

# BUNKER INTERPRETIVE CENTER ENERGY EFFICIENCY PROJECT

Engineering 333

December 6, 2011



# Introduction: LEED®

- ▣ LEED: Leadership in Energy and Environmental Design Certification
- ▣ Ratings:
  - Certified (40-49 points)
  - Silver (50-59 points)
  - Gold (60-79 points)
  - Platinum (80+ points)
- ▣ Encourages design of energy efficient buildings
- ▣ LEED (to date) does not address actual energy use



*Does LEED work?*



# Introduction: Energy Star<sup>®</sup>

- ▣ Addresses the energy use of a building
- ▣ Compares your building to “peer group” (e.g. K-12 school, hospital, office, etc.)
- ▣ Accounts for climate, size, purpose, etc.



Best 25% of a  
building category



# Introduction: BIC

- ▣ BIC - Bunker Interpretive Center
- ▣ BIC earned the LEED Gold rating
- ▣ Test case: if BIC can get Energy Star<sup>®</sup>, LEED works



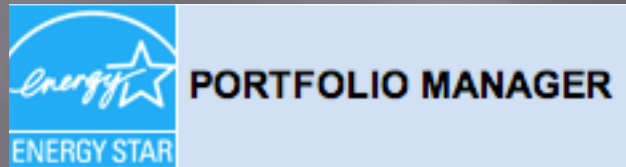


Can the Bunker Interpretive Center  
attain Energy Star<sup>®</sup> rating?



# Portfolio Manager

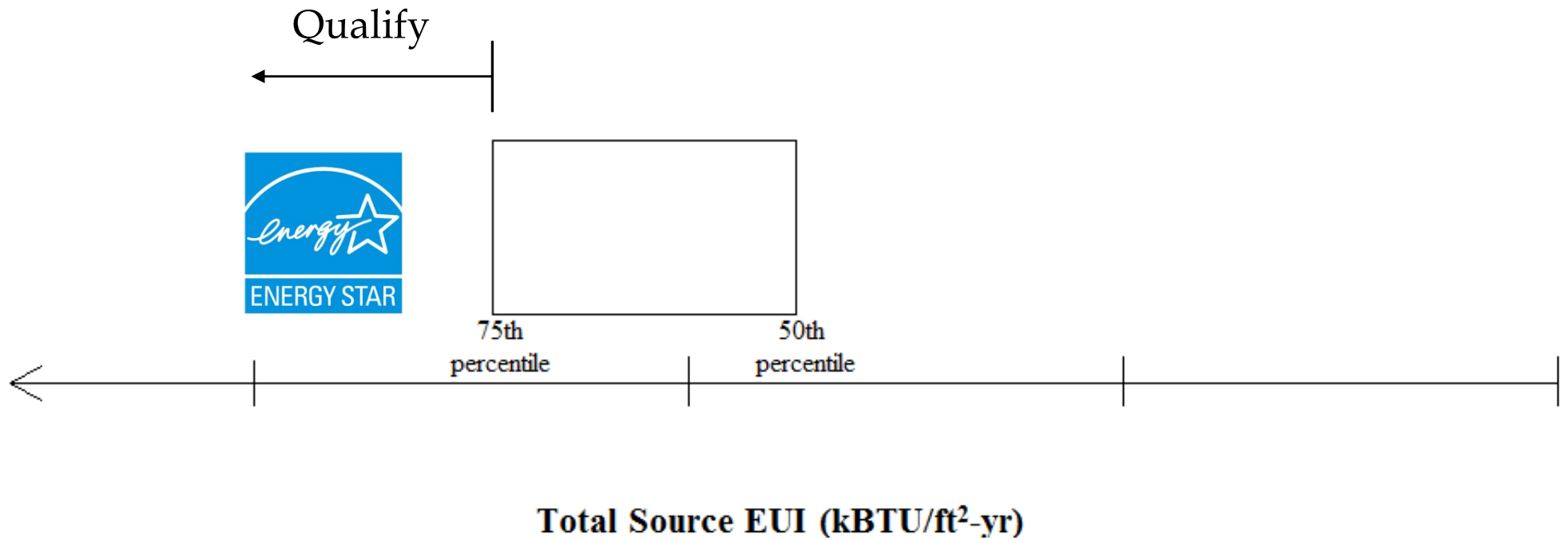
- ▣ Created by Environmental Protection Agency (EPA)
- ▣ Purpose: Generate an Energy Use Intensity (EUI)
  - Combines different energy forms into one broad statistic
  - Units of kBtu/ft<sup>2</sup>-yr



ENGR 333 used Portfolio Manager as a tool to determine if BIC meets Energy Star<sup>®</sup> requirements



# Understanding EUI



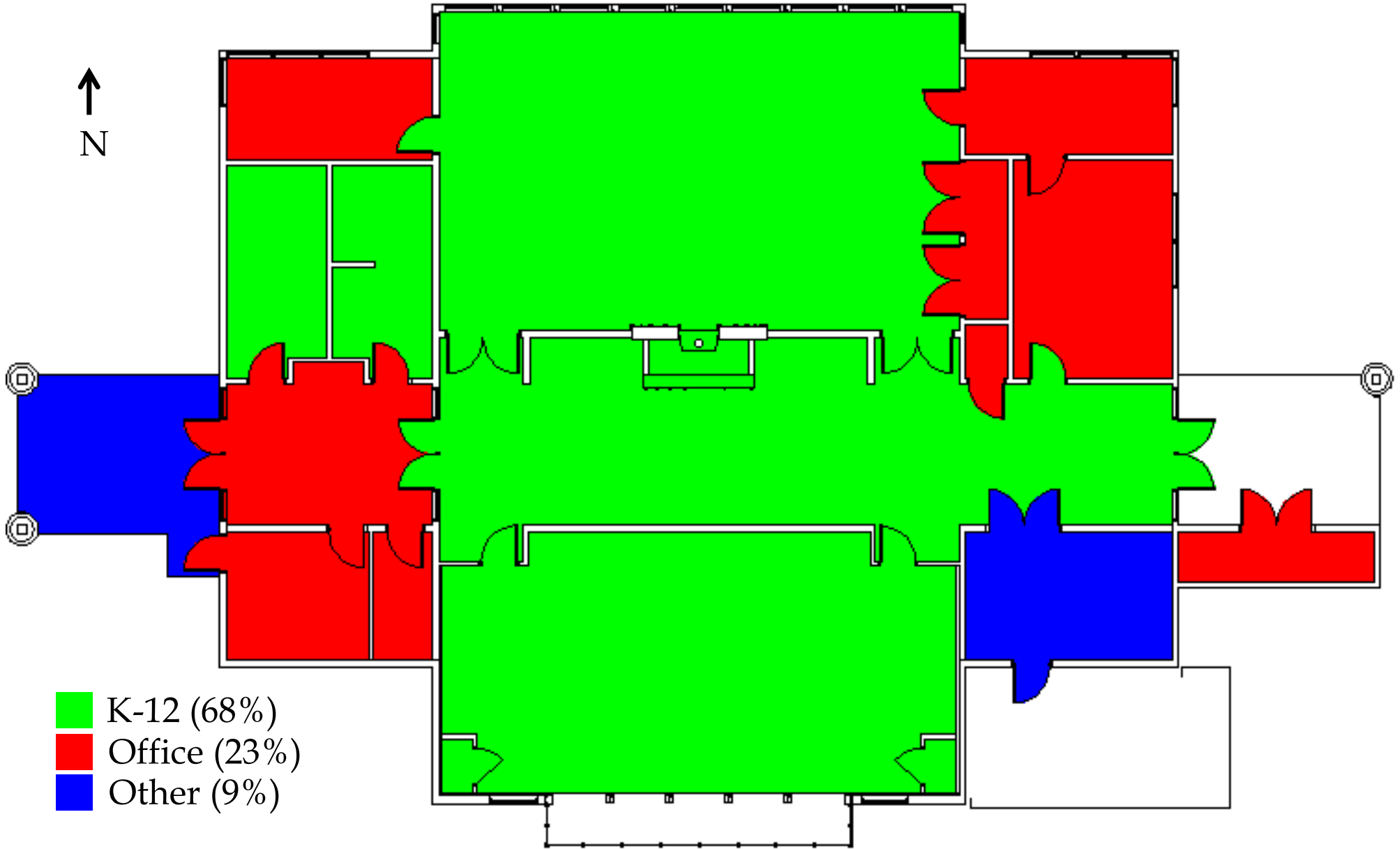
# BIC Star

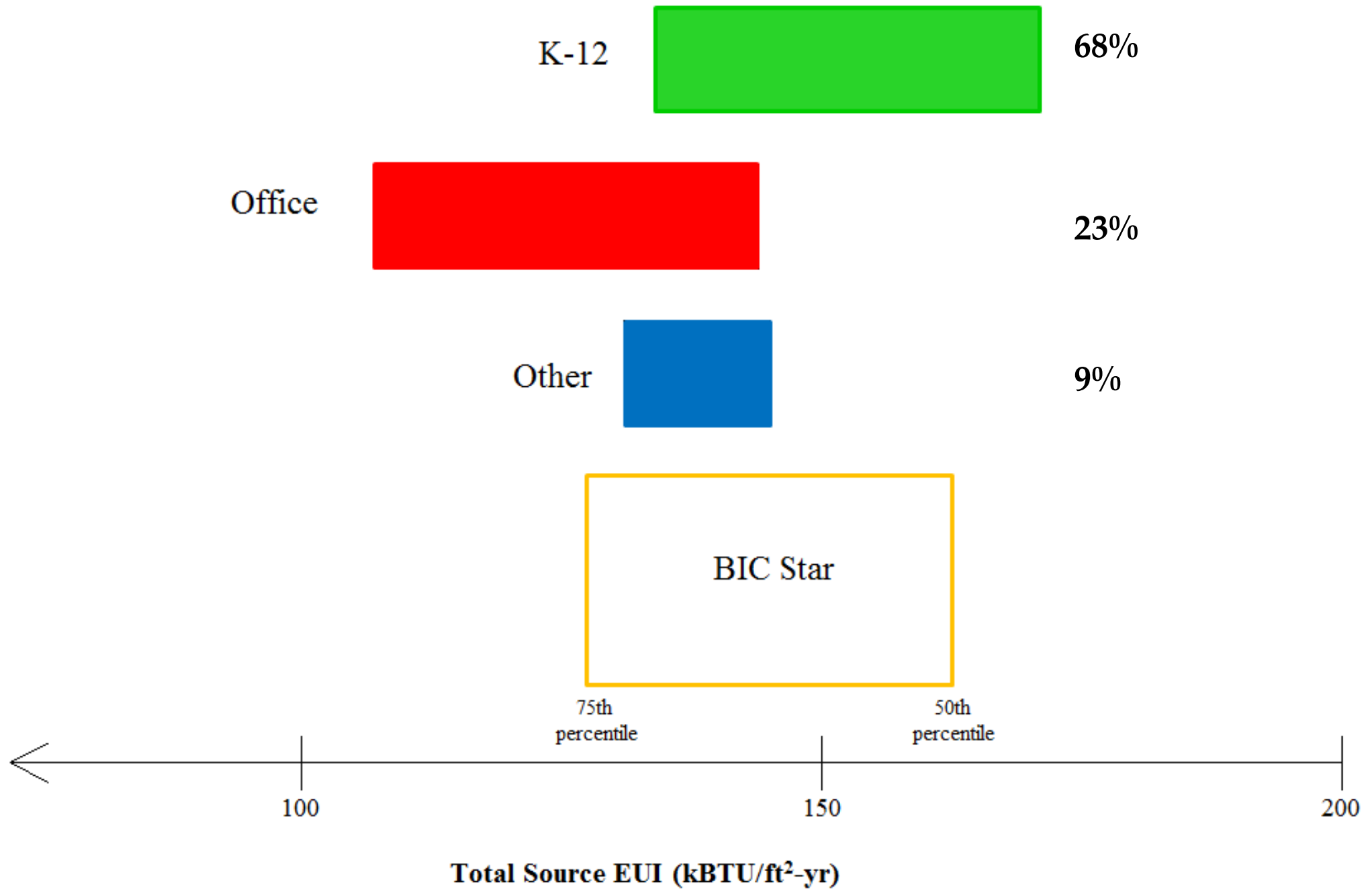
- ▣ Can only obtain Energy Star<sup>®</sup> in predefined categories
- ▣ BIC doesn't fit. Closest are:
  - K-12 School Building
  - Office

Solution: Create “BIC Star”



# BIC Floor Plan







How does the BIC  
perform?

# Investigation Overview



Lighting



Outlets & Small  
Appliances



Natural Gas



Air &  
Water Flow

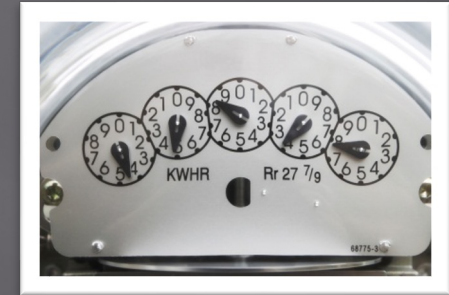


What is the BIC's actual performance?

