vermont passive house

Energy Efficient Buildings

CPHC®

CERTIFIED BUILDER

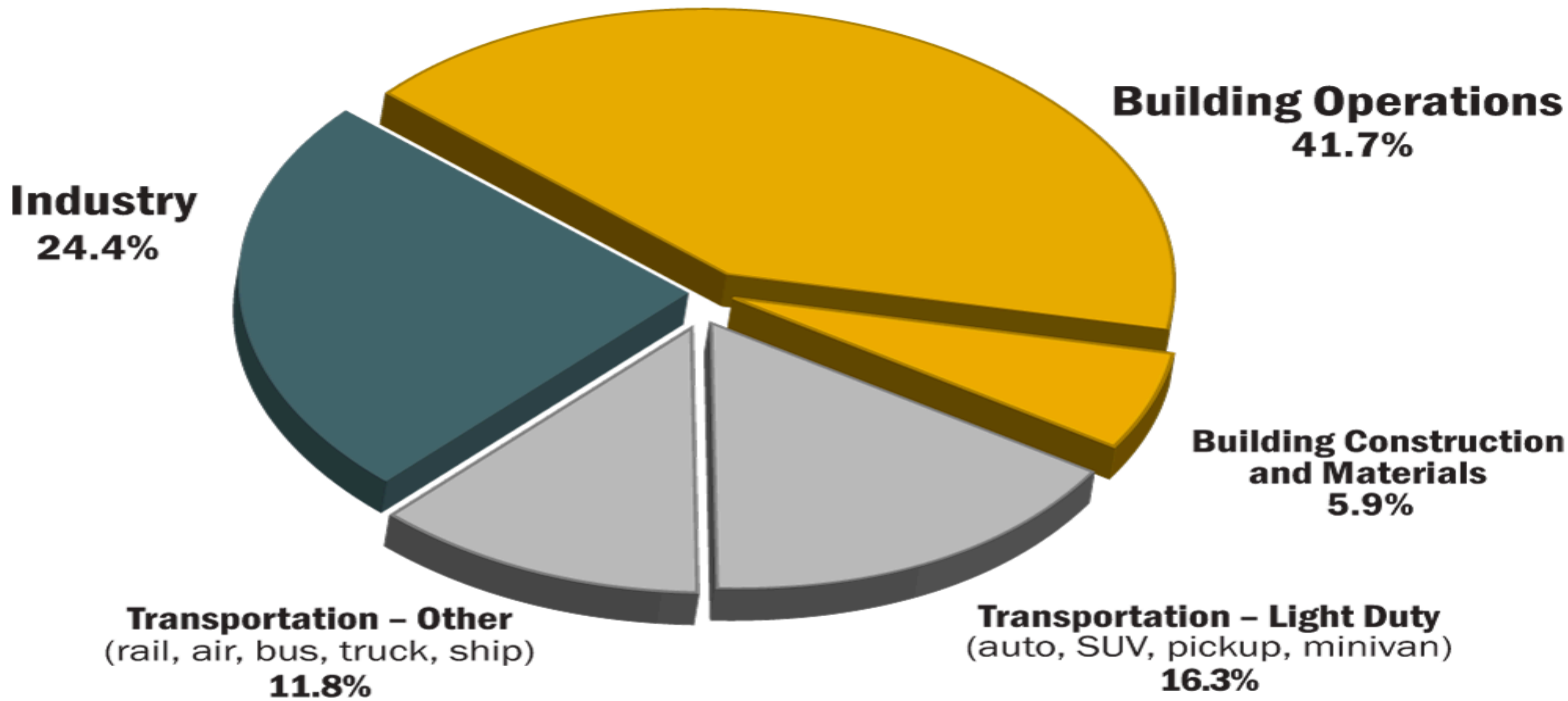
Save 90% in your heating bill - The Passive House Way

2016 Home & Garden Show

Champlain Valley Expo
April 16th & 17th, 2016

www.phausvt.org

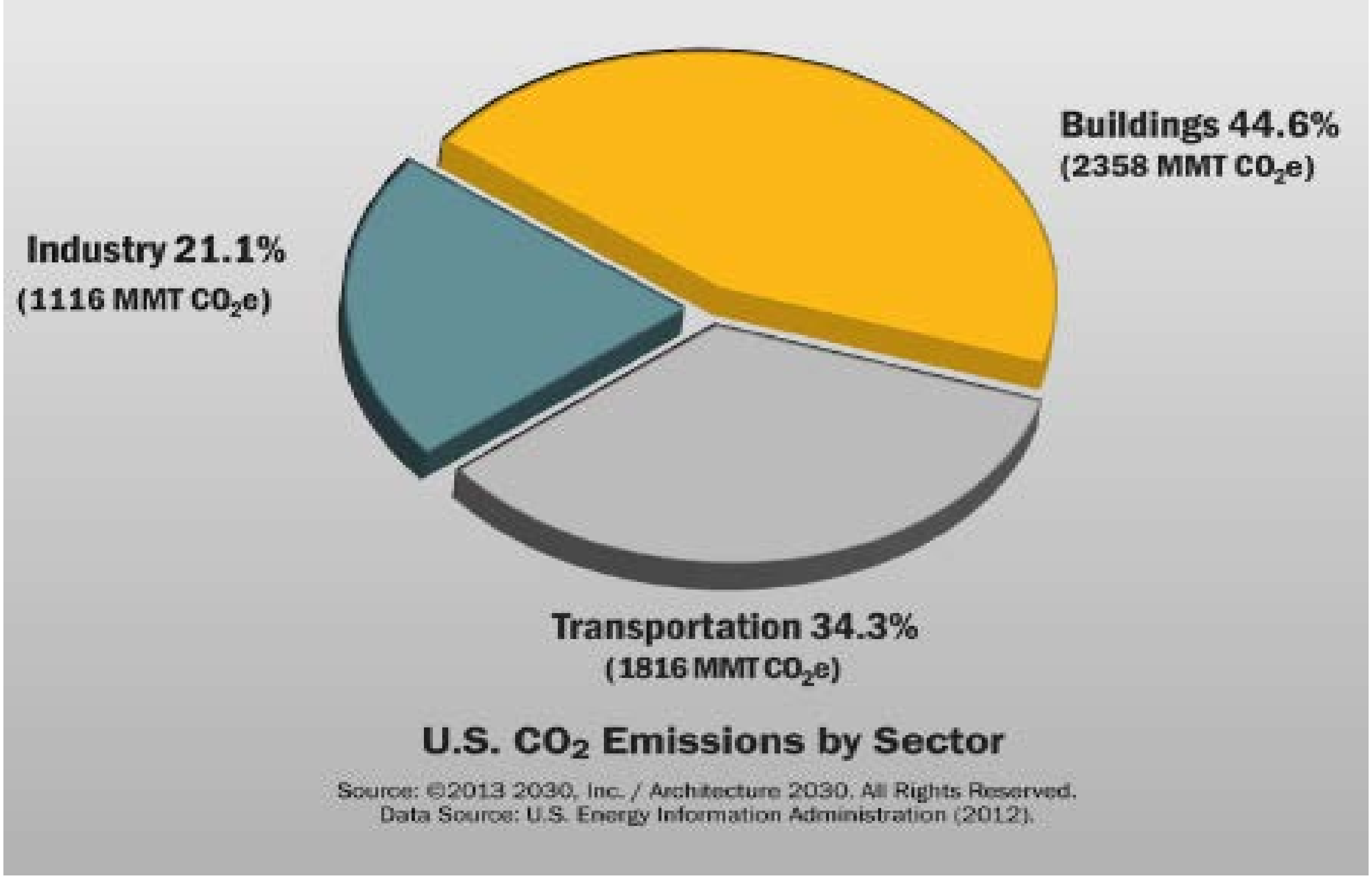
The Problem



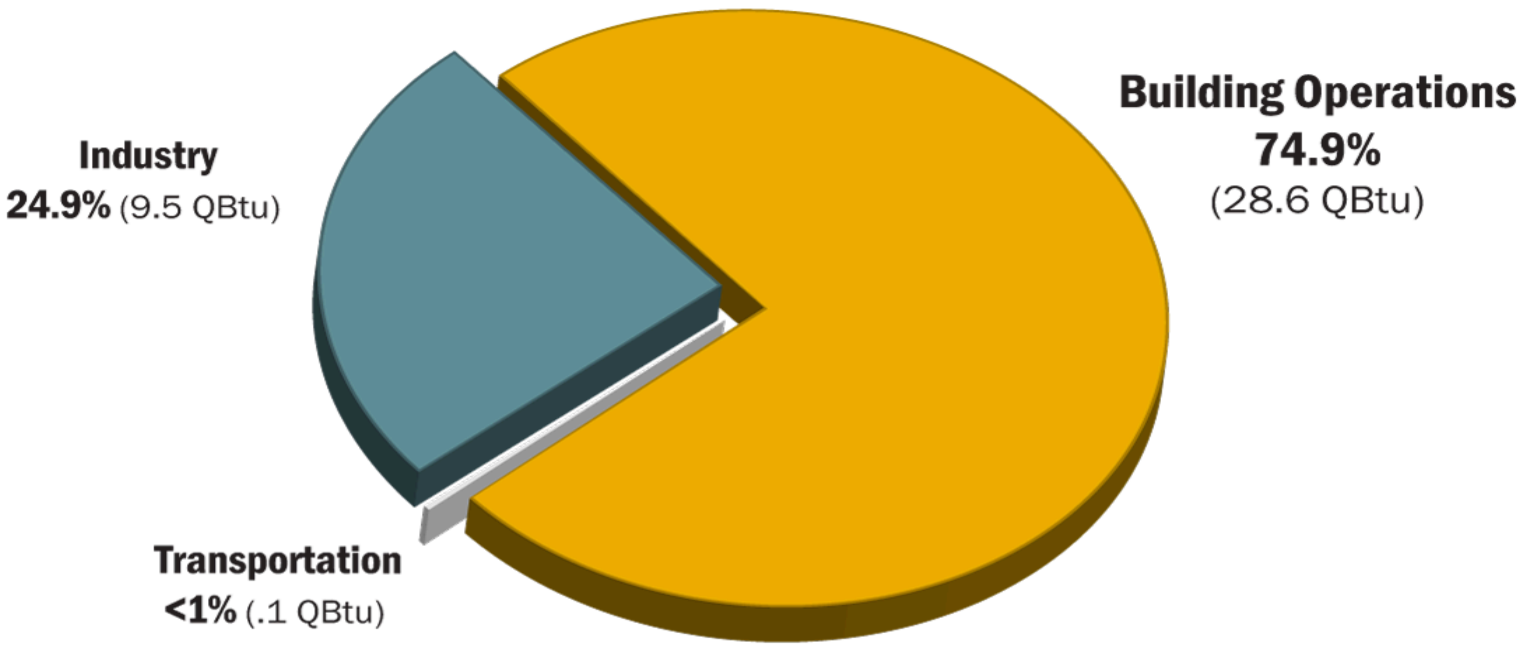
U.S. Energy Consumption by Sector

Data Source: U.S. Energy Information Administration (2012).

The Problem


Buildings 44.6%
(2358 MMT CO_2e)
Industry 21.1%
(1116 MMT CO_2e)
Transportation 34.3%
(1816 MMT CO_2e)
U.S. CO_2 Emissions by Sector
Source: ©2013 2030, Inc. / Architecture 2030. All Rights Reserved.
Data Source: U.S. Energy Information Administration (2012).

The Problem - **67% from Fossil Fuels***



U.S. Electricity Consumption by Sector

Source: ©2013 2030, Inc. / Architecture 2030. All Rights Reserved.
Data Source: U.S. Energy Information Administration (2012).

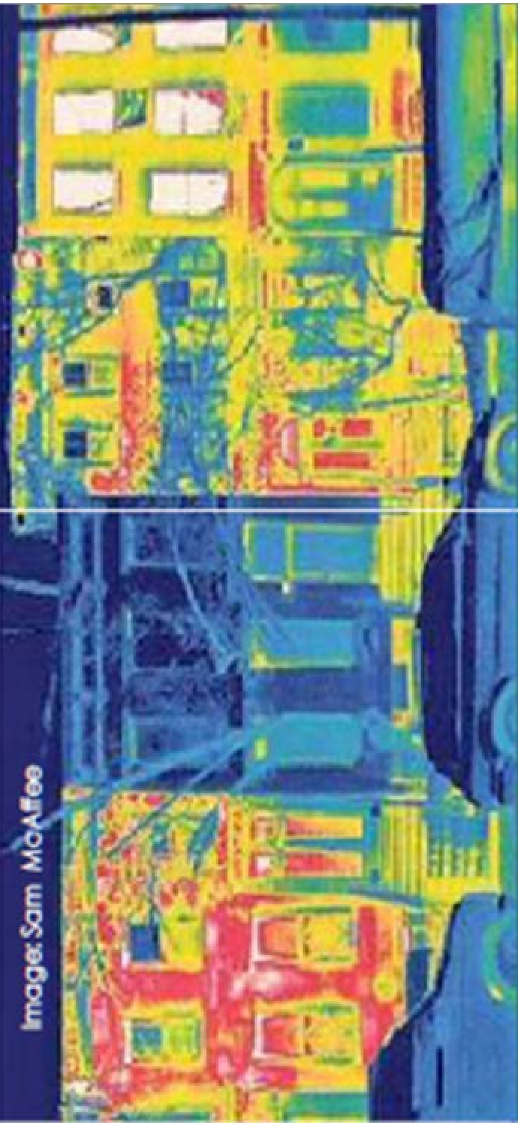
*US-EIA 2014

The Solution

Passive House Buildings

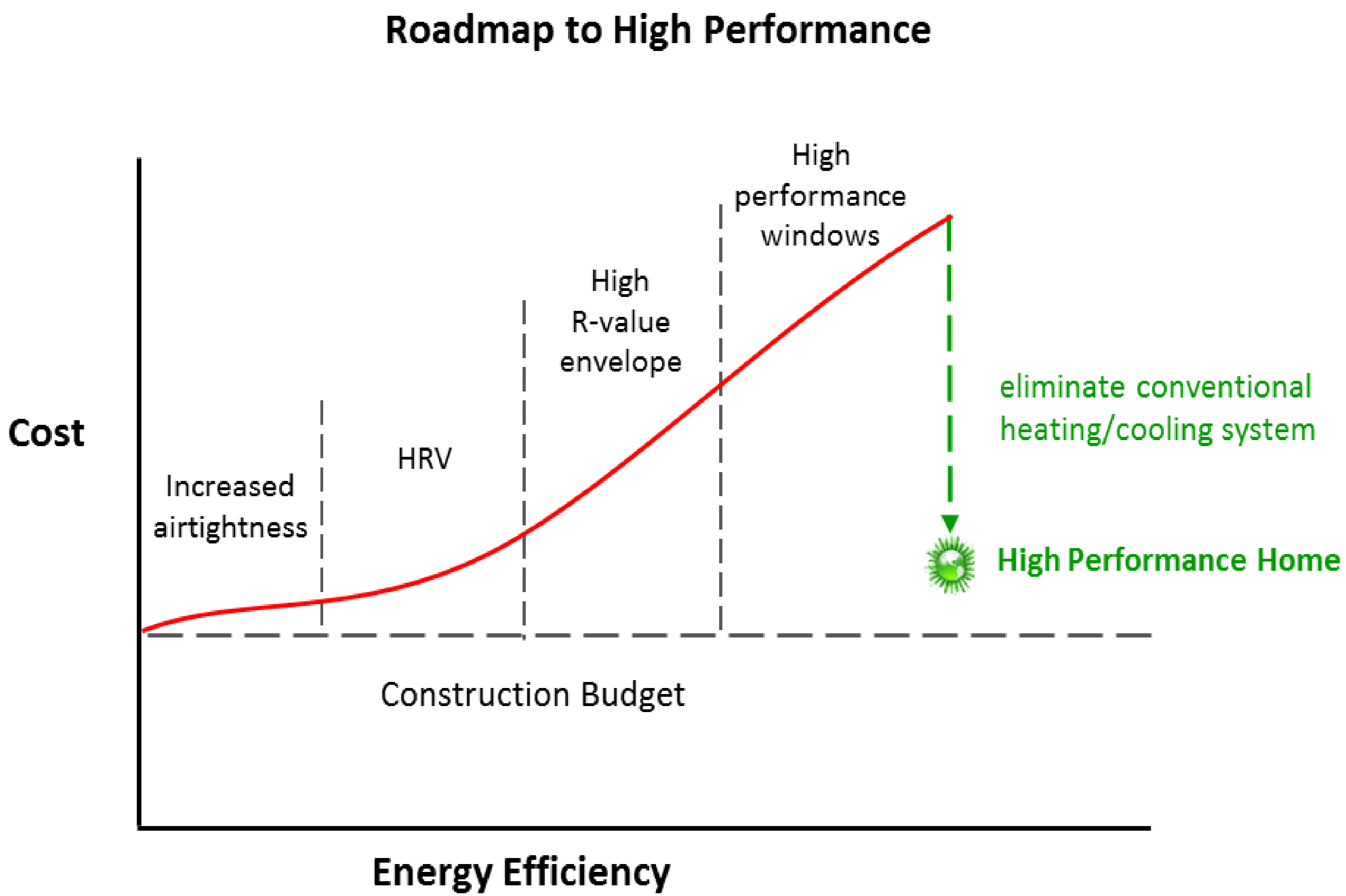
PH Concept Explained in 12 min.

