



NESEA

# Getting to Net Zero: The Nitty Gritty of Learning and Practicing the Steps

March 7, 2017

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Laura Bailey, CPHC, Research Director, Maclay Architects

# Agenda

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What is Net Zero?

Why Net Zero?

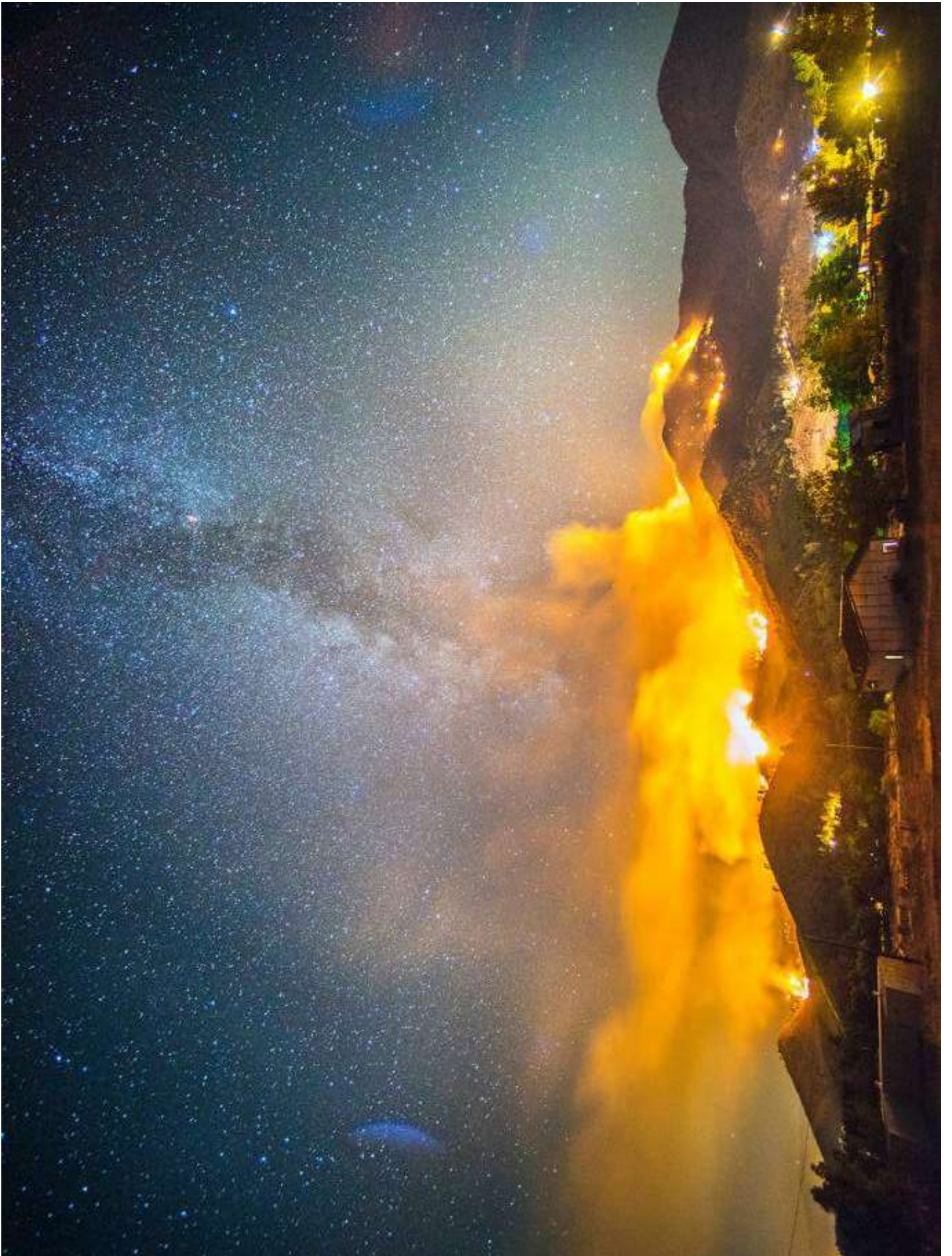
12 Steps to Net Zero

Exercises (throughout)

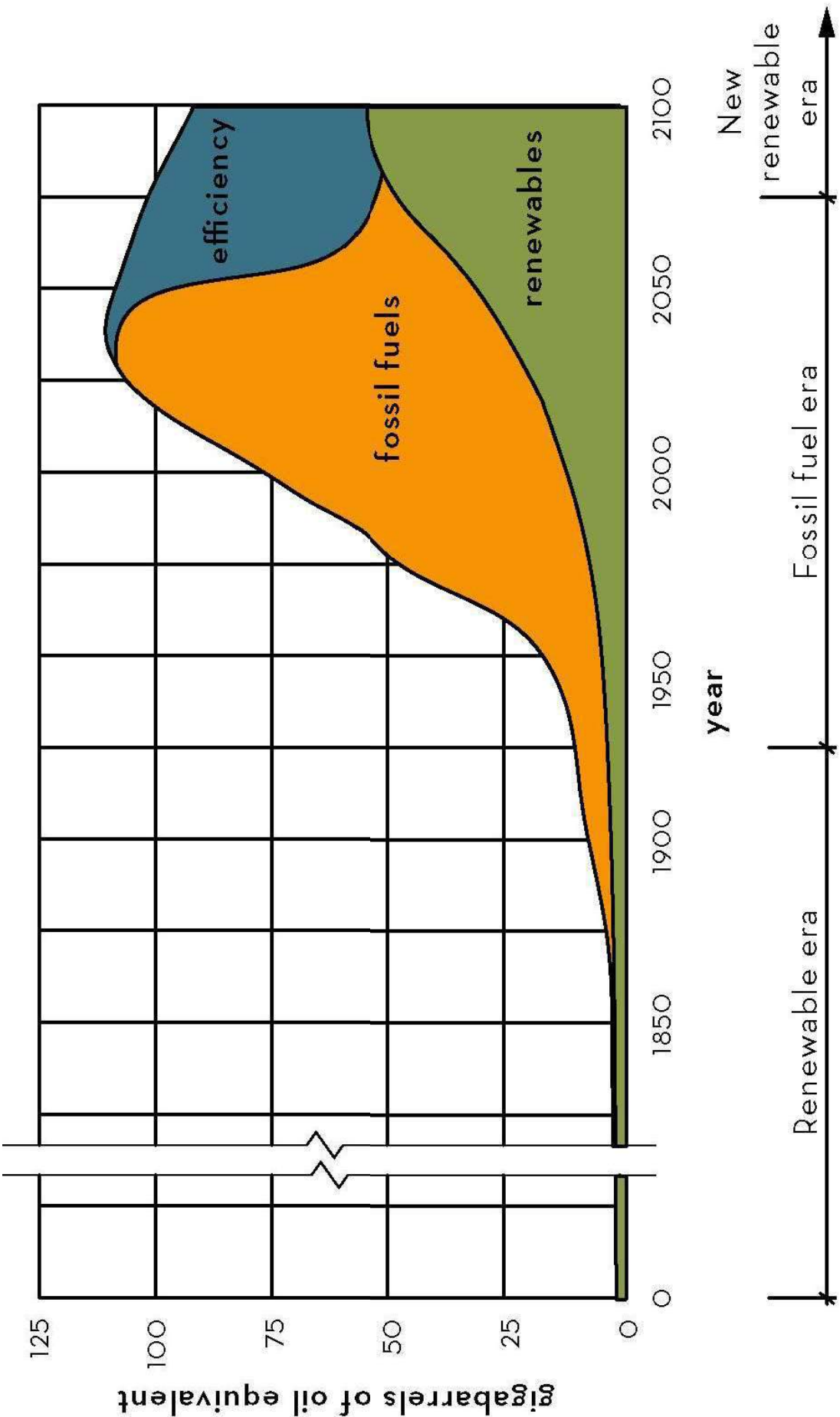
Case Studies (throughout)

The world is  
changing...

