



U.S. DEPARTMENT OF ENERGY  
**SOLAR DECATHLON**

2011

# Creating an Energy Efficient Home

## What to Expect and Ask When Making Improvements

# What is a Home Energy Audit?

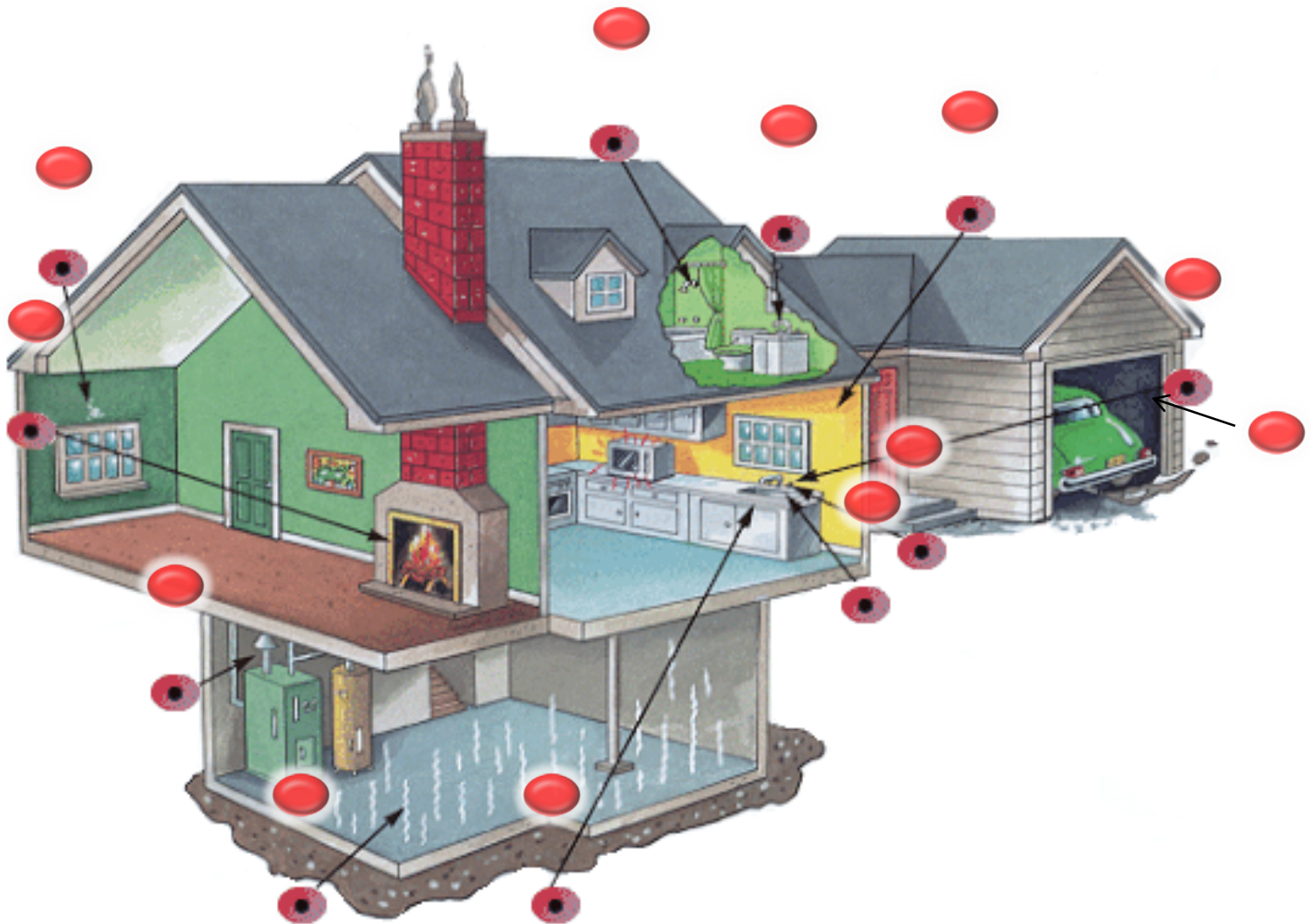
- Comprehensive inspection and analysis of your home to assess:
  - Structural issues that contribute to energy loss
  - Equipment issues that contribute to excessive energy use
  - Behavioral issues that contribute to energy loss
  - Health and Safety Concerns
  - Comfort Concerns

# 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.





This bathroom exhaust fan does not exhaust to outdoors – just to the soffit.



*Photos courtesy of The US Department of Energy*

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





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**SOLAR DECATHLON** Equipment

*Time to shine.*



**Draft Gauge**



**Smoke Tester (for Oil)**



**Inspection Mirror**



**Digital Probe Thermometer**

<http://www.omnicontrols.com>

# The Audit Field Form

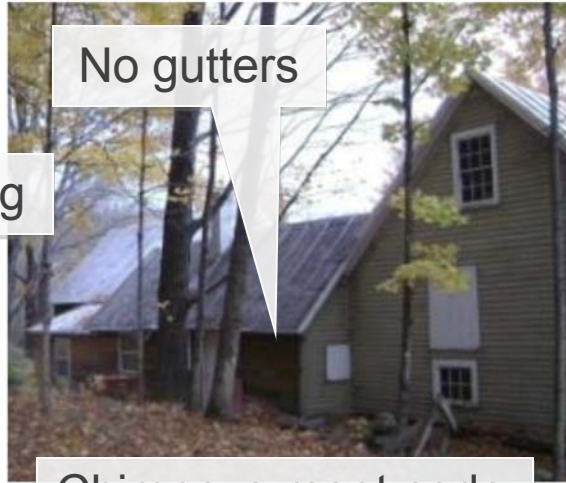
[illegible][illegible]



