Mixing water and electricity; finding the energy balance between boilers, chillers, and pumps in hydronic systems.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

1. Describe the energy flows in boilers, chillers, and cooling towers
2. Recognize the opportunity to improve energy performance in hydronic systems
3. Explain the trade-off between boiler, chiller, pump, and cooling tower energy consumption
4. Calculate the energy and dollar cost savings of making adjustments to the system

Why we're here

Pumps

V1 *(n2/n1) = V2

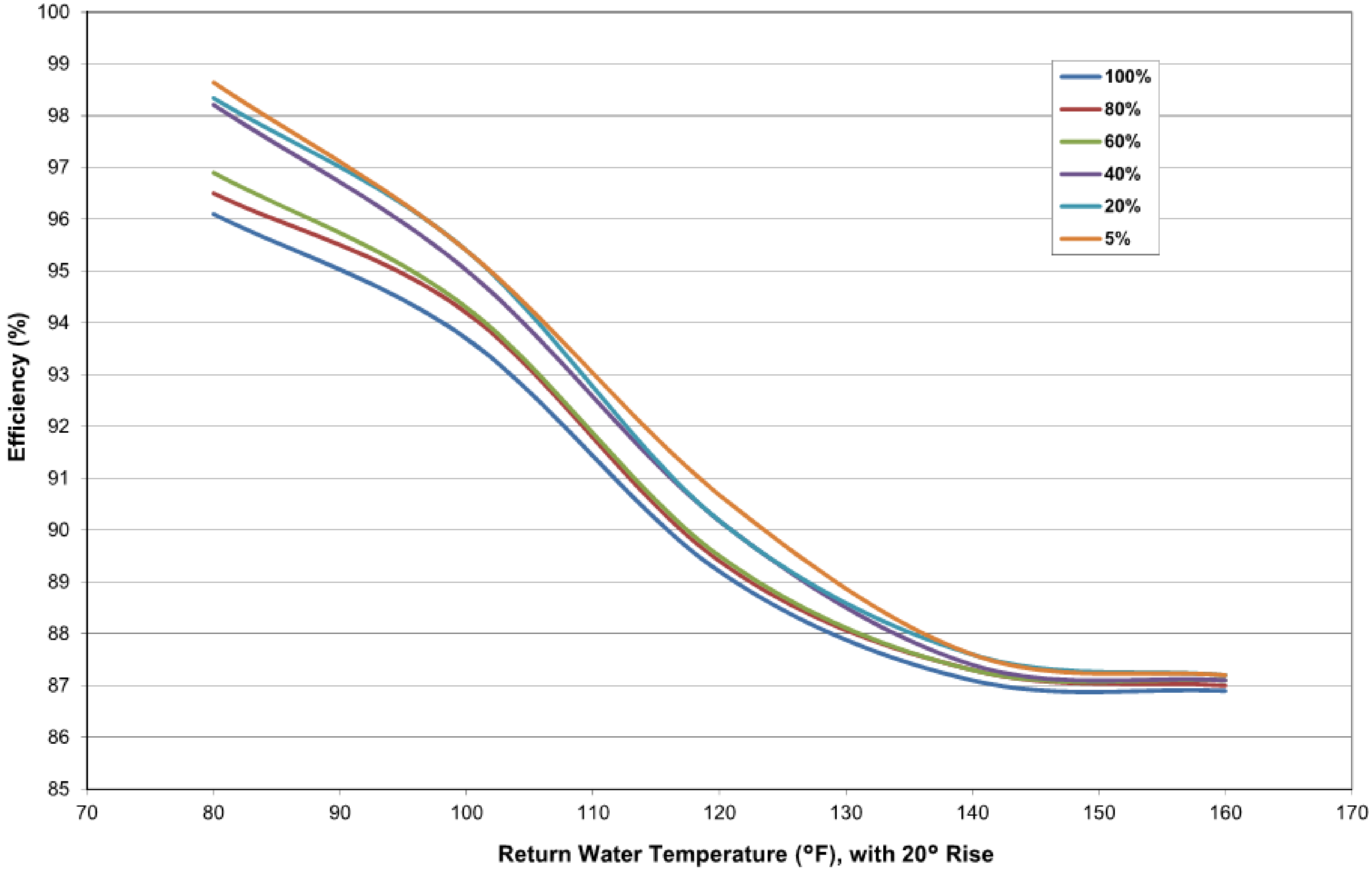
H1*(n2/n1)^2 = H2

P1*(n2/n1)^3 = P2

Where V = flow (GPM), H = head (psi),
and P = power (watts)

