What Happens After the Low-Hanging Fruit Has Been Picked?

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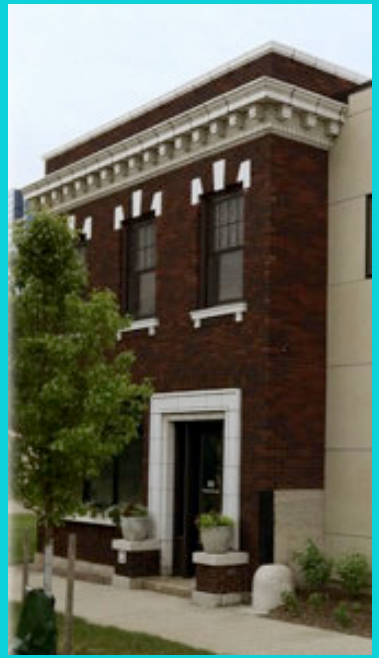
Learning Objectives

1. Describe and summarize how to track energy usage in a building.
2. Define and describe what to look for when evaluating energy usage data
3. Analyze and prescribe appropriate approaches to resolve issues uncovered in data collection.
4. List several ways to conserve energy and work to reduce an existing building's EUI.



Our Mission and Project Goals

We are committed to the creation of places where all species can flourish.

Our Company Goals:
Deliver net positive energy, water and materials on all projects by 2030.
Ensure that every project produces more energy than it uses each year of operation when accounted for at site.

We are seeking for our own building to be net positive energy this year to celebrate the 100th anniversary.

Project History

Our building has seen a century of use, growth and adaptation.

1917

Built

by the Watson Higgins Milling Company in 1917 with fireproof floors, walls and roof systems fabricated with terra cotta block, brick and concrete technologies.

2010

Renovated

Occupied in March of 2010. Certified LEED Platinum in 2012.

2018

Rejuvenated

Operating at an Energy Use Intensity (EUI) of less than 20.

Sense of Place

The Laurentian ”Great Lakes” Region

Grand Rapids, Michigan

Second-largest city in Michigan nestled on the Grand River about 30 miles (48 km) east of Lake Michigan. As of the 2010 census, the city population was 188,040.

01

Climate Zone 5A

Locations that are not Marine and not Dry.

02

Avg. Temp

January: 21.8 F
July: 71.6 F

03

Precipitation

January: 1.8
Rain/20.9 Snow:
July: 3.2” Rain

04

Heat/Cool Days

January: 1339
July: 208
Annual: 6,973/534

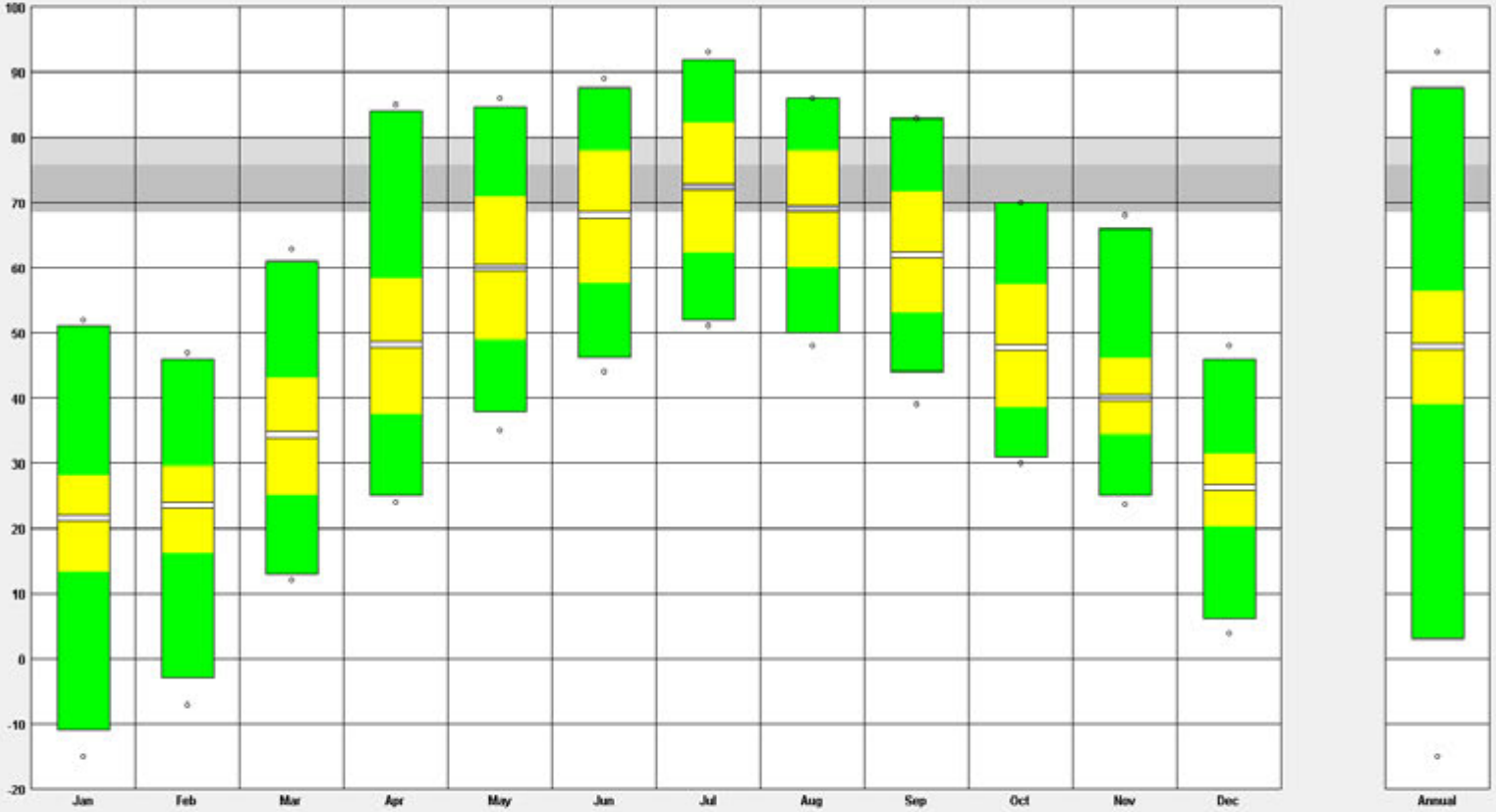
TEMPERATURE RANGE
ASHRAE Standard 55-2004 using PMV

LOCATION: **Grand Rapids Kent County Int, MI, USA**
Latitude/Longitude: 42.88° North, 85.52° West, **Time Zone from Greenwich** -5
Data Source: TMY3 726350 WMO Station Number, **Elevation** 793 ft

LEGEND

RECORDED HIGH
DESIGN HIGH
AVERAGE HIGH
MEAN
AVERAGE LOW
DESIGN LOW
RECORDED LOW

COMFORT ZONE
SUMMER
WINTER
(At 50% Relative Humidity)



DESIGN HIGH: Non-Residential
- 1% of Hours Above
- .5% of Hours Above
- 0% of Hours Above

DESIGN LOW: Non-Residential
- 1% of Hours Below
- .5% of Hours Below
- 0% of Hours Below

TEMPERATURE RANGE:
- 10 to 110 °F
- Fit to Data

Back Next

Our Building Pieces

Usage

Office Space

Restoration of office and storage spaces in the front grade level, second floors, and the high bay warehouse spaces. The lower garden level would also become office spaces.

Systems

Lighting, Geothermal, HVAC, DHW, Zoning, PV

Originally designed to exceed ASHRAE 90.1-2004 by 38% using passive design, natural ventilation and daylighting strategies with a lighting target of 0.7 W/SF.

Occupants

A sustainability consulting firm and commercial realtor

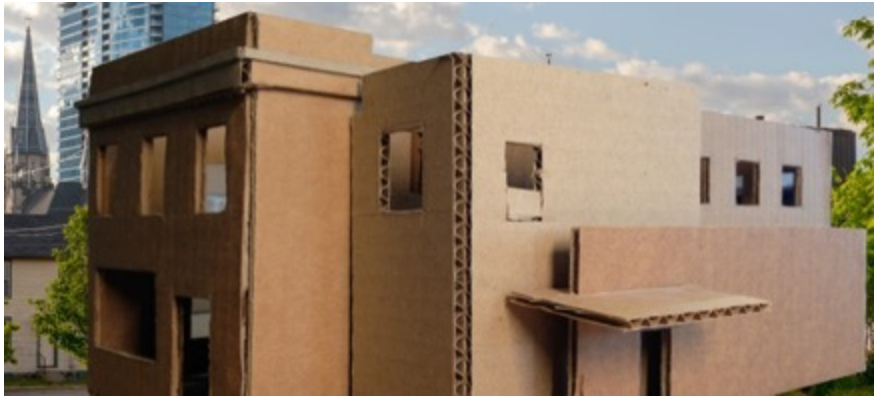
Specialists in high performance and restorative design protocols for buildings, interiors and products.
Focuses on retail real estate to owners and tenants.

