



# Shifting the Public Sector to Zero Energy

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CMTA Engineers  
November 15, 2017

# Session Objectives

## Learning Objectives:

1. How are Public Sector projects Shifting to Zero Energy.
2. Lessons Learned from 10 years of Zero Energy Projects.
3. Cost shifting techniques to make Zero Energy projects affordable.
4. Proactive Energy Tracking through simple techniques for energy consumption and energy production reporting.
5. How to get Zero Energy for FREE!

# If I was in the Audience

## What would I want as takeaways:

- Give strong examples of how past and present ZE Buildings became a reality.
- Give successes and failures.
  - Lessons learned with solutions
- Give performance results, be transparent.



# Zero Energy Projects (2007-2017)



Zero Energy Project	Sq Ft
Richardsville Elementary School	72,285
Turkey Foot Middle School	133,359
Locust Trace AgriScience Farm	70,100
Lenawee – Cntr Sustain Futures	8,743
Discovery Elementary	98,500
Lee Elementary	95,633
Cincinnati Police Station	38,500
Wilde Lake Middle School	106,221
Corvallis Toyota Dealership	34,868
Graceland Elementary School	78,250
Holabird Elementary School	78,250
Fleet Elem School	104,500
Lubber Run Community Center	52,000
Thaden Campus	125,000
Botanica Community Center	10,500
The Reed School	106,405
<b>Total</b>	<b>1,213,114</b>

# Where to start... Data

High Performance Buildings Matrix

Date: 2/20/2017

Project		General			HVAC			Electric			Thermal Envelope			Energy			Awards									
PM	Date Assigned	Code	Name	Year Designed	Year Occupied	Bldg Type	Bldg Size	Occupants	Type	Equipment SF/Connected Ton	Central Plant or Washfield SF/Ton	OA CFM	Connected W/SF	Kitchen W/SF	Lighting W/SF	Mech Btu/sf	Exterior Wall Surface Area Bldg SF	Exr Glazing %	Thermal Eff. vs. 99.1	Natural Gas (CCF)	Electric (KWH)	Modeled or Predicted EUI	EUI	LEED (Y/N)	Energy Star (Y/N)	
Aarvo	11/15/15	DRC11	UofL Rec Center	2011	2013	University Rec Center	128,300	1575	Geothermal	902	356	9.22 cfm/sf	11.06	0	0.84	6.1%	0.77	36.8	--	694	1,619,353	45.1	42.5	Y	N	
Andy	11/15/15	EDC15	Pikeville Data Center	2016	TBD	Data Center	11,422	60	Geothermal	66	--	21		N/A		3.2%	0.65	5.8	52%	TBD	TBD	--	TBD	N	TBD	
Brad	11/15/15	SOB14	State Office Building - Frankfort	2015	2016	Office Building	377,707	1500	Chiller, Boiler, High Performance VAV	630	387	0.11 cfm/sf	9.22	--	0.4	4.0%	0.18	38.0	9%	9,576	2,703,358	27.3	19.6	Y	TBD	
Brian B	11/15/15	BGN08	Boone National Guard									xx cfm/sf								TBD	TBD		TBD	Y	TBD	
Brian B	11/15/15	WEB07	Eschardsville Elem. - Warren County	2008	2010	Elementary School	72,285	500	Geothermal	665	630	17	8.99	--	0.68	3.1%	0.78	--	--	--	--	17.6	17	N	Y	
Brian T	11/15/15	NBC06	Norton - Brownsboro Hospital	2006	2008	Hospital	274,543	--	Conventional High Performance	213	150	0.31 cfm/sf	24.3	N/A	1	7.4%	--	--	--	316,840	5,373,600	N/A	182.2	EB	Y	
Brian T	11/15/15	NHP07	Norton - KCMC	2007	2009	Hospital	62,451	--	Geothermal	284	266	0.22 cfm/sf	31.4	N/A	0.86	9.8%	0.51	16.0	160%	N/A	2,224,500	96.1	113.1	Y	Y	
Brice	11/15/15	DES12	Barkley Elementary, Fort Campbell, KY	2012	2012	Elementary School	142,000	812	Geothermal	435	657	34.5	12.64	1.38	0.6	5.1%	0.29	22.4	27%	TBD	TBD		TBD	Y	Y	
Bruce	11/15/15	MAJ14	Major Hospital	2014	2016	Hospital	284,000	--	Conventional High Performance	xx cfm/sf										TBD	TBD		TBD	N	Y	
Carolyn	11/15/15	NRC11	NKU Rec Center	2013	2015	University Rec Center	147,142	1506	Geothermal	639	1037	0.175 cfm/sf	13.35	--	0.67	7.0%	0.17	56.0	9%	TBD	TBD		TBD	Y	N	
Carolyn	11/15/15	STC14	KCTCS - South Central	2015	under construction	Nursing, Technical	72,250	760	Geothermal	522	804	0.245 cfm/sf	9.5	69.5	0.52	3.8%	0.28	37.0	--	TBD	TBD		TBD	Y	N	
Chris B	11/15/15	OCR10	Centerfield Elem. - Oldham Co.	2010	2012	Elementary School	60,555	600	W/HP - Boiler/Chilling Tower	380	306	27	--	--	0.83	2.9% + Mezz.	--	--	--	2,798	475,360	--	31.5	N	Y	
Chris K	11/15/15	MCO11	Norton MOB	2012	2014	MOB	113,400	600	Packaged RTU, electric heat	515	--	07 cfm/sf	13.4	16	0.7	6.3%	0.36	25.0	--	N/A	2,239,000	N/A	67.4	N	N	
Chris K	11/15/15	TOB15	Thorton's SSC Office Building	2015	2017	Office Building	88,450	408	Geothermal HP, DOAS, Central	368.5	631.2	25	0.74	0.0%	0.31	0.0%	0.31	70.0	--	TBD	TBD		TBD	N	Y	
Chuck	11/15/15	OMR12	Oldham Co. Middle School - Oldham Co.	2012	2014	Middle School	89,800	900	W/HP - Boiler/Chilling Tower	460.5	391.8	26.4	14.81	4.00	1.01	4.6%	--	0.0	--	2,943	732,265	--	31.2	N	N	
Dave	11/15/15	PCB12	Perry County	2012	2015	Hospital	117,200	852	Geothermal	243	326	0.26 cfm/sf	26.96	1.96	1.28	5.0%	0.30	24.8	--	--	3,418,080	N/A	99.51	N	Y	
Dennis	11/15/15	FKH14	Pt Knox MS/HS Addition	2015	TBD	Middle School	58,345	330	Geothermal HP, DOAS, Central	467	--	29.4	10.2	N/A	0.7	1.8% + Mezz.	0.89	10.0	13%	TBD	TBD		TBD	Y	Y	
Dennis	11/15/15	ONG15	Near Gen HS - Oldham Co.	2016	2018	High School/STEM	75,000	510	W/HP - Boiler/Fluid Cooler	581	225	28.0	0.4	5.1%	0.30	13.6	26%	TBD	TBD		TBD		TBD	N	Y	
Dennis	11/15/15	OSO13	South Oldham Middle School - Oldham Co.	2013	2016	Middle School	83,000	775	W/HP - Boiler/Chilling Tower	641	362	0.175 cfm/sf	0.67	Mezz.	0.21	5.5	23%	TBD	TBD		TBD	27	TBD	N	Y	
Doug	11/15/15	NHS08	Thomas Nelson HS - Nelson Co.	2009	2012	High School	144,000	1,000	Geothermal Distributive	425	537	26.3	11.73	75.5	1	6.0%	0.27	16.0	--	--	972,527	35	22.7	N	Y	
Doug	11/15/15		Cox's Creek Elem. - Nelson Co.			Elementary School																				
Doug	11/15/15		Northeast Early Learning Center - Shelby Co.			Elementary School																				
Doug	11/15/15		Ramsay Middle School - JCPS	2006	2006	Middle School	129,000	900	4-Pipe VAV	473	430	27.2	8.8	--	1	3.5%	0.89	--	--							
Doug	11/15/15		Southside Elementary - Shelby Co.			Elementary School																				
Doug	11/15/15		IT Health Pavilion									xx cfm/sf														
Doug	11/15/15		WKU Health Science Center									xx cfm/sf														
Oreg	11/15/15	ADH14	Aeadia ETC - Chandler Az.	2014	2015	Psych Hospital	43,342	242	Packaged RTU, gas heat			xx cfm/sf								6,768	547,120					
Jeremy	11/15/15	USB11	UL Soccer Stadium	2013	2014	Athletic Complex	25,800	--	Boiler/Chiller/VAV	355	430	0.28 cfm/sf	35.6	53.25	0.64	4.0%	1.24	11.9	--	10,773	895,200		161	Y	N	
Jess	11/15/15	--	Capwood Elem. - Kenton Co.	2004	2004	Elementary School	79,350	625	Geothermal	306	367	31.7	10.7	--	1.22	6.3%	1.13	--	--	1,958	678,120		40.9 sports lighting	31.6	N	Y
Jess	11/15/15	--	Crestwood Elem. - Oldham Co.	2007	2007	Elementary School	86,422	700	Geothermal HP w/HP/CA	380	379	25.8	12.29	--	1.06	Mezz.	1.33	--	--	1,537	724,080		30.4	N	Y	
Jess	11/15/15	--	Hannoy Elem. - Oldham Co.	2003	2003	Elementary School	72,330	625	Geothermal	366	446	22.2	11.7	--	1.2	Mezz.	0.87	--	--	1,553	574,800		29.3	N	Y	
Jess	11/15/15	--	Kenwood Elem. - Oldham Co.	2003	2003	Elementary School	75,436	625	Geothermal	377	425	26.2	16.3	--	1.35	Mezz.	1.56	--	--	1,193	647,200		30.9	N	Y	
Jess	11/15/15	--	Loant Grove Elem. - Oldham Co.	2007	2007	Elementary School	84,669	700	Geothermal Distributive	321	384	28.8	10.32	--	1.03	Mezz.	1.28	--	--	2,475	616,980		27.8	N	Y	
Jess	11/15/15	--	Turkey Foot Middle - Kenton Co.	2008	2008	Middle School	134,814	1,000	Geothermal	567	661	16.4	10.95	--	0.73	5.0%	0.98	--	--	2,047	645,981		18.0	N	Y	
John	11/15/15	CTD12	Toyota of Corvallis	2014	ph1- 2015 ph2- 2016	Auto Dealership	34,868	120	Geothermal W/HP Distrib	1345	1806	14.9	11.08	--	0.64	Mezz.				TBD	TBD		26	TBD	Y	TBD
John	11/15/15	UCH15	UC - Health Sciences	2018		Higher Education						xx cfm/sf								TBD	TBD		TBD	Y	TBD	



