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Energy Efficient Buildings

Passive House Buildings – Mitigating Climate Change

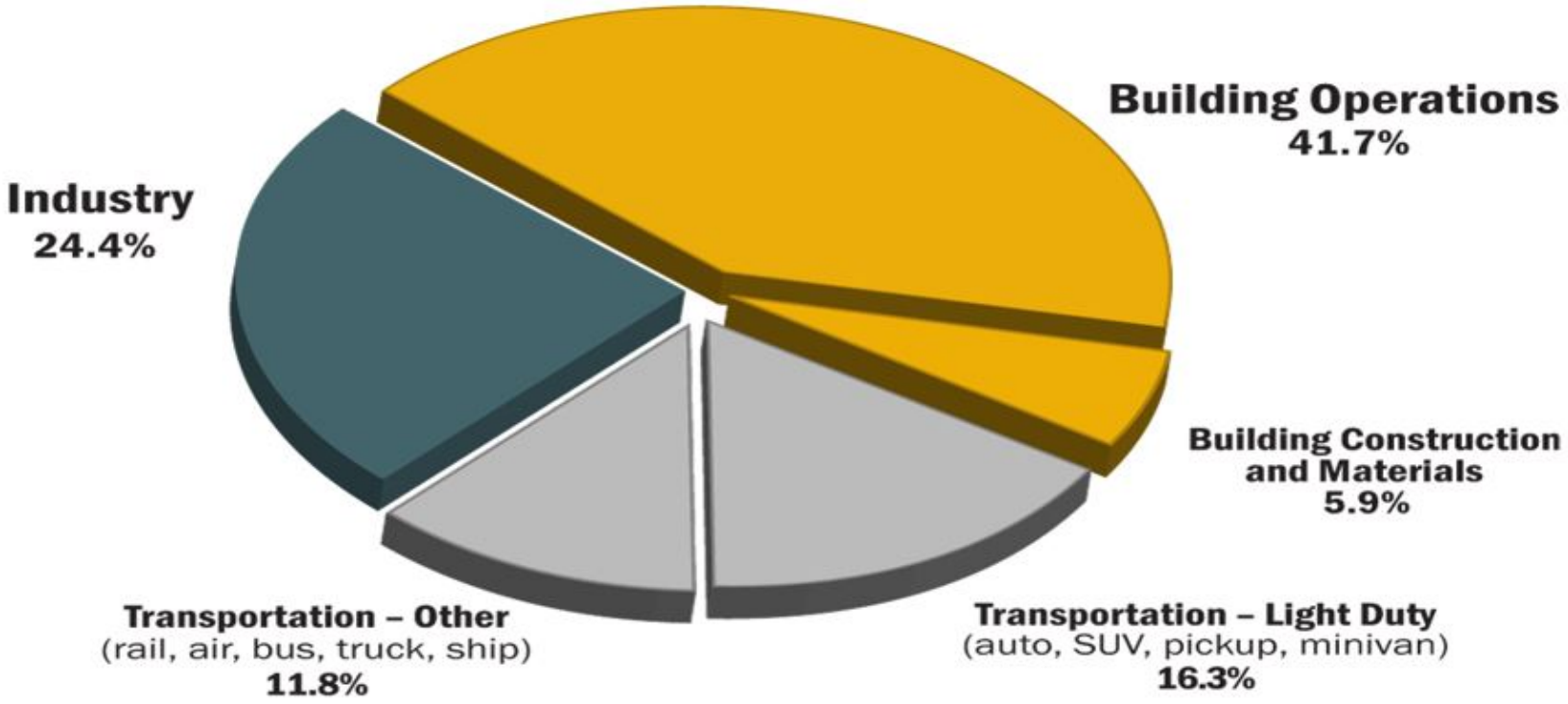
Implementing the Passive House Building Standard to minimize the energy intensity and CO_2 emissions in buildings

House Committee on
Natural Resources
Act 250 & Climate Change

www.vtph.org

February 28, 2019

The Problem



U.S. Energy Consumption by Sector

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

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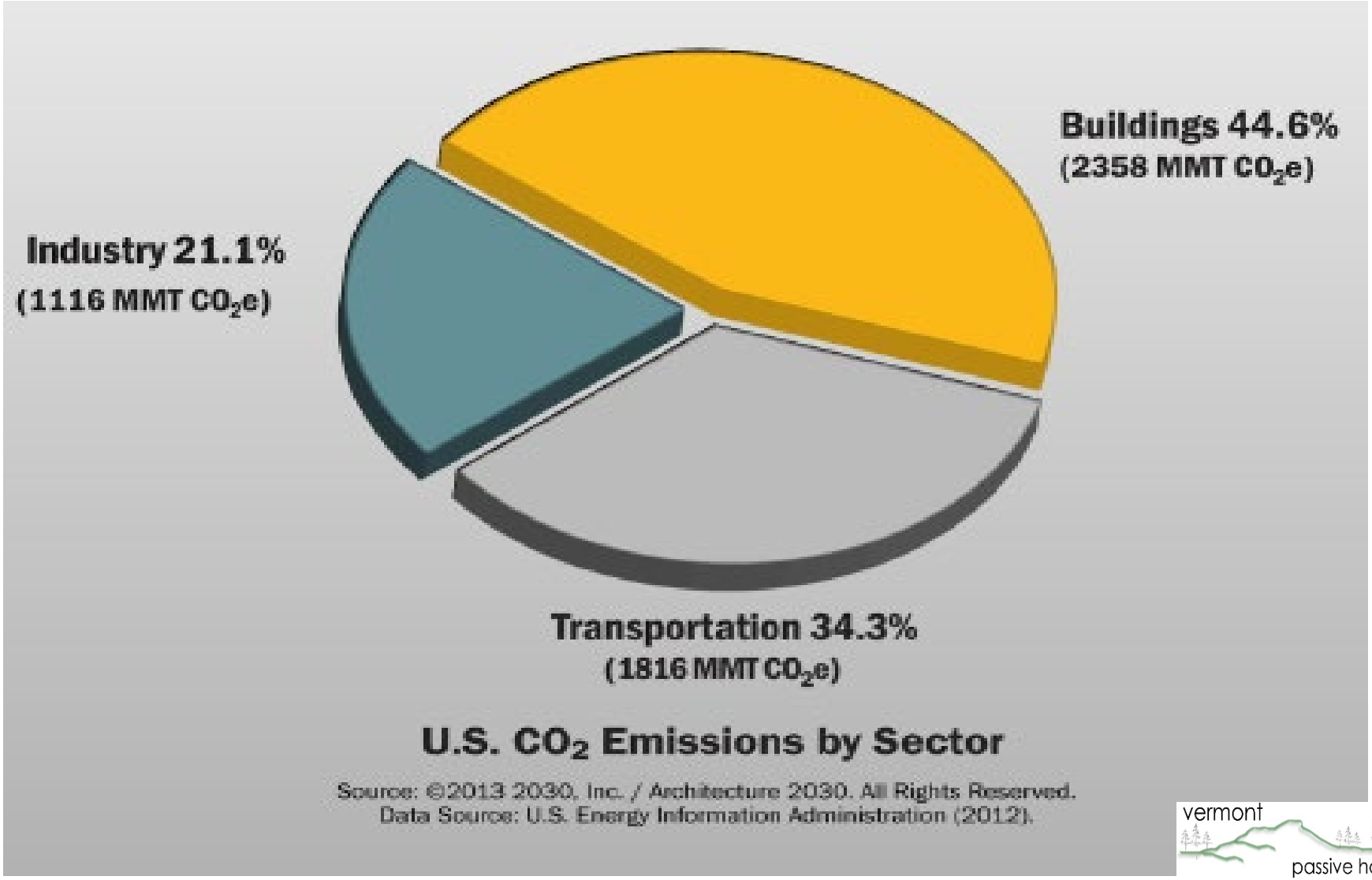
The Problem



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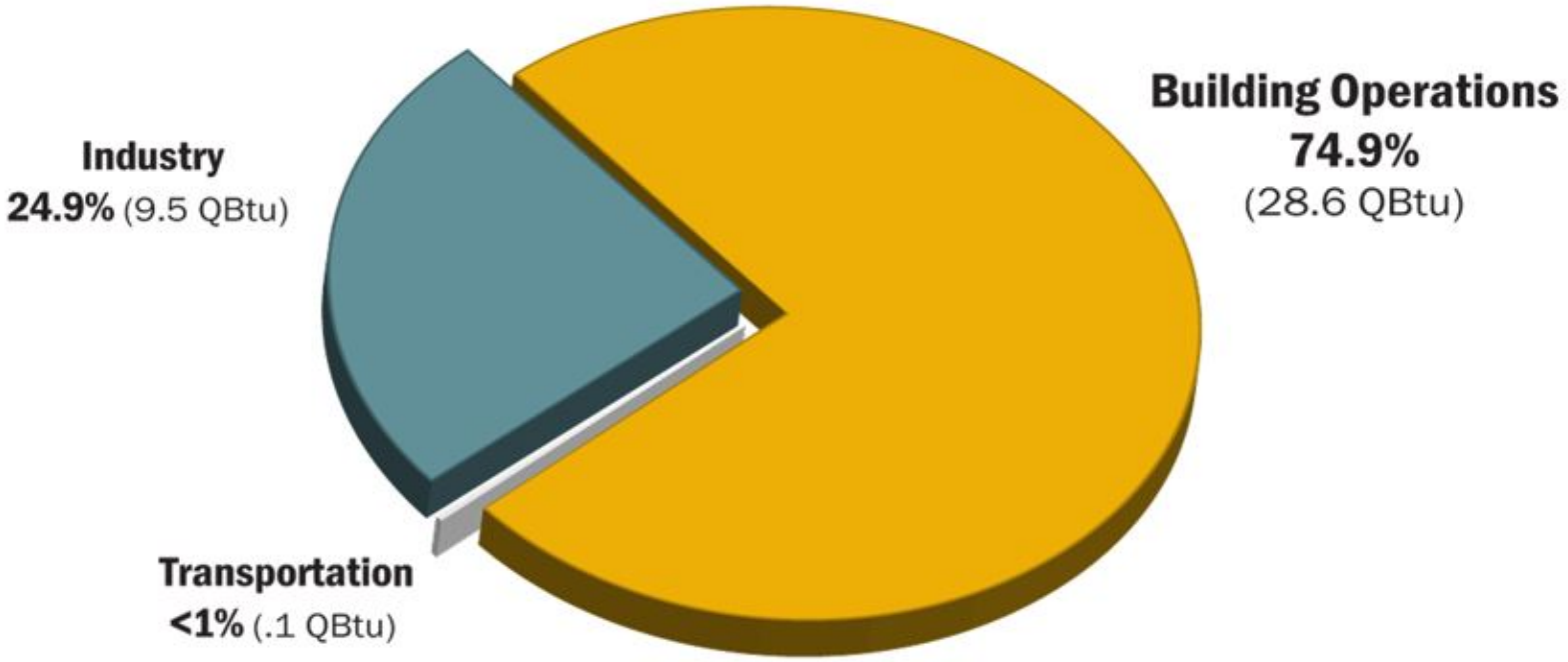
The Problem - **67% from Fossil Fuels***



