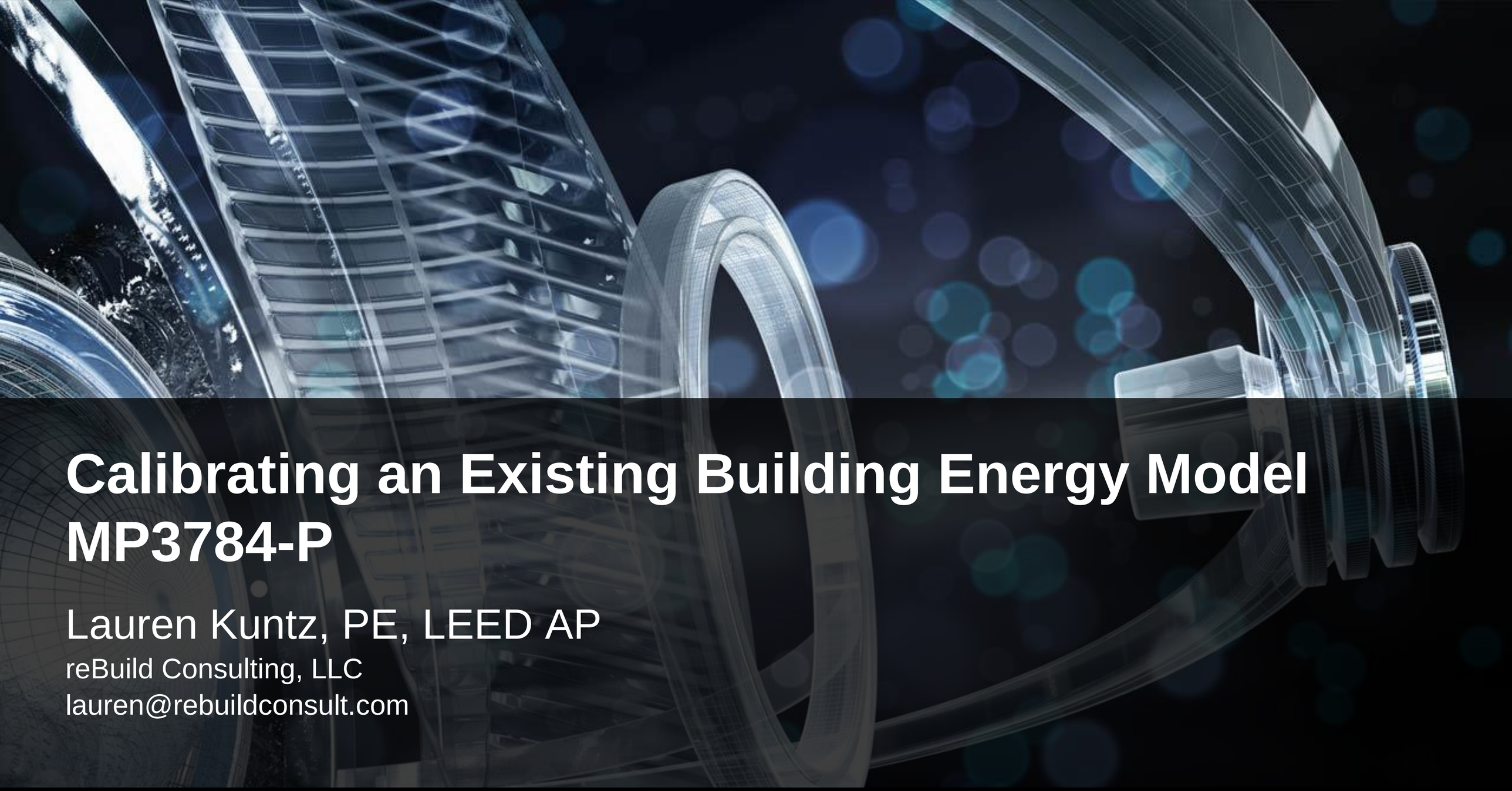

Calibrating an Existing Building Energy Model MP3784-P

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lauren@rebuildconsult.com

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Autodesk University 2012 Power Track

- Energy Optimization for Retrofits
  - MP3397-P - Taking Advantage of BIM for CFD Modeling
  - MP3565-P - Using a Retro-BIM Workflow: Case Studies in Energy-Driven Retrofit Projects
  - MP3765-P - Using BIM to Streamline Your Energy Modeling Workflows
  - ***MP3784-P - Calibrating an Existing Building Energy Model***

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Class Summary

This session discusses the process of calibrating an energy model for an existing building, based on actual energy consumption. The first part will go over how to build a simplified energy model in Autodesk® Vasari Beta 1.0 software and calibrate the model to monthly utility data in Autodesk® Green Building Studio® web-based software. The second, and more involved, portion will cover how to calibrate the simulated results of a DOE2 energy model to the actual building's energy performance as captured by a properly configured BEMS system. Both of these strategies will be covered in a case study on the Autodesk headquarters building in San Rafael, CA

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Learning Objectives

At the end of this class, you will be able to:

- Create a rapid energy model using Autodesk® Vasari Beta 1.0 and calibrate it using utility bills
- Create a baseline energy model using Autodesk® Revit, Green Building Studio® and eQuest
- Convert trended BMS data into useful spreadsheets and graphs using Excel
- Create comparison charts to graphically demonstrate the accuracy of the current model
- Use trended BMS data to calibrate your energy model

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“Always make the audience suffer as much as possible” – **Alfred Hitchcock**

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Why calibrate an energy model?

- Develop an accurate representation of the building
- Understand how the existing building is actually performing
- Define potential Energy Conservation Measures (ECMs)
- Compare the effectiveness of various ECMs

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111 McInnis Pkwy, San Rafael, CA

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Rapid Energy Modeling

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What do we need to create a rapid energy model?

- Autodesk® Vasari Beta 1.0 – Build 3D geometry, generate the rapid energy model, produce quick results, create .gbxml file

- Autodesk® Green Building Studio (GBS) – Upload utility data, modify some standard defaults, produce slightly calibrated results

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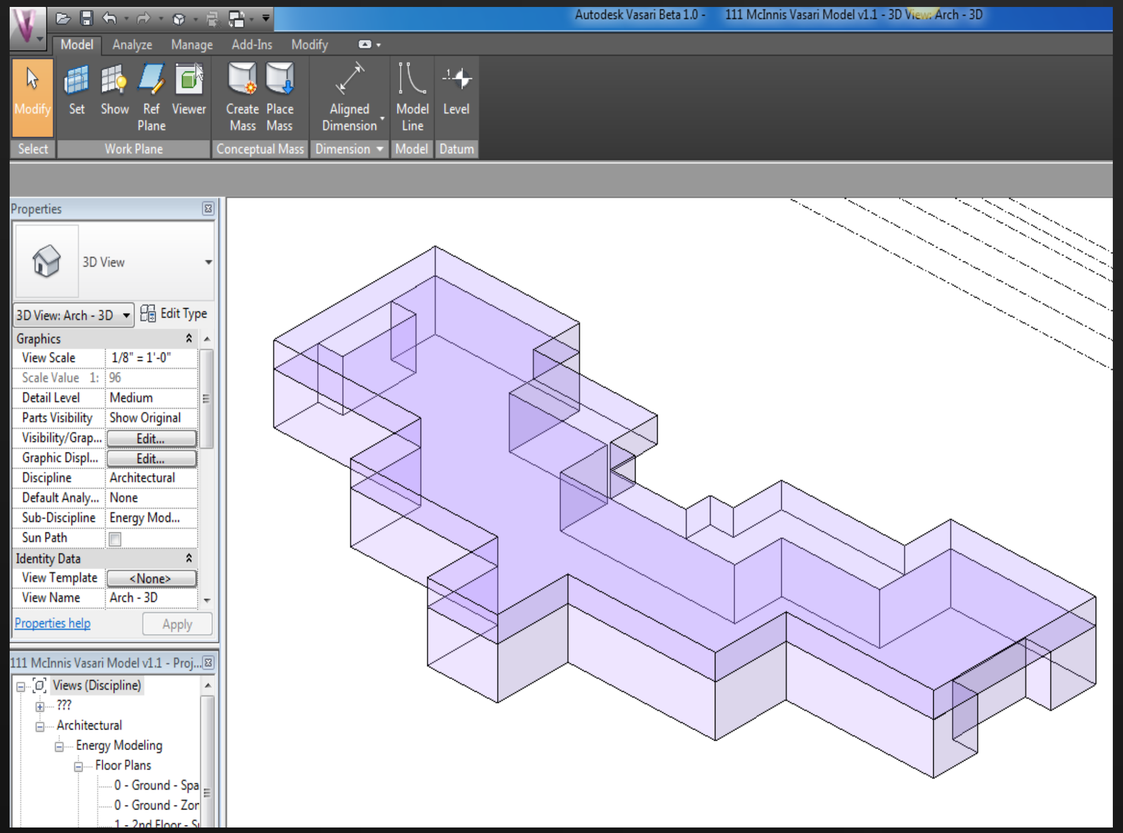
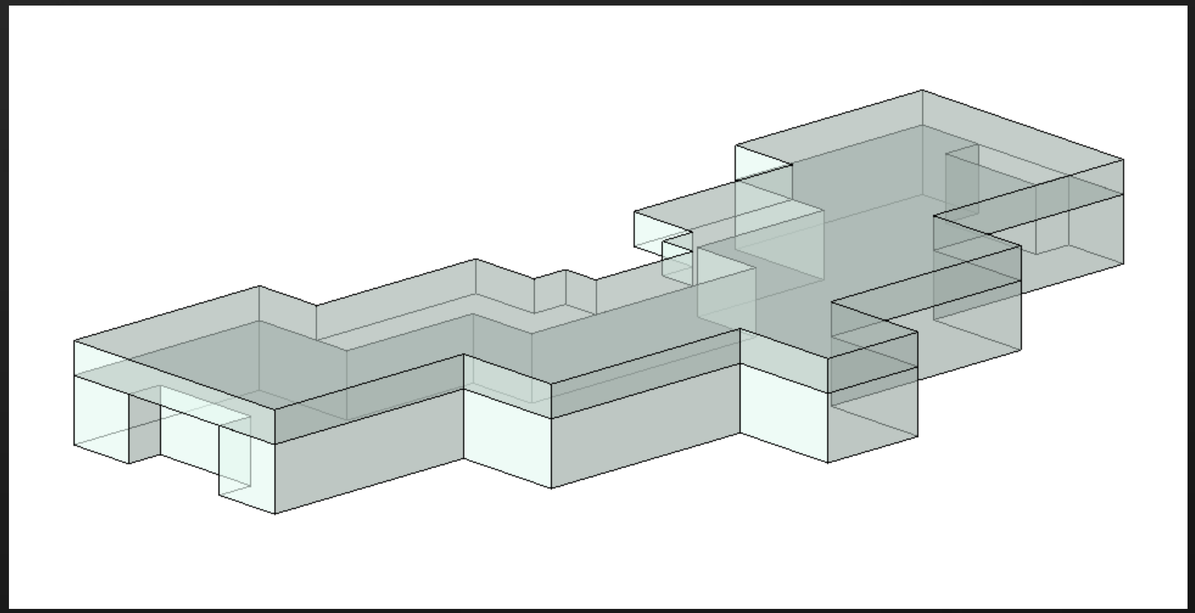
Vasari Beta 1.0





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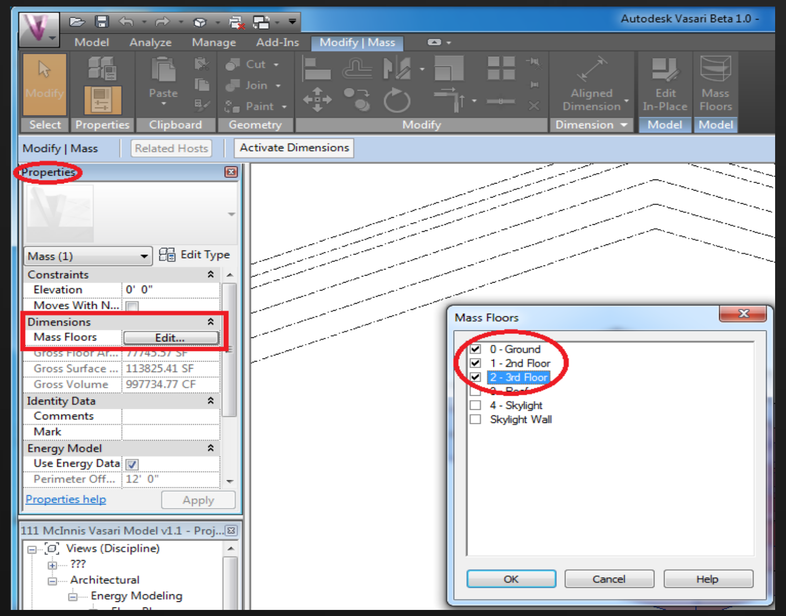
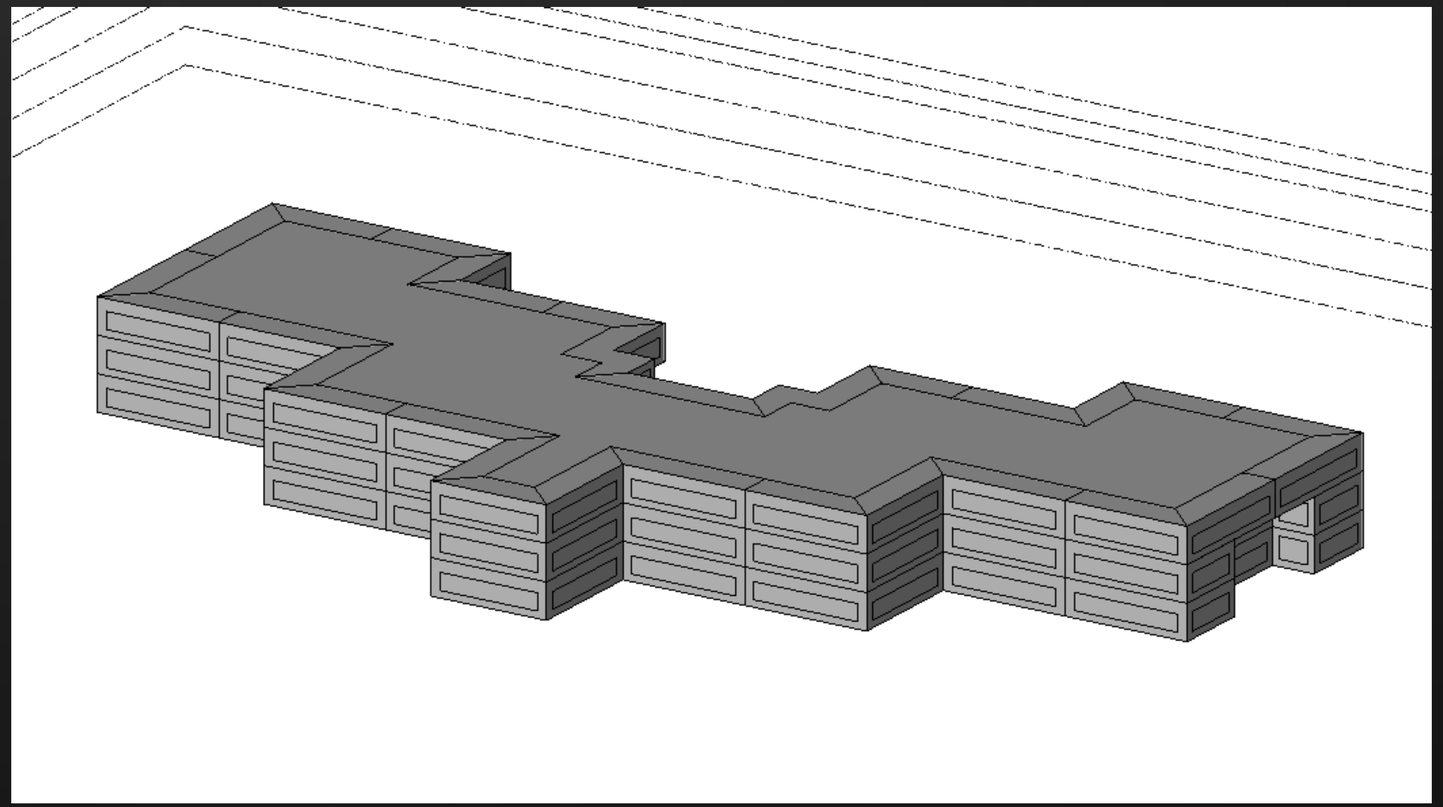
Vasari – Add Floors





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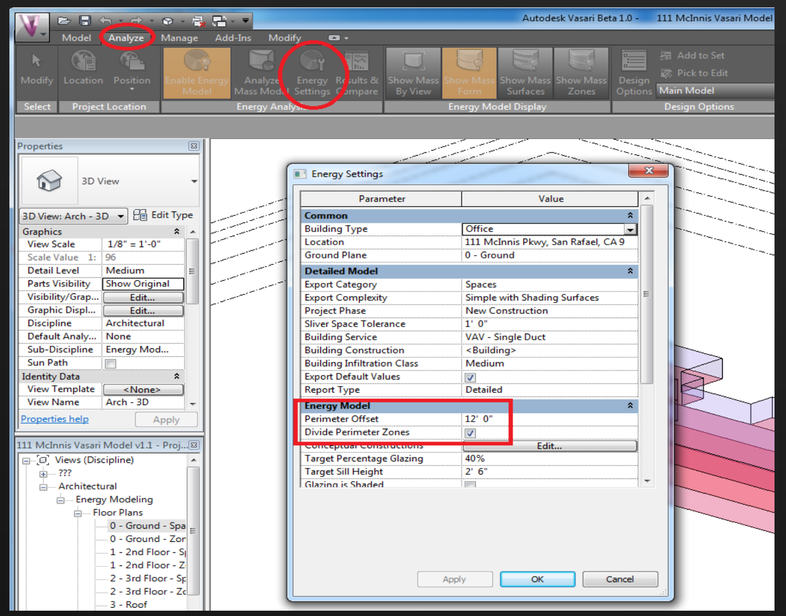
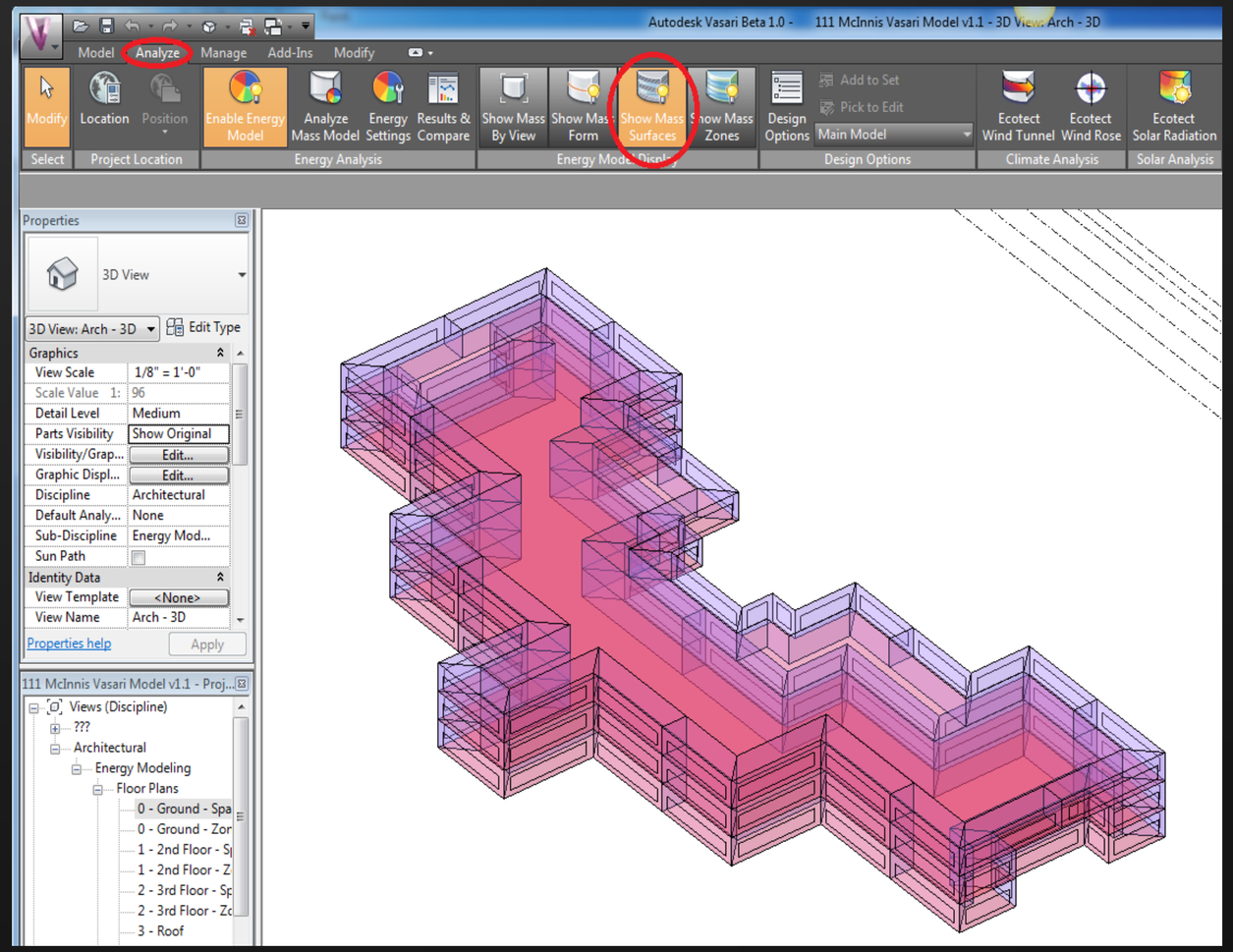
Vasari – Add Zones





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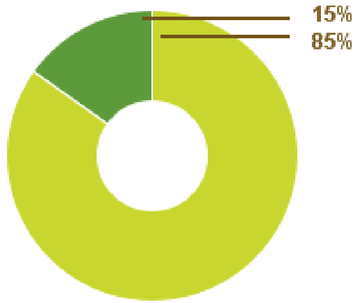
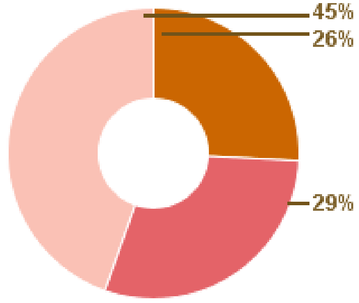
Vasari – Results

Annual Energy Use/Cost



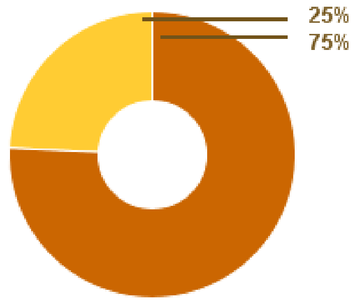
Electricity	85%	$169,372	1,436,570	kWh
Fuel	15%	$7,041	8,769	Therms
		$176,413		

Energy Use: Electricity



			(kWh)
HVAC	26%	$43,437	368,423
Lighting	29%	$49,732	421,816
Misc Equipment	45%	$75,010	636,222
		$168,179	1,426,461

Energy Use: Fuel



			(Therms)
HVAC	75%	$5,332	6,640
Domestic Hot Water	25%	$1,708	2,128
		$7,040	8,768

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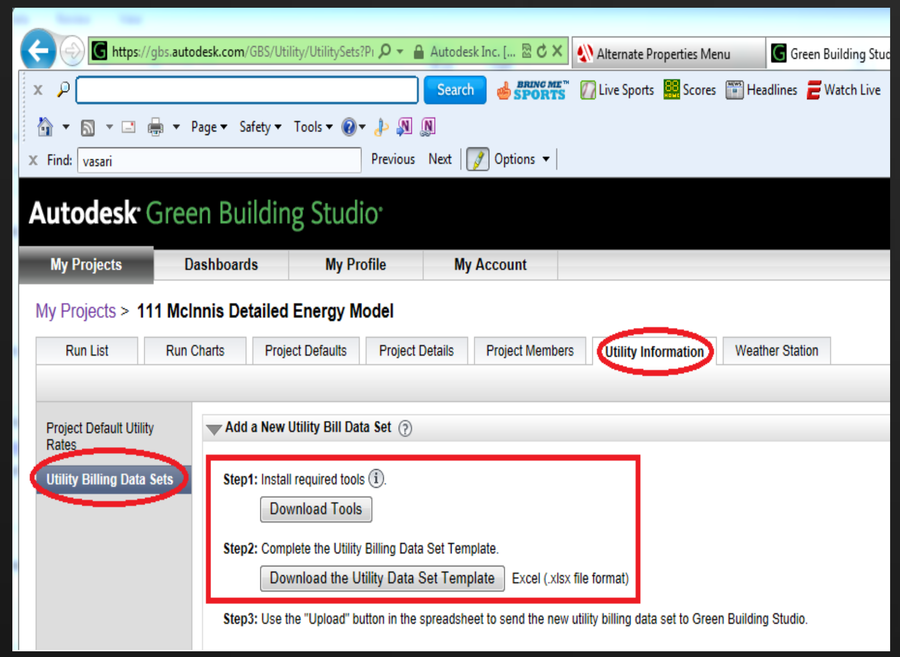
Green Building Studio – Utility Bills



1) Sign In to Green Building Studio using your Autodesk ID, and then select a project.

Sign In

Project List

2) All fields in white below can be completed, columns with asterisks (*) are required.

This is an all electric building

Green Button: import your monthly utility data into this spreadsheet.

a) Check to see if your utility company has adopted the Green Button initiative.

b) Go to your utility company's website to download your Green Button data file.

c) Import your monthly utility data.

Note: the Month and Units fields contain drop-down menus.

		units	kWh	kW	therm
Month	Year		* Electricity Usage	Electric Demand	* Fuel Usage (natural gas)
August	2011		167745.5089	498	1697
September	2011		163839.2104	521	1480
October	2011		151816.5736	472	1967
November	2011		125934.3847	432	3468
December	2011		120291.3204	410	4408
January	2012		125748.1001	389	4244
February	2012		121329.2535	417	3758
March	2012		128351.3189	406	3533
April	2012		130680.6354	452	2663
May	2012		148498.2613	460	2013
June	2012		143817.136	484	1603
July	2012		148962.6317	510	1458
		Annual Use or Peak	**1,677,014**	**521**	**32,292**
		Annual Cost	287201.61		28640
		Unit Cost	0.1713		0.8869
		Currency	US Dollar (USD)		

Note: currency is set by the selected project.

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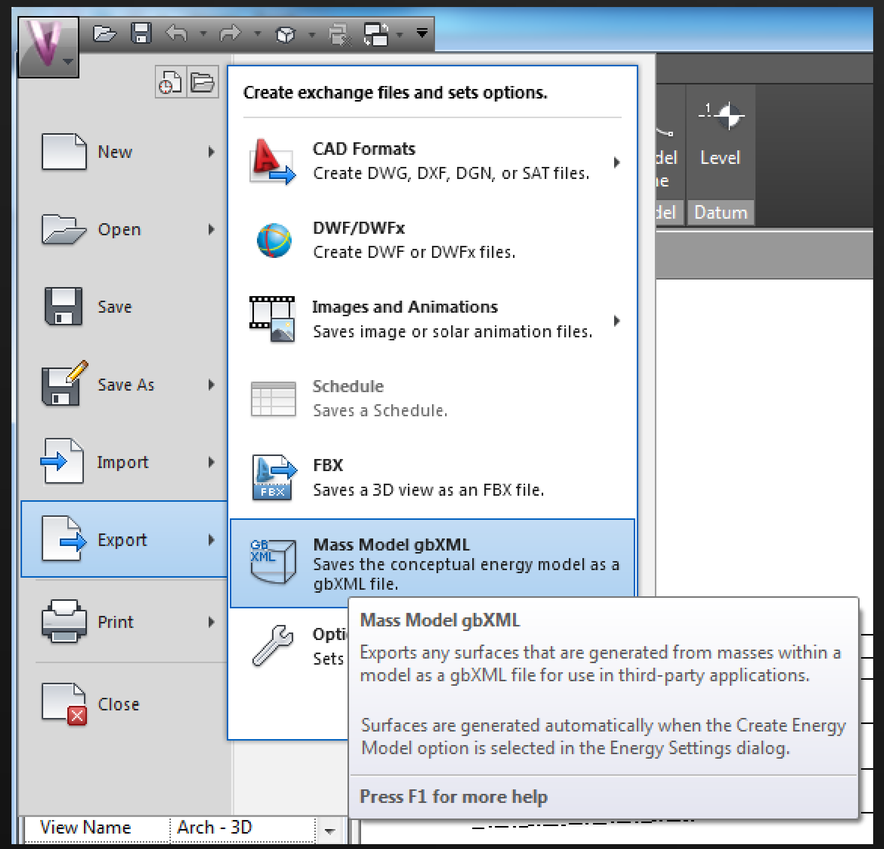
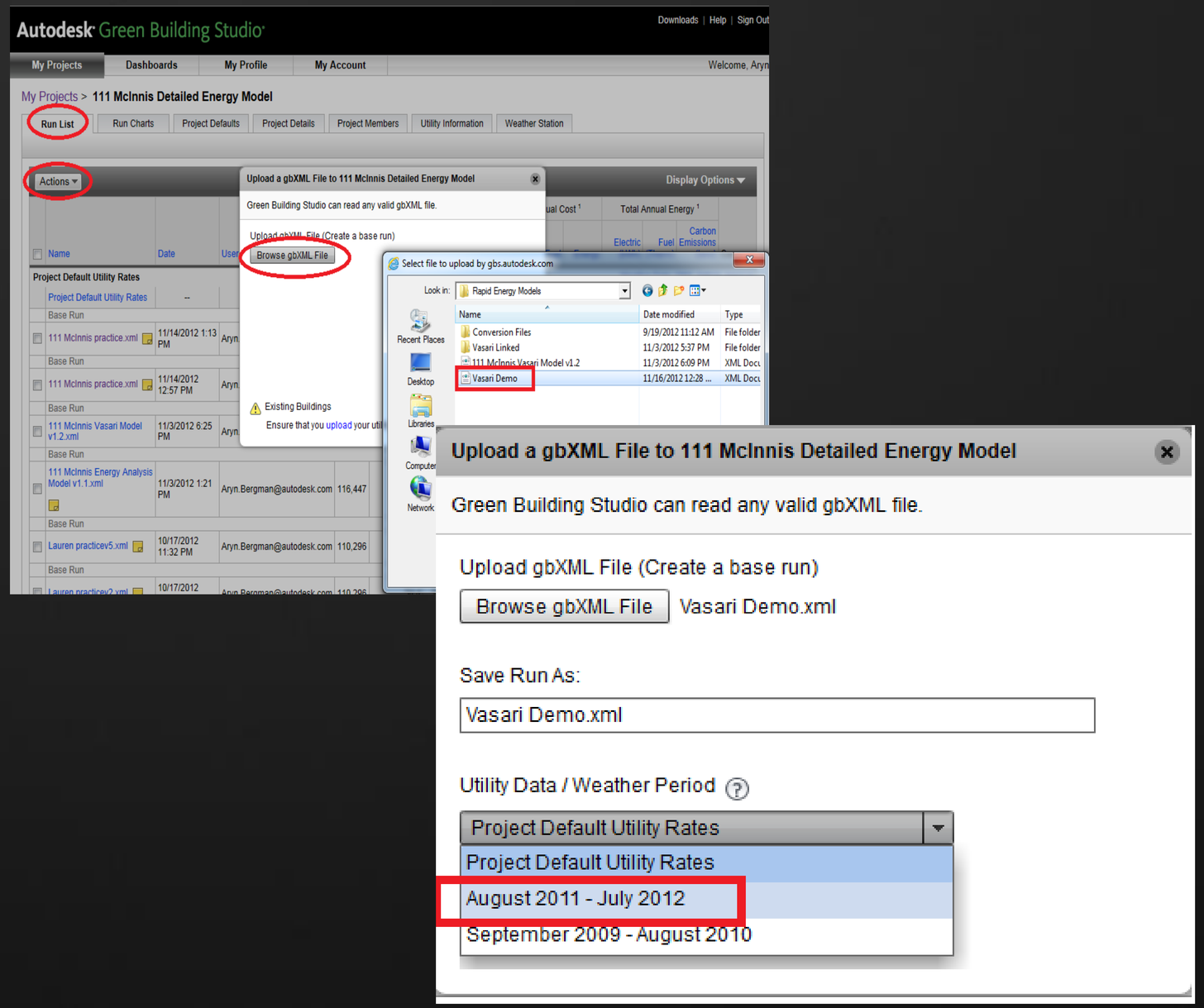
Vasari to GBS





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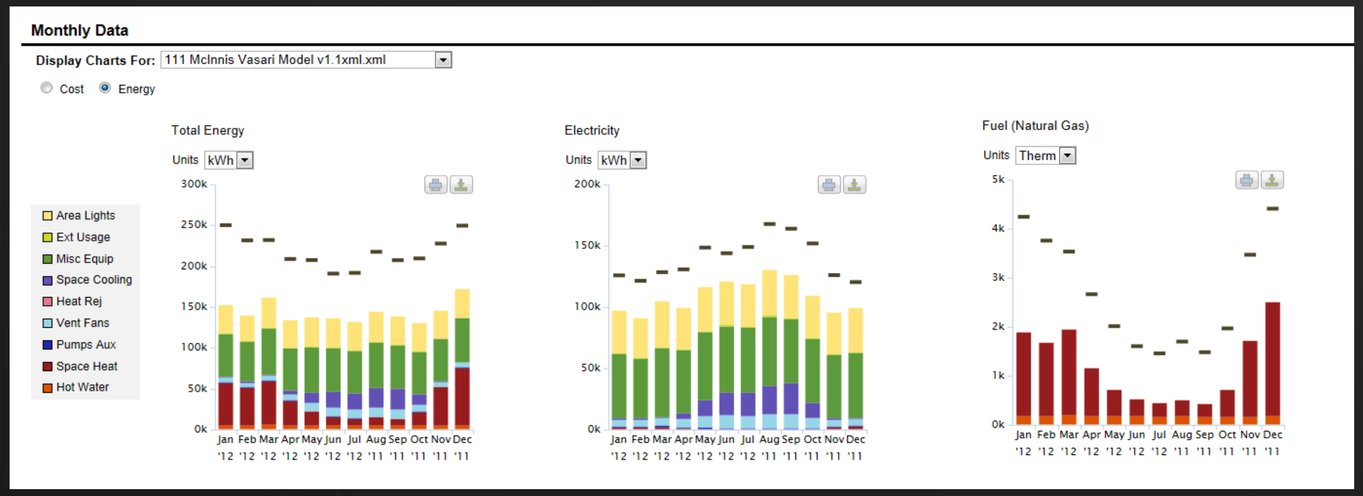
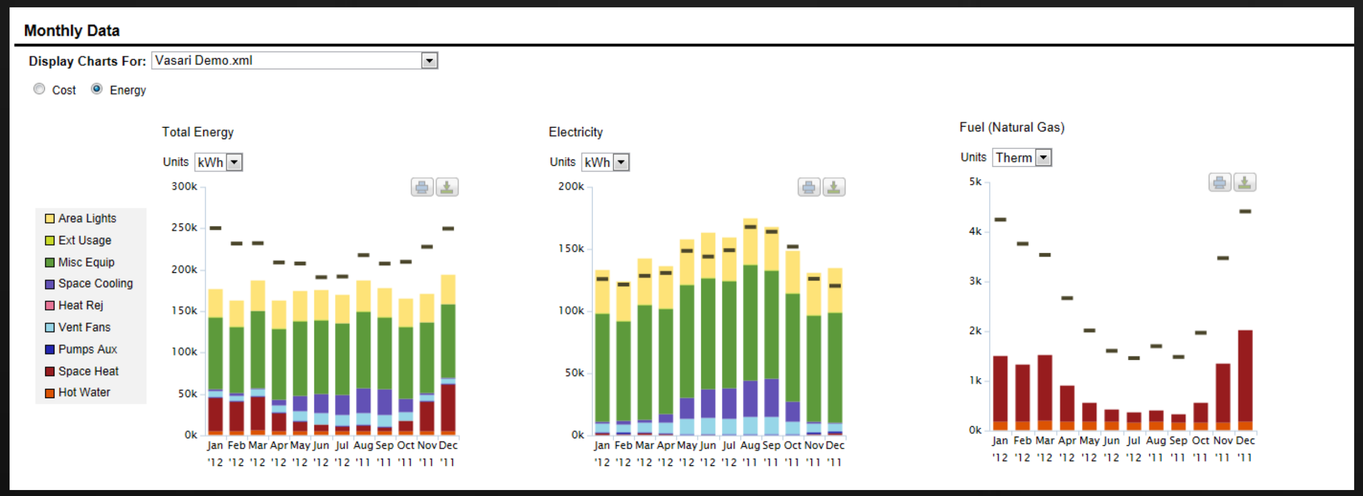
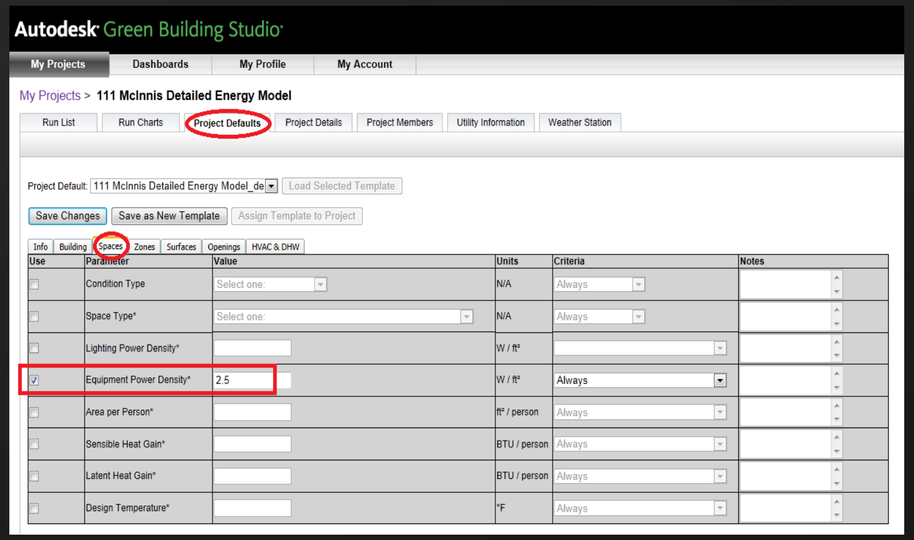
GBS Results







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Lessons Learned

Vasari Beta 1.0

- Quick way to generate a very basic energy model
- Can’t modify default settings
- Poorly suited for existing buildings
- Good for comparing new design options

Vasari + GBS

- Can incorporate actual utility rates
- Can modify some basic default settings
- Slightly better suited for existing buildings

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Detailed Energy Modeling

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What do we need to build and calibrate a detailed energy model?

