NECCO INC
NEW ENGLAND CONSTRUCTION CO.

Buildings

PH CERTIFIED BUILDER

Energy Efficient Buildings

PH CPHC®

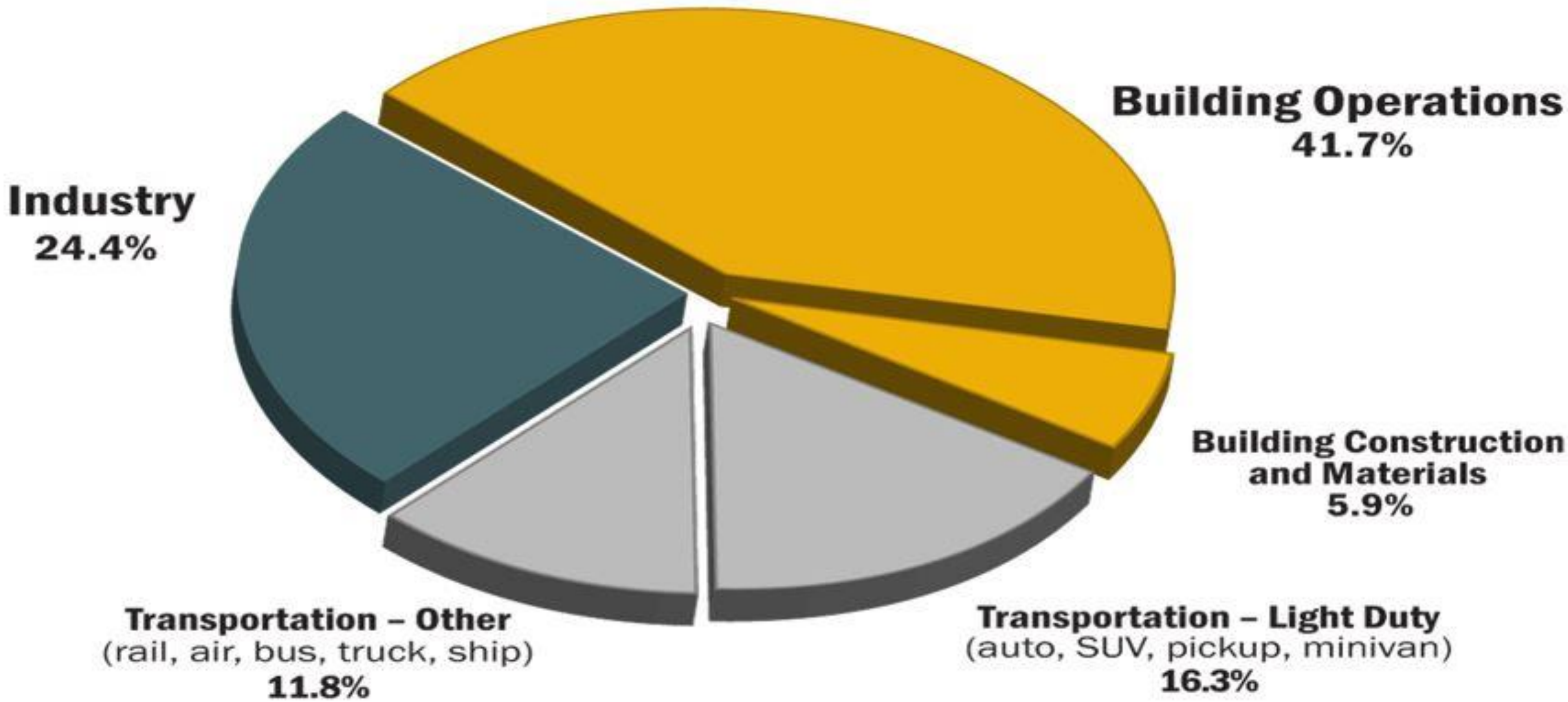
Passive House Retrofit of a VT House

BBbD-2018 Conference

Burlington VT
Feb. 7th, 2018

www.eplusbuildings.com

The Problem



U.S. Energy Consumption by Sector

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

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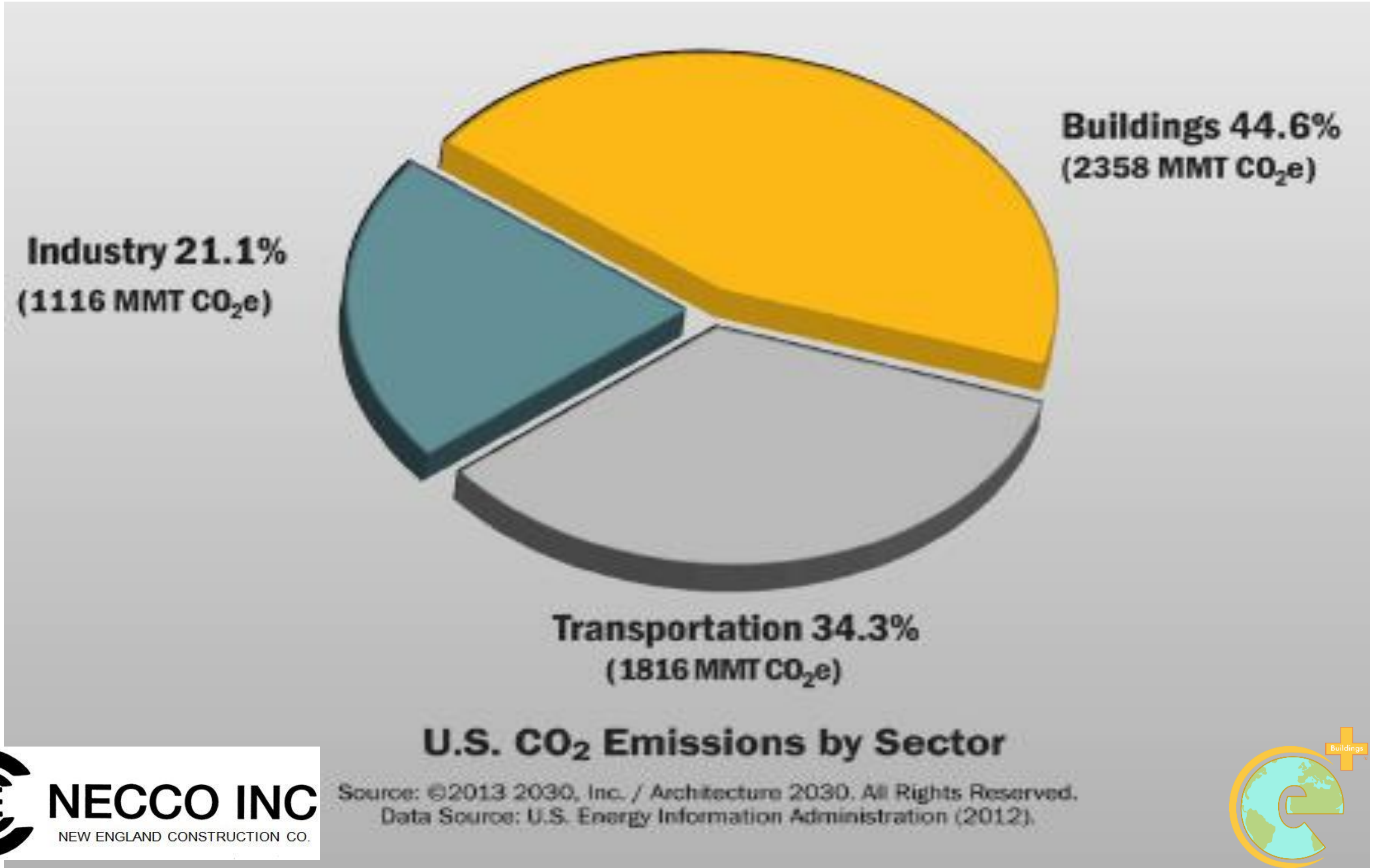
The Problem



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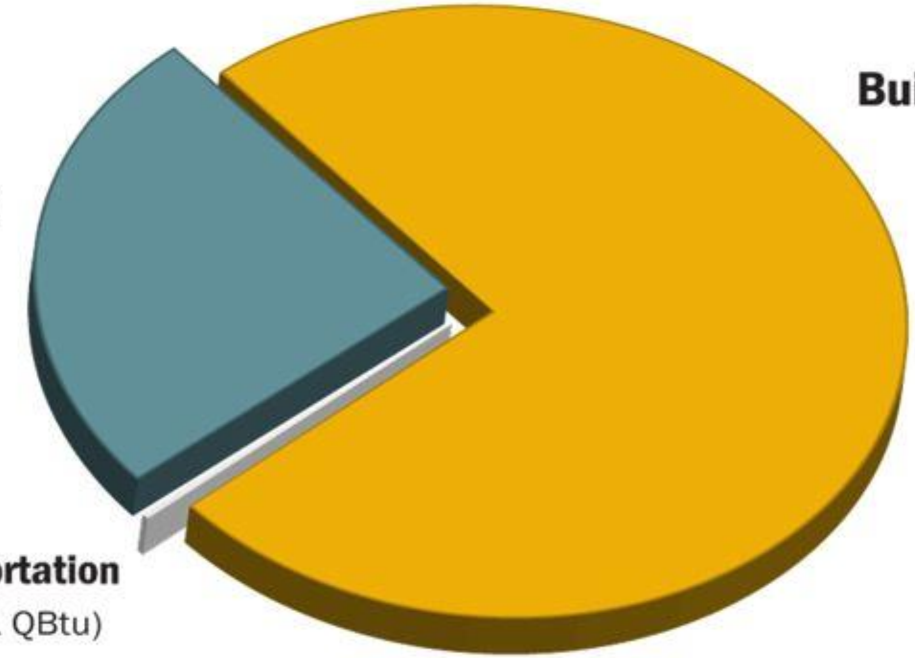
The Problem - **67% from Fossil Fuels***



U.S. Electricity Consumption by Sector

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

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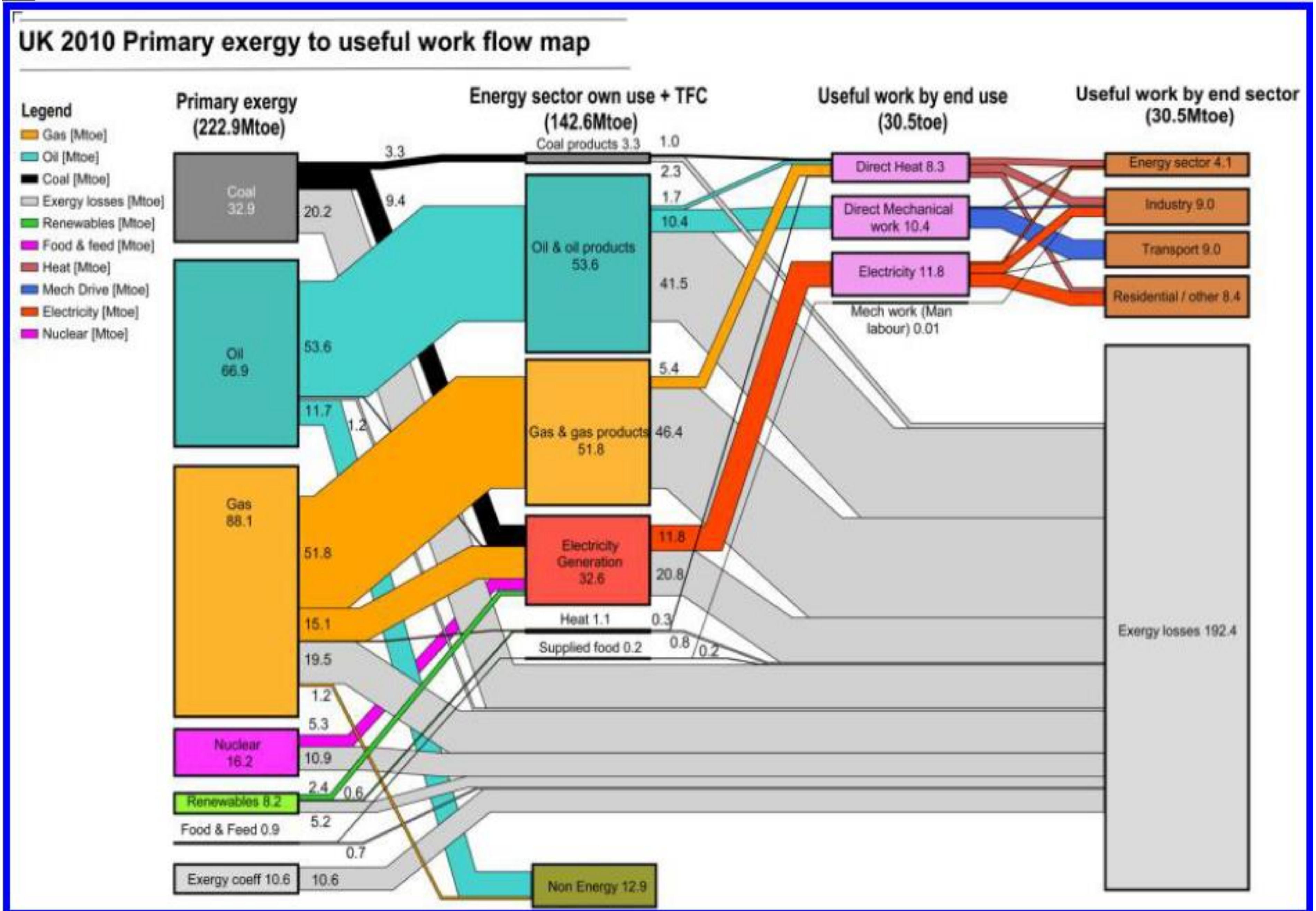
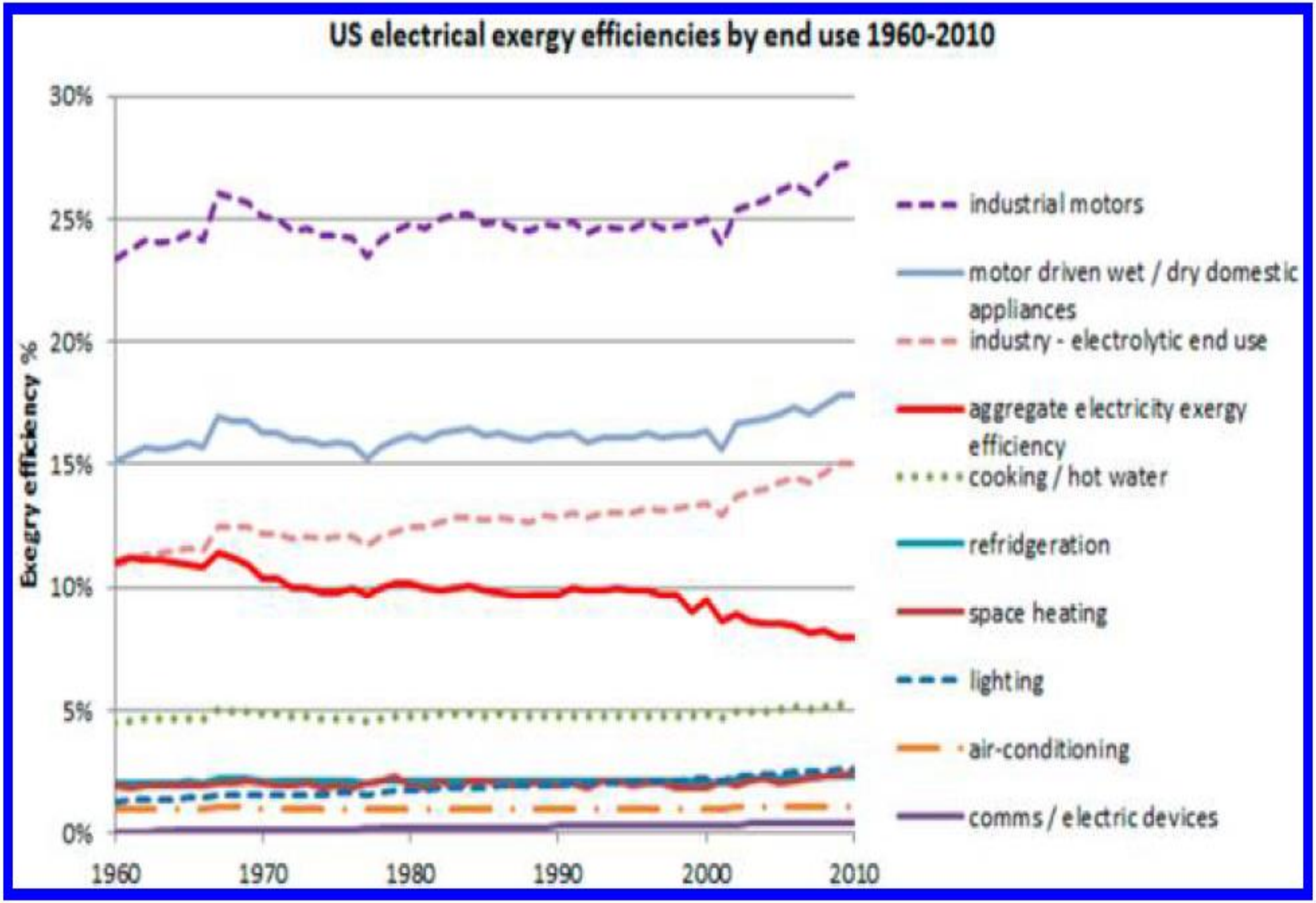
*US-EIA 2014



Source: http://pubs.acs.org/journal/esthag
University of Leeds, Leeds LS2 9JT, United Kingdom
Mtoe = million ton of oil equivalent / 1 toe = 11630 kWh

Useful work = 13% of Primary Exergy



Source: http://pubs.acs.org/journal/esthag
University of Leeds, Leeds LS2 9JT, United Kingdom

The Solution for Buildings

Passive House Buildings

PH Concept Explained in 90 Seconds

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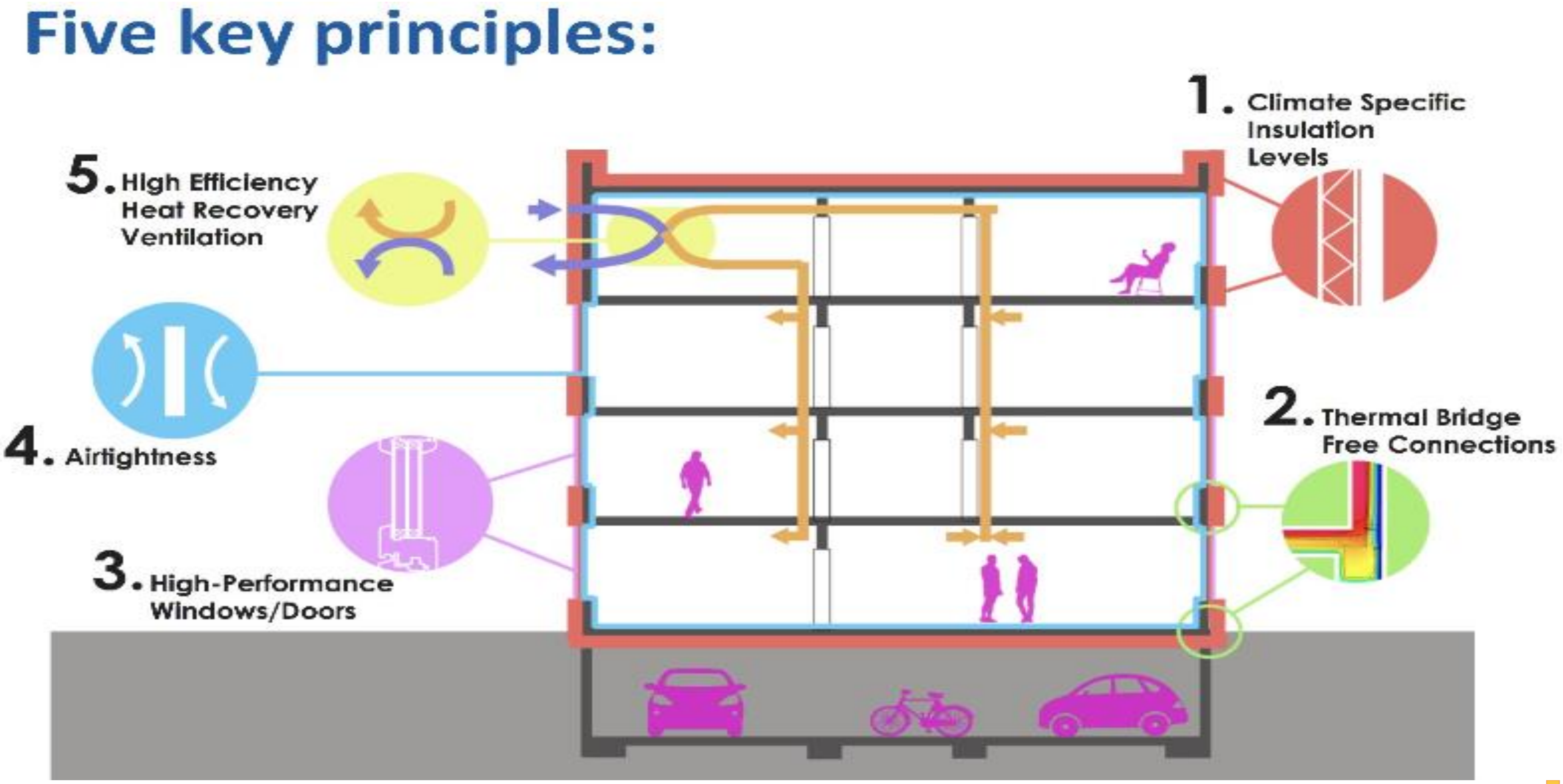
PASSIVE BUILDING PRINCIPLES



