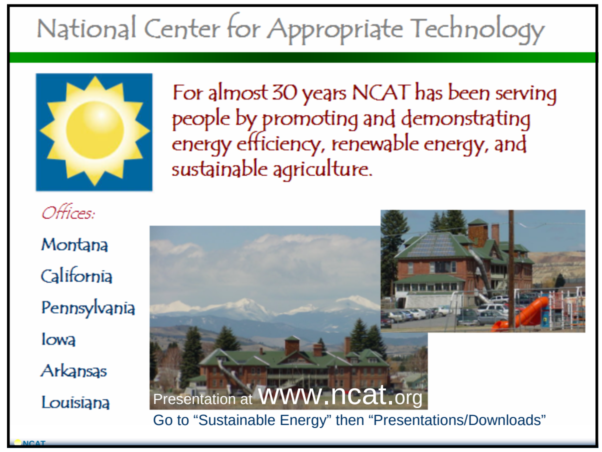

NorthWestern Energy
National Center for Appropriate Technology
Montana Joint Engineers Conference November 2008
Energy Efficiency: The Cornerstone of Green Design
Dale Horton, Architect
Dave Houser, PE


National Center for Appropriate Technology
For almost 30 years NCAT has been serving people by promoting and demonstrating energy efficiency, renewable energy, and sustainable agriculture.
Offices:
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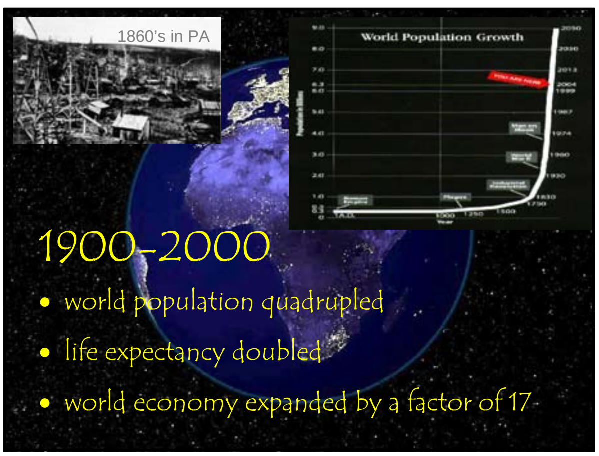
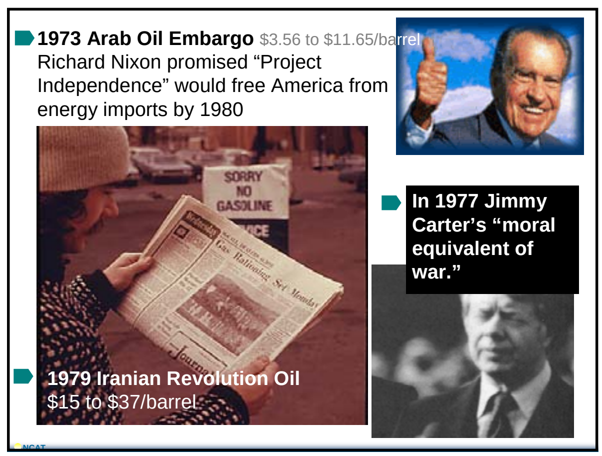
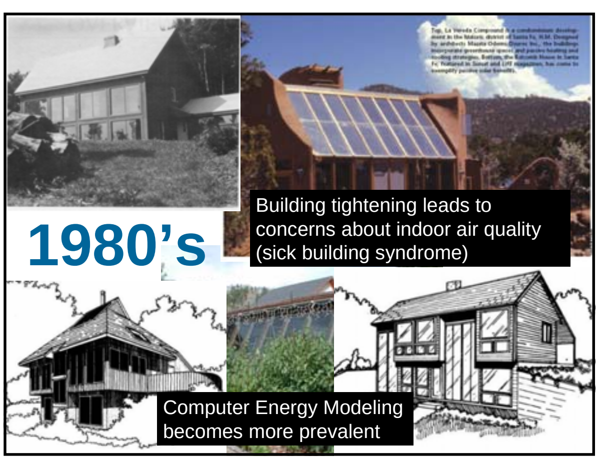
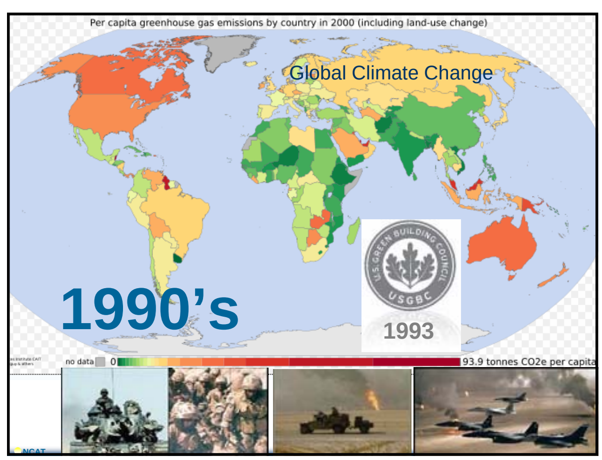
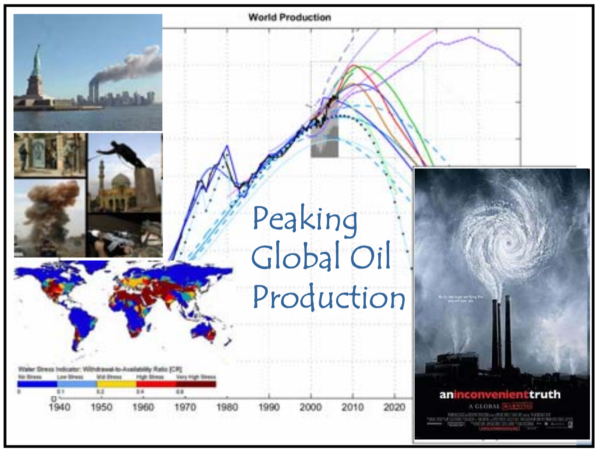
California
Pennsylvania
Iowa
Arkansas
Louisiana
Presentation at www.ncat.org
Go to "Sustainable Energy" then "Presentations/Downloads"