**THE TIME IS NOW!**



# Renewable Energy Transition



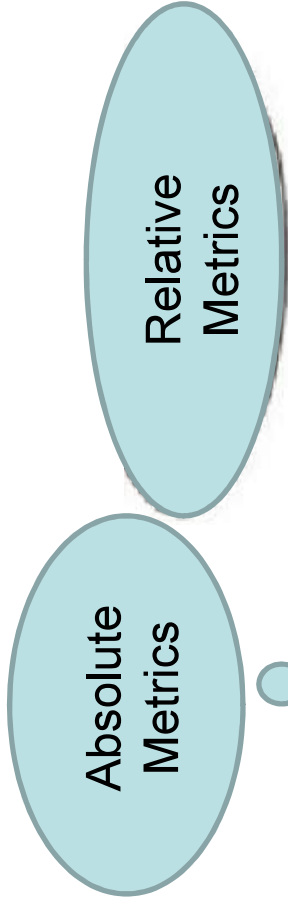
# Building Impact



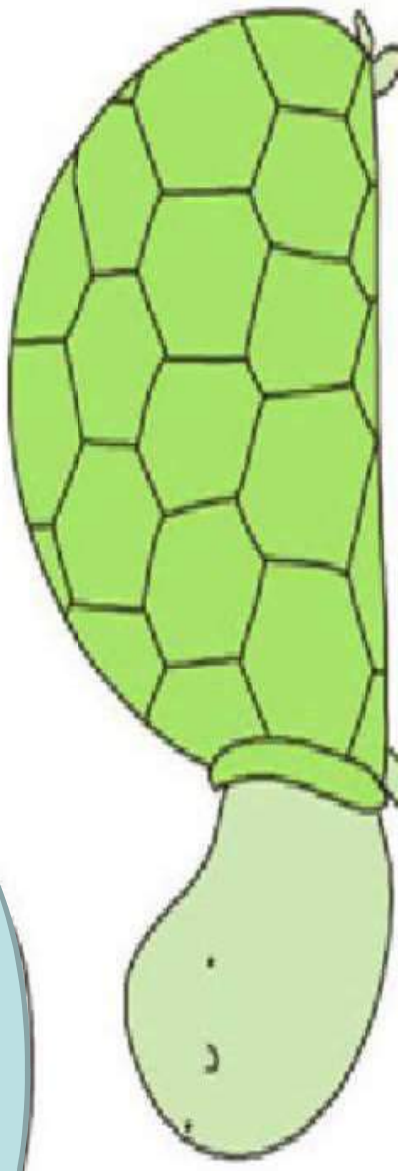
## U.S. Energy Consumption by Sector

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

# Paradigm Shift #1



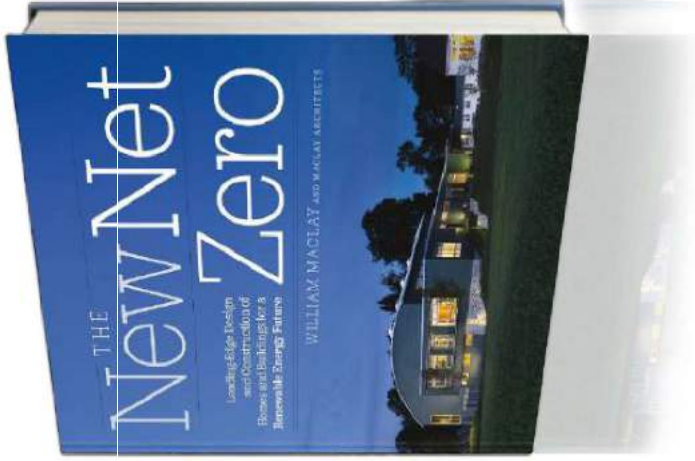
Covers @ FirstCovers.com



# What is Net Zero?

## The New Net Zero Definition

A building, a community, a country, or a planet that produces as much energy as it consumes on an annual basis using only renewable energy



Option Number	ZEB Supply-Side Options
0	Reduce site energy use through low-energy building technologies.
<b>On-Site Supply Options</b>	
1	Use renewable energy sources available within the building's footprint.
2	Use renewable energy sources available at the site.
<b>Off-Site Supply Options</b>	
3	Use renewable energy sources available off site to generate energy on site.
4	Purchase off-site renewable energy sources.

## NREL Definition

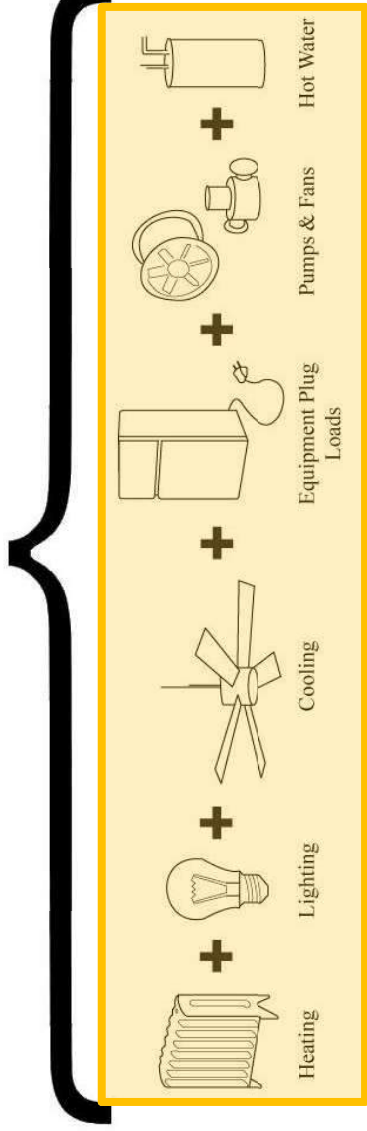


## Living Futures Definition

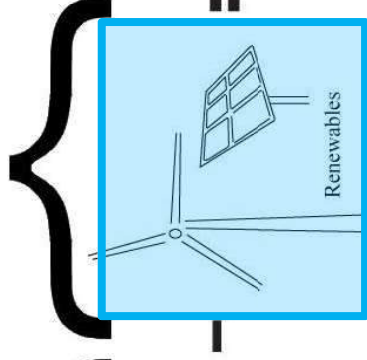


# Net Zero Buildings

ALL BUILDING LOADS



RENEWABLES



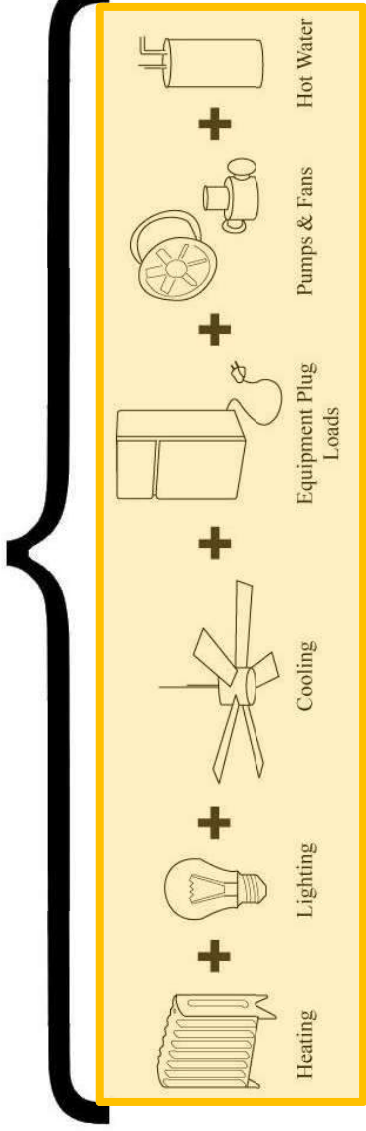
Net-zero energy  
0 kBtu/sf-yr

NZE

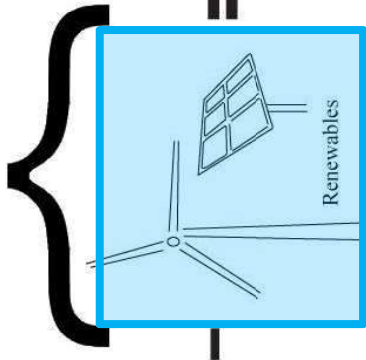
# Net Zero or Net Zero Ready?



