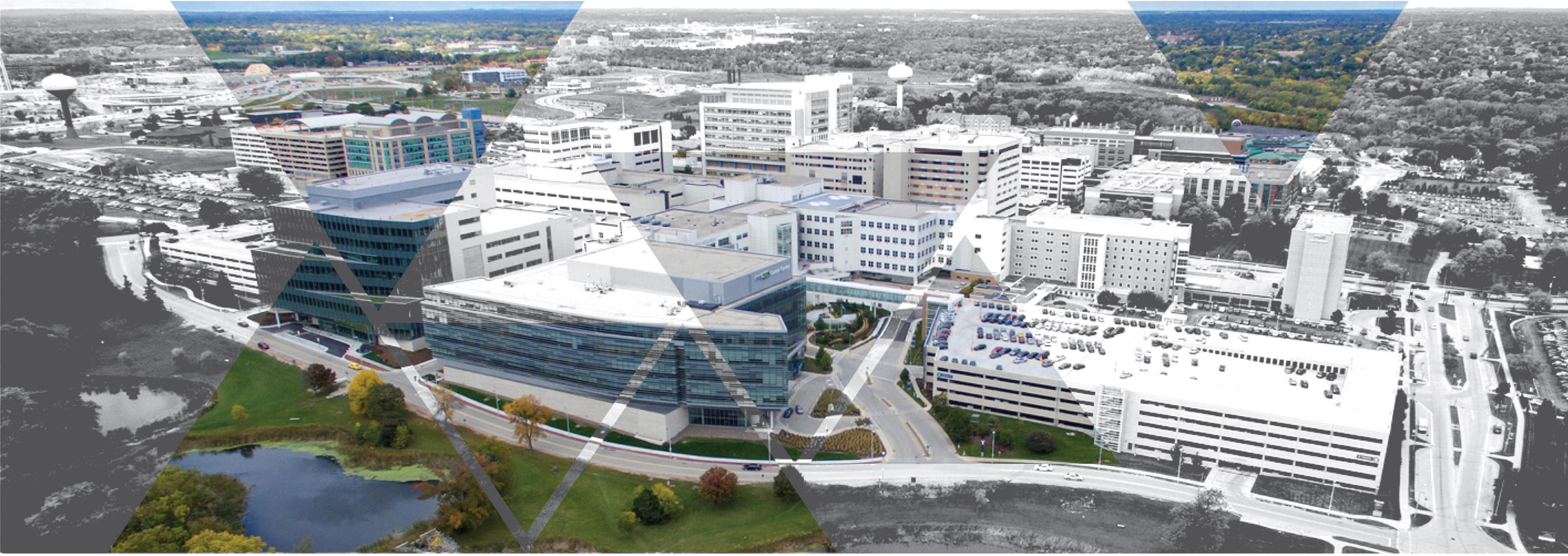


The Art of Replacing Boilers and Chillers in a Central Plant Without Impact to Production Needs

