Balancing Your Energy Investments When Funds Are Limited

John Rahill, Black River Design Architects

Bissell Residence
East Montpelier, VT

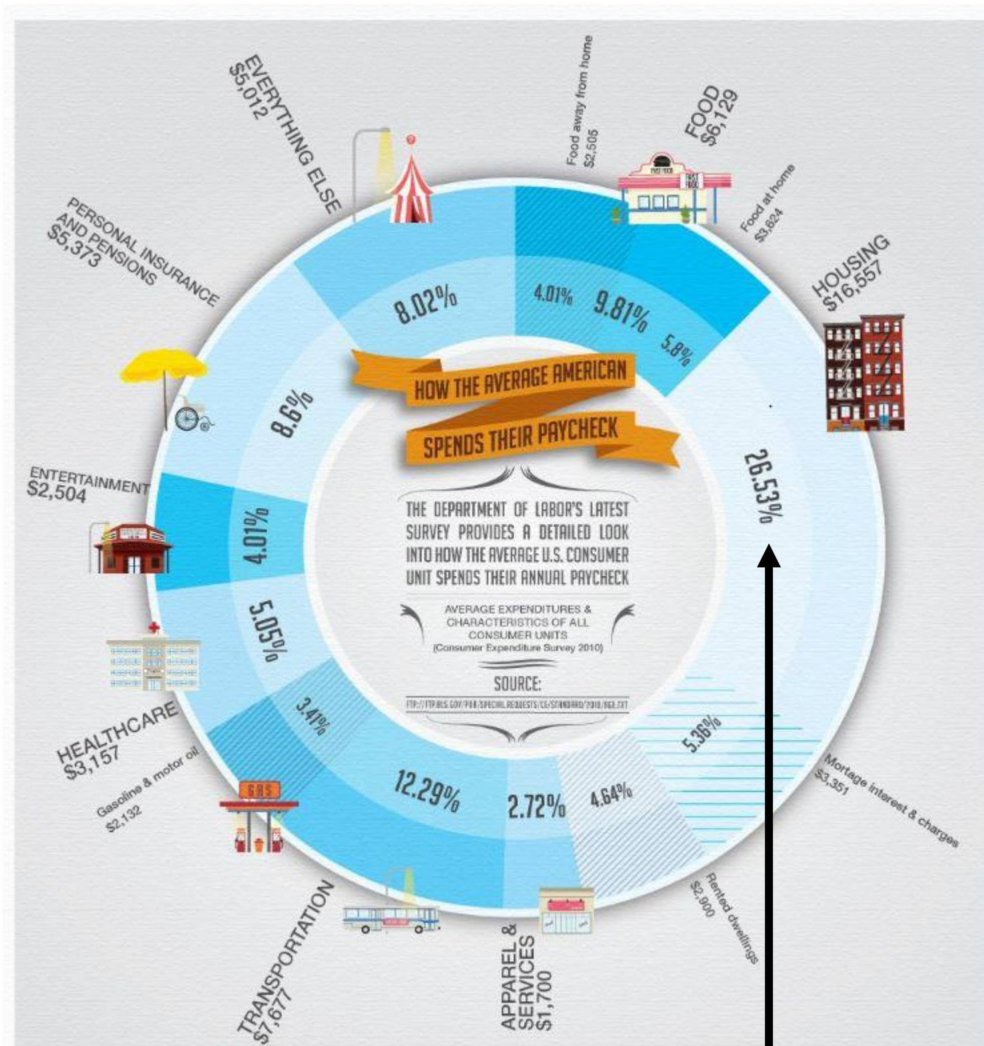
Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)
Foundation foot wall/under slab insul.													
Base	R-10	2" xps	3791	$ 1.05	$ 0.26	$ 4,966.21		10.50			$269.75		
1	R-15	3" xps (additional 1" thickness)	3791	$ 1.49	$ 0.26	6,634.25	$1,6[illegible]04	8.40	2.10	$ 794.30	$215.80	$53.95	30.9
	R-20	4"	[illegible]	$ [illegible]	[illegible]	[illegible]2.42	[illegible]	[illegible]	[illegible]	$ [illegible]	[illegible]	$69.36	47.5
	R-25	5"	3791	$ 2.54	$ 0.52	$ 11,600.46	$1,668.04	4.90	0.80	$ 2,085.05	$125.88	$20.55	81.2
2	R-30	6"	3791	$ 3.00	$ 0.52	$ 13,344.32	$1,743.86	4.30	0.60	$ 2,906.43	$110.47	$15.41	113.1
Above grade walls													
	R-13	2x4 Dense Pak in Cavity	2279	$ 0.17	$ 0.37	$ 1,230.66		20.00			$667.94		
	R-20	2x6 Dense Pak in Cavity	2279	$ 0.28	$ 0.46	$ 1,686.46		17.70			$454.71		
Base	R-13	2" ISO	2279	$ 1.05	$ 0.50	$ 3,532.45	$0.00	17.50	0.00		$449.58		
	R-19.5	3" ISO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	$357.09	$92.48	16.5
1	R-26	4" ISO	2279	$ 2.10	$ 1.00	$ 7,064.90	$2,005.52	10.00	3.90	$ 514.24	$256.90	$100.19	20.0
	R-32.5	5" ISO	2279	$ 2.77	$ 1.00	$ 8,591.83	$1,526.93	8.30	1.70	$ 898.19	$213.23	$43.67	35.0
2	R-39	6" ISO	2279	$ 3.44	$ 1.00	$ 10,118.76	$1,526.93	7.20	1.10	$ 1,388.12	$184.97	$28.26	54.0
Adding Rigid Polyiso to Cavity Insulation													
2	R-41	R26+R13(2x4 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,295.56	$7,064.90	7.90	18.10	$ 390.33	$202.95	$464.99	15.2
2	R-47	R-26 +R19(2x6 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,751.36	$7,064.90	7.00	10.70	$ 660.27	$179.83	$274.88	25.7
Adding Cavity Insulation to Rigid Polyiso													
2	R-41	R26+R13(4" ISO and 2x4 cavity)	2279	$ 0.17	$ 0.37	$8,295.56	$1,230.66	7.90	2.10	$ 586.03	$202.95	$53.95	22.8
2	R-47	R-26 +R19(4" ISO and 2x6 cavity)	2279	$ 0.28	$ 0.46	$8,751.36	$1,686.46	7.00	3.00	$ 562.15	$179.83	$77.07	21.9
Adding a second wall to the R-13 2x4 Dense Pak in Cavity Wall													
2	R-40	Double stud Wall 11 1/2"	2279		$ 5.20	$ 11,850.80	$ 10,620.14	7.70	10.00	$ 1,016.43	$197.81	$256.90	41.3

The title should be:

How to design an energy efficient building, responsibly

- *Introduction – Much has changed in the last 40 years*
- *Why is energy savings important?*
- *History of sustainable/green building*
    - *Phase 1 – Energy generation phase*
    - *Phase 2 – Energy savings phase*
    - *Phase 3 – Mature phase*
- *What is a good investment?*
- *Methodology for balancing energy investments*
- *Summary*

How Americans spent their income in 2010:



Housing is our greatest expense

Annual Load(MMBtu/yr)	UDRH
Heating	52.7
Cooling	0.0
Water Heating	10.1
Water Heating w/out Tank Loss	6.3

Annual Consumption(MMBtu/yr)	
Heating	63.9
Cooling	0.0
Water Heating	12.1
Lights & Appliances	16.7
Photovoltaics	-0.0
Total	**92.7**

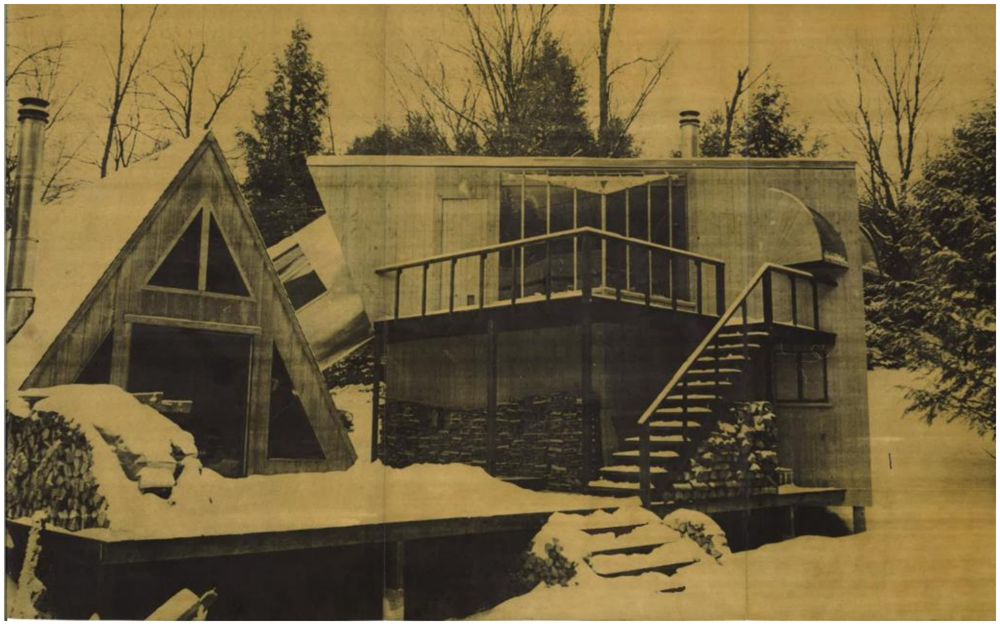
Annual Energy Cost ($/yr)	
Heating	1714
Cooling	0
Water Heating	318
Lights & Appliances	862
Photovoltaics	-0
Service Charges	147
Total	**3041**

Design Loads (kBtu/hr)	
Space Heating	24.9
Space Cooling	0.0

Utility Rates	
Electricity	WEC 4/16
Propane	LP, $2.41, 4/16

In New England, we are heating driven

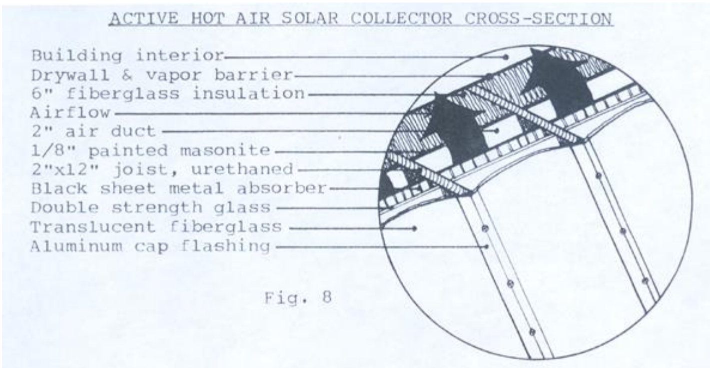
1970's – Lots of exciting stuff going on in Vermont

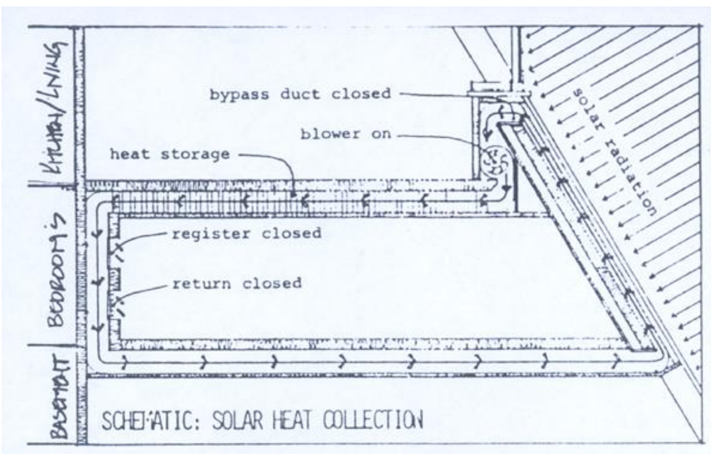


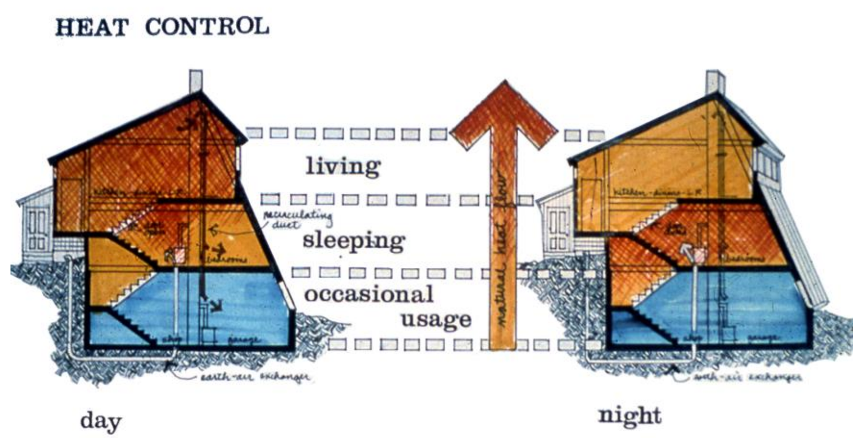
Solar, but…

Solar Alternatives: Flush mounted, integrated, domestic hot-water panels - elegant

