

# THC MAINE ANTIQUE REHAB (80% reduction)

## Sustainability Case Study “Optimization”

By: William Turner

Presentation at: BBBD2015, Efficiency Vermont, Burlington, VT.

Year-round home, 3,600 ft<sup>2</sup>, 7,500 degree days



1000 Home Challenge Candidate

# Agenda

- **Take a brief tour**
- **Look at what we did in 1981, examine the poor results & why**
- **Look at fixes implemented since 1981**
- **“Almost There” : items to finally meet or exceed 1000 Home Challenge (OPTION B)**

# Why Is This Relevant?

I did it “wrong”  
the first time in  
1982-1983

**30 years ago**  
**Santa Cruz**  
**Presentation 1982**

**Now I hope**  
**to meet 1000**  
**Home Challenge**  
**2014-2015?**



# Learning Objectives

*At the end of this session, participants will be able to:*

1. Describe what went wrong 30 years ago 1st attempt.
2. List 5 principle needs to be met for a successful D.E.R.
3. Identify 3 IAQ issues that can be addressed while improving the energy performance of a home.
4. Recognize the opportunity to simplify renovation strategies though a comprehensive approach, good planning, & logical sequencing of work to be performed.

# Step 1 of 5.

## Obvious Needs

### Where did we begin?

# Where we begin in 1981

No insulation, summer only use, mostly inaccessible dirt floor crawl space, interior wood finish, & squirrels. Two 30 ton rock fireplaces w. clay lined chimneys.



View  
Looking  
North

Most cedar shingles & asphalt roof shingles in OK shape

# No Basement, Unknown Septic

Nice Porch  
& Setting



Rock piers, hardpan soil, 2-4 foot frost wall north side

Looking Southwest

# General

## New England Climate Features

### ❑ Cold & damp

- ✓ Supplemental heat for 8 (?) months

### ❑ Hot and humid

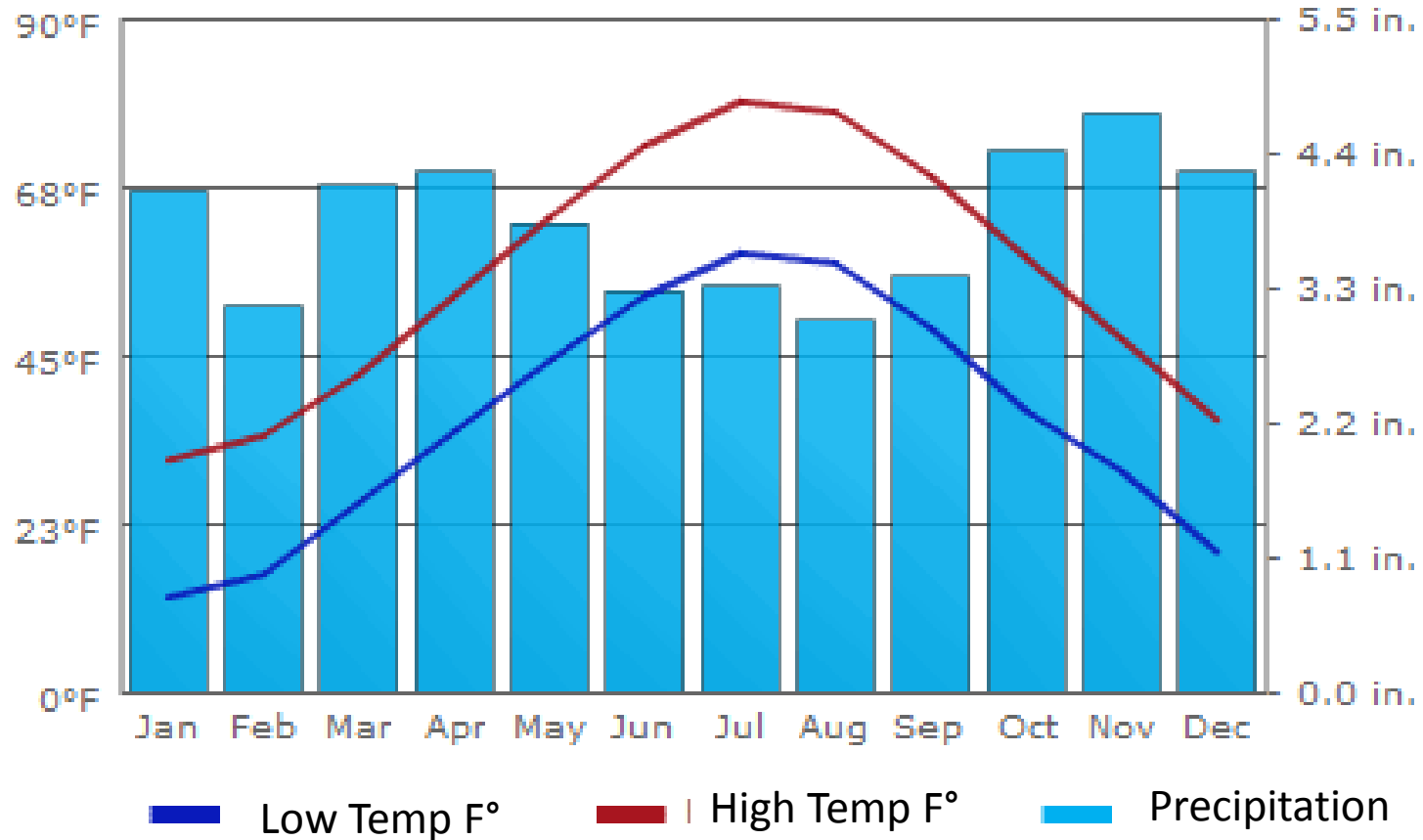
- ✓ Dehumidification & cooling for 3 (?) months

