Technical Report 2

Building & Plant Energy Analysis

Glen Burnie High School: Buildings D, E & F Glen Burnie, MD

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Executive Summary

Glen Burnie High School is a campus style high school located in Glen Burnie, MD. The campus is comprised of 6 buildings, but for the purposes of this report, only Buildings D, E & F were evaluated. Building D is primarily served by unit ventilators, with fan coil units and cabinet unit heaters providing supplemental heating and cooling in corridors, stairways and storage areas. Building E is a constant air volume system served by 9 air handling units with convectors and cabinet unit heaters again serving as supplemental heat. There is also an individual unit ventilator serving the gymnastics area. Building F is the only variable air volume system of the three buildings and is served by 4 air handling units and 1 roof top unit. In the same manner as the previous 2 buildings, fan coil units and unit heaters are used for extra heating and cooling.

Using Trane Trace, the rooms of each building were modeled and templates for internal loads, airflow, thermostat settings, and construction were created. Rate structures were also obtained for Baltimore Gas & Electric, the assumed provider to Glen Burnie High School. These rates were entered into Trace as well, along with their rate schedules. Once this was completed, load calculations were performed resulting in HVAC load, energy, and cost data.

The results of the load calculations were fairly close to the actual design conditions with variances most likely occurring from the differences in the modeling process. The designer's models were created on an individual room basis with actual occupant and load densities used when available. The model which was created for this report was a block load model and load densities had to be assumed based on room type and Trace defaults.

The energy use calculations were not as accurate to what was anticipated. The heating energy use for the buildings was close to what was expected season but the energy use for cooling was grossly inaccurate. The incorrect values were used to complete the remaining calculations, carrying through the mistakes. The inaccuracy of the cooling system's energy use only affected the percentage of the total energy use by each building system, but not their actual values. The overall cost of operation for each building was much lower than was anticipated because of the low cooling rates, but the remaining individual values were approximately what was expected based on the assumed rates.

The carbon footprints of the buildings were calculated using the modeled building energy usages and values from the Regional Grid Emission Factors 2007 pdf supplied. Once again, the inaccuracy of the cooling loads lowered the overall combined emissions of the three buildings, but the calculated values are reasonable based on the modeled, albeit inaccurate, results for overall building energy use.

Mechanical System Overview

Building D:

Building D is a typical classroom building housing the arts and acting arts classrooms, as well as a handful of foreign language classrooms. In addition to classrooms, there are a few faculty planning and conference rooms located around the building. Building D's heating and cooling is supplied by 35 unit ventilators, 8 fan coil units, and 21 cabinet unit heaters. Unit ventilators are primarily located in classroom locations with the fan coil units serving the faculty areas and corridors. Supplemental heating is supplied to the corridors, stairwells and storage rooms by the cabinet unit heaters.

The block load for Building D was performed by splitting the building into 3 zones. Because the room types and mechanical equipment are all fairly similar, the building was zoned by floor. This resulted in separate zones for the 1st, 2nd and 3rd floors.

Building E:

The primary school gymnasium is located in Building E. The building also contains locker rooms, a weight room and a gymnastics area. Heating and cooling is supplied to the building by 9 constant air volume air handling units, 9 hot water convectors, 3 cabinet unit heaters and a single unit ventilator.

Each system is designed to supply areas of similar occupancy and use so Building E was split into zones by system. This resulted in the following breakdown:

Building E Zone Summary	
System	**Zone/Location**
AHU-1	Men's Lockers/Ground Floor
AHU-2	Team Rooms/Ground Floor
AHU-3	Women's Lockers/ Ground Floor
AHU-4	Gymnasium/First Floor
AHU-5	Gymnasium/First Floor
AHU-6	Laundry Room/Ground Floor
AHU-7	Lobby/First Floor
AHU-8	Office/Second Floor
AHU-9	Weight Room/Ground Floor
UV-1	Gymnastics Area/Second Floor
CUH & CONV	Various

Table 1: Building E Zone Summary

Building F:

The most diverse of the 3 buildings is Building F which contains the auxiliary gym and locker rooms on the east end of the building and business education classrooms filling the rest. Building F is the only variable air volume system of the 3 buildings. Heating and cooling is supplied by 4 air handling units, 1 roof top unit, 2 fan coil units and 17 unit heaters.

In the same manner as Building E, the systems of Building F are serve areas of similar occupancy and use. In order to maintain consistency, Building F was also divided into zones by system. The flowing table shows the results:

Building F Zone Summary	
System	**Zone/Location**
AHU-1	First Floor
AHU-2	Second Floor
AHU-3	Gymnasium
AHU-4	Gymnasium
RTU-1	Dance Studio
FCU-1	Women's Locker Room
FCU-2	Men's Locker Room
Unit Heaters	Various

Table 2: Building F Zone Summary

Design Load Estimation

Assumptions:

As stated earlier, each building was divided into zones for the block load calculation. Building D was zoned by floor and Buildings E and F were zoned by system. The indoor and outdoor design air conditions for Baltimore, MD were used and obtained from ASHRAE Fundamentals 2009. Lighting power densities were based on the recommended values from ASHRAE Standard 90.1. Ventilation rates were taken from the design documents. Miscellaneous load densities and people loads came from the pre-sets in Trace for their respective cases. Whenever possible, actual room loads and people counts were used. Brief overviews of assumptions on air and load conditions are listed in the following tables:

Design Air Conditions					
Outdoor Design Conditions			Indoor Design Conditions		
Summer		Winter	Cooling	Heating	Relative Humidity
DB (F)	MCWB (F)	DB (F)	DB (F)	DB (F)	%
93.9	74.9	12.9	78	72	50

Table 3: Design Air Conditions

Occupied Space Design Load Conditions										
Load	Classroom		Gym		Health		Locker Room		Office	
Lighting (W/SF)	1.4		1.4		1.5		0.9		1.1	
Misc (W/SF)	0.22		0		0.5		0		0.5	
People (BTU/hr)	Sensible	Latent	Sensible	Latent	Sensible	Latent	Sensible	Latent	Sensible	Latent
	250	200	700	1000	250	200	275	275	250	200
People	By Room		By Room		By Room		By Room		By Room	

Table 4: Occupied Space Design Load Conditions

These tables only list the occupied spaces because they account for the majority of the loads experienced in the building. For a more detailed breakdown of assumptions and templates used in the Trace calculations, including unoccupied spaces, see the appendix at the end of this report.

Design Loads vs. Model:

Both models were calculated using Trane Trace, but there are differences in the way that the designer's model was created in comparison to the one calculated for this report. The designer's model was created on a room by room basis, while this report dealt with a block load. There were also differences in the load assumptions. In order to obtain a more accurate model the default climate design values in Trace were replaced with values from ASHRAE Fundamentals. Lighting, miscellaneous, and people loads were also set up for different room types, instead of using a default value for all spaces.