# Where to start... Data

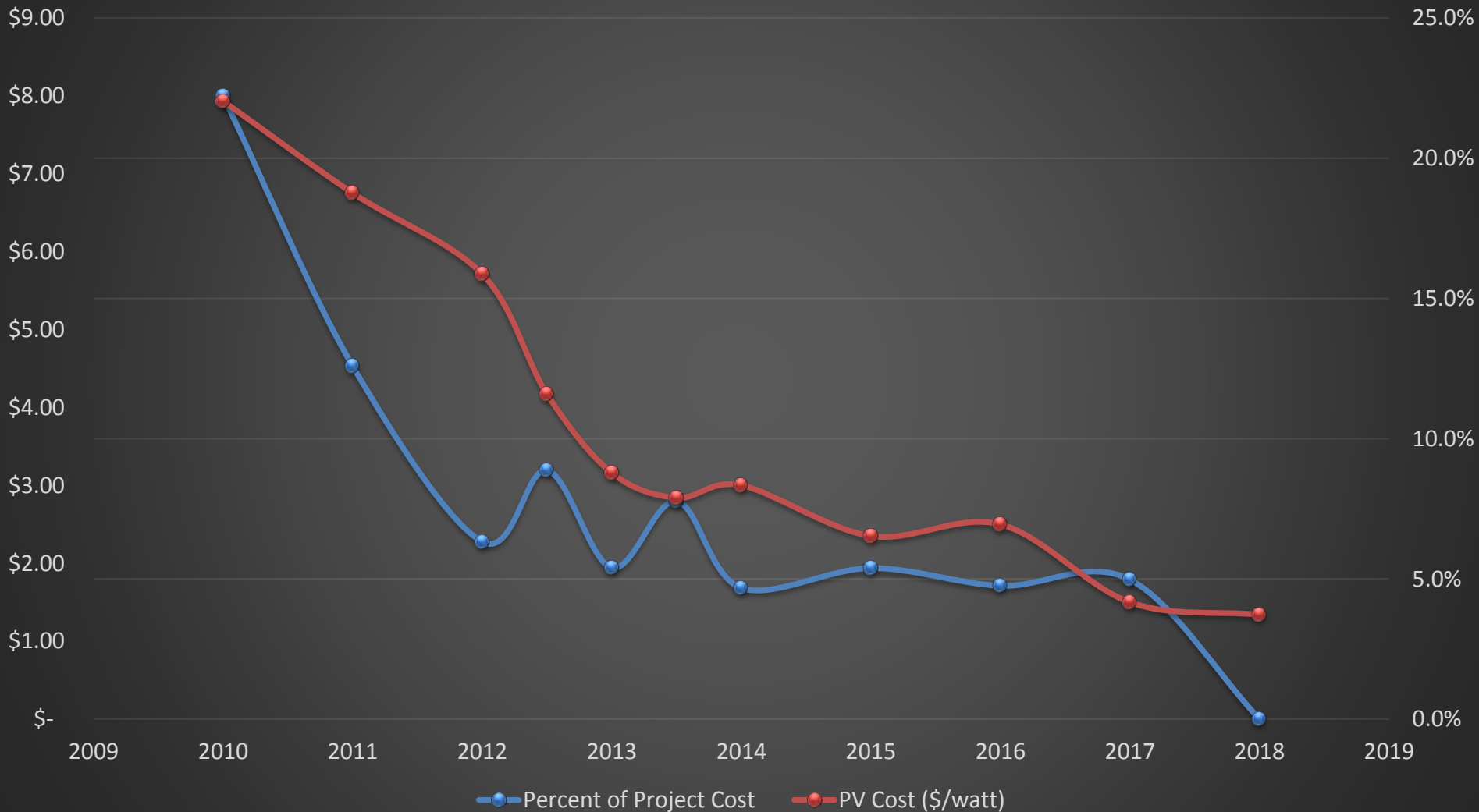
## 1st Zero Energy Educational Building in the Nation:

- Designed in 2007
- Opened 2010
- 72,285sf
- Cost/sf = \$172/sf
- Budget = \$12.5M
- 349kW PV Array
- \$7.93 \$/Watt
- 22.2%



# How Much Does Zero Energy Truly Cost?

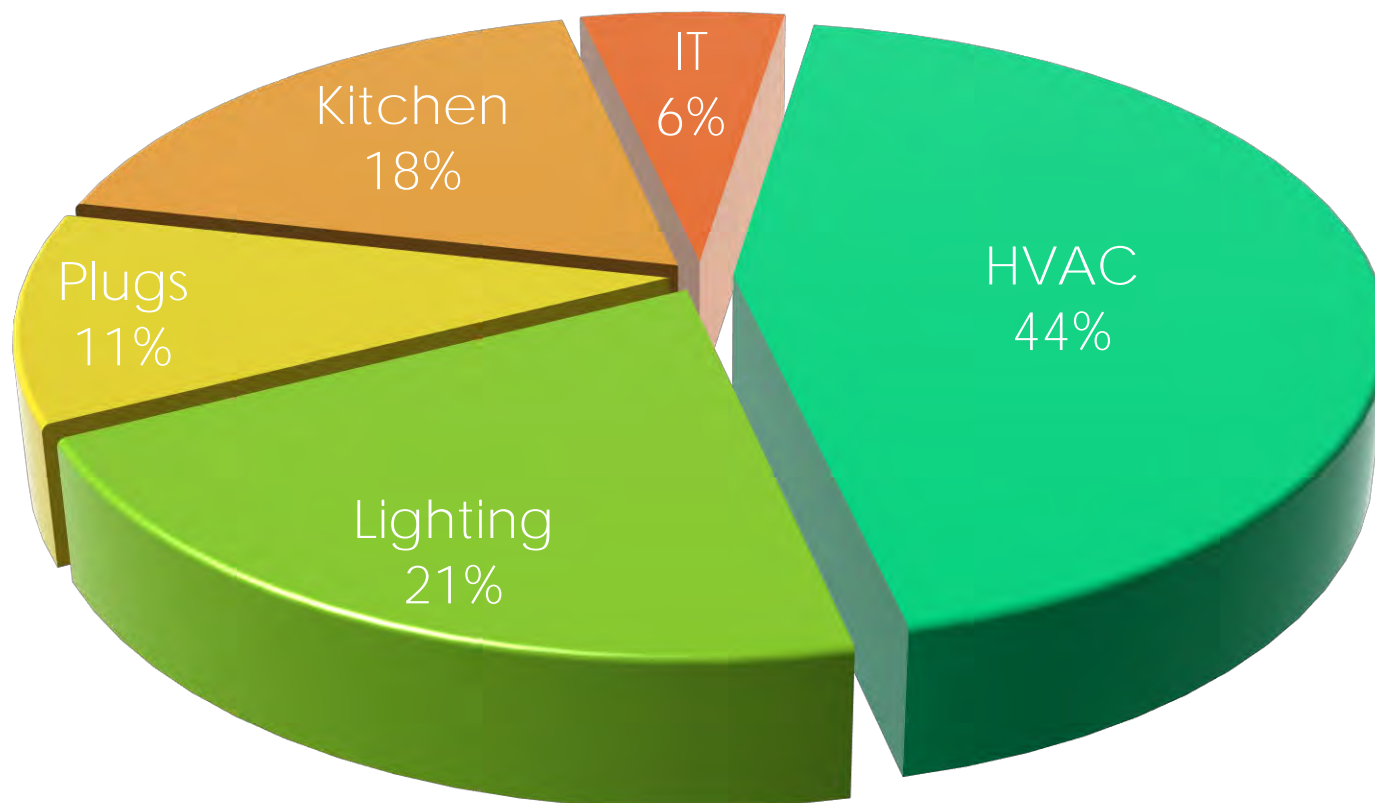
## Percent of Project Cost and PV Cost to Achieve Zero Energy



