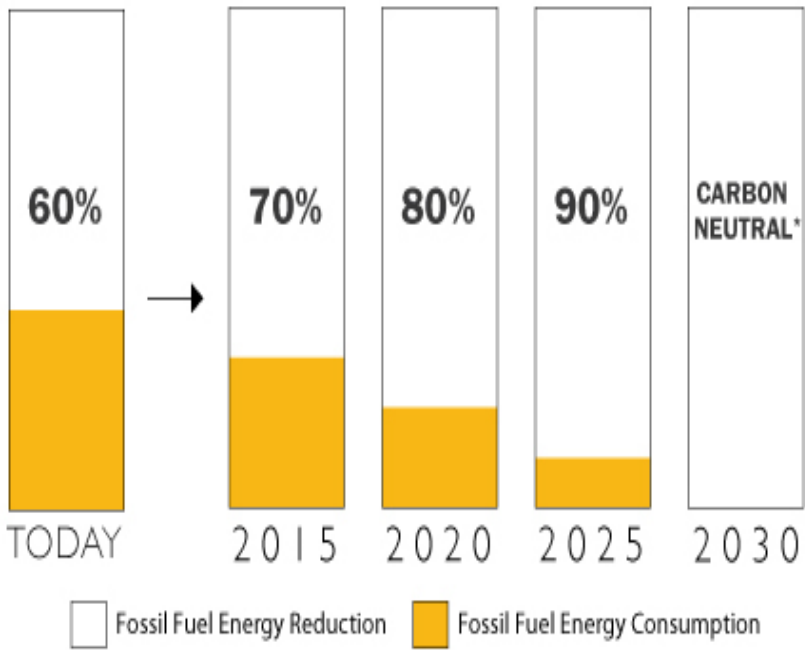


Using Real World Data to Make the Case for Passive House





The 2030 Challenge

Source: ©2010 2030, Inc. / Architecture 2030. All Rights Reserved.
 *Using no fossil fuel GHG-emitting energy to operate.



NEED FOR UNDERSTANDING HOW TO MAKE RETROFITS ENERGY EFFICIENT

PV ARRAY EQUIVILANT TO
AREA OF 5 HOMES

28,000kWh

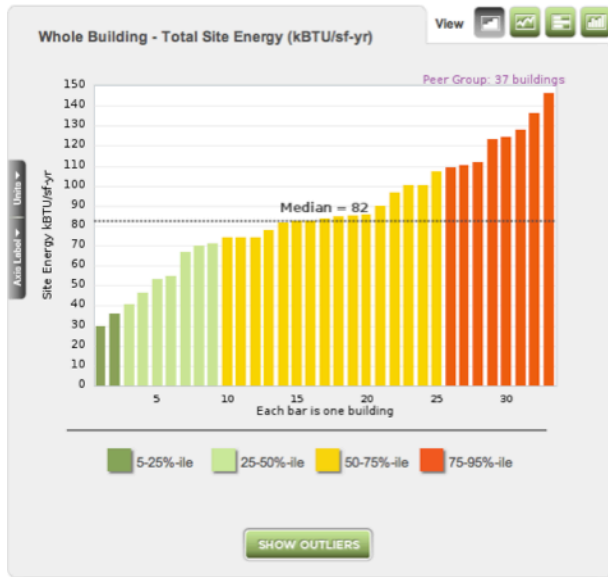
ENERGY REQUIRED TO POWER **1**
TYPICAL **SINGLE FAMILY HOME**

EU I

Energy Use Intensity

**The measure of a building's energy consumption measured in
kBTU / Gross Square Foot / Year**

BENCHMARK PERFORMANCE



CBECS: Commercial Building Energy Consumption Survey

DOE Commercial Reference Buildings
Version 1.4_7.0
New Construction, ANSI/ASHRAE/IESNA 90.1-2004
Site Energy Use Intensities (EUIs) [kBtu/ft²/yr]
August 2012

Climate Zone	Miami		Houston		Phoenix		Atlanta		Los Angeles		Las Vegas		San Francisco		Baltimore		Albuquerque		Seattle		Chicago		Denver		Minneapolis		Helena		Duluth		Fairbanks		Weighted Average
	1A	2A	2B	3A	3B	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8																	
Large Office	47	48	45	44	39	41	41	46	40	41	47	42	52	46	53	67	45																
Medium Office	51	51	51	48	41	47	43	51	46	45	52	47	57	51	59	78	50																
Small Office	52	51	53	47	41	46	41	51	47	47	54	49	59	54	61	83	51																
Warehouse	29	23	24	27	19	24	23	32	29	28	38	34	46	41	53	78	30																
Stand-alone Retail	60	63	62	63	46	58	53	74	64	68	84	72	96	87	107	150	72																
Strip Mall	57	61	60	65	48	61	57	78	68	74	89	76	103	94	115	164	71																
Primary School	57	57	57	55	46	54	52	62	56	55	66	59	75	67	80	103	60																
Secondary School	60	61	59	60	44	56	51	71	59	63	78	66	91	79	99	135	67																
Supermarket	158	169	161	173	156	162	169	186	171	184	197	183	211	200	225	272	183																
Quick Service Restaurant	536	553	546	566	507	551	535	614	576	584	660	612	711	666	760	930	598																
Full Service Restaurant	406	428	418	447	387	429	428	495	457	478	534	491	575	541	621	758	478																
Hospital	149	155	149	154	147	145	152	160	137	150	160	140	163	147	165	184	155																
Outpatient facility	221	225	233	227	212	227	216	233	230	219	232	228	239	233	239	258	230																
Small Hotel	68	67	66	66	60	64	61	68	65	63	71	67	76	71	79	95	68																
Large Hotel	105	115	107	125	111	113	121	138	130	135	151	144	164	159	181	214	132																
Mid-rise Apartment	37	38	37	37	31	36	32	42	37	38	47	41	54	48	59	78	40																

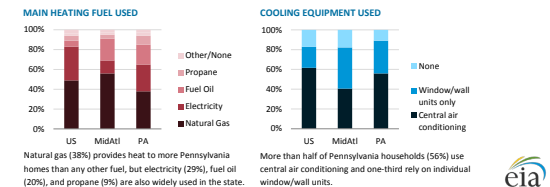
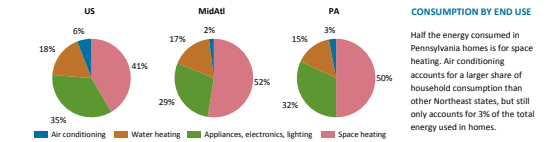
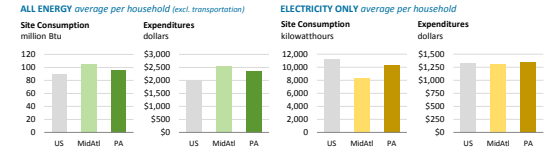
Household Energy Use in Pennsylvania

A closer look at residential energy consumption

All data from EPA's 2009 Residential Energy Consumption Survey
www.eia.gov/consumption/residential/



- Pennsylvania households consume an average of 96 million Btu per year, 8% more than the U.S. average. Pennsylvania residents also spend 16% more than the average U.S. households for energy consumed in their homes.
- Average electricity consumption in Pennsylvania homes is 10,402 kWh per year, which is lower than the national average, but 58% more than New York households and 17% more than New Jersey residents.
- Pennsylvania has a lower percentage of apartment units and homes are typically newer than homes in the other Middle Atlantic states.



RECS: Residential Energy Consumption Survey

DOE: Commercial Reference Buildings

HISTORIC UTILITY DATA

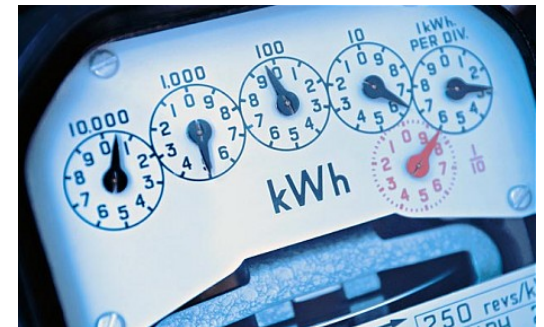


Can be used to calculate a building's *current* EUI

		YTD Actual	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15
Water	PA Amer	778.88	57.92	61.84	54.00	61.84	67.71	52.04	51.07	51.92	63.11	58.11	62.11	62.11	75.10
	Usage (in thousands)		4.4	4.8	4.0	4.8	5.4	3.80	3.7	3.5	4.6	4.1	4.5	4.5	5.8
	Est/Act		A	A	A	A	A	A	A	A	A	A	A	A	A
			5/29-6/26	6/27-7/29	7/30-8/28	8/29-9/29	9/30-10/29	10/30-11/26	11/27-12/29	12/30-1/28	1/29-3/2	3/3-3/30	3/31-4/28	4/29-5/27	5/28-6/26

Electric	Duquense Light	6,233.46	686.89	731.75	712.57	696.39	652.05	538.73	544.30	424.40	197.21	198.28	254.71	290.45	305.73
	Usage		6,310	6,590	6,470	6,240	5,680	4,450	4,599	4,046	-	-	-	-	-
	Est/Act		A	A	A	A	A	A	A	A	A	A	A	A	A
			5/5-6/4	6/4-7/3	7/3-8/5	8/5-9/4	9/4-10/6	10/6-11/4	11/6-12/8	12/8-1/8	1/8-2/9	2/9-3/10	3/10-4/8	4/8-5/9	5/10-6/10
	Guttman	2,334.13								341.37	367.67	319.93	354.88	464.23	486.05
	Usage									4,718	5,082	4,422	4,905	6,417	6,718.18
										1/7-2/4	2/5-3/6	3/7-4/6	4/7-5/5	5/6-6/6	6/7-7/6

