Demonstrating a Dual Heat Exchanger Rack Cooler "Tower" Water for IT Cooling

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BERKELEY LAB

Project Overview

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Researchers: Henry Coles, Steve Greenberg

Sponsors: California Energy Commission (CEC)

Partners: APC by Schneider Electric

Synapsense

LBNL Data Center – Building 50

Project Term: Concept July 2009/start July 2010-end Oct 2012

Presentation

- Goal/Objectives
- Background/Methods
- Cooling Design Concept
- Reverse Engineering – Construct Model
- Forward Engineering – Calculate Results
- Conclusions

Project Goal/Objective

Goal: Demonstrate the benefits of cooling IT equipment using high temperature water using a unique cooling unit.

Objectives:

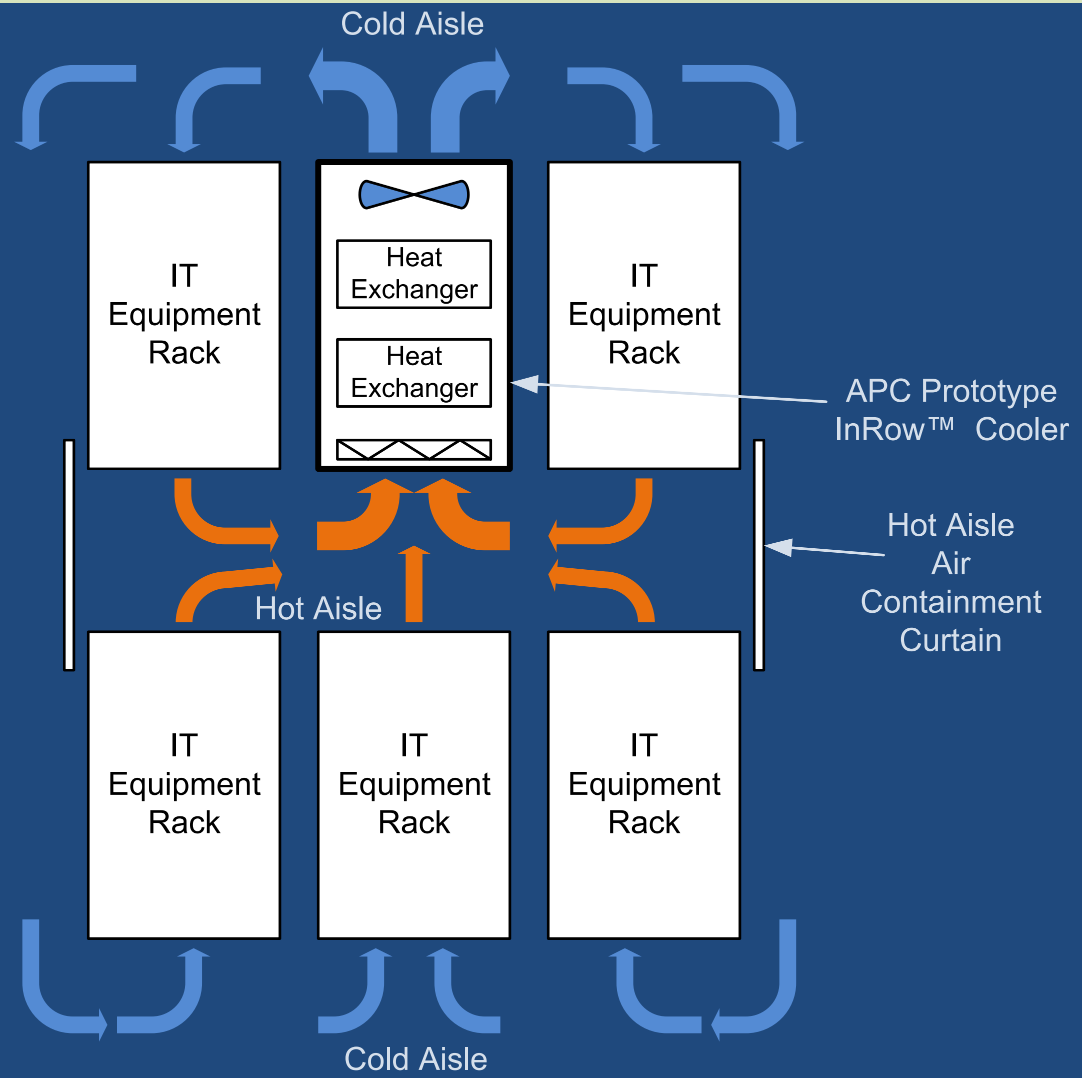
- Measure performance
- Develop a predictive model
- Calculate Metrics

Background / Methods

1. Discussed concept with APC
2. APC constructs prototype
3. Install Unit at LBNL Data Center
4. Instrument Heat Exchangers, Electrical Power and Air Temperature
5. Record Thermal/Power Performance
6. Reverse Engineer Heat Exchanger/Construct Closed Form Solution
7. Calculate Metrics/Plot Results /Draw Conclusions

