Efficient systems require efficient tools



Stuart Kirkwood
Johnson Controls
Building Efficiency

YORK® BY JOHNSON CONTROLS

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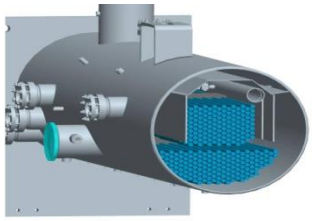
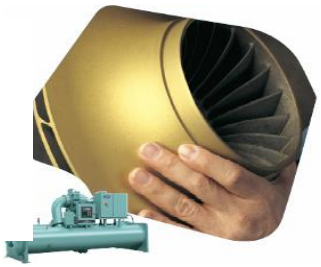
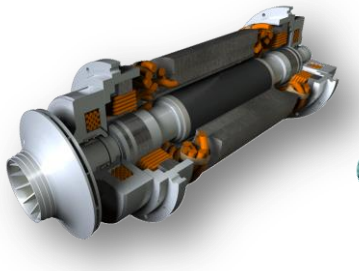
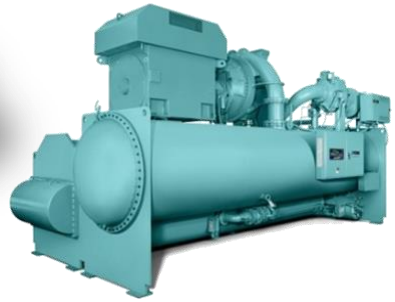
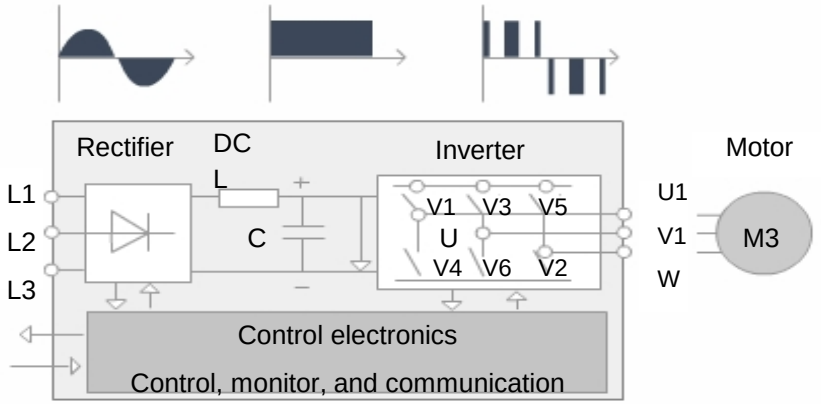
- In recent decades, significant gains in chiller efficiency at full & part load through advances in HX, compressor, motor, driveline, and cycle.

- The biggest single efficiency gain has been **at reduced 'lift' condition** with the adoption of the **variable speed drive.**





Comparative Energy Performance @ 450 tons

	At constant conditions			At AHRI relief conditions					
			YK		YK	YK VSD	YMC² VSD	YMC² VS YK	YMC² VS YK VSD
Load%	LWT	EWT	kW/Ton	EWT	kW/Ton	kW/Ton	kW/Ton	%	%
100	6.7	29.4	0.544	29.4	0.544	0.560	0.533	2.1	5.0
90	6.7	29.4	0.538	27.2	0.499	0.499	0.473	5.6	5.6
80	6.7	29.4	0.539	25.0	0.466	0.440	0.418	11.5	5.5
70	6.7	29.4	0.546	22.8	0.449	0.387	0.364	22.8	6.2
60	6.7	29.4	0.563	20.5	0.433	0.340	0.313	38.6	9.0
50	6.7	29.4	0.573	18.3	0.430	0.300	0.268	61.1	13.0
40	6.7	29.4	0.611	18.3	0.466	0.311	0.275	89.5	13.0
30	6.7	29.4	0.666	18.3	0.519	0.340	0.294	76.1	15.7
20	6.7	29.4	0.789	18.3	0.634	0.378	0.341	85.9	10.9
15	6.7	29.4	0.889	18.3	0.720	0.426	0.409	75.7	4.0



How to effectively apply high efficiency **VSD** chillers to HVAC systems in tropical climates?





One has to create the optimum operating environment



The optimum operating environment for VSD chillers is at reduced ‘lift’



Efficient chillers are a great foundation, but optimization is a process





White Paper

Seven Steps to Maximizing Central Plant Efficiency

David Klee
Director, Channel Marketing & Strategy, HVAC
Johnson Controls, Inc.

Gary Gigot
Vice President Business Development
Optimum Energy, LLC

Johnson Controls

Operating Decisions

Design Decisions

- **Maintain**
- **Measure & Verify**
- **Optimize System**
- **Automate System**
- **Apply components effectively, optimally**
- **Select components effectively, optimally**
- **Design system infrastructure to maximize efficiency potential**



