



Lessons in System Transformation and Resilience from Milwaukee Regional Medical Center

Mark Geronime, Milwaukee Regional Medical Center (MRMC)

Rory Peters, Ever-Green Energy

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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

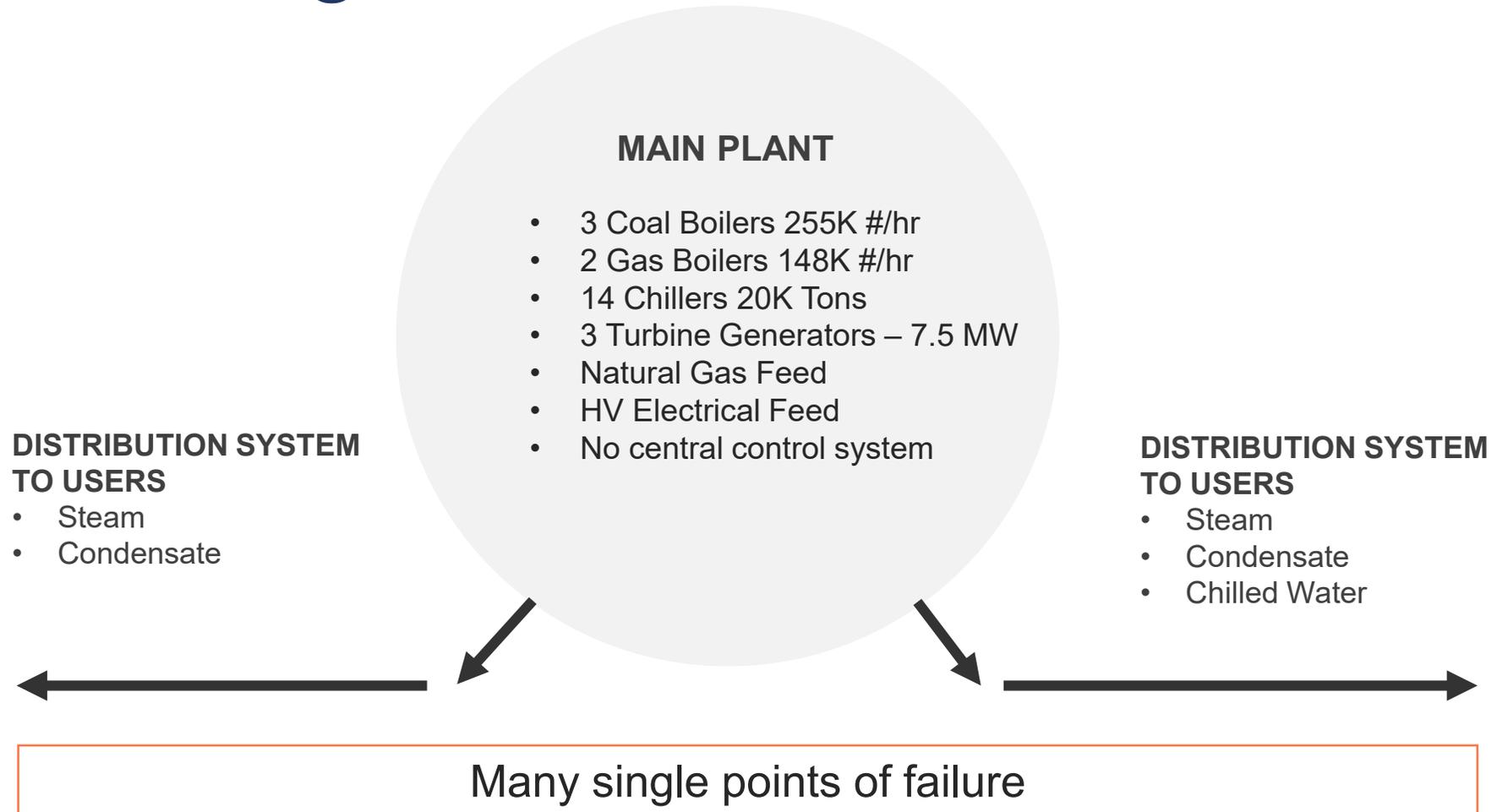
Acquired by MRMC Thermal in April 2016

- 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

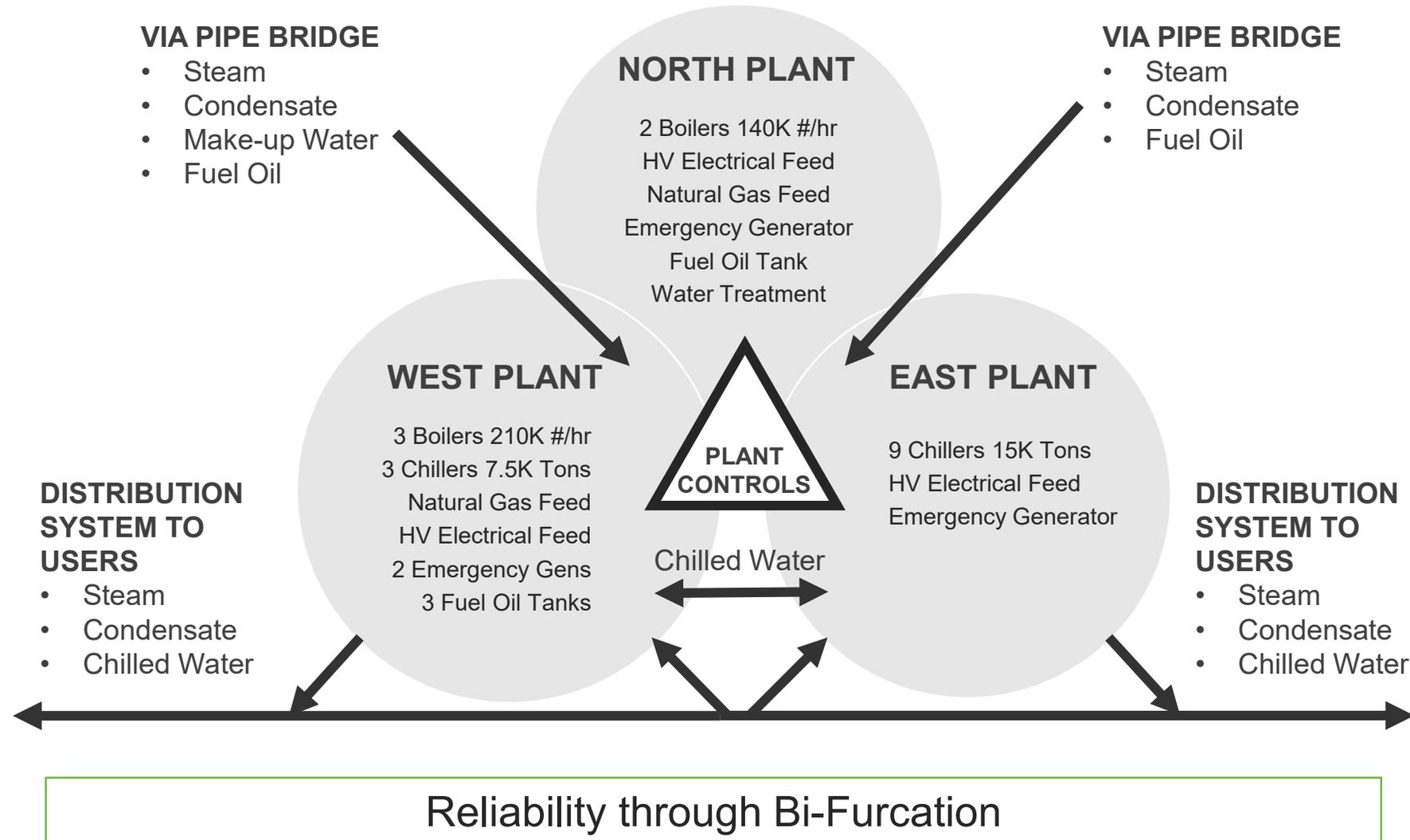
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Initial Configuration