PASSIVE BUILDING PRINCIPLES



- Minimize Loss/Optimize Gains
- Air-Tight Construction
- High Performance Windows/Doors
- Balanced Ventilation
- Optimize Space Conditioning

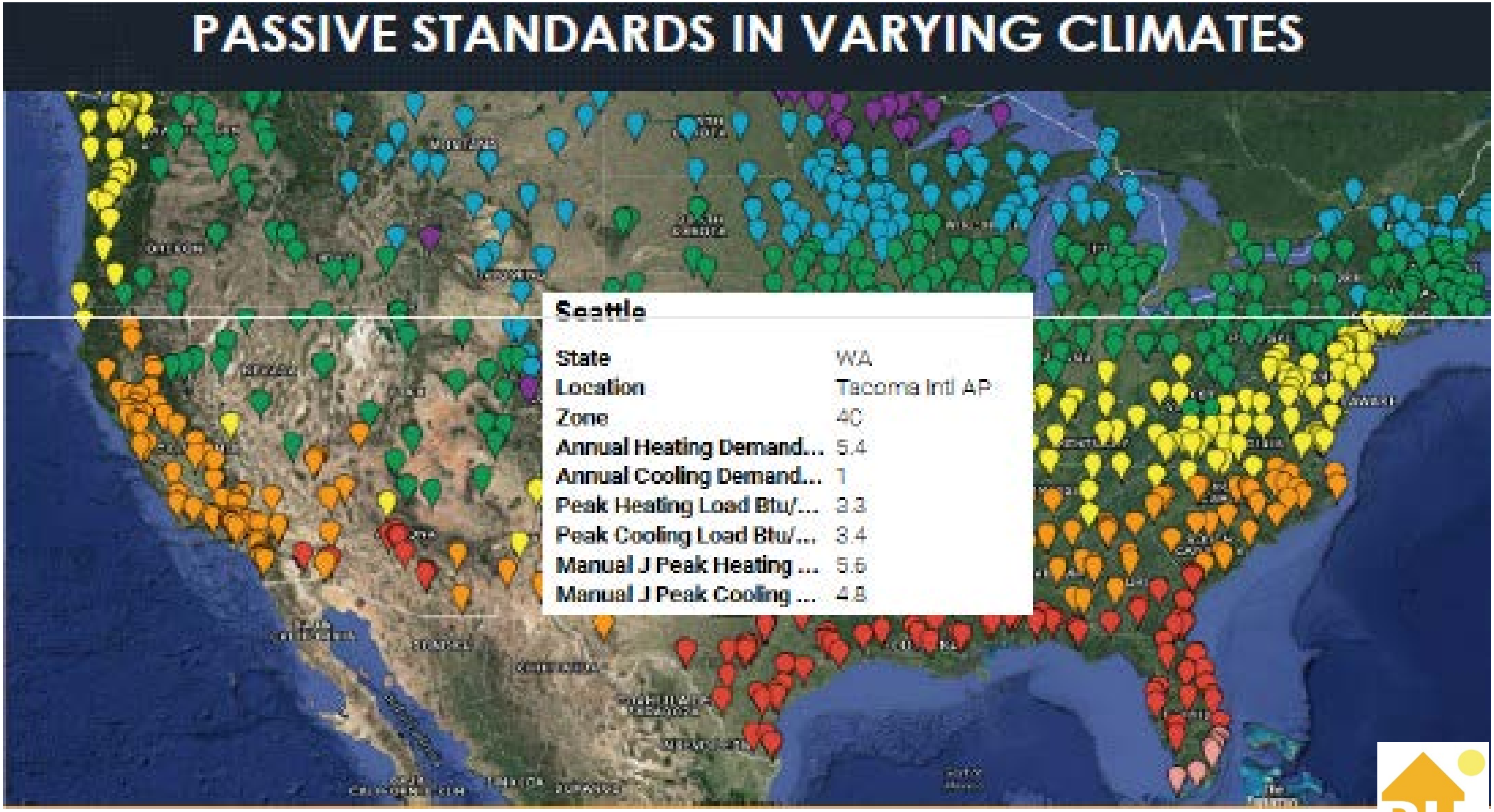
Rational Behind Passive House Approach



EU Passive House Energy Standard Clearly Defined

Heating Load (Site):	4.75 kBTU/Ft2-YR
Cooling Load (Site):	4.75 kBTU/Ft2-YR
Peak Heat Load :	3.14 BTU/Ft2-Hr
Peak Cooling Load:	2.54 BTU/Ft2-Hr
Total Energy Demand (Source):	38 kBTU/SF-YR
Air Tightness:	0.6 ACH @ 50pa (based on interior floor area)

PHIUS Climate Specific Criteria



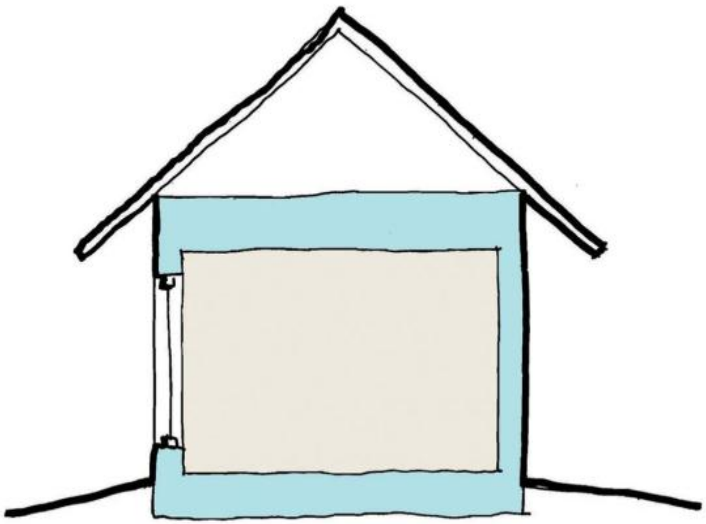
USA PHIUS+ 2015 Building Criteria

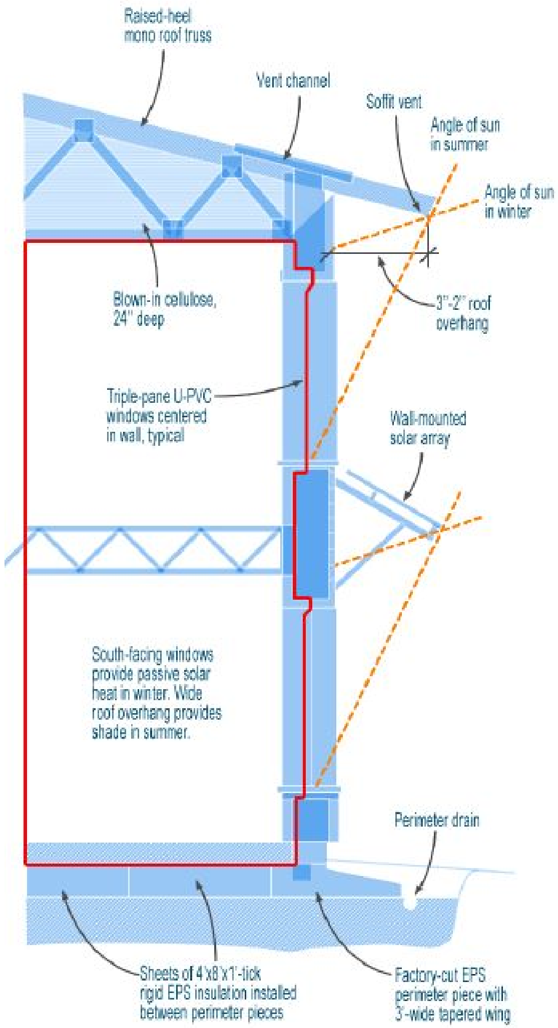
Heating Load (Site):	1 - 12 kBTU/Ft2-YR
Cooling Load (Site):	1 - 21.4 kBTU/Ft2-YR
Peak Heat Load :	0.8 - 5.4 BTU/Ft2-Hr
Peak Cooling Load:	1.8 - 8.9 BTU/Ft2-Hr
Total Energy Demand (Source):	Beds+1 / 21154 kBTU/PERSON-YR (Temporary) Beds+1 / 14330 kBTU/PERSON-YR (Future)
Air Tightness:	0.05 cfm/gross sqft shell @ 50 pa 0.08 cfm/gross sqft shell @ 75 pa

The Solution – Passive House

- Dramatic reduction in **wasted** energy
- Superior indoor air quality
- Superior occupant comfort
- Lower annual energy costs
- Smaller carbon footprint
- Reduces Maintenance and building deterioration
- Eliminates Dependence on Fossil Fuel
- **Equal or Lower Out of Pocket expense for Mortgage plus Energy**

Exceptionally high level of thermal INSULATION to control heat loss





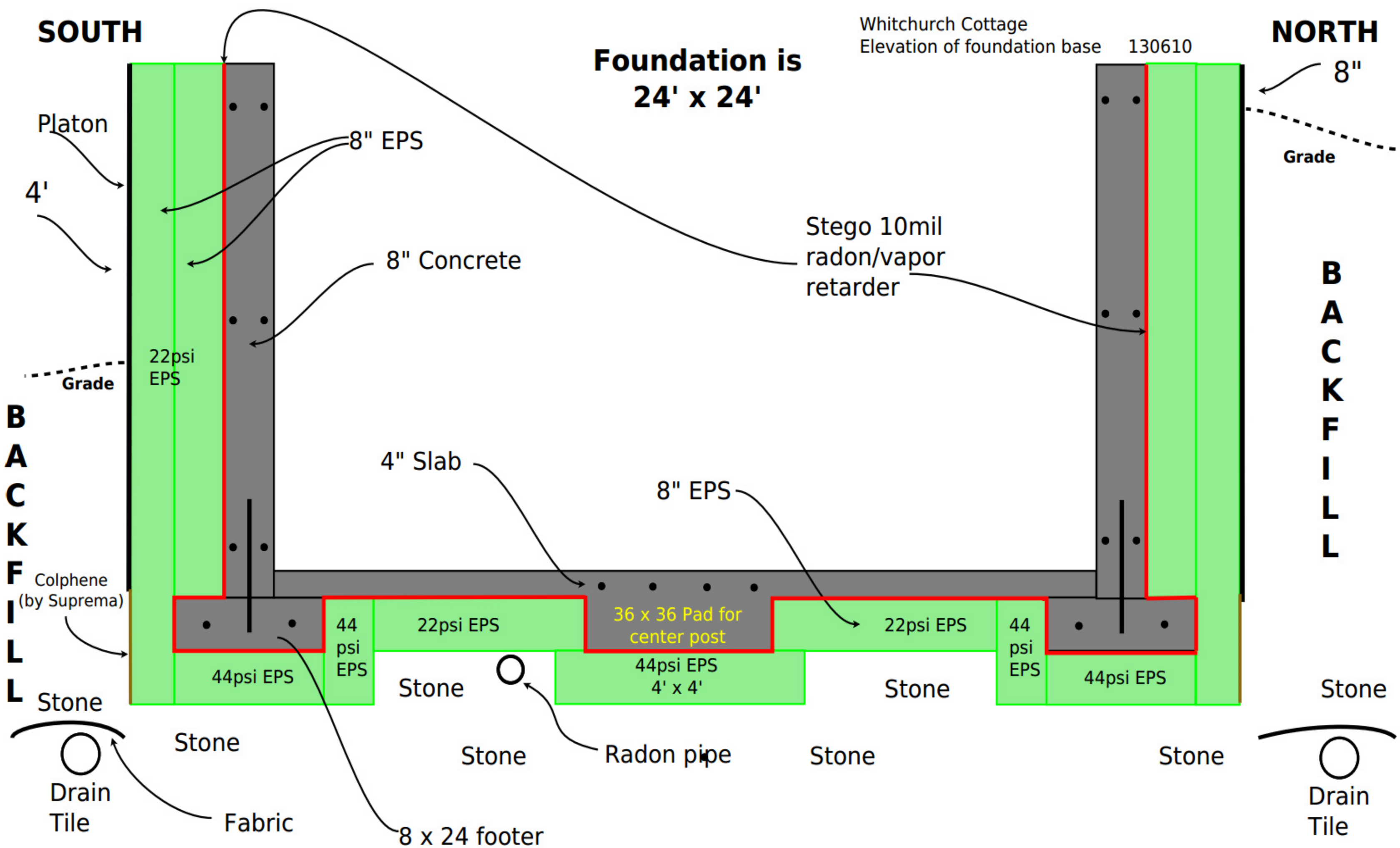
For Climate Zone 6
R60 WALLS: R90 CEILING: R60 SLAB
High Performance WINDOWS U value > 0.13 (R-7)

The proper level of insulation is critical to maintain the home warm in the winter and cool in the summer and to maintain homogenous temperature throughout the house.

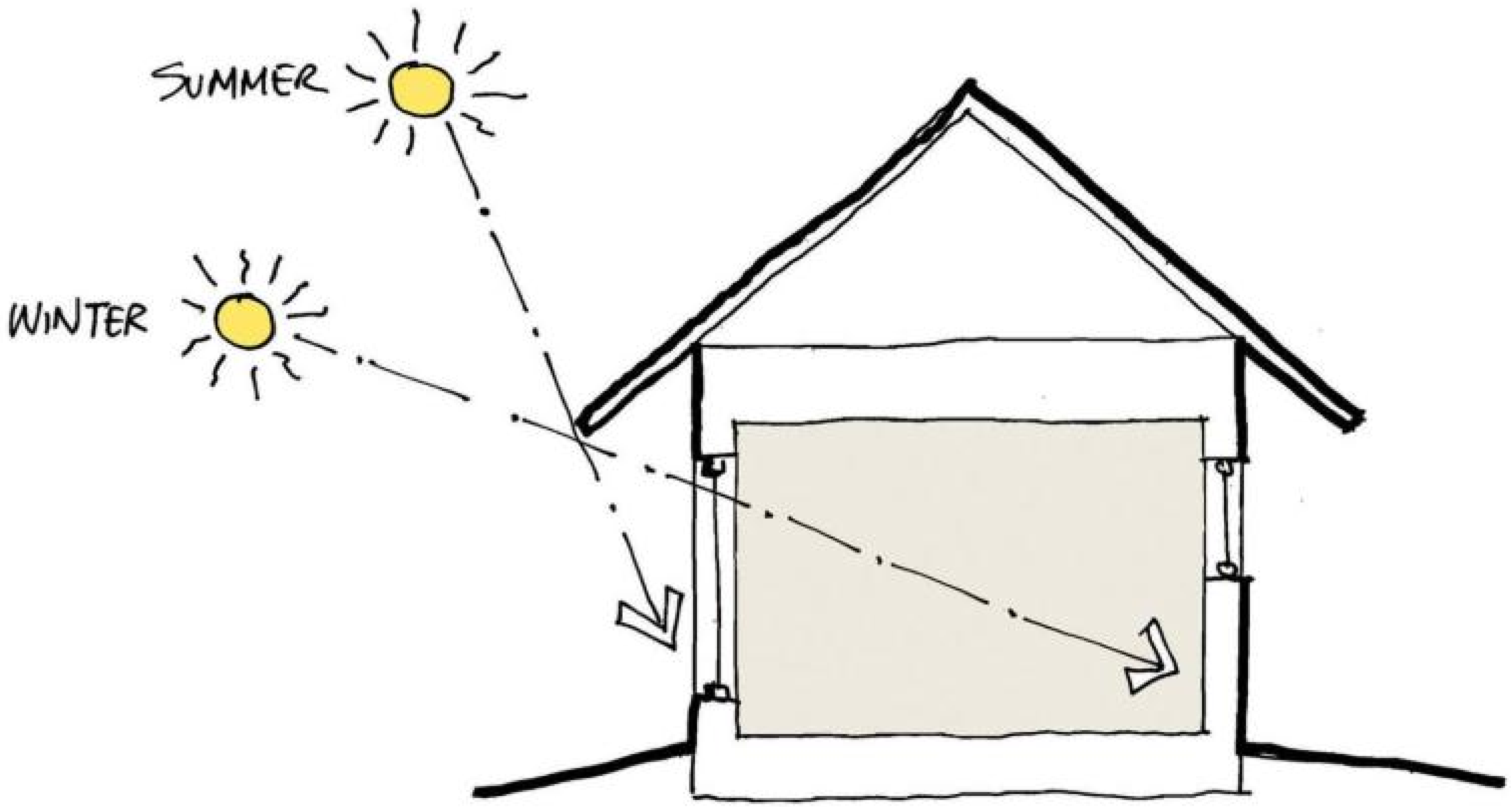
Insulated Slab on Grade

Insulated Slab on Grade

Basement Foundation Insulaion

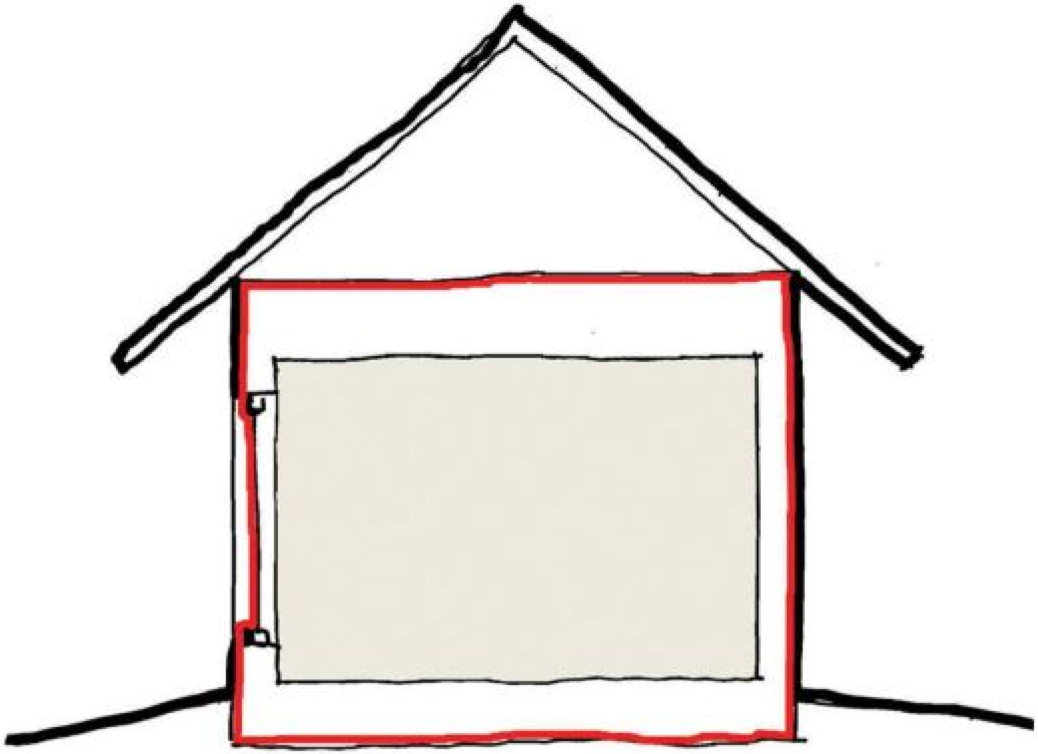


Passive House Concept: Controlling Gains Seasonally - Windows and Orientation



TRIPLE GLAZED: U VALUE < 0.13 (min R7);
0.60 Solar Heat Gain Coefficient on South Windows
for Climate Zone 6

