Making Work Orders Work: Utilizing the Home Performance Assessment (The Comprehensive Home Energy Audit)

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Home Performance Assessment

- This Presentation's Goals
  - What to look for during a Home Performance Assessment
  - Field Collection Form
  - Some Tricks of the Trade
    - Please contribute
  - Utility bill analysis

Home Performance Assessment

- **The "RESNET NATIONAL STANDARD FOR HOME ENERGY AUDITS" can be found in Chapter 7 of the RESNET Standards.**
  - After three years of consensus building the RESNET Board of Directors has adopted a national energy audit standard. The consensus building included a RESNET Task Force on National Standard for Energy Audit for Existing Homes.

Home Performance Assessment

- The purpose of the Comprehensive Home Energy Audit is:
  - to cause improvement to be made to the audited home.
  - includes an evaluation, performance testing and proposed treatments for improvement of an existing home.
- The Comprehensive Home Energy Audit shall include all of the following procedures:

Home Performance Assessment

- The Comprehensive Home Energy Audit shall include all of the following procedures:
  - measurement and performance testing;
  - combustion appliance testing;
  - computerized simulation analysis of the home's energy performance
  - a calculation of the energy and environmental savings from improving the energy performance of the home.

Home Performance Assessment

- The performance analysis shall determine the scope of work for the home.
- The qualified Auditor shall guide the homeowner to a Certified Contractor.

Home Assessment-What is it?

An analysis of the home's (and client's) energy use (and waste), including:

- Utility Bills
  - Analysis Software
- Insulation
- Air Leakage
- Mechanical Systems
  - Combustion Safety
  - Heating & Cooling
    - Distributions Systems
  - Ventilation
  - Domestic Hot Water
- Appliances & Lighting
- Windows
- Building IAQ
- Diagnostic testing for any occupant issues (health & safety, comfort, conservation)
- Anything else?

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The Energy Auditor…

- The Energy Auditor Must Be able to multi-task. They are part…
  - Building Scientist
    - Need to understand the principles of energy use, heat loss, heat gain air and moisture movement.
  - Detective
    - Needs to be a keen observer of exiting systems in the home, including signs of excessive energy use and safety problems.
  - Social Worker / Therapist
    - Needs to listen carefully to what the occupants want, and compare this to what they need to help solve their problem.
  - Business Person
    - Needs to help them make informed decisions while you can sell them services.
- LOOK AND LISTEN!

Observe…
What might these things tell you?

Observe…
What might these things tell you?

Observe…
What might these things tell you?

Homeowner:
“I’m always cold when I stand under this skylight”.

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Observe…
What might these things tell you?

Homeowner:
“I’m always cold when I stand under
this skylight”.

Assessment Techniques

- Test Mechanical Equipment (CAZ).
  - Do this test first after interview & walkthrough
- Blower Door Testing
  - Smoke (& mirrors). A *great* visual for the homeowner.
- Room Pressures
- IR Camera for Insulation & Air Leakage
  - (with *and* without blower door)
- Dominant Duct Leakage Test/Airflow Tests
  - Duct blasting
- Appliance Testing (at a minimum, 1 refrigerator)
- Use your digital camera.
  - You can show the homeowner immediately what's going on in the attic or other hard to access places. This is especially helpful for reports.
- Do only the important tests.

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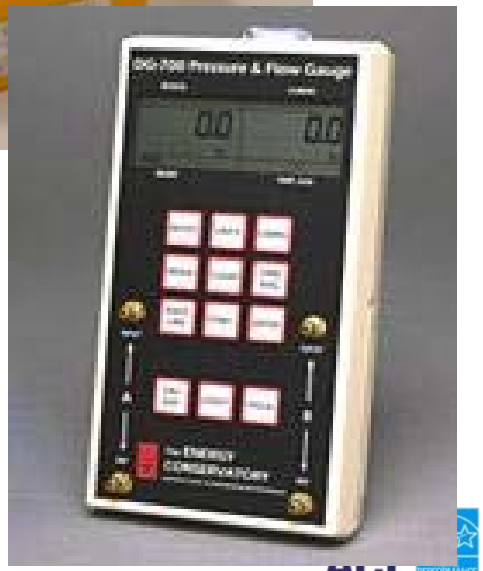
Tools

- Blower Doors
  - The Energy Conservatory & Retrotec
    - Provide leakage #, air changes per hour, zone pressures & connections, information for ventilation requirements, etc.
- Digital Pressure Gauge
  - Invaluable tool for measuring
    - Air leakage, duct leakage, zone connections
    - Room Pressures
    - Draft pressures
    - Combustion appliance zone pressures



More Tools

- Combustion Analyzer
  - CO Meter and Efficiency Testing
- Duct Blaster

More Tools

- Hand Held Smoke
- Fog Machine
- Low E Detector
- Digital & IR Cameras

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More Tools

- Flow Hood
  - Garbage Bag
- True Flow™ Grid
- Kill-A-Watt Meter
- Hygrometer

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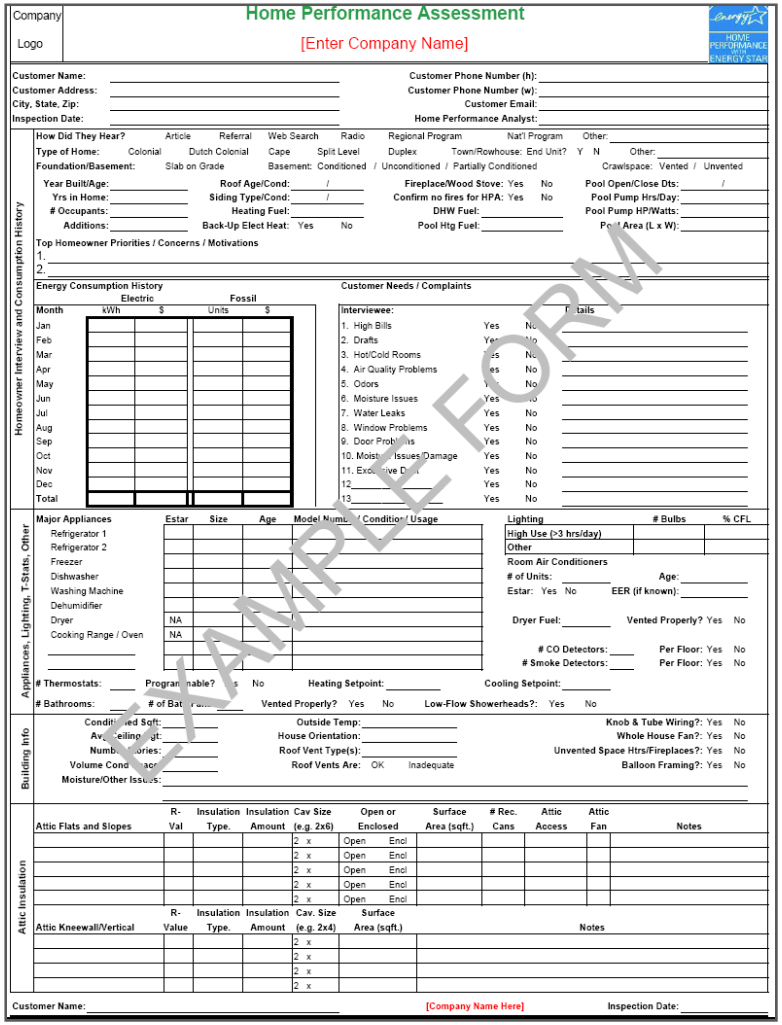
PERFORMANCE WITH ENERGY STAR

Data Collection Form(s)



Company Logo

Home Performance Assessment

[Enter Company Name]

HOME PERFORMANCE WITH ENERGY STAR

Customer Name: _____ **Customer Phone Number (h):** _____
Customer Address: _____ **Customer Phone Number (w):** _____
City, State, Zip: _____ **Customer Email:** _____
Inspection Date: _____ **Home Performance Analyst:** _____

Homeowner Interview and Consumption History

How Did They Hear? Article Referral Web Search Radio Regional Program Nat'l Program Other: _____

Type of Home: Colonial Dutch Colonial Cape Split Level Duplex Town/Rowhouse: End Unit? Y N Other: _____