Gas	Equitable	591.23	17.00	17.00	17.00	18.33	21.76	50.47	88.94	109.86	110.96	75.64	29.54	17.73	17.00
	Customer Charge		17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
	Usage (MCF)		-	-	-	0.2	1.2	9.1	19.3	25.3	25.6	16.4	3.5	0.2	-
	Est/Act		A	A	A	A	A	A	A	A	A	A	A	A	A
			5/29-6/29	6/29-7/30	7/30-8/28	8/28-9/29	9/30-10/30	10/31-11/25	11/26-12/30	12/31-1/29	1/30-2/26	2/27-3/30	3/31-4/29	4/30-5/28	5/28-6/29
01-820075-43300	Dominion	429.39	-	-	-	-	5.13	38.85	82.39	107.97	109.27	69.99	14.93	0.86	-
	Usage (DTH)		-	-	-	-	1.2	9.1	19.3	25.3	25.6	16.4	3.5	0.2	-
			5/29-6/29	6/29-7/30	7/30-8/28	8/28-9/29			12/1-12/31	1/1-1/31	2/1-2/28	3/1-3/31	4/1-4/30	5/1-5/31	



PREDICTED ENERGY PERFORMANCE

Passive House Planning PRIMARY ENERGY VALUE

Building: **McKeesport Downtown Housing**
Location: **North America**

Building Type/Use: **Multi-Unit (Single Room Occupa**
Treated Floor Area A_{TFA}: **36643** ft²
Space Heat Demand incl. Distribution: **1.8** kWh/(ft2yr)
Useful Cooling Demand: **0.3** kWh/(ft2yr)

Final Energy Primary Energy Emissions
CO₂-Equivalent

CHOOSE UNITS: kWh/(ft2yr) kWh/(ft2yr) lb/(ft²·yr)

		PE Value	CO ₂ -Emissions Factor (CO ₂ -Equivalent)
Electricity Demand (without Heat Pump)			
Covered Fraction of Space Heat Demand	(Project)	kWh/kWh	lb/kWh
Covered Fraction of DHW Demand	(Project)	2.7	1.50
Direct Electric Heating	Q _{h,de}	0.0	0.00
DHW Production, Direct Electric (without Wash&Dish)	Q _{DHW,de} (DHW+Distribution, Solar/DHW)	0.0	0.00
Electric Postheating DHW Wash&Dish	(Electricity, Solar/DHW)	0.0	0.00
Electricity Demand Household Appliances	(Electricity, household)	1.3	1.00
Annual Energy Demand, Space Heating		0.0	0.00
Annual Energy Demand, DHW (without DHW Wash&Dish)		2.0	1.01
Non-Electric Demand, DHW Wash&Dish	(Electricity worksheet)	0.0	0.01
Non-Electric Demand Cooking/Drying (Gas)	(Blatt Strom)	0.3	0.15
Total - Other		2.1	1.17
		kWh/(ft2yr)	lb/(ft ² ·yr)
Cooling with Electric Heat Pump		PE Value	CO ₂ -Emission Factor (CO ₂ -Equivalent)
Covered Fraction of Cooling Demand	(Project)	kWh/kWh	lb/kWh
Heat Source	Electricity	2.7	1.50
Annual Cooling COP			
Energy Demand Space Cooling		0.1	0.11
		kWh/(ft2yr)	lb/(ft ² ·yr)
Heating, Cooling, DHW, Auxiliary and Household Electricity		5.4	6.00
		kWh/(ft2yr)	lb/(ft ² ·yr)
Total Primary Energy Use Intensity	11.0	kWh/(ft2yr)	
Total Emissions, CO ₂ -Equivalent	6.0	lb/(ft ² ·yr)	(Yes/No)
Primary Energy Requirement	11.1	kWh/(ft2yr)	Yes

Results from the PHPP can be used to calculate a "Predicted EUI"

Sample Calculation:
5.4 kWh X 36643 ft² = 197,872 kWh

197,872 kWh X 3.412 kWh/kBTU = 675,140 kBTU

675,140 kBTU/67,500 GSF = 10

PHPP predicts an EUI of 10

CAUTION:

Primary Energy Use Intensity is NOT the same as EUI

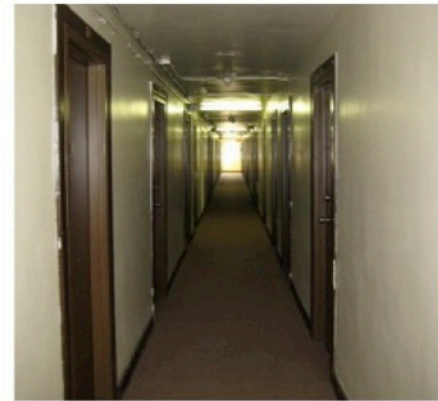
Final Energy Use Intensity is NOT the same as EUI

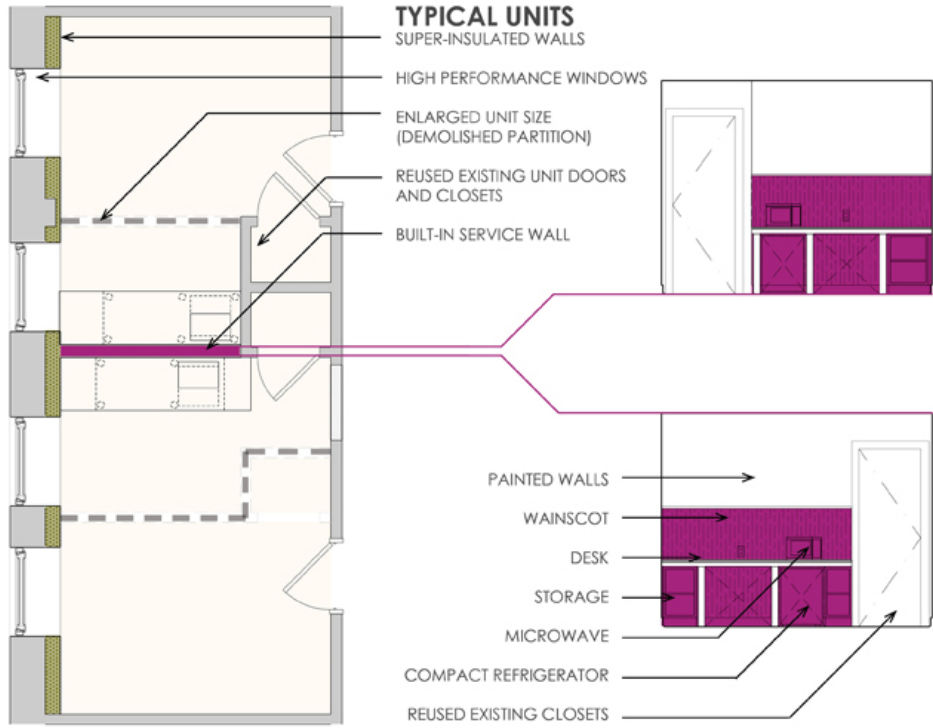
PHPP uses TFA (Treated Floor Area) EUI uses GSF (Gross SF)

**Real World Utility
Data:
Two Passive House
Retrofit Case
Studies**



MCKEESPORT YMCA







McKeesport Downtown Housing \$124 per sf



Denmarsh Photography, Inc.



Denmarsh Photography, Inc.



Denmarsh Photography, Inc.





Ever wonder what
14,100 CFM50
actually looks like?



2.0 ACH50

30°

**PASSIVE
HOUSE
EXTERIOR**



57°

**STANDARD
BUILDING
EXTERIOR**



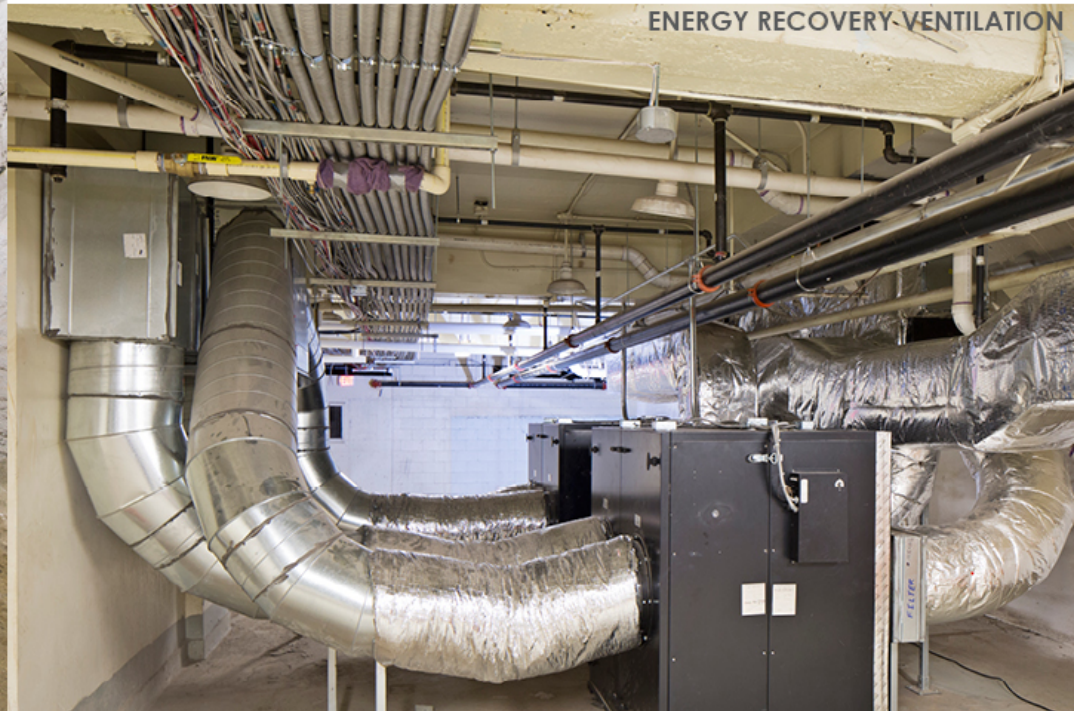
GEOTHERMAL HEAT PUMPS

MEASURED ENERGY PERFORMANCE

75% less energy consumption than SRO dwellings according to CBECS

68% less energy consumption than the original building
AFTER adding...