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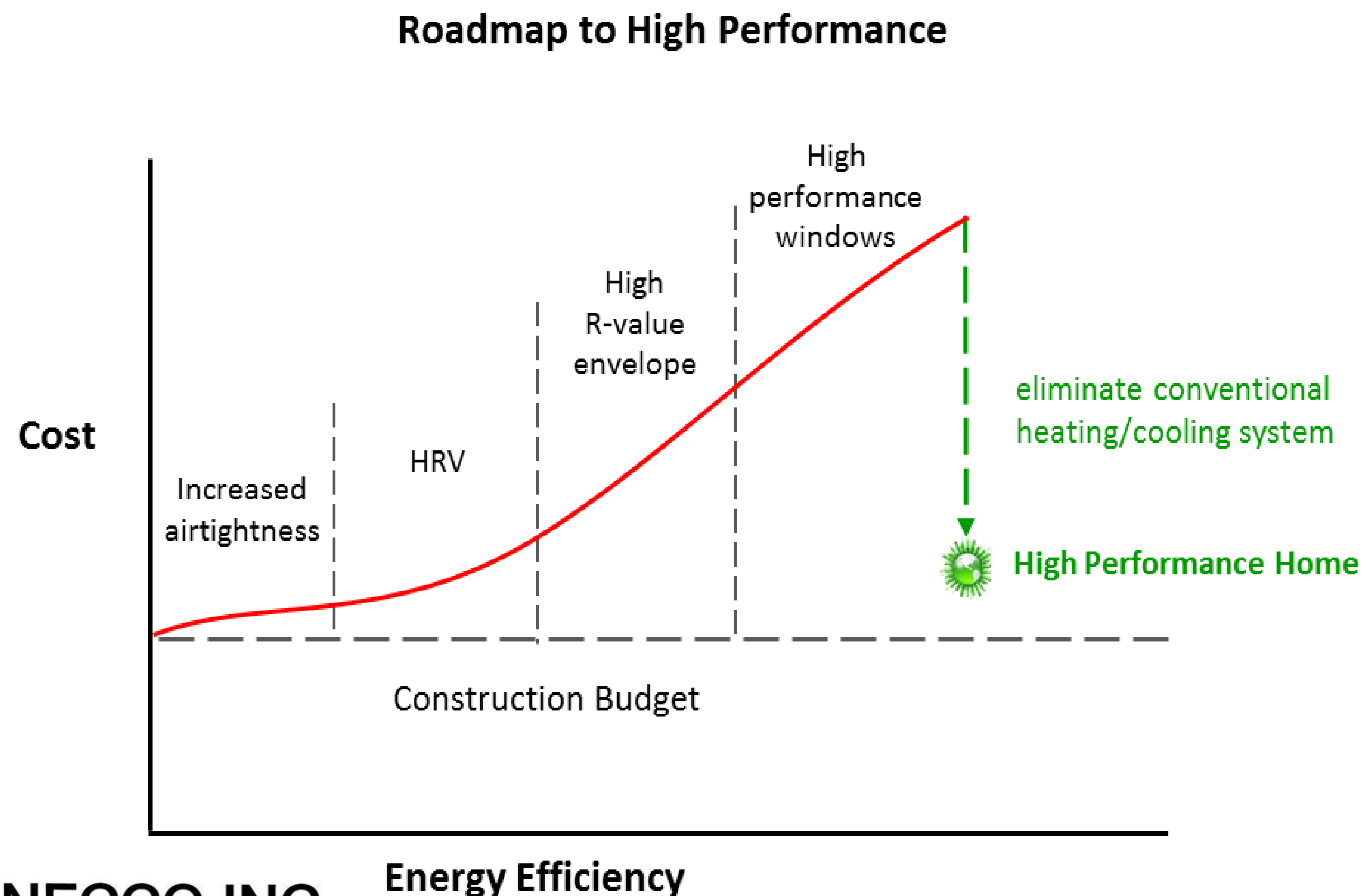
Rational Behind Passive House Approach



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EU Passive House Energy Standard Clearly Defined

Heating Demand (Site):	4.75 kBTU/Ft2-YR
Cooling Demand (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)

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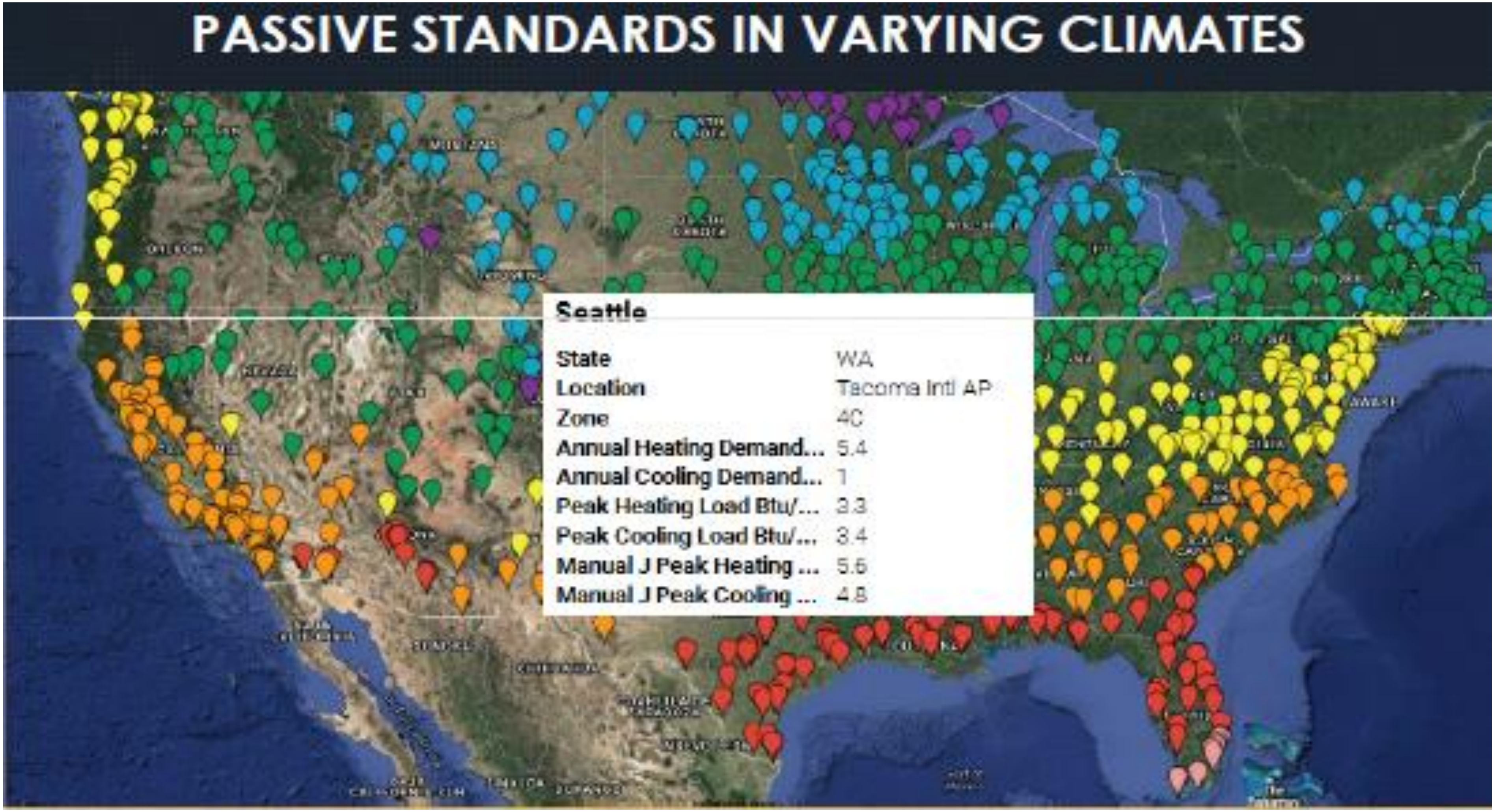
PHIUS Climate Specific Criteria



USA PHIUS+ 2015 Building Criteria

Heating Demand (Site):	1 - 12 kBTU/Ft2-YR
Cooling Demand (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 / 6200 kWh/PERSON-YR (Temporary) Beds+1 / 4200 kWh/PERSON-YR (Future)
Air Tightness:	0.05 cfm/gross sqft shell @ 50 pa 0.08 cfm/gross sqft shell @ 75 pa

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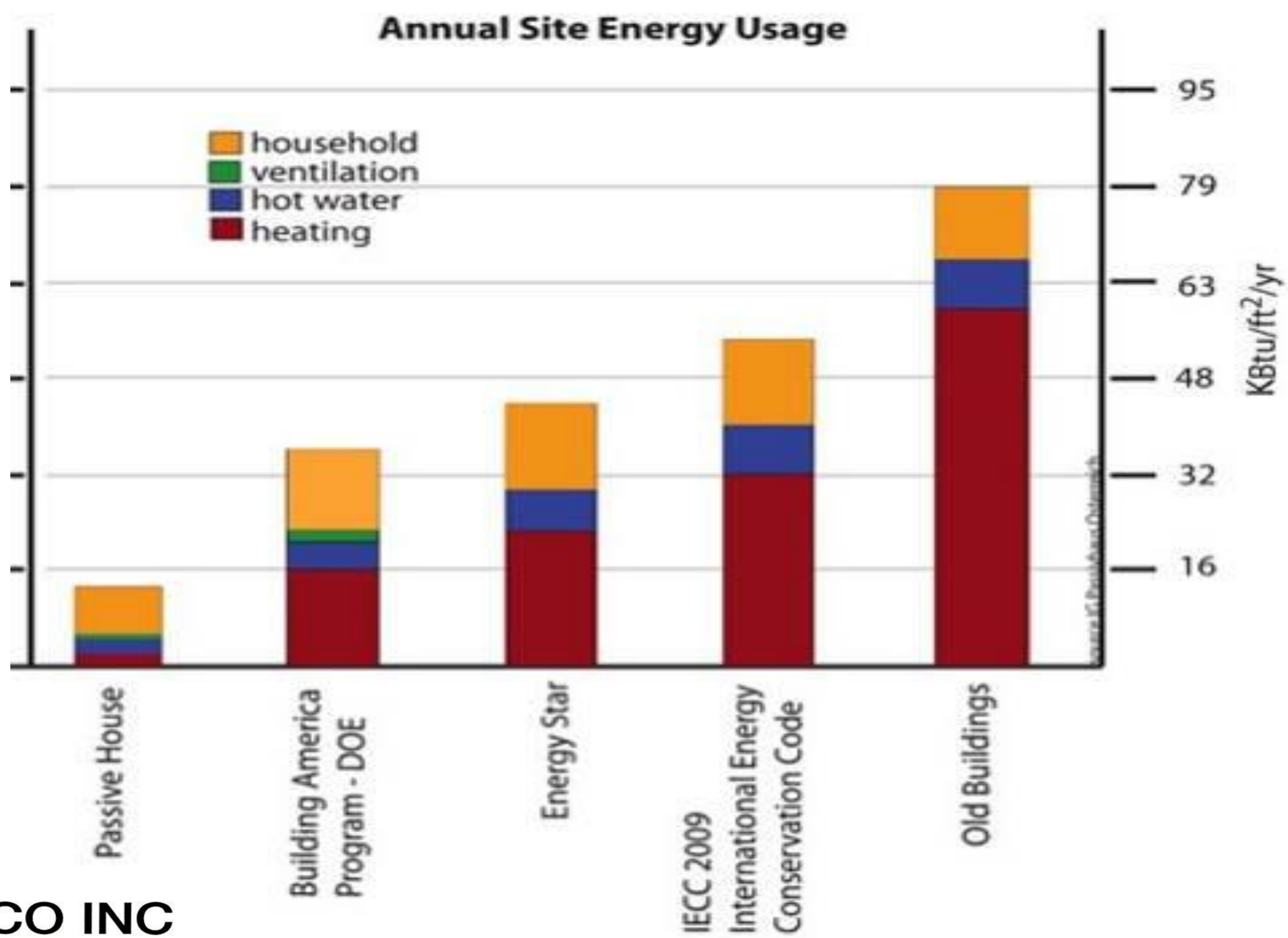
The Solution – Reduce **Energy Waste**

Comparison of Energy Standards



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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**

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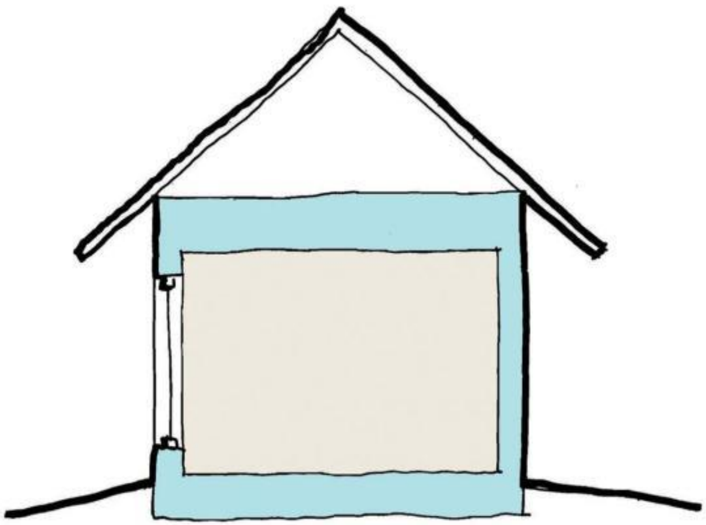
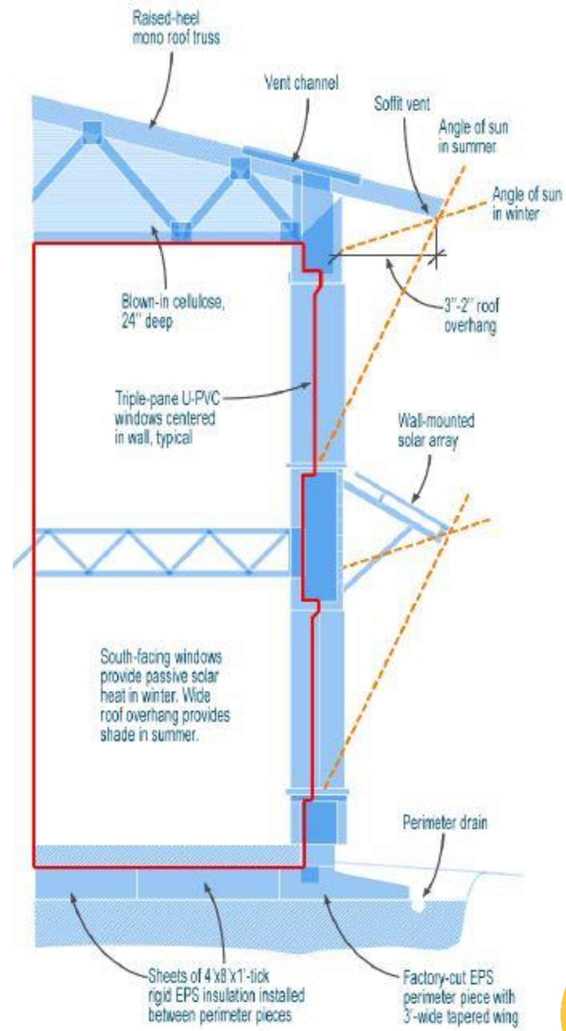
Climate Specific Level of Thermal INSULATION to control heat loss





For Climate Zone 6

R60 WALLS: R90 CEILING: R60 SLAB

High Performance WINDOWS U value < 0.13 (R-7)

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Insulated Slab on Grade

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Insulated Slab on Grade

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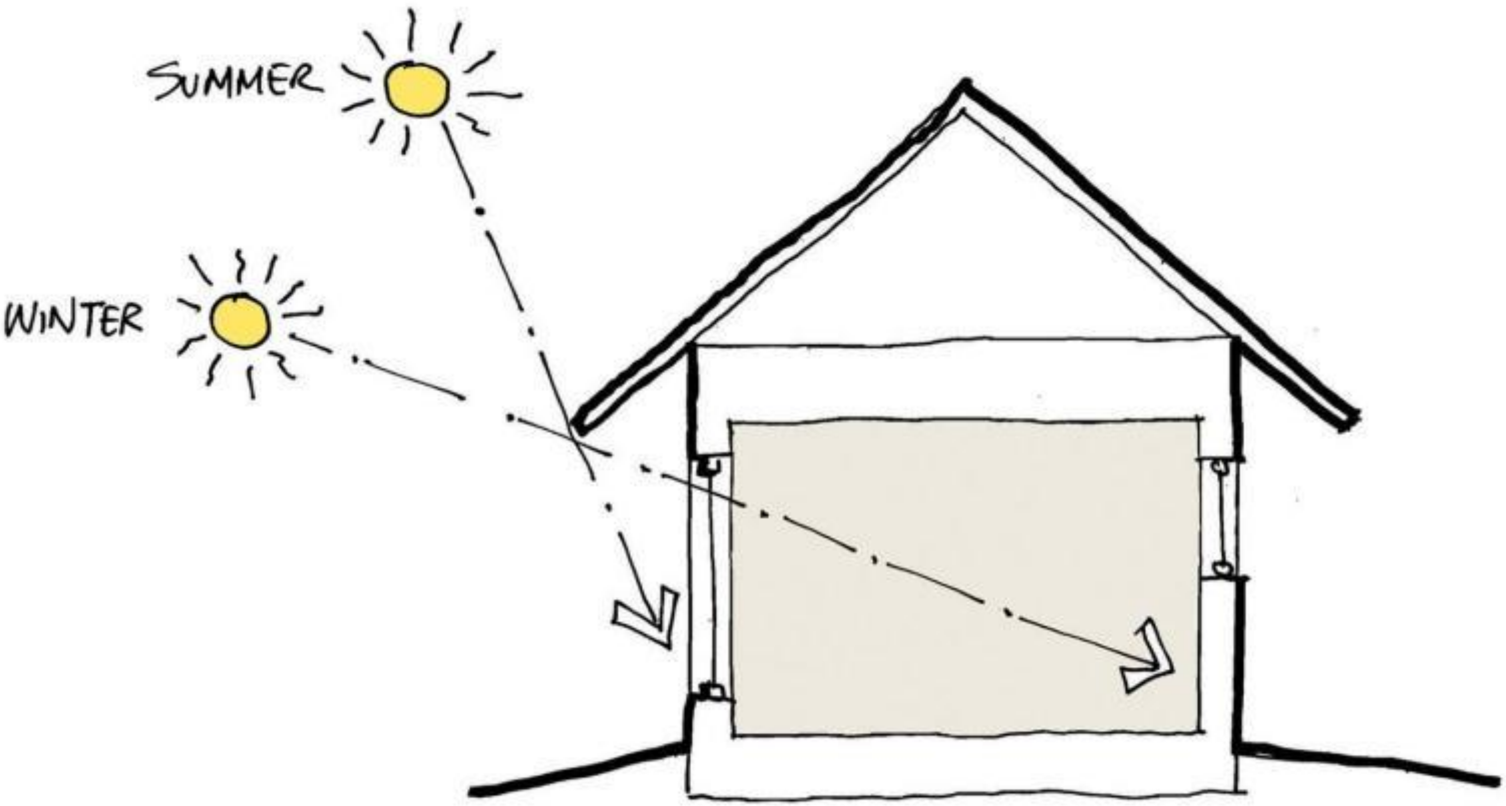
Passive House Concept: Controlling Gains Seasonally - Windows and Orientation



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

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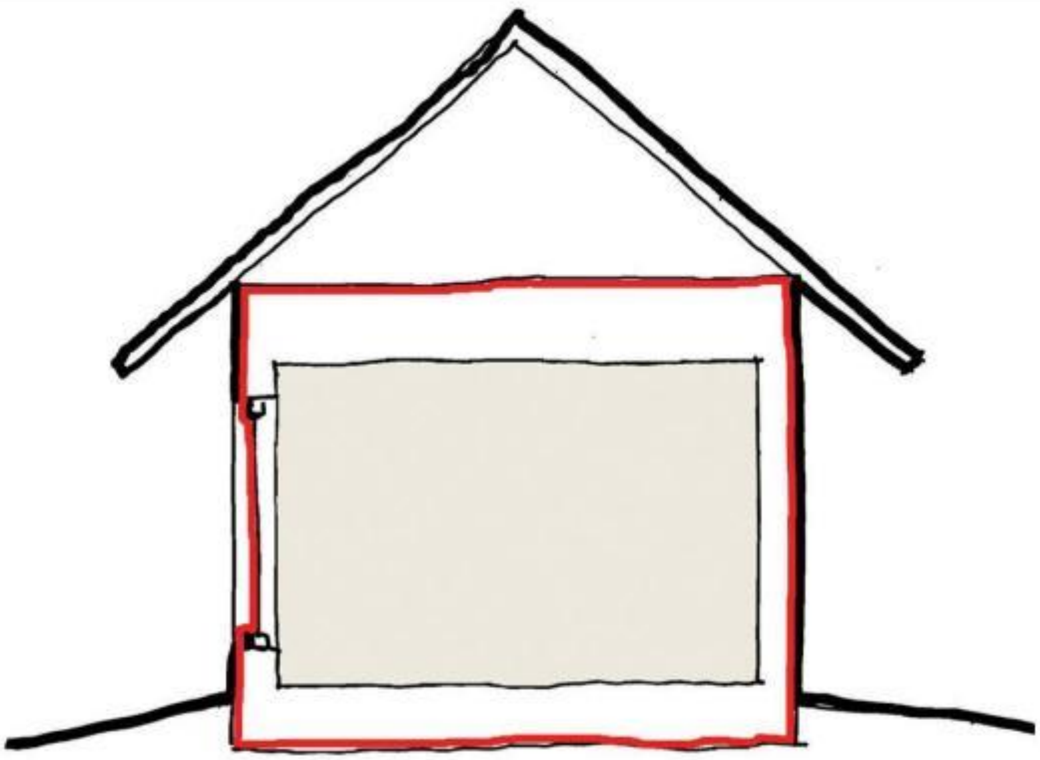
Passive house Concept: Controlling Heat Loss - Eliminate Air In/Ex-filtration

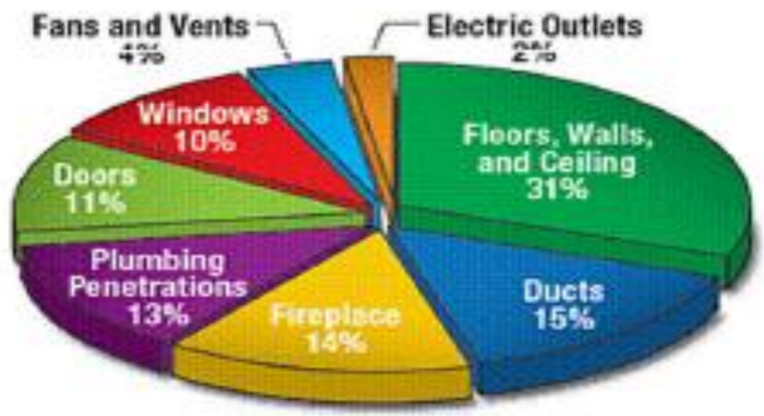


Max. 0.6 ACH @ 50 PA (based on interior floor area)
Max. 0.05 cfm/gross sqft shell @ 50 pa

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.O.C.

