AABC Commissioning Group

AIA Provider Number 50111116

Energy Modeling as a Tool for Retrocommissioning

Course Number: CXENERGY1714

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NV5 - Sebesta

April 26, 2017

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Course Description

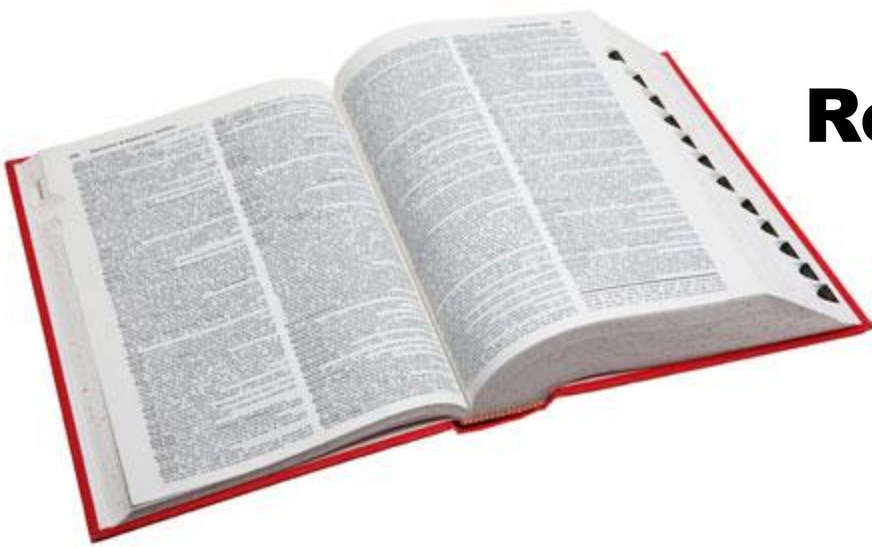
Energy modeling and retrocommissioning (RCx) can effectively share information to aid in building investigations. The session provides an overview of the mechanics of energy modeling, specific energy model inputs that can be enhanced by RCx information, examples of how to include RCx findings in energy models, and discussion of the insights ged from an energy model that should be used in RCx, strategies to capitalize on synergies between the services.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understanding of an energy model.
2. Understand how an energy model can be utilized for existing building analysis.
3. Identify the increased value that can be captured by combining energy modeling and retrocommissioning.
4. Understand how to interpret model outputs in the context of known performance.

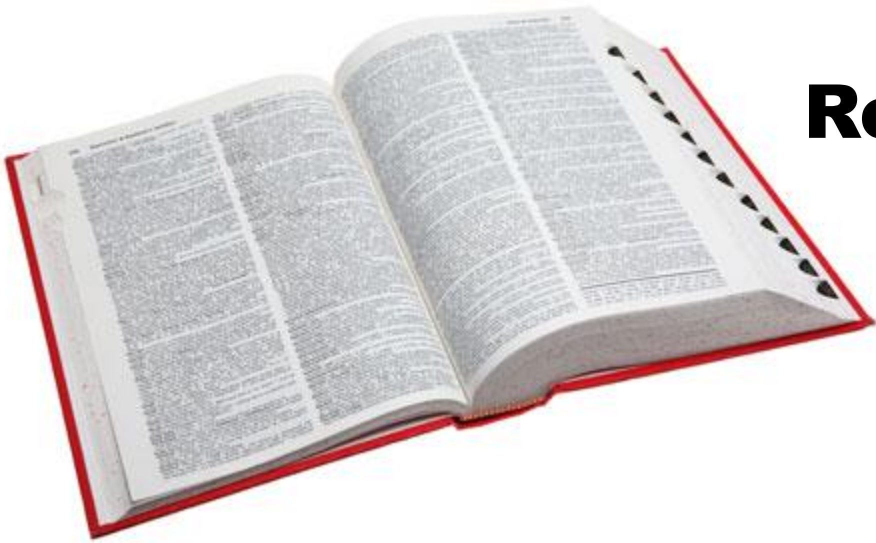
DEFINITIONS



Retro-Commissioning:

- ASHRAE: The Cx process applied to an existing facility that was not previously commissioned
- AABC (ACG): Purpose of RCx could be to diagnose the cause of ongoing, unresolved problems, or done as part of a maintenance program

DEFINITIONS



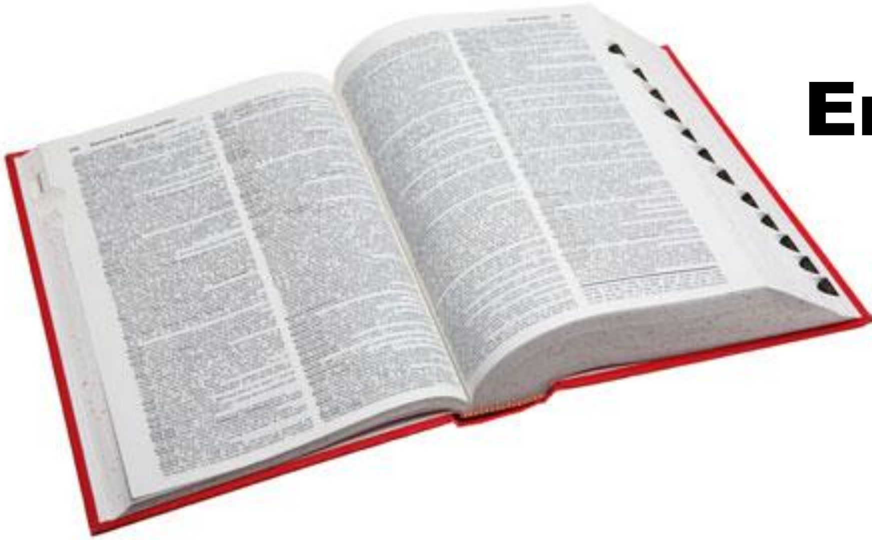
Retro-Commissioning:

Today's definition: Performance analysis of a building that has existed long enough to have useful energy use data

Retro-Commissioning:

- Existing drawing review
- Operator interviews
- Data loggers
- BAS system investigation
- Functional testing
- Trend data analysis
- Utility bill review

DEFINITIONS



Energy Modeling:

DoE definition: Physics-based software simulation of building energy use

AIA take on Energy Modeling:

"The energy model and focus on energy performance is not meant to supplant the importance of design. Rather, a building energy model is a tool that can be utilized throughout the design process to test various design options and optimize the performance of all building typologies."