ALL BUILDING LOADS



RENEWABLES

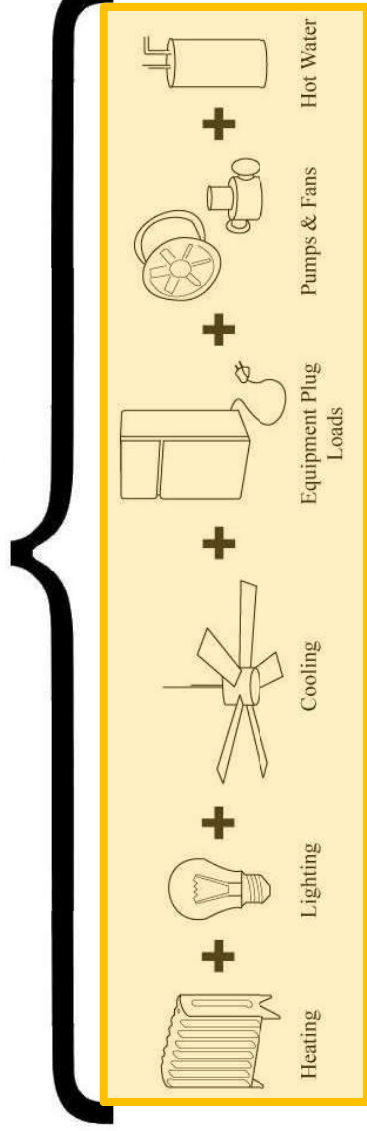


NET ZERO READY - RENEWABLES

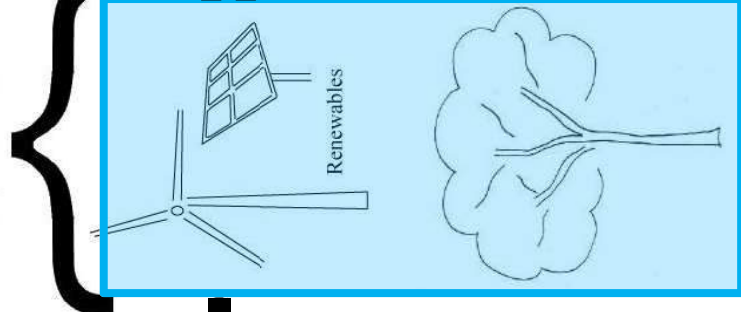
= NZE

# Net Zero or Carbon Neutral?

NET ZERO READY



RENEWABLES



CARBON  
NEUTRAL

+ BIOMASS

# Fuel Mileage for Buildings?

## EPA Fuel Economy Estimates

These estimates reflect new EPA methods beginning with 2008 models.

<b>CITY MPG</b> <b>18</b> Expected range for most drivers <b>15 to 21 MPG</b>	<b>HIGHWAY MPG</b> <b>25</b> Expected range for most drivers <b>21 to 29 MPG</b>
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**Estimated Annual Fuel Cost**  
**\$2,039**  
based on 15,000 miles at \$2.80 per gallon

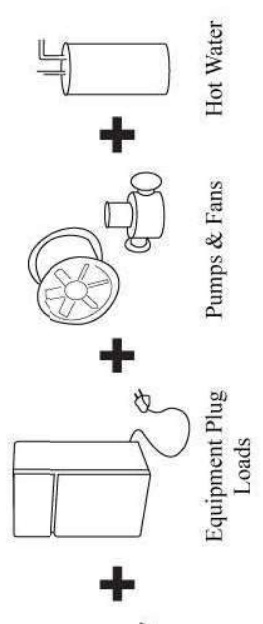
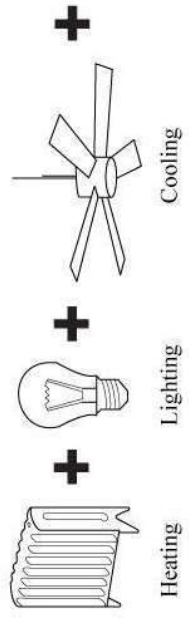
**Combined Fuel Economy**  
This Vehicle **21** | All SUVs 10 — 31

See the FREE Fuel Economy Guide at dealers or [www.fueleconomy.gov](http://www.fueleconomy.gov)