# Exterior Walk-Around



Land slopes to building



No gutters



Steel roof



Attached  
Garage



Chimneys meet code  
height requirements



Clapboard siding  
in good condition

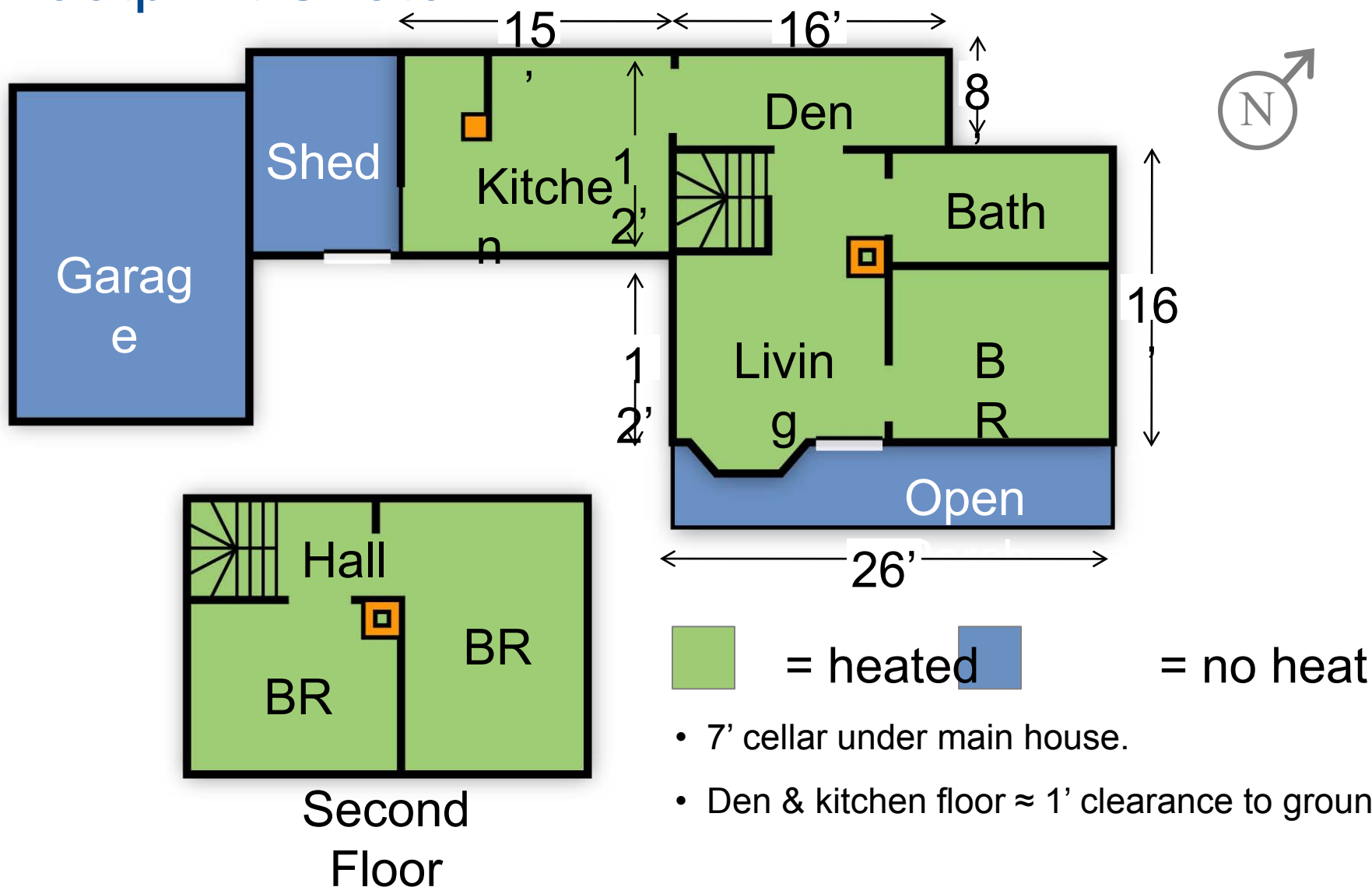
All windows are  
double-pane

No storm  
doors

Window below ground



# Footprint Sketch



## **Excessive window condensation**

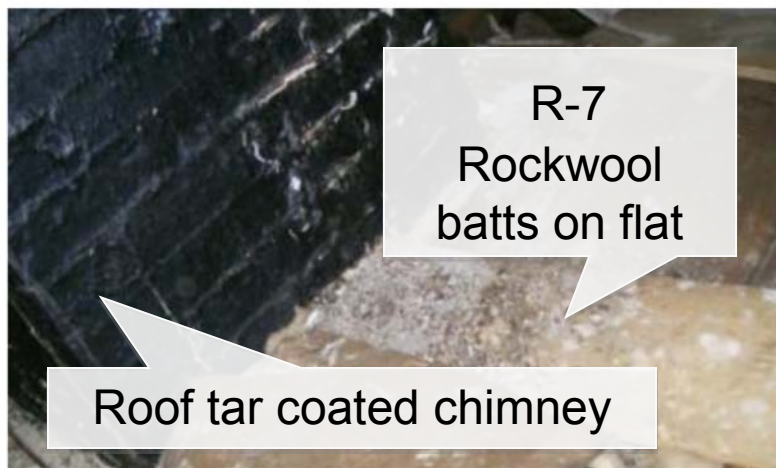


*Photo courtesy of PA WTC*

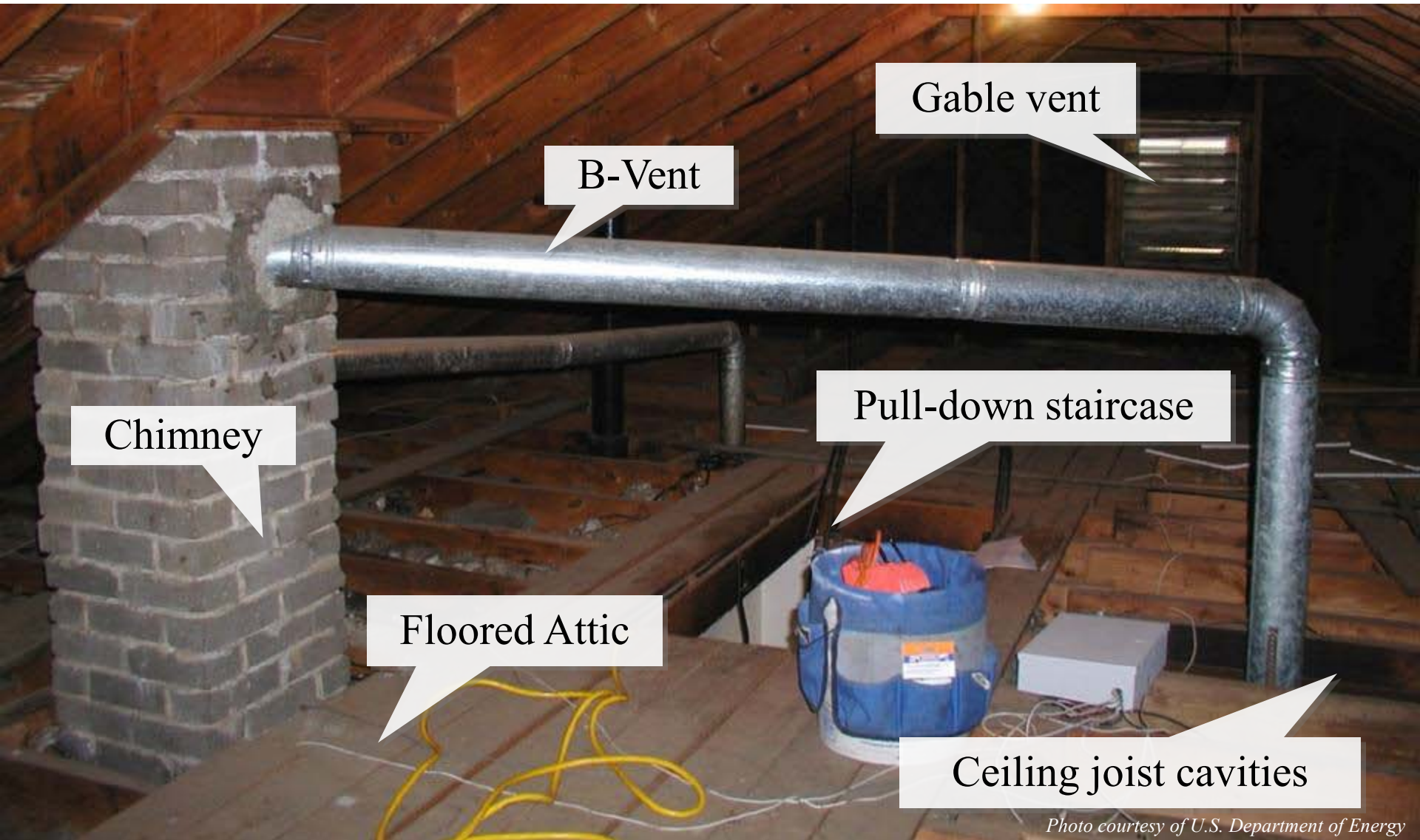
## Interior Walk-Through - Attic



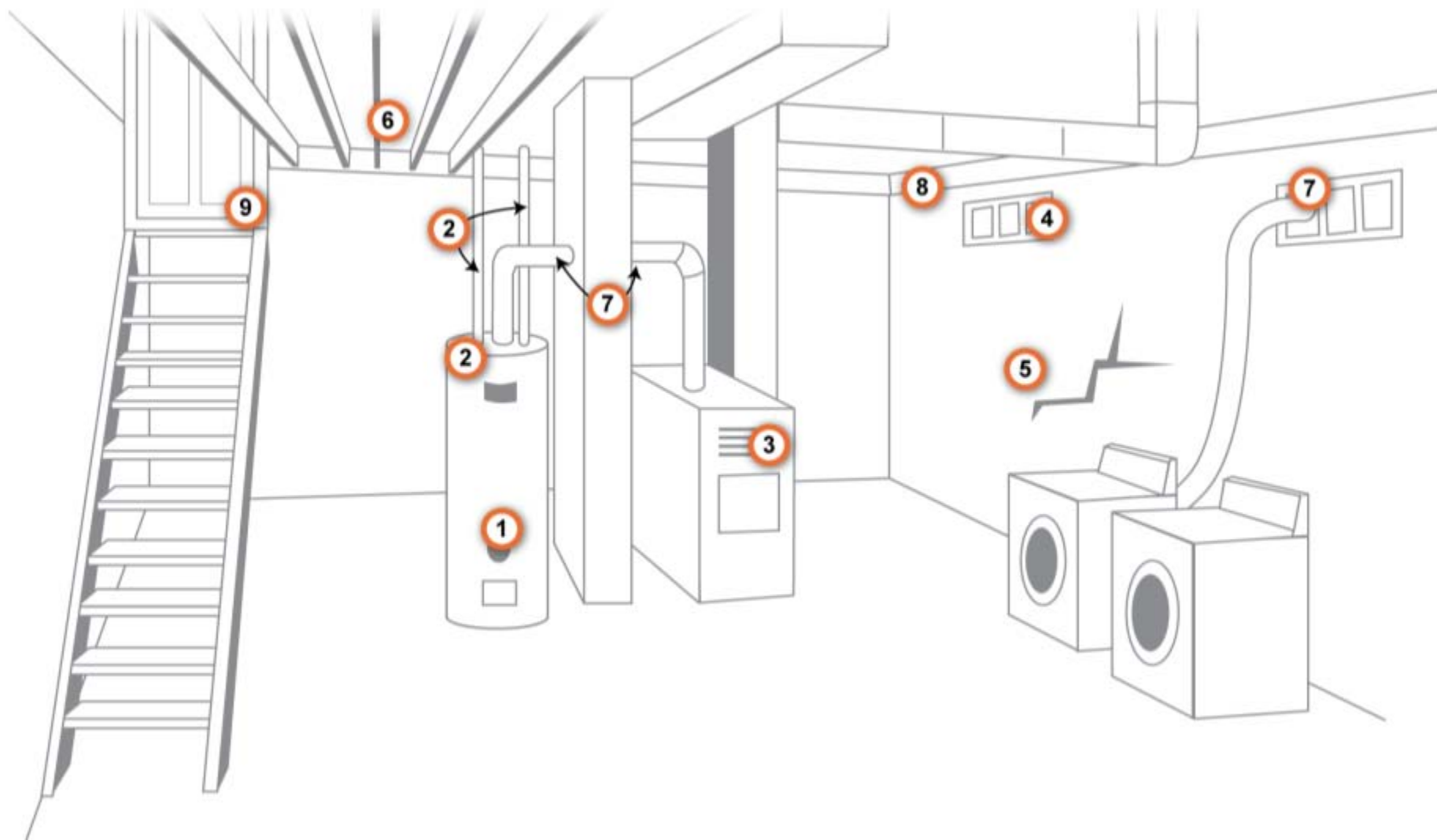
R-7 Rockwool  
batts on flat