Three Negatives

What is keeping us from achieving Net Zero Energy?

1. Existing masonry façade
2. Sharing of one mechanical unit, even though it is zoned in to four areas.
3. Poor envelope air Infiltration

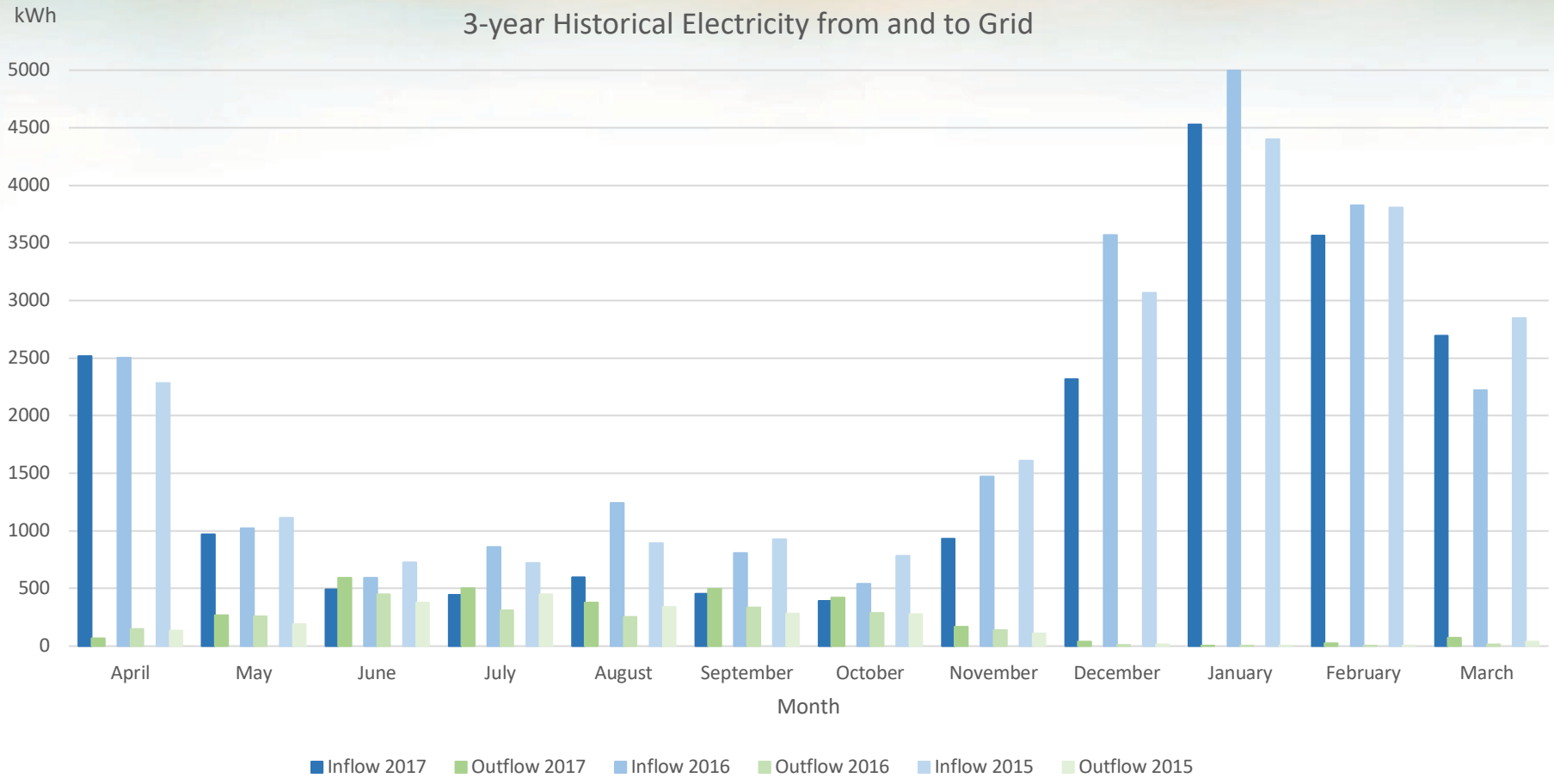
Three Positives



What helped us to get where we are today?

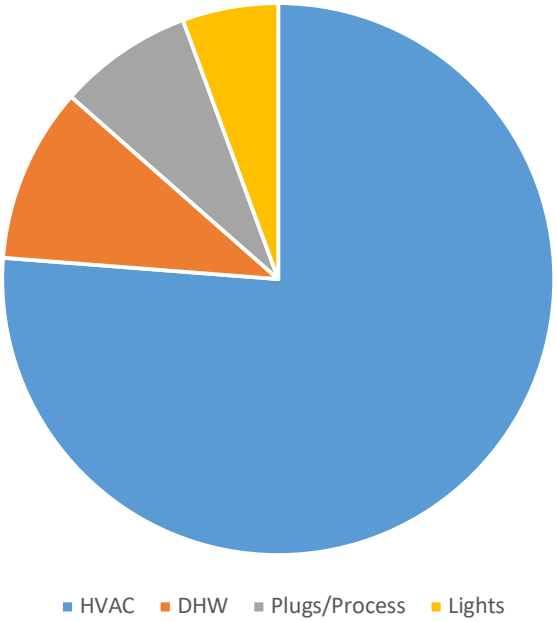
1. Started with a highly efficient building.
2. Existing PV array.
3. Over half of the building users are focused professionally on energy conservation.

