CampusEnergy2021

BRIDGE TO THE FUTURE

Feb. 16-18 | CONNECTING VIRTUALLY

WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

Effect of Lowering Condenser Water Temperature on Chiller Efficiency.

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Q&A Will Not Be Answered Live

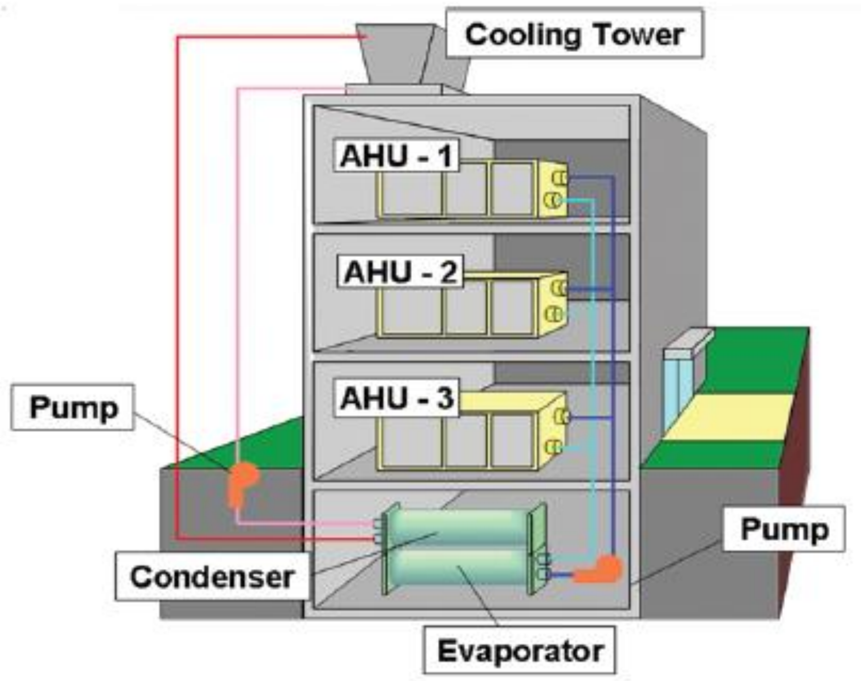
Please submit questions in the Q&A box.
The presenters will respond to questions off-line.