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AIR BARRIER | VCL | WRB MATERIAL

ASSURING DURABILITY OF ASSEMBLY

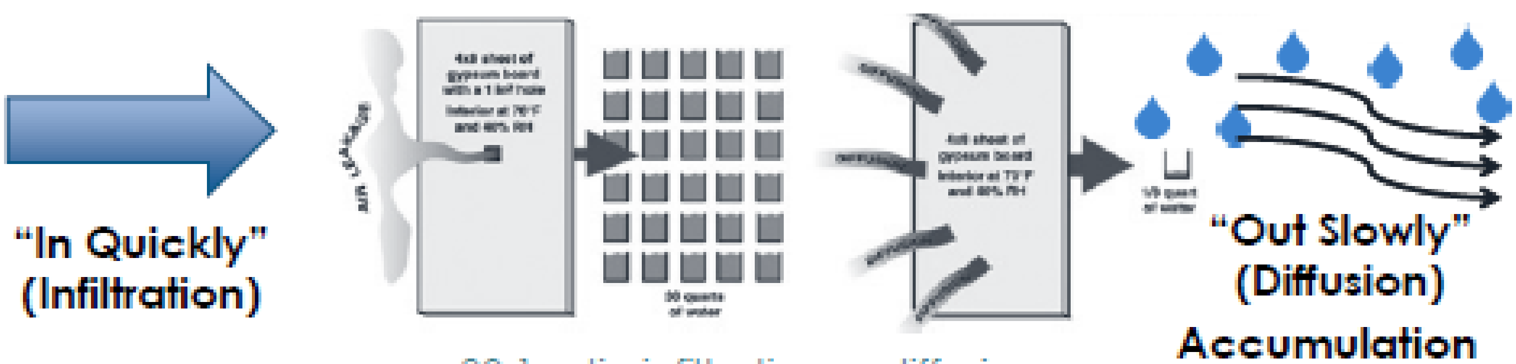
MOISTURE TRANSFER

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

Infiltration: 1 in² 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

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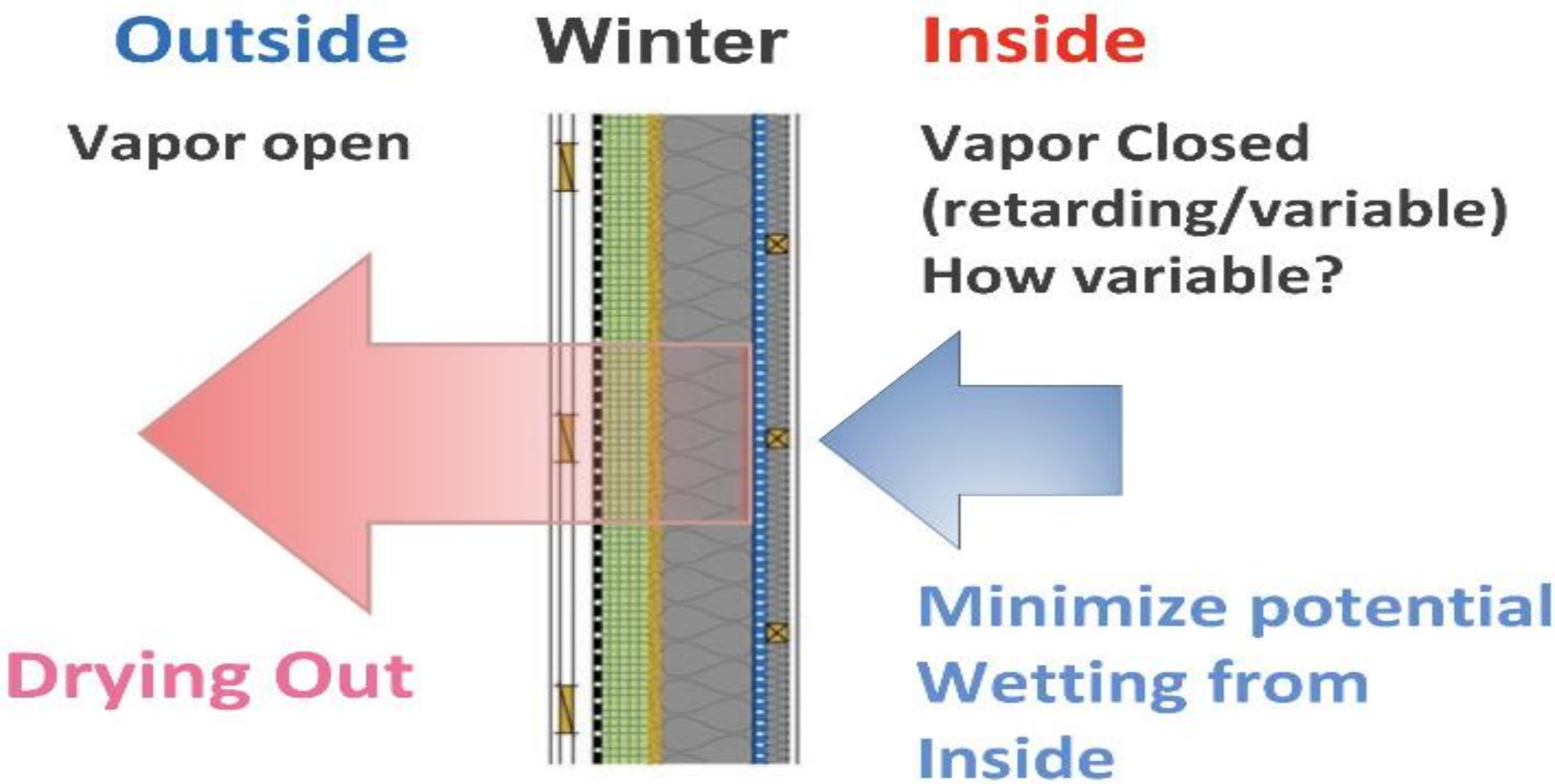
Source: Building Science Corp.

Moisture Dynamics in Wall Assembly



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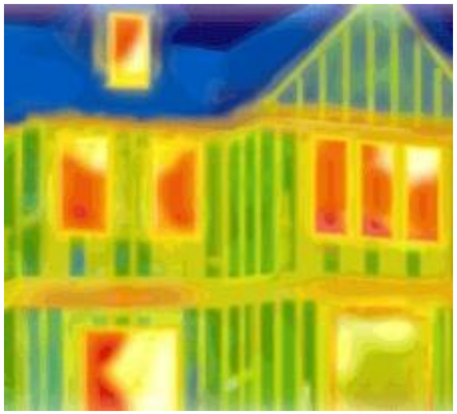
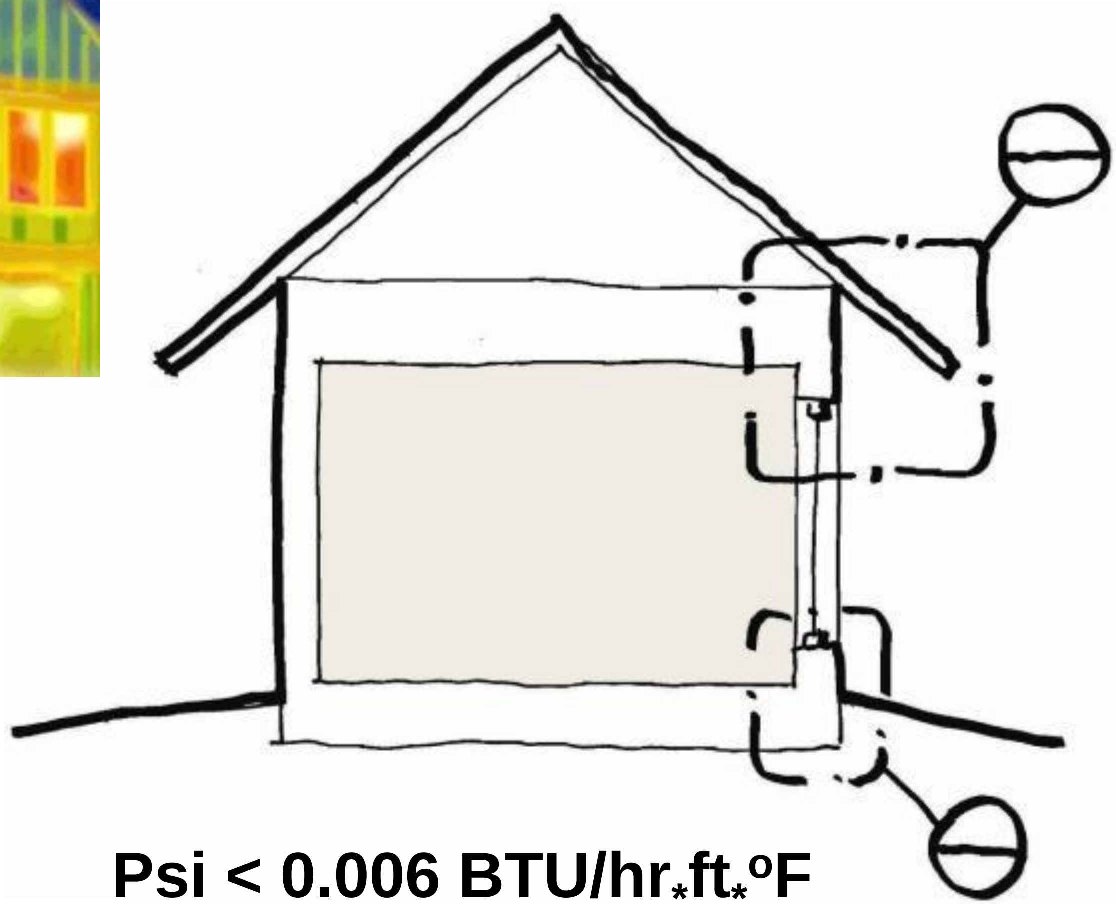
WUFI Analysis Comes Handy

Passive House Concept: Controlling Heat Loss – Eliminate Thermal Bridges





Psi < 0.006 BTU/hr*ft*ºF

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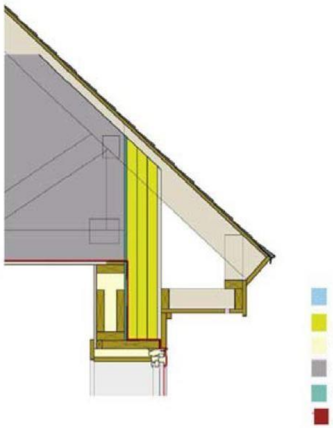
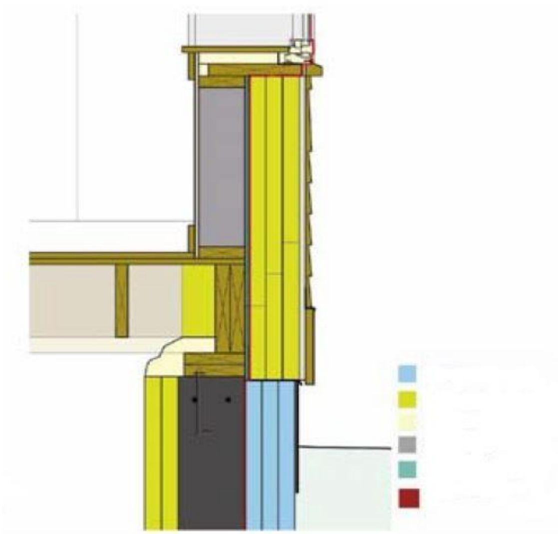
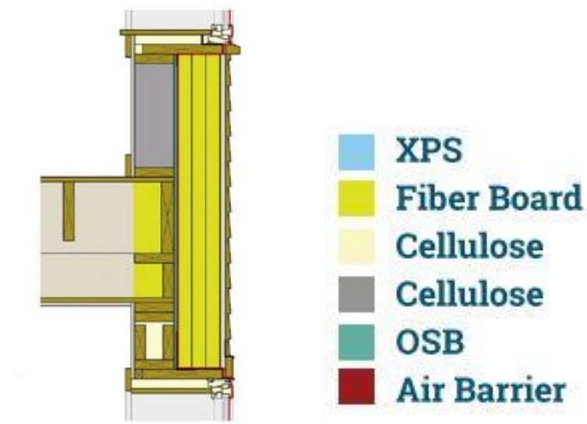
Thermal-bridge-free construction - Roof Assembly, Wall Assembly, Floor Assembly



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.

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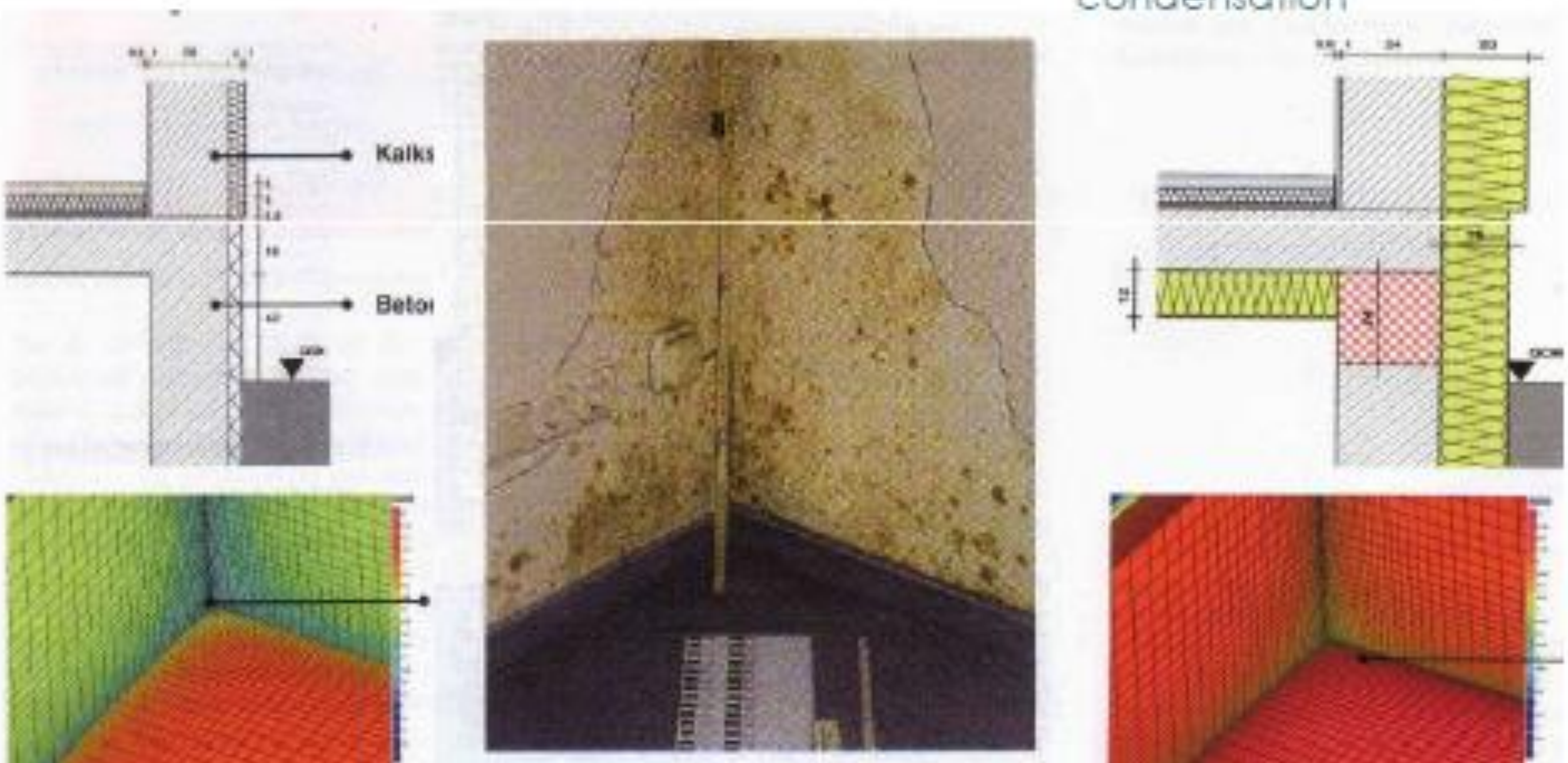
MINIMIZE LOSS:

ELIMINATING THE THERMAL BRIDGE MINIMIZES HEAT LOSS CONDENSATION/BUILDING DETERIORATION

BAD = high heat loss + risk of condensation

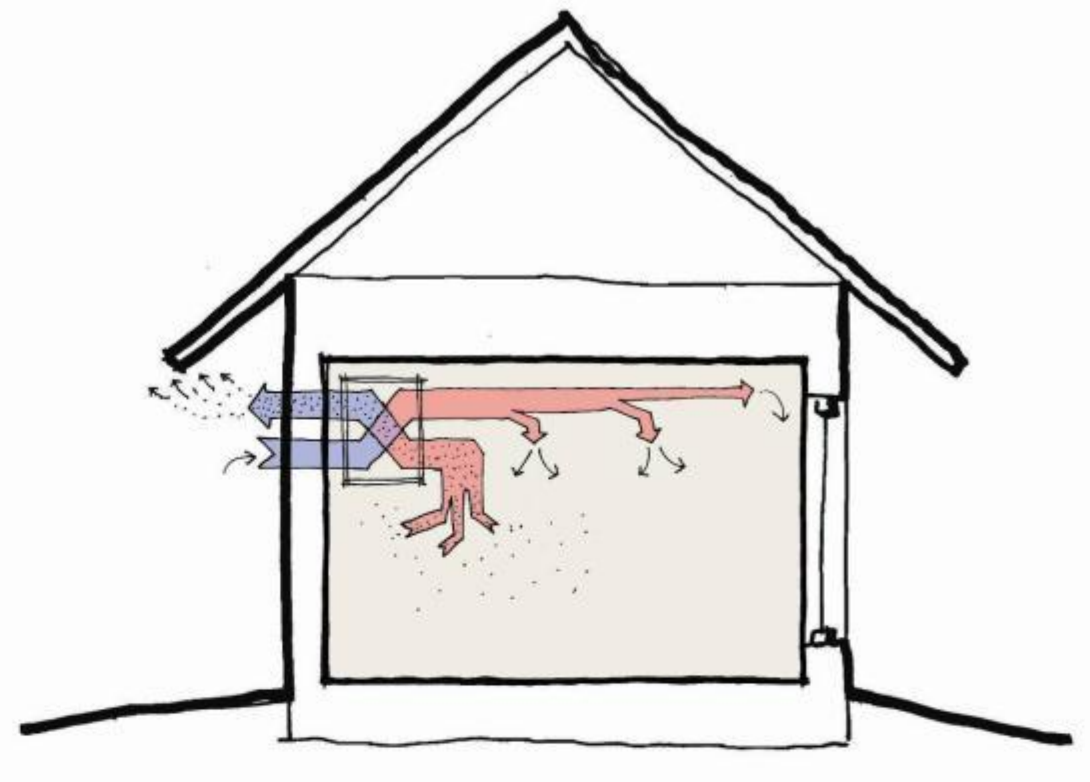
GOOD = low heat loss, warm interior surface + no condensation