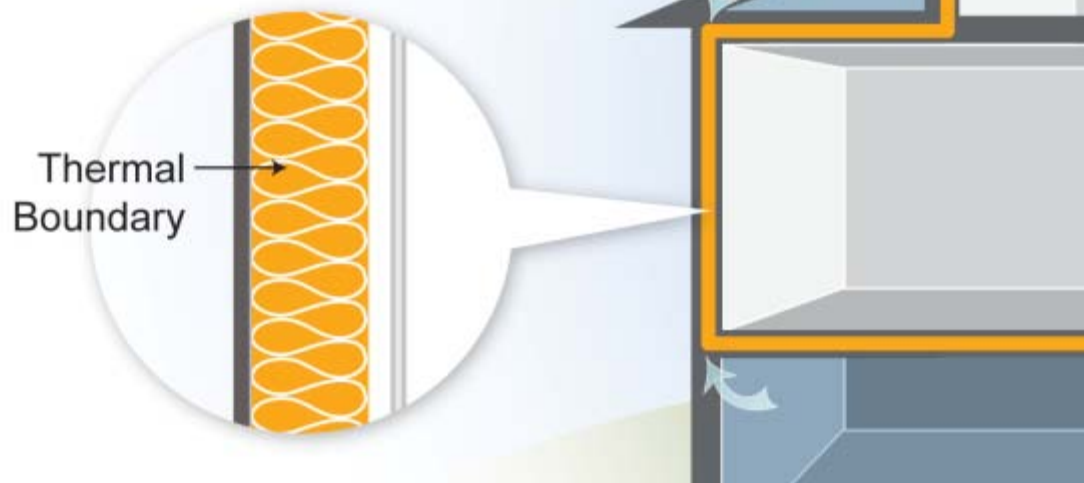




# Thermal Boundary

## The Thermal Boundary:

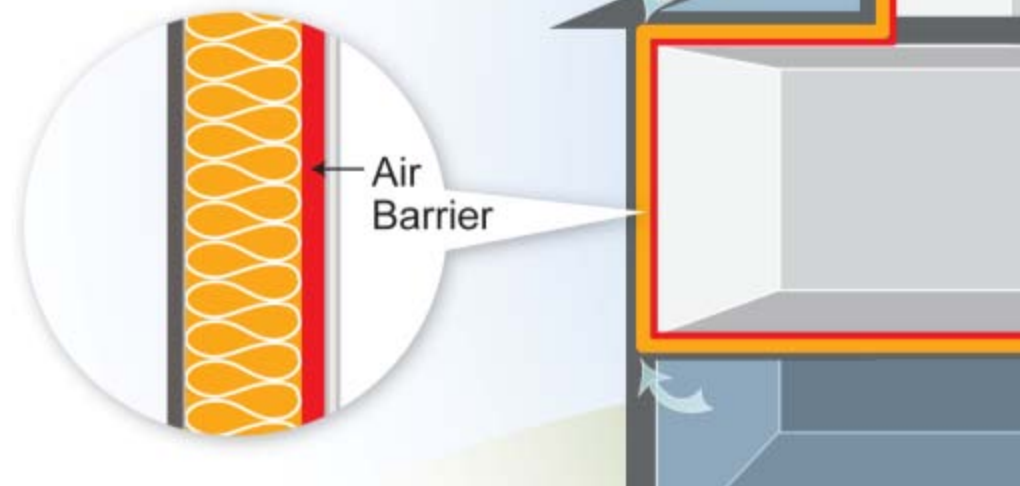
- Limits heat flow between inside and outside.
- Easy to identify by presence of insulation.
- The location of insulation in relation to other building components is critical to its effectiveness.
- Even small areas of missing insulation are very important.
- Voids of 7% can reduce effective R-value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



# Air Barrier

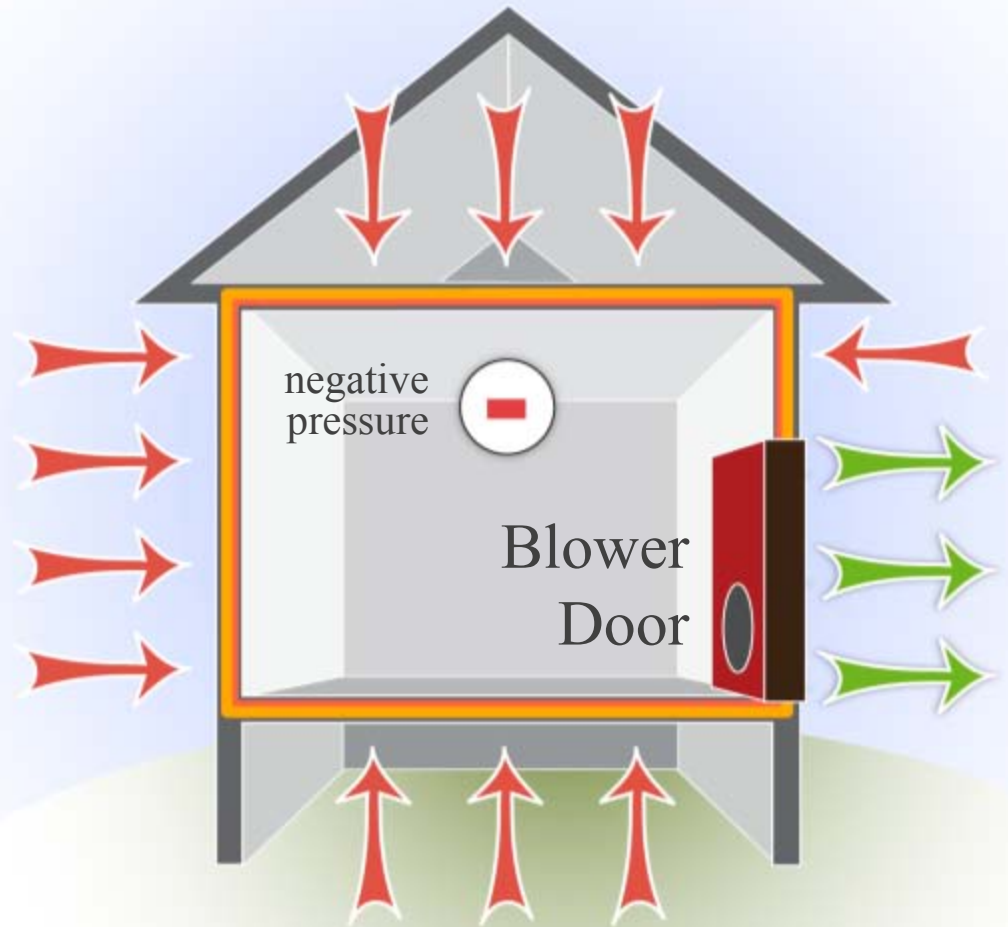
## The Air Barrier:

- 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.



