Passive Survivability:
A New Design Criterion for Buildings

Better Buildings by Design
February 13, 2008

Alex Wilson
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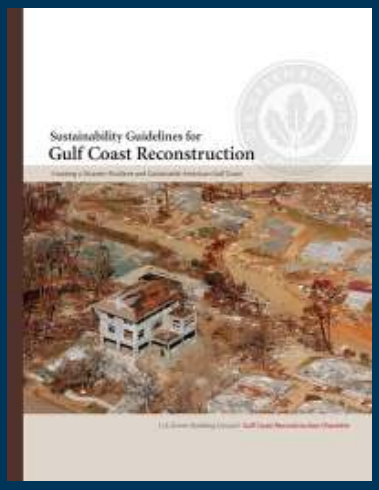
Passive Survivability - Definition

"Maintaining livable conditions in a building in the event of an extended power outage or loss of heating fuel or water."

–Environmental Building News, May 2006

Origin of the Idea



- Aspects of this idea have been around for years
- Articulated in the Gulf Coast Reconstruction Reports
- Series of charrettes at Greenbuild Conference in Atlanta in Nov. 2005
- How to rebuild the Gulf Coast with an emphasis on sustainability
- Three reports, including ***The New Orleans Principles***

Download reports at www.BuildingGreen.com

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Why Passive Survivability is a High Priority

- More intense storms and flooding, temperature extremes, and drought
- Risk of terrorism
- Vulnerability of electricity and fuel distribution systems
- Fuel shortages and blackouts possible with "peak oil"?
- Water shortages

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Impacts of Global Warming

- More severe storms
- Rising sea levels will increase flooding
- Increased rainfall events
- Increased likelihood of drought in some areas

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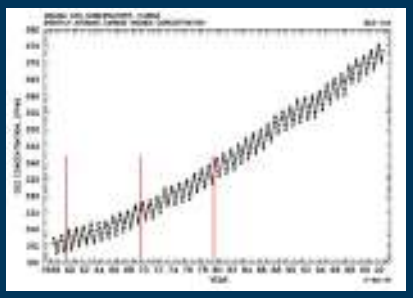
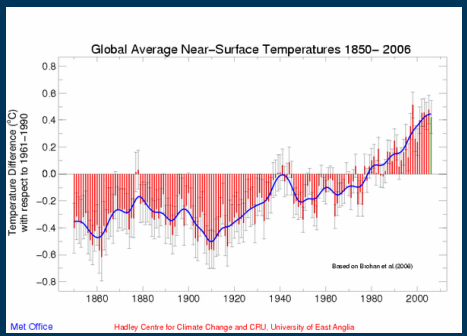
Climate Change

Mauna Loa CO_2 levels





Global Temp. 2007 IPCC Report

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Hurricane Intensity and Frequency

Graphic by Ethan Gibnay, NOAA

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Hurricane Intensity and Frequency

Graphic by Ethan Gibnay, NOAA

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Hurricane Katrina

May 7, 2006 - Lower 9th Ward, New Orleans

- A tipping point in public awareness
- An area the size of Great Britain affected by storm
- As many as 3 million people evacuated
- Over 1,300 people dead
- Much of New Orleans not yet reoccupied

