# Improving the Energy Performance of Homes and Households

**Presented by:**
**Allen Zimmerman, Professor**
**The Ohio State University**
**Wooster Campus**
**and ATI students enrolled in the Construction Management Program**
**November 15, 2007**

# Improving the Energy Performance of Homes and Households

- Residential Energy Use
- Water
  - Water Conservation
  - Heated Water Energy Conservation
- Heat Transfer Basics
  - Conduction
  - Convection
  - Radiation
- Moisture Transfer Through the Building Envelope (Via Vapor)
  - Diffusion
  - Air Transport
  - Dew Point

# Improving the Energy Performance of Homes and Households - Continued

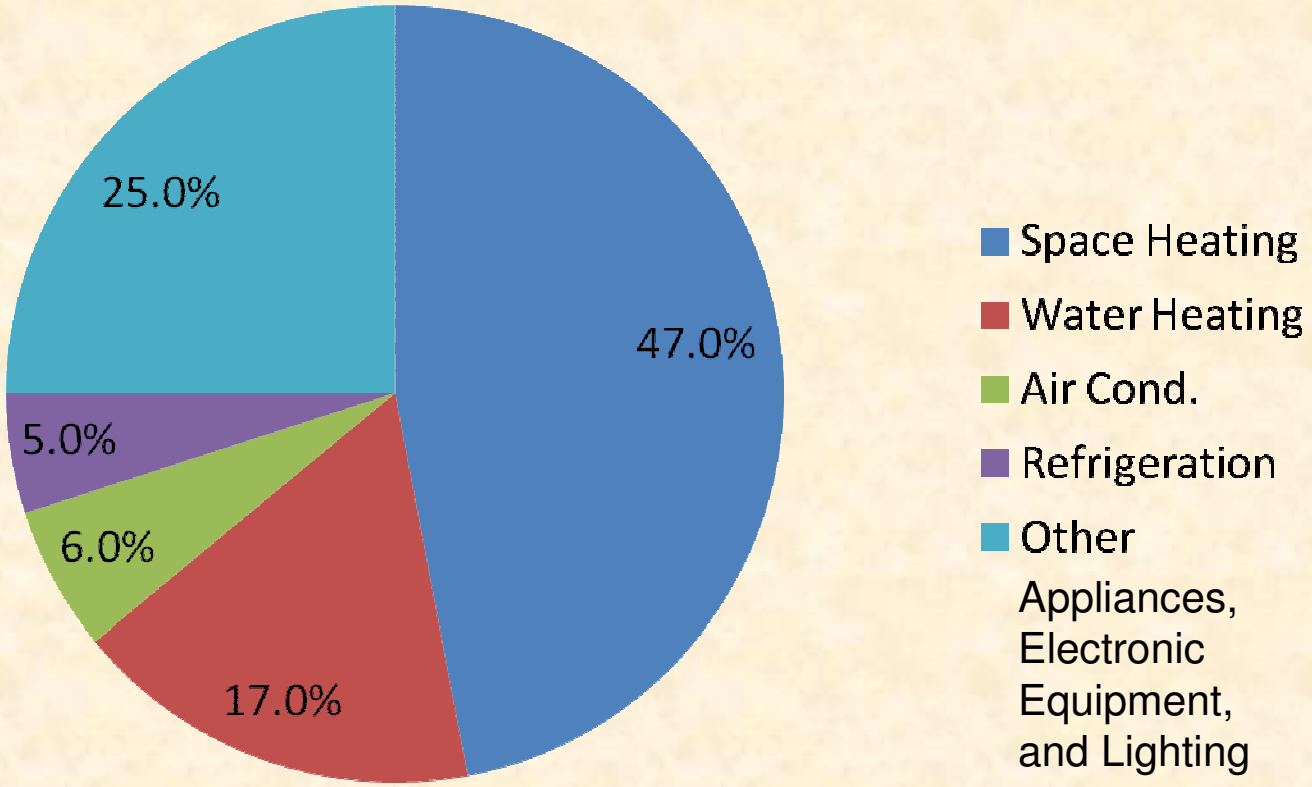
- Thermal/Airtight Envelope Design & Construction
  - Insulation
  - Air Sealing
  - Controlled Ventilation
- Windows
  - Location
  - Total Area
  - Selection
- Heating, Ventilation and Air Conditioning
  - System Design
  - Equipment Selection
  - Installation and Maintenance

