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Advanced Concepts for High Performance Buildings: Maximizing Sustainability, Minimizing Energy

WE12

Wednesday, May 2, 2007, 8:00 AM - Noon

Advanced Concepts for High Performance Buildings: Maximizing Sustainability, Minimizing Energy

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Acknowledgements/Credits

AIA Center for Building Science and Performance (CBSP)

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Building Enclosure Technology and Environment Council of the National Institute of Building Sciences

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Advanced Concepts for High Performance Buildings: Maximizing Sustainability, Minimizing Energy

Learning Objectives

As published on www.aiaconvention.com Web site

1. Identify building science concepts and design strategies for high performance buildings, using case studies and details for illustration
2. Evaluate building systems to minimize energy and maximize sustainability
3. Explain how building performance and enclosures can help AIA achieve its policies on sustainability

Content

"Advanced Concepts for High Performance Buildings" (pdf attached)

Building Science for High Performance Green Buildings

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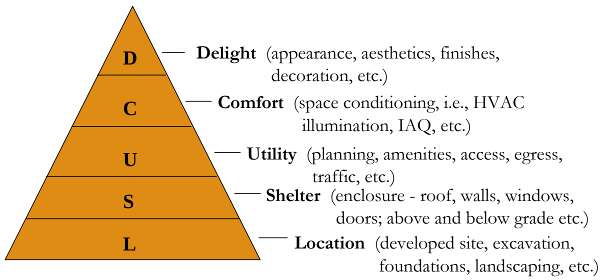
Presentation Outline

- Background: Buildings, Energy, Environment
- What is Green? High Performance?
- Strategies & Techniques
- Technology and Details
- Case Studies

Why Buildings?



- Human needs and desires lead to building function
- Adapted from Maslow's five-level hierarchy of human needs

Building Functions Historical Perspective

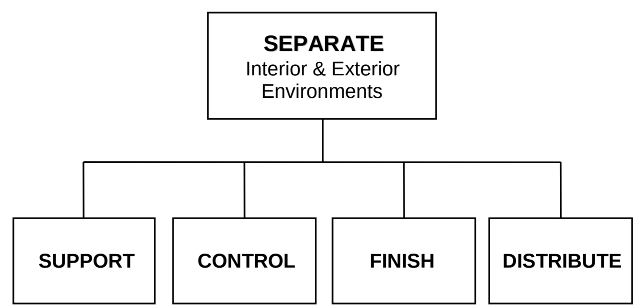
- *"Durability, Convenience, and Beauty"* Vitruvius, 70 BC
- *"Firmness, Commodity, and Delight"* Sir Wotton, 1684
- *"Provide **the desired environment** for human use and occupancy"*

Climate Modification

- Buildings modify/filter exterior environment
- Building & Site (overhangs, trees…)
  - Creates microclimate
- Building Enclosure (walls, windows, roof…)
  - Separates environments using materials
  - **Passive** modification
- Building Environmental Systems (HVAC…)
  - Use energy to change climate
  - **Active** modification

Building Enclosure Functions

That component of the building that separates the interior from the exterior



Support

- Support, resist, transfer and otherwise accommodate all the structural forms of loading imposed by
  - interior environment
  - exterior environments
  - the building
  - the enclosure itself

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Control

- Control, regulate and/or moderate all the loadings due to the separation of the interior and exterior environments:
  - Flow of mass (air, moisture, etc.)
  - Energy (heat, sound, light etc.)

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Finish

- Finish the enclosure surfaces
  - i.e. the interfaces of the envelope with the interior and exterior environments.
- Must meet the relevant requirements
  - Visual
  - Esthetic
  - Durability
  - Etc.

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Distribute

- Distribute services or utilities such as
  - Power
  - Communication
  - Water (Potable, sewage, etc.)
  - Gas
  - Conditioned air
  - to, from, through and within the enclosure itself

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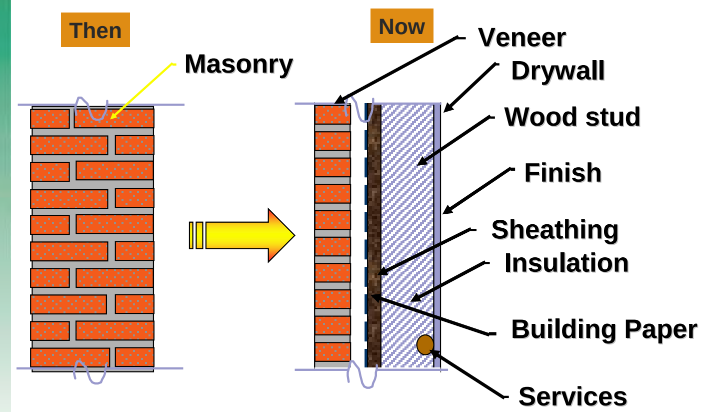
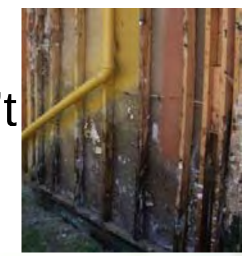
Enclosure Evolution

- Older Buildings
  - One layer does everything
- Newer Building
  - Separate layers,
  - . . . separate functions

Changes …



Many Buildings Don't



- Most buildings don't work well
- Often related to moisture & the enclosure

Poor performance

- Building deterioration, deficiency and inefficiency
  - Threatens that which we consider valuable
    - Economically, culturally
  - Increases resource use and waste production
    - Ultimately destroys our underpinnings
- Market for *high performance* (healthy, low operating cost, durable, "green") buildings is growing and few can deliver

Buildings and the Environment

- Environment is glaring example of poor performance
- Building Industry is a/the major
  - Consumer of resources
    - 40% + of all mined resources
  - Emitter of pollutants
    - Almost 50% of CO_2
    - 50% of SO_2
    - 68% of all electricity
- Designers have a strong ethical responsibility

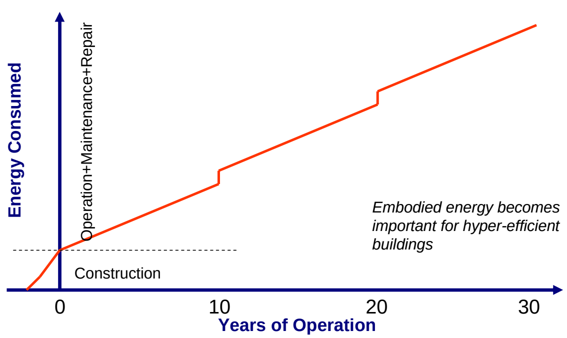
Damage Components

- Resource Extraction
  - Cutting trees, mining, drilling oil, etc.
- Processing
  - Refining, melting, etc. Pollutants and energy
- Transportation
  - Mass and Mode (ship/truck) and Mileage
- Construction
  - Energy, worker transport
- Operational Energy

The Majority of Impact

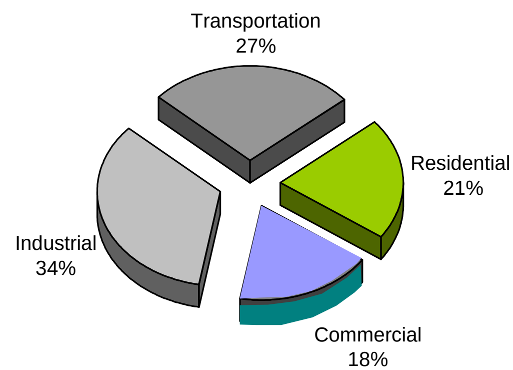
Operation vs Embodied Energy

- Embodied is << Operational Energy



Assessing the Impact

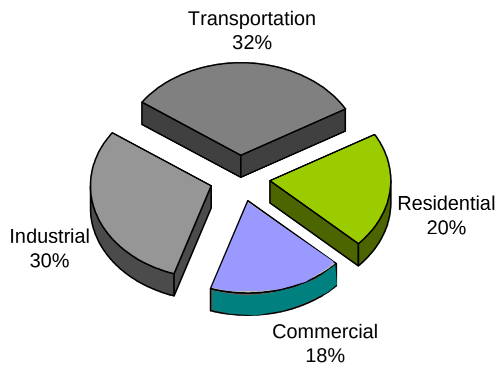
Primary Energy Consumption by Sector, 2001



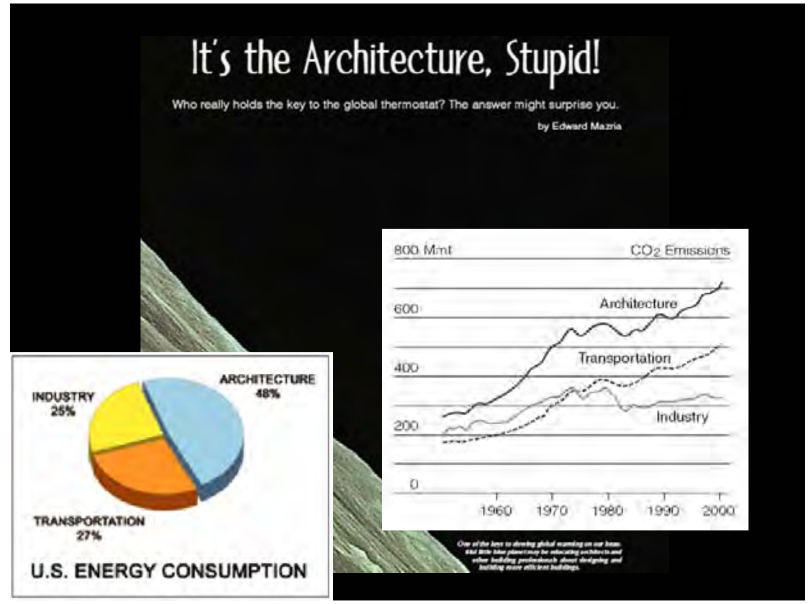
Source: EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

