			Credit 4	**Enhanced Refrigerant Management**	**2**
			Credit 5	**Measurement and Verification**	**3**
			Credit 6	**Green Power**	**2**

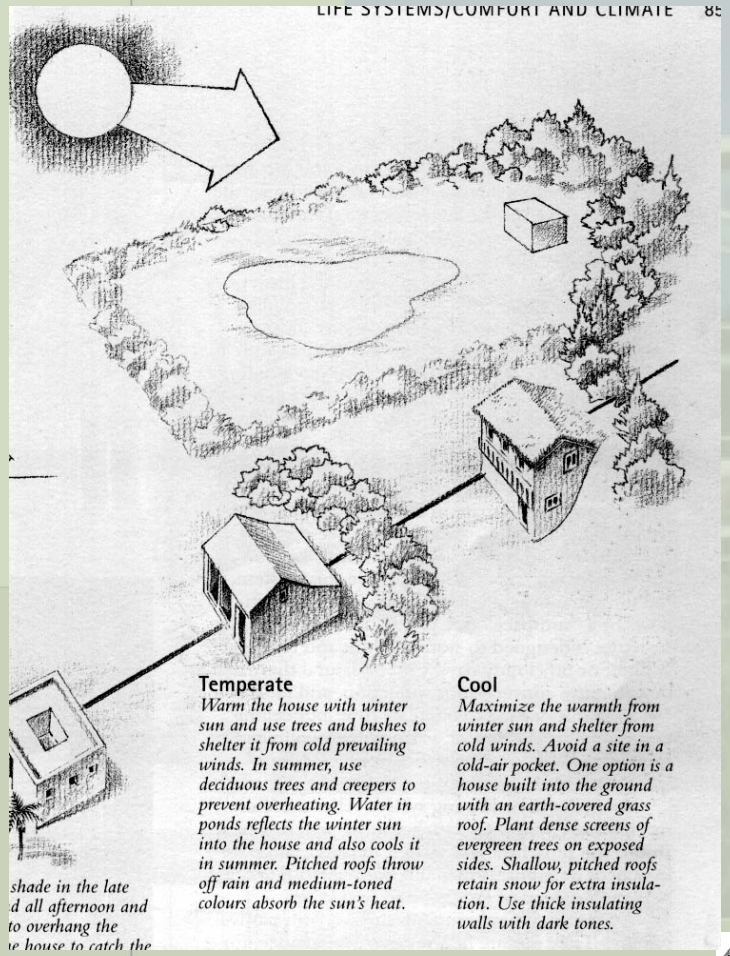
LEED 2009 for New Construction and Major Renovation
Project Scorecard

Project Name:
Project Address:

Yes	?	No			
	2		**MATERIALS & RESOURCES**		**14 Points**
Y			Prereq 1	**Storage and Collection of Recyclables**	**Required**
			Credit 1.1	**Building Reuse** - Maintain Existing Walls, Floors and Roof	**1 to 3**
				Reuse 55%	1
				Reuse 75%	2
				Reuse 95%	3
			Credit 1.2	**Building Reuse -** Maintain Interior Nonstructural Elements	**1**
	2		Credit 2	**Construction Waste Management**	**1 to 2**
				50% Recycled or Salvaged	1
				75% Recycled or Salvaged	2
			Credit 3	**Materials Reuse**	**1 to 2**
				Reuse 5%	1
				Reuse 10%	2
			Credit 4	**Recycled Content**	**1 to 2**
				10% of Content	1
				20% of Content	2
			Credit 5	**Regional Materials**	**1 to 2**
				10% of Materials	1
				20% of Materials	2
			Credit 6	**Rapidly Renewable Materials**	**1**
			Credit 7	**Certified Wood**	**1**
Yes	?	No			
			INDOOR ENVIRONMENTAL QUALITY		**15 Points**
Y			Prereq 1	**Minimum Indoor Air Quality Performance**	**Required**
Y			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	**Required**
			Credit 1	**Outdoor Air Delivery Monitoring**	**1**
			Credit 2	**Increased Ventilation**	**1**
			Credit 3.1	**Construction Indoor Air Quality Management Plan -** During Construction	**1**
			Credit 3.2	**Construction Indoor Air Quality Management Plan -** Before Occupancy	**1**
			Credit 4.1	**Low-Emitting Materials -** Adhesives and Sealants	**1**
			Credit 4.2	**Low-Emitting Materials -** Paints and Coatings	**1**
			Credit 4.3	**Low-Emitting Materials -** Flooring Systems	**1**
			Credit 4.4	**Low-Emitting Materials -** Composite Wood and Agrifiber Products	**1**
			Credit 5	**Indoor Chemical and Pollutant Source Control**	**1**
			Credit 6.1	**Controllability of Systems -** Lighting	**1**
			Credit 6.2	**Controllability of Systems -** Thermal Comfort	**1**
			Credit 7.1	**Thermal Comfort -** Design	**1**
			Credit 7.2	**Thermal Comfort -** Verification	**1**
			Credit 8.1	**Daylight and Views -** Daylight	**1**
			Credit 8.2	**Daylight and Views -** Views	**1**
Yes	?	No			
			INNOVATION IN DESIGN		**6 Points**
			Credit 1	**Innovation in Design**	**1 to 5**
				Innovation or Exemplary Performance	1
				Innovation or Exemplary Performance	1
				Innovation or Exemplary Performance	1
				Innovation	1
				Innovation	1
			Credit 2	**LEED® Accredited Professional**	**1**
Yes	?	No			
			REGIONAL PRIORITY		**4 Points**
			Credit 1	**Regional Priority**	**1 to 4**
				Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1
				Regionally Defined Credit Achieved	1
Yes	?	No			
	2		**PROJECT TOTALS (Certification Estimates)**		**110 Points**

Certified: 40-49 points Silver: 50-59 points Gold: 60-79 points Platinum: 80+ points

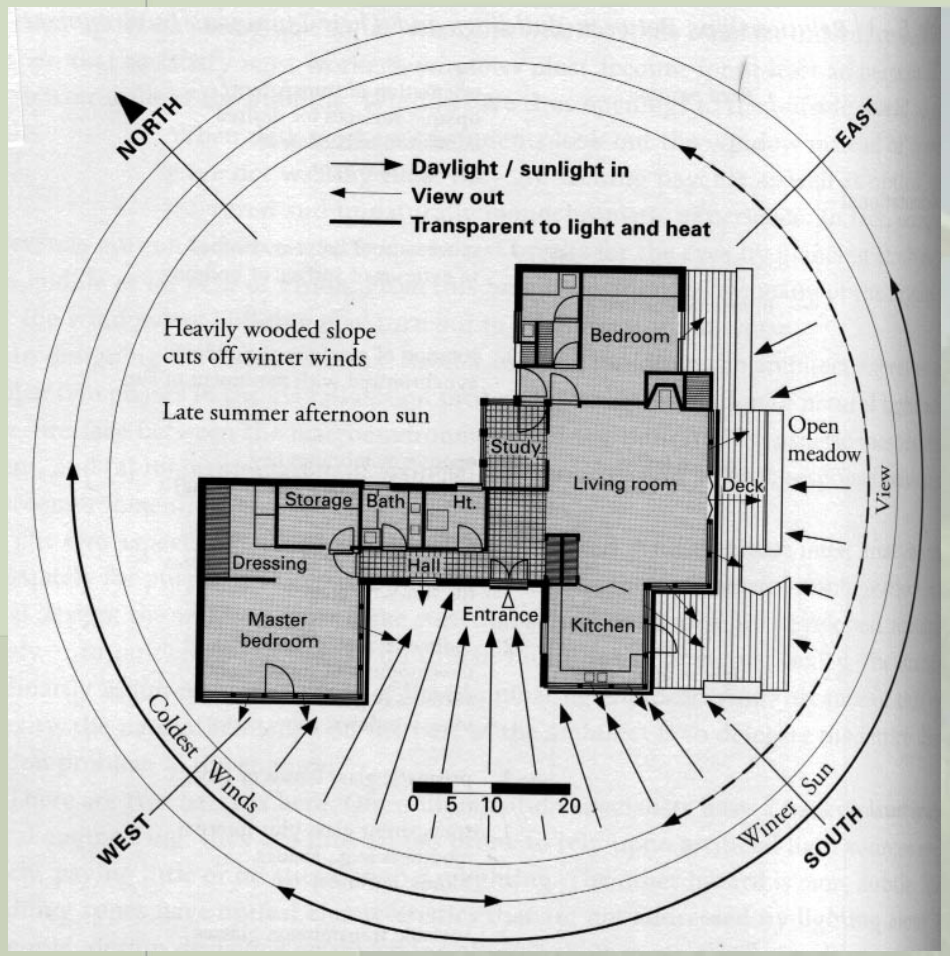
Passive Strategies
Climatic Design & Siting



<u>Temperate Climate</u>

- Warm house in winter with south sun
- Use trees, bushes, etc. to shelter it from cold prevailing winds
- Use deciduous trees to prevent over-exposure in summer
- Water reflects winter sun into house and cools in summer
- Pitched roofs for drainage
- Medium to dark tones best absorb heat

Climatic Design
Site-Sensitive Design



- **Orientation considers view and insolation access**
- **Subterranean opportunities**
- **S facing glass protected**
- **E & W glass, special treatments**

Greenbuilding Design

3 Passive Systems

Passive Heating
Passive Cooling
Natural Daylighting

Achieving ZNE and ZNC

“Passive design integrates a combination of building features to reduce or even eliminate the need for mechanical heating, cooling and daytime artificial lighting.”

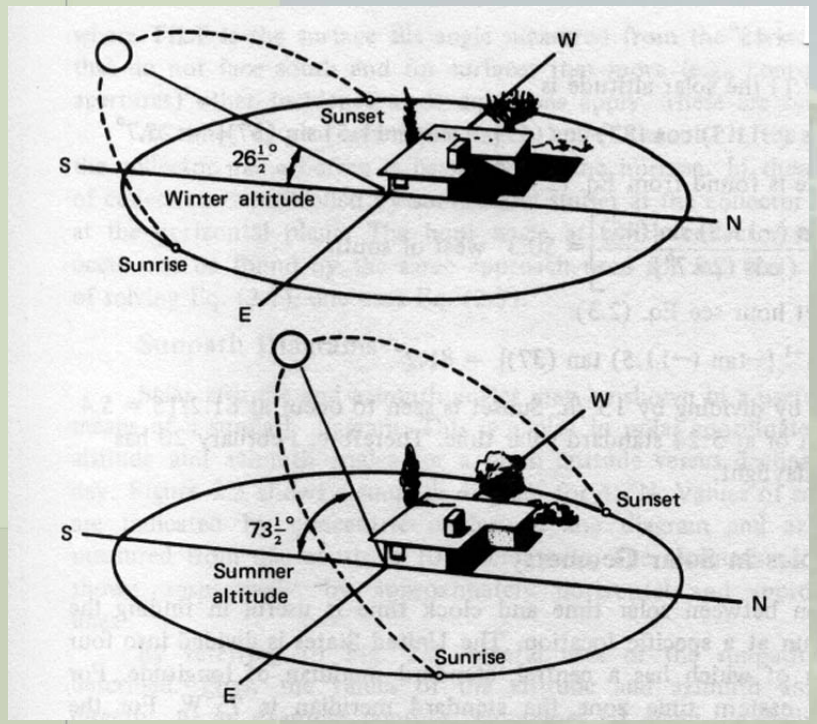
Passive Principles
SMART

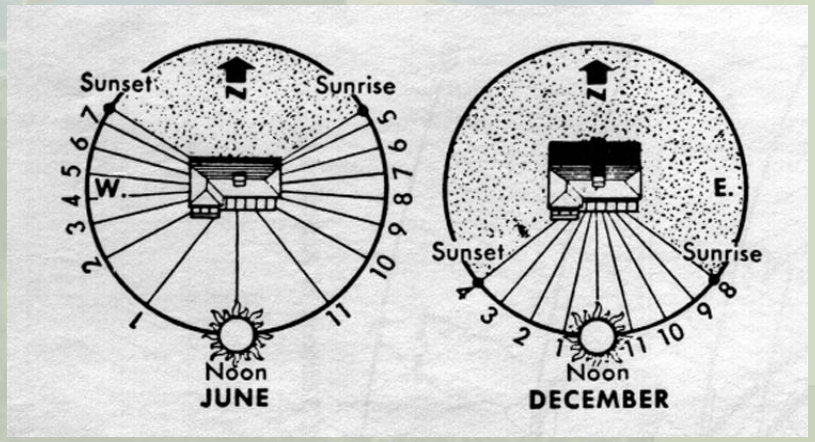
High Tech

- **Passive Solar Heating, Gain and Controls**
- **Passive Solar Cooling, the hotter the better**
- **Thermal Storage & Inertia, store & distribute**
- **Daylighting, open space high and wide light**
- **Integration of Systems, active and passive**

Passive Principles

Sun Path – Summer and Winter





Passive Solar Heating

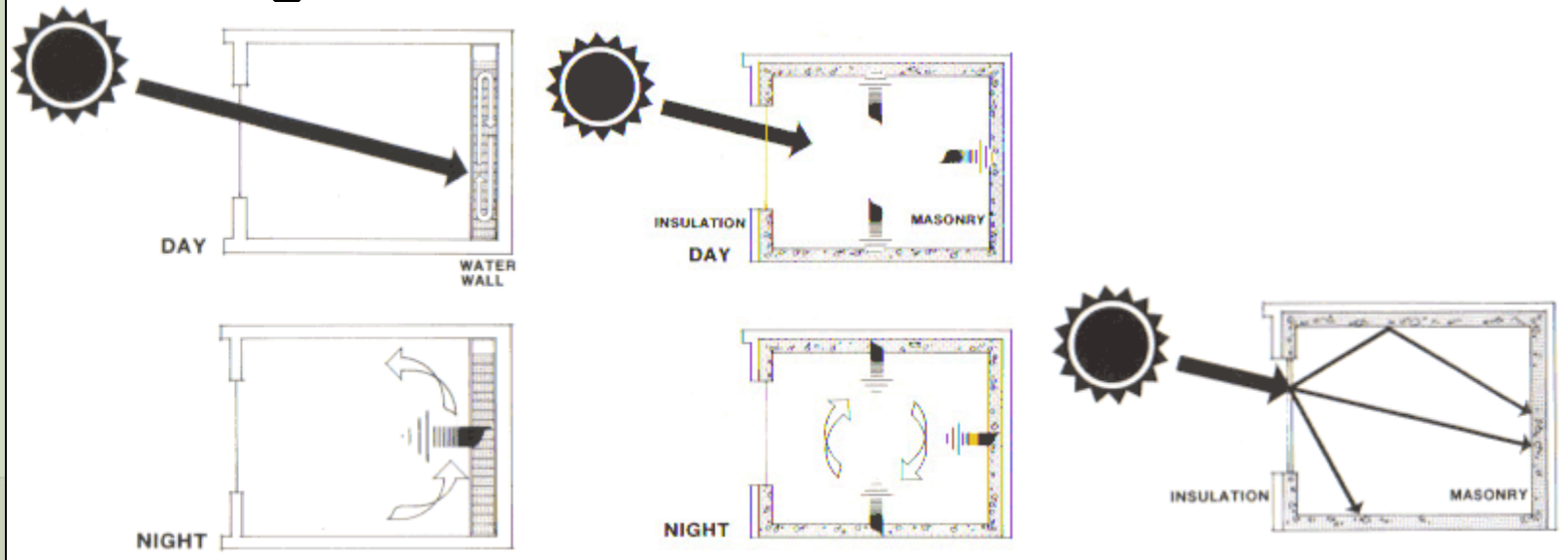
5 Controls

- Glass type
- Solar Thermal Mass
- Solar Shading/Orientation
- Ventilation
- Insulation

