10th Street Chiller Plant Capacity Optimization

June 22, 2016

Problem Summary

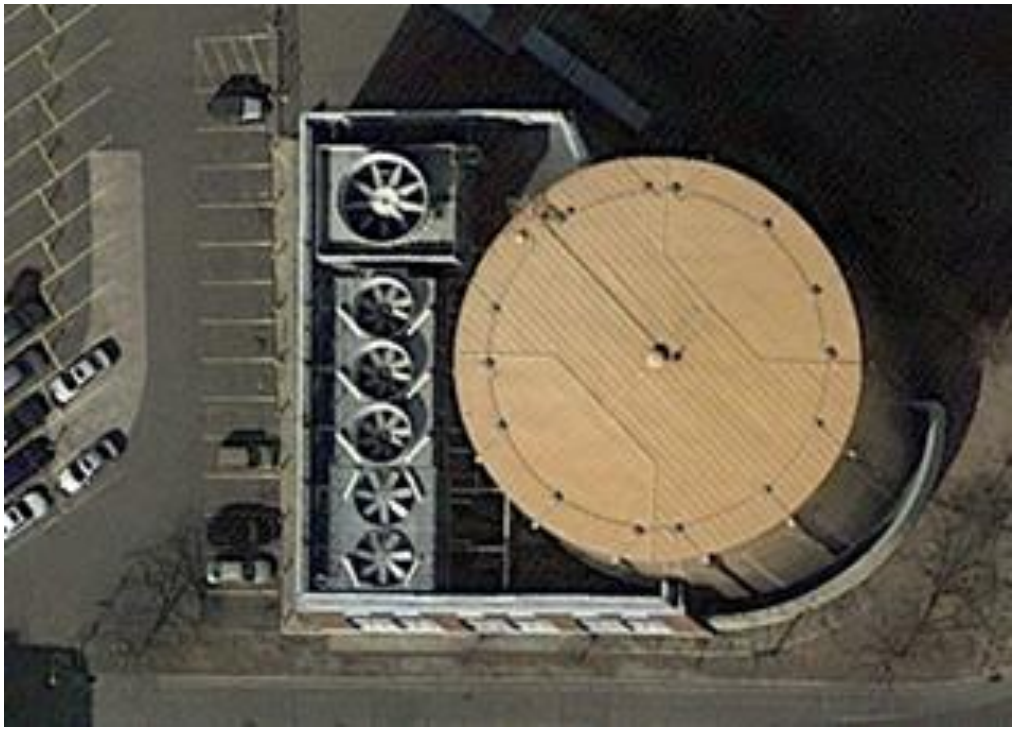
- 10th Street Plant operating below capacity on design day
- Towers were not able to achieve design return temperature
- How much was plant performance reduced?
- How do you determine performance loss and improvement on real time basis?
- How do you measure improvement when implementing changes?

Project Objective

- Evaluate methods to improve or increase capacity
- Implement improvements to optimize plant performance
- Set up data collection and trend operating data to determine plant performance based on historic and real time data
- Allow for periodic review of historical performance
- Allow operators to monitor performance in real time basis
- Minimize project cost

10th Street Plant

- Chillers: 1 x 2000 TR, 2 x 2500 TR
- Cooling towers: 1 x 6,500 gpm, 5 x 3,000 gpm
- Storage tank: 1 x 35,000 ton-hr



Step 1 Troubleshooting

- Ockham's Razor: *look at simple solutions first*
  - Housekeeping
  - Mechanical
  - Commissioning

Step 1 Troubleshooting

Visual Inspection

- Tower fouling

Solution

- Review water treatment
- Scale: water jet pipes

Step 1 Troubleshooting

Operational

- Tower 4 overflow soaking cars and drift
- Fans on Tower 5 and 6 VFD choked at 50 hz