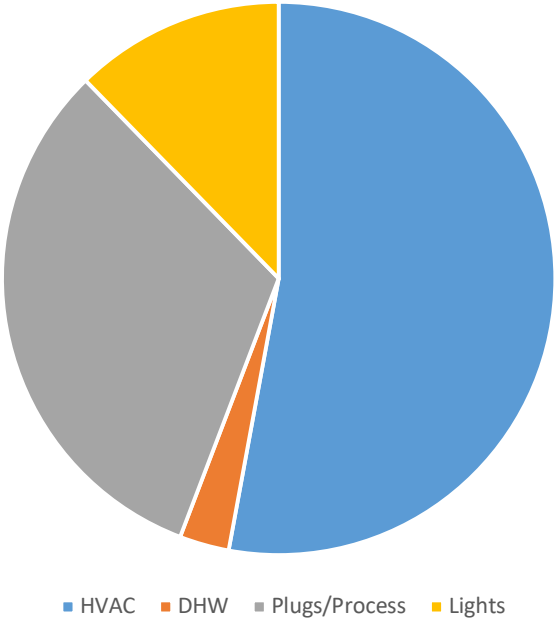
Historic Site Energy



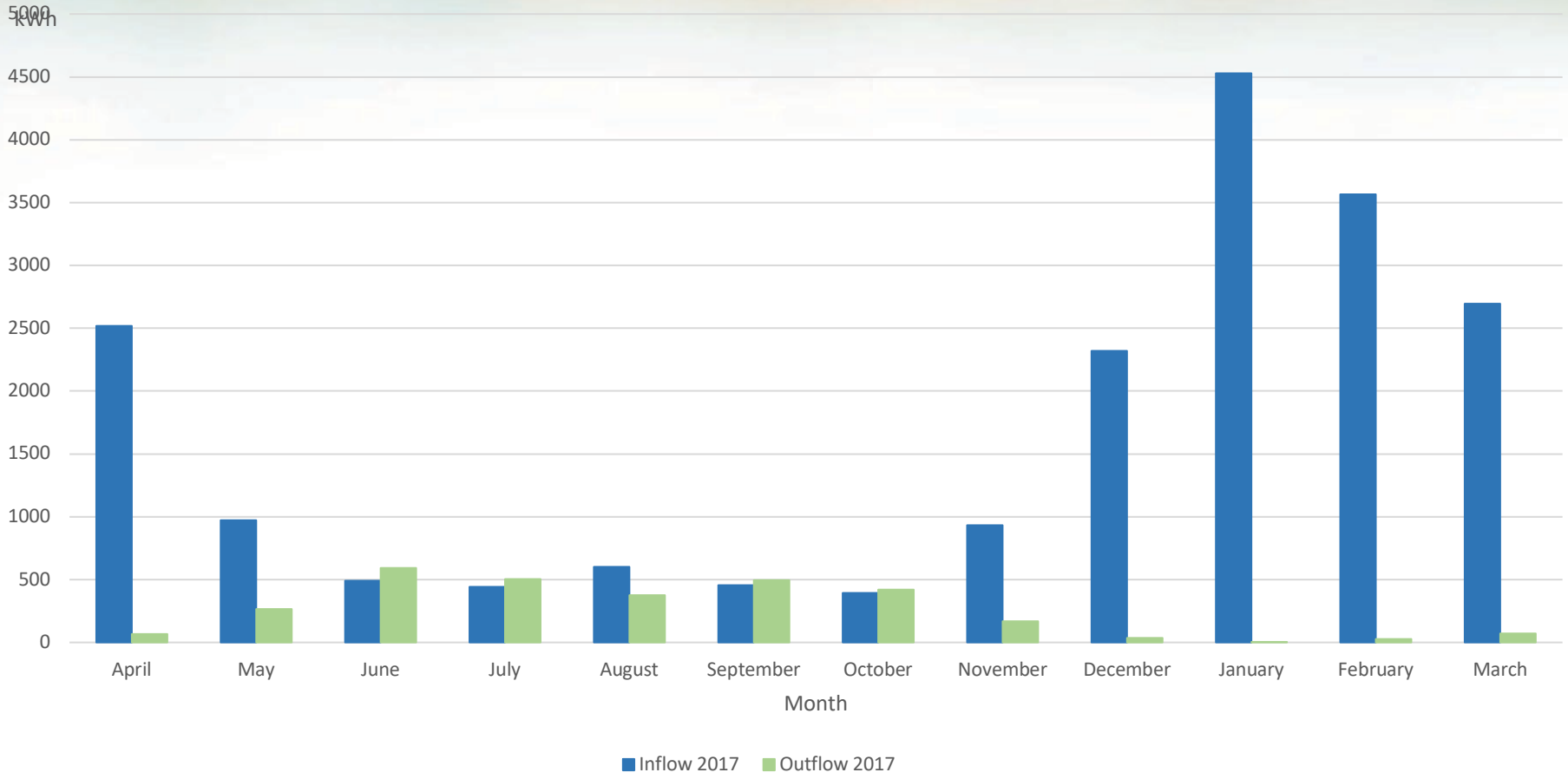
End-Use Breakdown

True end-use breakdown: available via our energy monitoring system.





Net Positive



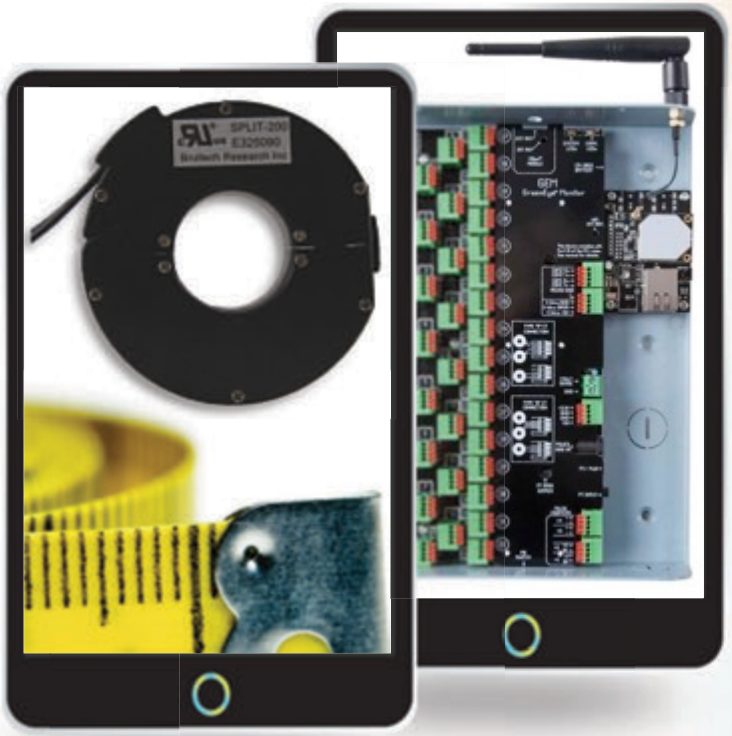
The Prius Effect?

Discovery Phase

Energy Monitoring

We used a BRULTECH GreenEye Monitor (GEM) to monitor electrical consumption of up to 32 electrical circuits. This is the easy part.

“You can't know whether or not you are successful unless success is defined and tracked. With a clearly established metric for success, you can quantify progress and adjust your process to produce the desired outcome. Without clear objectives, you're stuck in a constant state of guessing.”
~Peter Drucker



Data Analysis

February 6th to 13th, 2017

First full week of DashBox operation: System ran continuously through the days and nights.

Electric Furnace

Max: 8,935 Watts
Min: 137 Watts
Average: 5,579 Watts

Electric Heat – 10k

Max: 3 Watts
Min: 1 Watt
Average: 2 Watts

Electric Furnace

Feb 6, 2017 - Feb 13, 2017

Max: 8935 Watts

Min: 137 Watts

Avg: 5579 Watts

Electric Heat 10k

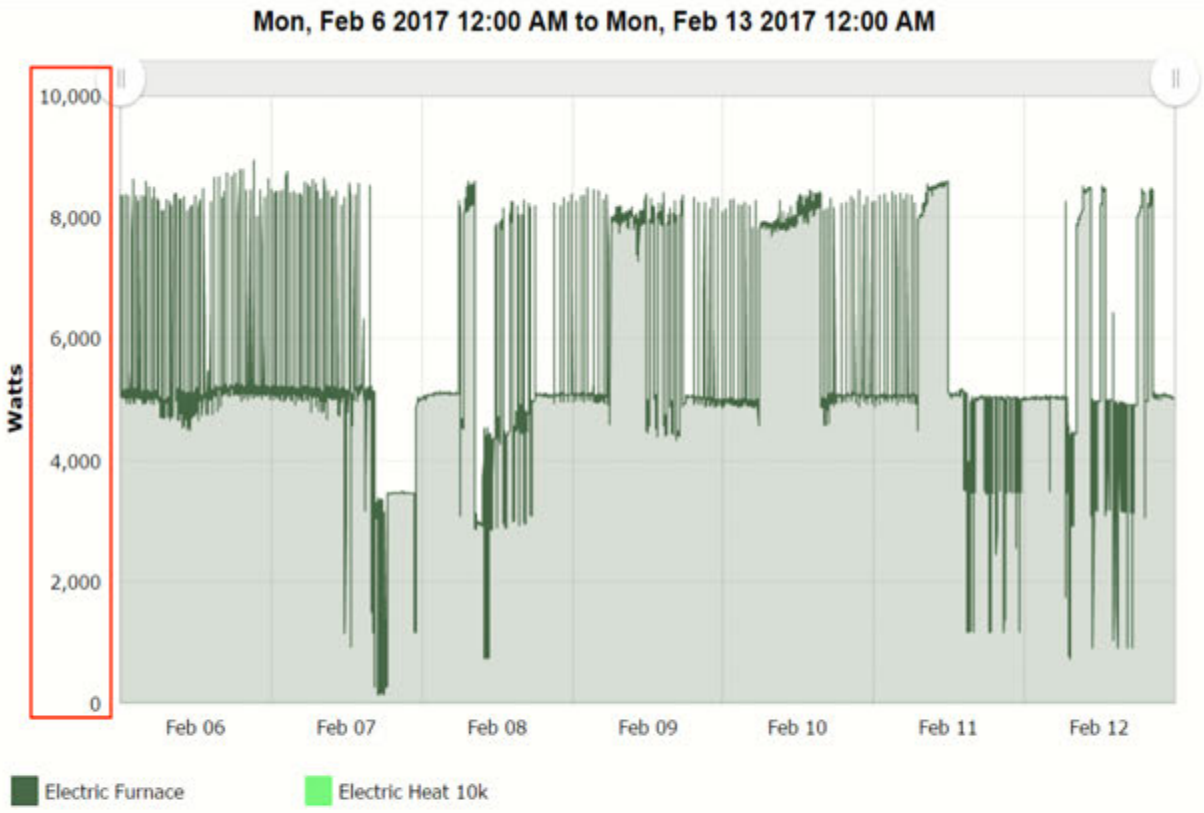
Feb 6, 2017 - Feb 13, 2017

Max: 3 Watts

Min: 1 Watts

Avg: 2 Watts

Select Channel



Data Analysis

March 13th to 20th, 2017

A fairly mild week in March: We were able to put all four thermostats in the building on a consistent program - eliminating all the run hours during the nights. We were not able to troubleshoot the weekend quite yet.

