RETROCOMMISSIONING
 Challenges & Opportunities

Stephany Cull, BEP, CBCxP, CSDP
Bio for Stephany L. Cull, BEP, CBCP, CSDP


Stephany has been involved in the energy & technical services industry for more than twenty-five years. She has direct experience in facility operations & maintenance, HVAC & lighting control systems, and demand side energy efficiency applications, in both the United States and Canada. Ms. Cull holds designations as a Certified Business Energy Professional, as a Certified Building Commissioning Professional and as a Certified Sustainable Development Professional, from the Association of Energy Engineers.

Ms. Cull is a sought after speaker and recognized subject matter expert on the topics of Energy Retrocommissioning and Ongoing Commissioning. She has presented papers at events across the U.S. including the World Energy Engineering Congress, IFMA Industries Forum, IFMA California Sustainability Mayday, at the Pacific Energy Center, the Bay Area Sustainable Buildings Conference, the Green Action Summit, Facility Decisions Conference, at the National Facility Management & Technology Conference, at the California Society for Healthcare Engineering Annual Institute, at the Institute of Real Estate Management, and others.

Stephany is the author of the Retrocommissioning section in the Encyclopedia of Energy Engineering & Technology and she has published articles appearing in the BOMA San Francisco Bulletin, the California Society for Healthcare Engineering News and Facility Care Magazine. Ms. Cull is a member of the BOMA California Energy Committee and the BOMA International Energy & Environment Committee. Ms. Cull has represented BOMA on energy legislation issues in Washington, DC and she is an active and supportive voice for energy efficiency and sustainable operations in public and private sector facilities.
Basic Definitions

- **Commissioning (Cx)** performed during original project design and construction

- **ReCommissioning (Rx)** periodic testing, adjusting, and/or repair to maintain performance achieved during original Cx or RCx process

- **RetroCommissioning (RCx) or Existing Building Commissioning** performed for existing buildings that were not originally Commissioned - Almost all buildings
Basic RCx Definitions

- A systematic process used to discover existing building system design & operating deficiencies that adversely impact energy use.
- Typically focused on:
  - Heating, Ventilating & Air Conditioning Equipment
  - HVAC Control Systems
  - Lighting & Lighting Control systems
  - Domestic Water Systems
  - Building Envelope
- This is **not** an ASHRAE Level 1/2/3 Energy Audit.
- This **is** about making what you already have work more efficiently.
- This is low cost and sometimes, no cost repairs and adjustments.
RCx Financial Facts

- Median annual savings for RCx projects is 16% (LBNL)
  - Much higher in Healthcare and other 24/7 facilities

- Median simple paybacks for RCx are 1.1 years (LBNL)
  - Most EPC retrofits carry paybacks greater than 10 years

- Median cash on cash returns for RCx are 91% (LBNL)
  - Hard to compete when compared to other investments

*LBNL - Lawrence Berkeley National Laboratories, July 2009 RCx Study*
Challenges

- Most of the existing building stock in the US was not Commissioned during construction.
- Owners inherit buildings with existing deficiencies that are difficult to discover.
- This is not the fault of Architect or the MEP - rather it is just our construction paradigm.
- "Value Engineering" which is a normal part of the construction process does not contain any value at all.
- The norm is having the General, Mechanical, Electrical, Plumbing, or Controls vendor "Commission" their own work.
- Control systems are particularly vulnerable to programming & completion abuse.
Our Construction Paradigm

} Design Issues
  } Boiler Plate specs create a high rate of misapplication
  } Risk mitigation by over sizing – up to 15% is common
  } Project cost pressure & urgency – owner driven

} Construction Defects
  } Generally from the absence of Commissioning
  } Nobody is looking out for the owner’s interest
  } Low Bid = skinny margins = corners cut
Existing Building Realities

- Equipment & Systems are complex & inter-dependent
  - Poorly controlled “efficient systems” tends to defeat the purpose

- Traditional maintenance activities are devoid of tasks that impact energy performance
  - Maintenance tasks emphasize “uptime” instead of “performance”
  - Grease, oil, visually inspect, tighten, observe, check
  - Little energy value in many of the tasks we take for granted
  - Cleaning a coil does not ensure the economizer works
  - Information at the BAS front end is not necessarily accurate

- Building Operators are expected to do more with less!
  - Today’s building systems are complex beyond the basic training provided to facility personnel & building operators
  - And remember, we “Value Engineered” all the training out!
Consequences
The Case for Commissioning

The Case for Commissioning

Newer buildings are equally represented across all quartiles.

