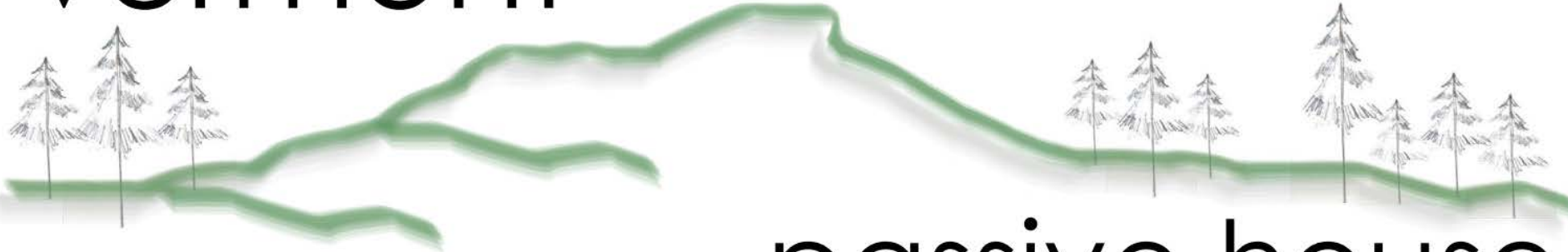


vermont



passive house



Energy Efficient Buildings



Passive House Buildings – VT Building Code Upgrade

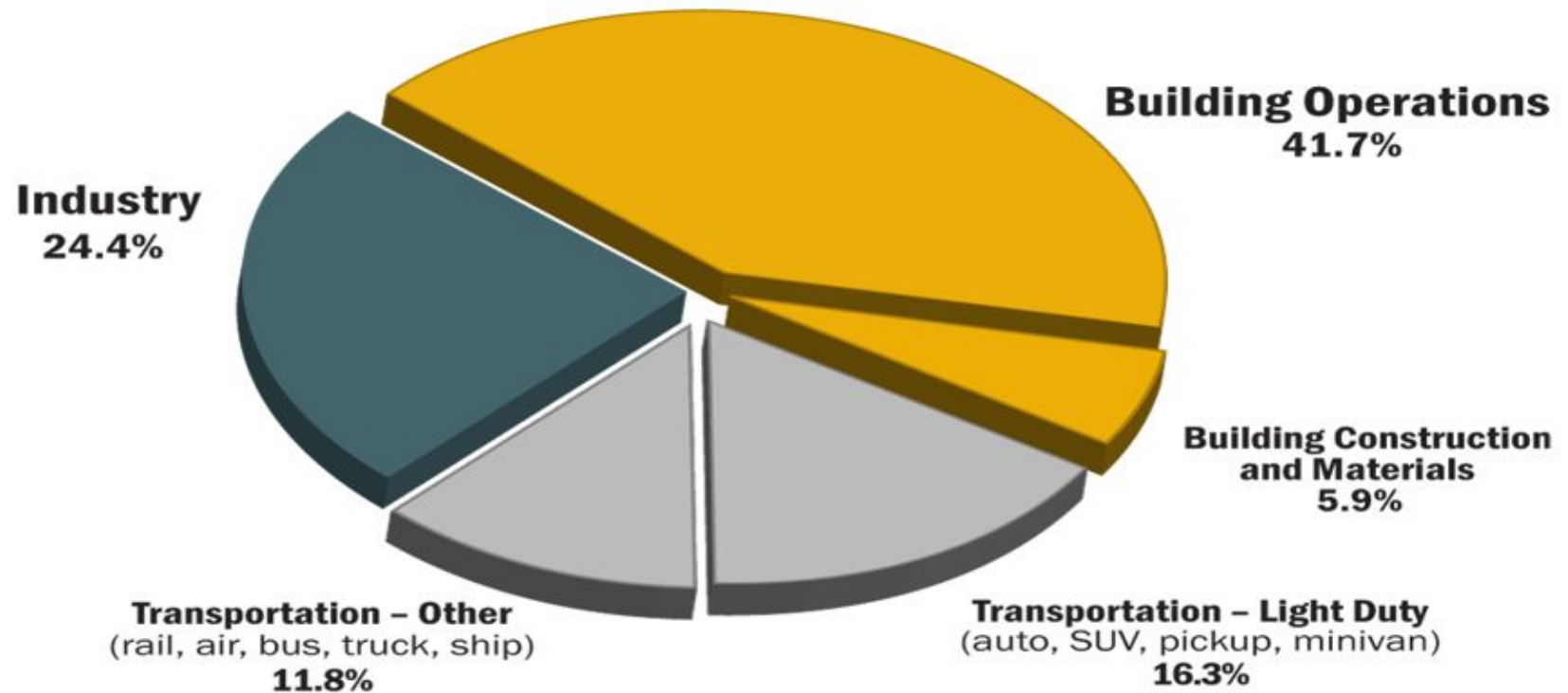
Implementing the Passive House Building Standard to minimize the energy intensity in buildings

Senator P. Leahy
Senator B. Sander
Congressman P. Welch

www.vtph.org

December 17, 2018

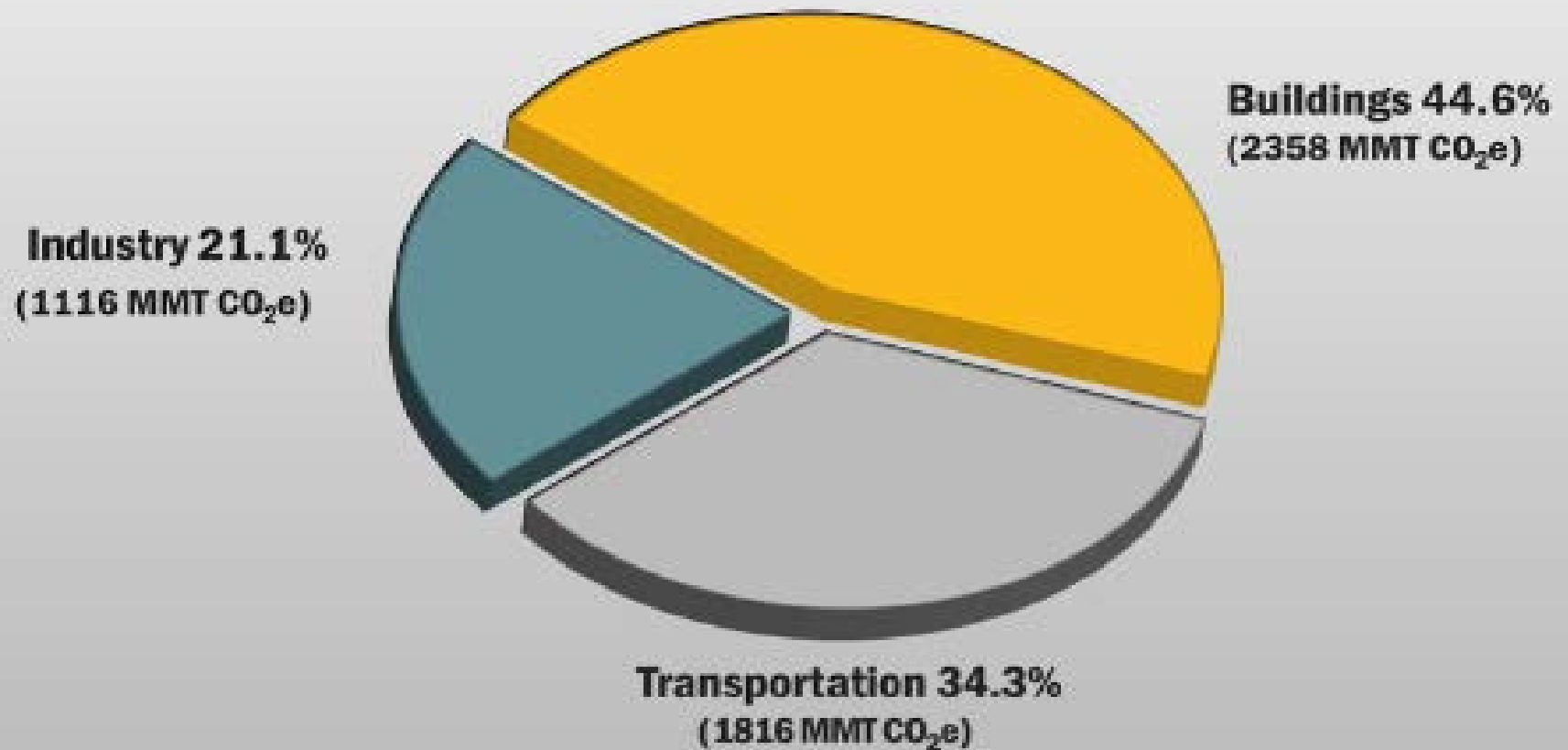
The Problem



U.S. Energy Consumption by Sector

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

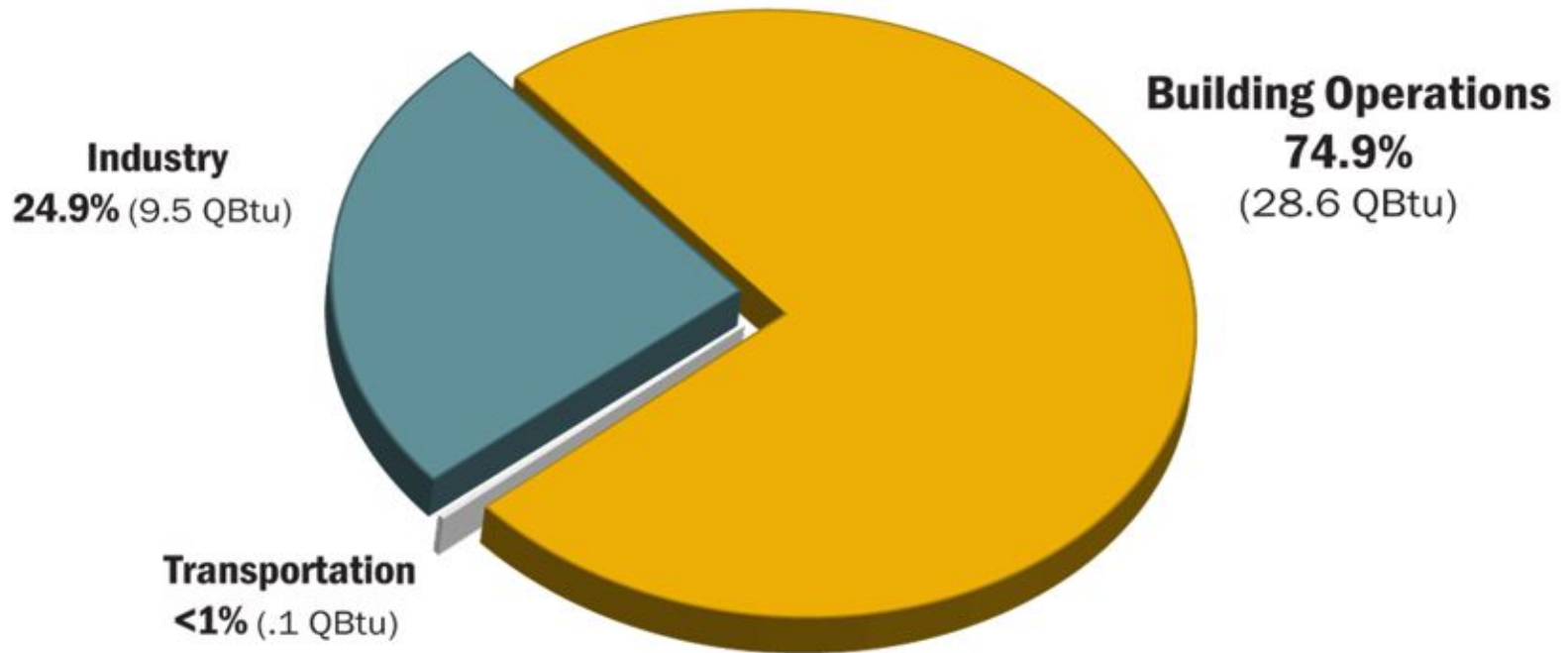
The Problem



U.S. CO₂ Emissions by Sector

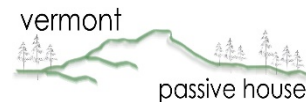
Source: ©2013 2030, Inc. / Architecture 2030. All Rights Reserved.
Data Source: U.S. Energy Information Administration (2012).