Pump kWh = pump hp*0.746*hours of operation

Boilers



100%
80%
60%
40%
20%
5%
Efficiency (%)
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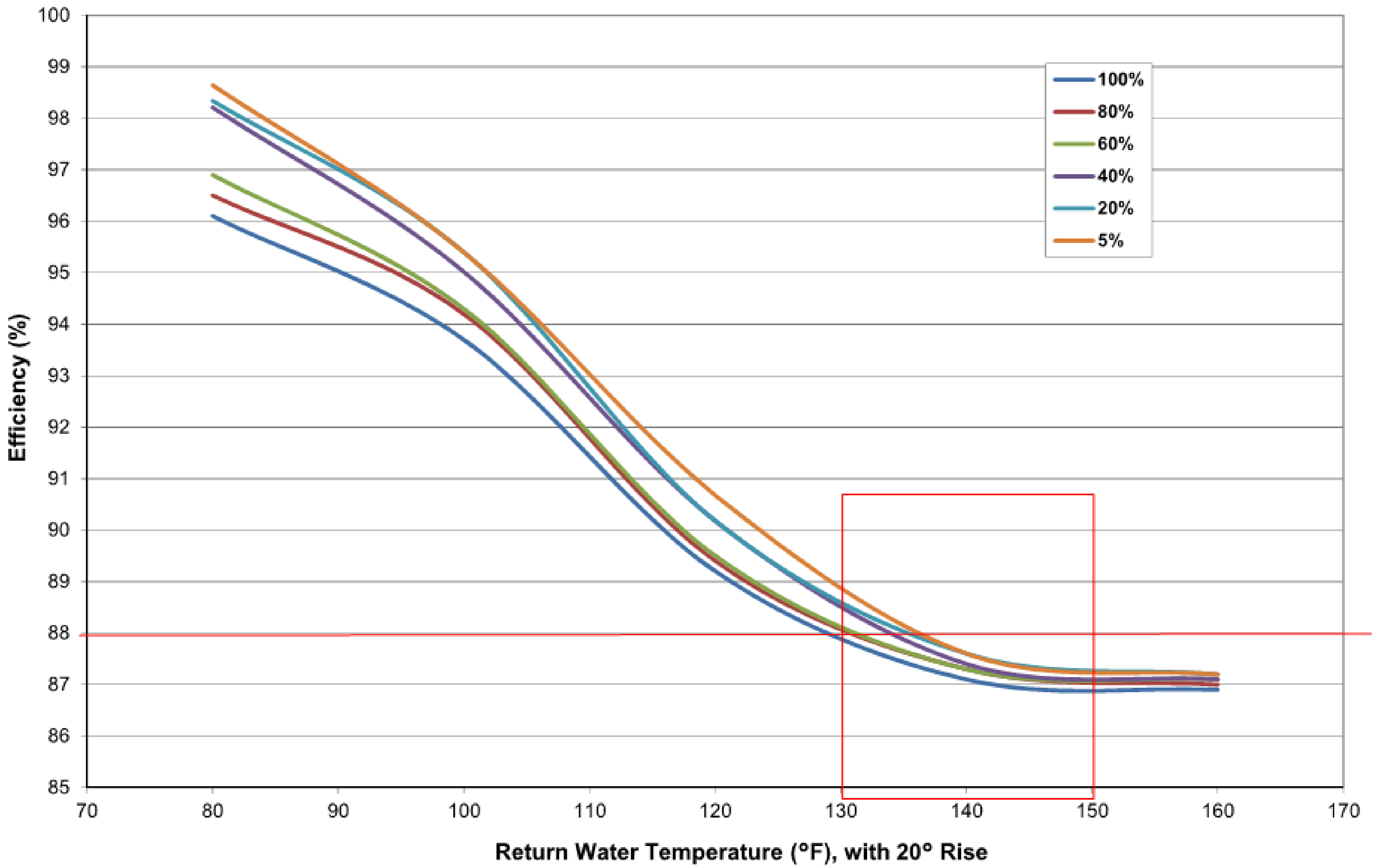
Return Water Temperature (°F), with 20° Rise

Boilers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Return Water Temperature (°F), with 20° Rise
100%
80%
60%
40%
20%
5%