U.S. Electricity Consumption by Sector

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

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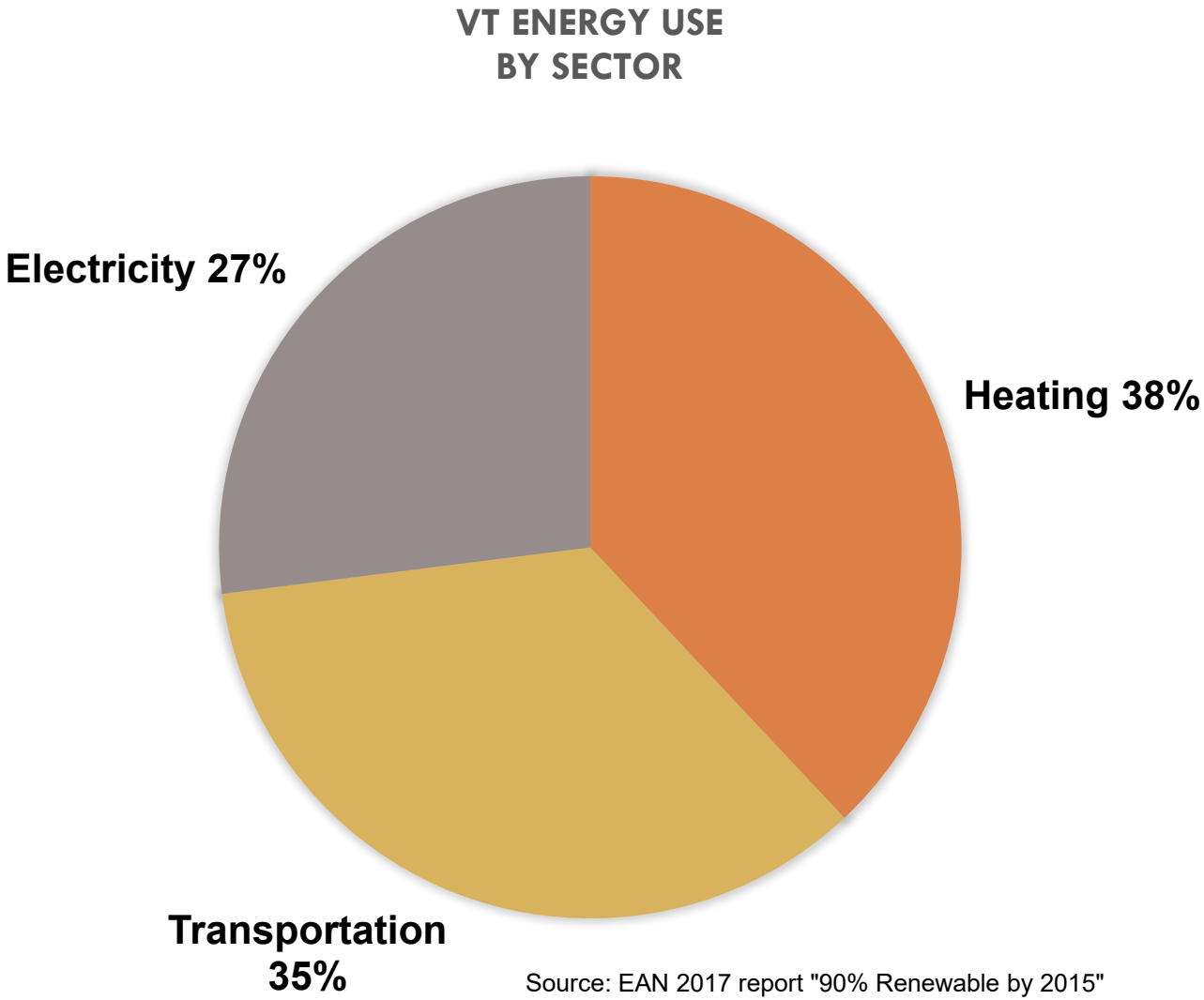
*US-EIA 2014

The Problem in VT

76% of Heating comes from Fossil Fuels



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

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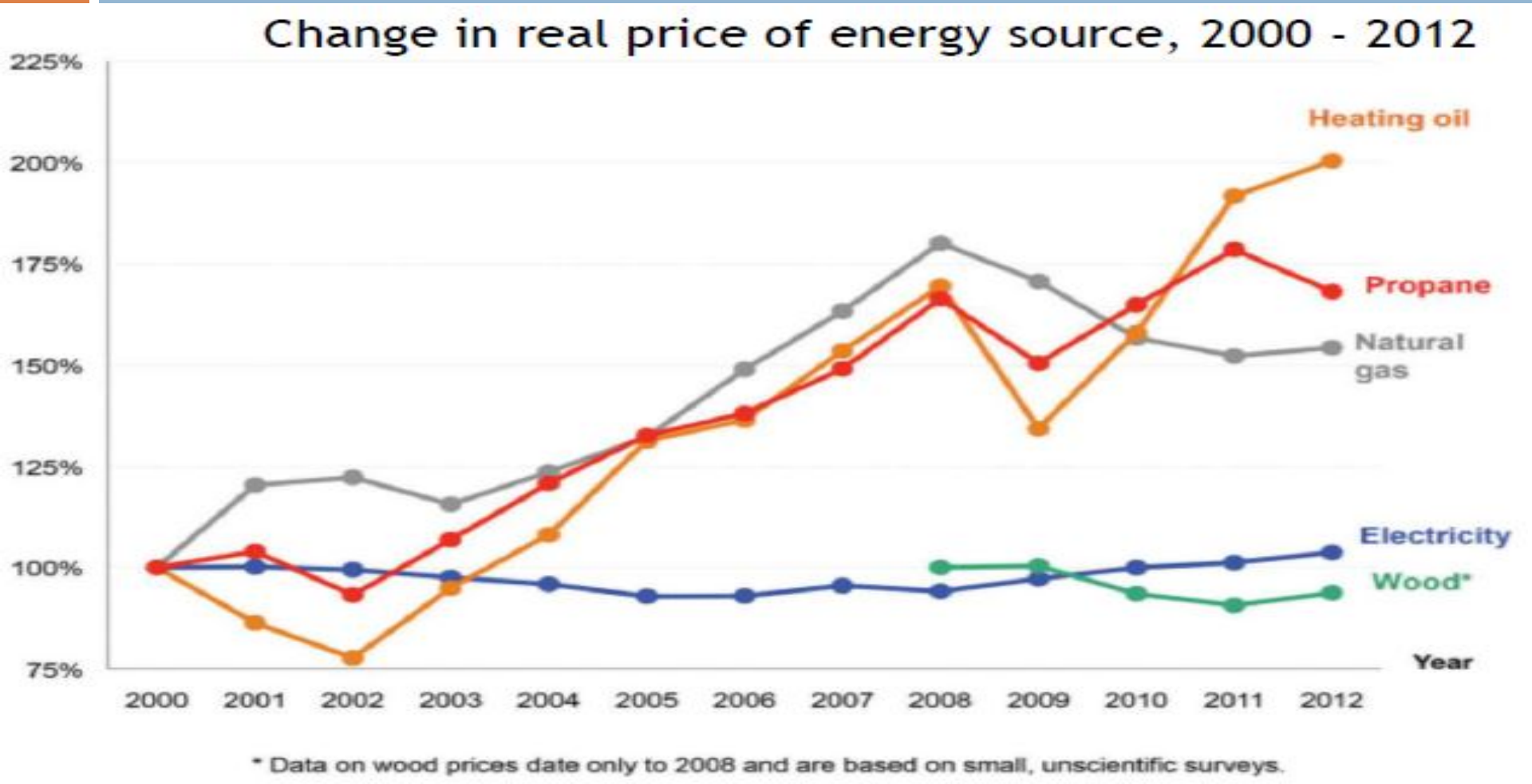
The Problem in VT

Energy prices are increasing



Source: VLS Report. Energy Costs and Burdens in Vermont: Burdensome for Whom?
Data from the Census Bureau's American Community Survey

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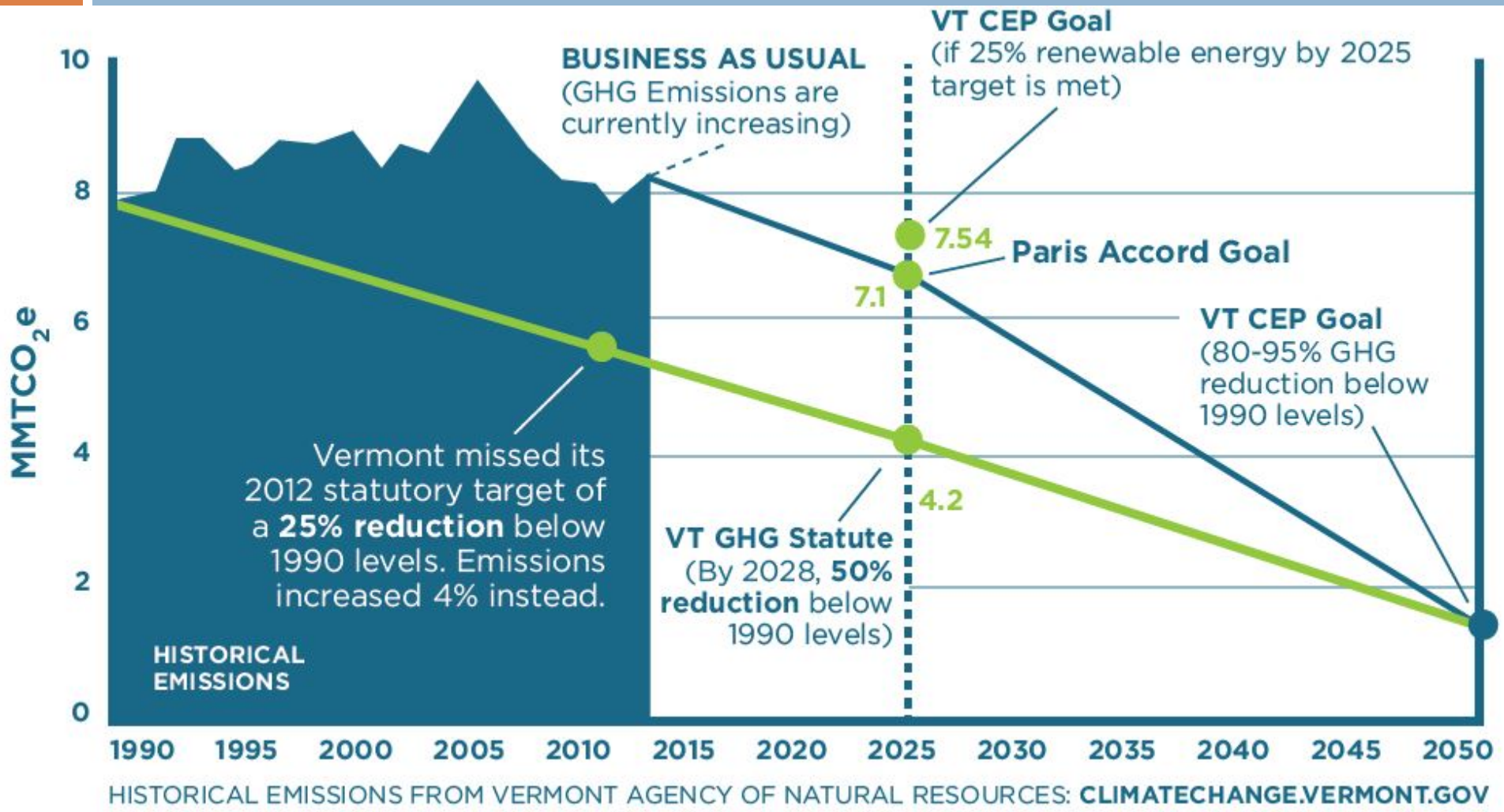
The Problem in VT

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"