The following tables show the comparisons by building between the design values and those of the newly calculated model for cooling loads, heating loads, supply airflows, and ventilation percentages:

Building D Comparisons								
Zone	Cooling SF/ton		Heating BTUh/SF		Supply CFM/SF		Ventilation %OA	
	Design	Model	Design	Model	Design	Model	Design	Model
1st Floor	397.51	498.97	22.95	30.01	0.98	0.81	22	27.8
2nd Floor	317.84	389.77	27.07	33.2	0.85	0.81	24	34.1
3rd Floor	229.37	309.05	33.32	40.07	1.19	1.14	24	25.2

Table 5: Building D Comparisons

Building E Comparisons								
Zone	Cooling SF/ton		Heating BTUh/SF		Supply CFM/SF		Ventilation %OA	
	Design	Model	Design	Model	Design	Model	Design	Model
AHU-1	217.72	449.64	56.84	34.77	0.92	0.61	100	48
AHU-2	184.93	218.45	51.99	65.94	0.91	0.98	100	96.2
AHU-3	219.69	385.33	52.75	32.24	1.09	0.8	100	37.1
AHU-4	133.78	109.22	75.61	42.84	1.55	1.99	42	15.1
AHU-5								
AHU-6	37.72	42.07	101.71	81.38	18.4	10.95	100	1.1
AHU-7	245.33	341.47	50.44	17.73	0.75	0.38	27	17.7
AHU-8	257.85	527.02	51.46	23.15	0.63	0.52	11	14.8
AHU-9	246.15	396.77	47.37	29.16	0.65	0.63	100	47.6
UV-1	221.3	361.47	64.11	41.46	0.77	0.64	28	46.9
CUH & CONV	--	--	57.11	23.28	--	--	--	--

Table 6: Building E Comparisons

Building F Comparisons								
Zone	Cooling SF/ton		Heating BTUh/SF		Supply CFM/SF		Ventilation %OA	
	Design	Model	Design	Model	Design	Model	Design	Model
AHU-1	307.09	384.94	19.01	16.01	1.05	0.77	28	36.3
AHU-2	231.38	324.88	31.19	37.07	1.04	0.89	31	35
AHU-3	284.16	170.81	36.67	49.1	1.09	2.07	20	14.1
AHU-4								
RTU-1	238.81	254.07	42.05	41.76	1.24	1.1	18	26.6
FCU-1	272.53	203.89	31.63	37.69	1.33	1.83	0	0
FCU-2	322.94	236.63	34.41	34.43	1.49	1.64	0	0
UH	--	--	8.99	17.51	--	--	--	--

Table 7: Building F Comparisons

Conclusions:

As seen in the tables, the majority of the values from the model are very close to the values used in the design of the renovation, with a few exceptions. Building D's cooling loads are generally smaller than designed, while the heating loads are larger. The heating load being larger makes sense since the model created for this report was a block load compared to a room by room model for the design, but the cooling load should also be larger. Because it is not, it must be assumed the actual load conditions in the building are larger than assumed. The designer was able to use more accurate information for room occupancy and equipment loadings, but the model was based on standard load densities found in Trace and the occupant density was assumed based on room type. Supply airflow is also smaller, most likely due to the reduced cooling load in the model. A higher outdoor air percentage was calculated for the model but this can be attributed to the larger airflows used by the designer, meaning that a smaller percentage of this larger volume is needed to meet the same rate.

Building's E and F share similar conclusions. In these buildings both the cooling and heating loads are generally smaller, but the heating loads are slightly more accurate than for Building D. Again, this should be attributed to the difference in modeling techniques and load conditions used. Airflow rates are again a small amount lower except for in the AHUs which serve the gymnasiums. The changes with respect to these AHUs is most likely caused by modeling the two together since they serve the same area and have the load split between them. Because of this, the outdoor air percentages are again higher than designed except in cases where the OA percentage was intentionally increased by the designer, such as in the gym and laundry areas.

Annual Energy Consumption and Operating Costs

Assumptions:

In order to keep the model as accurate as possible, each building was modeled separately in Trace. All room types were imported as accurately as possible. For room types in which Trace does not have presets or standards for, the values were found in ASHRAE Fundamentals 2009, ASHRAE Standard 62.1 and ASHRAE Standard 90.1, or the closest match was used/estimated. All room types which were shared between multiple buildings were modeled identically in the program. The cooling and heating plants in Trace were modeled as an air cooled chiller and gas-fired steam boiler, respectively, to match the type of equipment that is currently in operation or being installed as part of this renovation.

Actual energy use and utility bills were not available from the owner for use in this report. A major supplier of gas and electric in the Baltimore, MD area is Baltimore Gas & Electric, so it was assumed that BG&E was the supplier for Glen Burnie High School for these calculations. The following two tables list the rates for both electricity and gas during peak and non-peak times, as well as the rate schedules for when these different rates occur:

Baltimore Gas & Electric Rates					
Electricity				Gas	
Demand Charge	Peak	Mid-Peak	Off-Peak	≤10000 therms	>10,000 therms
($/kW)	(¢/kWh)	(¢/kWh)	(¢/kWh)	($/therm)	($/therm)
3.95	11.551	9.265	8.824	0.1975	0.0948

Table 8: Baltimore Gas & Electric Rates

BG&E Rate Schedule		
Start	End	Rate
11:00 PM	7:00 AM	Off-Peak
7:00 AM	10:00 AM	Mid-Peak
10:00 AM	8:00 PM	Peak
8:00 PM	11:00 PM	Mid-Peak

Table 9: BG&E Rate Schedule

At the time of this report, it was not discovered if an energy or cost analysis was performed by the designer for the mechanical renovation. Therefore, it is assumed to have not occurred. This could be because the project is a renovation and not new construction. Being so, the renovation could be sized to match the current conditions experienced by the owner, not creating any changes.

Building D Results:

MONTHLY UTILITY COSTS
By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Alternative 1													
Electric													
On-Pk Cons. ($)	635	575	690	611	1,053	1,458	1,686	743	1,071	676	644	612	10,453
Off-Pk Cons. ($)	83	75	66	53	45	43	49	41	43	57	62	80	698
Mid-Pk Cons. ($)	250	229	268	234	262	337	465	62	243	256	248	241	3,097
On-Pk Demand ($)	190	189	209	233	406	559	573	299	495	280	250	194	3,877
Off-Pk Demand ($)	22	22	22	22	15	15	28	10	15	22	22	22	235
Mid-Pk Demand ($)	188	188	188	188	258	363	486	160	339	189	188	188	2,924
Total ($):	1,368	1,278	1,443	1,341	2,039	2,775	3,287	1,316	2,206	1,480	1,414	1,337	21,283
Gas													
On-Pk Cons. ($)	178	166	76	20	0	0	0	0	0	26	39	118	622
Off-Pk Cons. ($)	120	112	30	4	0	0	0	0	0	8	19	81	374
Mid-Pk Cons. ($)	198	174	143	67	0	0	0	0	0	79	108	157	926
Total ($):	496	452	249	90	0	0	0	0	0	113	166	356	1,922
Monthly Total ($):	1,865	1,731	1,692	1,431	2,039	2,775	3,287	1,316	2,206	1,593	1,580	1,693	23,206