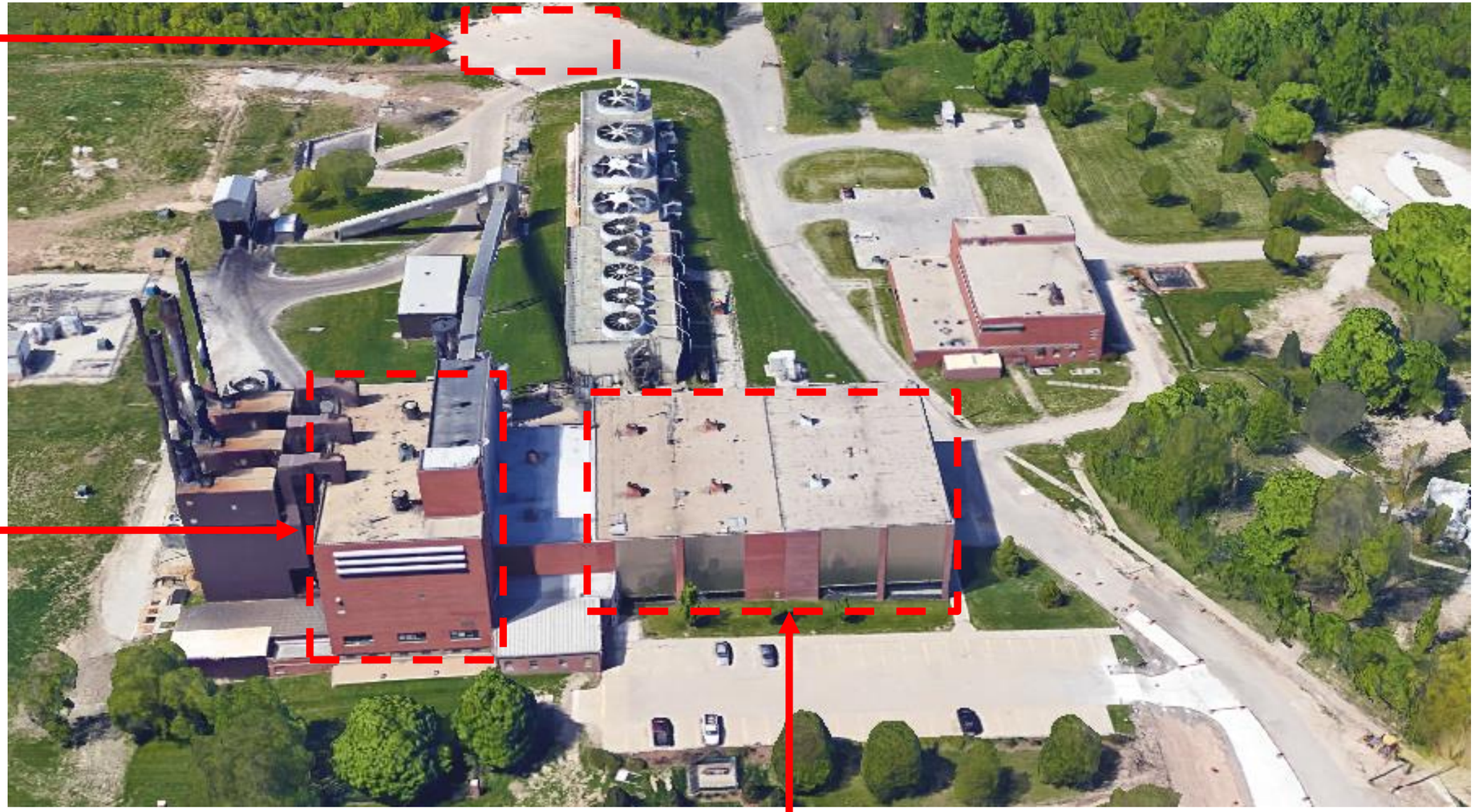
CampusEnergy2018 Conference

Jay Ehrfurth-PE

BOLDT®

PLANT SITE OVERVIEW

NORTH PLANT



WEST PLANT

EAST PLANT

MRMC STATISTICS

Milwaukee Regional Medical Center Thermal

- 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

PROJECT & DESIGN PHILOSOPHY

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

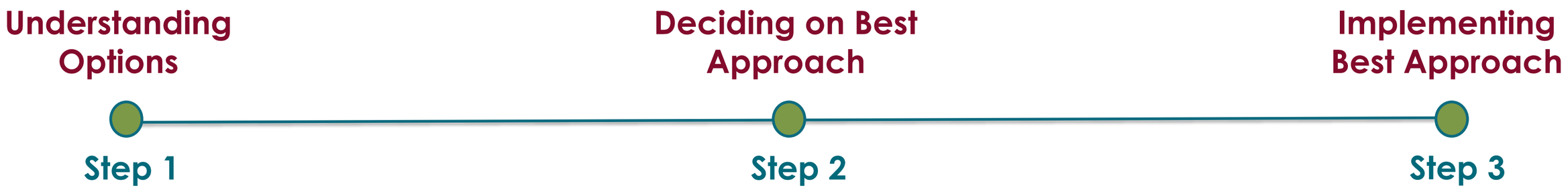
Growth

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

DECISION MATRIX FOR SEASONAL ACTIVITY



- **STEP 1**

  Work with an engineering consultant and Owner to develop clear definition around needs and options when removing existing equipment from service.

