Characteristics, Costs and Design Features of Passivhaus Schools

2013 High Performance Sustainable Schools Workshop

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DESIGN STUDIO

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Passivhaus Schools for Kentucky

- **Passivhaus Building Energy Standard established in Germany in 1991**
- **More than 50,000 Passivhaus buildings in Europe including many schools**
- **CSC Design Studio among the Passivhaus pioneers in the US—Passivhaus Consultants for the first Passivhaus Net-Zero Energy neighborhood in KY**
- **Passivhaus Schools would perform at 12-14 kBTU/sf/yr—this is about 30% better than our best schools in Kentucky**

Passivhaus Schools for Kentucky

- **An established Energy Standard that sets ambitious but economically attainable energy goals**
- **An economical and replicable way for School Districts to build Net-Zero Energy Schools**
- **Lowest Life-Cycle Cost and Lowest Cost to achieve Net-Zero Energy**
- **Performance-based Standard that allows a variety of strategies to be employed to meet performance targets**
- **Energy- and cost-optimized design strategies developed using PHPP software that encourages 'what if' experimentation during the design process**

PASSIVE HOUSE PLANNING PACKAGE ENERGY MODELING

Year of Construction:	2010			Utilization Pattern:	Dwelling
Number of Dwelling Units:	1	Interior Temperature:	68.0 °F	Type of Values Used:	Standard
Gross Enclosed Volume V_n:	19935 ft³	Internal Heat Gains:	0.7 BTU/hr.ft²		
Number of Occupants:	3.8			**Planned Number of Occupants:**	4 Verification

Specific Demands with Reference to the Treated Floor Area

Treated Floor Area: 1445 ft²

	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	4.66	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	Yes
Pressurization Test Result:	0.6	ACH_{50}	0.6 ACH_{50}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	28.5	kBTU/(ft²yr)	38.0 kBTU/(ft²yr)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	14	kBTU/(ft²yr)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	29	kBTU/(ft²yr)		
Heating Load:	5	BTU/(ft²hr)		
Frequency of Overheating:	3	%	over 77.0 °F	
Specific Useful Cooling Energy Demand:		kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	
Cooling Load:	4	BTU/(ft²hr)		

Verification: Monthly Method

Specific Space Heat Demand, .

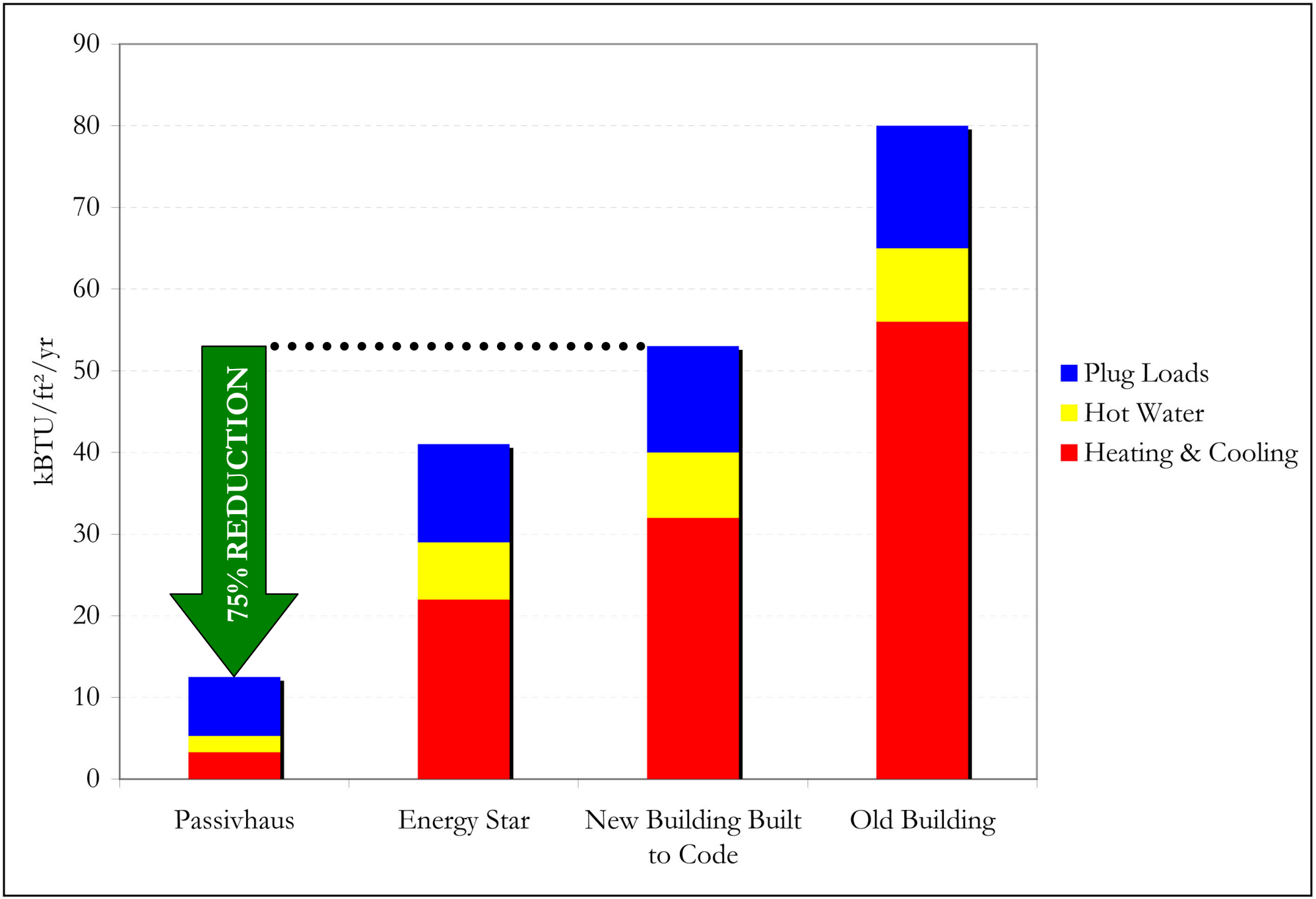
Specific Space Heat Demand, I

We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The calculations with PHPP are attached to this application.