Based on a sample of 4,000 buildings nationwide.
The Case for Commissioning

Nobody noticed that the Chiller was coming on in the middle of the night.
The Case for Commissioning

Out of Sight, Out of Mind!
The Case for Commissioning

Outdoor Air Damper linkage is in need of attention
The Case for Commissioning

Static Pressure Sensor is too close to the supply fan to deliver appropriate control at the zone level.
The Case for Commissioning

Which valve is controlling flow?
The Case for Commissioning

According to the CEC, 70% of the Economizers in the State are incorrectly sequenced.
The Case for Commissioning

Apparently the Photocell is not functioning
The Case For Commissioning

This chilled water system had a history of failing to meet demand!
The Case for Commissioning

There is no substitute for first hand observation. The inlet vanes on this fan were frozen in position.
The Case for Commissioning

I wonder if these Damper Actuators actually work?
The Case for Commissioning

The filters need to fit the application!
The Case for Commissioning

General Controls Problems
Example from a 300,000 sq ft cleanroom facility

Implementation Cost $7,000
Annual Savings $84,000
Payback: 0.1 year

*Courtesy of Portland Energy Conservation Inc.*
Cost Implications
### RCx Rewards

80,000SF Office Building

<table>
<thead>
<tr>
<th>#</th>
<th>Recommended Measures</th>
<th>kWh/yr Savings</th>
<th>$/therm Savings</th>
<th>$ Maint Savings</th>
<th>Total $ Savings</th>
<th>Estimated $ Cost</th>
<th>In House</th>
<th>Simple Payback</th>
<th>Cumulative Net Cost</th>
<th>Cumulative Savings</th>
<th>Cumulative SPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overhaul &amp; Reestablish scheduled operation of Rooftop HVAC Units</td>
<td>189,305</td>
<td>1,728</td>
<td>$0</td>
<td>$24,037</td>
<td>$8,500</td>
<td>No</td>
<td>0.3</td>
<td>$8,500</td>
<td>$24,037</td>
<td>0.27</td>
</tr>
<tr>
<td>2</td>
<td>Overhaul and Reestablish scheduled operation of Boilers &amp; HW pumps</td>
<td>27,140</td>
<td>31,426</td>
<td>$0</td>
<td>$34,288</td>
<td>$5,800</td>
<td>No</td>
<td>0.2</td>
<td>$12,300</td>
<td>$58,322</td>
<td>0.21</td>
</tr>
<tr>
<td>3</td>
<td>Install Damper on Heat Pump Outdoor Air Intake</td>
<td>10,691</td>
<td>0</td>
<td>$0</td>
<td>$1,308</td>
<td>$2,400</td>
<td>No</td>
<td>1.7</td>
<td>$14,700</td>
<td>$59,720</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>Provide schedule control for DHW recirculation pumps</td>
<td>2,146</td>
<td>4</td>
<td>$0</td>
<td>$287</td>
<td>$700</td>
<td>No</td>
<td>2.4</td>
<td>$15,400</td>
<td>$60,007</td>
<td>0.26</td>
</tr>
<tr>
<td>5</td>
<td>Repair or replace GE Lighting Controller, connect relay panels on Floors 2 - 6 and program</td>
<td>97,742</td>
<td>0</td>
<td>$0</td>
<td>$12,802</td>
<td>$6,400</td>
<td>No</td>
<td>0.5</td>
<td>$21,800</td>
<td>$72,909</td>
<td>0.30</td>
</tr>
<tr>
<td>6</td>
<td>Stairwell Lighting Retrofit</td>
<td>19,049</td>
<td>0</td>
<td>$0</td>
<td>$2,514</td>
<td>$6,120</td>
<td>No</td>
<td>2.4</td>
<td>$27,920</td>
<td>$75,423</td>
<td>0.37</td>
</tr>
<tr>
<td>7</td>
<td>Retrofit Two Existing Ultrasonic Occupancy Sensors with Two Infrared Occupancy Sensors</td>
<td>5,276</td>
<td>0</td>
<td>$0</td>
<td>$696</td>
<td>$400</td>
<td>No</td>
<td>0.6</td>
<td>$28,320</td>
<td>$76,120</td>
<td>0.37</td>
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<tr>
<td>8</td>
<td>Basement Lighting Retrofit</td>
<td>20,249</td>
<td>0</td>
<td>$0</td>
<td>$2,673</td>
<td>$3,000</td>
<td>No</td>
<td>1.1</td>
<td>$31,320</td>
<td>$78,793</td>
<td>0.40</td>
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<td>9</td>
<td>Shut down redundant 3-ton Liebert Unit</td>
<td>10,306</td>
<td>0</td>
<td>$0</td>
<td>$1,360</td>
<td>$0</td>
<td>Yes</td>
<td>0.0</td>
<td>$31,320</td>
<td>$80,153</td>
<td>0.39</td>
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<tr>
<td>10</td>
<td>Increase control differentials on 3-ton Liebert unit</td>
<td>7,200</td>
<td>0</td>
<td>$0</td>
<td>$950</td>
<td>$0</td>
<td>Yes</td>
<td>0.0</td>
<td>$31,320</td>
<td>$81,103</td>
<td>0.39</td>
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<tr>
<td>11</td>
<td>Reset Heating Hot Water Setpoint to minimize total energy usage</td>
<td>0</td>
<td>424</td>
<td>$0</td>
<td>$414</td>
<td>$800</td>
<td>No</td>
<td>1.9</td>
<td>$32,120</td>
<td>$79,207</td>
<td>0.41</td>
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<td>12</td>
<td>Reset Condenser Water Setpoint to minimize total energy usage</td>
<td>1,269</td>
<td>0</td>
<td>$0</td>
<td>$168</td>
<td>$400</td>
<td>No</td>
<td>2.4</td>
<td>$32,520</td>
<td>$79,374</td>
<td>0.41</td>
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<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td><strong>370,273</strong></td>
<td><strong>33,581</strong></td>
<td><strong>$0</strong></td>
<td><strong>$81,685</strong></td>
<td><strong>$32,520</strong></td>
<td><strong>0.4</strong></td>
<td><strong>0.41</strong></td>
<td><strong>$79,374</strong></td>
<td><strong>0.41</strong></td>
<td><strong>0.41</strong></td>
</tr>
</tbody>
</table>