Passive Solar Heating

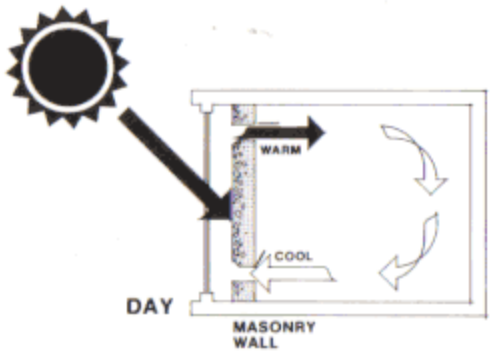
3 types: Direct, Indirect, Isolated

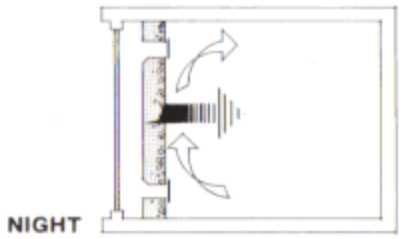
Direct gain

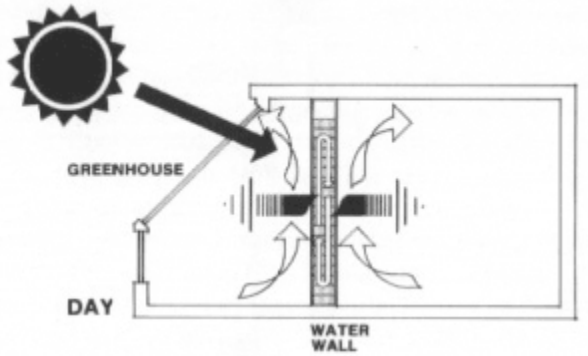


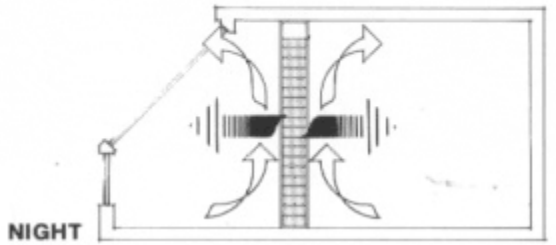
Passive Solar Heating

Indirect Gain



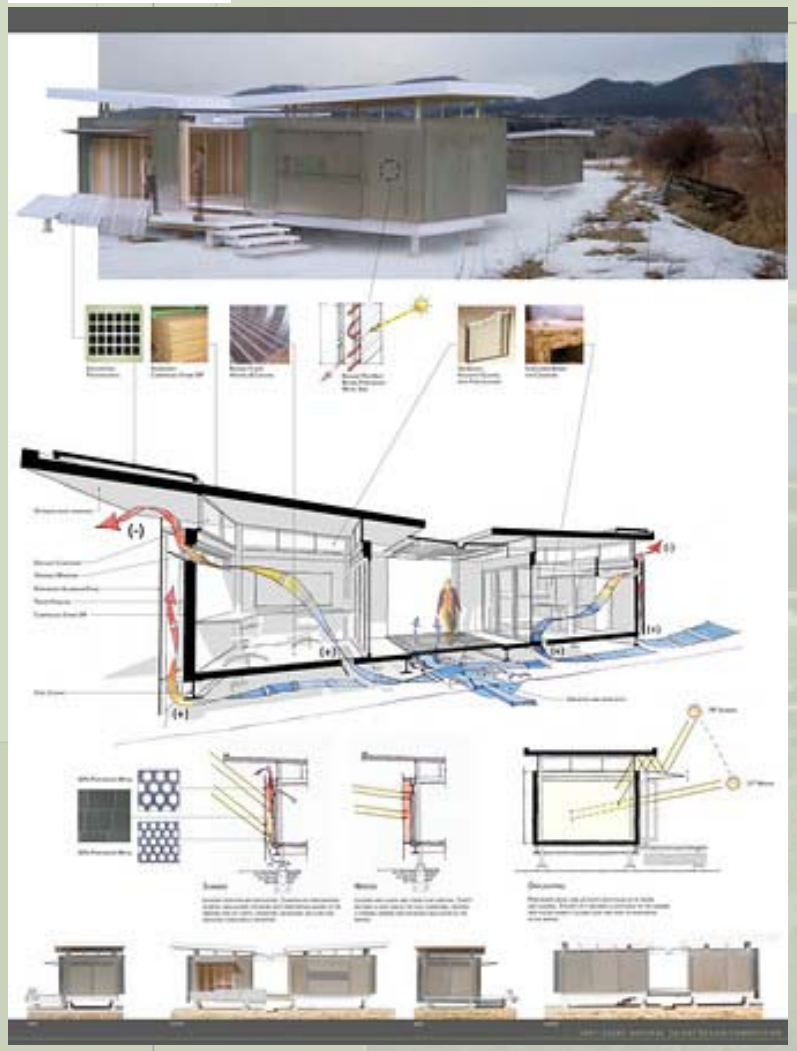






Greenbuilding Studio 2007

CAP STUDENTS PLACE IN TOP 4 OF 5 CATAGORIES
USGBC NATURAL TALENT DESIGN COMPETITION



Greenbuilding Studio 2007

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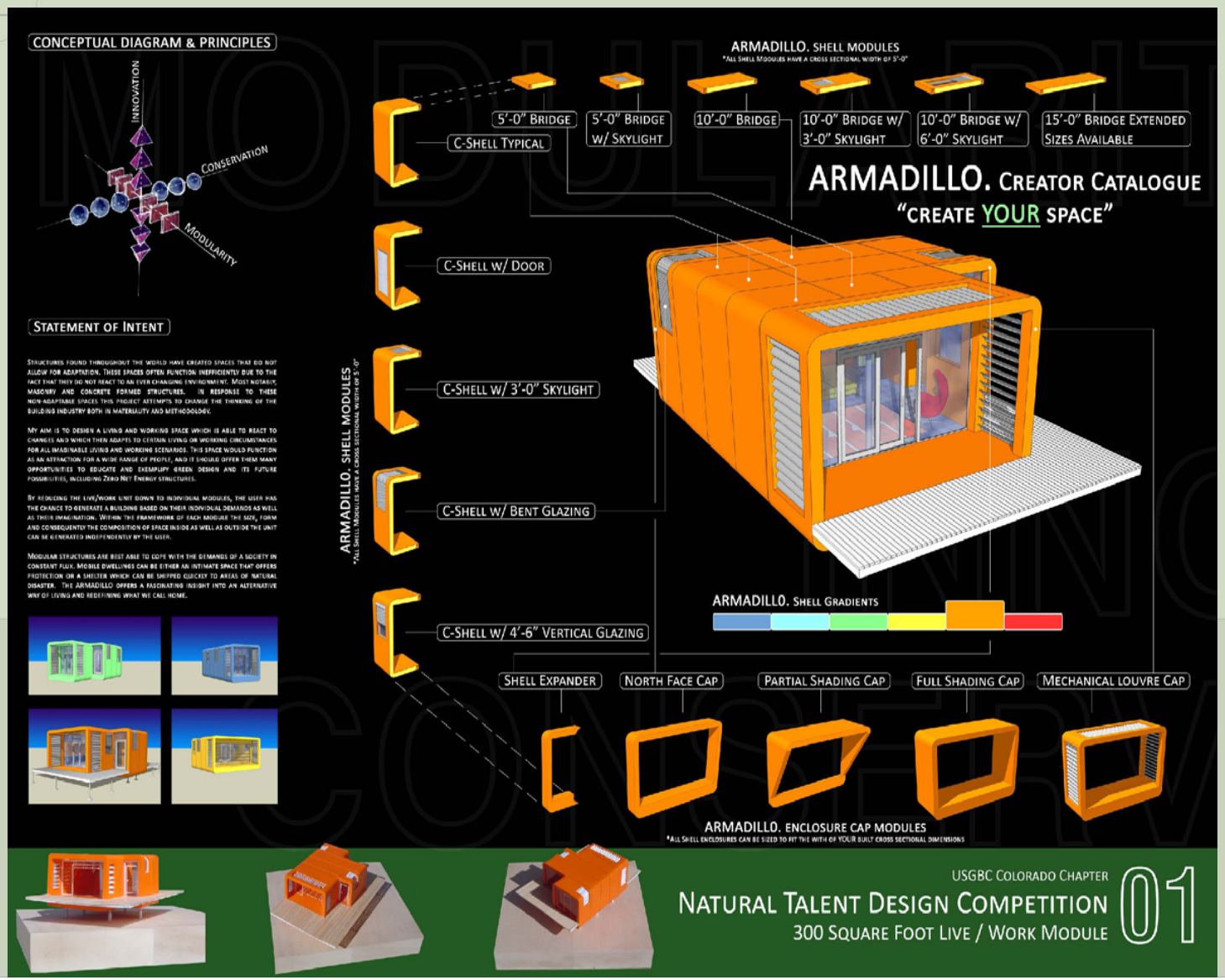
USGBC NATURAL TALENT DESIGN COMPETITION



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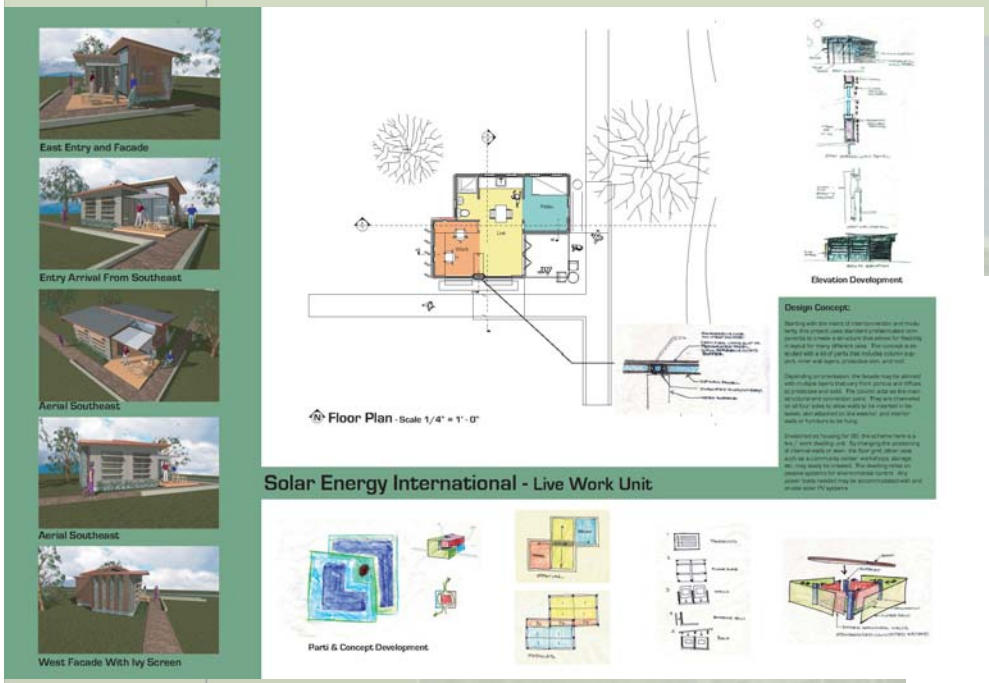
USGBC NATURAL TALENT DESIGN COMPETITION



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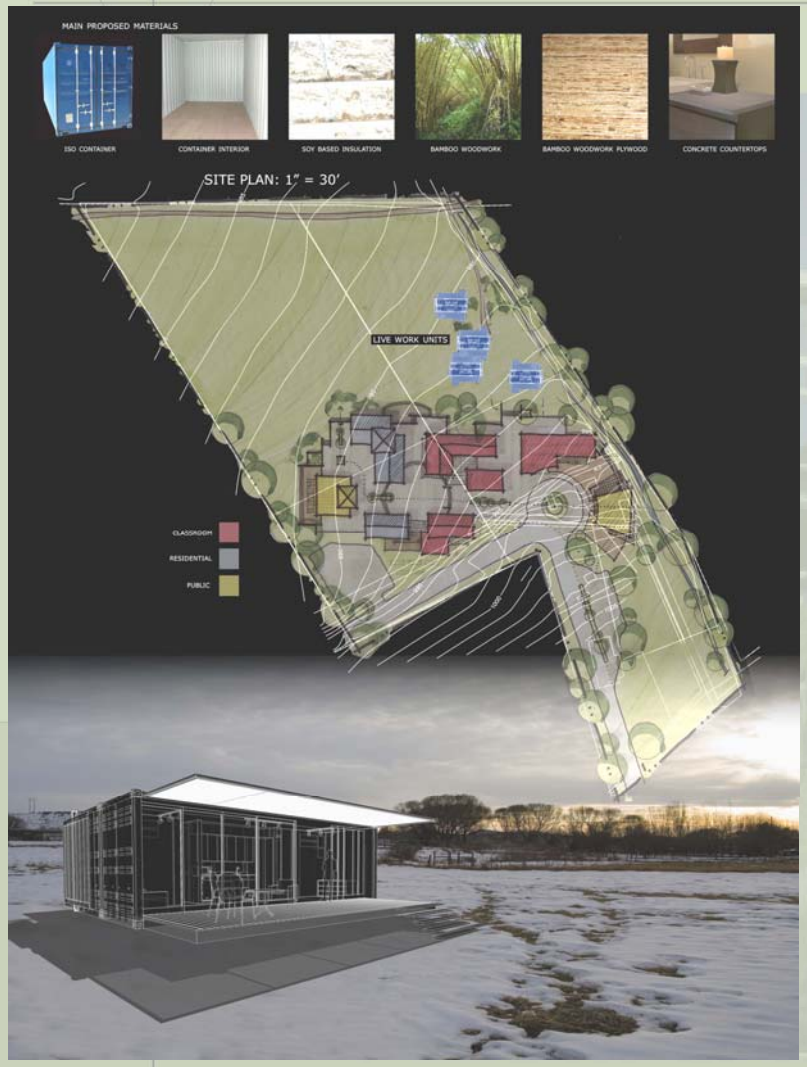
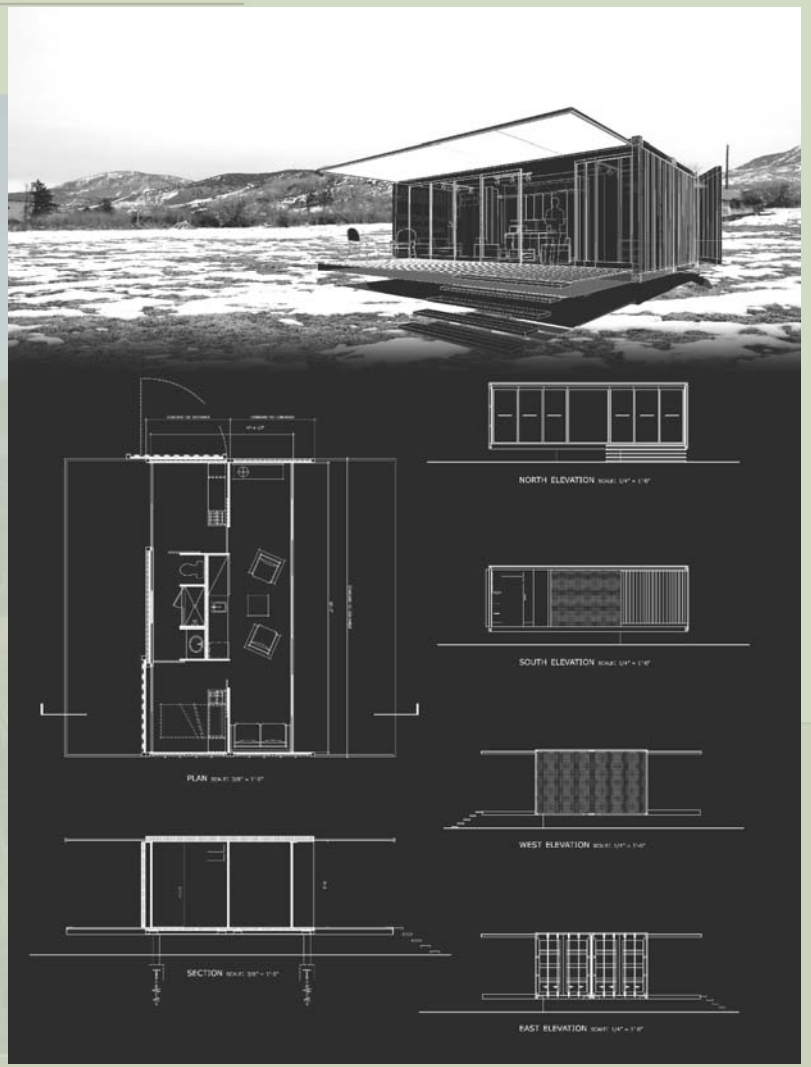
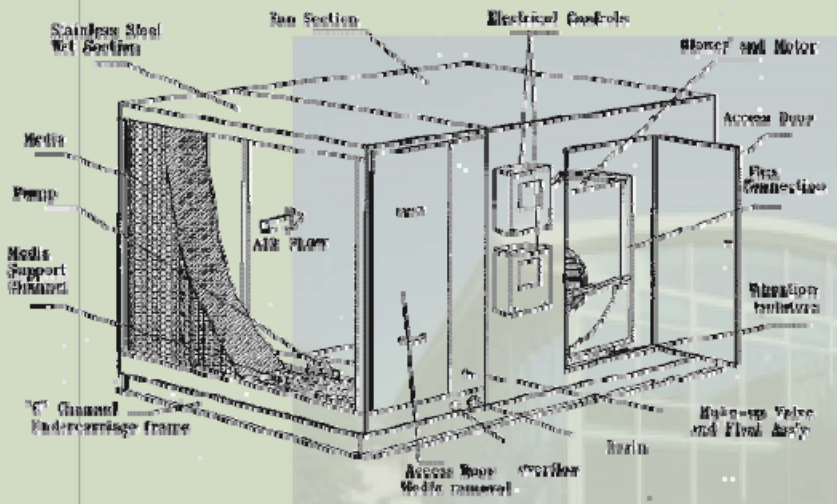


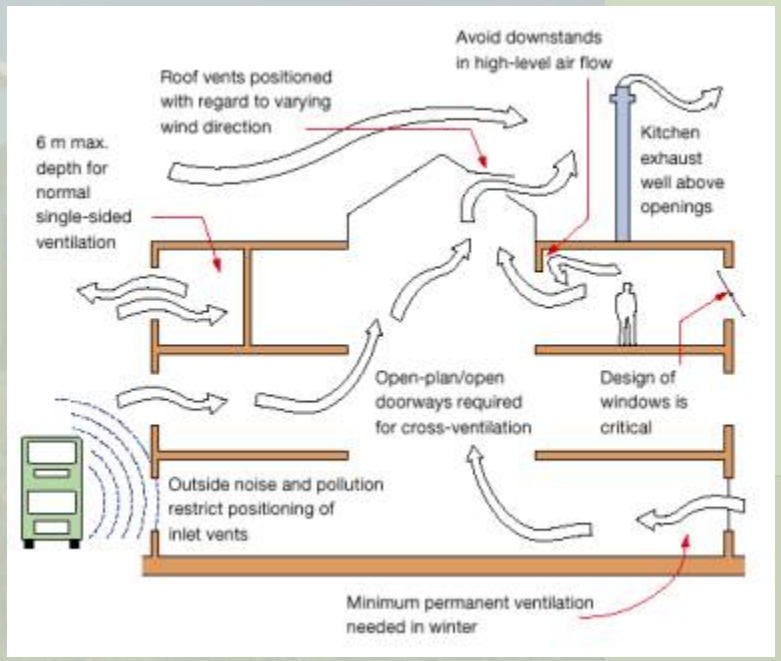


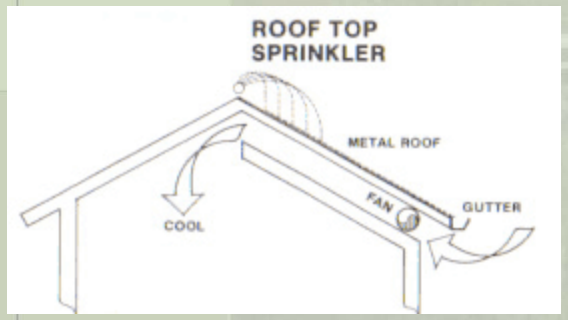
Passive Solar Cooling

- Interstitial wall systems
- **SMART** Buildings
- Shading devices
- More heat = more cooling
- Thermal gradient enhancements
- Natural and conditioned ventilation
- Climatic strategies
- Ground coupled cooling “M”
- Evaporative cooling “M” and natural
- Dehumidification

Passive Solar Cooling

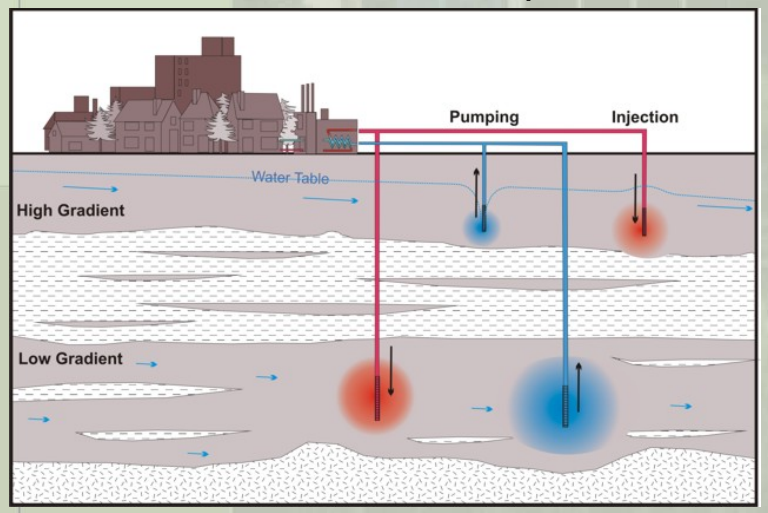






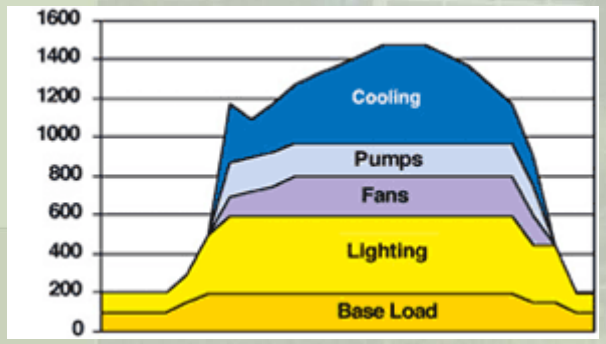
Thermal Inertia
Heating and Cooling

- Mass (water, masonry, etc.)
- Air movement coupled with thermal gradient
- Ice production and storage
- Aquifer & water system thermal exchange/sink
- Parabolic-Trough Thermal Energy Storage
  - Molten Salt, Mineral Oils, Concrete