Issued on:

signed:

Intro | Conversion | Verification | cTFA | Areas | R-List | R-Values | Ground | WinEntry | Window | WinType | Shading | Ventil


90
80
70
60
50
40
30
20
10
0
kBTU/ft²/yr
75% REDUCTION
Passivhaus
Energy Star
New Building Built to Code
Old Building
Plug Loads
Hot Water
Heating & Cooling

The Passivhaus Standard

- Heating Load (Site): 4.75 kBTU/SF/YR
- Cooling Load (Site): 4.75 kBTU/SF/YR
- Total Energy Demand (Source): 38 kBTU/SF/YR (approximately 12-14 kBTU/SF/YR Site Energy)
- Air Tightness: 0.6 ACH @ 50pa

* Square footage referenced to "treated floor area" not gross

- 90% reduction in heating and cooling cost and 70%-80% reduction in total energy use compared to typical new construction

Passivhaus Strategies for KY Schools

(Beyond Current "Net-Zero Ready" Practices)

- **High levels of Airtightness (0.6 ACH50 maximum, 0.3 ACH50 is recommended)**
- **Increased Envelope Insulation (particularly in the slab and roof, ICF walls may be OK)**
- **Thermal Bridge Reduction (roof to wall, wall to windows and doors, second floor to wall, wall to slab, interior columns, envelope penetrations, etc.)**
- **Increased Window and Door Performance**

Passivhaus Strategies for KY Schools

(Beyond Current "Net-Zero Ready" Practices)

- **Envelope and Airtightness Commissioning (in addition to commissioning of systems)**
- **Higher Efficiency Energy Recovery Ventilation (perhaps smaller distributed units, CO2 Monitors)**
- **Optimizing DHW Production & Distribution**
- **Prioritizing a Compact Building Form (surface area to volume ratio has one of the largest impacts on overall building efficiency)**
- **Variable Speed Geothermal Heat Pump Compressors**