### ❑ Wind speed & snowfall vary

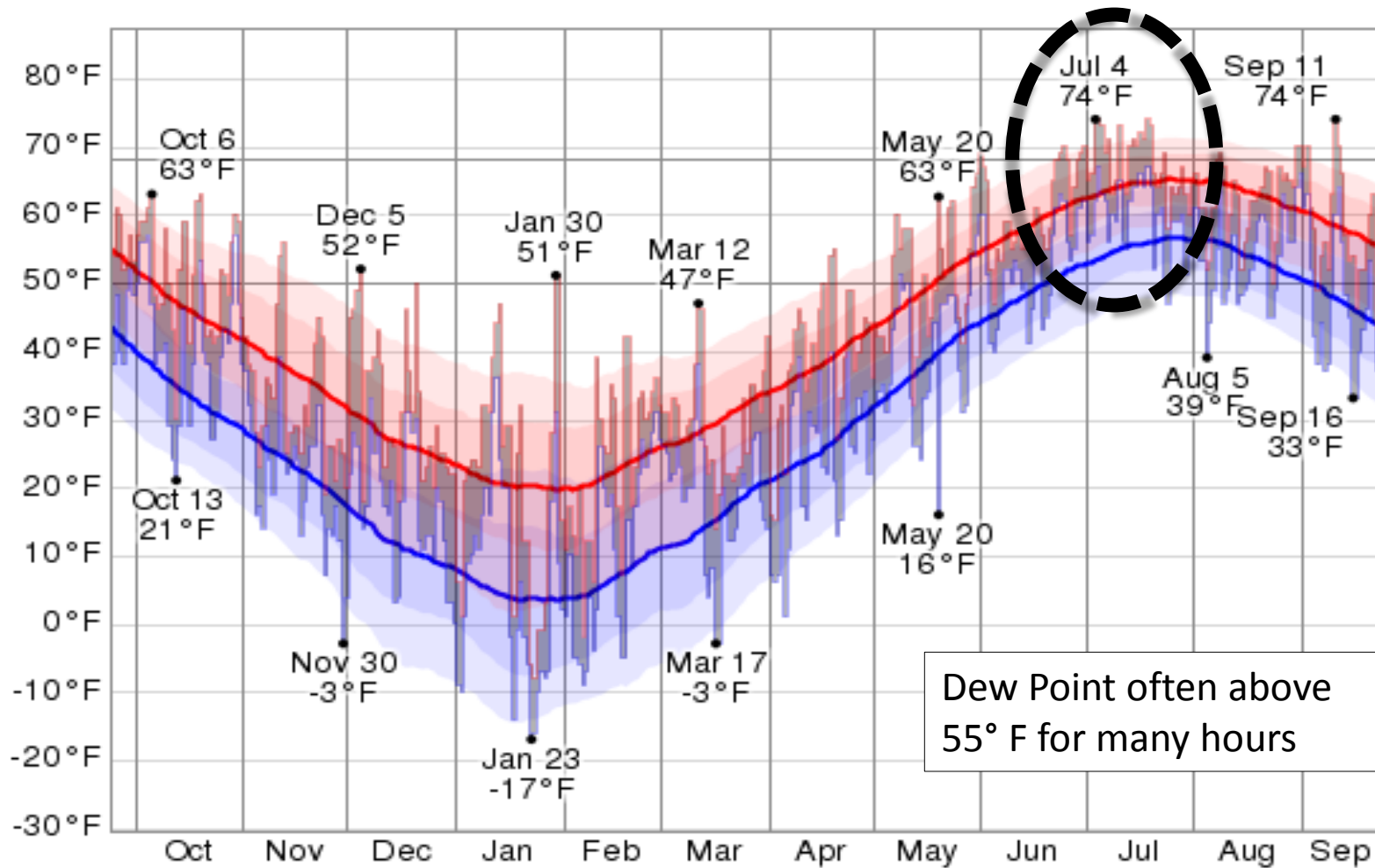


# Portland Maine Climate Graph

Cold and Wet, or Hot and Wet, all year



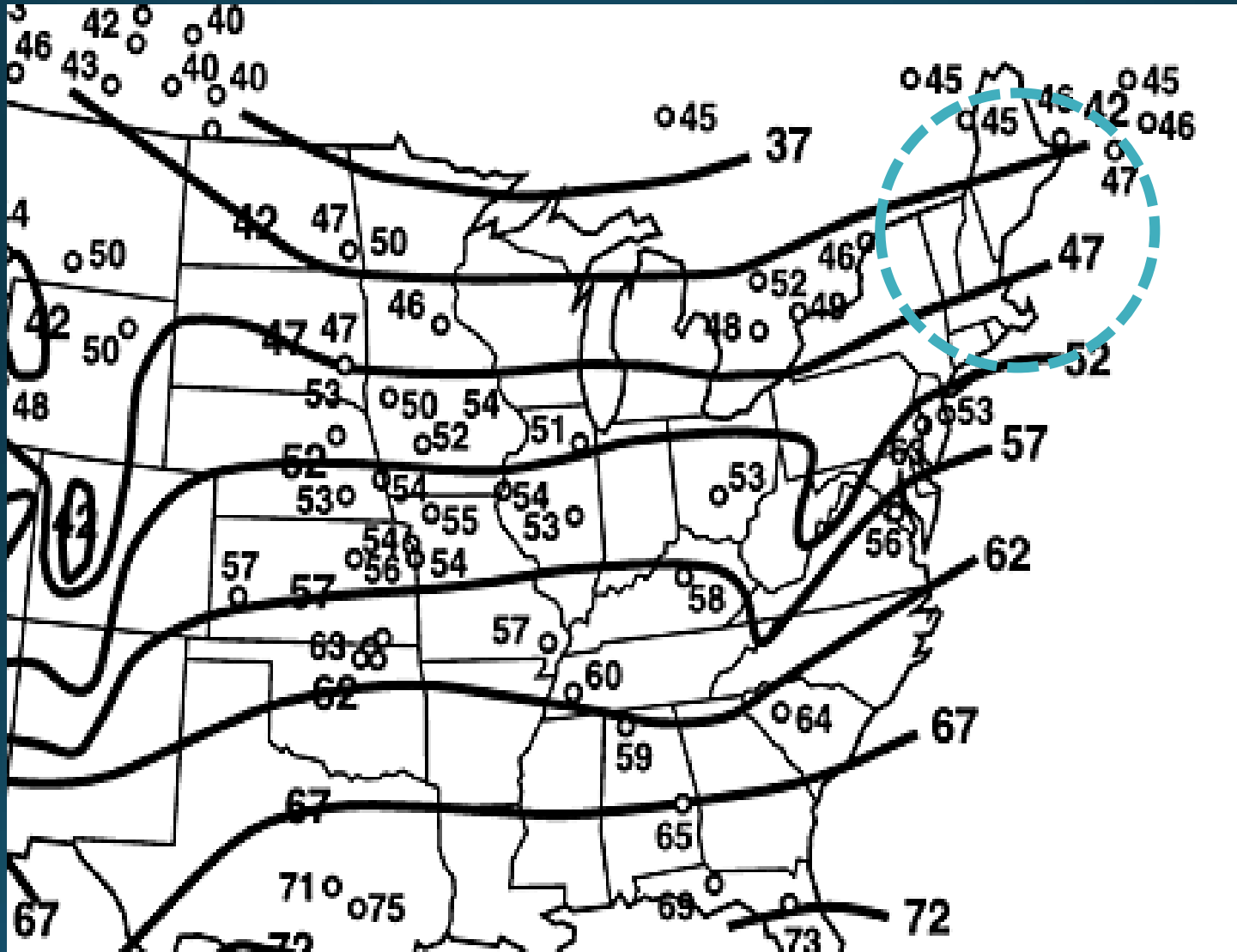
# Portland, Maine Dew Point Climate Graph



Portland, last 12 months, {source WeatherSpark.com Beta}

# Mean Annual Earth Temperature

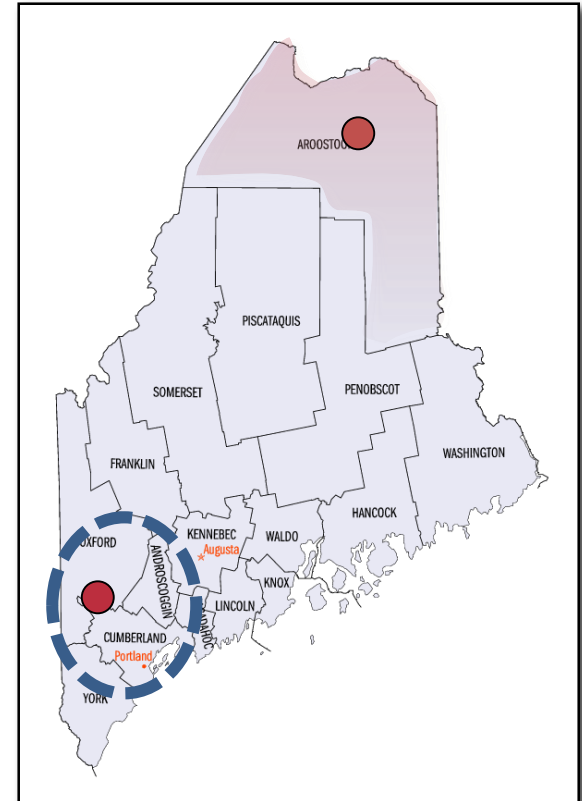
*Source: Virginia Tech*



# Maine Extreme Climate Features

## Range of weather

- ✓ 105° (1911, Bridgton) to  
-50° (2009, Black River)
  - ✓ 21” rain in Great Flood of October, 1996
  - ✓ 40” to 60” average annual rainfall
  - ✓ zones, #6 & #7
    - ✓ Aroostook County and the rest of Maine
- IECC Table 301.1*
- Not unusual to be -20 ° F with a 30 MPH North Westerly wind, or
  - 95° F and dry,
  - or have a dew point of 74° F for many hours



