EBCx Workshop Series 18

Session 2

Suhvhqwhg#E|=

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Senior Engineer

Vhoi#Vwxg|#Jrdov

What You Should be Doing

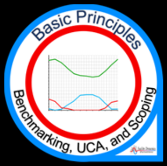
Identify a Project Building

- Begin to fill out the building information form Ryan will provide
- Benchmark the building
  - EnergyStar
  - DOE Building Performance Database
- Start a Utility Consumption Analysis
- Make a site visit to scope it and start a findings list

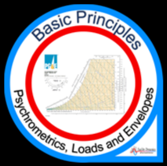
Steps for Your Self-Study Effort

Collect your merit badges

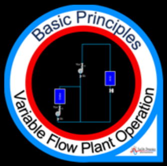
- https://tinyurl.com/SSBenchmarkUCAScoping



- https://tinyurl.com/SSLoadsAndPsych



- https://tinyurl.com/SSSystemDgmIntro



Steps for Your Self-Study Effort

Continue to Develop your System Diagram Skills

Developing the Hijend Hotel CHW Distribution Loop Diagram

- https://tinyurl.com/HijendDistLoop

Add the Evaporator Loop to the Diagram

- https://tinyurl.com/HijendEvapLoopFlyThru

Field Verify Joe DeNugy’s Central Plant Diagram

- https://tinyurl.com/HijendCHWFieldVerify

Next Steps for Your Self-Study Effort

Reach Out to Ryan if You Have Questions or Need Some Help

r2s2@pge.com

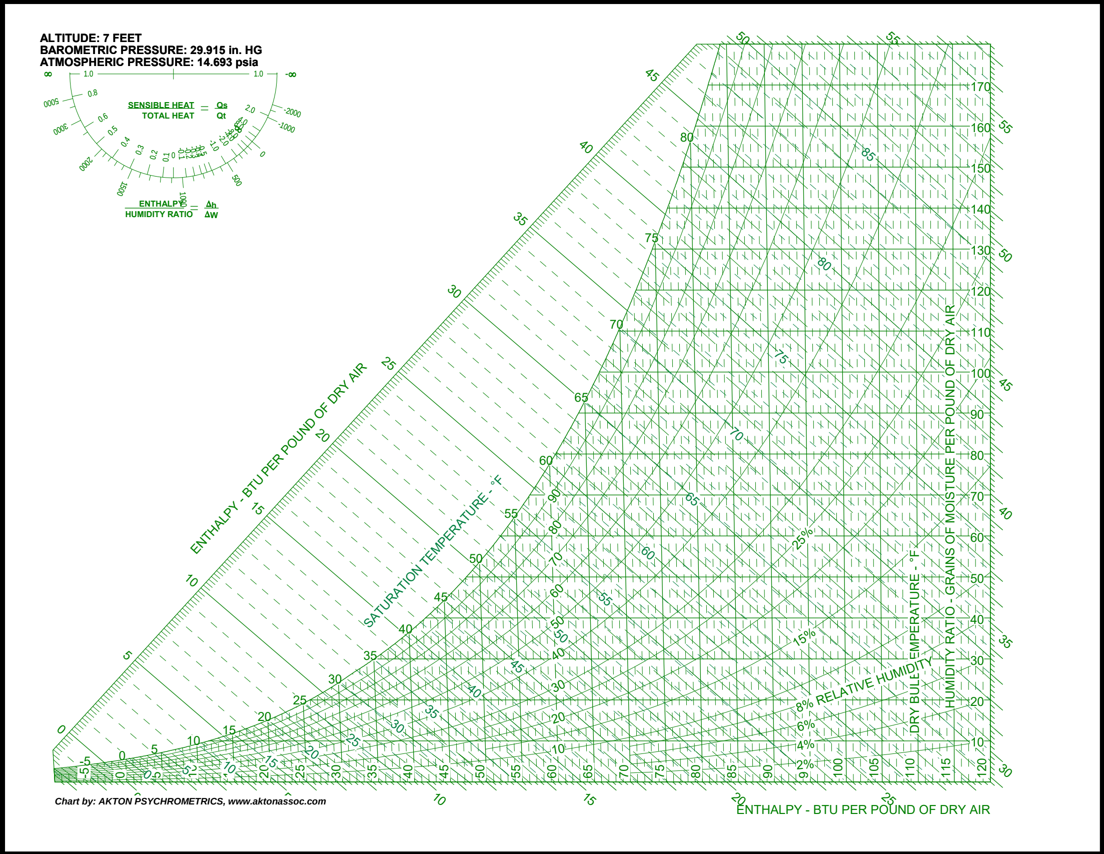
Vlwxdwlrqdo#Dzduhqhvv

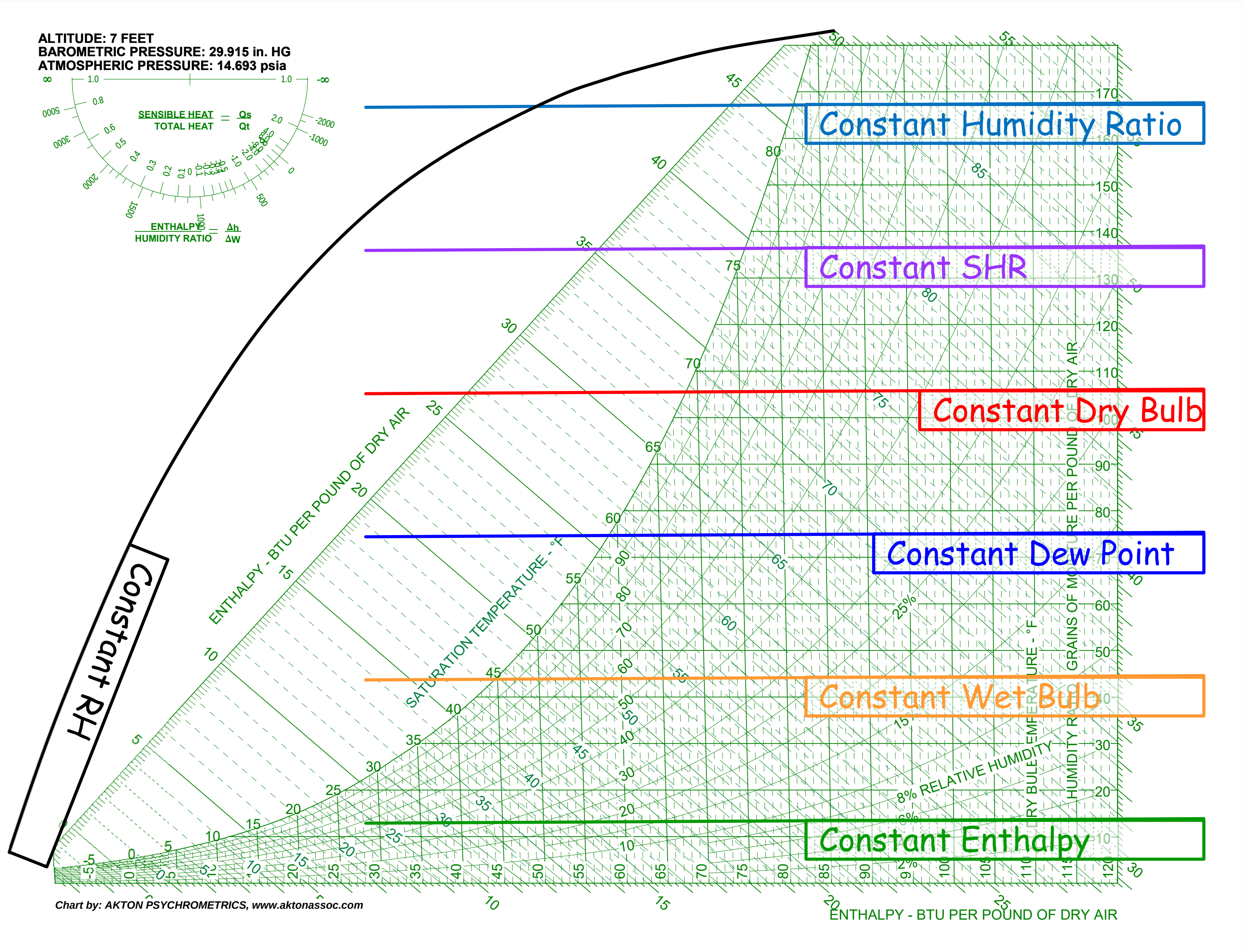
D#Sv|fk#Fkduw#Jhiuhvkhu

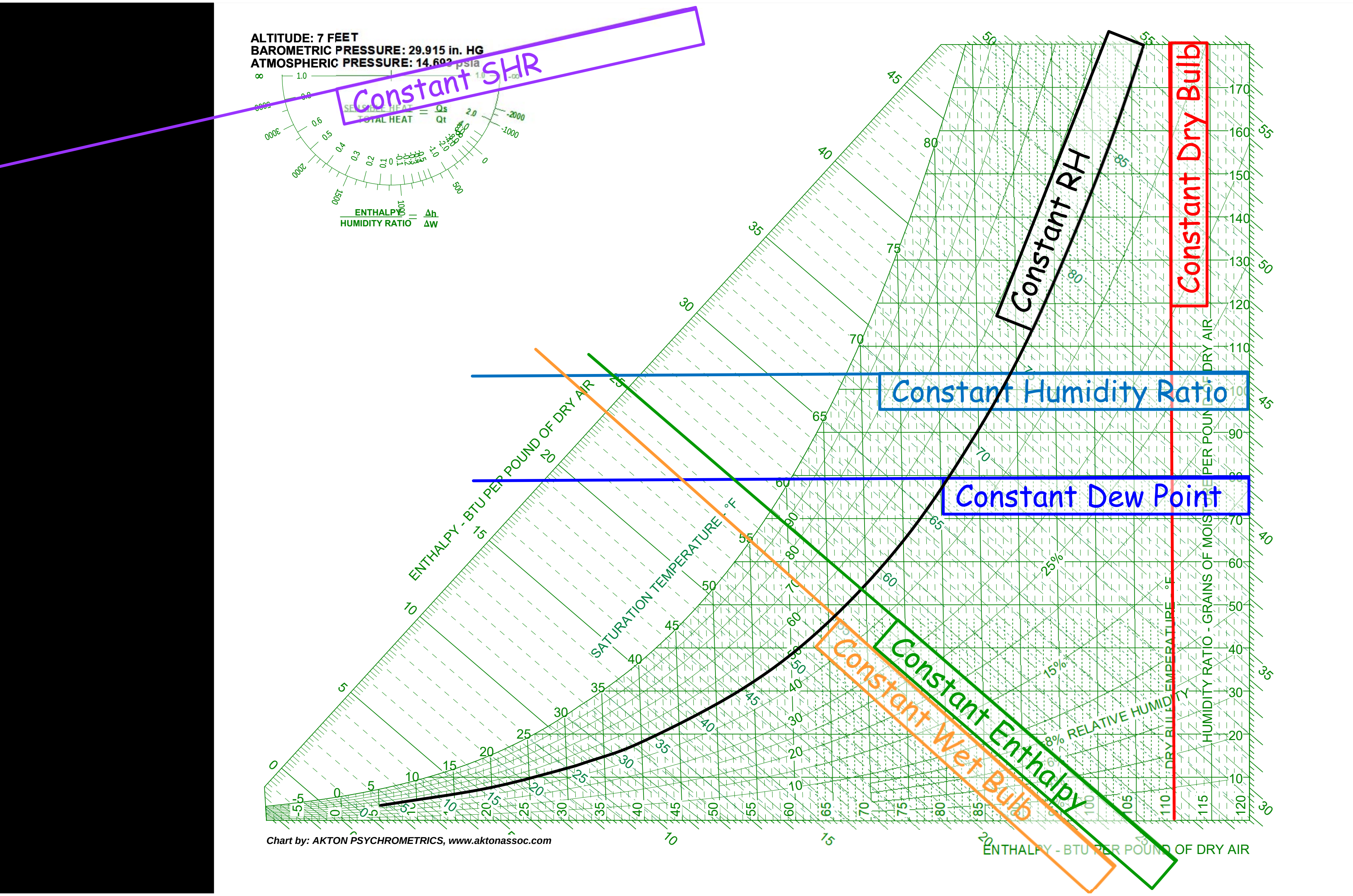
A Psych Chart Refresher

Identify the different lines on a psych chart

- Constant dry bulb
- Constant wet bulb
- Constant dew point
- Constant humidity ratio
- Constant relative humidity
- Specific heat ratio




ALTITUDE: 7 FEET
BAROMETRIC PRESSURE: 29.915 in. HG
ATMOSPHERIC PRESSURE: 14.693 psia
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
Constant Humidity Ratio
Constant SHR
Constant Dry Bulb
Constant Dew Point
Constant Wet Bulb
Constant Enthalpy
Constant RH
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
8% RELATIVE HUMIDITY
25%
DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - GRAINS OF MOISTURE PER POUND OF DRY AIR
Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com



ALTITUDE: 7 FEET
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DRY BULB TEMPERATURE - °F
HUMIDITY RATIO - GRAINS OF MOIS
PER POUN
DRY AIR
Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com

May 12, 2001

May 12(ish), 2023

Vlwxdwlrqdo#Dzduhqhvv

Wkh#Edoo#Urrp #Ghvljq#Frqglwlrqv

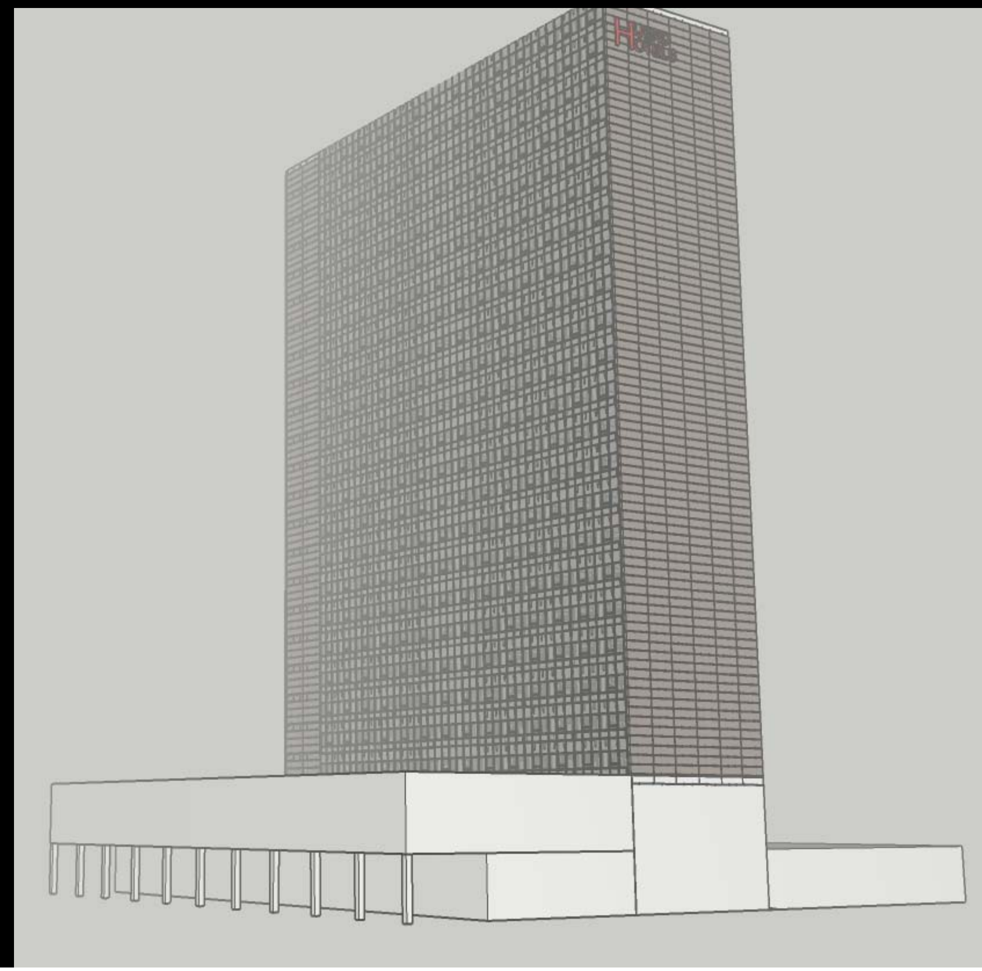
Current Conditions

Current Conditions

- Foggy
- Furnace running at home when you left
- Low 50’s °F through early afternoon, then clearing and sunny with a high of 68-70°F anticipated

Let’s see what you have learned

https://tinyurl.com/EBCxWS0201SitAware



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We Already Have Some Clues

1. Utility data insights based on the EUI and average daily consumption patterns
2. Building documents
   - Provide insights regarding the building and equipment
   - Allow preliminary system diagrams to be developed
3. Operating conditions on the day of our visit frame up expectations

The EUI Relationship

- The EUI relationship

$$EUI = \frac{((kWh_{Annual} \times 3,413) + Fuel_{Annual})}{(1,000 \times Area_{Building})}$$

Where:

EUI	=	Energy Use Intensity (some say Energy Use Index), typically in kBtu/sq.ft./year
kWh_{Annual}	=	Annual building electrical consumption in kWh
$3,413$	=	Unit conversion constant; there are 3,413 Btus per kWh
$Fuel_{Annual}$	=	Annual building fuel consumption in Btus; Note that you may have to convert the units of measure from what is used on the bill. For instance, gas is often billed as therms and there are 100,000 Btu per therm.
$1,000$	=	Unit conversion constant; there are 1,000 Btu per kilo-Btu
$Area_{Building}$	=	Building gross square footage

Adding Things Up

Project Energy Metrics - Source as indicated			
Electric rate -	$0.09	$/kWh	
Thermal energy rate -	$0.58	$ per therm	
Electrical incentive -	$0.00	$ per kWh	
Thermal incentive -	$0.00	$ per therm	
Building square footage -	485,000	From Benchmarking Data	
Site energy electrical energy conversion factor -	3,413	Btu/kWh	
Source energy electrical energy conversion factor -	11,485	Btu/Kwh	
Source energy thermal energy conversion factor -	1.050	Therms at the well head per therm delivered	
Annual Consumption - From a baseline report, utility bills, utility meters, etc.			
	Energy	$	
Electricity - kWh/$ per year	6,477,564	$555,906	
Thermal at the Central Plant - Therms/$ per year	365,139	$213,452	
TOTAL		$769,358	$ per year
		$1.59	$/sq.ft. /yr
EUI Factors	Site Energy	Source Energy	
Electrical Energy	46	153	kBtu/sq.ft./yr.
Thermal Energy	75	79	kBtu/sq.ft./yr.
Total	121	232	kBtu/sq.ft./yr.

Adding Things Up

TOTAL		$769,358	$ per year
		$1.59	$/sq.ft. /yr
EUI Factors	Site Energy	Source Energy	
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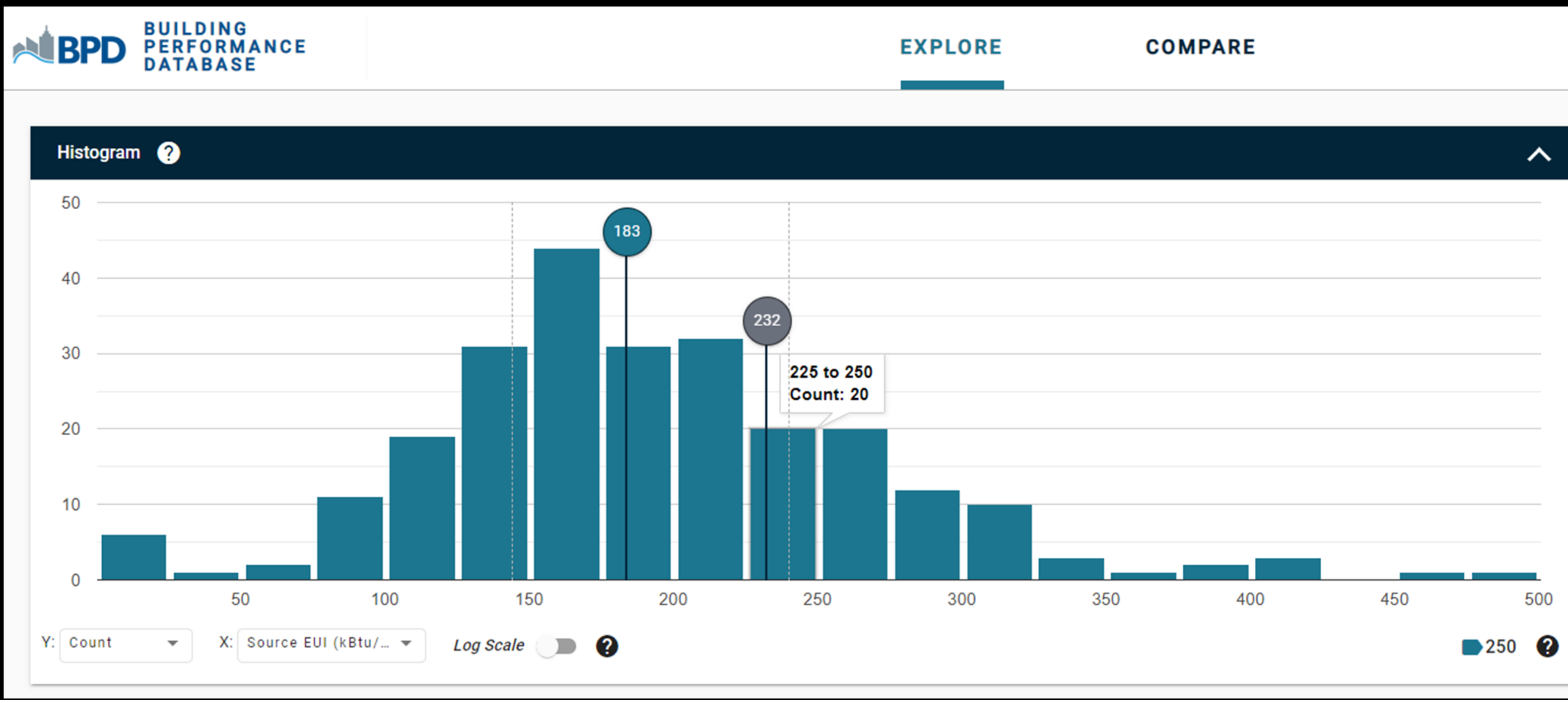
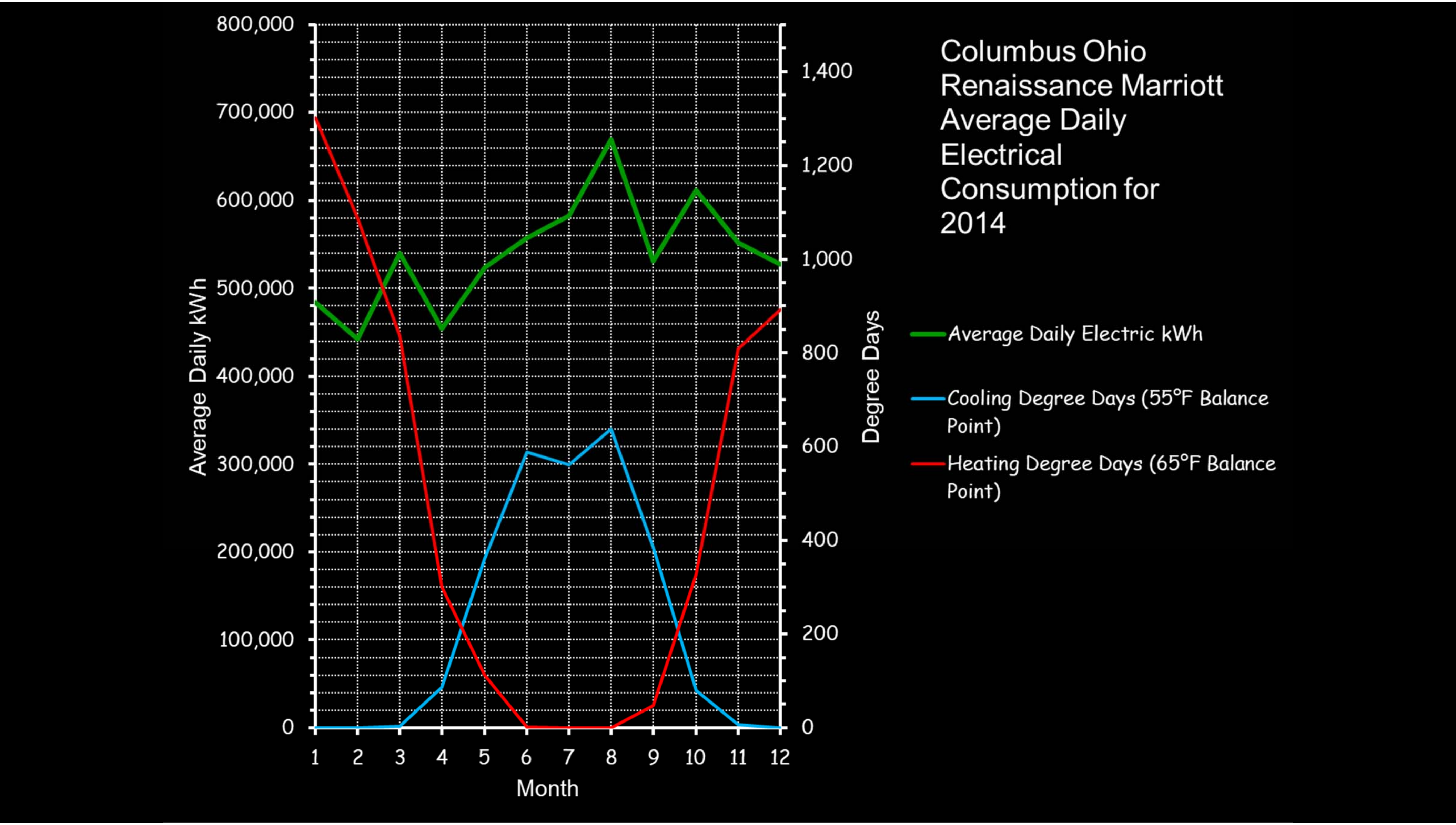