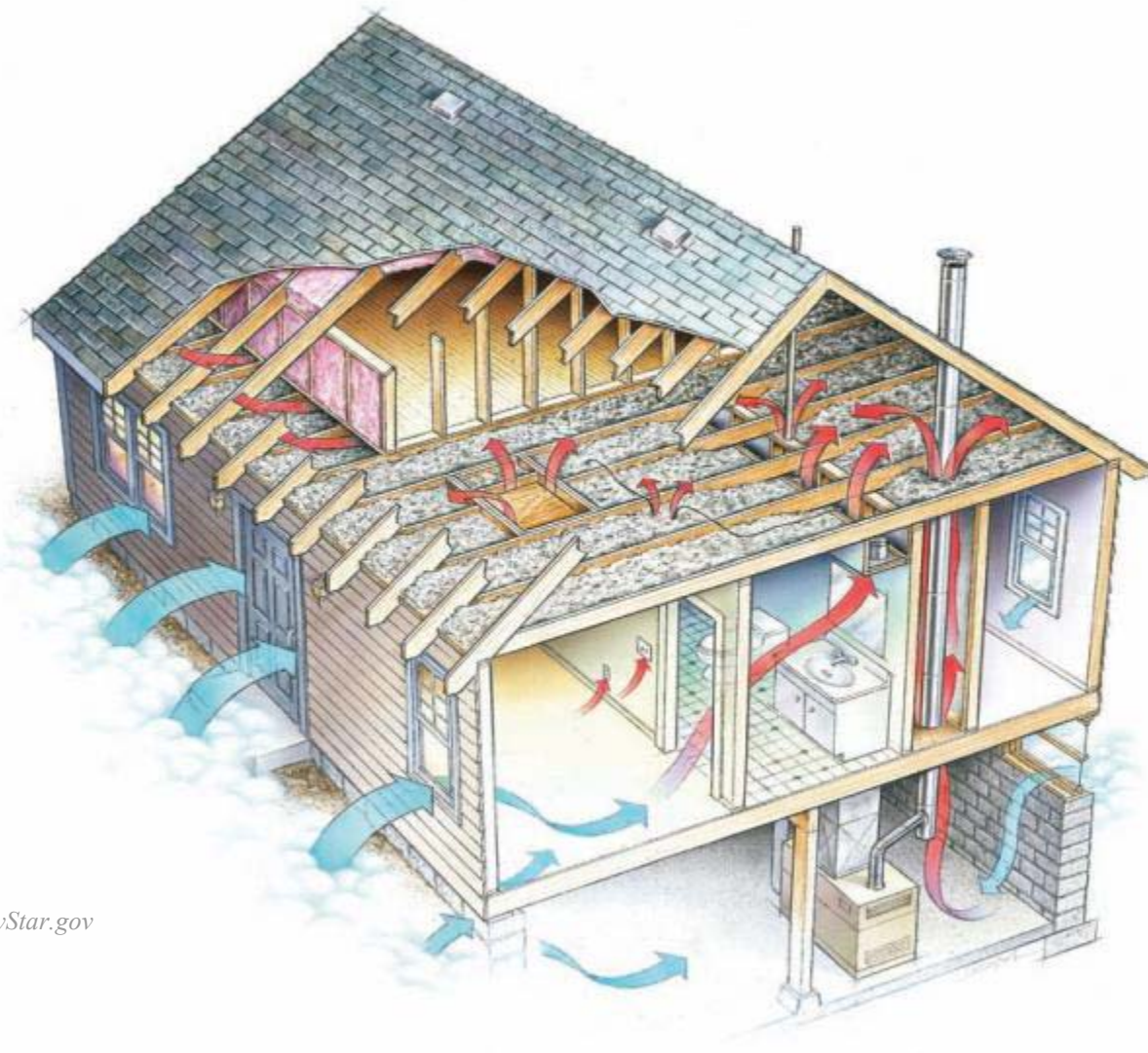
## Use a Blower Door as a Controlled Driving Force

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*



Attic bypasses

A photograph of an attic space showing a brick chimney and wooden framing. A white speech bubble with the text 'Attic bypasses' points to a gap in the insulation and framing around the chimney.

Major attic bypasses like these should be documented.



*Photos courtesy of NRCERT*

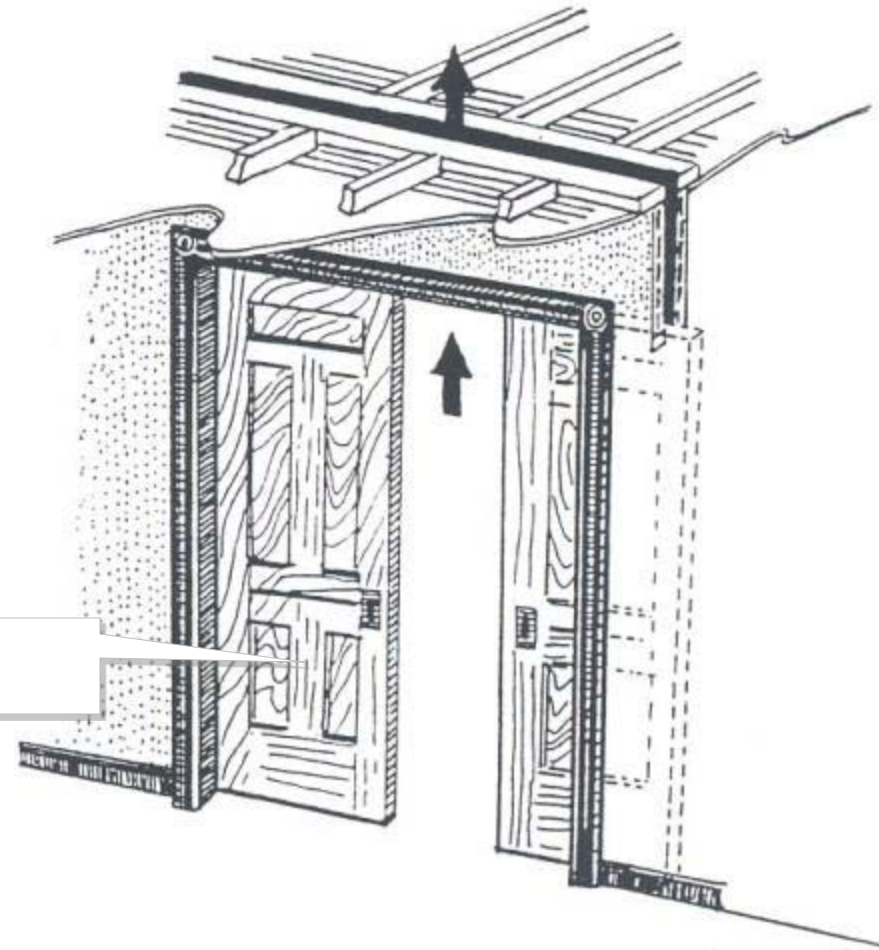
More materials will be needed than for typical air sealing.

# Interior Air Leakage Sites

**Specify cost-effective  
air sealing by:**

- Addressing large leaks first.
- Not focusing on smaller inconsequential leaks.