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).

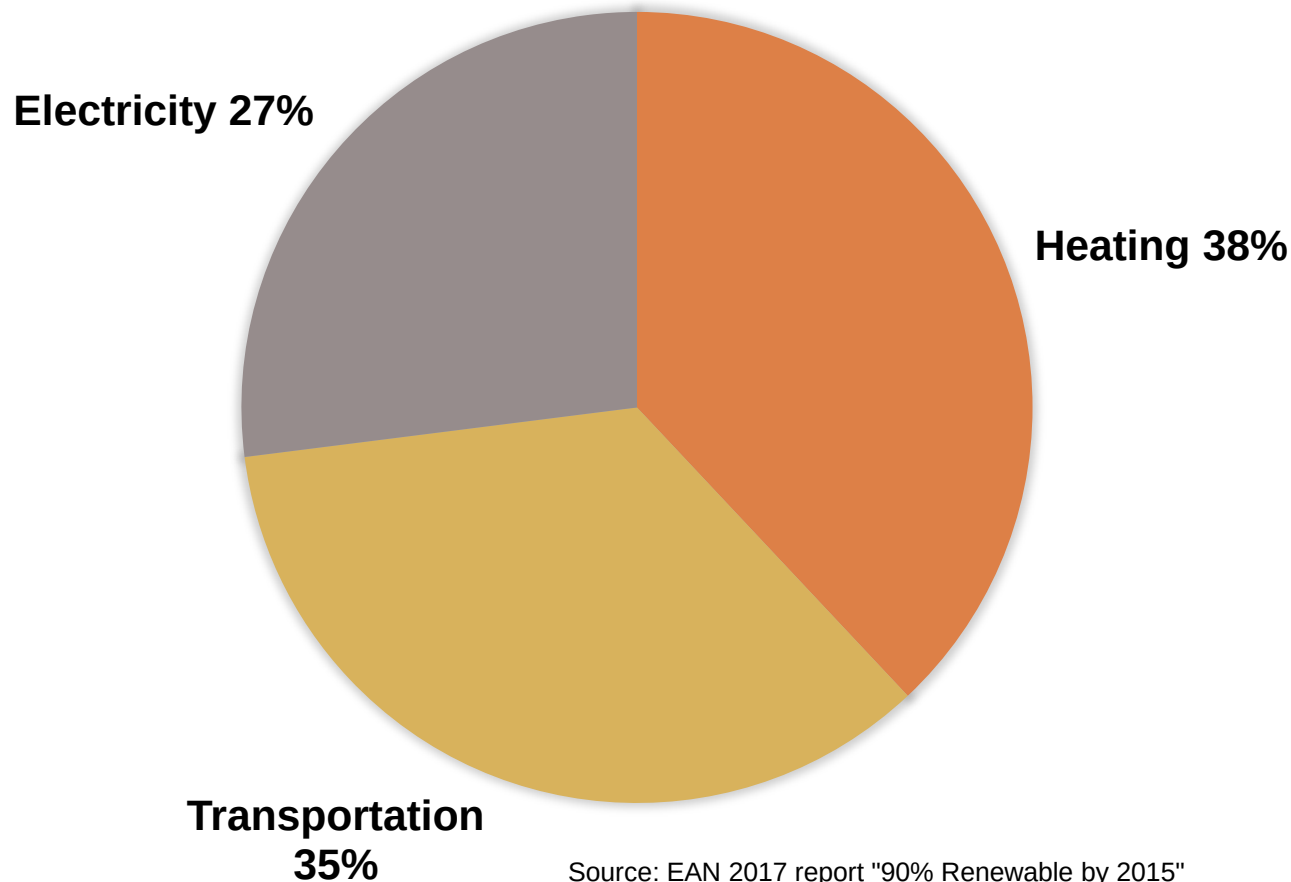


*US-EIA 2014

The Problem in VT

76% of Heating comes from Fossil Fuels

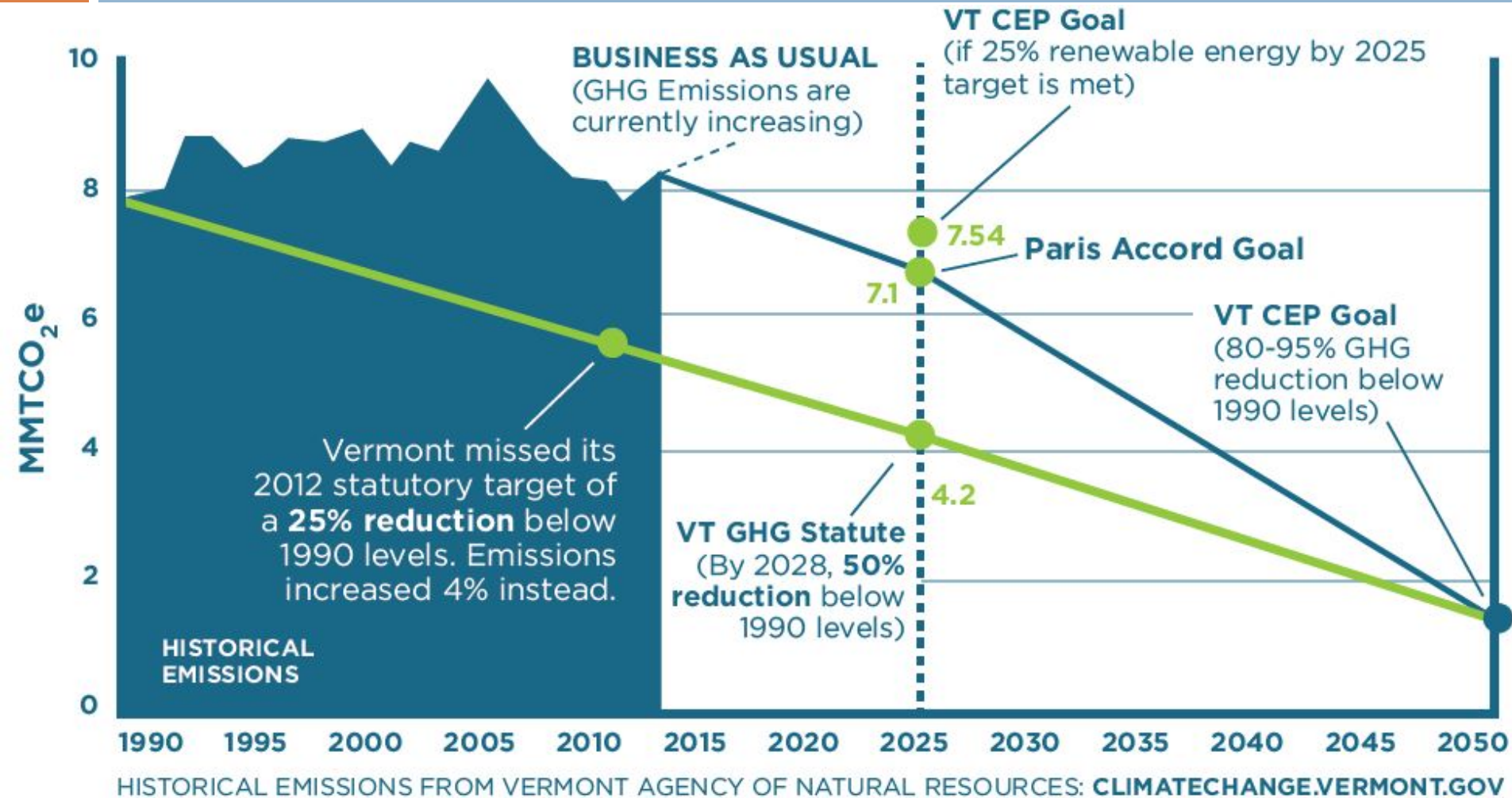
VT ENERGY USE
BY SECTOR



Source: EAN 2017 report "90% Renewable by 2015"

The Problem in VT

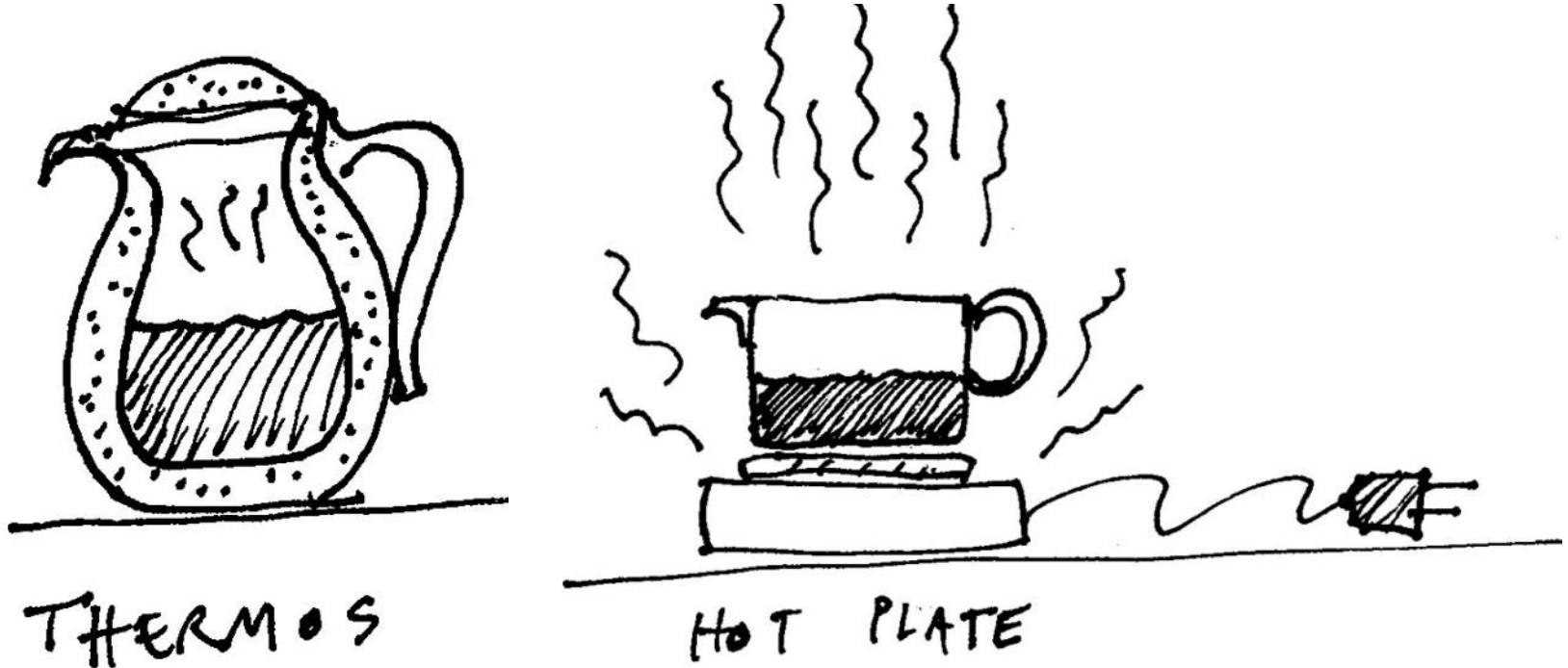
**VT's CO₂ emissions increased by 11% from 2012 to 2015
by 2015 we were 55% above the goal**



