Building and Plant Energy Analysis

Technical Report 2

Freetown Elementary School

Glen Burnie, MD

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Executive Summary

The purpose of this report is to do a block load analysis by creating a model. From this different calculations could be done; such as, building energy consumption, operating costs, and emissions from the building.

Creating a model is vital in determining heating and cooling loads, sizing equipment, and determining systems. A model was created in Revit Architecture from the design documents. It was necessary to group some of the rooms together to do a block load analysis. This estimate is not the most accurate because of the grouping of rooms. A more accurate model would be a room by room analysis.

Closely following the design documents of Freetown Elementary School was important when comparing the modeled values to the actual design values. The biggest issue was determining the right air handler in correspondence to the design documents. Another issue that contributed to values not matching up to the design documents was the schedule for different rooms which led to a fluctuation in modeled values.

Calculations were done for building energy consumption was based on the model created in Revit and the loads assigned to the building. Operating costs were calculated based off of values from the local Electric and Gas company rates. The emissions for the building were determined from the North American Electrical Grid and the following were calculated: CO_2, SO_x, NO_x, and PM10 in lbs of total pollution.

Overall, the building resulted in reasonable measurements from the model created in Revit. Discussions of results, assumptions and further explanations can be found throughout this report when determining values.

Mechanical Overview

Freetown Elementary School contains multiple systems to ventilate the occupiable spaces. Six rooftop air handling units serve the music rooms, cafeteria, gymnasium, administration, and media center. Two energy recovery units serve each of the classroom wings. An air source heat pump serves the extended day program area. Fan coil units with outdoor air condition the food prep area and the computer lab. All other areas such as offices, storage areas and electrical rooms are cooled or heated by a ductless split system or a unit heater.

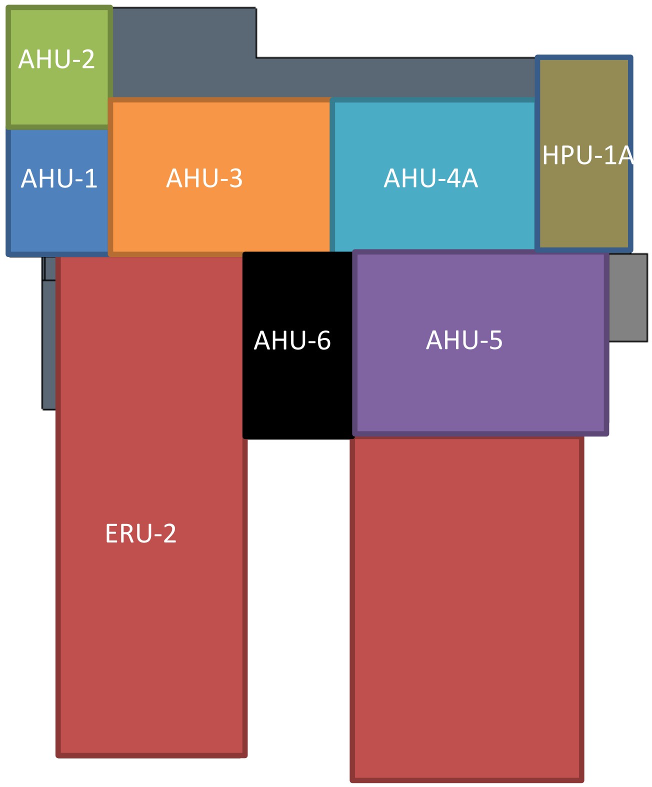


Figure 1 - Air Handling Units Assigned to Each Area

The following tables contain the supply air from each unit serving the school.

System	Supply Air (CFM)
AHU-1	1530
AHU-2	1530
AHU-3	6000

System	Supply Air (CFM)
AHU-4A	7500
AHU-5	3200
AHU-6	4680

System	Supply Air (CFM)
ERU-1	8100
ERU-2	9800
HPU-1A	3600

Table 1 – Supply Air by Design

Design Load Estimation

Trane Trace 700 was used to create a model for Freetown Elementary School. The model was made following the architectural layout. The following table **Building Design Criteria,** as well as other equipment information, was referenced from the design documents for Freetown Elementary School. This information was inputted into the model to simulate the design load calculations.

Building Design Criteria		
Interior	Summer	78°F
	Winter	70°F
Exterior	Summer	95°F
	Winter	0°F
Interior Load	Lighting	2.0 Watts/SQ. FT.
	Misc.	150 Watts/Computer
Ventilation Load	Classrooms	15 CFM OA/Person
	Admin. and Media	20 CFM OA/Person
	Dining	7.5 CFM OA/Person
	Corridors	0.10 CFM OA/SQ. FT.
People Density	Based on Architectural Furnishing Plans	
Wall "U" Coefficient	0.083 BTU/(HR)(SQ.FT.)(DEG. F)	
Roof "U" Coefficient	0.033 BTU/(HR)(SQ.FT.)(DEG. F)	
Glass Transmission "U"	0.49 BTU/(HR)(SQ.FT.)(DEG. F)	
Glass Solar Factor	0.55	

Table 2 – Building Design Criteria

Ventilation Rates

Ventilation rates can be found in the table above for the classrooms, administration, dining areas, and corridors. The rooms not classified into these spaces will be modeled with the ASHRAE recommended ventilation rate.

Lighting and Equipment Electrical Loads

Lighting and miscellaneous loads are included in the table above and were inputted into the Trace model.

Design Occupancy

The amount of occupants per room was calculated based off of the architectural plans. These values were included in the energy model and if a value was not determined from the design documents, the ASHRAE values were used under the Standard 62.1.

Design Indoor and Outdoor Air Conditions

Although the indoor and outdoor air conditions are stated in the design documents, the guidelines for this report specifies to use the ASHRAE Handbook of Fundamentals weather data values. The values that are used include the 0.4% and 99.6% values. Data from Baltimore, MD was used because it is the closest reported city to Glen Burnie, MD where Freetown Elementary School is located. Glen Burnie is approximately 12 miles south of Baltimore. This reference can be found in Appendix A.

ASHRAE Values	Summer Design Cooling 0.4%	Winter Design Heating 99.6%
OA Dry Bulb (°F)	93.6	12.3
OA Wet Bulb (°F)	75.0	~

Table 3 – ASHRAE Weather Design Values

The table above includes the outdoor air, dry and wet bulb temperatures at summer and winter conditions. The indoor air dry bulb temperature will be based off of the design criteria located in Table - 2.

Load Sources and Schedules

The main load sources in the building are electrical and lighting loads, solar loads, occupants, mechanical equipment and electrical equipment.

