Quantifying Envelope Energy Loss

Key terms:

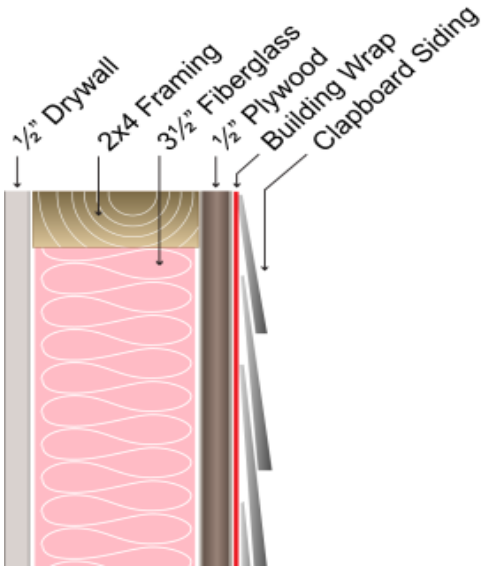
- British Thermal Unit (Btu)
  - The amount of heat required to raise 1 pound of water 1 degree Fahrenheit
- Heating Degree Day (HDD)
  - Developed by the oil heat industry to help predict fuel use. To determine HDD, divide the sum of the day's high and low temperatures by 2 and subtract the result from 65°F.
  - Why 65°F? Because of the heat from mechanicals and occupants—called *internal gain*—the house will stay at 70°F until the exterior temperature drops to 65°F. The heating system will not be needed until then.
  - The sum of all individual HDD in the heating season is the annual HDD.
- R-Value
  - A number assigned to a material to quantify its resistance to heat transfer. It is expressed in terms of resistance per unit of depth. For example, wood is typically R-1 per inch of thickness.
  - R values can be added
  - R-value is approximately the reciprocal of U-factor. $1/R = U$
- U-Factor
  - A material's thermal transmittance – how well it transfers heat. It is found by measuring how long it takes a known quantity of heat to equalize across the material.
  - U-factor cannot be added
  - U-factor is approximately the reciprocal of R-value. $1/U = R$
- Guarded hot box
  - A process to determine R-value of a material. Performing a guarded hot box test requires a box enclosed by another box so that the surface of the inner box—the guarded hot box—can be kept at a known temperature. The tested material is then installed so that it forms a barrier between a constant heat source and a thermometer in the inner box.
- Conductive heat losses of a wall sample are based on:
  - Temperature difference on each side of the material
  - U-Value
  - Area
- Radiation
  - Heat being transferred through waves or particles
- Conduction
  - Heat being transferred through a material
- Convection
  - Heat being transferred through a medium like air or water
- Intrusion
  - Air moving into and out of insulation without going through the wall or ceiling assembly. It will occur even when a good air barrier is present on one surface. Knee walls without an air barrier would be an example.

- Wind-washing
    - A phenomenon particular to fiberglass attic insulation. Air entering and leaving the attic through the attic eave vent openings is frequently able to blow through or underneath flat fiberglass attic insulation, removing heat as it goes.
    - Intrusion and wind-washing can combine to reduce insulation effectiveness up to 50%.

Assembly R-Values:

To calculate the R-value of an assembly, look up the R-value for each component and add the R-values together.

- Remember that the result is theoretical only. Any audit protocol or software will de-rate an assembly by some percentage to bring the calculated heat loss more in line with actual performance based on actual fuel use.



Assume a wall assembly with ½" drywall, a 2x4 cavity with 3 ½" inches of fiberglass, ½" plywood with house-wrap and wood siding.

- Theoretically, it has an R-14 value. But, in reality, it will test at about 20% lower – about an R-10.

Reasonable assumptions:

- A properly insulated wall or ceiling assembly will approximate the insulation R-value less 10%
    - If there is R-11 insulation in the attic, the assembly would be rated at R-10 (11 – 10% = 9.9 – approximately an R-10)
- Un-insulated wall assembly – R-3
- A ceiling with no attic floor – R-1
- A ceiling with an attic floor – R-2