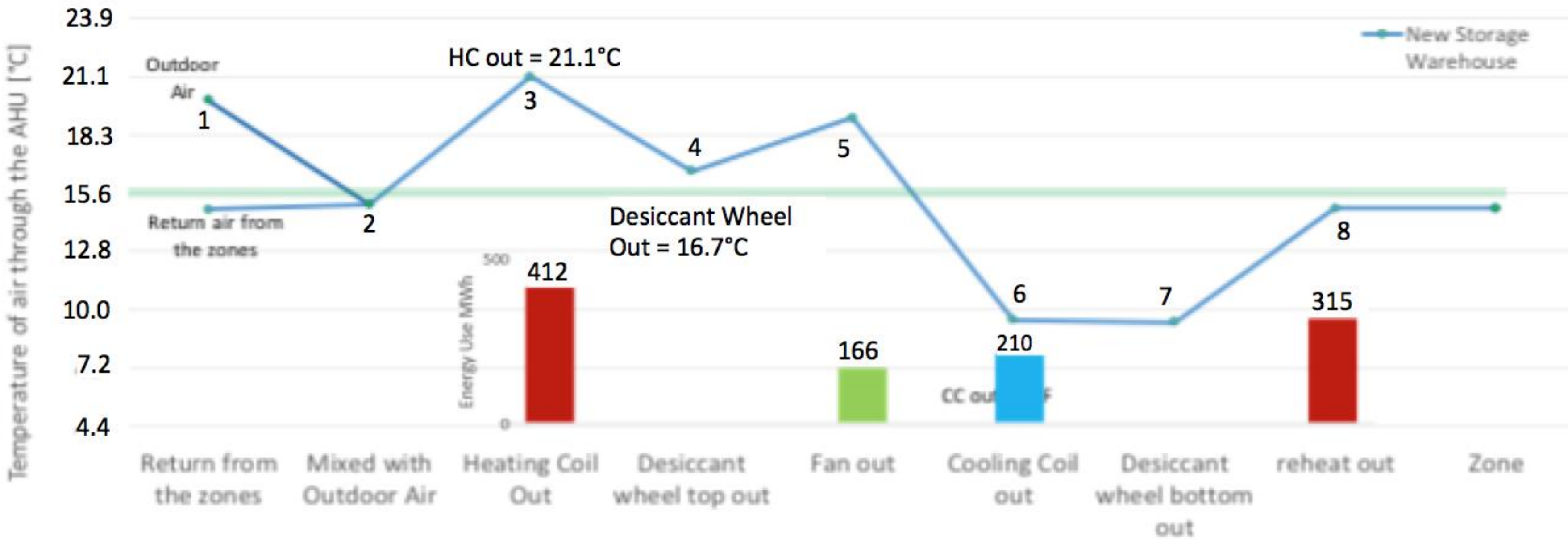


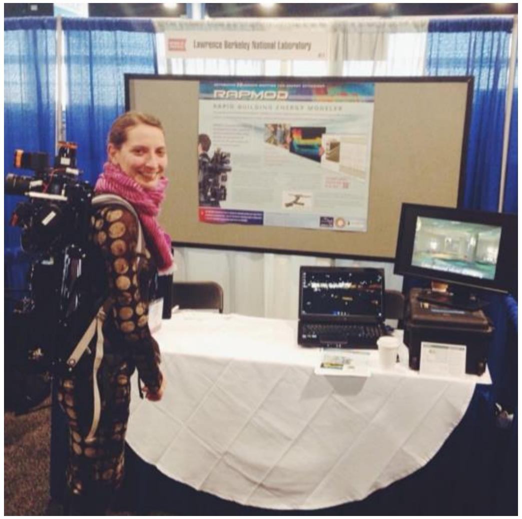
Simulation Diagnostics | Hacking Simulation CIBSE simulation Group

Annie Marston Ph.D., BEMP, LEED AP | 20th March 2018

SIM^2

Don't Compromise -- Simulate

About Me



Ph.D. in Renewable Energy and Architecture

Worked on mostly American and German buildings

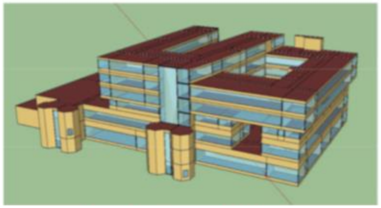
Simulation Specialist

Over 10 years of experience

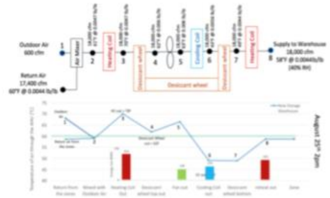
My work Includes:

- Over 75 LEED projects (8 Platinum)
- 2 net zero buildings
- Research projects for American government
- 10 IEMPs
- CFD studies, thermal comfort studies, daylighting studies, optimization studies.

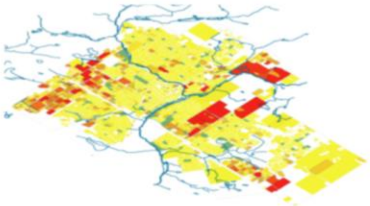
Services



Energy modelling for LEED



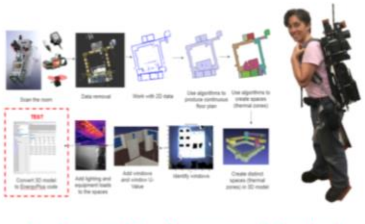
Complex HVAC and controls



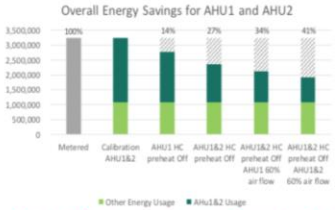
IEMP and community co-ops

Teaching and online courses

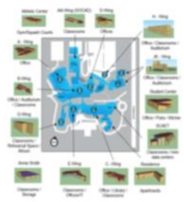
Simulation beyond certification and compliance



Automatic Energy Model



Post Occupancy Controls



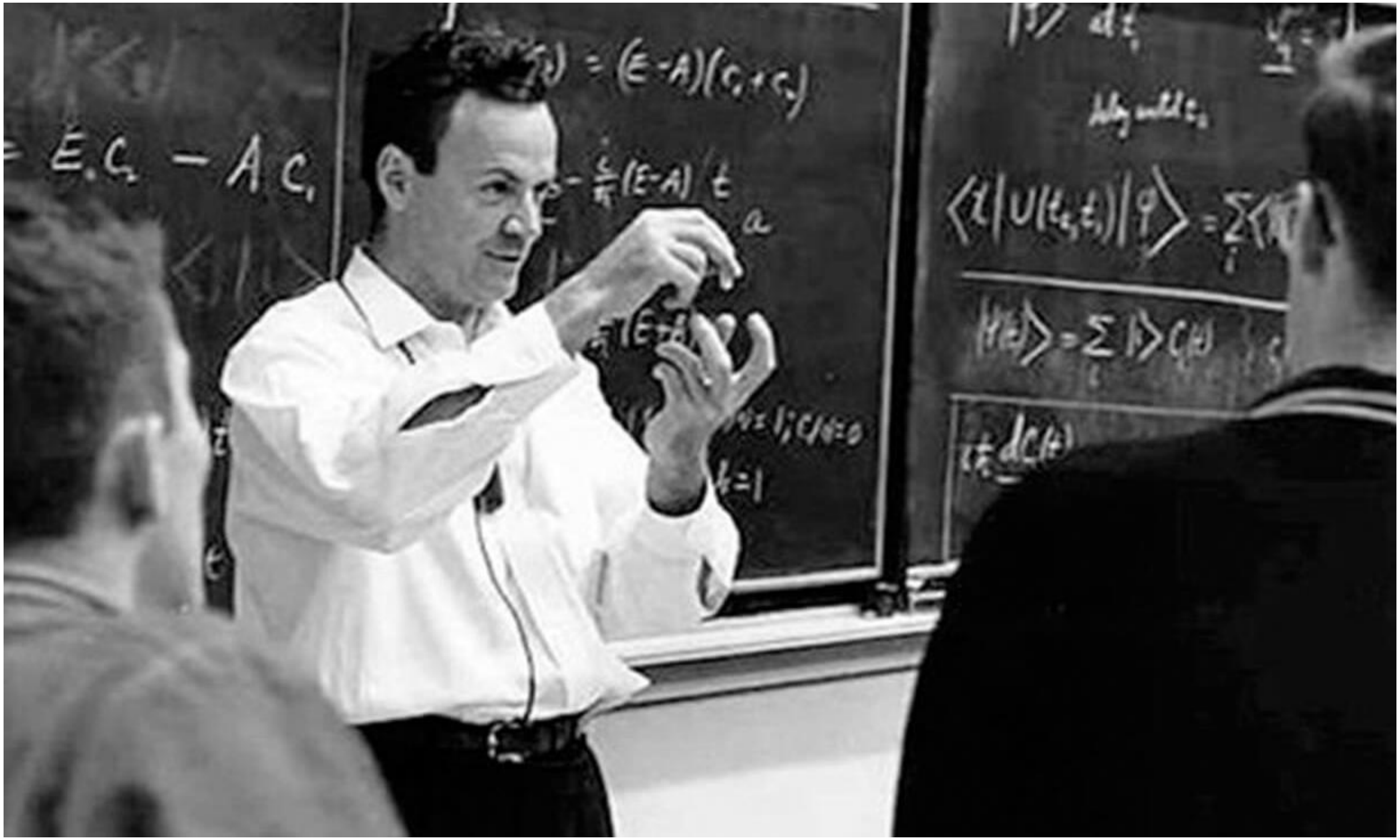
Integrated Energy Master Plans

OD for Energy Models

About Sim^2

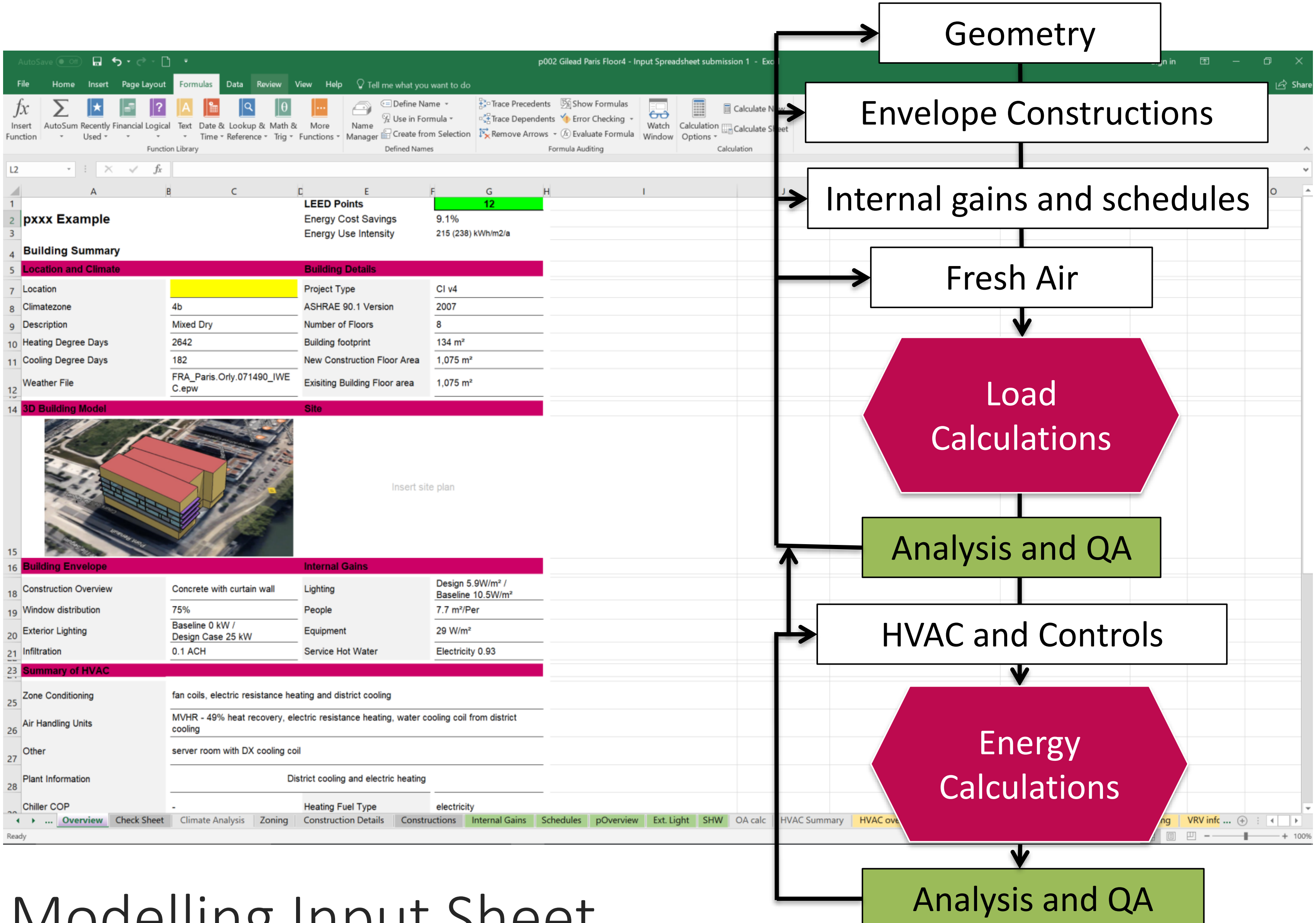
PROBLEM 1: Inputting data into a simulation engine GUI takes lots of time, is complicated and prone to errors

PROBLEM 2: Input errors and misunderstanding outputs leads to poor results, lack of confidence in modelling and, at worse, incorrect analysis and advice to the client