# Improving the Energy Performance of Homes and Households - Continued

- Conservation of Electricity
  - Appliances
  - Electronic Equipment (Entertainment, Communications, etc.)
  - Lighting
- Measuring Energy Performance
  - Home Heating Index
  - Home Electrical Energy Index
- Information Sources
  - Books
  - Magazines
  - Websites

# Typical Energy Use in Homes

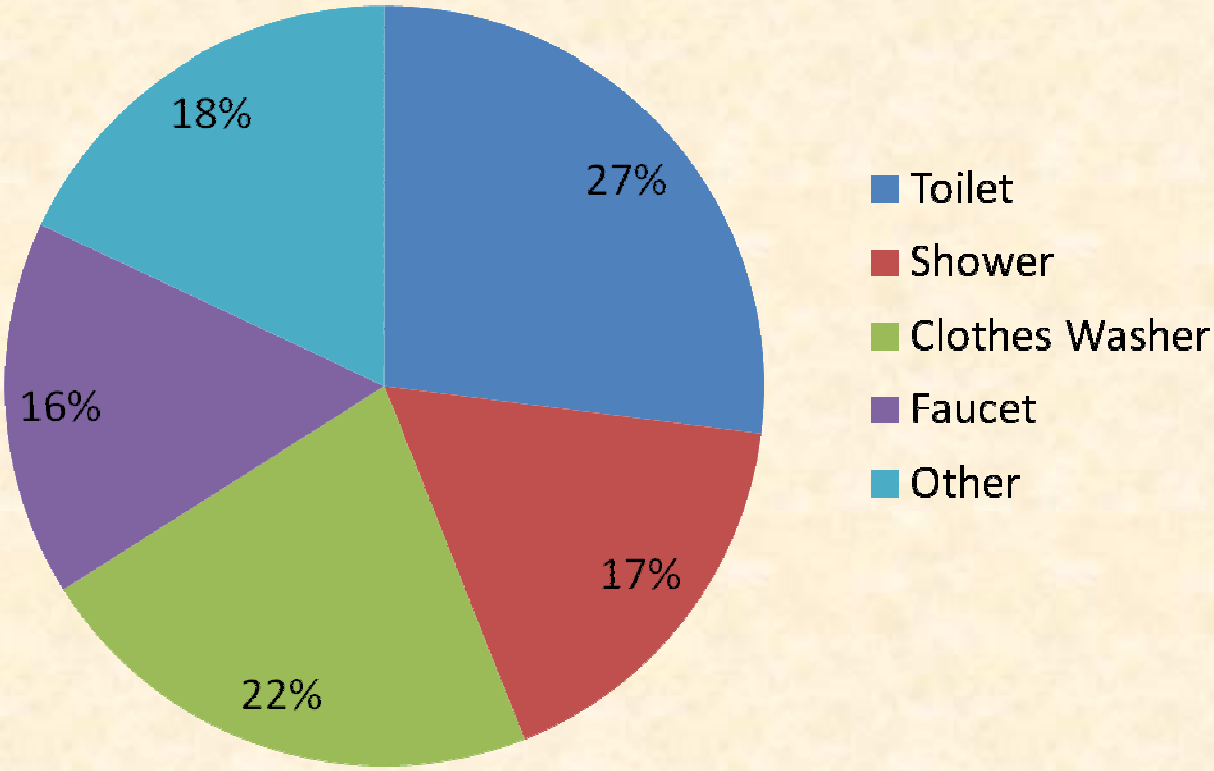
Residential energy use accounts for more than 20% of total energy consumption in the USA