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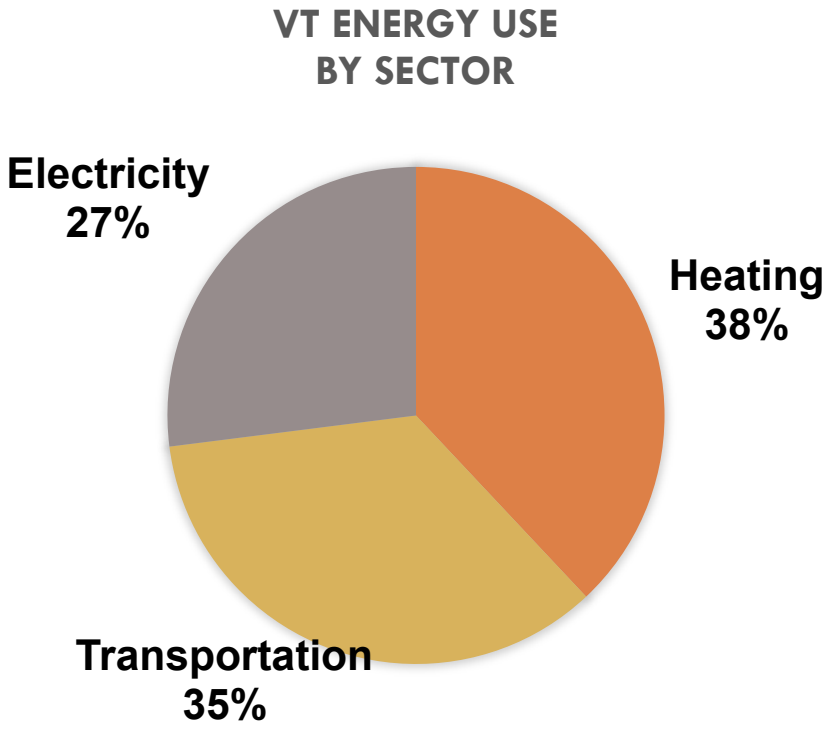
A Solution to the Problem in VT
90% Reduction in Heating Energy Consumption
Implementing the Passive House Building Standard



Source: EAN 2017 report "90% Renewable by 2050"

76% of Heating comes from Fossil Fuels

90% of Heating Energy Reduction = 34% reduction in **<u>total</u>** VT energy consumption

90% reduction on Heating Energy from **Fossil Fuels = only 3%** of Fossil Fuels dependency

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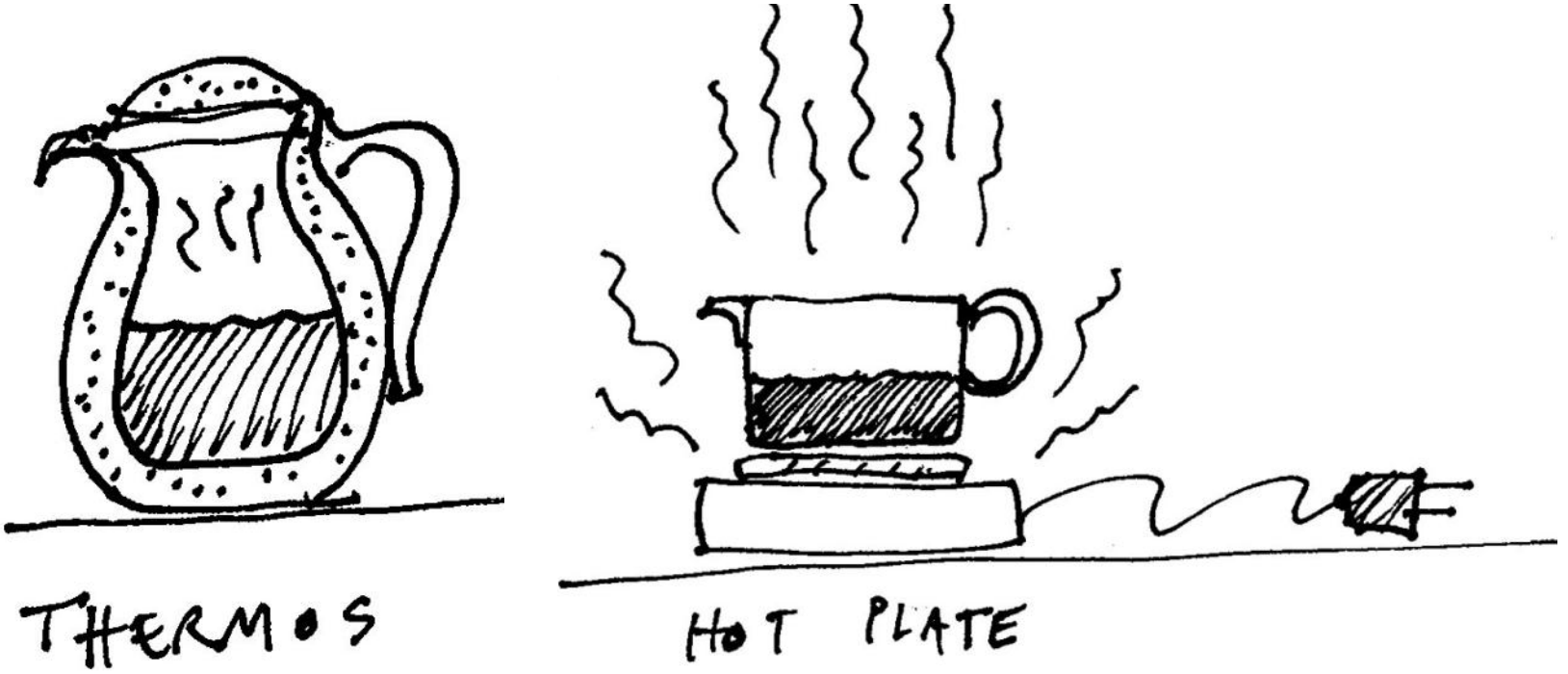
The Passive House Approach



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

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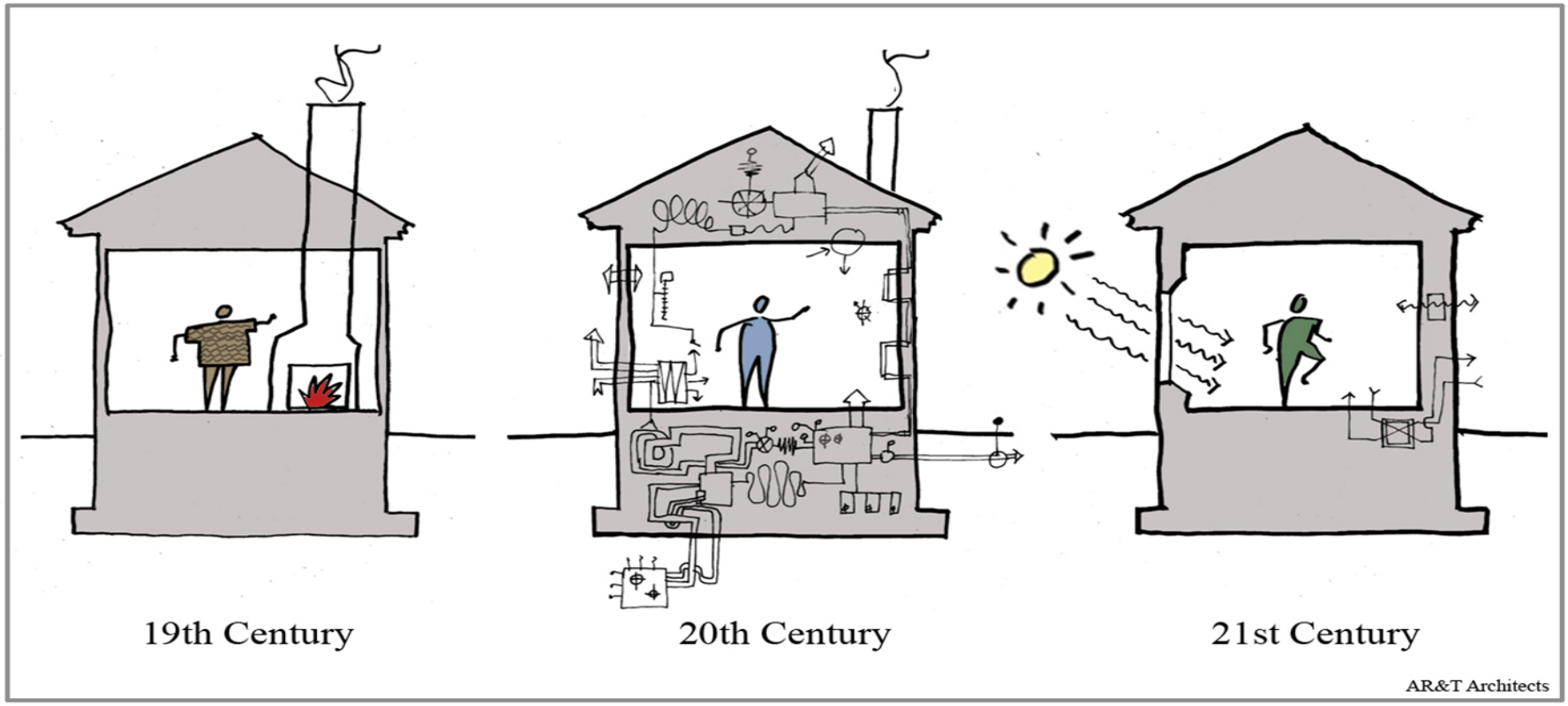
Passive House Moves Toward Simplicity

Moving Towards Simplicity



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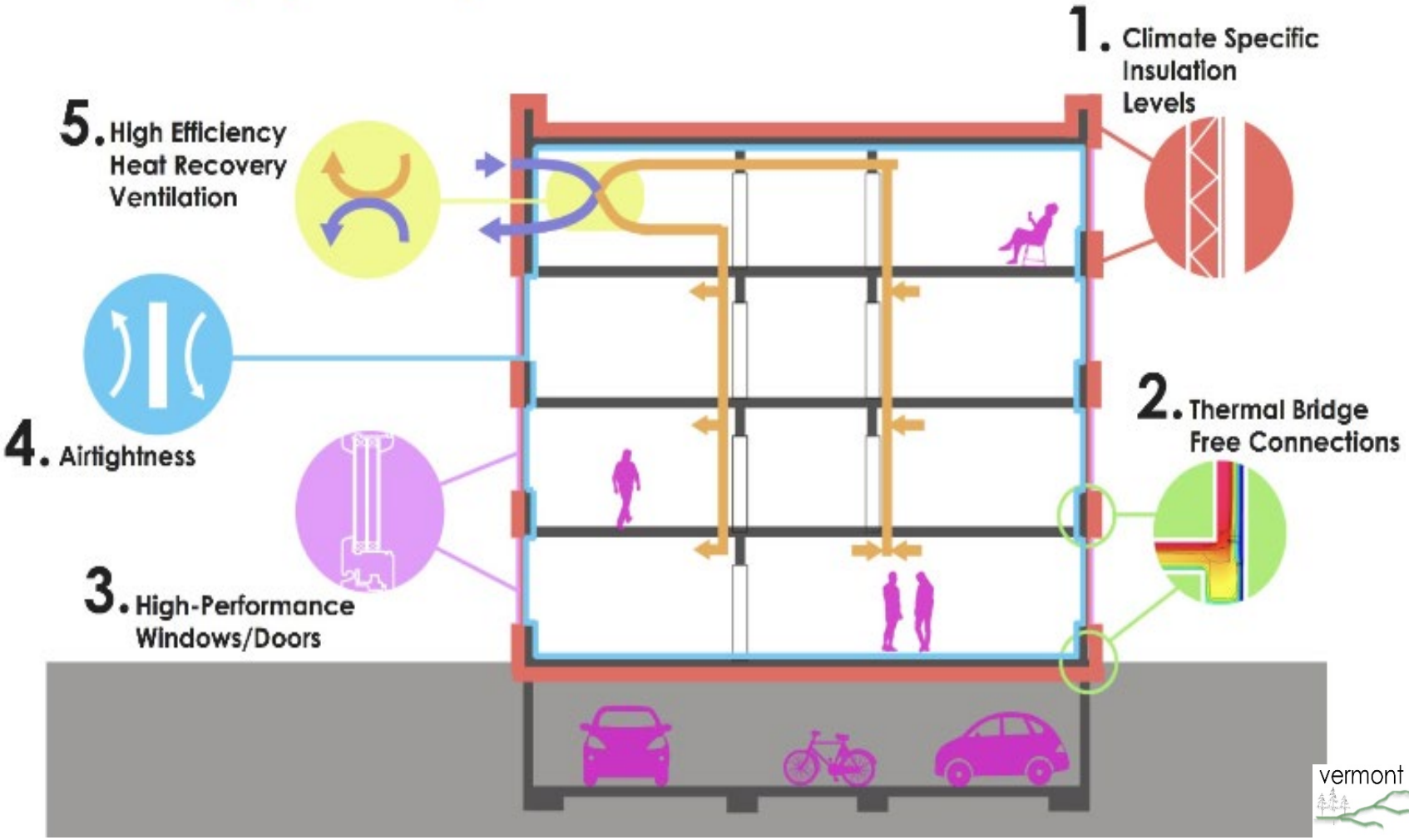
PASSIVE BUILDING PRINCIPLES