Passive house Concept: Controlling Heat Loss - Eliminate Air In/Ex-filtration



.6 ACH @ 50 PA (based on interior floor area)

AIR BARRIER | VCL | WRB MATERIAL

ASSURING DURABILITY OF ASSEMBLY

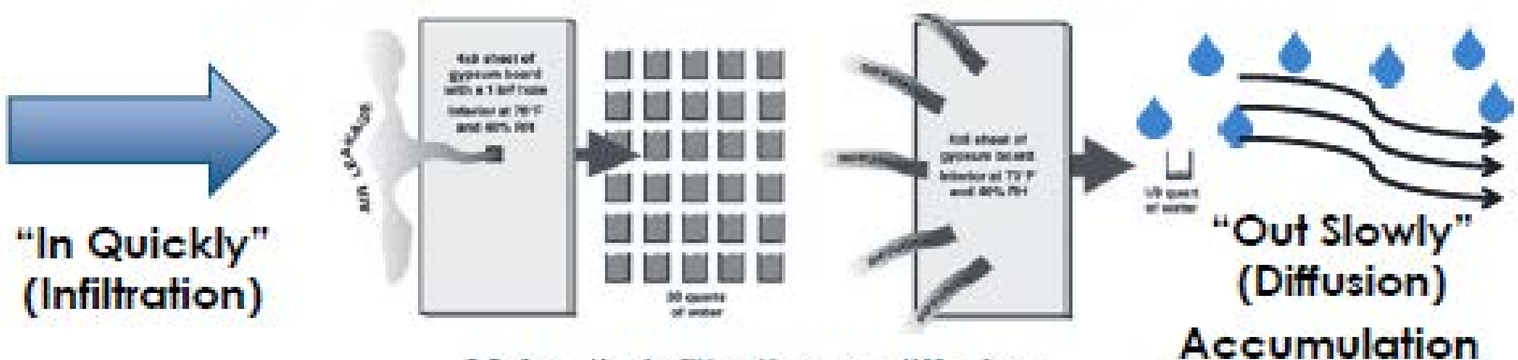
MOISTURE TRANSFER

Air Movement = 98%+ Water Vapor Movement in Building Cavities

Infiltration: 1 in^2 hole = **30 quarts** **of water**

Diffusion: 4'x8' sheet of drywall (4608 in2) = **1/3 quart of water**

One Heating Season (Indoors @ 70°F, 40% Relative Humidity)



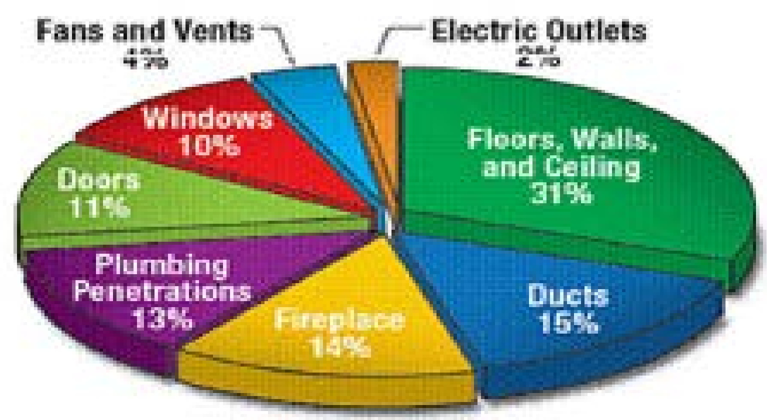
90:1 ratio infiltration vs diffusion

Source: Building Science Corp.

Effects of Air Infiltration on Heat Loss

HEAT LOSS **FACTS** EXISTING BUILDINGS

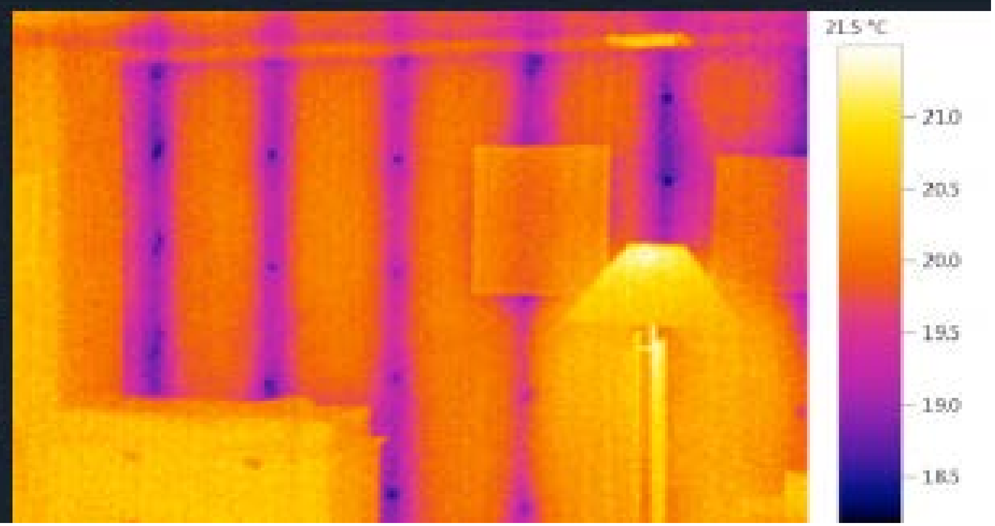
- 30-50% of Space Conditioning Energy (DOE)
- 8 MPH wind = -30% R Value (DuPont, 2007)
- Average US house: 3 ft^2 of holes
- Typical 2500 ft^2 home: ½ mile of cracks



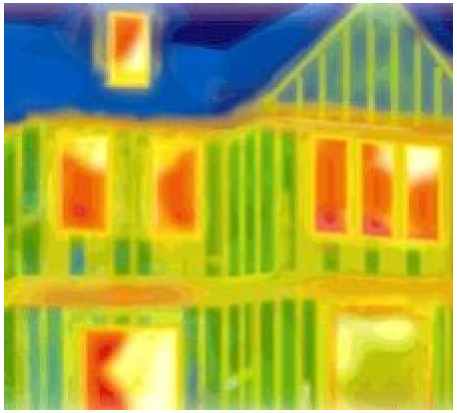
Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use (NISTIR 7238) - NIST, US D.

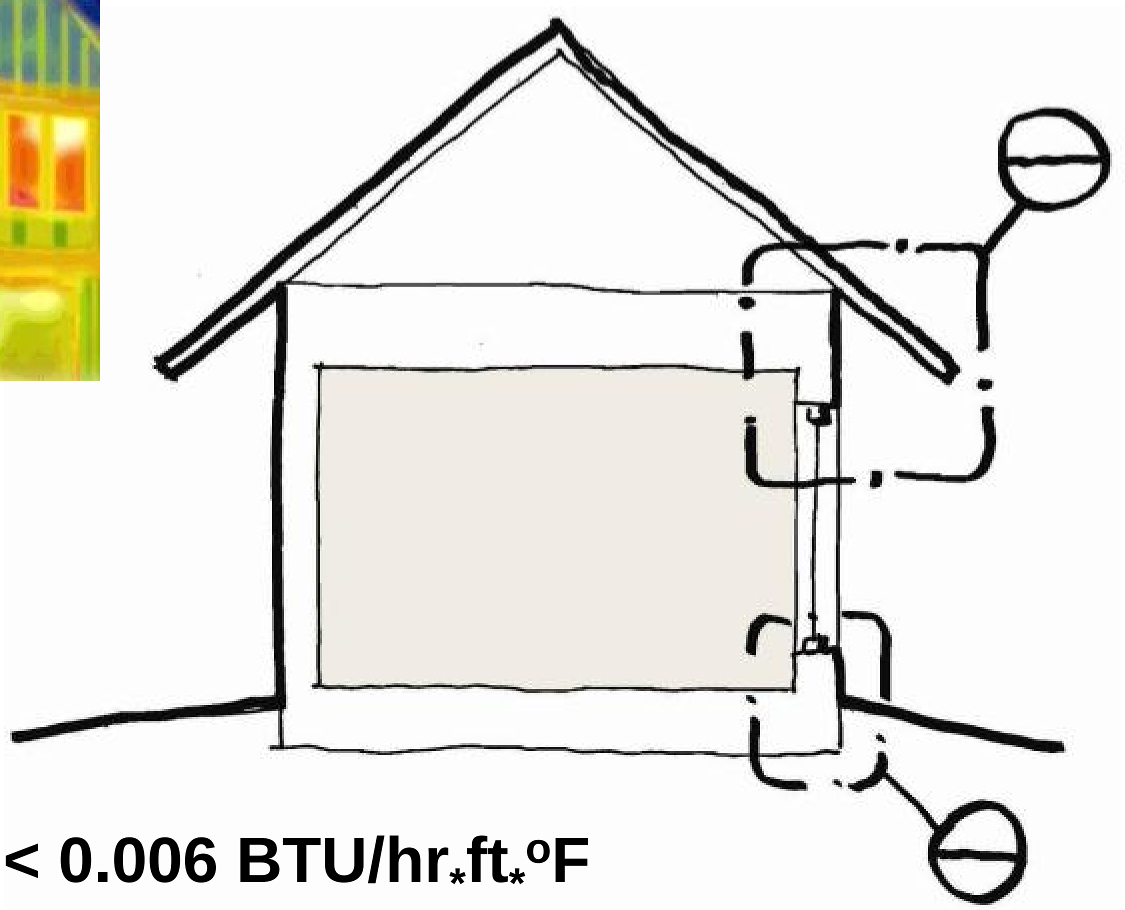
MINIMIZE LOSS/GAIN

THERMAL BRIDGING



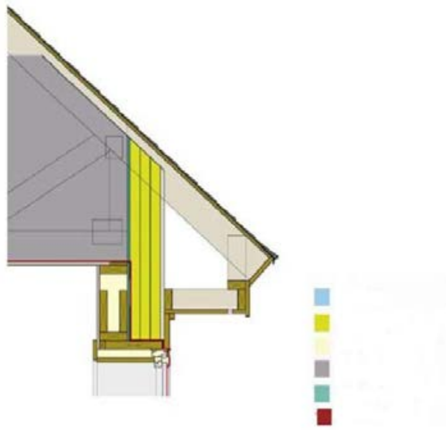
Passive House Concept: Controlling Heat Loss – Eliminate Thermal Bridges





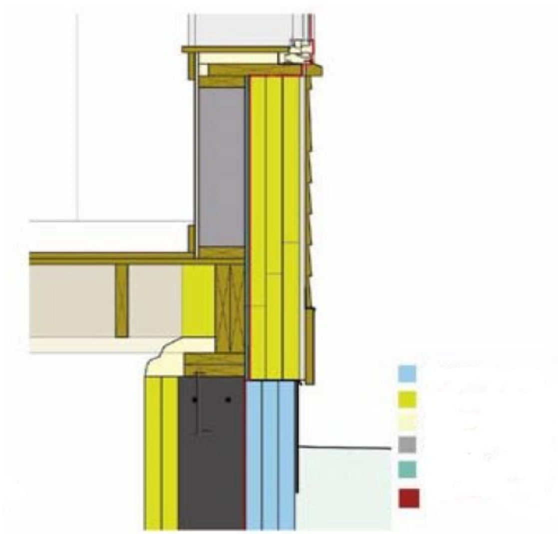
Psi < 0.006 BTU/hr*ft*°F

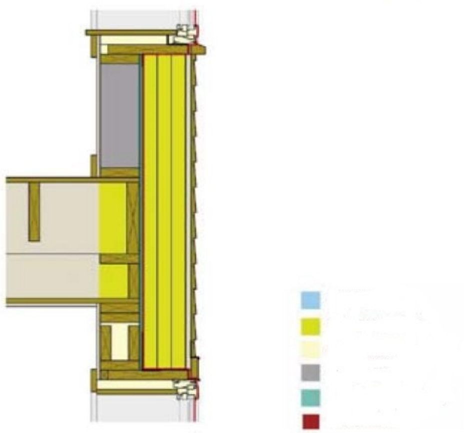
Thermal-bridge-free construction - Roof Assembly, Wall Assembly, Floor Assembly



Roof Assembly

Wall Assembly



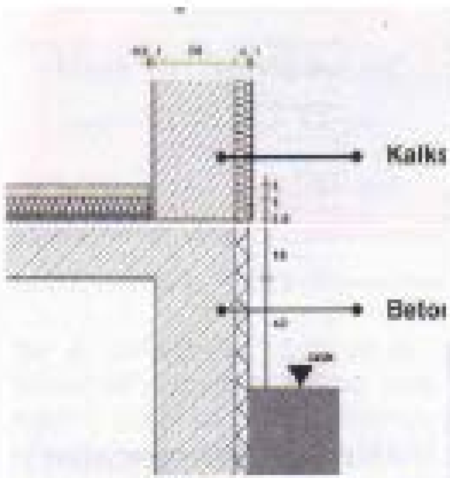


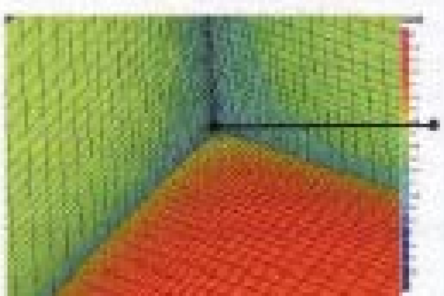
Floor Assembly

With Thermal-bridge-free construction temperature bridges are eliminated and in turn homogenous temperature throughout the structure are achieved.