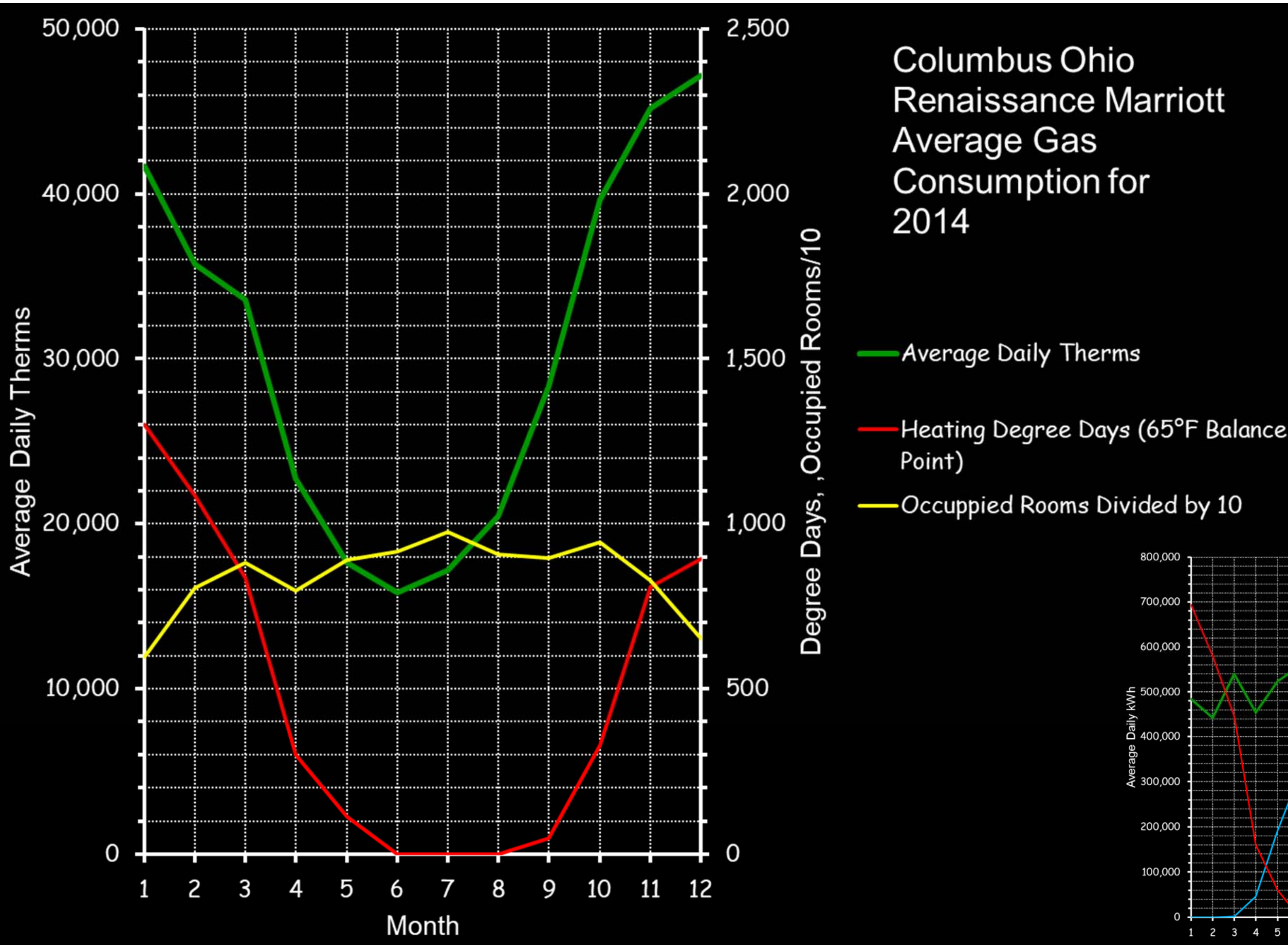
Projecting Savings

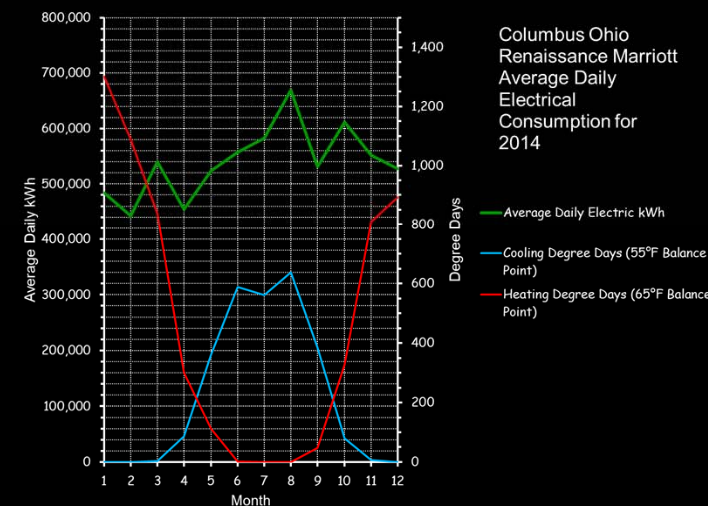
Savings Projection Based on the LBNL Cost Benefit Study					
LBNL Cx Cost Benefit Median Energy Savings (2009 update) -	16%	of Whole Building Energy Use			
	Low End	High End			
Potential savings range for the purposes of our discussion -	10%	16%			
Potential annual savings -	$76,936	$123,097	$ per year		
Percentage of the annual savings to be allocated electricity -	50%				
Percentage of the annual savings to be allocated to thermal -	50%				
Potential electrical savings -	448,238	717,181	kWh per year		
Potential thermal savings -	65,805	105,287	Therms per yr.		
Projected EUIs Post Implementation					
	Low End		High End		
	Site Energy	Source Energy	Site Energy	Source Energy	
Electrical Energy	42	143	41	136	kBtu/sq.ft./y
Thermal Energy	62	65	54	56	kBtu/sq.ft./y
Total	104	208	94	193	kBtu/sq.ft./y

Projecting Savings

Expenditure Justified by Anticipated Savings				
Simple payback time frame -	2 years		5 years	
Savings range -	Low End	High End	Low End	High End
Energy savings after the indicated interval, 2013 $ -	$153,872	$246,195	$384,679	$615,487
Incentive, 2013 $ -	$0	$0	$0	$0
Total, 2013 $ -	$153,872	$246,195	$384,679	$615,487

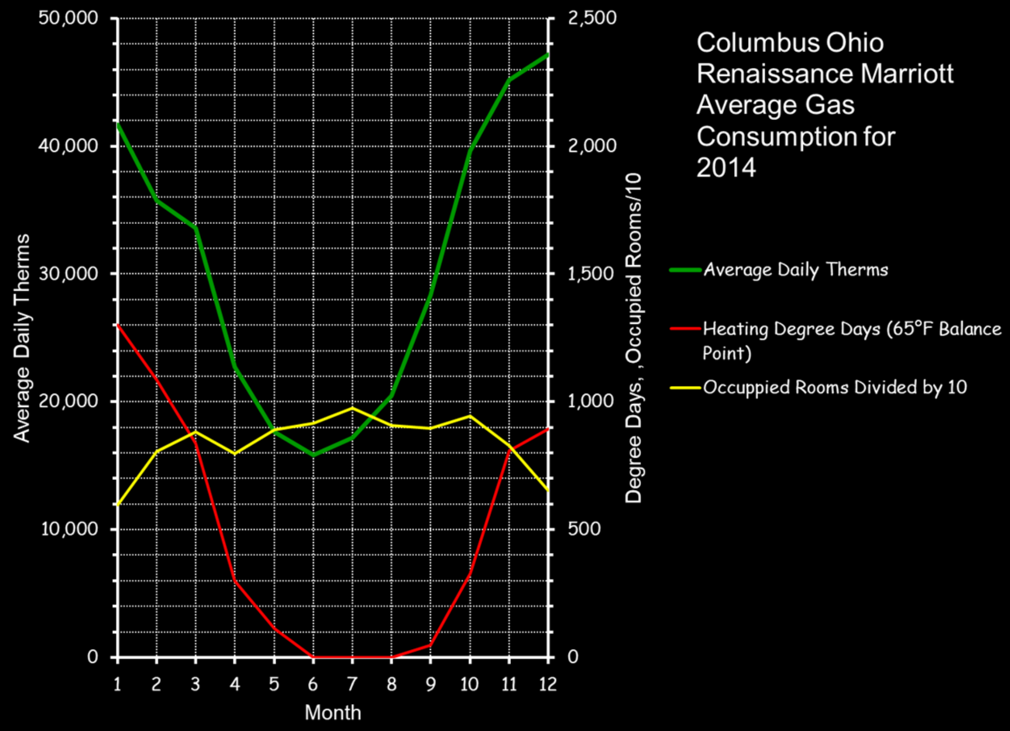

Columbus Ohio
Renaissance Marriott
Average Daily
Electrical
Consumption for
2014
Average Daily kWh
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Degree Days
1,400
1,200
1,000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10
11
12
Month
Average Daily Electric kWh
Cooling Degree Days (55°F Balance Point)
Heating Degree Days (65°F Balance Point)

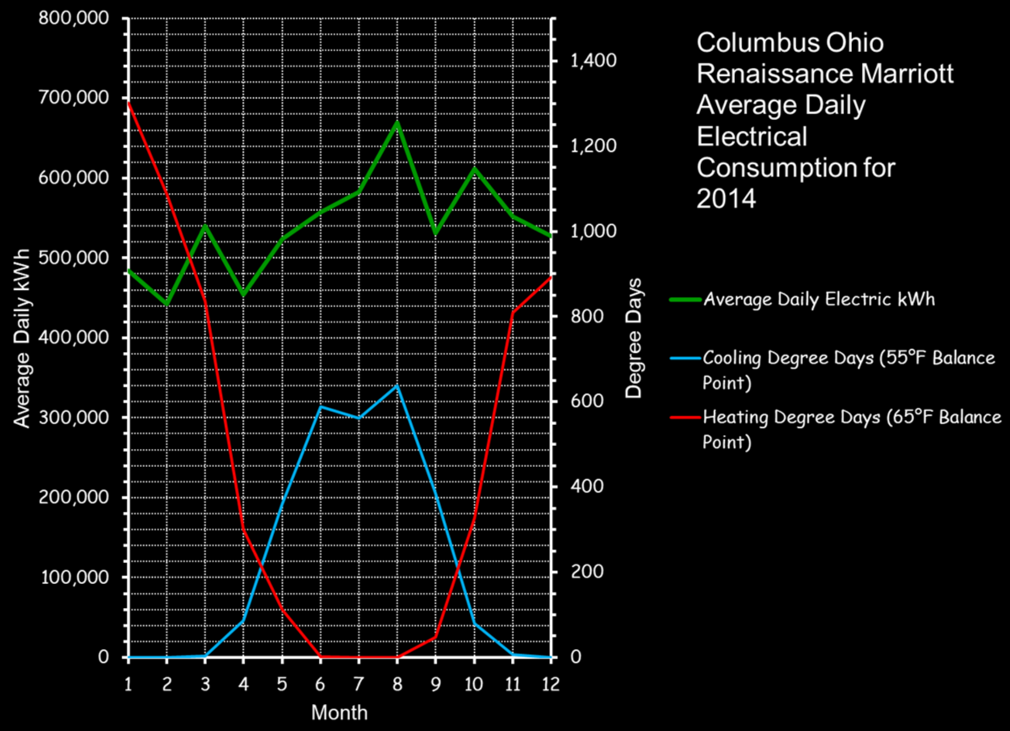

Columbus Ohio
Renaissance Marriott
Average Gas
Consumption for
2014
Average Daily Therms
Degree Days, ,Occupied Rooms/10
Month
Average Daily Therms
Heating Degree Days (65°F Balance Point)
Occupied Rooms Divided by 10


Columbus Ohio
Renaissance Marriott
Average Daily
Electrical
Consumption for
2014
Average Daily kWh
Degree Days
Month
Average Daily Electric kWh
Cooling Degree Days (55°F Balance Point)
Heating Degree Days (65°F Balance Point)

Think About It

It Will Come Up as We Work With the Hijend Hotel





Start Your Findings List the Day You Start Your Project

Number	Brief Description	Total Savings $		Incentive, $		Implementation Cost Projections, $		Implementation Cost After Incentives, $		Simple Payback Range After Incentives, Years		Electricity						Gas				Other Savings						Notes
												kWh savings				kW savings		Therm Savings										
												Low end		High end				Low end		High end		Low end			High end			
		Low End	High End	Low End	High End	Low End	High End	Low End	High End	Low End	High End	kWh	$	kWh	$	Low End	High End	Therm	$	Therms	$	Amount	Units	$	Amount	Units	$	
1.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
2.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
3.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
4.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
5.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
6.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
7.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
8.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
9.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
10.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
11.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
12.		To Be Determined	To Be Determined	None Offered	None Offered			$0	$0	To Be Determined	To Be Determined	0	$0	0	$0	0.0	0.0	0	$0	0	$0	None	N/A	$0	None	N/A	$0	
TOTALS		To Be Determined	To Be Determined	None Offered	None Offered	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined			To Be Determined			To Be Determined	

https://tinyurl.com/EBCxCostBenefitSpreadsheet

A (Potentially) Informative Relationship

This relationship tells us that the power used by a pump is directly related to the flow and head it produces and inversely related to the pump, motor and drive system efficiency

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

Where:

kW	=	Input to the system to produce the flow and head
$Flow$	=	Flow rate in gallons per minute
$Head$	=	The pump head in ft.w.c. water column
3,960	=	A units conversion constant that is good for water between 40°F and 220°F
η_{Pump}	=	Pump efficiency.
η_{Motor}	=	Motor efficiency
η_{VSD}	=	Variable speed drive efficiency
.746	=	Horsepower to kW conversion constant

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

Energy

Power used over a period of time

$$kWh = \left[\left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746 \right] \times Hours$$

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

Energy

Power used over a period of time

$$kWh = \left[\left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746 \right] \times Hours$$

Thermal energy is similar

$$Q_{Btu/Hr} = 500 \times Flow_{gpm} \times \left(t_{In,°F} - t_{Out,°F} \right)$$

$$Q_{Btu/Hr_{Sensible}} = 1.08 \times Flow_{cfm} \times \left(t_{In,°F} - t_{Out,°F} \right)$$

$$Q_{Btu/Hr_{Total}} = 4.5 \times Flow_{cfm} \times \left(h_{In,Btu/lb} - h_{Out,Btu/lb} \right)$$

$$Q_{Btu} = \left[500 \times Flow_{gpm} \times \left(t_{In,°F} - t_{Out,°F} \right) \right] \times Hours$$

$$Q_{Btu_{Sensible}} = \left[1.08 \times Flow_{cfm} \times \left(t_{In,°F} - t_{Out,°F} \right) \right] \times Hours$$

$$Q_{Btu_{Total}} = \left[4.5 \times Flow_{cfm} \times \left(h_{In,Btu/lb} - h_{Out,Btu/lb} \right) \right] \times Hours$$

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

Can be established by a test

1. Variations in flow and head will shift the operating point and cause variations in power
2. Shifting the operating point can cause pump efficiency to vary, also affecting power
3. Variations in power will cause variations in motor and drive efficiency

Energy

Power used over a period of time

$$kWh = \left[\left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746 \right] \times Hours$$

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

For a constant flow system:

1. Nothing varies
2. Only one test point is required

Energy

Power used over a period of time

$$kWh_{Total} = Kw_{TestPoint} \times Hours_{OnLine}$$

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3{,}960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

For a *variable* flow system:

1. Everything can vary
2. Multiple test points are required

Energy

Power used over a period of time

$$kWh_{Total} = \left(Kw_{TestPoint_1} \times Hours_{TestPoint_1}\right) + \left(Kw_{TestPoint_2} \times Hours_{TestPoint_2}\right) + \left(Kw_{TestPoint_3} \times Hours_{TestPoint_3}\right) \; . \; . \; . + \left(Kw_{TestPoint_n} \times Hours_{TestPoint_n}\right)$$

Power vs. Energy

Power

Instantaneous rate of energy use

$$kW = \left(\frac{Flow_{gpm} \times Head_{ft.w.c.}}{3,960 \times \eta_{Pump} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

For a variable flow system:

Establishing the load or flow profile for your energy calculations is critical

Energy

Power used over a period of time

$$kWh_{Total} = \left(Kw_{TestPoint_1} \times Hours_{TestPoint_1} \right) + \left(Kw_{TestPoint_2} \times Hours_{TestPoint_2} \right) + \left(Kw_{TestPoint_3} \times Hours_{TestPoint_3} \right) \cdot \cdot \cdot + \left(Kw_{TestPoint_n} \times Hours_{TestPoint_n} \right)$$

Establishing Load and Flow Profiles

Calculated

1. Potentially time consuming
2. May require complex mathematics or software
3. Only as good as the assumptions

Start thinking about it while you are scoping and look for ways you could do it

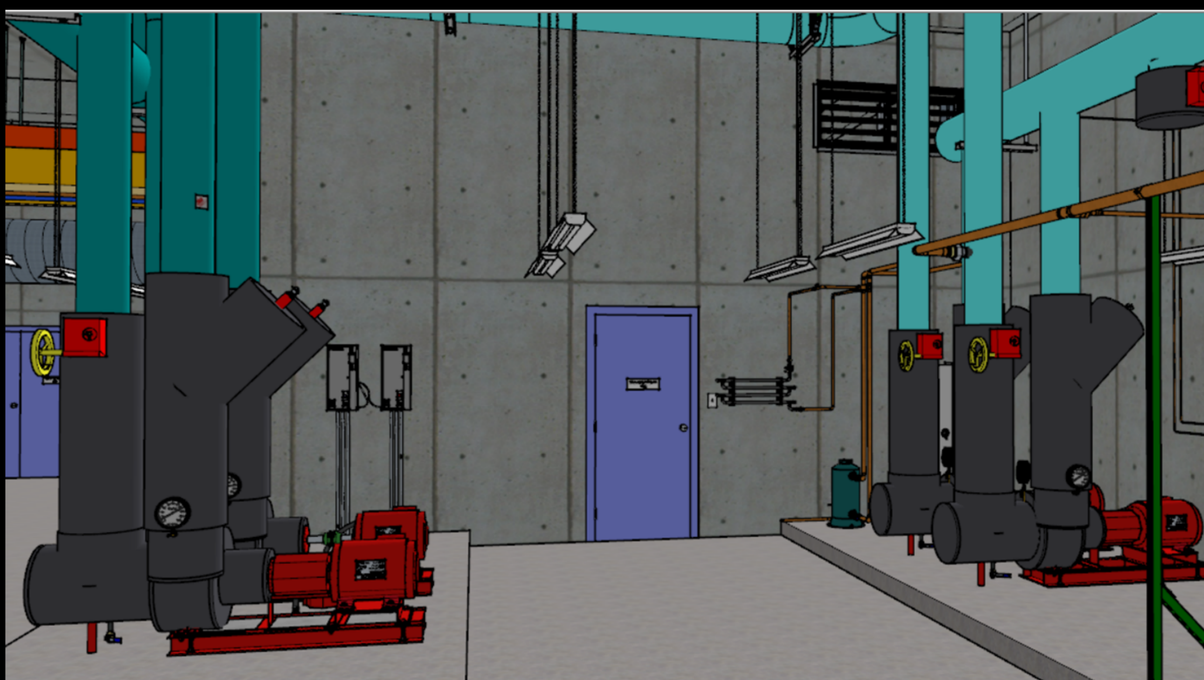
Measured

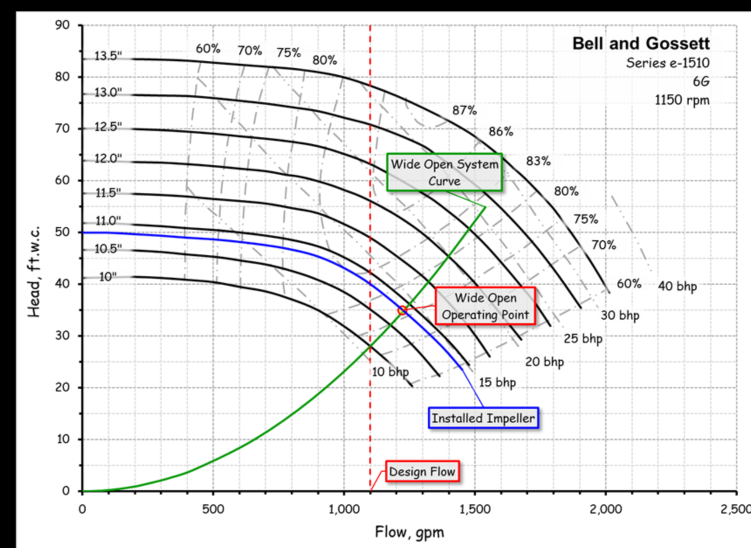
1. No assumptions!
   - Reflects the current state of affairs
2. May require complex mathematics or software
   - But typically, you can handle it with Excel
3. Requires some time to establish
   - Using regressions can compress the timeline
   - Need to start gathering data early

