# We will be starting soon!

*Thanks for joining us*

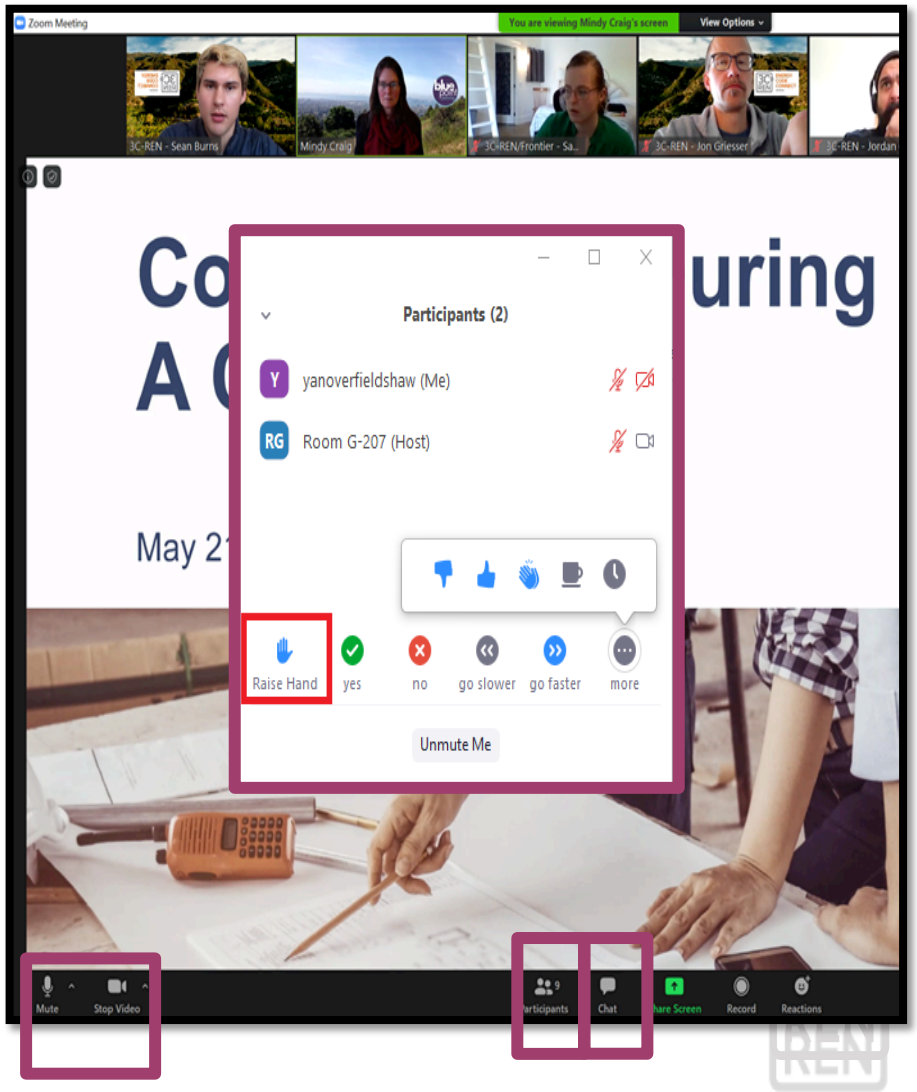
# Whole House Assessment: The Home Energy Audit Explained

*Judy Rachel – Home Performance Pro*

**July 26, 2022**

# Zoom Orientation

- Please be sure your full name is displayed
- Please **mute** upon joining
- Use "**Chat**“ box to share questions or comments
- Under "**Participant**" select "**Raise Hand**" to share a question or comment verbally
- The session may be **recorded** and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



# 3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region


3C
REN
ENERGY
CODE
CONNECT


3C
REN
BUILDING
PERFORMANCE
TRAINING


3C
REN
HOME
ENERGY
SAVINGS


3C
REN

# 3C-REN Staff Online

Need help or have questions about 3C-REN?

Send us a message!

# More Information

- **1.5 AIA LU's Available**
  - Contact spburns@countyofsb.org for any questions regarding LUs
- **Coming to Your Inbox Soon!**
  - Slides, Recording, & Survey – Please Take It and Help Us Out!
- **Upcoming Courses**
  - 8/9 - **Stay Cool This Summer with Higher-Performing Air Conditioning: Local residents share their experiences with heat pumps for space heating and cooling**
  - 8/16 – **How to Market Yourself as a High-Performance Professional**
  - 8/23 - **Duct Leakage Testing: Basics & Beyond**

## Thank you!

For more info:
3c-ren.org

For questions:
info@3c-ren.org

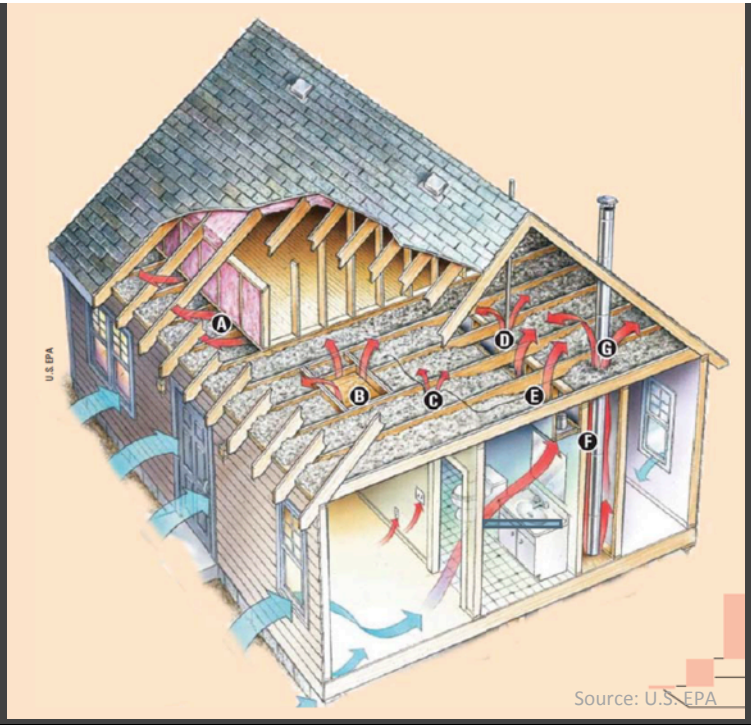
3C REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA

# Elements of a Whole House Assessment

## The Energy Audit Explained




# The "Energy" in Home Energy Audit

2nd Law of Thermodynamics

Energy flows naturally from high to low concentrations

- Pressure flows from HIGH to LOW
- Heat flows from WARM to COLD
- Moisture flows from MORE to LESS
- Energy In = Energy Out
- 1 CFM In = 1 CFM Out

# Purpose of a Home Energy Audit

- To assess the energy flows and how those flows are impacting building durability, indoor air quality, occupant safety, health and thermal comfort.
- To learn the homeowner's wants, needs, motivations and expectations for their home.
- To determine how the house is currently functioning through a combination of visual inspection and diagnostic testing.
- Provides the information necessary to offer substantive solutions through a comprehensive scope of work.
- Establishment of a trust relationship between the parties.

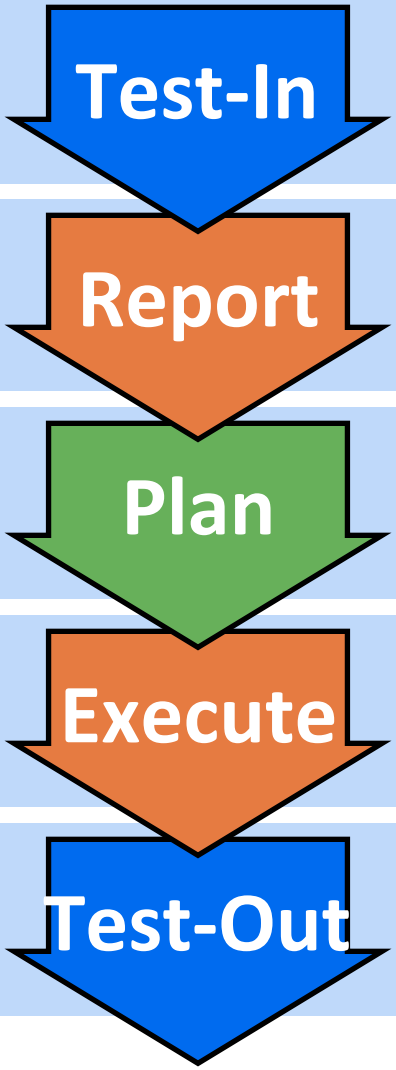
# The "Whole House" Inspection

There are many tests and inspections to perform.

Do the tests that fit the situation.

1. **Pre-Arrival Tasks**
2. **Occupant Interview**
3. **Visual Site Inspection**
4. **Ventilation, Moisture & IAQ**
5. **Enclosure Tightness & Blower Door Testing**
6. **Insulation Performance**
7. **Space Heating Equipment**
8. **Space Cooling Equipment**
9. **Air Flow and Ducts**
10. **Diagnostic Tests**
11. **Combustion Appliance Safety Testing**
12. **Appliances and Water Heating**
13. **Lighting**

# The Process




- Often called an "Energy Audit"
- Scientific measurements of current home's performance

- Findings and recommendations
- Provides a road map for retrofitting the home

- Decide on the improvements which address the issues and fit the budget
- **Every project is a unique job – one size does not fit all**

