# Balancing your energy dollars in a cold climate:

## 3 Examples employing energy modeling to guide the process


**Presenters**

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BLACK RIVER DESIGN ARCHITECTS

integrated ecostrategy

# Outline

A. Introduction
B. Our challenge: To be credible advocates for energy saving investments
C. Traditional ways of deciding on how to spend your energy dollars – 2 simple examples
    - Payback analysis
    - Net cash flow basis
    - Assumptions are critical to the outcome and involve rubbing the crystal ball
D. 3 Projects – All seeking Net Zero, but all very different
    - Williamstown Youth Center
    - Williams College Kellogg House: Living Building Challenge means Net Zero a given goal
    - Rumney Memorial Elementary School
E. Summary

# Our Qualifications

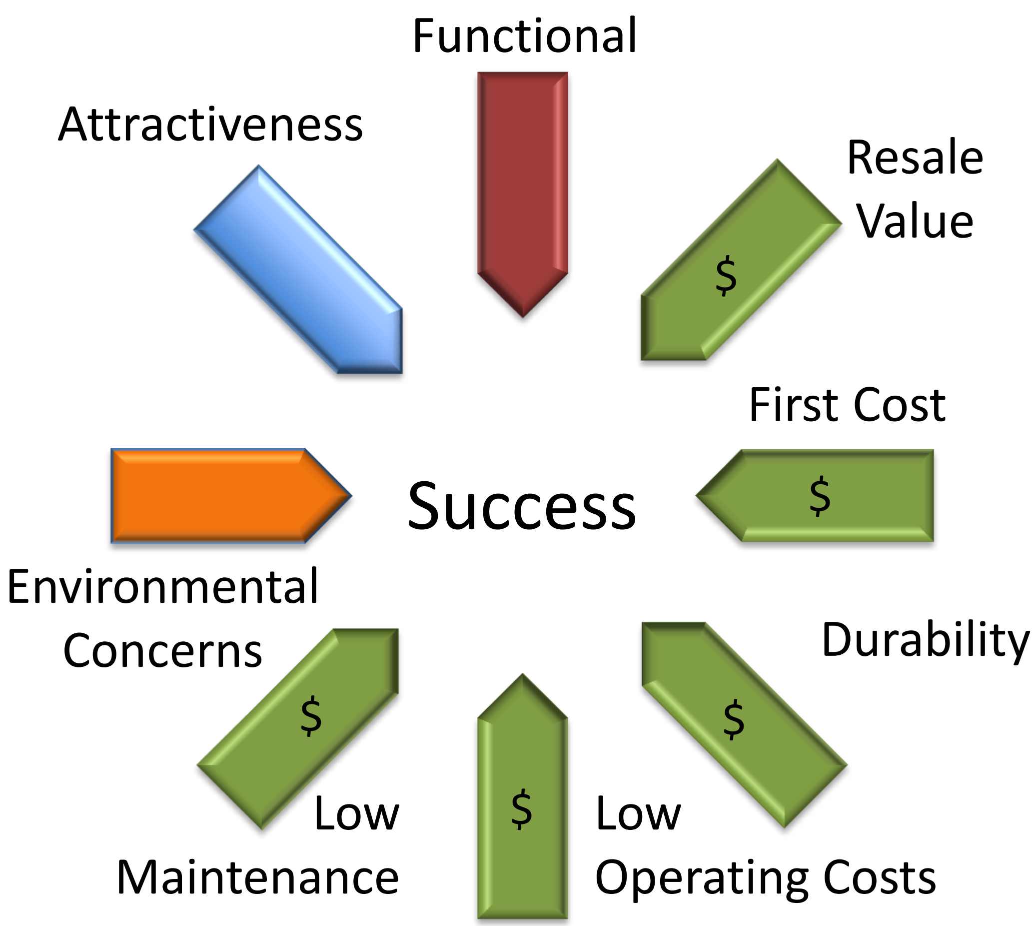
1973 Active Solar

1975 Passive Solar

# The Many Choices Facing a Building Owner

We in the building business have a role in helping owners make good choices, in the face of an overwhelming number of options.  With limited resources, we all have a different view of what we think they should spend their money on.

**Competing goals**




*Where can we apply science/rational economics to this inexact process?*

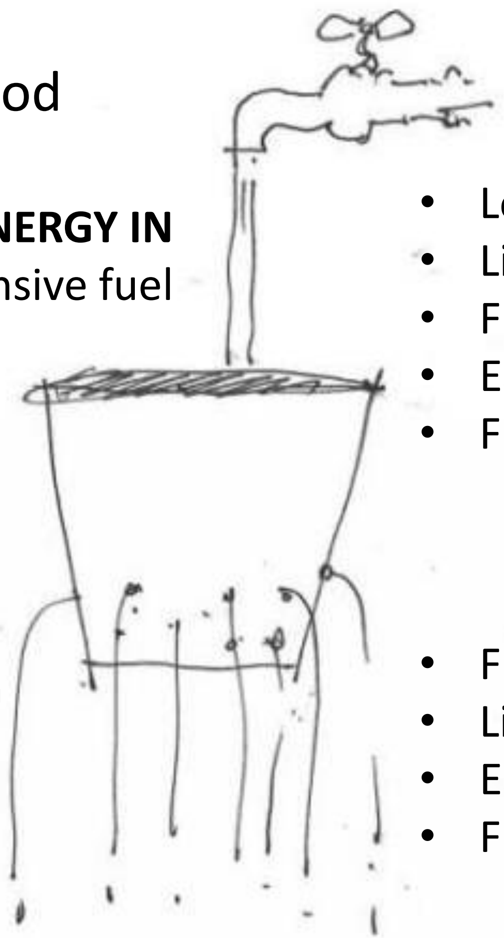
*How many of these areas are approached rationally?*

# Balancing investments in fuel system with investments in energy savings

- Traditional ways to evaluate cost effectiveness
  A. Payback Method
  B. Net Cash Flow Method

**ENERGY IN**
Least expensive fuel

- Lowest first cost
- Life span of system
- Future cost of replacement
- Ease and cost of maintenance
- Future energy inflation



**ENERGY OUT**
Least long term cost of energy out

- First cost
- Life span of measures
- Ease of replacement
- Future cost of replacement