Heat transfer air to water at a coil

Q = Btu/hr or BTUH

Q = 1.08*CFM*delta T for air

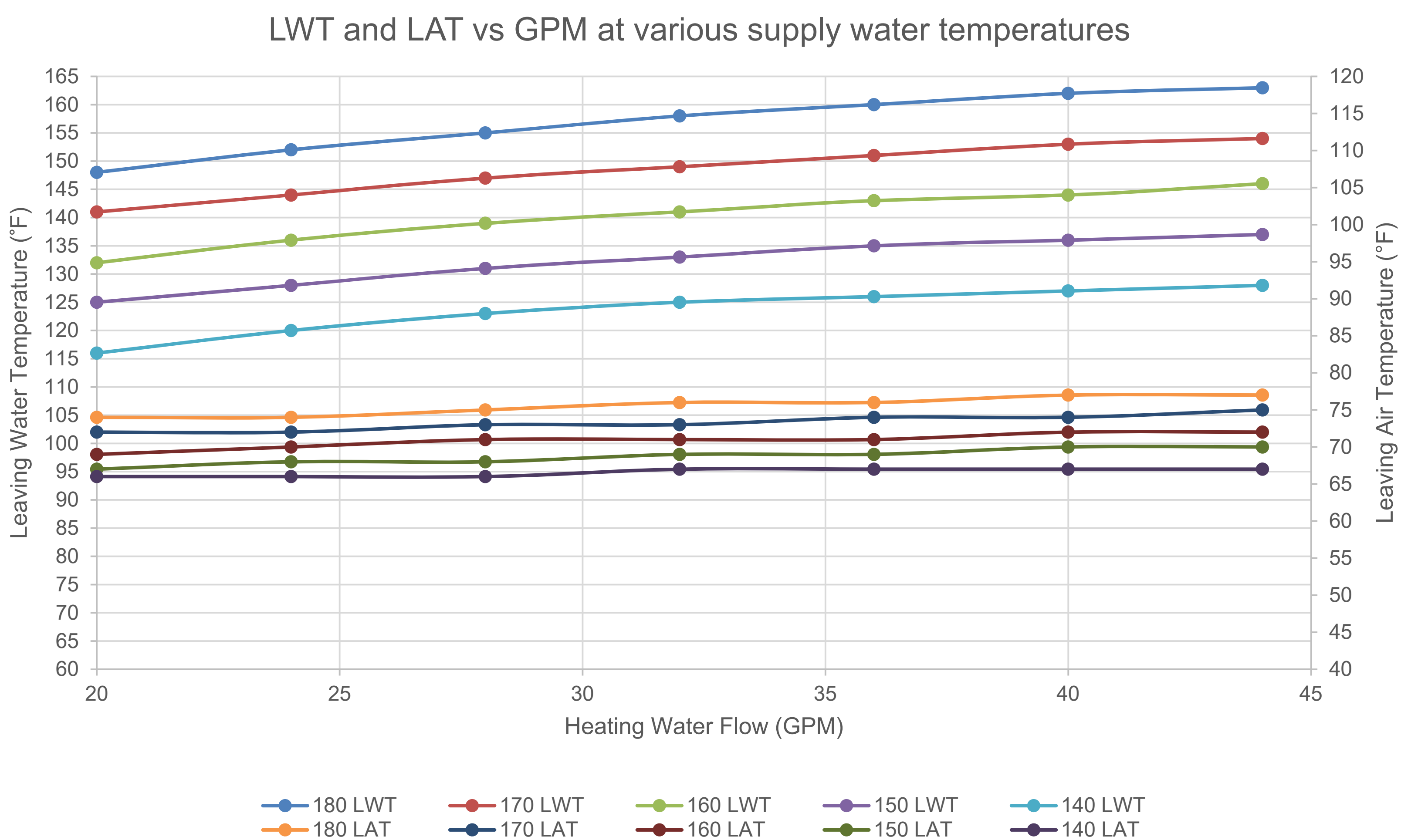
Q = 500*GPM*delta T for water

Assuming a 20 degree delta T for each (45-65 ˚F air, 180-160 ˚F water), then each gallon is worth about 463 CFM. If you have a 10,000 CFM AHU, then you're looking at 22 GPM.