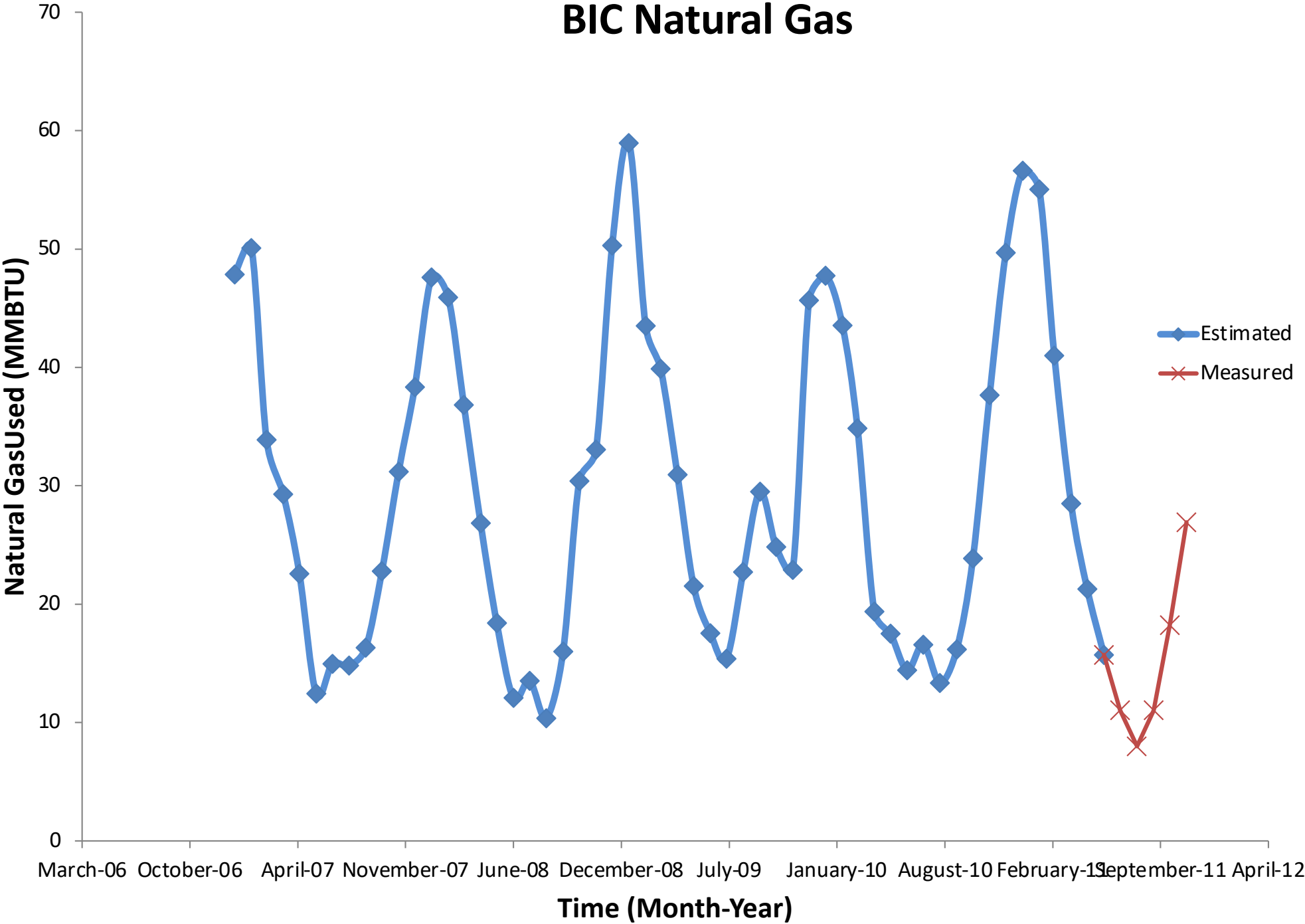


# BIC Performance: Natural Gas

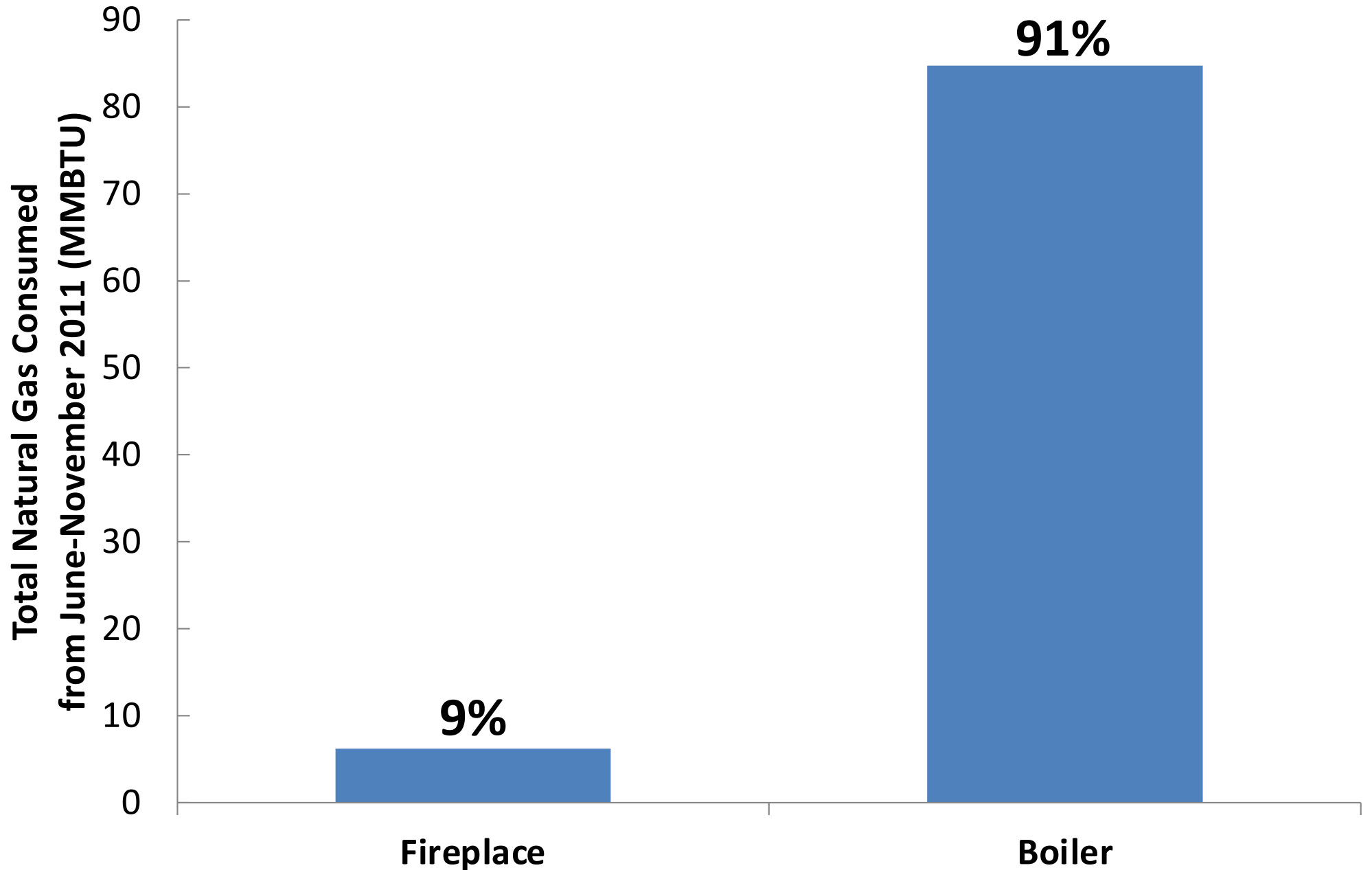
- ▣ Boiler
  - Floor heating
  - Domestic water (taps)
- ▣ Fireplace
  - Aesthetic value
  - Space heating



# BIC Natural Gas



# BIC Natural Gas Consumption (June-November 2011)





# BIC Performance: Electricity

- ▣ Air and Water Flow:
  - Circulation Fans
  - Pumps
- ▣ Outlets and Small Appliances:
  - Refrigerator & microwave
  - Wall outlets
- ▣ Lighting
  - All interior lights