Existing consumption: 1,511,700 kWh, 62,338 therms
% of existing consumption: 24% kWh, 54% therms

A 31% Decrease in Energy Costs!

Note the Simple Payback
80,000SF Office Building

RCx Rewards
<table>
<thead>
<tr>
<th>#</th>
<th>Measure</th>
<th>Updated Annual Electric Savings (kWh)</th>
<th>Updated Annual Electric Savings ($)</th>
<th>Updated Annual Gas Savings (therms)</th>
<th>Updated Annual Gas Savings ($)</th>
<th>Updated Annual Total Savings ($)</th>
<th>Updated Peak Demand Savings (kW)</th>
<th>Actual Implementation Cost ($)</th>
<th>Updated Simple Payback (years)</th>
<th>Final Program Incentive ($)</th>
<th>Updated Simple Payback with Incentive (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Turn off atrium lights when sufficient daylight is available, and late nights/weekends when building</td>
<td>139,606</td>
<td>$11,107</td>
<td>0</td>
<td>$0</td>
<td>$11,107</td>
<td>1</td>
<td>$13,338</td>
<td>1.2</td>
<td>$0</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>Control chiller #4 with VFD to match load</td>
<td>266,635</td>
<td>$20,660</td>
<td>0</td>
<td>$0</td>
<td>$20,660</td>
<td>0</td>
<td>$48,000</td>
<td>2.3</td>
<td>$21,331</td>
<td>1.3</td>
</tr>
<tr>
<td>3</td>
<td>Reset CHW based on ambient between 42 and 44°F; Reset CW based on ambient wet bulb temperature plus cooling tower range, between minimum and maximum recommended by chiller manufacturer</td>
<td>126,274</td>
<td>$4,374</td>
<td>0</td>
<td>$0</td>
<td>$4,374</td>
<td>21</td>
<td>$1,640</td>
<td>0.4</td>
<td>$0</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Control CW pumps with VFDs, setting speed for rated flow with valves 100% open</td>
<td>161,610</td>
<td>$12,986</td>
<td>0</td>
<td>$0</td>
<td>$12,986</td>
<td>64</td>
<td>$21,840</td>
<td>1.7</td>
<td>$12,929</td>
<td>0.7</td>
</tr>
<tr>
<td>5</td>
<td>Open throttled valves, control CHW pumps with VFDs, and control speed based on differential pressure at 48th floor</td>
<td>114,434</td>
<td>$10,107</td>
<td>0</td>
<td>$0</td>
<td>$10,107</td>
<td>50</td>
<td>$27,440</td>
<td>2.7</td>
<td>$9,155</td>
<td>1.8</td>
</tr>
<tr>
<td>6</td>
<td>Open throttled valves, control HW pumps with VFDs, and control speed based on differential pressure at 48th floor</td>
<td>35,864</td>
<td>$3,522</td>
<td>0</td>
<td>$0</td>
<td>$3,522</td>
<td>4</td>
<td>$1,680</td>
<td>0.5</td>
<td>$0</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>Resheave 18 AHU fans back to near design CFM ratings</td>
<td>174,933</td>
<td>$26,682</td>
<td>0</td>
<td>$0</td>
<td>$26,682</td>
