The Art of Replacing Boilers and Chillers in a Central Plant Without Impact to Production Needs
MRMC STATISTICS

- 7,500,000 square foot of conditioned space
- 22 buildings from 5 customers
- Approximately 2 miles of steam and chilled water lines
- Approximately 2,500 feet of tunnel
- Peak chilled water demand – 18,000 tons
- Peak steam demand - 205,000 lbs/hr.
- Largest chilled water line = 42” HDPE and 36” PCCP
- Largest steam line = 24” 15 psi and 12” 135 psi
PROJECT OVERVIEW

• SCOPE: Total removal of all assets associated with coal combustion and permanent replacement with gas/oil fired boilers. Replacement of steam driven assets and replaced with electric driven equipment. Addition of chillers and demo of older absorption chillers. New electrical feed to plant and internal distribution. Separation of steam and chilled water systems into two distinct plants.

• BUDGET: $93,340,000

• SCHEDULE: Started spring of 2016 with projected completion fall of 2018
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 noxious emissions through elimination of coal

Growth
Creating capacity for growth including and beyond the new Center for Advanced Care at Froedtert & The Medical College of Wisconsin POB
DECISION AXIOMS

• What is best for Owner (50 year solutions)

• Minimize any event that reduces reliability of utility production

• Incurred costs shall be spent wisely

• Understand if schedule impacts can be minimized

• Look for “Best use of space”
  • Operations – Accessibility and location
  • Maintenance – Footprint area around equipment, headroom, rigging access and aisle/openings for ingress and egress
• **STEP 1**
  Work with an engineering consultant and Owner to develop clear definition around needs and options when removing existing equipment from service.

• **STEP 2**
  Understand when new equipment can be tested and started up based on plant capacity to support needed loads on new equipment as well as loads on the plant at that time.

• **STEP 3**
  Work with Owner to implement the chosen approach so new equipment can be commissioned under all load conditions, that the plant is never placed in jeopardy and plant assets are not overburdened, i.e. operational staffing.
STEAM = N+1 CHART

[Graph showing the steam production and consumption across different months, with various boilers indicated by different colors and line graphs for total capacity and minimum ambient air temps.]
STEAM PRE-PROJECT CONDITIONS

- Boilers 1-3 (1955) – Coal-Fired
  Administratively limited for runtime
  Retain for continued use

- Boiler MACT was looming
- NOx compliance is an issue

<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>
# STEAM PRE-PROJECT CONDITIONS

<table>
<thead>
<tr>
<th>Peak Steam Load</th>
<th>Current Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>242,000 lb/hr</td>
<td>Boiler 1 – 85,000 lb/hr&lt;br&gt;Boiler 2 – 85,000 lb/hr&lt;br&gt;Boiler 3 – 85,000 lb/hr&lt;br&gt;Boiler 4 – 80,000 lb/hr&lt;br&gt;Boiler 5 – 67,500 lb/hr</td>
</tr>
</tbody>
</table>

**Total Capacity (N+1)** – 402,500 lb/hr  
**Firm Capacity** – 317,500 lb/hr
## STEAM POST-PROJECT CONDITIONS

<table>
<thead>
<tr>
<th>Peak Steam Load</th>
<th>Current Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>205,000 lb/hr</td>
<td>Boiler 15 – 70,000 lb/hr</td>
</tr>
<tr>
<td></td>
<td>Boiler 16 – 70,000 lb/hr</td>
</tr>
<tr>
<td></td>
<td>Boiler 21 – 70,000 lb/hr</td>
</tr>
<tr>
<td></td>
<td>Boiler 22 – 70,000 lb/hr</td>
</tr>
<tr>
<td></td>
<td>Boiler 5 – 67,500 lb/hr</td>
</tr>
</tbody>
</table>

**Capacity**

- **Total Capacity (N+1)** – 347,500 lb/hr
- **Firm Capacity** – 277,500 lb/hr
DEMO OF COAL BOILERS STEP 2
INSTALLATION OF NEW GAS/OIL PACKAGE

BOILERS STEP 3
INSTALLATION OF NEW GAS/OIL PACKAGE BOILERS STEP 3
CHILLED WATER = N+1 CHART
CHILLED WATER PRE-PROJECT CONDITIONS

Capacity
3,750 tons 19% 25 yrs
4,660 tons 23% 20-25 yrs
0 tons 0% 15-20 yrs
4,820 tons 24% 10-15 yrs
6,850 tons 34% <10 yrs

Age
Absorption technology inefficient, less reliable

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

<table>
<thead>
<tr>
<th>Peak Chilled Water Load</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,800 tons</td>
<td>Electric Chillers (8) – 13,390 tons</td>
</tr>
<tr>
<td></td>
<td>Steam Turbine Chillers (1) – 1,890 tons</td>
</tr>
<tr>
<td></td>
<td>Absorption Chillers (5) – 4,800 tons</td>
</tr>
</tbody>
</table>

Total Capacity (N+1) – 20,080 tons  
Firm Capacity – 17,560 tons
# Chilled Water Post-Project Conditions

<table>
<thead>
<tr>
<th>Peak Chilled Water Load</th>
<th>Current Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,000 tons</td>
<td>Electric Chillers (8) – 13,390 tons</td>
</tr>
<tr>
<td></td>
<td>Steam Turbine Chillers (1) – 2,070 tons</td>
</tr>
<tr>
<td></td>
<td>Absorption Chillers (3) – 7,500 tons</td>
</tr>
</tbody>
</table>