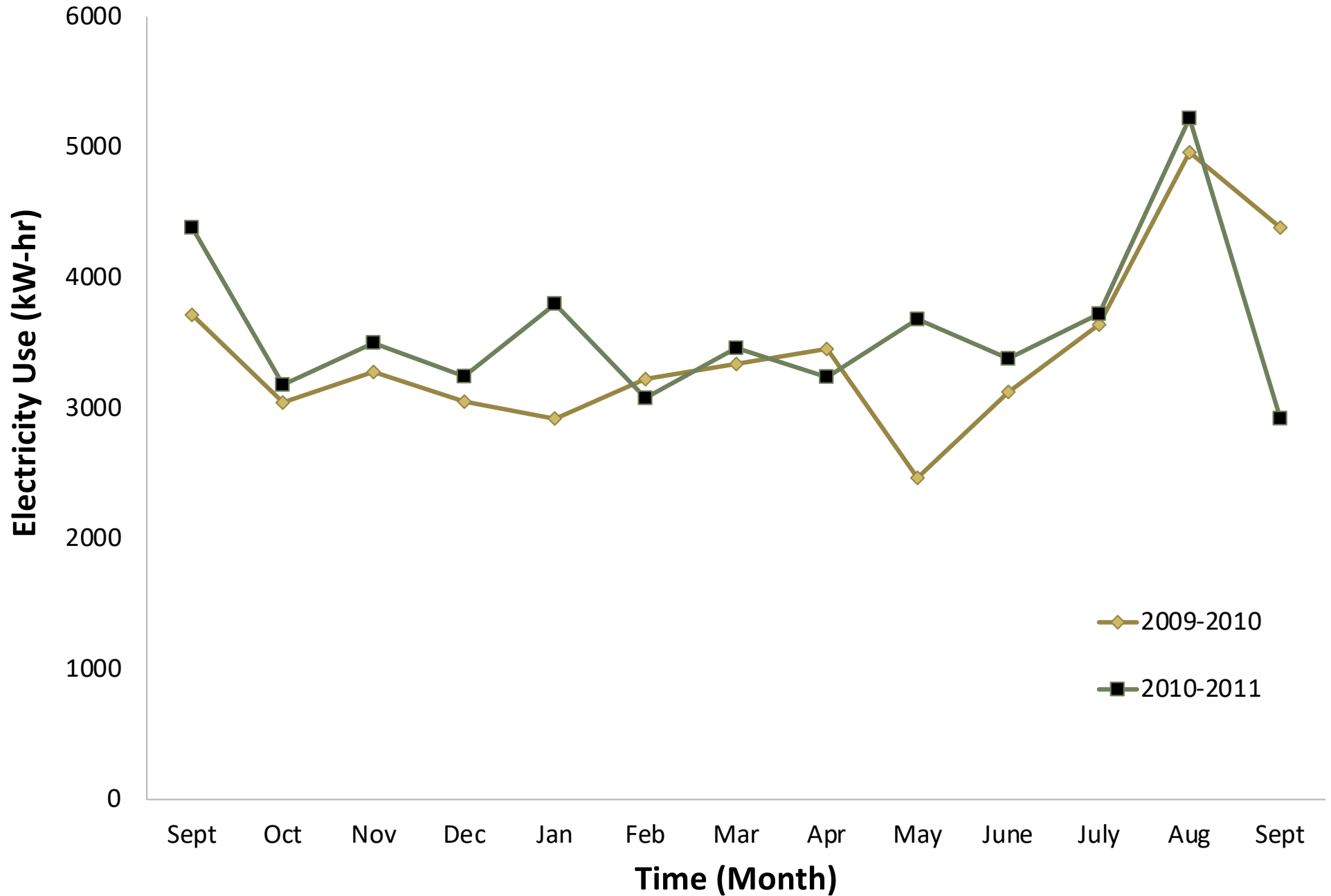


Hobbs Meter

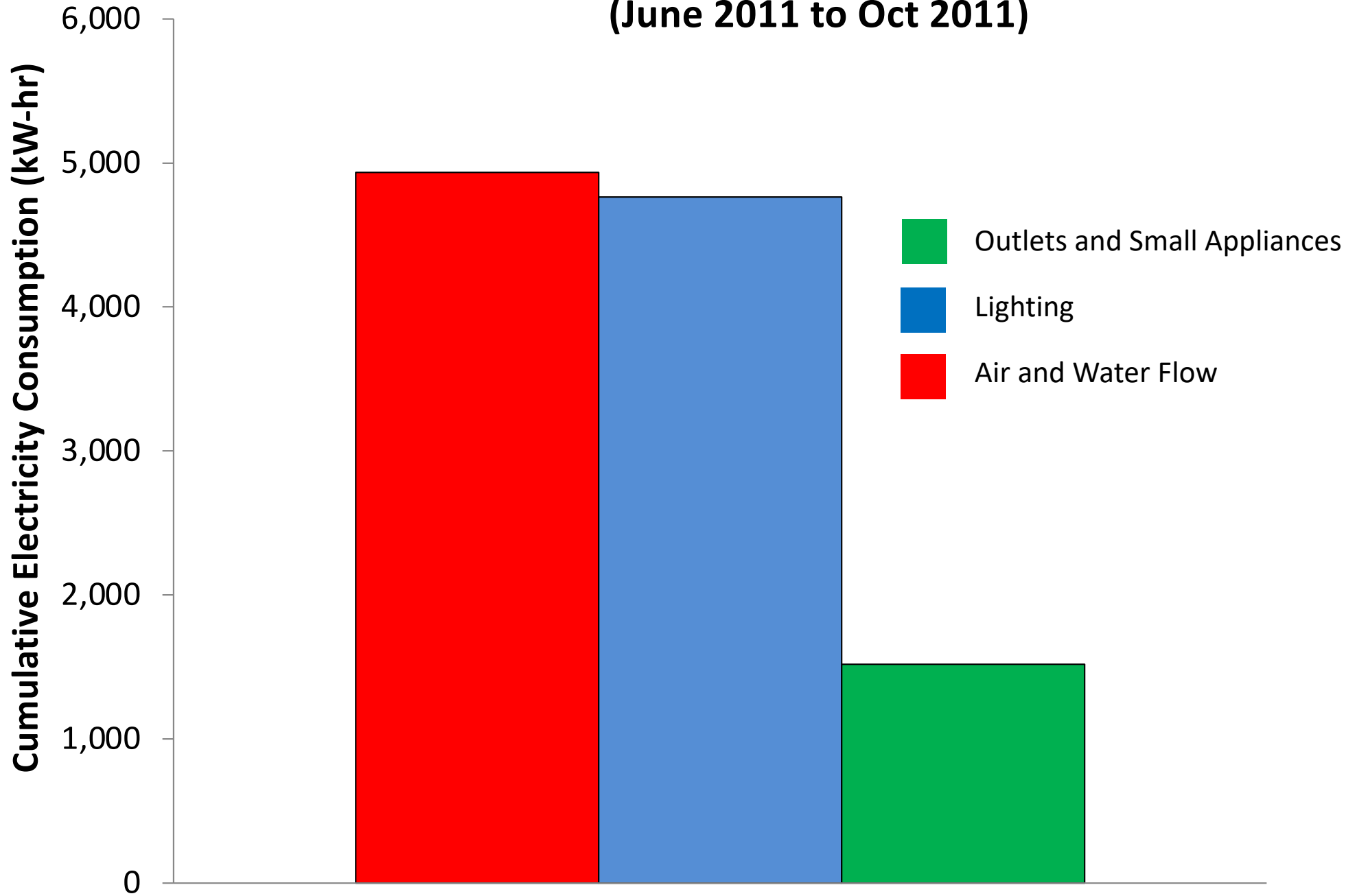


Kill-A-Watt Meter

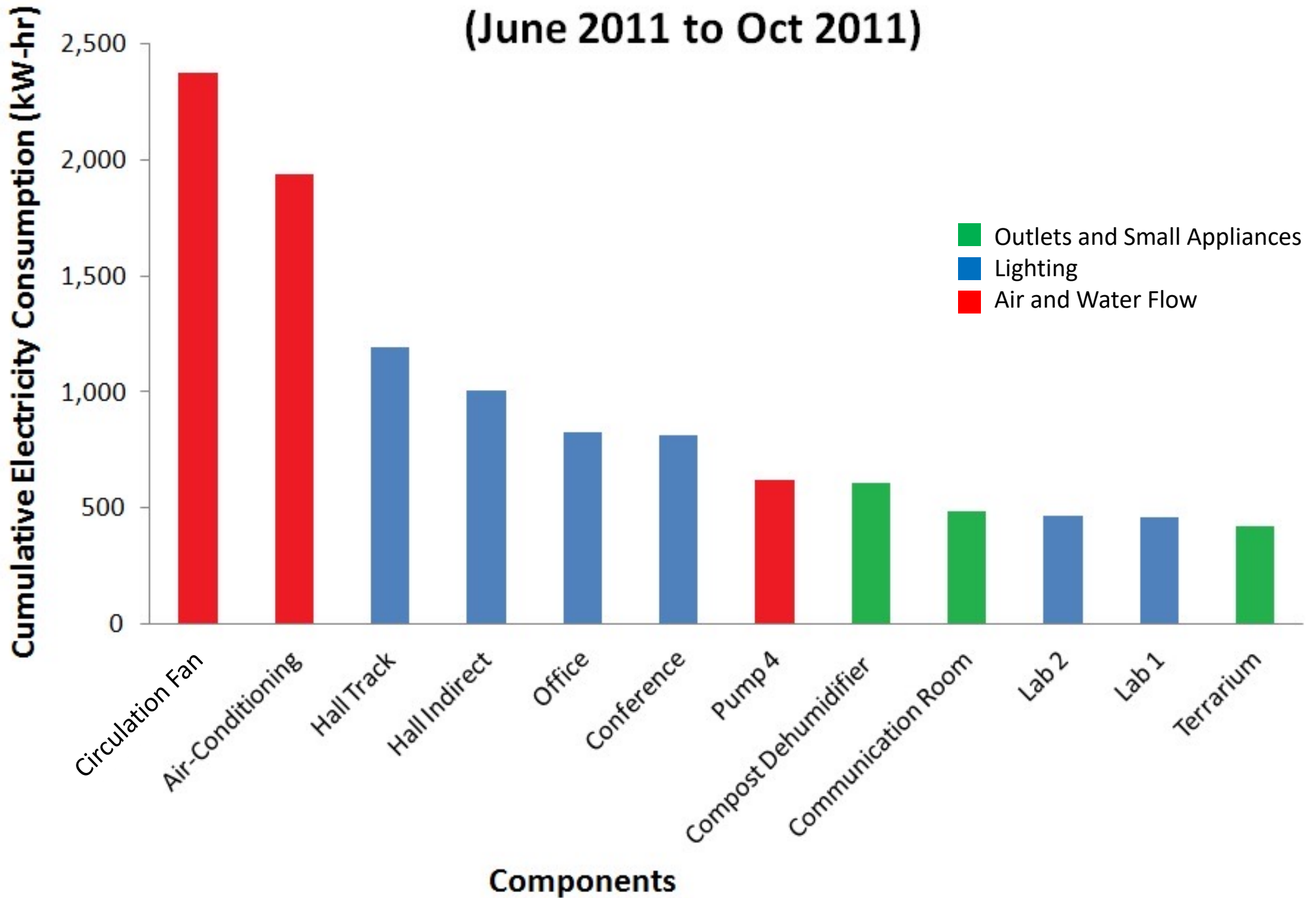
# Electricity Use (Sept. 2009 to Sept. 2011 )