In Ten Years: From 22% to Less Than < 5%

Energy Exchange: Connect • Collaborate • Conserve

## Recent Zero Energy Project



### Successes:

- Process NOT a Product
- ZE Parallel to Design
- Set Goal as a Project Priority



# Lessons Learned from Successes & Failures

Discovery Elementary School  
Arlington, Virginia

AIA COTE Award  
A4LE National Award  
Green Schools Award



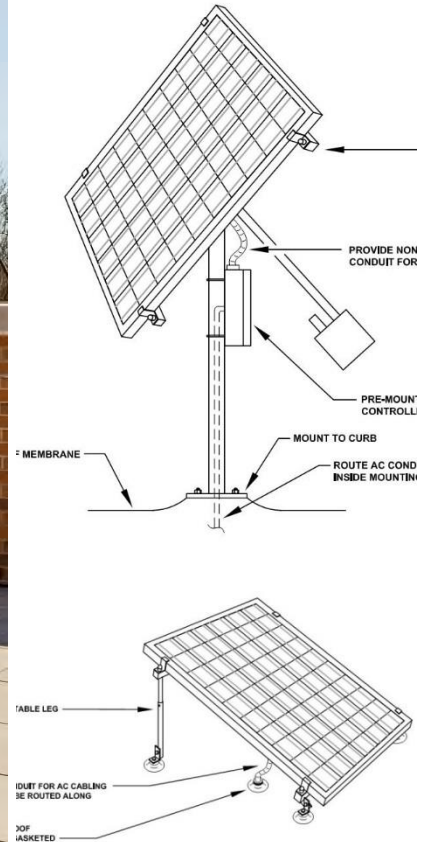
VMDO



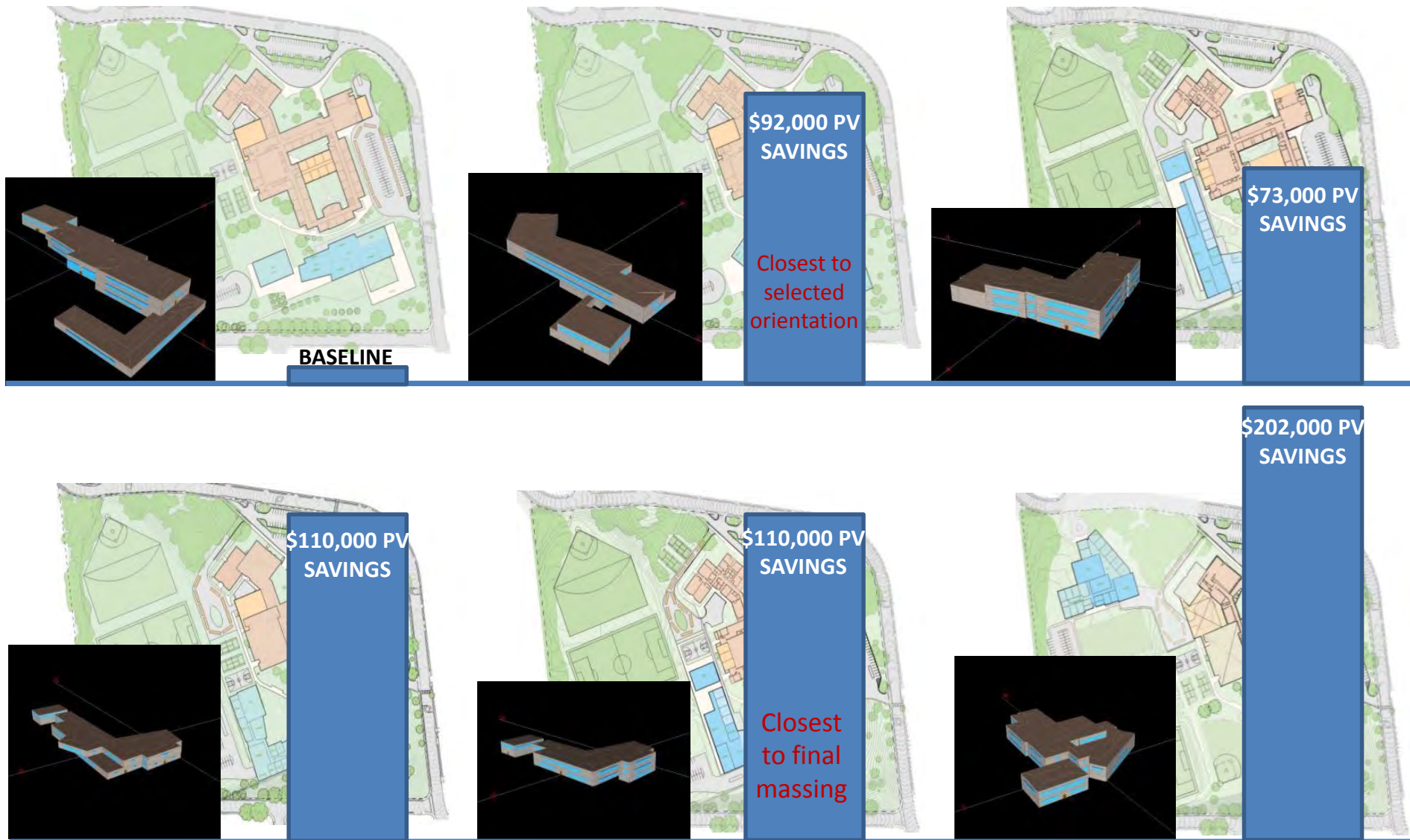
# Lessons Learned from Successes & Failures

## Successes:

- Connection to “WHY” of Bldg
- Educational Integration



# Lessons Learned from Successes & Failures





# Lessons Learned from Successes & Failures



Failures:  
Triple Pane Window vs Solar PV

VMDO



# Lessons Learned from Successes & Failures



Successes:  
Connection to “WHY” of Bldg  
- Educational Integration  
Process ZE Parallel to Design

VMDO

# Energy tie to “Why of the Building”

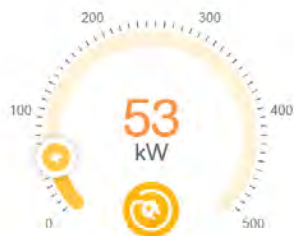
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HOME