*Experience dew points above 55° 63% of the summer*

*Issue: Florida conditions with 50° ground temperatures*

# Without indoor humidity control, mold often grows on your organic stuff in Maine



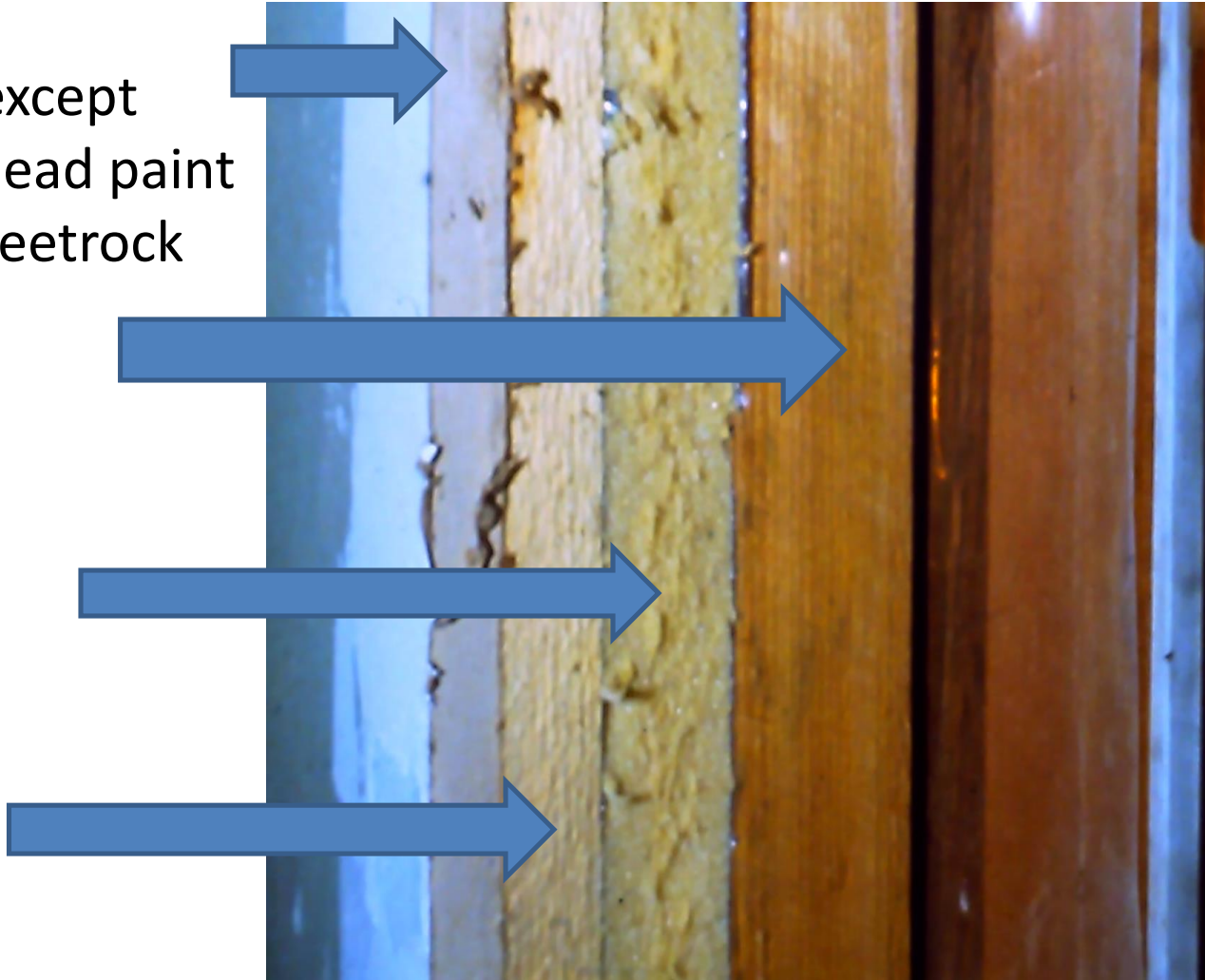
**What We Did, 1981:**

**Step 2 of 5. “Optimize Enclosure”**

**Owner: “Want Warm & Dry Highly Insulated Building with Good IAQ”**

# Decision: Gut from Interior & Reuse Most of Wood Finish

- Guted inside & re-used wood, except bathrooms & 1 lead paint bedroom got sheetrock
- Added 2 by 2 to 2 by 4
- 6" FG batt & 1" Thermax™
- ¾" air space



No Effort to Air Seal Joints



# Blown Cellulose in some unopened cavities



# Initial Heat 1981: Wood Stoves & Oil Furnace Backup



# DHW Coil in Wood Stove: Real Bad Idea

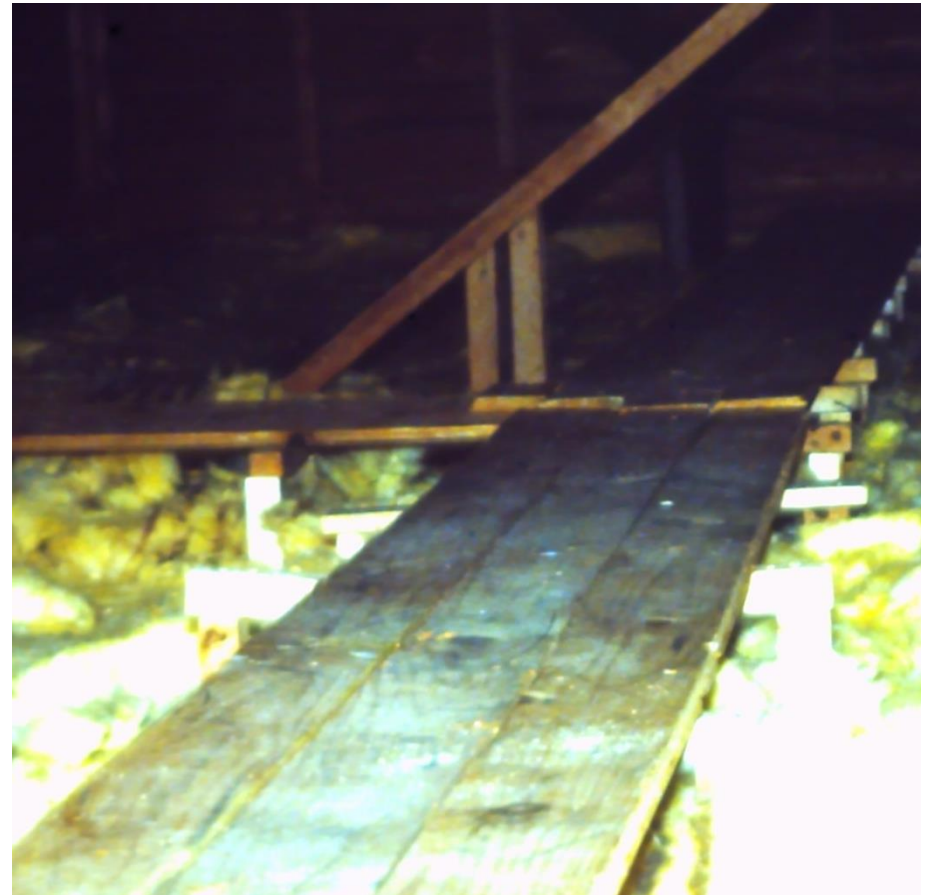


# Restored Interior Finish: Wood & Matched Hard Pine



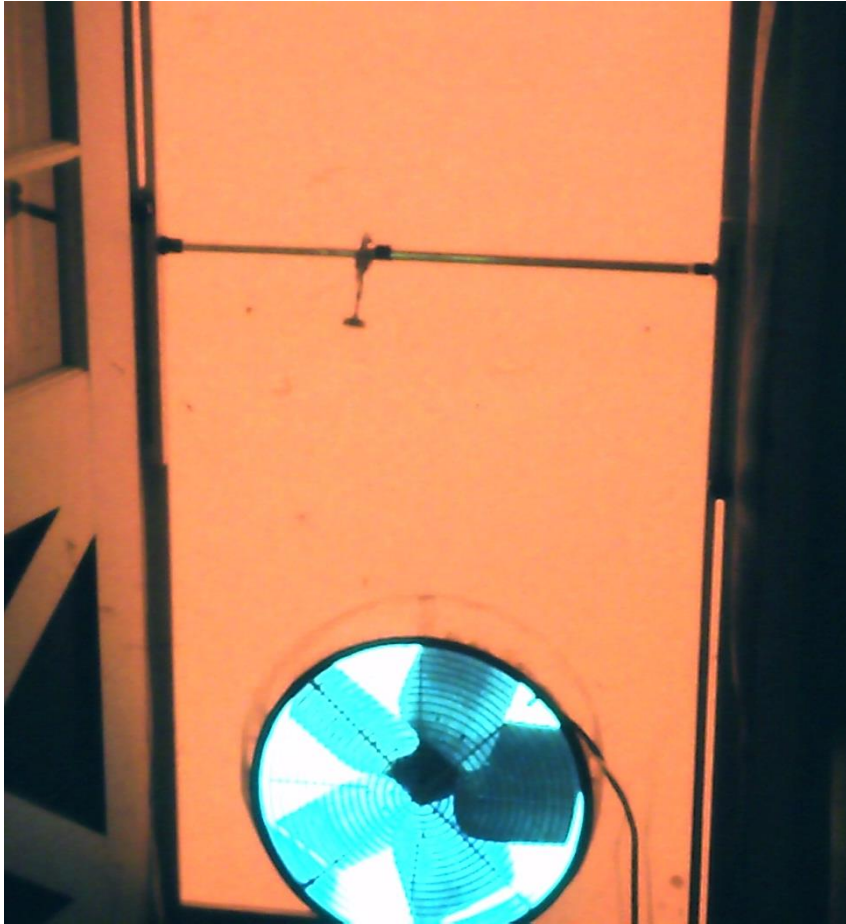
# **Attic:** Foil VB Strips, 12" FG Batts, **Big Mistake**

**In 1981, I listened to “don’t make it too tight, a house has to breath”, very bad advice.**



# House Was Cold & Drafty With (2) 60,000 BTU Stoves

Called Princeton Energy Partners, David Harrje & Gautam Dutt



# 1982 Attic Air Sealing: removed attic batts to fasten and caulk 6 mil poly on entire attic floor, reinstalled.



# 1982 Fix: Insulated 2 sides (250 ft<sup>2</sup>) of 30-ton exposed back of fireplace and rock chimney





# 1982 Windows: 33 French Style, 24 replaced with double hung thermal pane; all windows covered with triple track aluminum storms



**1982:** Installed  
96 ft<sup>2</sup> of  
Vertical  
Sunspace  
(southwest  
exposure)



**1982 DHW & Heat:** 6 glazed 40 ft<sup>2</sup> plastic Sealed Air hot water panels flat mounted on roof with drain-back 100 gal. PVC soft tank & 80 gal. ducted heat pump backup, eliminated wood stove heat coil loop