## BIC Electricity Consumed Over 5 Months by Category (June 2011 to Oct 2011)

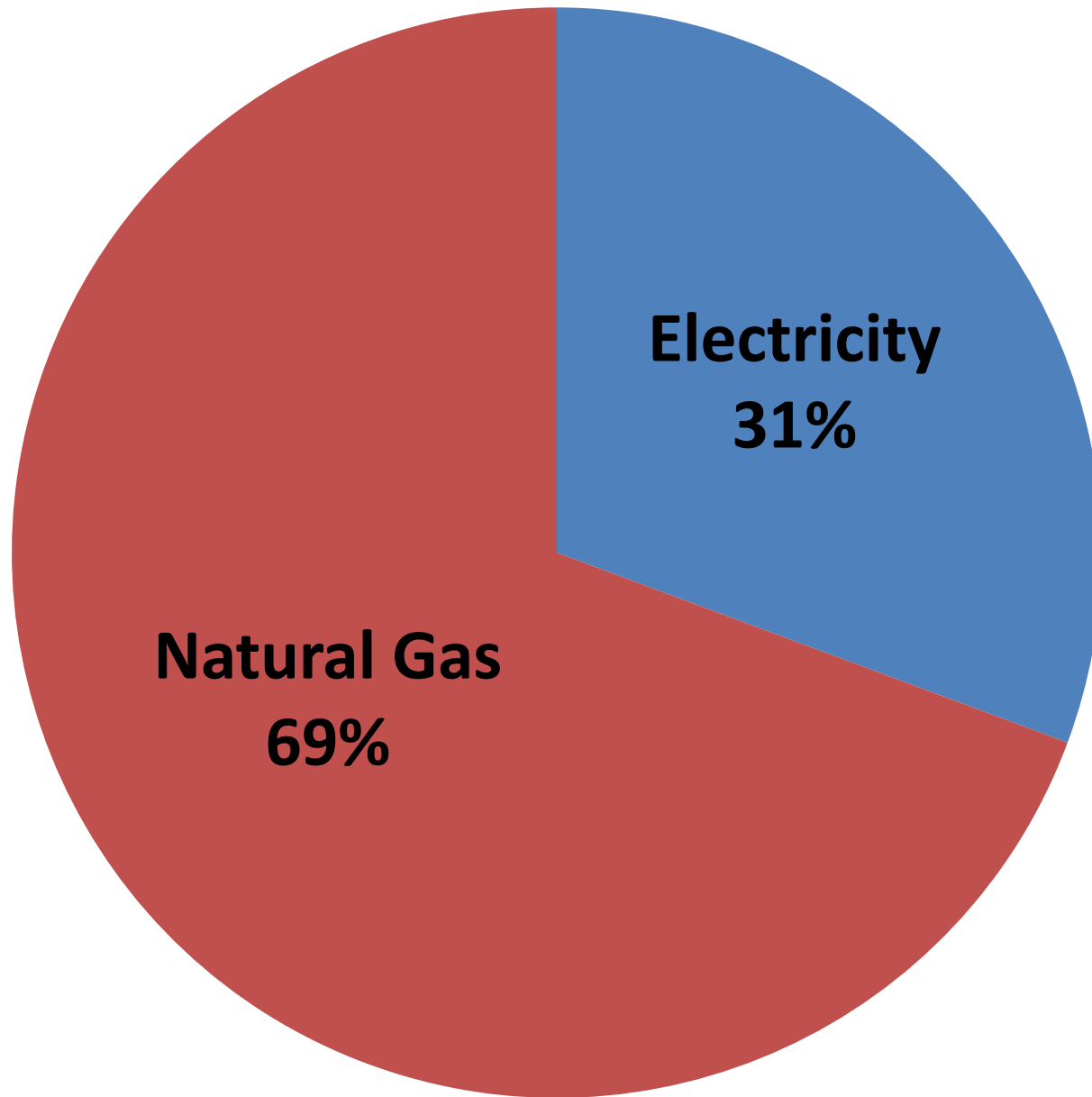


# Top 12 Electricity Consumers Over 5 Months (June 2011 to Oct 2011)

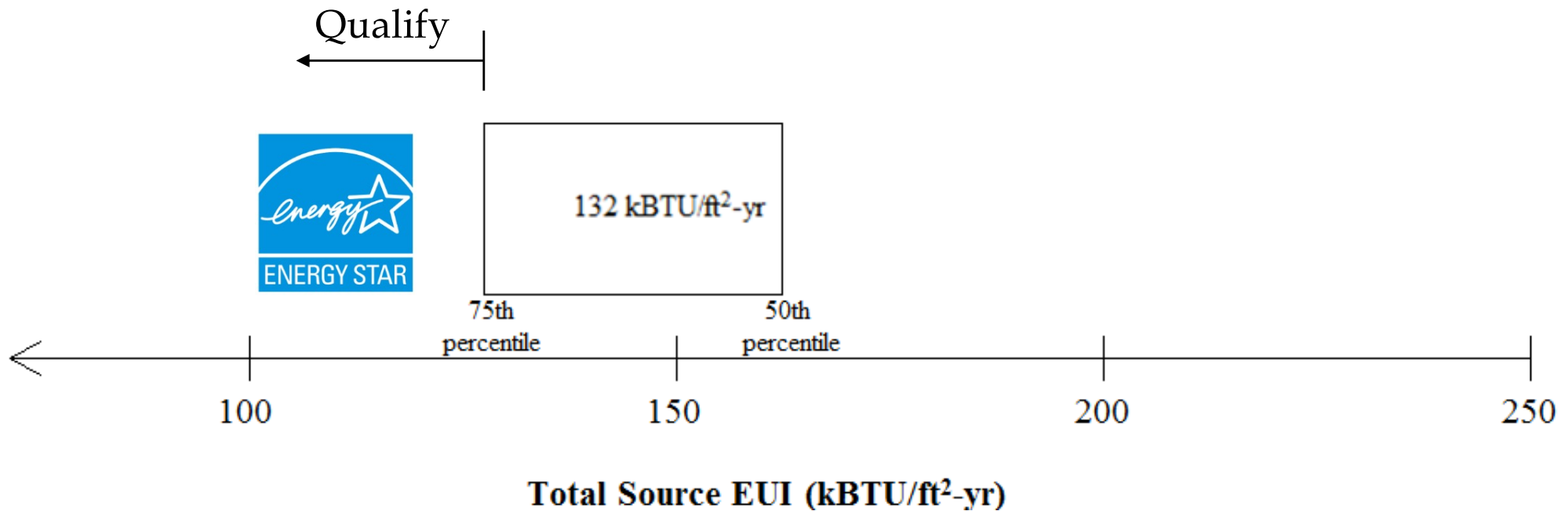




**Electricity Natural Gas**



# BIC Performance

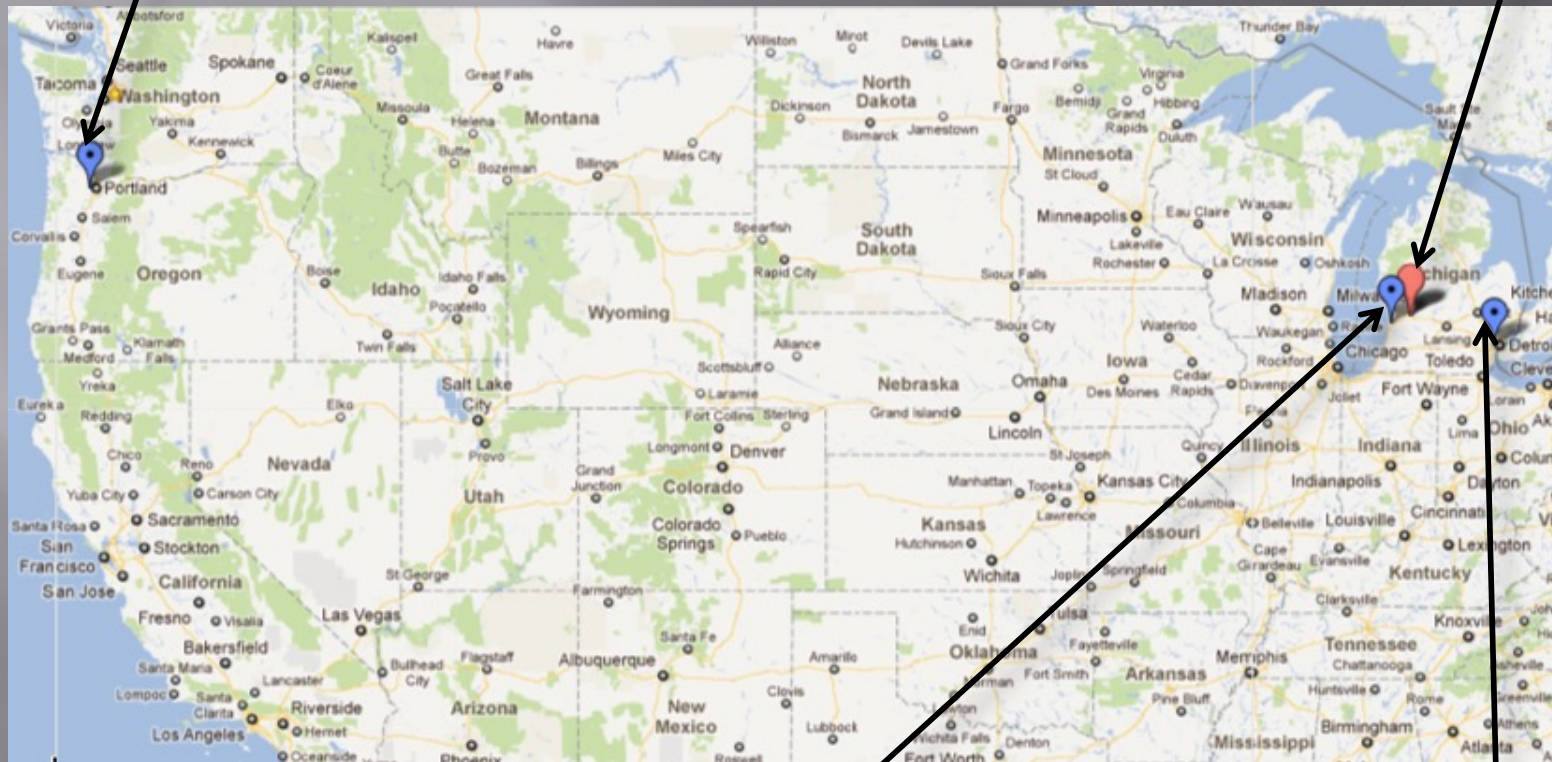


# Building Comparisons

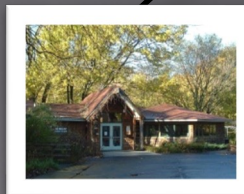


Nature Park  
Interpretive Center

Bunker  
Interpretive  
Center



De Graaf  
Nature  
Center



Environmental  
Interpretive  
Center

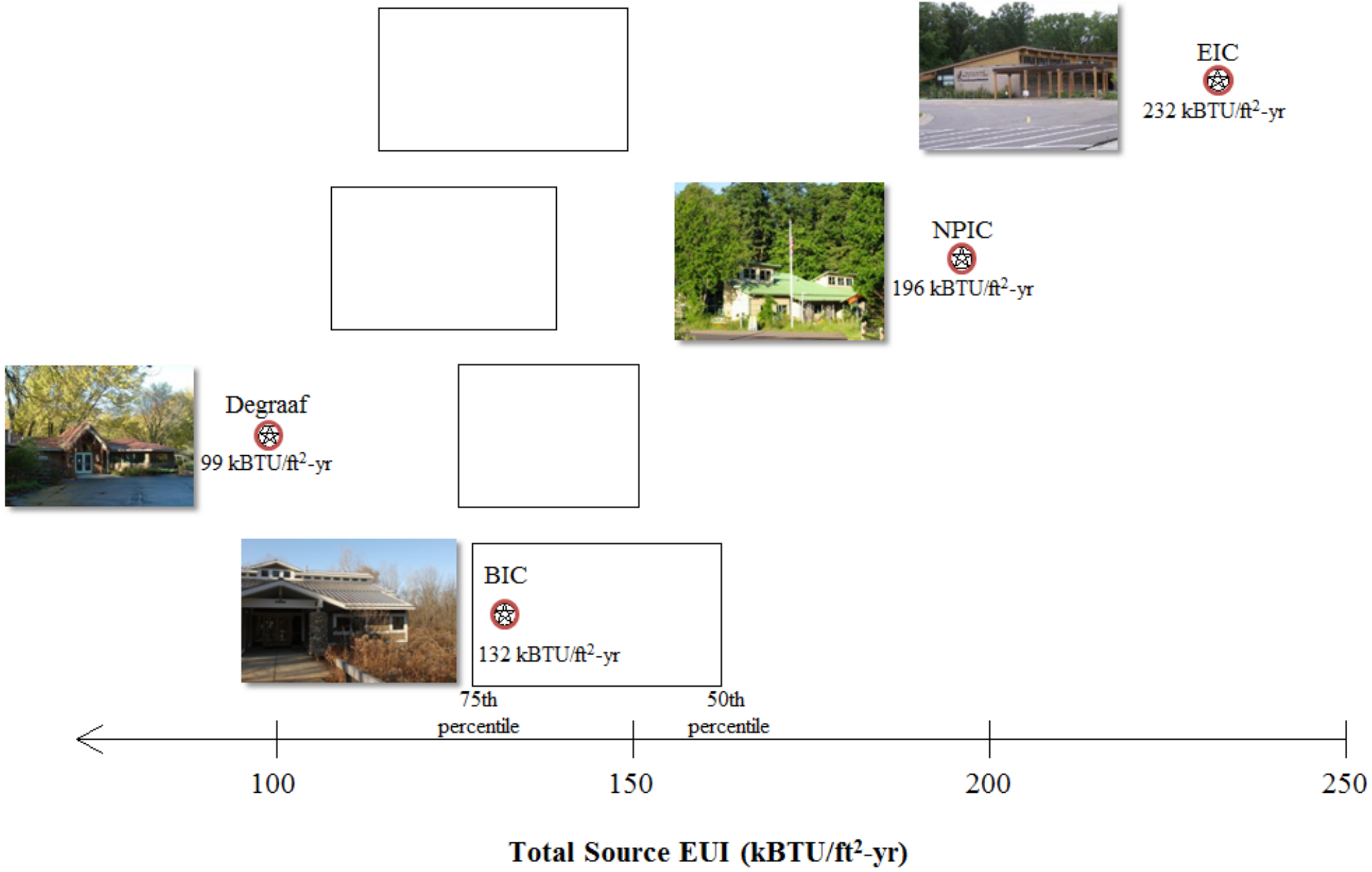


# Building Comparisons



Building	Operated by	Location	Area (ft <sup>2</sup> )
Bunker Interpretive Center (BIC)	Calvin College	Grand Rapids, MI	5,300
DeGraaf Nature Center (DeGraaf)	City of Holland	Holland, MI	3,100
Environmental Interpretive Center (EIC)	University of Michigan	Dearborn, MI	13,000
Nature Park Interpretive Center (NPIC)	Tualatin Hills Park & Recreation District	Beaverton, OR	7,700



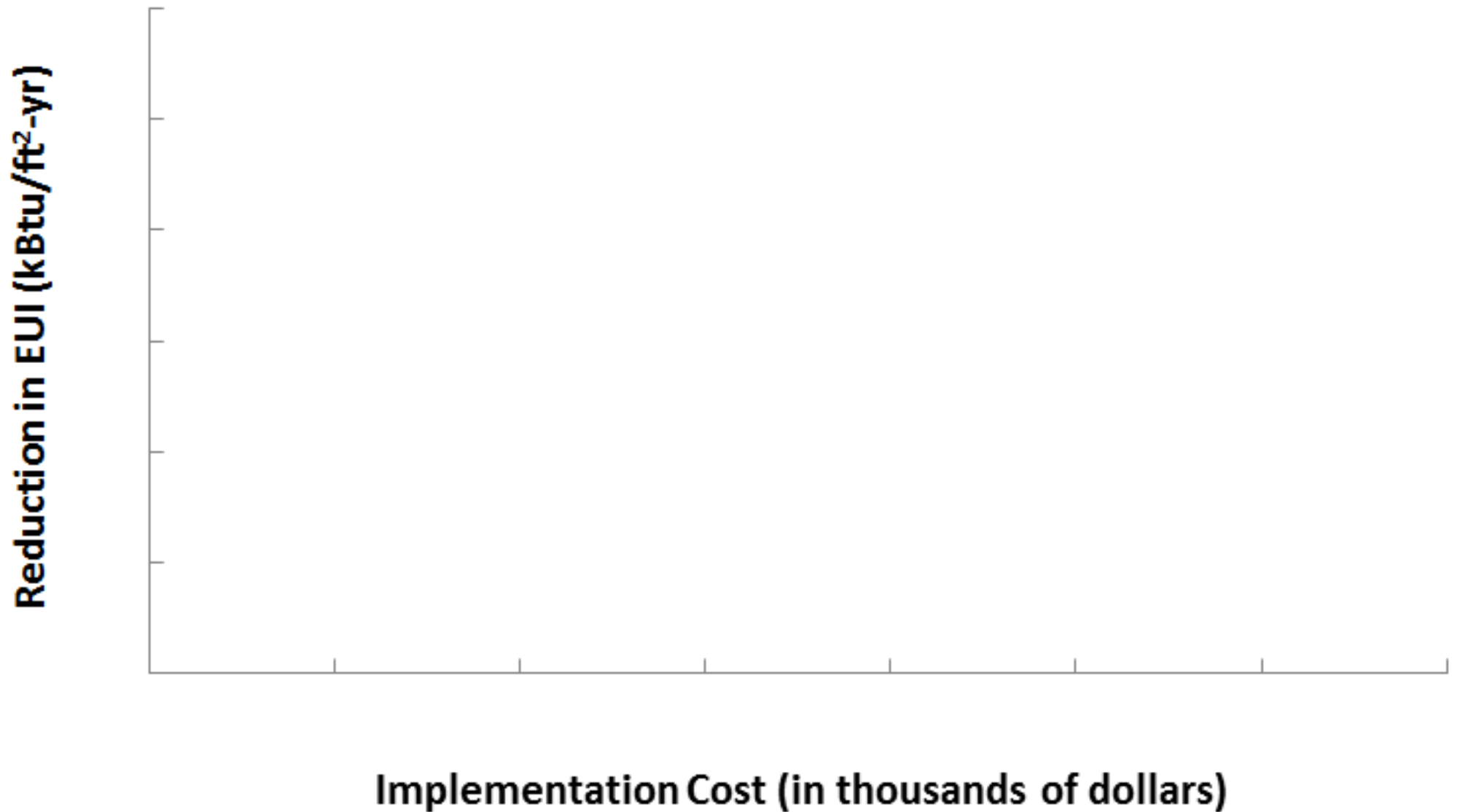


What can we do?

# Options for Reducing EUI

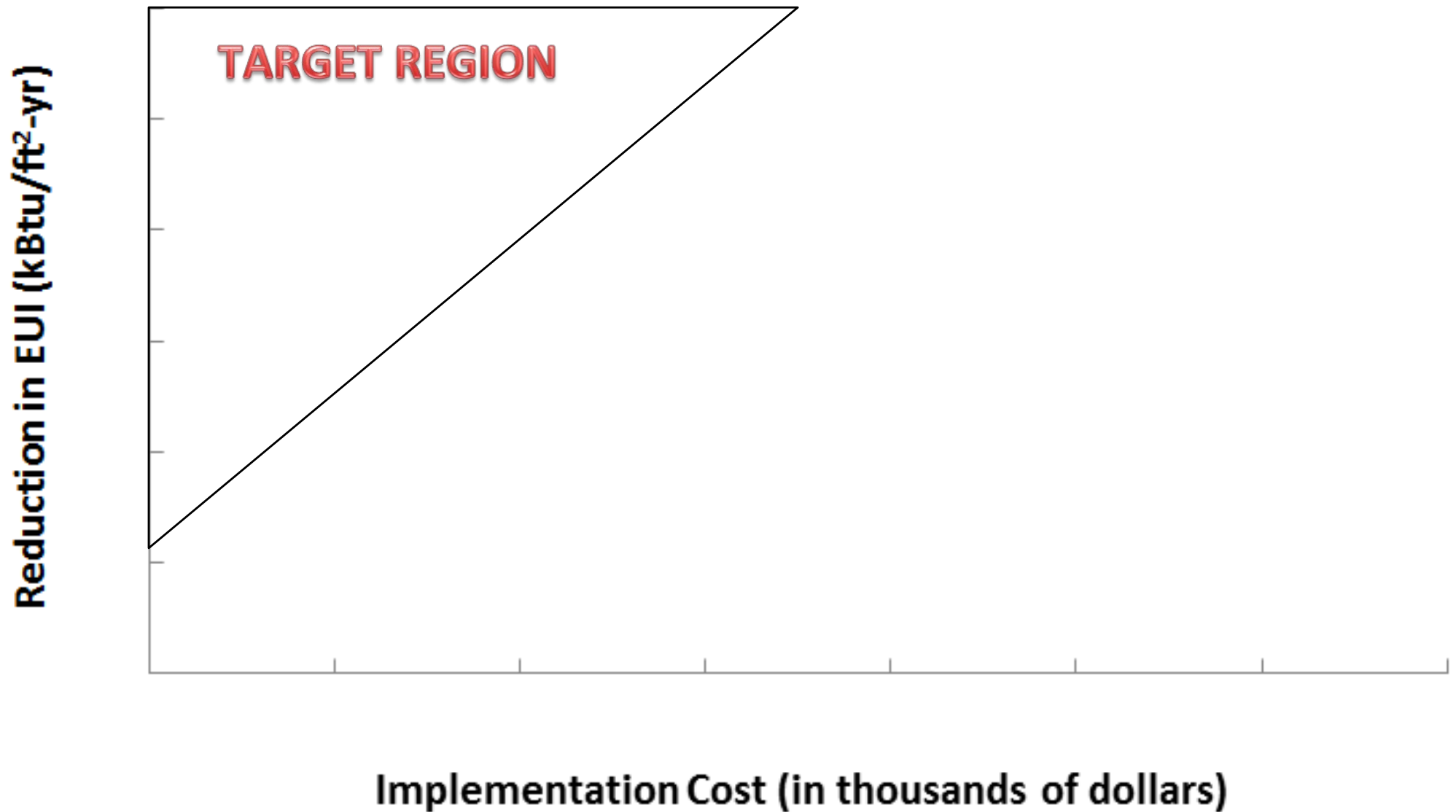
- ▣ Behavior modification
- ▣ Natural gas efficiency
- ▣ Electricity efficiency
- ▣ Renewables

# EUI Improvement Effects and Costs





# EUI Improvement Effects and Costs



# BIC Improvements

- ▣ Behavioral
  - Leaving the BIC closed on Monday
  - Closing the BIC 30 minutes early every day
  - Turning off the fireplace
  - Shades on the windows

→ All violate the intended purpose of the BIC!

