GREEN AND EFFICIENT: THE FUTURE OF HOUSING

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GREEN AND EFFICIENT

- What are the issues?
- Where are we going?
- Who says it’s green?
- How do we get there?
IMPACTS OF BUILDINGS

- Energy production and use account for early 80% of air pollution, more than 88% of greenhouse gas emissions, and more environmental damage than any other human activity.
- Residential buildings in the United States are responsible for:
  - 37% of electricity production.
  - 22% of total energy flows.
  - 26.4% of CO2 emissions.
  - Typical home uses 293 gallons of water per day.
  - Each new home consumes 1 acre, about 44 trees.
- Overall energy consumption by the residential sector continues to increase.
IMPACT OF BUILDINGS ON ENERGY

Energy Use by Sector

- Buildings
- Industry
- Transportation

Quads

U.S. energy related CO₂ emissions by sector

- **1990**
  - Industry: 1600 million metric tons of carbon
  - Transportation: 1600 million metric tons of carbon
  - Buildings: 1600 million metric tons of carbon

- **2000**
  - Industry: 2000 million metric tons of carbon
  - Transportation: 2000 million metric tons of carbon
  - Buildings: 2000 million metric tons of carbon

- **2007**
  - Industry: 2000 million metric tons of carbon
  - Transportation: 2000 million metric tons of carbon
  - Buildings: 2000 million metric tons of carbon

**Legend**
- Industry
- Transportation
- Buildings
ENERGY EFFICIENCY

- The cost of saving energy is going down while the price of energy is going up.
- Efficiency is the cleanest, cheapest, safest, and most secure source of energy we have.
- These savings from energy efficiency to date have not yet come close to tapping the full potential for savings.
WHY INCREASE ENERGY EFFICIENCY

- Reduce operating costs of buildings.
- Stabilize atmospheric carbon & reduce global climate change impacts.
- Improve the quality of life in our buildings and communities.
- Reduce demand for fossil fuels.
- Meet increasingly stringent codes, qualify for rebates, and meet LEED criteria.
IECC 2009

- New state law.
- Applies to residential.
- Results in efficiencies about 17% beyond IECC 2006.
- New requirements
  - Building envelope tightness
  - Duct testing
  - Lighting equipment
  - Pool controls and covers
  - Snow melt controls
Sec. 201 of the American Clean Energy and Security Act of 2009 (H.R. 2454) passed by the House calls for national building code energy reduction targets of:

- 30% below the baseline energy code in 2010
- 50% below the baseline energy code in 2014-2015
- 5% additional reduction every three years to 2029-2030.

The Senate bill contains a similar provision, requiring 30% improvements in 2010 and 50% improvements in 2016, but without the additional 5% improvements every three years.
U.S. BUILDING SECTOR CO$_2$ EMISSIONS [11]
WHAT IS “GREEN” DESIGN?

Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas:

- Sustainable site planning and linkages
- Safeguarding water and water efficiency
- Energy efficiency and renewable energy
- Conservation of materials and resources
- Indoor environmental quality
- Owner training and awareness
The International Code Council along with NAHB and others have developed a green construction code for residential buildings. Four rating levels: bronze, silver, gold, and emerald. Energy efficiency and other criteria increase with each level. Adoptable by municipalities and other entities such as developers.
LEED FOR HOMES 2009

- Green Building rating system.
- 8 categories of credits:
  - Innovation & Design Process
  - Location & Linkages
  - Sustainable Sites
  - Water Efficiency
  - Energy & Atmosphere
  - Materials & Resources
  - Indoor Environmental Quality
  - Awareness & Education
- 136 Points – Certified, Silver, Gold, or Platinum Ratings
How Do You Define a Green Home

- Energy
- Indoor Air Quality
- Water
- Sites
- Materials

Healthy

Comfortable

Durable

Energy Efficient

Environmentally Responsible
STORMWATER MANAGEMENT

- Managing stormwater runoff begins with the following steps:
  - Minimize land disturbance on the site.
  - Preserve existing topography, vegetation, and landforms as much as possible.
  - Separate impervious surfaces with turf, vegetation, or gravel to increase filtration and reduce runoff.
  - Use porous paving materials and avoid curbs.
Managing runoff (cont.)