Climate Change

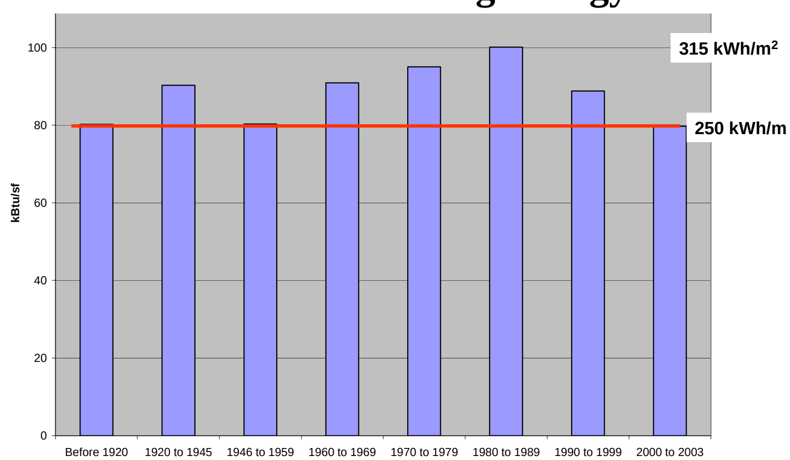
Carbon Dioxide Emissions from Energy Consumption by Sector, 2001



 5/2/2007 Source: EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

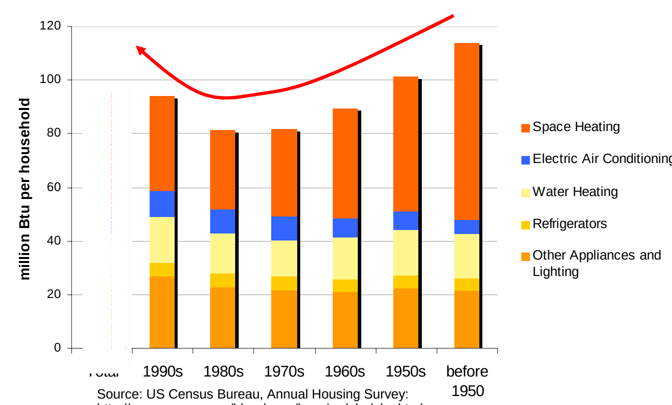


US Commercial Building Energy Use



Old & New Houses Energy Use

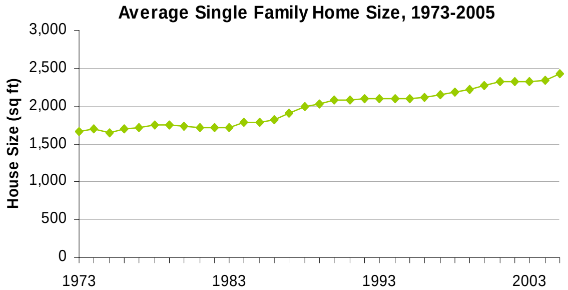
Total Btu Consumption per Household, 2001



Source: US Census Bureau, Annual Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html

More Efficient, but Bigger

- Average House Size in **1940**: **~1100 sq ft**[1]
- Average House Size in **1973**: **1660 sq ft**[2]
- Average House Size in **2005**: **2434 sq ft**

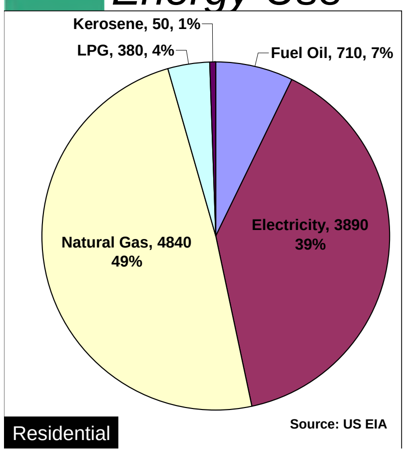


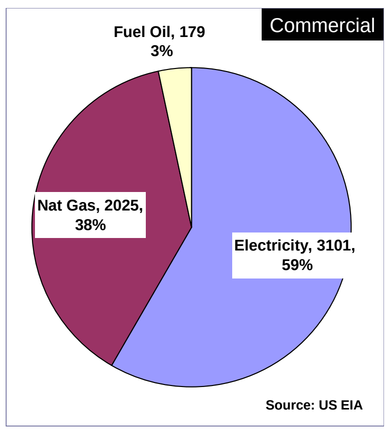
1. Wilson, Alex and Jessica Boehland "Small is Beautiful" *Journal of Industrial Ecology*, Vol 9, No 1-2. 2005
2. EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

Where does all the energy go?

- Heating, Cooling, lights, equipment
- Type of energy influences CO_2
  - Oil
  - Coal
  - Natural gas
  - Electricity

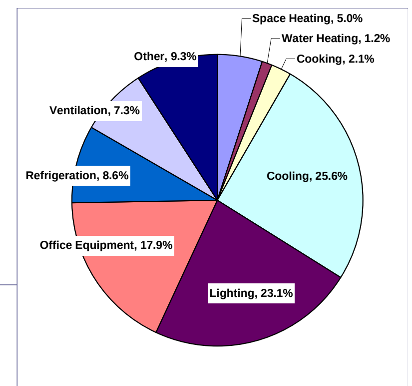
Building *Energy* Use

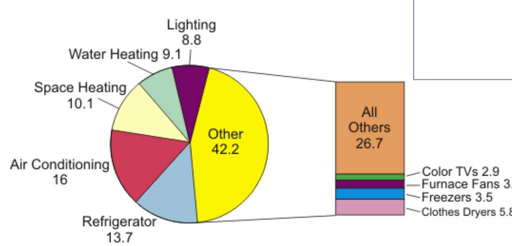




Mostly NG (heating, hotwater) and electricity (cooling, lighting, etc)

Building *Electrical* Use





Source: Energy Information Administration, Form EIA-457A, B, C, E, and H of the 2001 Residential Energy Consumption Survey.

Energy and Green

- Existing Buildings
  - Energy use is easy to measure
  - Vast majority of damage done by energy consumption *during operation*
- *<u>Operational energy reduction is key</u>*
  - *Energy consumption is the metric*
- Material choices less significant
  - Nice to choose lower energy lower polluting alternatives

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The new "buzz" words

- Net Zero Energy
- Carbon-neutral
- LEED
- "xx% below ASHRAE 90.1"
- How about good buildings?
  How about reducing energy use?
  How about REAL NUMBERS?

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Is it Green? Learning to count

- Depends on answers to:
  - Does it use less <u>non renewable</u> energy to operate?
  - Will it last longer? (less life-cycle resources)
  - Does it use fewer <u>non renewable</u> resources to build?
  - Does it pollute less?
  - Does it displace fewer habitats?
- Compared to what?:
  - Zero (sustainable)
  - Average (move forward, "green")

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Sustainable buildings

- "Can keep doing what we are doing indefinitely"
  - *Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs.*
    Bruntland Commission Report – the source and inspiration for the popularization of the concept of sustainability
  - A sustainable society, process, or product is one that can be sustained or continue to be produced over the long term, without adversely affecting the natural conditions (e.g, soil, ecosystem, water quality, climate, etc) necessary to support those same activities in the future.
  - Even the greenest buildings today are not sustainable

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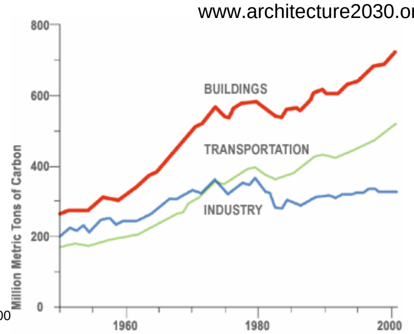
Mazria 2030 Challenge

- Set targets, measure performance
  - 60% reduction by 2010

www.architecture2030.org/news/targets.html



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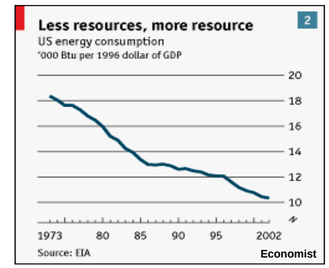
And the answer is …Efficiency

- People want services not energy
  - Warm house, not gas
  - Light, not electricity
- Hence, efficiency allow us to have our cake and eat it
- Energy reductions after '73 / '79
- California brownouts(2001):
  - 14% cut in 6 months simply by citizen action



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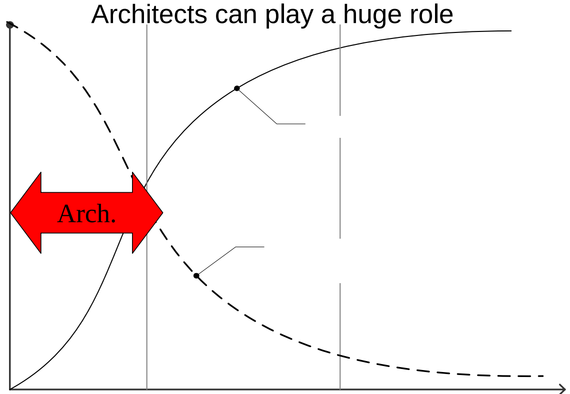
Design & Performance vs Cost

Architects can play a huge role



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"Good" Buildings

•Green Buildings are just one part of Good Buildings

•Must consider all aspects of the whole system

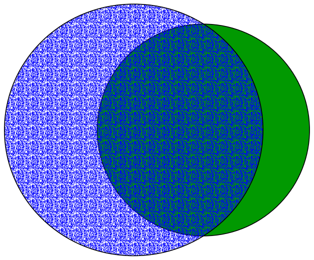
- Functional
  - meet the program of present & future occupants
- Healthy
  - few chemicals given off, no mould, fresh air
- Durable
  - so that they can be used for a long time
- Adaptable
  - for many uses so they can be re-used easily
- Energy efficient
  - in operation and in construction
- Capital Efficient
  - to allow investment on other uses
- Non-polluting
  - in operation and production

High performance Buildings

- Snazzy term for good buildings
  - Functional, energy efficient, durable, affordable, adaptable, healthy
- Green Buildings should be High Performance
  - No magic material, widget
  - A systems approach is required
  - Trade-offs, compromises, competence
  - Systems Design, Holisitic

Building Science=Green Buildings

- What is Building Science
  - The science of making buildings that work
- What are Green Buildings
  - Buildings that work . . . well



Designing for high performance

- Durability and Efficiency are the focus
  - Largely involves the massing, form, enclosure
- Health, comfort, and affordability result from above when done right
- Architects must still concern themselves with planning space and process