# Energy In

## Factors in the fuel decision

delivered cost

**Comparing the Cost of Heating Fuels**

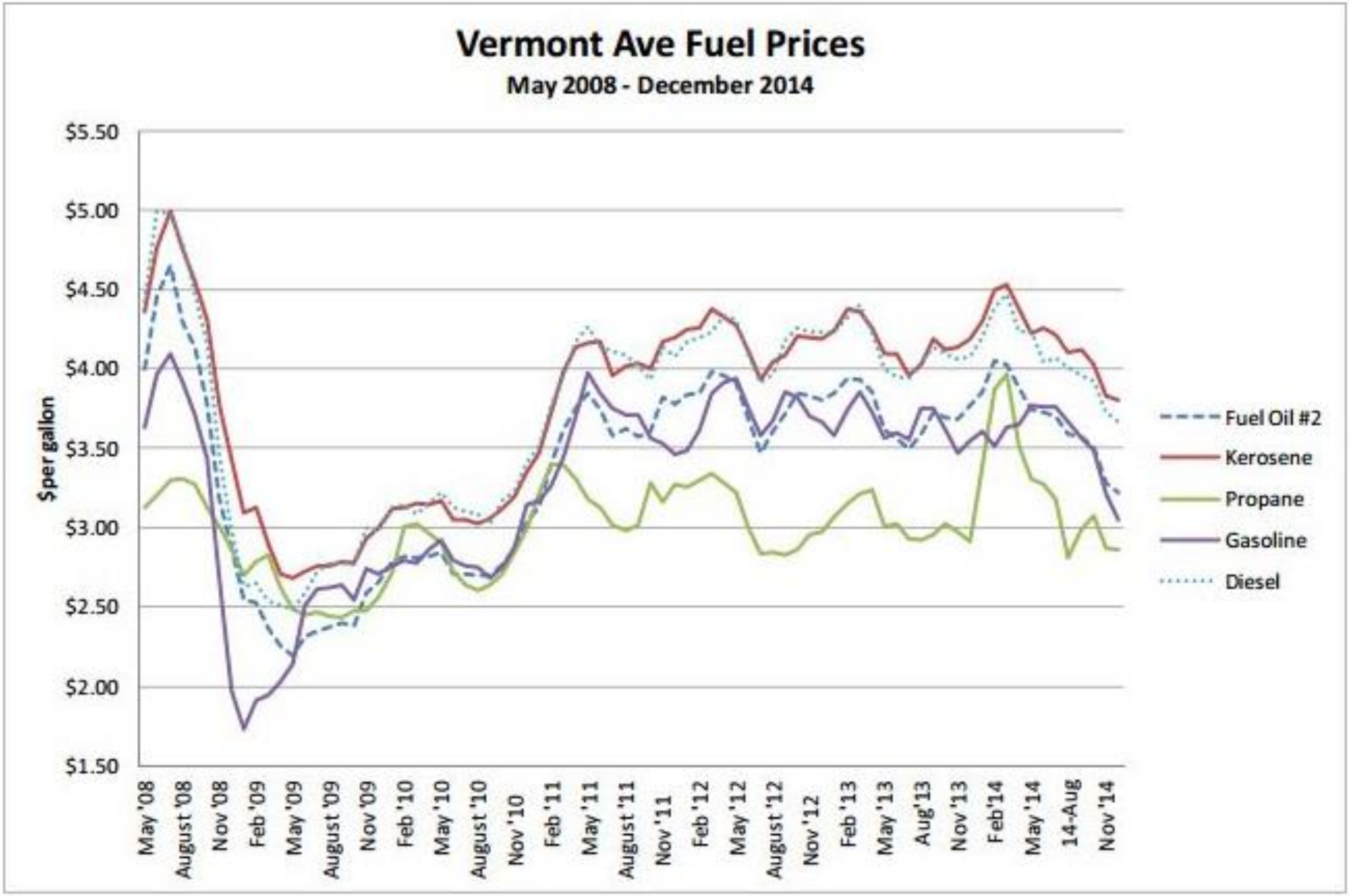
| Type of Energy | BTU/unit | Typ Effic | $/unit | $/MMBtu | | High Efficiency | $/MMBtu |
|---|---|---|---|---|---|---|---|
| Fuel Oil, gallon | 138,200 | 80% | $3.22 | $29.11 | | 95% | $24.52 |
| Kerosene, gallon | 136,600 | 80% | $3.80 | $34.78 | | | |
| Propane, gallon | 91,600 | 80% | $2.86 | $38.99 | | 93% | $33.54 |
| Natural Gas, therm | 100,000 | 80% | $1.48 | $18.52 | * | 95% | $15.60 |
| Electricity, kWh (resistive heat) | 3,412 | 100% | $0.15 | $43.46 | | | |
| Electricity, kWh (cold climate heat pump) | 3,412 | | $0.15 | | | 240% | $18.32 |
| Wood, cord (green) | 22,000,000 | 60% | $ 227.14 | $17.21 | * | | |
| Pellets, ton | 16,400,000 | 80% | $294.00 | $22.41 | * | | |

* The natural gas price is based on the rate effective 11/1/14. *Wood green and Pellets updated 9/19/14.

VT Fuel Report 12.14

- Equipment efficiency
- First cost of installation
- Fuel inflation rate
- Replacement cost of heating unit
- Maintenance cost
- Fuel availability

# Predicting Future Energy Costs is Not an Exact Science




VT Fuel Report 12.14

# Simple Payback Driving Factors

Example 1

Solar PV System

**Cost of Installation**

- Life expectancy
- Alternate use of money
- General rate of inflation
- Maintenance

**Savings**

- Annual savings
- Avoided future electric rate inflation
- Backup system
- Value of redundancy

# Simple Payback Method

Example 1

Solar PV System

Solar PV System Cost

| 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 |

Savings

Cost after rebates and tax credits

*Is this a good investment?*

# Net Cash Flow Method

Example 1

Solar PV System

| | January | February | March | April | May | June | July | August | September | October | November | December | Annual Bill |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Usage | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | $ 1,099 |
| 1st Tier Usage | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 2,400 |
| 2nd Tier Usage | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 2,640 |
| Production | 235 | 247 | 257 | 266 | 318 | 281 | 343 | 383 | 275 | 189 | 155 | 139 | |
| Initial Block Credit | 15 | 27 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | -31 | -65 | -81 | |
| Second Block Credit | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | |
| "Excess" | | | | -154 | -102 | -139 | -77 | -37 | -145 | | | | |

Annual Usage 5040 Annual Energy bill $ 782

Annual Production 3091.55 kWh to offset Energy bill 2606

Projected annual savings
$523/12 = $43.58/month

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solar Value kWh** | **$ 0.204** | **$ 0.196** | **$ 0.251** | **$ 0.124** | **$ 0.129** | **$ 0.126** | **$ 0.131** | **$ 0.133** | **$ 0.125** | **$ 0.230** | **$ 0.260** | **$ 0.278** | **$** [illegible] |
| Solar Value | $ 47.87 | $ 48.46 | $ 64.32 | $ 33.07 | $ 41.15 | $ 35.45 | $ 44.95 | $ 51.13 | $ 34.49 | $ 43.38 | $ 40.17 | $ 38.71 | $ 523 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tier 1 $ | $ 1.41 | $ 2.58 | $ 18.87 | $ 18.87 | $ 18.87 | $ 18.87 | $ 18.87 | $ 18.87 | $ 18.87 | $ (2.96) | $ (6.17) | $ (7.63) | |
| Tier 1 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | $ 0.094 | |
| Tier 2 $ | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | $ 46.34 | |
| Tier 2 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | $ 0.21 | |
| Excess $ | | | | $ (30.83) | $ (20.31) | $ (27.73) | $ (15.37) | $ (7.33) | $ (28.97) | | | | |
| Excess | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | $ 0.20 | |
| EVT Charge | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | $ 0.01 | |
| Fee $ beyond monthly service charge | $ 0.12 | $ (0.45) | $ (0.88) | $ (1.31) | $ (3.74) | $ (2.03) | $ (4.89) | $ (6.75) | $ (1.74) | $ - | $ - | $ - | $ (21.67) |
| Fee | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | $ (0.0463) | |

*Solar PV System - Is this a good investment?*

# Net Cash Flow Method

Example 1

Solar PV System

Home Value: 50000 $

Loan amount: 5683 $

Interest rate: 5 %

Get Today's Best Mortgage Rates

Loan term: 10 years

Start date: Jan ▼ 2015 ▼

Property tax: 0 %

PMI: 0.0 %

## Mortgage Repayment Summary

| | |
|---|---|
| **$60.28** | **$7,233.24** |
| Monthly Payment | Total of 120 Payments |
| **$1,550.24** | **Dec, 2024** |
| Total Interest Paid | Pay-off Date |

Compare to $43.58/month

# Net Cash Flow Method

Example 1

Solar PV System

| | | |
|---|---|---|
| Home Value: | 50000 | $ |
| Loan amount: | 5683 | $ |
| Interest rate: | 4 | % |

Get Today's Best Mortgage Rates

| | | |
|---|---|---|
| Loan term: | 10 | years |
| Start date: | Jan ▼ | 2015 ▼ |
| Property tax: | 0 | % |
| PMI: | 0.0 | % |

## Mortgage Repayment Summary

| | |
|---|---|
| **$57.54** | **$6,904.51** |
| Monthly Payment | Total of 120 Payments |
| **$1,221.51** | **Dec, 2024** |
| Total Interest Paid | Pay-off Date |

Compare to $43.58/month

# Net Cash Flow Method

Example 1

Solar PV System

Home Value: 50000 $

Loan amount: 5683 $

Interest rate: 5 %

Get Today's Best Mortgage Rates

Loan term: 15 years

Start date: Jan 2015

Property tax: 0 %

PMI: 0.0 %

## Mortgage Repayment Summary

| | |
|---|---|
| $44.94 | $8,089.34 |
| Monthly Payment | Total of 180 Payments |
| $2,406.34 | Dec, 2029 |
| Total Interest Paid | Pay-off Date |