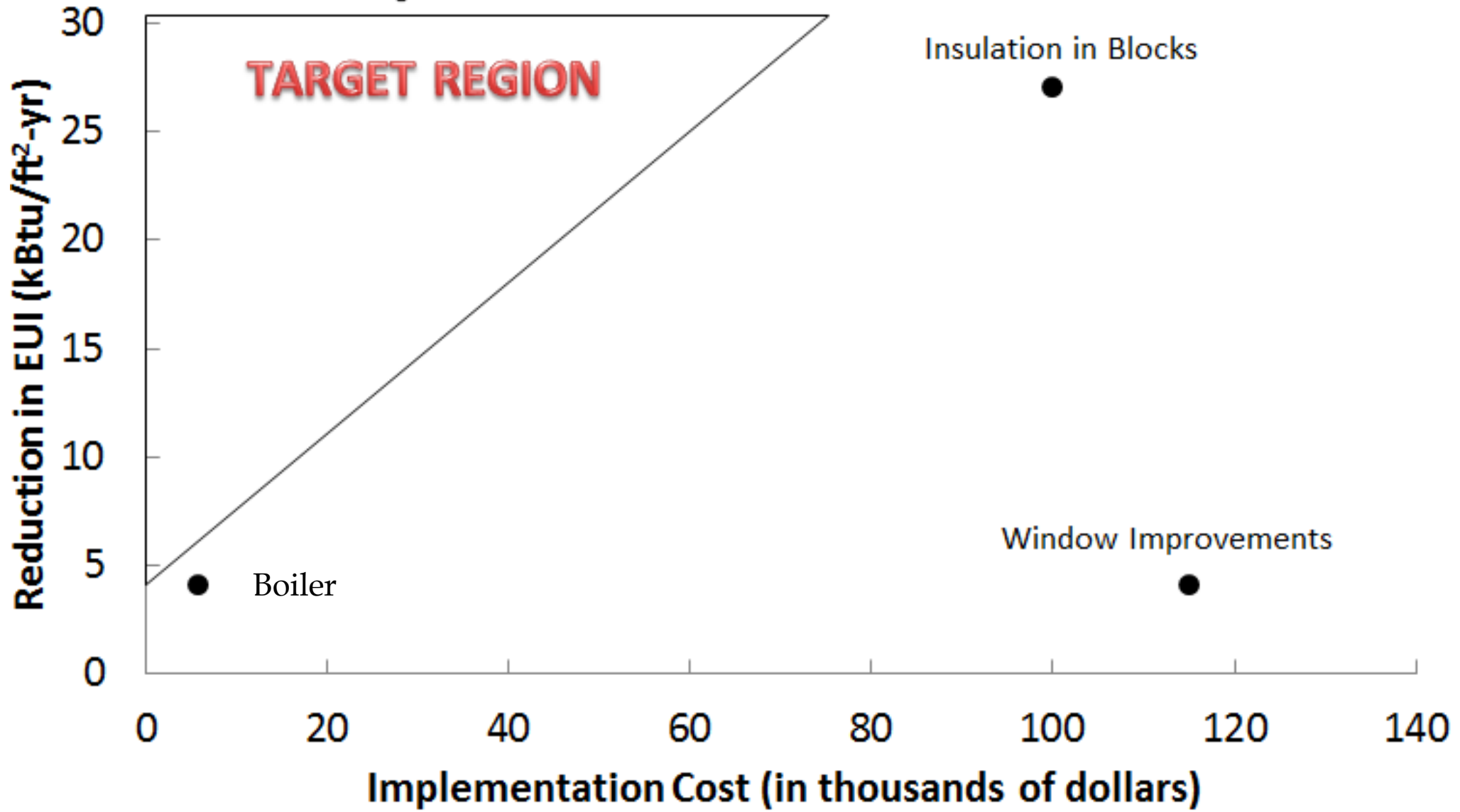
“One purpose of the facility is to help visitors understand their role in the world as stewards of creation”

-Professor Randy Van Dragt

# BIC Improvements (cont.)

- ▣ Natural Gas
  - High-efficiency Boiler
  - Improving Insulation
  - Replacing Windows

# EUI Improvement Effects and Costs

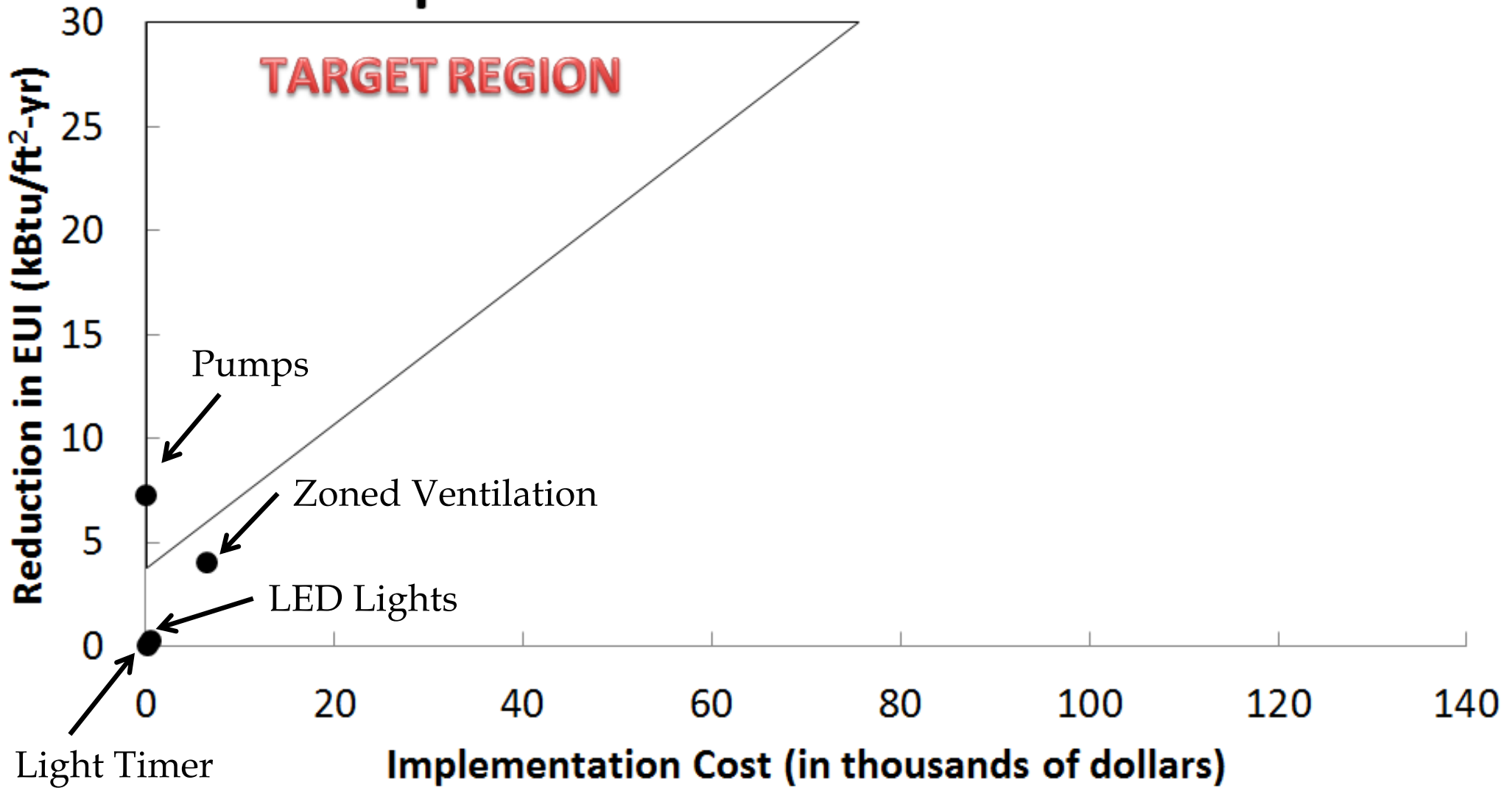




# BIC Improvements (cont.)

- ▣ Electricity
  - LED lights
  - Replacing appliances
  - Shutting off water pumps
  - Zoned Ventilation