- Minimize the amount of road salt, animal waste, and vehicle fluids, especially on impervious surfaces.
- Avoid using pesticides and fertilizers on landscaping.
- Increase infiltration rather than direct runoff.
- Every home should have an individual drainage plan.

http://www.epa.gov/nps/MMGI/Chapter4/ch4-2a.html
CLIMATE

- The general climate of the region sets the stage. It is expressed in data on temperature, humidity, precipitation, cloudiness, wind speed, and direction, and sun path.
- Good planning takes these factors into consideration when developing sites. Average conditions will not suffice. The extreme range must also be reviewed. It is the extremes that are uncomfortable. The ranges and average maximums, and minimum are likely to be most useful.
Illinois’ Climate Migrates South

Changes in average summer “heat index”—a measure of how hot it actually feels based on a specific combination of temperature and humidity—could strongly affect Midwesterners’ quality of life in the future. For example, the red outlines track what summers in Illinois could feel like over the course of the century under the higher-emissions scenario; the yellow outlines track what summers could feel like under the lower-emissions scenario.
## CLIMATE SUMMARY

<table>
<thead>
<tr>
<th>Data</th>
<th>Chicago</th>
<th>Belleville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Zone</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Mean Temp</td>
<td>48.7°F</td>
<td>56°F</td>
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<tr>
<td>HDD</td>
<td>6630</td>
<td>4612</td>
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<tr>
<td>CDD</td>
<td>702</td>
<td>1339</td>
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<tr>
<td>Highest Temp</td>
<td>105°F (Jul)</td>
<td>110°F (Jul)</td>
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<tr>
<td>Days &gt; 90°F</td>
<td>15.4</td>
<td>44.1</td>
</tr>
<tr>
<td>Lowest Temp</td>
<td>-27°F (Jan)</td>
<td>-27°F (Jan)</td>
</tr>
<tr>
<td>Days &lt; 32°F</td>
<td>44.5</td>
<td>20.4</td>
</tr>
<tr>
<td>Total Precipitation</td>
<td>36.8 inches</td>
<td>39.4 inches</td>
</tr>
<tr>
<td>Annual Snowfall</td>
<td>33.4 inches</td>
<td>16.6 inches</td>
</tr>
</tbody>
</table>
Proper landscaping should be esthetically pleasing while saving up to 25% of the home annual heating and cooling costs (an average $100-$250).
COLD CLIMATES

- Block winter winds with evergreens to the north, northwest, and west sides. They can also block the afternoon sun.
- Plant the windbreak trees and shrubs contiguously, at distance from the home of two to five times the mature height of the trees.
- Do not plant evergreens on the south side as they will block the winter sun, depending on distance and species.
- Deciduous trees on the east and south are best. Plan for canopies to be large enough to shade roofs, reducing cooling costs and increasing summer comfort.
- Plant shrubs and bushes next to the home to create and additional wind or snow break and a pocket of dead air acts as insulation – allow at least 1 foot spacing between full-grow plants and house walls.
- Use native species.
RESIDENTIAL WATER USAGE

- Lawns and gardens - 36%
- Showers and baths - 20%
- Clothes and dishwashing - 16%
- Potable uses - 9%
- Toilets - 19%
WATER USE IN RESIDENTIAL BUILDINGS

- Energy Policy Act of 1992 requires all new residential toilets use no more than 1.6 g / flush.
- Toilet flushing - largest single use of water in buildings (19%) - 4.8 billion gallons of water per day (EPA).
- Dual-flush toilets use 40% less water than 1.6 gal / flush.
- WaterSense toilets use 20% less water.
- Check performance reviews done by consumer testing groups as not all toilets are created equal.
- Switching to water-efficient plumbing fixtures could save the average household as much as $80 to $100 a year on water and wastewater bills.
Showers account for roughly 20% of residential water use: no more than 2.5 gpm -- models range from 1.75-2.5 gpm.

