



An Introduction to Sustainable

# Building Renovation Envelope and Materials

Key Factors and Selection Criteria

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# Building Envelope



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# Thermal Criteria

- Use at LEAST the minimum insulation values required by the Energy Code.
  - **Locate in the proper configuration to be fully effective.**
  - **Add more in the roof for best payback**
- Install the best windows that can be afforded.
  - **Thermally broken frames, low-e double paned glass**
- Control heat gain appropriately for climate and orientation.
  - **Tint glass & provide overhangs to block solar gains & glare**
  - **Consider color and thermal mass of roof material**
  - **Add vestibules on main entrances to the building**
- Attic ventilation can make or break the envelope.

# Daylighting Criteria

- Balance thermal walls & area of windows to provide the best daylighting situation
- **Provide light shelves and reflective ceilings to bring sunlight further into interior spaces**
- Use clerestories and skylights to enhance light in deep interior spaces where permissible by roof & space conditions.
- **Provide shades or blinds for light control**

# Attention to Details

- Seal & insulate all penetrations
- Avoid thermal bridging in exterior envelope
- Install door thresholds, bottoms & weatherstripping
- Consider the vapor drive of the building's climate to appropriately place vapor barriers
- Provide as much control of lighting & daylighting for occupants as possible.

# Green Material Selection



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# Setting Priorities

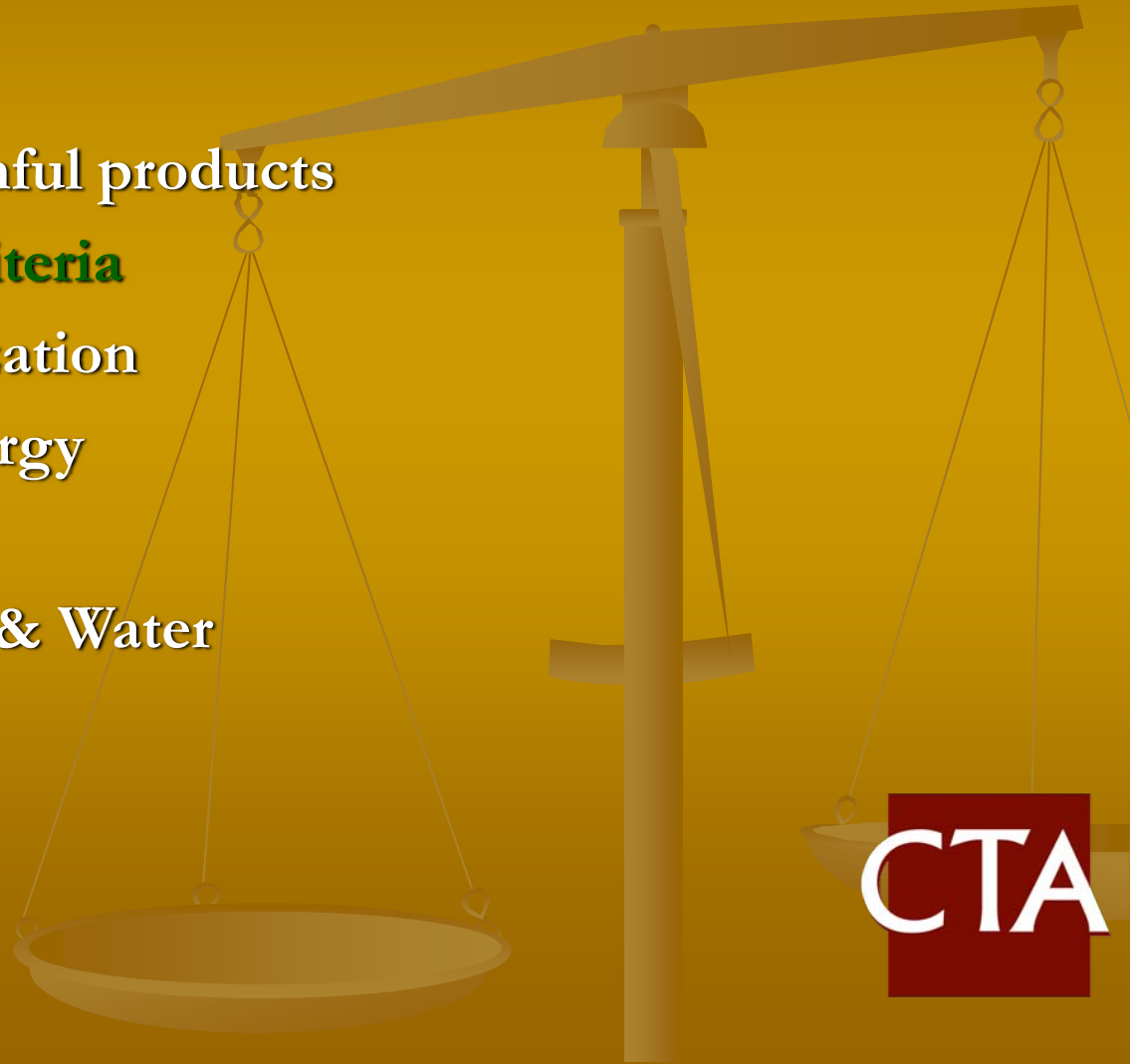
“What is the greenest product/material I can specify?”