- Do the work
- Quality is critical to success

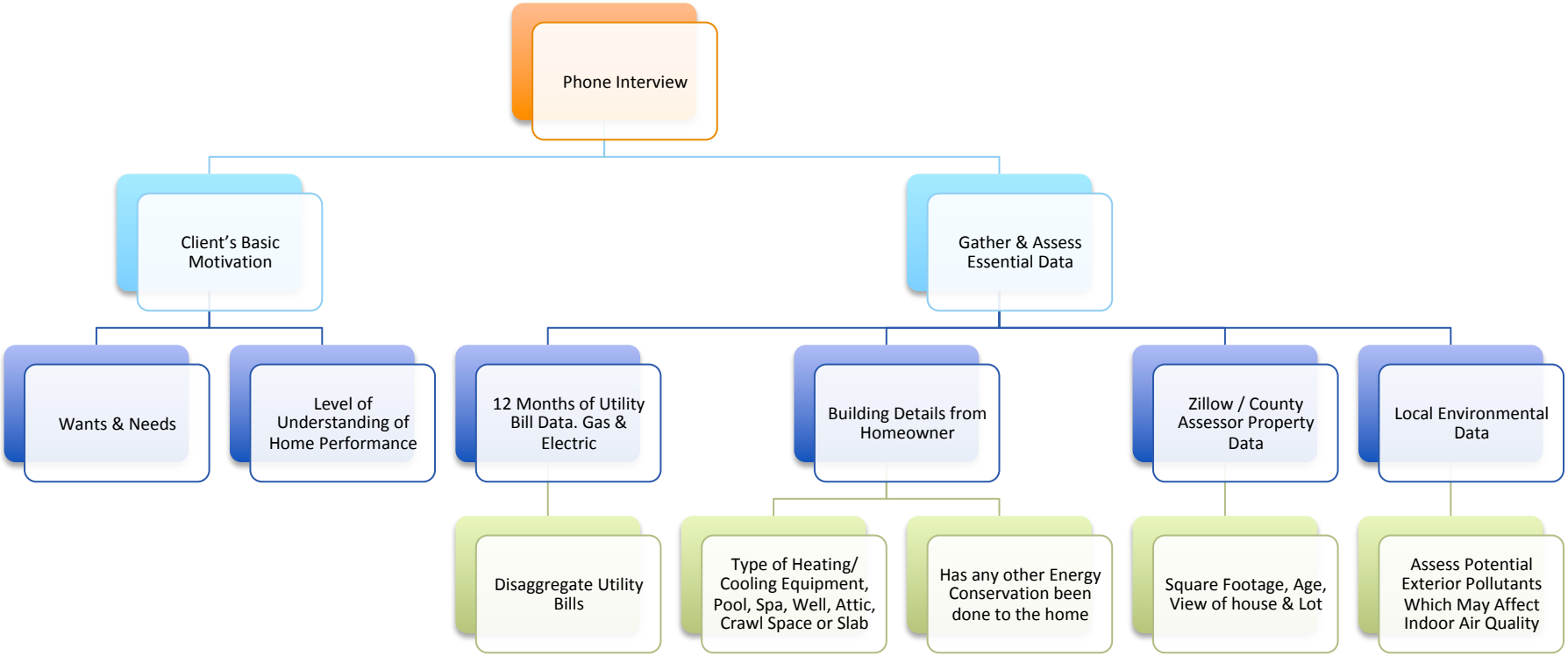
- Test again to verify the results
- Provides feedback


# The Energy Audit

## "Test – Don't Guess"

- Testing helps us to:
  - Direct our efforts
  - Direct our time
  - Direct your client's money
- Provides a baseline against which to measure results

# Pre-Visit Preparation



# Utility Bills

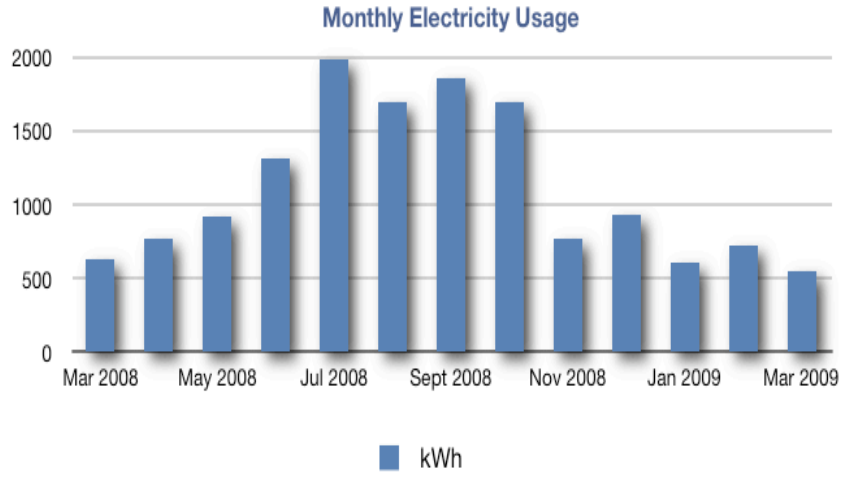
- Useful tool for gauging a building's energy efficiency
- Contain an array of useful information such as energy consumption and rate information
- A scorecard measuring energy savings from Home Performance upgrades

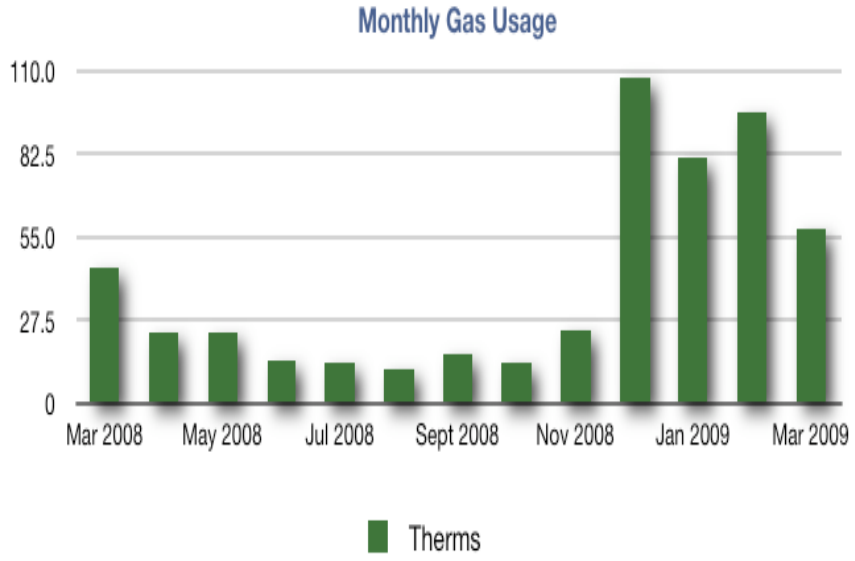
# Purpose of a Utility Bill Disaggregation

To estimate baseload and calculate seasonal loads.

Seasonal Heating / Cooling Loads can comprise ~ 40 to 50% of a home's energy consumption.

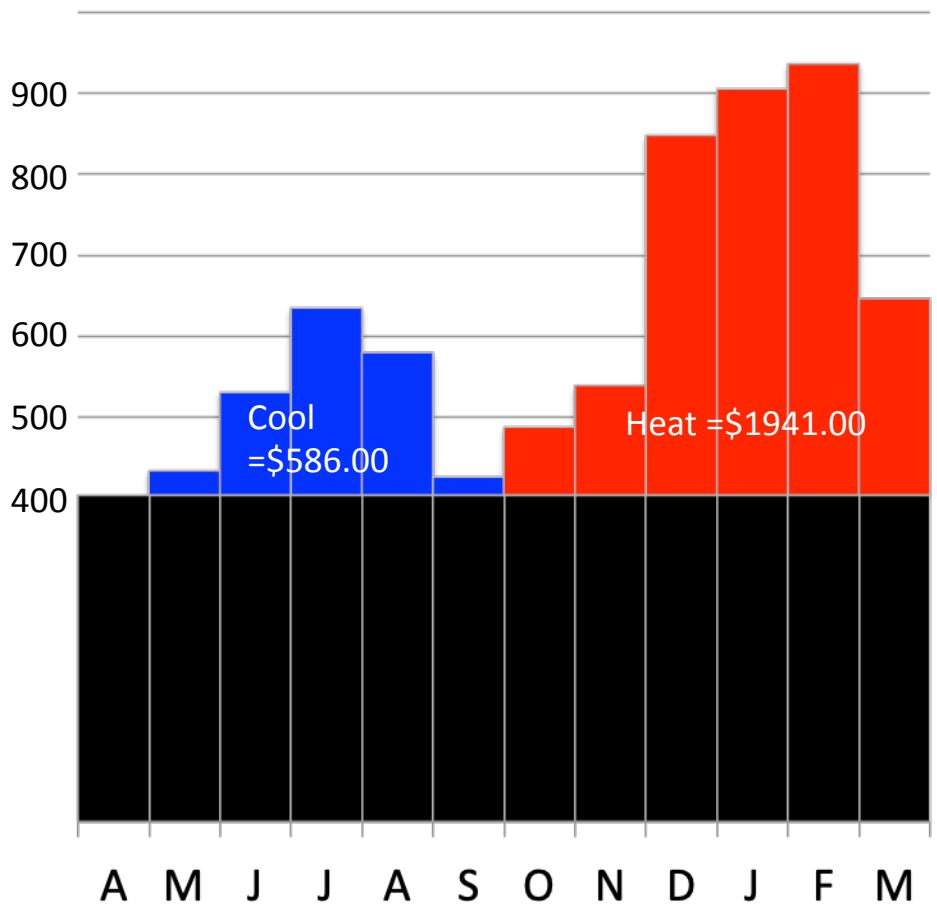
Baseload – Lighting, Appliances, Hot Water, etc.



# Utility Bill Disaggregation

| | | |
|---|---|---|
| Jan | 03 | $905.55 |
| Dec | 02 | $848.28 |
| Nov | 02 | $539.35 |
| Oct | 02 | $487.77 |
| Sept | 02 | $426.22 |
| Aug | 02 | $579.94 |
| July | 02 | $634.93 |
| June | 02 | $530.67 |
| May | 02 | $433.85 |
| April | 02 | $403.88 |
| March | 02 | $646.66 |
| Feb | 02 | $936.72 |
| Total | | $7374.00 |



# Energy Consumption in Dollars

| | |
|---|---|
| Base Load | $404.00 per month |

| | |
|---|---|
| Annual Base Load | $4,847.00 |
| Annual Cooling Load | $586.00 |
| Annual Heating Load | $1,941.00 |
| Annual Total | $7,374.00 |

| | |
|---|---|
| Conditioned Floor Area | 6,000 sq.ft. |
| Total Heating & Cooling | $2,527.00 |
| Space Conditioning Cost | $ 0.42/sq.ft. |

(2004 dollars and utility rates)

# Comparing Dis-aggregation of Redding Showcase Homes

| | $100 K Geothermal Heat pump | $15K Conventional Heating/Cooling |
|---|---|---|
| Conditioned Floor Area | 6,000 sq.ft. | 3,500 sq.ft. |
| Total Heating & Cooling | $2,527.00 | $317.00 |
| Space Conditioning Cost | $ 0.42/sq.ft. | $.09/sq.ft. |

Un-retrofitted existing homes typically range from .25/ sq.ft. to $2.50/sq.ft. for heating and cooling.

# Environmental and Regional Considerations

- Soil types and soil gases
- Industrial pollution of air, soil and water
- Wildland Urban Interface
- Elevation of the home
- Wind factors
- Annual temperatures
- Annual precipitation

Image courtesy of Colorado State University

# The Evaluation of the House Begins as You Drive Up to the House

- Upgrades?
- Additions?
- Roof Condition?
- Rain Gutters?
- Site Drainage?
- Vent Terminations?
- Overall Neighborhood?