Faucets requirements: no more than 2.2 gpm.
- In many cases much lower flows would suffice.
- Bathroom sinks - 1 gpm should be OK.
ENERGY IN BUILDINGS

- The design, construction, and maintenance of buildings has a tremendous impact on our environment and our natural resources.
- There are more than 130 million residential buildings and nearly 6 million commercial buildings in the U.S. today.
- These buildings together use 42% of all the energy consumed in the U.S., and 71% of all electricity.
ENERGY EFFICIENCY

- An orderly progression through opportunities.
  - Orientation and Natural Flows
  - Building Envelope
  - Windows
  - Appropriate ventilation
  - Efficient fixtures & appliances
  - HVAC
  - Renewable energy
ORIENTATION AND NATURAL FLOWS

- Take advantage of the physical features of the site and microclimate:
  - Orient for optimum solar access:
    - Full southern exposure.
    - Porches on east or west.
  - Topographic modifications.
- For temperate climates:
  - Maximize warming effects of the sun in the winter.
  - Maximize shade during the summer.
  - Deflect winter winds away from buildings.
  - Funnel summer breezes toward the home.
BUILDING ENVELOPE

- Everything that separates the interior of a building from the outdoor environment.
- Three boundaries:
  - Pressure
  - Thermal
  - Vapor
- All must be contiguous and in the proper order. Sometimes they are the same material.
BUILDING ENVELOPE

- Appropriate assembly of walls, roof, foundation, & windows provide good thermal and moisture control while supporting reductions in building loads.

- A good envelope harnesses natural energy through effective use of passive tempering and daylighting and also reduces system size and costs.
PASSIVE TEMPERING

- Regulate solar impact through fenestration and shading devices.
- Moderate interior temps with thermal mass - use building mass as flywheel.
- Use light-colored, reflective roofing.
PASSIVE COOLING AND VENTILATION

Air exhausted through high windows in stairwell

Prevailing Breezes

Open windows

Open Stairwell
RATING WINDOWS

- U-factor measures how well a product prevents heat from escaping.
- SHGC measures how well a product blocks heat caused by sunlight.
- Visible Transmittance measures how much light comes through a product.
- Air Leakage is indicated by a rating expressed as the equivalent cubic feet of air passing through a square foot of window area.
- Condensation Resistance measures the ability of a product to resist the formation of condensation on the interior surface of that product.

Source: www.nfrc.org
WALLS AND FRAMING

- New framing techniques and strategies have evolved that can improve a home’s energy efficiency and durability, while reducing construction costs and maintaining structural integrity of the building.
- By optimizing the amount of lumber used to frame homes, more space is created for insulation in exterior walls. Consequently, cold spots, which are susceptible to condensation, and mold growth are eliminated.
- Material cost savings of $500 for 1,200 square foot homes and $1000 for 2,400 square foot homes can be realized. Additionally, labor savings are estimated at around three to five percent.
ADVANCED FRAMING TECHNIQUES

- Utilizing two-stud corner framing with inexpensive drywall clips.
- Increasing stud spacing from 16 inches to 24 inches.
- Increasing floor joist and rafter spacing to 24 inches.
- Eliminating headers in non-load bearing walls.
- Using single top plates with in-line framing to transfer loads directly.
**MODIFIED HEADER AND WINDOW OPENING**

Reduced waste and increased insulation can be achieved by supporting an insulated header with hangers and by nailing surfaces for siding scabbled toward the outside edge of studs.
STRUCTURAL INSULATED PANELS

Habitat House - SIPs
INSULATING CONCRETE FORMS

- Superior insulation and sound control
- High thermal mass
- Low infiltration
- Durable
- Energy efficient: R-20 walls
Add rigid insulation

- Raised heel trusses.
- Reduce heat loss at wall-ceiling junction.
- Same insulation depth over entire ceiling.
AIR SEALING

- Air leakage accounts for between 25 percent and 40 percent of the energy used for heating and cooling in a typical residence.
- Source of moisture, cold drafts, and unwanted noise
- All penetrations through the envelope must be sealed.