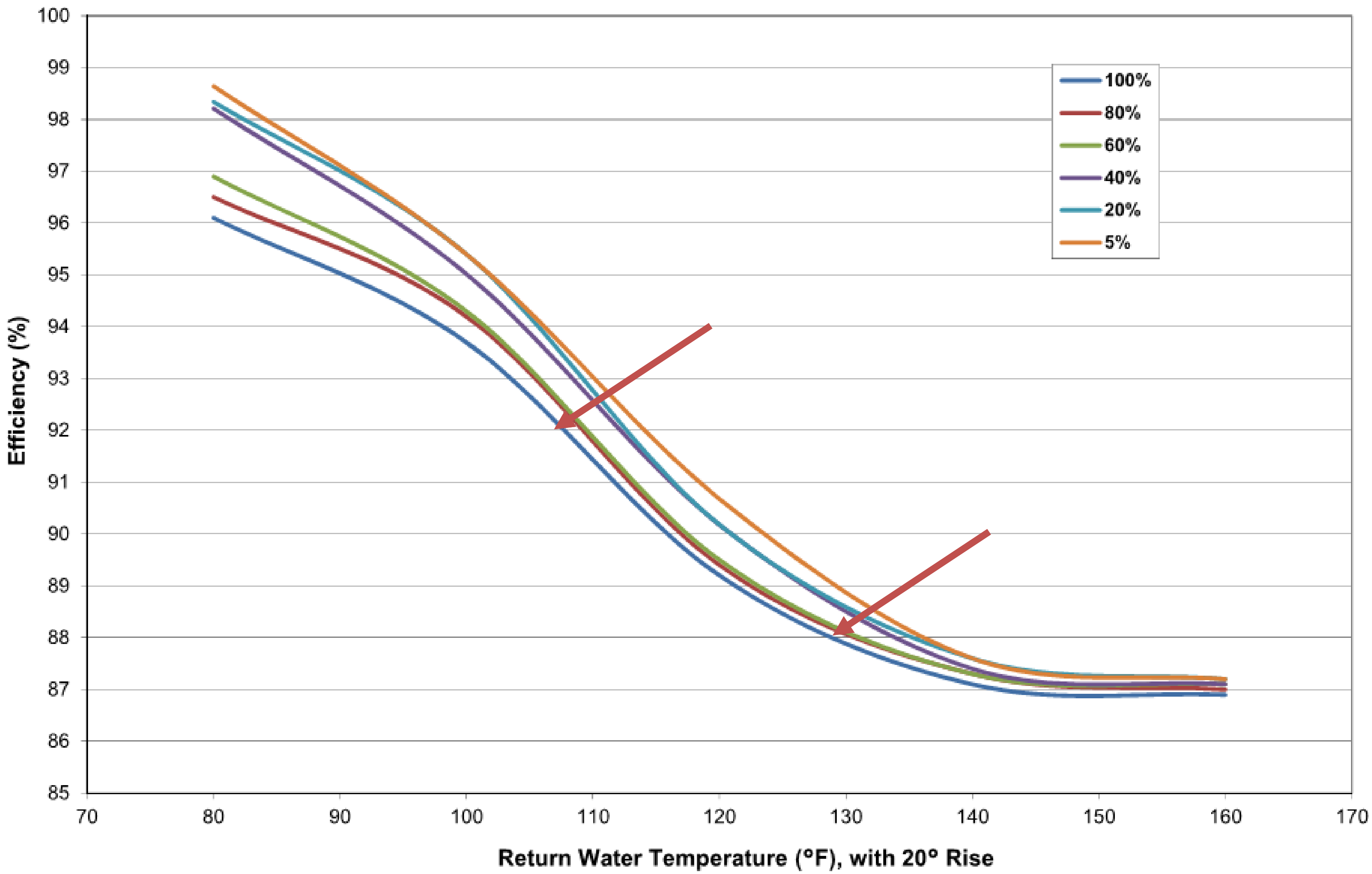
1.08*10000*20 = 216,000 BTUH

216000/(500*20) = 21.6 GPM

Coil Performance



Boilers



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Return Water Temperature (°F), with 20° Rise
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Boiler

MBH*Eff%*$/therm*10 = cost of operation

For a 2MMBH boiler operating at 88% efficiency for 2000 hours a year paying $0.90/therm, the cost of operation would be $40,000/year. Increasing the efficiency to 92% would cost $38,298, saving $1,702 per year.

Achieving an increase of 4% in efficiency would be like going from 135 to 110 degrees entering water temperature.

