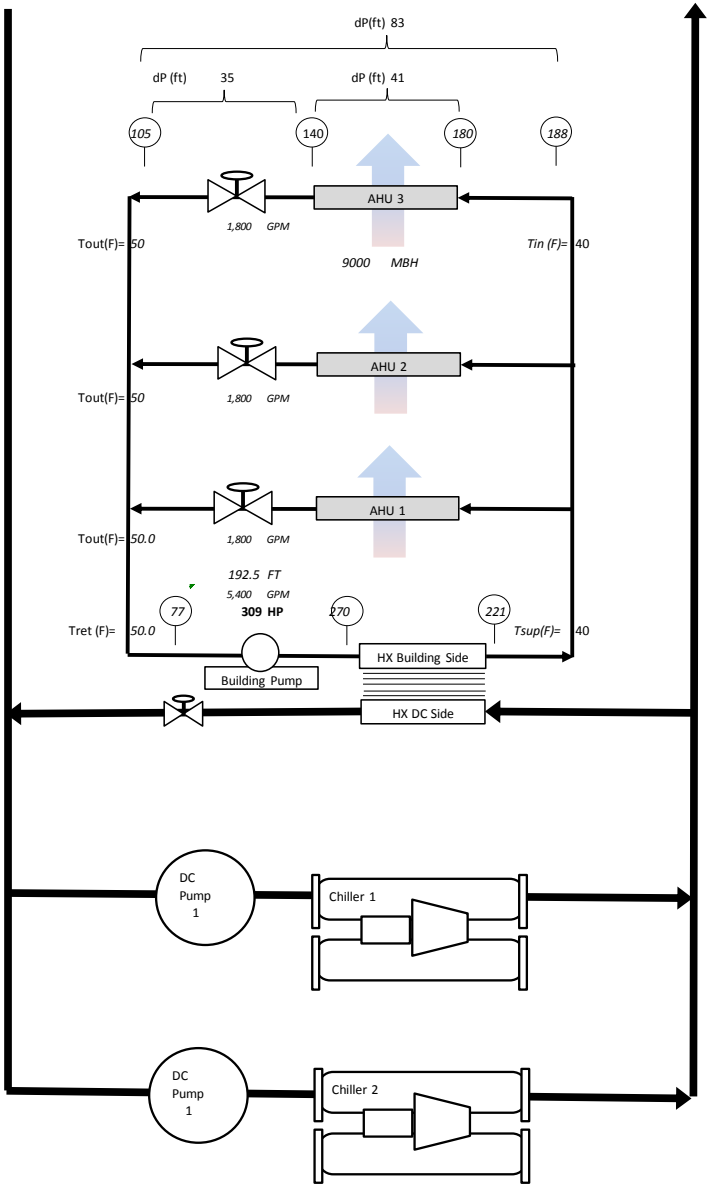
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Managing Delta T in Buildings



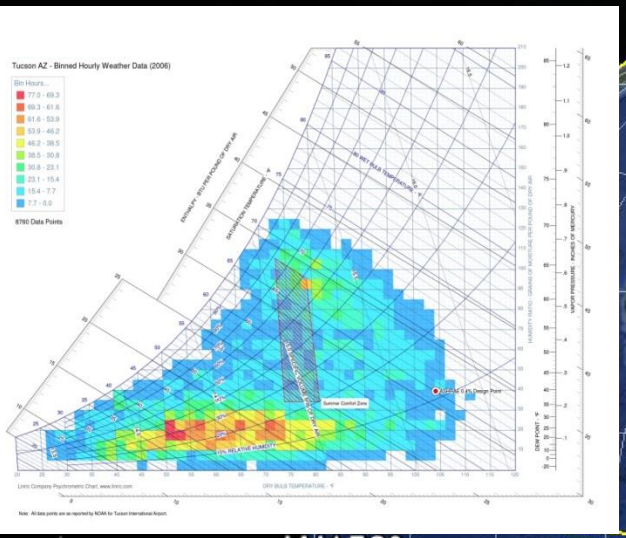
Presented By:

Henry W. Johnstone, P.E.

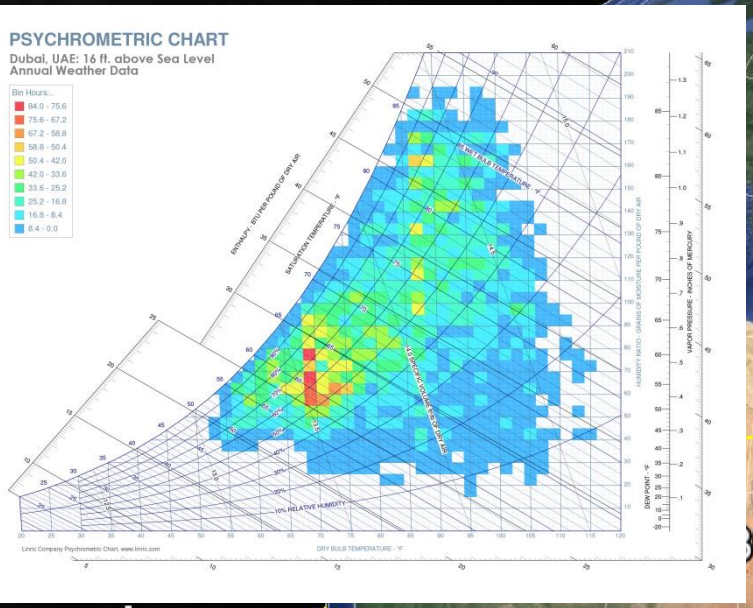
President and Director of Mechanical Engineering

GLHN Architects & Engineers, Inc.

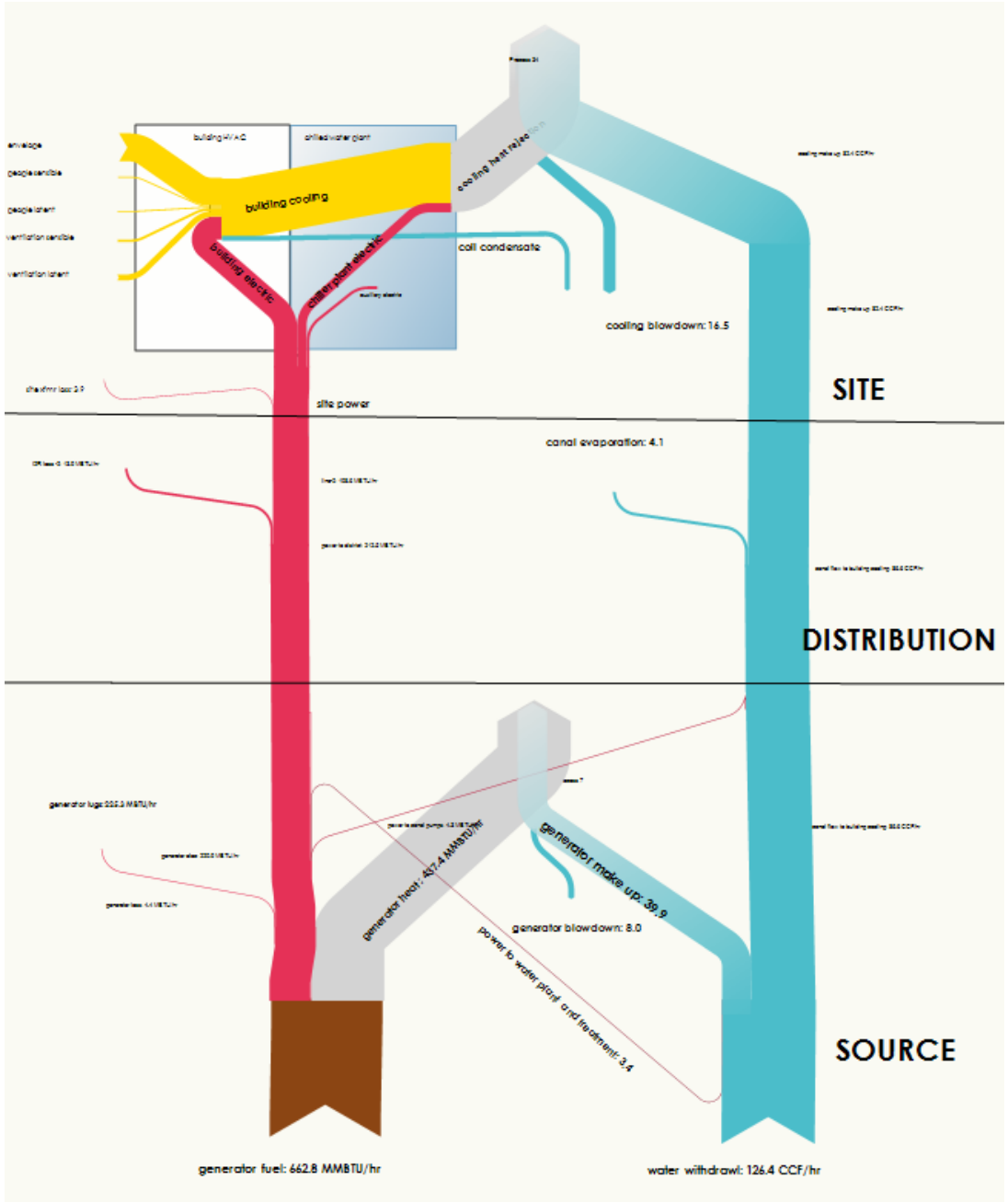
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Water Cooled Air Conditioning