# 1982 Crawl Space Fix: Added 3 " or 6" of XPS foam under the FG batts, sealed all joints



# Complete Crawlspace Isolation



Added Interceptor Drain

Courtesy of Turner Building Science & Design

# After Fixes How Did We Do (until 2012)?

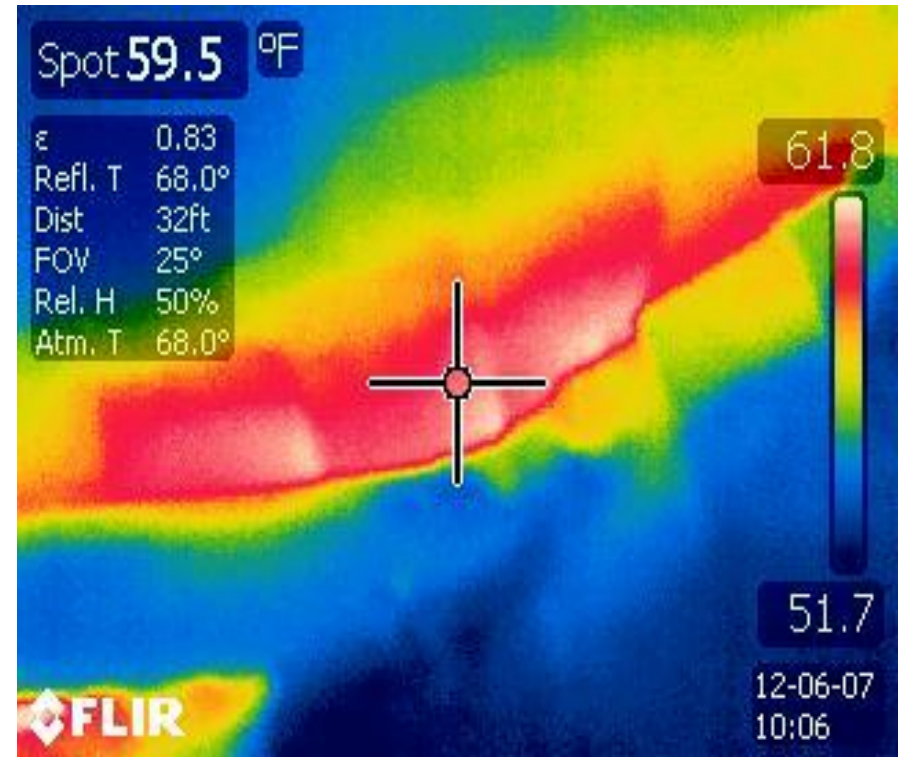
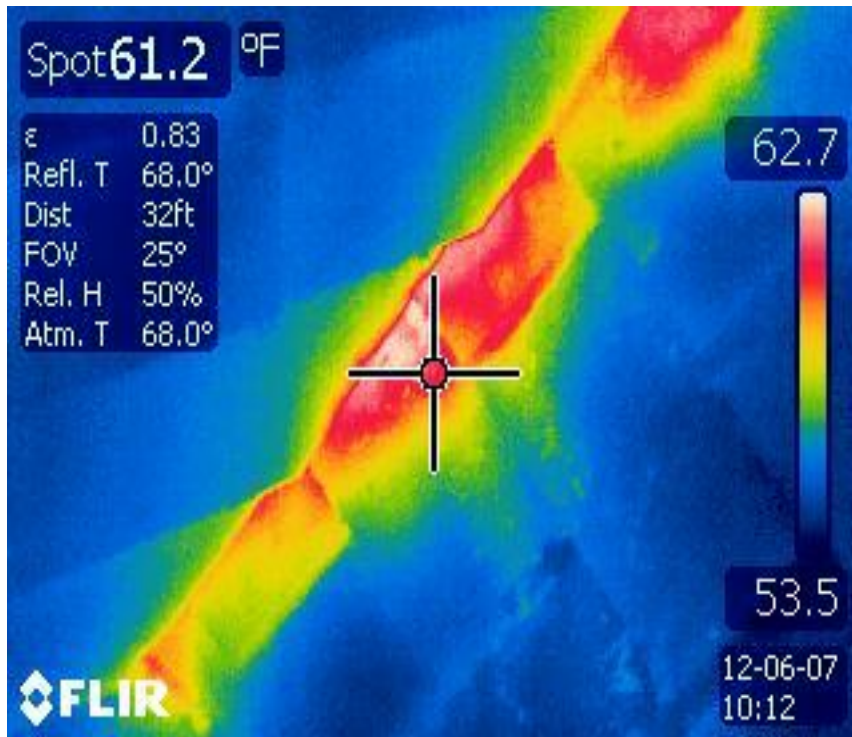
6-7 cords of wood a year & 1 tank of oil,  
then switched to 200-400 gallons of propane &  
always evaporated lots of water on top of wood stoves

## THC inspiration : 2012 Paradigm Shift

1. Wood supplier stop supplying 3 cords a year
2. I new enough now to fix house to use much less energy
3. Major flying squirrel infestation (15) in 1<sup>st</sup> floor ceiling cavity



# IR Inside Attic: Identified Remaining Major Attic Bypasses (2011-12 winter)



Red & white indicate remaining air leaks inside cold attic at floor, mainly at junctions in framing.

# Interstitial cavity between 1<sup>st</sup> and 2<sup>nd</sup> floor accessed for cellulose dense packing, insulation and air sealing





# Interstitial floor space is where flying squirrels were living & commuting at perimeter of space



# Air Sealing, Interstitial squirrel cavity between 1<sup>st</sup> & 2<sup>nd</sup> floors were accessed for cellulose dense packing



# Interstitial cavity between floors accessed for cellulose dense packing (185 bales added including attic)



# Installer prepped for coating rock chimney base with 2-part spray foam in 18" crawl space



# Addressed Lead Paint On All Trim



# New Chest Freezer, Replaced Old Upright



14 Ft<sup>3</sup>



New 8 Ft<sup>3</sup> freezer  
measured 1/3  
energy use of 14 Ft<sup>3</sup>  
upright unit

Replaced ten old T-12 four foot 32 watt lamps with new electronic ballasts with T-8 25 watt lamps (about ½ energy use). Winter use: 8-12 hours/day.

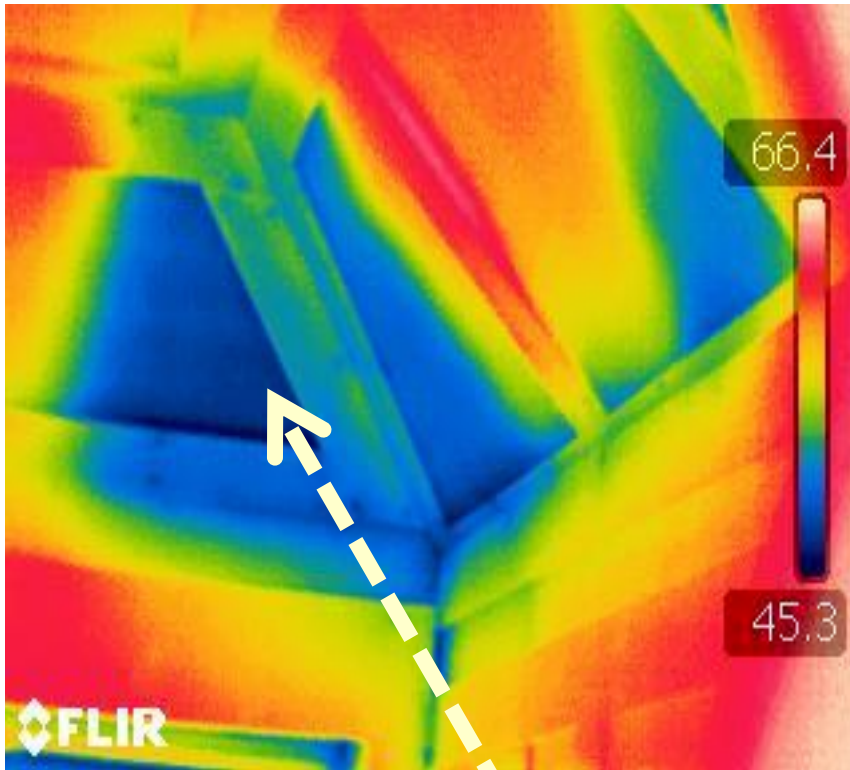


# How many BTU's? Scales for THC wood weighing

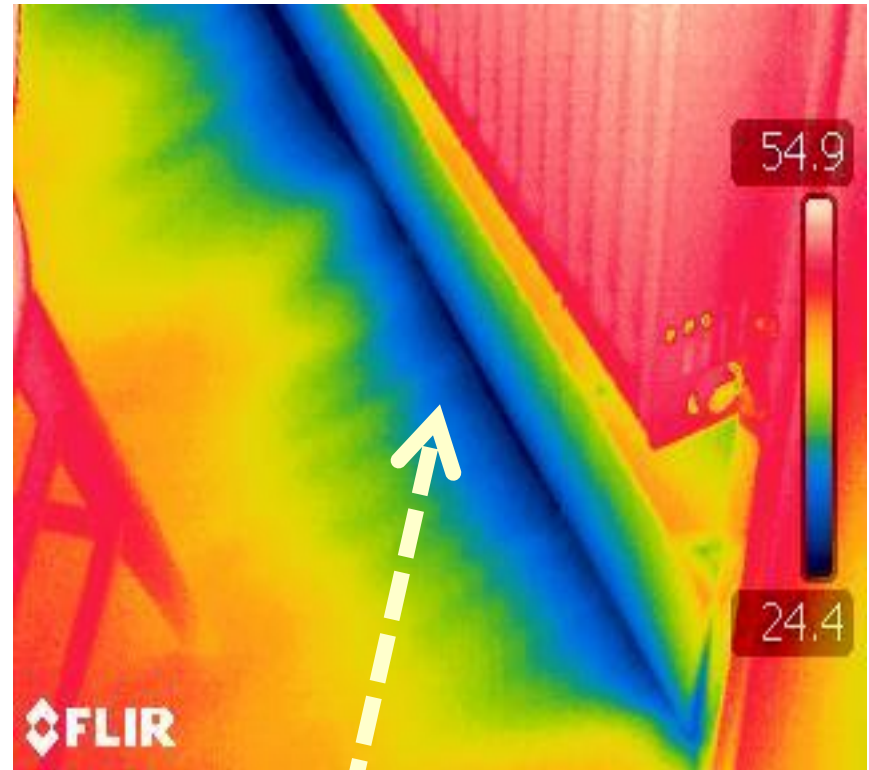




# IR Images Prior Final Dense Pack (Interior)



**Missed dormer corners**



**Air leaks at base of wall**

# IR Images Prior to Final Dense Pack (Exterior)



**2<sup>nd</sup> Dense Pack: First floor walls dense packed into FG batts (25 bales) to air seal walls top & bottom as well as increase R value**