Five key principles:



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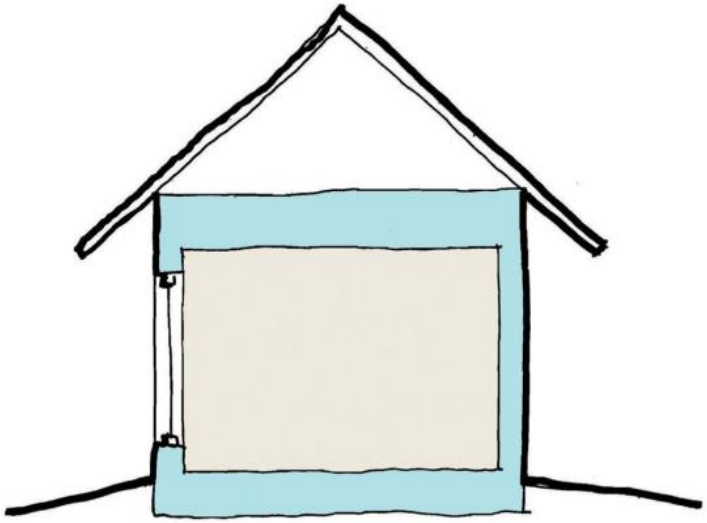
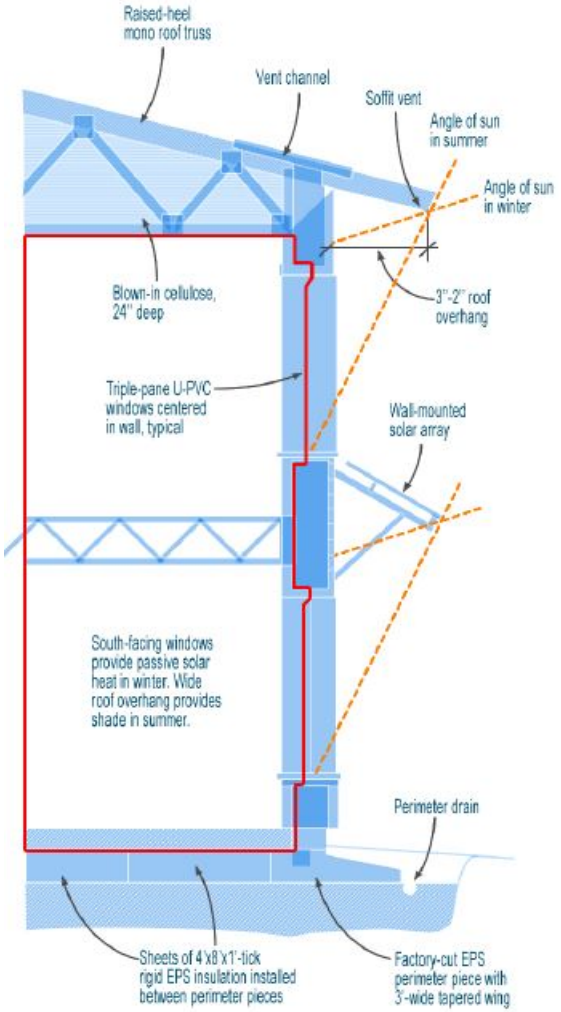
Appropriate level of thermal INSULATION to control energy loss





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.

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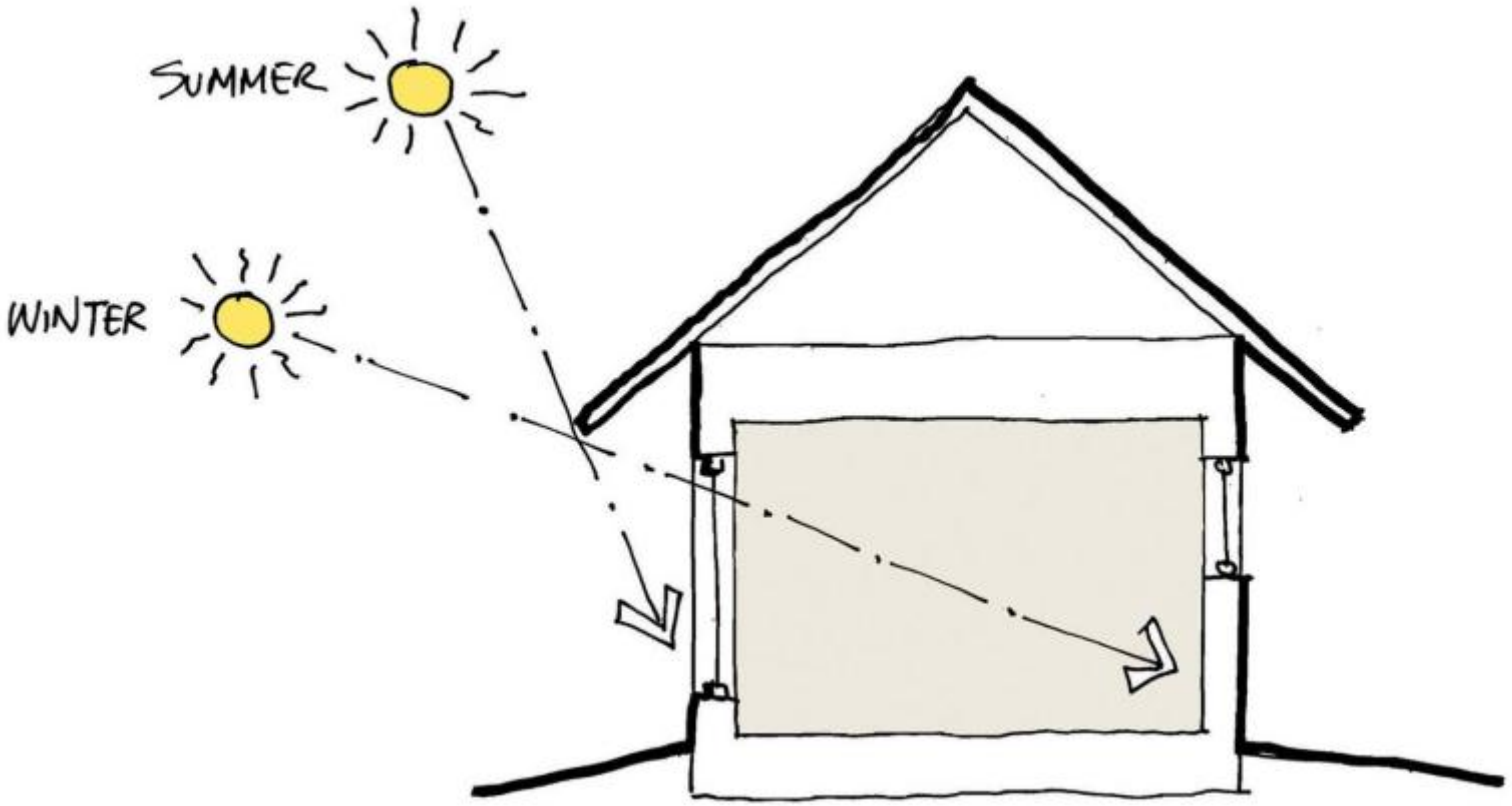
Controlling Solar Gains Seasonally Through Windows and Orientation



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

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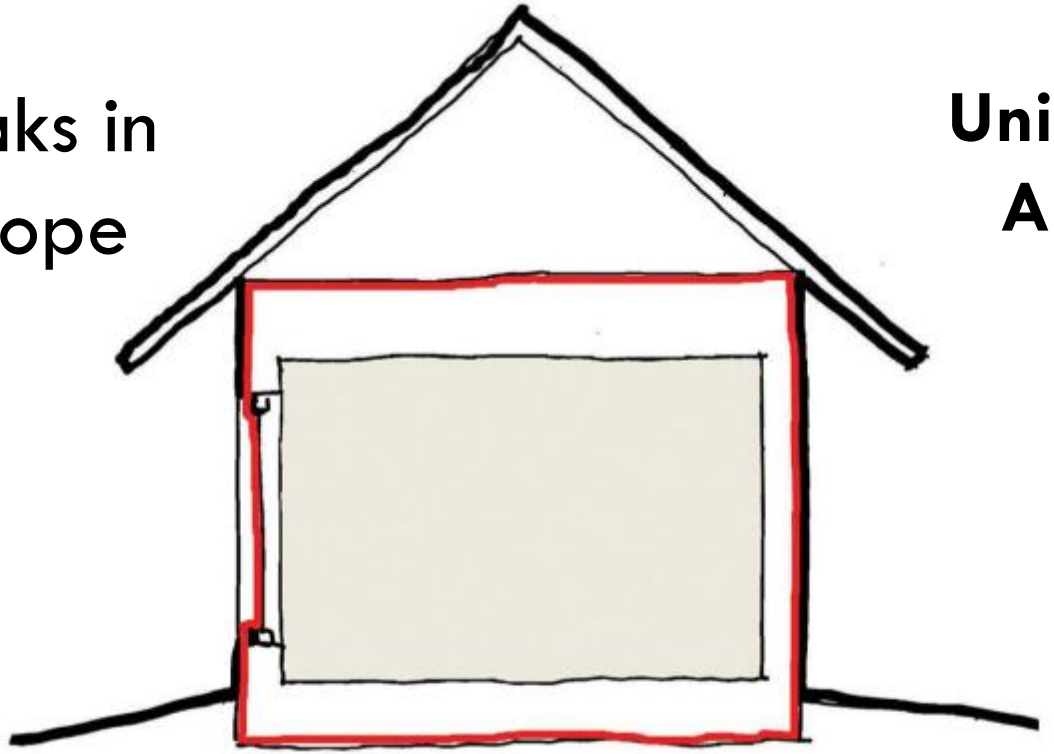
Controlling Energy Loss by
Eliminating Air In/Ex-filtration

