Efficiency Vermont



Pushing the Envelope in Vermont

A look at EVT's High Performance Homes

Matt Sargent
Senior Energy Consultant
Efficiency Vermont

Better Buildings by Design
February 4, 2015

Efficiency Vermont

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.

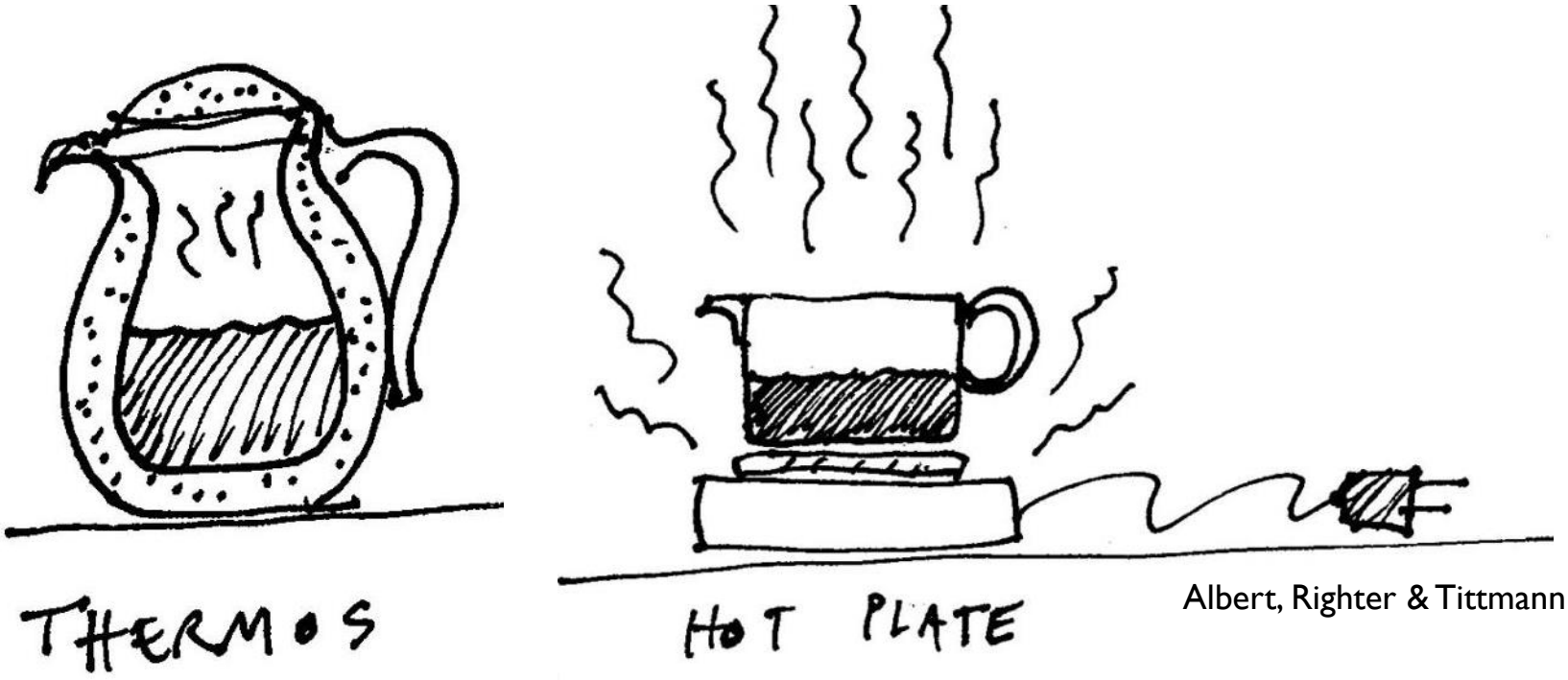
In Vermont this translates to approximately 275 single family homes built to HPH standards per year.

High Performance Homes Program

- Pathway to Net Zero
- Lessons learned from Passive House
- Pilot program 2012 and 2013
- Monitoring 2012 - 2014
- Prescriptive Specifications
- Revised for 2015

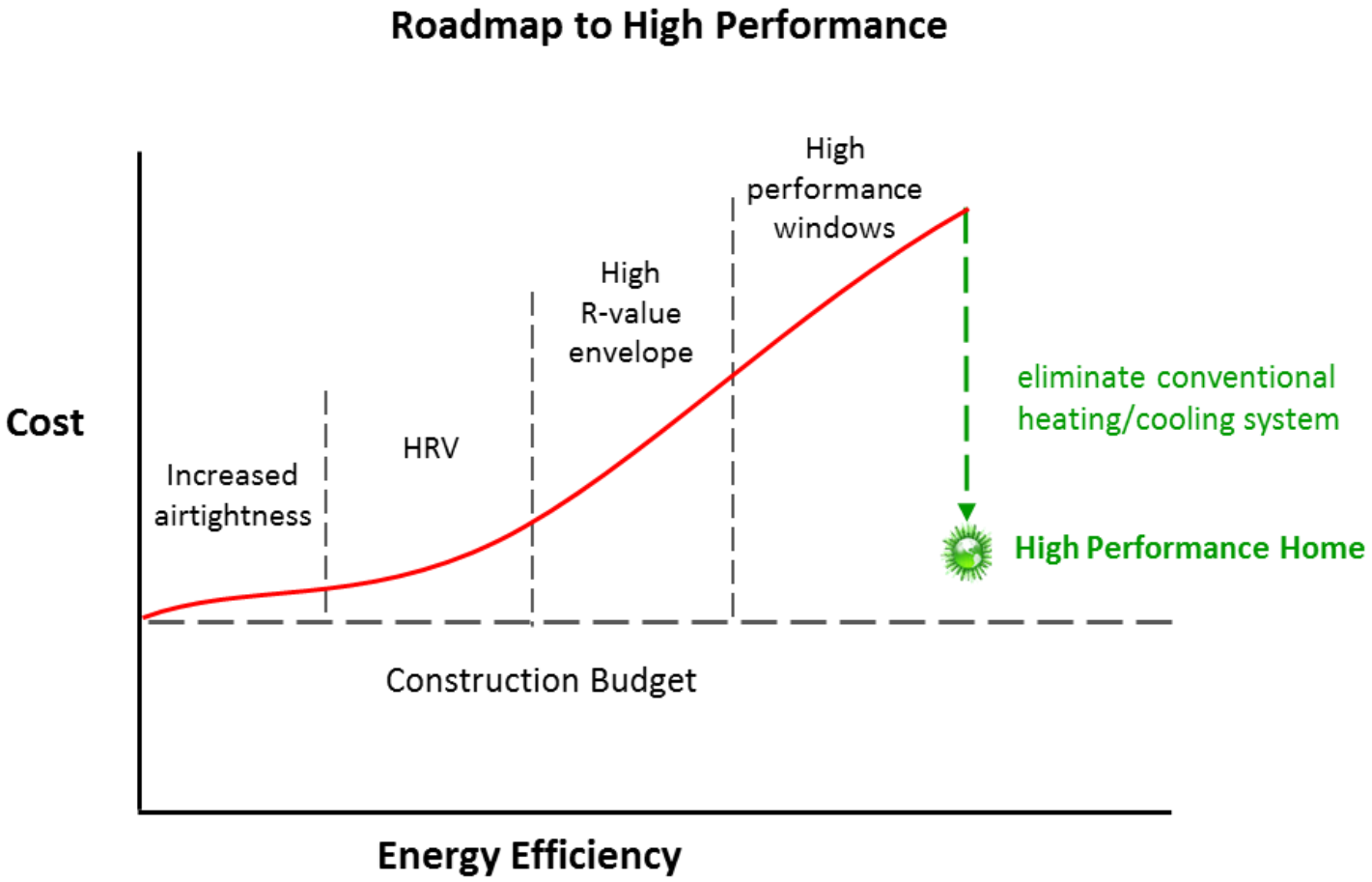
High Performance Home Concept

Maintain the temperature using insulation, rather than by using energy.