Phase 1: Sustainable meant Solar

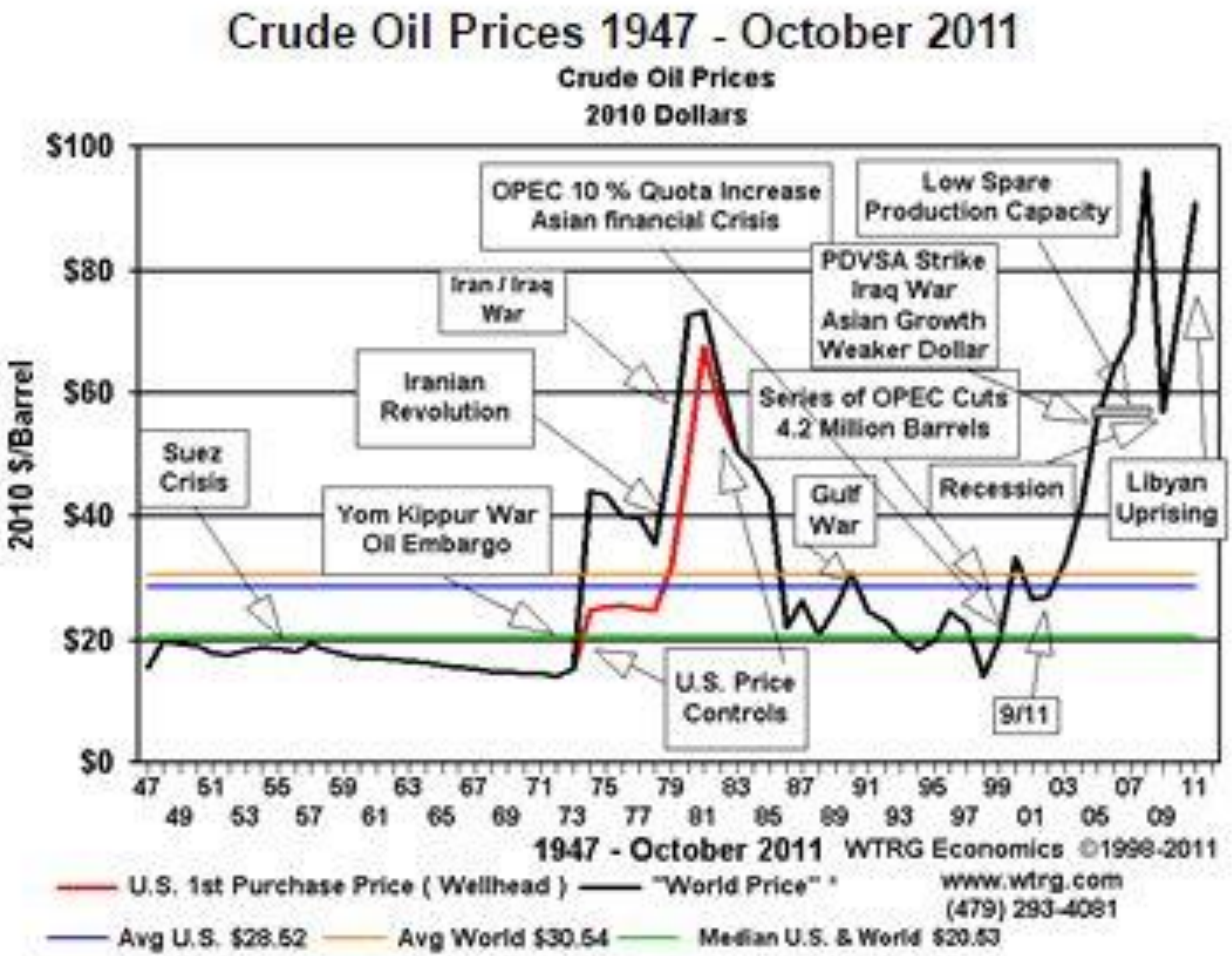






1973 Hood House

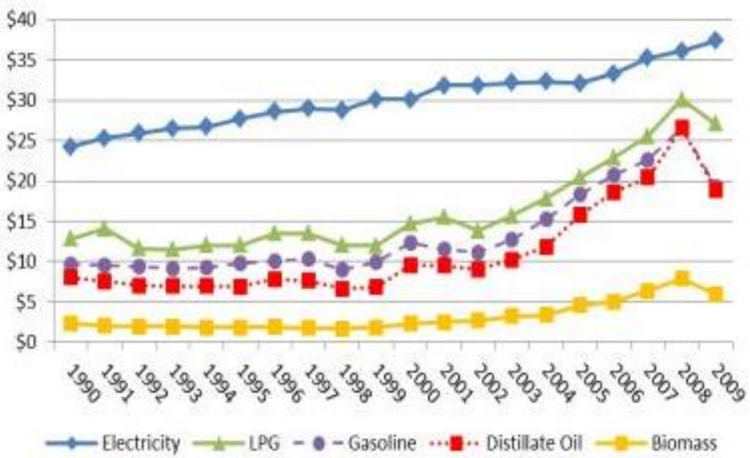
Near Net Zero, but…

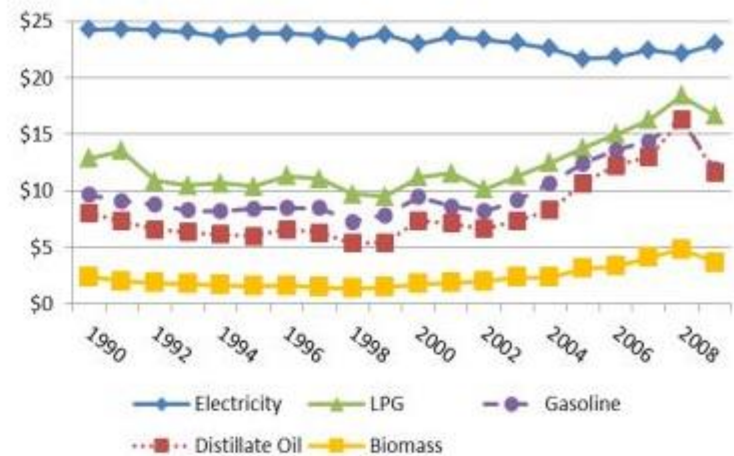


Oil prices were predicted to rise significantly in the 1970's

Energy Costs

Energy Source Prices ($ /million BTU & inflation-adjusted 1990 $ /million BTU)





Electricity is the highest priced energy source, yet costs have risen less than the rate of inflation (US CPI). Gasoline and distillates prices have outpaced inflation.

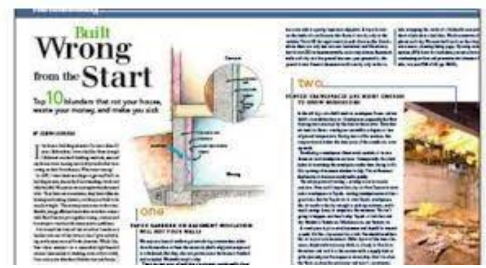
VERMONT
DEPARTMENT OF PUBLIC SERVICE

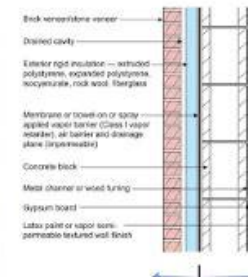
Use of electricity for heating was a bad idea, discouraged

Phase 2: Many changes since the early days

- Building Science appears:
  - Independent
  - Critical
  - Science was involved in analysis of failures
  - Understanding of what works, what doesn't work, and why
- Energy modeling becomes available
- Focus on improving the envelope, rather than depending on a renewable (solar) energy source


The Future of Framing Is Here


Built Wrong from the Start



"More is better"

More insulation leads to moisture problems

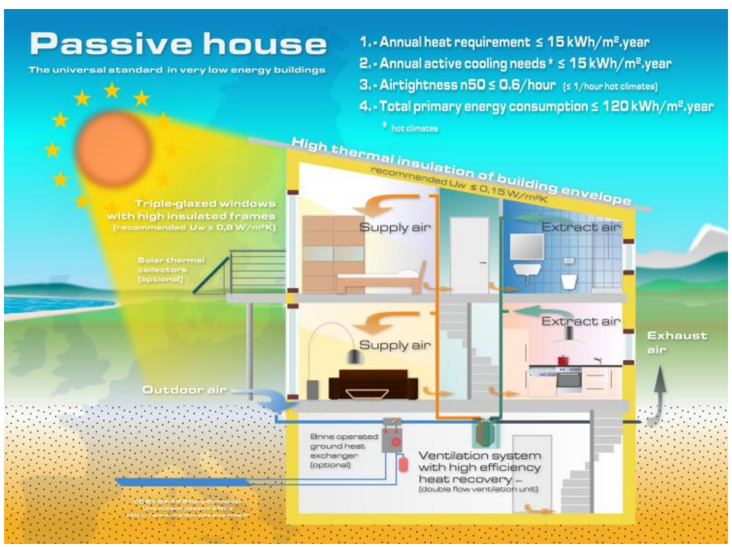
WUFI software predicts moisture behavior