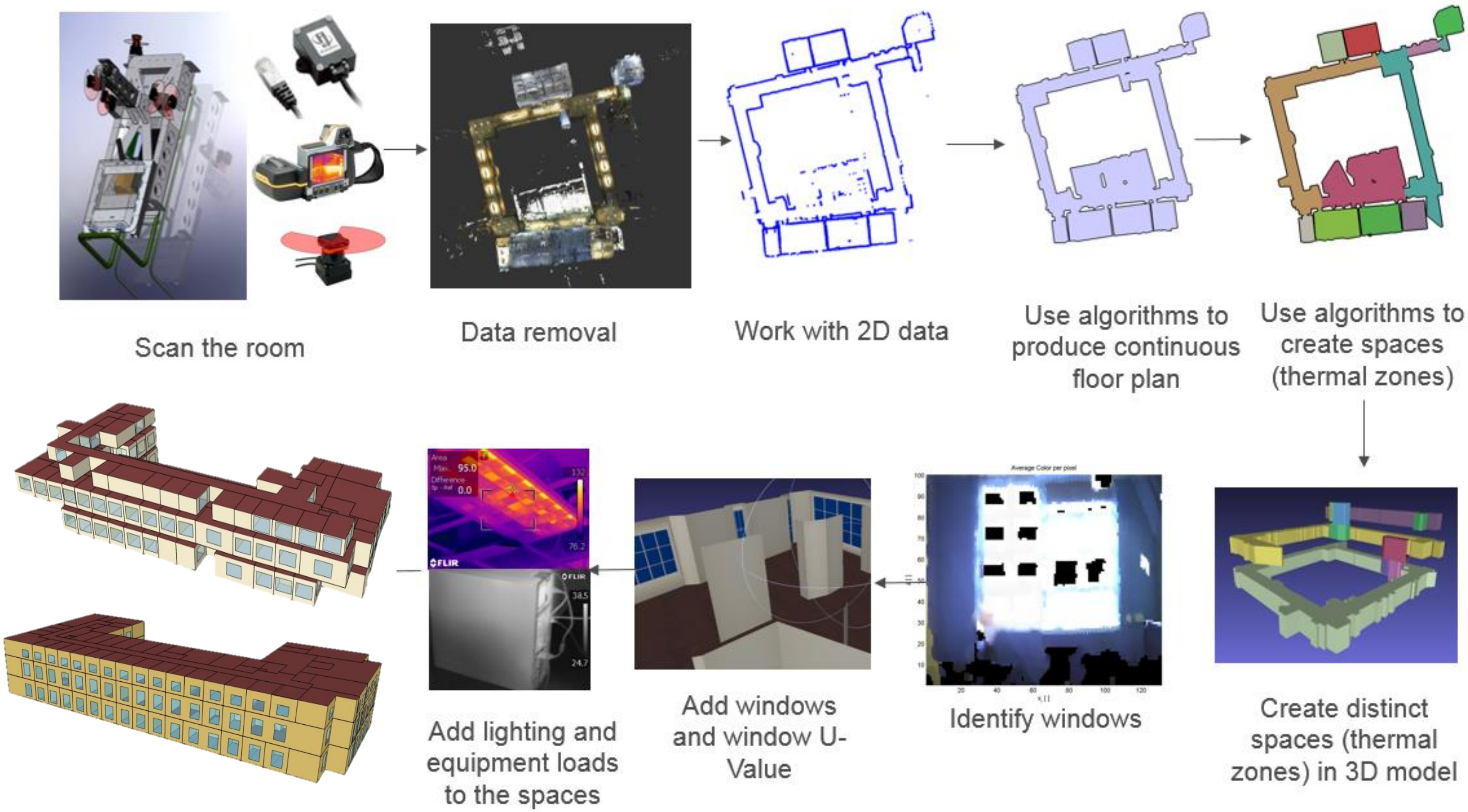
"The first principle is you must not fool yourself – and you are the easiest person to fool" Richard Feynman*

SIM^2



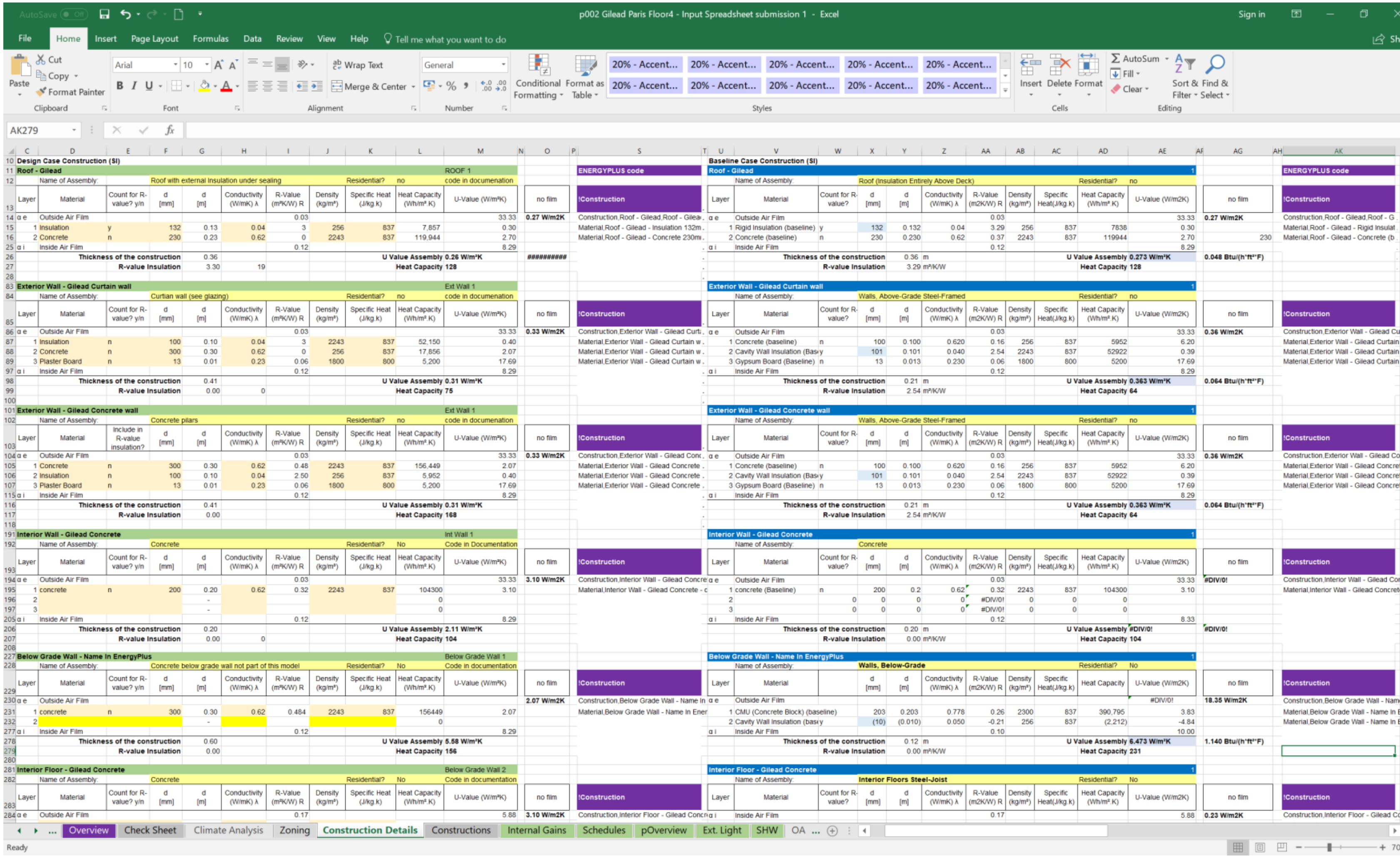
Modelling Input Sheet

SIM²



Data Input - Geometry

SIM^2



Data Input – Envelope Constructions

SIM^2

Table 7 Occupancy Load Densities by Space Use

Occupancy	Occupancy m^2/Person	Occupancy ft^2/Person	Occupancy TOTAL	Schedules Occupancy
Office	13.7 m^2/person	147.1 ft^2/person	18	Office
OpenOffice	6.5 m^2/person	70.3 ft^2/person	66	Office
Storage	m^2/person	ft^2/person	-	Storage
Corridor	m^2/person	ft^2/person	-	Office
TeaRoom	15.4 m^2/person	165.2 ft^2/person	2	MeetingRoom
MeetingRoom	2.3 m^2/person	24.9 ft^2/person	44	MeetingRoom
CopyRoom	m^2/person	ft^2/person	-	MeetingRoom
PhoneBooth	4.7 m^2/person	50.6 ft^2/person	2	MeetingRoom
Shower	m^2/person	ft^2/person	-	Office
AV	m^2/person	ft^2/person	-	Storage
Average	7.7 m^2/per			

Table 8 Equipment Load Densities by Space Use

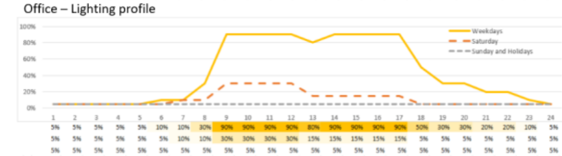
Equipment	Equipment W/m^2	Equipment W/ft^2	Equipment TOTAL	Schedules Equipment
Office	35 W/m^2	3.3 W/ft^2	8,610	Office
OpenOffice	35 W/m^2	3.3 W/ft^2	15,094	Office
Storage	- W/m^2	0.0 W/ft^2	-	Office
Corridor	- W/m^2	0.0 W/ft^2	-	Office
TeaRoom	- W/m^2	0.0 W/ft^2	-	Office
MeetingRoom	22 W/m^2	2.0 W/ft^2	2,199	MeetingRoom
CopyRoom	10 W/m^2	0.9 W/ft^2	180	Office
PhoneBooth	- W/m^2	0.0 W/ft^2	-	Office
Shower	- W/m^2	0.0 W/ft^2	-	Office
AV	10 W/m^2	0.9 W/ft^2	73	Mechnical
Average	29.0 W/m^2			

Table 9 Lighting Load Densities by Space Use

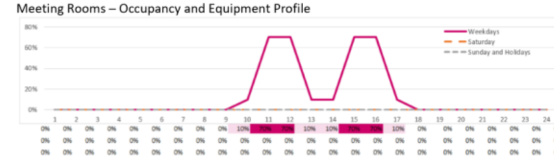
Lighting	Design Case W/ft^2	Design Case W/m^2	Design Case Total (W)	Baseline Case W/ft^2	Baseline Case W/m^2	Baseline Case Total (W)	Schedule
Office	0.51 W/ft^2	5.5 W/m^2	1,361	1.11 W/ft^2	11.9 W/m^2	2,939	Office
OpenOffice	0.56 W/ft^2	6.0 W/m^2	2,608	0.98 W/ft^2	10.5 W/m^2	4,549	Office
Storage	0.44 W/ft^2	4.7 W/m^2	252	0.63 W/ft^2	6.8 W/m^2	361	Storage
Corridor	0.64 W/ft^2	6.8 W/m^2	1,172	0.66 W/ft^2	7.1 W/m^2	1,215	Office
TeaRoom	0.38 W/ft^2	4.1 W/m^2	126	1.11 W/ft^2	11.9 W/m^2	367	Office
MeetingRoom	0.50 W/ft^2	5.4 W/m^2	546	1.23 W/ft^2	13.2 W/m^2	1,348	MeetingRoom
CopyRoom	0.43 W/ft^2	4.7 W/m^2	84	1.11 W/ft^2	11.9 W/m^2	214	Office
PhoneBooth	0.83 W/ft^2	8.9 W/m^2	84	1.11 W/ft^2	11.9 W/m^2	112	Office
Shower	0.64 W/ft^2	6.9 W/m^2	42	0.98 W/ft^2	10.5 W/m^2	65	Office
AV	0.54 W/ft^2	5.8 W/m^2	42	1.11 W/ft^2	11.9 W/m^2	87	Storage
Average	5.9 W/m^2			10.5 W/m^2			

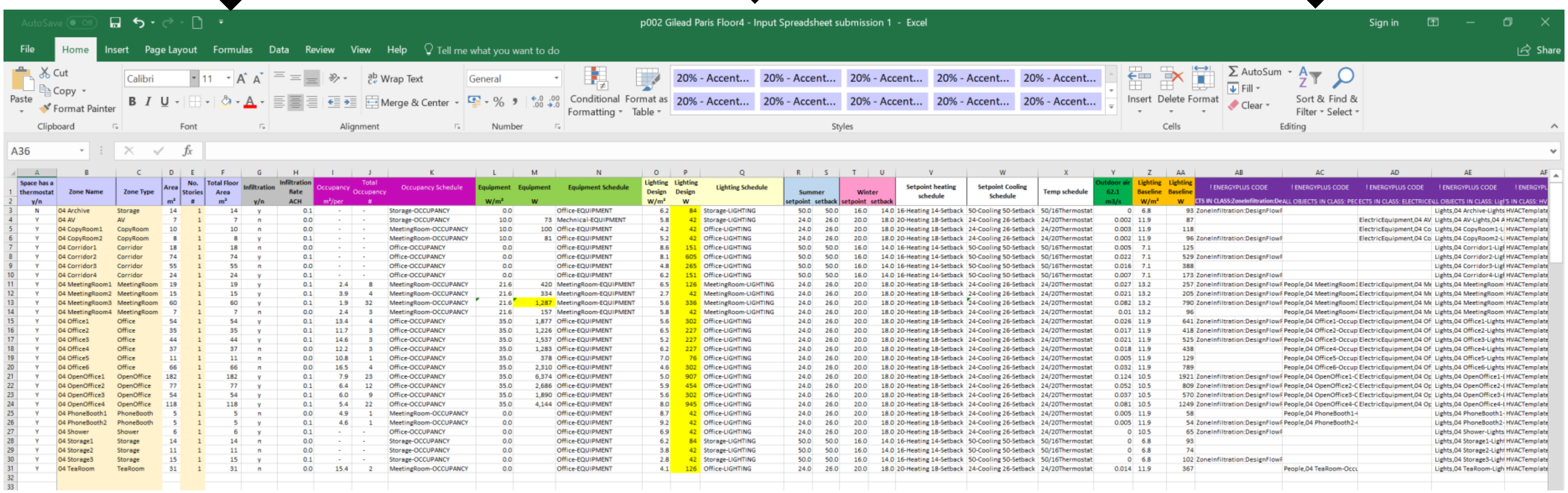
Office – Occupancy and Equipment profile