Getting Green

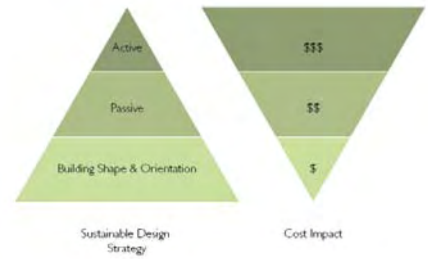
- Siting
  - Orient with sun, wind, rain, earth shelter?
- Shape and Form
  - Compact, simple
- Exceptional building enclosure
  - Insulated, airtight, durable, solar control
- Efficienct Equipment
  - Not there or off is best
- Renewable Energy Generation

Approach

- Climate, Site, Form and Massing
  - Make choices and accommodation
  - Near zero cost impacts
- Enclosure Design
  - Invest resources in capital to reduce on-going energy, repair, maintenance
  - Often costs
- Active (Mechanical) systems
  - Choose efficient, right-size

Energy Saving Strategies

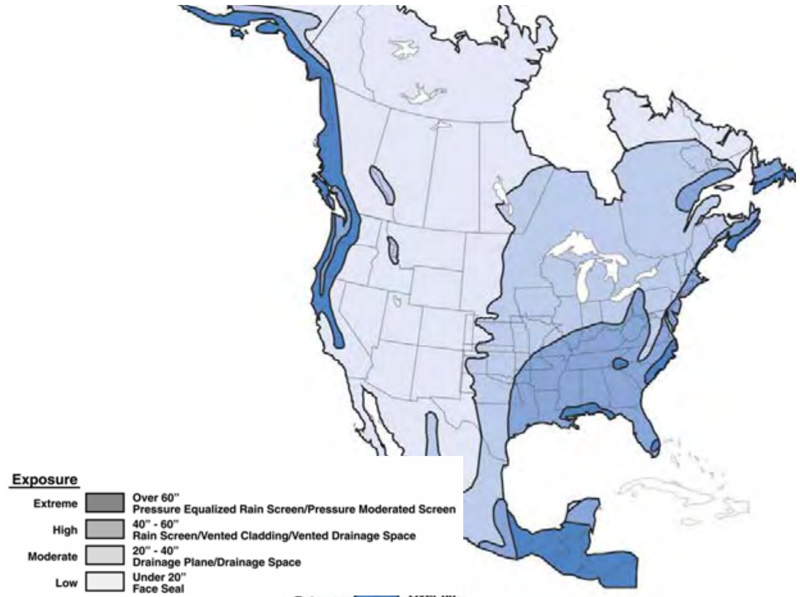
- Proper choices early on result in no or little in increased cost



Site

- Climate!
  - Hot? cold? both?
- Site
  - Earth Sheltering
  - Slope
  - Footprint / damage
  - Tree lines, ponds

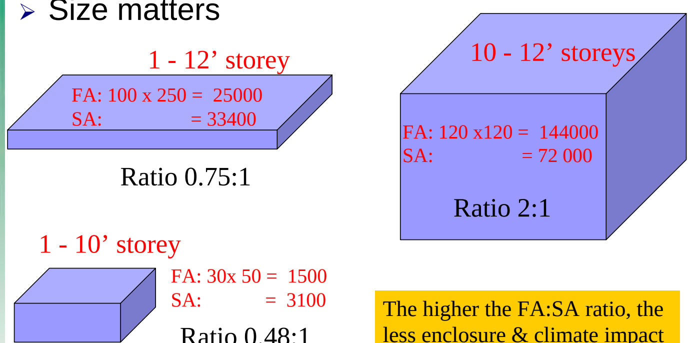
Zones



Where are these?

Size: Surface Area to Floor Area

- Size matters



The higher the FA:SA ratio, the less enclosure & climate impact on performance

Size

- Large floor area to enclosure area means
  - Less interaction with climate
  - Interior gains much more important
  - Daylighting, energy of lights, equipment, matter!
- Smaller buildings and homes are enclosure dominated
  - Climate and enclosure critical

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Internal Gains

- Increase in gains = heat loss less important
  - Commercial, assembly buildings have larger cooling problems
  - Don't throw this away in cold weather
- Energy efficiency reduces this waste heat
  - Requires more insulation to reduce heating needs in cold weather
- Solar is a key gain to manage
  - Solar dominates air conditioning loads in most types of occupancy

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Small, Compact Form

- Fewer resources
- Less heat loss and gain

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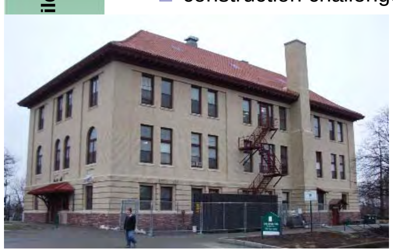
Form & Massing

- Keep it simple
- Cheaper, easier, faster
- Fewer
  - thermal bridges, air leaks
  - Material volumes
  - construction challenges



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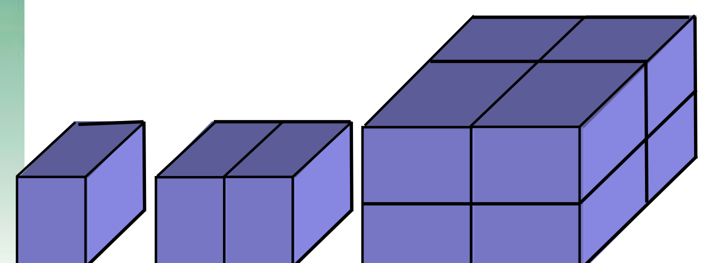
Grouping buildings

- Grouping units reduces heat loss/gain through shared walls
- Reduces resource use per unit



Grouping buildings

Fuggerei, Augsburg Germany

Social housing 1500

City planning has a large impact on the micro-climate

Large open solar absorbing and rain rejecting surfaces

Basic Goals (cold/mixed)

- Keep heat in
  - When it is cold
- Keep heat / sun out
  - When it is warm/hot

Insulation
Airtightness
Solar Control

- Last a long time — **Rain Control**
  - Reduce construction/repair resources over time
- Use efficient equipment
  - Efficient lighting
  - Efficient computers, elevators

Off is very efficient

Basic Goals (hot-humid)

- Keep heat in
  - When it is cold (easy)
- Keep heat / sun out
  - When it is warm/hot
- Last a long time
  - Reduce construction/repair resources over time
- Use efficient equipment
  - Efficient lighting
  - Efficient computers, elevators

Solar Control*
Airtightness
Insulation

Rain Humidity / UV

Off is very efficient

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Basic Goals (hot-cold dry)

- Keep heat in
  - When it is cold (easy)
- Keep heat / sun out
  - When it is warm/hot
- Last a long time
  - Reduce construction/repair resources over time
- Use efficient equipment
  - Efficient lighting
  - Efficient computers, elevators

Solar Control*
Airtightness
Insulation
Thermal mass

Rain Control / UV

Off is very efficient

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Strategies- Airtightness

- Airtightness critical for all climates
  - Humidity loads from air critical health comfort and durability issue in hot-humid
  - Control condensation and energy waste critical in cold climates
  - Natural ventilation useful in dry (night) and moderate climates (e.g., marine)

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Strategies- Insulation

- Resists heat loss/gain = energy savings
  - Large temperature differences: cold and hot climates, roofs (hot)
  - Less important in warm-humid and mixed climates
- Warms surfaces = durability
  - Avoids condensation in hot and cold weather
  - = durability and health strategy
  - Keep structure warm and dry and stable

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Strategies- Solar Control

- Solar gain and rejection
  - Can make use of solar heat gain in enclosure dominated buildings in cold/mixed climates
    - This can mean cold-dry (e.g. Sante Fe)
  - Must reject/shade sun in hot-humid, hot-dry
  - Excess glass (>25%) require shade in mixed and cold climate buildings, esp. offices

Strategies- Rain control

- Rain Control = manage moisture
  - Critical to Durability
  - Common mold/health problem
- High wind and rain zones requires care
  - Exposure very important, not just rainfall zone!
  - High-rise exposed more than low-rise

Strategies- Humidity Control

- Interior Humidity = moisture
- Cold weather require lower RH
  - to stop surface condensation (mold)
  - To avoid interstitial condensation (durability)
- Humid weather require lower RH
  - To control condensation on cold surfaces (mold)
  - Often requires separate dehumidification in humid climates (sometimes cold ones)
  - East of Mississippi River has humid summers

Humidity loads

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

HPAC 2001 Harriman & Brennan

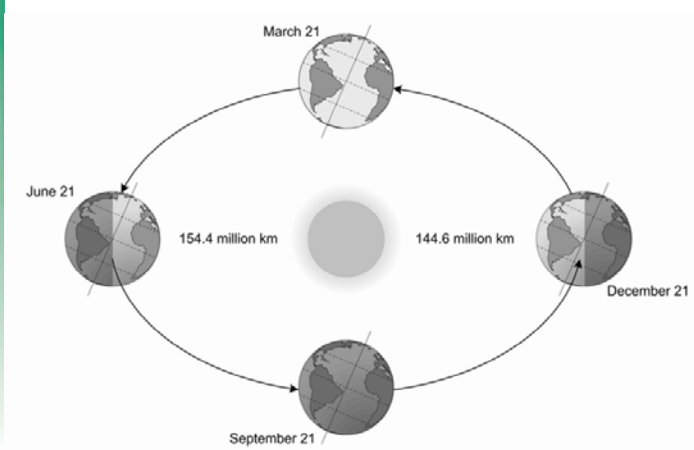
Strategies- Thermal mass

- Structure may provide thermal mass
  - Encourage interaction with the interior
    - (no carpets, leave exposed ceiling)
    - Must allow inside temperature to swing (e.g. 70-76 F)
    - Better insulation means greater mass effect
- Thermal mass allows one to
  - Shift peak loads
  - Collect solar heat or cool for later
- Requires careful design to take advantage of

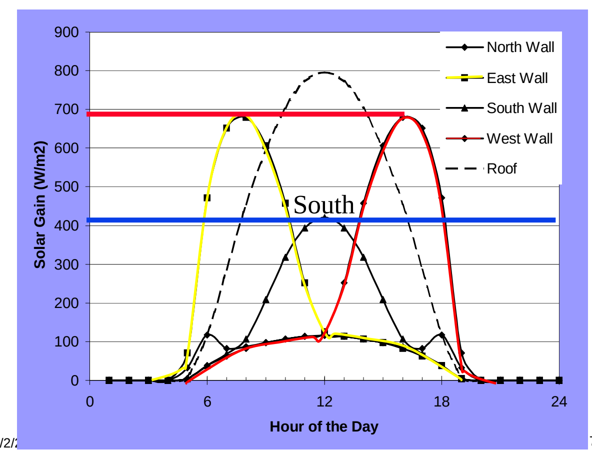
Solar Management

- Collect when you want
  - Usually cold climate
  - Mixed/dry climate during cold weather
  - Easy to over-do
- Avoid when you don't
  - This is more important for insulated, airtight buildings that are internal gain dominated

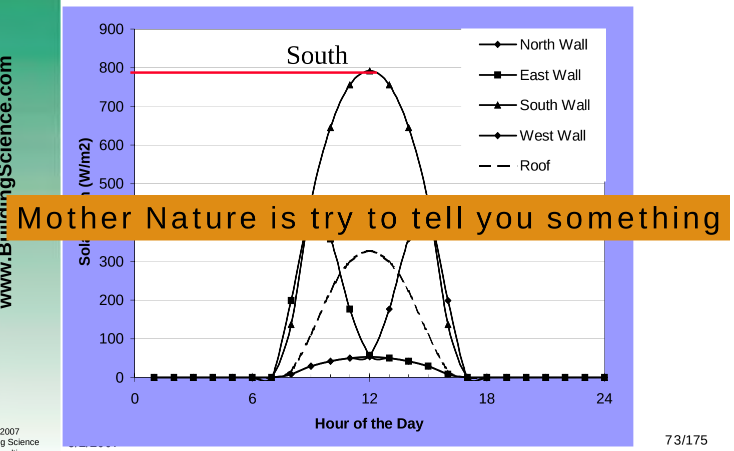
The Sun is predictable!