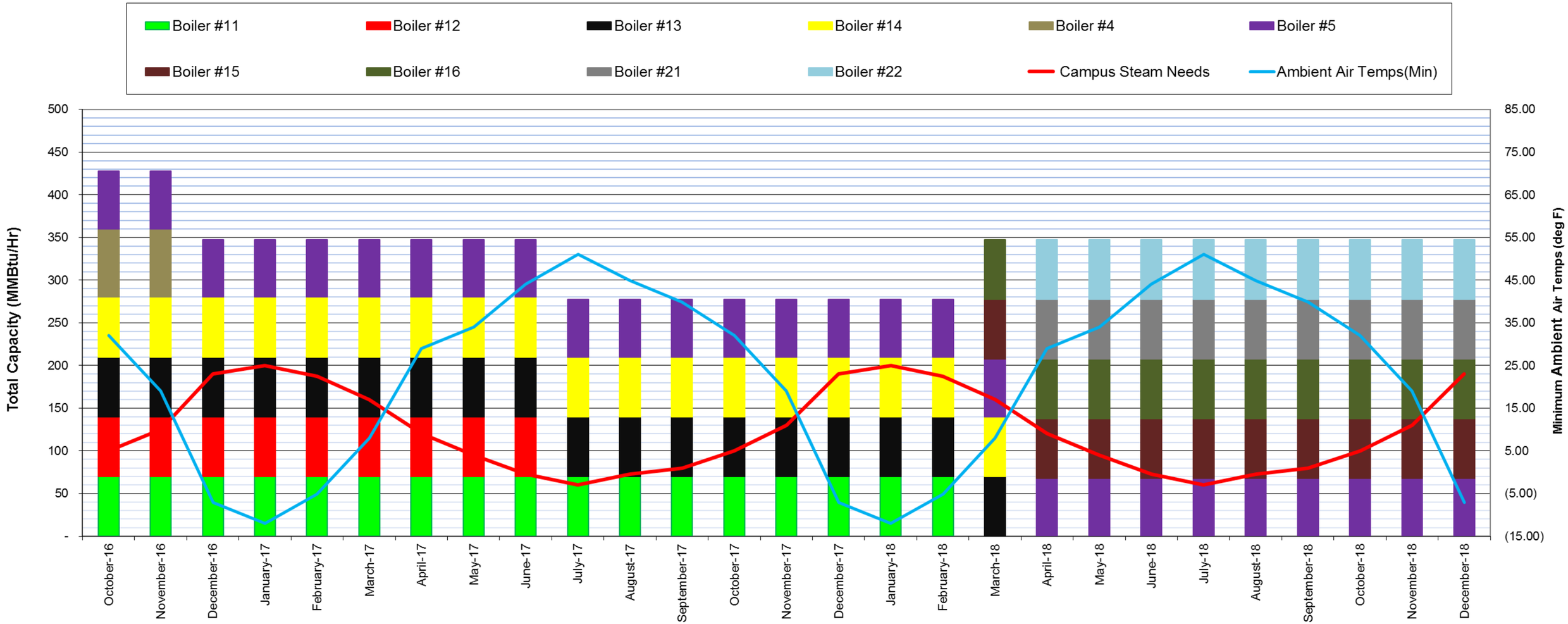
- **STEP 2**

  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.

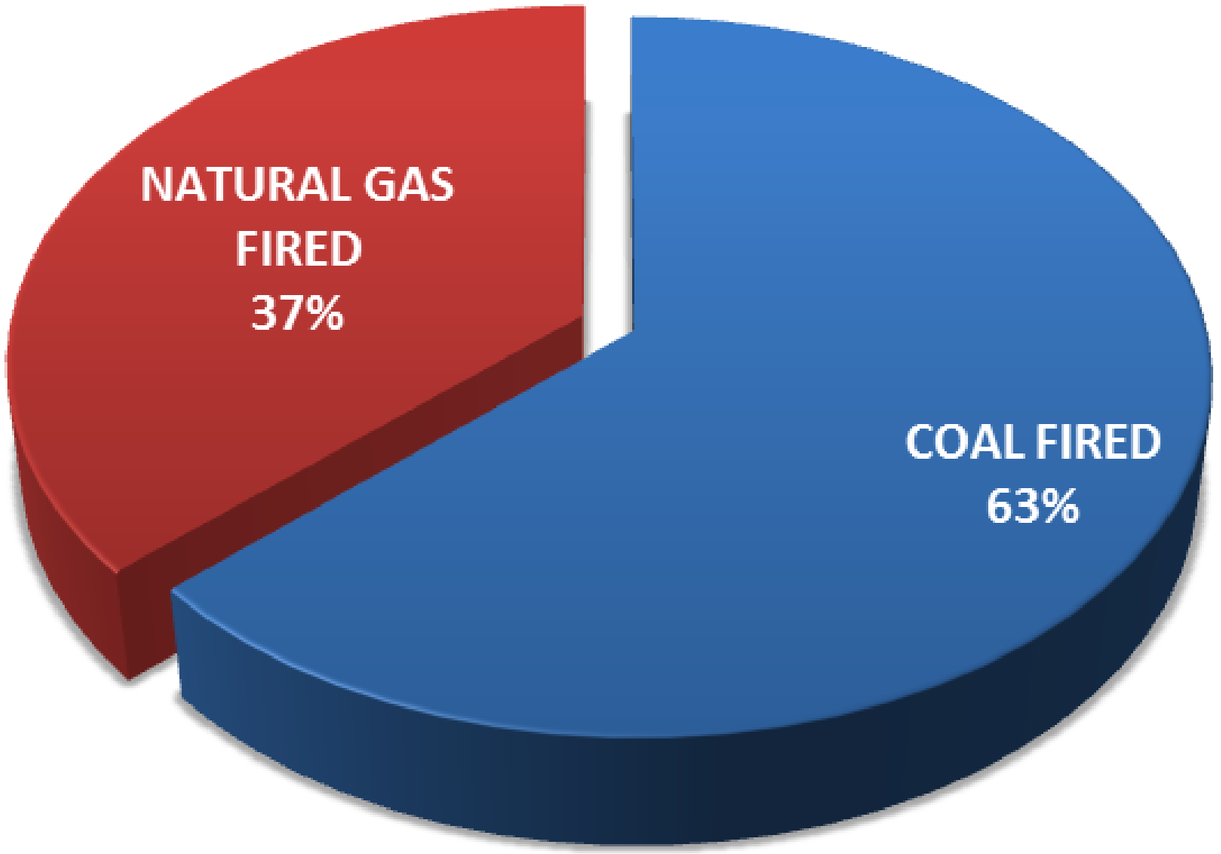
STEAM = N+1 CHART



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

Capacity	Pct	Age
255,000 lb/hr	63%	~60 yrs
80,000 lb/hr	20%	~45 yrs
67,500 lb/hr	17%	~10 yrs