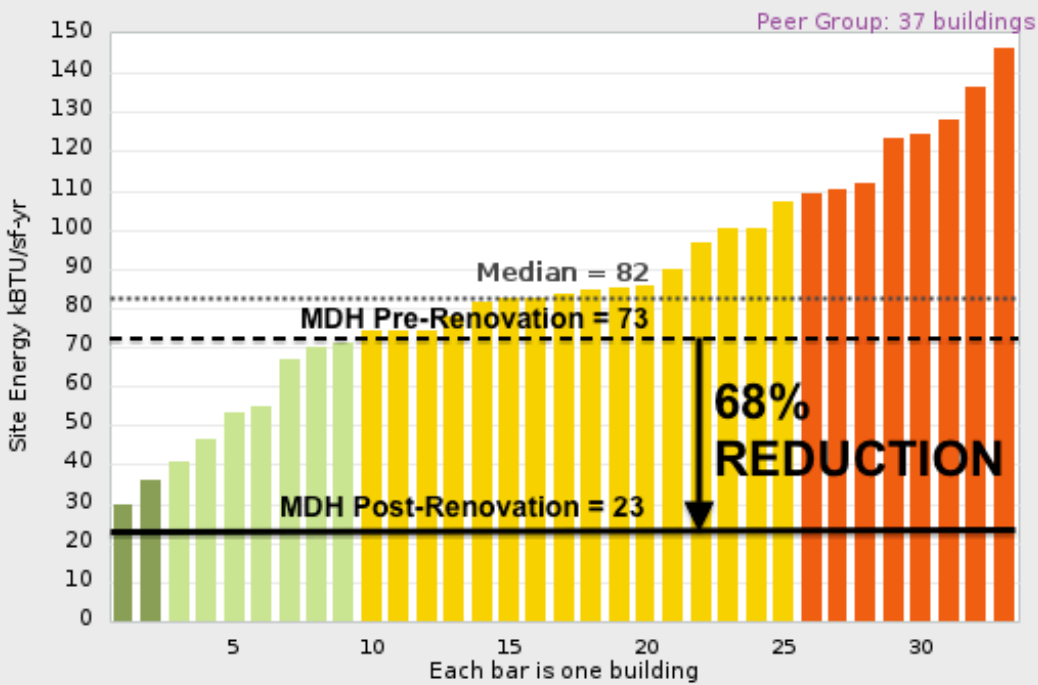
- ...lighting
- an elevator
- cooking equipment
- constant ventilation
- air-conditioning...



ENERGY RECOVERY-VENTILATION

Whole Building - Total Site Energy (kBTU/sf-yr)

View



SHOW OUTLIERS

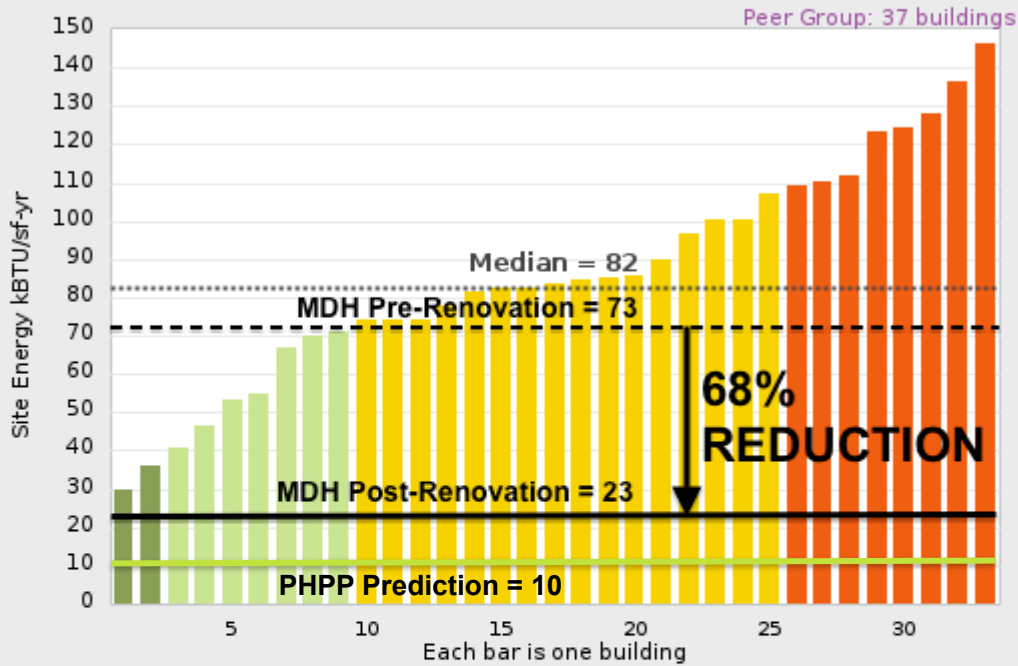
Peer Group Information

SUMMARY The Site Energy for typical buildings of the type(s) you've specified is 83.1 kBTU/sf-yr [median value], with a range of 19.9 to 143.3 kBTU/sf-yr [5th to 95th percentiles] for the population. Select "Add a Building" button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes population weights for each building.

The data in the plot is an *unweighted* representation of the values you selected.

- DATA SET** U.S. National (CBECS)
- LOCATION** Us Climate= <2000 CDD, 5500-7000 HDD, <2000 CDD, 4000-5499 HDD
- SIZE** 25000 - 100000 sqft
- HOURS OF OPERATION** 0 - 168 hours/week
- VINTAGE** 1920 to 1945, 1946 to 1959, 1960 to 1969, 1970 to 1979, 1980 to 1989, 1990 to 1999, 2000 to 2003, Before 1920
- OCCUPANCY** Government, Private
- TYPE** Dormitory/fraternity/sorority, Hotel, Motel or inn, Other lodging

Whole Building - Total Site Energy (kBtu/sf-yr)



5-25%-ile | 25-50%-ile | 50-75%-ile | 75-95%-ile

SHOW OUTLIERS

Peer Group Information

SUMMARY The Site Energy for typical buildings of the type(s) you've specified is 83.1 kBtu/sf-yr [median value], with a range of 19.9 to 143.3 kBtu/sf-yr [5th to 95th percentiles] for the population. Select "Add a Building" button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes population weights for each building.

The data in the plot is an *unweighted* representation of the values you selected.

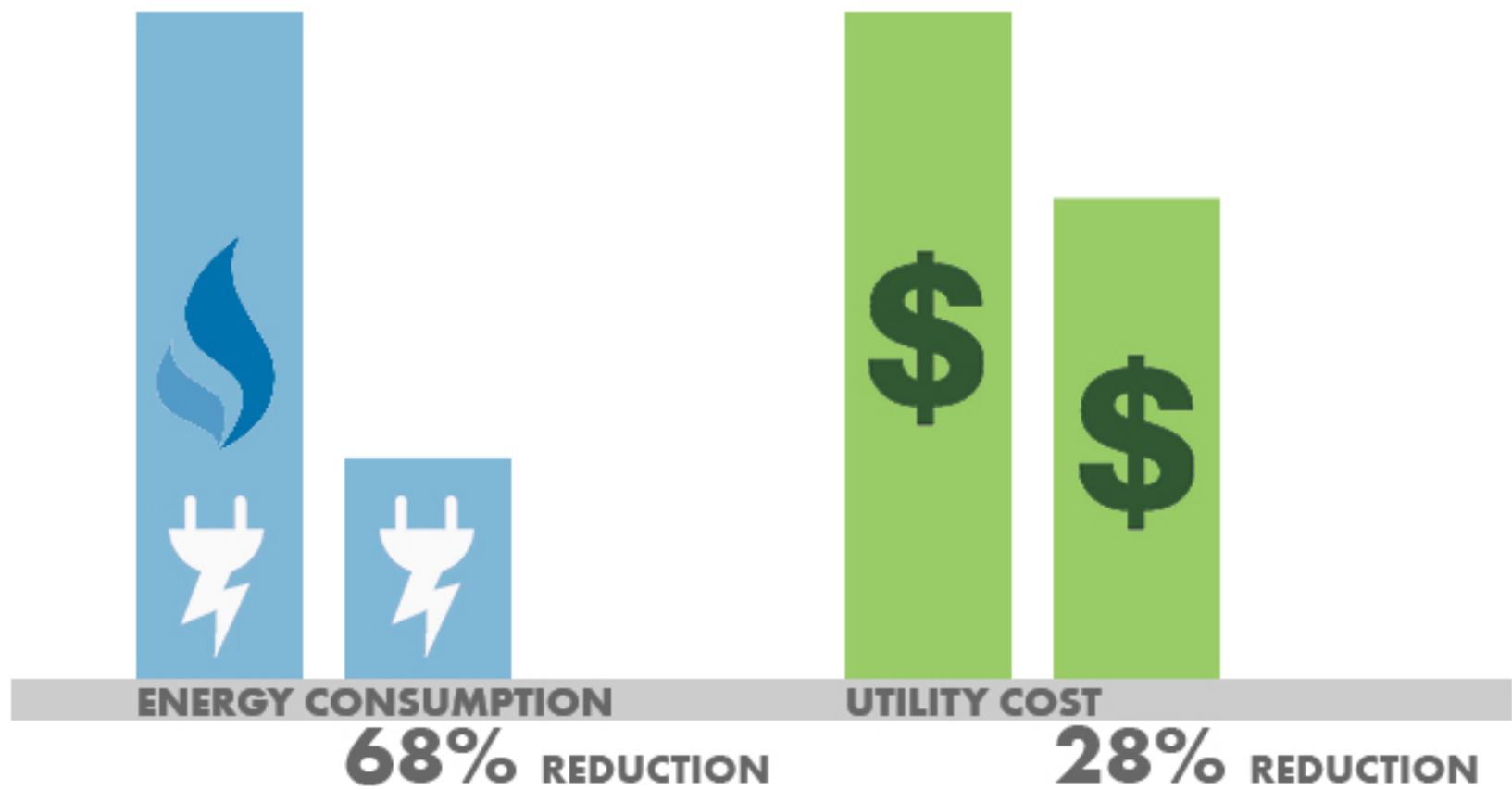
- DATA SET** U.S. National (CBECS)
- LOCATION** Us Climate= <2000 CDD, 5500-7000 HDD, <2000 CDD, 4000-5499 HDD
- SIZE** 25000 - 100000 sqft
- HOURS OF OPERATION** 0 - 168 hours/week
- VINTAGE** 1920 to 1945, 1946 to 1959, 1960 to 1969, 1970 to 1979, 1980 to 1989, 1990 to 1999, 2000 to 2003, Before 1920