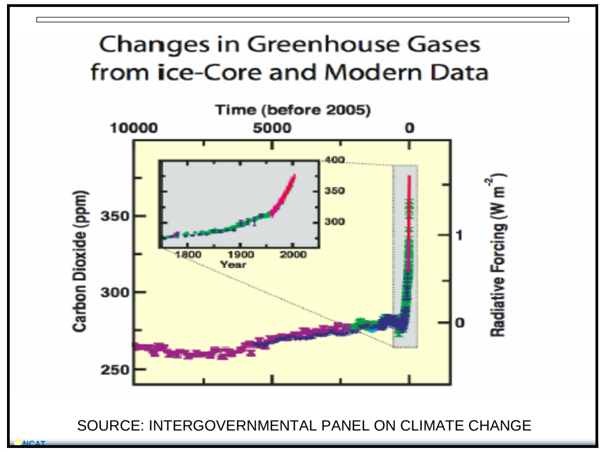

1860's in PA
World Population Growth
1900–2000
• world population quadrupled
• life expectancy doubled
• world economy expanded by a factor of 17


1973 Arab Oil Embargo $3.56 to $11.65/barrel
Richard Nixon promised "Project Independence" would free America from energy imports by 1980
SORRY NO GASOLINE
In 1977 Jimmy Carter's "moral equivalent of war."
1979 Iranian Revolution Oil $15 to $37/barrel

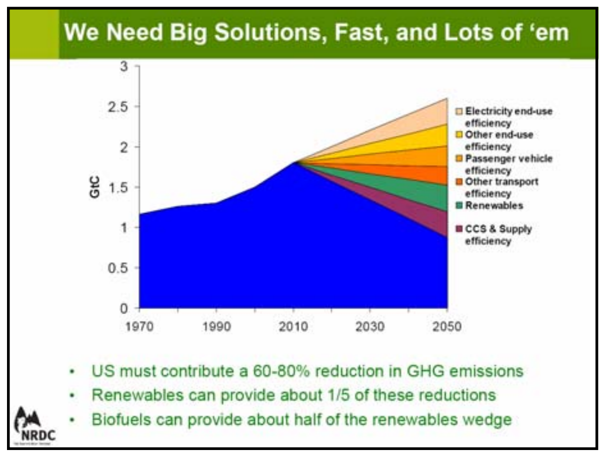

1980's
Building tightening leads to concerns about indoor air quality (sick building syndrome)
Computer Energy Modeling becomes more prevalent


Per capita greenhouse gas emissions by country in 2000 (including land-use change)
Global Climate Change
1990's
1993
no data
0
93.9 tonnes CO2e per capita

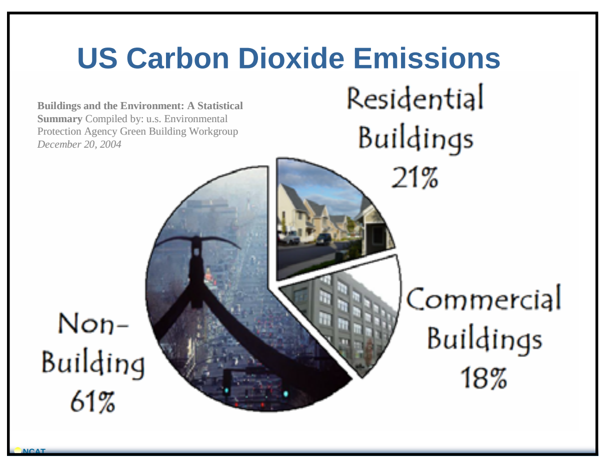

World Production
Peaking
Global Oil
Production
an inconvenient truth
1940
1950
1960
1970
1980
1990
2000
2010
2020

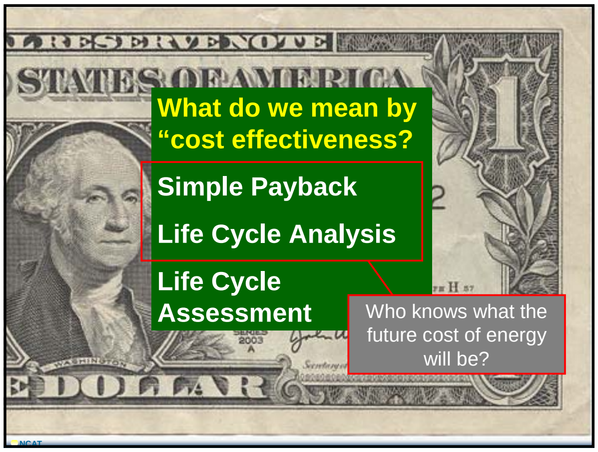

Changes in Greenhouse Gases
from ice-Core and Modern Data
Time (before 2005)
10000
5000
0
Carbon Dioxide (ppm)
Radiative Forcing (W m^{-2})
350
300
250
400
1800
1900
2000
Year
1
0
SOURCE: INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

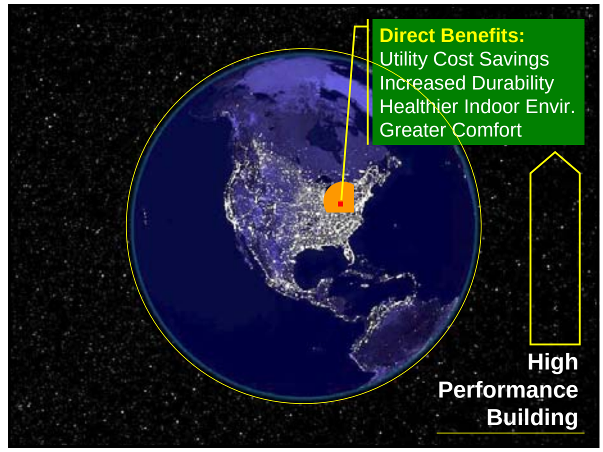

2008
Los Angeles
San Diego
Global Climate Change
The United States accounts for about as many emissions as the former Soviet bloc, the Middle East, Central America, South America, and Africa combined.
SOURCE: THE CONGRESSIONAL BUDGET OFFICE