- **Health Criteria**

- Eliminate harmful products

- **Environmental Criteria**

- Resource Utilization
- Embodied Energy
- Solid Waste
- Pollution – Air & Water



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# Health Criteria

A golden balance scale is positioned on the right side of the image. The scale is tilted, with the right pan being higher and lighter than the left pan. The left pan is large and empty, while the right pan is small and also empty. The scale's beam and central pillar are also golden.

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# Key Health Criteria

for material selection

- **PVC-free materials**  
for flooring, wall covering, carpet backing, ceiling tile, furniture, piping, siding, roofing, windows, electrical insulation & sheathing
- **No added formaldehyde**  
particularly in wood products such as in casework, furnishing & flooring
- **Low or no VOCs**  
paints, adhesives, stains, finishes, floor coverings & furniture
- **Brominated Flame Retardants**  
electronics, building materials, & furnishings

The logo for the Center for the Textile and Apparel Industry (CTA) is located in the bottom right corner. It consists of the letters "CTA" in a white, serif font, set against a dark red square background.

# Polyvinyl Chloride (PVC)

## the major hazards

- By-products of PVC production are highly persistent, bioaccumulative, and toxic
  - Hazardous by-products are formed throughout the PVC lifecycle
  - Workers and communities are exposed to toxic substances due to PVC production
  - PVC is the largest use of chlorine gas in the world
    - Chlorine production consumes enormous amounts of energy & causes mercury pollution
- Flexible PVC harms indoor air quality
- PVC is extremely difficult to recycle
- PVC is one of the most environmentally hazardous consumer materials ever produced

# Alternatives to PVC

## ■ Piping

- Cast iron, steel, concrete vitrified clay, and plastics such as HDPE (high density polyethylene)

## ■ Siding

- Fiber-cement board, stucco, recycled or reclaimed FSC certified sustainably harvested wood, OSB, brick, and polypropylene

## ■ Roofing Membranes

- TPO, EPDM, FPO, MBM, NBP and low-slope metal roofing

## ■ Flooring & Carpet

- Linoleum, bamboo, ceramic tile, carpeting with natural fiber backing or polyolefins, reclaimed or FSC certified wood, cork, recycled rubber, concrete, and non-chlorinated plastic polymers

## ■ Wall Coverings & Furniture

- Natural fibers such as wood and wool, polyethylene, polyester, & paint

## ■ Electrical Insulation & Sheathing

- Halogen free, LLDPE (linear low-density polyethylene) & XLPE (thermoset crosslinked polyethylene)

## ■ Windows & Doors

- Recycled, reclaimed or FSC certified wood, fiberglass, & aluminum

# Urea-Formaldehyde

## the major hazards

- Formaldehyde is a flammable, colorless gas with a pungent, suffocating odor that causes:
  - **Burning sensations in the eyes and throat**
  - **Nausea**
  - **Difficulty breathing, trigger asthma attacks**
  - **Fatigue**
  - **Skin irritation**
  - **Has been known to cause cancer in animals**
    - **Is a probable human carcinogen**
- Can emit for the life of the product but 80% occurs in 1<sup>st</sup> year and most offgassing done in 7 – 8 years.