# Energy Use Intensity (EUI)

# The Million MPG Car/Building?

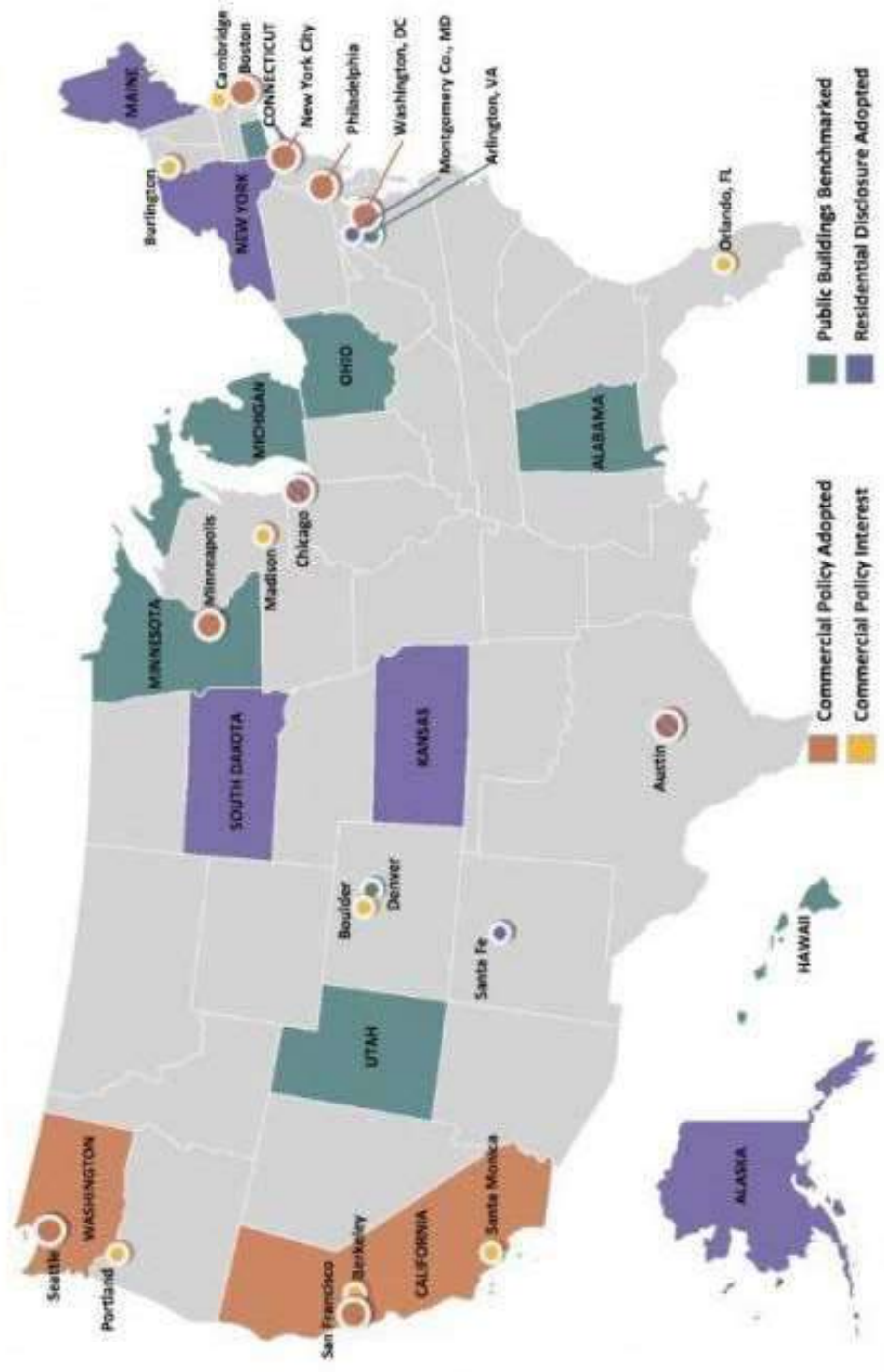


**Net  
= Zero**

# Cities with EUI – Public Disclosure

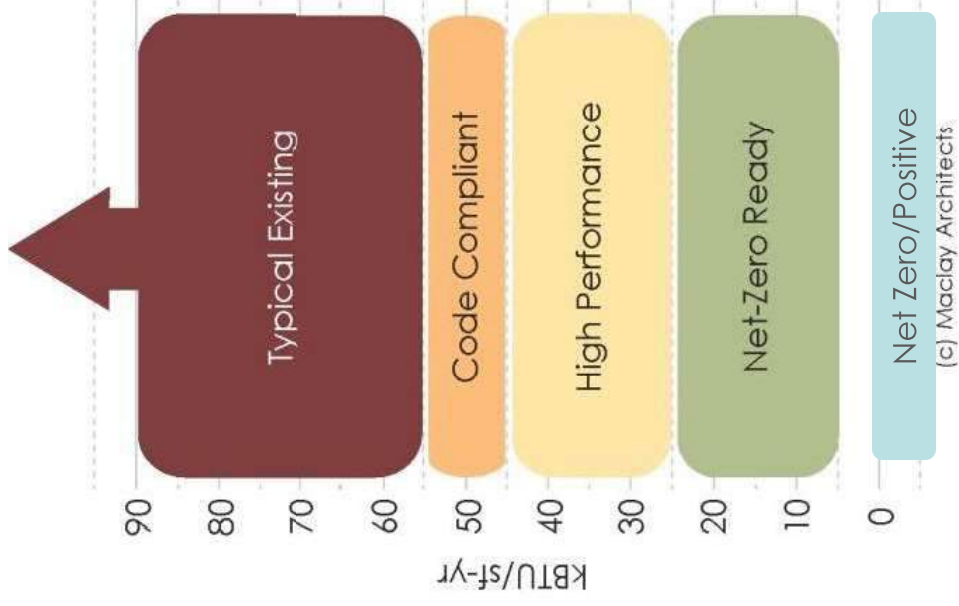


## U.S. Building Benchmarking and Disclosure Policies

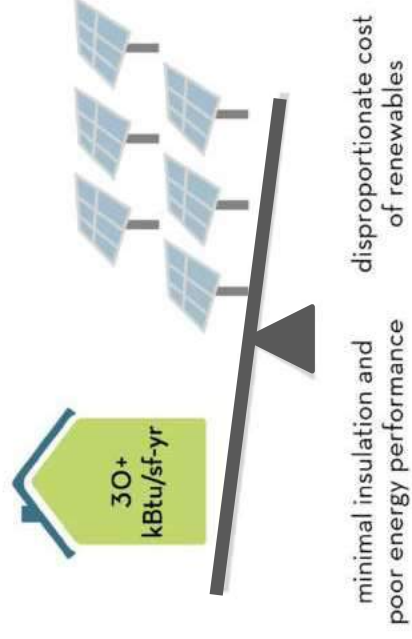
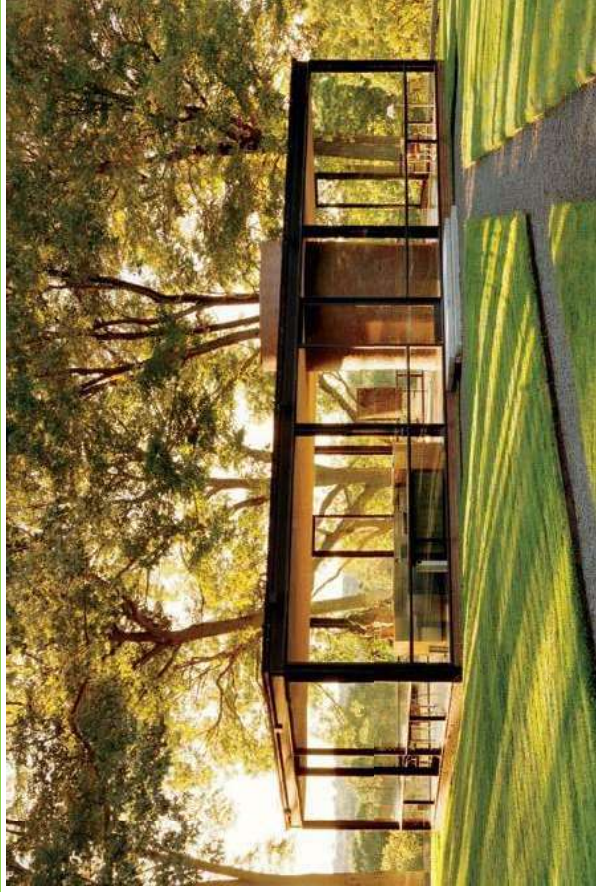