Schedules for all of the rooms are computed using the "Vent – Elementary School". A summary of the schedule is located in the tables below.

*Note: Heating design from 12am through 12am is 100%.

Summer	
Time	%
12am-7am	0
7am-8am	30
8am-3pm	80
3pm-5pm	30
5pm-12am	0

School Year - Weekday	
Time	%
12am-7am	0
7am-8am	50
8am-5pm	100
5pm-12am	0

Weekend	
Time	%
12am-12am	0

Table 4 – Schedule for Building from Trace

Additional Assumptions

It is assumed that for the infiltration rates, the building type is average construction and is pressurized. The thermostat is set at 78°F for cooling and 70°F for heating. The construction materials are based off of the architectural sections for wall assemblies. The U-factor and the shading coefficient for the glass was inputted based off of the design criteria from the design documents.

Occupants for the cafeteria had to be adjusted from what ASHRAE recommended of 10 sq ft /person. Figuring on 24 students per classroom with 32 classrooms, leads to 768 total students. Assuming there is three lunch periods, breaks the number down to 256 students at one time when it is fully occupied. The overall schedule for the building is used for this which is detailed in Table - 4. Since lunch only occurs for about 2 hours during the day when the 256 students will be in there, the tonnage will be oversized when the space is empty.

Occupants for the gymnasium were determined on two classroom sessions at once. Therefore a class size of 48 students throughout the day will occupy the gymnasium. Including the gym teacher and a helper, the estimated occupants is 50 people occupying the gymnasium.

Air Handler Assumptions

Energy Recovery Units are modeled as constant volume with mixing terminal air blender. This is different from the design documents in that the energy recovery units do not have a reheat after the room air mixes with the supply air according to the schematic.

Model Created in Revit Architecture 2011

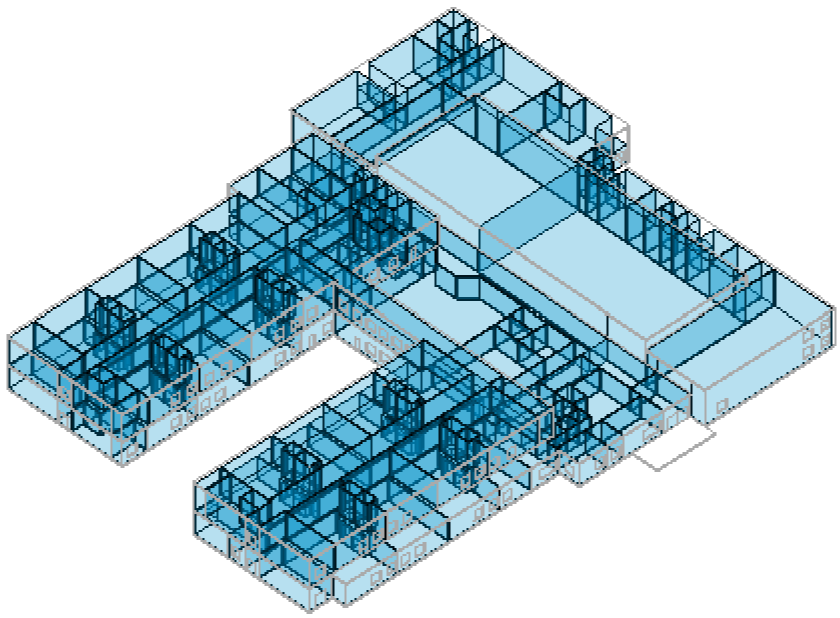


Figure 2 – Freetown Elementary School Model

Discussion of Results

In creating the model, multiple rooms were combined to give an estimate that is reasonable in creating a block load analysis. With combining rooms for block loads, airflow calculations and heating/cooling capacity are not as closely related to the design documents. The following table displays how the model compared to the actual design. A breakdown of each system is further explained in detail as to how the model differs from the actual design. For a more accurate analysis, a room by room analysis should be calculated.

Modeled vs. Designed								
	Cooling (tons)		Heating (MBH)		Total Supply Air (CFM)		Ventilation Supply Air (CFM)	
	Modeled	Designed	Modeled	Designed	Modeled	Designed	Modeled	Designed
AHU-1	5.6	6.5	55	78	1660	1530	780	600
AHU-2	4.6	5.2	43	61	1400	1530	440	375
AHU-3	30.6	23	214	280	4640	6000	2120	2000
AHU-4A	16.9	29	151	355	4200	7500	1000	2500
AHU-5	8.1	10.3	7	120	2630	3200	350	700
AHU-6	14.7	14.6	69	183	3050	4680	1590	1080
ERU-1	77.7	33.1	252	613	21320	8100	6990	8100
ERU-2	83.7	42.2	235	741	22100	9800	8000	9800
HPU-1	7.3	9.6	72	119	2273	3600	420	800

Table 5 – Modeled VS. Designed Measurements from Trace

AHU-1 and AHU-2 were modeled reasonably close to the design conditions. These two air handlers only serve one or two rooms with furniture in it so it was accurate in terms of occupants.

AHU-3 and AHU-4A were difficult to model because of the spaces they serve. These air handlers serve the cafeteria and the gymnasium. In the design documents the occupants per room were not discussed therefore an estimation was made. Originally, the ASHRAE recommended number was used for square foot per person. This called for an approximate 500 people in the cafeteria at once. This number had to be adjusted since there are approximately 768 students in the school (32 classrooms of 24 students each). Assuming three lunch periods, a value for the cafeteria was numbered at 256 students. The values are not near design conditions because the schedule is also assumed constant for all rooms. This causes the air handler to work harder when no one is occupying the cafeteria when lunch is not in session or when the gymnasium is not being used. Another issue arises when the partition located between the gymnasium and cafeteria is removed for assemblies or gatherings. This was not taken into effect when modeling these two air handlers.

AHU-5 was modeled as a variable volume reheat. In the design documents, there is also a bypass damper from the return air stream to bypass the air handling unit to serve the space. This was not available in the systems for the model in Trace. Therefore the heating energy is not a reasonable estimate.

AHU-6 was modeled as a constant volume – non-mixing computer room unit because it serves the media center. In the model, there is a reheat before the room but there is no reheat after it leaves the fan in the design documents so this number is not comparable.

ERU-1 and ERU-2 were difficult to model. They were modeled as a constant volume with mixing, terminal air blender. This does not take into consideration that they are energy recovery units and the model schematic also differs from the design schematic. The model schematic has a reheat and an extra fan before the supply air and room air enter the room. The design documents do not show these two features. The design documents simply have the room air mixing with the supply air before entering the room again. In conclusion, the results calculated were not comparable to the design conditions.