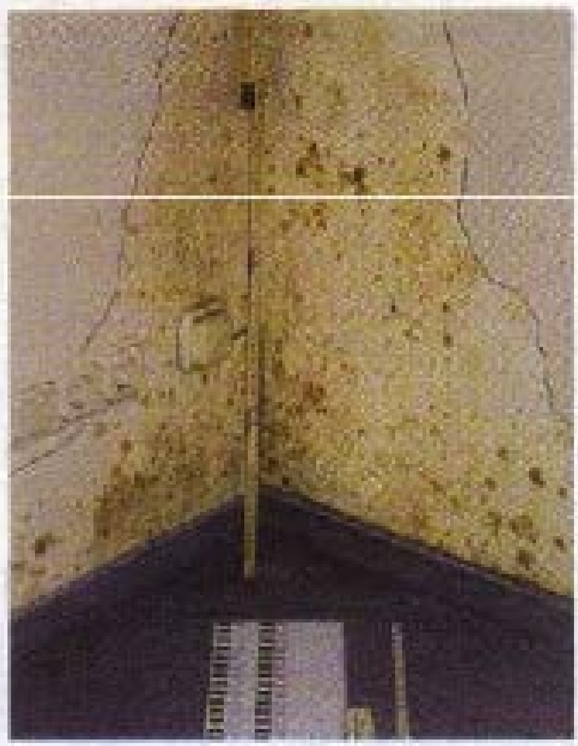
MINIMIZE LOSS:
ELIMINATING THE THERMAL BRIDGE MINIMIZES HEAT LOSS CONDENSATION/BUILDING DETERIORATION

BAD = high heat loss + risk of condensation

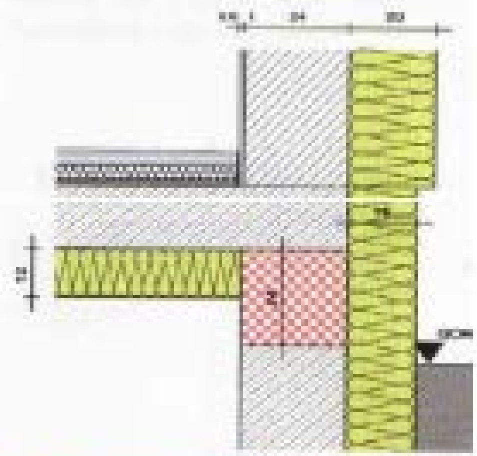




Minimum temperature 48 F below dew-point, risk of condensation



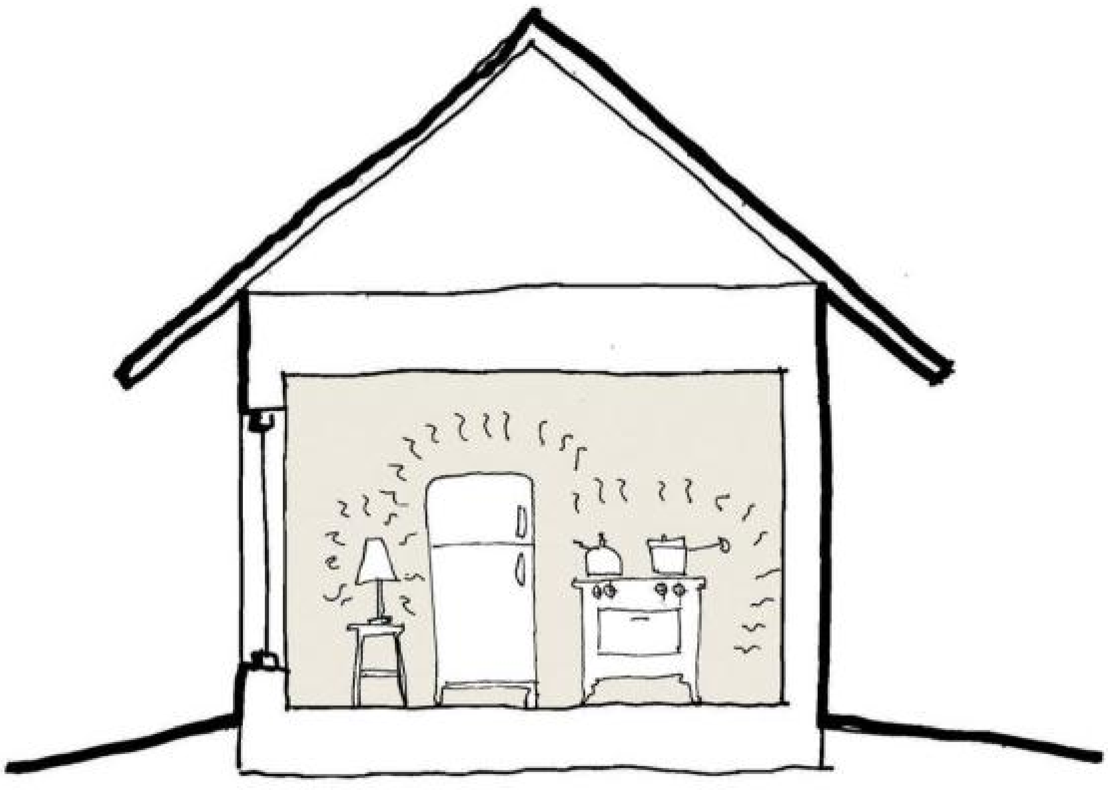
GOOD = low heat loss, warm interior surface + no condensation



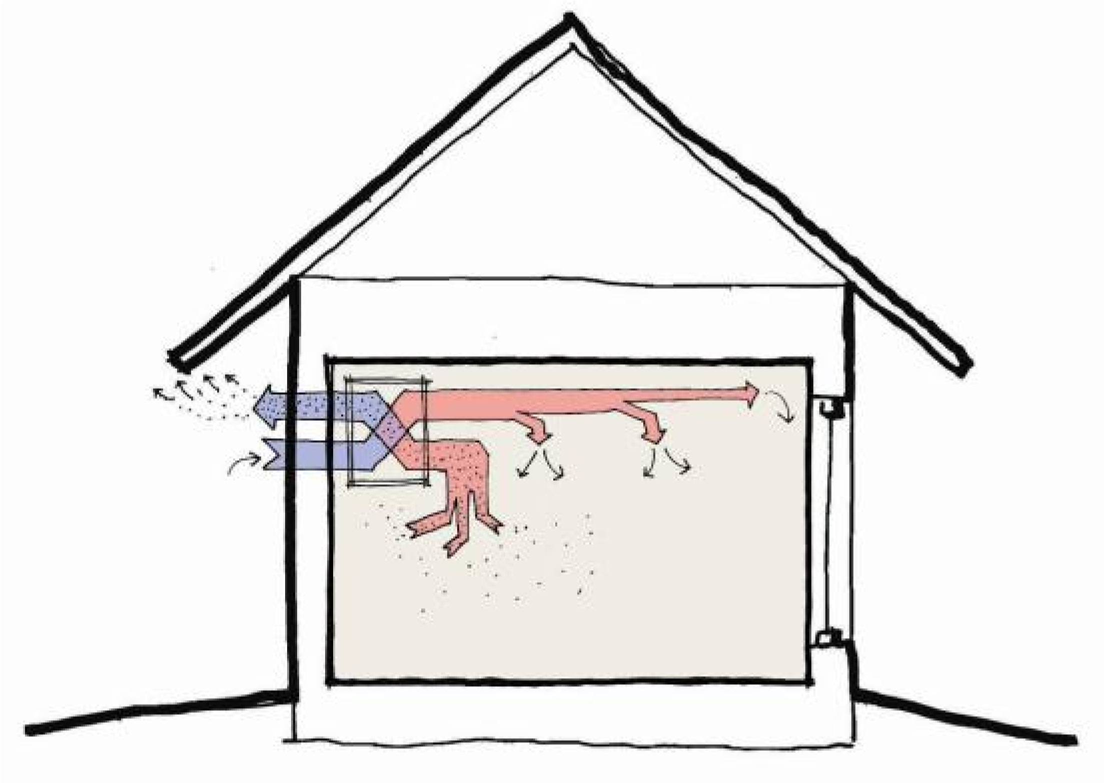
Minimum temperature 58 F above dew-point, no risk of condensation

Passive House Concept: Capturing Heat Gains - People

Passive House Concept: Capturing Heat Gains… Equipment



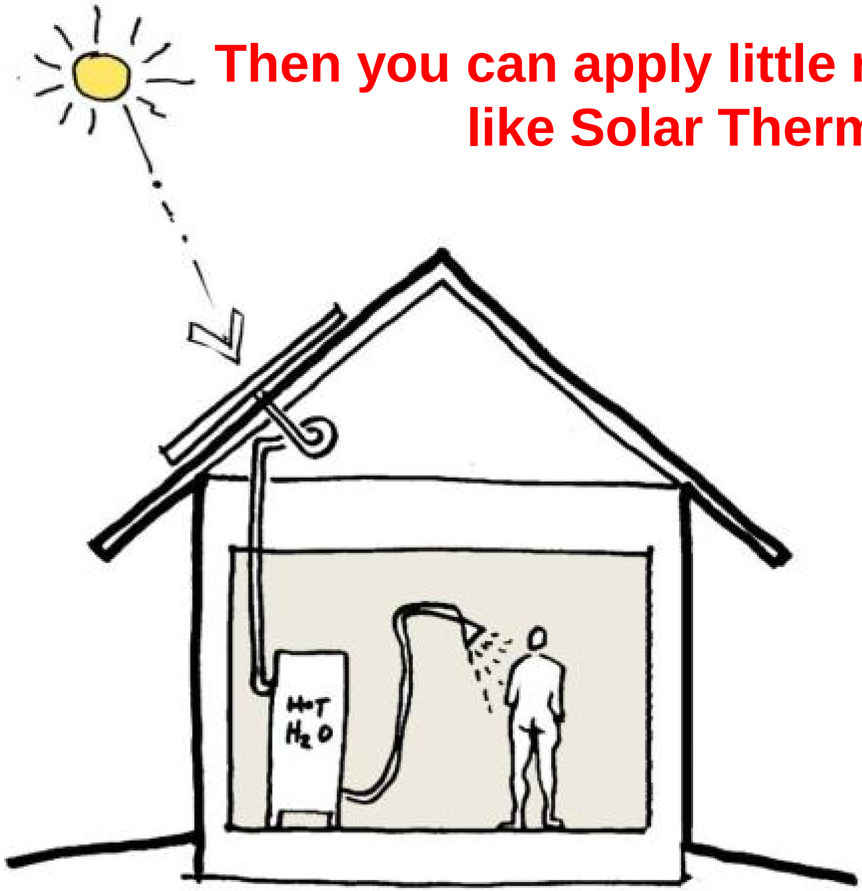
Passive House Concept: Provide Fresh Air… Heat Recovery Ventilation



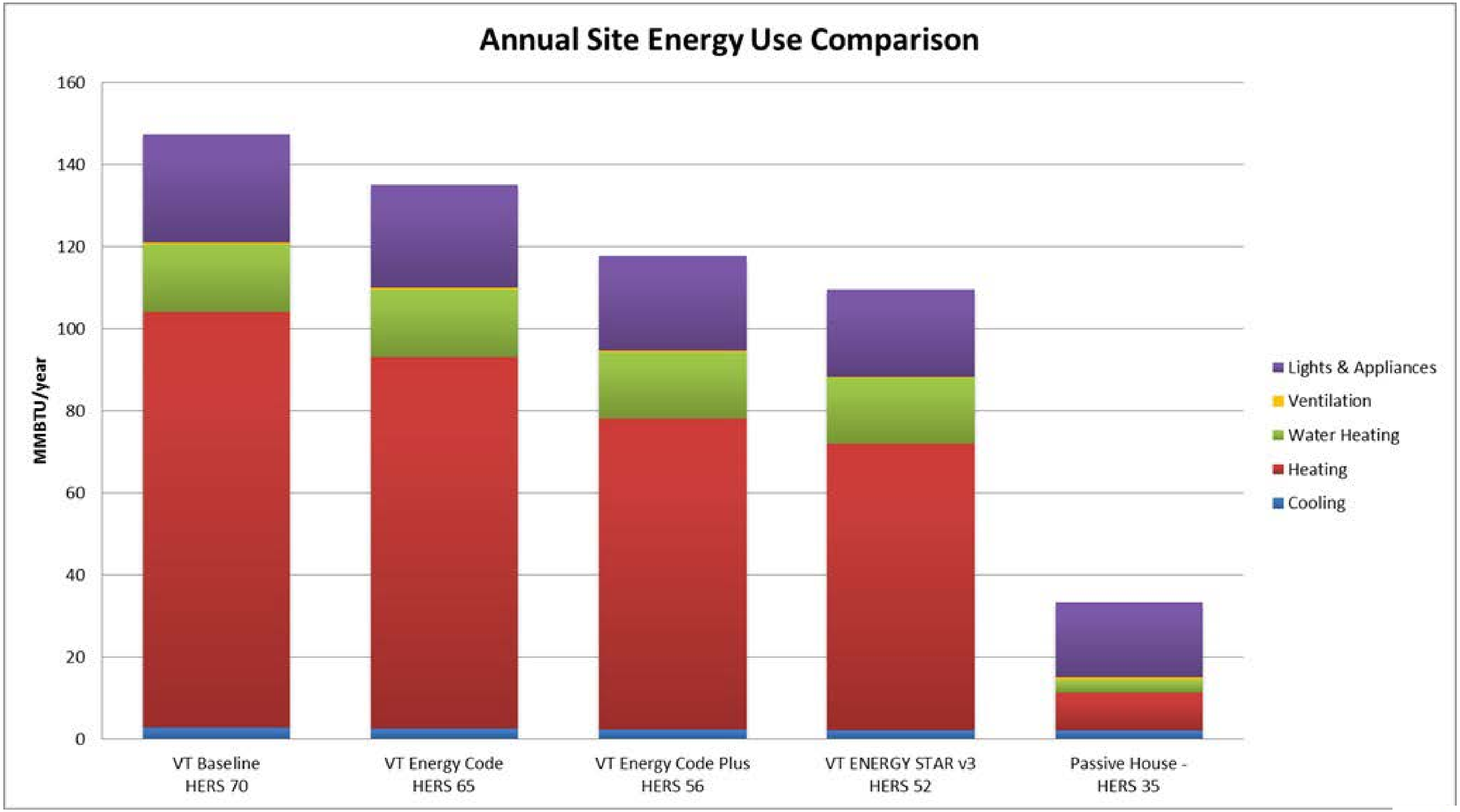
MINIMUM .30 ACH

Passive House Concept: Once the Wasted Energy is Reduced to the maximum…

Then you can apply little renewable sources like Solar Thermal or PV



Energy Usage Comparison



How does it relate to other programs?

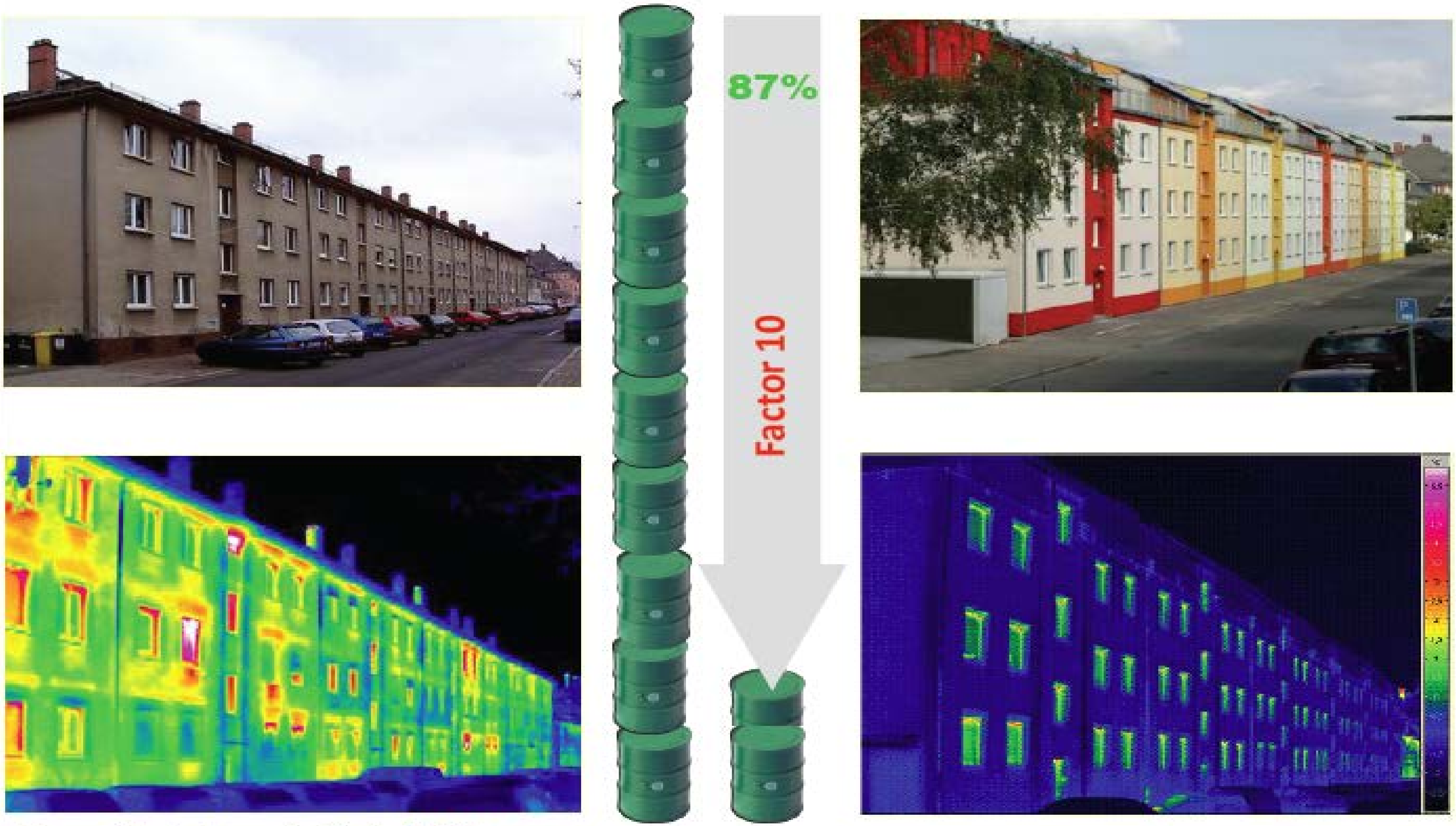
Energy Efficient Housing Concepts in the US:

- Vermont Energy Code (RBES): required for all new construction
- Energy Star 3.0: DoE Program (30% more efficient than Code)
- Building America: DoE super energy savings Program (15% better than EStar)
- Passive House: 90% more efficient than Code
- 70% more efficient than Energy Star
- 55% more efficient than Building America
- Can be cost equivalent to conventional building for single family and equal or less for multifamily and commercial construction.