Pocket Door



*Graphic source: PA WTC*



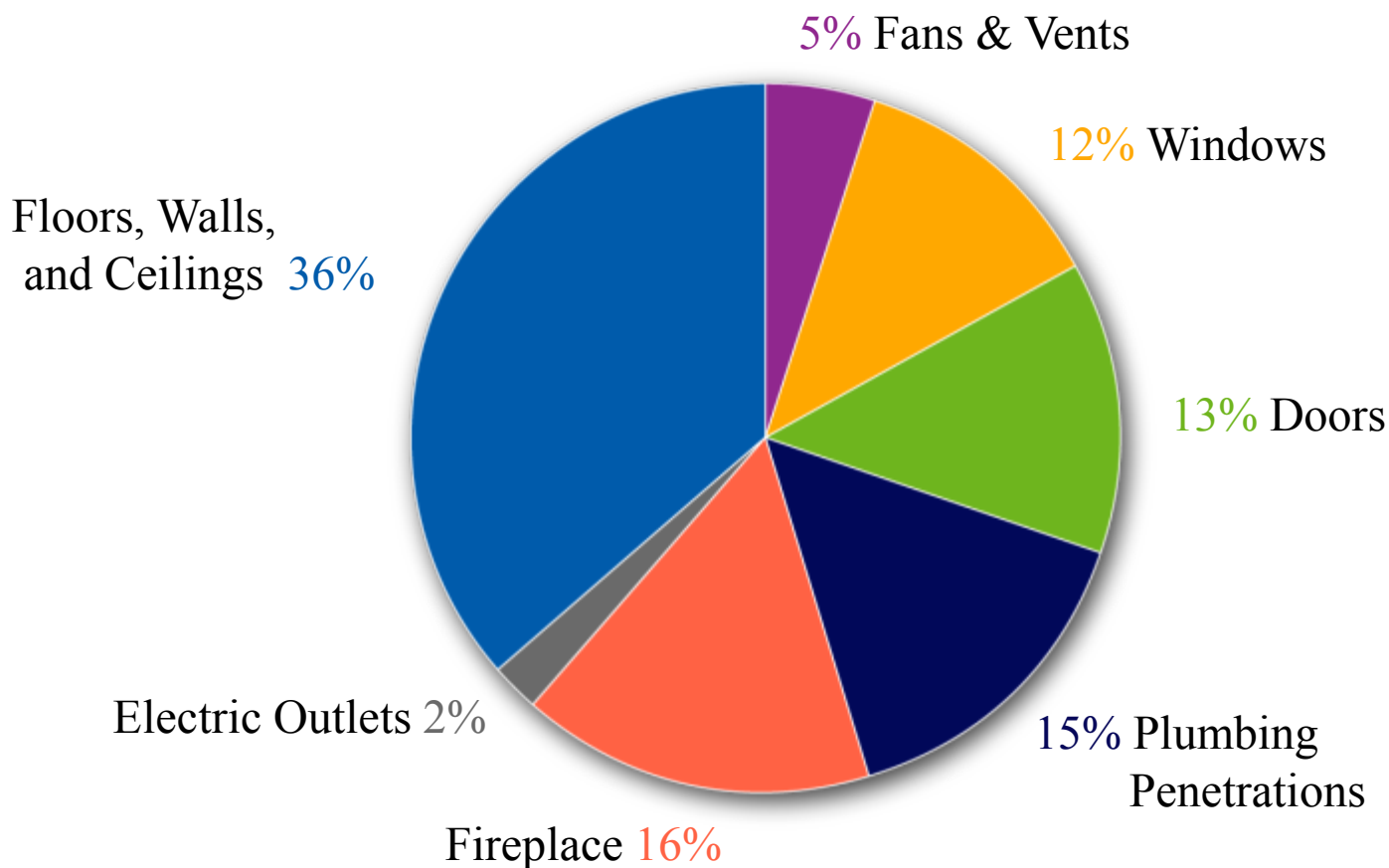


**Why seal  
the leaks at all?**

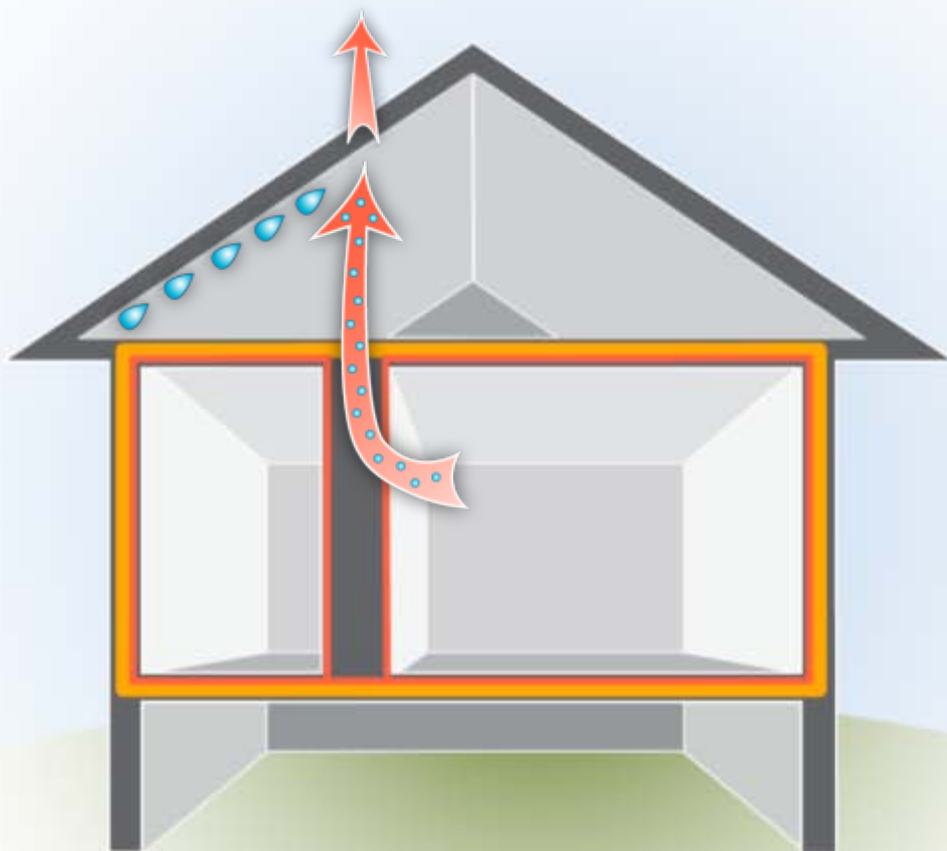




# Primary Air Infiltration Sites



# 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**

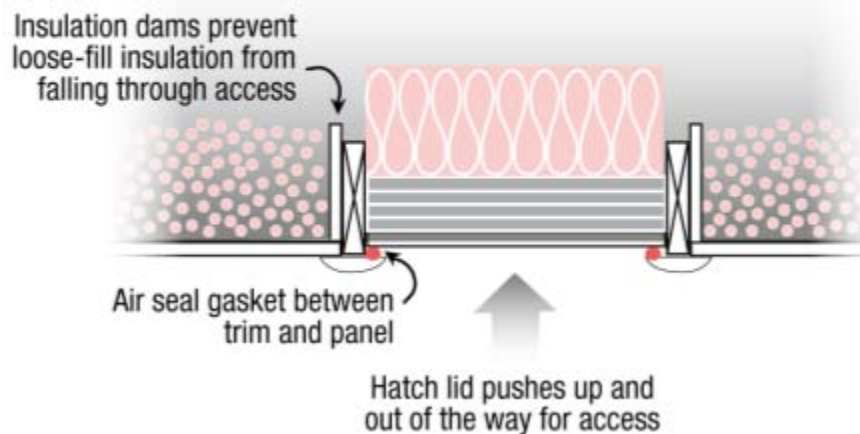


*Photo courtesy of PA WTC*

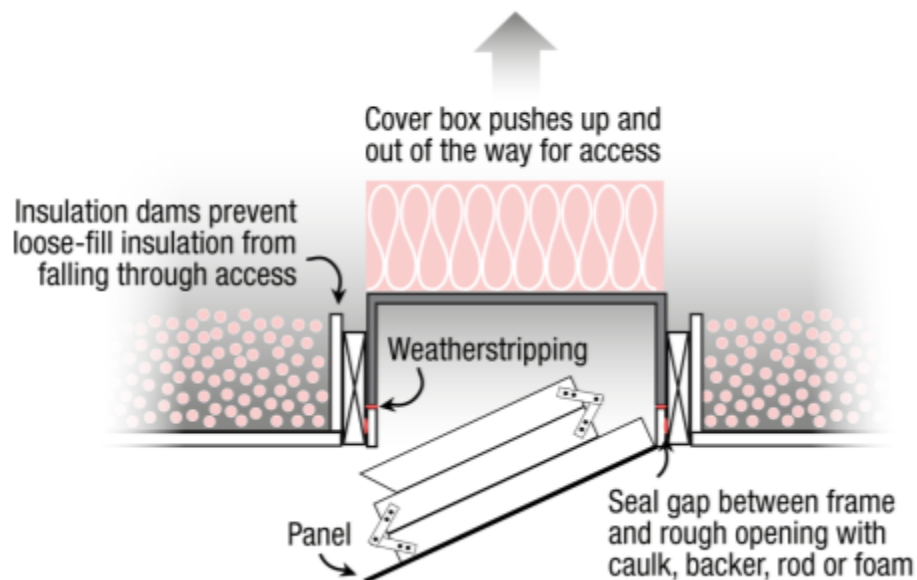