APC Prototype Dual Hex Cooler

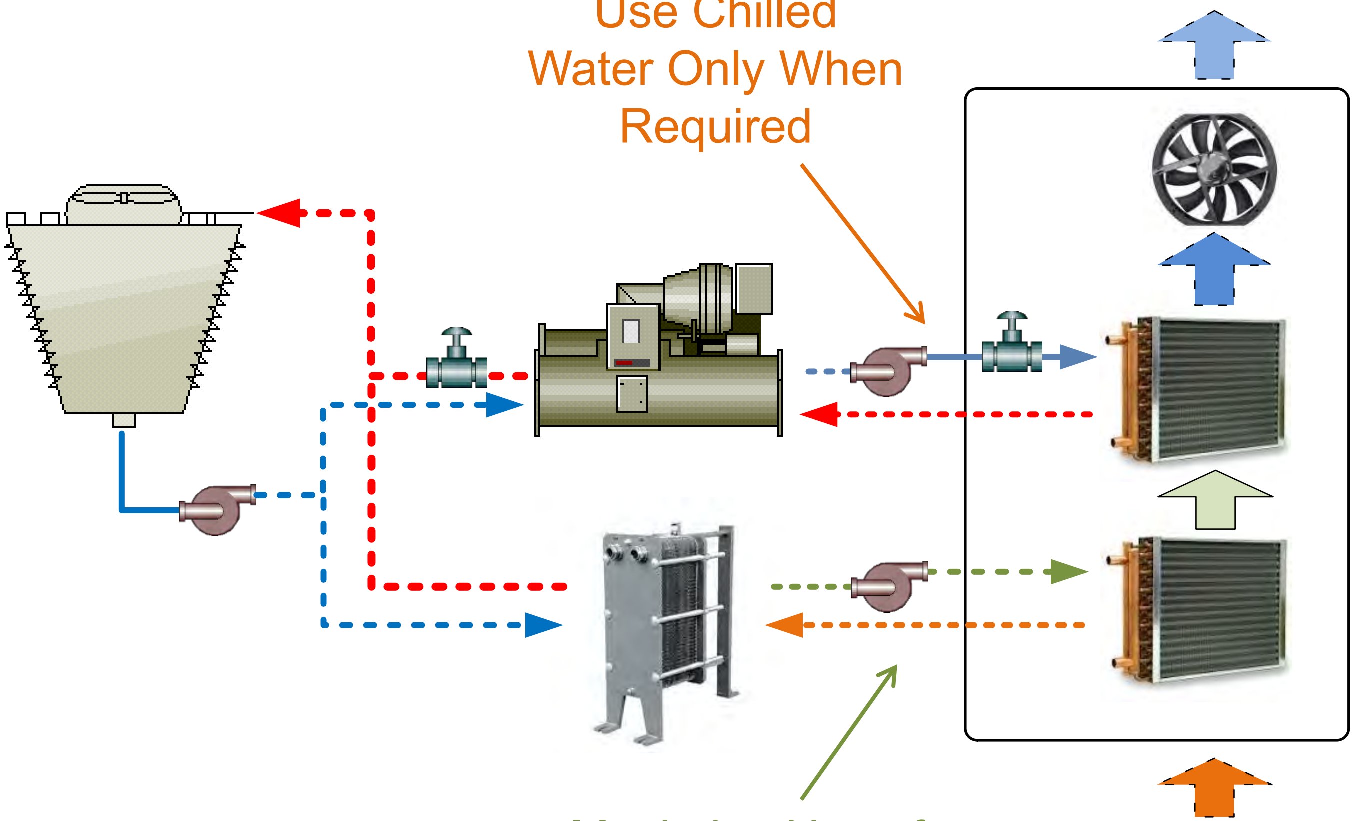
Demonstration Installation



Function Concept

Cold Air
Going to Cold Aisle
(IT Equipment Intake)