No air leaks in the envelope



Uninterrupted Air Barrier

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

Max. 0.05 cfm/gross sqft shell @ 50 PA

Blower Door Test limits

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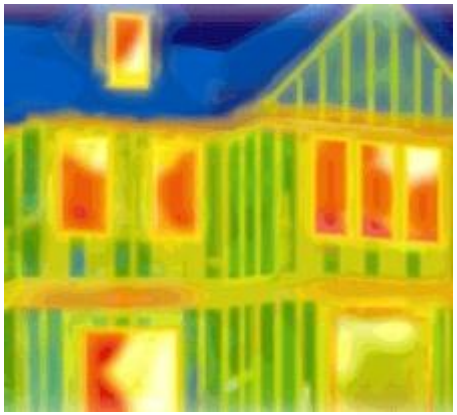
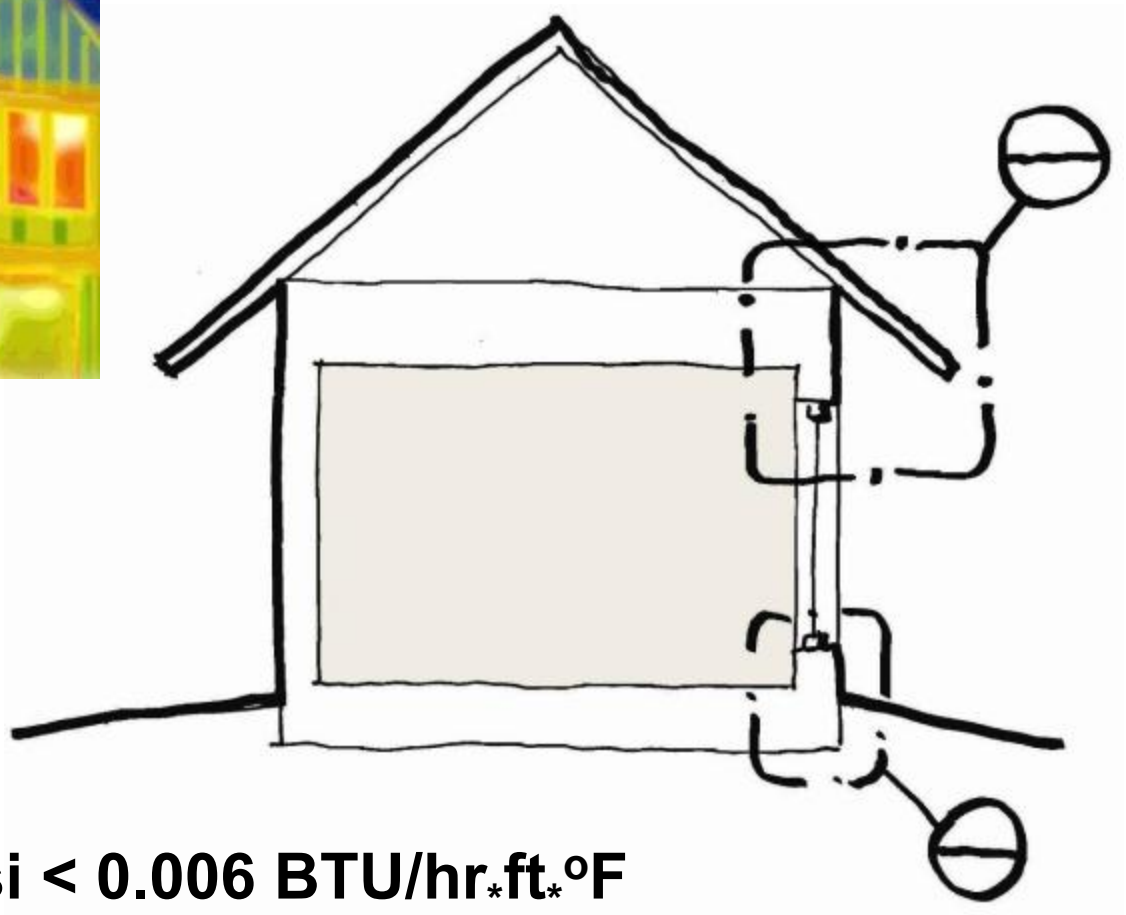
Controlling Energy Loss by Eliminating Thermal Bridges





Psi < 0.006 BTU/hr*ft*°F

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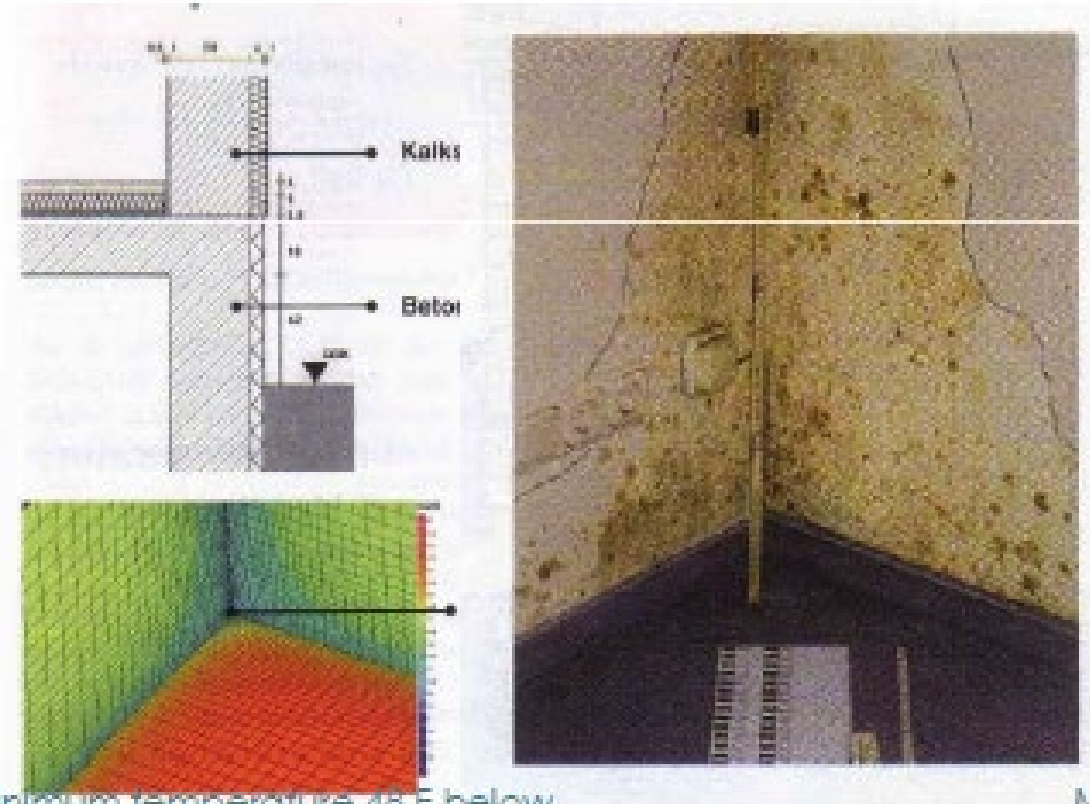
MINIMIZE LOSS:

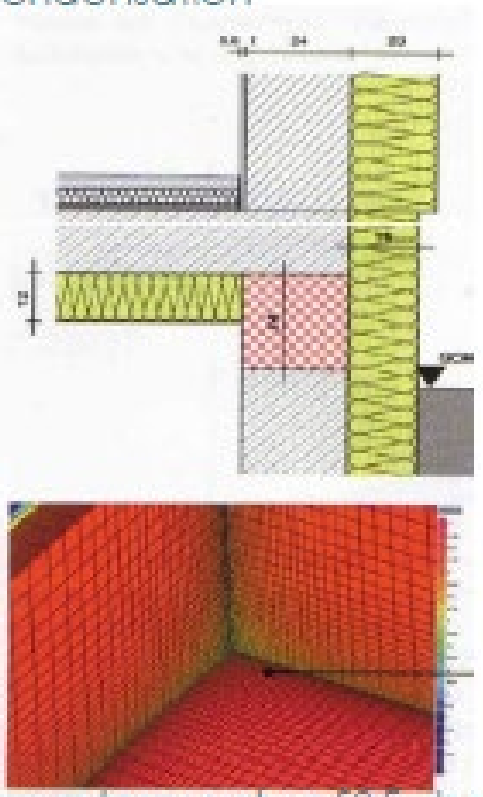
ELIMINATING THE THERMAL BRIDGE MINIMIZES HEAT LOSS CONDENSATION/BUILDING DETERIORATION

BAD = high heat loss + risk of condensation



Minimum temperature 46 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

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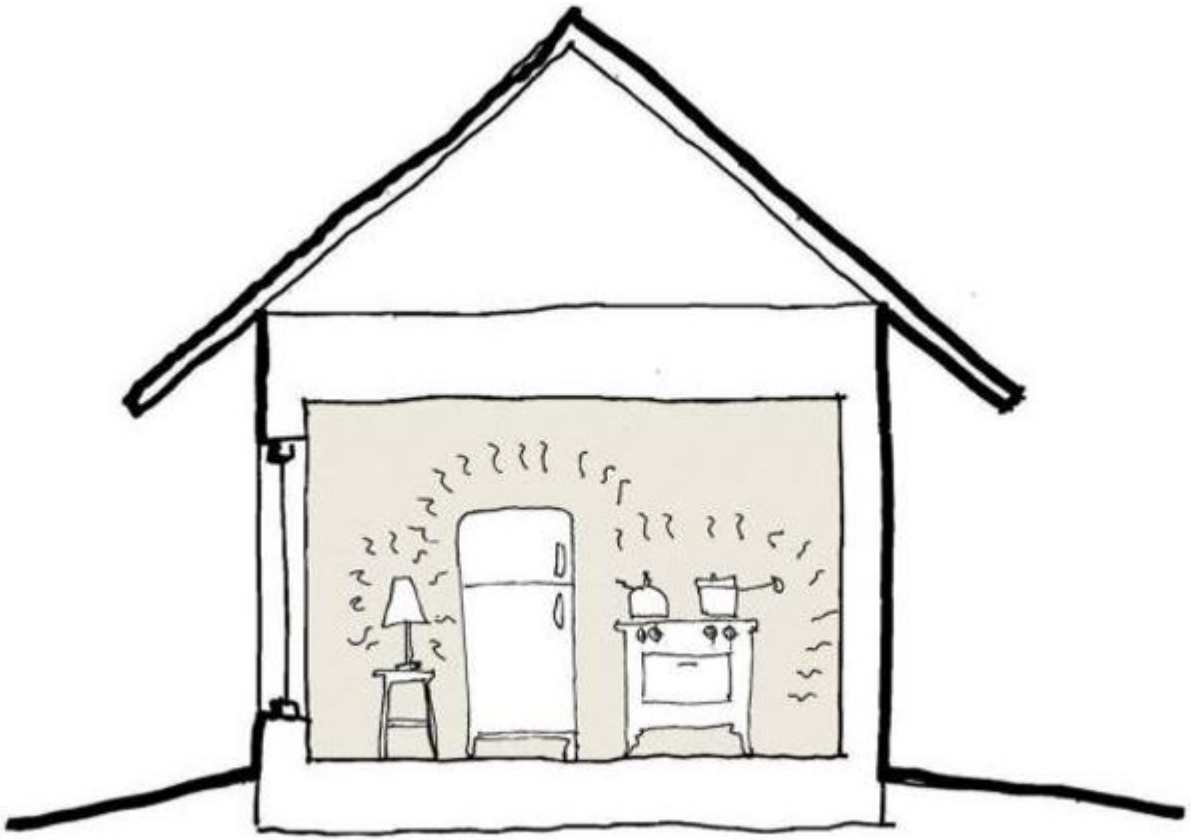
Passive House Standard

