University of Wisconsin-Madison Case Study
Chiller Performance Improvement
Via Tube Fouling Prevention

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IDEA – Campus Energy
University of Wisconsin-Madison

- Founded in 1848 as Wisconsin’s land-grant university
- Flagship campus of the 26-campus University of Wisconsin System
- 936-acre main campus (including 300-acre Lakeshore Nature Preserve)
- Largest land owner on Lake Mendota with 4 miles of lakefront
- 9,647 acres statewide including agricultural research stations, experimental farms, arboretum lands and other off-campus properties
- Over 45,300 students and almost 22,400 faculty & staff (67,700 total)
- Over 24 million GSF of conditioned space
- Over 451,000 living alumni worldwide
- $3.2 billion annual operating budget
- Ranked 6th nationally in research funding
## UW-Madison Campus Utility Plant Evolution

- **Radio Hall** 1885 – 1908
- **Ag Bulletin** 1899 – 1937
- **Service Building Annex** 1908 – 1958
- **Charter Street Utility Plant** *(Cooling - 1966)* 1958 – Present
- **Walnut Street Utility Plant** 1975 – Present
- **West Campus Cogeneration Plant** 2005 – Present
West Campus Cogeneration Facility
- 500,000 PPH Steam (Nat. Gas)
- 11,200 Tons Chilled Water (Electric)
- 9,000 Tons Chilled Water (Steam)

Walnut Street Heating Plant
- 400,000 PPH Steam – To UW
- 30,000 Tons Chilled Water (Electric) – 17.0 MW To UW
- 85.4 MW Combustion Turbine Generator (Nat. Gas) – To MGE
- 68.2 MW Extraction/Condensing Steam T/G – To MGE

Charter Street Heating Plant
- 1,100,000 PPH Steam (Nat. Gas)
- 24,000 Tons Chilled Water (Steam)
- 9.7 MW Back Pressure Steam Turbine Generator

Approximate Lake Intake Location
UW-Madison Campus Utility Summary

• Steam Summary
  – 2,100,000 PPH Total (Installed)
  – 1,800,000 PPH Firm (Less Largest Unit)
  – 1,316,000 PPH Peak (Historical Max)
  – 879,000 PPH Peak (Jan 2019)

• Chilled Water Summary
  – 74,000 Tons Total (Installed)
  – 66,000 Tons Firm (Less Largest Unit)
  – 64,000+ Tons Peak (Historical Max)
  – 56,000 Tons Peak (Jul 2019)

• Electrical Summary
  – 88.7 MW Peak (Sep 2013 Max)
  – 82.6 MW Peak (Sep 2016)
  – 83.4 MW Peak (Jul 2019)
UW-Madison Utility Plant Water Source

- **Primary Uses:**
  - Cooling Tower Make-Up
  - Boiler Make-Up (Restarting in 2020)
  - Process Cooling

- **2016 Consumption**
  - 435 Million Gallons – UW
  - 165 Million Gallons – MG&E
  - 600 Million Gallons – Total

- **Approximately the Amount Lost From Lake Evaporation During 11 Hot Summer Days**

- **Cost:**
  - City Water $5.89/1,000 Gallons
  - Lake Water $0.25/1,000 Gallons
  - Savings $5.64/1,000 Gallons
  - Savings $2,450,000/Year UW Consumption
Chillers represent >50% of building’s energy use during warm months.

Studies show >97% of shell & tube heat exchangers suffer tube fouling.

(Muller-Steinhagen, 2011; Steinhagen et al., 1992; Garrett-Price et al., 1985)

Scale Particulate Biofilm

>$25 Billion wasted every year in USA due to chiller inefficiency
Background Info & Project Setup

Background Information:
- UNIVERSITY OF WISCONSIN—MADISON CENTRAL UTILITY PLANT - CHILLERS 1 & 2
- TWIN CHILLERS 4,000 TONS CAPACITY EACH
- COMMON CHILLED WATER AND CONDENSER WATER HEADERS

Project Set-Up:
- INSTALL AUTOMATIC TUBE CLEANING SYSTEM (ATCS) ON CHILLER 2 EVAPORATOR & CONDENSER
- BEFORE & AFTER EFFICIENCY EVALUATION OF CHILLER 2 ATCS INSTALLATION
- SIDE-BY-SIDE EVALUATION OF CHILLER 2 WITH ATCS VS. CHILLER 1 WITHOUT ATCS
ATCS – Condenser Side Installation
ATCS – Evaporator Side Installation
ATCS – Evaporator & Condenser Pump Skids
ATCS Increased Chiller Cooling Capacity!