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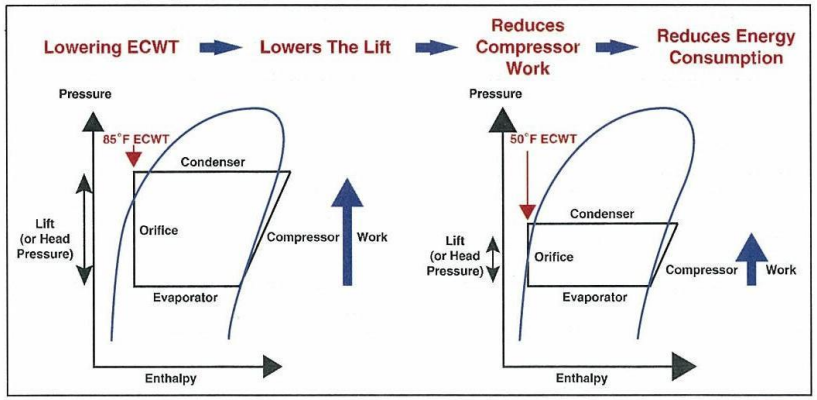
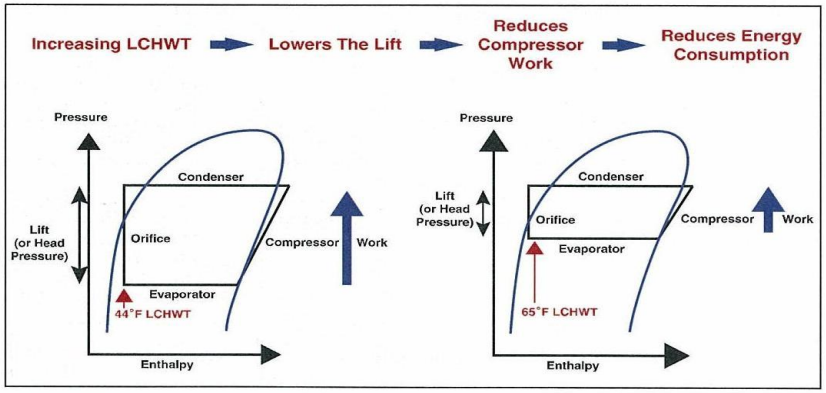
What is reduced lift or lift ‘relief’ ?