<td>52</td>
<td>$3,689</td>
<td>0.1</td>
<td>$0</td>
<td>0.1</td>
</tr>
<tr>
<td>10</td>
<td>Control garage lighting based on time of day schedule to be on 4am - 11pm weekdays and off weekends</td>
<td>55,263</td>
<td>$4,009</td>
<td>0</td>
<td>$0</td>
<td>$4,009</td>
<td>0</td>
<td>$4,500</td>
<td>1.1</td>
<td>$0</td>
<td>1.1</td>
</tr>
<tr>
<td>11</td>
<td>Control restroom lights with occupancy sensors</td>
<td>73,455</td>
<td>$9,762</td>
<td>0</td>
<td>$0</td>
<td>$9,762</td>
<td>0</td>
<td>$13,398</td>
<td>1.4</td>
<td>$0</td>
<td>1.4</td>
</tr>
<tr>
<td>All Findings</td>
<td></td>
<td>1,148,074</td>
<td>$103,208</td>
<td>0</td>
<td>$0</td>
<td>$103,208</td>
<td>191</td>
<td>$135,525</td>
<td>1.3</td>
<td>$43,414</td>
<td>0.9</td>
</tr>
</tbody>
</table>
## 25 Story Office Building

### Table of Energy Efficiency Measures:

<table>
<thead>
<tr>
<th>#</th>
<th>Measure</th>
<th>peak kW</th>
<th>kWh</th>
<th>lb steam</th>
<th>$ svgs</th>
<th>Cost</th>
<th>Simple Payback</th>
<th>Estimated Incentives</th>
<th>SPB w/ Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reset CW temp based on OA WB temp</td>
<td>21.0</td>
<td>13,555</td>
<td>-</td>
<td>$3,742</td>
<td>$1,770</td>
<td>0.5</td>
<td>$890</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>Optimize start time of fans, pumps</td>
<td>-</td>
<td>59,295</td>
<td>58,446</td>
<td>$9,143</td>
<td>$5,220</td>
<td>0.6</td>
<td>$2,610</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>Optimize economizer &amp; CO2 control</td>
<td>13.3</td>
<td>2,334</td>
<td>41,832</td>
<td>$2,922</td>
<td>$1,980</td>
<td>0.7</td>
<td>$990</td>
<td>0.3</td>
</tr>
<tr>
<td>4</td>
<td>Reset CHW differential pressure</td>
<td>1.2</td>
<td>4,288</td>
<td>-</td>
<td>$650</td>
<td>$1,000</td>
<td>1.5</td>
<td>$500</td>
<td>0.8</td>
</tr>
<tr>
<td>5</td>
<td>Add occupancy sensor lighting controls</td>
<td>-</td>
<td>431,437</td>
<td>-</td>
<td>$53,056</td>
<td>$126,330</td>
<td>2.4</td>
<td>$21,570</td>
<td>2.0</td>
</tr>
<tr>
<td>6</td>
<td>Control open CW loop pumps with VFDs</td>
<td>1.9</td>
<td>38,050</td>
<td>-</td>
<td>$4,871</td>
<td>$12,110</td>
<td>2.5</td>
<td>$3,910</td>
<td>1.7</td>
</tr>
<tr>
<td>7</td>
<td>Convert interior zones to VAV</td>
<td>15.1</td>
<td>233,869</td>
<td>-</td>
<td>$30,248</td>
<td>$115,680</td>
<td>3.8</td>
<td>$38,240</td>
<td>2.6</td>
</tr>
<tr>
<td>8</td>
<td>Control chiller CW pumps with VFDs</td>
<td>7.9</td>
<td>12,513</td>
<td>-</td>
<td>$2,323</td>
<td>$15,010</td>
<td>6.5</td>
<td>$4,000</td>
<td>4.7</td>
</tr>
</tbody>
</table>