- Autodesk® Revit – Build 3D geometry and create .gbxml file
- Autodesk® Green Building Studio (GBS) – Check for major errors and convert our model into DOE-2 or Energy Plus
- eQuest/DesignBuilder/IES/etc – Perform energy simulation
- Microsoft® Excel – Create spreadsheets and generate graphs to better organize data
- Building End-Use Energy Data (trended BMS data/utility bills) – Represent how the building is actually performing

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Create a Base Energy Model

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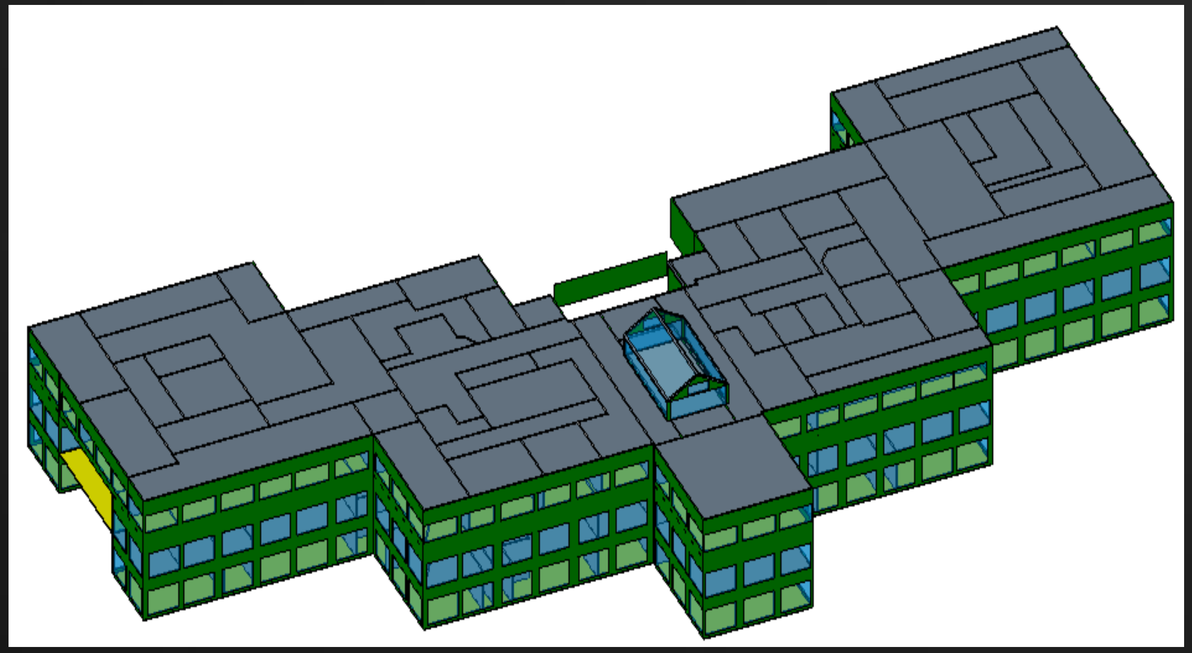
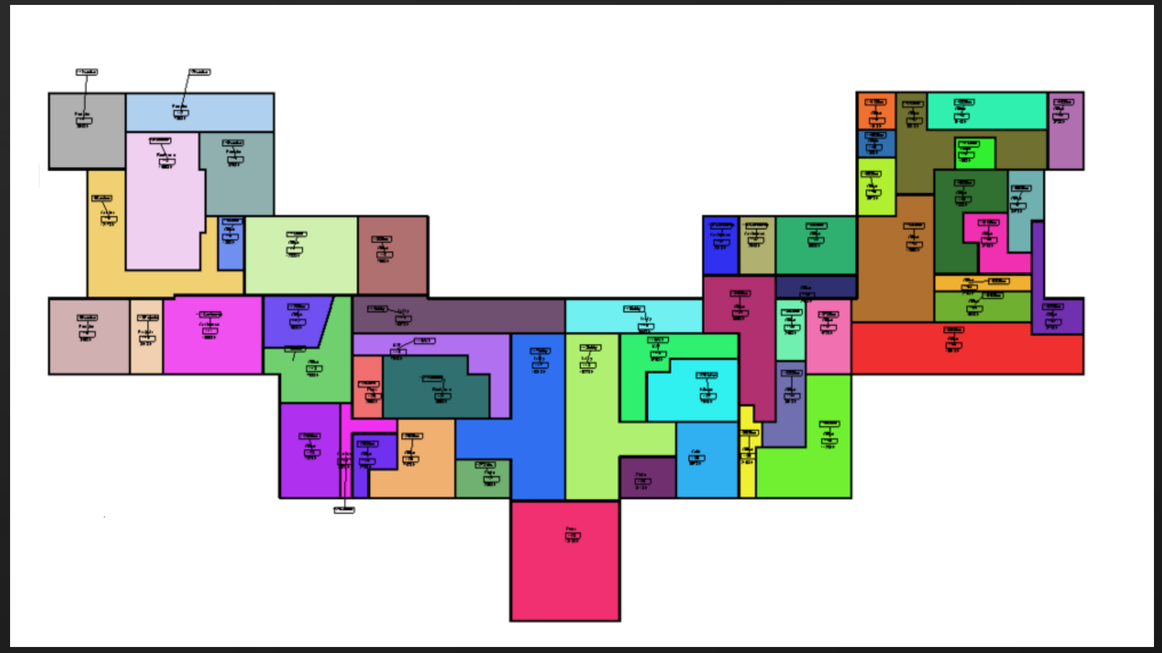
Autodesk® Revit





To learn how to create building geometry in Revit for energy models, attend the AU class MP7120 – Creating BIM for Energy Analysis by Aryn Bergman on Thursday morning from 8-930am

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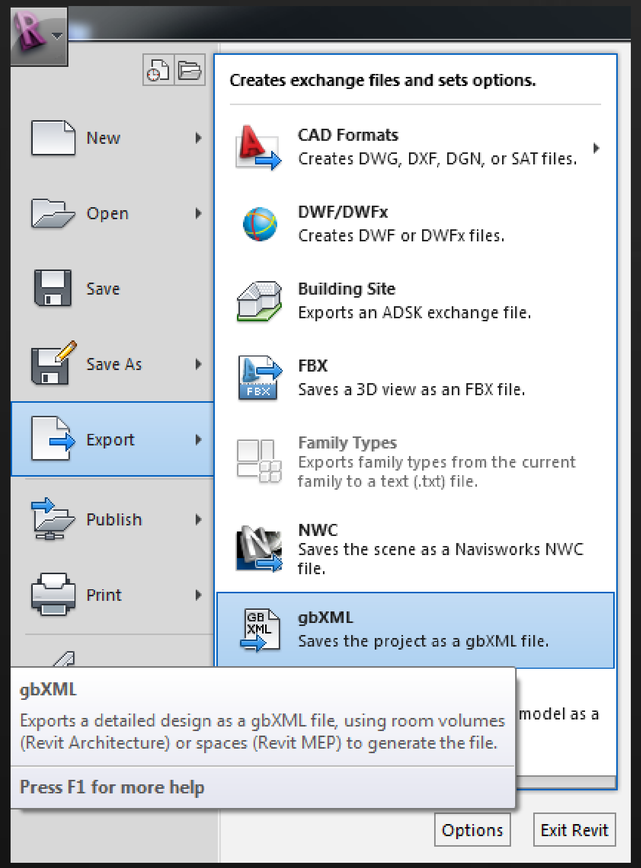
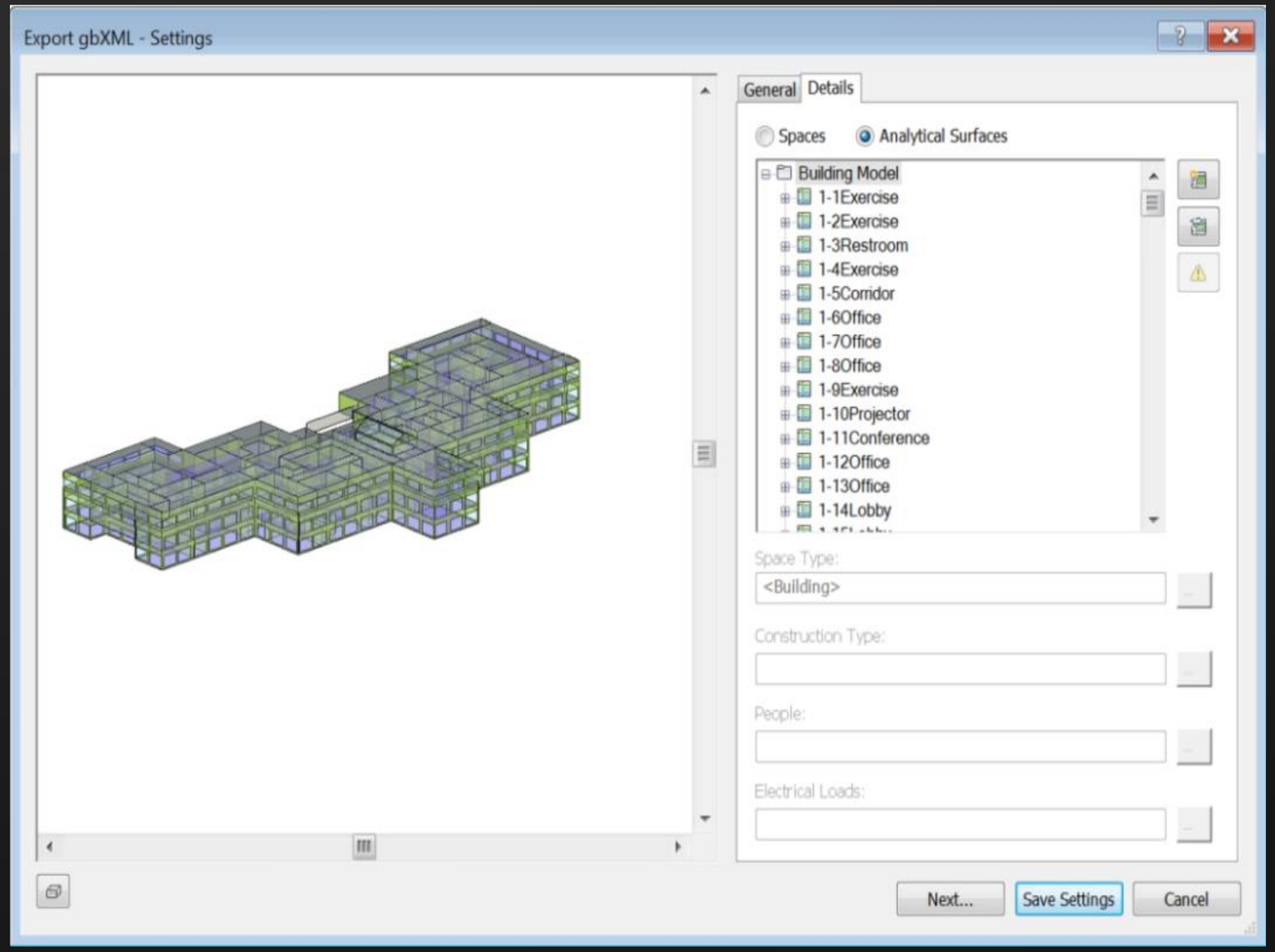
Autodesk® Revit





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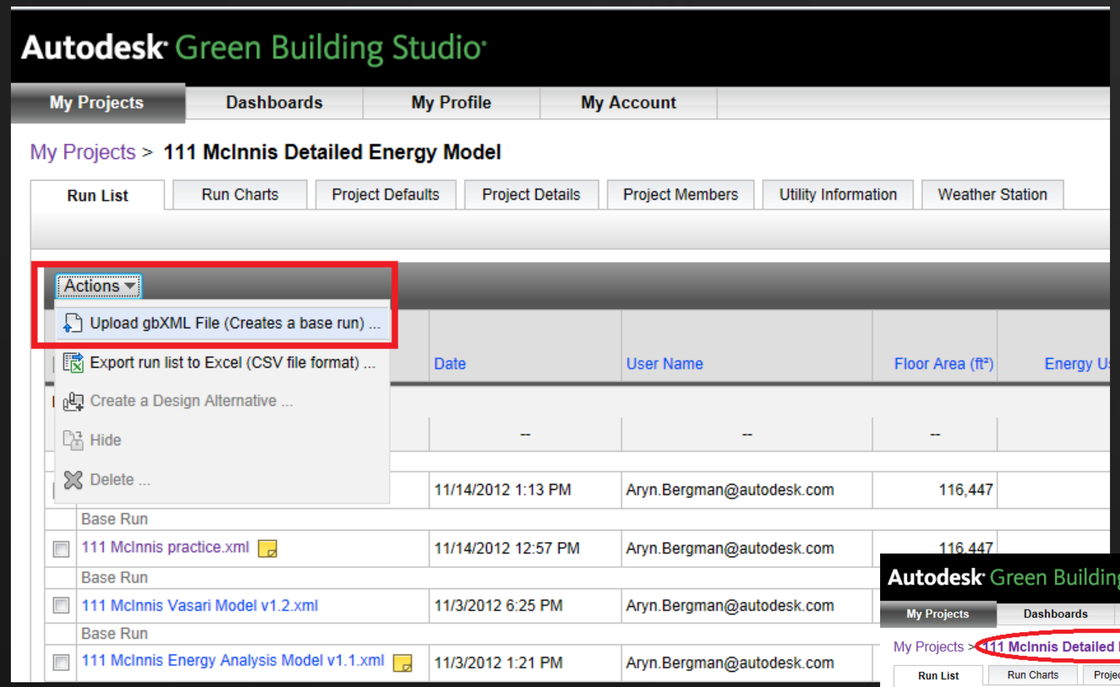
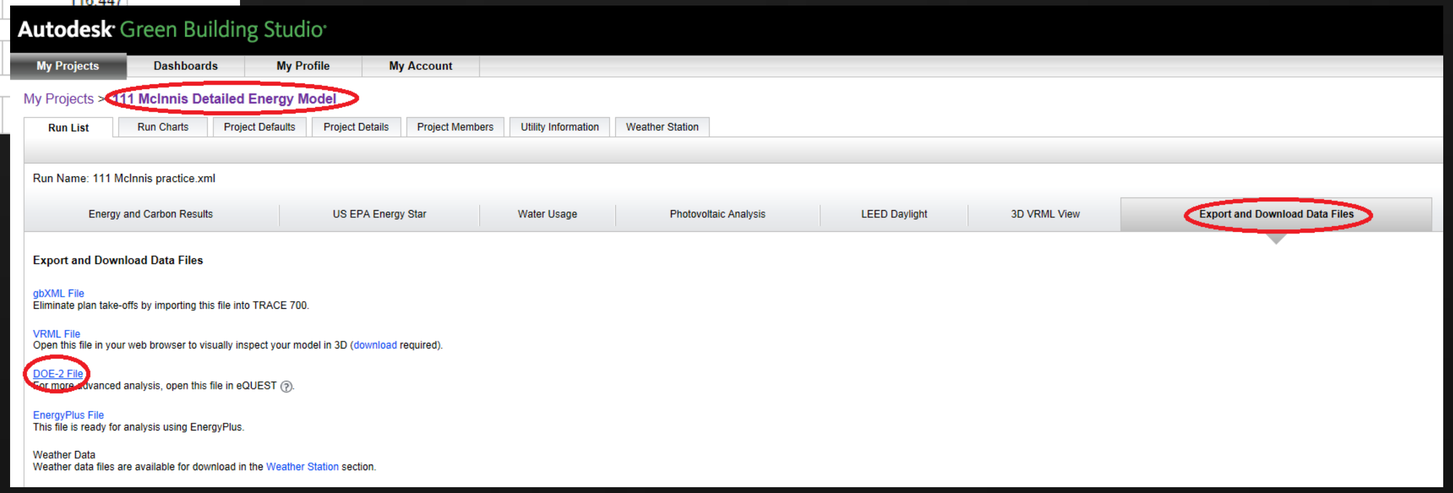
Autodesk® Green Building Studio





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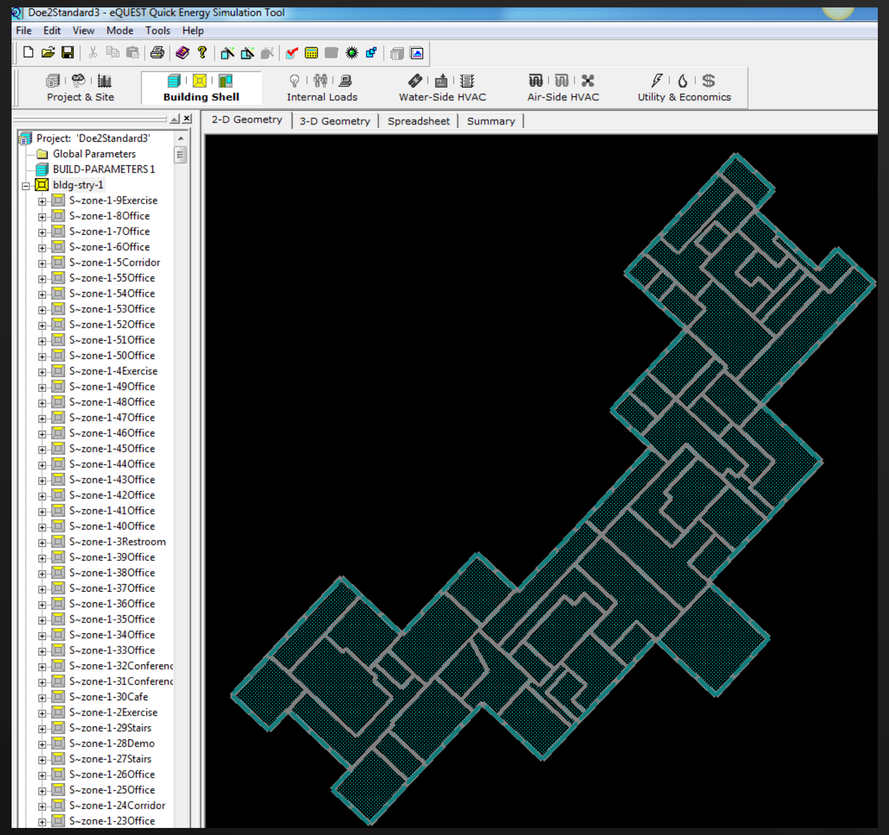
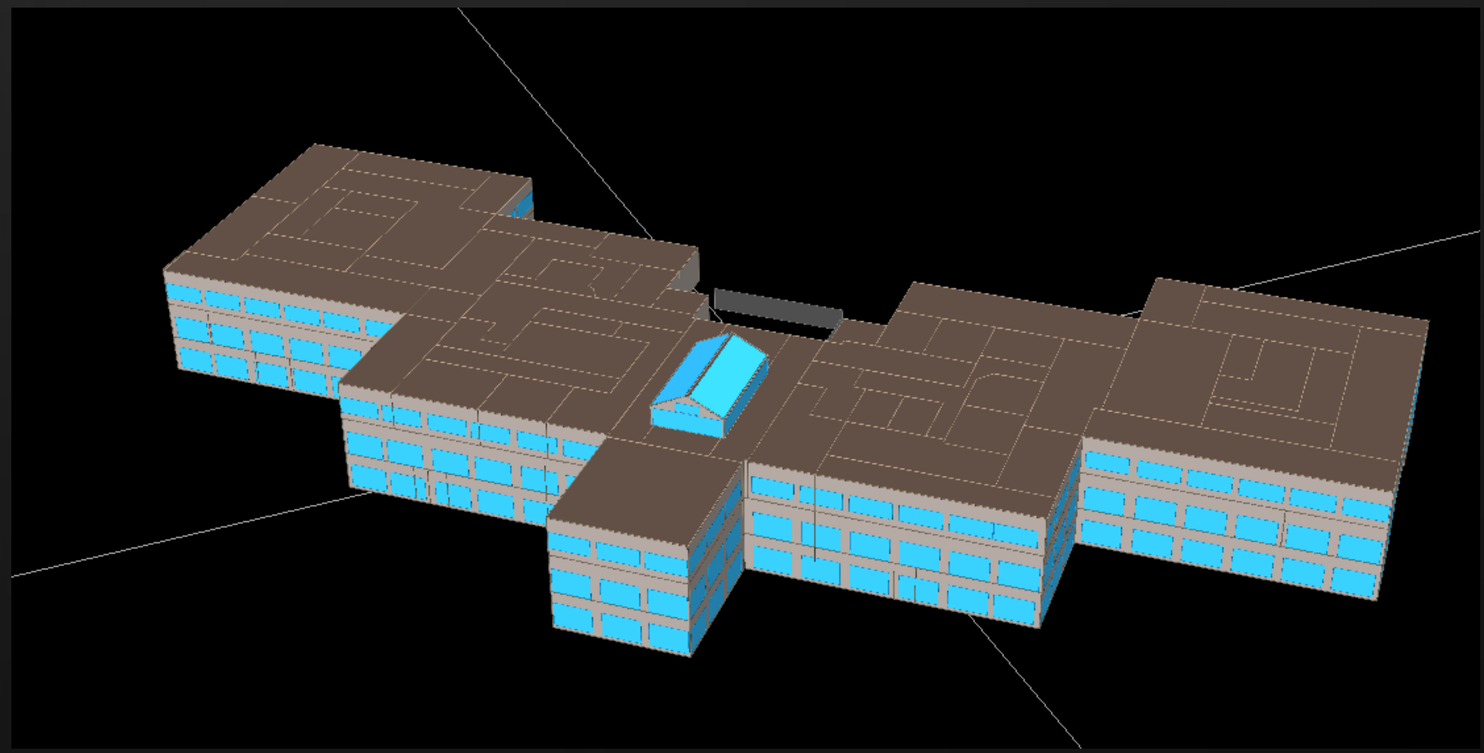
eQUEST





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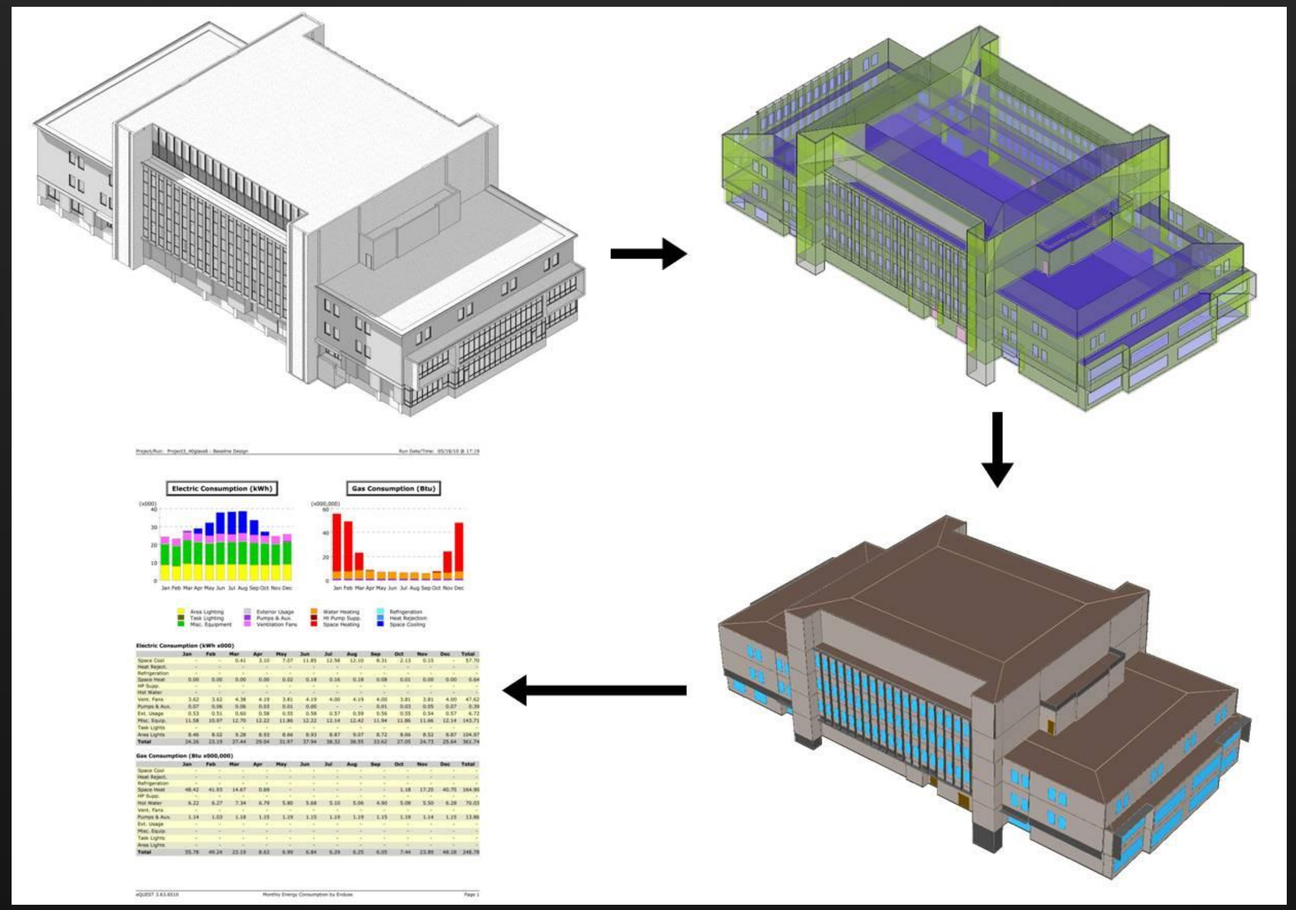
Revit to GBS to eQUEST



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Organize Trended Data

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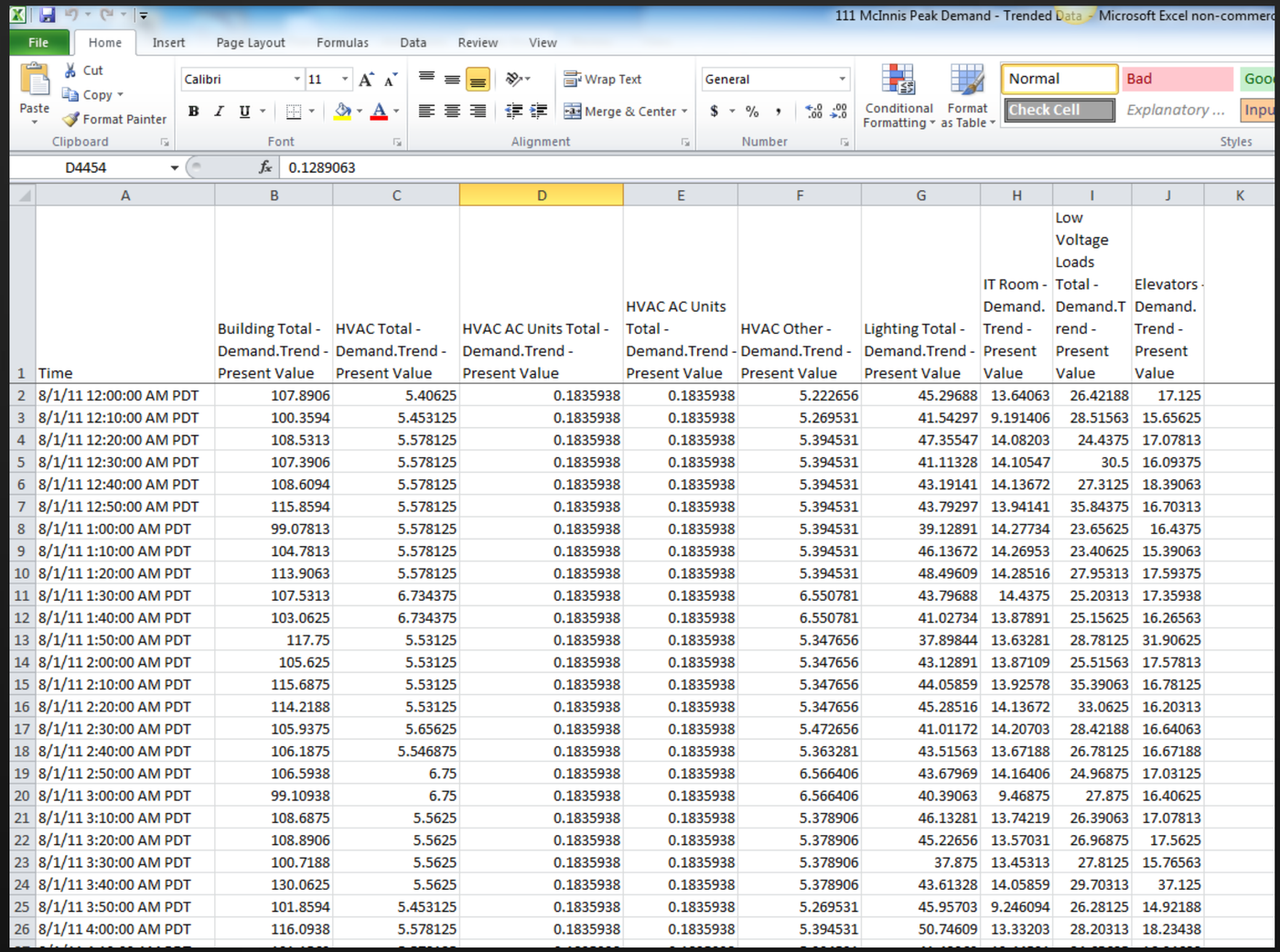
Trended Data



	A	B	C	D	E	F	G	H	I	J	K
1	Time	Building Total - Demand.Trend - Present Value	HVAC Total - Demand.Trend - Present Value	HVAC AC Units Total - Demand.Trend - Present Value	HVAC AC Units Total - Demand.Trend - Present Value	HVAC Other - Demand.Trend - Present Value	Lighting Total - Demand.Trend - Present Value	IT Room - Demand. Trend - Present Value	Low Voltage Loads Total - Demand.Trend - Present Value	Elevators - Demand. Trend - Present Value	
2	8/1/11 12:00:00 AM PDT	107.8906	5.40625	0.1835938	0.1835938	5.222656	45.29688	13.64063	26.42188	17.125	
3	8/1/11 12:10:00 AM PDT	100.3594	5.453125	0.1835938	0.1835938	5.269531	41.54297	9.191406	28.51563	15.65625	
4	8/1/11 12:20:00 AM PDT	108.5313	5.578125	0.1835938	0.1835938	5.394531	47.35547	14.08203	24.4375	17.07813	
5	8/1/11 12:30:00 AM PDT	107.3906	5.578125	0.1835938	0.1835938	5.394531	41.11328	14.10547	30.5	16.09375	
6	8/1/11 12:40:00 AM PDT	108.6094	5.578125	0.1835938	0.1835938	5.394531	43.19141	14.13672	27.3125	18.39063	
7	8/1/11 12:50:00 AM PDT	115.8594	5.578125	0.1835938	0.1835938	5.394531	43.79297	13.94141	35.84375	16.70313	
8	8/1/11 1:00:00 AM PDT	99.07813	5.578125	0.1835938	0.1835938	5.394531	39.12891	14.27734	23.65625	16.4375	
9	8/1/11 1:10:00 AM PDT	104.7813	5.578125	0.1835938	0.1835938	5.394531	46.13672	14.26953	23.40625	15.39063	
10	8/1/11 1:20:00 AM PDT	113.9063	5.578125	0.1835938	0.1835938	5.394531	48.49609	14.28516	27.95313	17.59375	
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13	8/1/11 1:50:00 AM PDT	117.75	5.53125	0.1835938	0.1835938	5.347656	37.89844	13.63281	28.78125	31.90625	
14	8/1/11 2:00:00 AM PDT	105.625	5.53125	0.1835938	0.1835938	5.347656	43.12891	13.87109	25.51563	17.57813	
15	8/1/11 2:10:00 AM PDT	115.6875	5.53125	0.1835938	0.1835938	5.347656	44.05859	13.92578	35.39063	16.78125	
16	8/1/11 2:20:00 AM PDT	114.2188	5.53125	0.1835938	0.1835938	5.347656	45.28516	14.13672	33.0625	16.20313	
17	8/1/11 2:30:00 AM PDT	105.9375	5.65625	0.1835938	0.1835938	5.472656	41.01172	14.20703	28.42188	16.64063	
18	8/1/11 2:40:00 AM PDT	106.1875	5.546875	0.1835938	0.1835938	5.363281	43.51563	13.67188	26.78125	16.67188	
19	8/1/11 2:50:00 AM PDT	106.5938	6.75	0.1835938	0.1835938	6.566406	43.67969	14.16406	24.96875	17.03125	
20	8/1/11 3:00:00 AM PDT	99.10938	6.75	0.1835938	0.1835938	6.566406	40.39063	9.46875	27.875	16.40625	
21	8/1/11 3:10:00 AM PDT	108.6875	5.5625	0.1835938	0.1835938	5.378906	46.13281	13.74219	26.39063	17.07813	
22	8/1/11 3:20:00 AM PDT	108.8906	5.5625	0.1835938	0.1835938	5.378906	45.22656	13.57031	26.96875	17.5625	
23	8/1/11 3:30:00 AM PDT	100.7188	5.5625	0.1835938	0.1835938	5.378906	37.875	13.45313	27.8125	15.76563	
24	8/1/11 3:40:00 AM PDT	130.0625	5.5625	0.1835938	0.1835938	5.378906	43.61328	14.05859	29.70313	37.125	
25	8/1/11 3:50:00 AM PDT	101.8594	5.453125	0.1835938	0.1835938	5.269531	45.95703	9.246094	26.28125	14.92188	
26	8/1/11 4:00:00 AM PDT	116.0938	5.578125	0.1835938	0.1835938	5.394531	50.74609	13.33203	28.20313	18.23438	

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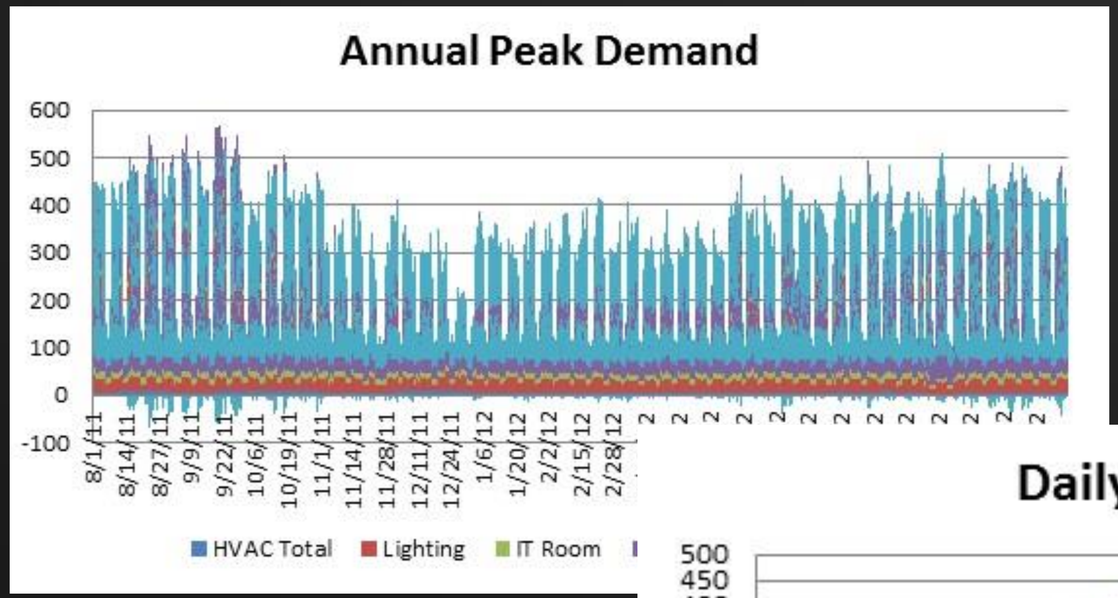
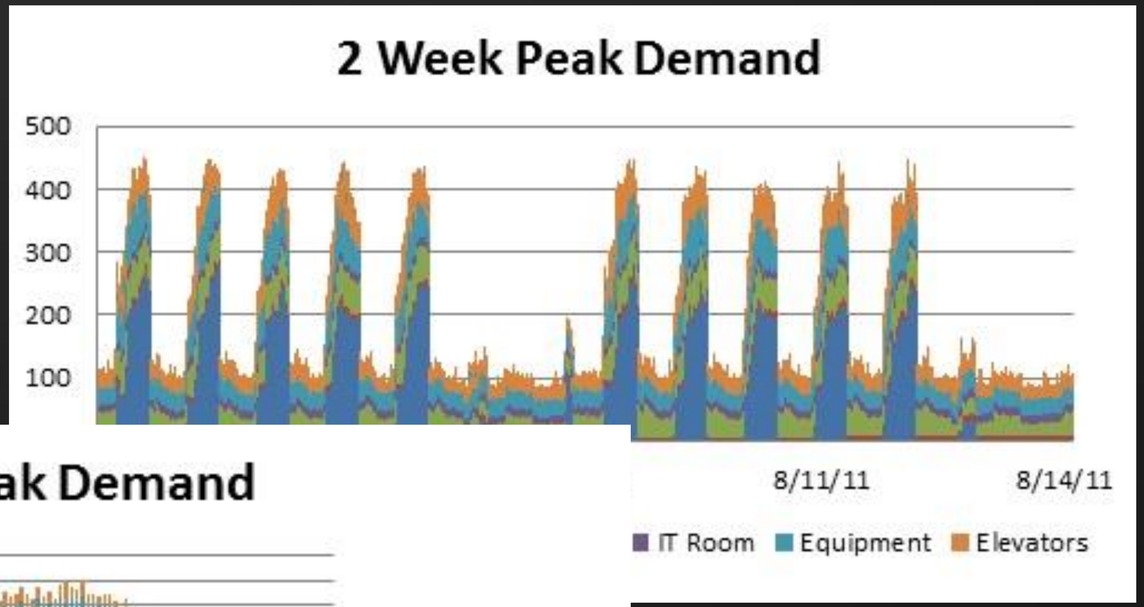
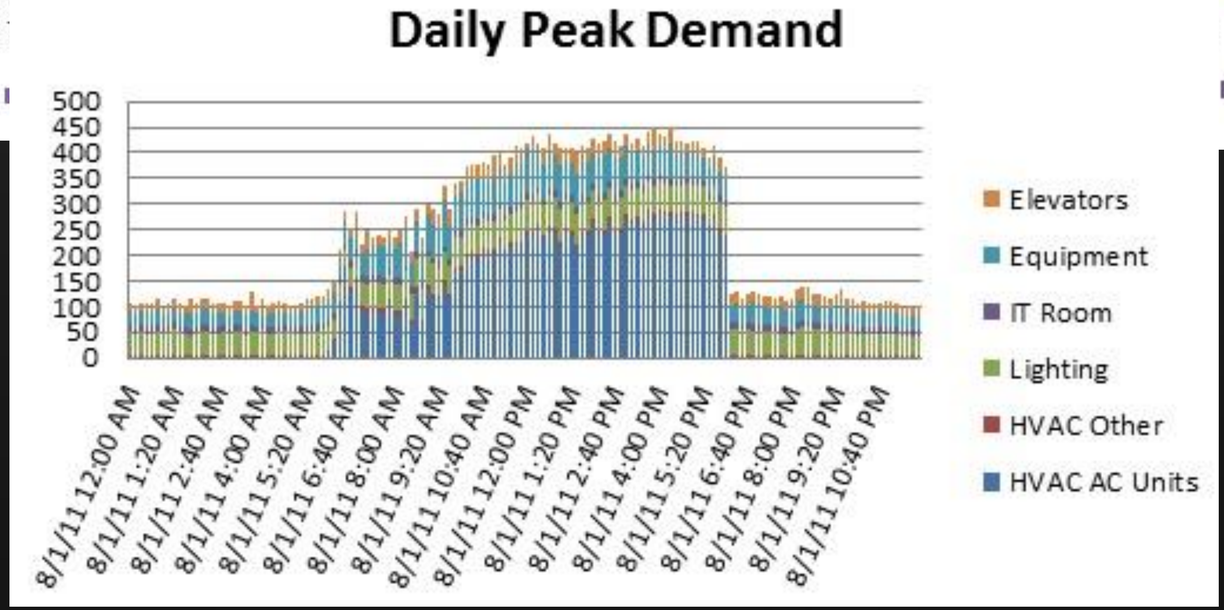
Create Energy Consumption Graphs