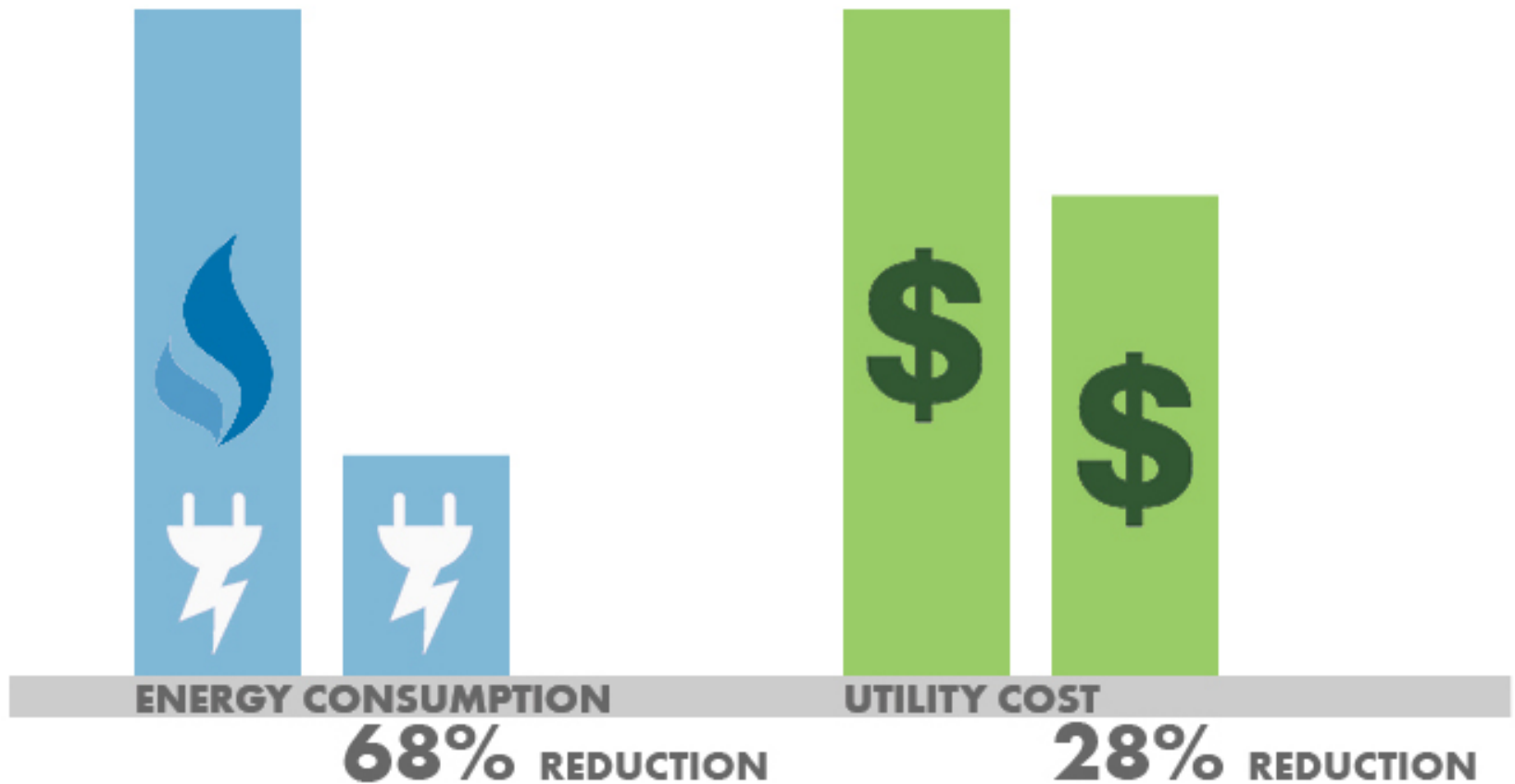
OCCUPANCY Government, Private

TYPE Dormitory/fraternity/sorority, Hotel, Motel or inn, Other lodging



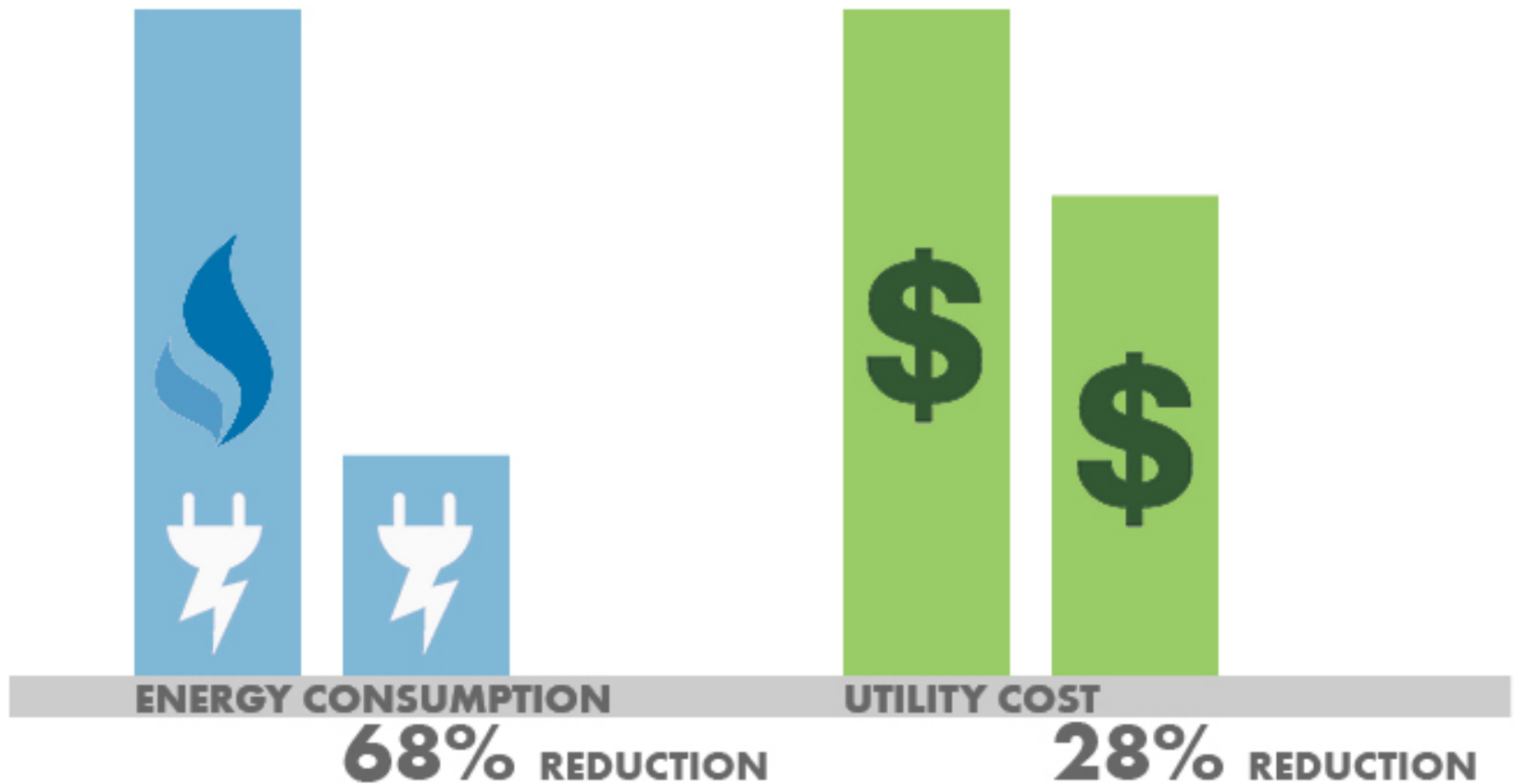
Energy Savings are Not Always Equal to Money Savings





What's going on here?