Use Chilled
Water Only When
Required

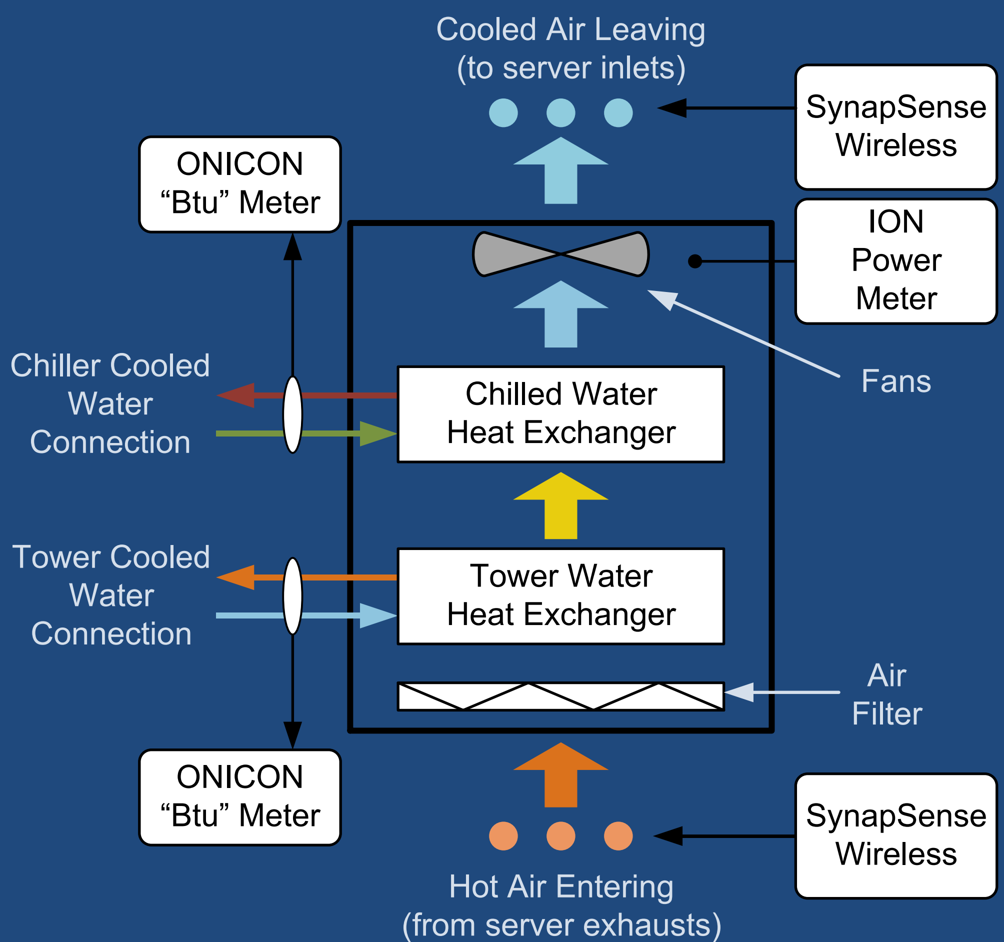


Provides Localized WSE

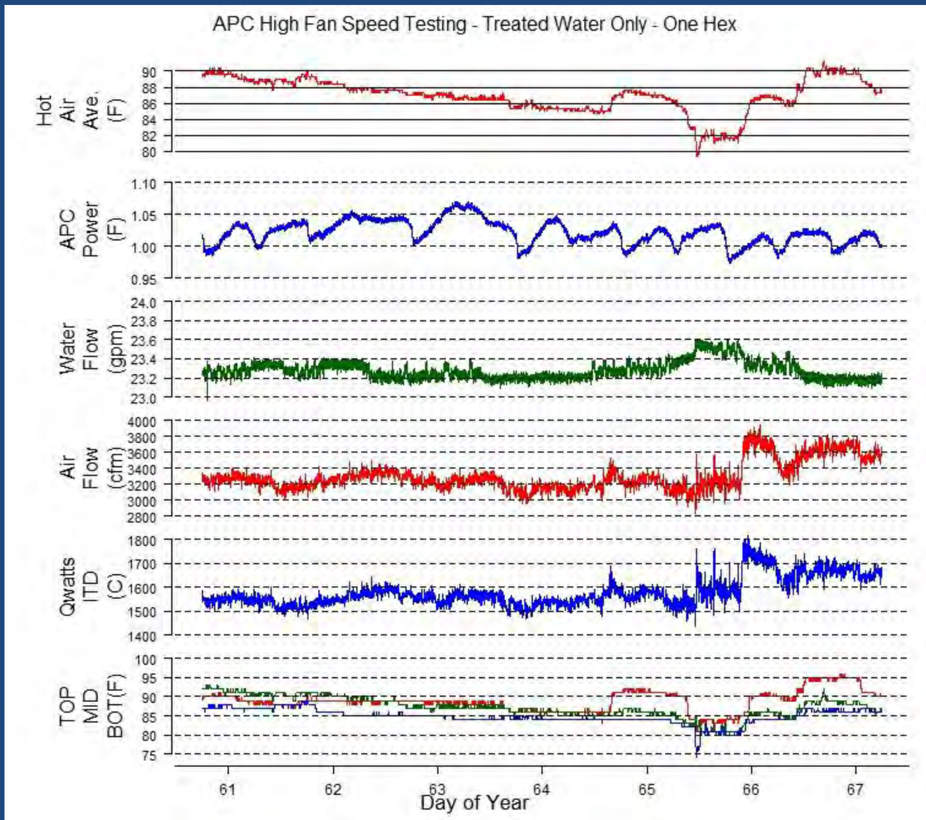
Maximize Use of
“Tower” Water

Hot Air
From Hot Aisle
(IT Equipment Exhaust)

Data Collection



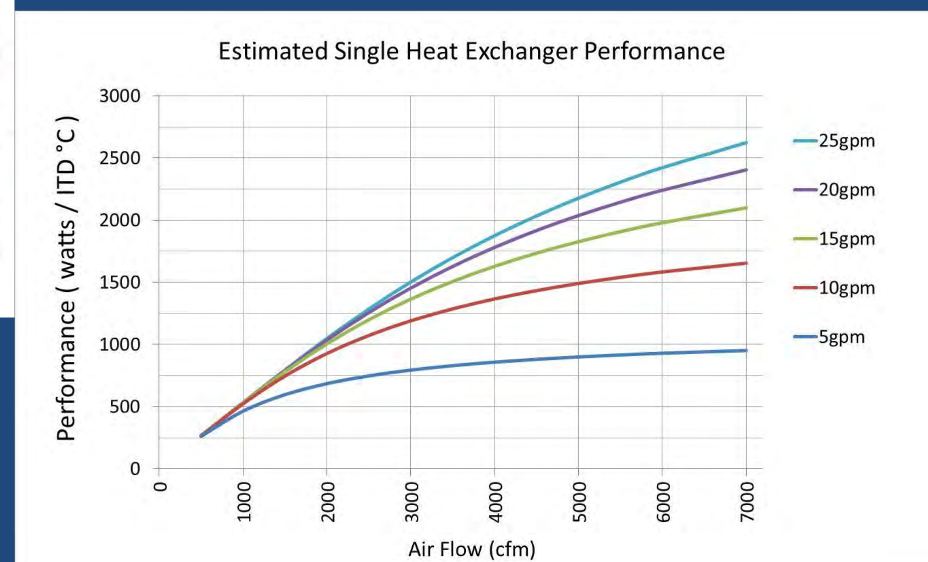
Reverse Engineering Problem



Heat Exchanger Performance
Not Provided

gathered data

need closed form model



Reverse Engineering (cont.) [DBPP warning]

Fit to Hex Theory: Cross Flow, One Fluid Mixed, Other Unmixed

C = mass flow rate x heat capacity

If Cmax = Cmixed (air)

[1] $E = 1 - \exp(-Tau * (C_{max} / C_{min}))$

↑

$Tau = 1 - \exp(-N_{tu} * (C_{min} / C_{max}))$

If Cmax = Cmixed (water)

