City of Fort Collins
Building Automation Systems – Enhances Savings and Commissioning Efficiency Works Training

November 18, 2015
Agenda

• Commissioning
• Monitoring Based Commissioning
• Building Tune-up Case Studies
• Small Commercial Building Solutions
Building Commissioning Terms

- **Cx** = New Construction Commissioning
- **RCx** = Retro-Commissioning
- **Re-Cx** = Re-Commissioning
- **CCx** = Continuous Commissioning
- **MBCx** = Monitoring Based Commissioning
- **Ongoing Cx** = Ongoing Commissioning

**Single Instance / Periodic Activities**

**Ongoing Optimization**
Drivers for Ongoing Cx

• Four years after energy efficiency projects were completed, energy savings dropped by 25% (loss of ~ 6%/year)

• 22 of 96 (23%) energy efficiency measures failed since installation 3-4 years ago
  *SBW, Final Report 2006-08 CA RCx Impact Evaluation, 2010
Figure 1. MBCx provides three streams of additional energy savings relative to RCx.

*Lawrence Berkeley National Laboratory, June 2009 report - Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects
OCx Drivers – Common RTU Faults

- Economizers
- Refrigerant charge
- Low airflow
- Cycling fans during occupied period
- Fans run during unoccupied period
- Simultaneous heating and cooling
- No outside air intake at unit

*Public Interest Energy Research Program, 500-03-082*
Ongoing Cx Process

• **Optimize** with Cx/RCx – correct issues, change sequences
• **Track** performance - monitor operation over time
• **Test** equipment with faults, make **repairs** (fix issues, calibrate, fine tune)
• Update **documentation** and **staff training**
• **Verify** energy consumption and savings with monitored data
Implementing OCx / MBCx

• Monitoring Based Commissioning (MBCx)
  – Automated Ongoing Cx
  – Integrate to the Building Automation System
• Bacnet, Lon, OBIX, SQL, Haystack
• Link MBCx Software Server to BAS data
Iconergy Project Approach

- Monitoring Based Commissioning
  - Retro-Commissioning
  - Ongoing Commissioning

- Continuous Monitoring-based Commissioning
- Performance for the life of the building
Measures Identified and Completed:

✓ Replaced Broken Pool Humidity Sensor
✓ Corrected schedules for Non-Pool RTUs
✓ Reset outside airflow and controls for Pool RTUs
✓ Improved Pool Exhaust Airflow Control
✓ Optimized Heat Recovery Pump and Damper Control
✓ Optimized Water Feature Controls
✓ Implemented Pool Daylighting Controls
✓ Optimized 2 RTU Economizers
## RCx Case Study: Mulberry Pool

<table>
<thead>
<tr>
<th>RCM Measure Description</th>
<th>Total Cost Savings</th>
<th>Measure Cost ($)</th>
<th>Simple Payback (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule Non-Pool RTUs (RTU-1 and RTU-2)</td>
<td>$998</td>
<td>$675</td>
<td>0.68</td>
</tr>
<tr>
<td>Control Outside Air on Pool RTUs (RTU-3 and RTU-4)</td>
<td>$16,101</td>
<td>$2,500</td>
<td>0.16</td>
</tr>
<tr>
<td>Pool Exhaust AirFlow Control</td>
<td>$11,442</td>
<td>$2,900</td>
<td>0.25</td>
</tr>
<tr>
<td>Optimize Heat Recovery Pump and F/B Damper Control</td>
<td>$2,617</td>
<td>$900</td>
<td>0.34</td>
</tr>
<tr>
<td>Optimize Water Feature Pumping</td>
<td>$532</td>
<td>$75</td>
<td>0.14</td>
</tr>
<tr>
<td>Pool Daylighting Controls</td>
<td>$636</td>
<td>$400</td>
<td>0.63</td>
</tr>
<tr>
<td>RTU-1 &amp; RTU-2 Economizer Optimization</td>
<td>$71</td>
<td>$600</td>
<td>8.48</td>
</tr>
<tr>
<td><strong>Totals (For all Selected (X) values only)</strong></td>
<td><strong>$32,396</strong></td>
<td><strong>$8,050</strong></td>
<td><strong>0.25</strong></td>
</tr>
</tbody>
</table>