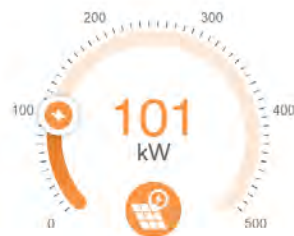
4:11 PM | TUESDAY, AUGUST 15 2017

☀️ 73°/79°



TODAY'S HIGH 102 kW  
TODAY'S LOW 0 kW

LIVE POWER CONSUMPTION



TODAY'S HIGH 175 kW  
TODAY'S LOW 0 kW

LIVE POWER PRODUCTION



TODAY'S HIGH 113 kW  
TODAY'S LOW -93 kW

LIVE NET POWER



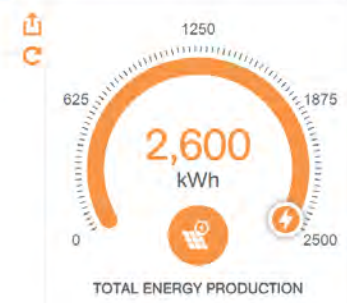
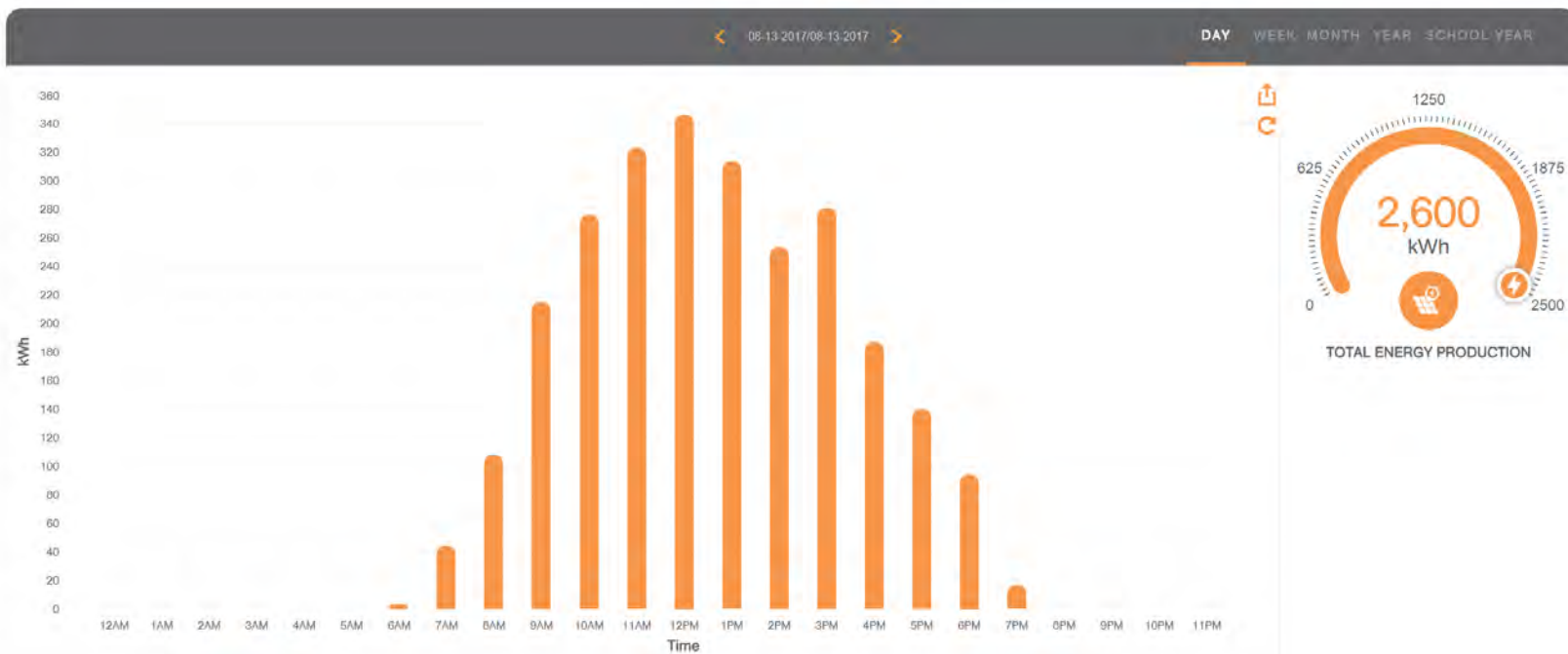
# Energy tie to “Why of the Building”



## ENERGY PRODUCTION

4:11 PM | TUESDAY, AUGUST 15 2017

73°/79°



**?**  
WHAT DOES THIS DATA MEAN?

This shows the total amount of energy that the rooftop solar panels produced for the selected time frame. The panels can produce energy even in very low light, but are most productive in direct sunlight.

**↗**  
PERCENT CHANGE  
(from previous period)

**65.6%**

**=**  
EQUIVALENTS

Typical Houses	87
Typical 60 watt LED Bulbs	12,037
Typical Smartphones charged	273,684

# Lessons Learned from Successes & Failures

## Wilde Lake Middle School Howard County, Maryland

### Maryland Energy Alliance Program for ZE Buildings:

Geothermal HVAC

LED Lighting

Demand control ventilation

Lighting controls

Energy efficient kitchen

106,000 SF

435 kW Solar PV

Opened January 2017





# Lessons Learned from Successes & Failures

## Wilde Lake Middle School Howard County, Maryland

Previous EUI of 65

- Full Paradigm Shifts in Process

Energy Goal of 23EUI

- Performing at 14EUI





# ENERGY TRACKING FORM



## PROJECT INFORMATION:

Project Name: Wilde Lake Middle

Facility GSF: 106,221 sqft

Monitoring Start Date: 2/1/2017

## UTILITY BILL INPUT:

Month	Total Cost (\$)	Electrical Usage (kWh)	Gas Usage (ccf)	Electrical Energy (kBtu)	Gas Energy (kBtu)	Total Energy (kBtu)	Actual (kBtu/sf)
Feb-17	\$1,417	44,020		150,197	0	150,197	1.4
Mar-17	\$1,373	44,902		153,207	0	153,207	1.4
Apr-17	\$966	29,832		101,787	0	101,787	1.0
May-17	\$525	35,360		120,648	0	120,648	1.1
Jun-17	\$409	25,861		88,237	0	88,237	0.8
Jul-17	\$409	19,987		68,196	0	68,196	0.6
Aug-17	\$617	32,563		111,104	0	111,104	1.0
Sep-17	\$749	32,985		112,545	0	112,545	1.1
Oct-17				0	0	0	0.0
Nov-17				0	0	0	0.0
Dec-17				0	0	0	0.0
Jan-18				0	0	0	0.0
<b>Totals</b>	<b>\$6,465</b>	<b>265,510</b>	<b>0</b>	<b>905,921</b>	<b>0</b>	<b>905,921</b>	<b>8.5</b>

Proj. EUI= 13.7

# Energy Tracking

## ENERGY MODEL INPUT [CONFIDENTIAL]: (omit if not available)

Month	Total Cost (\$)	Electrical Usage (kWh)	Gas Usage (ccf)	Electrical Energy (kBtu)	Gas Energy (kBtu)	Total Energy (kBtu)	Designed (kBtu/sf)
Feb-17		56,679		193,389	0	193,389	1.8
Mar-17		58,139		198,370	0	198,370	1.9
Apr-17		50,742		173,132	0	173,132	1.6
May-17		60,123		205,140	0	205,140	1.9
Jun-17		65,421		223,216	0	223,216	2.1
Jul-17		24,657		84,130	0	84,130	0.8
Aug-17		19,123		65,248	0	65,248	0.6
Sep-17		58,764		200,503	0	200,503	1.9
Oct-17		55,104		188,015	0	188,015	1.8
Nov-17		52,358		178,645	0	178,645	1.7
Dec-17		60,606		206,788	0	206,788	1.9
Jan-18		71,549		244,125	0	244,125	2.3
<b>Totals</b>	<b>\$0</b>	<b>633,265</b>	<b>0</b>	<b>2,160,700</b>	<b>0</b>	<b>2,160,700</b>	<b>20.3</b>

EUI= 20.3

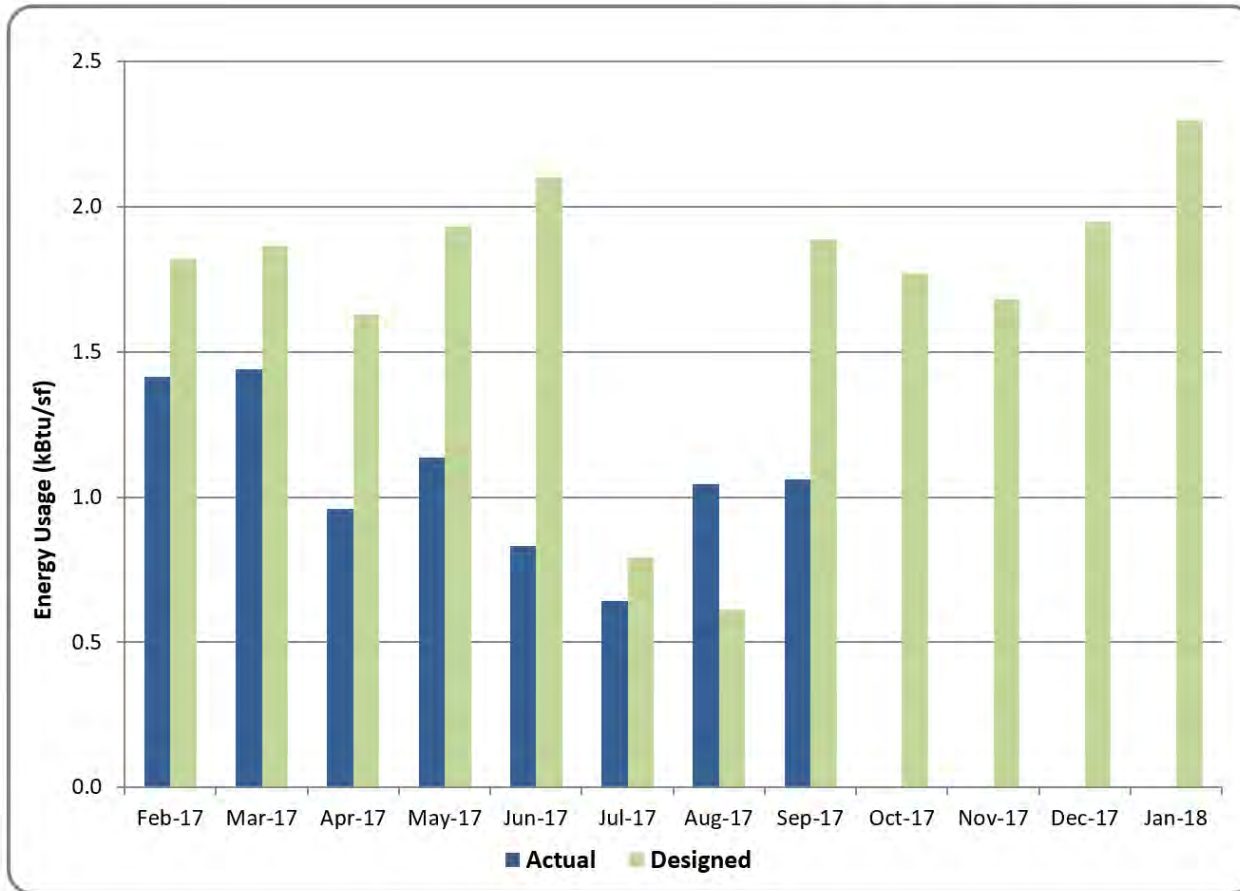
## PHOTOVOLTAICS INPUT: (omit if not applicable)