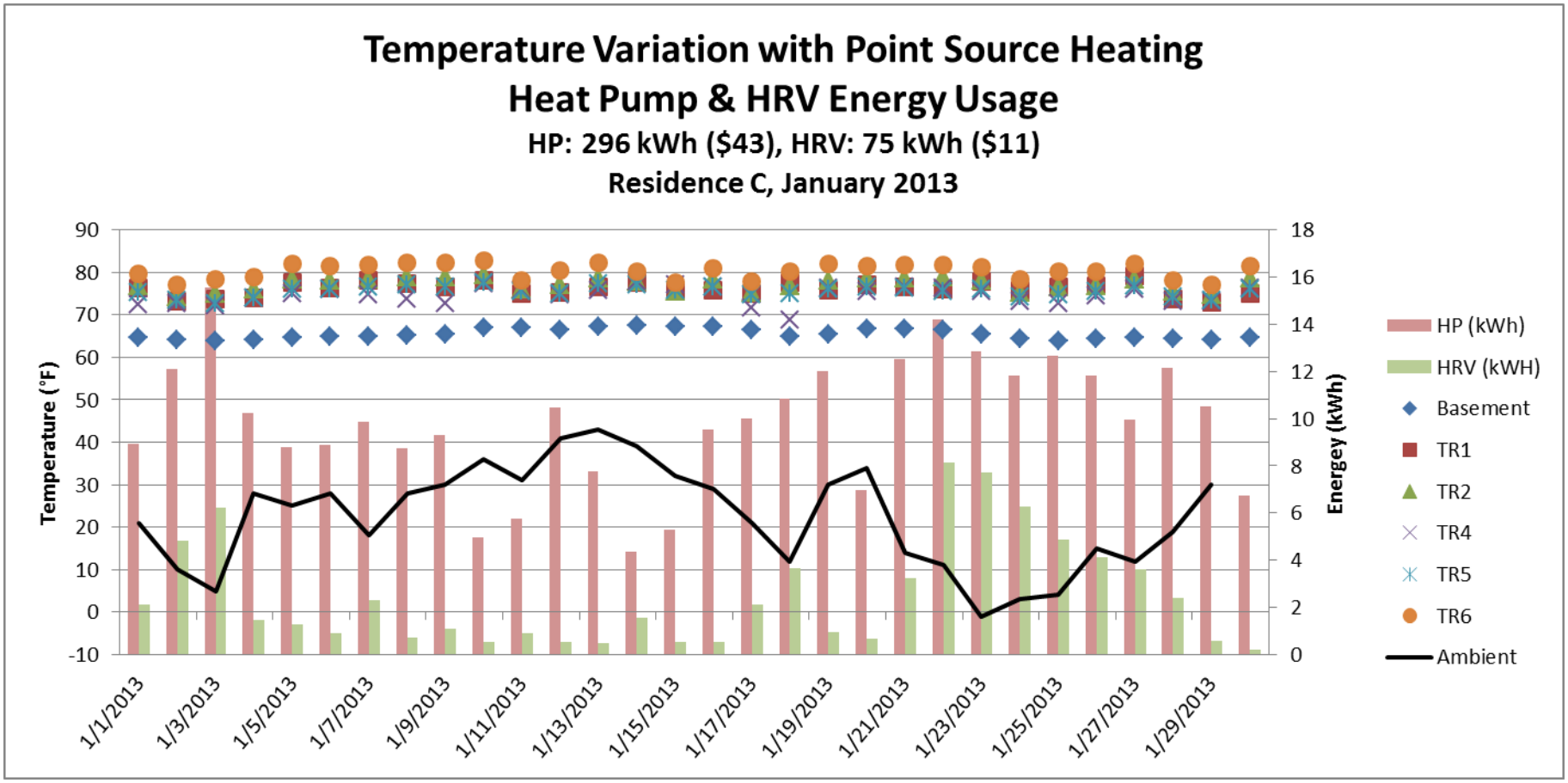


Albert, Righter & Tittmann

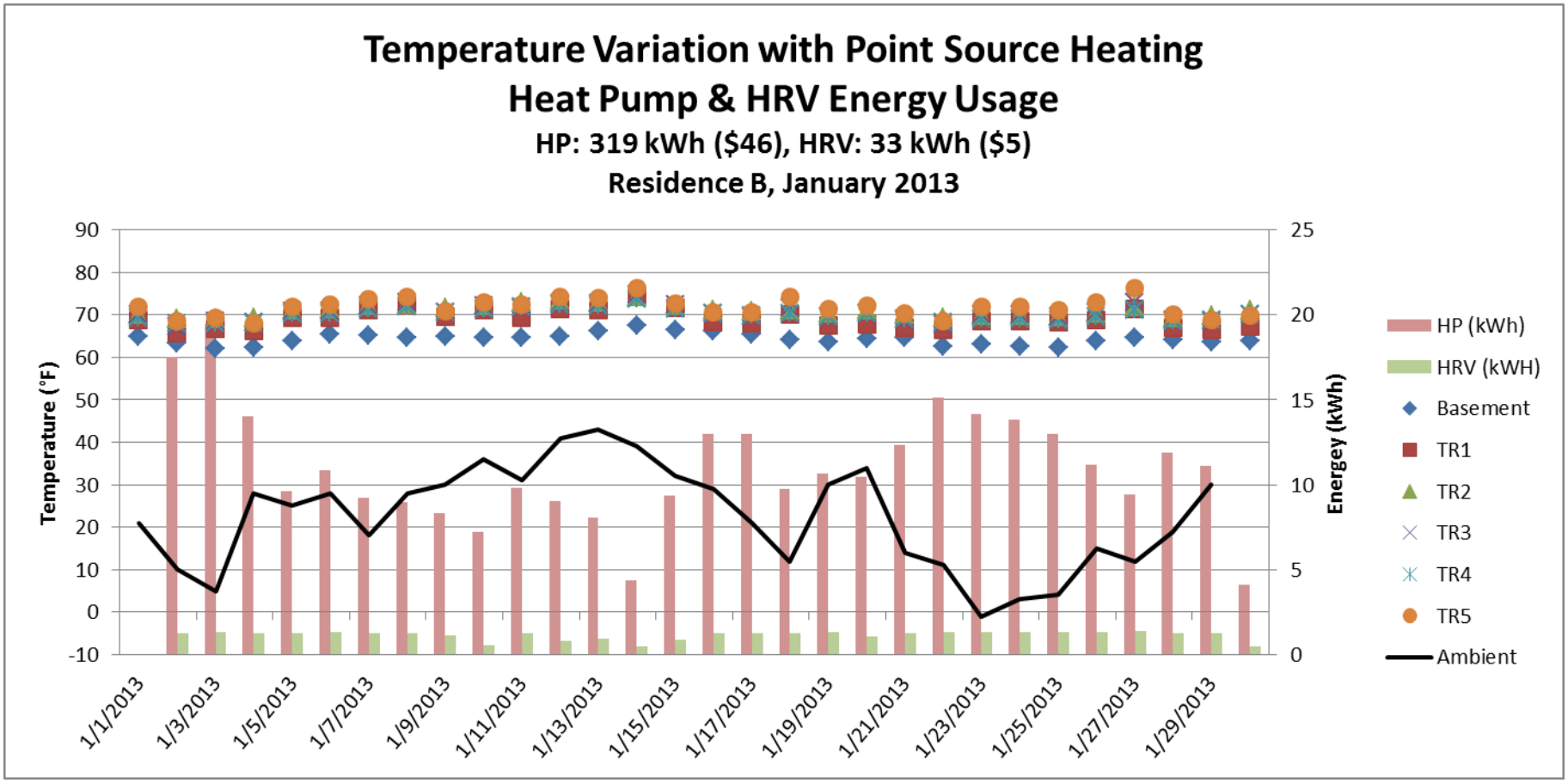
Cost Analysis for High Performance Home



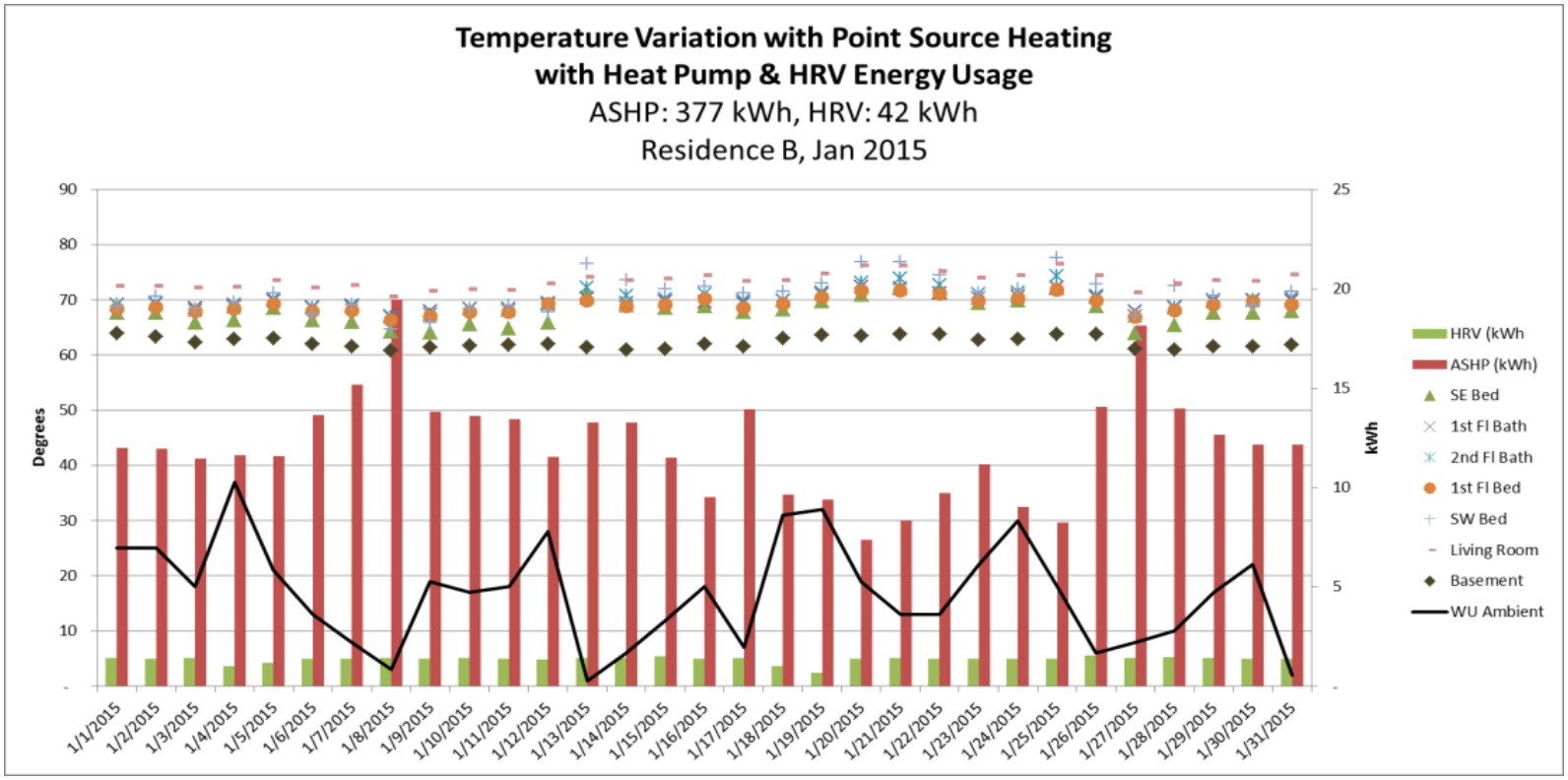
Point Source Heating Adequate for Vermont



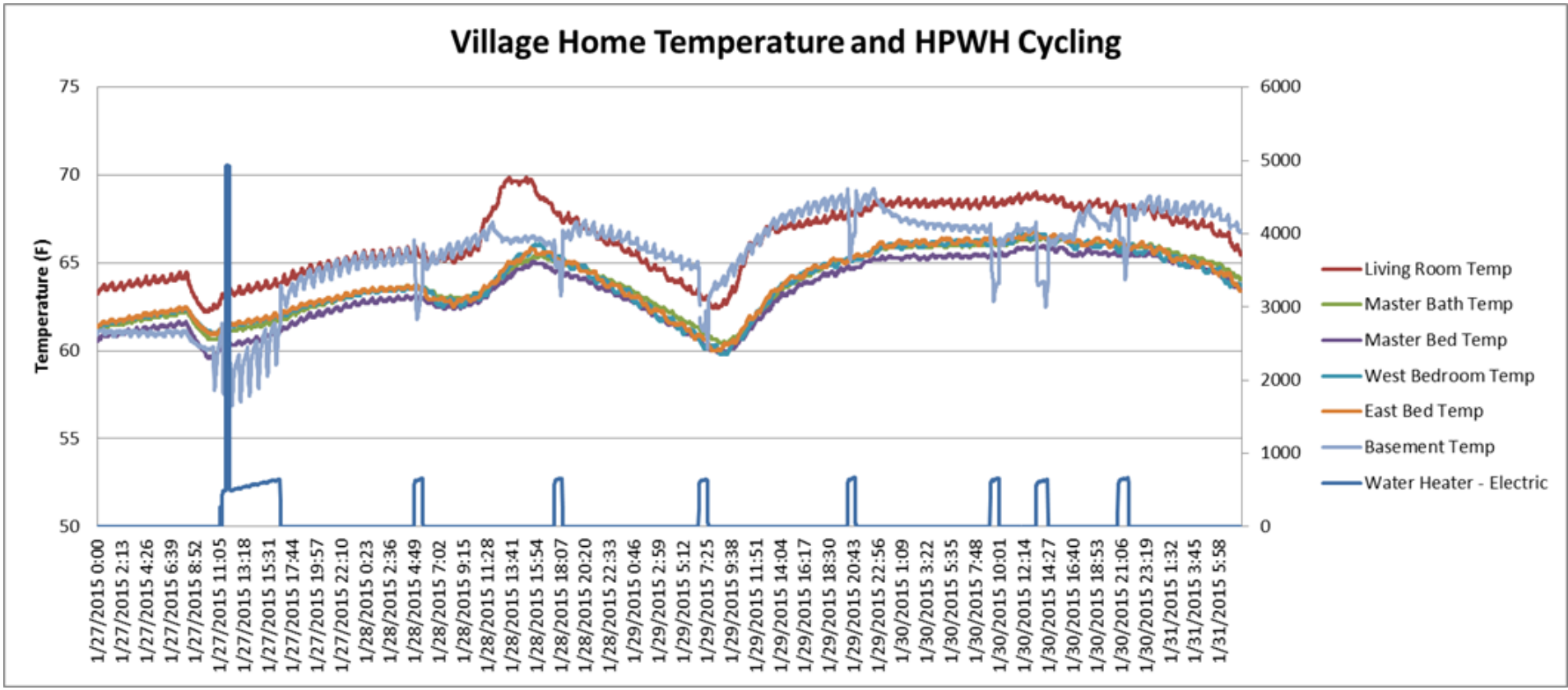
Point Source Heating Adequate for Vermont



Point Source Heating Adequate for Vermont



Efficiency Vermont


Village Home Temperature and HPWH Cycling
Temperature (F)
75
70
65
60
55
50
6000
5000
4000
3000
2000
1000
0
Living Room Temp
Master Bath Temp
Master Bed Temp
West Bedroom Temp
East Bed Temp
Basement Temp
Water Heater - Electric
1/27/2015 0:00
1/27/2015 2:13
1/27/2015 4:26
1/27/2015 6:39
1/27/2015 8:52
1/27/2015 11:05
1/27/2015 13:18
1/27/2015 15:31
1/27/2015 17:44
1/27/2015 19:57
1/27/2015 22:10
1/28/2015 0:23
1/28/2015 2:36
1/28/2015 4:49
1/28/2015 7:02
1/28/2015 9:15
1/28/2015 11:28
1/28/2015 13:41
1/28/2015 15:54
1/28/2015 18:07
1/28/2015 20:20
1/28/2015 22:33
1/29/2015 0:46
1/29/2015 2:59
1/29/2015 5:12
1/29/2015 7:25
1/29/2015 9:38
1/29/2015 11:51
1/29/2015 14:04
1/29/2015 16:17
1/29/2015 18:30
1/29/2015 20:43
1/29/2015 22:56
1/30/2015 1:09
1/30/2015 3:22
1/30/2015 5:35
1/30/2015 7:48
1/30/2015 10:01
1/30/2015 12:14
1/30/2015 14:27
1/30/2015 16:40
1/30/2015 18:53
1/30/2015 21:06
1/30/2015 23:19
1/31/2015 1:32
1/31/2015 3:45
1/31/2015 5:58