Office – Lighting profile



Meeting Rooms – Occupancy and Equipment Profile





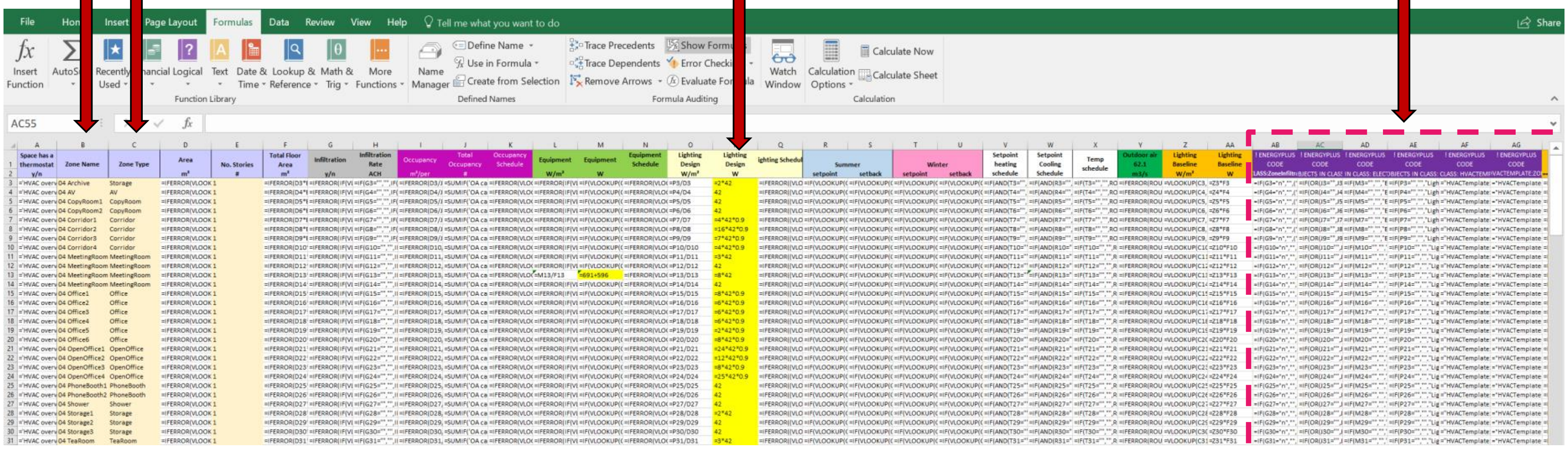
Data Input - Ideal Loads

SIM^2

All zone names and zone types to be entered in this sheet

Information edited over formulas

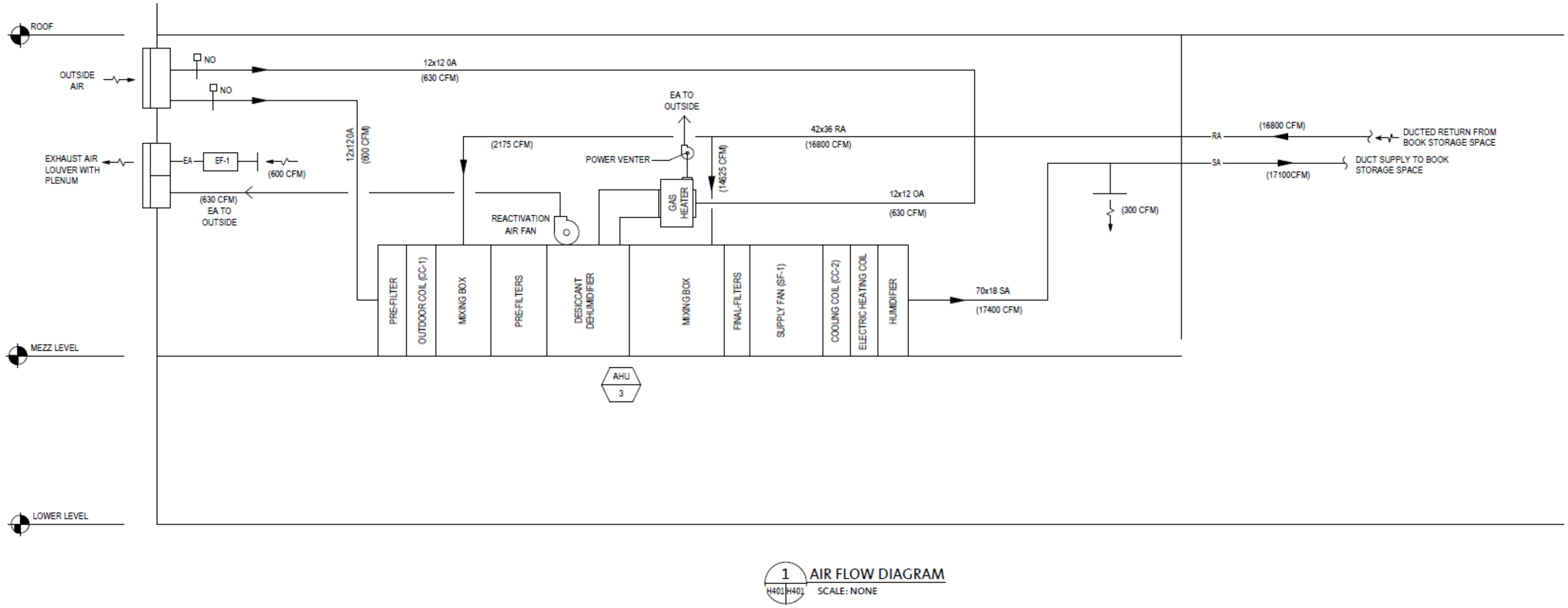
Automatically generated Simulation Code



Data Input - Ideal Loads

SIM^2

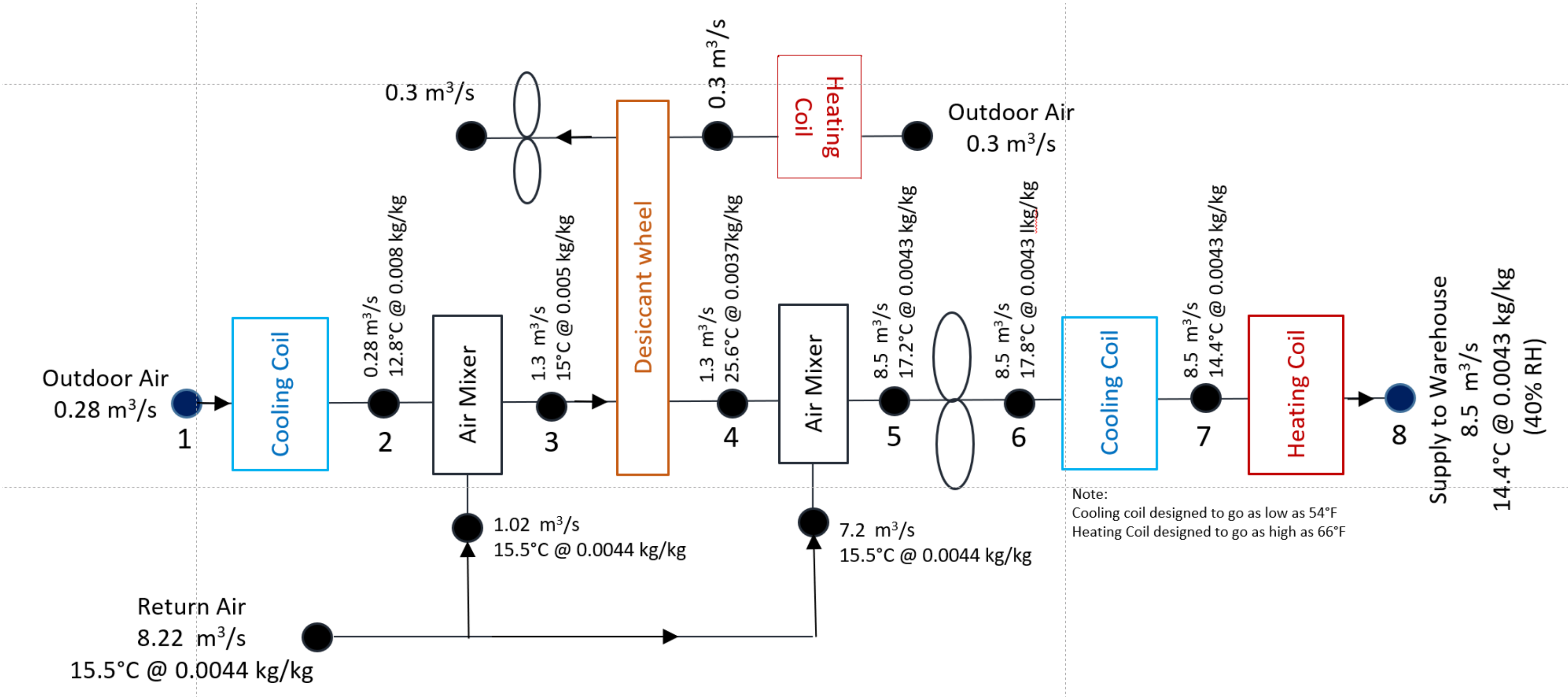
Translating a mechanical drawing to energy component drawings



Data Input – HVAC and Controls

SIM²

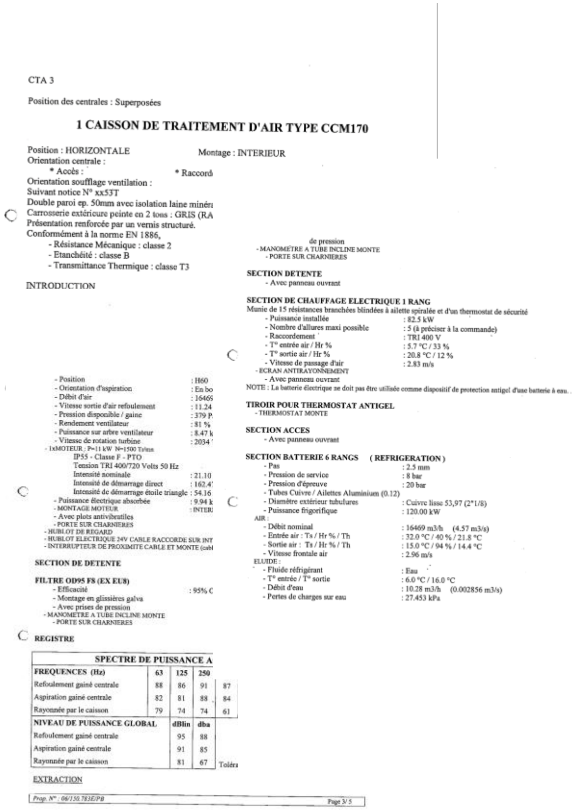
Translating a mechanical drawings to energy component drawings



Data Input – HVAC and Controls

SIM²

Translating mechanical information to simple table to record inputs and generate mechanical system for simulation.



CTA 3

Position des centrales : Superposées

1 CAISSON DE TRAITEMENT D'AIR TYPE CCM170

Position : HORIZONTALE Montage : INTERIEUR
Orientation centrale :
* Accès : * Raccord
Orientation soufflage ventilation :
Suivant notice N° xx53T
Double paroi ep. 50mm avec isolation laine minéra
Carrosserie extérieure peinte en 2 tons : GRIS (RA
Présentation renforcée par un vernis structuré.
Conformément à la norme EN 1886,
- Résistance Mécanique : classe 2
- Etanchéité : classe B
- Transmittance Thermique : classe T3

INTRODUCTION

- Position : H60
- Orientation d'aspiration : En bo
- Débit d'air : 16469
- Vitesse sortie d'air refoulement : 11.24
- Pression disponible / gaine : 379 P
- Rendement ventilateur : 81 %
- Puissance sur arbre ventilateur : 8.47 k
- Vitesse de rotation turbine : 2034
- 1xMOTEUR : P=11 kW N=1500 Tr/mn
IP55 - Classe F - PTO
Tension TRI 400/720 Volts 50 Hz
Intensité nominale : 21.10
Intensité de démarrage direct : 162.47
Intensité de démarrage étoile triangle : 54.16
- Puissance électrique absorbée : 9.94 k
- MONTAGE MOTEUR : INTERI
- Avec plots antivibratiles
- PORTE SUR CHARNIERES
- HUBLOT DE REGARD
- HUBLOT ELECTRIQUE 24V CABLE RACCORDE SUR INT
- INTERRUPTEUR DE PROXIMITE CABLE ET MONTE (cab

SECTION DE DETENTE

FILTRE OD95 F8 (EX EU8)
- Efficacité : 95% C
- Montage en glissières galva
- Avec prises de pression
- MANOMETRE A TUBE INCLINE MONTE
- PORTE SUR CHARNIERES

REGISTRE

SPECTRE DE PUISSANCE A				
FREQUENCES (Hz)	63	125	250	
Refoulement gainé centrale	88	86	91	87
Aspiration gainé centrale	82	81	88	84
Rayonnée par le caisson	79	74	74	61
NIVEAU DE PUISSANCE GLOBAL		dBlin	dba	
Refoulement gainé centrale		95	88	
Aspiration gainé centrale		91	85	
Rayonnée par le caisson		81	67	Toléra

EXTRACTION

Prop. N° : 06/150.783E/PB Page 3/ 5

de pression
- MANOMETRE A TUBE INCLINE MONTE
- PORTE SUR CHARNIERES

SECTION DETENTE
- Avec panneau ouvrant

SECTION DE CHAUFFAGE ELECTRIQUE 1 RANG
Munie de 15 résistances branchées blindées à ailette spiralée et d'un thermostat de sécurité
- Puissance installée : 82.5 kW
- Nombre d'allures maxi possible : 5 (à préciser à la commande)
- Raccordement : TRI 400 V
- T° entrée air / Hr % : 5.7 °C / 33 %
- T° sortie air / Hr % : 20.8 °C / 12 %
- Vitesse de passage d'air : 2.83 m/s
- ECRAN ANTIRAYONNEMENT
- Avec panneau ouvrant

NOTE : La batterie électrique ne doit pas être utilisée comme dispositif de protection antigel d'une batterie à eau. .

TIROIR POUR THERMOSTAT ANTIGEL
- THERMOSTAT MONTE

SECTION ACCES
- Avec panneau ouvrant

SECTION BATTERIE 6 RANGS (REFRIGERATION)
- Pas : 2.5 mm
- Pression de service : 8 bar
- Pression d'épreuve : 20 bar
- Tubes Cuivre / Ailettes Aluminium (0.12)
- Diamètre extérieur tubulures : Cuivre lisse 53,97 (2"1/8)
- Puissance frigorifique : 120.00 kW

AIR :
- Débit nominal : 16469 m3/h (4.57 m3/s)
- Entrée air : Ts / Hr % / Th : 32.0 °C / 40 % / 21.8 °C
- Sortie air : Ts / Hr % / Th : 15.0 °C / 94 % / 14.4 °C
- Vitesse frontale air : 2.96 m/s

FLUIDE :
- Fluide réfrigérant : Eau
- T° entrée / T° sortie : 6.0 °C / 16.0 °C
- Débit d'eau : 10.28 m3/h (0.002856 m3/s)
- Pertes de charges sur eau : 27.453 kPa

Table 21 Specifications for proposed AHU

General Information						
AHU Nr.	System description	Areas that the system feeds	Max Air Flow rate	Min Air Flow rate	Outdoor Air Flow Rate	Exhaust Air Flow rate
	repeat description where possible, ie dedicated outdoor air system, AHU VAV, etc	name zone types that the system feeds	m^3/s	m^3/s	m^3/s	m^3/s
CTA3	Dedicated outdoor air system	west side of the building offices	0.364	0.36	0.36	0.364
CTA4	Dedicated outdoor air system	east side of the building offices	0.666	0.67	0.67	0.67

Supply Fan					Return Fan				Heat Exchanger	
Filter	Supply fan Pressure Drop	Fan Power Supply/Extract	Efficiency	Fresh Air/Fan Schedule	Filter	Return Fan Pressure Drop	Fan Power Supply/Extract	Efficiency	Type	Efficiency
Category	PA	[kW]	[%]		Category	PA	[kW]	[%]		
F8	379	8.5 kW	81%	MVHR-CTA3 - Fresh Air Schedule	F5	592	6.2 kW	80%	Flat Plate	47%
F8	624	16.0 kW	81%	MVHR-CTA4 - Fresh Air Schedule	F5	782	11.8 kW	82%	Flat Plate	47%

	Heating Coil			Cooling Coil					
AHU Nr.	Heating Coil	Entering Air Temperature	Leaving Air Temperature	Cooling Coil Total	Water temp. in	Water temp. out	Flow Rate	Entering Air Temperature DB	Leaving Air Temperature DB
	[kW]	[°C]	[°C]	[kW]	[°C]	[°C]	[m^3/s]	[°C]	[°C]
CTA3	82.5	5.7°C	20.8°C	120	6°C	16°C	4.57	32°C	15°C
CTA4	144	5.6°C	22.1°C	193	6°C	16°C	16.54	32°C	15°C

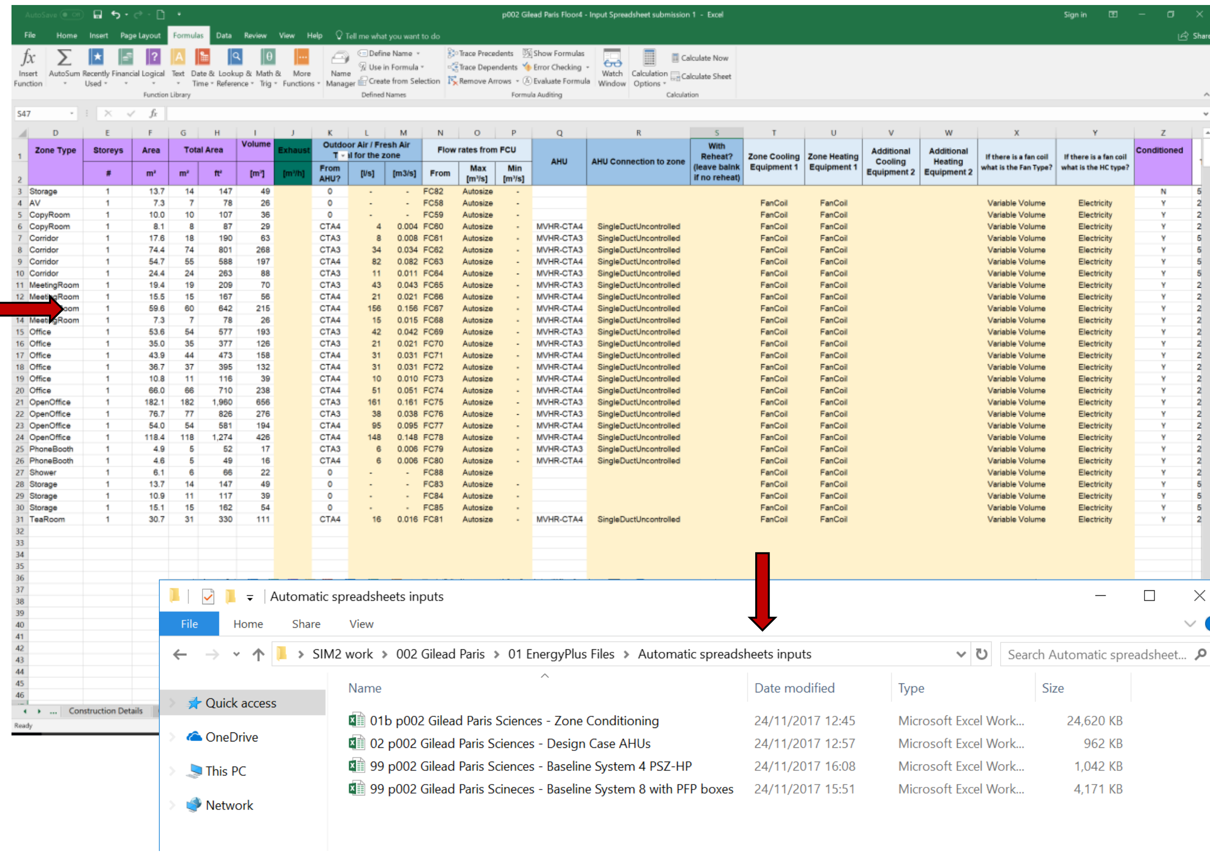
Data Input – Automation Process

SIM²

Translating mechanical information to simple table to record inputs and generate mechanical system for simulation.

Proposed Design						
Space Use	Zone Heating	Zone Cooling	Mechanical Ventilation	Connection to zone	Cooling Supply	Heat Supply
Office	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
OpenOffice	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
Storage	FanCoil	FanCoil			Water	Electric
Corridor	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
TeaRoom	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
MeetingRoom	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
CopyRoom	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
PhoneBooth	FanCoil	FanCoil	MVHR	SingleDuctUncontrolled	Water	Electric
Shower	FanCoil	FanCoil			Water	Electric
AV	FanCoil	FanCoil			Water	Electric

Fresh Air Calculation	Area		Number of people	Outdoor Air - ASHRAE 62.1 2010 Calculation						TOTAL
	m2	ft2	#	ASHRAE 62.1 Type	cfm /person	cfm/ft²	TOTAL cfm	l/s . Person	l/s.m²	l/s/.m2
Office	246.0	2,648	18	Office Building - office space	5.0	0.1	248.9	2.5	0.3	0.48
OpenOffice	431.3	4,642	66	Office Building - office space	5.0	0.1	608.5	2.5	0.3	0.68
Storage	53.3	573	-		-	-	-	-	-	-
Corridor	171.1	1,841	-	General - Corridors	-	0.1	110.5	-	0.3	0.30
TeaRoom	30.7	330	2	Office Building - office space	5.0	0.1	29.8	2.5	0.3	0.46
MeetingRoom	101.8	1,096	44	General - Confernce Meeting	5.0	0.1	285.7	2.5	0.3	1.38
CopyRoom	18.0	194	-	Office Building - office space	5.0	0.1	11.6	2.5	0.3	0.30
PhoneBooth	9.4	101	2	Office Building - Breakrooms	5.0	0.1	22.2	2.5	0.6	1.13
Shower	6.1	66	-		-	-	-	-	-	-
AV	7.3	78	-	Office Building - office space	5.0	0.1	4.7	2.5	0.3	0.30



Data Input – HVAC and Controls

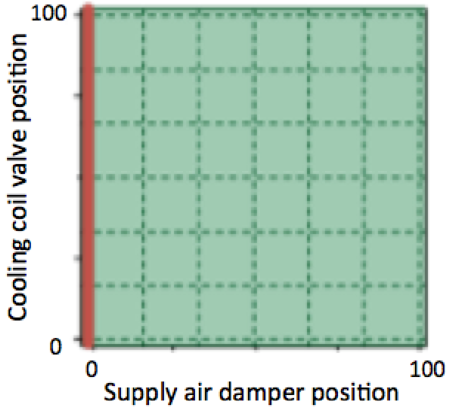
SIM²

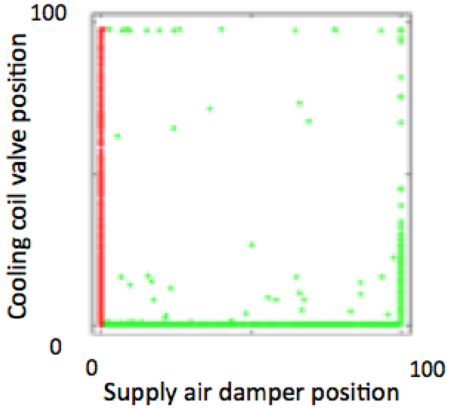
Problem 1: Inputting data into a simulation engine GUI takes lots of time, is complicated and prone to errors

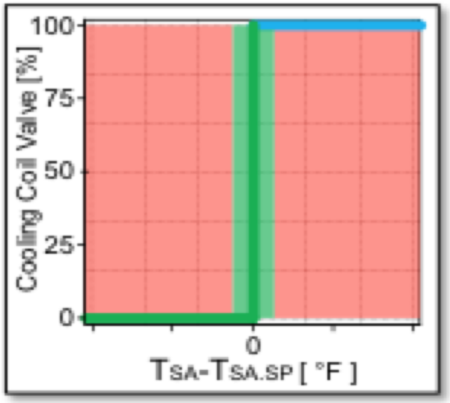
Solution 1: Excel GUI, utilize the power of excel and its formulas to record all inputs, do the necessary calculations, automatically generate simulation code and provide neat information for the client report. Use excel to QA your inputs

Model Control

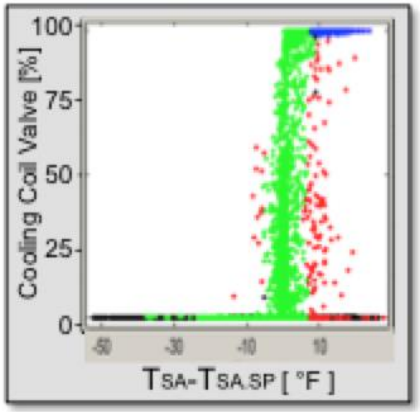
“If you can’t ~~draw~~ it, you can’t ~~build~~ it”