Foundation/Basement: Slab on Grade Basement: Conditioned / Unconditioned / Partially Conditioned Crawlspace: Vented / Unvented

Year Built/Age: _____ **Roof Age/Cond:** ____ / ____ **Fireplace/Wood Stove:** Yes No **Pool Open/Close Dts:** ____ / ____
Yrs in Home: _____ **Siding Type/Cond:** ____ / ____ **Confirm no fires for HPA:** Yes No **Pool Pump Hrs/Day:** _____
 # Occupants: _____ **Heating Fuel:** _____ **DHW Fuel:** _____ **Pool Pump HP/Watts:** _____
Additions: _____ **Back-Up Elect Heat:** Yes No **Pool Htg Fuel:** _____ **Pool Area (L x W):** _____

Top Homeowner Priorities / Concerns / Motivations
1. _____
2. _____

Energy Consumption History

Month	Electric kWh	Electric $	Fossil Units	Fossil $
Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				
Total				

Customer Needs / Complaints

Interviewee: _____ **Details**

1. High Bills	Yes	No
2. Drafts	Yes	No
3. Hot/Cold Rooms	Yes	No
4. Air Quality Problems	Yes	No
5. Odors	Yes	No
6. Moisture Issues	Yes	No
7. Water Leaks	Yes	No
8. Window Problems	Yes	No
9. Door Problems	Yes	No
10. Moisture Issues/Damage	Yes	No
11. Excessive Dust	Yes	No
12. _____	Yes	No
13. _____	Yes	No

Appliances, Lighting, T-Stats, Other

Major Appliances	Estar	Size	Age	Model Num. / Condition / Usage
Refrigerator 1				
Refrigerator 2				
Freezer				
Dishwasher				
Washing Machine				
Dehumidifier				
Dryer	NA			
Cooking Range / Oven	NA			
_____				
_____				

Lighting	# Bulbs	% CFL
High Use (>3 hrs/day)		
Other		

Room Air Conditioners
# of Units: _____ **Age:** _____
Estar: Yes No **EER (if known):** _____

Dryer Fuel: _____ **Vented Properly?** Yes No

 # CO Detectors: ____ **Per Floor:** Yes No
 # Smoke Detectors: ____ **Per Floor:** Yes No

 # Thermostats: ____ **Programmable?** Yes No **Heating Setpoint:** _____ **Cooling Setpoint:** _____
 # Bathrooms: ____ **# of Bath Fans:** ____ **Vented Properly?** Yes No **Low-Flow Showerheads?:** Yes No

Building Info

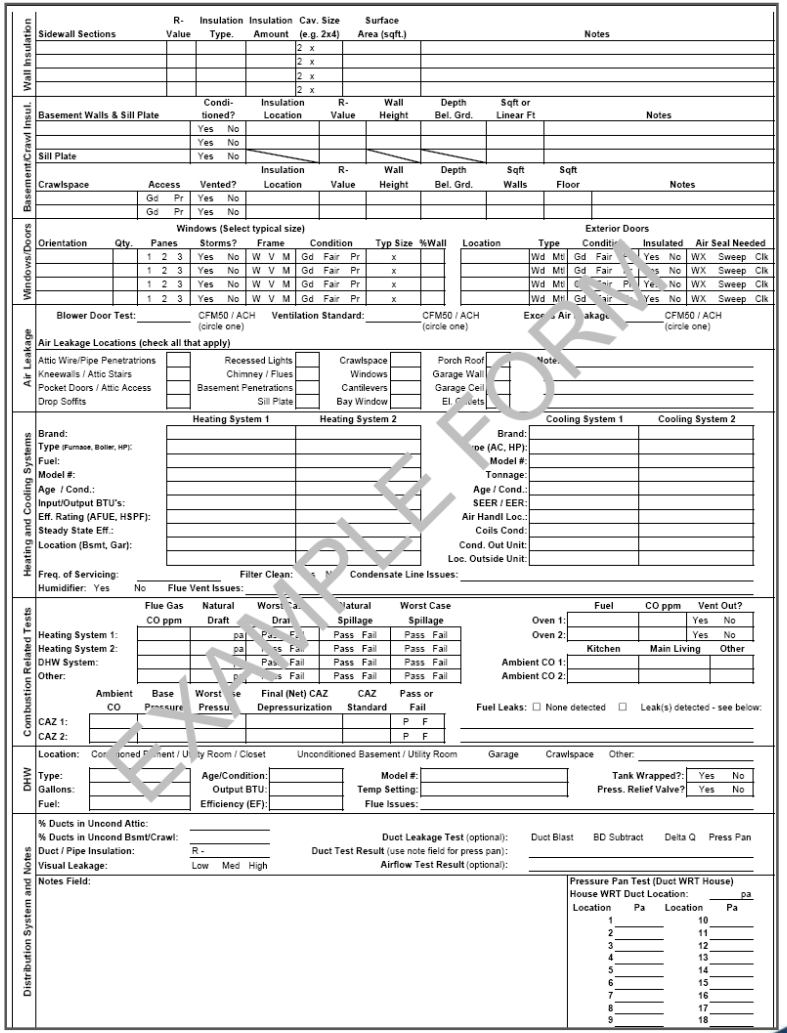
Conditioned Sqft: _____ **Outside Temp:** _____ **Knob & Tube Wiring?:** Yes No
Avg Ceiling Ht: _____ **House Orientation:** _____ **Whole House Fan?:** Yes No
Number Stories: _____ **Roof Vent Type(s):** _____ **Unvented Space Htrs/Fireplaces?:** Yes No
Volume Conditioned: _____ **Roof Vents Are:** OK Inadequate **Balloon Framing?:** Yes No
Moisture/Other Issues: _____

Attic Insulation

Attic Flats and Slopes	R-Val	Insulation Type.	Insulation Amount	Cav Size (e.g. 2x6)	Open or Enclosed	Surface Area (sqft.)	# Rec. Cans	Attic Access	Attic Fan	Notes
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					

Attic Kneewall/Vertical	R-Value	Insulation Type.	Insulation Amount	Cav. Size (e.g. 2x4)	Surface Area (sqft.)	Notes
				2 x		
				2 x		
				2 x		
				2 x		

Customer Name: _____ [Company Name Here] **Inspection Date:** _____



Wall Insulation

Sidewall Sections	R-Value	Insulation Type.	Insulation Amount	Cav. Size (e.g. 2x4)	Surface Area (sqft.)	Notes
				2 x		
				2 x		
				2 x		
				2 x		

Basement/Crawl Insul.

Basement Walls & Sill Plate	Condi-tioned?	Insulation Location	R-Value	Wall Height	Depth Bel. Grd.	Sqft or Linear Ft	Notes
	Yes No						
	Yes No						
Sill Plate	Yes No						

Crawlspace	Access	Vented?	Insulation Location	R-Value	Wall Height	Depth Bel. Grd.	Sqft Walls	Sqft Floor	Notes
	Gd Pr	Yes No							
	Gd Pr	Yes No							

Windows/Doors

Windows (Select typical size)

Orientation	Qty.	Panes	Storms?	Frame	Condition	Typ Size	%Wall
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	

Exterior Doors

Location	Type	Condition	Insulated	Air Seal Needed
	Wd Mt Gl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mt Gl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mt Gl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mt Gl	Gd Fair Pr	Yes No	WX Sweep Clk

Air Leakage

Blower Door Test: _____ CFM50 / ACH (circle one) **Ventilation Standard:** _____ CFM50 / ACH (circle one) **Exceptional Air Leakage:** _____ CFM50 / ACH (circle one)

Air Leakage Locations (check all that apply)

Attic Wire/Pipe Penetrations		Recessed Lights		Crawlspace		Porch Roof	
Kneewalls / Attic Stairs		Chimney / Flues		Windows		Garage Wall	
Pocket Doors / Attic Access		Basement Penetrations		Cantilevers		Garage Ceil	
Drop Soffits		Sill Plate		Bay Window		Elec Outlets	

Note: _____

Heating and Cooling Systems

	Heating System 1	Heating System 2	Cooling System 1	Cooling System 2
Brand:				
Type (Furnace, Boiler, HP):				
Fuel:				
Model #:				
Age / Cond.:				
Input/Output BTU's:				
Eff. Rating (AFUE, HSPF):				
Steady State Eff.:				
Location (Bsmt, Gar):				