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Hurricane Katrina

May 7, 2006 - Lower 9th Ward, New Orleans

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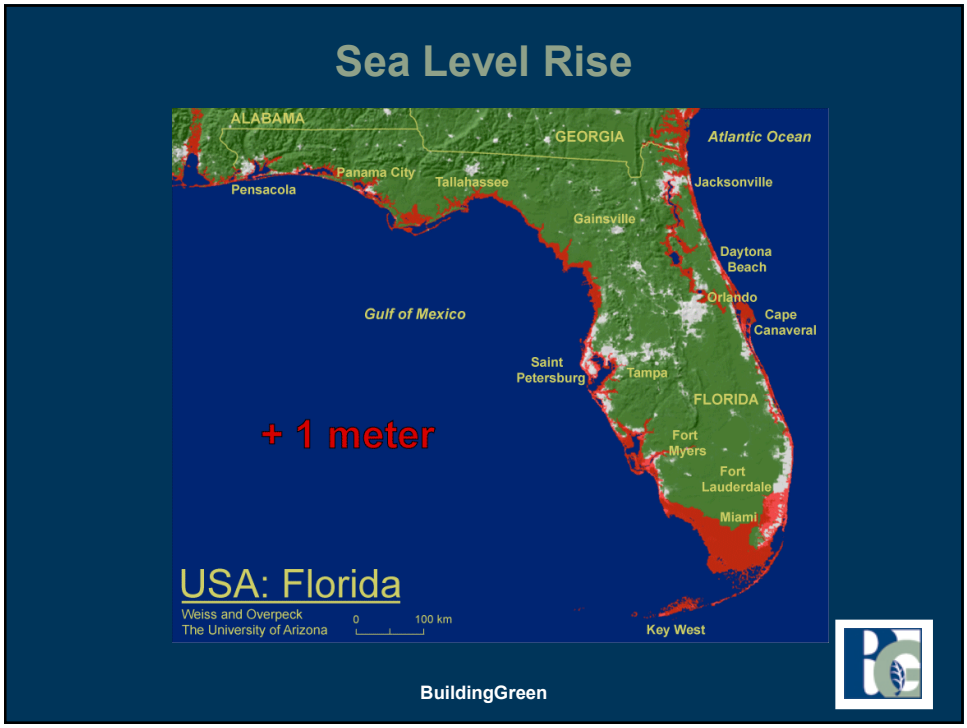
Sea Level Rise
ALABAMA
GEORGIA
Atlantic Ocean
Panama City
Pensacola
Tallahassee
Jacksonville
Gainsville
Daytona Beach
Orlando
Cape Canaveral
Gulf of Mexico
Saint Petersburg
Tampa
FLORIDA
+ 1 meter
Fort Myers
Fort Lauderdale
Miami
USA: Florida
Weiss and Overpeck
The University of Arizona
0
100 km
Key West
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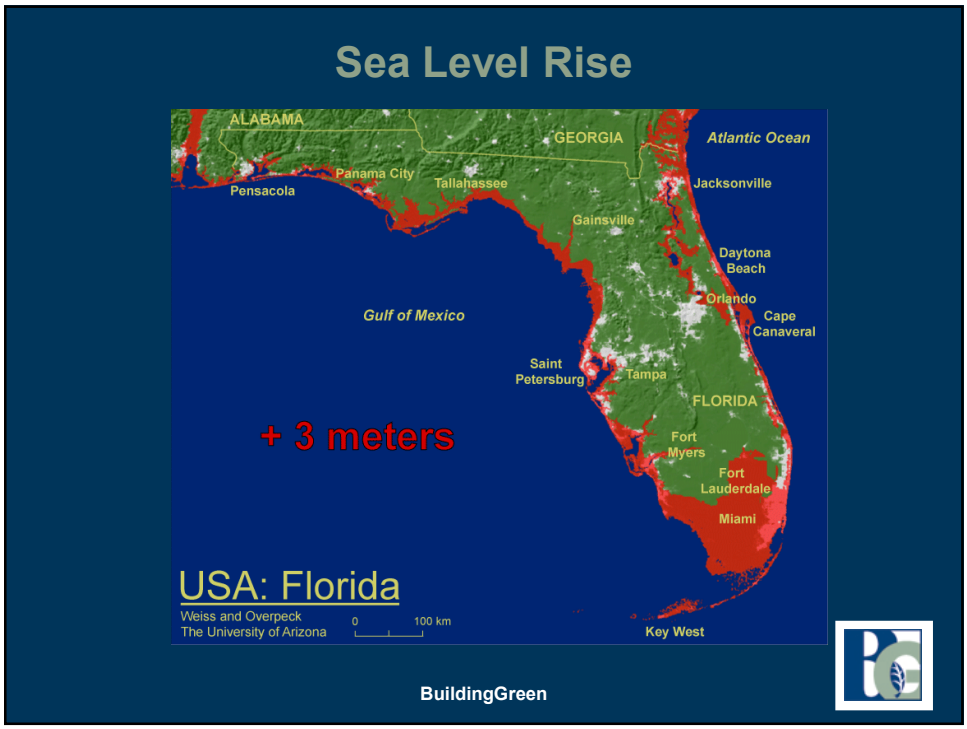
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0
100 km
Key West
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Sea Level Rise

