High Performance Mobile Home Replacement

In partnership with: Vermod, CVOEO, University of Vermont Community Development and Applied Economics, High Meadows Fund, and Vermont Community Foundation
“It’s expensive to be poor,” Shlachter says.
# Manufactured Homes in Vermont

<table>
<thead>
<tr>
<th>Location</th>
<th>Homes in VT</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Mobile Home Parks</td>
<td>7,194</td>
</tr>
<tr>
<td>On Private Land</td>
<td>15,124</td>
</tr>
<tr>
<td>Pre-1976</td>
<td>23%</td>
</tr>
<tr>
<td>1976-1993</td>
<td>46%</td>
</tr>
<tr>
<td>1994-Present</td>
<td>31%</td>
</tr>
</tbody>
</table>
MH Residents in Vermont

VT Mobile Home Park Resident Demographics

2011 MHP Survey Respondent Household Income by HUD Income Levels
n=283

<table>
<thead>
<tr>
<th>Income Category</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTREMELY LOW-INCOME (30% AMI)</td>
<td>14.3%</td>
</tr>
<tr>
<td>VERY LOW INCOME (50% AMI)</td>
<td>26.9%</td>
</tr>
<tr>
<td>LOW INCOME (80% AMI)</td>
<td>32.3%</td>
</tr>
<tr>
<td>GREATER THAN LOW INCOME</td>
<td>26.5%</td>
</tr>
</tbody>
</table>

~ 14% would be considered to be “extremely low income” according to HUD Area Median Income guidelines

Data from 2011 UVM Survey of 363 residents in 127 Vermont mobile home parks
## Cost of Homes & Ability to Pay

### High Performance Home on purchased land

<table>
<thead>
<tr>
<th></th>
<th>MSA</th>
<th>Southern VT</th>
<th>Wash-Lam-Add</th>
<th>Orange-Windsor</th>
<th>NEK</th>
<th>VT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median lot cost</strong></td>
<td>$119,000</td>
<td>$ 47,000</td>
<td>$ 59,500</td>
<td>$ 36,000</td>
<td>$ 30,000</td>
<td>$ 55,000</td>
</tr>
<tr>
<td><strong>Site work and foundation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 47,775</td>
<td></td>
</tr>
<tr>
<td><strong>Vermod Home cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 107,000</td>
<td></td>
</tr>
<tr>
<td><strong>Vermod Total Price</strong></td>
<td>$273,775</td>
<td>$201,775</td>
<td>$214,275</td>
<td>$190,775</td>
<td>$184,775</td>
<td>$209,775</td>
</tr>
<tr>
<td><strong>Income required to afford Vermod</strong></td>
<td>$ 81,309</td>
<td>$ 60,106</td>
<td>$ 63,834</td>
<td>$ 56,824</td>
<td>$ 55,219</td>
<td>$ 62,641</td>
</tr>
</tbody>
</table>

*For homes on purchased land, assumes a 30-year fixed rate mortgage with 5% down payment and average VT insurance, taxes, closing costs and interest rates. Estimated income required to afford home is based on 30% housing cost-income affordability ratio.
Cost of Homes & Ability to Pay

<table>
<thead>
<tr>
<th>Vermod in MH park</th>
<th>State-wide averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average monthly lot rent</td>
<td>$ 270</td>
</tr>
<tr>
<td>Site work and foundation</td>
<td>$ 24,275</td>
</tr>
<tr>
<td>Home cost</td>
<td>$ 107,000</td>
</tr>
<tr>
<td>Total Price</td>
<td>$ 131,545</td>
</tr>
<tr>
<td>Income required to afford home*</td>
<td>$ 40,193</td>
</tr>
</tbody>
</table>

For homes on rented lot in MH park, assumes average state-wide monthly lot rent in total annual housing costs. Estimated income required to afford home is based on 30% housing cost-income affordability ratio.
Existing Manufactured Homes
Manufactured Homes and Energy

• Spend *66%* more of their household income on energy than residents of stick built housing

• Pay *2x* as much per square foot for energy as owners of detached homes

• LIHEAP historically provided *50%* more assistance per square foot to manufactured housing residents
New and Existing Manufactured Housing

• Manufactured Housing Construction Safety Standards (MHCSS) is the “preemptive code” and typically less than state site built codes;
• Durability issues associated with poor design details and materials lead to high maintenance costs and structure deterioration;
• High off-gassing materials and poor ventilation leads to unhealthy indoor air quality;
• Not designed for Northern climates so high energy costs and comfort issues.
New and Existing Manufactured Housing
“Tropical Storm Irene: Irene Spares Big Cities, but Vermont Sees Huge Floods”
– Huffington Post