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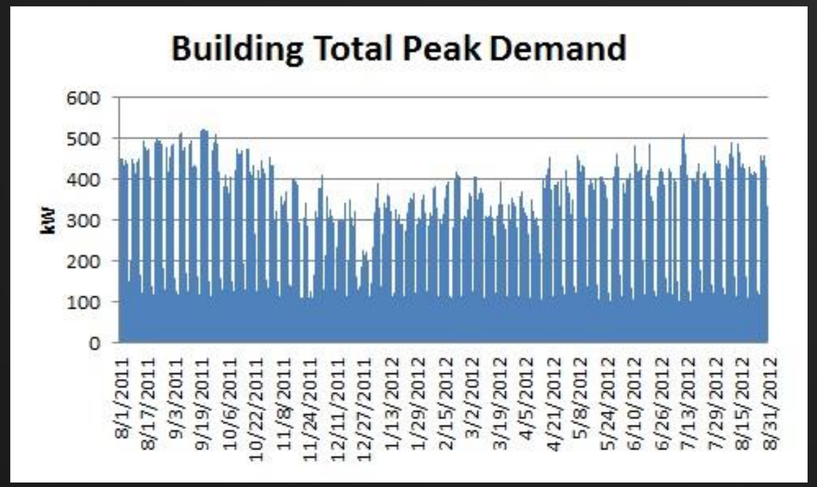
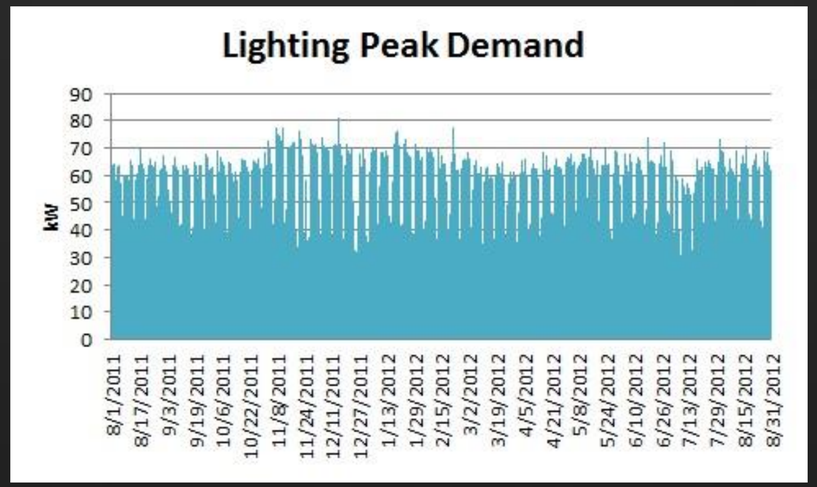
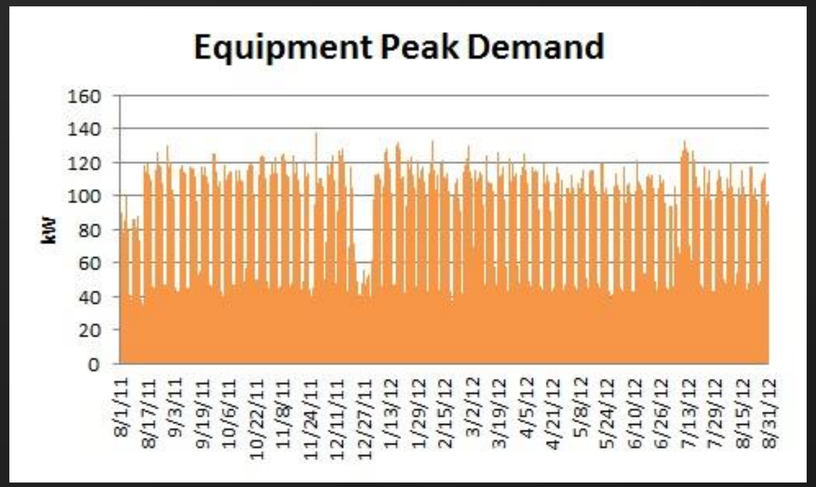
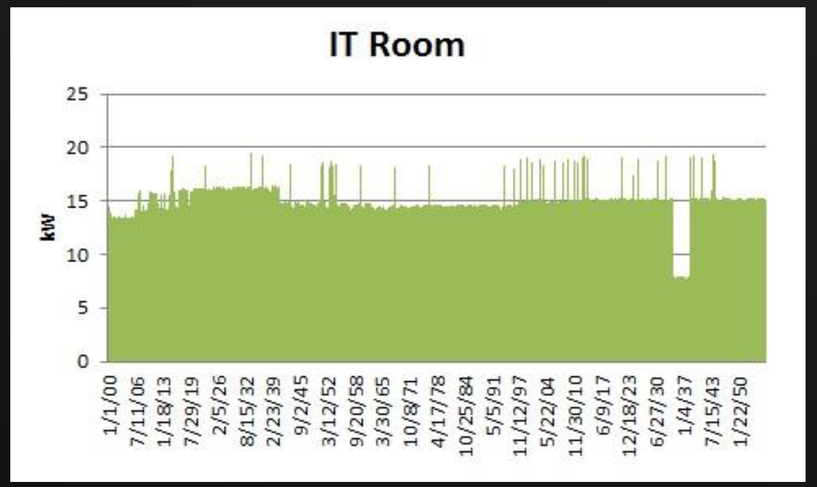
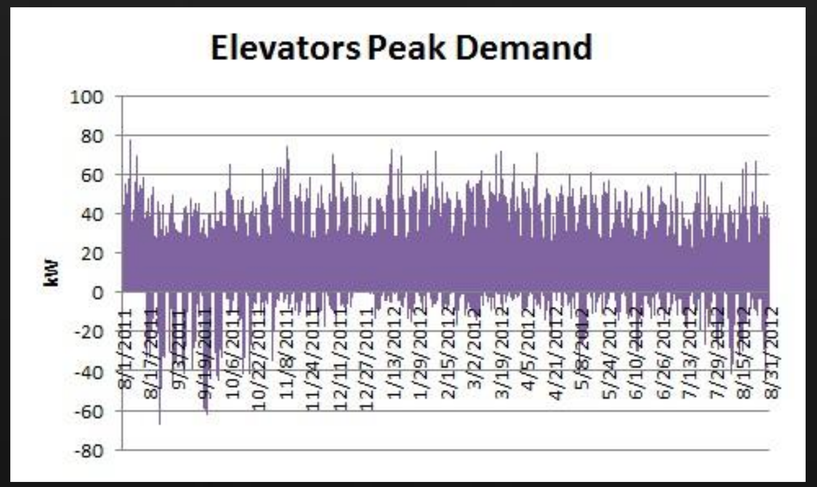
Create Energy Consumption Graphs

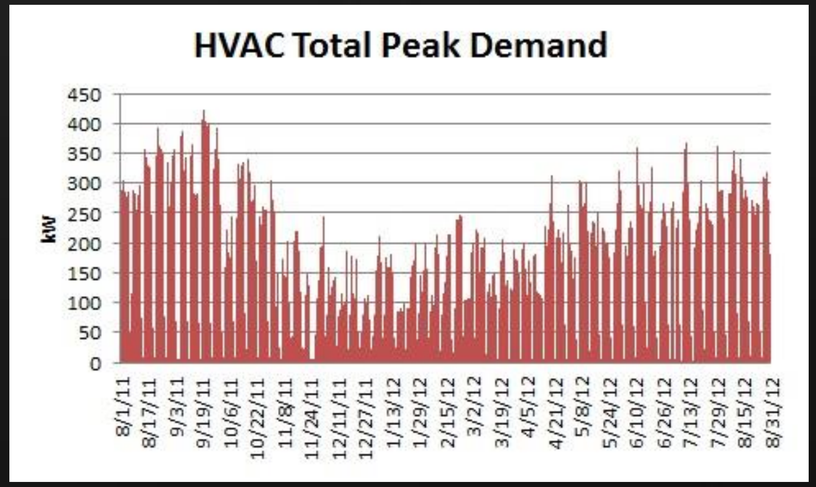












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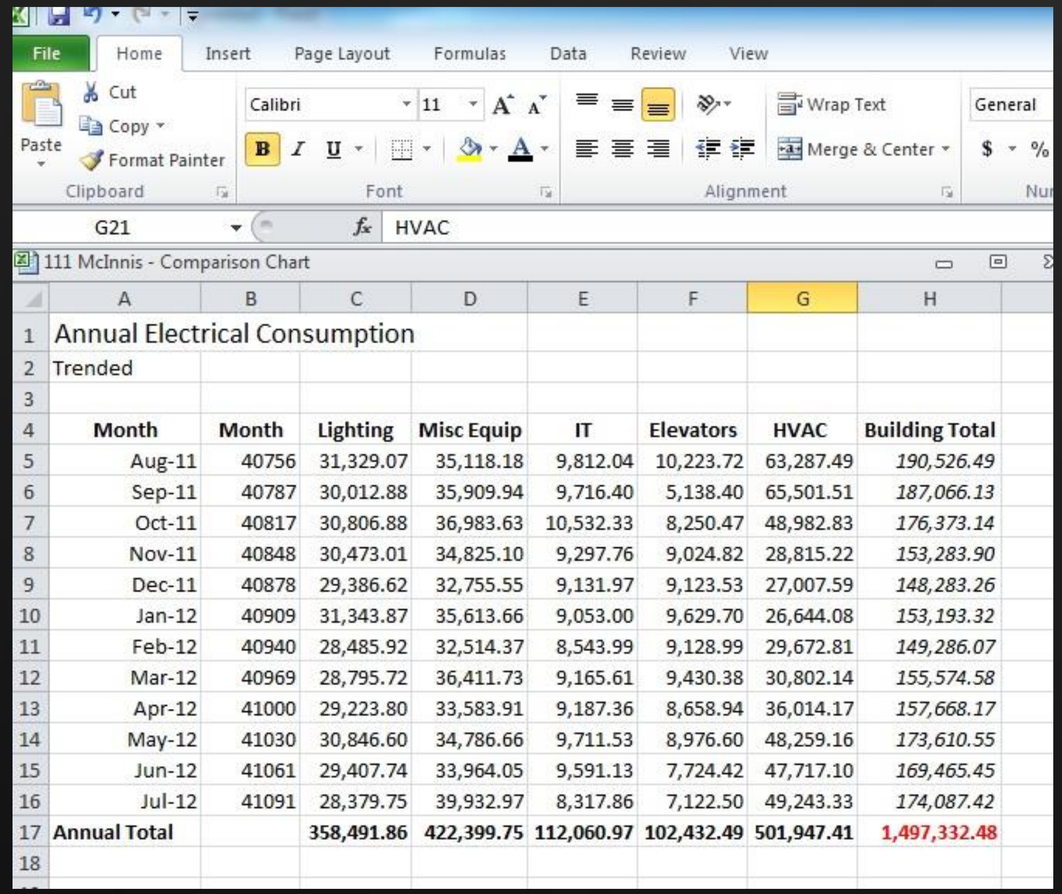
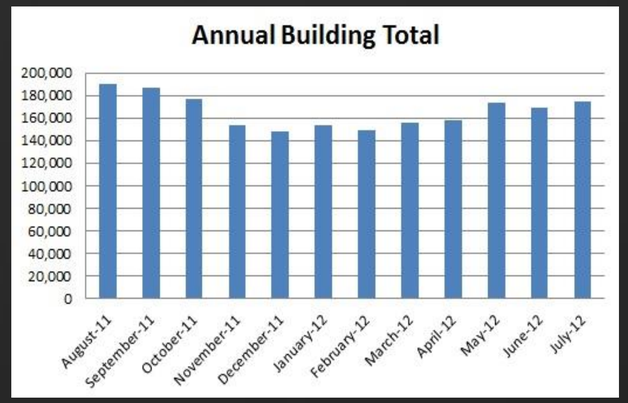
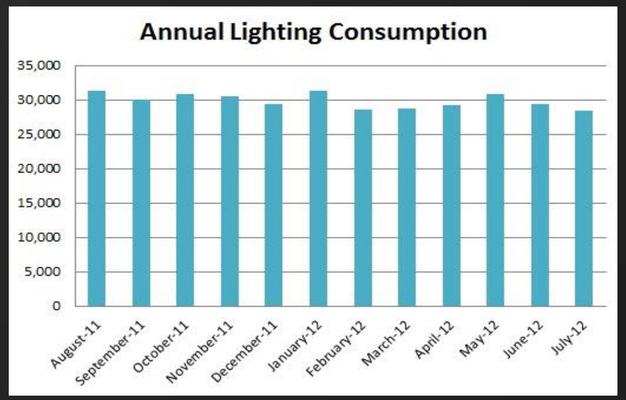
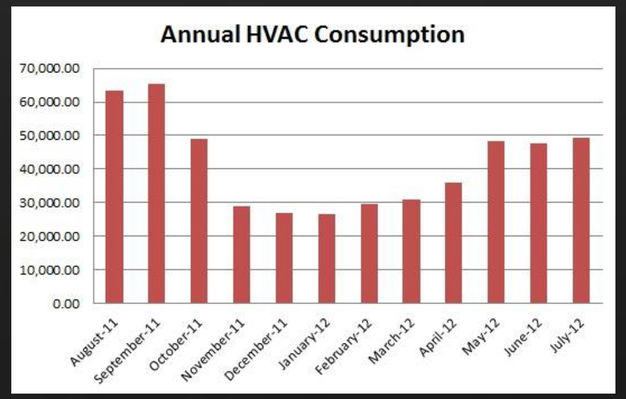
Monthly Graphs

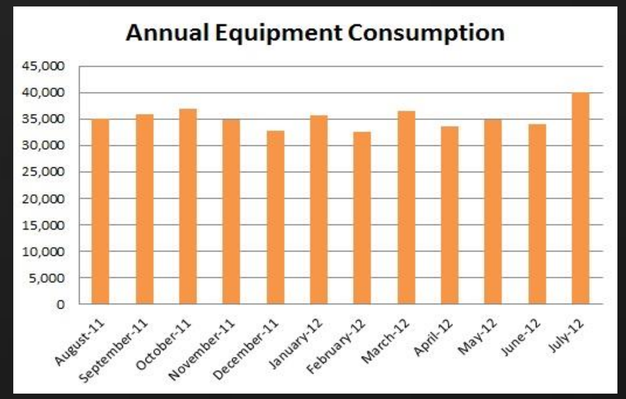


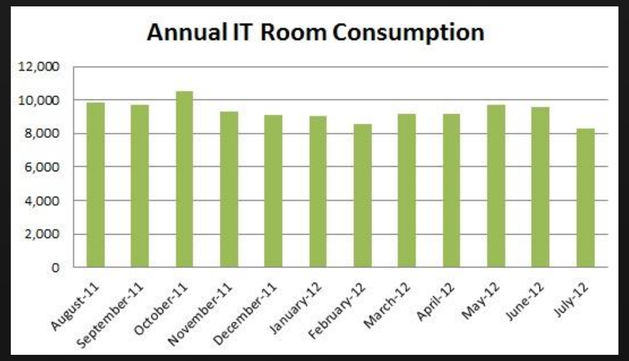
	A	B	C	D	E	F	G	H
1	Annual Electrical Consumption							
2	Trended							
3								
4	**Month**	**Month**	**Lighting**	**Misc Equip**	**IT**	**Elevators**	**HVAC**	**Building Total**
5	Aug-11	40756	31,329.07	35,118.18	9,812.04	10,223.72	63,287.49	*190,526.49*
6	Sep-11	40787	30,012.88	35,909.94	9,716.40	5,138.40	65,501.51	*187,066.13*
7	Oct-11	40817	30,806.88	36,983.63	10,532.33	8,250.47	48,982.83	*176,373.14*
8	Nov-11	40848	30,473.01	34,825.10	9,297.76	9,024.82	28,815.22	*153,283.90*
9	Dec-11	40878	29,386.62	32,755.55	9,131.97	9,123.53	27,007.59	*148,283.26*
10	Jan-12	40909	31,343.87	35,613.66	9,053.00	9,629.70	26,644.08	*153,193.32*
11	Feb-12	40940	28,485.92	32,514.37	8,543.99	9,128.99	29,672.81	*149,286.07*
12	Mar-12	40969	28,795.72	36,411.73	9,165.61	9,430.38	30,802.14	*155,574.58*
13	Apr-12	41000	29,223.80	33,583.91	9,187.36	8,658.94	36,014.17	*157,668.17*
14	May-12	41030	30,846.60	34,786.66	9,711.53	8,976.60	48,259.16	*173,610.55*
15	Jun-12	41061	29,407.74	33,964.05	9,591.13	7,724.42	47,717.10	*169,465.45*
16	Jul-12	41091	28,379.75	39,932.97	8,317.86	7,122.50	49,243.33	*174,087.42*
17	**Annual Total**		**358,491.86**	**422,399.75**	**112,060.97**	**102,432.49**	**501,947.41**	**1,497,332.48**
18								

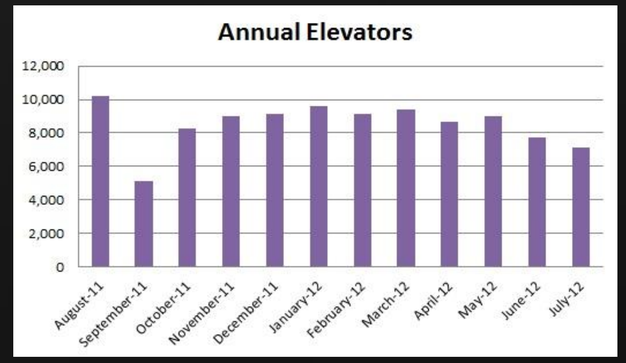












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Create Comparison Charts

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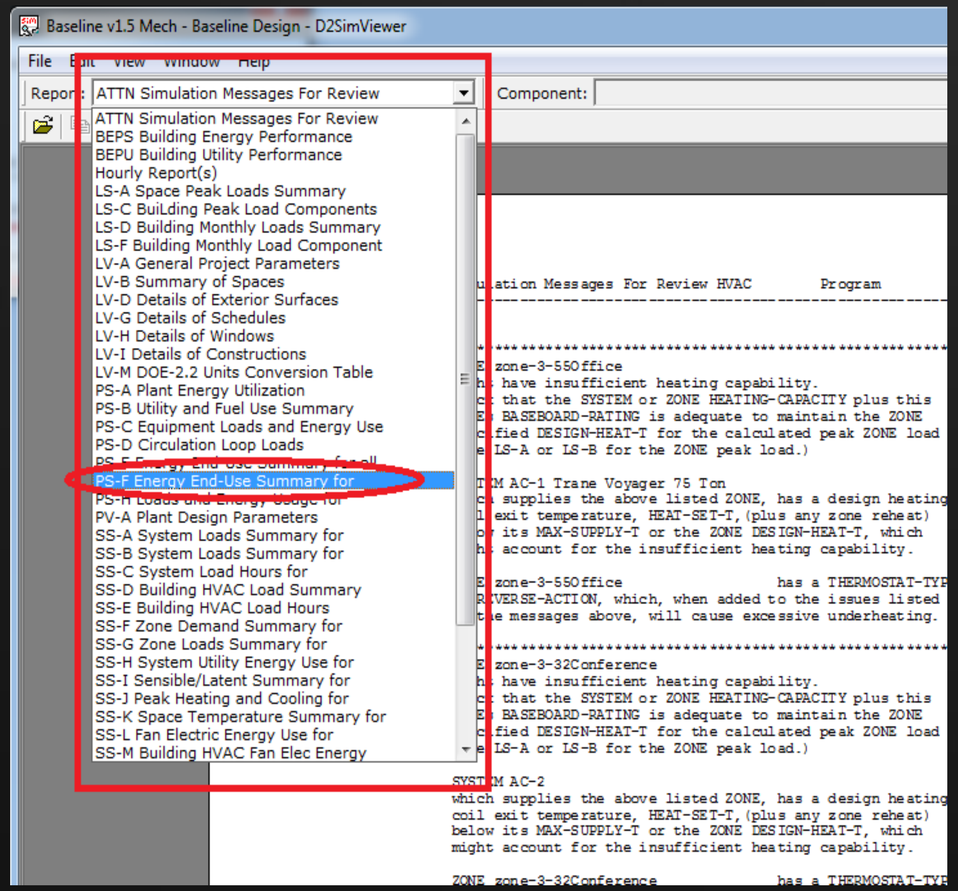
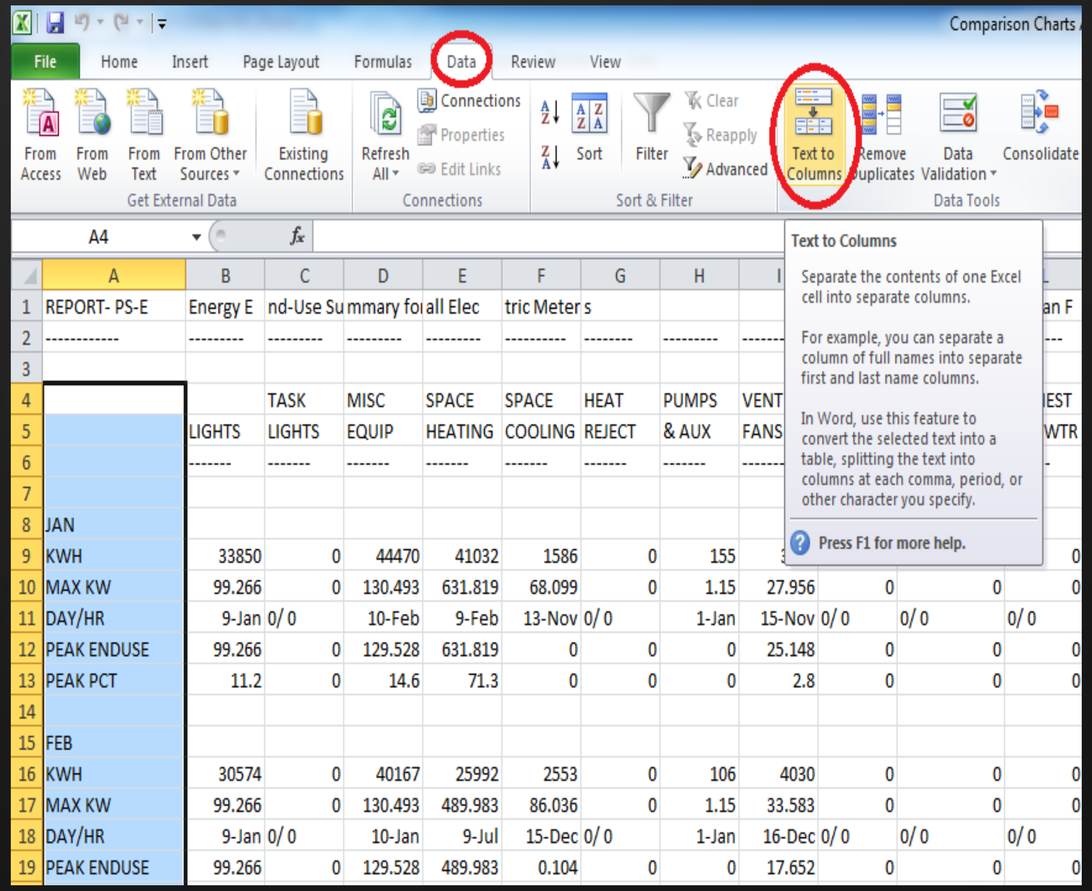
Bringing PS-F Data to Excel from eQUEST





	A	B	C	D	E	F	G	H	I	J	K	L
1	REPORT- PS-E	Energy E	nd-Use Su	mmary for	all Elec	tric Meter	s					an F
2	----------	---------	---------	---------	---------	----------	--------	---------	-------			---
3												
4			TASK	MISC	SPACE	SPACE	HEAT	PUMPS	VENT			EST
5		LIGHTS	LIGHTS	EQUIP	HEATING	COOLING	REJECT	& AUX	FANS			WTR
6		-------	-------	-------	-------	-------	-------	-------	-------			-
7												
8	JAN											
9	KWH	33850	0	44470	41032	1586	0	155				0
10	MAX KW	99.266	0	130.493	631.819	68.099	0	1.15	27.956	0	0	0
11	DAY/HR	9-Jan	0/ 0	10-Feb	9-Feb	13-Nov	0/ 0	1-Jan	15-Nov	0/ 0	0/ 0	0/ 0
12	PEAK ENDUSE	99.266	0	129.528	631.819	0	0	0	25.148	0	0	0
13	PEAK PCT	11.2	0	14.6	71.3	0	0	0	2.8	0	0	0
14												
15	FEB											
16	KWH	30574	0	40167	25992	2553	0	106	4030	0	0	0
17	MAX KW	99.266	0	130.493	489.983	86.036	0	1.15	33.583	0	0	0
18	DAY/HR	9-Jan	0/ 0	10-Jan	9-Jul	15-Dec	0/ 0	1-Jan	16-Dec	0/ 0	0/ 0	0/ 0
19	PEAK ENDUSE	99.266	0	129.528	489.983	0.104	0	0	17.652	0	0	0

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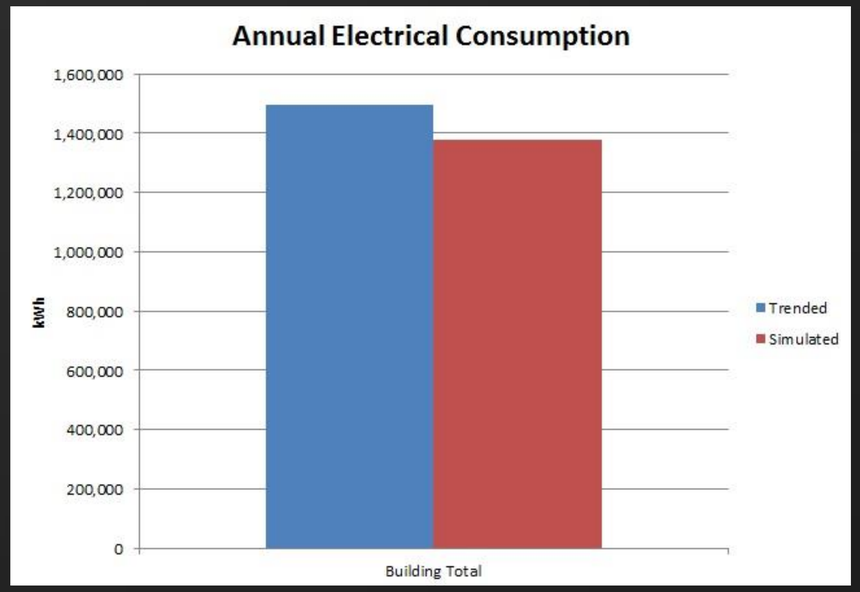
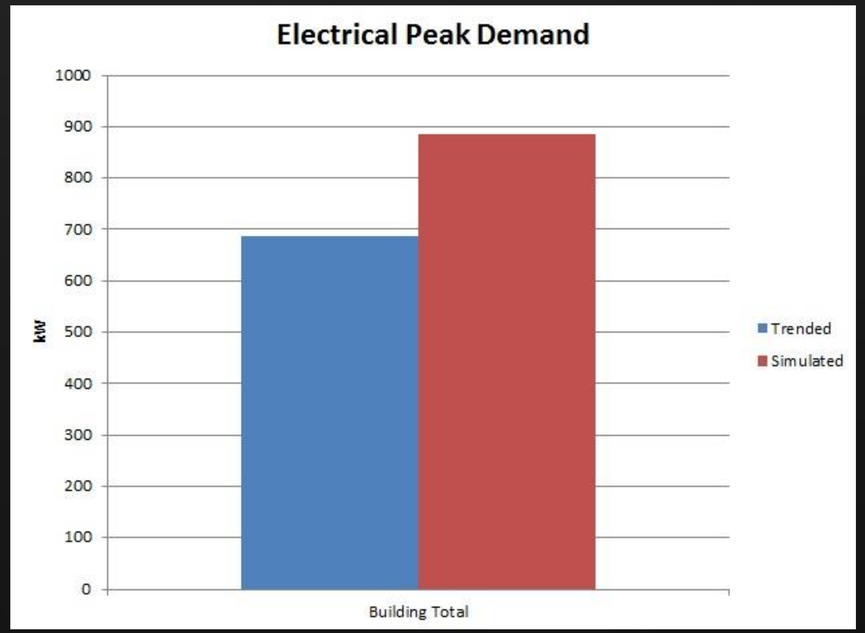
Comparison Charts

	A	B	C	D	E	F	G	H
1	Annual Electrical Consumption							
2	**Trended**							
3	Month	Month	Lighting Consu	Misc Equipment	IT Room	Elevators	HVAC Consumption	
4	Aug-11	40,756	31329.06686	35118.17563	9812.04	10223.72	63,287.49	
5	Sep-11	40,787	30012.88066	35909.93671	9716.4	5138.404	65501.50812	
6	Oct-11	40,817	30806.88463	36983.63066	10532.3	8250.47	48982.83081	
7	Nov-11	40,848	30473.00502	34825.10207	9297.76	9024.821	28815.21508	
8	Dec-11	40,878	29386.62351	32755.55267	9131.97	9123.53	27007.58727	
9	Jan-12	40,909	31343.87414	35613.66263	9053	9629.705	26644.07692	
10	Feb-12	40,940	28485.91647	32514.36575	8543.99	9128.994	29672.80619	
11	Mar-12	40,969	28795.71659	36411.73491	9165.61	9430.379	30802.13986	
12	Apr-12	41,000	29223.79924	33583.90541	9187.36	8658.942	36014.17129	
13	May-12	41,030	30846.60265	34786.66192	9711.53	8976.598	48259.1568	
14	Jun-12	41,061	29407.74202	33964.05199	9591.13	7724.423	47717.09924	
15	Jul-12	41,091	28379.75239	39932.97327	8317.86	7122.502	49243.33128	
16	Annual Total		358,492	422,400	112,061	102,432	501,947	
17								
18	**Simulated**							
19	Month	Month	Lighting Consu	Misc Equipment	IT Room	Elevators	HVAC Consumption	
20	Aug-11	40,756	33,850	44,470			46,617	
21	Sep-11	40,787	30,574	40,167			32,681	
22	Oct-11	40,817	33,850	44,481			36,083	
23	Nov-11	40,848	32,758	43,043			30,058	
24	Dec-11	40,878	33,850	44,481			31,985	
25	Jan-12	40,909	32,758	43,043			36,951	
26	Feb-12	40,940	33,850	44,470			45,987	
27	Mar-12	40,969	33,850	44,492			50,982	
28	Apr-12	41,000	32,758	43,021			37,405	
29	May-12	41,030	33,850	44,481			31,714	
30	Jun-12	41,061	32,758	43,032			28,651	
31	Jul-12	41,091	33,850	44,459			44,687	
32	Annual Total		398,556	523,640	0	0	453,801	
33								





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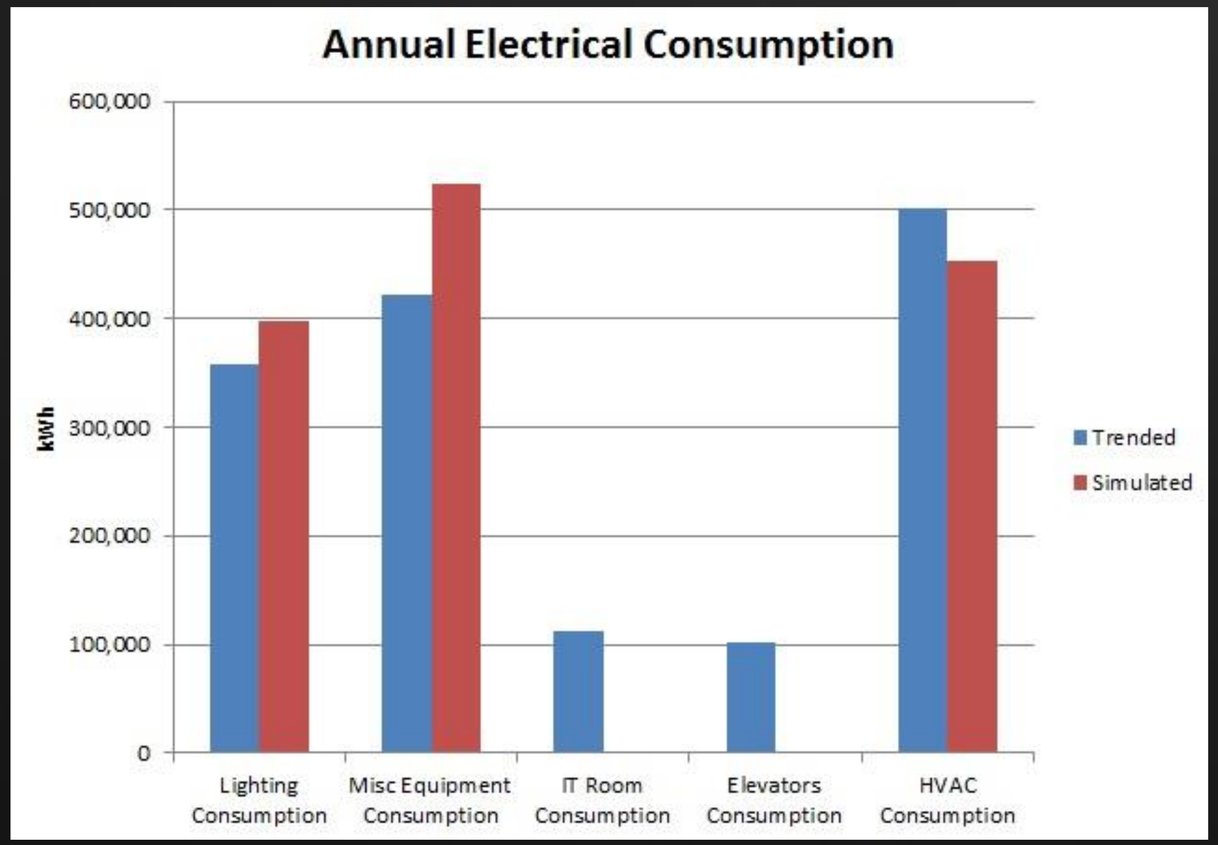
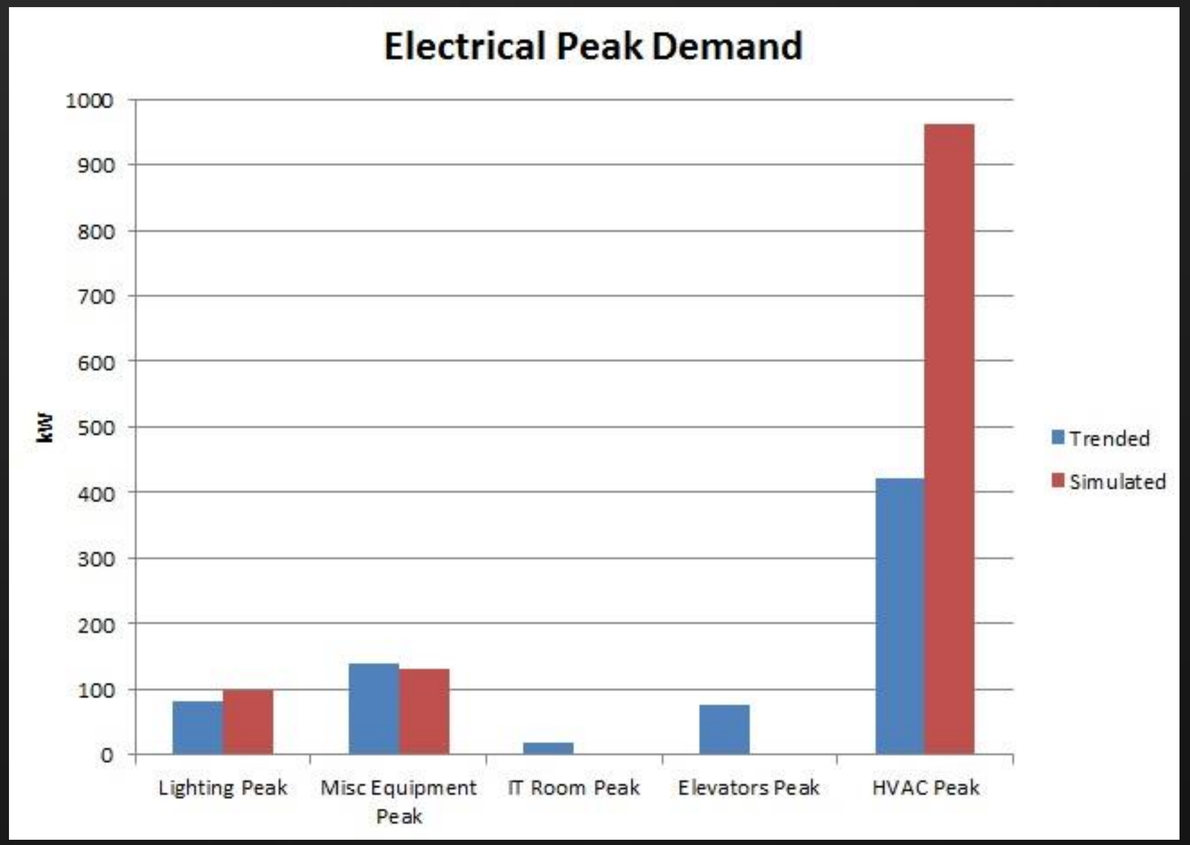
Comparison Charts