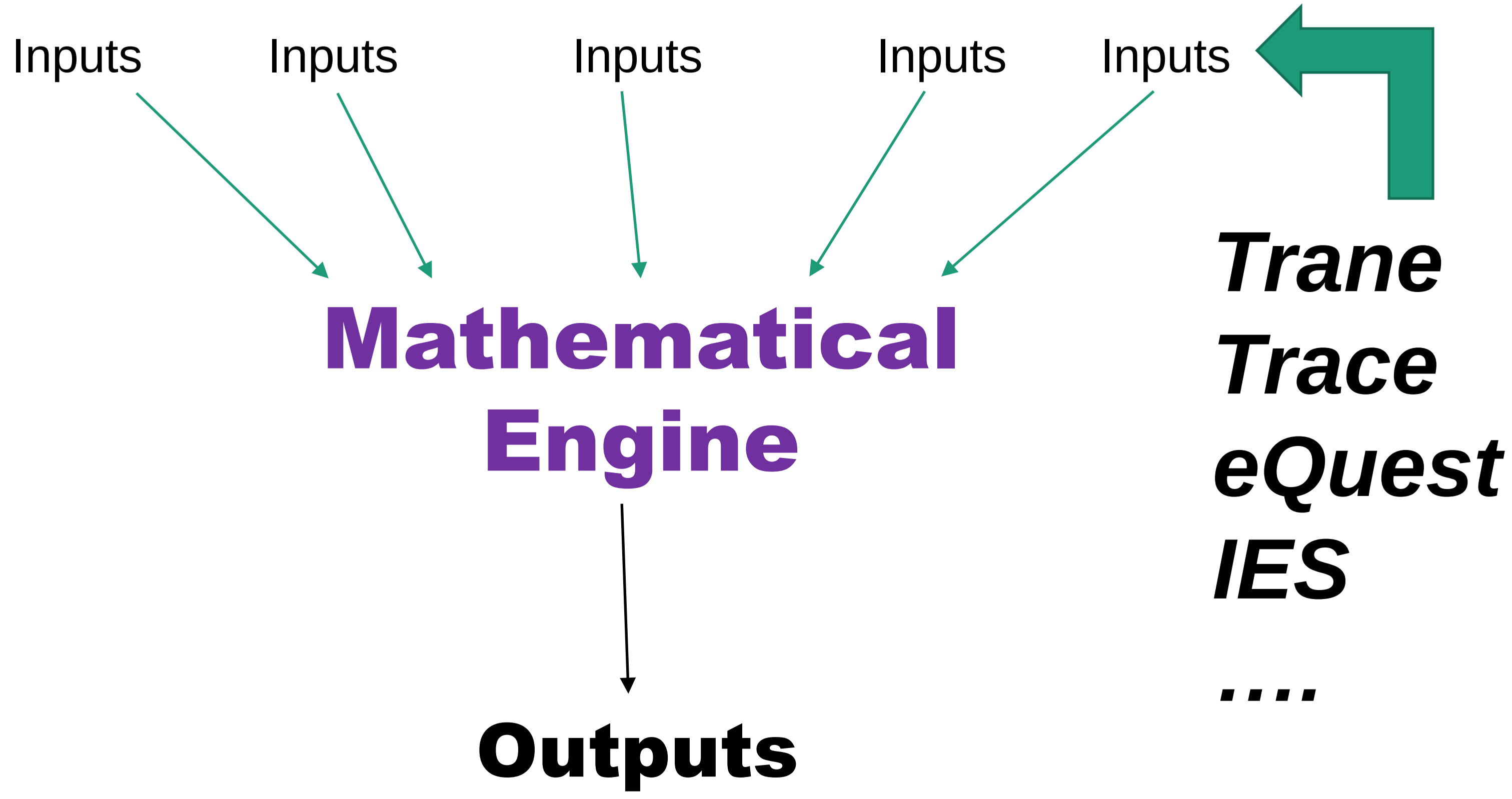
….

One key message of the guide is that architects needn't become technical experts on energy modeling or the myriad software tools currently available. However, a working understanding of the energy modeling process is needed to empower us to fold this necessary and valuable capability into our fundamentally integrative work"

Inputs Inputs Inputs Inputs Inputs

Mathematical Engine

Outputs


Inputs
Inputs
Inputs
Inputs
Inputs
Mathematical Engine
Outputs
Trane
Trace
eQuest
IES
….

Weather data – including temp, humidity, wind for up to 8760 data points/year

Occupancy schedules
Lighting schedules
Occupant density
Occupant activity

Inputs Inputs Inputs Inputs Inputs

Efficiency
Sequencing
Auxillary equipment
Pump characteristics

Mathematical Engine

Building dimensions
wall construction
Roof construction
Insulation values
Adjacent shading
Overhangs
Window performance
Thermal mass

Outputs

System design
Zoning
Fan characteristics
System losses
System schedules
OA requirements