# Alternatives to Formaldehyde

- Use exterior grade pressed wood products (contains phenol formaldehyde in lieu of urea formaldehyde)
- Coating pressed wood products on all sides with polyurethane / laminate
- Wheatboard
- Formaldehyde-free MDF
- Solid wood
- Bamboo

# Volatile Organic Compounds

the major hazards

**Volatile:** evaporates readily at typical room temperatures

**Organic:** a compound containing carbon

- Eye, nose, & throat irritation
- Headaches
- Loss of coordination
- Nausea
- Fatigue
- Dizziness
- Damage to liver, kidney, & central nervous system

# Sources of VOCs

- Paints, adhesives, wood preservatives, coatings, sealants
- Cleaning products
- Dry cleaned clothing
- Aerosol sprays
- Air fresheners
- Office equipment such as copiers and fax machines
- Furnishings
- Permanent markers

**VOCs react with sunlight and create ground-level ozone (i.e. "smog")**



# Alternatives to high VOC Content

- Plant-based oils
- Citrus peel oil
- Propylene glycol (vs. ethylene glycol)
- Factory finished
- Should still be used with adequate ventilation
- Building flushing before occupancy can help significantly

# Environmental Criteria

## Includes:

- Resource Utilization
- Embodied Energy
- Solid Waste
- Pollution – Air & Water

# Resource Utilization

- Durability of materials/ low maintenance
- Abundance & Replenishment of resource, Efficiency of resource use
- Efficient use of other resources, e.g. water, energy
- Recycled content of material/ salvaged materials
- Recyclability of material

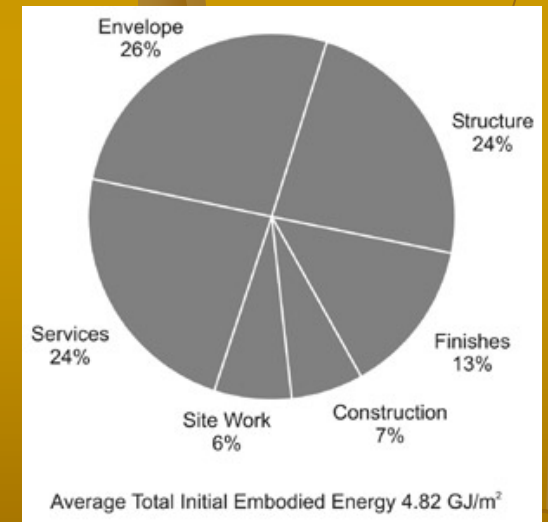


# Embodied Energy

- **Embodied energy of material:** includes all of the energy required to produce the product, produce the constituents that go into the product, transport it, install it, and in some cases, maintain and dispose of it.

Embodied Energy for production of several common building materials (Thousand Btu per pound)

- **Lumber: 1** (640 kWh/ton to harvest and process)
- **Brick: 4**
- **Cement: 5**
- **Plastic: 6**
- **Glass: 14**
- **Steel: 24**
- **Aluminum: 126**
- **Aluminum (recycled): 5**



Breakdown of Initial Embodied Energy by Typical Office Building Components Averaged Over Wood, Steel and Concrete Structures [Cole and Kernan, 1996].

# Solid Waste

- Diversion of materials from landfill
- Reuse of building materials / components
- Avoided production of solid waste (design to avoid cutting losses)

# Pollution – Air & Water

- Global warming (carbon dioxide, fossil fuel emissions)
- Ozone depletion (CFCs, HCFCs)
- Heavy metals, toxins
- Biocides, pesticides
- Indoor air quality (VOCs, dust, mold, combustion by-products, etc.)



# What should we be asking?

- Where does it come from?
- What are the impacts of its use (intentional & unintentional)?
- Where does it go?
- How do I verify the product's sustainable attributes?