Reconstruction: Production Resiliency



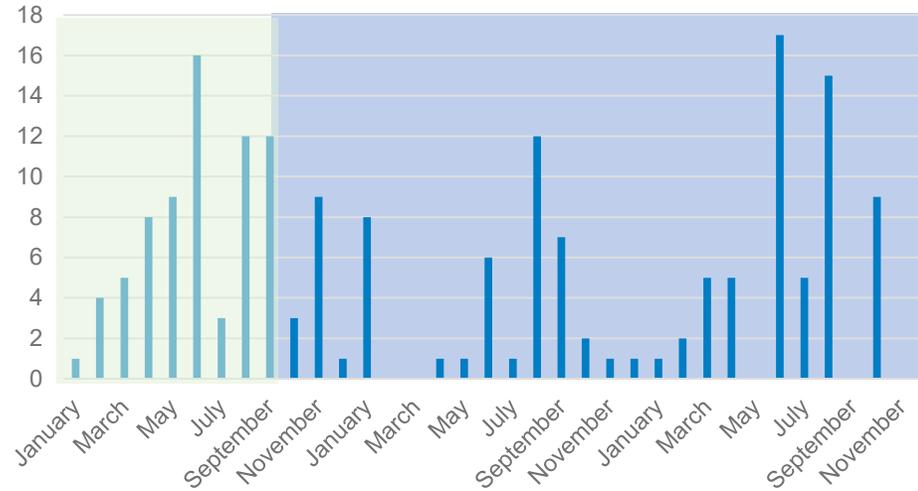
Added Scope

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

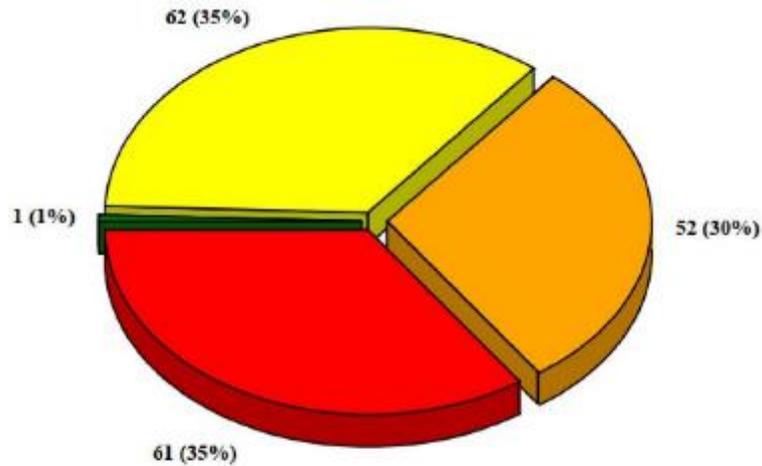
Flywheel UPS

Startup
9/21/17

Power Quality Events 2017-2019

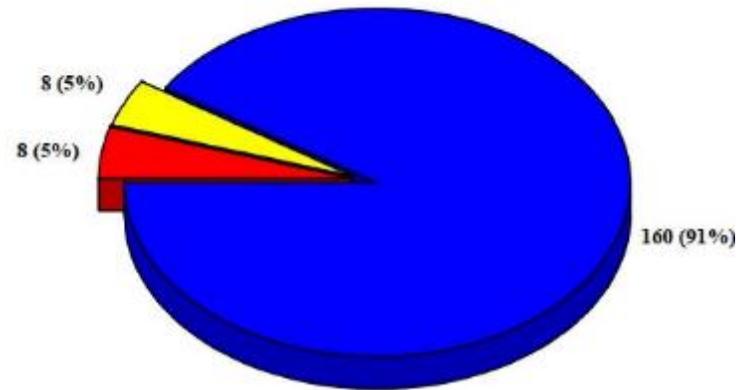


112 Events