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1998 Ice Storm - Eastern Canada

Granby, Quebec 1/12/98

- Freezing rain January 5-10, 1998 in eastern Canada & northern New England
- 3-4 inches of ice in many areas
- 4 million people lost power; 700,000 remained without power after three weeks
- 600,000 people forced from their homes
- 130 power transmission towers and 30,000 utility poles destroyed

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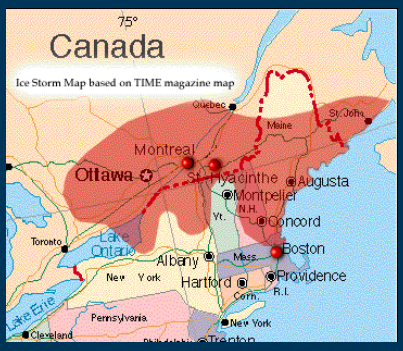
1998 Ice Storm



Hydro Quebec pylon
Drummondville, Quebec
January, 1998

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2006 Ice Storm in St. Louis

Photo: N..J. Fooch, November 30, 2006

Photo: S.E. Douglas, November 30, 2006

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Increasing Frequency of Drought

- With climate change, predicted changes in precipitation
- More frequent drought in the West
- Not only climate-related
- Potential water shortages

Crete, Nebraska, 2002

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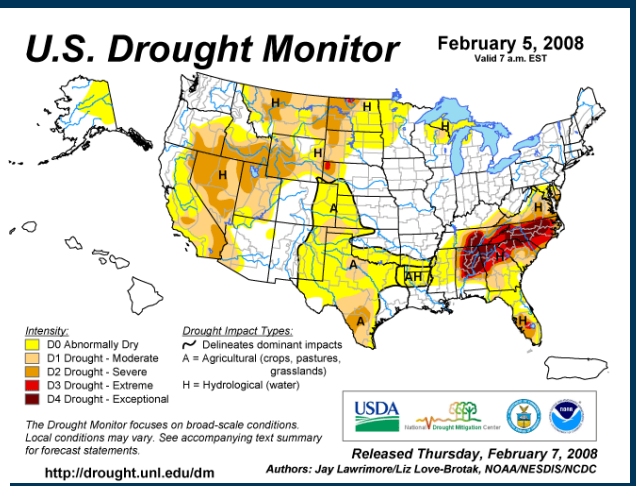
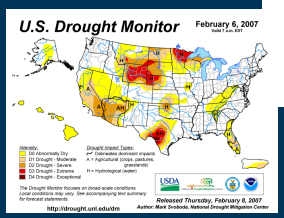
U.S. Drought Conditions





Source: National Drought Mitigation Center
University of Nebraska - Lincoln

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Increasing Frequency of Drought

Lake Mead in Arizona, 2002. Water intake for Las Vegas shown in photo on left

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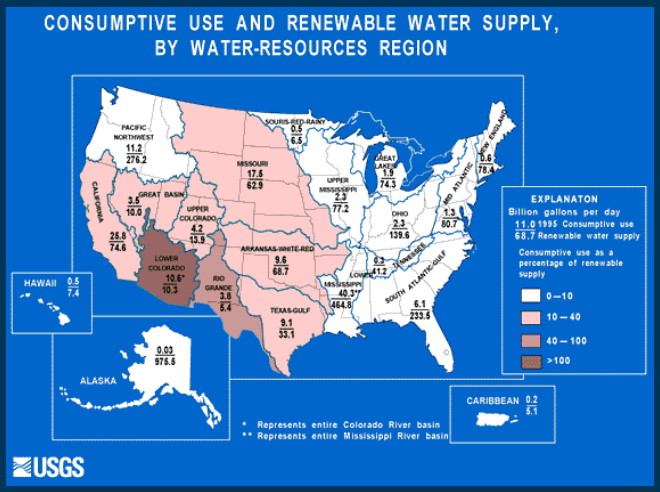
Consumptive & Renewable Water Supply