[1] $E = (C_{max} / C_{min}) * (1 - \exp(-Tau' * (C_{min} / C_{max})))$

↑

$Tau' = 1 - \exp(-N_{tu})$

[1] $N_{tu} = AU/C_{min}$

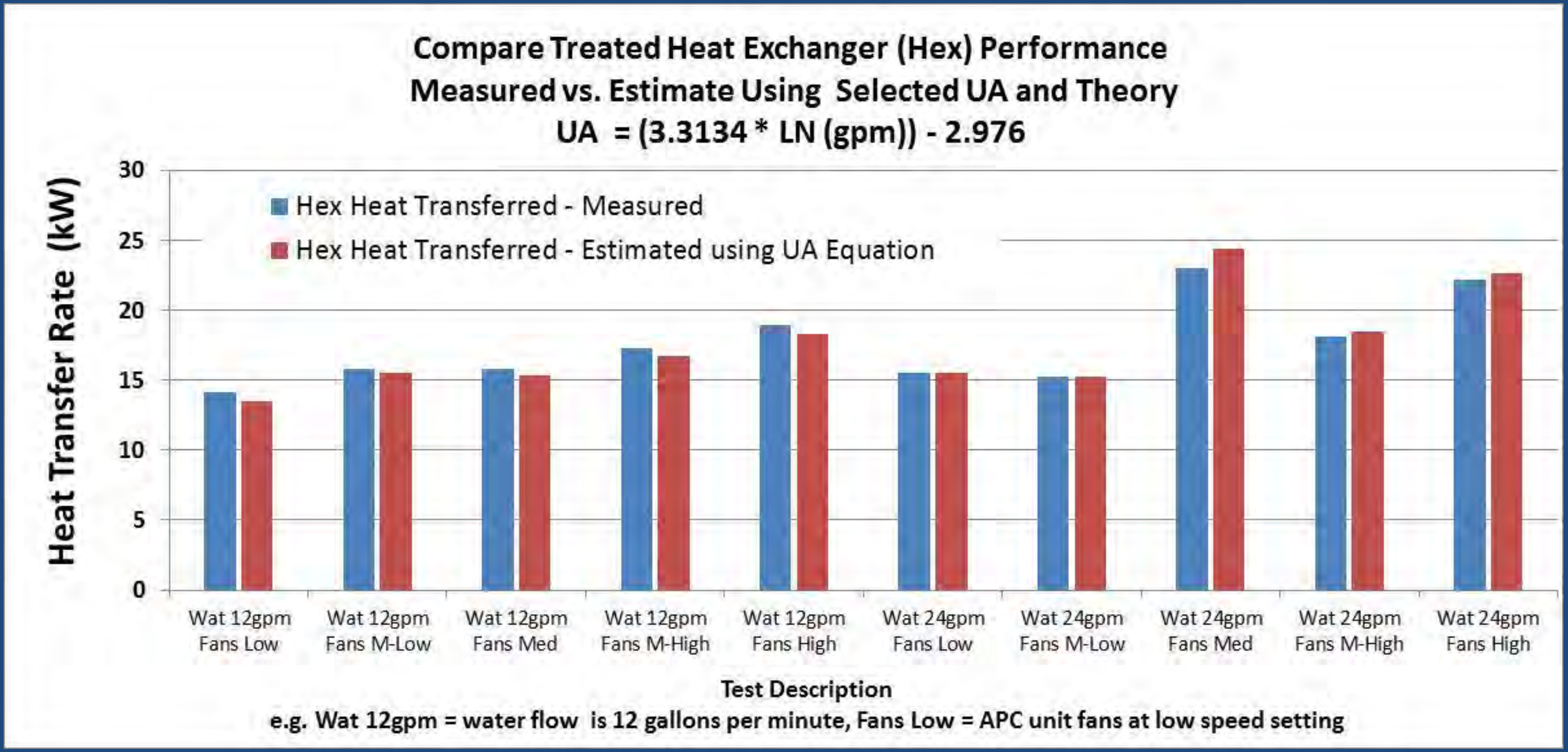
solve for AU

q (heat transferred) $= E\, C_{min} (T_{hot\ in} - T_{cold\ in})$

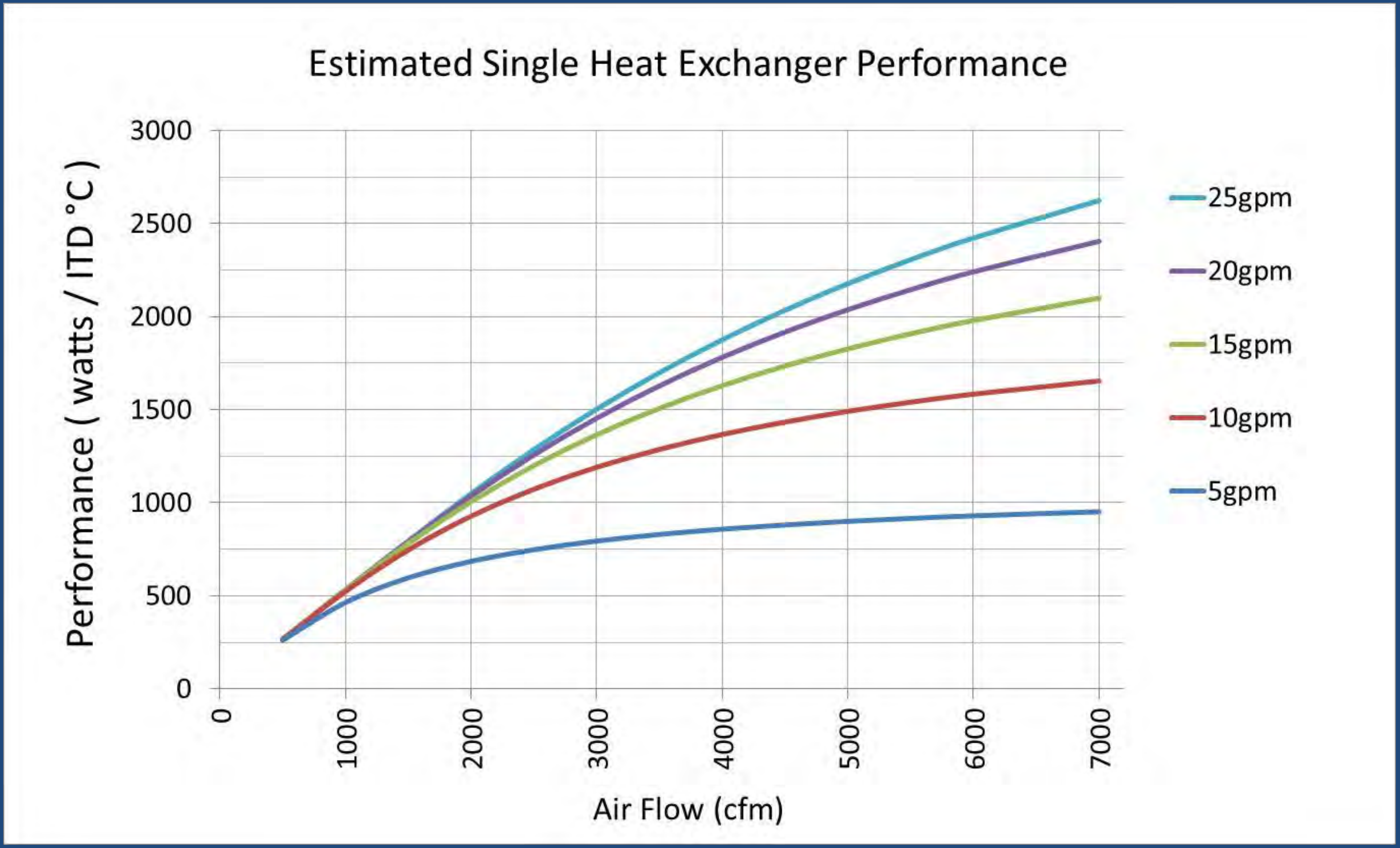
calculate exiting temperatures $(T_{hot\ out},\ T_{cold\ out})$

[1]Kays, W. M. and A. L. London. 1964. C*ompact Heat Exchangers, 2nd Edition.* Stanford University. Page 19

