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


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
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
3-year Historical Electricity from and to Grid

![Graph showing electricity data from different months and years](image-url)
End-Use Breakdown

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

502 Second St.

CBECS 2012
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
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
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
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

<table>
<thead>
<tr>
<th>Energy Use Intensity (kBtu/ft²)</th>
<th>Current Design (2016)</th>
<th>Improved Wall</th>
<th>Improved Wall &amp; Roof</th>
<th>Improved Envelope</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>20.1</td>
<td>20.0</td>
<td>19.7</td>
<td>18.7</td>
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</tbody>
</table>

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

Energy Use Intensity (kBtu/ft²)

- Current Design (2016): 20.1
- Improved Wall: 20.0
- Improved Wall & Roof: 19.7
- Improved Envelope: 18.7
- Improved Env & Ltg: 17.0

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.

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<tr>
<th>kWh</th>
<th>Inflow</th>
<th>Outflow</th>
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<tr>
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<td>2520</td>
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<tr>
<td>May 2017</td>
<td>971</td>
<td>267</td>
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<td>June 2017</td>
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<td>July 2017</td>
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<td>November 2017</td>
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<td>December 2017</td>
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<tr>
<td>January 2018</td>
<td>4528</td>
<td>1</td>
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<tr>
<td>February 2018</td>
<td>3565</td>
<td>26</td>
</tr>
<tr>
<td>March 2018</td>
<td>2697</td>
<td>71</td>
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<tr>
<td><strong>Annual Total</strong></td>
<td><strong>19,919</strong></td>
<td><strong>3,029</strong></td>
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</table>

**Step 1:** Convert utility data to kBtu

**Step 2:** Divide by building SF

\[
\times 3.412 = 67,964\quad /3,950 \text{ SF} = 17.2 \text{ kBtu/sf/yr}
\]
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.

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

PV for ZNE

Baseline ZNE kW: 18.8
Available PV: 6
Proposed ZNE kW: 15.7

12 kW

Graph and Image courtesy of Consumers Energy.
Monitoring

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

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

Coordinate meetings, review deliverables, and provide technical assistance and guidance throughout the project.