**Total Capacity (N+1)** – 22,960 tons  
**Firm Capacity** – 20,460 tons
CONSTRUCT NEW AREA FOR CENTRIFUGAL CHILLERS STEP 1
INSTALLATION OF NEW CENTRIFUGAL CHILLERS STEP 2
## PROJECT MANAGEMENT TOOLS – MILESTONE SCHEDULE

### Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Start</th>
<th>End</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1550</td>
<td>09-Oct-17</td>
<td>09-Oct-17</td>
<td>West Plant WE Energize MV Switchgear #1A &amp; #2A</td>
</tr>
<tr>
<td>A2760</td>
<td>01-Nov-17</td>
<td>01-Nov-17</td>
<td>East Plant Energize Switchyard Line #1 To Section #1 MV Switchgear</td>
</tr>
<tr>
<td>A2880</td>
<td>02-Nov-17</td>
<td>02-Nov-17</td>
<td>North Plant BOILER Mechanical Completion - Full Release to Start Up</td>
</tr>
<tr>
<td>A2960</td>
<td>21-Dec-17</td>
<td>21-Dec-17</td>
<td>Energize Switchyard Line #2 To Section #2 MV Switchgear</td>
</tr>
<tr>
<td>JC-GN-MS-0026</td>
<td>07-Feb-16</td>
<td>07-Feb-16</td>
<td>BOILER Mechanical Completion</td>
</tr>
<tr>
<td>JC-GN-MS-0090</td>
<td>05-Feb-16</td>
<td>05-Feb-16</td>
<td>West Plant Mechanical Completion - Boiler Complete</td>
</tr>
<tr>
<td>A2610</td>
<td>01-Mar-16</td>
<td>01-Mar-16</td>
<td>Turbine Hall Relocate SJE Offices &amp; Utilities To Release Demo</td>
</tr>
<tr>
<td>A2650</td>
<td>16-Mar-16</td>
<td>16-Mar-16</td>
<td>West Plant Mechanical Completion - Chiller Complete Complete</td>
</tr>
<tr>
<td>A2660</td>
<td>02-Apr-16</td>
<td>02-Apr-16</td>
<td>Water Treatment Mechanical Completion</td>
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<tr>
<td>JC-GN-MS-0070</td>
<td>15-May-16</td>
<td>15-May-16</td>
<td>North Plant Mechanical Completion</td>
</tr>
<tr>
<td>JC-GN-MS-0010</td>
<td>19-Apr-16</td>
<td>19-Apr-16</td>
<td>Jarar DeMobilize Of-Site</td>
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<tr>
<td>A2640</td>
<td>19-Jul-16</td>
<td>19-Jul-16</td>
<td>Turbine Hall Work Complete</td>
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<tr>
<td>JC-GN-MS-0110</td>
<td>31-Aug-16</td>
<td>31-Aug-16</td>
<td>Subassemly Completion</td>
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</tbody>
</table>

### Equipment

- **East Plant**
  - Receipt Condensate Pumps (CDP-11 & 12, CDT-11 & 12)
  - Receipt Condensate Tank (CDT-11 & 12)
  - Receipt Air Compressor
  - Receipt Condensate Pumps (CDP-11 & 12, CDT-11 & 12)
  - Receipt Condensate Tank (CDT-11 & 12)
  - Receipt Air Compressor
- **West Plant**
  - Receipt Compressed Air Dryer (DRYR-21)
  - Receipt Heat Exchanger (HEX-21)
  - Receipt Condensate Pumps (CDP-11 & 12, CDT-11 & 12)
  - Receipt Condensate Tank (CDT-11 & 12)
  - Receipt Air Compressor
- **North Plant**
  - Receipt Condensate Pumps (POL-11)
  - Receipt Water Softener (SWF-11)
  - Receipt Reverse Osmosis (RO-11)
  - Receipt Condensate Pumps (POL-11)
  - Receipt Water Softener (SWF-11)
  - Receipt Condensate Pumps (POL-11)
  - Receipt Water Softener (SWF-11)

**Project ID:** MPMC Plant Mech
**Data date:** 02-Oct-17
**Plan date:** 09-Oct-17

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Milwaukee Regional Medical Center - Mechanical Project...
Schedule as of 09-Oct-17

![Diagrams and Tables]

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PROJECT MANAGEMENT TOOLS – PULL PLANNING
LESSONS LEARNED FROM
PROJECT IMPLEMENTATION

• Use Integrated Lean Project Delivery® (ILPD) processes to reduce waste and keep everyone “in the know” of each other’s work, and accountable as a team player
• Involve trade partners as early as possible, manage buy-outs with best quality for the project and not just short term gains
• Keep a cross function/cross party management team for rapid decision-making
• Look at equipment load profiles to take advantage of current capacities or optimize operations
• Use seasonal operation evolutions for phased construction approaches
• Establish contingency budgets early, and who manages
• Establish communication matrix to address key people and/or positions for information dissemination and timing of interactions
• Establish an approval/permit matrix and understand when, who, how and why in order to maintain a continuous project flow.
• Integrate operations and maintenance into the project early for smooth transition at turnover
• Seek simple solutions…the advantages will amaze you