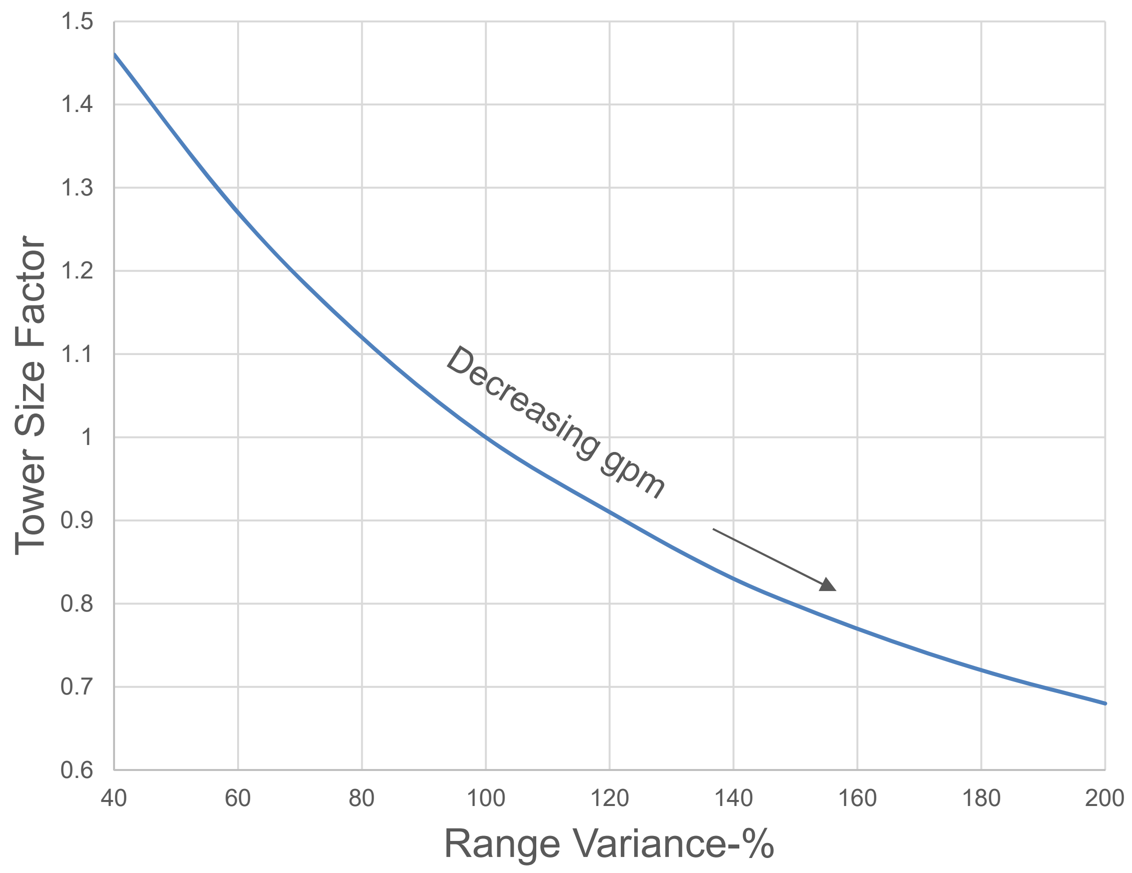
Cooling Towers

Approach – difference between leaving water temperature and entering wet bulb temperature. In other words, how close can the tower get to the ambient wet bulb temperature.