How does it relate to other programs?

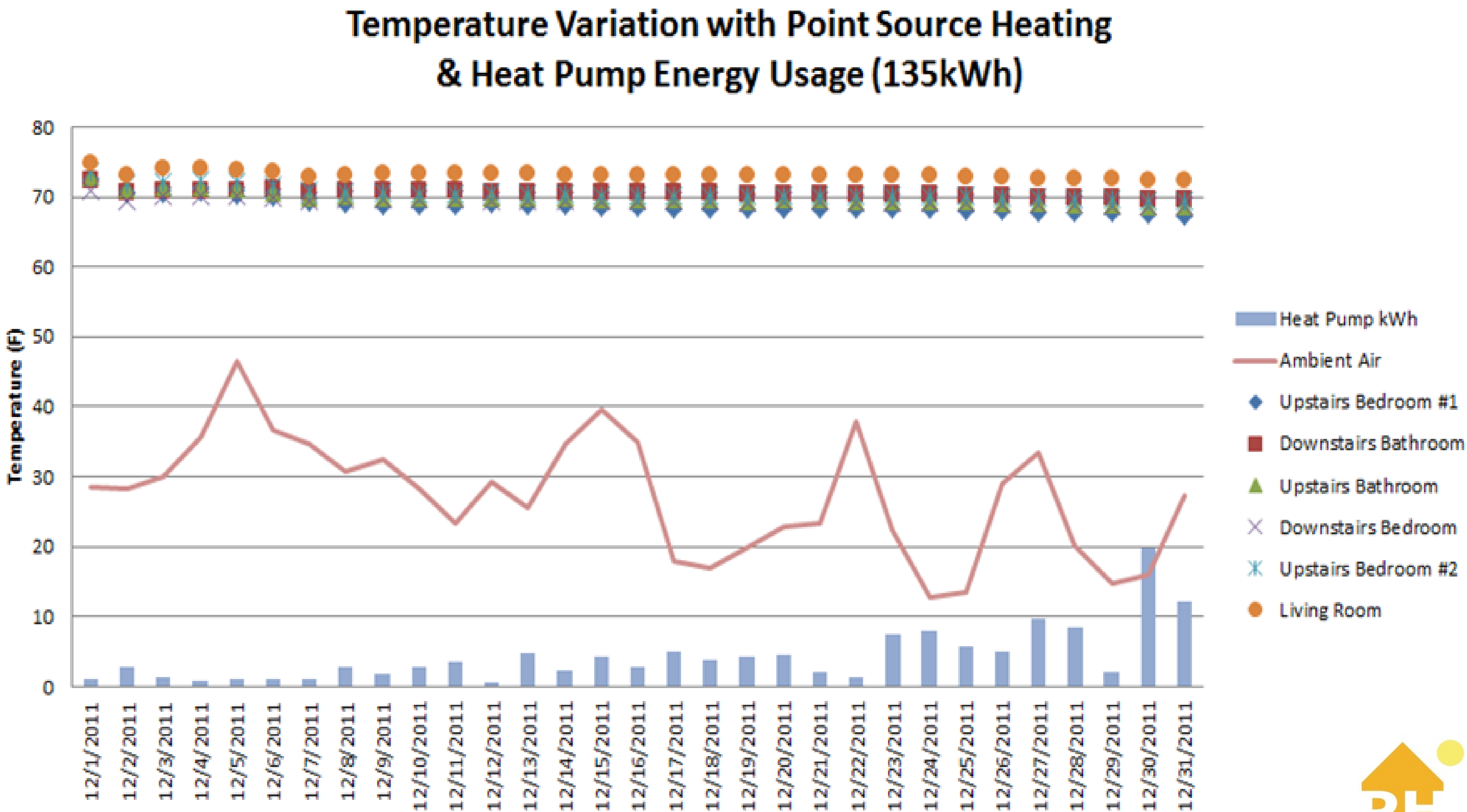
It is no Rocket Science and applies to retrofits too

Frankfurt Teverstrasse, Refurbishment using Passive House Principles

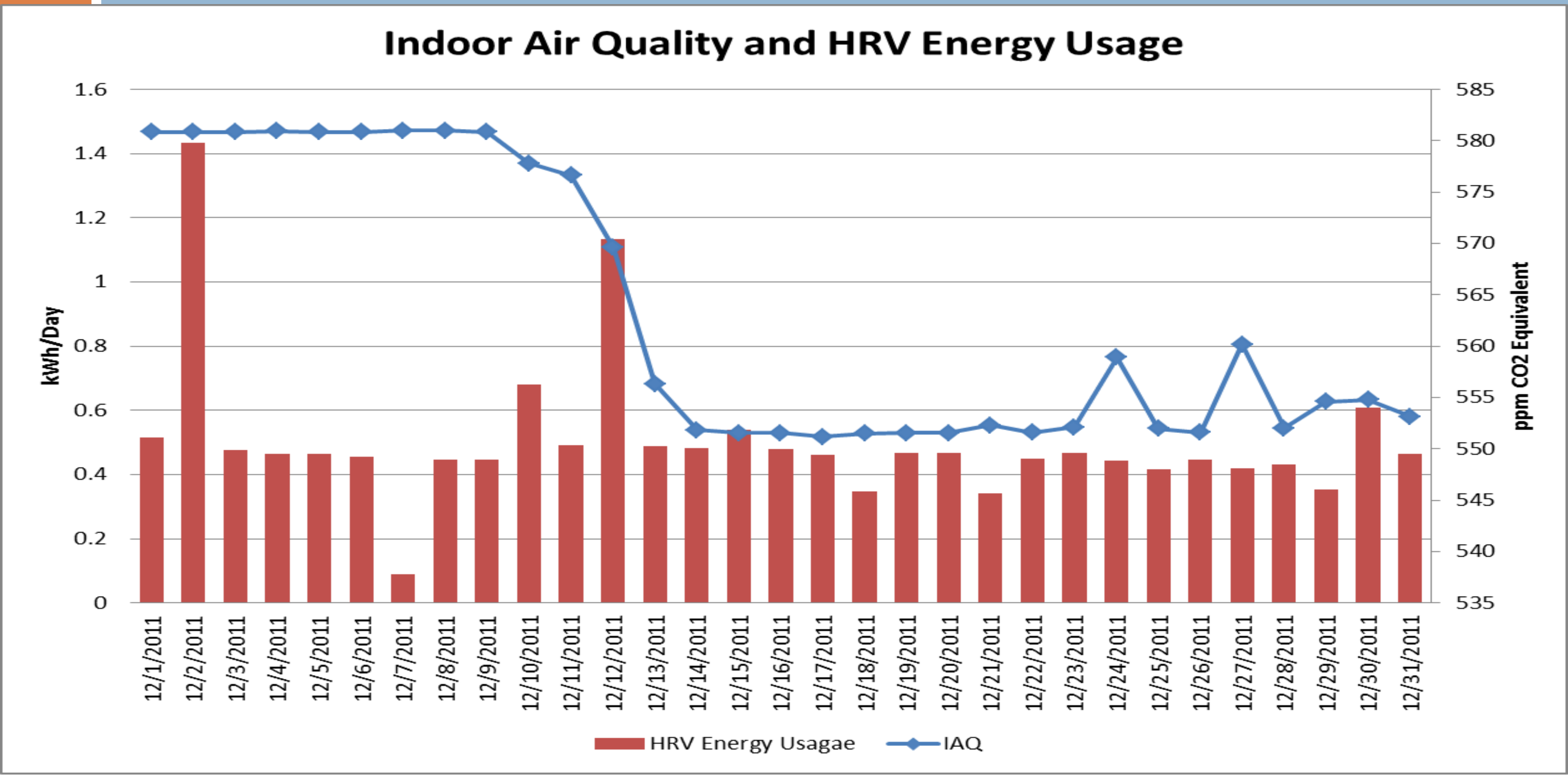


Source: Passivehouse Institute / DENA

Heating Energy Needed to Meet Comfort



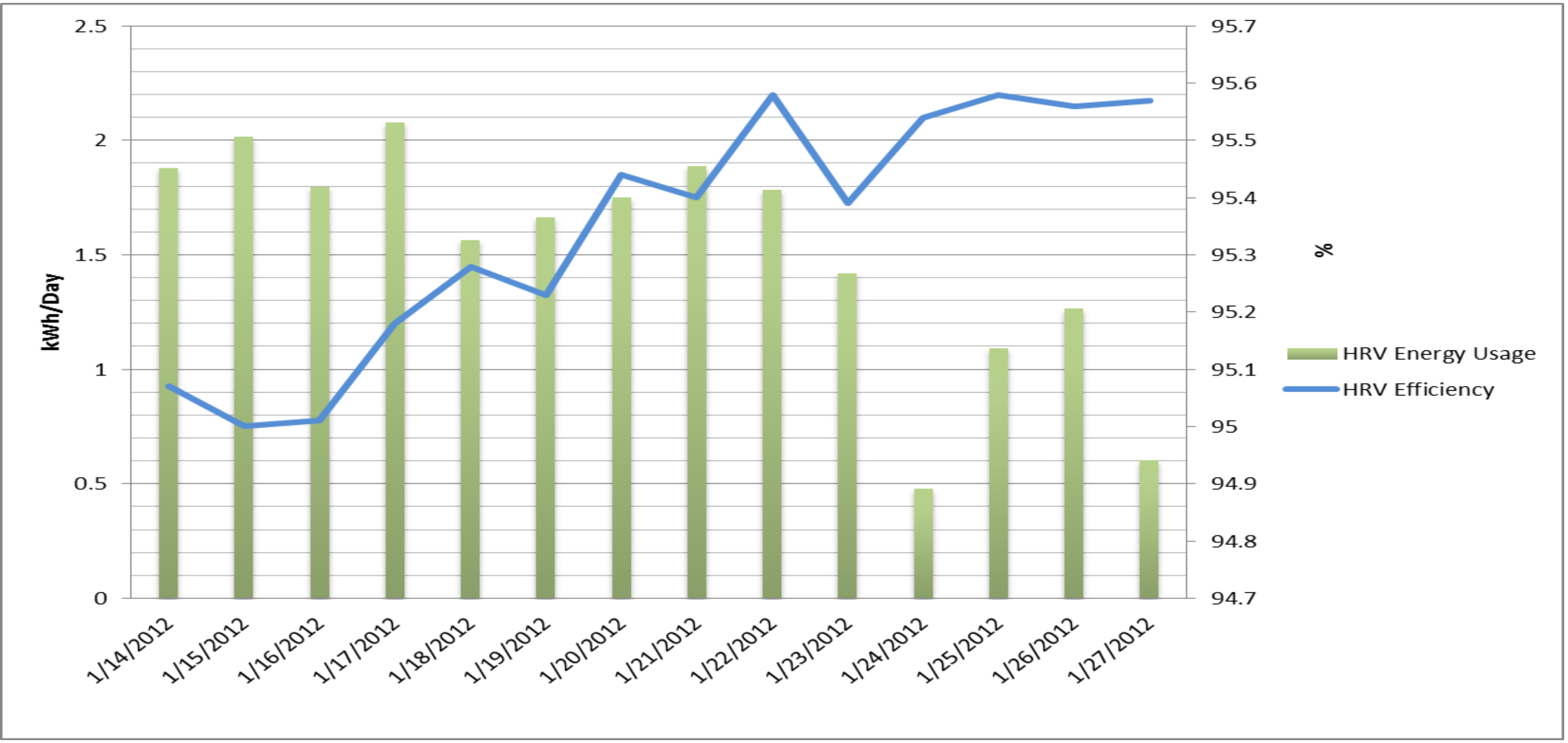
HRV Energy to Meet IAQ Needs



HRV Efficiency & Energy Use

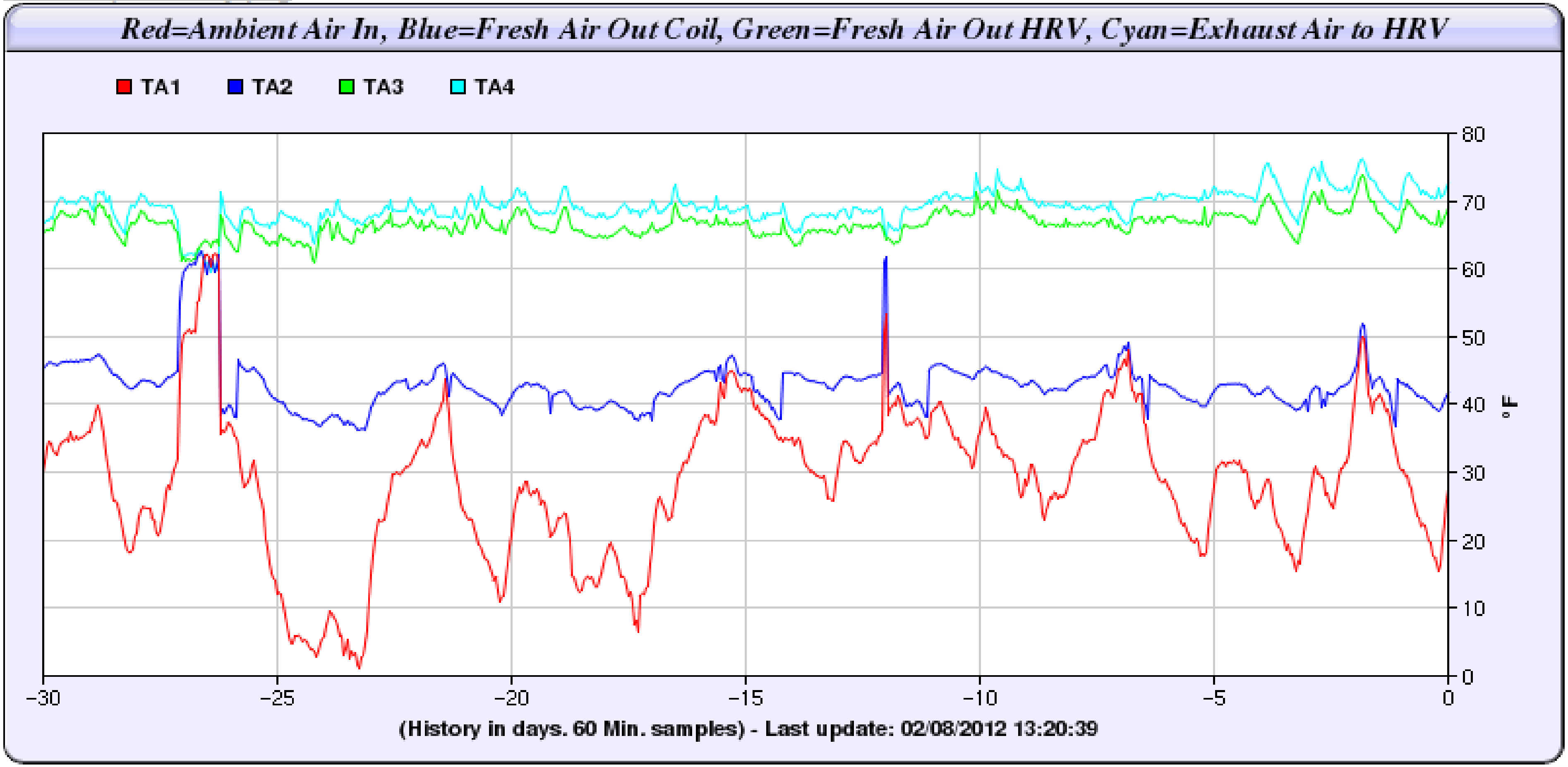
ENERGY PERFORMANCE

	SUPPLY TEMPERATURE °C	°F	NET AIR FLOW L/S	CFM	POWER CONSUMED WATTS	SENSIBLE RECOVERY EFFICIENCY	APPARENT SENSIBLE EFFECTIVENESS
HEATING	0	+32	31	65	20	88	93
	0	+32	47	99	32	87	93
	0	+32	61	129	50	85	91

