Basic Energy Auditing & House Assessment

Presenters: Rod Burk & Ken Robinette
South Central Community Action Partnership
Twin Falls, Idaho

Forms of Energy


Coal


Wind


Hydro


Oil


Natural Gas


Fire


Solar

Laws of Thermodynamics

- Governing heat's behavior in the universe
- Energy is never created or destroyed – it just moves from place to place
- Heat moves from a higher temperature region to a lower temperature region

Heat Energy

- A British thermal unit is approximately equal to the heat produced by a kitchen match
- Common fuel source energy measurements:
  - Electricity 3,413 BTU/KWH
  - Propane 92,000 BTU/Gal.
  - Natural Gas 100,000 BTU/Therms
  - Fuel Oil 138,000 BTU/Gal.

BTU=

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Three Types of Heat Flow

- Conduction
  Heat transport molecule to molecule in a solid
- Convection
  Heat transport by movement in a fluid
- Radiation
  Heat waves traveling through space

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Conduction Heat Flow

- Conduction is heat flow though solids such as wood and masonry
- Examples:
  Rapid heat flow through an un-insulated foundation
  Rapid heat flow through aluminum window frames
  Walking on a hot sidewalk with bare feet

Convection Heat Flow

- Convection is heat flow in fluids such as air or water
- Common examples:
  - Downdrafts at windows during the winter
  - Operation of a gas water heater
  - Convection currents between primary window and storm window

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Radiant Heat Flow

Two types of radiation heat flow:

- Solar heat radiation
  - High-energy radiation from the sun
- Thermal heat radiation
  - Lower temperature radiation from objects on earth

Radiation flows from higher temperature bodies to lower temperature bodies

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Heat Flow in Buildings

- Transmission heat flow
  - Ceiling transmission
  - Wall transmission
  - Floor/foundation transmission
  - Window/door transmission
- Air Flow
  - Mechanical ventilation
  - Air leakage

How Does This Science Apply to The Work We Do in Weatherization?

Making it work

- With the combination of building science and the physics of energy transfer, energy auditors can evaluate houses and determine cost effective energy improvements.
- A successful energy analysis can be achieved by following these 7 easy steps.

7 Easy Audit Step Process

- Prepare
- Home Visit
- Client Concerns
- Visual Inspection
- Measurement Collection
- Putting it All Together
- Calculate Energy Savings/ Computerized Energy Audit

Step 1 – Preparation

- Gather information about Client
  - Determine location/address
    Use Map Quest/GPS if not familiar with area
  - Job Work Order Sheet
  - Forms to be signed by Client (ex. owner/renter agreement)
  - EPA Forms and pamphlets
  - Client Education handouts
  - Other necessary Agency forms

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Preparation: Gather Necessary Equipment to include:

- Step & Extension Ladders
- Tape Measure
- Blower Door
- Duct Blaster (Optional)
- Furnace Diagnostic Testing Equipment
- Digital camera /Infra red camera (if available)
- Multi-Volt Meter
- Data Logger
- Flash Light
- Cooking Thermometer
- Drill (Cordless Preferred)
- Misc. Hand Tools (Hammer, Awl, Screwdrivers Mirror)
- Personal Protective Equipment (Mask, Coveralls, Kneepads)
- Field Manual/ Clipboard & Cell Phone

ENERGY Energy Efficiency & Renewable Energy

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Hand Tools & misc Supplies

Diagnostic Testing Equipment

ENERGY Energy Efficiency & Renewable Energy

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Step 2 – Home Visit

- Introduction
  - Introduce yourself and provide client with audit plan
  - Present energy educational pamphlets to client
  - Discuss risks from lead base paint, mold and moisture
  - Give Client an overview of what will be done with Lead Safe Work Practices to assure their safety

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Step 3 – Client Concerns

- Ask Client if there specific problems or concerns relating to their home.

Try to keep concerns to house and energy related issues only.

In some cases you will hear their life story.

Step 4 – Visual Inspection

- Perform a visual inspection of the inside and outside of the home and collect measurements.
- Begin at the front door and move to the right or left, but stay consistent.
- Look for possible hazards that could effect the *Health and Safety* of your crews or contractors
  - Mold, evidence of drug use, dogs, nasty stuff in crawlspaces, spiders, bare wiring, open sewage, skeletons, etc. (deferral/walk-away policy)
- Measure the house and draw a picture showing dimensions.

