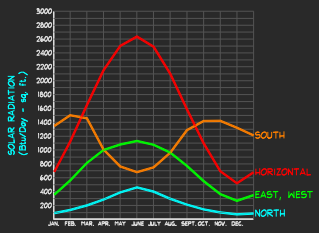

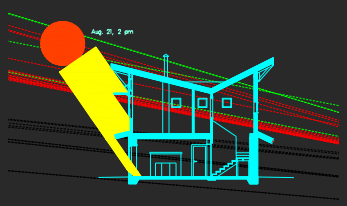

Energy Efficiency, Green Building, & the Integrated Design Process

Climate Change: Science & Society
Nov. 20, 2008

HIGH PLAINS ARCHITECTS

What is Green Building?

- Not a "style" of architecture (*eg.* Victorian or Modernist)
- Does not necessarily involve green paint
- Rather, Green Building is a philosophy on how to build, rooted in the belief that environmental destruction and health problems are not a necessary outcome of constructing and operating buildings.

Green Building is a holistic approach, considering:

- Energy
- Water
- Materials
- Indoor Environ. Quality
- Reducing Auto Dependence

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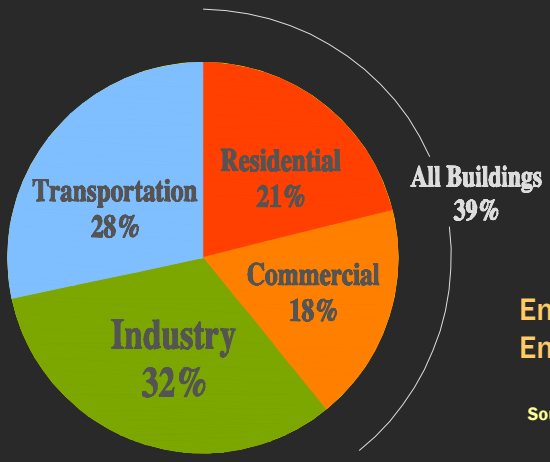
Nov. 20, 2008

HIGH PLAINS ARCHITECTS

Some Context for Green Building



Energy Use in U.S. by End Use Sector

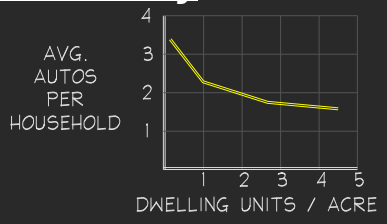
Source: US Energy Information Agency

Climate Change: Science & Society
Nov. 20, 2008

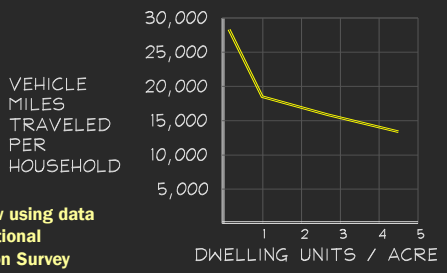
HIGH PLAINS ARCHITECTS

Relationship of Transportation & Neighborhood Density

Fewer cars per household in compact neighborhoods...



...and fewer vehicle miles traveled.



Source: John Holtzclaw using data from 1992 US DOT National Personal Transportation Survey

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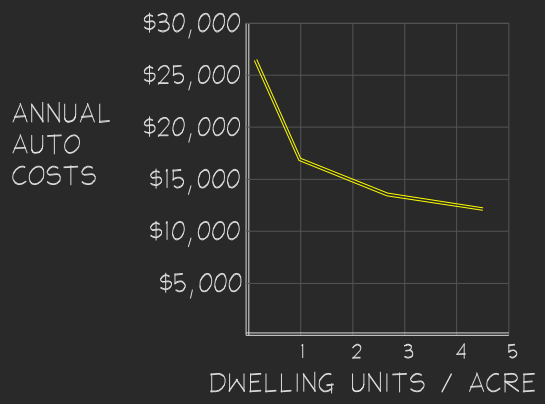
HIGH PLAINS ARCHITECTS

