# DEEP ENERGY RETROFIT OF A 1976 RAISED RANCH IN N. VT.

Looking at what it takes and how we did it

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# The House Before the Retrofit

Classic 1976 Raised Ranch with tuck under two car garage purchased in 2009

Orientation is East/West

Walk-out garage was unfinished and “heated”

Wooded lot – Solar Pathfinder 70% Insolation

Raised Ranch has between two and three feet of cinder block  wall sub grade and between one and two feed of cinder block wall above grade.

External chimney on North Face.

House Valued at $250k

# The House Before the Retrofit

Windows

Original Single Pane/Double Hung Windows – 56%

Bay Window DG – 14%

Sliding DG Glass Door to North facing Deck – 15%

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tion:

2x4” filled with fiber glass above grade

No insulation on cinder block wall above or below grade

No Slab insulation

12” of blown cellulose in attic

# The House Before the Retrofit

Heating Plant

30 year old oil burner for heat and hot water

Wood Stove insert in fireplace with blower fan to help push heat further into house.

Fuel use – 500 to 700 gal oil
+ 3.5 cords hard wood (approx. 89 kBtu/sq ft/yr

Ventilation: Panasonic direct vent bathroom fan with light -120 cfm

Initial Blower Door Test: 1806 cfm = 8.25 $ACH_{50}$

Vermont is a Climate Zone 6 Cold – Humid with 7200 – 8200 HDD/yr.

# What was done before the Plan

Prior to taking CPHC classes in Dec 2010

On advice from local renovator the best windows available in the US were

**Andersen Super Low-E Double Glazed Double Hung Vinyl Clad**

U – 0.29
Whole window R-3.5
SHGC – 0.39

Worst decision in the entire history of this house!

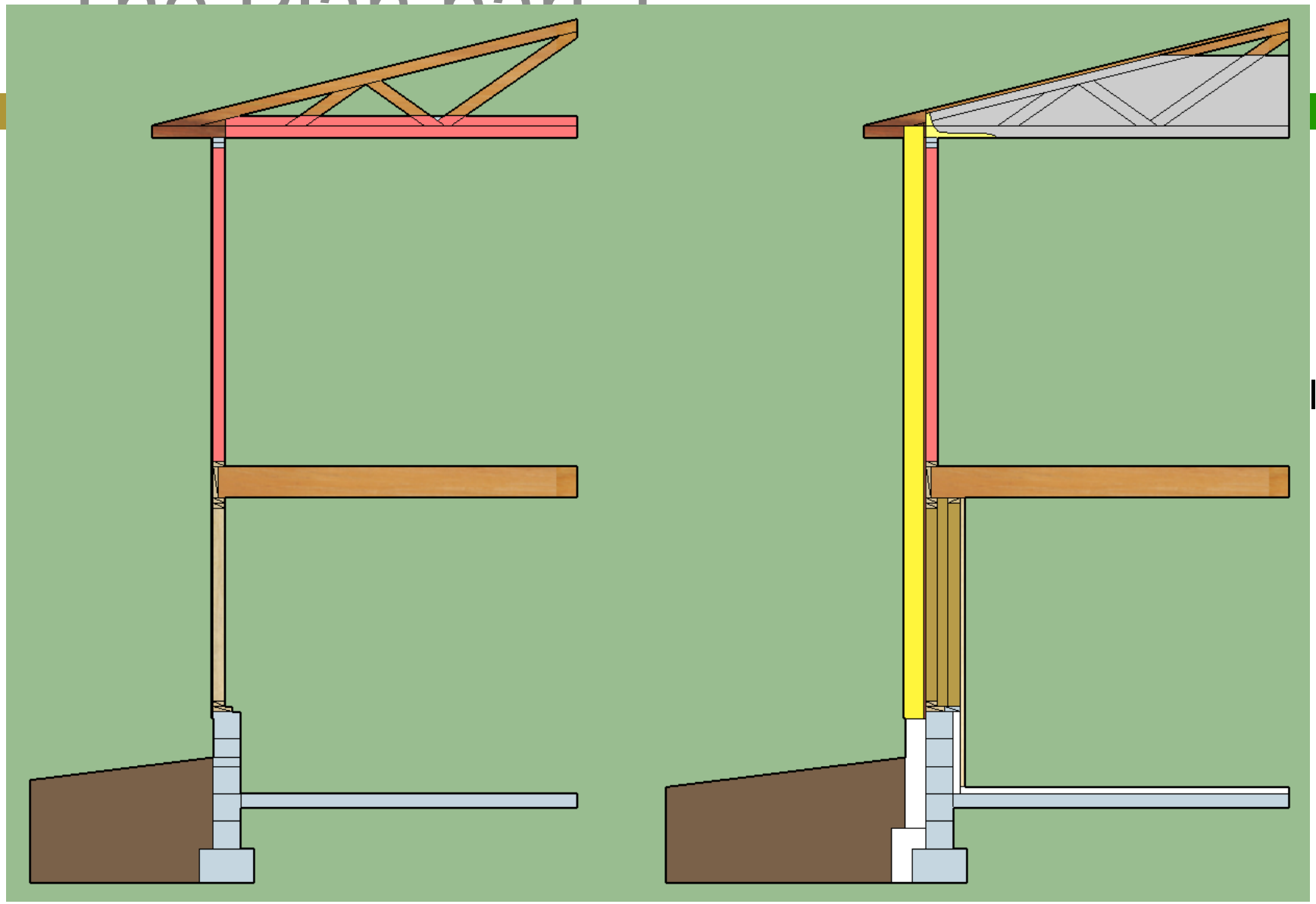
I have brand new, really poor windows for the next 20 yrs!