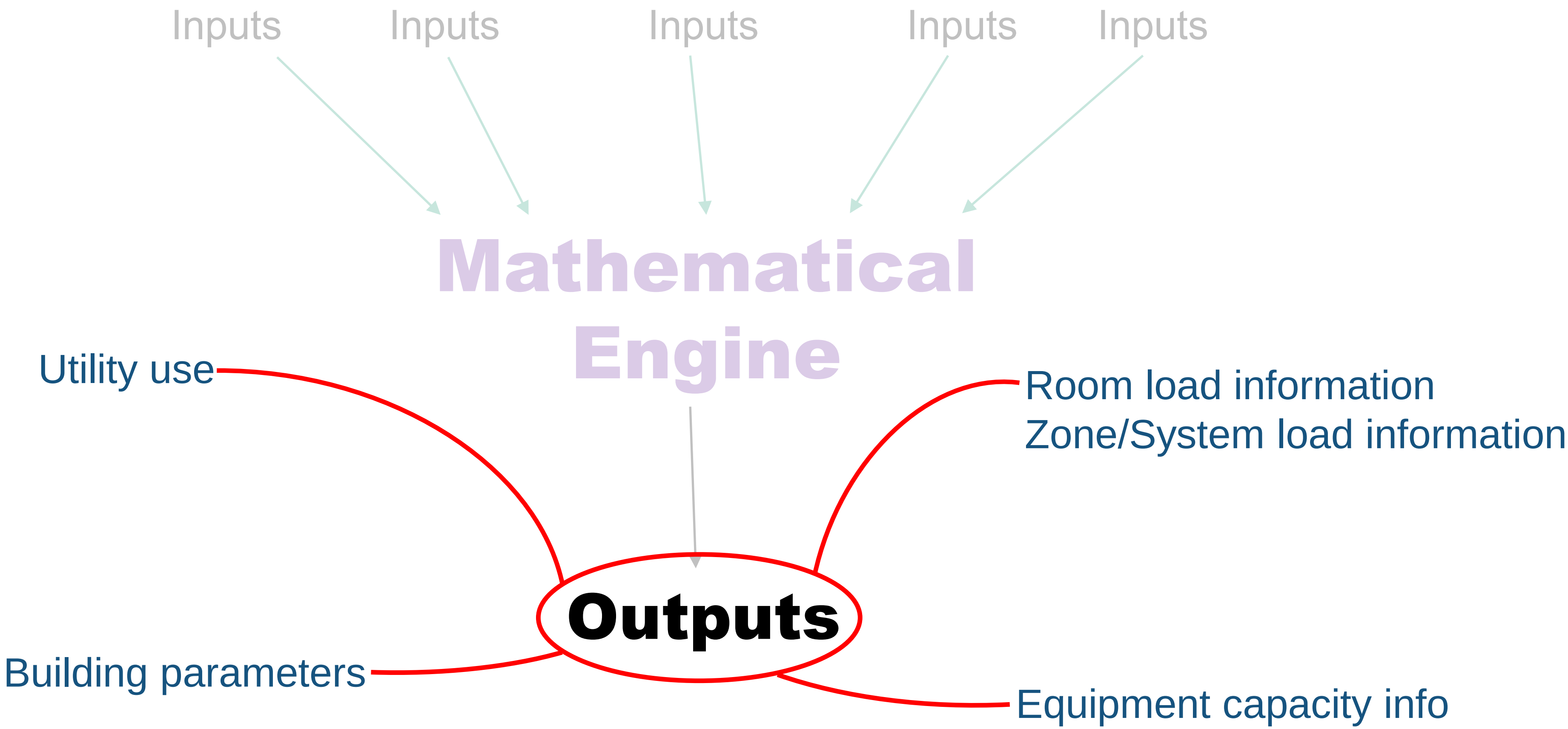
Inputs

Mathematical Engine

Outputs

Inputs

Mathematical Engine



Inputs
Inputs
Inputs
Inputs
Inputs
Mathematical Engine
Utility use
Room load information
Zone/System load information
Outputs
Building parameters
Equipment capacity info

Load Information

AHU 1 — **Variable Volume Reheat (30% Min Flow Default)**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 6 / 15; Outside Air: OADB/WB/HR: 88 / 84 / 173

Clg Space Peak — Mo/Hr: 6 / 17; OADB: 86

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	14,280	14,280	0	0	0
Glass Solar	334,637	0	334,637	11	358,771	30
Glass/Door Cond	92,584	0	92,584	3	91,166	8
Wall Cond	37,730	36,980	74,709	2	51,216	4
Partition/Door	-2,161		-2,161	0	-2,092	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	519,203		519,203	17	84,280	7
Sub Total ==>	981,992	51,259	1,033,252	34	583,341	48
Internal Loads						
Lights	235,502	58,876	294,378	10	235,502	20
People	231,500	0	231,500	8	115,750	10
Misc	202,391	0	202,391	7	202,391	17
Sub Total ==>	669,393	58,876	728,269	24	553,643	46
Ceiling Load	-62,771	62,771	0	0	-60,874	-5
Ventilation Load	0	0	803,281	27	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	148,438		148,438	5	127,519	11
Exhaust Heat		160,107	160,107	5		
Sup. Fan Heat			124,752	4		
Ret. Fan Heat		26,439	26,439	1		
Duct Heat Pkup		-275,863	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	1,737,052	83,589	3,024,537	100.00	1,203,630	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -15

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-33,253	1.26
Glass Solar	0	0	0.00
Glass/Door Cond	-561,872	-561,872	21.22
Wall Cond	-225,941	-393,289	14.85
Partition/Door	-22,208	-22,208	0.84
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-501,453	-501,453	18.94
Sub Total ==>	-1,311,475	-1,512,076	57.11
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-64,634	0	0.00
Ventilation Load	0	-777,121	29.35
Adj Air Trans Heat	0		0
Ov/Undr Sizing	-189,432	-189,432	7.15
Exhaust Heat		177,988	-6.72
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-346,950	13.10
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-1,565,540	-2,647,590	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.9	89.0
Ra Plenum	68.0	63.9
Return	68.3	63.9
Ret/OA	70.3	48.4
Fn MtrTD	0.1	0.0
Fn BldTD	0.3	0.0
Fn Frict	0.9	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	68,484	64,594
Terminal	76,094	71,771
Main Fan	84,549	80,226
Sec Fan	0	0
Nom Vent	6,945	6,945
AHU Vent	8,574	8,574
Infil	5,533	5,533
MinStop/Rh	64,594	64,594
Return	89,538	85,216
Exhaust	13,563	13,564
Rm Exh	543	543
Auxiliary	0	0
Leakage Dwn	7,609	7,177
Leakage Ups	8,455	8,455