Relationship of Transportation & Neighborhood Density

Transportation costs decrease with compact communities

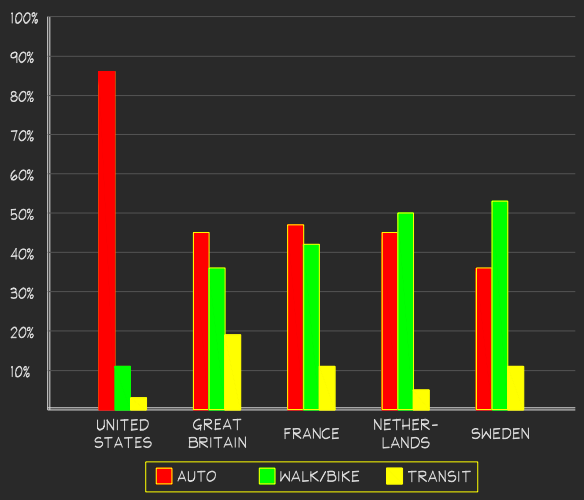


Source: Gulick, using John Holtzclaw data from 1992 US DOT National Personal Transportation Survey; Auto costs updated to reflect $5/gal gas

HIGH PLAINS ARCHITECTS

Relationship of Transportation & Neighborhood Density

Mode Split as % of Total Trips...



Source: Peter Calthorpe, The Next American Metropolis, 1993

HIGH PLAINS ARCHITECTS

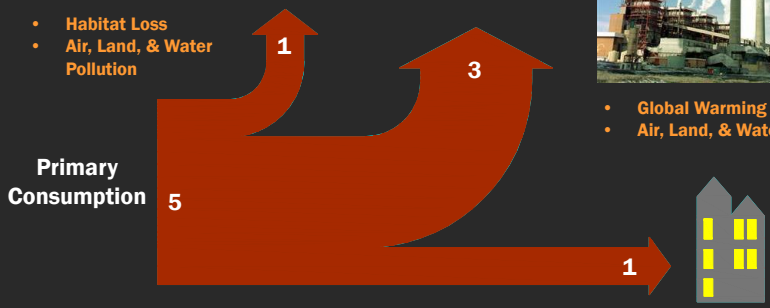
Green Building
Focuses on End Use

- Habitat Loss
- Air, Land, & Water Pollution

Extraction & Refining Losses

Generation & Transmission Losses

- Global Warming
- Air, Land, & Water Pollution



Analogous Diagram for Building Materials

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HIGH PLAINS ARCHITECTS

Fine Cuisine

1) Quality Ingredients

Green Building

1) Quality "Green" Materials & Products:

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Nov. 20, 2008

HIGH PLAINS ARCHITECTS

Material & Product Certification Programs

- Provide third party verification for end user
- Give recognition & market differentiation to suppliers that achieve higher standards

Energy Efficiency	Recycled Content	Product Air Emissions	Sustainably Harvested Lumber	Non-toxic Ingredients

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Nov. 20, 2008

HIGH PLAINS ARCHITECTS

Fine Cuisine

1) Quality Ingredients

2) Good Recipe

Green Building

1) Quality "Green" Materials & Products

2) Good Design

How the materials and products are configured is critical!

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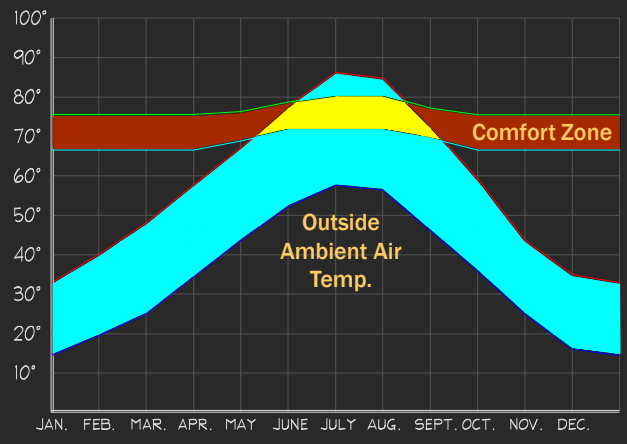
HIGH PLAINS ARCHITECTS

Energy Fundamentals: Comfort Zone



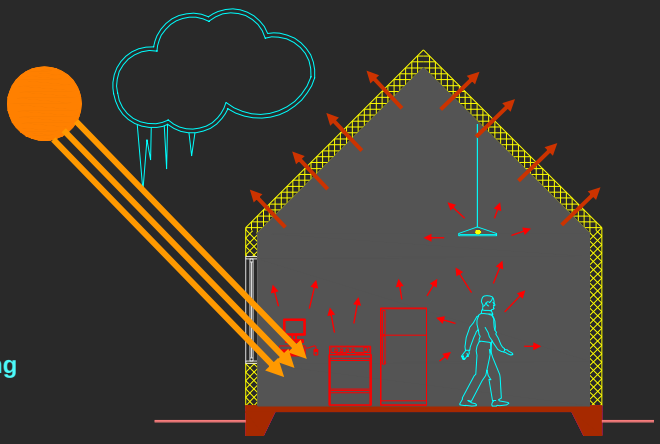
HIGH PLAINS ARCHITECTS

Energy Fundamentals: Heat Transfer

Variables

- Climate
- Sun
- Lighting
- Equipment
- Occupants

The Art of Green Building is balancing these variables to advantage.