Photo courtesy of Judy Rachel

# Occupant Interview

## *Ask About…*

- The number of occupants and percentage of occupancy
- Ventilation: Are windows opened? Are bath fans used?
- Health concerns, allergies or IAQ complaints
- Thermostat wars
- Seasonal issues: crawl space flooding, mold, odors
- The more information you gather, the better . . .

# Explain what you will be doing

- Explain the tests you will be performing
- Explain the time required for testing
- Encourage customer participation


# Exterior Inspection

Moisture

Landscaping

Solar orientation

Siding penetrations/cracks

Roof, flashings, penetrations

Rain gutters & downspouts

Windows & doors

Deferred maintenance

Unusual conditions

# The More Information You Have, the Better

## Take Lots of Pictures

Photo courtesy of Judy Rachel

# Wind – A primary driving force for air infiltration

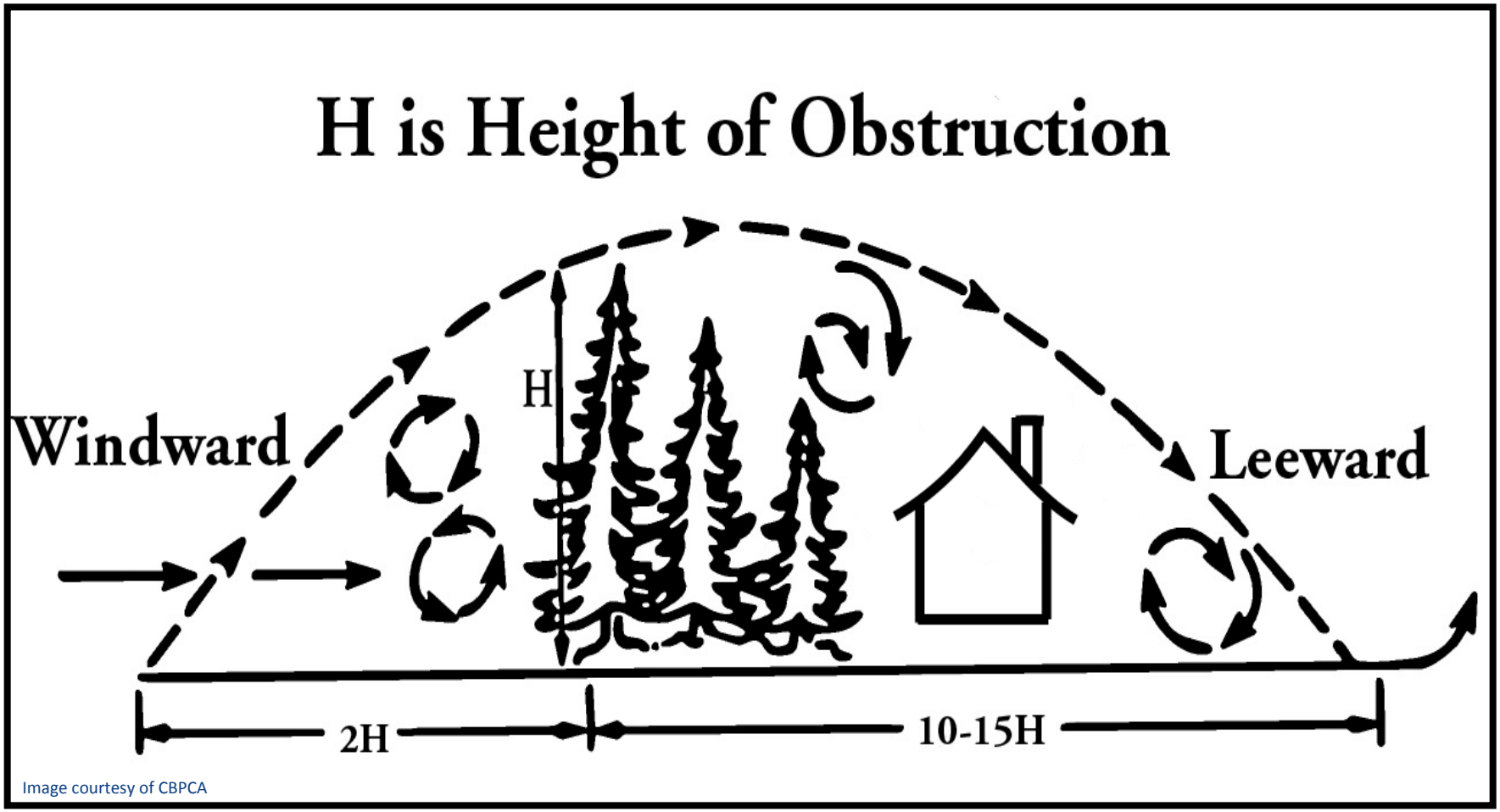



Image courtesy of CBPCA

# Trees and Plants

Foliage – Can help buffer a building from extremes, help control surface water, but can harm a home if too close.

# How Water Enters a Building

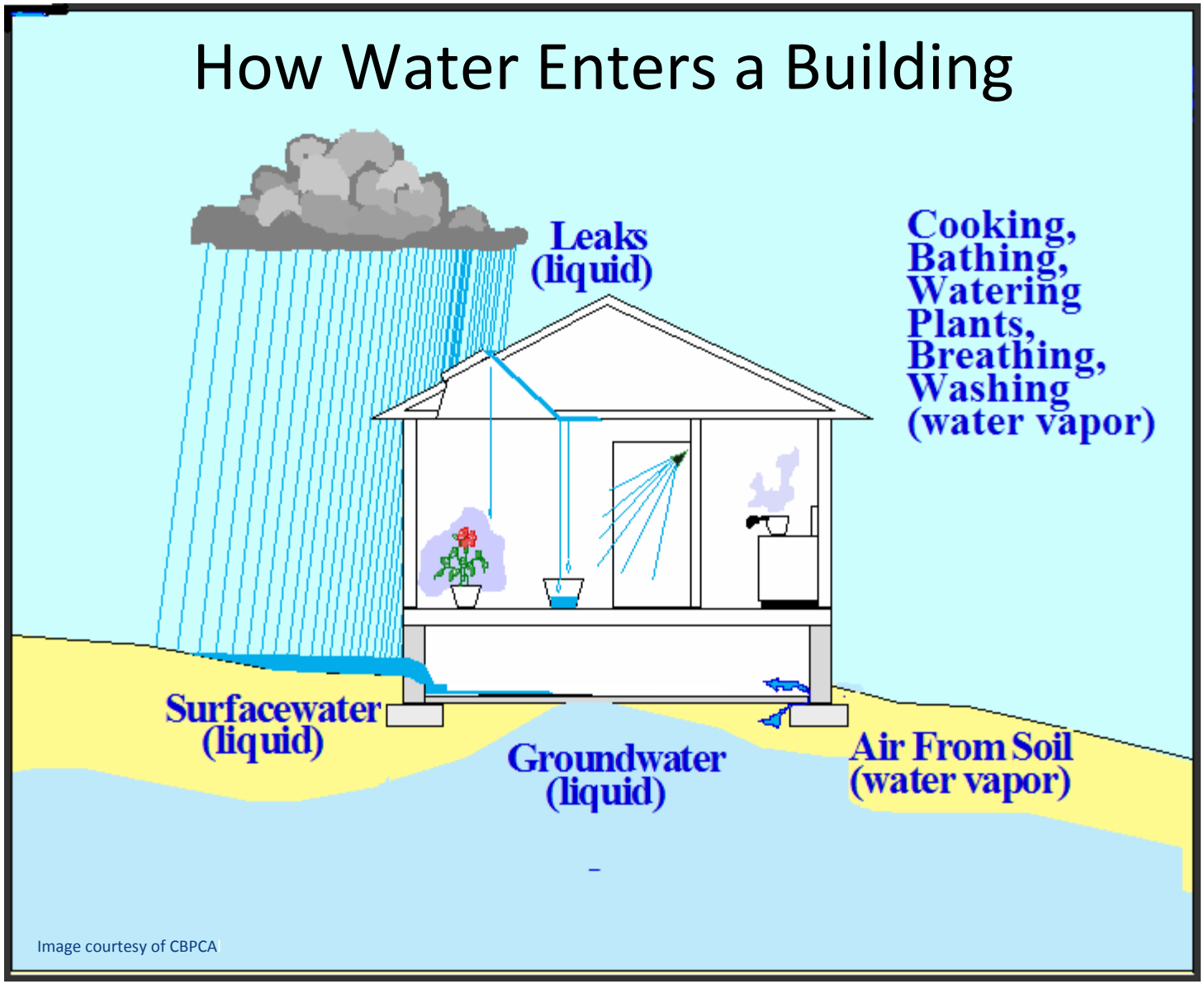



Image courtesy of CBPCA

# Bulk Moisture – Water

**Water in and around homes needs to be controlled**

1. **Identify the <u>Source</u>** – Where is the moisture coming from?
2. **Determine the <u>Pathway</u>** – How is it getting in?
3. **How is it being <u>Transported</u>?**


Photo courtesy of Judy Rachel

1 inch of rainfall equals 1,250 gallons of roof runoff for a 2,000 square foot house

# Moisture


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Plants Need To Be Watered
# Not Houses