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

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

Passive House Concept: Provide Fresh Air… Heat Recovery Ventilation



MINIMUM of 0.30 ACH

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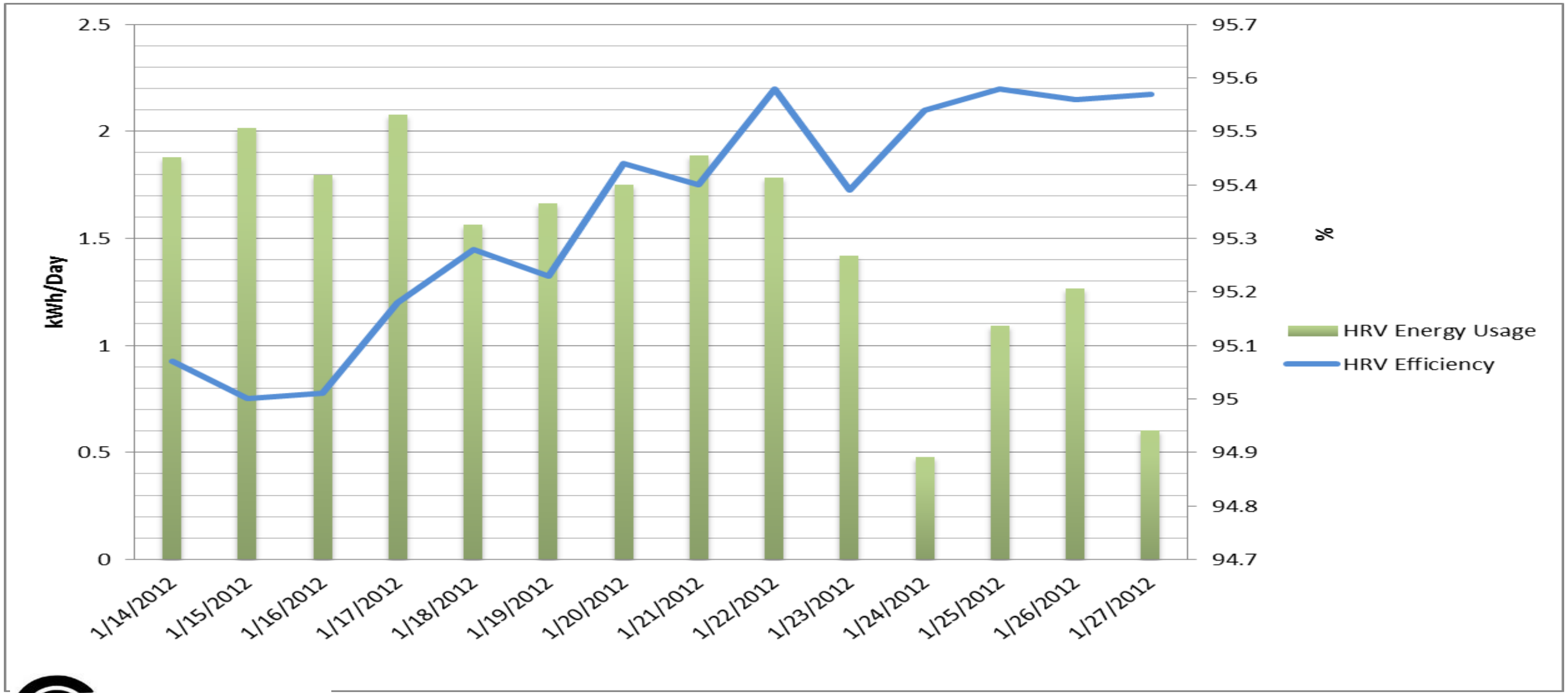
HRV Efficiency & Energy Use

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



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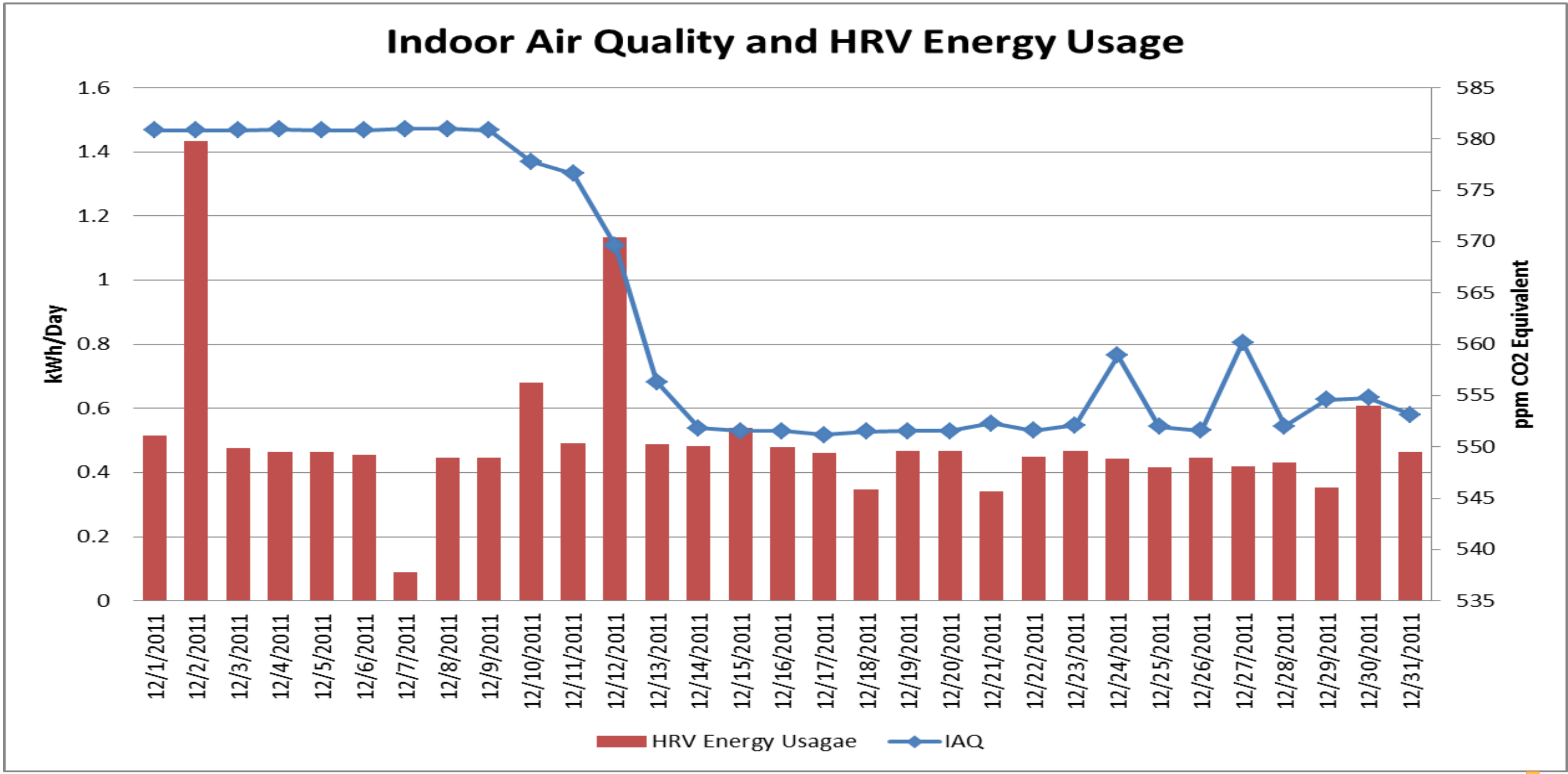
Source: Peter Schneider - VEIC

HRV Energy to Meet IAQ Needs



Source: Peter Schneider - VEIC

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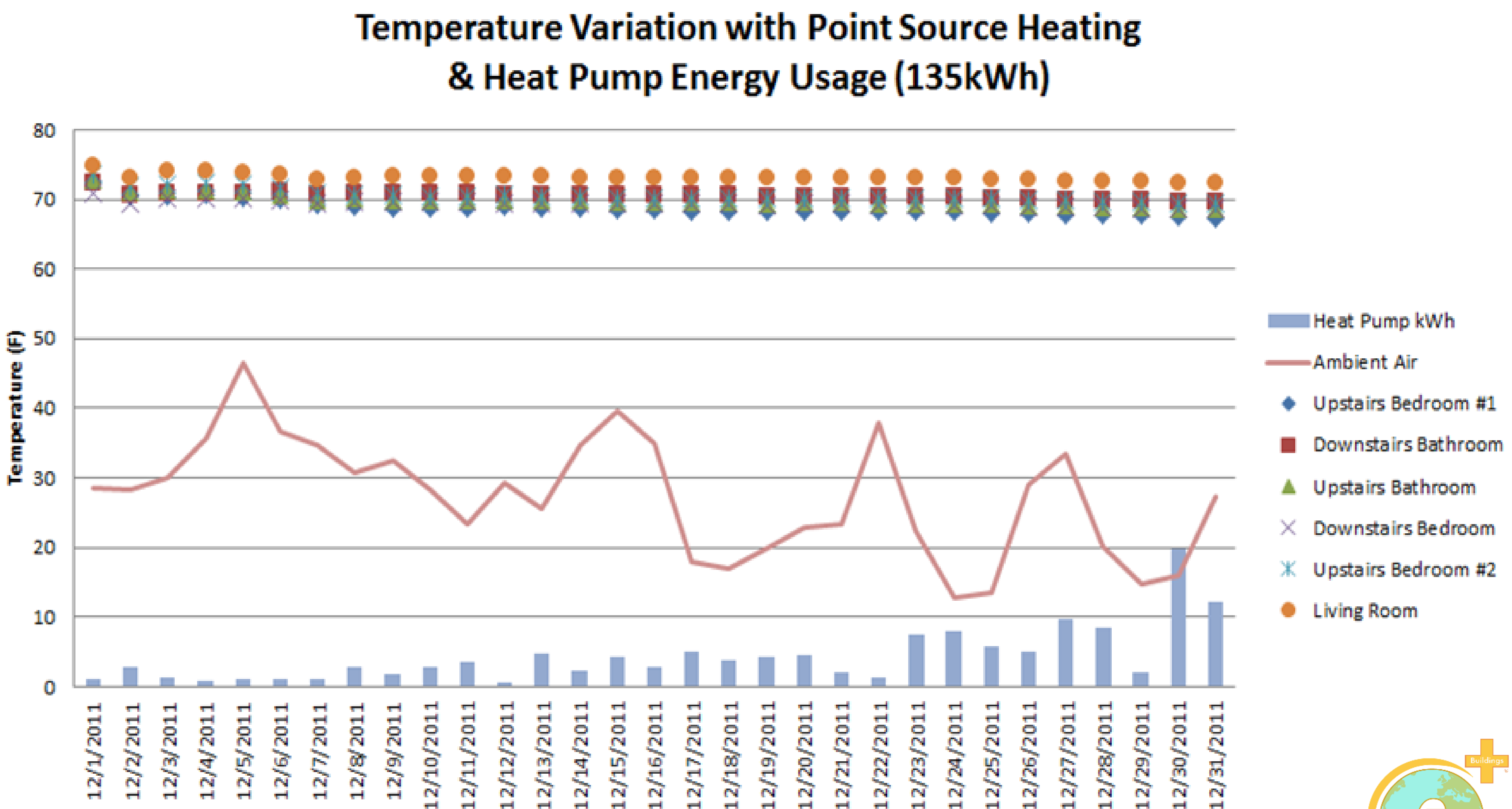
Heating Energy Needed to Meet Comfort



Source: Peter Schneider - VEIC

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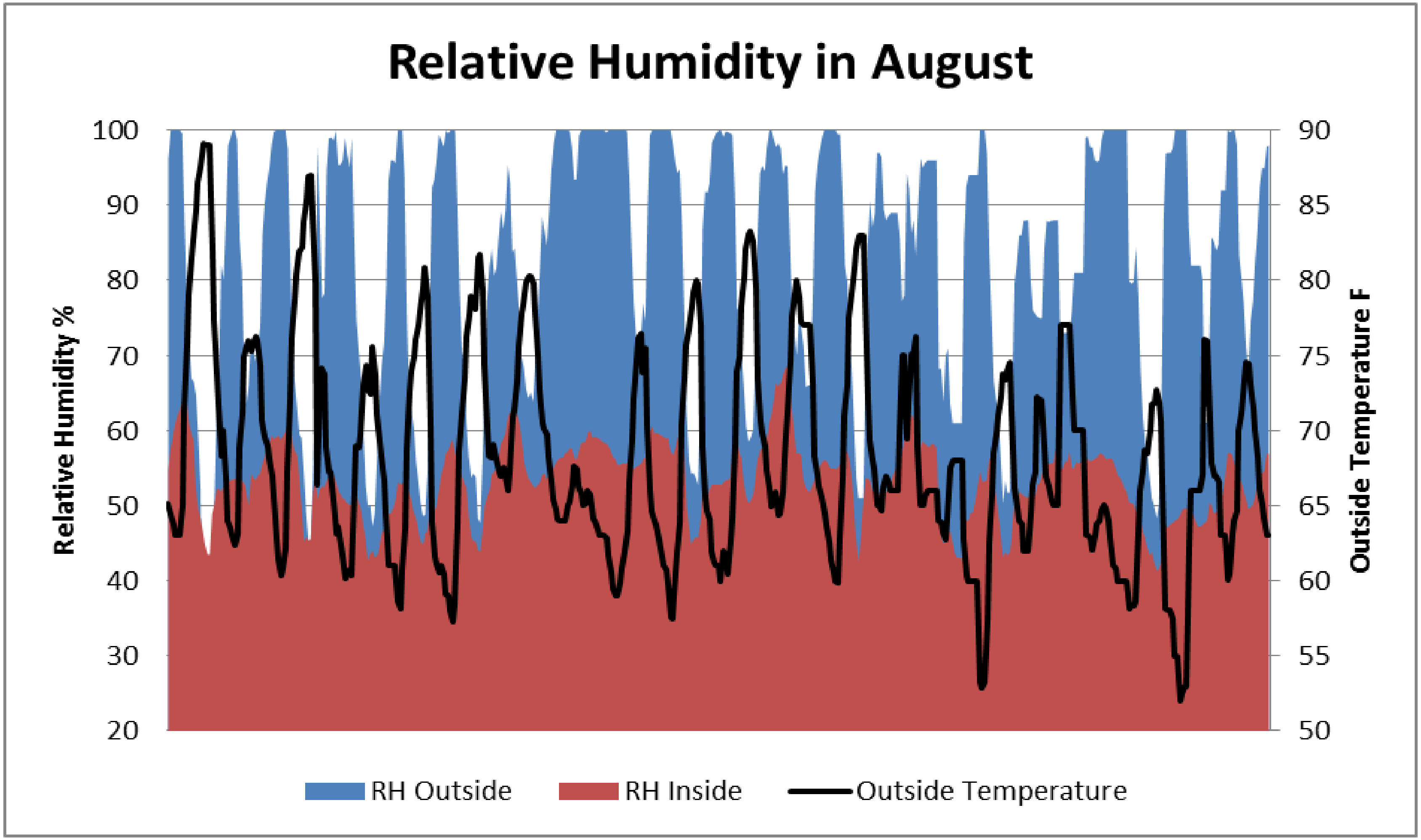
RH and Comfort



Source: Peter Schneider - VEIC

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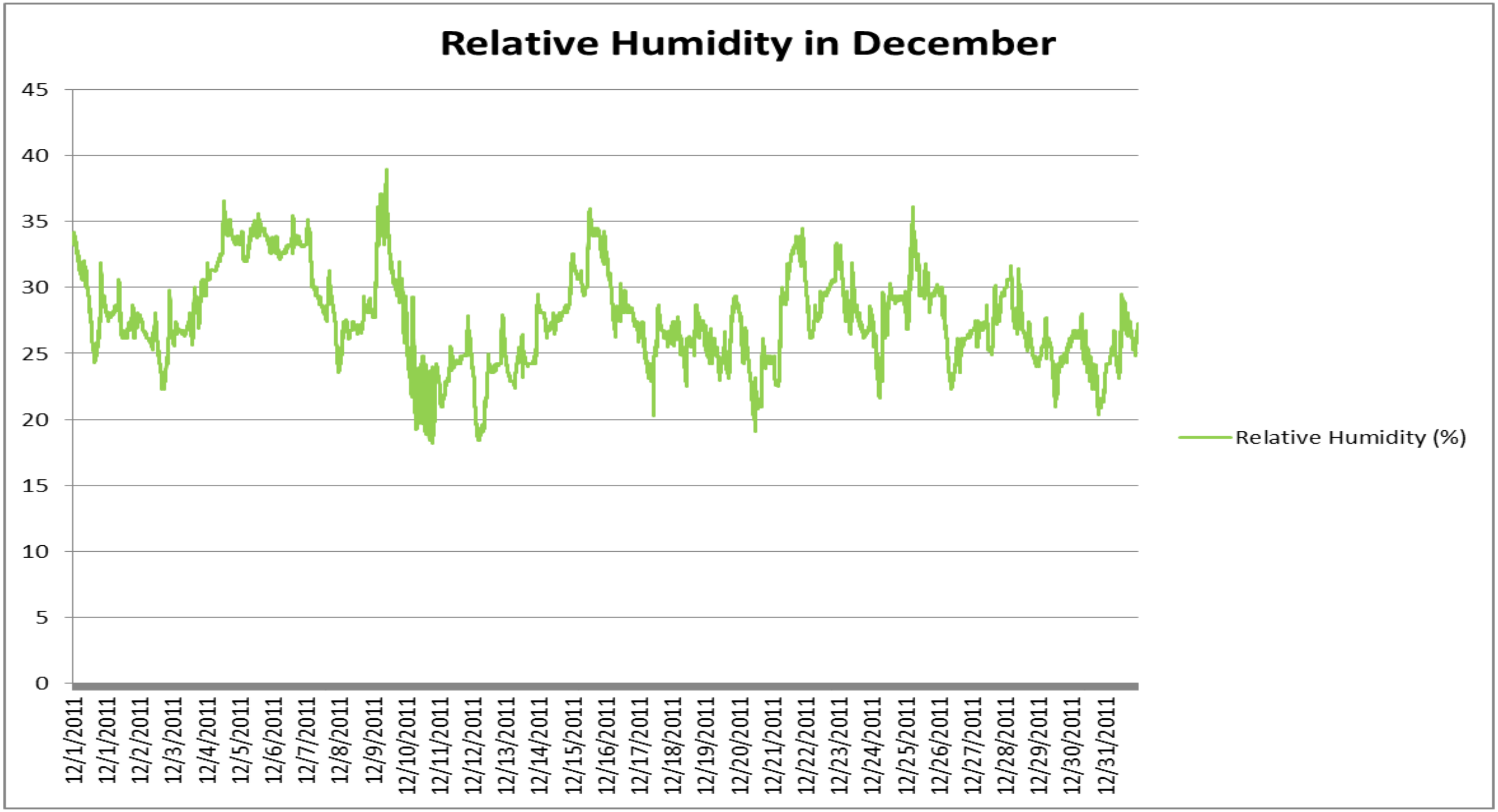
RH and Comfort



Source: Peter Schneider - VEIC

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Passive House Concept: Capturing Heat Gains - People

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Buildings

Passive House Concept: Capturing Heat Gains… Equipment

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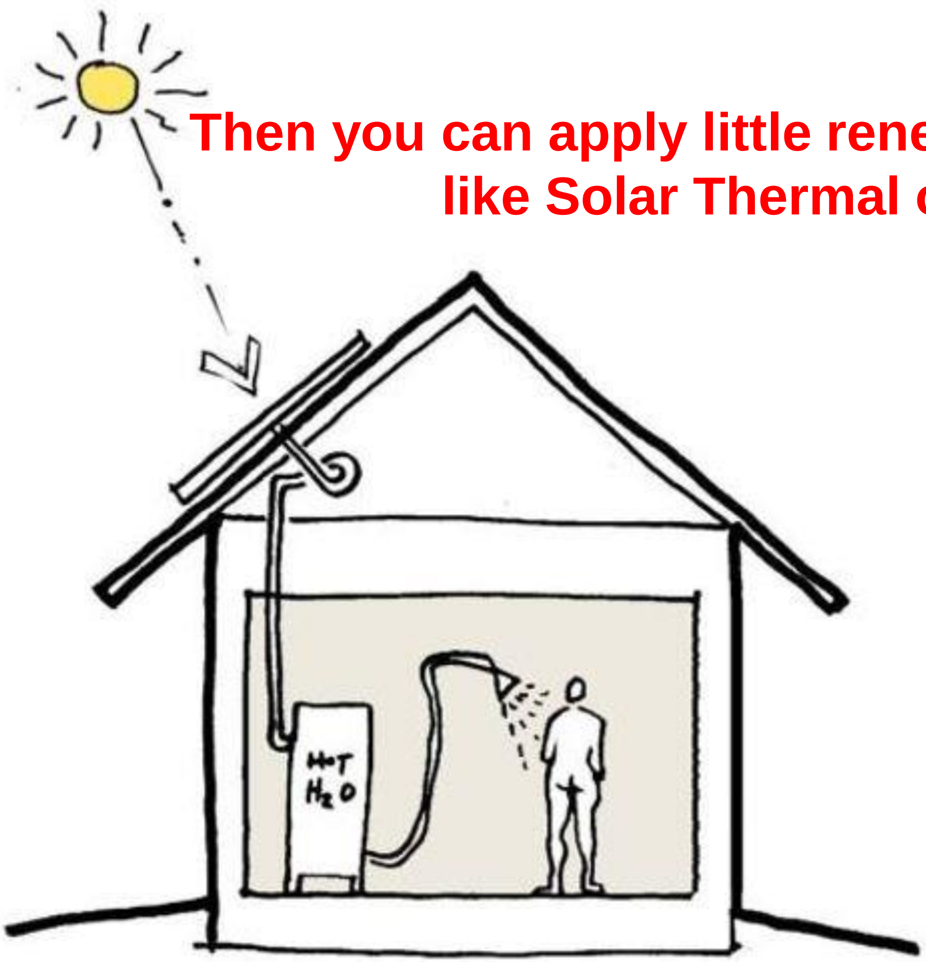
Passive House Concept: Once the Wasted Energy is Reduced to the maximum…