**Total Savings:**

- kWh: 795,341
- lb steam: 100,278
- $ svgs: 106,955
- Cost: 279,100
- Payback: 2.6
- Estimated Incentives: $72,710
- SPB w/ Incentives: 1.9
<table>
<thead>
<tr>
<th>#</th>
<th>RetroCommissioning Measures</th>
<th>peak kW savings</th>
<th>kWh/yr savings</th>
<th>therm/yr savings</th>
<th>$ maint savings</th>
<th>Total $ savings</th>
<th>Estimate d $ cost</th>
<th>Simple Payback</th>
<th>$ rebates</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adjust start and stop times</td>
<td>0.0</td>
<td>137,429</td>
<td>2,954</td>
<td>$0</td>
<td>$14,234</td>
<td>$0</td>
<td>0.0</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Implement holiday schedules</td>
<td>0.0</td>
<td>25,768</td>
<td>554</td>
<td>$0</td>
<td>$2,669</td>
<td>$0</td>
<td>0.0</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Move janitorial hours earlier</td>
<td>0.0</td>
<td>43,000</td>
<td>0</td>
<td>$0</td>
<td>$3,354</td>
<td>$0</td>
<td>0.0</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Repair/adjust economizers; replace controls</td>
<td>0.0</td>
<td>183,711</td>
<td>1,986</td>
<td>$0</td>
<td>$16,693</td>
<td>$16,000</td>
<td>1.0</td>
<td>$0</td>
<td>104%</td>
</tr>
<tr>
<td>5</td>
<td>Reset supply air temps; upgrade controls</td>
<td>8.2</td>
<td>49,284</td>
<td>5,844</td>
<td>$0</td>
<td>$11,227</td>
<td>$15,696</td>
<td>1.4</td>
<td>$8,618</td>
<td>159%</td>
</tr>
<tr>
<td>6</td>
<td>Reduce heating lockout temp setpoints</td>
<td>0.0</td>
<td>1,808</td>
<td>986</td>
<td>$0</td>
<td>$1,315</td>
<td>$0</td>
<td>0.0</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Calibrate zone thermostats</td>
<td>2.4</td>
<td>11,791</td>
<td>273</td>
<td>$0</td>
<td>$1,368</td>
<td>$3,240</td>
<td>2.4</td>
<td>$1,162</td>
<td>66%</td>
</tr>
<tr>
<td>8</td>
<td>Adjust VAV box min volume settings</td>
<td>0.0</td>
<td>6,485</td>
<td>150</td>
<td>$0</td>
<td>$685</td>
<td>$4,320</td>
<td>6.3</td>
<td>$639</td>
<td>19%</td>
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<td>9</td>
<td>Reset chilled water temperature</td>
<td>0.0</td>
<td>85,324</td>
<td>0</td>
<td>$0</td>
<td>$6,655</td>
<td>$2,400</td>
<td>0.4</td>
<td>$0</td>
<td>277%</td>
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<tr>
<td>10</td>
<td>Reset condenser water temperature</td>
<td>0.0</td>
<td>56,883</td>
<td>0</td>
<td>$0</td>
<td>$4,437</td>
<td>$2,400</td>
<td>0.5</td>
<td>$0</td>
<td>185%</td>
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<tr>
<td>11</td>
<td>Programmable thermostat for AC-101C</td>
<td>0.0</td>
<td>5,568</td>