# Direct water away from/out of the house

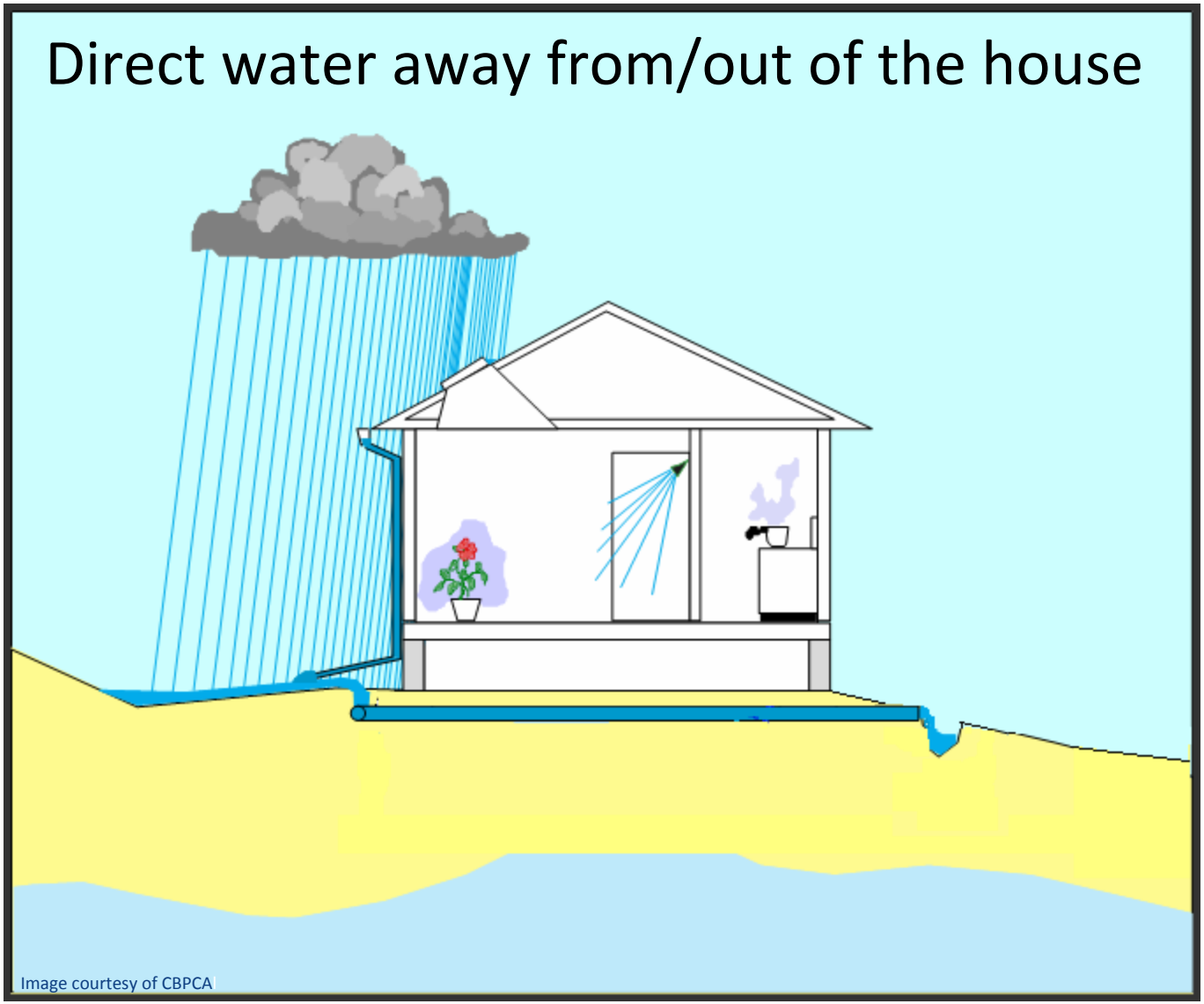


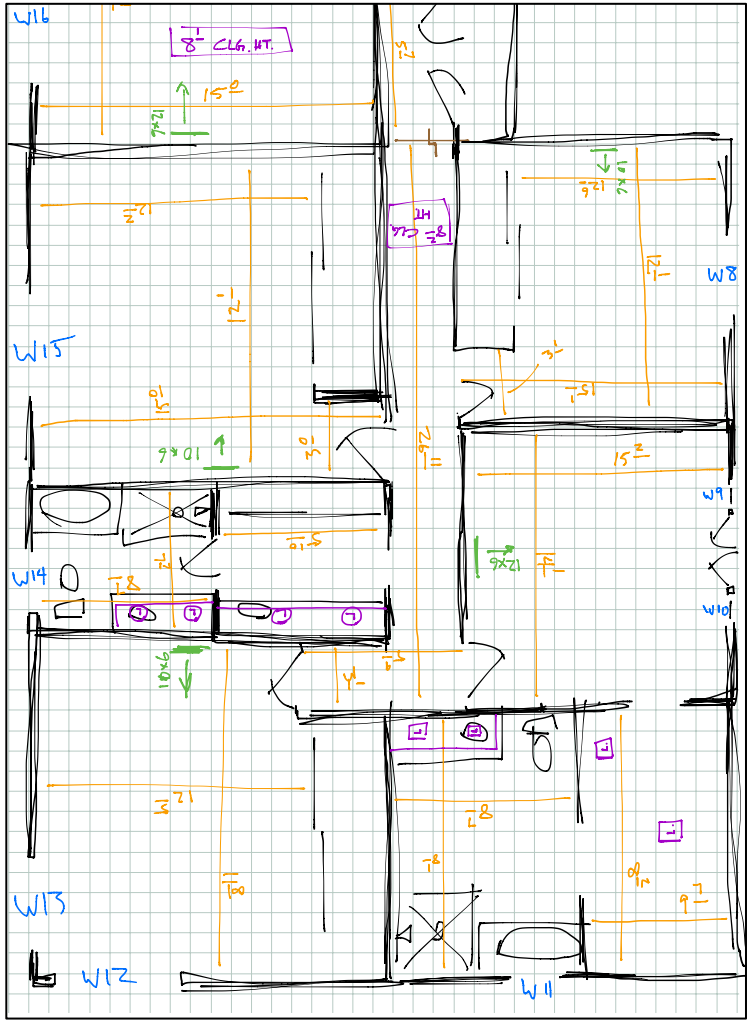
Image courtesy of CBPCA

# Deferred Maintenance


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Sketch the Home




Measure the house for:

- Accurate square footage and volume
- Load calculation
- To mark architectural features
- A way to figure out how much insulation will be needed . . .
- etc