Accounts for Internal Heat Gains - Appliances



… and appliances efficiency

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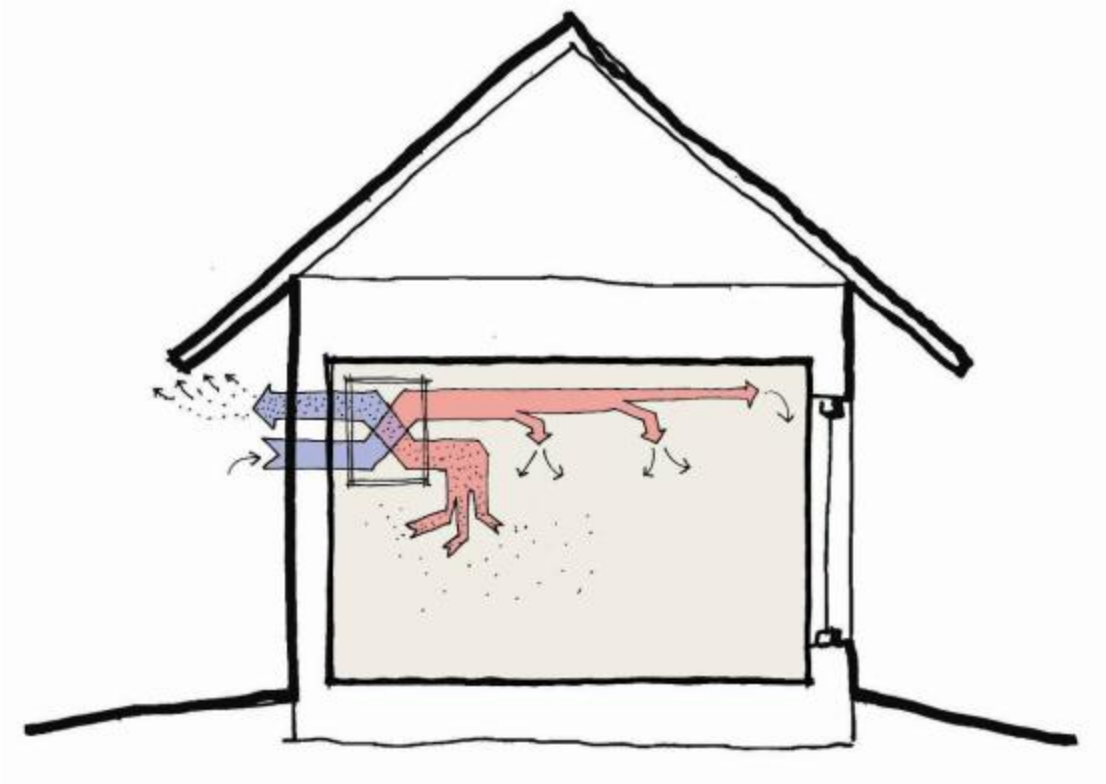
Passive House Standard

Provides Fresh Air via Heat/Energy Recovery Ventilation



MINIMUM of 0.30 ACH

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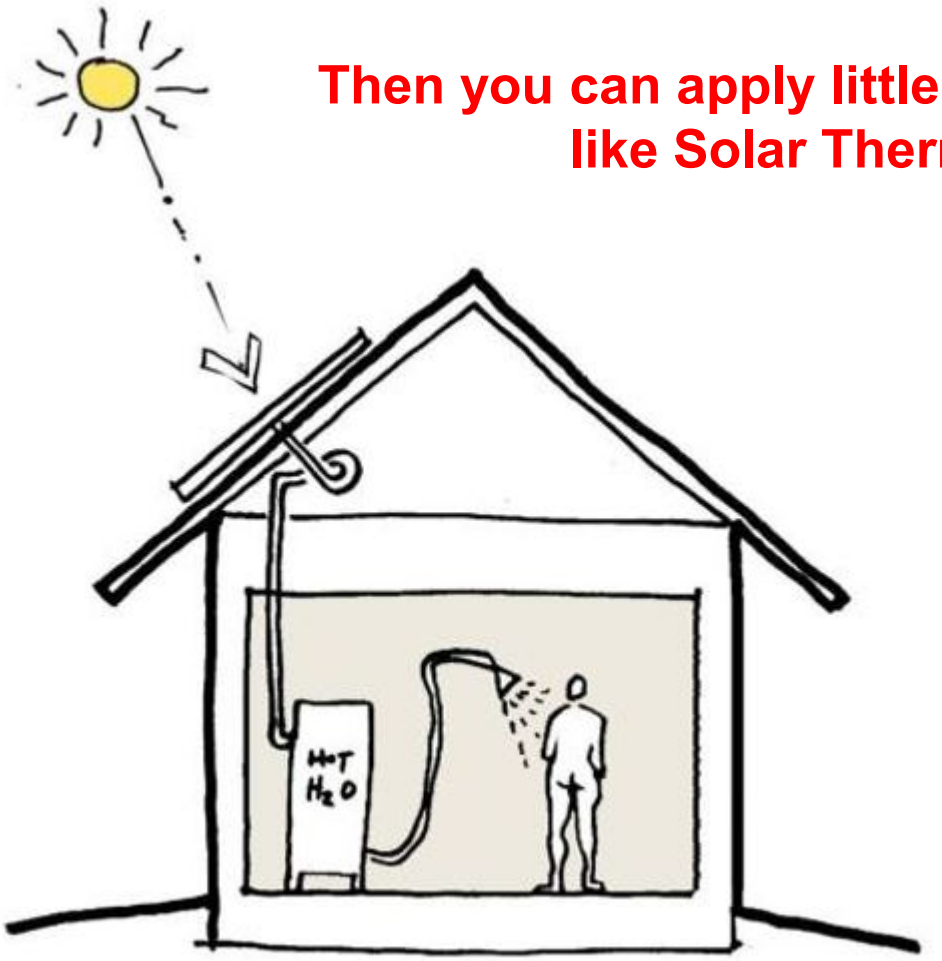
Passive House Concept: Once the Wasted Energy is Reduced to the minimum…



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

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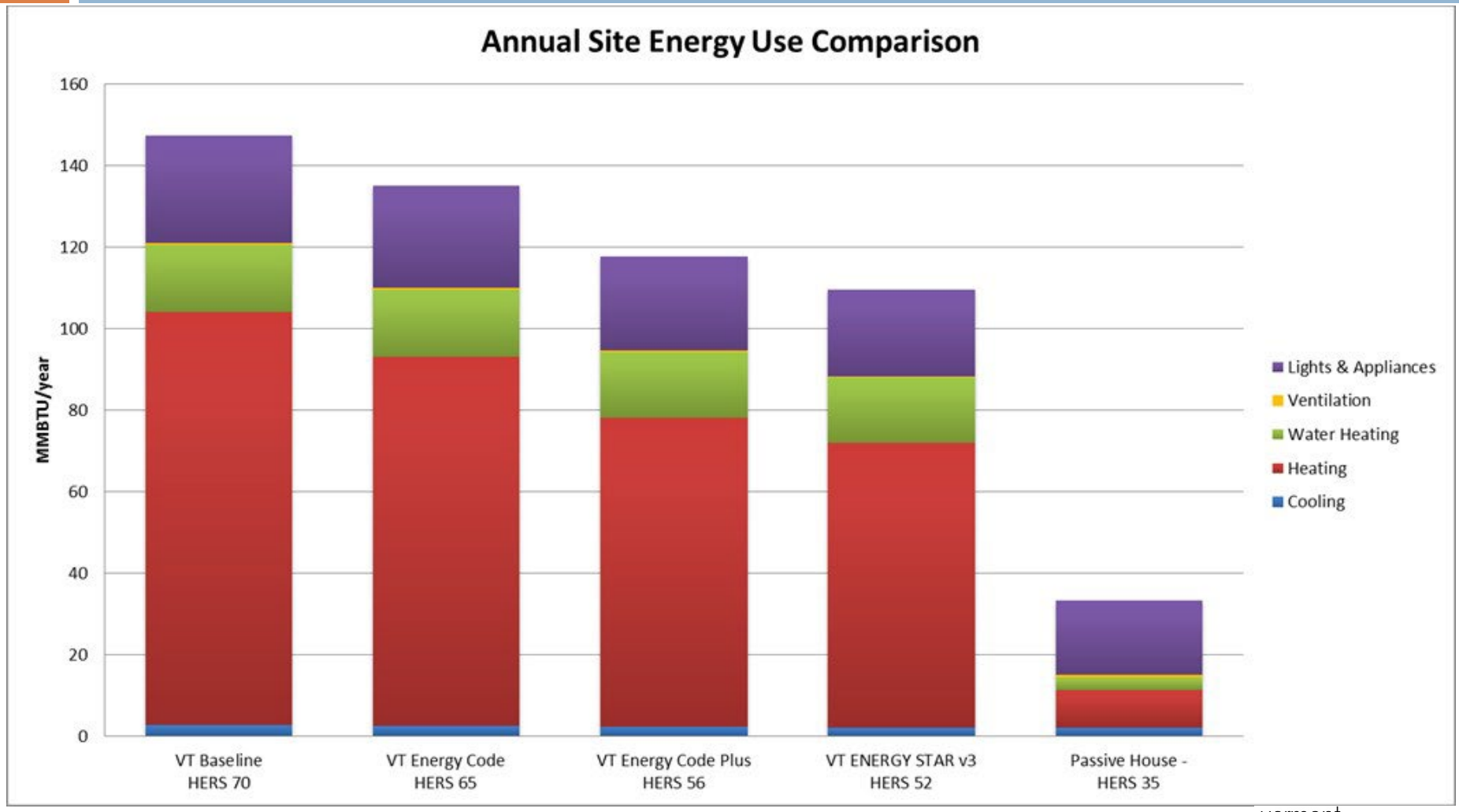
Energy Usage Comparison



Source: Efficiency VT

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How does it relate to other programs?

Energy Efficient Housing Concepts in the US:

- Vermont Energy Code (RBES): required for all new construction **but not enforced**
- 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.

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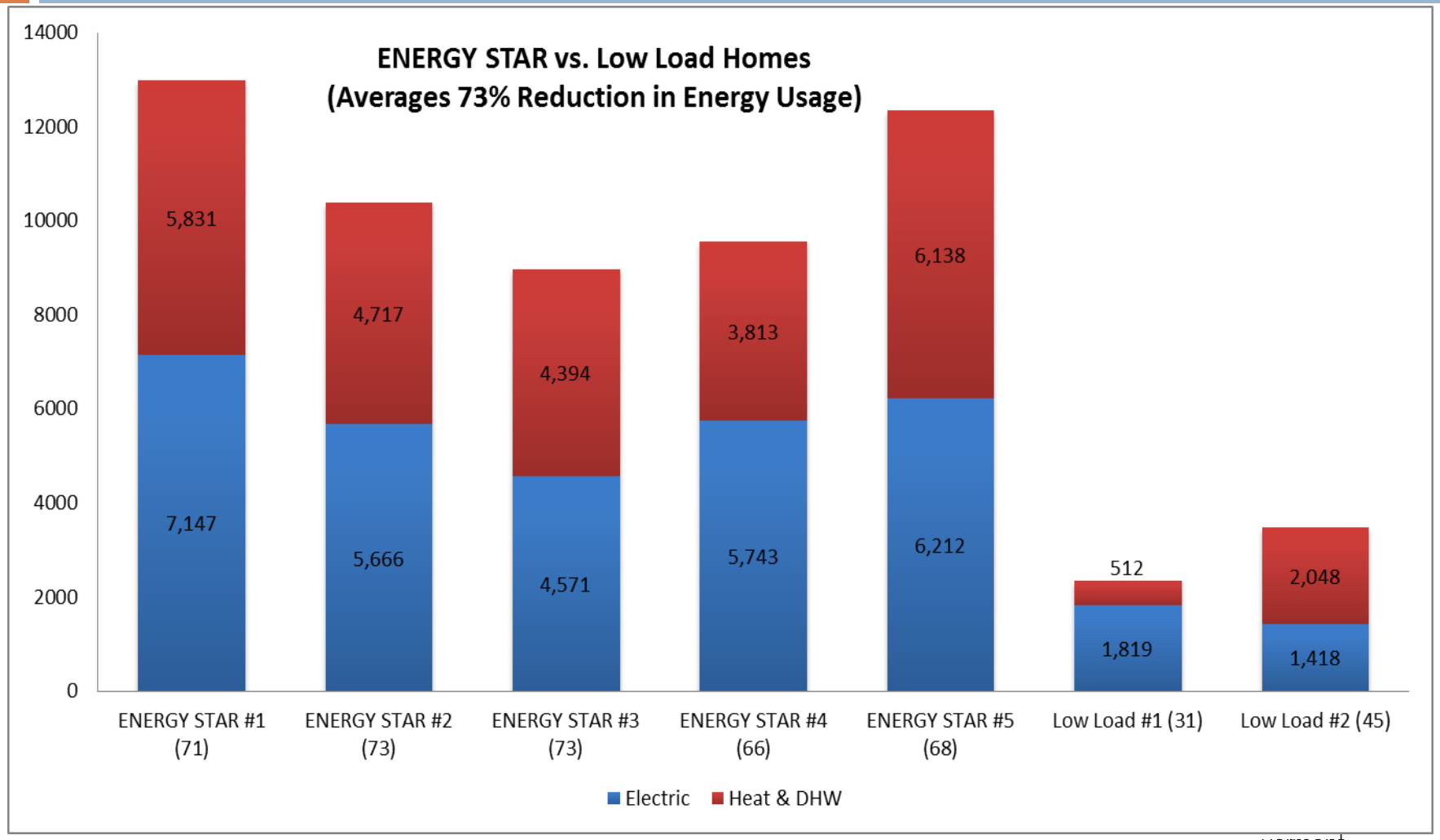
Actual Energy Consumption Comparison of five Energy Star Homes, one Passive House and one Low Load



Source: Efficiency VT

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How does it relate to other programs?

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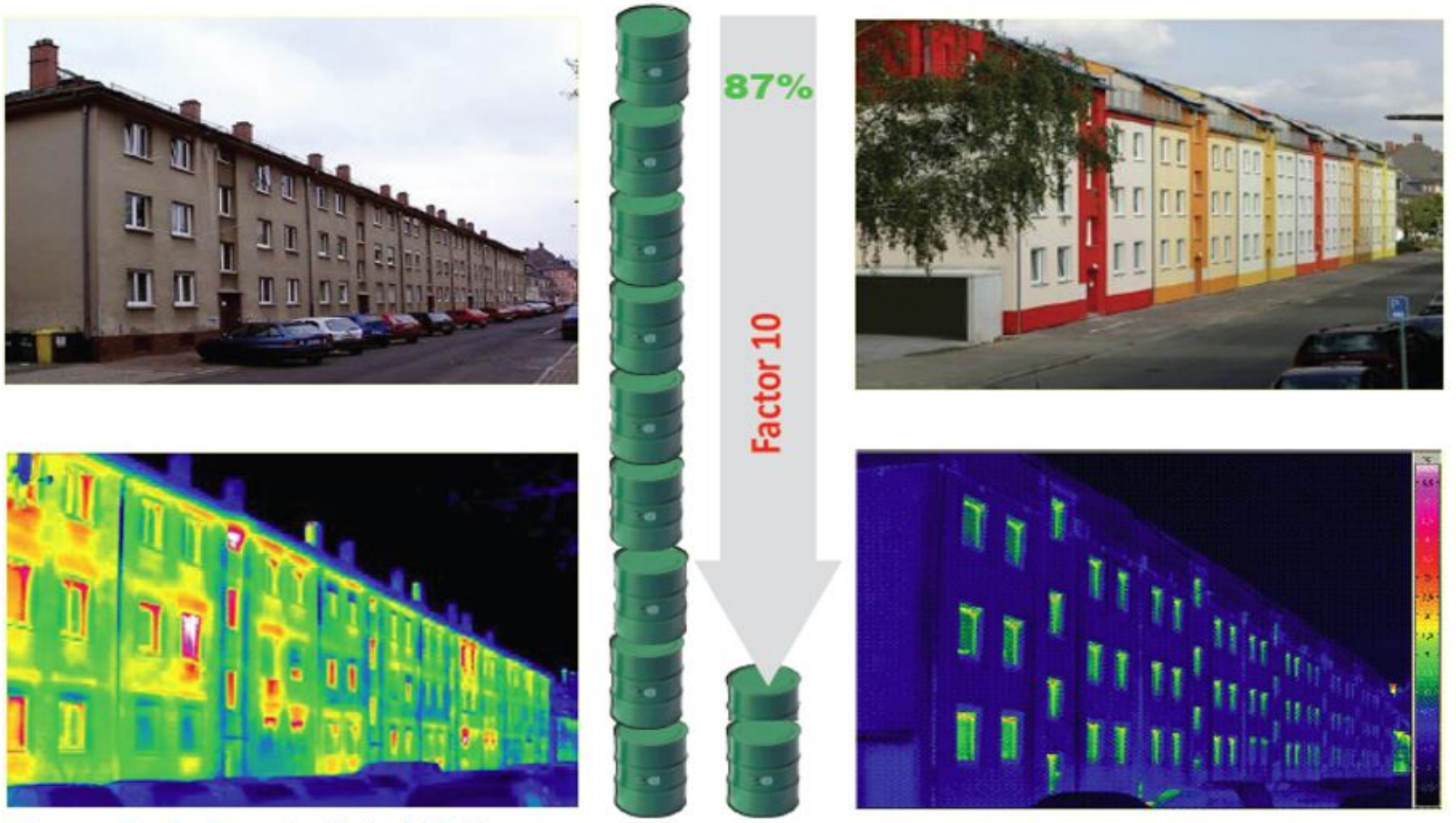
It is not Rocket Science and applies to retrofits too

Frankfurt Teverstrasse, Refurbishment using Passive House Principles



Source: Passivehouse Institute / DENA

© Jens Laustsen 2011

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

Source PHIUS Projects Database

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51 Upper Pines 1440 sqft - / Warren VT

90% Reduction in Heating Demand

Before weatherization estimated
Heating Demand 62.25 kBTU/ft^2-yr
Heating Load 36.58 BTU/(hr-ft^2)

After weatherization
Heating Demand 6.39 kBTU/fr^2-yr
or 9200 kBTU/yr
Peak Heat Load 4.29 BTU/hr-ft^2
or 6435 BTU/hr

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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 by Passive House retrofit	**7188**
PHIUS+ 2015 Threshold (4 occupants)	**7750**
Actual 12 month usage (4 occupants)	**7121**

54% less total energy consumption

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Passive House Projects
North East USA

High Rise – Cornell-Tech - NYC

School
Portland ME

Affordable Senior Housing
Milton VT

Affordable Housing
Brewer - ME

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East Harlem - NYC
East 111th Street development

Rendering Courtesy of Handel Architects

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

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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 construction cost

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Gilford Village Knolls III
New Hampshire

Multifamily
Affordable
Senior Housing
24 Units
20,571 ft²

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Passive House Projects Vermont

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

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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

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Habitat for Humanities
Charlotte - VT

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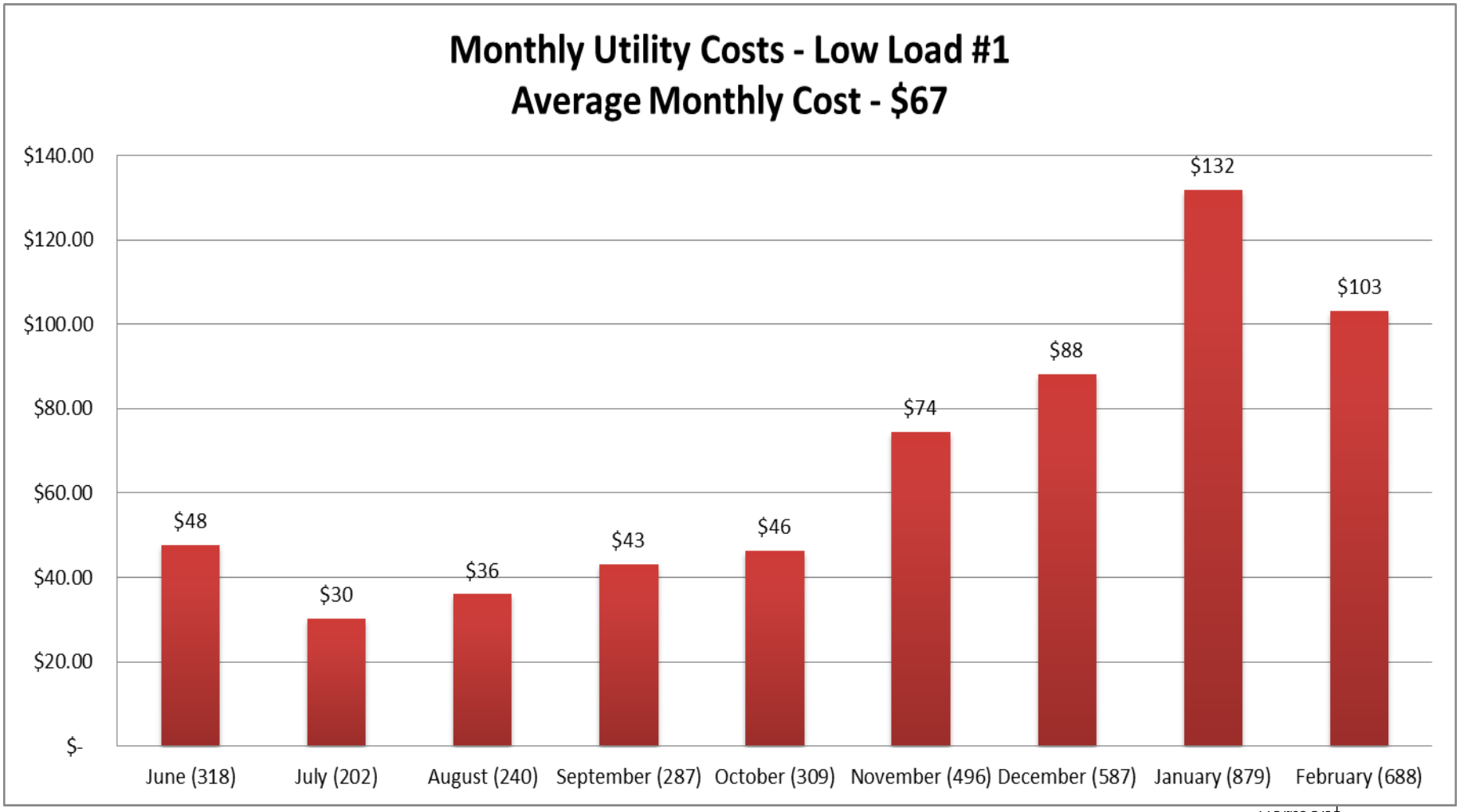
Habitat for Humanities
Charlotte - VT



Source: Efficiency VT 2012

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Habitat for Humanities
East Montpelier

$61/month average at $0.156/kWh - all energy plug loads, heating, cooling and DHW !!