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Increasing Frequency of Drought

Republican River in Nebraska in 2003

Lake Lanier, Atlanta, October 2007
Chris Rank, Washington Post

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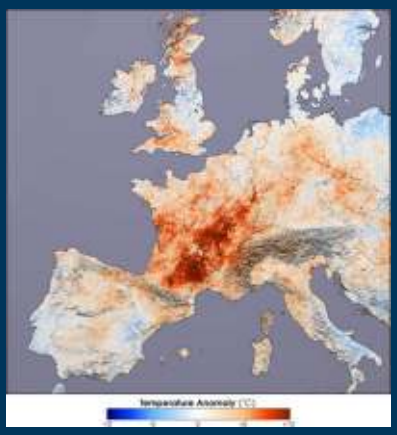
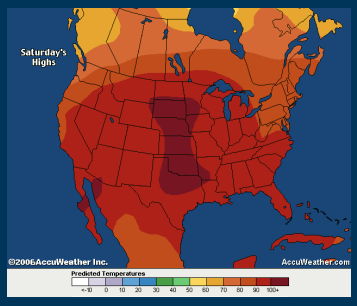
Heat Waves with Global Warming



European temperature extremes, Summer, 2003

- Risk from high temperatures
- 739 deaths in Chicago in 1995 attributed to heat
- At least 35,000 deaths in Europe in 2003



July, 2006 heat wave

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Terrorism

- 9/11 Awakened the U.S. to risk of terrorism
- Now an ever-present danger
- Hardening buildings to direct acts of terrorism not the focus of this presentation
- Risk of power outages can be planned for in our building designs

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Blackout of 2003 - New York City

New York City during blackout of August, 2003

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Blackout of 2003 - New York City

Rush hour with no power

Sleeping on Post Office steps 33rd St.

Trying to get through the Lincoln Tunnel

West 38th St. Ferry Terminal

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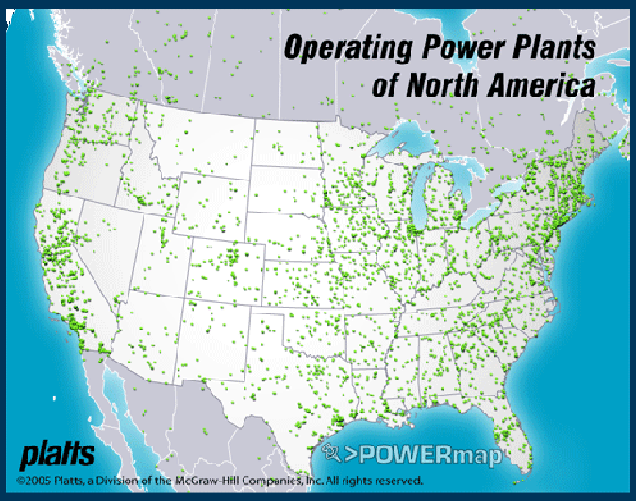
Electricity Production and Distribution



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Electricity Distribution

- 160,000 miles of high-voltage (over 230 kilovolts) transmission lines in U.S. according to ASCE (2003)
- August 2003 blackout affecting the Midwest and Northeast illustrated vulnerability
- During 2006 heat wave, reserve capacity in the U.S. electricity grid fell to 15% according to IEEE