HIGH PLAINS ARCHITECTS

Energy Strategy

1. Optimize building envelope to reduce demand for energy
   - Passive Solar Design
   - High levels of insulation
   - Daylighting
   - Natural ventilation
2. Recycle waste heat flows
   - Heat exchangers
3. Supply remaining demand for lighting, heating, & cooling with highly efficient electrical & mechanical systems
   - Radiant floor heating
   - Evaporative cooling
   - Daylight sensors for lighting
4. Maximize % of energy supply from renewable sources
   - On-site photovoltaic system
   - Off-site renewable energy credits
   - Solar hot water

HIGH PLAINS ARCHITECTS

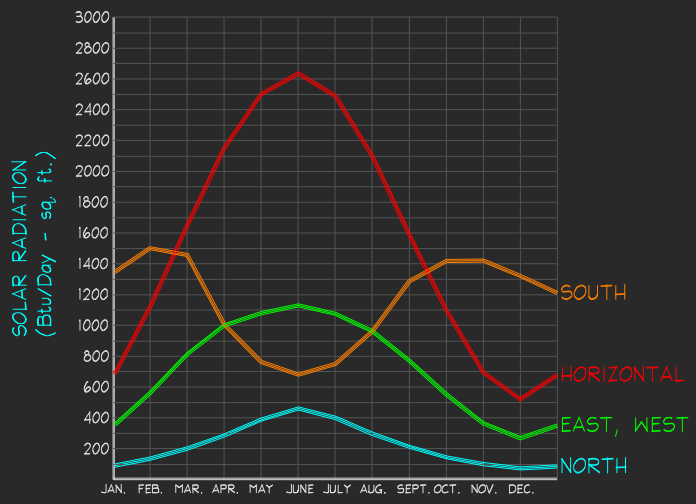
Some Models for Inspiration…

Clipper Ship: 250 ft. long, 2,300 ton displacement
Design cleverly manipulates natural energy flows to propel ships 15-20 knots

Termite Mound: design uses solar gain, ventilation, & metabolism to maintain temperature range of 85-87 deg. F for fungi and egg production;

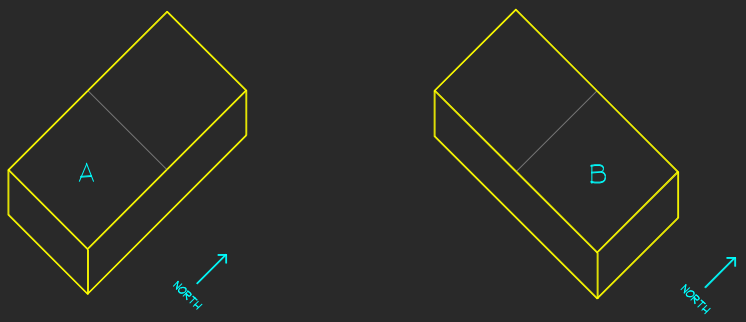
HIGH PLAINS ARCHITECTS

Solar Insolation @ 46 deg. N.



HIGH PLAINS ARCHITECTS

Building Orientation



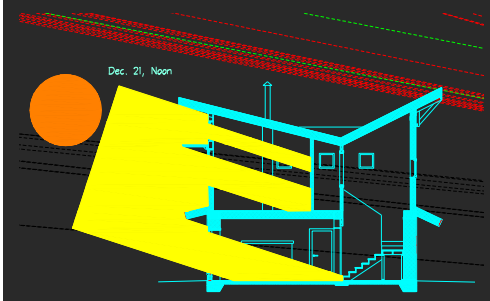
Two buildings identical in size but different in orientation.