Compare to $43.58/month

# Net Cash Flow Method

Example 1

Solar PV System

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

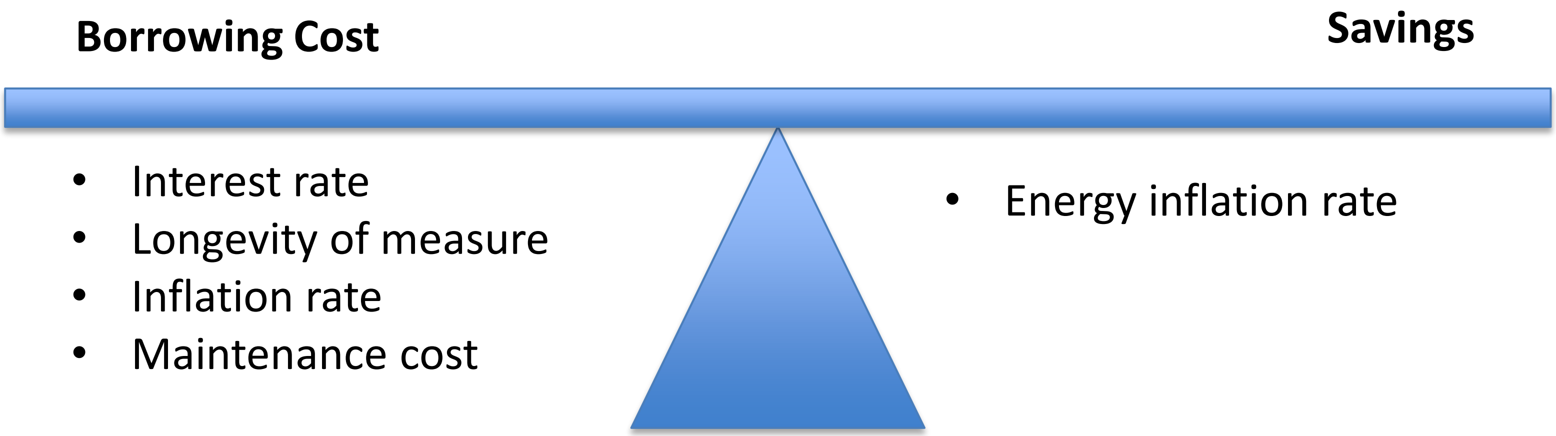
Compare to
$43.58/month

# Net Cash Flow Driving Factors

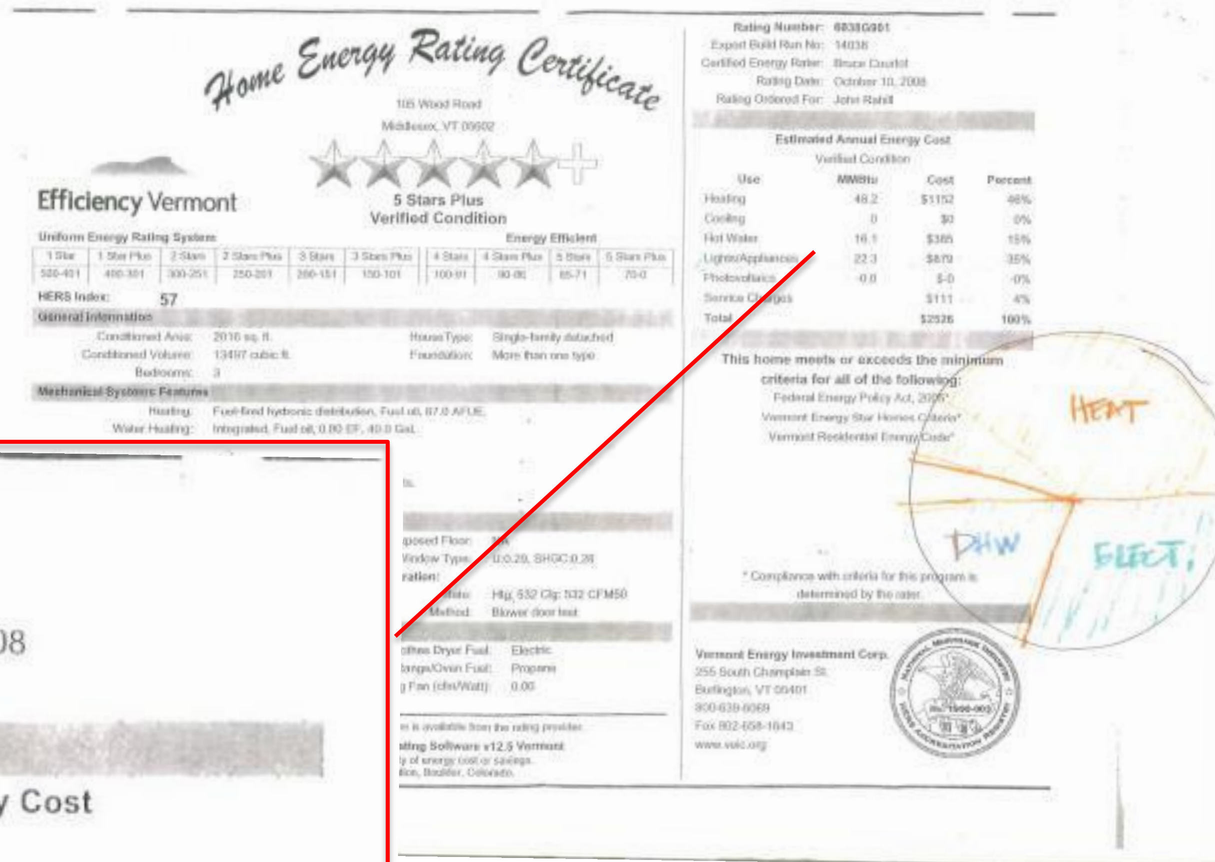
Example 1

Solar PV System

- Duration of loan vs. lifetime of equipment
- Interest rate
- Fuel inflation rate projection
- Next best alternative for your money
- Expected maintenance costs



Example 2


Home Energy Rating Certificate

105 Wood Road
Middlesex, VT 05602

Efficiency Vermont

5 Stars Plus
Verified Condition

Uniform Energy Rating System — Energy Efficient

| 1 Star | 1 Star Plus | 2 Stars | 2 Stars Plus | 3 Stars | 3 Stars Plus | 4 Stars | 4 Stars Plus | 5 Stars | 5 Stars Plus |
|---|---|---|---|---|---|---|---|---|---|
| 500-401 | 400-301 | 300-251 | 250-201 | 200-151 | 150-101 | 100-91 | 90-86 | 85-71 | 70-0 |

HERS Index: 57

General Information

Conditioned Area: 2016 sq. ft.
Conditioned Volume: 13497 cubic ft.
Bedrooms: 3
House Type: Single-family detached
Foundation: More than one type

Mechanical Systems Features

Heating: Fuel-fired hydronic distribution, Fuel oil, 87.0 AFUE.
Water Heating: Integrated, Fuel oil, 0.80 EF, 40.0 Gal.

This home meets or exceeds the minimum criteria for all of the following:
Federal Energy Policy Act, 2005*
Vermont Energy Star Homes Criteria*
Vermont Residential Energy Code*

* Compliance with criteria for this program is determined by the rater.

Vermont Energy Investment Corp.
255 South Champlain St.
Burlington, VT 05401
800-639-6069
Fax 802-658-1643
www.veic.org



