Grunenwald Science and Technology Building

Clarion University- Clarion, PA

Technical Report Two:

Building and Plant Energy Analysis Report

Shane Helm
The Pennsylvania State University
Architectural Engineering- Mechanical
Advisor: Dr. Jelena Srebric
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Executive Summary

In order, to estimate the loads of the building an energy simulation model was run in Trane Trace 700 to determine the cooling and heating loads, energy consumption, and annual cost to operate the Grunenwald Science and Technology Building. The input of the building into Trace was done as a block load simulation rather than a room by room analysis typically used to obtain a more accurate energy model. This was done since the block load will still supply a reasonable estimate while requiring less time to input the model to an energy simulation program.

The process for creating the zones for the block load analysis was done by combining all the similar room types into one large space were the ventilation requirements will be the same as one another. From this point, exterior wall areas and directions were determined for each space type and placed into Trace, along with the roof areas associated with 3rd floor rooms. The energy analysis was run obtaining results that were reasonable when compared with the designer's energy analysis results. The results obtained by the designer were calculated by Carrier HAP, a different energy simulation tool. The need for an energy simulation was dictated by the application for LEED energy credits. The same location was used as that of the designer of Erie, PA, as this is the closest location to the building site at Clarion University in Clarion, PA.

An energy simulation was run to provide the design loads and energy consumption of the building. After analysis, the individual systems in the building were broken apart and compared with the as-designed, while also seeing which systems required the most energy. The utility rates provided were added into the simulation to determine the overall cost for each system and the overall building consumption cost.

The results obtained by the Trace analysis for the design loads varied to be more or less than that of the design calculations depending on the air handling unit analyzed. The percent error between the loads was no more than 30 percent for any air handling unit. The energy consumption varied due to the variances in the load calculations, with the receptacles and the heating consumption being less than the design values. The lower heating consumption resulted in a lower energy cost for the steam when compared to the design documents, while the electricity cost was higher mostly due to the receptacle consumption being larger than design calculations. In this report, the emissions for the building were calculated based on the electricity consumption, along with the natural gas consumption. The natural gas is used at the central plant in a gas fired boiler and is used to power the micro turbine used to generate on-site energy. Overall the block load model gave a reasonable estimate when compared with the designer's room by room analysis. Variances do exist in the calculated data, which may be explained by the different methods, programs, or assumptions made to allow the simulation to be completed in a timely manner.

Mechanical System Overview

The mechanical system for the Grunenwald Science and Technology Building serves approximately 50 percent university laboratories, 25 percent classrooms, and 25 percent faculty offices. The laboratory spaces are served from one of three VAV 100 percent outdoor air units, of various sizes ranging from 24,000 cfm to 45,000 cfm. One of these air handling units serves only an Organic Chemistry Lab due to the high loads and need for ideal control over the temperature and humidity in the space. The offices and classrooms are served from one of two VAV modular units both similar in size of about 25,000 cfm. All of the air handling units are modular and are located in the penthouse of the building. The use of 2 energy recovery wheels helps to offset the large energy consumption associated with the 100 percent outdoor air. The exhaust air from the fume hoods, and snorkels located in the labs is used along with the waste heat from the micro turbine, producing on-site energy for the building, in the recovery wheels to pretreat the air entering into the system. Economizers are used on the VAV systems to supply additional energy savings associated with heating and cooling the mixed air.

Chilled water is produced on site by two 250 ton centrifugal chillers located in the mechanical room on the first floor of the Science and Technology Building. The building uses campus generated steam and does not have a boiler located onsite. The steam is passed through a plate frame heat exchanger to produce the needed hot water for the heating coils and domestic uses. The water enters the heat exchanger at a temperature of 140 degrees Fahrenheit and leaves to be used in the heating coils at a temperature of 180 degrees Fahrenheit. The building exhaust air from the potentially contaminated lab spaces through the use of three 40,000 cfm fans which throw the air out 26 foot stacks located on the roof with high velocity. With the high velocity the effective height of 69 feet with high wind speeds of approximately 15 mph. The reason for the discharge air to be at a high velocity is so that exhausted air reentering the building or providing problems for the surrounding campus and community of Clarion. The mechanical system does use two 750 gpm cooling towers.

The micro turbine used in the building supplies some of the energy needed to power specific equipment located in the Science and Technology Building. The turbine is operated by natural gas which does produce emissions that will be calculated later in this report. The use of the turbine was not seen by the designers to be optimal as the payback period was near fifteen years, but the university was able to obtain a grant enabling the turbine to begin to pay for itself as soon as it was installed. The use of on-site generated energy was important to Clarion University as can be seen not only in the use of a micro turbine, but the use of large array of photovoltaic panels covering a large area of the roof plan.

Design Load Estimation

Trane Trace 700 was used to calculate the heating and cooling loads on the building using a block load analysis. Trace was chosen for this analysis since the interface is much more user friendly when compared to other energy simulation programs and the user knowledge of the program. In order to achieve the block load analysis zones were created by combining similar spaces based on occupancy and air handling unit. The zones were split between each of the five air handling units and the typical occupancies for the building. The determination of zones along with the general calculations needed before entering the building into the program can be seen in Appendix A. The exterior wall areas where then calculated along with percentage of glass for each room. The room exterior wall totals where added based on the zone and direction of the wall. This allowed for each wall to be placed into Trace in order to obtain a more accurate model.

For the purpose of the design, an energy simulation was run in Carrier HAP to compare the as-designed to the standard ASHRAE 90.1 baseline. The use of an energy simulation was necessary in the process for applying for the LEED energy credits, and the simulation shows the total percent of energy that was saved in comparison to the ASHRAE baseline building. The designer's model uses a more accurate approach by using the room by room analysis, which gives a greater control over the inputs for each room type. The block load saves time for the user to input the building information accurately into Trace, and is one of the reasons that this method was chosen over any other method.

Outdoor Air Ventilation Rates and Infiltration

The outdoor air ventilation rates were obtained from the ventilation schedules submitted to LEED to show compliance with ASHRAE Standard 62.1. The infiltration for the entire building was assumed to be 0.3 air changes per hour as this is common for a slightly pressurized building with average construction.

Design Occupancy

The occupancy used for particular spaces was obtained by the function of the room and the designer communicating with the university to the maximum class limits and specific research teams. In all cases when these known values where greater than the calculated value of people per square foot they were used rather than the calculation values. The total number of people for each space can be found on the room ventilation schedule located on the mechanical drawings.

Design Indoor and Outdoor Air Conditions for Heating and Cooling:

Grunenwald Science and Technology Building is located on the campus of Clarion University in Clarion, PA. The city that has similar weather conditions and location to the Science and Technology Building was Erie, PA. The design outdoor air conditions for Erie, Pa were obtained from the ASHRAE Handbook of Fundamentals 2009. The heating design month was July, while the cooling design month was January, and can be seen in the following table. The data was used for the 0.4 percent and 99.6 percent design conditions.

Table 1- Outdoor Air Design Conditions

Summer		Winter
DB (F)	MCWB (F)	DB (F)
85.8	72.7	2.9

The indoor design conditions were obtained from the design documents and can be seen in the following table.