Type (AC, HP):			
Model #:			
Tonnage:			
Age / Cond.:			
SEER / EER:			
Air Handl Loc.:			
Coils Cond:			
Cond. Out Unit:			
Loc. Outside Unit:			

Freq. of Servicing: _____ **Filter Clean:** Yes No **Condensate Line Issues:** _____
Humidifier: Yes No **Flue Vent Issues:** _____

Combustion Related Tests

	Flue Gas CO ppm	Natural Draft	Worst Case Draft	Natural Spillage	Worst Case Spillage
Heating System 1:		pa	Pass Fail	Pass Fail	Pass Fail
Heating System 2:		pa	Pass Fail	Pass Fail	Pass Fail
DHW System:		pa	Pass Fail	Pass Fail	Pass Fail
Other:		pa	Pass Fail	Pass Fail	Pass Fail

	Fuel	CO ppm	Vent Out?
Oven 1:			Yes No
Oven 2:			Yes No

	Kitchen	Main Living	Other
Ambient CO 1:			
Ambient CO 2:			

	Ambient CO	Base Pressure	Worst Case Pressure	Final (Net) CAZ Depressurization	CAZ Standard	Pass or Fail
CAZ 1:						P F
CAZ 2:						P F

Fuel Leaks: ☐ None detected ☐ Leak(s) detected - see below: _____

DHW

Location: Conditioned Basement / Utility Room / Closet Unconditioned Basement / Utility Room Garage Crawlspace Other: _____

Type: _____ **Age/Condition:** _____ **Model #:** _____ **Tank Wrapped?** Yes No
Gallons: _____ **Output BTU:** _____ **Temp Setting:** _____ **Press. Relief Valve?** Yes No
Fuel: _____ **Efficiency (EF):** _____ **Flue Issues:** _____

Distribution System and Notes

% Ducts in Uncond Attic: _____
% Ducts in Uncond Bsmt/Crawl: _____
Duct / Pipe Insulation: R - **Duct Test Result** (use note field for press pan): _____
Visual Leakage: Low Med High **Airflow Test Result** (optional): _____

Duct Leakage Test (optional): Duct Blast BD Subtract Delta Q Press Pan

Notes Field: _____

Pressure Pan Test (Duct WRT House)
House WRT Duct Location: ____ pa

Location	Pa	Location	Pa
1		10	
2		11	
3		12	
4		13	
5		14	
6		15	
7		16	
8		17	
9		18	

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HOME PERFORMANCE WITH ENERGY STAR

Company Logo

Home Performance Assessment

[Enter Company Name]

HOME PERFORMANCE WITH ENERGY STAR

Customer Name: _____ **Customer Phone Number (h):** _____

Customer Address: _____ **Customer Phone Number (w):** _____

City, State, Zip: _____ **Customer Email:** _____

Inspection Date: _____ **Home Performance Analyst:** _____

Homeowner Interview and Consumption History

How Did They Hear? Article Referral Web Search Radio Regional Program Nat'l Program Other: _____

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Year Built/Age: _____ **Roof Age/Cond:** _____ / _____ **Fireplace/Wood Stove:** Yes No **Pool Open/Close Dts:** _____ / _____

Yrs in Home: _____ **Siding Type/Cond:** _____ / _____ **Confirm no fires for HPA:** Yes No **Pool Pump Hrs/Day:** _____

 # Occupants: _____ **Heating Fuel:** _____ **DHW Fuel:** _____ **Pool Pump HP/Watts:** _____

Additions: _____ **Back-Up Elect Heat:** Yes No **Pool Htg Fuel:** _____ **Pool Area (L x W):** _____

Top Homeowner Priorities / Concerns / Motivations

1. _____
2. _____

Energy Consumption History

	Electric		Fossil	
Month	kWh	$	Units	$
Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				
Total				

Customer Needs / Complaints

Interviewee:			**Details**
1. High Bills	Yes	No	
2. Drafts	Yes	No	
3. Hot/Cold Rooms	Yes	No	
4. Air Quality Problems	Yes	No	
5. Odors	Yes	No	
6. Moisture Issues	Yes	No	
7. Water Leaks	Yes	No	
8. Window Problems	Yes	No	
9. Door Problems	Yes	No	
10. Moisture Issues/Damage	Yes	No	
11. Excessive Dust	Yes	No	
12_____	Yes	No	
13_____	Yes	No	

Disaggregate Cooling, Heating, DHW, Base-load fossil and electricity usage

- Disaggregate-To break apart; to separate out
- (Recommended): Receive information and disaggregate the bills before going out to the house in order to save time
  - (A utility bill disaggregation tool is available from EPA/DOE that can be distributed by program sponsors to their participating contractors)
- Educate homeowner on the benefits of core air sealing, insulation, high efficiency HVAC and water heating.
- Discuss observations about disaggregated energy usage with homeowner, and identify measures to reduce energy use
- Educate homeowner on base-loads, discuss benefits of high-efficiency appliances and lighting.

Utility Bill Analysis

- A compilation and analysis of a client's utility bill from (at least) one year, that allows auditor to:
  - Figure highest annual heating & cooling months.
  - Observe any abnormalities in energy use.
  - Determine seasonal and non-seasonal (baseload) use.
  - Baseload:
    - Non seasonal-driven gas and electric use, such as hot water heating, clothes drying, lighting & refrigeration
  - Helps auditor target items (and homes) for improvement.

Utility Bill Analysis

- A "Home Energy Disaggregation Tool" is available through the Home Performance with Energy Star Program.
- Energy consumption history is extremely valuable for the participating contractor (to build) an understanding of the home's energy performance and motivating the homeowner to invest in recommended measures.
- Acquiring utility data and performing an analysis *before* visiting the home equips you with advance knowledge of the home and the homeowners energy habits.

Client Interview & Walkthrough

- Start setting up the house while doing your walk through:
  - Position exterior windows & doors for CAZ test.
    - Open all interior doors, note any door threshold stains
  - Note position of delivery registers, and open all of them.
  - Close fireplace dampers.
  - Gas fireplaces: note if open or closed combustion.
  - Set Hygrometer(s) in place.
  - Set thermostats to off
  - Turn off all exhaust fans & dryers

Client Interview & Walkthrough

- Observe: gas or electric stove?
- Plug in the Kill-Watt Meter?
- Outside: Take pictures of all exterior elevations, and of any venting problems (rusting, soot, damage, sufficient height?)
- Air Conditioning
  - Observe size. Save time-use your digital camera.
  - Turn off disconnect (if wintertime) for CAZ test.
- Take pictures indoors of any problems, especially mechanical equipment, moisture issues, etc.
- Ask questions:
  - Any home or mechanical system repairs?
  - Any unusual noises?

Appliances, Lighting, T-Stats, Other

Major Appliances	Estar	Size	Age	Model Number/ Condition/ Usage
Refrigerator 1				
Refrigerator 2				
Freezer				
Dishwasher				
Washing Machine				
Dehumidifier				
Dryer	NA			
Cooking Range / Oven	NA			
_____				
_____				

Lighting	# Bulbs	% CFL
High Use (>3 hrs/day)		
Other		

Room Air Conditioners

# of Units: _____ Age: _____

Estar: Yes No EER (if known): _____

Dryer Fuel: _____ Vented Properly? Yes No

CO Detectors: ____ Per Floor: Yes No

Smoke Detectors: ____ Per Floor: Yes No

Thermostats: ____ Programmable? Yes No Heating Setpoint: _____ Cooling Setpoint: _____

Bathrooms: ____ # of Bath Fans: ____ Vented Properly? Yes No Low-Flow Showerheads?: Yes No

Building Info

Conditioned Sqft: _____ Outside Temp: _____ Knob & Tube Wiring?: Yes No

Avg Ceiling Hgt: _____ House Orientation: _____ Whole House Fan?: Yes No

Number Stories: _____ Roof Vent Type(s): _____ Unvented Space Htrs/Fireplaces?: Yes No

Volume Cond Space: _____ Roof Vents Are: OK Inadequate Balloon Framing?: Yes No

Moisture/Other Issues: _____

Attic Insulation

Attic Flats and Slopes	R-Val	Insulation Type.	Insulation Amount	Cav Size (e.g. 2x6)	Open or Enclosed	Surface Area (sqft.)	# Rec. Cans	Attic Access	Attic Fan	Notes
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					
				2 x	Open Encl					

Attic Kneewall/Vertical	R-Value	Insulation Type.	Insulation Amount	Cav. Size (e.g. 2x4)	Surface Area (sqft.)	Notes
				2 x		
				2 x		
				2 x		
				2 x		

Wall Insulation

Sidewall Sections	R-Value	Insulation Type.	Insulation Amount	Cav. Size (e.g. 2x4)	Surface Area (sqft.)	Notes
				2 x		
				2 x		
				2 x		
				2 x		

Basement/Crawl Insul.