# The Plan part 0

Ask smarter people that I for advice

- Lots of time asking watching others presentations about retrofits on similar construction
- Asked smarter people that I am about their opinions of assemblies I came up with regarding durability
- Lean on the shoulders of giants
- Try it on your own house before you do it for a paying client

# The Plan part 1



# The Plan part 2

Wrap house in air sealing membrane

Remove bay window and replace with picture window

Make wood stove sealed combustion

Remove oil boiler and replace with air to air heat pump

Install HRV

Model house to estimate size of HRV and Heating Plant

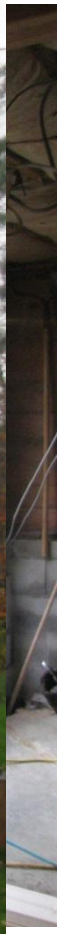
Budget of $70k

# Windows?

Not replacing windows!

Already spent too much $ on that – not enough $ to do it again.

# The Work-Replace garage doors with walls

# Repurposed Insulation Saves $

Second Hand 3” EPS and Polyiso cost $3900 for the entire project!
Never mind keeping it out of a landfill!
Price included $500 for delivery.

InsulationDepot.com or Hickory Street Rentals in Oneonta, NY

# The Work – Modified Chainsaw Retro

3/12 Pitch Roof – not much room for full chainsaw retrofit.
Went with Thermal Break in ceiling joist.

# The Work – Air sealing in attic

Foam in first 12” from top plate for air sealing and higher R-value at low part of roof.
This ties in with the polyiso outside and was then refilled with cellulose.

All ceiling penetrations, lighting fixtures, ceiling fans, recessed lights, etc were air sealed during this process.

Final R-value = 84

# The Work – Attached deck and stairs moved away from house

To remove thermal bridging, make applying insulation and detailing easier the deck and front stairs were detached and moved one foot from the structure.

# The Work – Dig up sub grade and insulate

My pull along backhoe! Took about four hours to dig a 45’ long 4’ deep 4’ wide trench.

# The Work – Dig up sub grade and insulate


Why not add a new perimeter drain while we are at it?

Soprema Bitumen EPS Waterproofing peel and stick membrane.

Final R-value = 35 (w/2” on

# The Work – A nice wooly sweater

Adding two courses of 3” Polyisocyanurate Board

First course with 4” screws

Second course with 8” screws

All screws carefully set into 2x4 framing.

Sheathing mostly ½” homasote!

With original 2x4 w/ Fglass Total R-value for upstairs walls = 48


# The Work – Wrapping it up

Air Sealing the entire frame section with Mento 1000

Vapor open 34 perm

Tescon tape used for seams and window detailing

Twice as expensive as Typar/Tyvec

Took twice as long to install due to level of detail

# The Work – Strapping for rain screen

A 1” x 4” strapping was used for siding nailer and rain screen

Screwed on using 10” screws

Screwed into 2x4 framing of house

Corners with extra wide plywood

Windows framed to receive trim

# The Work – Window bucks

Windows sit 6” into wall now – built bucks for window frames


Used a special jig to make bucks

Bucks made of PVC trim for low maintenance

Simple, but crucial detail

Buck attached into stud through membrane. Tight fit will seal hole.

Window trip attached to strapping.

# The Work – Bay window gone

Bay windows are a nightmare! Try to add 6” of insulation around this and get the detailing right! Thermal bridge on top and bottom!


Solution – Remove and replace with picture window

- Same detail as all other windows
- No special thermal bridging issues
- Less rot and future maintenance

Due to cost and availability/time went with Marvin double pane (3/4” spacer) fixed.

# The Work – Chimney? Take it off?

In Vt Wood is plentiful and cheap. Up to 50% of Vt'ers use at least some wood to heat their homes.

Chimneys are huge thermal bridges – especially if it is outside like mine!

What to do?

Wrap it!

3" of Roxul board (R-4/in)
¾" plywood on top
3" of Roxul board
Wrap it with Mento 1000 for air sealing
Top of ceiling insulation is 2' below roxul.

# The Work – Downstairs walls

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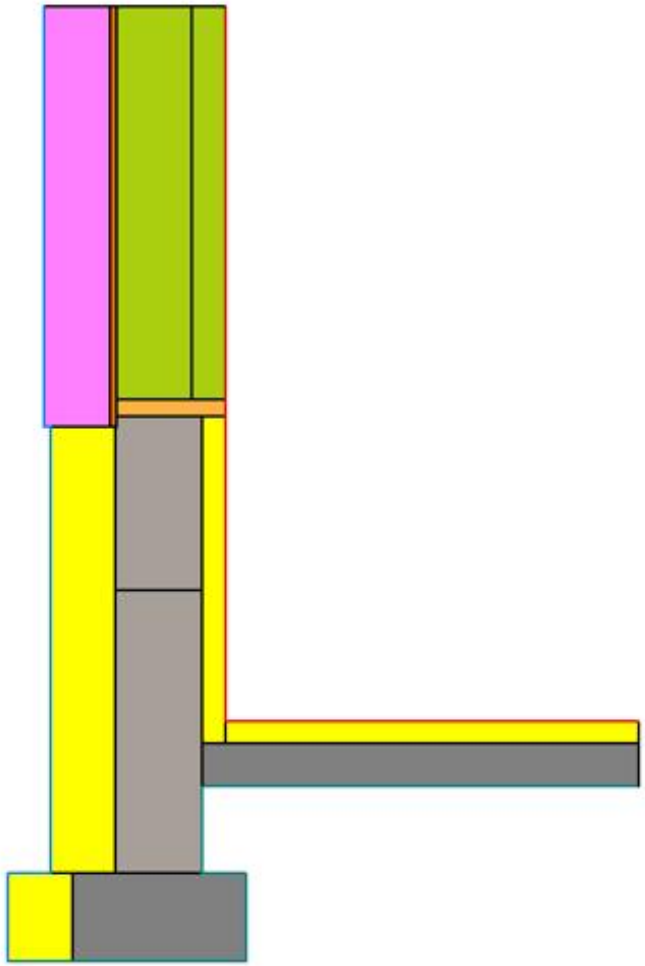
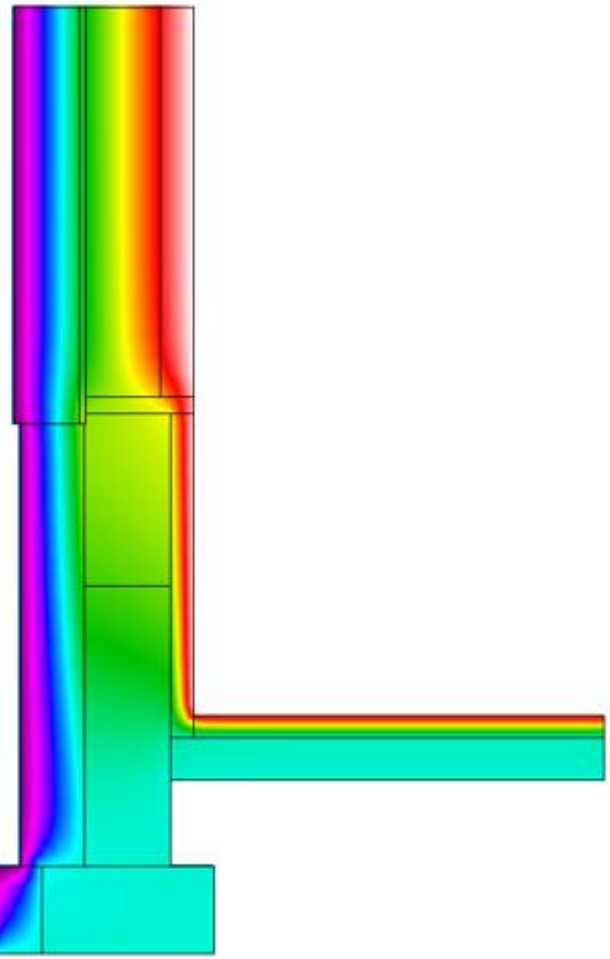




# The Work – Wood stove sealed combustion

Existing wood stove didn't have options for sealed combustion.


New stove for sealed comb.

Fresh air through back of chimney

Filled and sealed through Mentos

Chimney flue sealed with plate

Issues were found at BD Test being addressed

# The Work – Air Sealing Penetrations

Make a list of existing and planned penetrations

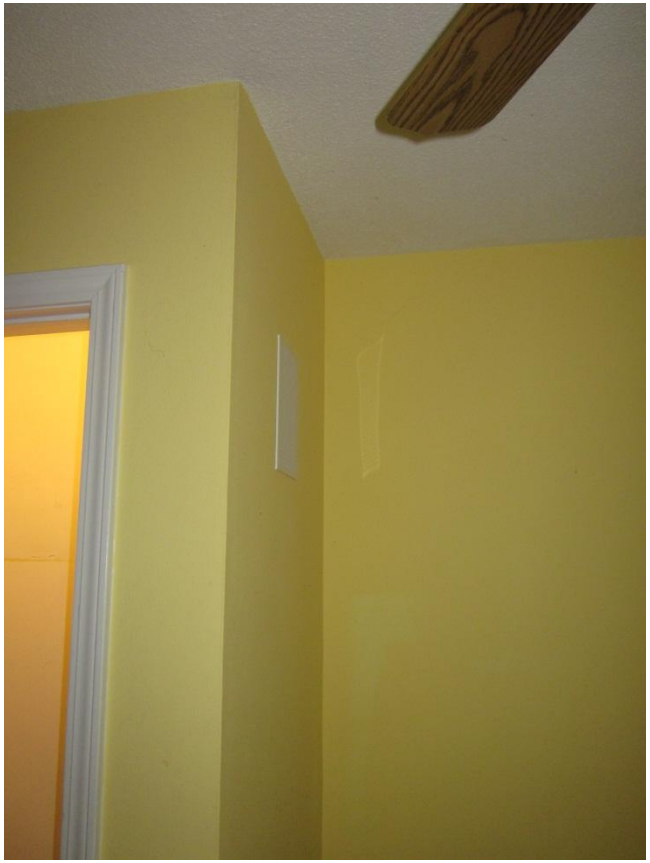
- HRV Supply and Exhaust Duct
- Outside garden hose
- Well water supply hose
- Outside lights (deck, front door, side door)
- Outside electric sockets (deck, next to Air to Air Heat pump)
- Fresh air supply for wood stove
- Old floor drains in ‘garage’ needed to be sealed
- Old ceiling access for attic needed to be sealed

Wonderful sealing gaskets from 475 High Perf. Bldg. Supply

Check your membrane for cat attacks (and other post installation damage)!