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



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Buildings

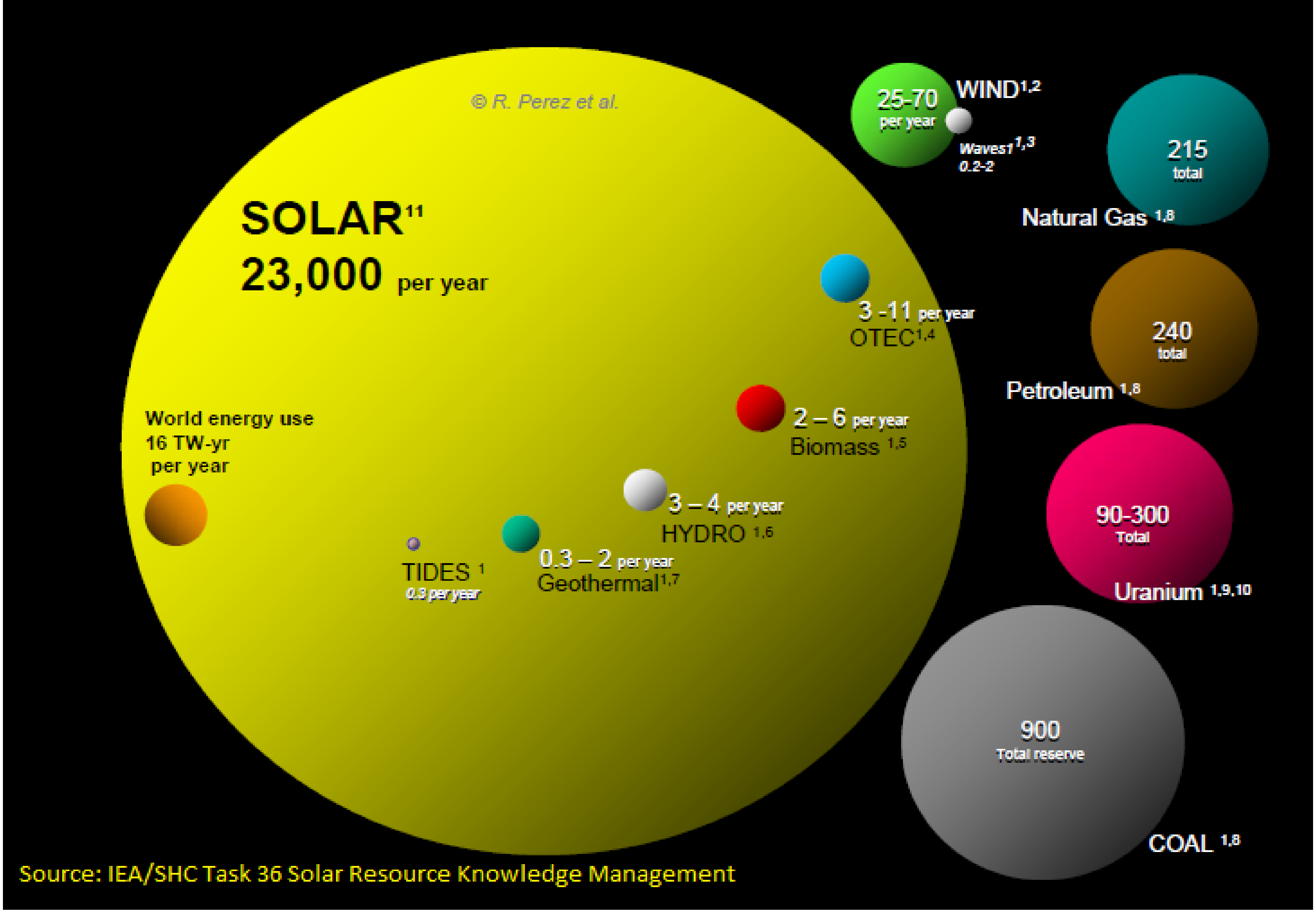
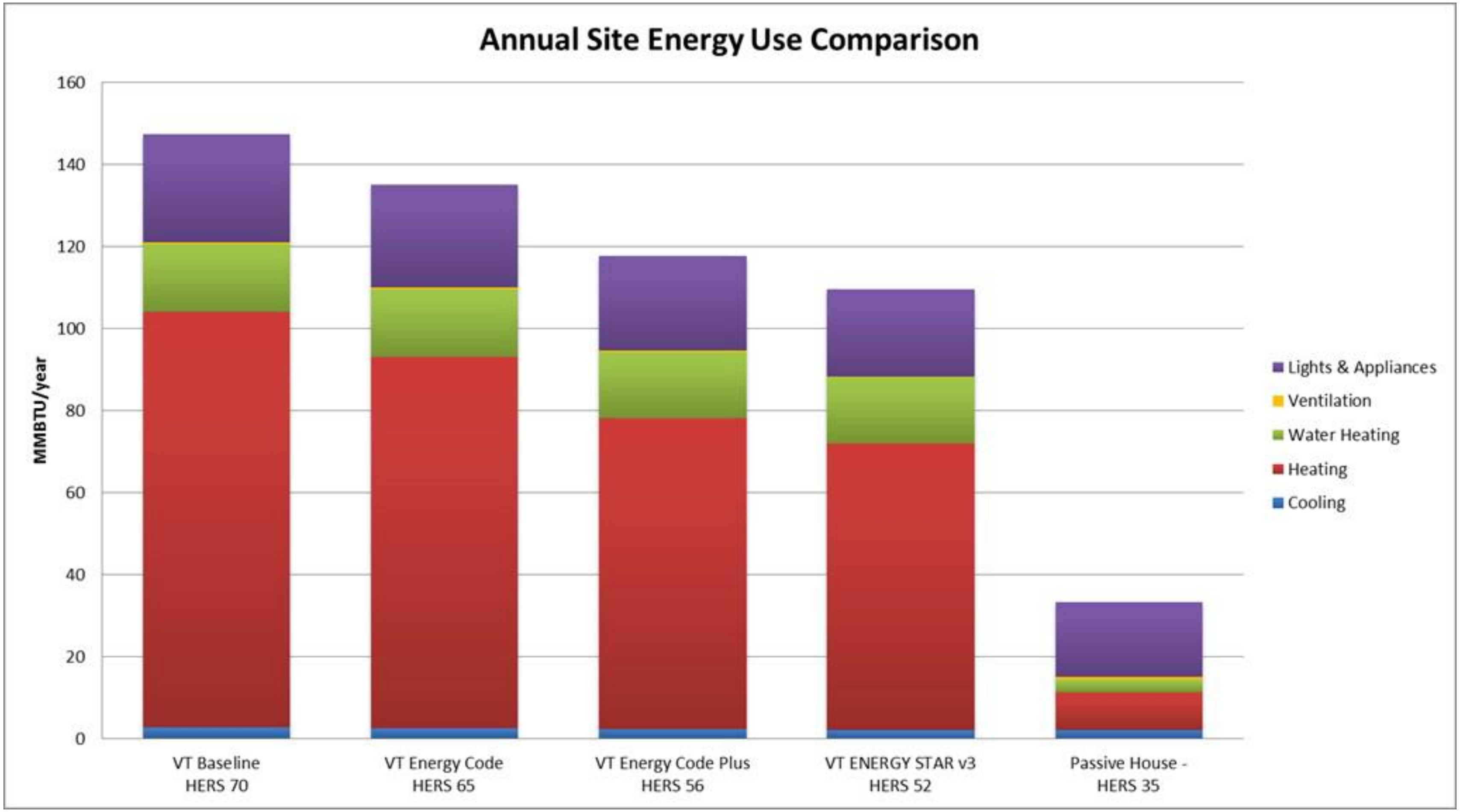


Figure 1: Comparing finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables.

Energy Usage Comparison



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Source: Peter Schneider - VEIC

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.

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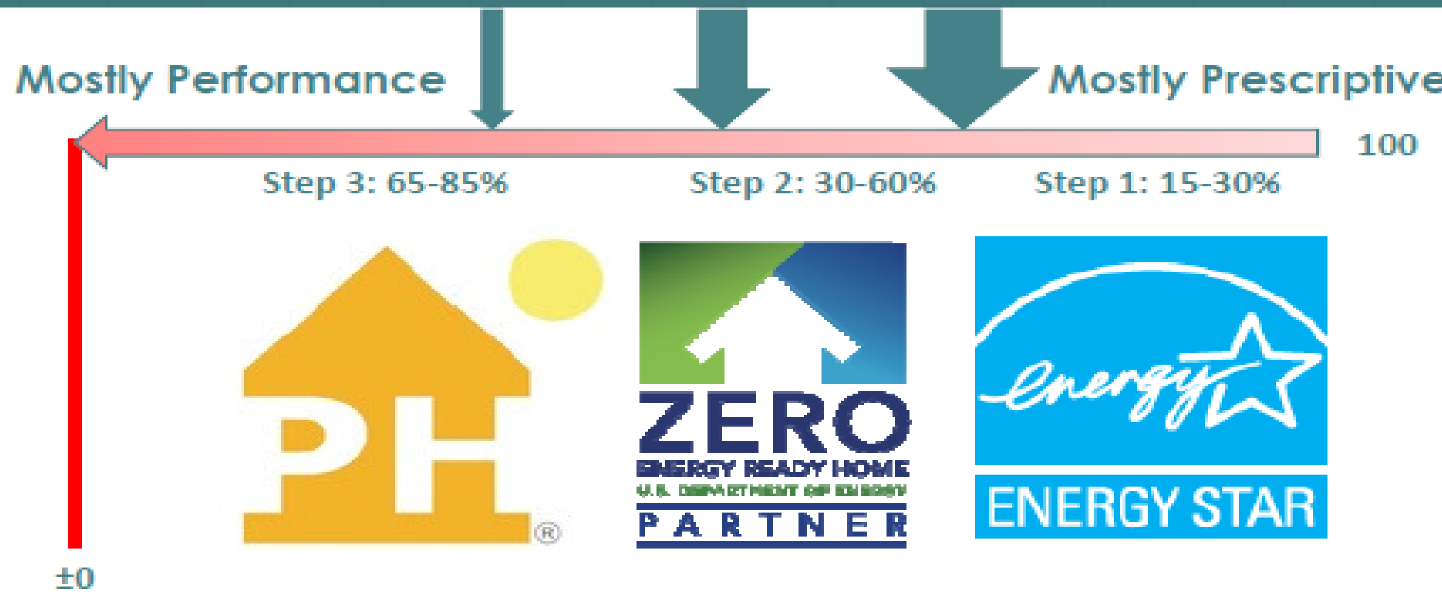
How does it relate to other programs?

A STEPPING STONE PROCESS TO HIGH PERFORMANCE AND QUALITY THROUGH **COLLABORATION**



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PH Norwich VT
2457 sqft of conditioned area

Source: Owner

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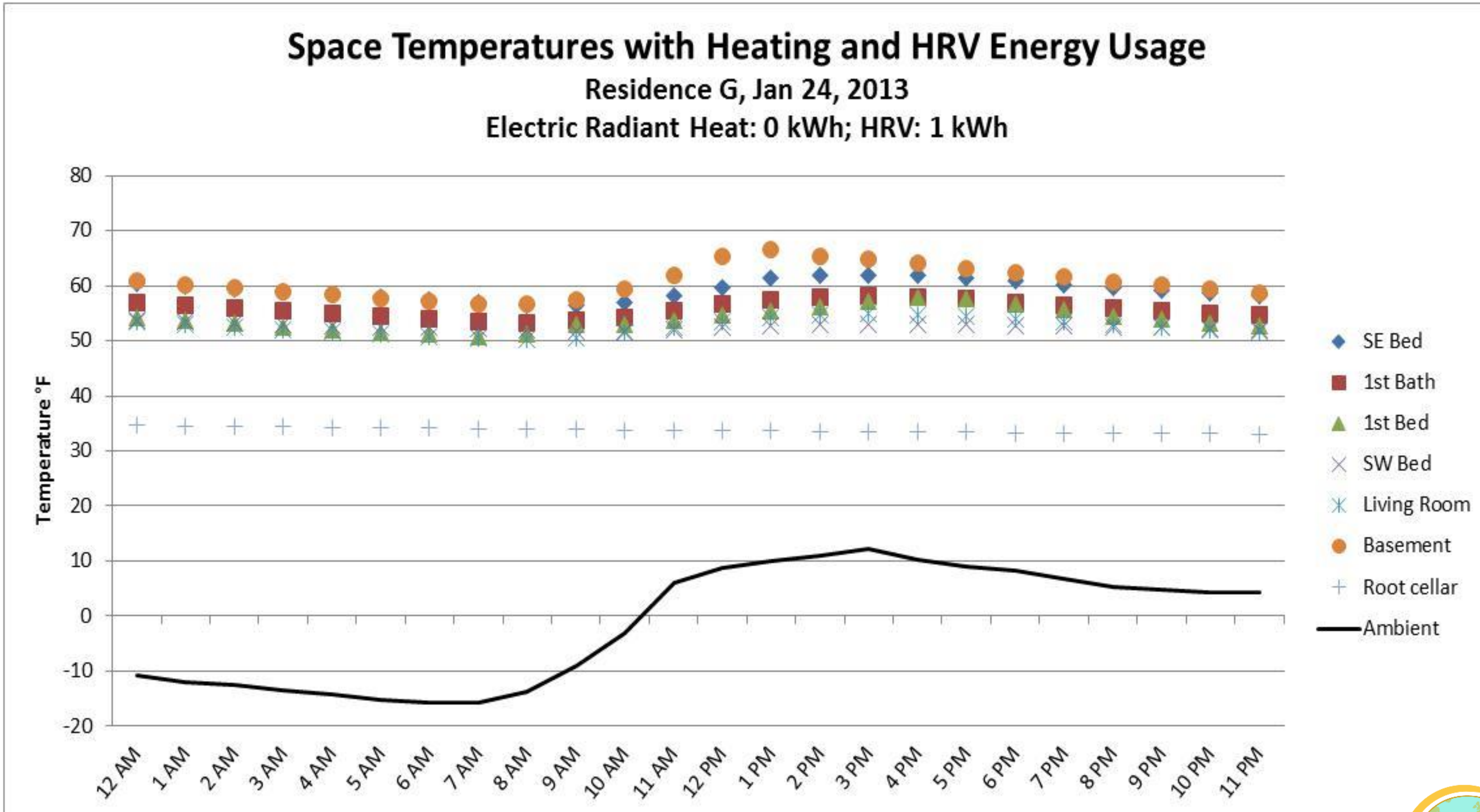
Independently monitored by Efficiency VT

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



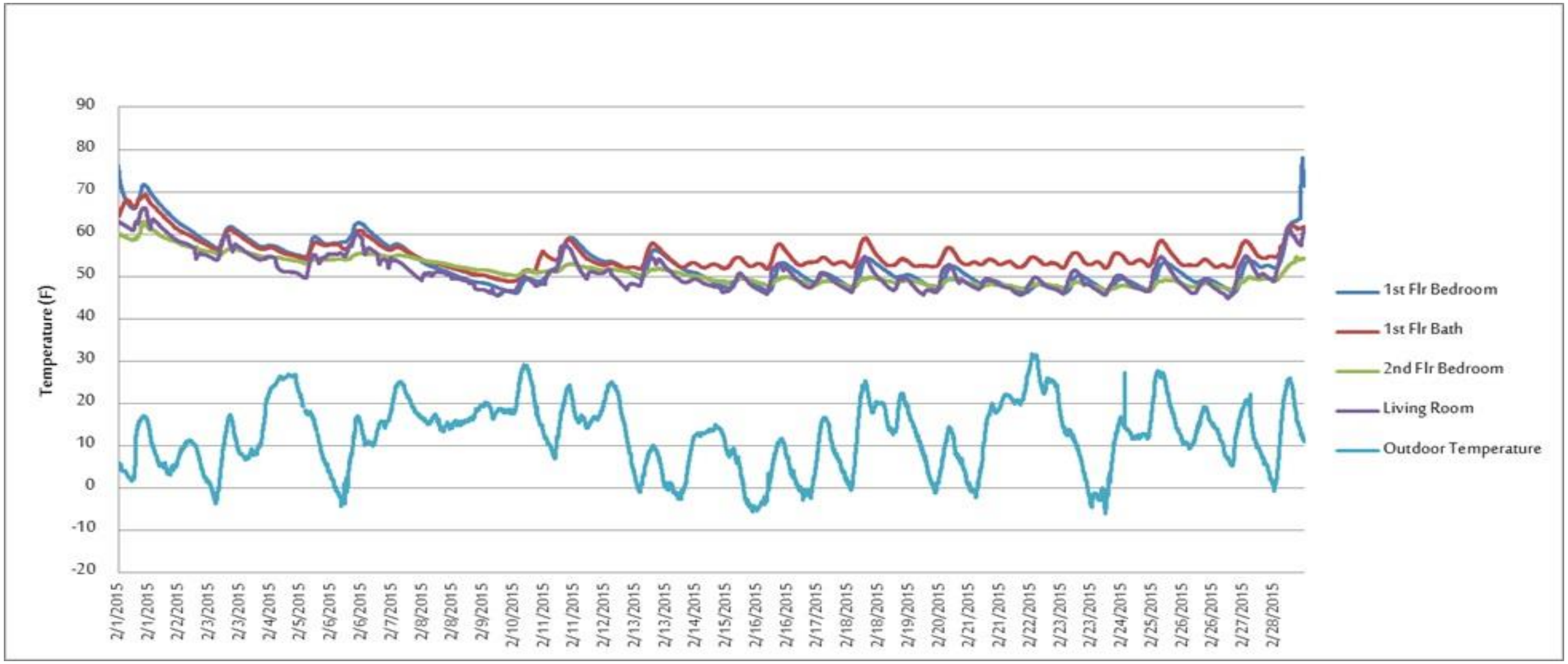
Source: Peter Schneider - VEIC

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

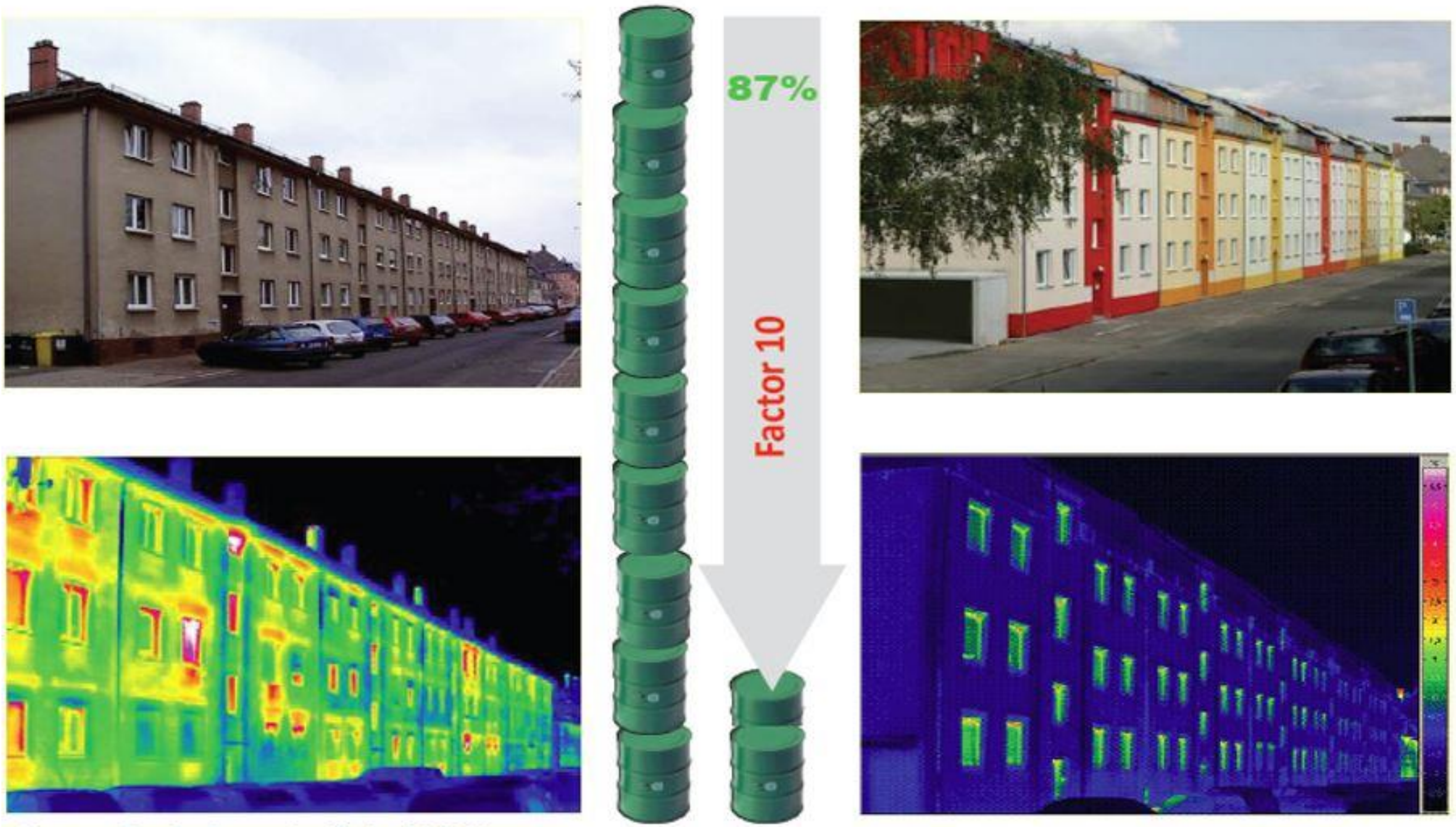


Source: Peter Schneider - VEIC

Independently monitored by Efficiency VT

It is no Rocket Science and applies to retrofits too

Frankfurt Teverstrasse, Refurbishment using Passive House Principles



Source: Passivehouse Institute / DENA

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McKeesport Downtown Housing (Residential)
McKeesport, PA
84 units - 36643 sqft

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Source PHIUS Projects Database

Retrofit of Existing Buildings

Glasswood – Portland OR Mixed-Use Commercial

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Floor Area: 1397 ft^2
Air-tightness: 0.39 ACH50

Cold Spring, NY
Small Commercial

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Floor Area: 1097 sqft
HHD: 6035

North Street Passive House – Cold Spring NY Residential

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NEW ENGLAND CONSTRUCTION CO.