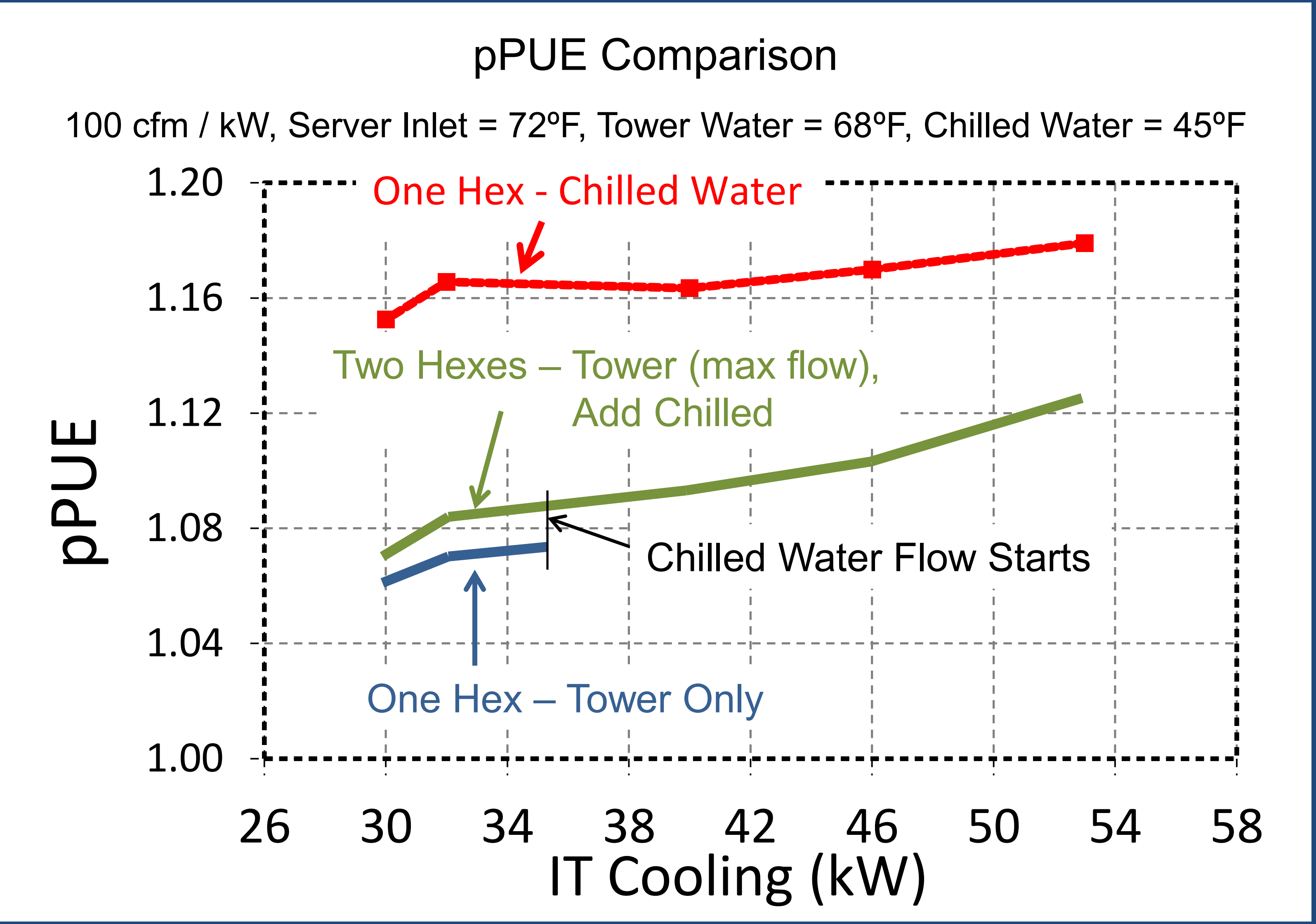
Check Closed Form Solution



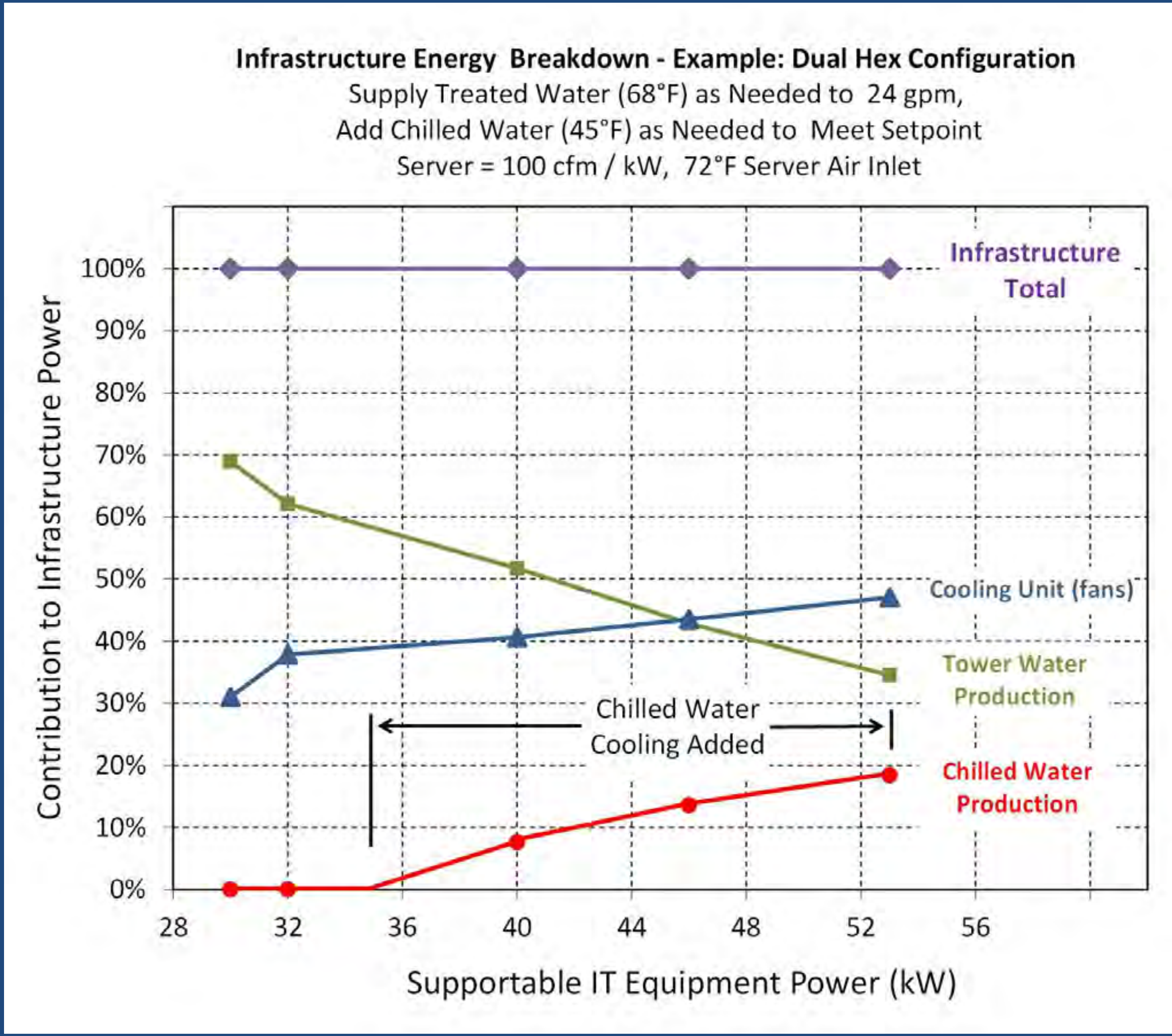
Heat Exchanger Reverse Engineering Results