# EUI is the Foundation

## Energy Performance Metrics



# Is this Net Zero?



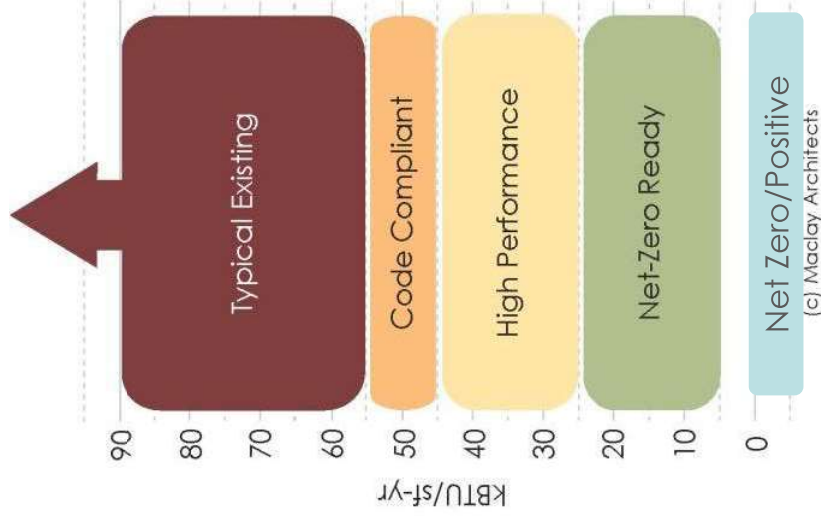


# Net Zero Building Metrics

## Performance Metrics

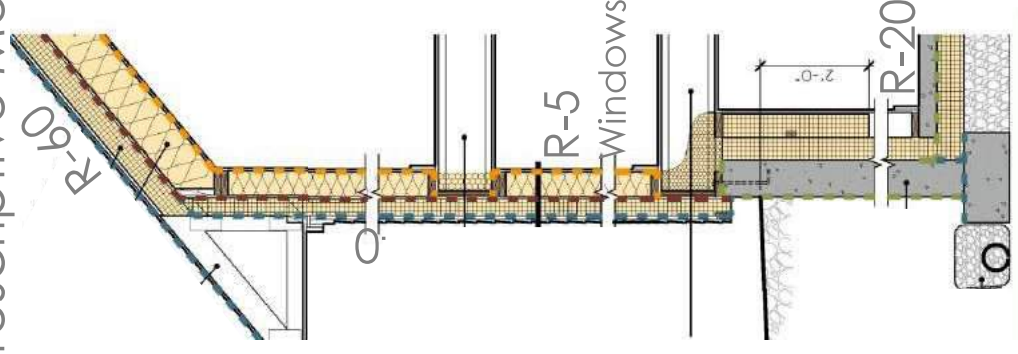
10-25 EUI kBTU/sf

\*without process loads



## Prescriptive Metrics

0.1 cfm/sf  
above grade  
surface area@  
50 Pascals



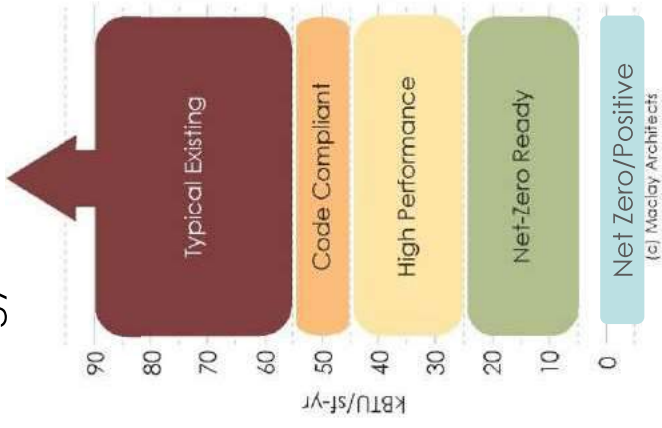
# Key Elements

Conservation +

High-Efficiency  
Systems

+ Renewables

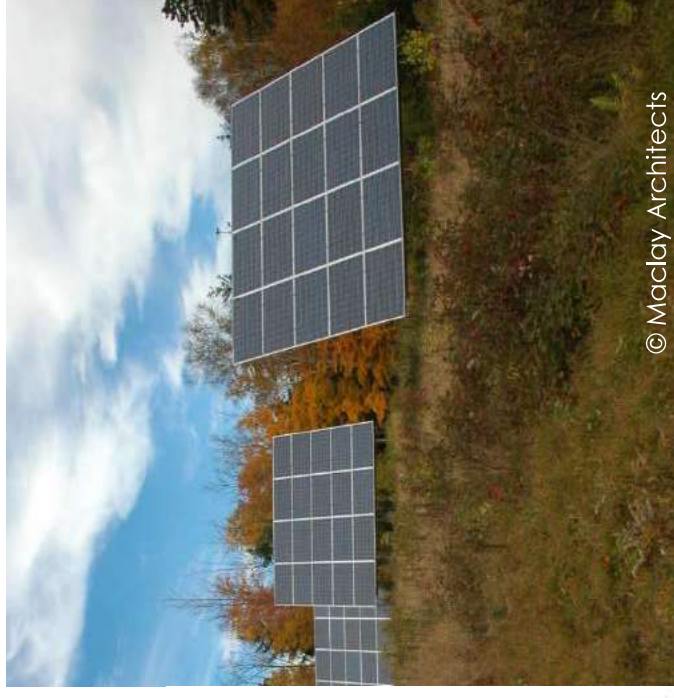
Energy Performance Metrics



Energy Use Intensity  
(EUI)



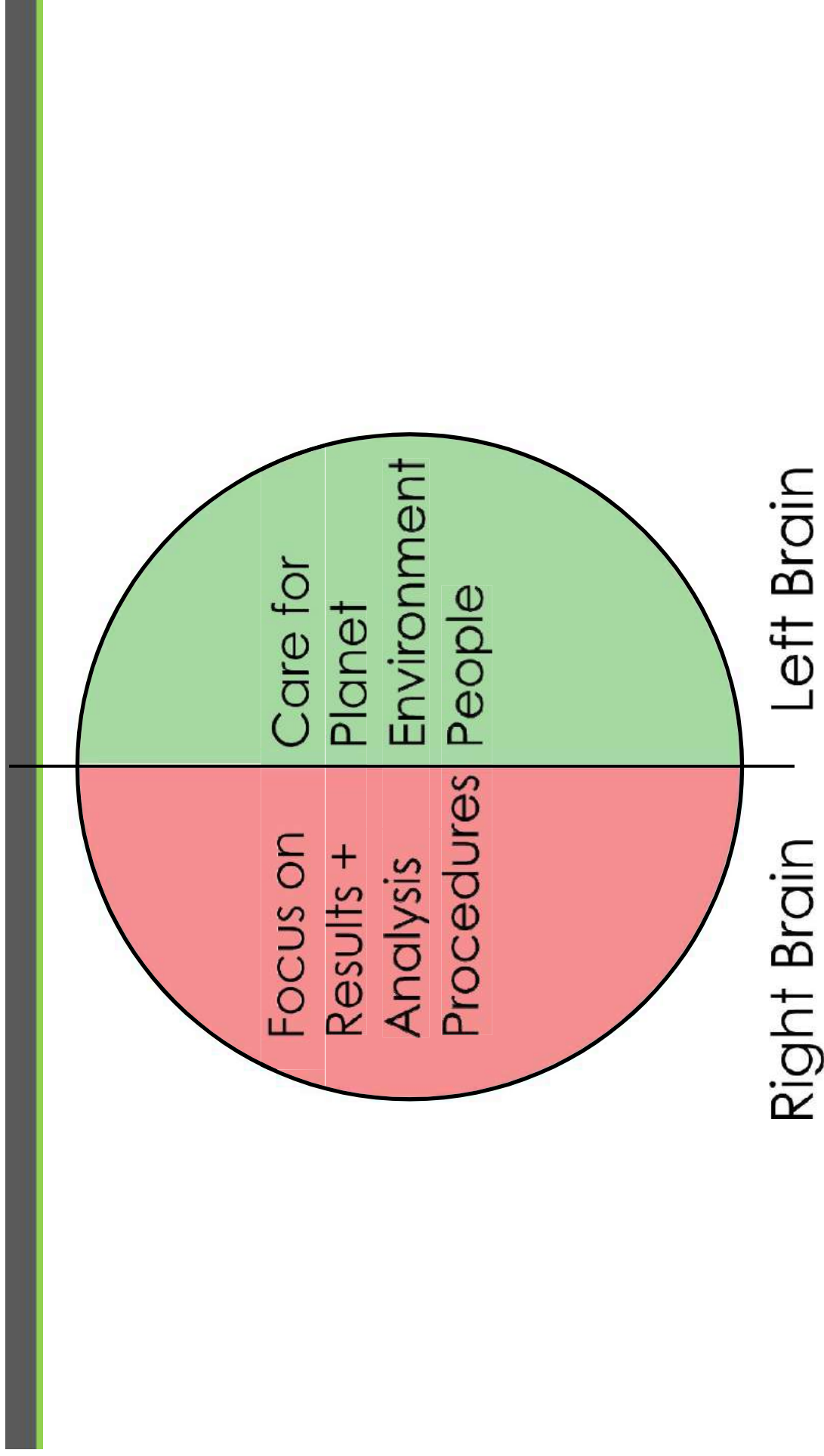
Heat Pumps  
(COP 2.3-3.0)