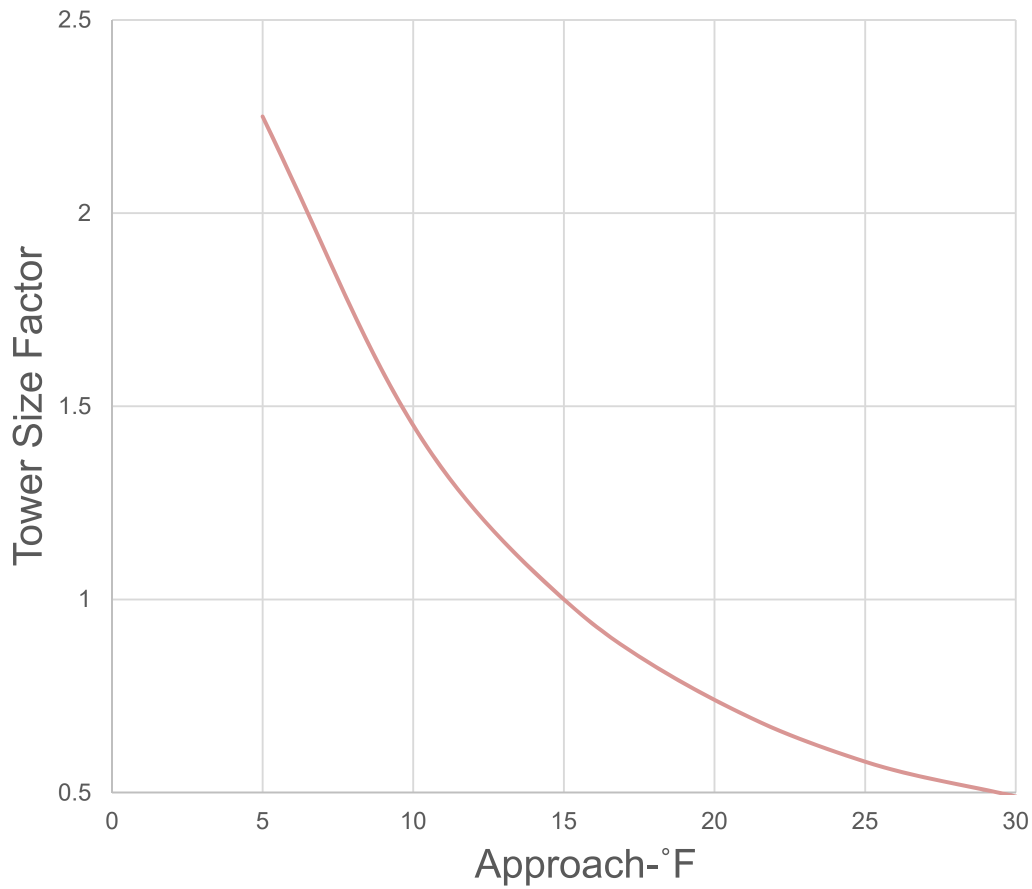
Range – water delta-t

Temp and flow determined by process

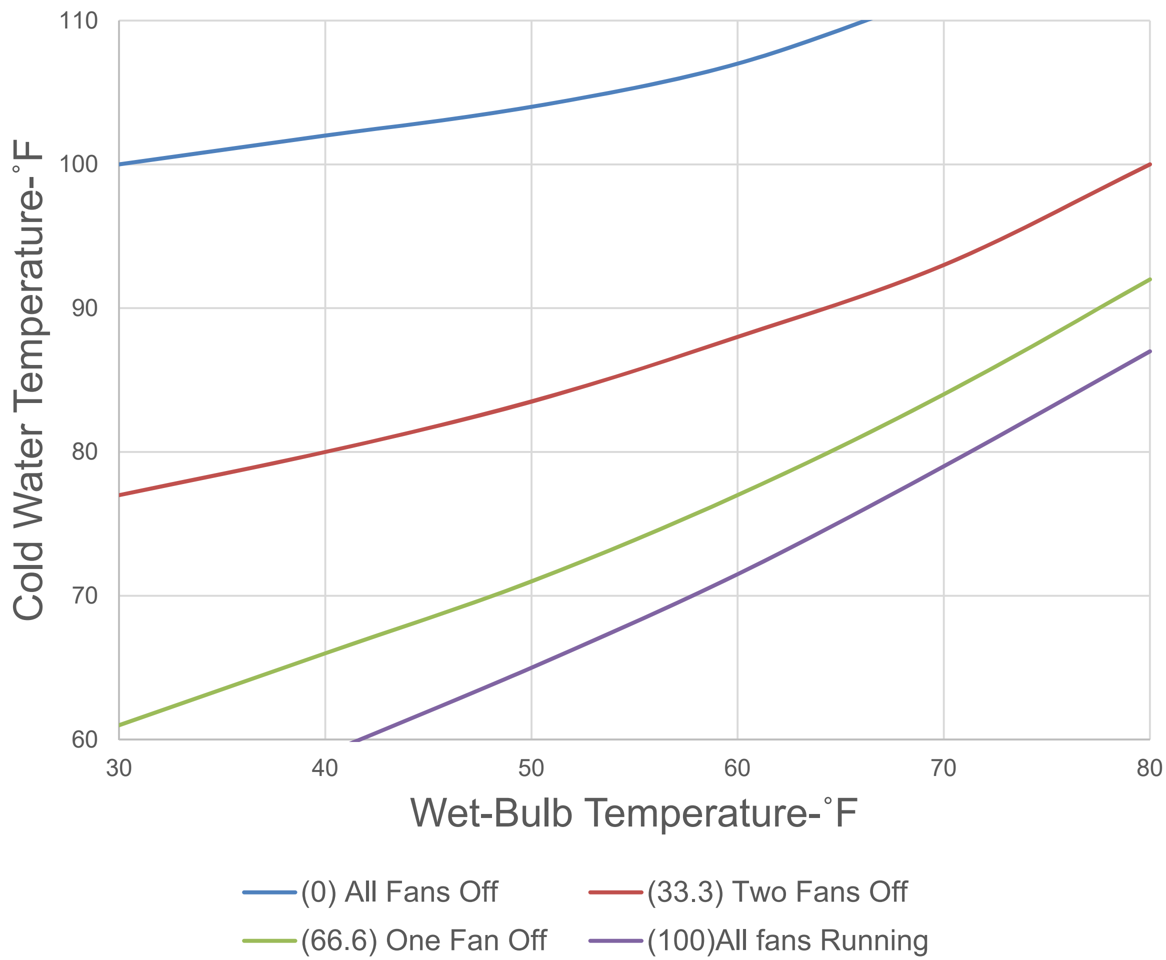
Effect of range on tower size



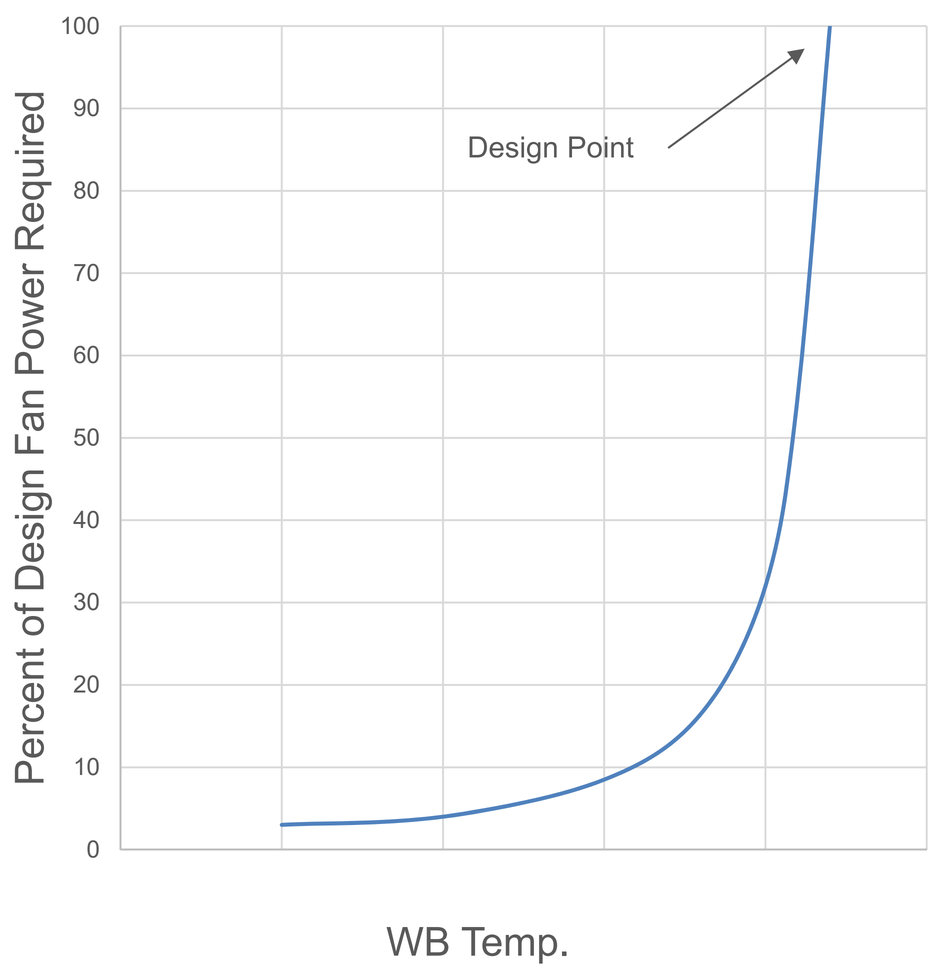
Effect of approach on tower size



Modulating Cooling Tower Fans



Fan Power versus Wet Bulb Temperature



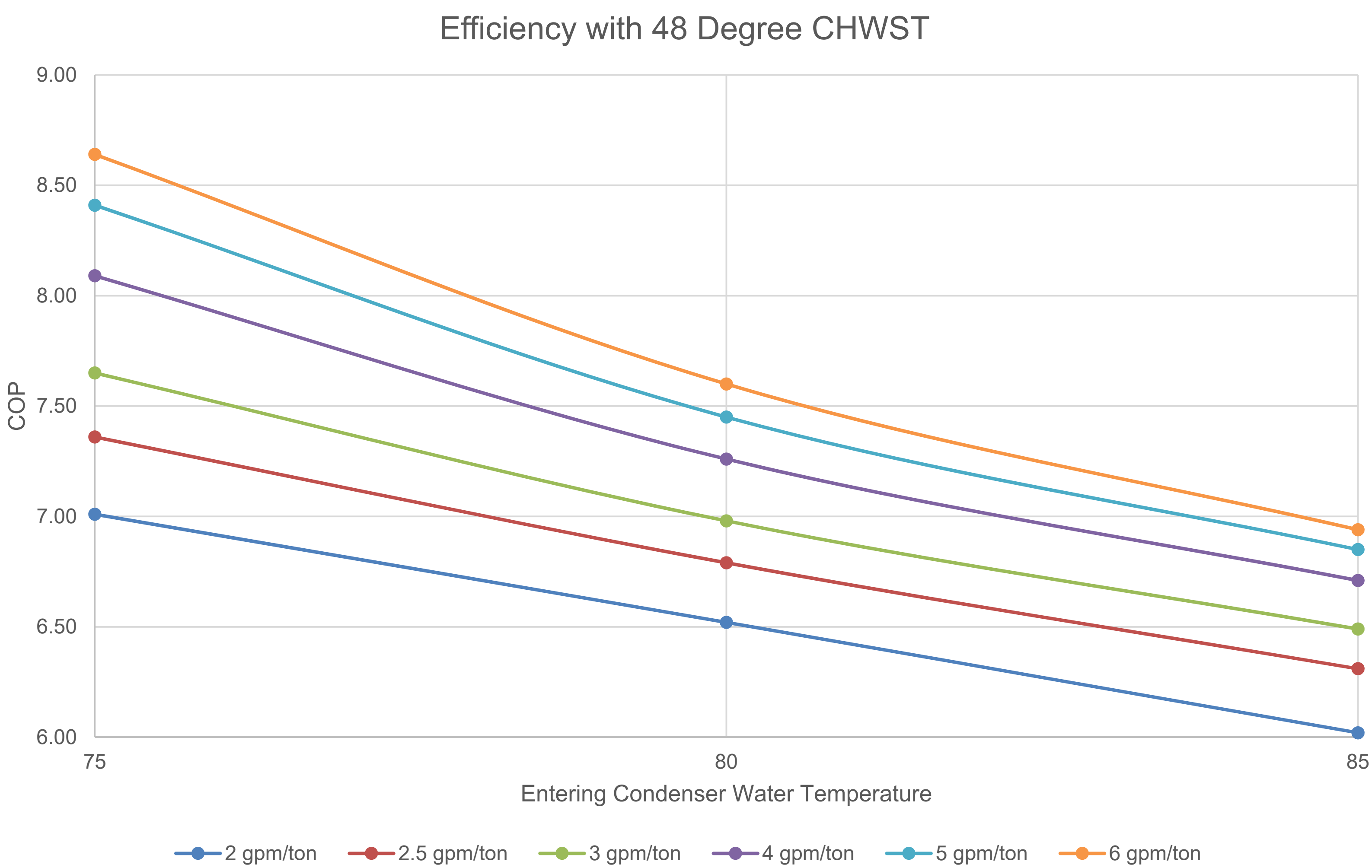
Chilled Water Systems

Chilled water supply temperature set point

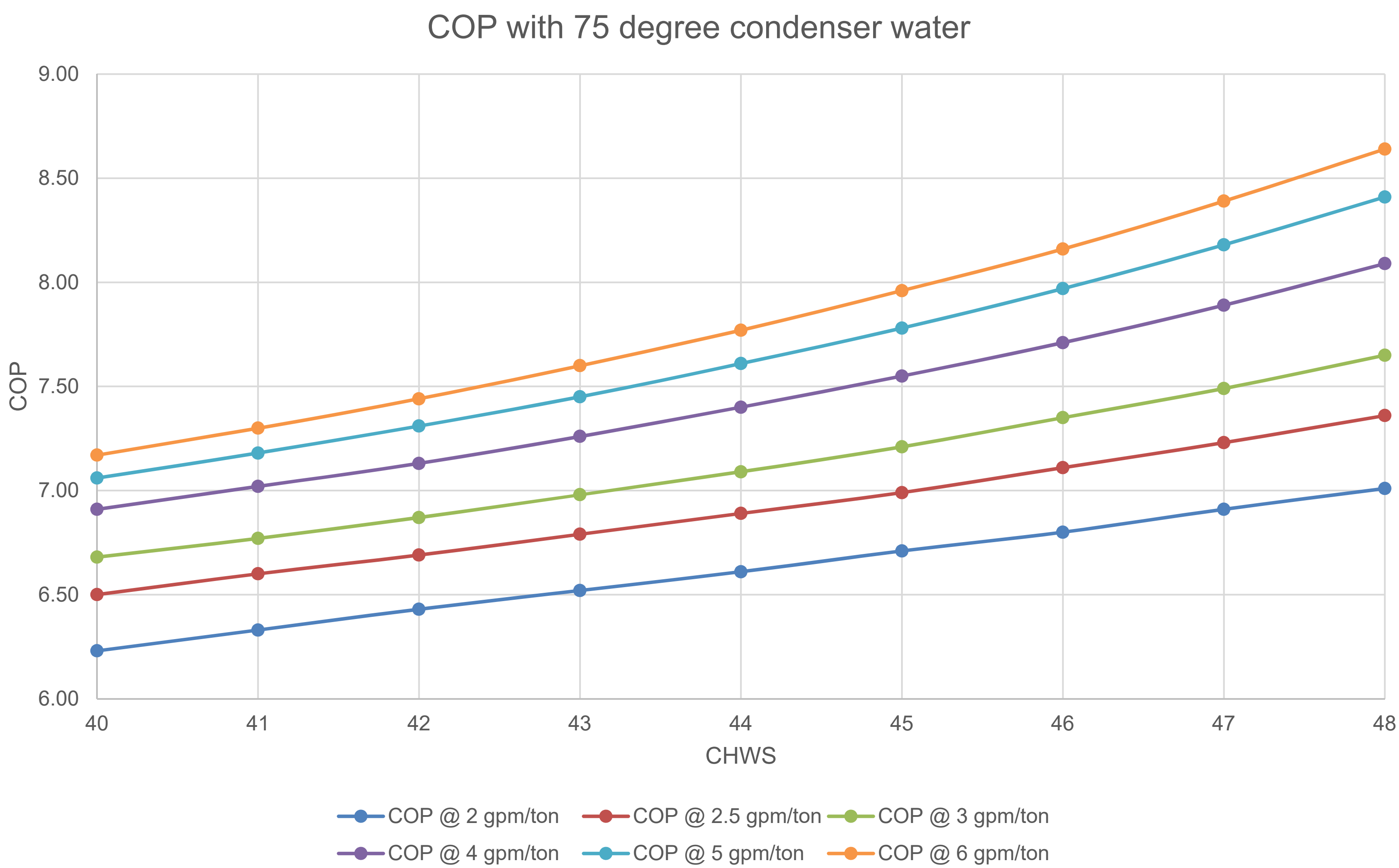
Lift

Condenser water temperature set point and effects on chiller operation

Effect of Condenser Water Temperature



Effect of Chilled Water Temperature Set Point



Energy Savings Calculations

Kw

Hp

Time (hours)

Assume $0.09/kwh

Not considering demand charges

COP = (1 ton * 12,000 btu/ton)/(0.8kW/ton x 3412 btu/kw) = 4.4

Condenser Water Pumping

Does increasing the gpm of condenser water to improve chiller COP outweigh the cost of running more pump?

Condenser water system (300 ton chiller)

Pumps

- 2 gpm/ton
- 600 gpm
- Hp*.746*hours = kw
- $1,657

- 6 gpm/ton
- 1800 gpm (30 HP)
- 27 times as much electricity
- $44,760
- **$43,103 increase in cost**

Condenser Water System

Chiller

- COP 6.6
- 0.53 kW/ton
- 159 kw
- $318,000/yr

- COP 7.7
- 0.45 kW/ton
- 135 kw
- $270,000/yr
- **$48,000/yr savings**

Reality

- The system delta T is much lower than design
- Optimize the delta Ts on the coils
  - Coil water flow
- More water is not always better
  - Over/under flow of systems
- The temperature is what matters
- Monitor the results

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