Phase 3: “Mature” phase

Technology has changed

Wall mounted heat pump

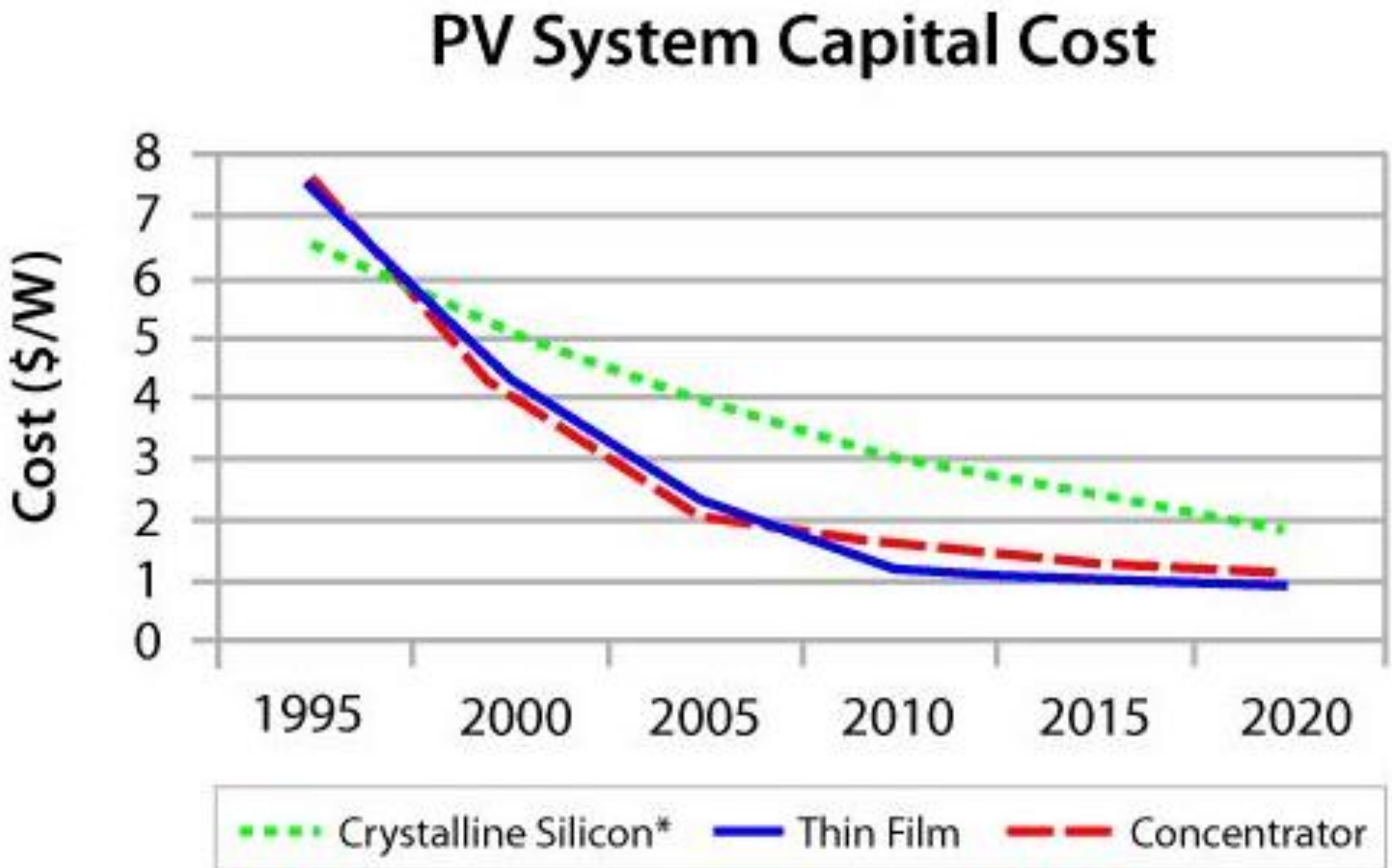
DHW heat pump



Passive House: Technologically feasible

Split system heat pump

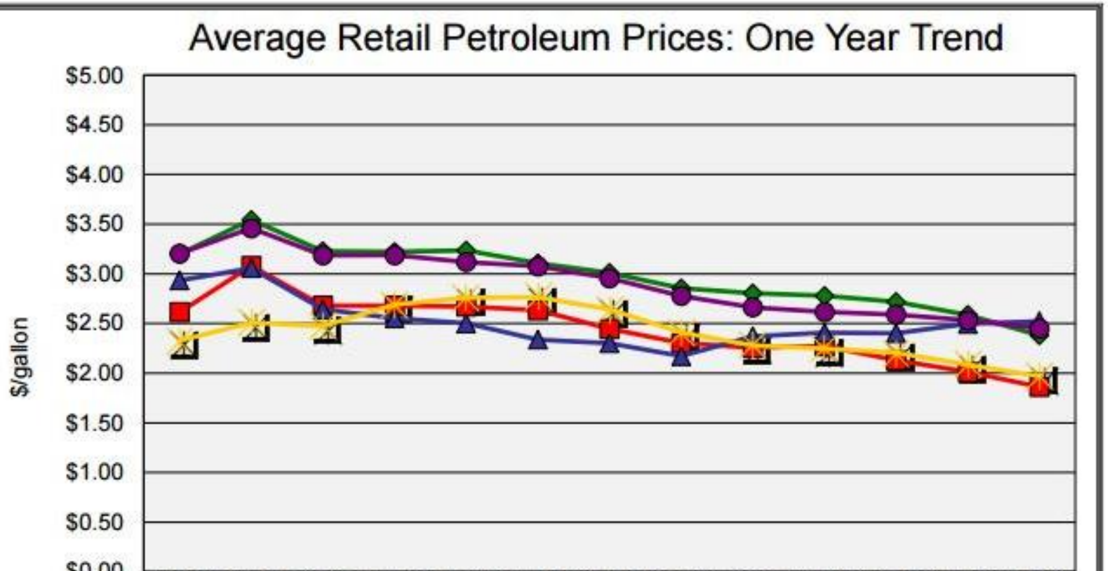
Phase 3: “Mature” phase



Amon Han, “Efficiency Of Solar PV, Then, Now And Future” https://sites.lafayette.edu/egrs352-sp14-pv/

PV cost continues to fall

Fuel costs have been dropping recently



	Feb '15	Mar '15	Apr '15	May '15	June '15	July '15	Aug '15	Sept '15	Oct '15	Nov '15	Dec '15	Jan' 16	Feb' 16
Fuel Oil #2	$2.61	$3.08	$2.68	$2.68	$2.67	$2.63	$2.45	$2.30	$2.26	$2.27	$2.13	$2.01	$1.86
Kerosene	$3.20	$3.54	$3.23	$3.22	$3.24	$3.11	$3.01	$2.85	$2.80	$2.78	$2.72	$2.59	$2.38
Propane	$2.93	$3.06	$2.64	$2.55	$2.50	$2.34	$2.30	$2.17	$2.37	$2.41	$2.40	$2.50	$2.52
Gasoline	$2.33	$2.51	$2.47	$2.69	$2.76	$2.77	$2.64	$2.41	$2.28	$2.25	$2.21	$2.09	$1.97
Diesel	$3.21	$3.46	$3.19	$3.19	$3.12	$3.08	$2.96	$2.78	$2.66	$2.62	$2.59	$2.53	$2.45

Vermont Fuel Report, 2016

Average Retail Petroleum Prices ($ per gallon)					
	Feb' 16	Jan' 16	% Change	Feb '15	% Change
No. 2 Fuel Oil	$1.86	$2.01	-7.4%	$2.61	-28.8%
Kerosene	$2.38	$2.59	-8.0%	$3.20	-25.6%
Propane	$2.52	$2.50	1.1%	$2.93	-14.0%
Reg. Unleaded Gasoline	$1.97	$2.09	-5.7%	$2.33	-15.5%
Diesel	$2.45	$2.53	-3.2%	$3.21	-23.5%

Vermont Fuel Price Report

November 2016

Comparing the Cost of Heating Fuels

Type of Energy	BTU/unit	Typical Efficiency	$/unit	$/MMBtu	High Efficiency	$/MMBtu
Fuel Oil, gallon	138,200	80%	$2.23	$20.14		
Kerosene, gallon	136,600	80%	$2.80	$25.65		
Propane, gallon	91,600	80%	$2.54	$34.64		
Natural Gas, Ccf	100,000	80%	$1.41	$17.67 *		
Electricity, kWh (resistive)	3,412	100%	$0.15	$43.46		
Electricity, kWh (heat pump)	3,412		$0.15	#		
Wood, cord (green)	22,000,000	60%	$227	$17.21 ^		
Pellets, ton	16,400,000	80%	$275	$20.96 ^		

* Natural Gas price is based on VGS residential rate effective Aug 5th, 2016.

see October 2015 Fuel Price Report for discussion of heat pump coefficient of performance

^ Cord Wood price updated 8/2015 from small survey sample. Pellet price updated 5/2016 from small survey sample

Vermont Fuel Report, 2016

Electric heating is no longer a "crazy" option

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Fuel Oil, gallon	138,200	80%	$2.23	$20.14		95%	$16.96
Kerosene, gallon	136,600	80%	$2.80	$25.65			
Propane, gallon	91,600	80%	$2.54	$34.64		95%	$29.17
Natural Gas, Ccf	100,000	80%	$1.41	$17.67	*	95%	$14.88
Electricity, kWh (resistive)	3,412	100%	$0.15	$43.46			
Electricity, kWh (heat pump)	3,412		$0.15		#	240%	$18.32
Wood, cord (green)	22,000,000	60%	$227	$17.21	^		
Pellets, ton	16,400,000	80%	$275	$20.96	^		

* Natural Gas price is based on VGS residential rate effective Aug 5th, 2016.
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Vermont Fuel Report, 2016

Electric heating is no longer a "crazy" option

Net Zero Under Living Building Challenge

Class of '66 Environmental Center at Williams College

- PVs changed our thinking
- It is sustainable
- Relatively permanent (avoids speculation)
- Net Zero is easy to understand

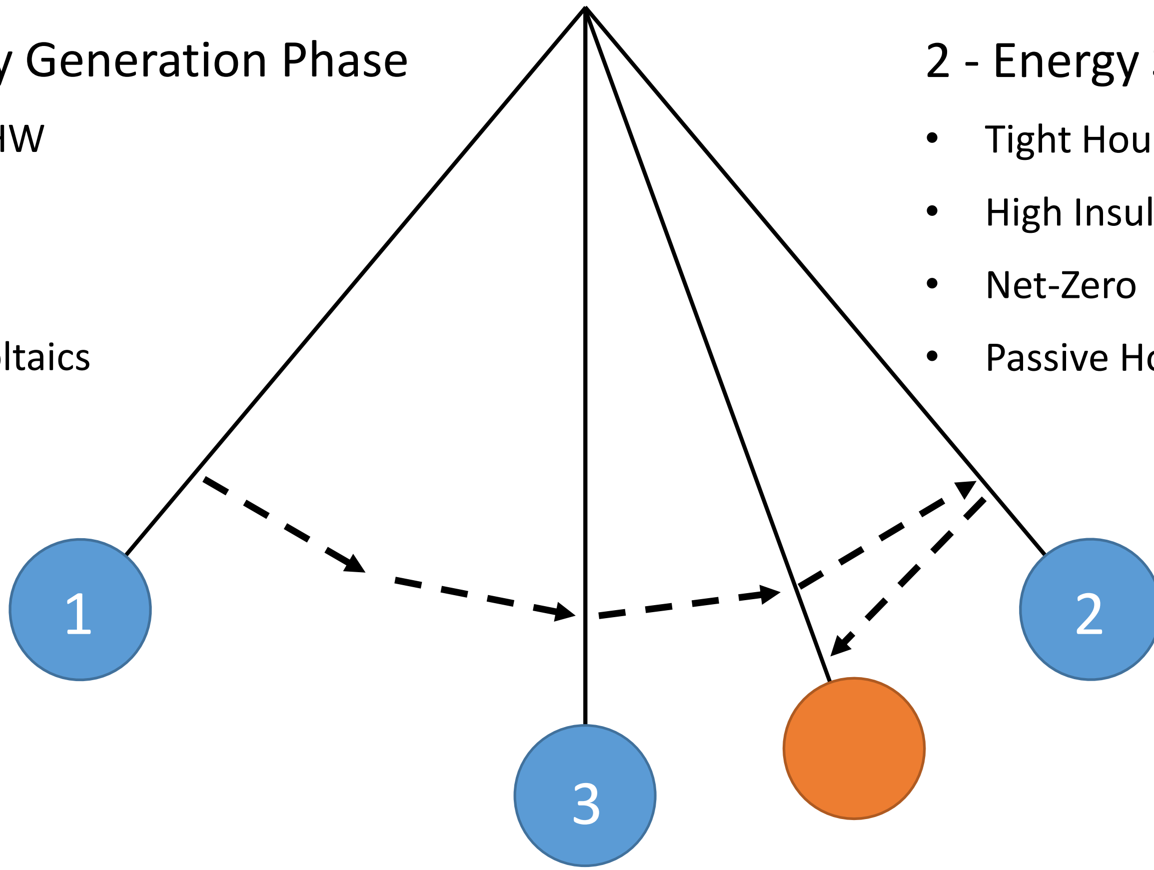
Phase 3: “Mature Phase”

1 - Energy Generation Phase

- Solar DHW
- Wind
- Hydro
- Photovoltaics

2 - Energy Saving Phase

- Tight Houses
- High Insulation levels
- Net-Zero
- Passive House



3- “Mature Phase”

- We have the tools to both be green and use our money wisely

Understanding when to stop investing in energy savings on an individual project allows for greater state-wide impact.

Efficiency Vermont is moving beyond the early adopters to have a greater impact on overall energy use

High R-Values Doubling Code Requirements

The R-value code requirements in Philadelphia (Climate Zone 4) are R-13 for walls and R-38 for ceilings or roofs. Newer code requirements would increase the wall values from R-13 to R-20. In general we are aiming to double code requirements for wall and ceiling/roof insulation in our homes. This means we are aiming for **around R-40 in our walls and R-70 in our roofs**.