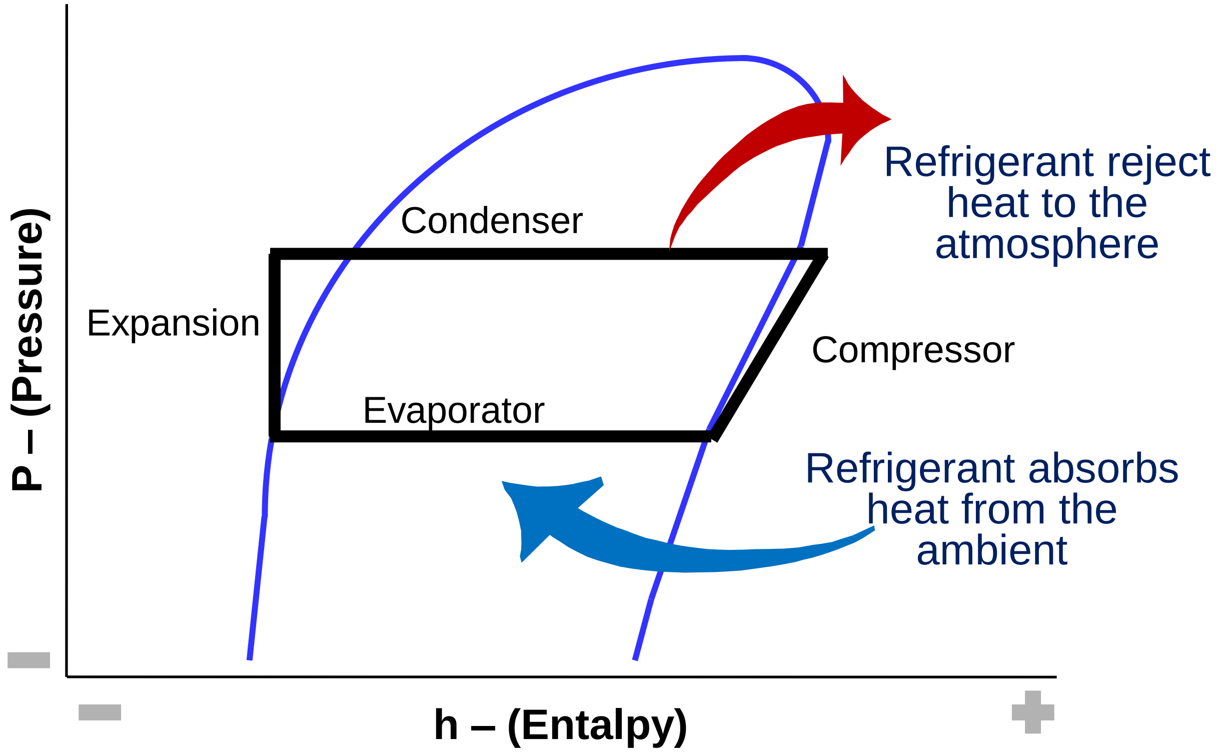
AGENDA

1. Introduction to Chilled Water Plants.
2. Design conditions of cooling towers.
3. Efficiency gain in modern chillers.
4. Simulation parameters and results.
5. Conclusion.

Chilled Water Plants

➢ Objective: demonstrate that water cooled chillers can take advantage of real world conditions according to the local psychrometric conditions.

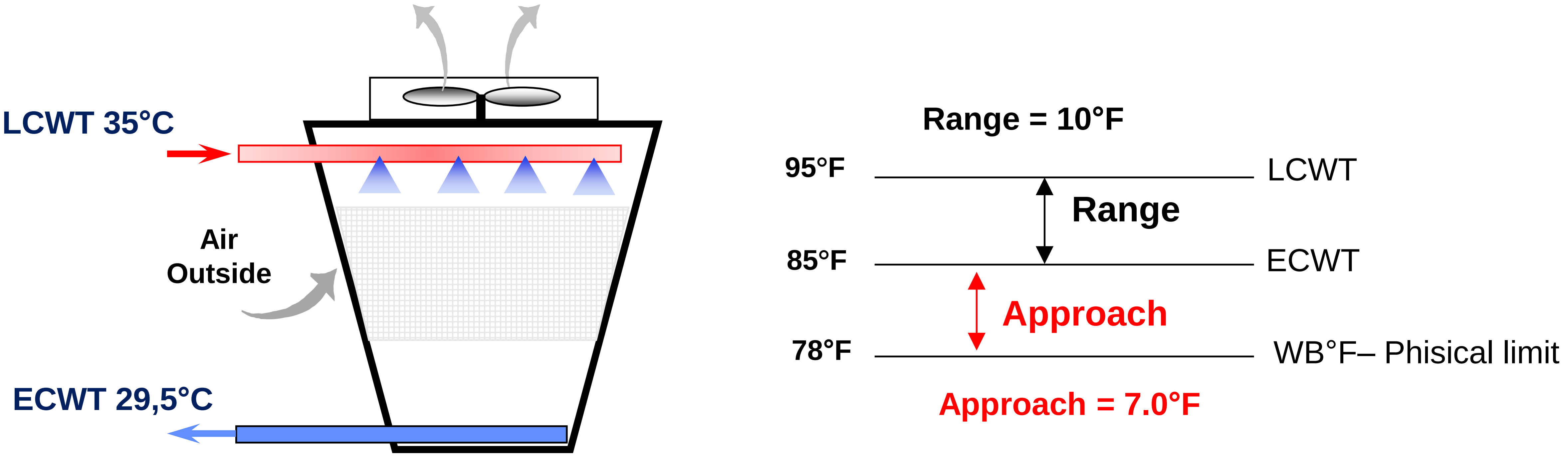




Cooling Towers

YORK

- Responsible for the rejection of the heat absorbed in the condenser, into the atmosphere.
- This process combines heat and mass transfer with sensible and latent exchanges.
- Tower capacity = 1.25 kW/kW chiller capacity (ASHRAE, Handbook HVAC Systems).