Table 2- Indoor Air Design Conditions

Cooling Set Point	75 F
Heating Set Point	68 F
Relative Humidity	50%

Loads and Schedules:

The internal loads of the building were based on the function and type of space, whether it was a laboratory, office, classroom, or corridor. The occupancy load was based on the space and the designed occupancy for each individual space. The lighting loads and miscellaneous loads were provided in the design documents by the engineer. The miscellaneous loads used in the calculations were obtained by surveying the previous Science and Technology Building at Clarion University. Table 3 shows the loads associated with each occupancy type for the particular spaces. In Appendix B the inputs for Trace can be seen for the Internal Loads of each space type.

The schedules used for the analysis are a few of the schedules provided by the Trace software. With the use of the building serving as a classroom/laboratory building for Clarion University, the assumption that it operated the same as a typical office building. The following schedules for the lighting loads and occupancy of the building can be found in Table 4 and Table 5. The interface for setting up a schedule in Trace can be found in Appendix B, along with other interfaces that can be found in the software.

Table 3- Internal Loads by Space Type

Space Type	Lighting Load (W/sf)	Miscellaneous Load (W/sf)
Corridor	0.8	0
Classroom	1	1.2
Laboratory	1	3.0
Lobby	1.2	1.5
Office	0.85	1.5
Mechanical/Storage	0.6	0
Restroom	0.6	0

Table 4- Lighting Schedule

Time Period	Percentage
12 am to 7 am	5
7 am to 8 am	80
8 am to 10 am	90
10 am to 12 pm	95
12 pm to 2 pm	90
4pm to 5 pm	95
5 pm to 6 pm	90
6 pm to 7 pm	70
7 pm to 8 pm	60
8 pm to 9 pm	40
9 pm to 10 pm	30
10 pm to 12 am	20

Table 5- Typical Occupancy Schedule

Time Period	Percentage
12 am to 7 am	0
7 am to 8 am	30
8 am to 11 am	100
11 am to 12 pm	80
12 pm to 1 pm	40
1pm to 2 pm	80
2 pm to 5 pm	100
5 pm to 6 pm	30
6 pm to 9 pm	10
9 pm to 12 pm	5

Design vs. Modeled Building Block Load:

The modeled building load was calculated using Trane Trace 700 for the five air handling units serving the building spaces. These five units will be compared to the as-designed units listed in the design documents in the following areas; cooling ft^2/ton, heating Btuh/ft^2, total supply air cfm/ft^2, and ventilation supply cfm/ft^2. Table 6 summarizes the as-designed information with the data collected from the block load model run in Trace.

Table 6- Comparison Between As-designed vs. Modeled

Area (sf)	AHU	Cooling sf/ton		Heating Btuh/sf		Supply Air cfm/sf		Ventilation OA %	
		Designed	Modeled	Deigned	Modeled	Designed	Modeled	Designed	Modeled
19493	1	211.4	283.9	34.0	23.5	2.05	1.98	100	100
16653	2	177.3	202.6	40.6	31.8	2.51	2.11	100	100
32055	3	370.0	295.4	27.8	31.7	0.86	0.77	13.0	35.1
18163	4	240.3	230.8	42.9	31.7	1.51	1.68	4.56	21.9
15730	5	237.8	265.7	23.1	8.4	1.53	1.21	100	100

The modeled does vary from the designer's calculated loads, which could be due to a number of reasons. The first reason for a slight variation in loads is the modeling approach used a block load in order to get a reasonable estimate while the engineer used a room by room analysis that should be more accurate. The calculations used for determining wall and window areas is not as accurate as directly importing a 3D building model such as from Revit. Another reason for slightly different results is the use of different simulation programs to obtain the data.

The loads vary in both directions due to the inaccuracies of the block model that was utilized and the other reasons listed previously. The percent of error is in the range of 20 to 35 percent for both the cooling and heating loads, with a few loads having less than 10 percent error. The total cooling load for the Science and Technology Building was calculated to be different than the design calculated by 5 percent more, while the heating total was increased by 24 percent in the student model. The total CFM for the building was calculated to be less than that found in the design documents, which may explain the higher percentage of outdoor air for AHU-3 and AHU-4.

Annual Energy Consumption and Operation Costs

The annual energy consumption was calculated using the same Trace simulation used to obtain the load calculations. For comparisons to the values obtained by the engineers in the LEED submittal for EA Credit 1 will be used for the utilities cost. The building has been open since June 2009, but utility bills could not be obtained within the past few months from Clarion University for the single building located on their campus. The energy and operating cost analysis was done by the engineers using Carrier HAP as was there load calculation. The results obtained by Brinjac Engineering were supplied for reference and for comparison to the block load model. The results were compared with the LEED submission data supplied from the project. For the purpose of the submission the average utility rates were used by Brinjac, which were the same costs that were used as the inputs into Trace for the block load model. The costs were 4.8 cents/kWh for electricity and 1.195 $/therm for the purchased steam from the central campus steam plant.

Annual Energy Consumption:

The following table shows the comparison in energy consumption between the design calculation and the block load model calculation. All the data in the table was obtained from the LEED submission for the design values and Trane Trace 700 for the modeled loads.

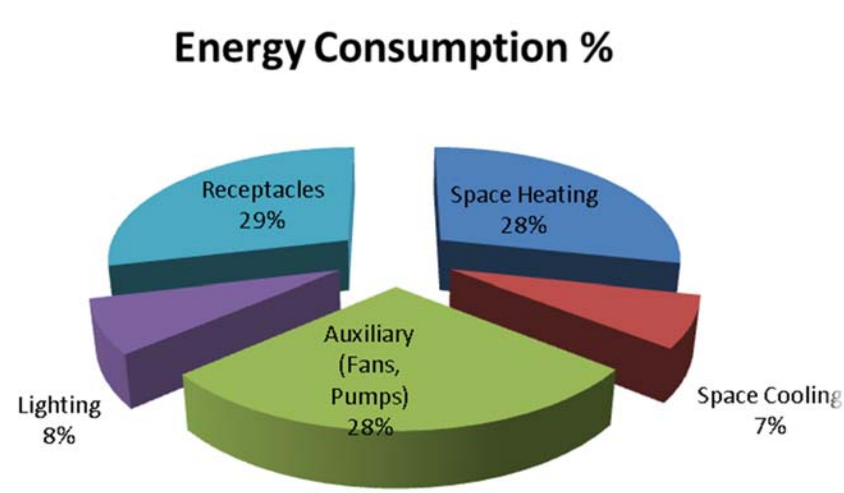
Table 7- Annual Energy Consumption Comparison

Energy Use	Modeled	Designed
Space Heating	334,000 (kBtu)	448,521 (kBtu)
Space Cooling	289,042 (kWh)	252,002 (kWh)
Auxiliary (Fans, Pumps)	1,132,269 (kWh)	1,188,325 (kWh)
Lighting	302,358 (kWh)	558,189 (kWh)
Receptacles	1,153,669 (kWh)	608,648 (kWh)
Cogeneration	Not Modeled	-1,515,247 (kBtu)

The differences seen in the receptacle consumption may be due to the assumptions made in the W/sf that were used while the designer had specific data on the equipment that was used in each space.