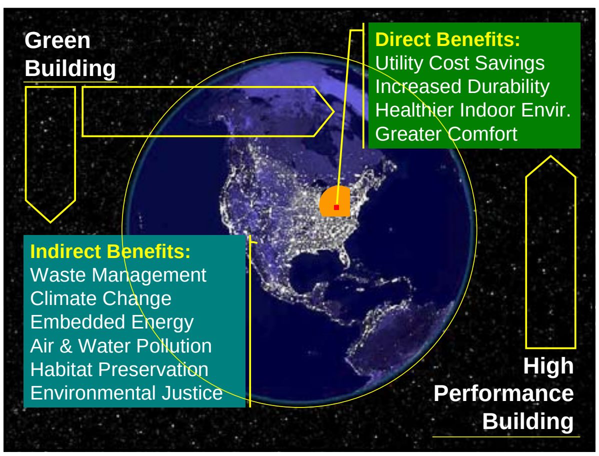

We Need Big Solutions, Fast, and Lots of 'em
GtC
3
2.5
2
1.5
1
0.5
0
1970
1990
2010
2030
2050
Electricity end-use efficiency
Other end-use efficiency
Passenger vehicle efficiency
Other transport efficiency
Renewables
CCS & Supply efficiency
US must contribute a 60-80% reduction in GHG emissions
Renewables can provide about 1/5 of these reductions
Biofuels can provide about half of the renewables wedge
NRDC

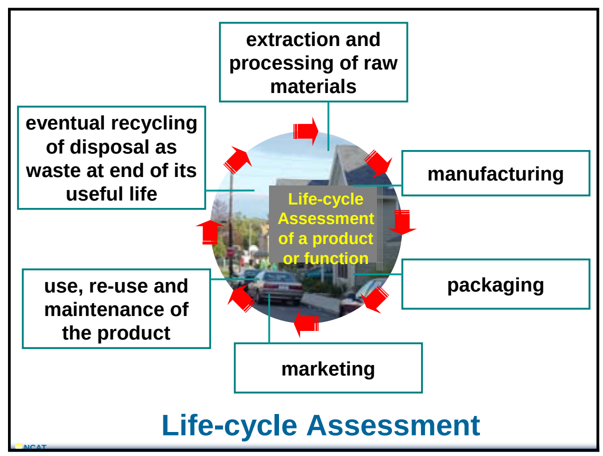

In the US buildings account for:
65% of electricity consumption
36% of energy use
30% of raw materials use
30% of waste output
12% of potable water consumption

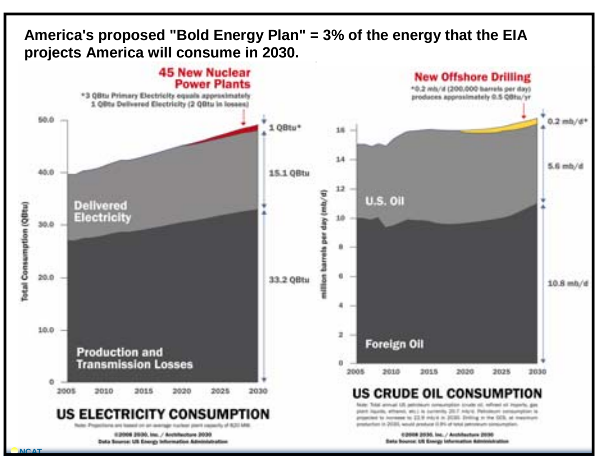

US Carbon Dioxide Emissions
Buildings and the Environment: A Statistical Summary Compiled by: u.s. Environmental Protection Agency Green Building Workgroup
December 20, 2004
Residential Buildings 21%
Commercial Buildings 18%
Non-Building 61%

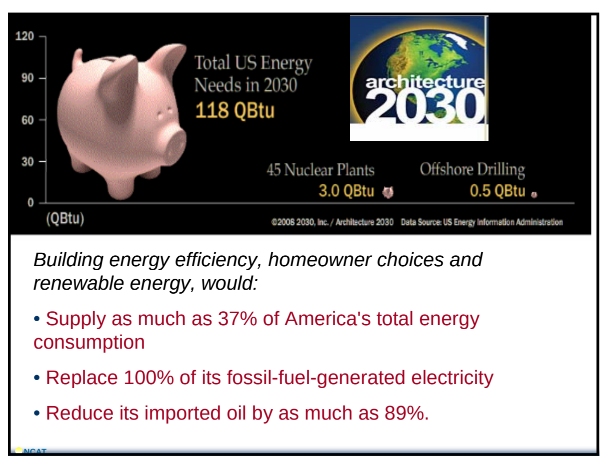

What do we mean by “cost effectiveness?
Simple Payback
Life Cycle Analysis
Life Cycle Assessment
Who knows what the future cost of energy will be?


Direct Benefits:
Utility Cost Savings
Increased Durability
Healthier Indoor Envir.
Greater Comfort
High Performance Building


Green Building
Direct Benefits:
Utility Cost Savings
Increased Durability
Healthier Indoor Envir.
Greater Comfort
Indirect Benefits:
Waste Management
Climate Change
Embedded Energy
Air & Water Pollution
Habitat Preservation
Environmental Justice
High Performance Building


extraction and processing of raw materials
manufacturing
packaging
marketing
use, re-use and maintenance of the product
eventual recycling of disposal as waste at end of its useful life
Life-cycle Assessment of a product or function
Life-cycle Assessment


America's proposed "Bold Energy Plan" = 3% of the energy that the EIA projects America will consume in 2030.
45 New Nuclear Power Plants
Delivered Electricity
Production and Transmission Losses
1 QBtu*
15.1 QBtu
33.2 QBtu
US ELECTRICITY CONSUMPTION
New Offshore Drilling
U.S. Oil
Foreign Oil
0.2 mb/d*
5.6 mb/d
10.8 mb/d
US CRUDE OIL CONSUMPTION


Total US Energy Needs in 2030
118 QBtu
architecture 2030
45 Nuclear Plants
3.0 QBtu
Offshore Drilling
0.5 QBtu
(QBtu)
Building energy efficiency, homeowner choices and renewable energy, would:
• Supply as much as 37% of America's total energy consumption
• Replace 100% of its fossil-fuel-generated electricity
• Reduce its imported oil by as much as 89%.