Montessori School Germany

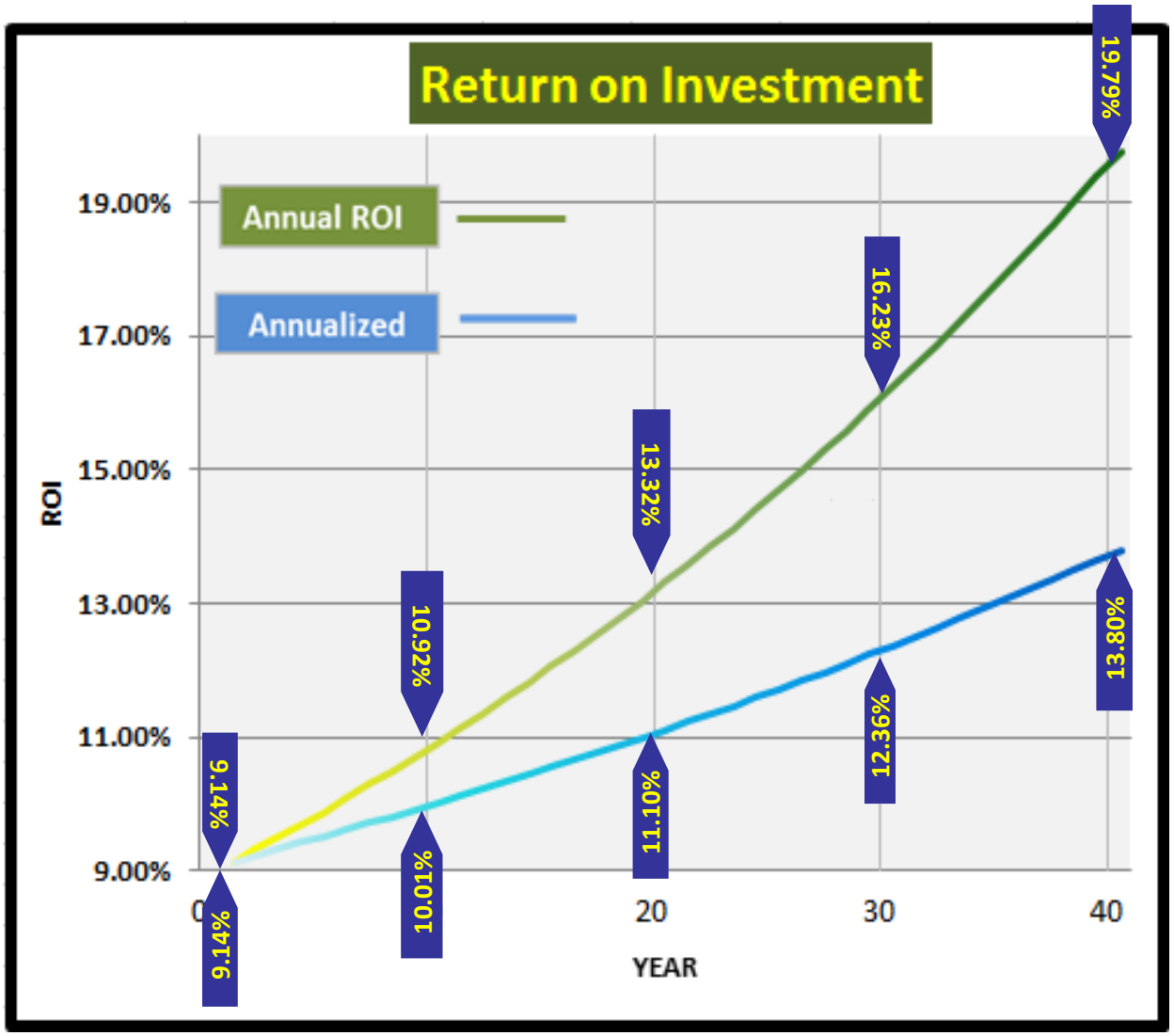
Passive House Institute US

15
STADT
GRUNDS

The BioHaus – 2006, MN

PHIUS

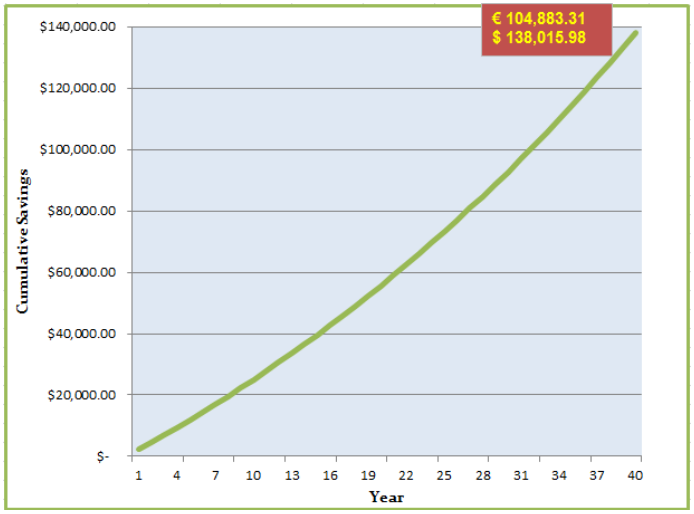
Passive House Institute US



Center for Energy Efficient Design

Franklin County, Virginia

Building Type:	Public School
Size:	334 m^2 3,600 ft^2
Passivhaus Investment:	€ 18,930 $ 25,000
Cost / kWh (US average)	€ 0.876 $ 0.1153