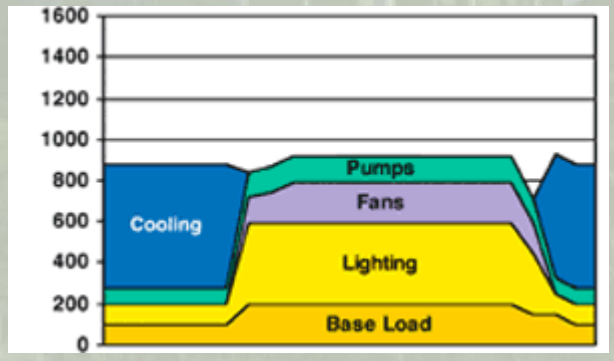


Thermal Inertia

- Stores thermal energy
- Enhances passive heating and cooling
- Creates opportunities for air movement patterns
- Distributes existing thermal energy
- Lowers annual and peak energy costs
- Assists in a ZNE strategy



Traditional day use building energy footprint:



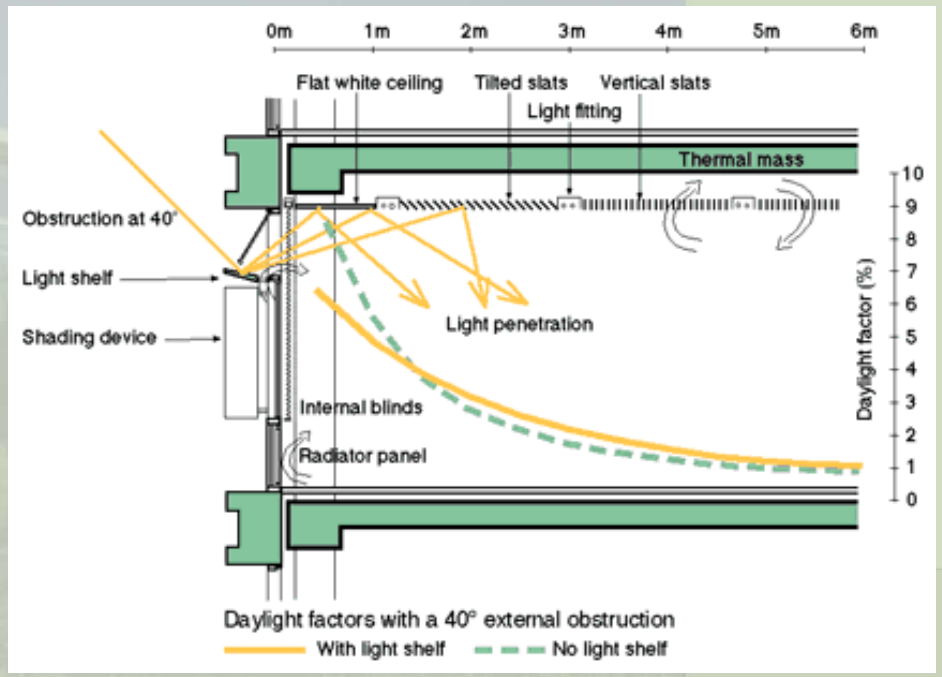
Energy footprint of building implementing a ice storage cooling system:

Daylighting
Placement of Openings

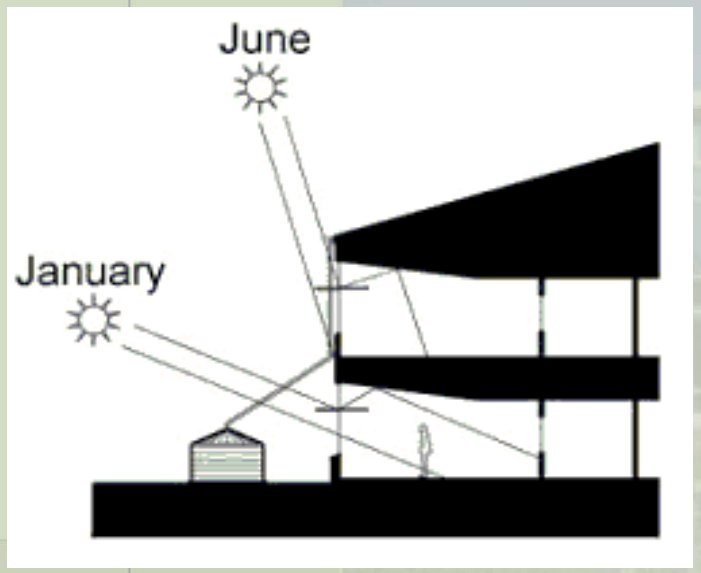
- **Designate appropriate line of sight avoid extreme contrast and glare.**
- **Glare control strategies**
- **interior glazing locations**
  - **High**
  - **Wide**
- **Floor plan & core strategies maximize daylighting potential**
- **Standard windows light penetration = 1.5 times the height of the window**
- **Light shelves increase to 2.0 times.**
- **General rule: The higher the window the better the light penetration**

Daylighting
Designing Windows

- **Three sources of daylight on work surfaces**
  - **Light reflected from the exterior**
  - **Light reflected from the interior**
  - **Direct sunlight and light from the sky**
- **Top lighting strategies, good**
- **Rear wall reflecting surfaces, better**
- **Ceiling is reflecting surface, best**
- **Suggested Room Surface Reflectance's**
  - **Ceilings >80%**
  - **Walls 50%-70%**
  - **Floors 20%-40%**
  - **Furnishings 25%-45%**
- **Room proportions and daylighting factors, it's all in the geometry**



Daylighting
Light Shelves and Top lighting



- **Separating the viewing aperture** from the daylighting aperture allows for a higher transmittance of daylight to the interior
- **Light shelves** are a horizontal plane placed above eye level
- **Exterior light shelves** efficient to bounce & shade, interior shelves less efficient
- **Top lighting** consists of:
  - Clerestories, Vertical Skylights –reflectors, prismatic lenses, light pipes
  - Saw tooth & Monitor Roofs – vertical glazing with BIPV

Daylighting
Controls and Design Coordination

- **Daylighting energy loses sans integrated systems**
- **Types of lighting controls**
  - **Sensors with M & V**
  - **Occupancy sensors**
  - **Light Level sensors**
- **Layout and rigging of lighting should correspond with the daylight aperture**
- **Dark interior finished can hinder daylighting techniques**

Daylighting

- Southern glass with exterior shading
- Northern clerestories and dormers
- Light sensors, timers, and electronic dimmers

Effectiveness of Daylighting
NREL Case Study

•Lighting use only decreased by 20%

•Uneven lighting levels

•Glare

•Suggestions: higher reflectivity surface,

more shading, more lighting controls

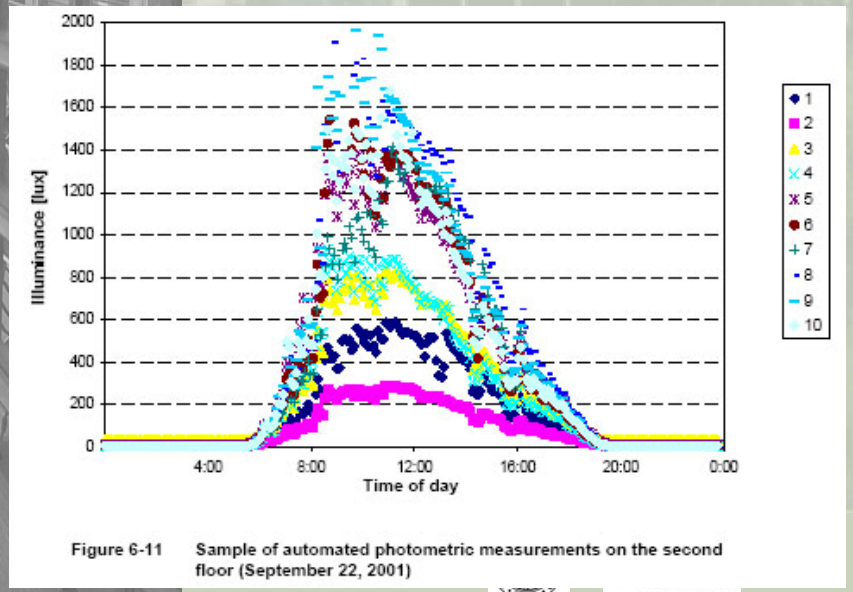


Figure 6-11 Sample of automated photometric measurements on the second floor (September 22, 2001)

Hybrid Design

Alliance for Sustainable Colorado Building

Combines Passive Heating, Cooling and Lighting

Hybrid Buildings

"Formed or composed of heterogeneous elements"

Passive Heating, Cooling, Daylighting

Describes a building with two thermal conditions

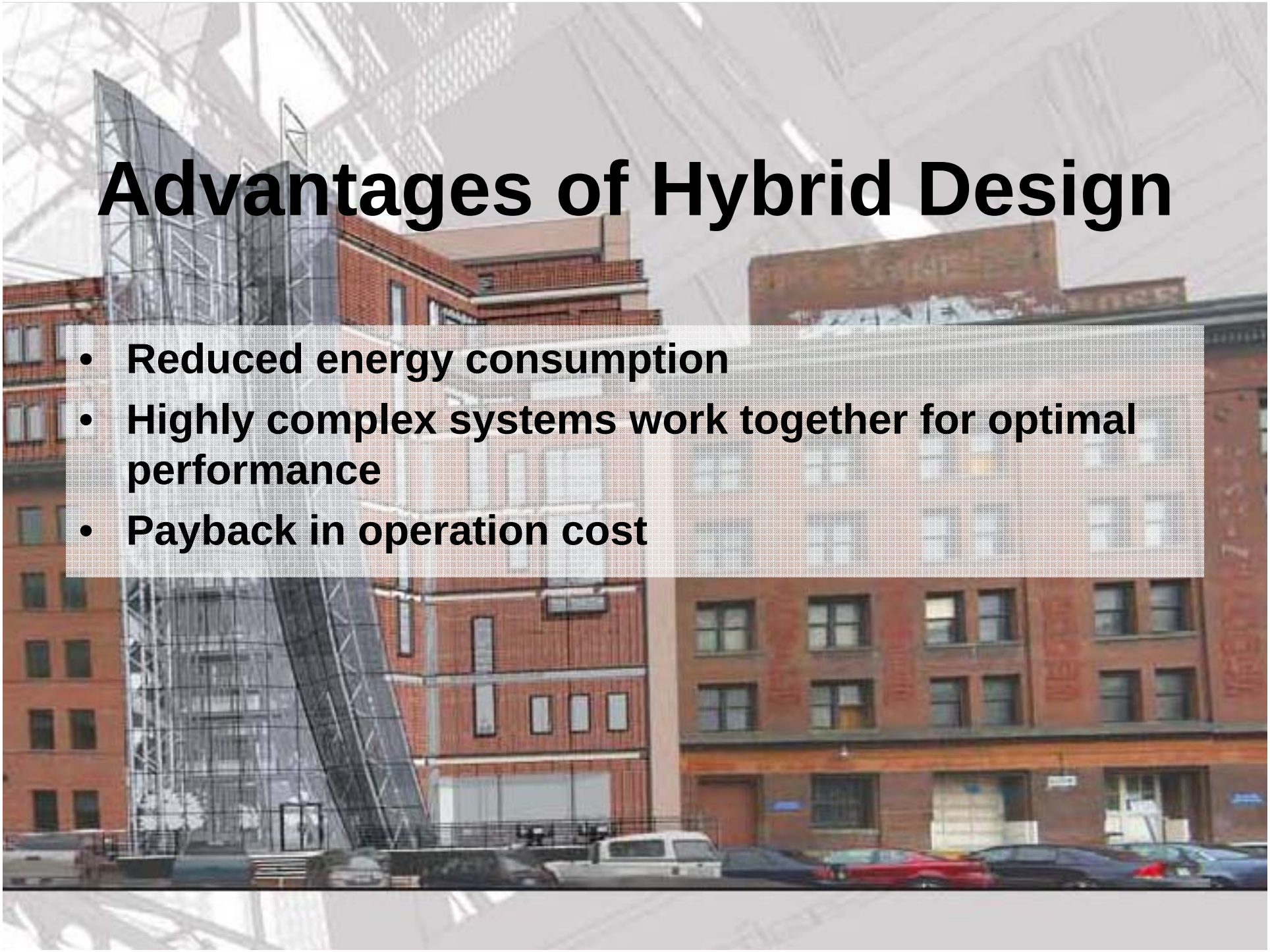
- **Skin Dominated and Load Dominated**
- **i.e. Church, Day Care**

Uses complex integrated systems

Uses integrated design approach

Establishes a holistic approach to building

Advantages of Hybrid Design

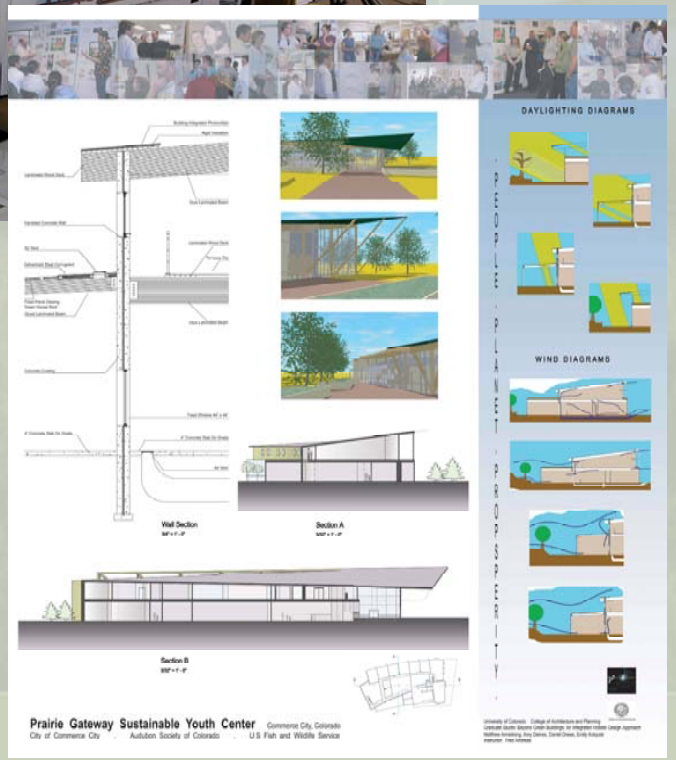


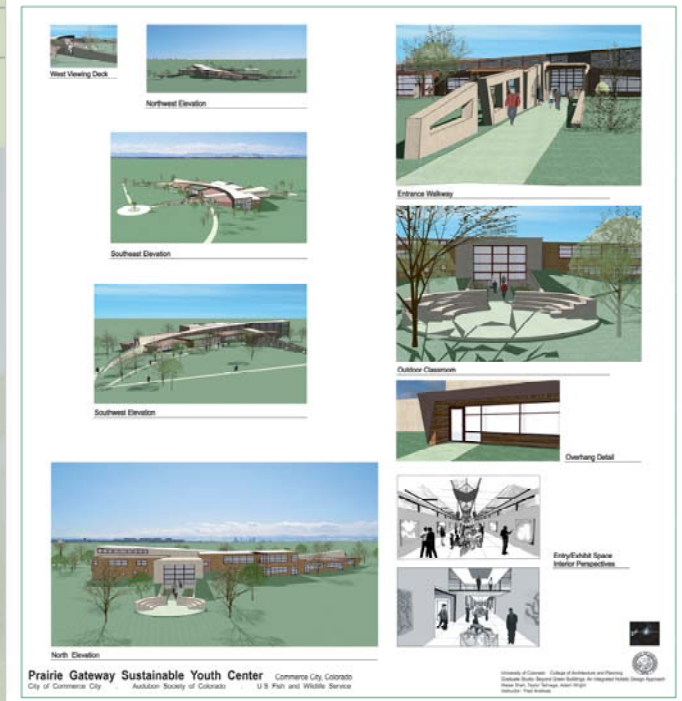
- Reduced energy consumption
- Highly complex systems work together for optimal performance
- Payback in operation cost

Greenbuilding Studio 2005

Audubon Fish & Wildlife Center – Commerce City, CO

P3 Competition, Washington, D.C.





Greenbuilding Studio 2005

Audubon Fish & Wildlife Center – Commerce City, CO
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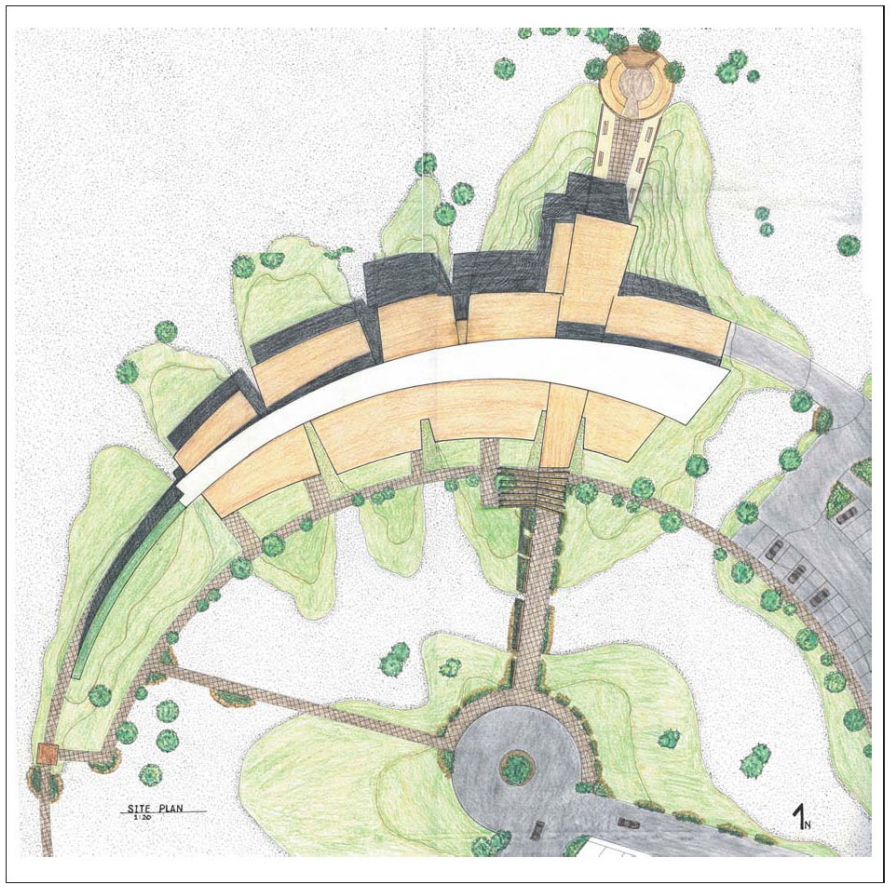


Site Plan
1" = 20' - 0"

Prairie Gateway Sustainable Youth Center Commerce City, Colorado
City of Commerce City . Audubon Society of Colorado . U S Fish and Wildlife Service

Southwest Elevation

North Elevation

Prairie Gateway Sustainable Youth Center Commerce City, Colorado
City of Commerce City . Audubon Society of Colorado . U S Fish and Wildlife Service

