San Jose State University On-Going Chiller Plant Improvements

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MSI Auditorium

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Agenda

• Campus Overview
• Project Overview
• Pre-Retrofit Plant Design
• Retrofit Features
• Post-Retrofit Plant Design
• MBCx Optimization
• Project Savings
• Project Economics
• Lessons Learned
• On-going Improvements
• Questions
Campus Overview

• Chiller plant serves 26 campus buildings

• Plant:
  • 2 electric chillers
  • 2 steam absorption chillers
  • Ice thermal energy storage
  • 1 glycol chiller

• Campus peak demand: 4,300 tons
• Minimum cooling demand: 200 tons
• Average campus demand: 700 tons
Project Overview

• Two projects: Retrofit in 2012, MBCx in 2016

• Chiller Plant Retrofit Goals:
  • Address anticipated load growth on campus
  • Increase operational efficiency of the plant

• Monitoring-Based Commissioning (MBCx) Goals:
  • Verify equipment is operating properly through pre-functional testing
  • Optimize sequence of operations to reduce energy use
    • Condenser water pump speeds
    • Cooling tower condenser water setpoint reset
    • Transitional states
    • Evaporator pumping to primary only
Pre-Retrofit Plan Design
Retrofit Features

• Two new electric chillers, 750 tons to 1,200 tons each
  • Constant speed to variable speed - more efficient performance
  • Refrigerant change from R-123 to R-134A
• Convert primary chilled water pumping to variable flow
• Modify piping to allow centrifugal and absorption chillers to operate in series
  • Allow chillers to operate where they are most efficient
  • Series-counterflow configuration
• Staging sequence with time-of-day rate structure
• Upgrade plant control system to PLC
  • Allows for complex sequence of operations and robust trending
  • Common control platform with cogeneration system
Post-Retrofit Plan Design
Post-Retrofit Plan Design
Two Absorbers with Hx

Two Absorption Chillers and Heat Exchanger in Parallel
Series Operation- CW

Absorption-Centrifugal in Series- Condenser Side
MBCx Optimization

• Develop equipment performance curves for all equipment using:
  • Manufacturer’s data and performance specifications
  • Four months of trend data
  • Spot measurements from pre-functional tests

• Develop models to simulate the performance of the chiller plant
  • Varying load and weather (dry bulb and wet bulb temperature) conditions
  • Data consolidated and equations developed using data fit algorithms
  • Write SOOs containing algorithms for chiller staging, condenser water temperature, and flow conditions which optimize system-wide performance and minimize overall operating costs for conditions throughout the year
# Project Savings

<table>
<thead>
<tr>
<th></th>
<th>Electricity (kWh/yr)</th>
<th>Natural Gas (therms/yr)</th>
<th>Total Utility Cost ($/yr)</th>
<th>CO$_2$e Savings (metric tons/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit Project</td>
<td>680,887</td>
<td>369,247</td>
<td>$319,080</td>
<td>2,094</td>
</tr>
<tr>
<td>MBCx Project</td>
<td>190,248</td>
<td>87,740</td>
<td>$84,177</td>
<td>503</td>
</tr>
<tr>
<td>Total Savings</td>
<td>871,135</td>
<td>456,987</td>
<td>$403,257</td>
<td>2,597</td>
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</tbody>
</table>
## Project Economics

<table>
<thead>
<tr>
<th></th>
<th>Retrofit</th>
<th>MBCx</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Project Cost</strong></td>
<td>$5,531,914</td>
<td>$315,033</td>
<td>$5,846,947</td>
</tr>
<tr>
<td><strong>Annual Cost Savings Achieved ($/yr)</strong></td>
<td>$319,080</td>
<td>$84,177</td>
<td>$403,257</td>
</tr>
<tr>
<td><strong>Simple Payback Before Incentive</strong></td>
<td>17.3 years</td>
<td>3.7 years</td>
<td>14.5 years</td>
</tr>
<tr>
<td><strong>Incentive</strong></td>
<td>$532,670</td>
<td>$133,399</td>
<td>$666,069</td>
</tr>
<tr>
<td><strong>Adjusted Project Cost</strong></td>
<td>$4,999,244</td>
<td>$181,634</td>
<td>$5,180,878</td>
</tr>
<tr>
<td><strong>Simple Payback After Incentive</strong></td>
<td>15.7 years</td>
<td>2.2 years</td>
<td>12.85 years</td>
</tr>
</tbody>
</table>
Lessons Learned

• Must be a collaborative process to meet desired goals
  • University, design engineer, contractors, commissioning agent
  • Work closely with controls contractor when implementing sequences
  • Work closely with plant operators and controls contractor during functional testing

• Divide projects into phases to get individual components working
• Be cognizant of CSU/UC/IOU program year requirements and deadlines
On-going Improvements

• Continued optimization of the plant
• Adaptive-predictive control
  • Day-ahead predication using weather and historical data
Questions?

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