COP 7
0.6 kW/Ton

2.25Gal/Tonhr @ 5 Cycle

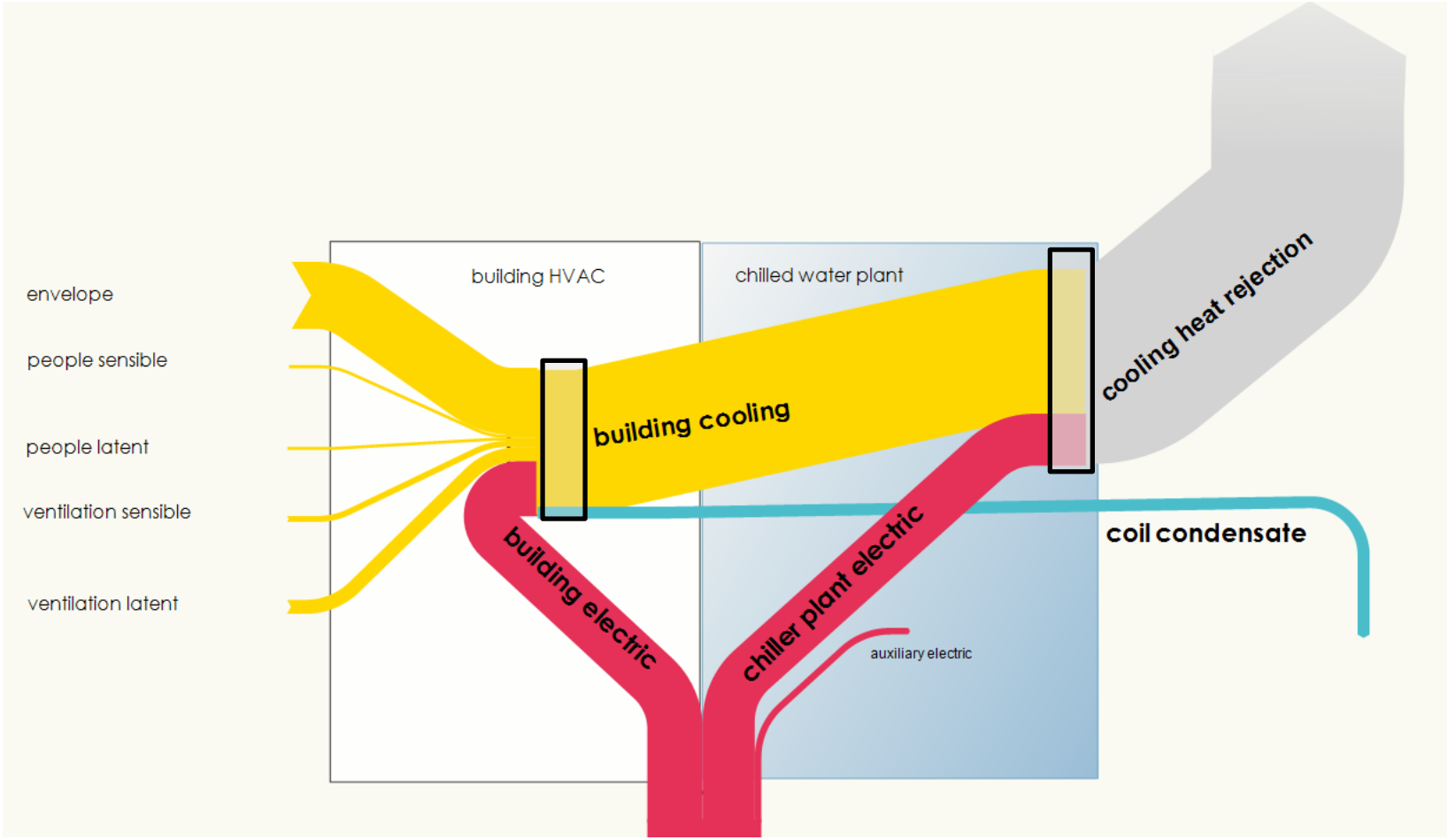
Steam cycle -450 Gal/MWH
Combined cycle -250 Gal/MWH

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Building Cooling Load

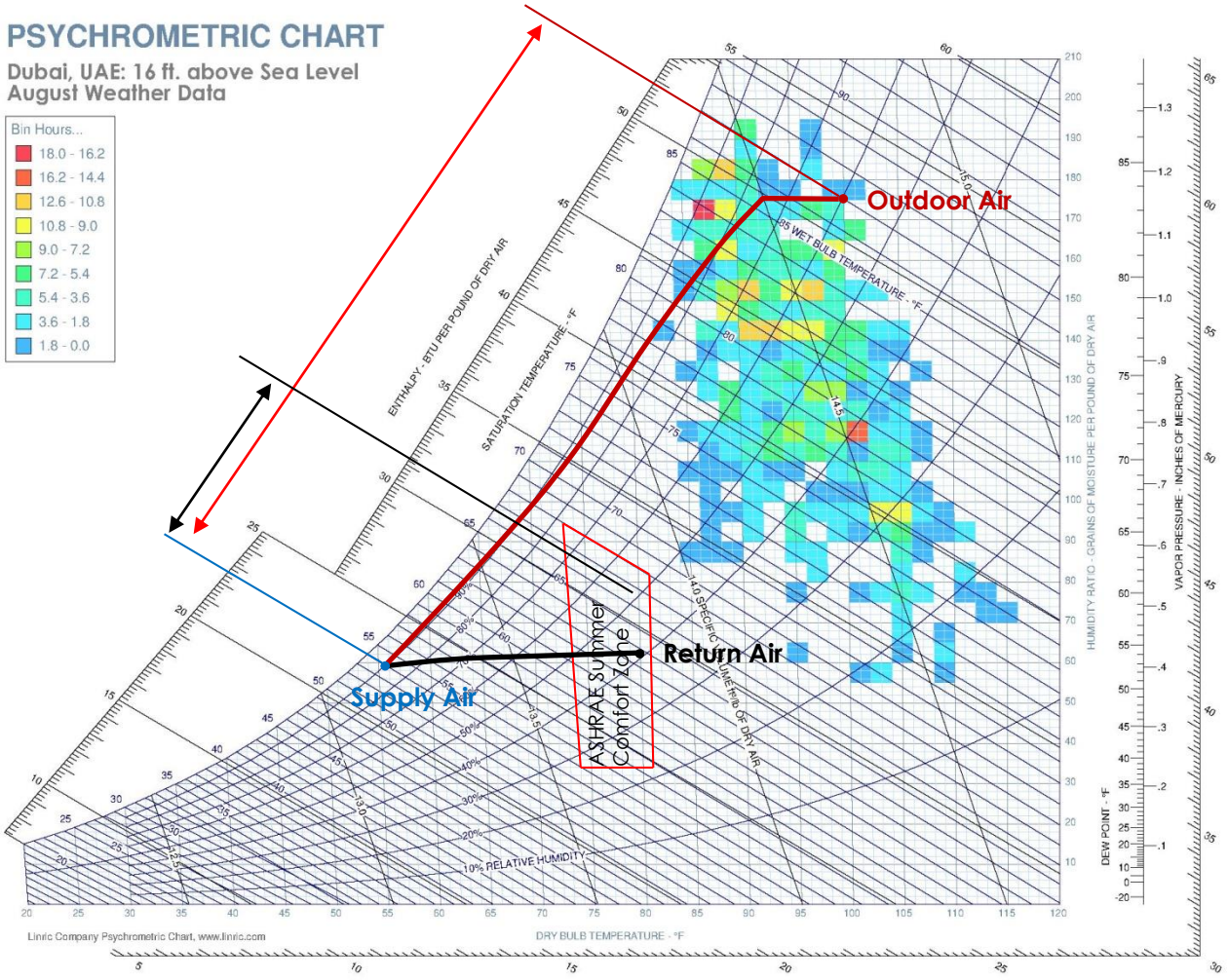
Q_h

Q_c



W

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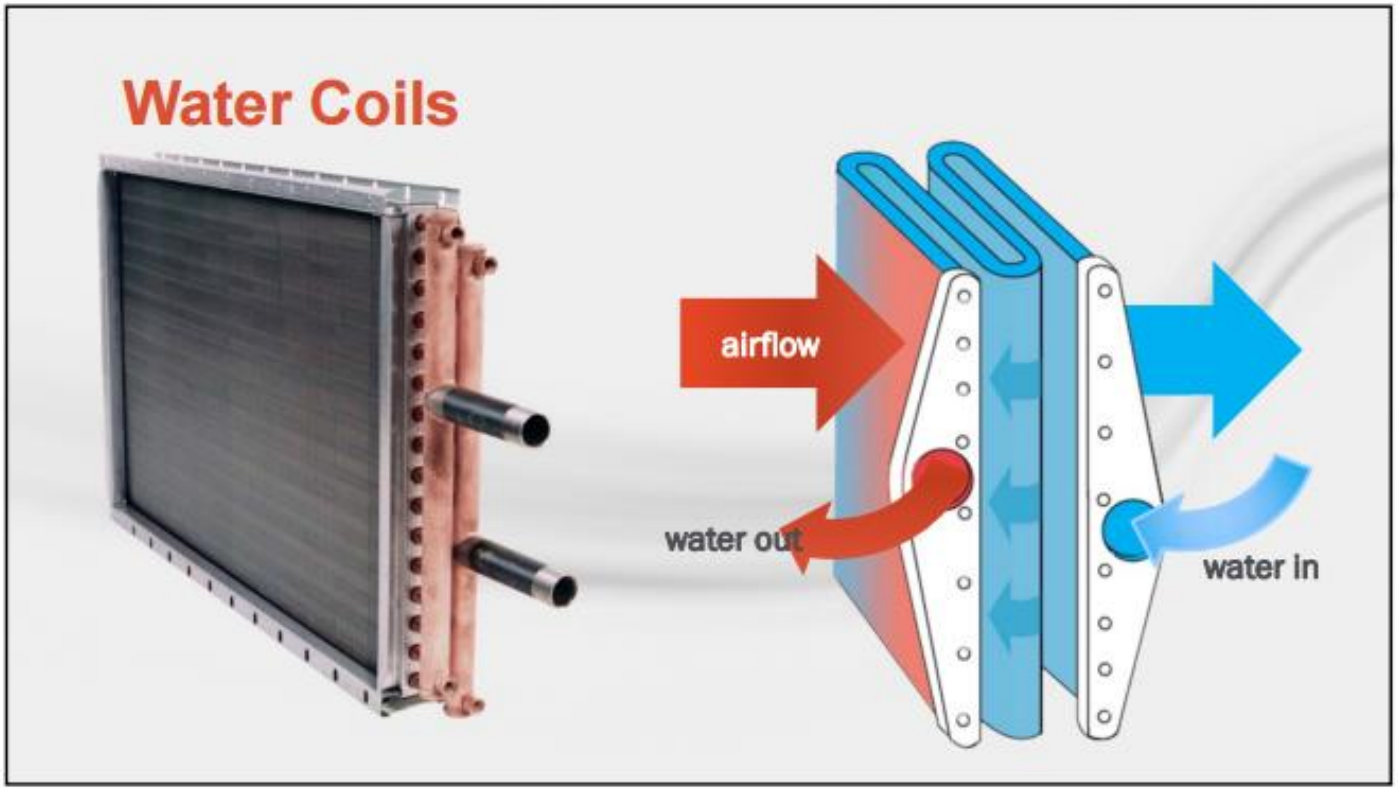


