THE UN-TAPPED POTENTIAL OF EXISTING BUILDINGS IN THE QUEST FOR CARBON NEUTRALITY

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AGENDA (THERE WILL BE BABY PICTURES)

1. Climate Context
2. Zero Energy Buildings Industry
3. The Ohio History Center
4. Deep Energy Retrofit
5. A Path to Zero
6. Power Purchase Agreements
7. Throwing Rocks (Q&A)
GO SUSTAINABLE ENERGY

Energy Consultants
3rd Party
Accurate, Unbiased
CLIMATE CONTEXT

< 350 ppm goal
REMEMBER THAT CLIMATE THING?

https://www.esrl.noaa.gov/gmd/ccgg/trends/
WHY OHIO CARES?

- Polar Bears – just the zoo
- Sea level – we don’t have ocean beaches
- Hurricanes – those give us nice warm rain
• “... we need quick wins ... going beyond 1.5°C will increase the frequency and intensity of climate impacts, such as the heatwaves and storms witnessed across the globe in the last few years. We cannot afford to fail.”

• “even if all unconditional Nationally Determined Contributions (NDCs) under the Paris Agreement are implemented, we are still on course for a 3.2°C temperature rise.”
“Net zero must become the new mantra, and we must pursue this goal with confidence”
NET-ZERO DEFINITIONS

- Site Energy
- Source Energy
- Energy Cost
- Emissions
- California
- All increasing efficiency & RE
ZEB RESOURCES FOR NEW CONSTRUCTION

DOE, NREL, ILFI, NBI, ACEEE, etc...

Barriers overcome
Technology
Case Studies
Cost

Remaining barriers:
Perception (what?)
Market (who wants?)

NEW CONSTRUCTION SCENARIO

2030
• AIA 2030 Challenge Achieved!
• 100% ZEB New Construction

2050
• Emissions Neutral Economy Goal

2080 - 2130
• Zero Energy Building Sector @ 1-2% Turnover Rate

• New buildings only approach misses the goal

• How does the building sector bend the curve?
  • Massive grid-scale renewables
  • Existing Buildings!!!!!!!!!!!!!!!
THE OHIO HISTORY CENTER

...speaking of existing buildings
THE OHIO HISTORY CENTER
THE OHIO HISTORY CONNECTION

- Statewide non-profit
  - Founded 1885
  - 57 Sites
  - > 300 buildings

“spark discovery of Ohio history as we embrace the present, share the past, and work to transform the future”
THE BUILDING

- Completed in 1970
- Designed by W. Byron Ireland & Associates
- Lauded by Architectural Record as “the most architecturally significant public structure built in Ohio since the State Capitol Building.”
- One of the premier examples of Brutalism in the United States
- Early adopter of sustainable practices – a green roof
# A DECADE OF PROGRESS

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 - December</td>
<td>Chiller disabled in winter. $19,000 in annual savings measured</td>
</tr>
<tr>
<td>2011 - Fall</td>
<td>ASHRAE Level III energy audit of the Center</td>
</tr>
<tr>
<td>2012</td>
<td>Low cost opportunities from the audit are implemented; lighting replacements begin</td>
</tr>
<tr>
<td>2013 - Summer</td>
<td>Retro-commissioning study, demand control ventilation, AHU scheduling, economizing</td>
</tr>
<tr>
<td>2013 - 2014</td>
<td>Hot water plant replacement: boilers, pumps, variable speed pumping control</td>
</tr>
<tr>
<td>2014</td>
<td>All halogen or incandescent exhibit floor lighting replaced with LED</td>
</tr>
<tr>
<td>2014 - 2015</td>
<td>Chilled water plant replacement includes aggressive commissioning and LCC analysis</td>
</tr>
<tr>
<td>2015 - Autumn</td>
<td>BAS comprehensive upgrade, controllers for major equipment, etc.</td>
</tr>
<tr>
<td>2016 - Spring</td>
<td>Plug load campaign and automated settings on computers, printers, and copiers.</td>
</tr>
<tr>
<td>2016 - Summer</td>
<td>AHU filter replacements with higher MERV</td>
</tr>
<tr>
<td>2016 - Autumn</td>
<td>Ventilation upgrades to AHUs for new space programming. New HVAC for security</td>
</tr>
<tr>
<td>2016-2018</td>
<td>LEED EB certification process (not yet certified) including ongoing commissioning</td>
</tr>
<tr>
<td>2018</td>
<td>Exterior lighting HID to LED project being finalized</td>
</tr>
<tr>
<td>2018-2020</td>
<td>Scheduled renovation for facility's aging AHUs</td>
</tr>
</tbody>
</table>
MEASUREMENT & VERIFICATION – RESULTS!
M&V RESULTS

50% Savings
>$1.2 Million Cumulative
Weather Normalized

<table>
<thead>
<tr>
<th>Year</th>
<th>Electrical Utility Savings ($)</th>
<th>Electrical Demand Savings ($)</th>
<th>Natural Gas Utility Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>$15,035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>$65,752</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>$74,774</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>$81,837</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>$99,645</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>$129,438</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>$197,373</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>$217,225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>$226,938</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 (Jan-Mar)</td>
<td>$67,932</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DEEP ENERGY RETROFIT

How did we do it?
ORGANIC STRATEGIC ENERGY MANAGEMENT

**Culture**
- Curious & Engaged Champions
- Continuous Improvement
- Don’t accept No

**Planning**
- Capital Cycles
- Incremental Investment (Chiller, Boiler, AHUs)
- Lighting, Schedules, Controls

**Team**
- Architectural Staff
- Go – Efficiency Consult & Cx
- Korda - Design

**Goals**
- Effective Use of Public Funds
- No ESCO / Performance Contracts $1 for every $2 (Urbatsch & Boyer 2016)
EXAMPLE: CHILLER PLANT REPLACEMENT