Electric Furnace

Max: 13,869 Watts
Min: 19 Watts
Average: 3,787 Watts

Electric Heat – 10k

Max: 10,290 Watts
Min: 1 Watt
Average: 403 Watts

Electric Furnace

Mar 13, 2017 - Mar 20, 2017

Max: 13869 Watts

Min: 19 Watts

Avg: 3787 Watts

Electric Heat 10k

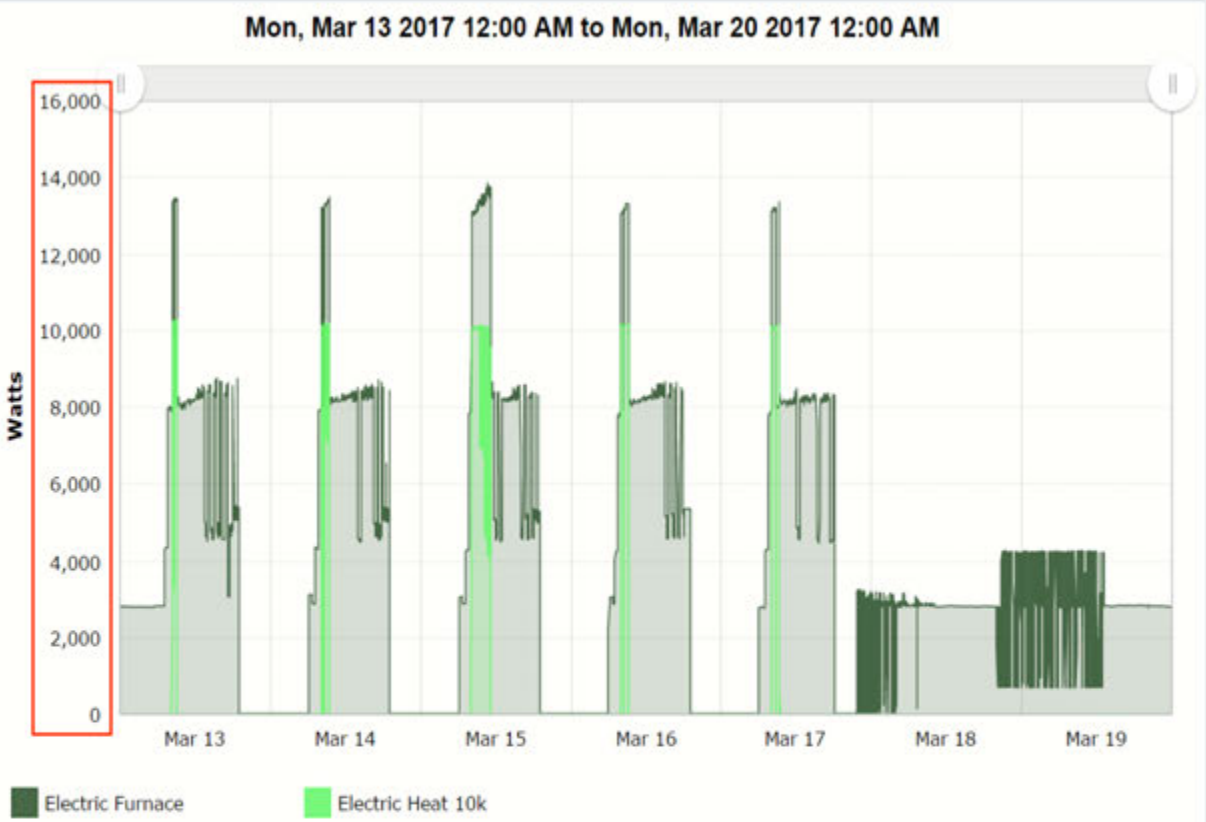
Mar 13, 2017 - Mar 20, 2017

Max: 10290 Watts

Min: 1 Watts

Avg: 403 Watts

Select Channel



Data Analysis

April 24th to May 1st, 2017

The mildest week of 2017 - we didn't even need the system from 4/25 ~11am until the morning of 4/28. We were able to reduce the run hours on the weekend down to a few hours each day - still further investigation needed to shut down the system completely.