The energy SOURCES changed...

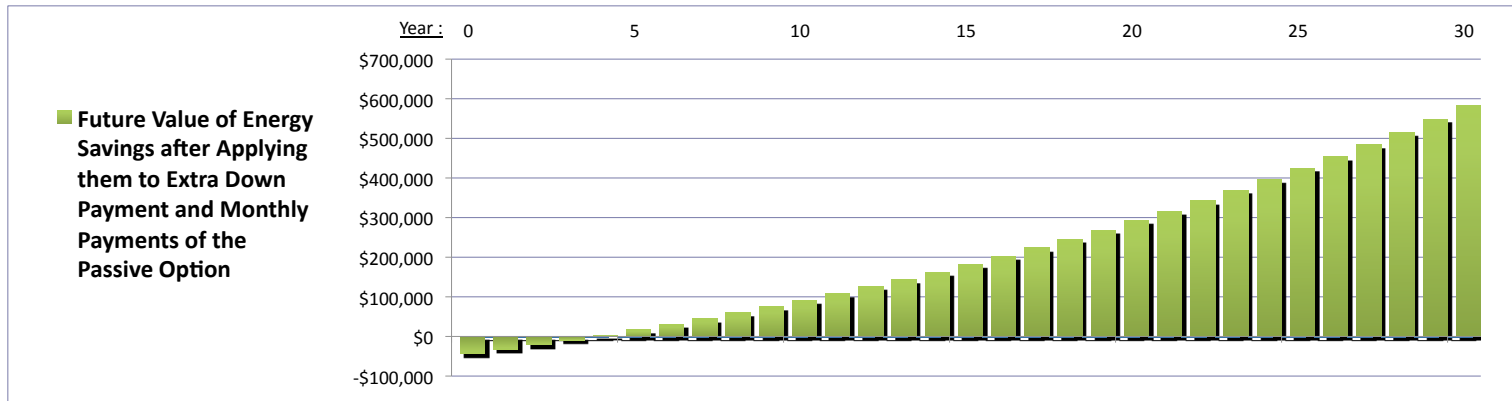


The cost of energy varies by SOURCE...

Gas: \$16.35 per MMBTU Electric: \$27.65 per MMBTU

Cost of Building Options	Cost of Baseline Renovation	Cost to Upgrade to Passive House	Cost of Passive House Renovation
	7,225,000	3%	7,441,750

Energy Cost, Baseline Building (\$ per month)	5,000
Annual Rate of increase in Energy Costs Projected	3%
Utility Cost Reduction from Passive House Approach (%)	28%



Areas below zero indicate that the extra down and monthly payments exceed the value of the energy savings to date.

When the value reaches zero, it's all gravy - and the energy savings each month will add up to a substantial sum!



INFORMATION PRESENTED BY:

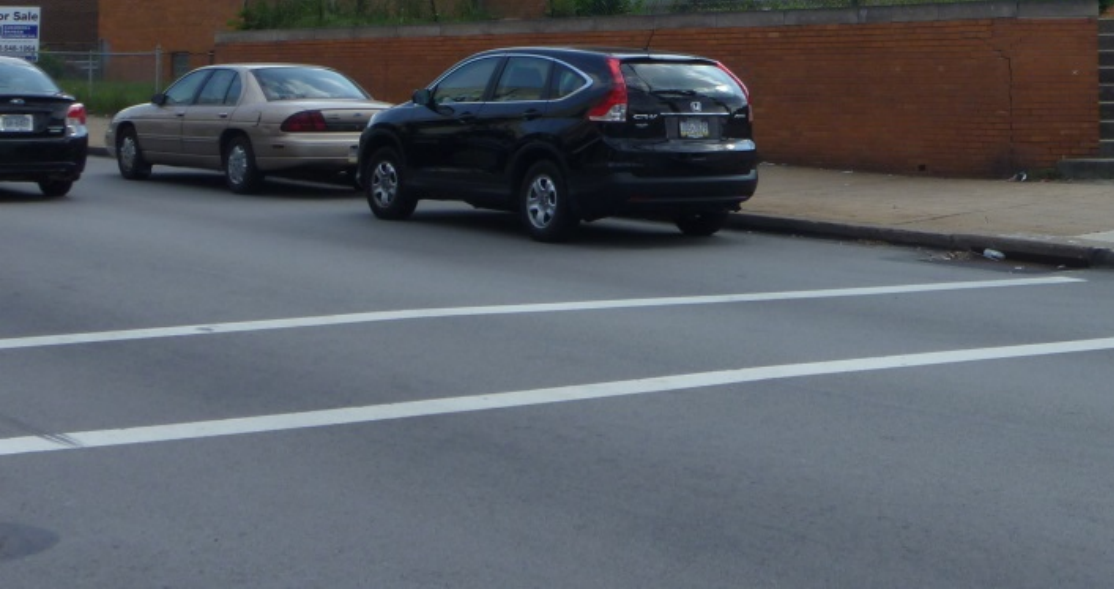
Michael Whartnaby, C.P.H.C., Thoughtful Balance, inc.

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Five-year PAYBACK \$600,000 SAVED over 30 years of building operation



What Kind of Future Do You Want?

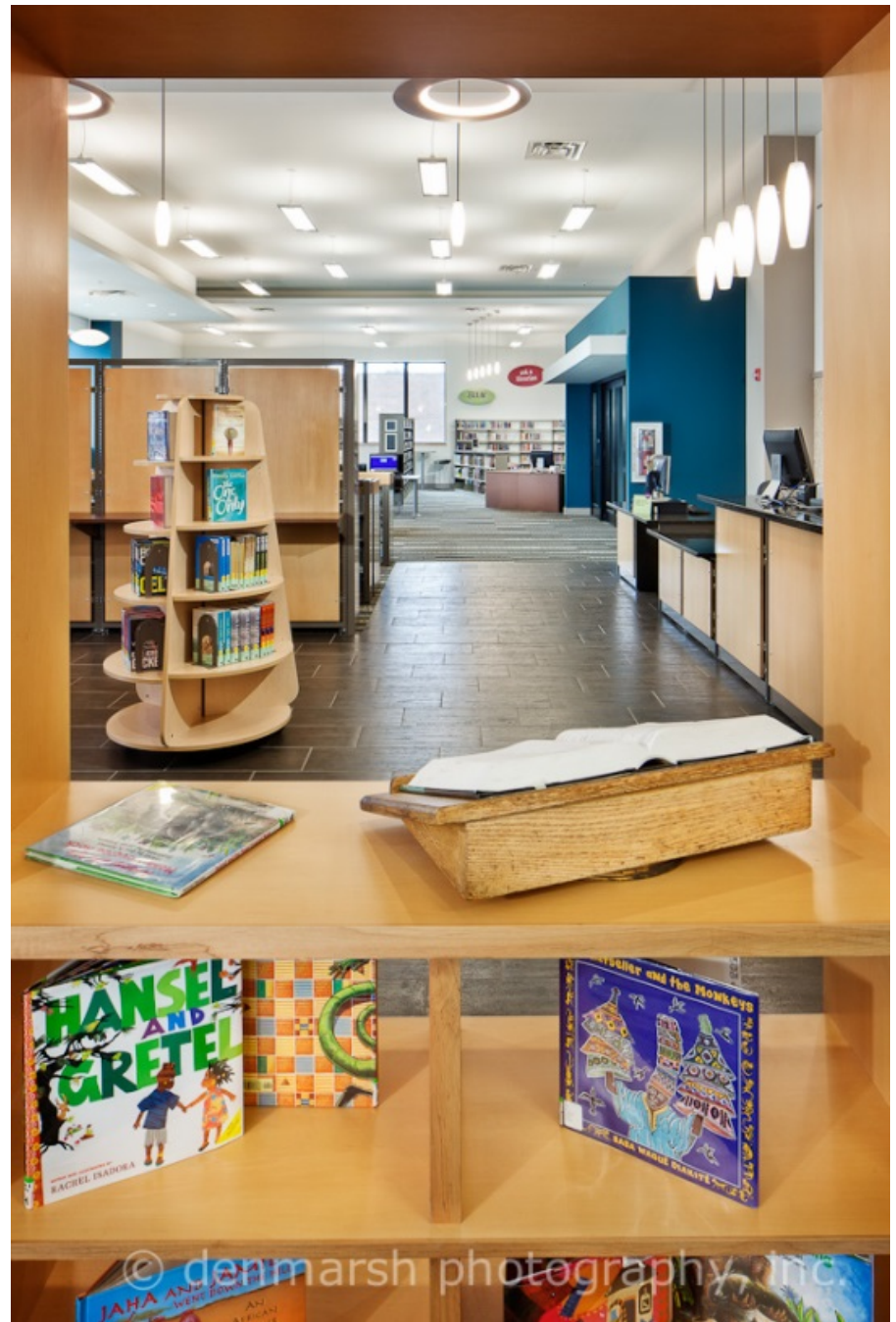




HAZELWOOD LIBRARY

\$117 per sf core & shell
\$37 per sf library interiors
\$45 per sf family center interiors