“Raging Water in Vermont From Hurricane Irene”
– Weather Channel

• 438 mobile homeowners were eligible for FEMA assistance
• 129 mobile homes required complete demolition or removal
Key Partners Come Together

- High Meadows Fund
- Vermont Housing and Conservation Board
- Efficiency Vermont
- Vermont Housing and Finance Agency
  - CVOEO
  - UVM
- Champlain Housing Trust
- Other Statewide Regional Partners

http://www.vhcb.org/mhip/
Manufactured Housing Innovation Pilot Project

Focus: 10 HP units targeted at single wide mobile home replacement market

Major Funders: High Meadows Fund, VHCB, Efficiency Vermont, VHFA Tax Credit Program

Project Management: VHCB and Efficiency Vermont

Design Team: Pill-Maharam Architects, Artisan Engineering, VERMOD Homes

Construction Partner: VERMOD Homes, Wilder, Manufactured Housing Innovation Pilot Project
Mobile Home Replacement High Performance Approach

• Apply lessons learned from HPH Tier pilot phase related to envelope and mechanical specifications
• Installation of monitor devices in homes to track energy use, HVAC performance, comfort and indoor air quality
• Optimizing everything for lowest cost, and assessing total cost of ownership
• Supporting the financial sector in offering better terms
• Homeowner training and follow up support
Vermont’s Comprehensive Energy Plan

…60% of all new homes in Vermont to ENERGY STAR standards or Efficiency Vermont’s Energy Code Plus and broader market penetration of net-zero energy buildings, with a goal of having 30% built to net-zero design standards by 2020 as an interim target on the way to 100% net-zero buildings by 2030.

In Vermont this translates to approximately 275 single family homes built to NZE standards per year.
Rational Behind High Performance Approach

- Increased airtightness
- HRV
- High R-value envelope
- High performance windows
- Eliminate conventional heating/cooling system

High Performance Home
Rational Behind High Performance Approach

Average Energy Consumption by End Use

- **EIA RECS 2009, New England**
  - Heating: 60%
  - Cooling: 17%
  - Hot Water: 15%
  - Lights & Appliances: 1%

- **Vermont ENERGY STAR Homes 2012**
  - Heating: 58%
  - Cooling: 51%
  - Hot Water: 5%
  - Lights & Appliances: 5%

- **Vermont High Performance Homes**
  - Heating: 32%
  - Cooling: 25%
  - Hot Water: 17%
  - Lights & Appliances: 1%

- **113 Annual MMbtu**
- **94 Annual MMbtu**
- **34 Annual MMbtu**

*End use 'Heating' for High Performance Homes is Heating and Cooling combined*
High Performance Concept

Maintain the temperature through conservation rather than by using energy.

Albert, Righter & Tittmann
Benefits of High Performance Specification

- Superior Indoor Air Quality
- Reduced Maintenance
- Comfortable and Quiet Home
- A Home that Holds its Value
- Eliminate Dependence on Fossil Fuel Deliveries, Section 8 energy allowance and LIHEAP
- Lower Cost per Month for Mortgage and Energy
Mobile Home Parks
- Open floor plan
- Sound-dampened mechanical room
- Plenty of closet space
- Large kitchen
Finally, a home made for our New England weather... and built right here in Vermont.

Quality, comfort, and long-term affordability
Typical Manufactured Home

10 50-gallon barrels of oil a year

High Performance Manufactured Home

3 and 1/4 50-gallon barrels of oil a year

With solar PV

One 50-gallon barrel of oil a year
3/4" ROOF SHEATHING (HUBER ZIP SYSTEM) WITH ICE & WATER SHIELD OVER

16' TOTAL WIDTH

5" SEAMLESS GUTTER

1/2" SHEATHING WITH TAPE JOINTS (HUBER ZIP SYSTEM)

VINYL SIDING

8'

SUBFLOOR EL. 3'-6"

3/4" FLOOR DECKING (ADVANTECH)

(2) 2x4 STUD WALLS, WOOD STUDS AT 24" O.C., 10" CAVITY

10" BLOWN-IN INSULATION (FIBERGLASS, R-40)

LOW-VOC VAPOR RETARDER PRIMER ON WALLS AND CEILING

2" ADVANTECH TOP PLATE

3/8" GYPSUM WALL BOARD (GLUED TO STUDS)

ROOF TRUSSES AT 24" O.C.