Lower tower water temps

Some opportunity due to climate



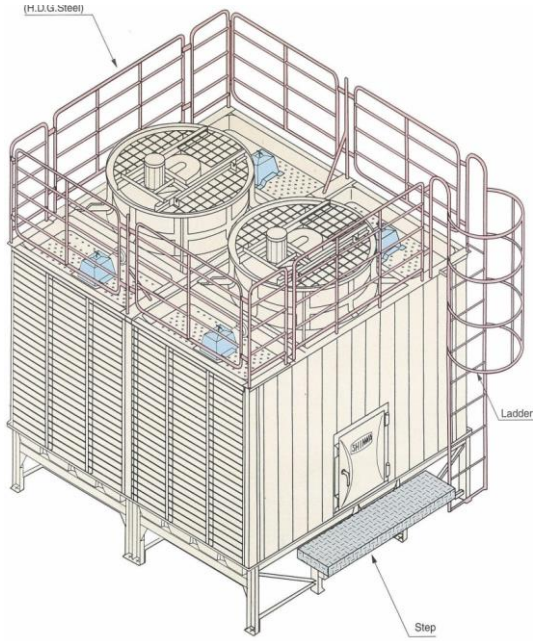
Higher chilled water temps

Significant opportunity with HT CHW and airside system design



The cooling tower is the most effective heat transfer device in the system

Lower tower water temps



250 ton tower

Efficiency = 7.5 kW / 250 Ton
= 0.030 kW / Ton

Singapore Design Condition

32 - 37 deg C

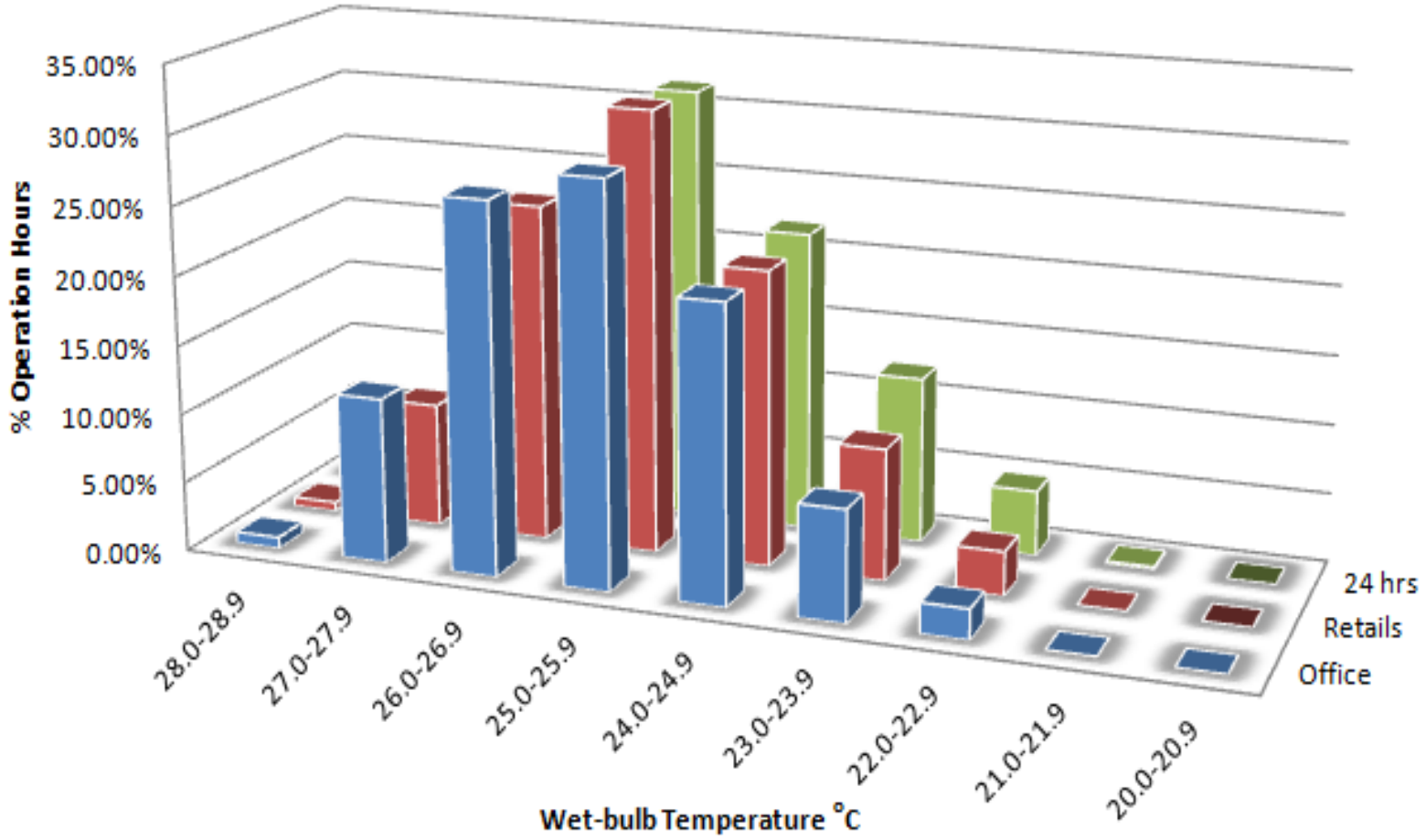
OR

30 - 35 deg C

Singapore tower water does not have to be held constant



Singapore Building Operation Profiles



Source: ASHRAE IWEC Weather Bin Data



Chiller condenser water set-point is determined by wet bulb

	Office	Retail	24/7
WB Bin	**HRS**	**HRS**	**HRS**
27-27.9	11.9%	9.0%	6.7%
26-26.9	26.8%	24.4%	22.5%
25-25.9	28.9%	31.9%	31.5%
24-24.9	21.3%	21.3%	21.9%
23-23.9	8.0%	9.5%	12.1%
22-22.9	2.2%	3.2%	4.7%
Annual Run HRS	2634	4380	8760
% < 24 WB	10.2 %	12.7%	16.8%
HRS	258	556	**1471**

Singapore tower water will achieve 3 deg C of relief with potentially 5 deg C beneficial for 24/7 systems



Chilled Beam Systems

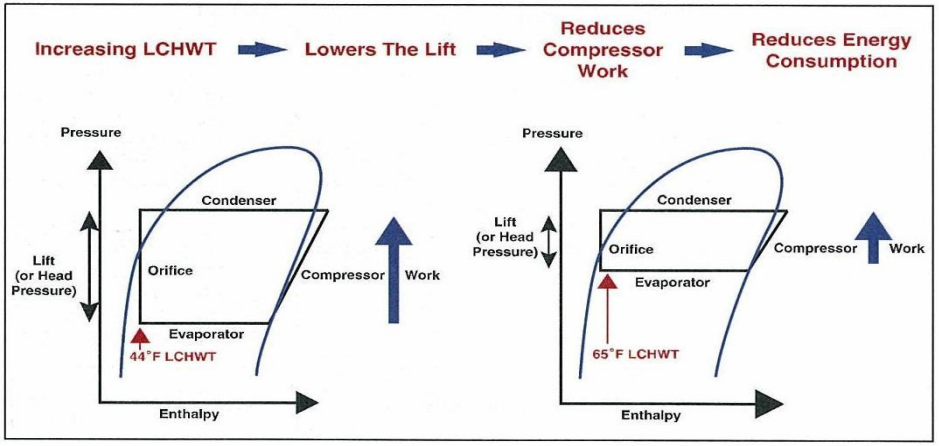
Higher chilled water temps

Chilled Beam Systems





Active chilled beam systems use chilled water supply temperatures of 14 degrees C



One HVAC system performs all dehumidification

De-coupled

One HVAC system performs sensible cooling only

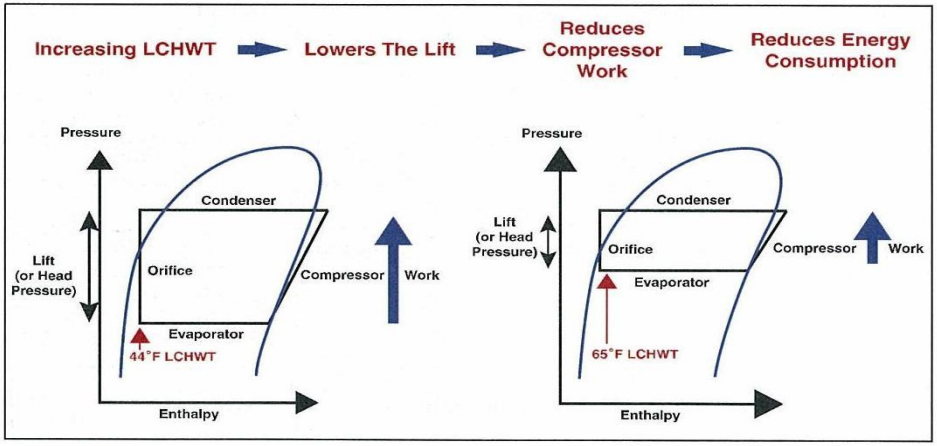


UFAD Systems



Under floor air distribution systems use supply air temperatures of 15-18 degrees C

Supply chilled water temperatures can be 12-13 degrees C



One HVAC system performs all dehumidification

De-coupled

One HVAC system performs sensible cooling only



The most efficient HVAC systems treat the latent loads separately

"De-coupling"

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Cooling Load Component	Latent	Sensible
Conduction thru walls, roof etc		▶
Solar radiation		▶
Lights		▶
People	▶	▶
Equipment	▶	▶
Infiltration	▶	▶
Ventilation	▶	▶
System heat gains		▶



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Treating latent loads separately = Dedicated Outside Air System (DOAS)

- satisfies the entire building humidity load
- controls space dew point
- maintains prescribed ventilation rate
- operates in combination with a sensible cooling system

A DOAS treats 100 % of the outside air.