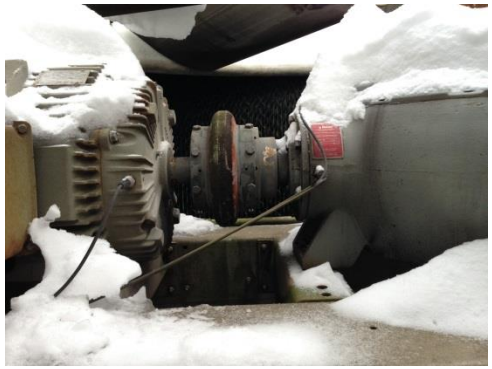
Solution

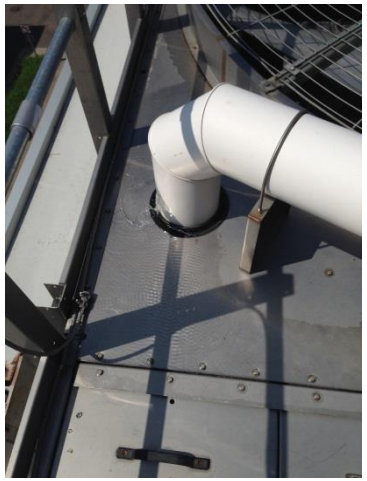
- Verify drift eliminators install properly
- Install overflow pipe and route to basin
- Vibration problem - analyze

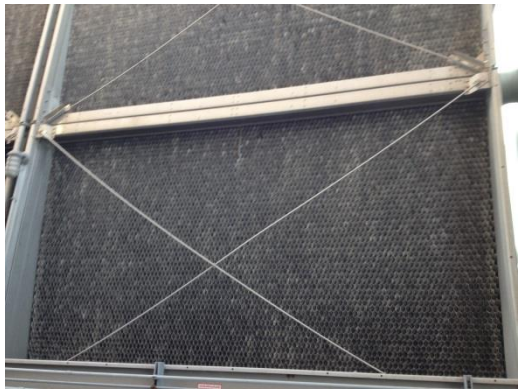
Step 1 Troubleshooting

Vibration Problem

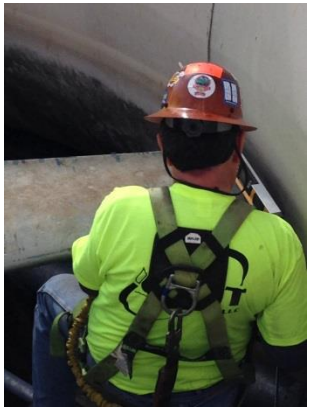
- Check vibration switch calibration
- Tower mechanical (visual and vibration testing)
- Install method to tension cross bracing
- Test at full speed
- Repeat until problem resolved







Step 2 Recommission



- Optimize fan operation with blade pitch to draw design power on design day (all fans found to be drawing below design power)

Description 10th Street Plant Cooling Tower As Left
Date: 23-May-14
Ambient Temp: 65 dF

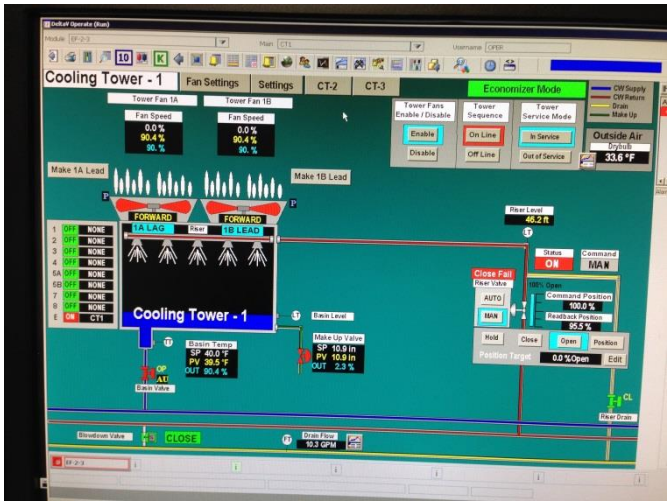
Tower	HMI Speed	VFD	VFD (Amps)		Motor Nameplate***						Fan Blade Pitch		Vib. Switch		
	(hz)	(hz)	As FND	As LFT	Hp	FLA	Voltage	RPM	SF	Inverter Duty	As FND	AS Left	Model	Trip	Alarm
4	LO				100	114	460		1.15	Two Speed	13.0	14.0	PMC 440D	8.0	60%
	HI		105	110	100										
5a	60	60	82	107	100	116	460	1790	1.15	Yes	14.0	21.0	PMC 440D	8.0	100%
5b	60	60	77	108	100	116	460	1790	1.15	Yes	14.5	21.0	PMC 440D	8.0	100%
5c	60	60	86	106	100	116	460	1790	1.15	Yes	15.5	21.0	PMC 440D	8.0	100%
6a	60	60	83	-	75	84	460	1780	1.15	Yes	No Change	No Change	Metrix Mechanical		
6b	60	60	81	-	75	84	460	1780	1.15	Yes	No Change	No Change	Metrix Mechanical		