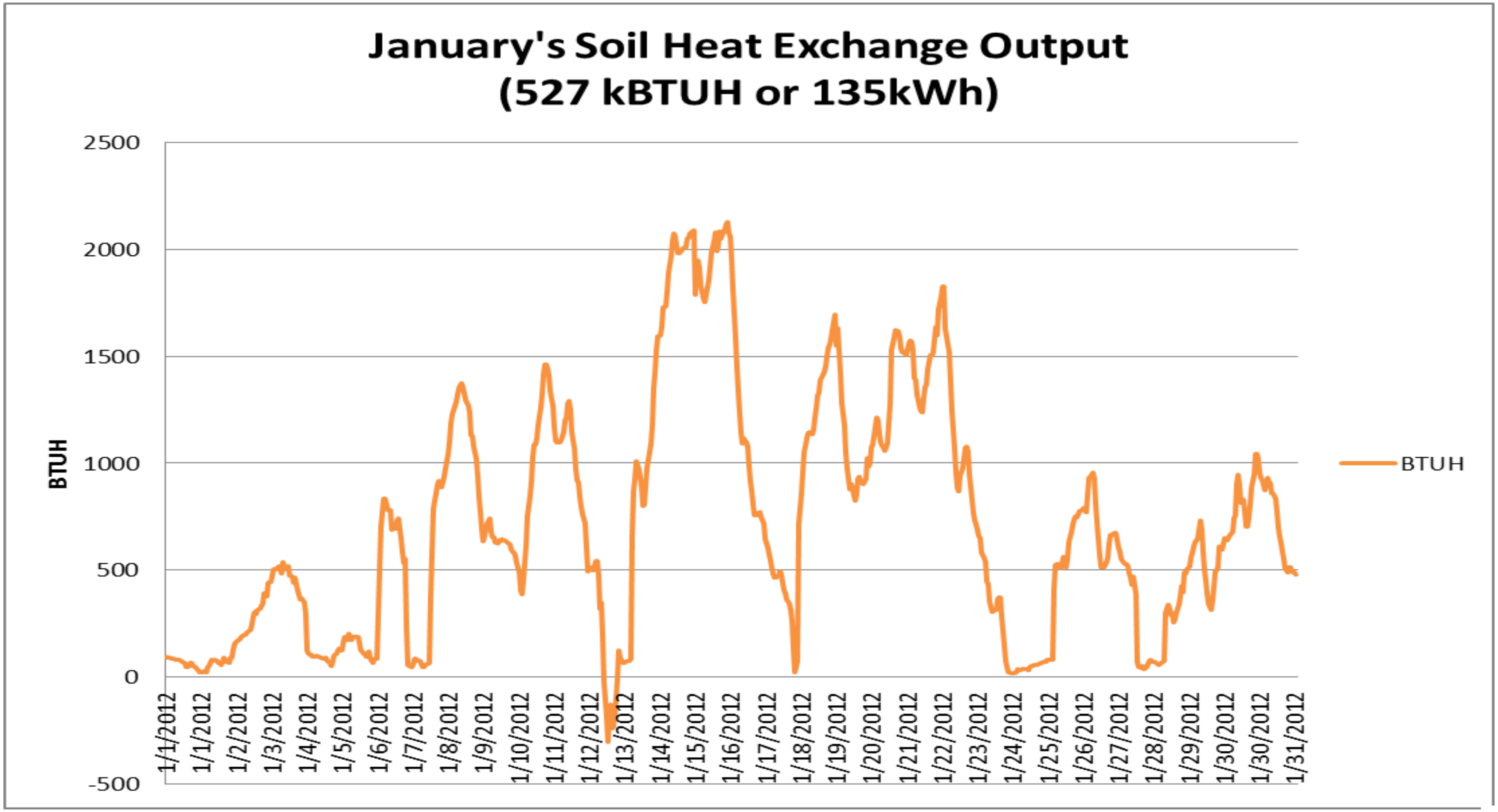


Soil Heat Exchange Output

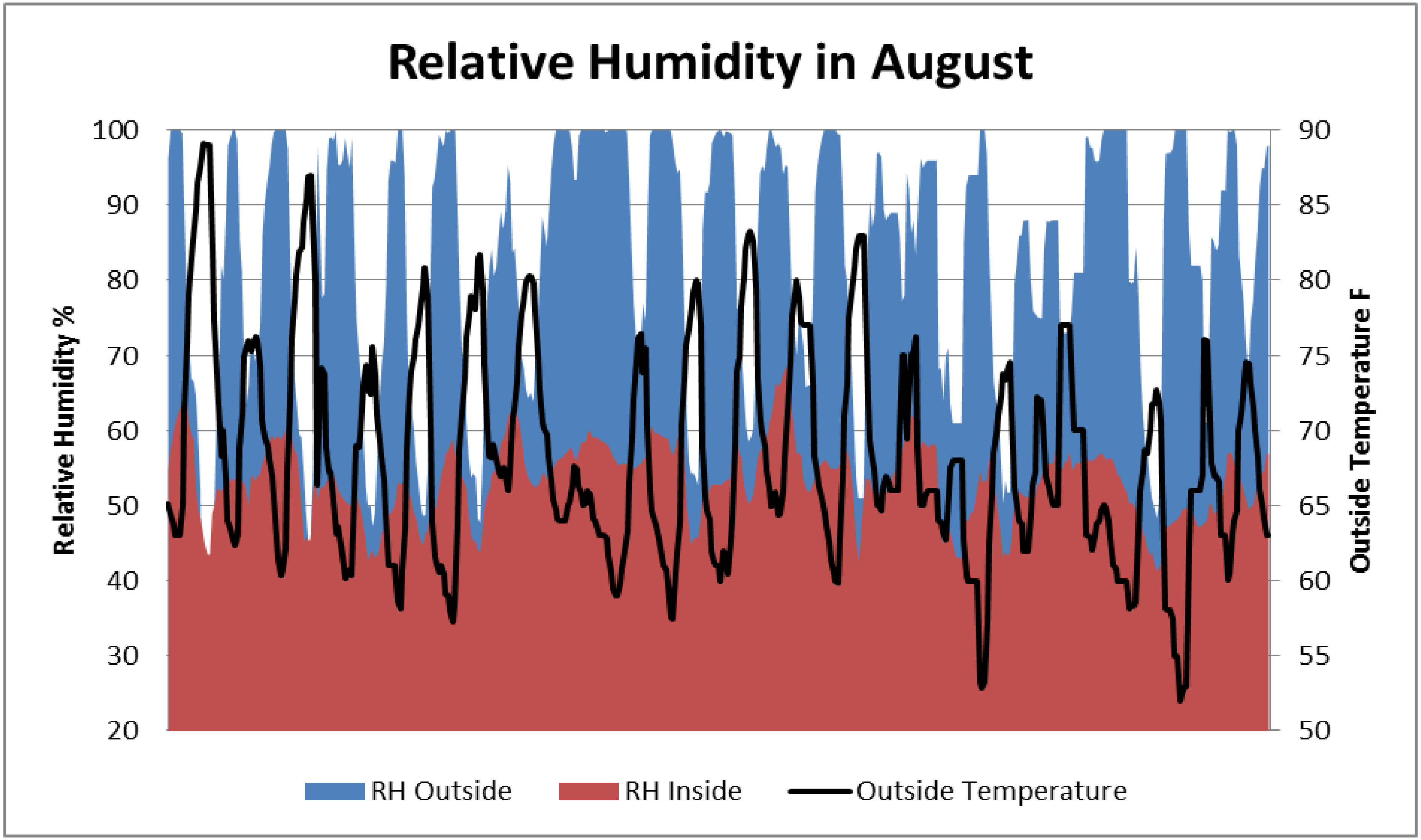
HRVTempsmonthly.png



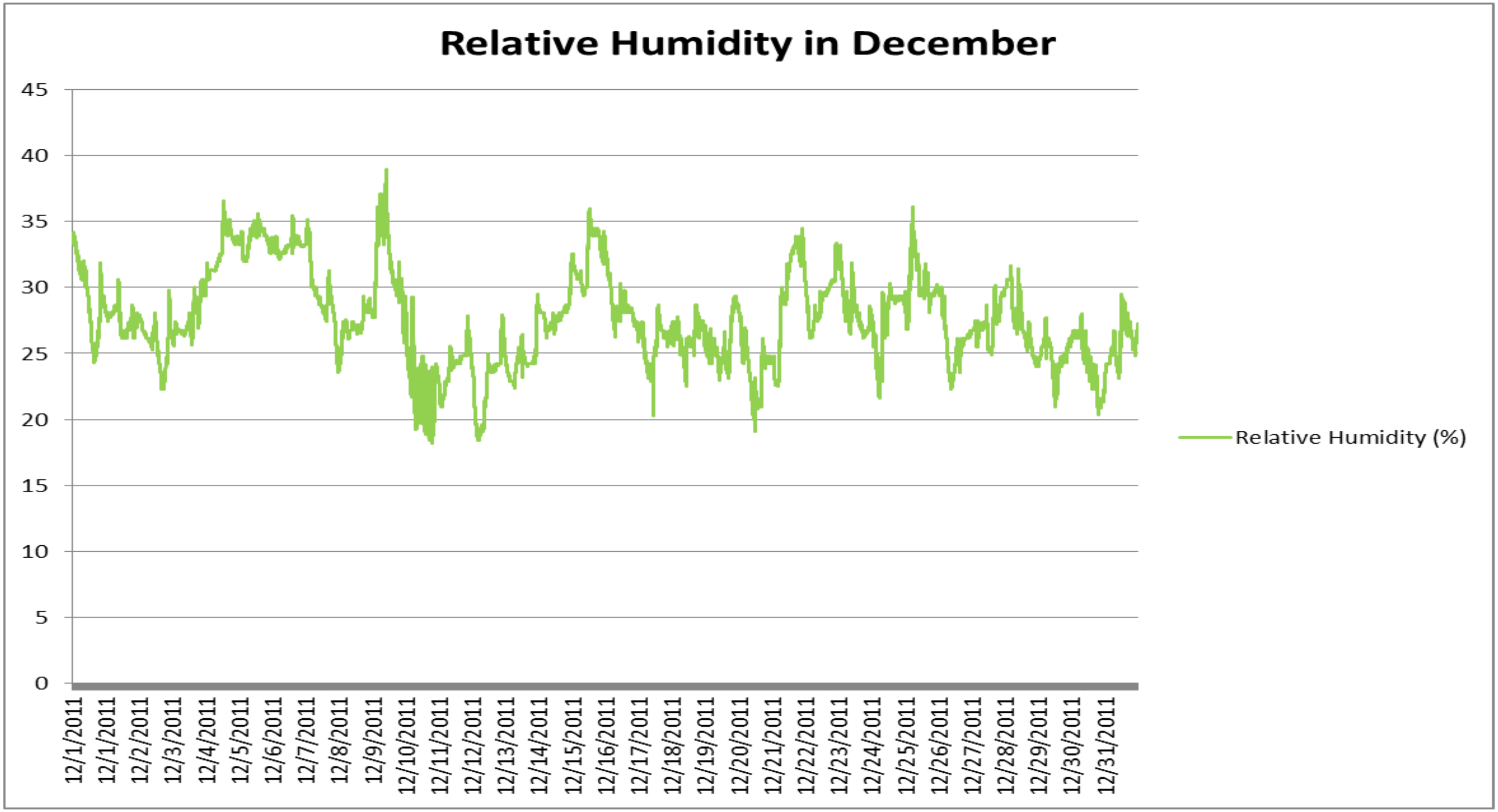
Soil Heat Exchange Output



RH and Comfort



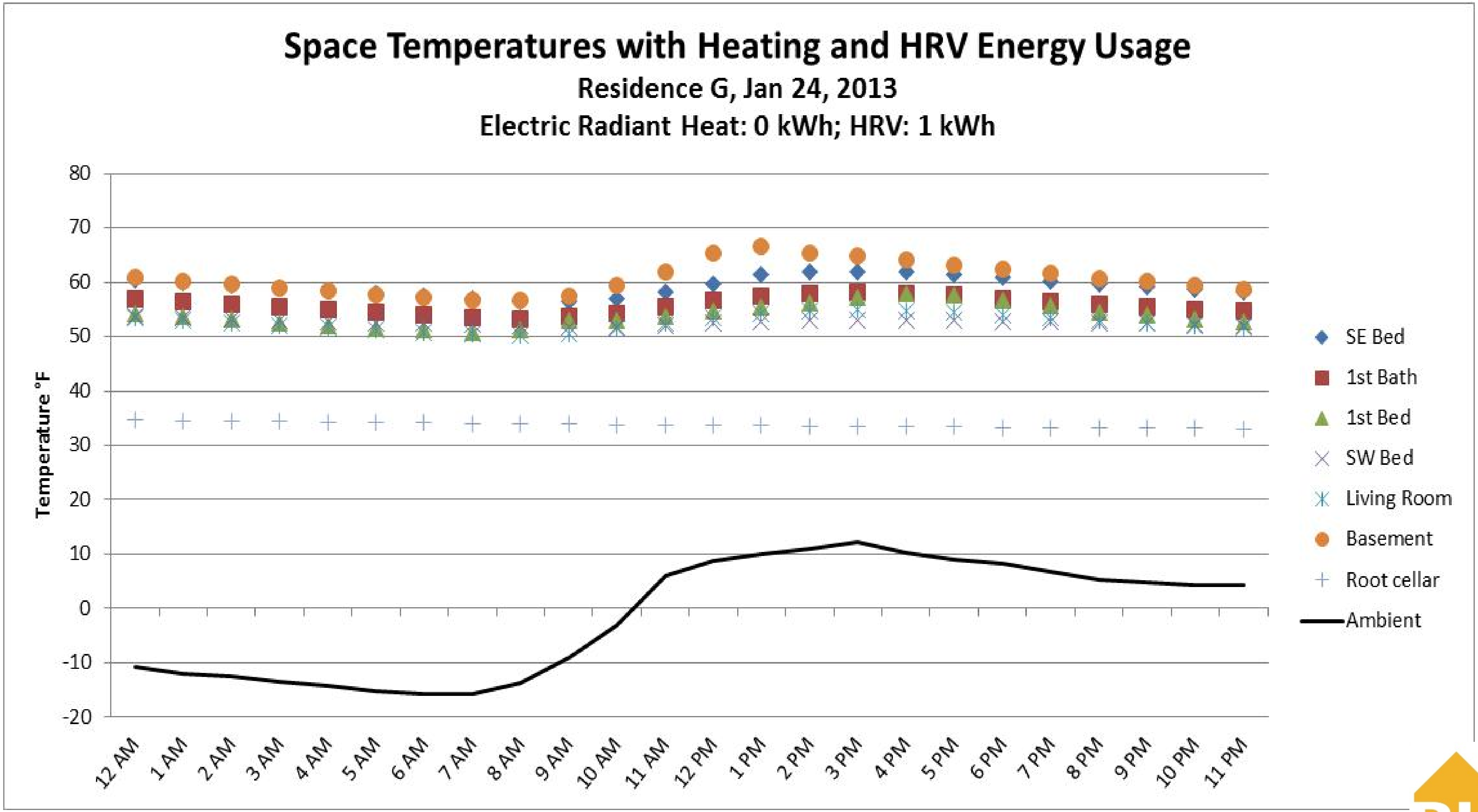
RH and Comfort



PH Norwich VT
2457 sqft of conditioned area

Independently monitored by Efficiency VT

PH Norwich VT
Coldest Day Jan.2013 - **No Heat ! – No Occupants**

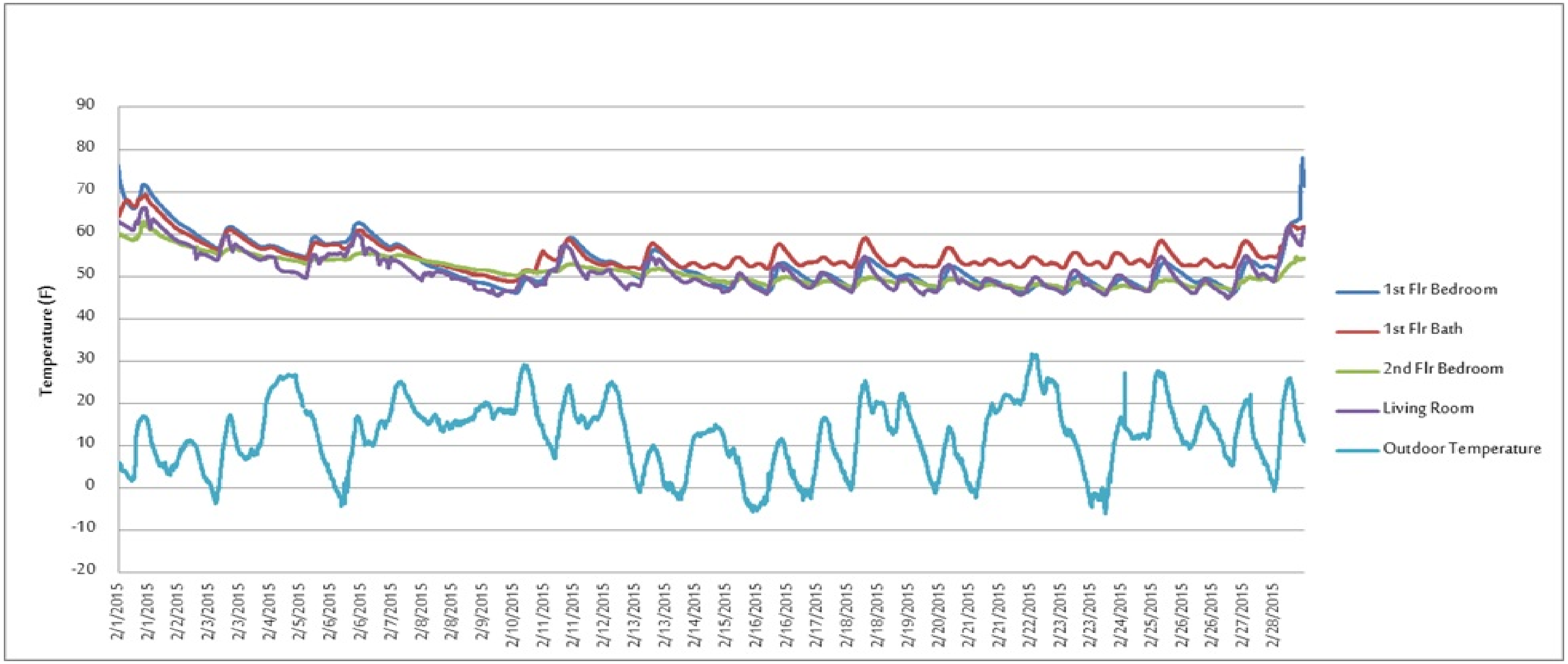


Independently monitored by Efficiency VT

PH Norwich VT
Coasting February 2015

With only 1 kWatt of floor matt heater

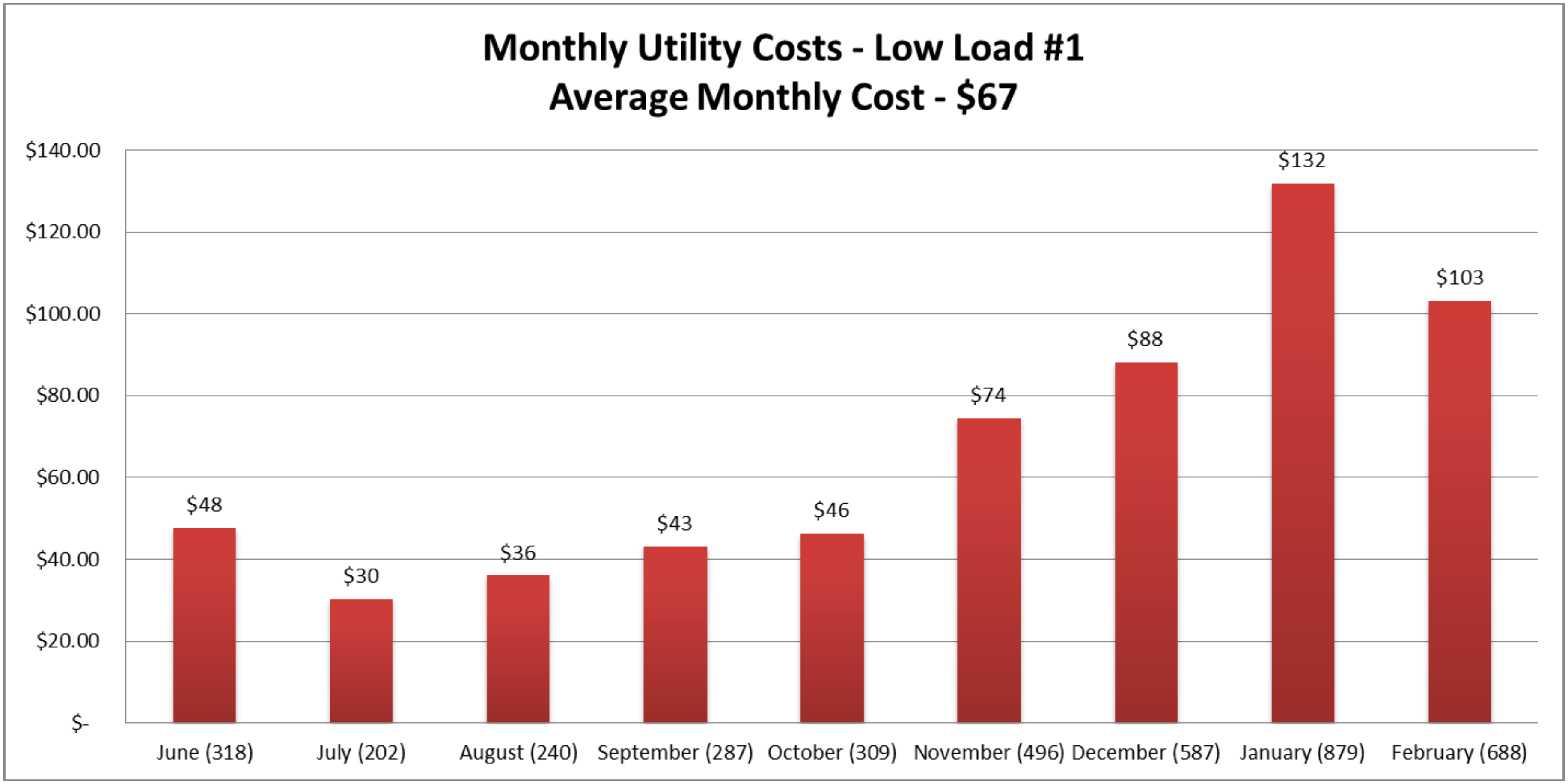
No occupants and minimal Solar Gain



Independently monitored by Efficiency VT

Habitat For Humanities House – Charlotte VT
1800 sqft of conditioned area

Habitat For Humanities House – Charlotte VT
1800 sqft of conditioned area

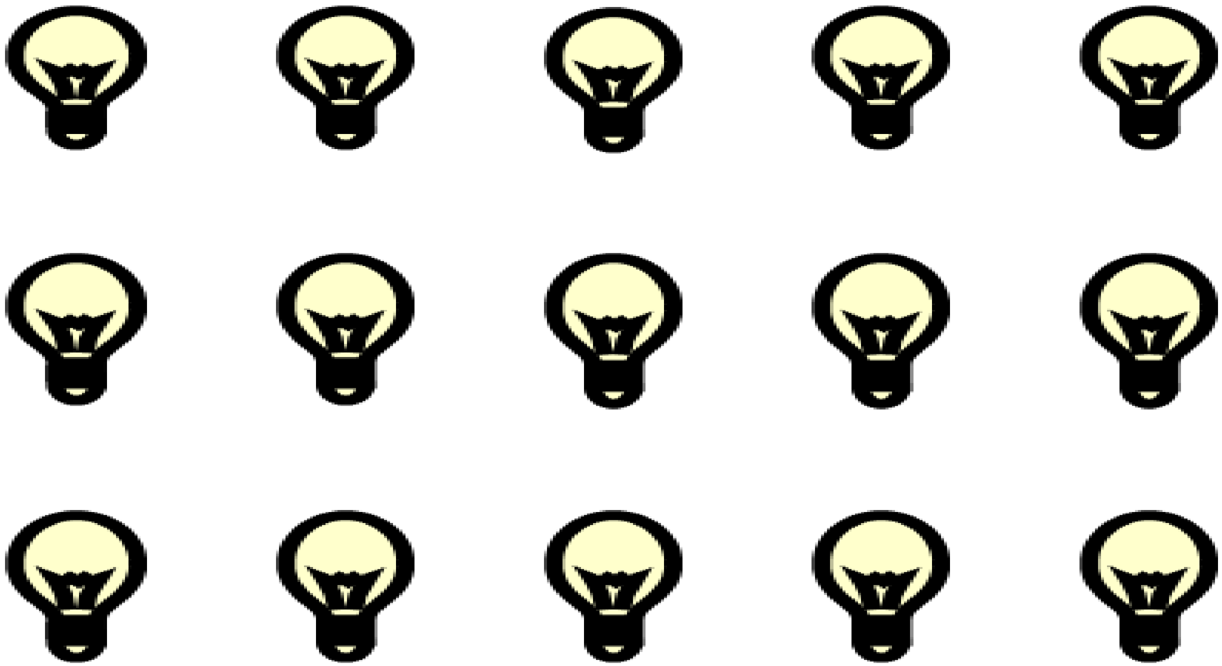


Independently monitored by Efficiency VT

Middlesex-VT Cottage
No active heating System

Middlesex-VT Cottage
No active heating System

Heating load on coldest days =
5,096BTU/hr = 1494 Watts
Heating system equivalent to
15, 100W light bulbs



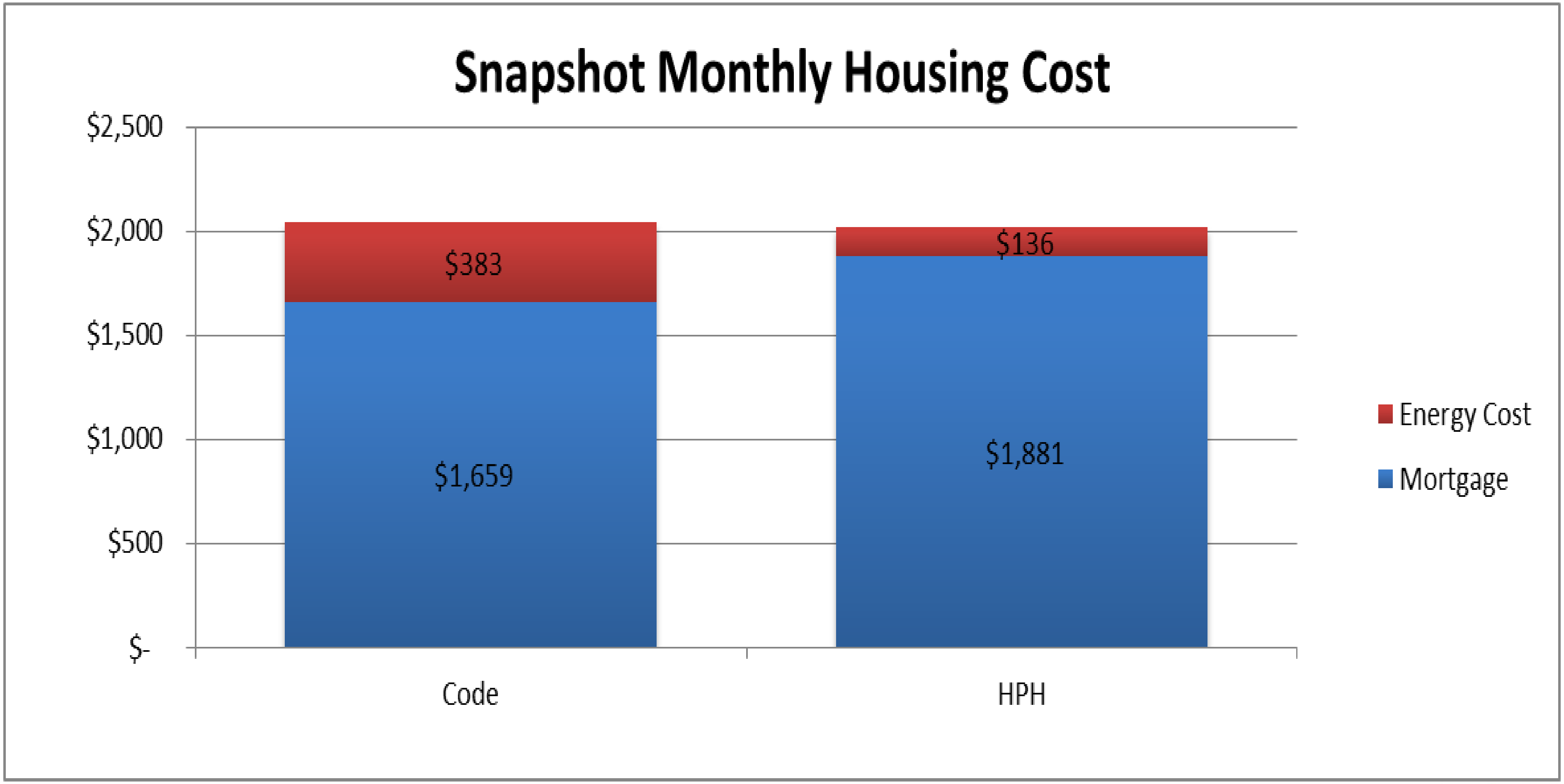
Other Passive Houses in VT

Stowe

Charlotte

Norwich

Cost Analysis for High Performance Home



Source: Efficiency VT

PH Projects Worldwide

PH Projects
Austria

Passive Apartments NHT Lodenareal, Innsbruck

Largest certified "Passive House" complex in the world, 2009

Herz & Lang
Architects & Engineers
House of the future!