# The Work – HRV ventilation

Challenges of installing HRV in an existing home



Zehnder CA 350 HRV

Old garage gave opportunities to run ducting in unfinished rooms

Run the ducts as much as possible through the walls of closets.

Try to minimize amount of drywall work after the fact.

Reduce disruption in occupied spaces

# HRV/ERV – Issues

Challenges of installing HRV in an existing home

First year HRV core dried the house out
Moved to ERV

Lack of ground preheater loop (due to ledge) meant too cold air supply on really cold days (below 0F)
Just turned it off for this time (2 ACH50)

Left space between wall and ERV to allow for addition of ground preheater loop in future if desired (but where?)

# The Work – Heating Plant

Removing Oil Boiler and replacing with Air-to-Air Heat Pump

Modeling shows Heat Load from 112,000 Btu/hr to 22,500 Btu/hr (82% reduction) Nowhere near Enerfit but a major reduction!

New Heating Plant

Wood stove 55,000 Btu/hr – incidental extra heat

Mitsubishi Hyperheat A2A Heat Pump 22,500 Btu/hr (to 5 F)
or 15,750 Btu/hr (to -18 F)

We added a 2nd heat pump this summer for better distribution.

Use wood stove to offset deficiencies in heat pump performance at very cold temps.

# The Costs

Retrofits are expensive!

Reduced costs through:

- Doing as much work as possible myself
- Used repurposed materials when possible

Hired Professionals when necessary and sought out companies that were already known for doing good work/winning awards from Efficiency Vermont.

Jim Bradley and his crew at Caleb Construction, Cambridge, Vt.

# The Costs

Encountered Costs:

| | |
|---|---|
| Air Sealing and Outside Insulation Installation | 35,000 |
| Floor Insulation and flooring | 5,000 |
| Drywall | 5,000 |
| Hot Water Heater | 300 |
| Ventilation | 5,500 |
| Air to Air Heat Pump | 4,000 |
| Insulation | 4,000 |
| Vinyl Siding | 9,300 |
| Unexpected Costs | 9,000 |
| My labor | 11,500 |
| Estimated Total Cost | 89,300 |
| Actual Out of Pocket | 77,100 |

# The Results

Heating Load Reduced from 89 kBtu/hr to 24 kBtu/hr PHPP

Three times the Enerfit numbers

Why?

- No new windows (the $20k was too much for our budget).
- Only 2” EPS on floor – Not 10” to 12” under slab
- Orientation all wrong – If the house burned down we could change the orientation then all of the E window losses would turn to gains.
- Couldn’t get rid of some thermal bridges easily

# The Results

Air infiltration reduced from 8.25 ACH50 to 2 ACH50!


1802 cfm to 425 cfm!

A 76.4% reduction!

Found a leak at a seam in the chimney block which Jim Bradley estimated was approx 30 cfm. This brings us to 395 cfm once that is fixed!

# The Results

Comfort in house is greatly increased.

Much lower heating fuel usage

- Was 750+ gal oil per heating season and 3 cords wood Approximately $3150/year
- Actual with HP and some wood: $780 in elect and ¼ cord wood ($56)  a 73% reduction
- Net Zero reached with 27 PV panels (off site community farm)
  - With Community PV farm 12 year loan @ $255/month
  - Currently paying $200/month for all electricity (heat incl.)s

