The Value of O&M Training

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BUILDING performance LAB
Operations & Maintenance (O&M)

- O&M is more than maintenance and repair
- Analyzing operations for efficiency is a skill
- Energy equipment, commissioned, retro-commissioned—now what?
- NYC is considering making O&M certification mandatory for operators who manage larger buildings because...

‘...even when staff meticulously maintain equipment, operation that relies on inadequate control strategies or improper scheduling can result in significant energy waste, higher energy bills, reduction equipment life, and poor indoor environmental quality.’ – PECI
Beyond the O&M Assessment

To achieve savings, we need to go beyond the O&M assessment:

- Challenges going from recommendations to implementation

- Persistence of Savings
  (One-time O&M consultants vs. training long-term personnel)

- Knowledge Diffusion
O&M Training Programs in NYC

- BPI Multifamily Energy Efficient Building Operator XX Hr
- BOC Building Operator Certification 60-90 Hr
- BRT Building Re-Tuning 15 Hr
- GPRO Green PROfessionals 12 Hr
# Topics in O&M Training

<table>
<thead>
<tr>
<th>BOC Level I</th>
<th>BOC Level II</th>
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<tr>
<td>Building Systems Overview</td>
<td>Preventative Maintenance &amp; Operations</td>
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<td>Advanced Electrical Diagnosis</td>
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<td>HVAC Systems and Controls</td>
<td>HVAC Troubleshooting &amp; Maintenance</td>
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<td>Efficient Lighting Fundamentals</td>
<td>HVAC Controls and Optimization</td>
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<td>Maintenance and Related Codes</td>
<td>Advanced Indoor Air Quality</td>
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<td>Indoor Air Quality</td>
<td>Energy Audit</td>
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<tr>
<td>Facility Electrical Systems</td>
<td>Advanced Lighting Applications</td>
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O&M Training – Results & Benefits

**Facilities Personnel**

- Familiar with the baseline performance of the building systems
- Track building performance
- Monitor/maintain equipment efficiency
- Optimize equipment operations
- Specify energy and environmental goals with suppliers and contractors
- Familiarity with local utility energy and water efficiency programs/requirements

**Building Performance**

- Energy and demand Savings
- Persistence in savings from commissioning activities
- Improved Indoor Environmental Quality (IEQ)
- Increase equipment life

Performance improvement by:

- Better scheduling
- Equipment performance tracking
- Diagnosing inefficiencies (ex. simultaneous heating and cooling)

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*Adapted from Cynthia Putnam and Stan Price’s The Right Stuff: Preparing the Facilities Engineering Workforce for the Sustainable Workplace*
O&M Training

Methods for Achieving Better Performance
O&M Training: Learning Tools of the Trade

- All stocked in BPL’s Field Equipment Lending Library!
• Even a seemingly modest (small) increase in motor efficiency can lead to measurable (often large) reductions in energy use and costs.

• Electrical should be inspected with a thermographic scan to ensure that connections at the motor and starter are clean and tight.

• Provide good ventilation to dissipate heat.

For every 20° F increase in motor operating temperature, motor life is estimated to be halved!
O&M Training: Identifying Equipment Operation Issues
O&M Training: Managing Oversized Equipment

- Buildings always designed for peak conditions (winter/summer).
- Equipment operates most efficiently at designed load.
- Most of the year the equipment is oversized! (Operates at partial load.)

O&M can address by: Load Matching – Partial Load Management

- **Modulation**
  Control of the capacity of the equipment over a range. Ex. 25%-100%.

- **Lead-lag Adjustment**
  Control capacity by controlling the number of boilers on-line.

- **Temperature Reset**
  Change the set point of the system’s working fluid based on outdoor temperature.
  Applies well to hot water but not to steam.

- **Variable Drives**
  Variable speed/frequency drives for pumps and fans
O&M Training: Addressing Simultaneous Heating/Cooling

- Often significant energy savings comes from reducing energy use in the shoulder months.

- Cold mornings + warm afternoons = buildings prone to simultaneous heating and cooling.

- Can be identified with close monitoring and addressed through operations.
O&M Training: Optimizing Heating and Cooling

- Loads are not steady over the course of a day or in all areas of a building
- Morning start-up issues
  - How long does it take the building to come up to temperature?
  - Demand prices vary by time of day
- Thermal momentum
  - The difference of “heavy” vs “light” construction
  - Dealing with “control overshoot”
  - Identifying opportunities for early shut-down?
- Varying solar gains and activities
  - Heightening awareness and perception
- Data loggers can help identify solutions!
O&M Training: Optimizing Scheduling

Results

- Optimized for occupancy
- Reduced energy demand (kW)
- Reduces energy use (kWh)

Graphs showing consumption over time with marked periods for Long Shutdown and Small consumption increase when building is unoccupied on weekends. Graphs also highlight 80% reduction in load from peak to base and Good startup/shutdown with no weekend operation.
Energy Savings from O&M

O&M Training Evaluation Results
**Energy Savings from O&M**

### Summary of Commercial Building O&M-Related Energy Savings Studies

<table>
<thead>
<tr>
<th>Estimated Savings, %</th>
<th>Date of Study</th>
<th>Information Source</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.4</td>
<td>1992</td>
<td>Herzog, P., and L. LaVine, “Identification and Quantification of the Impact of Improper Operation…” ACEEE.</td>
<td>3-year study of seven office buildings to quantify improved operations potential</td>
</tr>
<tr>
<td>23</td>
<td>1994</td>
<td>Liu, M., et al., “Identifying and Implementing Improved Operation and Maintenance Measures…” ACEEE.</td>
<td>35-building and 104-school summary of energy cost savings from improved O&amp;M.</td>
</tr>
</tbody>
</table>