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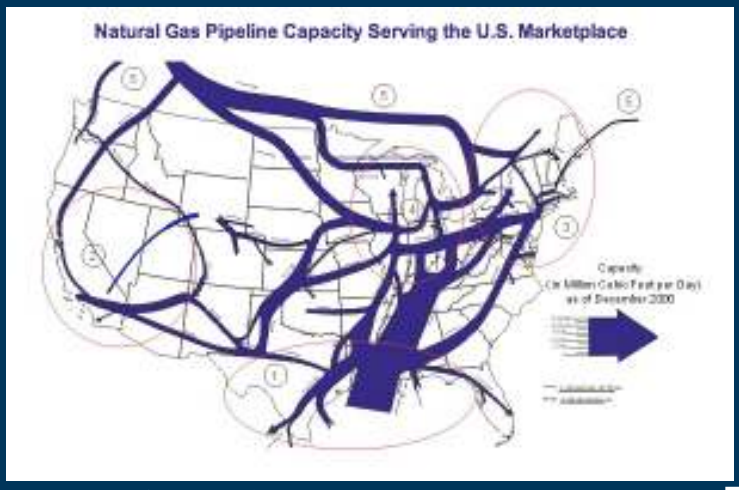
Natural Gas Distribution - 2000



DOE Energy Information Administration, 2002

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Crude Oil Distribution

Alaska Pipeline

- Completed May, 1977
- 800 miles
- 48-inch diameter pipe
- Almost entirely unprotected

Bureau of Land Management photos

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Oil Refining & Storage

Oil refining in U.S.

- 149 refineries (July 2006)
- 17 million barrels per day
- 47% U.S. oil refinery capacity in Gulf Coast region

Conoco refinery, New Orleans - August 2005

Palsboro, NJ oil refineries, New York Times photo

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Vulnerability of Nuclear Power

Indian Point Nuclear Power Plant on the Hudson River north of New York City

American Airlines Flight 11 on 9/11

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Energy Supply

- Risk that shortages might occur in coming years or decades
  - Well within the life of buildings we're designing today
- Concern about "peak oil"
- Concern with both petroleum and natural gas

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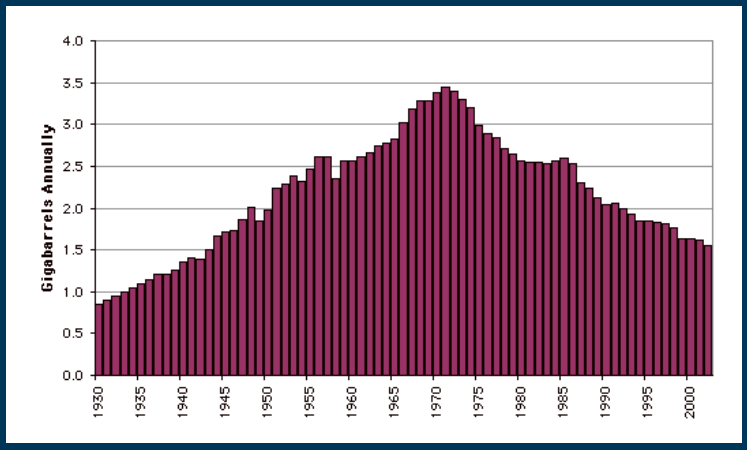
Petroleum Production - U.S.



"Hubbert Curve" of U.S. oil production 1930 - 2003

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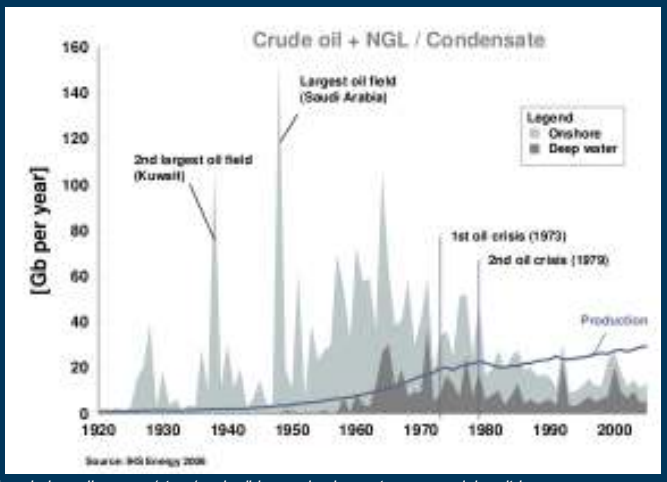
Historical Oil Discoveries & Production



http://sydney.indymedia.org.au/story/peak-oil-has-arrived-report-warns-social-meltdown