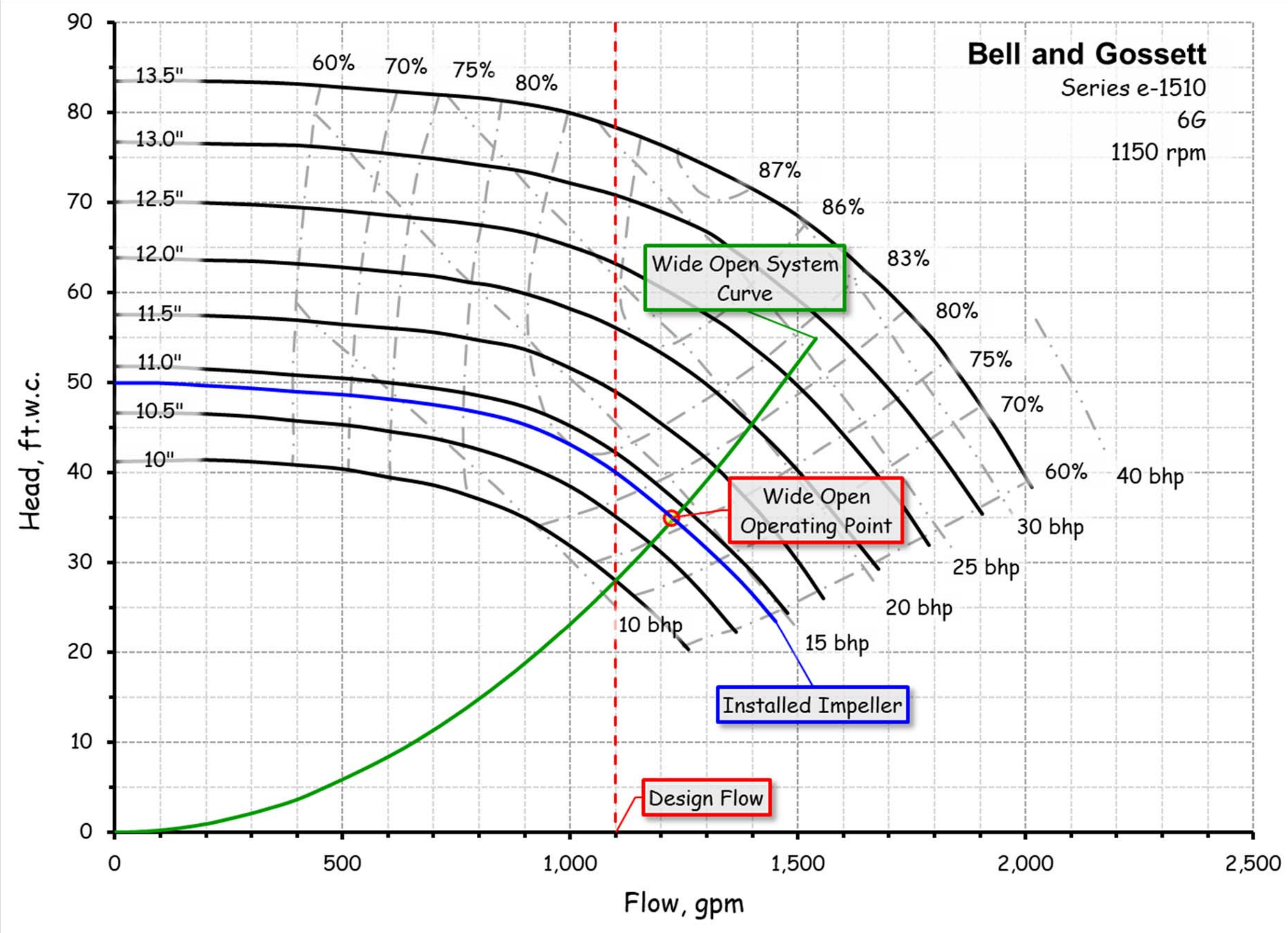
Pumps are Common EBCx Targets

The Hijend Hotel chilled water plant seems to have a number of them

- Here 's a question for you https://tinyurl.com/EBCxWS0102PumpOpt







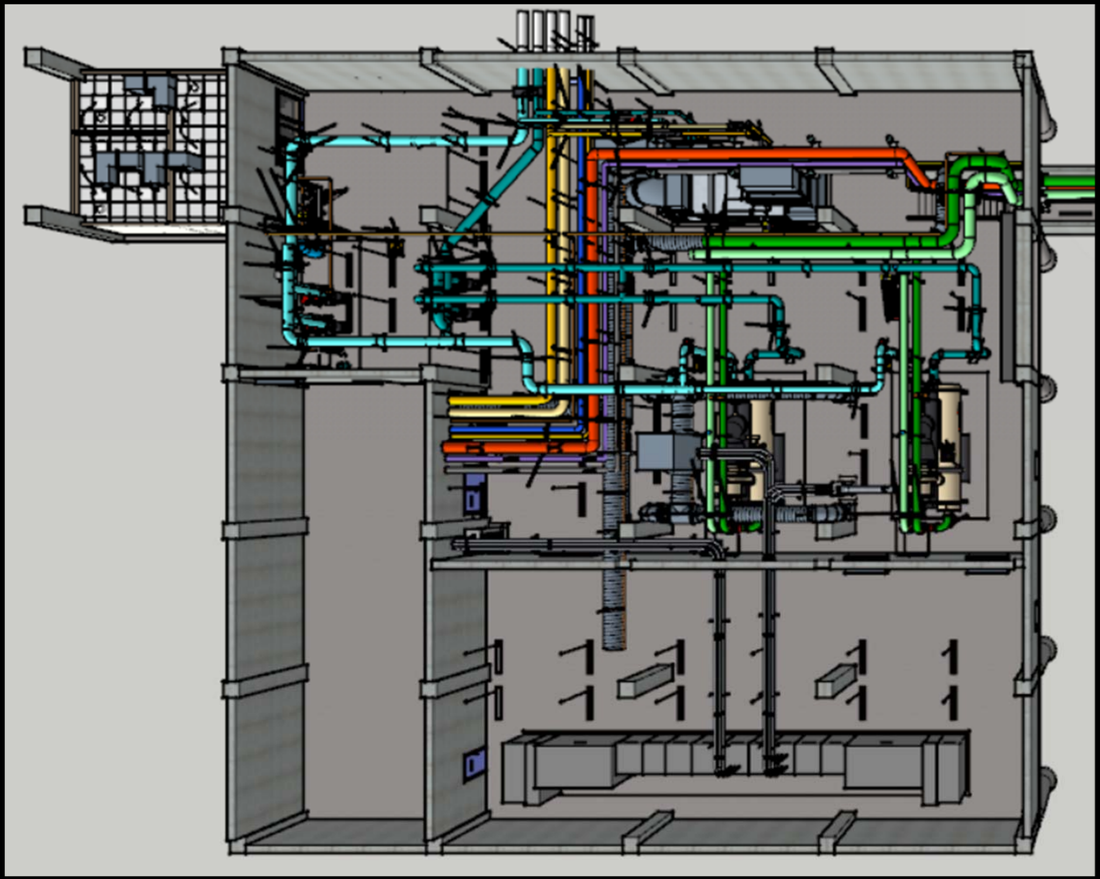
Bell and Gossett
Series e-1510
6G
1150 rpm
13.5"
13.0"
12.5"
12.0"
11.5"
11.0"
10.5"
10"
60%
70%
75%
80%
87%
86%
83%
80%
75%
70%
60%
40 bhp
30 bhp
25 bhp
20 bhp
15 bhp
10 bhp
Wide Open System Curve
Wide Open Operating Point
Installed Impeller
Design Flow
Head, ft.w.c.
Flow, gpm
0
10
20
30
40
50
60
70
80
90
0
500
1,000
1,500
2,000
2,500

Assessing the Plant Load Condition

Break Out Session

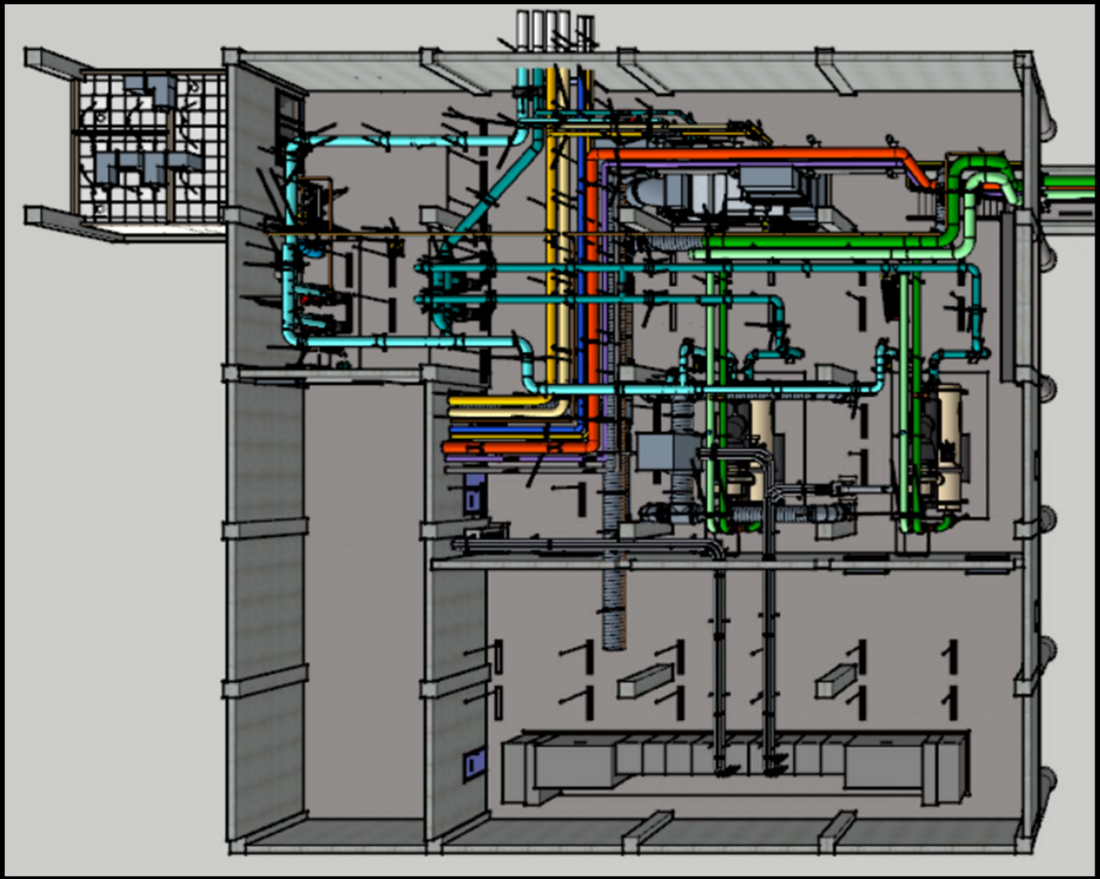
Assessing the Plant Load Condition

Let’s get oriented



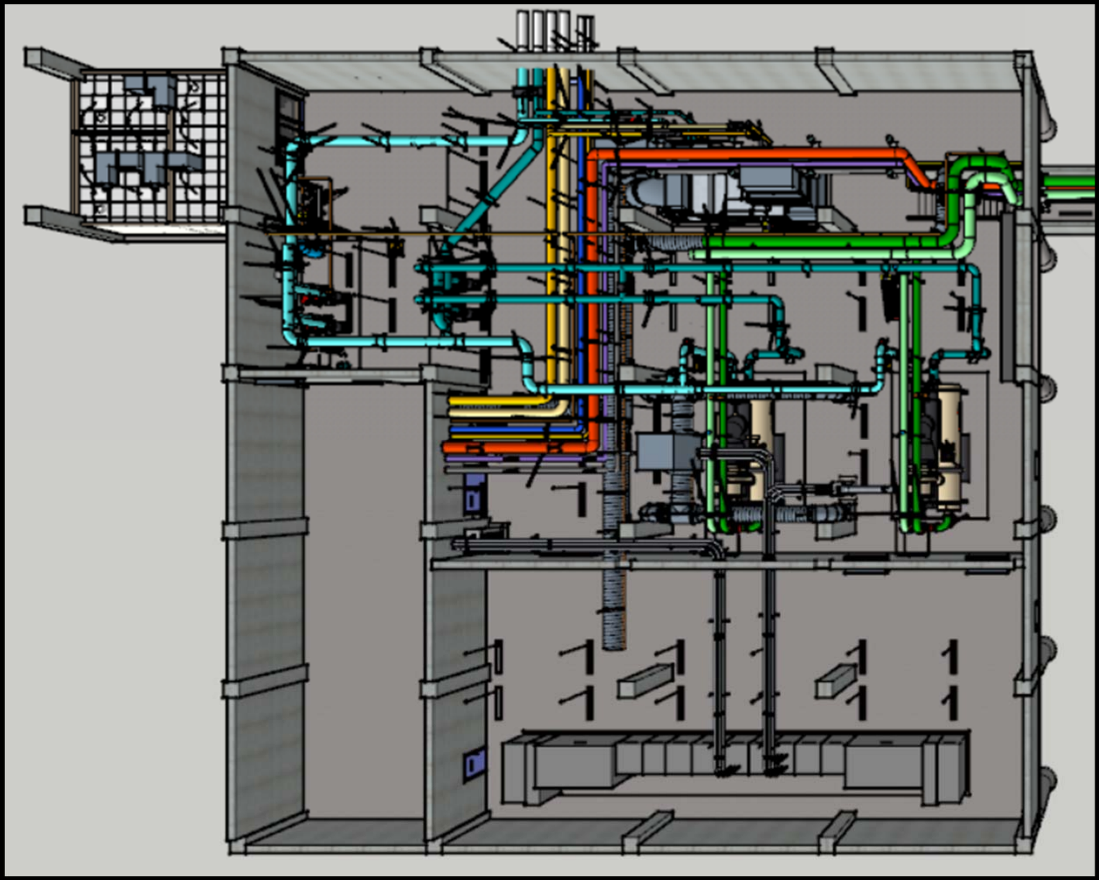
Given:

- The central plant model
- The drawings you have for the plant
- The work we have done up to this point



Assignment:

- Estimate the current load condition on the central plant
- Look for ways that you could develop a load profile
  - There could be more than one
  - Some will be better than others
  - What are the pro's and con's for your list?



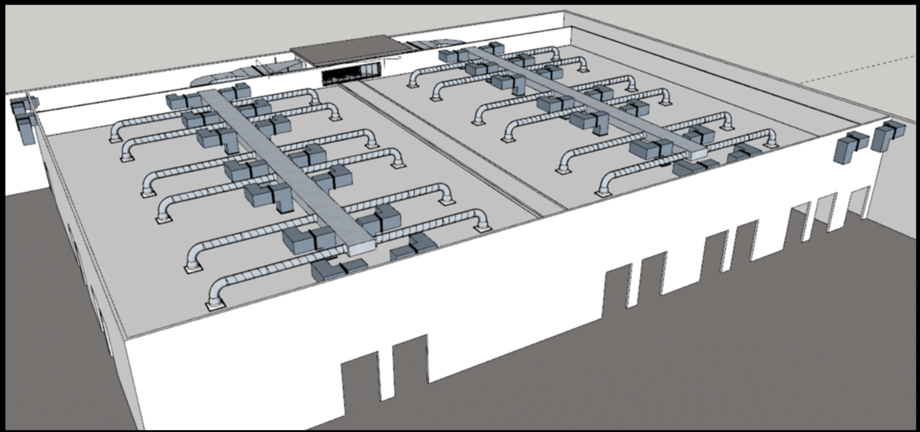
Let's Go to the Breakout Rooms

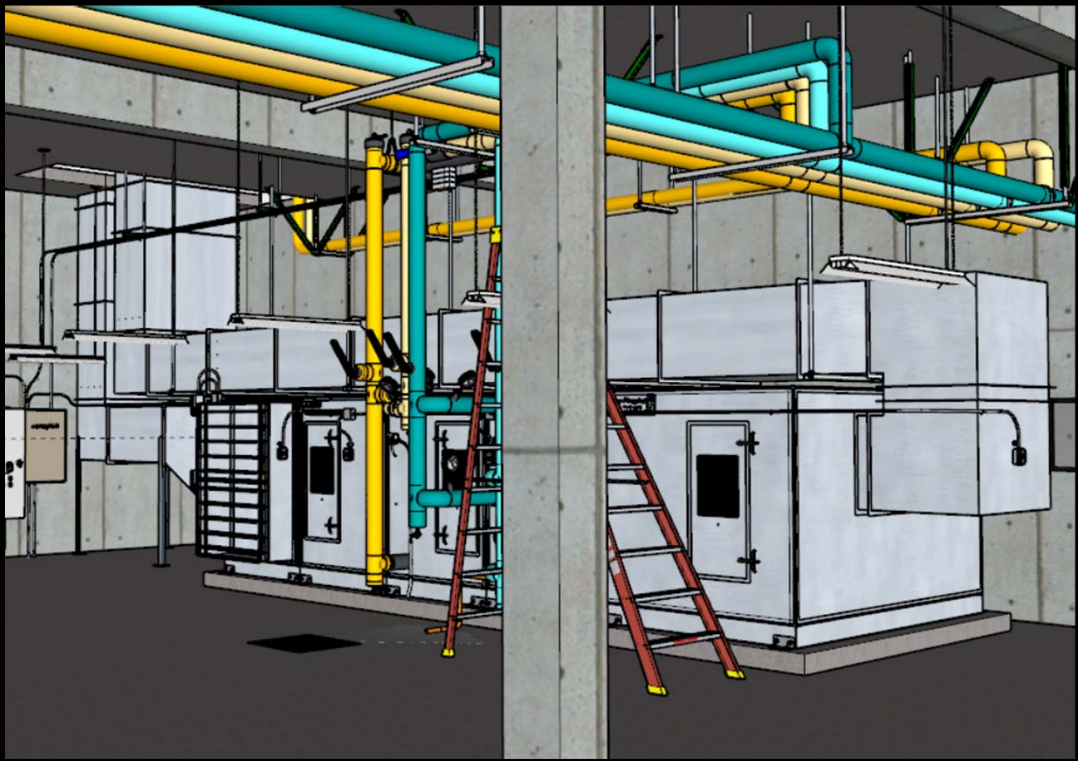
Scoping the Ball Room AHU

Break Out Session

Scoping the Ball Room AHU

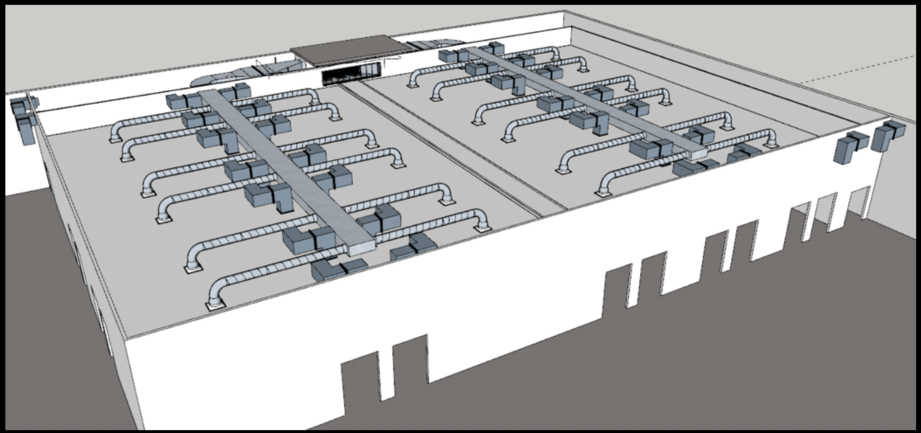
The Ball Room AHU is one of the components of the current load on the central plant