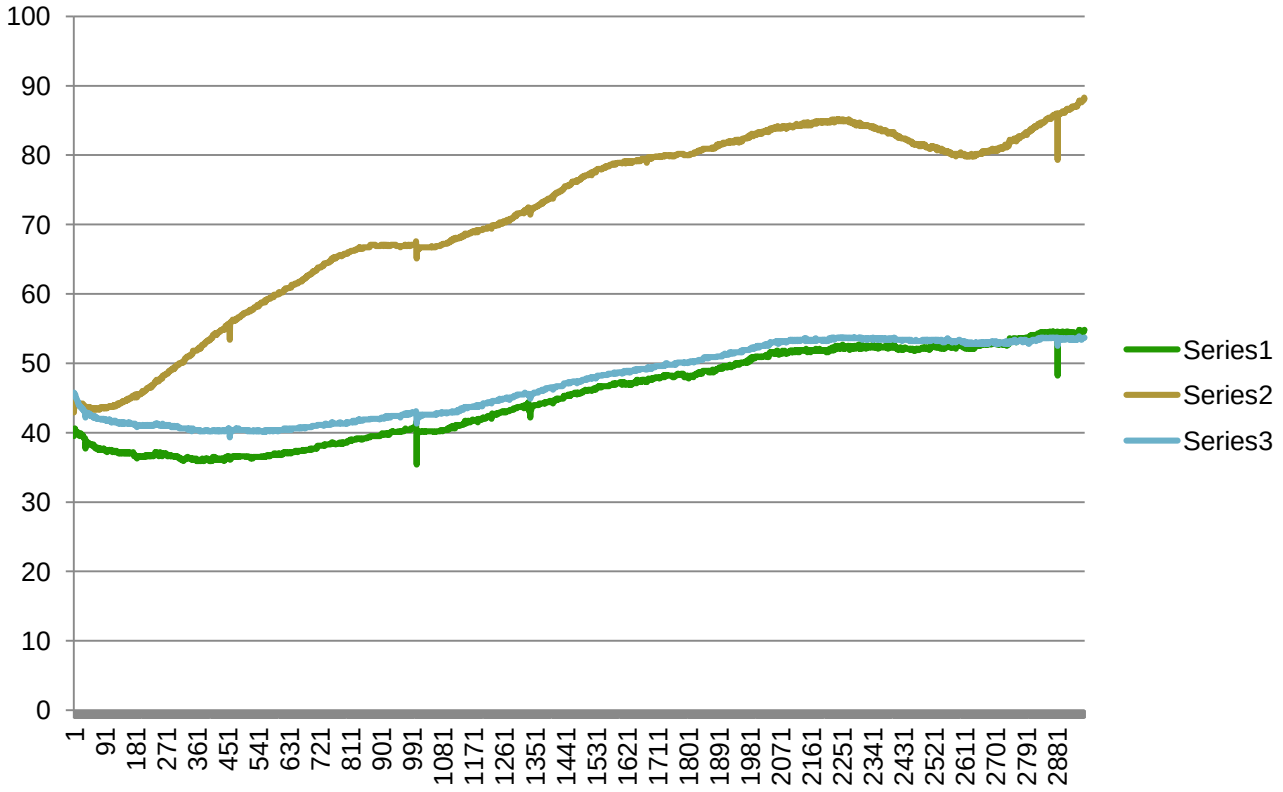
# Lessons Learned

- Be realistic about costs and achievable goals
- ERV over HRV in Cold Climates
  - Without ground loop preheater may need to turn off at very cold temps
- Single Head heat pump distribution through ERV is overstated without a ground loop preheater
- You are stuck with some Thermal Bridges (slab edge, stem wall)
  - Existing door thresholds are often big TB's
- Invest in the best windows you can!!!
- Be careful with wrapping a chimney – must have a liner!
- Retrofits are never perfect…for super insulated better to start from scratch – no inherited issues

# Lessons Learned: Testing the Chimney

- Blog post on Green Building Advisor
  - Contributor brought up issues of charification of wood
    - Wood exposed to +170F temps turn to charcoal which has a much lower ignition temp
- What to do?
  - Test it with sensors
    - 72 hour test with 40F outside temp and wood stove at highest temp
    - Sensors – one on each of three sides of chimney at inside of wood plywood
    - Considered worst case
    - Results showed…

# Testing the Chimney




Temp did not get above 100F. Wood in assembly is safe from charification

When in doubt…measure it!

# Conclusions on DER in Vermont

More than 99% of housing stock is existing stock.

The biggest savings is to be found making these houses energy efficient.

It cost approximately 30% of the value of a house to do a Deep Energy Retrofit, never mind hitting the Enerfit standard.

Vermont is a Climate Zone 6 Cold – Humid with 7200 – 8200 HDD/yr

Very challenging place to build/retrofit homes.

# Questions?

Follow the blog on this project at www.ecohousesofvt.com