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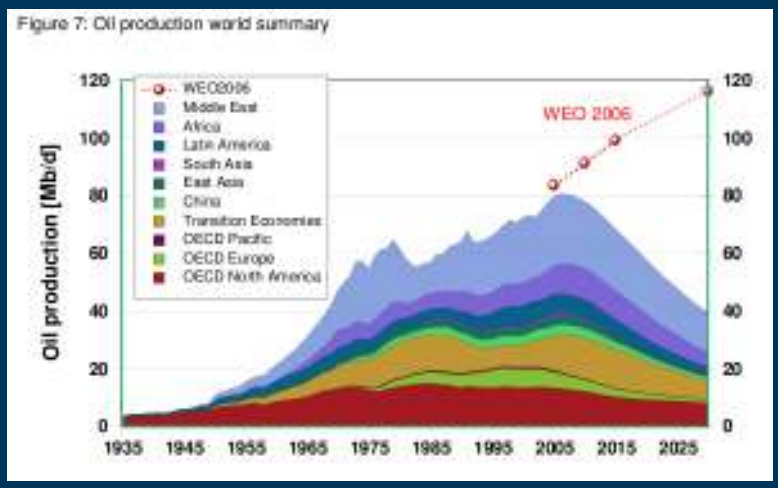
Petroleum Production - World



http://sydney.indymedia.org.au/story/peak-oil-has-arrived-report-warns-social-meltdown
The World Energy Outlook 2006 predicted continued increases in production.

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Achieving Passive Survivability

- Given these concerns, we should be designing buildings that maintain livable conditions in the event of power outages or loss of fuel or water
- Mostly strategies we are familiar with--
  we know how to do this
- Energy-saving, green design practices from the past three decades

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High-performance envelope

- High insulation levels
- Tight buildings (with ventilation)

Superinsulation in Sweden

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High-Performance Glazings

- Triple glazing
- Low-emissivity, spectrally selective glazings
  - *Multiple* low-e coatings
- Low-conductivity gas fill (argon, krypton)
- Advanced edge spacers
- Better frame materials

Triple-glazed window in Sweden

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High-Performance Glazings

Alpen Windows:

- Suspended Heat Mirror films (up to 3)
- Use of low-e coated glass *and* low-e film
- Use of low-iron glass to improve visible transmittance
- 1-3/8" fiberglass frames, available with NanoPore vacuum-pack silica aerogel
- Low-conductivity spacers
- www.alpeninc.com

Greg Franta home - Boulder

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Alpen Glass & Alpen Window Performance

Center Of Glass & Window Unit Values for Inline/Duxton Fiberglass Series 325 Fixed & Casement

Application	General Use	Cold Climate, south facing–favoring passive solar gain	Cold climate, east- or west-facing–favoring solar protection	North-facing and extreme climates–maximum insulation
CONFIGURATION				
Outer Lite	1/8" Cardinal LoE² 272	1/8" Low Iron	1/8" Cardinal LoE² 272	1/8" Low Iron
Interspaces And Thickness	1 @ 1/2"	2 @ 9/16"	3 @ 3/8"	4 @ 1/4"
Suspended Coated Film(s)	None	1 HM88	2 HM-TC88	3 HM TC88
Gas Fill	Argon	Argon	Krypton	Xenon
Inner Lite	1/8" Clear	1/8" Low Iron	1/8" Cardinal LoE² 272	1/8" Low Iron
Overall Thickness	3/4"	1 3/8"	1 3/8"	1 3/8"
PERFORMANCE				
Center-of-Glass R-value	4.1	5.1	14.7	20.0
Casement Unit R-value¹	3.3	3.6	5.9	7.4
Fixed Unit R-value²	3.6	3.8	7.7	10.4
Center-of-glass U-factor	0.24	0.20	0.07	0.05
Casement Unit U-factor¹	0.30	0.25	0.17	0.14
Fixed Unit U-factor²	0.28	0.23	0.13	0.10
Solar Heat Gain Coefficient (SHGC)	0.41	0.63	0.29	0.37
Visible Transmittance (Tvis)	71%	75%	40%	43%
"Winter" Inner Glass Temp (°F)³	56	58	66	67
UltraViolet Blockage	84.6%	98.7%	99.0%	99.5%
STC Acoustic Rating (estimated—glass only)	29	34	35	37