Source: EAN 2017 report "90% Renewable by 2015"

Contributing to the Solution

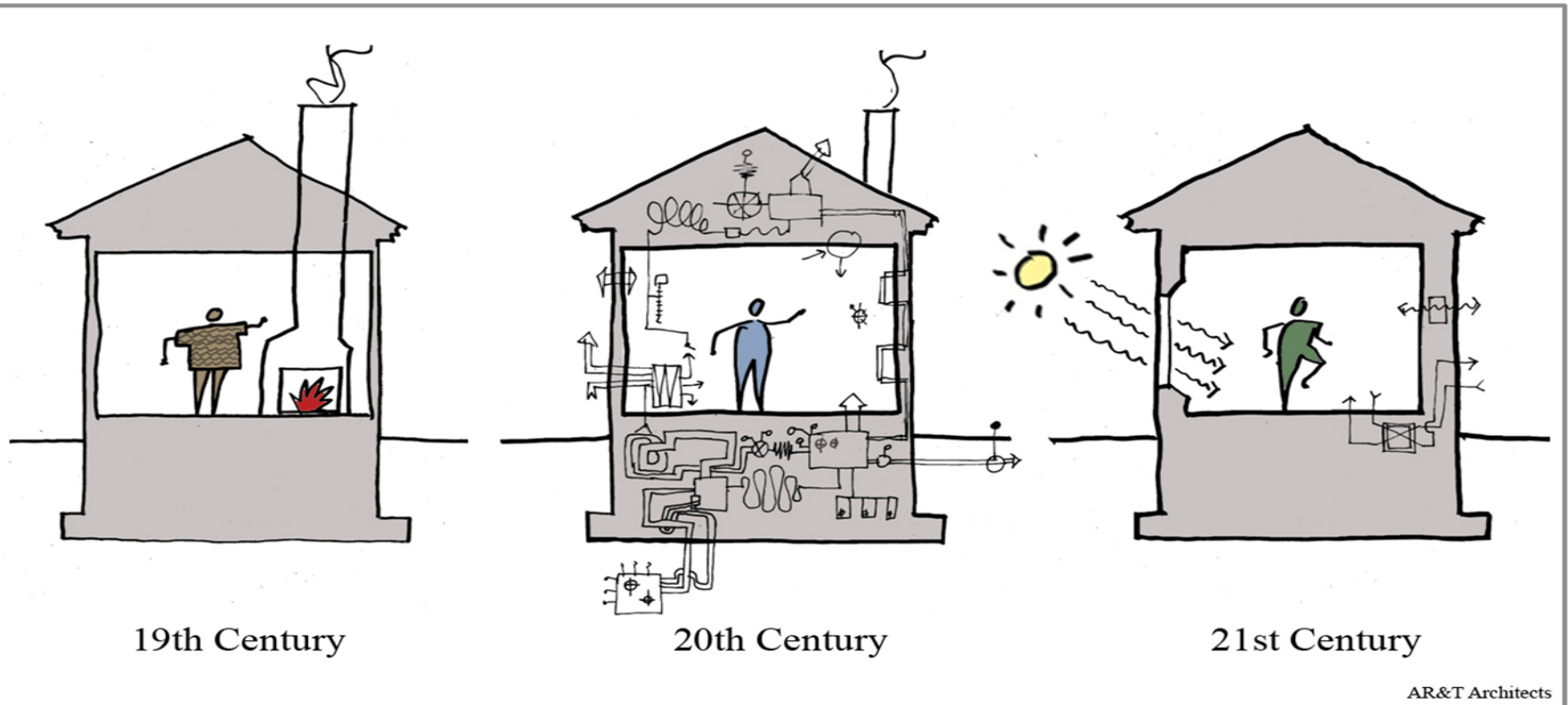
The Passive House Approach



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

Passive House Moves Toward Simplicity

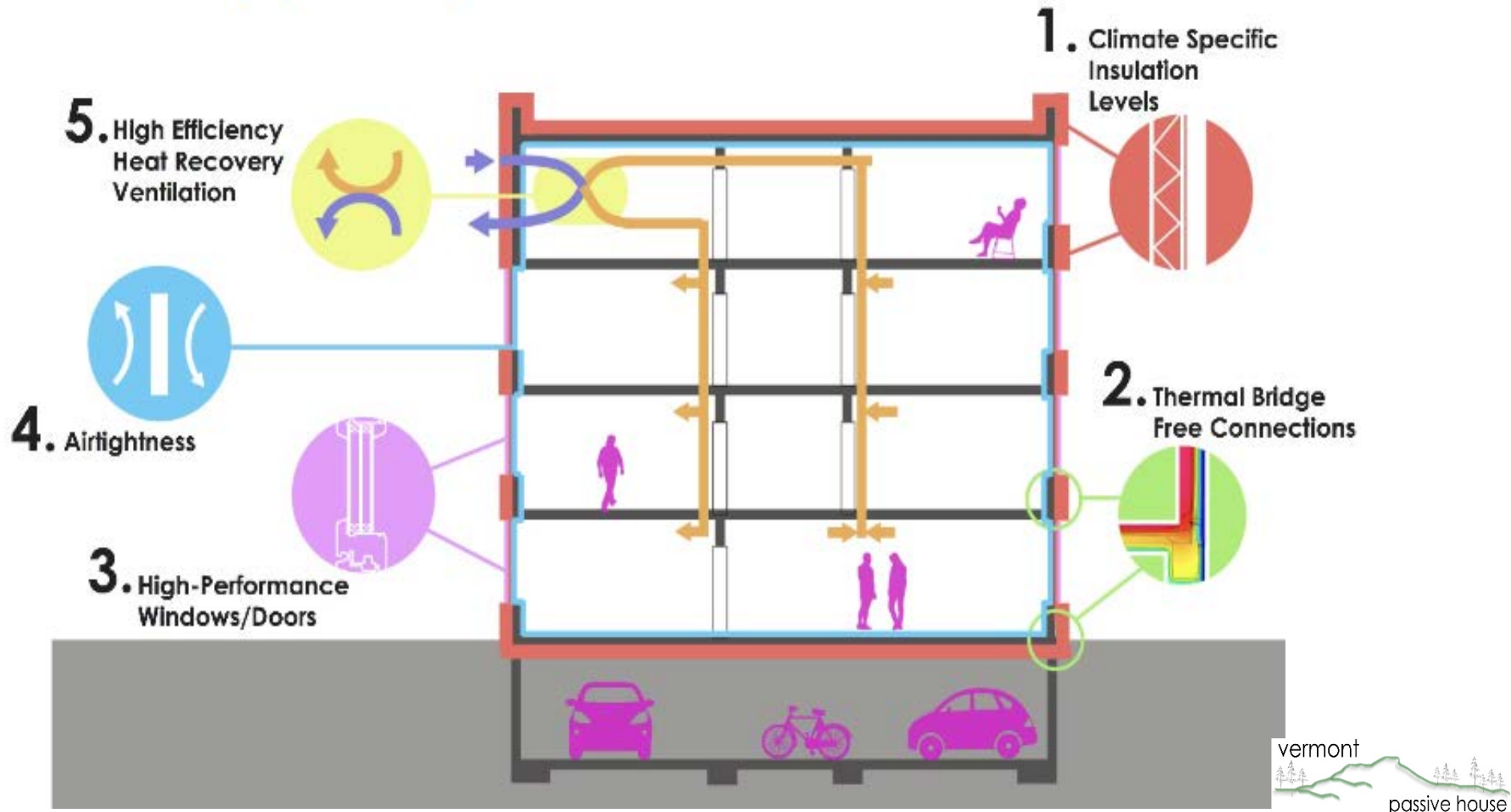
Moving Towards Simplicity



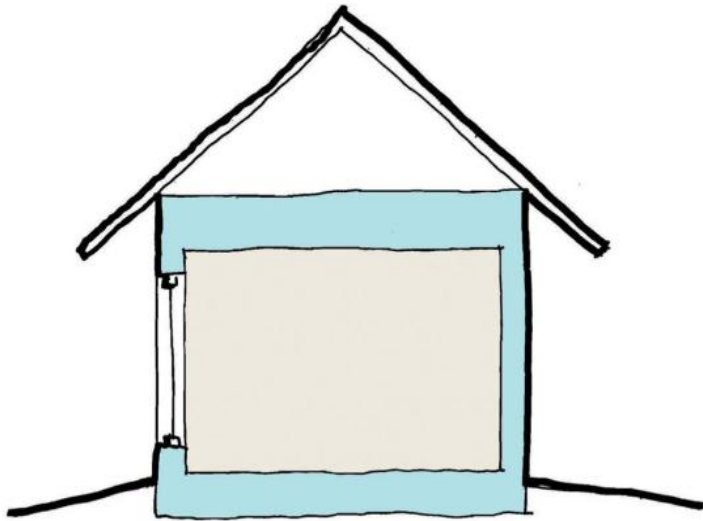
AR&T Architects

PASSIVE BUILDING PRINCIPLES

Five key principles:



Appropriate level of thermal **INSULATION** to control energy loss

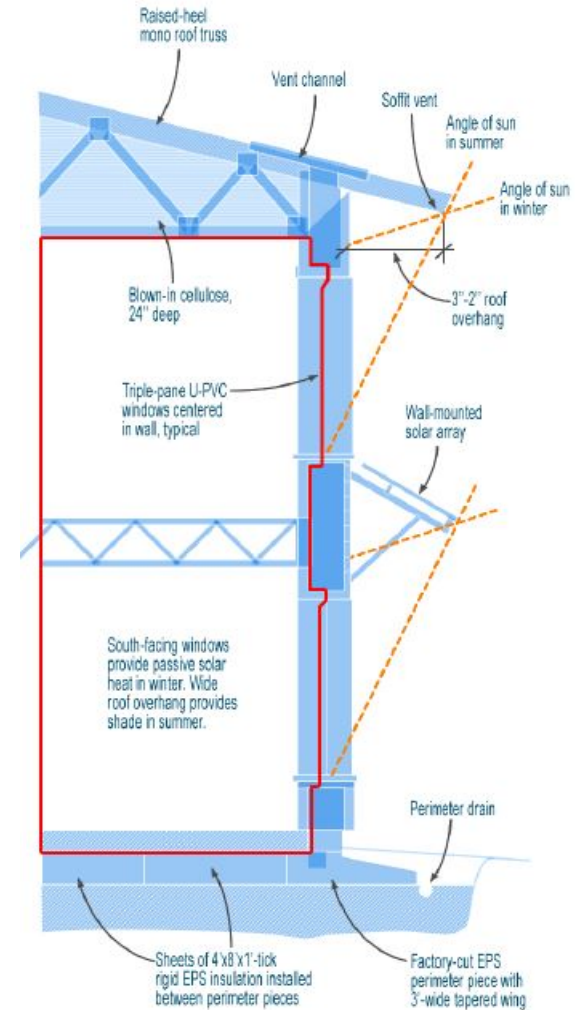


For Climate Zone 6

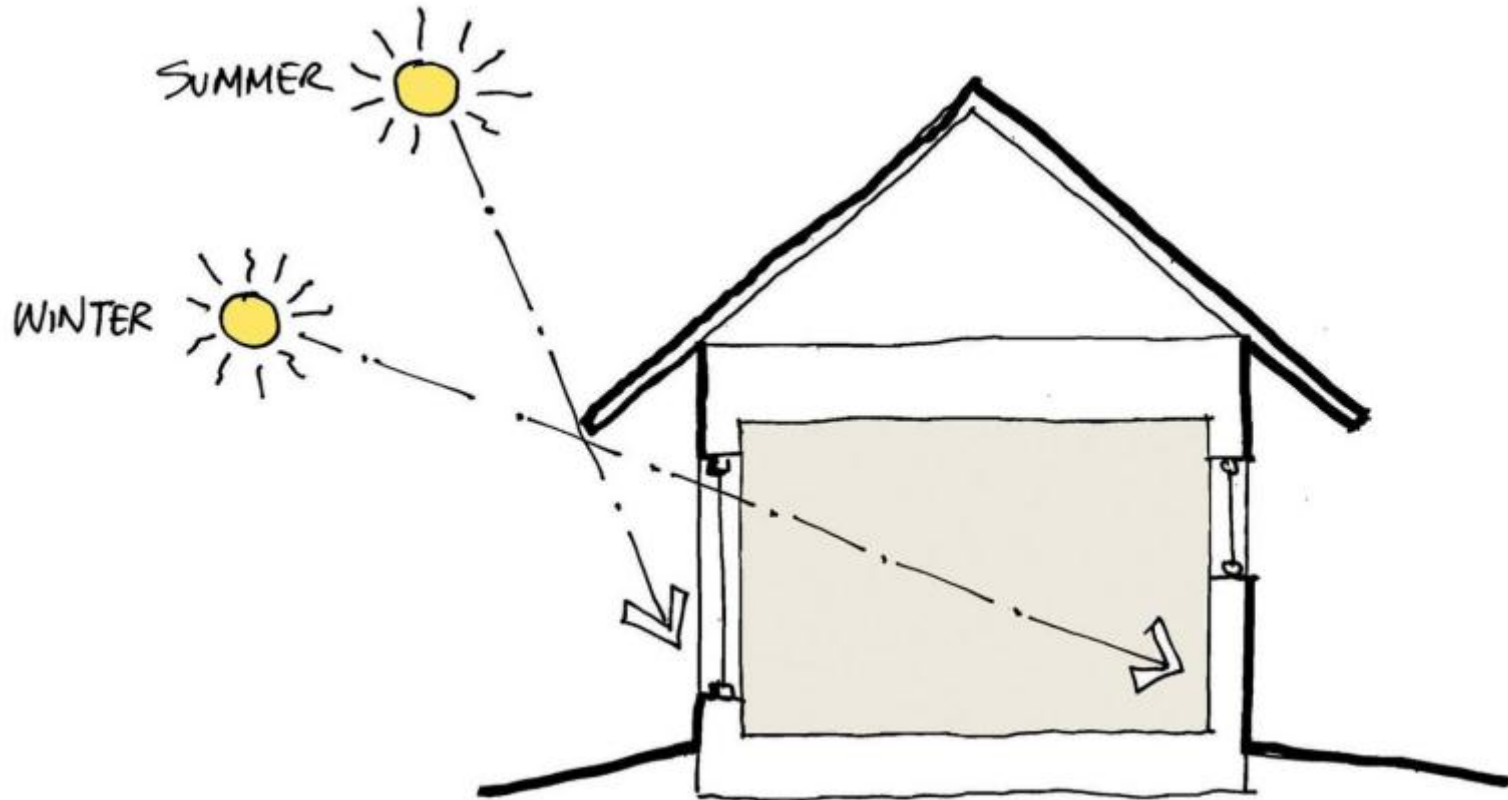
R60 WALLS: R90 CEILING: R60 SLAB

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.

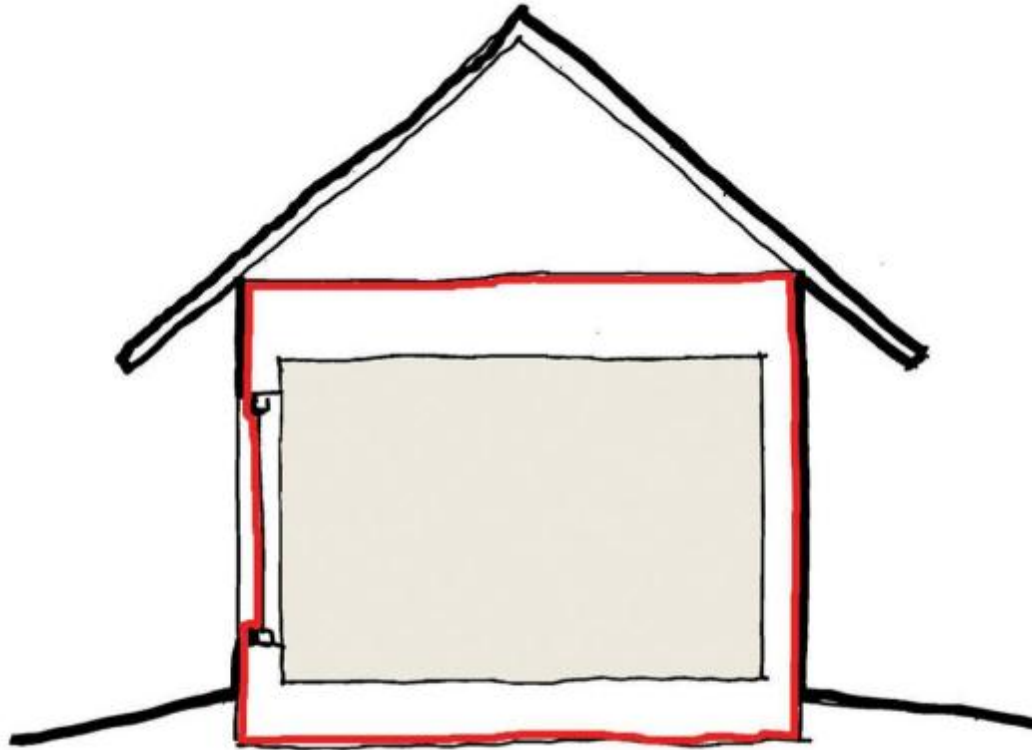


Controlling Solar Gains Seasonally Through Windows and Orientation



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

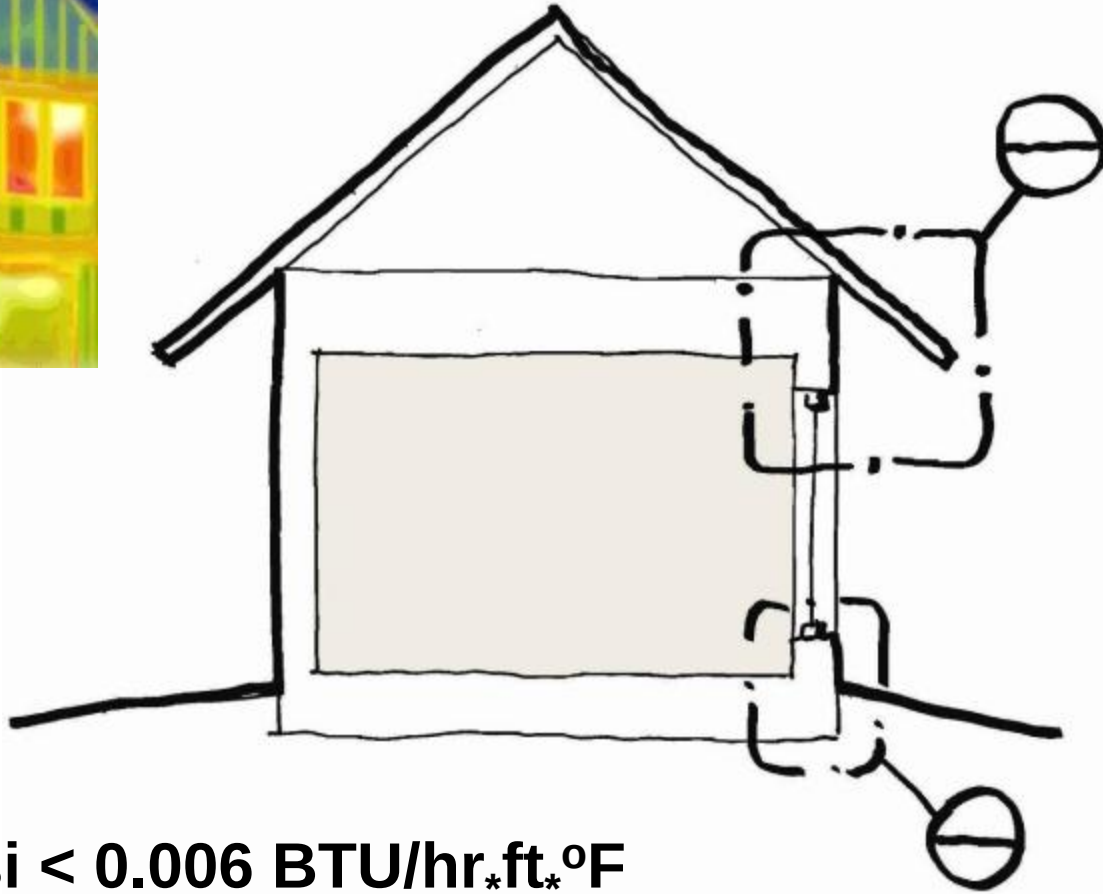
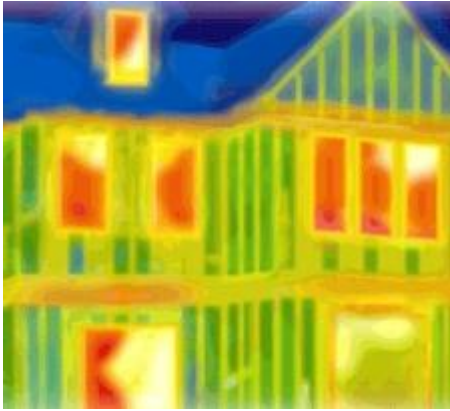
Controlling Energy Loss by Eliminating Air In/Ex-filtration