Month	PVWatts Expected (kWh)	Actual Generation (kWh)	PV Δ (kWh)	Total Usage (kWh)	Facility Δ (kWh)	Net Zero Tracking
Feb-17	51,545	59,158	7,613	44,020	15,138	15,138
Mar-17	68,907	69,667	760	44,902	24,765	39,903
Apr-17	78,339	73,676	-4,663	29,832	43,844	83,747
May-17	86,511	87,593	1,082	35,360	52,233	135,980
Jun-17	89,699	98,738	9,039	25,861	72,877	208,856
Jul-17	89,370	109,407	20,037	19,987	89,420	298,276
Aug-17	79,366	87,538	8,172	32,563	54,976	353,252
Sep-17	66,272	62,364	-3,908	32,985	29,379	382,631
Oct-17	60,628		-60,628	0	0	382,631
Nov-17	41,030		-41,030	0	0	382,631
Dec-17	33,727		-33,727	0	0	382,631
Jan-18	41,646		-41,646	0	0	382,631
<b>Totals</b>	<b>787,040</b>	<b>648,141</b>	<b>-138,899</b>	<b>265,510</b>	<b>382,631</b>	

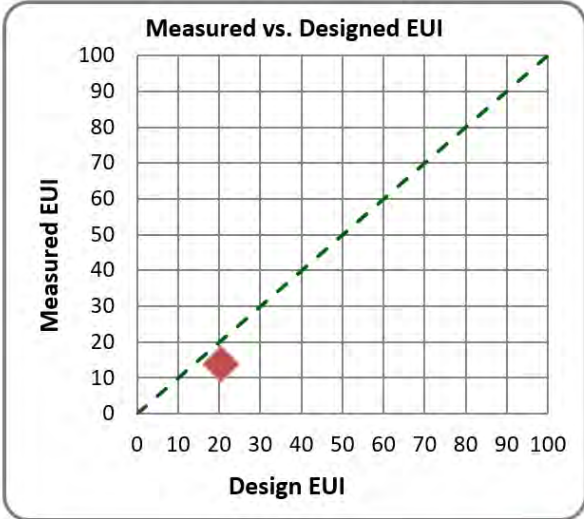
# Energy Tracking

## Wilde Lake Middle

Monthly Energy Consumption (kBtu/sf)



**Designed EUI= 20.3**  
**YTD kBtu/sf= 8.5**  
**Projected EUI= 13.7**

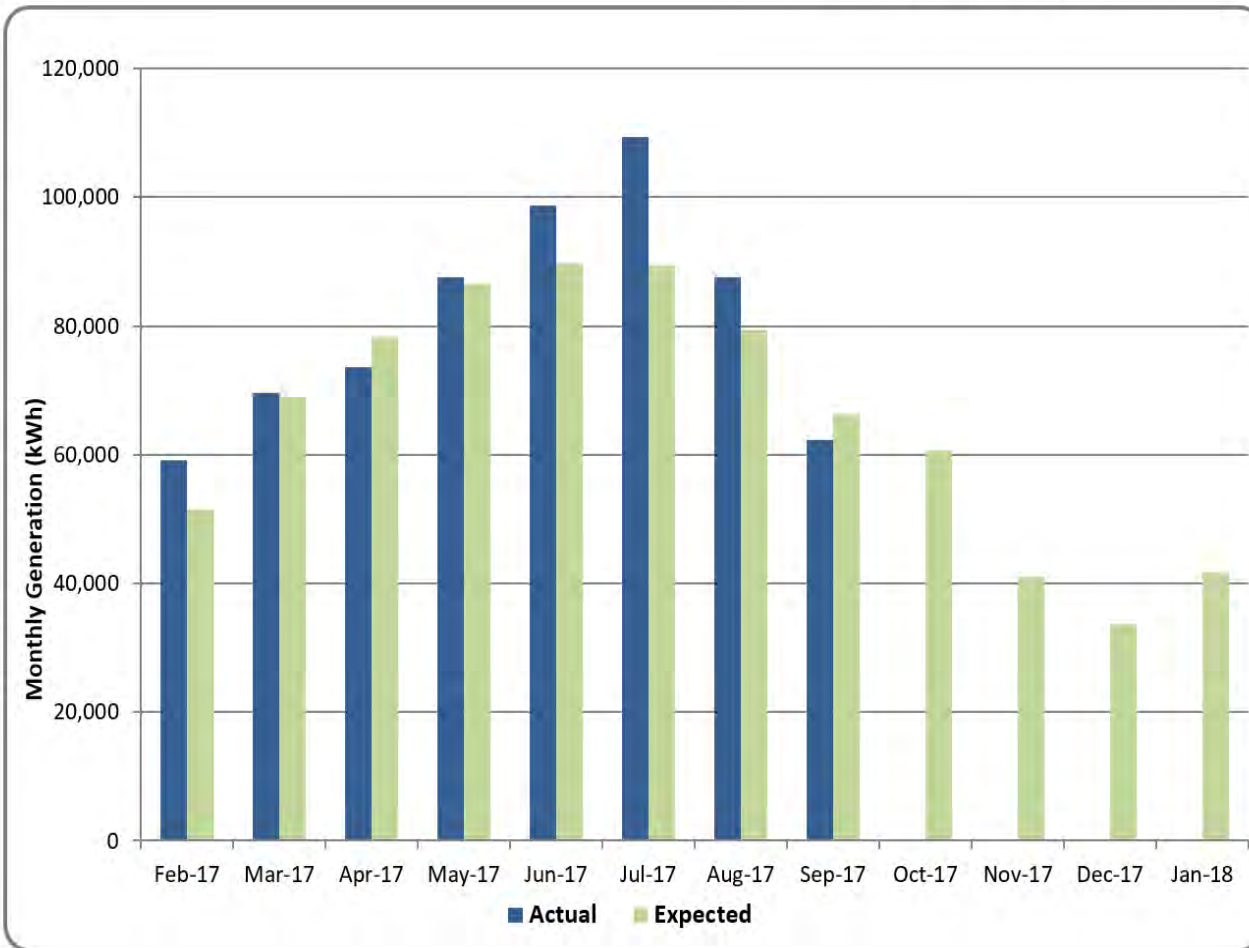




# Energy Tracking

## Wilde Lake Middle

Monthly Energy Production (kWh)



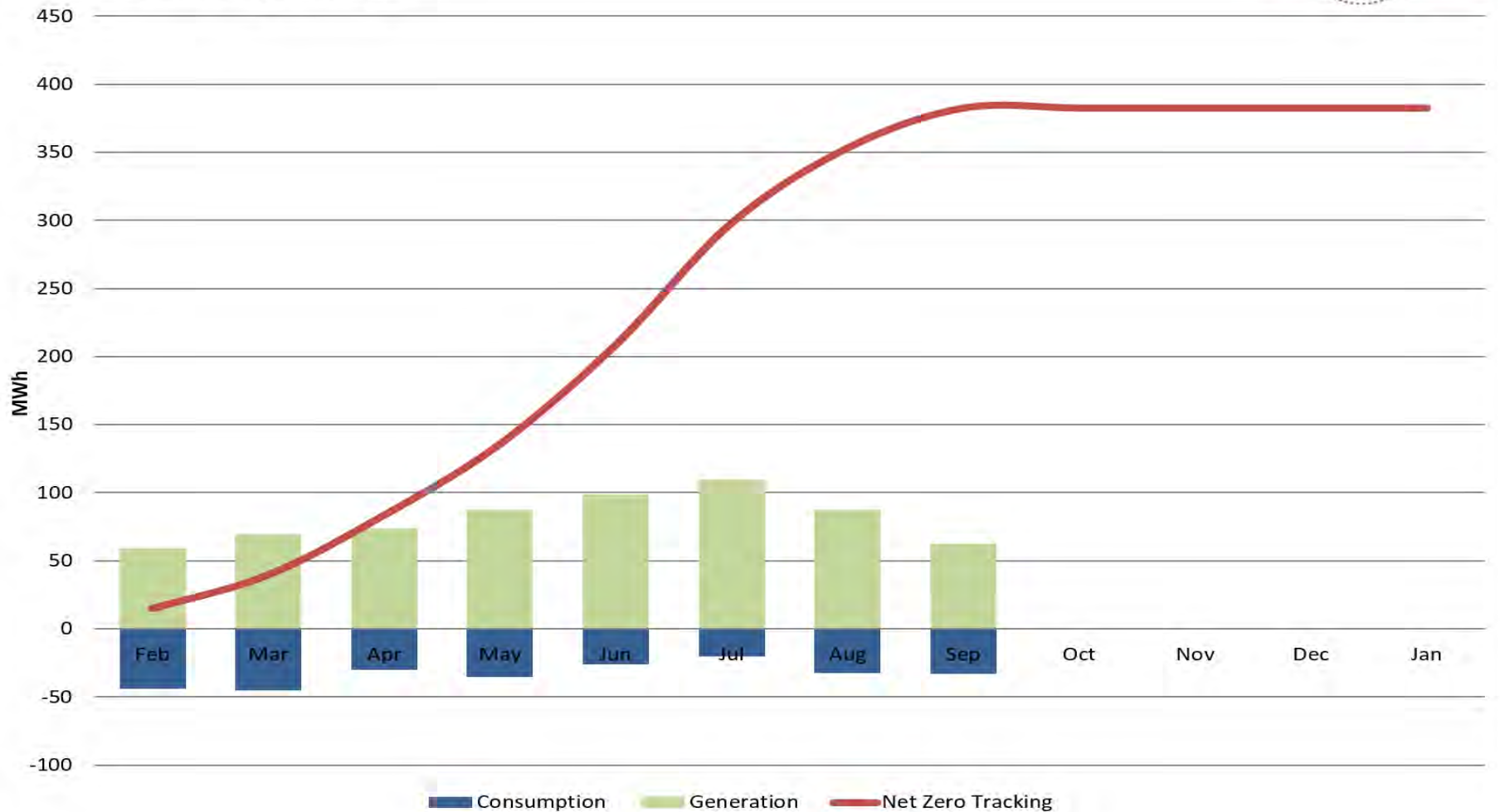
**Expected Production= 787,040**  
**YTD Production= 648,141**  
**Projected Production= 836,238**  
**Projected Production= 106.3%**



# Energy Tracking

## Wilde Lake Middle

Net Zero Energy Tracking





# Zero Energy as a Betterment

City Government Police Station

ON Schedule and under Budget

1st Zero Energy and LEED Platinum Police Station on the Planet

True IPD in most all aspects of Design and Construction



Cincinnati, OH District 3 Police Station



# Zero Energy as a Betterment

- ASHRAE Technology Award – First Place – Commercial Buildings
- 39,000 ft<sup>2</sup>, \$14,349,000, ~161 occupants
- LEED Silver was original goal
- LEED Platinum, Zero Energy was Accomplished
- Under Budget

Cincinnati, OH District 3 Police Station



# Zero Energy as a Betterment

## Design/Build Pursuit:

- Two Stage Selection - Owner Values:
  - Energy Efficiency
  - Maintenance & Operations Cost
  - First Cost

- IPD Delivery was Primary to Pursuit
- Integrated Team led to Zero Energy Goal
- Under Budget and Zero Energy led to Project Award

# Zero Energy as a Betterment

## Building Envelope:

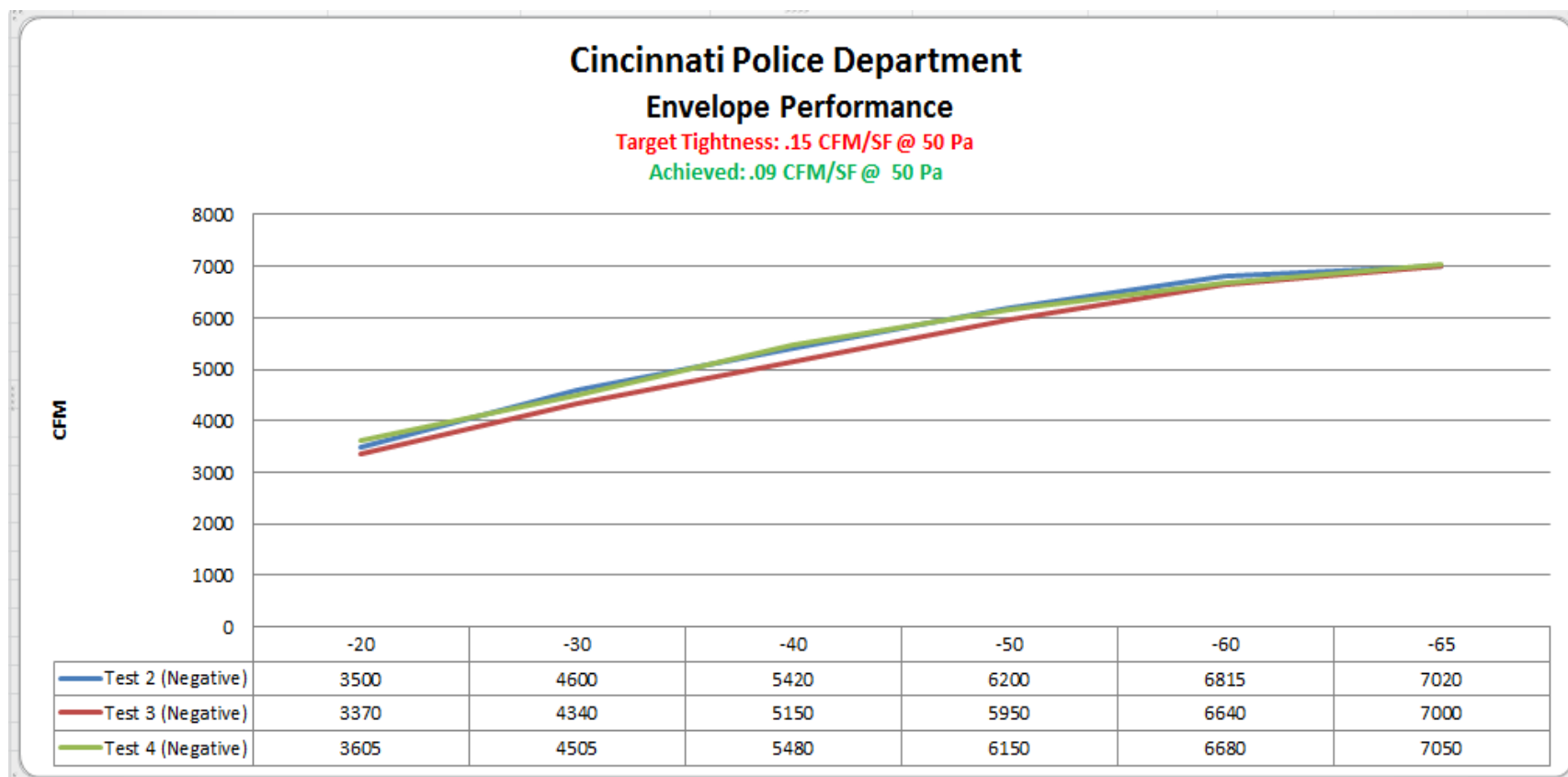
- A/E: Ecotech and EQuest
- Enhanced Thermal Envelope
  - R22 Wall (Tiltup / Polystyrene & Sprayfoam)
  - Improved Air Infiltration Metric
  - Increased HVAC SF/Ton
  - Decreased First Cost



# Zero Energy as a Betterment

## Building Pressurization Test:

- PreDesign / PreConstruction / PostConstruction
- 85% reduction in Air Infiltration





# Zero Energy as a Betterment

## HVAC / Exhaust:

- Life Cycle Cost led to Geothermal DOAS System
- Forty 400' Deep Wells
- +500 SF/Ton (exhaust heavy)
- 49% better than code (All LEED EAc1 Points - Platinum)