Electric Furnace

Max: 5,214 Watts
Min: 18 Watts
Average: 495 Watts

Electric Heat – 10k

Max: 4 Watts
Min: 2 Watts
Average: 2 Watts

Electric Furnace

Apr 24, 2017 - May 1, 2017

Max: 5124 Watts

Min: 18 Watts

Avg: 495 Watts

Electric Heat 10k

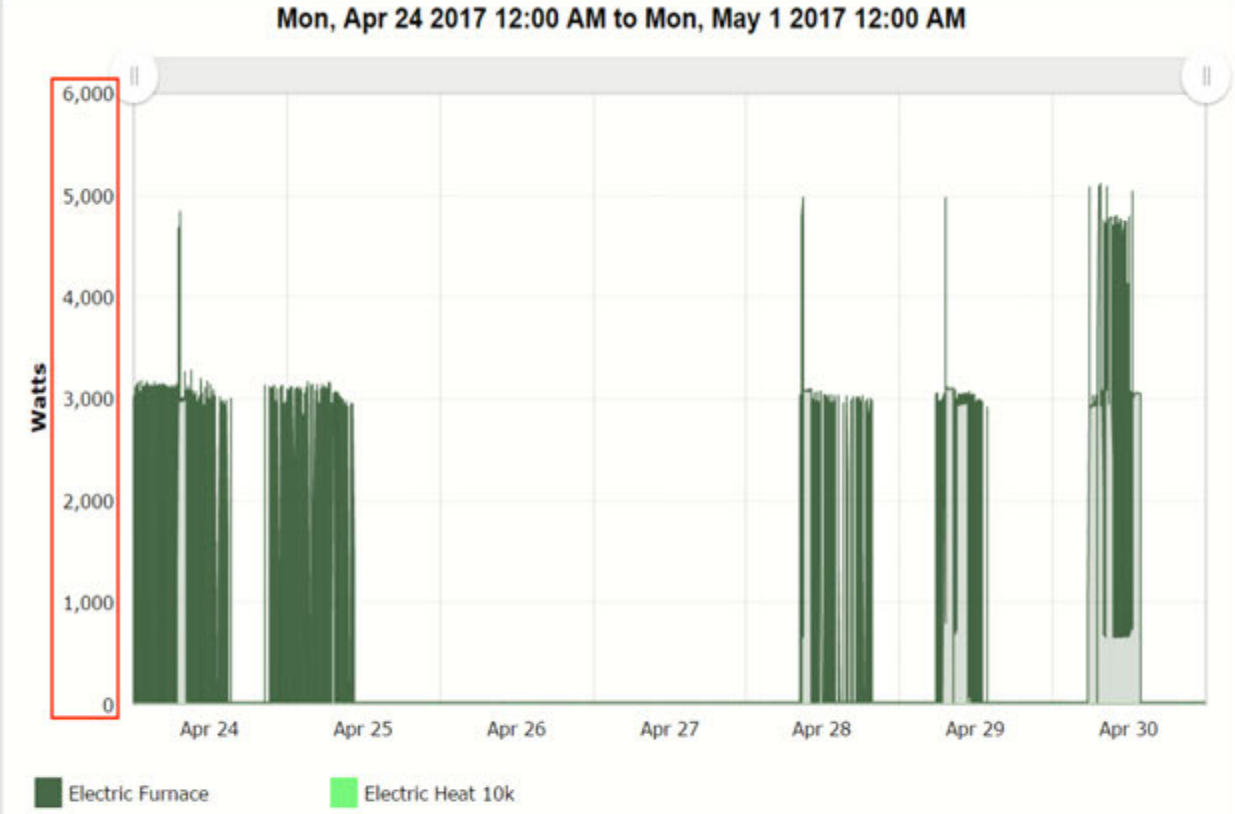
Apr 24, 2017 - May 1, 2017

Max: 4 Watts

Min: 2 Watts

Avg: 2 Watts

Select Channel

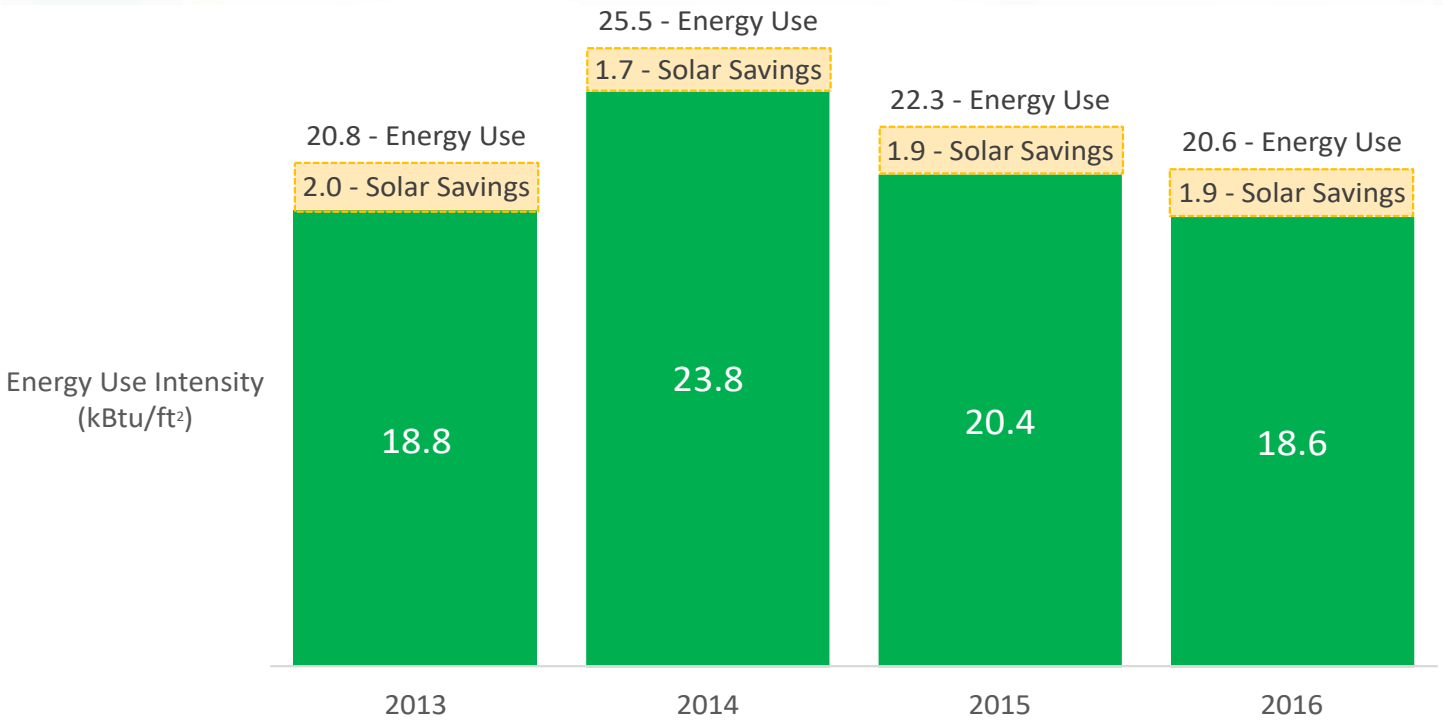


What’s Next?

Setting our ZNE EUI Goal – 17 kBtu/SF

EUI

Several years of EUI data helped us to drive toward our target.



Graph courtesy of Consumers Energy.

Envelope

Terra Cotta

16” of terra cotta tile walls, built to withstand a great fire, which they did back in the mid-60’s.

Existing Construction: R-7 board Insulation, three layers of 4" Terra Cota Clay w/air spaces, 1/2" gyp plaster, 0.108 overall U-value New Construction: Exterior siding, stud wall w/R-19 batt, drywall. 0.073 overall U-value.

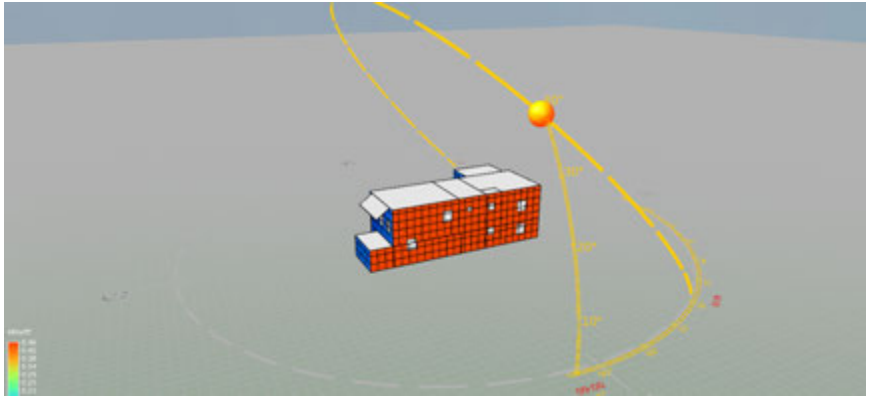
Path to Zero Envelope

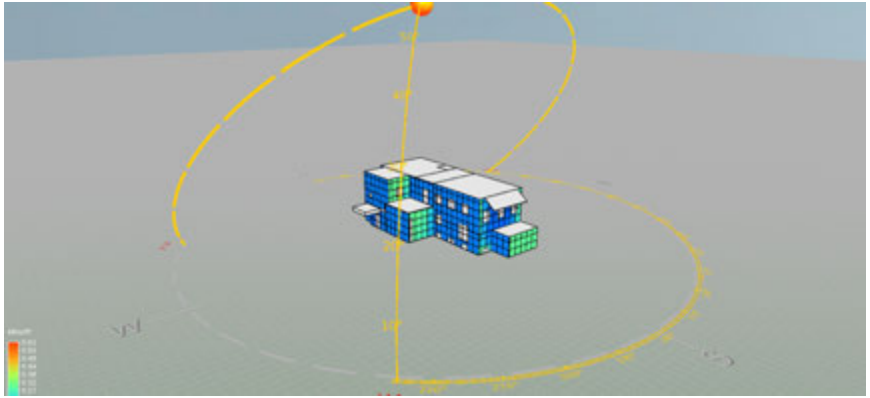
Replacing existing envelope with an air/vapor barrier, board insulation, and insulated metal panel – R-18.

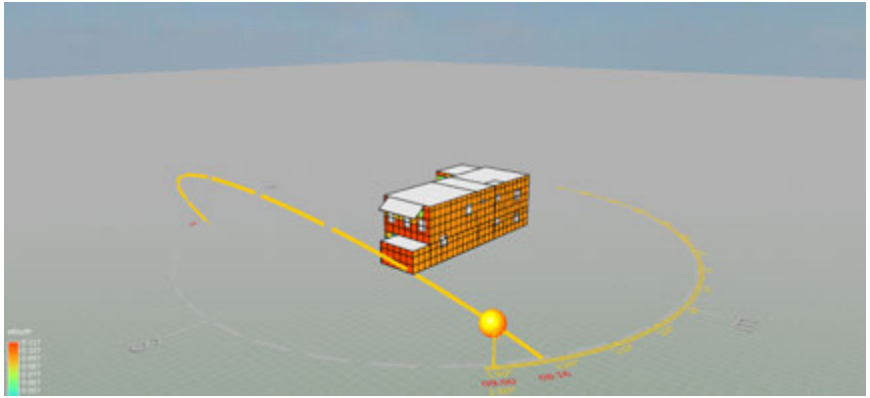
Vertical Fins for Southern, Eastern & Western Facades.

Canopy/Overhang for Deck.