Source: Opinion Dynamics
## Energy Savings from O&M | Heating

### Savings Associated with Specific O&M Heating System Efficiency Measures

<table>
<thead>
<tr>
<th>Efficiency Measure</th>
<th>Approximate Fuel Savings</th>
<th>Related O&amp;M Behaviors in Building w/o BMS</th>
</tr>
</thead>
</table>
| Keep heating and hot water systems well maintained with regular boiler tube cleanings and yearly combustion efficiency tests. Adjust air/fuel ratio for increased efficiency. Maintain well-functioning steam traps, air valves and shutoff valves on all radiators [4]. | 20% or more              | • Identify and promptly repair system leakage.  
• Maintain boiler efficiency.                                                      |
| Install an energy or building management system (EMS/BMS) that takes indoor air temperature into account for heating control [4]. | 15-25%                   | • Reduce unnecessary heating  
• Optimize boiler and/or RTU start and stop.  
• Adjust temperatures and/or flow resets on hot water systems                        |
| Use an EMS/BMS and zoning system to create different heating zones in a building [4]. | 20% or more              | • Identify and reduce unnecessary heating                                                                 |

Source: Adapted from Urban Green Council & EDF
## Savings from BOC

### Evaluation of BOC Savings Results (Units / Participant / Sq. Ft.)

<table>
<thead>
<tr>
<th>Area Served</th>
<th>Electric (kWh)</th>
<th>Gas (Therms)</th>
<th>Annual Energy (MMBtu)</th>
<th>Water (Gal)</th>
<th>Rebates</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>0.18</td>
<td>-</td>
<td>0.71</td>
<td>0.14</td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>Northeast</td>
<td>0.35</td>
<td>-</td>
<td>0.74</td>
<td>0.14</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Kansas City</td>
<td>0.02</td>
<td>0.52</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>2</td>
</tr>
<tr>
<td>Minnesota</td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

*Adapted from RLW Analytics and Opinion Dynamics*
### Savings Evaluation Factors

#### Table 3. Basis of Savings Quantified by Program

<table>
<thead>
<tr>
<th>Measures Installed and O&amp;M Changes</th>
<th>NEEA</th>
<th>MN MEEA</th>
<th>KCP&amp;L (I, O&amp;M)</th>
<th>NEEP</th>
<th>APS (O&amp;M)</th>
<th>Other Programs</th>
</tr>
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<tbody>
<tr>
<td>Lighting Controls</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X (I, O&amp;M)</td>
</tr>
<tr>
<td>Lighting Equipment</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X (I, O&amp;M)</td>
</tr>
<tr>
<td>Efficient Motors</td>
<td>X</td>
<td>X</td>
<td>X (I, O&amp;M)</td>
<td>X</td>
<td>X (O&amp;M)</td>
<td>X (I, O&amp;M)</td>
</tr>
<tr>
<td>VFDs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>HVAC</td>
<td>X (I, O&amp;M)</td>
<td>X (I, O&amp;M)</td>
<td>X (I, O&amp;M)</td>
<td>X (I, O&amp;M)</td>
<td>X (I, O&amp;M)</td>
<td>X (I, O&amp;M)</td>
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<tr>
<td>Domestic Hot Water</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X (I, O&amp;M)</td>
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Case Studies in O&M Savings
Case Studies in O&M | Raytheon
1.8 million square feet; 2 city blocks

10 MW feeder to the building

All electric, perimeter box reheat

4 chillers, 3 1500-ton, 1 500-ton

Variable chilled water flow

Paired VAV air handler for each floor

Mostly glass all sides

True VAV facility

~ 100 air handlers total
Atlanta Federal Center - Before & After BRT

- Re-commission unoccupied modes.
- Re-commission variable chilled water pumping and chillers.

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>Three 150 HP secondary chilled water pumps running 100% 24/7.</td>
<td>One, sometimes two, pumps most days. One pump 50% at night.</td>
</tr>
<tr>
<td>Chilled water temperature: 42°F.</td>
<td>Reset to 48°F based on humidity and load at coils.</td>
</tr>
<tr>
<td>Two 1,500 ton chillers run all night to cool 2-250 SF server rooms.</td>
<td>Forced the engineers to fix the smaller chiller at 500 ton and made it run all night, to save energy.</td>
</tr>
<tr>
<td>This 500 SF space out of 1.8 million SF was driving the cost of the building.</td>
<td></td>
</tr>
</tbody>
</table>
- Installed **discharge air temperature resets** based on warmest interior & coolest exterior zones.

- **Locked out outside air** during morning warm-up/cool-down.

- Installed **discharge air pressure resets** based on VAV box damper positions. Run at 75% open. Now 3 identical floors will run from 0.5” to 1.5” of static pressure.

- Changed dead bands on interior and exterior to allow for **floating temperature**. Open bays with set points as much as 5 degrees difference from zone to zone.
Atlanta Federal Center - Impact

- Received Energy Star rating.
- Energy down 15% to 20%.
- Peak down on shoulder months.
- Tenant complaints down 35%.
QUESTIONS?

Thanks!