In Pursuit of Performance
A multifamily retrocommissioning case study

Presenter:
Kimberly Vermeer

BuildingEnergy Boston 2019
Friday, March 15, 2019
8:30 – 9:30 a.m.
Marina 4
Session Agenda

- The “virtuous circle”
- Background Information
- Retrocommissioning & Response
- Evaluating Impact
- VRF Design Considerations
- Discussion

CEUs:

- AIA—1.0 LU/HSW
- BPI—1.0 hour
- GBCI 1.0 hour BD+C, ID+C, O+M, WELL
- MA CSL 1.0 hour Energy
learning Objectives

- Participants will review *highlights of a retrocommissioning report* for a multifamily building and explore how a retrocommissioning report can inform decision-making to improve a building’s energy performance.

- Participants will gain an understanding of *design considerations for using VRFs* in a multifamily building.

- Participants will be able to *evaluate* how the measures taken by the owner's team affected *building performance data* from pre to post.

- Participants will *participate in a discussion* to identify strategies to employ during design and operations to achieve desired energy performance for a property.
The “Virtuous Circle”
Background
And Initial Design Features
Benfield Farms

- Metrowest location—rural, no natural gas service
- 26 units of senior rental housing, mostly affordable
- “Friendly 40B” but complicated, with opposition
- Operational early 2014
Going-in Design Considerations

- Aesthetics/Opposition
- Gas vs. Electric
- VRFs vs. Mini-splits
- Heat Pumps Location
Initial Heat Pumps Location

Notice ductwork!
Terrible!

Bills Very High!

Demand Charges!
## Initial Cost 2014 & 2015

<table>
<thead>
<tr>
<th>YEAR</th>
<th>$/kWh</th>
<th>Total Use kWh</th>
<th>Gross Cost</th>
<th>PV kWh</th>
<th>PV Value</th>
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<th>Net Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014 (11 mo)</td>
<td>0.200</td>
<td>318,800</td>
<td>$63,661</td>
<td>0</td>
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</tr>
</tbody>
</table>
- Grasp Demand Charges
- Consider alternate supply sources
- Evaluate Impact of on-site PV
Initial Response: Add PV

- 44 kW system
- Completed late 2016
- Qualified for SRECs
Site with Roofs and PV locations
MEASURE AGAIN: Electricity Cost

**Improvement:**

- 2016 Meter Cost: $69,748
- 2017 Meter Cost: $57,857
- 2017 SRECs payments: $7,457
- Net reduction: $19,348
## Costs 2014-2017

<table>
<thead>
<tr>
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<td>$(1,418)</td>
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<tr>
<td>2019 (2 mo)</td>
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<td></td>
<td></td>
<td></td>
<td>Costs still considered high: What next?</td>
</tr>
</tbody>
</table>
Retrocommissioning

1. Design
2. Measure
3. Analyze
4. Adjust
5. Measure again
Next Step: Retrocommissioning Opportunity

- 2016: program funded through MassCEC, administered by Boston LISC
- Provided:
  - Site Inspection
  - Analysis
  - Report with Recommendations
- Work done by CLEAResult
- Report delivered early 2017
Findings:

- Agreed: Costs very high
- VRFs work: They do meet the heating & cooling loads of the building
- VRFs are NOT working efficiently
- Other high energy-use concerns to follow up on
Report Components

- Plans and Information
- Engineering documentation
- Building Energy Use
- Utility cost analysis
- Recommendations
Other Energy Use Concerns:

- Baseboard heat
- Air sealing at attic
- General high use relative to benchmarks
Graph 1: ACCU 1 - The ambient air around the outside units (Intake Air) is consistently cooler than the ambient air far away from the units (outside temperature). Heat pumps in heating mode work by making the outside air colder. The exhaust air is supposed to be colder than outside air. However, the intake air is supposed to be exactly equal in temperature to the outside air measured at a remote location. This demonstrates that colder rejection air is being re-entrained into the intakes of the outside units. The lack of delta between the Intake and Exhaust air also shows that the system is barely able to extract heat from the heat reservoir. A final note from this graph is that the system goes into defrost 5 times over the course of one day, which is often and is an energy efficiency penalty.
### Report Recommendations

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Priority</th>
<th>Who can do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address air flow at heat pump outdoor units</td>
<td>1</td>
<td>Mechanical contractor</td>
</tr>
<tr>
<td>Address insulation and line set routing at heat pump outdoor units</td>
<td>2</td>
<td>Mechanical contractor</td>
</tr>
<tr>
<td>Reconfigure outside units relative to area served</td>
<td>3</td>
<td>Mechanical contractor</td>
</tr>
<tr>
<td>Reduce fraction of electric resistance heat</td>
<td>4</td>
<td>Owner</td>
</tr>
<tr>
<td>Air seal attic</td>
<td>5</td>
<td>Air sealing contractor</td>
</tr>
<tr>
<td>Implement demand limiting on heat pumps</td>
<td>6</td>
<td>Owner with manufacturer’s representative</td>
</tr>
<tr>
<td>Reduce common area electrical baseload</td>
<td>7</td>
<td>Owner. May need assistance from electrical and/or energy contractors</td>
</tr>
</tbody>
</table>