Max. 0.6 ACH @ 50 PA (based on interior floor area)

Max. 0.05 cfm/gross sqft shell @ 50 PA

Controlling Energy Loss by Eliminating Thermal Bridges

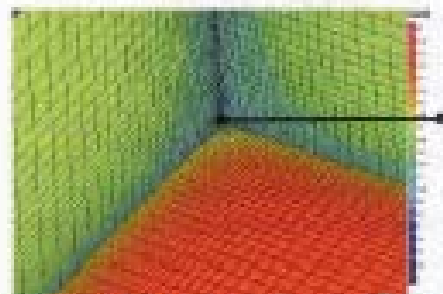
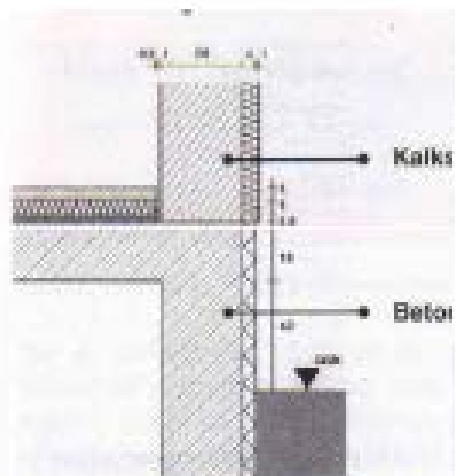


$\Psi < 0.006 \text{ BTU/hr}\cdot\text{ft}\cdot^{\circ}\text{F}$

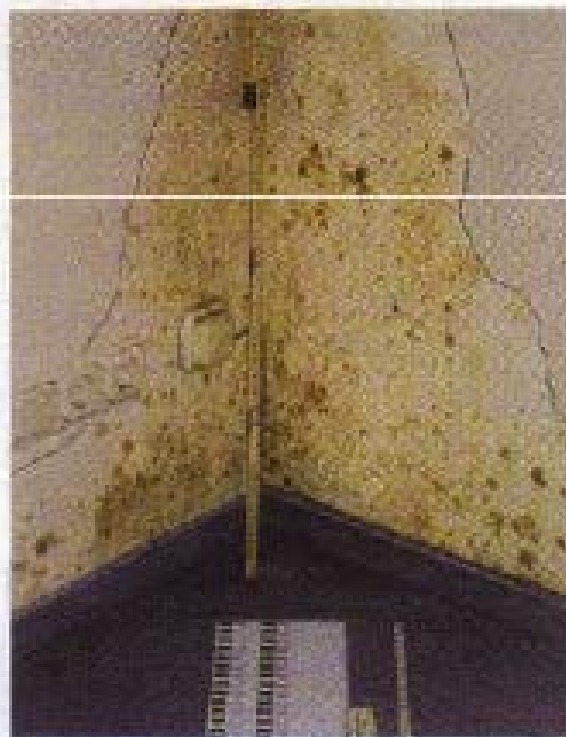
MINIMIZE LOSS:

ELIMINATING THE THERMAL BRIDGE MINIMIZES HEAT LOSS
CONDENSATION/BUILDING DETERIORATION

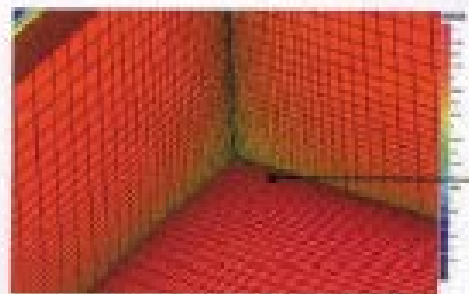
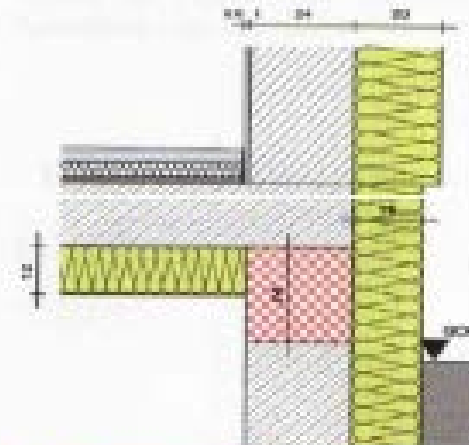
BAD = high heat loss + risk of
condensation



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 Standard

Accounts for Internal Heat Gains - People



Passive House Standard

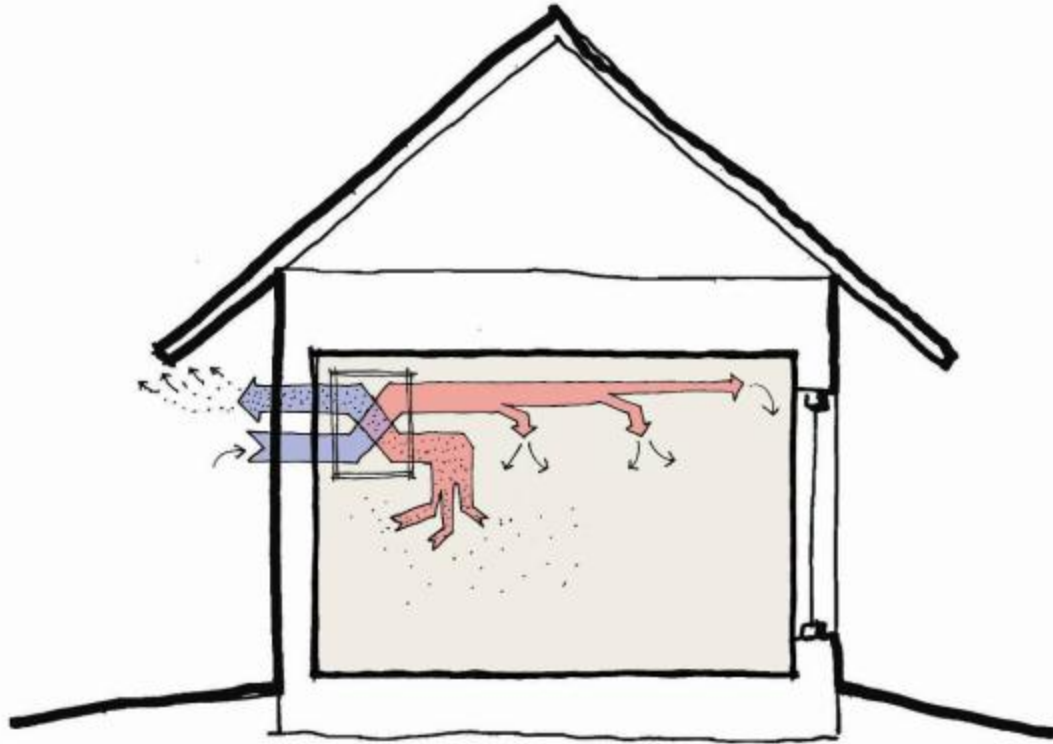
Accounts for Internal Heat Gains - Appliances