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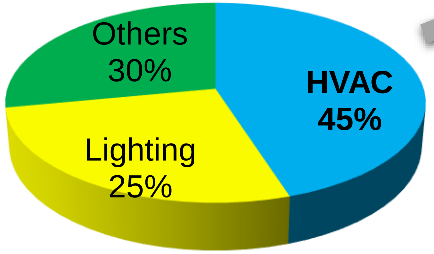
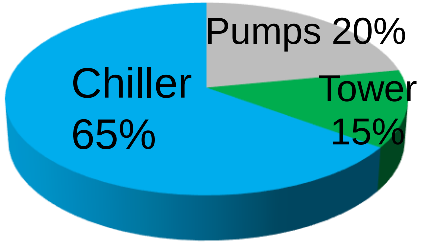
Why chasing energy efficiency in HVAC ?

- HVAC and lighting trend to be greater energy consumers in comercial building (70% off all energy consumption).
- Focus on the chiller as the principal consumer in the plant.
- Mag tecnology used to reach new benchmarking of efficiency.

Energy usage in a typical biulding

Total biulding energy usage



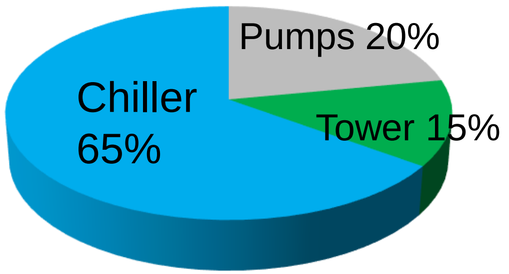


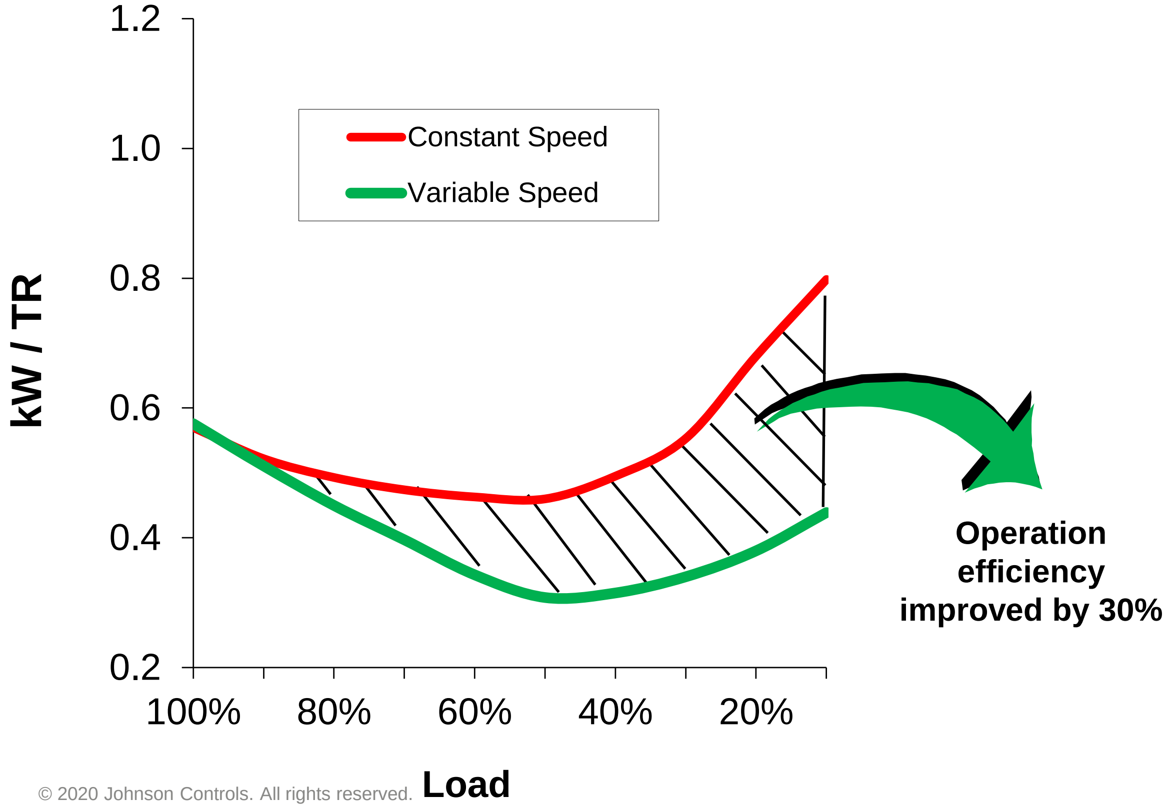
Plant energy usage

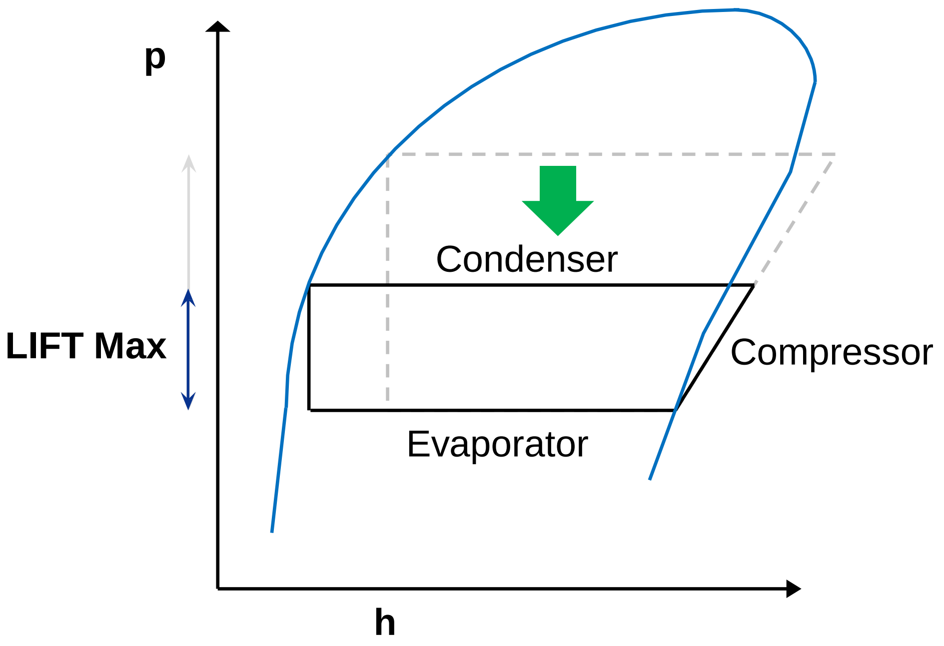
0.49 kW/TR (7.18 COP) 100%
0.297 kW/TR (11.84 COP) IPLV
AHRI Conditions

How gain efficiency in the chiller ?

- Startegies to reduce energy
  - Use VSD in the compressor;
  - Reduce the compressor lift → Design condition is ECWT 85°F (29.5°C).







500 TR Part load performance

➢ **Inverted Duty =** Operation Extra-Low ECWT – Real World Energy Operation

Partload Data (Minimum Condenser Water Temperature)										
CEFT (°F)	% LOAD									
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