The cogeneration was not modeled in Trace due to user knowledge of modeling a micro turbine and photovoltaic solar panels in order to be able to calculate an energy savings from these energy producing products. The largest producer of electricity in the Science and Technology Building is the receptacles followed by the fans and pumps for the systems in the buildings. The space heating consumptions differ due to difficulty modeling the heating system with the use of a plate frame heat exchanger between steam and water for use in the heating coils. The cogeneration is on site produced energy that will be used for heating and electricity throughout the building. The figure below shows the energy consumption percentage for each use for the Science and Technology Building. The Receptacles use 29 percent, while the Auxiliary energy and space heating accounts for 28 percent of the energy consumption each.

Figure 1- Energy Consumption %

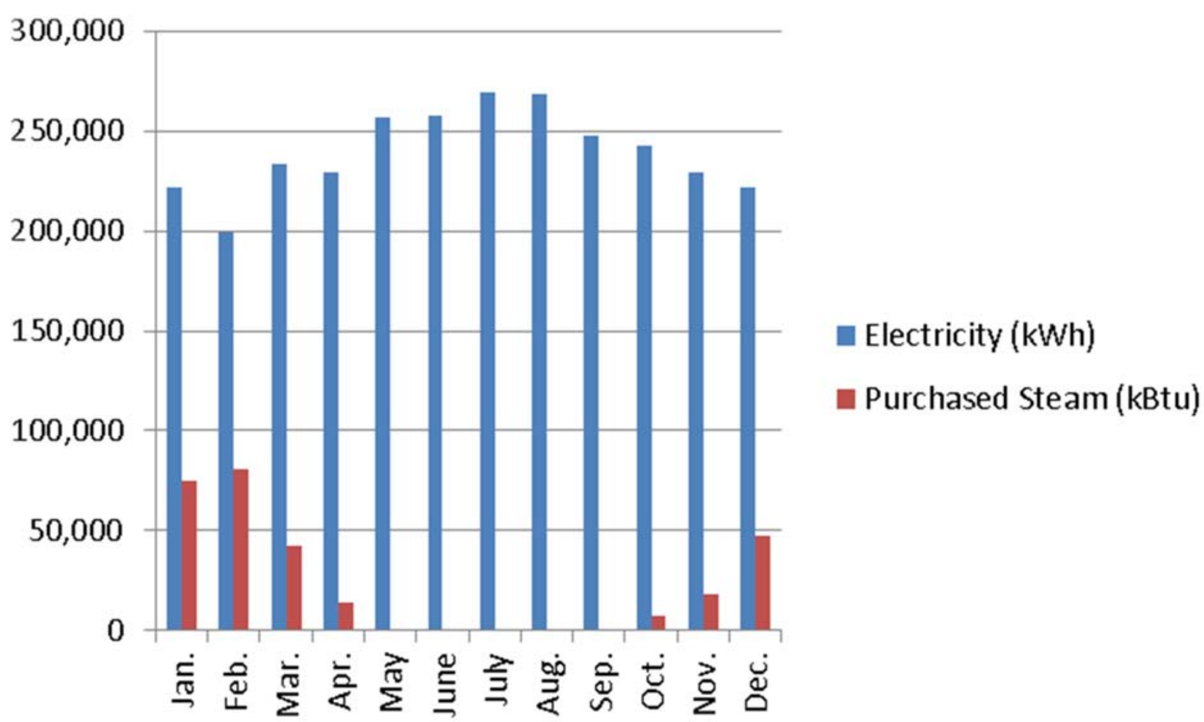


Using Trane Trace 700 the monthly energy consumption was calculated for electricity use and purchased steam total, these values can be seen in Table 8 and in Figure 2. Figure 2 is a graphical representation for usage per month.

Table 8- Monthly Energy Consumption Electricity & Purchased Steam

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Electricity (kWh)	222,089	199,515	233,795	229,135	256,651	257,323	269,448	268,688	247,377	242,935	228,835	222,047
Purchased Steam (kBtu)	75000	80400	42500	14100	900	400	200	400	500	7700	18500	47400

Figure 2- Monthly Energy Consumption



As can be seen in the graph the purchased steam has a near zero energy consumption during the summer months since it is used for heating only. The electricity is at its highest during the summer months as this is the peak cooling load for the Science and Technology Building.

Energy Costs:

The energy cost calculations were done in Trace using the cost rates provided by the designer in the LEED EA CR-1 submission. The cost for the individual energy consumptions can be seen in Table 9, and the percent of total cost is the same as the energy consumption percentage. This occurs since all the energy uses are based on the same cost, except for the space heating which depends on the cost of steam and does not affect the overall percentage. The results obtained from Trace are nearly identical to those calculated by the design engineer for total energy cost for electricity and purchased steam as can be seen in Table 10. The percentage of total cost for each use can be seen where receptacles are 39 percent with space heating the lowest percent at 2.8. A monthly cost analysis can be seen in Figure 3 including both the cost of electricity and steam. Table 11 has the calculated cost per month for electricity and purchased steam.

Table 9- Energy Cost per Year Each Load Type

Energy Use	Modeled	Cost	% of Cost
Space Heating	334,000 (kBtu)	$3,996	2.8
Space Cooling	289,042 (kWh)	$13,874	9.8
Auxiliary (Fans, Pumps)	1,132,269 (kWh)	$54,349	38.2
Lighting	302,358 (kWh)	$14,513	10.2
Receptacles	1,153,669 (kWh)	$55,376	39.0

Table 10- Energy Cost Building Total Comparison

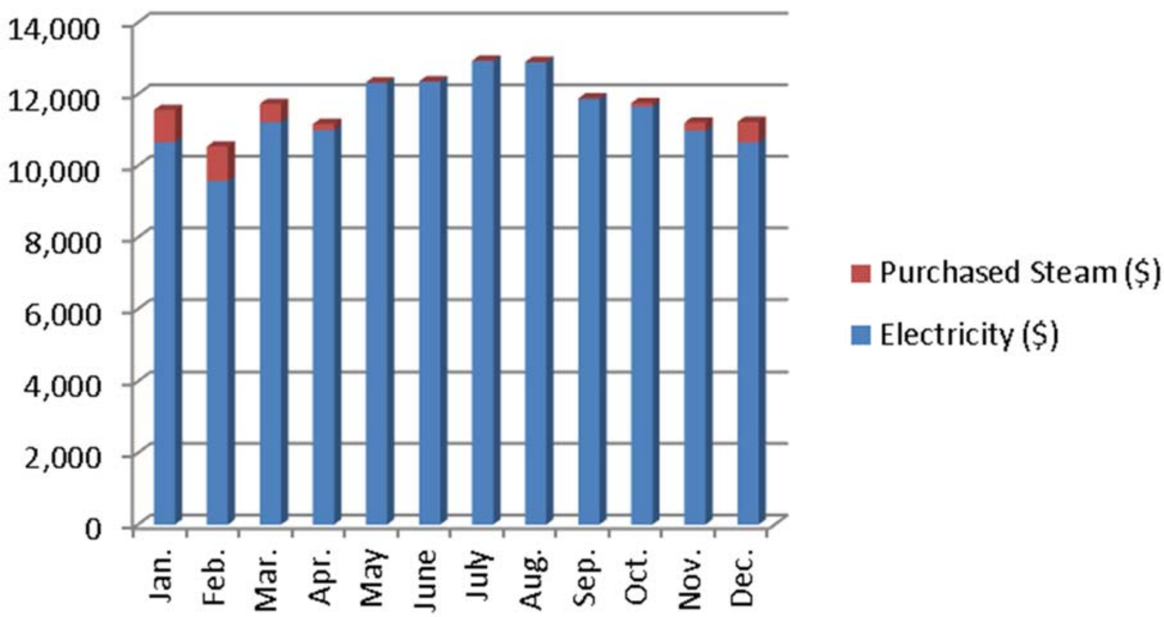
Utility	Modeled Building Energy Cost	Designed Building Energy Cost
Electricity	$ 138,143	$ 134,949
Purchased Steam	$ 3,965	$ 10,893
Total	$ 142,108	$ 145,842
Cost per Square Foot	$ 1.39	$ 1.43