"The road to energy independence, economic recovery and reductions in greenhouse gas emissions runs through the Building Sector."
-Edward Mazria

The 2030 Challenge asking the global building community to adopt the following fossil fuel, GHG-emitting, energy performance standards :

All **new buildings & major renovations** shall be designed to meet a 50% of the regional (or country) average.

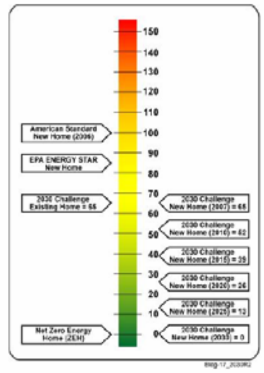
Equal amount of **existing building** area shall be renovated annually to 50% of the regional (or country) average.

The fossil fuel reduction standard for all new buildings shall be increased to:

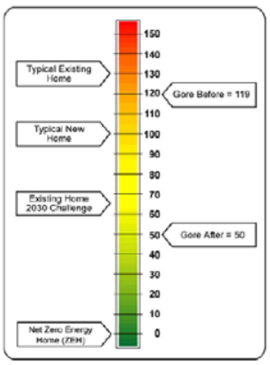
60% in 2010
70% in 2015
80% in 2020
90% in 2025

The 2030 Challenge

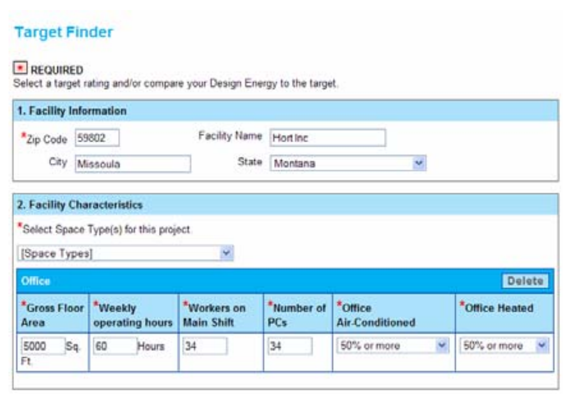
- Challenge that all new American homes will be carbon neutral by 2030
- Adopted by:
  - U.S. Conference of Mayors
  - American Institute of Architects
  - ASHREA
- Adopted RESNET HERS Index for residential challenge

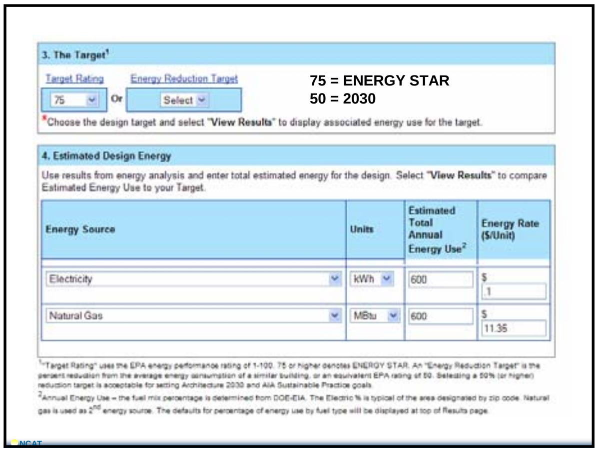


Al Gore's Home



ENERGY STAR is a US EPA program that helps businesses and individuals reduce energy use and protect the environment through "superior energy efficiency."





3. The Target[1]

Target Rating | Energy Reduction Target

75 Or Select

75 = ENERGY STAR
50 = 2030

*Choose the design target and select "**View Results**" to display associated energy use for the target.

4. Estimated Design Energy

Use results from energy analysis and enter total estimated energy for the design. Select "**View Results**" to compare Estimated Energy Use to your Target.

Energy Source	Units	Estimated Total Annual Energy Use[2]	Energy Rate ($/Unit)
Electricity	kWh	600	$ .1
Natural Gas	MBtu	600	$ 11.36

[1] "Target Rating" uses the EPA energy performance rating of 1-100. 75 or higher denotes ENERGY STAR. An "Energy Reduction Target" is the percent reduction from the average energy consumption of a similar building, or an equivalent EPA rating of 50. Selecting a 50% (or higher) reduction target is acceptable for setting Architecture 2030 and AIA Sustainable Practice goals.

[2] Annual Energy Use – the fuel mix percentage is determined from DOE-EIA. The Electric % is typical of the area designated by zip code. Natural gas is used as 2nd energy source. The defaults for percentage of energy use by fuel type will be displayed at top of Results page.