Notes:
* Vibration Switch adjusted per input from Marley. Trip limits in SCADA eliminated.
** Tower 6A/B not adjusted.
*** Motor Nameplates read and verified in field.
**** Design Pitch for 5 A/B/C is 15.4 degrees
**** Design Pitch for 4A is 14.0 degrees

Step 3 Data Collection and Trending

Plant Performance (kW/ton)

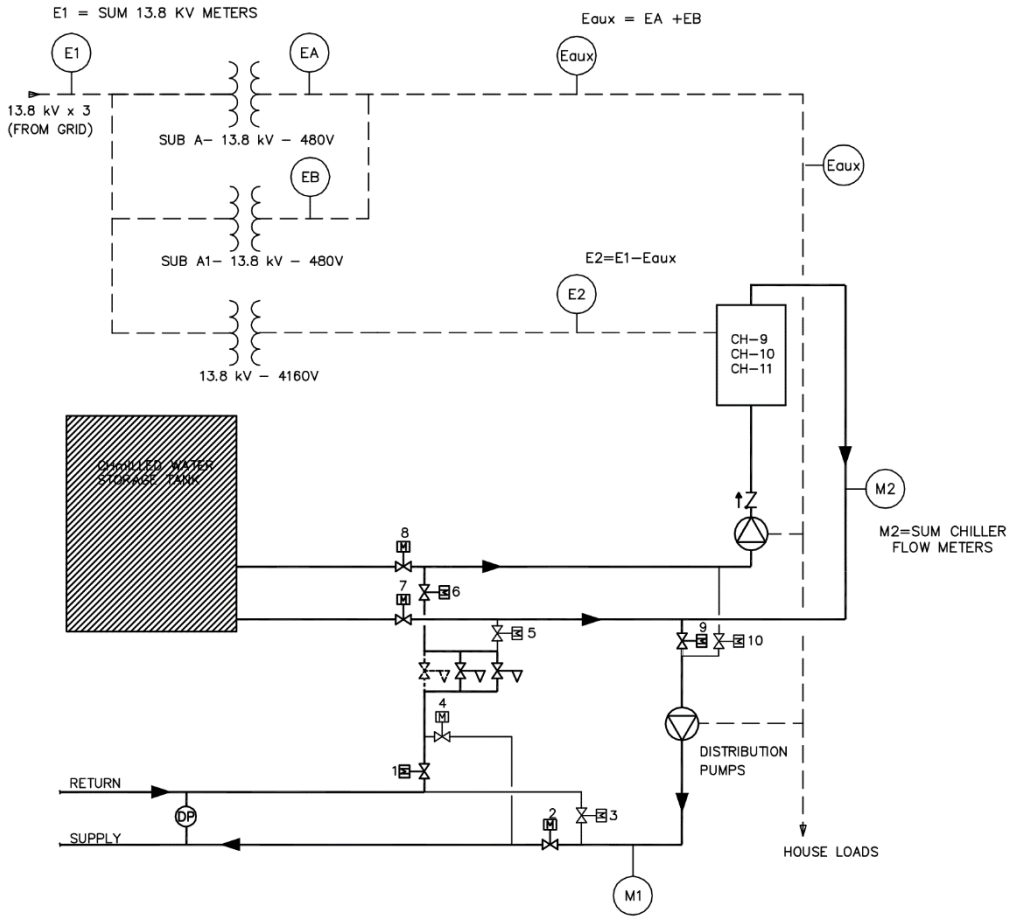
- Power Monitoring Equipment- SCADA Data collection
  - Install PTs, CTs, and Power Meters
  - Connect to SCADA
  - Trend Data in Historian



Step 3 Data Collection and Trending

- Performance trending
- Multi mode plant operation
- Efficiency calculation
  - kW/ton
  - Tank on line
  - Tank off line
  - Charging from distribution