* Courtesy of Passiv Structures, LLC

Hickory Hall

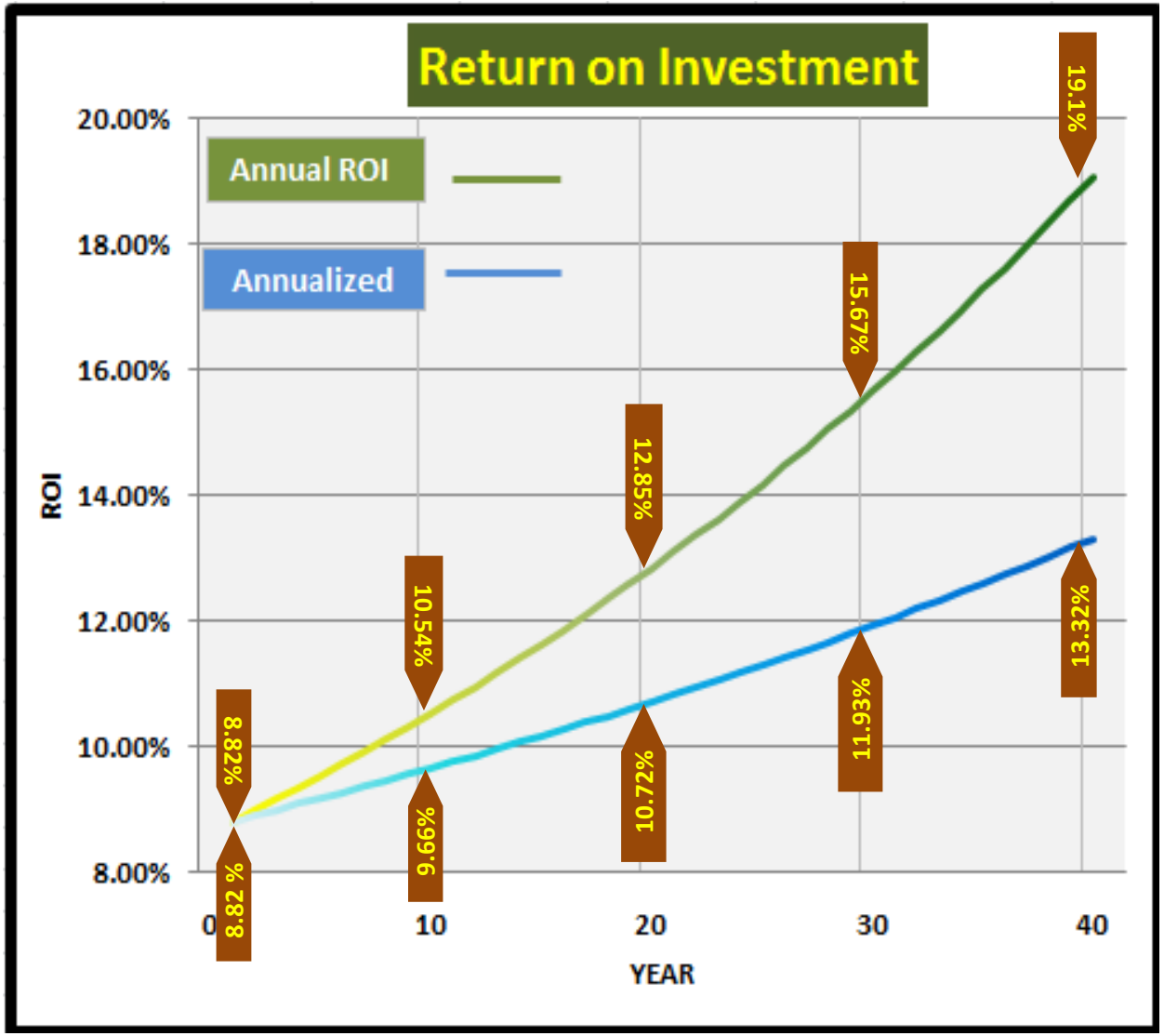
Emory and Henry College

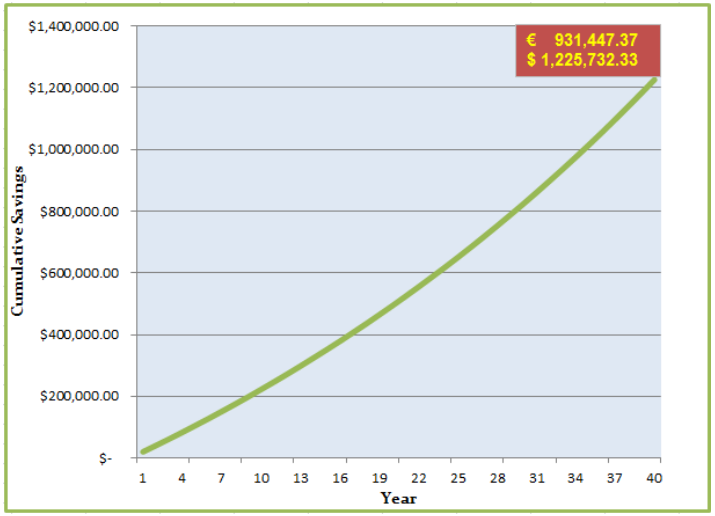
Building Type: Dormitory

Size: 40,000 ft^2

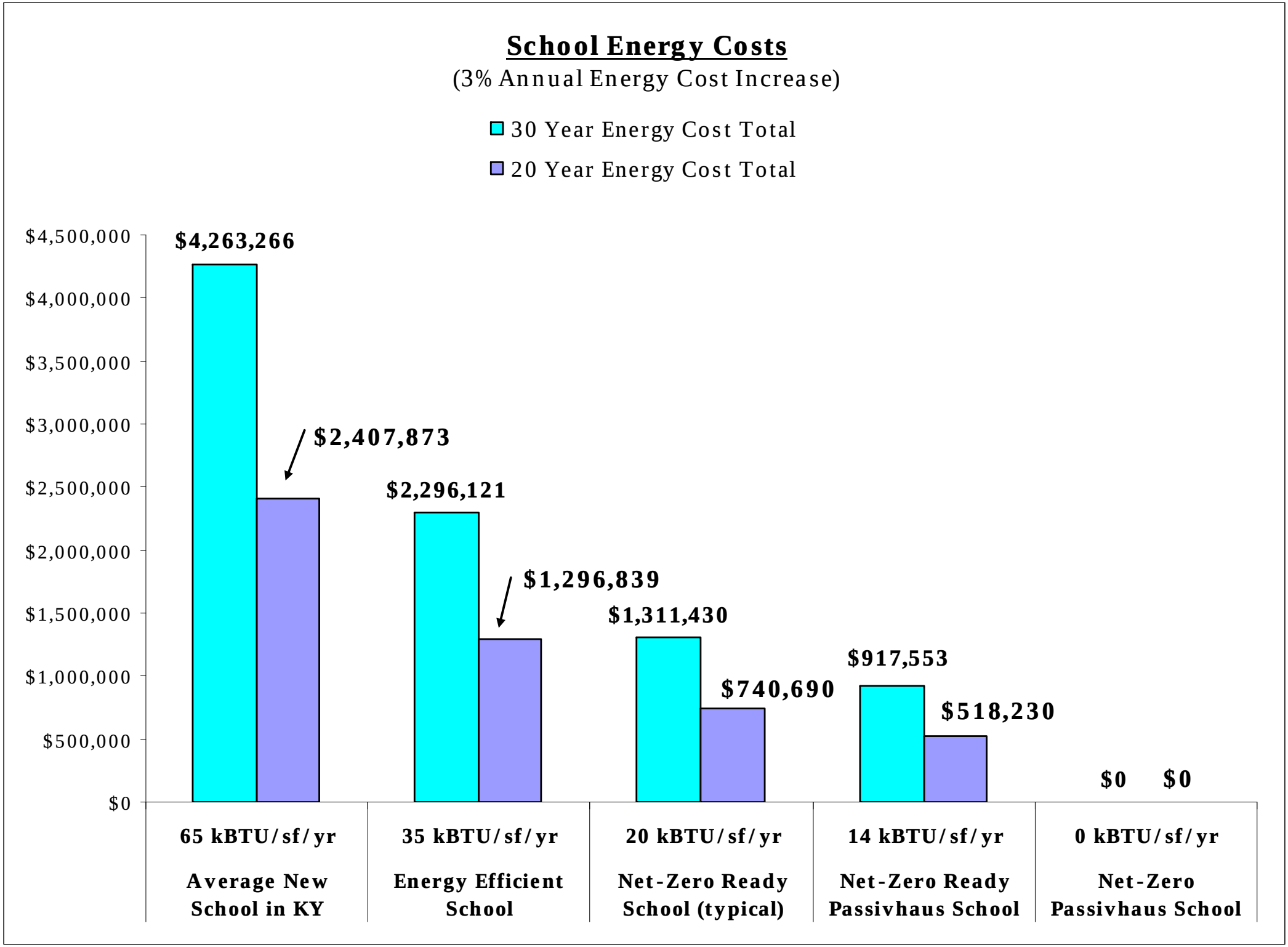