Solar Gains - July 21 @45 N



Solar Gains - Jan 21 @ 45 N



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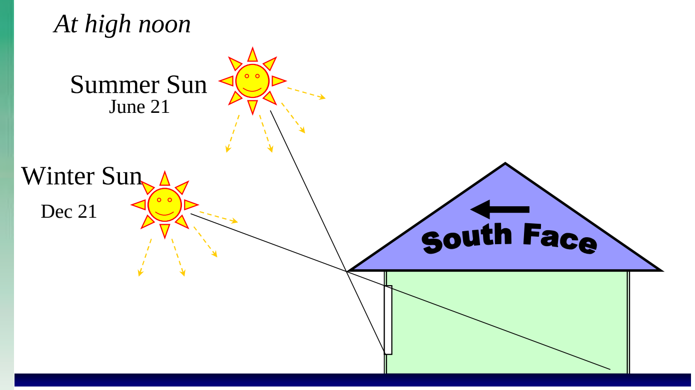
Solar Control - Shading



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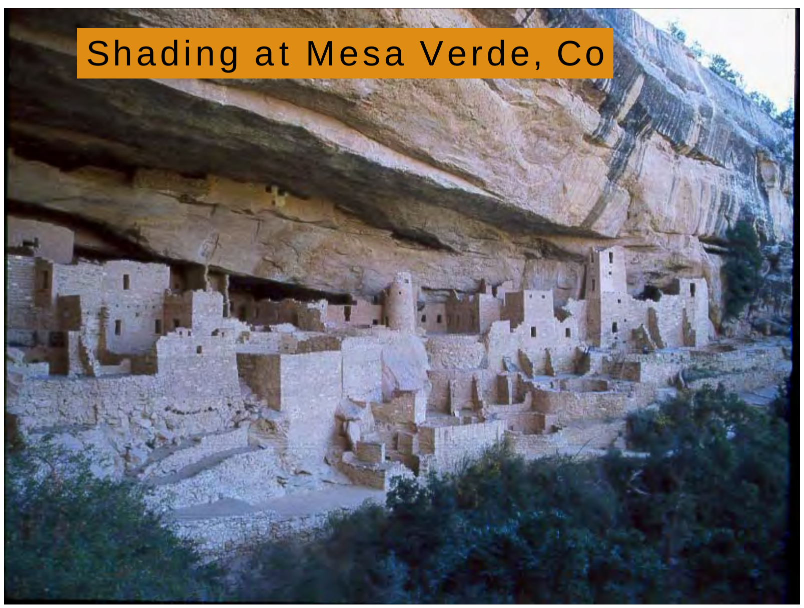

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“Shade is expensive” = often BS

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Overhangs

- “Are too expensive”?

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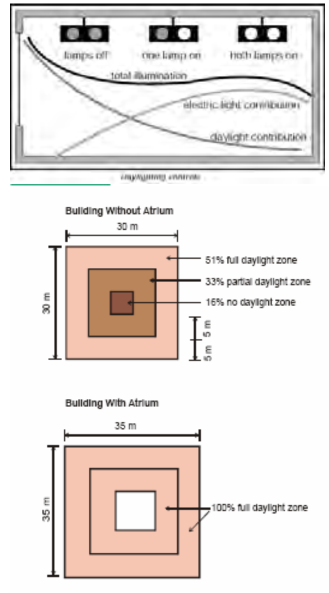
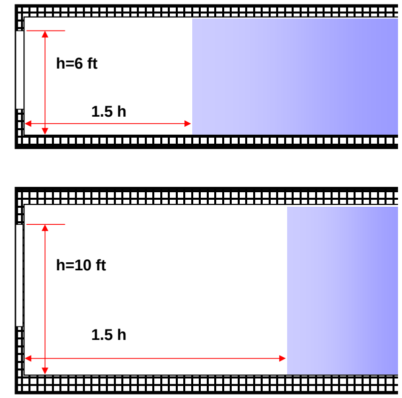
Anaheim, California

- “Plantings are a rural solution”??

e.g., Real Goods, Arkin Tilt

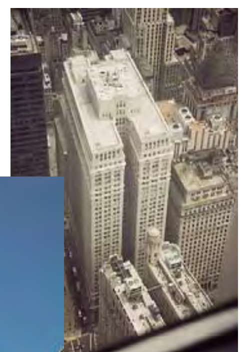
Daylighting





Building Shape

- Alphabet Soup
  - H I A B E



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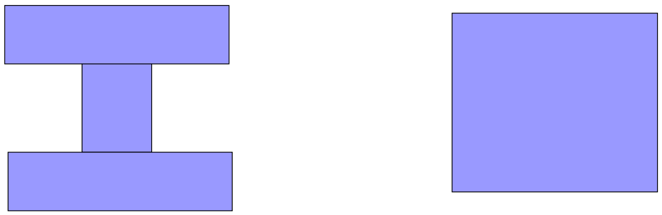
Expanded Plans

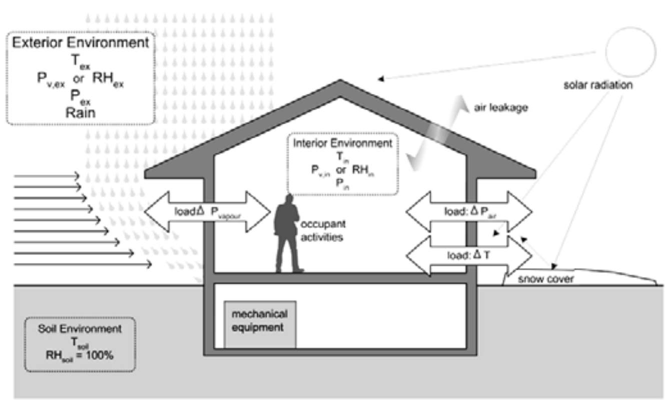
- Better daylight, easier ventilation
- but more enclosure heat loss and gain and air leaks so still need better enclosure



Trade offs

- Large rectangular buildings have a reduced surface to volume ratio
  - Equals lower heat loss and gain
- Complex building shapes increase surface area
  - Heat loss and gain increase
  - Increased materials and cost
  - Require better insulation and solar control

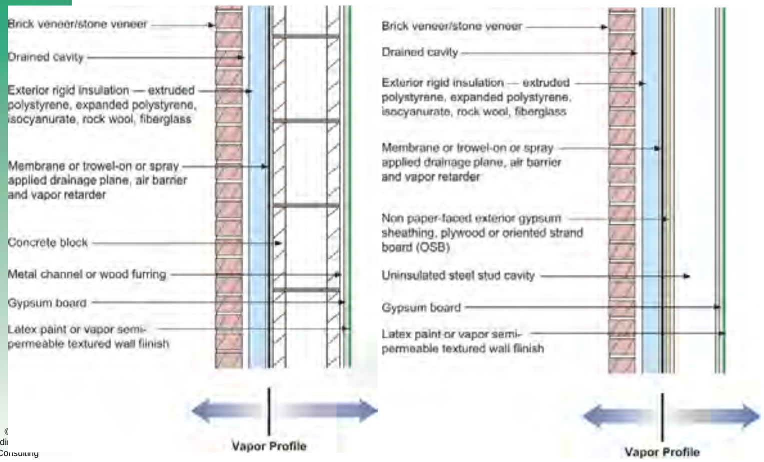
The role of the building enclosure



The Enclosure: Adding the Layers

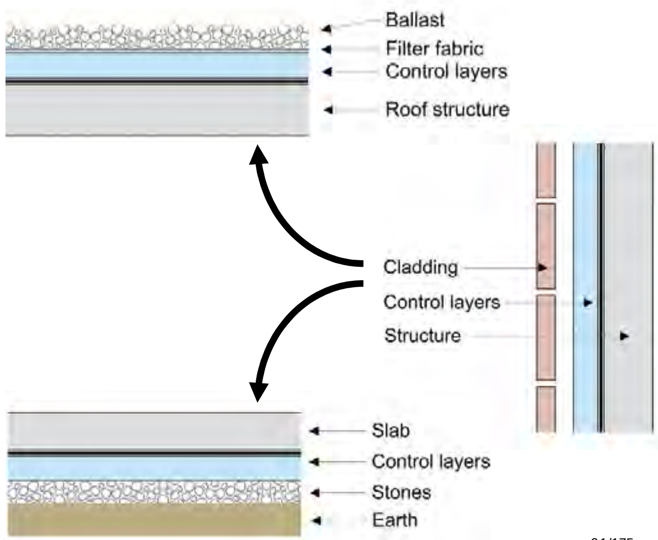
- Structure
- Air Barrier
- Insulation
- Rain Control
- Finish