# EUI Improvement Effects and Costs

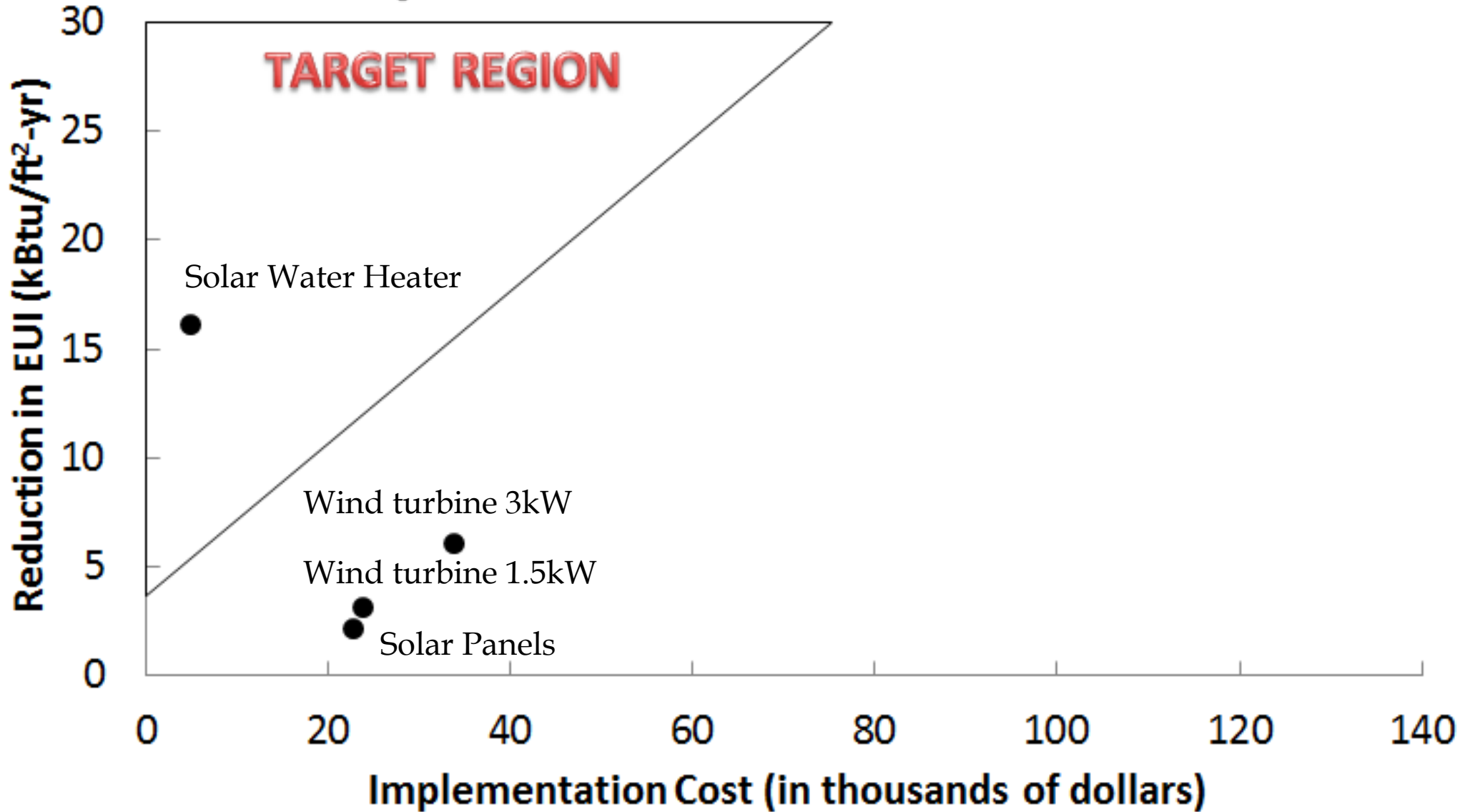


# BIC Improvements (cont.)

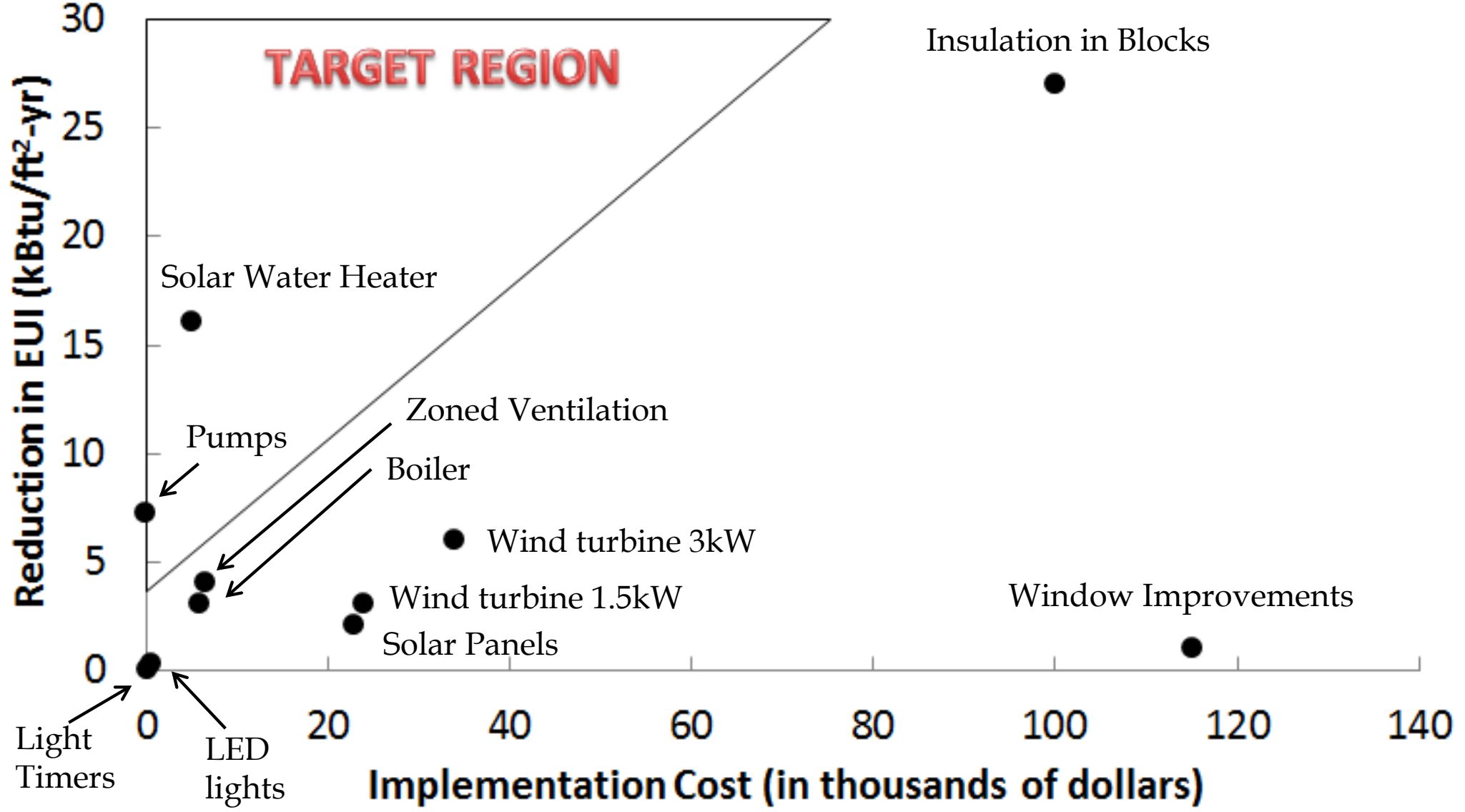
## Renewable Energy Improvements

- Increased Solar PV Panels
- Wind Turbine
- Solar Water Heater

# EUI Improvement Effects and Costs



# EUI Improvement Effects and Costs



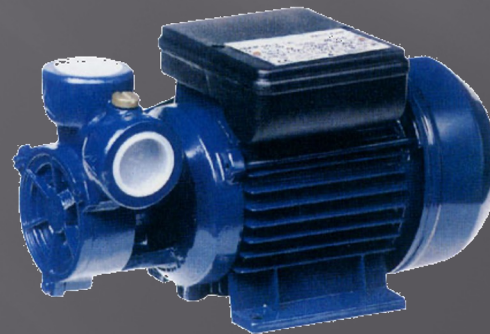


# Recommendations

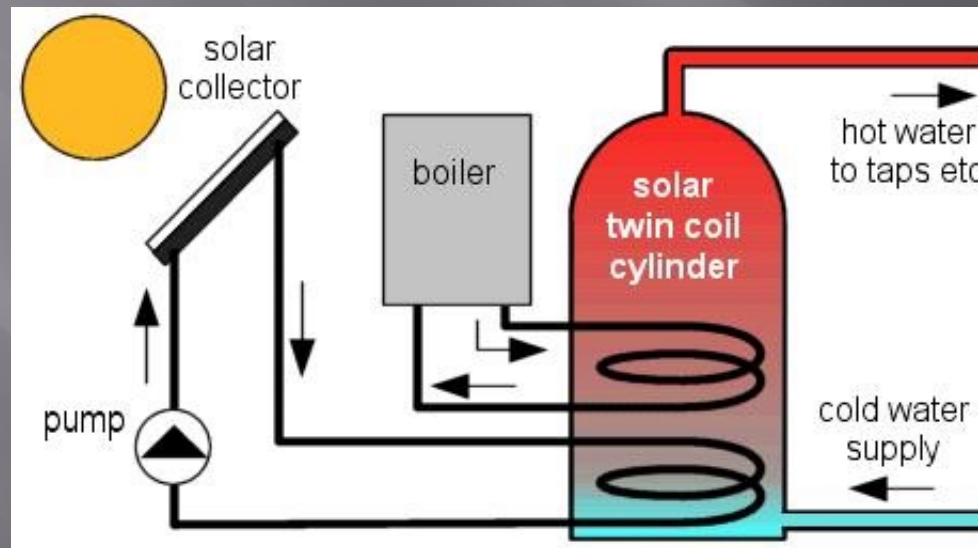
- ▣ Solar Water Heater



- ▣ Pump Operation



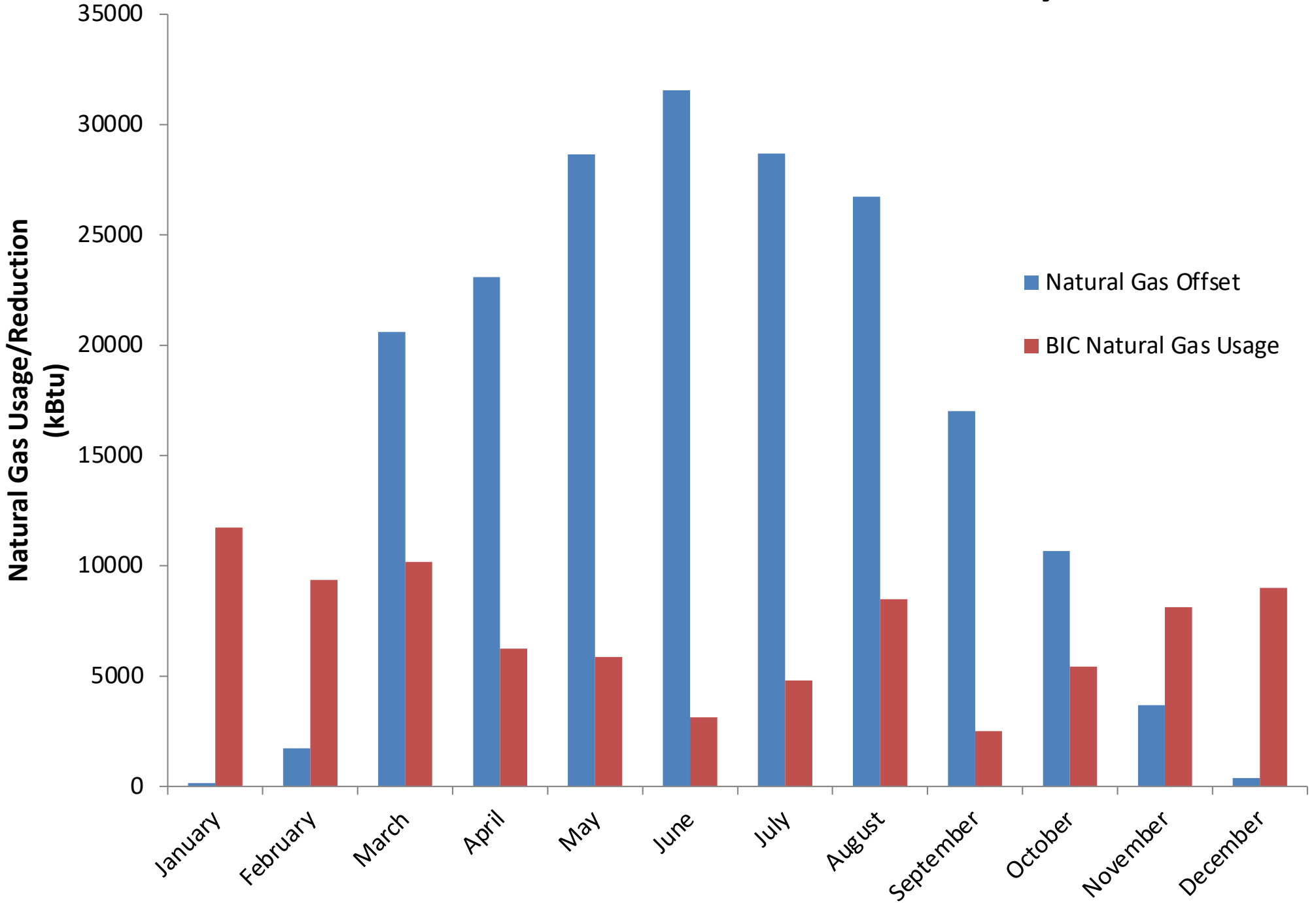
# Solar Water Heater



# Solar Water Heater Specifications

- ▣ Solar Water Heater: heats water inside concentrated tubes using sun's energy
- ▣ Total Cost Estimation
  - \$615 for system
  - \$5,000 estimated installation
- ▣ EUI reduction of 16 kBtu/ft<sup>2</sup>-yr
- ▣ Payback in 2 years

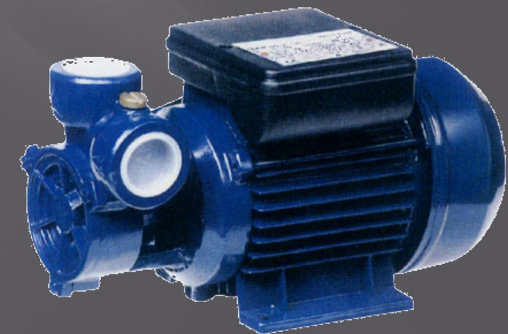
# Solar Water Heater Natural Gas Analysis





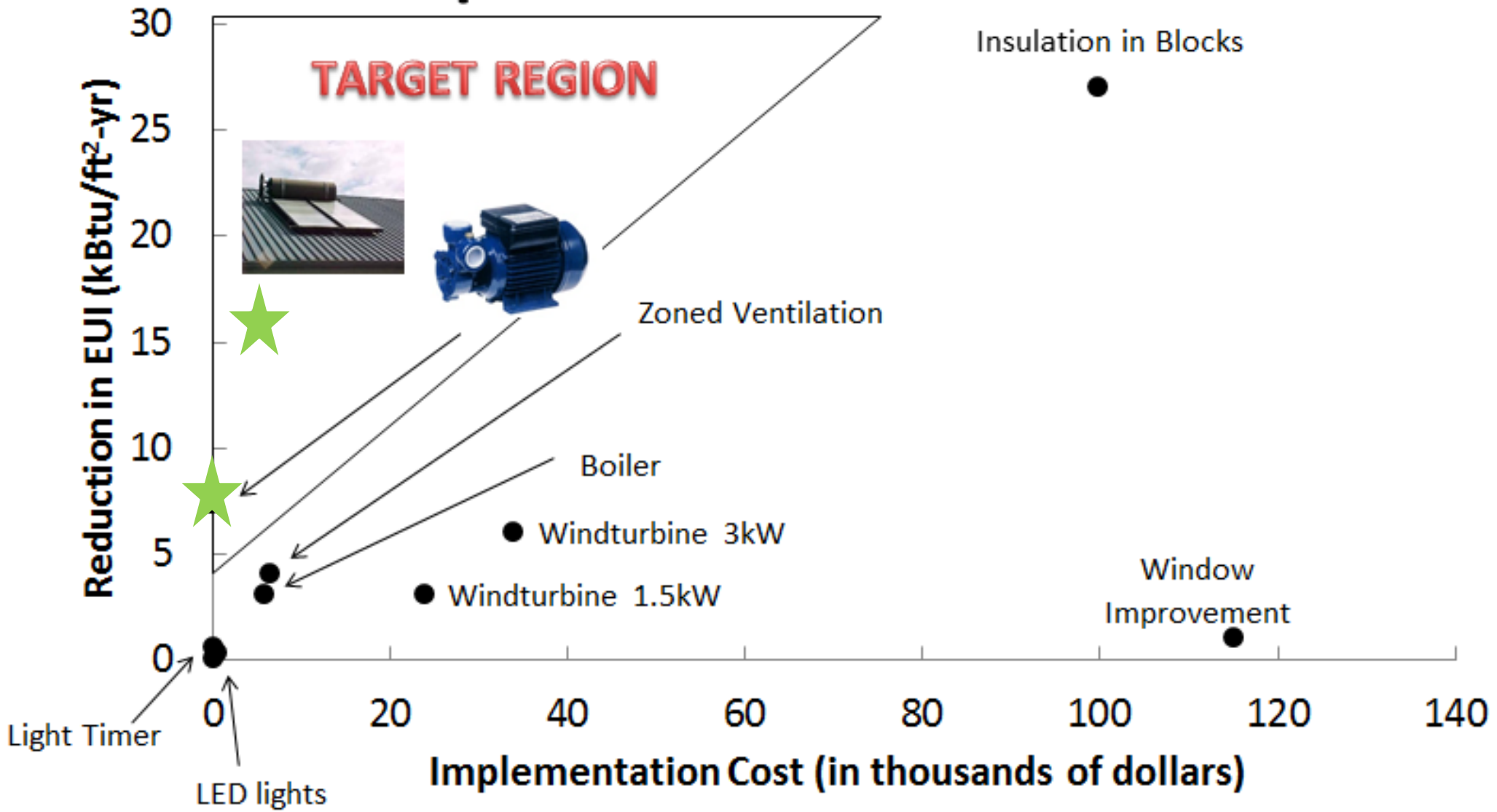
# Pump Description

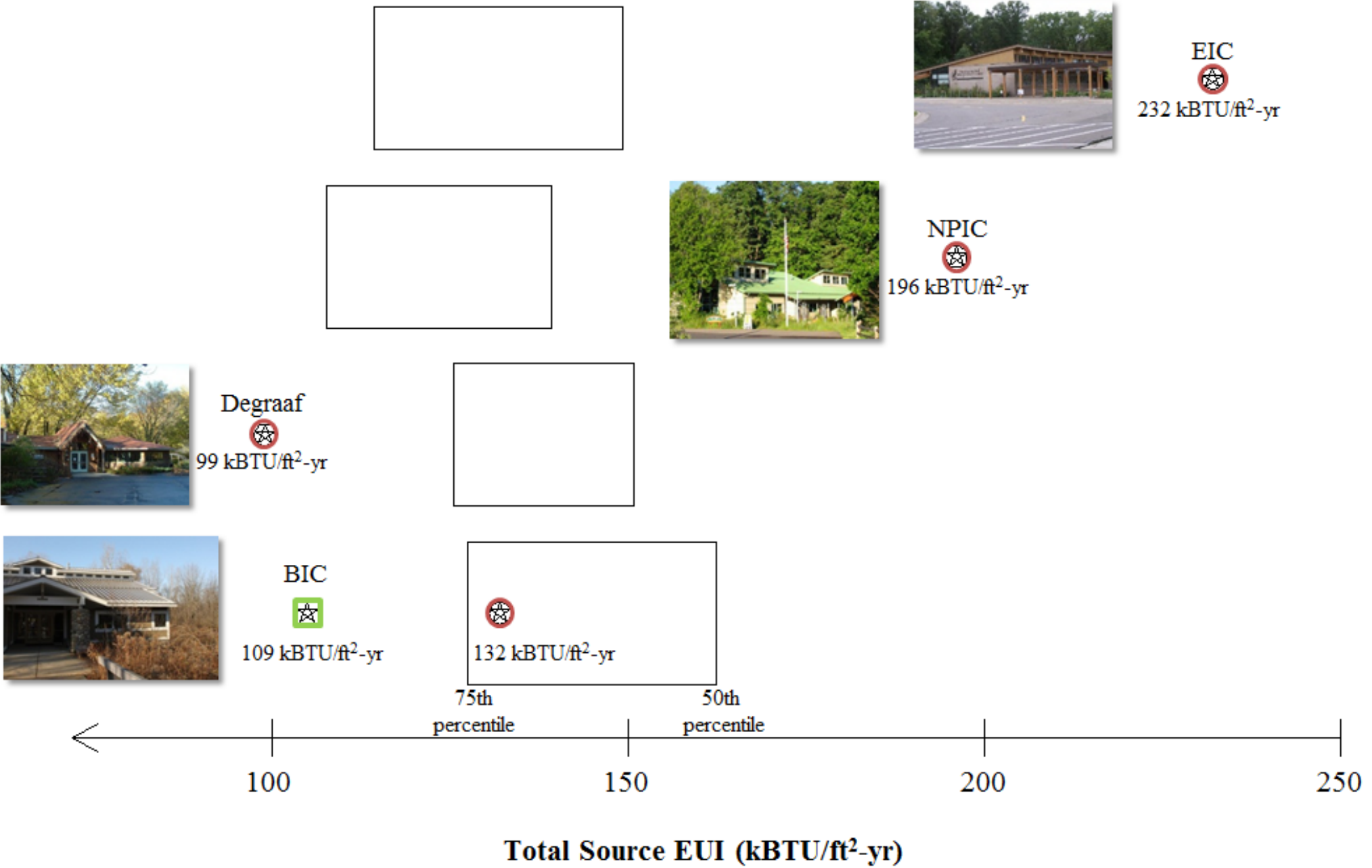
- ▣ Turn off pumps for the floor radiant heating loops during the summer months
- ▣ Total Cost Estimation:
  - Electronic Controller - \$200
- ▣ EUI Reduction: 7 kBtu/ft<sup>2</sup>-yr
- ▣ Payback in 56 days