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**

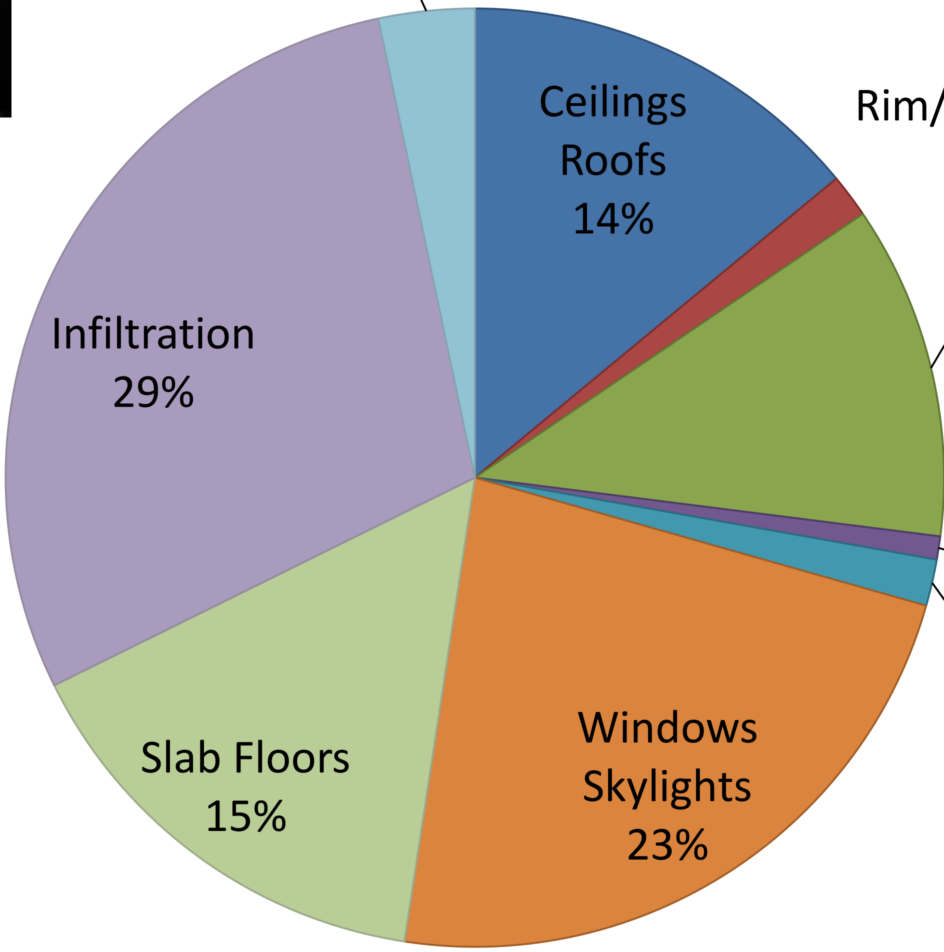
Verified Condition

| 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?*

Example 2

# Energy Model of Proposed Design




$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?*

# What's Different About A Cold Climate?

"A penny saved is a penny earned"

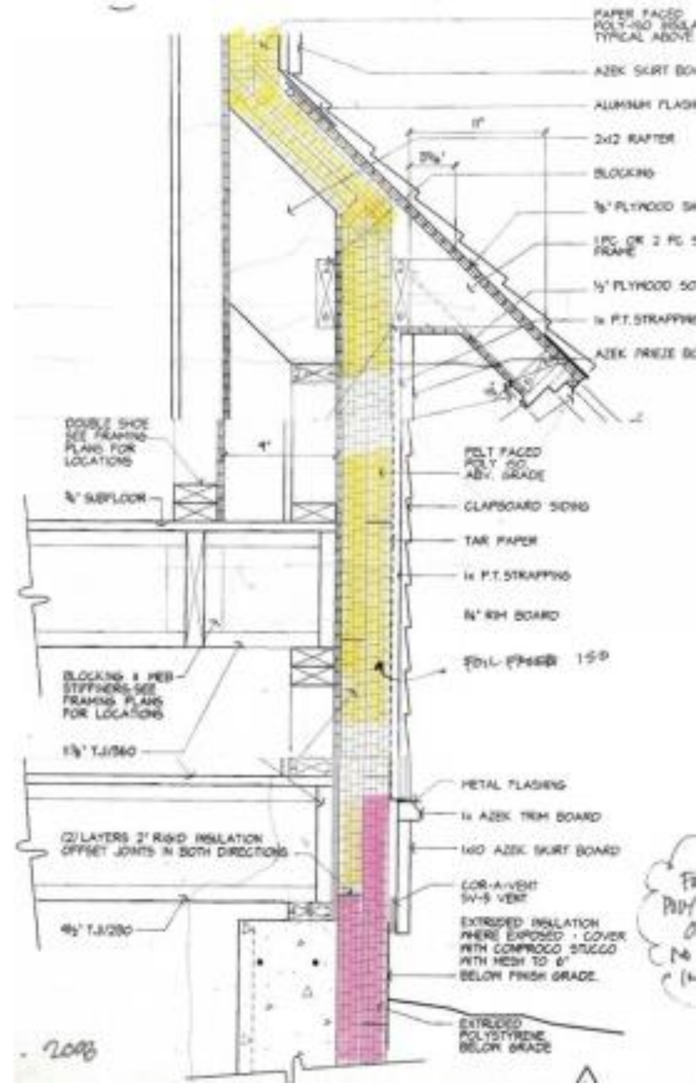
- Reducing Heat Loss - Instinctively, the first places to invest, especially in cold climates
  - A hedge against inflation
  - Often less expensive to invest initially, rather than later (opportunity for "doing it later" may not exist)
  - Less speculative

*There is nothing different about the methodology of balancing your energy dollars.*

# How Our Understanding of the Challenge has Changed

1973 Active Solar

1975 Passive Solar




Continuous Outsulation

*It's not enough to "go solar." We have learned (the hard way) that you have to balance energy saving measures with solar systems.*

# 3 Recent Projects

Williamstown Youth Center

Williams College Kellogg House

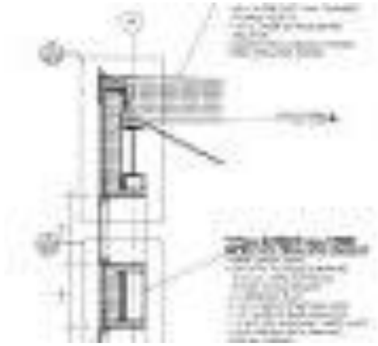
Rumney Memorial Elementary

# Building Systems

| | WYC | Kellogg | Rumney |
|---|---|---|---|
| Heating/Cooling | VRF ASHP | VRF ASHP | Central wood pellet/oil burner (limited cooling) |
| Ventilation | Multi-zone HRV | Multi-zone ERV | Multi-zone ERV |
| Lighting | Fluorescent | LED | LED |
| Controls | Packaged HVAC | Full Building Management System (BMS) | BMS |

# Envelope Performance

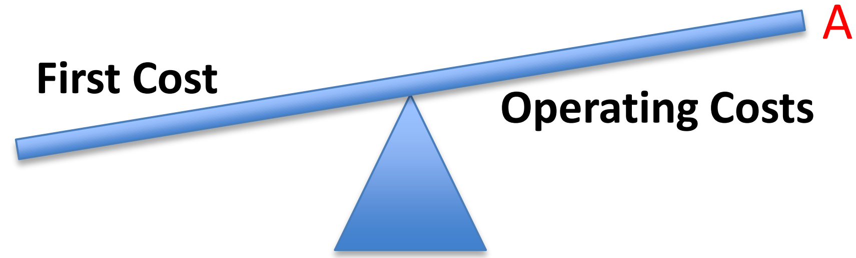
| Measure | WYC | Kellogg | Rumney |
|---|---|---|---|
| Roof | R-40 | R-35 | R-40 |
| Walls | R-30 | R-35 | R-20-25 |
| Windows | R-3 | R-5 | R-3 |
| Below Grade walls | R-25 | R-25 | R-15 |
| Slab | R-10 | R-15 | R-0 (existing)<br>R-10 (new) |
| Air Barrier | 2.6 ACH @ 50 Pa | .8 ACH @50 Pa | 3.32 ACH @50 Pa (existing) |



# Qualitative Building Performance

| Measure | WYC | Kellogg | Rumney |
|---|---|---|---|
| Southern overhangs | Yes | Yes | No |
| Solar sunshades | No | Yes | No |
| Clerestory windows | Yes | Yes | No |
| Balanced daylight harvesting | Yes | Yes | No |

# Williamstown Youth Center




- Limited budget
- LEED® Silver requirement
- MASS stretch code compliance mandated

- AC Air-to-air heat pumps
- Heat recovery ventilation
- Balanced daylighting
- High efficiency lighting
- All electric, no fossil fuels
- Southern overhangs

A

# Energy Modeling to Explore Potential

Energy of:

- Roof overhangs
- Solar sunshades
- Clerestory windows
- Double vs. triple glazing
- Storefront vs. thermally broken curtain wall