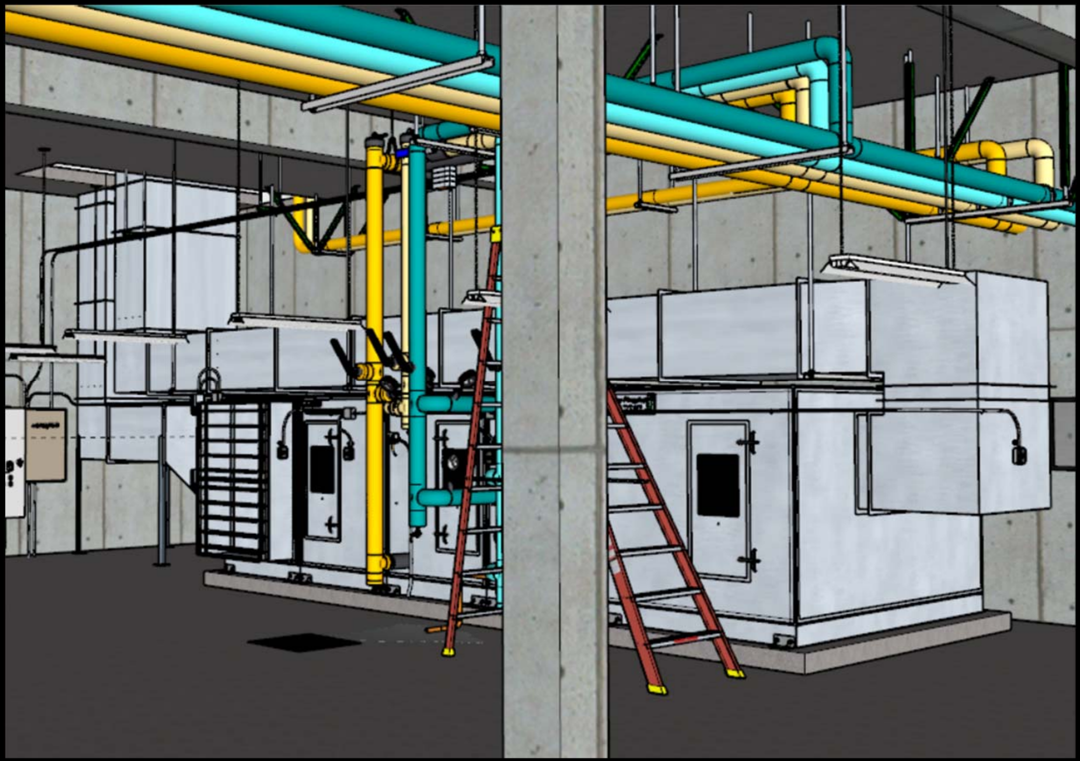




Scoping the Ball Room AHU

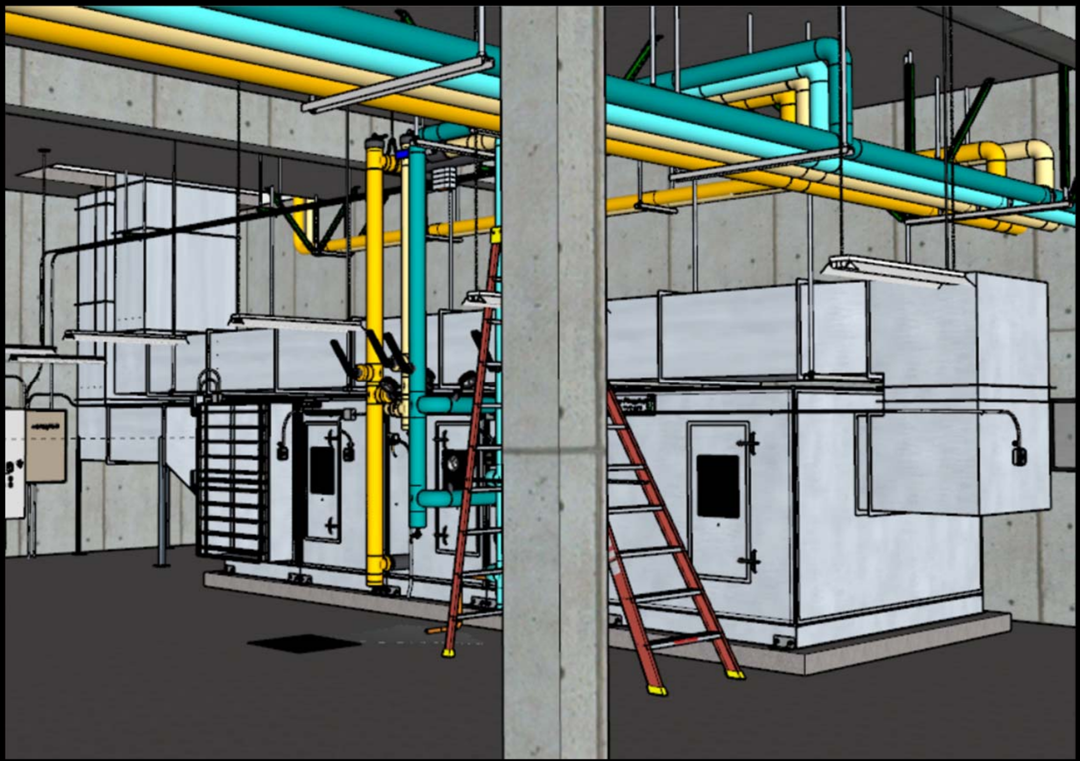
Let's Get Oriented





Given:

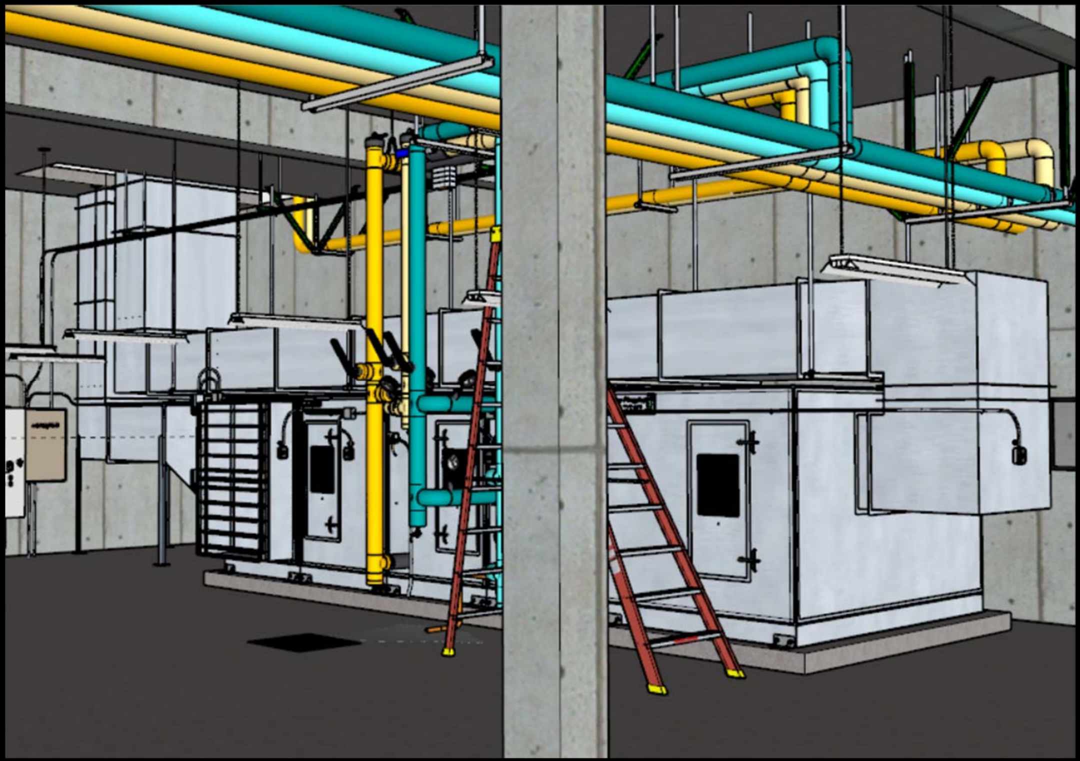
- The Ball Room AHU model
- The documents you have for the equipment room and ball room
- Previous observations



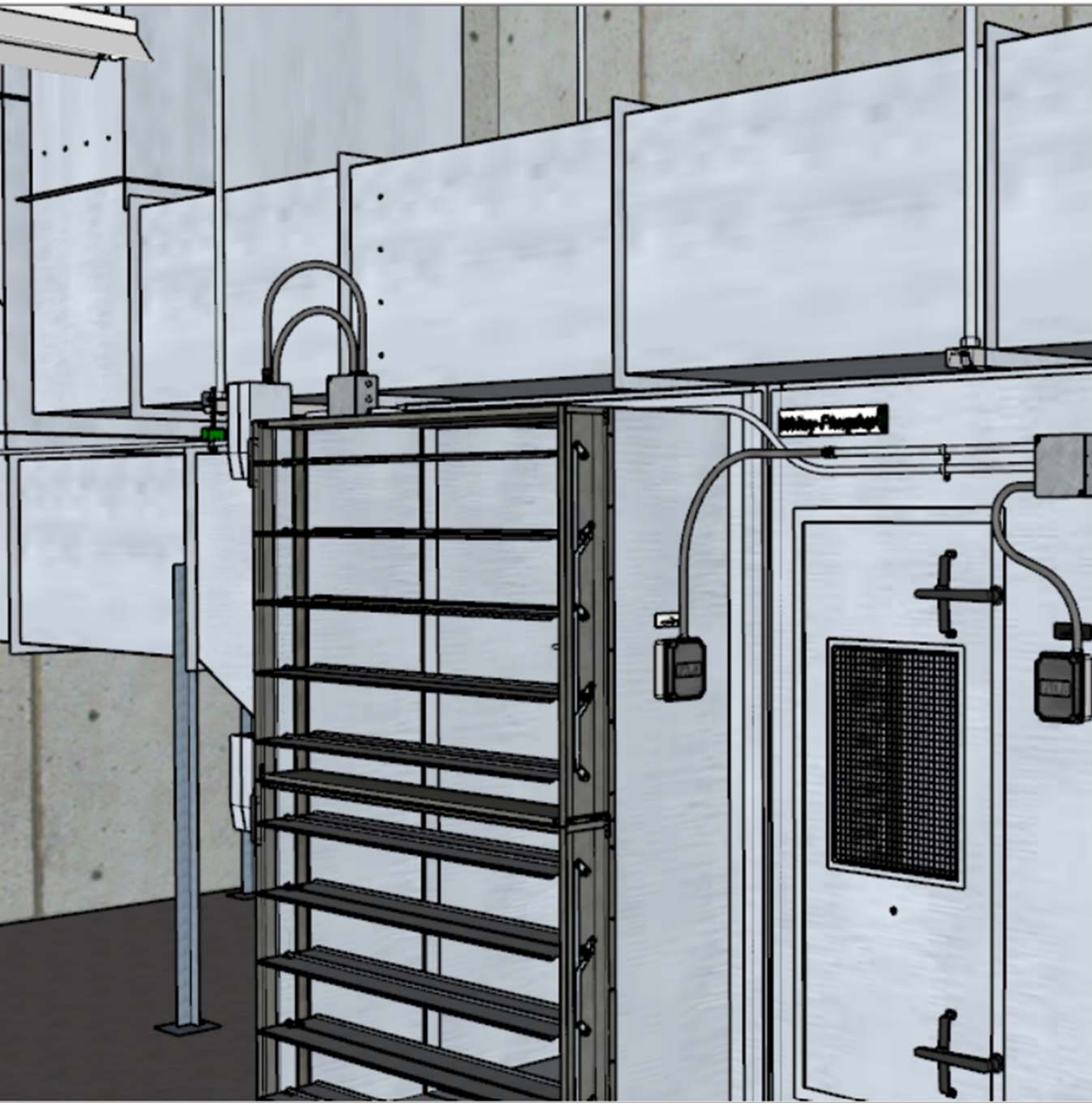
Assignment:

Scope the Ball Room AHU and expand the findings list

- Are you finding things that may be contributors to the load condition you observed at the central plant?
- If so, why?



Let’s Go to the Breakout Rooms



An HVAC Relationship and Few Handy Rules of Thumb for Assessing an Economizer in the Field

An HVAC Relationship and Few Handy Rules of Thumb for Assessing an Economizer in the Field

Velocity, flow rate and cross-sectional area are all related:

$$Q = V \times A$$

Where:

Q = Flow rate in consistent units

V = Velocity in consistent units

A = Area in consistent units

For example $\frac{ft}{\text{min}} \times ft^2 = \frac{ft^3}{\text{min}}$

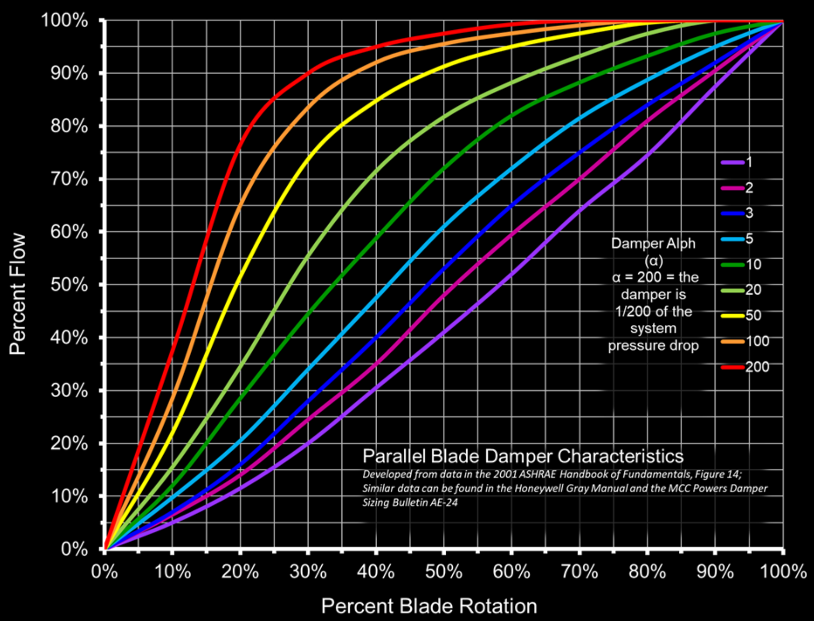
An HVAC Relationship and Few Handy Rules of Thumb for Assessing an Economizer in the Field

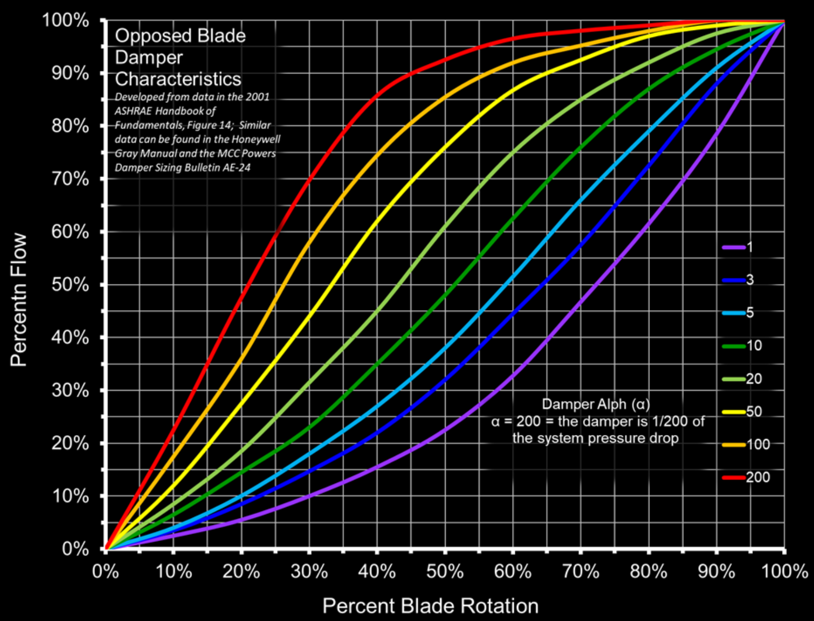
As a general rule, air handing unit face velocities will be 500 fpm or less with a lower limit of approximately 350 fpm.

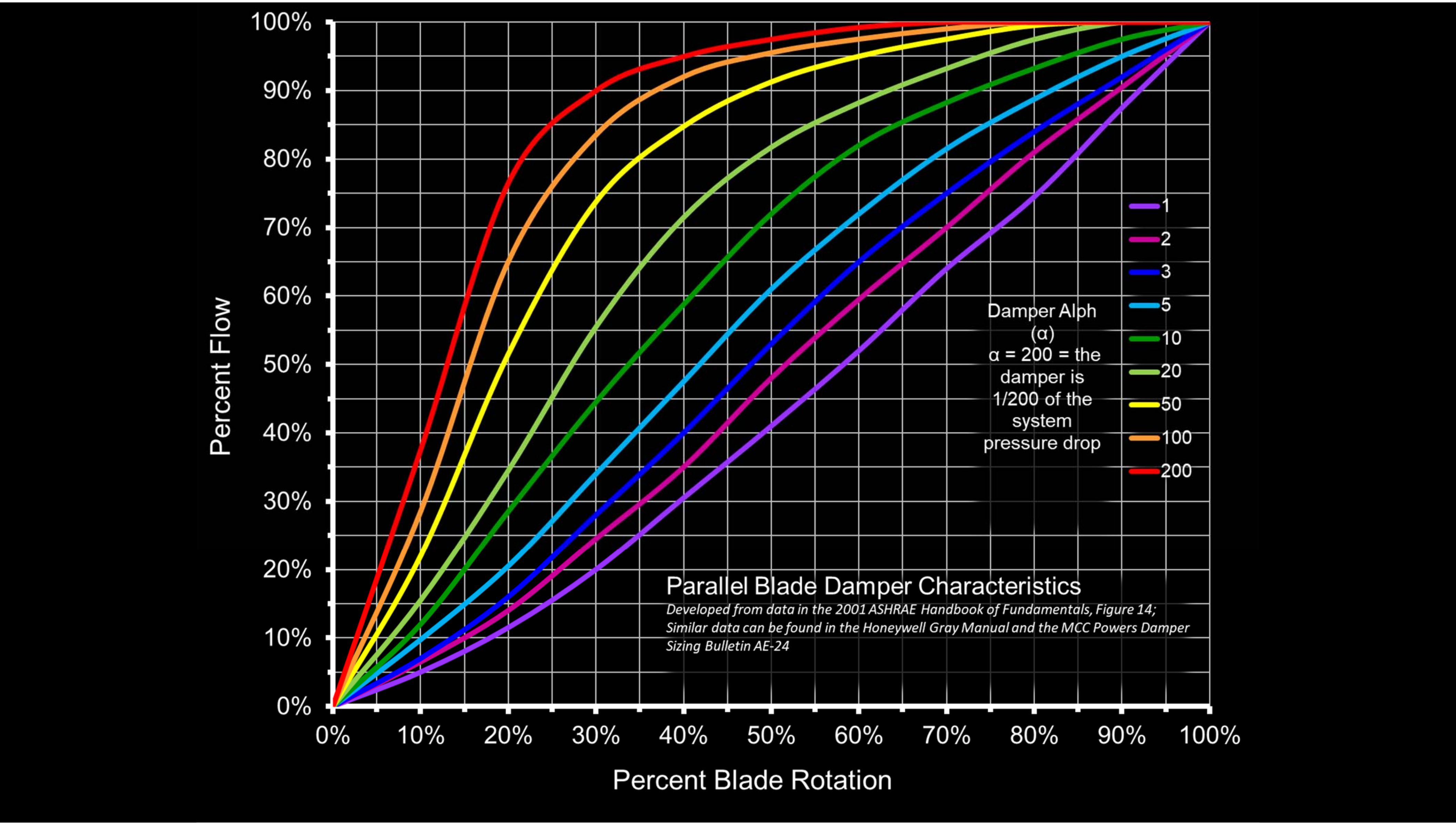
As a general rule, for a modulating control damper in an HVAC system to have a reasonable, somewhat linear flow characteristic, the face velocity through the damper will need to be in the range of 1,500 fpm to 2,500 fpm.

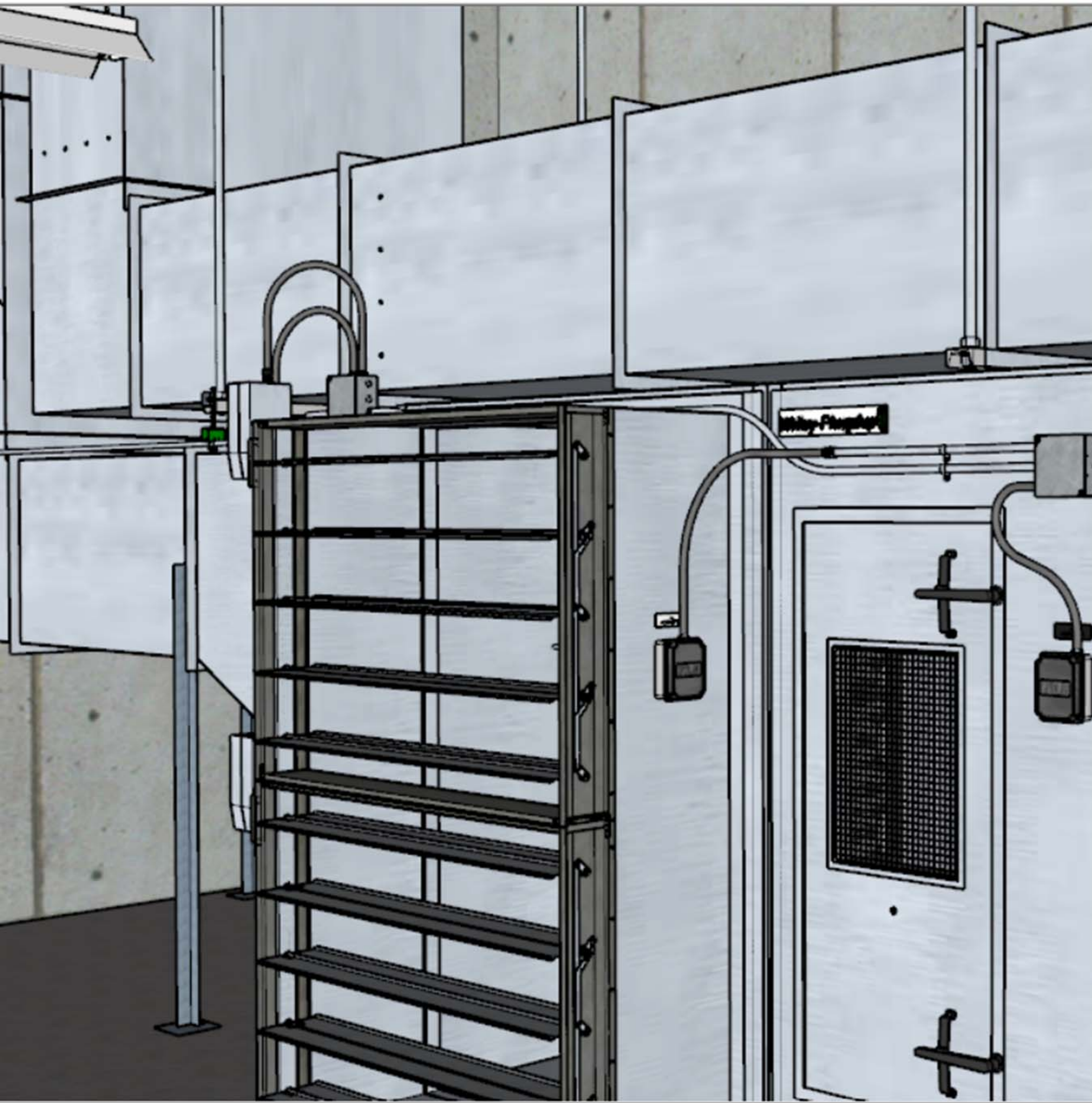
An HVAC Relationship and Few Handy Rules of Thumb for Assessing an Economizer in the Field

As a general rule, for a modulating control damper in an HVAC system to have a reasonable, somewhat linear flow characteristic, the face velocity through the damper will need to be in the range of 1,500 fpm to 2,500 fpm.