Path to Zero Envelope





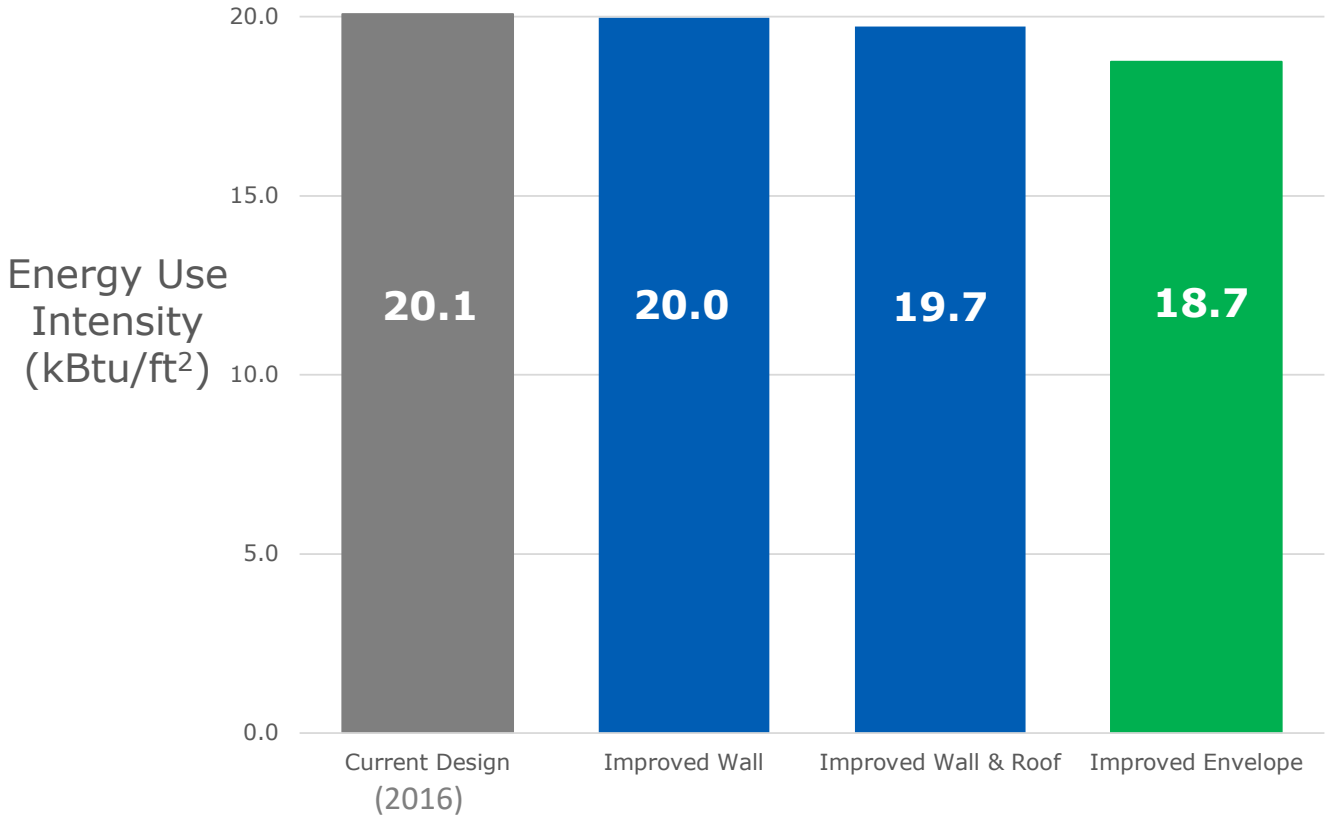


Façade Analysis

Top Left: Summer – East Façade
Top Right: Summer West Façade
Lower Left: Winter East Façade

Images courtesy of Consumers Energy.

Path to Zero Envelope



Graph courtesy of Consumers Energy.

Electrical

Fluorescent Lighting

Paired with 20 - 250w PV panels to maximize wattage output for a 5kW system of panels located on the top of our roof and a 1kW system on the south facing wall. This small system provides approximately 20% of our electricity needs throughout the entire year. During the summer, we regularly get checks from the power utility instead of bills.

The shown racking system is about 7 pounds per square foot which was an easy load for the roof to handle.

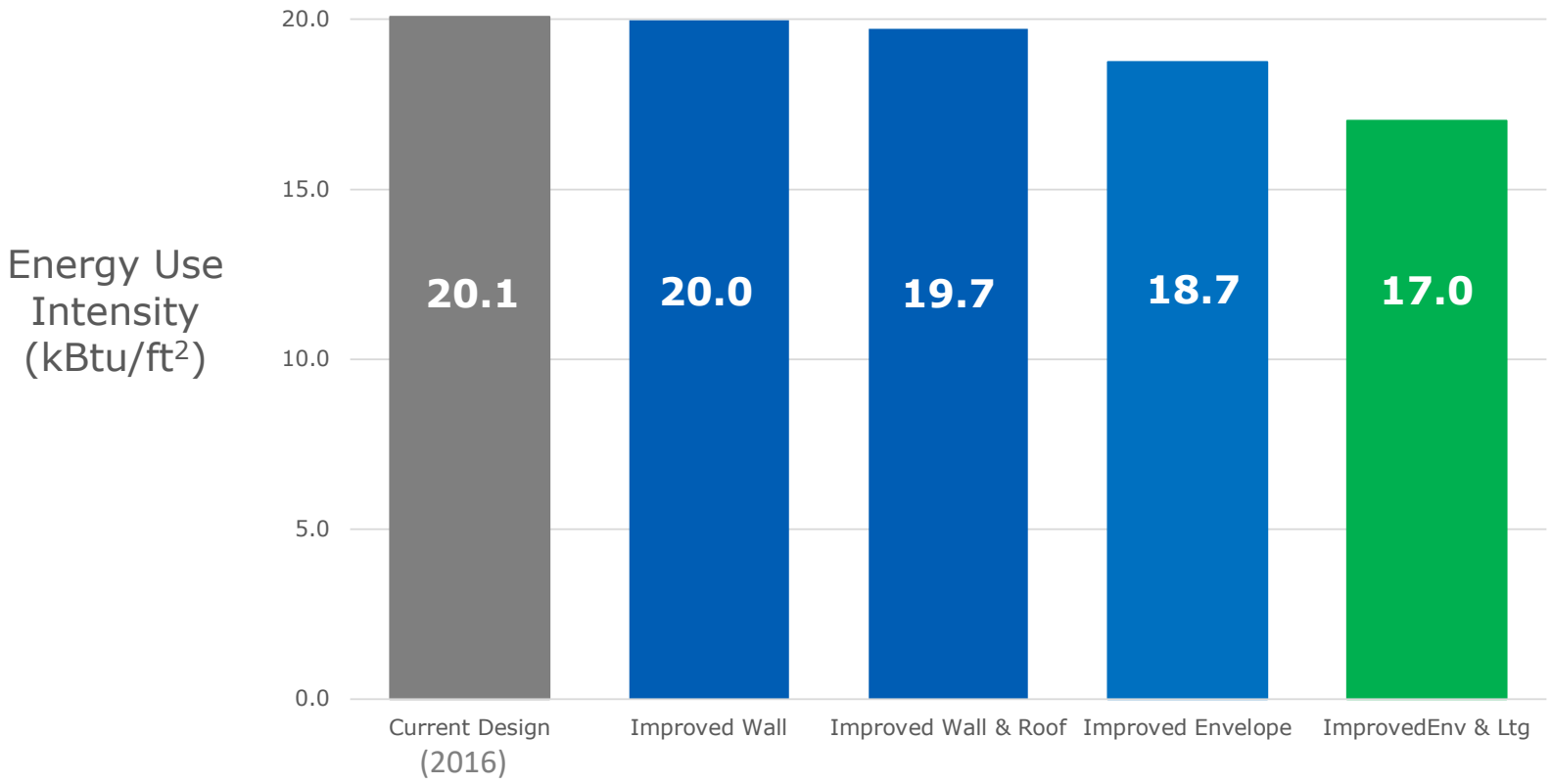
Path to Zero Electrical

Retro Commissioning of existing lighting controls.

Solar tubes for additional daylighting in darker spaces.

Reduce connected plug load.

Path to Zero Electrical

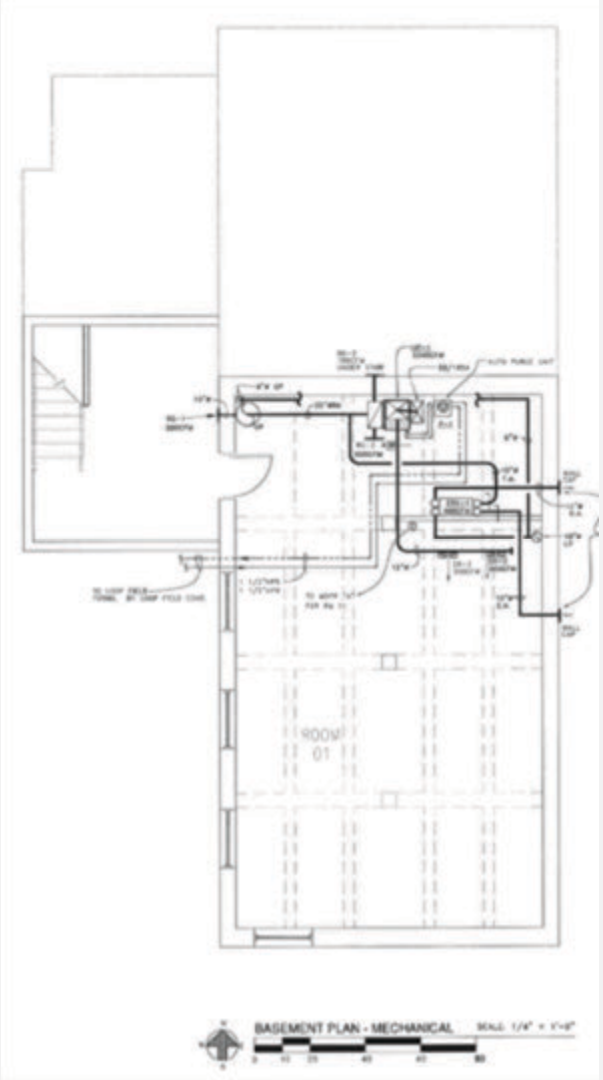


Graph courtesy of Consumers Energy.