Air Type	Dry Bulb (°F)	Wet Bulb (°F)	Humidity Ratio (gr/lb)	Enthalpy btu/lb	Air Flow (cfm)	Energy Content (MBtu/hr)	Moisture Content (gal/hr)
Outside	100.00	83.94	163.08	39.84	8,500	1,354	41
Return	80.00	67.00	97.00	29.84	8,500	1,084	12
Supply	55.00	54.00	60.81	22.60	8,500	842	2
Total Cooling			10,000	Difference (Coil Cooling)		183	14

Air Type | Dry Bulb (°F) | Wet Bulb (°F) | Humidity Ratio (gr/lb) | Enthalpy btu/lb | Air Flow (cfm) | Energy Content (MBtu/hr) | Moisture Content (gal/hr)
Outside | 100.00 | 83.94 | 163.08 | 39.84 | 8,500 | 1,354 | 41
Return | 80.00 | 67.00 | 97.00 | 29.84 | 8,500 | 1,084 | 12
Supply | 55.00 | 54.00 | 60.81 | 22.60 | 8,500 | 842 | 2
Total Cooling | | | 10,000 | Difference (Coil Cooling) | | 183 | 14

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The Coil Story



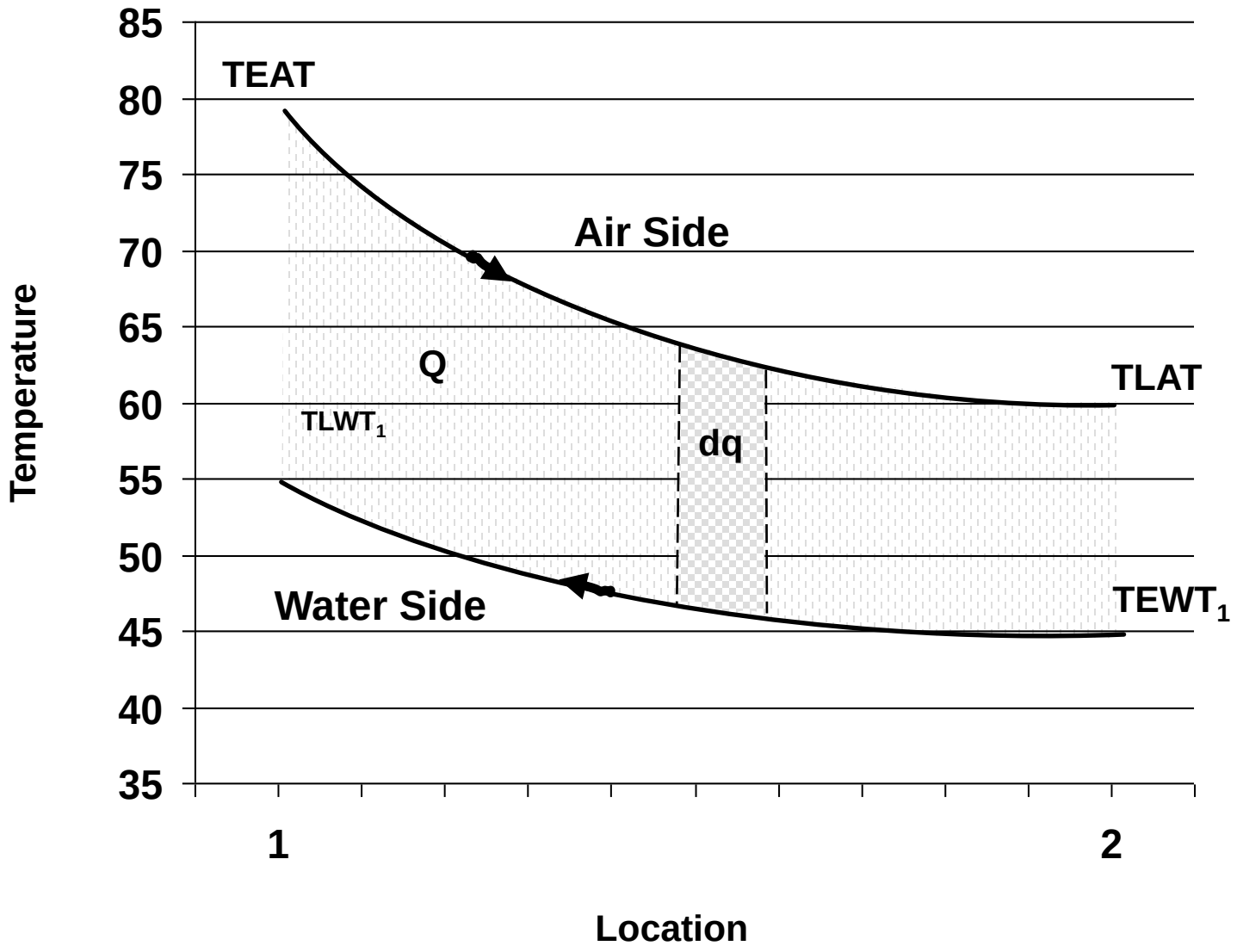
Cooling Coil

q (heat exchanged) = m (mass flow) Cp (specific heat) dT (log mean)

load (BTUH) = 500 x flow (gpm) x Dt WTR (°F) on the water side
and
load (BTUH) = 1.08 x flow (CFM) x dT AIR (°F) on the air side

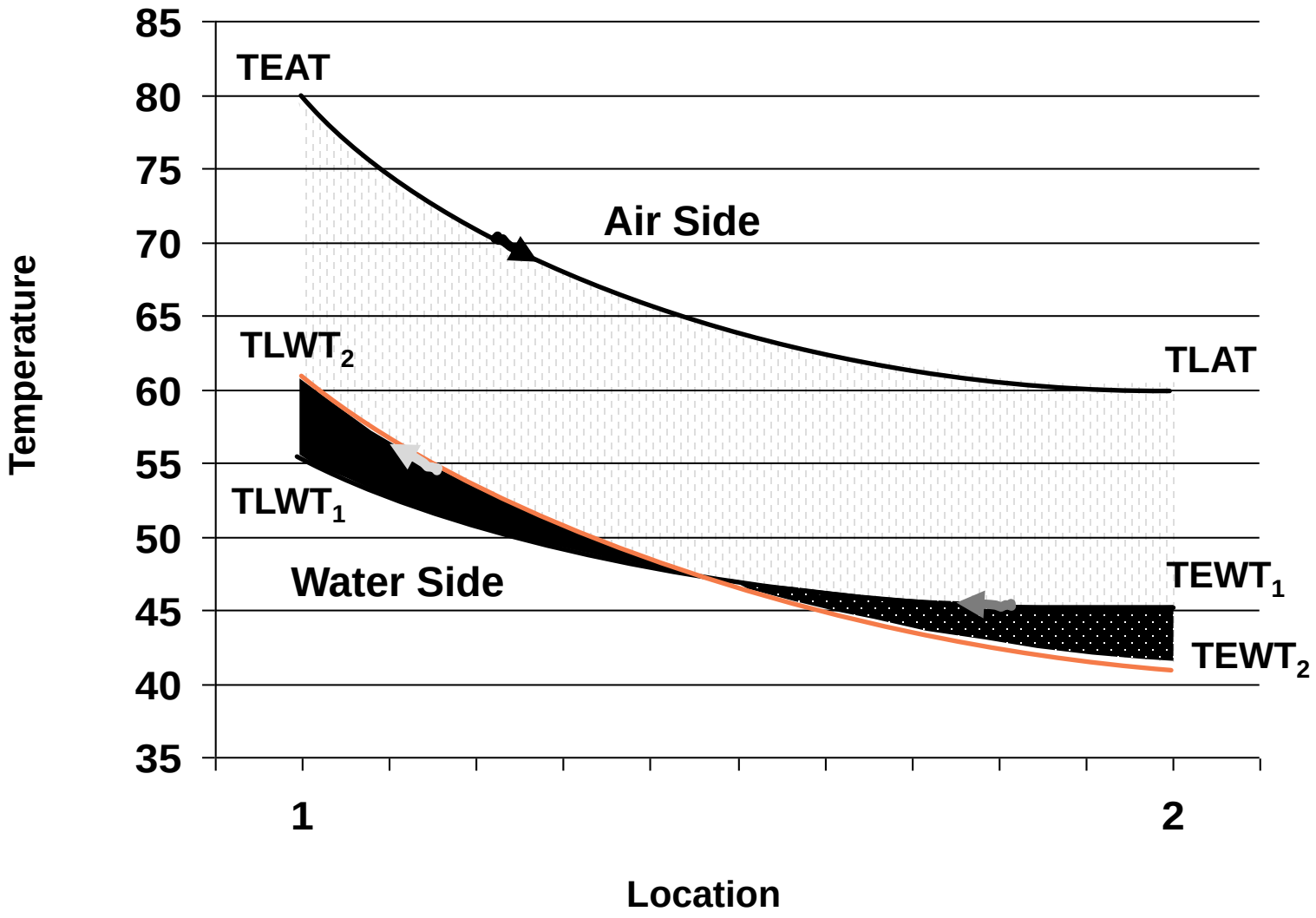
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The Coil Story