Source: EPA 430-F-97-028, 6202J, Dec 2000
Larger heating and cooling equipment can overcome a multitude of sins committed in the design and construction of the house and HVAC system by throwing more size and horsepower at the problem.

This adds expense and wastes energy. It may also affect the ability of the cooling system to dehumidify.
EQUIPMENT & SYSTEM SIZING

- Properly sized heating and cooling equipment contributes to comfort and efficiency in several ways:
  - The closer the heating and cooling equipment is sized to the load, the more frequently it will run, helping to mix the air in the house and providing more uniform temperatures.
  - A properly sized air conditioner will run longer, reducing the indoor coil temperature and removing moisture from the air. The longer it runs, the drier the air becomes, and comfort can be achieved at higher indoor temperatures.
  - If an air conditioner is oversized, it will reach the space temperature desired in a very short time, creating cold air with a great deal of moisture. This can result in a cold, clammy house and actually increase the potential for mold problems.
EFFICIENCY VERSUS RUNTIME

- Properly sized equipment with longer run times also operates more efficiently, much in the way a car gets better gas mileage running at a steady 55 miles per hour rather than in stop-and-start traffic.

Source: EPA 430-F-97-028
December 2000
DUCTWORK IN CONDITIONED SPACES

Figure 1: Ducts in Unconditioned Spaces
- Conditioned air lost into attic through leaks in ducts
- Summer heat gains from surrounding surfaces
- Extreme air temperatures in attic
- Winter heat losses to surrounding surfaces

Figure 2: Ducts within Conditioned Spaces
- Plenum
- Insulated building envelope
- AIR HANDLING UNIT LOCATED IN CLOSET
- Supply air duct
- Stable air temperatures
- Return air duct
INSTALLATION

- If quality control is not taken seriously during construction, all of the design and engineering effort that went before is worthless.
- Defects can arise from faulty insulation installation, inadequate air sealing, or the wrong window being delivered and installed.
- If the distribution system is not tightly sealed with mastic, air does not get to the space which it was intended.
High efficiency:
- Two-stage
- Variable Speed
- Condensing
- Up to 95% AFUE

Lennox G71 MPP
Variable Capacity
Gas Furnace
HVAC EQUIPMENT - AIR CONDITIONER

- High efficiency:
  - 16.2 SEER
  - Non-ozone depleting R-410
  - Scroll compressor
  - Must be mated to a larger evaporator coil and a multi-speed air handler (furnace)
  - Qualifies for 30% tax credit.

Lennox XC14
HEAT RECOVERY VENTILATION

- An enthalpy air-to-air heat exchanger draws fresh outside air through a duct into the heat exchange equipment and recaptures heating or cooling energy from the exhaust air.
- Room air can either be ducted to the unit from several rooms or a single source.
- Some units are designed to be mounted in living space while other for utility rooms.
- $400-$2000
ENERGY STAR APPLIANCES

- **Energy Star** is the symbol for energy efficiency. It's a label created by the U.S. Environmental Protection Agency and the Department of Energy to help consumers save money and minimize air pollution.
- The Energy Star logo may be found on clothes washers, refrigerators, dishwashers, consumer electronics, and room air conditioners.
- An appliance receives the Energy Star rating if it is significantly more energy efficient than the minimum government standards.
- Energy Star rated products are usually among the most efficient available today.
IEQ is a big area and covers many topics:

- Indoor air quality.
- Interior lighting and daylighting.
- Temperature and humidity control.
- Ventilation effectiveness and control.
- Separation of activities.
- Occupant control of their environment.

