Energy Analytics, LLC

# AYALA CHILLER PERFORMANCE

### Data Analysis Of EcoCOOL® Energy Reduction

## Chiller's Performance Analysis by Dr. Igor Yatskar, Ph.D., CEO Energy Analytics, LLC

**Chiller's Performance – Efficiency Improvement** 

#### Pre- and Post-installation chiller's efficiency change

**Pre Test** 

**Post Test** 

Baseline Chiller Efficiency, 0.96 kW/ton

Post Installation Efficiency, 0.88kw/ton

~8.4% chiller's efficiency improvement, associated with EcoCOOL treatment

#### Subject of Analysis – Pilot Chiller#2

Unit : Centrifugal Chiller, 650 Tons capacity Brand : York Model: YKEKEKP8-CUF Compressor Model: YDHE 580DD



#### Data Analyzed and Test Arrangement

- Pre- and Post- EcoCOOL installation chiller performance parameters were collected by Customer's Building Automation System (BAS) and their Fluke Data Logger in 10min time intervals for duration of about four weeks (Jun-Jul, 2016) before and about four months (Sep, 2016 – Jan, 2017) after EcoCOOL treatment
- List of parameters monitored is presented below
  - Electric consumption, kWh
  - o Cooling Load, Ton-hr
  - Chilled Water Flow, m^3/hr converted to GPM (gallons per minute)
  - Evaporator Water Supply and Return Temperatures, degree (Celsius to Fahrenheit)
  - Chiller Load (% Loading)
  - Chillers Efficiency, kW/ton, EER, COP

Some additional data, collected in Oct, 2016-Jan, 2017 (\*.txt files), also included Condenser Water Supply and Return Temperatures, Actual Chilled Water Supply Temperature Set-point, Compressor Pressures and Oil Temperatures

 All available data was utilized in analysis and presented on slides that follow. Time interval Jun-Jul, 2016 was considered as "baseline" pre-installation data; period between EcoCOOL installation date of Sep 11, 2016 till the end of September, 2016 was considered as "transition period" assigned for system relaxation. All data from Oct, 2016 till Jan, 2017 was considered as post-installation data – all this information was "un-folded", graphically presented and interpreted in analysis, but only Oct-Nov, 2016 records having kWh readings were utilized for calculating average post -installation efficiency kW/ton

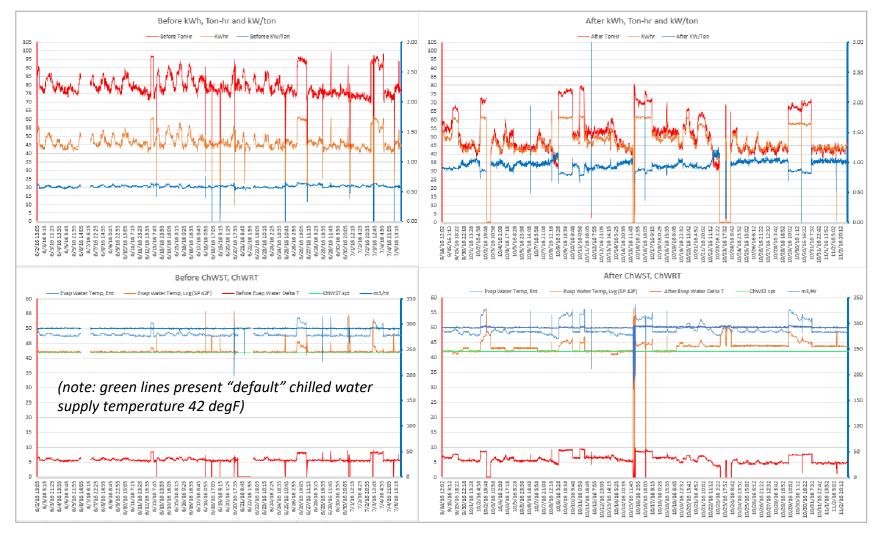
	"Before-" and "After-" installation Data																
							~	10174									
_															$\wedge$		
									Evap Water	5.60 Before Evap					5.61		0.96 Before
	0:10	Time	KWhr •	Before TonHr	m3/Hr 👻	Before GPM	CHWST spt	Evap Water Temp, Ent	Temp, Lvg (SP 42F)		Chiller % (Lmt 95%)	Beforee KW/Ton	EER	СОР	Before Calc dT Cal	Before Ton-hr	Calc kW/to
6/2	/16 13:05	6/2/16 13:05	47	80	292	1284	42	47.8	42.1	5.7	79	0.58	20.54	6.02	5.7	51	0.92
6/2	/16 13:15	6/2/16 13:15	47	<mark>80</mark>	292	1286	42	47.8	41.9	5.9	81	0.58	20.62	6.04	5.9	53	0.88
	/16 13:25	6/2/16 13:25	48	79	292	1285	42	47.9	42.5	5.4	79	0.60	19.96	5.85	5.4	48	0.9
6/2	/16 13:35	6/2/16 13:35	48	<b>80</b>	292	1283	42	48	42.1	5.9	84	0.60	20.03	5.87	5.9	53	0.91
6/2	/16 13:45	6/2/16 13:45	48	80	291	1279	42	48	42.3	5.7	79	0.61	19.82	5.81	5.7	51	0.96
	/16 13:55	6/2/16 13:55	49	81	292	1284	42	48	42.2	5.8	80	0.61	19.80	5.80	5.8	52	0.95
	/16 14:05	6/2/16 14:05	51	<b>81</b>	290	1274	42	48.5	42.5	6	84	0.62	19.30	5.66	6.0	53	0.9
	/16 14:15	6/2/16 14:15	52	84	292	1285	42	48.5	42.2	6.3	86	0.61	19.60	5.74	6.3	56	0.9
	/16 14:25	6/2/16 14:25	52	85	291	1281	42	48.6	42.1	6.5	83	0.61	19.60	5.75	6.5	58	0.90
	/16 14:35	6/2/16 14:35	52	86	291	1282	42	48.5	42.1	6.4	82	0.61	19.80	5.80	6.4	57	0.91
	/16 22:55	1/0/00 22:58	43	74	291	1281	42	47.6	41.8	5.8	78	0.58	20.52	6.01	5.8	52	0.84
	/16 23:05	1/0/00 23:08	43	75	291	1282	42	47.6	42	5.6	79	0.58	20.83	6.11	5.6	50	0.8
	/16 23:15	1/0/00 23:18	44	77	291	1280	42	47.6	41.9	5.7	79	0.57	21.21	6.22	5.7	51	0.87
	/16 23:25	1/0/00 23:28	44	78	292	1284	42		42.1	5.6	78	0.57	21.04	6.17	5.6	50	0.89
	/16 23:35	1/0/00 23:38	44	78	292	1284	42	47.6	42	5.6	78	0.57	21.02	6.16	5.6	50	0.89
	/16 23:45	1/0/00 23:48	45	79	292	1284	42	47.5	41.8	5.7	78	0.57	21.11	6.19	5.7	51	0.88
7/5/	/16 23:55	1/0/00 23:58	44	79	292	1283	42	47.5	41.8	5.7	78	0.56	21.35	6.26	5.7	51	0.87