Passivhaus Investment: $ 230,000

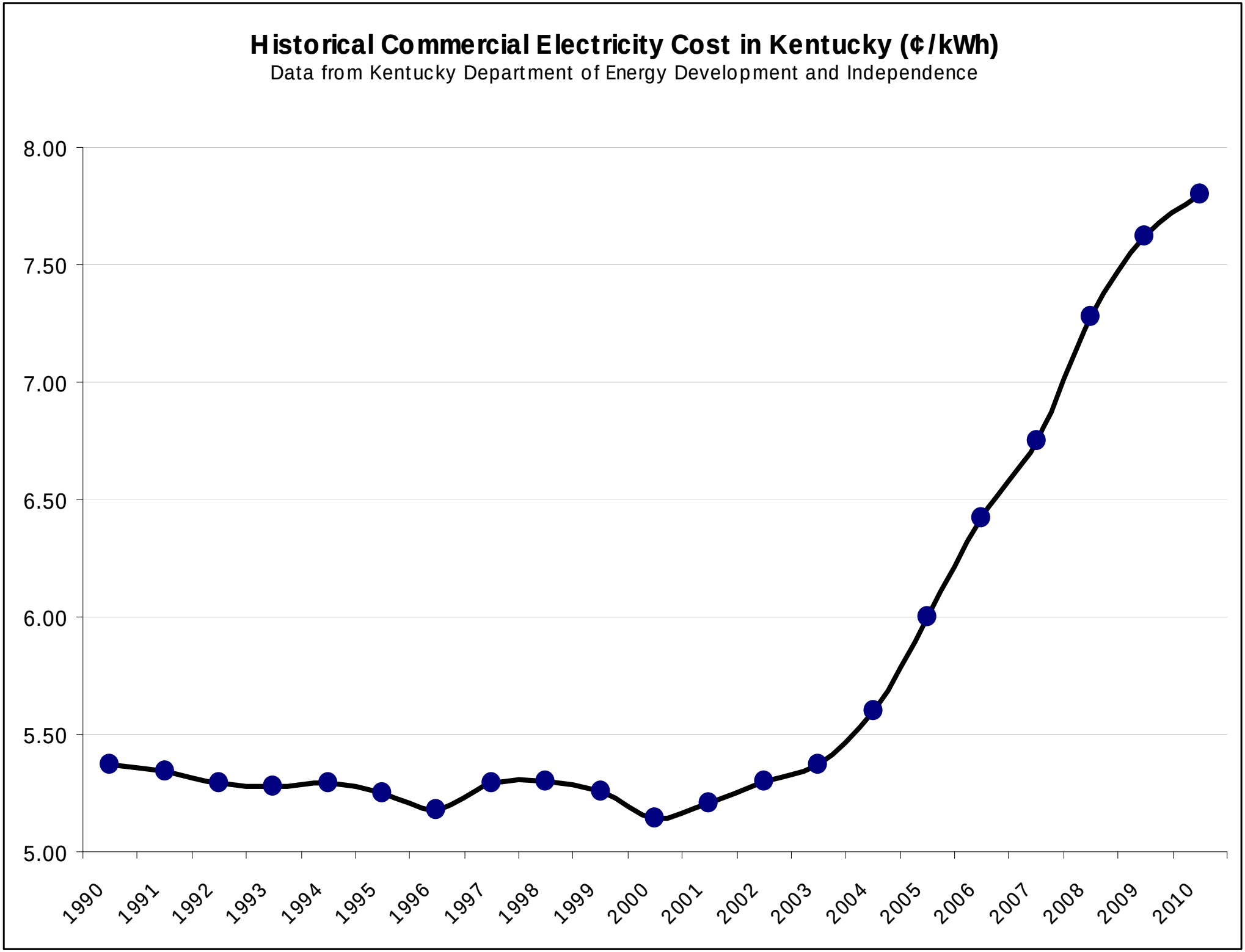
Cost / kWh (US average) $ 0.1153

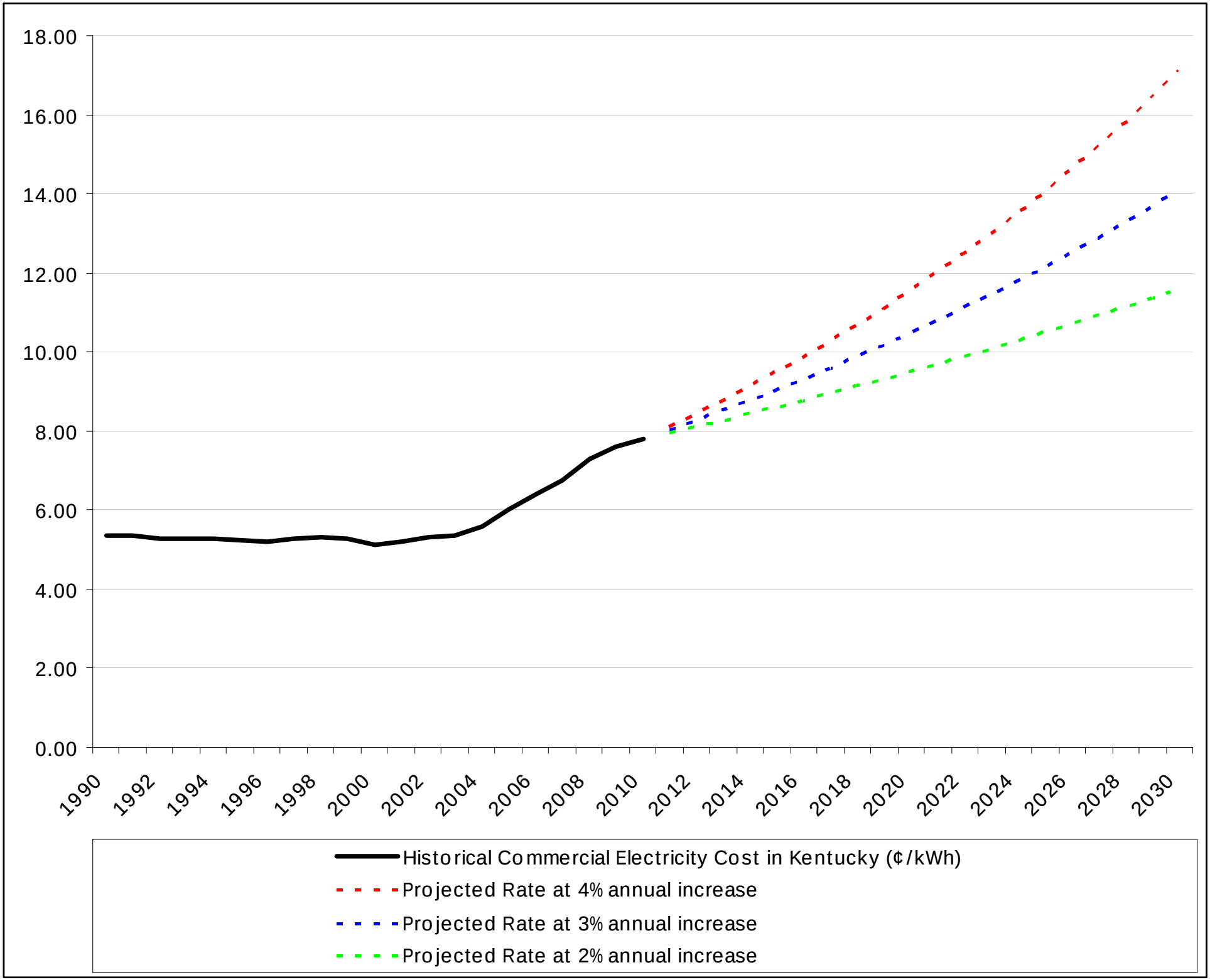


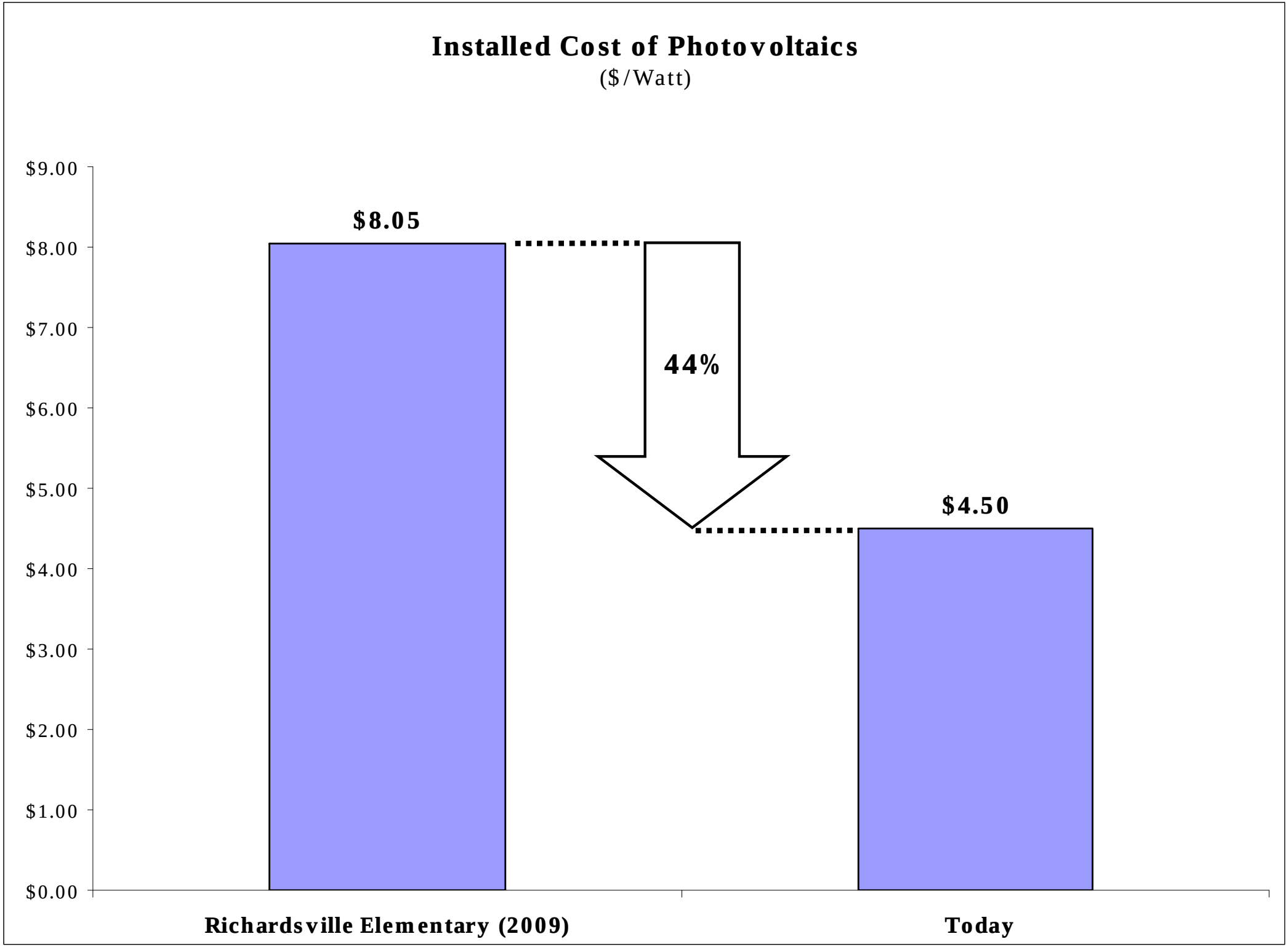


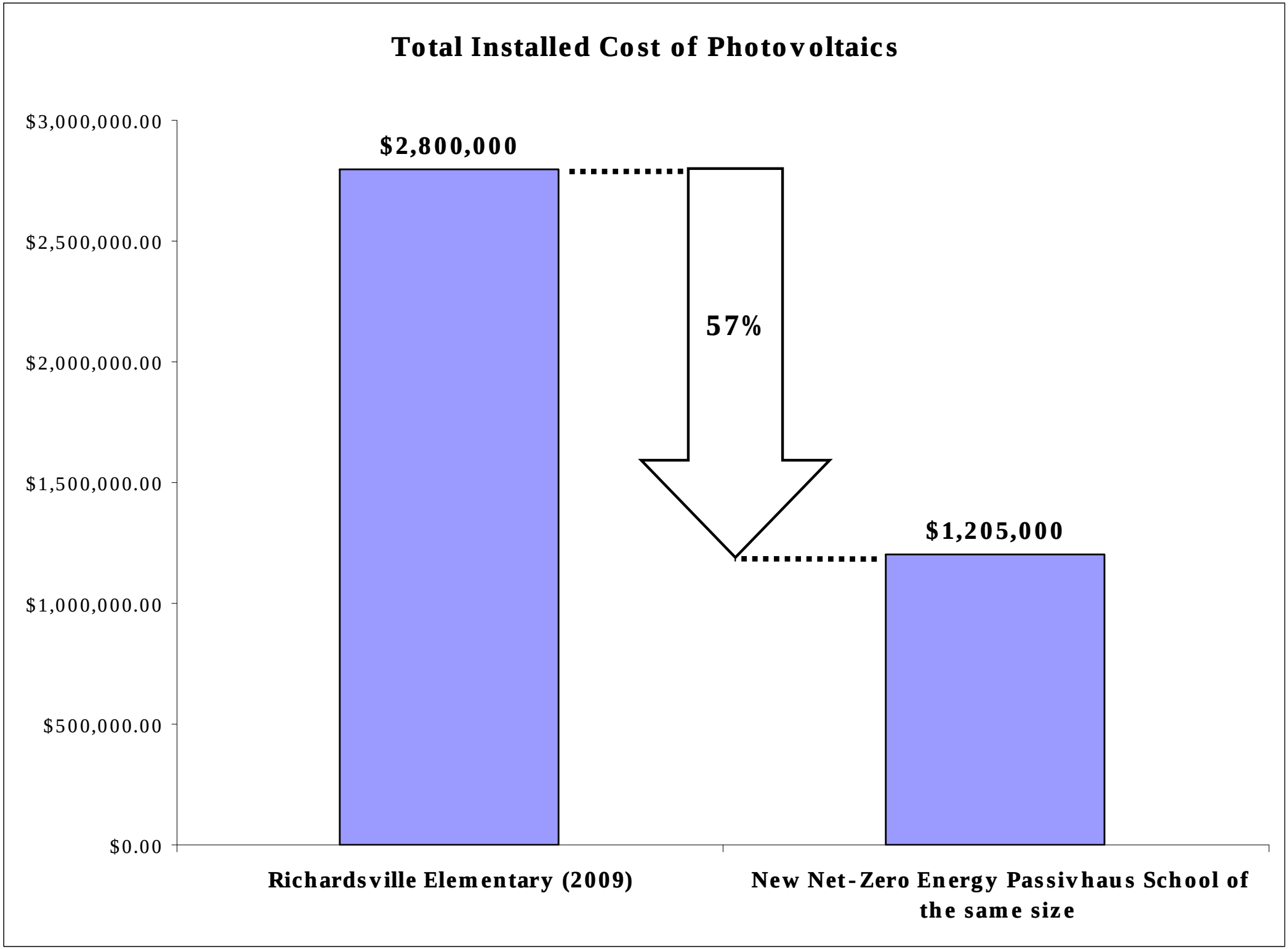
* Courtesy of Passiv Structures, LLC