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Calibrate the eQUEST Model

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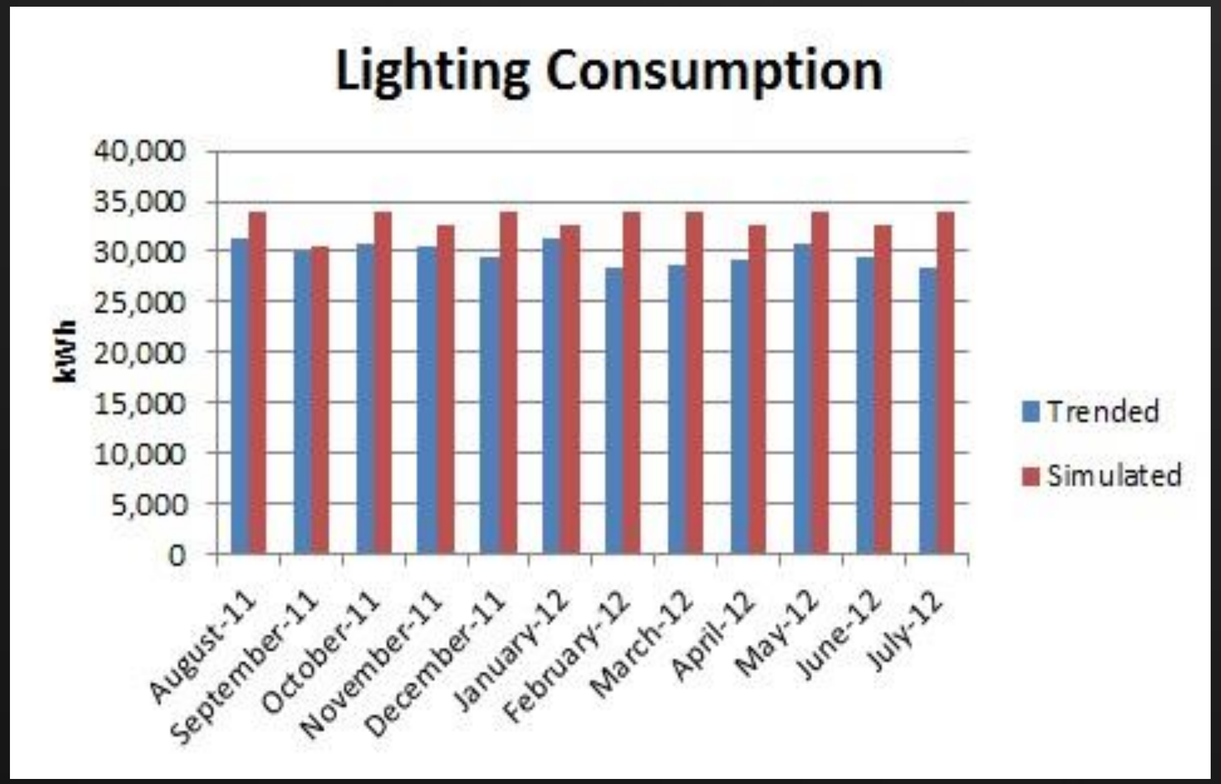
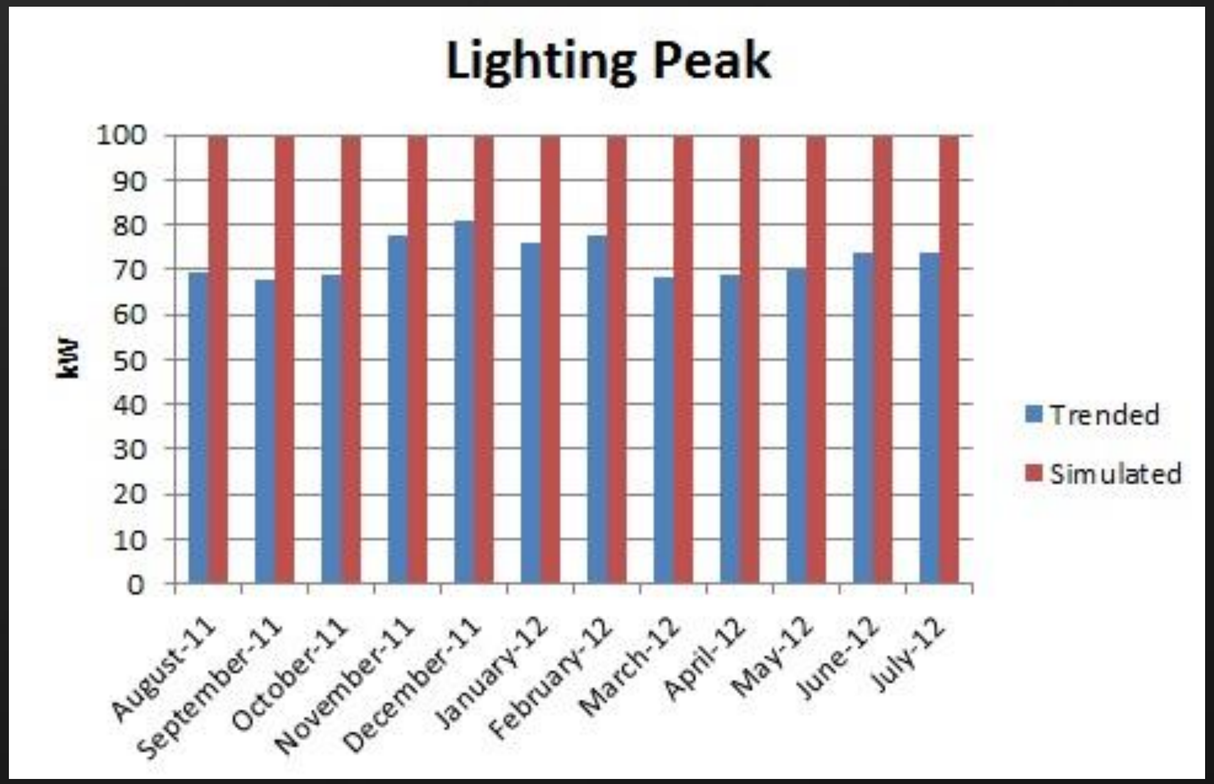
Lighting – Initial Comparison Charts





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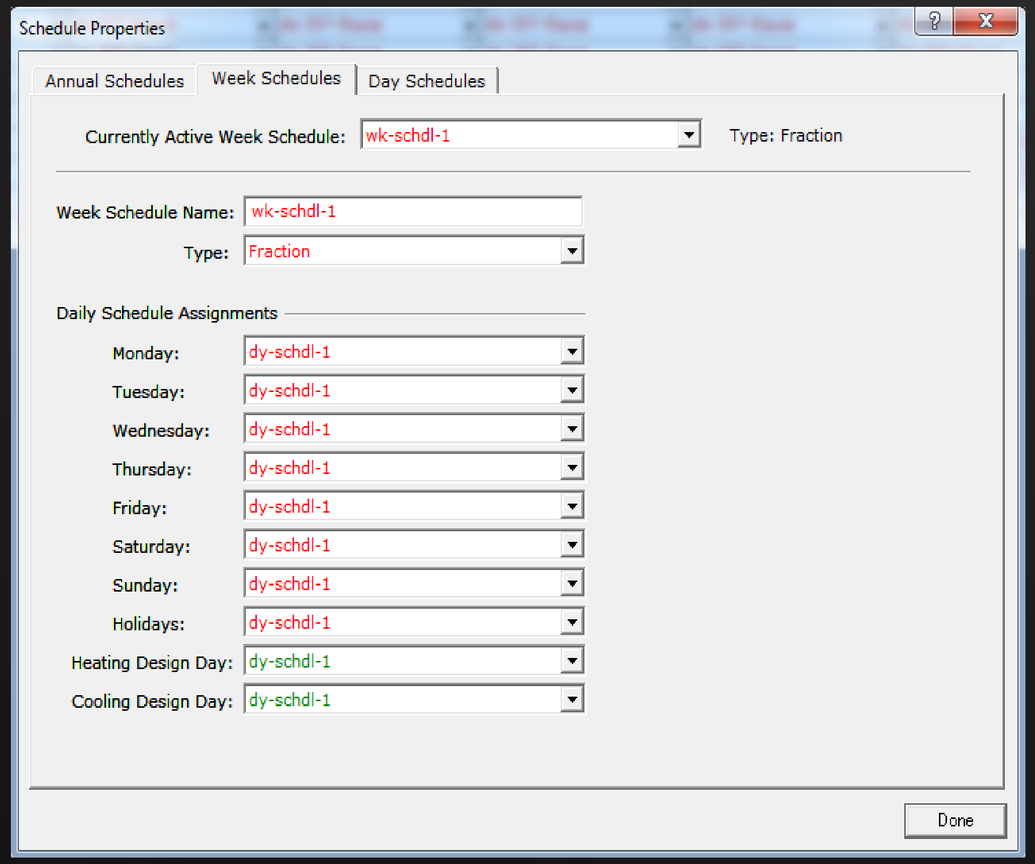
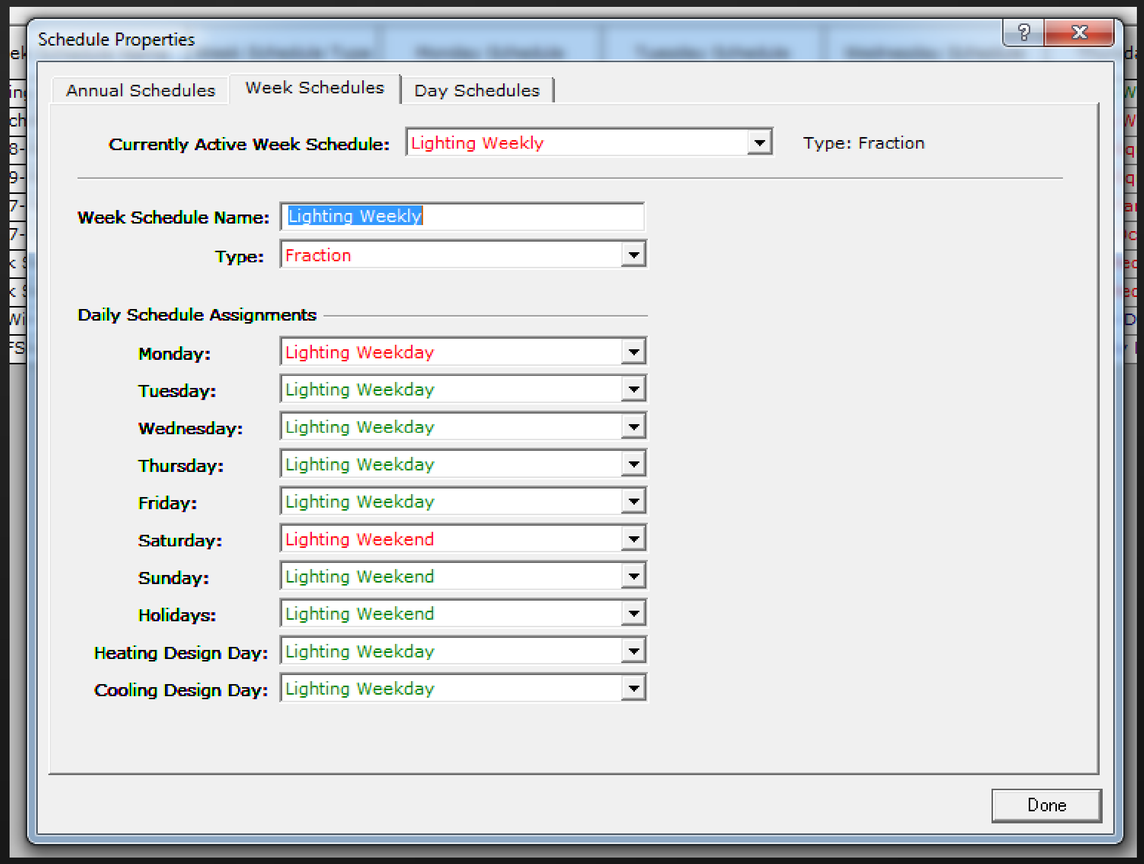
Develop Accurate Lighting Schedules





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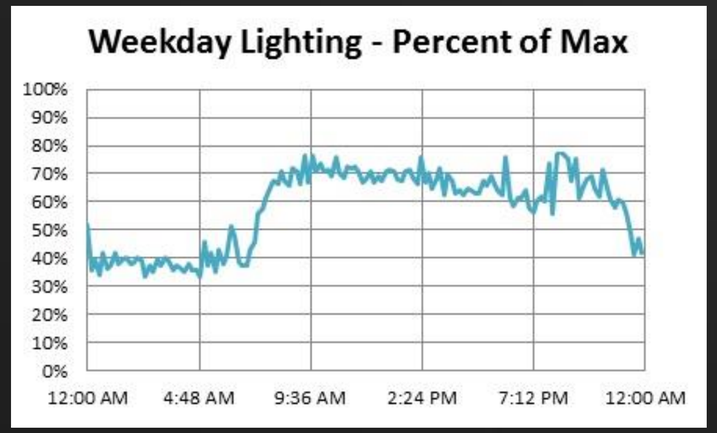
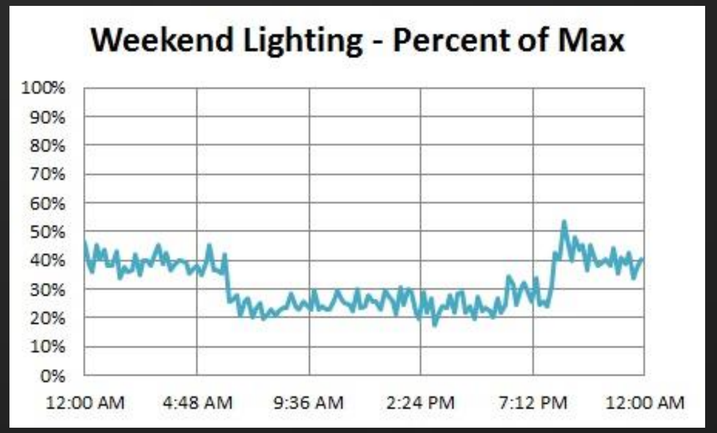
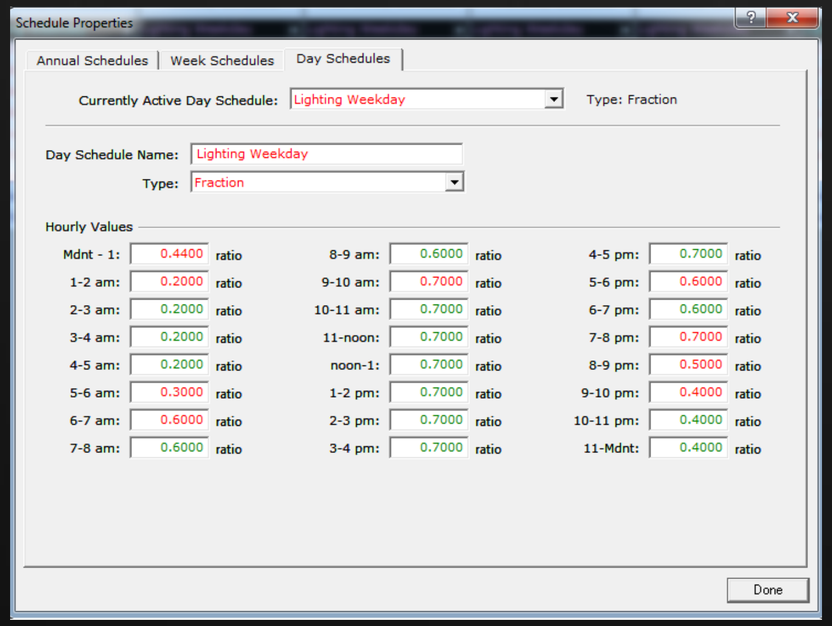
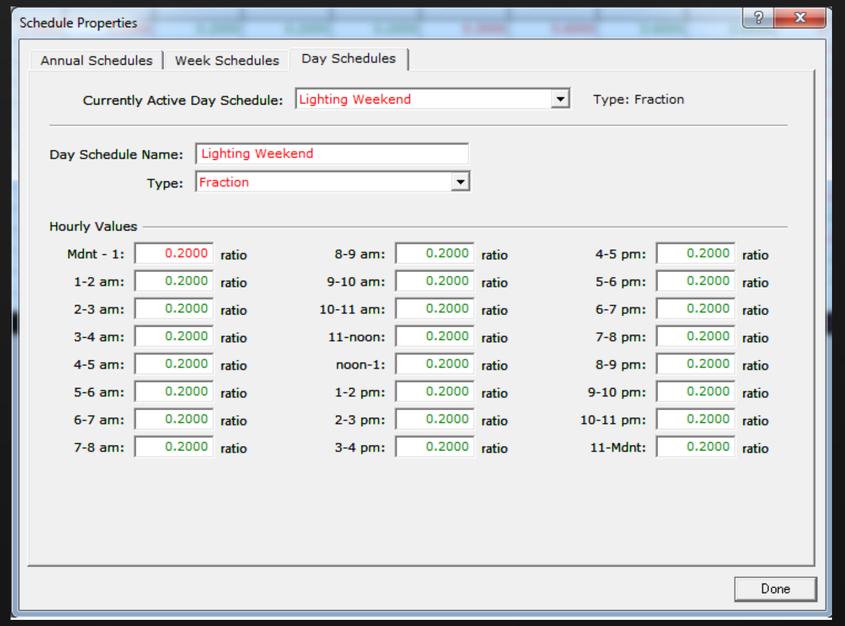
Develop Accurate Lighting Schedules









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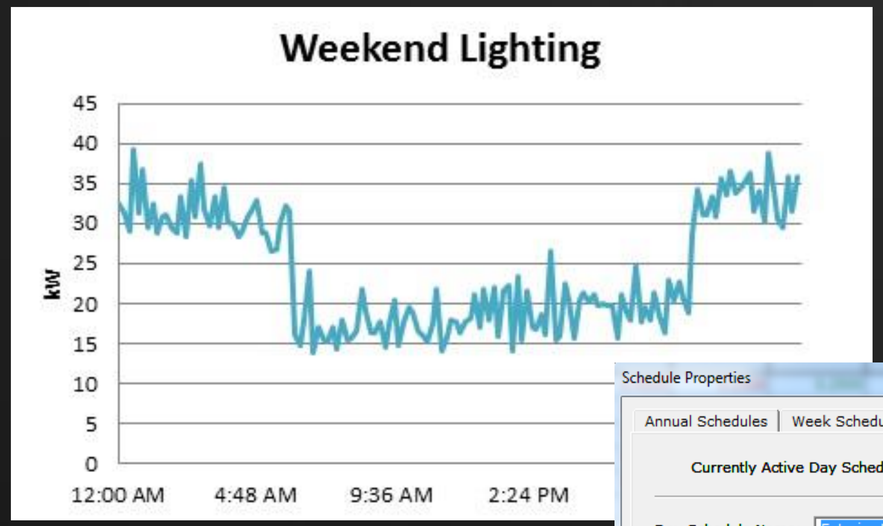
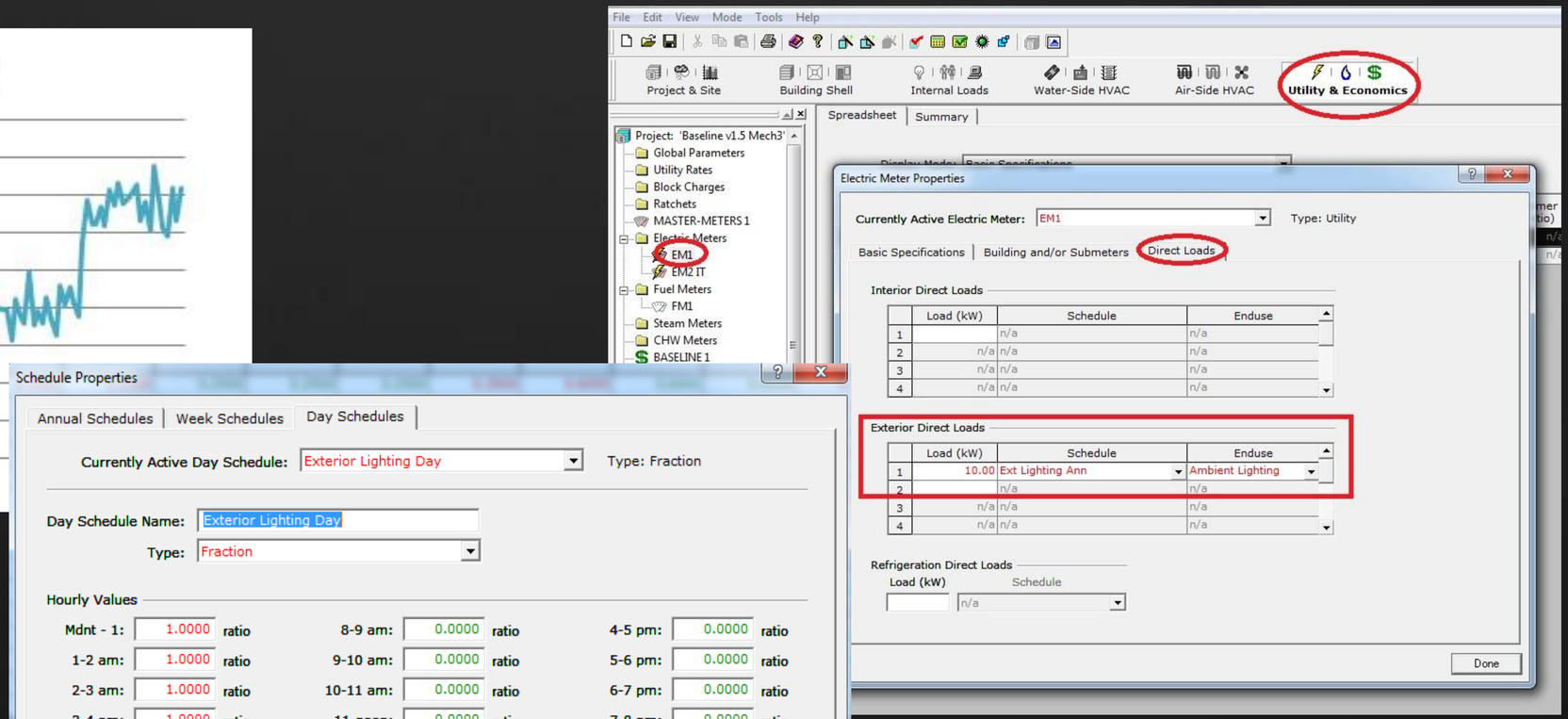
Incorporate Exterior Lighting





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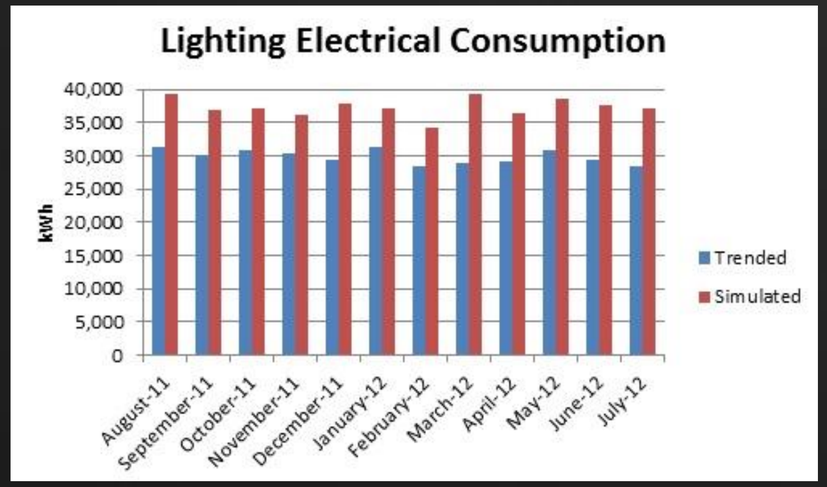
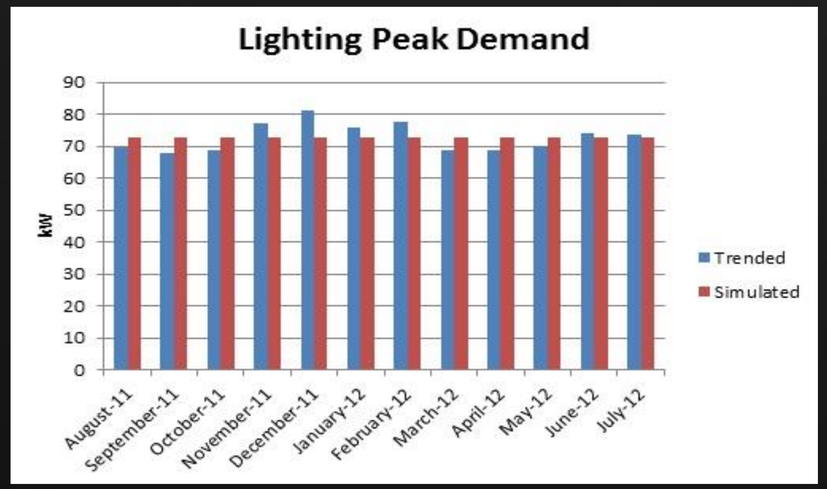
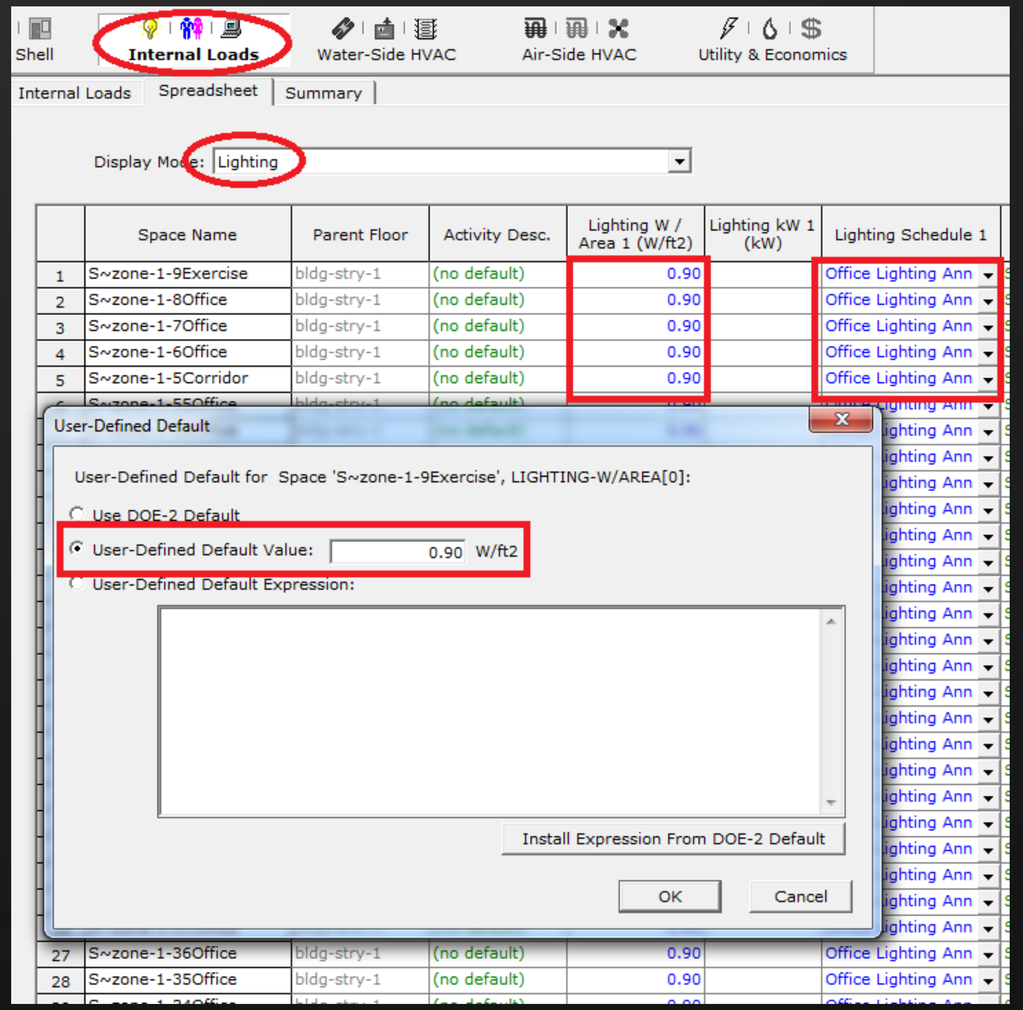
Modify LPD







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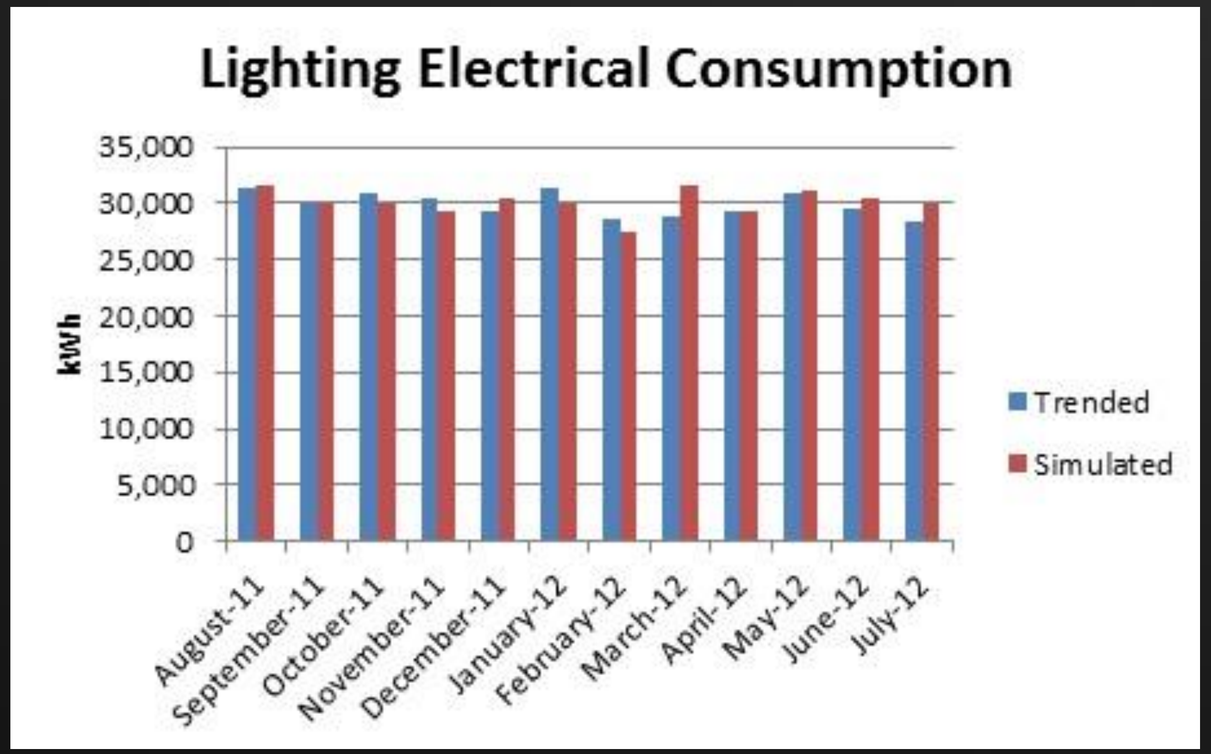
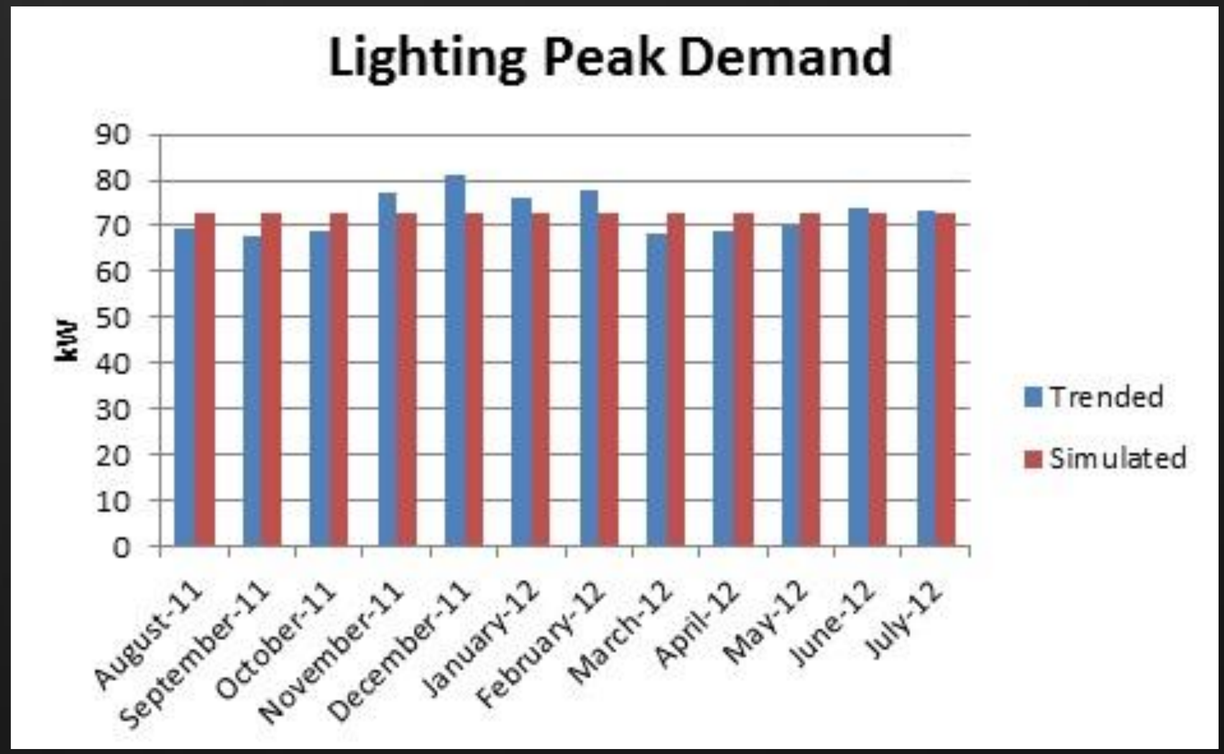
Lighting – Final Comparison Charts





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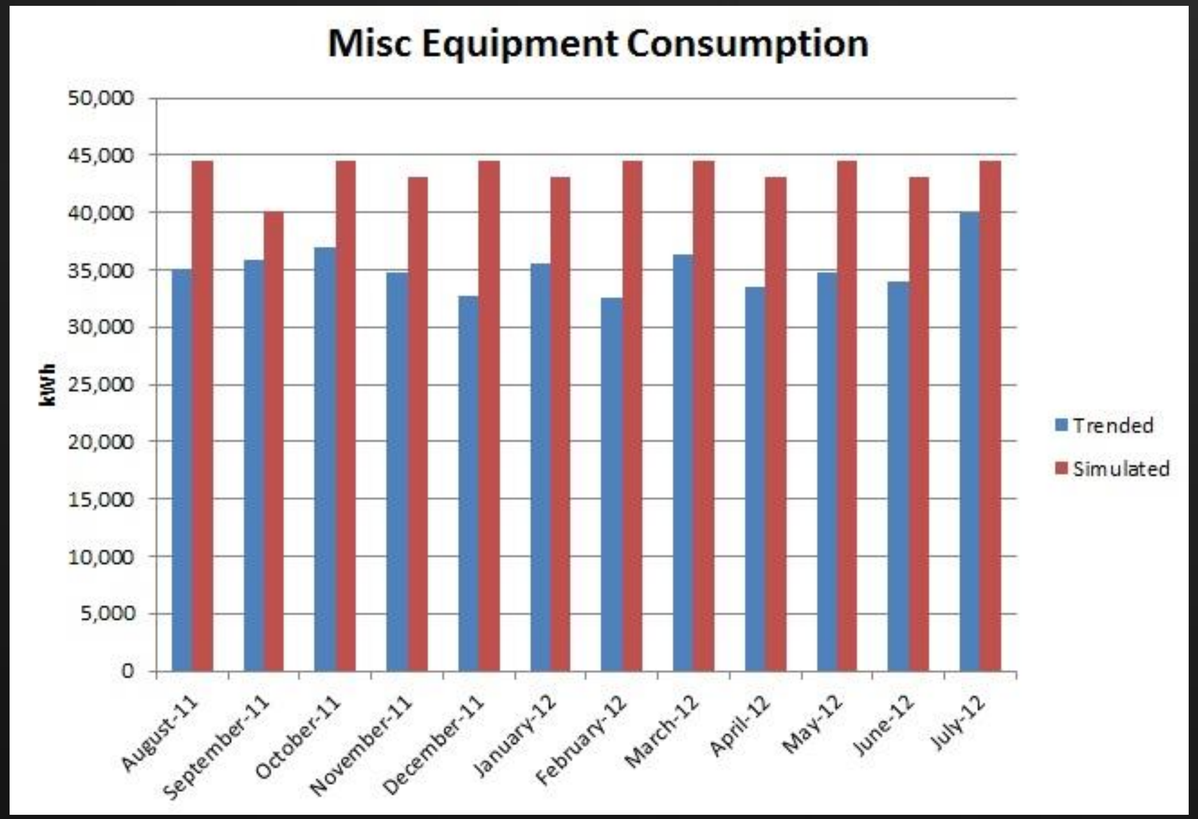
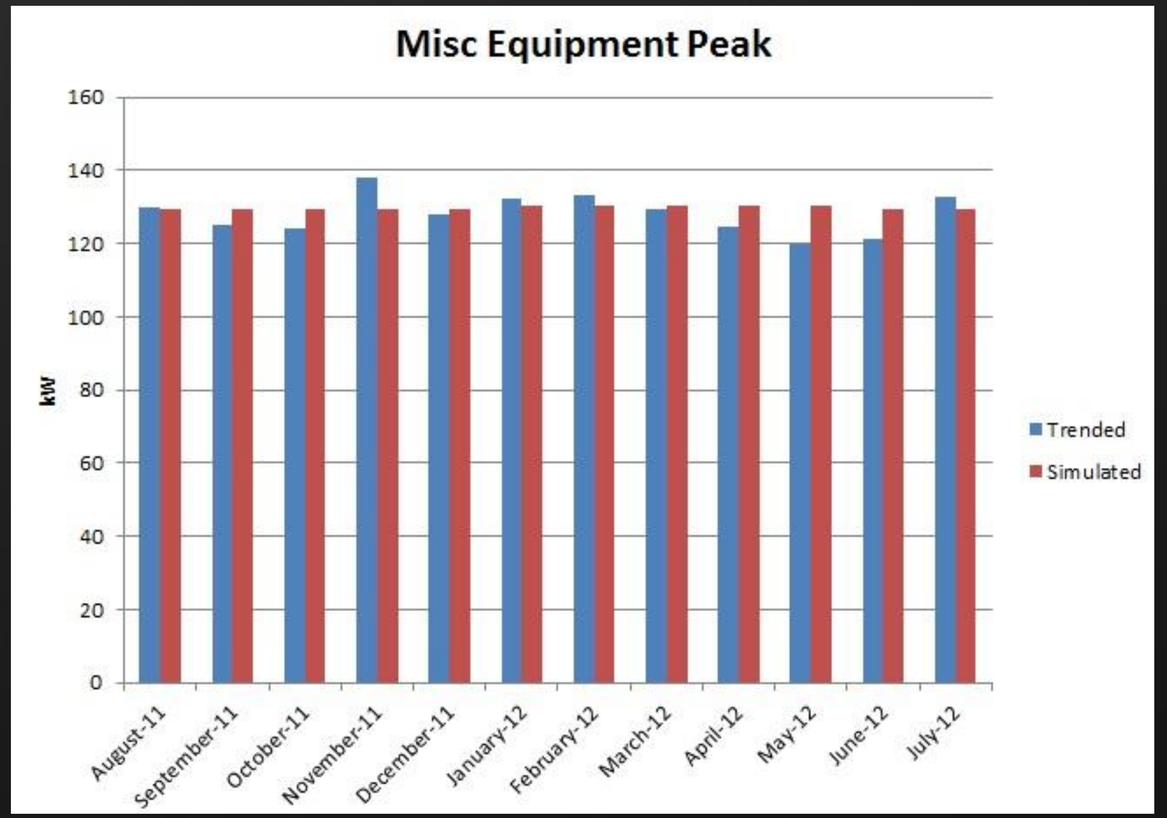
Equipment – Initial Comparison Charts