<td>130</td>
<td>$0</td>
<td>$589</td>
<td>$130</td>
<td>0.2</td>
<td>$0</td>
<td>453%</td>
</tr>
<tr>
<td>12</td>
<td>Calibrate and tune AHU controls</td>
<td>0.0</td>
<td>30,223</td>
<td>1,488</td>
<td>$0</td>
<td>$4,128</td>
<td>$800</td>
<td>0.2</td>
<td>$0</td>
<td>516%</td>
</tr>
<tr>
<td>13</td>
<td>downstream</td>
<td>3.4</td>
<td>20,289</td>
<td>0</td>
<td>$0</td>
<td>$1,759</td>
<td>$7,600</td>
<td>4.3</td>
<td>$1,623</td>
<td>29%</td>
</tr>
<tr>
<td>14</td>
<td>Reduce air leakage from rooftop AC units</td>
<td>2.4</td>
<td>11,712</td>
<td>336</td>
<td>$0</td>
<td>$1,440</td>
<td>$6,000</td>
<td>4.2</td>
<td>$1,206</td>
<td>30%</td>
</tr>
<tr>
<td>15</td>
<td>Trim HW pump impellers</td>
<td>0.8</td>
<td>5426</td>
<td>0</td>
<td>$0</td>
<td>$467</td>
<td>$900</td>
<td>1.9</td>
<td>$434</td>
<td>100%</td>
</tr>
<tr>
<td>16</td>
<td>Replace inlet vanes with VFDs</td>
<td>28.2</td>
<td>169,078</td>
<td>0</td>
<td>$0</td>
<td>$14,656</td>
<td>$85,425</td>
<td>5.8</td>
<td>$12,250</td>
<td>20%</td>
</tr>
<tr>
<td>17</td>
<td>VFD control of CHW pumps</td>
<td>18.5</td>
<td>161,790</td>
<td>0</td>
<td>$0</td>
<td>$13,581</td>
<td>$14,400</td>
<td>1.1</td>
<td>$2,000</td>
<td>110%</td>
</tr>
<tr>
<td>18</td>
<td>VFD control of CW pumps</td>
<td>7.0</td>
<td>60,960</td>
<td>0</td>
<td>$0</td>
<td>$5,117</td>
<td>$11,600</td>
<td>2.3</td>
<td>$1,000</td>
<td>48%</td>
</tr>
<tr>
<td>19</td>
<td>VFD control of cooling tower fans</td>
<td>6.5</td>
<td>57,348</td>
<td>0</td>
<td>$0</td>
<td>$4,814</td>
<td>$19,100</td>
<td>4.0</td>
<td>$2,500</td>
<td>29%</td>
</tr>
<tr>
<td>20</td>
<td>Add boiler cycling optimization controls</td>
<td>0.0</td>
<td>0</td>
<td>6,619</td>
<td>$0</td>
<td>$7,877</td>
<td>$7,200</td>
<td>0.9</td>
<td>$0</td>
<td>109%</td>
</tr>
<tr>
<td>21</td>
<td>motion/light head</td>
<td>0.2</td>
<td>1,183</td>
<td>0</td>
<td>$16</td>
<td>$116</td>
<td>$32</td>
<td>0.3</td>
<td>$0</td>
<td>363%</td>
</tr>
<tr>
<td>22</td>
<td>Upgrade Bldg 101 electric room lighting</td>
<td>0.1</td>
<td>1,577</td>
<td>0</td>
<td>$0</td>
<td>$127</td>
<td>$300</td>
<td>2.4</td>
<td>$126</td>
<td>73%</td>
</tr>
<tr>
<td>23</td>
<td>Install occupancy sensor lighting control</td>
<td>0.0</td>
<td>147,370</td>
<td>0</td>
<td>$0</td>
<td>$11,495</td>
<td>$13,500</td>
<td>1.2</td>
<td>$11,790</td>
<td>672%</td>
</tr>
<tr>
<td>24</td>
<td>Convert lobby downlights to CFL; change switches</td>
<td>0.4</td>
<td>3,495</td>
<td>0</td>
<td>$48</td>
<td>$341</td>
<td>$145</td>
<td>0.4</td>
<td>$0</td>
<td>235%</td>
</tr>
</tbody>
</table>