House Information & Measurements

- Collect information on the following:
  - Windows
    - Type? Condition? U-Value?
    - With or Without Storm Windows?
    - Measure Each Window
  - Doors
    - Type? Condition? U-Value?
    - With or Without Storm Door?
    - Measure Each Door

Collect Information

- Walls
  - Type of Siding?
  - Condition?
  - With or Without Insulation?
  - If Insulation – What Type?
  - How Much?
  - R-Value?
  - Wiring? (Knob & Tube, Romex)
  - Other Possible Problems/Issues

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Collect Information

- Inspect Roof
  - Condition?
  - Ventilation?
  - Type?
  - Size?
  - How Many?
- Inspect Attic
  - Type of Insulation?
  - How Much?
  - Heat Producing Devices? (Flues, Recess Lights, Fans)
  - Bypasses?
  - Other Possible Problems/Issues

ENERGY Energy Efficiency & Renewable Energy

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Collect Information

- Inspect Foundation (If Applicable)
  - Condition?
  - Venting – Type, Size, How Many?
  - Clearance?
  - Type of Floor Joist (2"x6", 2"x10" Etc.)
  - Type of Insulation (If Any) How Much?
  - Ground Barrier?
  - Water Pipes?
  - Heat Ducts? (If Applicable)
  - Other Possible Problems/Issues

ENERGY Energy Efficiency & Renewable Energy

Heating System

- Type?
- Condition?
- Check T-Stat for Heat Anticipator Setting
- Fire Up Furnace
- Complete Diagnostic Testing
  - Combustion Fired Units– CO Analyzer, Draft Test (Coal, Oil, Gas, Wood, Propane)
  - Oil – Perform Smoke Test First
  - Electric – Volt/Amp Meter

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Water Heater, Blower Door & Duct Blaster

- Test
  - Type?
  - Condition?
  - If Electric – Test Elements / T-Stat
  - If Gas – Test for Draft and CO
- Run Blower Door Test
- Run Duct Blaster Test (if Applicable)

ENERGY Energy Efficiency & Renewable Energy

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Wrap Up

- Inform Client of your findings and what you project to do to make their home more energy efficient.
- Return to office and…

put it all together

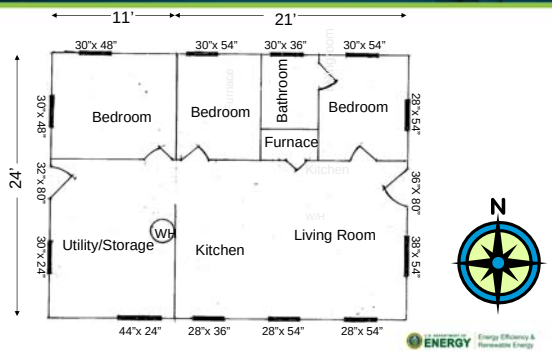
ENERGY Energy Efficiency & Renewable Energy

Exercise

- Fill out Audit with information from house provided on Job Work Order Sheet.
  - Complete Square Footage
  - Calculate Window Area
  - Calculate Door area
  - Calculate Attic Area
  - Calculate Walls Area
  - Calculate Floor Area

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA



House Characteristics

- Ranch Style w/crawlspace, Twin Falls, ID
  - Built in 1951
  - Siding Metal No Insulation (Nothing Between Steel and Wood)
  - Walls 11'x24'x7' 2"x4" Studs
    21'x24'x8' 2"x4" Studs
  - Attic 3" Redwood Shavings R-4
    3" Blown fiberglass R-7
  - Venting 3-12"x24" Gable Vents
    3-9" Roof Vents
  - Foundation - 6" Concrete Foundation with 4-8"x10" Foundation Vents
  - Floor – 3' High Crawlspace – 2"x6" Joist – 24" OC – 0 Insulation and no Ground Barrier
  - Sub-Floor – Single Layer with Carpet

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

House Characteristics

- Water Heater – 19" x 46" (50 Gal. Tank)
  - Water Temperature 120°
  - Upper Element 18 amps
  - Lower Element 18 amps
- Water Pipes – 120 L/F in Crawlspace
- Windows – Wood Sash Single Glaze/Single Hung
- Doors – 1-36"x 80" 1 3/4" Metal Insulated Door w/Storm Door
  1-32"x 80" 1 3/8" Panel Door w/ Storm Door
- Heating System – Natural Gas Forced Air with Standing Pilot Light, Located in Center of Home
  - 80% Steady State
- Heat Ducts – 140'-6" un-insulated Rigid Ducts in Crawlspace

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Price List

- Materials Price List

Cellulose Insulation	$5.20 per 30# Bag
R-19 Fiberglass	$15.00 per Roll (48 sq ft Roll)
R-11 Vinyl Duct Wrap Insulation	$60.00 per Roll (4'x50' Roll)
Tie Straps	$ .27 per Strap
Duct Mastic	$19.00 per Gallon
R-4 Tubular Pipe Insulation	$ .61 per L/F (6' Lengths)
6 mil Visqueen (Black)	$41.00 (10'x100' Roll)
Wood Lath	$11.00 per bundle (50 Pcs)
1 ¾" Metal Insulated Pre-Hung Door	$127.00 (36"x80")
1 ¾" Metal Insulated Pre-Hung Door	$127.00 (32"x80")
Keyed Entrance	$8.75 ea
Vinyl Insulated Window	$9.88 per sq ft

