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Project Background

In early 2016 Athletics realized that the energy costs at the North End Zone Building (NEZ) had become too high. Athletics asked the University’s Utilities and Energy Management about the high bill, and was directed to our department, Energy Management & Optimization, or EMO (formerly EWC). We were in a good position to help with NEZ’s high energy costs due to the fact that we specialize in performing existing building commissioning (EBCx) on buildings on campus. After introduction, we worked with Athletics to set up a capital project to pay for our in-house labor hours, and we began work later that spring. We wrapped up the project in early 2018.

Repairs

During the course of the project, we scanned the system for any system components in need of repair and replaced them as necessary. In order to optimize a HVAC system, we need to first ensure that the entire system is functioning as we expect it to. We identified the following repairs, which were performed by zones maintenance staff, and Athletics’ in-house maintenance staff.

- Replaced stuck chilled water valve
- Cleaned or replaced broken outside airflow sensors
- Replaced faulty air temperature sensors
- Replaced faulty humidity sensors
- Replaced faulty C02 sensors
- Replaced faulty air pressure sensors
- Replaced faulty thermostats
- Repair stuck VAV dampers
- Replaced failed VAV controllers

Sequence Updates

During the course of the project, we reprogrammed the sequence of operations for all 13 Air Handlers [AHU], 320 Variable Air Volume [VAV] boxes, and the building’s hot water supply system.

Air Handlers

The Air Handler sequencing was customized to each unit, tailoring each unit’s operation to the needs within the space. Each unit was unique, but below is some examples of the type of strategies we implemented on the AHU Level.

Unoccupied Scheduling and Holiday Scheduling

When the space is unoccupied, we slow the supply fan and setback the space temperatures. Part of this strategy includes finding the best time to return to normal operation so the occupants will not be uncomfortable in the morning.

Supply Temperature Resets

This allows the AHU supply temperature to get warmer when we don’t need as much cooling.
Outdoor Air Reduction
Reduced the outdoor air intake to match requirements dictated by code. Where applicable, we also allowed less outdoor air where we can monitor the CO2 levels in the space. In these cases the units will bring in more air as needed to keep CO2 levels to an acceptable level.

Optimize Pre-heat Setpoints
Optimized outdoor air pre-heating setpoints to match campus standards.

Variable Air Volume Boxes
The following strategies were implemented across all 320 VAVs in the building.

Reduce Airflow Minimums to reduce Reheat
In a typical design, a VAV’s minimum airflow setpoint is often set too high. This causes a room to overcool, which in turn causes the VAV to unnecessarily add heat. By tuning the airflow minimum, we allow the box to provide just enough cooling, thereby preventing both wasted heating and cooling. This often also results in better comfort for the occupant due to the more consistent temperature control.

Average Zone Temps (where applicable)
If multiple VAVs serve a single space, we average their thermostat control. This prevents VAVs from “fighting” where one VAV is cooling and another is heating at the same time.

Expand Temperature Band
By design, the system is setup to control to a tight deadband. We find that expanding this band a few degrees allows the system to relax more, often without the occupants noticing the difference.

Hot Water Space Heating
Similar to the AHU supply temperature resets, we allow the hot water system to supply cooler water when not as much heating is needed. We also allow the pump to relax when the heating needs are met in the building.
Results

After collecting over a year’s worth of data after project completion we are able to quantify the building’s annual 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.

Annual Energy Savings

To find the total avoided cost to date we compare the actual building use (gray line) to what the building would have used if we had done nothing (orange line). Our savings are represented by the orange line minus the gray line.

<table>
<thead>
<tr>
<th>% Avoidance</th>
<th>Cost Avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water</td>
<td>Electricity</td>
</tr>
<tr>
<td>30%</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>21%</td>
</tr>
<tr>
<td>Total</td>
<td>Annual</td>
</tr>
<tr>
<td></td>
<td>$233,129</td>
</tr>
<tr>
<td></td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>$638.71</td>
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<tr>
<td></td>
<td>Cost Reduction</td>
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<td></td>
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Project Payback

<table>
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<th>Simple Payback</th>
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</thead>
<tbody>
<tr>
<td>$35,650</td>
<td>$233,129</td>
<td>1.8 months</td>
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</tbody>
</table>
M&V Model Outputs

Pre vs. Post Usage Scatter Plots

Below are some pre vs. post project scatter plots. These are helpful in further showing how energy was saved in a building by looking at the data in another way. These plots show the post model usage for each utility plotted against average outdoor air temperature. These help us to see a building’s energy profile with regard to outdoor air conditions.

The black line represents the pre-project model average.

Each data point represents a daily usage for each utility in the post period. There are 365 points for each graph, representing a year’s usage. The gray line represents the best fit line for each post usage scatter. Obviously we want to see the gray lines to be lower than the black lines.