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The Coil Story

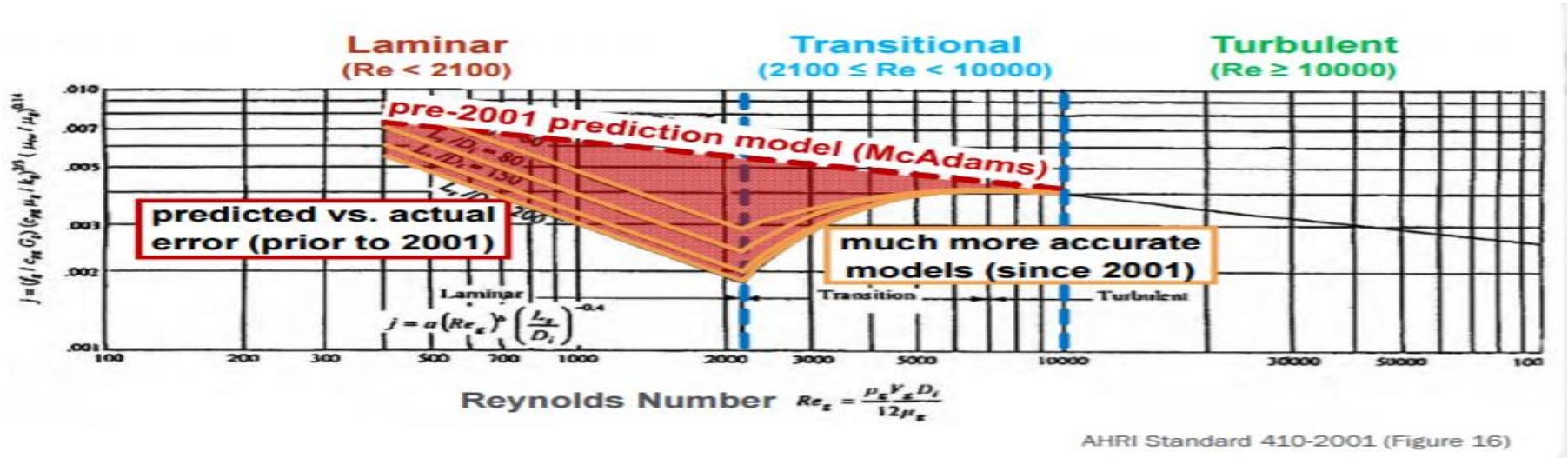


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The Coil Story

That Simple?

- Dehumidification- Dewpoint
- Airside Velocity- Wetability
- Materials, Fin Configuration, Circuiting
- Fouling
- Water Velocity- Flow Regime - Turbulators

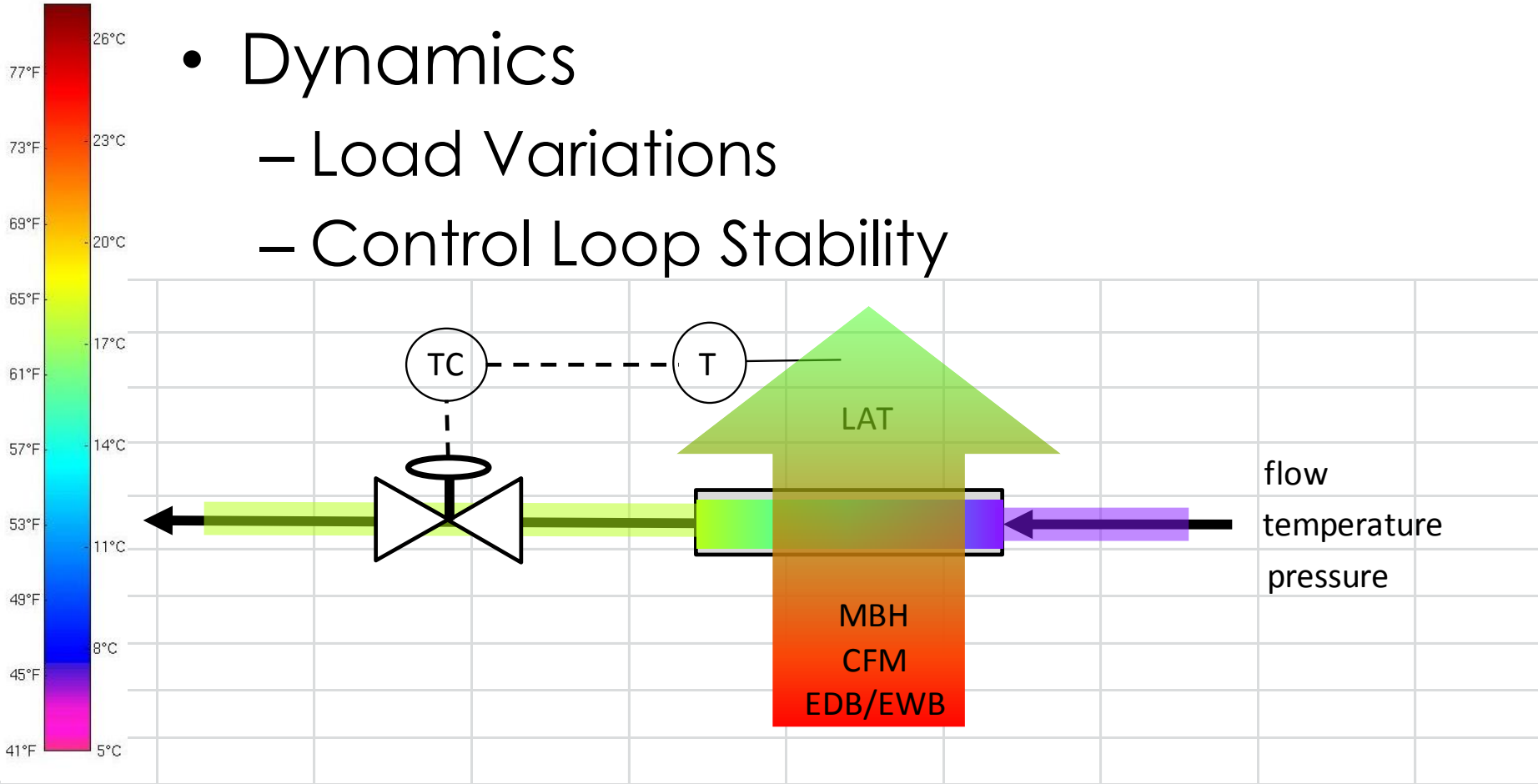


AHRI Standard 410-2001 (Figure 16)

The Coil Story

That Simple?

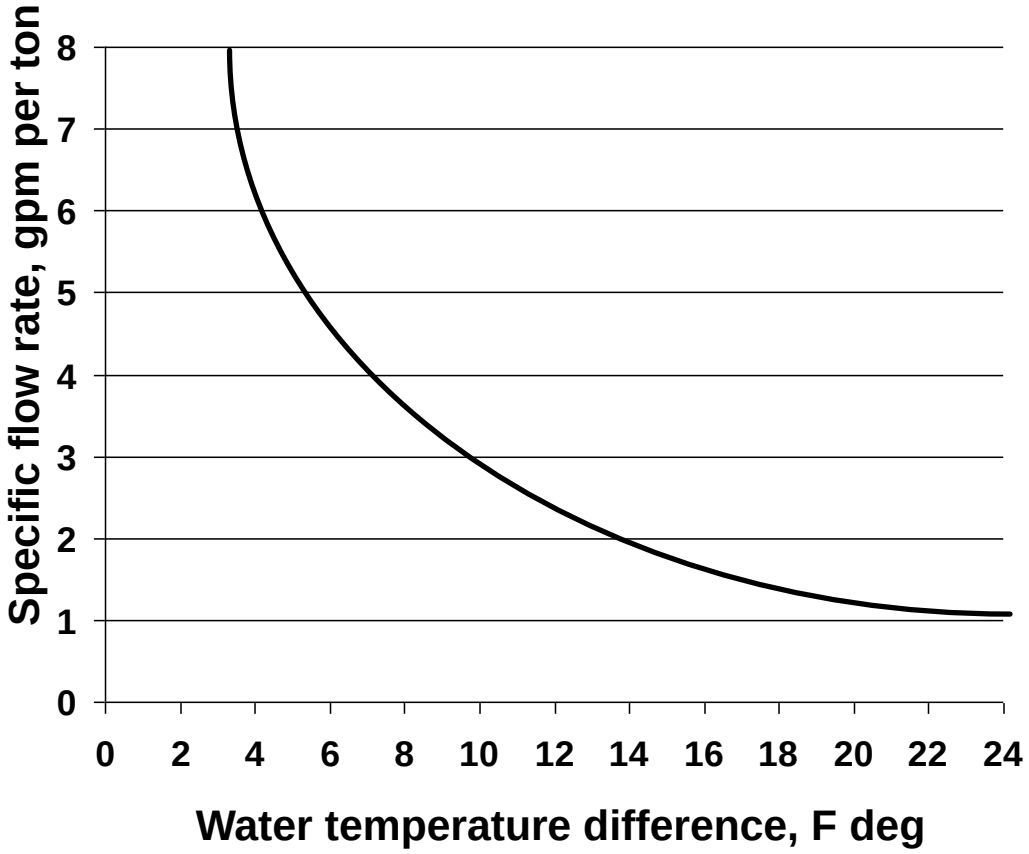
- Dynamics
  - Load Variations
  - Control Loop Stability