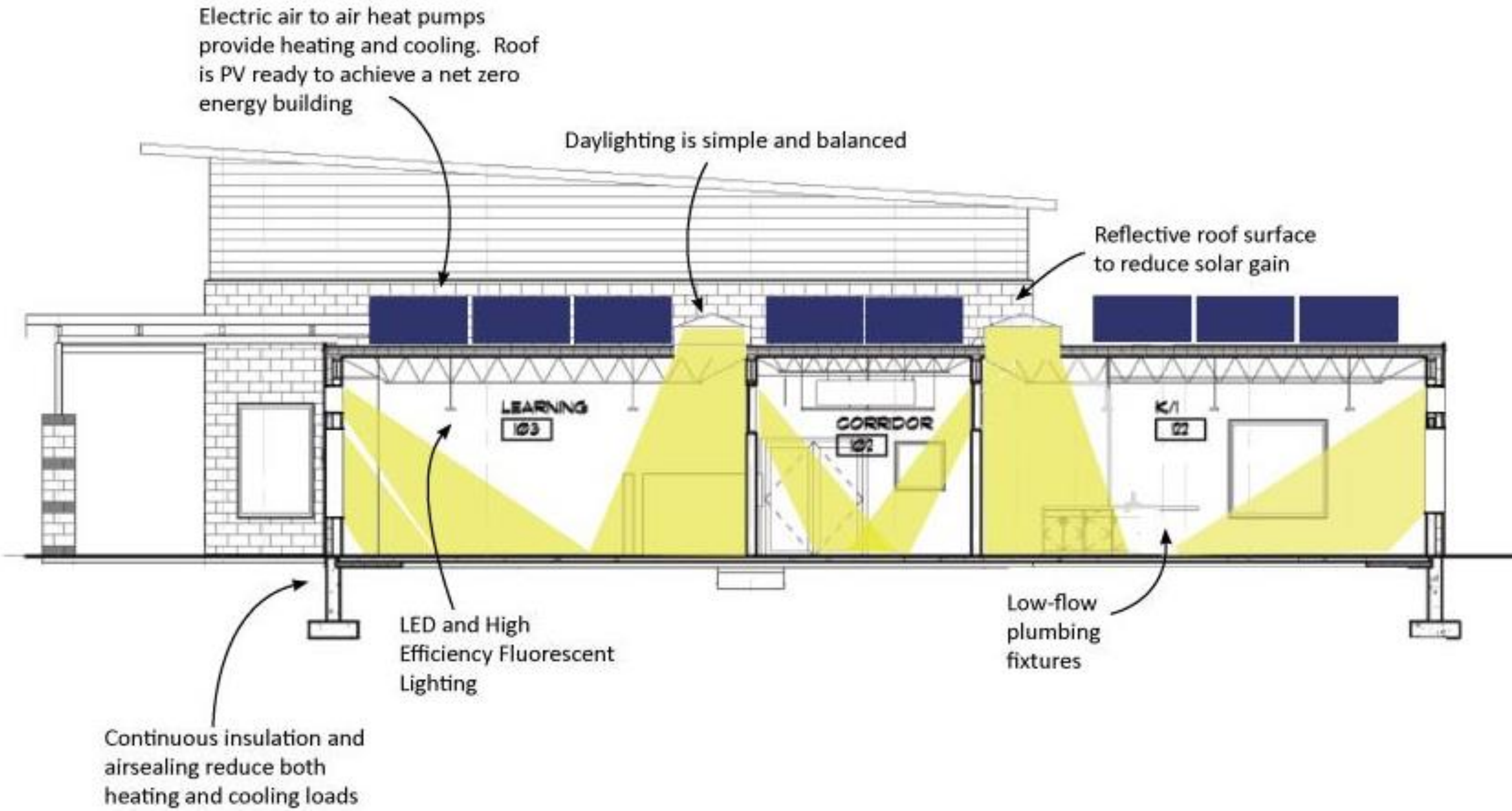
Then, “Value Engineering”

- Eliminate number of skylights vs. LEED required daylighting heat loss
- Reduce R-value of skylights (R20 to R5)
- Types of insulation and thickness
- Mechanical equipment options – rooftop units vs. air to air heat pumps

*Starting point was MASS Stretch Code*

# Net Zero Ready

A

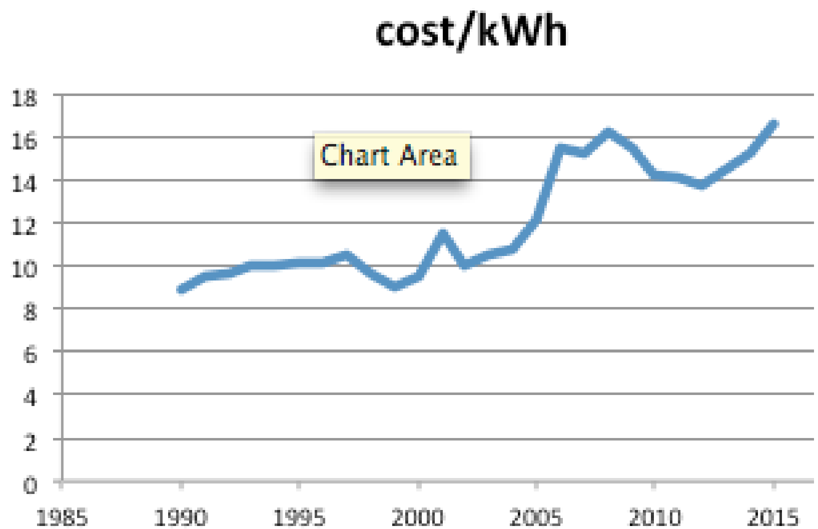


A

# Solar Feasibility Results

- Net Zero ready
  - Capacity for 50 to 80kW on roof
  - No leftover capital in initial project
  - Uncertainty of solar value
    - Will equipment improve?
    - Who reaps benefits from PPA?
    - Will a better deal come along?

# Electricity market drives interest




Steady demand for electricity attracts financiers

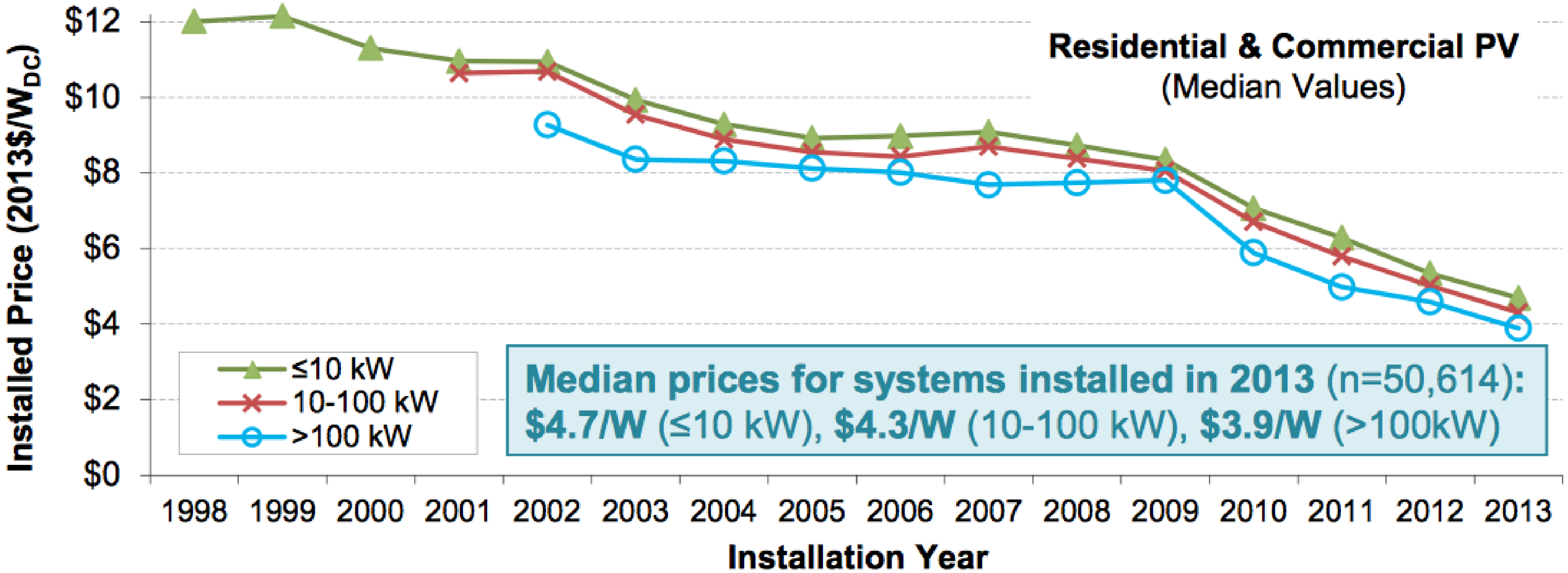
Massachusetts incentives yield 6-8 year payback

