Bi-Furcating a Central Plant for Redundancy and Reliability

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SPEAKERS

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INTRODUCTION – What is MRMC?

• Both a location and a company

✓ Location

  o 250 acre Milwaukee Regional Medical Center campus

  o Part of original “Milwaukee County Grounds” which provided a variety of county-delivered services starting in the 1850s

• Among those county-provided services was district heating and district cooling to buildings on the campus
INTRODUCTION – What is MRMC?

- Both a location and a company

  ✓ Company

  o Consortium composed of 6 members operating on the campus.
    ➢ Froedtert Memorial Lutheran Hospital
    ➢ Children’s Hospital of Wisconsin
    ➢ The Medical College of Wisconsin
    ➢ Blood Center of Wisconsin
    ➢ Milwaukee County Behavioral Health

- Provides central planning, shared services, and infrastructure for the member entities
INTRODUCTION – The Original System

- Campus Thermal Energy Systems
  - Built by County in 1954 as coal-fired steam with steam turbine electric generators
  - Chilled water added in 1974
  - Purchased by Wisconsin Energy Corporation in 1996

- Acquired by MRMC Thermal, a wholly-owned subsidiary of MRMC, in April 2016
  - MRMC and its members had a vision for the thermal energy systems that served the campus
OWNERSHIP – Transferred Assets

• All components of the MCPP including:
  ➢ Nine acre site
  ➢ Chilled water production (chillers, pumps, cooling towers, etc.)
  ➢ Steam production (boilers, water treatment, stacks, etc.)
  ➢ All coal handling and ash reclaiming equipment
  ➢ Plant structures, balance of plant, process controls, etc.
  ➢ Steam & chilled water distribution system

• Easements for access and operation of steam and chilled water distribution systems.
  ➢ Included tunnels, box conduit and direct buried runs.

• What was not transferred:
  ➢ Environmental permits.
  ➢ Plant staff (supervision, operators, maintenance or distribution)
MRMC STATISTICS

- 7,500,000 square foot of conditioned space
- 22 buildings from 5 customers
- 4 miles of steam and condensate lines
- 4 miles of chilled water piping
- 2,500 feet of steam tunnels
- Peak chilled water demand: 17,100 tons
- Peak steam demand: 217,000 lbs/hr.
- Largest chilled water line: 42” HDPE and 36” PCCP
- Largest steam line: 24” (15 psi) and 12” (135 psi)
Aspirations for a Steam and Chilled Water Future

Redundancy
A second plant to provide continuous supply of critical thermal service with geographic source diversity, on site alternate fuel backup

Reliability
Investment in plant and distribution infrastructure to enhance uninterrupted, consistent source of thermal service

Environmental
Reduce emissions through elimination of coal

Growth
Creating capacity for growth as the campus expands
INTRODUCTION – What is MRMC?
INTRODUCTION – Existing Plant
INTRODUCTION – Existing Plant
MRMC Thermal - Risk Analysis

- Risk Categories
  - The identified risks have been placed into four categories:
    - Internal Utility Failures - Originating in Thermal’s utility assets or operations
    - External Utility Failures - External utility service failure
    - Disasters - Natural or man-made disasters
    - Other - Public Perception
MRMC Thermal - Risk Analysis

Risk Probability

Loss Limit

< 33% Loss  
Minimal Disruption

50% Loss  
Manageable Disruption

100% Loss
Significant Disruption
MRMC Thermal - Risk Analysis

Parallel Sites Risk Summary

- **Fire**
  - Large Plane or Jet Crash
  - Structure Failure
  - Tornado
  - Flood
  - Earthquake
  - External Sabotage
  - Operator Sabotage
  - Boiler Explosion

- **Transition Phase Failure**
  - Distribution Isolation
  - Valve Failure
  - Loss of Water Supply
  - Inadequate Backup Fuel Supply

- **Operator Error**
  - Control System Failure
  - Major Refrigerant Leak

- **Electrical Component Failure**
  - Loss of Electric Supply
  - Winter Storm
  - Lateral Distribution Pipe Failure
  - Boiler Failure
  - Chiller Failure
  - Cooling Tower Failure
  - Pump Failure
  - Auxiliary Equipment Failure

Loss Limit

- **High**
  - Small Plane or Helicopter Crash
  - Major Gas Leak
  - In-Plant Isolation Valve Failure
  - Water Quality Failure
  - In-Plant Pipe Failure
  - Roof Failure

- **Medium**
  - Main Distribution Pipe Failure
  - Loss of Natural Gas Supply

- **Low**
  - Very Low
  - Fairly Low
  - Low
  - High
  - Fairly High
  - Very High

Risk Probability
INTRODUCTION – Existing Plant
PLANT SITE OVERVIEW - ORIGINAL

A – Emission Controls

B- Boiler Room
  • Steam to Users

C – Turbine Hall

D – Chiller Room
  • Steam to Users
  • Chilled Water to Users
  • No Emergency Generators
  • No Fuel Oil
PLANT SITE OVERVIEW

NORTH PLANT
PLANT SITE OVERVIEW

NORTH PLANT

WEST PLANT
PLANT SITE OVERVIEW

NORTH PLANT

WEST PLANT

EAST PLANT
STEAM PRE-PROJECT CONDITIONS

- **Boilers 1-3 (1955) – Coal-Fired**
- **Boiler 4 (1970) – Gas-Fired**
  Administratively limited for runtime
- **Boiler 5 (2009) – Gas-Fired**
  Retain for continued use