Since Startup



Events by Remaining RMS Voltage

- < 60%
- 60-80%
- 80-88%
- 88-112%
- > 112%



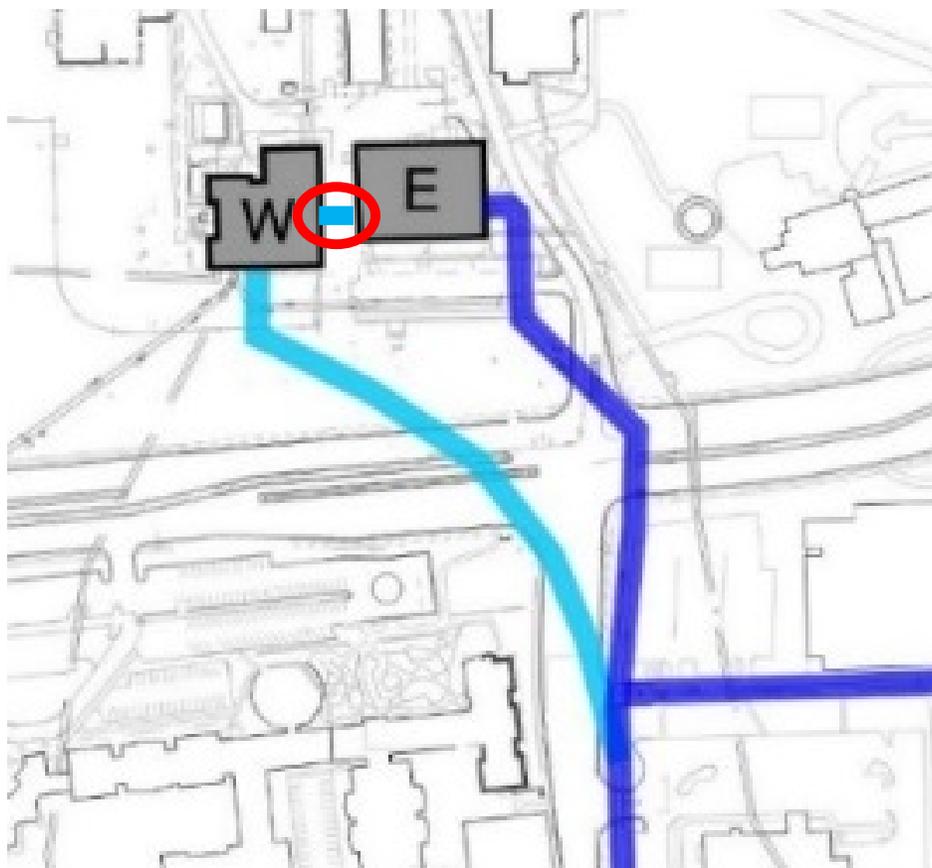
Events by Duration

- < 120 cycles
- 120-900 cycles
- > 900 cycles

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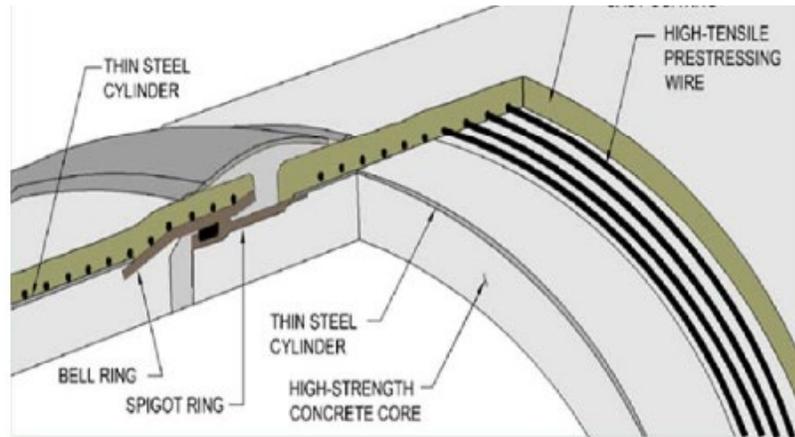