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# Examples of Green Materials



# Site/Landscaping

- Recycled Plastic Lumber
- Rainwater Harvesting systems
- FSC Certified wood
- Alternatives to Treated Wood
- Fly Ash Concrete
- HDPE Pipe
- Permeable Pavement
- Salvaged Building Material (i.e. crushed brick)
- Rooftop planting media

# Building Shell

- Fly Ash Concrete
- Permanent Concrete Forms
- Recycled Plastic Lumber
- Alternatives to Treated Wood
- FSC Certified Wood
- Low VOC Paints
- High Performance Windows
- Salvaged Building Materials
- Cellulose Insulation
- Cotton Insulation
- Greener Fiberglass Insulation
- High Recycled Content Materials (i.e. steel)

# Interiors

- Bamboo Flooring
- Cork Flooring
- Cradle to Cradle Carpet
- Natural Linoleum Flooring
- Recycled Ceramic Content Tile
- FSC Certified Wood
- AgFiber Composite Wood
- Low or No VOC Paints
- Salvaged Building Materials
- Recycled Content finishes

# Resources

- The Green Resource Center

<http://www.greenresourcecenter.org/>

- Green Seal

<http://www.greenseal.org/>

- Oikos

<http://www.oikos.com>

- Environmental Building News

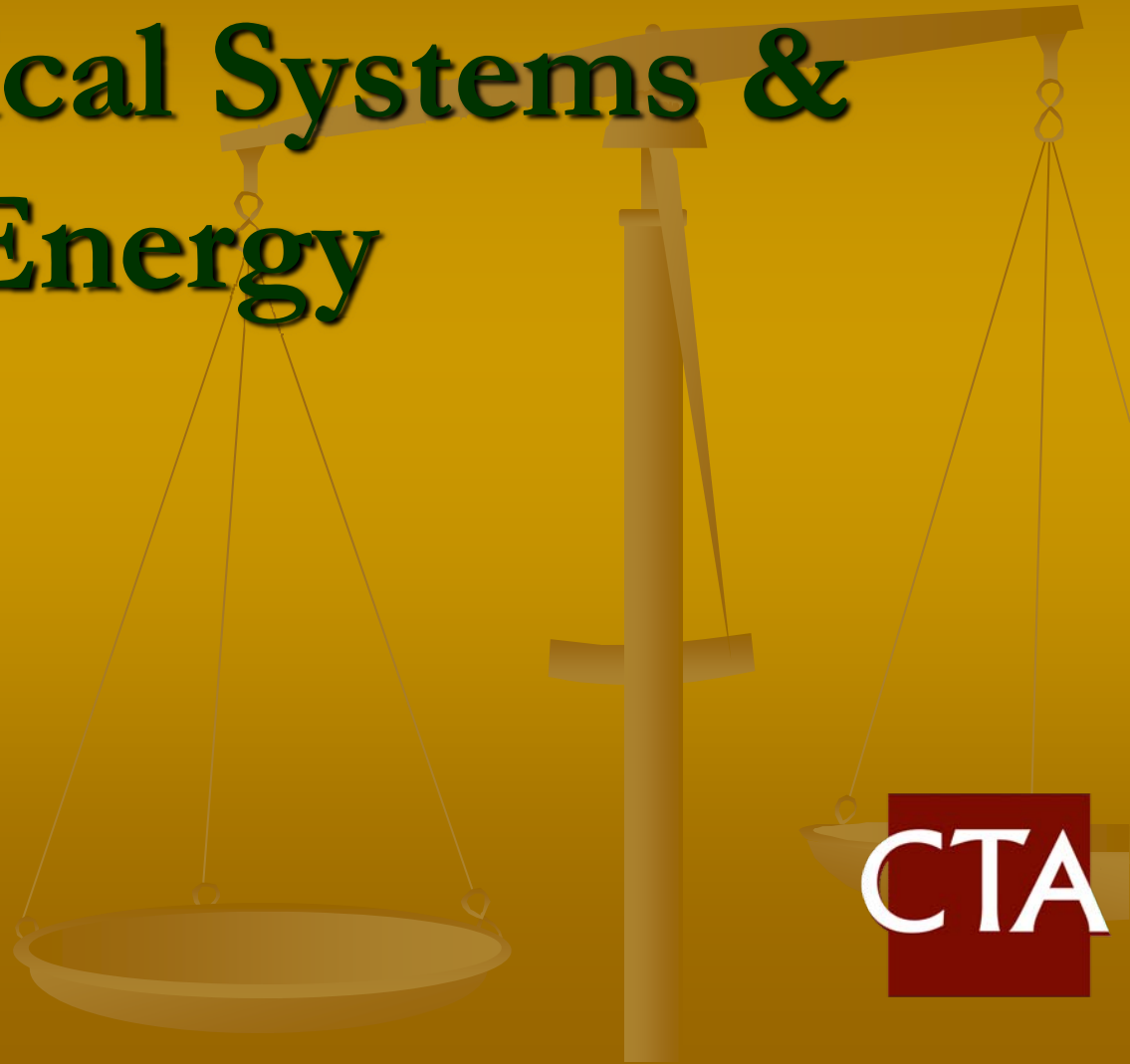
<http://www.buildinggreen.com>

- Carpet & Rug Institute Green Label

<http://www.carpet-rug.org>

The logo for the Carpet & Rug Institute (CTI) is located in the bottom right corner. It consists of the letters "CTA" in a white, serif font, set against a dark red square background. The background of the entire slide features a faint, stylized image of a balance scale.

# Mechanical Systems & Energy



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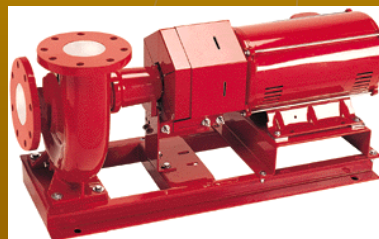
# Mechanical Systems & Energy

## ■ Energy Audits

- Benchmark energy use associated with water, fossil fuels and electrical loads