# Zero Energy as a Betterment

## Lighting and Daylighting:

- Intentional Passive Solar Design
- Reflective finishes, 100% LED Lighting.
- 0.54 W/sf ( >50% Reduction in LPD).
- Bi-level Site Lighting with Motion Sensor activation.
- Crime Prevention Through Environmental Design (CPTED)





# Zero Energy as a Betterment

## Energy Use & Generation:

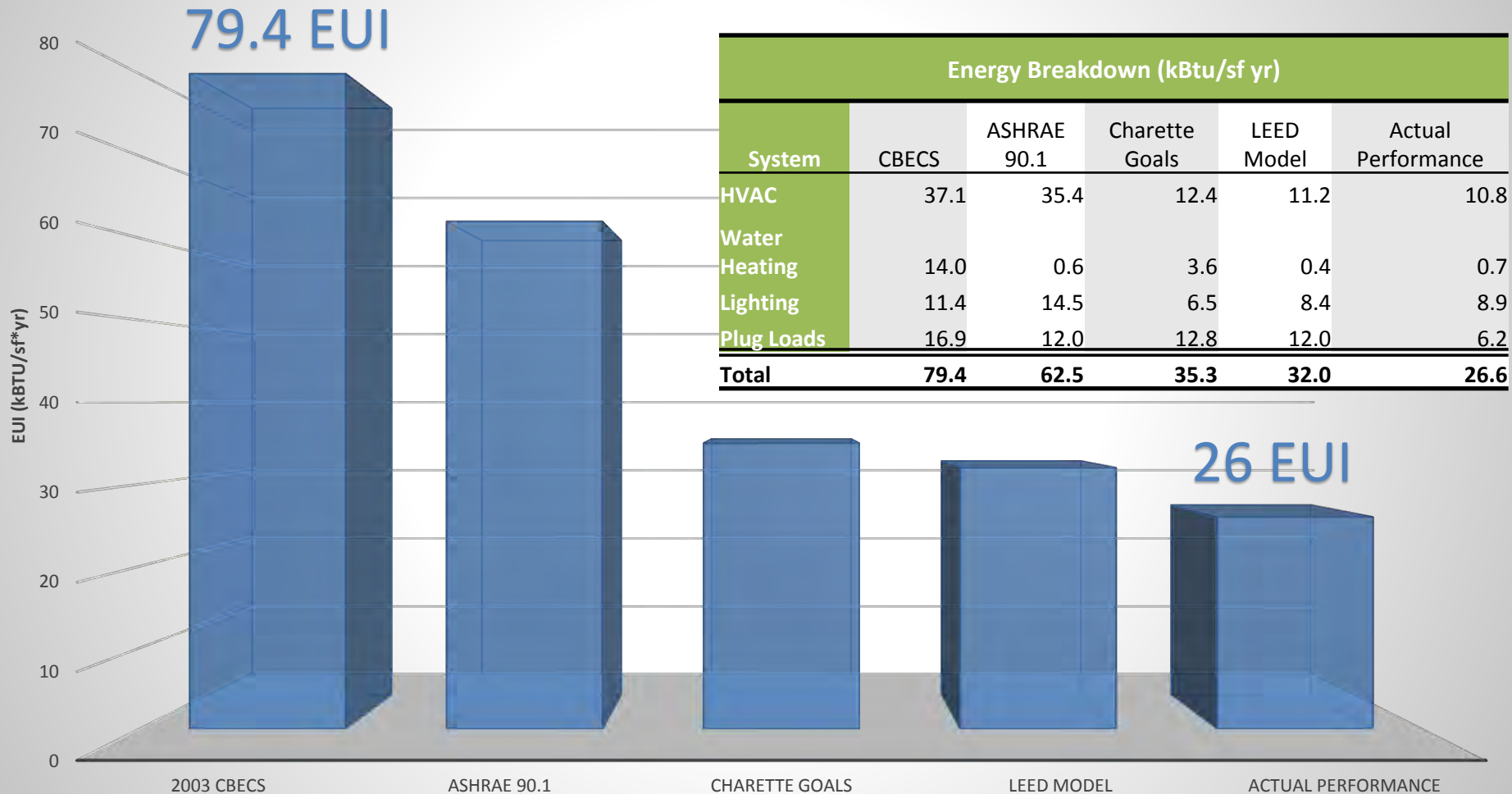
- Annual pEUI & Generation = 35 kBTU/sf
- Annual EUI = 26.6 kBTU/sf
- 1078 Panels, 320kW
- On Site Generation = 34 kBTU/sf
- Annual Energy Exported = 7.4 kBTU/sf
- Savings vs Energy Code = 57%