### Percent Savings

<table>
<thead>
<tr>
<th>Type</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>11%</td>
</tr>
<tr>
<td>Gas</td>
<td>38%</td>
</tr>
</tbody>
</table>
RCx Case Study: Mulberry Pool

Natural Gas Cost

Electric Cost
RCx Case Study: Mulberry Pool

Mulberry Pool Natural Gas Greenhouse Gas Emissions

- December
- November
- October
- September
- August
- July
- June
- May
- March
- February
- January
RCx Case Study: Mulberry Pool

Electric Use

Mulberry Pool

Natural Gas Use

Mulberry Pool

Note 2015 gas data is missing Oct, Nov, Dec
Note 2015 electric data is missing Nov, Dec
RCx Case Study: Museum of Discovery

Measures Identified and Completed:

✓ Heating Plant ran 24/7/365
✓ Chiller Thermal Ice Storage Plant made ice every night
✓ AHUs and ERV were operating 24/7/365
✓ AHU Evap Cooling had a broken valve, didn’t operate
✓ Optimized AHU temp and pressure setpoints
✓ De-lamp daylight areas
Implementing OCx / MBCx
Implementing OCx / MBCx

- Writing “Rules”
  - Rules are used to identify operational or efficiency issues. Fault Detection Diagnostics
Implementing OCx / MBCx

CHWS = 13F
Implementing OCx / MBCx

• “Rule” Example
  – Ice Tank Thermal Energy Storage
    • Every night (7 days) Ice Charge enables when ice is already Full!
    • Pumps run, chiller runs at 100% for 1.5 hr
    • Secondary valve is 60% instead of 0% bldg
      – 13°F water to entire building
### RCx Case Study: Museum of Discovery

<table>
<thead>
<tr>
<th>RCM Measure Description</th>
<th>Annual Electric Energy Savings (kWh/yr)</th>
<th>Annual Gas Energy Savings (Therms/yr)</th>
<th>Total Cost Savings</th>
<th>Measure Incremental Cost ($)</th>
<th>Simple Payback (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Plant Lockout</td>
<td>1,781</td>
<td>1,444</td>
<td>$939</td>
<td>$675</td>
<td>0.72</td>
</tr>
<tr>
<td>Cooling Plant Lockout</td>
<td>5,964</td>
<td>-</td>
<td>$245</td>
<td>$675</td>
<td>2.76</td>
</tr>
<tr>
<td>Chiller Ice-Making Operation</td>
<td>22,562</td>
<td>-</td>
<td>$945</td>
<td>$675</td>
<td>0.71</td>
</tr>
<tr>
<td>Chilled Water Pump VFD Control</td>
<td>6,699</td>
<td>-</td>
<td>$275</td>
<td>$2,450</td>
<td>8.92</td>
</tr>
<tr>
<td>Utility Hot Shot Demand Limiting</td>
<td>-</td>
<td>-</td>
<td>$189</td>
<td>$675</td>
<td>3.57</td>
</tr>
<tr>
<td>AHU + ERV Schedule Operation</td>
<td>23,214</td>
<td>2,922</td>
<td>$2,714</td>
<td>$675</td>
<td>0.25</td>
</tr>
<tr>
<td>AHU Supply Duct Static Pressure Reset</td>
<td>530</td>
<td>-</td>
<td>$22</td>
<td>$675</td>
<td>31.02</td>
</tr>
<tr>
<td>AHU Unoccupied Mixed Air Temperature Control</td>
<td>1,909</td>
<td>605</td>
<td>$441</td>
<td>$375</td>
<td>0.85</td>
</tr>
<tr>
<td>ERV Direct Evap Control &amp; SAT Reset</td>
<td>1,510</td>
<td>206</td>
<td>$169</td>
<td>$1,700</td>
<td>10.08</td>
</tr>
<tr>
<td>South Hall and Entry Daylighting Control</td>
<td>818</td>
<td>-</td>
<td>$34</td>
<td>$4,075</td>
<td>119.04</td>
</tr>
<tr>
<td>Plug Load Management (3)</td>
<td>9,100</td>
<td>-</td>
<td>$378</td>
<td>$3,375</td>
<td>8.92</td>
</tr>
<tr>
<td><strong>Totals (For all Selected (X) values only)</strong></td>
<td><strong>74,086</strong></td>
<td><strong>5,177</strong></td>
<td><strong>$6,350.46</strong></td>
<td><strong>$16,025.00</strong></td>
<td><strong>2.52</strong></td>
</tr>
</tbody>
</table>
Note 2015 gas data is missing Oct, Nov, Dec
Note 2015 electric data is missing Nov, Dec
RCx Case Study: Museum of Discovery