ENGINEERING CKS

	Cooling	Heating
% OA	10.1	10.8
cfm/ft²	1.70	1.61
cfm/ton	335.45	
ft²/ton	196.81	
Btu/hr·ft²	60.97	-67.51
No. People	463	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	252.0	3,024.5	1,727.8	84,207	70.3	60.3	63.8	51.6	46.9	41.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	252.0	3,024.5								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	49,606		
Part	1,435		
Int Door	0		
ExFlr	0		
Roof	6,400	0	0
Wall	19,492	6,563	34
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-2,726.0	64,594	51.6	90.2
Aux Htg	0.0	0	0.0	0.0
Preheat	-623.1	8,574	-15.0	51.6
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-3,349.1			

Load Information

Add load profiles pictures

Outputs

TOWER ANALYSIS

By Sebesta Inc.

Alternative: 1

Plant / Tower Description	--- Maximum --- Temp	Mo	Hr	Day	--- Leaving Water Temperature Hours at each Temperature Range (°F) --- >100°	100-95	95-90	90-85	85-80	80-75	75-70	70-65	65-60	60-55	55-50	< 50°	Hours Off	--- Minimum --- Temp	Mo	Hr	Day
Air-cooled chiller - 04																					
90.1 Min Air Cooled Condenser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,760	0	0	0	0
Water-cooled chiller - 02																					
Cooling tower for Cent. Chillers	82	7	15	1	0	0	0	0	80	282	509	242	152	0	0	0	7,495	59	4	13	1
Water-cooled chiller - 03																					
90.1-10 Min CC Cooling Tower Axial Fan	87	7	16	1	0	0	0	60	386	496	83	0	0	0	0	0	7,735	71	8	10	10

Outputs

ENERGY CONSUMPTION SUMMARY

By Sebesta Inc.

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating		1,149,043		42.5 %	1,149,043	1,209,519
Other Htg Accessories	10,652			1.3 %	36,354	109,073
Heating Subtotal	**10,652**	**1,149,043**		**43.8 %**	**1,185,397**	**1,318,592**
Primary cooling						
Cooling Compressor	70,606			8.9 %	240,979	723,009
Tower/Cond Fans	14,770		243	1.9 %	50,412	151,250
Condenser Pump	4,912			0.6 %	16,766	50,303
Other Clg Accessories	4,689			0.6 %	16,005	48,020
Cooling Subtotal....	**94,978**		**243**	**12.0 %**	**324,162**	**972,582**
Auxiliary						
Supply Fans	111,798			14.1 %	381,568	1,144,818
Pumps	18,351			2.3 %	62,632	187,914
Stand-alone Base Utilities				0.0 %	0	0
Aux Subtotal....	130,149			16.4 %	444,200	1,332,732
Lighting						
Lighting	120,900			15.3 %	412,633	1,238,023
Receptacle						
Receptacles	99,029			12.5 %	337,984	1,014,054

Outputs

MONTHLY UTILITY COSTS

By Sebesta Inc.

Utility	Jan	Feb	Mar	Apr	------- May	Monthly Utility Costs June	July	------- Aug	Sept	Oct	Nov	Dec	Total
Alternative 1													
Electric													
On-Pk Cons. ($)	3,115	2,822	3,368	3,110	4,666	5,169	5,177	5,111	4,340	3,503	3,091	3,012	46,482
Gas													
On-Pk Cons. ($)	1,698	1,444	1,641	651	0	0	0	0	3	578	1,248	1,846	9,110
Monthly Total ($):	4,814	4,265	5,009	3,761	4,666	5,169	5,177	5,111	4,343	4,081	4,339	4,858	55,592

Building Area = 55,056 ft²
Utility Cost Per Area = 1.01 $/ft²

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 2 - 0° Rotation													
Electric													
On-Pk Cons. ($)	2,640	2,384	2,850	2,532	4,020	4,702	5,150	4,614	3,599	2,876	2,589	2,558	40,514
Gas													
On-Pk Cons. ($)	2,006	1,714	1,787	649	109	90	84	96	110	582	1,047	2,247	10,521
Monthly Total ($):	4,646	4,098	4,638	3,182	4,129	4,792	5,233	4,710	3,708	3,458	3,636	4,806	51,035

Building Area = 55,056 ft²
Utility Cost Per Area = 0.93 $/ft²

Outputs

Alternative 2	ASHRAE Baseline 90.1-10 C		
Yearly Time of Peak: 17(Hr) 7(Month)			

Equipment Description		Electrical Demand (kw)	Percent of Total (%)
Cooling Equipment			
Air-cooled unitary - 001		125.59	47.10
	Subtotal	125.59	47.10
Heating Equipment			
Boiler - 001		2.13	0.80
	Subtotal	2.13	0.80
Fan Equipment			
Sys 5: System - 005		2.05	0.77
Sys 4: System - 004		12.10	4.54
Sys 3: System - 003		14.79	5.55
Sys 2: System - 002		15.33	5.75
Sys 1: System - 001		18.30	6.86
	Subtotal	62.57	23.47
Miscellaneous			
Base Utilities		0.00	0.00