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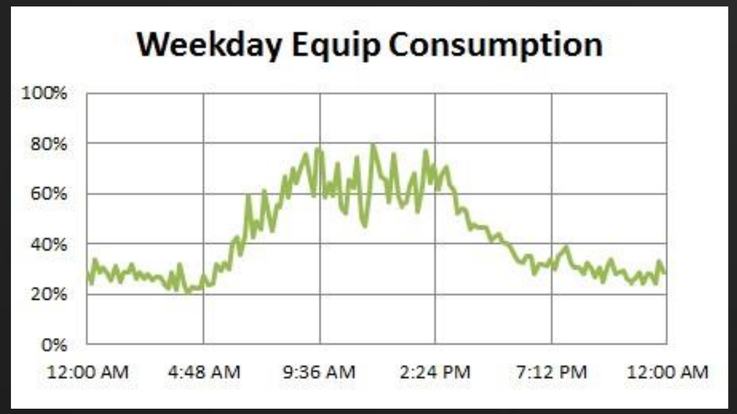
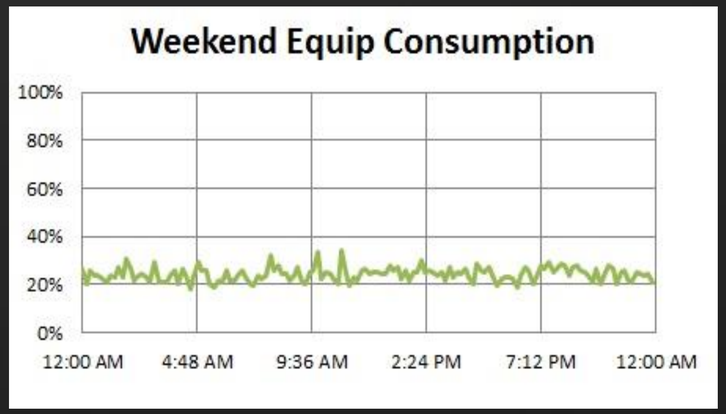
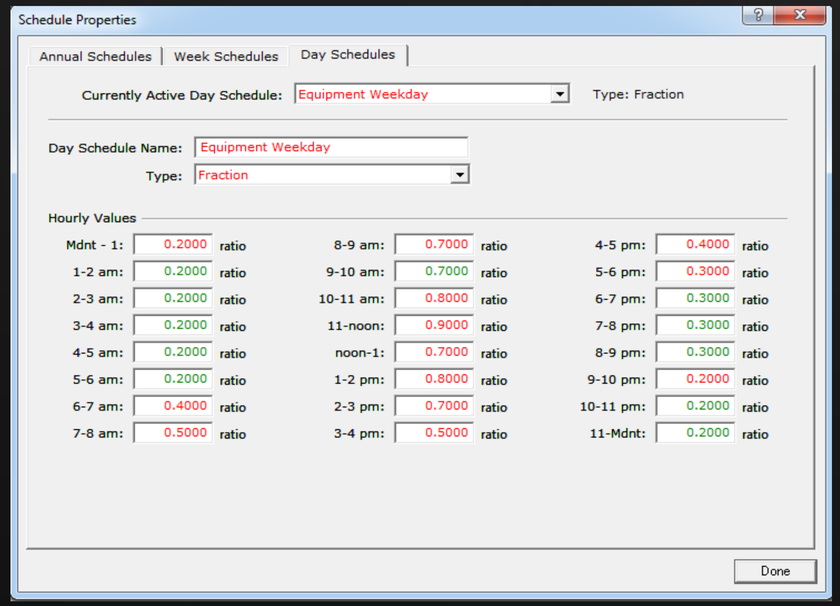
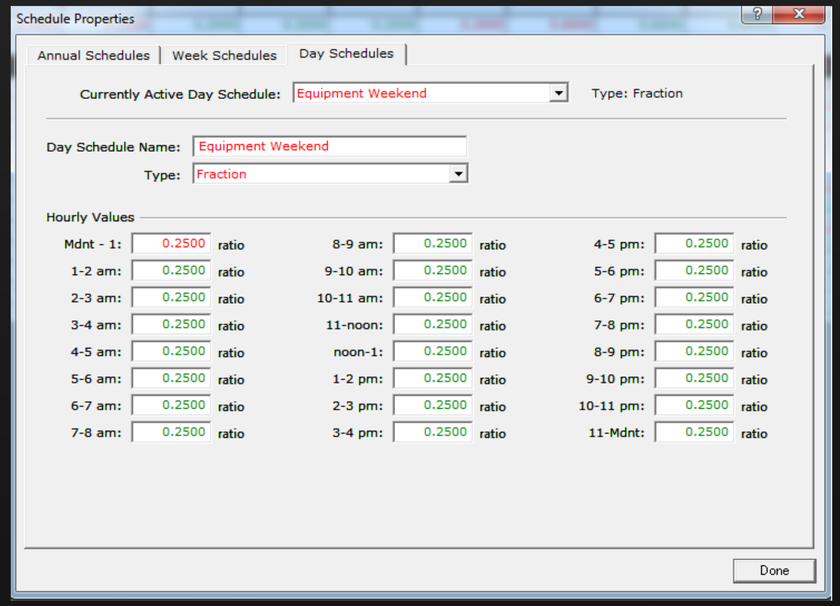
Develop Accurate Equipment Schedules









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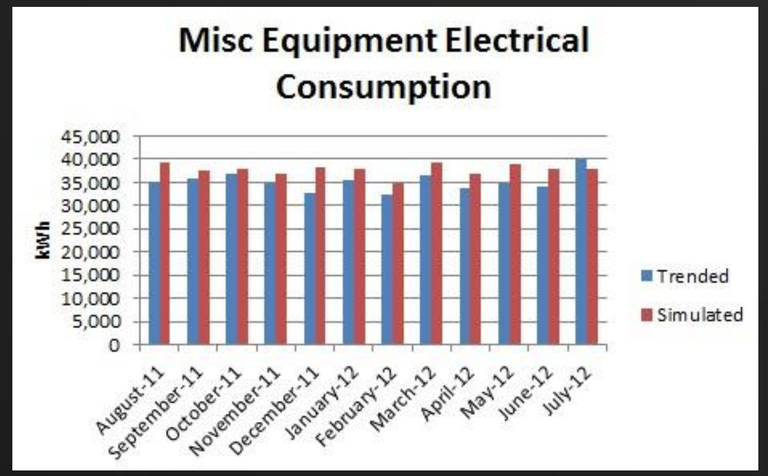
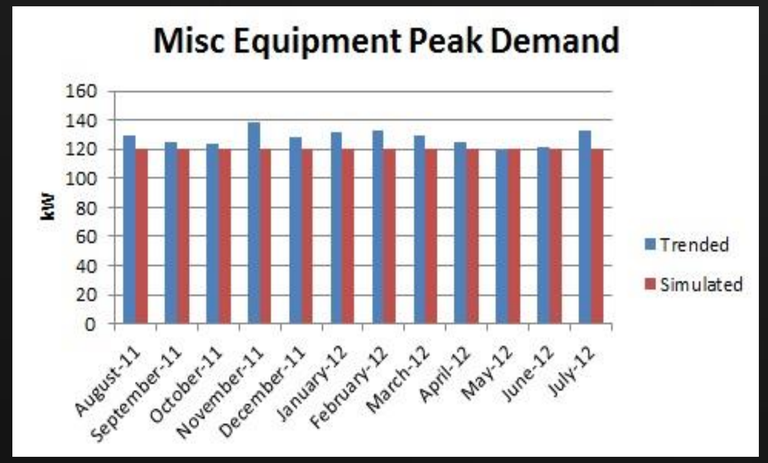
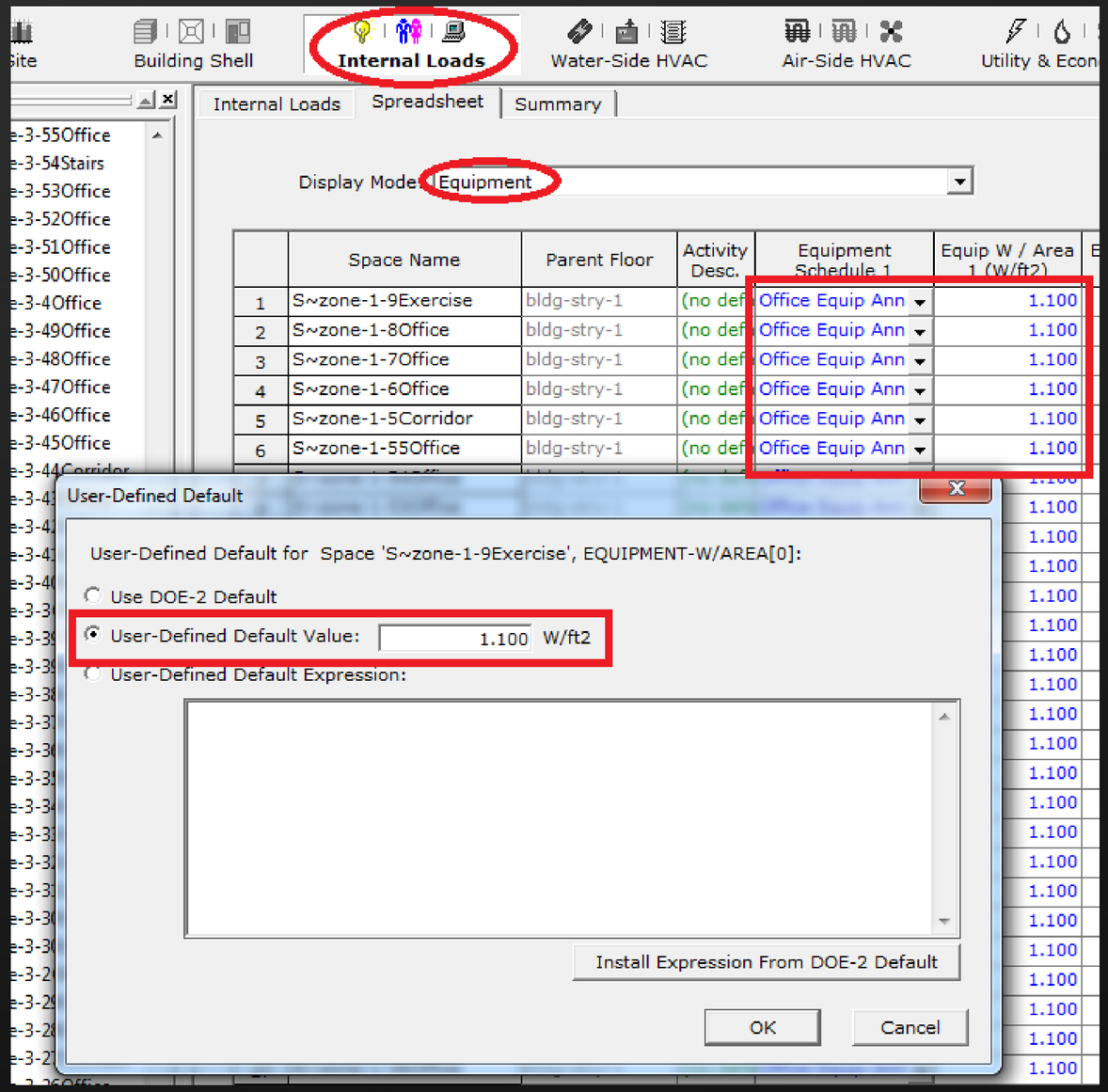
Modify EPD







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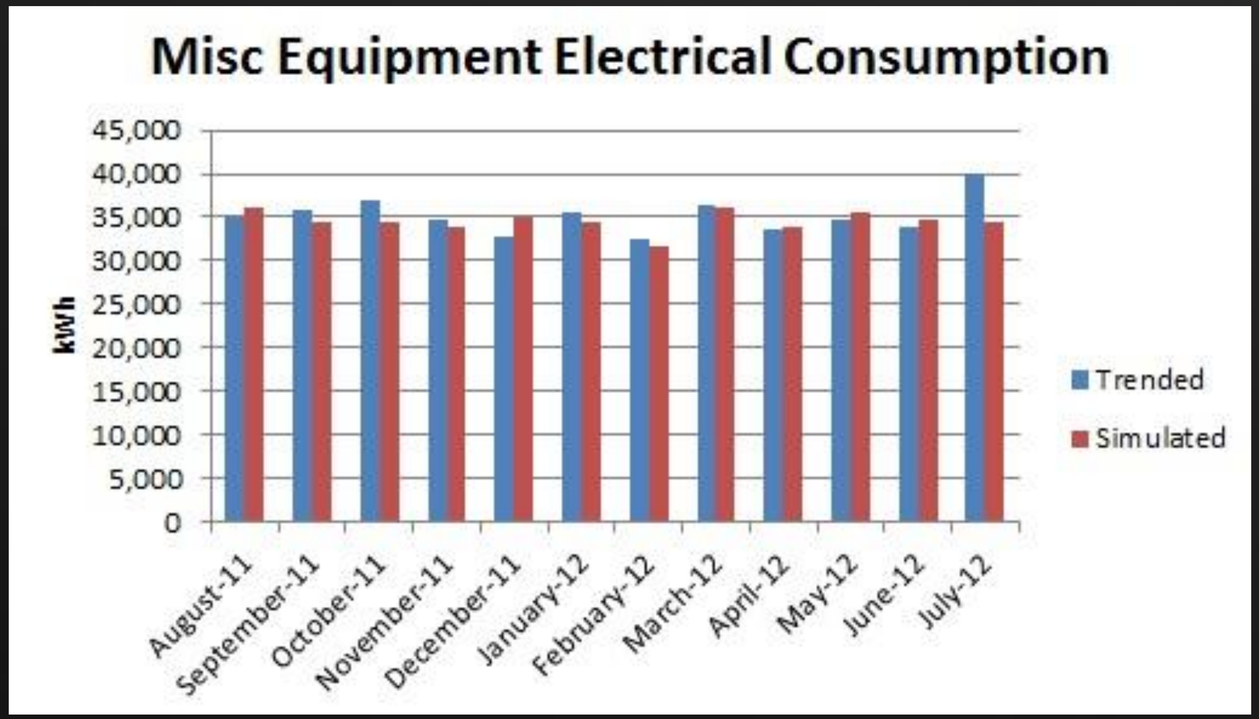
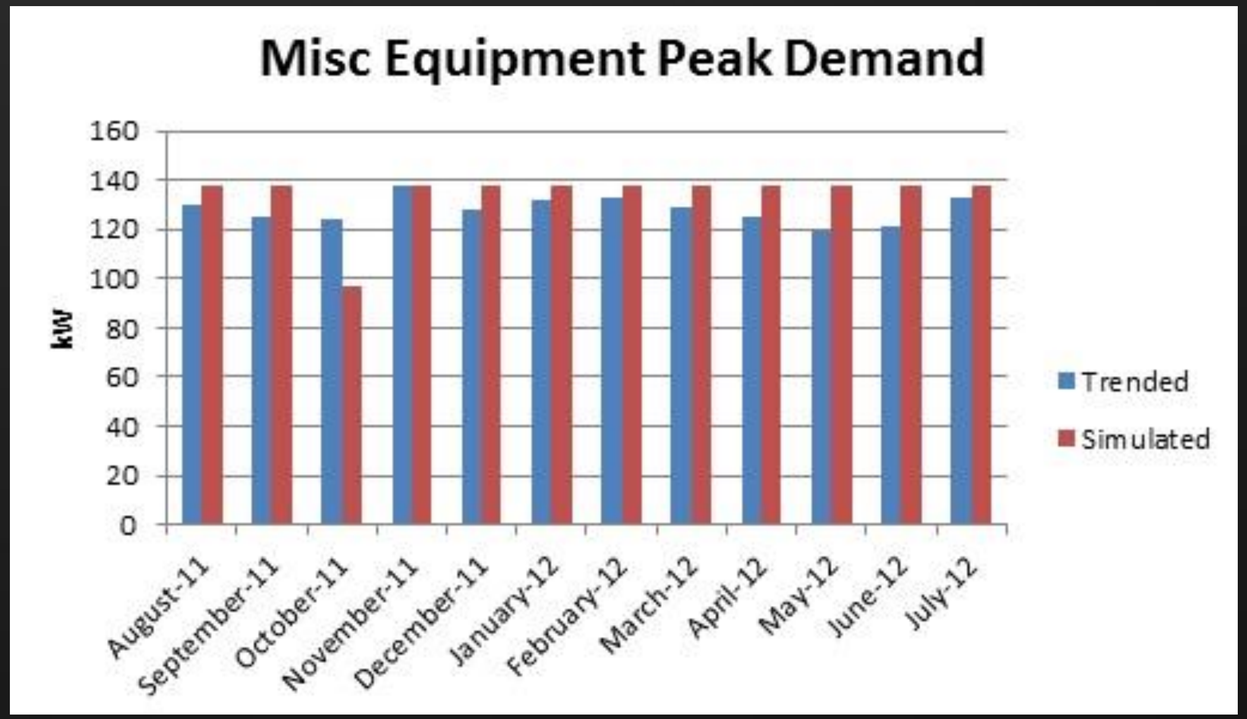
Equipment – Final Comparison Charts





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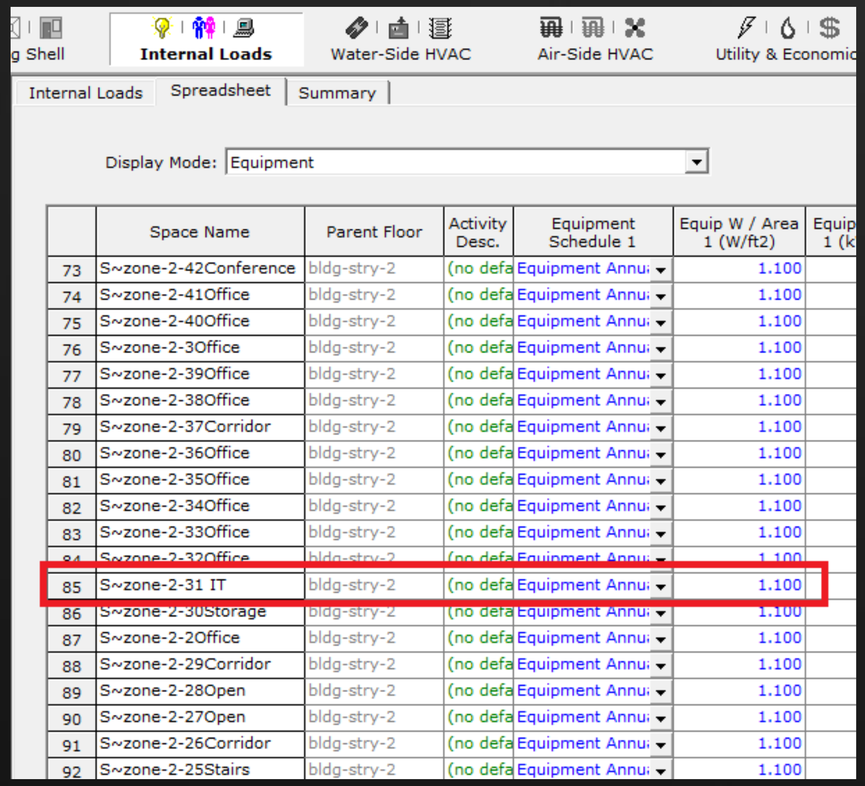
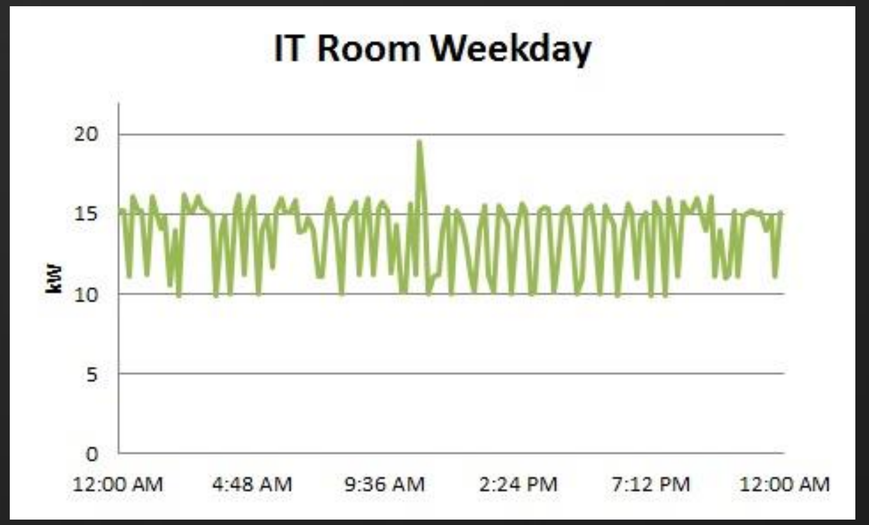
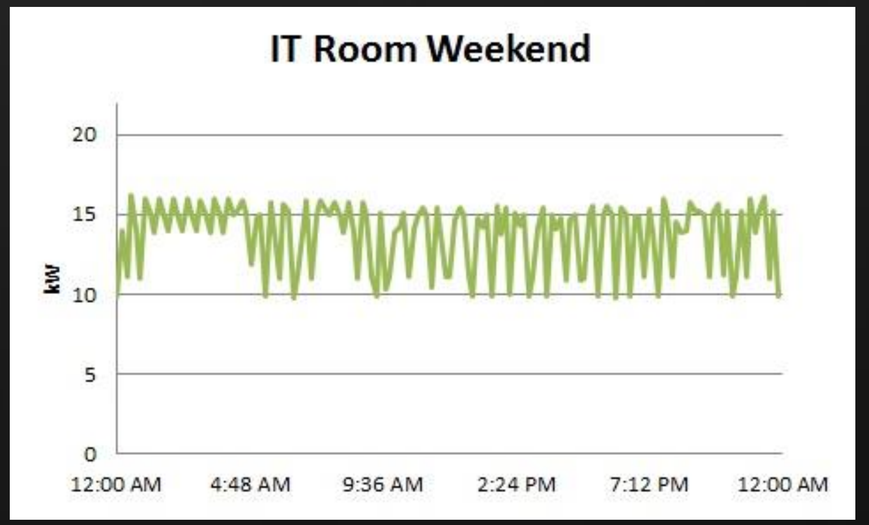
IT Room



	Space Name	Parent Floor	Activity Desc.	Equipment Schedule 1	Equip W / Area 1 (W/ft2)	Equip 1 (k
73	S~zone-2-42Conference	bldg-stry-2	(no defa	Equipment Annu	1.100	
74	S~zone-2-41Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
75	S~zone-2-40Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
76	S~zone-2-3Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
77	S~zone-2-39Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
78	S~zone-2-38Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
79	S~zone-2-37Corridor	bldg-stry-2	(no defa	Equipment Annu	1.100	
80	S~zone-2-36Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
81	S~zone-2-35Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
82	S~zone-2-34Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
83	S~zone-2-33Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
84	S~zone-2-32Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
85	S~zone-2-31 IT	bldg-stry-2	(no defa	Equipment Annu	1.100	
86	S~zone-2-30Storage	bldg-stry-2	(no defa	Equipment Annu	1.100	
87	S~zone-2-2Office	bldg-stry-2	(no defa	Equipment Annu	1.100	
88	S~zone-2-29Corridor	bldg-stry-2	(no defa	Equipment Annu	1.100	
89	S~zone-2-28Open	bldg-stry-2	(no defa	Equipment Annu	1.100	
90	S~zone-2-27Open	bldg-stry-2	(no defa	Equipment Annu	1.100	
91	S~zone-2-26Corridor	bldg-stry-2	(no defa	Equipment Annu	1.100	
92	S~zone-2-25Stairs	bldg-stry-2	(no defa	Equipment Annu	1.100	





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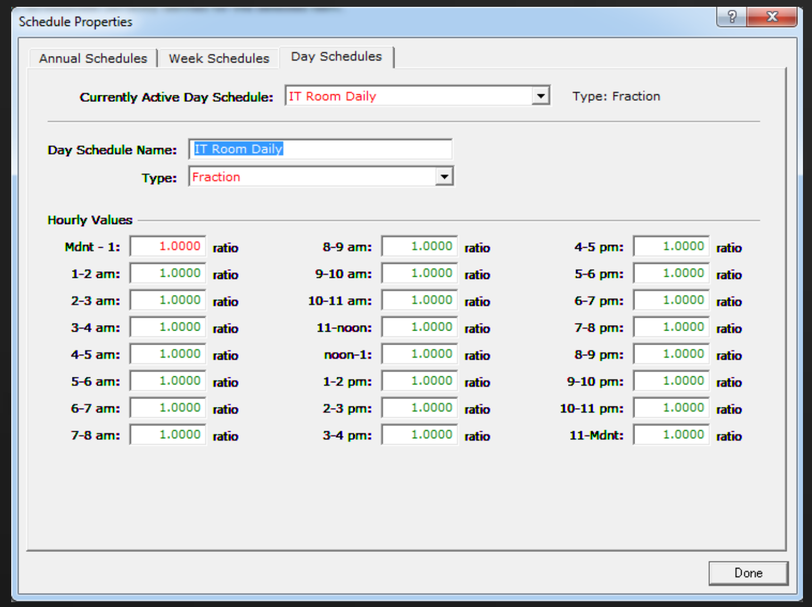
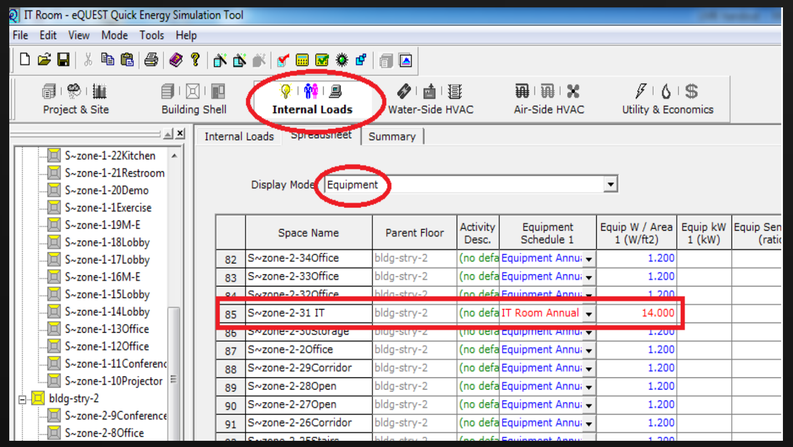
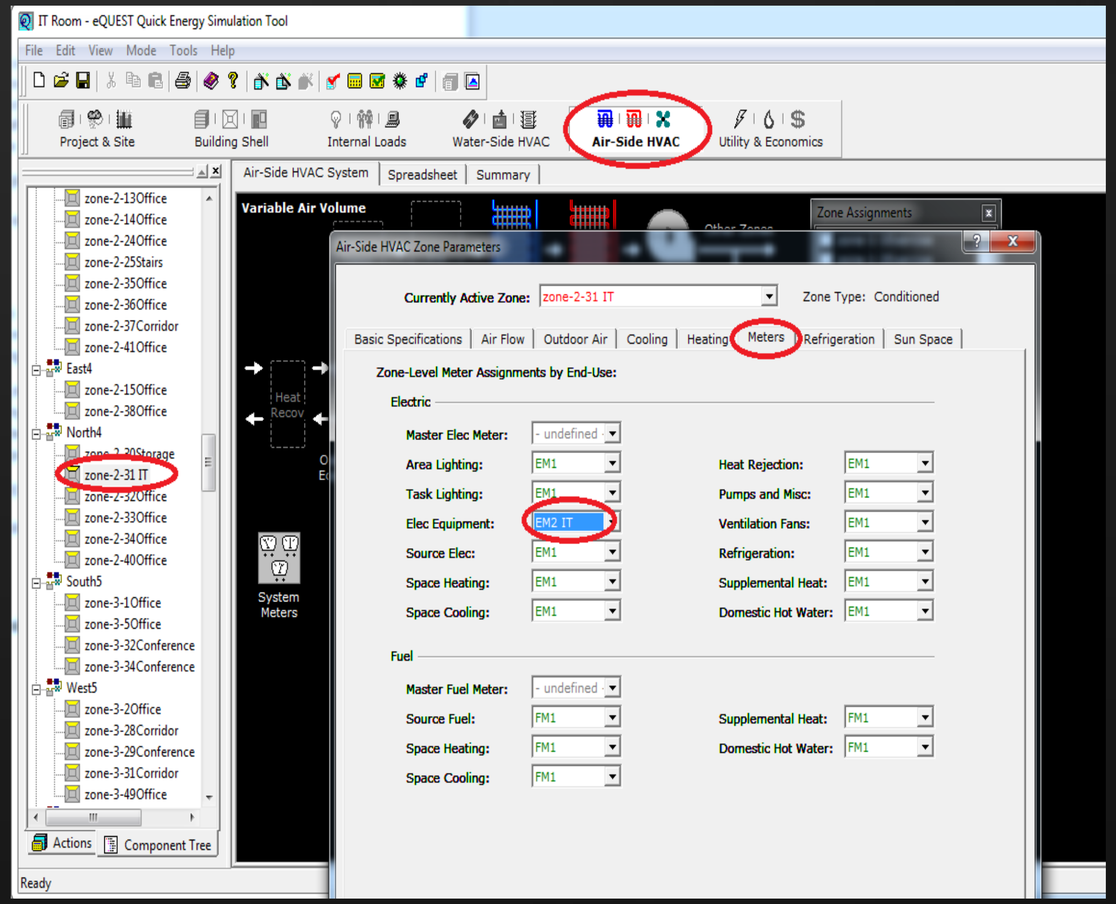
IT Room







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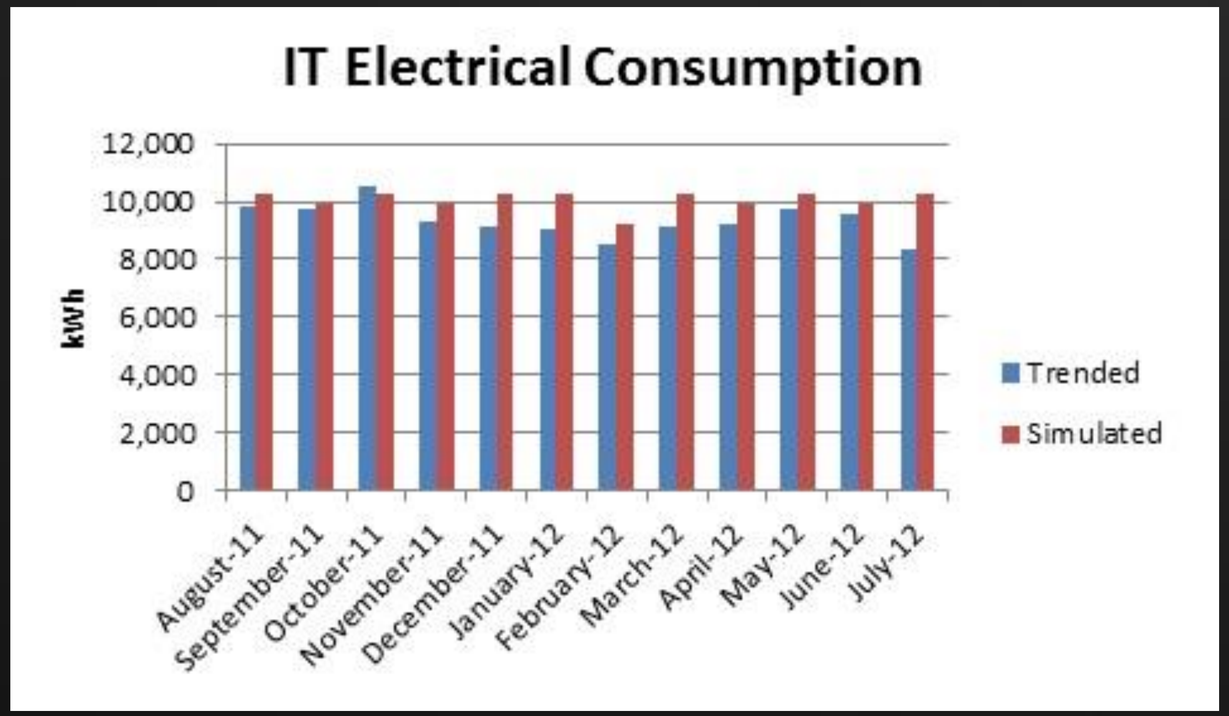
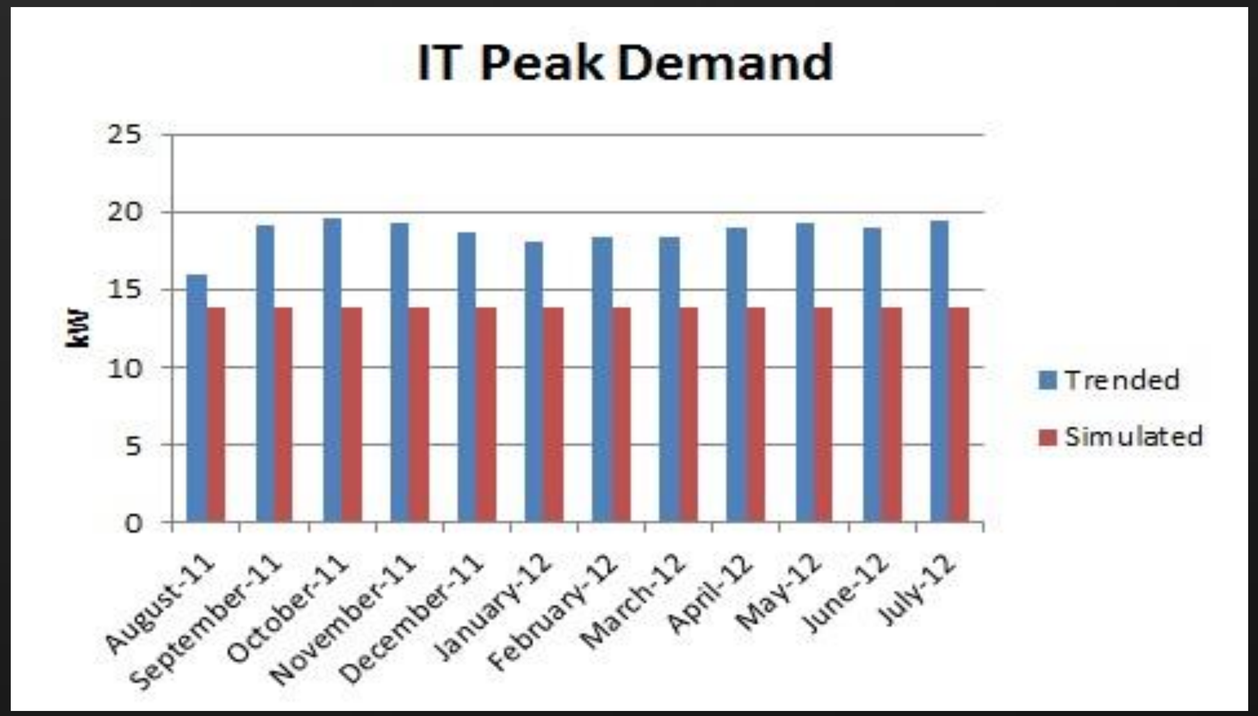
IT Room – Initial Comparison Charts