Floor Area: 1845 sqft
Air-tightness: 0.86 ACH50

Passive Lodge at Silver Lake – Sharon CT Residential

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Floor Area: 2423 ft^2
Air-tightness: 0.0317 CFM50/ft^2-envelope

Weinberg Commons – Washington DC Multi-Family

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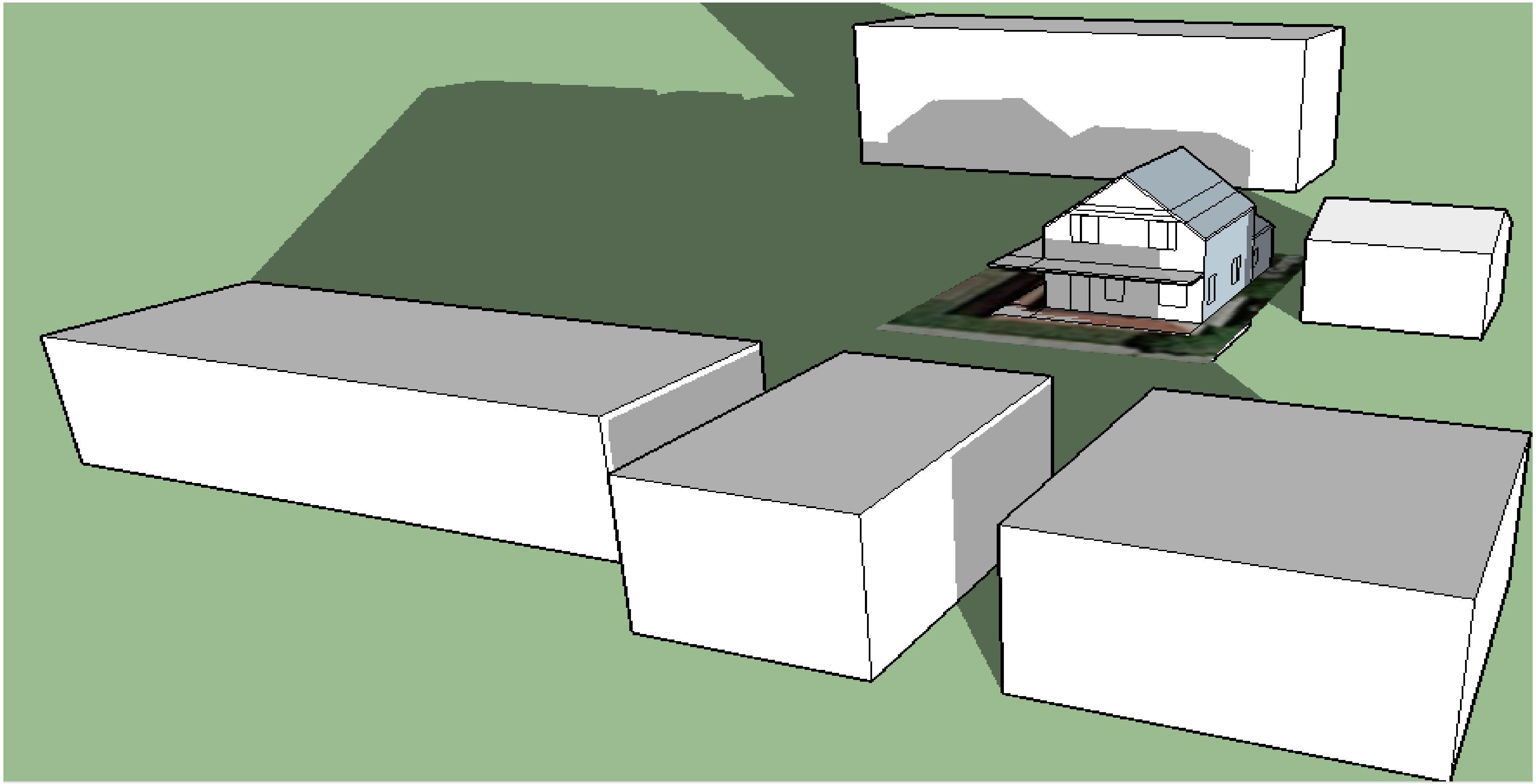
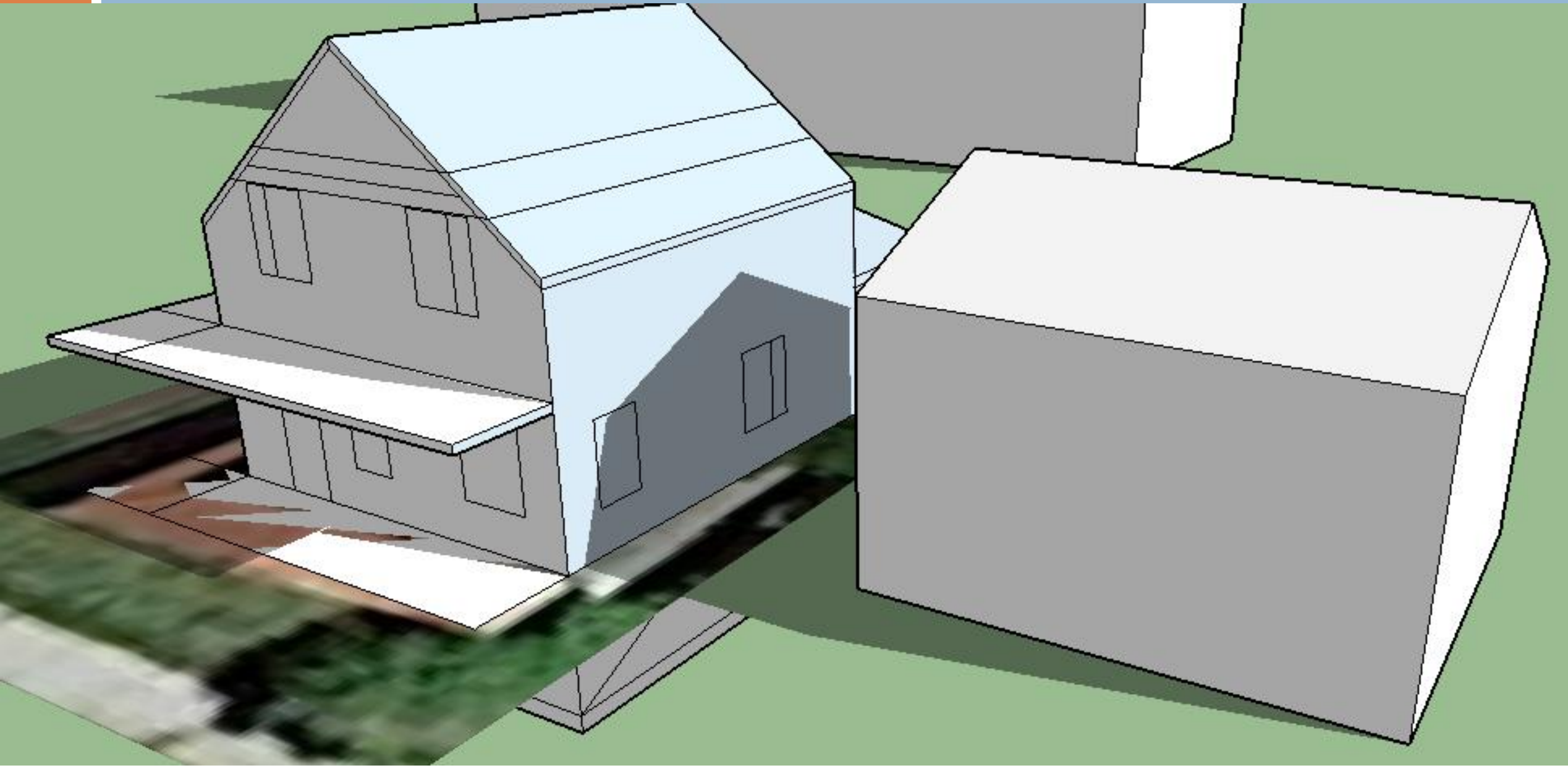
13 Units
Floor Area: 9380 ft^2
Air-tightness: 0.56 ACH50

Shading by Objects is also taken in consideration in PHPP



Shading Representation December 5:00 PM

Shading by Objects is also taken in consideration in PHPP



Shading Representation February @ Noon

Passive House Projects Worldwide

PH Projects
Austria

Passive Apartments NHT Lodenareal, Innsbruck
Largest certified "Passive House" complex in the world, 2009

- 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

Herz & Lang
Architects & Engineers
House of the future!

NHT
NEUE HEIMAT TIROL
Gemeinnützige WohnungsGmbH

Passive House Projects North East USA


Handel Architects

High Rise – Cornell-Tech - NYC


School Portland ME


Affordable Housing Brewer - ME

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PH Projects
Vermont

Affordable Senior Housing
Elm Place - Milton VT
Only 127,651 kBTU/yr at 2ºF for 27,690 sqft floor area

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Habitat for Humanity
East Montpelier

PH Projects
Vermont

83% less energy for heating/cooling

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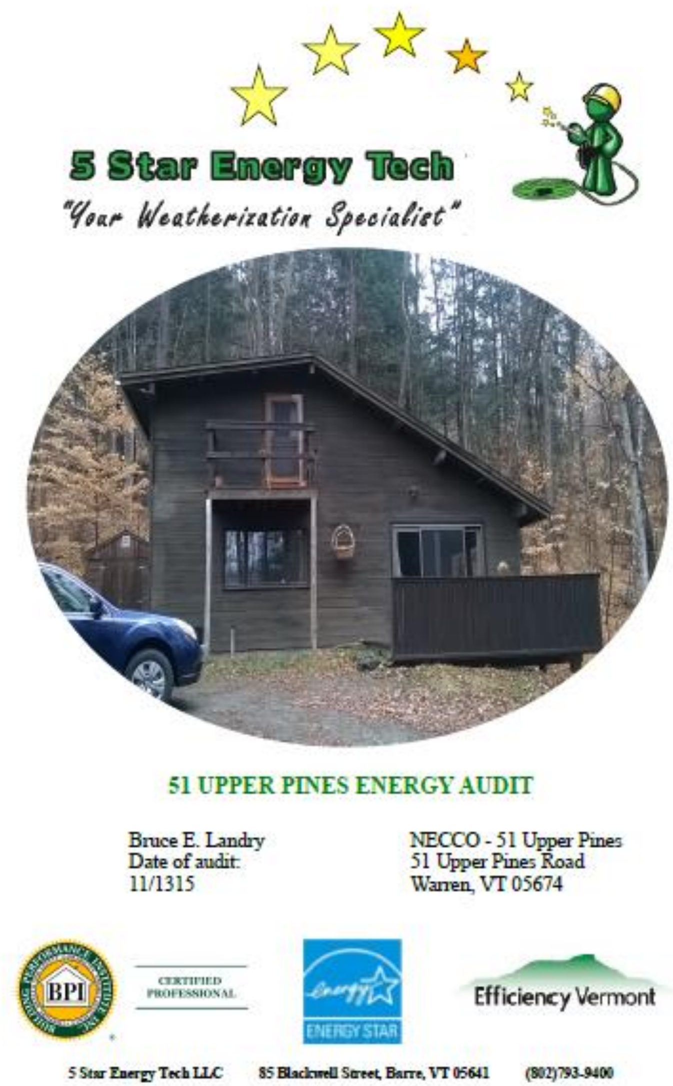
@ only 2% more than conventional building cost

51Upper Pines – Warren VT
Case History

Built in the early 70’s.
Simple in construction
Slab on grade floor
Inexpensive widows
Fiberglass insulation,
Fireplace in great
room and cathedral
ceilings with no attic.


5 Star Energy Tech
"Your Weatherization Specialist"

51 UPPER PINES ENERGY AUDIT

Bruce E. Landry
Date of audit:
11/1315

NECCO - 51 Upper Pines
51 Upper Pines Road
Warren, VT 05674

CERTIFIED PROFESSIONAL

Efficiency Vermont

5 Star Energy Tech LLC 85 Blackwell Street, Barre, VT 05641 (802)793-9400

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51Upper Pines – Warren VT

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51Upper Pines – Warren VT Initial Condition

The 516 gallon of propane usage at 62-65 degrees in a 1440 sq ft home indicated the boiler was running often to keep up. Averaged in all the categories the house performed at a 60% efficiency which is below average

The 2 bathrooms have poor ventilation with potential to mold formation. One fan was pulling only 6-10 CFM, while a BR-fan should be pulling 50-80 CFM.

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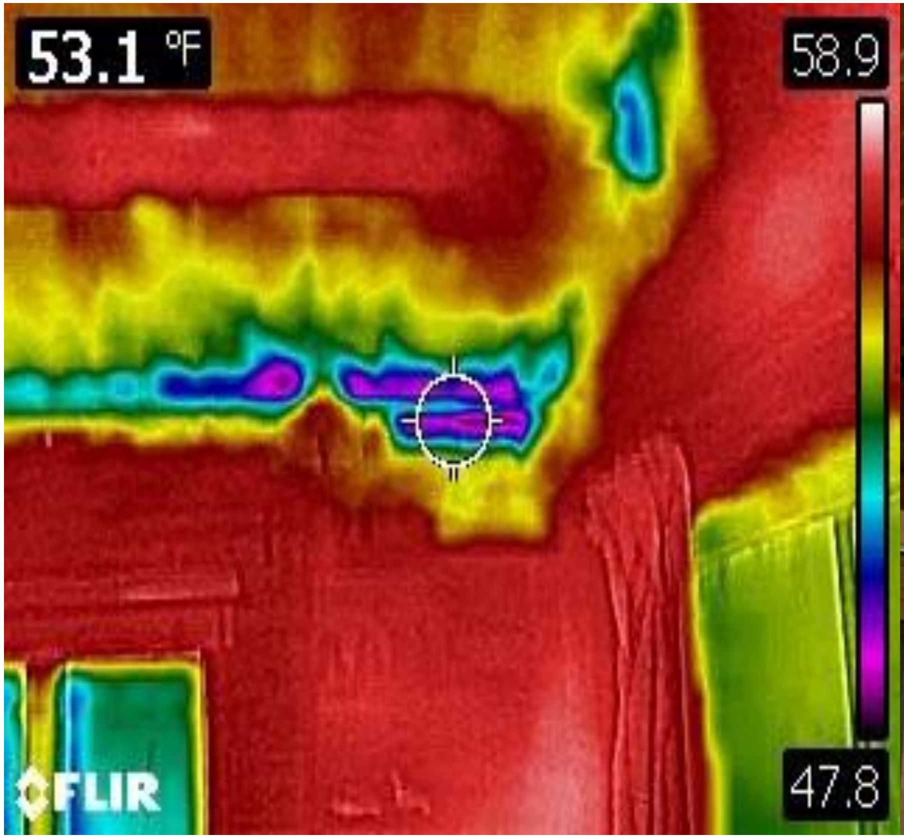
51Upper Pines – Warren VT
Initial Condition

Thermal Bridges Everywhere



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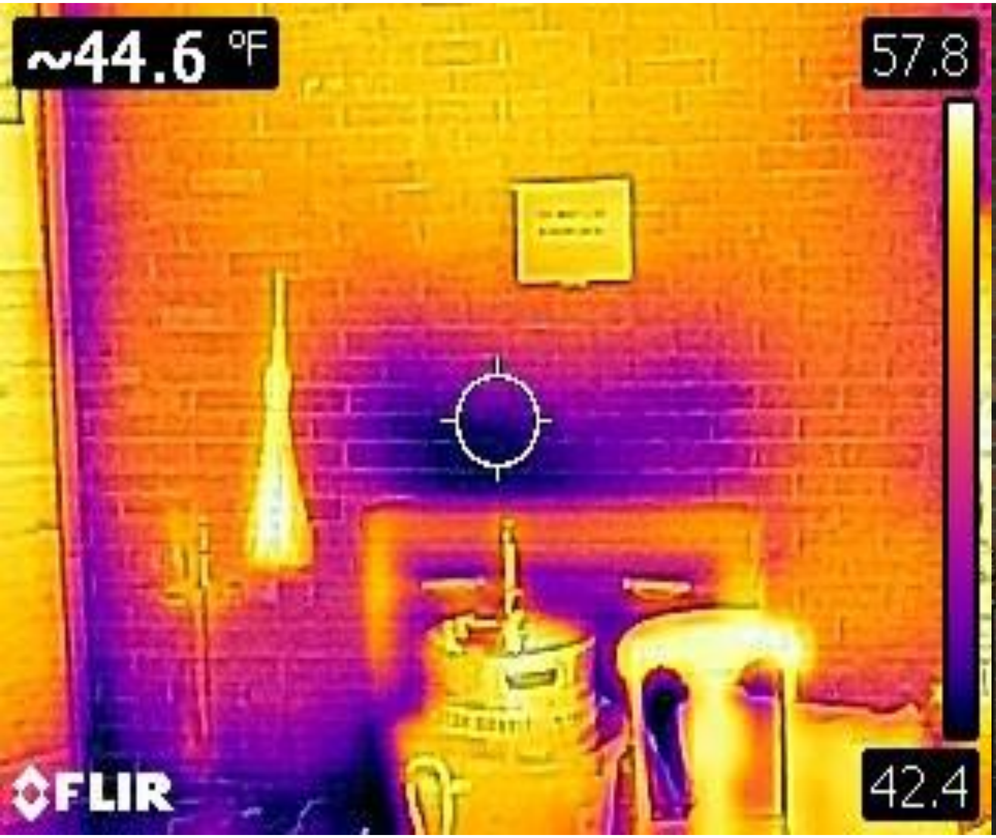
51Upper Pines – Warren VT
Initial Condition

Thermal Bridges Everywhere



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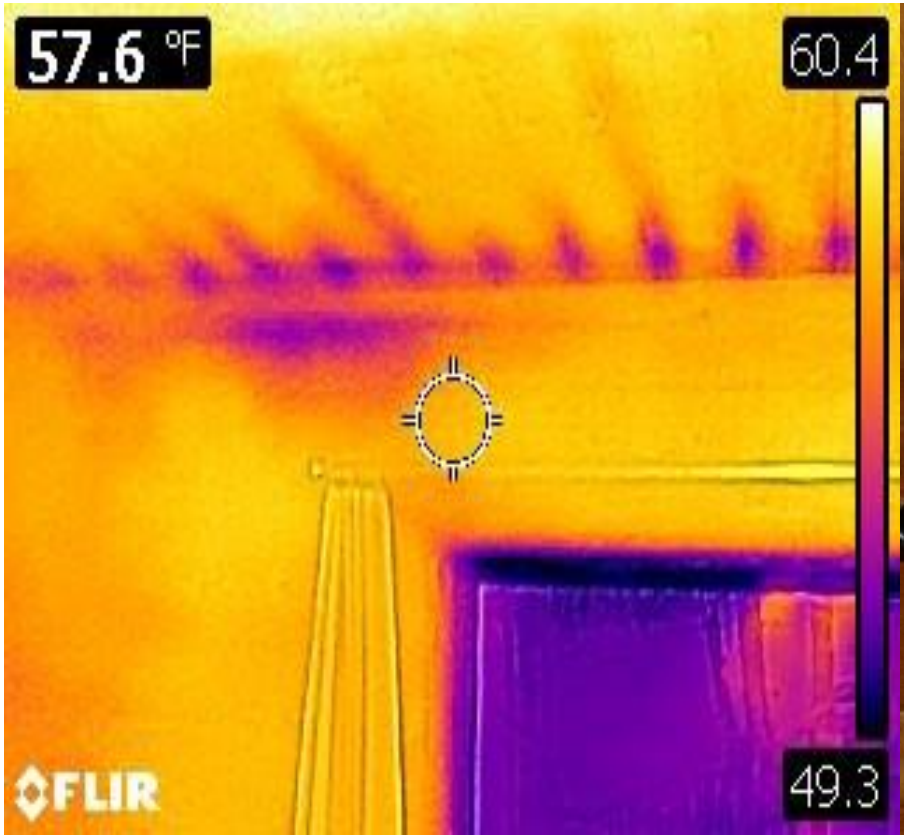
51Upper Pines – Warren VT
Initial Condition