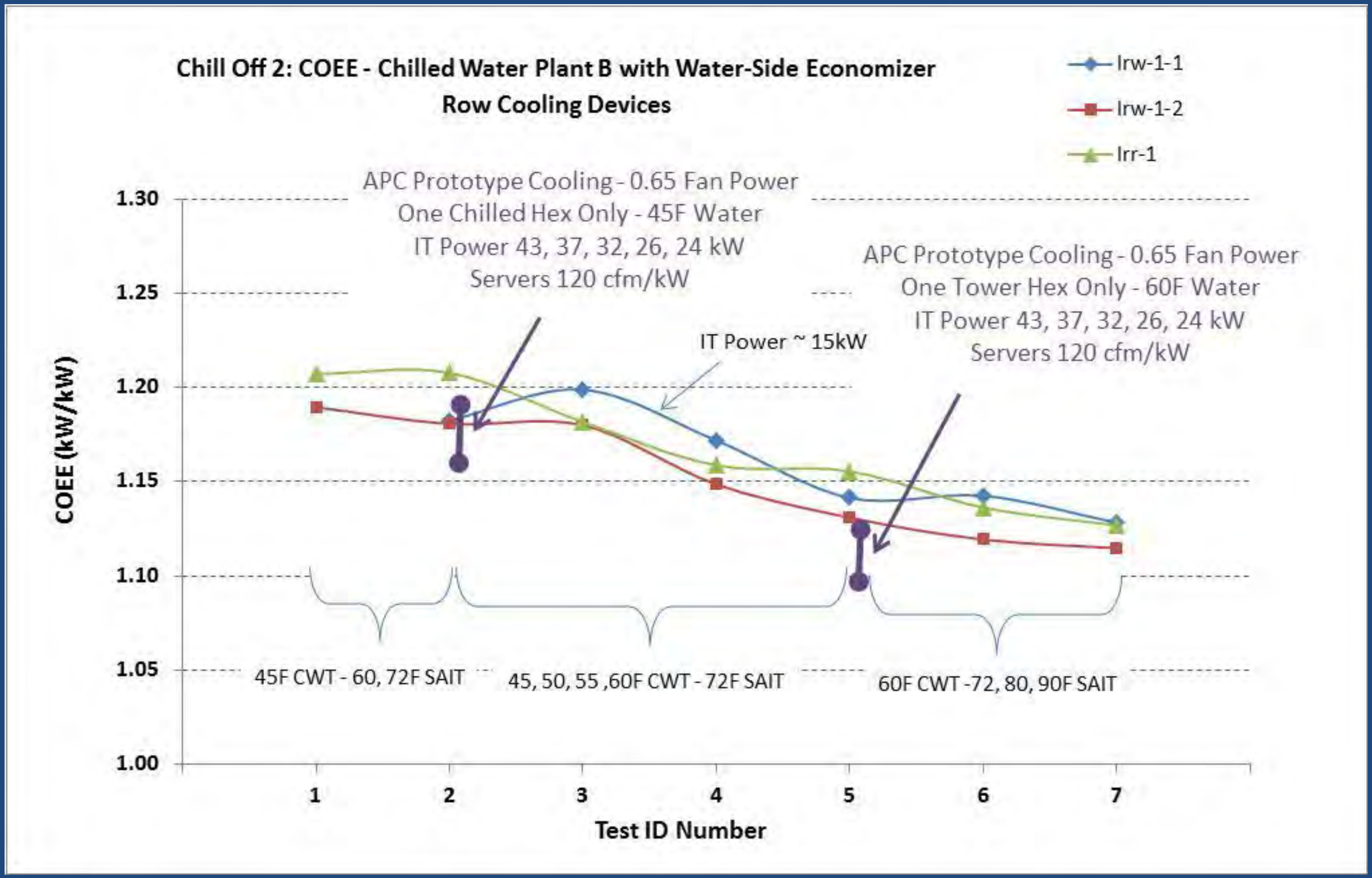
Results (forward engineering)



Results (cont.)