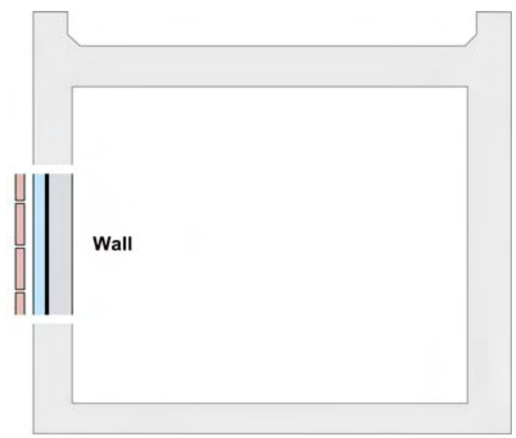
The perfect wall



Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish





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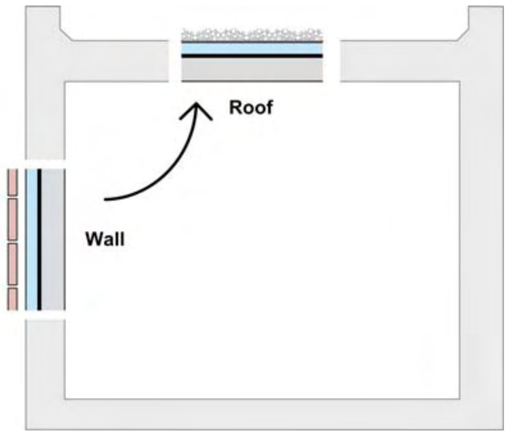

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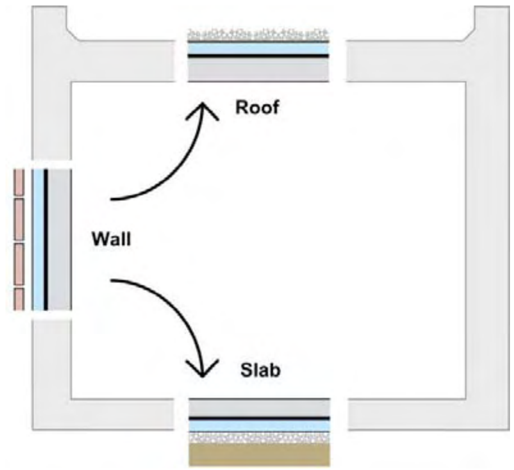

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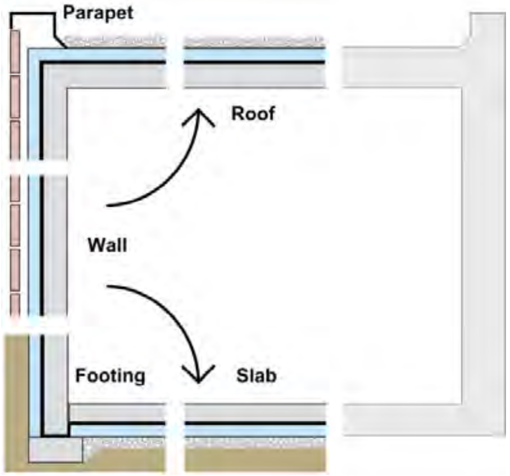

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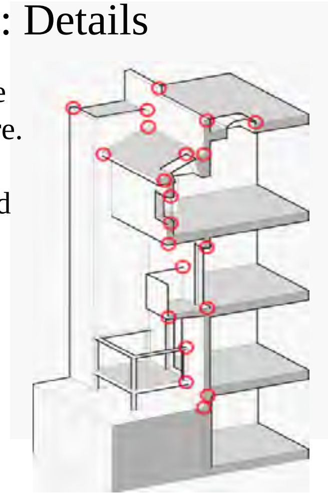
Enclosure Design: Details

- Details demand the same approach as the enclosure.
- Scaled drawings required at ○



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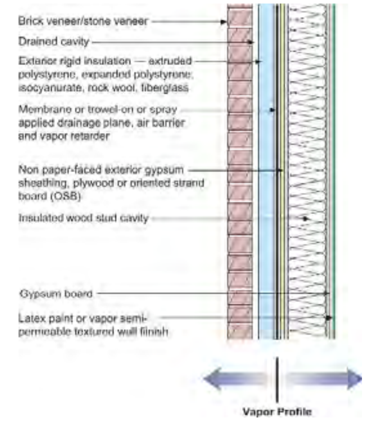
More challenging …

- Compromise
  - Wood
  - High R-value steel
    - R40+



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Good Practice

- Structure
  - connect all parts together to foundation
- Continuous Rain Control
  - Drainage plane, gap and flashing is needed
- Continuous Insulation
  - Exterior insulation layer to slow heat flow, blunt cold spots (R>5-10)
- Air barrier
  - Continuous air barrier to control air flow
  - Vapor retarder less important, may have holes

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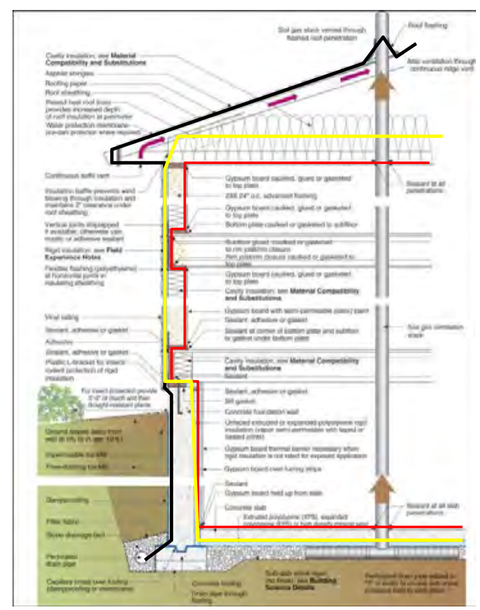
Houses

- Rain
- Heat
- Air



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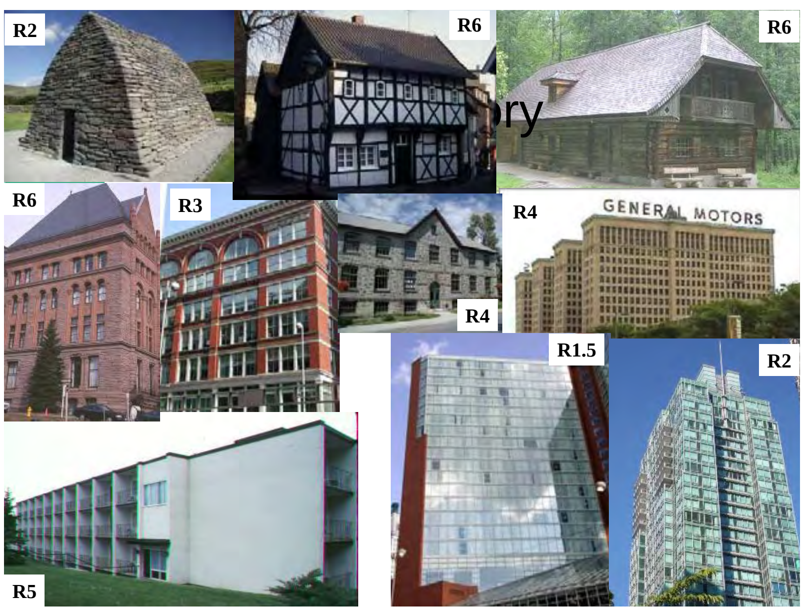
Basic Enclosure Details

- Reduce heat loss and gain
  - Insulation
  - Avoid thermal bridges
  - Use good windows
  - Airseal and test!

Heat flow through materials

- Low density materials insulate better!
- Past – relied on high density (but **thick**) structural materials to control heat, air, and moisture flow
  - Wood R 1.000 /inch
  - Clay Straw R 0.700 /inch
  - Old brick R 0.180 / inch
  - Concrete R 0.070 /inch
  - Steel R 0.004 / inch

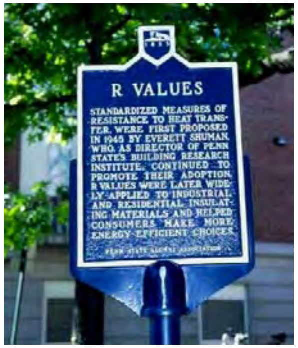


How much insulation?

- Regardless of type, use *more*
- For Comfort & Moisture Control
  - **True** R5-10 is enough (!), but …..
- For energy and the environment
  - As much as practical & economical
  - Cold/mixed R20-40 walls, R25-60 roofs, Slabs R5-15, basements R10-20
  - Hot R15-25 walls, R20-40 roofs, slabs 5-10
- reduce HVAC capital cost as well as operating!

Insulation vs R-value

- R-value= material
- We build systems
  - Thermal bridging
  - Air leakage
  - Installation
  - Thermal mass

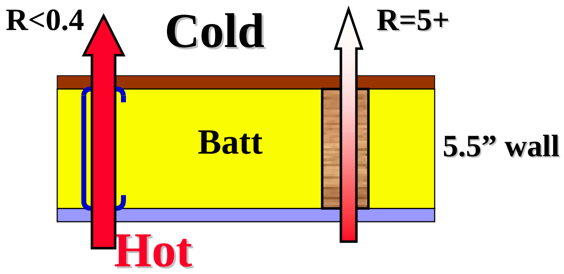


Insulation

- We often use lots of insulation . . . .
  . . . . but not everywhere
- We need *to plug the holes*!
- Heat gained/lost because of
  - Thermal bridging through structural components
  - Too many/ too bad Windows
  - Uncontrolled Air leakage
  - Poor Installation of air permeable insulation

Thermal Bridging

- **Steel is 400 times more conductive than wood**
- **Steel studs are about 40 times thinner**