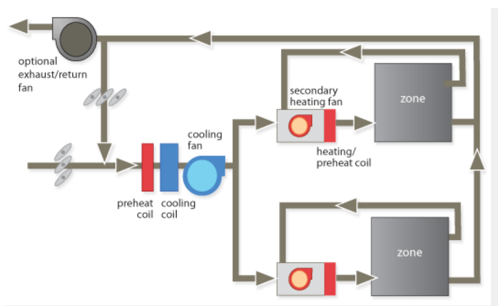


Figure 3- Schematic from Trace of ERU

HPU-1 serving the Extended Daycare Program did not indicate ventilation rates or the amount of occupants that were in the space so the numbers were not comparable.

Overall, the results from the model were a reasonable estimate from the assumptions made and the altering of the air handler units. A more accurate model would be made with a better understanding of manipulating the Trace systems, also with more accurate values for places such as the cafeteria and gymnasium. Altering the schedules for each system would benefit in the accuracy of the calculations depending on the use.

Possible Errors

Since the person modeling the information from the design documents is not fully familiar with the program, possible errors or wrong assumptions may have been made. Any of these errors made could have resulted in other errors that were in connection to the first error. Possible errors within the program may have also been resulted when doing the load calculations.

Energy Analysis

An energy analysis was not performed on this building. This is not a LEED certified school so the analysis would not be most important.

Utility Assumptions

Actual utility bills are not available won't be compared to the actual energy use. Baltimore Gas and Electric Company was used for determining rates for both gas and electric. It is assumed that Freetown Elementary School is using this because it is so close to Baltimore, MD. Since the demand load for the building is 1,056.9kW, the 2,000kWh or more in any month option was used for the following rates. This is listed under commercial, industrial, and lighting rates. For gas distribution, the general category was assumed.

Electricity Customer Charge: $17.50 per month
Energy Charge: $0.10 per kilowatt hour per month

Gas Customer Charge: $35.00 per month
Distribution Charge: 19.75 cents per therm for first 10,000 therms
9.48 cents per therm over 10,000 therms

Energy Consumption: Freetown Elementary School consumes 2,112,000 kWh of electricity and 119,000 kBtu of gas annually based on the model. Below is a breakdown of energy consumption for each category. The main energy consumption is by the air cooled chiller and the boiler (when converted to kWh, it is comparable to the air cooled chiller). Lighting is also a large portion of the energy consumption at peak load.

Equipment Energy Consumption		
Boiler	Gas (therms)	1190
	Peak (therms/hr)	4.9
Air Cooled Chiller	Electric (kWH)	482800
	Peak (kW)	213.4
Lighting	Electric (kWH)	133100
	Peak (kW)	152
Miscellaneous	Electric (kWH)	233900
	Peak (kW)	26.7

Table 6 – Equipment Energy Consumption Calculated in Trace

Total Energy Cost: The total annual energy cost for Freetown Elementary School was modeled to be $212,000 or a cost per area of $2.79/ft^2.

System Emission Rates

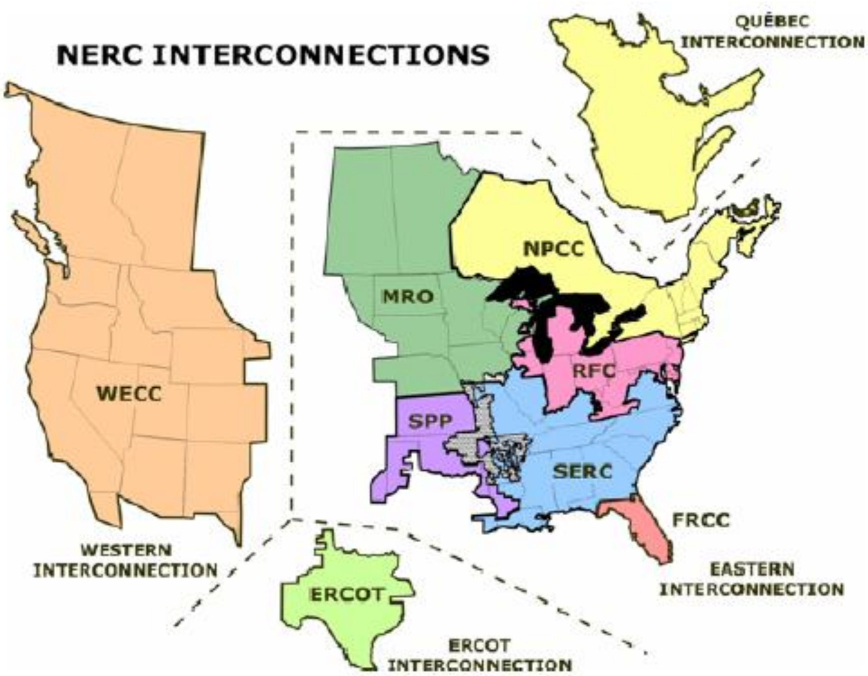


Figure 4 – Map of North American Interconnection Grid

According to the National Renewable Energy Laboratory, Glen Burnie, MD is located in the RFC section on the electricity grid for the United States.

Table 7 – Total Emissions from the building

Emissions from Electricity			
	Total Electricity Usage (kWh)	Electricity Emission Factor (lb pollutant/kWh)	Total Pollution (lbs)
CO_2	2,112,000	1.64	3,463,680
SO_x		8.57E-03	18,100
No_x		3.00E-03	6,336
PM 10		9.26E-05	196

Emissions from Natural Gas			
	Total Natural Gas Usage (ft^3)	Natural Gas Emission Factor (lb pollutant/1000ft^3)	Total Pollution (lbs)
CO_2	115,437	1.22E+02	14,083.3
SO_x		6.32E-04	0.1
No_x		1.11E-01	12.8
PM 10		8.40E-03	1.0

Values for electricity and natural gas emission factors were referenced from the National Renewable Energy Laboratory in order to calculate the total pollution from Freetown Elementary School. The PM factors do not include particulate formation in the atmosphere from chemical reactions of sunlight with emissions of NO_x, SO_x, and other gases. Composition of the fuel, the equipment, and the maintenance of the equipment determine the emissions from combustion on the boilers located in the school.

Resources

ASHRAE (2005). *Handbook – Fundamentals*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

James Posey Associates. 2008. MEP Construction Documents. James Posey Associates, Baltimore, MD. 2008.

"Rates and Tariffs." *Baltimore Gas & Electric Company*. Web. 26 Oct. 2010. <http://www.bge.com/portal/site/bge/menuitem.1dac74e4b8ebc087047eb471016176a0/>.