# EUI Improvement Effects and Costs





# Summary

- ▣ Does LEED work?
  - Almost
- ▣ What will it take for the BIC to get Energy Star<sup>®</sup>?
  - Can't!
- ▣ Small improvements will earn BIC Star
  - Solar Water Heater
  - Pump Operation

# Future Work

- ▣ Continue monitoring BIC energy use
- ▣ Design a solar water heater system
- ▣ Modify pump operation

# Acknowledgements

- ▣ *Dr. Henry DeVries*
  - Calvin College VP Finance
- ▣ *Professor Randy Van Dragt*
  - Calvin College Ecosystem Preserve Director
- ▣ *Jeanette Henderson*
  - Calvin College Ecosystem Preserve Manager
- ▣ *Dan Slager*
  - Calvin College Energy Purchasing
- ▣ *Paul Pennock*
  - Calvin College Physical Plant Mechanical Dept.
- ▣ *Eric DeVries*
  - Midwest Energy Group
- ▣ *Mike Troupos*
  - Calvin College CERF Intern
- ▣ *Professor Matthew Heun*
  - ENGR 333

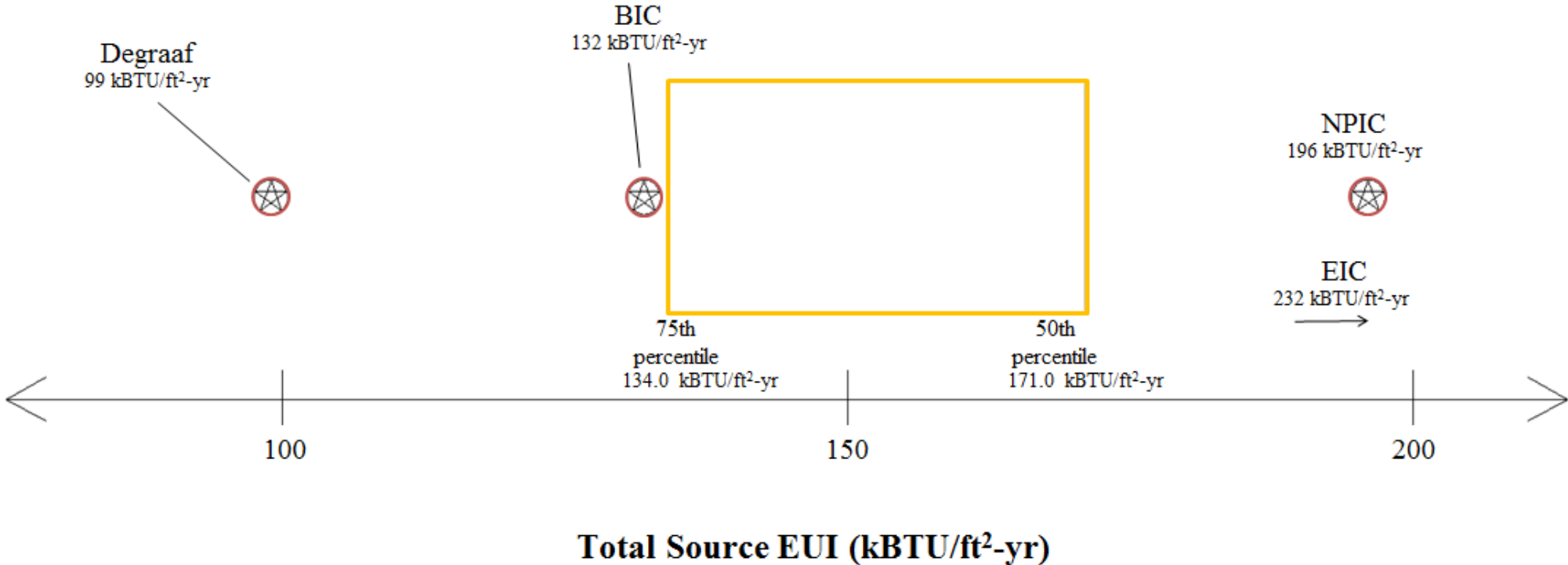


Questions or Comments?

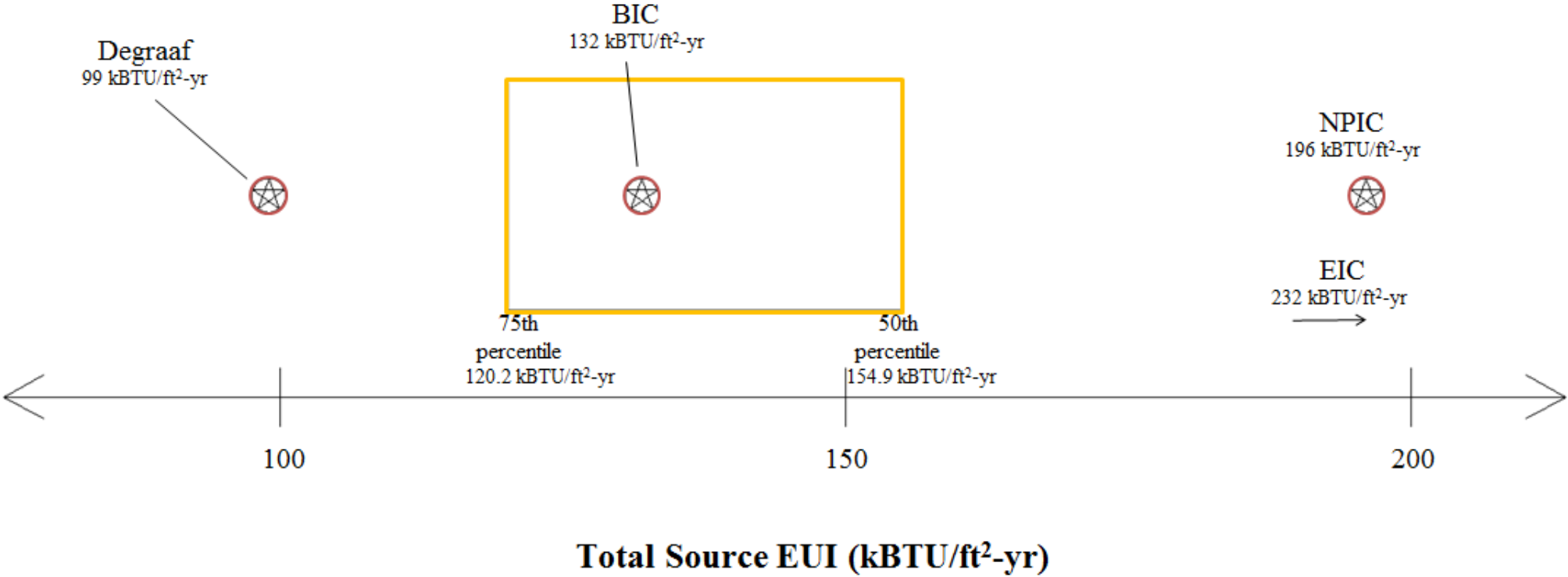


# Appendix

# Upper BIC-Star Range

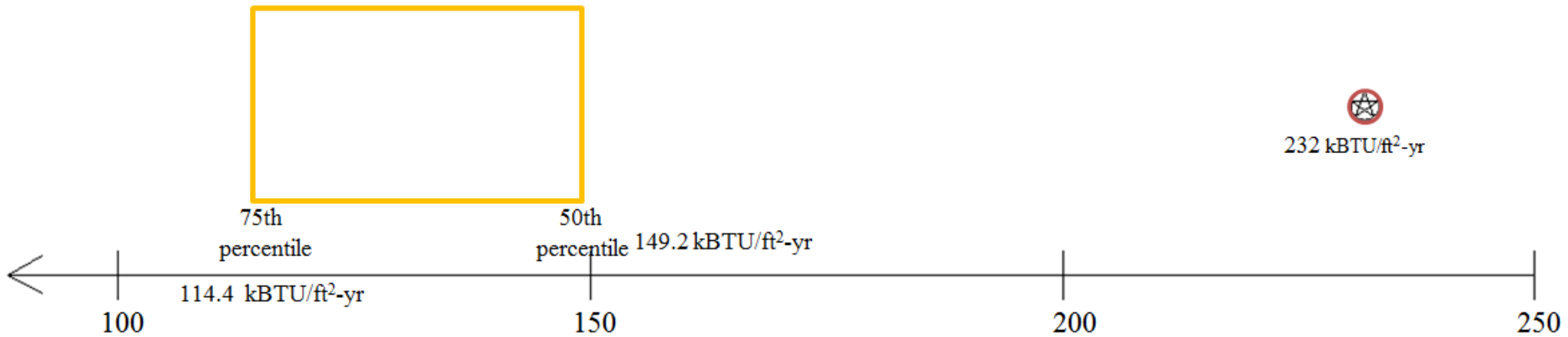


# Lower BIC-Star Range





# Environmental Interpretive Center



Total Source EUI (kBTU/ft<sup>2</sup>-yr)

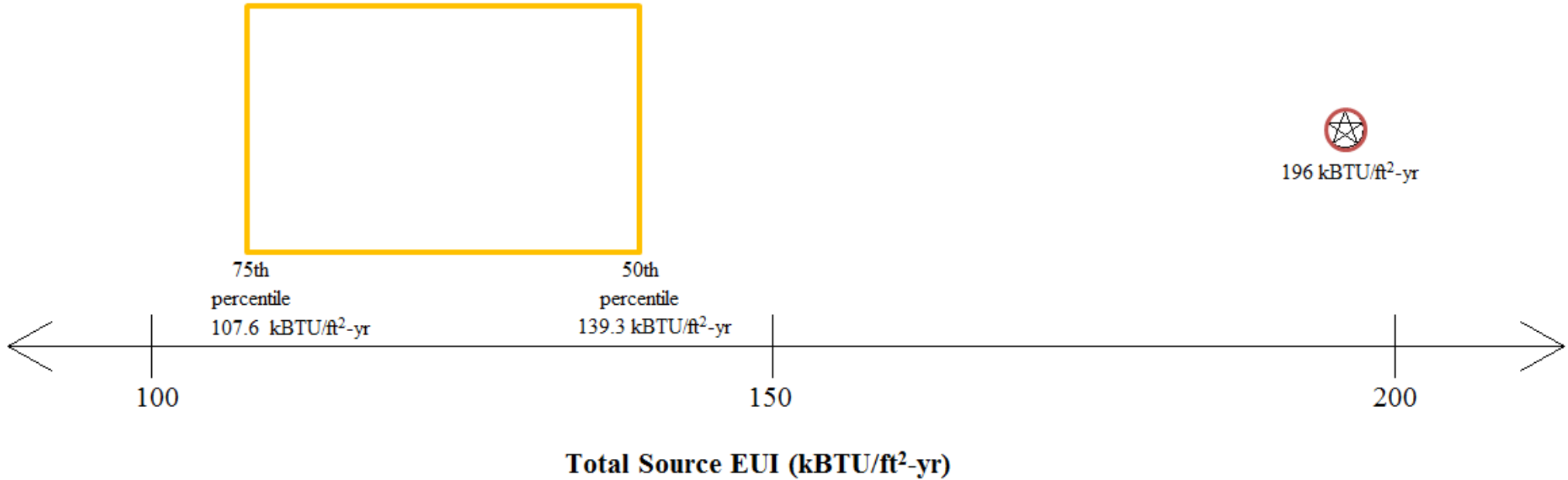
**ASSUME**

70%	K-12
30%	Office

	K-12		Office		Weighted	
	50th	75th	50th	75th	50th	75th
Degraaf Nature Center	145	139	164	94	150.7	125.5
Environmental Interpretive Center	148	115	152	113	149.2	114.4
Nature Park Interpretive Center	148	116	119	88	139.3	107.6

NOTE: 50<sup>th</sup> and 75<sup>th</sup> percentiles numbers have units of kBtu/ft<sup>2</sup>-yr