Air Leaks Everywhere



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1740 CFM

A lot of infiltration for a 1440 ft2 house

First Phase of the Project
The Roof Overhaul

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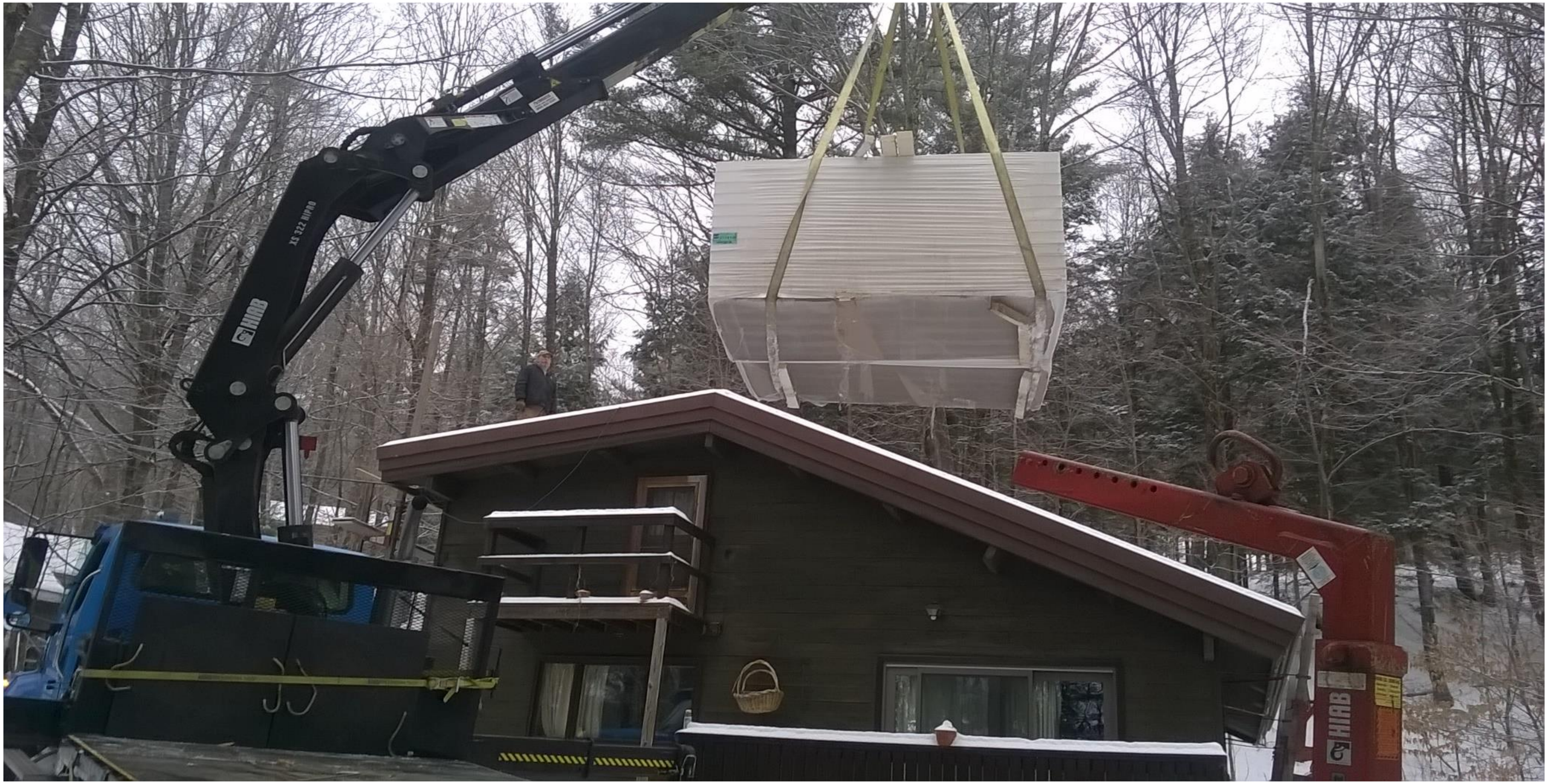
First of 7 lifts



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Buildings

ISO sealed to insulation box

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All Joints Carefully Taped

First Phase of the Project
The Roof Overhaul

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12” PolyIso for R-83 Finished Roof

First Phase of the Project
Finished Roof

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12” PolyIso for R-83 Finished Roof

Second Phase of the Project
The Passive House Planning Package Energy Model

PHPP = PASSIVE HOUSE PLANNING PACKAGE

The energy modeling software developed by Passivhaus Institut - Germany

- Climate and orientation data input

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ENERGY BALANCE

PHPP POPULATION PROCESS

Climate Data input

EnerPHit planning: **CLIMATE DATA**

Building: 51 Pines - Warren VT

Transfer to annual method (Annual Heating)

Climate building: Montpelier AP VT — H_T: 222 day/yr

Heating Degree Days, G_t: 7468 °F.day/yr

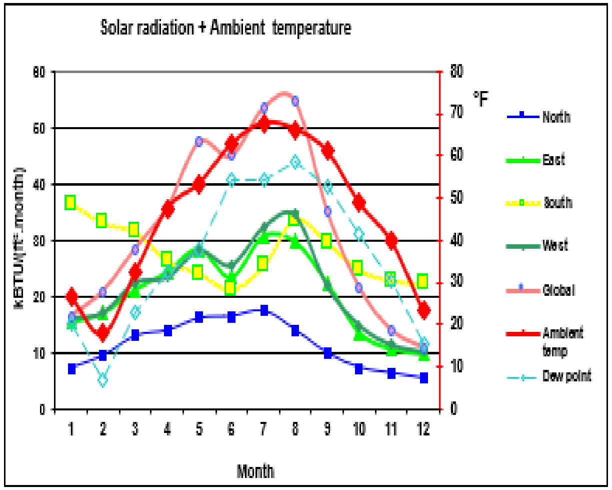
Monthly data:	MONTPELIER AP VT - Montpelier AP VT	North	66	kBTU/(ft²yr)
Annual data:		East	118	kBTU/(ft²yr)
Use annual climate data set	no	South	200	kBTU/(ft²yr)
Results:		West	121	kBTU/(ft²yr)
Annual heating demand	6.39 kBTU/(ft²yr)	Horizontal	158	kBTU/(ft²yr)
Heating load	4.29 BTU/h.ft²			
Primary energy	54.46 kBTU/(ft²yr)			

Region: User Data

Climate data set: MONTPELIER AP VT - Montpelier AP VT

Weather station (altitude): 1125.3 ft

Building location (altitude): 896 ft



	Month	1	2	3	4	5	6	7	8	9	10	11	12	Heating load		Cooling load	
	Days	31	28	31	30	31	30	31	31	30	31	30	31	Weather 1	Weather 2	Weather 1	Weather 2
Parameters for PHPP calculated ground temperatures:	ONTPELIER AP VT - Montpelier AP	Latitude °:	44.2	Longitude °:	-72.6	Altitude ft	1125	Daily temperature swing Summer (°F)			21.4	Radiation data:	kBTU/(ft²month)	Radiation: BTU/hr.ft²		Radiation: BTU/hr.ft²	
Phase shift months	Ambient temp	26.8	17.8	32.4	47.5	53.5	62.6	67.7	66.2	61.0	48.8	39.8	23.2	0.2	28.1	76.1	76.1
0.60	North	7.3	9.5	13.0	13.9	16.2	16.5	17.4	13.9	9.8	7.3	6.3	5.4	12.7	5.7	22.8	22.8
Damping	East	15.5	17.1	21.2	24.4	28.5	23.5	30.7	29.8	22.5	13.6	10.8	9.8	23.1	9.2	42.2	42.2
-0.31	South	36.5	33.0	31.4	26.3	24.1	21.2	25.4	33.6	29.5	24.7	22.8	22.2	58.6	13.9	37.4	37.4
Depth ft	West	16.2	17.1	22.5	23.5	28.2	25.7	32.3	34.6	21.9	14.9	11.4	10.1	29.2	8.6	46.6	46.6
3.27	Global	16.5	20.9	28.5	35.8	47.5	45.0	53.6	54.8	35.2	21.6	13.9	10.8	31.4	9.8	78.0	78.0
Average Temp Shift °F	Dew point	19.9	6.8	22.8	32.5	37.9	54.3	54.3	58.5	52.5	41.4	30.6	15.3			63.9	63.9
1.8	Sky temp	0.1	-16.1	6.3	20.3	26.6	45.7	44.8	47.7	42.8	30.6	16.7	-4.0			59.7	63.9
	Ground temp	39.4	35.4	34.8	37.8	43.5	50.4	56.8	60.8	61.4	58.5	52.7	45.8	34.7	34.7	61.5	61.5
	Comment:		PHIUS														

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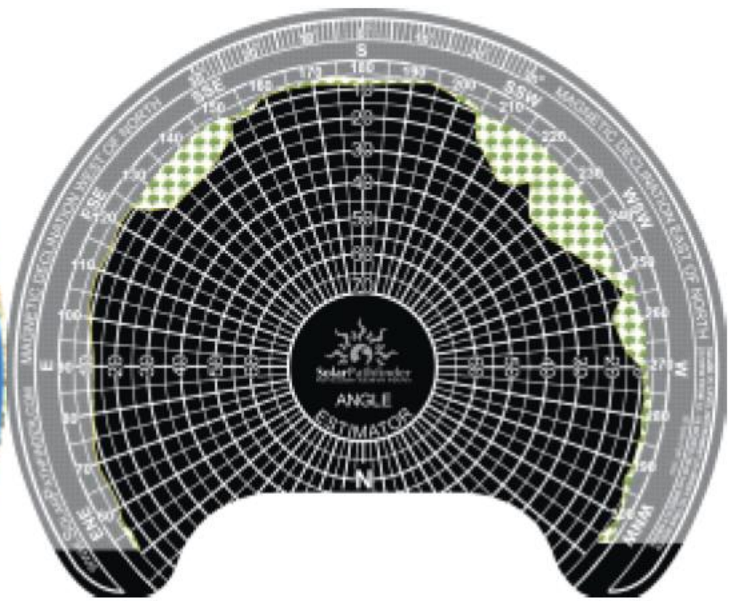
Buildings

ENERGY BALANCE
PHPP POPULATION PROCESS

Orientation- Windows Input and Shading Analysis

Notes: South Angle Estimator



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ENERGY BALANCE
PHPP POPULATION PROCESS

PHPP = PASSIVE HOUSE PLANNING PACKAGE

The energy modeling software developed by Passivhaus Institut - Germany

- Climate and orientation data input
- Assembliesʼ R-value Calculation

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ENERGY BALANCE

COMPILING ENERGY LOSSES

Assemblies' R-Value Calculation

Assembly no.	Building assembly description	Interior insulation?
2	Roof	

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.	T&G board	1.280					1.500
2.	Glass-Fiber Batts	3.330	sleepers 24" OC	1.280			1.500
3.	Plywood	1.470					0.500
4.	Polyiso unfaced	6.200					12.000
5.	OSB	1.390					0.625
6.							
7.							
8.							
		Percentage of sec. 1		Percentage of sec. 2		Percentage of sec. 3	Total
		75%		25.0%			16.13 in

U-value supplement BTU/hr.ft^2.°F

R-Value: 82.6 hr.ft^2.°F/BTU

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ENERGY BALANCE
COMPILING ENERGY LOSSES

PHPP = PASSIVE HOUSE PLANNING PACKAGE

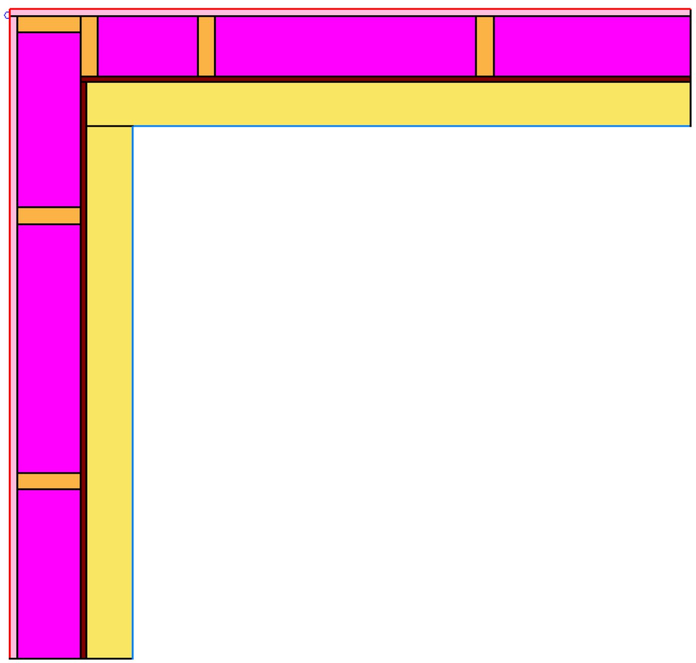
The energy modeling software developed by Passivhaus Institut - Germany

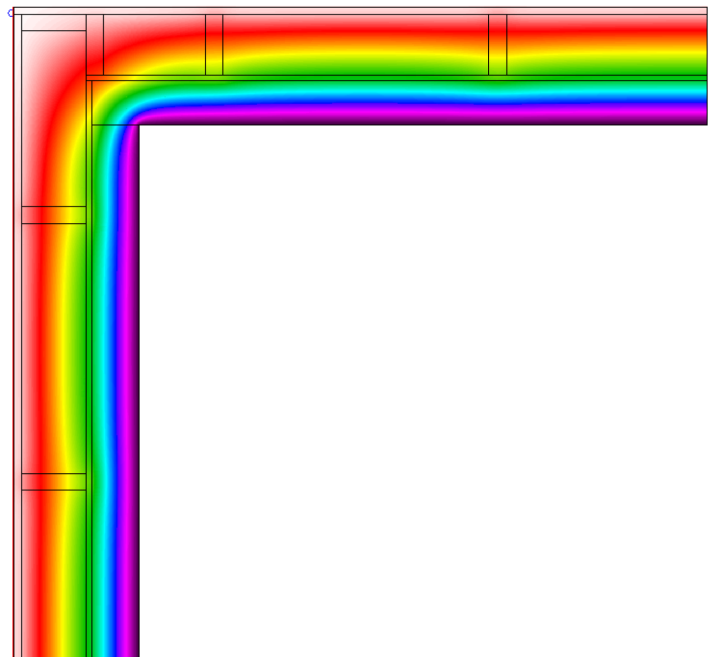
- Climate data input
- Assemblies' R-value Calculation
- Heat loses through the ground
- Areas and Thermal Bridges' input

ENERGY BALANCE
COMPILING ENERGY LOSSES

Thermal Bridges' input

Each one positive or negative is accounted for





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

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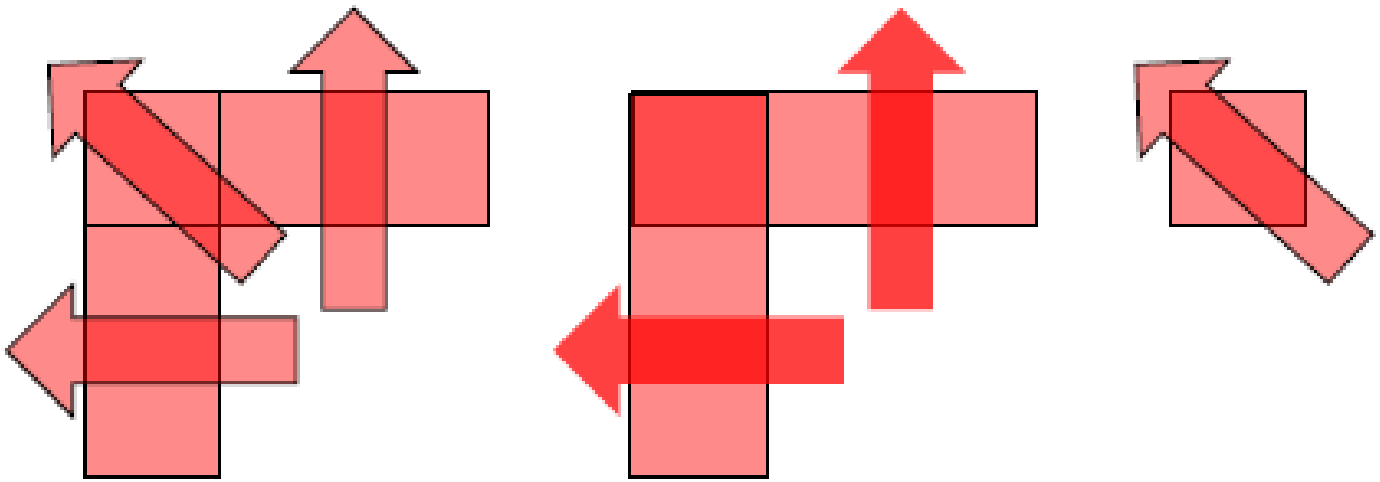
Ψ_e (for PHPP) **0.010** Btu/hr*f*F

ENERGY BALANCE
COMPILING ENERGY LOSSES

Thermal Bridge Pitfall



$$L2D \quad - \quad (U1*A1 + U2*A2) = \psi*L$$

(from THERM)

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ENERGY BALANCE
COMPILING ENERGY LOSSES

PHPP = PASSIVE HOUSE PLANNING PACKAGE

The energy modeling software developed by Passivhaus Institut - Germany

- Climate data input
- Assemblies' R-value Calculation
- Heat loses through the ground
- Areas and Thermal Bridges' input
- Orientation- Windows Input and Shading Analysis

ENERGY BALANCE
COMPILING ENERGY LOSSES

Orientation, Windows Input and Shading Analysis

EnerPHit planning: **REDUCTION FACTOR SOLAR RADIATION, WINDOW U-VALUE**

Building: 51 Pines - Warren VT

Annual heating demand: 7.08 kBTU/(ft²yr)

Heating degree days: 7468 °F.day/yr

Climate: MONTPELIER AP VT - Montpelier AP VT

Window area orientation	Global radiation (cardinal points)	Shading	Dirt	Non-perpendicular incident radiation	Glazing fraction	SHGC	Solar irradiation reduction factor	Window area	Window U-Value	Glazing area	Average global radiation	Transmission losses	Heat gains solar radiation
maximum:	kBTU/(ft²yr)	0.75	0.95	0.85				ft²	BTU/hr.ft².°F	ft²	kBTU/ft²yr	kBTU/yr	kBTU/yr
North	66	0.46	0.95	0.85	0.61	0.37	0.23	13	0.16	8	66	380	73
East	118	0.39	0.95	0.85	0.60	0.37	0.19	42	0.16	25	118	1205	349
South	200	0.35	0.95	0.85	0.67	0.54	0.19	62	0.17	41	200	1828	1270
West	121	0.38	0.95	0.85	0.53	0.37	0.16	25	0.17	13	121	748	177
Horizontal	158	1.00	0.95	0.85	0.00	0.00	0.00	0	0.00	0	158	0	0
	Total or average value for all windows.					0.45	0.19	142	0.16	88		4161	1868

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

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ENERGY BALANCE
COMPILING ENERGY LOSSES

Ventilation Heat Losses

In cases of direct venting, the PHIUS Make Up Air calculator must be used to account for direct venting of:

- Exhaust Dryer
- Exhaust Range Hood at Kitchen

This provided a new CFM average and a new efficiency of the ERV down from the one specified by the manufacturer

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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 overheating
- DHW recirculation line gains if required

And leave the building Net Zero ready

ENERGY BALANCE OPTIMIZATION
Once all losses are accounted for…then

The Primary Energy load is also considered in PHPP since:

- For each kW required on site, the power plant must produce 3.2 kW

- PHPP also correlates this with the source of fuel (coal, natural gas, renewables, etc.) used in generation to calculated the CO2 impact

ENERGY BALANCE OPTIMIZATION

Mechanicals for supplemental heating/cooling & ventilation

Heating / Cooling

- Fujitsu 12000 BTU – Single Source located in the living room

Ventilation

- Lunos e^2 – Two pairs located in the bedrooms and living room
- Lunos eGO – One unit in each bathroom

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51 Upper Pines - / Warren VT
Forecasted Heat Demand &Peak Heat Load

The Passive House Retrofit has a heating demand of only 7655 kBTU/yr for 1440 sqft floor home and a Peak Heat Load of 5139 BTU/hr

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Execution of Second Phase
Inside Slab Insulation

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Remove Old Floor and cover Slab with 5" of PolyIso

Buildings

Execution of Second Phase
Inside Slab Insulation

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Interior floor plywood over ISO board

Execution of Second Phase
Inside Slab Insulation

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Joints and perimeter air sealed

Execution of Second Phase
Finished Floor

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Execution of Second Phase
Outside Frost-Wall Insulation

Dig Trench and cover Frost Wall with 6” of XPS

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Execution of Second Phase Foundation Insulation Complete

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Foundation/floor insulated & Heat pump installed End Phase II

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Begin Phase III Sheathing Removed At South Wall

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear at chimney, actual insulation

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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Rear and West wall sill repair

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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East wall cantilevered beam

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Naked with air sealing at joints

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

stud with tape

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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stud with tape

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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All joints sealed with tape

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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All joints/studs sealed with tape

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Insulation Dam Rear Wall Chimney Cavity

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

East Side air sealed

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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Taped joints overlapped corners

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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Rear wall SPF complete

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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East wall foam complete

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rough opening prep

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Sill, membrane, window

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Air and water sealed

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

South Wall Partially Foamed

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Third Phase
Insulation of Walls and Replacement of Windows

West Wall Foam Complete

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear wall
1st Layer
3” ISO

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

West Wall
ISO
Complete

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

First layer of 3” ISO board with window box

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

1st layer ISO sealed, second layer installed

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

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Typical 1st layer sealing

Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

1st ISO taped to XPS found insulation

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Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Rear 2nd Layer ISO w/strapping

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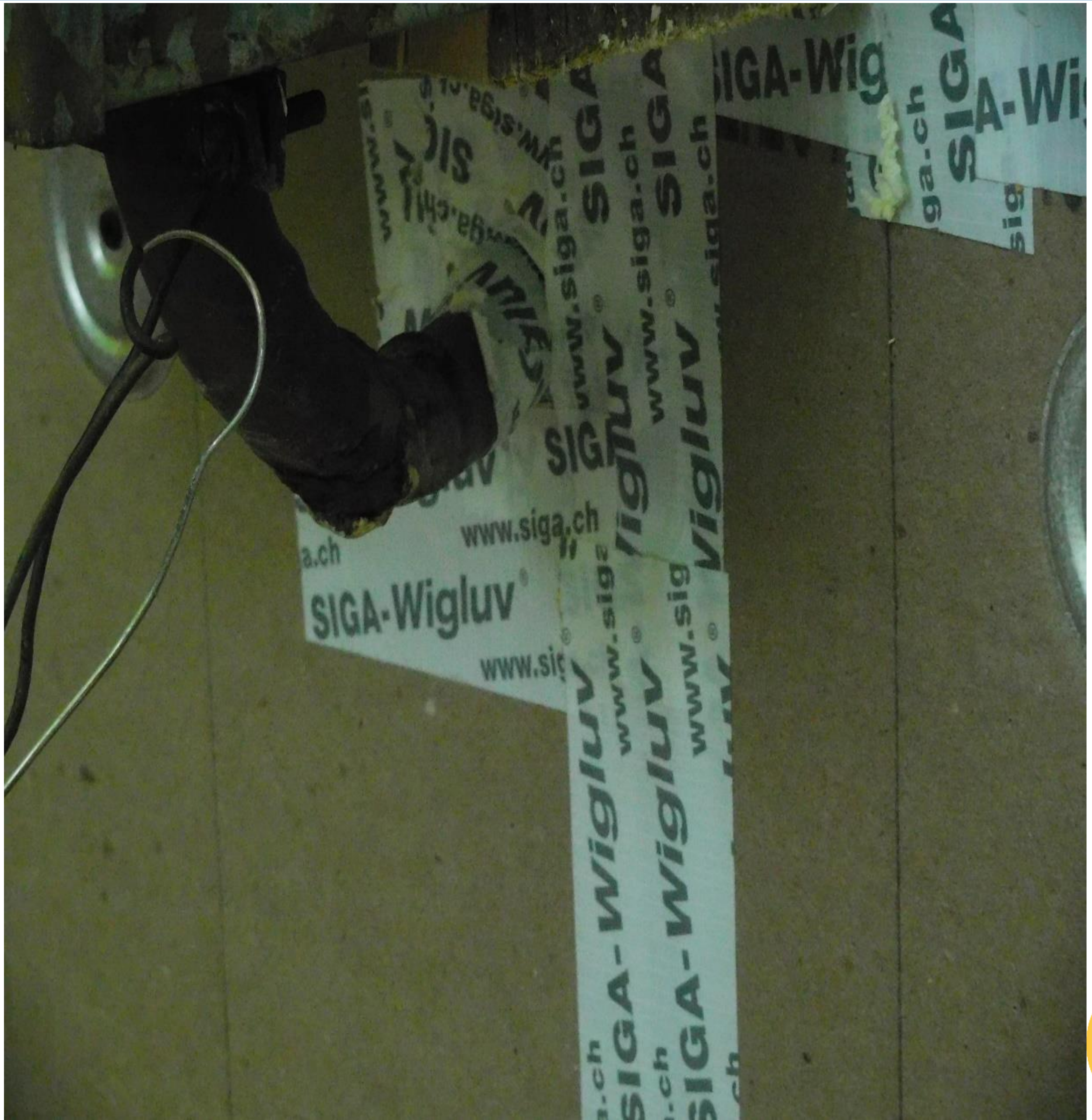
Third Phase
Air-Sealing/Insulation of Walls and Replacement of Windows

Air seal penetrations



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Third Phase
Siding Finishing

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Buildings

Third Phase
Siding Finishing

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Buildings

End
Third Phase

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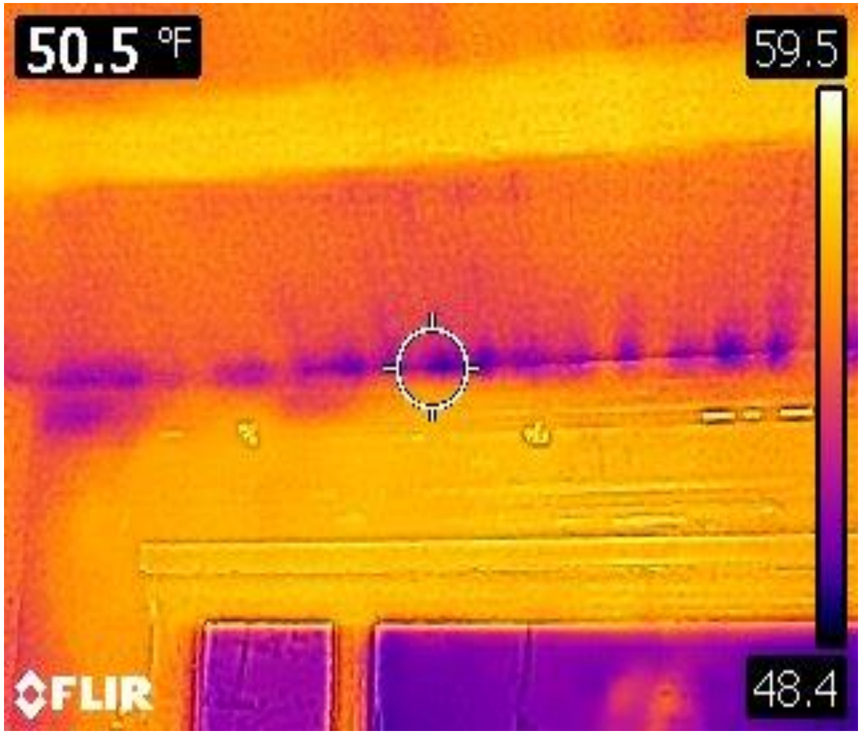
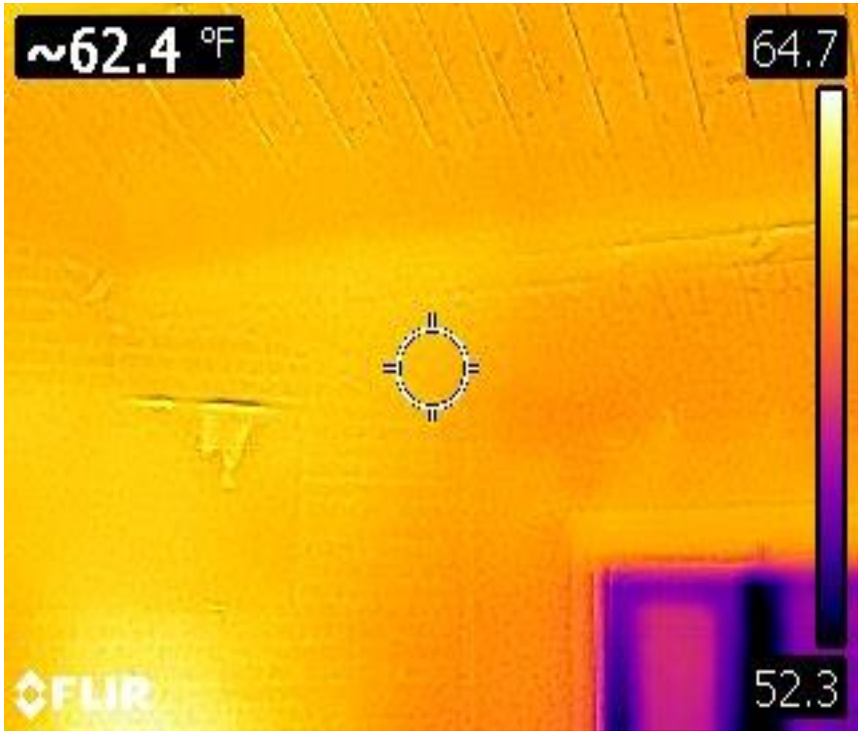
Buildings

End Results
Third Phase

Living Room East

Before - After





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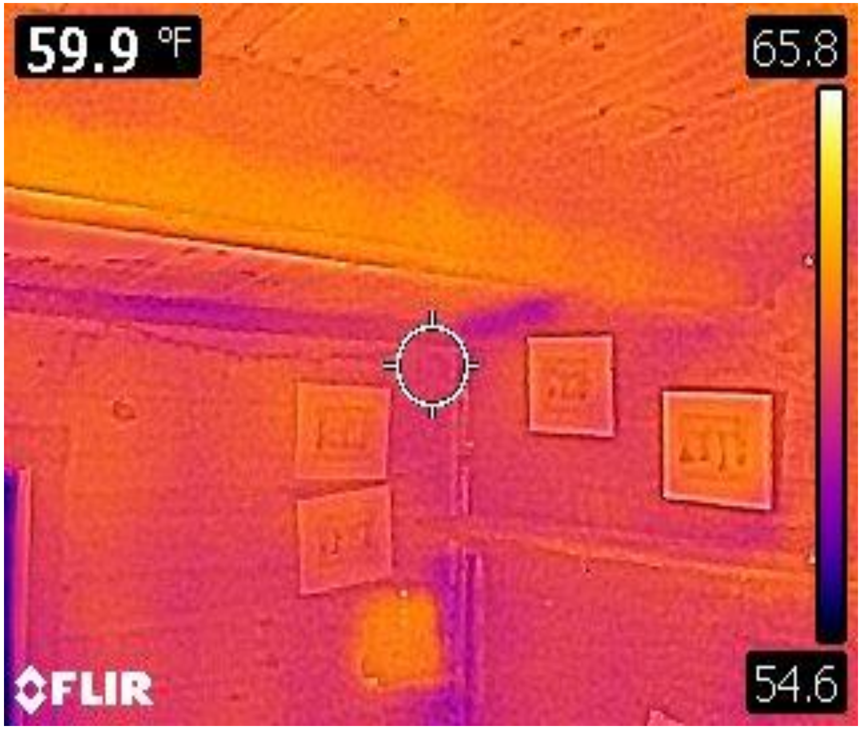
End Results
Third Phase

2^{nd} floor BR rear

Before - After



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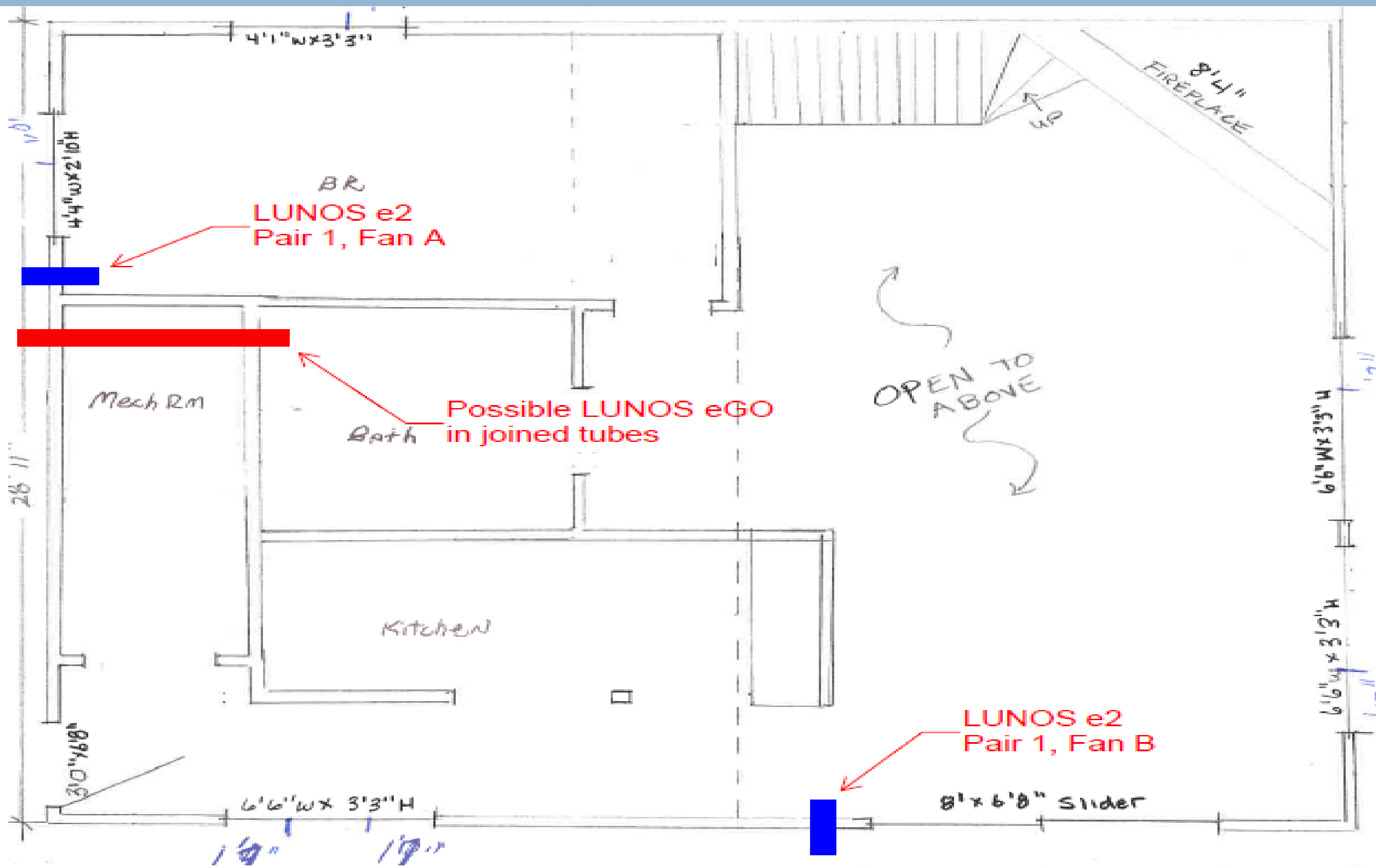
Mechanicals

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

Lunos e^2

Lunos eGO

Ventilation ERV's Locations 1st Floor



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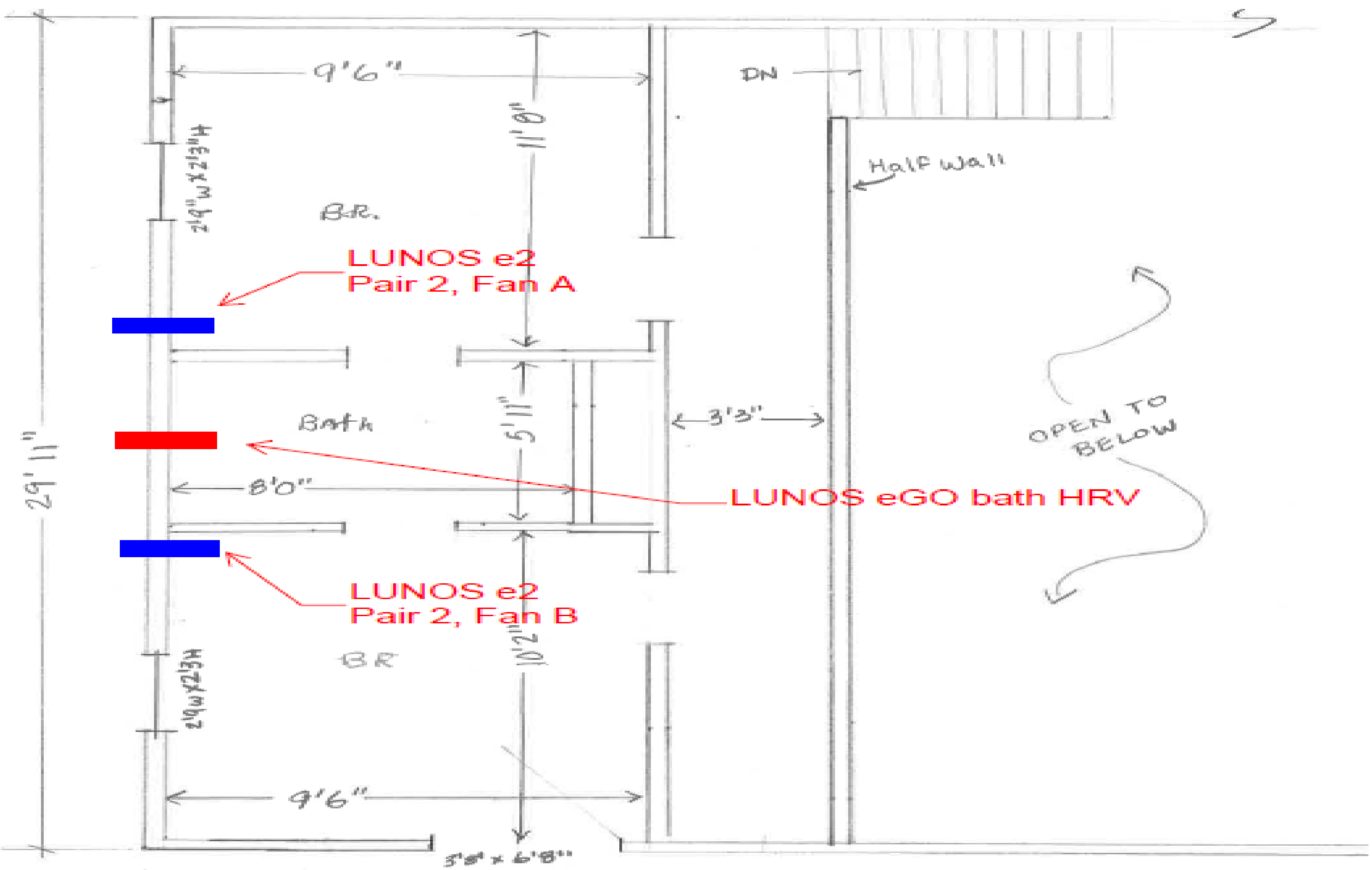
Ventilation ERV's Locations 2nd Floor



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Final Results
Blower Door Test

The final Blower Door Test was

48cfm@50Pa

a reduction of **97%** air infiltration from the**1740 CFM** (10 ACH50) in the initial condition

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Final Results
Blower Door Test

48cfm@50Pa

Is equivalent to

0.27 ACH50

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Buildings

Passive House Planning Package – PHPP modeling comparison

Estimated BEFORE Renovation

Space heating	Heating demand	65.25	kBTU/(ft²yr)	870% of	7.50 kBTU/(ft²yr)
	Heating load	36.58	BTU/(hr.ft²)	717% of	5.10
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	118.0	kBTU/(ft²yr)	167% of	70.6 kBTU/(ft²yr)

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Buildings

Passive House Planning Package – PHPP modeling comparison

Forecasted with Renovation

Space heating	Heating demand	6.39	kBTU/(ft²yr)	85% of	7.50 kBTU/(ft²yr)
	Heating load	4.29	BTU/(hr.ft²)	84% of	5.10
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	54.5	kBTU/(ft²yr)	77% of	70.6 kBTU/(ft²yr)

90% Reduction in Heating Demand

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THE TAKE-AWAY

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

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Thank you

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Because we care about you saving money and living healthy, and care about the environment, our legacy and our future, we make

energy efficient buildings.

Enrique Bueno – ebueno@eplusbuildings.com

Paul Sipple – necco@gmavt.net

CPHC®

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