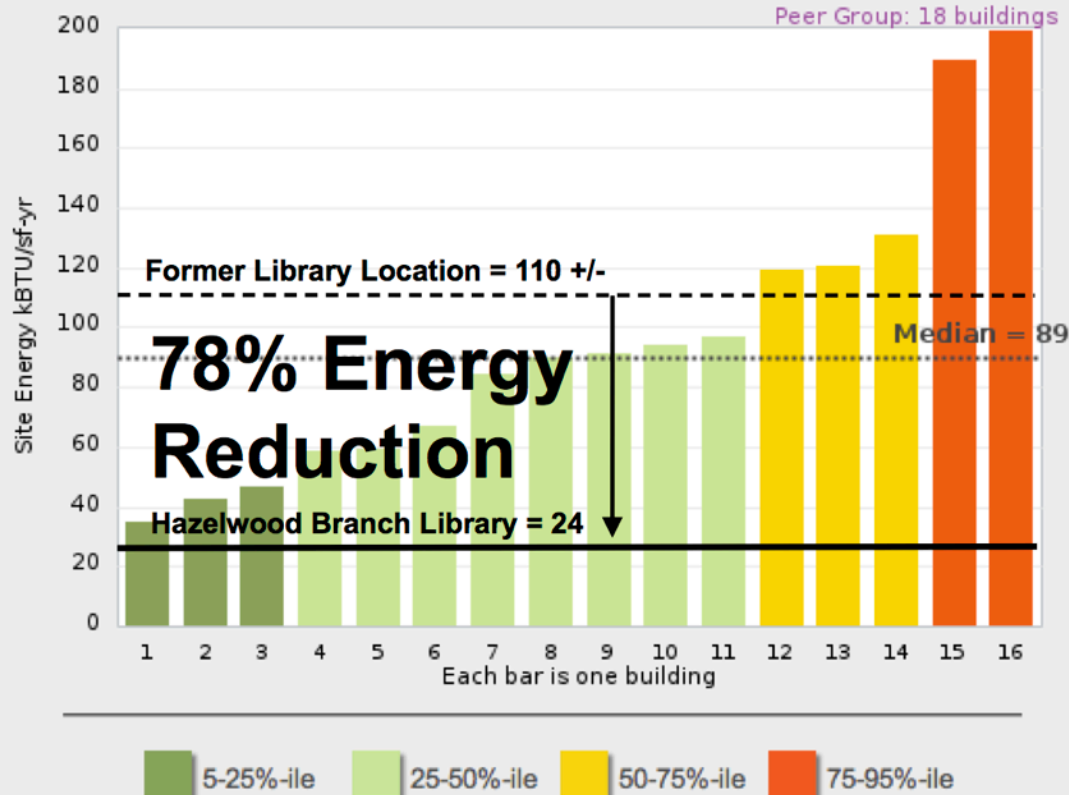






Whole Building - Total Site Energy (kBTU/sf-yr)

View



SHOW OUTLIERS

AND...

73% less energy consumed than the MEDIAN for this building type!

Peer Group Information

SUMMARY The Site Energy for typical buildings of the type(s) you've specified is 90.2 kBTU/sf-yr [median value], with a range of 34.6 to 193.7 kBTU/sf-yr [5th to 95th percentiles] for the population. Select "Add a Building" button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes population weights for each building.

The data in the plot is an *unweighted* representation of the values you selected.

DATA SET U.S. National (CBECS)

LOCATION Us Climate= <2000 CDD, >7000 HDD, <2000 CDD, 5500-7000 HDD, <2000 CDD, 4000-5499 HDD, <2000 CDD, <4000 HDD, >=2000 CDD, <4000HDD

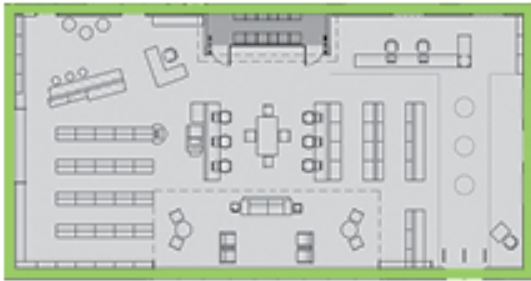
SIZE 0 - 50000 sqft

HOURS OF OPERATION 0 - 168 hours/week

VINTAGE 1920 to 1945, 1946 to 1959, 1960 to 1969, 1970 to 1979, 1980 to 1989, 1990 to 1999, 2000 to 2003, Before 1920

OCCUPANCY Government, Private

TYPE Library

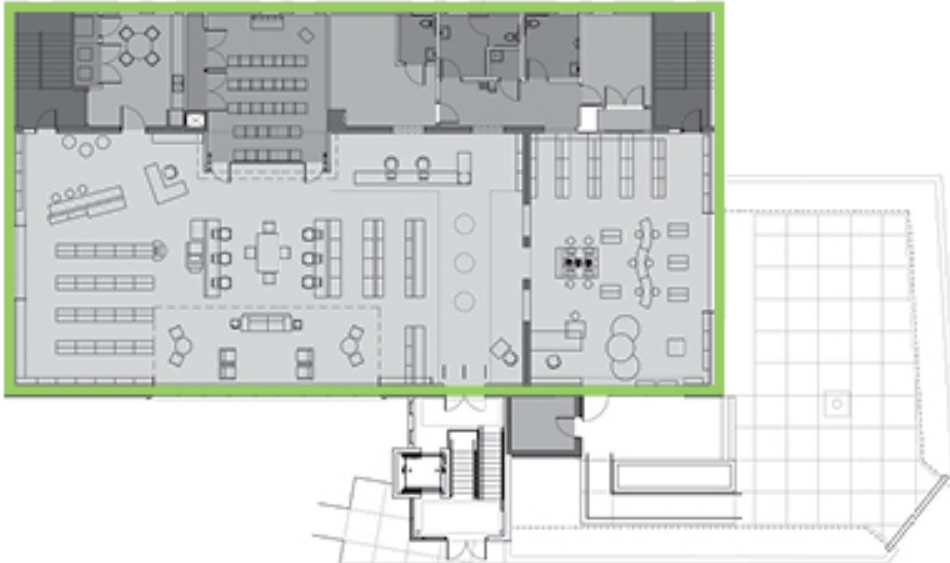


BUILDING SIZE

2x MORE

UTILITY COST

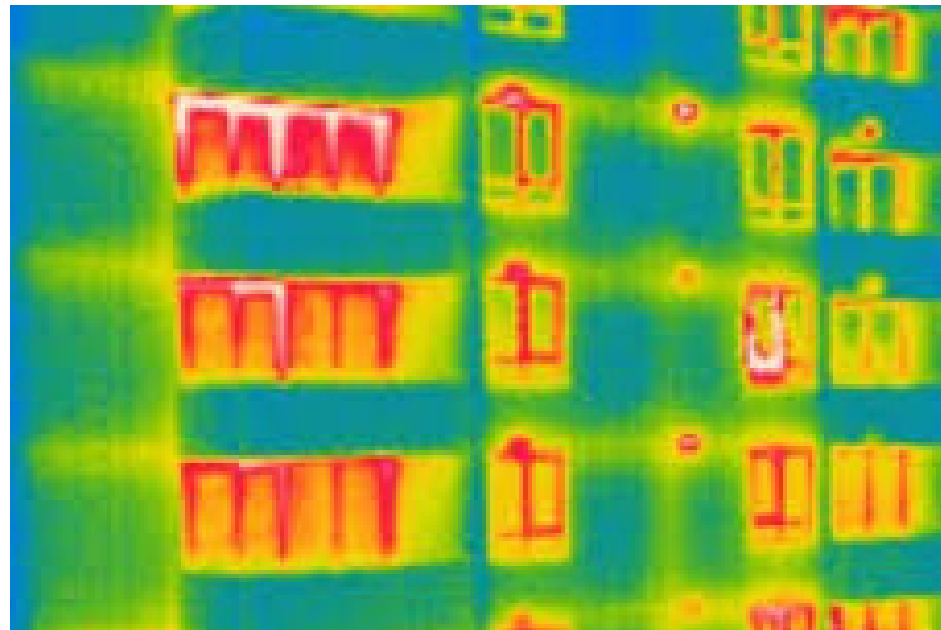
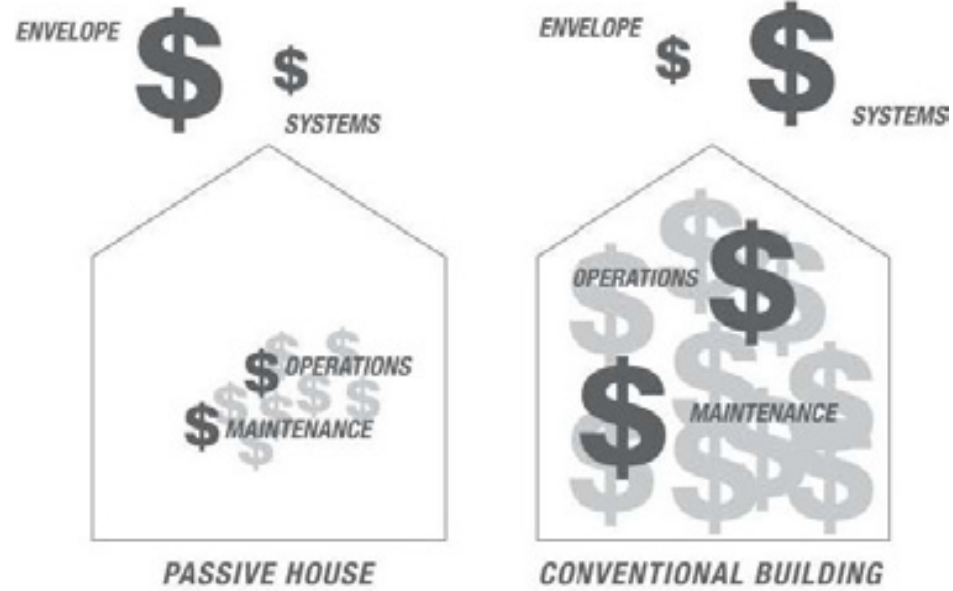
14% LESS