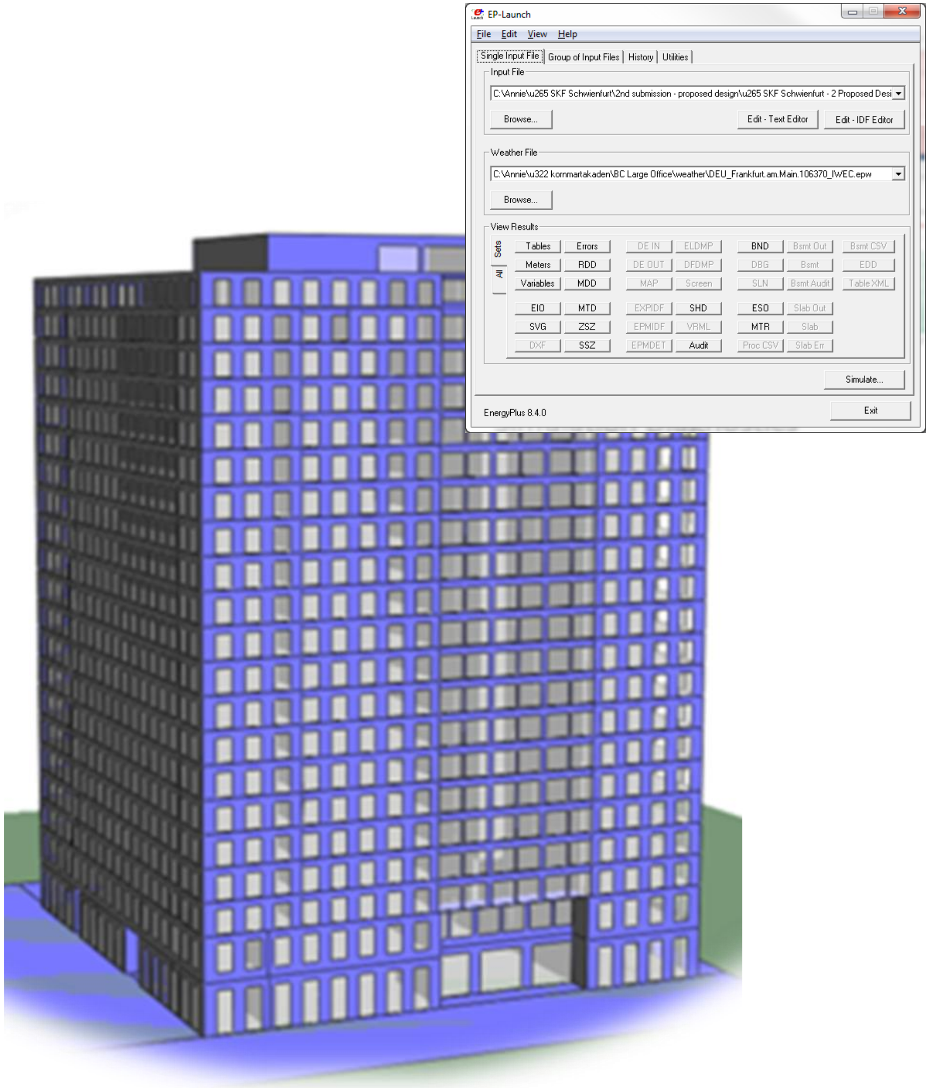
Operation Pattern

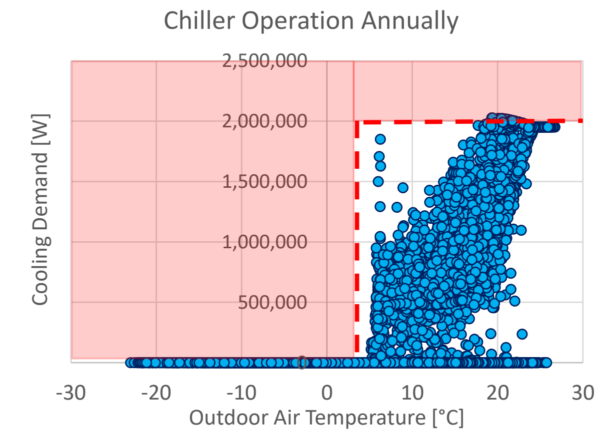


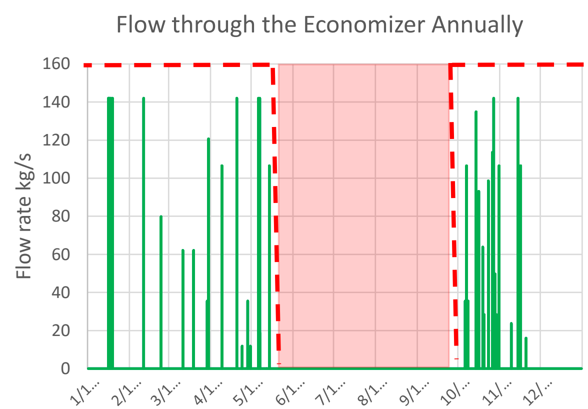
Trend data visualization

Operation Diagnostics - Commissioning

SIM²

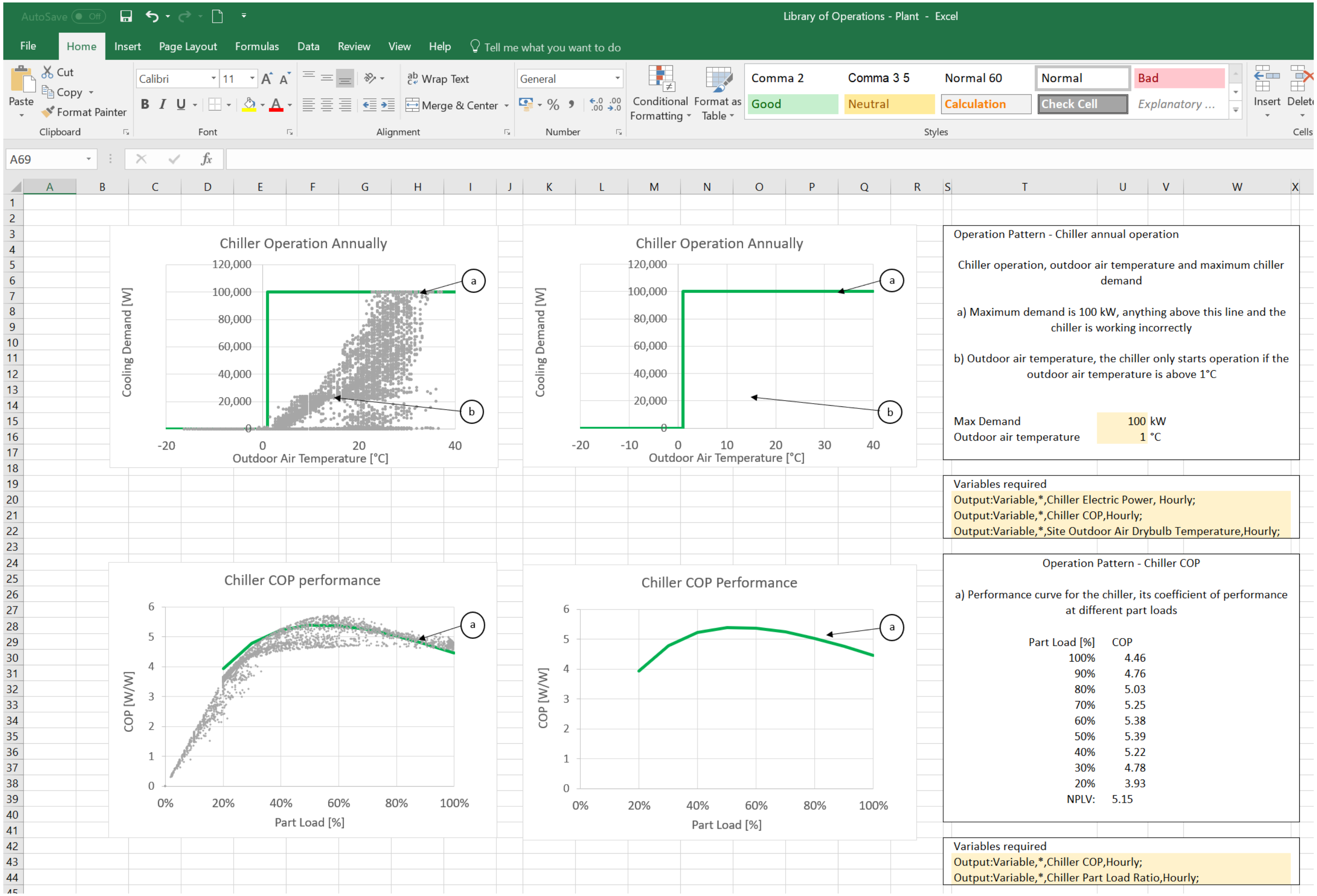




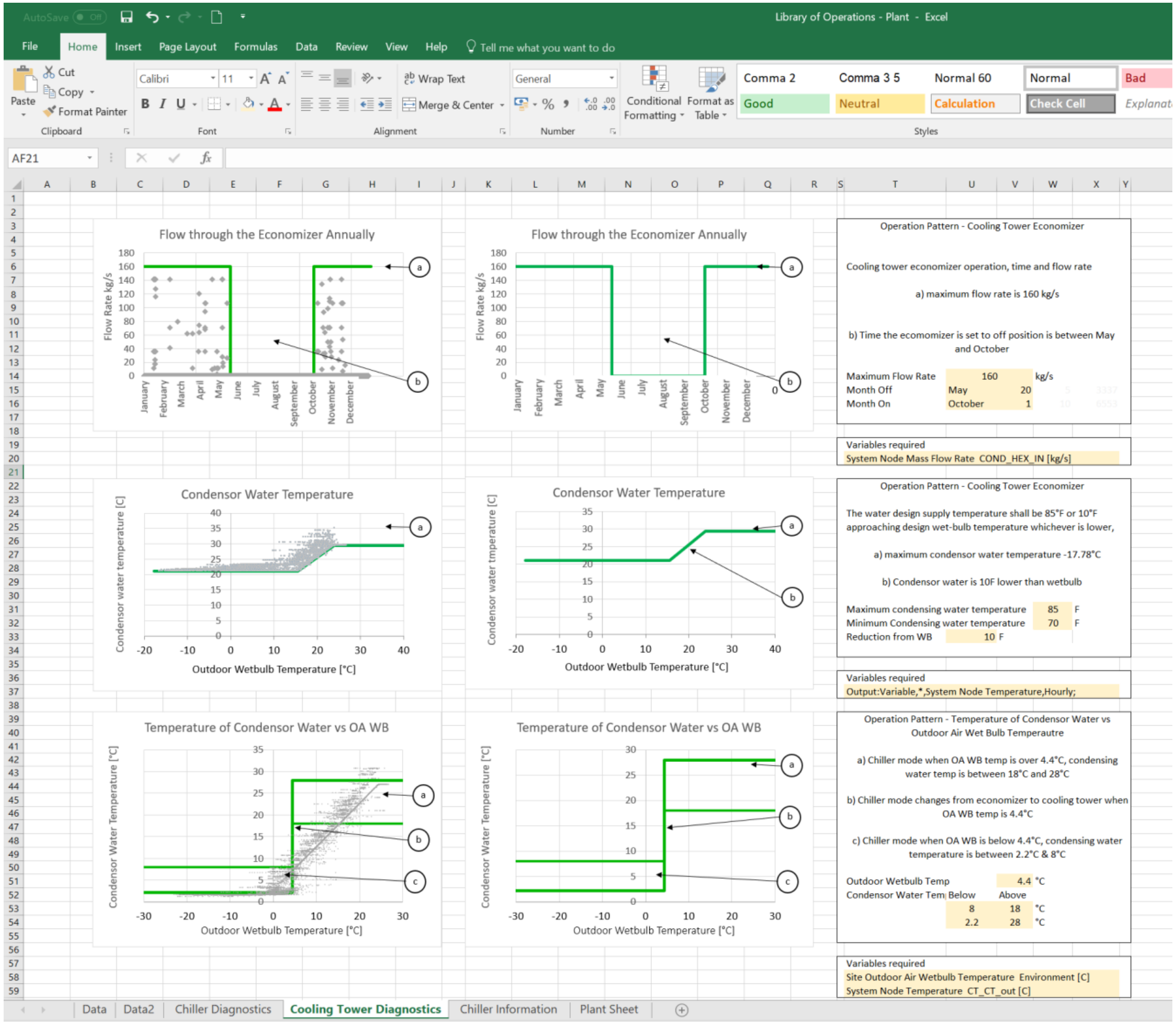


Simulation Diagnostics

SIM²



Output Data – Scripting Process



Output Data – Scripting Process

SIM^2

4.11.1.2 Fans and Pumps

The fan power calculation for the baseline building design is based on G3.1.2.9 of ASHRAE Standard 90.1 2010 Appendix G and 6.5.3.1 of ASHRAE Standard 90.1 2010. The fan supply volume was calculated using 20°F difference between the supply air and the room air temperature according to G3.1.2.8.

The minimum outdoor air flow into each zone is identical to the outdoor air flow for the design case. The minimum outdoor air flow into the zones in the baseline case will never drop below that required for the design case. The peak fan power supply flow was calculated for the baseline case using Table G3.1.2.10 – System 3 through 8:

Fan power = bhp x 746 / fan motor efficiency

Table 18 Baseline Appendix G Fan Power Calculations

				Baseline FanPower	11.8	kW							
				Baseline outdoor air flow rate	1.03	m^3/s							
				Baseline total flow rate	5.21	m^3/s							
Fan Name	Variable / Constant	AHU or Terminal Box?	Supply/ Return/ Exhaust (AHU) / unconditioned (exhaust fan)	Outdoor Air Flow rate [m^3/s]	Peak flow rate [m^3/s]	flow rate [l/s]	Electricity required for the fan p_{Fan} [W]	bHP	Motor Efficiency	cfm	Pressure Drop	BASELINE system	Fan Efficiency
BASELINE				1.0	5.2		11848			11044			
AHU04	Variable	AHU	Supply	0.9	5.0	4971	11414	13.7	89.5%	10,534	1,492	8	0.65
04 Corridor1	Constant	AHU	Supply	0.0	0.0	8	14	0.0	82.5%	17	1,171	4	0.65
04 Corridor2	Constant	AHU	Supply	0.0	0.1	73	131	0.1	82.5%	154	1,171	4	0.65
04 Corridor3	Constant	AHU	Supply	0.1	0.1	82	148	0.2	82.5%	174	1,171	4	0.65
04 Corridor4	Constant	AHU	Supply	0.0	0.0	11	20	0.0	82.5%	23	1,171	4	0.65
04 Storage3	Constant	AHU	Supply	0.0	0.0	11	19	0.0	82.5%	23	1,171	4	0.65
04 TeaRoom	Constant	AHU	Supply	0.0	0.1	56	101	0.1	82.5%	119	1,171	4	0.65

Fan calculations from the modelling input master file

The fans were modelled with a night cycle which was put on during unoccupied times. The fans cycle on and off during this time when temperature of the space is required to be met. An analysis of the fan operation in the model is detailed below:

The total number of hours the fan is operating for is 4088
The total number of hours the fan is operating during unoccupied times is 87
The peak fan power is 5.9kW

Operating hours during occupied and unoccupied times and peak fan power, all automatically generated from the output file

Output Data – Night Cycle Analysis Project Example

SIM^2

Output Data – Night Cycle Analysis Project Example

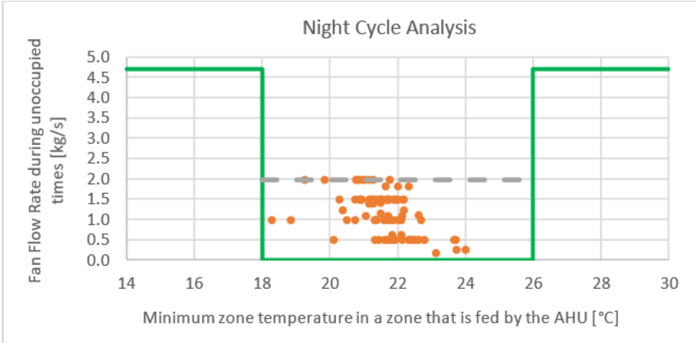


Figure 19 Night Cycle Analysis for the Baseline Fan (unoccupied times)

Automatically generated from outputs, showing that the fans are cycling on and off at night to maintain temperature

The green line represents the setback temperatures during unoccupied times and the maximum flow rate of the system. The grey dotted line represents the minimum air flow rate during occupied times. During unoccupied times the night cycle comes on to maintain the setback temperatures and is between 0 kg/s and 1.97kg/s flow rate.

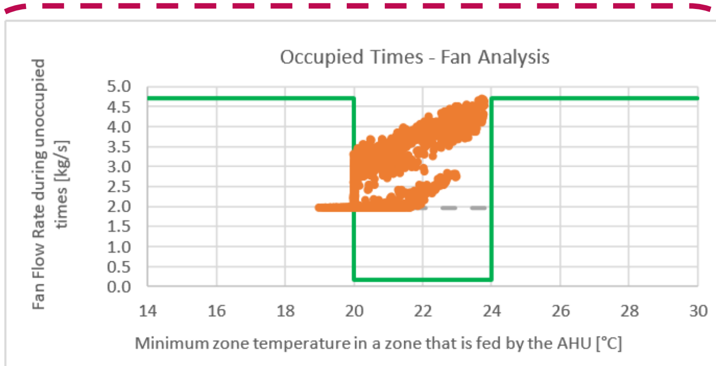
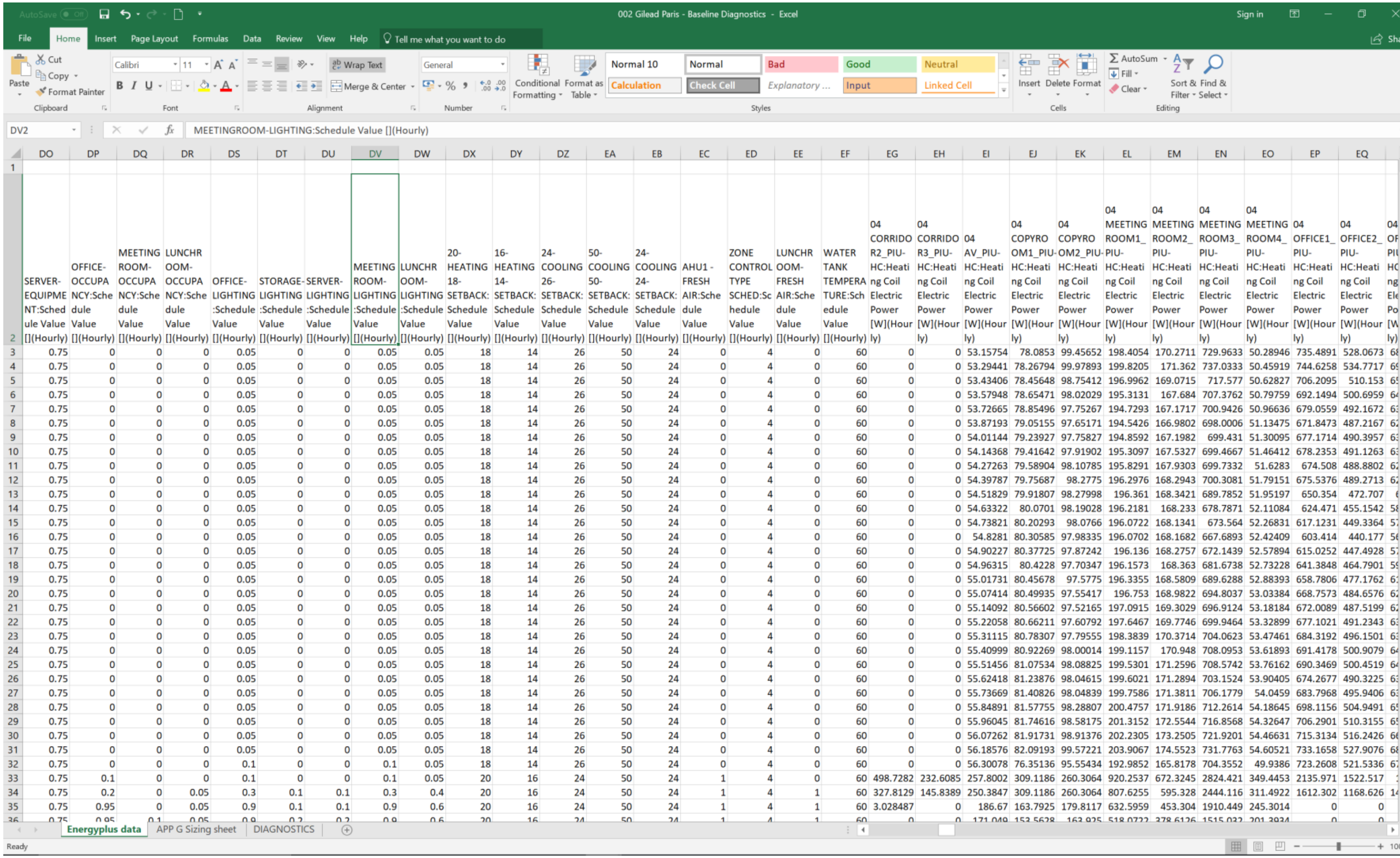


Figure 20 Occupied Times Baseline Fan Analysis

Automatically generated showing how the fan is operating during occupied hours and that the zone is reaching temperature during those times

The graph above shows the fan operation during occupied times. The orange dots represent the flow rate and the minimum zone temperature fed by the AHU. The fan operation is always above the minimum flow rate of 1.97 kg/s and ramps up during the cooling season. The dots fall below the set temperature of 20C as this includes zones which have a lower setpoint such as the corridors and storage rooms.