85.00°	0.5321	0.5174	0.5031	0.4959	0.4993	0.5126	0.5418	0.5992	0.8012	-
80.00°	0.4766	0.4582	0.4452	0.4372	0.4346	0.4412	0.4603	0.5096	0.6544	1.309
75.00°	0.4227	0.4038	0.3904	0.3818	0.3733	0.3788	0.3945	0.4245	0.5379	1.074
70.00°	0.3729	0.3537	0.3386	0.3271	0.3191	0.3165	0.3270	0.3516	0.4060	0.8188
65.00°	0.3296	0.3079	0.2909	0.2775	0.2678	0.2605	0.2639	0.2825	0.3216	0.6545
60.00°	0.2901	0.2668	0.2470	0.2312	0.2194	0.2110	0.2081	0.2196	0.2487	0.3775
55.00°	0.2540	0.2293	0.2073	0.1891	0.1749	0.1652	0.1589	0.1629	0.1819	0.2587
50.00°	0.2242	0.1959	0.1718	0.1519	0.1356	0.1218	0.1135	0.1099	0.1194	0.1618
45.00°	0.2067	0.1760	0.1481	0.1277	0.1045	0.09002	0.08009	0.08320	0.1234	0.2102
40.00°	0.2017	0.1744	0.1493	0.1266	0.09643	0.08215	0.07320	0.08944	0.1424	0.2180
39.00°	0.2016	0.1746	0.1495	0.1273	0.09676	0.08256	0.07130	0.08812	0.1407	0.2166
38.00°	0.2019	0.1751	0.1499	0.1279	0.09762	0.08352	0.07167	0.08682	0.1388	0.2154
37.00°	0.2025	0.1757	0.1505	0.1285	0.09914	0.08494	0.07283	0.08557	0.1368	0.2141
36.00°	0.2033	0.1765	0.1511	0.1293	0.1024	0.08640	0.07402	0.08436	0.1348	0.2128