Compare to Chill-Off 2 Devices



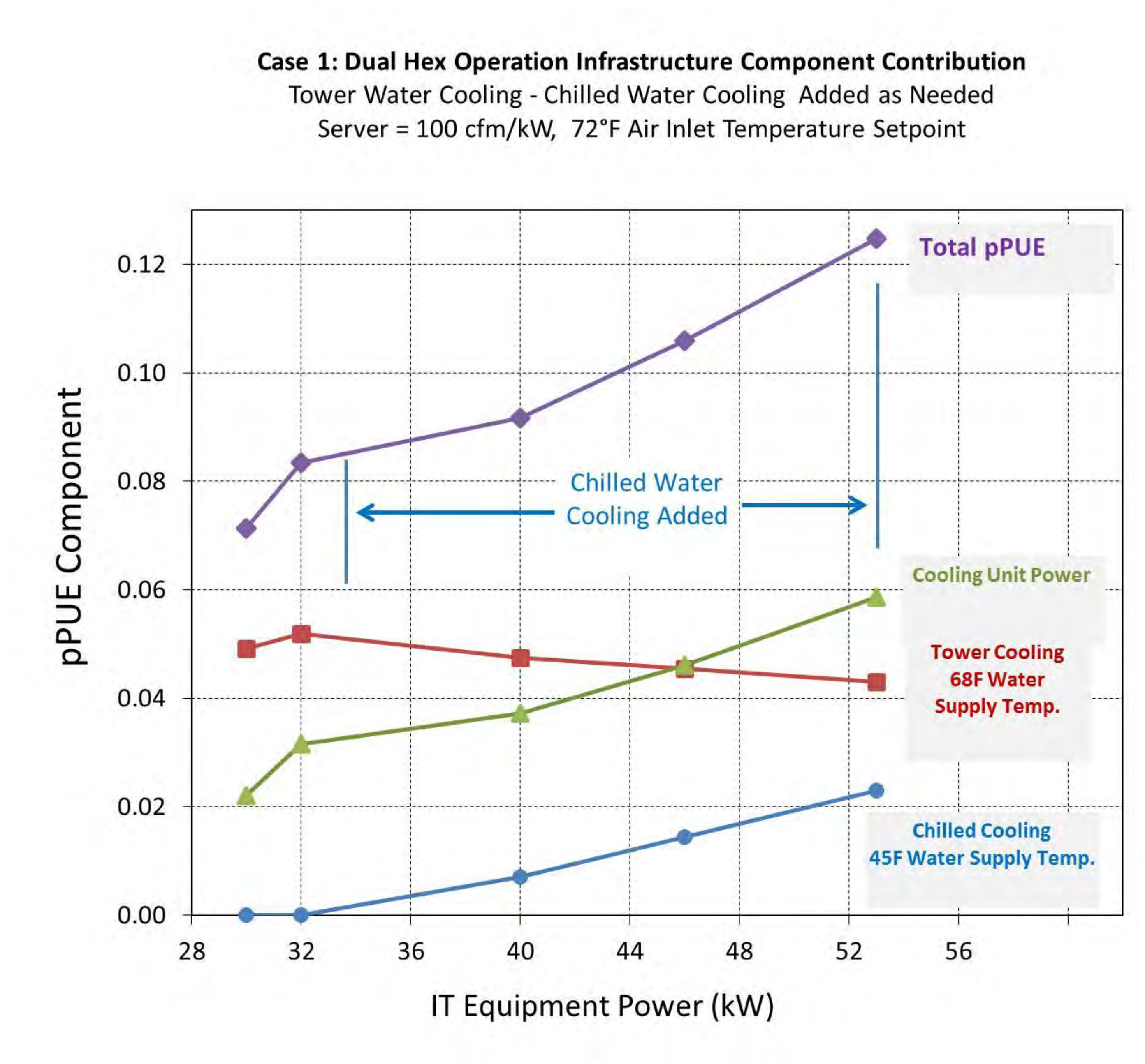
Conclusions

- Warmer (tower/economizer) water provides 30 to 50 % cooling efficiency improvements, compared to water supplied using compressor-based (chiller) cooling.
- Design minimizes compressor based cooling

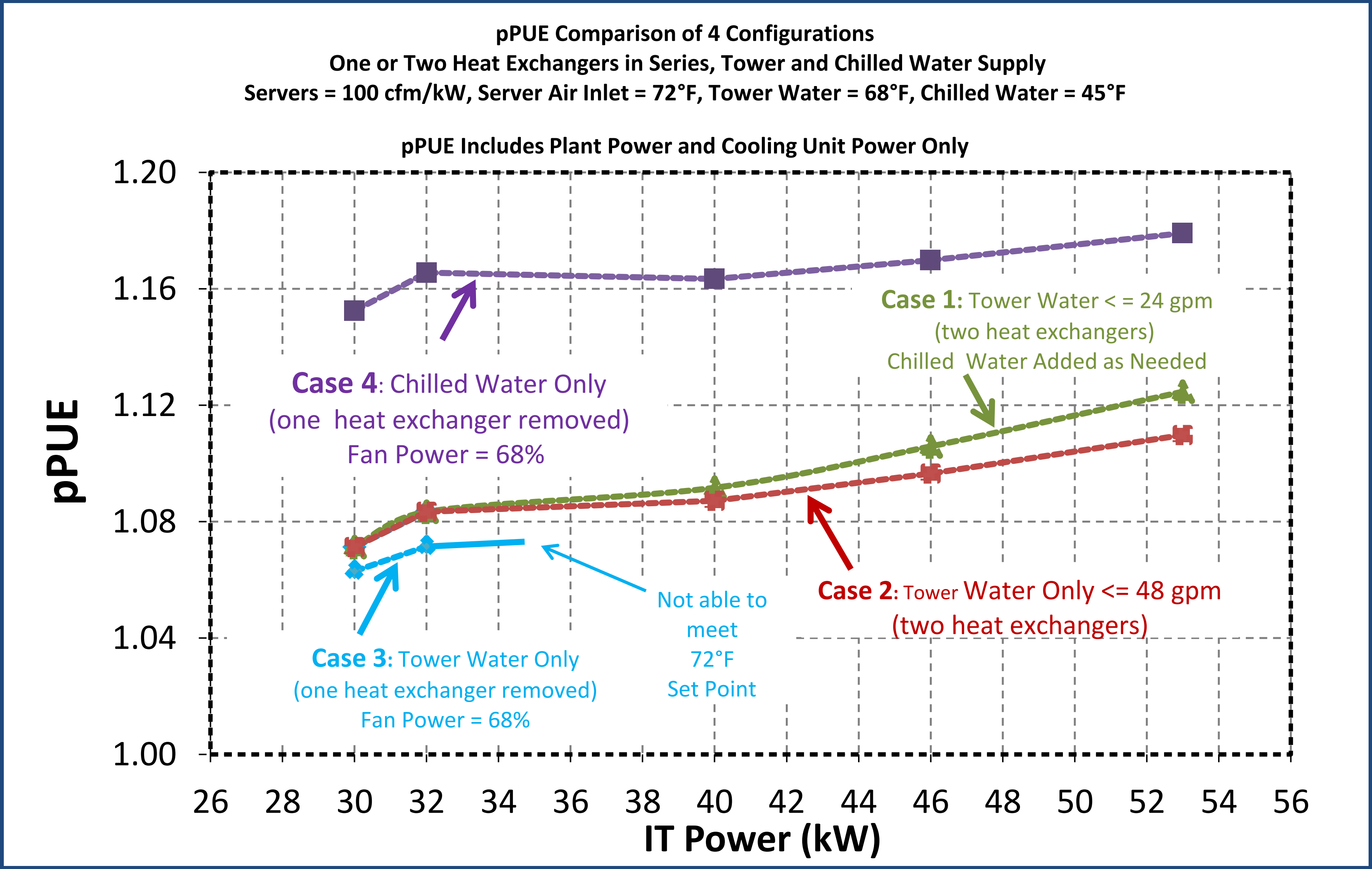
  (individual **localized** economizer, lower pPUE)
- Fan energy has a significant effect on efficiency at high air flow rates.
- The prototype cooling unit compared favorably (20-30 percent improvement) to similar devices evaluated in a past PIER demonstration project (Chill-Off 2)

End
Questions?