The total energy cost for the building is similar, but individually the electricity is slightly more than as-designed since the receptacles and space cooling have a greater energy consumption. The reduced cost of steam is due to the energy consumption of the heating being less than the design value calculated by the engineer. The total cost per square foot for the Grunenwald Science and Technology Building came out to $1.39 similar to the design value of $1.43. The integration of the micro turbine and photovoltaic panels saves on average $6,800 dollars a year as calculated by the design engineers, even offsetting the cost of purchasing natural gas to operate the micro turbine.

Table 11- Monthly Cost Electricity and Purchased Steam

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Electricity ($)	10,660	9,577	11,222	10,998	12,319	12,352	12,934	12,897	11,874	11,661	10,984	10,658
Purchased Steam ($)	896.25	960.78	507.875	168.495	10.755	4.78	2.39	4.78	5.975	92.015	221.075	566.43

Figure 3- Monthly Cost Analysis



The cost for the steam is shown to be nearly negligible compared to the cost for electricity for the entire building. During every month the electricity dominates the cost of the total energy consumed in the building. The highest monthly cost is in July at $12,936, with the lowest monthly cost occurring in February at $10,538.

Annual Emissions:

The annual emissions for the building were calculated using the Regional Grid Emission Factors 2007 file. The Grunenwald Science and Technology Building is located within the Eastern Interconnection found on Figure 1, map of the North American Interconnections, in the file for emission factors. For the purpose of the report, the emissions associated with the electricity consumption, purchased steam, and natural gas for the building will be analyzed. The purchased steam is created at a campus central plant containing four natural gas burning boilers. The micro turbine is powered by natural gas as well. The boilers have an efficiency of near 85 percent, and the micro turbine has an efficiency of near 35 percent, with the waste heat used in the pre-heating of outdoor air. The pollution produced by the electricity emissions is the greatest since this accounts for the highest percentage of energy consumption. While the boiler accounts for less pollutants as the kBtu/year is less than that supplied to the micro turbine.

Table 12- Emissions Due to Electricity Consumption

Pollutant (lb)	lb/kWh	kWh/year	lb/year
CO_{2e}	1.74	2,877,979	5,007,683
CO_2	1.64	2,877,979	4,719,886
CH_4	3.59E-03	2,877,979	10,332
N_2O	3.87E-05	2,877,979	111
NO_x	3.00E-03	2,877,979	8,634
SO_x	8.57E-03	2,877,979	24,664
CO	8.54E-04	2,877,979	2,458
TNMOC	7.26E-05	2,877,979	209
Lead	1.39E-07	2,877,979	0.4
Mercury	3.36E-08	2,877,979	0.1
PM10	9.26E-05	2,877,979	267
Solid Waste	2.05E-01	2,877,979	589,986

Table 13- Emission Due to Natural Gas Consumption- Boiler

Pollutant (lb)	lb/1000 cf	kBtu/year	Btu/cf	lb/year
CO_{2e}	1.23E+02	331,800	1050	38,868
CO_2	1.22E+02	331,800	1050	38,552
CH_4	2.50E-03	331,800	1050	0.8
N_2O	2.50E-03	331,800	1050	0.8
NO_x	1.11E-01	331,800	1050	35.1
SO_x	6.32E-04	331,800	1050	0.2
CO	9.33E-02	331,800	1050	29.5
VOC	6.13E-03	331,800	1050	1.9
Lead	5.00E-07	331,800	1050	0.0
Mercury	2.60E-07	331,800	1050	0.0
PM10	8.40E-03	331,800	1050	2.65

Table 14- Emission Due to Natural Gas Consumption- Micro Turbine

Pollutant (lb)	lb/1000 cf	kBtu/year	Btu/cf	lb/year
CO_{2e}	1.25E+02	3,435,000	1050	408,928
CO_2	1.25E+02	3,435,000	1050	408,928
CH_4	5.26E-02	3,435,000	1050	172.1
N_2O	4.54E-03	3,435,000	1050	14.9
NO_x	3.51E-01	3,435,000	1050	1,148
SO_x	6.32E-04	3,435,000	1050	2.1
CO	1.75E-01	3,435,000	1050	572
VOC	2.06E-03	3,435,000	1050	6.7
Lead	5.00E-07	3,435,000	1050	0.0
Mercury	2.60E-07	3,435,000	1050	0.0
PM10	2.64E-02	3,435,000	1050	86.4

References

Torcellini, M. D. (June 2007). Source Energy and Emission Factors for Energy Use in Buildigns. Golden, Colorado: National Renewable Energy Laboratory.

Brinjac Engineering, Inc. MEP Construction Documents & Specifications. Brinjac Engineering, Inc., Harrisburg, PA

Michael Jacobs. Brinjace Engineering, Inc. Harrisburg, PA.

Trane Trace 700 User Manual and Simulation Program

BCJ Architects. Architectural Construction Documents. BCJ Architects, Pittsburgh, PA

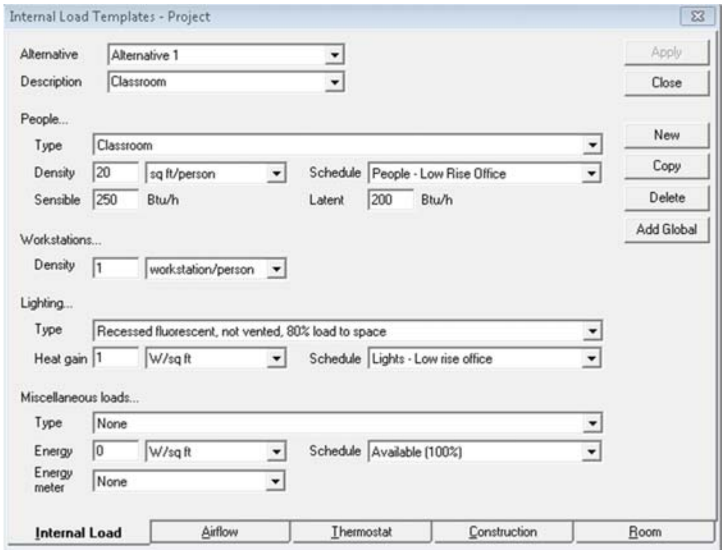
Appendix A- Exterior Wall and Window Area Calculation for Input to Trace