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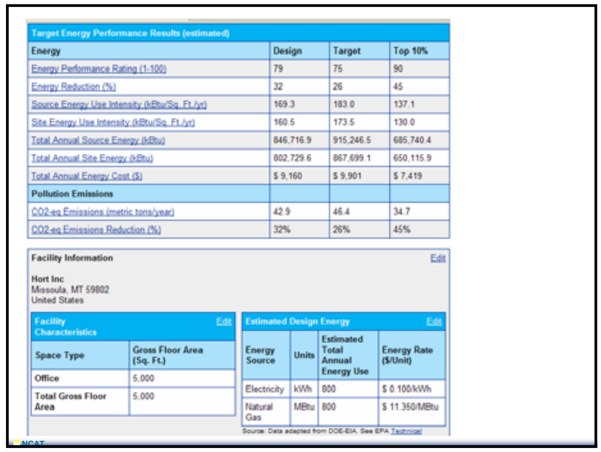

Target Energy Performance Results (estimated)

Energy	Design	Target	Top 10%
Energy Performance Rating (1-100)	79	75	90
Energy Reduction (%)	32	26	45
Source Energy Use Intensity (kBtu/Sq. Ft./yr)	169.3	183.0	137.1
Site Energy Use Intensity (kBtu/Sq. Ft./yr)	160.5	173.5	130.0
Total Annual Source Energy (kBtu)	846,716.9	915,246.5	685,740.4
Total Annual Site Energy (kBtu)	802,729.6	867,699.1	650,115.9
Total Annual Energy Cost ($)	$ 9,160	$ 9,901	$ 7,419
Pollution Emissions			
CO2-eq Emissions (metric tons/year)	42.9	46.4	34.7
CO2-eq Emissions Reduction (%)	32%	26%	45%

Facility Information Edit

Hort Inc
Missoula, MT 59802
United States

Facility Characteristics Edit

Space Type	Gross Floor Area (Sq. Ft.)
Office	5,000
Total Gross Floor Area	5,000

Estimated Design Energy Edit

Energy Source	Units	Estimated Total Annual Energy Use	Energy Rate ($/Unit)
Electricity	kWh	800	$ 0.100/kWh
Natural Gas	MBtu	800	$ 11.350/MBtu

Source: Data adapted from DOE-EIA. See EPA Technical

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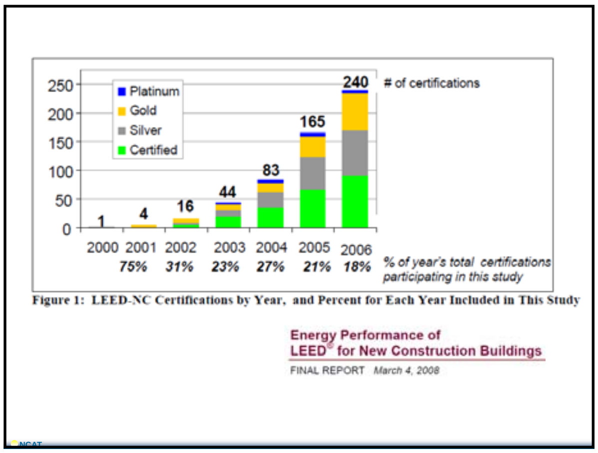

Figure 1: LEED-NC Certifications by Year, and Percent for Each Year Included in This Study

Energy Performance of LEED® for New Construction Buildings

FINAL REPORT March 4, 2008

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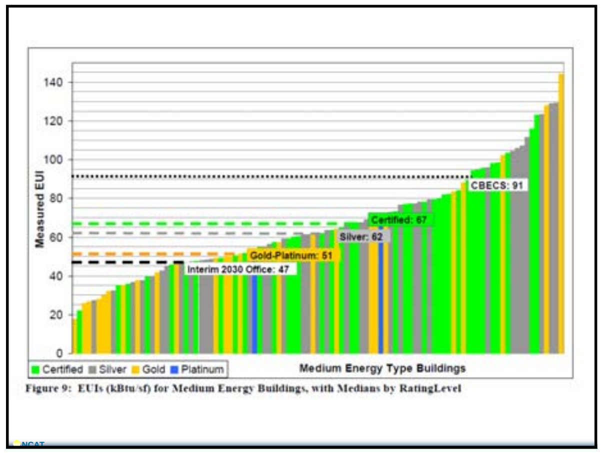

Figure 9: EUIs (kBtu/sf) for Medium Energy Buildings, with Medians by RatingLevel

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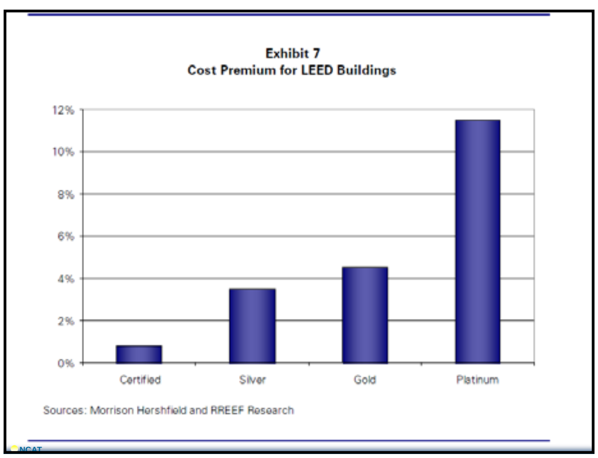

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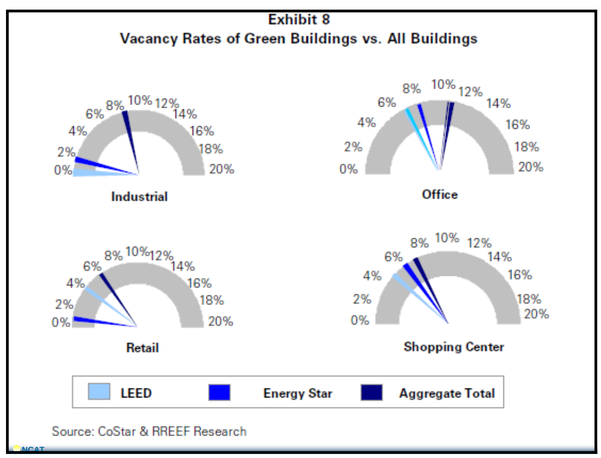