Rubeling Associates, Inc. 2008. Architectural Construction Documents. Rubeling Associates, Inc., Towson, MD. 2008.

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

Appendix A – ASHRAE Weather Data

2005 ASHRAE Handbook - Fundamentals (IP)

Design conditions for BALTIMORE, MD, USA

Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
1a	*1b*	*1c*	*1d*	*1e*	*1f*	*1g*	*1h*	*1i*
BALTIMORE	**724060**	**39.17N**	**76.67W**	**154**	**14.614**	**-5.00**	**NAE**	**7201**

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	*3a*	*3b*	*4a*	*4b*	*4c*	*4d*	*4e*	*4f*	*5a*	*5b*	*5c*	*5d*	*6a*	*6b*
1	**12.3**	**16.7**	**-3.5**	**4.6**	**16.4**	**1.1**	**5.8**	**20.8**	**27.3**	**33.0**	**24.9**	**30.9**	**8.8**	**270**

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	*8*	*9a*	*9b*	*9c*	*9d*	*9e*	*9f*	*10a*	*10b*	*10c*	*10d*	*10e*	*10f*	*11a*	*11b*
7	**18.7**	**93.6**	**75.0**	**90.9**	**74.3**	**88.2**	**73.1**	**78.1**	**88.3**	**76.9**	**86.4**	**75.6**	**84.3**	**10.5**	**280**

Dehumidification DP/MCDB and HR									Enthalpy/MCDB					
0.4%			1%			2%			0.4%		1%		2%	
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
12a	*12b*	*12c*	*12d*	*12e*	*12f*	*12g*	*12h*	*12i*	*13a*	*13b*	*13c*	*13d*	*13e*	*13f*
75.4	**133.6**	**82.4**	**74.1**	**128.0**	**81.2**	**72.9**	**122.9**	**80.1**	**33.8**	**88.7**	**32.5**	**86.4**	**31.4**	**84.6**

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
14a	*14b*	*14c*	*15*	*16a*	*16b*	*16c*	*16d*	*17a*	*17b*	*17c*	*17d*	*17e*	*17f*	*17g*	*17h*
23.0	**19.5**	**17.7**	**84.6**	**97.8**	**4.8**	**3.0**	**6.3**	**100.0**	**0.3**	**101.7**	**-3.4**	**103.4**	**-7.0**	**105.6**	**-11.5**

Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18a	*18b*	*18c*	*18d*	*18e*	*18f*	*18g*	*18h*	*18i*	*18j*	*18k*	*18l*
0.4%	**64.9**	**58.7**	**70.2**	**56.1**	**80.1**	**62.7**	**86.7**	**66.3**	**90.5**	**71.2**	**94.4**	**74.5**
1%	**61.7**	**56.1**	**65.8**	**54.6**	**75.6**	**60.0**	**83.0**	**64.9**	**88.4**	**69.8**	**92.7**	**74.2**
2%	**58.2**	**53.1**	**62.1**	**53.4**	**71.1**	**58.0**	**79.2**	**62.9**	**86.2**	**68.9**	**91.0**	**73.7**

%	Jul		Aug		Sep		Oct		Nov		Dec	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18m	*18n*	*18o*	*18p*	*18q*	*18r*	*18s*	*18t*	*18u*	*18v*	*18w*	*18x*
0.4%	**97.9**	**76.6**	**96.1**	**76.1**	**92.7**	**73.5**	**82.9**	**68.3**	**75.3**	**63.9**	**68.3**	**60.0**
1%	**96.0**	**76.2**	**94.1**	**75.5**	**90.2**	**73.2**	**80.2**	**67.2**	**72.5**	**61.6**	**65.0**	**56.8**
2%	**94.3**	**75.6**	**92.2**	**75.2**	**87.8**	**72.9**	**77.8**	**66.7**	**69.8**	**60.0**	**62.0**	**55.6**

Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19a	*19b*	*19c*	*19d*	*19e*	*19f*	*19g*	*19h*	*19i*	*19j*	*19k*	*19l*
0.4%	**60.2**	**63.5**	**60.0**	**66.0**	**64.8**	**77.7**	**68.7**	**80.2**	**74.7**	**85.5**	**78.5**	**88.2**
1%	**57.5**	**61.3**	**57.4**	**62.7**	**62.4**	**72.4**	**67.3**	**78.4**	**73.3**	**83.9**	**77.3**	**87.1**
2%	**54.4**	**57.8**	**54.4**	**60.0**	**60.0**	**68.6**	**65.6**	**75.9**	**72.0**	**81.7**	**76.3**	**85.8**

%	Jul		Aug		Sep		Oct		Nov		Dec	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19m	*19n*	*19o*	*19p*	*19q*	*19r*	*19s*	*19t*	*19u*	*19v*	*19w*	*19x*
0.4%	**80.3**	**91.2**	**79.5**	**89.0**	**77.3**	**86.2**	**71.5**	**77.8**	**66.5**	**71.3**	**61.7**	**66.5**
1%	**79.3**	**90.5**	**78.4**	**88.1**	**76.3**	**84.7**	**70.5**	**76.4**	**64.7**	**68.9**	**59.5**	**63.1**
2%	**78.4**	**89.2**	**77.7**	**87.5**	**75.3**	**83.2**	**69.1**	**74.7**	**63.4**	**67.3**	**56.9**	**60.7**

Monthly Mean Daily Temperature Range

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20a	*20b*	*20c*	*20d*	*20e*	*20f*	*20g*	*20h*	*20i*	*20j*	*20k*	*20l*
15.3	**16.7**	**18.2**	**20.1**	**20.0**	**19.5**	**18.7**	**18.2**	**18.3**	**20.0**	**18.2**	**15.8**

WMO#	World Meteorological Organization number	Lat	Latitude, °	Long	Longitude, °
Elev	Elevation, ft	StdP	Standard pressure at station elevation, psi		
DB	Dry bulb temperature, °F	DP	Dew point temperature, °F	WB	Wet bulb temperature, °F
WS	Wind speed, mph	Enth	Enthalpy, Btu/lb	HR	Humidity ratio, grains of moisture per lb of dry air
MCDB	Mean coincident dry bulb temperature, °F	MCDP	Mean coincident dew point temperature, °F	MCWB	Mean coincident wet bulb temperature, °F
MCWS	Mean coincident wind speed, mph	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East		

Appendix B – Regional Grid Emission Factors

Table 3 Total Emission Factors for Delivered Electricity
(lb of pollutant per kWh of electricity)