AFTER

								5.87					5.87		0.88	8.32%	txt filesOct/	2016-Jan2017
Time	KWhr	After TonHr	m3/Hr 🔻	After GPM	ChWST	Evap Water Temp, Ent	Evap Water Temp, Lvg (SP 42F) 🗣	After Evap Water Delta 🚽	Chiller % (Lmt 95%)	After KW/Ton	EER	СОР	After Calc (T	After Calc Ton- hr 🖵	After Calc kW/1 →	Ton	Ton Calc	New Ton
9/14/16 12:02	52	59	292	1283	42	48.9	42.1	6.8	84	0.88	13.71	4.02	6.8	61	0.86	355.7	363.5	
9/14/16 12:12	53	60	291	1282	42	48.9	41.8	7.1	85	0.87	13.71	4.02	7.1	63	0.83	361.1	379.3	
9/14/16 12:22	52	60	292	1286	42	48.8	41.8	7	85	0.87	13.81	4.05	7.0	63		359.6	375.0	
9/14/16 12:32	51	59	291	1280	42	48.7	41.9	6.8	81	0.86	13.90	4.07	6.8	60		355.2	362.8	
9/14/16 12:42	51	60	292	1283	42	48.6	41.9	6.7	81	0.85	14.11	4.14	6.7	60	0.85	360.1	358.2	
9/14/16 12:52	51	58	291	1280	42	48.7	41.9	6.8	85	0.88	13.60	3.99	6.8	60	0.84	345.7	362.8	
9/14/16 13:02	51	57	292	1283	42	48.7	41.8	6.9	81	0.89	13.50	3.96	6.9	61	0.83	343.4	368.9	
9/14/16 13:12	51	58	293	1287	42	48.7	41.8	6.9	84	0.88	13.56	3.98	6.9	62	0.83	346.8	370.2	
9/14/16 13:22	51	58	291	1280	42	48.7	41.9	6.8	85	0.89	13.46	3.94	6.8	60	0.85	346.4	362.6	
9/14/16 13:32	52	58	292	1283	42	48.8	42.0	6.8	83	0.90	13.40	3.93	6.8	61	0.85	345.5	363.5	
1/17/17 8:53				¢														416.1
1/17/17 9:03													ļ	ļ				406.4
1/17/17 9:13													ļ					416.3
1/17/17 9:23													ļ	ļ				414.9
1/17/17 9:33														ļ				425.7
1/17/17 9:43																		416.9
1/17/17 9:53																		427.2
1/17/17 10:03								ļ					ļ					415.8