14" BLOWN-IN INSULATION (FIBERGLASS, R-60)

ASPHALT SHINGLE ROOFING

POSSIBLE DUCT LOCATION

10'-6" TO TOP OF RIDGE CAP

12'-3 1/8"

9 1/2" 23Ø TJ 1/4 AT 24" O.C.

3/4" SHEATHING (HUBER ZIP SYSTEM)

(2) 12" X 12" LVL
Testing Insulation Installation on Mock Walls
The Start of a Modular Unit
10” Thick Walls
Staggered or Not

Effective R-values for walls from THERM analysis.

<table>
<thead>
<tr>
<th>Wall Cavity Thickness</th>
<th>12 in</th>
<th>10 in</th>
<th>9 in</th>
<th>8 in</th>
<th>7 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap Between Framing</td>
<td>5 in</td>
<td>3 in</td>
<td>2 in</td>
<td>1 in</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R-Value [ft²h°F/Btu]</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-line</td>
</tr>
<tr>
<td>Offset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R-Value [ft²h°F/Btu]</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-line</td>
</tr>
<tr>
<td>Offset</td>
</tr>
</tbody>
</table>
Insulated Corners – Not a Weak Spot
14” Truss Roof System for Heavy Loads and High Insulation Value
Ceiling Sheathed Before Interior Walls Installed and Vapor Barrier Primer
Climate Pro FG: R-4.3/in – 1.8/lbs per cu ft
Cellulose: R-3.6/in – 3.5-4/lbs per cu ft
Floor, Walls & Roof Dense-Packed with Fiberglass
Complete Air Barrier Around House to Eliminate Leakage
U-0.19 SHGC-Low or High
Resulting Air Tightness < 1 ACH50
Windows & Doors Sealed and Siding Installed
Lifts for Belly Insulation and Detailing
Heat Loss – 8 kBtu/hour
Mini-Heat & CERV & HPWH

Total Home Efficiency

~ 260%
Electric Heat & CERV & HPWH

Heating Season

Total Home Efficiency
~ 130%
Mini-Cool & CERV & HPWH

Cooling Season

Diagram of Mini-Cool and CERV systems with energy benefits and total home efficiency.
Conditioning Energy Recovery Ventilator - CERV

**Heating and Cooling Capacities**

- Watts Heating/Cooling vs. Outside Temperature (F)

**Heating and Cooling COP**

- Coefficient of Performance vs. Outside Temperature (F)

- Performance data for approximately 200CFM-250CFM air flow

Legend:
- Recirc Cool
- Vent Cool
- Recirc Heat
- Vent Heat
CERV Controller

Current Conditions:
- Temperature: 73°F (80% humidity), 86°F (74% humidity)
- CO₂: 800 PPM
- VOC: 1050 PPM

Cool Setpoint: 81°F
Heat Setpoint: 70°F

Home status:
- Normal (green)

Settings & Alerts:
- Ventilation Setpoint: 1000 PPM
- Minimum Ventilation: On Demand

Auxiliary Device Type:
- Heating

Auxiliary Setpoint: 65°F
### Specifications: ATI 66

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Size</td>
<td>66 gallons</td>
</tr>
<tr>
<td>Energy Factor (Hybrid Mode)</td>
<td>2.25</td>
</tr>
<tr>
<td>1st Hour Rating (Hybrid Mode)</td>
<td>75 Gallons</td>
</tr>
<tr>
<td>Heat Pump BTU Rating</td>
<td>2.5 kW</td>
</tr>
<tr>
<td>Compressor Make</td>
<td>Panasonic</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>R410A</td>
</tr>
<tr>
<td>Tank Capsule (Stainless Steel)</td>
<td>SS304</td>
</tr>
<tr>
<td>Noise</td>
<td>48 db</td>
</tr>
</tbody>
</table>

#### Heat Pump Hot Water Heater

**1ST HOUR RATING (GAL) BY MODE**

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Hybrid</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.1</td>
<td>67.5</td>
<td>59.1</td>
</tr>
</tbody>
</table>

**ENERGY FACTOR BY MODE**

<table>
<thead>
<tr>
<th>Model</th>
<th>Gallon Capacity</th>
<th>Efficiency</th>
<th>Hybrid</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHPT-50</td>
<td>50</td>
<td>2.78</td>
<td>2.75</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Primary Heating and Cooling