... and appliances efficiency

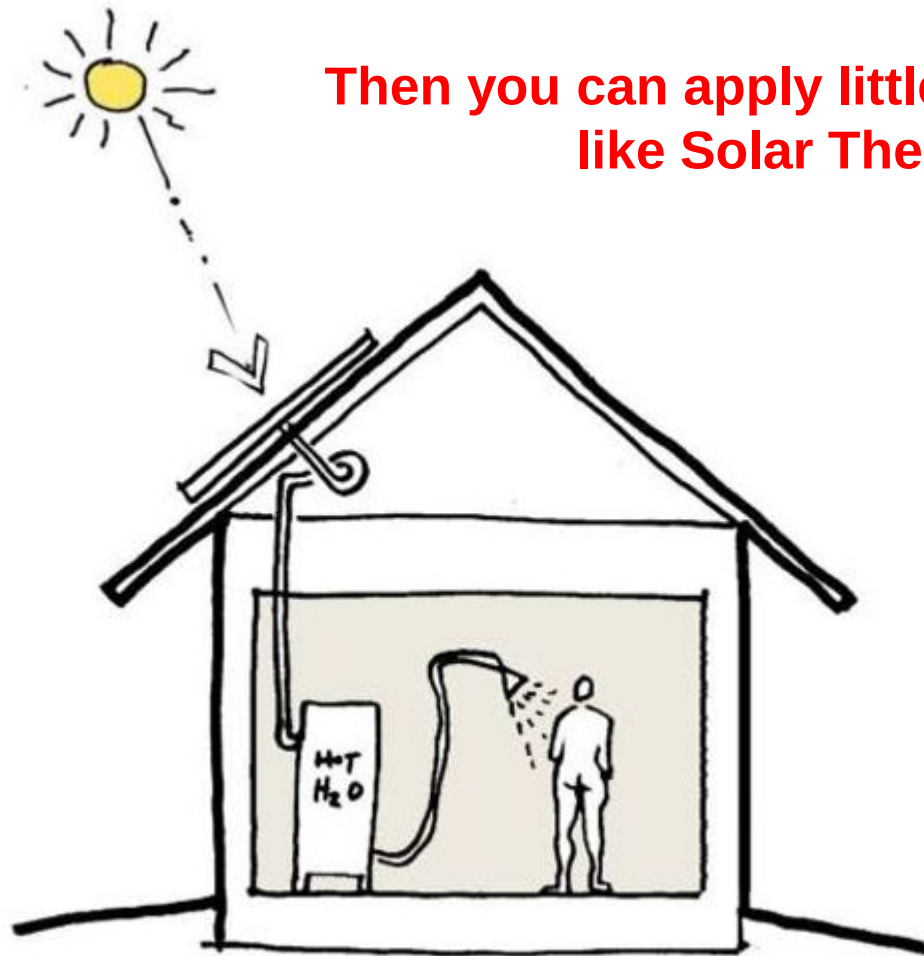
Passive House Standard

Provides Fresh Air via Heat/Energy Recovery Ventilation



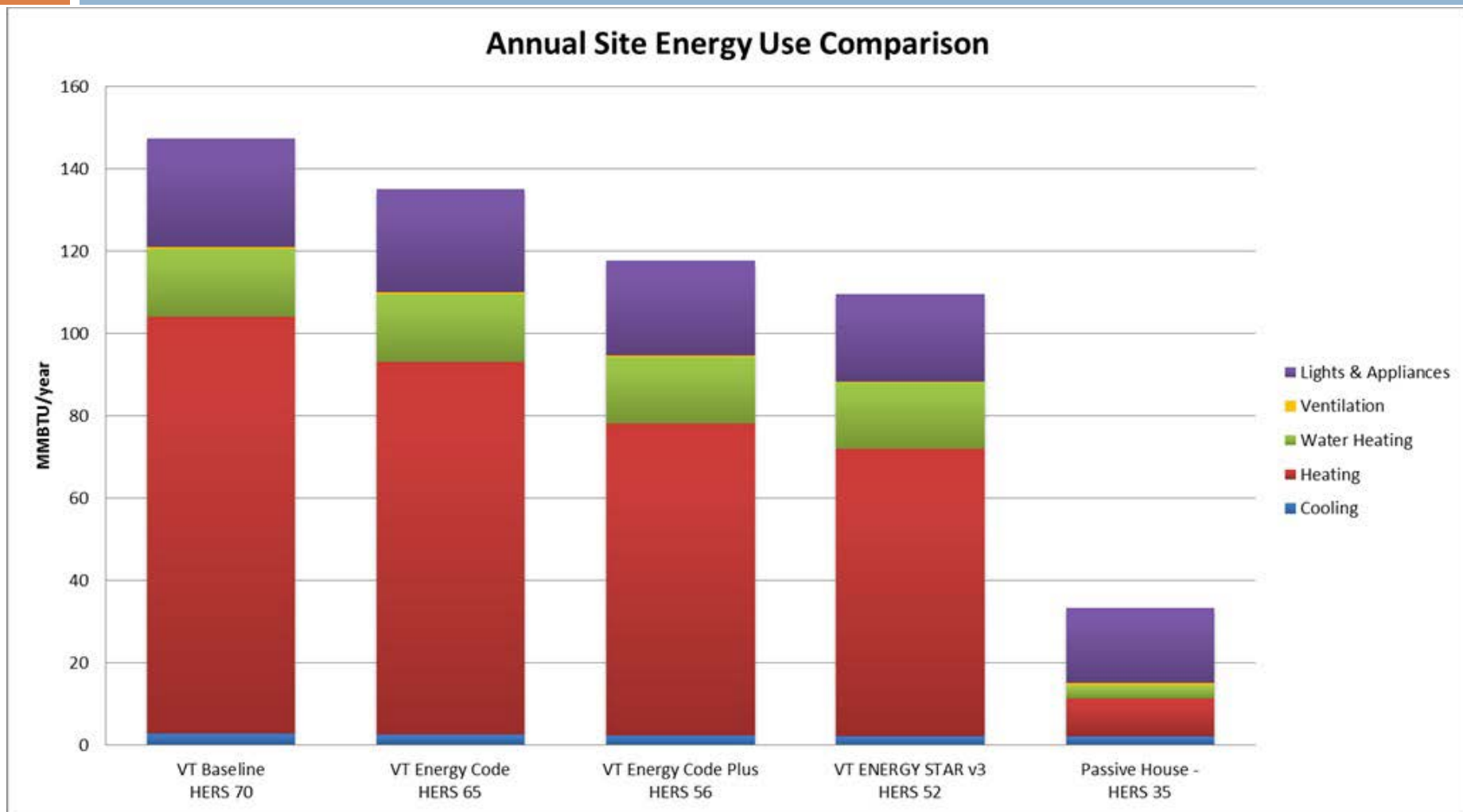
MINIMUM of 0.30 ACH

Passive House Concept: Once the Wasted Energy is Reduced to the minimum...



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

Energy Usage Comparison

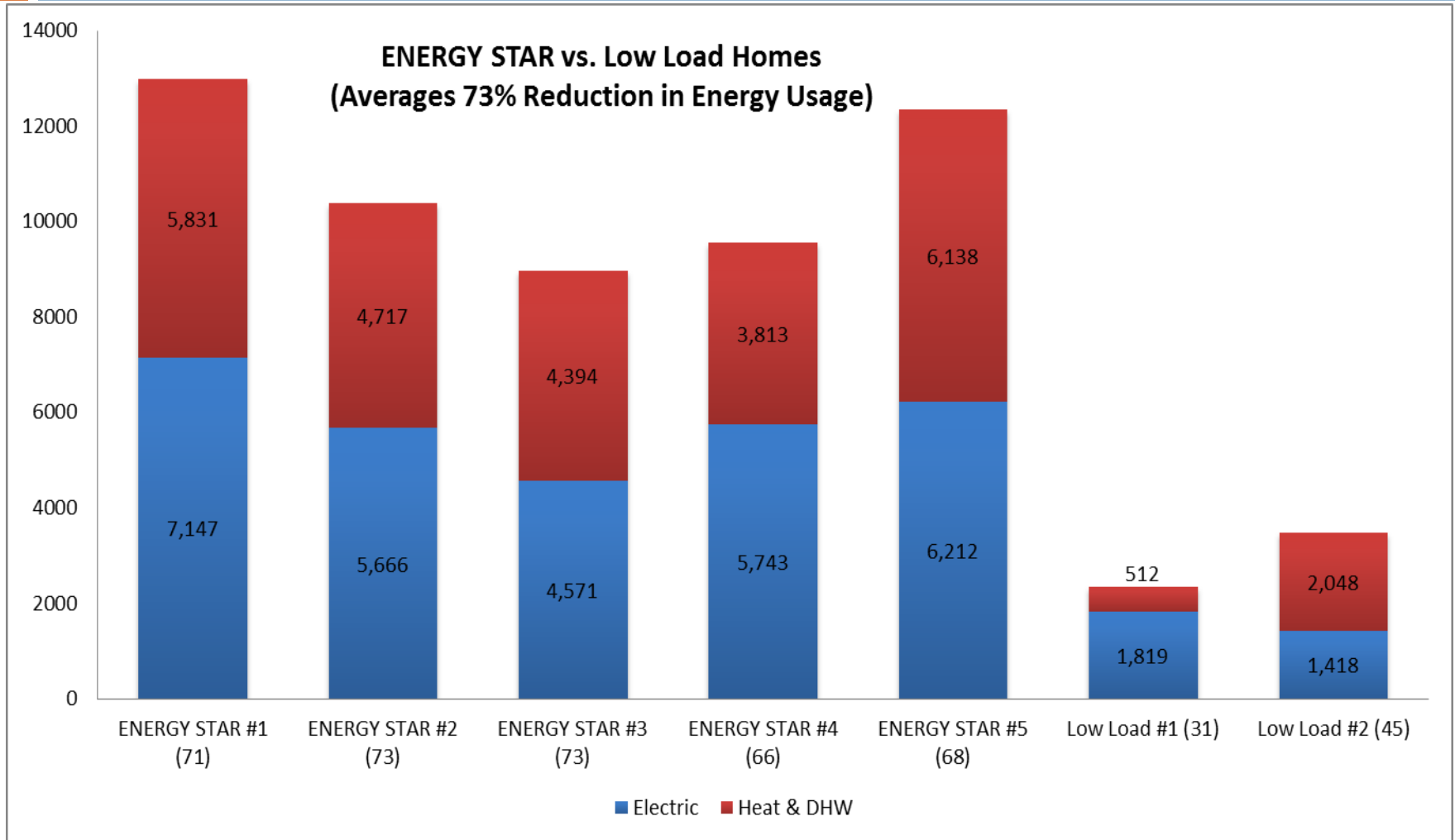


How does it relate to other programs?

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 VT Building 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?



Source: Efficiency VT

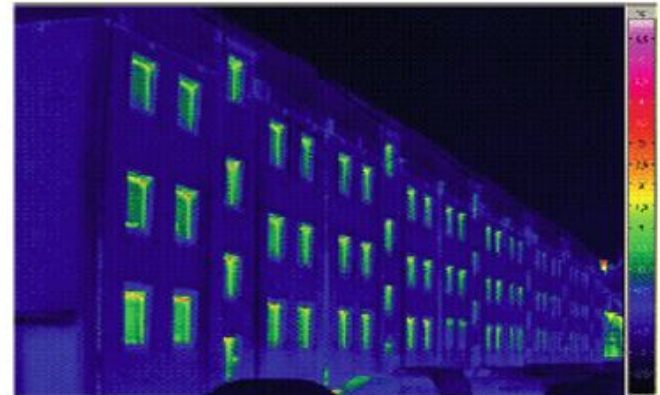
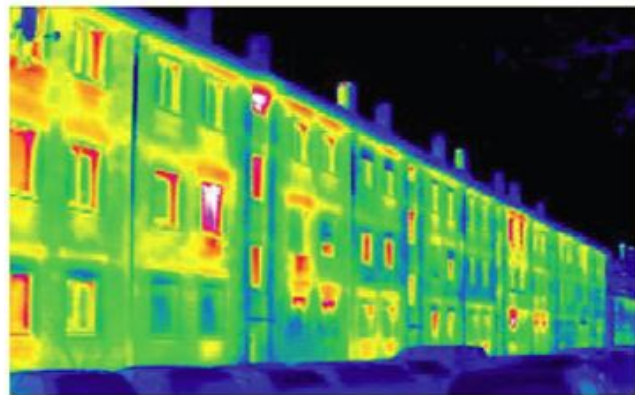
How does it relate to other programs?

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



It is not Rocket Science and applies to retrofits too

Frankfurt Teverstrasse, Refurbishment using Passive House Principles



Source: Passivehouse Institute / DENA

McKeesport Downtown Housing (Residential)

McKeesport, PA

84 units - 36643 sqft



51 Upper Pines 1440 sqft - / Warren VT

90% Reduction in Heating Demand

Before estimated
Heating Demand 62.25 kBTU/ft²-yr
Heating Load 36.58 BTU/(hr-ft²)



After
Heating Demand 6.39 kBTU/ft²-yr
or 9200 kBTU/yr
Peak Heat Load 4.29 BTU/hr-ft²
or 6435 BTU/hr

51 Upper Pines - / Warren VT

Actual Total Energy Usage 2017-08 to 2018-08

On Site Energy Comparison	kWh/yr
Estimated before retrofit	15563
Forecasted in PHPP with retrofit	7188
PHIUS+ 2015 Threshold (4 occupants)	7750
Actual 12 month usage (4 occupants)	7121

54% less total energy consumption

Passive House Projects North East USA



Handel Architects

High Rise – Cornell-Tech - NYC



School

Portland ME



**Affordable Senior Housing
Milton VT**



**Affordable Housing
Brewer - ME**

East Harlem - NYC

East 111th Street development



Mixed-use, 655 affordable apartments complex including

- Seniors' housing
- Harlem RBI/Dream Charter School
- YMCA facility
- Mount Sinai Health Center
- Urban Market & Retail Space
- Public gardens

Income from \$19,050 to \$106,080

Rendering Courtesy of Handel Architects

Village Center Apartments

Brewer, ME



48 Affordable
Housing Units
51,778 SqFt
Interior Floor Area
1,2 & 3 Bedroom
units
3 common areas
1 dog washing
room
\$135/sqft