Basement Walls & Sill Plate	Condi-tioned?	Insulation Location	R-Value	Wall Height	Depth Bel. Grd.	Sqft or Linear Ft	Notes
	Yes No						
	Yes No						
Sill Plate	Yes No						

Crawlspace	Access	Vented?	Insulation Location	R-Value	Wall Height	Depth Bel. Grd.	Sqft Walls	Sqft Floor	Notes
	Gd Pr	Yes No							
	Gd Pr	Yes No							

Windows/Doors

Windows (Select typical size)

Orientation	Qty.	Panes	Storms?	Frame	Condition	Typ Size	%Wall
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	
		1 2 3	Yes No	W V M	Gd Fair Pr	x	

Exterior Doors

Location	Type	Condition	Insulated	Air Seal Needed
	Wd Mtl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mtl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mtl	Gd Fair Pr	Yes No	WX Sweep Clk
	Wd Mtl	Gd Fair Pr	Yes No	WX Sweep Clk

Air Leakage

Blower Door Test: _____ CFM50 / ACH (circle one) **Ventilation Standard:** _____ CFM50 / ACH (circle one) **Excess Air Leakage:** _____ CFM50 / ACH (circle one)

Air Leakage Locations (check all that apply)

Attic Wire/Pipe Penetratrions		Recessed Lights		Crawlspace		Porch Roof		**Notes:**			
Kneewalls / Attic Stairs		Chimney / Flues		Windows		Garage Wall					
Pocket Doors / Attic Access		Basement Penetrations		Cantilevers		Garage Ceil					
Drop Soffits		Sill Plate		Bay Window		El. Outlets					

Heating and Cooling Systems

	Heating System 1	Heating System 2
Brand:		
Type (Furnace, Boiler, HP):		
Fuel:		
Model #:		
Age / Cond.:		
Input/Output BTU's:		
Eff. Rating (AFUE, HSPF):		
Steady State Eff.:		
Location (Bsmt, Gar):		

	Cooling System 1	Cooling System 2
Brand:		
Type (AC, HP):		
Model #:		
Tonnage:		
Age / Cond.:		
SEER / EER:		
Air Handl Loc.:		
Coils Cond:		
Cond. Out Unit:		
Loc. Outside Unit:		

Freq. of Servicing: _____ **Filter Clean:** Yes No **Condensate Line Issues:** _____

Humidifier: Yes No **Flue Vent Issues:** _____

Combustion Related Tests

	Flue Gas CO ppm	Natural Draft	Worst Case Draft	Natural Spillage	Worst Case Spillage
Heating System 1:		pa	Pass Fail	Pass Fail	Pass Fail
Heating System 2:		pa	Pass Fail	Pass Fail	Pass Fail
DHW System:		pa	Pass Fail	Pass Fail	Pass Fail
Other:		pa	Pass Fail	Pass Fail	Pass Fail

	Fuel	CO ppm	Vent Out?
Oven 1:			Yes No
Oven 2:			Yes No

	Kitchen	Main Living	Other
Ambient CO 1:			
Ambient CO 2:			

	Ambient CO	Base Pressure	Worst Case Pressure	Final (Net) CAZ Depressurization	CAZ Standard	Pass or Fail
CAZ 1:						P F
CAZ 2:						P F

Fuel Leaks: ☐ None detected ☐ Leak(s) detected - see below:

_____

_____

DHW

Location: Conditioned Bsment / Utility Room / Closet Unconditioned Basement / Utility Room Garage Crawlspace Other: _____

Type:		**Age/Condition:**		**Model #:**		**Tank Wrapped?:**	Yes No
Gallons:		**Output BTU:**		**Temp Setting:**		**Press. Relief Valve?**	Yes No
Fuel:		**Efficiency (EF):**		**Flue Issues:**			

Distribution System and Notes

% Ducts in Uncond Attic: _____

% Ducts in Uncond Bsmt/Crawl: _____

Duct / Pipe Insulation: R -

Visual Leakage: Low Med High

Duct Leakage Test (optional): Duct Blast BD Subtract Delta Q Press Pan

Duct Test Result (use note field for press pan): _____

Airflow Test Result (optional): _____

Notes Field:

Pressure Pan Test (Duct WRT House)

House WRT Duct Location: _____ pa

Location	Pa	Location	Pa
1		10	
2		11	
3		12	
4		13	
5		14	
6		15	
7		16	
8		17	
9		18	

CAZ….HELP!!!

- Some ideas to help CAZ and Mechanical testing go smoothly
  - Do this test first.
    - If you find that there are serious mechanical system or CAZ problems, you may not be able to/need to proceed with further home testing.
  - Determining "Worst Case" can be tricky. While doing your client interview and house walkthrough, close and lock all exterior windows and doors. Open all interior doors. Start setting up the test as you take notes on the home, while listening to the homeowner (that's right…multi-task)

COMBUSTION SAFETY TEST PROCEDURE FOR VENTED APPLIANCES

1. **Measure the Base Pressure.** Start with all exterior doors and windows closed and the fireplace damper closed. Set all combustion appliances to the pilot setting or turn off the service disconnect. Combustion appliances include: boiler, furnace, space-heaters, and water heater. With the home in this configuration, measure and record the baseline pressure of the mechanical room WRT outside.

2. **Establish the Worst Case.** Turn on the dryer and all exhaust fans. Close all interior doors that make the CAZ pressure more negative. Turn on the air handler, if present, and leave on if the pressure in the CAZ becomes more negative, then recheck the door positions. Measure the net change in pressure from the CAZ to outside, correcting for the base pressure. Record the "worst case depressurization" and compare to the CAZ Depressurization Limit Table.

3. **Measure Worst Case Spillage, Draft, CO.** Fire the appliance with the smallest Btu capacity first, test for spillage at the draft diverter with a mirror or smoke test, and test for the CO at the flue at steady-state (if steady state is not achieved within 10 minutes, take the CO readings at the 10 minute mark). If the spillage test fails under worst case, go to Step 4. If spillage ends within 1 minute, test the draft in the connector 1' - 2' after the diverter or first elbow. Fire all other connected appliances simultaneously and test the draft diverter of each appliance for spillage. Test for CO in all appliances before the draft diverter.

4. **Measure Spillage, Draft, CO under Natural Conditions.** If spillage fails under worst case, turn off the appliance, the exhaust fans, open the interior doors and allow the vent to cool before re-testing. Test for CO, spillage, and draft under "natural conditions." Measure the net change in pressure from worst case to natural in the CAZ to confirm the "worst case depressurization" taken in Step 2 outside. Repeat the process for each appliance, allowing the vent to cool between tests.

5. **Ambient CO.** Monitor the ambient CO in the breathing zone during the test procedure and abort the test if ambient CO goes over 35 ppm. Turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics. If the ambient levels exceed 35 ppm during testing under natural conditions, disable the appliance and instruct the homeowner to have the appliance repaired prior to operating it again.

6. **Action Levels.** Make recommendations or complete work order for repairs based on test results and the Combustion Safety Test Action Level Tables.

RANGES AND OVENS*

1. Remove any items/foil in or on oven/range top
2. Make sure self-cleaning features are not activated
3. Test oven in vent sleeve, before dilution air
4. **100 ppm to 300 ppm** as measured you must install a carbon monoxide detector and recommendation for service must be made to the consumer.

   Greater than 300 ppm as measured—the unit must be serviced prior to work. If greater than 300 ppm after servicing, exhaust ventilation must be provided with a capacity of 25 CFM continuous or 100 CFM intermittent.