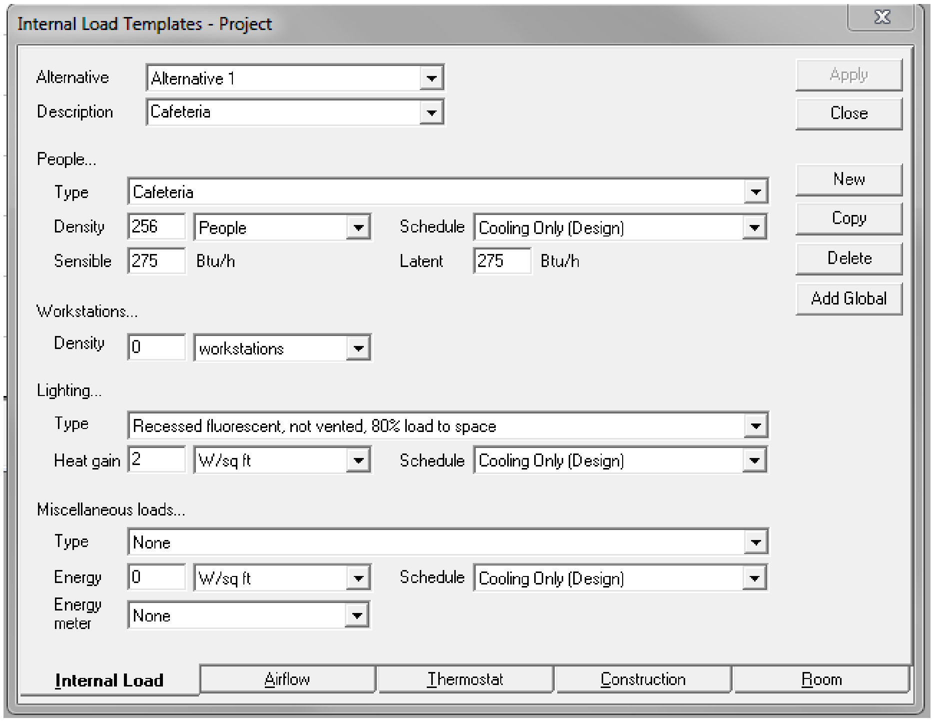
Pollutant (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.67E+00	1.74E+00	1.31E+00	1.84E+00	1.71E+00	1.91E+00
CO_2	1.57E+00	1.64E+00	1.22E+00	1.71E+00	1.55E+00	1.83E+00
CH_4	3.71E-03	3.59E-03	3.51E-03	5.30E-03	6.28E-03	2.96E-03
N_2O	3.73E-05	3.87E-05	2.97E-05	4.02E-05	3.05E-05	2.00E-05
NO_X	2.76E-03	3.00E-03	1.95E-03	2.20E-03	1.95E-03	4.32E-03
SO_X	8.36E-03	8.57E-03	6.82E-03	9.70E-03	1.12E-02	8.36E-03
CO	8.05E-04	8.54E-04	5.46E-04	9.07E-04	2.05E-03	7.43E-03
TNMOC	7.13E-05	7.26E-05	6.45E-05	7.44E-05	8.40E-05	1.15E-04
Lead	1.31E-07	1.39E-07	8.95E-08	1.42E-07	6.30E-08	1.32E-07
Mercury	3.05E-08	3.36E-08	1.86E-08	2.79E-08	3.80E-08	1.72E-07
PM10	9.16E-05	9.26E-05	6.99E-05	1.30E-04	1.09E-04	1.79E-04
Solid Waste	1.90E-01	2.05E-01	1.39E-01	1.66E-01	7.89E-02	7.44E-02

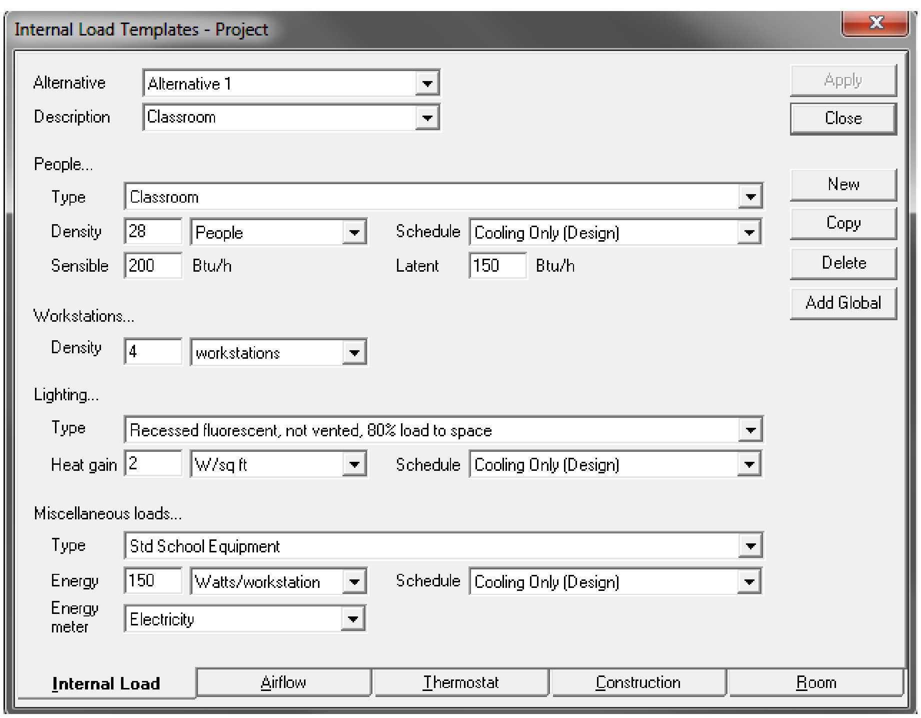
Table 8 Emission Factors for On-Site Combustion in a Commercial Boiler
(lb of pollutant per unit of fuel)