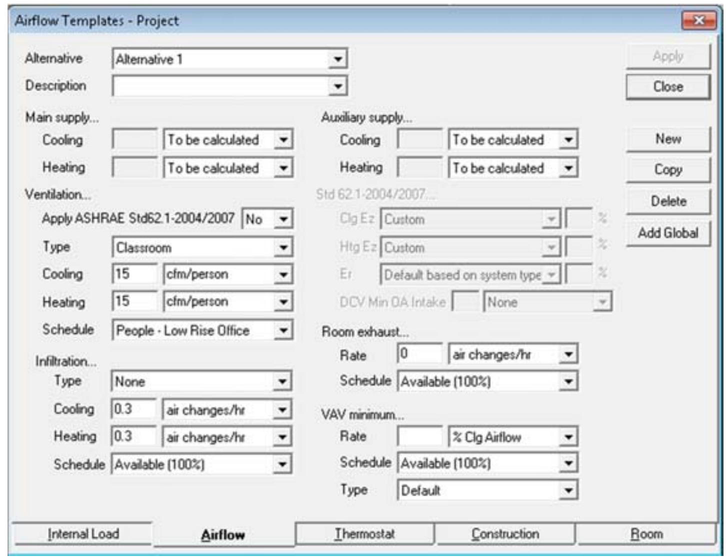
Unit-Space		Wall Elevation (sf)								
AHU-1	Total Floor Area	Exterior Wall-N	Exterior Wall- NE	Exterior Wall-NW	Exterior Wall-SSW	Exterior Wall-SE	Exterior Wall-SW	Wall U-Value	Roof Area	Roof U-Value
1st and 2nd Floor										
Laboratory Space	6500	0	3533.73	316.89	0	0	0	0.056	0	-
Corridor	2780	107.33	276	0	276	0	0	0.056	0	-
Storage Room	1873	0	0	0	0	0	0	0.056	0	-
Lobby	885	0	0	0	0	0	0	0.056	0	-
3rd Floor										
Lobby	445	343.76	0	0	0	0	0	0.056	445	0.034
Laboratory Space	5510	0	2130.69	316.89	0	0	0	0.056	5510	0.034
Corridor	1500	0	0	0	0	0	0	0.056	1500	0.034
AHU-2										
1st and 2nd Floor										
Laboratory Space	8688	0	0	417.07	4224.84	0	0	0.056	0	-
Corridor	225	0	0	0	276	0	0	0.056	0	-
Storage Room	1480	224.39	0	149.59	157.17	0	0	0.056	0	-
3rd Floor										
Laboratory Space	5915	0	0	572.16	2514.18	0	0	0.056	5915	0.034
Storage Room	345	0	0	0	0	0	0	0.056	345	0.034
AHU-3										
1st and 2nd Floor										
Lobby	3450	0	0	0	0	0	0	0.056	0	-
Corridor	4390	0	0	0	0	0	0	0.056	0	-
Classroom	7095	0	2362.77	0	1085.63	0	0	0.056	0	-
Storage Room	285	0	0	0	0	0	0	0.056	0	-
Lecture Classroom	2945	0	1115.48	613.32	0	766.5	0	0.056	0	-
Lecture Hall	2945	0	1115.48	613.32	0	766.5	0	0.056	0	-
Laboratory Space	3070	0	1562.1	0	0	0	0	0.056	0	-
3rd Floor										
Laboratory Space	1025	0	245.33	0	0	0	0	0.056	1025	0.034
Corridor	3890	0	0	0	0	0	0	0.056	3890	0.034
Classroom	2770	0	1302.53	0	0	0	0	0.056	2770	0.034
Office	190	0	0	0	0	0	0	0.056	190	0.034
AHU-4										
1st and 2nd Floor										
Classroom	3694	0	301.54	0	608.85	521.32	0	0.056	0	-
Office	5137	0	0	0	608.85	419.2	5710.12	0.056	0	-
Corridor	1540	0	0	0	0	0	0	0.056	0	-
Lobby	585	0	0	0	307	0	0	0.056	0	-
3rd Floor										
Classroom	3586	0	150.77	0	299	260.66	0	0.056	3586	0.034
Office	2581	0	0	0	309.85	209.56	2855.06	0.056	2581	0.034
Corridor	1040	0	0	0	0	0	0	0.056	1040	0.034
AHU-5										
3rd Floor										
Laboratory Space	2130	0	633.17	0	0	0	0	0.056	2130	0.034
Mechanical/Janitor Closets/Restrooms	13600	1103.97	2223.28	0	306.66	414	0	0.056	0	-
Total:	102094									

Unit-Space	Glazing (sf)					
AHU-1	N	SSW	NE	SE	NW	SW
1st and 2nd Floor						
Laboratory Space	0	0	674.36	0	0	0
Corridor	0	0	276	0	0	0
Storage Room	0	0	0	0	0	0
Lobby	0	0	0	0	0	0
3rd Floor						
Lobby	343.7	0	0	0	0	0
Laboratory Space	0	0	503.4	0	0	0
Corridor	0	0	0	0	0	0
AHU-2						
1st and 2nd Floor						
Laboratory Space	0	724.88	0	0	0	0
Corridor	0	276	0	0	0	0
Storage Room	0	0	0	0	0	0
3rd Floor						
Laboratory Space	0	682.24	0	0	42.64	0
Storage Room	0	0	0	0	0	0
AHU-3						
1st and 2nd Floor						
Lobby	0	0	0	0	0	0
Corridor	0	0	0	0	0	0
Classroom	0	525.64	495.76	0	0	0
Storage Room	0	0	0	0	0	0
Lecture Classroom	0	0	0	0	0	0
Lecture Hall	0	0	0	0	0	0
Laboratory Space	0	0	426.4	0	0	0
3rd Floor						
Laboratory Space	0	0	85.28	0	0	0
Corridor	0	0	0	0	0	0
Classroom	0	0	255.84	0	0	0
Office	0	0	0	0	0	0
AHU-4						
1st and 2nd Floor						
Classroom	0	608.86	170.56	0	0	0
Office	0	608.85	0	0	0	1449.76
Corridor	0	0	0	0	0	0
Lobby	0	306.67	0	0	0	0
3rd Floor						
Classroom	0	299	85.24	0	0	0
Office	0	309.85	0	0	0	724.88
Corridor	0	0	0	0	0	0
AHU-5						
3rd Floor						
Laboratory Space	0	0	170.56	0	0	0
Mechanical/Janitor Closets/Restrooms	0	77	0	0	0	0

