

Simplicity and Contradiction

15 years in the making of *net better*

Outline

- Context
 - Actions
 - Results
 - Mistakes

Disclaimer:

This is not a traditional Deep Energy Retrofit (DER), but rather a DGR or Damn Good Renovation. Try this at home, but keep in mind these stunts were performed by an idiot with no adult supervision. The opinions and actions expressed herein are solely the author's and at time in contrast to better professional judgment that would be given by the author.



My house was built in 1913, a Sears kit house (photo: Jones Library)



From the 1930's- side view (photo: Jones Library)

One renter known to have lived in 4 Amherst Road was that of Amherst College professor and poet Robert Frost [1874-1963] who, along with his family, resided there in the fall of 1917 to 1919.





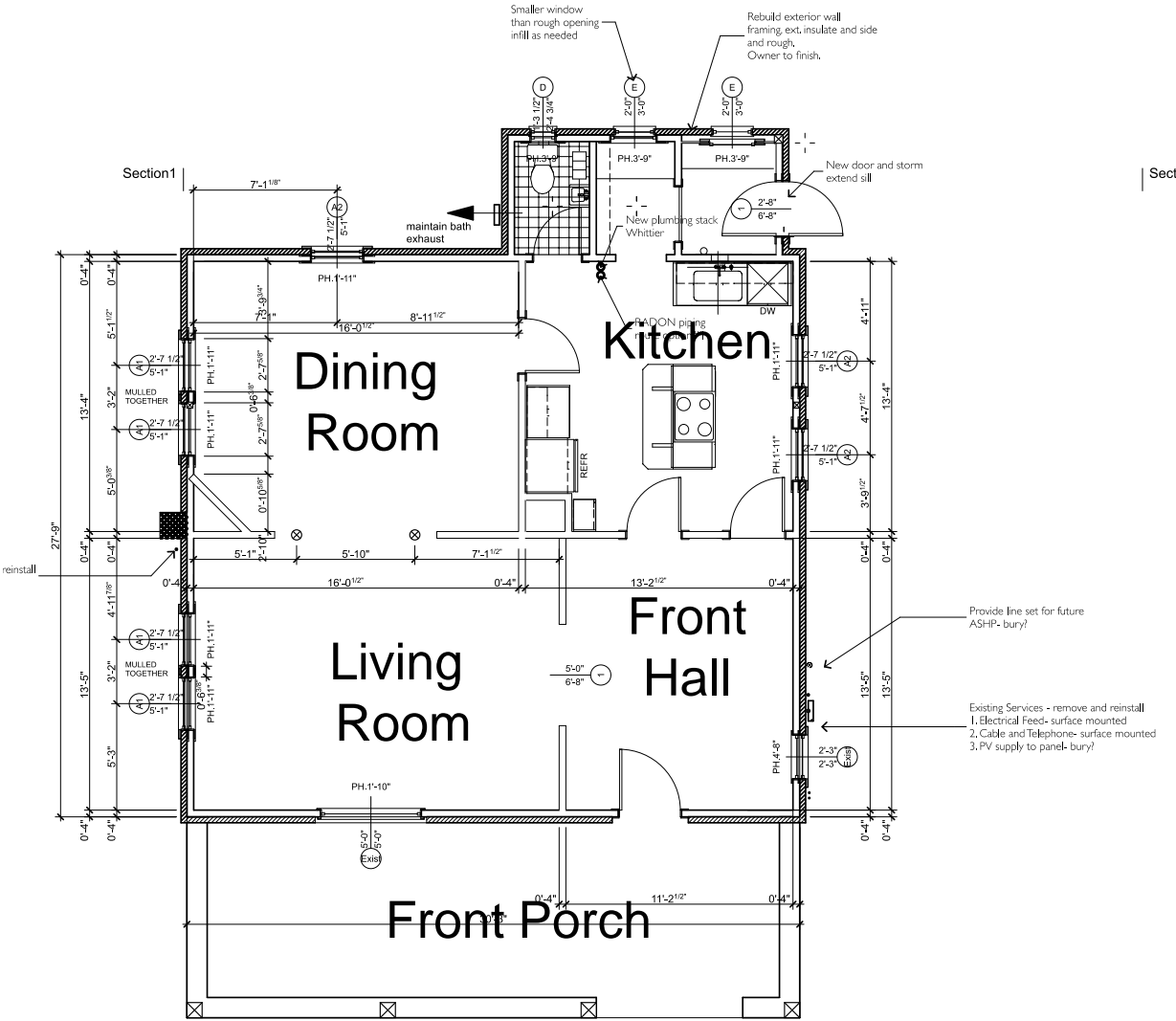
Side view - 2000



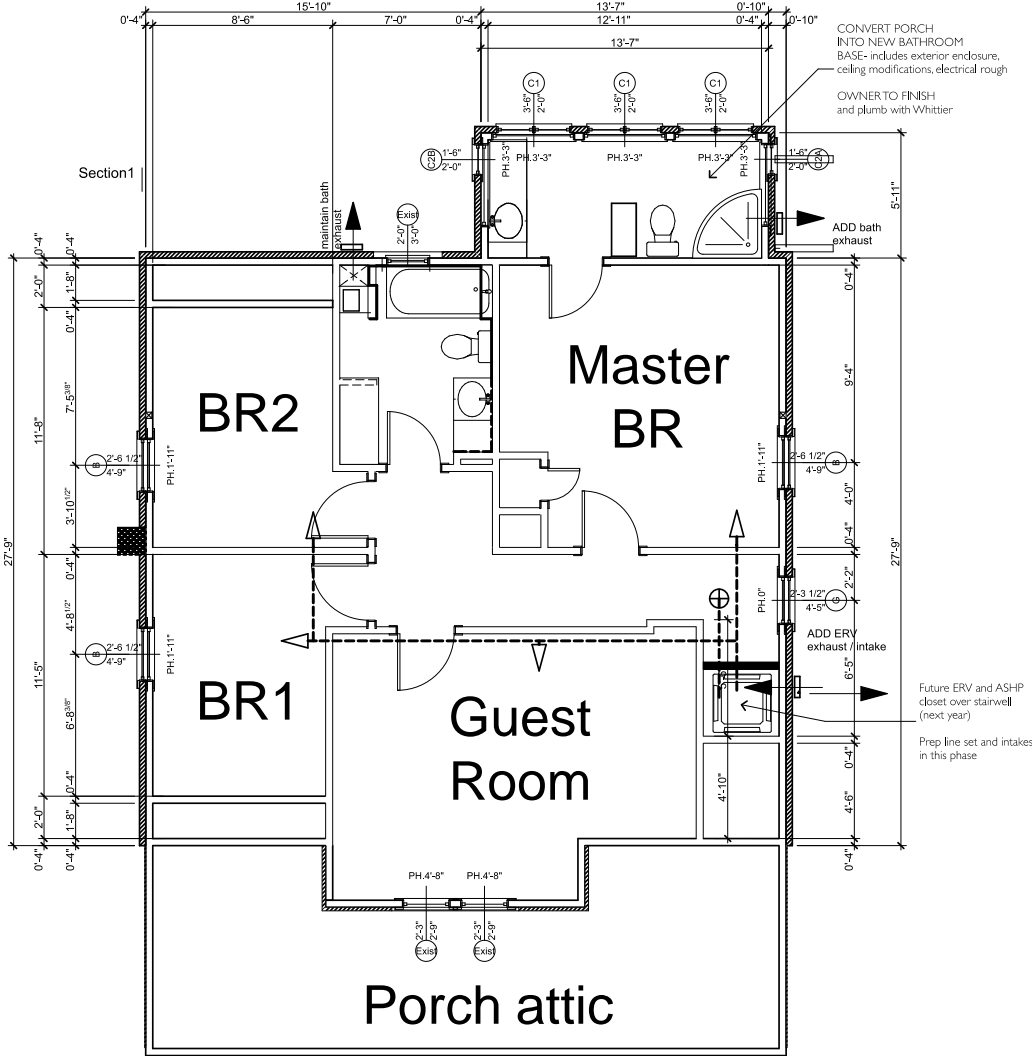


Yard side- 2008

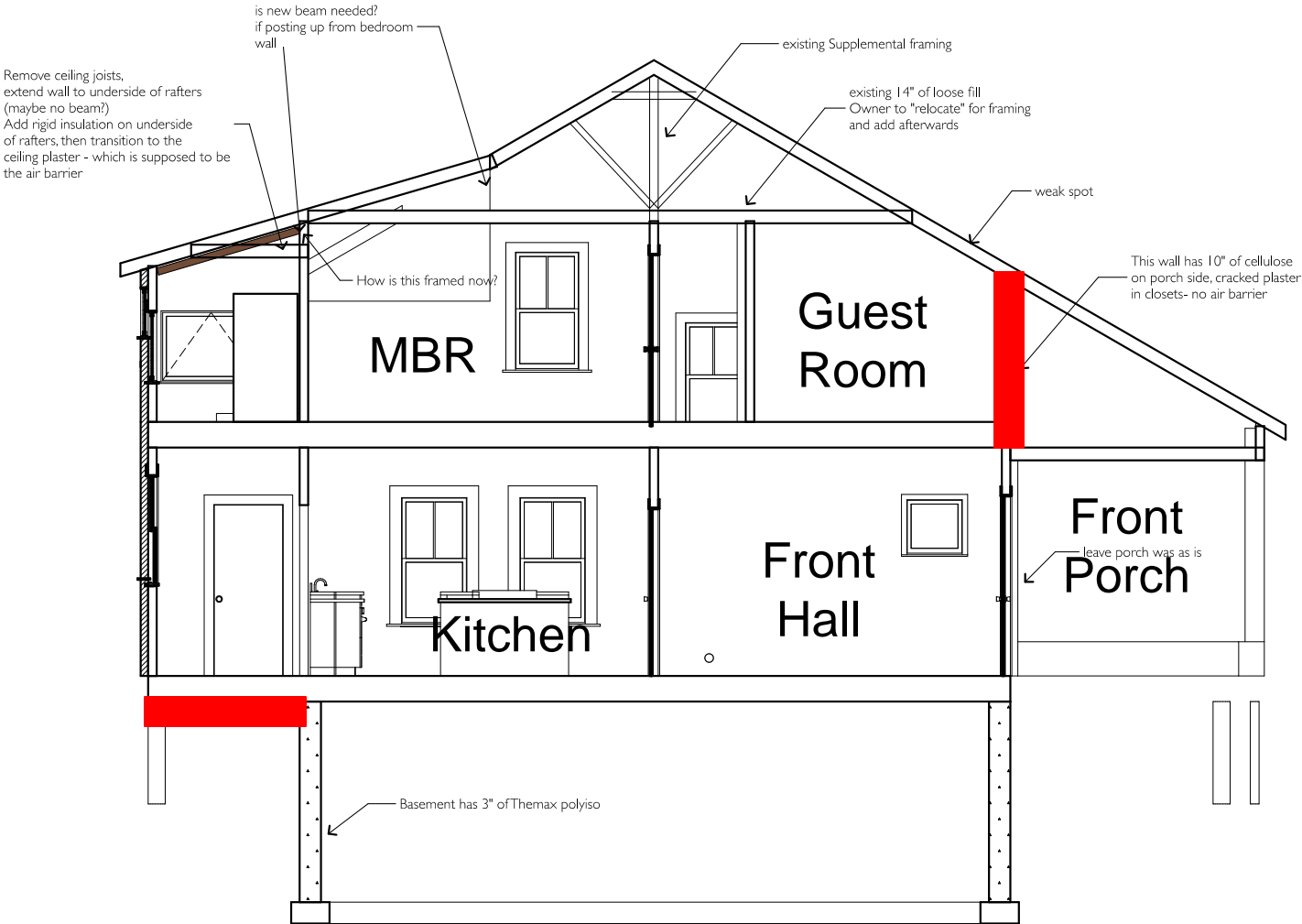




First Floor plan

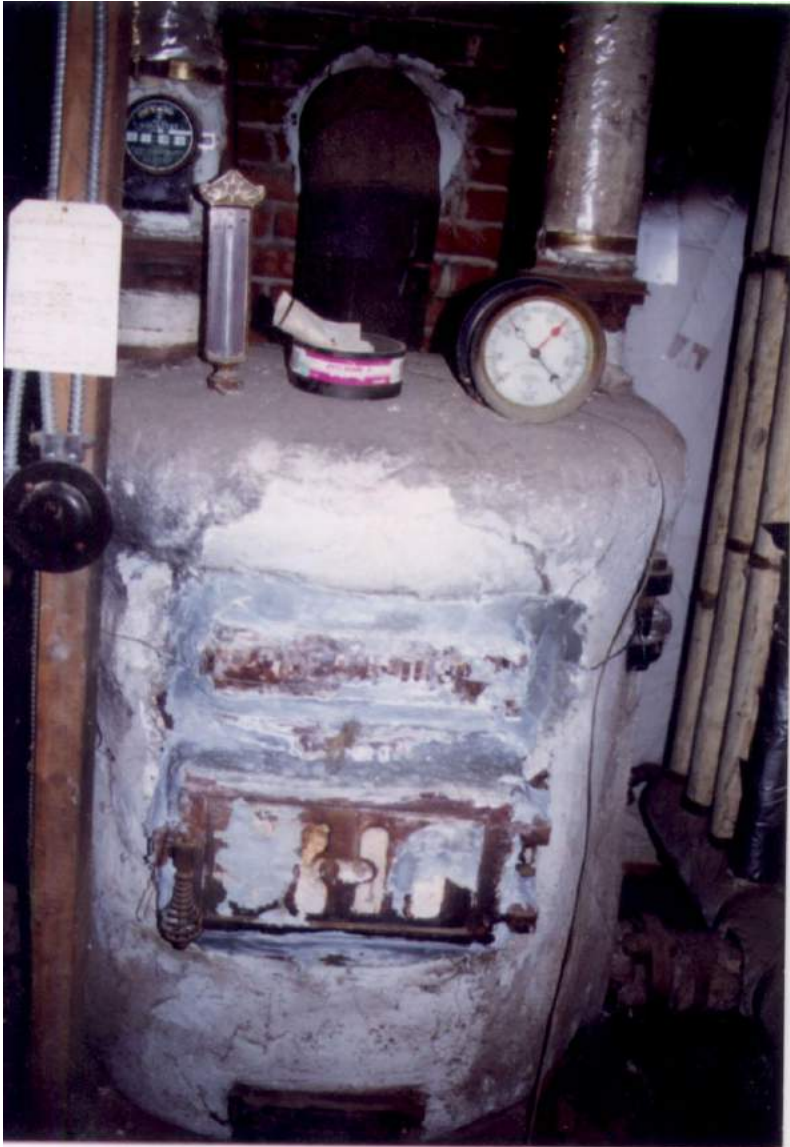


Second Floor plan



Section- red areas are for later discussion

- 2000- Purchased House, new boiler, new kitchen
- 2002- Renovate bathrooms, replace electric water heater with indirect tank
- 2004- New roof, insulate bandjoists with Icynene
- 2005- Electrical upgrades- hard wire smoke detectors
- 2007- 2.2 kw PV system
- 2008- Remove old insulation in the attic and replace with loose fill cellulose
Insulate basement walls with Thermax,
Insulate exterior wall over front porch with cellulose
- 2010 Replace front dormer windows with triple glazed fiberglass casements
low flow shower head (not trivial)
- 2011- install Stiebel Eltron heat pump water heater (still have indirect off boiler)
2.7 kw PV system, replaced all lights with LED bulbs



Snowman boiler with asbestos and electric hot water



New boiler in 2000 and indirect tank for hot water in 2002



2008- Remove all the old insulation (tiny hatch) and Insulate the attic



Thank you Mr. Tauer, then to a Ziggy Marley show



2004- insulate bandjoist with Icynene and intumescent paint

2008- 2 layers of 1 ½" Thermax Insulation on the concrete foundation walls



2009- Harsh winter-
The house across the street built at the same time has major ice dams



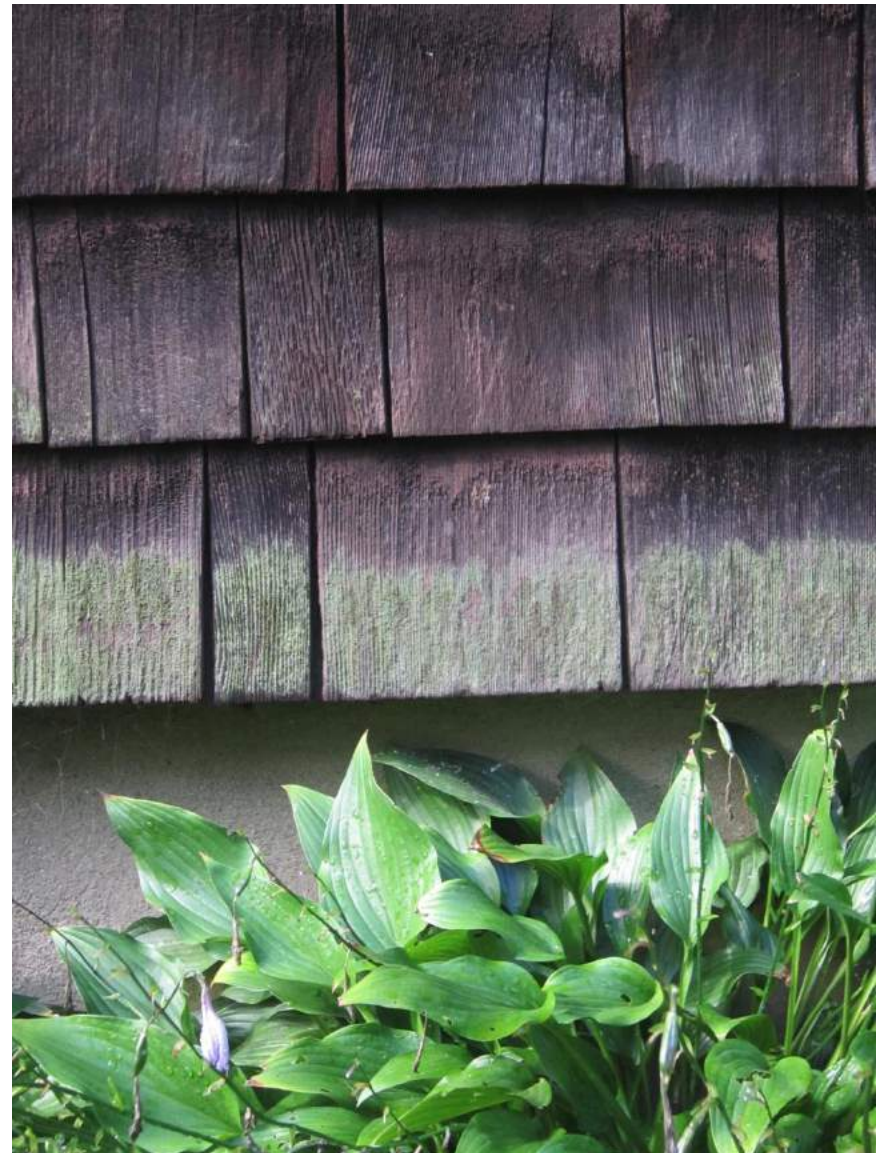
Cozy – enough?

Shingles were original and
100 years old

Splitting, squirrel damage,
paper thin on the west.

Weather tight- barely

I'm getting antsy to do
something...



DGR- 4 Amherst Road

BE 2016

2011
369 gallons

	Average	Normalized via Degree Day averages	Date	Degree Day	Gallons	Price per gallon		
			05/02/12	heat on/off			3/4 full	344.7 year total
			02/29/12		114.1	\$3.999	fill up	
			01/09/12	2210	102.2			
2011	369.4		11/01/11	475	128.4	\$3.749	FILL UP	
			07/22/11				5/8 full	Shut off indirect with new HPWH
			06/01/11				3/4 full	
			03/19/11	5551	117.8	\$3.799		
			01/25/11	3734	123.2	\$3.390		

2009
483 gallons

2010	437.8		12/23/10	1850	113.9	\$3.149		
			09/07/10	12	103.6	\$2.599	fill up	
			09/01/10	0	0	5/8 full	heat off	
			05/01/10	0	0	3/4 full	heat off	
			03/12/10	5378	122.2	\$2.799		
			01/22/10	3606	98.1	\$2.799		
			01/01/10				7/8 full	
2009	483.9		12/21/09	1853	109.7	\$2.599		
			09/15/09	101	121.5	\$2.399	Fill up	
			03/16/09		78.5	\$1.990		
			02/06/09	4567	92.3	\$2.199		
			01/07/09	3080	81.9	\$2.349	FULL	
2008	424.2		12/12/08	1651	131.9	\$2.490	FULL	
			09/05/08	0	100	\$3.849	Half FULL	Basment Wall Insulation- July 2008
			05/09/08	6838	100	??		
								NOTE: DREW TANK TO NEAR EMPTY
			01/24/08		92.3	\$3.199		

2006
497 gallons

2007	593.4		12/20/07	2255	74.5	\$3.249		
			11/12/07	844	160.4	\$3.190		
			04/06/07	6177	132	\$2.499		
			02/16/07	4418	110	\$2.349		
			01/20/07	3073	116.5	\$2.149		
2006	497.7		12/06/06	1620	138.1	\$2.349		October 2006-Airsealing and attic insulation completed
			07/24/06	6868	155	\$2.499		
			03/06/06	5238	70.7	\$2.350		
			03/06/06	5238	49.8	\$2.350		
			01/26/06	3670	84.1	\$2.350		

2003
859 gallons

2005	720.5		12/28/05	2597	104.9	\$2.350		
			11/30/05	1411	103.9	\$2.350		
			09/22/05	22	157.3	\$2.350		Piet born Oct' 05
			03/18/05	5856	132.7	\$2.149		July 2005-Icynene at band joists, under back entry, airseal
			02/11/05	4437	105.1	\$1.849		
			01/18/05	3289	116.6	\$1.869		
2004	837.3		12/17/04	2011	120.7	\$1.929		
			11/11/04	919	155.8	\$1.899		
			04/16/04	6343	129.6	\$1.459		
			03/05/04	5162	127.4	\$1.459		
			02/05/04	4141	158	\$1.529		
			01/13/04	2983	145.8	\$1.510		
2003	859		12/13/03	1839	146.6	\$1.359		
			10/30/03	623	172.3	\$1.299		
			04/15/03	6789	169.5	\$1.499		
			03/01/03	5439	152.9	\$1.769		
			02/01/03	4172	217.7	\$1.499		



Grey Squirrels!!! – getting into 1970's fiberglass insulation-
Flying squirrels in the attic too!

What would YOU do?

Move?

Fix it?

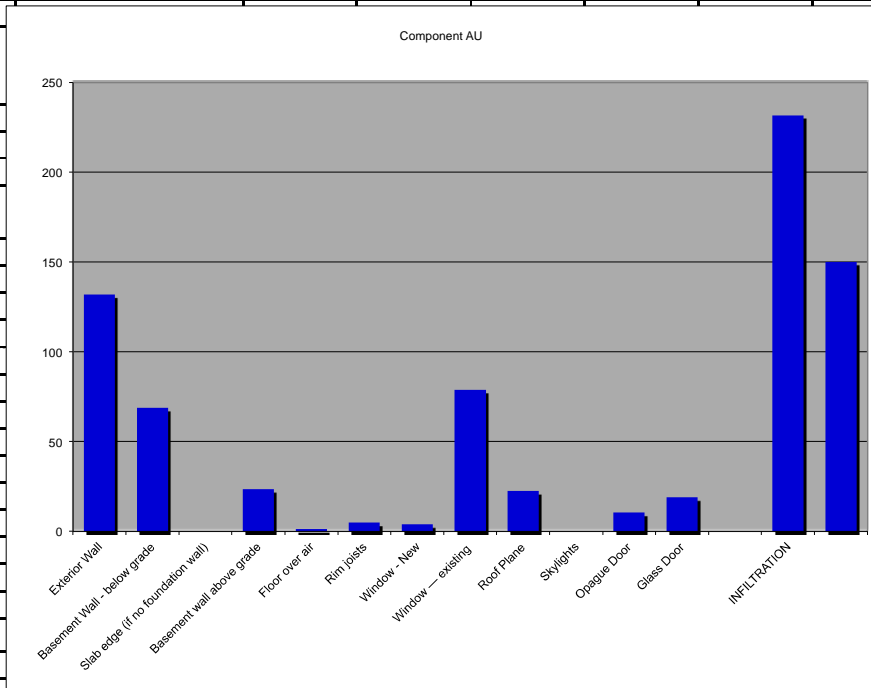
Leave it alone?

***Kristin and I went to Italy to
discuss
the next 100 years,
and the legacy of this house.***



The green light! (photo: Matthew Cavanaugh)

Heat Loss Component Budget — EXISTING Conditions				11-May-12						
4 Amherst Road										
		Design Temperature Difference	70	deg F	BASED ON BLOWER DOOR TESTING- 2008					
R VALUES	1/(Btu/hr*degF*sf)				Before attic insulation and airsealing					
Exterior Wall (4" stud cavity w/ fiberglass— settled)	14.00	Roof plane	40.00		ACH 50 11.23					
Floor over air	35.00	Rim joists	24.00		After attic insulation and airsealing					
Window — New	5.00	Skylights	1		3,000 cfm					
Window — Existing	2.50	Opaque Door R Value	2.00		ACH50 = 9.69 6.7 not including basement					
		Glass Door R Value	2.00		ACH Nat = 0.57					
Slab edge		Basement Wall R Value	10.00		CFM 50 = 2517					
VOLUME of Building	22568	cf (Est.)	Floor area (nic basement)	1832	sf					
		Ventilation system capacity	60	cfm						
ELEMENT	AREA (s.f.)	ACH-Natural	AU (Btu/hr*deg F)							
Exterior Wall	1,845		131.79	Slab edge perimeter						
Basement Wall - below grade			68.76	Basement perimeter	116	linear ft				
Slab edge (if no foundation wall)			0.00							
Basement wall above grade	236		23.60	Bast. modification factor (to account for lower temp. diff.)	1					
Floor over air	48		1.37							
Rim joists	118		4.92							
Window - New	20		4.00							
Window — existing	197		78.80							
Roof Plane	901		22.53							
Skylights	0		0.00							
Opague Door	21		10.50							
Glass Door	38		19.00	Total shell area	3,424					
		ACH-Natural								
INFILTRATION	0.57		231.55	Equiv. AU						
Ventilation (@ 75% eff.)			16.20							
AU Conduction Only	365.26									
AU Total	613.01	Btu/hr*deg F								
Design Heat Loss, BTU/Hr	42,911	Btu/hr		(Capacity of Heating System)						
Design Heat Loss, Kw	12.57									
Design heat loss per unit area	23.4	Btu/hr/sf								



Heat Loss Component Budget — PROPOSED Conditions

11-May-12

4 Amherst Road

Design Temperature Difference **70** deg F

BASED ON BLOWER DOOR TESTING- 2008

R VALUES

1/(Btu/hr*degF*sf)

Exterior Wall (4" stud cavity w/ fiberglass— settled)	33.00	Roof plane	40.00
Floor over air	35.00	Rim joists	24.00
Window — New	5.00	Skylights	1
Window — Existing	4.12	Opaque Door R Value	2.00
Slab edge	 	Glass Door R Value	2.00
VOLUME of Building	22568 cf (Est.)	Basement Wall R Value	10.00
		Floor area (nic basement)	1832 sf
		Ventilation system capacity	60 cfm

Before attic insulation and airsealing

ACH 50 11.23

After attic insulation and airsealing

3,000 cfm

ACH50 = 9.69

6.7 not including basement

ACH Nat = 0.57

CFM 50 = 2517

ELEMENT

AREA (s.f.) AU (Btu/hr*deg F)

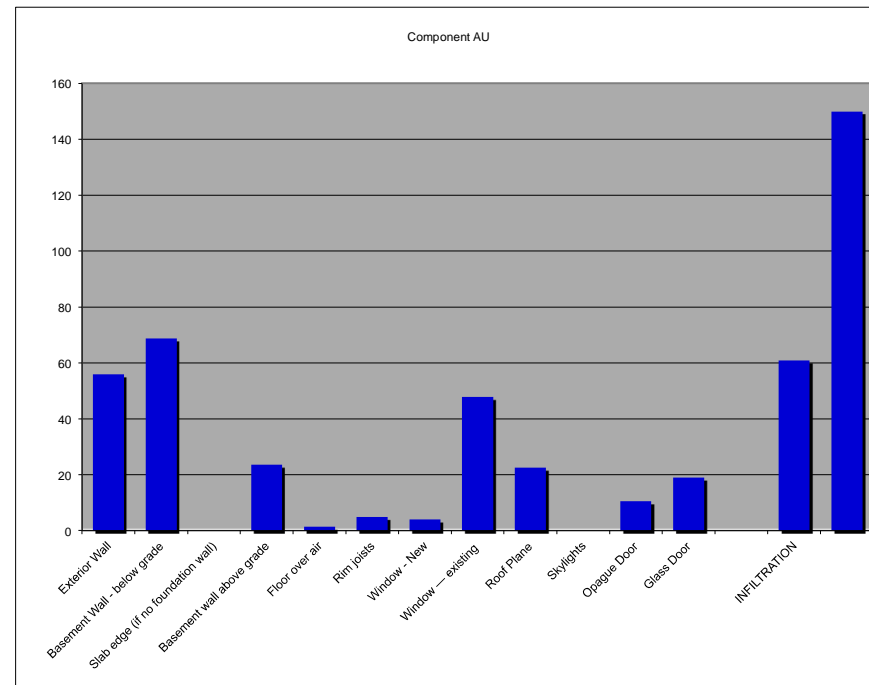
Exterior Wall	1,845	55.91	Slab edge perimeter	 linear ft
Basement Wall - below grade		68.76	Basement perimeter	116 linear ft
Slab edge (if no foundation wall)		0.00		
			Bast. modification factor (to account for lower temp. diff.)	1
Basement wall above grade	236	23.60		
Floor over air	48	1.37		
Rim joists	118	4.92		
Window - New	20	4.00		
Window — existing	197	47.82		
Roof Plane	901	22.53		
Skylights	0	0.00		
Opaque Door	21	10.50		
Glass Door	38	19.00		
			Total shell area	3,424

ACH-Natural

INFILTRATION **0.15** 60.93 Equiv. AU

Ventilation (@75% eff.) 16.20

AU Conduction Only	258.40
AU Total	335.53 Btu/hr*deg F
Design Heat Loss, BTU/Hr	23,487 Btu/hr (Capacity of Heating System)
Design Heat Loss, Kw	6.88



Design heat loss per unit area **12.8** Btu/hr/sf

Proposed Peak Heat Loss

2012- RENOVATION

- New shingle siding, 3” polyiso rigid insulation
- Triple glazed wood double hung windows, Marvin
- Renovate sleeping porch into Master Bathroom
- More insulation in attic- to R50

2013- 8,000 btu/hr Mitsubishi Heat Pump in living room

2014- 8,000 btu/hr Mitsubishi Heat Pump in master bedroom

2016- ???-

- More airsealing!
- Fix wall over porch done in 2008.
- Move mbr heat pump into kitchen, add ERV with integral heating and cooling capacity- *any products?*
- Finish front porch repairs and steps



Acer lived another year to greet the workers



West Side view-2015 (photo: Ethan Drinker Photography)



Yard side- 2015 after the renovation (photo: Ethan Drinker Photography)



East side entrance- 2013





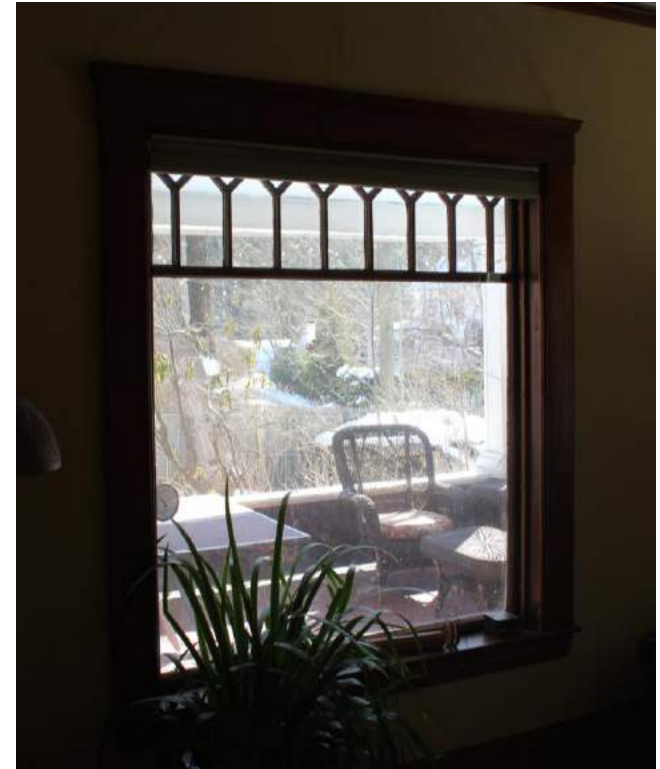
Front of house- now with Luna (photo: Ethan Drinker Photography)



Inside from the Dining Room (photo: Ethan Drinker Photography)

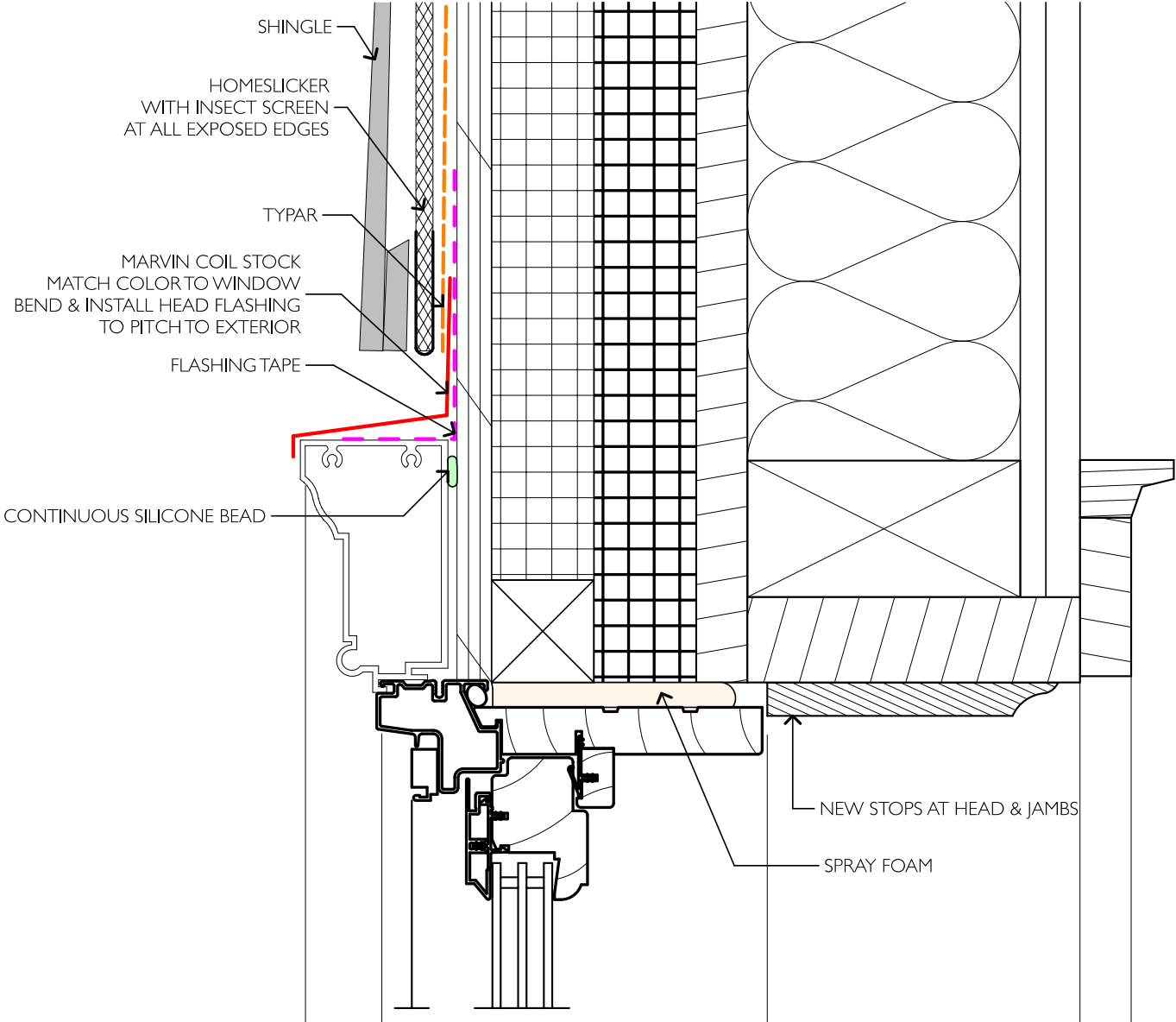


Inside from the Front Hall (photo: Ethan Drinker Photography)

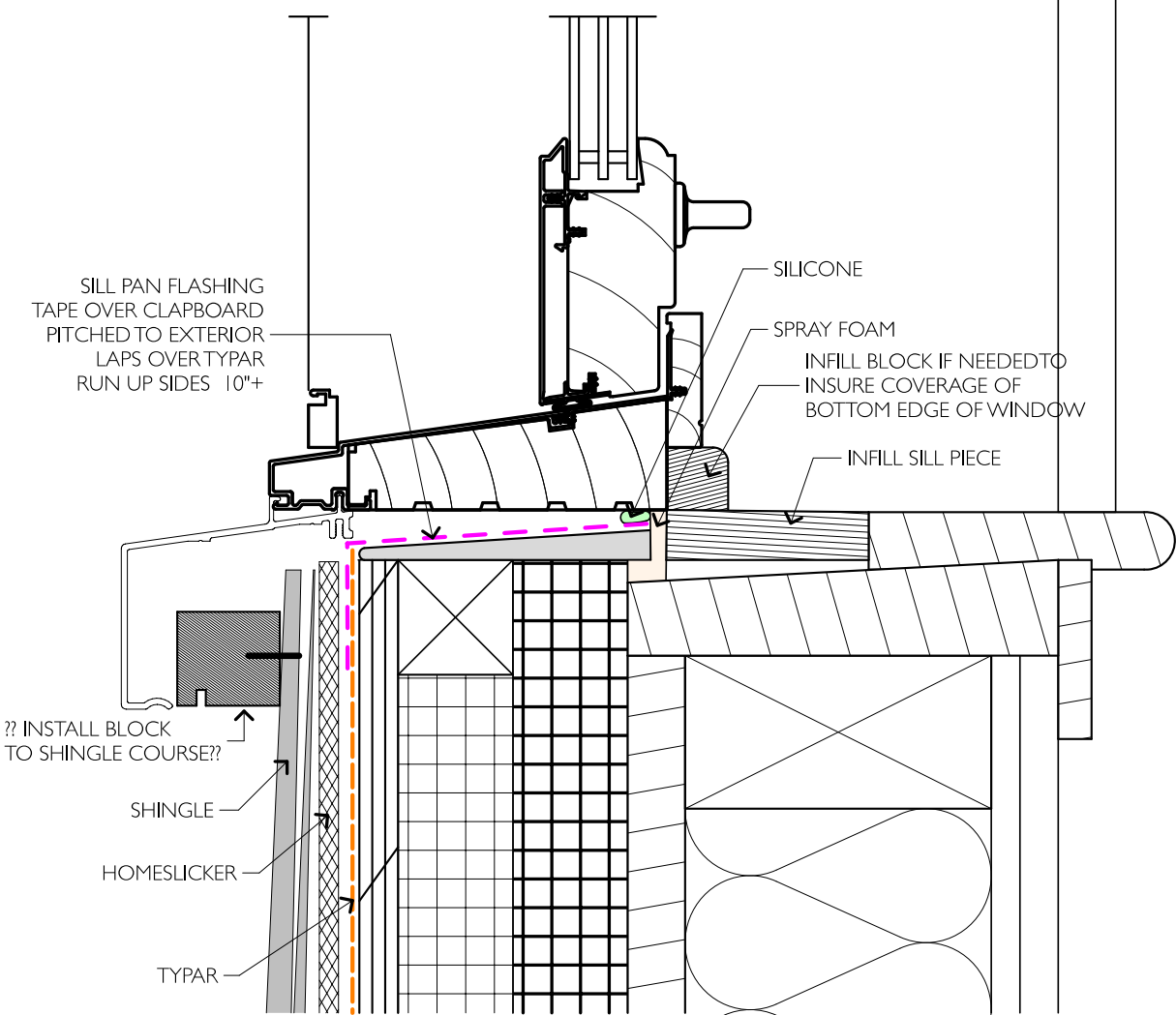


The front dormer windows were replaced in 2010, and given the complexity of redoing the roofing step flashing, I decided to only re-shingle and not add 3" of insulation here.

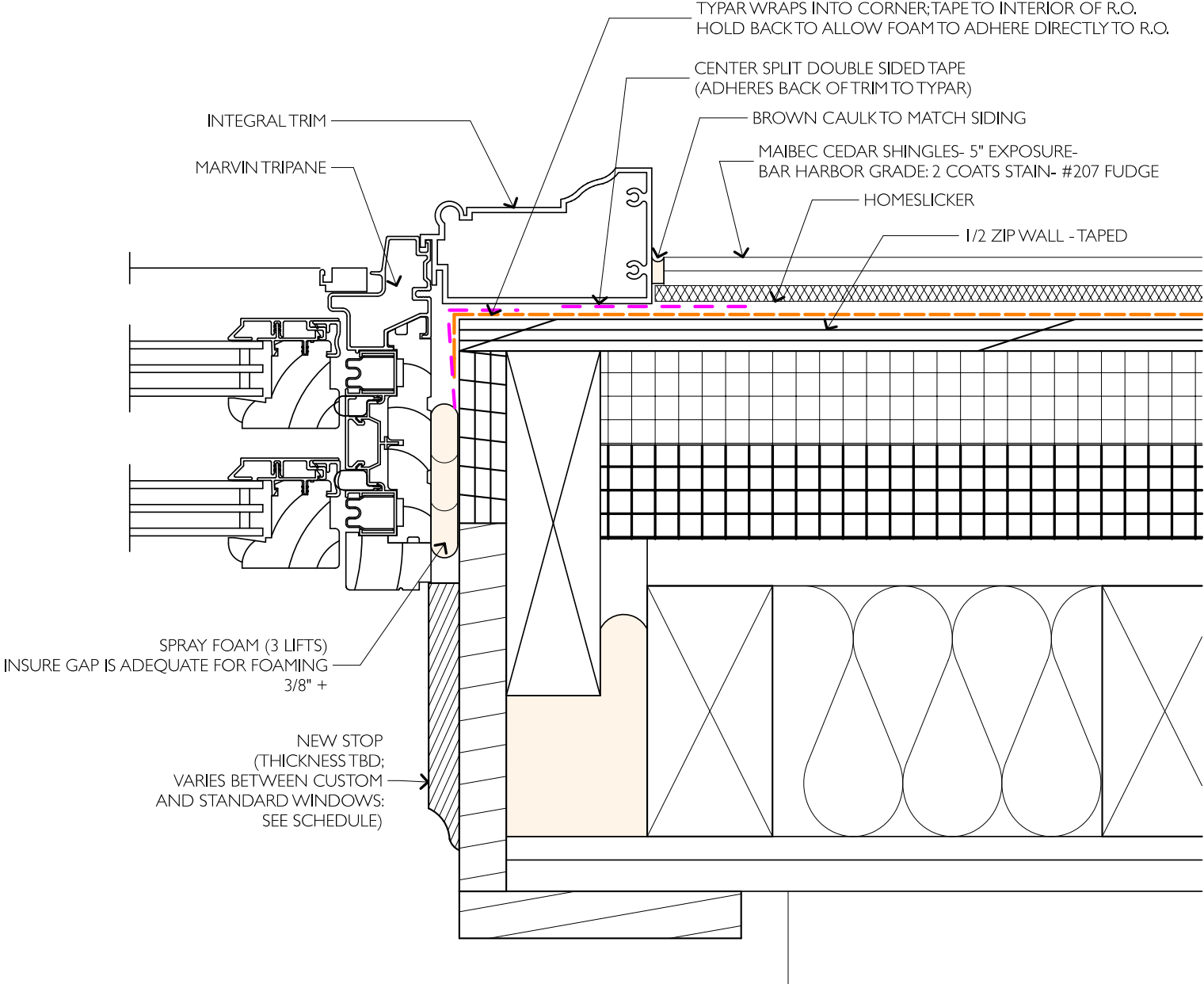
Two single glazed fixed accent windows were not replaced. Both received plexiglass storm windows on the exterior. The large picture window on the front received plexi on the interior as a safety concern. (Boys throw things).



6" = 1'-0"; HARTMAN HEAD



6" = 1'-0"; HARTMAN SILL

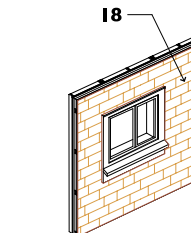
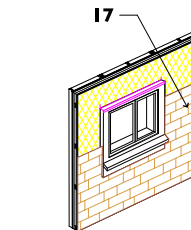
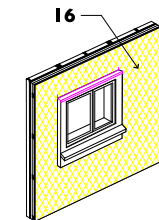
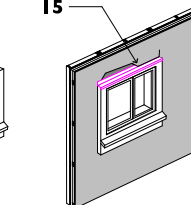
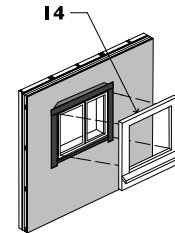
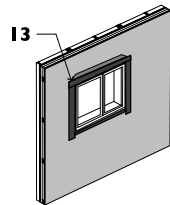
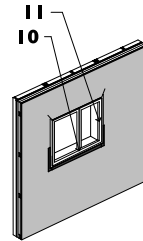
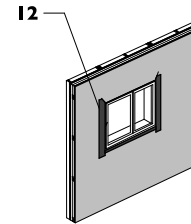
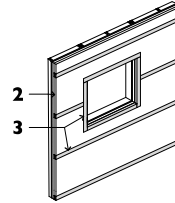
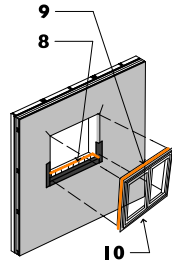
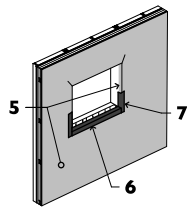
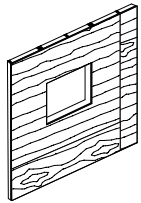


4 WHY TAPE?

WINDOW INSTALLATION SEQUENCE

STEP ONE, CUT A HOLE IN A BOX.

1. EXTERIOR SHEATHING TAPED FOR AIR BARRIER
2. INSTALL TWO LAYERS OF 1 1/2" EXTERIOR FOIL-FACED POLY-ISOCYANURATE FOAM.
3. INSTALL HORIZONTAL 2X3s IN THE PLANE OF THE OUTER FOAM LAYER AT 2'-0" O.C. & WINDOW OPENINGS
4. INSTALL OUTER PLYWOOD LAYER PERPENDICULAR TO HORIZONTAL STRAPPING.
5. INSTALL WEATHER RESISTIVE BARRIER (WRB), WRAP JAMBS AND SILL INTO R.O. 0'-1" ONLY. THIS WILL ALLOW THE WINDOW TO BE FOAMED DIRECTLY TO THE R.O. CUT & LEAVE THE TOP OF WRB UNATTACHED TO LAP OVER THE HEAD FLASHING.
6. INSTALL SILL PAN FLASHING TAPE OVER CEDAR CLAPBOARD PITCHED TO EXTERIOR.
7. SIDES - FLASH UP 10" WITH SELF ADHESIVE FLASHING - LAP SELF ADHESIVE FLASHING OVER "SILL PAN."
8. SILICONE CAULK SIDES & UPPER INSIDE EDGE OF SILL PAN TO CREATE WATER DAM
9. SILICONE CAULK BACK SIDE OF NAILING FLANGE ON SIDES AND TOPS ONLY.
10. SET WINDOW INTO R.O. SHIM PLUMB AND SQUARE. ATTACH NAILING FLANGE TO WINDOW STRAPPING
11. INSIDE - APPLY SPRAY FOAM TO GAP BETWEEN WINDOW AND R.O. WITH CONTINUOUS CONTACT TO BOTH. APPLY IN MULTIPLE LIFTS. BE CAREFUL NOT TO OVERSPRAY.
12. SIDES - TAPE FLANGES TO WRB W/ SELF ADHESIVE FLASHING. EXTEND THE SELF ADHESIVE FLASHING ABOVE THE TOP OF THE WINDOW.
13. HEAD - TAPE FLANGE TO SHEATHING BEHIND THE WRB W/ SELF ADHESIVE FLASHING.
14. INSTALL EXTERIOR WINDOW CASING.
15. INSTALL HEAD Z-FLASHING FROM OUTER SHEATHING TO HEAD CASING, LEAVING A 1' EXTENSION ON EACH SIDE. TAPE FLASHING WITH PEEL AND STICK. LAY WRB OVER FLASHING.
16. INSTALL HOMESLICKER TO WALL.
17. INSTALL SHINGLE SIDING
18. INVITE NOR'EASTER OVER FOR DINNER







Window detail



Thickened wall

XXX



Old growth red cedar
Dipped in creosote

10-12" wide



Amazing shingles- keep front porch??



Front porch unchanged- restrained



Storm windows salvaged for re-use and window weights to scrap metal



Old shingles go to the dump- salvaged from bathroom for garage





Second Layer of Polyiso







Old sleeping porch becomes a M Bath



New Master Bathroom- Frankly the BEST benefit!





Minimal disruption- sashes stay in place until new unit installed





These guys are fast!



Maintain existing trim, but with reduced glazing area - ☹️



House wrap and home slicker, casings look great.



Pre-stained shingles to match original going on



Break metal flashing sealed to foundation wall to protect foam



Heat pump mockup- 36 hrs to notice



Blower door testing

1st test series- 2006, little work done- just the BIG holes
3,026 cfm, 8.3 ACH50, 0.58 cfm50/sfs

2nd test series- 2008, post attic and basement work
2,517 cfm, 6.9 ACH50, 0.48 cfm50/sfs

3rd test series- 2013, post renovation
1,450 cfm, 4.0ACH50, 0.28 cfm50/sfs
note: boiler and chimney flue not taped off

NOT GREAT



		Oil consumption 4 Amherst Road																				
		Volume- c.f 1 ACH	21845 364	Shell area- s.f.		5225	sf		meters		conditioned area		0.0929			180.8						
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015						
gallons oil	gallons of delivered oil	580	725	859	837	721	498	593	424	484	438	369	316	175	75	50	last two are used, not delivered					
oil in kbtu		138.8	80,504	100,630	119,229	116,176	100,075	69,122	82,308	58,851	67,179	60,794	51,217	43,861	24,290	10,410	6,940					
	electric total consumed	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015						
total in kbtu		3.412	11,942	11,942	11,942	11,942	11,942	11,942	12,461	12,873	10,622	13,484	16,743	15,402	18,623	21,015	27,804					
	net electricity import	<i>estimated</i>					3500	3500	3500	3500	3500	3500	1,359	1,335	1,194	1,337	981	-1,019	227	2,883	3,992	Note, this includes pv used on site
net in kbtu	produced	3.412	11,942	11,942	11,942	11,942	11,942	11,942	4,637	4,555	4,074	4,562	3,347	-3,477	775	9,837	13,621					
consumed total kbtu		92,446	112,572	131,171	128,118	112,017	81,064	94,769	71,725	77,801	74,279	67,960	59,263	42,913	31,425	34,744						
net total kbtu		92,446	112,572	131,171	128,118	112,017	81,064	86,945	63,406	71,253	65,356	54,564	40,384	25,065	20,247	20,561						
	consumed EUJ- kbtu	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017				
	net EUJ- kbtu/sf/year	47.5	57.8	67.4	65.8	57.6	41.7	48.7	36.9	40.0	38.2	34.9	30.5	22.1	16.1	17.9						
		47.5	57.8	67.4	65.8	57.6	41.7	44.7	32.6	36.6	33.6	28.0	20.8	12.9	10.4	10.6						
convert		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015						
	1.1Source-oil	88,554	110,693	131,152	127,793	110,082	76,035	90,539	64,736	73,897	66,874	56,339	48,247	26,719	11,451	7,634						
	3.16Source-Electricity	37,737	37,737	37,737	37,737	37,737	37,737	39,376	40,680	33,564	42,610	52,907	48,670	58,848	66,406	87,862						
	20000Wood in kbtu per chord	10,000	10,000	10,000	10,000	10,000	15,000	5,000	5,000	5,000	5,000	2,000	2,000	2,000	2,000	1,000						
	TOTAL	136,291	158,430	178,889	175,530	157,819	128,771	134,915	110,417	112,461	114,484	111,246	98,916	87,567	79,857	96,496						
	Per person	68,146	52,810	59,630	58,510	39,455	32,193	33,729	27,604	28,115	28,621	27,811	24,729	21,892	19,964	24,124						
	3.412Total source energy in Kwh	39,945	46,433	52,429	51,445	46,254	37,741	39,541	32,361	32,961	33,553	32,604	28,991	25,664	23,405	28,281						
120 kwh/m2	old Passive haus standard	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694	21,694						
	Source kwh/person	19,972	15,478	17,476	17,148	11,564	9,435	9,885	8,090	8,240	8,388	8,151	7,248	6,416	5,851	7,070						
	PH per person-6200 kwh	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200	6200						
	Chords	0.50	0.50	0.50	0.50	0.50	0.75	0.25	0.25	0.25	0.25	0.10	0.10	0.10	0.10	0.05						
	People	2	3	3	3	4	4	4	4	4	4	4	4	4	4	4						





Water heater Heat Pump Metering

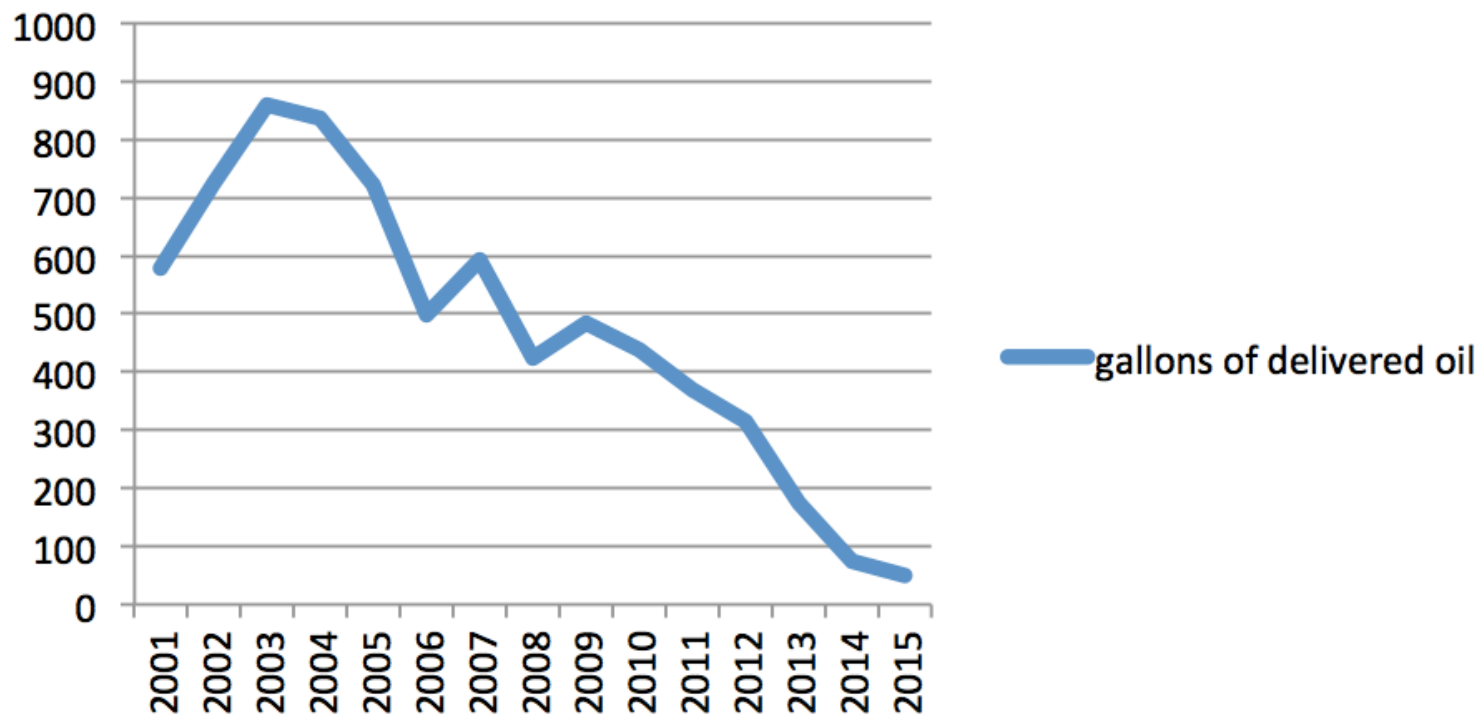


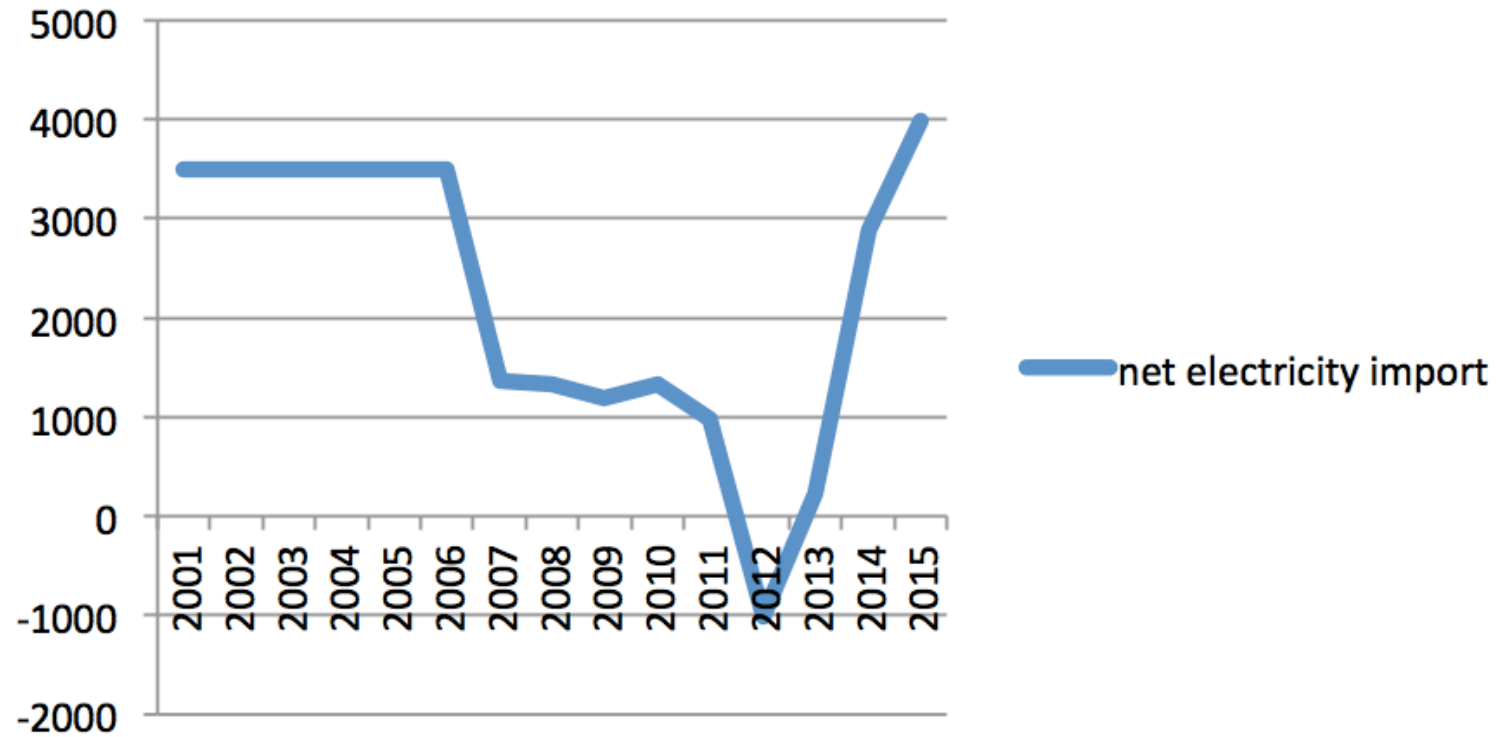
Heat Pump Metering

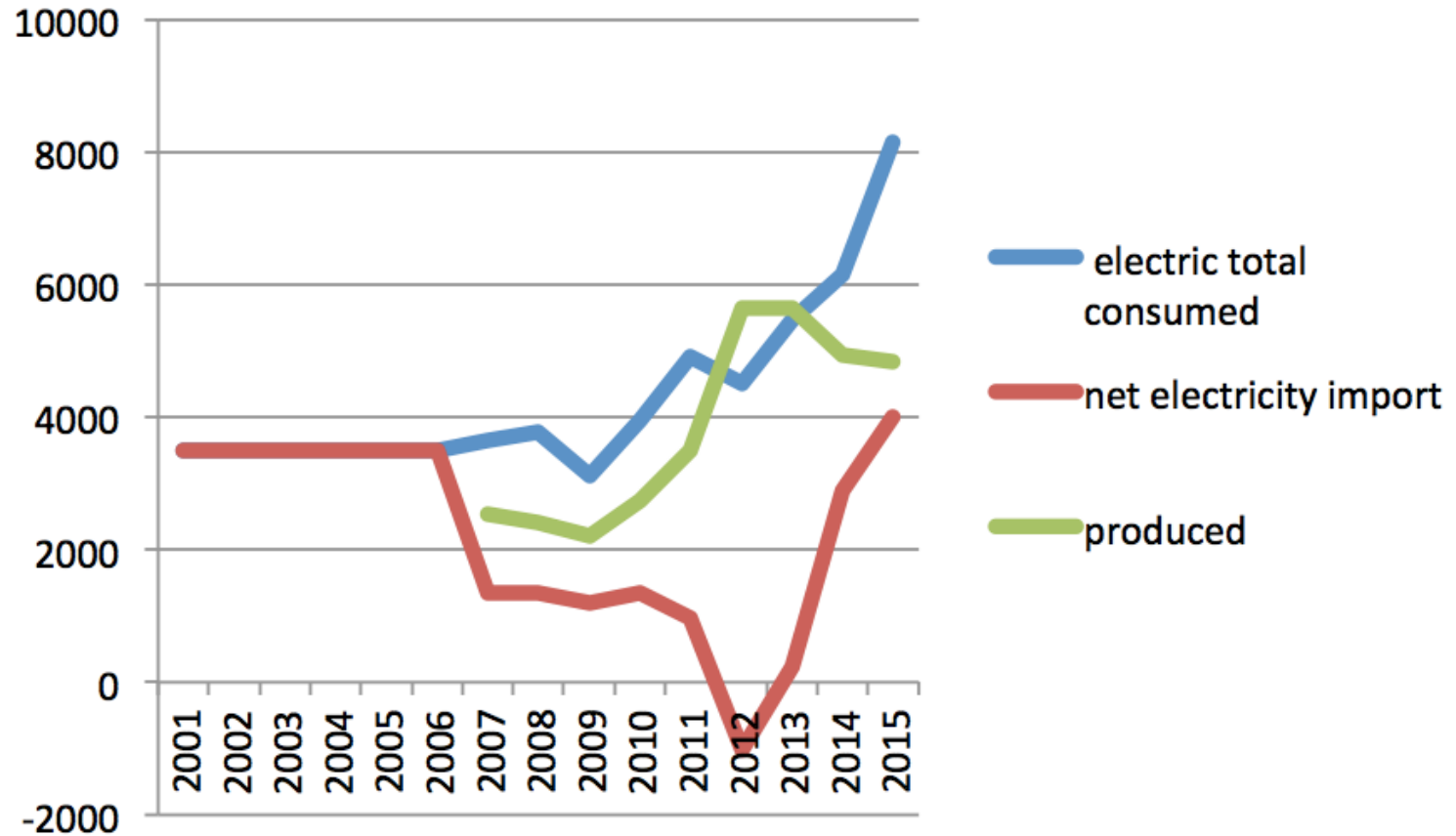


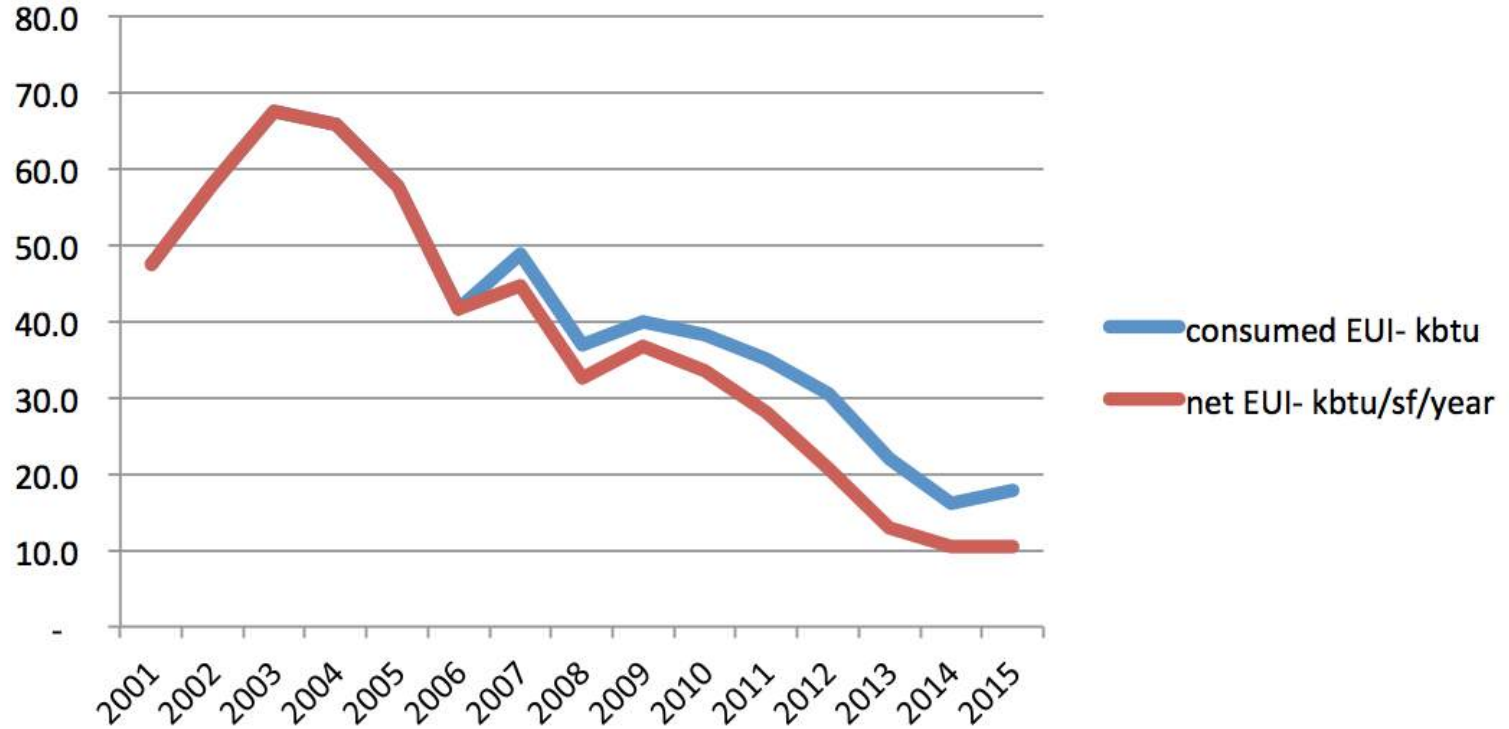
Hot Water Metering- flow meter on cold inlet

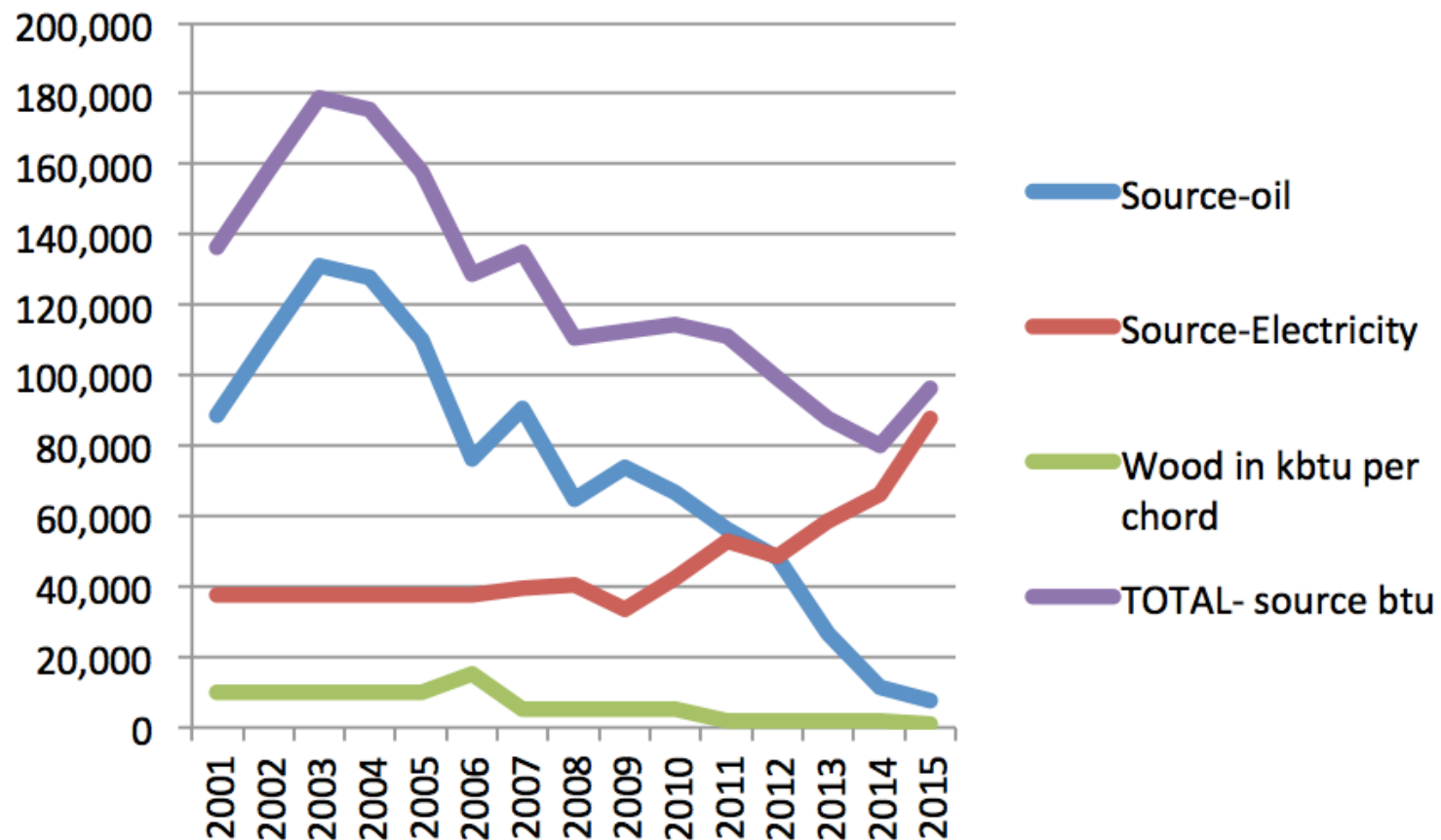
gallons of delivered oil

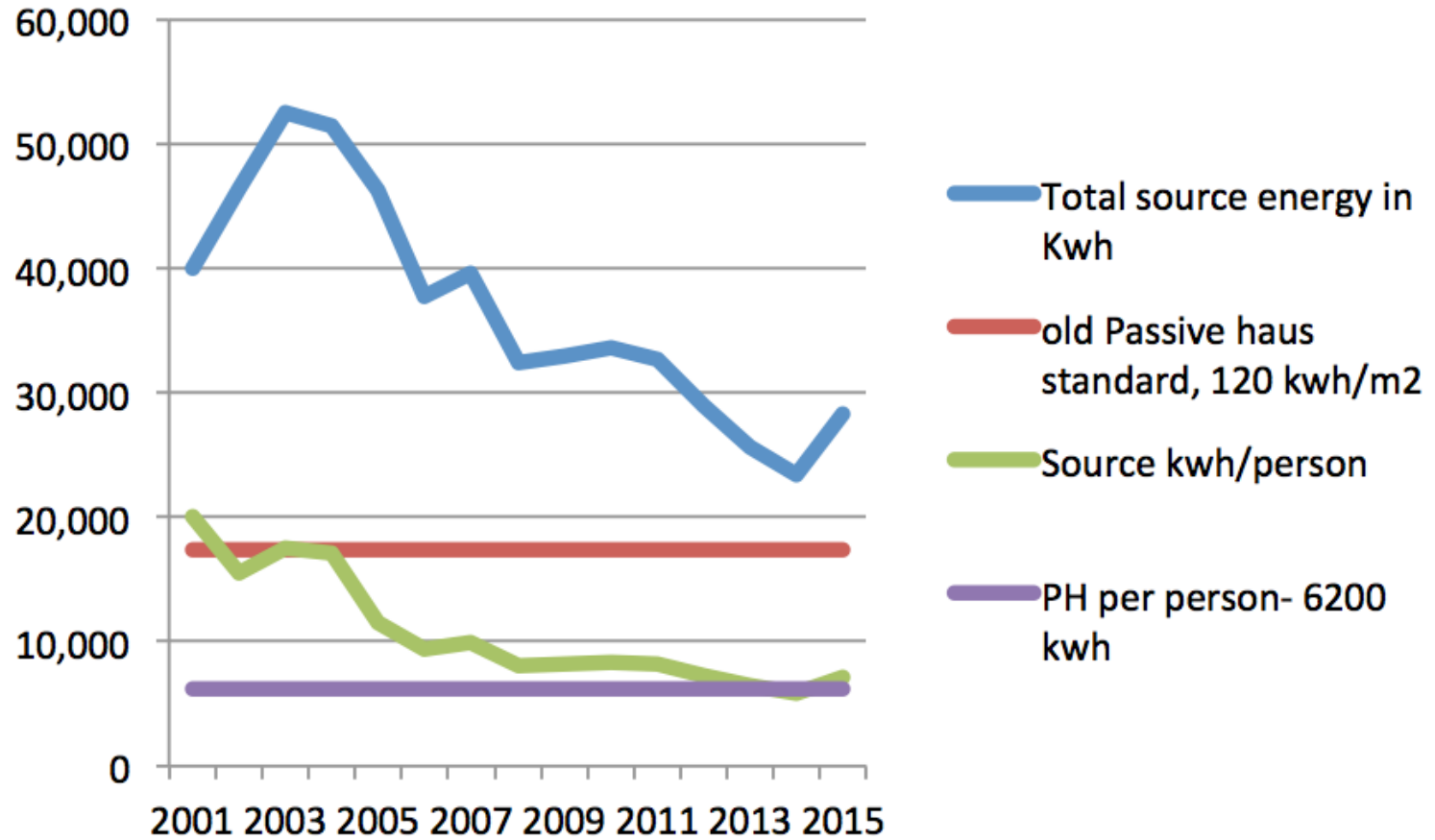












What did the project cost? WHICH PART?