Opportunities for ‘friendly’ investment and crowd sourcing

Benefits shared between investors and host

A

# Waiting is okay



# Williams College Kellogg House

## A Living Building Challenge Project

- Net Zero Energy and Water requirement
- Living Building Challenge requires "no combustion"
- On site generation required to achieve Net Zero Energy
- Performance based certification


B

# Step 1: Model energy loss of a base case and establish increments of investment on every type of energy saving measure

B

| 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 | 6.4 | | $ 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 2: Balance investment between measures

B

| Locations | # Inches | Total Cost | Difference | MMBtu Saved/year | Cost Per mmbtu saved/year | Cost to produce mmbtu/year with PV array | Energy Cost kwh | Arrary 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.*

# Step 3: Invest in energy savings until it is less expensive to invest in energy generation

## Above Grade Walls

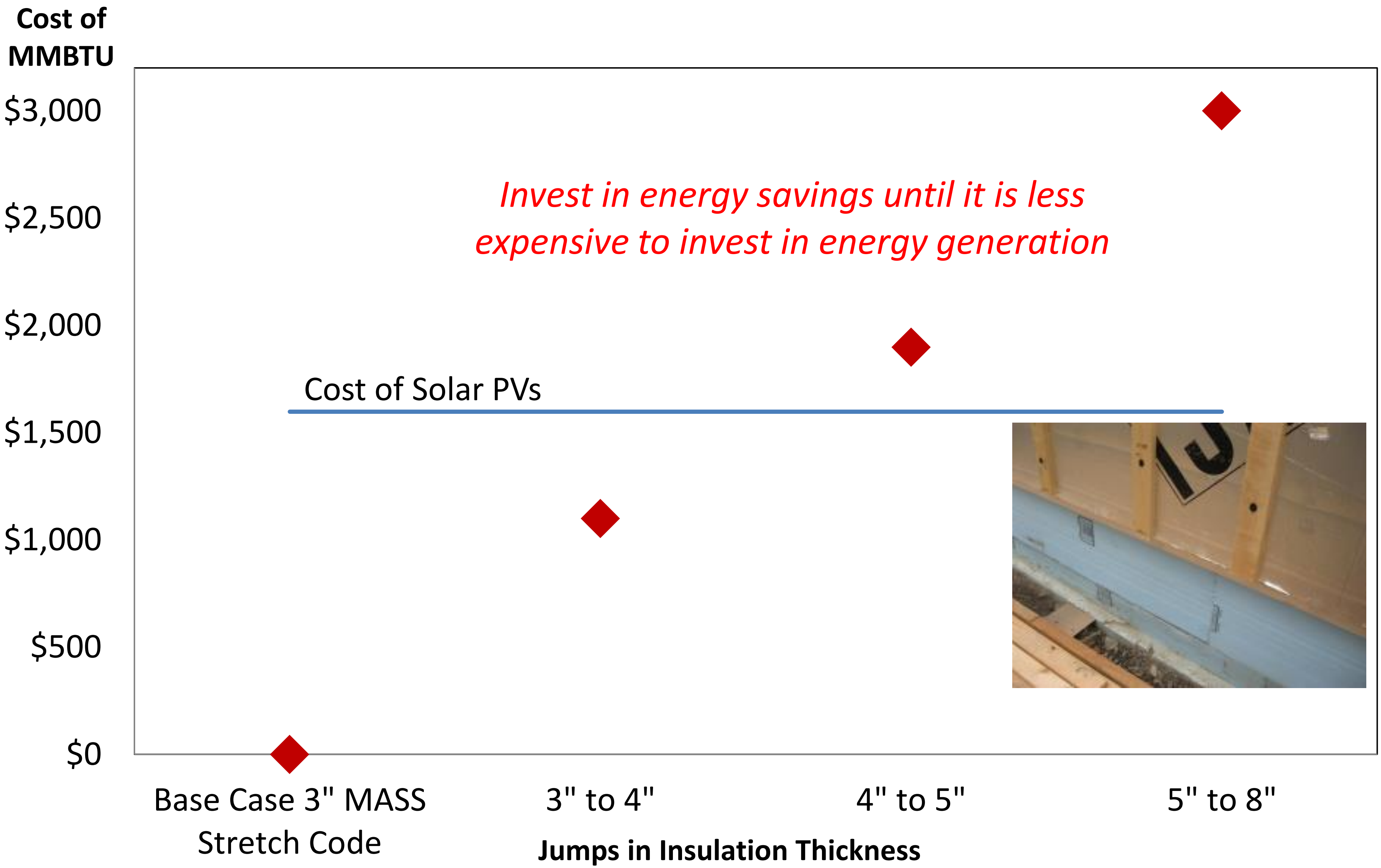
| Locations | # Inches | Total Cost | Difference | MMBtu Saved/year | Cost Per mmbtu saved/year | Cost to produce mmbtu/year with PV array |
|---|---|---|---|---|---|---|
| Option 1 | 2 | $ 14,746.20 | | 27.4 | | |
| Mass Stretch Min | 3 | $ 22,119.30 | | 33.8 | | |
| Difference | | | $ 7,373.10 | 6.4 | | $ 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 |

50% was added to account for replacement cost

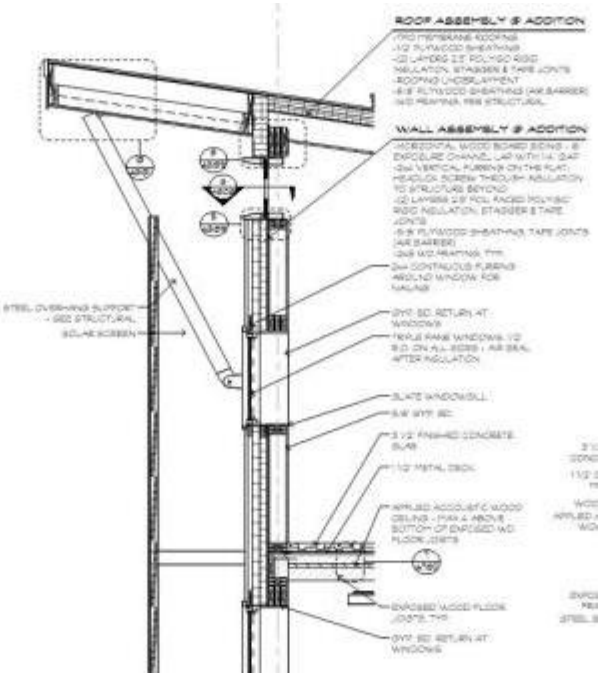
*Conclusion: Balancing all energy investments results in the most cost effective overall investment (any variation from the balanced investment is less efficient.)*

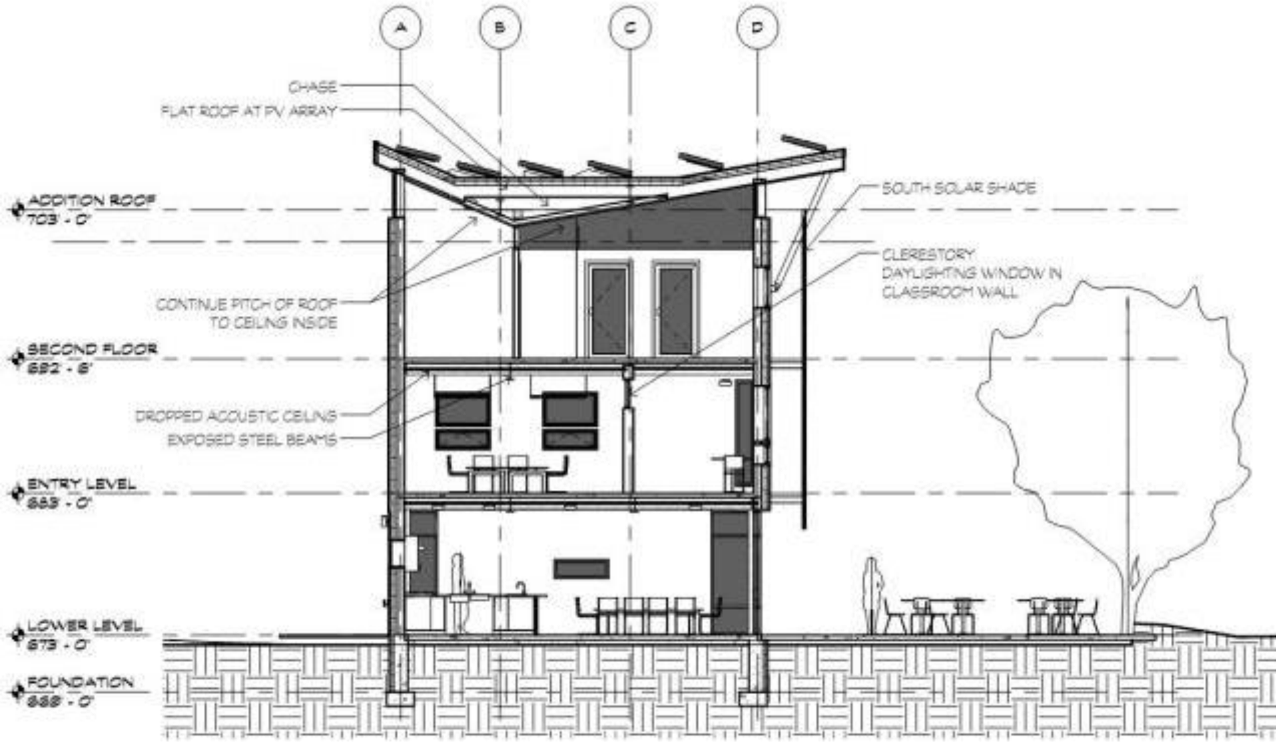
# Law of Diminishing Returns: Higher Cost of Saving a BTU for each Incremental Increase