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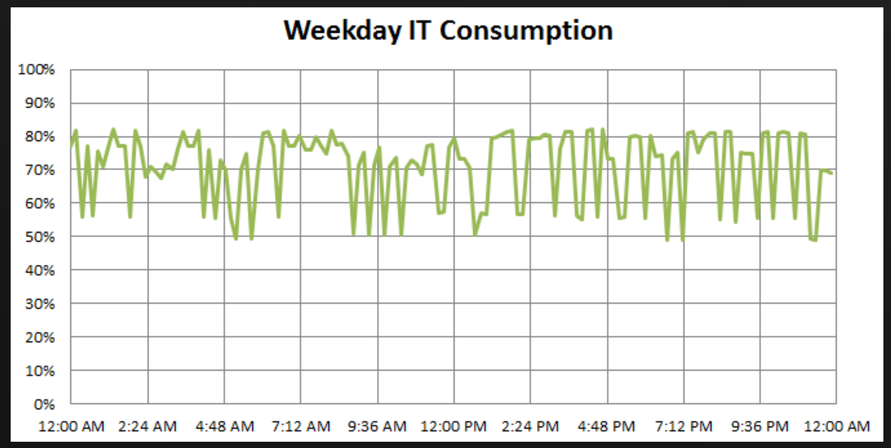
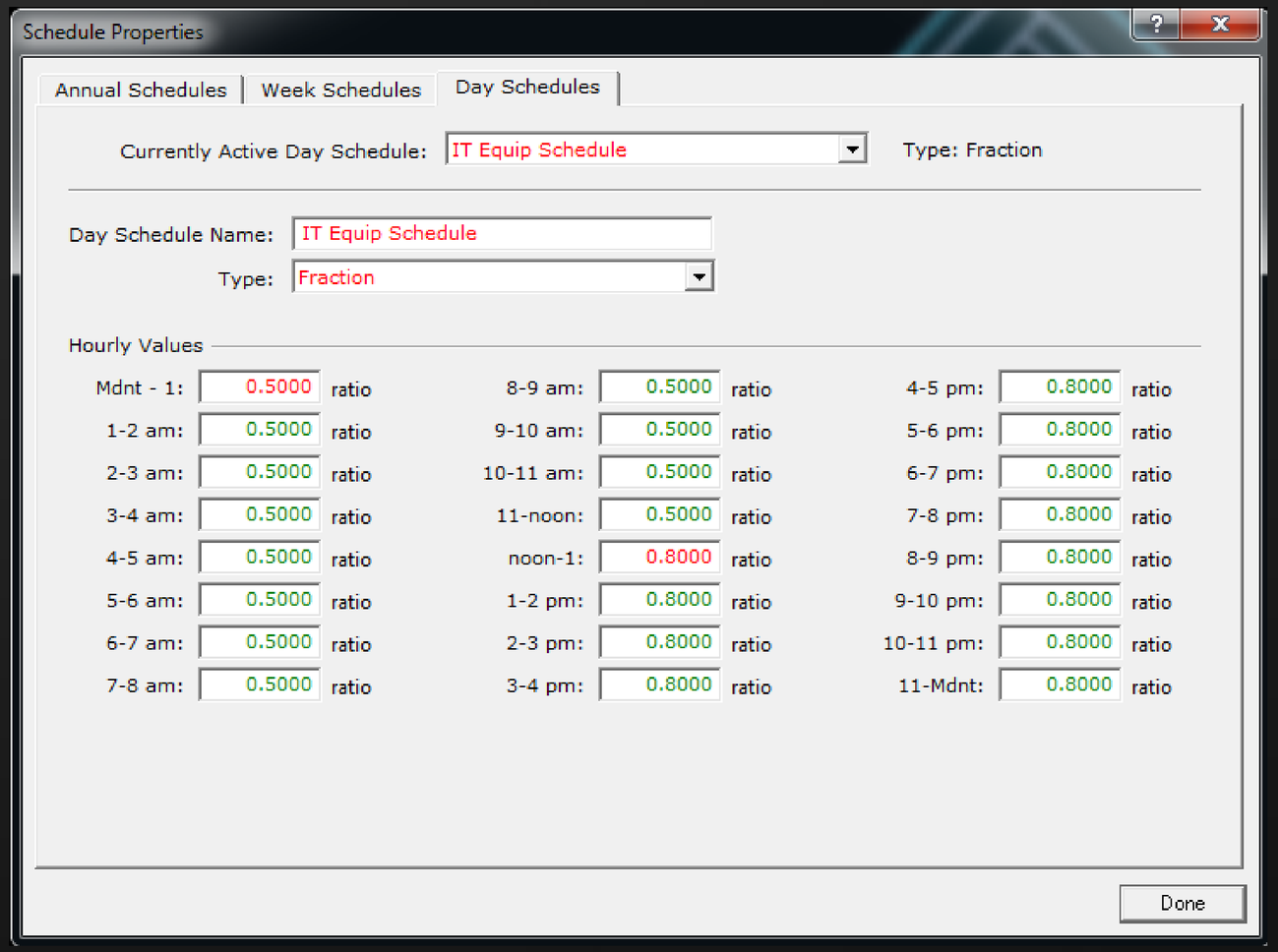
IT Room Calibration

Enduse	Peak Demand [kW]
Building Total	521.22
HVAC Total	422.41
HVAC AC Units	412.31
HVAC Other	17.75
Lighting	80.98
IT Room	19.57
Low Voltage	138.02
Elevators	77.31





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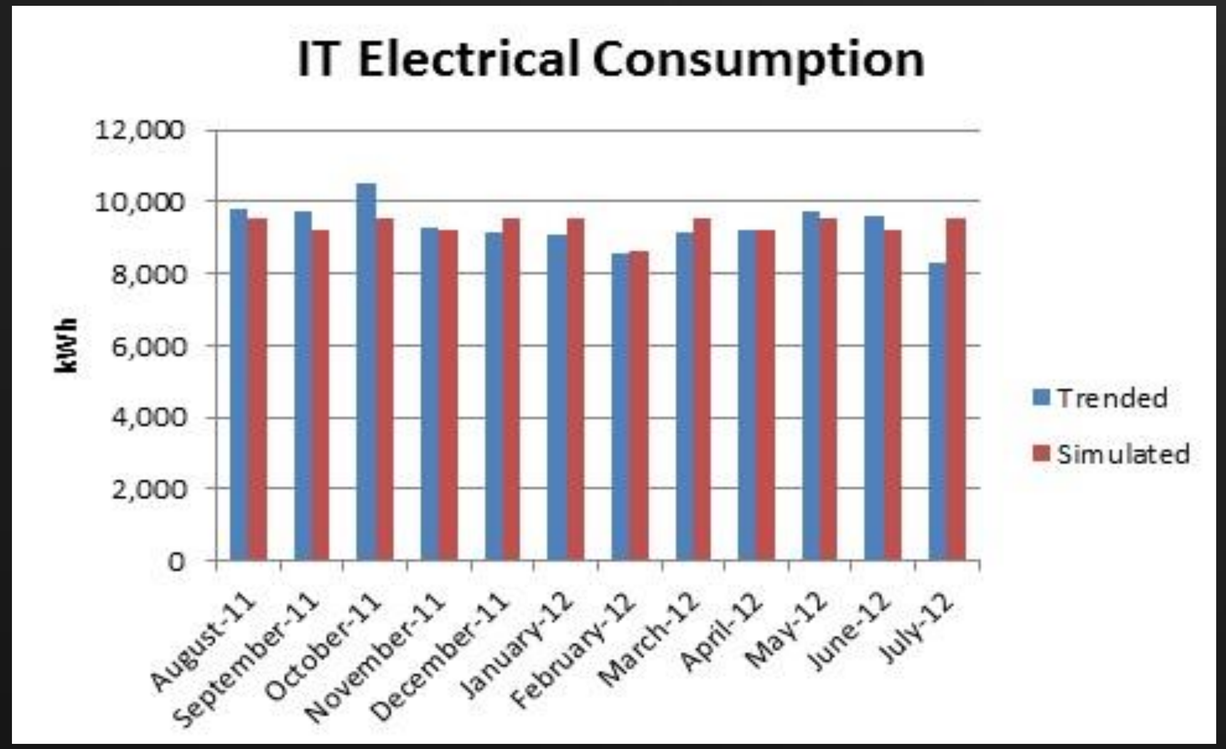
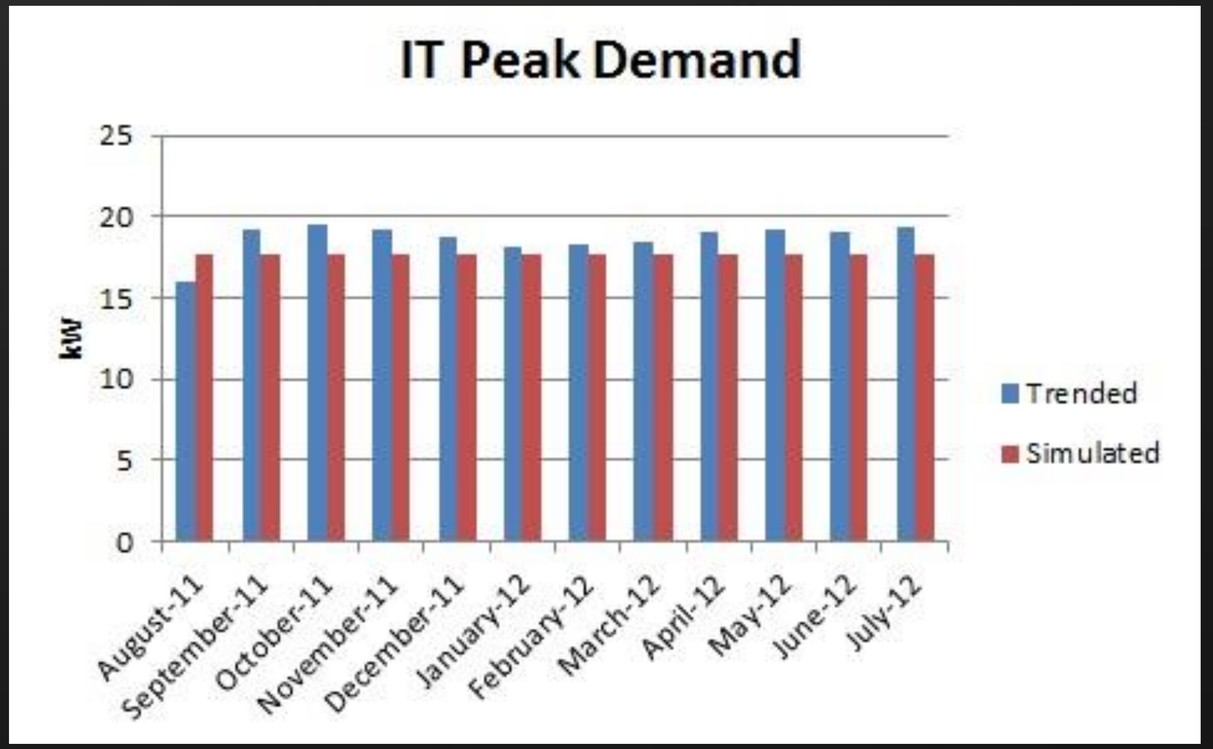
IT Room – Final Comparison Charts





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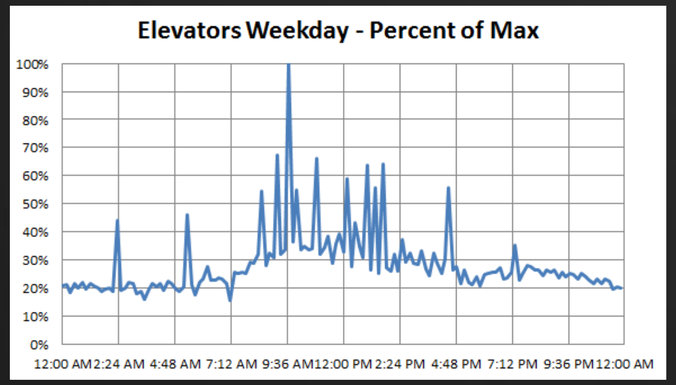
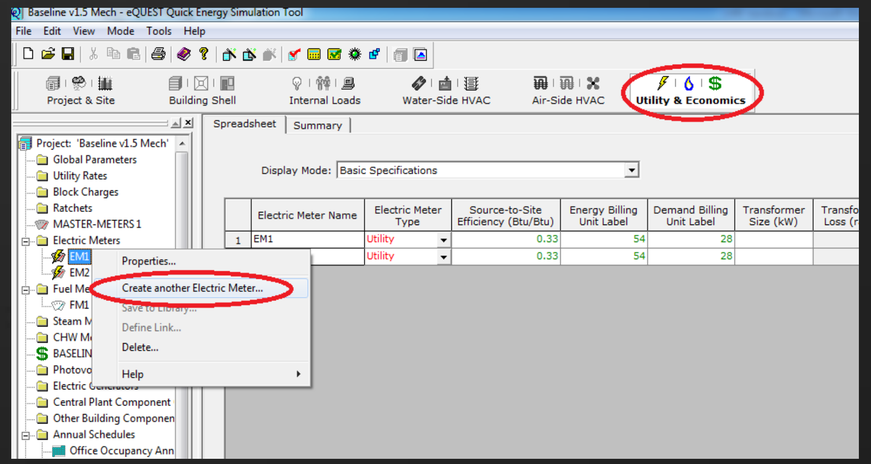
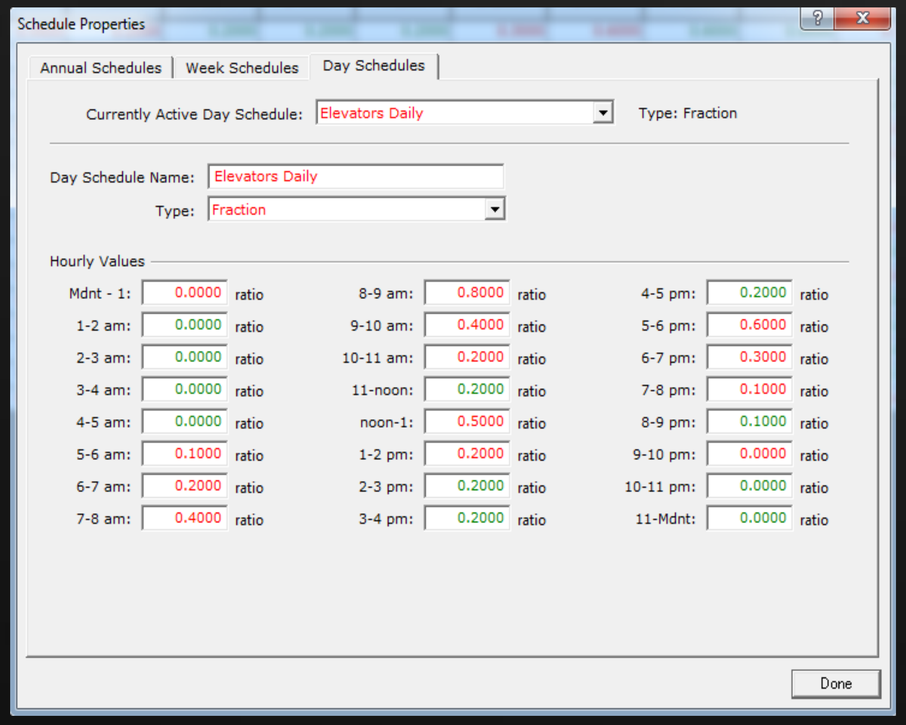
Elevators







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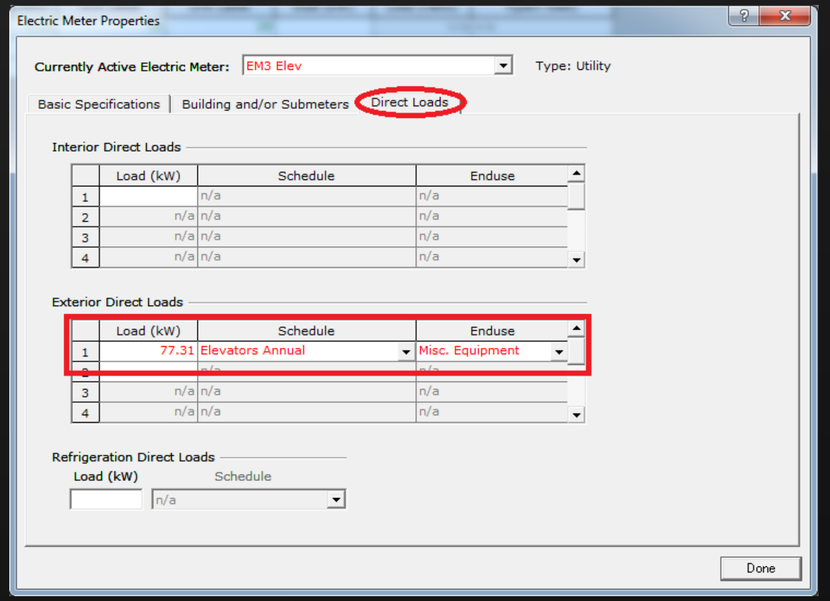

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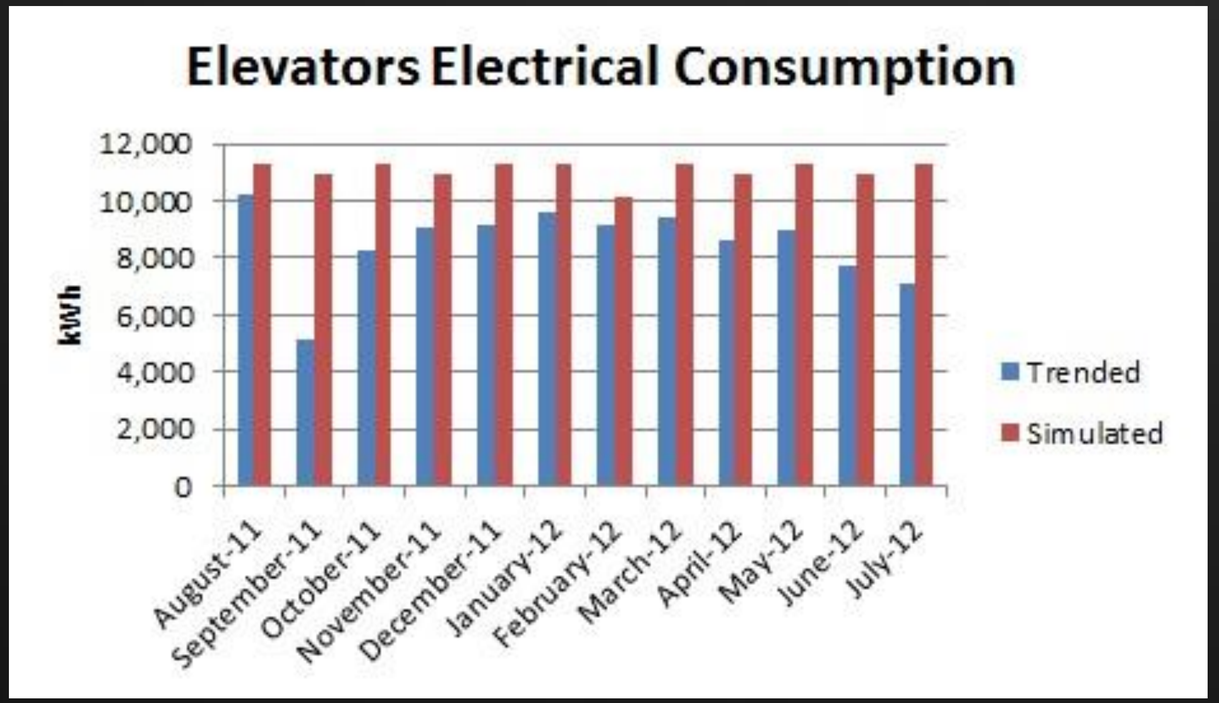
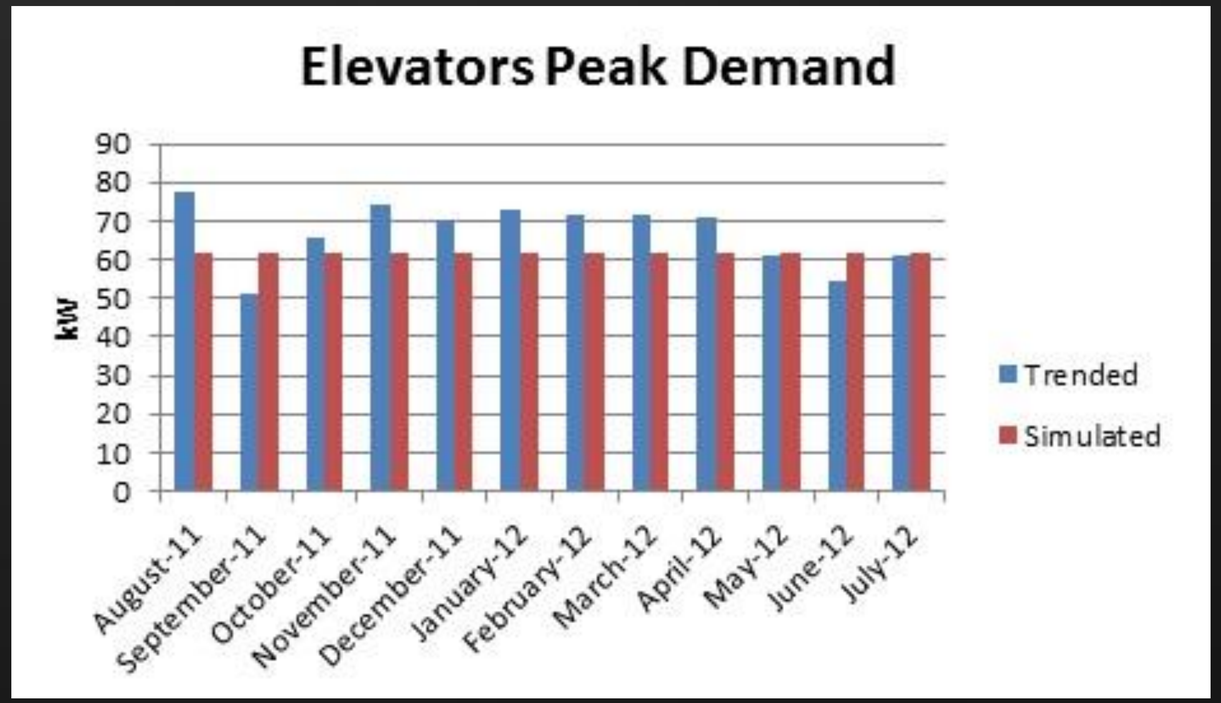
Elevators – Initial Comparison Charts





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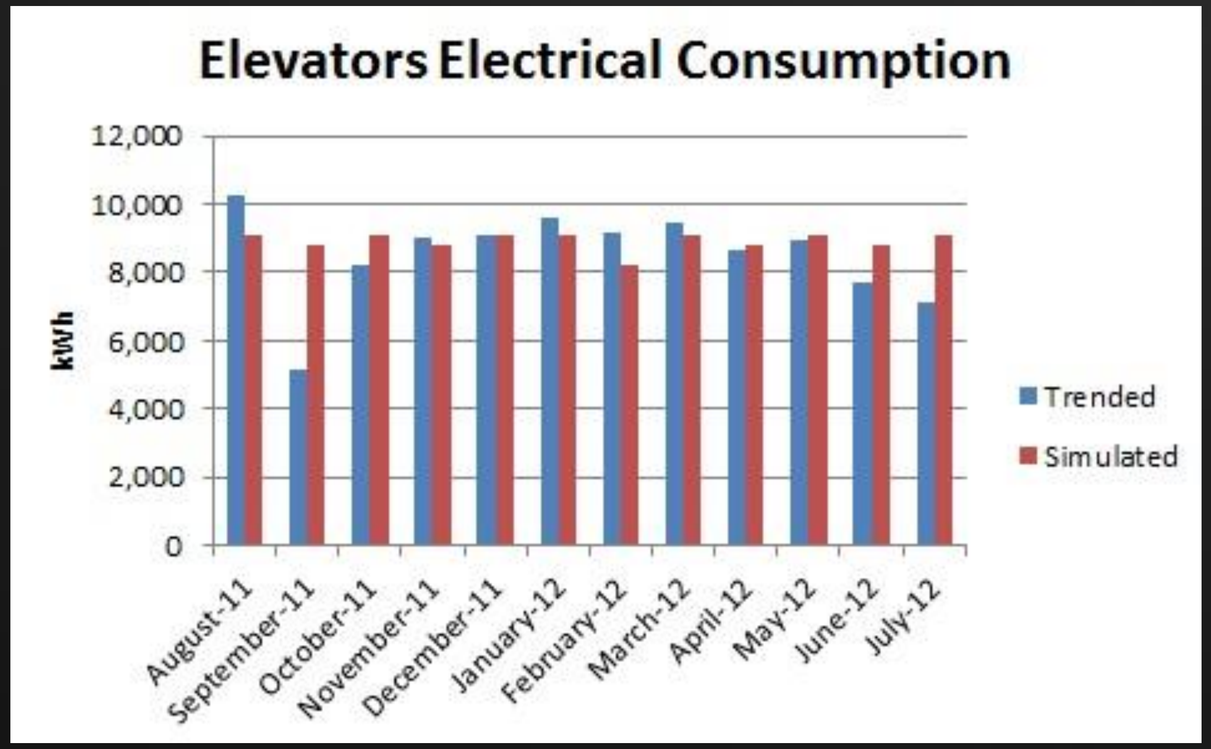
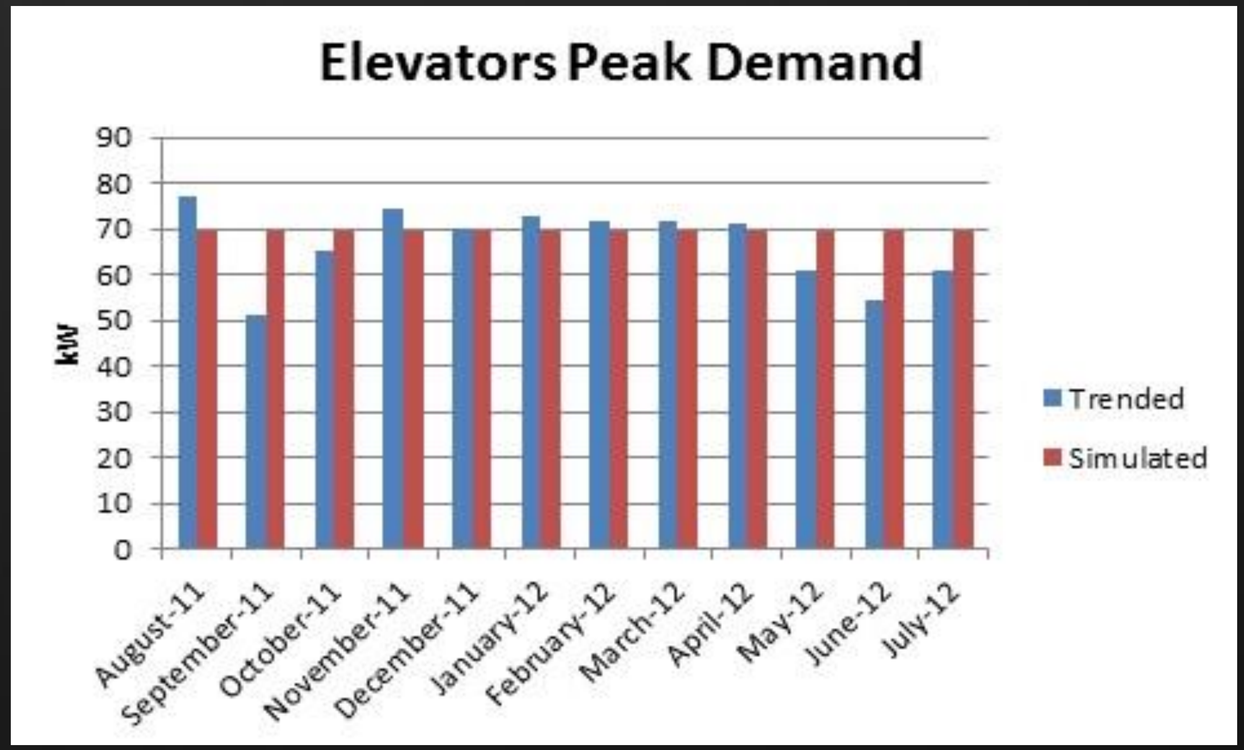
Elevators – Final Comparison Charts





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HVAC

Unlike the other end-uses, the HVAC system has multiple variables that must be established prior to calibration:

- Occupancy Schedules
- Building Envelope
- HVAC System and Components
- HVAC Zoning
- Infiltration
- Heating/Cooling Schedules

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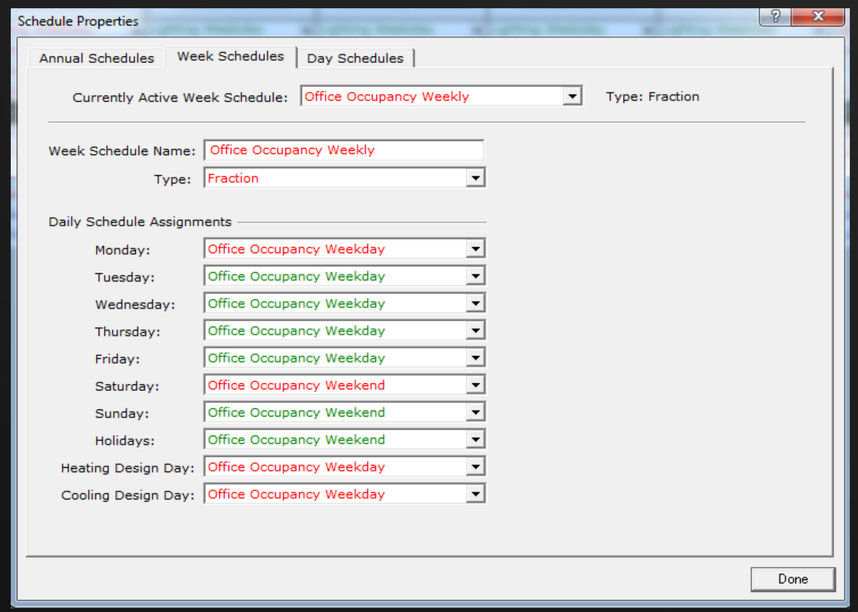
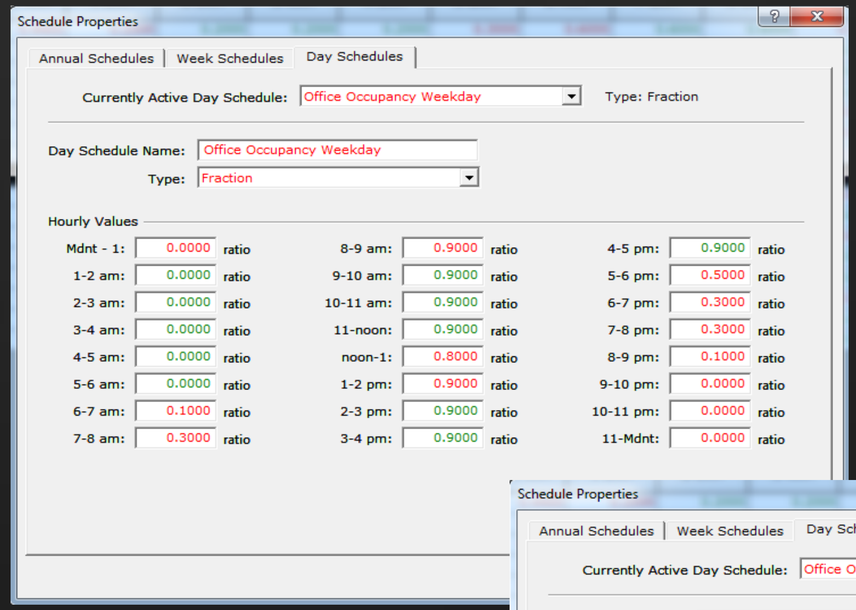
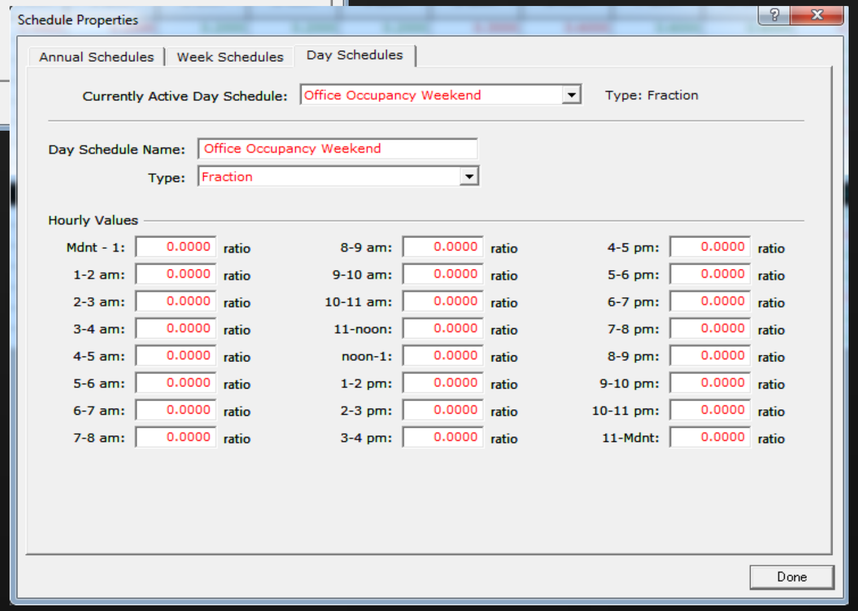
HVAC – Occupancy Schedules







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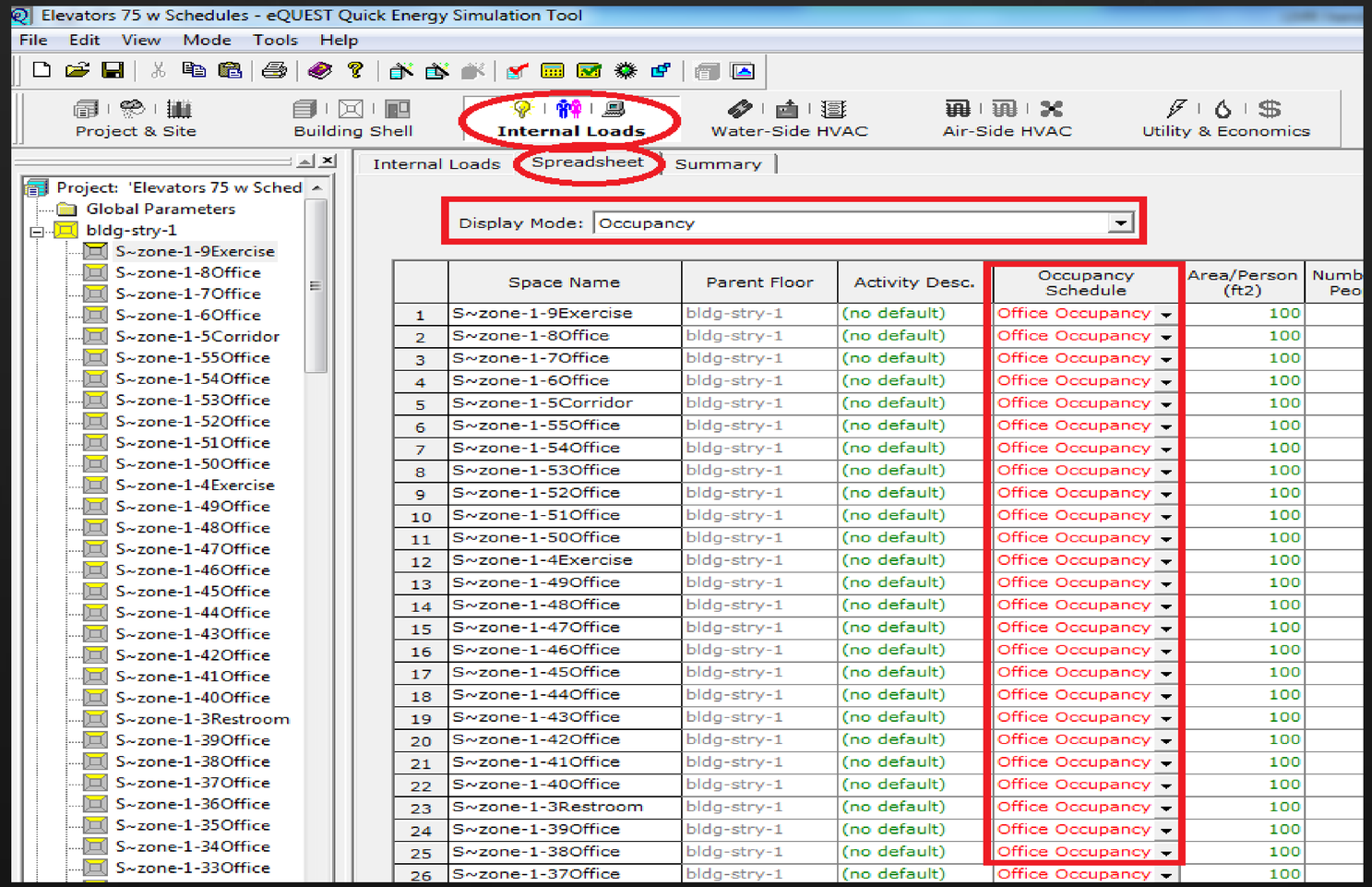
HVAC – Occupancy Schedules



	Space Name	Parent Floor	Activity Desc.	Occupancy Schedule	Area/Person (ft2)	Numb Peo
1	S~zone-1-9Exercise	bldg-stry-1	(no default)	Office Occupancy	100	
2	S~zone-1-8Office	bldg-stry-1	(no default)	Office Occupancy	100	
3	S~zone-1-7Office	bldg-stry-1	(no default)	Office Occupancy	100	
4	S~zone-1-6Office	bldg-stry-1	(no default)	Office Occupancy	100	
5	S~zone-1-5Corridor	bldg-stry-1	(no default)	Office Occupancy	100	
6	S~zone-1-55Office	bldg-stry-1	(no default)	Office Occupancy	100	
7	S~zone-1-54Office	bldg-stry-1	(no default)	Office Occupancy	100	
8	S~zone-1-53Office	bldg-stry-1	(no default)	Office Occupancy	100	
9	S~zone-1-52Office	bldg-stry-1	(no default)	Office Occupancy	100	
10	S~zone-1-51Office	bldg-stry-1	(no default)	Office Occupancy	100	
11	S~zone-1-50Office	bldg-stry-1	(no default)	Office Occupancy	100	
12	S~zone-1-4Exercise	bldg-stry-1	(no default)	Office Occupancy	100	
13	S~zone-1-49Office	bldg-stry-1	(no default)	Office Occupancy	100	
14	S~zone-1-48Office	bldg-stry-1	(no default)	Office Occupancy	100	
15	S~zone-1-47Office	bldg-stry-1	(no default)	Office Occupancy	100	
16	S~zone-1-46Office	bldg-stry-1	(no default)	Office Occupancy	100	
17	S~zone-1-45Office	bldg-stry-1	(no default)	Office Occupancy	100	
18	S~zone-1-44Office	bldg-stry-1	(no default)	Office Occupancy	100	
19	S~zone-1-43Office	bldg-stry-1	(no default)	Office Occupancy	100	
20	S~zone-1-42Office	bldg-stry-1	(no default)	Office Occupancy	100	
21	S~zone-1-41Office	bldg-stry-1	(no default)	Office Occupancy	100	
22	S~zone-1-40Office	bldg-stry-1	(no default)	Office Occupancy	100	
23	S~zone-1-3Restroom	bldg-stry-1	(no default)	Office Occupancy	100	
24	S~zone-1-39Office	bldg-stry-1	(no default)	Office Occupancy	100	
25	S~zone-1-38Office	bldg-stry-1	(no default)	Office Occupancy	100	
26	S~zone-1-37Office	bldg-stry-1	(no default)	Office Occupancy	100	