SIM²



Row	DO: SERVER-EQUIPMENT:Schedule Value [](Hourly)	DP: OFFICE-OCCUPANCY:Schedule Value [](Hourly)	DQ: MEETING ROOM-OCCUPANCY:Schedule Value [](Hourly)	DR: LUNCHROOM-OCCUPANCY:Schedule Value [](Hourly)	DS: OFFICE-LIGHTING:Schedule Value [](Hourly)	DT: STORAGE-LIGHTING:Schedule Value [](Hourly)	DU: SERVER-LIGHTING:Schedule Value [](Hourly)	DV: MEETING ROOM-LIGHTING:Schedule Value [](Hourly)	DW: LUNCHROOM-LIGHTING:Schedule Value [](Hourly)	DX: 20-HEATING 18-SETBACK:Schedule Value [](Hourly)	DY: 16-HEATING 14-SETBACK:Schedule Value [](Hourly)	DZ: 24-COOLING 26-SETBACK:Schedule Value [](Hourly)	EA: 50-COOLING 50-SETBACK:Schedule Value [](Hourly)	EB: 24-COOLING 24-SETBACK:Schedule Value [](Hourly)	EC: AHU1 - FRESH AIR:Schedule Value [](Hourly)	ED: ZONE CONTROL TYPE SCHED:Schedule Value [](Hourly)	EE: LUNCHROOM-FRESH AIR:Schedule Value [](Hourly)	EF: WATER TANK TEMPERATURE:Schedule Value [](Hourly)
3	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
4	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
5	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
6	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
7	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
8	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
9	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
10	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
11	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
12	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
13	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
14	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
15	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
16	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
17	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
18	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
19	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
20	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
21	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
22	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
23	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
24	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
25	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
26	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
27	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
28	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
29	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
30	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
31	0.75	0	0	0	0.05	0	0	0.05	0.05	18	14	26	50	24	0	4	0	60
32	0.75	0	0	0	0.1	0	0	0.1	0.05	18	14	26	50	24	0	4	0	60
33	0.75	0.1	0	0	0.1	0	0	0.1	0.05	20	16	24	50	24	1	4	0	60
34	0.75	0.2	0	0.05	0.3	0.1	0.1	0.3	0.4	20	16	24	50	24	1	4	1	60
35	0.75	0.95	0	0.05	0.9	0.1	0.1	0.9	0.6	20	16	24	50	24	1	4	1	60

Row	EG: 04 CORRIDOR2_PIU-HC:Heating Coil Electric Power [W](Hourly)	EH: 04 CORRIDOR3_PIU-HC:Heating Coil Electric Power [W](Hourly)	EI: 04 AV_PIU-HC:Heating Coil Electric Power [W](Hourly)	EJ: 04 COPYROOM1_PIU-HC:Heating Coil Electric Power [W](Hourly)	EK: 04 COPYROOM2_PIU-HC:Heating Coil Electric Power [W](Hourly)	EL: 04 MEETING ROOM1_PIU-HC:Heating Coil Electric Power [W](Hourly)	EM: 04 MEETING ROOM2_PIU-HC:Heating Coil Electric Power [W](Hourly)	EN: 04 MEETING ROOM3_PIU-HC:Heating Coil Electric Power [W](Hourly)	EO: 04 MEETING ROOM4_PIU-HC:Heating Coil Electric Power [W](Hourly)	EP: 04 OFFICE1_PIU-HC:Heating Coil Electric Power [W](Hourly)	EQ: 04 OFFICE2_PIU-HC:Heating Coil Electric Power [W](Hourly)
3	0	0	53.15754	78.0853	99.45652	198.4054	170.2711	729.9633	50.28946	735.4891	528.0673
4	0	0	53.29441	78.26794	99.97893	199.8205	171.362	737.0333	50.45919	744.6258	534.7717
5	0	0	53.43406	78.45648	98.75412	196.9962	169.0715	717.577	50.62827	706.2095	510.153
6	0	0	53.57948	78.65471	98.02029	195.3131	167.684	707.3762	50.79759	692.1494	500.6959
7	0	0	53.72665	78.85496	97.75267	194.7293	167.1717	700.9426	50.96636	679.0559	492.1672
8	0	0	53.87193	79.05155	97.65171	194.5426	166.9802	698.0006	51.13475	671.8473	487.2167
9	0	0	54.01144	79.23927	97.75827	194.8592	167.1982	699.431	51.30095	677.1714	490.3957
10	0	0	54.14368	79.41642	97.91902	195.3097	167.5327	699.4667	51.46412	678.2353	491.1263
11	0	0	54.27263	79.58904	98.10785	195.8291	167.9303	699.7332	51.6283	674.508	488.8802
12	0	0	54.39787	79.75687	98.2775	196.2976	168.2943	700.3081	51.79151	675.5376	489.2713
13	0	0	54.51829	79.91807	98.27998	196.361	168.3421	689.7852	51.95197	650.354	472.707
14	0	0	54.63322	80.0701	98.19028	196.2181	168.233	678.7871	52.11084	624.471	455.1542
15	0	0	54.73821	80.20293	98.0766	196.0722	168.1341	673.564	52.26831	617.1231	449.3364
16	0	0	54.8281	80.30585	97.98335	196.0702	168.1682	667.6893	52.42409	603.414	440.177
17	0	0	54.90227	80.37725	97.87242	196.136	168.2757	672.1439	52.57894	615.0252	447.4928
18	0	0	54.96315	80.4228	97.70347	196.1573	168.363	681.6738	52.73228	641.3848	464.7901
19	0	0	55.01731	80.45678	97.5775	196.3355	168.5809	689.6288	52.88393	658.7806	477.1762
20	0	0	55.07414	80.49935	97.55417	196.753	168.9822	694.8037	53.03384	668.7573	484.6576
21	0	0	55.14092	80.56602	97.52165	197.0915	169.3029	696.9124	53.18184	672.0089	487.5199
22	0	0	55.22058	80.66211	97.60792	197.6467	169.7746	699.9464	53.32899	677.1021	491.2343
23	0	0	55.31115	80.78307	97.79555	198.3839	170.3714	704.0623	53.47461	684.3192	496.1501
24	0	0	55.40999	80.92269	98.00014	199.1157	170.948	708.0953	53.61893	691.4178	500.9079
25	0	0	55.51456	81.07534	98.08825	199.5301	171.2596	708.5742	53.76162	690.3469	500.4519
26	0	0	55.62418	81.23876	98.04615	199.6021	171.2894	703.1524	53.90405	674.2677	490.3225
27	0	0	55.73669	81.40826	98.04839	199.7586	171.3811	706.1779	54.0459	683.7968	495.9406
28	0	0	55.84891	81.57755	98.28807	200.4757	171.9186	712.2614	54.18645	698.1156	504.9491
29	0	0	55.96045	81.74616	98.58175	201.3152	172.5544	716.8568	54.32647	706.2901	510.3155
30	0	0	56.07262	81.91731	98.91376	202.2305	173.2505	721.9201	54.46631	715.3134	516.2426
31	0	0	56.18576	82.09193	99.57221	203.9067	174.5523	731.7763	54.60521	733.1658	527.9076
32	0	0	56.30078	76.35136	95.55434	192.9852	165.8178	704.3552	49.9386	723.2608	521.5336
33	498.7282	232.6085	257.8002	309.1186	260.3064	920.2537	672.3245	2824.421	349.4453	2135.971	1522.517
34	327.8129	145.8389	250.3847	309.1186	260.3064	807.6255	595.328	2444.116	311.4922	1612.302	1168.626
35	3.028487	0	186.67	163.7925	179.8117	632.5959	453.304	1910.449	245.3014	0	0

How this works – Output data from Software

SIM²

Calculations

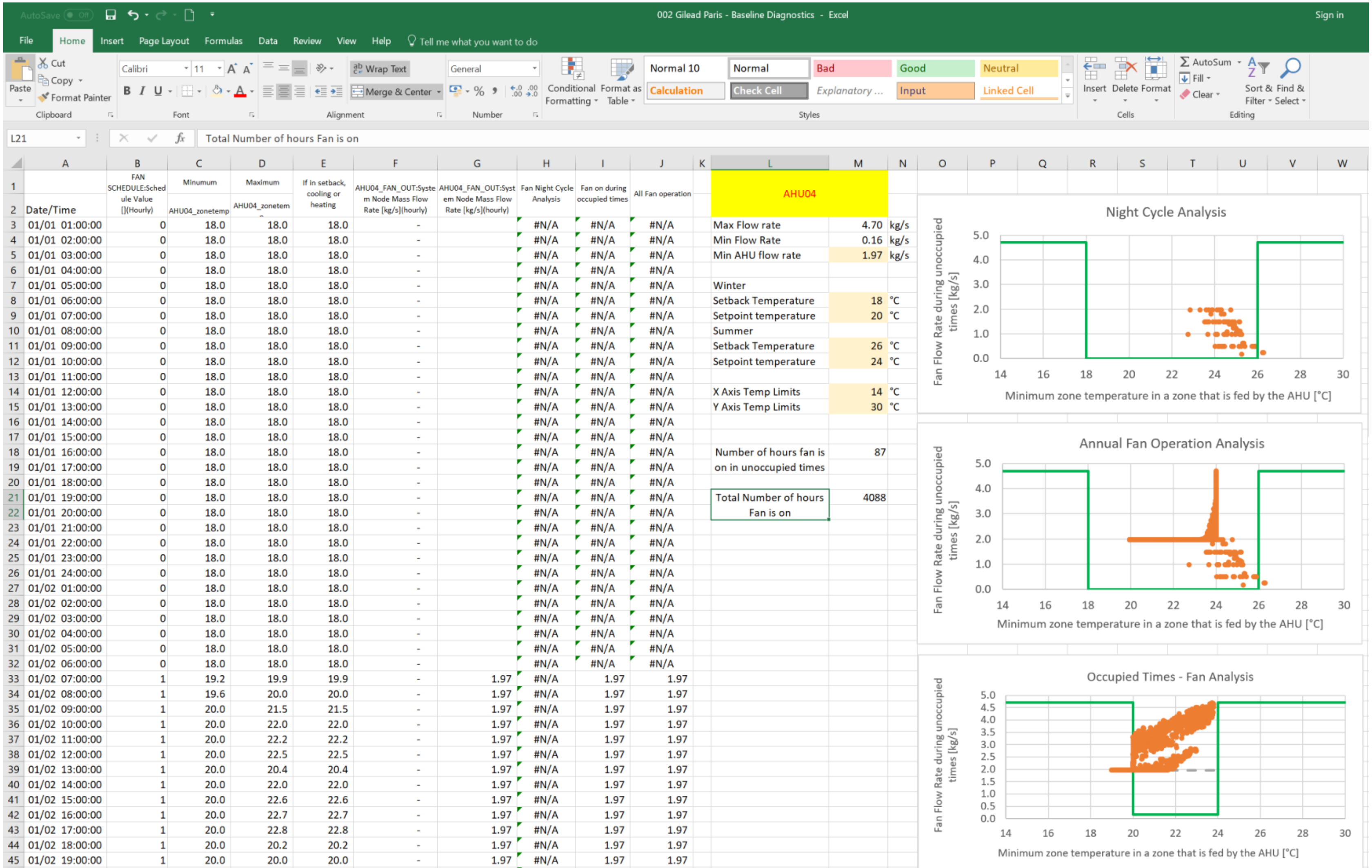
Generating the correct data output names

Row	level	Zone Name	floor area m²	deta temp (deg F)	Delta T (Deg K)	Peak cooling load (kW)	Peak Heating Load (kW)	Peak load (kW)	Maximum flow rate for 20'F (m3/s)	Baseline system	AHU name	W/m²	Average W/m² for the system	Does this zone differ by 31.2W/m2? By how much?
2	04	04 Archive	14	20	11.1	-	0.09	0.1	0.01	4	04 Archive	7	7	n
3	04	04 AV	7	20	11.1	0.25	0.13	0.3	0.02	8	AHU04	34	67	n
4	04	04 CopyRoom1	10	20	11.1	0.36	0.23	0.4	0.03	8	AHU04	36	67	n
5	04	04 CopyRoom2	8	20	11.1	0.31	0.24	0.3	0.02	8	AHU04	38	67	n
6	04	04 Corridor1	18	20	11.1	-	0.02	0.0	0.00	4	04 Corridor1	1	1	n
7	04	04 Corridor2	74	20	11.1	-	0.97	1.0	0.07	4	04 Corridor2	13	13	n
8	04	04 Corridor3	55	20	11.1	-	0.34	0.3	0.03	4	04 Corridor3	6	6	n
9	04	04 Corridor4	24	20	11.1	-	0.08	0.1	0.01	4	04 Corridor4	3	3	n
10	04	04 MeetingRoom1	19	20	11.1	1.44	0.51	1.4	0.11	8	AHU04	74	67	n
11	04	04 MeetingRoom2	15	20	11.1	1.06	0.44	1.1	0.08	8	AHU04	68	67	n
12	04	04 MeetingRoom3	60	20	11.1	5.61	1.94	5.6	0.42	8	AHU04	94	67	n
13	04	04 MeetingRoom4	7	20	11.1	0.54	0.15	0.5	0.04	8	AHU04	74	67	n
14	04	04 Office1	54	20	11.1	4.46	1.83	4.5	0.33	8	AHU04	83	67	n
15	04	04 Office2	35	20	11.1	3.02	1.34	3.0	0.23	8	AHU04	86	67	n
16	04	04 Office3	44	20	11.1	3.71	1.68	3.7	0.28	8	AHU04	84	67	n
17	04	04 Office4	37	20	11.1	2.39	1.31	2.4	0.18	8	AHU04	65	67	n
18	04	04 Office5	11	20	11.1	0.82	0.66	0.8	0.06	8	AHU04	76	67	n
19	04	04 Office6	66	20	11.1	4.05	1.90	4.1	0.30	8	AHU04	61	67	n
20	04	04 OpenOffice1	182	20	11.1	16.30	5.95	16.3	1.22	8	AHU04	90	67	n
21	04	04 OpenOffice2	77	20	11.1	6.29	2.34	6.3	0.47	8	AHU04	82	67	n
22	04	04 OpenOffice3	54	20	11.1	4.43	1.66	4.4	0.33	8	AHU04	82	67	n
23	04	04 OpenOffice4	118	20	11.1	10.61	3.86	10.6	0.80	8	AHU04	90	67	n
24	04	04 PhoneBooth1	5	20	11.1	0.20	0.13	0.2	0.02	8	AHU04	41	67	n
25	04	04 PhoneBooth2	5	20	11.1	0.21	0.17	0.2	0.02	8	AHU04	45	67	n
26	04	04 Shower	6	20	11.1	0.20	0.24	0.2	0.02	8	AHU04	39	67	n
27		0						0.0	-				-	
28		0						0.0	-				-	
29	04	04 Storage3	15	20	11.1	-	0.14	0.1	0.01	4	04 Storage3	9	9	n
30	04	04 TeaRoom	31	20	11.1	0.75	0.44	0.8	0.06	4	04 TeaRoom	24	24	n