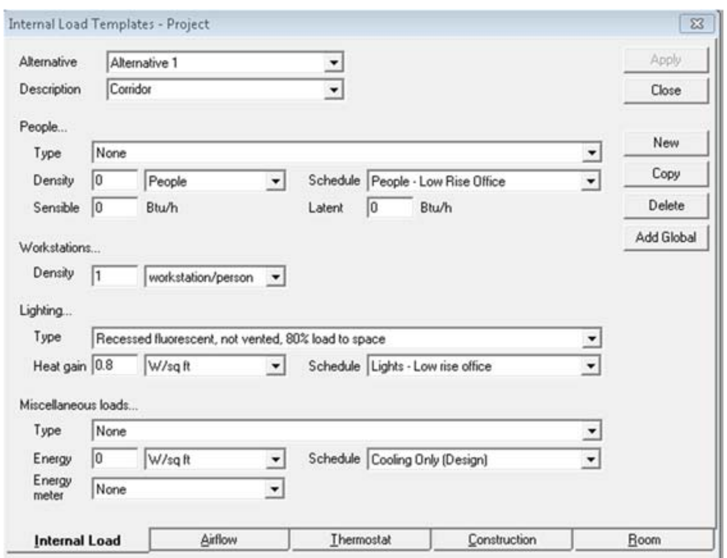
Appendix B- Trace Templates

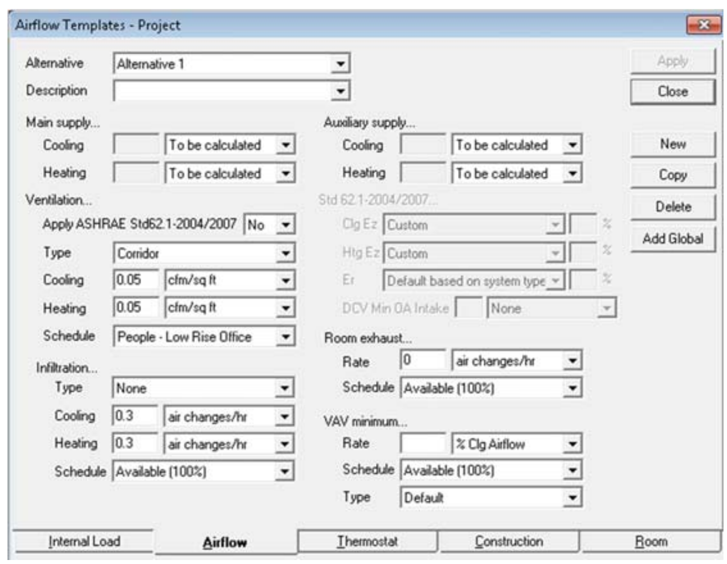
Typical Classroom:



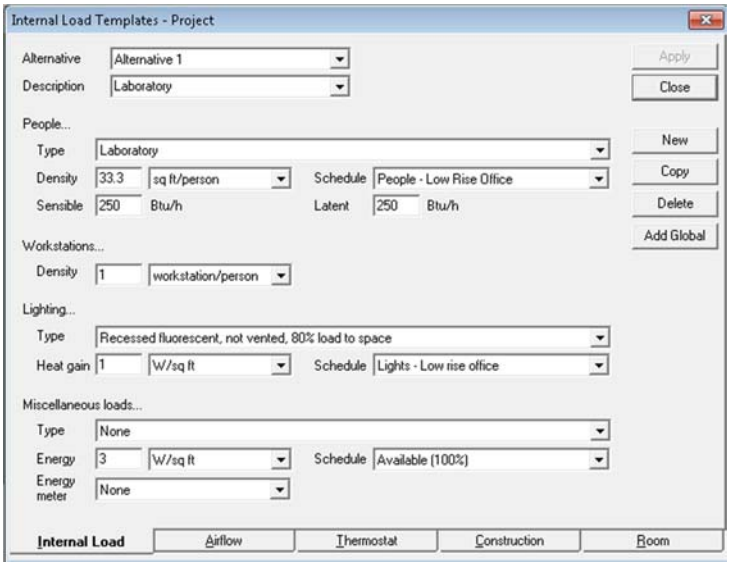


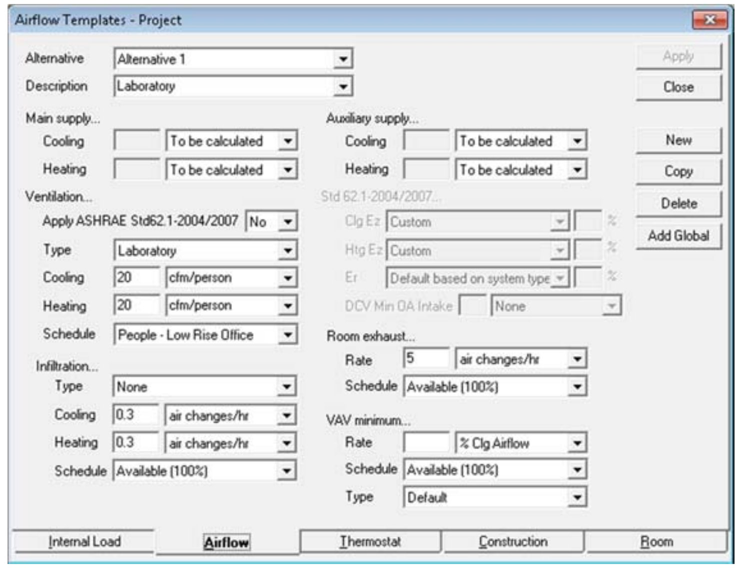
Typical Corridor:



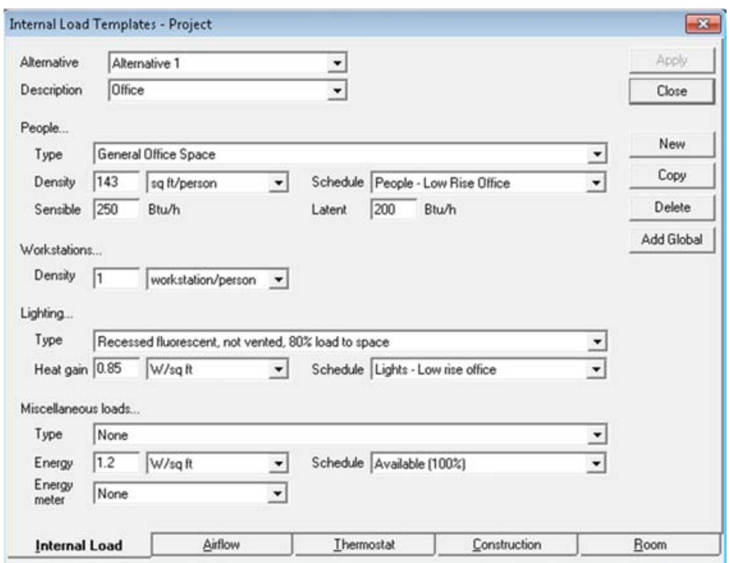


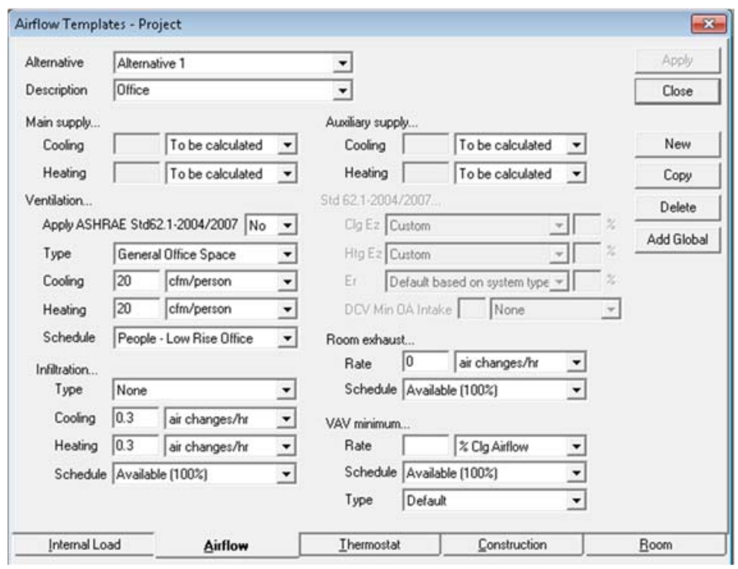
Typical Laboratory:



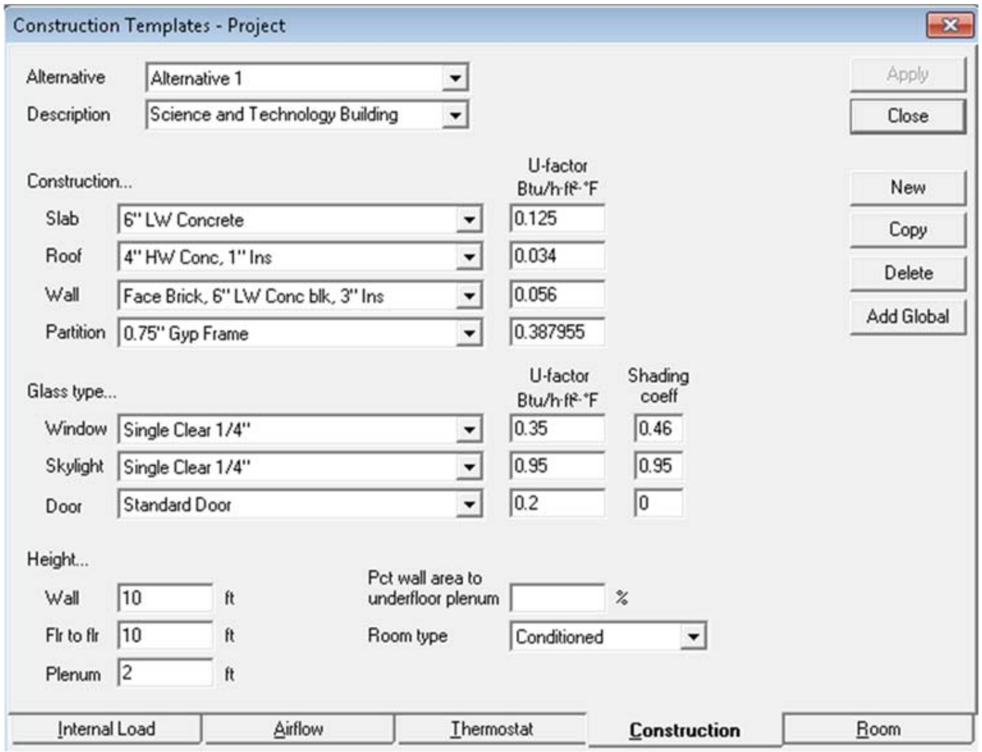


Typical Office:

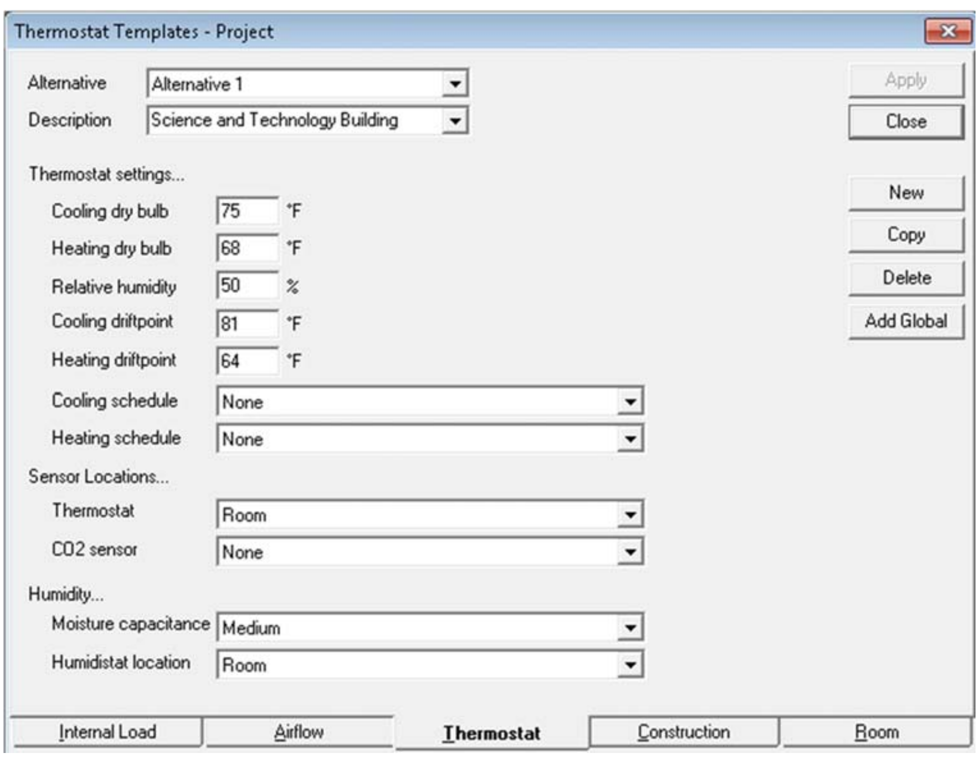




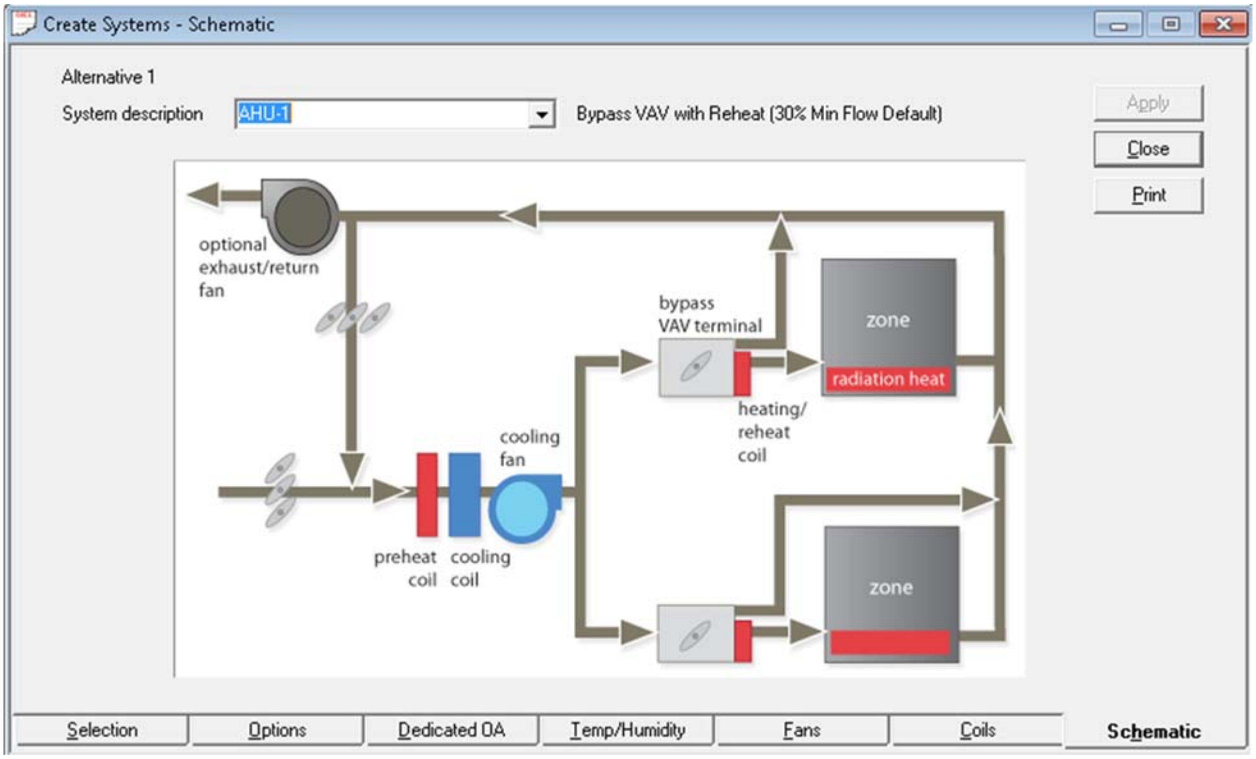
Typical Construction U-Values:



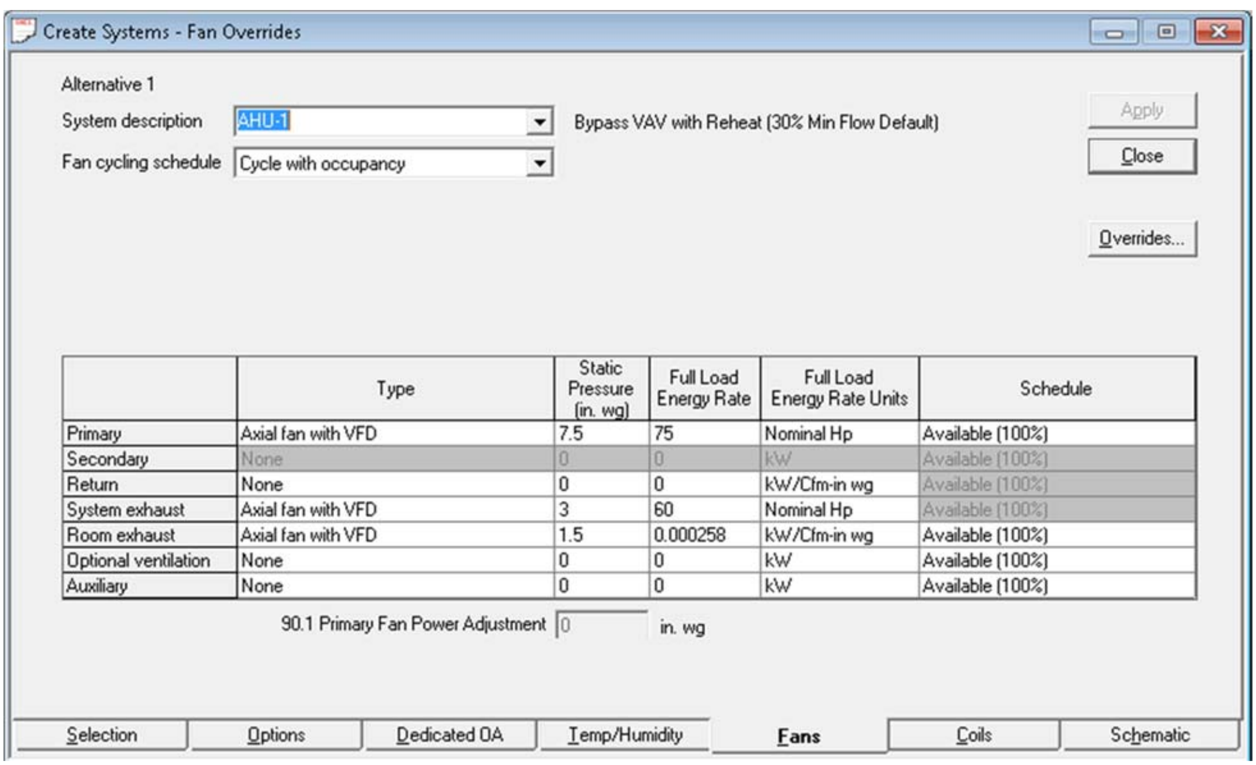
Typical Thermostat Settings:



Typical System AHU 1 to 5:

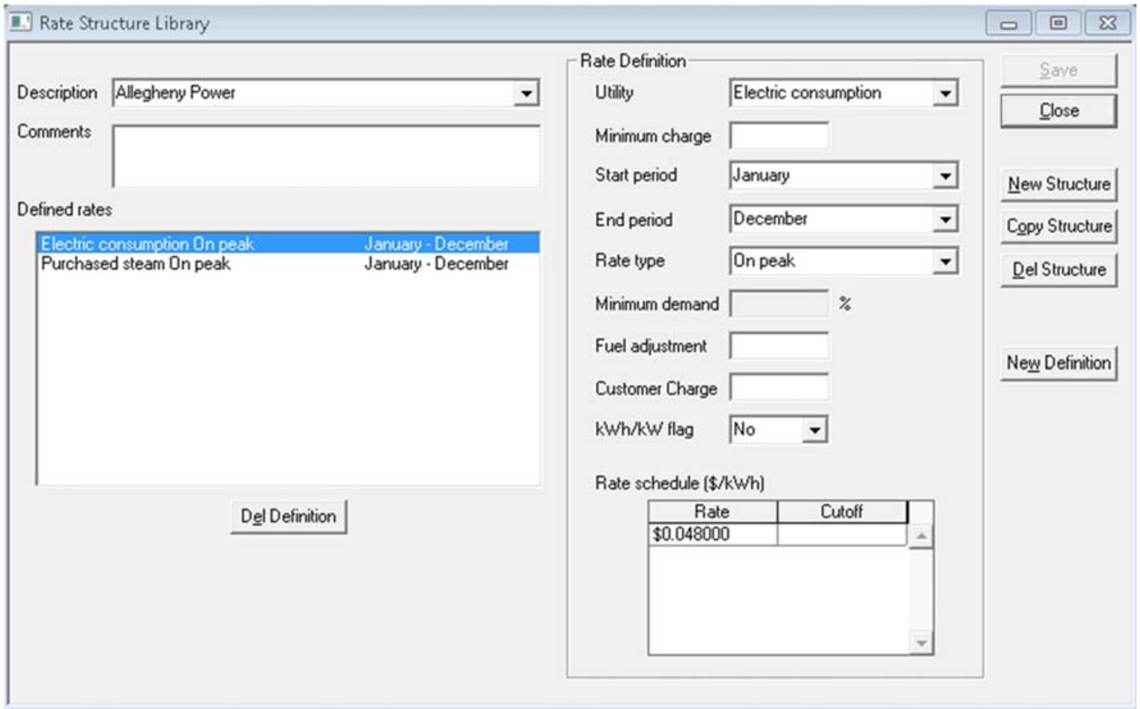


Example System Fan Overrides:



	Type	Static Pressure (in. wg)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	Axial fan with VFD	7.5	75	Nominal Hp	Available (100%)
Secondary	None	0	0	kW	Available (100%)
Return	None	0	0	kW/Cfm-in wg	Available (100%)
System exhaust	Axial fan with VFD	3	60	Nominal Hp	Available (100%)
Room exhaust	Axial fan with VFD	1.5	0.000258	kW/Cfm-in wg	Available (100%)
Optional ventilation	None	0	0	kW	Available (100%)
Auxiliary	None	0	0	kW	Available (100%)

Electricity Power Structure:



Purchase Steam Rate Structure: