Creating an Energy Efficient Home

What to Expect and Ask When Making Improvements
What is a Home Energy Audit?

• Comprehensive inspection and analysis of your home to assess:
  ▪ Structural issues that contribute to energy loss
  ▪ Equipment issues that contribute to excessive energy use
  ▪ Behavioral issues that contribute to energy loss
  ▪ Health and Safety Concerns
  ▪ Comfort Concerns
Comfort, Safety, and Efficiency

A comfortable, safe, and energy-efficient home requires:

• A fully insulated thermal envelope.
• A well-sealed air boundary.
• The thermal and air boundaries to be continuous and in contact with one another.
• Efficient, properly sized equipment to condition the living space and heat water.
• A well-designed and balanced air distribution system.
• Healthy indoor air quality.
House as a System
House as a System

A house is a system of interdependent parts.

- The operation of one part affects many others.
- When they all work together, the house is comfortable, safe, efficient, and durable.

A house will experience problems when its house parts don’t work together properly.

- Some obvious, some invisible.
- Some now, some years down the road.
Leaky recessed lighting fixtures...

Increases heat loss/gain, and can cause ice dams.

Photos courtesy of The US Department of Energy
This bathroom exhaust fan does not exhaust to outdoors – just to the soffit.

The moisture condenses on the roof deck and trusses causing damage.
Blower Door

Photo courtesy of The US Department of Energy
Combustion Analyzer

Combustible Gas Detector
Draft Gauge

Smoke Tester (for Oil)

Inspection Mirror

Digital Probe Thermometer

http://www.omnicontrols.com
The Audit Field Form
Exterior Walk-Around

- All windows are double-pane
- Chimneys meet code height requirements
- Attached Garage
- Land slopes to building
- No gutters
- Steel roof
- Clapboard siding in good condition
- No storm doors
- Window below ground
• 7’ cellar under main house.
• Den & kitchen floor ≈ 1’ clearance to ground.
Excessive window condensation

Photo courtesy of PA WTC
Interior Walk-Through - Attic

- Hatch
- K&T wiring in attic
- R-7 Rockwool batts on flat
- R-7 Rockwool batts on flat
- Roof tar coated chimney
- Empty slopes

Photos courtesy of US Department of Energy
BUILDING ASSESSMENT

Gable vent

B-Vent

Pull-down staircase

Chimney

Floored Attic

Ceiling joist cavities

Photo courtesy of U.S. Department of Energy
Thermal Boundary

The Thermal Boundary:

- Limits heat flow between inside and outside.
- Easy to identify by presence of insulation.
- The location of insulation in relation to other building components is critical to its effectiveness.
- Even small areas of missing insulation are very important.
- Voids of 7% can reduce effective R-value by almost 50%.
The Air Barrier:

- Limits airflow between inside and outside.
- More difficult to identify.
- Not always where you think it is.
- Blower door is used to locate air barrier.
Use a Blower Door as a Controlled Driving Force

Using the blower door depressurizes the house drawing air through all the holes between inside and outside.
General Air Leakage

Photo courtesy of EnergyStar.gov
Major attic bypasses like these should be documented. More materials will be needed than for typical air sealing.
Specify cost-effective air sealing by:

• Addressing large leaks first.

• Not focusing on smaller inconsequential leaks.

Graphic source: PA WTC
Why seal the leaks at all?
Primary Air Infiltration Sites

- Floors, Walls, and Ceilings: 36%
- Fireplace: 16%
- Plumbing Penetrations: 15%
- Electric Outlets: 2%
- Doors: 13%
- Windows: 12%
- Fans & Vents: 5%

Data courtesy of California Energy Commission
Moisture

Moisture flows with warm air through breaks in the air barrier, causing damage when it condenses on cool surfaces.

- **Air Barrier**
- **Thermal Barrier**
Frost on underside of roof sheathing
Mold on interior surfaces

Photo courtesy of PA WTC
Scuttle Hole Cover

Pull-Down Attic Stairs

Graphics courtesy of http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11400
• Also known as “Can Lights”
• Often leak air to attic

Photos courtesy of The PA WTC
Walk-Up Attics

Where Is the Thermal Boundary? Where Should It Be?
Basements: Conditioned or Unconditioned?

- Conditioned Basement
  - Conditioned Main Level
  - Conditioned Basement
- Unconditioned Basement
  - Conditioned Main Level
  - Unconditioned Basement

Thermal Barrier
Air Barrier
It’s a Fine Line.....

Not Enough Insulation

Too Much Insulation
## Cost-Effective Insulation Levels

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<th>Gas</th>
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Duct Leakage

Duct leakage can create positive and negative pressures in different areas of the house.

The pressures associated with duct leaks can be larger and more important because the driving force is stronger.
The handle allows for easy testing of hard-to-reach ducts.
Duct Specifications

- Specify duct sealing where ducts are located in unconditioned spaces.
- Ducts in unconditioned spaces should be insulated to recommended levels.
- Seal all returns in spaces where atmospheric fossil fuel appliances are located.

It is often necessary to remove duct insulation to properly seal ducts. Seal with mastic, then re-insulate.
Indoor Air Quality
What Determines IAQ?

Photos courtesy of The US Department of Energy
Outside Air and IAQ

How much outside air do we need for good IAQ?
How do we get it?

- Wind
- Buoyancy: Stack effect - warm air rising
- Mechanical Fans

Mechanical Fans
ASRAE 62.2

- 7’ cellar under main house.
- Den & kitchen floor ≈ 1’ clearance to ground.
Combustion Appliance Test Kit

- Smoke pump and filter paper.
- Lighter.
- Combustion analyzer and manual.
- High-temp sealant.
- Appropriate drill bits for test holes.
Why Test Combustion Appliances?

We test to assure:

- Health and safety.
- Building integrity.
- Comfort.
- Energy efficiency.

*Photo courtesy of New River Center for Energy Research and Training (NRCERT)*
What do we test on combustion appliances?

- Fuel leaks.
- Fuel input rate.
- Sufficient combustion air.
- Worst case draft.
- Carbon monoxide.
- Combustion efficiency.
Using a calibrated gas leak detector to locate fuel leaks.

Photo Courtesy of NRCERI

Bacharach
www.bacharach-inc.com
Burn marks above the burner compartment are evidence of flame roll out.

Spillage of flue gases or insufficient draft is often a result of an improper installation such as this.
• Understanding the basic principles of combustion, distribution, and venting will enable the auditor to recognize safety problems.
• Health and safety issues related to combustion equipment are some of the most important aspects of auditing a home.
• Visual and diagnostic combustion appliance safety and efficiency inspections, and worst case CAZ testing reveal potentially dangerous situations and guide retrofit strategies.
• Understanding the relationship between combustion safety problems and poorly designed or non-compliant vent systems is important to finding solutions.
Base Load Defined

**Base Load:**
The energy used by electric or gas appliances in a home that is not used for space conditioning, thus not a seasonal load.

**Typical Measures include:**
- Lighting Retrofits.
- Refrigerator Replacement.
- Water Heater Modification.
- Low-flow Fixtures.
Why Target Electric Base Loads?

**Percent of Total Energy Costs**

- Lighting: 6%
- Refrigerator: 9%
- Appliances: 27%
- (other)
- Space Cooling: 9%
- 30% Space Heating
- 4% Cooking
- 15% Water Heating
Consumption Analysis

1. Bill Analysis
2. Site Survey
3. Reconcile the Two
Lighting

- Lighting accounts for up to 10% of total home energy use.
- With Compact Fluorescent Lighting (CFL) retrofits, can cut that by 75%.
- Overall energy reduction of 7.5% for the home.
Hot Water
Hot Water Use

- Showers: 37%
- Bath Filling: 20%
- Sink Filling: 14%
- Faucet Flow: 6%
- Clothes Washer: 14%
- Dishwasher: 10%

Summary

• A successful weatherization project begins with a systematic approach of visual and diagnostic evaluation.

• Good building assessments begin with a thorough client interview.

• A successful audit relies on the application of accurate visual assessment and diagnostic procedures.

• A successful building assessment incorporates all of the knowledge of building systems and the interaction of their components.

• Auditors must document moisture, electrical, and health and safety problems.

• Understanding the components of the thermal boundary will help the auditor determine the most cost effective retrofit strategies.
The Fundamental Audit Protocol

• Exterior Inspection
• Interior Inspection
• Blower Door Test
• Duct Leakage Test
• Combustion Appliance Test
• Utility Bill Analysis and Baseload Analysis
• IAQ inspection
Worth Some Thought

- Thermal Imaging
- Certifications
- The great window debate
- Should your auditor also be your contractor?
- Blower Door directed airsealing
Thanks!

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