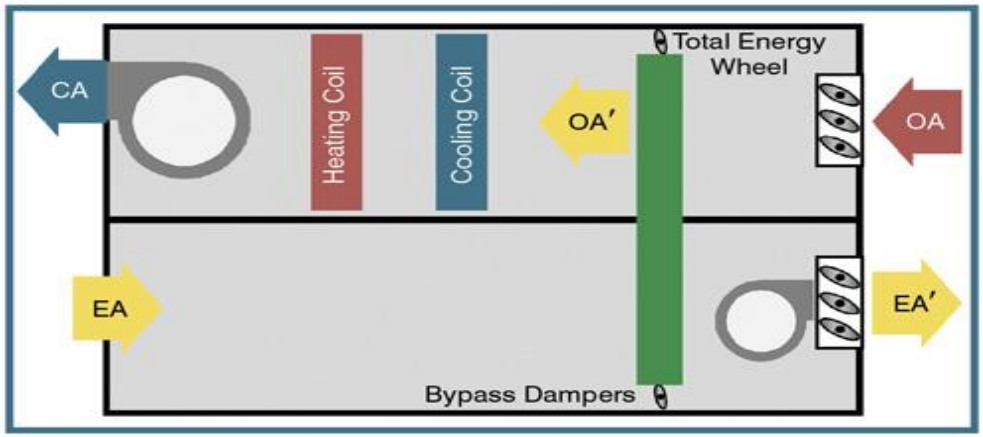


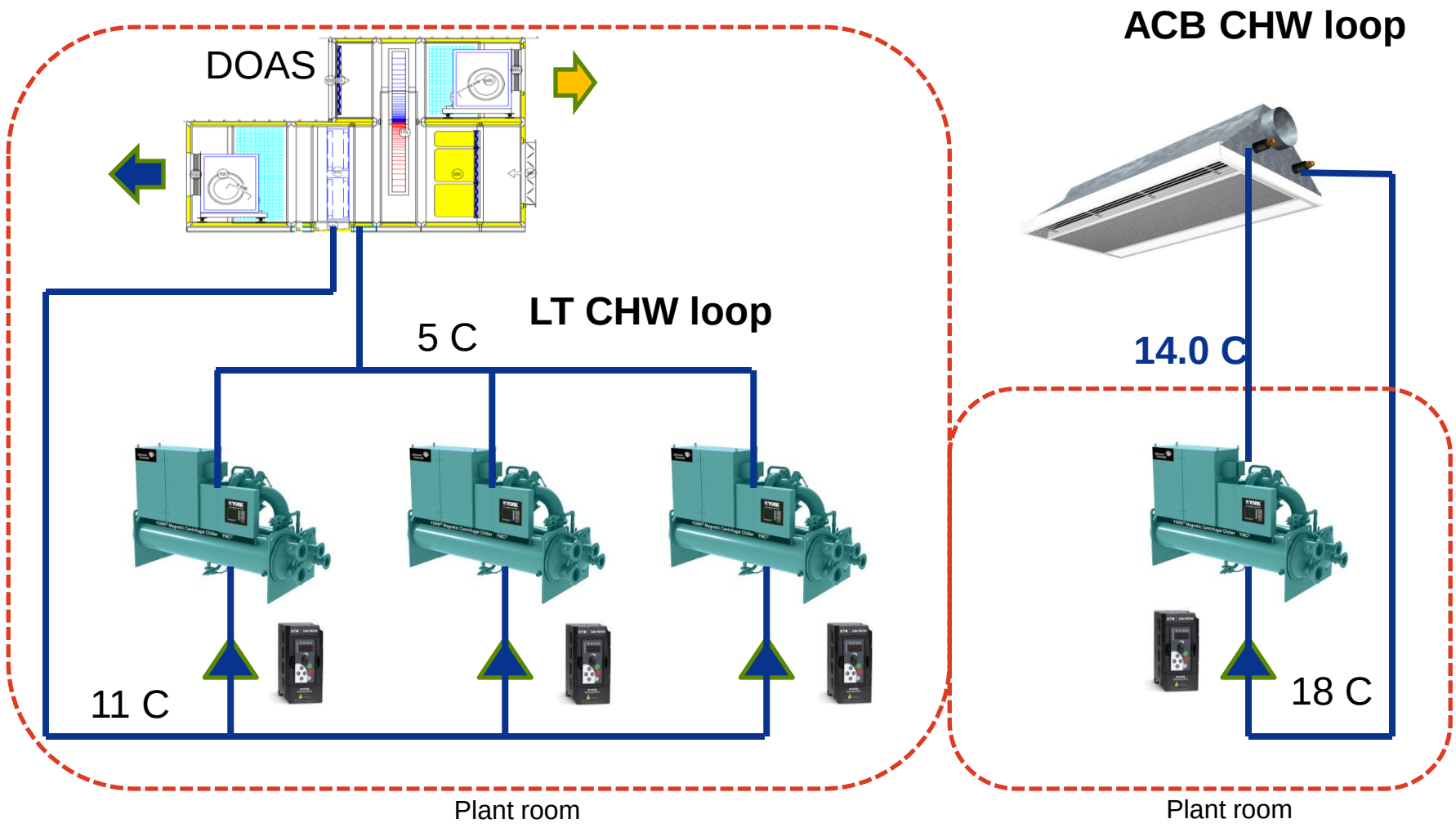
Figure 1: Exhaust-air energy recovery in a dedicated OA system.