© MacLay Architects

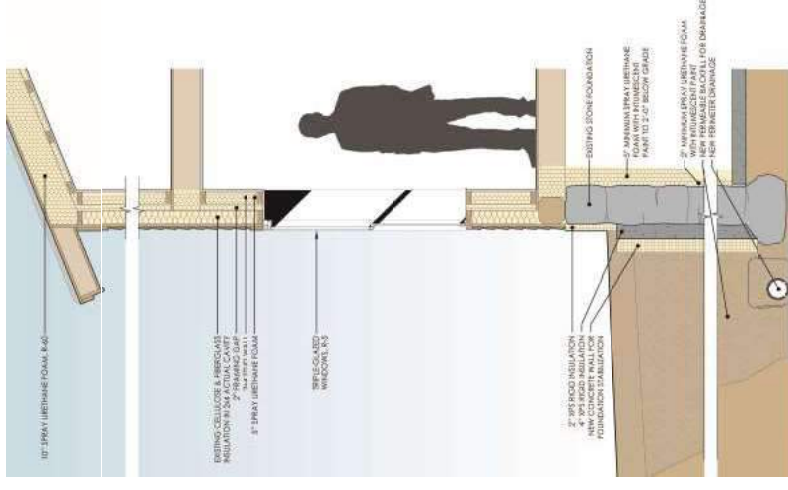
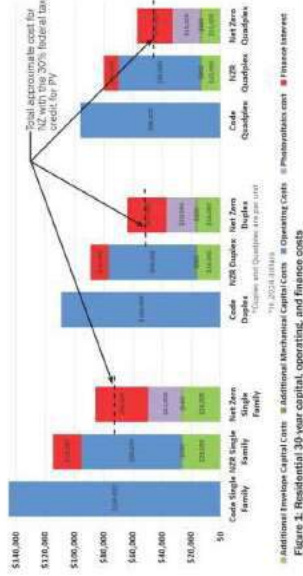
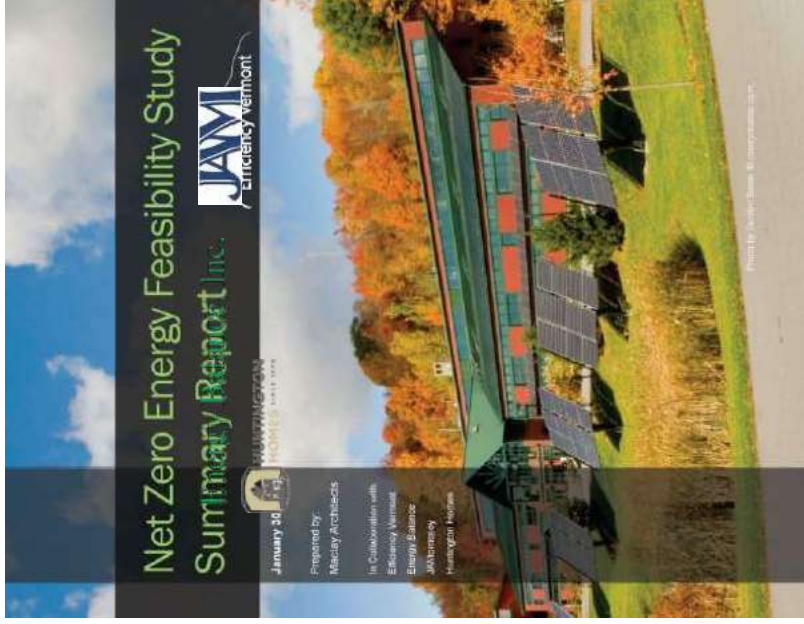
Usually Photovoltaics  
(sized for annual load)

# Why Net Zero?



# Best Investment Today

- Envelope + ROI
- Heat Pumps + ROI
- Renewables + ROI
- \$5-\$20/sf Capital Cost
- 3-10% of Construction Cost
- Solar Financing



# Financial Analysis Methodology

## INPUTS

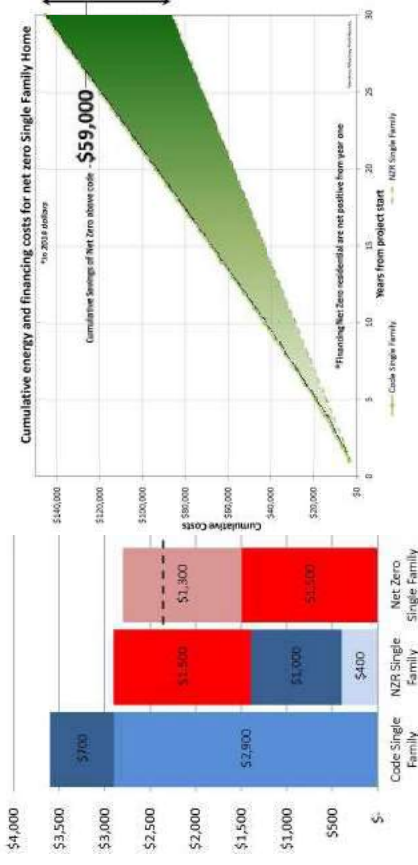
- Energy Consumption
- Increased Capital Costs for Efficiency
- Capital Cost for PV
- Financing Assumptions

	Code [2]		Net Zero Ready		% energy savings above code
SF	(kBTU/sf-yr)	(kWh/sq. m-yr)	(kBTU/sf-yr)	(kWh/sq. m-yr)	
27,000	49	156	17	54	65%



## OUTCOMES

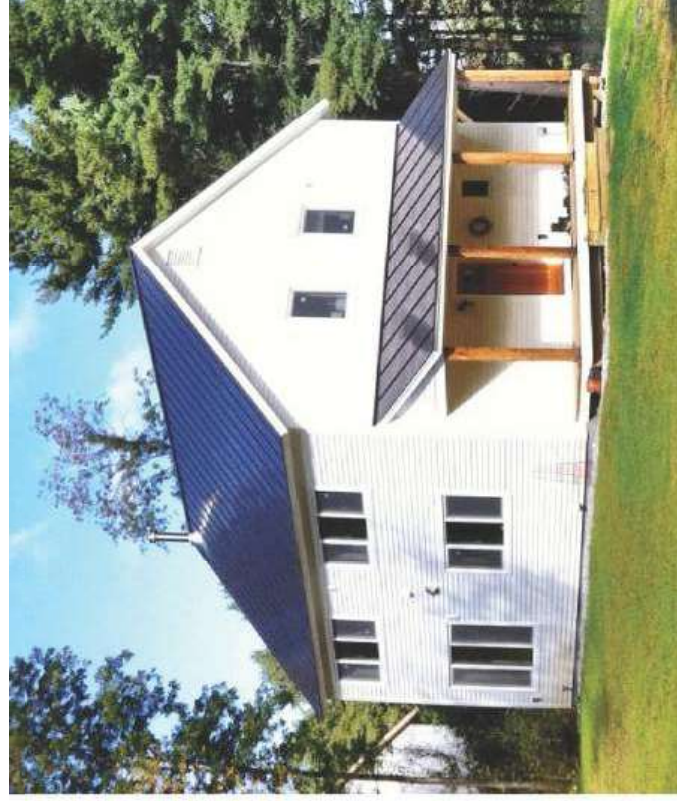
- Capital and operating costs
- Cash Flow



# Single Family Home

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- 1,600 sf
- \$16/sf additional construction costs
- \$14/sf additional solar costs



# Financial Analysis – Energy Consumption

## INPUTS: Energy Model

CODE	
Heat	19,826
Hot Water	5,000
Cooling	--
Lighting	585
Other Elec	3,878
<b>Total</b>	<b>29,289</b>

NET ZERO READY	
Heat	2,406
Hot Water	2,667
Cooling	--
Lighting	585
Other Elec	3,953
<b>Total</b>	<b>9,611</b>

**% ENERGY SAVINGS ABOVE CODE 67%**

Energy Usage, kWh/yr

# Financial Analysis—Increased Net Zero Ready Cost

## Residential Capital Costs

### SINGLE FAMILY

- INPUTS**
- Capital costs for Net Zero over Code

Building Component	Code Single Family	NZR Single Family	Added Cost	Category Added Cost	
Envelope	Windows	Double-glazed windows; U=0.32	\$ 6,792		
	Air/Vapor Barrier	Air infiltration of 0.5 cfm50/sf above grade surface area	\$ 2,172		
	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	\$ 6,176	\$ 25,724
		Rim insulation R21	Rim insulation R42	\$ 696	
		Walls: R-25	Walls: R-40	\$ 8,064	
		Attic R-49	Attic R-60	\$ 1,824	
	Ventilation	Rate: (# BR's + 1 ) *25 cfm, exhaust only	Rate: (# BR's + 1 ) *25 cfm, heat recovery ducted	\$ 3,800	
		From boiler	ASHP with a net COP of 1.5 [1]	\$ 2,600	\$ 500
	Domestic Hot Water	propane 85% sealed combustion boiler	ASHP, annual heat COP 2.3	\$ (5,900)	
	PV	Solar PV	7.7 kW system	\$ 23,332	\$ 23,332

<b>Total Added Cost without PV</b>	<b>\$ 26,000</b>
<b>Total Added Cost Per Square Foot</b>	<b>\$ 16</b>



# Financial Analysis—Increased Net Zero Ready Cost

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	Insulation	Basement Walls, R-15; basement slab none	Basement Walls, R-20; R-20 slab edge; basement slab R-20	\$ 6,176	\$ 25,724
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		Domestic Hot Water	From boiler	\$ 2,600	\$ 500
	Mech	HVAC	propane 85% sealed combustion boiler	\$ (5,900)	
		Solar PV	none	\$ 23,332	\$ 23,332
<b>Total Added Cost without PV</b>			<b>\$ 26,000</b>		
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**Total Added Cost without PV**

**\$ 26,000**

**Total Added Cost Per Square Foot**

**\$ 16**

# Financial Analysis – Financial Assumptions

## INPUTS

- Interest Rate
- Loan Duration
- Fuel Escalation Rate

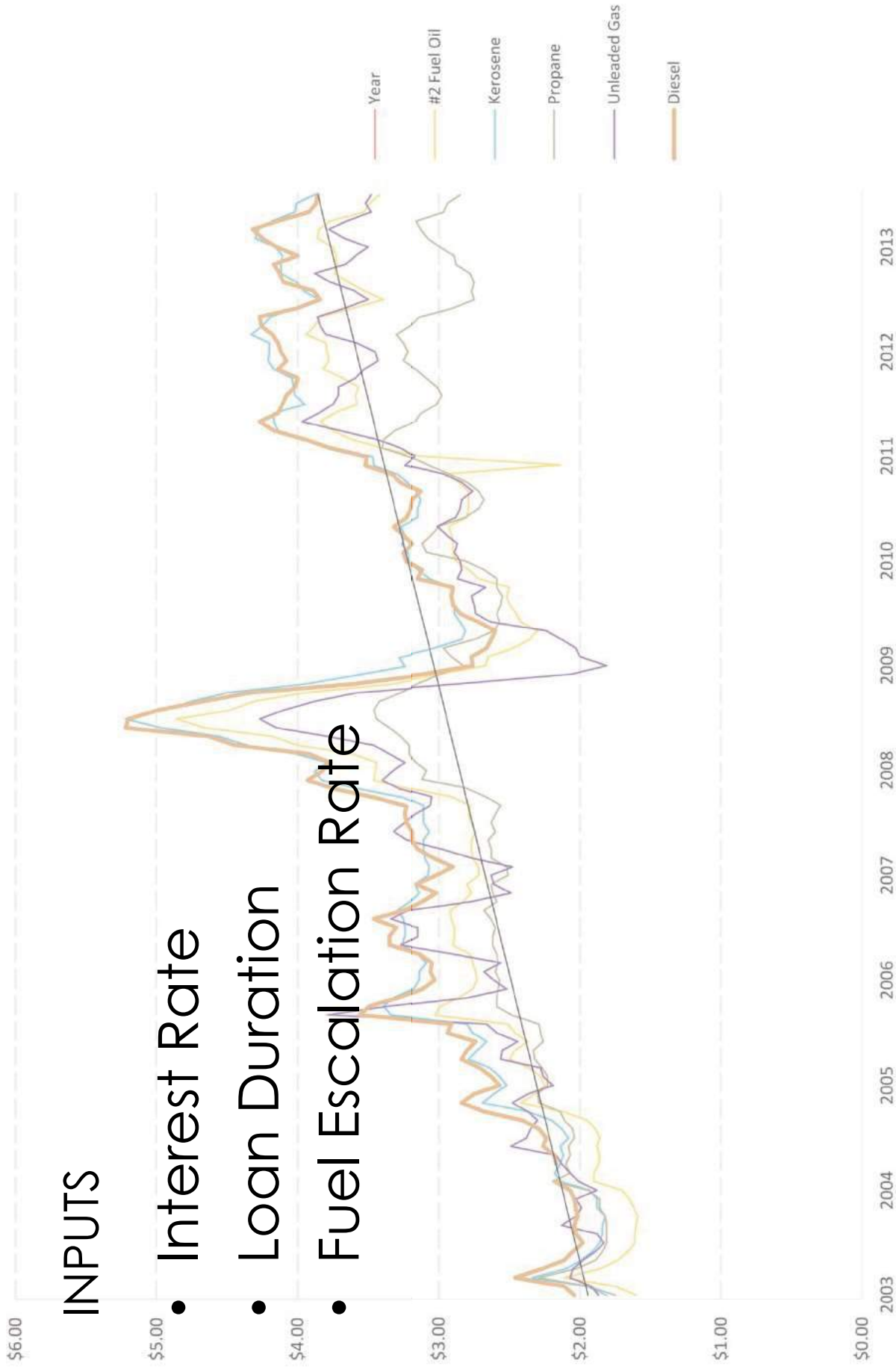
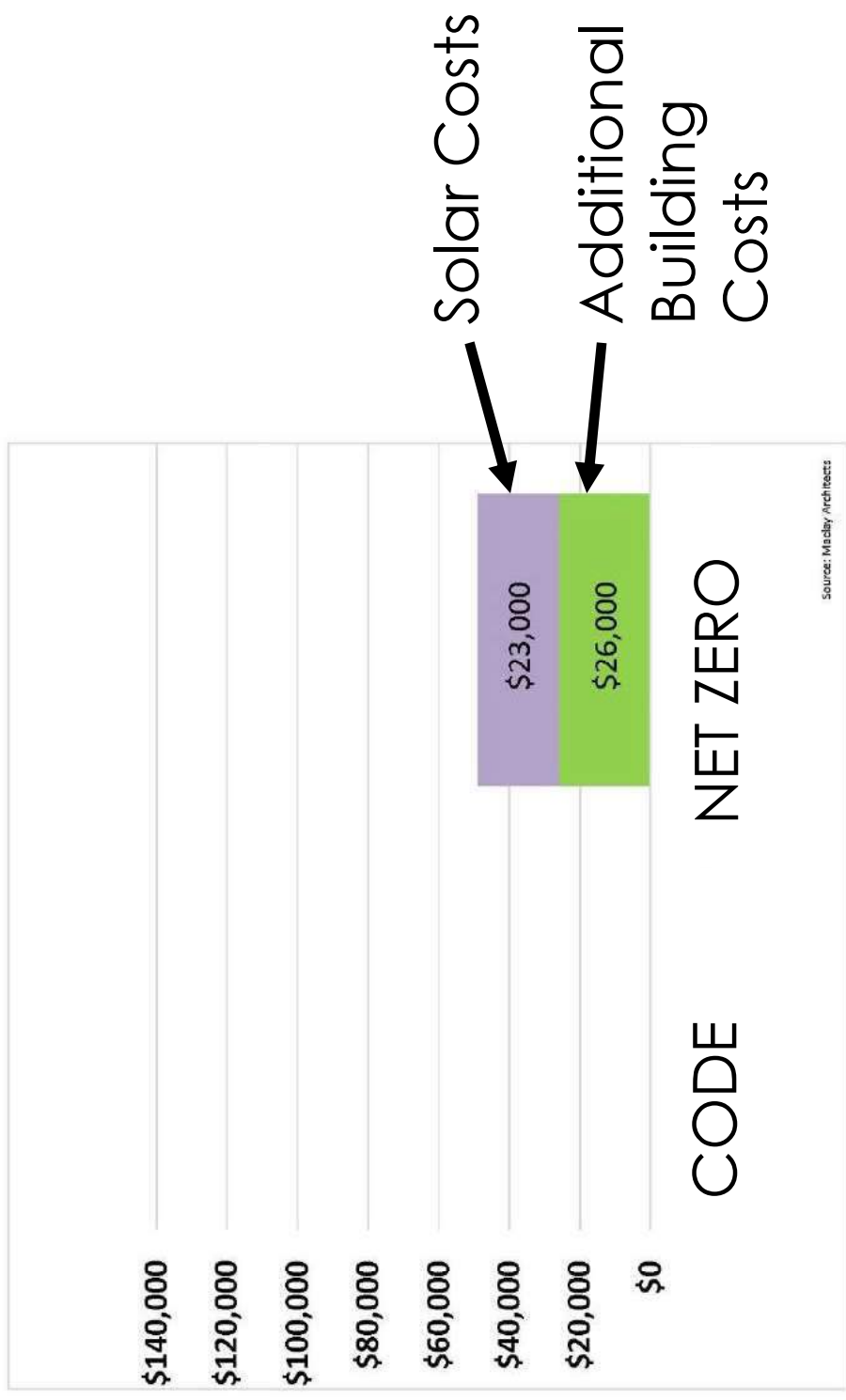
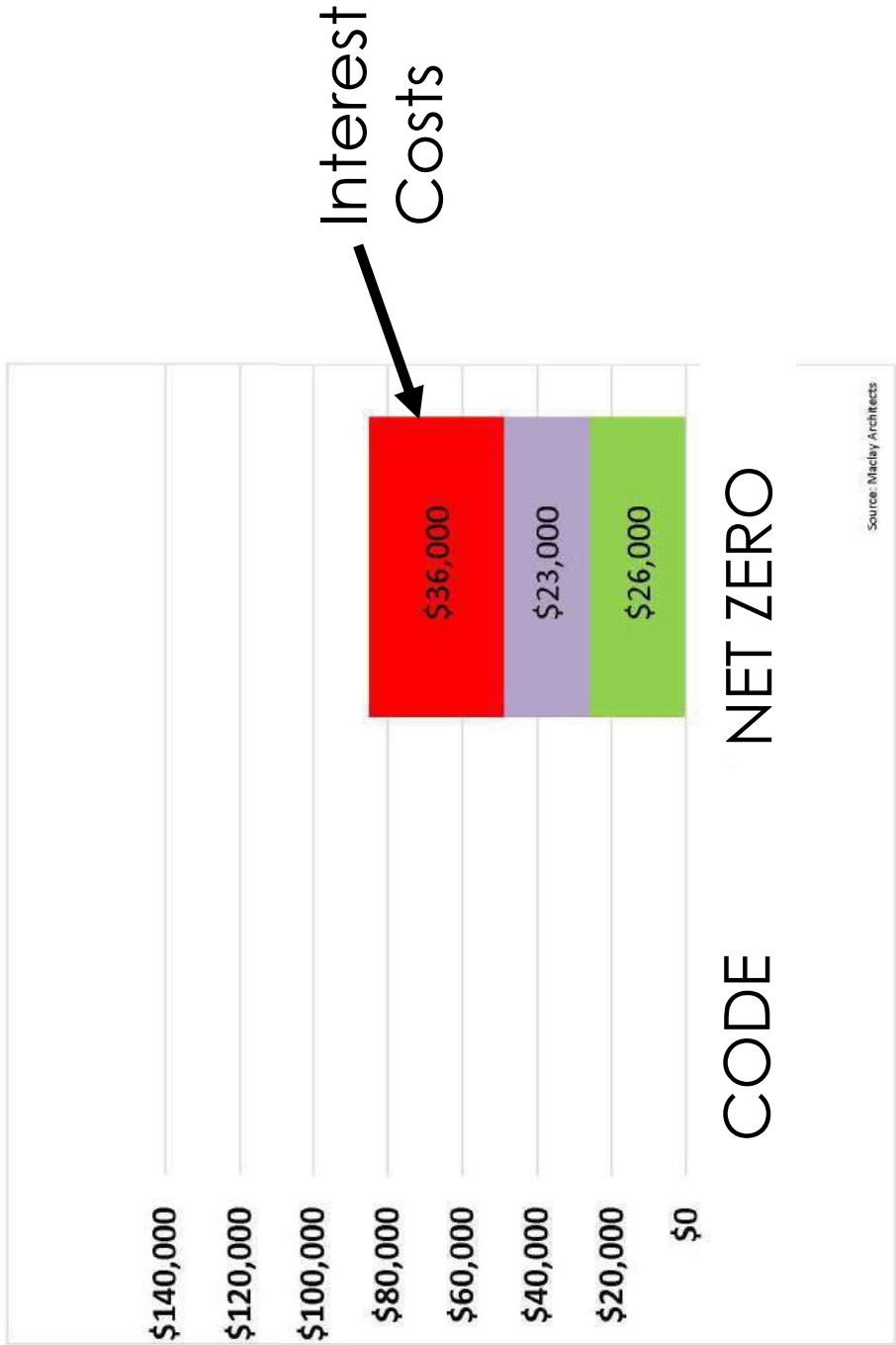