Find the thermal bridge

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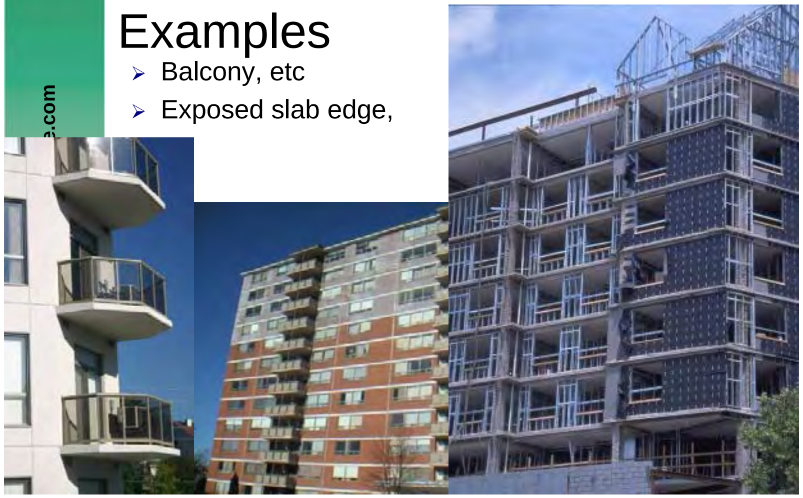
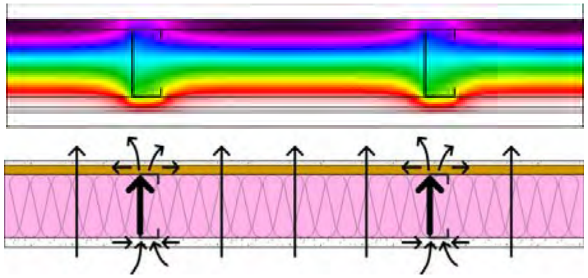
Thermal Bridge Examples

- Balcony, etc
- Exposed slab edge,



Heat bridging through steel studs



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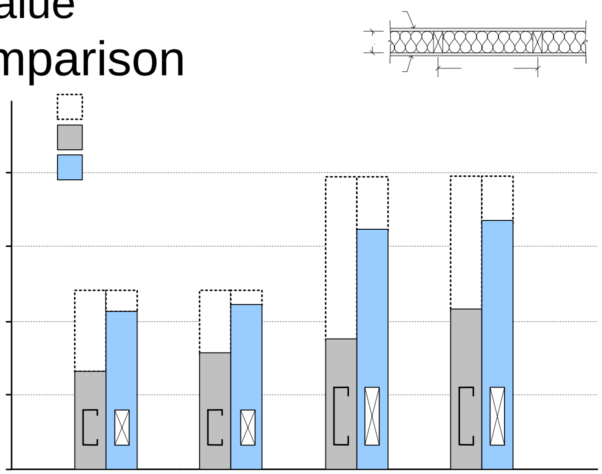
R-value Comparison



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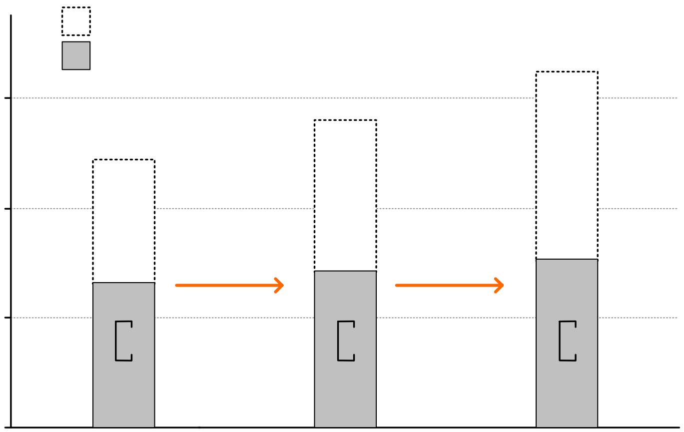
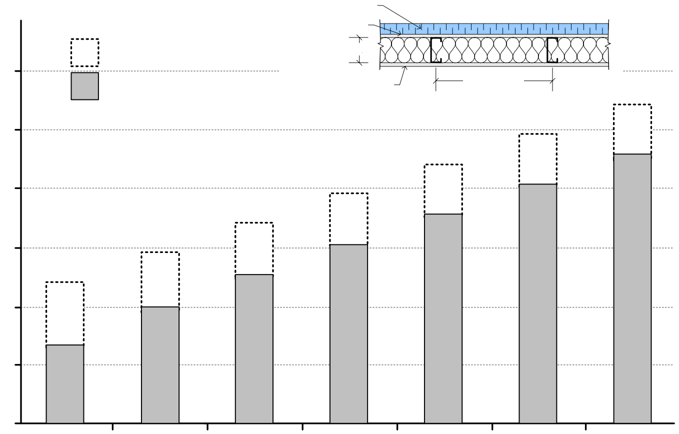
Adding Batt/Foam to cavity does not help!



Impact of Insulating Sheathing

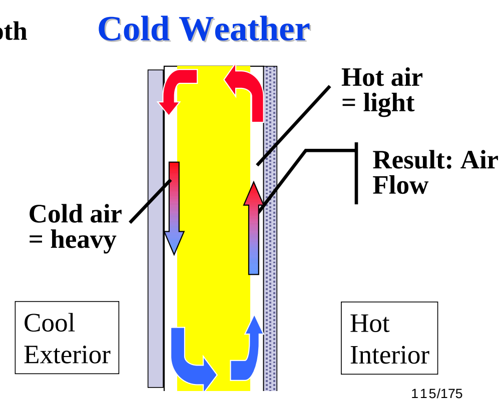


R_{cc}

R_{avg} (steel framing)

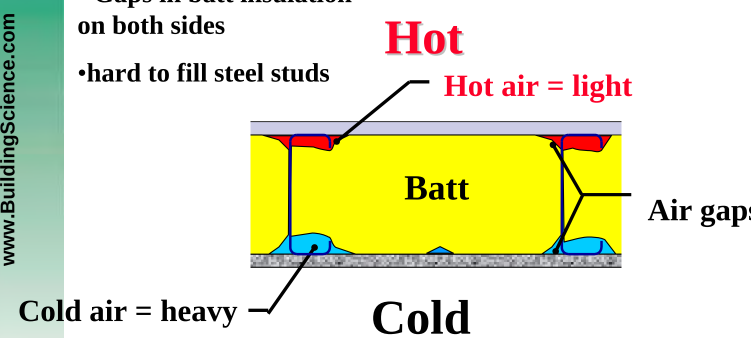
Internal Stack Effect

- Gaps in batt insulation on both sides
- closed circuit
- energy cost
- cold surfaces



Steel studs provide conduits

- Gaps in batt insulation on both sides
- hard to fill steel studs



.0

Add R2

Get R0.6

6.6

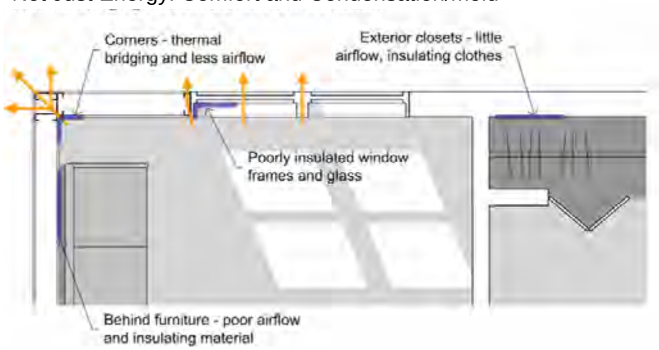
55%

7.2

51%

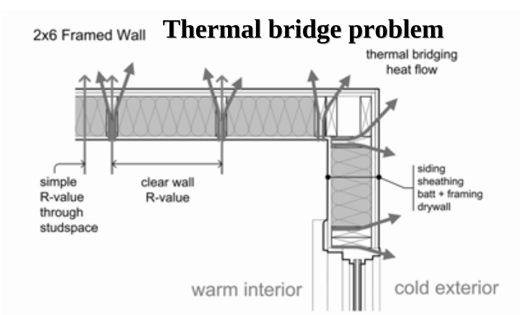
Thermal Bridging: Common Problems

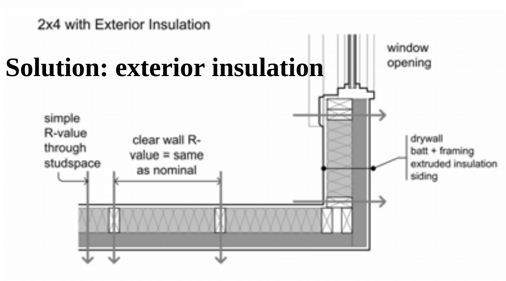
Not Just Energy: Comfort and Condensation/mold



Solving Thermal Bridging

- Insulate the thermal bridge
  - Exterior insulation solves most thermal bridges
  - Inside insulation: difficult to cover structural penetrations
- Common Band-Aid Fix
  - Lower interior RH to stop condensation





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How difficult is this?

- Exterior insulation

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Air leakage & Ventilation

- Hard to save energy with the door open
- Buildings getting tighter, but . . .
  - Many still leak way too much
  - We can't identify the leakers
  - Need to test! Commission!
- Ventilation: Many try to improve air quality by increasing quantity
  - Target good air when and where needed

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Air Barriers and Energy

- Require a strong, stiff, durable, and above all continuous barrier to airflow over the whole building
- Easily 1/3 of total heat loss is due to air leakage in well insulated building

Air Barriers vs Vapor Barriers

- ***Vapour Barriers Control Vapour Diffusion***
  - Why? 1. Moisture wetting and drying
- ***Air Barriers Control Air Leakage***
  - Why? ***Six*** reasons.
  - Heat (for 1. comfort &
    2. energy considerations)
  - 3. Moisture
  - 4. Sound
  - 5. Smoke &
  - 6. odours and dust

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Vapor barriers = drying retarders

- Vapor diffusion is a slow process
- Uniform action = small holes don't matter
- Use as needed, not more
  - Beware air conditioned buildings
  - Don't place peel & stick outside insulation!

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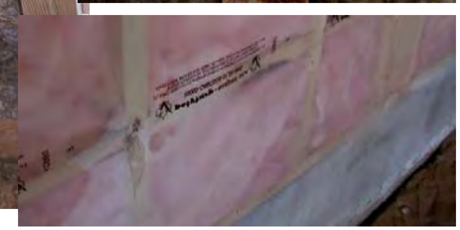
Warm climates

Cool climates



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Air Barriers are Systems (not materials)

- Air barrier systems are required to stop airflow through enclosure
- ABS can be placed anywhere in the enclosure
- Must be **strong** enough to take wind gusts
- Air barrier systems must be continuous
  They leak at joints, interfaces, penetrations
- multiple air barrier planes are useful for redundancy

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A Green Building?