Continually monitor ambient CO levels during test

BUILDING PERFORMANCE INSTITUTE, INC.™
Updated: 4/07

This is the BPI protocol for CAZ Testing. If you are doing a Home Performance with Energy Star audit, it is a required step. Other approved protocols may be used in other programs.

Be prepared for the CAZ testing. Make sure that all of your equipment is operating and ready to use at the appropriate time. Calibrate CO meter outdoors, and monitor ambient air at all times. Calibrate gas sniffer outdoors.

CAZ Testing

- Measuring Baseline
  - Find an easy spot to run a reference tube to the outdoors from the CAZ.
    - Rim joist penetrations (Line Set, Gas line, Electric penetrations, etc.)
    - Under the sill plate?
    - Use a window and tape over the remaining gap.
    - Use time averaging feature if windy.

CAZ Testing

- Turn on "regular" fans and dryer first, then proceed with air handler. The air handler must be run at the *highest* speed used.
  - If possible, observe CAZ change with *each* fan.
  - Gourmet Cooktop Exhaust? Add separately.
  - Dryer…Don't forget to clean lint filter.
  - Is air handler's filter clean?
- Cooling present? Run cooling from thermostat, with outdoor unit off. (You are only concerned about air pressure, not temperatures.)
- No cooling? Run air handler with fan control ("summer switch"), or you may have to run heating.

RESNET
Setting the Standards for Quality

ACI
HOME PERFORMANCE with ENERGY STAR

CAZ Testing

- Positioning interior doors-use smoke. Rooms that are positively pressurized should have doors closed. Negatively pressurized rooms should have doors open.
  - A good rule of thumb is: If the smoke comes toward you, the door comes toward you. If the smoke goes away from you, the door goes away from you". (Note – this only applies to bedroom or other doors that open *in* to the room, away from the CAZ.
- Worst case CAZ pressure is the strongest *negative* pressure in the appliance zone, of whatever configuration the fans/doors, etc. It does *not* include baseline the stack effect.

CAZ Testing

- (Optional) While running furnace in the "Heat" mode, install thermometers to measure heat rise at 5 minutes.
  - Supply air minus return air.
- While running furnace (whatever speed), use smoke to find duct leaks. (You've got ~ 5 minutes to get the equipment to Steady State!)
- Listen for air flow noises, duct popping, or whistling. These are signs of leakage, excessive pressures, or other duct problems.
- At Steady State, measure the CO, draft & spillage. **Appliances must remain ignited for the entire test!**
- When you are finished, set the DHW & furnace for Blower Door Test. Keys on water heater!

Blower Door Testing

- Tips to help this go faster and more effectively.
  - Practice setting up your blower door.
  - Hold off on installing crossbar until frame & fabric are securely in place.
  - Consolidate your gear.
    - Use color-coded hoses. Mark ends with electrical tape to find easily.
    - It must be set up in an exterior door. No garage doors.
    - If doors are oversized/arched, etc., consider installing it in a window.
- Check house @ low pressure (10-15 pa) for problems (i.e. fireplace ashes.)

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Show the Homeowner

- With the blower door @ 50
  - Open a window and demonstrate the airflow through this "leak".
  - Close the window and check for the leak again/
    - Windows usually aren't the air leakage problem most homeowners think they are.
  - Now take them through the house and show them more leaks…

Where to look for air leaks

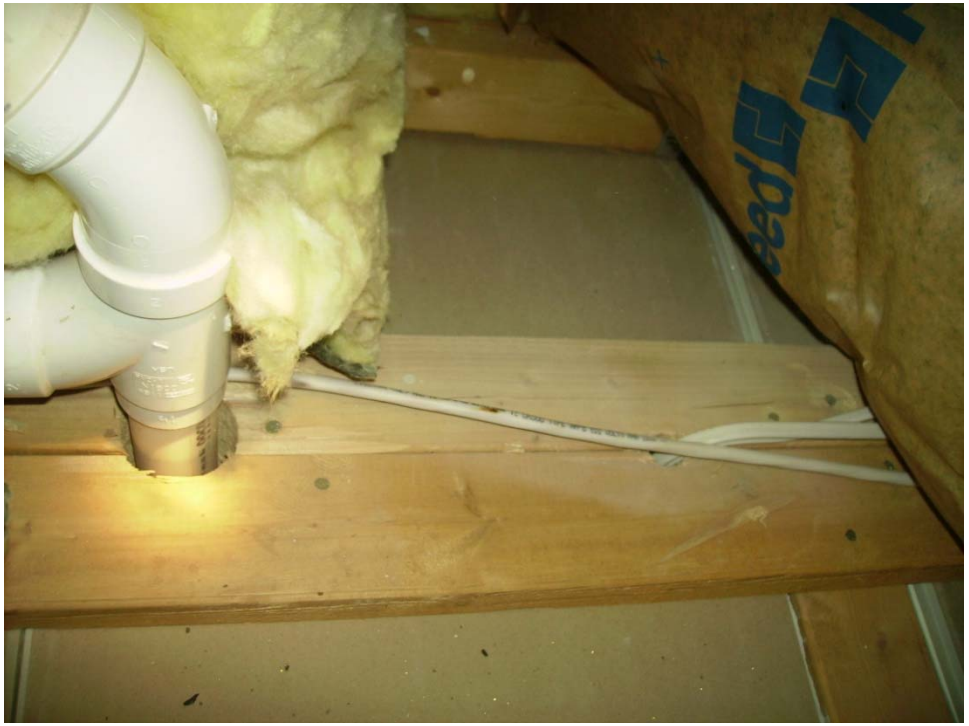
- Whole House Fans.
  - These are prime air leakage spots because of location and stack effect.
  - Remember that the fan will pull the shutters shut, making them tighter.
- Evaporative Coolers. They're *intended* to bring in outdoor air!
- Ductwork, especially returns using building cavities.
- Floor spaces (especially cantilevers and floors over garages). Check around supply boots.

Floor Spaces…

- With the blower door at 50 pa, measure the pressure in the floor space WRT the living space. It should read 0 pa. A reading of 20 pa tells you that there is some connection to the outside. Verify with smoke. You can usually do this around a supply boot.
- Do a pressure pan test to those supply and return ducts that may run through outdoor zones (rooms over garages, crawlspaces, cantilevers). Pressure should be 0 pa. (Air in the ducts should be only house air.)

Where to look for air leaks

- Recessed lights
- Attic access panels
- Chimneys
- Interior wall penetrations
  - Connected through attic top plates



Where to look for air leaks

- Interior pocket (sliding) doors
- Rim Joists
  - Along foundation wall
  - Line set penetrations
  - Plumbing penetrations
    - Under bathtubs
  - Gas lines
- Around Gas Fireplaces