**SUBTOTALS**

|                | 78.0  | 1,277,503 | 21,321 | $64  | $129,143 | $211,188 | 1.6  | $43,348 | 77%  |
# Recommended Measures | peak kW savings | kWh/yr savings | therm/yr savings | $ maint savings | Total $ savings | Estimated In- house Payback | ROI w/ rebates | Savings, Cost & Payback |
---|---|---|---|---|---|---|---|---|
1. **Schedule control for AHUs serving intermittently occupied areas** | 0.0 | 593,912 | 55,365 | $0 | $102,828 | $6,960 | Yes | 0.1 | $6,960 net cost |
2. **Repair and optimize control of economizers** | 0.0 | 462,156 | 134,489 | $0 | $177,878 | $17,100 | Yes | 0.1 | $17,100 net cost |
3. **Optimize variable volume CHW pump control** | 29.4 | 514,489 | 0 | $0 | $61,104 | $9,525 | No | 0.2 | $9,525 net cost |
4. **Optimize and tune control loops for CW pump speed controls** | 13.4 | 234,987 | 0 | $0 | $27,909 | $4,400 | No | 0.2 | $4,400 net cost |
5. **Reset HHW temperatures** | 0.0 | 0 | 40,347 | $0 | $37,280 | $8,200 | No | 0.2 | $8,200 net cost |
6. **Test and adjust ED/CCU air volumes and optimize VFD controls** | 6.6 | 291,100 | 0 | $0 | $34,090 | $8,420 | No | 0.2 | $8,420 net cost |
7. **Reset AHU supply air temperature setpoints** | 0.0 | 244,733 | 123,134 | $0 | $142,165 | $35,775 | Yes | 0.3 | $19,579 878% |
8. **Optimize staging of cooling tower flow and fan speed** | 0.0 | 61,366 | 0 | $0 | $7,118 | $4,480 | No | 0.6 | $4,480 net cost |
9. **Replace damaged/missing steam/HW pipe insulation** | 0.0 | 0 | 10,979 | $0 | $10,145 | $6,600 | No | 0.7 | $0 154% |
10. **Add VFDs where applicable or where existing VFD inoperable** | 6.4 | 280,400 | 0 | $0 | $32,837 | $31,000 | No | 0.9 | $22,432 383% |
11. **VFDs and Intellihood™ Control for kitchen makeup/exhaust** | 0.0 | 105,638 | 7,294 | $0 | $18,994 | $19,300 | No | 1.0 | $8,451 175% |
12. **Upgrade all incandescent lighting to more efficient sources** | 1.5 | 8,729 | 0 | $0 | $1,084 | $1,184 | Yes | 1.1 | $436 145% |
13. **Reset CHW temperatures** | 0.0 | 33,214 | 0 | $0 | $3,853 | $4,300 | No | 1.1 | $2,657 235% |
14. **Adjust/replace clocks/photo controls for exterior lighting** | 2.3 | 10,100 | 0 | $0 | $1,283 | $1,855 | Yes | 1.4 | $505 95% |
15. **Provide daylighting controls for lighting in daylit areas** | 6.6 | 24,678 | 0 | $196 | $3,379 | $5,400 | No | 1.6 | $1,234 81% |
16. **Install vending machine controls** | 1.3 | 23,078 | 0 | $0 | $2,741 | $4,460 | No | 1.6 | $1,846 105% |
17. **Calibrate zone thermostats** | 0.0 | 46,627 | 20,441 | $0 | $24,296 | $45,250 | No | 1.9 | $0 54% |
18. **Replace damaged/missing CHW pipe insulation** | 0.0 | 2,885 | 1,536 | $0 | $1,754 | $3,800 | No | 2.2 | $0 46% |
19. **Repair leaking steam traps** | 0.0 | 0 | 1,251 | $0 | $1,156 | $2,525 | Yes | 2.2 | $1,001 76% |
20. **Control lighting in support spaces with occupancy sensors** | 0.0 | 105,608 | 0 | $0 | $12,251 | $28,300 | No | 2.3 | $5,280 53% |
21. **Upgrade all fluorescent lighting to latest generation T8** | 74.0 | 546,120 | 0 | $0 | $66,937 | $162,800 | No | 2.4 | $27,306 49% |
22. **Repair and re-seal leaking plenums, flex connectors** | 0.0 | 514 | 853 | $0 | $848 | $3,168 | Yes | 3.7 | $0 27% |

**TOTALS** | 141.5 | 3,590,335 | 395,689 | $196 | $771,929 | $414,802 | 0.5 | $149,813 291% |
750KSF Hospital
Critical Issues for RCx Programs

- Most of the existing buildings in the US are RCx candidates
  - Including many LEED Certified buildings
- Many buildings contain control systems that are beyond the training threshold of existing operations personnel
  - Control contractors are happy to maintain the status quo
- We have not significantly altered the way we train Building Operators or care for building systems in the last 50 years
  - Uptime does not equal Performance – quite the opposite in fact
  - Building systems have changed dramatically but our skill levels have not
  - Traditional tasks do not reflect our new energy & GHG challenges
- RCx should be viewed as an opportunity to train building operators to perform Ongoing Commissioning
  - The most valuable opportunity in RCx is not having to do it again in 4 years – to make the results sustainable!