Backup Slides

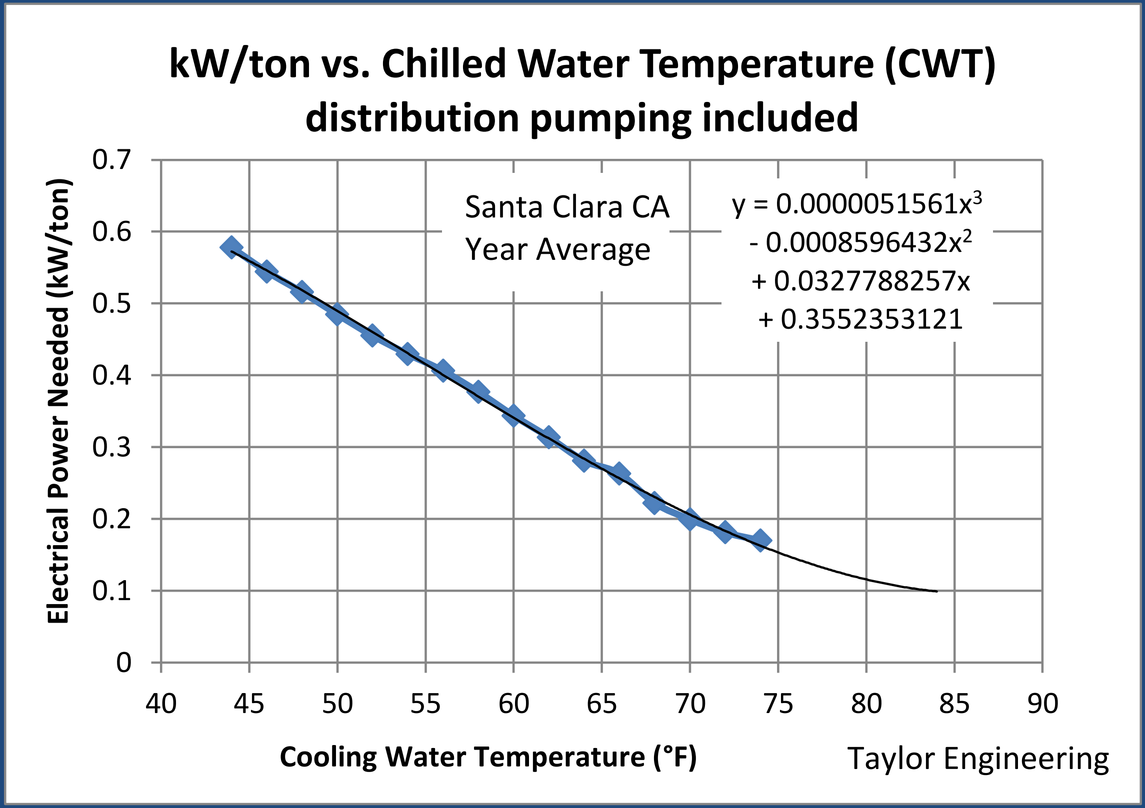


Case 1: Dual Hex Operation Infrastructure Component Contribution
Tower Water Cooling - Chilled Water Cooling Added as Needed
Server = 100 cfm/kW, 72°F Air Inlet Temperature Setpoint
pPUE Component
0.12
0.10
0.08
0.06
0.04
0.02
0.00
28
32
36
40
44
48
52
56
IT Equipment Power (kW)
Total pPUE
Chilled Water
Cooling Added
Cooling Unit Power
Tower Cooling
68F Water
Supply Temp.
Chilled Cooling
45F Water Supply Temp.


pPUE Comparison of 4 Configurations
One or Two Heat Exchangers in Series, Tower and Chilled Water Supply
Servers = 100 cfm/kW, Server Air Inlet = 72°F, Tower Water = 68°F, Chilled Water = 45°F
pPUE Includes Plant Power and Cooling Unit Power Only
pPUE
1.20
1.16
1.12
1.08
1.04
1.00
IT Power (kW)
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
Case 1: Tower Water < = 24 gpm
(two heat exchangers)
Chilled Water Added as Needed
Case 4: Chilled Water Only
(one heat exchanger removed)
Fan Power = 68%
Case 2: Tower Water Only <= 48 gpm
(two heat exchangers)
Case 3: Tower Water Only
(one heat exchanger removed)
Fan Power = 68%
Not able to
meet
72°F
Set Point

Plant Model

kW / ton vs. supplied water temperature

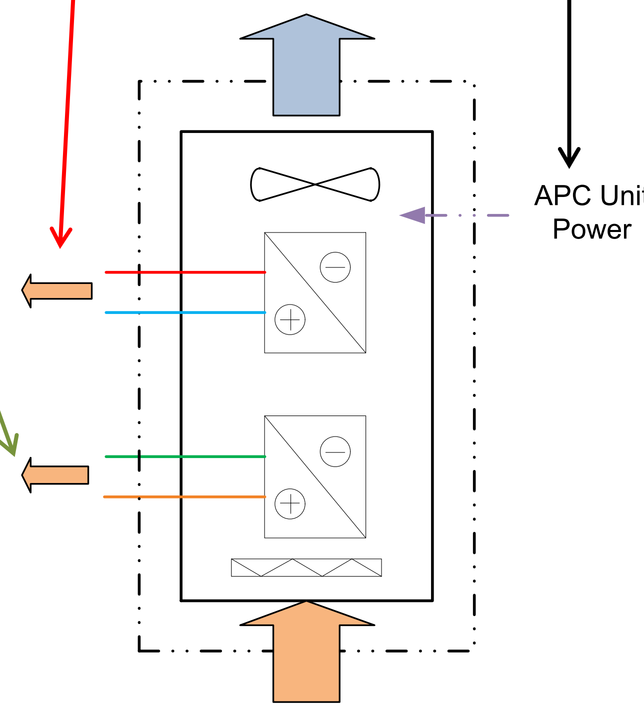


COP Metric Definition

COP [$kW_{thermal}$ / $kW_{elec.}$] = cooling provided / power needed

cooling provided (kW) = treated water cooling + chilled water cooling – APC Unit Power

power needed (kW) = (kW/ton * tons) + (kW/ton * tons) + APC Unit Power



~~pCOP?~~ using PUE and pPUE