# Nature Park Interpretive Center



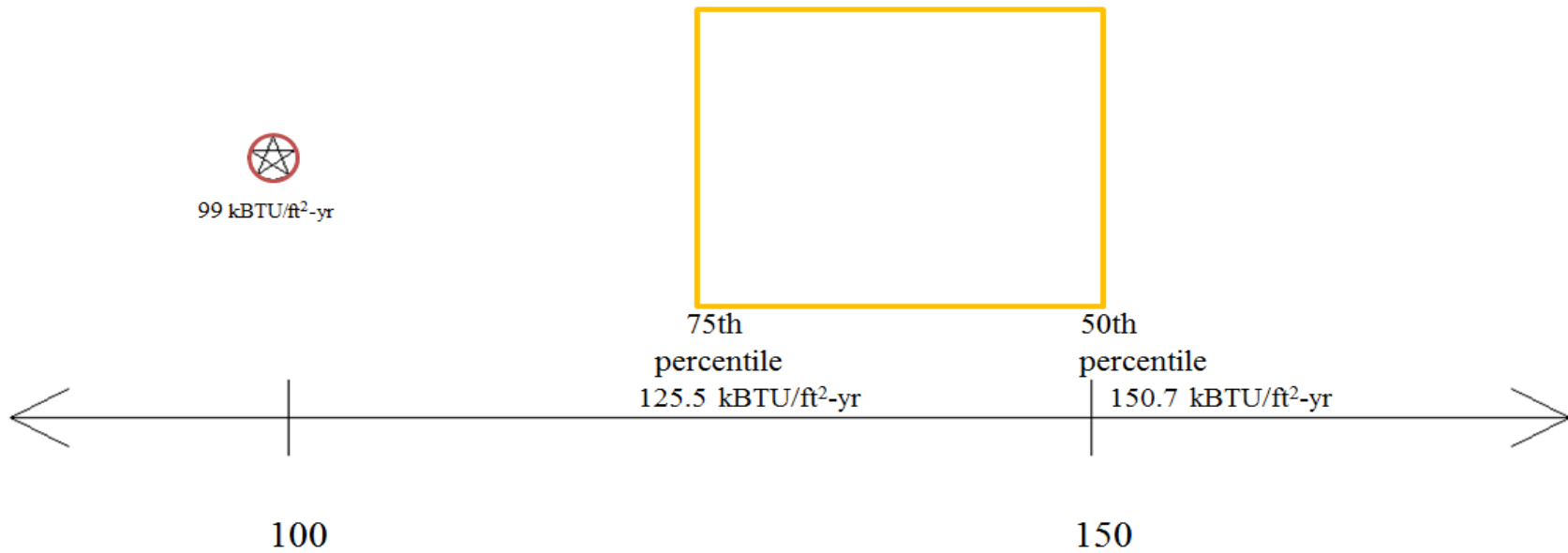
## ASSUME

70%	K-12
30%	Office

	K-12		Office		Weighted	
	50th	75th	50th	75th	50th	75th
Degraaf Nature Center	145	139	164	94	150.7	125.5
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NOTE: 50<sup>th</sup> and 75<sup>th</sup> percentiles numbers have units of kBtu/ft<sup>2</sup>-yr

# Degraaf Nature Center

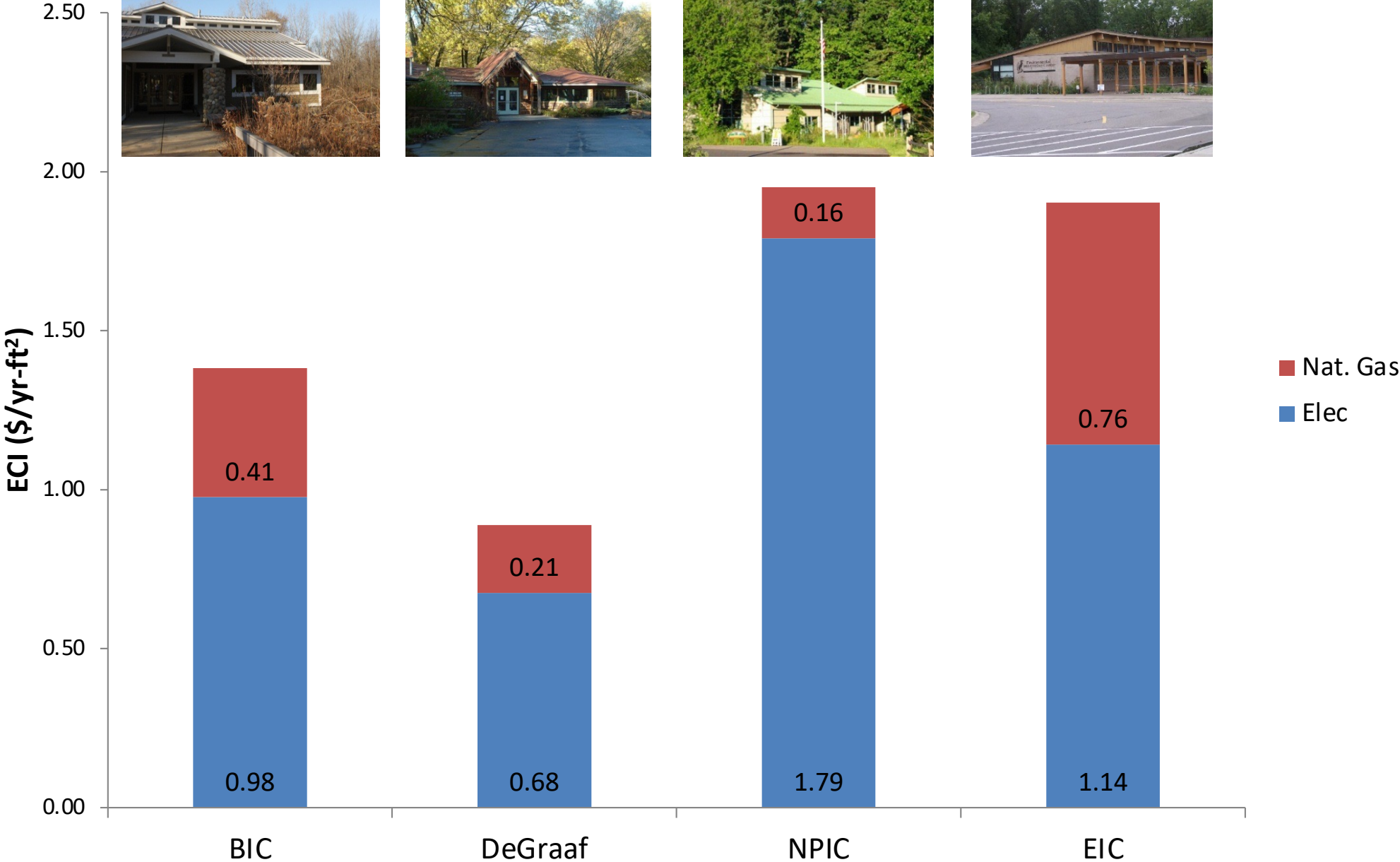


## Total Source EUI (kBTU/ft<sup>2</sup>-yr)

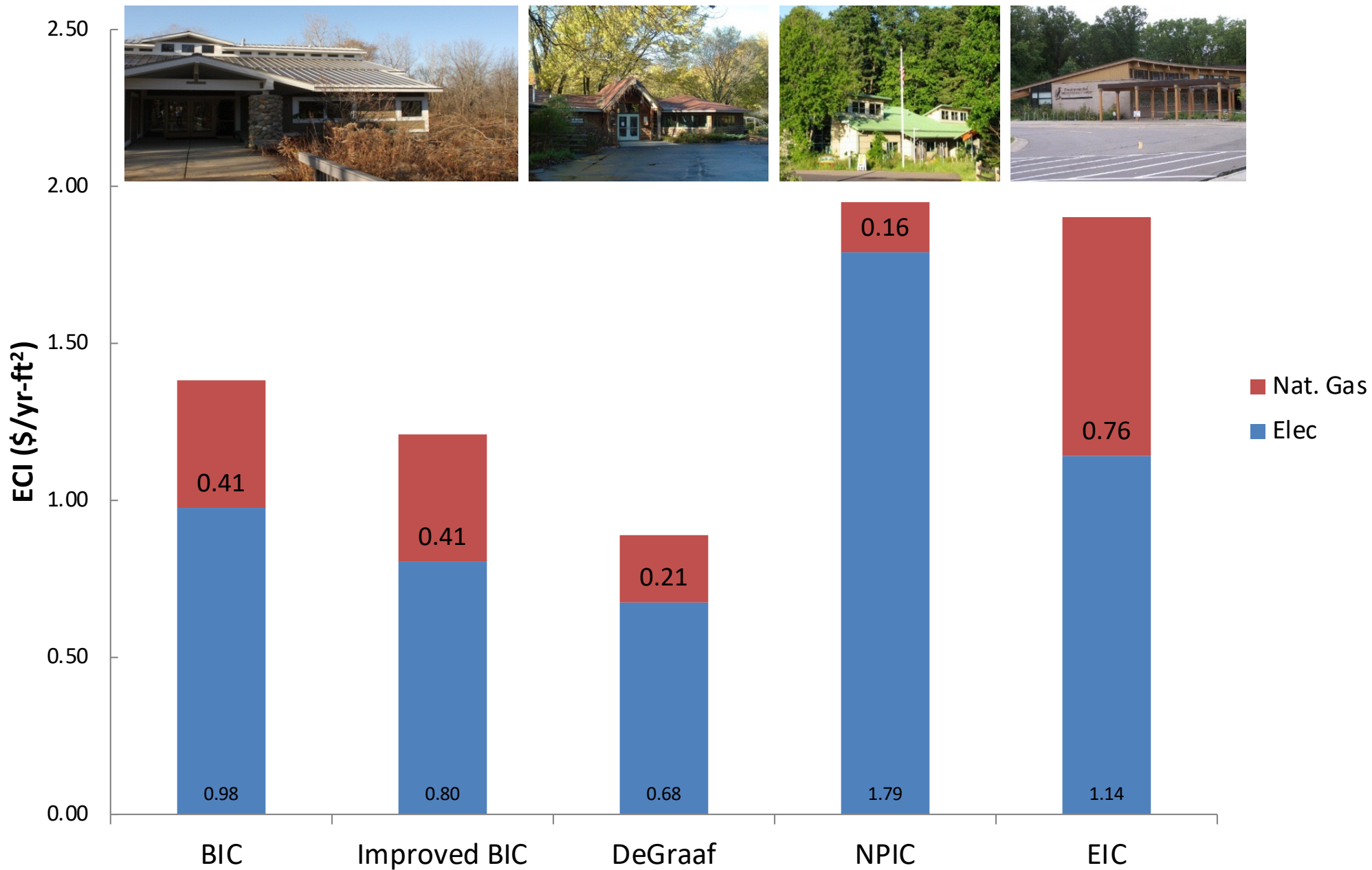
ASSUME		K-12		Office		Weighted	
70%	K-12	50th	75th	50th	75th	50th	75th
30%	Office						
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NOTE: 50<sup>th</sup> and 75<sup>th</sup> percentiles numbers have units of kBtu/ft<sup>2</sup>-yr

# ECI Comparison



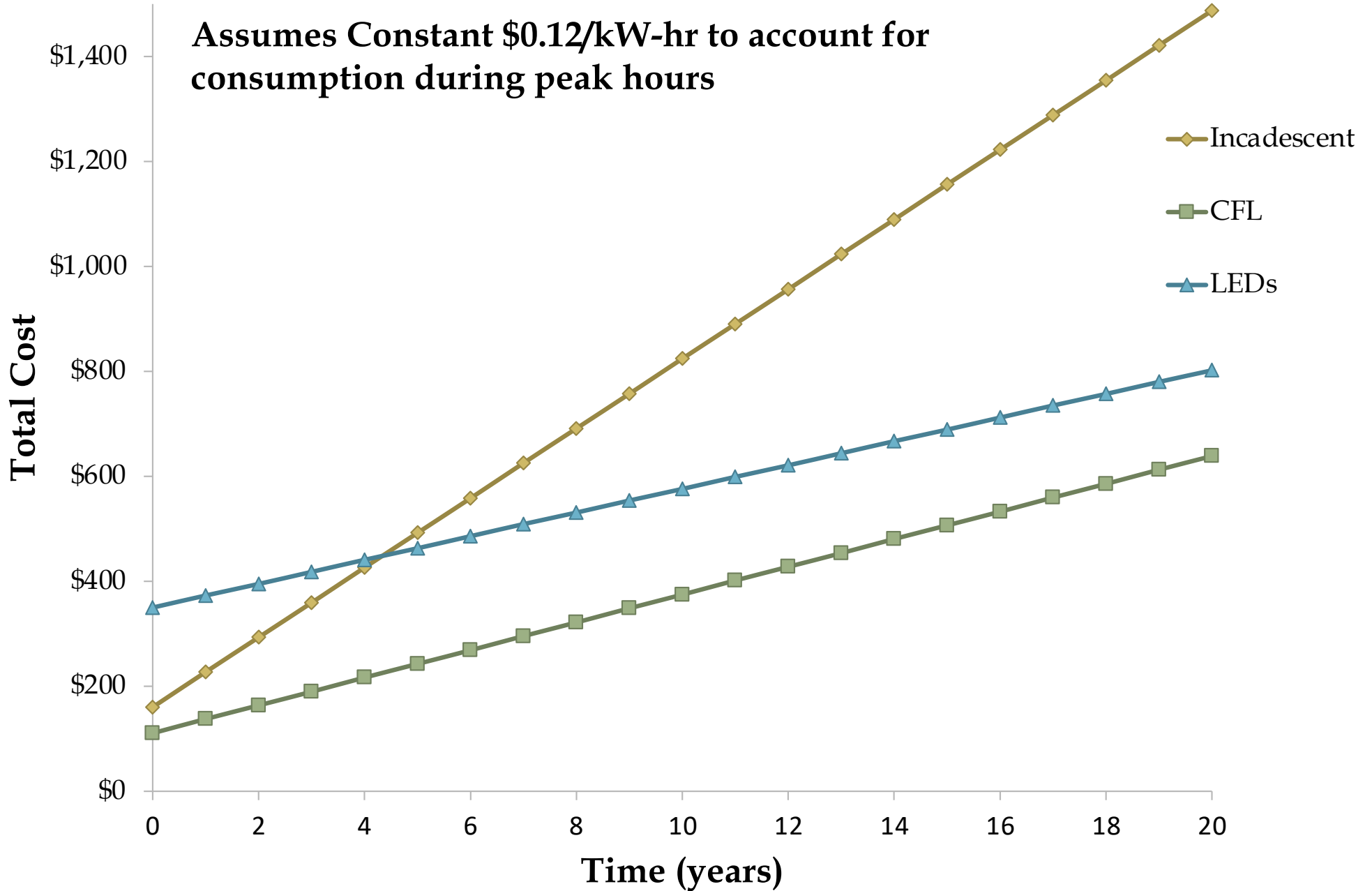
# ECI Comparison





# Cost Analysis

Assumes Constant \$0.12/kW-hr to account for consumption during peak hours



## Total Money Savings for Calvin College from BIC Solar Panel Energy since Installation