HVAC

Geothermal

All spaces are conditioned through a high efficiency central water source heat pump heating, ventilating, and air conditioning (HVAC) system. Occupancy sensors, temperature sensors, and motorized dampers adjust airflow to each space. The space set-point is determined by the occupants by setting thermostats. As more thermostats call for heating or cooling, motorized dampers open, fan speed is increased, and compressors are energized in the heat pump to meet output needs.

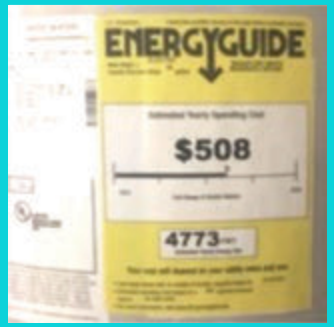


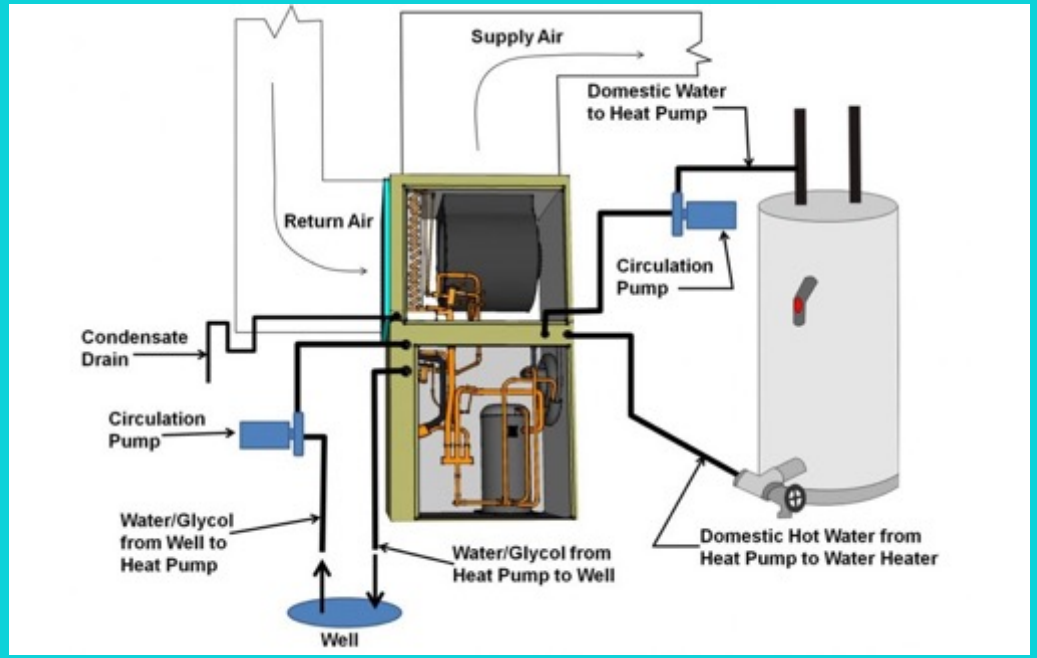
Path to Zero HVAC Systems

Additional heat source to High-Bay Workspace.

Earth Tubes.

Sweaters and Shorts





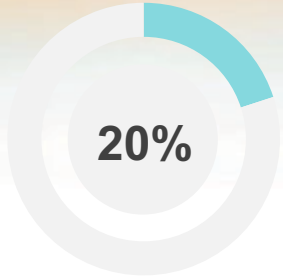
Domestic Hot Water (DHW)

The source of major system failures in the past three years.

A desuperheater is a secondary heat exchanger that transfers heat from the earth in the winter, and from your home in the summer, into your domestic hot water tank. The desuperheater is part of the geothermal heat pump's domestic hot water generating system (HWG).

Occupants

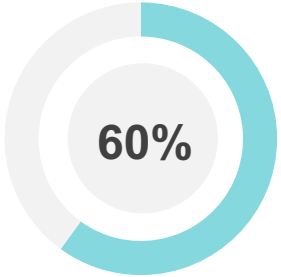
Cost vs. Difficulty to enact change.



01

Human Behavior Change

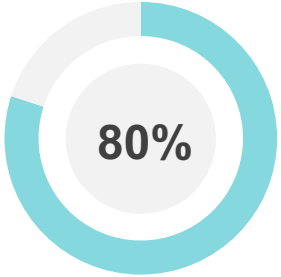
The least costly change but likely the hardest thing to actually accomplish.



02

Thermal Improvements

Improving the performance of the building will likely improve the performance of our occupants.



03

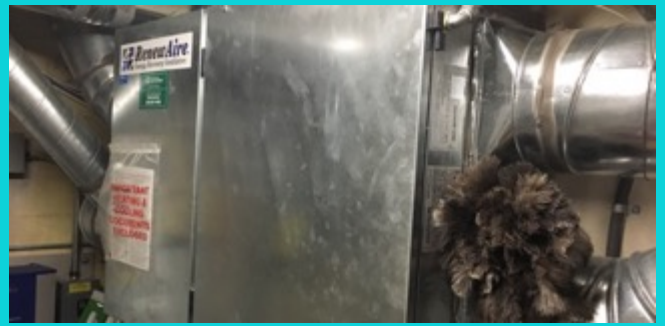
Adding Renewables

Most costly, but having all of our energy sourced on site will help to reduce our dependence on the grid.

Other Considerations

Have you heard of a thing called Acoustics?

During our retro Commissioning and Energy Monitoring process, we discovered that our Energy Recovery Ventilator (ERV) was running at too high of a volume. Additionally, during our iBEAM audit, noise complaints about the return air system were noted throughout the building. A variable speed controller (low-cost) was installed and reduced energy and noise..



Results

Things we need to focus on as we move forward.

Step-by-Step EUI

Continue to monitor our electricity usage and track the performance.

kWh	Inflow	Outflow
April 2017	2520	66
May 2017	971	267
June 2017	492	594
July 2017	444	504
August 2017	600	378
September 2017	457	496
October 2017	393	419
November 2017	933	169
December 2017	2319	38
January 2018	4528	1
February 2018	3565	26
March 2018	2697	71
Annual Total	**19,919**	3,029

Step 1: Convert utility data to kBTU

Step 2: Divide by building SF

x3.412 = 67,964

/3,950 SF = **17.2 kBtu/sf/yr**

PV Analysis

Current Array Configuration

The best configuration of PV was for 10 rows of two panels laying in the portrait position at 15 degrees. At the 15 degree angle and with the parapet wall, wind loads were minimized. Due to shadowing, a 20 degree configuration would only allow for 9 rows of panels. And to put a 4-wide row in would have required a full racking system to be raised two feet above the rooftop level to clear shadows of the parapet.