100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Flow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Blade Rotation
1
2
3
5
10
20
50
100
200
Damper Alph (α)
α = 200 = the damper is 1/200 of the system pressure drop
Parallel Blade Damper Characteristics
Developed from data in the 2001 ASHRAE Handbook of Fundamentals, Figure 14; Similar data can be found in the Honeywell Gray Manual and the MCC Powers Damper Sizing Bulletin AE-24



Given:

- The Ball Room AHU Economizer (Scenes 10 and 11 will be handy)
- The documents you have for the equipment room and ball room
- The relationships we just discussed

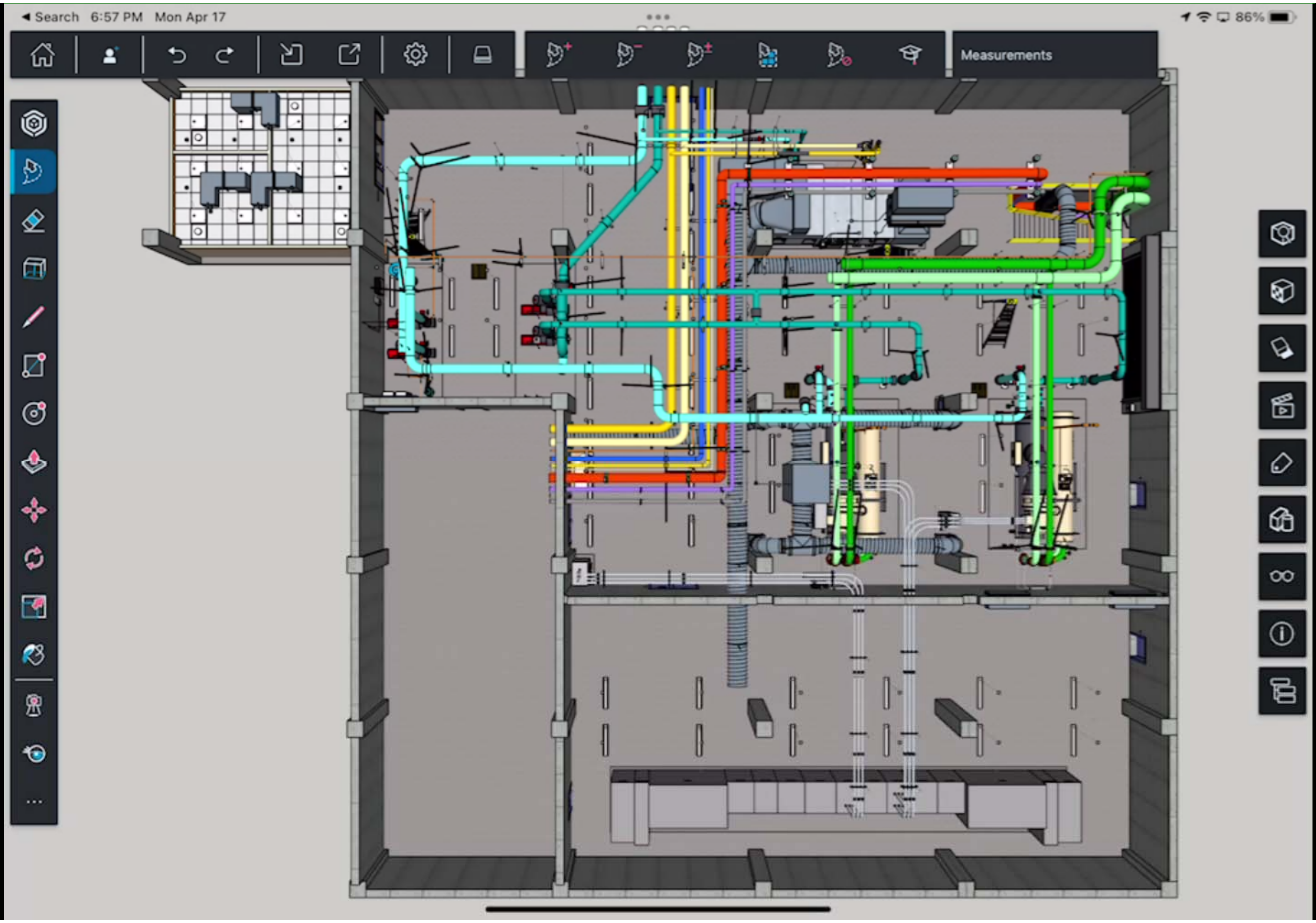
Assignment

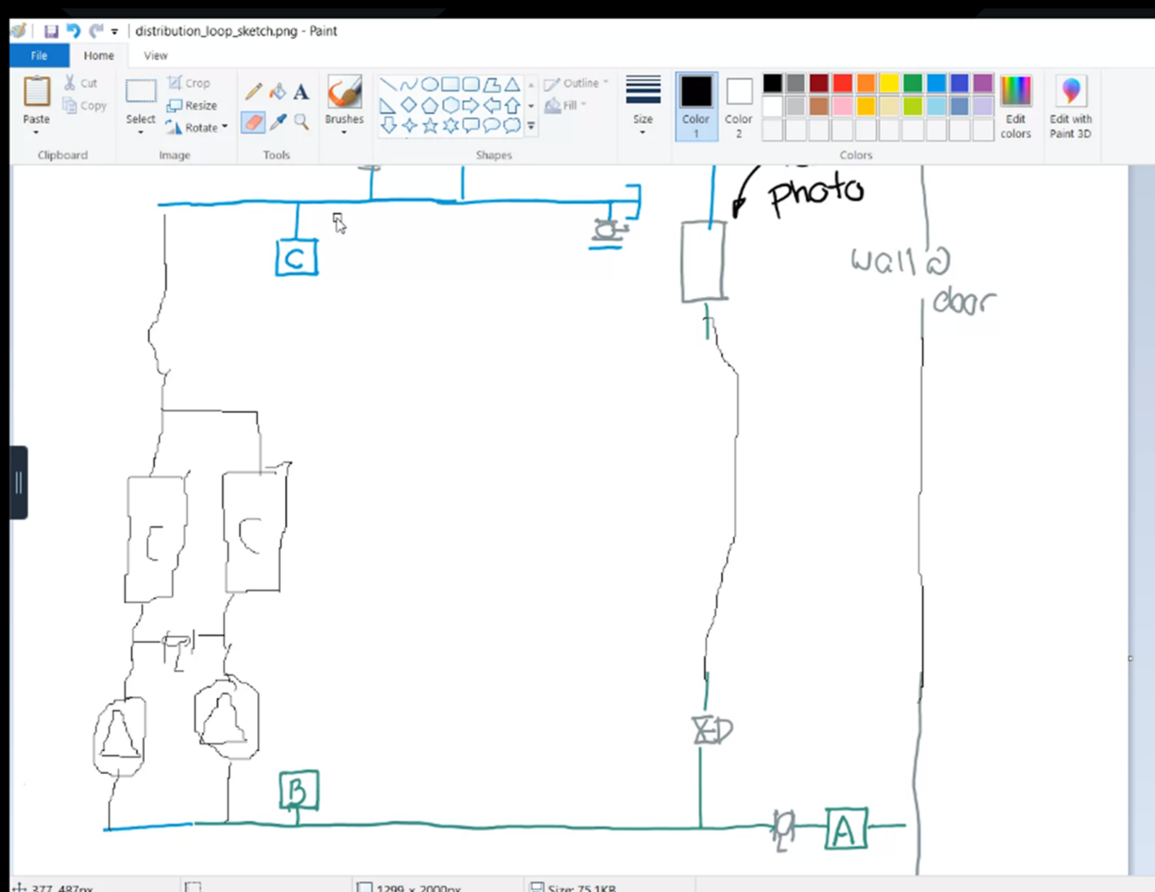
Evaluate the Ball Room AHU Economizer dampers

- Do you think the dampers will have a linear characteristic
- Do you think mixing will be thorough?
- What are some of the implications of your observations?

Let’s Go to the Breakout Rooms

Developing a System Diagram in the Field


◂ Search 6:57 PM Mon Apr 17
86%
Measurements


distribution_loop_sketch.png - Paint
File
Home
View
Paste
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Clipboard
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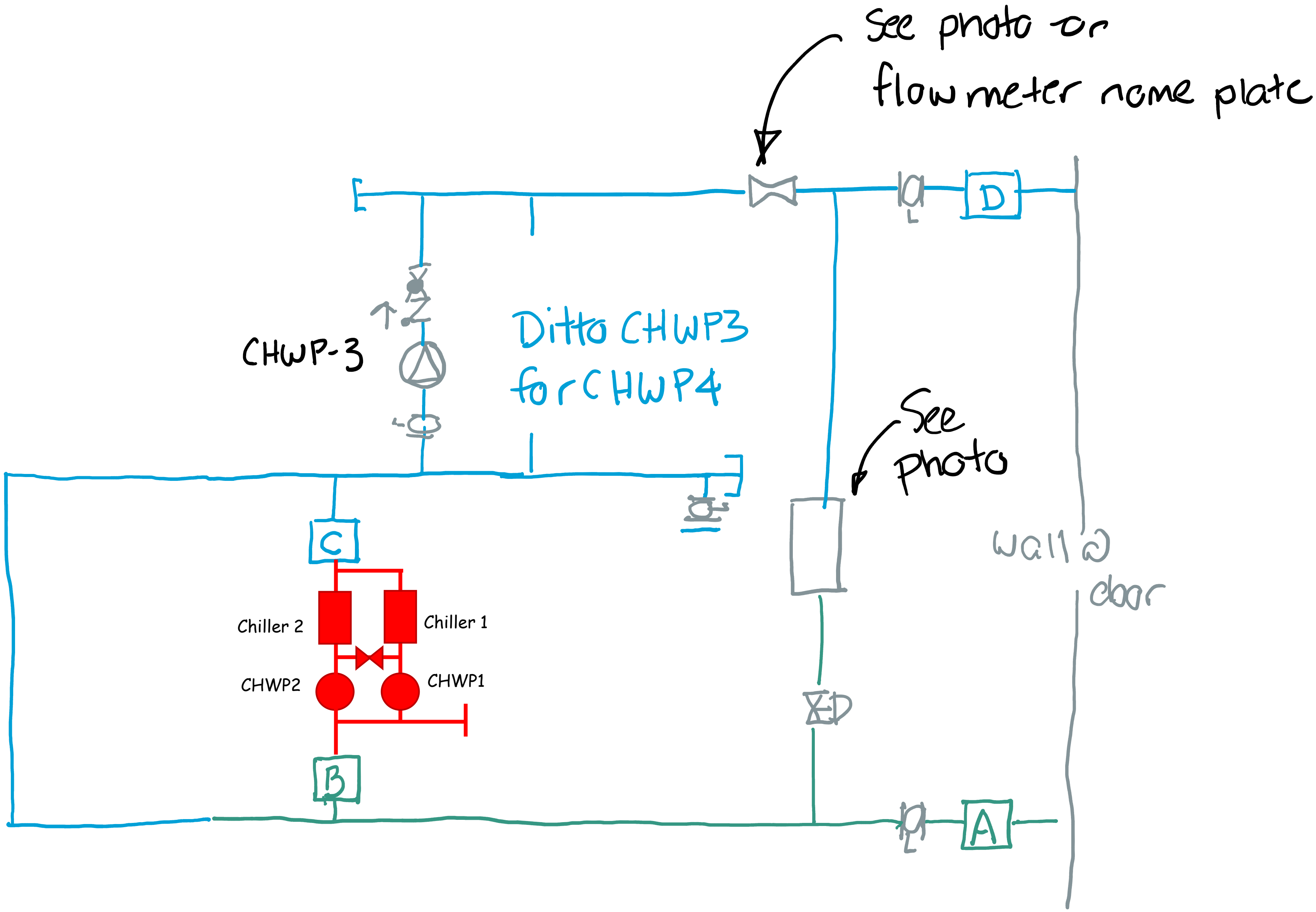
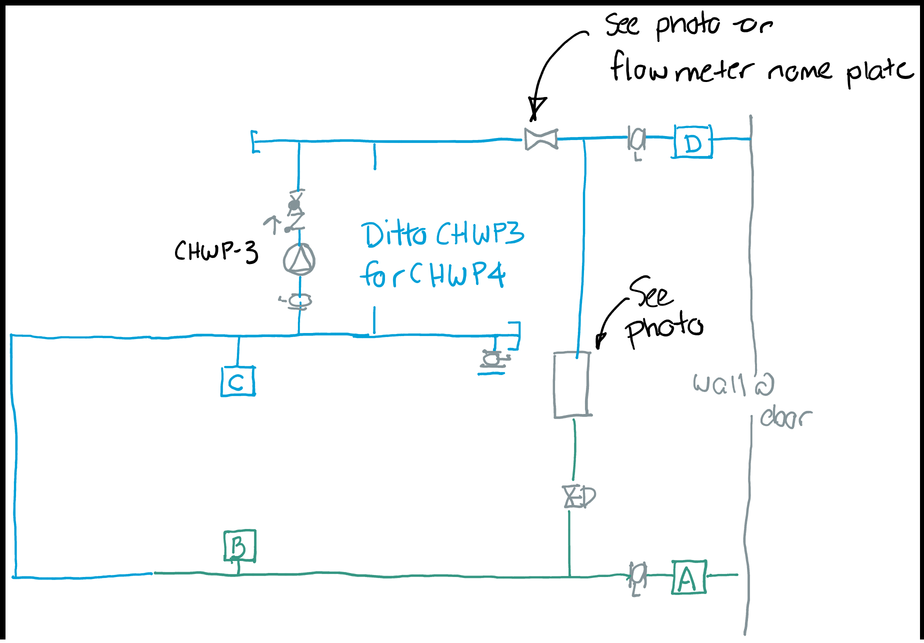
Crop
Resize
Rotate
Image
Tools
Brushes
Outline
Fill
Shapes
Size
Color 1
Color 2
Colors
Edit colors
Edit with Paint 3D
photo
wall @ door
C
B
A
377, 487px
1299 × 2000px
Size: 75.1KB

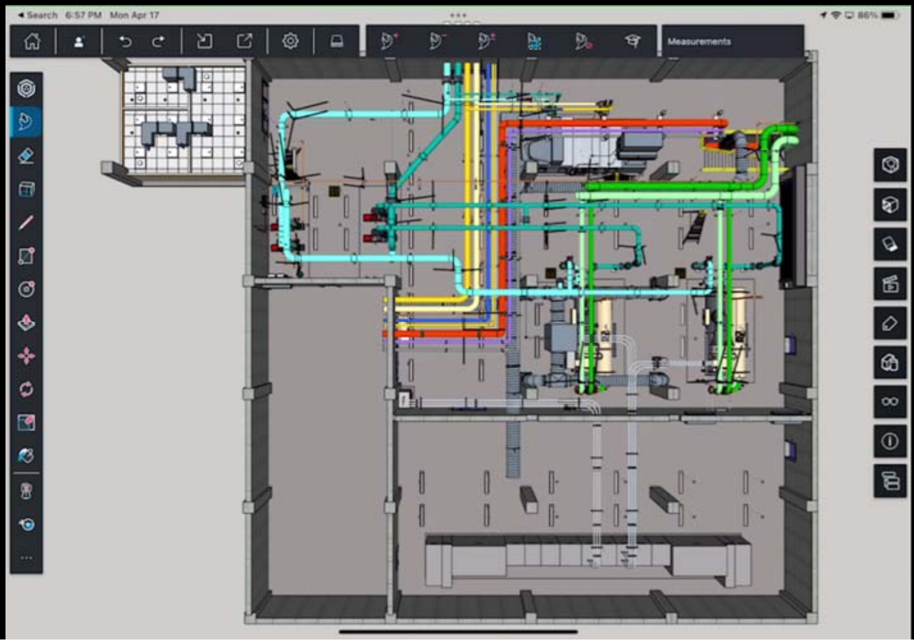
The Distribution Loop



Given:

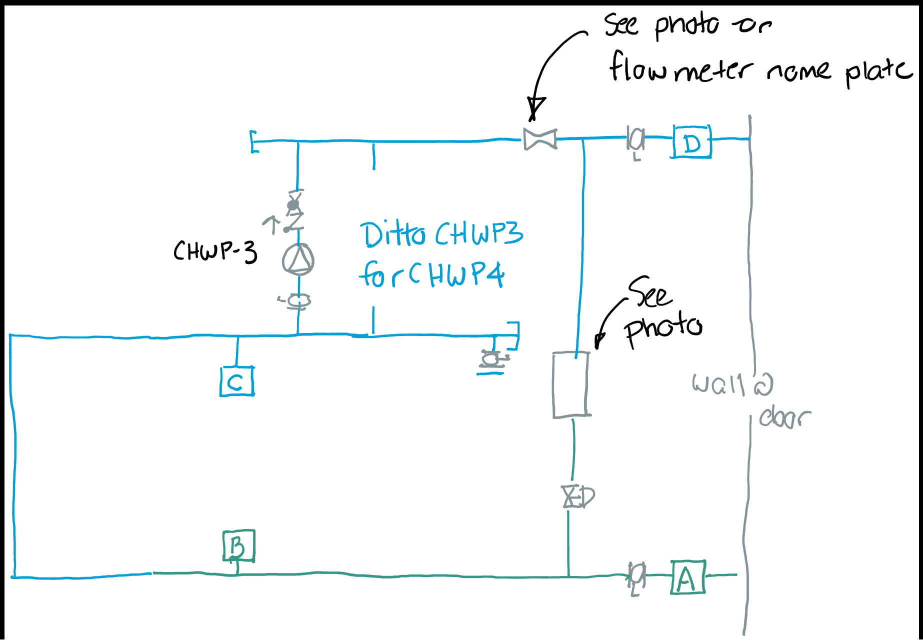
- The distribution loop sketch
- The Hijend Hotel chilled water plant model

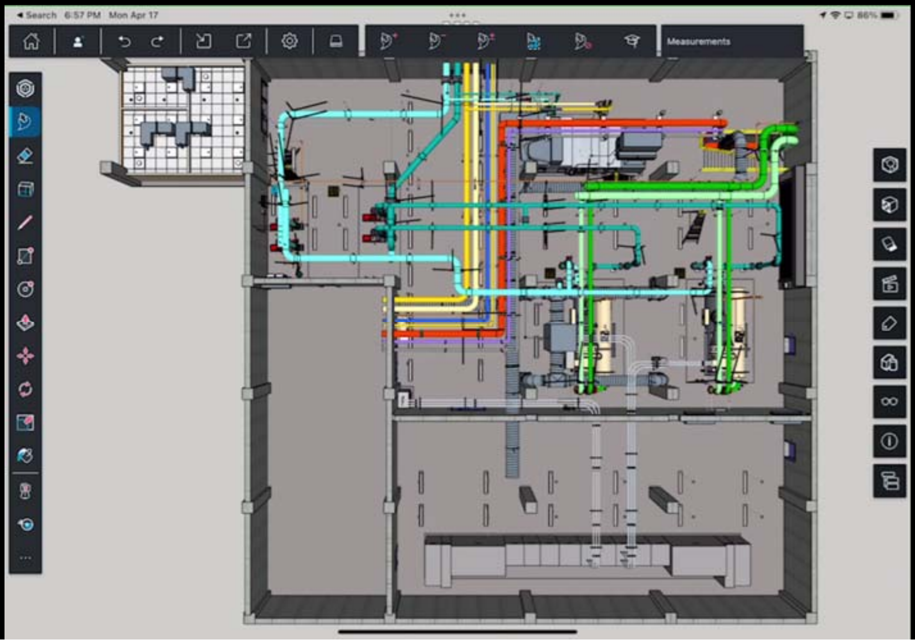




Assignment:

- Add the evaporator loops to the sketch (hint: they will plug in between points C and D)