Building Area = 37,466 ft²
Utility Cost Per Area = 0.62 $/ft²

Figure 1: Building D Monthly Utility Costs

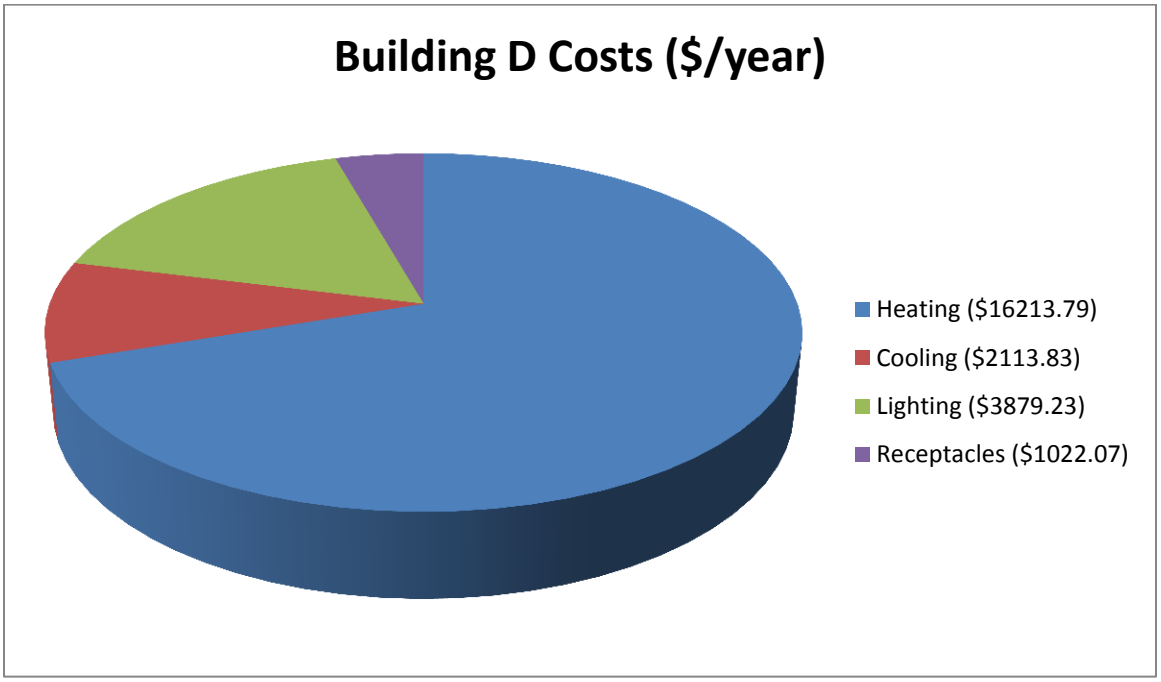

Figure 2: Building D Costs

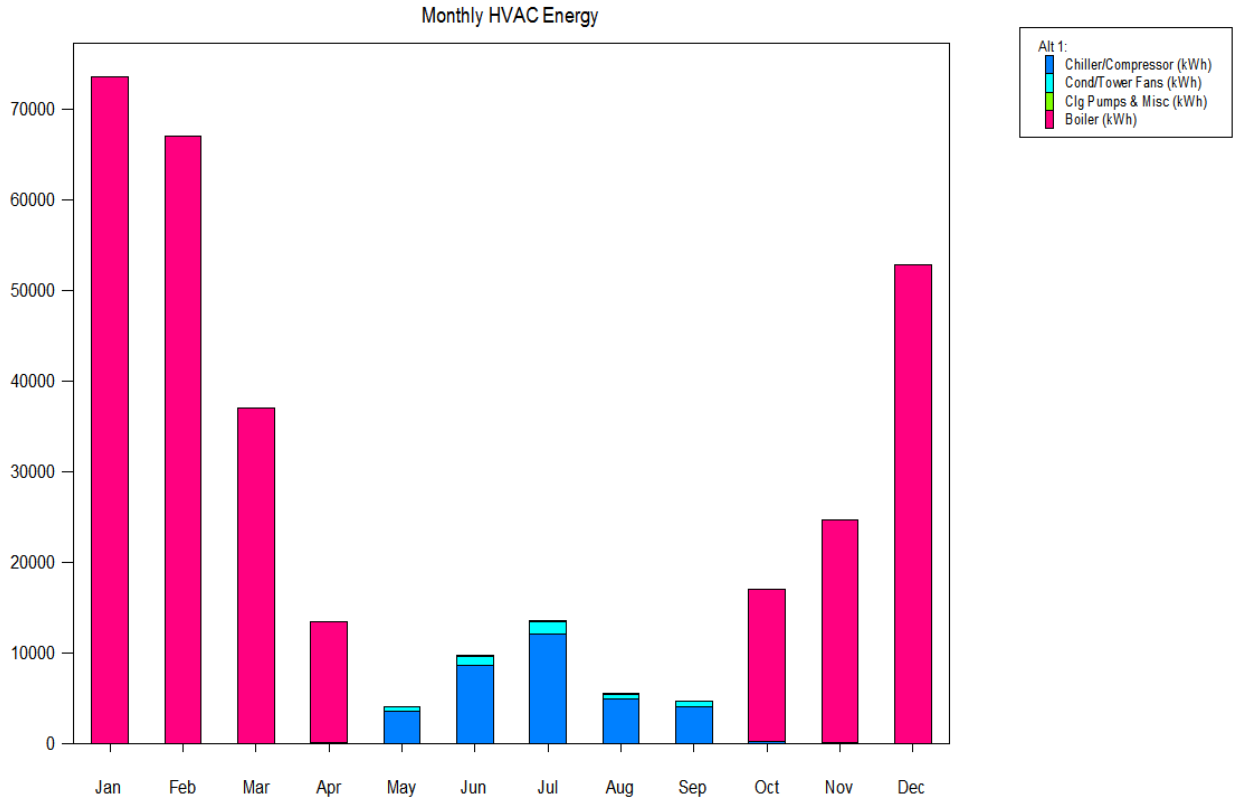

Figure 3: Building D Monthly HVAC Energy

ENERGY CONSUMPTION SUMMARY
By ACADEMIC

	Elect Cons. (kWh)	Gas Cons. (kBtu)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1					
Primary heating					
Primary heating		973,361	68.4 %	973,361	1,024,590
Other Htg Accessories	6,011		1.4 %	20,514	61,548
Heating Subtotal	**6,011**	**973,361**	**69.8 %**	**993,875**	**1,086,138**
Primary cooling					
Cooling Compressor	33,352		8.0 %	113,830	341,523
Tower/Cond Fans	4,219		1.0 %	14,400	43,204
Condenser Pump			0.0 %	0	0
Other Clg Accessories	298		0.1 %	1,017	3,052
Cooling Subtotal....	**37,869**		**9.1 %**	**129,247**	**387,778**
Auxiliary					
Supply Fans			0.0 %	0	0
Pumps			0.0 %	0	0
Stand-alone Base Utilities			0.0 %	0	0
Aux Subtotal....			0.0 %	0	0
Lighting					
Lighting	69,748		16.7 %	238,049	714,218
Receptacle					
Receptacles	18,196		4.4 %	62,104	186,332
Cogeneration					
Cogeneration			0.0 %	0	0
Totals					
Totals**	**131,824**	**973,361**	**100.0 %**	**1,423,274**	**2,374,466**

Figure 4: Building D Energy Consumption Summary

Building E Results:

MONTHLY UTILITY COSTS
By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------ Monthly Utility Costs ------								
Alternative 1													
Electric													
On-Pk Cons. ($)	416	377	569	720	1,197	1,552	1,181	204	1,140	668	589	405	9,018
Off-Pk Cons. ($)	66	60	67	50	33	33	35	31	32	47	53	66	574
Mid-Pk Cons. ($)	162	146	173	147	270	384	462	30	257	158	152	157	2,498
On-Pk Demand ($)	143	214	319	343	505	648	629	151	553	349	326	289	4,468
Off-Pk Demand ($)	17	17	17	17	11	11	15	7	11	17	17	17	175
Mid-Pk Demand ($)	113	113	113	114	354	466	555	58	387	113	113	113	2,614
Total ($):	918	927	1,258	1,390	2,370	3,094	2,878	480	2,381	1,353	1,250	1,047	19,347
Gas													
On-Pk Cons. ($)	184	172	82	13	0	0	0	0	0	15	25	132	623
Off-Pk Cons. ($)	189	163	63	5	0	0	0	0	0	6	21	146	593
Mid-Pk Cons. ($)	195	174	121	47	2	0	0	0	1	52	74	158	825
Total ($):	568	509	266	65	2	0	0	0	1	73	121	437	2,042
Monthly Total ($):	1,487	1,436	1,524	1,456	2,372	3,094	2,878	480	2,382	1,426	1,371	1,483	21,388