Photo courtesy of Judy Rachel

# Interior Inspection

Moisture

Indoor Air Quality

Air Leakage Paths

Health & Safety

Pressure Imbalances

Supplies & Returns

Ventilation

Baseload Appliances

# Moisture

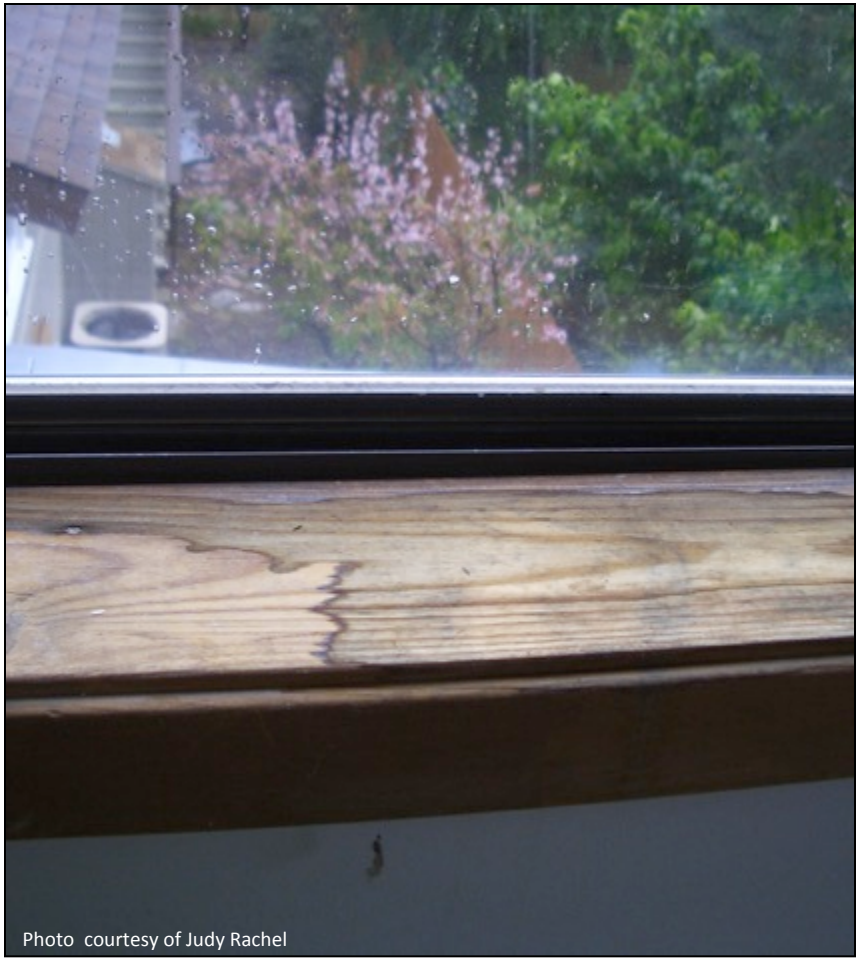


Photo courtesy of Judy Rachel

Photo courtesy of Judy Rachel

# Indoor Air Quality

## Mold


## IAQ / Air Leakage Path

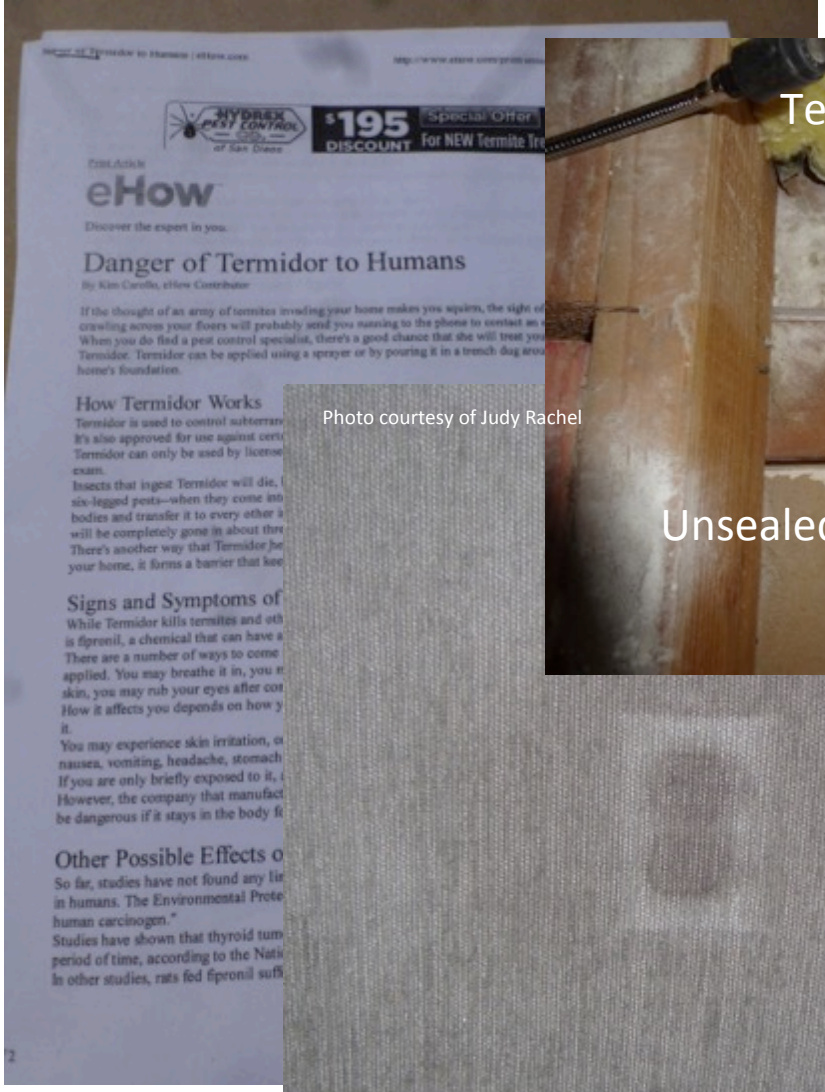




Photo courtesy of Judy Rachel

Unsealed attic top plate

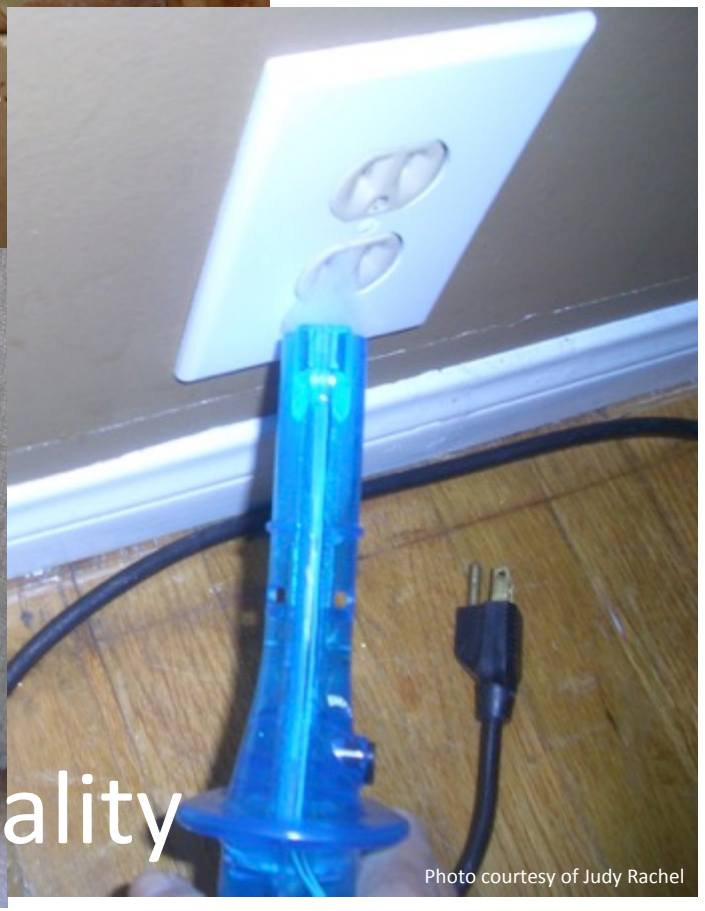
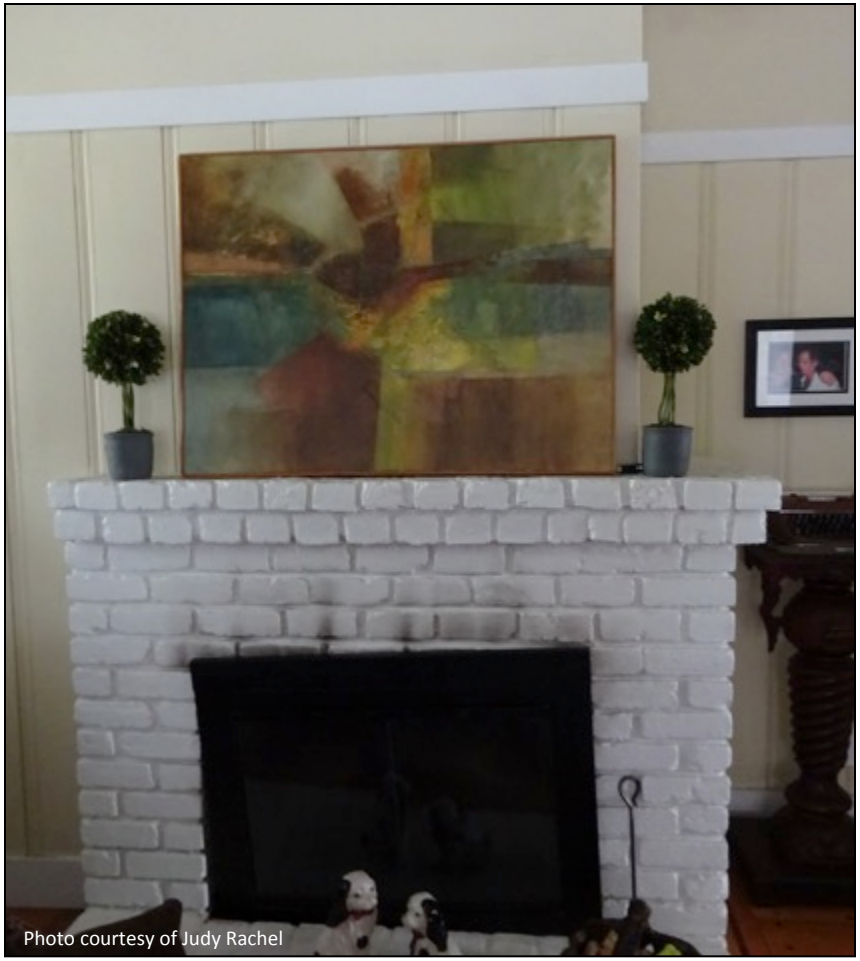


Photo courtesy of Judy Rachel

# Indoor Air Quality

# Indoor Air Quality


# Clues to Pressure Imbalances




# Pressure Imbalances


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Air Leakage Path


# Air Leakage Paths

## Interior stairs on exterior wall


## Behind baseboards

# Ventilation

## Passive Kitchen Ventilation blocked off but replaced with nothing


## Passive closet ventilation into attic

# Insulation Contact Air Tight Recessed Can Lights

**Are these or aren't these?**


**Remove the trim ring & look for the orange label.**

# Safety


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Crawl Space/Attic Inspection

Moisture

Insulation

Air Leakage Paths

Ducts

Health & Safety

Deferred Maintenance

Building Durability

Ventilation

# A Crawl Space is Not a Dry Space


# Roofing nail shows signs of moisture


Photo courtesy of Judy Rachel

# Water Vapor

## Powder dry soil still evaporates moisture


## Ground Source Vapor Barrier

# Air Sealing Opportunities
# Crawl Space

Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# The Underside of Bathtubs

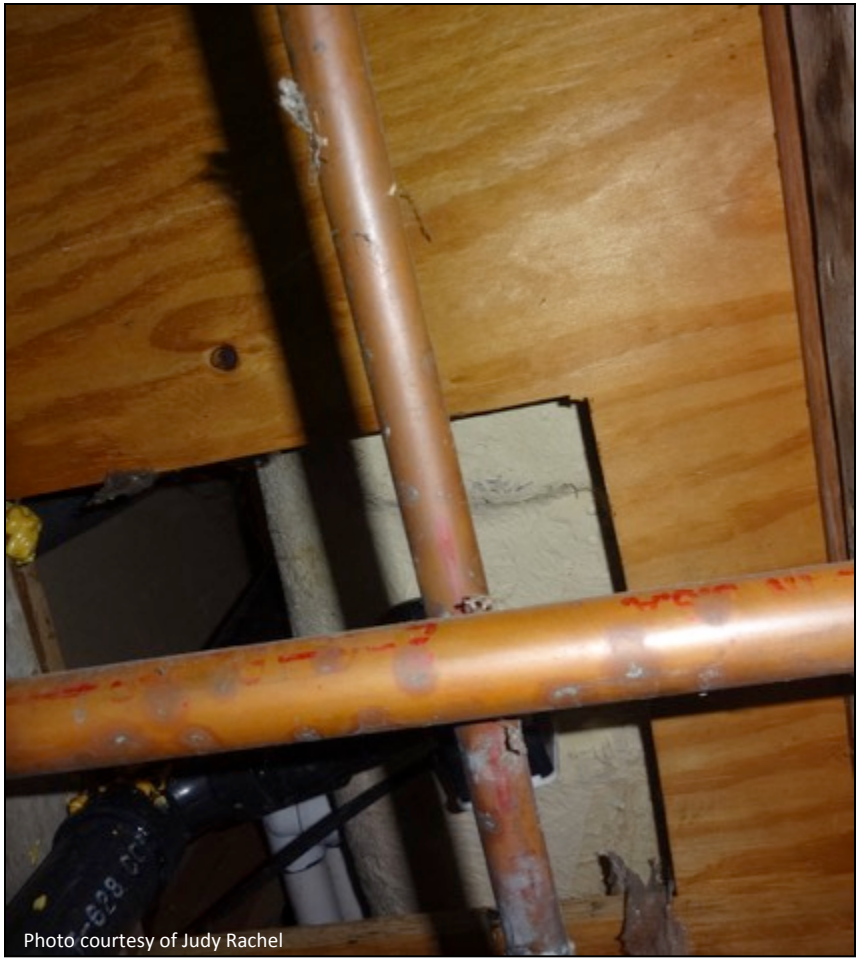


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Deferred Maintenance


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Indoor Air Quality

# Indoor Air Quality


# Quantity / Quality of Insulation

- Attic?
- Walls?
- Floors?