<table>
<thead>
<tr>
<th>Chiller Options</th>
<th>Initial Cost</th>
<th>20-yr Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$0</td>
<td>-$60k</td>
</tr>
<tr>
<td>2</td>
<td>$200,000</td>
<td>+$102k Lifecycle</td>
</tr>
<tr>
<td>3</td>
<td>$400,000</td>
<td>+$99k Lifecycle</td>
</tr>
<tr>
<td>4</td>
<td>$600,000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>$800,000</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$1,000,000</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>$1,200,000</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>$1,400,000</td>
<td>+$32k</td>
</tr>
</tbody>
</table>
A PATH TO ZERO

Where to from here?
Viable and cost-effective?
Emissions or energy?
CHANGES IN ENERGY USE INTENSITY

- ZEB-Ready at ~40 kBtu/ft²
  - 80th percentile of ZEB (NBI)
  - Most projects already identified!

EUI 95 to 55 in a decade!
A UTILITY PRICING SNAPSHOT

- NG – 50%
- Elec – 153%

- Effective stakeholder communication
  - Energy Savings
  - Cost Savings

### Graph

- **Electricity Cost ($/kWh)**
- **Natural Gas Cost ($/Mcf)**

- **Y-axis:** $0.00, $0.01, $0.02, $0.03, $0.04, $0.05, $0.06, $0.07, $0.08, $0.09, $0.10, $0.11, $0.12, $12

### Key Points
- **Natural Gas Cost ($/Mcf):**
  - Jul 2008 - Jun 2009: $2
  - 2009: $2
  - 2010: $2
  - 2011: $2
  - 2012: $2
  - 2013: $2
  - 2014: $2
  - 2015: $2
  - 2016: $2
  - Oct 2016 - Sep 2017: $2

- **Electricity Cost ($/kWh):**
  - Jul 2008 - Jun 2009: $0.02
  - 2009: $0.02
  - 2010: $0.02
  - 2011: $0.02
  - 2012: $0.02
  - 2013: $0.02
  - 2014: $0.02
  - 2015: $0.02
  - 2016: $0.02
  - Oct 2016 - Sep 2017: $0.02
GENERATION NEEDED FOR ZERO?

• Solar on ~50% of Parking Lot

• Electrification (carbon definition)
  • A touchy subject & tangent
  • Cost of fuel
  • New vs existing infrastructure
  • Renewable NG (electrolysis + Sabatier = CH₄) as alternate to battery, reservoir generation, etc.

<table>
<thead>
<tr>
<th>Solar Generation (MW)</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>ZEB per DOE Common Definition</td>
</tr>
<tr>
<td>1.5</td>
<td>Net Zero Emissions (Pless &amp; Torcellini 2010)</td>
</tr>
<tr>
<td>1.7 – 2.6</td>
<td>ZEB / Net-Zero Emissions with natural gas converted to electric. 2.6 MW with electric resistance heat, 1.7 with COP of 3.</td>
</tr>
</tbody>
</table>
POWER PURCHASE AGREEMENTS

An economic silver bullet?
PPA BENEFITS – A 3\textsuperscript{RD} PARTY

• The 3\textsuperscript{rd} Party...
  • Owns
  • Finances
  • Install
  • Maintains
  • Grid stuff

• Non-taxable entities – a bridge to
  • Federal tax credits
  • MACRS depreciation

• Major uptake in last few years
• NPV would enhance the PPAs
• 2 MW, $2.5M, $0.08/kWh, Ohio, 3% utility cost escalation rate, RECS retained and retired
WHAT ABOUT 2030 DISTRICT MEMBERS?

CINCINNATI

26 MILLION SQUARE FEET COMMITTED
GRID DATA – PANDEMIC EDITION

Source: Go Sustainable Energy Sponsored University of Dayton Research Project April 2020
OPERATIONS EFFICIENCY MANTRAS

• Why is it on?

• What does this do?

• Do we need it?

• Is this the right setting?

• Can we not use it?
WHERE TO START... JUST SOME EXAMPLES

• Methods
  • Walk-through
  • BAS observation

• General
  • Schedules!!!
  • Settings
  • Turn off when possible
  • Idle
  • Consolidate

• HVAC
  • Thermostat settings
  • Fan setting
  • Optimize ventilation

• Lights
  • Minimize use
  • Dim when possible

• Pumps & Fans
  • Eliminate throttling with VFDs
  • Scale back % flow settings
• Lighting Renovation to LED
  • Metal Halides
  • T12 & T8 fluorescent
  • Interior and Exterior
• Controls
  • Remote-accessibility
  • Set-back and schedule-based opportunities
  • Supply air and water temperature resets
  • Lighting occupancy and dimming
  • Chiller & Boiler plant optimization
  • Aggressive approach to sequences
• Equipment end-of-life
  • HVAC Units (AHUs, RTUs, Condensing Units)
  • Chillers
  • Boilers
• Motors
  • Replace with higher-efficiency version
  • Understand if VFDs are appropriate
• Kitchens
  • Variable hoods
  • Local controls for lower flow
SCHOOL DISTRICT – PANDEMIC OR NOT!

- $13.5 million annual utility spend
- Over 130 facilities
- Over 8.5 million ft²

Opportunities
- $1.5-$2.5 million cash-flow positive savings
- 11-19% for the district
- Over half is low-to-no-cost – settings related
THROWING ROCKS (Q&A)