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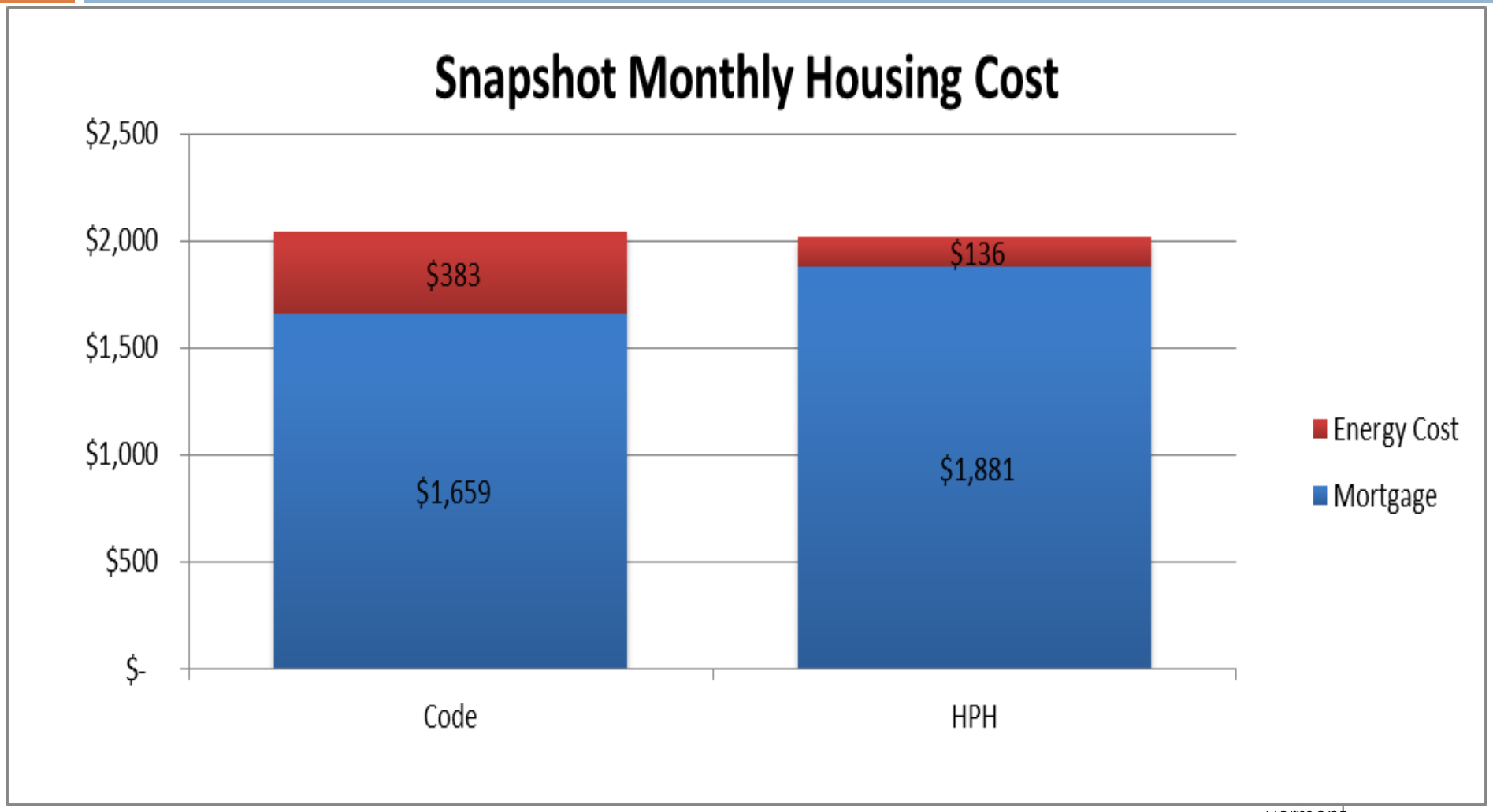
Cost Analysis for HP Home



Source: Efficiency VT

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Second & Delaware
Multifamily Passive House Complex
Kansas City MO
The Arnold Development Group LLC

Comparison with other equivalent project

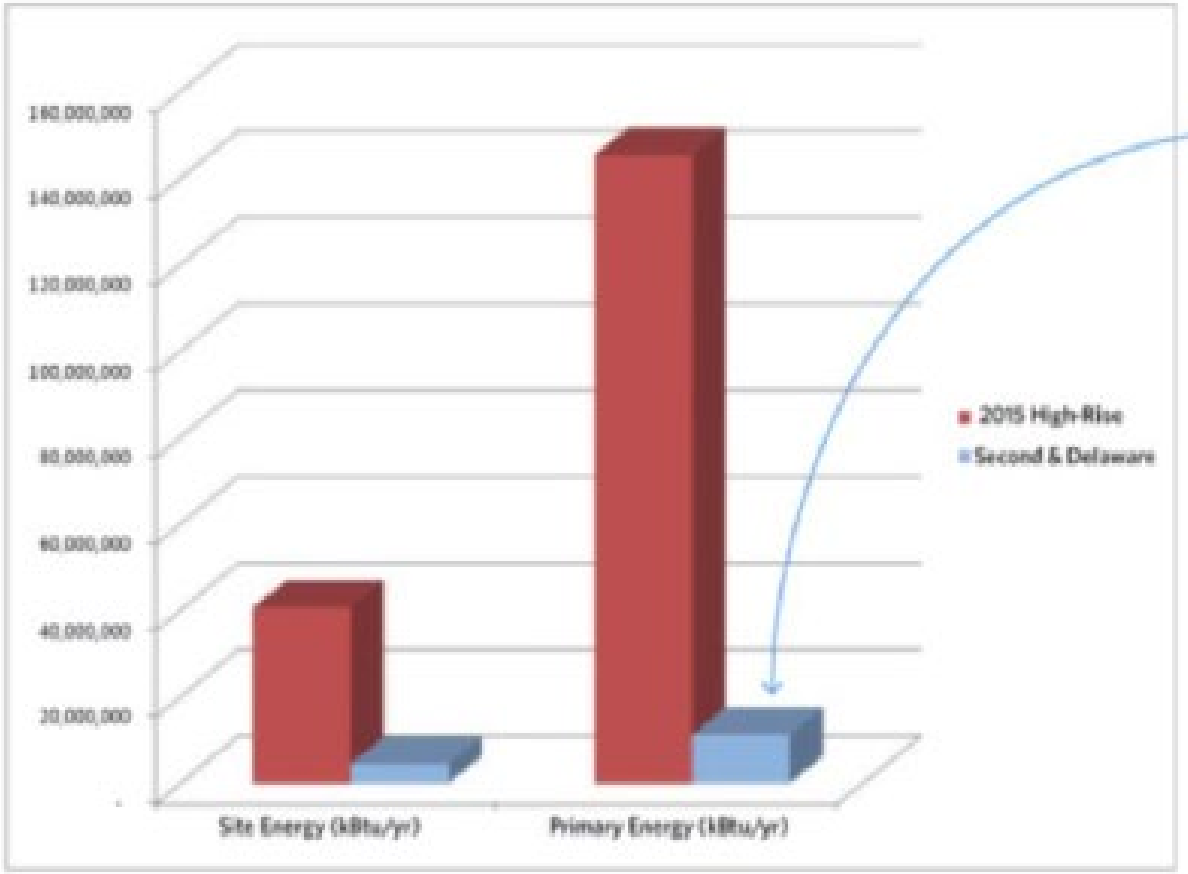
Kansas City High Rise

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	$587,361	$ 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	$ 5.98	$ 11.97
9	Tile Work	$0		$ 0.62
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	$963,841	$ 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

In the USA for the next 50 years

- 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

100,000 x 36,183,952,000 BTU =
3,618,395,200,000,000 BTU =
1,060,447,061,499 kWatt-hr

1.06045×10^{12} kW-hr

1.06045×10^{6} GWh = 1 Million GWh

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

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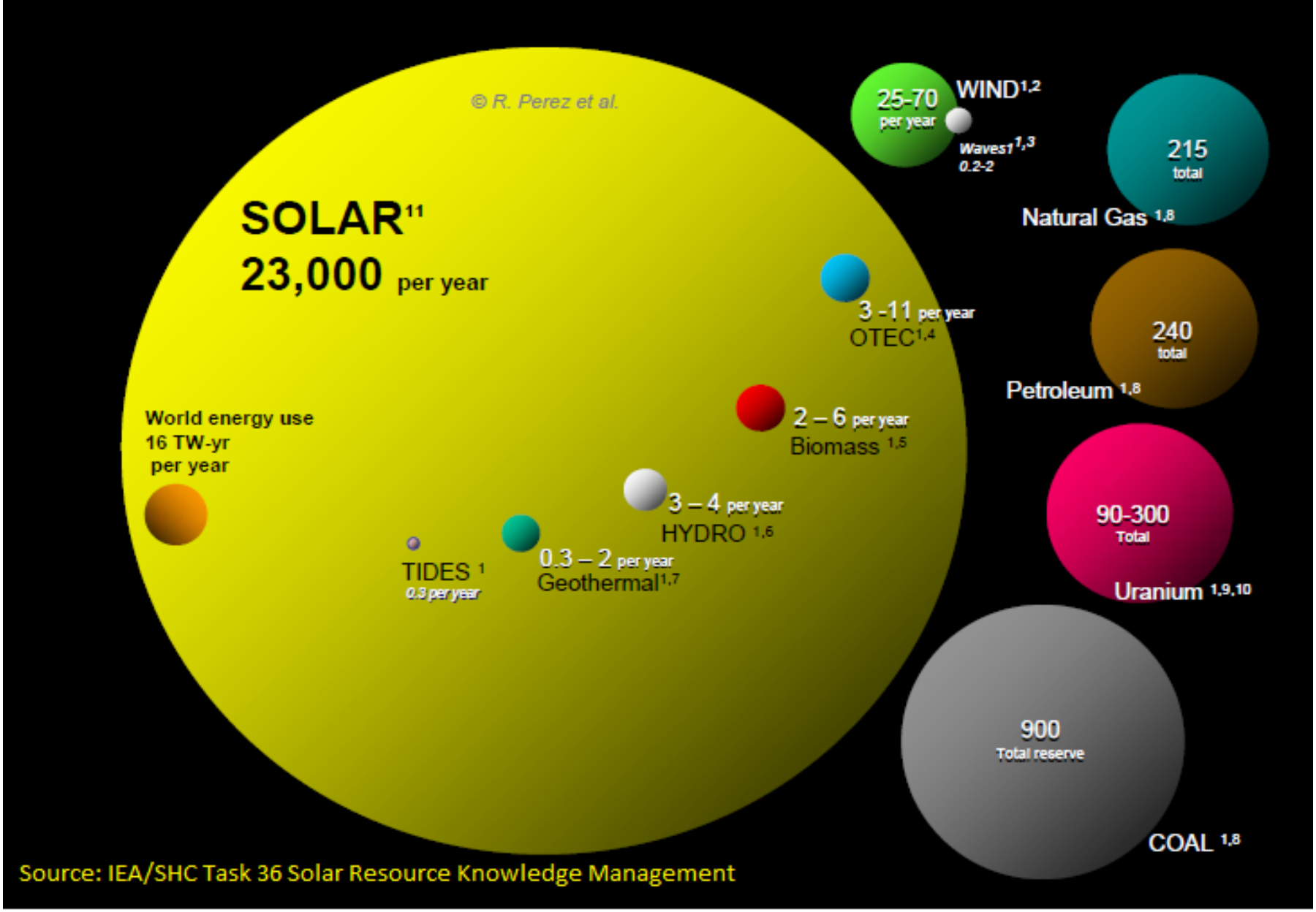

Figure 1: Comparing finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables.

VT's URGENT MISSION

- **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. And enforce it !**

- **VT has qualified PASSIVE HOUSE 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 PASSIVE HOUSE Standard will provide security to people in events of power loss and healthy indoor environment.**

- **Adopting the PASSIVE HOUSE 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.**

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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 design and build

energy efficient buildings.

Enrique Bueno - ebueno@eplusbuildings.com

PH CPHC®

PH CERTIFIED BUILDER