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The Coil Story

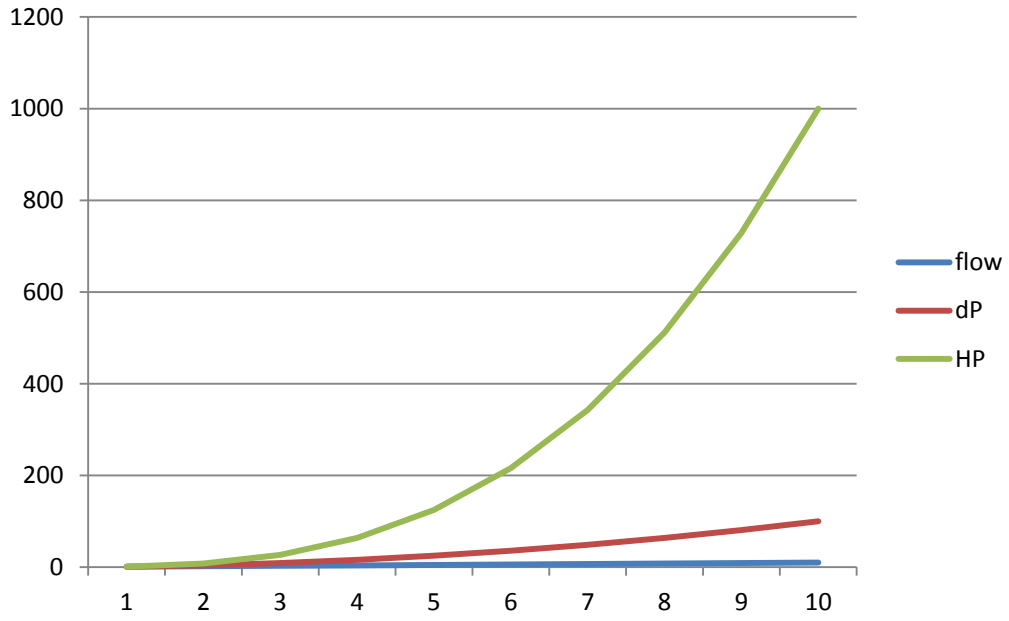
Flow Rate as a Function of Water Temperature Difference (dT)



$$\frac{Q(gpm)}{Load\ (Tons)} = \frac{24}{dt(^{o}F)}$$

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The Coil Story



Distribution System

$$h_L = f \frac{L}{D} \frac{V^2}{2}$$

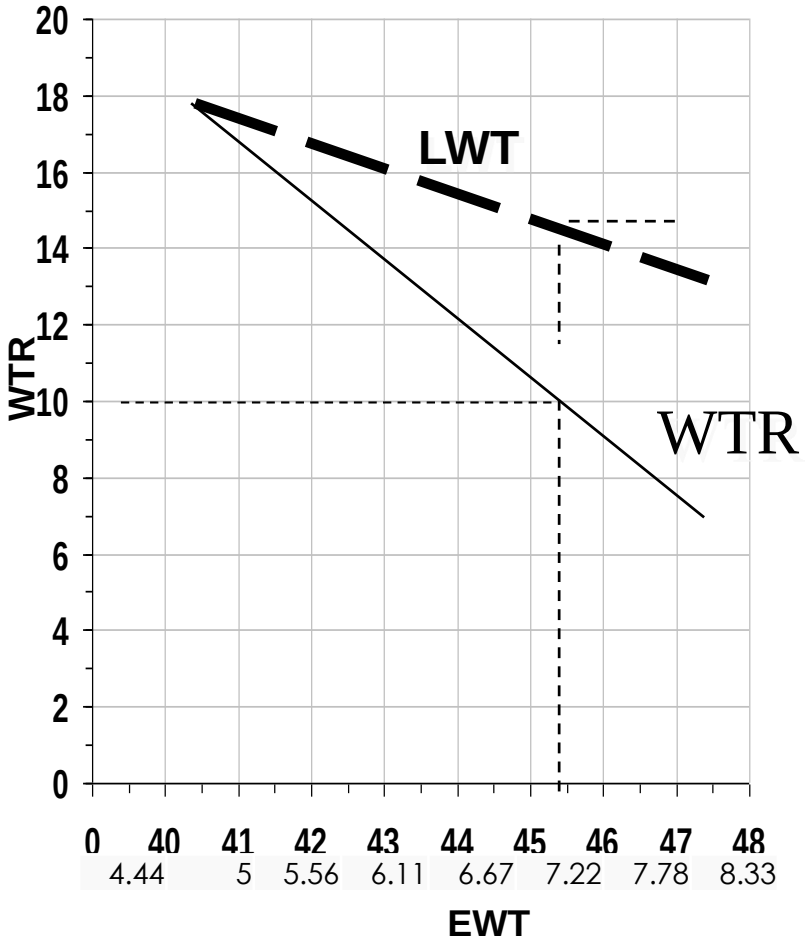
$$\text{Pump Work (hp)} = \frac{\text{Head (ft) x flow (gpm)}}{3960 \times \text{eff}}$$

OR

$$\text{Pump Work} = k\,(\text{flow})^3$$

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The Coil Story

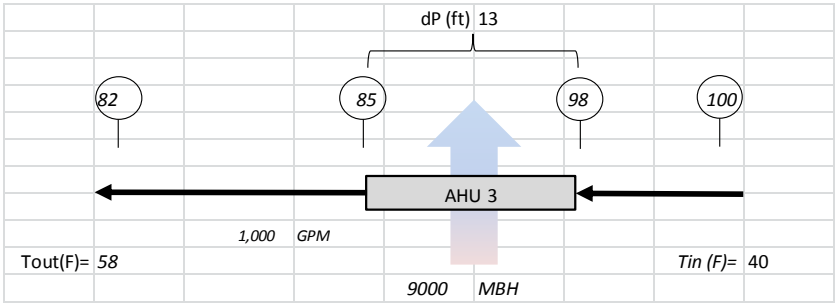


EWT	WRT	LWT	Flow	MBH
40	18.1	58.1	120	1089
41	16.6	57.6	132	1089
42	15.0	57.0	146	1089
43	13.4	56.4	163	1089
44	11.7	55.7	186	1089
45	10.0	55.0	218	1089
46	8.3	54.3	263	1089
47	6.5	53.5	336	1089

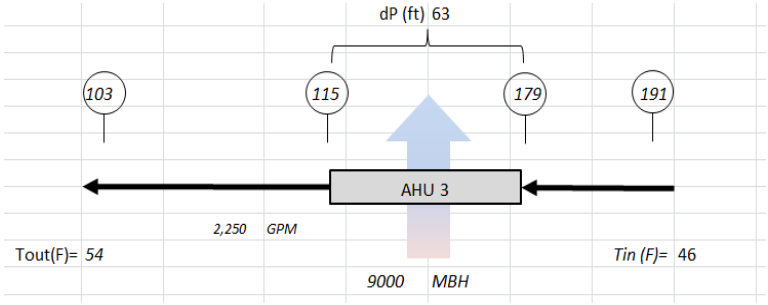
EDB/EWB =
85/67
ACFM = 30,000

EWT	dT	LWT	Flow	TR
4.44	10.06	14.50	1902	90.8
5.00	9.22	14.22	2092	90.8
5.56	8.33	13.89	2314	90.8
6.11	7.44	13.56	2584	90.8
6.67	6.50	13.17	2948	90.8
7.22	5.56	12.78	3455	90.8
7.78	4.61	12.39	4169	90.8
8.33	3.61	11.94	5326	90.8

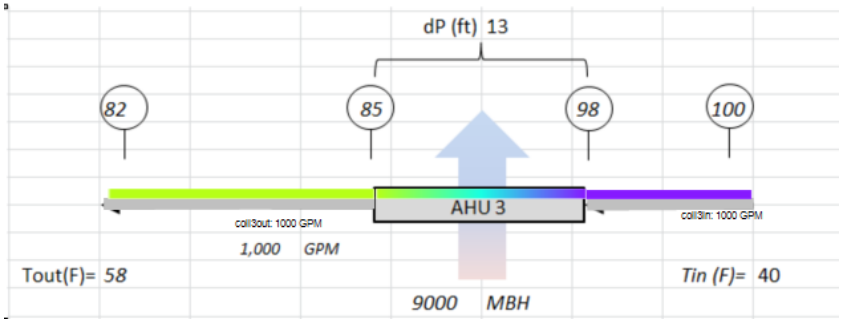
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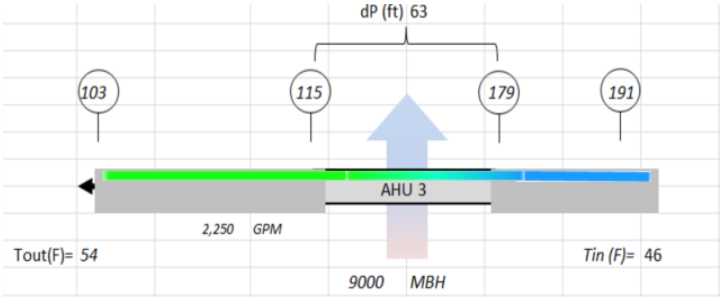
Case 1: 40 F EWT/58 LWT **18 F dT**