# 2013 1<sup>st</sup> Ductless Heat Pump: one DHP serves about 2/3 of home, 1.5 ton



# Outside Unit (3 ft above earth, out of snow, SW exposure)



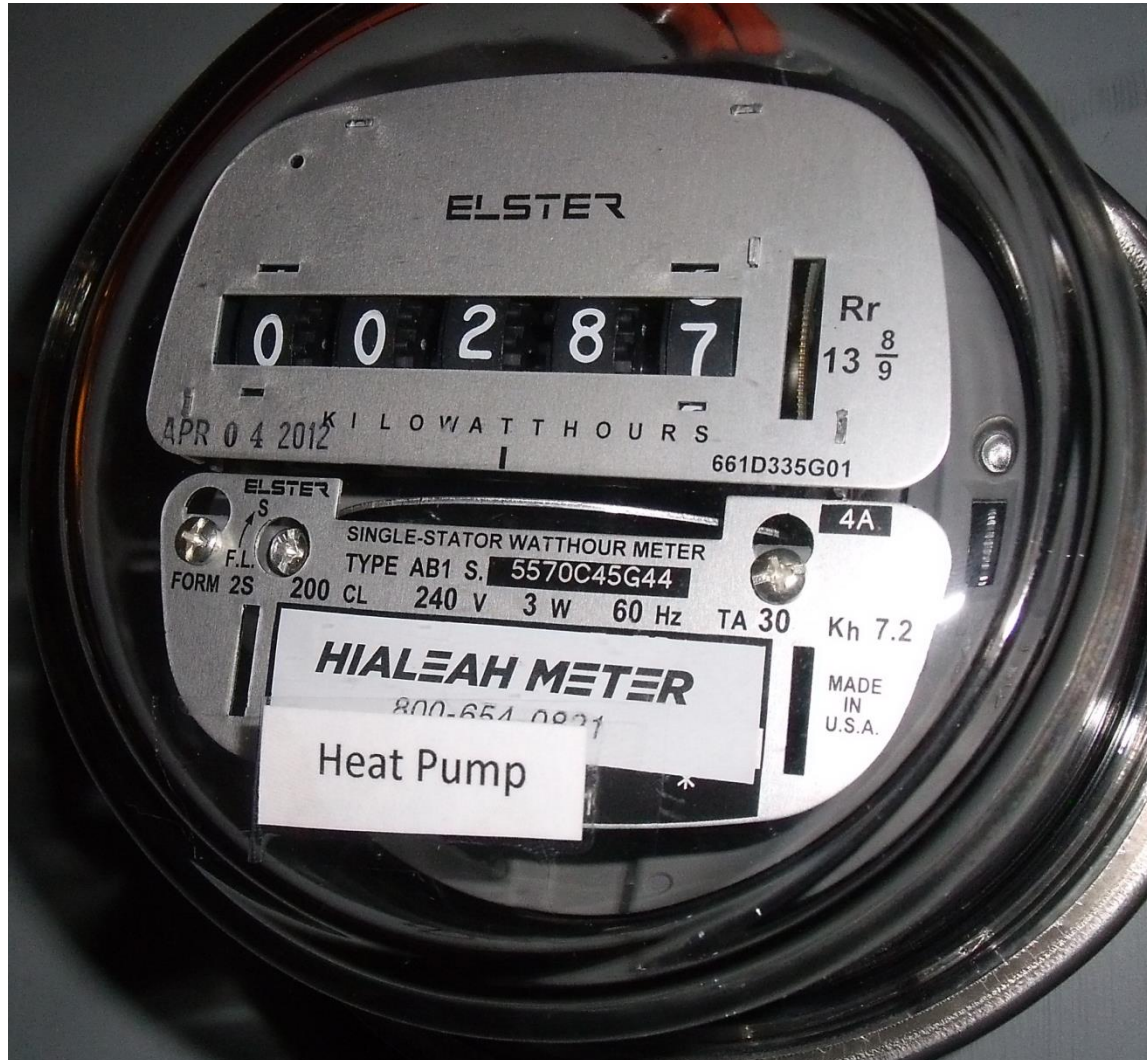
# Inside Unit & Low Wattage Ceiling Fan



# Why Ductless Heat Pump

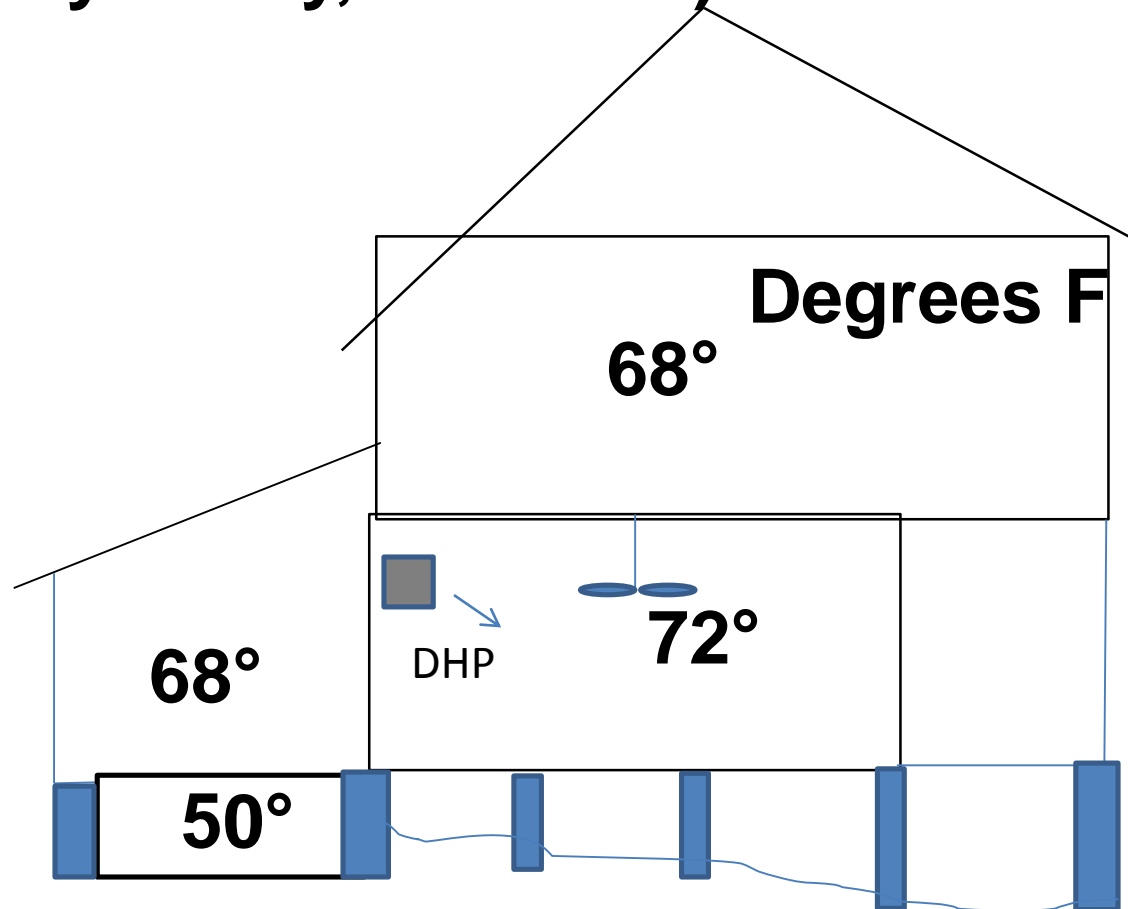
- **IAQ Drying Function: no more mold on boots,**  
Summer is humid for 2-3 months
- **Temp Control:** Can be cloudy or very sunny in winter, Sunspace requires very controllable auxiliary heat during heating months of the year, wood stove not easy to control or sun to plan for
- On extremely cold & windy winter days, can use wood stove if needed, & 1-2 hrs. of propane boiler operation during morning warm-up when needed
- **DHP offers precise control for main living area, second floor stays at 68° F, with 1<sup>st</sup> at 72 ° F.**

