Lessons in System Transformation and Resilience from Milwaukee Regional Medical Center

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Agenda

• Who We Are
• Reconstruction Project Scope
• Added Scope
• Operational Lessons Learned
• Results
Milwaukee Regional Medical Center Thermal Service

Provide steam and chilled water for 7M sq ft of premier healthcare space
• Managed by Ever-Green Energy, a subsidiary of District Energy St Paul

Campus Thermal Energy Systems
• Coal-fired CHP built by Milwaukee County in 1955
• Chilled water added in 1970s
• Purchased by the local electric utility in late 1990s

Acquired by MRMC Thermal in April 2016
• Capital investment of $150M (2016-2019)
• Improved the reliability of critical steam and chilled water service to the hospitals and research facilities on campus
• Modernized the plant and distribution facilities to increase resiliency, reduce costs, improve efficiency, and reduce greenhouse gas emissions
Initial Configuration

MAIN PLANT
- 3 Coal Boilers 255K #/hr
- 2 Gas Boilers 148K #/hr
- 14 Chillers 20K Tons
- 3 Turbine Generators – 7.5 MW
- Natural Gas Feed
- HV Electrical Feed
- No central control system

DISTRIBUTION SYSTEM TO USERS
- Steam
- Condensate

DISTRIBUTION SYSTEM TO USERS
- Steam
- Condensate
- Chilled Water

Many single points of failure
Reconstruction: Production Resiliency

VIA PIPE BRIDGE
- Steam
- Condensate
- Make-up Water
- Fuel Oil

NORTH PLANT
- 2 Boilers 140K #/hr
- HV Electrical Feed
- Natural Gas Feed
- Emergency Generator
- Fuel Oil Tank
- Water Treatment

WEST PLANT
- 3 Boilers 210K #/hr
- 3 Chillers 7.5K Tons
- Natural Gas Feed
- HV Electrical Feed
- 2 Emergency Gens
- 3 Fuel Oil Tanks

EAST PLANT
- 9 Chillers 15K Tons
- HV Electrical Feed
- Emergency Generator

DISTRIBUTION SYSTEM TO USERS
- Steam
- Condensate
- Chilled Water

Reliability through Bi-Furcation
Added Scope

• Flywheel UPS
• Chilled Water Cross-Connect
• Pre-stressed Concrete Cylinder Piping (PCCP) Inspection and Repair
• Boiler and Chiller Turbine Conversion
Flywheel UPS

Power Quality Events 2017-2019

Startup
9/21/17

112 Events
Since Startup

Events by Remaining RMS Voltage
- < 60%
- 60-80%
- 80-85%
- 85-112%
- > 112%

Events by Duration
- < 120 cycles
- 120-900 cycles
- > 900 cycles
Cross-Connect
PCCP Inspection and Repair

Table 2.2: Pipes with Broken Wire Wraps in the Chilled Water Lines

<table>
<thead>
<tr>
<th>Rank</th>
<th>Pure Reference Number</th>
<th>Low Station</th>
<th>Pipe Length (feet)</th>
<th>Pipe Class</th>
<th>Break Positional Range (feet)</th>
<th>Number of Broken Wire Wraps by Region</th>
<th>Total Number of Broken Wire Wraps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4009</td>
<td>0+94</td>
<td>16</td>
<td>N/A</td>
<td>2.5-4.0</td>
<td>15-10</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>4007</td>
<td>0+74</td>
<td>16</td>
<td>N/A</td>
<td>2.5-5.5</td>
<td>10-5</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>4011</td>
<td>1+32</td>
<td>16</td>
<td>N/A</td>
<td>3.5</td>
<td>15</td>
<td>15</td>
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<tr>
<td>4</td>
<td>9932</td>
<td>6+56</td>
<td>15</td>
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<td>14.0</td>
<td>10</td>
<td>10</td>
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<tr>
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<td>9007</td>
<td>3+16</td>
<td>16</td>
<td>N/A</td>
<td>14.0</td>
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<td>5</td>
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<tr>
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<td>9018</td>
<td>4+70</td>
<td>16</td>
<td>N/A</td>
<td>10.5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Longitudinal Crack observed at the invert of Pipe 8019 pipe
Boiler / Turbine Conversion

10 YEAR NPV SAVINGS FROM BOILER CONVERSION: $1.8M
Lessons Learned

• OEM Training
• Operations Project Coordinator
• Commissioning Agent
• Service Contracts and Warranties
• Segmented Distribution
OEM Training Agenda

• Description of Operation
• Basic process flow
• General arrangement including component nomenclature
• Controls, safeties, permissives, and interlocks
• Troubleshooting
• Mechanical and Electrical isolations

*Insist on using the drawings!*
Project Coordinator Role

- Interface between Operations and Project Team
- Design and Specification Review
- Daily project support
  - LOTO, Hotwork, Confined Space, area access, laydown area designation, quality control, RFI development
- Startup/commissioning/problem solving support
- SOP / Maintenance Procedure Development
- Project documentation QA/QC
- Ongoing Operations training resource
Commissioning Agent Role

• Third-party confirmation of installation and testing in accordance with specification
• Design and specification review
• Startup / commissioning / problem solving support
• Project documentation collection

Get what you paid for!
Service Contracts and Warranties

• Factor a 10 year service agreement into equipment procurement as part of the LCCA
  • Service rates 30-40% higher than the same labor as install
• Guarantees on response times
• Service tech capabilities / bios
• Manufacturer vs. OEM parts
• Parts availability guarantees
• Beware the parts-only warranty
• Consider equipment run-time versus calendar-based warranties
Steam Distribution Segmentation

Initial Configuration

New Configuration
Chilled Water Distribution Segmentation

Initial Configuration

New Configuration
Results

• Consistent, High Reliability
• Emissions Reduction
• Cost Reduction & Reinvestment
2016-2019 Reliability

- Chilled Water: 100.000%
- High Pressure Steam: 99.993%
- Low Pressure Steam: 100.000%

**Combined: 99.998%**

Against **Contract Requirements**
Emissions Reductions

CY17/18 average (42,706 mtons) is 33% of CY13-15 average (129,740 mtons)
Costs

- Member savings since acquisition estimated to be $83M through year end 2019 (~$2M/month)
- Real Time Market Pricing (RTMP) for electricity expected to save >15% on future electrical costs (starting in 2020)
- Hedging gas has locked in much lower rates and provides budget certainty. Savings >20% over daily purchase (Previous method of supplying gas)
- Favorable financing continues. Refinancing completed 2018
- No rate increase 2016 with moderate rate increases in years 2 – 4 and no rate increase in current year (2020)
- 2020 budgets <2019 which was <2018/2017 budgets
- Savings have exceeded original pro forma

MRMC Thermal: Member-owned since 2016
1950s VINTAGE STOKER COAL BOILERS
NEW DUAL-FUEL BOILERS
1970s VINTAGE ABSORPTION CHILLERS
NEW CENTRIFUGAL CHILLERS
TEMPORARY BOILER PLANT
NEW NORTH PLANT BOILERS
Questions?

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Thank you!