Cross-Connect



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PCCP Inspection and Repair



Typical LCP Cross Section



Longitudinal Crack observed at the invert of Pipe 8019 pipe

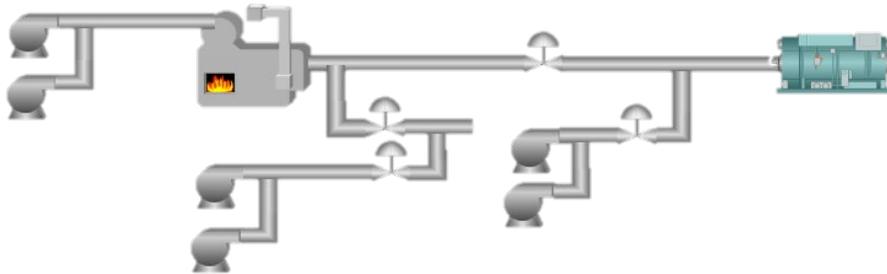
Table 2.2: Pipes with Broken Wire Wraps in the Chilled Water Lines

Rank	Pipe Reference Number	Low Station	Pipe Length (feet)	Pipe Class	Break Positional Range (feet)	Number of Broken wire wraps by Region	Total Number of Broken wire wraps
<i>36-inch West Pipeline</i>							
1	4009	0+94	16	N/A	2.5;4.0	15;10	25
2	4007	0+74	16	N/A	2.5;5.5	10;5	15
3	4011	1+32	16	N/A	13.5	15	15
4	9032	6+96	16	N/A	14.0	10	10
5	9007	3+16	16	N/A	14.0	5	5
6	9018	4+72	16	N/A	10.5	5	5

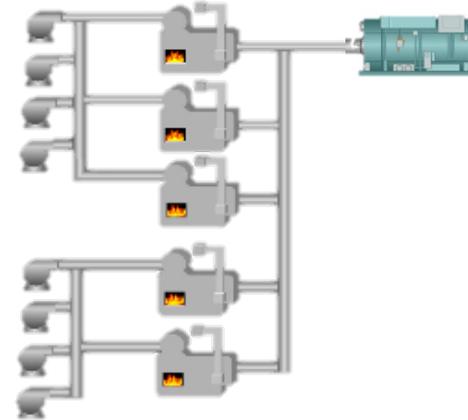


Boiler / Turbine Conversion

Original Process Flow



Current Process Flow



**10 YEAR NPV SAVINGS FROM BOILER CONVERSION:
\$1.8M**

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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!

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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!

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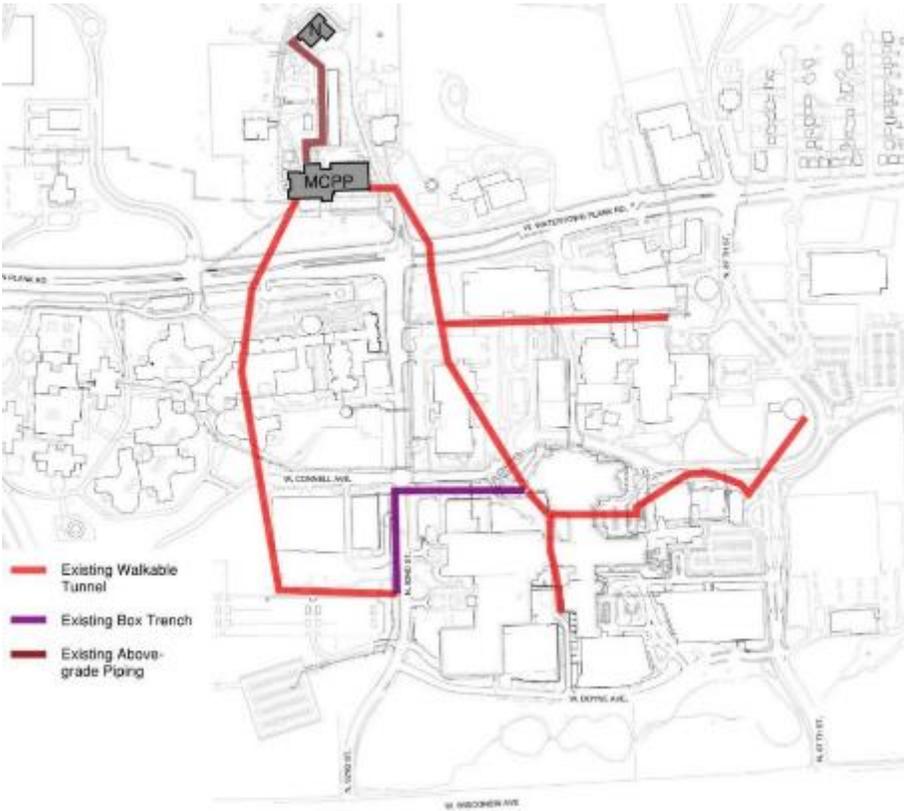