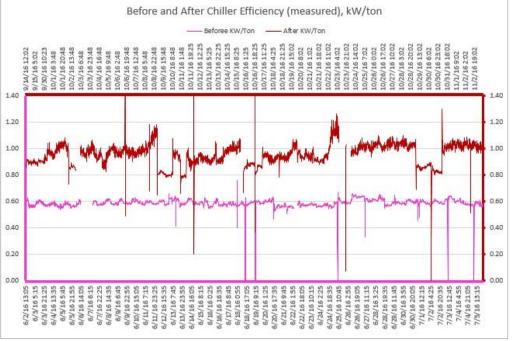
#### **Overview of Chiller's Performance Data**

Charts below present chiller's performance parameters, as they measured by Customer's BAS System Please note large Cooling Load (~80 ton-hrs/10min, ~480 tons) and low ~0.6 kW/ton in "Before" measurements



#### The Issue Analyzed and Resolution Proposed

 The main "problem in hand" is discrepancy between expected chiller's efficiency (less than baseline efficiency ~0.6 kW/ton), and actually observed much larger (much worse) post-installation efficiency of ~0.9 kW/ton

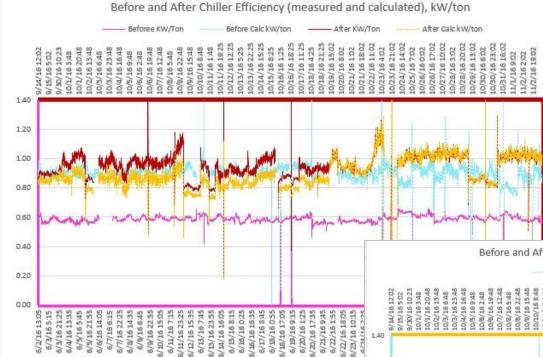


#### **Proposed Resolution**

The following three claims were derived from our analysis:

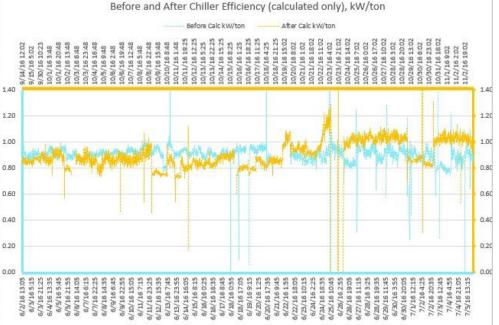
- We came-up with higher than presented by BAS pre-installation efficiency 0.96 kW/ton. This efficiency is result of direct calculation of chiller's load (tons) from provided chilled water flow and supply/return temperatures. Post-installation efficiency is in the same range, but slightly (8.4%) better – it's equal in average 0.88 kW/ton
- Claimed by Customer's BAS %Load (~70-80%, while max is 95%) can't be confirmed by existing data neither before, nor after EcoCOOL installation all available data indicate, that chiller worked at much lower load of 350-400 tons (while chillers capacity is 650 tons), at 40-50% capacity. Accordingly, chiller efficiency is 0.9 kW/ton much more realistic (than 0.6 kW/ton) value for half-loaded chiller, operating with ~5 degF chilled water deltaTonly.
- Additional data (\*.txt files) for Oct-Nov, 2016 indicate, that Chilled Water Supply Temperature Set-point was changed several times for extended periods time intervals from default value of 42F to 43-44F, which also affected comparison

#### "Before" and "After" Chiller's Efficiency – BAS-measured vs Calculated



Ton = 500\*GPM\*deltaT/12,000 deltaT = ChWRetT – ChWSupT

> Large difference between After (brown line) and Before (magenta line) Chiller Efficiencies is due to incorrect "Before" load (tons) calculation by Fluke meter