Source: Energy Information Administration

# Water Conservation

**Typical Household Water Use: 100+ gallons per day of which 60% plus is hot water**



# Water Conservation

- Low-flow & ultra-low-flow toilets & fixtures
- Efficient use of appliances
- Personal habits
- Landscaping options
- EPA WaterSense Program

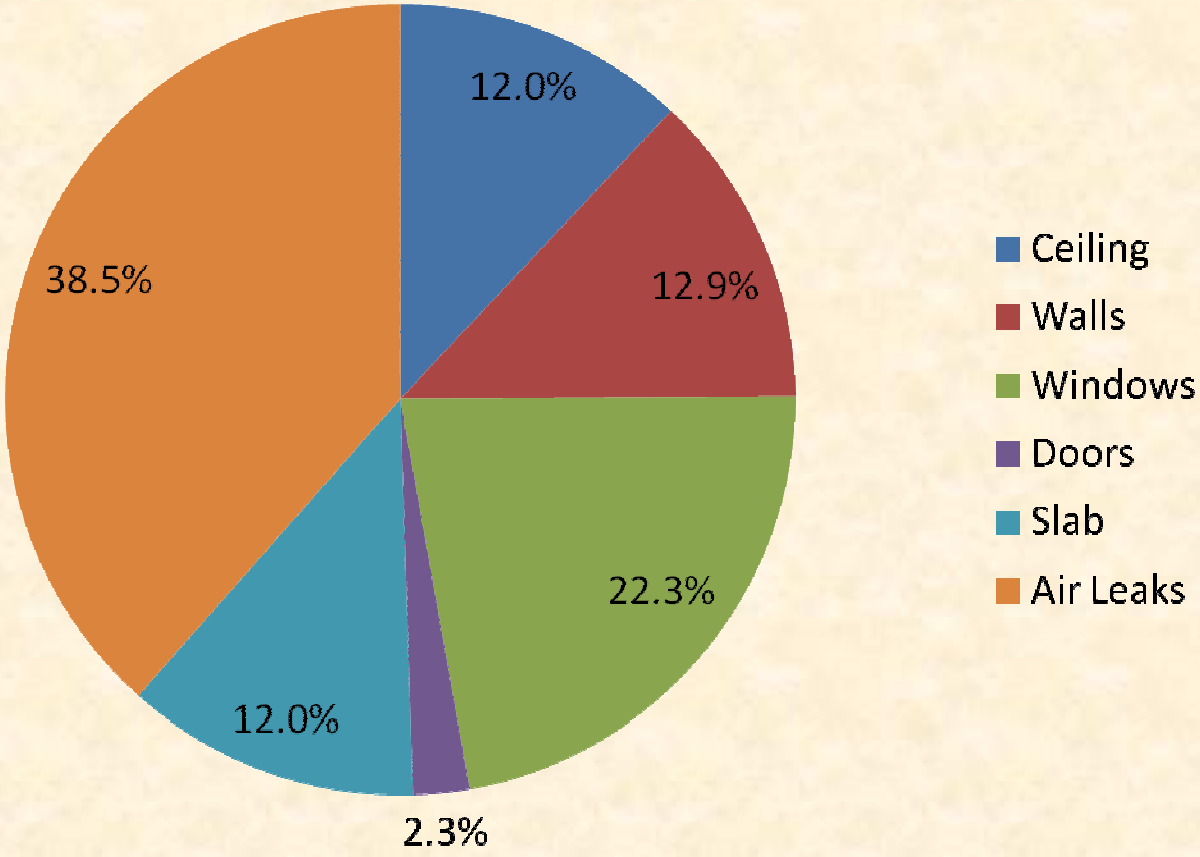
# Heated Water Energy Conservation

- House design & floor plans
- Water heater efficiency – EF Ratings
- Pipe insulation
- Temperature setting: 120°F
- Low-flow & ultra-low-flow fixtures
- Efficient use of appliances
- Personal habits
- EPA WaterSense Program