Environmental Building News - October 2007

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Alpen Windows

Re-glazing the Rocky Mountain Institute Sept 2007

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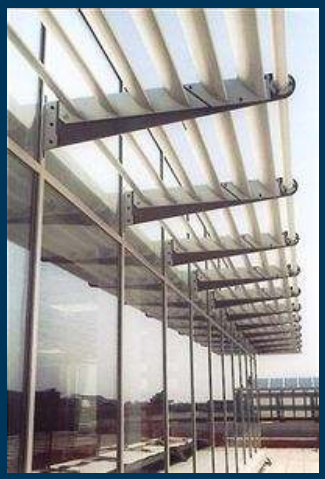
Cooling Load Avoidance



Ruskin sun-control louvers

- Orient buildings on an east-west axis
- Minimize glazing on east & west
- Tune glazing by orientation (low SHGC glass on east and west)
- Provide reflective roofs
- Use overhangs and vegetative shading

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Natural Ventilation

Zion Visitor's Center, Zion National Park showing passive cooling towers in which hot air drawn in at the top and falls down through evaporative pads (NREL photo)

- Even if not designed to rely on natural ventilation during normal operation, provide that capability for emergencies
- Operable windows
- *Solar chimneys* for stack-effect natural ventilation
- Vegetation that channels natural breezes into the building
- Spaces that extend living area outdoors - such as wrap-around porches

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Passive Solar Heating

- Most important with smaller, skin-dominated buildings
- Direct-gain
- Thermal storage wall
- Indirect-gain (sunspace)
- Thermal mass
- Energy modeling is key to success (e.g., Energy-10 & DOE-2 software)

Passive solar home in Golden, Colorado (NREL photo)

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Daylighting

- Balance of natural light without too much unwanted heat gain
- Exterior windows
- Skylights, clerestory windows, roof monitors
- Tubular skylights
- Proper glazing specification is key (high visible light transmittance, low SHGC)
- Reflective ceilings and walls
- Lightshelves to distribute light deeper into building

Daylit classroom in North Carolina (Innovative Design photo)

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Limit Building Height?

New York City during 2003 blackout

- High-rise buildings are more dependent on electricity than low-rise buildings, especially for elevators
- They also block solar access to other buildings
- Author Sue Roaf suggests that six to eight stories is a reasonable maximum height
- Note that this strategy can conflict with goal of density

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Rainwater Harvesting

Rainwater cisterns at the Chesapeake Bay Foundation headquarters

- Harvest and store rainwater for use during power outages or supply interruption
- Store water high in building for gravity-delivery
- A portion of collected rainwater can be used for irrigation during normal building operation

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Rainwater Harvesting

Rainwater cistern - New Orleans

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Minimizing Water Consumption

Delta H2Okinetics 1.6 gpm Showerhead

Duet clothes washer and dryer from Whirlpool

Kohler 1.1 gpf pressure-assist toilet

- Water-conserving toilets
- Low-flow showerheads
- Water-conserving faucets
- Water- and energy-efficient clothes washers and dishwashers
- Xeriscaping (landscaping note dependent on irrigation)

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Composting Toilets and Waterless Urinals