Where to look for air leaks

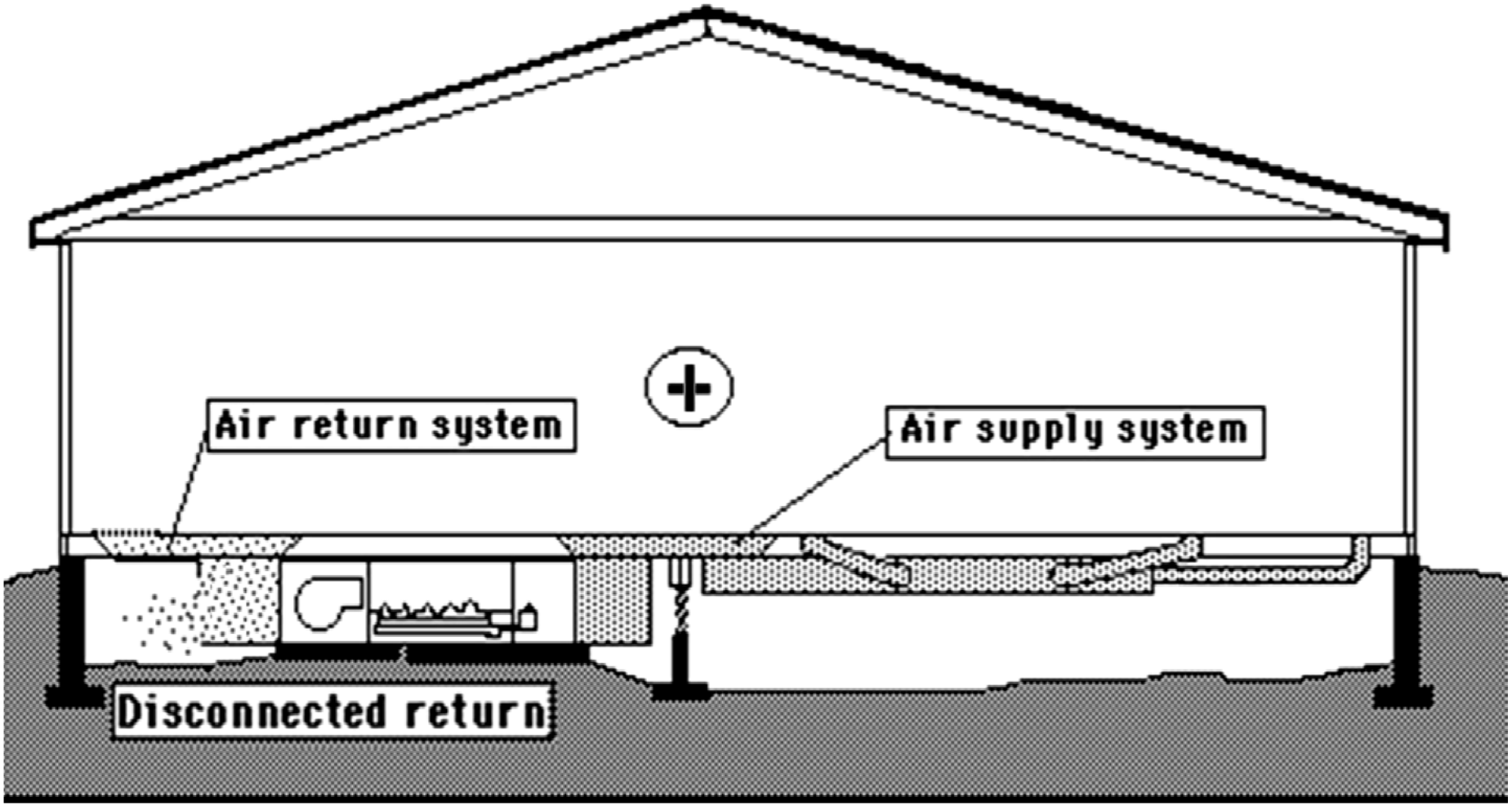
- Medicine cabinets
- Drop soffit & false ceilings
- Exhaust fans
  - Damper closing fully?

Some Duct & Pressure Tests

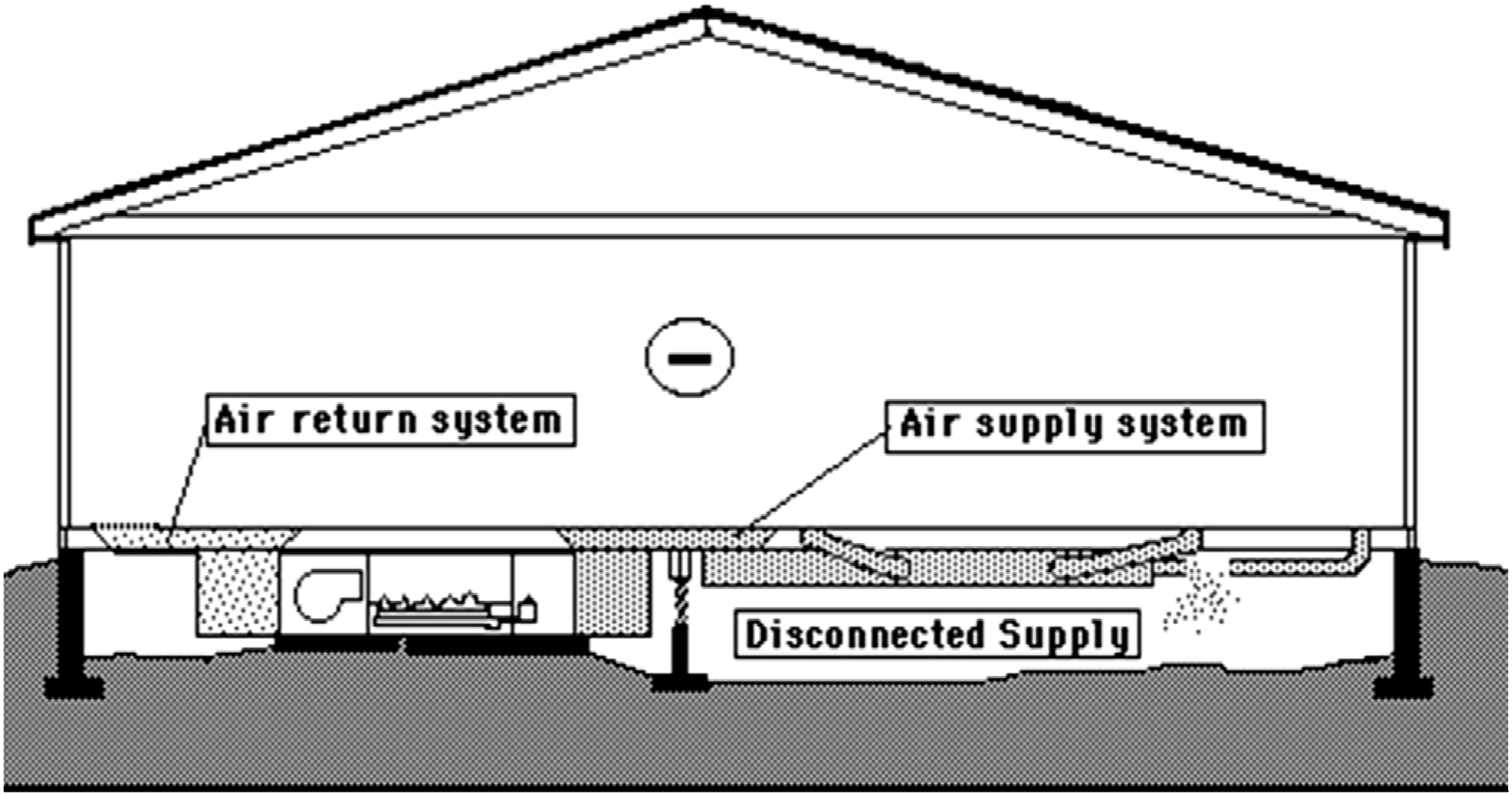
- Room Pressure Test
  - This is the same test you do when setting doors for the CAZ test.
  - Close the bedroom/office door while the air handler is operating.
  - Measure the room pressure WRT the core of the house. It should not exceed +/- 3 pascals

The Dominant Duct Leakage Test.

- A simple test that allows you to determine if there are duct leaks *to the outdoors*, and if there are more of those leaks on the supply side or the return side.
- With the air handler operating, measure the core pressure of the home WRT to the outdoors.
  - Positive pressure means more return leaks to outdoors than supply leaks.
  - Negative pressure means more supply leaks than return.



Return leakage from the outside (in this case a crawlspace) imposes excessive positive pressure on the home, resulting in air exfiltration from the living space.
It can also allow transfer of any pollutants from this area to the living space.



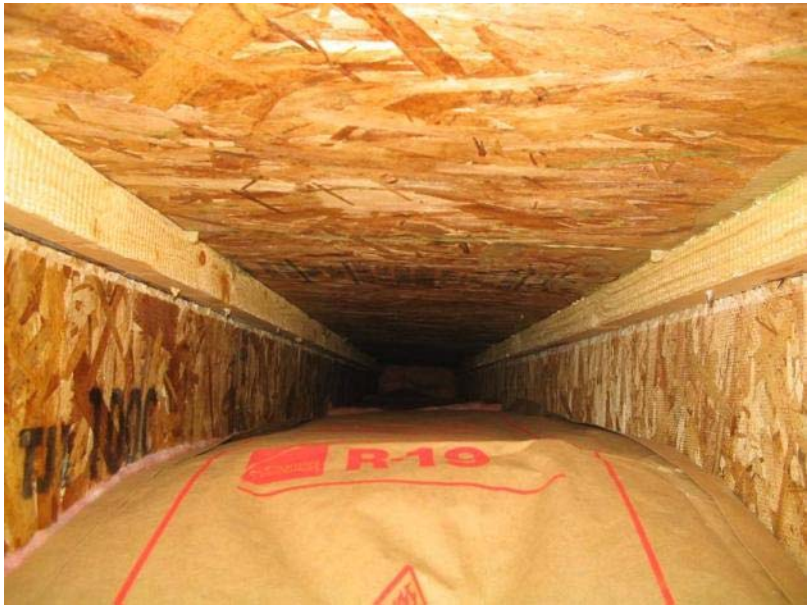
Supply leakage to the outside imposes excessive negative pressure on the home, resulting in air infiltration into the living space.