Service Contracts and Warranties

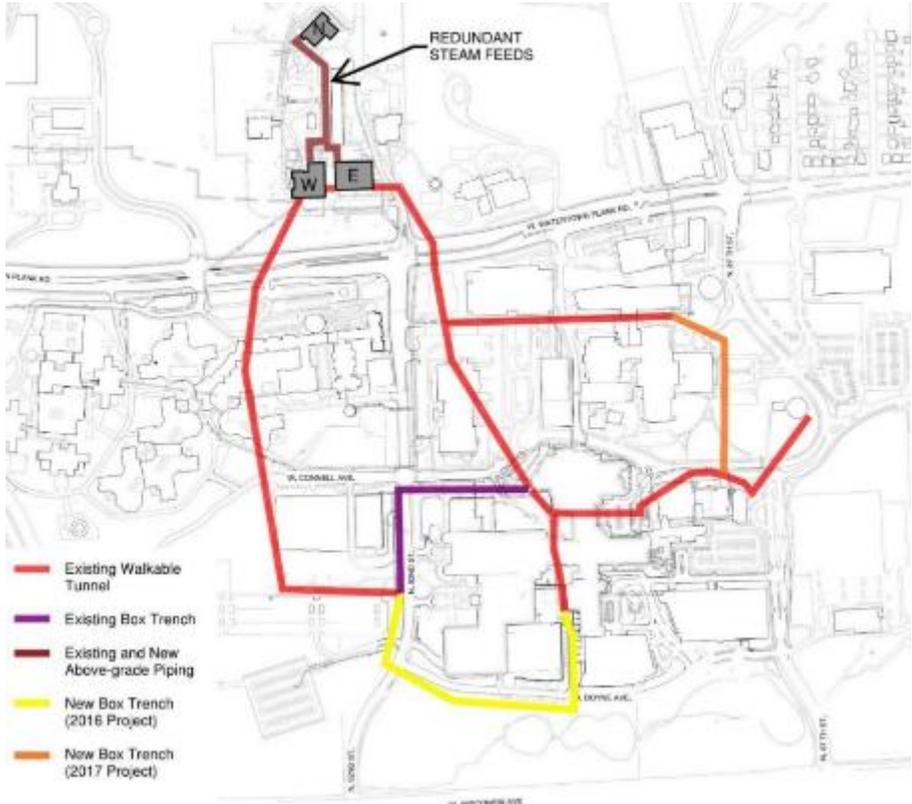
- Factor a 10 year service agreement into equipment procurement as part of the LCCA
 - Service rates 30-40% higher than the same labor as install
- Guarantees on response times
- Service tech capabilities / bios
- Manufacturer vs. OEM parts
- Parts availability guarantees
- Beware the parts-only warranty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