Monitoring Equipment can Help Optimize HVAC Performance

Efficiency Vermont Residential New Construction Requirements

	EVT Certified Home 2015	EVT High Performance Home 2015
Energy Code Compliance	Meet RBES and file certificate	Meet RBES and file certificate
Foundation Wall	R-15	R-30
Slab on Grade	Unheated R-15 edge (4') Heated R-15 Edge and R-15 under	R-30
Slab below grade	Heated R-15	Heated R-30 Unheated R-20
Exposed floor	38	40
Above Grade Wall	R-20	R-40
Ceiling	R-49 sloped R-60 flat	R-60
Insulation quality	Grade 2 (inspection required)	Grade 1 (inspection required)

Efficiency Vermont Residential New Construction Requirements

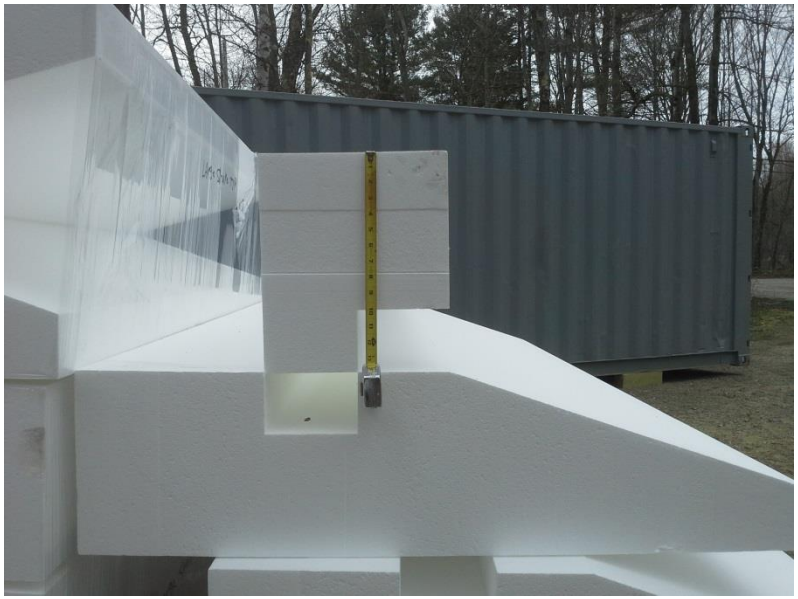
	EVT Certified Home 2015	EVT High Performance Home 2015
Air Leakage	Tested < 3 ACH50	Tested < 1 ACH50
Windows	U-0.28	U-0.21
Doors	U-0.28	U-0.25
Heating and Cooling	Energy Star certified or equivalent	Energy Star certified or equivalent Boiler > 94% AFUE
Water Heating	Federal Minimum Standard	Energy Star or equivalent Drain Water Heat Recovery recommended
Distribution	Programmable Thermostat Ducts inside thermal envelope	Custom approach
Ventilation	RBES min whole house Bathroom 50/20	ASHRAE 62.2 2013 or PH Standard Balanced > 80% SRE
Lighting	80%	95%
Appliances	Energy Star certified	Custom List

Foundation Insulation: R-30

R-8 footing insulation required

ICF and Interior Foundation Insulation

Slab on Grade, R-30



Wall Insulation: R-40

Above Grade and Band Joist

Above Grade Walls

Double Stud Walls

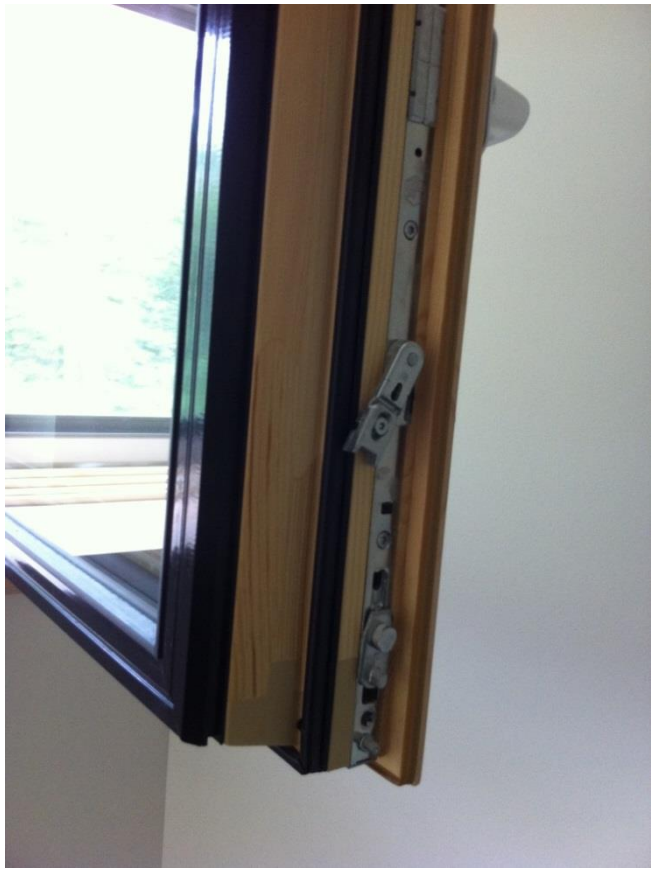
Sloped Ceiling: R-60

16”+ Dense-Pack Cellulose

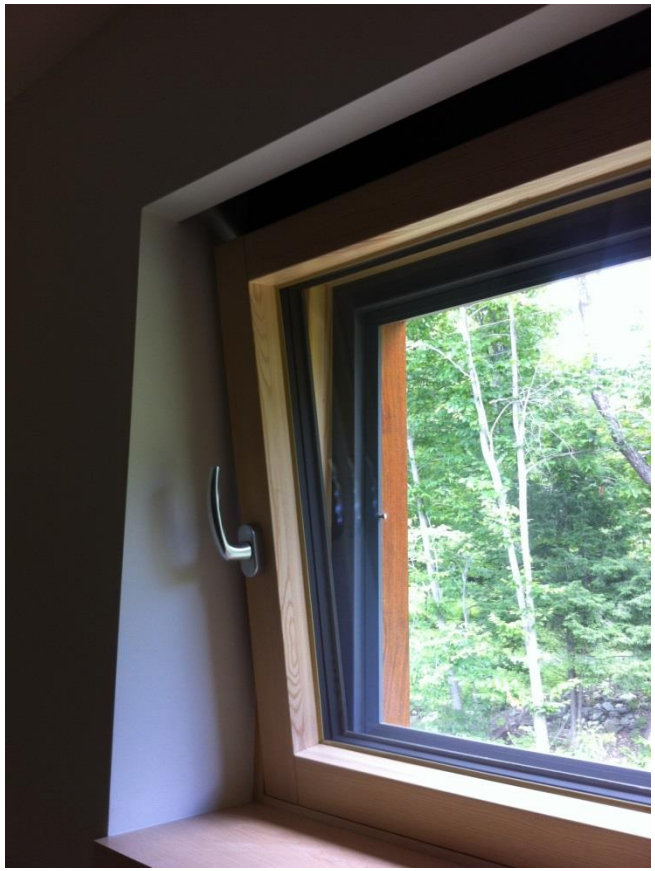
Flat Ceiling: R-60

18” Loose Fill Cellulose

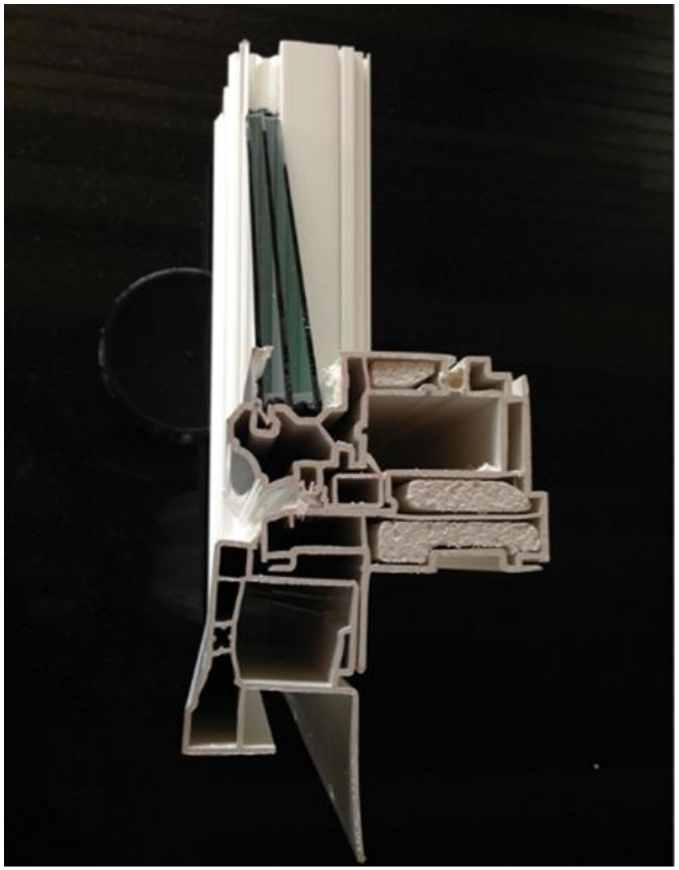
Windows: U-Value 0.21



Tilt and Turn



Local Options



Doors: U-Value 0.25

Heating and Cooling Equipment

Energy Star or equivalent, 94% AFUE boilers

Supplemental and Alternative Systems

Water Heating Equipment

Energy Star or equivalent, Drain Water Recovery Recommended

Ventilation:

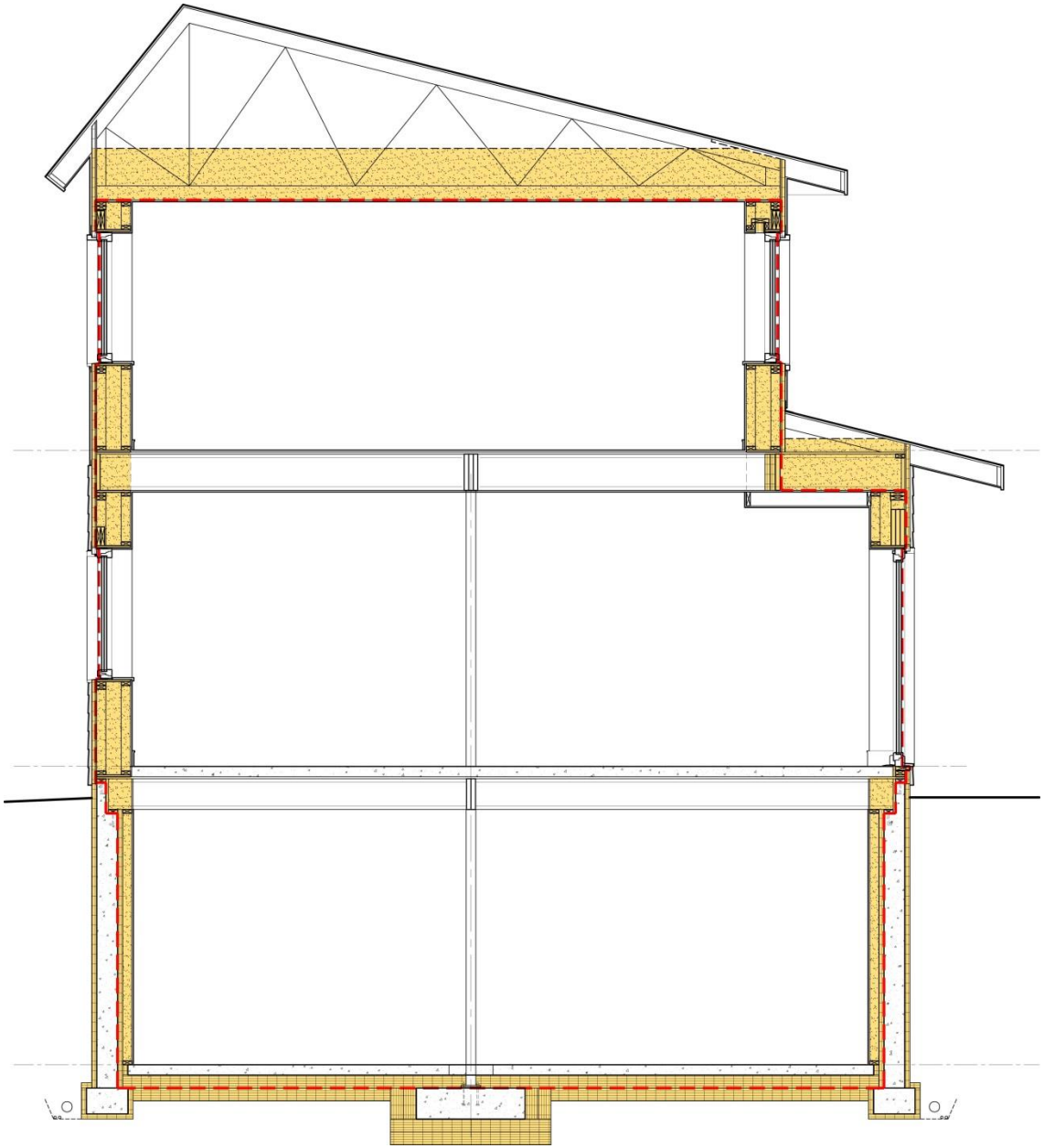
Recovery Efficiency > 80%

ASHRAE 62.2 or Passive House Whole Ventilation

Kitchen and Bath Spot Ventilation

Air Leakage < 1.0 ACH50

Well Defined Air Barrier



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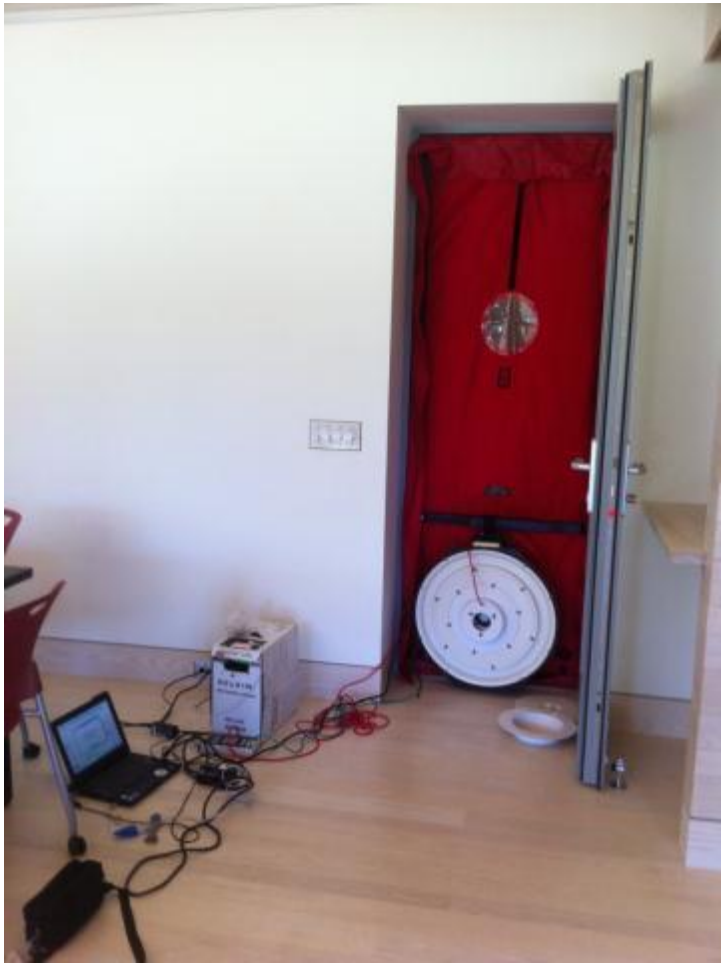
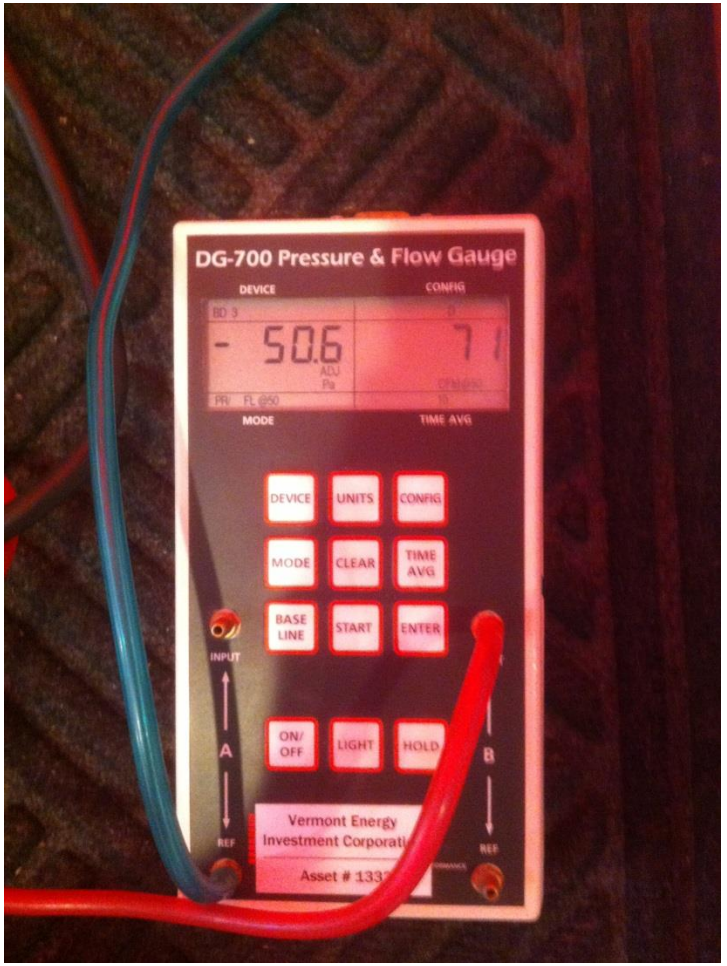
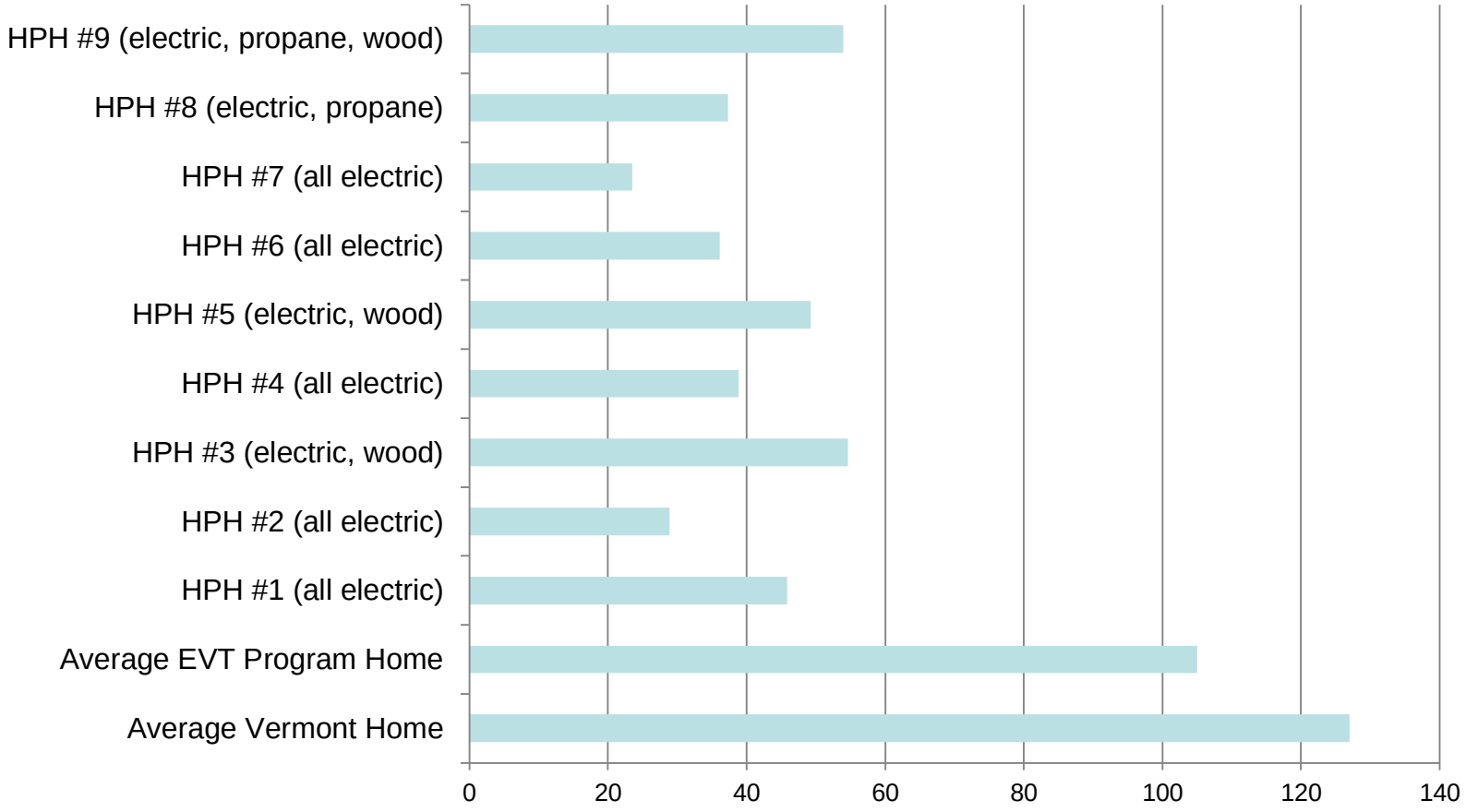
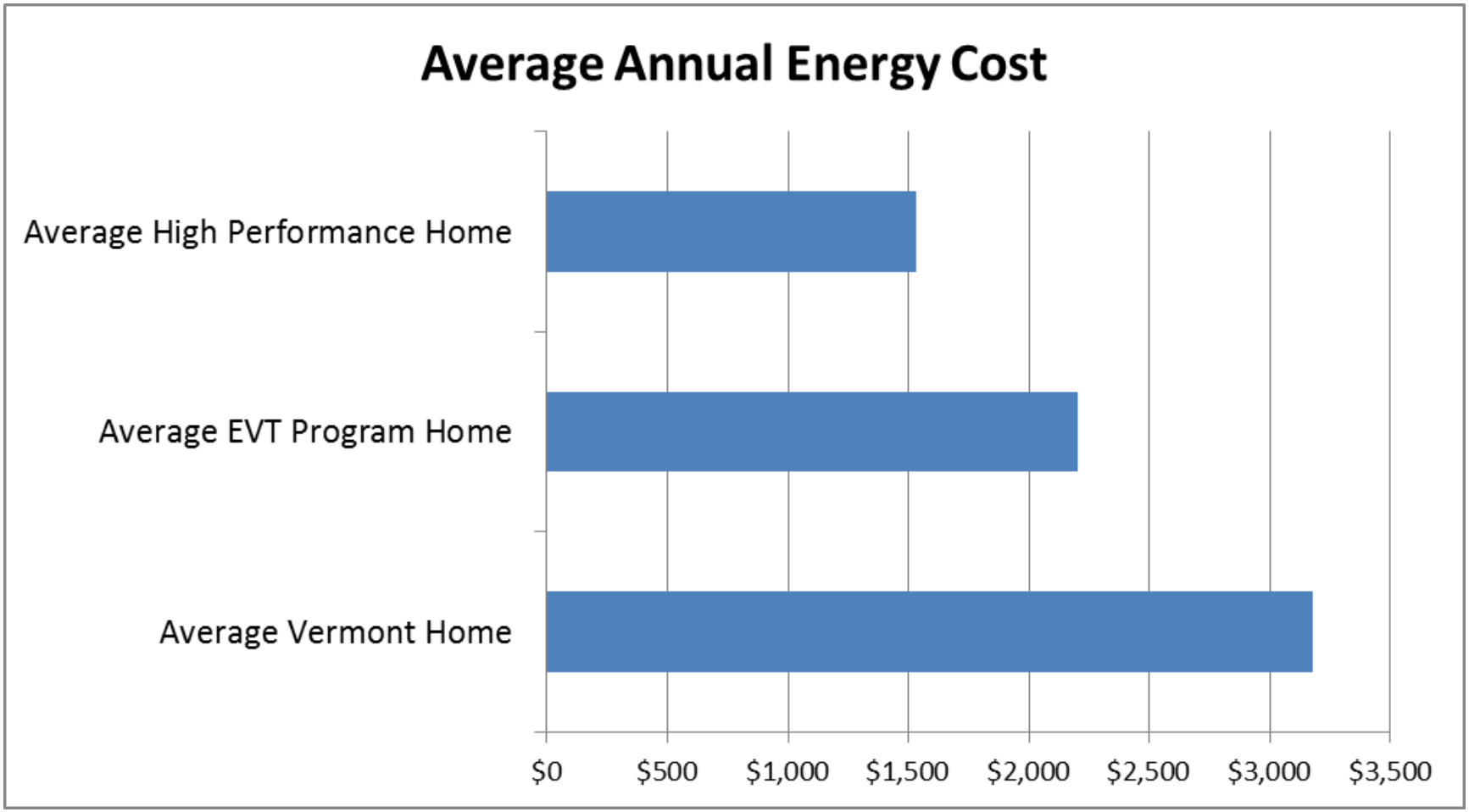
Results




DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
- 50.6
ADJ
Pa
MODE
TIME AVG
DEVICE
UNITS
CONFIG
MODE
CLEAR
TIME AVG
BASE LINE
START
ENTER
INPUT
A
REF
ON/ OFF
LIGHT
HOLD
B
REF
Vermont Energy
Investment Corporati
Asset # 133

Average Annual MMBtu




Average Annual Energy Cost
Average High Performance Home
Average EVT Program Home
Average Vermont Home
$0
$500
$1,000
$1,500
$2,000
$2,500
$3,000
$3,500

Total Cost of Ownership

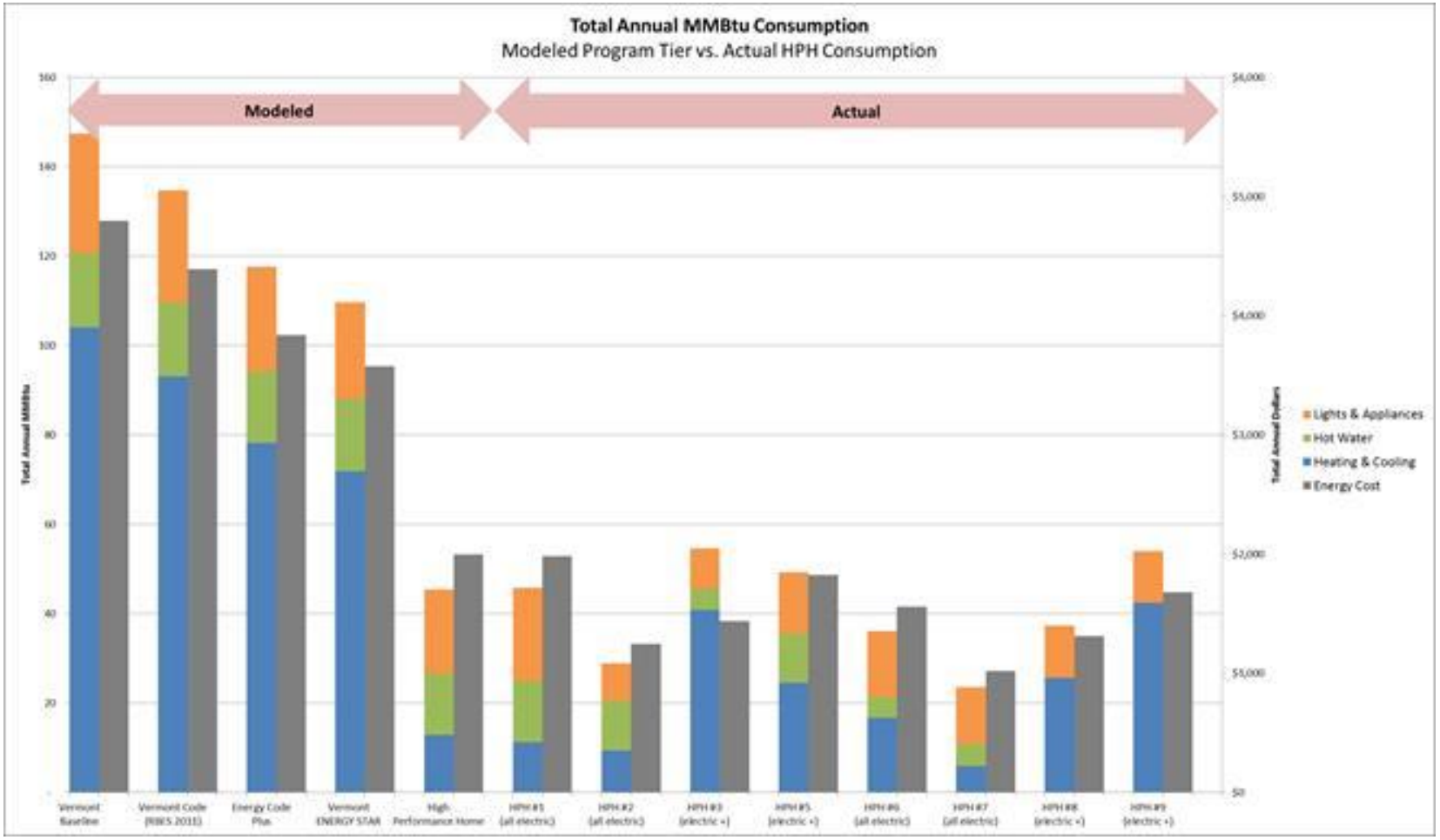
Home Costs		Avg. VT home	10% HPH	cost increase
	Home Price	$300,000	$330,000	$30,000
	Mortgage	$225,000	$247,500	$22,500
	Downpayment	$75,000	$82,500	$7,500
	Monthly payment	$1,042	$1,104	$62
Energy Costs				
	Annual	$3,175	$1,530	-$1,645
	Average Monthly	$265	$128	-$137
Combined				
	Annual	$15,679.12	$14,776.32	-$903
	Monthly	$1,307	$1,231	-$75

Assume 3.527% APR, as of 2/3/2015
10% construction cost increase

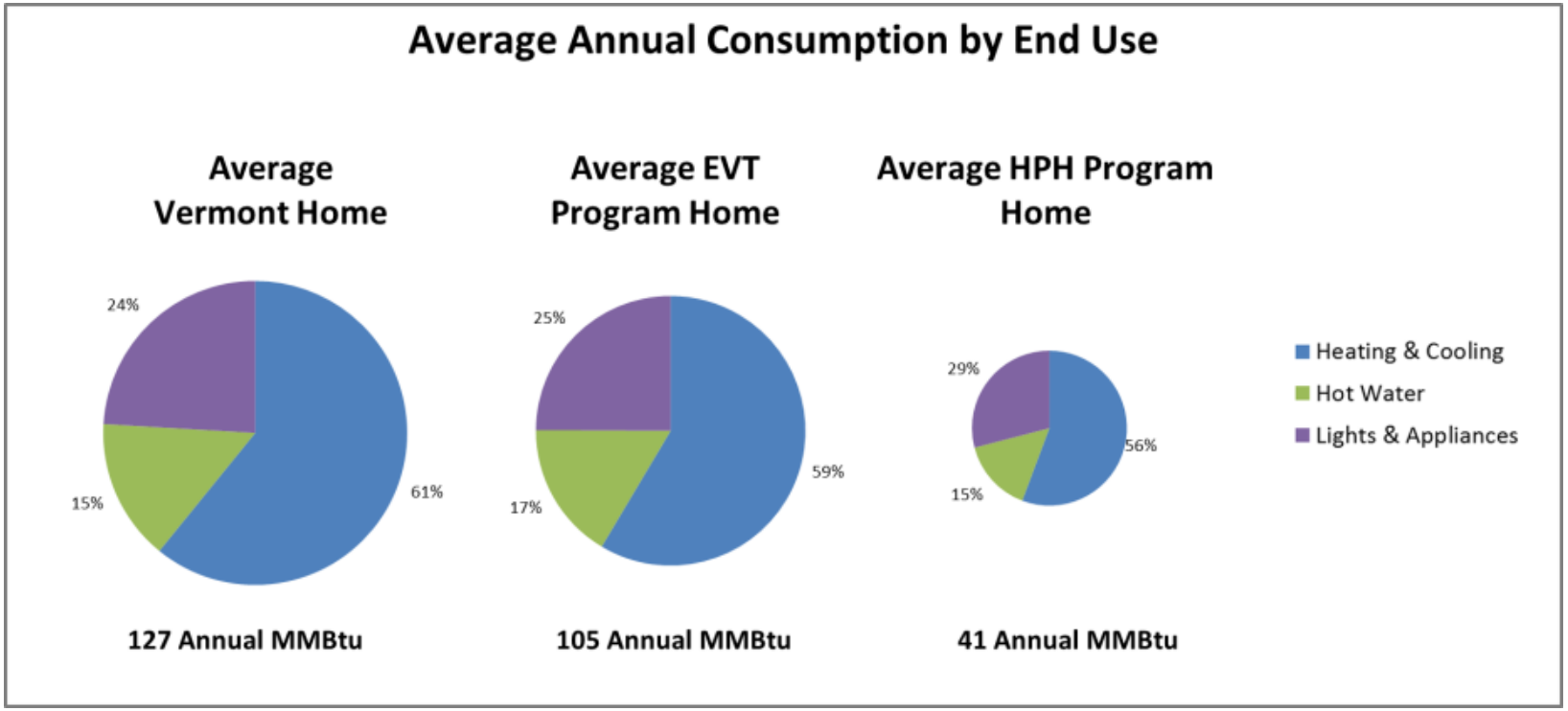
Total Cost of Ownership

Home Costs		Avg. VT home	15% HPH	cost increase
	Home Price	$300,000	$345,000	$45,000
	Mortgage	$225,000	$258,750	$33,750
	Downpayment	$75,000	$86,250	$11,250
	Monthly payment	$1,042	$1,198	$156
Energy Costs				
	Annual	$3,175	$1,530	-$1,645
	Average Monthly	$265	$128	-$137
Combined				
	Annual	$15,679.12	$15,909.72	$231
	Monthly	$1,307	$1,326	$19

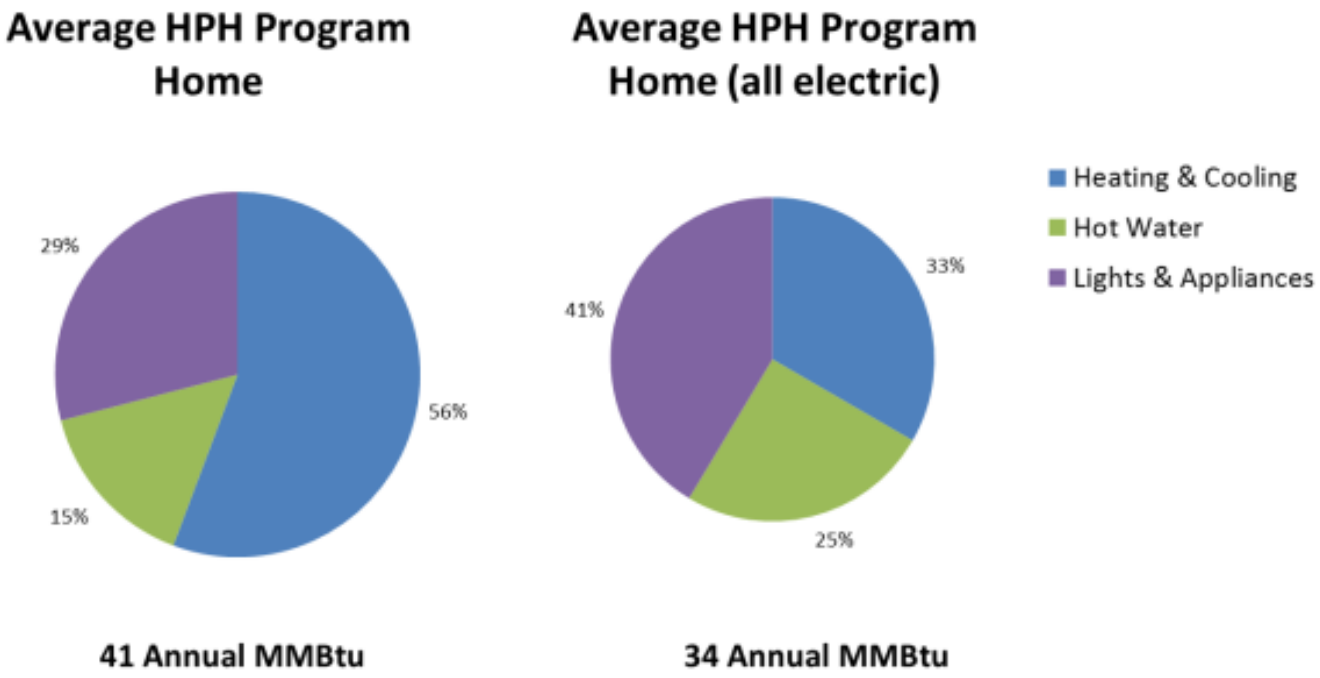
Assume 3.527% APR, as of 2/3/2015
15% construction cost increase