Outputs

The (original) Purpose…

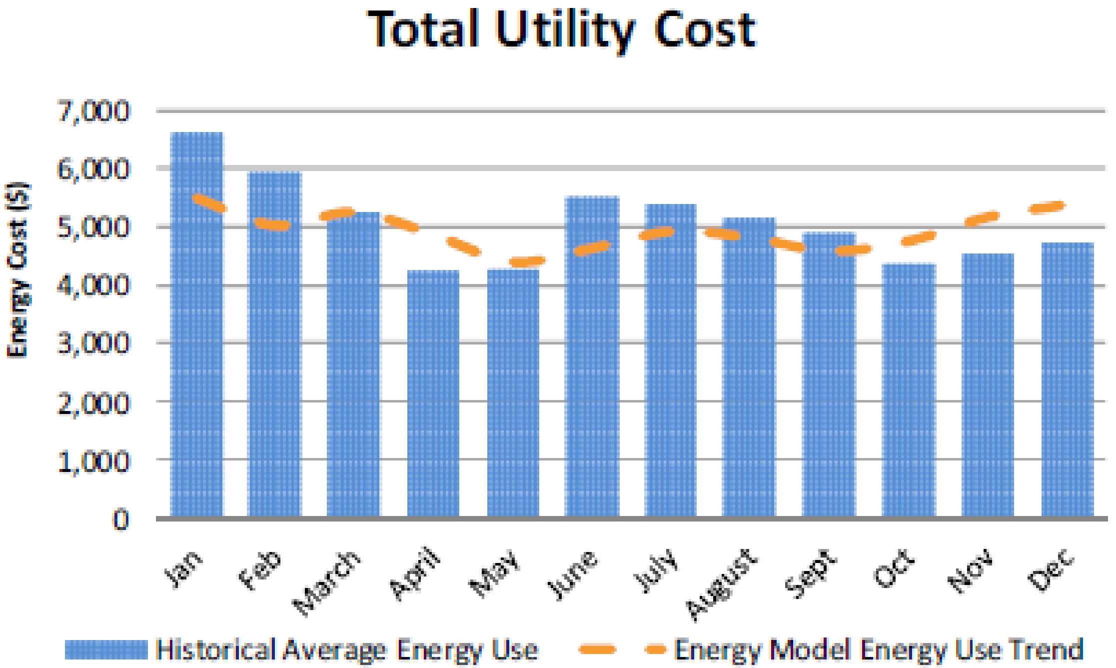
Existing Buildings

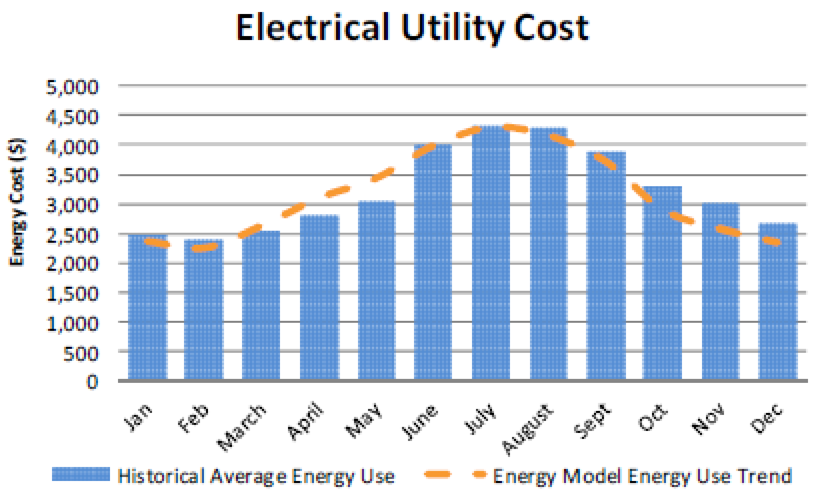
Inputs Inputs Inputs Inputs Inputs

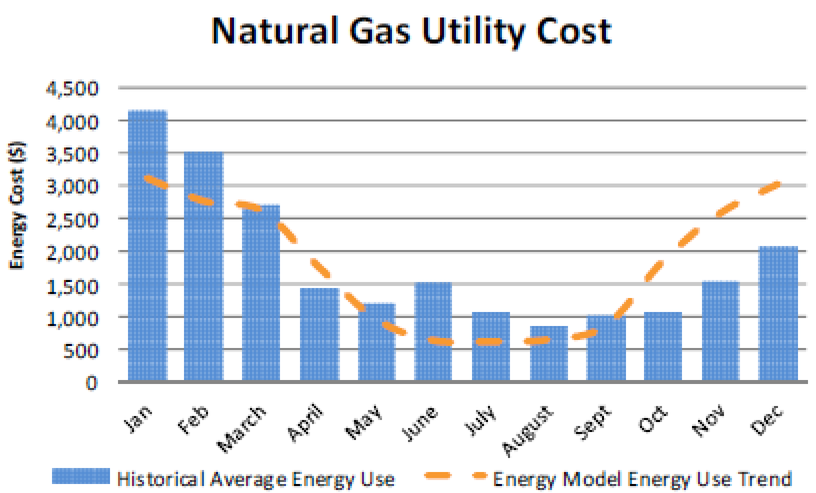
Mathematical Engine

Outputs

Existing Buildings
Calibrated Outputs

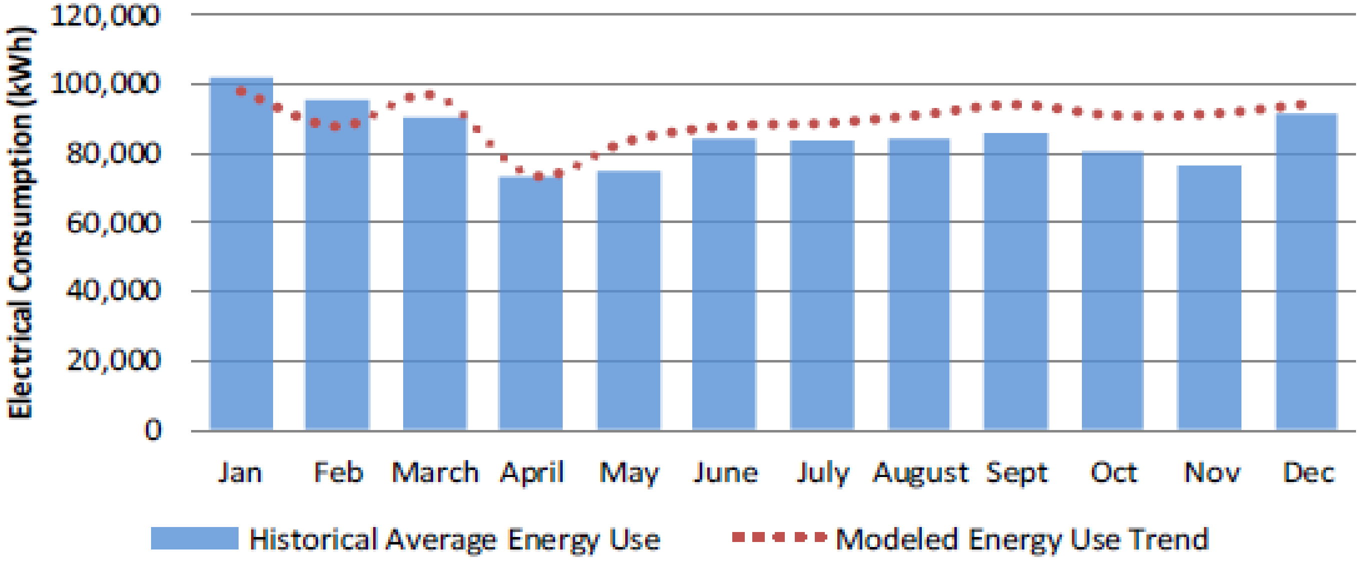



Electrical Utility Cost
Energy Cost ($)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan
Feb
March
April
May
June
July
August
Sept
Oct
Nov
Dec
Historical Average Energy Use
Energy Model Energy Use Trend


Natural Gas Utility Cost
Energy Cost ($)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan
Feb
March
April
May
June
July
August
Sept
Oct
Nov
Dec
Historical Average Energy Use
Energy Model Energy Use Trend

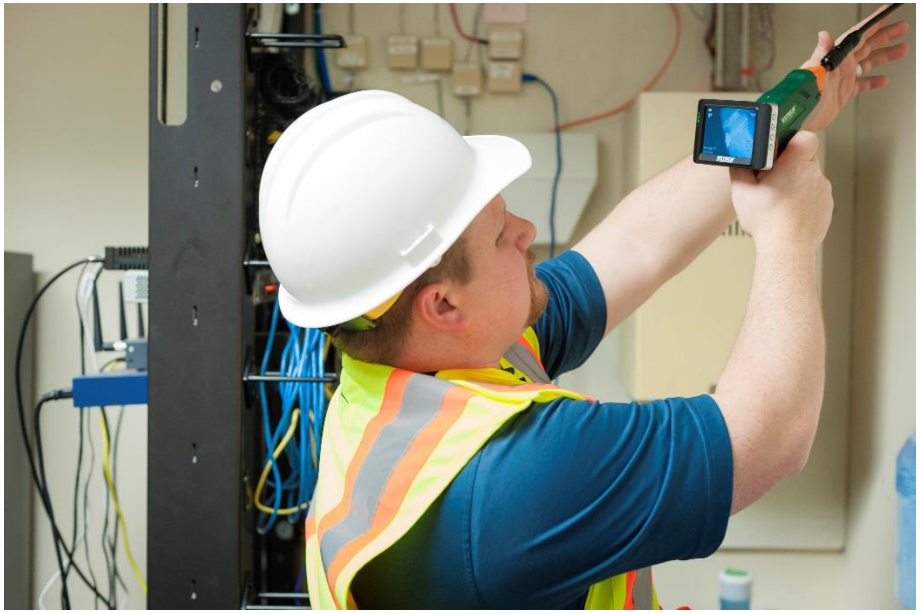
Existing Buildings
Calibrated Outputs

Figure 2.3: Average Monthly Usage from May 2008 to June2011.



Existing Buildings
Calibrated Outputs

Onsite Observations



Energy Model

Implications:

Quantify savings
Evaluate sizing
Determine deficiency magnitude
Environmental conditions
Understand interactions

GUIDE DECISIONS

Building Deficiency

ACTION	REQUIRED REACTION	Y (✓)	N (✓)	COMMENTS	R (✓)	C (✓)
2. Adjust thermostat set-point to equal current space temperature.	Damper goes to minimum position.	☐	☑	VAV is wide open	☐	☐
	Heating valve closed.	☑	☐		☐	☐
	Record CFM.	☑	☐	1343 cfm (total of outlets)	☐	☐
	CFM is at minimum per TAB set-point.	☐	☑		☐	☐
	Initial discharge temp.	☐	☐		☐	☐
	Final discharge temp.	☐	☐		☐	☐
	Final upstream temp.	☑	☐	78°F	☐	☐