Steam Distribution Segmentation

Initial Configuration

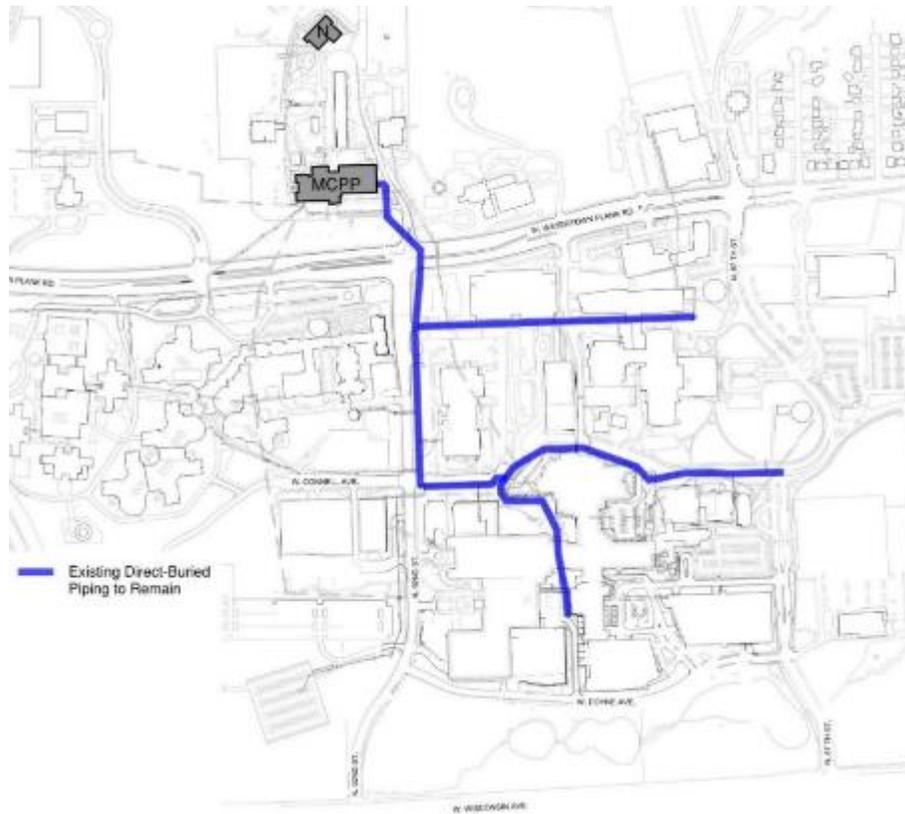


New Configuration

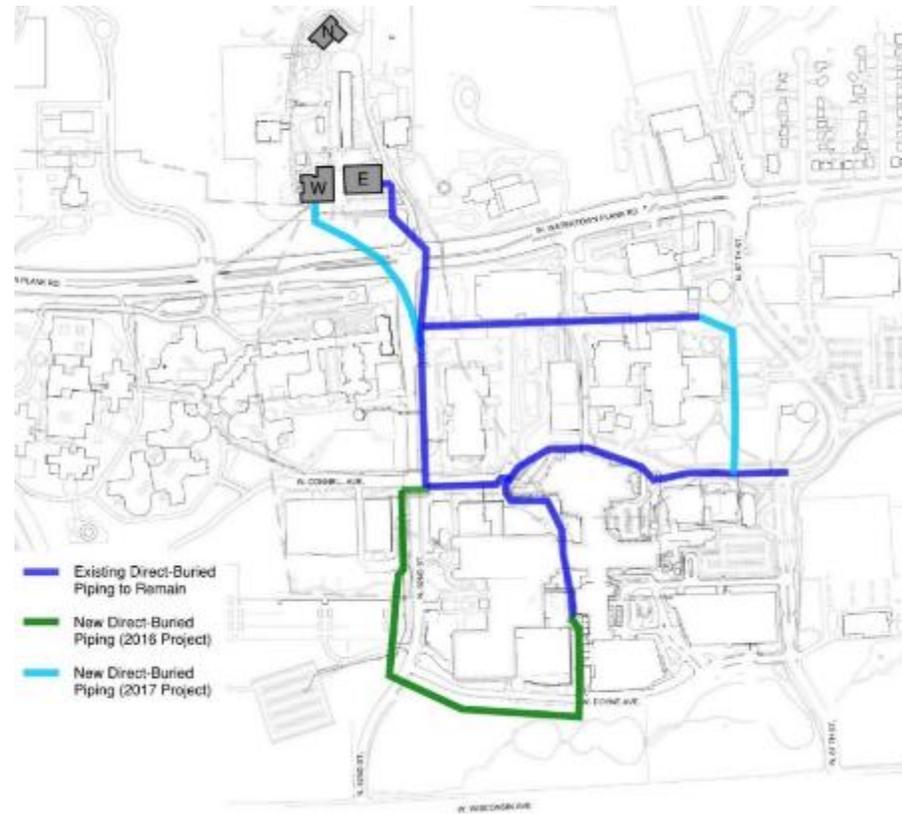


Chilled Water Distribution Segmentation

Initial Configuration



New Configuration



Results

- Consistent, High Reliability
- Emissions Reduction
- Cost Reduction & Reinvestment