Insulation Inspection

- Where to look and what to look for:
  - Look in the hardest places to insulate.
  - Back panels of skylight chase (the hardest one to reach!)
  - Remote kneewalls.

Insulation Inspection

- Cantilevers
- Garage ceilings under living spaces



Appliance Testing

- Kill-A-Watt Meter
  - Used to measure the electrical consumption of an appliance, usually the refrigerator or freezer.
  - Check the "second" refrigerator in the basement or garage. It's usually older.
  - Is there anything in it?
    - Fill with jugs of water if mostly empty, or recommend not using it & unplugging it.

Appliance Testing

Newer flat screen TV's may use 300-500 watts or more when turned on, and 30-50 watts in the *off* position.

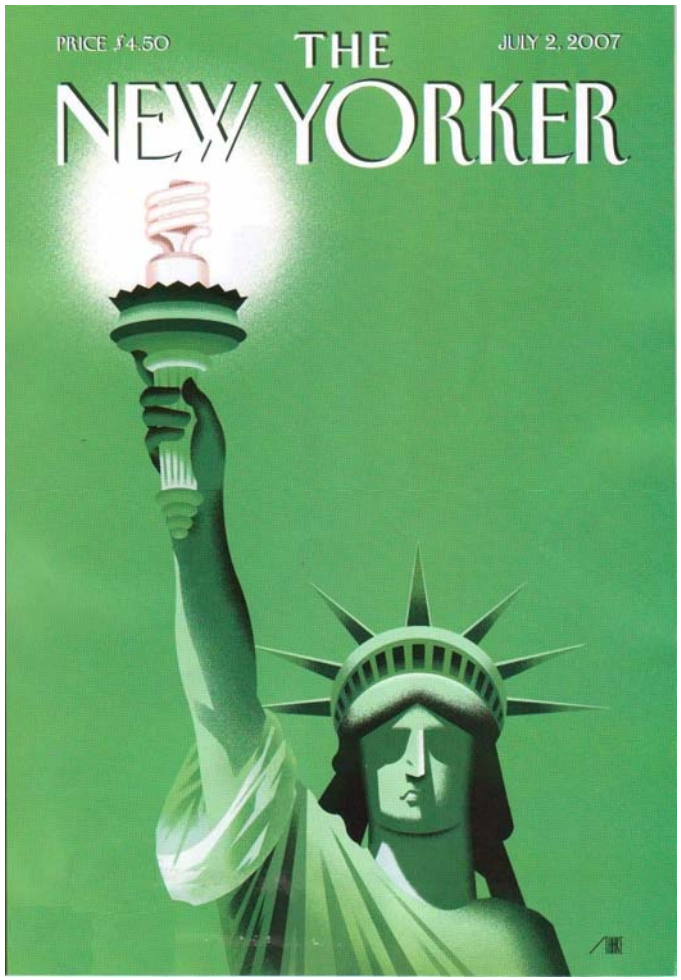
Use your Kill-A-Watt meter to measure consumption in both off & on positions.

Encourage using a power strip to avoid phantom loads.

This is also true for computers TV games, etc.

Lighting

- CFL lighting opportunities are everywhere in the home.
- Install them in those areas where lights are most often left on.
  - Outdoors/porches
  - Use photo cells or timers
- *If all 110 million households in America replaced just one 60-watt bulb with a CFL, the energy saved would power a city of 1.5 million people*



Client Communications

- Listen to your client!
  - You may know more about *how* their house works, but they live there all the time.
- Use plain English!
  - For example:
    - Don't try to explain what blower door rings do.
    - Don't use "pascals"or other technical jargon.
- Keep it simple and concise!
- Don't make promises you can't keep!

"We'll start out by speaking in simple declarative sentences."

Home Performance Assessment Summary Report

Smith Home Performance Contracting

1 Address Street, City, ST 00000 • Phone: 000-000-0000 • Fax: 000-000-0000 • smithhpc@smithhpc.com

Customer Name:		**Customer Phone Number (h):**	
Customer Address:		**Customer Phone Number (w):**	
City, State, Zip:		**Customer Email:**	
Inspection Date:		**Home Performance Analyst:**	

Your Home Performance Assessment identifies opportunities to improve the performance of your home based on our analysis. This report summarizes the findings, prioritizes recommended improvements, and helps you determine the best improvements for your home.

Findings and Recommendations

Building Envelope Evaluation

Air Sealing

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Blower door test: _____cfm50 Tightness std: _____ cfm50 **Leakage pathways observed:** ○ Basement/crawl ceiling ○ Interior baseboard/top molding/fireplaces ○ Sill plate ○ Window and door frames ○ Attic floor ○ *Attic hatch(es)* ○ *Band joist between floors* ○ *Recessed lights* ○ *Major air leakage bypass(es).* ○ Other: _____	○ Reduce leaks by _____ % ○ No recommendations **Air seal the following leakage pathways:** ○ Basement/crawl penetrations ○ Exposed sill plate ○ Attic penetrations ○ Top wall plates in attic ○ Flue/chimney penetrations ○ Open attic stairs/walls ○ Attic hatch/pull-down ○ Base and ceiling molding ○ Door and window frames ○ Around fireplace/mantle ○ Weatherstrip: ○ doors ○ windows ○ hatches ○ outlets ○ Recessed lights: ○ *covers* ○ *inserts* ○ *new housings*

Duct Sealing

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Duct leakage observed at: ○ No ducts in unconditioned space ○ Main trunk connections ○ Duct disconnects/failures at: ○ Branch line connections _____ ○ Accessible register connections _____ ○ Unable to visually diagnose duct work _____	○ Duct sealing: _____ hours ○ Air flow balancing ○ Include duct blaster test for leakage to outside ○ Repair or reconnect ducts ○ Add return(s) ○ Replace approx. ____% of duct system ○ Duct cleaning ○ *No recommendations*

Insulation Levels

Priority	Findings on Existing Conditions	Recommendations for Improvements
	R-Value/Inches Insulation	**Insulate in the following locations:** **R-Value/Inches Insul.**
	○ Above grade walls _____	○ Walls _____
	○ Attic (flat) _____	○ Attic (flat) _____
	○ Attic (slope) _____	○ Attic (slope) _____
	○ Kneewall(s) _____	○ Kneewall _____
	○ Floor over uncond. _____	○ Floor _____
	○ Rimjoists _____	○ Rimjoist
	○ Crawl walls _____	○ Foundation walls _____
	○ Basement walls _____	○ Ductwork _____
	○ Ductwork (uncond. space) _____	○ No recommendations

Windows and Doors

Priority	Findings on Existing Conditions	Recommendations for Improvements
	○ Single pane windows Condition: ○ Good ○ Fair ○ Poor ○ Double pane windows Condition: ○ Good ○ Fair ○ Poor ○ Double pane low-e Condition: ○ Good ○ Fair ○ Poor ○ Storm windows Condition: ○ Good ○ Fair ○ Poor ○ Doors Condition: ○ Good ○ Fair ○ Poor	○ Replace windows with a u-value ≤ _____ and solar gain ≤ _____ ○ Replace _____ door(s) w/ _____ ○ Solar screens ○ Other: _____ ○ No recommendations

Mechanical Equip. Evaluation

Space Heating

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Main heating system is a _____ System efficiency is _____ and age _____ Condition: ○ Good ○ Service ○ Replace Prog. thermostat ○ Yes ○ No # of thermostats: _____ **2nd heating system** is a _____ System efficiency is _____ and age _____ Condition: ○ Good ○ Service ○ Replace Prog. thermostat ○ Yes ○ No Filter condition: _____ Filter size: _____ Qty: _____ Condensate line: Blocks: ○ Yes ○ No Leaks: ○ Yes ○ No ○ Other: _____	○ Replace **main heating system** with new _____ with _____ rated efficiency ○ Replace **2nd heating system** with new _____ with _____ rated efficiency ○ Fix/replace condensate line ○ Remove **2nd heating system** ○ Install prog. thermostat ○ Replace filter(s) ○ Fix/replace condensate line ○ Other: _____ ○ No recommendations

Findings and Recommendations (cont.)