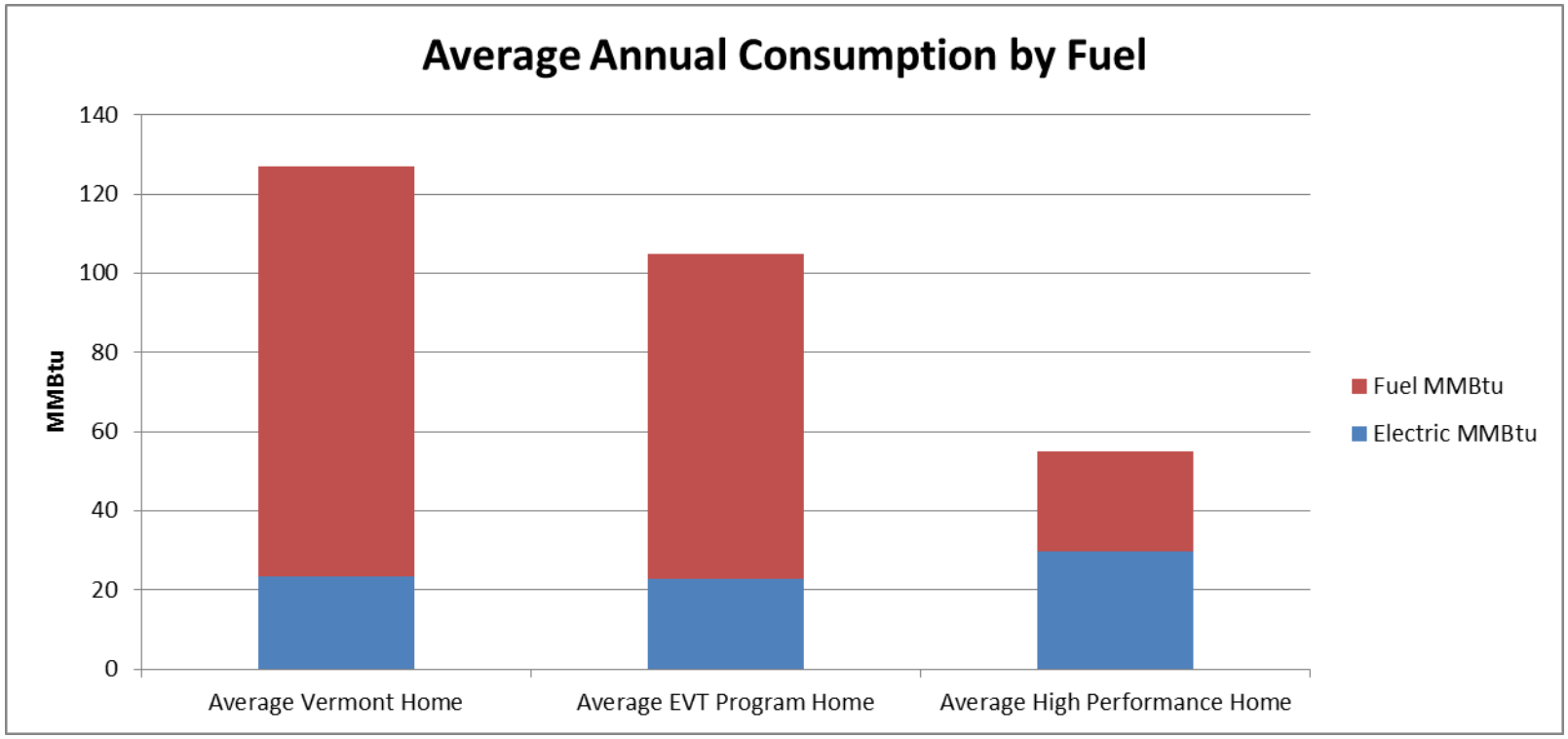

Total Annual MMBtu Consumption
Modeled Program Tier vs. Actual HPH Consumption
Modeled
Actual
Total Annual MMBtu
Total Annual Dollars
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Lights & Appliances
Hot Water
Heating & Cooling
Energy Cost
Vermont Baseline
Vermont Code (RBES 2011)
Energy Code Plus
Vermont ENERGY STAR
High Performance Home
HPH #1 (all electric)
HPH #2 (all electric)
HPH #3 (electric +)
HPH #5 (electric +)
HPH #6 (all electric)
HPH #7 (all electric)
HPH #8 (electric +)
HPH #9 (electric +)