We did not come up with these figures arbitrarily. There are a couple of key reasons that we pack this much fluffy stuff into our walls and roofs. Let's make a bulleted list of them:

- This amount of insulation is the backbone of our strategy to cut energy usage by a minimum of 50% over a code house. That means a HERs rating of 50 or better.
- Passive House Modeling – We've modeled multiple projects using the Passive House Performance Spreadsheet with a number of certified consultants. They all lead us to this level of insulation (among many other details) in order to achieve the stringent Passive House standard for extreme energy efficiency.

Phil: Let's get back to residential for one second. Have you heard anything about the Pretty Good House movement? Is that on your radar? And what do you think about it?

John: Yes, and I love it. I love the concept. I don't know much about the particular targets, but I think it's a sign of maturity. Things like net-zero homes or Passivhaus show us how we can get to really high performance and low energy use. But that does not mean they are necessarily what everyone can and should build, or is able to build. We at Building Science Corporation have often had the opinion that we could go off and build 10 or 20 net-zero energy homes a year, but from the of point of impact on the environment, they are virtually nonexistent. Nothing happens. If you have 10 or 20 houses that are zero energy, who cares?

It only matters when thousands and thousands of homes are done. We've spent a lot of our time — and been criticized for it — making 5,000 houses a year that use 30% less energy. And from an impact on the environment, an impact on energy security, and carbon, that's a much bigger deal. If we can demonstrate that 30% reductions can be achieved by three tract builders, well, then it makes everyone else look bad.

The fact that a bunch of highly motivated, well-funded zealots can produce net-zero energy houses — well, we know we can do that! Those net-zero energy and Passivhaus things are really about us learning where the extreme is or where the next generation is. They don't necessarily inform — although they may inspire — the current generation or the next 10 years.

So, we're constantly flitting between getting awful buildings to good, more so than getting the good buildings to great. Great buildings get much better press. But the real impact is making good buildings. If we could get the idea of a Pretty Good Building, or a Pretty Good Home, out to tens of thousands of people, that's success. Then, over time, we could change "pretty good" to a lower and lower energy number or a higher and higher comfort number.

We need to try to avoid making these high-performance houses just technology demonstrations. It's like concept cars — I don't care how many concept cars GM produces this year. What I care about is that the Sierra pickup gets 6 miles more per gallon this year than last year.

Interview with John Straube

MUSINGS OF AN

energy nerd

BY MARTIN HOLLADAY

"Musings of an Energy Nerd" showcases the best of Martin Holladay's weekly blog at GreenBuildingAdvisor.com, where he provides commonsense advice about energy issues to residential designers and builders. His conclusions usually fall between minimum code compliance and the Passive House standard, which often makes them controversial to both building-science geeks and everyday builders.

Green Building Advisor

Green Building Advisor is for designers, engineers, builders, and homeowners who craft energy-efficient and environmentally responsible homes.

How much insulation is too much?

Adding insulation in a house saves energy, but with each extra inch, the savings per inch diminishes. At some point, the cost of adding more insulation becomes hard to justify.

At this year's BuildingEnergy conference in Boston, three energy experts explored two questions regarding high-performance houses: At what point are envelope improvements a waste of money? And what metrics should we use to determine when enough insulation is enough? One point to these questions was to determine whether the thick levels of insulation required by the Passive House standard, an approach to superinsulation developed in Germany that is gaining traction in the United States, were justified. Because of the declining cost of PV, all three reached the same conclusion: They are not.

The three presenters were David White, an energy consultant from Brooklyn; Marc Rosenbaum, director of engineering at South Mountain Company in Massachusetts; and Rachel Wagner, a designer at Wagner Zaun Architecture in Duluth, Minn.

energy-independent house. White was a consultant on the project.

White started by comparing the annual energy savings attributable

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The most remarkable thing about the annual energy use of these very different houses is how little difference there is between the worst house and the best house. "Energy used for hot water is constant, and energy used for plug loads, lights, and appliances is constant," Rosenbaum noted.

If a homeowner wanted to add enough PV to achieve net zero, the worst house would require a PV system rated at 7.0kw, while the best house would require a PV system rated at 5.9kw. The smaller PV system required for the super-duper house would save only $3850 compared to the cost of installing the larger PV system needed for the code-minimum house. Needless to say, the cost to install R-60 wall insulation, R-90 roof insulation, and low-U-factor windows would be far more than $3850.

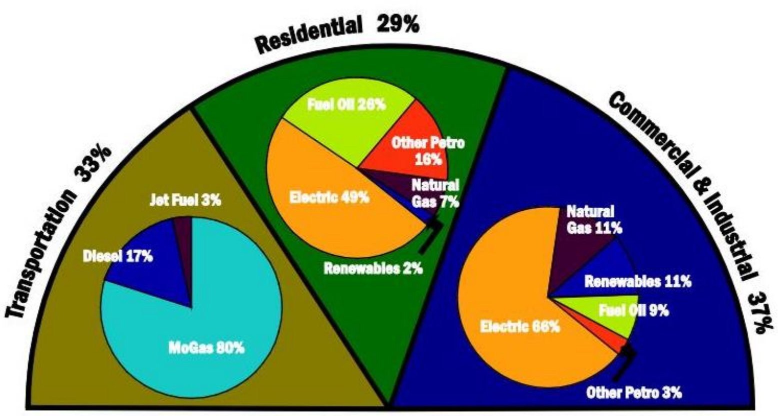
Some new questions:

- How do I balance first cost with long term operating expense?

- How do I <u>balance</u> my investment between the various energy impacting components of the envelope?

- With solar PVs coming down in price, when is it cheaper to purchase energy rather than invest in saving energy?

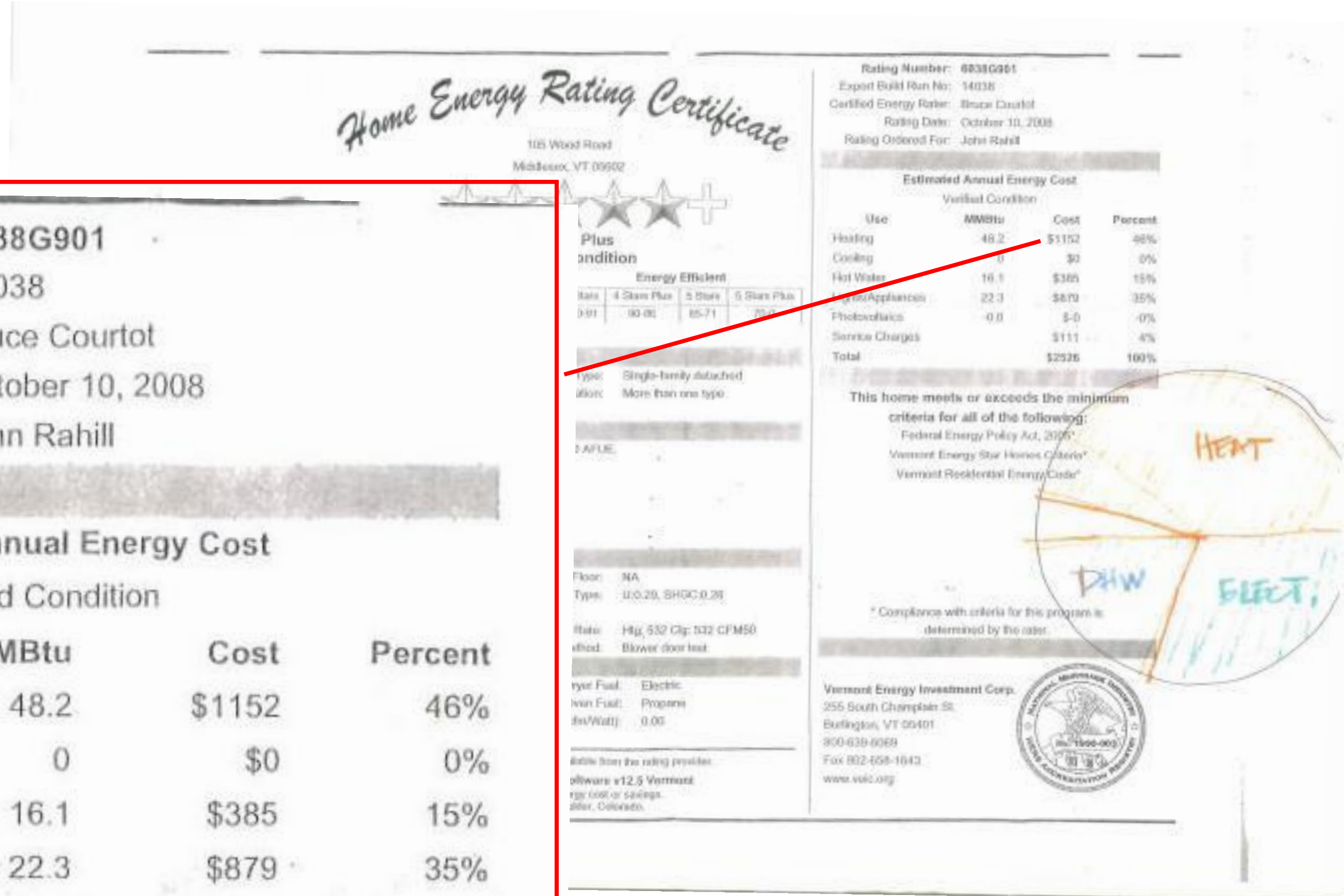
Vermont Energy Use by Sector
(Percent of BTUs **consumed**, 2008)



5 Steps to Balancing Your Investment

1. Have an energy model done, so you can see where your energy is going
2. Put a cost on each increment of each energy improvement
3. Decide what your idea of a good investment is for you.
4. Push insulation levels (and other energy saving components) to a point after which it is no longer a good investment.
5. Balance this approach for each component

Step 1: Energy modeling



Rating Number: 6038G901
Export Build Run No: 14038
Certified Energy Rater: Bruce Courtot
Rating Date: October 10, 2008
Rating Ordered For: John Rahill

Estimated Annual Energy Cost

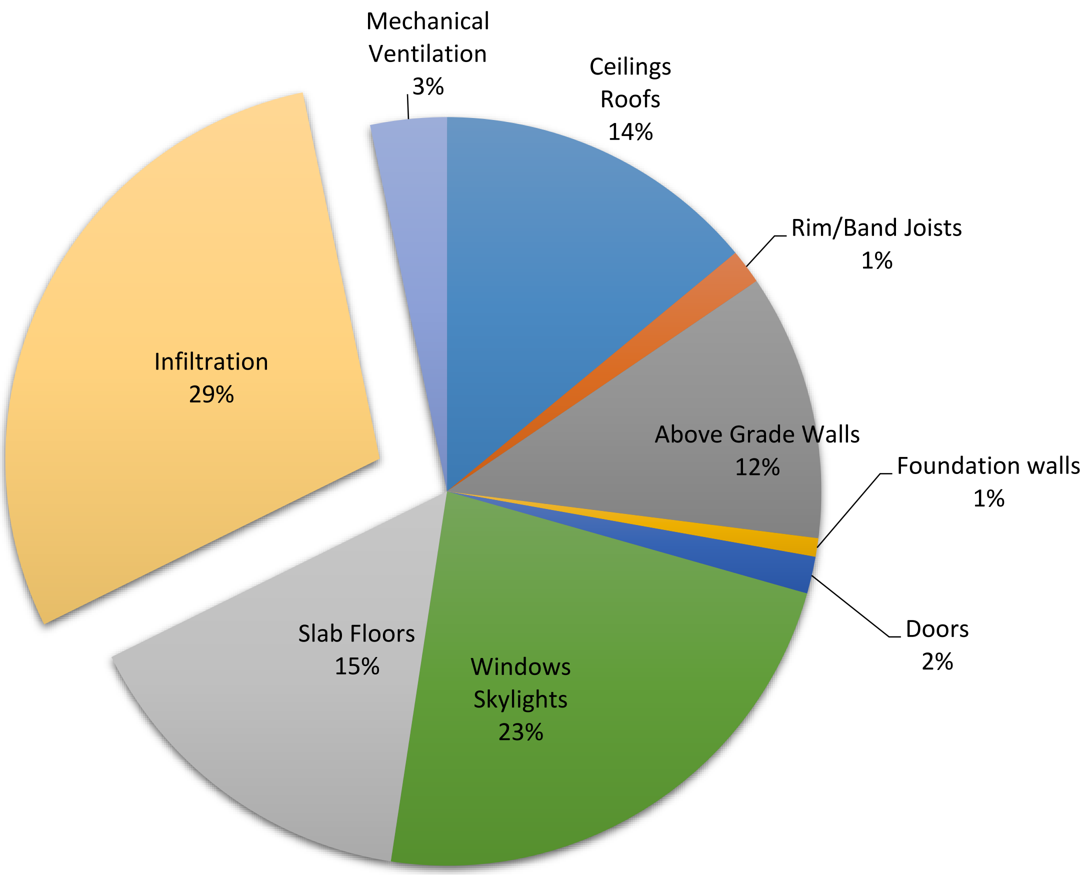
Verified Condition

Use	MMBtu	Cost	Percent
Heating	48.2	$1152	46%
Cooling	0	$0	0%
Hot Water	16.1	$385	15%
Lights/Appliances	22.3	$879	35%
Photovoltaics	-0.0	$-0	-0%
Service Charges		$111	4%
Total		$2526	100%

Should I add insulation in the cavity?