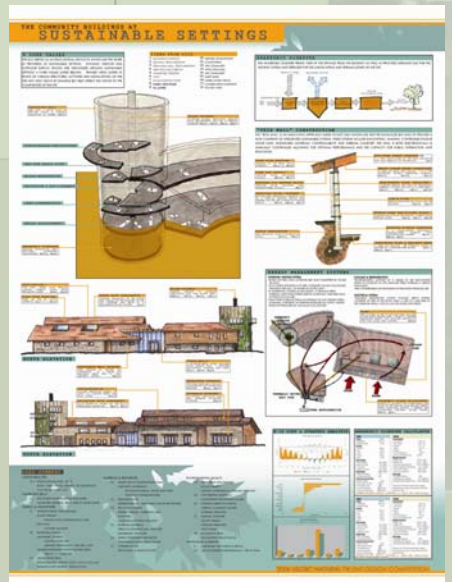
Greenbuilding Studio 2006

Sustainable Settings – Carbondale, CO

THIS WEEK in the College of Architecture and Planning

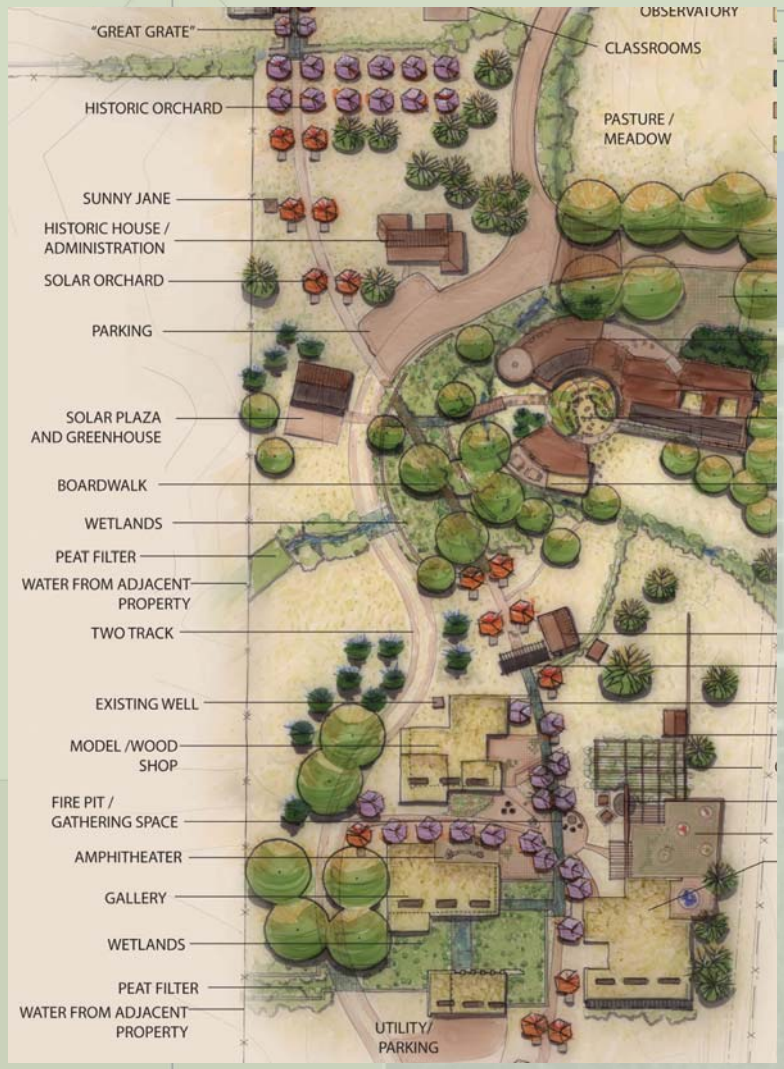
July 10-14, 2006

CAP STUDENTS SWEEP LOCAL USGBC NATURAL TALENT DESIGN COMPETITION WIN NATIONAL HONORABLE MENTION



Greenbuilding Studio 2006

Sustainable Settings – Carbondale, CO



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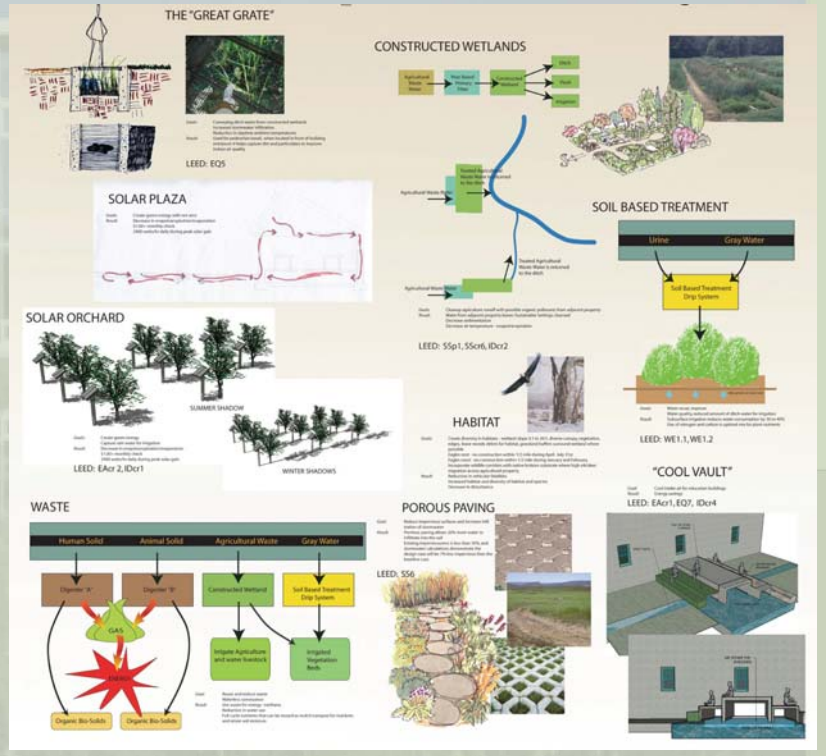

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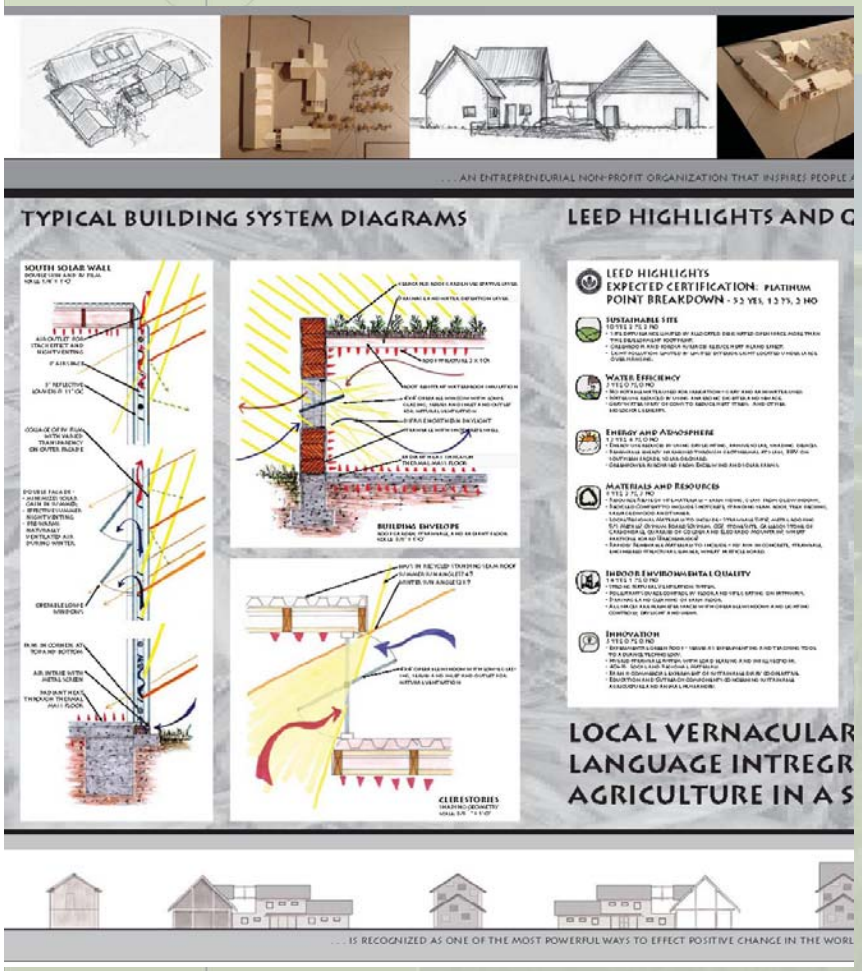
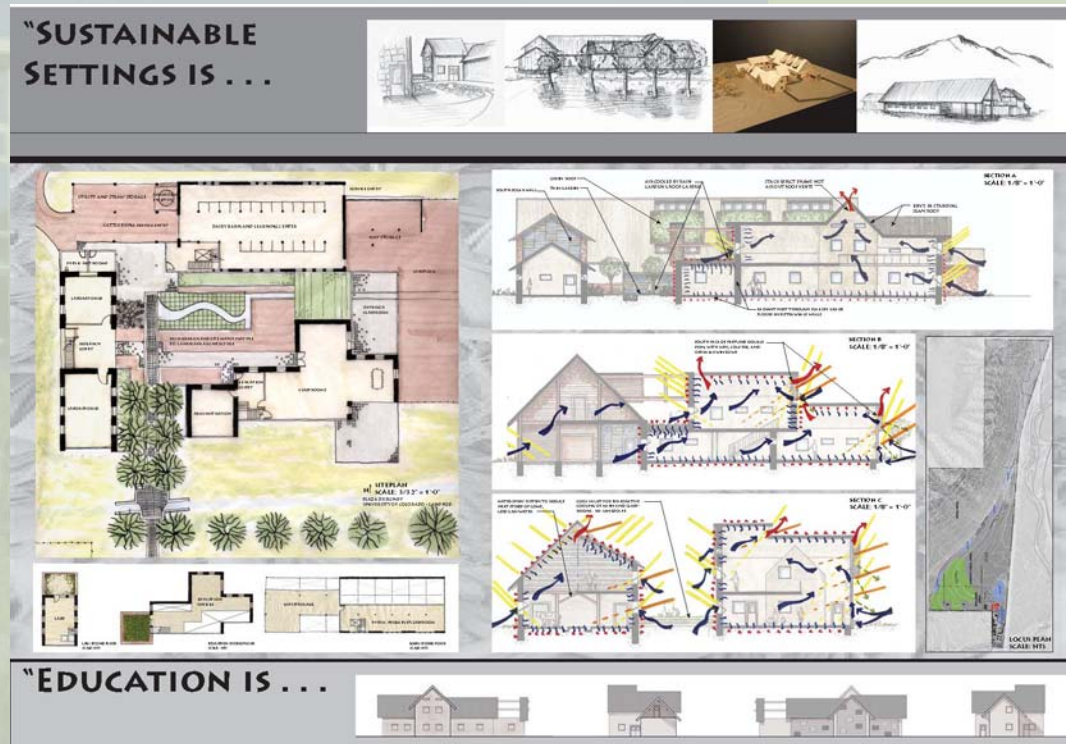
July 10-14, 2006

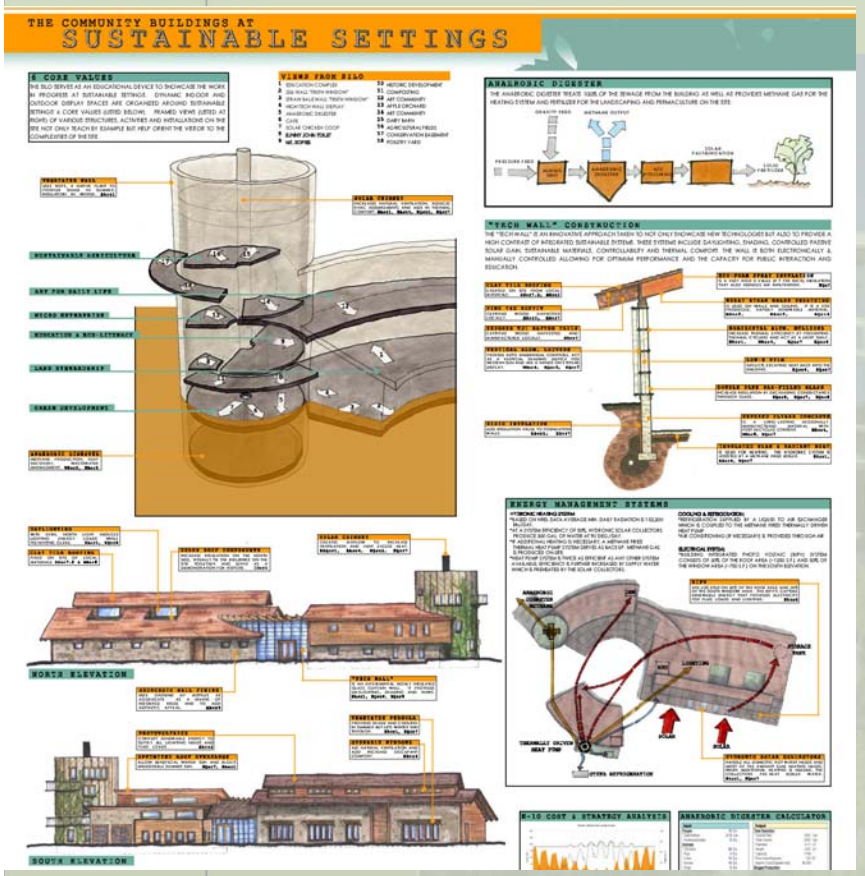
CAP STUDENTS SWEEP LOCAL USGBC NATURAL TALENT DESIGN COMPETITION WIN NATIONAL HONORABLE MENTION

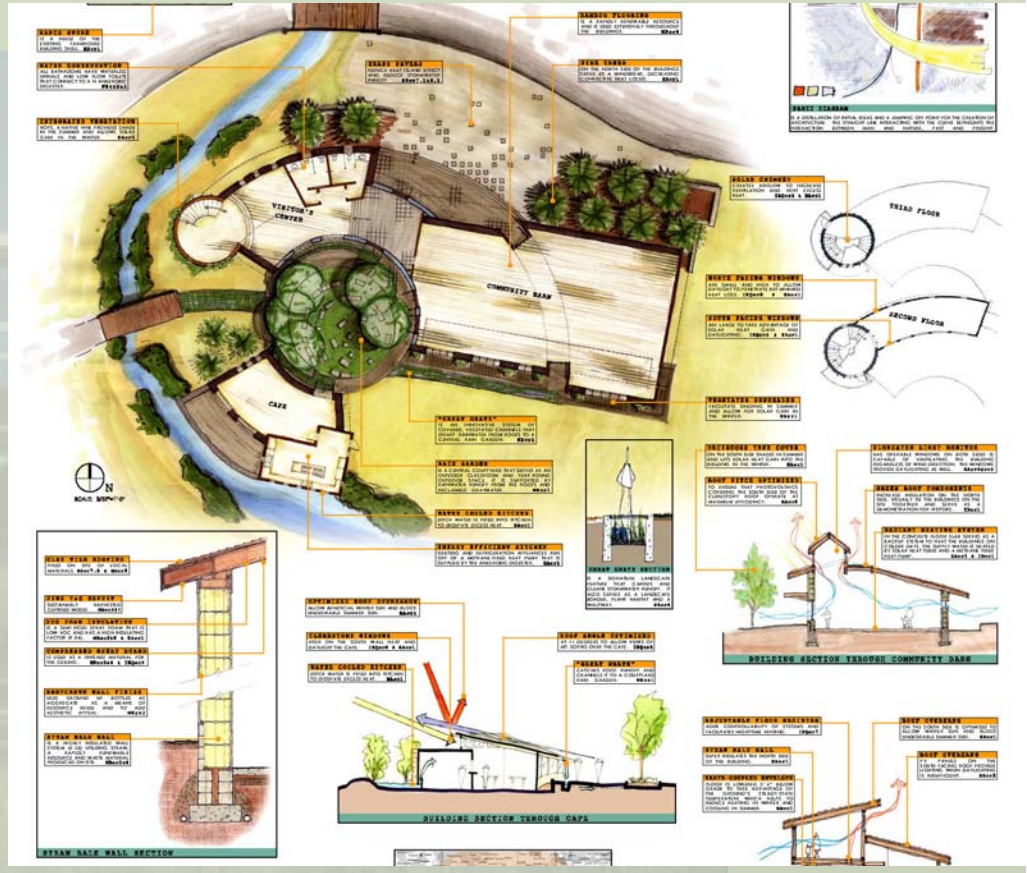




Greenbuilding Studio 2006

Sustainable Settings – Carbondale, CO

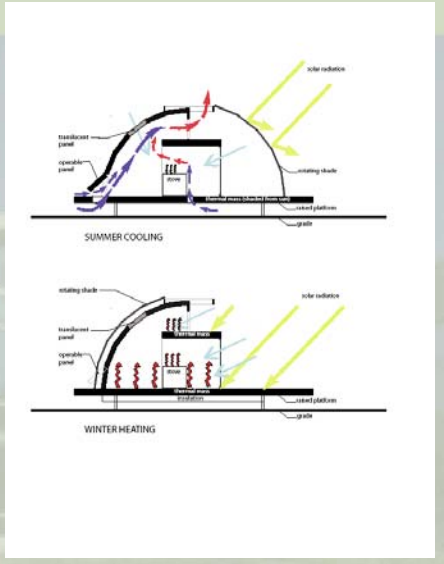


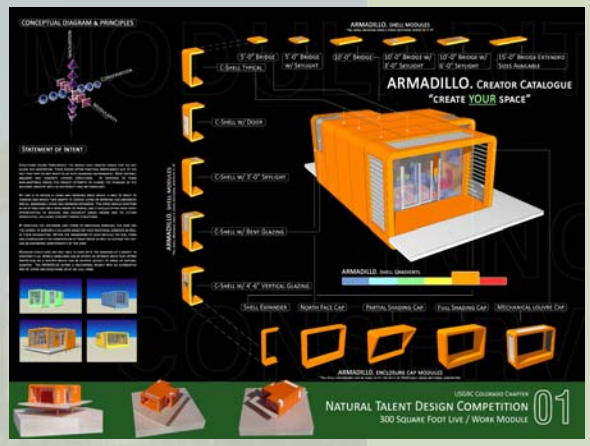


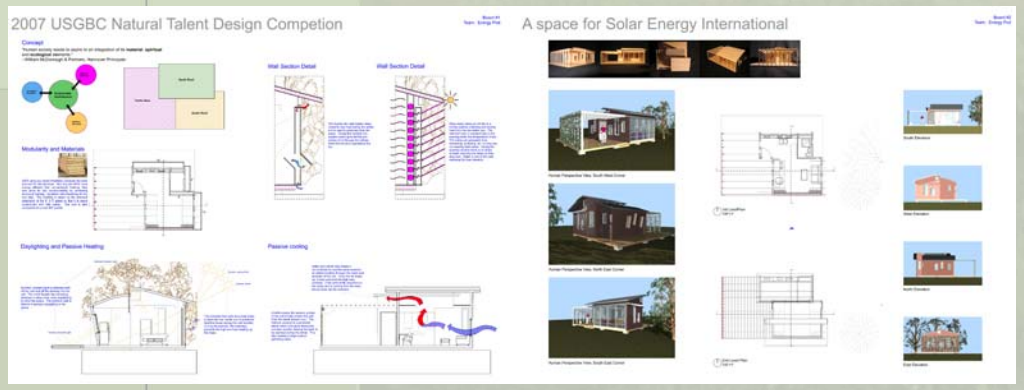
Greenbuilding Studio 2007

Sustainable Settings – Paonia, CO

CAP STUDENTS PLACE IN TOP 4 OF 5 CATAGORIES
USGBC NATURAL TALENT DESIGN COMPETITION

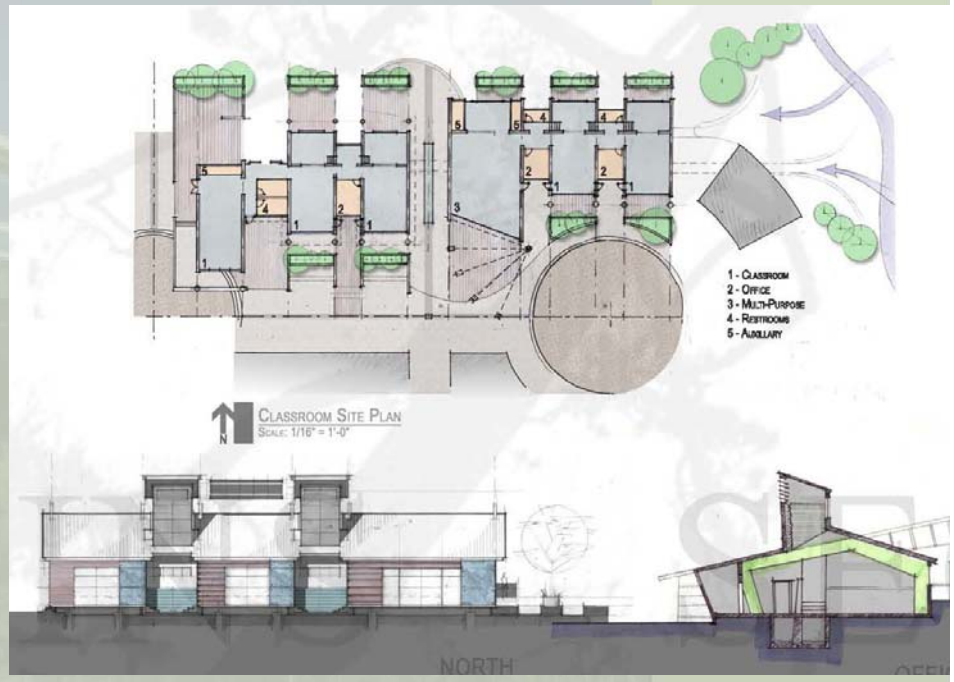






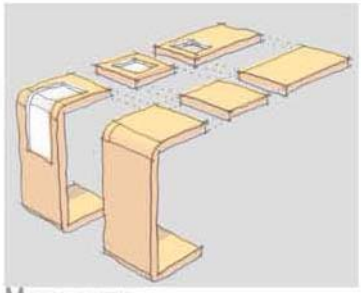
Greenbuilding Studio 2007

Sustainable Settings – Paonia, CO



Greenbuilding Studio 2007

Sustainable Settings – Paonia, CO



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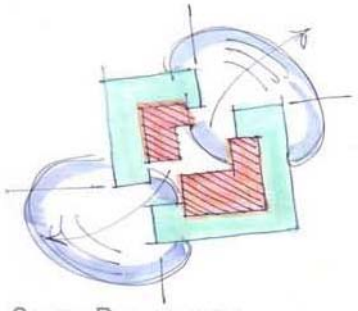