- Fujitsu 9RLS2h
- Mitsubishi MSZ/MUZ FH09
### MITSUBISHI FH09

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Indoor Unit</th>
<th>Outdoor Unit</th>
<th>MSZ-FH09NA</th>
<th>MUZ-FH09NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rated Capacity</td>
<td>Btu/h</td>
<td></td>
<td>9,000</td>
</tr>
<tr>
<td>Cooling *1</td>
<td>Capacity Range</td>
<td>Btu/h</td>
<td></td>
<td>1,700-12,000</td>
</tr>
<tr>
<td></td>
<td>Rated Total Input</td>
<td>W</td>
<td></td>
<td>560</td>
</tr>
<tr>
<td></td>
<td>Energy Efficiency</td>
<td>SEER</td>
<td></td>
<td>30.5</td>
</tr>
<tr>
<td></td>
<td>Moisture Removal</td>
<td>Pints/h</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Sensible Heat Factor</td>
<td></td>
<td></td>
<td>0.920</td>
</tr>
<tr>
<td>Heating at 47° F *2</td>
<td>Rated Capacity</td>
<td>Btu/h</td>
<td></td>
<td>10,900</td>
</tr>
<tr>
<td></td>
<td>Capacity Range</td>
<td>Btu/h</td>
<td></td>
<td>1,600 - 18,000</td>
</tr>
<tr>
<td></td>
<td>Rated Total Input</td>
<td>W</td>
<td></td>
<td>710</td>
</tr>
<tr>
<td></td>
<td>HSPF (IV)</td>
<td>Btu/h/W</td>
<td></td>
<td>13.5</td>
</tr>
<tr>
<td>Heating at 17° F *3</td>
<td>Rated Capacity</td>
<td>Btu/h</td>
<td></td>
<td>6,700</td>
</tr>
<tr>
<td></td>
<td>Rated Total Input</td>
<td>W</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Maximum Capacity</td>
<td>Btu/h</td>
<td></td>
<td>12,200</td>
</tr>
<tr>
<td>Heating at 5° F</td>
<td>Maximum Capacity</td>
<td>Btu/h</td>
<td></td>
<td>10,900</td>
</tr>
</tbody>
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### FUJITSU ASU9RLS2h

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<thead>
<tr>
<th>Outdoor temperature</th>
<th>°FDB</th>
<th>°FWB</th>
<th>TC</th>
<th>IP</th>
<th>°FDB</th>
<th>°FWB</th>
<th>TC</th>
<th>IP</th>
<th>°FDB</th>
<th>°FWB</th>
<th>TC</th>
<th>IP</th>
<th>°FDB</th>
<th>°FWB</th>
<th>TC</th>
<th>IP</th>
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<tbody>
<tr>
<td>-15</td>
<td>-17</td>
<td></td>
<td>11.6</td>
<td>2.010</td>
<td></td>
<td></td>
<td>11.4</td>
<td>2.140</td>
<td></td>
<td></td>
<td>11.1</td>
<td>2.180</td>
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<td></td>
<td>14.0</td>
<td>2.200</td>
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<tr>
<td>-5</td>
<td>-7</td>
<td></td>
<td>14.7</td>
<td>2.120</td>
<td></td>
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<td>14.3</td>
<td>2.160</td>
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<td></td>
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<td>2.200</td>
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<tr>
<td>5</td>
<td>3</td>
<td></td>
<td>16.1</td>
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<td>15.7</td>
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<td>2.200</td>
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<tr>
<td>14</td>
<td>12</td>
<td></td>
<td>16.8</td>
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<td>16.4</td>
<td>2.100</td>
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<td>2.140</td>
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<td>2.140</td>
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<tr>
<td>23</td>
<td>19</td>
<td></td>
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<td>1.990</td>
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<td>17.9</td>
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<td></td>
<td>17.5</td>
<td>2.070</td>
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<td>32</td>
<td>28</td>
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<td>18.8</td>
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<td>17.9</td>
<td>2.000</td>
</tr>
<tr>
<td>41</td>
<td>37</td>
<td></td>
<td>21.3</td>
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<td></td>
<td></td>
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<td>1.890</td>
<td></td>
<td></td>
<td>20.3</td>
<td>1.930</td>
<td></td>
<td></td>
<td>20.3</td>
<td>1.930</td>
</tr>
<tr>
<td>47</td>
<td>43</td>
<td></td>
<td>23.1</td>
<td>1.910</td>
<td></td>
<td></td>
<td>22.6</td>
<td>1.950</td>
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<td>1.990</td>
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<td>50</td>
<td>47</td>
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<td>2.020</td>
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<td>24.3</td>
<td>2.020</td>
</tr>
<tr>
<td>59</td>
<td>50</td>
<td></td>
<td>26.5</td>
<td>1.950</td>
<td></td>
<td></td>
<td>25.8</td>
<td>1.990</td>
<td></td>
<td></td>
<td>25.2</td>
<td>2.030</td>
<td></td>
<td></td>
<td>25.2</td>
<td>2.030</td>
</tr>
</tbody>
</table>