# Heat Transfer Basics

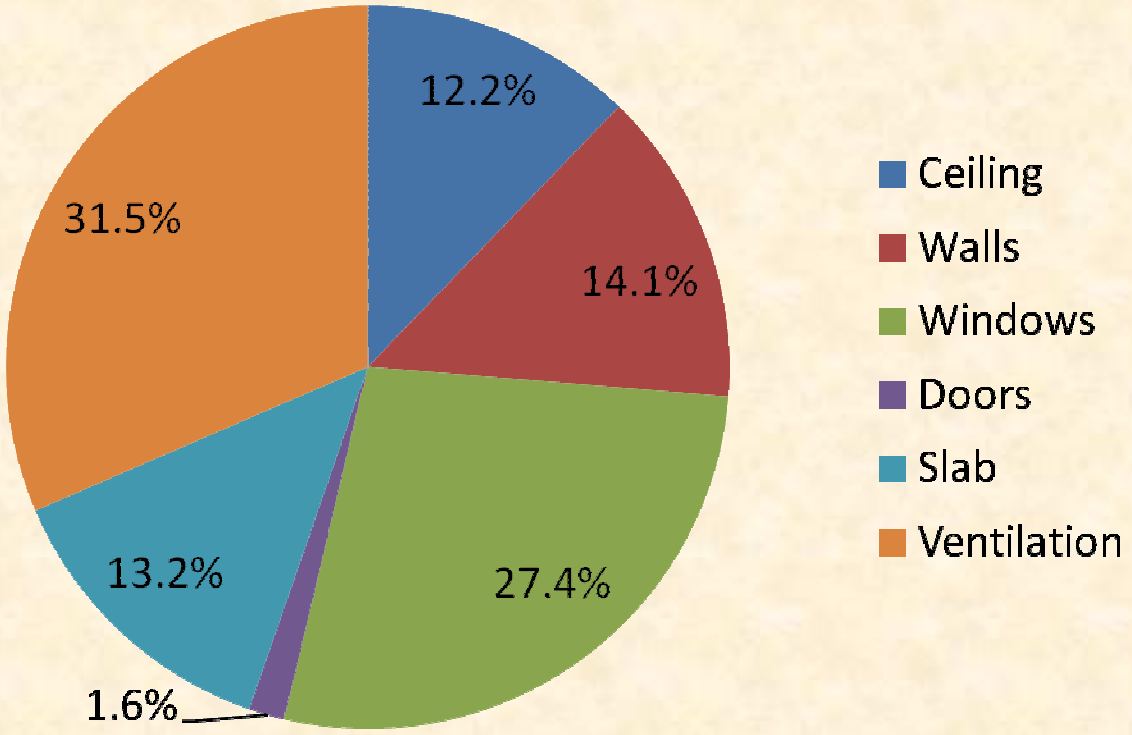
- Conduction – Heat transfer through stationary building components
  - R values
- Convection – Heat transfer via moving air
  - Air leakage and controlled ventilation
  - Measured in air changes per hour or CFM
  - Blower door test
- Radiation – Heat transfer via electromagnetic radiation (EMR)
  - Of lesser importance, typically included with conduction

# Heat Loss for a Typical House




For a 2000 sq ft house with a natural gas furnace
Annual heating requirement: 800 Therms (100 $ft^3$), $ _____
Annual AC requirement: 3000 KWH , $ _____

# Heat Loss for a Well-Insulated, Tight & Properly Ventilated House




For a 2000 sq ft house with a natural gas furnace
Annual heating requirement: 235 Therms (100ft$^3$), $ _____
Annual AC requirement: 875 KWH, $ _____
Additional benefits: comfortable, safe, healthy, durable, and quiet

# Moisture Transfer Through the Building Envelope (Via Vapor)

- Diffusion (5%): Water vapor transfer through materials.
  - Vapor retarders
- Air Transport (95%): Water vapor transfer via air leakage.
  - Air sealing
- Dew Point