Here is where building green can really pay-off.
LOW EMITTING MATERIALS

Reduce the quantity of indoor air contaminants that are odorous, potentially irritating, and/or harmful to the health, comfort, and well-being of installers and occupants.
LOW EMITTING MATERIALS

- Carpet systems should meet or exceed the requirements of the Carpet and Rug Institute Green Label Indoor Air Quality Test Program.
- Composite wood and agrifiber products should contain no added urea-formaldehyde resins.
- Specify no/low-VOC materials.
- Ensure that VOC limits are clearly stated when adhesives, sealants, paints, coatings, carpet systems, and composite woods are specified.
SUGGESTED VOC LIMITS

- Adhesives: Total VOCs 10 mg/m²/HR
- Sealants
  - Architectural: 250 g/L
  - Roofing materials installations: 450 g/L
- Paints and Coatings:
  - Non-flat - 150 g/L
  - Flat - 50 g/L
- Carpets:
  - Total VOCs - 0.5 mg/m²/HR
  - Cushion Total VOCs – 1.0 mg/m²/HR
  - Installation - 150g/L
OUT-GASSING BEFORE OCCUPATION

- Anything you can smell is generally a pollutant.
- The smallest, most deeply respirable ones, such as VOCs, may be the most dangerous.
- Dissipate them before they enter the home or make sure that they have fully out-gassed before occupation:
  - “Bake-in” – heating the house while ventilating it.
  - Coat materials that out-gas with a “vapor lock” sealer.
  - Keep pollution from ever entering by allowing product to out-gassing before using them.
VENTILATION AND MOISTURE CONTROL

- Ventilation and moisture control strategies are key to safeguarding the quality of indoor air.
- A home should be neither too dry or too humid:
  - Relative humidity below 25% can lead to dry skin, nose, throat, and eyes.
  - Most homes have enough water-generating activities to make dry conditions relatively rare.
  - Relative humidity above 60% can promote damp conditions and mold growth.
  - Excess moisture can enter the home from defects in construction and be the result of poor design.
ASHRAE recommends 0.35 air changes per hour (ACH) for residences.

When system operates it draws out air from several rooms.

Air is drawn in either through grills or an outside air damper connected to the HVAC ductwork.

Units can work on timers and have multiple speeds for different levels of ACH.
GARAGES

- Cars, lawn mowers, and appliances in attached garages can generate exhaust which gets carried into the home.
- Treat the wall between the garage and the house as a full outside wall.
- Consider an exhaust fan tied to the garage door openers (~$200).
- Consider detached garage connected by covered walkway.
CARBON MONOXIDE

- Backdrafting appliances, including gas water heaters, furnaces, stoves, and ovens, can also produce deadly carbon monoxide and other combustion by-products.
  - Newer forced-air furnaces and water-heaters are more efficient leading to cooler combustion gases and weaker drafting (up the chimney).
  - Excessively powerful exhaust fans for range hoods and bathrooms can lead to backdrafting.
  - Here bigger is not better for fan sizing.
- Consider sealed combustion units for furnaces and water heaters.
- Don’t use unventilated combustion devices.
The purpose of this map is to assist National, State, and local organizations to target their resources and to implement radon-resistant building codes. This map is not intended to be used to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones. All homes should be tested regardless of geographic location.

IMPORTANT: Consult the EPA Map of Radon Zones document (EPA-402-R-93-071) before using this map. This document contains information on radon potential variations within counties. EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.
Special techniques may be required to prevent radon gas from entering the home.
OTHER ISSUES

- Range hoods should be ducted to the outside:
  - This is especially true for gas appliances.
  - Moisture buildup is not prevented without ducting.
  - General guidelines call for 100cfm. This may be too much, or certainly the maximum.
  - Consider venting in when laying out the kitchen.

- Central vacuum systems:
  - Exhausts to the outside, removing the contaminated air from the living space.
  - Studies have shown significant reduction in nasal symptoms.
  - Don’t put it in the garage unless you vent it to the outside.
NEW CONSTRUCTION

- New construction is a major opportunity.
- Think about the issues of site, water, energy, materials, and indoor environmental quality as you make your housing plans.
- You can do much for little or no cost.
- Any higher first costs should be leveraged to life cycle savings and considered in the total cost of ownership.