CH 2 w/ ATCS produces up to 350 tons more cooling than CH 1 at ECWT 80F.
Chiller 2 Efficiency Curve Before & After ATCS

Average Efficiency Gain After Helios: 11%

Downward curve shift indicates efficiency gain from ATCS.
Chiller Efficiency Curves Side by Side Comparison

Average Efficiency Advantage With Helios: 15%

Chiller 2 w/ ATCS has lower efficiency curve which indicates efficiency gain from ATCS.
Chiller Tube Cleanliness Millipore Test

Chiller #1 Without ATCS

Sample 1-2
Filter: 6.24 plugged filter

Chiller #2 With ATCS

Sample 2-2
Filterability 30 sec
University of Wisconsin Case Study Summary Results

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Average Chiller Efficiency Gain:</td>
<td>12%</td>
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<tr>
<td>Chiller Capacity Increase:</td>
<td>Up to 400 tons</td>
</tr>
<tr>
<td>Annual Energy Savings:</td>
<td>10,370 MMBtu</td>
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<tr>
<td>Annual Energy Cost Savings:</td>
<td>$40,000</td>
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<tr>
<td>Project Lifetime CO2 Emission Reductions:</td>
<td>9,200 tons</td>
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<tr>
<td>Project Lifetime Savings (15 Yrs):</td>
<td>$850,000</td>
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Automatic Tube Cleaning Systems (ATCS): Multiple Value Dimensions

• Avg. chiller efficiency improves 5-15%
• Increase chiller cooling output up to 10%
• Reduce or eliminate manual tube brushing & chemical cleaning
• Improves chiller plant availability
• Reduce GHG emissions and environmental impact
How Auto Tube Cleaning Systems (ATCS) Work
How Auto Tube Cleaning Systems (ATCS) Work
-Consistent Performance Elsewhere-
Xcel Energy Case Study

BACKGROUND INFORMATION:
• XCEL ENERGY DISTRICT COOLING PLANT – CHILLER 4
• 2,500 NOMINAL TONS
• DENVER DOWNTOWN DISTRICT COOLING
## Xcel Energy Case Study Summary Results

<table>
<thead>
<tr>
<th>Metric</th>
<th>Result</th>
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<tbody>
<tr>
<td>Average Chiller Efficiency Gain:</td>
<td>4%</td>
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<tr>
<td>Chiller Capacity Increase:</td>
<td>Up to 200 tons</td>
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<tr>
<td>Annual Energy Savings:</td>
<td>180,000 kW-hrs</td>
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<tr>
<td>Annual Cost Savings:</td>
<td>$20,000</td>
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<tr>
<td>Project Lifetime CO2 Emission Reductions:</td>
<td>2,200 Tons</td>
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<td>Project Lifetime Savings (15 Yrs):</td>
<td>$410,000</td>
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- Consistent Performance Elsewhere -

Xcel Energy Case Study Results
Consistent Performance Elsewhere—George Mason University

**FIGURE 1**
Chiller 10 Approach Temperature Maintained at 0.5 Degree F with Helios Tube Cleaning System™ while Chiller 9 Approach Temperature Increases Due to Tube Fouling.

**FIGURE 2**
Chiller 9 Approach Temperature Flatlines After Helios Tube Cleaning System™ Installation.

**FIGURE 3**
Chiller 10 Approach Temperature Maintained at 0.5 Degree F for 2 Years due to Helios Tube Cleaning System™.

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**George Mason University Case Study Results**

- **Average Chiller Efficiency Gain:** 10%
- **Chiller Capacity Increase:** Up to 200 tons
- **Annual Energy Savings:** 550,000 kW-hrs
- **Annual Cost Savings:** $45,000
- **Project Lifetime GHG Reductions:** 6,500 Tons
- **Project Lifetime Savings (15 Yrs):** $900,000
Questions?

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