Record issues VAV does not go to minimum.	Issue Log Item:	
	Initial	Date

Zone Design Flow Rates

Min Design Flow: 0.50 cfm/ft2

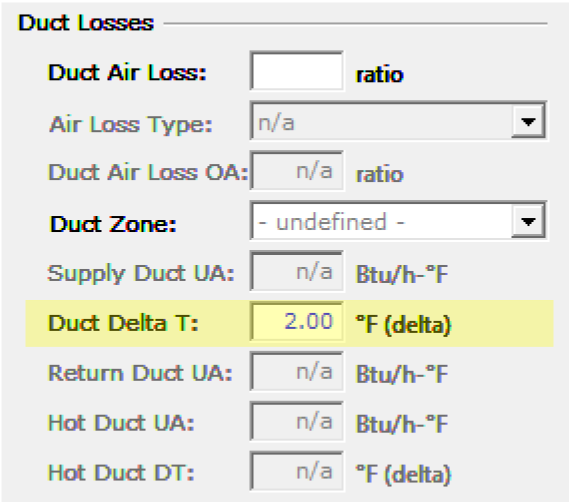
OA Flow/Person: 39.0 cfm

Minimum Flow Ratio: 0.70 ratio

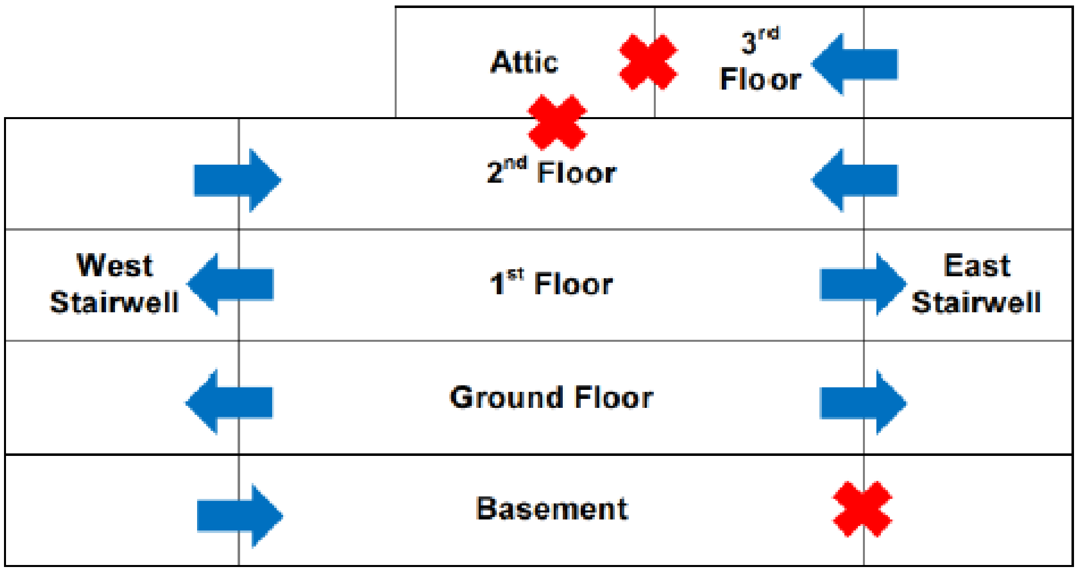
Building Deficiency

Table 9. Supply Duct Thermal Gain Results

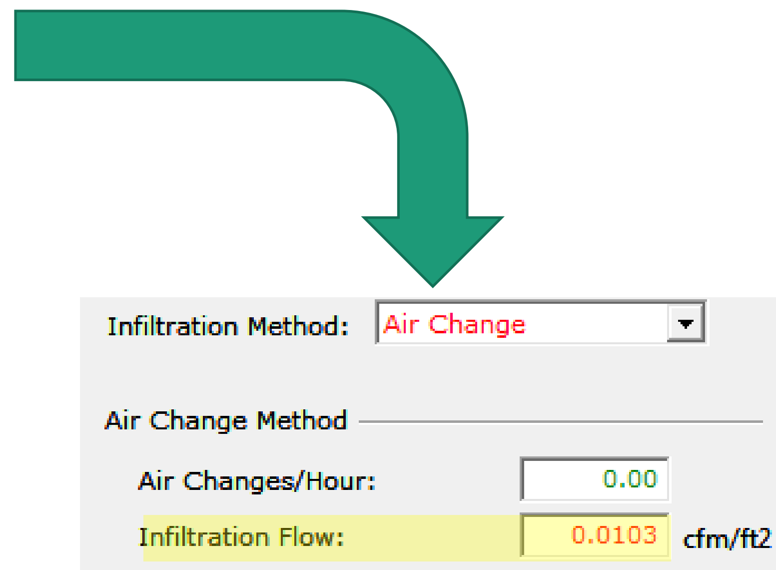
	AHU-BB (1969)	AHU-BQ (1964)	AHU-BM (1960)	AHU-BD (1949)
Insulated	Yes	Yes	No	No
AHU Discharge temp	60.6	56.4	59.4	62.4
VAV Upstream temp	61.7	-	-	-
VAV Downstream temp	61.9	-	-	-
Diffuser Neck temp	62.4	-	-	66.3
Diffuser Face temp	65.7	59.8	65.8	67.5
Delta T	5.1	3.4	6.4	5.1