- **Boiler MACT was looming**
- **NOx compliance is an issue**

STEAM PRE-PROJECT CONDITIONS

	Capacity	
Peak Steam Load	**Current Configuration**	
242,000 lb/hr	Boiler 1 – 85,000 lb/hr	**COAL**
	Boiler 2 – 85,000 lb/hr	**COAL**
	Boiler 3 – 85,000 lb/hr	**COAL**
	Boiler 4 – 80,000 lb/hr	**NATURAL GAS**
	Boiler 5 – 67,500 lb/hr	**600psi Remains**

Total Capacity (N+1) – 402,500 lb/hr

Firm Capacity – 317,500 lb/hr

STEAM POST-PROJECT CONDITIONS

	Capacity
Peak Steam Load	**Current Configuration**
205,000 lb/hr	Boiler 15 – 70,000 lb/hr **NATURAL GAS/OIL** Boiler 16 – 70,000 lb/hr **NATURAL GAS/OIL** Boiler 21 – 70,000 lb/hr **NATURAL GAS/OIL** Boiler 22 – 70,000 lb/hr **NATURAL GAS/OIL** Boiler 5 – 67,500 lb/hr **NATURAL GAS**

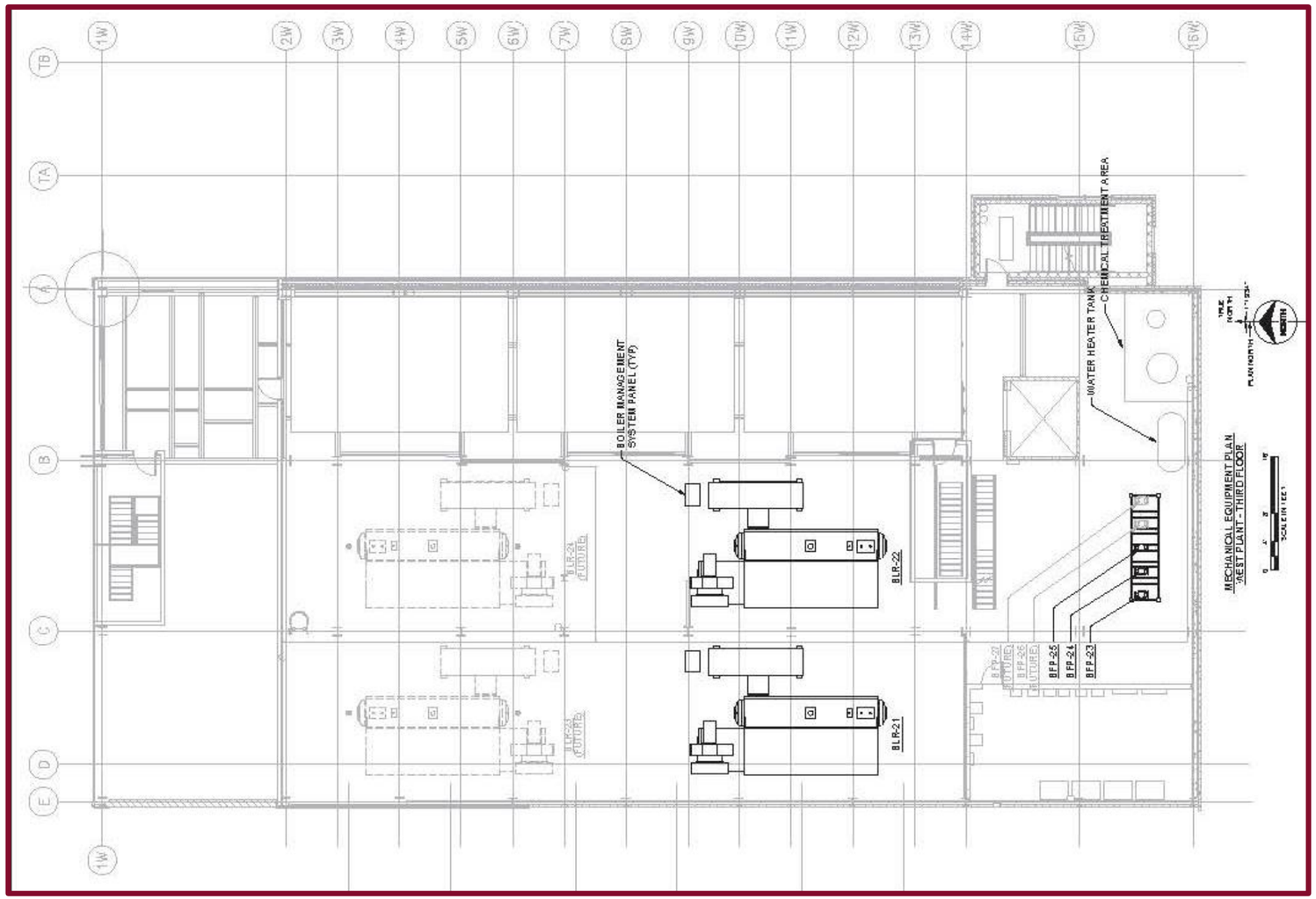
Total Capacity (N+1) – 347,500 lb/hr

Firm Capacity – 277,500 lb/hr

NEW RENTAL BOILERS STEP 1

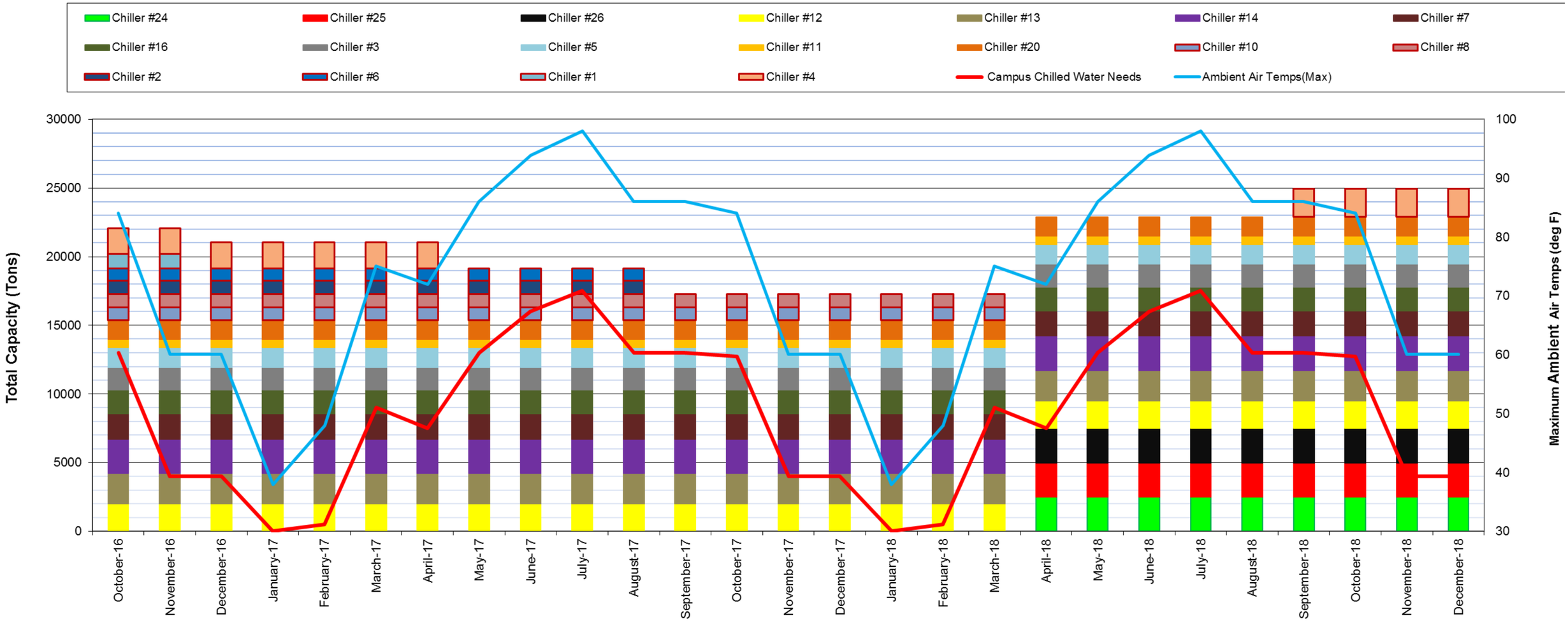
DEMO OF COAL BOILERS STEP 2

INSTALLATION OF NEW GAS/OIL PACKAGE BOILERS STEP 3



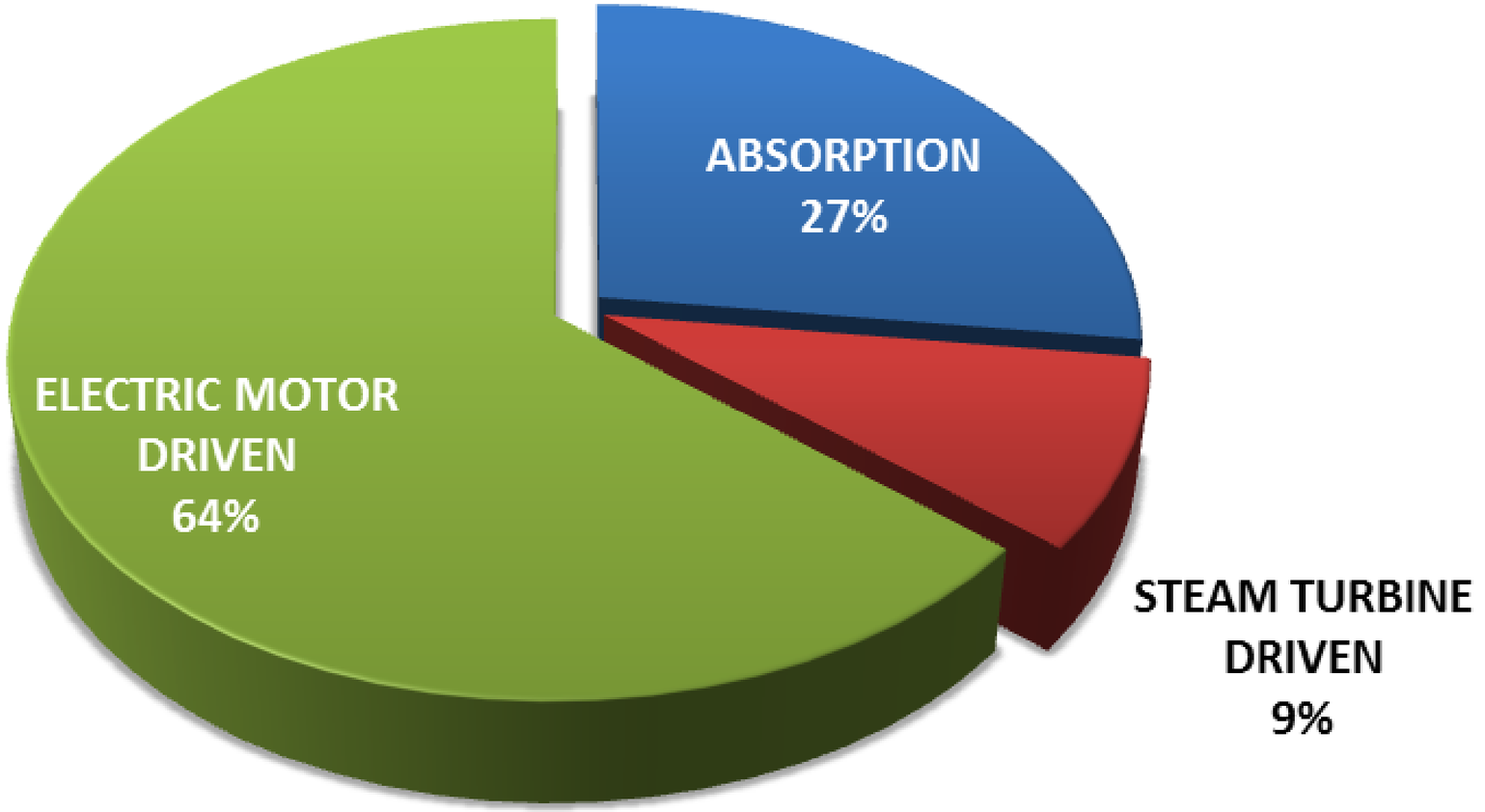
INSTALLATION OF NEW GAS/OIL PACKAGE BOILERS STEP 3

CHILLED WATER = N+1 CHART



CHILLED WATER PRE-PROJECT CONDITIONS

Capacity	Pct	Age
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



- Significant age
- Absorption technology inefficient, less reliable

CHILLED WATER PRE-PROJECT CONDITIONS

	Capacity
Peak Chilled Water Load	**Current Configuration**
16,800 tons	**Electric Chillers (8) – 13,390 tons** **Steam Turbine Chillers (1) – 1,890 tons** **Absorption Chillers (5) – 4,800 tons**

Total Capacity (N+1) – 20,080 tons

Firm Capacity – 17,560 tons

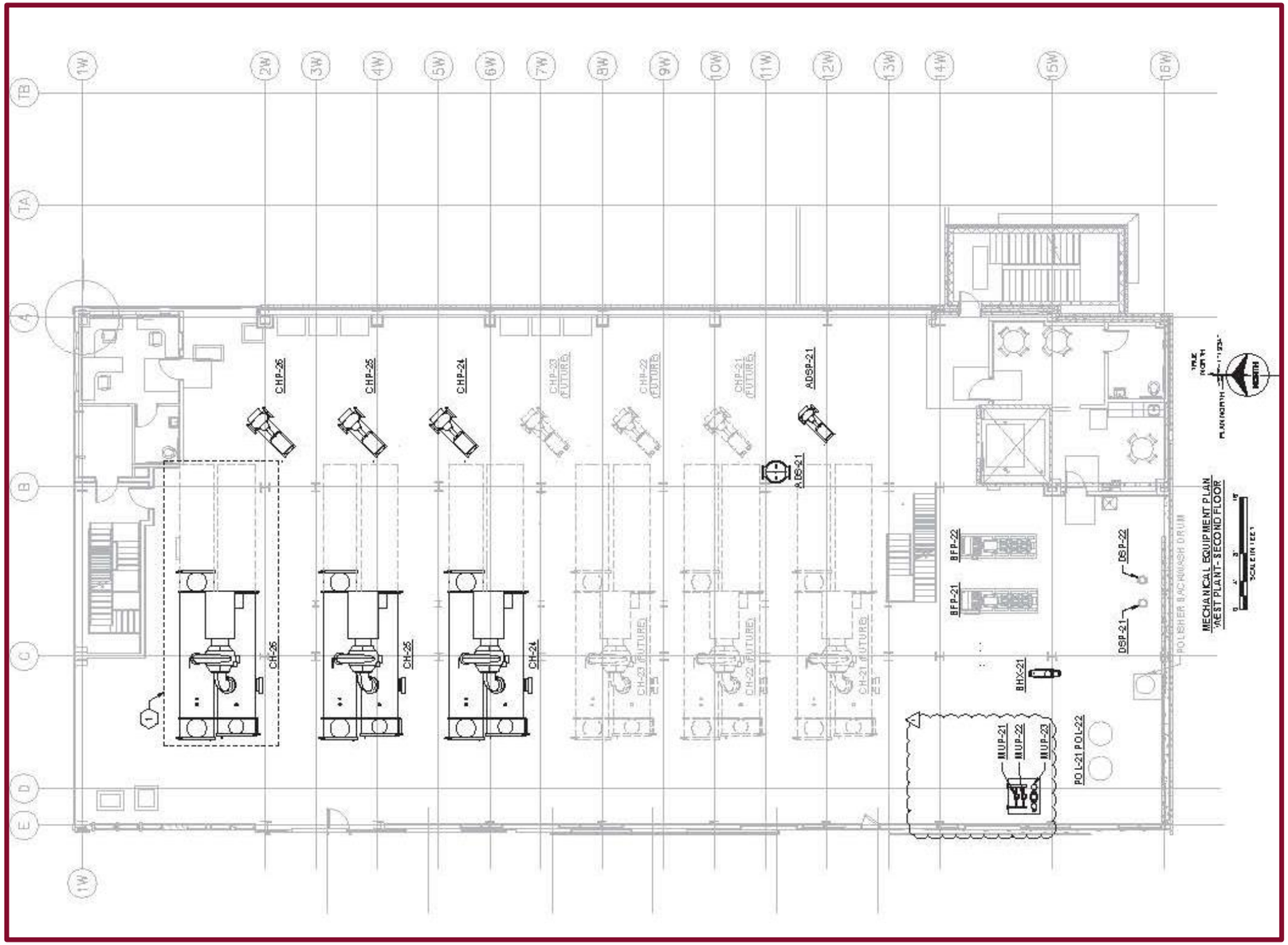
CHILLED WATER POST-PROJECT CONDITIONS

	Capacity
Peak Chilled Water Load	**Current Configuration**
18,000 tons	**Electric Chillers (8) – 13,390 tons** **Steam Turbine Chillers (1) – 2,070 tons** **Absorption Chillers (3) – 7,500 tons**