**Making the Case:
Three Proposed
Passive House
Projects**



WHERE THE MONEY IS GOING



Export

Email

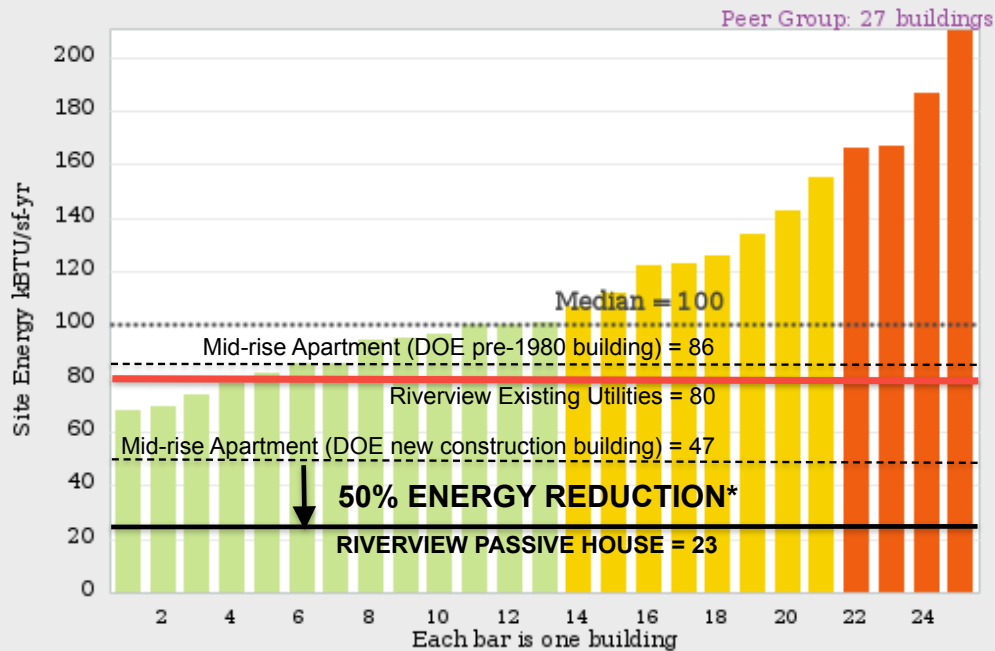
Add to Dashboard

Create New Chart

Add Your Building

Whole Building - Total Site Energy (kBtu/sf-yr)

View



SHOW OUTLIERS

Peer Group Information

SUMMARY The Site Energy for typical buildings of the type(s) you've specified is 94.6 kBtu/sf-yr [median value], with a range of 20.9 to 196.3 kBtu/sf-yr [5th to 95th percentiles] for the population. Select "Add a Building" button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes population weights for each building.

The data in the plot is an *unweighted* representation of the values you selected.

DATA SET U.S. National (CBECS)

LOCATION Us Climate= <2000 CDD, 5500-7000 HDD, <2000 CDD, 4000-5499 HDD

SIZE 65000 - 330000 sqft

HOURS OF OPERATION 0 - 168 hours/week

VINTAGE 1920 to 1945, 1946 to 1959, 1960 to 1969, 1970 to 1979, 1980 to 1989, 1990 to 1999, 2000 to 2003, Before 1920

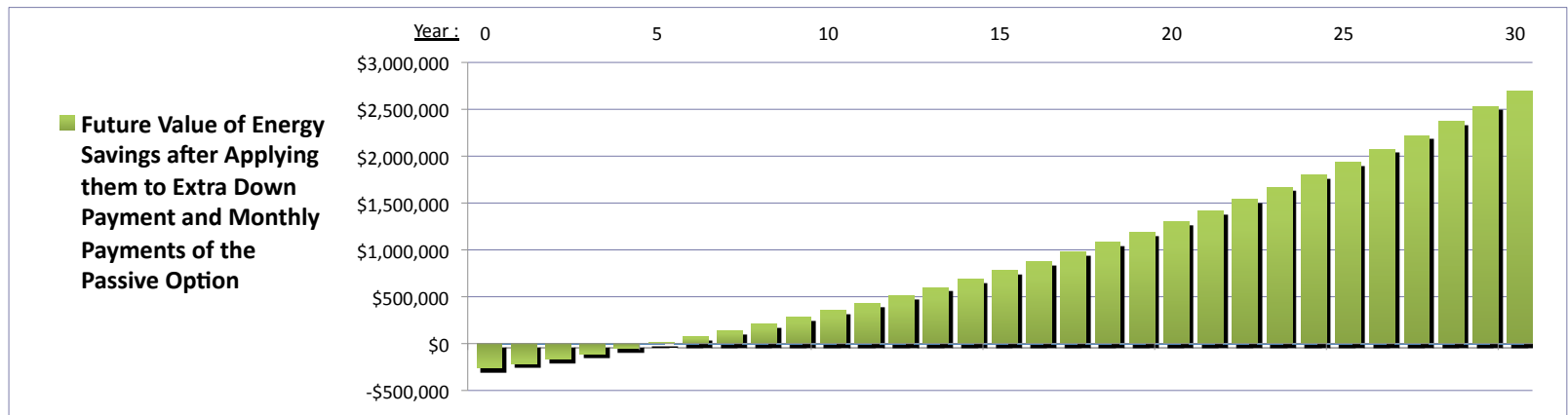
OCCUPANCY Government, Private

TYPE Dormitory/fraternity/sorority, Hotel, Other lodging

* Passive House is projected to reduce energy consumption by 50% (or more) over DOE benchmark for New Construction OR a "typical" Energy Retrofit.

Cost of Building Options	Cost of Baseline Renovation	Cost to Upgrade to Passive House	Cost of Passive House Renovation
	13,000,000	10%	14,300,000

Energy Cost, Baseline Renovated Building (\$ per month)	14,000
Annual Rate of increase in Energy Costs Projected	3%
Utility Cost Reduction from Passive House Approach (%)	50%



Areas below zero indicate that the extra down and monthly payments exceed the value of the energy savings to date.

When the value reaches zero, it's all gravy - and the energy savings each month will add up to a substantial sum!



INFORMATION PRESENTED BY:

Michael Whartnaby, C.P.H.C., Thoughtful Balance, inc.

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www.ArtisansGroup.com

Five-year PAYBACK and over \$2.5 MILLION dollars saved compared to a DOE New Construction Commercial Reference Building!

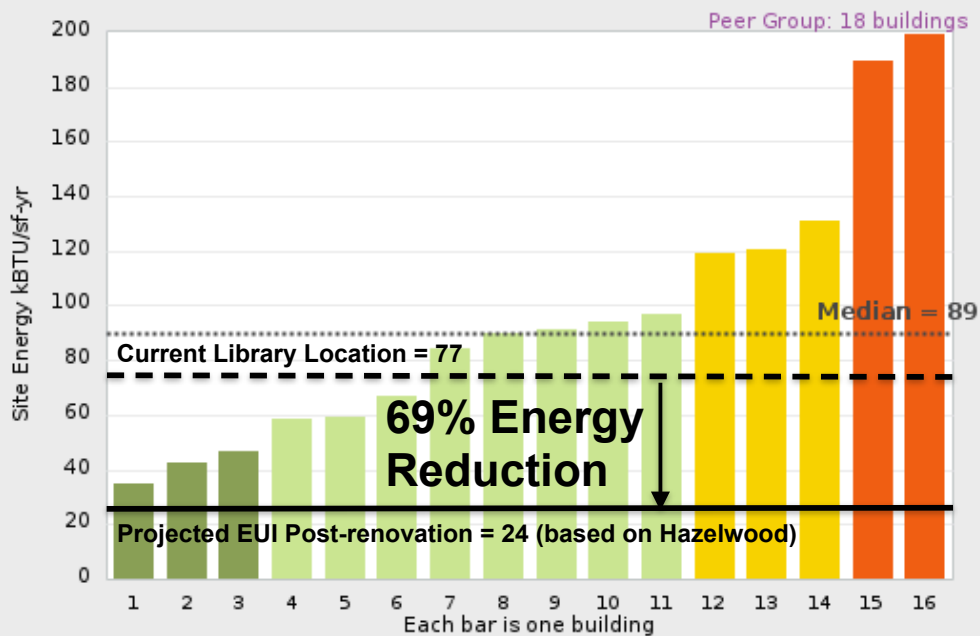


[Export](#)[Email](#)[Add to Dashboard](#)[Create New Chart](#)[Add Your Building](#)

View



Whole Building - Total Site Energy (kBTU/sf-yr)



5-25%-ile 25-50%-ile 50-75%-ile 75-95%-ile

[SHOW OUTLIERS](#)

Peer Group Information

SUMMARY The **Site Energy** for typical buildings of the type(s) you've specified is 90.2 kBTU/sf-yr [**median** value], with a range of 34.6 to 193.7 kBTU/sf-yr [5th to 95th percentiles] for the population. Select "Add a Building" button to see how yours compares. Try other Views for graphical and tabular detail. This analysis includes **population weights** for each building.