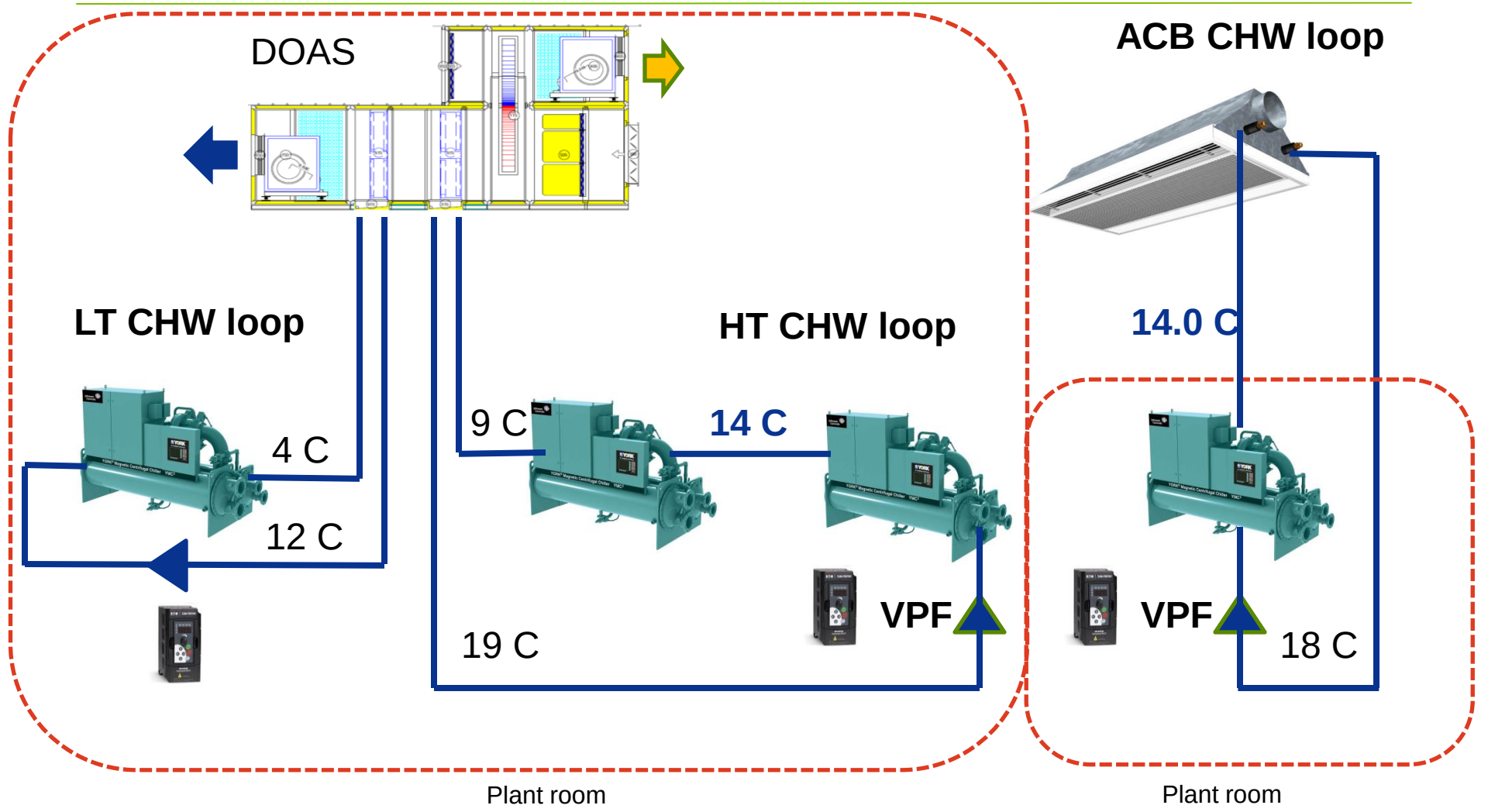




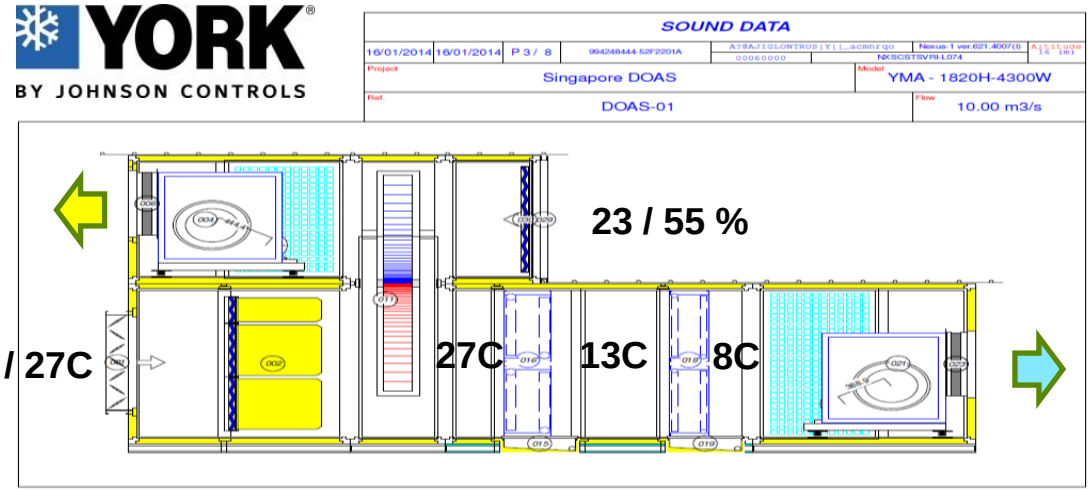
ACB System Conventional design for LT & HT CHW water loops



Alternate design - Multiple CHW water loop systems



Multi-stage DOAS cooling for de-hum and condensation control





Significant gains in system efficiency when maximizing HT CHW cooling contribution



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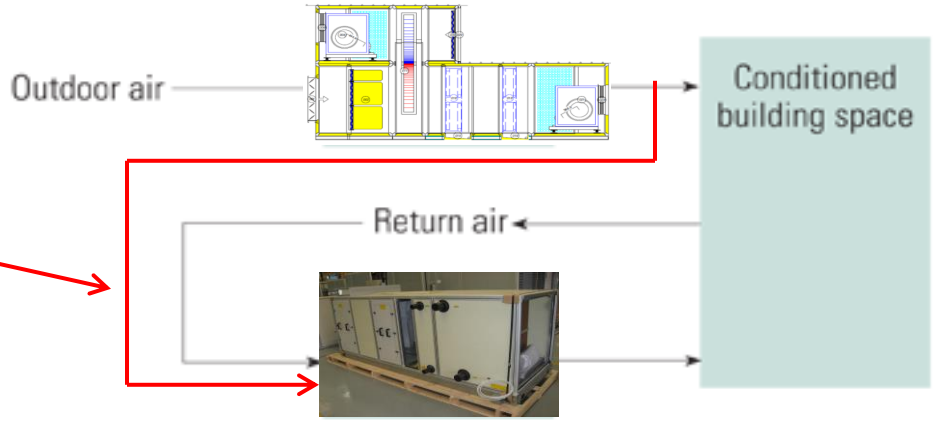
What about conventional VAV systems ?
Can DOAS & HT CHW also be applied to VAV systems ?