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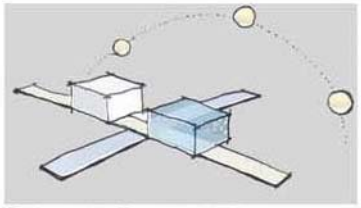
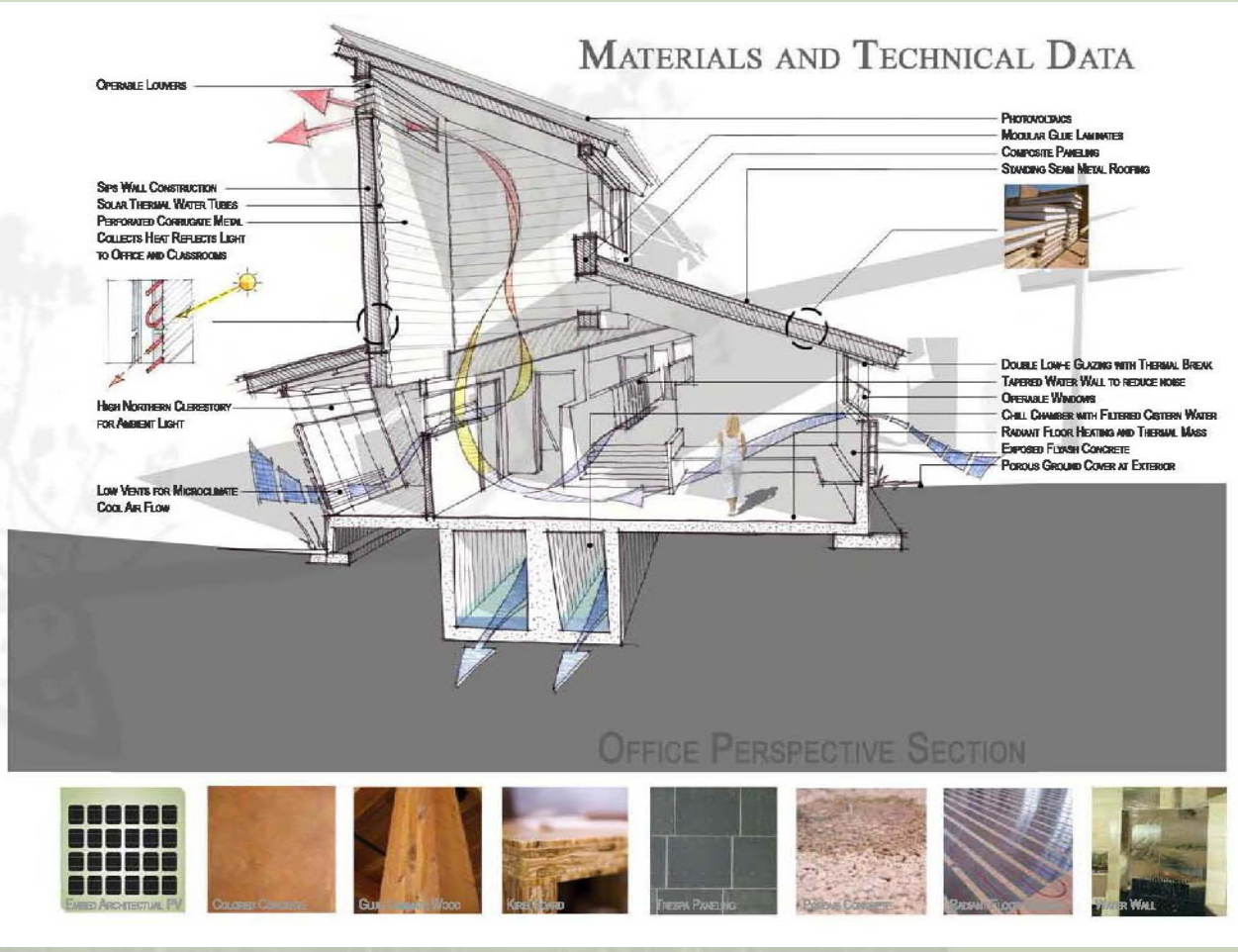


Symbiotic Relationships



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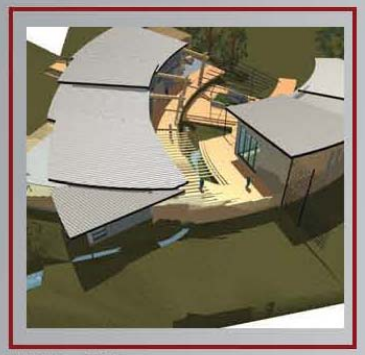
Sustainable Settings – Paonia, CO



AERIAL - EAST

AERIAL - NORTH

AERIAL - SOUTH

SOUTH ELEVATION - VISITOR CENTER - 1/8" = 1'-0"

SOUTH ELEVATION - OFFICE AND CONFERENCE ROOM - 1/8" = 1'-0"

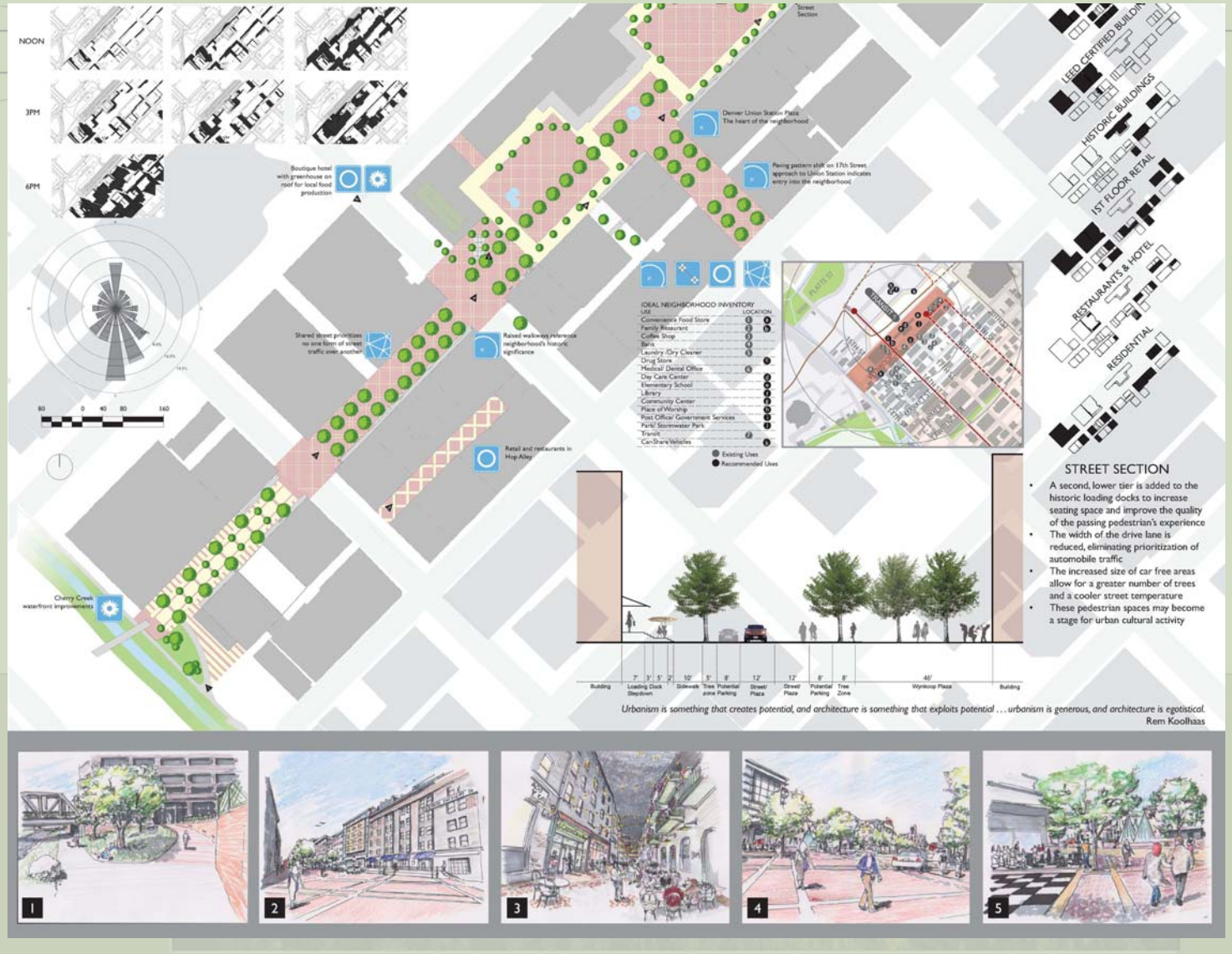
NORTH ELEVATION - VISITOR CENTER - 1/8" = 1'-0"

Greenbuilding Studio 2007

Sustainable Settings – Paonia, CO

Advanced Green Building Studio ‘08

Alliance for Sustainable Colorado – Denver, CO



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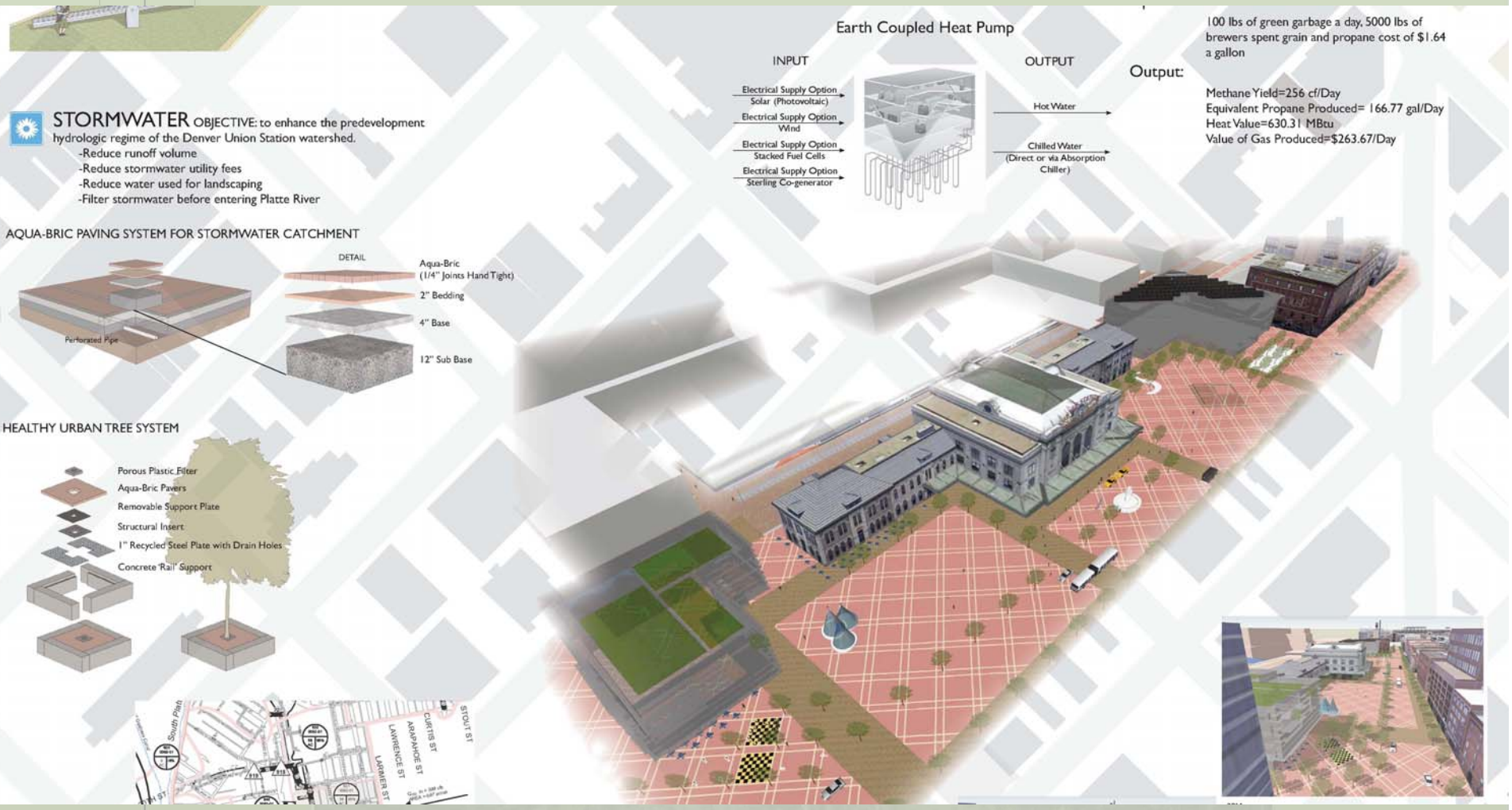

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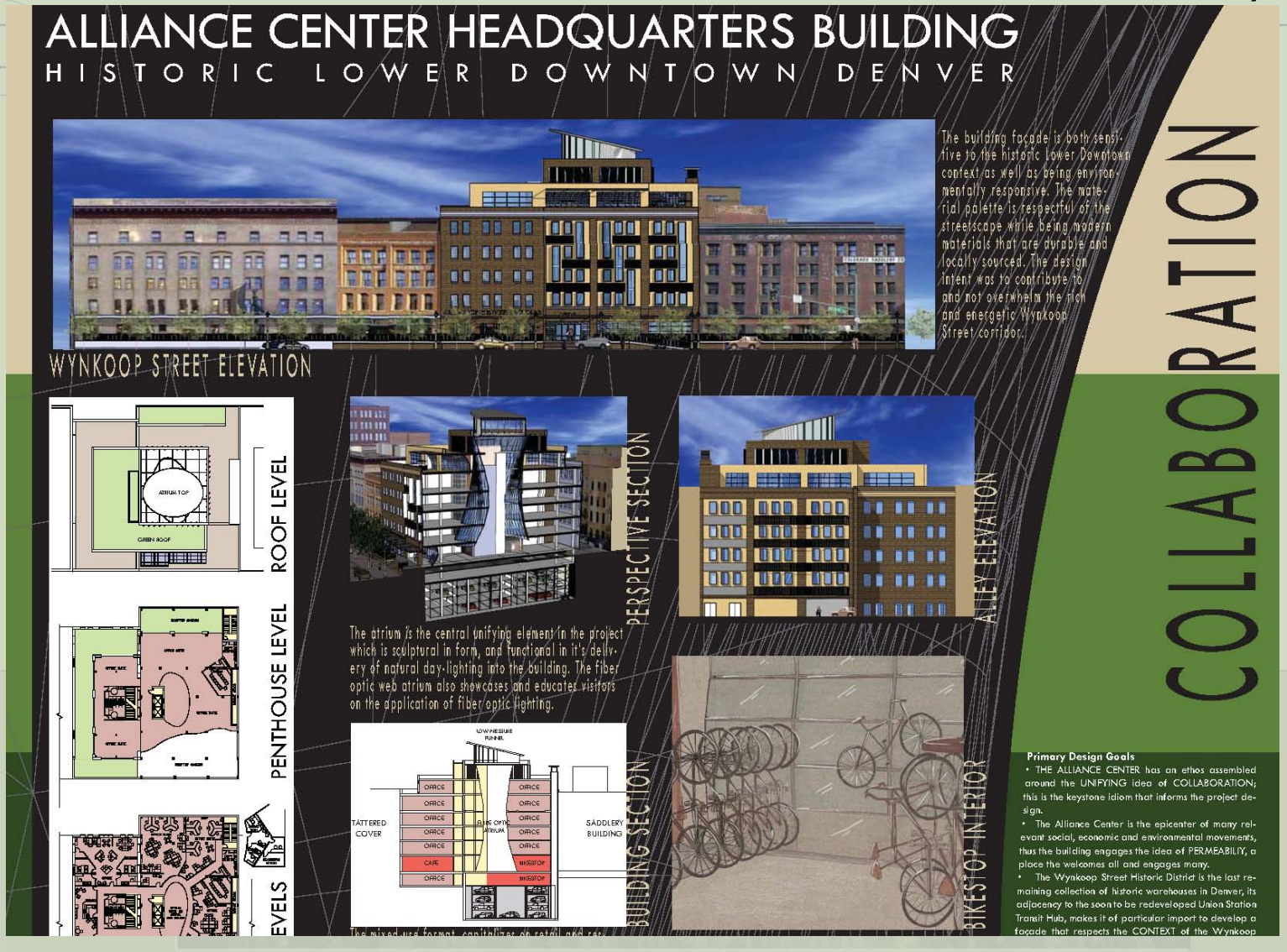