Visual inspection, infrared aided with blower door, probing past switch plates in walls, asking occupants questions


# Lack of Insulation

## Interstitial cavity


**Uninsulated water lines run mid attic. In the summer homeowners are afraid toddler will get scalded if he turns on the cold water**

# Under-insulated/Poorly Run Ducts

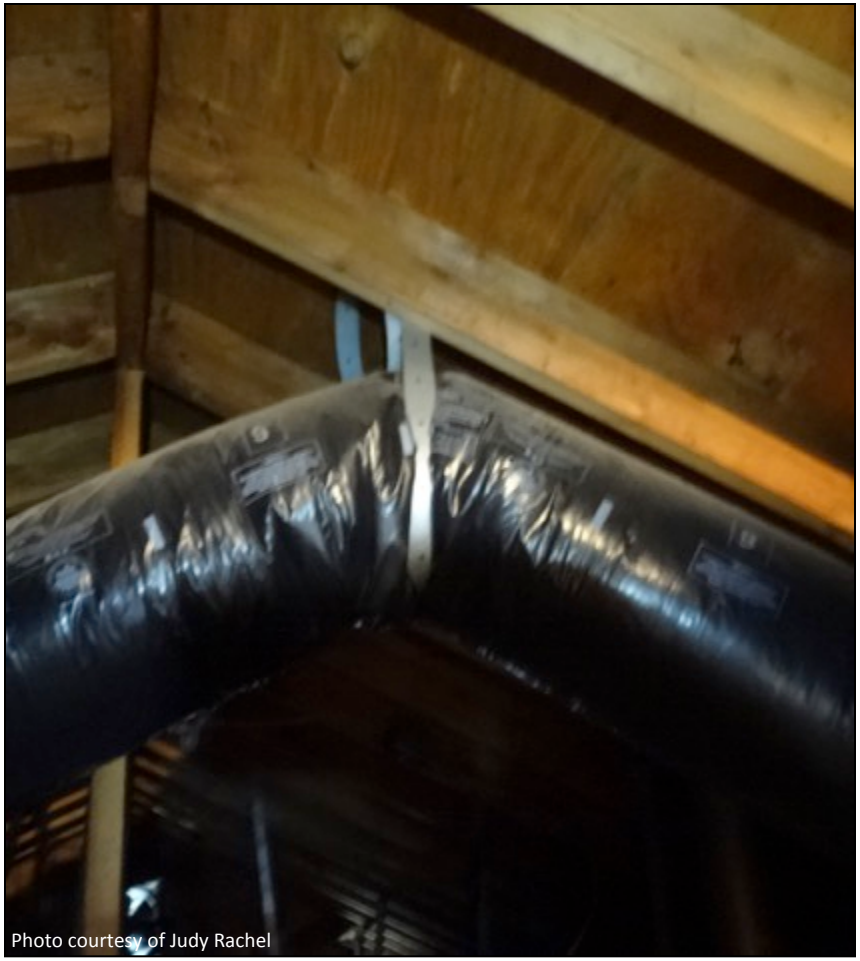


Photo courtesy of Judy Rachel

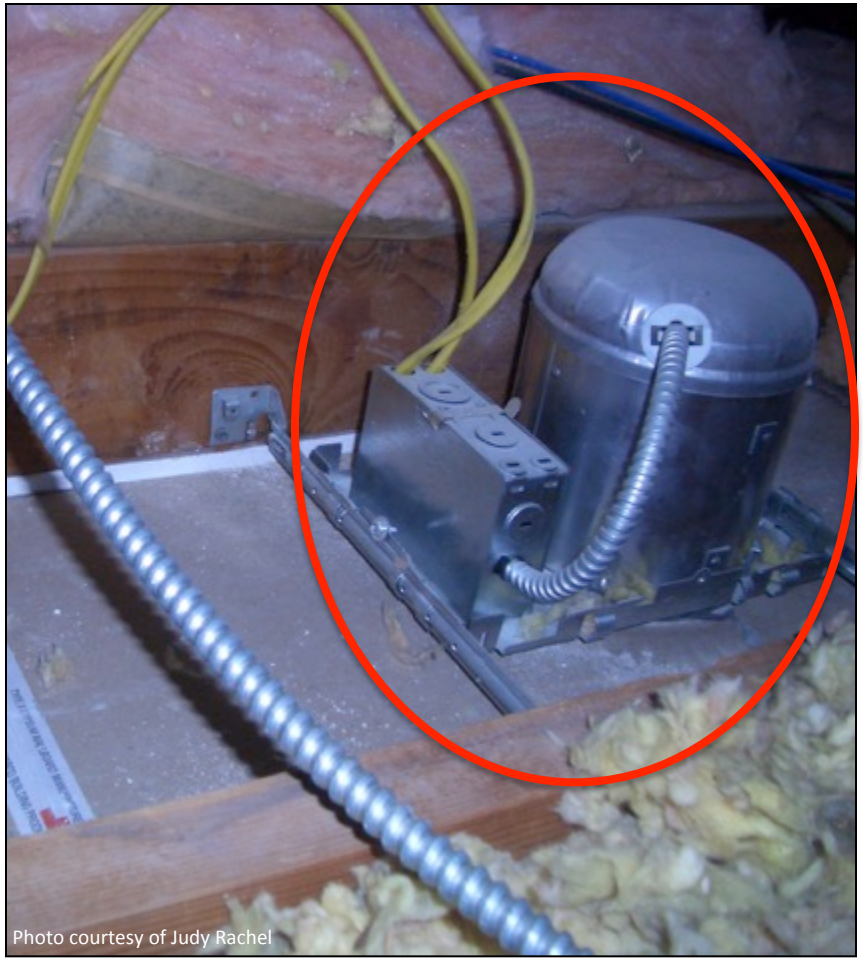
Photo courtesy of Judy Rachel

# Wind washing

## Vented Bay


## Unintentionally Vented Bay

# Same Attic. Which Can Light Can be In Contact with the Insulation?

# Evaluate Ventilation


# Junction Boxes Need Covers

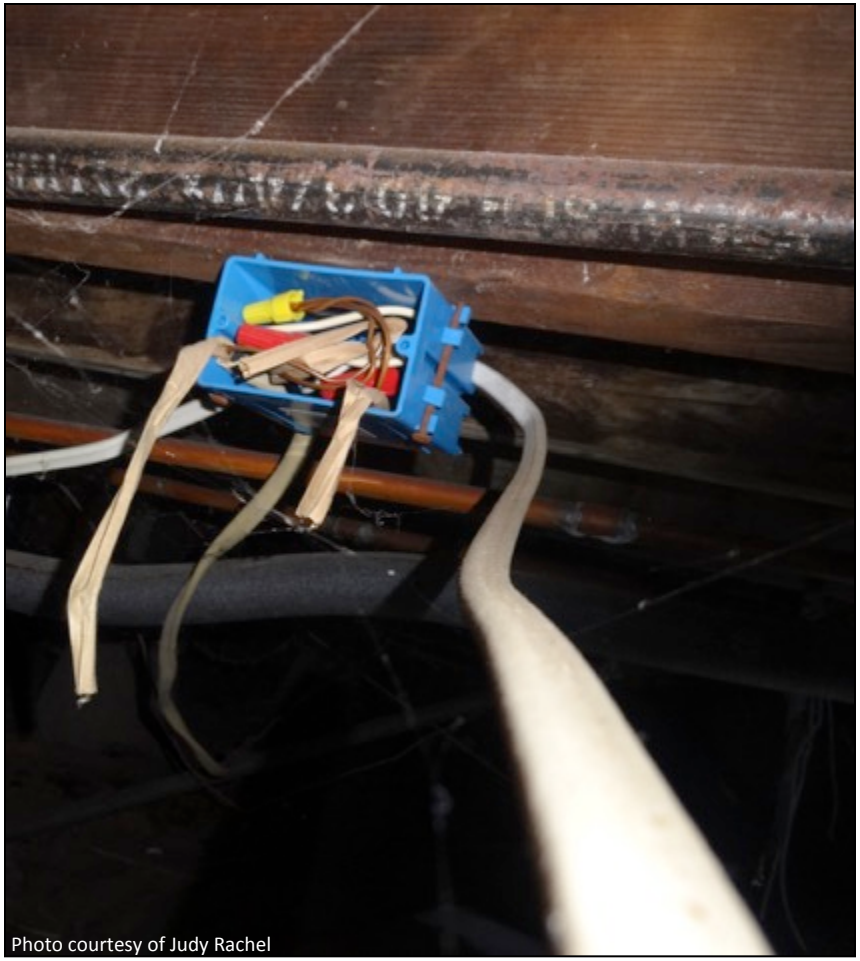


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Safety Issues


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

# Fire Hazards

## Chimney has no clearance to wood

Photo courtesy of Judy Rachel

## Paper facing left exposed in attic


Photo courtesy of Judy Rachel

# Health & Safety


# Asbestos Containing Material


Photo courtesy of Judy Rachel


Photo courtesy of Judy Rachel

Energy Conservatory Duct Blaster

# Mechanical Systems/ Diagnostic Performance Tests

Heating System

Cooling System

Ventilation

Ducts

Water Heating

# Performance Testing

- Blower Door
  - Quantify total leakage
  - Search for leakage paths
  - Assist with IR inspection
- Infrared Inspection
- Duct Leakage
  - Total duct leakage
  - Half Nelson
  - Leakage to outside
- Measure Airflow of HVAC Systems
- Heating Stratification Test
- Delivered Capacity
- Static Pressure
- Various Pressure Tests
- System Watt Draw
- Pool Pump Watt Draw

Retrotec Blower Door

# Blower Door

**Manufactured by 2 companies**

**The Energy Conservatory**

**Retrotec**

- **Quantifies air leakage**
- **Helps locate air leaks**
- **Measures the effectiveness of air sealing efforts**
- **Enhances infrared camera diagnostics**
- **Necessary part of duct leakage to the outside test**


Photo courtesy of Judy Rachel

# Energy Conservatory Blower Door

Set-up for Depressurization

# Manometer

- A multi-functional differential pressure gauge
- Provides high resolution pressure measurements. These all have 2 independent measurement channels.
- Accurately calculates air flow

Photo courtesy of Judy Rachel

DG-700


DM-2


DM32


DG-1000

# Infrared Inspection

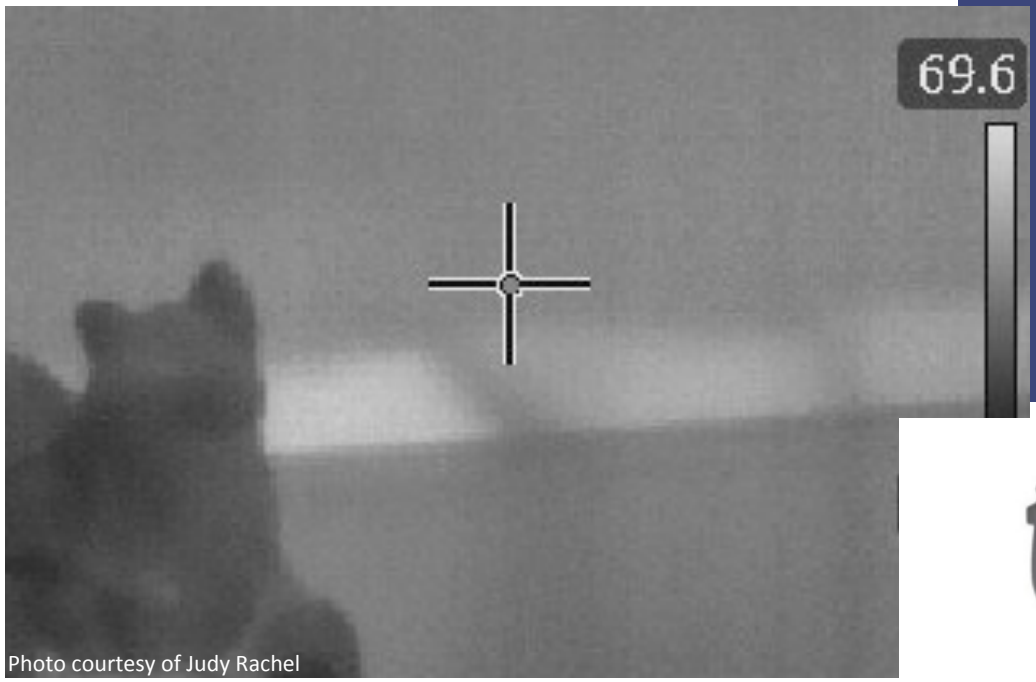


Photo courtesy of Judy Rachel

Provides the ability to locate:

- Air Leaks
- Thermal Bridging
- Missing or Poorly Performing Insulation
- Water Leaks


Fluke


Flir

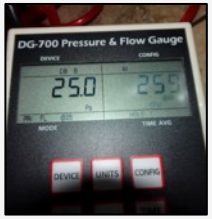
Retrotec DucTester System


# Duct Testing Equipment

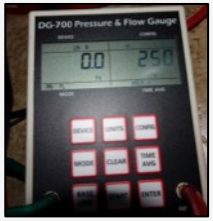
- A calibrated air flow measurement system designed to test and document the air tightness of forced air duct systems

- Estimating HVAC system losses from duct leakage
- Diagnose duct leakage locations
- Measure the effectiveness of duct sealing efforts
- Documenting and certifying duct leakage compliance for building code

# Duct Testing




**Total Duct Leakage**




**Duct Leakage to the Outside**


**Half Nelson**

Photo courtesy of Judy Rachel

Energy Conservatory Duct Blaster

# Duct Blaster

TEC and Retrotec equipment can be used:

- As a powered flow hood to accurately measure total air flow through supply and return registers, exhaust fans and other air flow devices
- As a small Blower Door to test the airtightness of small or tightly built houses
- To accurately measure total air flow through the air handler using the plenum pressure matching procedure

# Air Flow Measuring Devices

Delivered system air flow: the sum of the supplies

Ventilation systems

Exhaust Fans

Powered flow device compensates for pressure losses created by funneling air flow through a device.

Flow Finder®

Passive flow device where air is directed over a manifold which averages the velocity pressure. Less accurate than powered devices.


LoFlo Balometer

# Heating Stratification Test


Photo courtesy of Judy Rachel

**Home Temperature Stratification Test**

Test Date: _____ Test Conducted By: _____

Owners: _____

Address: _____

_____

Description of house and test conditions: _____

_____

_____

| CBPCA-Strat Test Measurements: | Start | Finish | **Temperature Increase** |
|---|---|---|---|
| Test start and finish times | _____ | _____ | Test Duration: _____ |
| 1. Floor level (6" above floor) | _____°F | _____°F | _____**°F** |
| 2. 1st floor thermostat | _____°F | _____°F | _____**°F** |
| 3. 2nd floor thermostat (2 story homes) | _____°F | _____°F | _____**°F** |
| 4. Ceiling level (6" below ceiling) | _____°F | _____°F | _____**°F** |

**House Temperature Stratification Grade: _____°F** (line 4 minus line 1)
- ❑ **Excellent Comfort** (floor to ceiling variations less than 3°F)
- ❑ **Good Comfort** (floor to ceiling variations between 3°F and 6°F)
- ❑ **Unacceptable Comfort Levels** (floor to ceiling variations greater than 6°F)

**Heating System Sizing: _____°F** (average temperature increase)
- ❑ **Undersized Heating System** (average temperature increase less than 2°F/hour)
- ❑ **Properly Sized System** (average temperature increase between 2°F/hour and 5°F/hour)
- ❑ **Oversized Heating System** (average temperature increase greater than 5°F/hour)

**Ceiling Heat Loss Increase due to Stratification: _____°F** (line 4 minus line 2)
- ❑ **Low Ceiling Heat Loss** (ceiling temperature less than 2°F above thermostat temperature)
- ❑ **Slightly Elevated Ceiling Loss** (ceiling temperature 2°F to 6°F above thermostat temperature)
- ❑ **Unacceptably High Ceiling Heat Loss** (ceiling temperature 6°F above thermostat temp.)

# Delivered System Capacity

## Need measured air flows


## Temperature of air at grilles

# Total External Static Pressure

- Similar to taking a person's blood pressure to measure the "health" of the HVAC system
- Manufacturer's maximum acceptable TESP is on the equipment's label

Photo courtesy of Judy Rachel

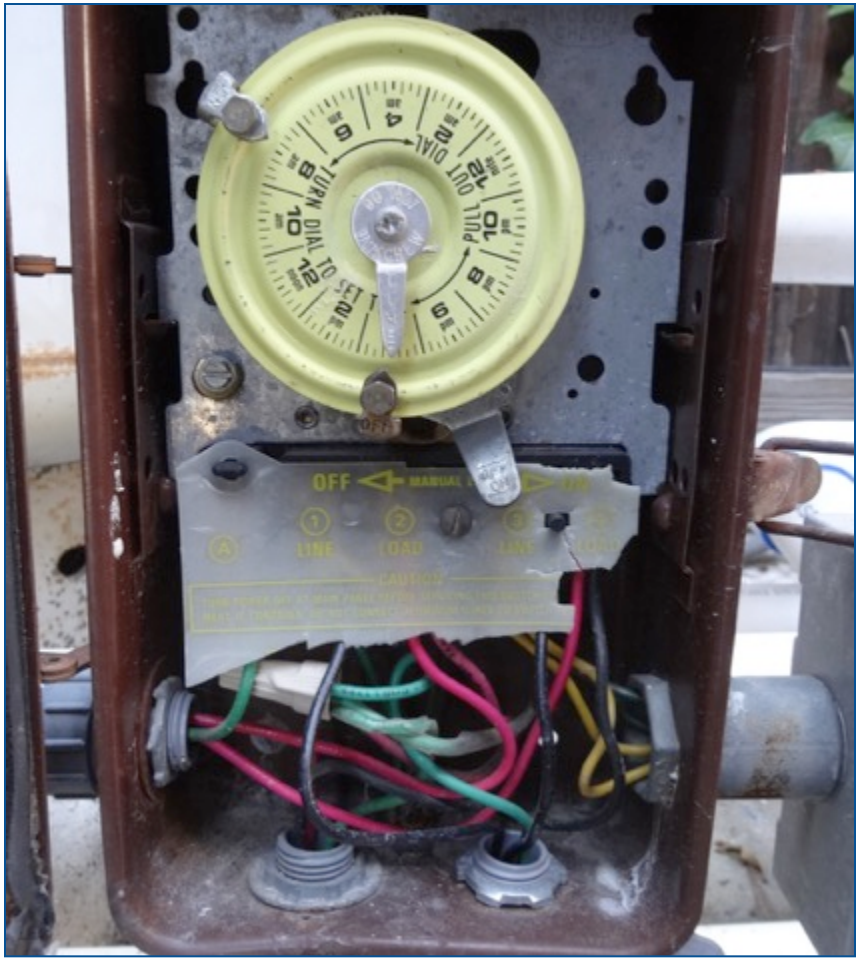
# Air Handler & Condenser Watt Draw


Photo courtesy of Judy Rachel

# Pressure Across Doors With HVAC System On Should Never Exceed 5 Pa


Photo courtesy of Judy Rachel

# Pool Pump Watt Draw




- Watt Draw of the pool pump multiplied by the number of hours the pump runs per day gives you total energy use of the pool pump.
- Extrapolate out for annual energy use and cost.


Photo courtesy of Judy Rachel

# Combustion Appliances & Safety

Visual evidence of spillage on an induced draft furnace

Most homes still have combustion appliances typically for heating, water heating, cooking or drying clothes.

The by-products of combustion can cause serious health problems and even death

- Appliances that rely upon combustion must be vented properly to the outside
- Adequate air must be provided for the combustion process and for draft to be sustained
- Competition for air can cause combustion appliances to spill their vent gasses back into the home, cause flame roll-out or extinguish pilot lights, causing natural gas to build up in the area around the appliance.
- Tighter houses mean even greater vigilance is necessary to ensure proper venting

# Combustion Safety Tests

- Visual Inspection
- Combustible Gas Leaks
- Worst Case Depressurization
- Spillage
- Draft
- Carbon Monoxide (CO)
- Oven and Stovetop CO

# Hazardous Condition


# The Home Energy Audit

- Provides the vehicle for gathering information about a house from the occupant, through visual inspection and diagnostic testing.
- There are many factors that affect home energy performance.  The auditor must be an expert in building science and the climates they work in.
- Figuring out moisture, air and heat movement in our homes is critical for durability, energy efficiency, comfort, safety and IAQ.


Compiling and reporting the results of the Energy Audit

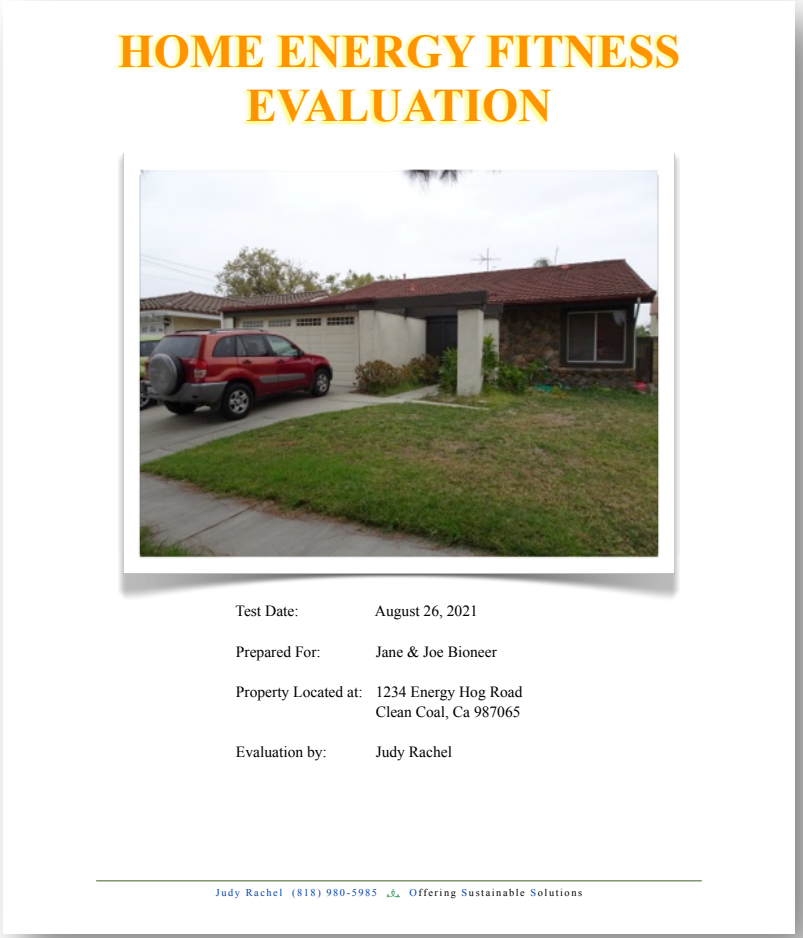
# PROPOSAL WRITING

# Site Visit Findings Report

- Provide a written report containing the findings from the site visit.