Image: Vermont Fuel Price 2003-2014

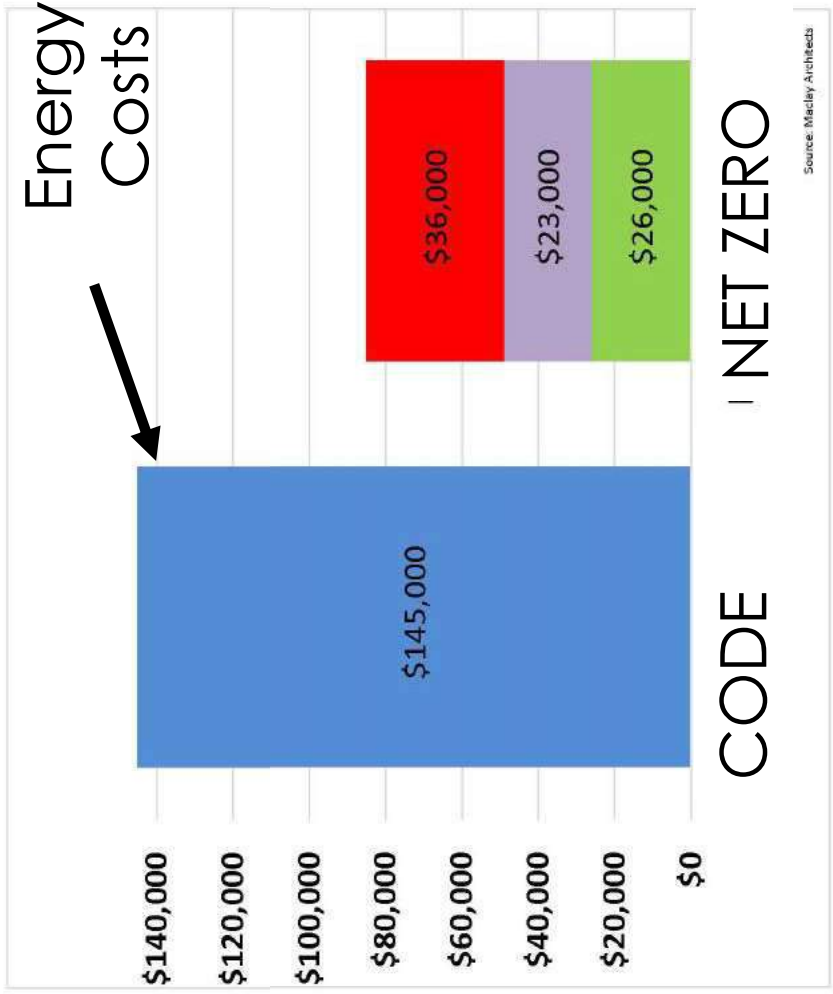
# Single Family 30-year Costs



# Single Family 30-year Costs



# Single Family 30-year Costs



Source: Masley Architects