- **Building 'B' receives 25% more solar energy on walls in January**
- **Building 'B' receives 18% less solar energy on walls in July**

HIGH PLAINS ARCHITECTS

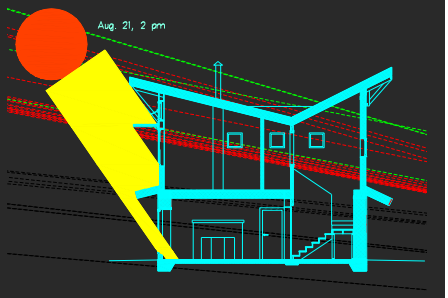
South Façade Design

Section



Admit winter sun through south-facing windows

Section

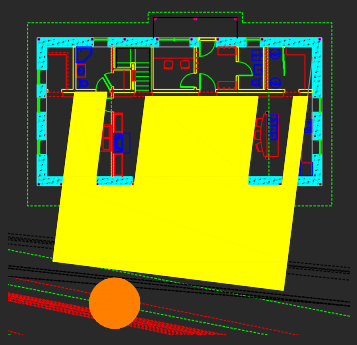


Shade windows from summer sun

HIGH PLAINS ARCHITECTS

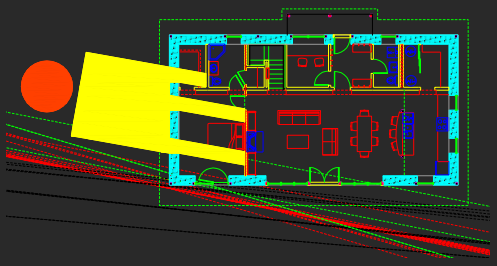
Window Size

Plan



Admit winter sun through large south-facing windows

Plan



Use small windows on east and west walls to limit admittance of low angle summer sun.

HIGH PLAINS ARCHITECTS

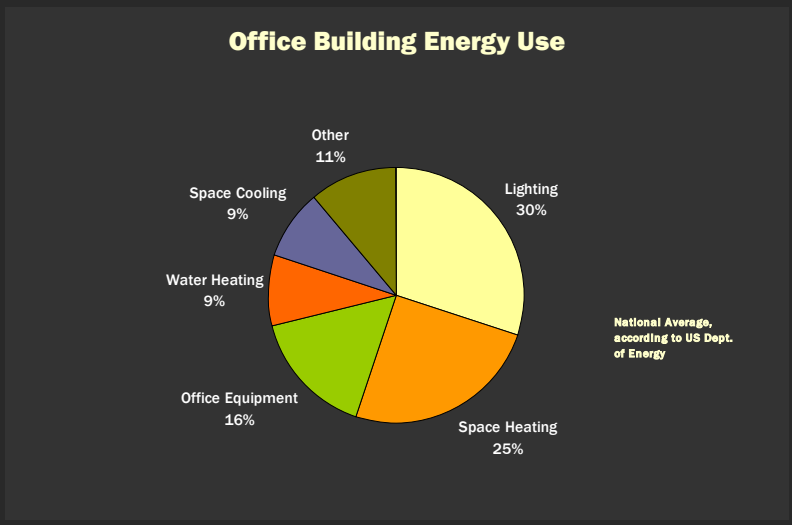
Super-insulated building envelope

Effective insulations that minimize *both* air infiltration & thermal conduction:

- Structural Insulated Panels (SIPs)
- Stabilized cellulose
- Water-based polyurethane foam
- Plastered straw bale

HIGH PLAINS ARCHITECTS

Context for Daylighting



HIGH PLAINS ARCHITECTS

Other Daylighting Aspects

Stapleton Building - Billings, MT

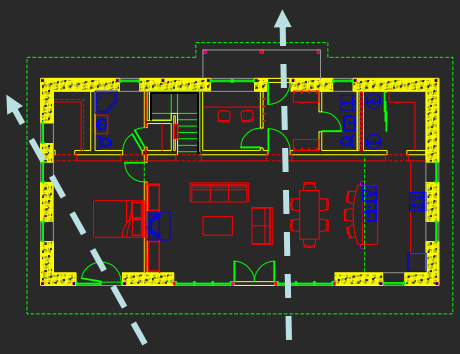
Research confirms daylighting benefits:

1. 7-18% improvement on student test scores (comparing schools with most daylight vs. those w/ least in study)*
2. 31-49% higher sales per square foot (comparing stores with & without skylight daylighting in study)**
3. Office workers with good views—particularly vegetation—have 10-25% better memory recall (comparing offices with best views vs. offices without any views in study)***

*Daylighting in Schools, Heschong Mahone Group, 1999
**Skylighting & Retail Sales, Heschong Mahone Group, 1999
***Windows & Offices, Heschong Mahone Group, 2003

HIGH PLAINS ARCHITECTS

Natural ventilation



An effective night ventilation design eliminates need for costly air conditioning.