*Values are in kW/Ton.R

IPLV points

60% + efficient -> Std. Condition

70% more efficient

80% more efficient

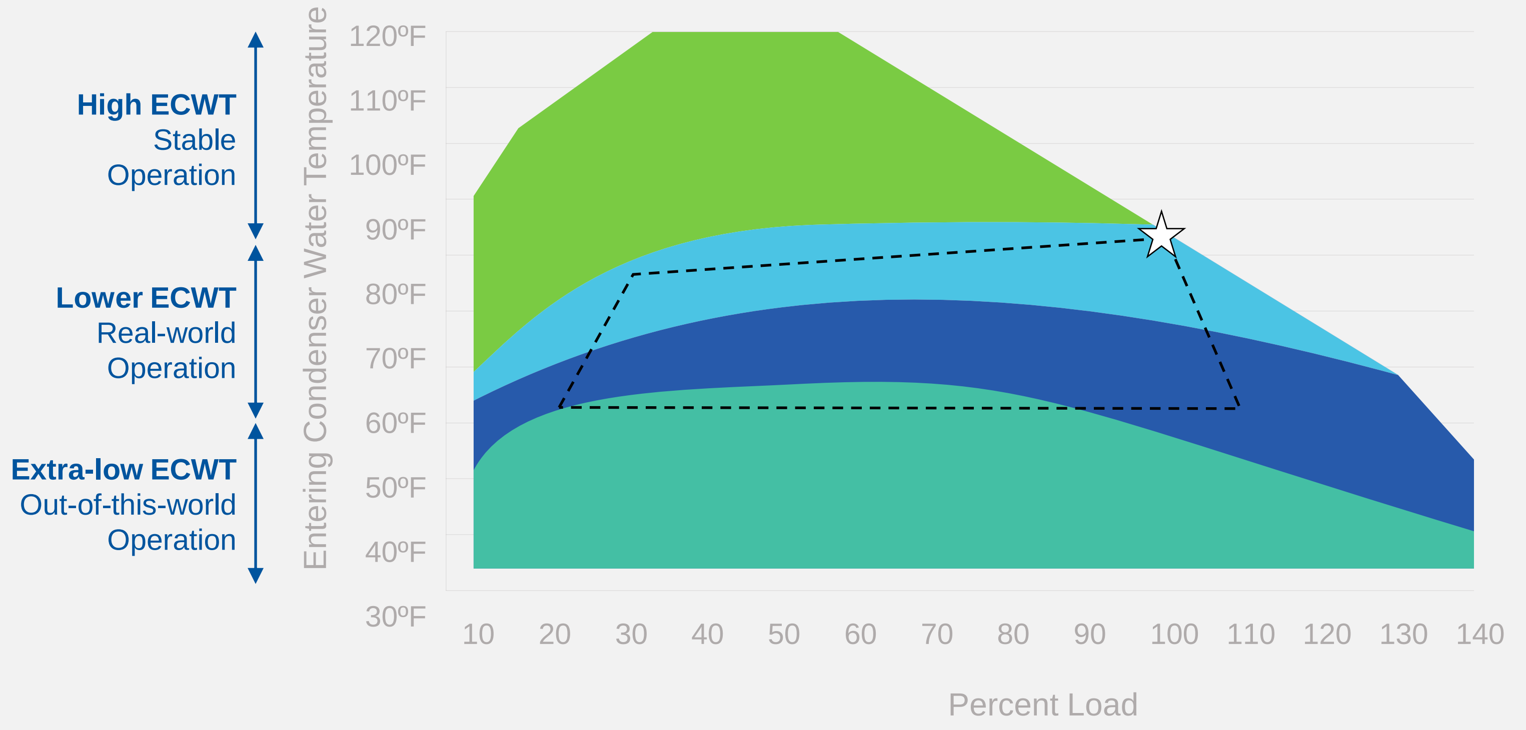
Widest Operating Map in the Industry

YORK

Higher ECWT

Lower ECWT

Extra Low ECWT



Design Point | Typical Competitor Operation | Stable Operation | Design Efficiency | >25% Efficiency Improvement | >50% Efficiency Improvement