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2016-2019 Reliability

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

Combined: 99.998%

Against Contract Requirements

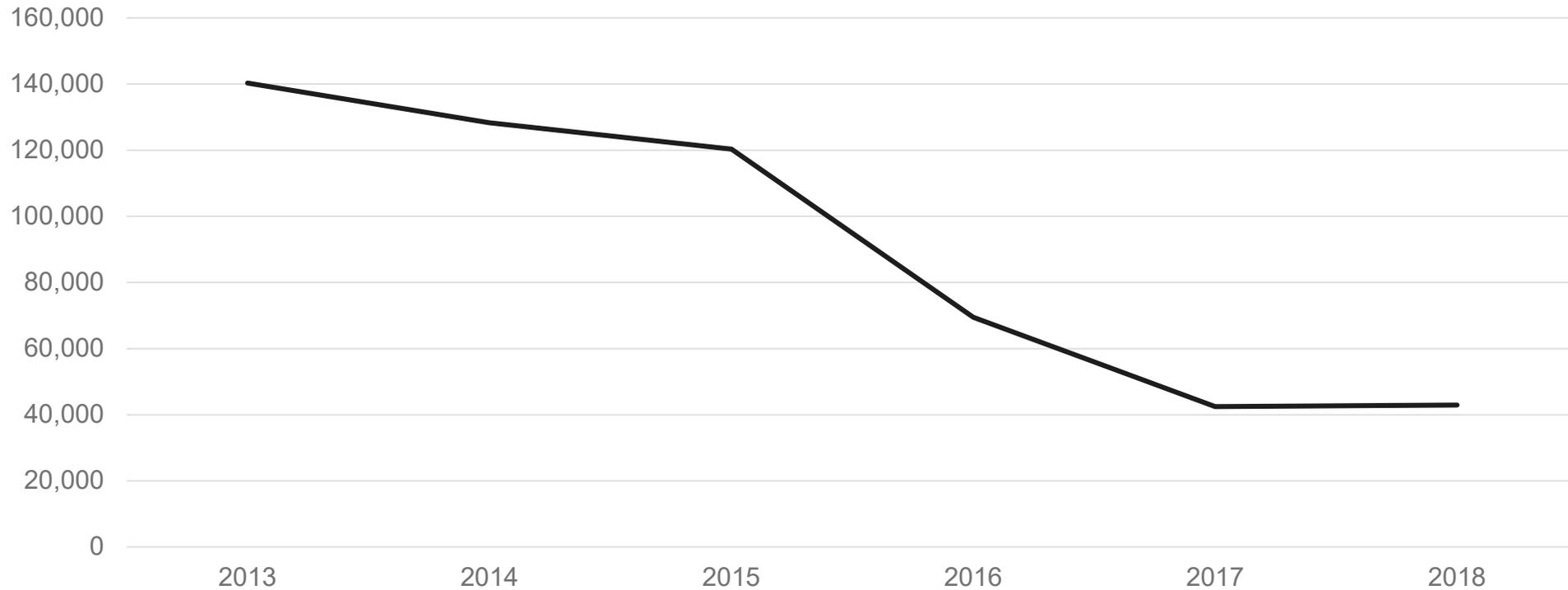
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Emissions Reductions

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

Thermal Site CO2e Annual Emissions (mtons)



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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

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1950s VINTAGE STOKER COAL BOILERS



NEW DUAL- FUEL BOILERS



1970s VINTAGE ABSORPTION CHILLERS



NEW CENTRIFUGAL CHILLERS



WEST PLANT



EAST PLANT

TEMPORARY BOILER PLANT



NEW NORTH PLANT BOILERS



Questions?

Mark Geronime

mgeronime@mrmcfl.org

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Rory Peters

rory.peters@ever-greenenergy.com



Thank you!