Gilford Village Knolls III

New Hampshire



**Multifamily
Affordable
Senior Housing
24 Units
20,571 ft²**

PH Projects Vermont



**THIRD ANNUAL PASSIVE
PROJECTS COMPETITION
WINNERS!**

**ELM PLACE -
Best Overall
Passive Building
Winner**

Multifamily project category Winner
Affordable project category Honorable
Mention

2017 PHIUS Passive House Projects
Competition

**83% less energy for heating/cooling
@ only 2% more than
conventional building cost**

Elm Place Senior Housing Milton-VT

Predicted Heat Load



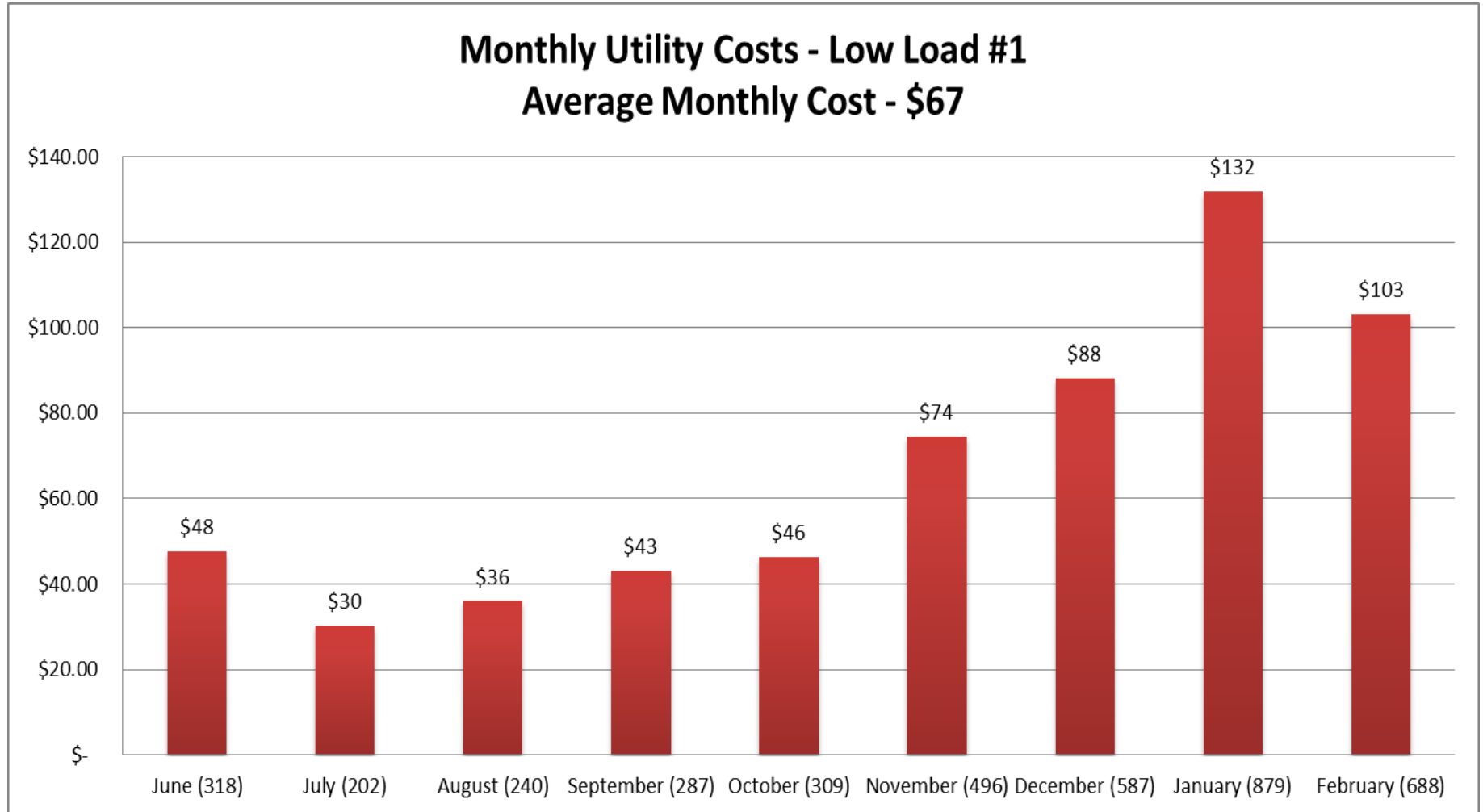
**Only 127,651 kBTU/yr at 2°F
for 27,690 sqft floor area
A 20 kW PV rooftop array produces
67,085 kBTU/yr**

Habitat for Humanity Charlotte - VT



Habitat for Humanity

Charlotte - VT



Source: Efficiency VT 2012

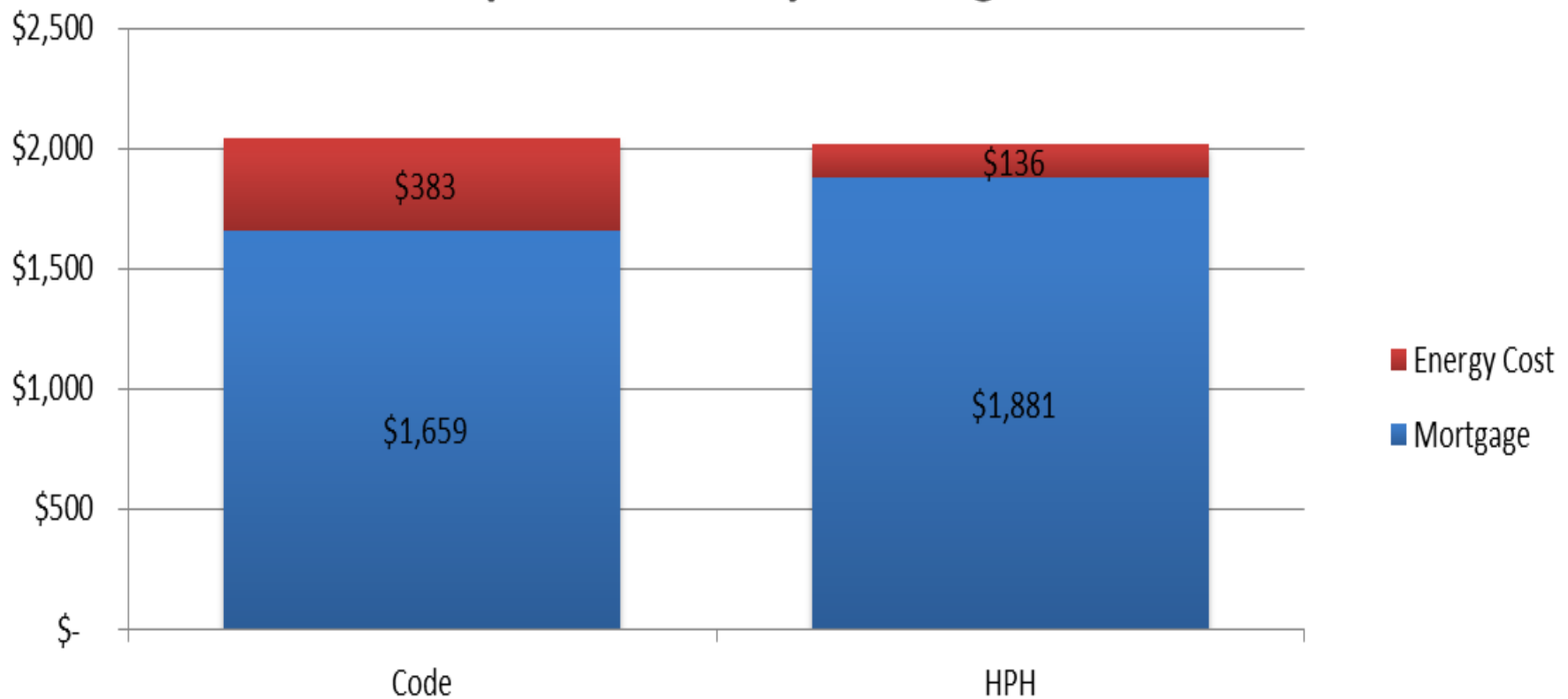
Habitat for Humanity East Montpelier



Total energy used = 4704 kWh from 6/2017 to 6/2018
\$61/month average at \$0.156/kWh - all energy
plug loads, heating, cooling and DHW !!

Cost Analysis for HPH Home

Snapshot Monthly Housing Cost





The Arnold Development Group LLC

Environmental Benefits



Kansas City High Rise

Building Size 277,512 SF

Site Energy **40,703,695** kBtu/yr

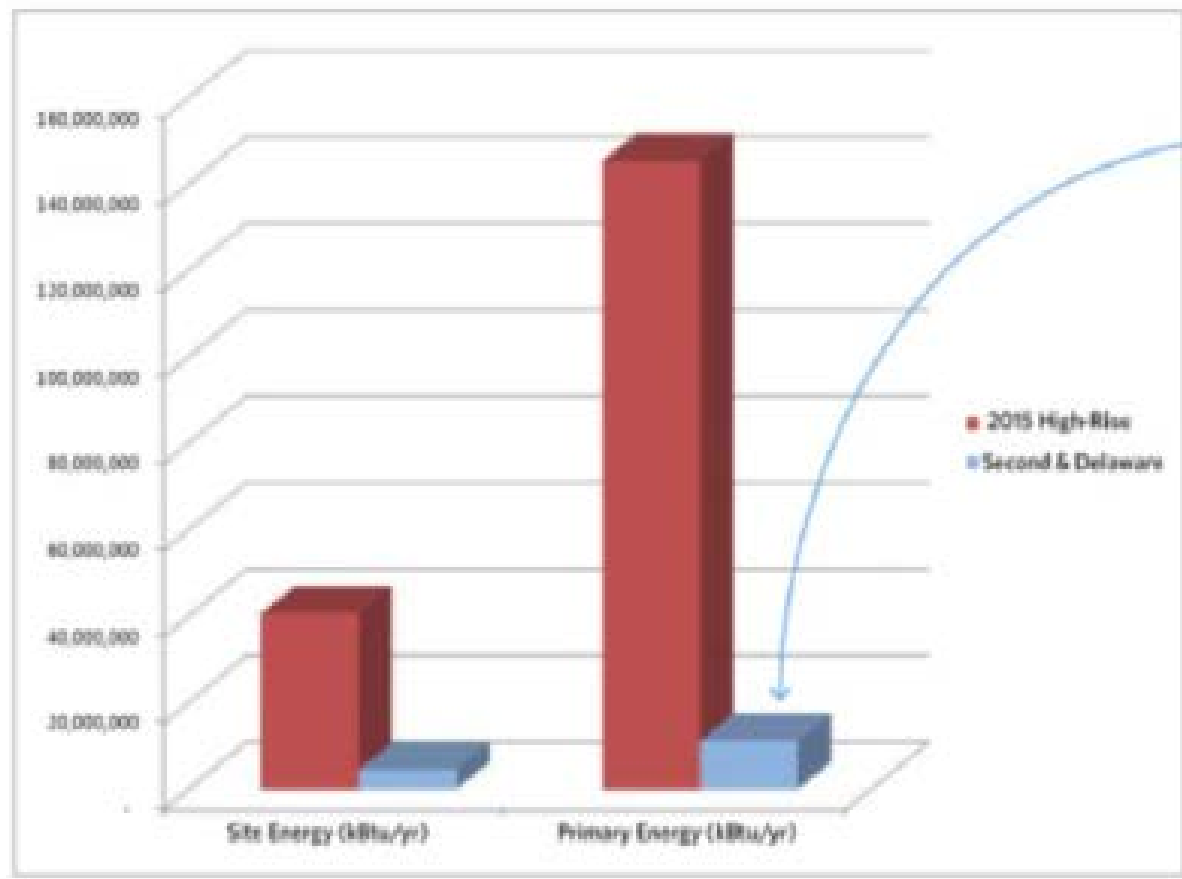


Second and Delaware (Passive House)