Building Area = 26,154 ft²
Utility Cost Per Area = 0.82 $/ft²

Figure 5: Building E Monthly Utility Costs

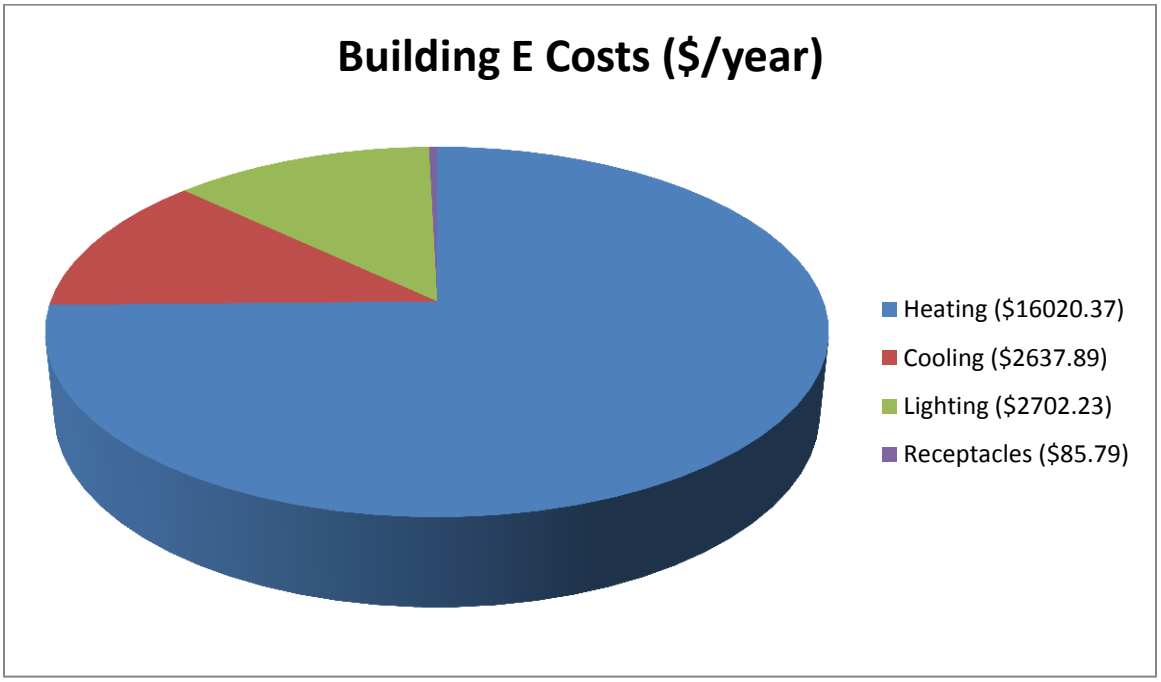

Figure 6: Building E Costs

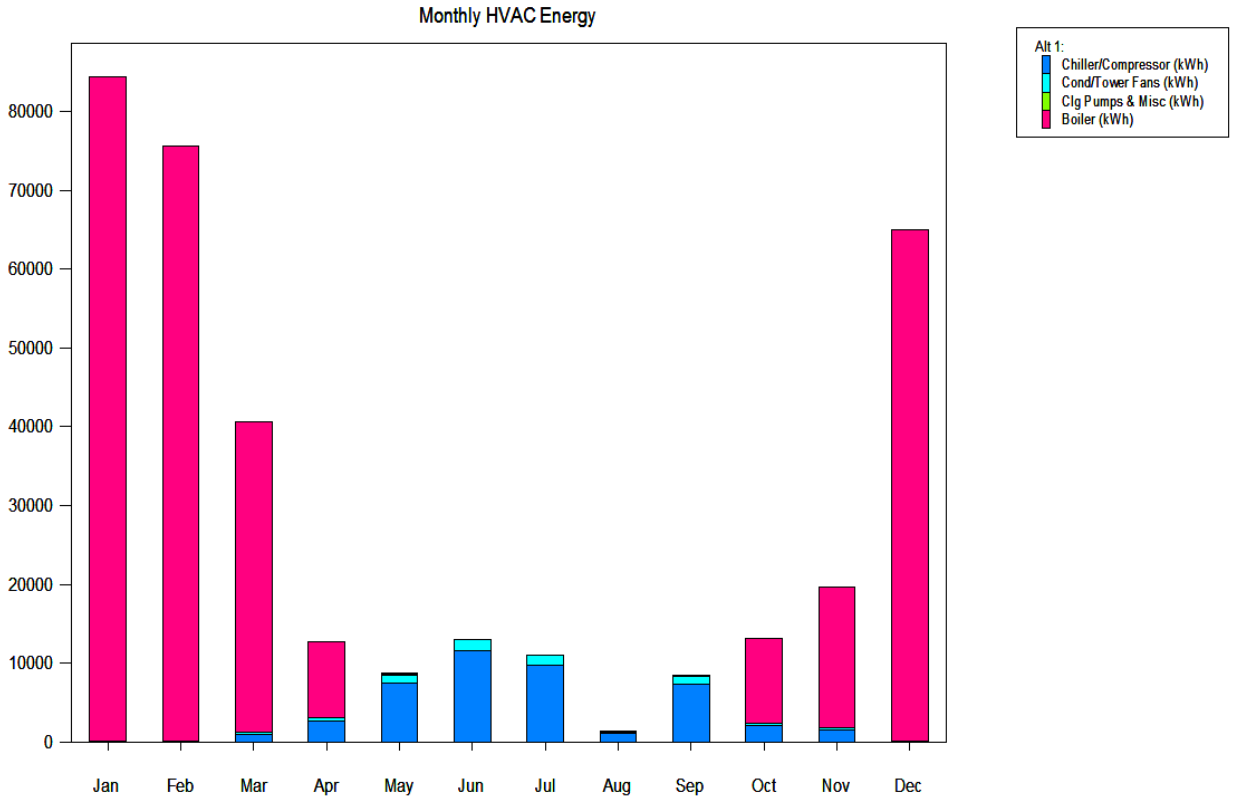

Figure 7: Building E Monthly HVAC Energy

ENERGY CONSUMPTION SUMMARY
By ACADEMIC

	Elect Cons. (kWh)	Gas Cons. (kBtu)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1					
Primary heating					
Primary heating		1,033,694	73.1 %	1,033,694	1,088,099
Other Htg Accessories	6,556		1.6 %	22,374	67,130
Heating Subtotal	**6,556**	**1,033,694**	**74.7 %**	**1,056,069**	**1,155,229**
Primary cooling					
Cooling Compressor	44,541		10.8 %	152,018	456,098
Tower/Cond Fans	6,093		1.5 %	20,794	62,390
Condenser Pump			0.0 %	0	0
Other Clg Accessories	410		0.1 %	1,398	4,194
Cooling Subtotal....	**51,043**		**12.3 %**	**174,210**	**522,682**
Auxiliary					
Supply Fans			0.0 %	0	0
Pumps			0.0 %	0	0
Stand-alone Base Utilities			0.0 %	0	0
Aux Subtotal....			0.0 %	0	0
Lighting					
Lighting	52,390		12.6 %	178,806	536,471
Receptacle					
Receptacles	1,548		0.4 %	5,284	15,855
Cogeneration					
Cogeneration			0.0 %	0	0
Totals					
Totals**	**111,537**	**1,033,694**	**100.0 %**	**1,414,369**	**2,230,237**

Figure 8: Building E Energy Consumption Summary

Building F Results:

MONTHLY UTILITY COSTS
By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------ Monthly Utility Costs ------								
Alternative 1													
Electric													
On-Pk Cons. ($)	1,066	964	1,159	1,040	1,272	1,561	1,402	301	1,345	1,116	1,079	1,027	13,332
Off-Pk Cons. ($)	118	106	118	114	72	70	74	67	69	100	114	118	1,141
Mid-Pk Cons. ($)	425	384	457	407	433	394	525	89	395	432	422	409	4,771
On-Pk Demand ($)	317	317	326	335	525	776	790	309	694	389	341	319	5,441
Off-Pk Demand ($)	32	32	32	32	32	24	24	13	24	32	32	32	343
Mid-Pk Demand ($)	315	315	316	318	333	446	606	126	441	320	317	315	4,165
Total ($):	2,273	2,119	2,408	2,246	2,668	3,272	3,421	905	2,968	2,388	2,306	2,219	29,192
Gas													
On-Pk Cons. ($)	286	270	116	33	1	0	0	0	0	43	70	182	1,001
Off-Pk Cons. ($)	249	233	95	23	0	0	0	0	0	29	60	186	875
Mid-Pk Cons. ($)	298	270	220	108	1	0	0	0	0	117	162	239	1,415
Total ($):	833	773	431	165	2	0	0	0	0	188	291	607	3,290
Monthly Total ($):	3,107	2,891	2,839	2,410	2,669	3,272	3,421	905	2,968	2,577	2,597	2,826	32,482

Building Area = 54,460 ft²
Utility Cost Per Area = 0.60 $/ft²

Figure 9: Building F Monthly Utility Costs

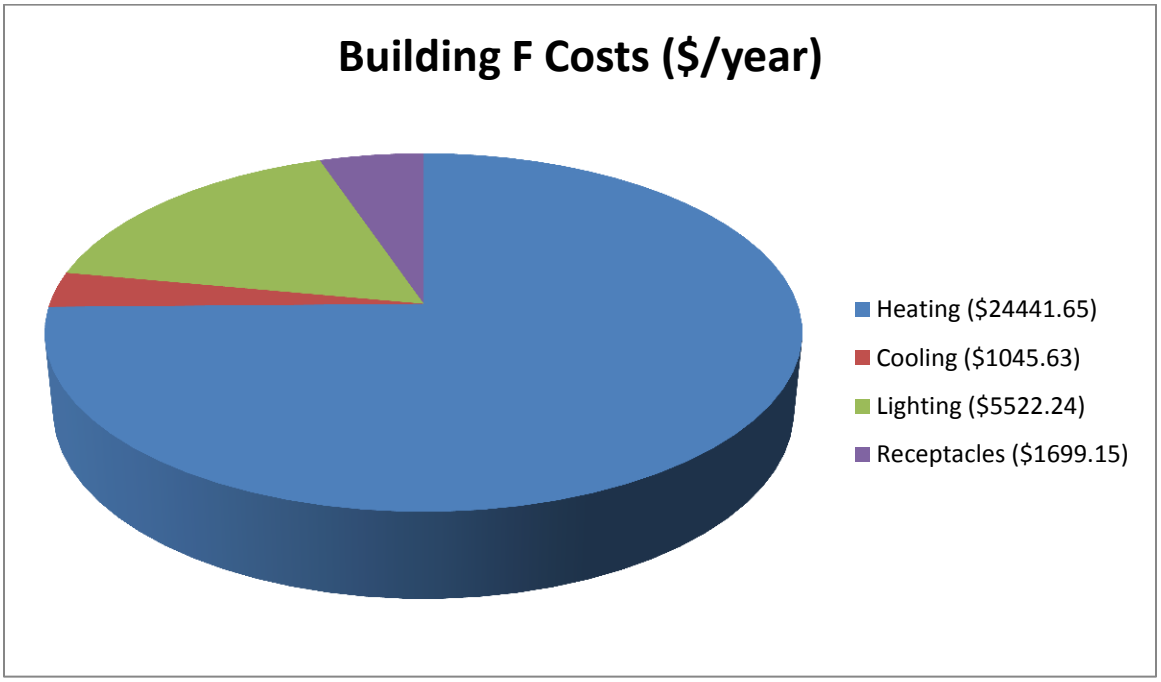

Figure 10: Building F Costs

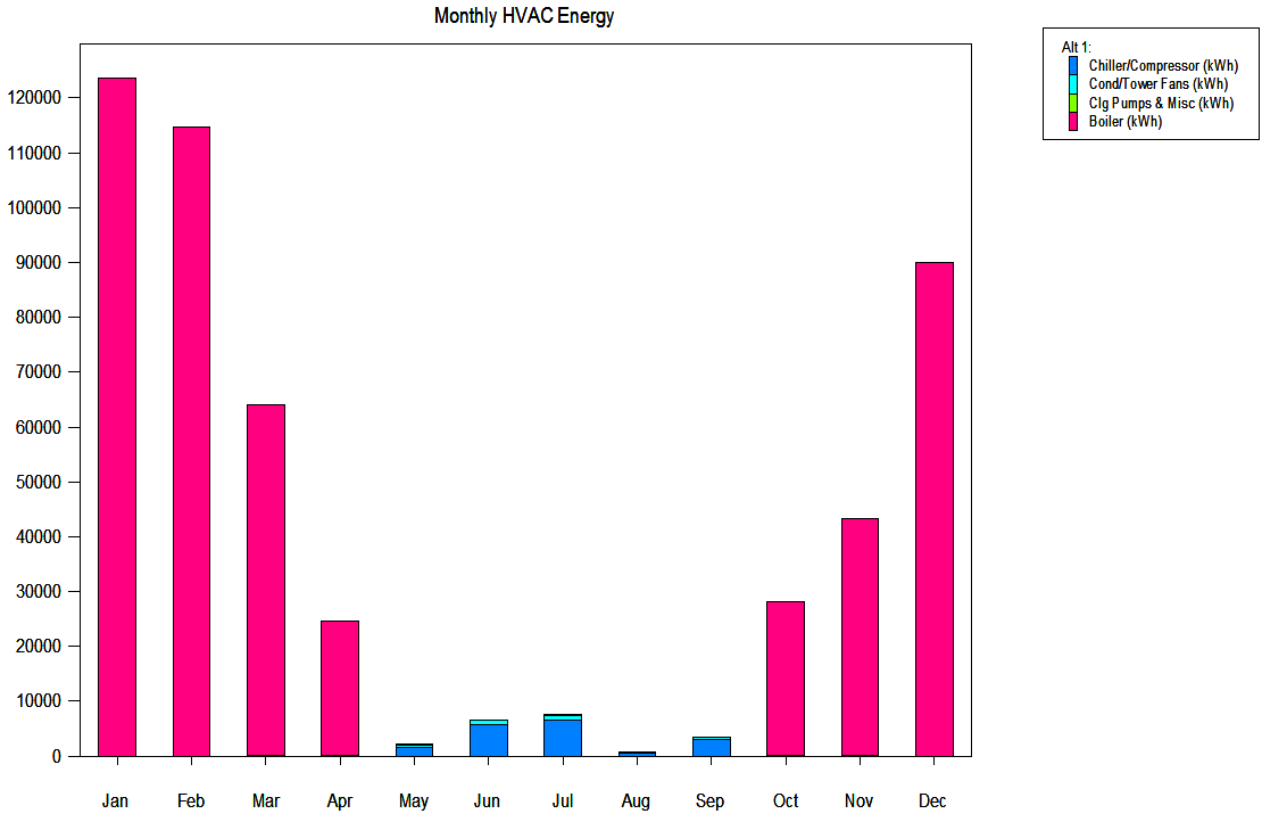

Figure 11: Building F Monthly HVAC Energy

ENERGY CONSUMPTION SUMMARY
By ACADEMIC

	Elect Cons. (kWh)	Gas Cons. (kBtu)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy * (kBtu/yr)
Alternative 1					
Primary heating					
Primary heating		1,665,839	73.1 %	1,665,839	1,753,515
Other Htg Accessories	11,440		1.7 %	39,044	117,145
Heating Subtotal	**11,440**	**1,665,839**	**74.8 %**	**1,704,883**	**1,870,659**
Primary cooling					
Cooling Compressor	17,852		2.7 %	60,928	182,802
Tower/Cond Fans	2,867		0.4 %	9,785	29,357
Condenser Pump			0.0 %	0	0
Other Clg Accessories	301		0.1 %	1,029	3,086
Cooling Subtotal....	**21,020**		**3.2 %**	**71,741**	**215,245**
Auxiliary					
Supply Fans			0.0 %	0	0
Pumps			0.0 %	0	0
Stand-alone Base Utilities			0.0 %	0	0
Aux Subtotal....			0.0 %	0	0
Lighting					
Lighting	112,916		16.9 %	385,381	1,156,258
Receptacle					
Receptacles	34,463		5.2 %	117,621	352,899
Cogeneration					
Cogeneration			0.0 %	0	0
Totals					
Totals**	**179,838**	**1,665,839**	**100.0 %**	**2,279,627**	**3,595,062**