Row	New AHU names	New Baseline System Numbers	For Simulation Diagnostics Zone temperature variable name	For Simulation Diagnostics Zone temperature variable name	Remove duplicates, (for the calculation s
2	04 Archive	4	04 Archive:Zone Air Temperature [C](hourly)	04 Archive_zoneTemp	
3	AHU04	8	04 AV:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHU00
4	AHU04	8	04 CopyRoom1:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHU01
5	AHU04	8	04 CopyRoom2:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHU02
6	04 Corridor1	4	04 Corridor1:Zone Air Temperature [C](hourly)	04 Corridor1_zoneTemp	AHU03
7	04 Corridor2	4	04 Corridor2:Zone Air Temperature [C](hourly)	04 Corridor2_zoneTemp	AHU04
8	04 Corridor3	4	04 Corridor3:Zone Air Temperature [C](hourly)	04 Corridor3_zoneTemp	AHU05
9	04 Corridor4	4	04 Corridor4:Zone Air Temperature [C](hourly)	04 Corridor4_zoneTemp	AHU06
10	AHU04	8	04 MeetingRoom1:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHU07
11	AHU04	8	04 MeetingRoom2:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHU08
12	AHU04	8	04 MeetingRoom3:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHUU01
13	AHU04	8	04 MeetingRoom4:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	AHUU02
14	AHU04	8	04 Office1:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.00_ITRoom
15	AHU04	8	04 Office2:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.00_KitchenNorth
16	AHU04	8	04 Office3:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.01_KitchenNorth
17	AHU04	8	04 Office4:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.02_ITRoom
18	AHU04	8	04 Office5:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.02_KitchenNorth
19	AHU04	8	04 Office6:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.03_ITRoom
20	AHU04	8	04 OpenOffice1:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.03_KitchenNorth
21	AHU04	8	04 OpenOffice2:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.04_ITRoom
22	AHU04	8	04 OpenOffice3:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.04_KitchenNorth
23	AHU04	8	04 OpenOffice4:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.05_ITRoom
24	AHU04	8	04 PhoneBooth1:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.05_KitchenNorth
25	AHU04	8	04 PhoneBooth2:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.06_ITRoom
26	AHU04	8	04 Shower:Zone Air Temperature [C](hourly)	AHU04_zoneTemp	EB.06_KitchenNorth
27			0:Zone Air Temperature [C](hourly)	_zoneTemp	EB.07_ConferenceNo
28			0:Zone Air Temperature [C](hourly)	_zoneTemp	EB.07_ITRoom
29	04 Storage3	4	04 Storage3:Zone Air Temperature [C](hourly)	04 Storage3_zoneTemp	EB.07_Kitchen
30	04 TeaRoom	4	04 TeaRoom:Zone Air Temperature [C](hourly)	04 TeaRoom_zoneTemp	EB.07_OpenOfficeNo
31			:Zone Air Temperature [C](timestep)	_zoneTemp	EB.07_OpenOfficeNo
32			:Zone Air Temperature [C](timestep)	_zoneTemp	EB.07_OpenOfficeSou
33			:Zone Air Temperature [C](timestep)	_zoneTemp	EB.U01_EntranceEas
34			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.00_EntranceSout
35			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.01_ITRoom
36			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.01_OfficeSouthw
37			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.02_ITRoom
38			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.02_OfficeSouthw
39			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.02_ReceptionBric
40			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.03_ITRoom
41			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.03_OfficeSouthw
42			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.03_ReceptionBric
43			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.04_ITRoom
44			:Zone Air Temperature [C](timestep)	_zoneTemp	NB.04_OfficeSouthw

Energyplus data | APP G Sizing sheet | DIAGNOSTICS

How this works – Scripting what data needs to be called



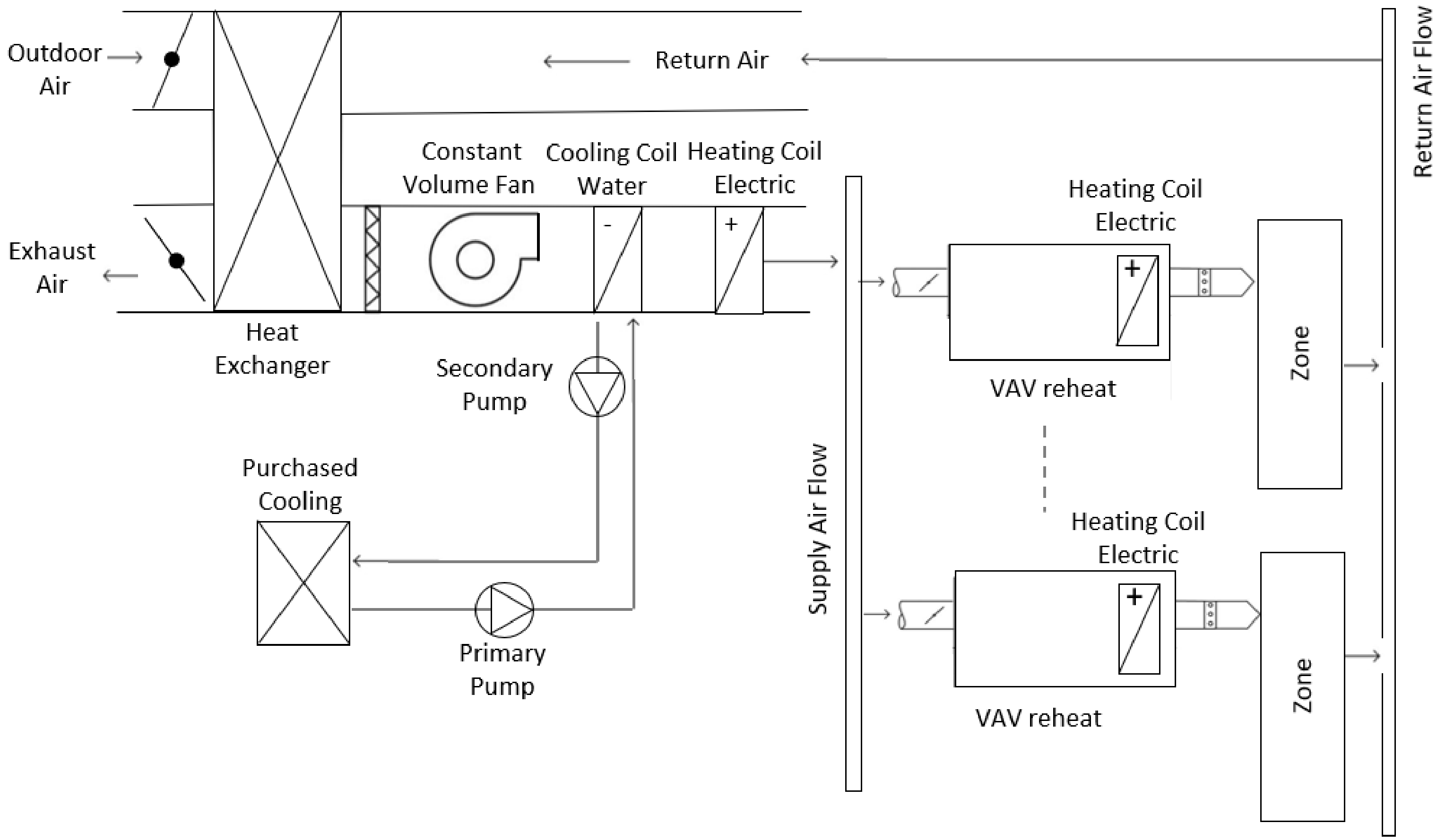
	A	B	C	D	E	F	G	H	I	J
1		FAN SCHEDULE:Schedule Value [](Hourly)	Minumum	Maximum	If in setback, cooling or heating	AHU04_FAN_OUT:System Node Mass Flow Rate [kg/s](hourly)	AHU04_FAN_OUT:System Node Mass Flow Rate [kg/s](hourly)	Fan Night Cycle Analysis	Fan on during occupied times	All Fan operation
2	Date/Time		AHU04_zonetemp	AHU04_zonetem						
3	01/01 01:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
4	01/01 02:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
5	01/01 03:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
6	01/01 04:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
7	01/01 05:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
8	01/01 06:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
9	01/01 07:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
10	01/01 08:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
11	01/01 09:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
12	01/01 10:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
13	01/01 11:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
14	01/01 12:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
15	01/01 13:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
16	01/01 14:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
17	01/01 15:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
18	01/01 16:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
19	01/01 17:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
20	01/01 18:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
21	01/01 19:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
22	01/01 20:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
23	01/01 21:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
24	01/01 22:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
25	01/01 23:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
26	01/01 24:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
27	01/02 01:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
28	01/02 02:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
29	01/02 03:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
30	01/02 04:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
31	01/02 05:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
32	01/02 06:00:00	0	18.0	18.0	18.0	-		#N/A	#N/A	#N/A
33	01/02 07:00:00	1	19.2	19.9	19.9	-	1.97	#N/A	1.97	1.97
34	01/02 08:00:00	1	19.6	20.0	20.0	-	1.97	#N/A	1.97	1.97
35	01/02 09:00:00	1	20.0	21.5	21.5	-	1.97	#N/A	1.97	1.97
36	01/02 10:00:00	1	20.0	22.0	22.0	-	1.97	#N/A	1.97	1.97
37	01/02 11:00:00	1	20.0	22.2	22.2	-	1.97	#N/A	1.97	1.97
38	01/02 12:00:00	1	20.0	22.5	22.5	-	1.97	#N/A	1.97	1.97
39	01/02 13:00:00	1	20.0	20.4	20.4	-	1.97	#N/A	1.97	1.97
40	01/02 14:00:00	1	20.0	22.0	22.0	-	1.97	#N/A	1.97	1.97
41	01/02 15:00:00	1	20.0	22.6	22.6	-	1.97	#N/A	1.97	1.97
42	01/02 16:00:00	1	20.0	22.7	22.7	-	1.97	#N/A	1.97	1.97
43	01/02 17:00:00	1	20.0	22.8	22.8	-	1.97	#N/A	1.97	1.97
44	01/02 18:00:00	1	20.0	20.2	20.2	-	1.97	#N/A	1.97	1.97
45	01/02 19:00:00	1	20.0	20.0	20.0	-	1.97	#N/A	1.97	1.97

L	M	N
Max Flow rate	4.70	kg/s
Min Flow Rate	0.16	kg/s
Min AHU flow rate	1.97	kg/s
Winter		
Setback Temperature	18	°C
Setpoint temperature	20	°C
Summer		
Setback Temperature	26	°C
Setpoint temperature	24	°C
X Axis Temp Limits	14	°C
Y Axis Temp Limits	30	°C
Number of hours fan is on in unoccupied times	87	
Total Number of hours Fan is on	4088	