Case 2: 46 F EWT/54 LWT **8 F dT**

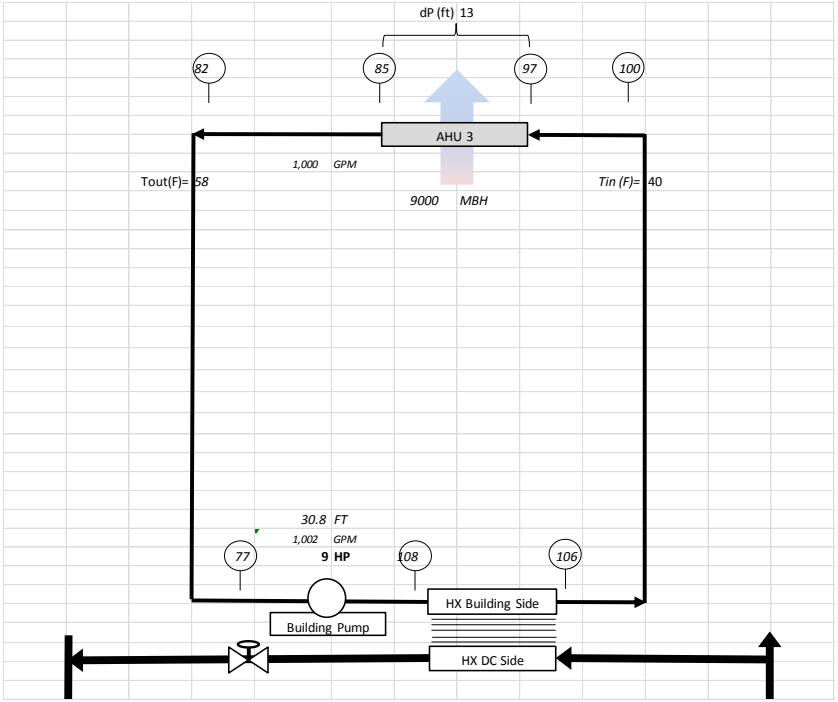


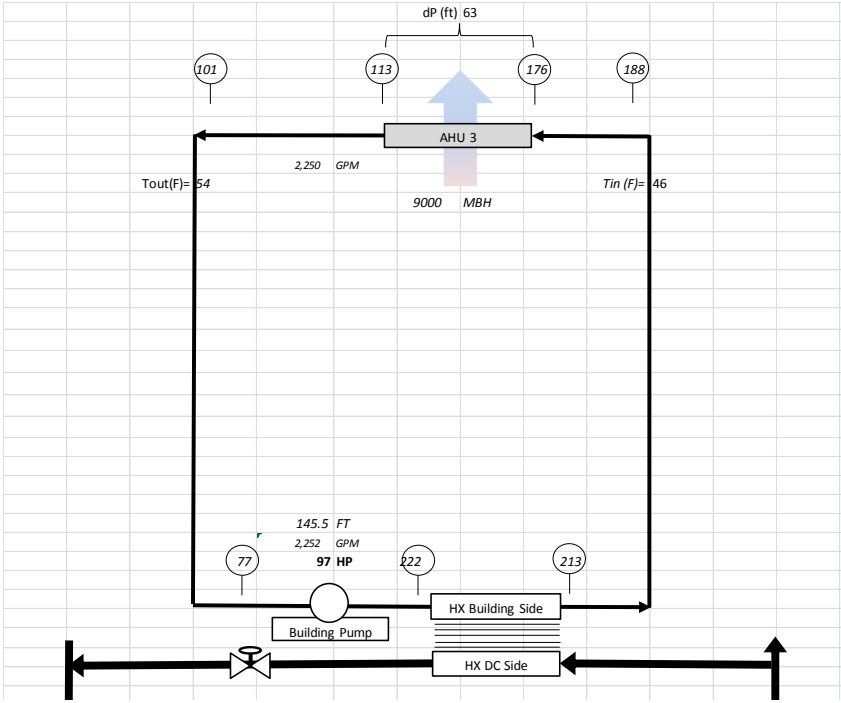
Flow = 1,000 GPM



Flow = 2,250 GPM

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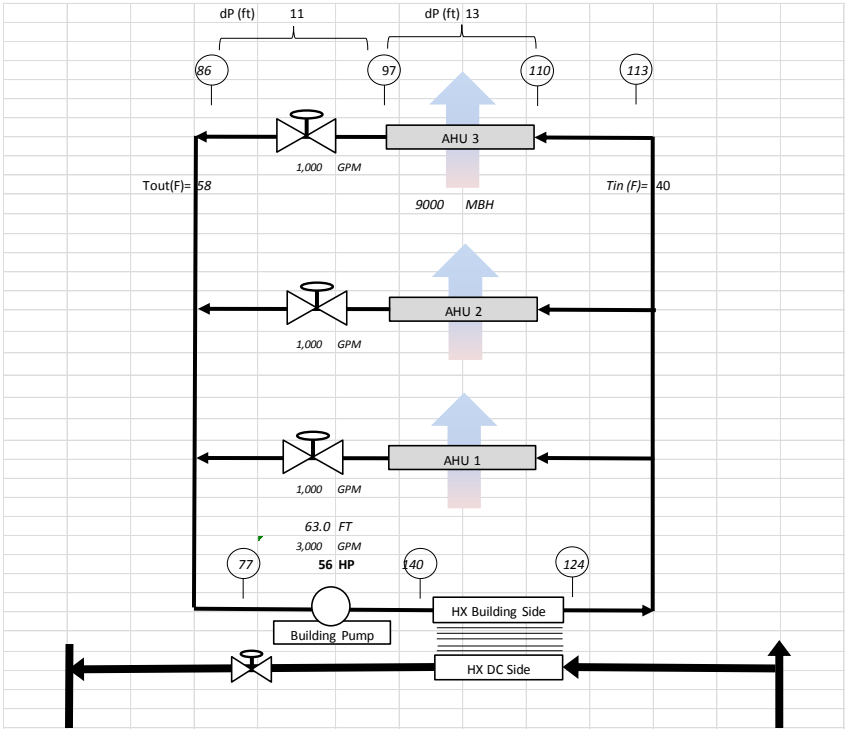




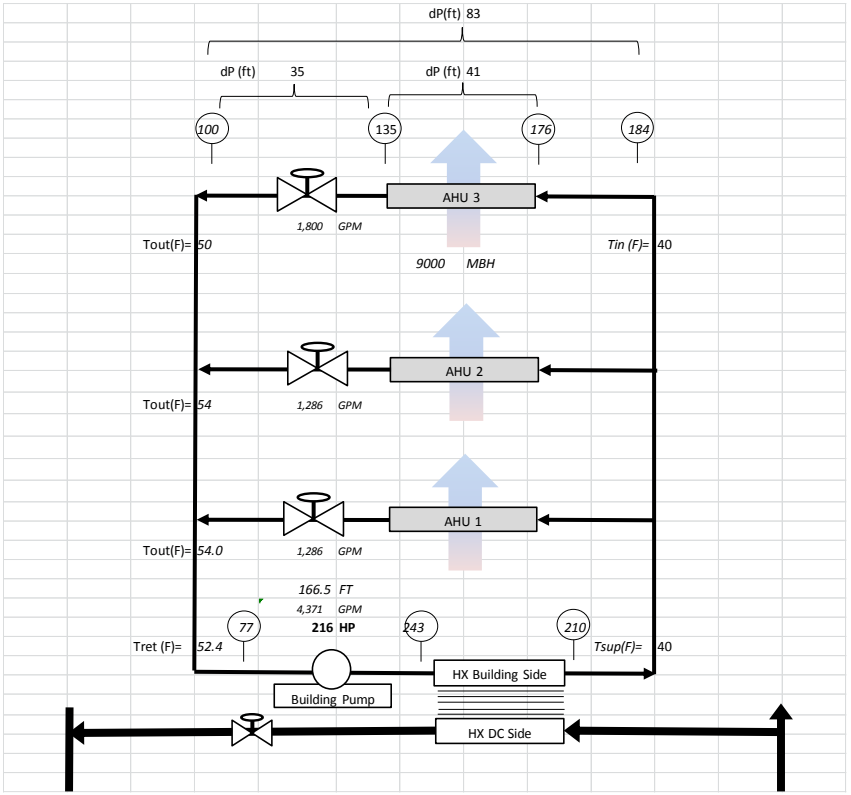
Case 1: one coil
40 F EWT/58 LWT **18 F dT**
1,000 GPM
31 ft dP
9 HP

Case 2: one coil
46 F EWT/54 LWT **8 F dT**
2,250 GPM
145 ft dP
97 HP

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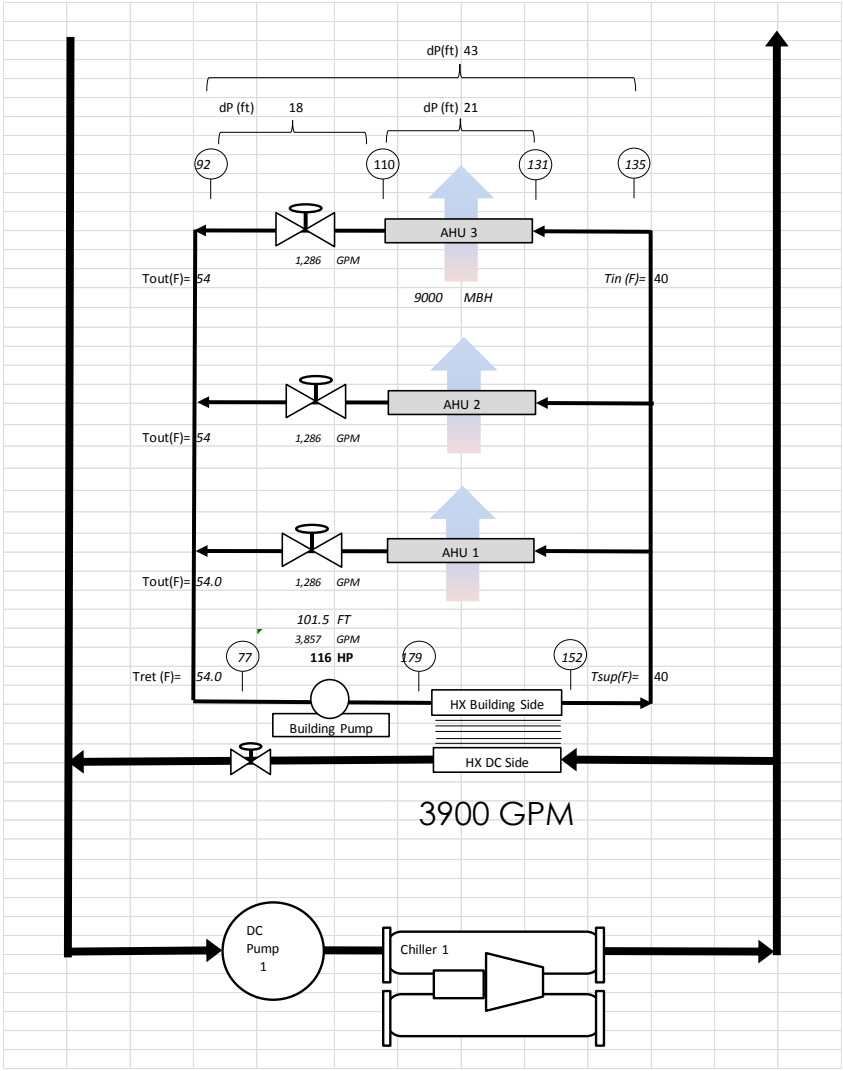


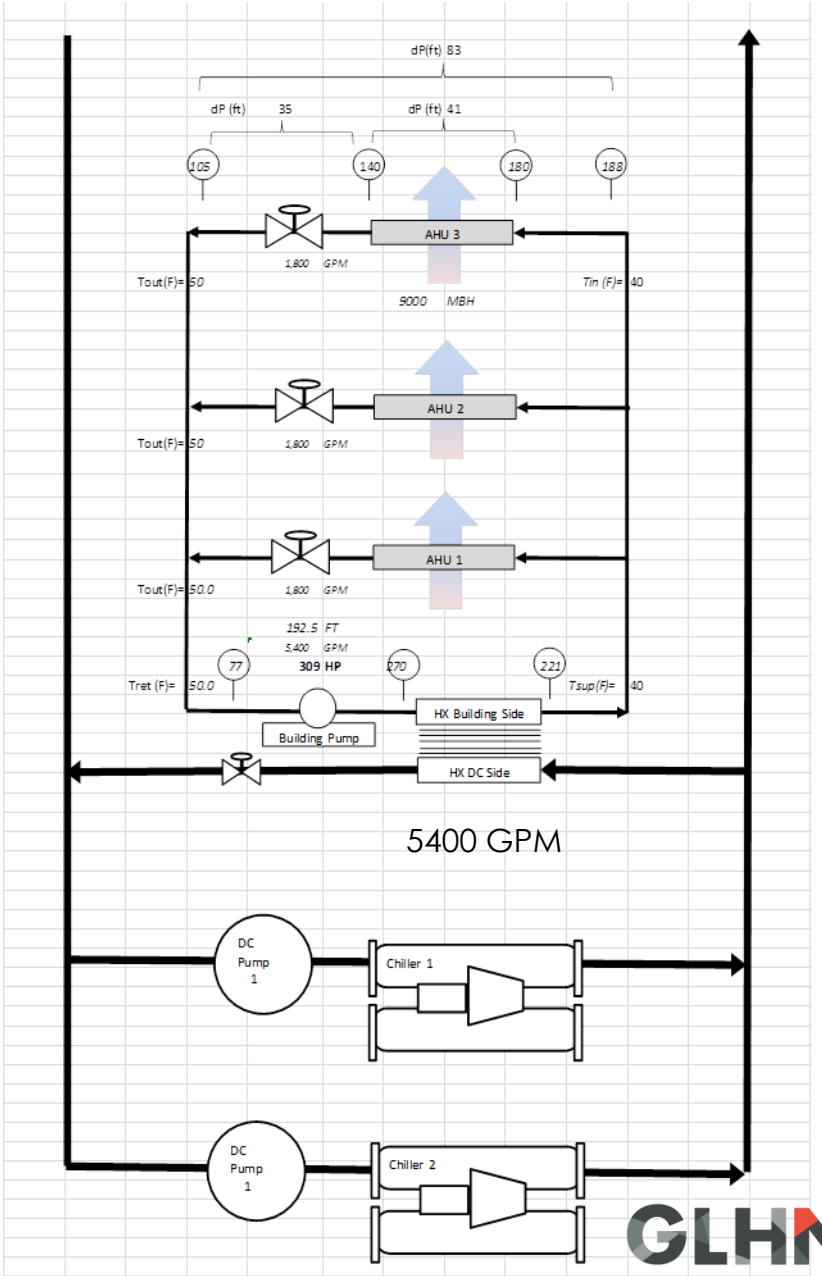
Case 1: three coils
All at 40 F EWT/58 LWT **18 F dT**
3,000 GPM
63 ft dP
56 HP



Case 3: three coils
All at 40 F EWT in
2 at 54 LWT **14 F dT**
1 at 50 LWT 10 F dT
4,371GPM
167 ft dP
216 HP

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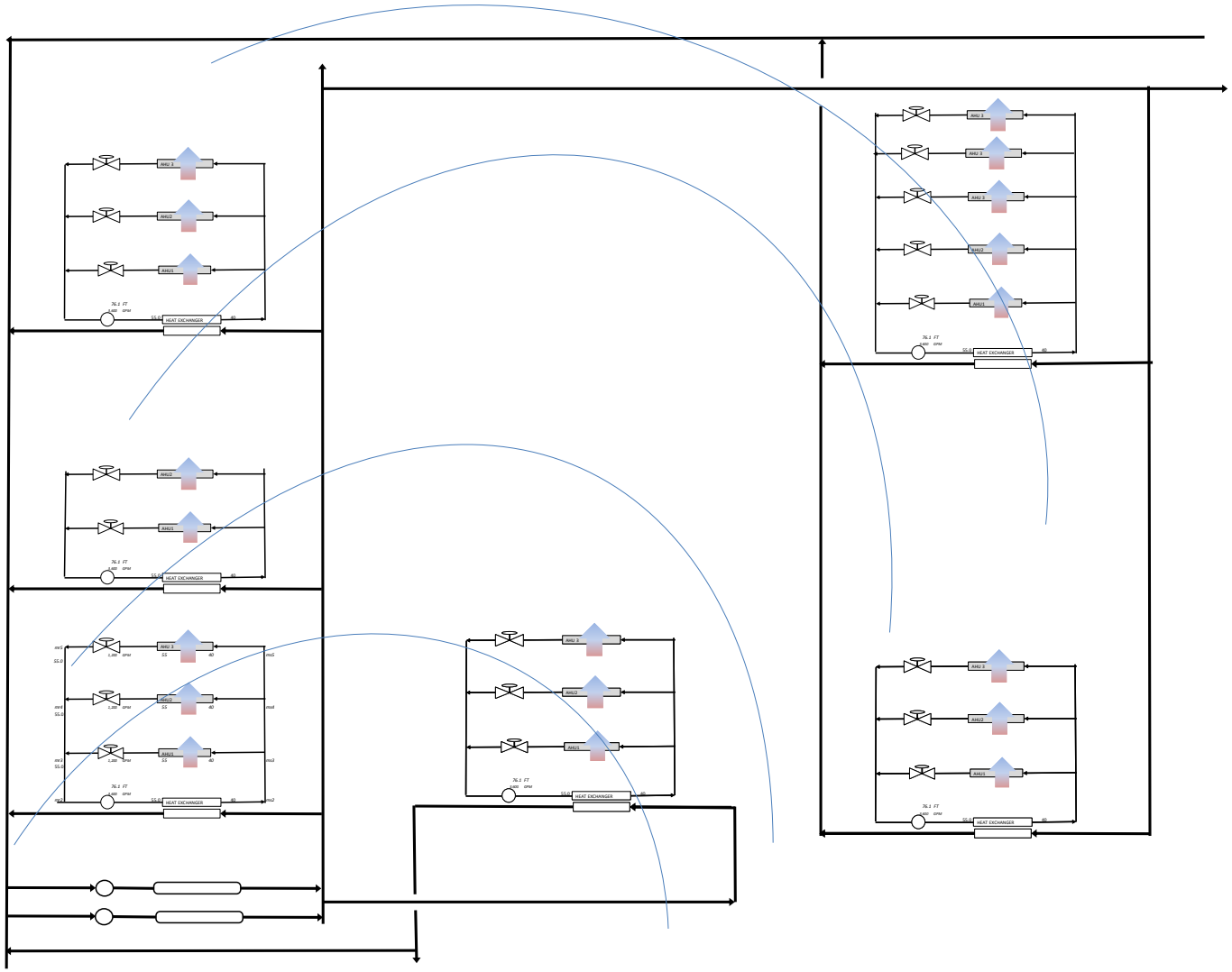




Impact on DC Loop

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District Diagram



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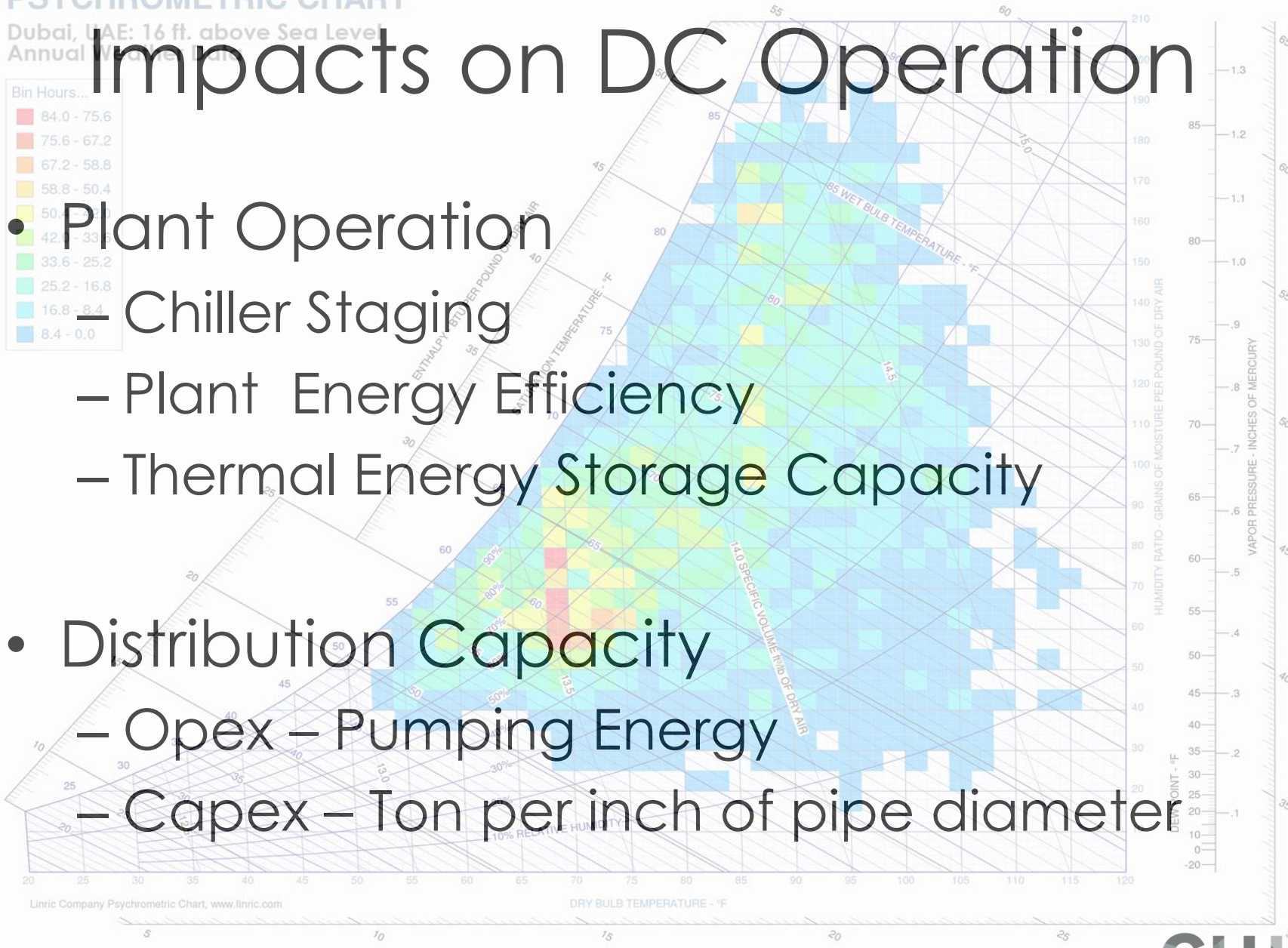
Impacts on Building Operation

- Design Intent - Customer Satisfaction
  - Space Humidity and Temperature Control
- Building Energy Consumption - Cost
  - Pump and Fan
  - Hot Calls and Maintenance
- DC Interface-Contractual Obligation
  - Building Leaving Water Temperature/Flow

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Impacts on DC Operation

- Plant Operation
  - Chiller Staging
  - Plant Energy Efficiency
  - Thermal Energy Storage Capacity
- Distribution Capacity
  - Opex – Pumping Energy
  - Capex – Ton per inch of pipe diameter



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Solutions

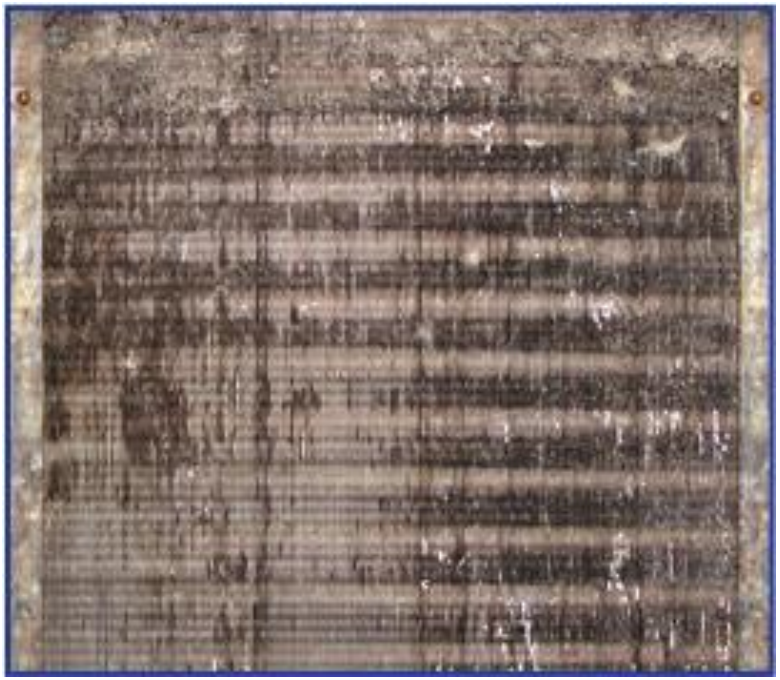
- Supply Side dT Erosion
  - Bypass
  - Fouling at HX and Coils
- Return Side dT Erosion
  - Air Side Terminal Design and Diagnosis
  - Separate Control on Sensible and Latent
  - Leaving Air Setpoint Control
  - Chilled Water Valve Control: Pressure Independence
  - Monitoring and Intelligence
- Analysis
  - Design and Operation

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Heat Exchanger Fouling

- Coil Air Side
- Coil and HX Water Side
- Chiller Evaporator





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Terminal Design

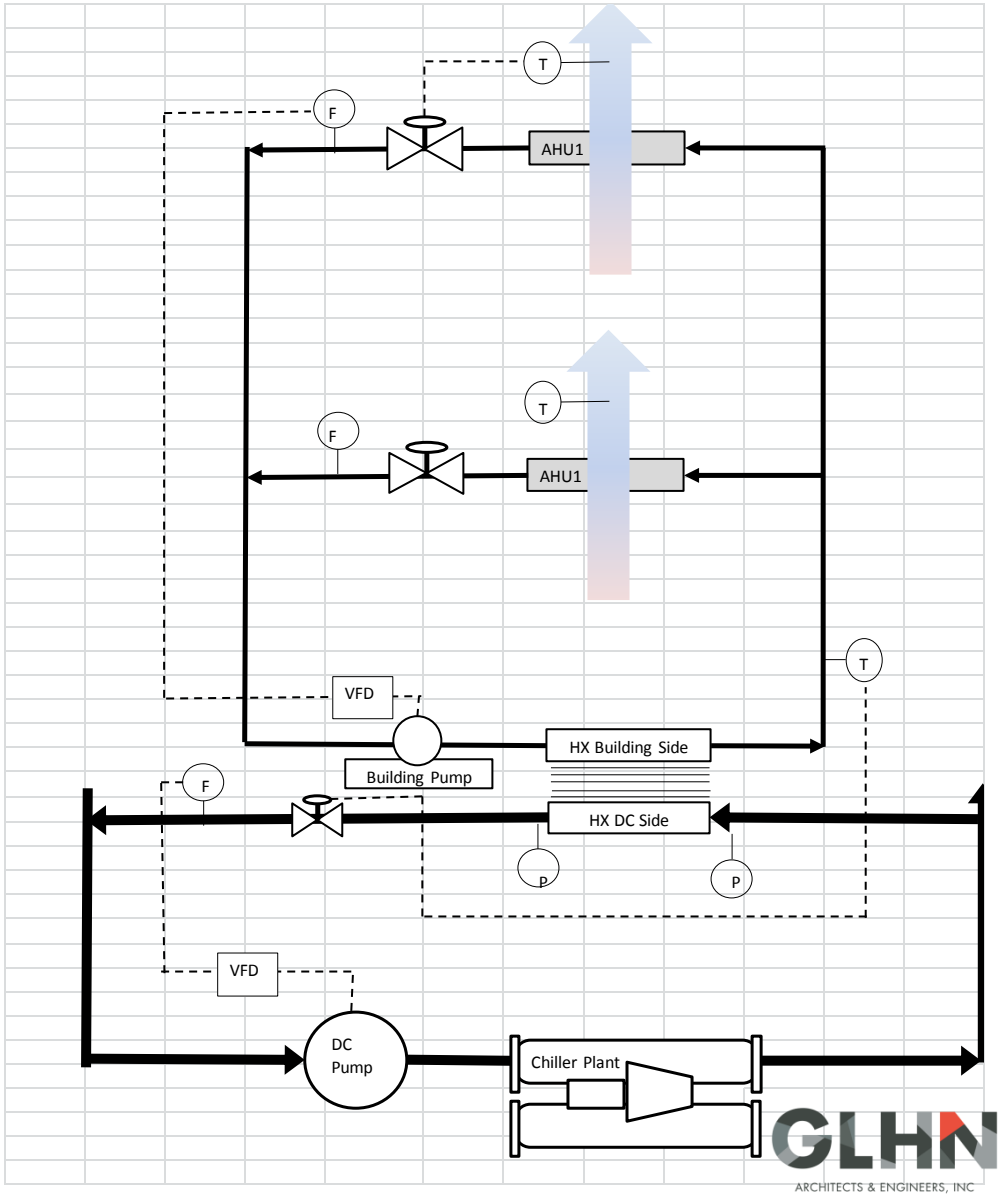
- Dedicated Outdoor Air
  - Exhaust Air Heat Recovery
  - Separate Sensible and Latent
    - Series Latent and Sensible
- Elimination of Reheat
- Data Acquisition
  - Real Time Load Analytics

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Pressure Independent Control







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Summary

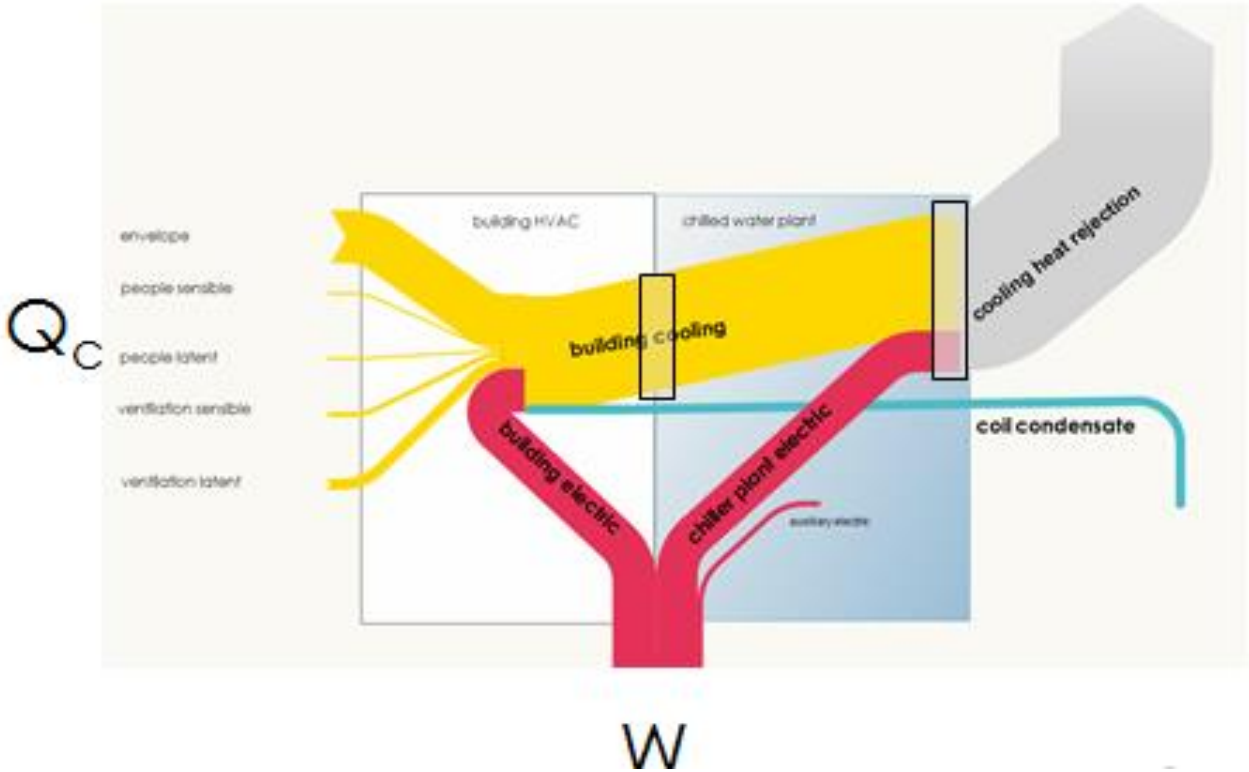
Diligence

Data

Analysis

Technology

Persistence



Questions?
hjohnsto@glhn.com

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