Building Size 290,754 SF

Site Energy **4,519,743** kBtu/yr

Energy Consumption Comparison



**92% Reduction
in Energy
Consumption**

	2015 High-Rise	Second and Delaware Apartments
Conditioned Space (sf)	277,512	290,754
Total Energy Consumption kBtu/yr	40,703,695	4,519,743
Source Energy (kBtu/yr)	145,370,339	11,292,706

Structure Cost Per Square Foot:

			ADG Model	Stick
0	Land	\$4,256,000	\$ 7.74	\$ 10.06
3	Concrete	\$14,289,502	\$ 25.98	\$ 8.50
4	Masonry	\$899,800	\$ 1.64	\$ 1.64
5	Metals	\$1,423,506	\$ 2.59	\$ 2.18
6	Rough Carpentry	\$377,280	\$ 0.69	\$ 8.00
6	Finish Carpentry	\$686,830	\$ 1.25	\$ 1.25
7	Waterproofing	\$380,002	\$ 0.69	\$ 0.69
7	Insulation	\$0		\$ 0.50
7	Roofing	\$1,352,451	\$ 2.46	\$ 2.46
7	Sheetmetal	\$54,277	\$ 0.10	\$ 0.10
8	Doors	\$587,381	\$ 1.07	\$ 1.07
8	Windows	\$1,743,247	\$ 3.17	\$ 3.17
8	Glass	\$0	-	-
9	Lath and Plaster	\$0	-	-
9	Drywall	\$3,290,604	\$ 5.95	\$ 11.97
9	Tile Work	\$0		\$ 0.82
9	Wood Flooring	\$0		\$ 3.80
9	Painting and Decorating	\$813,231	\$ 1.48	\$ 1.48
10	Specialties	\$108,388	\$ 0.20	\$ 0.20
11	Special Equipment	\$15,000	\$ 0.03	\$ 0.03
11	Cabinets	\$893,875	\$ 1.63	\$ 1.63
11	Appliances	\$863,841	\$ 1.75	\$ 1.75
12	Blinds and Shades, Artwork	\$136,836	\$ 0.25	\$ 0.25
12	Carpets	\$229,790	\$ 0.42	\$ 0.42
13	Special Construction	\$1,721,503	\$ 3.13	\$ 3.13
14	Elevators	\$536,560	\$ 0.98	\$ 0.98
15	Plumbing and Hot Water	\$2,732,365	\$ 4.97	\$ 4.97
15	Heat and Ventilation	\$2,602,679	\$ 4.73	\$ 8.01
16	Electrical	\$4,209,080	\$ 7.65	\$ 7.65
	Subtotal (Structures)	\$40,048,008	\$80.55	\$84.68

Opportunity

- Demand: 40 million units
- Stay in Homes: (13 million)
- Remaining: 27 million units
- 100,000 Second and Delaware Buildings
- Globally - 60 million people move to cities each year.

Imagine the Savings

$$\begin{aligned} 100,000 \times 36,183,952,000 \text{ BTU} &= \\ 3,618,395,200,000,000 \text{ BTU} &= \\ 1,060,447,061,499 \text{ kWatt-hr} \end{aligned}$$

$$1.06045 \times 10^{12} \text{ kW-hr}$$

$$\mathbf{1.06045 \times 10^6 \text{ GWh} = 1 \text{ Million GWh}}$$

The installed capacity of wind power in Germany was 25.8 GW by 2010
Fukushima Daiichi Nuclear Power Plant = 4.7 GW

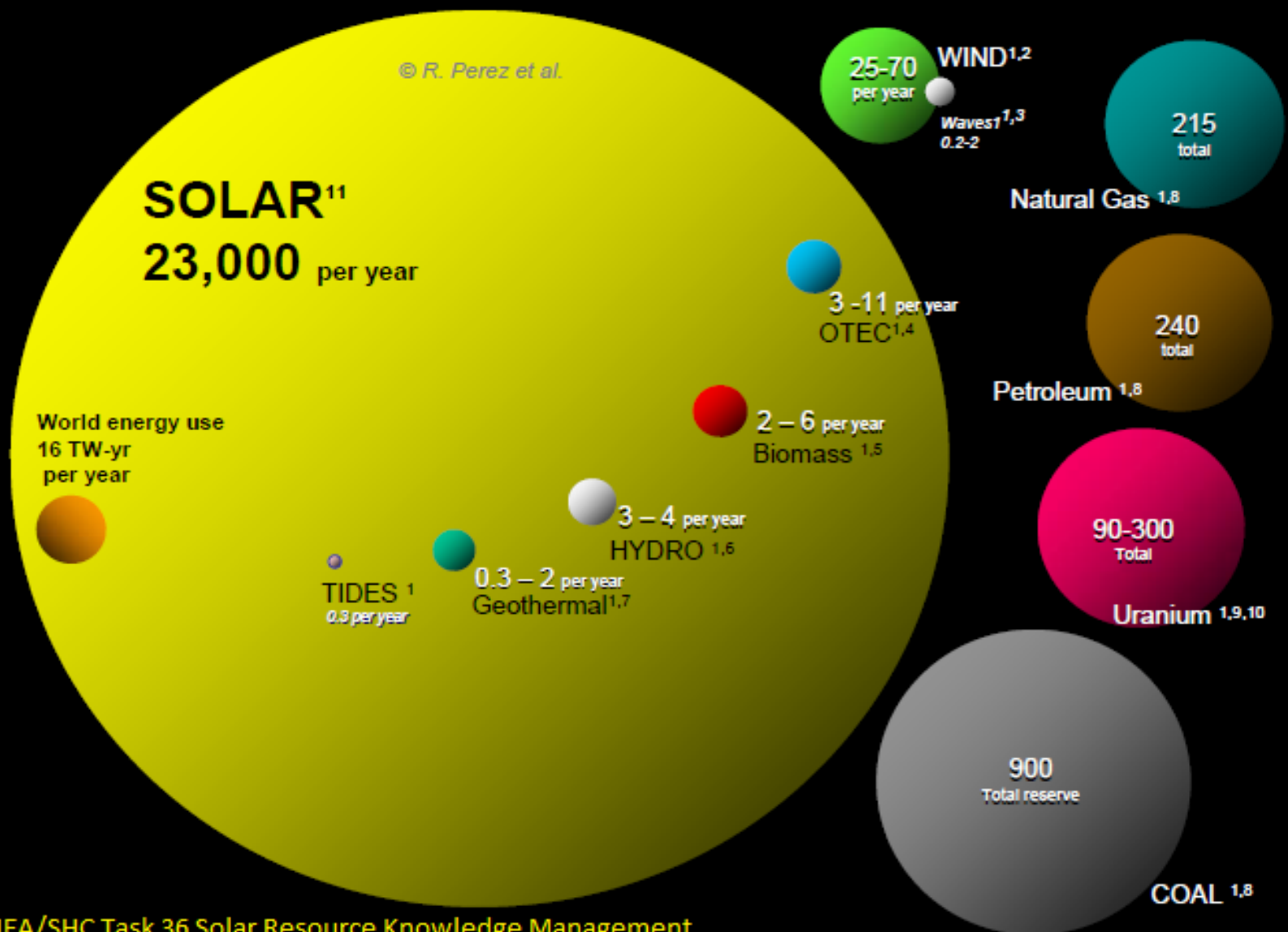


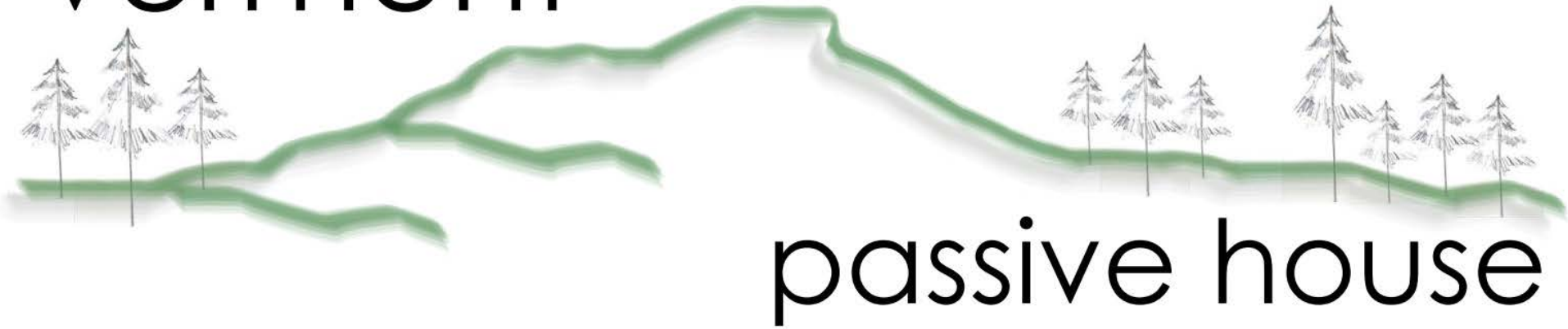
Figure 1: Comparing finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables.

THE TAKE-AWAY

- VT must act now to reduce the energy consumption and CO2 emissions related to buildings.
- VT needs bold and immediate upgrades to the VT building code and should make resolutions to be at the Passive House levels of energy and carbon reductions now.
- VT has qualified PH builders and PH trainers to meet the challenge. VTPH and Eff VT can help now, and it can be done with off the shelf materials at neutral cost.
- By challenging the myth that we need fossil fuels for a sustainable economy, we must reduce VT's dependency on fossil fuels as it relates to heating and cooling buildings, stop supporting an out of State fossil fuel economy and keep VT dollars at home invested in our own State economy.
- Subsidies similar to or greater than what is available for solar electric will need to be implemented for existing home upgrades. The results will reduce energy and carbon much more than solar electric.
- The PH Standard will provide security to people in events of power loss and healthy indoor environment.
- Adopting the PH Standard as building code can be another VT first for our State.
- VT can help Carbon capture through managed and sustainable forestry practices and drive economic growth with the production of wood fiber products such as building insulation materials.

Thank you

vermont



passive house

Because we care about you saving money and living healthy, and care about the environment, our legacy and our future, we design and build
energy efficient buildings.



Enrique Bueno - ebueno@eplusbuildings.com
Chris Miksic - chris@monpelierconstruction.com
Paul Sipple - necco@gmavt.net