## Mold on interior surfaces



## Scuttle Hole Cover



## Pull-Down Attic Stairs





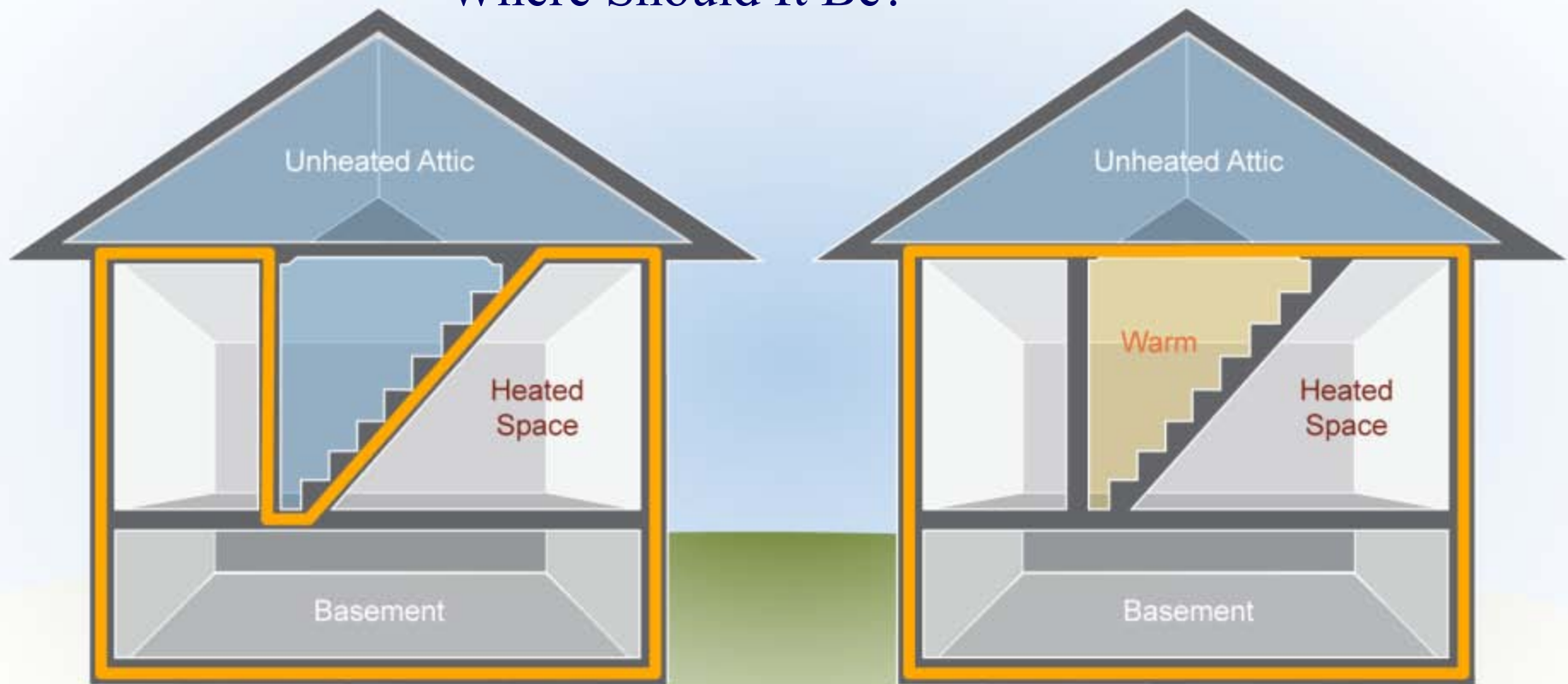
- Also known as “Can Lights”
- Often leak air to attic



*Photos courtesy of The PA WTC*

# Walk-Up Attics

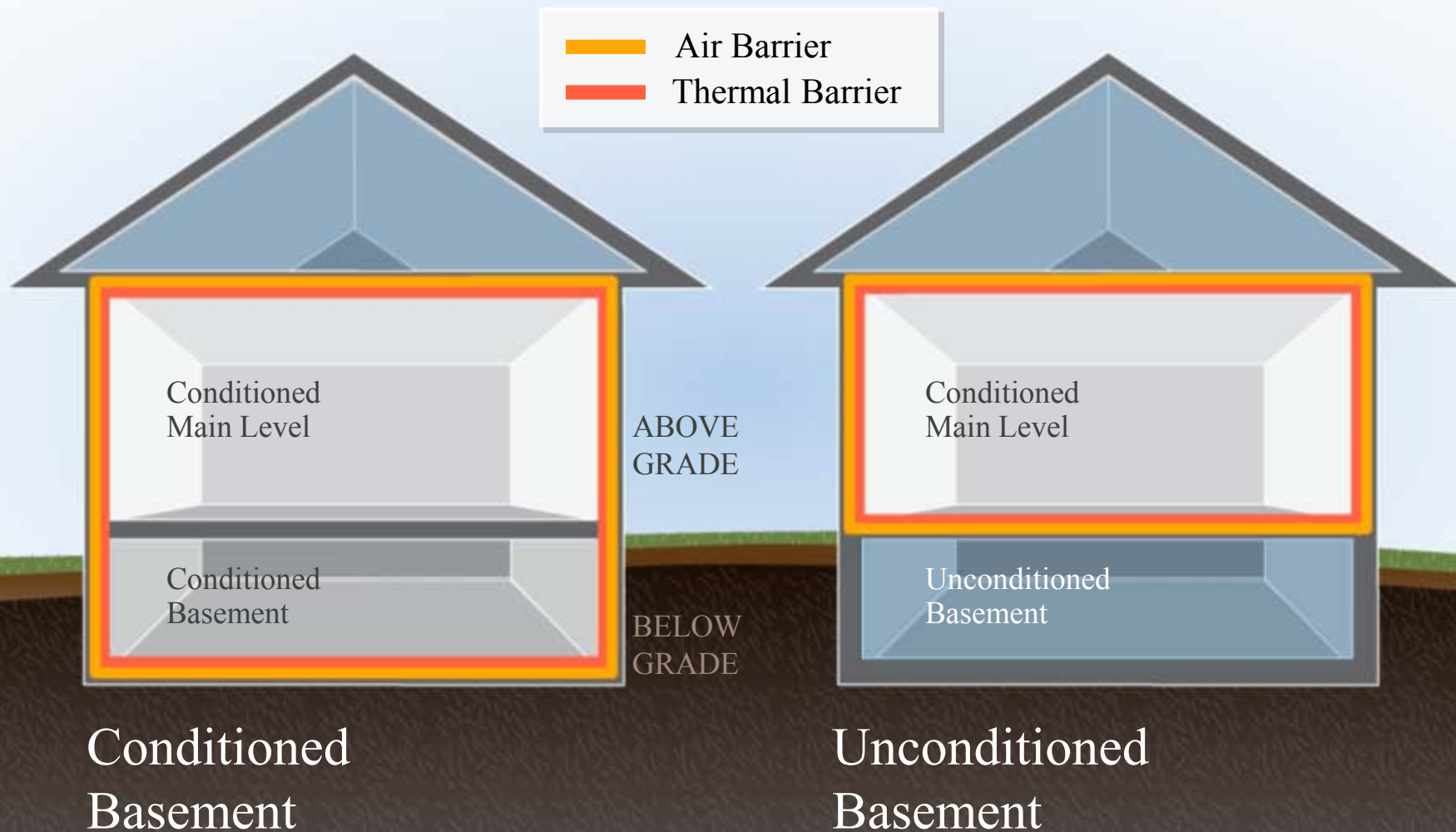
Where Is the Thermal Boundary?  
Where Should It Be?