- Pilot project in Tirol, 354 apt.
- Construction cost 54 Mil euro
- 250 Excursions since 2009

Neue Heimat Tirol has built over 1000 apt. with PH Consulting since 2007

"The Lodenareal is the key project for the future of housing in Europe"

Wolfgang Feist 2009

Monitoring 2009-2012: Best PH in Austria

Source: nht, din a4, team k2

NHT
NEUE HEIMAT TIROL
Gemeinnützige WohnungsGmbH

Low Income Housing Passive House Philadelphia

BELFIELD HOMES

Cornell Tech's Roosevelt Island NY City Campus Residential Building

The first high-rise residential building in the world built according to energy-efficient "Passive House" principles, with 350 units, it will reach 270 feet making it the tallest building on the campus

Milton-VT Senior Housing Project
25,000 ft^2 of interior conditioned area

First Multifamily filing for Passive House Certification

in the Nation in Climate Zone 6

To start construction in May 2016

Milton-VT Senior Housing Project
Peak Heat Load

VIEW FORM SOUTH WEST

VIEW FORM SOUTH EAST

VIEW FORM NORTH WEST

VIEW FORM NORTH EAST

The Passive House Senior Housing Complex has a heat load of only 126,750 BTU/hr at 2^{o}F for 25,000 sqft floor area

Milton-VT Senior Housing Project
Peak Heat Load at -19ºF

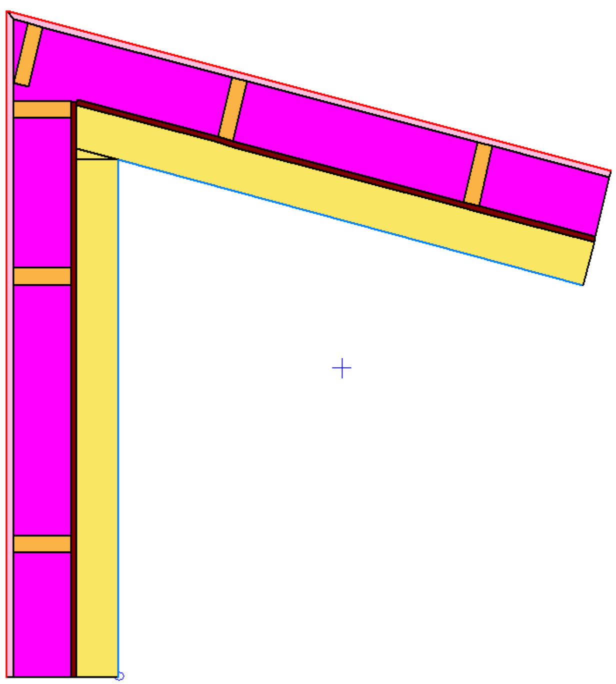
VIEW FROM MIDDLE RD.

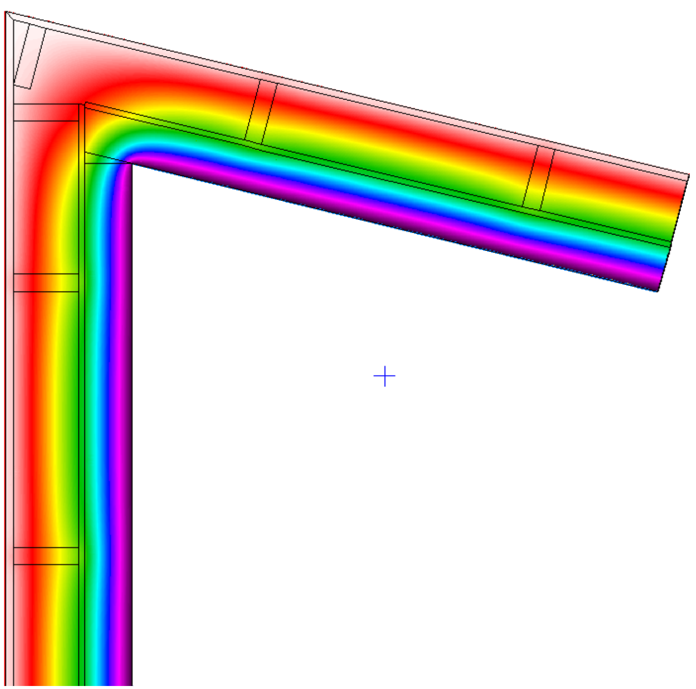
VIEW FROM BOMBARDIER ST.

The Passive House Senior Housing Complex has a peak heat load of **only 167,000 BTU/hr at -19ºF for 25,000 sqft floor area**

How do we do it ?