Total Capacity (N+1) – 22,960 tons

Firm Capacity – 20,460 tons

CONSTRUCT NEW AREA FOR CENTRIFUGAL CHILLERS STEP 1

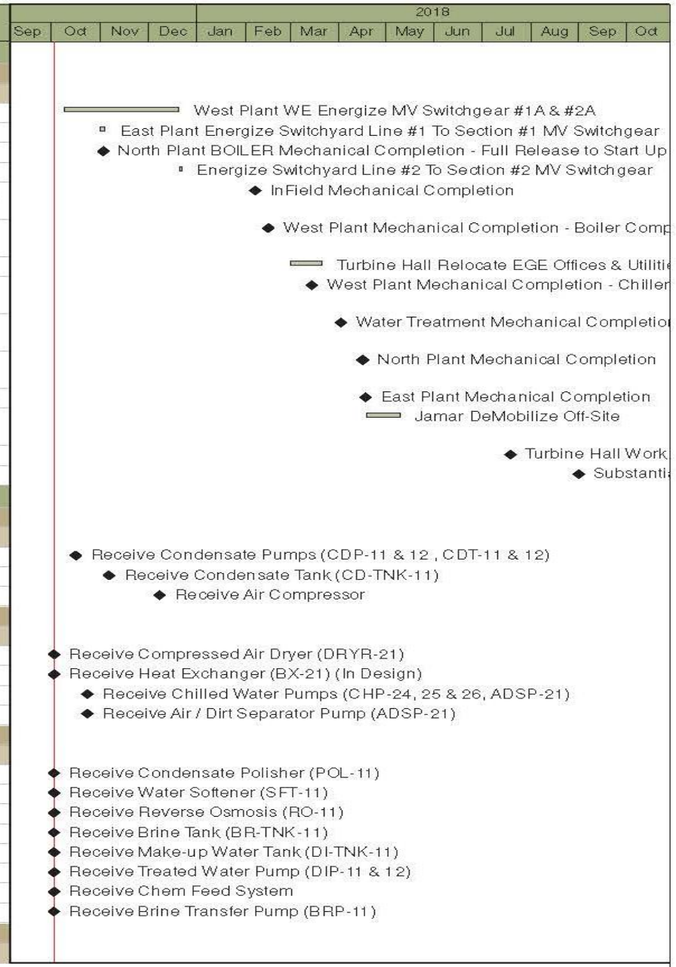


INSTALLATION OF NEW CENTRIFUGAL CHILLERS STEP 2

DEMO OF ABSORPTION CHILLERS STEP 3

PROJECT MANAGEMENT TOOLS – MILESTONE SCHEDULE

Act ID	Activity Name	Remaining Duration	Start	Finish	Predecessors
Milestones		228d	09-Oct-17	31-Aug-18	
-		228d	09-Oct-17	31-Aug-18	
Miscellaneous		228d	09-Oct-17	31-Aug-18	
A1690	West Plant WE Energize MV Switchgear #1A & #2A	51d	09-Oct-17*	20-Dec-17	
A2570	East Plant Energize Switchyard Line #1 To Section #1 MV Switchgear	3d	01-Nov-17*	03-Nov-17	
A2620	North Plant BOILER Mechanical Completion - Full Release to Start Up	0d		02-Nov-17	A1560
A2580	Energize Switchyard Line #2 To Section #2 MV Switchgear	2d	21-Dec-17*	22-Dec-17	
JC-GN-MS-0025	InField Mechanical Completion	0d		07-Feb-18	JC-CN-IF-0150, JC-CN-IF-0130, JC-CN-IF-0060, JC-CN-IF-0020,
JC-GN-MS-0060	West Plant Mechanical Completion - Boiler Complete	0d		15-Feb-18	JC-CN-WP-0470, JC-CN-WP-0340,
A2610	Turbine Hall Relocate EGE Offices & Utilities To Release Demo	15d	01-Mar-18*	21-Mar-18	
A2650	West Plant Mechanical Completion - Chillers Complete Complete	0d		15-Mar-18*	JC-CN-WP-0470, JC-CN-WP-0340,
A2630	Water Treatment Mechanical Completion	0d		02-Apr-18*	JC-CN-NP-0410, JC-CN-NP-0390,
JC-GN-MS-0090	North Plant Mechanical Completion	0d		16-Apr-18*	JC-CN-NP-0170, JC-CN-NP-0150,
JC-GN-MS-0070	East Plant Mechanical Completion	0d		18-Apr-18	JC-CN-EP-0500, JC-CN-EP-04
JC-GN-MS-0100	Jamar DeMobilize Off-Site	16d	19-Apr-18	10-May-18	JC-CN-NP-0230, JC-GN-MS-0070
A2640	Turbine Hall Work Complete	0d		19-Jul-18	A1120,A1130,A1140,A1150
JC-GN-MS-0110	Substantial Completion	0d		31-Aug-18*	JC-GN-MS-0070
Procurement		85d	02-Oct-17	01-Feb-18	
East Plant		37d	16-Oct-17	08-Dec-17	
Equipment - East Plant		37d	16-Oct-17	08-Dec-17	
JC-PR-EP-0090	Receive Condensate Pumps (CDP-11 & 12 , CDT-11 & 12)	0d		16-Oct-17*	
JC-PR-EP-0100	Receive Condensate Tank (CD-TNK-11)	0d		06-Nov-17*	
A2600	Receive Air Compressor	0d		08-Dec-17*	
West Plant		16d	02-Oct-17	23-Oct-17	
Equipment - West Plant		16d	02-Oct-17	23-Oct-17	
JC-PR-WP-0180	Receive Compressed Air Dryer (DRYR-21)	0d		02-Oct-17*	
JC-PR-WP-0080	Receive Heat Exchanger (BX-21) (In Design)	0d		02-Oct-17*	
JC-PR-WP-0050	Receive Chilled Water Pumps (CHP-24, 25 & 26, ADSP-21)	0d		23-Oct-17*	
JC-PR-WP-0070	Receive Air / Dirt Separator Pump (ADSP-21)	0d		23-Oct-17*	
North Plant		0d	02-Oct-17	02-Oct-17	
Equipment - North Plant		0d	02-Oct-17	02-Oct-17	
JC-PR-NP-0010	Receive Condensate Polisher (POL-11)	0d		02-Oct-17	
JC-PR-NP-0020	Receive Water Softener (SFT-11)	0d		02-Oct-17	
JC-PR-NP-0030	Receive Reverse Osmosis (RO-11)	0d		02-Oct-17	
JC-PR-NP-0040	Receive Brine Tank (BR-TNK-11)	0d		02-Oct-17	
JC-PR-NP-0050	Receive Make-up Water Tank (DI-TNK-11)	0d		02-Oct-17	
JC-PR-NP-0060	Receive Treated Water Pump (DIP-11 & 12)	0d		02-Oct-17	
JC-PR-NP-0070	Receive Chem Feed System	0d		02-Oct-17	
JC-PR-NP-0100	Receive Brine Transfer Pump (BRP-11)	0d		02-Oct-17	
Infield / Pump House		85d	02-Oct-17	01-Feb-18	
Equipment - Infield		85d	02-Oct-17	01-Feb-18	



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Data date: 02-Oct-17
Run date: 09-Oct-17

TASK filter: % Complete less than 100.
Layout:MRMC Master

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

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