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DATA SET U.S. National (CBECS)

LOCATION Us Climate= <2000 CDD, >7000 HDD, <2000 CDD, 5500-7000 HDD, <2000 CDD, 4000-5499 HDD, <2000 CDD, <4000 HDD, >=2000 CDD, <4000HDD

SIZE 0 - 50000 sqft

HOURS OF OPERATION 0 - 168 hours/week

VINTAGE 1920 to 1945, 1946 to 1959, 1960 to 1969, 1970 to 1979, 1980 to 1989, 1990 to 1999, 2000 to 2003, Before 1920

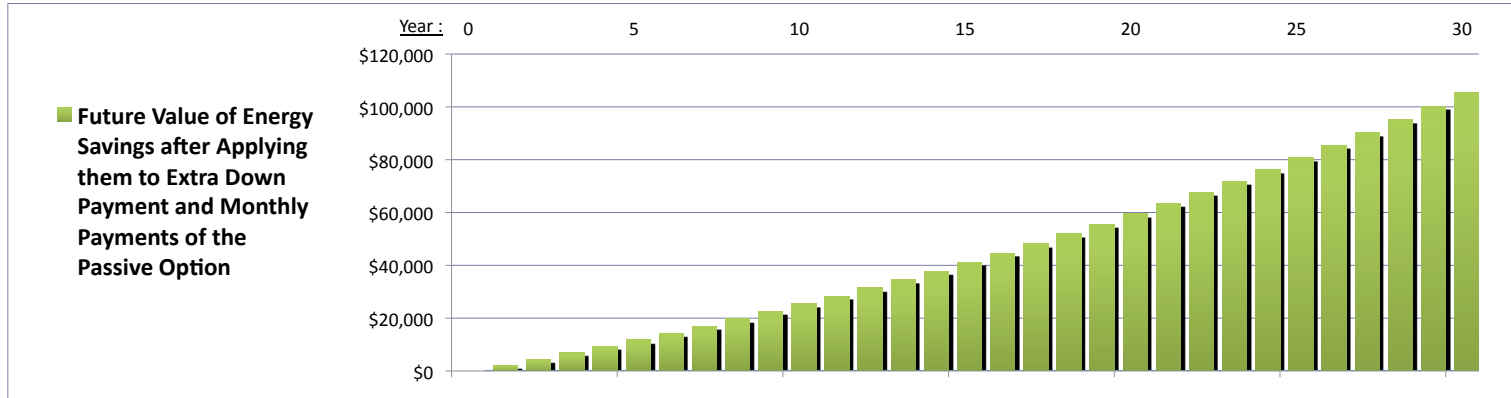
OCCUPANCY Government, Private

TYPE Library

A 69% REDUCTION in energy consumed per square foot allows for a building that is 1.8 TIMES LARGER, yet costs 26% LESS TO OPERATE...

Cost of Building Options	Cost of Baseline Renovation	Cost to Upgrade to Passive House	Cost of Passive House Renovation
	1,200,000	0%	1,200,000

Energy Cost, Baseline Building (\$ per month)	710
Annual Rate of increase in Energy Costs Projected	3%
Utility Cost Reduction from Passive House Approach (%)	26%



Areas below zero indicate that the extra down and monthly payments exceed the value of the energy savings to date.

When the value reaches zero, it's all gravy - and the energy savings each month will add up to a substantial sum!

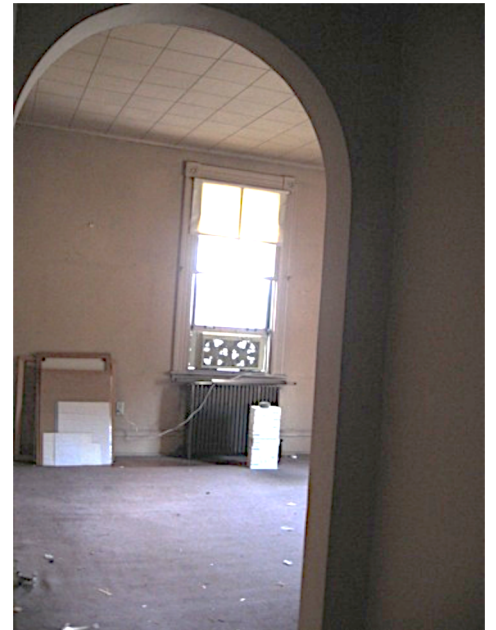


INFORMATION PRESENTED BY:

Michael Whartnaby, C.P.H.C., Thoughtful Balance, inc.

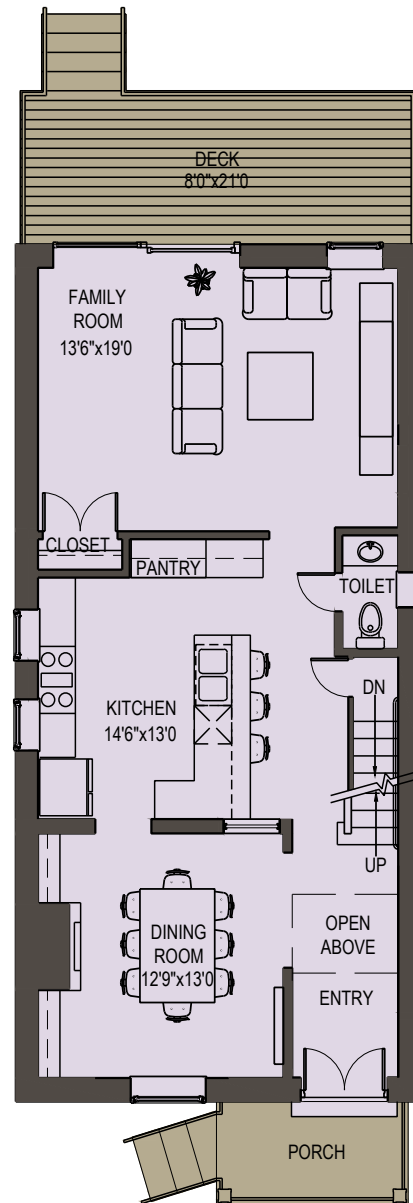
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Saving this non-profit more than \$100,000 over 30 years of building operation!





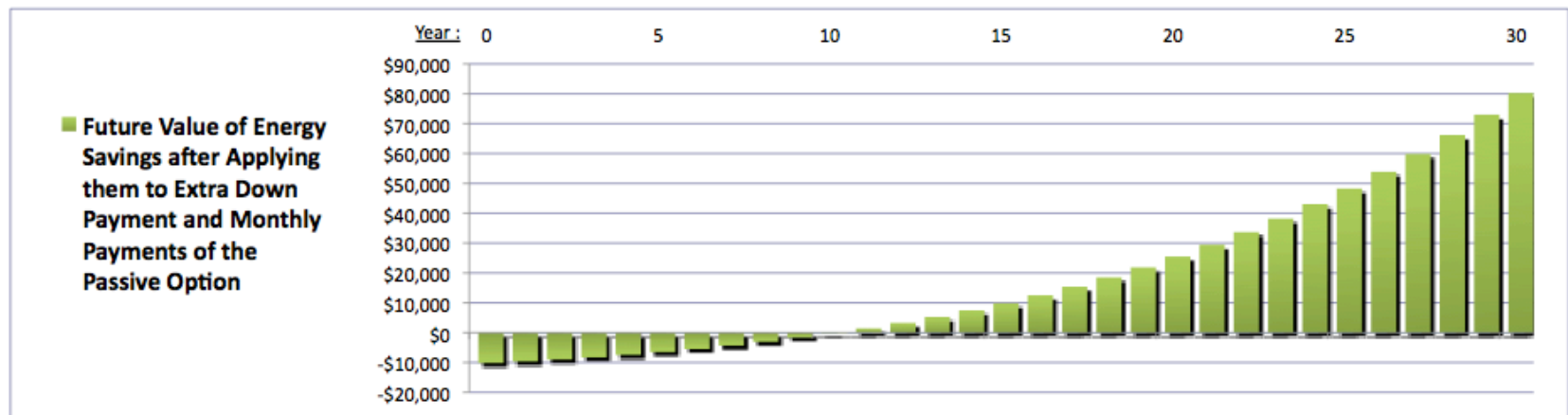
Cost is \$184.00 per Square foot





Cost of Home Options	Cost of Baseline Home	Cost to Upgrade to Passive House	Cost of Passive House
	510,000	10%	561,000

Energy Cost, Baseline Home (\$ per month)	320
Annual Rate of increase in Energy Costs Projected	3%
Energy Cost Reduction from Passive House Approach (%)	71%



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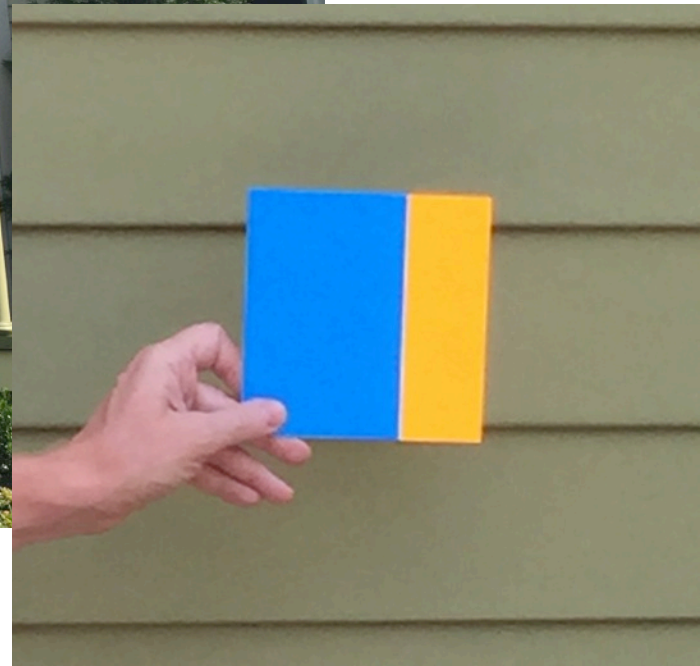
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1.5
ACH50



Effective Leakage Area: 28 square inches +/-



thoughtful

balance

ARCHITECTURE THAT WORKS