# Conditioned or Unconditioned?

*Time to shine.*



It's a Fine Line.....

Too Much Insulation



Not Enough Insulation







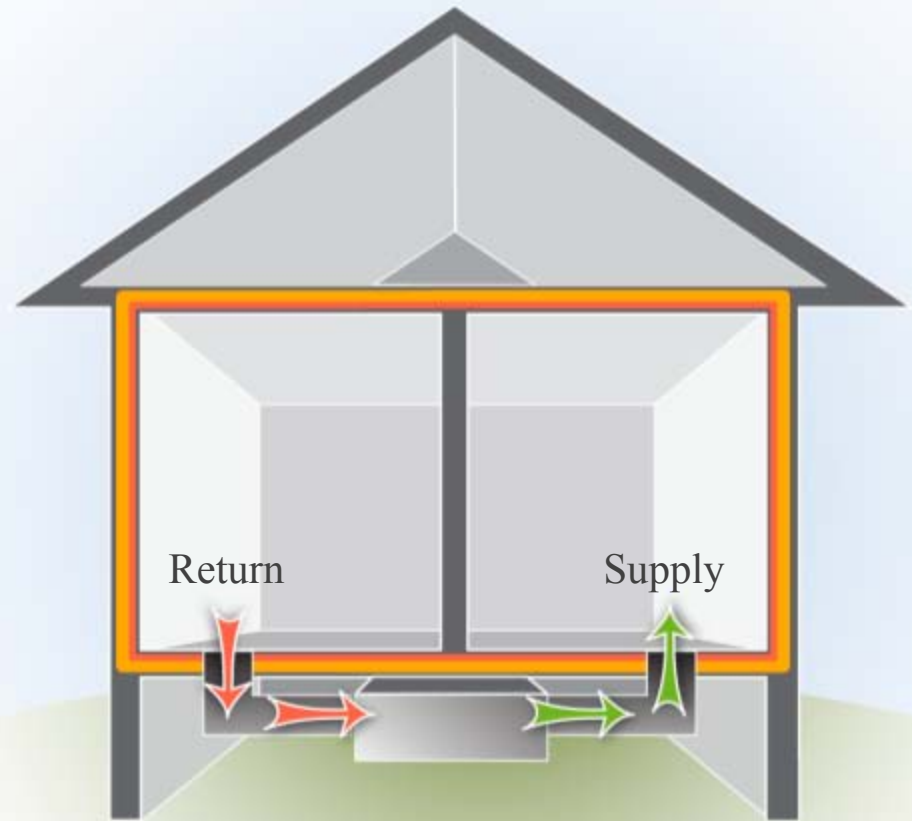
# Cost-Effective Insulation Levels

Zone	Gas	Heat Pump	Fuel Oil	Electric Furnace	Attic	Cathedral Ceiling	Wall		Floor
							Cavity	Insulation Sheathing	
1	✓	✓	✓	✓	R30 to R49	R22 to R38	R13 to R15	None	R13
2	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R13
2				✓	R30 to R60	R22 to R38	R13 to R15	None	R19 - R25
3	✓	✓	✓		R30 to R60	R22 to R38	R13 to R15	None	R25
3				✓	R30 to R60	R22 to R38	R13 to R15	R2.5 to R5	R25
4	✓	✓	✓		R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 - R30
4				✓	R38 to R60	R30 to R38	R13 to R15	R5 to R6	R25 - R30
5	✓	✓	✓		R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25 - R30
5				✓	R38 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
6	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
7	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30
8	✓	✓	✓	✓	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 - R30

## 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.





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# SOLAR DECATHLON Terminations

*Time to shine.*



*Photo courtesy of PA WTC*



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# Pre SOLAR DECAATHLON Core Summary

*Time to shine.*



*Photos courtesy of NRCERT*



## 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?

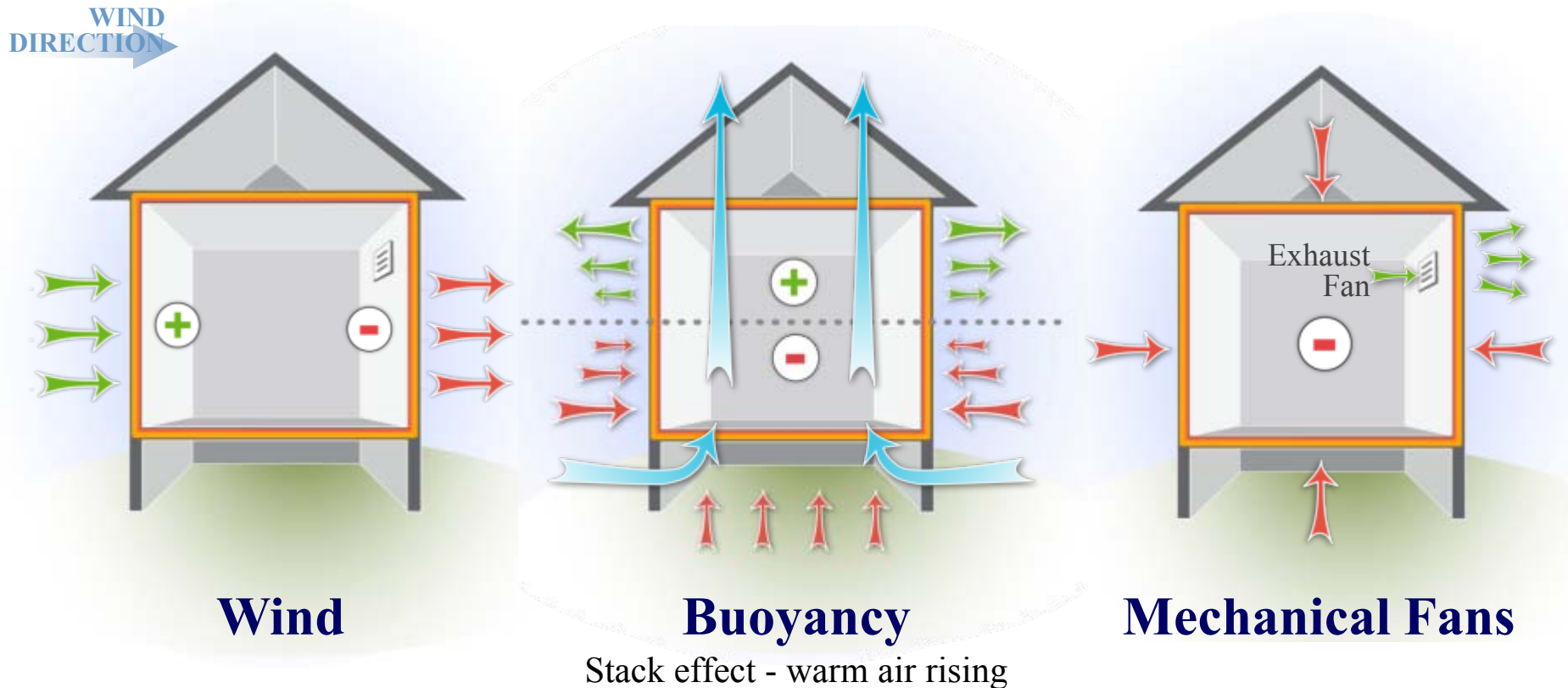


*Photos courtesy of The US Department of Energy*

# Outside Air and IAQ

**How much outside air do we need for good IAQ?**

**How do we get it?**







# Combustion Appliance Test Kit

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



*Photo courtesy of The US Department of Energy*

# 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 NRCERT*



Bacharach  
[www.bacharach-inc.com](http://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:**