PLANT EFFICIENCY		TANK OFFLINE (TKO)	TANK ONLINE (TK1)
DESCRIPTION	KW/TON	KWH/TON–HR	KWH/TON–HR
CHILLERS	E2/M2	SUM(E2)/SUM(M2)	SUM(E2)/SUM(M2)
AUX LOADS	Eaux/M2	SUM(Eaux)/SUM(M2)	SUM(Eaux)/SUM(M2)
TOTAL PRODUCTION	E1/M2	[SUM(E2)+SUM(EAux)]/SUM(M2)	[SUM(E2)+SUM(EAux)]/SUM(M2)
PLANT AVERAGE	–	SUM(E1)/SUM(M1)	SUM(E1)/SUM(M1)



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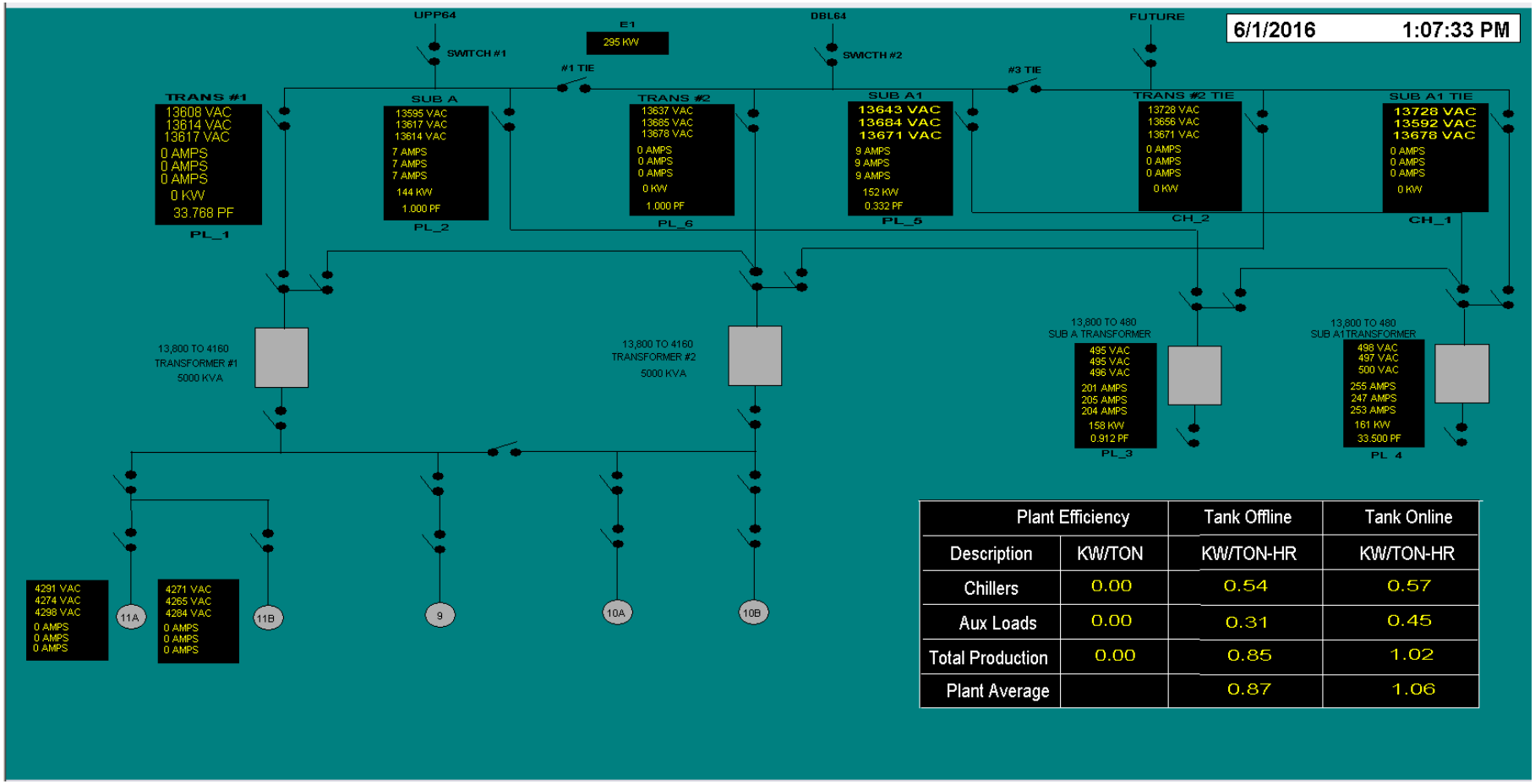