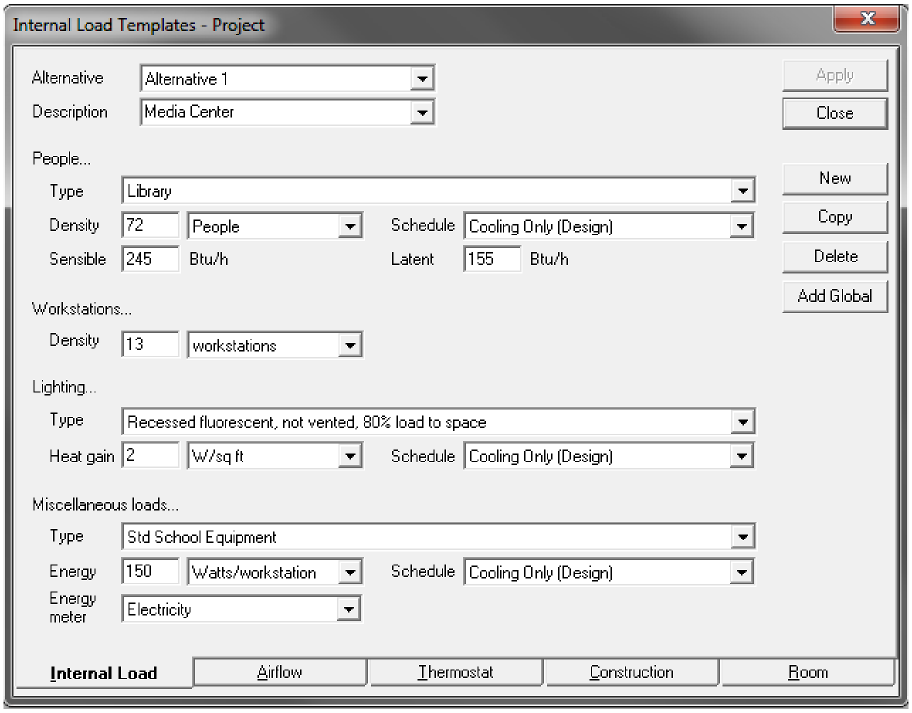
Pollutant (lb)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 lb	1000 lb	1000 ft^3 ***	1000 gal	1000 gal	1000 gal
CO_{2e}	2.74E+03	2.30E+03	1.23E+02	2.56E+04	2.28E+04	1.36E+04
CO_2	2.63E+03	2.30E+03	1.22E+02	2.55E+04	2.28E+04	1.32E+04
CH_4	1.15E-01	2.00E-02	2.50E-03	2.31E-01	2.32E-01	2.17E-01
N_2O	3.68E-01	ND †	2.50E-03	1.18E-01	1.19E-01	9.77E-01
NO_X	5.75E+00	5.97E+00	1.11E-01	6.41E+00	2.15E+01	1.57E+01
SO_X	1.66E+00	1.29E+01	6.32E-04	4.00E+01	3.41E+01	0.00E+00
CO	2.89E+00	4.05E-03	9.33E-02	5.34E+00	5.41E+00	2.17E+00
VOC	ND †	ND †	6.13E-03	3.63E-01	2.17E-01	3.80E-01
Lead	1.79E-03	6.86E-02	5.00E-07	1.51E-06	ND †	ND †
Mercury	6.54E-04	6.54E-04	2.60E-07	1.13E-07	ND †	ND †
PM10	2.00E+00	ND †	8.40E-03	4.64E+00	1.88E+00	4.89E-01

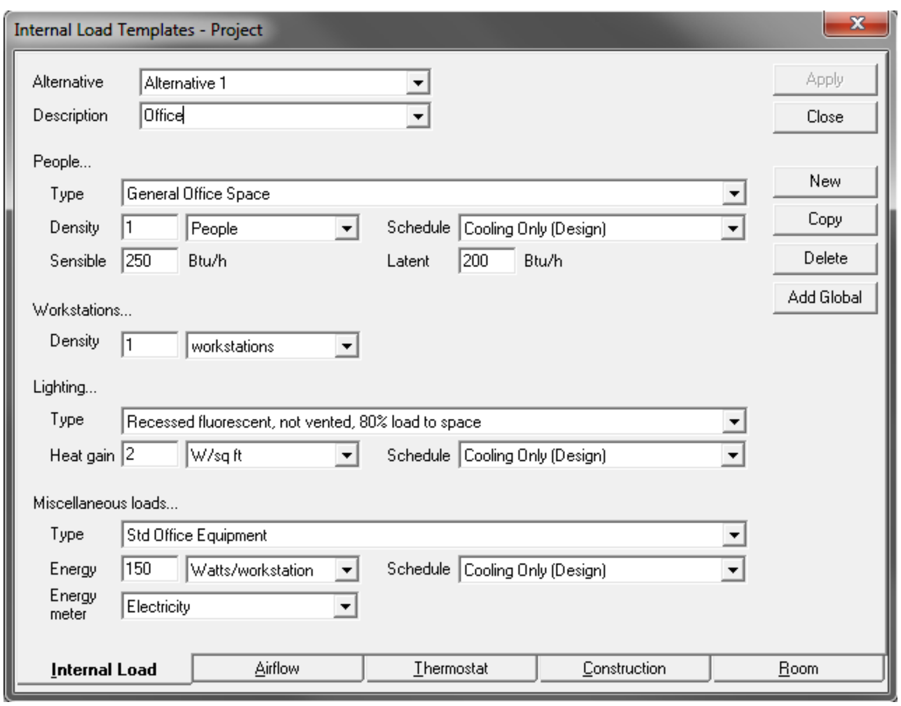
* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 60°F and 14.70 psia.
† no data available