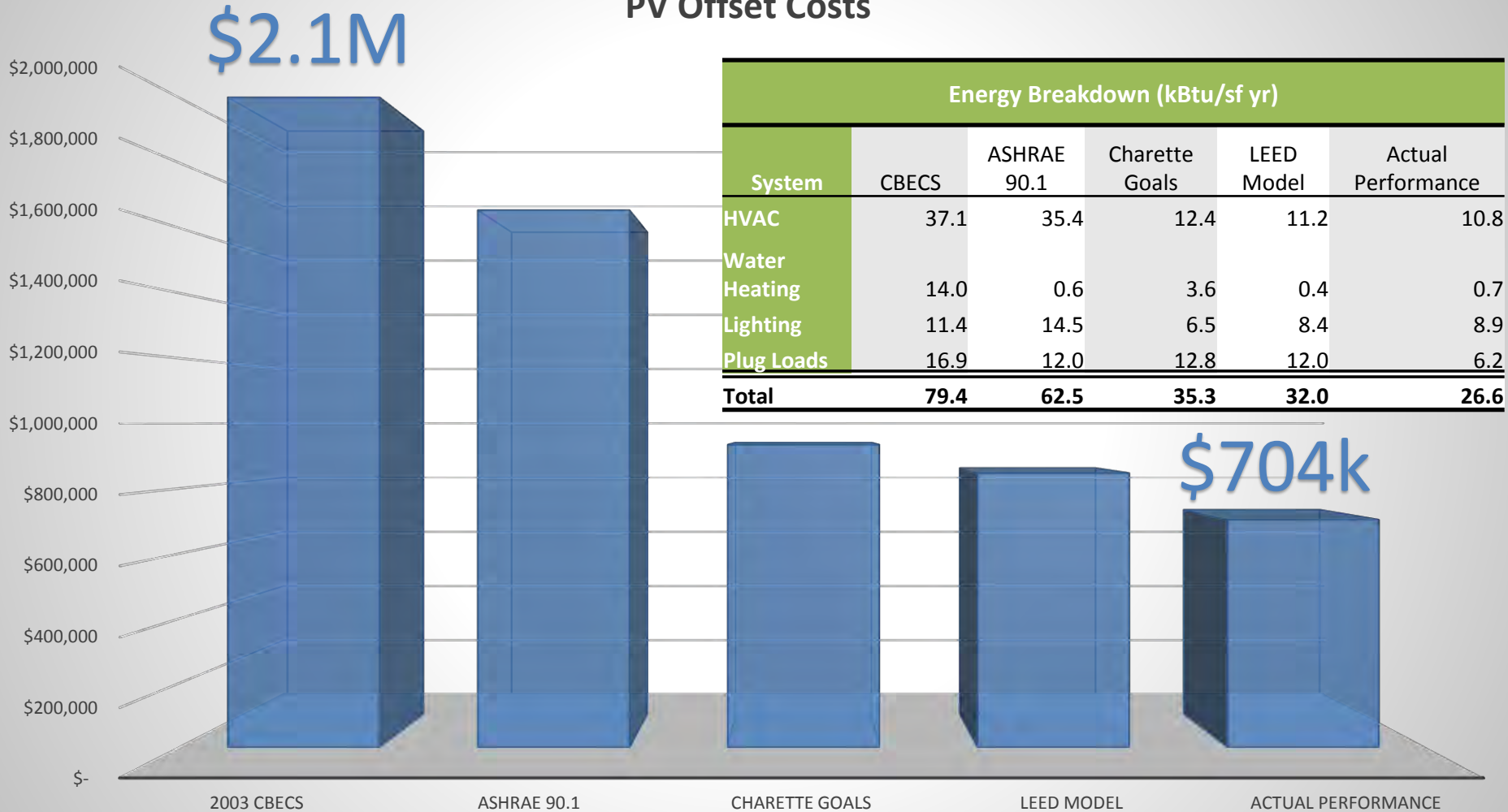
# Energy Performance

## Cincinnati District 3 Police Station Energy Consumption



# Energy Performance

## Cincinnati District 3 Police Station PV Offset Costs

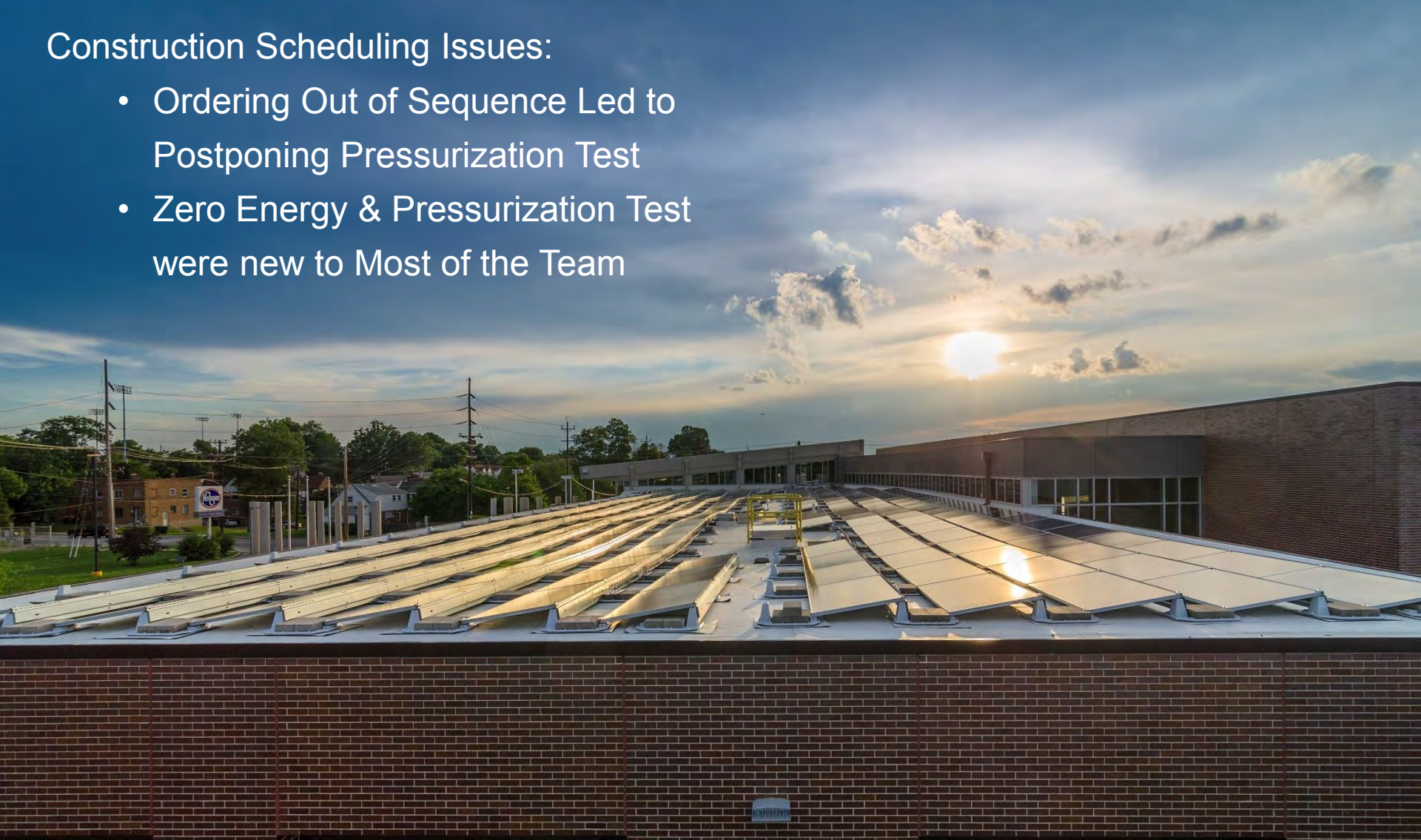




# Lessons Learned

## Construction Scheduling Issues:

- Ordering Out of Sequence Led to Postponing Pressurization Test
- Zero Energy & Pressurization Test were new to Most of the Team





# Lessons Learned

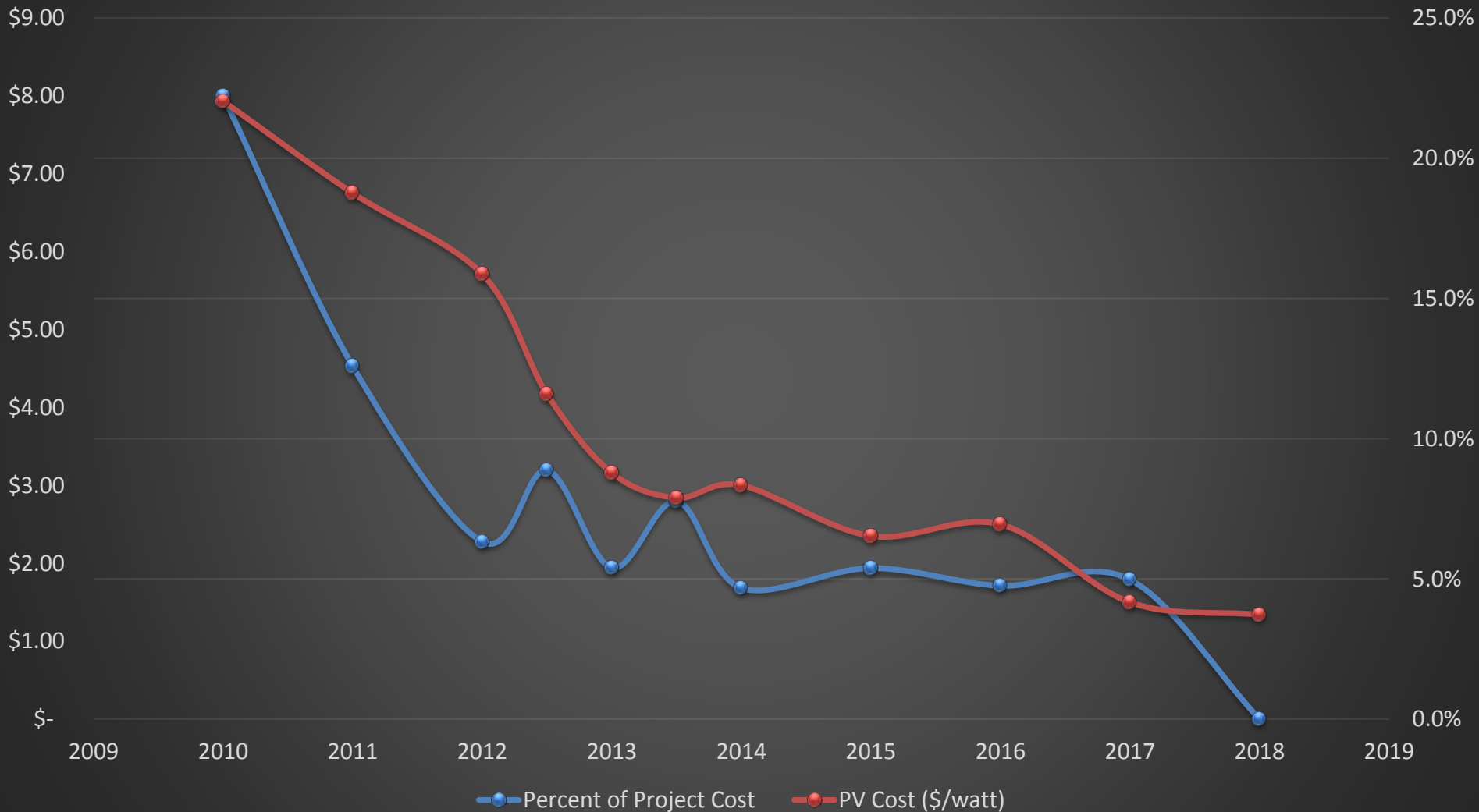


## Integration with Owner's Goals / Owner Handoff

- Solar PV Array Partial Shutdown
- 3 Months of Poor Performance
- Due to Energy Performance, Made ZE 1<sup>st</sup> Year

# How Much Does Zero Energy Truly Cost?

## Percent of Project Cost and PV Cost to Achieve Zero Energy



In Ten Years: From 22% to Less Than < 5%

Energy Exchange: Connect • Collaborate • Conserve



# Zero Energy for FREE!

- Three ZE Options:
  - Own Renewable Energy Solution
    - Not For Profit vs Tax Incentives
  - Power Purchase Agreement
    - Large Roof sf Needed
    - 1.5MW to 2MW and Above
    - \$0.06/kWH, 0% escalation, 20 Years
    - **Zero Owner Costs**
  - Guaranteed Energy Savings Project
    - Leverage Future Energy Costs
    - Numerous Sites
    - 15 to 20 Year Bond
    - **Zero Owner Costs**



# Thank you!

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