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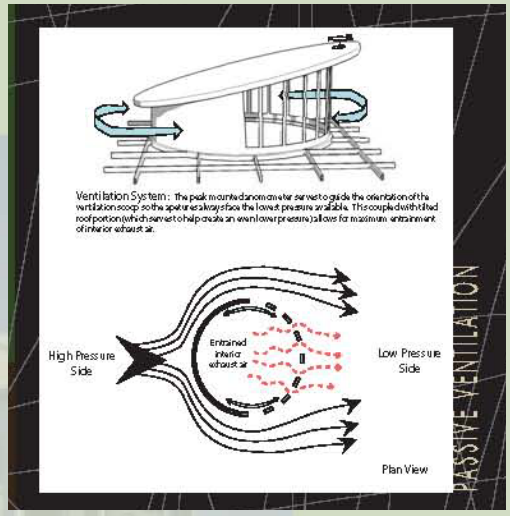

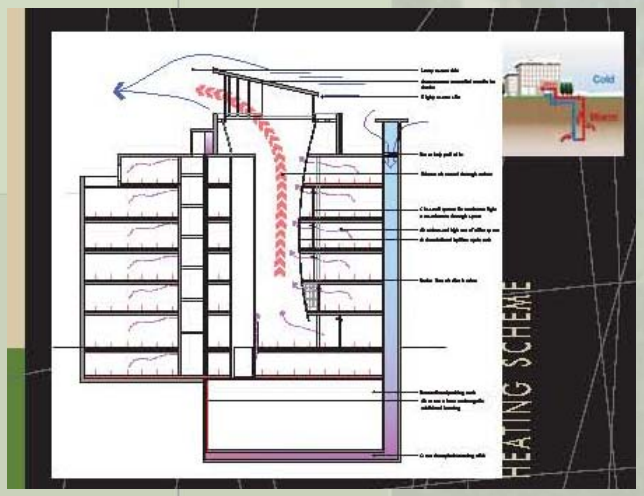

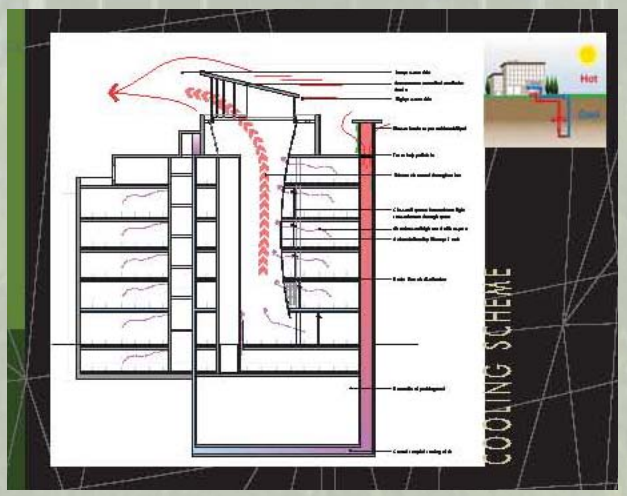

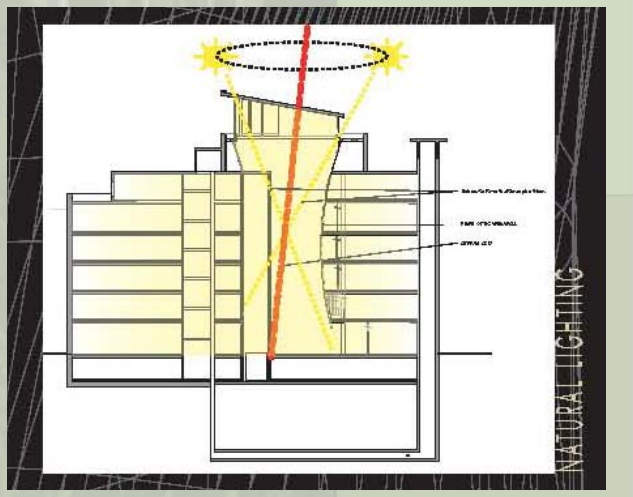

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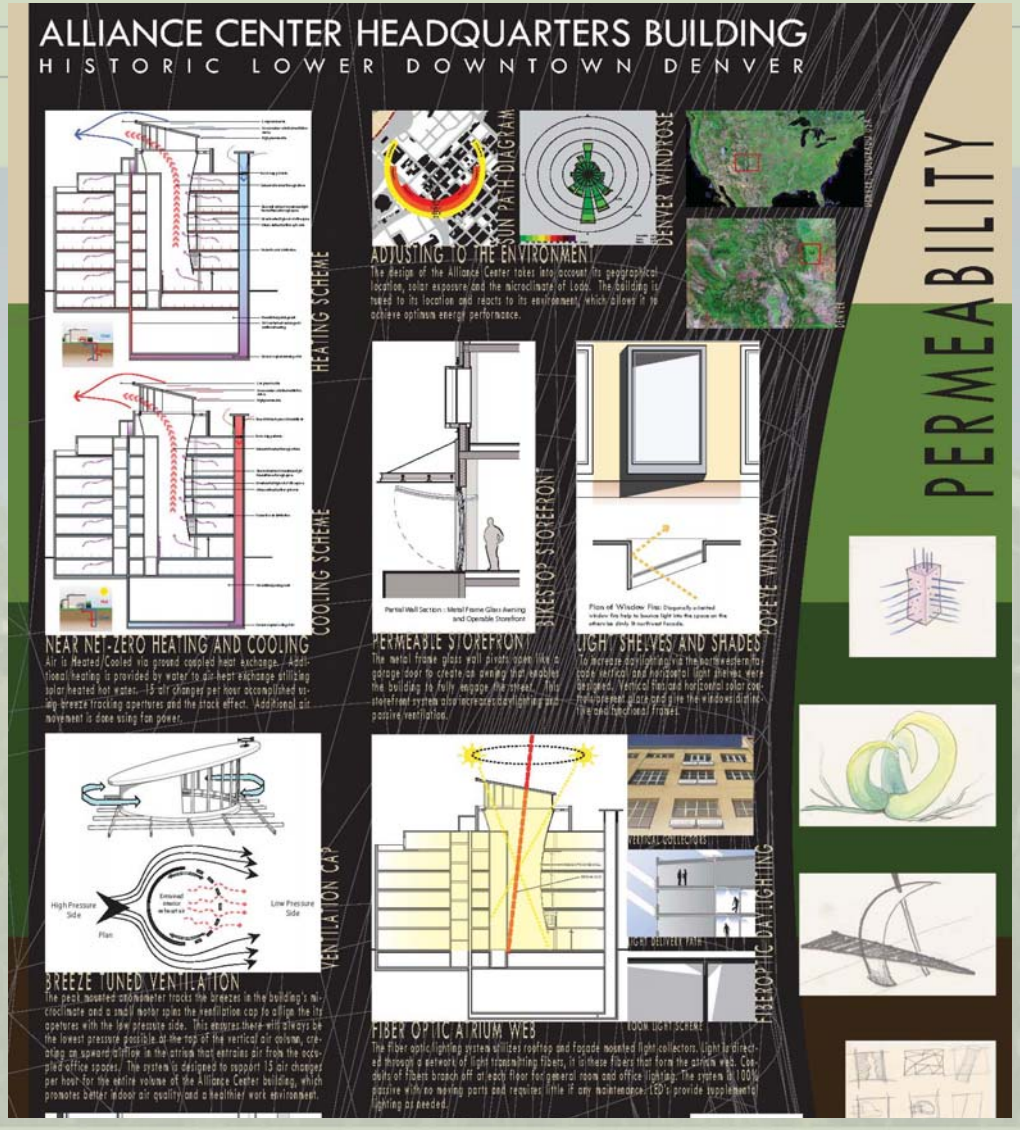

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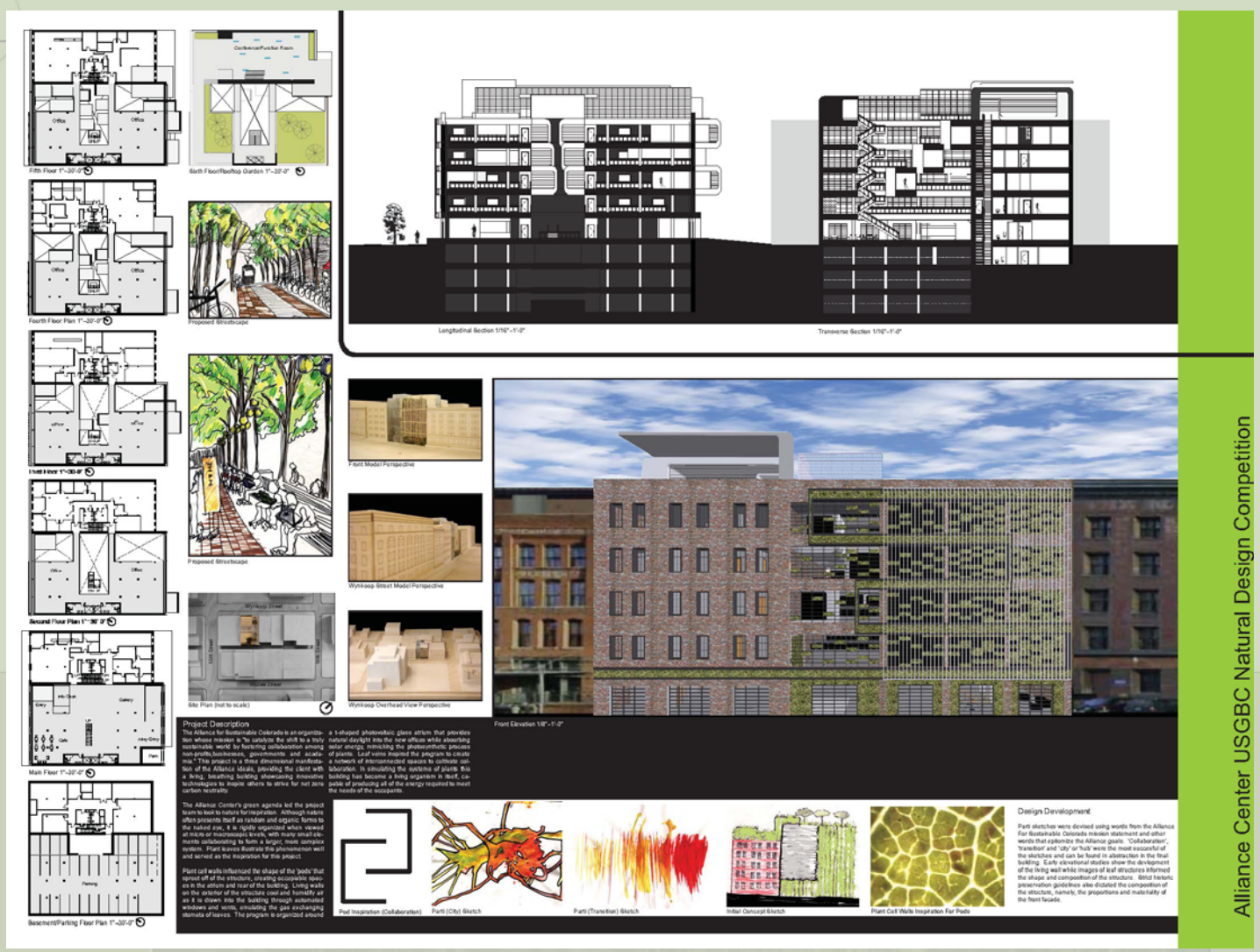

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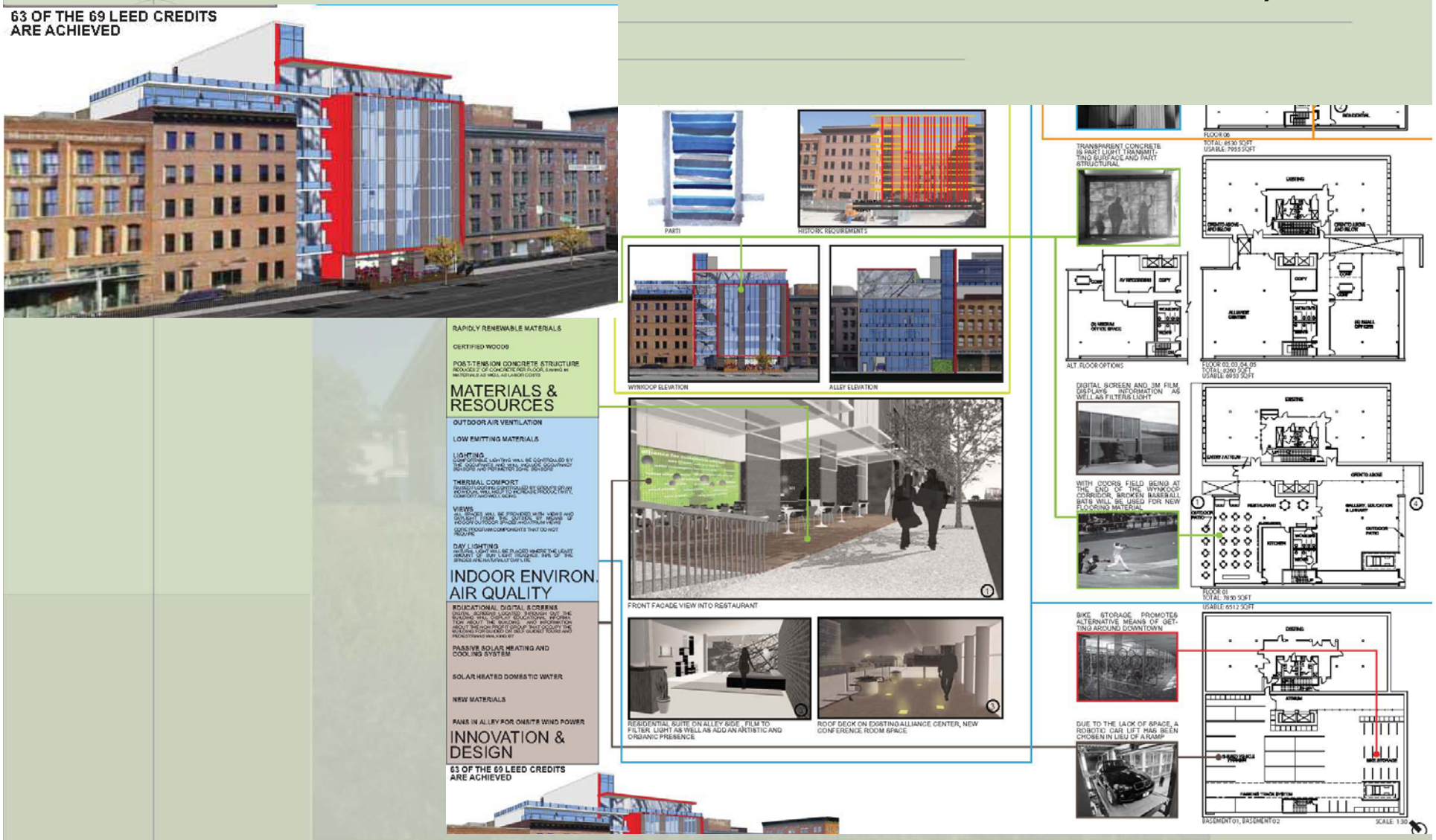

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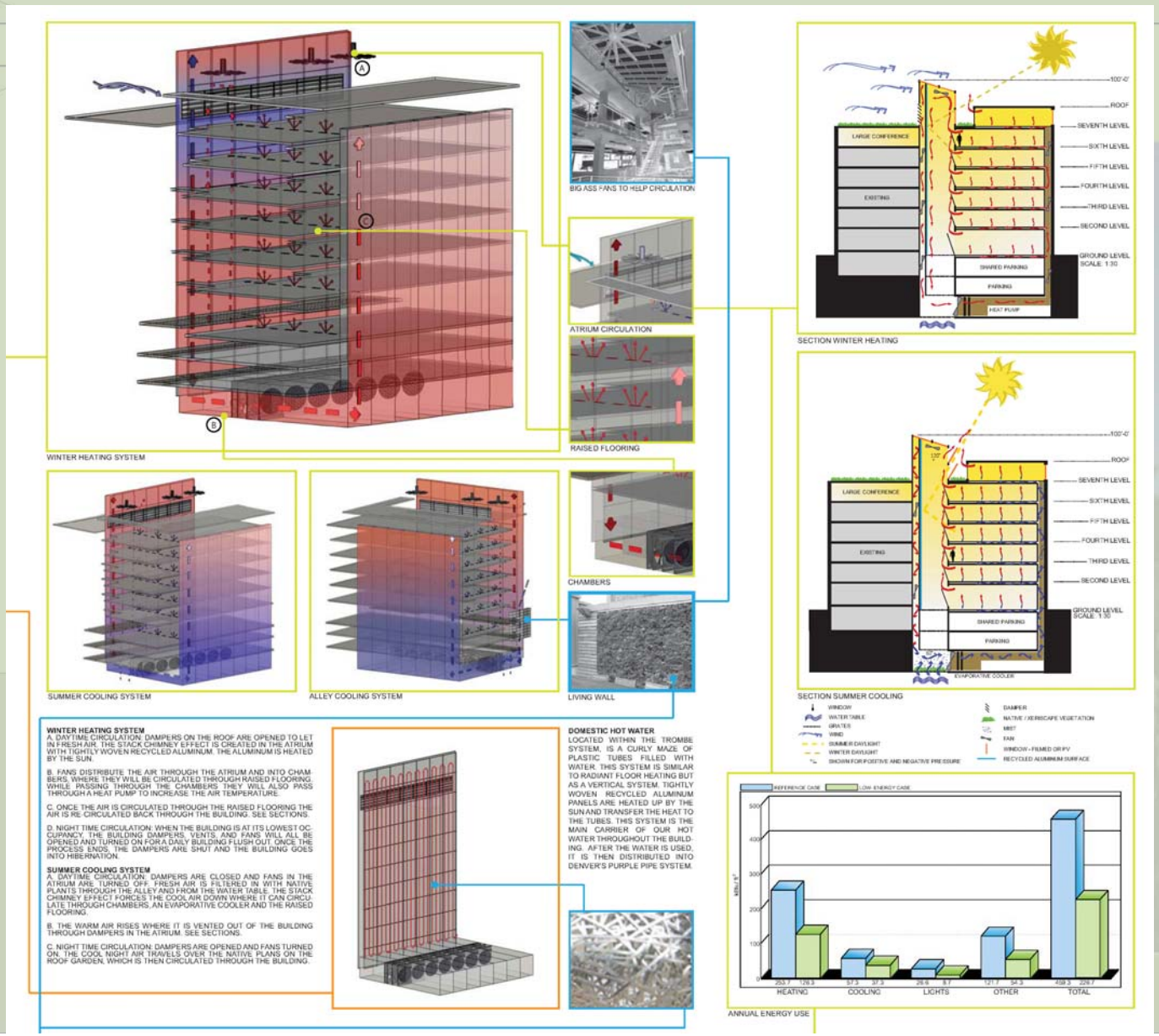