# Thermal/Airtight Envelope (Shell) Design and Construction

Importance of house size in energy conservation


www.energystar.gov

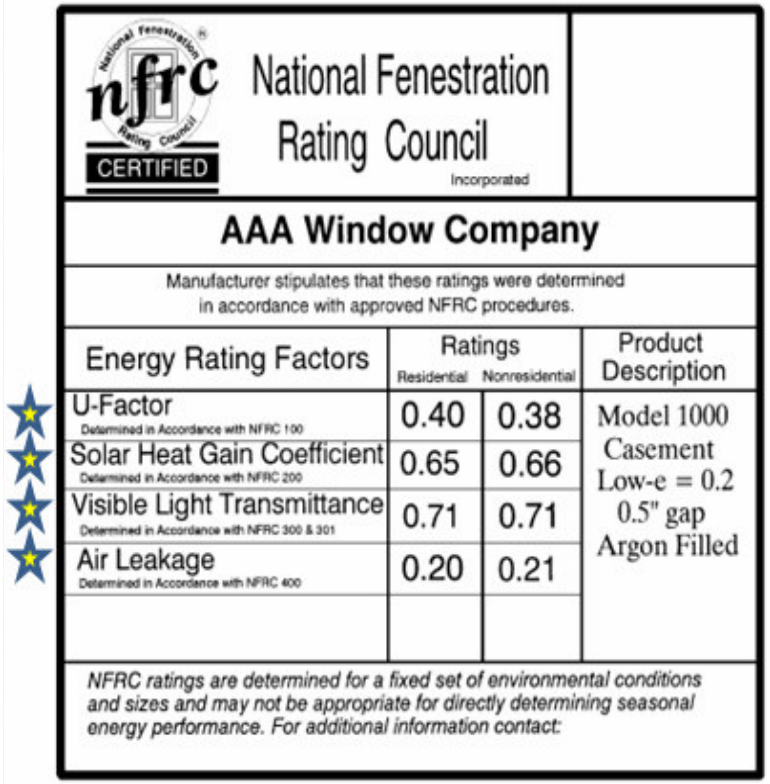
# Thermal/Airtight Envelope Design and Construction

- Insulation
  - Versus Air Barriers
  - Versus Vapor Retarders
  - R value
  - Types & Forms
  - Voids
  - Air Intrusion
  - Thermal Bridging
    - Advanced Framing
    - Exterior Rigid Insulation

# Thermal/Airtight Envelope Design and Construction

- Air Sealing
  - Versus Insulation
  - Versus Vapor Retarders
  - Leakage Area (100 – 200 $in^2$ typical)
  - Materials
  - Methods
    - Airtight Drywall Approach
- Controlled Ventilation
  - Built Tight, Ventilate Right

# Windows - Selection



National Fenestration Rating Council Incorporated

CERTIFIED

**AAA Window Company**

Manufacturer stipulates that these ratings were determined in accordance with approved NFRC procedures.

| Energy Rating Factors | Ratings Residential | Ratings Nonresidential | Product Description |
|---|---|---|---|
| U-Factor Determined in Accordance with NFRC 100 | 0.40 | 0.38 | Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled |
| Solar Heat Gain Coefficient Determined in Accordance with NFRC 200 | 0.65 | 0.66 | |
| Visible Light Transmittance Determined in Accordance with NFRC 300 & 301 | 0.71 | 0.71 | |
| Air Leakage Determined in Accordance with NFRC 400 | 0.20 | 0.21 | |
| | | | |

*NFRC ratings are determined for a fixed set of environmental conditions and sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:*

**U-Factor: Reciprocal of R value**
***Measure of heat conductance**

**Solar Heat Gain Coefficient: Values range between 0 – 1**
***Higher values increase passive solar gain, lower values reduce air conditioning loads**