- Build an energy model to determine when building meets or exceeds expected energy use
- Required air changes will be more significant than building envelope in determining energy consumption. Inefficient equipment will be a greater concern than an inefficient building envelope.

# Components of Building Energy Use

- Cooling
- Heating
- Fans
- Pumps
- Domestic Water Heating
- Lighting (Indoor / Outdoor)
- Appliances / Plug Loads
- Process Energy



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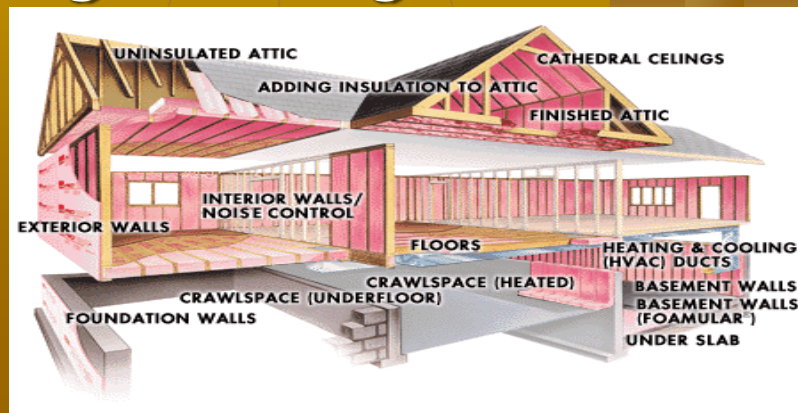
# Energy

- Identify potential energy projects
  - Replace lighting
  - Install occupancy sensors
  - Replace boiler
  - Replace condensing units with ground-source cooling
  - Add economizers to air handling equipment
  - Add digital controls/night set backs
  - Replace roof, add insulation
  - Replace windows



# Energy

- Combine energy projects with short and long paybacks (and no energy savings)
  - Short: digital controls & lighting replacement
  - Medium: mechanical system replacement
  - Long: additional insulation
  - Millennial: window replacement (most expensive component of building envelope with lowest R-value)
  - No energy savings: re-configure for 21<sup>st</sup> century learning



# Commissioning



- Re-commissioning existing equipment can often save 10-25% (do this before any energy projects)
- Commissioning
  - Optimize performance of new & expensive equipment
  - Identify major problems with mechanical systems before years of operation and excessive energy use
  - Include real-time review of energy consumption- compare to on-site weather station. Save energy hourly, daily in order to achieve monthly and annual savings.
  - Service what you buy- don't run to failure

# Questions?

- Thank You!

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