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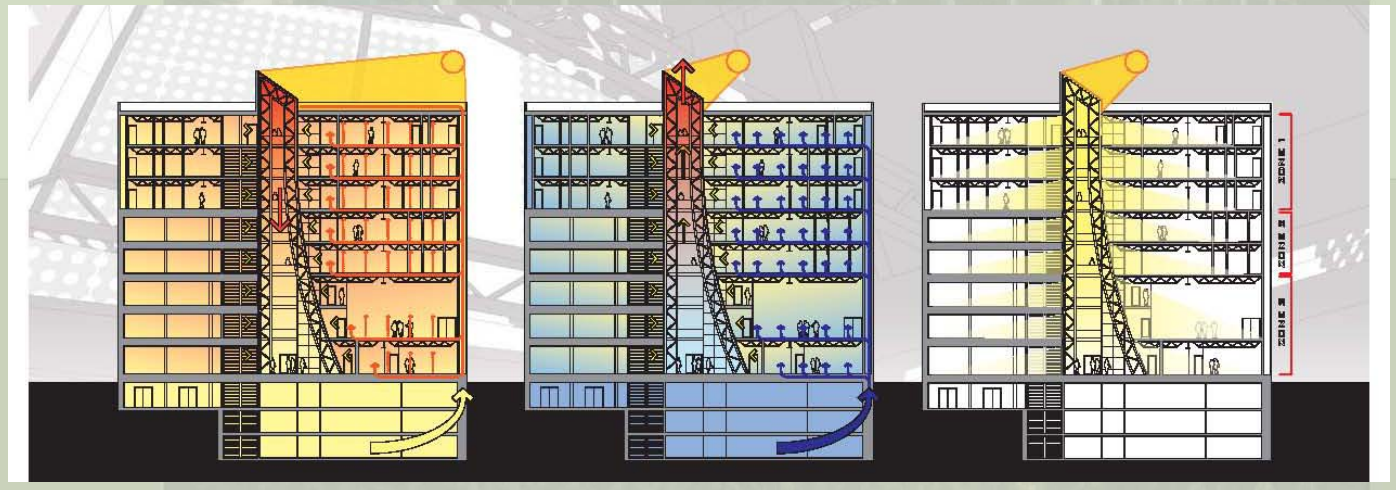

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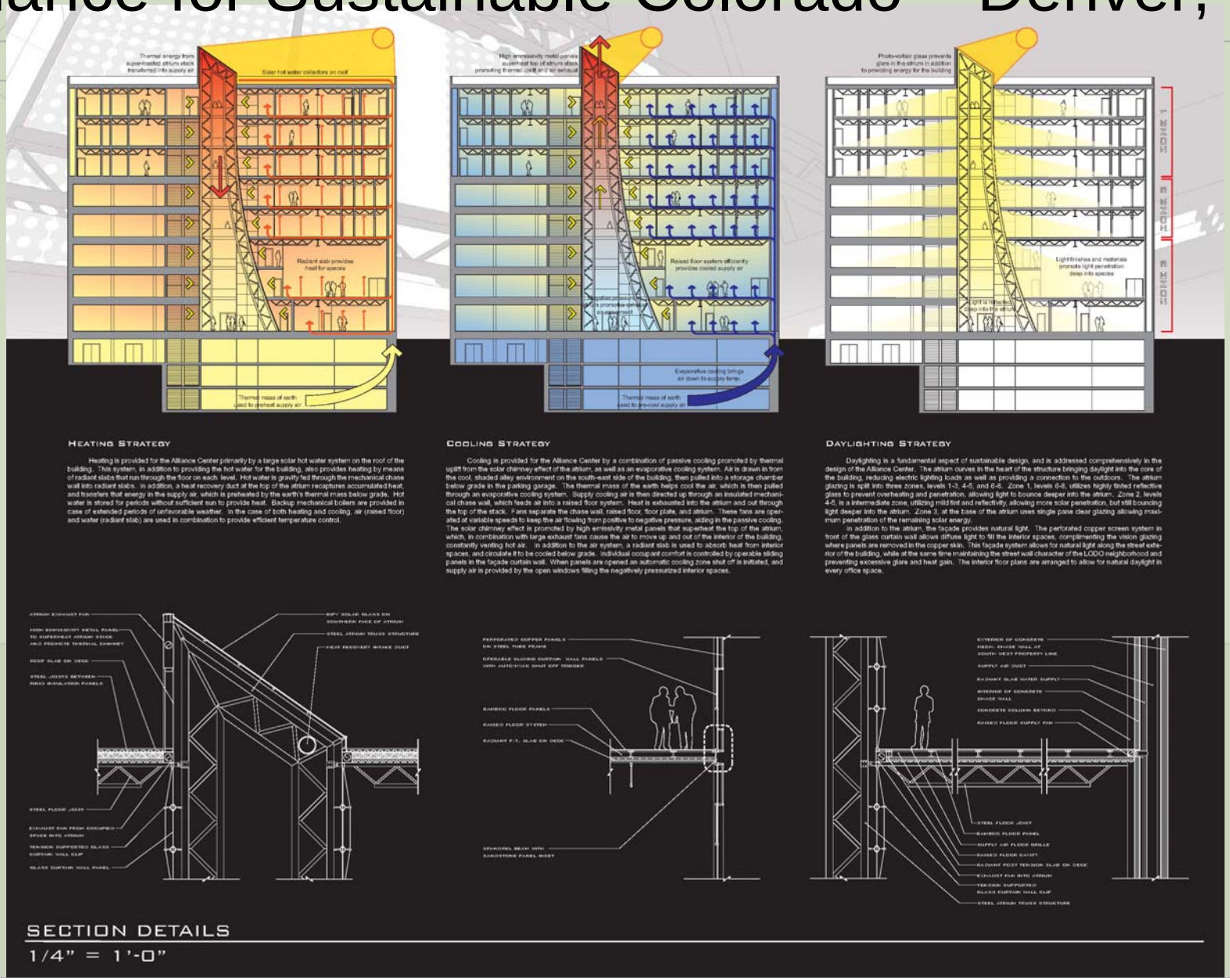
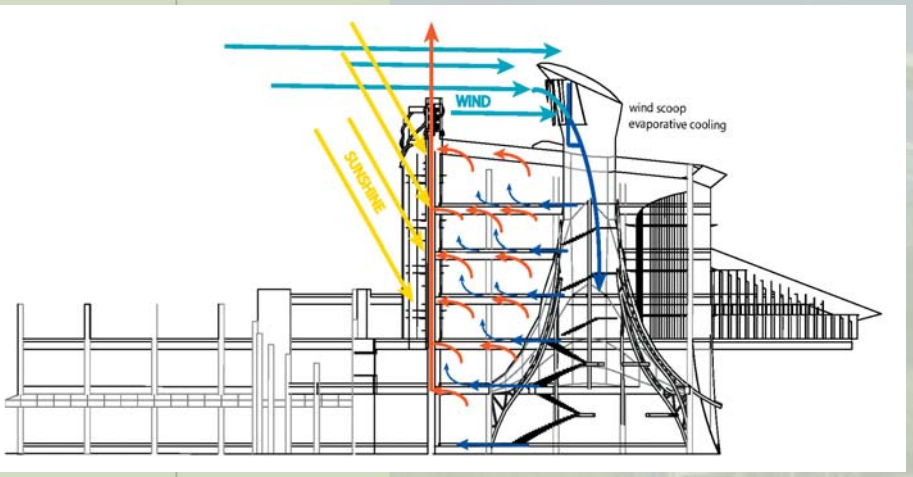
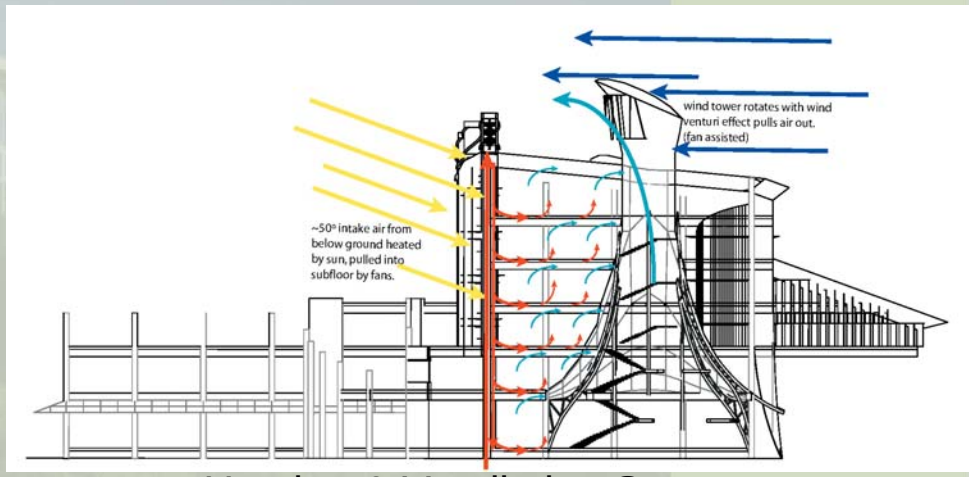


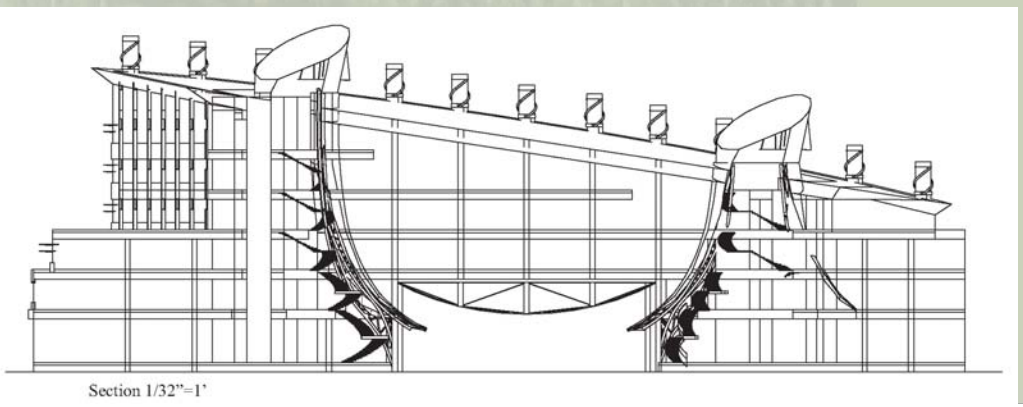
Greenbuilding Studio 2009



Cooling & Ventilation Strategy

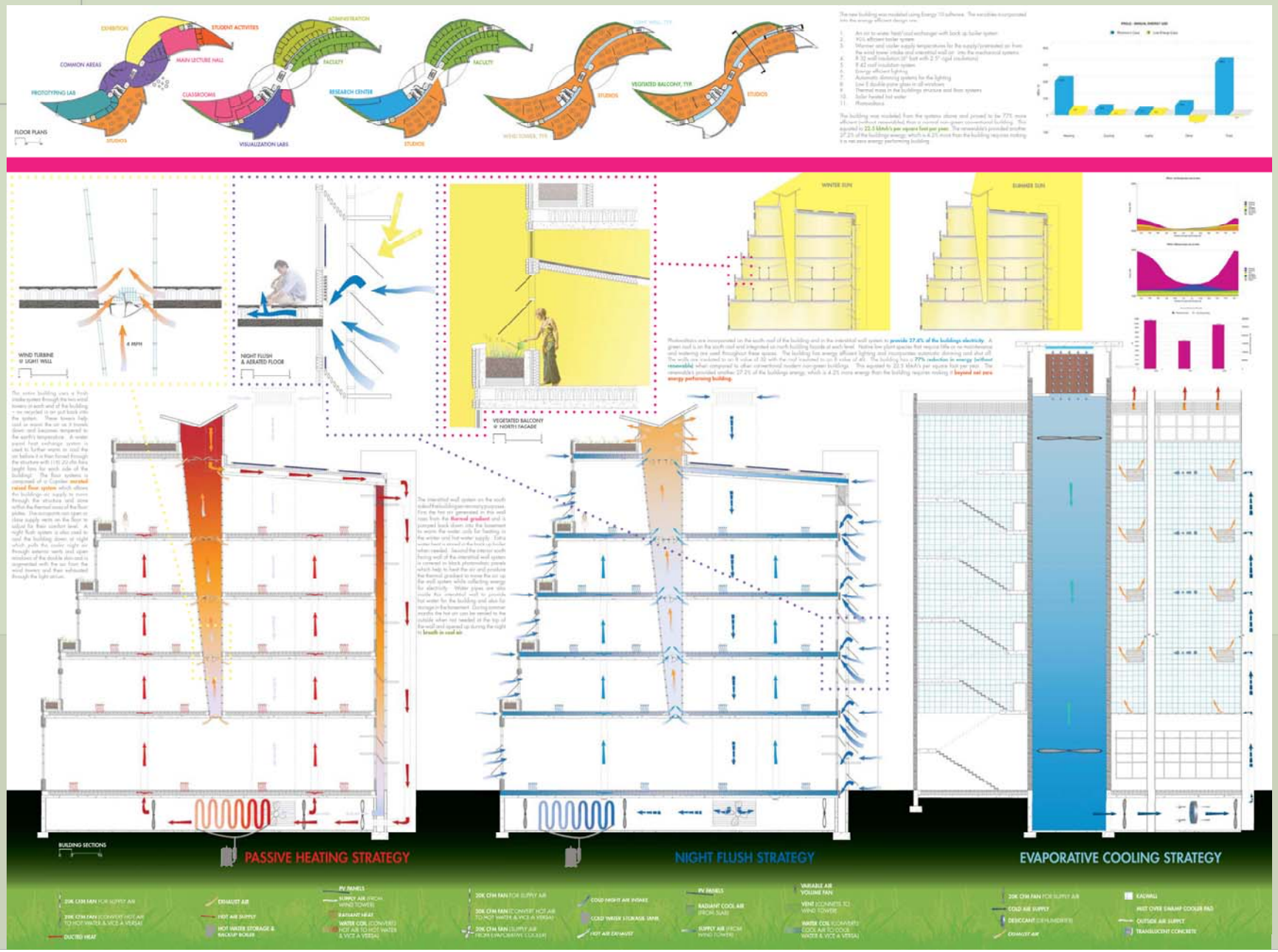


Heating & Ventilation Strategy



Section 1/32"=1'

Greenbuilding Studio 2009



Resource Guides & Research

Green Systems a greenbuilding resource guide

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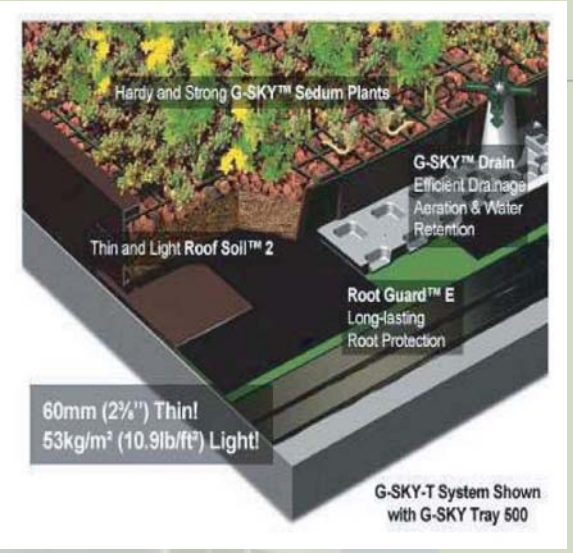
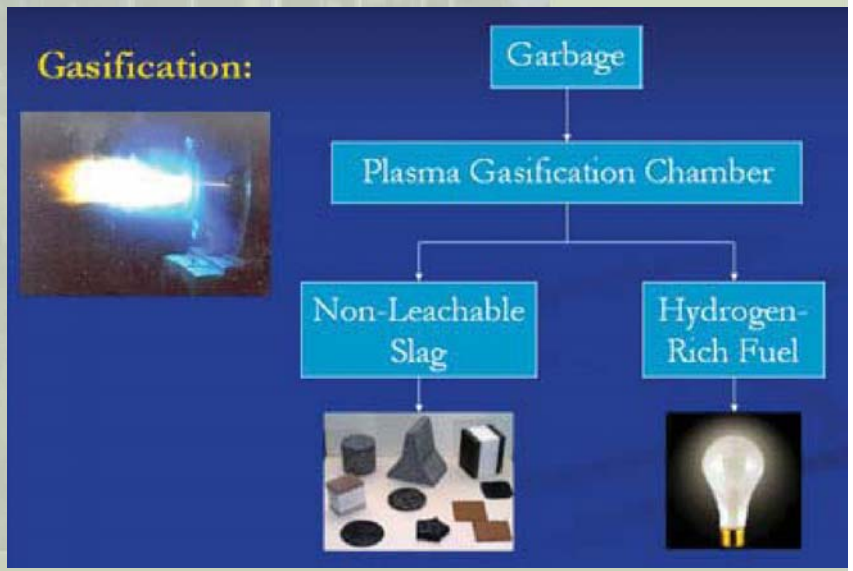


Green Roof Integration



Waste Stream Building Integration

Translucent Walls

Check List

DMCA

Double Skin Facades

Beijing Swimming Center

ETFE Film

Nanogel

Case Study: Beijing National Swimming Center

Overview:
Architects: PTW Architects

Engineers: ARUP

Status: Under Construction – Ready for October 2007

Use: Swimming Center for the 2008 Summer Olympics

Size: The overall size will be 177x177x31m = 70,000m²

Cost: $100,000,000

Facilities: 2 Olympic Pools, 1 Diving Pool, and a Water Park

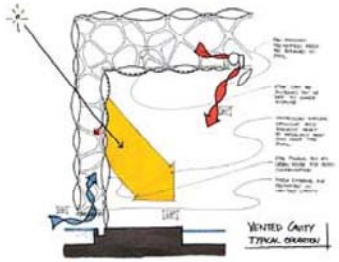
Capacity: 6000 Permanent Seats

11000 Additional Temporary Seats for the Olympics

Issue: Building Skin – Using ETFE Film

Beijing Swimming Center. (The Water Cube)

Skin:
Facts:
-1,0760,000 Square feet of ETFE film cover the building.
-4,000 Bubbles of various sizes.
-Designed to react to lighting and projection.
-This state-of-the-art material provides a cost-effective cladding solution
-Extremely low energy consumption during manufacturing process of ETFE
-Complete system weighs between 50 -90% less than systems of other materials.
-The entire system can be recycled.

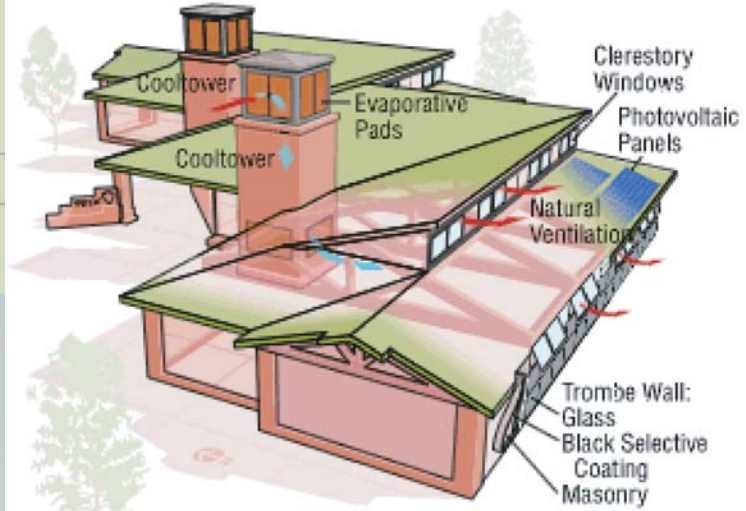


Energy:
The Beijing National Swimming Center (The Water Cube) is designed to act as a greenhouse

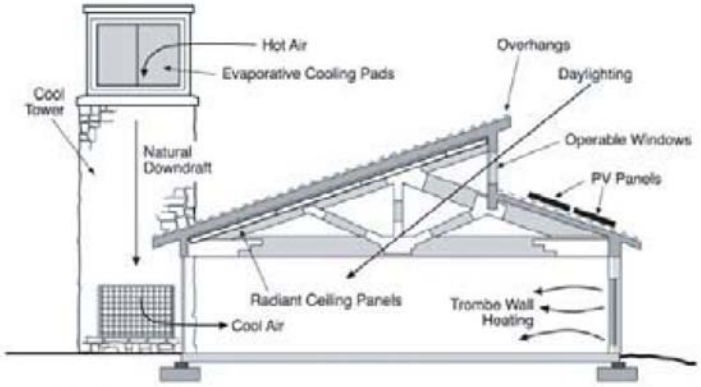
- 90% of the ambient solar energy will be used to passively heat the building and pools.
- Will reduce the energy consumption in the building by 30%.
- 55% savings on lighting energy during the day
- Heat recovery system integrated into the design.
- Heat loads are minimized in the summer, and maximized in the winter by ventilating the heat out of the wall cavity in the summer and containing it in the winter.