**Visible Light Transmittance: Values range between 0 – 1**

**Air Leakage: Rated in units of CFM per sq ft of window area**

**Energy Star Ratings**

**Condensation**

**Comfort**

# Windows – Location & Total Area

- Heat Loss (Winter)
- Heat Gain (Summer)
- Daylighting
- Solar Gain: Winter versus Summer
- Cross Ventilation
- Sound Control
- Safety
- Views
- Aesthetics
- Window Placement
  - Example: 40% South, 30% East, 20% West, 10% North
- Total Area
  - 12 - 15% of floor area

# HVAC System Design & Equipment Selection

- Air Conditioning Contractors of America (ACCA) Manual J, Manual S, Manual D, & Manual T
- Right-sizing of Heating and Cooling Systems
- Furnaces - Annual Fuel Utilization Efficiency (AFUE)
- Air Conditioners - Seasonal Energy Efficiency Ratio (SEER)
- Heat Pumps - Heating Season Performance Factor (HSPF)
- Ducts in Conditioned Space or Insulated
- Return Grills in Bedrooms, etc.

# HVAC System Installation and Maintenance

- Sealed Ducts
- Programmable Thermostat
- High-Quality Filters
- Performance Testing
- Annual Maintenance

# Conservation of Electricity

- Appliances
  - Selection
  - Efficient Use
  - Personal Habits
  - Energy Star Ratings

# Conservation of Electricity

- Electronic Equipment (Entertainment, Communications, etc.)
  - Selection
  - Efficient Use
  - Personal Habits
  - Standby (Vampire) Loads
  - Energy Star Ratings

# Conservation of Electricity

- Lighting
  - Selection
  - Efficient Use
  - Personal Habits
  - Energy Star Ratings

# Home Heating Index (HHI)

- The annual heating load (BTU) divided by the floor area of the house ($ft^2$) and the heating degree days (HDD) for the locality.
  - Unit is BTU/$ft^2$/HDD
- HHI Performance Ratings for Houses with Combustion Heat Sources:
  - Very Poor >10
  - Poor 7.5-10
  - Moderate 5.0-7.5
  - Good 2.5-5.0
  - Very Good <2.5

# Calculating Home Heating Index

- For a House with a Gas Furnace and Water Heater
  - House Size ($ft^2$) _____
  - Heating Degree Days (HDD) _____
  - 1)Therms (100 $ft^3$) of Natural Gas used during the heating season (Oct-April) _____
  - 2)Therms of Gas required for water heater (use shoulder months as baseline) _____
  - Subtract 2 from 1 and convert to BTU

    (1 therm = 100,000 BTU) _____
  - Calculate HHI: BTU/$ft^2$/HDD _____

# Home Electrical Energy Index (HEEI)

- Annual electrical consumption divided by the floor area of the house
  - Unit is KWH/$ft^2$
- Representative values
  - Houses with gas furnaces & gas water heaters in Central Ohio: 4.4
  - Houses with heat pumps & electric water heaters in Central Ohio: 9.3
  - Houses with heat pumps & electric water heaters in Northern Ohio: 11.7

Data Source: Partnership for Advanced Technology in Housing

# Some Recommended References on Residential Energy Conservation

- Books
  - *Residential Energy*, John Krigger and Chris Dorsi, 2004
  - *Insulate and Weatherize*, Bruce Harley, 2002
  - *Builder's Guide: Cold Climates*, Joseph Lstiburek, 2004
  - *Your Green Home*, Alex Wilson, 2006

# References: Continued

- Magazines
  - *Journal of Light Construction*
  - *Fine Homebuilding*
  - *Home Energy*

  - Note: Relevant articles are now common in all general readership magazines.

# References: Continued

- Websites
  - Alliance to Save Energy: www.ase.org
  - American Council for an Energy-Efficient Economy: www.aceee.org
  - Energy Star Program: www.energystar.gov
  - Green Building Council: www.usgbc.org
  - Rocky Mountain Institute: www.rmi.org

  - Note: Relevant websites are now common. Use "Home Energy Conservation" and "Green Homes" as search engine subjects.