B



# Impact on Envelope




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

*We were surprised that the envelope didn’t seem too extreme*

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# Rumney Memorial Elementary School Renovation

## Project Description

- Heating and ventilating system at the end of it's life – 40 years old
- Latest addition – 23 years old (lighting needs update)
- Asking tax payers for a tax increase (bond) is challenging

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# Efficiency Vermont Net Zero Pilot

## EXPECTATIONS

### Efficiency Vermont will:

1. **Explain net zero pilot guidelines** including requirements, process and incentives.
2. **Work closely with design team** to develop key energy goals, charrette agenda & provide customized technical assistance from design through one year of occupancy.
3. Issue an **incentive agreement** to communicate incentive terms and conditions. **Pay incentives** according to incentive agreement schedule.
4. **Track performance data** in first year of occupancy and review progress with building owner towards goal of net zero performance.
5. Present **net zero plaque** after one year of energy data verifies performance. Develop, with building owner and design team, a building recognition plan.

### Customer will:

1. **Review net zero pilot guidelines** provided and confirm understanding the basic process and requirements.
2. **Include Efficiency Vermont in design team meetings** and the project process.
3. **Complete deliverables and requirements** as summarized below.
4. Review, sign, and return **incentive agreement**.
5. **Complete project and verify** with Efficiency Vermont Energy Consultant compliance with all requirements including post occupancy data collection. Collaborate on building recognition.

## EFFICIENCY VERMONT: NET ZERO PILOT

**Technical Assistance**
For design teams and building owners who participate in the Net Zero Pilot, Efficiency Vermont will facilitate efficiency and energy goal discussions, sponsor an energy charrette and cashflow financial analysis. Increased technical assistance will be offered from design through to one year of occupancy. Services will go beyond Efficiency Vermont typical building systems focus to include assistance on metering equipment for energy data collection, renewable energy systems and transportation analysis services.

**Financial Assistance**
- Design/construction incentive includes all envelope, lighting and mechanical efficiency upgrades
- Energy charrette incentive - $2,500
- Energy simulation incentive - 50% of cost
- Energy monitoring equipment incentive - 50% of cost
- Commissioning incentive - 25% of cost
- Performance Incentive - up to 25% based on building operation for one year after construction

**Recognition Pre- and Post-occupancy**
Efficiency Vermont will work with design teams and owners to provide recognition for building accomplishments. This will include a net zero plaque after one year of data confirming performance. Other recognition could include:
- Case study and distribution through local and national professional networks
- Entering building into national databases for net zero and high performance construction

## Net Zero Pilot Memorandum of Agreement

Efficiency Vermont

## CUSTOMER: NET ZERO PILOT

**Energy Charrette -** As part of participation in the Net Zero Pilot the design team will hold an energy charrette presenting the challenges and solutions to achieving a net zero building. Topics could include building and equipment efficiency, renewable energy sources, transportation and other green building issues. The charrette could include unresolved issues and the group could give input to help create a path forward and solution to the design challenge. The energy charrette will be led by the design team and will include the building owner, Efficiency Vermont and the commissioning agent.

**Energy Design & Performance -** The building will be designed, and achieve, over a one-year period, performance as a net zero site energy building. The building will produce as much renewable energy on-site as it uses in one year. Energy can be exchanged with the power grid as long as the net energy balance is zero on an annual basis. Renewable energy sources available off-site used to generate energy through on-site processes may be used (e.g. wood). Eligible renewable energy technologies include photovoltaics, wind energy, solar thermal, low-impact hydroelectric, bio based electrical and thermal systems (e.g. wood and agricultural products).

**Energy Efficiency -** The building will use no more than 50% of the site energy of a building built to meet the 2011 Vermont Commercial Building Energy Standards (VT CBES), before site-produced renewable energy is counted. Focusing on efficiency first, renewables second is typically the most cost-effective way to net zero.

**Energy Simulation -** A whole-building energy simulation will be performed. This model will be used to verify the building is designed to operate using no more than 50% of site energy compared to code and as a net zero building. Modeling will be performed in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Standard 90.1-2010 Appendix G, with the baseline adjusted to the 2011 VT CBES.*

**Energy Monitoring -** The building will incorporate measurement devices for each energy supply source to the building, including electric and fuel (oil, gas), each on-site renewable energy production system and each major building electric system: HVAC, lighting, and plug loads. All measurement devices will automatically communicate the energy consumption data to a data acquisition system. All measurements will be taken and stored at a minimum of hourly increments. The data acquisition system will electronically store the data for a minimum of 3 years, and have the ability to create user reports, showing hourly, monthly, and annual energy use. Efficiency Vermont will have access/permission to the acquired data for a minimum of 5 years. Source of requirements and for more detail see: *ASHRAE 189.1 2011 Section 7.3.3 Energy Consumption Management*

**Commissioning -** Throughout the design, construction, and first-year-of-occupancy phases, building commissioning will be performed, including acceptance testing, for mechanical systems (heating, ventilating, air-conditioning, indoor air quality, refrigeration, and controls), domestic hot water, lighting systems (daylighting controls, occupancy sensing devices, automatic shut-off controls) , renewable energy systems, building envelope (thermal and moisture integrity, blower door test for air-tightness), and energy measurement devices. Source of requirements and for more detail see: *ASHRAE 189.1 2011 Section 10 Construction and Plans for Operation*

## 2 Pivotal Aspects:

- Wood heat is considered renewable
- Building must use <50% of 2011 VT Energy Code

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# Rumney Memorial Elementary School Bond Vote

- Taxpayers look at it very skeptically
  - Don't trust "expected savings"
  - Don't trust "new technology"
  - Will it save me money immediately?
- Result – net cash flow basis was used to evaluate energy saving investments.
  - Solar PVs project brought with it much skepticism

**Rumney Memorial School Renovation – Tax Impact**

**Estimated annual tax increase associated with a $3.5 million building project:**

Educational taxes are based on a combination of home value and household income. Use this table to find your annual tax based on your situation. This tax would pay only for the building project. It would be above and beyond the regular U32 and Rumney school budget taxes.

| Step 1: Find your housesite value: | Step 2: Find your Vermont household income: | | | | |
|---|---|---|---|---|---|
| | If capped at 5% of income Under $47,000 | $50,000 | $70,000 | $90,000 | Without education tax adjustment and income over $105k |
| | Step 3: Find the intersection of steps 1 and 2 – this is how much your taxes would be: | | | | |
| $50,000 | $0 | $59 | $59 | $59 | $59 |
| $100,000 | $0 | $117 | $117 | $117 | $117 |
| $160,000 | $0 | $159 | $187 | $187 | $187 |
| $200,000 | $0 | $159 | $222 | $234 | $234 |
| $260,000 | $0 | $159 | $222 | $285 | $304 |
| $300,000 | $0 | $159 | $222 | $285 | $351 |
| $400,000 | $0 | $159 | $222 | $285 | $468 |

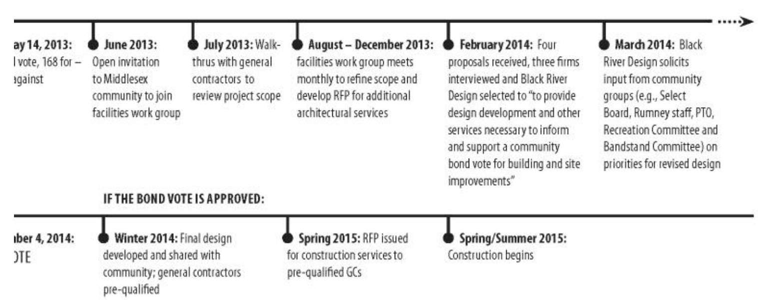
**Example 1:** I own a house and 2 acres worth $100,000 and my taxable income is $46,000, so my tax increase is projected to be $0.