How the works – Data analysis and quality control

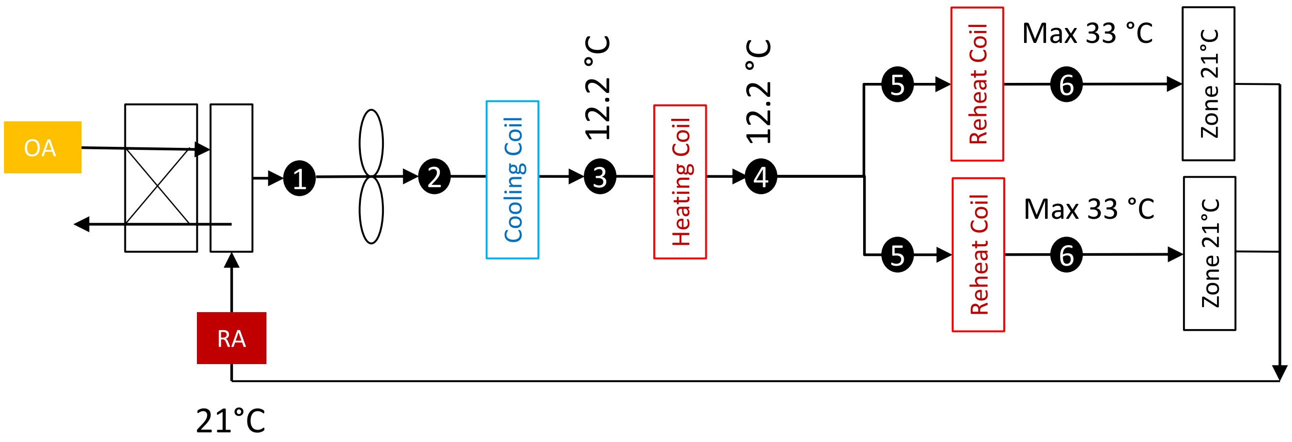
SIM²

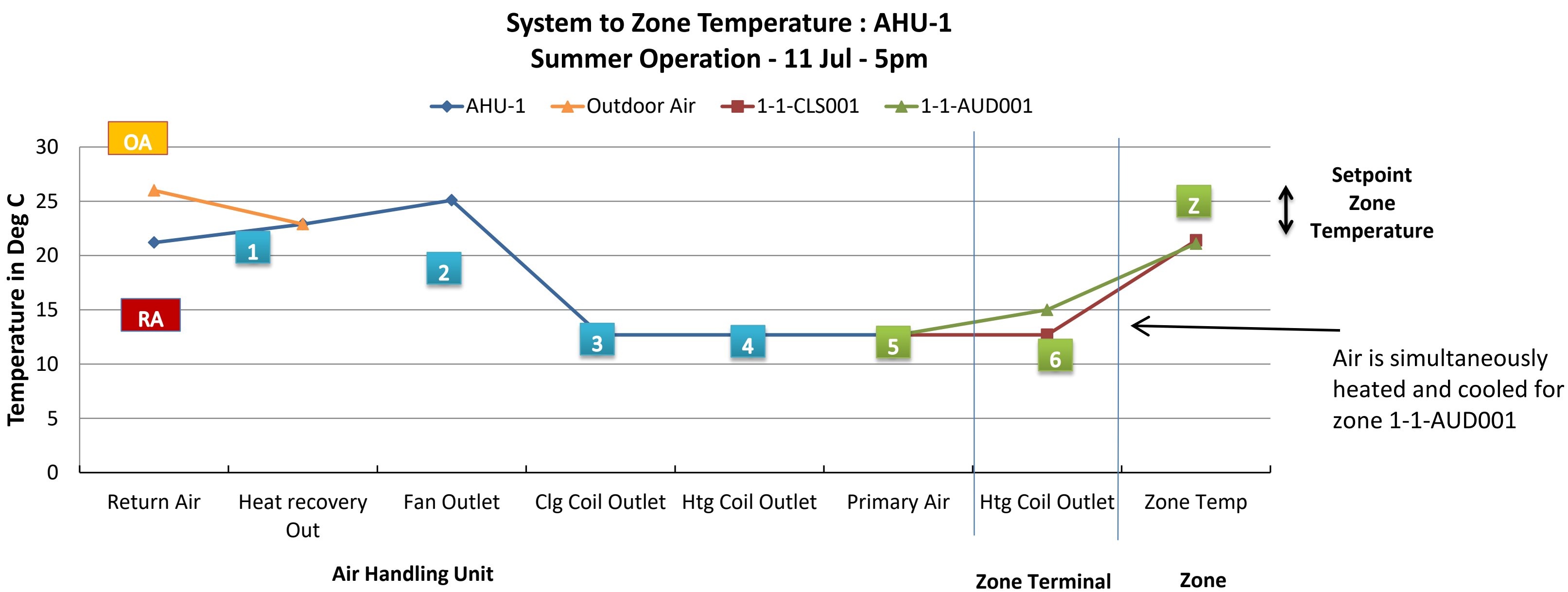
Energy Component Diagram



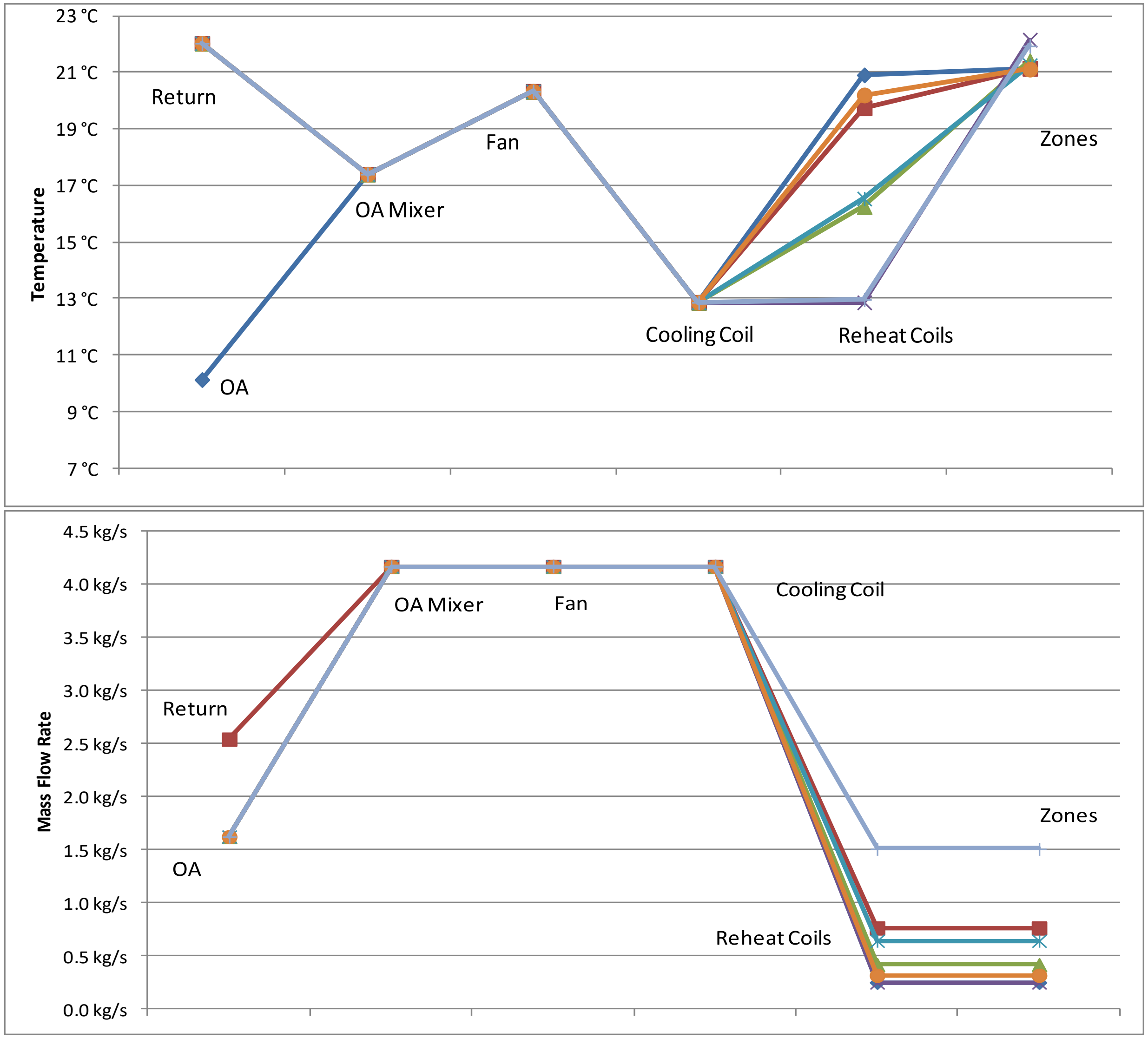
AHU Analysis – VAV reheat example

SIM²





AHU Analysis – Simultaneous Heating and Cooling

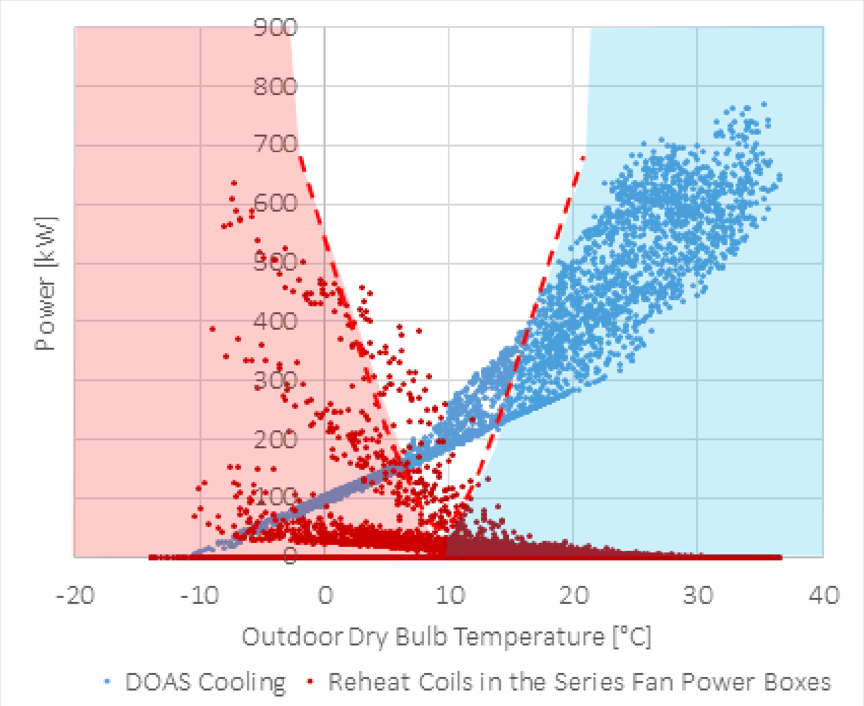


AHU Analysis – Heat Exchanger and Cooling Coil

SIM²

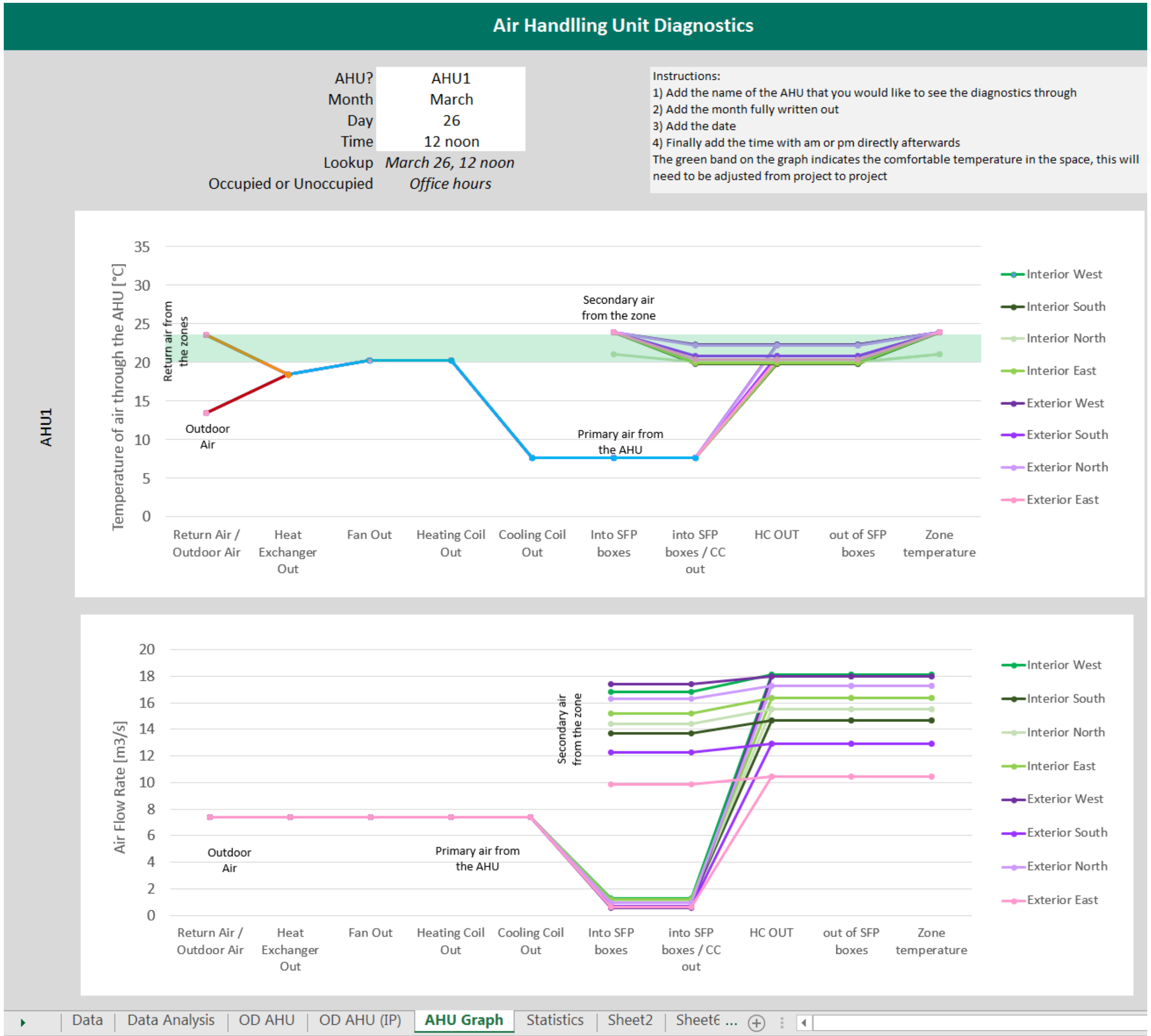
Statistics and Heating Cooling Analysis (SI)

	Hours in the year these conditions apply
Heat Exchanger exchanging heat	*2.680*
Heat Exchanger exchanging cool	*733*
AHU Heating Coil ON	-
AHU Cooling Coil ON	*3.388*
AHU heating and cooling on at the same time	-
Heat Exchanger exchanging Heat and Cooling Coil ON	*2.655*
Heat Exchanger exchanging Cool and heating Coil ON	-
Total number of hours system is on	*3.413*
Hours heat exchanger should be bypassed in the summer	-



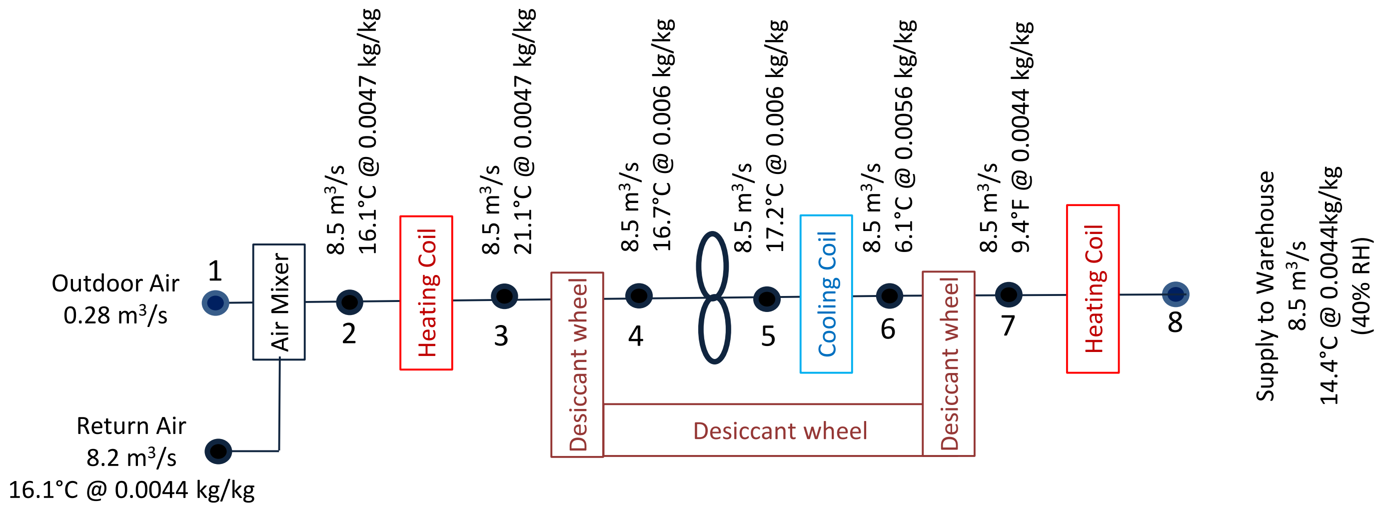
AHU Analysis – Heat Exchanger and Cooling Coil

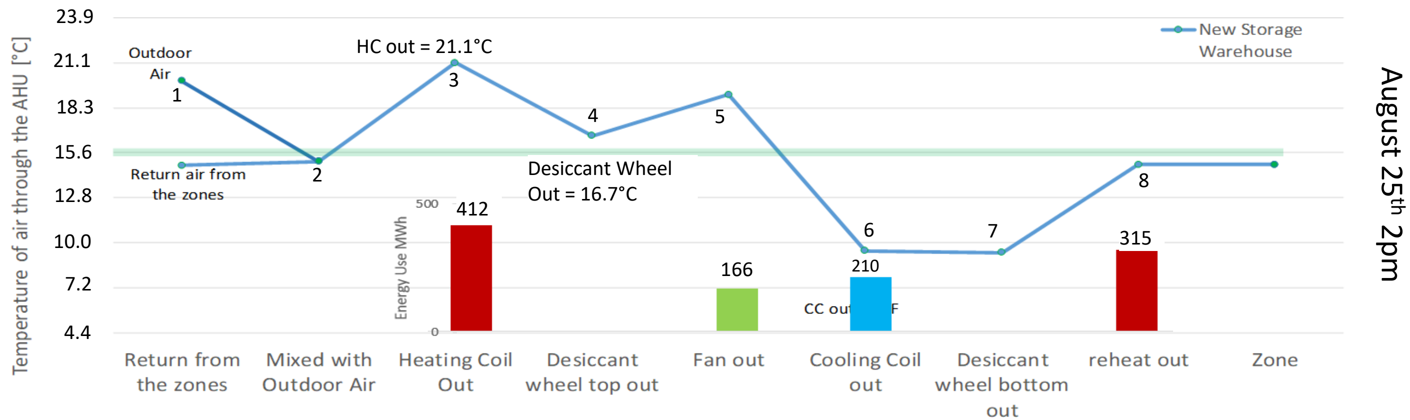
SIM²



AHU and Controls Analysis Tool

SIM^2





AHU Analysis – Case study

SIM²

- Unclear controls can easily lead to simultaneous heating and cooling.
- Heat exchangers can be added to systems thinking they will save energy but in fact cause the system to use more energy.
- Lack of analysis, misunderstanding how a systems actually works and business as usual leads to poor performance of building systems.
- Energy modellers can model and give extremely valuable feedback on controls for the building saving thousands of pounds of operational energy costs.

AHU and Controls Modelling and Analysis

SIM^2

PROBLEM 2: Input errors and misunderstanding outputs leads to poor results, lack of confidence in modelling and, at worse, incorrect analysis and advice to the client

SOLUTION 2: Simulation diagnostics!

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Don't compromise -- simulate

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