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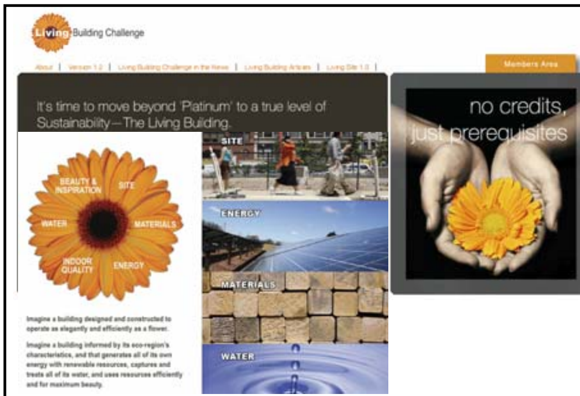


http://www.cascadiagbc.org/lbc

Quick Insulation Comparison

Material	Type	R-Value	Ozone Depleting Blowing Agent	Density	Vapor Retarder Perm Rating	Recycled Content	Common or Brand Name
Fiberglass	Batts	3.6	No	3 pcf	Permeable	Doubtful	
	Loose fill	3.2	No	2-3 pcf	Permeable	Doubtful	
Cellulose	Loose Dry	3.4	No	1.5-2.0 pcf	Permeable	Yes	
	Wet Blown	4.0	No		Permeable	Yes	
Expanded Polystyrene	Rigid Board	4.0	No	low 1 pcf	Permeable	Doubtful	beadboard
	Rigid Board	4.0	No	high 2-3 pcf	Semi-imperm.	Doubtful	
Extruded Polystyrene	Rigid Board	5.0	Yes	2 pcf	Semi-imperm.	Doubtful	Styrofoam Blue Board
Polyisocyanurate	Rigid Board	7.0	Yes	3 pcf	Imperm (facing)	Doubtful	Thermax
Polyurethane	Spray Foam	3.6-3.8	No, water	low 0.5 pcf	Permeable	Doubtful	Icynene, Sealection 500
	Spray Foam	3.7-3.6	No, soy	low 0.5 pcf	Permeable	Doubtful	Biobase 501, Healthy Seal
	Spray Foam	5.5	No, soy	high 1.7 pcf	Semi-imperm.	Doubtful	Biobase 1701
	Spray Foam	6.0 - 8.0	Yes	high 2 pcf	Semi-imperm.	Doubtful	

Remarks:
1. Fiberglass is susceptable to convective currents and poor installation and may contain ureaformaldehyde.
2. Styrene and urethane insulations may give off toxic gases when if burned.
3. In general, low density foams are open cell and high density foams are closed cell.
4. Vapor permeability depends thickness, especially with foams.

Perms	Vapor Impermeability
<=0.1	Impermeable
0.1> and <=1.0	Semi-impermeable
1.0> and <=10	Semi-permeable
>10	Permeable

Fiberglass

Susceptible to convective currents and poor installation, may contain ureaformaldehyde.

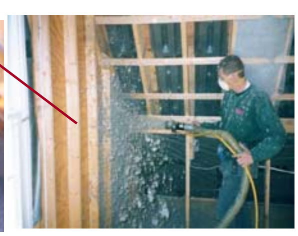
Type	R-Value	Ozone Depleting Blowing Agent	Density	Vapor Retarder Perm Rating	Recycled Content
Batts	3.6	No	3 pcf	Permeable	Doubtful
Loose fill	3.2	No	2-3 pcf	Permeable	Doubtful

Blown-In-Blanket



Cellulose

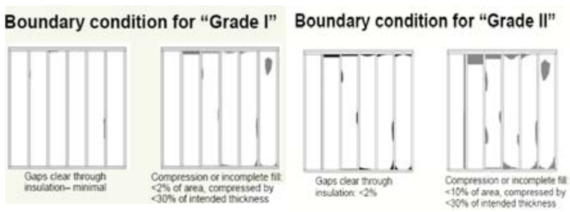
Material	Type	R-Value	Ozone Depleting Blowing Agent	Density	Vapor Retarder Perm Rating	Recycled Content
Cellulose	Loose Dry	3.4	No	1.5-2.0 pcf	Permeable	Yes
	Wet Blown	4.0	No		Permeable	Yes

Correct Installation


Grade I Assessment
Installed according to manufacturer's instructions, fills each cavity completely, no substantial gaps or voids, split and fit tightly around wiring and other services

Grade II Assessment
Moderate to frequent defects such as gaps around wiring, electrical outlets, plumbing, and other services; rounded edges or shoulders.



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Northwestern Electricity Markets

- **Consumer demands** have grown faster than population growth, due to increasing availability and use of electric end-use appliances and equipment.
- **Hydroelectric** generation resources were first developed across the region to support the early development of communities and industrial projects.
- **Coal, Natural Gas, and Nuclear plants** were then built to fuel further industrial expansion and population growth.

All of these energy sources have resource depletion, environmental degradation, and socio-economic impacts associated with their development and operation.

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Renewable Alternatives

- Recent development of utility scale wind power has been driven in part by government subsidies and is causing operating difficulties for transmission and distribution utilities.
- Solar Photoelectric generation is still expensive (15 to 20 cents/kWh), but it is economically justified for smaller loads that are distant from existing power lines.

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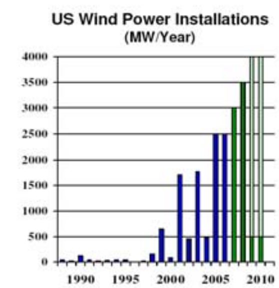
ACORE

Wholesale Power Generation

US Wind Power



Sources: AWEA (actual) and ACORE (forecast)

2,500 MW installed in 2006

11,900 MW Installed Base

Outlook: as much as 350,000 MW within 20-30 years

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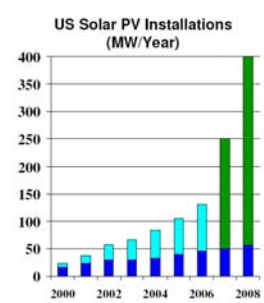
Distributed Generation

US Solar PV Market



Sources: PV News and ACORE

An exciting period of growth:
- **30% ITC to extended to 2008**
- **California program 2007- 2018**
- **Corporate greening "Walmart"**
- **VC in advanced PV**