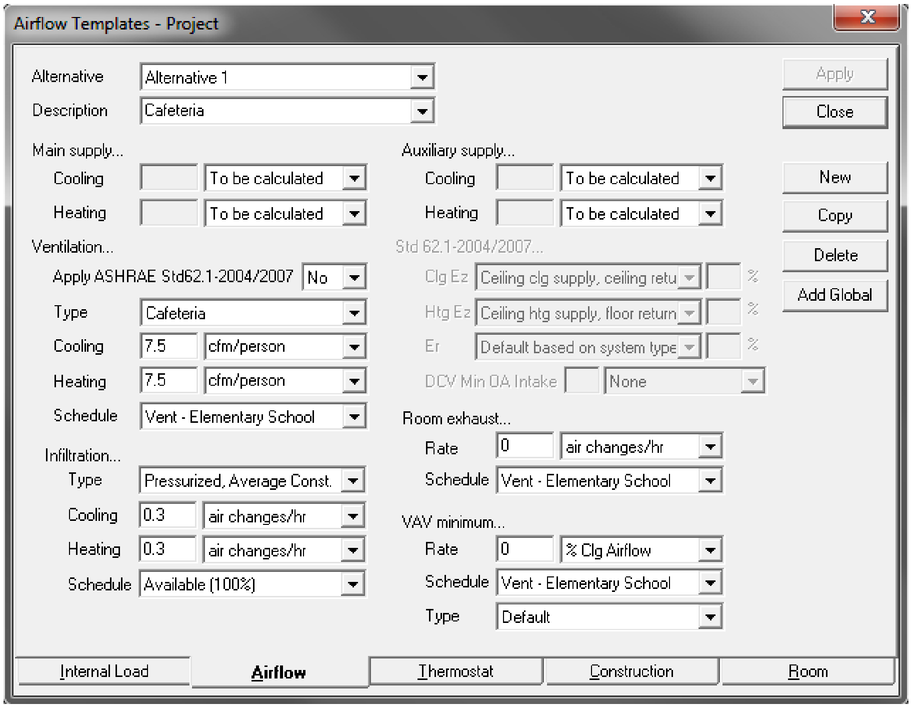
Appendix C – Trace Templates

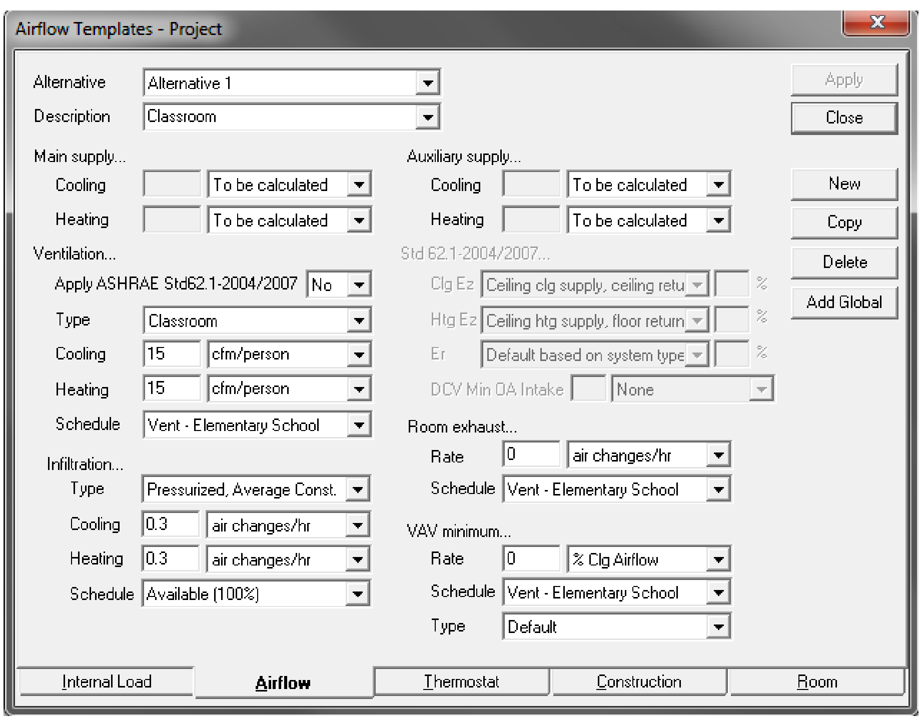


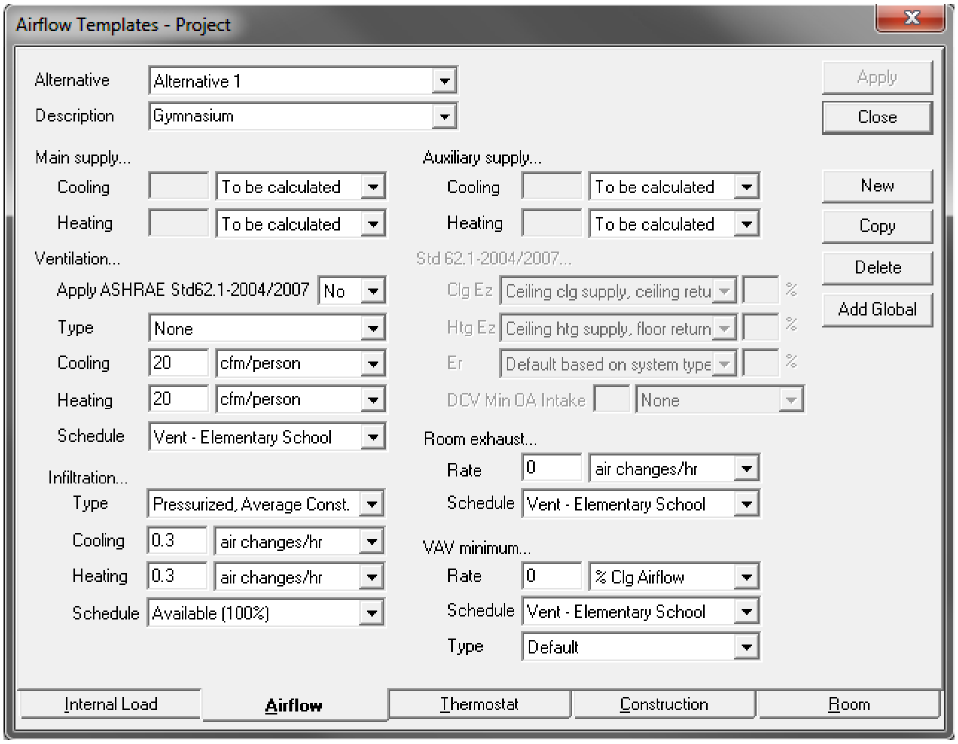


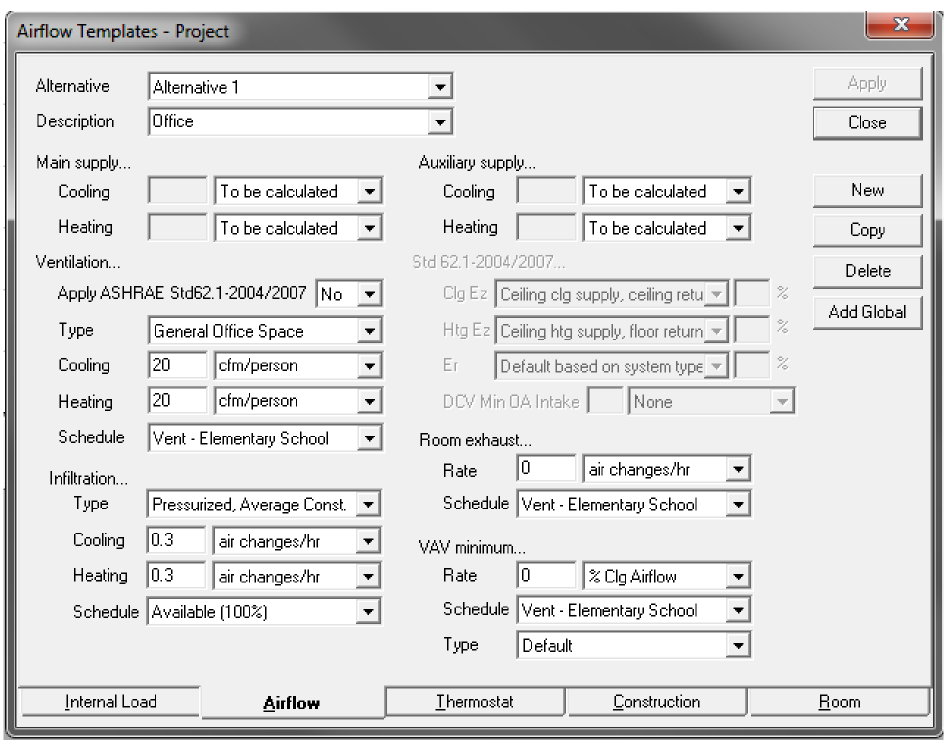

Internal Load Templates - Project
Alternative
Alternative 1
Description
Media Center
Apply
Close
People...
Type
Library
New
Density
72
People
Schedule
Cooling Only (Design)
Copy
Sensible
245
Btu/h
Latent
155
Btu/h
Delete
Add Global
Workstations...
Density
13
workstations
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
Heat gain
2
W/sq ft
Schedule
Cooling Only (Design)
Miscellaneous loads...
Type
Std School Equipment
Energy
150
Watts/workstation
Schedule
Cooling Only (Design)
Energy meter
Electricity
Internal Load
Airflow
Thermostat
Construction
Room


Internal Load Templates - Project
Alternative
Alternative 1
Description
Office
Apply
Close
People...
Type
General Office Space
New
Density
1
People
Schedule
Cooling Only (Design)
Copy
Sensible
250
Btu/h
Latent
200
Btu/h
Delete
Add Global
Workstations...
Density
1
workstations
Lighting...
Type
Recessed fluorescent, not vented, 80% load to space
Heat gain
2
W/sq ft
Schedule
Cooling Only (Design)
Miscellaneous loads...
Type
Std Office Equipment
Energy
150
Watts/workstation
Schedule
Cooling Only (Design)
Energy meter
Electricity
Internal Load
Airflow
Thermostat
Construction
Room


Airflow Templates - Project
Alternative
Alternative 1
Description
Cafeteria
Apply
Close
Main supply...
Cooling
To be calculated
Heating
To be calculated
Auxiliary supply...
Cooling
To be calculated
Heating
To be calculated
New
Copy
Delete
Add Global
Ventilation...
Apply ASHRAE Std62.1-2004/2007
No
Type
Cafeteria
Cooling
7.5
cfm/person
Heating
7.5
cfm/person
Schedule
Vent - Elementary School
Std 62.1-2004/2007...
Clg Ez
Ceiling clg supply, ceiling retu
Htg Ez
Ceiling htg supply, floor return
Er
Default based on system type
DCV Min OA Intake
None
Room exhaust...
Rate
0
air changes/hr
Schedule
Vent - Elementary School
Infiltration...
Type
Pressurized, Average Const.
Cooling
0.3
air changes/hr
Heating
0.3
air changes/hr
Schedule
Available (100%)
VAV minimum...
Rate
0
% Clg Airflow
Schedule
Vent - Elementary School
Type
Default
Internal Load
Airflow
Thermostat
Construction
Room


Airflow Templates - Project
Alternative
Alternative 1
Description
Classroom
Apply
Close
Main supply...
Cooling
To be calculated
Heating
To be calculated
Auxiliary supply...
Cooling
To be calculated
Heating
To be calculated