General rules of thumb:

1. Provide operable windows in all rooms
2. If possible, provide windows on two walls for cross ventilation in bedrooms
3. Night ventilation strategy: close windows in morning, open at night
4. Stack ventilation strategy: provide operable skylight, window, or exhaust fan in high space

HIGH PLAINS ARCHITECTS

Natural ventilation, continued

Research regarding operable windows

1. 1 - 11% increase in productivity for occupants who can control ventilation*
2. Increase in comfort zone for occupants who can operate windows**
3. 3.2% lower absenteeism in naturally ventilated buildings compared to mechanically ventilated buildings

*Estimates of Improved Productivity and Health from Better Indoor Environments, Fisk, W.J. & Rosefeld, A.H., 1997

**Developing an Adaptive Model of Thermal Comfort and Preference, de Bear, R., Brager, G., & Cooper, D. 1997

***The Impact of Different Ventilation Levels and Fluorescent Lighting Types on Building Illness, Sterling, E. & Sterling, T. 1983

HIGH PLAINS ARCHITECTS

Efficient Mechanical Systems

Energy Strategy:

1. Minimize energy demand with steps 3), 4), and 5)
2. Supply remaining energy needs with very efficient systems:

- Radiant floor heating (20% more efficient than air-based system)
- Evaporative cooling (400-500% more efficient in Montana's dry climate)

HIGH PLAINS ARCHITECTS

Renewable Energy

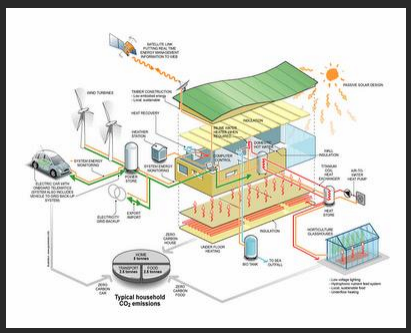
Renewable Strategy:

1. Design roof for solar orientation
2. Optimize mechanical systems for solar hot water heating
3. Make provision for both plumbing and electrical conduit to roof
4. Take advantage of current incentives for photovoltaic and solar hot water panels

HIGH PLAINS ARCHITECTS

Integrated Design Process

All decisions made about component parts affect the whole; optimize the system, not its parts.



- End Use/Least Cost Planning
- Performance Goals
- Whole Systems Design

HIGH PLAINS ARCHITECTS

Integrated Design Process

Conventional Approach

- Building treated as a series of unrelated components
- Architect & Engineers have linear relationship
- Design building to meet prescriptive building codes
- After designed & built, "find out" how much energy it consumes

Green Approach

- Building treated as a system—components are inter-related *(building as ecosystem)*
- *Architect & Engineers have dialogical relationship*
- Develop performance goals before design
- Design building accordingly to meet performance goals

HIGH PLAINS ARCHITECTS

End Use / Least Cost Planning

Providing Comfort:

Air conditioning

vs. Passive design

Growing Sanitation Needs:

Increasing sewer & water treatment

vs. Reducing water demand w/ efficiency

Transportation Convenience:

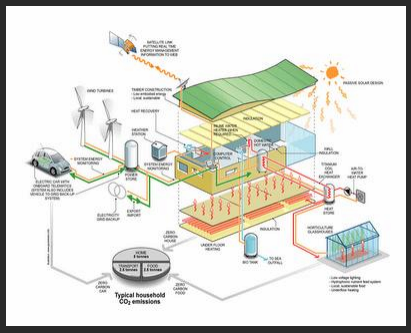
Big parking lots

vs. Mixed use development

HIGH PLAINS ARCHITECTS

Performance Goals

Set performance goals *BEFORE* starting design



For Example:

- No air conditioning
- 25% more efficient than building codes
- Energy Star® or LEED® certification

HIGH PLAINS ARCHITECTS

LEED® can provide guidance…

USGBC

"The U.S. Green Building Council (USGBC) is a non-profit composed of leaders from every sector of the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work."

LEED

"The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings."

