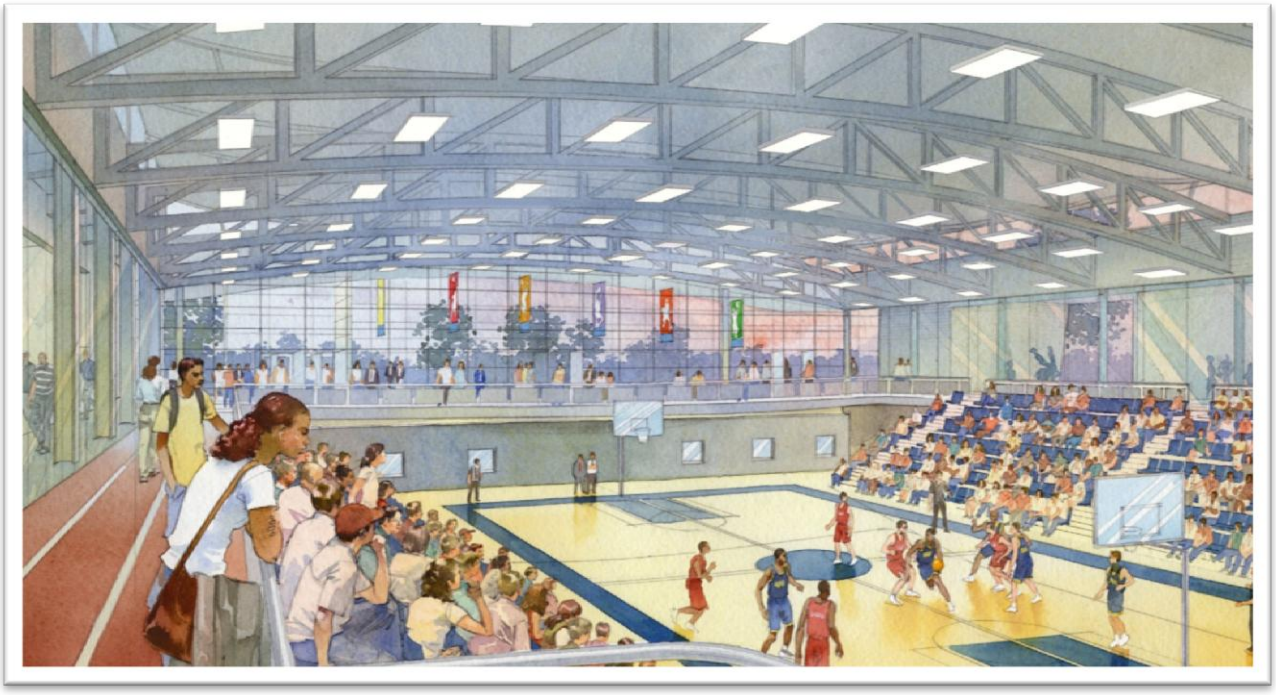
Technical Report 2:*(Building & Plant Energy Analysis Report)*

Due Date: October 27, 2010

The Mirenda Center for Sports, Spirituality, and Character Development



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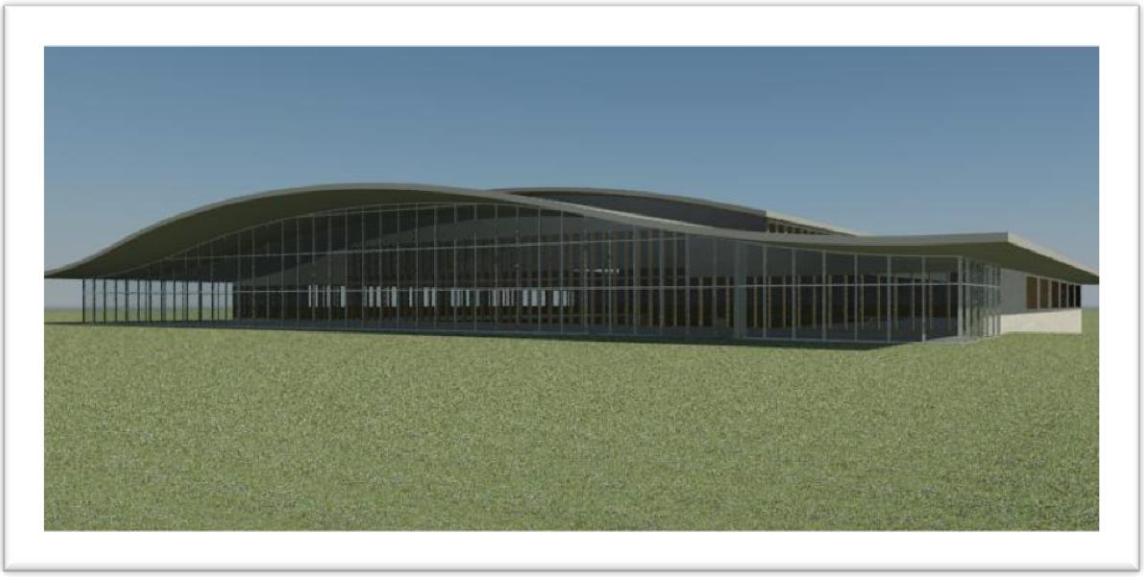
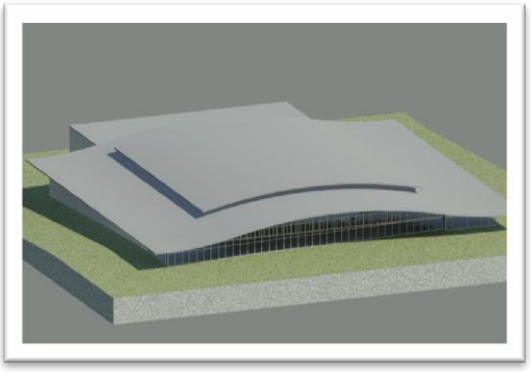
Executive Summary

General Building Overview

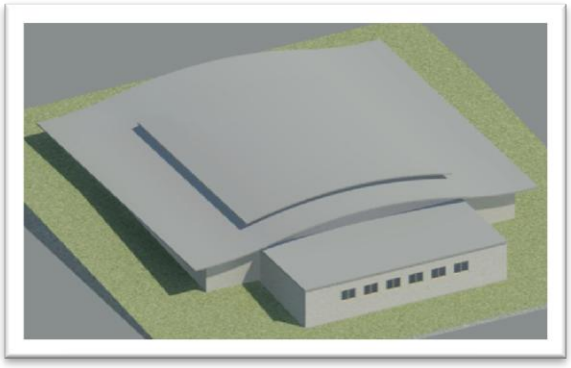
The Mirenda Center for Sports, Spirituality, and Character Development (CSSCD) is a two story building. The ground floor entrance is at the second level in the front of the building, while the lower level is underground at the front of the building while the sloping topography brings the lower level to exit at ground level in the rear of the building. See Exploded View on following page.