New
Copy
Delete
Add Global
Ventilation...
Apply ASHRAE Std62.1-2004/2007
No
Type
Classroom
Cooling
15
cfm/person
Heating
15
cfm/person
Schedule
Vent - Elementary School
Std 62.1-2004/2007...
Clg Ez
Ceiling clg supply, ceiling retu
Htg Ez
Ceiling htg supply, floor return
Er
Default based on system type
DCV Min OA Intake
None
Room exhaust...
Rate
0
air changes/hr
Schedule
Vent - Elementary School
Infiltration...
Type
Pressurized, Average Const.
Cooling
0.3
air changes/hr
Heating
0.3
air changes/hr
Schedule
Available (100%)
VAV minimum...
Rate
0
% Clg Airflow
Schedule
Vent - Elementary School
Type
Default
Internal Load
Airflow
Thermostat
Construction
Room


Airflow Templates - Project
Alternative
Alternative 1
Description
Gymnasium
Apply
Close
Main supply...
Cooling
To be calculated
Heating
To be calculated
Auxiliary supply...
Cooling
To be calculated
Heating
To be calculated
New
Copy
Delete
Add Global
Ventilation...
Apply ASHRAE Std62.1-2004/2007
No
Type
None
Cooling
20
cfm/person
Heating
20
cfm/person
Schedule
Vent - Elementary School
Std 62.1-2004/2007...
Clg Ez
Ceiling clg supply, ceiling retu
%
Htg Ez
Ceiling htg supply, floor return
%
Er
Default based on system type
%
DCV Min OA Intake
None
Room exhaust...
Rate
0
air changes/hr
Schedule
Vent - Elementary School
Infiltration...
Type
Pressurized, Average Const.
Cooling
0.3
air changes/hr
Heating
0.3
air changes/hr
Schedule
Available (100%)
VAV minimum...
Rate
0
% Clg Airflow
Schedule
Vent - Elementary School
Type
Default
Internal Load
Airflow
Thermostat
Construction
Room


Airflow Templates - Project
Alternative
Alternative 1
Description
Office
Apply
Close
Main supply...
Cooling
To be calculated
Heating
To be calculated
Auxiliary supply...
Cooling
To be calculated
Heating
To be calculated
New
Copy
Delete
Add Global
Ventilation...
Apply ASHRAE Std62.1-2004/2007
No
Type
General Office Space
Cooling
20
cfm/person
Heating
20
cfm/person
Schedule
Vent - Elementary School
Std 62.1-2004/2007...
Clg Ez
Ceiling clg supply, ceiling retu
%
Htg Ez
Ceiling htg supply, floor return
%
Er
Default based on system type
%
DCV Min OA Intake
None
Room exhaust...
Rate
0
air changes/hr
Schedule
Vent - Elementary School
Infiltration...
Type
Pressurized, Average Const.
Cooling
0.3
air changes/hr
Heating
0.3
air changes/hr
Schedule
Available (100%)
VAV minimum...
Rate
0
% Clg Airflow
Schedule
Vent - Elementary School
Type
Default
Internal Load
Airflow
Thermostat
Construction
Room