A. Basic arrangement of a conventional all-air VAV system



B. DOAS with separate conditioning of outdoor and return air



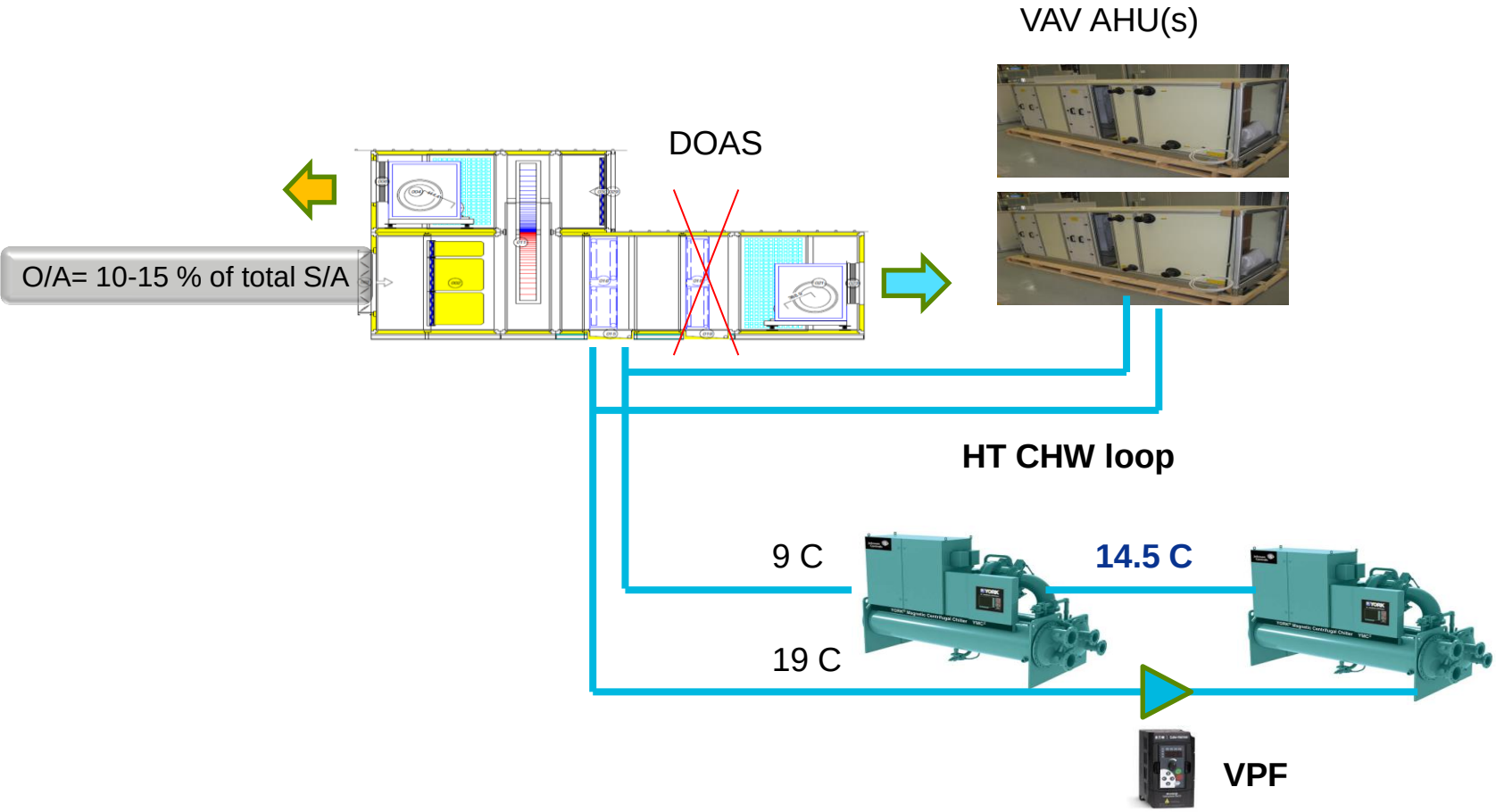
Pre-conditioned O/A can also be supplied directly to the VAV zone conditioner

Notes: DOAS = dedicated outdoor air system; VAV = variable air volume.

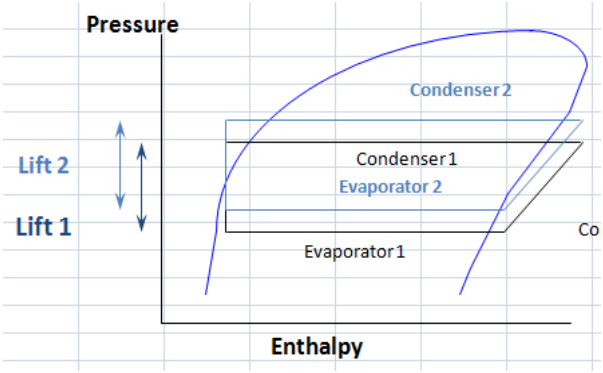
Source: E SOURCE



For VAV systems condensation control is not required.
In most applications, 9 deg C chilled water can provide 12-13 deg C supply air temperature



Why series counter-flow VSD chillers?