- Labor Cost $18.00 per Hour
- Overhead $85.00 per Job

Simple Heat Savings Calculation
&
Simple Payback

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Basic Heat Savings Calculations

CONDUCTIVE HEAT SAVINGS SYMBOLS

Δ	=	DIFFERENCE (DELTA)
A	=	AREA
U	=	U-VALUE
HDD	=	HEATING DEGREE DAYS
C	=	CORRECTION FACTOR
P	=	PRICE OF FUEL
S	=	SEASONAL EFFICIENCY (HEATING SOURCE)
V	=	VALUE OF FUEL

FORMULA FOR CONDUCTIVE HEAT SAVINGS

$$\$ = \frac{\Delta U \times A \times HDD \times C \times P}{S \times V}$$

FUEL PRICES (IDAHO) Electric .058 Gas RS-1 1.25 Oil 2.50

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Basic Heat Savings Calculation

Attic – Existing R-11 = U-Value .091

Proposed R-38 = U-Value .026

$$\$ = \frac{\Delta U \times A \times HDD \times C \times P}{S \times V}$$

1 Divided by R-Value = U-Value

ΔU = .065 **S = .61**
Area = 768 **V = 100,000**
HDD = 6324 **P = 1.25**
C = 17

$$\$ = \frac{0.065 \times 786 \times 6324 \times 17 \times 1.25}{0.61 \times 100{,}000} = \frac{6{,}865{,}730}{61{,}000}$$

= $112.55 = 1st Yr Savings

Simple Payback Calculation

C = Cost of Measure (includes Labor Costs)
S = 1ST year Savings (Calculated from Conductive Heat Savings Formula)
P = Payback in Years

C/S =P

Material – 24 Bags @ $4.95 = $118.80
Labor – 3 hrs x $18 x 2 Techs. = $108 + $85 Overhead = $193.00
Total Cost - $311.80

$311.80 / $112.55 = 2.8 Year Payback

Basic Heat Savings Calculation

Walls – Existing No insulation = U-Value 0.189
Proposed R-13 = U-Value 0.077

$$\$ = \frac{\Delta U \times A \times HDD \times C \times P}{S \times V}$$

Total Walls	**=**	**850 sq ft**
Less Windows	-	115 sq ft
Less Doors	-	38 sq ft
Less Studs	-	105 sq ft
Total Area		**592 sq ft**

ΔU = .112 **S = .61**
Area = 592 **V = 100,000**
HDD = 6324 **P = 1.25**
C = 17

$$\$ = \frac{.112 \times 592 \times 6324 \times 17 \times 1.25}{0.61 \times 100{,}000} = \frac{8{,}910{,}263}{61{,}000}$$

= $146.07 = 1st Yr Savings

Simple Payback Calculation

C = Cost of Measure (includes Labor Costs)
S = 1ST year Savings (Calculated from Conductive Heat Savings Formula)
P = Payback in Years

C/S =P

Material – 17 Bags @ $4.95 = $84.15
Labor – 8 hrs x $18 x 2 Techs. = $288 + $85 Overhead = $373.00
Total Cost - $457.15

$457.15 / $146.07 = 3.13 Year Payback

Basic Heat Savings Calculation

Kitchen Window – Existing U-Value 1.02

Proposed U-Value .34

New Window is a Vinyl ¾in. insulated, Low E window

Window – 28in x 36in / 144 = 7 sq ft

$$\$ = \frac{\Delta U \times A \times HDD \times C \times P}{S \times V}$$

ΔU = .68 **S = .61**
Area = 7 **V = 100,000**
HDD = 6324 **P = 1.25**
C = 17

$$\$ = \frac{0.68 \times 7 \times 6324 \times 17 \times 1.25}{0.61 \times 100{,}000} = \frac{639{,}673}{61{,}000}$$

= $10.49 = 1st Yr Savings

2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA

Simple Payback Calculation

C = Cost of Measure (includes Labor Costs)
S = 1ST year Savings (Calculated from Conductive Heat Savings Formula)
P = Payback in Years

C/S =P

Material – $9.50 x 7 sq ft = $66.50
Labor – 1 ½ hrs x $18 x 1 Tech. = $27 + $85 Overhead = $112.00
Total Cost - $178.50

$178.50 / $10.49 = 17 Year Payback