- Provide a preliminary work scope
  - Use test-in data to guide post-retrofit test-out goals

- Prioritize recommended measures
  - Recommendations should reflect the needs of the home and its occupants
  - Present options for comprehensive solutions that are consistent with building science principles



HOME ENERGY FITNESS EVALUATION

Test Date: August 26, 2021

Prepared For: Jane & Joe Bioneer

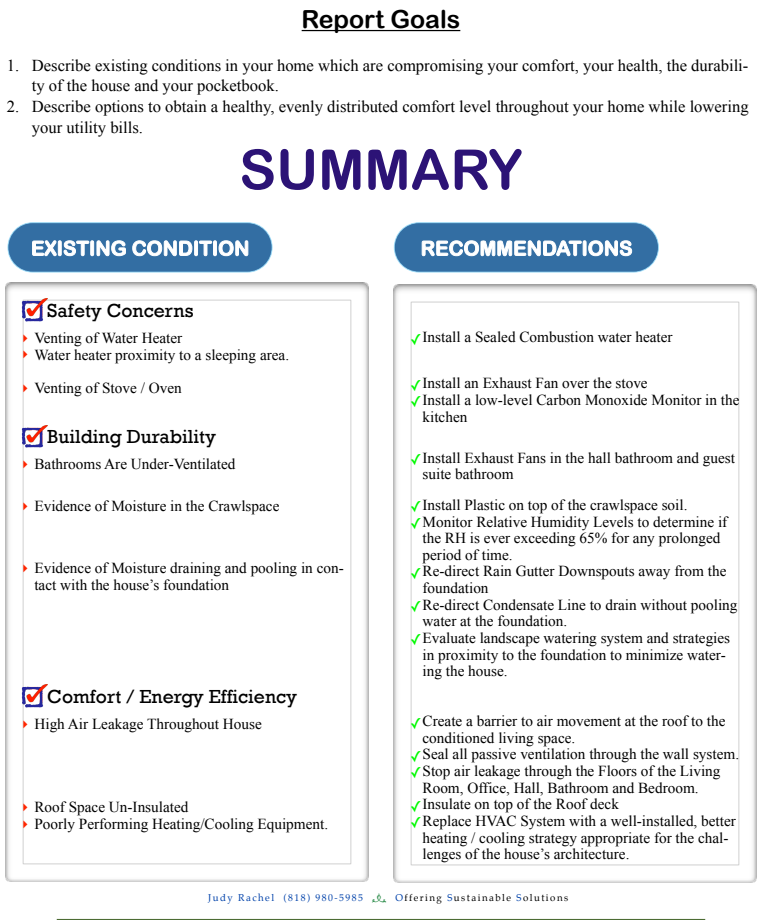
Property Located at: 1234 Energy Hog Road
Clean Coal, Ca 987065

Evaluation by: Judy Rachel

Judy Rachel (818) 980-5985 Offering Sustainable Solutions

# Site Visit Report

- Re-state Homeowner's concerns in their words
- Describe existing conditions & results of tests
- Make recommendations describing benefits
- Provide test data and pictures



**Report Goals**

1. Describe existing conditions in your home which are compromising your comfort, your health, the durability of the house and your pocketbook.
2. Describe options to obtain a healthy, evenly distributed comfort level throughout your home while lowering your utility bills.

## SUMMARY

| EXISTING CONDITION | RECOMMENDATIONS |
|---|---|
| **Safety Concerns** | |
| Venting of Water Heater<br>Water heater proximity to a sleeping area. | Install a Sealed Combustion water heater |
| Venting of Stove / Oven | Install an Exhaust Fan over the stove<br>Install a low-level Carbon Monoxide Monitor in the kitchen |
| **Building Durability** | |
| Bathrooms Are Under-Ventilated | Install Exhaust Fans in the hall bathroom and guest suite bathroom |
| Evidence of Moisture in the Crawlspace | Install Plastic on top of the crawlspace soil.<br>Monitor Relative Humidity Levels to determine if the RH is ever exceeding 65% for any prolonged period of time. |
| Evidence of Moisture draining and pooling in contact with the house's foundation | Re-direct Rain Gutter Downspouts away from the foundation<br>Re-direct Condensate Line to drain without pooling water at the foundation.<br>Evaluate landscape watering system and strategies in proximity to the foundation to minimize watering the house. |
| **Comfort / Energy Efficiency** | |
| High Air Leakage Throughout House | Create a barrier to air movement at the roof to the conditioned living space.<br>Seal all passive ventilation through the wall system.<br>Stop air leakage through the Floors of the Living Room, Office, Hall, Bathroom and Bedroom. |
| Roof Space Un-Insulated<br>Poorly Performing Heating/Cooling Equipment. | Insulate on top of the Roof deck<br>Replace HVAC System with a well-installed, better heating / cooling strategy appropriate for the challenges of the house's architecture. |

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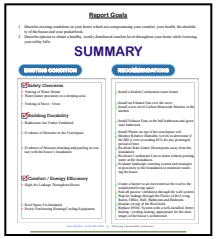
# The Structure of Effective Proposals

**Cover Sheet**

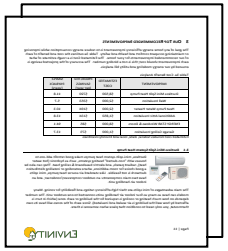
Be as creative as you want (or not)




**Part I**

List of client concerns, needs and wants

What the client knows



**Part II**

Measurements and observations

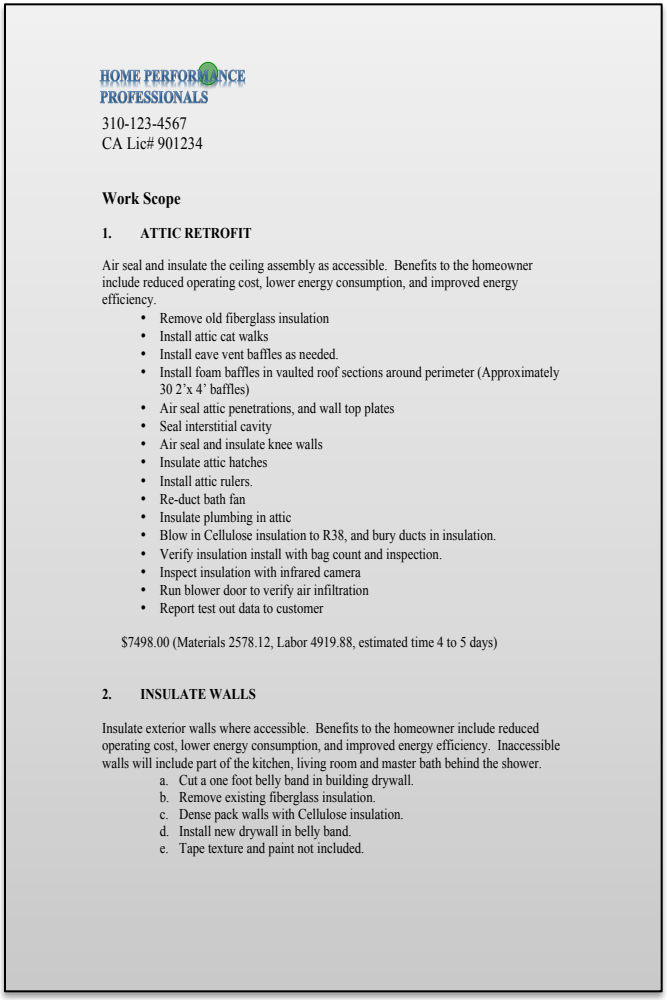
What you know now, and why it matters

**Part III**

Recommendations, costs and benefits

Everything else

# Work Scope



HOME PERFORMANCE PROFESSIONALS

310-123-4567
CA Lic# 901234

**Work Scope**

**1. ATTIC RETROFIT**

Air seal and insulate the ceiling assembly as accessible. Benefits to the homeowner include reduced operating cost, lower energy consumption, and improved energy efficiency.

- Remove old fiberglass insulation
- Install attic cat walks
- Install eave vent baffles as needed.
- Install foam baffles in vaulted roof sections around perimeter (Approximately 30 2'x 4' baffles)
- Air seal attic penetrations, and wall top plates
- Seal interstitial cavity
- Air seal and insulate knee walls
- Insulate attic hatches
- Install attic rulers.
- Re-duct bath fan
- Insulate plumbing in attic
- Blow in Cellulose insulation to R38, and bury ducts in insulation.
- Verify insulation install with bag count and inspection.
- Inspect insulation with infrared camera
- Run blower door to verify air infiltration
- Report test out data to customer

$7498.00 (Materials 2578.12, Labor 4919.88, estimated time 4 to 5 days)

**2. INSULATE WALLS**

Insulate exterior walls where accessible. Benefits to the homeowner include reduced operating cost, lower energy consumption, and improved energy efficiency. Inaccessible walls will include part of the kitchen, living room and master bath behind the shower.

a. Cut a one foot belly band in building drywall.
b. Remove existing fiberglass insulation.
c. Dense pack walls with Cellulose insulation.
d. Install new drywall in belly band.
e. Tape texture and paint not included.

- Development of a scope of work is one of the main goals of the home energy audit
- A description of the work to be performed with the goal of providing solutions based on your test-in findings and occupant complaints.
- Defines and identifies project expectations in writing including goals, targets and costs

# Typical Work Scope

Home Performance work scopes typically include:

- Removal of equipment which will be replaced
- Fixing any deferred maintenance / moisture problems
  - Correct wiring hazards
- Removal of dirty, poorly installed insulation
- Air seal crawlspace (if present)
  - Install ground source vapor barrier (GSVB)
- Air seal attic
  - Replace non-air tight can lights
- Install right-sized HVAC equipment including new ductwork
- Install new insulation

# Summary

- Your opportunity to fully inspect the home
- Use all your observation skills, building science and construction knowledge
- Use diagnostic testing to further inform your observations
- Create a work scope that provides value to the homeowner
- Include a full test-out of all your work
- Take pride in the measured improvements you have provided

Judy Rachel
Home Performance Pro

info@judyrachel.com