VPF = variable flow & fixed delta T

VPF



9 deg C

14.0 deg C

19 deg C





30 deg C

32.5 deg C

35 deg C

Lift is reduced 2.5 degrees C

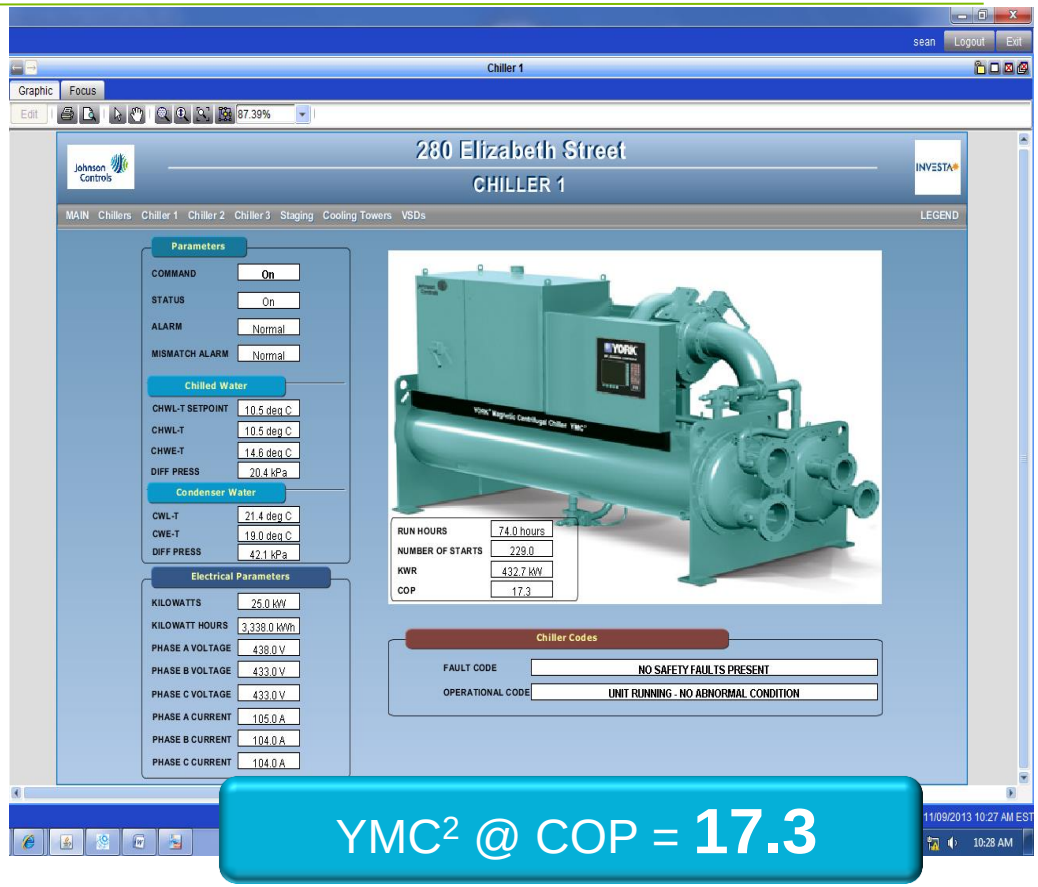
Lift is reduced 5.0 degrees C











YMC² @ COP = **17.3**

Green buildings are driving increasing demand for chiller plant optimization



Chiller Plant Optimization - Advanced control strategies

METASYS® BY JOHNSON CONTROLS



BACnet®



- Series counter-flow chillers
- Chiller /Tower optimization
- Supply chilled water reset
- Variable primary CHW flow
- Efficiency based staging

Johnson Controls – Chiller Plant Manager



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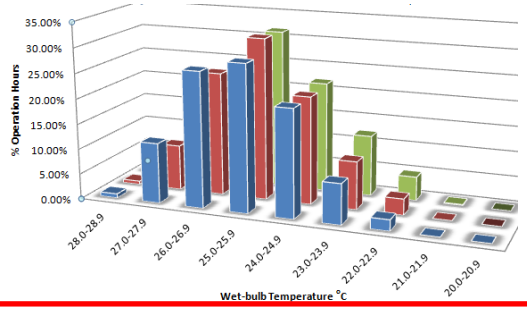

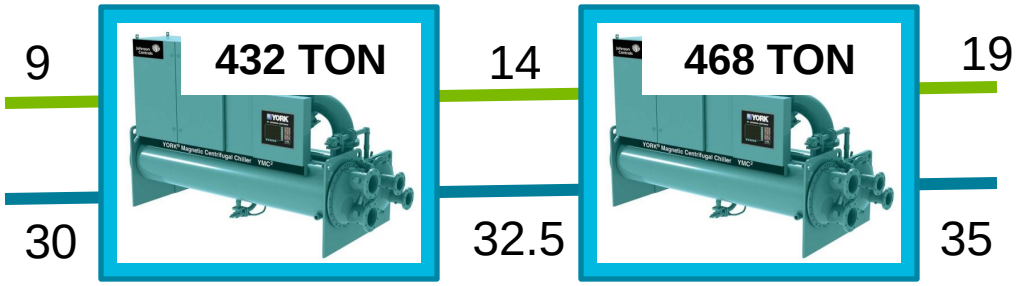

Series counter flow chiller performance at Singapore conditions (office hours)