AFR : Air Flow Rate (CFM)
TC : Total Capacity (kBTU/h)
IP : Input Power (kW)
Heat Pump as Primary Heating
Duct Design

All supply ductwork or the red lines needs to be wrapped with bubble wrap type insulation.

All ductwork seams to be sealed with duct sealer or foil tape.
<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.11</td>
<td>Hard-surface flooring in kitchens, baths, entry, laundry and utility rooms, AND piping in exterior walls insulated with pipe wrap.</td>
</tr>
<tr>
<td>4.2</td>
<td>Duct systems protected from construction debris AND no building cavities used as air supplies or returns.</td>
</tr>
<tr>
<td>4.7</td>
<td>Central forced-air HVAC system(s) have minimum MERV 8 filter AND no ozone generators in home.</td>
</tr>
<tr>
<td>5.2</td>
<td>CO alarms installed in each sleeping zone (e.g., common hallway) according to NFPA 720.</td>
</tr>
<tr>
<td>6.1</td>
<td>Certified low-formaldehyde composite wood materials AND structural plywood AND OSB PS1 or PS2 compliant.</td>
</tr>
<tr>
<td>6.2</td>
<td>Certified low-VOC or no-VOC interior paints and finishes used.</td>
</tr>
<tr>
<td>6.3</td>
<td>Carpet, carpet adhesives CRI Green Label Plus AND carpet cushion CRI Green Label.</td>
</tr>
<tr>
<td>7.1</td>
<td>HVAC system and ductwork verified to be dry and clean AND new filter installed.</td>
</tr>
</tbody>
</table>
Mobile Home Replacement
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(2) 2 1/2" x 11 1/2" LVL

SOLID WOOD BLOCKING

CRUSHED STONE OR OTHER NON-FROST SUSCEPTIBLE FILL

4" SLAB ON GRADE WITH 6X6, 1.4X1.4 WWF MIDWAY IN SPAN
# Sample Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Traditional Manufactured Home</th>
<th>High Performance Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory Home</td>
<td>$56,000</td>
<td>$105,000</td>
</tr>
<tr>
<td>Site Work</td>
<td>$12,000</td>
<td>$14,500</td>
</tr>
<tr>
<td>Delivery &amp; Set</td>
<td>$2,000</td>
<td>$7,000</td>
</tr>
<tr>
<td>Solar Package (6kW)</td>
<td>$0</td>
<td>$14,000</td>
</tr>
<tr>
<td>VHFA Tax Credit*</td>
<td>($35,000)</td>
<td>($35,000)</td>
</tr>
<tr>
<td>Efficiency Vermont Incentive*</td>
<td>$0</td>
<td>($17,000)</td>
</tr>
<tr>
<td>Purchase Price</td>
<td>$35,000</td>
<td>$88,500</td>
</tr>
<tr>
<td><strong>Annual Energy Cost</strong></td>
<td><strong>$3,811</strong></td>
<td><strong>$180</strong></td>
</tr>
<tr>
<td>Down Payment</td>
<td>$3,500</td>
<td>$8,850</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>7.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td>Mortgage Term (years)</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
Cost Comparison

Monthly Payments

- **Traditional Manufactured Home, 20-year loan**: $244 (Mortgage) + $318 (Energy Cost) = $562 (Total Cost)
- **New High Performance Home, 20-year loan**: $526 (Mortgage) + $15 (Energy Cost) = $541 (Total Cost)
- **New High Performance Home, Year 21**: $15 (Energy Cost) + $15 (Energy Cost) = $30 (Total Cost)
Housing Cost Over Ten Years (mortgage & energy)

*Assumes a 5% annual inflation in price of energy.
Total Housing Payments Over Ten Years (mortgage & energy)

- Your Neighbor's Home: $82,889
- Your Zero Energy Home - 20-Year: $74,808
- Your Zero Energy Home - 30-Year: $62,941
Future Plans - Financing

• Lenders will provide typical financing rates and terms to homeowners of high performance MH replacements.