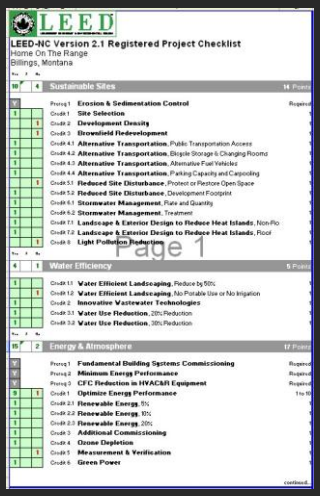
HIGH PLAINS ARCHITECTS

LEED rating system

Sustainable Sites

Water Efficiency

Energy & Atmosphere


LEED

LEED-NC Version 2.1 Registered Project Checklist

Home On The Range

Billings, Montana

Sustainable Sites 14 Points

Prereq 1 Erosion & Sedimentation Control Required

Credit 1 Site Selection

Credit 2 Development Density

Credit 3 Brownfield Redevelopment

Credit 4.1 Alternative Transportation, Public Transportation Access

Credit 4.2 Alternative Transportation, Bicycle Storage & Changing Rooms

Credit 4.3 Alternative Transportation, Alternative Fuel Vehicles

Credit 4.4 Alternative Transportation, Parking Capacity and Carpooling

Credit 5.1 Reduced Site Disturbance, Protect or Restore Open Space

Credit 5.2 Reduced Site Disturbance, Development Footprint

Credit 6.1 Stormwater Management, Rate and Quantity

Credit 6.2 Stormwater Management, Treatment

Credit 7.1 Landscape & Exterior Design to Reduce Heat Islands, Non-Roof

Credit 7.2 Landscape & Exterior Design to Reduce Heat Islands, Roof

Credit 8 Light Pollution Reduction

Water Efficiency 5 Points

Credit 1.1 Water Efficient Landscaping, Reduce by 50%

Credit 1.2 Water Efficient Landscaping, No Potable Use or No Irrigation

Credit 2 Innovative Wastewater Technologies

Credit 3.1 Water Use Reduction, 20% Reduction

Credit 3.2 Water Use Reduction, 30% Reduction

Energy & Atmosphere 17 Points

Prereq 1 Fundamental Building Systems Commissioning Required

Prereq 2 Minimum Energy Performance Required

Prereq 3 CFC Reduction in HVAC&R Equipment Required

Credit 1 Optimize Energy Performance 1 to 10

Credit 2.1 Renewable Energy, 5%

Credit 2.2 Renewable Energy, 10%

Credit 2.3 Renewable Energy, 20%

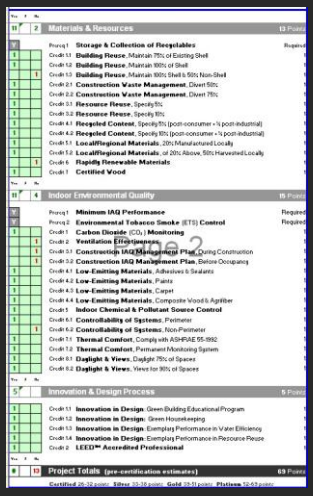
Credit 3 Additional Commissioning

Credit 4 Ozone Depletion

Credit 5 Measurement & Verification

Credit 6 Green Power

continued...


Materials & Resources 13 Points

Prereq 1 Storage & Collection of Recyclables Required

Credit 1.1 Building Reuse, Maintain 75% of Existing Shell

Credit 1.2 Building Reuse, Maintain 100% of Shell

Credit 1.3 Building Reuse, Maintain 100% Shell & 50% Non-Shell

Credit 2.1 Construction Waste Management, Divert 50%

Credit 2.2 Construction Waste Management, Divert 75%

Credit 3.1 Resource Reuse, Specify 5%

Credit 3.2 Resource Reuse, Specify 10%

Credit 4.1 Recycled Content, Specify 5% (post-consumer + ½ post-industrial)

Credit 4.2 Recycled Content, Specify 10% (post-consumer + ½ post-industrial)