Spray foam= air barrier drainage plane insulation vapor control

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Windows & Curtainwalls

- Our most expensive thermal bridges!
- U-value 0.33 = R3
  - Typical better quality vision curtainwall/window
- U-value 0.50 = R2
  - Typical commercial vision curtainwall

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Performance Issues and Metrics

- Heat Flow (R,U)
- Solar Heat Gain Coefficient (SHGC)
- Visual Transmittance (VT)
- Condensation resistance (CRI)
- Air Leakage
- Water penetration
- Impact and Blast

Windows vs Opaque Enclosures

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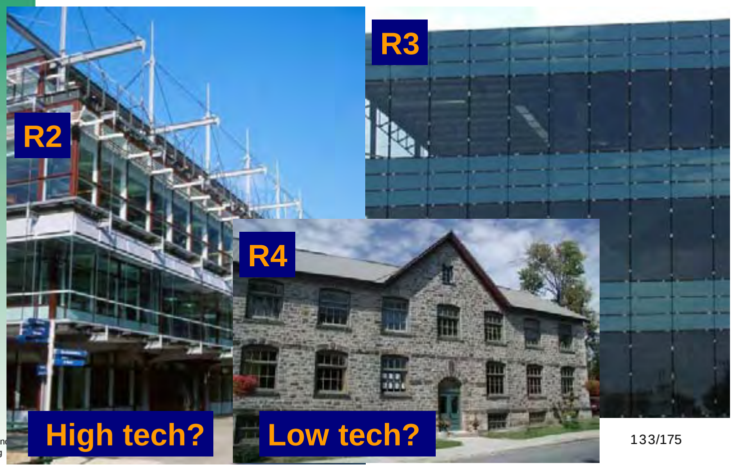
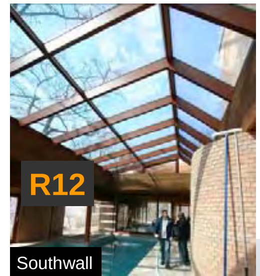
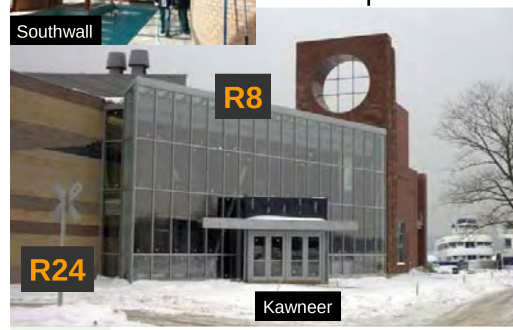
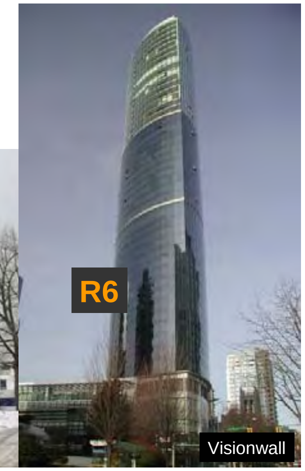


High Performance



- Good is possible





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How much glass?

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- 25-40% of wall area

Total Heat Flow

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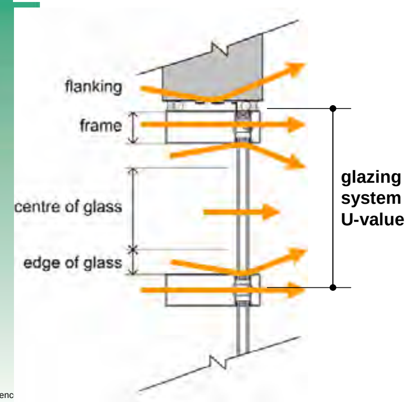
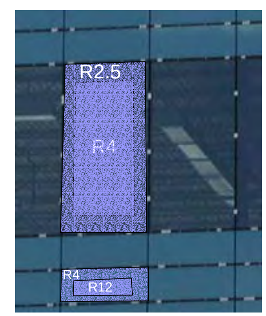
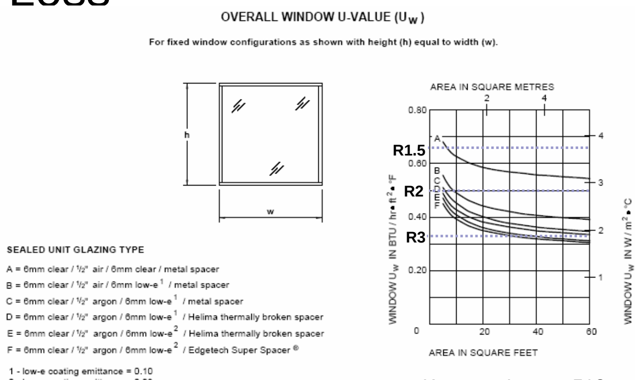
Curtain Wall Plan View

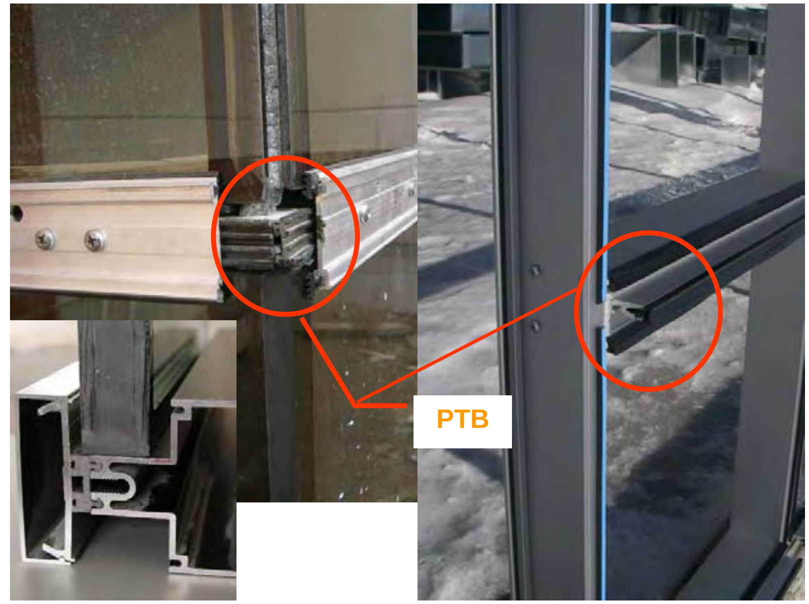


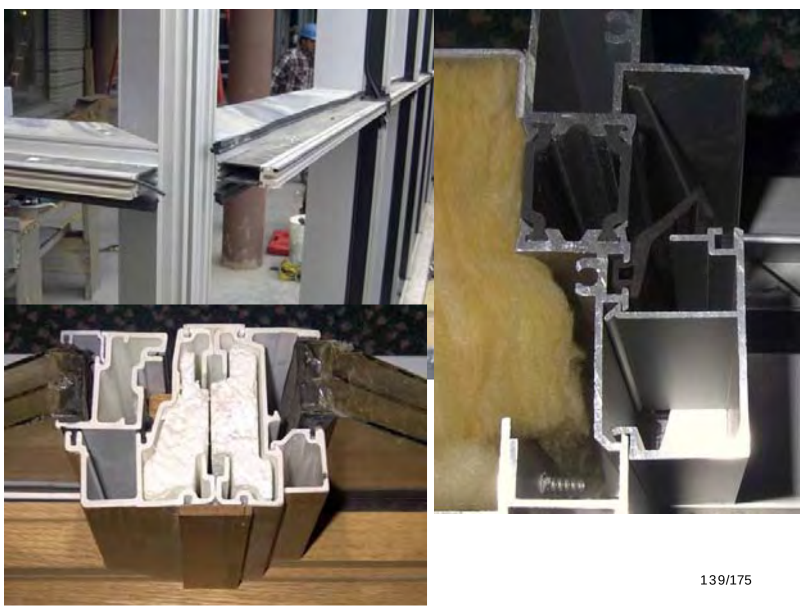


More Frames = More Heat Loss



Kawneer Isoport 518





Overall Window U-Value

- The overall thermal performance of the window depends on
  - Materials (Glazing, Coatings, Fills, Frame)
  - Geometry (Window, Frame)
  - Type of Window (Operable = more air leakage)
  - Installation (Position, Interface with walls)
- Generic overall U-values are provided in many text & handbooks (e.g. ASHRAE)
- U-value over 0.5 is bad!!- aim for U less than 0.33
- Most manufacturers publish overall U-values for their products (rated by the NFRC)

Solar Heat Gain

- Glazing ratio dominates size of AC equipment and ducts in all climates
- Solar Heat Gain Coefficient: SHGC
  - Ratio of solar gain on window that enters room as heat
  - Lower controls better
  - Typically below 0.5

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Solar Control

- Visual Transmittance (VT)
  - Ratio of daylight that hits a window that enters the room
- Spectrally selective
  - Control solar heat gain (SHGC<<0.50)
  - Allow plenty of daylight (VT >0.50)

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Solar Heat Gain

- Solar gain through glazing dominates cooling capacity installed
- Solar Heat Gain Coefficient
  - Ratio of solar heat available: penetrates
  - Clear double glass SHGC about 0.70
  - Spec < 0.50 if small window area
  - Spec <0.30 for larger window area
  - Exterior shades work, interior shades dont

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Double Facades

- "Controlling solar heat gain by placing building in a green house"
- Reported energy use high
- Research shows DF are energy pigs
- Great design is lipstick

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Windows & Curtainwalls

- Good windows or few of them
- Guidance
  - U< 0.33 WWR <25% (R3, SHGC<0.5)
    - Standard thermally broken alu with low-e argon
  - U<0.25 WWR < 50% (R4, SHGC<0.4)
    - Enhanced thermal break, best glazing
  - U<0.20 WWR >50% (R5+, SHGC<.3)
    - Fibreglass or high-perf curtainwall, triple glazed
- Curtainwall Spandrels
  - Insulation is compromised by frame
    - Need high performance frames, better design!