Table 1. Summary of ECM recommendations
<table>
<thead>
<tr>
<th>OPTION</th>
<th>Cost</th>
<th>KWh Savings/yr</th>
<th>$$ Savings/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move Heat Pumps to the outdoors</td>
<td>$100,000</td>
<td>72,000</td>
<td>$14,400</td>
</tr>
<tr>
<td>Make changes in existing HP location: ductwork, lines</td>
<td>$16,000</td>
<td>43,200</td>
<td>$8,640</td>
</tr>
<tr>
<td>Stop resistance heat use</td>
<td>$0</td>
<td>5,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>Improve attic air barrier</td>
<td>$3,000</td>
<td>11,400</td>
<td>$2,300</td>
</tr>
</tbody>
</table>
What would you do?
Response & Impact
Response: Relocate the heat pumps
Prep & Installation

Slab Prep

Completed Relocation
## Impact: Energy Use

### Total Electricity Use (Meter + PV)

<table>
<thead>
<tr>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>2014</td>
<td>***</td>
<td>55,600</td>
<td>40,800</td>
<td>33,600</td>
<td>19,400</td>
<td>22,600</td>
<td>22,800</td>
<td>20,600</td>
<td>20,600</td>
<td>19,200</td>
<td>29,200</td>
<td>34,400</td>
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<tr>
<td>2015</td>
<td>48,000</td>
<td>51,200</td>
<td>37,600</td>
<td>27,400</td>
<td>19,200</td>
<td>22,600</td>
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<td>22,200</td>
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<td>2016</td>
<td>44,200</td>
<td>41,000</td>
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<td>28,200</td>
<td>21,800</td>
<td>22,800</td>
<td>25,800</td>
<td>26,800</td>
<td>23,400</td>
<td>20,800</td>
<td>30,957</td>
<td><strong>38,186</strong></td>
</tr>
<tr>
<td>2017</td>
<td>41,582</td>
<td>42,833</td>
<td>38,895</td>
<td>28,218</td>
<td>24,345</td>
<td>25,696</td>
<td>25,626</td>
<td>24,042</td>
<td>22,662</td>
<td>19,118</td>
<td>26,247</td>
<td>38,932</td>
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<tr>
<td>2018</td>
<td><strong>48,332</strong></td>
<td>38,144</td>
<td>30,867</td>
<td>30,691</td>
<td>25,782</td>
<td>26,377</td>
<td>25,072</td>
<td>23,030</td>
<td>20,755</td>
<td>20,435</td>
<td>31,352</td>
<td>36,317</td>
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<tr>
<td>2019</td>
<td>42,325</td>
<td>38,050</td>
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*Heat Pump Move Complete*  
*PV Online*
## Costs through Feb 2019

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<td>$57,857</td>
<td>$(7,457)</td>
<td>$50,401</td>
</tr>
<tr>
<td>2018</td>
<td>0.210</td>
<td>357,153</td>
<td>$75,091</td>
<td>46953</td>
<td>$(9,872)</td>
<td>$65,220</td>
<td>$(13,685)</td>
<td>$51,535</td>
</tr>
<tr>
<td>2019 (2 mo)</td>
<td>0.190</td>
<td>80,374</td>
<td>$15,271</td>
<td>4574</td>
<td>$(869)</td>
<td>$14,402</td>
<td>$(4,674)</td>
<td>$9,728</td>
</tr>
</tbody>
</table>
Impact: Project Costs & Benefits

COSTS:
- $107,000
- Project components: Heat Pumps Move, Slab, New Fence Surround

BENEFITS
- Projected annual savings:
  - 72,000 kWh/yr
  - $14,400/yr
  - 7.5 yr payback
- Actual 2018 savings:
  - 1,044 kWh
  - $219
  - 498 yr payback
### Heating & Cooling Degree Days

<table>
<thead>
<tr>
<th>Year</th>
<th>HDD</th>
<th>CDD</th>
<th>TDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>5704</td>
<td>769</td>
<td>6473</td>
</tr>
<tr>
<td>2015</td>
<td>5651</td>
<td>921</td>
<td>6572</td>
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<tr>
<td>2016</td>
<td>5177</td>
<td>1035</td>
<td>6212</td>
</tr>
<tr>
<td>2017</td>
<td>5310</td>
<td>881</td>
<td>6191</td>
</tr>
<tr>
<td>2018</td>
<td>5391</td>
<td>1133</td>
<td>6524</td>
</tr>
</tbody>
</table>

- Design
- Measure
- Analyze
- Adjust
- Measure again
<table>
<thead>
<tr>
<th>Year</th>
<th>Total kWh/TDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>826</td>
</tr>
<tr>
<td>2016</td>
<td>863</td>
</tr>
<tr>
<td>2017</td>
<td>920</td>
</tr>
<tr>
<td>2018</td>
<td>821</td>
</tr>
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### 2017-2018 Comparison kWh/TDD

![Graph showing kWh/TDD comparison between 2017 and 2018]
Issues

- Gas vs. Electric
- VRFs vs Mini-splits
- Heat Pumps Locations
- **Demand Charges**
Discussion
Your Questions
My Questions

- Who should be tracking performance? Why is it so hard?
- Why is it so hard to get good data?
- How can small organizations manage big efforts like this?
- How can we get the best information to decision-makers—during design and for operations?
- Would solar storage help?
Recap: Learning Objectives

- Participants will review *highlights of a retrocommissioning report* for a multifamily building and explore how a retrocommissioning report can inform decision-making to improve a building’s energy performance.

- Participants will gain an understanding of *design considerations for using VRFs* in a multifamily building.

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- Participants will *participate in a discussion* to identify strategies to employ during design and operations to achieve desired energy performance for a property.
CONTACT INFORMATION:

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E: kim.vermeer@urbanhabitatinitiatives.com
T: (617) 423-5566

Thank-you!