Ballasted Racking, 15 deg, 4.9kW
Estimated 5,900 kWh/year
502 Second Street, Grand Rapids
Solar Winds Power Systems, LLC

Path to Zero Renewables

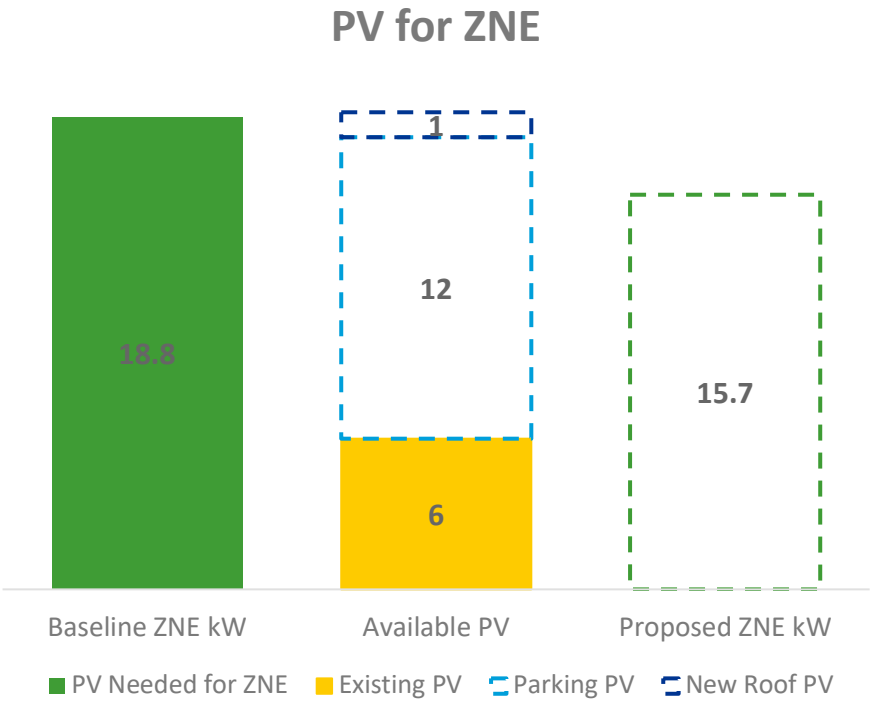
Additional PV array to support the remaining electrical needs of the building beyond improvements made.

PV Sizing

900 sf of available space for PV carports

100 sf of available space for new roof area

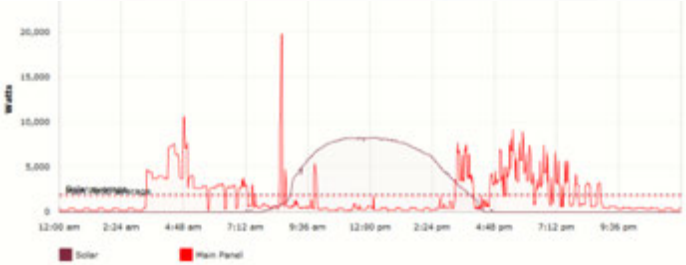
Additional 9.7 kW of PV needed for the Proposed design to reach ZNE

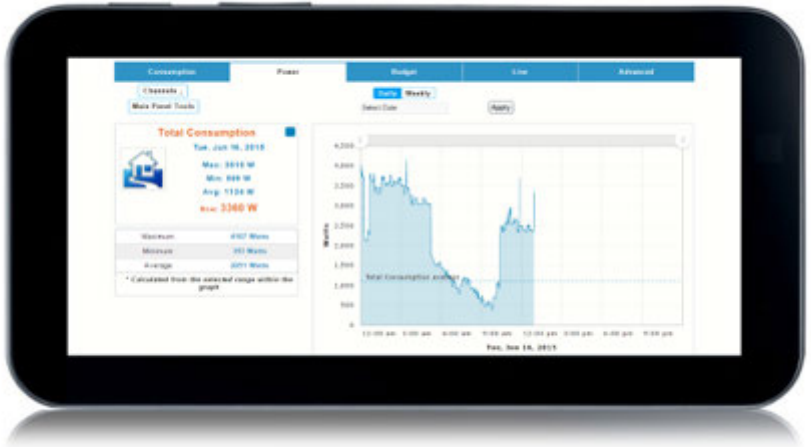


Graph and Image courtesy of Consumers Energy.

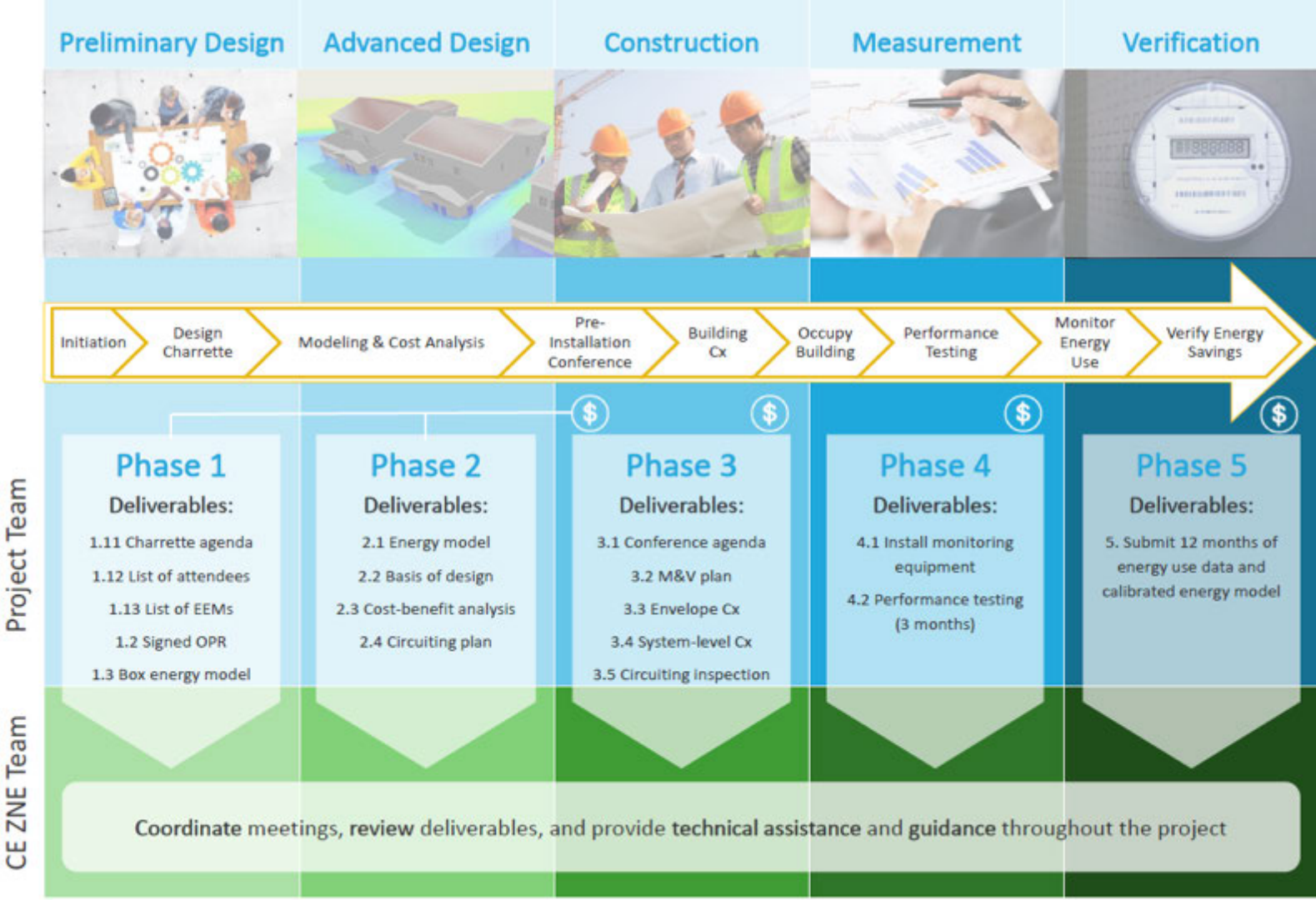
Monitoring

Continue to monitor the energy consumptions and system performance for one year post-implementation.





Success


Preliminary Design
Advanced Design
Construction
Measurement
Verification
Initiation
Design Charrette
Modeling & Cost Analysis
Pre-Installation Conference
Building Cx
Occupy Building
Performance Testing
Monitor Energy Use
Verify Energy Savings
Project Team
Phase 1
Deliverables:
1.11 Charrette agenda
1.12 List of attendees
1.13 List of EEMs
1.2 Signed OPR
1.3 Box energy model
Phase 2
Deliverables:
2.1 Energy model
2.2 Basis of design
2.3 Cost-benefit analysis
2.4 Circuiting plan
Phase 3
Deliverables:
3.1 Conference agenda
3.2 M&V plan
3.3 Envelope Cx
3.4 System-level Cx
3.5 Circuiting inspection
Phase 4
Deliverables:
4.1 Install monitoring equipment
4.2 Performance testing (3 months)
Phase 5
Deliverables:
5. Submit 12 months of energy use data and calibrated energy model
CE ZNE Team
Coordinate meetings, review deliverables, and provide technical assistance and guidance throughout the project