Translucent Walls

LEED Credits:
EA Credit 1
EQ Credit 8.1



(d) Diagram of Zion National Park Visitor's Center Sustainable Systems - Note the cooltower with evapoative cooling pads



Source: NREL and NPS drawings.

(e) Diagram of Zion National Park Visitor's Center cooltower with evapoative cooling pads

Photovoltaics: Embodied Energy & New Technology

Check List

- definition
- cost
- maintenance
- properties
- lifecycle
- **embodied energy**
- health
- benefits
- disadvantages
- final analysis

Zero Energy Media Wall - is a groundbreaking project applying sustainable and digital media technology to the curtain wall of Xicui entertainment complex in Beijing, near the site of the 2008 Olympics. Featuring the largest color LED display worldwide and the first photovoltaic system integrated into a glass curtain wall in China, the building performs as a self-sufficient organic system, harvesting solar energy by day and using it to illuminate the screen after dark, mirroring a day's climatic cycle.

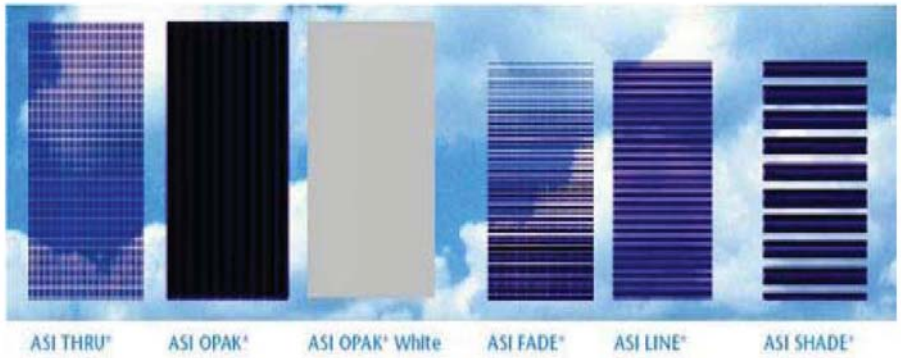
The polycrystalline photovoltaic cells are laminated within the glass of the curtain wall and placed with changing density on the entire building's skin. The density pattern increases building' s performance, allowing natural light when required by interior program, while reducing heat gain and transforming excessive solar radiation into energy for the media wall.

Solar Tree, created by Ross Lovegrove, was developed and produced by Artemide in collaboration with Sharp Solar, world leader in solar cells production. This revolutionary urban lighting project works with the most advanced solar technology respecting not only environmental issues but also cultural and social aspects of today's world. Solar Tree demanded very complex studies and analyses which Artemide has conducted with great commitment and sensitivity regarding ecological demands.
Lovegrove's innovative lighting project, the "Solar Tree," is a solar-powered streetlamp that also serves as a piece of modern art, infusing a bit of nature into the usually gray urban landscape.
Solar trees are able to provide enough light during the night-time even when the sun did not show for as much as four days in a row.

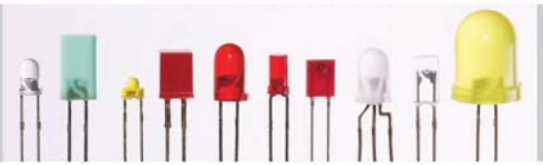
thin film technology

Example Products

Schott
ASI glass system



SUSTAINABLE LIGHTING



Check List

definitions

cost

maintenance

properties

lifecycle

embodied energy

health

benefits

disadvantages

final analysis

OLED Technology

Organic Roadmap (OLED)' "

Attribute	State of the Art	Target	Comments
Luminous Efficacy (lm/W) and Brightness (cd/m²)	White: 20, 1080	White: 150,	Combines electrical to optical power conversion with the ability of the human eye to detect. The real idea is to match emitted light with this response curve. *Is 200 lm/W really necessary?*
Lifetime (khrs to 50% degeneciation)	10	>100	Big challenge for OLEDs as they suffer a "steady, monotonous, irritating" degradation.
Flux/Lamp (lm/lamp)	Depends upon size	Depends upon size	OLEDs have an inherent advantage in that they are manufactured in "sheets" and therefore emit diffuse light.
Purchase Cost ($/m²)	>120	30	Combined with ownership to be competitive with fluorescent lamps.
Ownership Costs ($/Mlm-hr)	16.00	0.63	Cost of ownership = cost of capital + cost of operating. SSL is expected to overtake incandescent in 2005 and fluorescent in 2010. Note that at the limit, all costs are driven by operating costs. *What if operating costs were minimal?*
Color Rendering (CRI)	75	>90	Again, here the tradeoffs of quality vs. flexibility will be important.
			But, if the light is very flexible and has the ability to integrate with other materials, how important is CRI?
Color Temperature (CT) (°K)	3900	3900	Similar to LEDs – color temperature is addressable by combining different colors.

Organic SSL Advantages and Challenges

Organic LED Advantage	Comment
Simple and elegant	Light, designed by nature.
Flexibility. Thin.	OLEDs are amorphous and bendable. Embeddable in glass, metal and silicon.
Cool operation.	Safe. As with displays, these light emitters are cool to touch and harmless.
Transparent.	Transparent to their own radiation. Allows monochrome layers to be manufactured to create white light.
Small sizes. Lightweight.	Flexible form factors, no luminaries.
Environmental advantages	No mercury (0.5% of mercury released in 1999 from lighting). Ability to free over 125 GW of power (125 large power plants) and reduce CO_2 emissions by 200 million tons per year. Advantages are offset by issues in SSL manufacturing process.
Low turn on voltages	3 volts and lower.
Color Changing Capability	Using RGB emitters and intensity control, programmers can control lighting color and CRI.
Highly efficient electron to photon conversion	80% efficiencies have been demonstrated.

Organic LED Challenge	Comment
Lifetime	About one order of magnitude increase is needed *to compete with traditional lighting.*
More brightness	Relatively dim.
Packaging and encapsulation	OLEDs are very sensitive (darken) to moisture (they are a better indicator than currently available moisture detectors).
Edge emission	Much of the light "leaks" out of the edges of the package.
Color and color rendering	Multiple methods exist to generate white light. Unclear which will prevail.
Efficiency	Needs to be increased to 40% from 5%.
Manufacturing costs	Need to continue to decrease.
Materials	Increased *stability.*
Processing	Drive toward bulk roll processing.

OLED Future

"And, with thin-film flexible organic materials, computational circuits may dissolve into the products they control. Why have separate silicon driver circuits for an OLED display when the computer itself can be integrated into the display? Although it is unclear whether small molecule or polymer technologies (or both) will prevail, organic circuits are becoming a reality. 19 The only hanging question is in which lighting applications they will begin to disrupt first."

Edward A Dowdell, "Technology Migration and Distribution: A Case Study of the Solid State Lighting Industry."

http://dspace.mit.edu/handle/1721.1/29743?show=full

SOLID STATE

OLEDs
Roadmap
Advantages
Challenges
Future

MICROGRID & SMART GRID TECHNOLOGY

Check List

definitions

cost

maintenance

properties

lifecycle

embodied energy

health

benefits

disadvantages

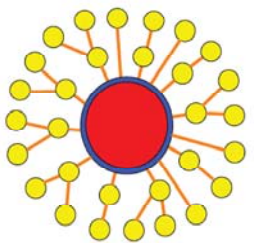
final analysis

MICROGRID & SMART GRID TECHNOLOGY

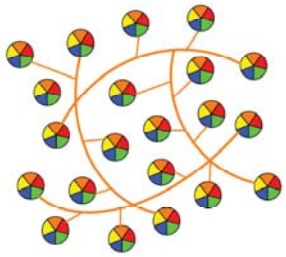
Properties

PROPERTIES

A large Utility Grid has five basic components: Generation, Distribution, Consumption, Management, and potentially some level of Storage. A Microgrid has all of the same components in a much smaller more localized package.



Current Grid



Micro- Grids

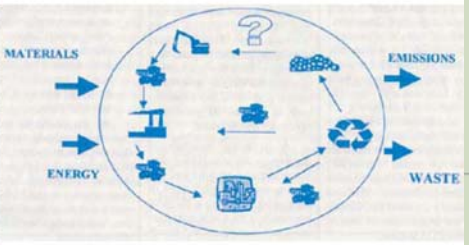
Generation Distribution Management Storage Consumption

GENERATION

A micro-grid may have single or multiple sources of internal energy generation. These will ideally be sustainable technologies such as, solar, wind, biomass, micro-hydro, etc... but may be supplemented by diesel, or natural gas based generation. The use of imported energy sources like fossil fuels will probably be eliminated over time due to cost and reliability issues. Generation sources will not only provide energy but information regarding their status, efficiency, capacity and history.

Photo Above: Bronsbergen Microgrid, Zutphen, the Netherlands, 108 homes fit with 315 kW capacity PV

LCA - BEES Calculation



Check List

cost

maintenance

properties

lifecycle

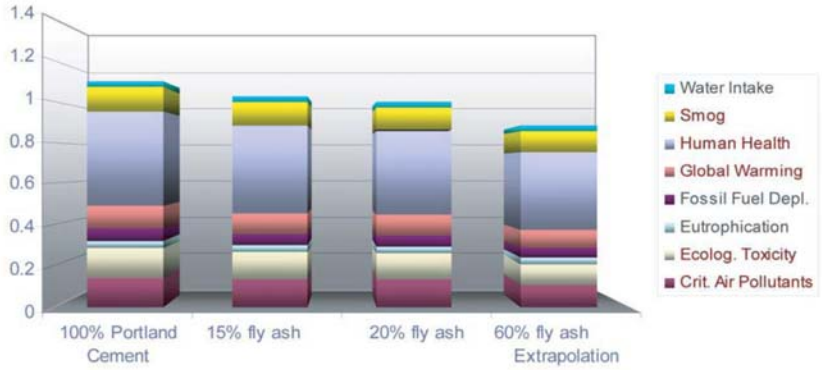
embodied energy

recycling

health

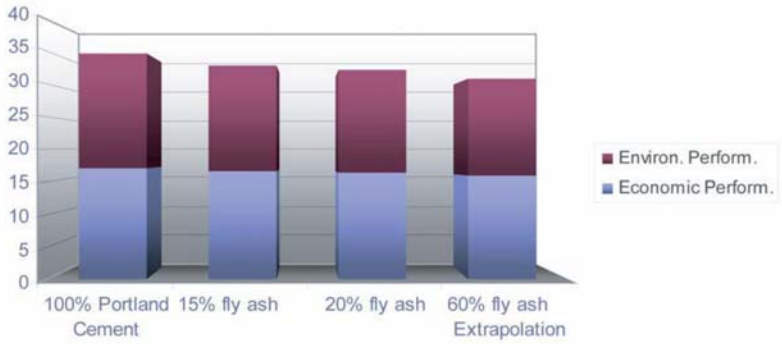
benefits

disadvantages



Beam 4ksi Environmental Performance

*Lower Values show better Performances
*Lower Strength Cement shows better performance (comparing to 5ksi)



Beam 4ksi Overall Performance

Environmental and Economic performance are combined into an Overall performance measure. Adding additional fly ash won't increase the cost.

Greener CONCRETE: SCM's

csi 03000

group D

Barriers to the AIA SustAIAnability2030 message

AIA National's Role In Sustainability …….

Carbon neutral?

Zero carbon?

Zero energy?

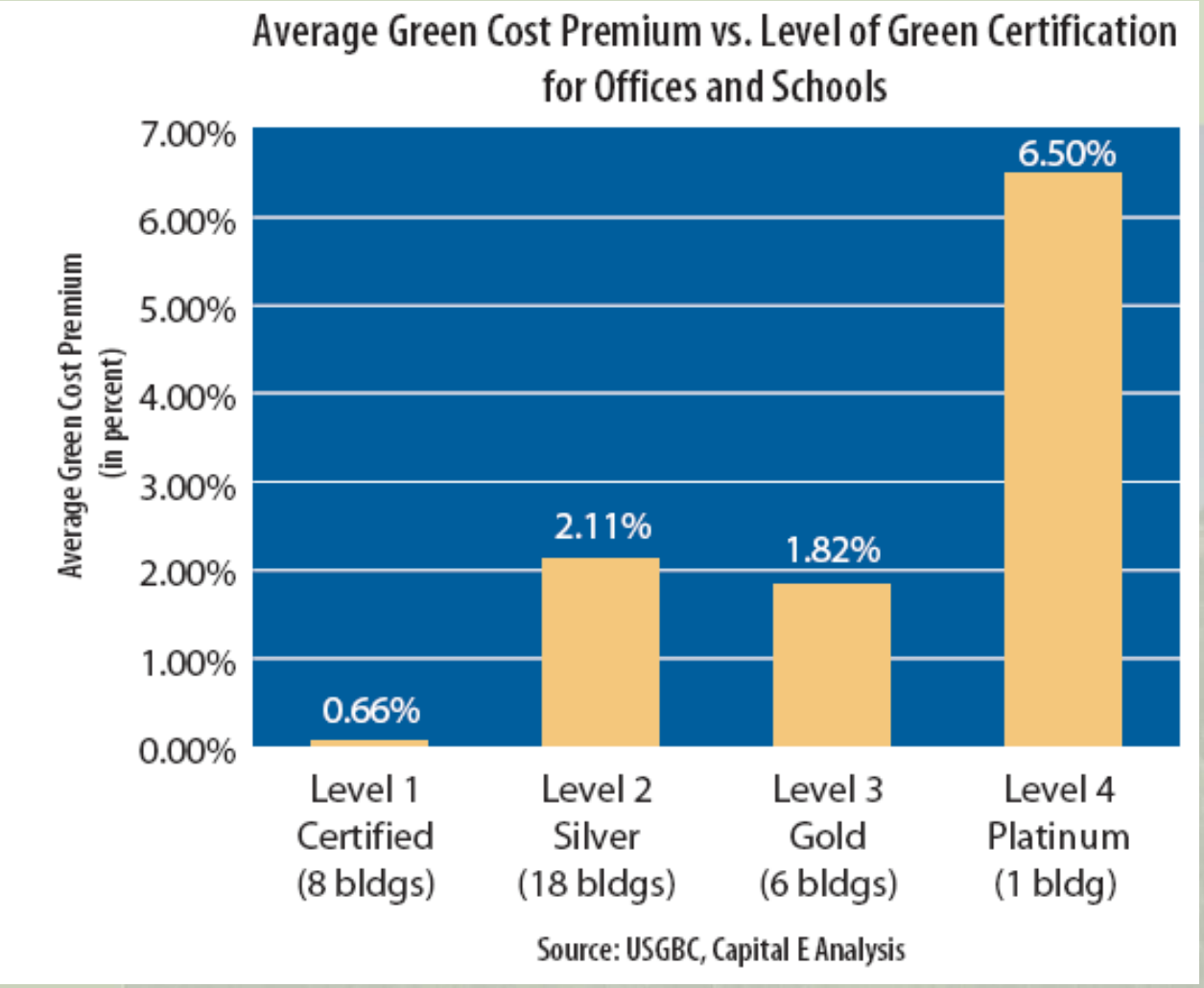
KBtu's/sf/year?

Site vs Source?

Carbon trading?

Confusing jargon!!!

Green Cost Premium



Solar Umbrella House

Pugh + Scarpa Architects

Venice, CA

’07 COTE Top Ten Winner

These panels provide 95% (soon to be 100%, they are adding more) of the house’s electricity and provide shading for indoor and outdoor spaces.

The photovoltaic panels on the top and side are used as an expressive and transformative part of the design.

The pool in the foreground is part of the house’s storm water retention system.

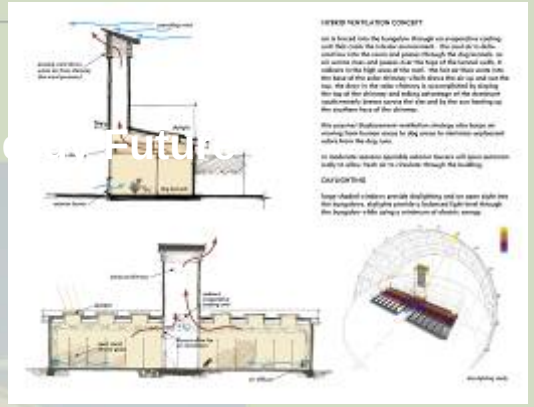
’07 COTE Top Ten Winner

Regional Animal Campus

Tate Snyder Kimsey Architects

Las Vegas, NV

Evaporative cooling is mixed with natural ventilation



The jury loved this unusual project

They achieved 81% energy reduction, 28% of needs provided by PVs, with a future wind farm planned

’07 COTE Top Ten Winner

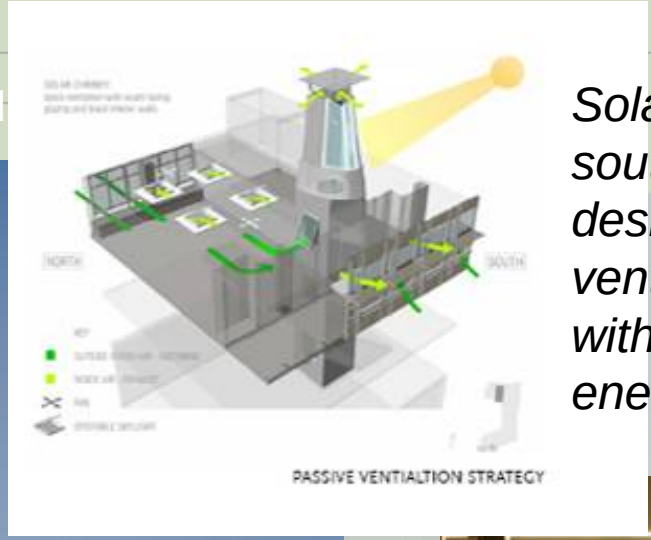
Sidwell Friends School

Kieran Timberlake Architects

Washington, DC

Designed to demonstrate an “ethical relationship between the natural and the built environment”

Measure 1: Sustainable Design Intent and



Solar chimneys with south-facing glass are designed for passive ventilation, operating without additional energy

Vertical slats at an angle are calculated to balance daylight and heat gain & maximize times when building does not need to rely on systems

’07 COTE Top Ten Winner

Heifer International

Polk Stanley Rowland Curzon Porter

Little Rock, AK

Deep balconies at ends shade from low sun on east and west

Most of the water from the roof is kept on site in the tank you can see in the glass tower -- the stairs wrap around it

Land reclamation -- it is a brownfield site that they cleaned

Greenbuilding Initiatives

High Performance Design

Presented by:

Fred Andreas AIA LEED AP

UNiT design studio

sustainable urban design and architecture