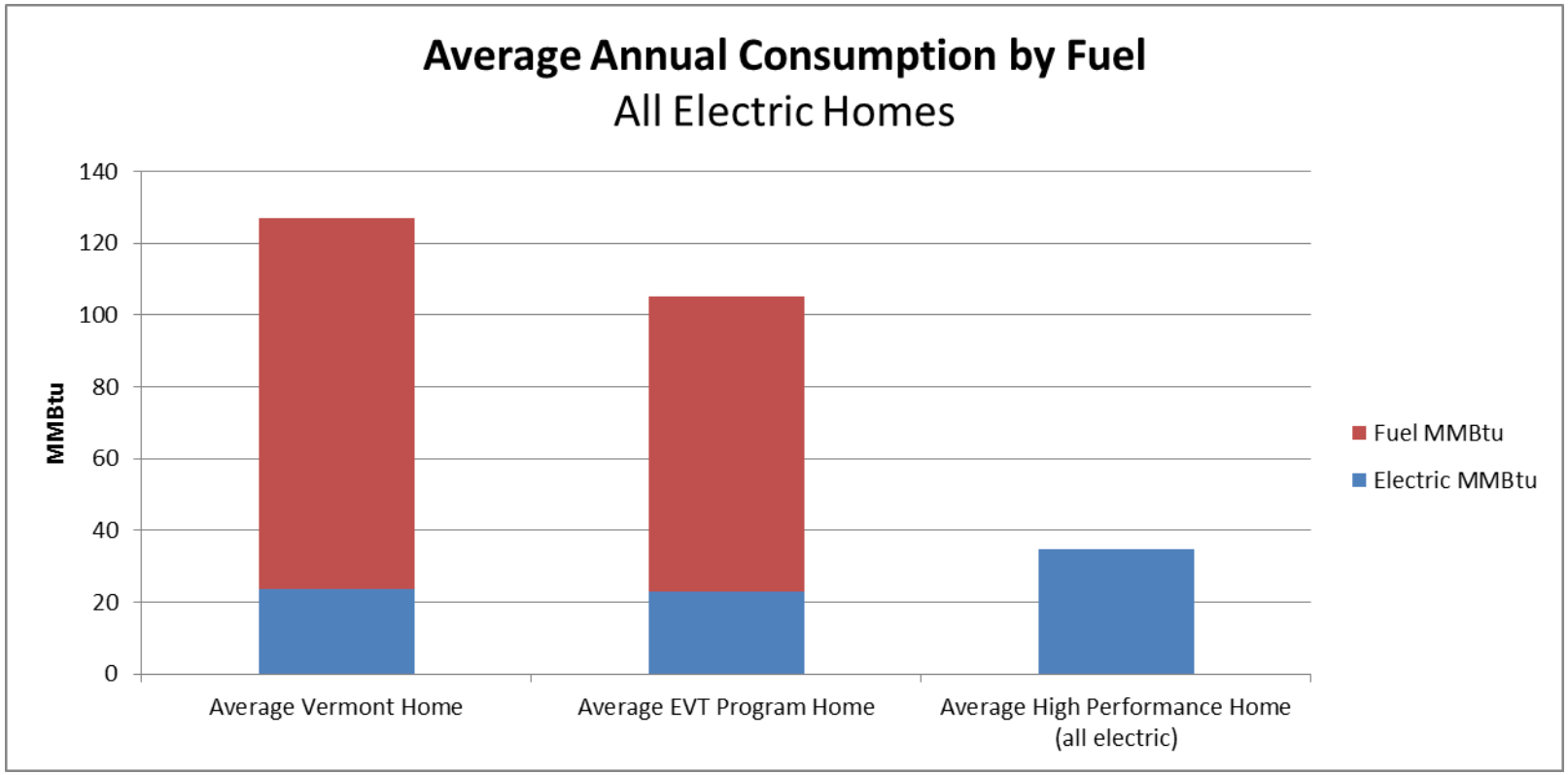
Average Annual Consumption by End Use

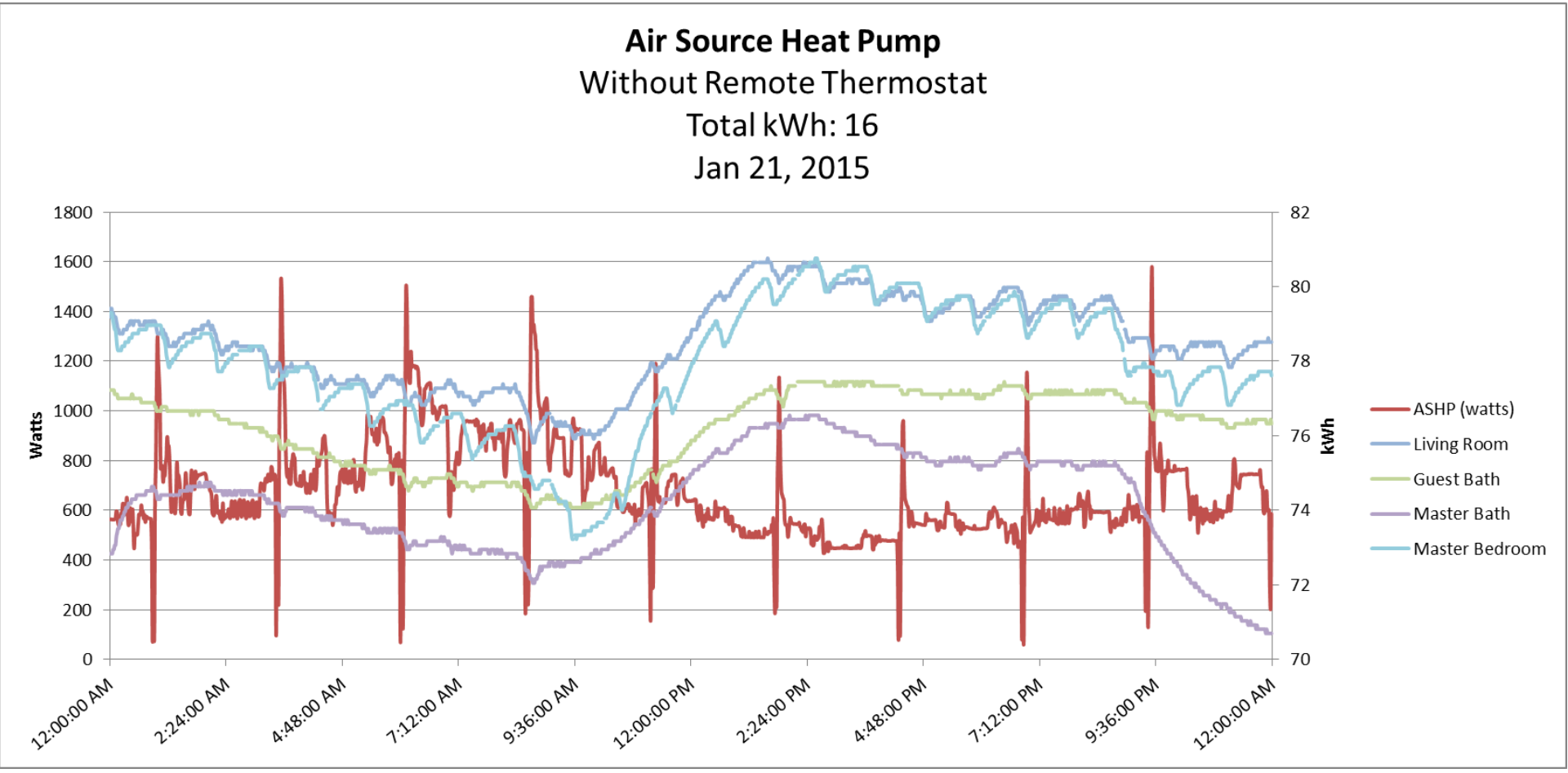


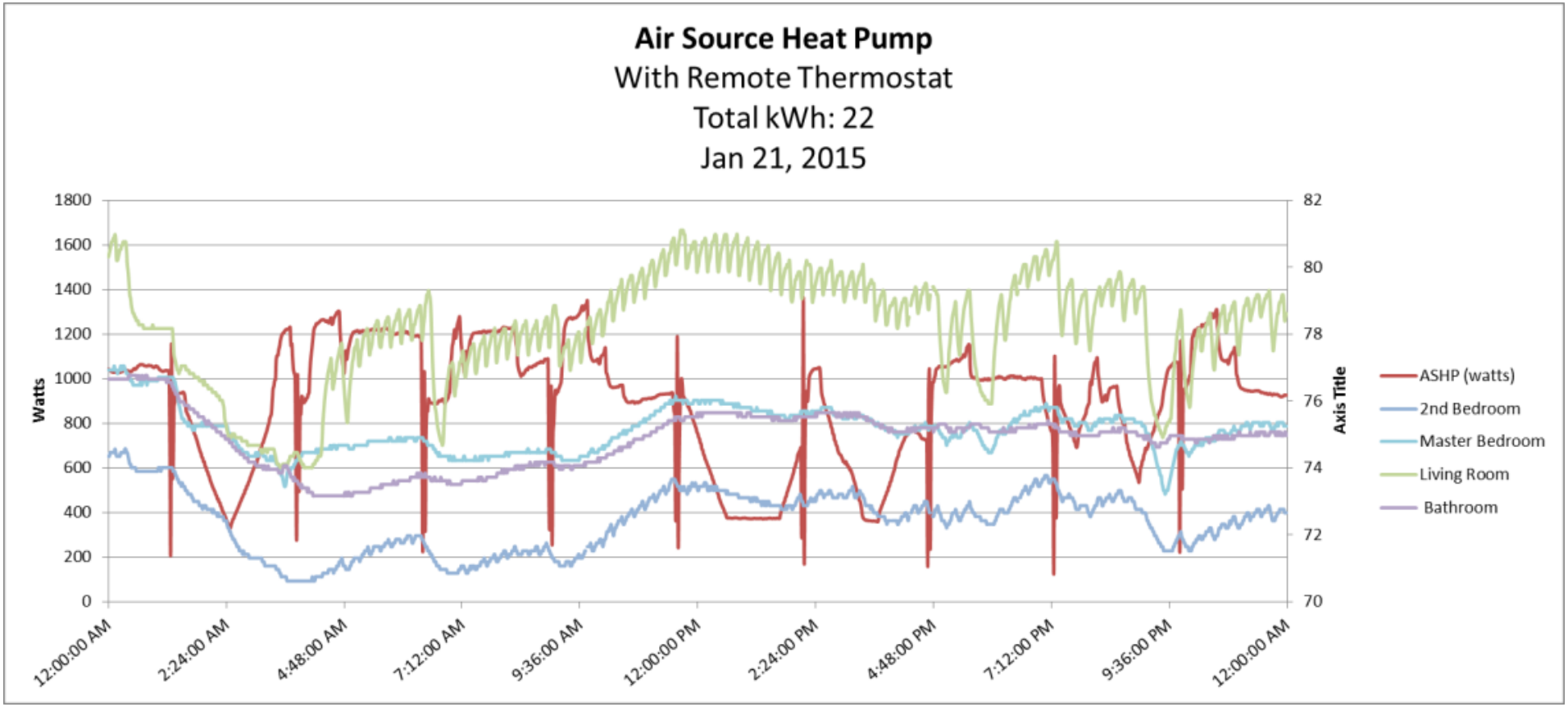
Average Annual Consumption by End Use

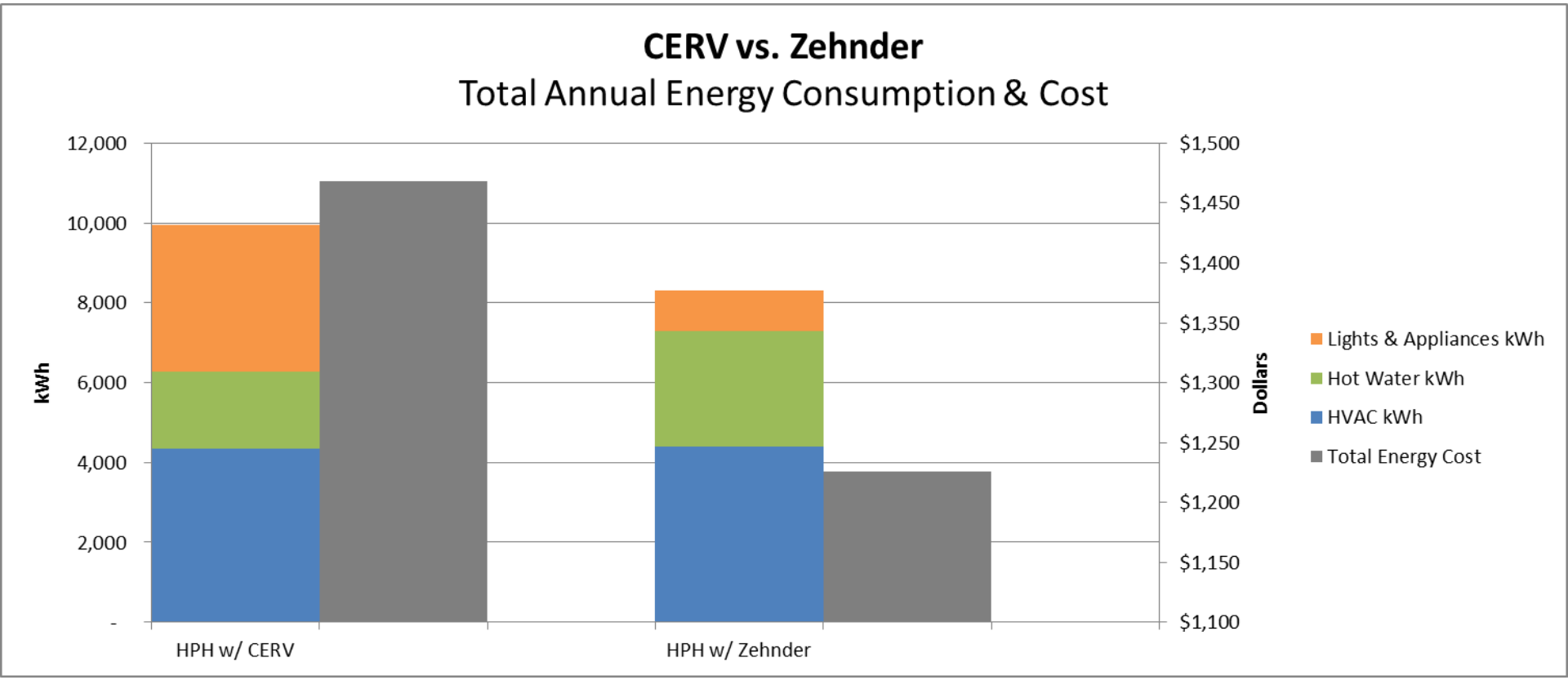


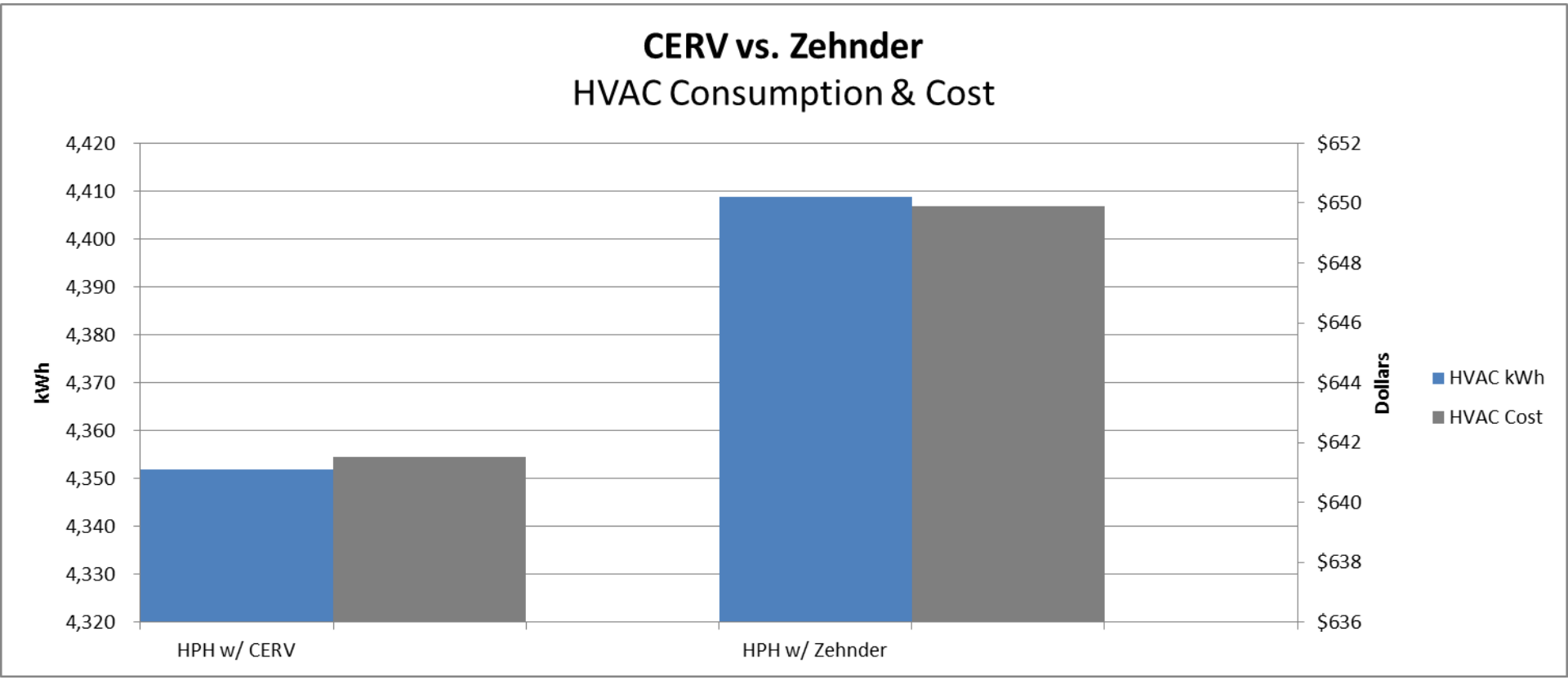

Average Annual Consumption by Fuel
MMBtu
140
120
100
80
60
40
20
0
Average Vermont Home
Average EVT Program Home
Average High Performance Home
Fuel MMBtu
Electric MMBtu


Average Annual Consumption by Fuel
All Electric Homes
MMBtu
140
120
100
80
60
40
20
0
Average Vermont Home
Average EVT Program Home
Average High Performance Home (all electric)
Fuel MMBtu
Electric MMBtu


Air Source Heat Pump
Without Remote Thermostat
Total kWh: 16
Jan 21, 2015
Watts
kWh
1800
1600
1400
1200
1000
800
600
400
200
0
82
80
78
76
74
72
70
12:00:00 AM
2:24:00 AM
4:48:00 AM
7:12:00 AM
9:36:00 AM
12:00:00 PM
2:24:00 PM
4:48:00 PM
7:12:00 PM
9:36:00 PM
12:00:00 AM
ASHP (watts)
Living Room
Guest Bath
Master Bath
Master Bedroom


Air Source Heat Pump
With Remote Thermostat
Total kWh: 22
Jan 21, 2015
Watts
Axis Title
1800
1600
1400
1200
1000
800
600
400
200
0
82
80
78
76
74
72
70
12:00:00 AM
2:24:00 AM
4:48:00 AM
7:12:00 AM
9:36:00 AM
12:00:00 PM
2:24:00 PM
4:48:00 PM
7:12:00 PM
9:36:00 PM
12:00:00 AM
ASHP (watts)
2nd Bedroom
Master Bedroom
Living Room
Bathroom