Infiltration: A significant component of heat

Heating Season	MMBtu/yr	% of total
Ceilings/Roofs	10.5	14
Rim/Band Joists	1.1	1.5
Above Grade Walls	8.6	11.5
Foundation walls	0.6	0.8
Doors	1.2	1.6
Windows/Skylights	17.2	23
Frame Floors	0	0
Crawl Space/Unht Bsmt	0	0
Slab Floors	11.5	15.3
Infiltration	22.1	29
Mechanical Ventilation	2.9	3.3
Ducts	0	0
Active Solar	0	0
Sunspace	0	0
Internal Gains	-16.3	0
Total	59.4	100
	+ 16.3	
	75.6	



Airtightness is achievable. Infiltration is the low hanging fruit.

Step 2: Assessing what’s right for you

How do you define using your money “most wisely”

I want to meet a target (EUI, Passive House, Code)

High-performance homes have many cool features that are not always obvious to buyers. As a builder, you want the effort and expense you’ve invested in the home to be effectively represented to potential buyers. That means engaging real estate brokers and appraisers who have the training, knowledge, and experience to recognize these features and communicate the benefits effectively.

Learn More about Zero Energy Homes

- **What does it cost to build zero energy?**
- **Speaking of cost, never mention "payback" if you want to make the sale.**
- **12 easy steps to building zero energy homes.**

http://zeroenergyproject.org/

Or

I want to balance my investment and get maximum benefit

Step 3: Criteria for a good investment

DESCRIPTION	QTY	COST	TOTAL
Sunmodule sw250 Mono	10	338.00	3,380.00
end clamp	8	4.55	36.40
Ironridge rail 12 foot sections	6	36.25667	217.54
L-feet (4-pack)	5	14.756	73.78
midclamp - grounding	18	3.90	70.20
Weeb grounding washer	25	1.5732	39.33
IronRidge ground strap and splice	2	11.70	23.40
Weeb grounding lug	4	7.02	28.08
Enphase MicroInverter	10	215.80	2,158.00
Engage Cable for Inverter	10	31.20	312.00
Branch terminator	1	22.43	22.43
Cable Clips - 10pk	2	11.375	22.75
M215 Disconnect tool	1	6.50	6.50
AC Jct Box bracket	1	16.74	16.74
Solar Surge protection 300 v	1	102.70	102.70
miscellaneous wire/conduit/labels/ground rod/boxes/fasteners	1	340.00	340.00
disconnect-unfusable	1	54.60	54.60
Meter base for KWH meter	1	75.40	75.40
ground kit for disconnect	1	7.62	7.62
energy management module	1	568.75	568.75
Hours of Installation Labor	16	50.00	800.00
shipping	1	450.00	450.00
total System Cost before incentives or credits			8,806.22
VT Small Scale Renewable Energy Incentive @ .25/watt		-687.00	-687.00
Pay to Sustainable Solutions			8,119.22
Federal Tax Credit		-30.00%	2,435.77
After all incentives and credit			5,683.45
Estimated Solar Value=$523 (see spreadsheet)			
$5683/523 = 10.8 years 9.2%ROI			
	TOTAL		$5,683.45

Solar PV System Cost

Savings

Cost after rebates and tax credits

Simple Payback Method - Is this a good investment?

Net Cash Flow Method

Home Value:	50000	$
Loan amount:	5683	$
Interest rate:	5	%

Get Today's Best Mortgage Rates

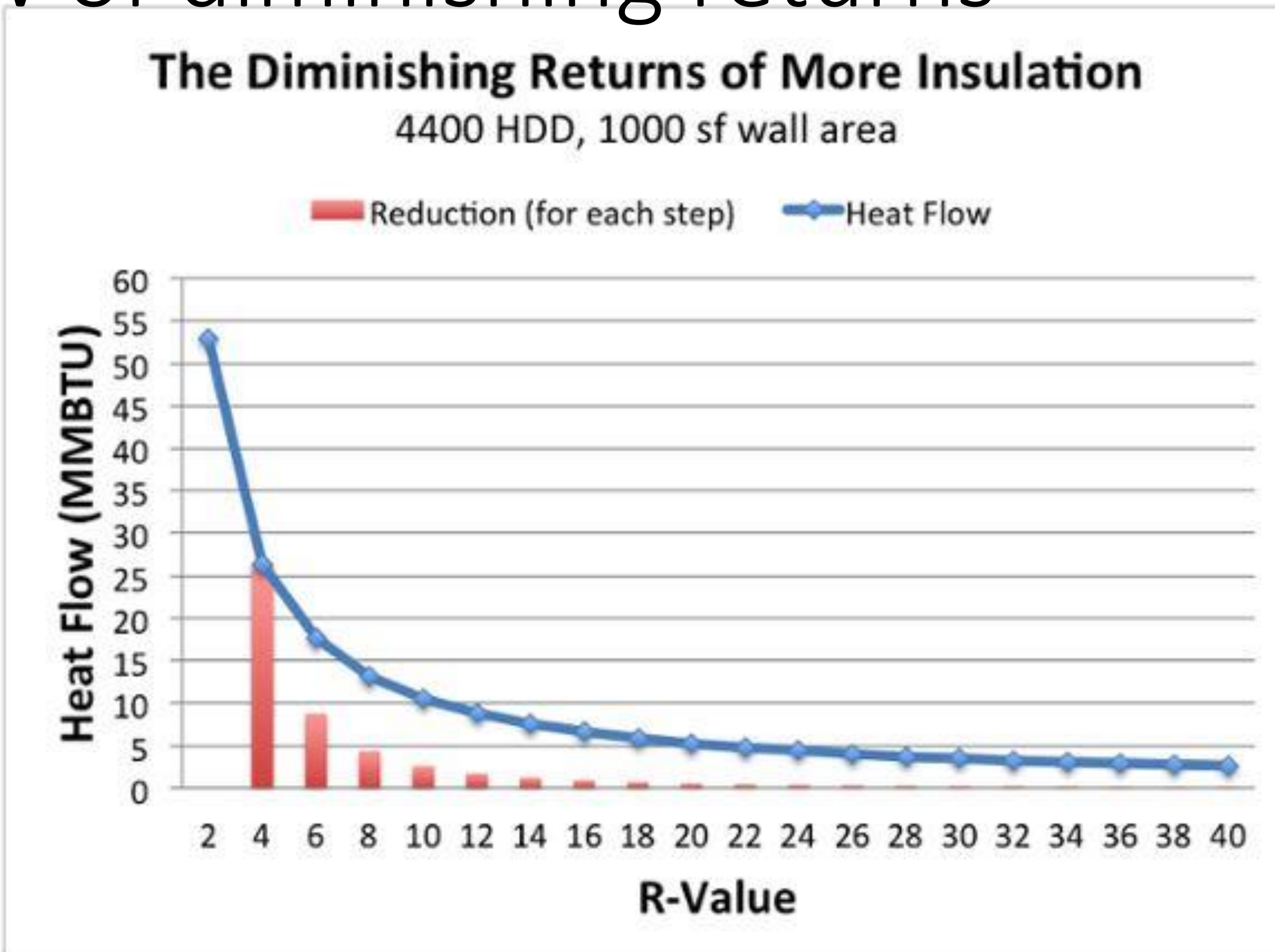
Loan term:	20	years
Start date:	Jan ▼	2015 ▼
Property tax:	0	%
PMI:	0.0	%

Mortgage Repayment Summary

$37.51 Monthly Payment	**$9,001.27** Total of 240 Payments
$3,318.27 Total Interest Paid	**Dec, 2034** Pay-off Date

Compare to $43.58/month

The law of diminishing returns



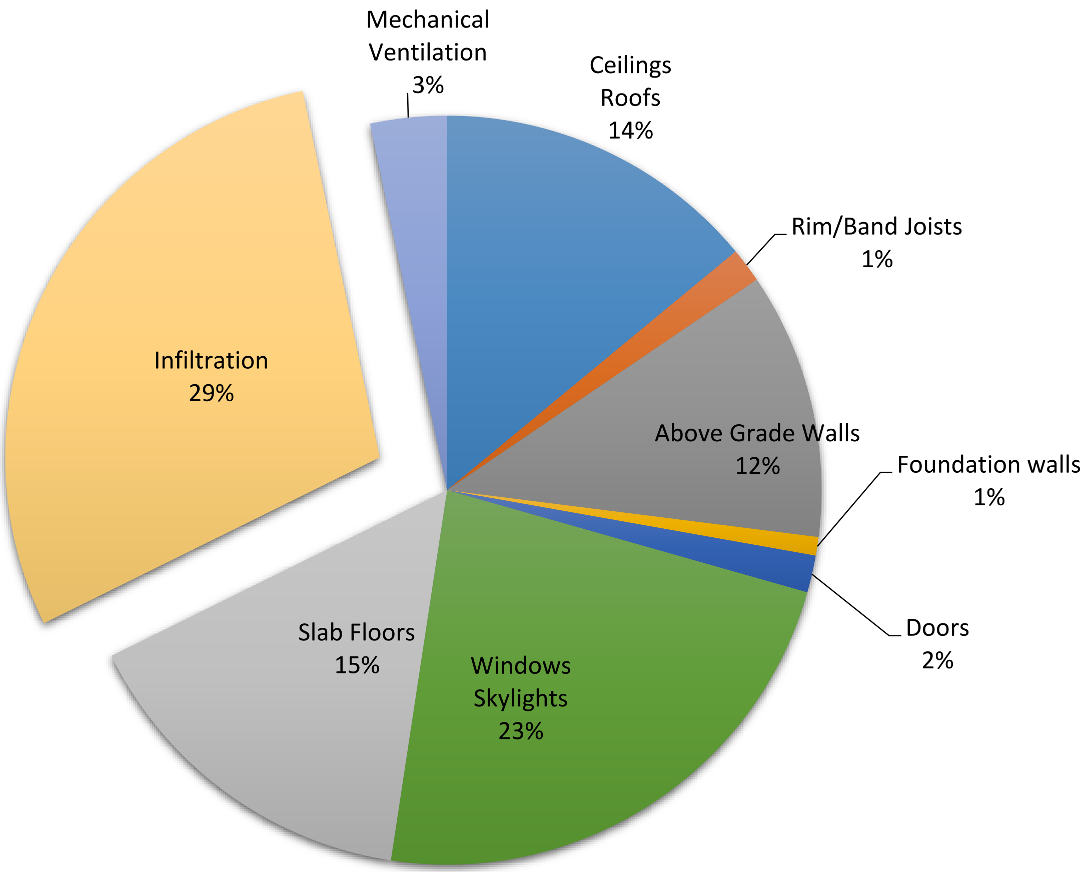
From this we can draw our first conclusion:

Important Lesson: *Adding any insulation to uninsulated homes can save more energy than adding more insulation to already-*

Alison Bailes, "The Diminishing Returns of Adding More Insulation"
http://www.energyvanguard.com

Evaluating Viability by <u>Incremental</u> Increases

$138/year
maximum savings
via walls



How much money does it make sense to spend to save up to $138/year? What would you do?