1.20

1.00

0.80

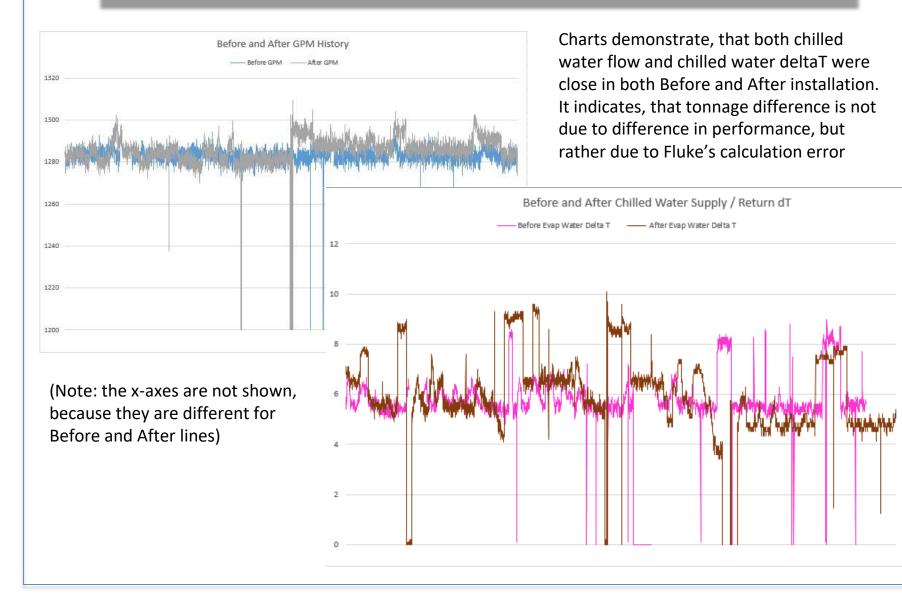
0.60

Large Before - After kW/ton difference is eliminated, when CALCULATED values are compared.

Both calculations were made by the same formula (shown above) using Fluke-provided water flow (GPM) and chilled water supply / return

temperatures

#### **Chiller's Load Calculation Details – ChW Flow and Temperatures**



#### "After" Tons – BAS-measured, calculated & additionally provided

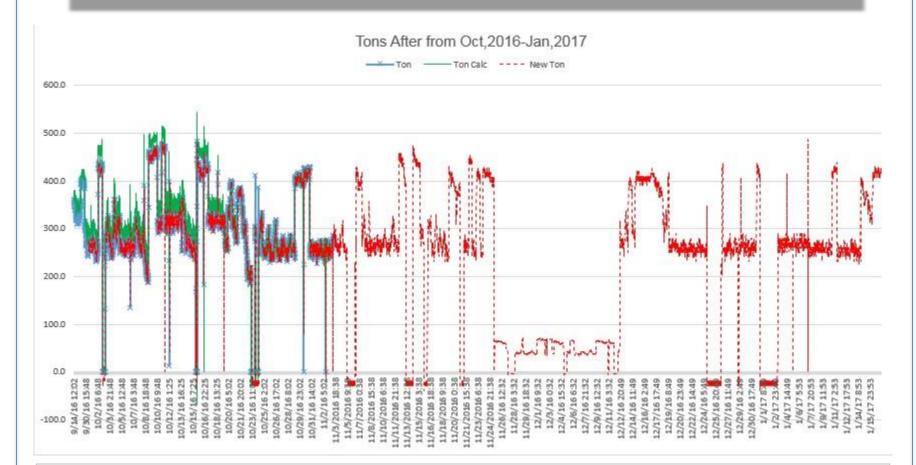


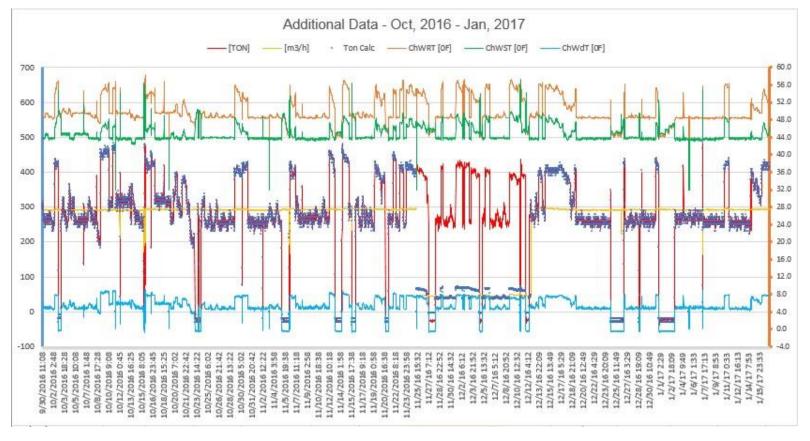
Chart above compares After-installation chiller load (Tons) (from original data set Oct, 2016), from our calculation (slide 6 formula), and from additionally provided \*.txt files (Oct, 2016-Jan, 2017) Customer's data. All data are in good correspondence, confirming formula used in calculations and conclusion made regarding ~half-load operation most of the time

#### Additional Data, "Before" Jun - Jul, 2016 and "After" Oct, 2016



#### Additional Data, Oct, 2016 – Jan, 2017, cont.

Data indicates, that chiller operates at load ~300-400 tons (or ton-hrs/hr), which is ~50 ton-hrs/10min, with load ~50% of full capacity, with ~5 degF deltaT (most of the time), while providing ~44 degF chilled water supply temperature. That, again, confirms, that cooling load of ~80 ton-hrs/10min, reported in "Before" load data is most probably incorrect.



Please note (almost always) perfect correspondence between calculated and measured Cooling Load (tons)