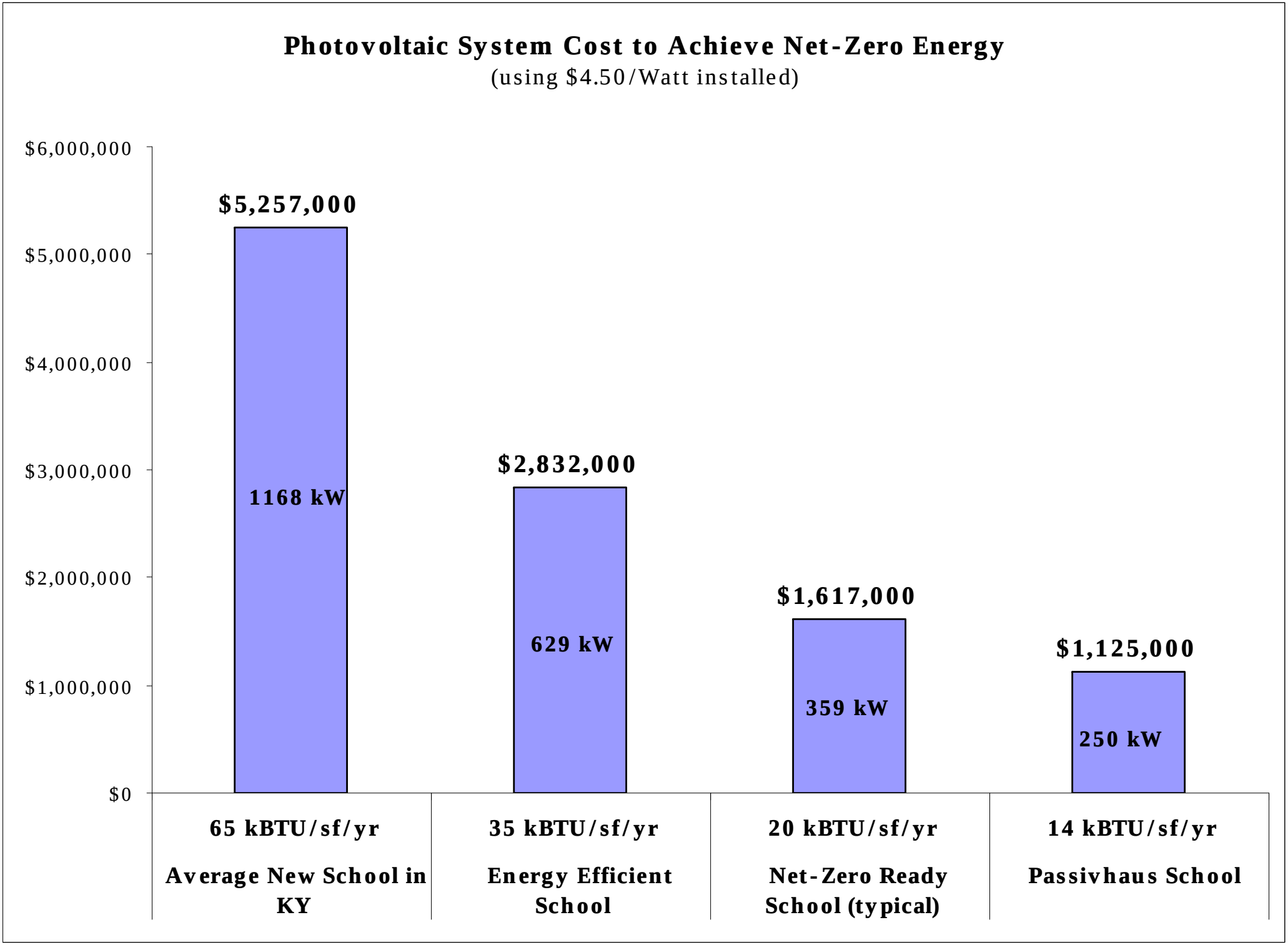

School Energy Costs
(3% Annual Energy Cost Increase)
30 Year Energy Cost Total
20 Year Energy Cost Total
$4,500,000
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
$4,263,266
$2,407,873
$2,296,121
$1,296,839
$1,311,430
$740,690
$917,553
$518,230
$0
$0
65 kBTU/sf/yr
Average New School in KY
35 kBTU/sf/yr
Energy Efficient School
20 kBTU/sf/yr
Net-Zero Ready School (typical)
14 kBTU/sf/yr
Net-Zero Ready Passivhaus School
0 kBTU/sf/yr
Net-Zero Passivhaus School