Plant Efficiency		Tank Offline	Tank Online
Description	KW/TON	KW/TON-HR	KW/TON-HR
Chillers	0.00	0.54	0.57
Aux Loads	0.00	0.31	0.45
Total Production	0.00	0.85	1.02
Plant Average		0.87	1.06

Step 4 Data

- Historic data
- 2009-2014 rising kw/ton
- 2015 falling kw/ton

Plant Efficiency		Tank Offline	Tank Online
Description	KW/TON	KW/TON-HR	KW/TON-HR
Chillers	0.00	0.54	0.57
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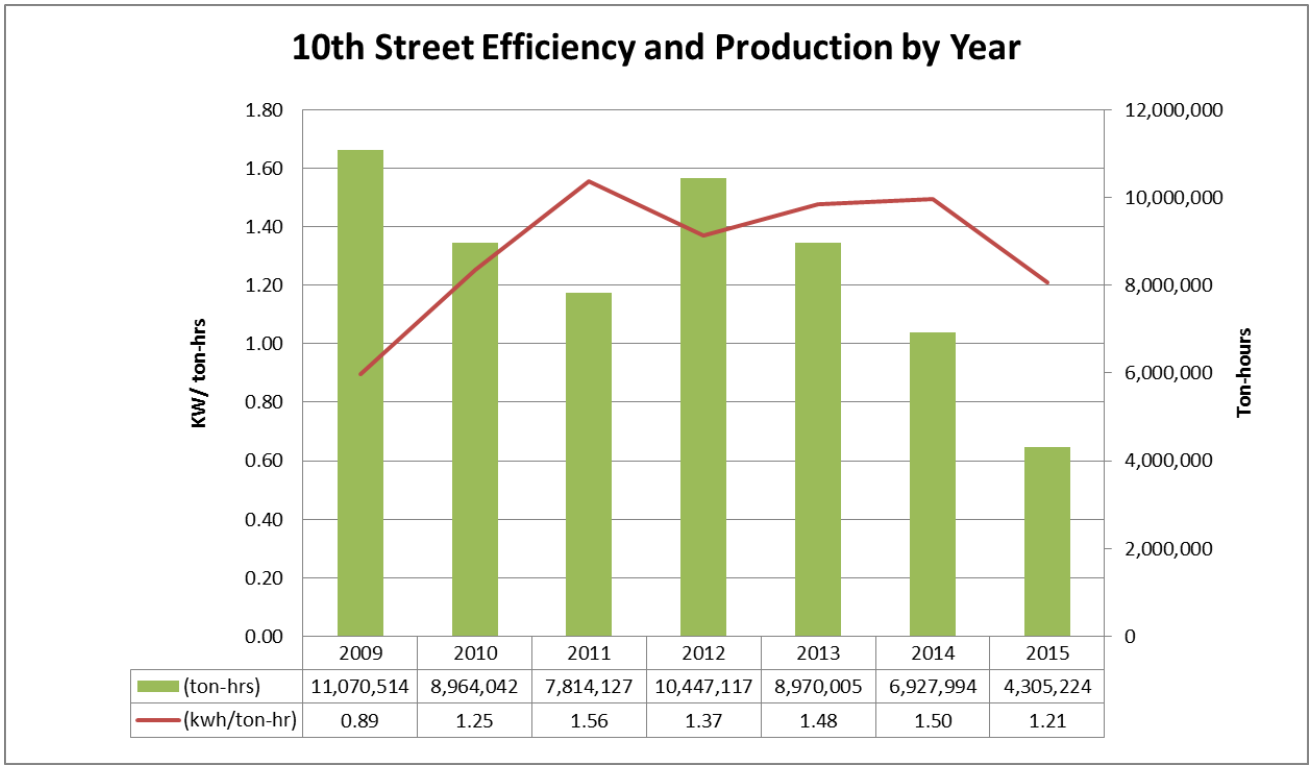

Project: Next steps to improve performance

- Train operators and encourage efficiency improvements by multipath problem solving
- Reduce condenser water temperature (55-60 df min)
- Normalize plant efficiency to wetbulb, generate plant efficiency curve based on actual measured variable
- Plant COP/real time cost. What metric is simplest to follow?
- Variable Speed drive on tower 4