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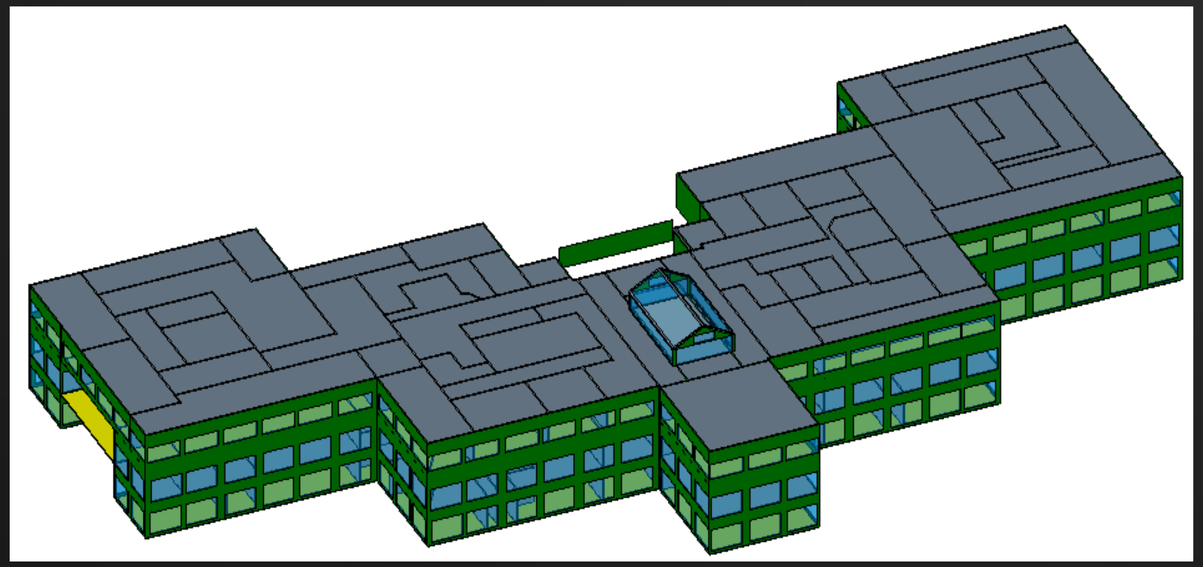
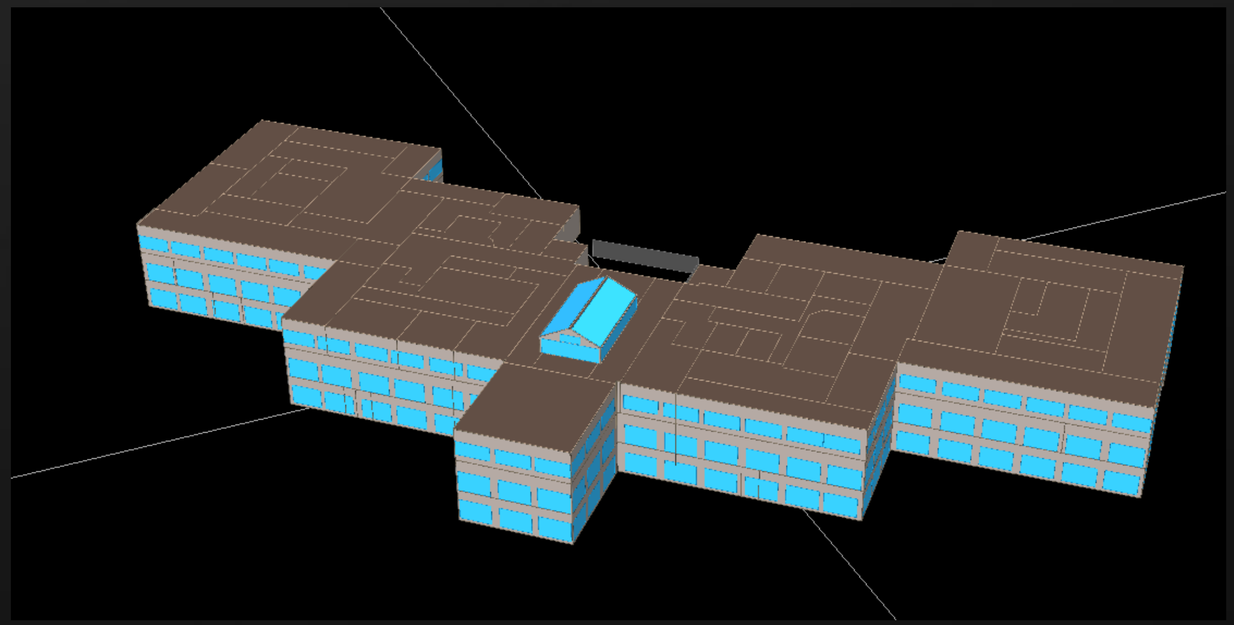
HVAC – Building Envelope





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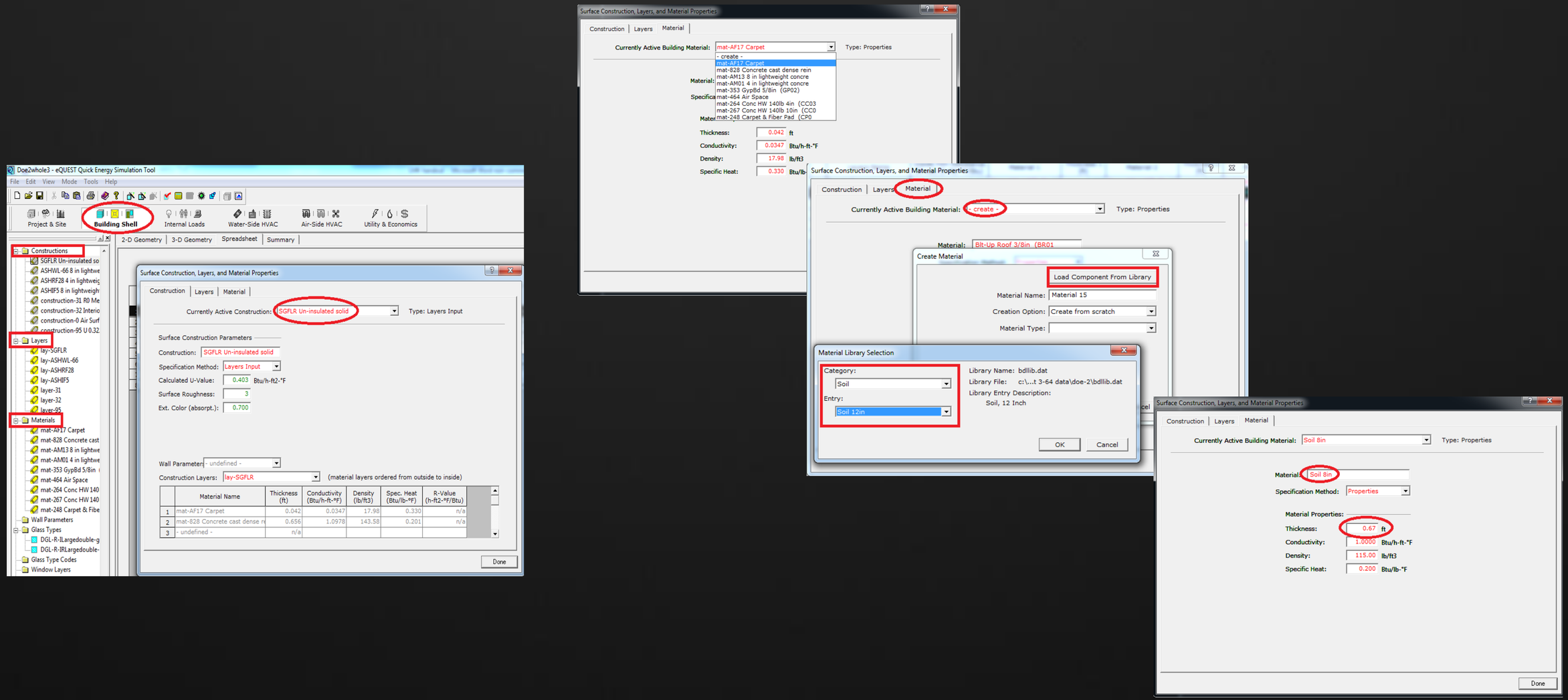
HVAC – Building Envelope



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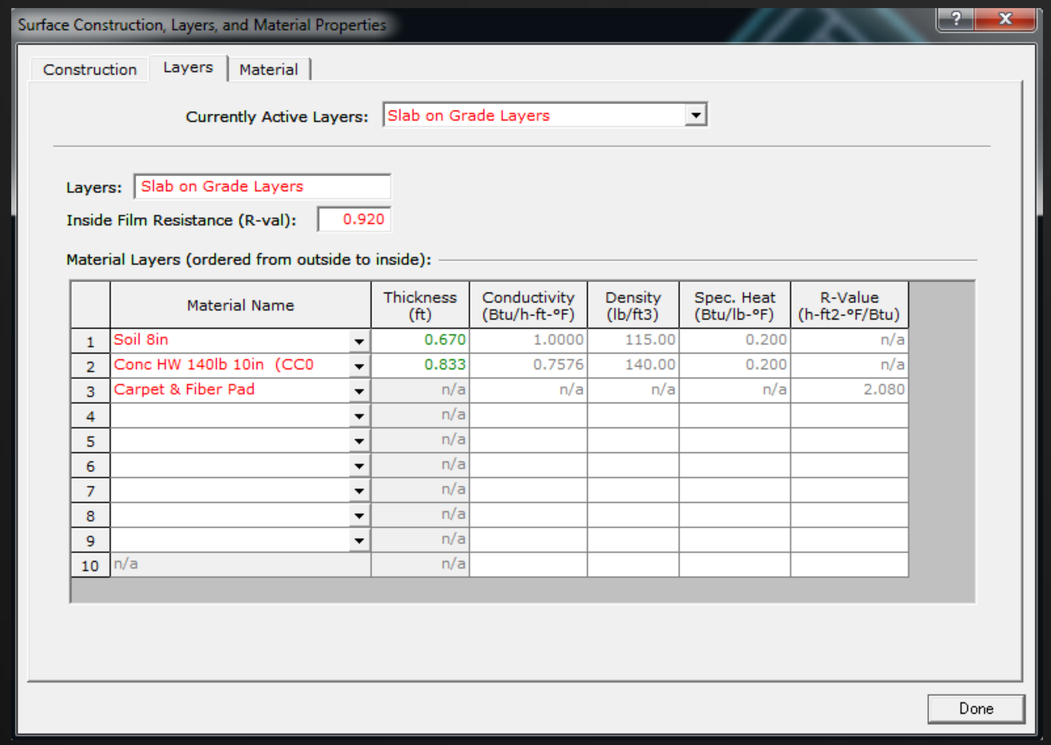
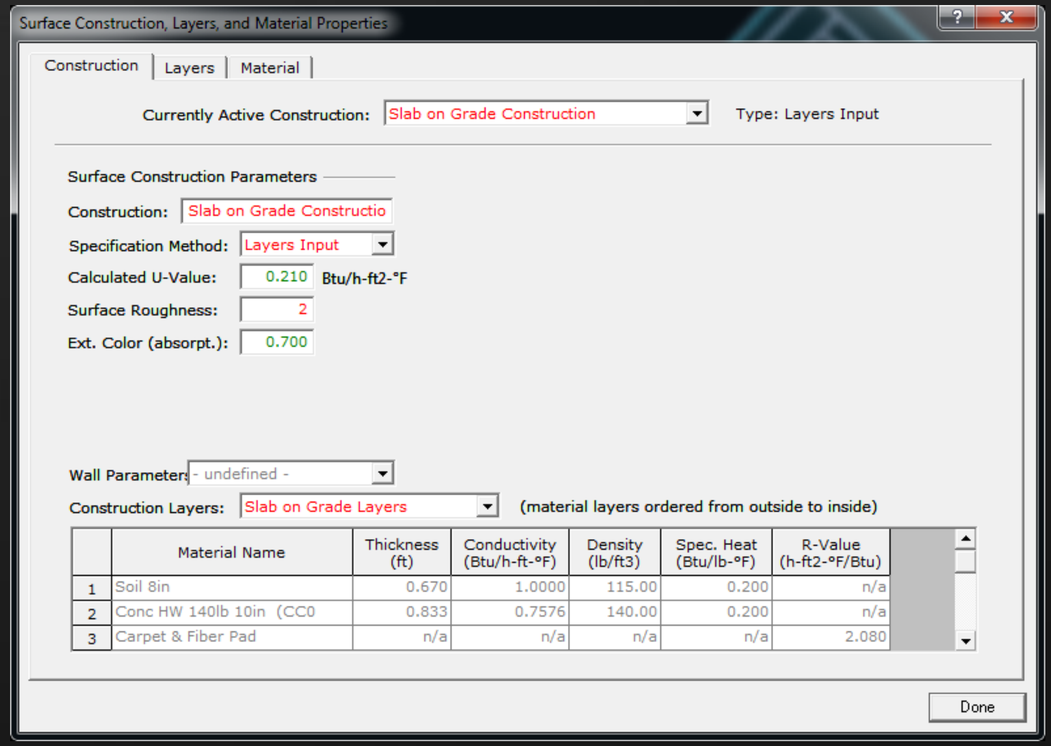
HVAC – Building Envelope





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HVAC – System & Components

Air-Side

- (4) 75 Ton Packaged Rooftop VAV Air Units
- (1) 15 Ton DX Unit
- (1) Heat Pump Unit

Water-Side

- (1) Hydronic Boiler
- (1) Domestic Hot Water Boiler

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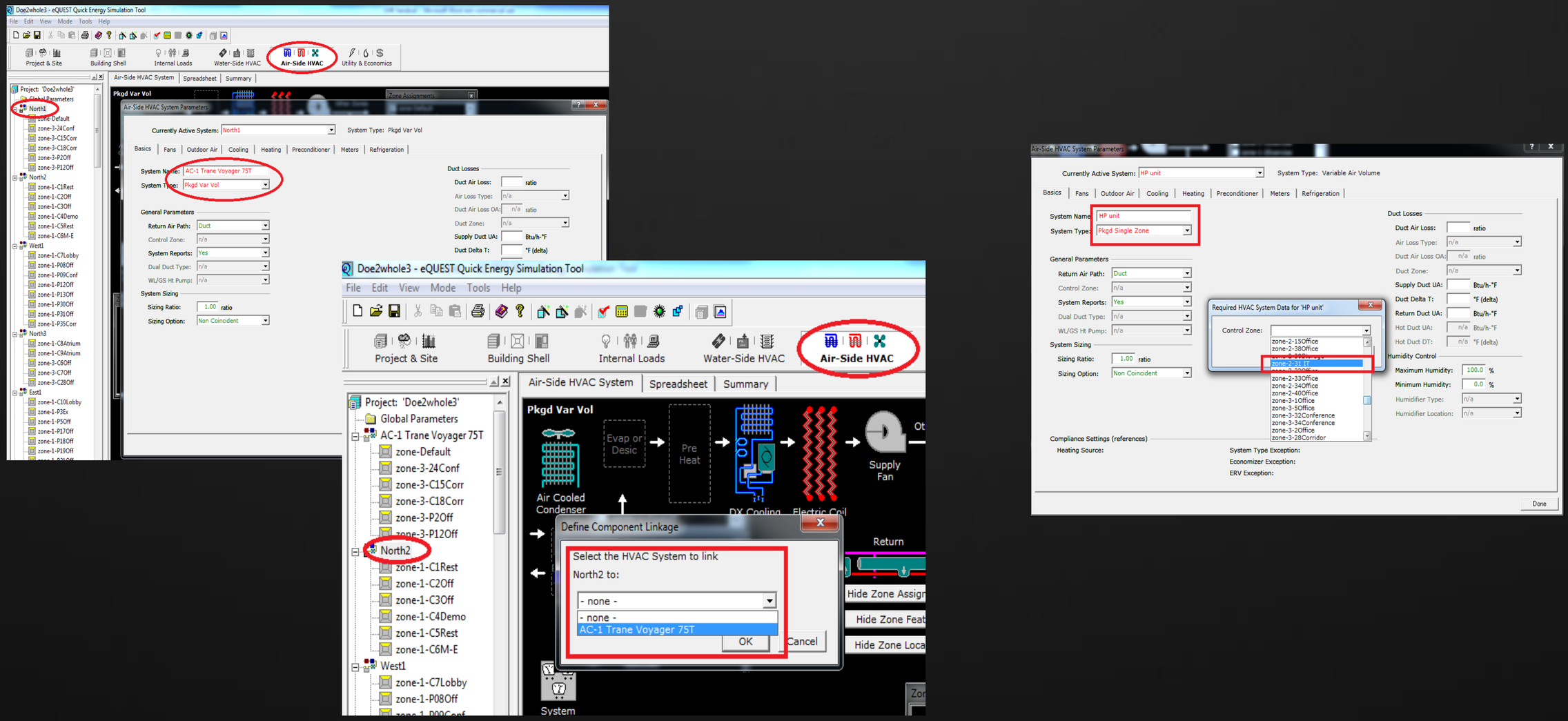
HVAC – Air-Side Components



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HVAC – Zoning

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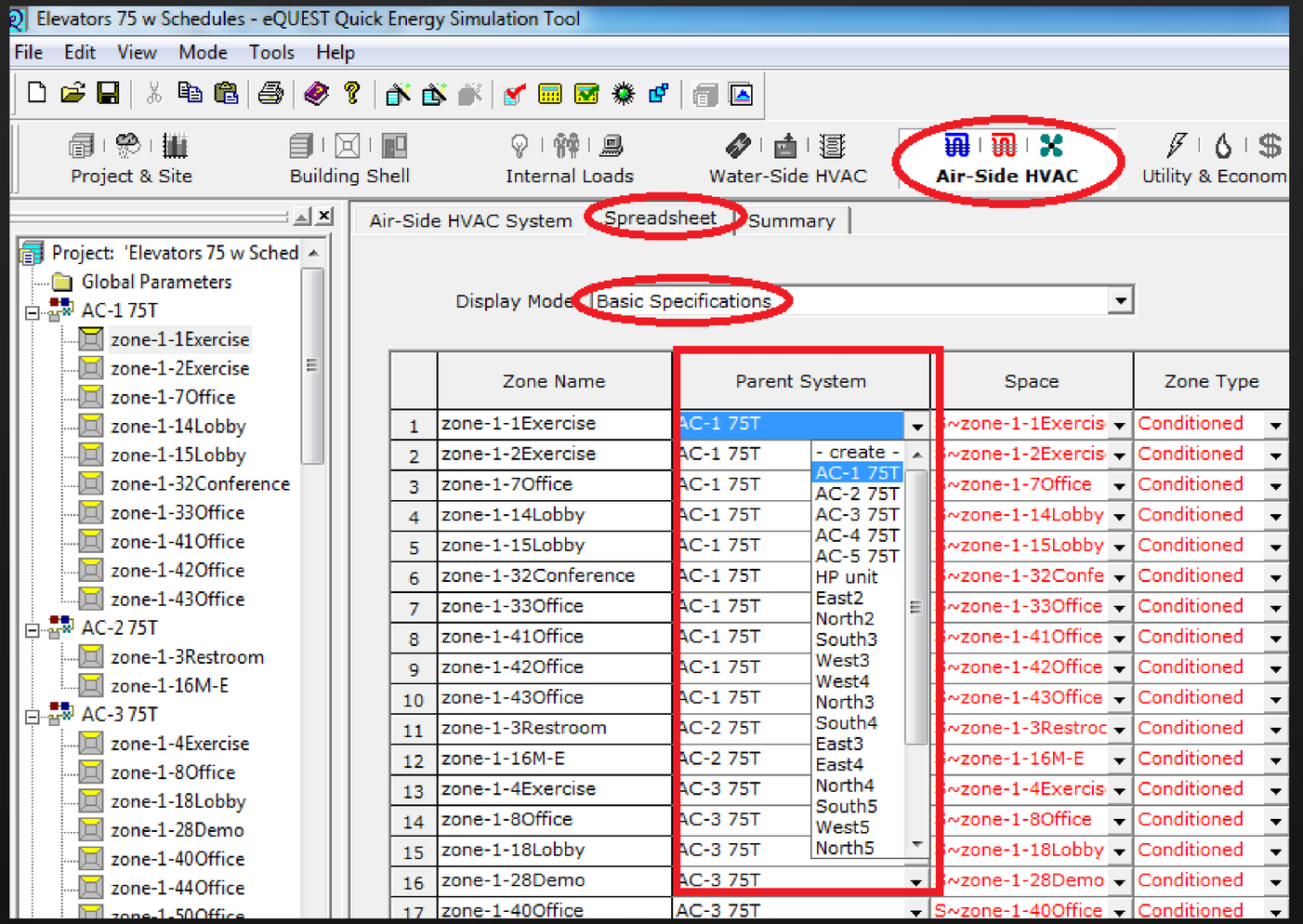
HVAC – Zoning



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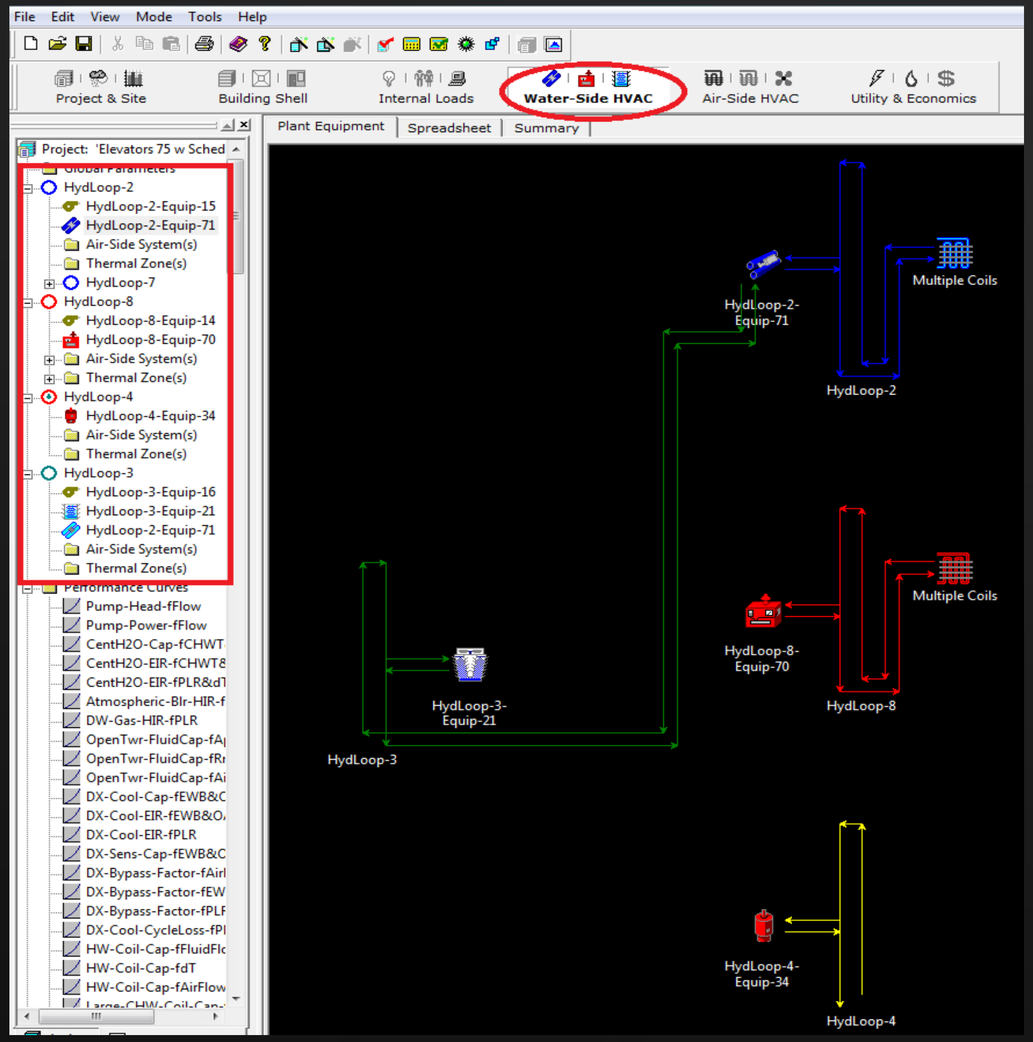
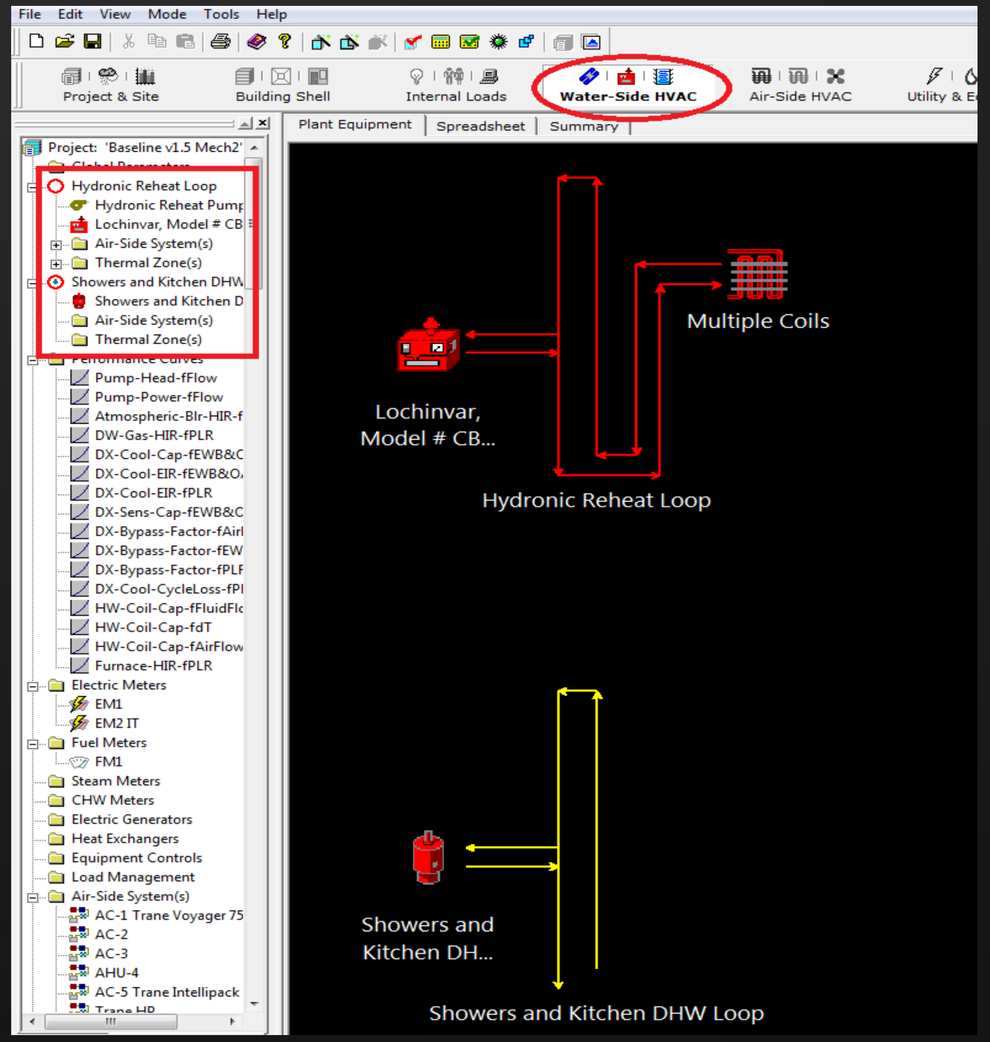
HVAC – Water-Side Components





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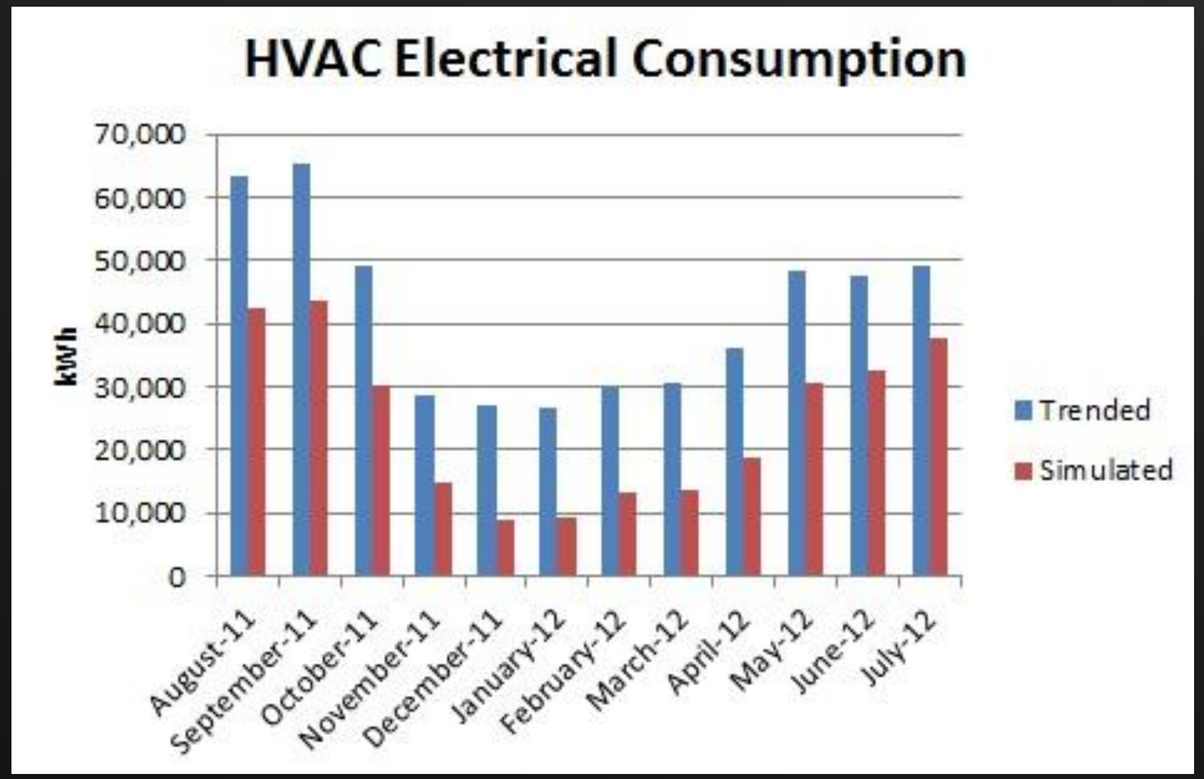
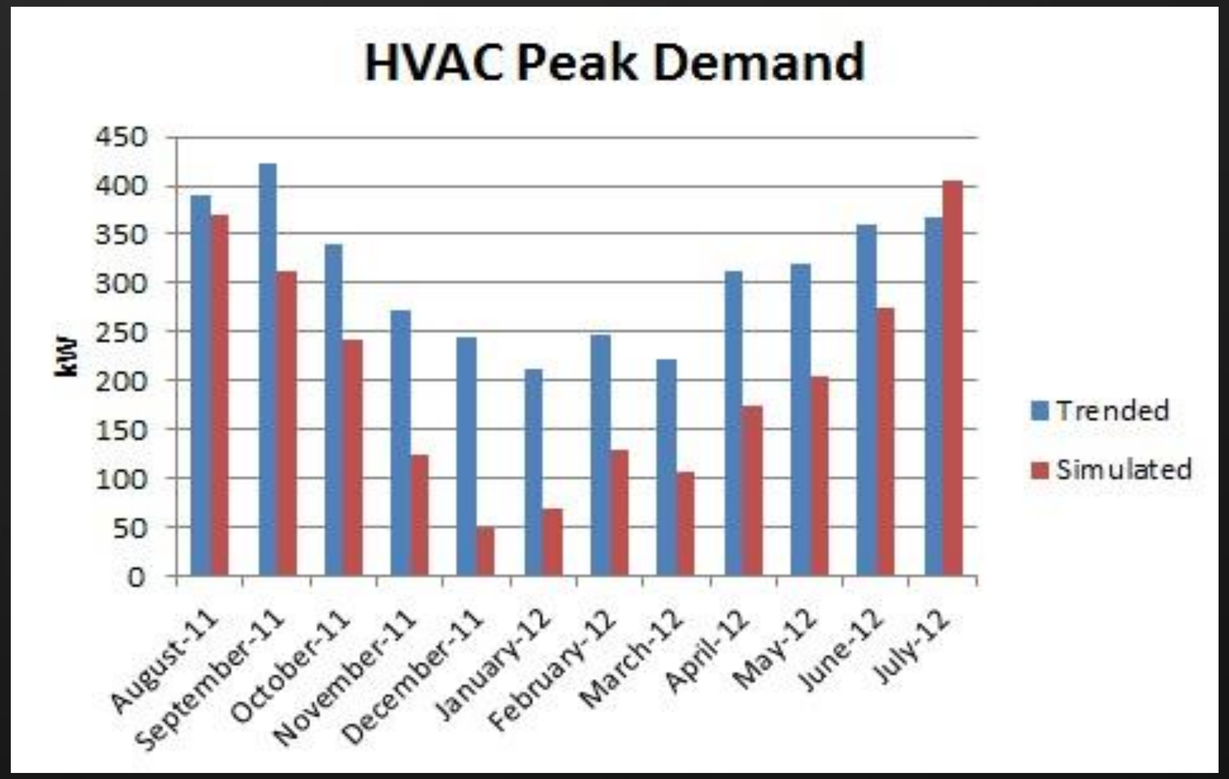
HVAC – Initial Comparison Charts





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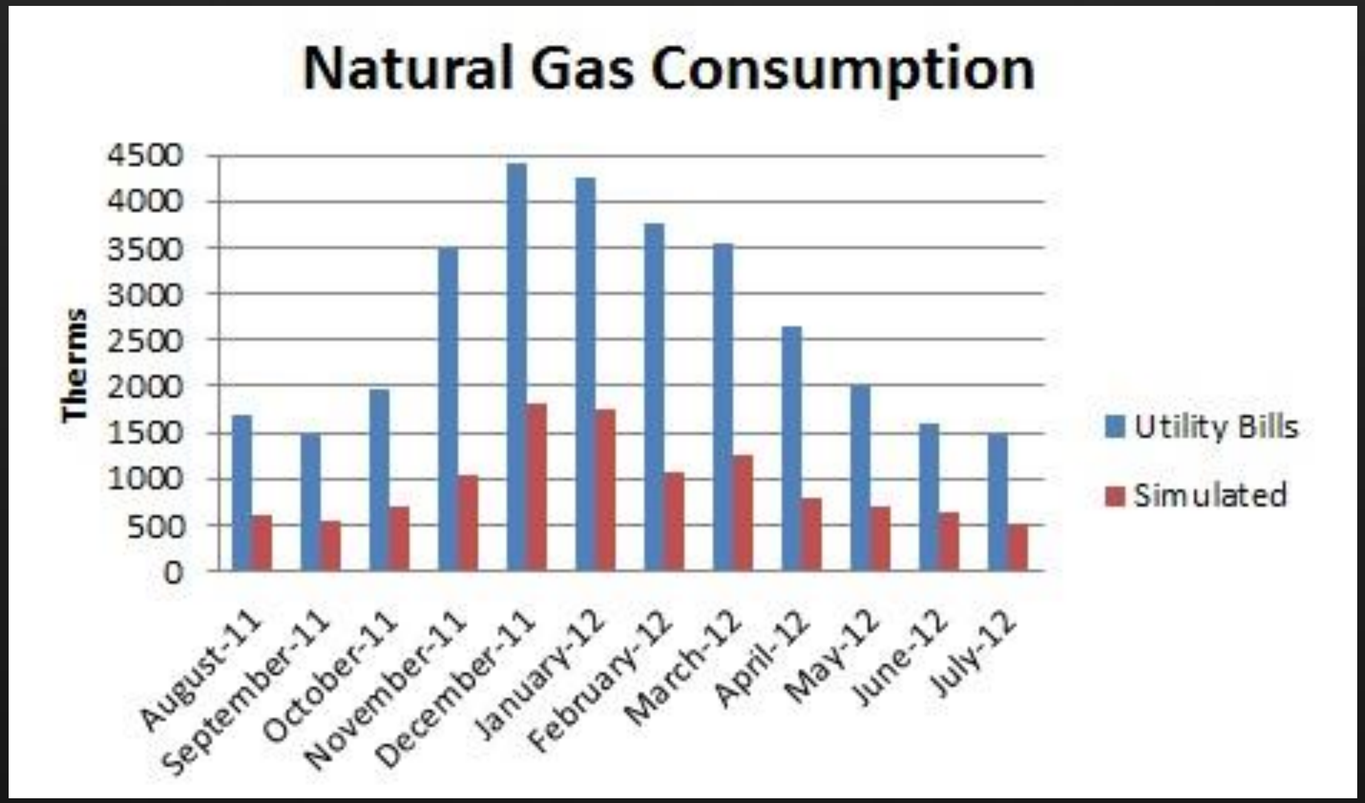
HVAC – Initial Comparison Charts



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HVAC – Calibration

Within the HVAC system, you can make modifications to:

- Heating/Cooling Schedules
- Heating/Cooling Temperature Setpoints
- Equipment Efficiencies
- Infiltration Quantity/Schedules
- Economizer Function/Outdoor Air Fraction
- DHW Flow