Purchased house in 2000 for \$145k (bought deferred maintenance too!)
Replaced boiler right away as term of sale. \$15k.

Attic and basement insulation in 2004 was paid for with sweat, barter and tax refund from President W- about \$3k.

First PV system was \$21k with grant and tax credits offsetting the cost.

Second PV system and HPWH was about \$26k and offset by small tax credit and SREC's. Free dehumidification in the summer a bonus.

Exterior insulation, windows and new master bathroom was about \$120k, but we budgeted \$100k (The bathroom was \$20k). We refinanced our mortgage from 5% to 3.25% and the payment remained the same, and our fuel costs went down. We owe about \$100k now after having the mortgage balance down to \$40k in 2012.

Two heat pumps added were \$5k total with \$1k rebate. More to come...

What would I do differently and what do I have to fix now?

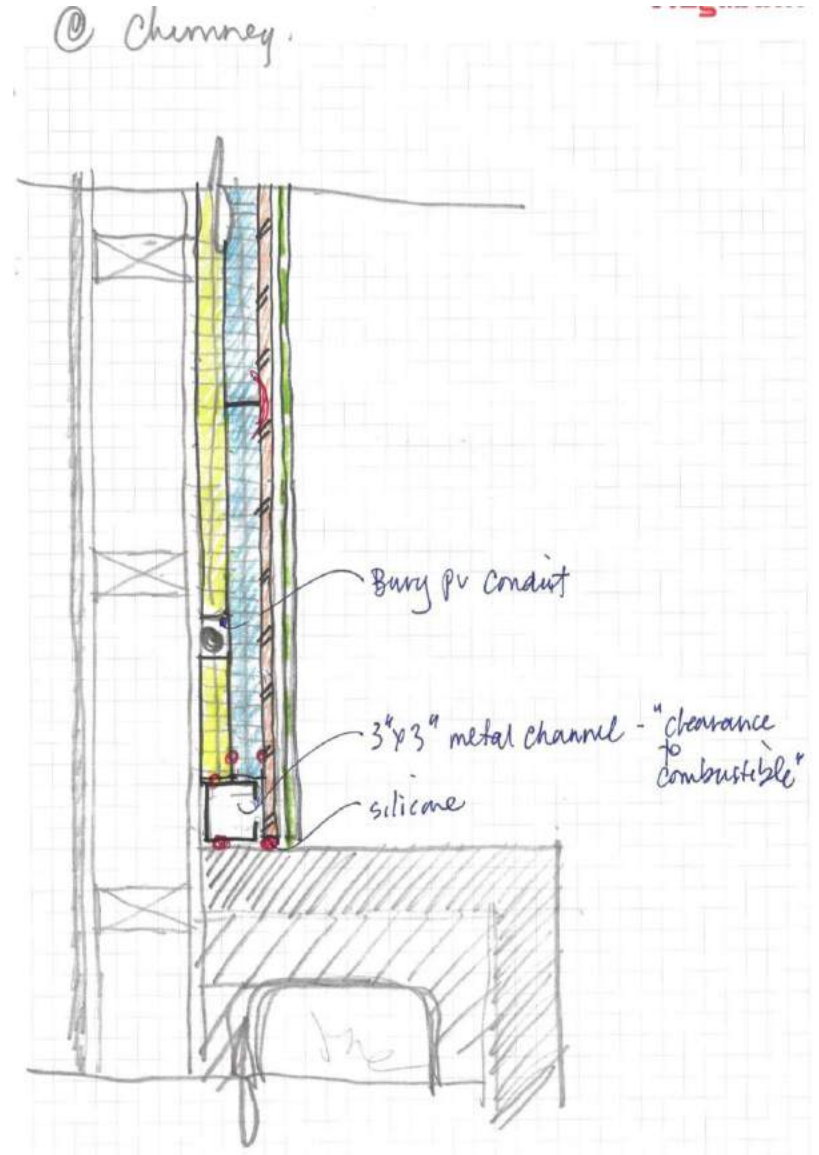
1. Use flash spray of closed cell foam on the attic lathe before adding loose fill insulation. The plaster is cracked and not the best air barrier.
1. Install better insulation over porch by framing a cavity and installing taped plywood rather than just netting. Mice get in. This will be done shortly and I had the plywood put up there before the siding went back on.
1. Use medium density close cell rather than icynene on the band joist in the basement.
1. Do a better job on the underside of the back bump out with a plywood enclosure. Probably won't get fixed.
1. Have more money, do it all at once when no one is living here.
1. Think more about how the transition at the chimney happens. There's a wee problem developing...



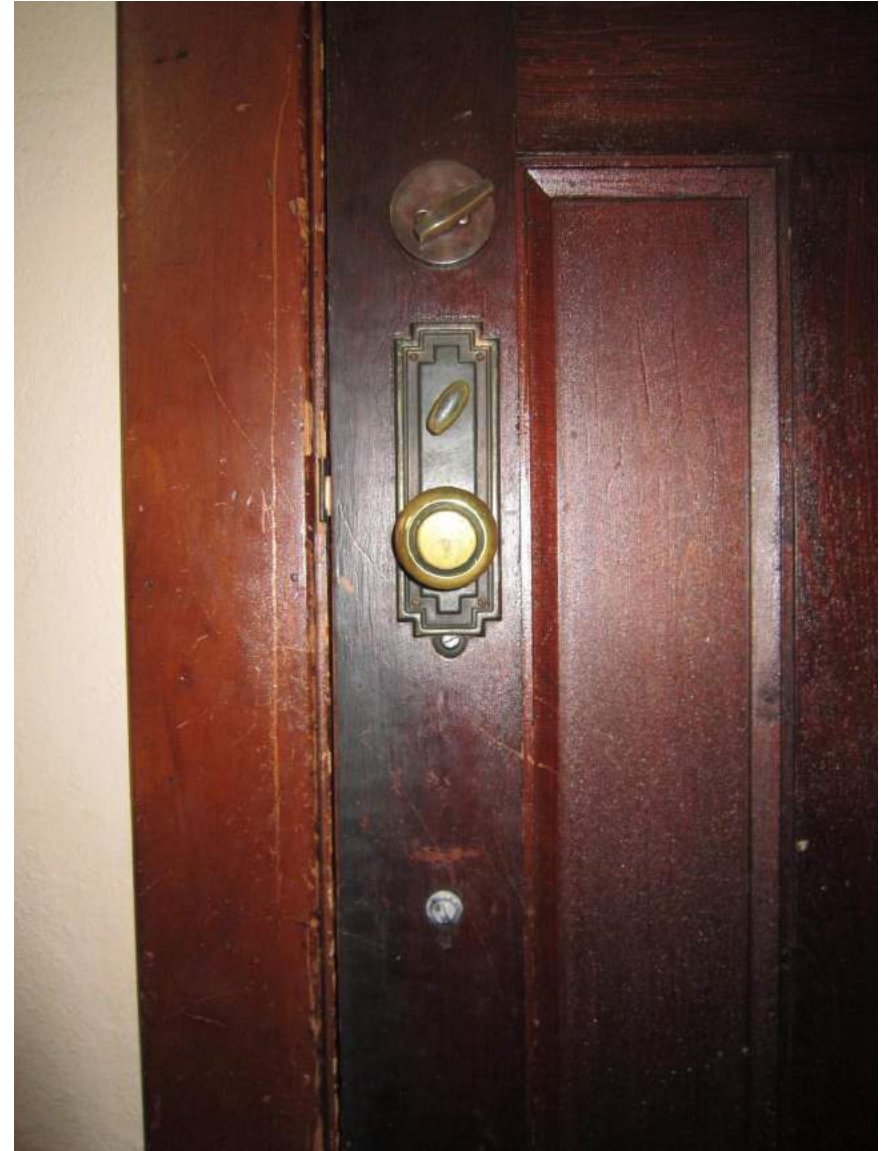
Chimney problem



Chimney problem



Chimney problem- triscuit not a wheat thin at board sheathing



Thermal bridging at the front door- FROST-new storm needed

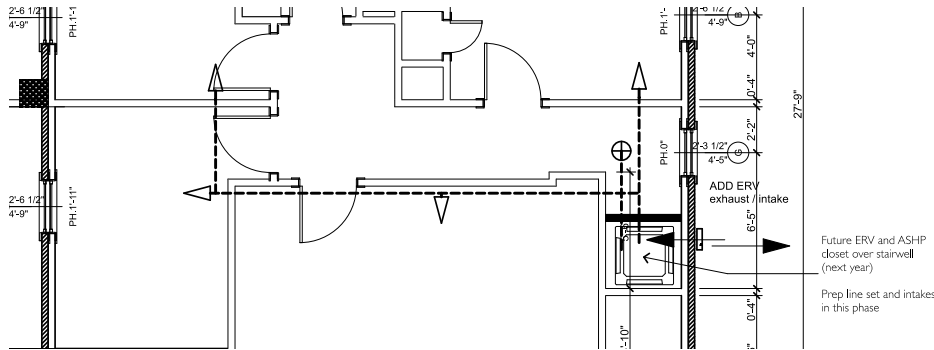
Radon level in the basement is high- about 12 pCi/L
There is a concrete slab which is cracked in several location
And no insulation underneath. FIX with epoxy paint to seal.

Multiple tests on ground floor- before and after renovation show
on average 1.5 pCi/L

Second floor is 1.0 pCi/L

Front porch (OUTSIDE) is 1.0 pCi/L as the house is built on fill
blasted from hill on the other side of the road.

EPA accepts ERV as a solution for radon mitigation.



Next step- add ERV above stairwell and another heat pump to get off.

Questions?

Thank you.