Using Observed Data During Early Design To Simulate Building Mechanical System Energy Performance

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Project Objectives and Goals

- Use real-world data to simulate internal building heat gains, occupancy and heat transfer through the building envelope.
- Use actual meteorological data to assess the building mechanical system reaction to atmospheric conditions.
- Combine physical and black-box models to represent mechanical equipment.

Methods & Procedures

Case Study

120,000 ft² Student Housing Building
- VAV air Handlers connected to campus central heating/cooling plant
- Air Source Variable Refrigerant Flow (VRF)
- Water Source VRF connected to cooling tower and electric boiler
- Water Source VRF connected to cooling tower and central heating plant
- Water Source VRF connected to cooling tower and central heating plant

Data and Results

<table>
<thead>
<tr>
<th>Case Study – 120,000 ft² Student Housing Building</th>
<th>VAV Air Handlers – Central Plant</th>
<th>Air Source VRF</th>
<th>Water Source VRF – Cooling Tower &amp; Electric Boiler</th>
<th>Water Source VRF – Cooling Tower &amp; Central Plant Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Operating Energy Costs</td>
<td>Central Heating: $19,650</td>
<td>$0</td>
<td>$0</td>
<td>$14,600</td>
</tr>
<tr>
<td></td>
<td>Central Cooling: $37,000</td>
<td>$0</td>
<td>$0</td>
<td>$14,600</td>
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<tr>
<td></td>
<td>Electricity: $24,000</td>
<td>$0</td>
<td>$0</td>
<td>$40,000</td>
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<tr>
<td></td>
<td>Total Operating Cost: $80,650</td>
<td>$67,000</td>
<td>$103,000</td>
<td>$55,600</td>
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<tr>
<td>Annual Emissions</td>
<td>Direct CO₂ (lb): 994,000</td>
<td>0</td>
<td>0</td>
<td>741,000</td>
</tr>
<tr>
<td></td>
<td>Indirect CO₂ (lb): 649,000</td>
<td>1,675,000</td>
<td>2,576,000</td>
<td>1,396,000</td>
</tr>
<tr>
<td></td>
<td>Total Emissions CO₂ (lb): 1,643,000</td>
<td>1,675,000</td>
<td>2,576,000</td>
<td>2,137,000</td>
</tr>
</tbody>
</table>

Conclusions

- A scalable energy model was developed for use with real-world data.
- The model is adaptable to many different functions by using data-sets from different building types.
- Four different mechanical systems were considered for a 120,000 ft² student housing building.
- Lowest Operating Cost: Water Source VRF, Cooling Tower, Central Heating Plant.
- Lowest Total Emissions: VAV AHU, Central Heating/Cooling Plant.
- Lowest Direct Emissions: Air Source VRF

Future Studies / Recommendations

- Expand framework to include additional mechanical systems such as: ground-source VRF
- Leverage machine learning to dynamically model the performance of central plant equipment
- Consider Multi-objective optimization for selecting mechanical systems for groups of buildings

Acknowledgments

- University of Utah Facilities Management for assistance with the research and access to building energy data.
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