**Example 2:** I own a house and 2 acres worth $200,000, plus additional acreage worth $50,000, and my taxable income is $70,000, so my tax increase is projected to be $222 for the housesite plus $59 for acreage for a total of $281.

**Example 3:** I own a house worth $180,000 and my taxable income is $60,000, so my tax increase is projected to be between $159 and $222.

**Considerations:**

1. This table assumes that the income adjustment under state law remains the same. See Vermont Title 32 S 6066 for the law.
2. This table applies to residential properties only. Non-residential, commercial and rental properties are subject to the Statewide rate set each year by the Vermont Legislature.
3. Income adjustment applies to a house and up to two acres (aka a housesite). Additional acreage is taxed at the full rate (the rightmost column).
4. This table is based on what year 1 of the bond repayment would cost ($305,335). Subsequent years would be lower.



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# Rumney Memorial Elementary School Renovation

Step 1: Look at energy saving investments

- Ideal time for energy saving investments in improving the envelope
  - Roof
  - Walls
  - Windows (all near the end of their useful life)

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# Balancing Investments in Energy Savings (based on energy modeling)

**RUMNEY MEMORIAL SCHOOL**
Energy Upgrade/Cost Analysis - Pellet Boiler Incorporated
9/2/2014

| Efficiency Measure | Description | Oil Savings vs. Basecase + Addition | | Year 1 Savings at $3.50/gal Oil | Initial Installation Cost | Bond Factor 1.4 | Annual Cost over 20 year bond | Net annual savings |
|---|---|---|---|---|---|---|---|---|
| Basecase | | 768 | ga. | $2,191 | | | | |
| Basecase with Addition | | 0 | ga. | n/a | | | | |
| **SLAB** | | | | | | | | |
| 1.a.ii | Insulate uninsulated slab edges-Add 3" | 241 | ga. | $842 | $7,728 | $10,819 | $541 | $847.93 |
| 1.c | New slab: Assume 3" continuous insulation under slab | 20 | ga. | $68 | $1,200 | $1,680 | $84 | $28.61 |
| **WALLS** | | | | | | | | |
| 2.a.iii | 2x6 w/fiberglass and poly vapor barrier – Add 3" Roxul | 153 | ga. | $535 | $10,415 | $14,580 | $729 | $153.12 |
| 2.c.ii | Block with almost no insulation – Add 3" XPS | 170 | ga. | $596 | $3,309 | $4,633 | $232 | $751.85 |
| 2.d.i | Block with 2" interior rigid insulation – Add 2" XPS | 53 | ga. | $187 | $1,620 | $2,268 | $113 | $194.41 |
| **ROOFS** | | | | | | | | |
| 3.a.i | Flat roof with 3" continuous existing – Add 2" Rigid | 202 | ga. | $705 | $14,850 | $20,790 | $1,040 | $124.16 |
| 3.a.ii | Flat roof with 3" continuous existing – Add 3" Rigid | 215 | ga. | $753 | $19,800 | $27,720 | $1,386 | ($143.51) |
| **WINDOWS** | | | | | | | | |
| 4.a | Replace windows with double glazed low e argon | 343 | ga. | $1,199 | $44,000 | $61,600 | $3,080 | ($1,101.77) |
| **UTILITIES** | | | | | | | | |
| | Pellet Boiler | 2540 | ga. | $8,890 | $90,000 | $126,000 | $6,300 | $8,368.21 |
| | | 3936 | ga. | (annual savings) | | | | |

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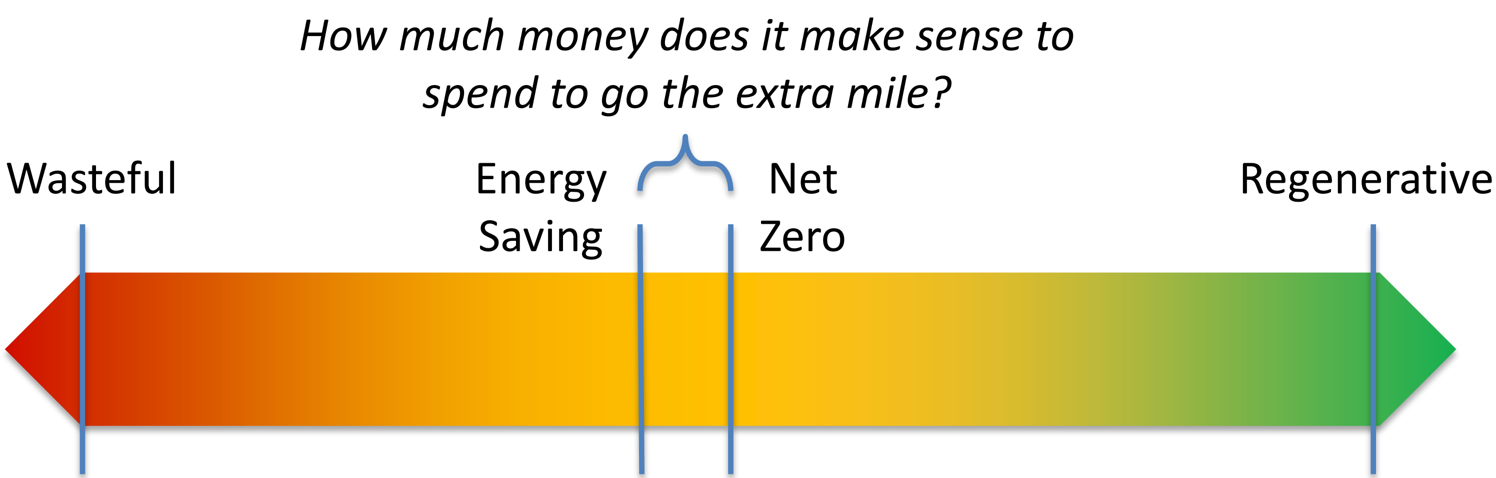
# Rumney Memorial Elementary School Renovation

Step 2 (to get to Net Zero): Investigate converting to 100% renewable energy

- 100% wood pellet heating (renewable)
- Photovoltaic system

# Aspects that Prevented Achieving Net Zero

- Solar grant was not received
- Site impact was a concern
- Because it's a publicly funded entity, tax credits are not available (impacting the viability of solar PVs to offset electrical)
- Presence of oil tank, good back up boiler and the efficiency of using oil for DHW and swing season heating (compared to pellet boiler)
- Some parts of the building envelope did not need replacement (energy savings measures were too expensive)



# Renewable energy motivation

- WYC: long-term energy price stability
- Kellogg: proven net Zero Energy performance
- Rumney: payback for taxpayers

**LOW**

- Trust cost
- Long term energy stability
- Net Zero ready

**HIGH**

- LBC
- No combustion
- Net Zero

**CAUTIOUS**

- Impact on taxes
- Skeptical
- Nearly Net Zero

# Summary

- Use energy modeling to project where your energy dollars are going
- Balance your investments in energy savings first(balancing results in the context of overall cost.)
- Investigate renewable energy generation options
- Invest in energy savings until it is less expensive to invest in energy production

# Balancing your energy dollars in a cold climate:

## Employing energy modeling to guide the process

**Presenters**

**John Rahill**
Principal
Black River Design Architects
Montpelier, VT

**Charles Stevenson**
Principal
Integrated Eco Strategy
Williamstown, MA

BLACK RIVER DESIGN ARCHITECTS

integrated ecostrategy

Questions?