Low-Energy Buildings
Intro and Retrofits
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What Do We Want To Do?
Safe
Healthy
Comfortable
Durable
Affordable
Environmentally Responsible

Existing US Housing

• Total Housing Units in 2001 (millions):
  Single-Family Homes       73.7
  Apartments (all buildings)     26.5
  Mobile Homes        6.8
  Constructed since 2001       10

Approx Existing Units: 115 million units

1. Energy Information Administration, Residential Energy Consumption Survey, 2001 data: www.eia.doe.gov/emeu/recs
2. EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/ear

Existing Housing Stock

Age of US Housing Stock (all unit types)

Number of Housing Units (thousands)

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

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How Old and New Houses Use Energy


Residential, single family
1. Comfortable, durable, healthy, safe
2. Insulate wall, roof basement, airtight
3. Limit window-to-wall ratio (WWR) to <30%
4. Control ventilation, use energy recovery ventilation
5. Upgrade windows (control SHGC and R-value)
6. Use efficient lighting, right-sized
7. Use efficient appliances
8. Use efficient heating and domestic hotwater equip.
9. Consider source of energy
10. Add renewables to push toward zero

Joe's attempts

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The Whole Building Approach

- Performance Issues driving Retrofit:
  - Comfort
  - More utility
  - Health concerns
  - Durability / repair needs
  - Operating Costs
  - Energy Efficiency & Environment

Retrofit: How to reduce energy?

- Changing mechanical systems is least invasive
  - Lifespan is moderate, say (20 yrs)
  - 10% eff improvement = 10% operating savings = easy
- Lighting and ventilation
  - Change is easy at any time
  - Lighting and controls payback quickly
- Enclosures
  - Windows last 25-50 yrs
  - Insulation last 100+ yrs
  - Cladding lasts 35-200+ years
- MUST have clear idea of enclosure upgrades before deciding on mechanical!
Mechanical Retrofit

- After enclosure upgrade
  - Much smaller and quieter systems can be chosen
- Air-based can be replaced with hydronic
- Steam-based can be replaced hotwater
- E.g. Low-temperature (more efficient) systems can be used
- For ventilations load add HRV
- Variable speed fans and CO₂ controls

Enclosure Retrofit

- Important target for most houses
  - Airtightness
  - Windows
  - Insulation
    - Roof
    - Walls
    - Basement
    - Slabs
- Prioritize by Ease and Impact

Deep Retrofit

Simple upgrades have great paybacks but have little impact
- Small upgrades very cost effective, but small (10-25% reductions)

Mid-range upgrades (15-50%)
- usually quite expensive per energy saved

Deep retrofits (>50%) secure buildings future
- Cost a lot, save a lot.
- But … allow for new styles, repair/replace, more use, etc.
- Leap frog current housing
Basements

- Easy to retrofit and improve from the interior
- Ceiling height is the big restriction for slab solutions
My retrofit

Sump pit basin in corner

Cap break = peel and stick
Above grade walls

- **Interior retrofit** limits improvements to airtightness, rain control, thermal bridge
- **Exterior retrofit** allows excellent improvements and increased durability
- Windows should be done at the same time! Risky
- Installation cost $200+/ so get good windows, eg vinyl triple glazed for $30/sf
Standard Alternate: 4” PIC= R26

Windows

- Important choice!
- Need better rain control
- Improved R-value of course
  - Triple-glazing becoming affordable
Fully Ventilated Attics

• Can re-roof whenever, with whatever
• Deal with moisture, then add insulation
  • Rain leaks, air leaks
• If possible, keep ventilated attic
  • Inspect ceiling plane, plug all holes with caulking and foam
  • Consider 1” of spray foam air barrier
  • Blow in minimum R60 cellulose, R75-R100 sensible
**Conditioned Attics**

- Needs a good new roof
  - Top quality underlayment needed
- Unvented roofs best for complex shapes
  - Air sealing is critical
- Venting if you can easily achieve this
  - Ensure real venting!

**Sloped Wood Roofs**

- Usually require re-roofing and structural repair
- Deal with moisture, then add insulation
- If possible, keep ventilated attic
  - Inspect ceiling plane, plug all holes with caulking and foam
  - Consider 1” of spray foam air barrier
  - Blow in minimum R60 cellulose.
- If cathedral, insulate AND airtighten
  - Insulation on exterior is a benefit
  - Airtighten
**Conditioned attics**

- Continuity of the air barrier is maintained at the roof to wall connection by the sprayed polyurethane foam.
- The air barrier provides interior plane of air tightness.
- R65, note air barrier continuity.

**Mechanicals**

- Definitely add mechanical ventilation.
- Heat recovery now or later.
- Remove and replace oil burners.
- Natural gas is cheap and low carbon.
  - Even if it is only cheap for 10 yrs, NG pays.
- If you don’t have natural gas:
  - Electricity via heat pumps.
  - Heat via biomass boilers.
40 Watts, 70 cfm HRV/ERV
30-50% duty cycle
Note: short duct runs