Figure 12: Building F Energy Consumption Summary

Conclusions:

The energy usage for the buildings appears to be reasonable for the heating season but grossly inaccurate for the cooling season. After several repeatedly failed attempts to find the error in the Trace files, the values were used to carry on with the rest of the calculations. Because the cooling system's energy use is so low, this affects the cost of operation. Values for energy use for the other building systems appear to be accurate, and the incorrect cooling values only affect the percentage of the total, the actual values themselves should not change if the cooling load is corrected.

For the cost analysis, the same issue exists. The overall cost of operation for each building was much lower than was anticipated, but the individual values, aside from cooling, were approximately what was expected based on the assumed rates. If the cooling load had been correct, a more balanced representation of the overall cost of operation for the building would be available.

Annual Carbon Footprint

Values to calculate the carbon footprint for each building were obtained from the supplied pdf "Regional Grid Emission Factors 2007". Tables B-10 and 8 in the document gave the emission factors for the state of Maryland based on electricity and a natural gas-fired commercial boiler, respectively. The following tables show the breakdowns for each:

Emission Factors for Electricity			
	(lb/kWh)	(kWh/year)	(lb/year)
CO_2e	1.82	423199	770222.2
CO_2	1.71	423199	723670.3
CH_4	4.02E-03	423199	1701.26
N_2O	3.54E-03	423199	1498.124
NO_X	3.10E-03	423199	1311.917
SO_X	1.11E-02	423199	4697.509
CO	1.19E-03	423199	503.6068
TNMOC	7.74E-05	423199	32.7556
Lead	1.16E-07	423199	0.049091
Mercury	3.56E-08	423199	0.015066
PM10	9.25E-05	423199	39.14591
Solid Waste	1.69E-01	423199	71520.63

Table 10: Emission Factors for Electricity

Emission Factors for Natural Gas				
	(lb/1000 CF)	(kBTU/year	(kBTU/CF)	(lb/year)
CO_2e	1.23E+02	3672.89	1.01	456283.1
CO_2	1.22E+02	3672.89	1.01	452573.5
CH_4	2.50E-03	3672.89	1.01	9.274047
N_2O	2.50E-03	3672.89	1.01	9.274047
NO_X	1.11E-01	3672.89	1.01	411.7677
SO_X	6.32E-04	3672.89	1.01	2.344479
CO	9.33E-04	3672.89	1.01	3.461074
VOC	6.13E-03	3672.89	1.01	22.73996
Lead	5.00E-07	3672.89	1.01	0.001855
Mercury	2.60E-07	3672.89	1.01	0.000965
PM10	8.40E-03	3672.89	1.01	31.1608

Table 11: Emission Factors for Natural Gas

References:

ASHRAE. 2007, ANSI/ASHRAE, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

ASHRAE. 2007, ANSI/ASHRAE, Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

ASHRAE. 2009, *2009 ASHRAE Handbook-Fundamentals.* American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA.

Bid Documents and Project Specifications for Glen Burnie High School Buildings D, E & F

Appendix:

The following appendix contains the Trace templates for each building used in the load calculations, including: Internal Loads, Airflow, Thermostat, and Construction.