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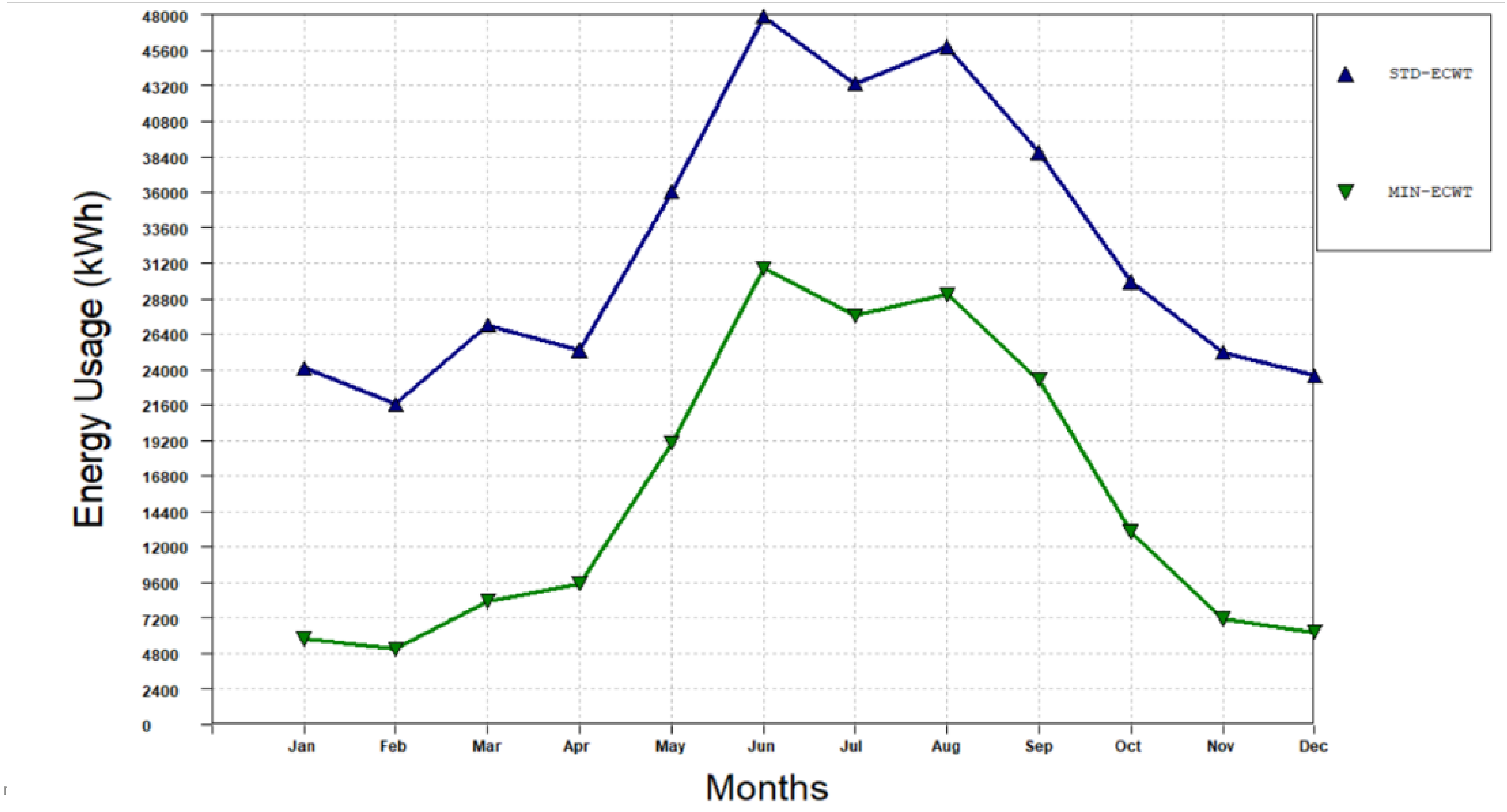
Simulation parameters

- One 500 Tons Centrifugal Chiller, rated with AHRI design conditions.
- Operation from Monday to Friday from 8 a.m to 18 p.m total 2600 hours/year.
- Weather data TRY/IWEC (Energy plus).
- Building load directly proportional to BIN temperatures.
- Usage Cost $0.20/kWh.
- Same chiller Plant with 2 alternative operation modes:
  - **Alternative 1:** ECWT fixed 29.5°C (85°F) so low demand of the cooling tower.
  - **Alternative 2:** ECWT variable based the climatic condition, so high demand of the tower.
    - ECWT as low as the local psychrometric allows.