Building Deficiency



As-Found Building Pressurization Diagram

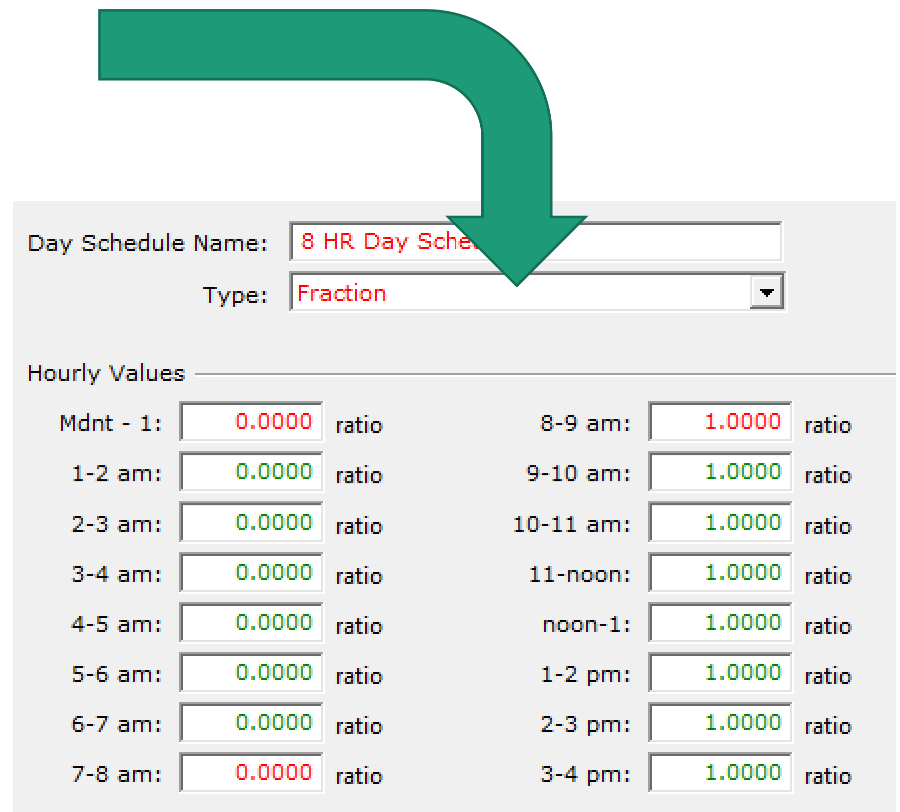


Building Deficiency

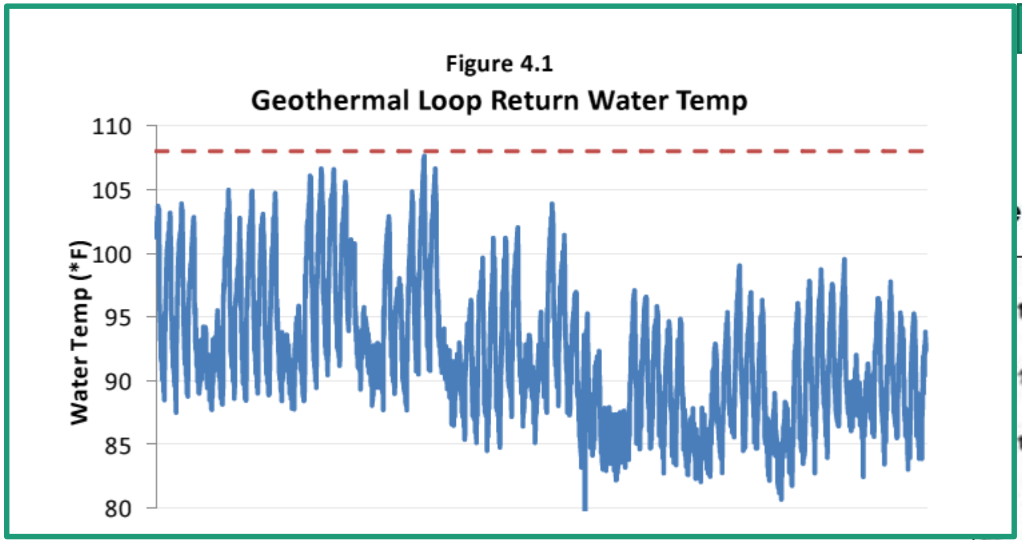
Table 4.11

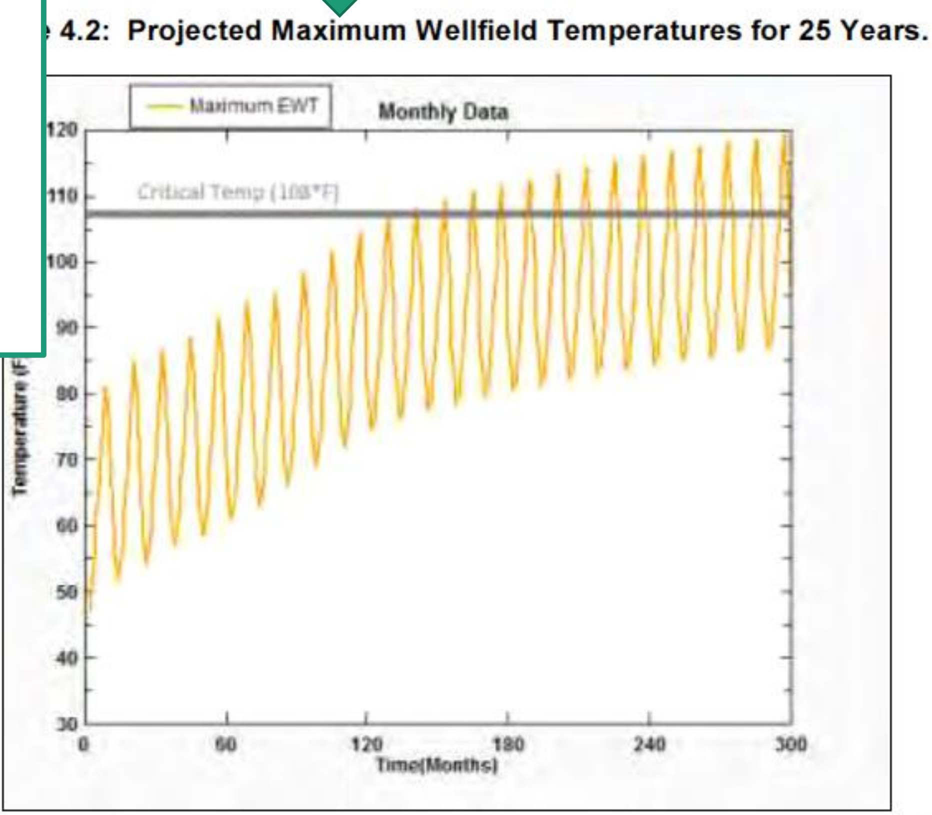
	Outside Humidity		ERV control sensors			Other zone sensors	
			ERV-1	ERV-2	ERV-3	C201	B200
Device Reading	32		37.7	37.7	36.5	38.6	36.8
Weather.com	34	*(Controls)*	57.1	65.5	48.7	57.1	57
Error	1.9		19.4	27.8	12.2	18.5	20.2

Average Sensor Error: 19.6 % RH



Building Deficiency





Energy modeling and retrocommissioning (RCx) can effectively share information to aid in building investigations and help guide decisions

Thank you for your time!

QUESTIONS?

This concludes the educational content of this activity

This concludes The American Institute of Architects Continuing Education Systems Course

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