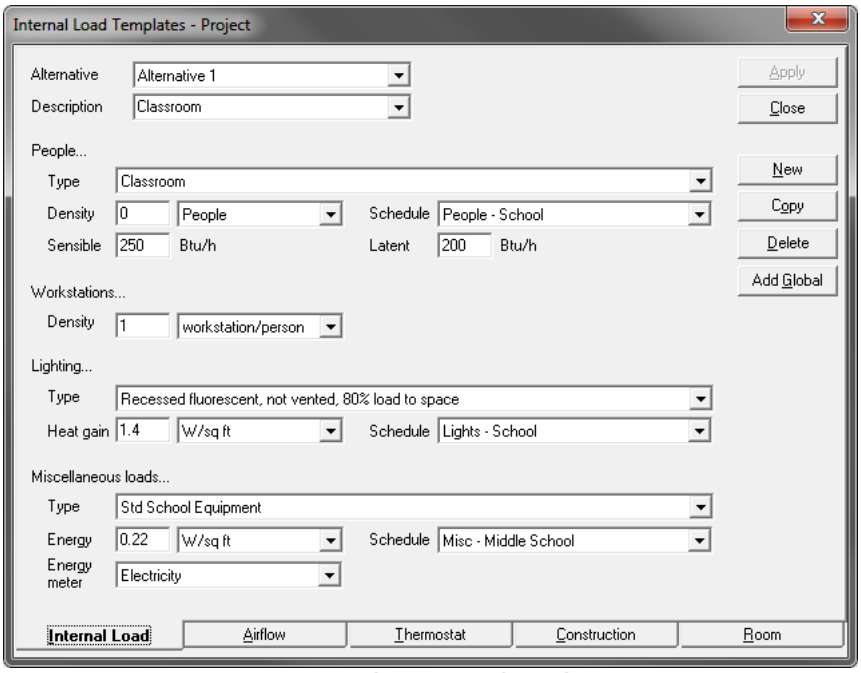

Figure A1: Classroom Load Template

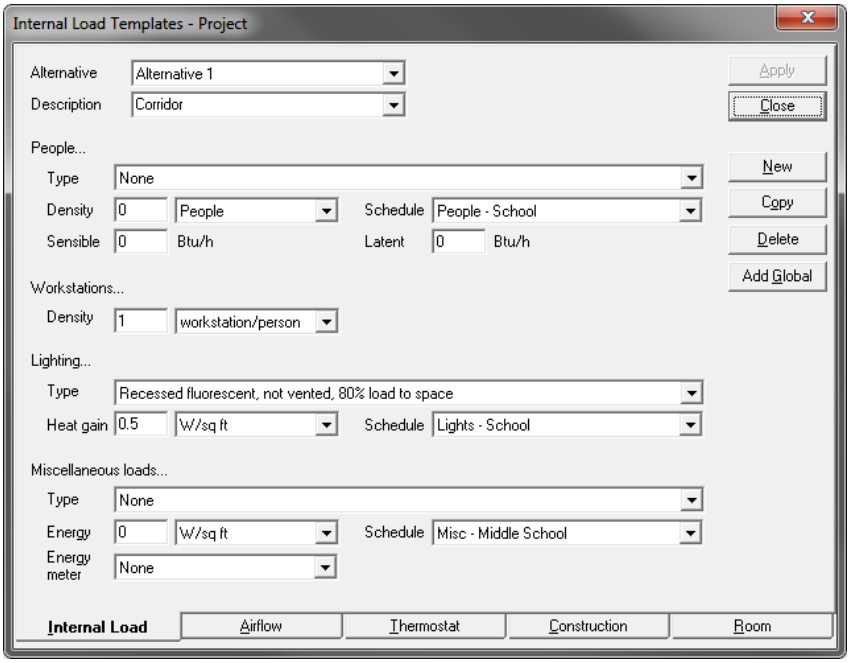

Figure A2: Corridor Load Template

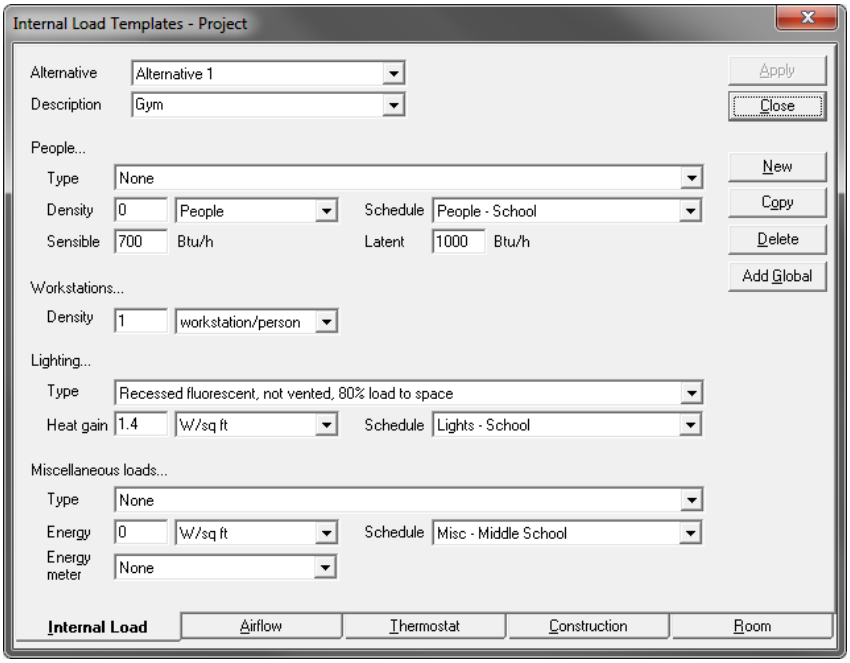

Figure A3: Gym Load Template

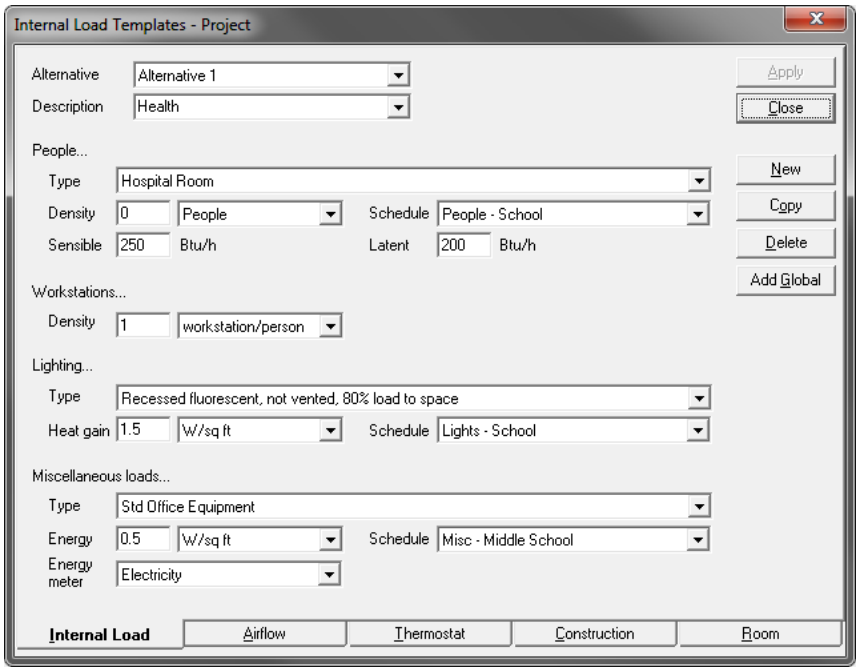

Figure A4: Health Load Template

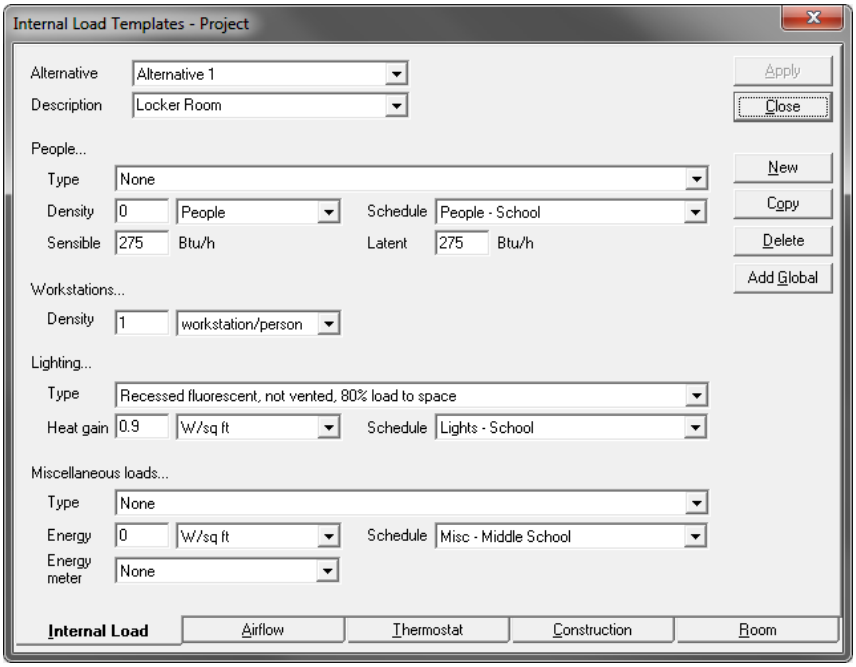

Figure A5: Locker Room Load Template

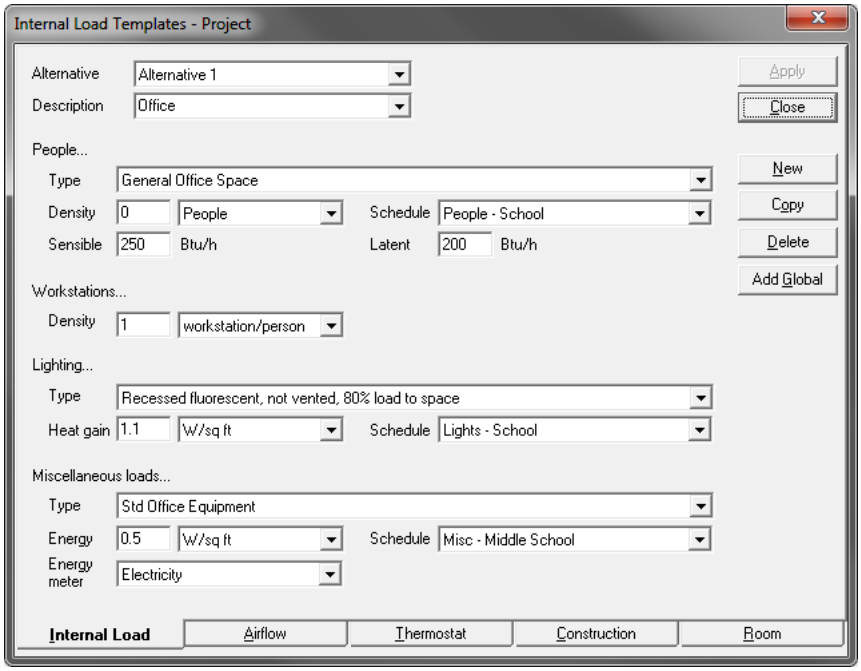

Figure A6: Office Load Template

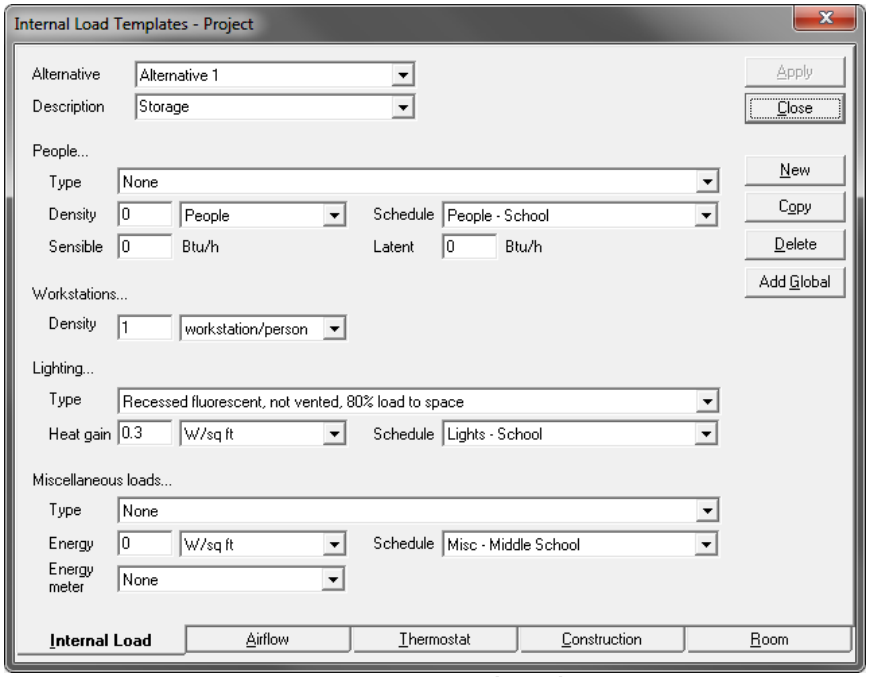

Figure A7: Storage Load Template

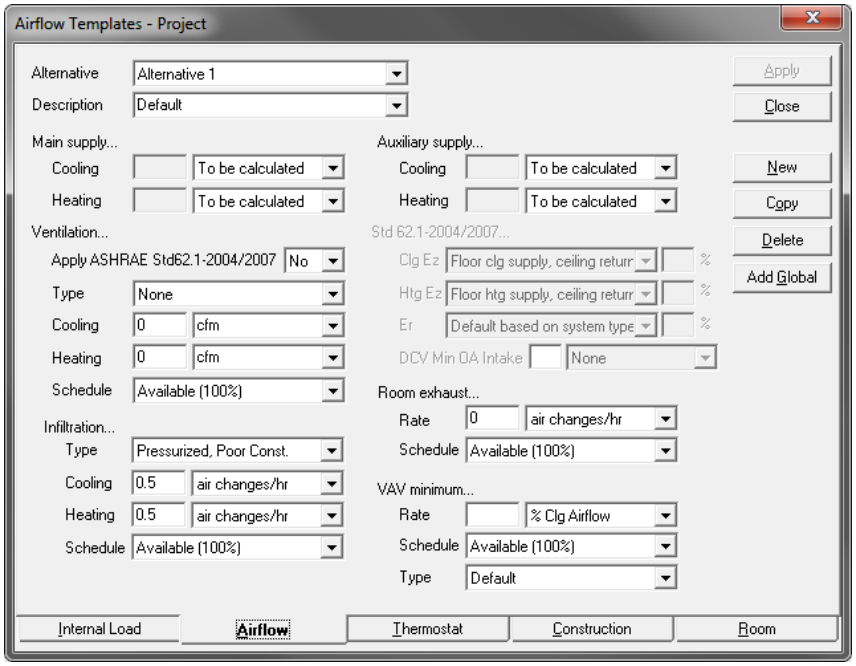

Figure A8: Default Airflow Template

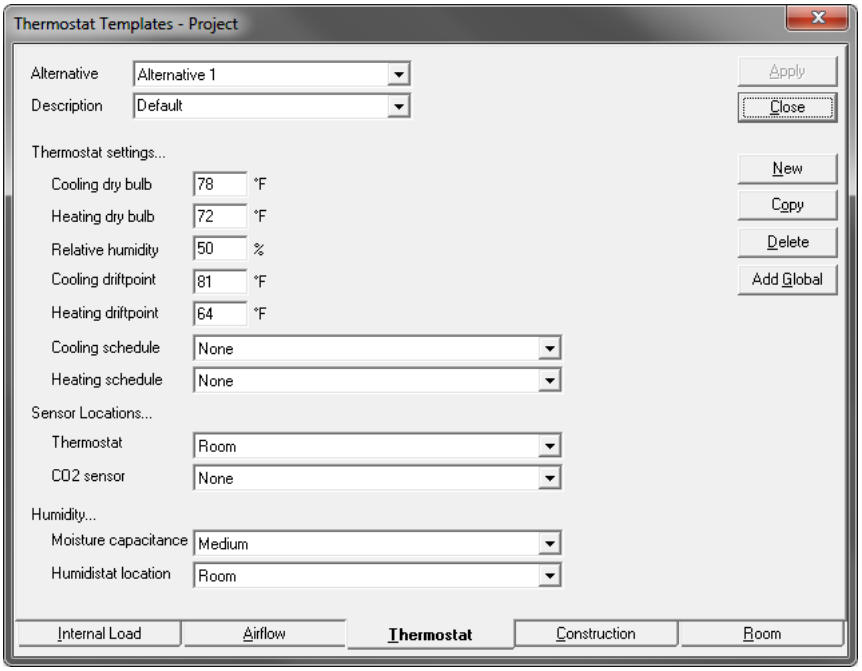

Figure A9: Default Thermostat Template

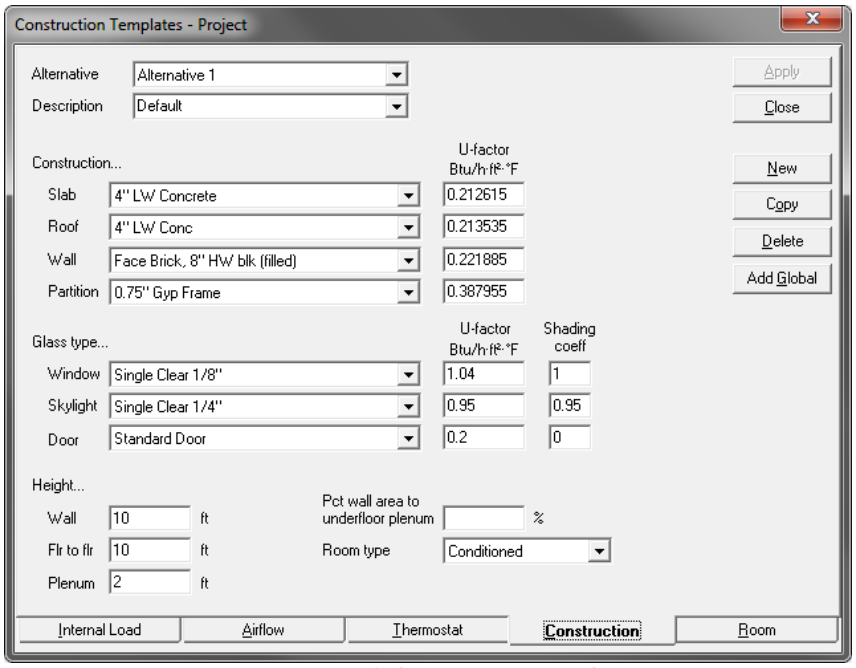

Figure A10: Default Construction Template