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Pct</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>255,000 lb/hr</td>
<td>63%</td>
<td>~60 yrs</td>
</tr>
<tr>
<td>80,000 lb/hr</td>
<td>20%</td>
<td>~45 yrs</td>
</tr>
<tr>
<td>67,500 lb/hr</td>
<td>17%</td>
<td>~10 yrs</td>
</tr>
</tbody>
</table>

- Boiler MACT was looming
- NOx compliance is an issue
### STEAM POST-PROJECT CONDITIONS

<table>
<thead>
<tr>
<th>Capacity</th>
<th>West Plant</th>
<th>North Plant</th>
<th>Total (N+1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1 (2018)</strong></td>
<td>2 x 70,000 lb/hr</td>
<td>2 x 70,000 lb/hr</td>
<td>347,500 lb/hr</td>
</tr>
<tr>
<td></td>
<td>Existing: 67,500 lb/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Full Build-out Capability</strong></td>
<td>347,500 lb/hr (5 Boilers)</td>
<td>280,000 lb/hr (4 Boilers)</td>
<td>627,500 lb/hr</td>
</tr>
</tbody>
</table>

Following this Phase of Construction:

- **Total Capacity (N+1):** 347,500 lb/hr
- **Firm Capacity:** 277,500 lb/hr
- **Projected Peak Load*:** 271,000 lb/hr

*Within 2023 Planning Horizon*
STEAM = N+1 CHART
CHILLED WATER PRE-PROJECT CONDITIONS

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Pct</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,750 tons</td>
<td>19%</td>
<td>&gt;25 yrs</td>
</tr>
<tr>
<td>4,660 tons</td>
<td>23%</td>
<td>20-25 yrs</td>
</tr>
<tr>
<td>0 tons</td>
<td>0%</td>
<td>15-20 yrs</td>
</tr>
<tr>
<td>4,820 tons</td>
<td>24%</td>
<td>10-15 yrs</td>
</tr>
<tr>
<td>6,850 tons</td>
<td>34%</td>
<td>&lt;10 yrs</td>
</tr>
</tbody>
</table>

- Significant age
- Absorption technology inefficient, less reliable
## CHILLED WATER POST-PROJECT CONDITIONS

<table>
<thead>
<tr>
<th>Capacity</th>
<th>East Plant</th>
<th>West Plant</th>
<th>Total (N+1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1 (2018)</strong></td>
<td>Existing: 16,780 tons</td>
<td>3 x 2,500 tons</td>
<td>24,280 tons</td>
</tr>
<tr>
<td><strong>Full Build-out Capability</strong></td>
<td>24,280 tons (13 Chillers)</td>
<td>15,000 tons (6 Chillers)</td>
<td>39,280 tons</td>
</tr>
</tbody>
</table>

Following this Phase of Construction:

- **Total Capacity (N+1):** 24,280 tons
- **Firm Capacity:** 21,780 tons
- **Projected Peak Load**: 21,400 tons

*Within 2023 Planning Horizon*
CHILLED WATER = N+1 CHART
STEAM DISTRIBUTION 2016

[Diagram of steam distribution network with labels for existing walkable tunnel, existing box trench, and existing above-grade piping]
CHILLED WATER DISTRIBUTION 2016
CHILLED WATER DISTRIBUTION 2018
MRMC Thermal – Reliability thru Bi-Furcation

**NORTH PLANT**
- 2 Boilers 140,000 #/hr
- Air Compressors
- HV Electrical Feed
- Natural Gas Feed
- Emergency Generator
- Fuel Oil Tank
- Water Treatment

**WEST PLANT**
- 3 Boilers 210,000 #/hr
- 3 Chillers 7,500 Tons
- Air Compressors
- Natural Gas Feed
- HV Electrical Feed
- 2 Emergency Generators
- 3 Fuel Oil Tanks

**EAST PLANT**
- 9 Chillers 17,000 Tons
- Air Compressors
- HV Electrical Feed
- Emergency Generator

**PLANT CONTROLS**

**DISTRIBUTION SYSTEM TO USERS**
- Steam
- Condensate
- Chilled Water

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

**VIA PIPE BRIDGE**
- Steam
- Condensate
- Fuel Oil

**DISTRIBUTION SYSTEM TO USERS**
- Steam
- Condensate
- Chilled Water
PLANT BI-FURCATION

HOW WAS IT DONE?
NEW RENTAL BOILERS STEP 1
NORTH PLANT
DEMO OF COAL BOILERS STEP 2
INSTALLATION OF NEW GAS/OIL PACKAGE BOILERS STEP 3A
ARRIVED: October 6, 2015

RETURNED: May 29, 2018
INSTALLATION OF NEW CENTRIFUGAL CHILLERS STEP 4
DEMO OF ABSORPTION CHILLERS STEP 5
DISTRIBUTION HOW WAS IT DONE?
DISTRIBUTION - STEAM HOW WAS IT DONE?
DISTRIBUTION - CW HOW WAS IT DONE?
DISTRIBUTION - CW HOW WAS IT DONE?
DISTRIBUTION – CW HOW WAS IT DONE?

Boring Pit

Receiving Pit
HOW WAS IT DONE?
DISTRIBUTION - CW HOW WAS IT DONE?