Simulation results – Chillers Efficiency.

- Focus on the chiller energy usage in Denver weather data.
- Chiller Plant became 30% more efficient in alternative 2.



Simulation results – Plant Summary

YORK

- Economy Ratio Chiller/Tower shows positive results in the region.

DENVER							
Operating Cost	Cooling Tower		Chiller		CWP		Economy Ratio
Alternative 1	$	2,872.00	$	105,154.00	$	139,108.00	Chiller / Tower
Alternative 2	$	12,407.00	$	54,122.00	$	97,611.00	
Result	**$**	**-9,535.00**	**$**	**51,032.00**	**$**	**41,497.00**	**5.35**

LAS VEGAS							
Alternative 1	$	4,275.00	$	122,252.00	$	157,609.00	Chiller / Tower
Alternative 2	$	12,715.00	$	78,003.00	$	121,800.00	
Result	**$**	**-8,440.00**	**$**	**44,249.00**	**$**	**35,809.00**	**5.24**

CHICAGO							
Alternative 1	$	3,674.00	$	102,789.00	$	137,545.00	Chiller / Tower
Alternative 2	$	12,018.00	$	68,924.00	$	112,024.00	
Result	**$**	**-8,344.00**	**$**	**33,865.00**	**$**	**25,521.00**	**4.06**

PHOENIX							
Alternative 1	$	5,409.00	$	132,725.00	$	158,955.00	Chiller / Tower
Alternative 2	$	12,730.00	$	100,801.00	$	130,798.00	
Result	**$**	**-7,321.00**	**$**	**31,924.00**	**$**	**28,157.00**	**4.36**

SAN ANTONIO							
Alternative 1	$	6,785.00	$	129,820.00	$	167,687.00	Chiller / Tower
Alternative 2	$	13,379.00	$	109,300.00	$	153,761.00	
Result	**$**	**-6,594.00**	**$**	**20,520.00**	**$**	**13,926.00**	**3.11**

NEW YORK							
Alternative 1	$	4,366.00	$	106,909.00	$	142,357.00	Chiller / Tower
Alternative 2	$	12,204.00	$	73,176.00	$	116,463.00	
Result	**$**	**-7,838.00**	**$**	**33,733.00**	**$**	**25,894.00**	**4.30**

MIAMI							
Alternative 1	$	8,984.00	$	144,145.00	$	184,211.00	Chiller / Tower
Alternative 2	$	13,400.00	$	133,798.00	$	178,280.00	
Result	**$**	**-4,416.00**	**$**	**10,347.00**	**$**	**5,931.00**	**2.34**