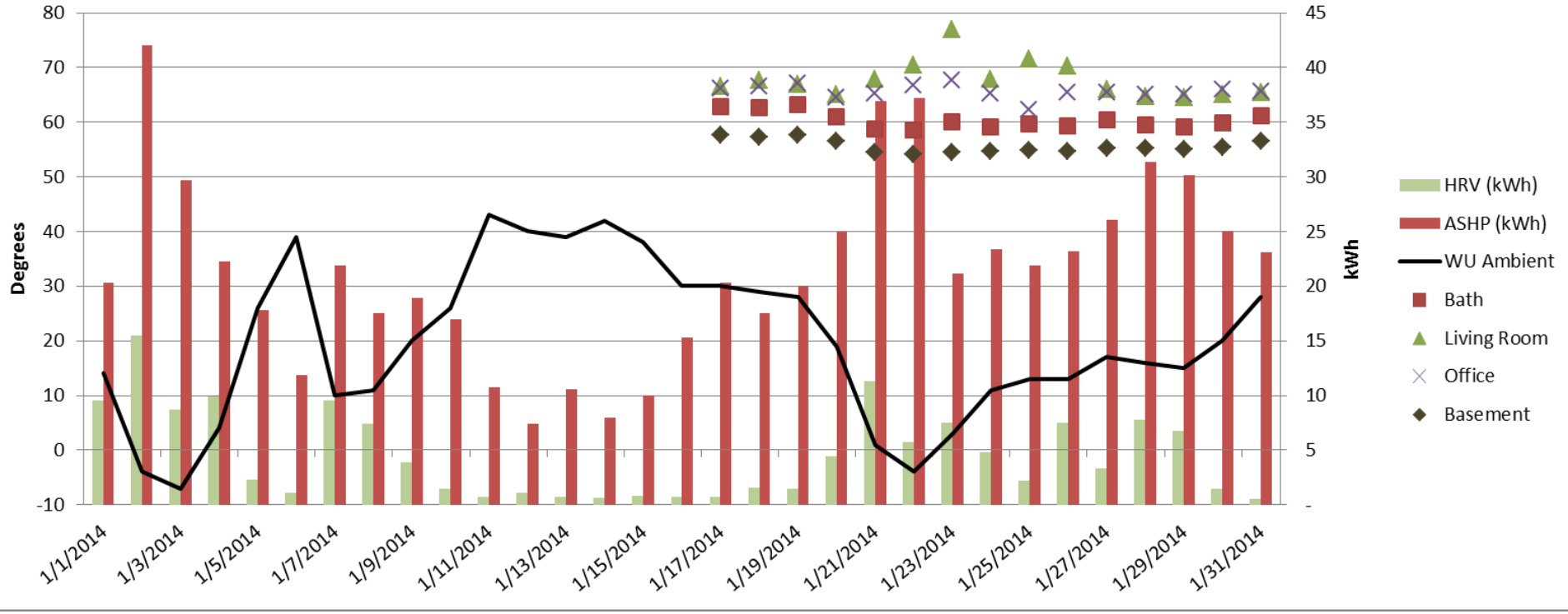

CERV vs. Zehnder
Total Annual Energy Consumption & Cost
12,000
10,000
8,000
6,000
4,000
2,000
-
kWh
$1,500
$1,450
$1,400
$1,350
$1,300
$1,250
$1,200
$1,150
$1,100
Dollars
HPH w/ CERV
HPH w/ Zehnder
Lights & Appliances kWh
Hot Water kWh
HVAC kWh
Total Energy Cost

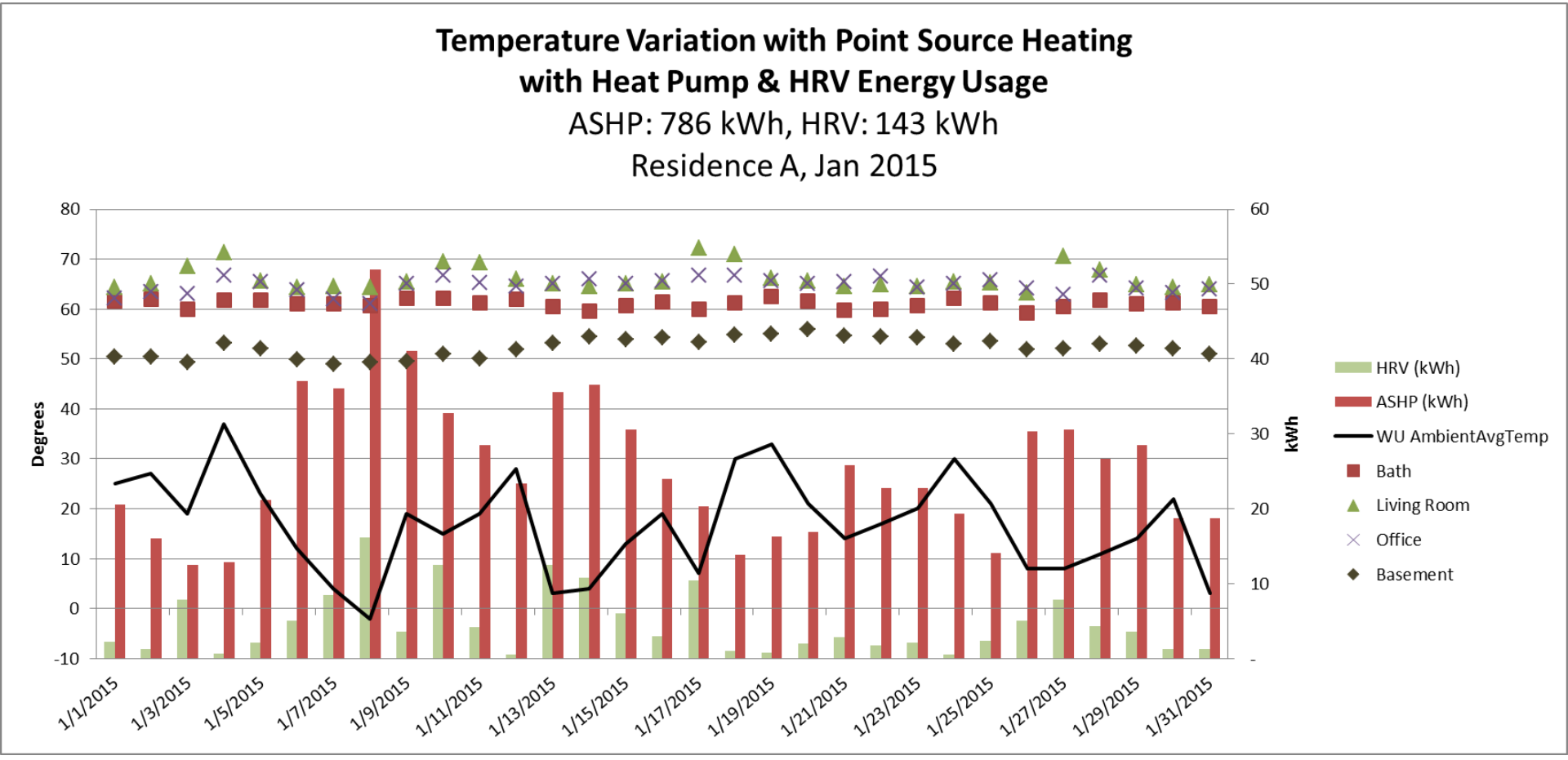

CERV vs. Zehnder
HVAC Consumption & Cost
kWh
4,420
4,410
4,400
4,390
4,380
4,370
4,360
4,350
4,340
4,330
4,320
Dollars
$652
$650
$648
$646
$644
$642
$640
$638
$636
HPH w/ CERV
HPH w/ Zehnder
HVAC kWh
HVAC Cost

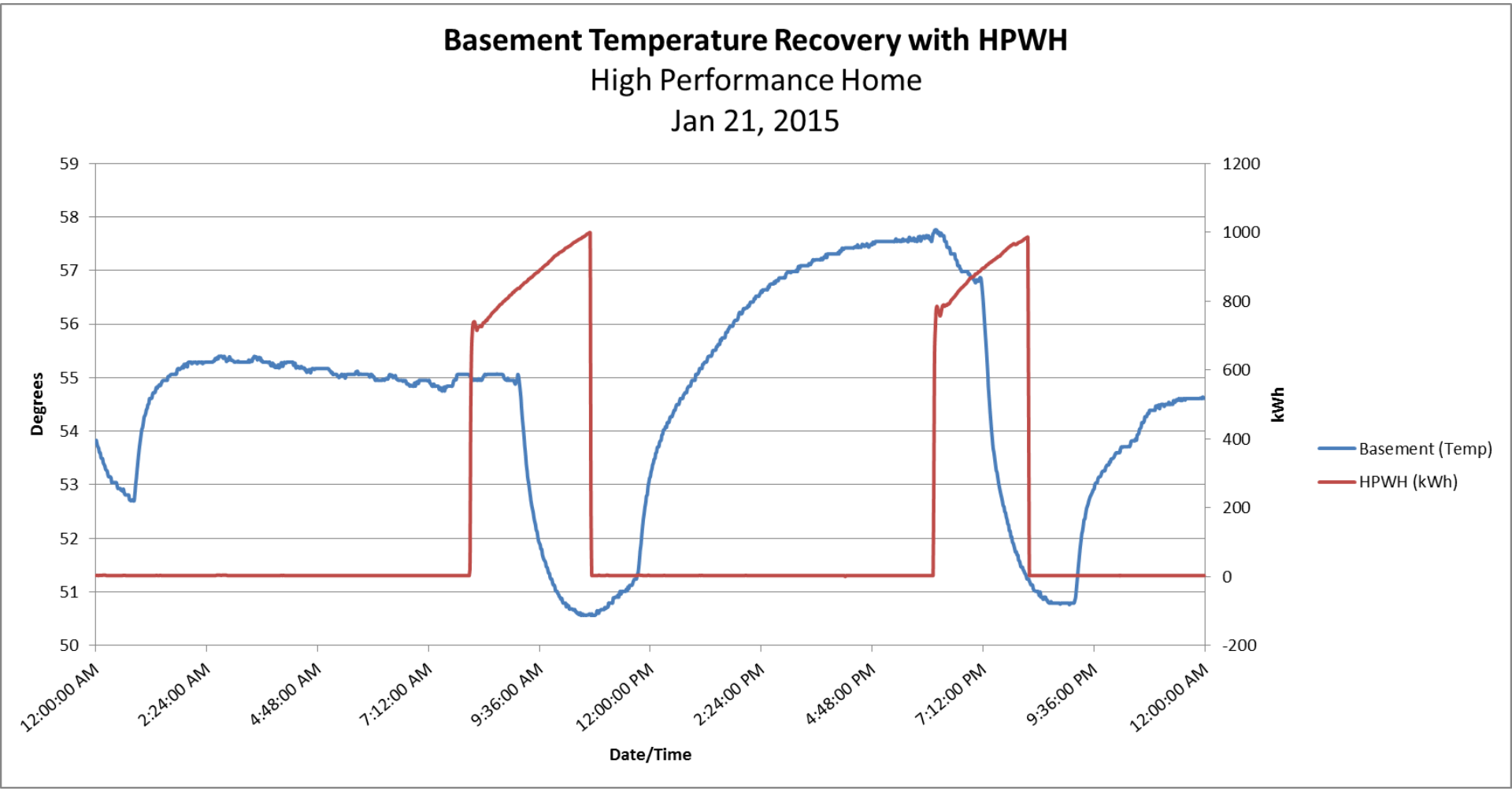
Temperature Variation with Point Source Heating with Heat Pump & HRV Energy Usage

ASHP: 663 kWh, HRV: 141 kWh

Residence A, Jan 2014




Temperature Variation with Point Source Heating
with Heat Pump & HRV Energy Usage
ASHP: 786 kWh, HRV: 143 kWh
Residence A, Jan 2015
Degrees
kWh
80
70
60
50
40
30
20
10
0
-10
60
50
40
30
20
10
-
1/1/2015
1/3/2015
1/5/2015
1/7/2015
1/9/2015
1/11/2015
1/13/2015
1/15/2015
1/17/2015
1/19/2015
1/21/2015
1/23/2015
1/25/2015
1/27/2015
1/29/2015
1/31/2015
HRV (kWh)
ASHP (kWh)
WU AmbientAvgTemp
Bath
Living Room
Office
Basement


Basement Temperature Recovery with HPWH
High Performance Home
Jan 21, 2015
Degrees
kWh
59
58
57
56
55
54
53
52
51
50
1200
1000
800
600
400
200
0
-200
12:00:00 AM
2:24:00 AM
4:48:00 AM
7:12:00 AM
9:36:00 AM
12:00:00 PM
2:24:00 PM
4:48:00 PM
7:12:00 PM
9:36:00 PM
12:00:00 AM
Date/Time
Basement (Temp)
HPWH (kWh)

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“Each bin is approximately 1/3 cord. We used one full bin and a partial bin for the 2013/14 heating season…the mini split was never powered up.”

- Chris Pike, Homeowner

Seeing is believing