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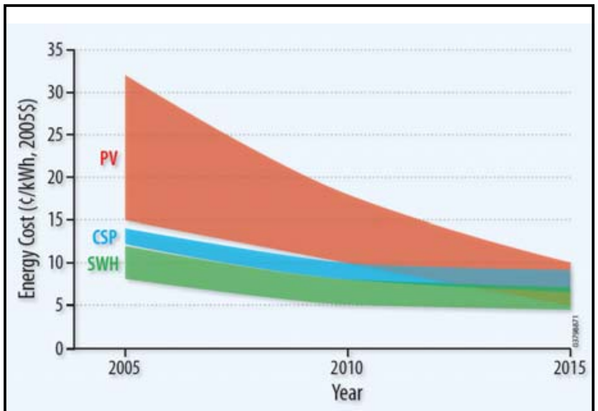


The Conservation Alternative

- Every conservation investment has a specific cost associated with freeing up energy and capacity that can now be used to serve other customers' demands.
- The cost of installing many conservation measures is lower than any other alternative energy supplies.
- Conservation is the only resource that normally reduces environmental impacts.
- Conservation investments reduce operating costs and can increase property values.
- Conservation investments also benefit utilities and other utility ratepayers by deferring the cost of transmission and distribution system expansions.

Building Energy Usage Goals

- **The Governor's 2010 Challenge** – Reduce energy use in Montana's State Buildings by 20% by 2010.
- The **Northwest Power and Conservation Council** recommends an aggressive investment in cost-effective conservation, with the goal of achieving 700 average megawatts during the next five years and 2,500 average megawatts during the 20-year planning period.

Note: An average megawatt is the amount of energy a one megawatt generator would produce in one year operating 24 hours per day (8,760,000 kWh).

Customer/Utility Partnerships

Utility incentive programs encourage investments by customers to improve the energy efficiency of their buildings and processes:

- **Rebate Programs** – Customers receive a standard rebate for the purchase and installation of listed conservation devices.
- **Custom Incentive Programs** – Utilities agree to provide a financial incentive to a customer based on the specific costs and benefits associated with installing cost-effective measures not covered by the rebate programs.

NorthWestern Energy's Non-Residential Efficiency Programs

- **The E+ Commercial Lighting Rebate Program**
- **The E+ Premium Efficiency Motor Rebate Program**
- **The E+ Business Partners Program**

NorthWestern Energy

NWE's Program Goals

- Total Electric Energy Conservation Acquisition – 5.0 Average Megawatts Per Year **(43,800,000 kWh or $3,285,000/yr @ $0.075/kWh)**
- NWE Expects to pay up to $8 Million in total costs each year to fund these programs.
- Other utilities serving the Montana's healthcare facilities may, or may not, have similar programs.

Building Energy Use

- About one third of all energy use occurs in support of the operation and occupancy of buildings
  - Maintaining space temperature through heating and cooling
  - Maintaining air quality through ventilation
  - Lighting for Aesthetics and Functionality
  - Water Heating, Refrigeration, Cooking, Washing, etc.

Heating Ventilation and Air-Conditioning Savings Opportunities

HVAC Savings

- **Central Plant Improvements**
  - New high-efficiency boilers or chillers
  - Burner replacements
  - Variable speed combustion air (large units)
  - Electric to gas conversions?
  - Exhaust gas heat recovery (economizer, condenser unit, etc.)
  - Equipment staging to optimize part-load efficiencies

HVAC Savings

- **Distribution System Improvements**
  - Variable speed motors on pumps and fans
  - Pipe or duct friction loss reduction
  - System conversion (i.e., constant volume dual-duct to VAV multi-zone)
  - Steam trap maintenance
  - Steam to hot water conversion

HVAC Savings

- **End-Use Equipment Improvements**
  - High SEER / High COP / High Eff. area units
  - Thermal Shell Improvements
  - Programmable Thermostats
  - Direct Digital Control Systems
  - Exhaust Air Heat Recovery

HVAC Savings

- **Air Flow Improvements**
  - Minimize outside air flow, within design constraints
  - Match air flows to zone requirements
  - Use VFDs to control fan/pump speeds instead of dampers or valves
  - Shut off fans during unoccupied time periods

HVAC Savings

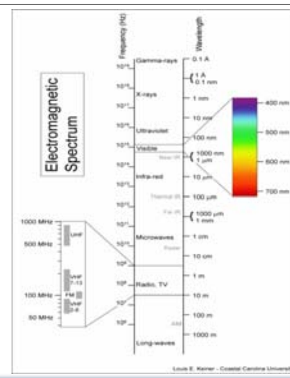
- Control System Improvements
  - Energy management systems
  - Outside air temperature resets
  - Return air CO or CO_2 sensors
  - Automated demand shedding

Lighting Technologies and Savings Opportunities

Definition of Light

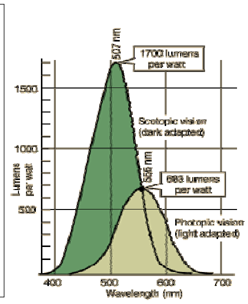
- That which makes things visible
- An electromagnetic radiation or energy transmitted through space or materials in the form of electromagnetic waves
- Visually evaluated radiant energy

The Electromagnetic Spectrum



Visual Perception

- The perceived color of a surface is the color of the light reflected from the surface
- The human eye's sensitivity is not uniform over the visible spectrum



Types of Light Sources

- **Incandescent**
  - First Type of Modern Electric Light (19th Century)
  - Low Initial Cost
  - Low Efficiency (90% of electricity is converted to heat)
  - High CRI (Color Quality)
  - Easily Dimmed
  - Banned in Some Countries
- **Halogen Incandescent**
  - Uses High Pressure Gas and Glass-Encased Filament (Safety Issues)
  - Slightly More Efficient (85% waste heat)
  - Smaller Than Standard Incandescent