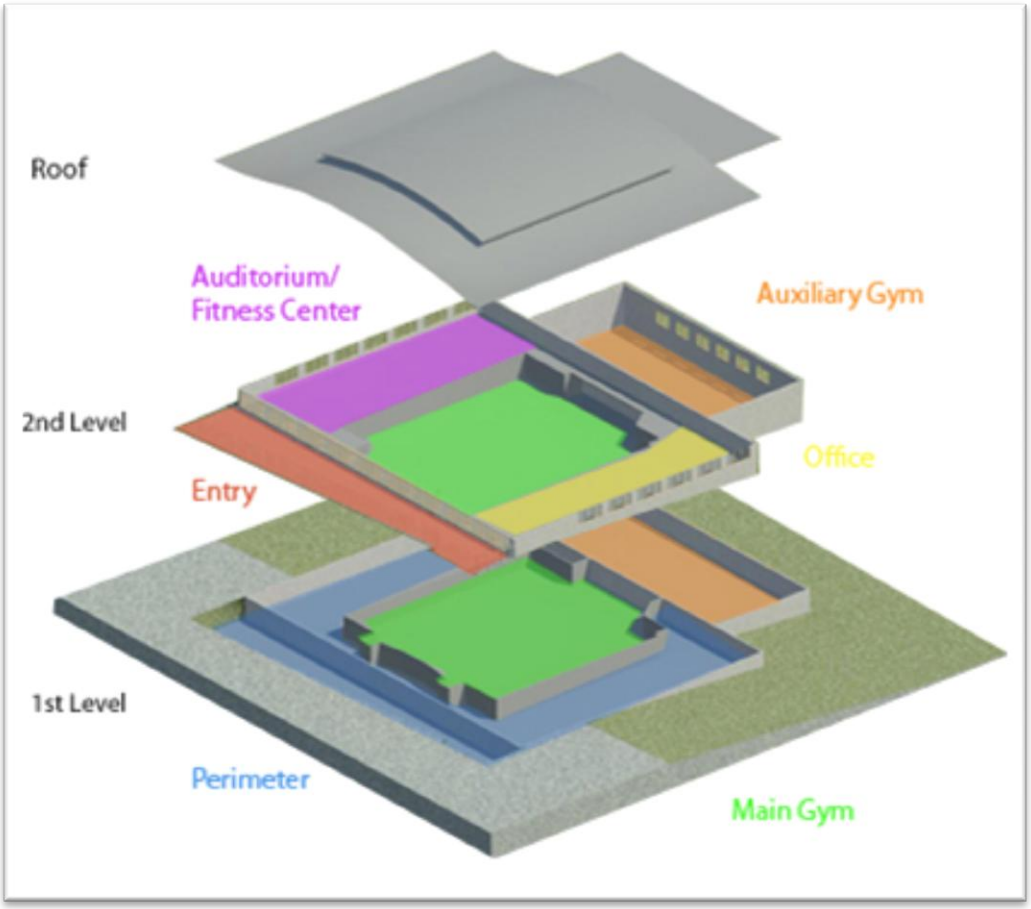
The core of the building is the main gymnasium that seats up to 1450 spectators at the lower level. Wrapped around the main gym at the second level is an indoor running track. The outer most perimeter is as follows: Offices on the east side, Auxiliary gym on the north side, multipurpose and fitness center on the west side, and open glazed atrium on the south side. See Exploded View on following page.



Front View



Rear View



Exploded View

Mechanical System Overview

The Mirenda Center is primarily heated and cooled by 6 roof top air handling units; their location is above the auxiliary gym. RTU-5&6 serve the main gymnasium and the indoor running track in unison. RTU-3 & 4 serve only the auxiliary gym. RTU-1 and 2 serve the remaining perimeter spaces: the auditorium and fitness center, the offices, and entry. There is natural gas burners for heating of the RTU's and reheats for each zone in the constant air volume boxes. There is also electric resistant strip heat around the perimeter of the building. This electric resistance heat is primarily to keep condensation from forming on the glazing.

Design Load Estimation

The MirendaCenter is located in Philadelphia, Pennsylvania. The location information is defined by ASHREA Handbook of Fundamentals for 4% for heating and 99.6% for cooling. This information was used for the Student Energy Model.

There is a set thermal capability of the TheMirenda Center to hold heat inside of itself due to its building material construction type. The values were selected based on wall construction masonry units, air gaps, membranes, and roof construction for a 'built up roof' with metal deck, 6 inch cellulose insulation, and also an epdm roofing membrane.

Overall U-Factors		
Roof	0.047	Btu/h·ft²·°F
Wall	0.121	Btu/h·ft²·°F
Building	0.078	Btu/h·ft²·°F

Once the materials are fixed and the design is complete, an outdoor weather load data of Philadelphiawas applied to the building. The annual weather load is only a piece of the total load on the building. There are also people that emit heat, both sensible and latent. People can will be a significant load on the building because at one situation there will be 1450 spectators/players in the main gymnasium. There are equipment loads such as standard office equipment in the office spaces. There will also be fitness equipment such as treadmills, ellipticals, stairmasters, etc. Each piece emits a constant thermally load that can sum to significant amount if not considered in the initial design. There are also lights. Incandescent light emit approximately 90% of the electrical power that it uses as heat. Fluorescent lights are much less approximately 10%. Both were considered for The Mirenda Center. Now that all the external and internally loads are considered the building must be separated into zones per piece of equipment that will be serving it. The sectioning of the building can be seen in the Mechanical System Overview.

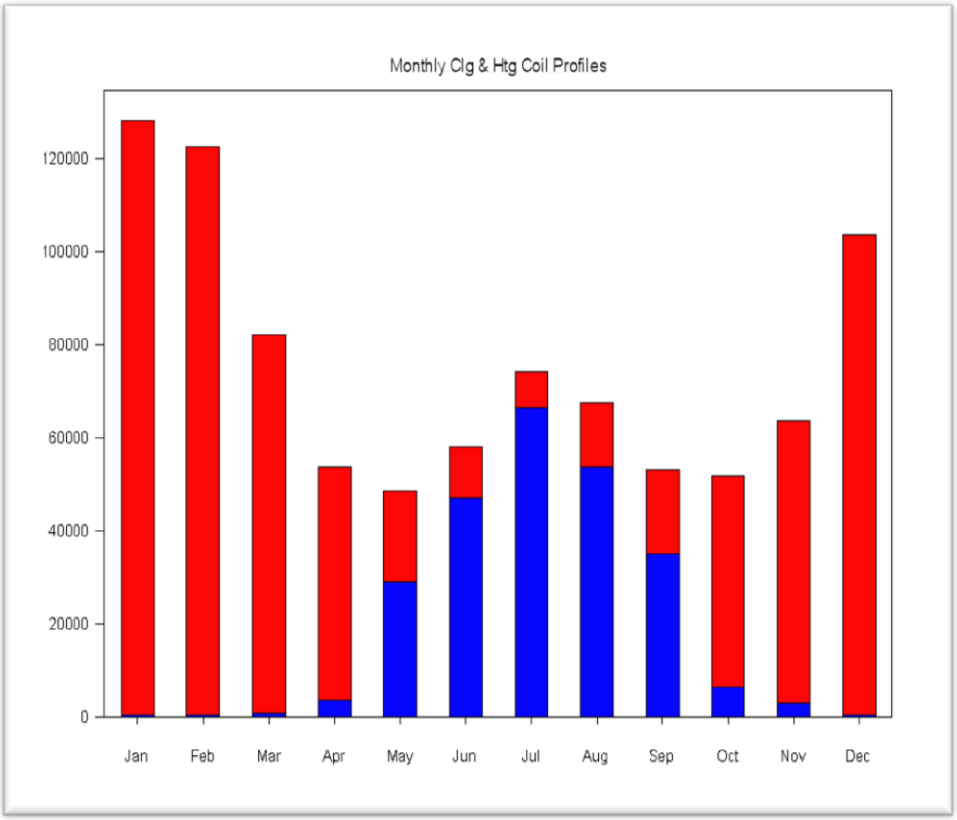
1. Heating and Cooling Loads

Heating Load

The heating load for the building is met by the combination of gas burners in the RTU units and the electric resistance heat both within the spaces, and reheat coils per system description. *(one or the other, or the combination of the two)* The heating load is found from the coldest day and the coldest hour prior to the sun rise. Typically this day is mid-winter. Max heating data for each system is as follows: Auxiliary Gym requires 571.0MBh of heating, Main gymnasium requires 575.9 MBh of heating, and the perimeter system requires 580.9MBh of heating.

Cooling Load

The max cooling load for The Mirenda Center is interesting, it is not necessary in the summer time. There are two possible scenarios that could happen in order to find the max cooling load. The first is the standard hottest day of the hot month at the hottest hour, which is July 16th.The second more interesting possibility is the basketball season. The Mirenda Center holds 1450 people with both the players and spectators includes. The human body load is so significant that the building is required to cool during the debt of winter. 1450 people is approximately 760,000 Btu/h. This load does not quiet trump the total load found in July. Thus equipment size shall be determined from the max monthly cooling load rules. July 16th data for each system is as follows: Auxiliary Gym requires 41 tons of cooling, Main gymnasium requires 152.4 tons of cooling, and the perimeter system requires 125.1 tons of cooling.



Cooling*(Tons)*
Heating*(Btu/hr)*

2. O.A. Ventilation Rates

Outdoor Ventilation rates were taken from the mechanical drawings of the construction documents. RTU 1 is 8800 cfm, RTU 2 is 8500 cfm, RTU 3&4 combined are 7200 cfm, and RTU 5&6 are 242000 cfm.

3. Lighting and Equipment Loads

Space Classification	**Lights**, W/sf
Main Gym	2.26
Aux Gym	1.27
Fitness Center	0.3
Offices	1
1st Floor Perimeter	0.84

The Perimeter spaces are compiled of the offices, teaching spaces, fitness center, restrooms, storage, and corridors. The lighting values for first floor perimeter spaces were averaged at 0.84 watts per square foot. This was done to simplify the energy model for the sake of doing a block load. The

Space Classification	**Equipment**, W/sf
Fitness Center	2
Offices	1
1sr Floor Perimeter	0.25

Equipment was considered for the fitness center, 2nd floor perimeter office, and 1st floor perimeter spaces. The fitness center is filled with the most recent cardio workout equipment. Nearly every piece of equipment in the fitness center has motorized parts and built in television combined with lcd monitors.

4. Occupancy Data

The occupants of The Mirenda Center are comprised of the following. The office has 178 occupants, the fitness center and auditorium has 100 occupants combined, the welcoming center/atrium/entry has 139 occupants, the remainder of the perimeter spaces has 230 occupants, the auxiliary gym has 240 occupants, and the main gymnasium has 564 for the non-basketball seasons schedule, and 1450 occupants for the basketball seasons schedule. The occupancy is at its maximum for all rooms, thus this is most likely an overestimate of the people load for the building. Rarely will all rooms be filled with people at once.

5. Indoor and Outdoor Air Conditions

Indoor conditions were determined by the designer with the acceptable range of the ASHRAE 55 Thermal Comfort. The values set for winter heating 72 °Fand the summer cooling are 74 °F.

Outdoor conditions as referenced in the Design Load Estimation of this section are from the ASHRAE Handbook of Fundamentals for 2008. The locality is Philadelphia, Pennsylvania. The outdoor drybulb temperaturesminimum and maximumtemperatures are 12 °F dB for the heating season and 93 °F dB/76 °F wBfor the cooling season.

6. Load Sources and Schedules

The exterior loads are the façade exposure to the variation of temperature for the year and variation of solar exposure. The interior loads are people, equipment, lights, and miscellaneous plugs loads. Each of these loads has a schedule associated with them, and the most difficult to quantity with a consistent schedule is not doubt people. There are 4 systems air systems RTUs – 1&2 essentially are for the perimeter loads, RTU-3&4 are paralleled and work together to meet the auxiliary gym's load, while RTU 5&6 are paralleled to meet the main gym's load.

The schedule for RTU – 1&2 is a more common School schedule 7am to 5pm with a dip in the middle for lunch during weekdays. RTU-3&4 is the auxiliary gym where is must be utilized during school hours for recreational class but then also for after school activities such as practices. The most difficult schedule is the main gymnasium with RTUs 5&6.

7. Comparison of Energy Model to Design Data

Students Energy Model				**Cooling**	**Heating**
	sqft/ton	*cfm/ton*	*cfm/sqft*	*cfm*	*cfm*
Main Gym	105	182	1.74	27848	27848
Aux Gym	213	175	0.82	7204	7204
Perimeter	327	262	0.8	26980	26980

Designed Documents				**Cooling**	**Heating**
	sqft/ton	*cfm/ton*	*cfm/sqft*	*cfm*	*cfm*
Main Gym	110	275	2.51	17300	12700
Aux Gym	154	282	1.83	7300	7200
Perimeter	221	211	0.95	24200	20100

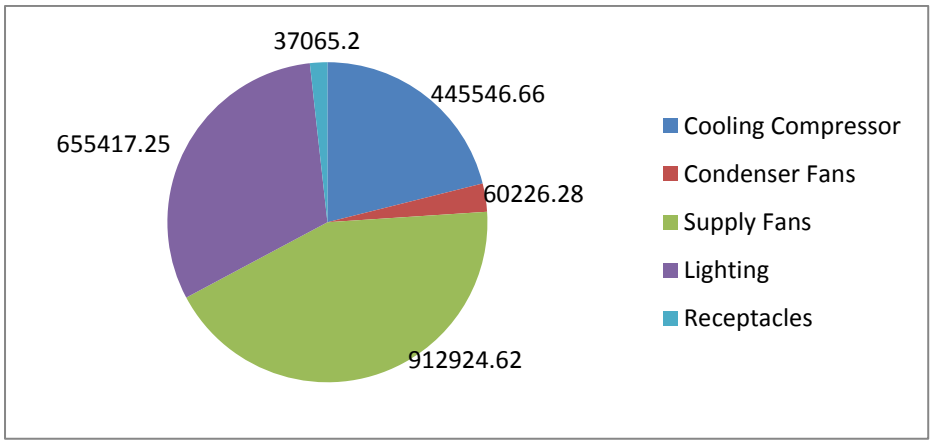
The Student Energy Model has redundant cfm values for the cooling and heating. This could partially be because of the outdoor air requirement of 100% in both seasons. The reason they are both so high is because of the maximum occupancy.

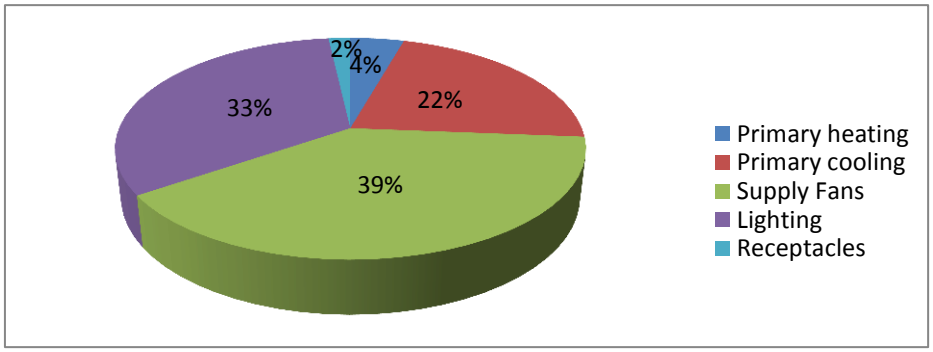
Annual Energy Consumption and Operating Costs

1. Annual Energy Consumption

The energy consumption of The Mirenda Center follows the standard cycle of the weather patterns. There is a higher heating rate in the winter months which convert to gas bills for the natural gas burners in the roof top units in conjunction with the electric bills for resistance heat for both space heat and reheat in ducts.

The highest energy consumed due to electrically ran equipment, such as fans, lights, and majority of the cooling equipment.



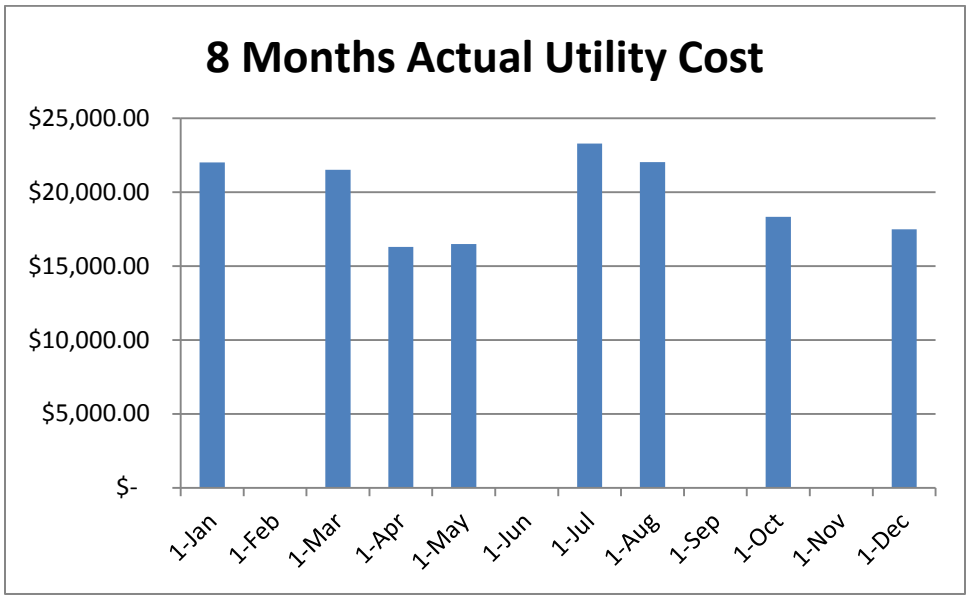


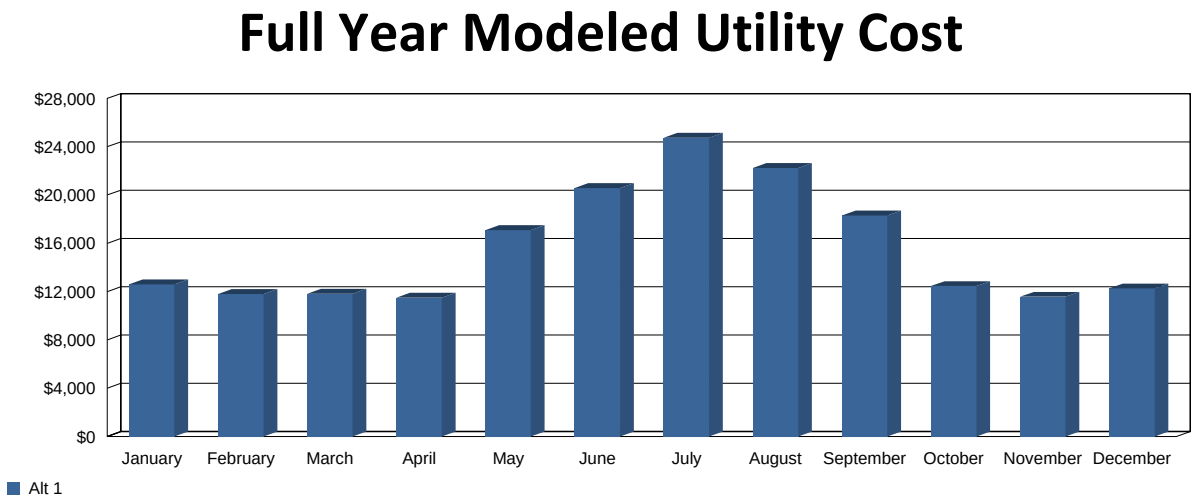
Total Source Energy	*(kBtu/yr)*
Primary heating	902839
Primary cooling	4478760
Supply Fans	8040356
Lighting	6711488
Receptacles	367432

Fairly high assumptions were made for the lighting values. Particularly in the main gymnasium, there was an allowance for 2.26 *W/sq ft*. This number is very large, however justified for the space that they serve

The rate structures for electricity are defined by peco electric.

- http://www.peco.com/pecobiz/energy_rates/our_rates_and_prices.htm





2. Schedule of Building Type

Overall Building Operation Schedule:

- Weekdays: 7 am to Midnight
- Weekends: 10 am to 11 pm
- Summer: 8:30 am to 10 pm

Fuel Costs:

Electrical Rate Structure

Peak Demand	$6.65 /kW
Off Peak Demand	$3.25 /kW
Peak Consumption	$0.07 /kWh
Off Peak Consumption	$0.06 /kWh

Gas Rate Structure

Fixed Rate	$25.00
Variable Rate	$3.78 Mcf for the first 200 Mcf
	$2.64 Mcf for additional

Equipment Performance Characteristics:

Constant Volume with Mixing

Main Gymnasium RTU 5&6	
Supply Fan	0.7 in w.g. @ 0.0002 kW/Cfm-in w.g.
Auxiliary Gymnasium RTU 3&4	
Supply Fan	0.7 in w.g. @ 0.0002 kW/Cfm-in w.g.
Perimeter RTU 1&2	
Supply Fan	0.7 in w.g. @ 0.0002 kW/Cfm-in w.g.

3. Confirmation from Engineer of Energy Analysis

Yes there was an energy model ran by the engineer. For detailed information of roof top air handling units from Engineers model see Appendix.

4. Compare results to Engineers Energy Model

	Engineer's Model		Student's Model	
	Cooling	Heating	Cooling	Heating
	MBh	*MBh*	*MBh*	*MBh*
RTU 1&2	1576	397	1501	581
RTU 3&4	541	256	493	575
RTU 5&6	1378	521	1829	571

The Student's Model according to the figure above has higher load values for heating on RTUs 1&2 and RTUs 3&4. When the model was simulated the internal heat from the occupants was only considered for cooling purposes. This may be the reason why more heating is required for the first two systems.

5. Compare Energy Model with Actual Energy Bills

Actual Building Utility Bills				
Dates -Period		Gas	Elect	Total
Begin	End			
9-Oct	9-Nov			$ -
9-Nov	9-Dec	$ 1,243.05	$ 16,233.99	$ 17,477.04
9-Dec	10-Jan	$ 2,689.61	$ 19,324.49	$ 22,014.10
10-Jan	10-Feb			$ -
10-Feb	10-Mar	$ 1,604.17	$ 19,914.08	$ 21,518.25
10-Mar	10-Apr	$ 496.22	$ 15,785.64	$ 16,281.86
10-Apr	10-May	$ 381.76	$ 16,102.70	$ 16,484.46
10-May	10-Jun			$ -
10-Jun	10-Jul	$ 135.66	$ 23,146.23	$ 23,281.89
10-Jul	10-Aug	$ 137.94	$ 21,885.70	$ 22,023.64
10-Aug	10-Sep			$ -
10-Sep	10-Oct	$ 279.69	$ 18,036.99	$ 18,316.68
	Totals	$ 6,968.10	$ 150,429.82	$ 157,397.92

According to the 8 months of utility data The Mirenda Center costs approximately $2.42 per eight months. Remembering that the utilities considered were only gas and electric. The modeled cost data can be seen the Annual Energy Consumption section of this report. Comparing $2.42 per square foot per eight months to $2.85 per square foot per year is fairly accurate data. The total actual data versus modeled data are gas $6.968 to $6,048 and for electric $150,429 to $180,930 respectively.

6. Annual Cost of Heating and Cooling Plants

The annual cost to run the cooling plant is $38,220. The annual cost to run the heating plant is $6048. The values are defined by the rate structure of the electrics and gas. The annual cost per square foot for the utilities is $2.85. The utilities include gas and electric consumption.

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative fo[illegible] E[illegible] stud[illegible]

		* Alt-1 The Mirenda Center		
		[illegible] 0[illegible]/yr	Proposed / Base %	P[illegible]k [illegible]tu
Lighting - Conditioned	Electricity	2,236.9	27	255
Space Heating	Gas	1,116.4	13	1,010
Space Cooling	Electricity	1,522.5	18	1,272
Heat Rejection	Electricity	205.6	2	157
Fans - Conditioned	Electricity	3,115.8	37	373
Receptacles - Conditioned	Electricity	126.5	2	14
Total Building Consumption		8,323.7		

		* Alt-1 The Mirenda Center
Total	Number of hours heating load not met	19
	Number of hours cooling load not met	0

	* Alt-1 The Mirenda Center	
	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	7,207.3	180,930
Gas	1,116.4	6,048
Total	8,324	186,978

7.Calculation of Emissions

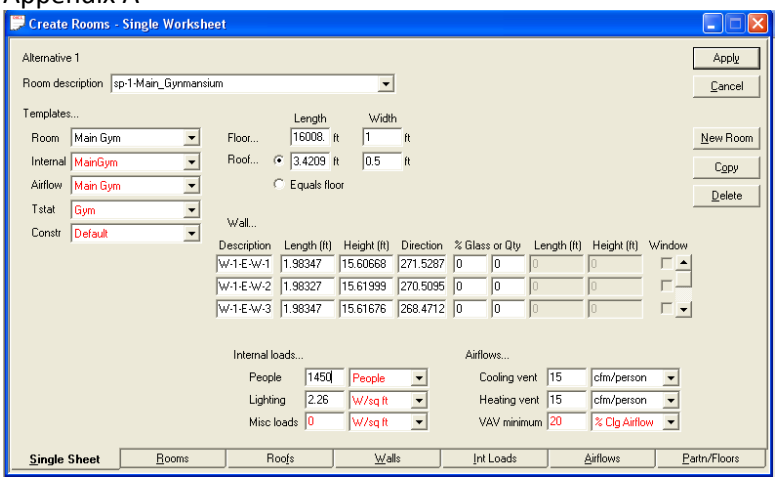
The Mirenda Center consumes 2,111,719.81 kWh amount of electricity and 7467.68 gallons of natural gas per year according to the energy model calculation. Consuming electricity and fuel will result in unwanted byproducts such as the sulfur oxide, nitrogen oxide and carbon dioxide. See the tables below for emittance of these byproducts and more. Pre combustion is the emissions of these pollutants from the vehicles, processes that needed to occur in order to get the natural gas on-site before The Mirenda Center could actually burn it.

	On-Site	**Pre-Combustion**	
	Natural Gas		**Electricity**
	1000 ft3	*1000 ft3*	*lbs*
CO2e	1.23E+05	4.45E+02	3.67E+06
CO2	1.22E+05	1.86E+02	3.46E+06
CH4	2.50E+00	1.13E+01	7.58E+03
N2O	2.50E+00	3.76E-03	8.17E+01
NOX	1.11E+02	2.62E-01	6.34E+03
SOX	6.31E-01	1.95E+01	1.81E+04
CO	9.31E+01	2.18E-01	1.80E+03
VOC	6.12E+00	7.29E-04	1.53E+02
Lead	4.99E-04	3.85E-06	2.94E-01
Mercury	2.60E-04	8.80E-07	7.10E-02
PM10	8.39E+00	1.31E-02	1.96E+02
Solid Waste			4.33E+05

Conclusion:

The Trane Trace 700 program allows to model baseline energy consumption. This baseline is a great tool to understand whether or not The Mirenda Center is performing operatively. The overall performance of The Mirenda Center is higher than the baseline presently. The reasons maybe due to underestimating schedule of use. The newness of the building may attract many unforeseen events that were unaccounted for in the design, such as commencement.

Appendix A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New Room
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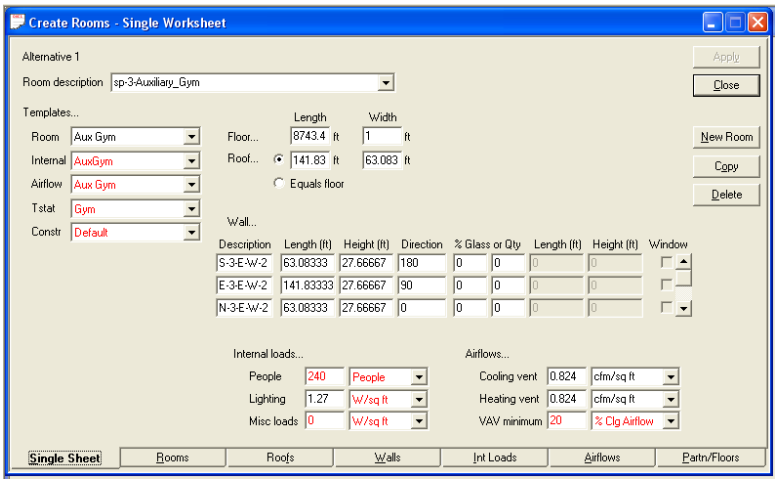
Internal loads...
People 1450 People
Lighting 2.26 W/sq ft
Misc loads 0 W/sq ft
Airflows...
Cooling vent 15 cfm/person
Heating vent 15 cfm/person
VAV minimum 20 % Clg Airflow
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors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People 240 People
Lighting 1.27 W/sq ft
Misc loads 0 W/sq ft
Airflows...
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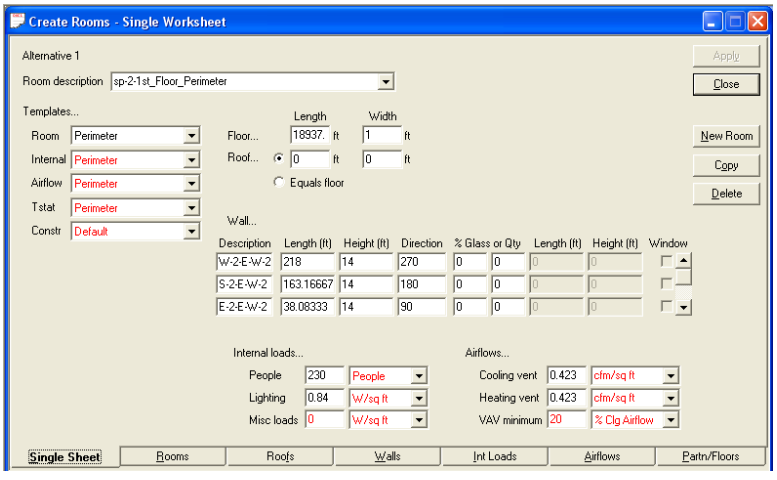
VAV minimum 20 % Clg Airflow
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors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E-2-E-W-2 38.08333 14 90 0 0 0 0
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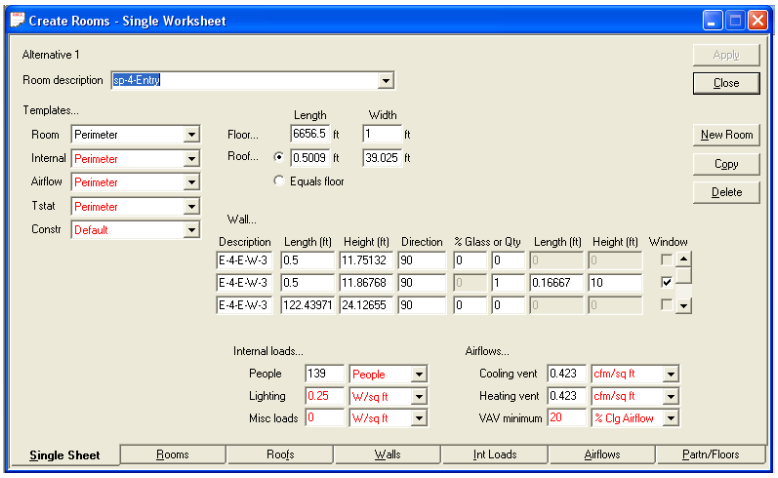
People 230 People
Lighting 0.84 W/sq ft
Misc loads 0 W/sq ft
Airflows...
Cooling vent 0.423 cfm/sq ft
Heating vent 0.423 cfm/sq ft
VAV minimum 20 % Clg Airflow
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors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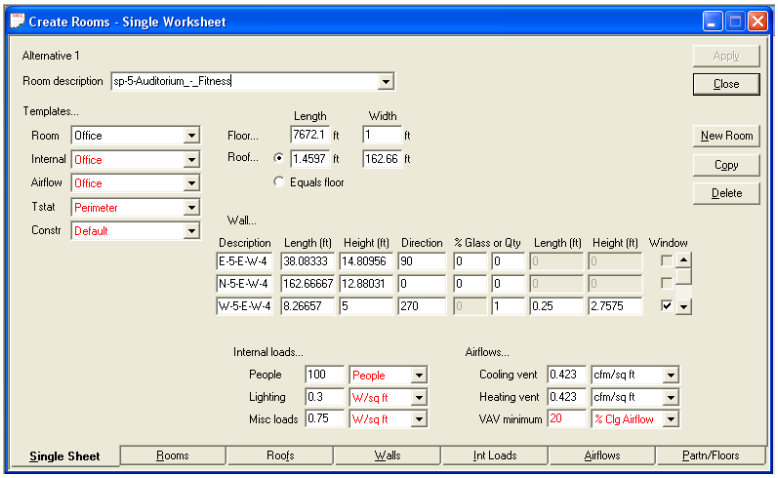
Internal loads...
People 139 People
Lighting 0.25 W/sq ft
Misc loads 0 W/sq ft
Airflows...
Cooling vent 0.423 cfm/sq ft
Heating vent 0.423 cfm/sq ft
VAV minimum 20 % Clg Airflow
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors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New Room
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N-5-E-W-4 162.66667 12.88031 0 0 0 0 0
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Lighting 0.3 W/sq ft
Misc loads 0.75 W/sq ft
Airflows...
Cooling vent 0.423 cfm/sq ft
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VAV minimum 20 % Clg Airflow
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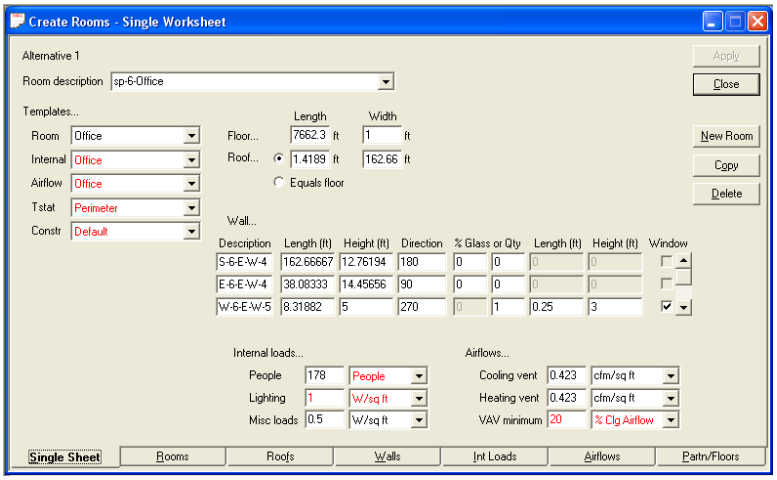
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors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Internal Office
Airflow Office
Tstat Perimeter
Constr Default
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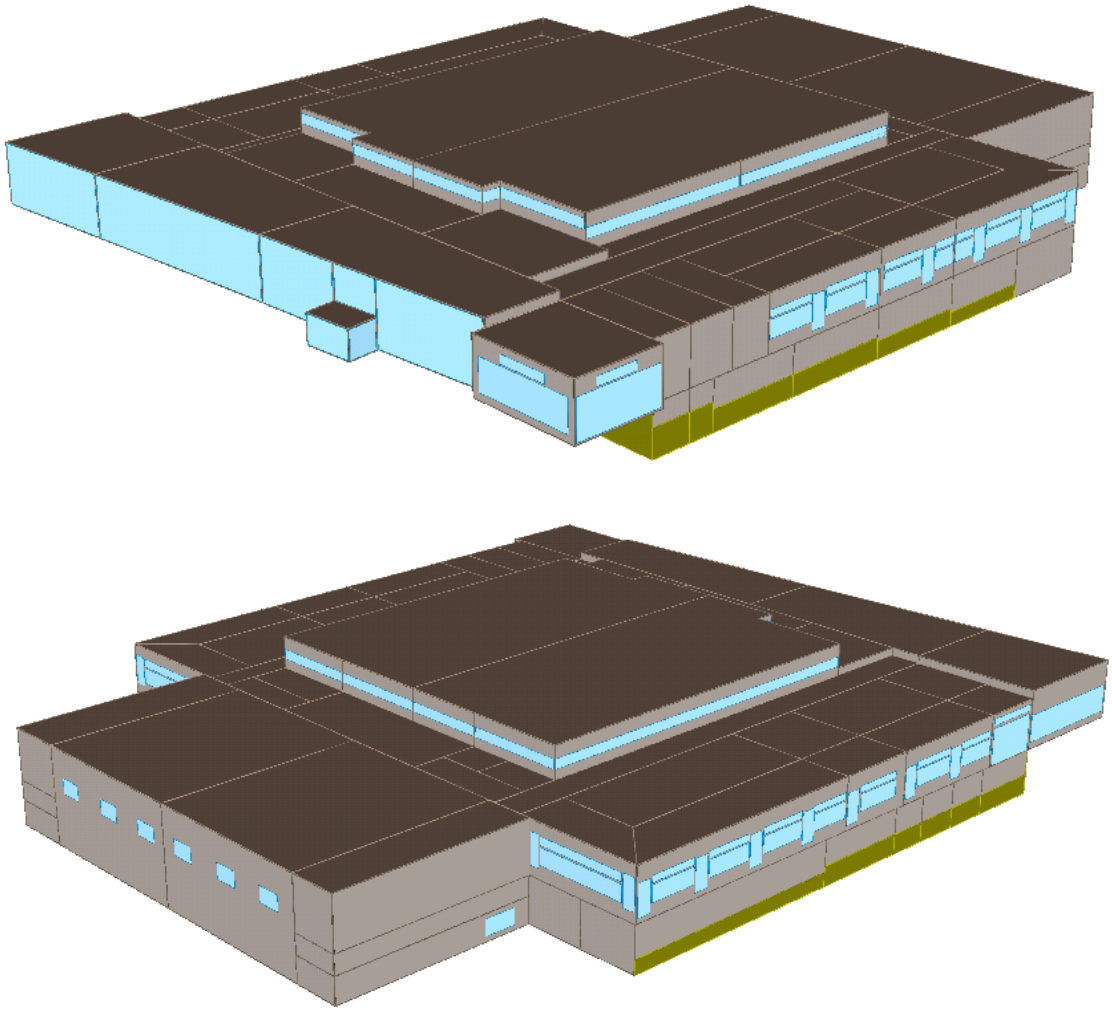
Width
Floor... 7662.3 ft 1 ft
Roof... 1.4189 ft 162.66 ft
Equals floor
New Room
Copy
Delete
Wall...
Description Length (ft) Height (ft) Direction % Glass or Qty Length (ft) Height (ft) Window
S-6-E-W-4 162.66667 12.76194 180 0 0 0 0
E-6-E-W-4 38.08333 14.45656 90 0 0 0 0
W-6-E-W-5 8.31882 5 270 0 1 0.25 3
Internal loads...
People 178 People
Lighting 1 W/sq ft
Misc loads 0.5 W/sq ft
Airflows...
Cooling vent 0.423 cfm/sq ft
Heating vent 0.423 cfm/sq ft
VAV minimum 20 % Clg Airflow
Single Sheet
Rooms
Roofs
Walls
Int Loads
Airflows
Partn/Floors

NeumannCollege Energy Model Comparisons 7/9/08



MODEL CONSTANTS

Energy Rates

- Electric: PECO General Service

- Gas: PECO

Occupancy Schedules

- OverallBuilding Operation:

    - Weekdays: 7 am to Midnight

    - Weekends: 10 am to 11 pm

    - Summer: 8:30 am to 10 pm

- Main Gym: Peak = 3 pm to 10 pm, 7 days, 25 Basketball Events (Nov. to April) 700 people peak occupancy, 1900 people peak occupancy events twice a year, 10 Volleyball Events (April to June) 700 peak occupancy, Summer Day Camp (6 weeks in summer) 380 peak occupancy

- Varsity Lockers, Coaches Lockers, FitnessCenter, Studio, Multipurpose, Alumni Hall, Track: Peak Hours: 3 pm to 10 pm

- Gym Storage, Equipment Storage: Peak Hours= 10 am to 9 pm

- Laundry, Training Room: Peak Hours= 10 am to Midnight

- Classroom: Peak Hours = 8 am to 10 pm

- Offices: Peak Hours = 8 am to 6 pm

- All Others: Occupancy Same as Building

- Summer Break: 5/7 to 8/20

- Winter Break: 12/13 to 1/14

- Standard US Holidays recognized

ASHRAE 90.1-2004 APPENDIX G BASELINE MODEL

Internal Loads

Space Classification	**Lights**, W/sf	**Equipment**, W/sf	**Occupancy**
Main Gym	1.4	0.4	1900 peak
Aux Gym	1.4	0.1	400 peak
Stairs	0.6	0	0
PE Lockers	0.6	0	80
Varsity Lockers	0.6	0	120
Mech/Elec	1.5	0.1	1
Student Lounge	1.3	0.5	30
Corridor	0.5	0	100
Lobby	1.3	0.5	100
Coach Lockers	0.9	0	18
Office	1.1	2	100 sf/per
Training Room	1.4	0.1	12
Equipment Storage	0.8	0	4
Gym Storage	0.8	0	4
Restroom	0.9	0	100 sf/per
Hospitality Suite	1.4	1	50
CSSCD Offices	1.1	2	8
Classroom	1.4	1	40
Athletics Office	1.1	2	20
Track	0.5	0.5	150
FitnessCenter	2.2	0.1	50
Studio	1.4	1	25
Multipurpose	1.4	1	50
Dining	1.3	0.5	80

Alumni Hall	1.3	0.5	80
IT/Media Rooms	2.3	2	100 sf/per

- External Lights = 1.922 kW

Envelope

Component	Description	U Factor (U_{eq})	Other
Window	ASHRAE Minimum performance	0.56	SHGC = 0.35
Roof	Built-up Roof, 2" Polystyrene	0.063	
External Walls	1" Stucco, 6" Metal Stud, R 6.8 Insulation, 1/2" Gypsum	0.124	
Slab	6" HW Concrete	0.0188	
Below-Grade Walls	16" HW Concrete	0.234	

- No Shades

- No Daylighting Controls

Air-Side System

- Refrigerant Hot Gas Reheat: Not included as preset for Packaged VAV system type. Therefore, not included in baseline.

- AHU 1:

- System 5**:** Packaged VAV with Reheat

  - Supply Fan: 0.000981 kW/cfm, 17,950 CFM

  - VAV terminals: Min flow ratio = 0.4 cfm/ft^2

  - Night Cycle Control: Cycle on any

  - Cooling source: DX Coils

- Total Coil Capacity = 759.0 MBh, 0.286 EIR w/ fans removed
- Supply Air Temperature = 54 ºF
- Room Design Temperature = 74 ºF

- Heating source: HW Loop
  - Supply Air Temperature = 92 ºF
  - Room Design Temperature = 72 ºF
  - HW RH Coil: DT = 50 ºF
  - Furnace PreHeat: Capacity = -648 MBh, 1.2462 HIR, disch T setpt = 53ºF
- Providing 20 cfm/person ventilation in office areas
- Exhaust Fan EF-1: 8,000 cfm from required zones, .000266 kW/cfm
- SAT reset: 55ºF - 59ºF

- AHU 2:

- System 5**:** Packaged VAV with Reheat
  - Supply Fan: 0.000981 kW/cfm, 18,370 CFM
  - VAV terminals: Min flow ratio = 0.4cfm/ft^2
  - Night Cycle Control: Cycle on any
  - Cooling source: DX Coils
    - Total Coil Capacity = 816.7 MBh, 0.301 EIR w/ fans removed
    - Supply Air Temperature = 54 ºF
    - Room Design Temperature = 74 ºF
  - Heating source: HW Loop
    - Supply Air Temperature = 92 ºF
    - Room Design Temperature = 72 ºF
    - HW RH Coil: DT = 50 ºF

- Furnace PreHeat: Capacity = -650 MBh, 1.25 HIR, disch T setpt = 53ºF

- Providing 20 cfm/person ventilation in office areas

- Exhaust Fan EF-2: 2,000 cfm from required zones, .000267 kW/cfm

- Exhaust Fan EF-4: 1,100 cfm from required zones, .000209 kW/cfm

- SAT reset: 55ºF - 59ºF

- AHU 3 & 4:

- System 5**:** Packaged VAV with Reheat

- Supply Fan: 0.000991 kW/cfm, 11,843 CFM

- VAV terminals: Min flow ratio = 0.4cfm/ft^2

- Night Cycle Control: Cycle on any

- Cooling source: DX Coils

- Total Coil Capacity = 541.2 MBh, 0.290 EIR w/ fans removed

- Supply Air Temperature = 54 ºF

- Room Design Temperature = 74 ºF

- Heating source: HW Loop

- Supply Air Temperature = 92 ºF

- Room Design Temperature = 72 ºF

- HW RH Coil: DT = 50 ºF

- Providing 20 cfm/person ventilation in office areas

- Exhaust Fan EF-3: 600 cfm from required zones, .000184 kW/cfm

- SAT reset: 55ºF - 59ºF

- AHU 5&6:

- System 5**:** Packaged VAV with Reheat

- Supply Fan: 0.000960 kW/cfm, 24,138 CFM

- VAV terminals: Min flow ration = 0.4cfm/ft^2

- Night Cycle Control: Cycle on any

- Cooling source: DX Coils

    - Total Coil Capacity = 1,378 MBh, 0.315 EIR w/ fans removed

    - Supply Air Temperature = 54 ºF

    - Room Design Temperature = 74 ºF

- Heating source: HW Loop

    - Supply Air Temperature = 92 ºF

    - Room Design Temperature = 72 ºF

    - HW RH Coil: DT = 50 ºF

- Providing 20 cfm/person ventilation in office areas

- SAT reset: 55ºF - 59ºF

Sources:

- Commercial Buildings Energy Consumption Survey
- ASHRAE Standards
- Trane Trace 700