Mechanical Equip. Evaluation (cont.)

Space Cooling

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Main cooling system is: ○ Central ○ Room ○ Heat pump System efficiency is _____ and age _____ Condition: ○ Good ○ Service needed **2nd cooling system** is: ○ Central ○ Room ○ Heat pump System efficiency is _____ and age _____ Condition: ○ Good ○ Service needed Air handler location: _____	○ Replace **main cooling system** with _____ SEER system ○ Replace **2nd cooling system** with _____ SEER system ○ Clean/adjust blower ○ Check and adjust charge ○ Clean coils inside/outside ○ Check and adjust airflow ○ Fix/replace condensate line ○ *Clean/adjust blower* ○ *Check and adjust charge* ○ *Clean coils* ○ *Check and adjust airflow* ○ No recommendations

Water Heating

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Water heating system is a _____ *Estimated system efficiency is* _____ *or age* _____ Condition: ○ Good ○ Replace *Temperature Setting:* _____ Size: _____ *Gallons* *Low flow showerheads* ○ *Yes* ○ *No*	○ Replace **water heating system** with new _____ with _____ std. efficiency ○ Install solar hot water ○ Pipe insulation ○ Install low flow showerhead ○ Insulation jacket ○ Other: _____ ○ No recommendations

Baseload and Renewables

Appliances and Lighting

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Refrigerator Age: _____ ○ ENERGY STAR Dishwasher Age: _____ ○ ENERGY STAR Clothes washer Age: _____ ○ ENERGY STAR Dryer Age: _____ Other: _____ ○ ENERGY STAR High-use lighting ____% CFL bulbs All lighting ____% CFL bulbs Renewable opportunities: _____	○ Replace with ENERGY STAR refrigerator ○ Replace with ENERGY STAR dishwasher ○ Replace with ENERGY STAR clothes washer ○ Replace with dryer ○ Install ____ ENERGY STAR CFL bulbs in high-use fixtures ○ Purchase ENERGY STAR CFLs when replacing bulbs ○ Install renewables: _____

Health, Safety, and Durability

Combustion Appliance Testing

Priority	Findings on Existing Conditions	Recommendations for Improvements
		○ We strongly recommend the following course of action(s): _____
		Heating System **Water Heater** CO tests ○ Pass ○ Fail ○ Pass ○ Fail Draft tests ○ Pass ○ Fail ○ Pass ○ Fail Spillage tests ○ Pass ○ Fail ○ Pass ○ Fail Ambient CO in living space ○ Pass ○ Fail Ambient CO in CAZ ○ Pass ○ Fail Oven CO test ○ Pass ○ Fail Gas or oil leaks detected ○ Yes ○ No CO Monitor ○ Yes ○ No Locations: _____ Htg/DHW sys venting issues ○ Yes ○ No Smoke Detector ○ Yes ○ No ○ Inoperable Description: _____
		○ No recommendations ○ Other: _____ ○ Fix fuel leaks at: _____ ○ Fix venting issues at: _____ ○ Install/fix smoke detector ○ Install low-level CO monitor ○ Recommend radon test

Moisture & Durability

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Locations with signs of moisture or durability issues: ○ Windows ○ Crawl/Basement ○ Attic ○ Walls ○ Roof ○ Soffits ○ Other: _____ ○ Sill plate ○ Interior: _____ ○ Other: _____	○ Add attic ventilation ○ Replace/fix roof ○ Re-grade around foundation ○ Add gutters ○ Install sump pump ○ Extend downspouts ○ Other: _____

Exhaust Vent.

Priority	Findings on Existing Conditions	Recommendations for Improvements
	Improperly vented, non-operable, or needs ventilation: ○ Master bath ○ 3rd bath ○ Dryer ○ Whole-house ○ 2nd bath ○ Range hood ○ Crawlspace ○ Other: _____	○ Replace/install exhaust fan ○ *Install dehumidifier* ○ *Add humidistat/timer* ○ Other: _____

Recommended Measures Summary

Estimated Annual kWh Savings	_____
Estimated Annual Therm Savings	_____
Estimated Annual Storage Fuel Savings	_____
Estimated Total Annual Energy Cost Savings	_____
Estimated Package of Improvements Installed Cost	_____
Monthly Payment at _____%, _____Yr. Term	_____
Simple Payback (Installed Cost ÷ Annual Savings)	_____

Non-Energy Benefits:

○ *Reduced drafts* ○ *Reduced maintenance* ○ _____
○ *Improved comfort* ○ *Improved indoor air* ○ _____
○ *Increased durability* ○ *Reduced dust* ○ _____
○ *Increased home value* ○ *Reduced odors* ○ _____
○ *Reduced moisture issues* ○ *Environmental* ○ _____

I understand that the above recommendations do not constitute a binding contract proposal. I am interested in receiving such a proposal as a next step.

Customer Signature: _____ **Date:** _____

Findings and Recommendations

Building Envelope Evaluation

Priority	Findings on Existing Conditions	Recommendations for Improvements
Air Sealing	Blower door test: _____cfm50 Tightness std: _____ cfm50 **Leakage pathways observed:** ○ Basement/crawl ceiling ○ Interior baseboard/top molding/fireplaces ○ Sill plate ○ Window and door frames ○ Attic floor ○ Attic hatch(es) ○ Band joist between floors ○ Recessed lights ○ Major air leakage bypass(es): _____ ○ Other: _____	○ Reduce leaks by _____ % ○ No recommendations **Air seal the following leakage pathways:** ○ Bsmnt/crawl penetrations ○ Exposed sill plate ○ Attic penetrations ○ Top wall plates in attic ○ Flue/chimney penetrations ○ Open attic stairs/walls ○ Attic hatch/pulldown ○ Base and ceiling molding ○ Door and window frames ○ Around fireplace/mantle ○ Weatherstrip: ○ doors ○ windows ○ hatches ○ outlets ○ Recessed lights: ○ covers ○ inserts ○ new housings ○ _____
Duct Sealing	**Duct leakage observed at:** ○ No ducts in unconditioned space ○ Main trunk connections ○ Duct disconnects/failures at: ○ Branch line connections _____ ○ Accessible register connections _____ ○ Unable to visually diagnose duct work _____	○ Duct sealing: _____ hours ○ Air flow balancing ○ Include duct blaster test for leakage to outside ○ Repair or reconnect ducts ○ Add return(s) ○ Replace approx. ____% of duct system ○ Duct cleaning ○ No recommendations
Insulation Levels	**R-Value/Inches Insulation** ○ Above grade walls _____ ○ Attic (flat) _____ ○ Attic (slope) _____ ○ Kneewall(s) _____ ○ Floor over uncond. _____ ○ Rimjoists _____ ○ Crawl walls _____ ○ Basement walls _____ ○ Ductwork (uncond. space) _____	**Insulate in the following locations:** **R-Value/Inches Insul.** ○ Walls _____ ○ Attic (flat) _____ ○ Attic (slope) _____ ○ Kneewall _____ ○ Floor _____ ○ Rimjoist _____ ○ Foundation walls _____ ○ Ductwork _____ ○ No recommendations _____
Windows and Doors	○ Single pane windows Condition: ○ Good ○ Fair ○ Poor ○ Double pane windows Condition: ○ Good ○ Fair ○ Poor ○ Double pane low-e Condition: ○ Good ○ Fair ○ Poor ○ Storm windows Condition: ○ Good ○ Fair ○ Poor ○ Doors Condition: ○ Good ○ Fair ○ Poor	○ Replace windows with a u-value ≤ _____ and solar gain ≤ _____ ○ Replace _____ door(s) w/ _____ ○ Solar screens ○ Other: _____ ○ No recommendations

Finally…

- Be Careful. Don't get in over your head. Don't be afraid to ask for help!
- Purchase AND USE your safety gear.

THANK YOU!

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303-919-9849

Save the Dates!

ACI Home Performance Conference 2009
Kansas City, MO

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April 27 – May 1, 2009

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