Types of Light Sources

- Fluorescent
  - More Efficient (60% of electricity converted to heat)
  - Glass Tube with Luminous Interior Coating which is Excited by an Electric Arc Passing Through the Tube
  - Needs a Ballast to Control Electric Current
  - Recent Innovations Include
    - Smaller Diameters (T-8, T-5)
    - Non-Linear Shapes (i.e., Spiral Compact Fluorescents)

Types of Light Sources

- High Intensity Discharge (HID)
  - Includes Mercury Vapor, High-Pressure Sodium, Low-Pressure Sodium and Metal Halide
  - Filament is Replaced by a Capsule of Gas
  - Electric Arc is Sealed in a Quartz Tube
  - 60 to 80% Efficient
  - Low Color Quality (except Metal Halide)
  - Long Strike Time – Bulb Must Cool then Re-light
  - Need Ballasts to Control Electric Current

Types of Light Sources

- Light Emitting Diodes (LED)
  - Extremely Long Life (100,000 hours)
  - Low Power Consumption
  - Low Heat Generation
  - Cold Temperature Applications
  - Low Intensity Applications (electronic devices, flashlights, accent lighting, refrigerated display cases, traffic signals)

Lighting Quality

- The relative intensity of light is typically measured in **foot-candles**, a standard value roughly equivalent to the amount of light produced by a single candle – measured one foot away from the flame.
- The amount of light hitting a one square foot surface one foot away from a one foot-candle source is called a **lumen**.
- The light output of commercially available light sources is commonly measured in terms of **initial and mean lumens**.
- The number of foot-candles present on a surface (such as a desk top) is a function of the number of lumens produced by all contributing light sources, the height and spacing of the lighting fixtures, and the efficiency and cleanliness of the lighting fixtures
- The relative ability of light sources to provide accurate color perception by the human eye is measured and reported in its **CRI – Color Rendition Index** (Higher CRI = Better Color Perception)

Performance of Light Sources

Light Source	Lumens per Watt	CRI
Incandescent	10 - 35	95 - 100
Mercury Vapor	20 - 60	20 - 40
Fluorescent	40 - 100	60 - 90
Metal Halide	50 - 110	65 - 90
High Pressure Sodium	50 - 140	20 - 30
Low Pressure Sodium	100 - 180	0

Lighting Design Parameters

- IES Foot-Candle Recommendations
  - Food Service Facilities
    - Cashier 20–50 foot-candles
    - Dining Area 5-20 foot-candles
    - Kitchen 50-100 foot-candles
  - Hospitals
    - Patient Rooms 10-30 foot-candles
    - Emergency Rooms 50-100 foot-candles
    - Corridors 5-30 foot-candles
    - Operating Rooms 100-200 foot-candles
  - Offices
    - Conference Areas 20-70 foot-candles
    - General / Private Offices 50-100 foot-candles
    - Drafting 20-200 foot-candles

Efficient Design Parameters

- Set ambient lighting levels close to minimum recommended foot-candle values
- Boost lighting levels in specific areas, as needed to support specific tasks, using task lighting strategies
- Use lighting sources with high lumen/Watt values and adequate CRI values
- Current energy codes specify energy budgets of near 1.0 Watts of connected lighting loads per square foot, older designs run as high as 3-4 Watts/square foot.
- Retrofit projects should target 1.0-1.5 Watts/square foot
- Consider combinations of de-lamping and re-lamping to address lighting system improvements
- Consider benefit of reduced lighting levels on reducing air-conditioning loads

Lighting Controls

- Shut off lights when they are not needed
- Take advantage of multilevel switching to turn on just enough lighting for the current task
- Use occupancy sensors to shut off and turn on lights automatically, as needed
- Consider using photocells, daylight sensors and time clocks, where appropriate
- Integrate lighting controls into facility energy management systems

Process Equipment Savings

- Air/water/steam leakage reduction – eliminate unnecessary usage
- Premium efficiency motor replacements
- Control Improvements
- Match equipment capacities to loads

Process Equipment Savings

- Consider incremental energy efficiency improvements whenever replacements or upgrades are evaluated
- Make sure that energy efficiency is a primary consideration during planning for retooling or process expansions

Case Study Examples

- Billings – Medical Office Building
  - VAV conversion from High-Pressure Dual Duct
  - Premium Efficiency Motors
  - DDC Controls
  - CO_2 Based Outside Air Controls
  - Fan Lock-Outs and Outside Air Reset Controls
  - $60,000 cost, $14,400 Incentive, $30,350 Annual Bill Savings – 1.5 Year Simple Payback

More Projects

- Helena - Industrial Manufacturing Facility
  - HID to T-5HO Fluorescent Lighting
  - T-12 to T-8 Fluorescent Tubes with Electronic Ballasts
  - Modified Illumination Levels
  - Occupancy Sensors
  - $60,000 Cost, $14,325 Rebate, $25,800 Annual Bill Savings – 1.8 Years Simple Payback

More Projects

- Public School District
  - Elementary Schools, Jr. High School, High School, Warehouse, Administrative Building, Transportation Building
  - T-12 to T-8 and T-12 to T-5 Conversions
  - Low Wattage (25W) T-8 Fluorescent Tubes and Occupancy Sensors in Halls, Offices and Classrooms
  - T-5HO Fluorescent Tubes and Occupancy Sensors in Gyms
  - $500,000 Cost, $134,000 Rebate, $108,000 Annual Bill Savings – 3.5 Year Simple Payback

More Projects

- Cold Storage Warehouse – Billings
  - High Pressure Sodium to T-8 High Bay fixtures with Occupancy Sensors
  - Cost $195,000, Rebate $95,000, $54,600 Annual Bill Savings – 1.8 Years Simple Payback
- Bank / Office Building
  - DDC Controls
  - VAV Conversion from Dual Duct
  - Smaller PE Motors
  - $245,000 Project Cost, $98,000 Cash Incentive, $41,000 Annual Bill Savings – 3.3 Years Simple Payback

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