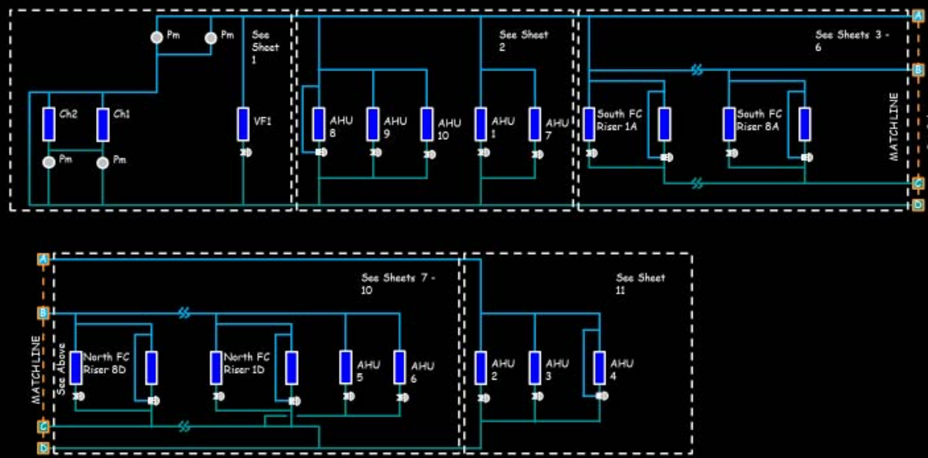


Let’s Go to the Breakout Rooms

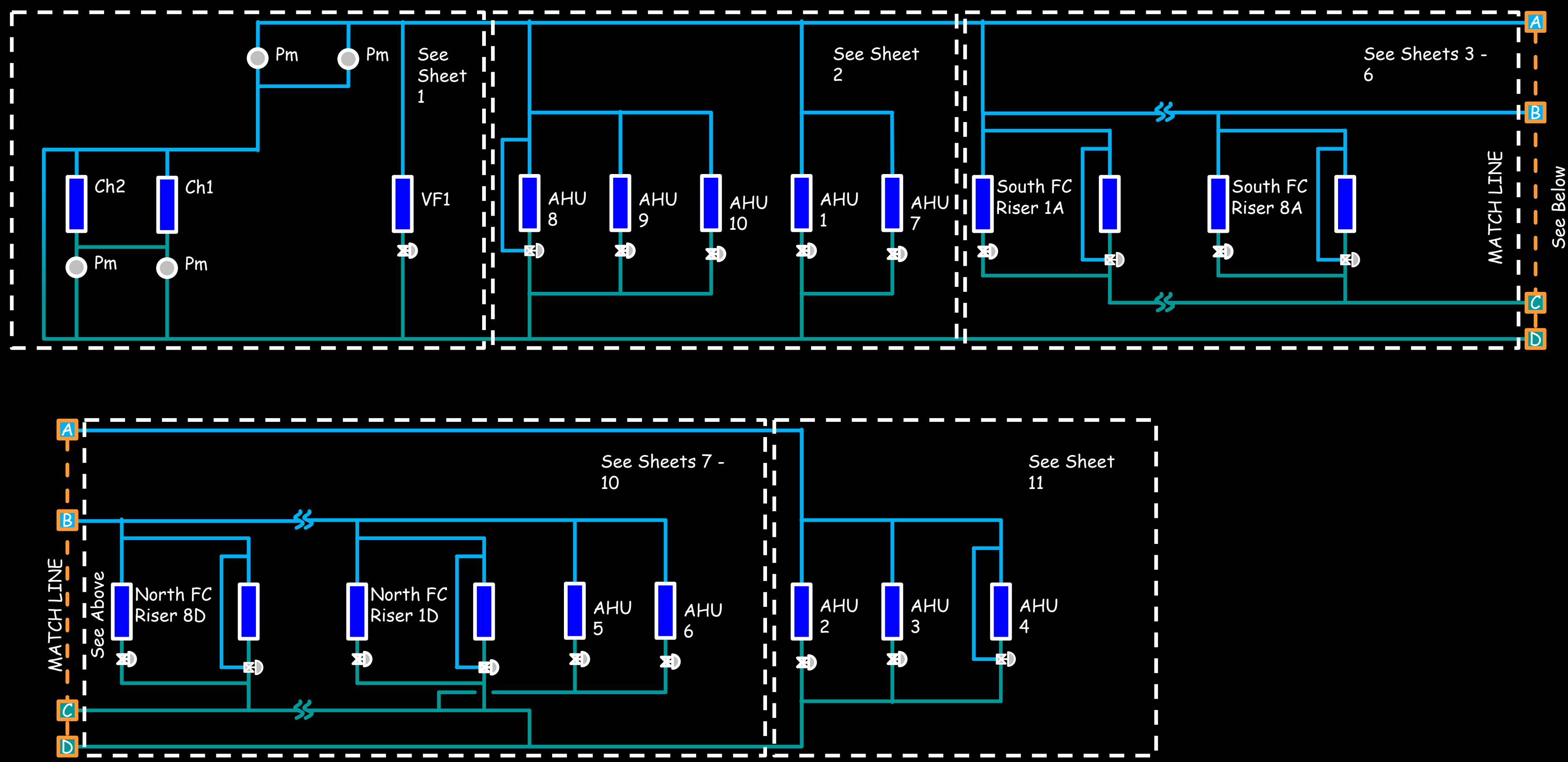
A System Diagram Development "Plan B"

- Develop a first draft diagram from the project documents
- Field verify it

The Simplified Design Intent System Diagram

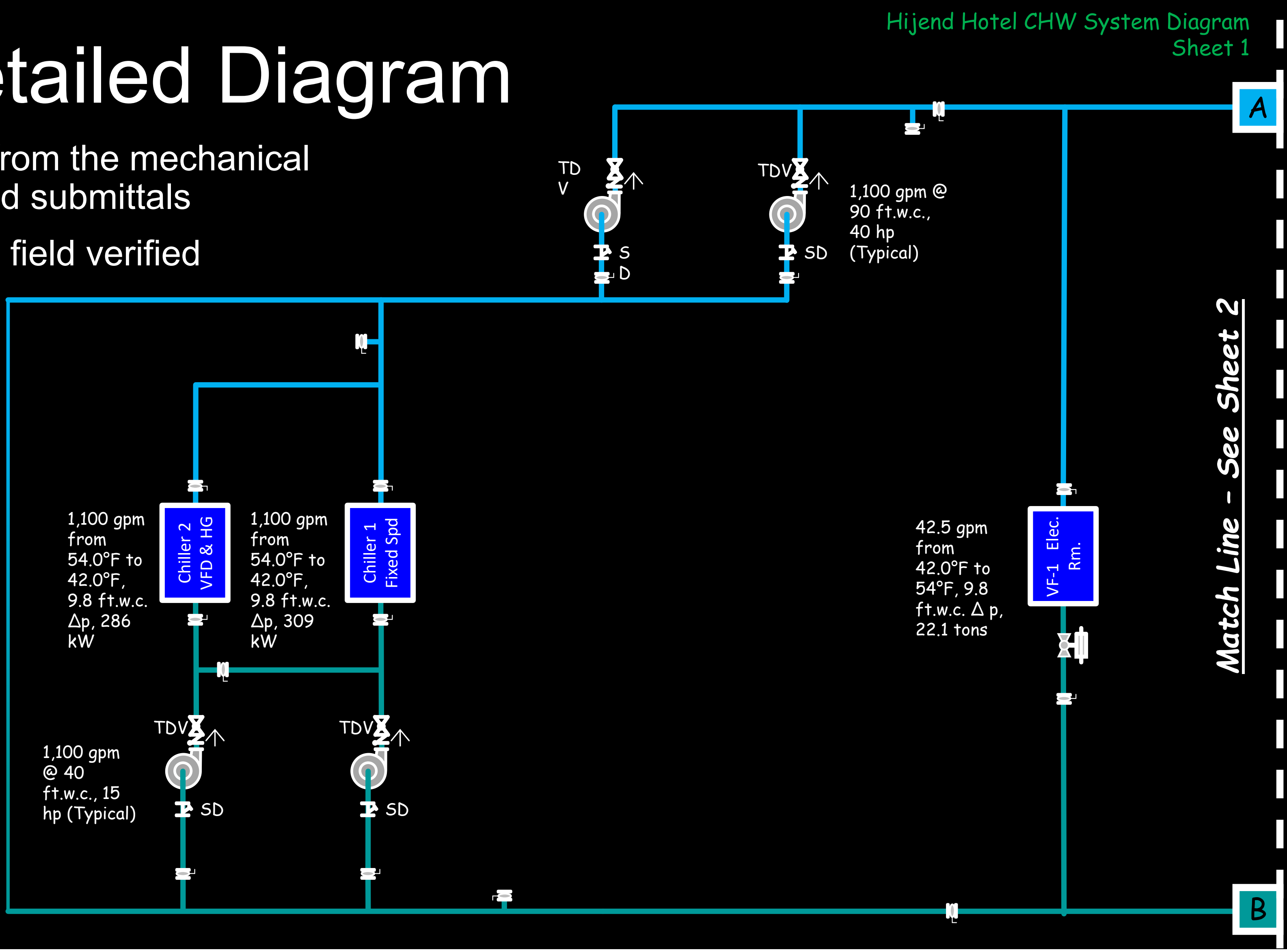


The Simplified Design Intent System Diagram

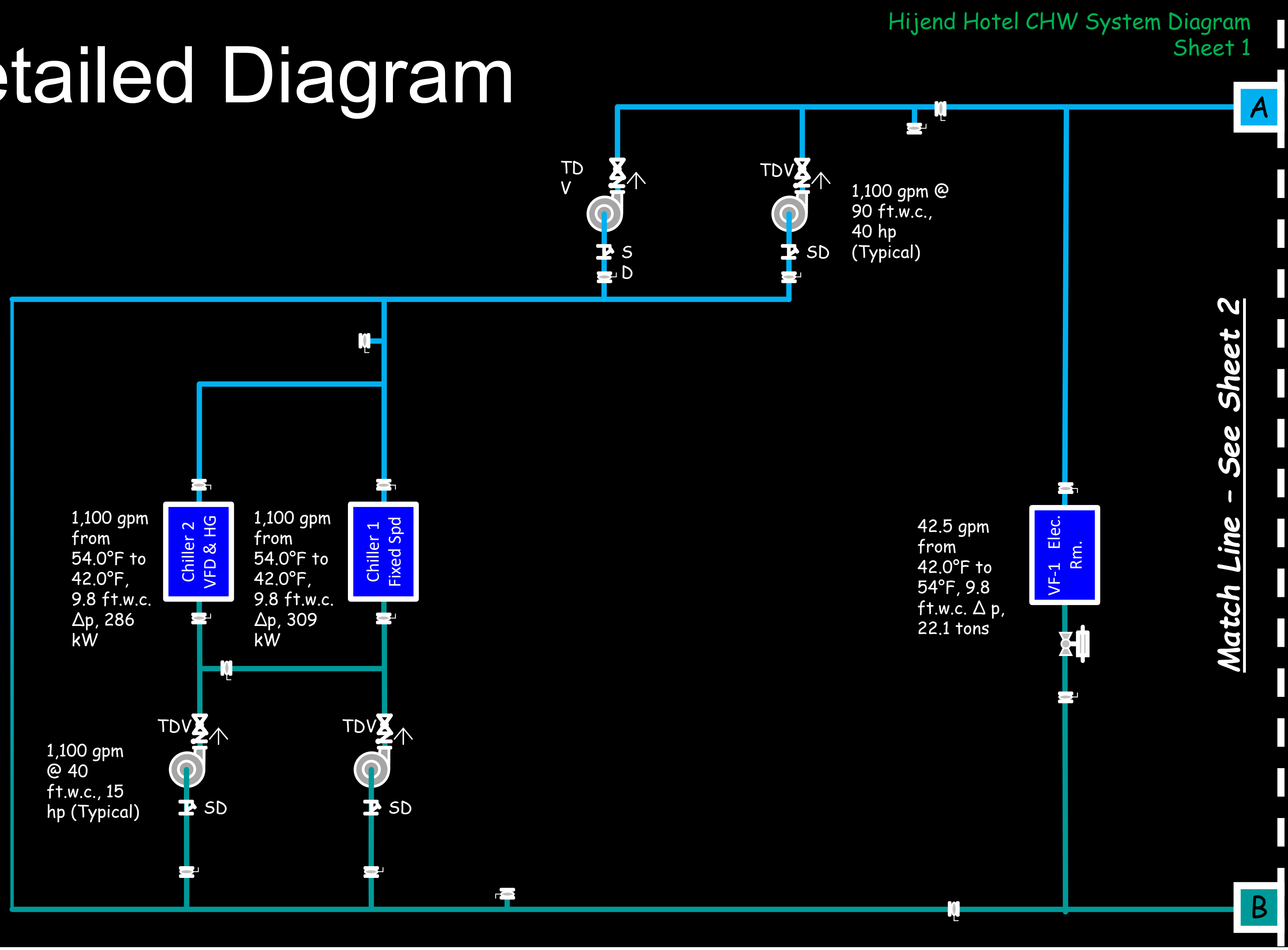


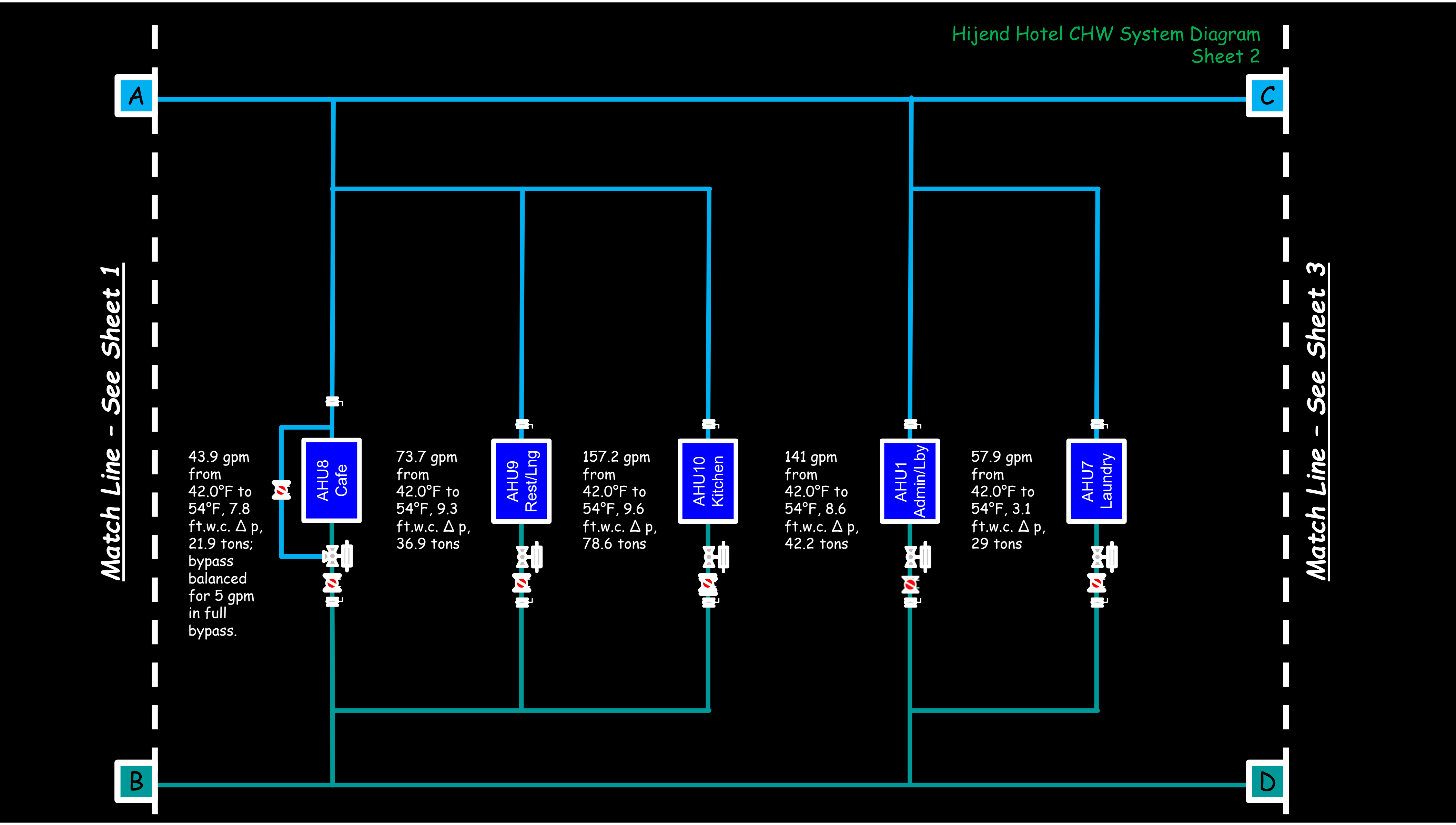
The Detailed Diagram

- Developed from the mechanical drawings and submittals
- Needs to be field verified

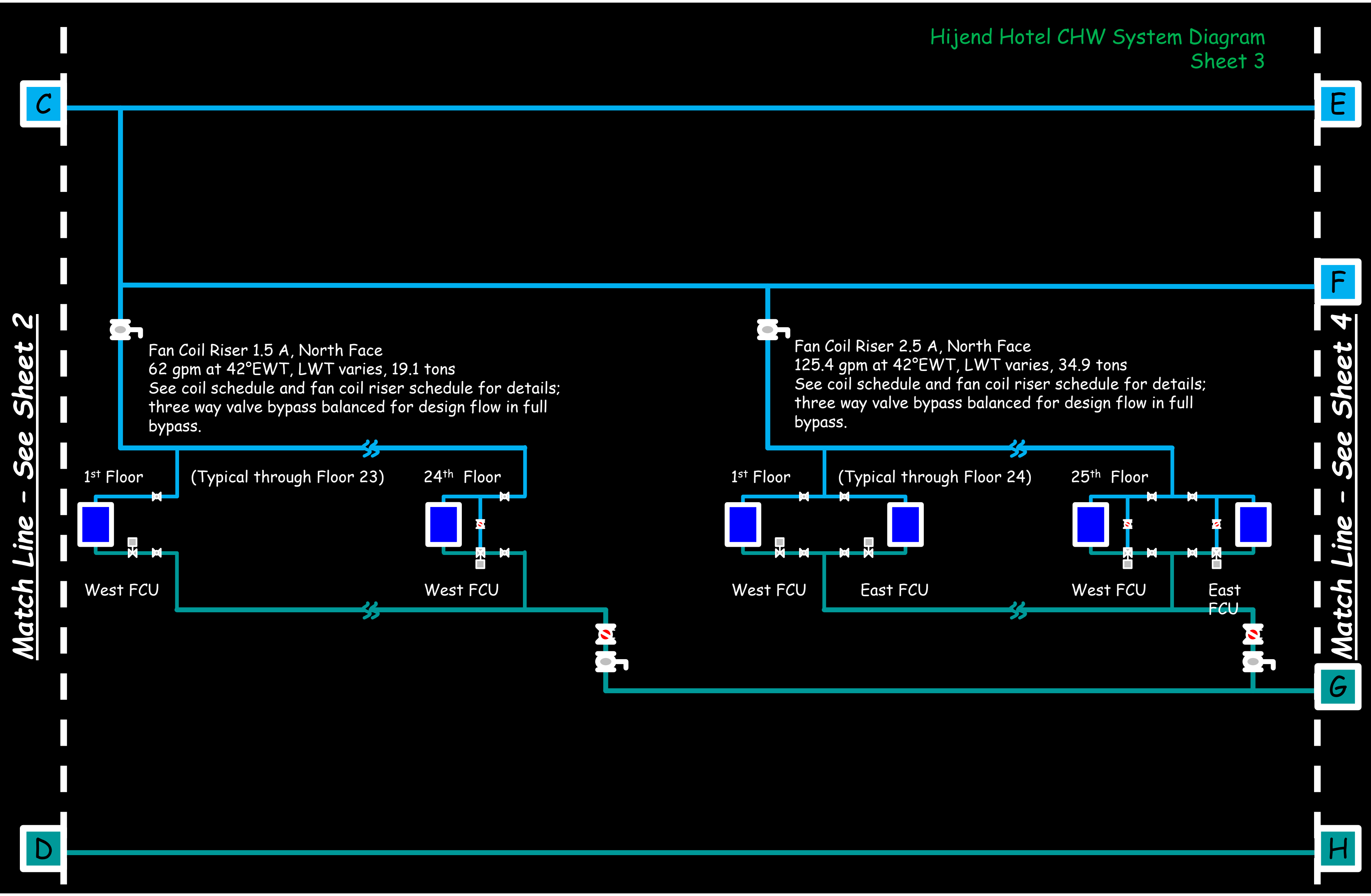


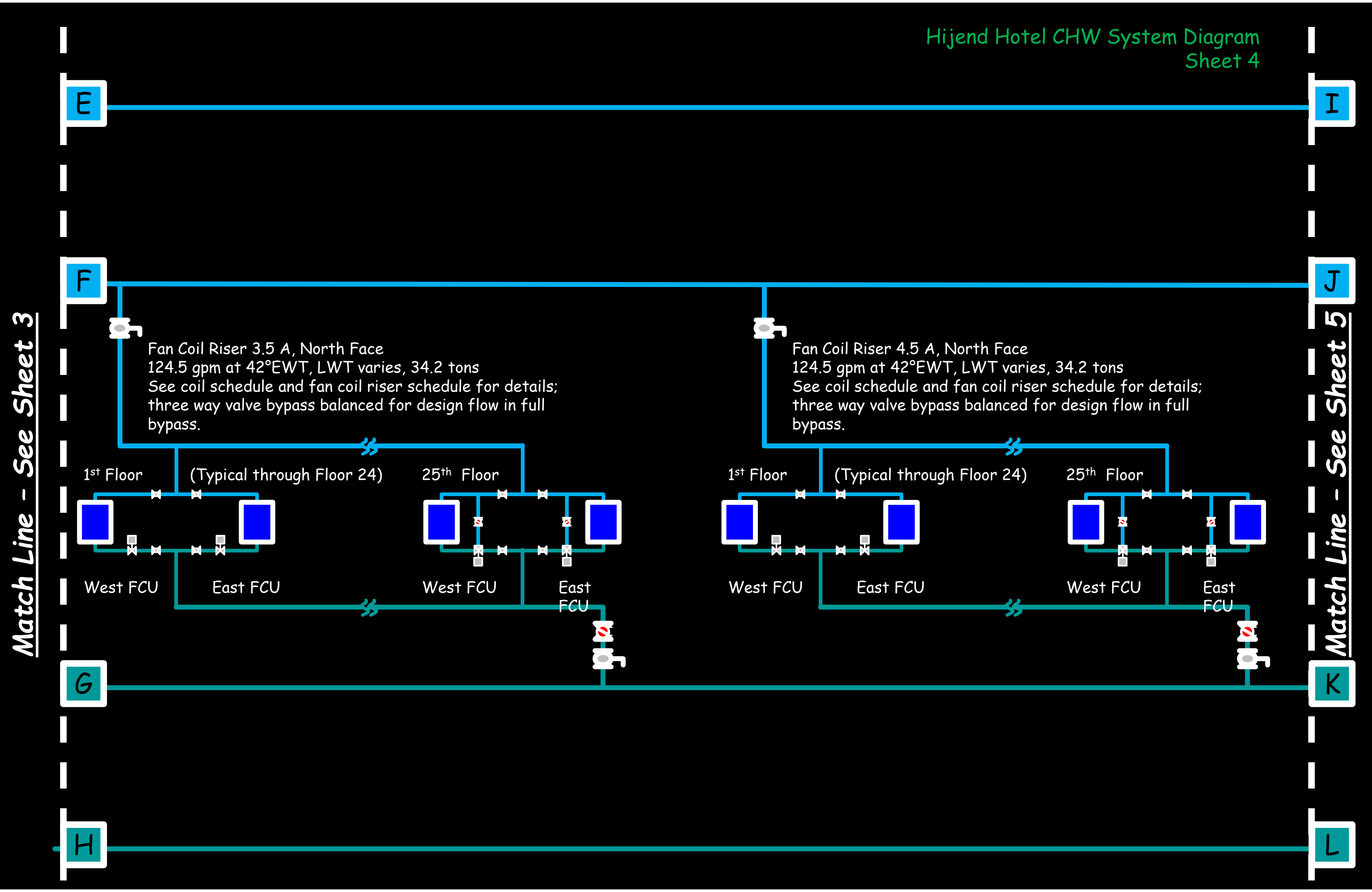
The Detailed Diagram



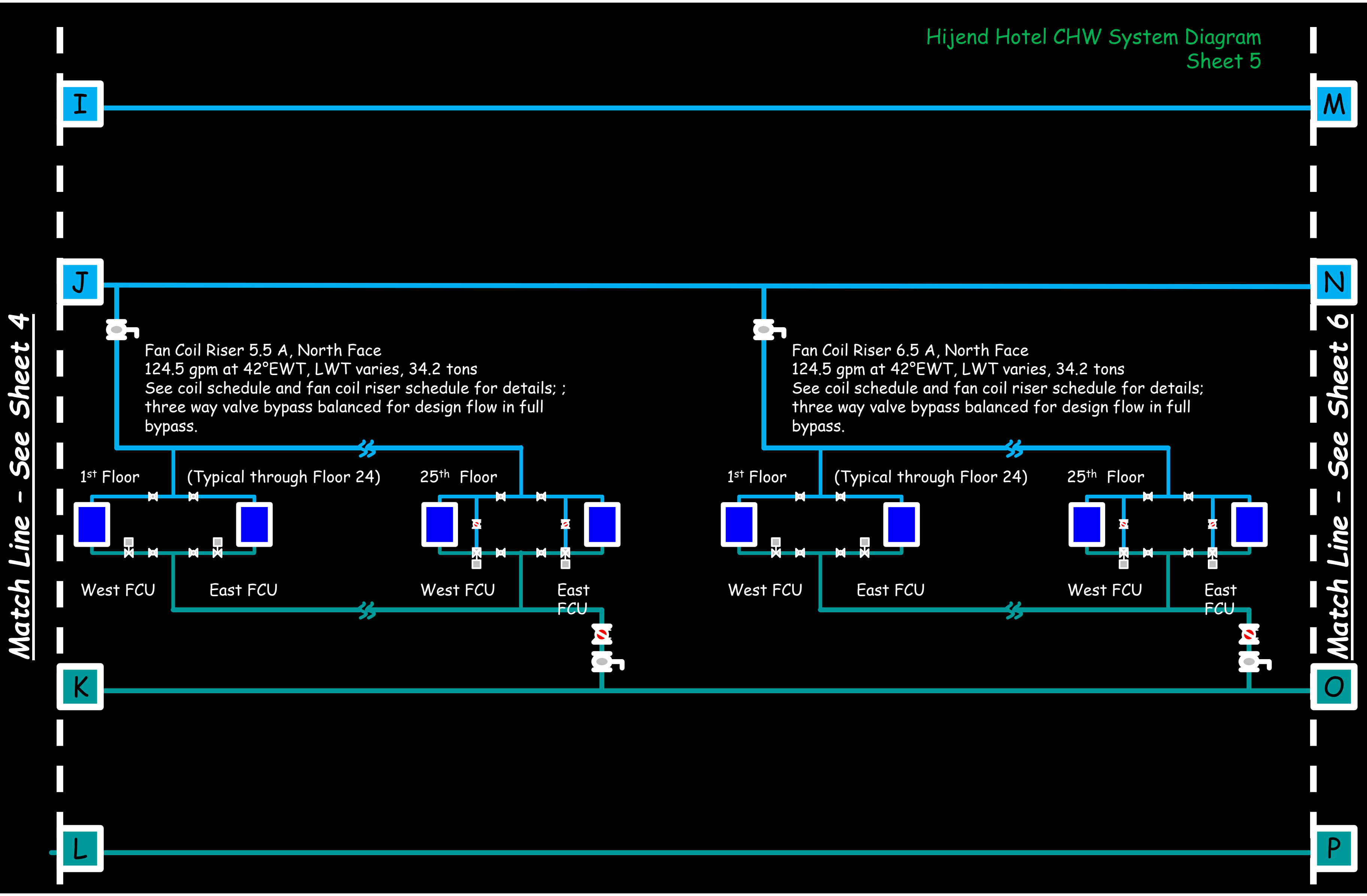


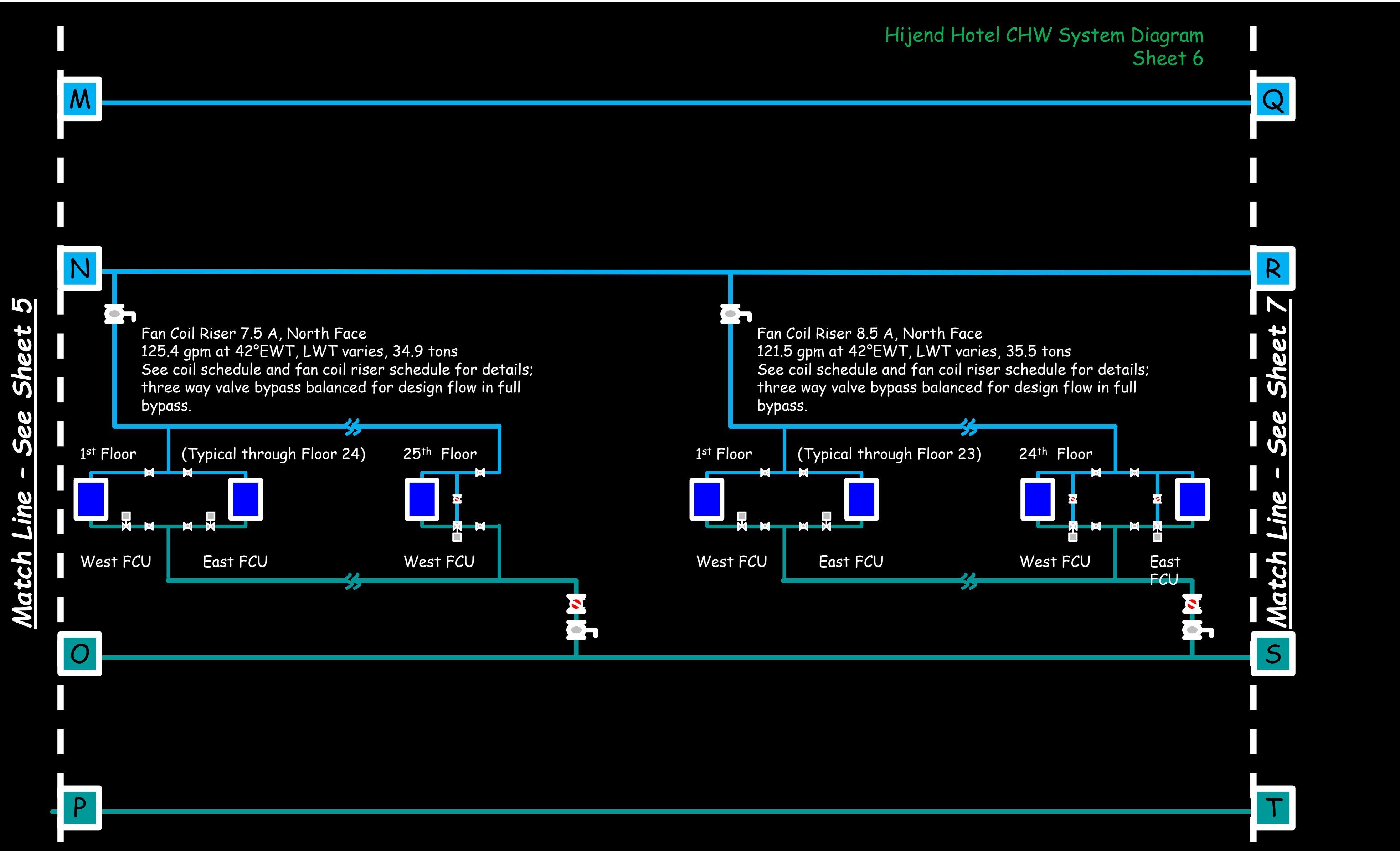
Hijend Hotel CHW System Diagram
Sheet 2
A
B
C
D
Match Line - See Sheet 1
Match Line - See Sheet 3
AHU8
Cafe
AHU9
Rest/Lng
AHU10
Kitchen
AHU1
Admin/Lby
AHU7
Laundry
43.9 gpm from 42.0°F to 54°F, 7.8 ft.w.c. Δ p, 21.9 tons; bypass balanced for 5 gpm in full bypass.
73.7 gpm from 42.0°F to 54°F, 9.3 ft.w.c. Δ p, 36.9 tons
157.2 gpm from 42.0°F to 54°F, 9.6 ft.w.c. Δ p, 78.6 tons
141 gpm from 42.0°F to 54°F, 8.6 ft.w.c. Δ p, 42.2 tons
57.9 gpm from 42.0°F to 54°F, 3.1 ft.w.c. Δ p, 29 tons

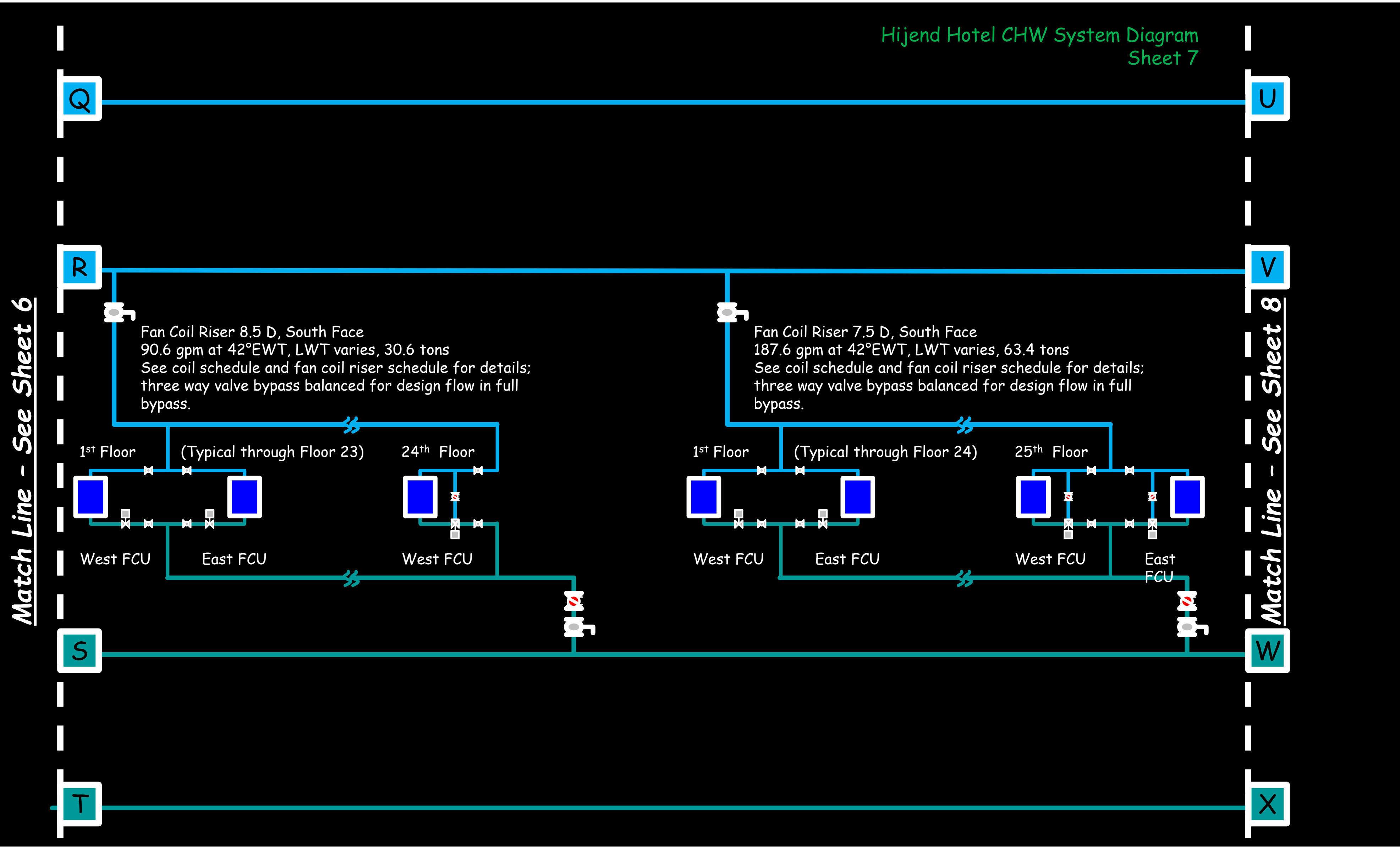

Hijend Hotel CHW System Diagram
Sheet 3
C
E
F
D
H
G
Match Line - See Sheet 2
Match Line - See Sheet 4
Fan Coil Riser 1.5 A, North Face
62 gpm at 42°EWT, LWT varies, 19.1 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 23)
24th Floor
West FCU
West FCU
Fan Coil Riser 2.5 A, North Face
125.4 gpm at 42°EWT, LWT varies, 34.9 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East FCU



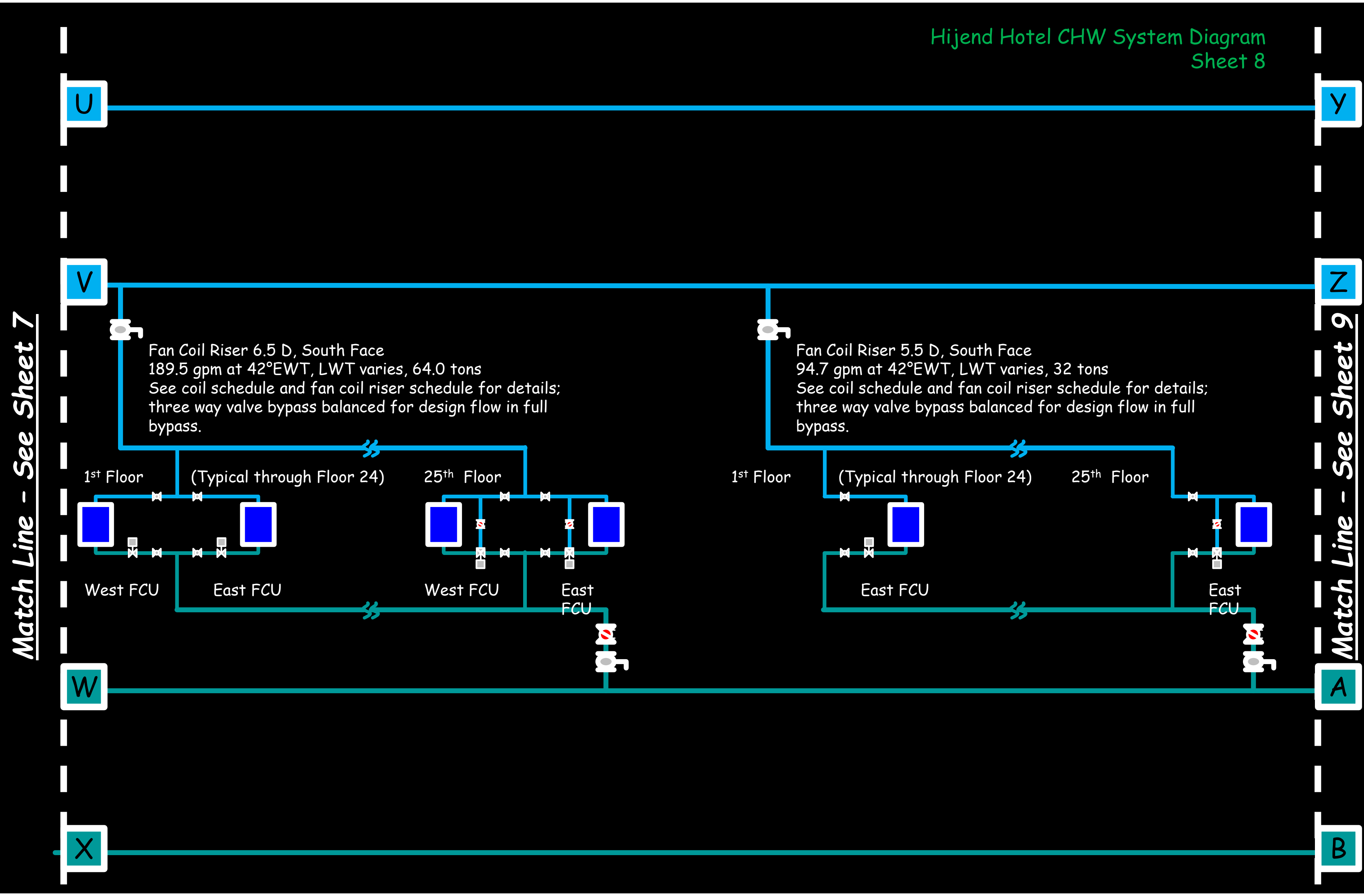
Hijend Hotel CHW System Diagram
Sheet 4
E
I
F
J
G
K
H
L
Match Line - See Sheet 3
Match Line - See Sheet 5
Fan Coil Riser 3.5 A, North Face
124.5 gpm at 42°EWT, LWT varies, 34.2 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East FCU
Fan Coil Riser 4.5 A, North Face
124.5 gpm at 42°EWT, LWT varies, 34.2 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East FCU

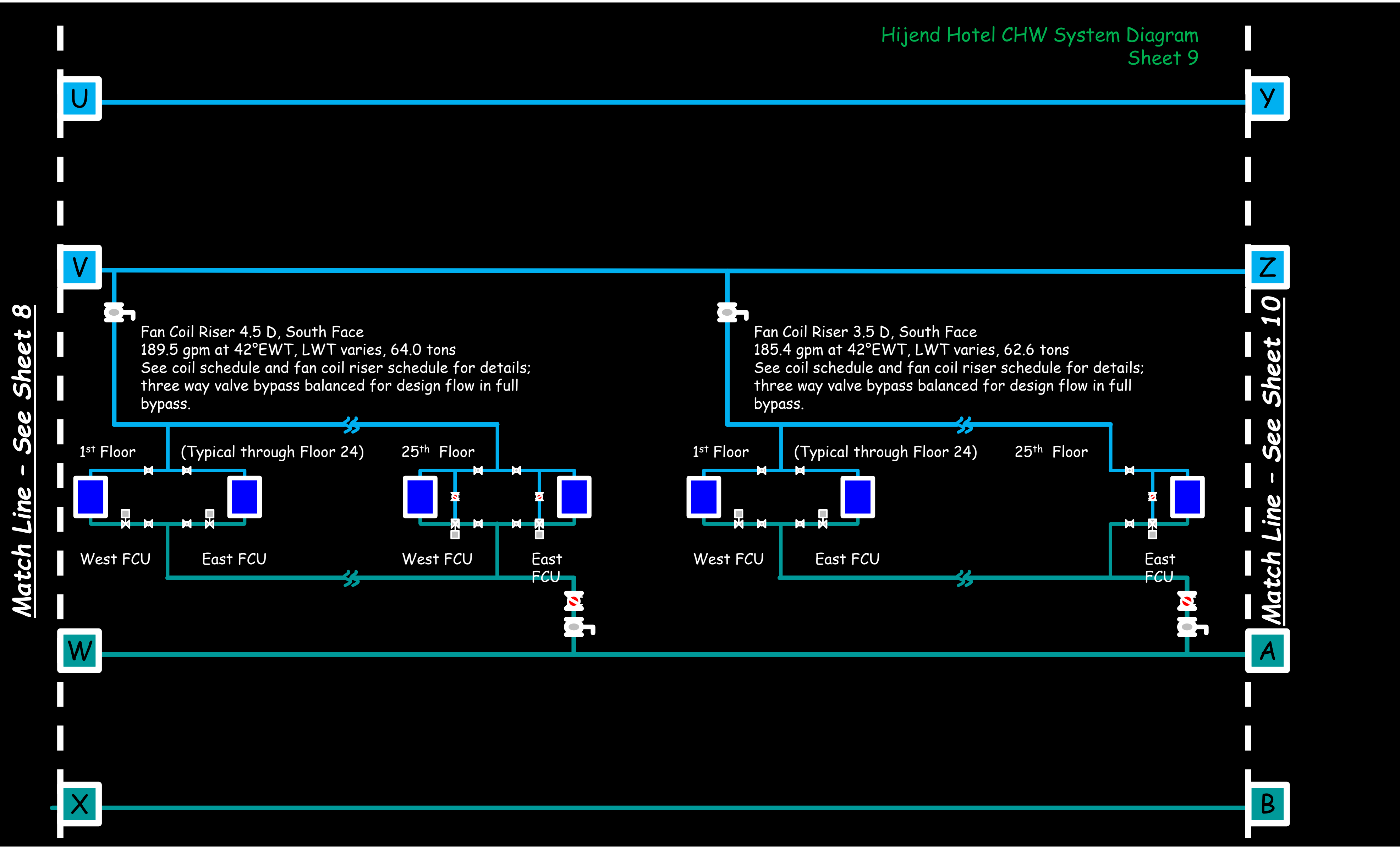

Hijend Hotel CHW System Diagram
Sheet 5
Match Line - See Sheet 4
Match Line - See Sheet 6
I
M
J
N
K
O
L
P
Fan Coil Riser 5.5 A, North Face
124.5 gpm at 42°EWT, LWT varies, 34.2 tons
See coil schedule and fan coil riser schedule for details; ;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East
FCU
Fan Coil Riser 6.5 A, North Face
124.5 gpm at 42°EWT, LWT varies, 34.2 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East
FCU


Hijend Hotel CHW System Diagram
Sheet 6
M
Q
N
R
O
S
P
T
Match Line - See Sheet 5
Match Line - See Sheet 7
Fan Coil Riser 7.5 A, North Face
125.4 gpm at 42°EWT, LWT varies, 34.9 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
Fan Coil Riser 8.5 A, North Face
121.5 gpm at 42°EWT, LWT varies, 35.5 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 23)
24th Floor
West FCU
East FCU
West FCU
East FCU

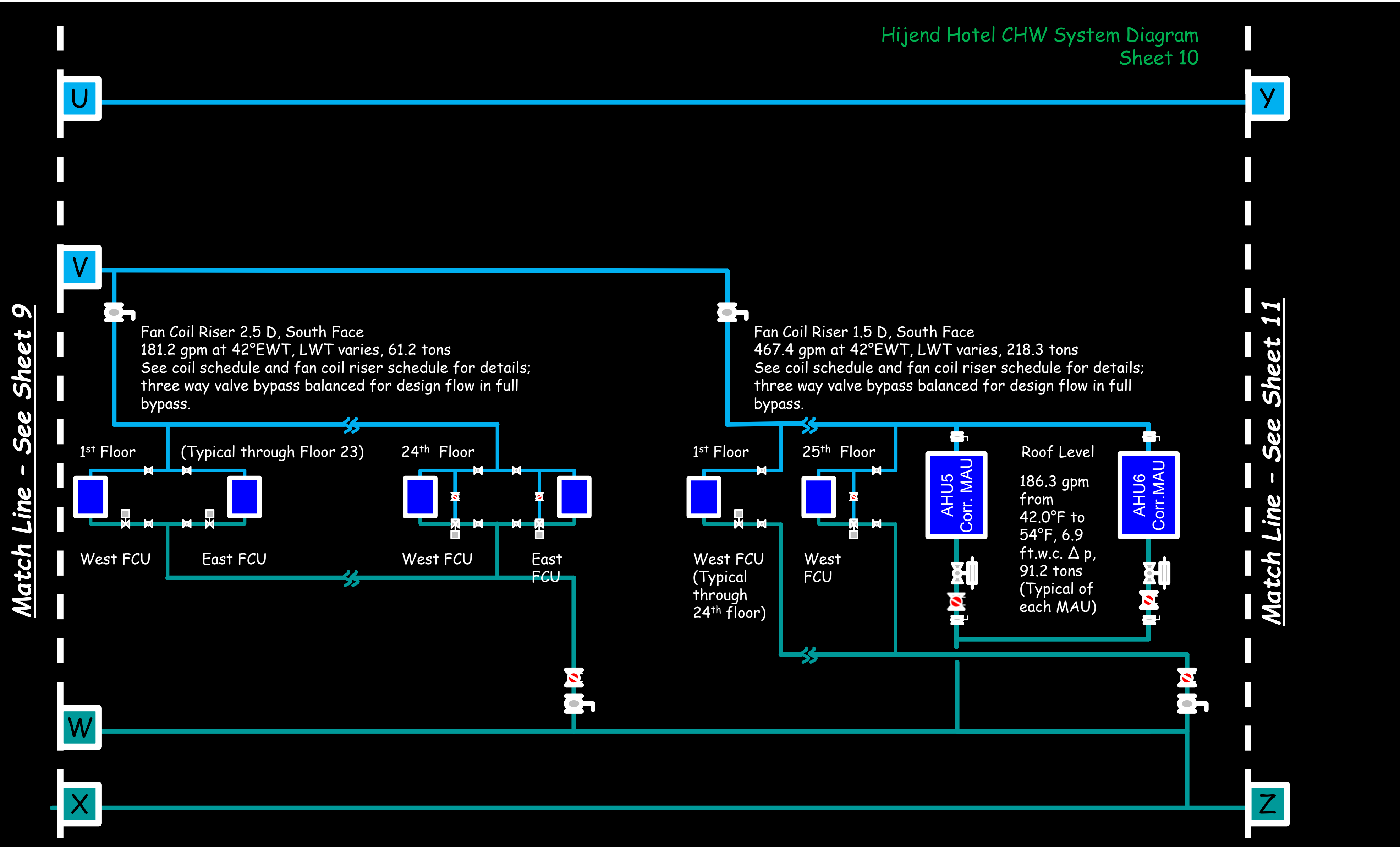


Hijend Hotel CHW System Diagram
Sheet 7
Match Line - See Sheet 6
Match Line - See Sheet 8
Q
U
R
V
S
W
T
X
Fan Coil Riser 8.5 D, South Face
90.6 gpm at 42°EWT, LWT varies, 30.6 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 23)
24th Floor
West FCU
East FCU
West FCU
Fan Coil Riser 7.5 D, South Face
187.6 gpm at 42°EWT, LWT varies, 63.4 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East FCU


Hijend Hotel CHW System Diagram
Sheet 8
U
Y
V
Z
W
A
X
B
Match Line - See Sheet 7
Match Line - See Sheet 9
Fan Coil Riser 6.5 D, South Face
189.5 gpm at 42°EWT, LWT varies, 64.0 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East
FCU
Fan Coil Riser 5.5 D, South Face
94.7 gpm at 42°EWT, LWT varies, 32 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 24)
25th Floor
East FCU
East
FCU

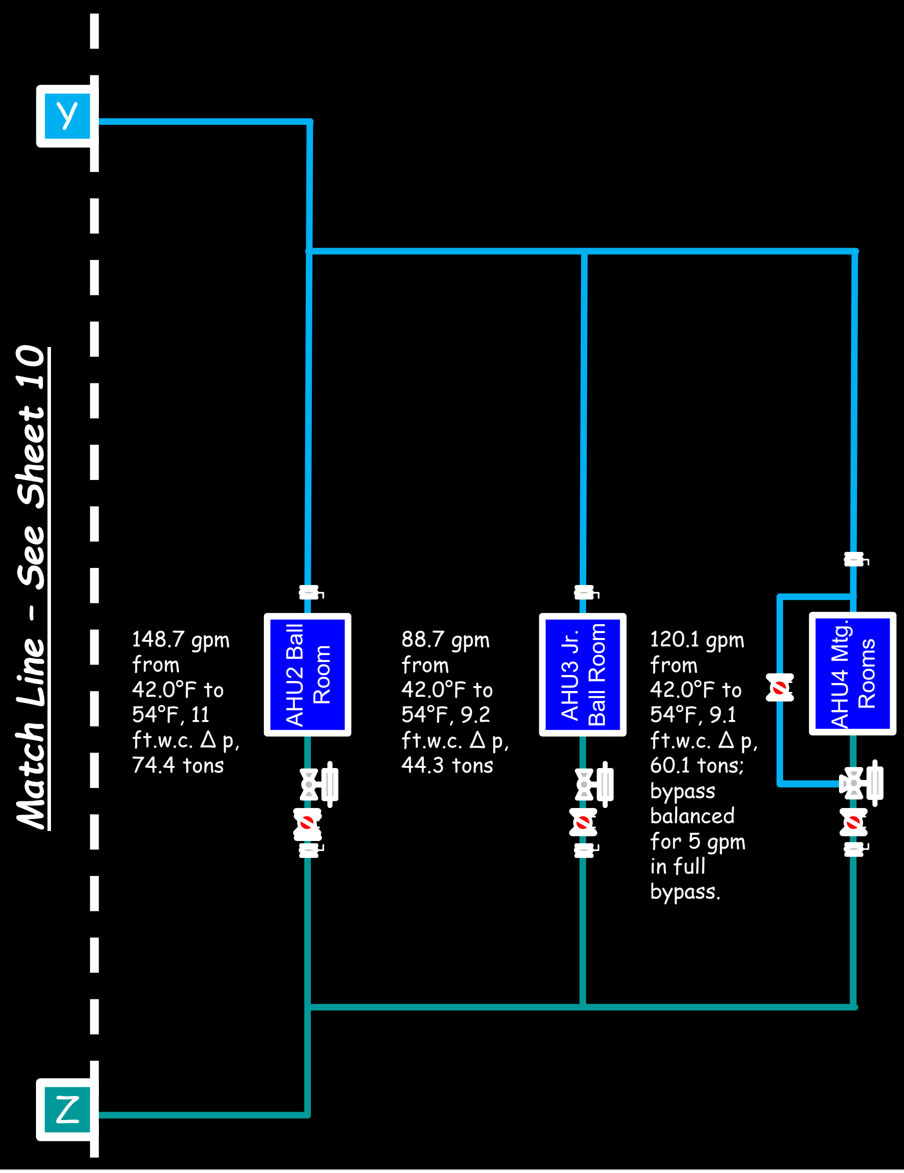


Hijend Hotel CHW System Diagram
Sheet 9
Match Line - See Sheet 8
Match Line - See Sheet 10
U
Y
V
Z
W
A
X
B
Fan Coil Riser 4.5 D, South Face
189.5 gpm at 42°EWT, LWT varies, 64.0 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
West FCU
East FCU
Fan Coil Riser 3.5 D, South Face
185.4 gpm at 42°EWT, LWT varies, 62.6 tons
See coil schedule and fan coil riser schedule for details; three way valve bypass balanced for design flow in full bypass.
1st Floor
(Typical through Floor 24)
25th Floor
West FCU
East FCU
East FCU



Hijend Hotel CHW System Diagram
Sheet 10
Match Line - See Sheet 9
Match Line - See Sheet 11
U
Y
V
W
X
Z
Fan Coil Riser 2.5 D, South Face
181.2 gpm at 42°EWT, LWT varies, 61.2 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
(Typical through Floor 23)
24th Floor
West FCU
East FCU
West FCU
East
FCU
Fan Coil Riser 1.5 D, South Face
467.4 gpm at 42°EWT, LWT varies, 218.3 tons
See coil schedule and fan coil riser schedule for details;
three way valve bypass balanced for design flow in full
bypass.
1st Floor
25th Floor
Roof Level
West FCU
(Typical
through
24th floor)
West
FCU
AHU5
Corr. MAU
AHU6
Corr.MAU
186.3 gpm
from
42.0°F to
54°F, 6.9
ft.w.c. Δ p,
91.2 tons
(Typical of
each MAU)

Hijend Hotel CHW System Diagram
Sheet 11



Fan Coil Unit Riser Schedule

Fan Coil Riser Schedule

Floor	Function	North Face Riser gpm																South Face Riser gpm																1.5D Reversed Return	Riser Sizing			
		1.5A		2.5A		3.5A		4.5A		5.5A		6.5A		7.5A		8.5A		8.5D		7.5D		6.5D		5.5D		4.5D		3.5D		2.5D		1.5D			Typical Riser based on 6.5D			
		W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E		Flow per Floor, gpm		Line Size, in.	
Roof	Mechanical Penthouses																															372.7		2,051.0	Supply	Return	Supply	Return
25	Guest Rooms	0.0	0.0	6.3	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	6.3	0.0	0.0	0.0	0.0	0.0	6.3	0.0	4.1	4.1	0.0	4.1	4.1	4.1	0.0	4.1	0.0	0.0	4.1	0.0	2,051.0	8.2	189.5	1.5	4.0
24	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	16.5	181.2	1.5	4.0
23	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	24.7	173.0	2.0	4.0
22	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	33.0	164.8	2.0	4.0
21	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	41.2	156.5	2.0	4.0
20	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	49.4	148.3	2.5	4.0
19	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	57.7	140.1	2.5	4.0
18	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	65.9	131.8	2.5	4.0
17	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	74.1	123.6	3.0	3.0
16	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	82.4	115.3	3.0	3.0
15	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	90.6	107.1	3.0	3.0
14	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	98.9	98.9	3.0	3.0
13	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	107.1	90.6	3.0	3.0
12	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	115.3	82.4	3.0	3.0
11	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	123.6	74.1	3.0	3.0
10	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	131.8	65.9	4.0	2.5
9	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	140.1	57.7	4.0	2.5
8	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	148.3	49.4	4.0	2.5
7	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	156.5	41.2	4.0	2.0
6	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	164.8	33.0	4.0	2.0
5	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	173.0	24.7	4.0	2.0
4	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	181.2	16.5	4.0	1.5
3	Guest Rooms	2.8	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.8	4.1	0.0	4.1	4.1	4.1	4.1	0.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0	2,051.0	189.5	8.2	4.0	1.5
	Total gpm	62.0		125.4		124.5		124.5		124.5		124.5		125.4		121.5		90.6		187.6		189.5		94.7		189.5		185.4		181.2		467.4		2,051.0				
	Minimimum Line size, inches	3.0		3.0		3.0		3.0		3.0		3.0		3.0		3.0		3.0		4.0		4.0		3.0		4.0		4.0		4.0		5.0						
	Header size. Inches																																	10.0				
	Total Tons	19.1		34.9		34.2		34.2		34.2		34.2		34.9		35.5		30.6		63.4		64.0		32.0		64.0		62.6		61.2		218.3						

Coil No.	Service	gpm	Tons
CC-GR01	Typcial North Exposure Guest Room (294 thus)	2.7	0.7
CC-GR02	Typcial East Exposure Guest Room (22 thus)	2.8	0.9
CC-GR03	Typcial South Exposure Guest Room (292 thus)	4.1	1.4
CC-GR04	Typcial West Exposure Guest Room (22 thus)	2.8	0.9
CC-CR05	Typcial Luxury Guest Room (4 thus)	6.3	2.2
CC-5	Corridor Make-up Air	186.3	93.2
CC-6	Corridor Make-up Air	186.3	93.2
	Three-way valve gpm (red boarder)	64.2	

Cooling Coil Schedule

Cooling Coil Schedule																	
Coil Number	Unit or System Served	Flow, cfm	Maximum Fins per Inch	Rows	Minimum Face Area, sq.ft.	Airside Performance: Entering Air Dry bulb, °F	Airside Performance: Entering Air Wet bulb, °F	Airside Performance: Leaving Air Dry bulb, °F	Airside Performance: Leaving Air Wet bulb, °F	Airside Performance: Face Velocity, fpm	Airside Performance: Pressure Drop, in.w.c.	Waterside Performance: Entering Water Temperature, °F	Waterside Performance: Leaving Water Temperature, °F	Waterside Performance: Flow Rate, gpm	Waterside Performance: Pressure Drop, ft.w.c.	Waterside Performance: Tons	Comments
CC-1	AHU1 - Hotel Lobby and Administration	26,000	8	6	52.0	81.0	63.8	51.0	50.5	433	0.63	42.0	56.0	141.0	8.6	82.2	
CC-2	Main Ball Room	20,000	9	6	40.0	86.6	66.1	51.4	50.9	500	0.82	42.0	54.0	148.7	11.0	74.4	
CC-3	Junior Ball Room	15,000	8	6	30.0	80.2	63.5	51.7	51.1	500	0.74	42.0	54.0	88.7	9.2	44.3	
CC-4	Meeting Rooms	15,000	9	6	30.0	90.3	67.6	52.2	51.6	500	0.83	42.0	54.0	120.1	9.1	60.1	3-way valve
CC-5	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.6	52.8	52.0	500	0.76	42.0	54.0	186.3	6.9	93.2	
CC-6	Corridor Make-up Air	23,775	8	6	47.6	90.3	67.6	52.8	52.0	472	0.70	42.0	54.0	186.3	6.9	93.2	
CC-7	Laundry	10,000	8	6	20.0	81.3	65.0	53.9	53.3	500	0.75	42.0	54.0	57.9	3.1	29.0	
CC-8	Breakfast/Lunch Café	6,500	8	6	13.0	82.7	64.5	50.9	50.4	406	0.56	42.0	54.0	43.9	7.8	21.9	3-way valve
CC-9	Restaurant and Lounge	11,500	8	6	23.0	82.7	64.5	51.8	51.2	479	0.70	42.0	54.0	73.7	9.3	36.9	
CC-10	Main Kitchen	19,000	8	6	38.0	88.5	67.6	51.5	51.0	396	0.56	42.0	54.0	157.2	9.2	78.6	
VF-1	Electrical Room	8,200	8	3	16.4	83.7	67.6	60.7	57.9	410	0.35	42.0	54.0	42.5	9.8	21.2	
CC-GR01	Typcial North Exposure Guest Room (294 thus)	300	14	3	1.4	72.0	60.0	49.4	49.0	214	0.15	42.0	48.6	2.7	3.5	0.7	3-way valve top of riser
CC-GR02	Typcial East Exposure Guest Room (22 thus)	400	14	3	1.4	72.0	60.0	51.2	50.5	285	0.22	42.0	49.4	2.8	3.7	0.9	3-way valve top of riser
CC-GR03	Typcial South Exposure Guest Room (292 thus)	600	14	3	2.2	72.0	60.0	50.4	49.8	275	0.21	42.0	50.1	4.1	9.7	1.4	3-way valve top of riser
CC-GR04	Typcial West Exposure Guest Room (22 thus)	400	14	3	1.4	72.0	60.0	51.2	50.5	285	0.22	42.0	49.4	2.8	3.7	0.9	3-way valve top of riser
CC-CR05	Typcial Luxury Guest Room (4 thus)	1,000	14	3	3.2	72.0	60.0	51.2	50.4	313	0.26	42.0	50.3	6.3	8.9	2.2	

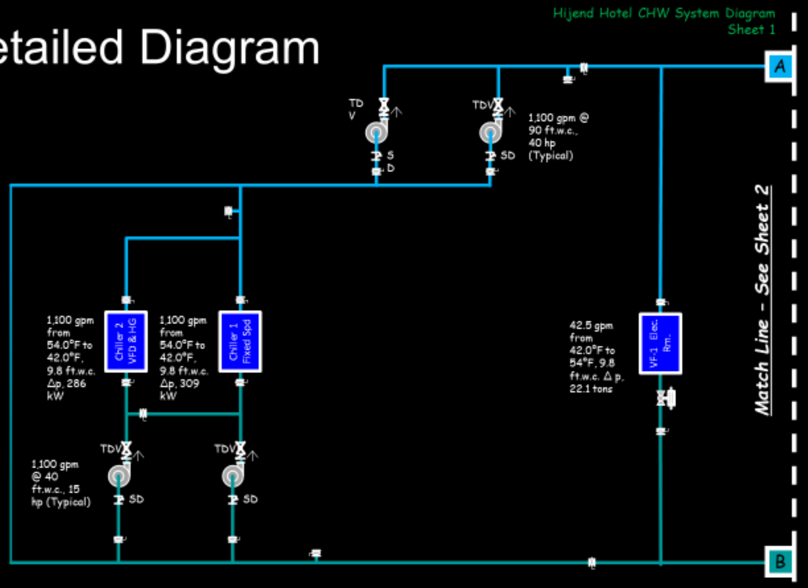
System Volume Projection

Item	Nominal Diameter, ft.		Nominal Area, sq.ft.	Length of run, ft.	Volume, cu.ft.	Pounds of Water	Gallons of Water
	in.	ft.					
Chiller 2 Pumping Loop			Sub Totals	173	81	7,048	845
Evaporator pump return header - bypass to Chiller 2 Pump	12.0	1.00	0.79	4	3	196	23
Chiller 2 return piping -	8.0	0.67	0.35	103	36	2,244	269
Chiller 2 tube bundle -						2,000	240
Chiller 2 supply piping -	8.0	0.67	0.35	23	8	501	60
Chiller supply piping to bypass -	12.0	1.00	0.79	36	28	1,764	211
Plant bypass -	12.0	1.00	0.79	7	5	343	41
Distibution Piping - Inside Plant			Sub Totals	141	99	6,202	743
Plant supply to distribution pump header	12.0	1.00	0.79	22	17	1,078	129
Central plant return to evaporator pump tee -	12.0	1.00	0.79	39	31	1,911	229
Distribution pump connection -	8.0	0.67	0.35	26	9	566	68
Supply header to central plant wall -	12.0	1.00	0.79	54	42	2,646	317
Distibution Piping - Outside Plant			Sub Totals	11,016	1,538	95,996	11,507
Supply main from plant to point where fan coil headers connect -	12.0	1.00	0.79	218	171	10,684	1,281
Return main from plant to point where fan coil headers connect -	12.0	1.00	0.79	218	171	10,684	1,281
Fan coil supply header -	10.0	0.83	0.55	474	259	16,132	1,934
Fan coil supply risers - 1st segment -	4.0	0.33	0.09	1,536	134	8,364	1,003
Fan coil supply risers - 2nd segment -	3.0	0.25	0.05	1,344	66	4,117	493
Fan coil supply risers - 3rd segment -	2.5	0.21	0.03	576	20	1,225	147
Fan coil supply risers - 4th segment -	2.0	0.17	0.02	576	13	784	94
Fan coil supply risers - 5th segment -	1.5	0.13	0.01	416	5	319	38
Fan coil return risers - 1st segment -	4.0	0.33	0.09	1,536	134	8,364	1,003
Fan coil return risers - 2nd segment -	3.0	0.25	0.05	1,344	66	4,117	493
Fan coil return risers - 3rd segment -	2.5	0.21	0.03	576	20	1,225	147
Fan coil return risers - 4th segment -	2.0	0.17	0.02	576	13	784	94
Fan coil return risers - 5th segment -	1.5	0.13	0.01	416	5	319	38
Active fan coil unit coils -					21	1,310	157
Fan coil supply header -	10.0	0.83	0.55	698	381	23,756	2,848
Mains to meeting room AHU -	5.0	0.42	0.14	44	6	374	45
Mains from meeting room AHU -	5.0	0.42	0.14	44	6	374	45
Meeting room AHU supply -	3.0	0.25	0.05	23	1	70	8
Meeting room AHU return -	3.0	0.25	0.05	23	1	70	8
Mains to cafe AHU -	5.0	0.42	0.14	166	23	1,412	169
Mains from cafe AHU -	5.0	0.42	0.14	166	23	1,412	169
Cafe AHU supply -	2.5	0.21	0.03	23	1	49	6
Cafe AHU return -	2.5	0.21	0.03	23	1	49	6
			Totals -	11,330	1,719	109,246	13,096

Given:

- The "Plan B" concept
- The Hijend Hotel chilled water plant model
- Joe DeNuguy's system diagram developed from the project documents before going on site

The Detailed Diagram

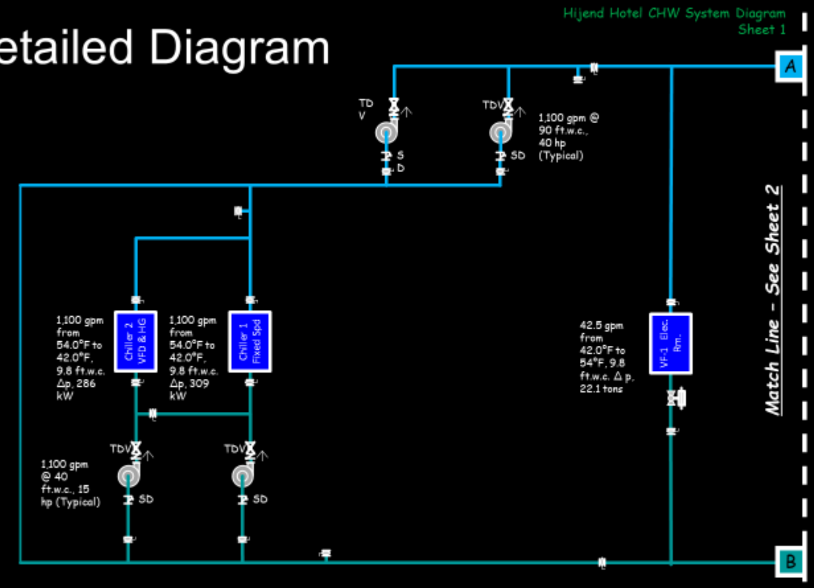


Assignment:

Field verify the central plant portion of Joe DeNuguy's system diagram

- Was the system installed as intended based on the project documents?

The Detailed Diagram



Let’s Go to the Breakout Rooms

Questions?

Thank you for participating!

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ADVANCED ENGINEERING PROGRAM

AEP 2023