Credit 5.1 Local/Regional Materials, 20% Manufactured Locally

Credit 5.2 Local/Regional Materials, of 20% Above, 50% Harvested Locally

Credit 6 Rapidly Renewable Materials

Credit 7 Certified Wood

Indoor Environmental Quality 15 Points

Prereq 1 Minimum IAQ Performance Required

Prereq 2 Environmental Tobacco Smoke (ETS) Control Required

Credit 1 Carbon Dioxide (CO_2) Monitoring

Credit 2 Ventilation Effectiveness

Credit 3.1 Construction IAQ Management Plan, During Construction

Credit 3.2 Construction IAQ Management Plan, Before Occupancy

Credit 4.1 Low-Emitting Materials, Adhesives & Sealants

Credit 4.2 Low-Emitting Materials, Paints

Credit 4.3 Low-Emitting Materials, Carpet

Credit 4.4 Low-Emitting Materials, Composite Wood & Agrifiber

Credit 5 Indoor Chemical & Pollutant Source Control

Credit 6.1 Controllability of Systems, Perimeter

Credit 6.2 Controllability of Systems, Non-Perimeter

Credit 7.1 Thermal Comfort, Comply with ASHRAE 55-1992

Credit 7.2 Thermal Comfort, Permanent Monitoring System

Credit 8.1 Daylight & Views, Daylight 75% of Spaces

Credit 8.2 Daylight & Views, Views for 90% of Spaces

Innovation & Design Process 5 Points

Credit 1.1 Innovation in Design, Green Building Educational Program

Credit 1.2 Innovation in Design, Green Housekeeping

Credit 1.3 Innovation in Design, Exemplary Performance in Water Efficiency

Credit 1.4 Innovation in Design, Exemplary Performance in Resource Reuse

Credit 2 LEED™ Accredited Professional

Project Totals (pre-certification estimates) 69 Points

Certified 26-32 points; Silver 33-38 points; Gold 39-51 points; Platinum 52-69 points

Materials & Resources

Indoor Environmental Quality

Innovation & Design Process

Climate Change: Science & Society

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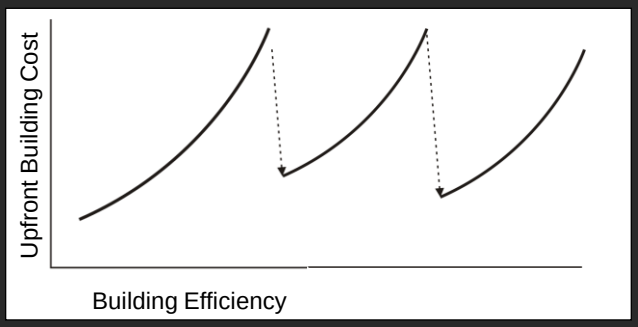
Whole Systems Thinking



"Tunneling through the cost barrier" (Rocky Mtn. Institute)

Climate Change: Science & Society

Nov. 20, 2008

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Integrated Design Attributes:

- Focus on demand as well as supply
- Materials and products do double or triple duty
  - Concrete floors
  - Operable windows
  - Low-e glazing
  - Green cleaning products

HIGH PLAINS ARCHITECTS

Fine Cuisine

1) Quality Ingredients

2) Good Recipe

3) Talented Chef

Green Building

1) Quality "Green" Materials & Products

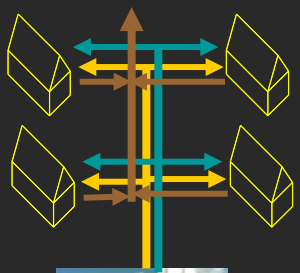
2) Good Design

3) Invested Contractor

HIGH PLAINS ARCHITECTS

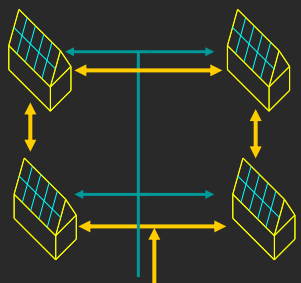
Paradigm Shift: Buildings as both Producers & Consumers

Buildings as units of consumption only



Fat one-way networks

Buildings as units of both consumption & production



Skinny two-way networks

HIGH PLAINS ARCHITECTS

Paradigm Shift: Buildings as both Producers & Consumers

Distributed Generation Benefits
- Reduced transmission losses
- More robust (not as vulnerable to disruption)

Rainwater Collection Benefits
- Reduced energy to pump water uphill
- Match treatment levels to end use

On-site Waste Treatment Benefits
- Eliminate pollution of potable water
- Re-create the nutrient cycle—turn a liability into an asset

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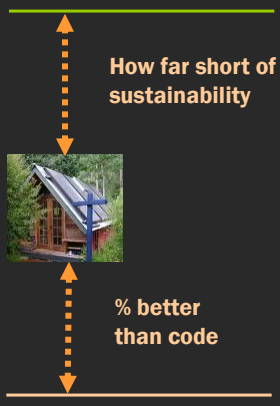
HIGH PLAINS ARCHITECTS

Green Building vs. Sustainable Building



Sustainable Building uses measure of "sustainability" as reference point

eg. Living Building Challenge:
- Build only on previously developed land
- Operate within current solar budget
- No toxic materials like PVC
- Water only from rainwater catchment
- Purchase carbon offsets for materials

Green Building uses "conventional" or current building codes as reference point

HIGH PLAINS ARCHITECTS

Home on the Range

The story of a LEED Platinum certified green building

HIGH PLAINS ARCHITECTS

The Owners…

- Northern Plains Resource Council organizes Montana citizens to protect our water quality, family farms and ranches, and unique quality of life.