How do we get the lowest “long-term” cost (1st cost + operating expenses)

Step 4: Model energy loss of a base case and establish increments of investment on every type of energy saving measure

Locations	# Inches	Total Cost	Difference	MMBtu Saved/year	Cost Per mmbtu saved/year	Cost to produce mmbtu/year with PV array
Above Grade Walls						
Option 1	2	$ 14,746.20		27.4		
Mass Stretch Min	3	$ 22,119.30		33.8		
Difference			$ 7,373.10			$ 1,598.16
Option 3	4	$ 29,492.40		26.8		
Difference			$ 7,373.10	7	$ 1,053.30	$ 1,598.16
Option 4	5	$ 36,865.50		22.3		
Difference			$ 7,373.10	4.5	$ 1,638.47	$ 1,598.16
Option 2	8	$ 58,984.80		15.2		
Difference			$ 22,119.30	7.1	$ 3,115.39	$ 1,598.16

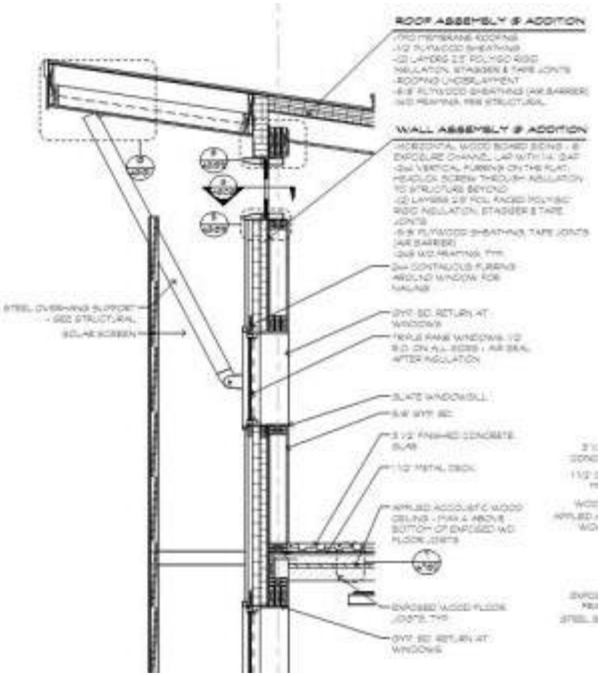
Step 5: Balance investment between measures

Locations	# Inches	Total Cost	Difference	MMBtu Saved/year	Cost Per mmbtu saved/year	Cost to produce mmbtu/year with PV array	Energy Cost kwh	Array in KW	Cost in PV array	Difference
Ceiling/Roofs										
Option 1	2	$ 7,404.60		13.4			3926	3.6	$ 21,415.44	
Mass Stretch Min	4	$ 14,809.20		13.9			4073	3.7	$ 22,214.53	
Difference			$ 7,404.60	0.5	$ 14,809.20	$ 1,598.16				$ 799.08
Option 3	5	$ 18,511.50		11.5			3369	3.1	$ 18,378.93	
Difference			$ 3,702.30	2.4	$ 3,393.78	$ 1,598.16				$ 3,835.60
Option 4	6	$ 22,213.80		9.8			2871	2.6	$ 15,662.04	
Difference			$ 3,702.30	1.7	$ 4,791.21	$ 1,598.16				$ 2,716.88
Option 2	8	$ 29,618.40		6.1			1787	1.6	$ 9,748.82	
Difference			$ 7,404.60	3.7	$ 2,001.24					$ 5,913.22
Above Grade Walls										
Option 1	2	$ 14,746.20		27.4			8028	7.3	$ 43,789.79	
Mass Stretch Min	3	$ 22,119.30		33.8			9903	9.0	$ 54,018.06	
Difference			$ 7,373.10	6.4		$ 1,598.16				$ (10,228.27)
Option 3	4	$ 29,492.40		26.8			7852	7.1	$ 42,830.89	
Difference			$ 7,373.10	7	$ 1,053.30	$ 1,598.16				$ 11,187.17
Option 4	5	$ 36,865.50		22.3			6534	5.9	$ 35,639.13	
Difference			$ 7,373.10	4.5	$ 1,638.47	$ 1,598.16				$ 7,191.75
Option 2	8	$ 58,984.80		15.2			4454	4.0	$ 24,292.15	
Difference			$ 22,119.30	7.1	$ 3,115.39	$ 1,598.16				$ 11,346.99
Foundation Walls										
Option 1	2.5	$ 5,180.23		11.3			3311	3.0	$ 18,059.29	
Mass Stretch Min	1.6	$ 3,315.34		17.2			5040	4.6	$ 27,488.48	
Difference			$ (1,864.88)	-5.9	$ 316.08	$ 1,598.16				$ (9,429.19)
Option 3	3	$ 6,216.27		10.7			3135	2.9	$ 17,100.39	
Difference			$ 2,900.93	6.5	$ 981.85	$ 1,598.16				$ 10,388.09
Option 4	4	$ 8,288.36		9.1			2666	2.4	$ 14,543.32	
Difference			$ 2,072.09	1.6	$ 2,849.12	$ 1,598.16				$ 2,557.07
Option 2	8	$ 16,576.72		5.1			1494	1.4	$ 8,150.65	
Difference			$ 8,288.36	4	$ 2,072.09	$ 1,598.16				$ 6,392.67
Slab/Floors										
Option 1	2.5	$ 7,248.50		6.6			1934	1.8	$ 10,547.91	
Mass Stretch Min	1.6	$ 4,639.04		8.8			2803	2.5	$ 15,286.62	
Difference										
Option 3	3	$ 8,698.20		6.3			2006	1.8	$ 10,943.83	
Difference			$ 4,059.16	2.5	$ 3,572.06	$ 1,598.16				$ 4,342.79
Option 4	4	$ 11,597.60		5.2			1656	1.5	$ 9,033.01	
Difference			$ 2,899.40	1.1	$ 5,798.80	$ 1,598.16				$ 1,910.83
Option 2	8	$ 23,195.20		3			879	0.8	$ 4,794.50	
Difference			$ 11,597.60	2.2	$ 5,271.64	$ 1,598.16		0.0		$ 4,238.50
Doors										
Option 1										
Option 2										
Windows/Skylights										
Option 1		$ 74,052.00		62.7			18371	16.7	$ 66,803.40	
Option 2		$ 108,900.00		27			7911	7.2	$ 28,767.01	
			$ 34,848.00	35.7	$ 2,147.50	$ 1,598.16				$ 38,036.38

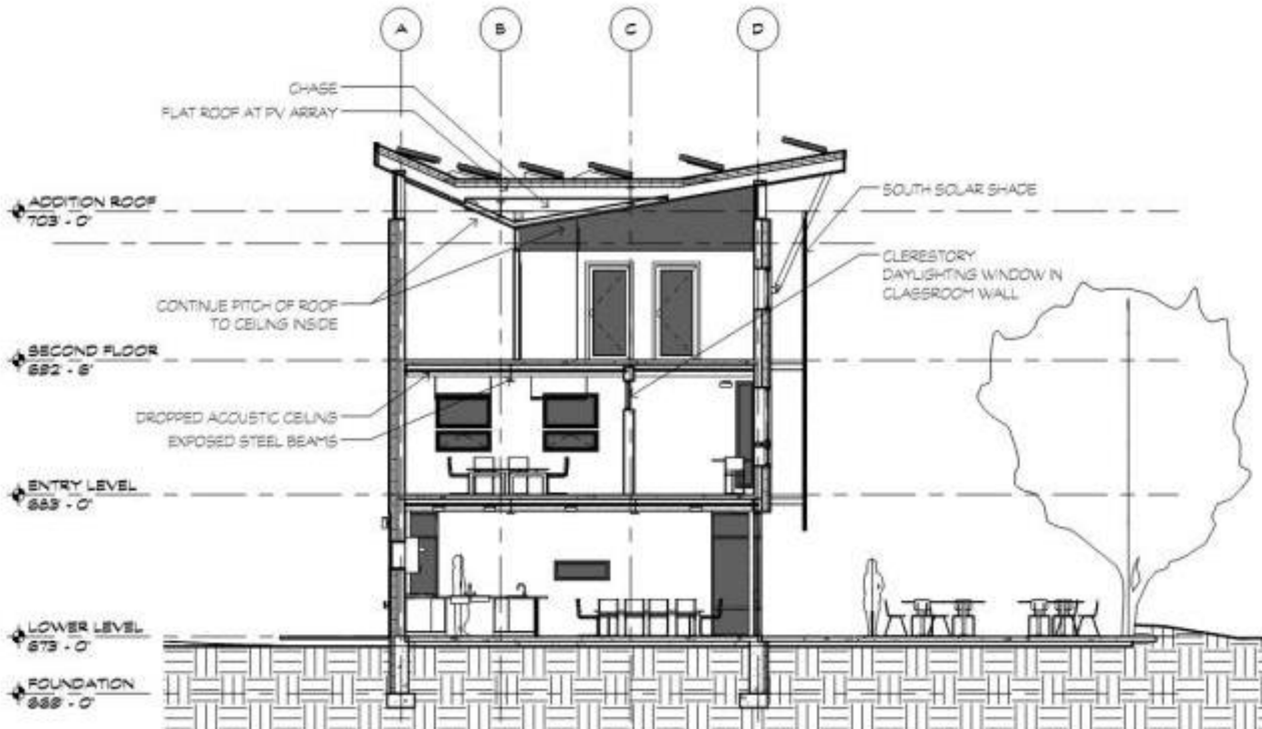
Energy modeling of every component

Sweet spots where investment in saving a BTU is equivalent to the investment in making a BTU.

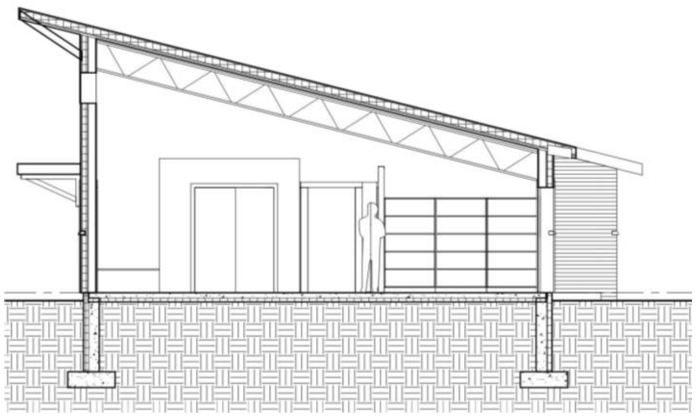
Impact on Envelope

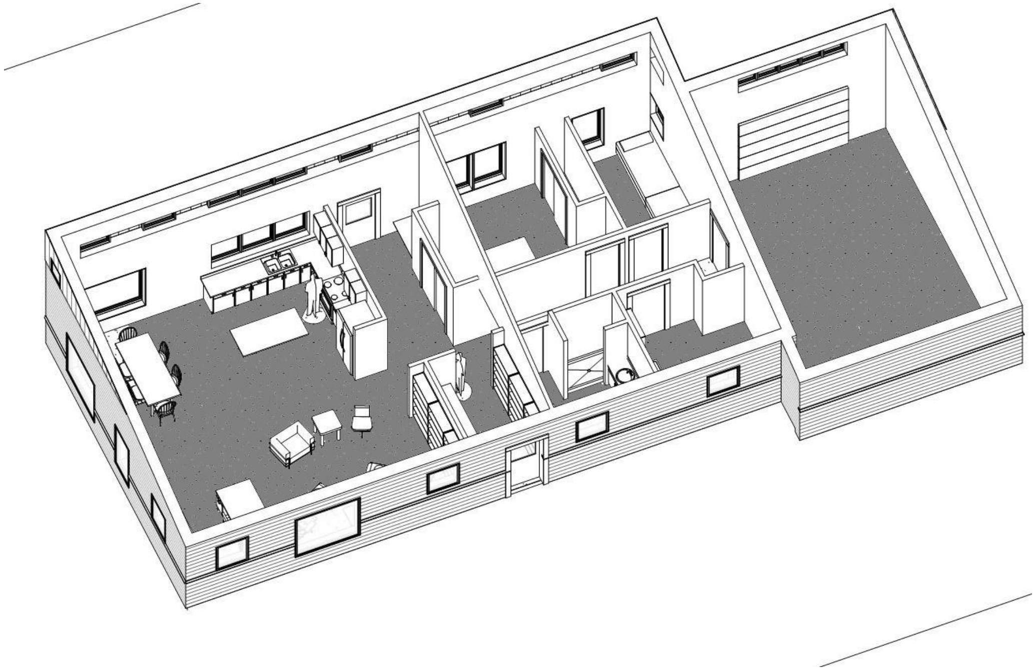


Roof / wall: 5” polyiso
Windows: R-5
Below grade walls: 5” XPS
Slab: 3” XPS



Bissell Residence 1,500 sf of heated space





There are lots of variables:

- **Construction cost**
- **“Starting point/”base case**
- Assumptions in energy model
- Fuel choice

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)
Foundation foot wall/under slab insul.													
Base	R-10	2" xps	3791	$ 1.05	$ 0.26	$ 4,966.21		10.50			$269.75		
1	R-15	3" xps (additional 1" thickness)	3791	$ 1.49	$ 0.26	$ 6,634.25	$1,668.04	8.40	2.10	$ 794.30	$215.80	$53.95	30.9
	R-20	4"	3791	$ 2.10	$ 0.52	$ 9,932.42	$3,298.17	5.70	2.70	$ 1,221.54	$146.43	$69.36	47.5
	R-25	5"	3791	$ 2.54	$ 0.52	$ 11,600.46	$1,668.04	4.90	0.80	$ 2,085.05	$125.88	$20.55	81.2
2	R-30	6"	3791	$ 3.00	$ 0.52	$ 13,344.32	$1,743.86	4.30	0.60	$ 2,906.43	$110.47	$15.41	113.1
Above grade walls													
	R-13	2x4 Dense Pak in Cavity	2279	$ 0.17	$ 0.37	$ 1,230.66		26.00			$667.94		
	R-20	2x6 Dense Pak in Cavity	2279	$ 0.28	$ 0.46	$ 1,686.46		17.70			$454.71		
Base	R-13	2" ISO	2279	$ 1.05	$ 0.50	$ 3,532.45	$0.00	17.50	0.00		$449.58		
	R-19.5	3" ISO	2279	$ 1.72	$ 0.50	$ 5,059.38	$1,526.93	13.90	3.60	$ 424.15	$357.09	$92.48	16.5
1	R-26	4" ISO	2279	$ 2.10	$ 1.00	$ 7,064.90	$2,005.52	10.00	3.90	$ 514.24	$256.90	$100.19	20.0
	R-32.5	5" ISO	2279	$ 2.77	$ 1.00	$ 8,591.83	$1,526.93	8.30	1.70	$ 898.19	$213.23	$43.67	35.0
2	R-39	6" ISO	2279	$ 3.44	$ 1.00	$ 10,118.76	$1,526.93	7.20	1.10	$ 1,388.12	$184.97	$28.26	54.0
Adding Rigid Polyiso to Cavity Insulation													
2	R-41	R26+R13(2x4 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,295.56	$7,064.90	7.90	18.10	$ 390.33	$202.95	$464.99	15.2
2	R-47	R-26 +R19(2x6 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,751.36	$7,064.90	7.00	10.70	$ 660.27	$179.83	$274.88	25.7
Adding Cavity Insulation to Rigid Polyiso													
2	R-41	R26+R13(4" ISO and 2x4 cavity)	2279	$ 0.17	$ 0.37	$8,295.56	$1,230.66	7.90	2.10	$ 586.03	$202.95	$53.95	22.8
2	R-47	R-26 +R19(4" ISO and 2x6 cavity)	2279	$ 0.28	$ 0.46	$8,751.36	$1,686.46	7.00	3.00	$ 562.15	$179.83	$77.07	21.9
Adding a second wall to the R-13 2x4 Dense Pak in Cavity Wall													
2	R-40	Double stud Wall 11 1/2"	2279		$ 5.20	$ 11,850.80	$ 10,620.14	7.70	10.00	$ 1,016.43	$197.81	$256.90	41.3

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)
Ceiling/Roof insulation													
Ceiling	R-26	4" iso(2) Layers of 2"	2913	$ 1.58	$ 1.00	$ 7,515.54	$0.00	8.40			$215.80		
	R-32.5	5"(2) Layers, 2", 3"	2913	$ 2.58	$ 1.00	$ 10,428.54	$2,913.00	7.40	1.00	$ 2,913.00	$190.11	$25.69	113.4
	R-39	6"	2913	$ 3.58	$ 1.00	$ 13,341.54	$2,913.00	6.30	2.10	$ 1,387.14	$161.85	$28.26	103.1
1	R-48.7	7 1/2"	2913	$ 5.00	$ 1.00	$ 17,478.00	$4,136.46	5.10	3.30	$ 1,253.47	$131.02	$30.83	134.2
2	R-61.75	9 1/2"	2913	$ 6.50	$ 1.50	$ 23,304.00	$5,826.00	4.10	4.30	$ 1,354.88	$105.33	$25.69	226.8
Ceiling	R-24	4" spray between joists	2913	$ 3.15		$ 9,175.95	$1,660.41	10.90	(2.50)	$ (664.16)	$280.02	-$64.23	-25.9
	R-40	6 1/2" spray	2913	$ 4.73		$ 13,778.49	$3,349.95	7.10	1.30	$ 2,576.88	$182.40	$97.62	34.3
Windows													
	U.29	D.G. - Marvin Integrity				$ 15,866.00		11.10			$285.16		
1	U.27	D.G. - w/Argon Low E				$ 17,223.00	$1,357.00	9.30	1.80	$754	$238.92	$46.24	29.3
2	U.19	Triple Pane				$ 26,081.00	$8,858.00	4.60	6.50	$1,363	$118.17	$120.74	73.4
ACH - AIR CHANGES PER HOUR													
	6	Ordinary Construction				$ -		17.10			$439.30		
1	3	Easily Achievable				$ 600.00	$600.00	8.60	8.50	$71	$220.93	$218.37	2.7
2	1	Additional work/care required				$ 1,800.00	$1,200.00	2.90	5.70	$211	$74.50	$146.43	8.2
	0.6					$ 2,600.00	$800.00	1.70	1.20	$667	$43.67	$30.83	26.0

Assumptions:
- Costs are for insulation only (assume framing and plywood is in place) unless additional framing is required.
- Drainage plane is not included is any system
- Incremental costs are typically the cost to add an increment of insulation(note exceptions)

Performance Report

Property	Organization	HERS
Rahill , VT Weather:Montpelier, VT Rahill P076p Rahill BGJ version.blg	VT Energy Investment Corp 888-921-5990 Bruce Courtot **Builder**	Projected Rating 5/31/16 Rating No:6038P076 Rater ID:5851998

Vermont Energy Investment Corporation

Annual Load(MMBtu/yr)	UDRH	Rahill	Savings	%Saved
Heating	52.7	24.9	27.8	52.8%
Cooling	0.0	0.0		
Water Heating	10.1	9.5	0.6	6.1%
Water Heating w/out Tank Loss	6.3	6.3		

Annual Consumption(MMBtu/yr)	UDRH	Rahill	Savings	%Saved
Heating	63.9	26.3	37.7	58.9%
Cooling	0.0	0.0		
Water Heating	12.1	9.9	2.1	17.8%
Lights & Appliances	16.7	14.8	1.9	11.4%
Photovoltaics	-0.0	-0.0		
Total	**92.7**	**51.0**	**41.7**	**45.0%**

Annual Energy Cost ($/yr)	UDRH	Rahill	Savings	%Saved
Heating	1714	697	1017	59.3%
Cooling	0	0		
Water Heating	318	261	57	17.8%
Lights & Appliances	862	719	143	16.6%
Photovoltaics	-0	-0		
Service Charges	147	147		
Total	**3041**	**1824**	**1217**	**40.0%**

Design Loads (kBtu/hr)	UDRH	Rahill	Savings	%Saved
Space Heating	24.9	14.0	10.9	43.8%
Space Cooling	0.0	0.0		

Utility Rates	
Electricity	WEC 4/16
Propane	LP, $2.41, 4/16

REM/Rate - Residential Energy Analysis and Rating Software v15.2 Vermont
This information does not constitute any warranty of energy cost or savings.

What are the different requirements and where does your project fit in?

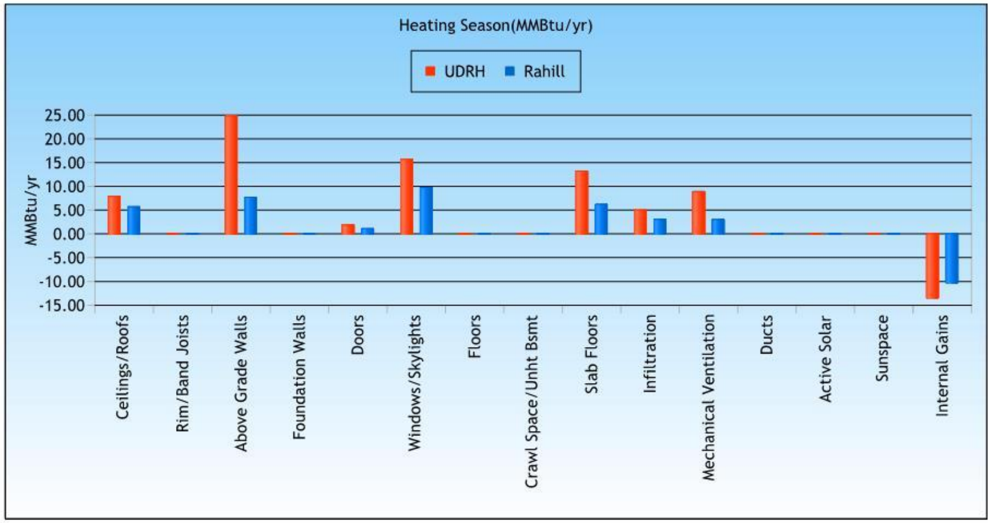
Certification Requirements	Choose your base case	Efficiency Vermont Certified: Base Level*	Efficiency Vermont Certified: High Performance Level
Energy Code Compliance		Meet Vermont energy code and file RBES certificates	
Foundation Wall Insulation– Minimum R-Value		R-15 continuous or R-20 cavity	R-30
Slab Edge Insulation (when within 12" finished grade)		R-15 Must extend a total of 4 ft. vertical or horizontal	R-30: slab on grade R-20: unheated fully below grade Footing: ≥ R-8
Insulation Under Slab		R-15 under heated slab only	R-20: unheated below grade R-30: unheated on grade R-30: all heated slabs
Floor Insulation (exposed)		R-38 or R-30 + R-5 continuous	R-40
Wall Insulation (above grade & band joist)– Minimum R-Value		R-20 cavity or R-13 cavity + R-10 continuous	R-40
Ceiling Insulation (flat & sloped)– Minimum R-Value		R-49 sloped R-60 flat	R-60
Insulation Installation– Installation quality (using RESNET Grading System) will be verified by Efficiency Vermont at pre-drywall inspection		Grade II	Grade I
Thermal Enclosure Inspection		Must pass visual inspection by Efficiency Vermont, prior to drywall installation	

Component Consumption

Property	Organization	HERS
Rahill	VT Energy Investment Corp	Projected Rating
, VT	888-921-5990	5/31/16
	Bruce Courtot	Rating No:6038P076
Weather:Montpelier, VT		ID:5851998
Rahill	**Builder**	
P076p Rahill BGJ version.blg		

Vermont Energy Investment Corporation

Heating Season(MMBtu/yr)	UDRH	Rahill	Savings	%Saved
Ceilings/Roofs	7.9	5.7	2.2	27.8%
Rim/Band Joists	0.0	0.0		
Above Grade Walls	24.8	7.7	17.2	69.2%
Foundation Walls	0.0	0.0		
Doors	1.9	1.1	0.8	40.0%
Windows/Skylights	15.7	9.8	5.9	37.9%
Floors	0.0	0.0		
Crawl Space/Unht Bsmt	0.0	0.0		
Slab Floors	13.2	6.2	7.0	52.9%
Infiltration	5.0	3.1	1.9	38.4%
Mechanical Ventilation	8.9	3.0	5.9	66.6%
Ducts	0.0	0.0		
Active Solar	0.0	0.0		
Sunspace	0.0	0.0		
Internal Gains	-13.5	-10.3	-3.3	-24.1%
Total	63.9	26.3	37.7	58.9%



What if my chosen payback was 15 years?