Load%	CHW_{in}	CHW_{int}	CHW_{out}	CW_{in}	CW_{int}	CW_{out}	UP kW/Ton	DN kW/Ton	SYS kW/Ton
100	19	13.8	9	30	32.4	35	**0.402**	**0.449**	**0.424**
90	19	13.8	9	29.4	31.6	33.9	**0.377**	**0.432**	**0.404**
80	19	13.8	9	28.8	30.7	32.8	**0.353**	**0.414**	**0.382**
70	19	13.8	9	28.2	29.9	31.7	**0.333**	**0.400**	**0.365**
60	19	13.8	9	27.6	29.1	30.7	**0.321**	**0.394**	**0.356**
50	19	13.8	9	27	28.2	29.5	**0.308**	**0.394**	**0.349**
40	19	13.8	9	27	28	29.1	**0.321**	**0.417**	**0.367**
30	18.5	13.6	9	27	27.7	28.5	**0.351**	**0.471**	**0.409**
20	15.4	12.1	9	27	27.5	28.1	**0.515**	**0.654**	**0.582**



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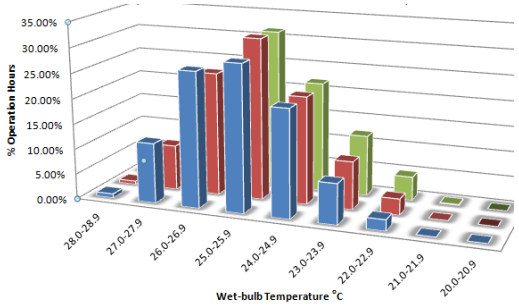

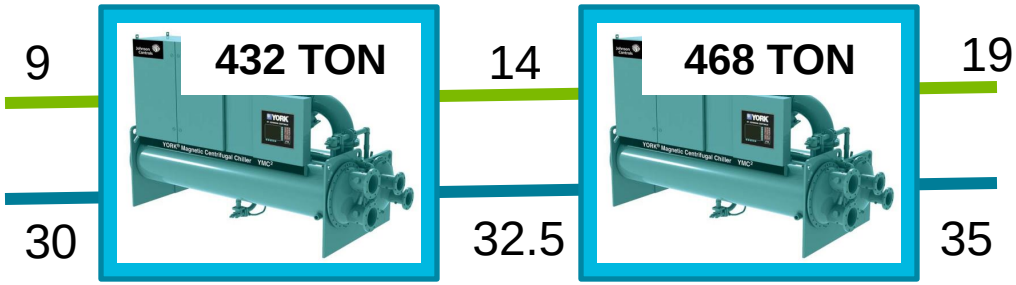

Series counter flow chiller performance at Singapore conditions (24/7 hours)

Load%	CHW $_{in}$	CHW$_{int}$	CHW$_{out}$	CW$_{in}$	CW$_{int}$	CW$_{out}$	UP kW/Ton	DN kW/Ton	SYS kW/Ton	
100	19	13.8	9	30	32.4	35	0.402	0.449	0.424	
90	19	13.8	9	29.4	31.6	33.9	0.377	0.432	0.404	
80	19	13.8	9	28.8	30.7	32.8	0.353	0.414	0.382	
70	19	13.8	9	28.2	29.9	31.7	0.333	0.400	0.365	
60	19	13.8	9	27.6	29.1	30.7	0.321	0.394	0.356	
50	19	13.8	9	27	28.2	29.5	0.308	0.394	0.349	
40	19	13.8	9	**26.4**	27.4	28.4	**0.307**	**0.403**	**0.353**	**4%**
30	19	13.8	**9.6**	**25.8**	26.5	27.3	**0.304**	**0.428**	**0.359**	**14%**
20	17	13.8	**10.5**	**25.2**	26.8	26.8	**0.382**	**0.507**	**0.444**	**31%**

Small changes can have a measurable impact



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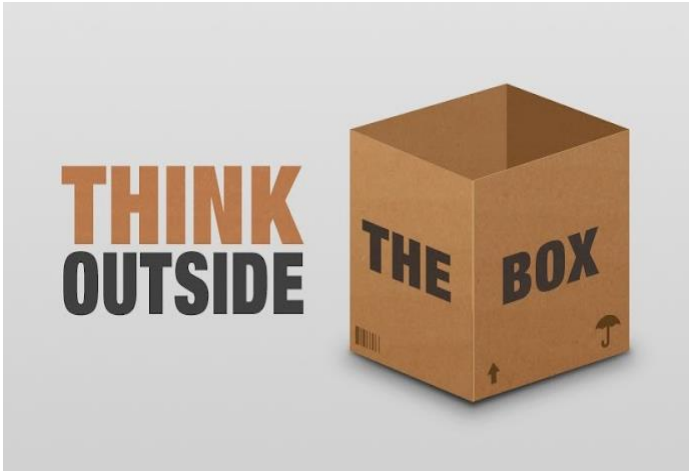
Summary YK fixed speed vs YMC²

	YK At constant	YMC² s/c at Singapore conditions				YMC² at 14 deg C
		Office profile		24/7 profile		
Load%	YK	YMC² s/c	▲	YMC² s/c	▲	YMC²
100	0.544	0.424	28%	0.424	28%	0.402
90	0.538	0.404	33%	0.404	33%	0.377
80	0.539	0.382	41%	0.382	41%	0.353
70	0.546	0.365	50%	0.365	50%	0.333
60	0.563	0.356	58%	0.356	58%	0.321
50	0.573	0.349	65%	0.349	65%	0.308
40	0.611	0.367	66%	0.353	73%	0.321
30	0.666	0.409	48%	0.359	85%	0.351
20	0.789	0.582	35%	0.444	77%	0.515

Based on a VAV system , chiller operating cost can be reduced on average by 50% or more.
Even greater scope with active chilled beam systems.







The innovation requirements of a green building is challenging traditional paradigms



Conclusion

- Yes, it is possible to effectively apply York variable speed chillers in Singapore and deliver value from the technology **Design system infrastructure to maximize the efficiency potential**
- YK VSD has excellent efficiency, but YMC² is the new benchmark
- Johnson Controls is an **Integrated System Solutions Company**
  - **Not just highly efficient products**
  - **Chillers + AHU + Controls + Strategies**

Smart Green
Integrated Sustainable Solutions