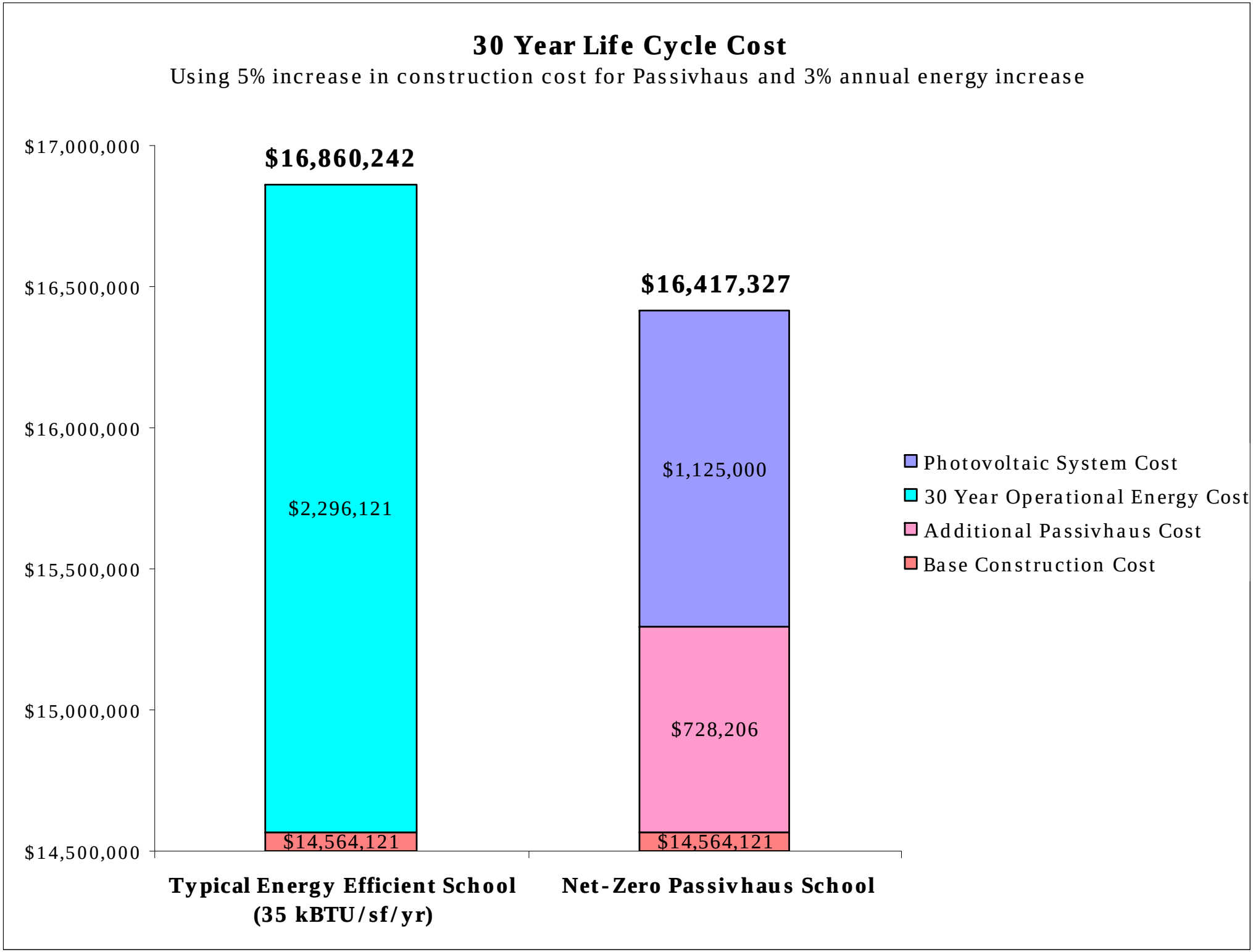

Historical Commercial Electricity Cost in Kentucky (¢/kWh)
Data from Kentucky Department of Energy Development and Independence
8.00
7.50
7.00
6.50
6.00
5.50
5.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Historical Commercial Electricity Cost in Kentucky (¢/kWh)
Projected Rate at 4% annual increase
Projected Rate at 3% annual increase
Projected Rate at 2% annual increase


Installed Cost of Photovoltaics
($/Watt)
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
$0.00
$8.05
44%
$4.50
Richardsville Elementary (2009)
Today


Total Installed Cost of Photovoltaics
$3,000,000.00
$2,500,000.00
$2,000,000.00
$1,500,000.00
$1,000,000.00
$500,000.00
$0.00
$2,800,000
57%
$1,205,000
Richardsville Elementary (2009)
New Net-Zero Energy Passivhaus School of the same size


Photovoltaic System Cost to Achieve Net-Zero Energy
(using $4.50/Watt installed)
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
$5,257,000
1168 kW
$2,832,000
629 kW
$1,617,000
359 kW
$1,125,000
250 kW
65 kBTU/sf/yr
Average New School in KY
35 kBTU/sf/yr
Energy Efficient School
20 kBTU/sf/yr
Net-Zero Ready School (typical)
14 kBTU/sf/yr
Passivhaus School


30 Year Life Cycle Cost
Using 5% increase in construction cost for Passivhaus and 3% annual energy increase
$17,000,000
$16,500,000
$16,000,000
$15,500,000
$15,000,000
$14,500,000
$16,860,242
$2,296,121
$14,564,121
$16,417,327
$1,125,000
$728,206
$14,564,121
Photovoltaic System Cost
30 Year Operational Energy Cost
Additional Passivhaus Cost
Base Construction Cost
Typical Energy Efficient School (35 kBTU/sf/yr)
Net-Zero Passivhaus School

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