- WORC's mission is to advance the vision of a democratic, sustainable, and just society through community action.

…wanted to "live their values."

The existing building…

- Grocery store built in 1940s
- Uninsulated, nearly windowless
- Large walk-in coolers and freezers
- Derelict eyesore when purchased

Integrated Design Process

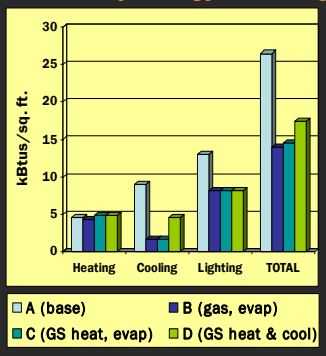
Performance Goals

- Demonstration green building
- LEED certification from US Green Building Council
- Work within tight budget

HIGH PLAINS ARCHITECTS

Energy Strategy

Preliminary Energy Modeling



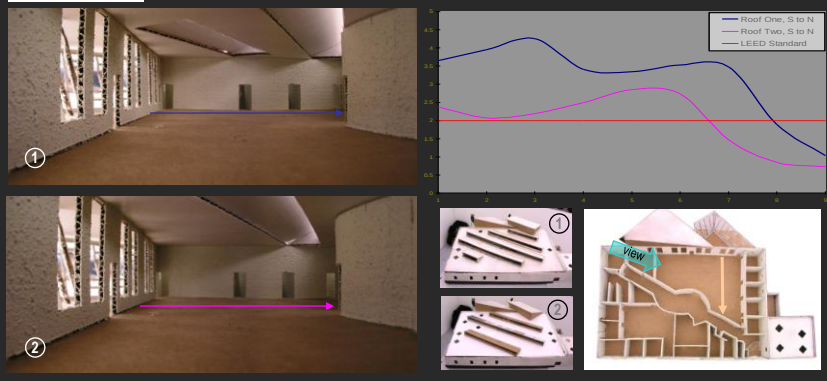
- Energy modeling: tool to achieve performance goals early in design process
- Indicated importance of daylighting strategy

1. Optimize building envelope to reduce demand for energy
   - High levels of insulation
   - Daylighting
2. Recycle waste flows of energy
   - N/A
3. Supply remaining demand for lighting, heating, & cooling with highly efficient electrical and mechanical systems
   - Radiant floor heating
   - Evaporative cooling
   - Daylight sensors for lighting
4. Maximize % of energy supply from renewable sources
   - 9.9 kW photovoltaic system
   - Solar hot water

HIGH PLAINS ARCHITECTS

Design Process: Daylighting

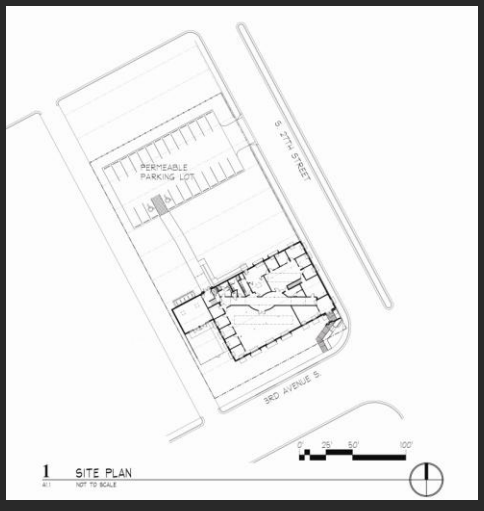
BETTERBRICKS DAYLIGHTING LAB SEATTLE



Daylighting model to test effectiveness of clerestories

HIGH PLAINS ARCHITECTS

Design: Site



- Downtown Billings street grid oriented 35 deg. off of cardinal directions
- Clerestory monitors oriented for maximum daylighting & solar energy
- Parking located away from building

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