# DHP Meter (March 2013 about 0.33 kWh per DD)

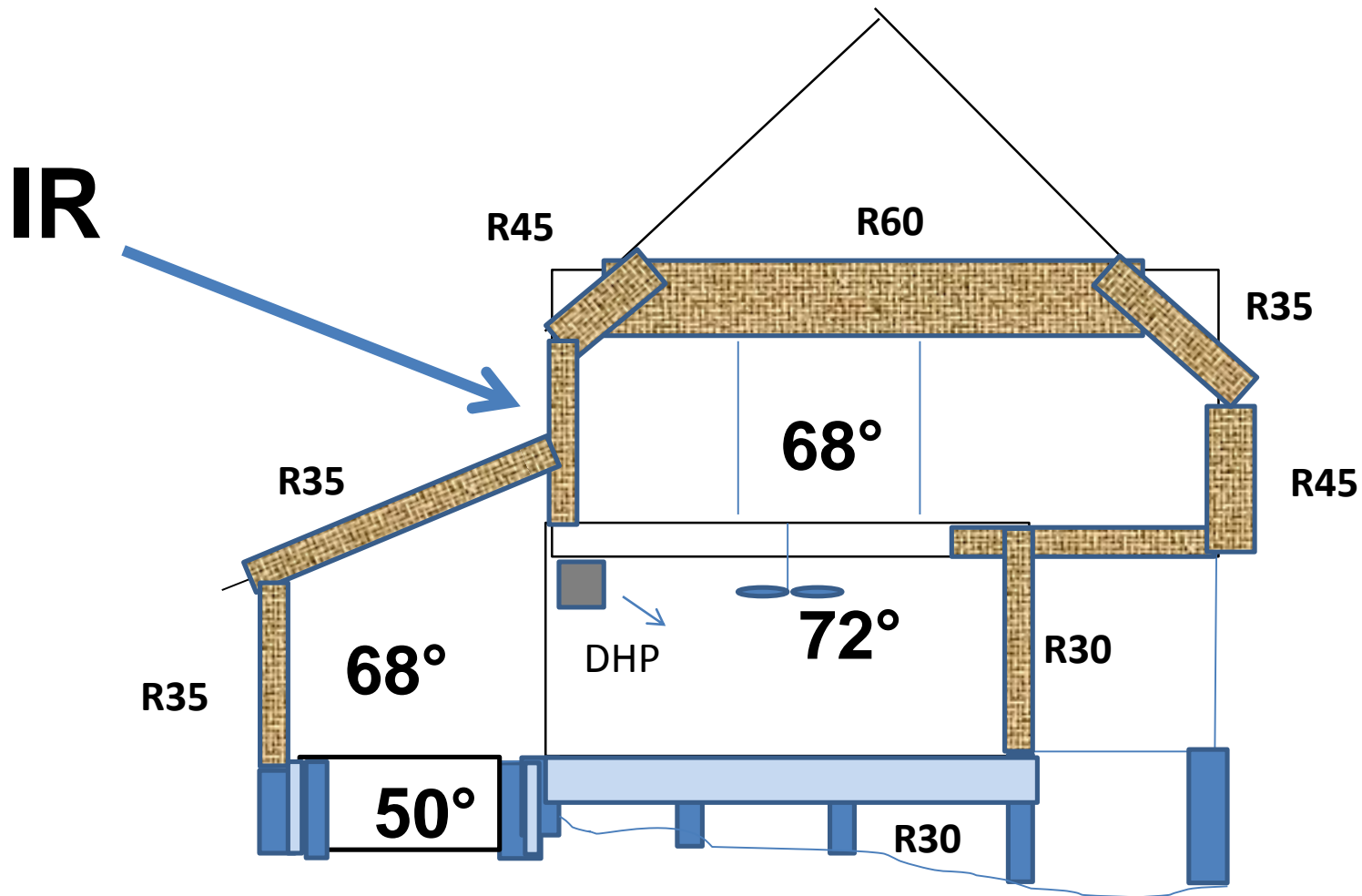




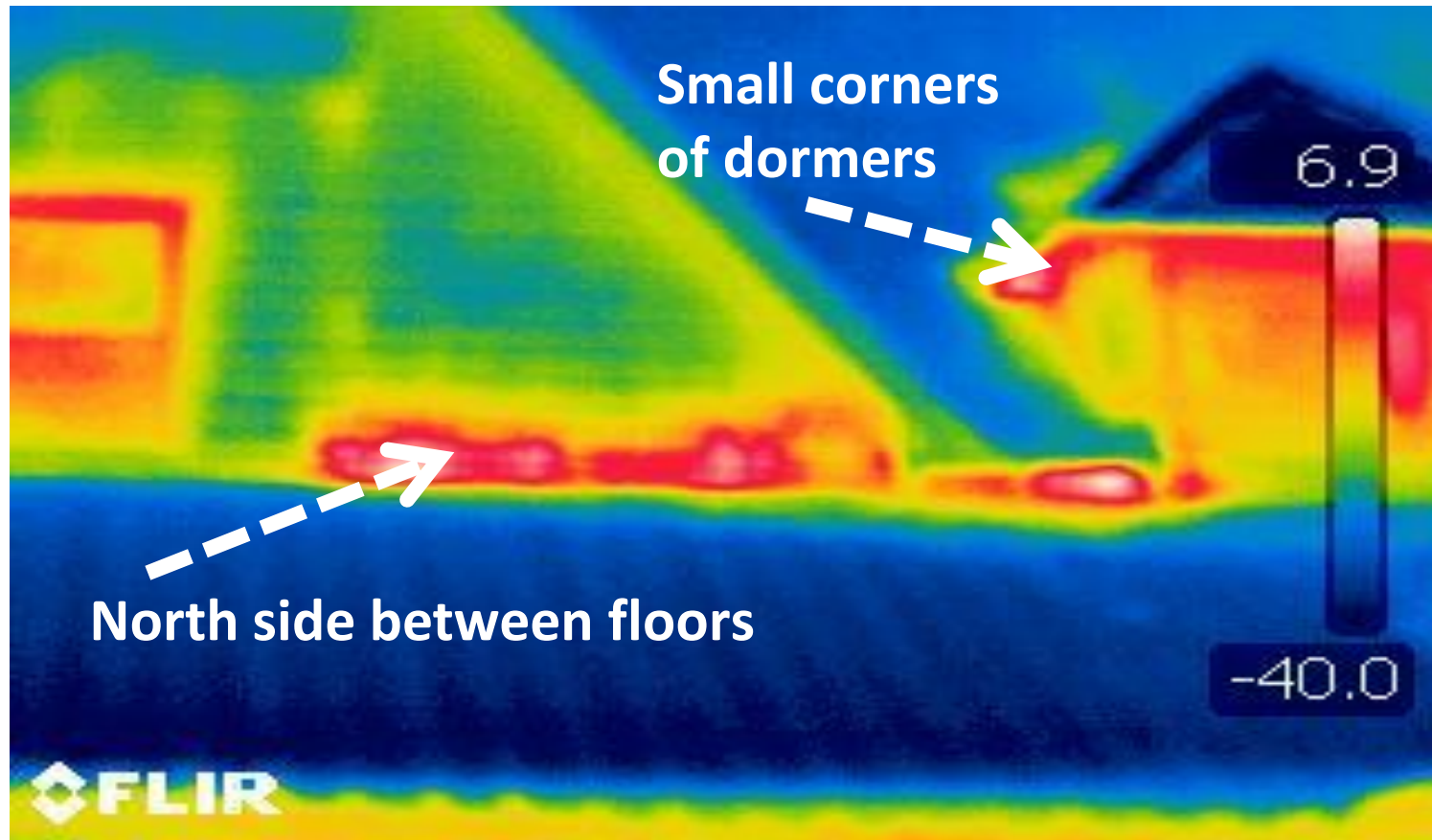
# Now Very Even Temperature Distribution & not too dry in winter (unless very windy, NW wind)



# Now: Thermal Enclosure Insulation Levels, better comfort



# Some Remaining Air Leakage Areas to Address



# 1<sup>st</sup> DHP Experience , prior to 2<sup>nd</sup> Dense Pack

- **1.5 ton system carries 2,000 Ft<sup>2</sup> of living space down to at least 20°F with no strong winds**
- Cost similar to burning cord wood **above 15°F?**
- **Drying function is wonderful on hot humid days in August (will drop 70% RH to 50% easy in a few hours)**
- **Comfort Concern:** My wife reports missing ambiance of radiant heat of a hot wood stove on cloudy wintery days
- In 2014, we put in a 2<sup>nd</sup> DHP unit in the east end apartment (1/3 of home)

# Current Ventilation Systems (IAQ)

- 2 kitchen exhaust hoods, also 2 bath fan exhausts on de-humidistats (all remote blowers)
- electric clothes driers ducted outdoors
- 1 roof-mounted solar hot air make up air panel on 25% timer 7 AM to 7 PM when 35°-55° outside
- 2 wood stoves without ducted OA, power vented boiler
- **Added:** 1 window-mounted 40 cfm supply fan for my bedroom during 30°-60° weather
- 30 year old double hung thermal pane windows

# THC Actions Taken Summary

- **Winter 2011-2012 blower door test & Infrared**
- **Cellulose dense pack interstitial space between 1<sup>st</sup> & 2<sup>nd</sup> floor**
- **Cellulose dense pack all slopped ceilings and 2<sup>nd</sup> floor walls**
- **Air sealed attic & add 2 feet of cellulose to 12 inch FG batts**
- **Add one DHP 1.5 ton unit**
- **Replace ten T-12, with Electronic Ballast T-8 25 watt 4 foot**
- **Replaced 14 cu ft freezer & old fridge in apartment**
- **Spray foam base of rock chimney 2 inches thick, replaced remaining 5 windows**
- **Rebuild solar hot water system with SS tank, HP back up**
- **Densepack 1<sup>st</sup> floor walls, add 2<sup>nd</sup> DHP**

