NORTH GROUNDS PLANT EXPANSION

2020 IDEA Campus Energy Conference
February 12, 2020
Denver, Colorado

PRESENTERS: PAUL ZMICK, JOE WITCHGER & BRENDAN HUSS
Context and Timeline

- **554K GSF of existing buildings (Law and JAG)**
- **250F to 140F Hot Water**
- **Renew equipment in an existing plant**
- **Add heat recovery chillers**

- **351K GSF of new buildings (Darden)**
- **Build out plant capacity and add new distribution**
- **Add boilers/chillers**
- **Replace heat recovery chillers**

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<tbody>
<tr>
<td>Initial Plant Renewal</td>
<td>Results and Reality</td>
<td>Plant Build-out and Darden Connection</td>
</tr>
</tbody>
</table>
Results and Reality

• Success!
  • Transitioned to LTHW
  • Efficient Plant

• Opportunity 😊
  • HRC performance
  • DHW issues
Project Success Criteria

- Construction
- Safety
- Continuity of Operations
- Schedule
- Cost
- Design
- Innovation
- Cost
- Schedule
Innovations at NGMP

• Conversion of MTHW to LTHW with minimal building modifications

• Integrating Commercial and Industrial Equipment

• Interface of Open and Closed Systems

• Control for System Efficiency
Key Performance Indicators (KPI) (2-year averages)

- Overall Plant Efficiency
- Chiller Plant Efficiency
- HR Chiller Efficiency
- Heating Plant Efficiency
- Cooling Delivered Efficiency

UVA Criteria: Total Energy Delivered by Plant

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Load Comparison

NGMP & Darden Heating Load (MBTU)
Load Comparison

NGMP + Darden CHW Load vs Dry Bulb

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Heating Hot Water Reset History

Heating Hot Water Reset Schedule

[Plot showing hot water temperature vs. Toadb (°F) with data points for Pre 2/22 in orange and Post 2/22 in blue]
Engageable Load Ratio- Function of Building

• Engaged Load Ratio (ELR) = \( \frac{\text{Engaged Thermal Load}}{\text{Total Thermal Load}} \)

Heating Engaged Load Ratio = \( \frac{\text{Engaged Heating Load}}{\text{Total Heating Load}} \)

Cooling Engaged Load Ratio = \( \frac{\text{Engaged Cooling Load}}{\text{Total Cooling Load}} \)
## Evaluation Tools

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<tr>
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<th>Total Load (MBTU)</th>
<th>Engageable Load (MBTU)</th>
<th>Engageable Load Ratio (ELR)</th>
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<td>NGMP Cooling</td>
<td>31,644,665</td>
<td>11,530,201</td>
<td>36%</td>
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<td>NGMP Heating</td>
<td>26,484,106</td>
<td>11,541,731</td>
<td>44%</td>
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<tr>
<td>Darden Cooling</td>
<td>18,656,502</td>
<td>6,509,167</td>
<td>35%</td>
</tr>
<tr>
<td>Darden Heating</td>
<td>7,857,116</td>
<td>6,515,676</td>
<td>83%</td>
</tr>
<tr>
<td>Combined Cooling</td>
<td>50,301,167</td>
<td>20,446,235</td>
<td>41%</td>
</tr>
<tr>
<td>Combined Heating</td>
<td>34,341,223</td>
<td>20,466,681</td>
<td>60%</td>
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Centrifugal Chillers

- R1233zd:
  - Full Load: 0.5825 kW/ton
  - NPLV: 0.3777 kW/ton

- R514
  - Full Load: 0.5454 kW/ton
  - NPLV: 0.3597 kW/ton

- Free Cooling: 430 Tons at 40°F ECWT
Heat Recovery Chillers – Centrifugal

• Up to 170°F HW
• Turndown concerns
• Takes space of CH-3
Heat Recovery Chillers – Ammonia

- Up to 195°F HW
- 200T cooling at 175°F
- 368T cooling at 140°F
- 8’ x 18’
- Long lead time
- >$1million per unit
Heat Recovery Chillers – Screw

- R-134a
- Up to 149°F HW
- 300T Peak Cooling
- ~200T cooling at 149°F
- Smaller unit with max temp of 140°F
  - (4) 160T units
Heat Recovery Chillers – Scroll

- R-134a
- Up to 160°F HW
- 4 Units fit in space
  - 312 Tons at 160°F
  - 6,500 MBH at 160°F
Heat Recovery Chillers – Modular Scrolls

- R-134a
- Up to 165°F HW
- 12-20 units fit in space
  - 25 Tons/unit at 165°F
  - 510 MBH/unit at 165°F
Achievable Load Ratios

• Machine Capacity
• Machine Efficiency – (Condenser Ratio)
• Turndown Capabilities
• Temperature Limits
• Building Required Reset Schedules
Achievable Load Ratio- Function of Equipment

- Achievable Load Ratio (ALR) = \frac{\text{Achievable Engaged Thermal Load}}{\text{Total Thermal Load}}

Heating Achievable Load Ratio (ALRh) = \frac{\text{Achievable Engaged Heating Load}}{\text{Total Heating Load}}

Cooling Achievable Load Ratio (ALRc) = \frac{\text{Achievable Engaged Cooling Load}}{\text{Total Cooling Load}}
Achievable Load Ratios

- Machine Capacity
- Machine Efficiency – (Condenser Ratio)
- Turndown Capabilities
- Temperature Limits
- Reset Schedules

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<td>18,656,502</td>
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<td>8%</td>
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<td>1,993,295</td>
<td>25%</td>
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Existing Thhws Reset and Scroll HRCH

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ELR Efficiency - How Equipment Performs in Bldg

- The ratio of Achievable Load Engagement to ELR - A Machine dependent measure of how effective the selected equipment will be in capturing the potential for thermal energy recovery for a given building.

\[ \eta_{\text{ELR}} = \frac{\text{ALR}}{\text{ELR}} \]
## ELR Efficiency

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Existing Thhws Reset and Scroll HRCH
Performance of Available Equipment Options

All Toa Conditions

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## Fully Engaged Heat Recovery (FHRE)

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<tr>
<th>Option</th>
<th>FHRE Savings ($/Yr)</th>
<th>Energy Reduction (MMBtu/Yr)</th>
<th>EUI Reduction (kBtu/SF/Yr)</th>
<th>Gas Savings (%)</th>
<th>Carbon Reduction (MteCD)</th>
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<tr>
<td>Base Case FHRE</td>
<td>$137,629</td>
<td>12,465</td>
<td>17.43</td>
<td>24.8%</td>
<td>648</td>
</tr>
<tr>
<td>Base + Exh</td>
<td>$155,228</td>
<td>16,762</td>
<td>23.44</td>
<td>38.2%</td>
<td>999</td>
</tr>
<tr>
<td>Base + Exh + ReA</td>
<td>$157,125</td>
<td>20,324</td>
<td>28.42</td>
<td>51.1%</td>
<td>1,345</td>
</tr>
<tr>
<td>Base + Exh + ReA + 3 HRCH</td>
<td>$170,107</td>
<td>23,929</td>
<td>33.46</td>
<td>62.6%</td>
<td>1,647</td>
</tr>
<tr>
<td>Base + Exh + ReA + 4 HRCH</td>
<td>$174,728</td>
<td>25,600</td>
<td>35.80</td>
<td>68.1%</td>
<td>1,793</td>
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Thank You

• Questions?

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