• Working with appraisers to incorporate the Green & Energy Efficient Addendum and PV Value Tool and put a value on high performance features.

• Allocate more affordable housing subsidies to the rebuilding of our mobile home parks in a sustainable manner.

• Integrate on bill financing with our electric utilities.
Future Plans - HVAC
Future Plans - HVAC
Future Plans - HVAC
Future Plans - HVAC

Red=Ambient Air In, Blue=Fresh Air Out Coil, Green=Fresh Air Out HRV, Cyan=Exhaust Air to HRV

(History in days, 60 Min. samples) - Last update: 02/02/2014 22:06:01
## Future Plans - HVAC

### inView Passive
Passive House Dashboard

<table>
<thead>
<tr>
<th>Data</th>
<th>Day</th>
<th>Week</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature HRV Supply Air</td>
<td>Min</td>
<td>Max</td>
<td>Avg</td>
</tr>
<tr>
<td>Temperature Air out of Hx/Air into HRV</td>
<td>37</td>
<td>51</td>
<td>44</td>
</tr>
<tr>
<td>Temperature HRV Return Air</td>
<td>66</td>
<td>69</td>
<td>67</td>
</tr>
<tr>
<td>Temperature HRV Exhaust Air Out</td>
<td>40</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>Temperature SHX Glycol In</td>
<td>49</td>
<td>55</td>
<td>51</td>
</tr>
<tr>
<td>Temperature SHX Glycol Out</td>
<td>48</td>
<td>55</td>
<td>52</td>
</tr>
<tr>
<td>Temperature Fresh Air In</td>
<td>26</td>
<td>43</td>
<td>35</td>
</tr>
<tr>
<td>VOC Return Air</td>
<td>534</td>
<td>2078</td>
<td>1012</td>
</tr>
<tr>
<td>Relative Humidity Return Air</td>
<td>30</td>
<td>45</td>
<td>36</td>
</tr>
</tbody>
</table>

*Image of a dashboard showing temperature and humidity data for a Passive House system.*

*November 12, 2:54pm
High today 37°, Partly Cloudy
Tomorrow 34°, Partly Cloudy*
Future Plans - Design
Move Towards Simplicity

OPEN HOUSES

Daily at VERMOD - Wilder, VT
Monitors ALL energy costs and all energy production

Proactively alerts – safety, cost & appliance performance

Pinpoints major cost contributors with granular information

Recommends targeted actions to save money

Controls HVAC via Thermostats - the largest cost

Delivers Cost Savings + Peace-of-Mind
Data Collection

- How much energy is required to heat and cool the house?
- How uniform is the temperature throughout the house?
- How much cooling/dehumidification and heating does the soil heat exchange system provide, net of the energy needed to run it?
- How much energy is saved through the HRV system and what is the recovery efficiency of the HRV?
- How much energy does the ventilation system require to run?
- How much energy does the hot water system require?
- How is the air quality of the house throughout the year (indicated by CO2 and VOC ppm)?
- What is the relative humidity level in the home?
- How much energy is each circuit using?
Data Collection
Data Collection
Equipment

One Wire Sensors

- ‘One wire’ digital sensors as opposed to analog
- High level of accuracy – Temp sensor is +/- .5C between -10C and 85C
- Thermometer resolution is +/- 1/16C
- Derives power from data line so no need for local power
- Can add sensors anywhere along the line
IAQ Engine

- Sensor continually auto calibrates baseline to 450ppm based on cleanest air tracked.

- Senses volatile organic compounds that deteriorate air quality, especially perceived air quality.

- High correlation with CO$_2$ reported as CO$_2$ equivalents.

- Detects human VOC emissions for occupancy detection and odors - beyond CO$_2$. 
Equipment

IAQ Engine

Substances Detected

- Alcohols
- Aldehydes
- Aliphatic hydrocarbons
  - Amines
  - Aromatic hydrocarbons
    - CO, CH4, LPG
    - Ketones
    - Organic acids
Data Collection
Data Collection

inView Passive™
Passive House Dashboard

Humidity 59%
Temp 49°

Watts
-1000 -500 0 500 1000

640 watts being consumed real time
Green Power: 0w Grid Power: 640w

Building Environment Details
Real-Time Electricity Details
ERV Details

Mini-split Details
HPWH Details
My Location
Performance - Comfort
Performance – Indoor Air Quality

CO2/VOC ppm changed from 1600 to 1000
Performance – Moisture at Exterior Sheathing