Museum of Discovery Natural Gas Greenhouse Gas Emissions

- December
- November
- October
- September
- August
- July
- June
- May
- April
- March
- February
- January

2015 Goal (tons) | 2014 GHG (tons) | 2015 GHG (tons)
RCx Case Study: Museum of Discovery

Natural Gas Cost

Electric Cost
Measures Identified and Completed:

- Added schedules to Terminal VAV boxes (set to 0CFM)
- Install synchronous belts on large fans
- RTU hot water valve water leakby
## RCx Case Study: Police Services

<table>
<thead>
<tr>
<th>RCM Measure Description</th>
<th>Annual Electric Energy Savings (kWh/yr)</th>
<th>Annual Gas Energy Savings (Therms/yr)</th>
<th>Total Cost Savings</th>
<th>Measure Incremental Cost ($)</th>
<th>Simple Payback (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Plant Lockout</td>
<td>1,028</td>
<td>598</td>
<td>$401</td>
<td>$375</td>
<td>0.94</td>
</tr>
<tr>
<td>Adjust Hot Water Supply Temp Reset</td>
<td>(369)</td>
<td>65</td>
<td>$20</td>
<td>$150</td>
<td>7.50</td>
</tr>
<tr>
<td>Repair Hot Water Loop Differential Pressure Control</td>
<td>39,761</td>
<td>-</td>
<td>$1,965</td>
<td>$675</td>
<td>0.34</td>
</tr>
<tr>
<td>Utility Hot Shot Demand Limiting</td>
<td>-</td>
<td>-</td>
<td>$1,805</td>
<td>$675</td>
<td>0.37</td>
</tr>
<tr>
<td>Terminal Unit Scheduling</td>
<td>45,354</td>
<td>317</td>
<td>$2,127</td>
<td>$1,800</td>
<td>0.85</td>
</tr>
<tr>
<td>RTU-1/2 Duct Static Pressure Reset</td>
<td>5,734</td>
<td>-</td>
<td>$377</td>
<td>$675</td>
<td>1.79</td>
</tr>
<tr>
<td>RTU-3 Meeting Room Occupancy Control</td>
<td>12,034</td>
<td>424</td>
<td>$756</td>
<td>$3,575</td>
<td>4.73</td>
</tr>
<tr>
<td>RTU-3 Economizer Control</td>
<td>173</td>
<td>-</td>
<td>$27</td>
<td>$900</td>
<td>33.33</td>
</tr>
<tr>
<td>RTU-1/2 Hot Water Valve Leakby</td>
<td>13,803</td>
<td>6,928</td>
<td>$4,745</td>
<td>$4,400</td>
<td>0.93</td>
</tr>
<tr>
<td>Corridor Delamping / Daylighting Controls</td>
<td>23,836</td>
<td>-</td>
<td>$1,032</td>
<td>$750</td>
<td>0.73</td>
</tr>
<tr>
<td>Install Synchronous Belts on RTUs</td>
<td>4,566</td>
<td>-</td>
<td>$1,292</td>
<td>$1,818</td>
<td>1.41</td>
</tr>
<tr>
<td>Lobby Electric Baseboard</td>
<td>23,743</td>
<td>-</td>
<td>$1,070</td>
<td>$225</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Totals (For all Selected (X) values only)</strong></td>
<td><strong>8,267</strong></td>
<td><strong>$4,960.00</strong></td>
<td><strong>$15,617.00</strong></td>
<td><strong>$15,868.00</strong></td>
<td><strong>1.02</strong></td>
</tr>
</tbody>
</table>
RCx Case Study: Police Services

Natural Gas Cost

Electric Cost
RCx Case Study: Police Services
RCx Case Study: Police Services

**Electric Use**

Police Services

- Electric Actual
- Electric Goal

**Natural Gas Use**

Police Services

- Natural Gas Actual
- Natural Gas Goal

Note 2015 gas data is missing Oct, Nov, Dec
Note 2015 electric data is missing Nov, Dec
Implementing OCx / MBCx