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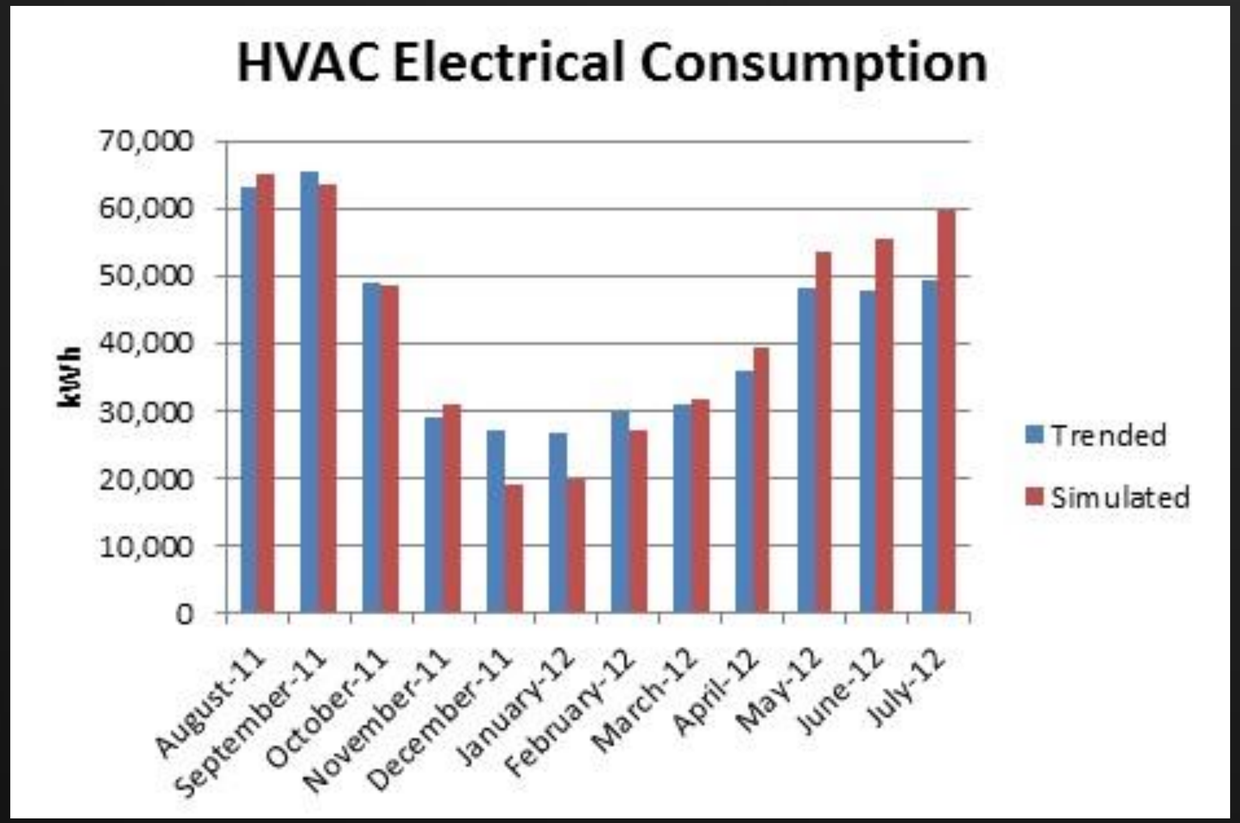
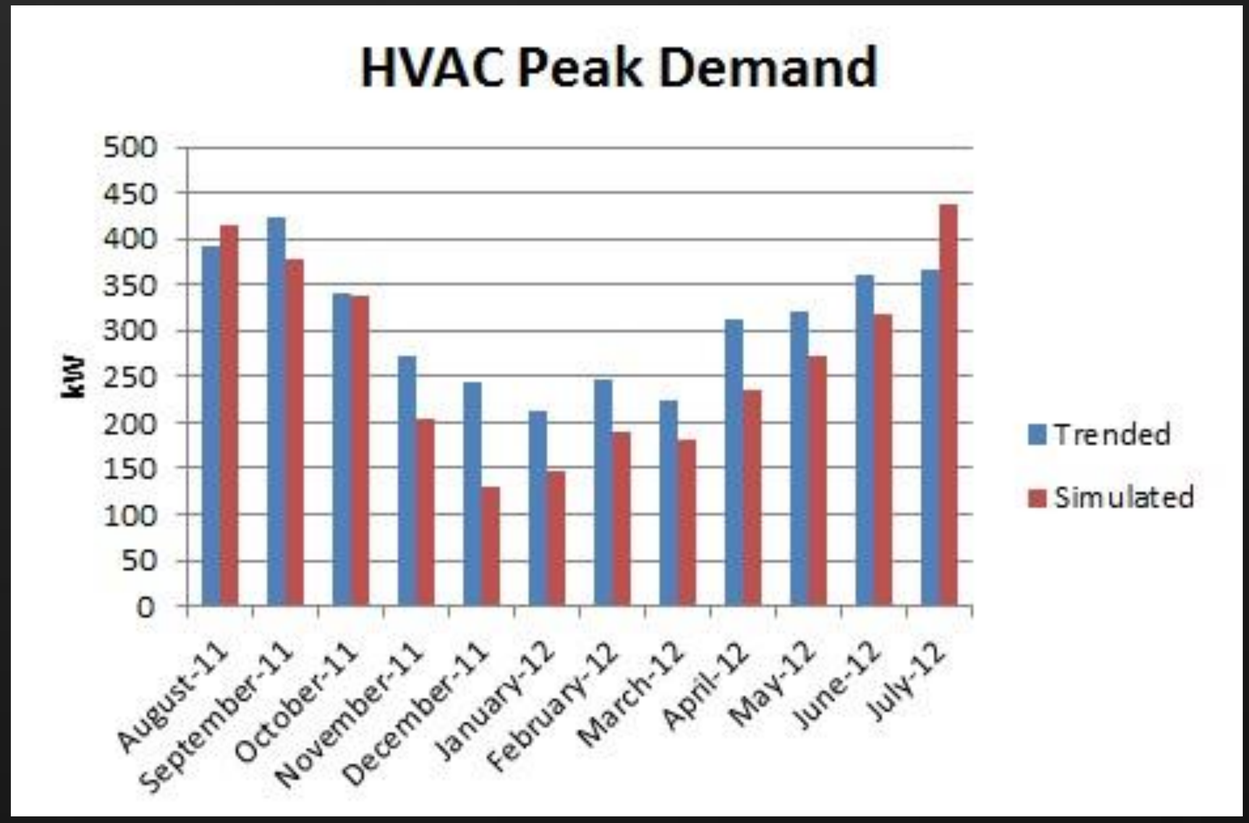
HVAC – Final Comparison Charts





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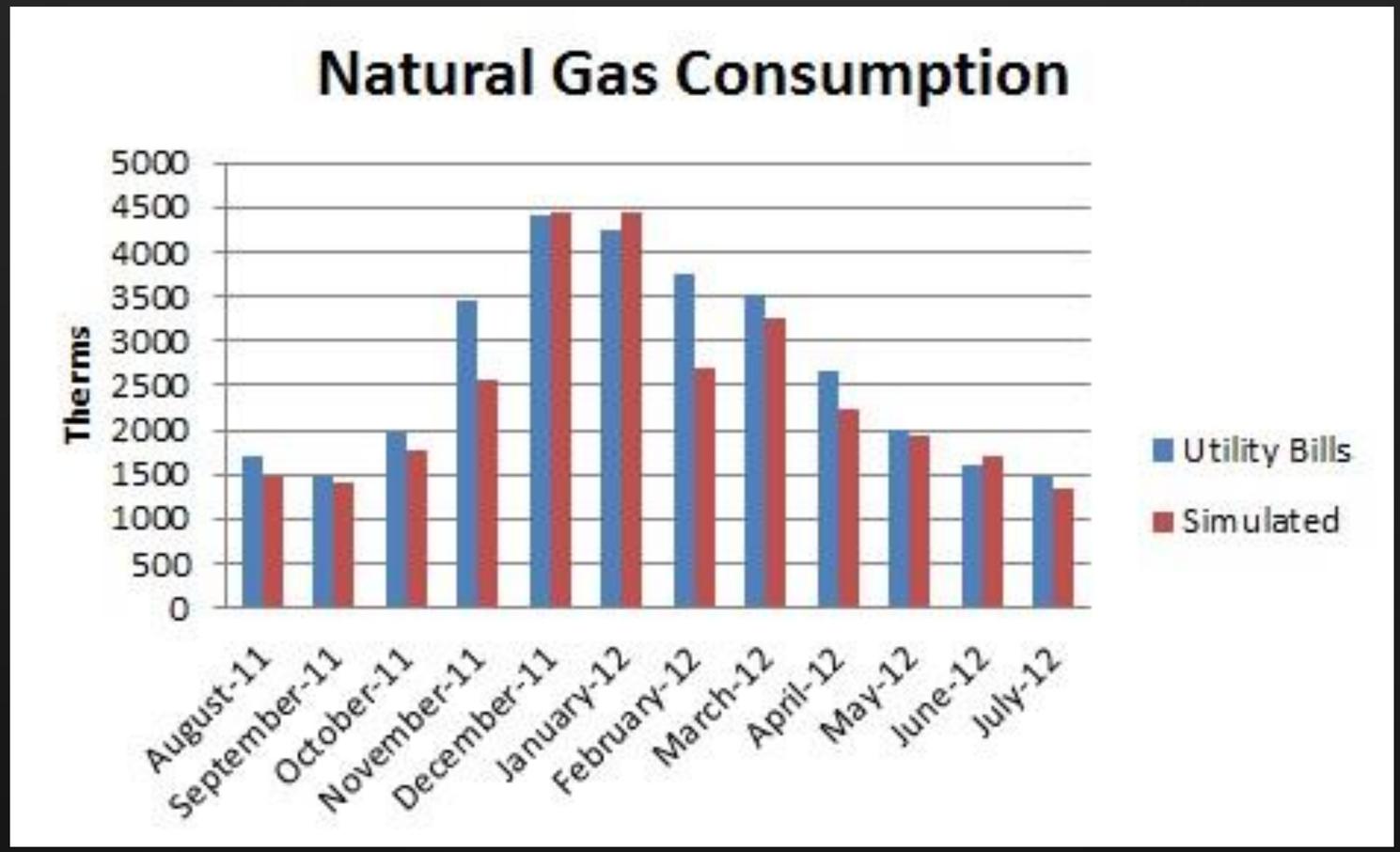
HVAC – Final Comparison Charts



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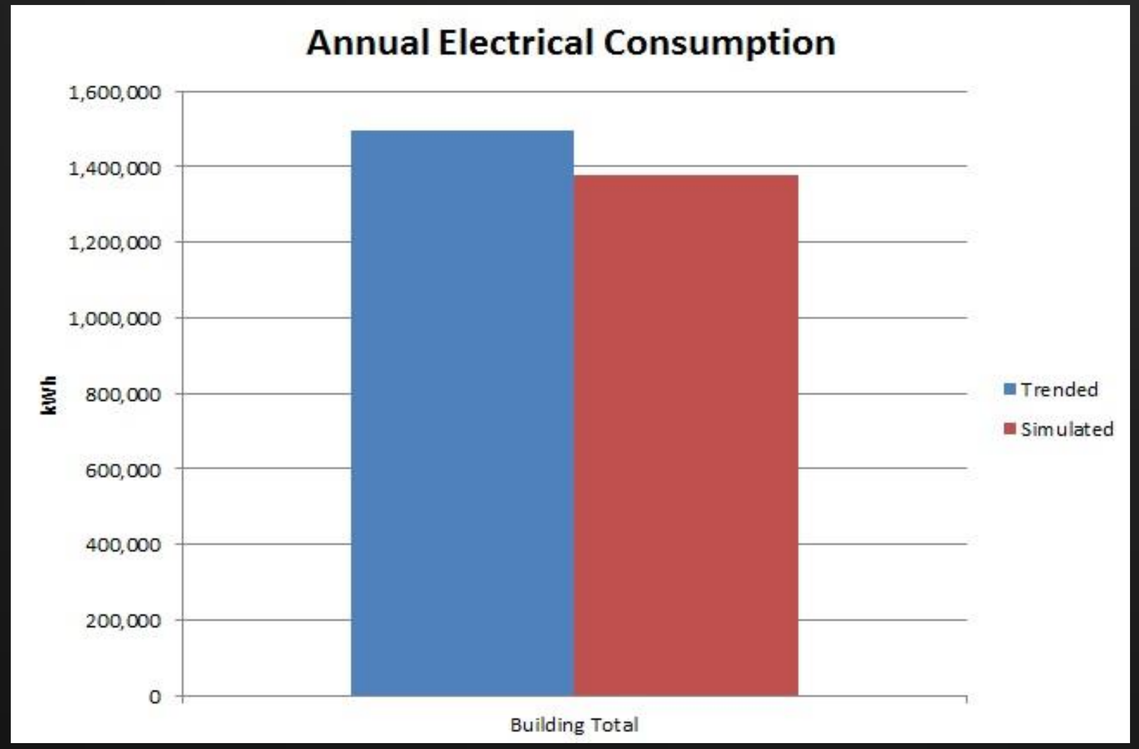
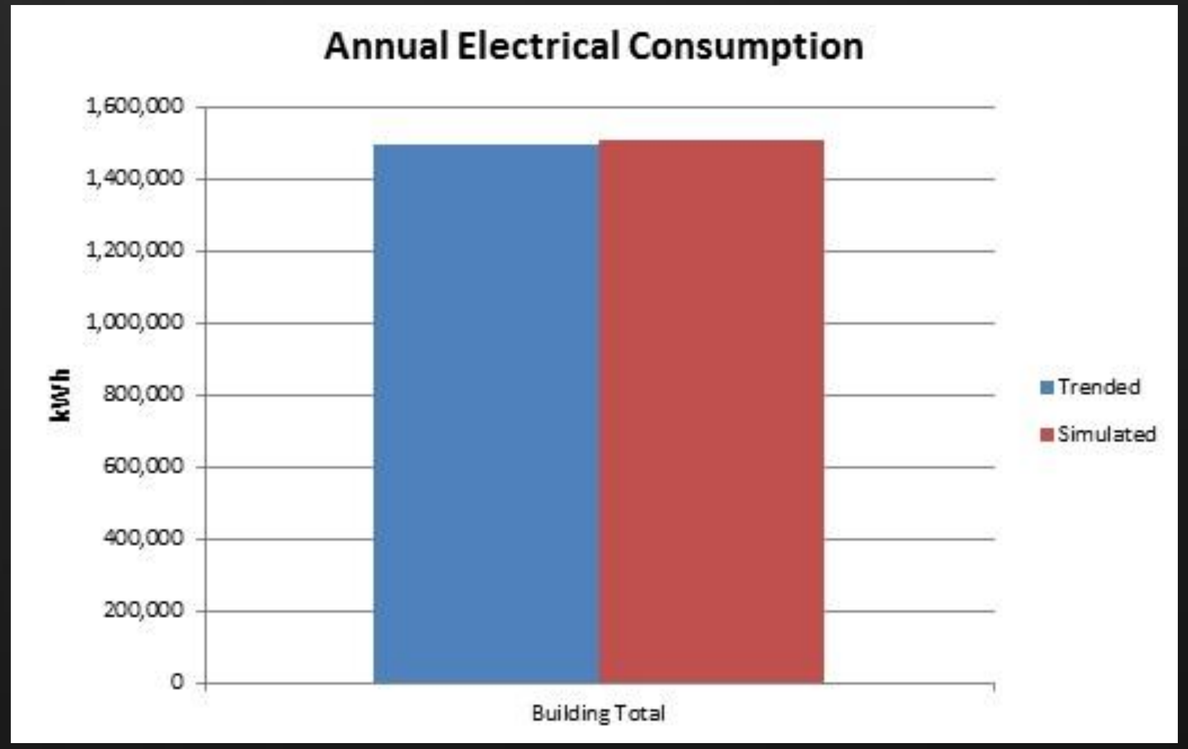
Final Results – Total Building Consumption





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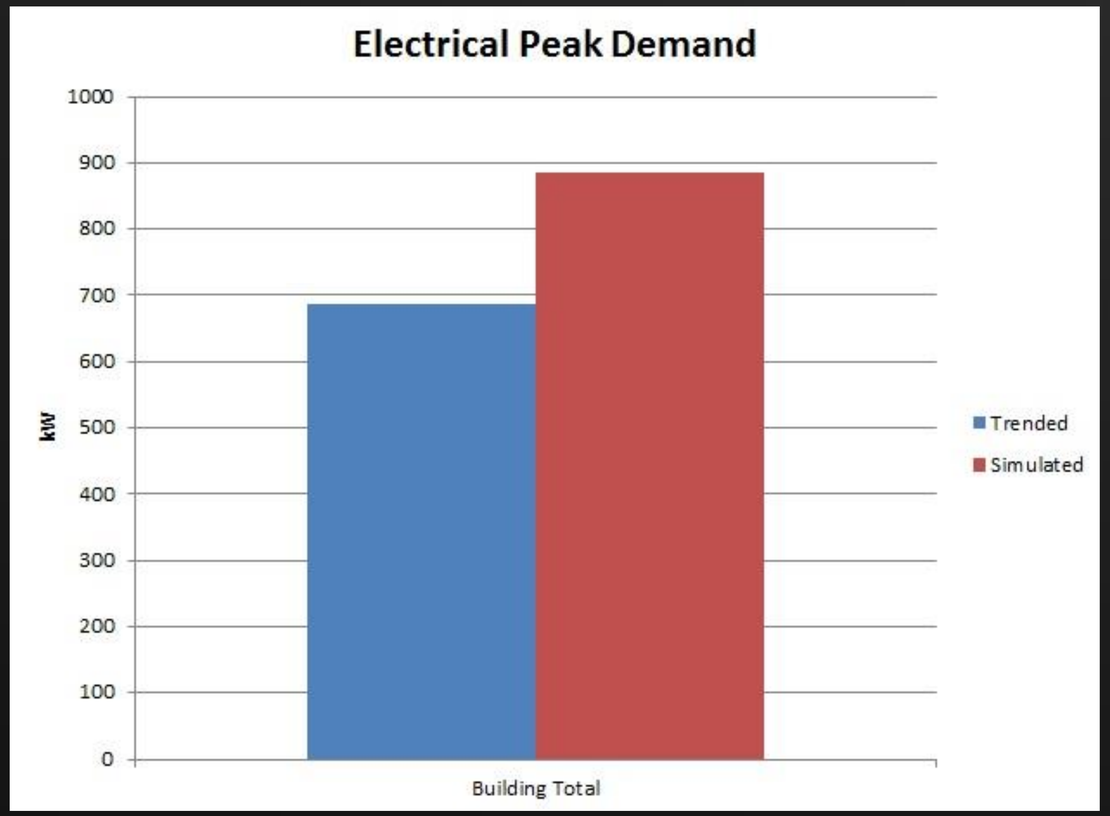
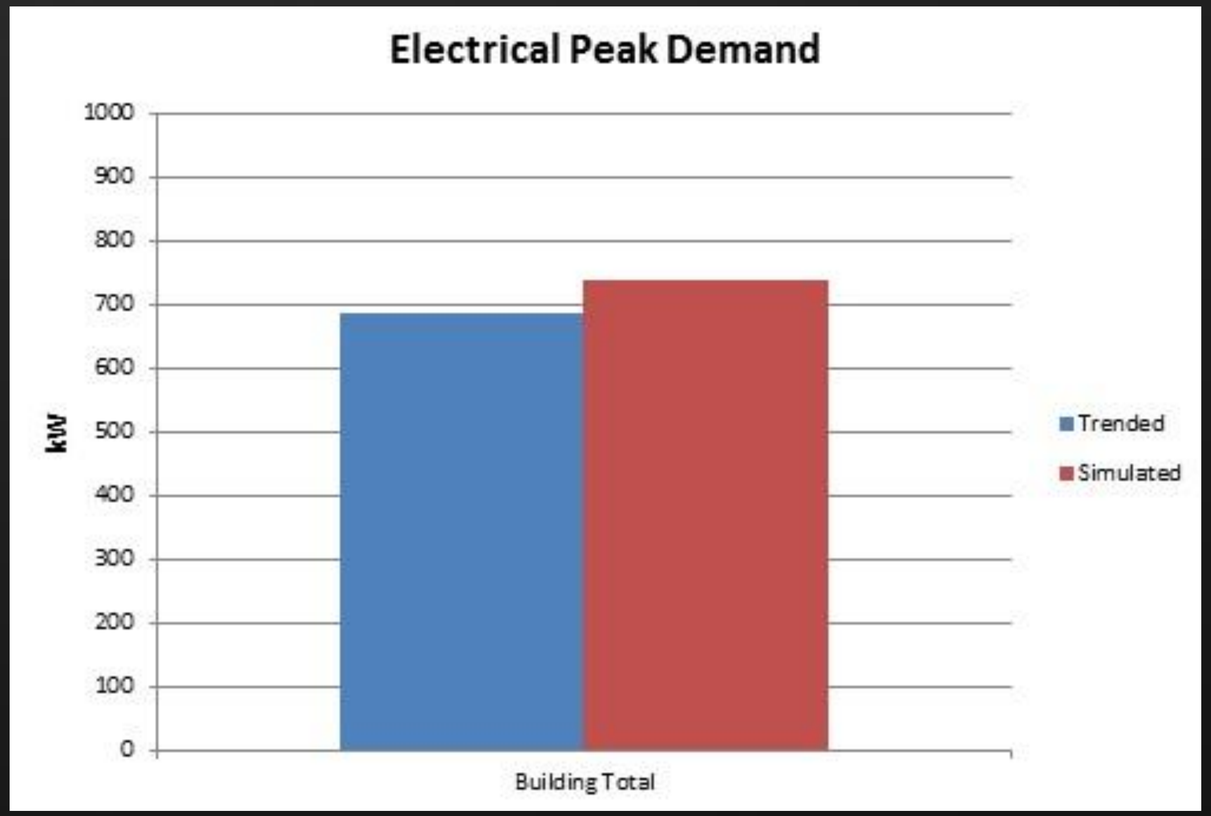
Final Results – Total Building Peak





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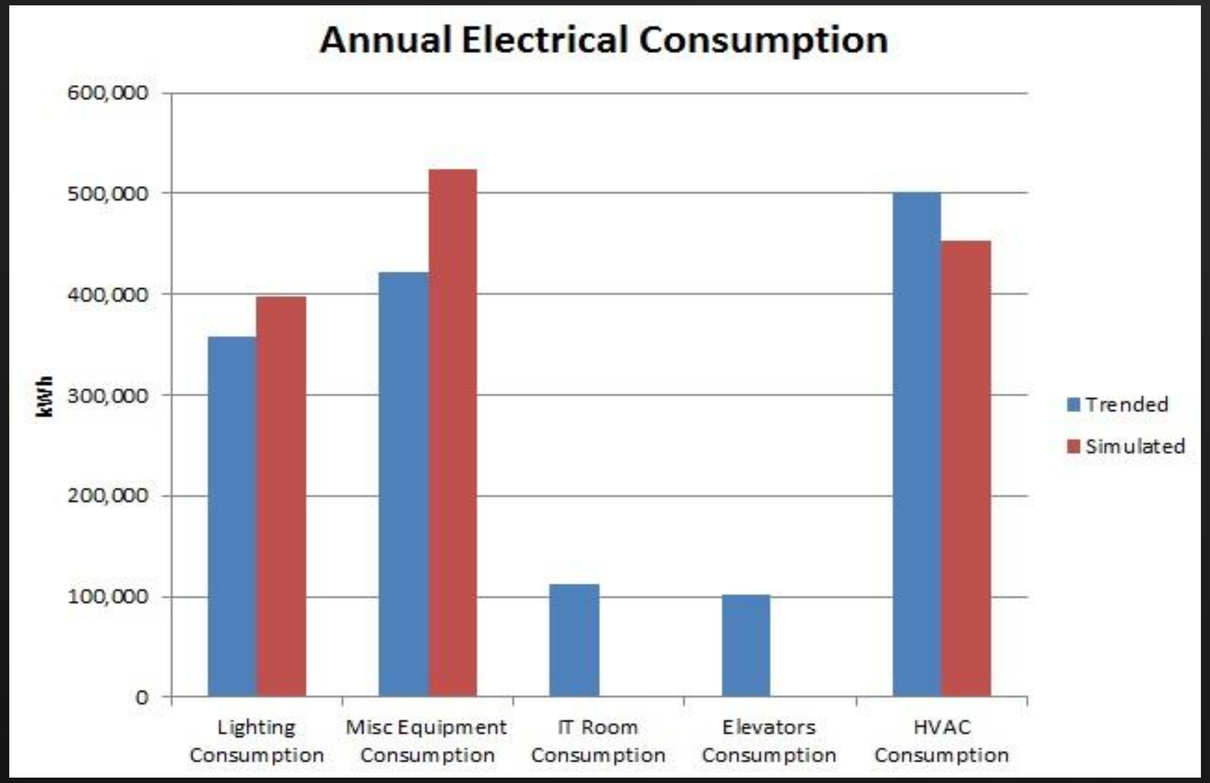
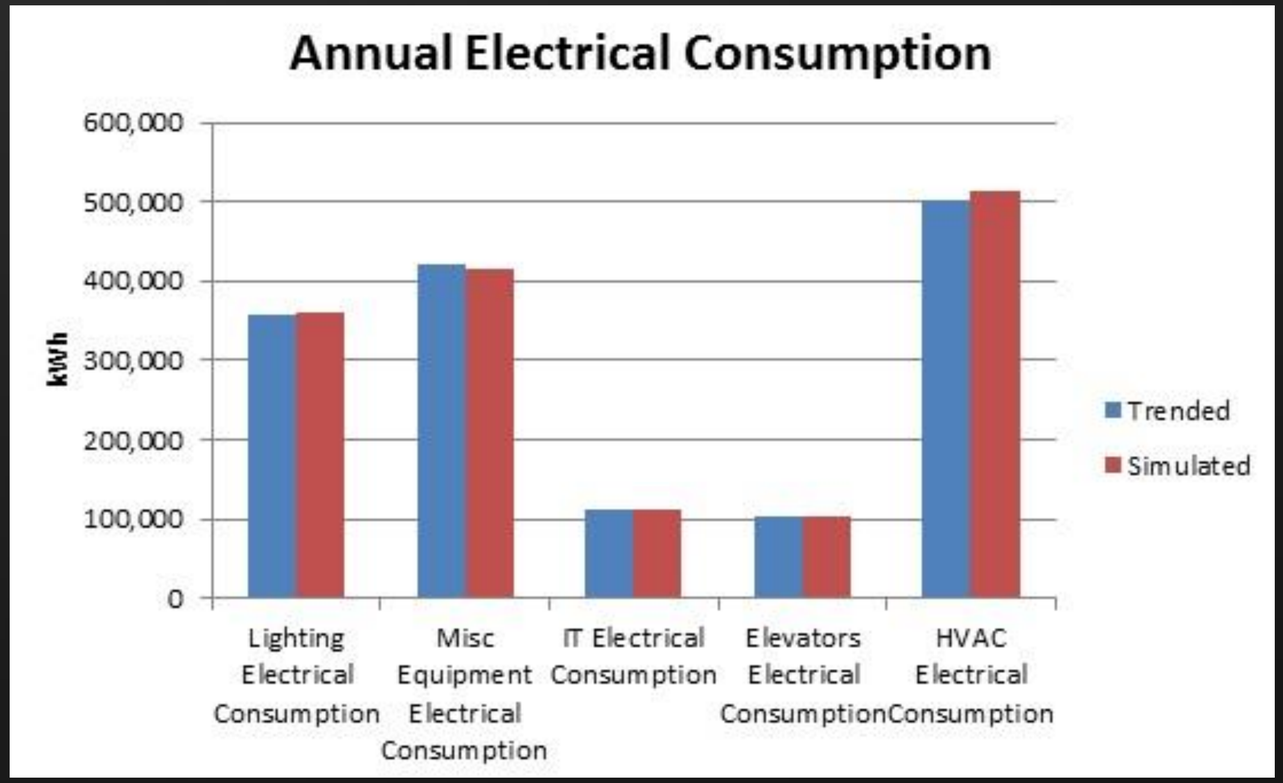
Final Results – End Use Electrical Consumption





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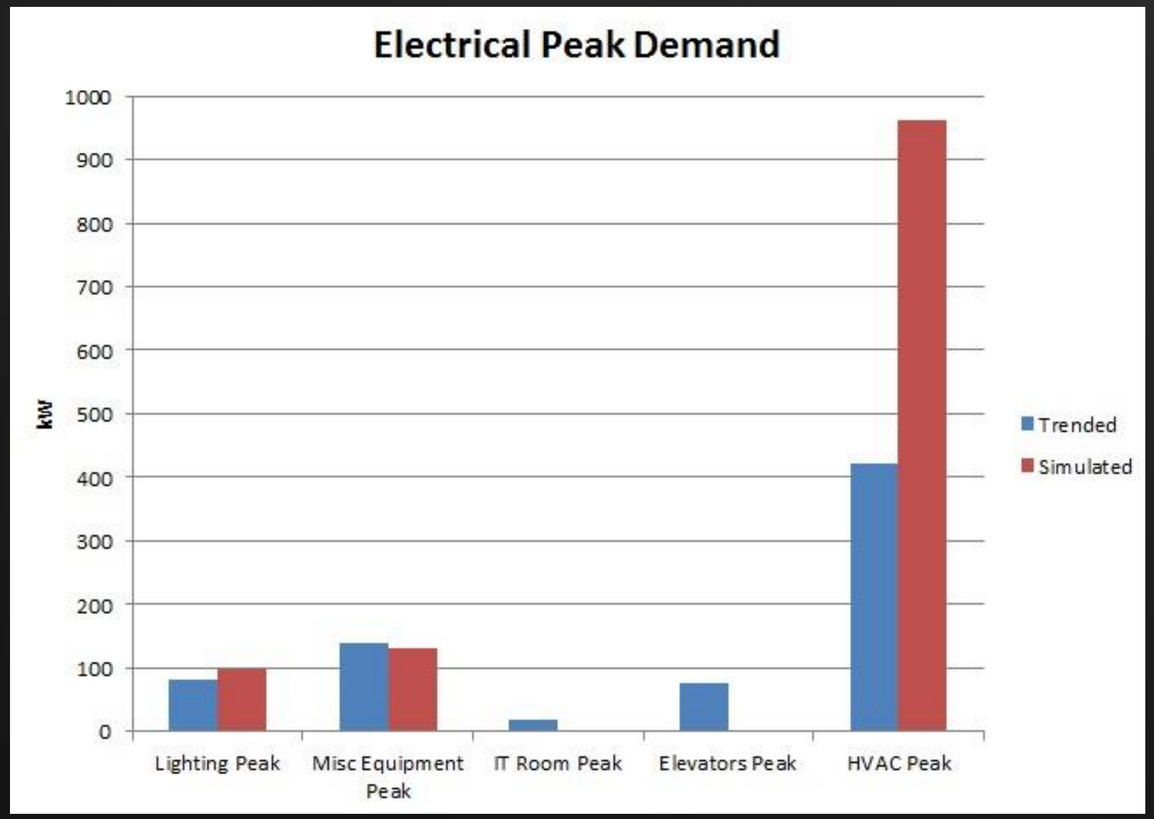
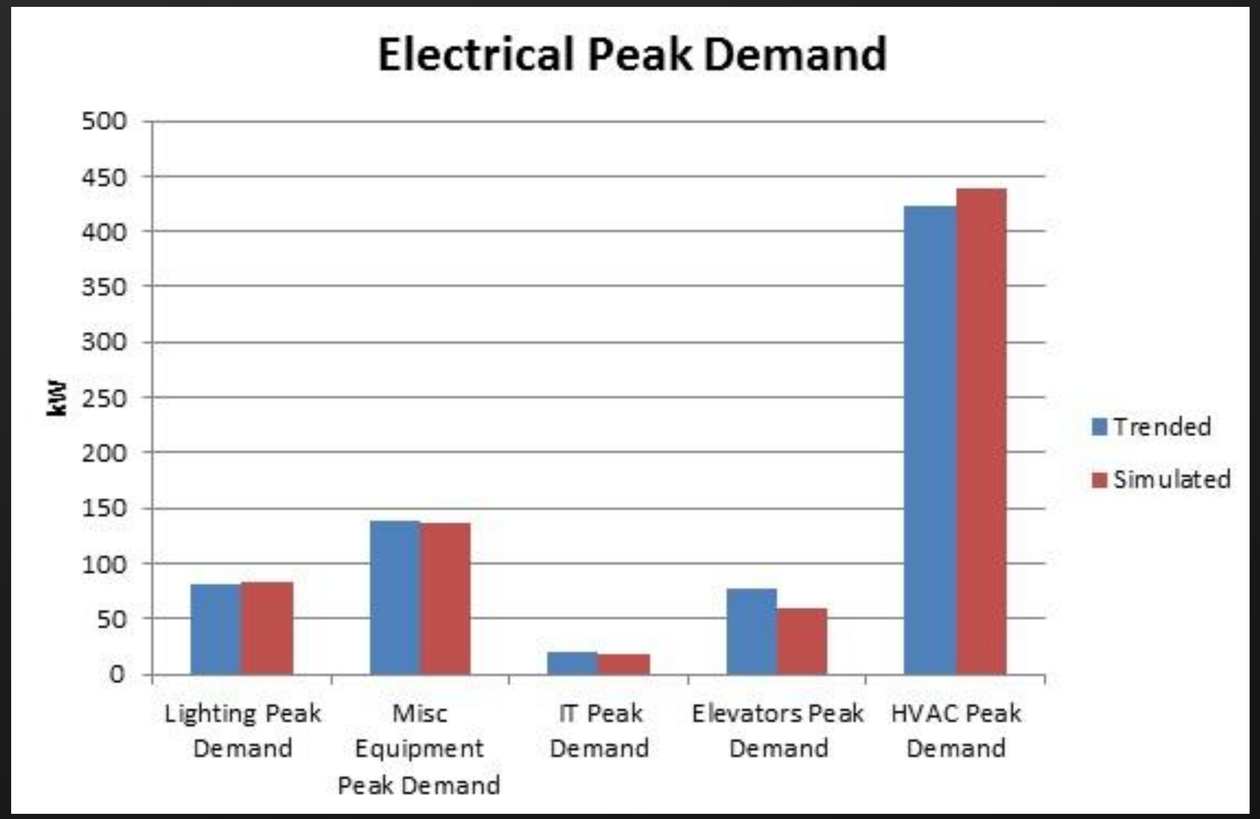
Final Results – End-Use Electrical Peak Demand





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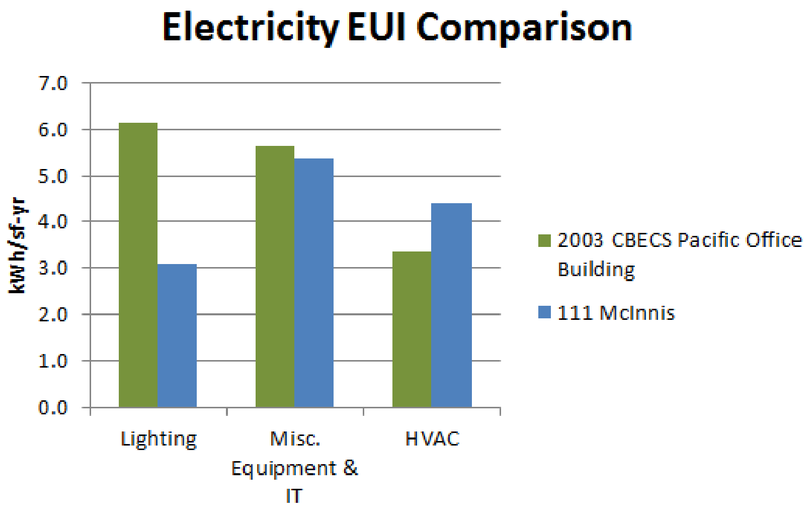
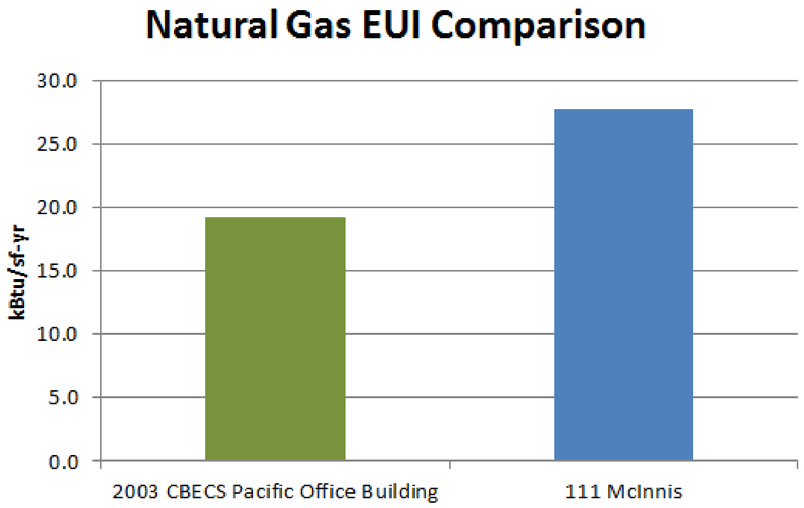
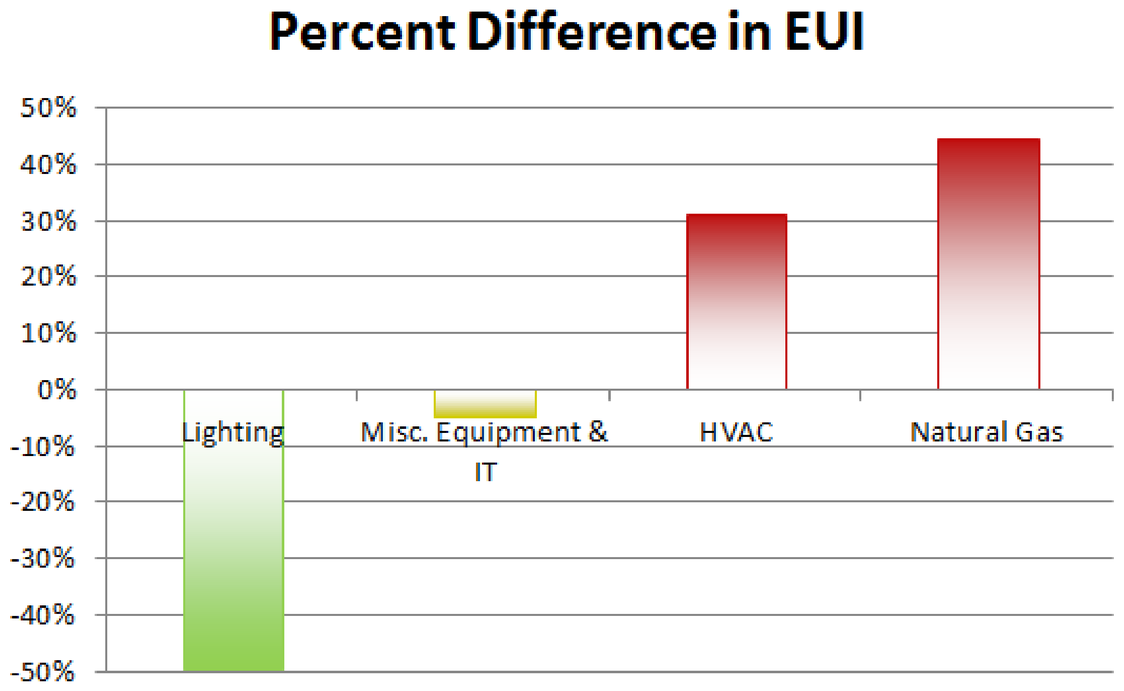
Comparing Building Energy Use to CBECS Surveyed Data







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ECM Recommendations

- Investigate window improvements to reduce thermal losses during high utility tariff rate time periods
- Install a combination of solar panels, better insulation and/or a cool roofing system when the current roof reaches its end of life
- Retro-commission the HVAC system
- Retro-commission or replace the IT HVAC system
- Implement a program to encourage employees to put their computers to sleep after hours
- Investigate the necessity other miscellaneous equipment being left on after hours
- Reduce exterior lighting by using more efficient lighting, occupancy sensors, and control strategies
- Evaluate the size and efficiency of the commercial kitchen equipment

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