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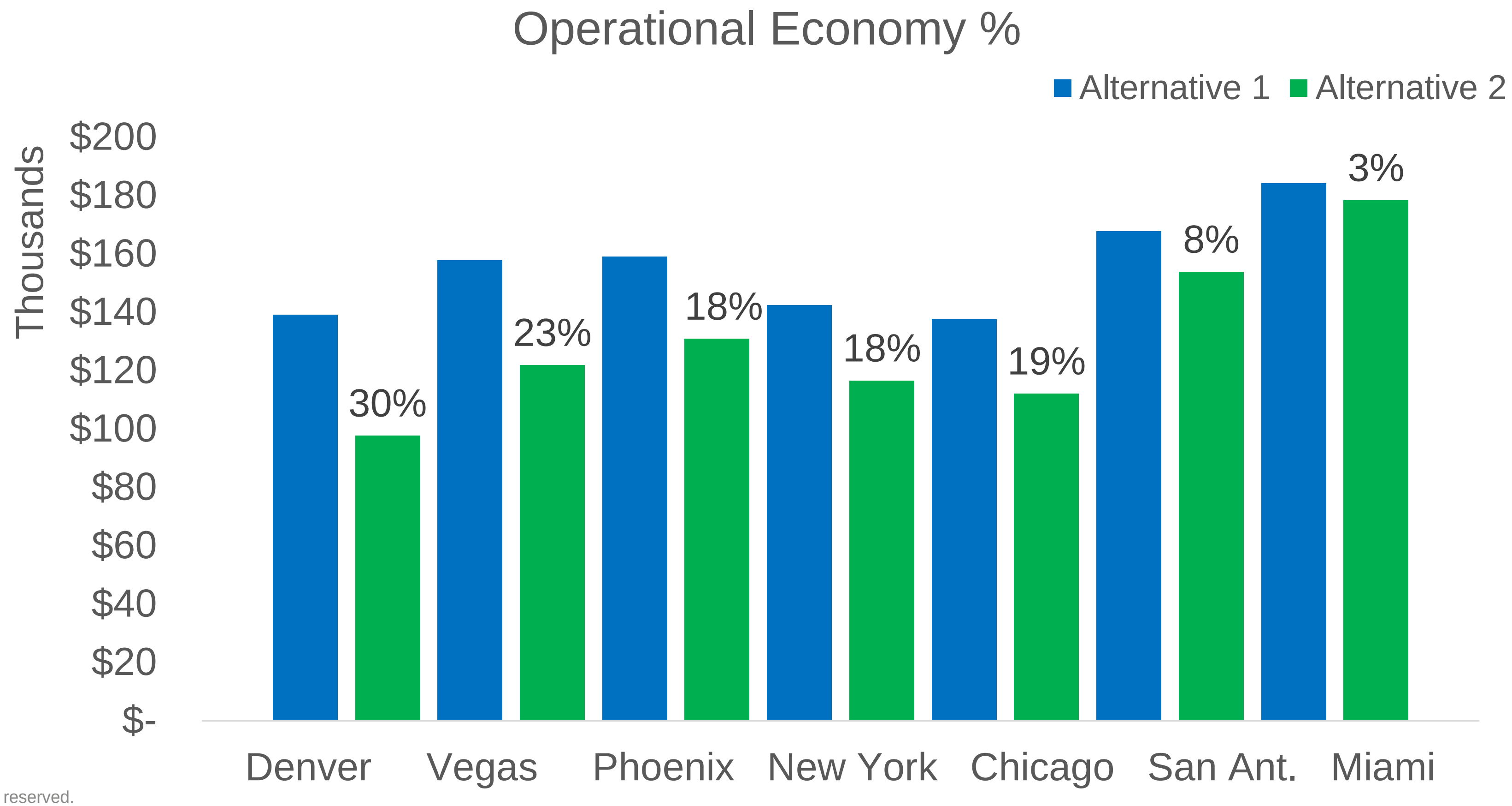
Simulation results – Plant Summary

- Economy Operational to all cities shows positive results to plant analysis.
- The local psychrometric conditions influence in the cooling tower operation, and whole plant.



Simulation results – Make Up Water

- With higher demand of the cooling tower the water usage trends to rise too.
- The main source of water consumtsion is evaporation, drift losses have also been added.
- The make up water in the alt. 2 is too small compare to the total water circulation in the condenser system.
  - Cooling water conditions 356.36 m^3/h * 2600 h/year = 926.536 m^3/year or 24.476*10^4 GPM/year.

Cooling Tower make up water

CITY	Alt 1 (m^3/year)	Alt 2 (m^3/year)	Increase BTW Alt %	Increase BTW CWP %
DENVER	3,351.05	3,918.61	14%	0.1%
Las Vegas	4,270.54	4,764.44	10%	0.1%
PHOENIX	4,846.03	5,918.45	18%	0.1%
NEW YORK	3,609.83	4,164.53	13%	0.1%
CHICAGO	3,399.52	3,987.80	15%	0.1%
SAN ANTONIO	4,912.63	5,359.27	8%	0.05%
MIAMI	5,897.01	6,247.54	6%	0.04%

Conclusions

- Lower ECWT = lower LIFT = Efficiency gain in the chiller.
- Operation of the plant remained optimized following the alternative 2.
- The Plant can be optimized without any initial cost, by only changing the operation mode of the system.
- The design conditions could be different based on climate, and the chiller could take advantage of this weather data.
- The results of the simulations varied according to the psychrometric conditions of each city.
  - All economic ratios for chiller/tower shows positive values.
- The control mode only by temperature set point is simple, and does not take into account the instant local climatic conditions during the operation.
  - BMS system could change the operation mode chasing the best operation point.

Questions?

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