Chesapeake Bay Foundation Headquarters, Annapolis, MD

- Composting toilets and waterless urinals can be used in the event of loss of water pressure
- Waterless urinals still need functional sewer system
- In a larger building (e.g., apartment building), consider installing two large-capacity composting toilets in lower floor

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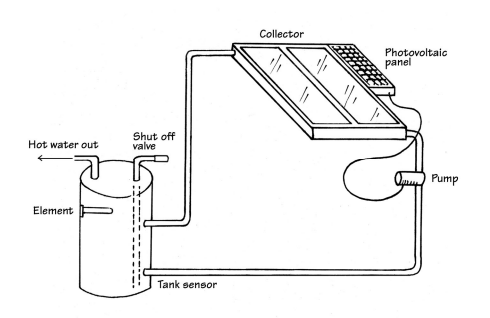
Solar Water Heating



Closed-loop solar water heater - PV pump
Illustration: Your Green Home

- To provide hot water during power outages or fuel supply interruptions
- Passive systems can operate without electricity
  - Integral collector-storage
  - Thermosiphon
- Or pump systems powered by PV

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Photovoltaic Power

- Can provide the ultimate in capability during power outages
- To provide power at night during outage, battery storage required
- Grid-connected: for power to be used during outage, necessary to provide components for safe disconnect from grid

Lord Residence, Maine (Solar Design Associates)

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Wood Heat as Back-up

- In more rural areas, install wood heat at least for emergency use
- Choose low-pollution models (less than 3 grams per hour EPA rating)
- Avoid use during high-pollution days
- With a pellet stove, provide back-up electricity: rechargeable battery or PV module, for example

Vermont Castings Encore NC wood stove
EPA-certified emissions of 0.6 grams/hour

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Heating Equipment that can use DC Power

- Most gas- and oil-fired heating equipment can't operate during power outages - even if there is fuel
- Heating equipment should be redesigned to permit operation of pump, fans, and controls with DC power
- Re-engineering of equipment required
- Integration with emergency PV modules

Energy Kinetics

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Distributed Power from Renewables

- Beyond single buildings
- Helping make the electric grid less vulnerable by putting power into it from renewable energy sources
- Wind, PV, solar thermal, biomass

Solargenix - solar thermal power systems

SEGS Plant,
Mojave Desert

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Distributed Power from Renewables

Biomass-fueled combined heat and power plant, Germany
Photo: Wärtsilä

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Compact, Smart, Walkable Communities

- Pedestrian-friendly places more livable if gasoline shortages
- Eco-villages, cohousing communities foster reliance on neighbors

Traffic calming, Venice, Florida

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Tremendous network of bicycle and pedestrian pathways in Lund, Sweden

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Bicycles are everywhere in Swedish cities - rain or shine

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Lund's cobblestone streets were packed with people--mostly on foot or bike

An almost-empty parking lot in the middle of Lund on a busy day

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Bicycle travel in Copenhagen

Traffic lights

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Provide for Food Production on the Site

- Whenever possible, provide for local food production in the site plan
- In new development, set aside the best land for agricultural uses
- Landscape with fruit trees and other edible landscaping (practice *permaculture*)

Fruit trees at Village Homes, Davis, California

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Storm Resilience

- 100-year storms are arriving about every ten years
- Expect more intense storms and storms in places where they have not been common
- Design buildings to withstand reasonably expected storms
- Build to Miami - Dade County Building Code, or comparable—even if not required

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Summary Thoughts

- Most Passive Survivability strategies won't be new to the green building crowd
- The strategies are building practices and technologies that we've been talking about for three decades
- What is different is the ***motivation*** for moving toward high-performance, renewably powered, green buildings
- Potential to appeal to a segment of policy makers who are less attuned to environmental concerns
- Potential get buy-in from a large segment of the population—and maybe from insurance companies

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Information Resources from BuildingGreen

For information, visit www.BuildingGreen.com or call 802-257-7300

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Home Building Resources from BuildingGreen

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Yellowstone National Park, Wyoming

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