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Durability

- All about moisture (& UV, and high temperatures and fire)
- Keep the rain out
- Control air leakage condensation
- Beware cold side vapor barriers
  - Cold side = inside in summer
- Keep the structure warm and dry

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Continuous Rain Control

- Deflection Drainage Drying
- First reduce rain on building with details
- Stop rain penetration by Drainage (or Storage or Perfect Barrier)
  - Drainage plane continuous
  - Drainage gap continuous
  - Lead to flashing and weep holes
- Dry remaining moisture

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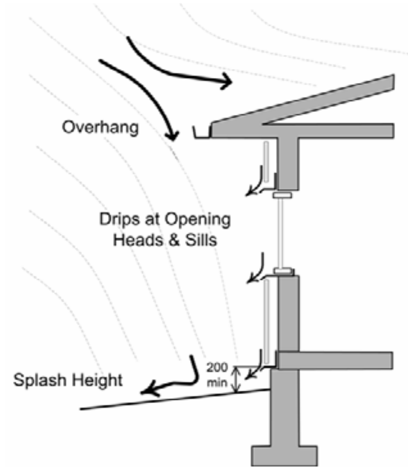
Deflection



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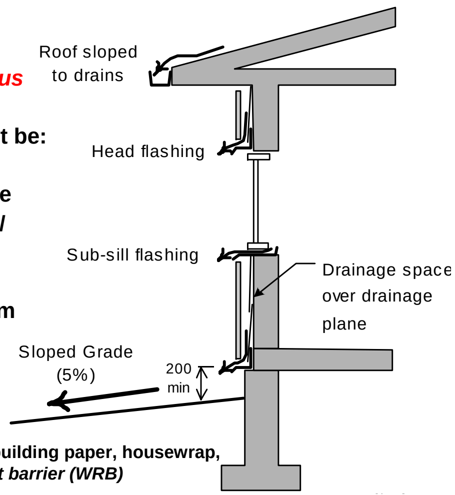
Drainage

- **Must have *continuous* drainage plane**
- **Drainage plane must be:**
  1. **Water tolerant**
  2. **Capillary inactive (water repellent / non-wicking)**
- **Small *gap* required**
  - **As small as 1 mm**
- **Flashing is *very* important**
- **Weep holes**



Terms: sheathing membrane, building paper, housewrap,
Stupid terms: *weather resistant barrier (WRB)*

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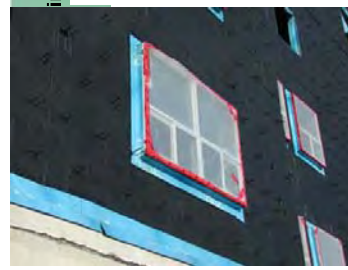
Types

- Format
  - Sprayed on
  - trowel applied
  - Sheet applied
- Desirable Attributes
  - Self sealing
  - Fully adhered
  - Vapor permeable



Drainage planes

Housewrap Problems: materials& installation

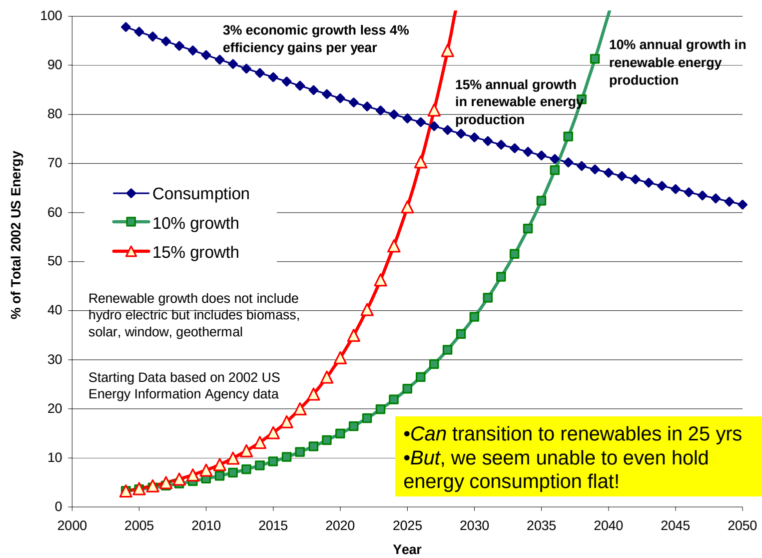
Gravity

Resource Efficiency

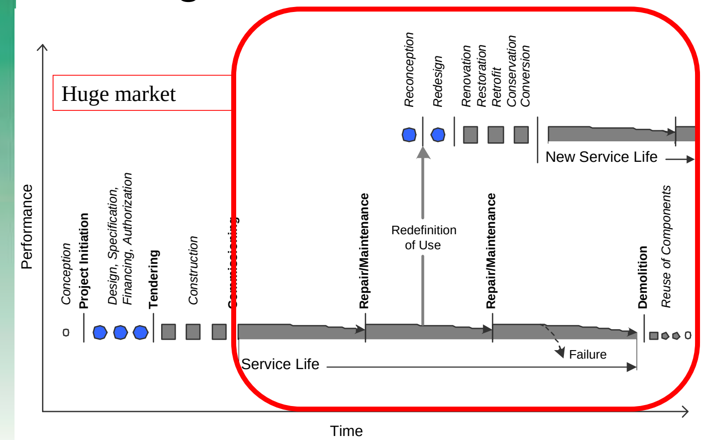
- Same safety with fewer materials
  - No new research, just better design
  - Simple shapes = fewer resources
- Switch to more renewable resources
  - Need to develop standards
  - Code acceptance
    - E.g. wood windows in schools

Efficiency, Renewables, Retrofits

- Reducing energy used (efficiency) allows renewables to be economically and environmentally practical
- Both are needed!
- Huge existing stock of buildings, means..
- Energy Efficient Retrofits must be part of any solution!



Building Retrofit



Technology Assesment

- Ask: does it meet the goals?
  - Low-embodied energy with energy savings is not green
  - Recycled content at cost of durability is questionable
  - High efficiency not useful if output is wasted

Greenwashing & fads

- Double Facades
  - Twice the price, half the performance
- UnderFloor Air Distribution
  - Another fad
  - IAQ??
  - Questionable energy savings
- Green materials
  - Bamboo flooring? Linoleum? Maybe.
- Green roofs?

Ask Tougher Questions
Be Critical

London City Hall

- Energy Consumption
  - 376 kWh/m²/yr actual reported consumption (public records)
  - Shape is nice, but too much glazing= poor solar control

Gehry's Stata Center

Seattle City Hall

CITY HALL ENERGY USAGE

Seattle's new City Hall is using more electricity than the larger building it replaced.

NEW BUILDING | OLD BUILDING

Average kilowatt-hours per day: 7,045 | 5,940

Average kilowatt-hours per year: 2,571,551 | 2,167,964

Month-by-month comparison*

Average kilowatt-hours per day

*Old building: Jan. 2002-March 2003
New building: Jan. 2004-March 2005

Source: Seattle City Light

SEATTLE POST-INTELLIGENCER

seattlepi.com

Local

Tuesday, July 5, 2005

Seattle's new City Hall is an energy hog

Higher utility bills take the glow off its 'green' designation

By KATHY MULADY
SEATTLE POST-INTELLIGENCER REPORTER

Seattle's new City Hall was designed with the environment in mind, using the most energy-efficient technologies.

But the building acts like an old-fashioned electricity hog. It has lofty public spaces and walls of glass designed to welcome citizens and suggest an open and transparent government. It also uses 15 percent to 50 percent more electricity some months than the older, larger building it replaced, according to Seattle City Light utility bills.

The high energy use is an embarrassment for the city at a time when Mayor Greg Nickels is urging municipalities across the country to cut their energy

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Waterloo Apartments

- Below average cost ($125/sf)
- About 1/3 energy consumption
  - Measured
    35 kBtu/sf
    105 kWh/m^2
- Better durability, quiet, healthy


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Strategies/Technology

- Spray foam air barrier drainage plane uninterrupted insulation
  - Thermally broken balconies
- Shading and low solar gain windows
- Double glazed FG, Argon low e super spacer
  - WWR < 25%
- All hydronic heat/refrigerant cooling
- Low energy ventilation

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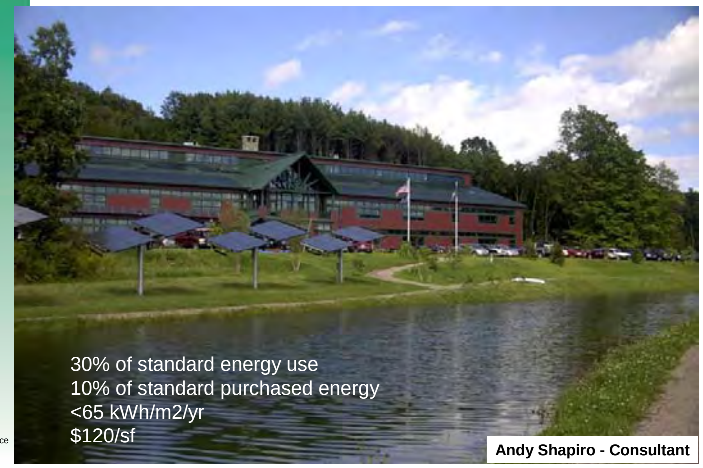
Hanover House

- Simple form, super-insulated, air tight, solar hotwater heat, passive solar

Marc Rosenabum

NRG Building Vermont



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Real Goods

- Arkin-Tilt Architects

How to do it

- Count - energy and resources
- System integration
  - "Professional specialization" disease
  - Sub-system optimization
  - Non-optimal whole system design
- Real benefits come as a system, not individual
  - Airtight, shade and solar windows save AC costs, fans, and ducts
  - Better insulation can mean no furnace
  - Reduced power req't = alternative energy economical

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Conclusions

- Good Building requires Building Science
- Green:Focus on operational energy
  - Insulation with no thermal bridges
  - Airtight w/controlled supply
  - Better windows, solar control Eventually embodied will matter more
- Durability matters!
  - Drainage plane, airtightness

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The Future: Goals

- Paradigm shift from "least evil" to "as much good"
- Buildings must eventually
  - Produce energy
  - Clean air and water
  - Enhance local ecology, provide habitat
  - Reuse materials, low-energy recycle

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Future: Hope?

- Produce power (CHP, PV), interconnect to grid, and/or manage peak demands
- "Smart" Grid
  - Internet connected power grid / appliances /users
- Convergence of Agriculture-Chemicals-Fuel
  - Hydrocarbon to Carbohydrate economy
    - From where do we get carbohydrates?
  - Naturally-sourced low-embodied energy or natural polymers
- Active/passive switchable/tuneable properties

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Resources

- BETEC Building Enclosure Councils
- This presentation will be at
  - **www.BuildingScienceSeminars.com**
- Much more free downloadable info at
  - **www.BuildingScience.com**
- Many drawings/figures from
  - *Building Science for Building Enclosure Design* Straube & Burnett, 2005

Evaluation

Speakers

1. John F. Straube, PhD, M.A.Sc., P. Eng.

AIA150

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