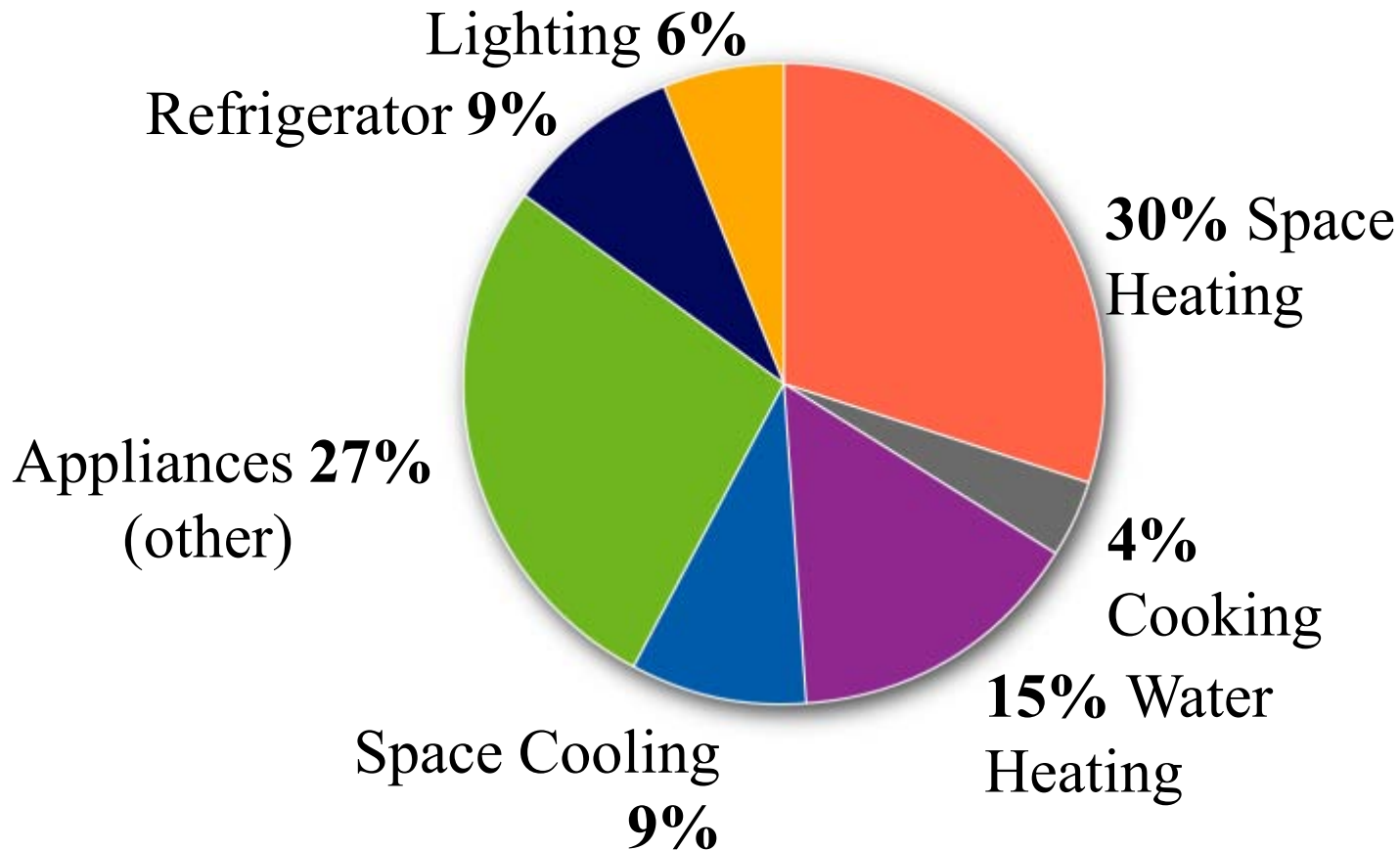
*The energy used by electric or gas appliances in a home that is not used for space conditioning, thus not a seasonal load.*

## **Typical Measures include:**

- Lighting Retrofits.
- Refrigerator Replacement.
- Water Heater Modification.
- Low-flow Fixtures.

# Why Target Electric Base Loads?

## Percent of Total Energy Costs



# Consumption Analysis



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.





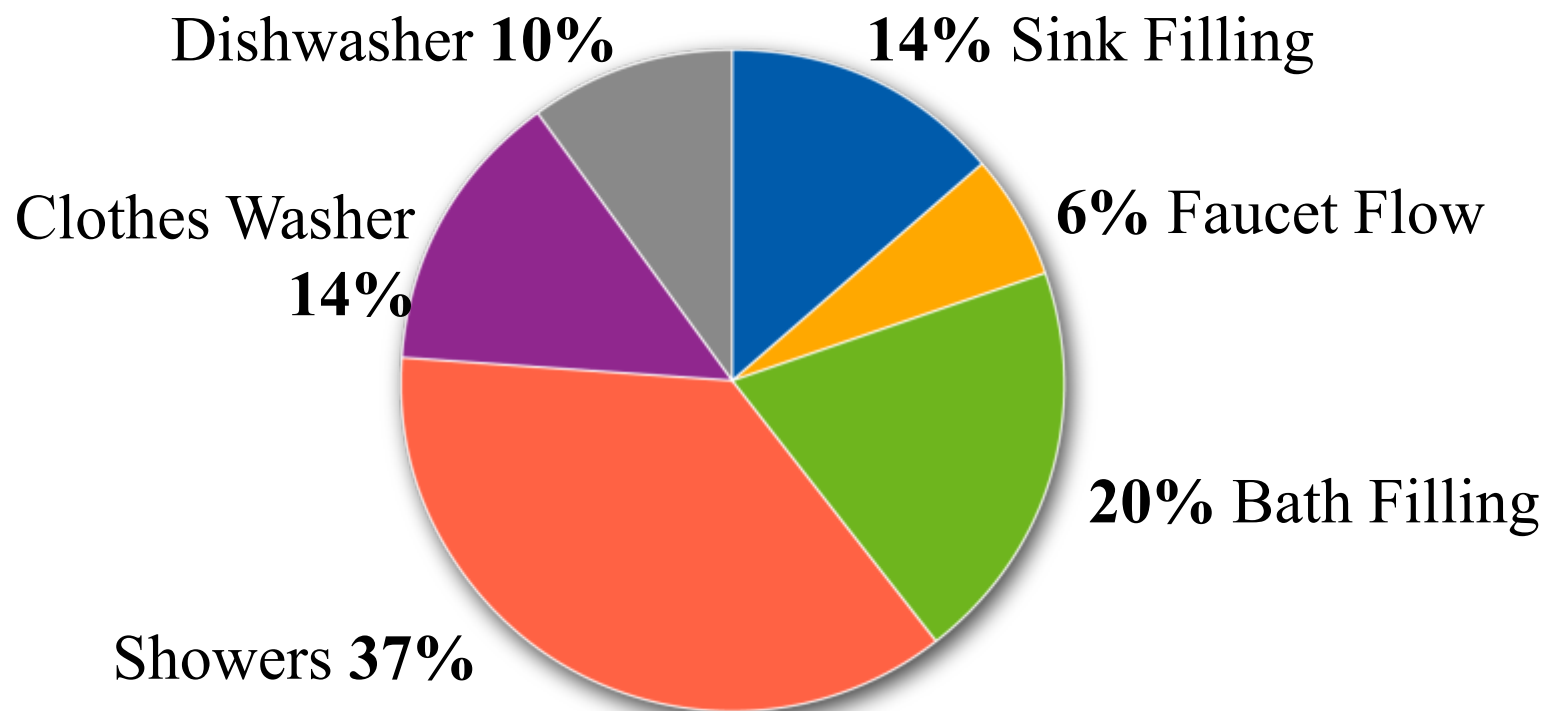


## Hot Water



*Photo courtesy of US Department of Energy*

## Hot Water Use



*Source: 2008 Buildings Energy Databook. US DOE*

# 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!

- Contact:
  - Josh Olsen  
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Weatherization Assistance Program  
202-287-1813  
[Joshua.olsen@ee.doe.gov](mailto:Joshua.olsen@ee.doe.gov)