• Use Monitoring Based Commissioning for Retro-Cx
  – Let *Automated Fault Detection* Look for Issues
  – Leave MBCx tool behind for client to do Ongoing Cx

• Include it in specifications for new construction

Optimize the Building, and... *KEEP IT THAT WAY*
Small Commercial Energy Projects

• Energy Retrofits – Easier
  – Evap Coolers
  – LED Lighting
  – Appliances
  – Plug Loads
  – Weatherization

Electric Rebates

Cash Incentives for Energy-Saving Improvements

This program is designed to support building efficiency improvements, save money and lower electric bills. Cash incentives are provided for upgrades that reduce electric demand and energy use, including:

- Lighting
- Air conditioning and cooling
- Building tune-up (retro-commissioning)
- Motor variable frequency drives
- Mechanical equipment
- Building envelope (windows, insulation and roofing)
- Kitchen, laundry and grocery equipment
- Office equipment/IT
- Custom projects for efficiency upgrades to your facility and operations (e.g., compressed air systems and process improvements)
- Commercial appliances


Small Commercial Energy Projects

- **Energy Retrofits** – More Challenging
  - **Evap Condensing**
  - **Thermostats, Controls**
  - **Rooftop Unit Replacements**

**Electric Rebates**

Cash Incentives for Energy-Saving Improvements

This program is designed to support building efficiency improvements, save money and lower electric bills. Cash incentives are provided for upgrades that reduce electric demand and energy use, including:

- Lighting
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- Mechanical equipment
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- Custom projects for efficiency upgrades to your facility and operations (e.g., compressed air systems and process improvements)
- Commercial appliances


Small Commercial Energy Projects

• Retrofits
  – *Thermostats, Controls*
• *Networked Thermostats, Wired or Wireless*

• Building Automation System Integration
• Great for multiple facilities managed by single entity

Wifi, Control from Anywhere
Small Commercial Energy Projects

- **Retrofits**
  - *High Efficiency Rooftop Units*

### Cooling Efficiency
Pre-approval required

<table>
<thead>
<tr>
<th>Equipment Type &amp; Cooling Capacity (tons)</th>
<th>Peak Efficiency</th>
<th>Seasonal or Part-Load Efficiency</th>
<th>Base Incentive ($/ton)</th>
<th>Increment</th>
<th>Incremental Incentive ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Split/Unitary Cooling Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5.4 tons, split system</td>
<td></td>
<td>12.5 EER</td>
<td>15.0 SEER</td>
<td>0.1</td>
<td>SEER</td>
</tr>
<tr>
<td>&lt;5.4 tons, unitary</td>
<td>&lt;65,000 Btu/h</td>
<td>12.0 EER</td>
<td>15.0 SEER</td>
<td>0.1</td>
<td>SEER</td>
</tr>
<tr>
<td>5.5–11.2 tons</td>
<td>65,000–134,999</td>
<td>12.0 EER</td>
<td>13.8 IEER</td>
<td>0.1</td>
<td>IEER</td>
</tr>
<tr>
<td>11.3–19.9 tons</td>
<td>135,000–239,999</td>
<td>12.0 EER</td>
<td>13.0 IEER</td>
<td>0.1</td>
<td>IEER</td>
</tr>
<tr>
<td>20–63.3 tons</td>
<td>240,000–759,999</td>
<td>10.6 EER</td>
<td>12.1 IEER</td>
<td>0.1</td>
<td>IEER</td>
</tr>
<tr>
<td>&gt;63.4 tons</td>
<td>&gt;760,000 Btu/h</td>
<td>10.2 EER</td>
<td>**</td>
<td>0.1</td>
<td>IEER</td>
</tr>
<tr>
<td><strong>Packaged Terminal Air Conditioning (PTAC) Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;4.2 tons, PTAC</td>
<td>&lt;50,000 Btu/h</td>
<td>11.0 EER</td>
<td>n/a</td>
<td>0.1</td>
<td>EER</td>
</tr>
</tbody>
</table>

* Economizer: when added to an existing AC unit or replacement unit where one didn’t previously exist: $250/unit

** Custom rebate may be available.
THANK YOU!

Doug Hargrave
303-246-4967
dhargrave@iconergyco.com

Erik Jeannette
720-949-5943
ejeannette@iconergyco.com

John Sellers
303-324-9471
jsellers@iconergyco.com

Stu Reeve
970-221-6274
sreeve@fcgov.com