Table of Contents

Project Background .................................................................................................................. 3
Repairs ....................................................................................................................................... 3
Sequence Updates ................................................................................................................... 3
Results ....................................................................................................................................... 3
  Project Baseline and Analysis Period ...................................................................................... 4
  Annual Energy Savings: ........................................................................................................... 5
  Annual Cost Savings: .............................................................................................................. 5
Appendix A: Baseline Data and M&V Model ................................................................. 6
  Baseline Regression Equations .............................................................................................. 6
  Baseline Model Statistics ......................................................................................................... 6
  Pre vs. Post Usage Scatter Plots ............................................................................................. 6
Project Background

During FY2014/15 the staff at The Recreational Sports Center (RSC) realized that the utility costs for their facility had increased. Utilities and Energy Management (UEM) reached out to assist Rec Sports. It was determined that there were several HVAC programming sequences that were driving the increased energy savings. Beginning in September 2015, we began working on changes to decrease energy and optimize the HVAC systems at RSC.

During the project, we replaced a number of system components that were necessary for proper Air handling Unit (AHU) operation. We then worked to correct the AHU performance by implementing a number sequence of operation changes and setpoint changes. After project completion, RSC saw a 40% reduction in chilled water usage, a 5% reduction in electricity usage, and a 60% reduction in steam usage, resulting in a 38% overall building energy reduction. This equates to $142,312 per year in utility cost savings. With a project cost of $1,819, the project resulted in a 0.2 month simple payback.

Repairs

During the course of the project, we scanned the system for any system components in need of repair, and replaced them as necessary. We identified the following repairs, which were performed by zones maintenance staff.

- Replaced broken space CO2 Sensor
- Replaced broken supply air temperature sensors for AHU 3 and 4.

Sequence Updates

During the course of the project, we implemented the following Air Handling Unit Sequence updates:

- Modified AHU operation to reduce the amount of air relieved
- Implemented program to have outdoor intake respond to CO2 concentrations within building. This reduces the amount of extra outdoor air that needs to be conditioned.
- Updated chilled water valve, steam valve, and supply fan sequence to eliminate overcooling problems.
- Updated operation to allow units to set back during unoccupied periods. A bug within the programming was preventing the units to do this.

Results

After collecting over a year’s worth of data after project completion we were able to quantify the building’s energy avoidance due to the project. The results were calculated following the guidelines of the International Performance Measurement and Verification Protocol (IPMVP) Option C – Whole Facility. Using this option, savings are determined by measuring the energy use of an entire facility. The building’s energy use after the project (Post or Analysis) is compared to a model based on typical previous usage (Baseline). A copy of all data and calculations can be made available upon request. Please see Appendix A for a summary of the M&V regression equations and model outputs.
Project Baseline and Analysis Period

The Baseline model was built using the weather and building consumption data for the 365 days prior to the first changes made to the system. This allows us to best estimate the typical usage of the building before we made any changes.

The Post model was built using the weather and building consumption data for the 365 days after the final changes were made to the system. This is shown above as “Analysis Period”. The project ended in December 2015, but the Post period begins in late November 2016. The reason for the late Post period is due to two issues that were found after project completion.

The first issue was a problem with the supply fan and chilled water valve operation that resulted in the space being overcooled. This problem was found and resolved during March 2016. The second issue is related to unoccupied operation. Due to a technical coding error, the units were not following the unoccupied programing during the unoccupied times. The error was found and resolved during October and November 2016. Since this error had significant energy impact, we are considering our “Post” period to be the 365 days after this issue was fixed.

It is also important to note that AHU 3 and 4 were shut down due to a floor refinishing project from late December 2016 to mid-January 2017. The building usage data for this time was replaced with data calculated from our Post model regression prediction. This was done as to not allow the reduced usage during this time to affect our final savings claims.
Annual Energy Savings:
To find the total avoided cost to date we used the Measurement and Verification (M&V) framework outlined by Utilities and EMO. The basic process compares the actual building use (red line) to what the building would have used if we had done nothing (blue line). Our savings are represented by the blue line minus the red line.

<table>
<thead>
<tr>
<th>Rec Sports Center Total Utility Energy Cost Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost [$]</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Baseline Model Usage (TMY)
- CHW (ton-hr): 1,091,125
- ELE (kWh): 1,328,054
- STM (lbs): 4,289,827
- Total (mmbtu): 1,091,125

Post Model Usage (TMY)
- CHW (ton-hr): 655,811
- ELE (kWh): 1,259,174
- STM (lbs): 1,710,746
- Total (mmbtu): 655,811

Normalized Energy Savings
- CHW (ton-hr): 435,314
- ELE (kWh): 68,880
- STM (lbs): 2,579,081
- Total (mmbtu): 435,314

Normalized Energy Savings (%)
- CHW: 40%
- ELE: 5%
- STM: 60%
- Total: 38%

Annual Cost Savings:

<table>
<thead>
<tr>
<th>Normalized Energy Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHW</td>
</tr>
<tr>
<td>$78,792</td>
</tr>
</tbody>
</table>

With a project cost of $1,819, the project resulted in a 0.2 month simple payback.
Appendix A: Baseline Data and M&V Model

Baseline Regression Equations

Daily Post CHW Usage [ton-hr] = 125 + 57 x CDD

Daily Post ELE Usage [kWh] = 3027 + 593 x (1 if weekday, 0 if weekend)

Daily Post STM Usage [lb] = -49449 + 238 x HDD

Baseline Model Statistics

<table>
<thead>
<tr>
<th></th>
<th>CHW</th>
<th>ELE</th>
<th>STM</th>
<th>IPMVP Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimized CDD/HDD base temperature</td>
<td>39.85</td>
<td>295.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Deleted data</td>
<td>6.8%</td>
<td>6.8%</td>
<td>6.8%</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td>Coefficient of determination ($R^2$)</td>
<td>68.4%</td>
<td>18.5%</td>
<td>44.5%</td>
<td>&gt; 75%</td>
</tr>
</tbody>
</table>

Pre vs. Post Usage Scatter Plots

- Post CHW usage vs temp
- Post ELE usage vs temp
- Post STM usage vs temp