# Blower Door Results & Fuel Use:

**1982** prior to attic VB: not testable

10+ cords  
+ 300 gal. oil

**2011** prior to dense pack: 12 ACH<sub>50</sub>  
6,675 CFM<sub>50</sub>

6 cords  
+ 400 gal. propane

after 1<sup>st</sup> dense pack: 7 ACH<sub>50</sub>  
5,000 CFM<sub>50</sub>

3 cords (8,900 lbs)  
+ 200 gal. propane

after additional dense pack  
4,000 CFM<sub>50</sub>

1 cord (1,249 lbs)  
110 gal. propane  
+ two DHP

# Reduced Emissions from Cord Wood Heating



## Relative Emissions of Fine Particles

When Burnt

Woodburning Fireplace	Uncertified Woodstove	EPA Certified Woodstove	Pellet Stove	Oil Furnace
Highest annual pollution	244 lbs. of annual pollution	97 lbs. of annual pollution	27 lbs. of annual pollution	<1/4 lb of annual pollution

VERY DIRTY

pscleanair.org  
Puget Sound Clean Air Agency



# IAQ

## No Central Air Filter

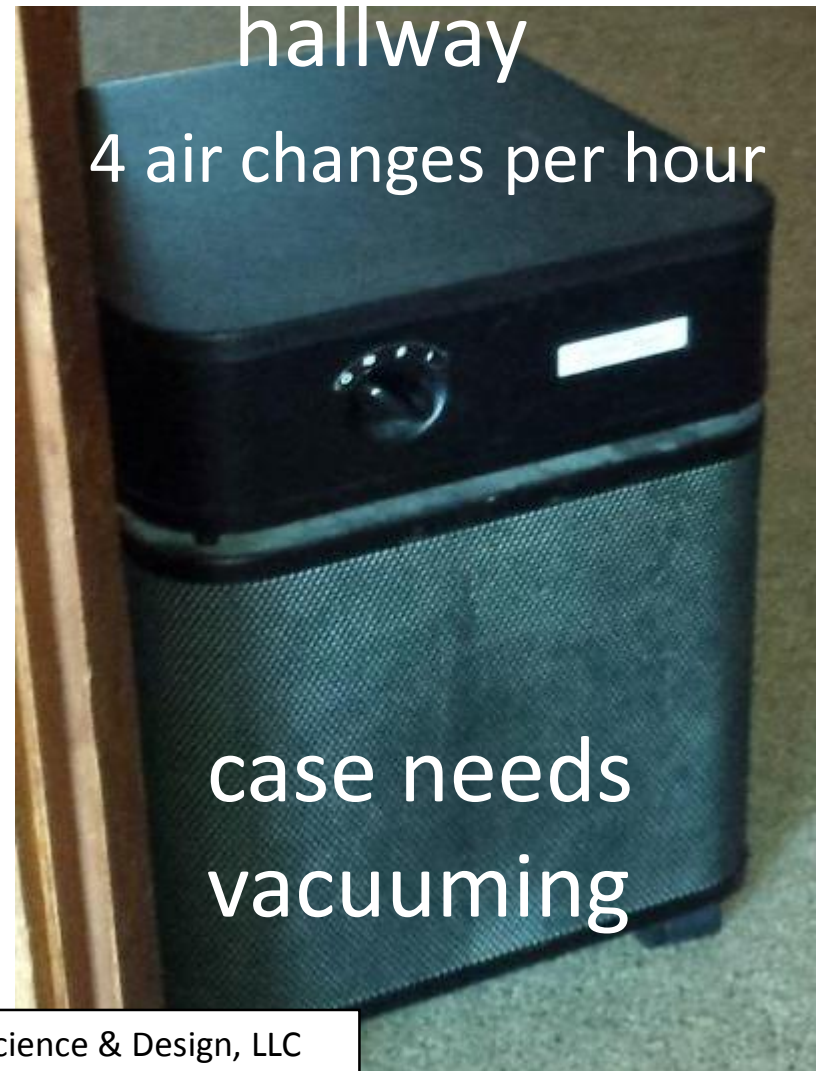
### Our “Sanctuary”

### Bedroom Areas,

Medium speed = 125 CFM



Courtesy: Turner Building Science & Design, LLC



# Current Renewables 2014

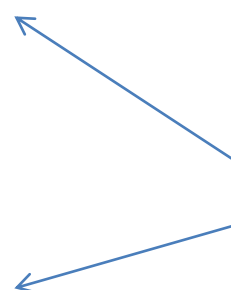
1. 20 Ft<sup>2</sup> hot air panel make up air, 40 watt fan
2. Now 7 Kw PV panels
3. 144 Ft<sup>2</sup> hot water, 110 gal storage, & fan coil north hall
4. 96 Ft<sup>2</sup> passive sunspace (new glass)



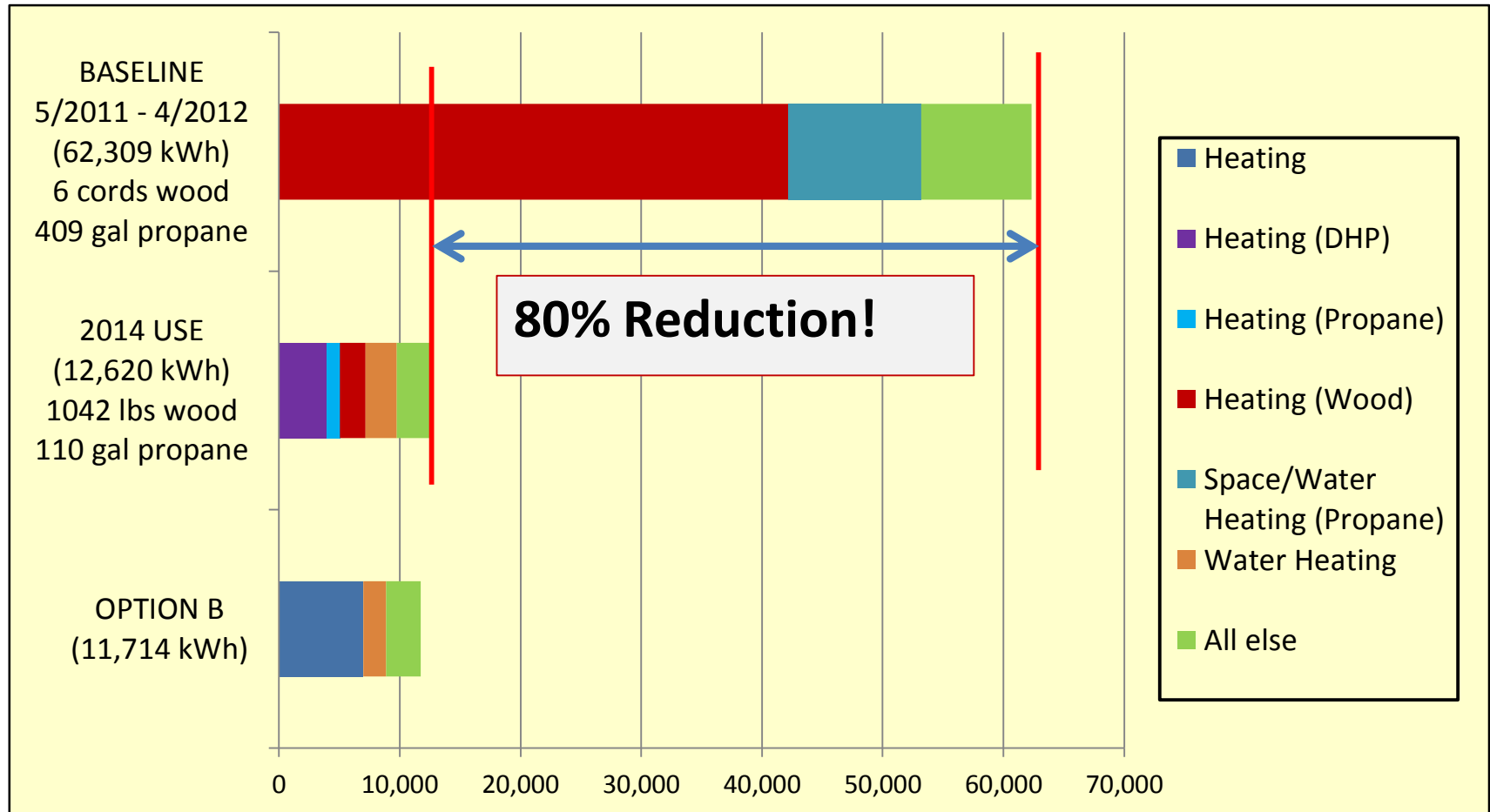
# Cost Summary:

▪ Org 1981-1982 Energy rehab	\$ 10,000	20% of house cost
▪ Dense Pack	\$ 15,000	5% of house value
▪ Two DHP	\$ 6,000	
▪ 5 Windows	\$ 2,500	
▪ Rebuild Solar HW	\$ 10,000 *	
▪ HP DHWater	\$ 1,500	
▪ Lead paint	\$ 3,500	
▪ add 7 kW PV	<u>\$ 20,500 *</u>	
	\$ 58,000	(20% of current value)

½ cost

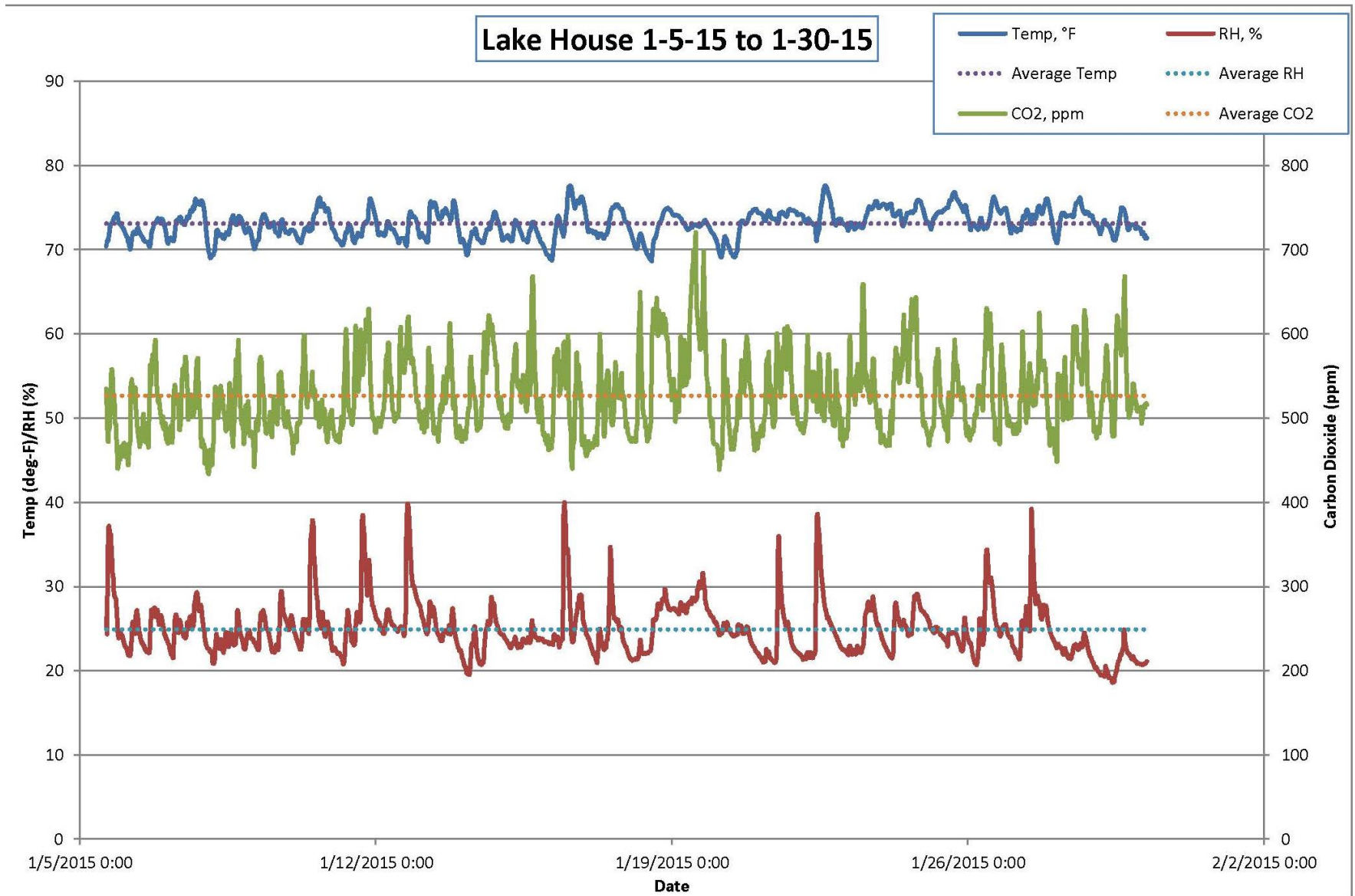


# Annual Energy Use Compared to THC OPTION B (in kWh)



THC OPTION B INPUTS: Auburn-Lewistown, ME weather station (7,615 HDD base 65);  
3,600 Ft<sup>2</sup> FFA; 54% electric heat

# RH, Temperature and Carbon Dioxide



# Thousand Home Challenge: 10 Steps

<http://www.thousandhomechallenge.com>

1. **Assess Needs, Site, Goals, & End Use of Space**
2. **Optimize Enclosures** (reduce heat & cooling load)
3. **Minimize Internal Loads** (lights, appliances, electronics)
4. **Provide Fresh Air**
5. **Control Humidity**
6. **Determine Cooling Needs**
7. **Integrate Hot Water with Other Loads**
8. **Determine Heating Needs**
9. **Integrate Renewables to Address Remaining Loads**
10. Incorporate **Verification, Feedback, & Evaluation**

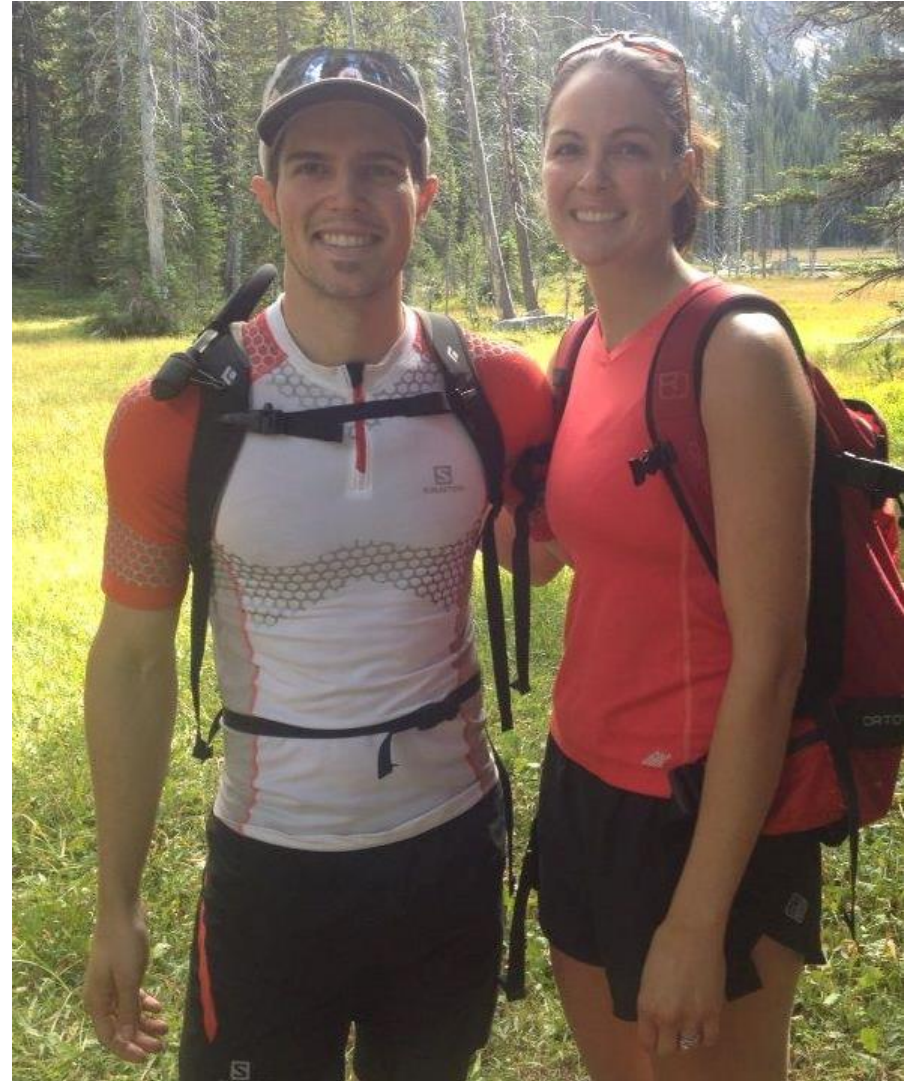
# Current Plan 2015:

(to meet THC: reduce 906 kW hours?)

- **Fix air binding problem in ground mount Solar DHW**      \$ 100
- **Address North side wall remaining air leakage**      \$ 200
- **Also Consider: ??**
  - **LED bulbs vs. CFL**      \$ 250
  - **Heat Pump Clothes Drier in Apt.**      \$1,600
  - **Low Water Use Clothes Washer in Apt.**      \$ 700
  - **Induction Unit 2 Burner?**      \$ 300
  - **Condensing Boiler**      \$4,000
  - **More Night Insulation?? Other Ideas?**

# Thank You

Members of My Family





# Questions?

**And Thank You** to THC, Curry Caputo,  
& “Sustainable Structures” dense packers

**Bill Turner**

**Turner Building Science & Design, LLC**

**bturner @turnerbuildingscience.com**

**www.turnerbuildingscience.com**