★ 15 year payback

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)	
Foundation foot wall/under slab insul.														
Base	R-10	2" xps	*3791*	*$ 1.05*	*$ 0.26*	*$ 4,966.21*		10.50			$269.75			★
1	R-15	3" xps (additional 1" thickness)	*3791*	*$ 1.49*	*$ 0.26*	*$ 6,634.25*	$1,668.04	8.40	2.10	*$ 794.30*	$215.80	$53.95	30.9	
	R-20	4"	3791	$ 2.10	$ 0.52	$ 9,932.42	$3,298.17	5.70	2.70	$ 1,221.54	$146.43	$69.36	47.5	
	R-25	5"	3791	$ 2.54	$ 0.52	$ 11,600.46	$1,668.04	4.90	0.80	$ 2,085.05	$125.88	$20.55	81.2	
2	R-30	6"	3791	$ 3.00	$ 0.52	$ 13,344.32	$1,743.86	4.30	0.60	$ 2,906.43	$110.47	$15.41	113.1	
Above grade walls														
	R-13	2x4 Dense Pak in Cavity	2279	$ 0.17	$ 0.37	$ 1,230.66		26.00			$667.94			
	R-20	2x6 Dense Pak in Cavity	2279	$ 0.28	$ 0.46	$ 1,686.46		17.70			$454.71			
Base	R-13	2" ISO	2279	$ 1.05	$ 0.50	$ 3,532.45	$0.00	17.50	0.00		$449.58			
	R-19.5	3" ISO	2279	$ 1.72	$ 0.50	$ 5,059.38	$1,526.93	13.90	3.60	$ 424.15	$357.09	$92.48	16.5	
1	R-26	4" ISO	2279	$ 2.10	$ 1.00	$ 7,064.90	$2,005.52	10.00	3.90	$ 514.24	$256.90	$100.19	20.0	
	R-32.5	5" ISO	2279	$ 2.77	$ 1.00	$ 8,591.83	$1,526.93	8.30	1.70	$ 898.19	$213.23	$43.67	35.0	
2	R-39	6" ISO	2279	$ 3.44	$ 1.00	$ 10,118.76	$1,526.93	7.20	1.10	$ 1,388.12	$184.97	$28.26	54.0	
Adding Rigid Polyiso to Cavity Insulation														
2	R-41	R26+R13(2x4 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,295.56	$7,064.90	7.90	18.10	$ 390.33	$202.95	$464.99	15.2	★
2	R-47	R-26 +R19(2x6 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,751.36	$7,064.90	7.00	10.70	$ 660.27	$179.83	$274.88	25.7	
Adding Cavity Insulation to Rigid Polyiso														
2	R-41	R26+R13(4" ISO and 2x4 cavity)	2279	$ 0.17	$ 0.37	$8,295.56	$1,230.66	7.90	2.10	$ 586.03	$202.95	$53.95	22.8	
2	R-47	R-26 +R19(4" ISO and 2x6 cavity)	2279	$ 0.28	$ 0.46	$8,751.36	$1,686.46	7.00	3.00	$ 562.15	$179.83	$77.07	21.9	
Adding a second wall to the R-13 2x4 Dense Pak in Cavity Wall														
2	R-40	Double stud Wall 11 1/2"	2279		$ 5.20	$ 11,850.80	$ 10,620.14	7.70	10.00	$ 1,016.43	$197.81	$256.90	41.3	

Bissell Residence
East Montpelier, VT

★ 15 year payback

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)
Ceiling/Roof insulation													
Ceiling	R-26	4" iso(2) Layers of 2"	2913	$ 1.58	$ 1.00	$ 7,515.54	$0.00	8.40			$215.80		
	R-32.5	5"(2) Layers, 2", 3"	2913	$ 2.58	$ 1.00	$ 10,428.54	$2,913.00	7.40	1.00	$ 2,913.00	$190.11	$25.69	113.4
	R-39	6"	2913	$ 3.58	$ 1.00	$ 13,341.54	$2,913.00	6.30	2.10	$ 1,387.14	$161.85	$28.26	103.1
1	R-48.7	7 1/2"	2913	$ 5.00	$ 1.00	$ 17,478.00	$4,136.46	5.10	3.30	$ 1,253.47	$131.02	$30.83	134.2
2	R-61.75	9 1/2"	2913	$ 6.50	$ 1.50	$ 23,304.00	$5,826.00	4.10	4.30	$ 1,354.88	$105.33	$25.69	226.8
Ceiling	R-24	4" spray between joists	2913	$ 3.15		$ 9,175.95	$1,660.41	10.90	(2.50)	$ (664.16)	$280.02	-$64.23	-25.9
	R-40	6 1/2" spray	2913	$ 4.73		$ 13,778.49	$3,349.95	7.10	1.30	$ 2,576.88	$182.40	$97.62	34.3
Windows													
	U.29	D.G. - Marvin Integrity				$ 15,866.00		11.10			$285.16		
1	U.27	D.G. - w/Argon Low E				$ 17,223.00	$1,357.00	9.30	1.80	$754	$238.92	$46.24	29.3
2	U.19	Triple Pane				$ 26,081.00	$8,858.00	4.60	6.50	$1,363	$118.17	$120.74	73.4
ACH - AIR CHANGES PER HOUR													
	6	Ordinary Construction				$ -		17.10			$439.30		
1	3	Easily Achievable				$ 600.00	$600.00	8.60	8.50	$71	$220.93	$218.37	2.7
2	1	Additional work/care required				$ 1,800.00	$1,200.00	2.90	5.70	$211	$74.50	$146.43	8.2
	0.6					$ 2,600.00	$800.00	1.70	1.20	$667	$43.67	$30.83	26.0

Assumptions:
- Costs are for insulation only (assume framing and plywood is in place) unless additional framing is required.
- Drainage plane is not included is any system
- Incremental costs are typically the cost to add an increment of insulation(note exceptions)

$8844	$829	9.7
Total added cost	*Savings*	*Payback*

What if my chosen payback was 30 years?

★ 15 year payback ■ 30 year payback

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)	
Foundation foot wall/under slab insul.														
Base	R-10	2" xps	3791	$ 1.05	$ 0.26	$ 4,966.21		10.50			$269.75			★
1	R-15	3" xps (additional 1" thickness)	3791	$ 1.49	$ 0.26	$ 6,634.25	$1,668.04	8.40	2.10	$ 794.30	$215.80	$53.95	30.9	■
	R-20	4"	3791	$ 2.10	$ 0.52	$ 9,932.42	$3,298.17	5.70	2.70	$ 1,221.54	$146.43	$69.36	47.5	
	R-25	5"	3791	$ 2.54	$ 0.52	$ 11,600.46	$1,668.04	4.90	0.80	$ 2,085.05	$125.88	$20.55	81.2	
2	R-30	6"	3791	$ 3.00	$ 0.52	$ 13,344.32	$1,743.86	4.30	0.60	$ 2,906.43	$110.47	$15.41	113.1	
Above grade walls														
	R-13	2x4 Dense Pak in Cavity	2279	$ 0.17	$ 0.37	$ 1,230.66		26.00			$667.94			
	R-20	2x6 Dense Pak in Cavity	2279	$ 0.28	$ 0.46	$ 1,686.46		17.70			$454.71			
Base	R-13	2" ISO	2279	$ 1.05	$ 0.50	$ 3,532.45	$0.00	17.50	0.00		$449.58			
	R-19.5	3" ISO	2279	$ 1.72	$ 0.50	$ 5,059.38	$1,526.93	13.90	3.60	$ 424.15	$357.09	$92.48	16.5	■
1	R-26	4" ISO	2279	$ 2.10	$ 1.00	$ 7,064.90	$2,005.52	10.00	3.90	$ 514.24	$256.90	$100.19	20.0	■
	R-32.5	5" ISO	2279	$ 2.77	$ 1.00	$ 8,591.83	$1,526.93	8.30	1.70	$ 898.19	$213.23	$43.67	35.0	
2	R-39	6" ISO	2279	$ 3.44	$ 1.00	$ 10,118.76	$1,526.93	7.20	1.10	$ 1,388.12	$184.97	$28.26	54.0	
Adding Rigid Polyiso to Cavity Insulation														
2	R-41	R26+R13(2x4 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,295.56	$7,064.90	7.90	18.10	$ 390.33	$202.95	$464.99	15.2	★
2	R-47	R-26 +R19(2x6 cavity and 4" ISO)	2279	$ 2.10	$ 1.00	$8,751.36	$7,064.90	7.00	10.70	$ 660.27	$179.83	$274.88	25.7	
Adding Cavity Insulation to Rigid Polyiso														
2	R-41	R26+R13(4" ISO and 2x4 cavity)	2279	$ 0.17	$ 0.37	$8,295.56	$1,230.66	7.90	2.10	$ 586.03	$202.95	$53.95	22.8	
2	R-47	R-26 +R19(4" ISO and 2x6 cavity)	2279	$ 0.28	$ 0.46	$8,751.36	$1,686.46	7.00	3.00	$ 562.15	$179.83	$77.07	21.9	■
Adding a second wall to the R-13 2x4 Dense Pak in Cavity Wall														
2	R-40	Double stud Wall 11 1/2"	2279		$ 5.20	$ 11,850.80	$ 10,620.14	7.70	10.00	$ 1,016.43	$197.81	$256.90	41.3	

Bissell Residence
East Montpelier, VT

★ 15 year payback ■ 30 year payback

Components			Area	SQ/FT cost Material	SQ/FT cost Labor	Total Construction Cost	Incremental Construction Cost	Annual Energy Loss (MBTU)	Annual Energy Savings (MBTU)	Cost/MBTU of Incremental Savings	Energy Costs (@$25.69 of propane/MBTU)	Annual Incremental Savings	Incremental Payback (years)	
Ceiling/Roof insulation														
Ceiling	R-26	4" iso(2) Layers of 2"	2913	$ 1.58	$ 1.00	$ 7,515.54	$0.00	8.40			$215.80			
	R-32.5	5"(2) Layers, 2", 3"	2913	$ 2.58	$ 1.00	$ 10,428.54	$2,913.00	7.40	1.00	$ 2,913.00	$190.11	$25.69	113.4	
	R-39	6"	2913	$ 3.58	$ 1.00	$ 13,341.54	$2,913.00	6.30	2.10	$ 1,387.14	$161.85	$28.26	103.1	
1	R-48.7	7 1/2"	2913	$ 5.00	$ 1.00	$ 17,478.00	$4,136.46	5.10	3.30	$ 1,253.47	$131.02	$30.83	134.2	
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ACH - AIR CHANGES PER HOUR														
	6	Ordinary Construction				$ -		17.10			$439.30			
1	3	Easily Achievable				$ 600.00	$600.00	8.60	8.50	$71	$220.93	$218.37	2.7	★
2	1	Additional work/care required				$ 1,800.00	$1,200.00	2.90	5.70	$211	$74.50	$146.43	8.2	★
	0.6					$ 2,600.00	$800.00	1.70	1.20	$667	$43.67	$30.83	26.0	■

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- Costs are for insulation only (assume framing and plywood is in place) unless additional framing is required.
- Drainage plane is not included is any system
- Incremental costs are typically the cost to add an increment of insulation(note exceptions)

Total added cost	Savings	Payback
$9,155	$765	12.3

Summary: We have come a long way

1. We know how to insulate
2. Heating/cooling technology continues to advance
3. PVs have dropped in price to such an extent that the are part of the economic equation
4. We have shown that with enough dollars we can achieve net zero
5. We have the tools to balance our investments to use our energy savings dollars most economically

How to make the best financial decision

1. Have an energy model done, so you can see where your energy is going
2. Put a cost on each increment of each energy improvement
3. Decide what your idea of a good investment is for you.
4. Push insulation levels (and other energy saving components) to a point after which it is no longer a good investment.
5. Balance this approach for each component
6. Figure out at what point it makes better sense to invest in PVs
7. Only then, add your own prejudices

Thank you. Questions?