- Thermal Bridge Potential – Elm Place Wall to Wall Inside Corner Acute Angle

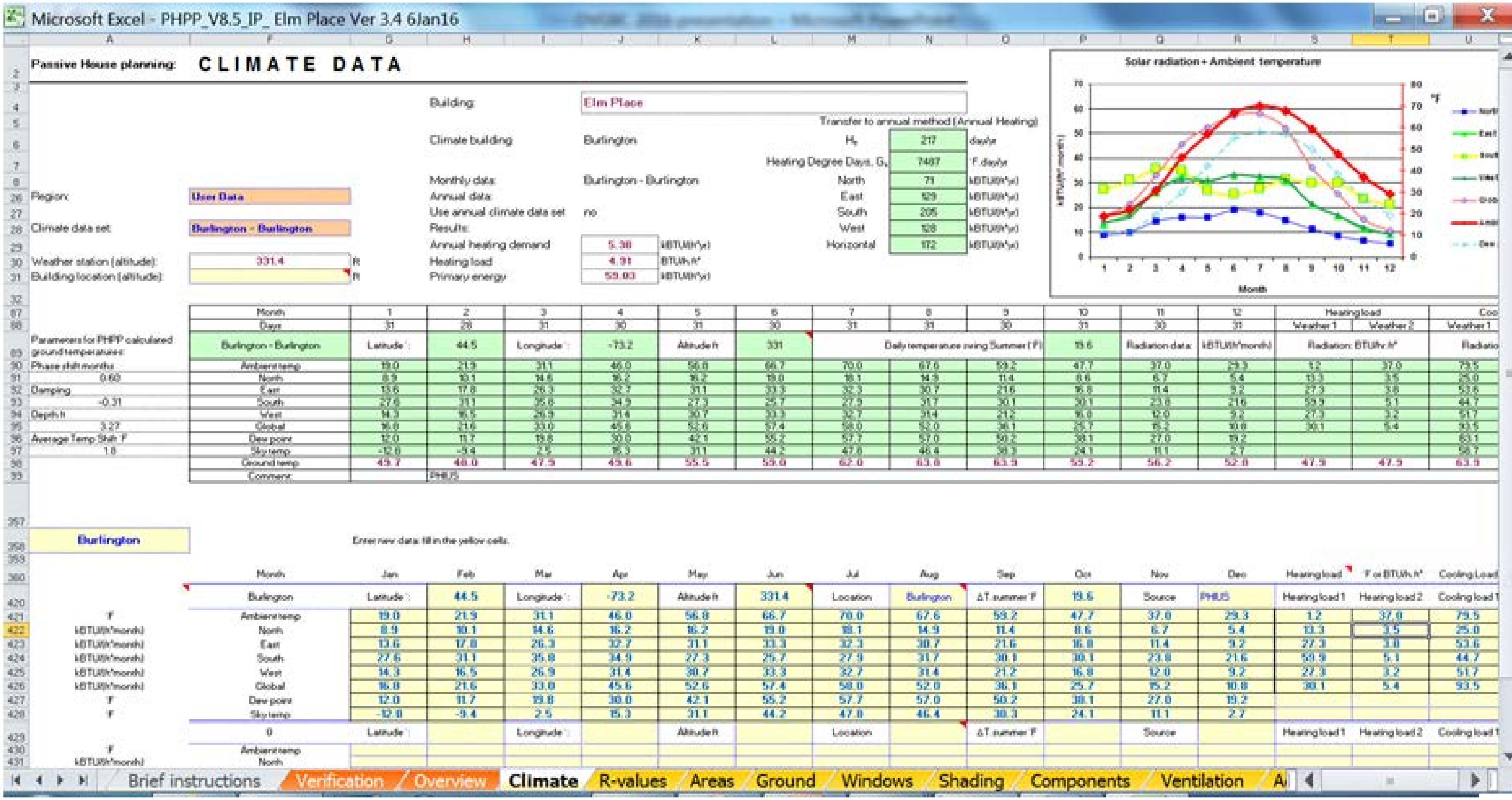




Internal Temperature	68.0
External Temperature	23.0
Lowest Surface Temp	66.0
f_{RSI} at 68 °F/ 23 °F	0.96

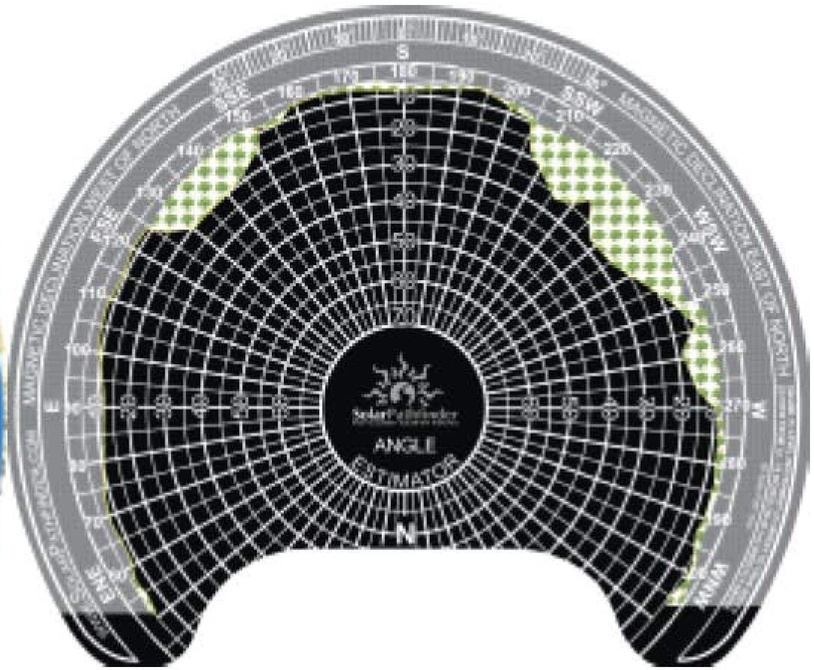
Ψ_e (for PHPP)	0.036 Btu/hr*f*F

Climate Data Input



Orientation- Windows Input and Shading Analysis

Notes: South Angle Estimator



Assemblies' R-Value Calculation

Passive House planning: R-VALUES OF BUILDING ELEMENTS

Assembly no.	Building assembly description	Interior insulation?
4	Roof 9.5" Truss with (avg) 6.5" Polyiso 85%	

Surface Film Resistance [hr.ft².F/BTU] interior Rsi : 0.57

exterior Rse : 0.23

	Area section 1	R per inch	Area section 2 (optional)	R per inch	Area section 3 (optional)	R per inch	Thickness [in]
1.	Sheetrock	0.91					0.63
2.	Fiberglass Low Density	3.30	2x4	1.28			1.50
3.	Fiberglass Low Density	3.30					5.00
4.	Fiberglass Low Density	3.30	2x4	1.28			1.50
5.	Fiberglass Low Density	3.30	2x4	1.28			1.50
6.	CDX	1.47					0.75
7.	Polyiso	5.90					6.50
8.							
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total
		85%		15.0%			17.38 in

U-value supplement BTU/hr.ft².°F

R-Value: 70.0 hr.ft².°F/BTU

Thermal Bridges' input
Each one positive or negative is accounted for

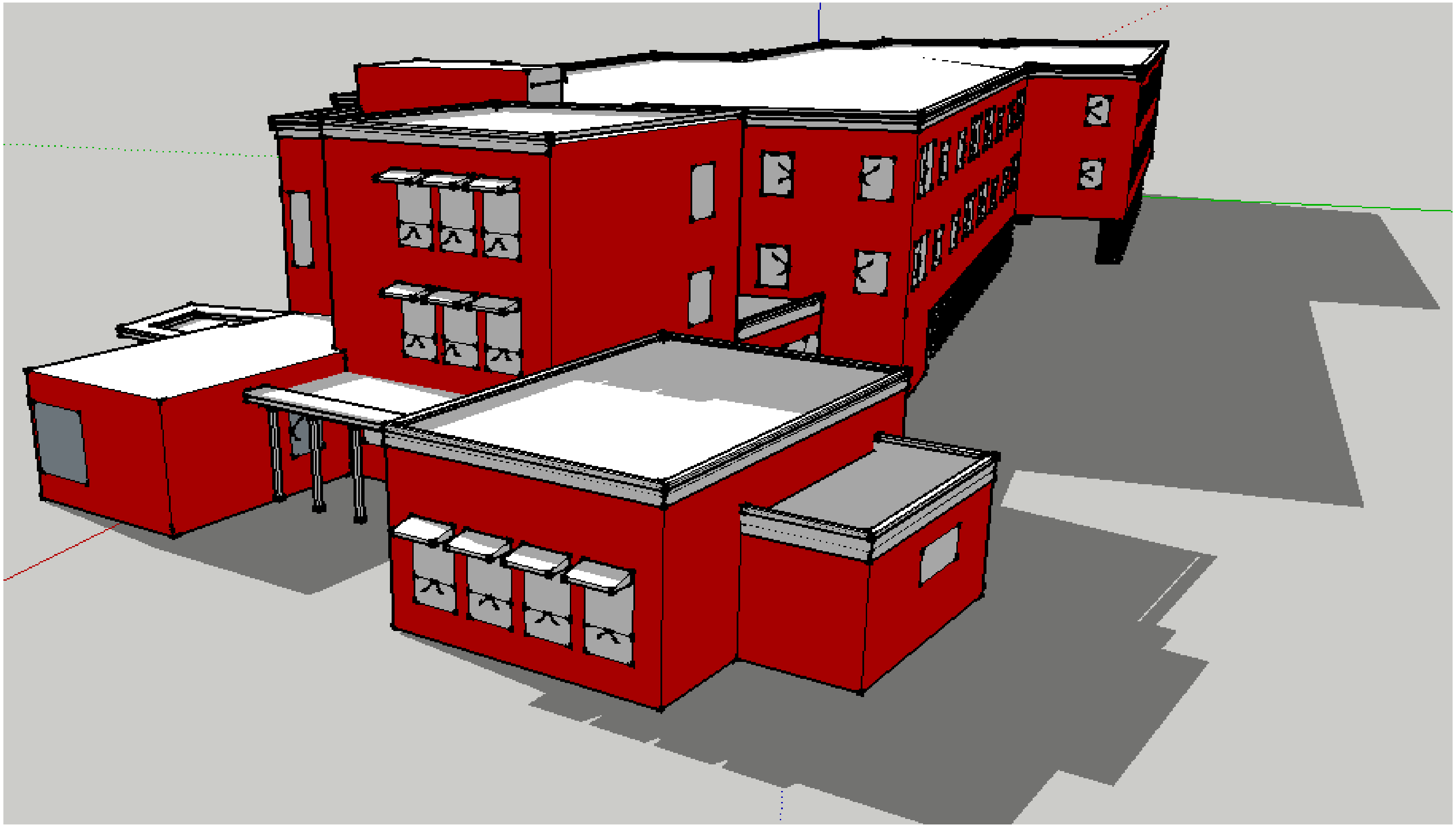
Thermal bridge description	length [ft]	Ψ BTU/hr.ft.F
Frame Wall to Garage Ceiling	385.00	-0.017
Slab To Wall	432.39	0.016
Wall to 9.5" Roof Outside Corner	293.00	-0.043
Wall to Roof 14" Out Corn	99.70	-0.032
Wall to Roof 9.5 Inside Corner	163.06	0.010
Wall to Roof 18" Inside Corner	10.70	0.014
Wall To Wall Compound Inside Corner	11.72	-0.007
Wall To Wall Acute Inside Corner	31.33	0.043
Wall To Wall Right Inside Corner	360.85	0.014
Wall To Wall Frame To Frame Outside Corner	566.22	-0.023
Wall To Wall Fire To Frame Outside Corner	41.09	-0.029
Garage Ceiling TB	24.00	0.760
Fire Wall to Garage Ceiling Inside Corner	73.00	0.016
Wall to 18"Roof Outside Corner	557.20	-0.029
Trash Chute	23.00	0.200
Storage Room Ceiling To Wall Inside Corner	18.21	0.091

Orientation, Windows Input and Shading Analysis

Window frames																	
	U_f-Value				Frame width				Glazing edge thermal bridge				Installation thermal bridge				Curtain wall facades:
Description	left	right	bottom	above	left	right	bottom	above	$\Psi_{Glazing\ edge}$ left	$\Psi_{Glazing\ edge}$ right	$\Psi_{Glazing\ edge}$ bottom	$\Psi_{Glazing\ edge}$ top	$\Psi_{Installation}$ left	$\Psi_{Installation}$ right	$\Psi_{Installation}$ bottom	$\Psi_{Installation}$ top	χ_{GC} -value Glass carrier
	BTU/hr.ft²°F	BTU/hr.ft²°F	BTU/hr.ft²°F	BTU/hr.ft²°F	in	in	in	in	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.ft°F	BTU/hr.°F
Schuco T&T	0.137	0.137	0.137	0.137	4.69	4.69	4.69	4.69	0.017	0.017	0.017	0.017	0.020	0.020	0.020	0.020	
Schuco Fixed	0.137	0.137	0.137	0.137	3.15	3.15	3.15	3.15	0.017	0.017	0.017	0.017	0.020	0.020	0.020	0.020	
Schuco Door	0.137	0.137	0.137	0.137	5.79	5.79	5.79	5.79	0.017	0.017	0.017	0.017	0.020	0.020	0.040	0.020	
Metal Door	0.294	0.294	0.294	0.294	5.79	5.79	5.79	5.79	0.030	0.030	0.030	0.030	0.020	0.020	0.040	0.020	
Metal Door w	0.294	0.294	0.294	0.294	32.00	32.00	43.00	8.00	0.030	0.030	0.030	0.030	0.020	0.020	0.040	0.020	

- All windows and doors thermal data is cataloged
- Every single window, location and shading input is registered

Orientation- Windows Input and Shading Analysis



ENERGY BALANCE OPTIMIZATION

Once all losses are accounted for…then

-**We can start to compile the heat gains**

- **South Windows SHGC 60**
- **West Windows SHGC 37 to control Summer**
- **DHW lines optimization**

-**And assess the Primary Energy load which is affected by:**

- **Plug-ins & Lighting**

For each kW of site energy the generation plant must produce 3.2 kW

Mechanicals for supplemental heating/cooling & ventilation

Heating / Cooling

- Mini Split Heat Pump
- Electrical Baseboard or Floor Matt heaters

Ventilation

- HRV - Mechanical Heat Recovery Ventilation System
- ERV - Energy Recovery Ventilation System

Mechanicals

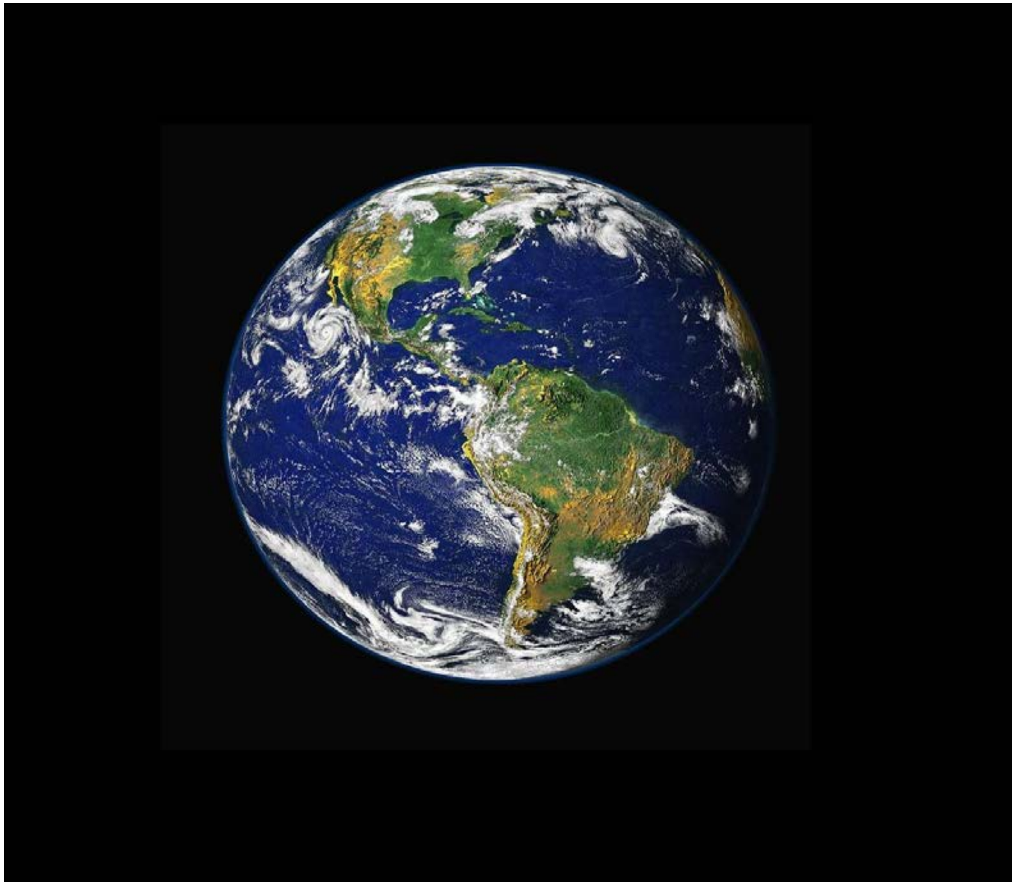
Ductless Mini-Split Heat Pump
Outdoor unit -- Indoor unit

ZEHNDER COMFOAIR 350 VENTILATION UNIT

THE TAKE-AWAY

If we want to make renewable energy sustainable we must start by eliminating the energy waste to the last kWatt possible

THE TAKE-AWAY



This is the only planet we have
This is the only home we have
We must preserve it with love

Thank you

CPHC®

Enrique Bueno

E+ Buildings

Chris Miksic

Montpelier Construction

CERTIFIED BUILDER