

GLEN A. NEED LIBRARY

COASTAL UNIVERSITY

Wilmington, NC

Load and Energy Analysis

Technical Assignment 3

AE 481W - Thesis



Glen Library Entrance Rendering

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EXECUTIVE SUMMARY

The Glen A. Weed Library located in Wilmington, North Carolina serves as a newly constructed building to supplement Coastal University's extensive library program. Glen Library includes open work spaces, group study rooms, an auditorium, technology labs, and creativity studios to enable learning, research, and collaboration. High investments were made for this building. At 253,000 square feet, the total project cost for this new library was \$93,750,000, leaving the cost per square foot to equal almost \$400. In comparison, most libraries in the past have cost less than \$200 per square foot to build.

Trane TRACE 700 was used as the load and energy simulation software to calculate heating and cooling loads for Glen Library. Templates were created in TRACE based on parameters from the design documents and information from the ASHRAE Handbook of Fundamentals, ASHRAE Standard 90.1, and ASHRAE Standard 62.1. Rooms were grouped into nine zones by perimeter and interior area with respect to similar interior climatic conditions. The calculated results through TRACE showed that the total block cooling load was 469.9 tons and the total heating load was 4779.4 MBh. Check figures were presented in comparison with modeled cooling figures of 1.43 CFM/sf, 181 CFM/ton, 127.38 sf/ton and heating at 18.9 BTUh/sf. The design engineer's values were slightly lower by about 10% than what was modeled. This was expected because the actual building location was not used for owner confidentiality purposes and a more southern location was chosen in Climate Zone 3A.

An energy analysis was also performed using results from TRACE. Glen Library uses 15,653,000 kBtu/yr or 64,700 BTU/sf-yr of energy. The electric consumption accounted for almost 75% of total energy consumption within the building which include lighting, receptacle, and auxiliary end uses at Glen Library and cooling, auxiliary, and a small amount of heating at the Central Utility Plant. Combined with natural gas, the total annual energy cost was \$342,811 assuming average utility rates in North Carolina. Finally, the Energy Use Intensity (EUI) was calculated to gain a better perspective on how the building was performing. Although electricity is a secondary source of energy, the building EUI at 61.55 kBtu/sf-yr was lower than most buildings of this size and occupancy type which proved the high end-use energy efficiency of Glen Library.

PROJECT BACKGROUND

After opening in January of 2013, the Glen A. Weed Library located in Wilmington, North Carolina serves as a newly constructed building to supplement Coastal University's extensive library program. Glen Library is an icon on campus that was designed not to mimic surrounding buildings but to compliment them with a futuristic look. Its main feature is the automated storage and retrieval system, also known as the ASRS or bookBot, which holds up to two-million volumes of books to reduce the building footprint size by almost 40%. Glen Library includes open work spaces, group study rooms, an auditorium, technology labs, and creativity studios all to enable learning, research, and collaboration.

At 253,000 square feet, the total project cost for this new library was \$93,750,000, leaving the cost per square foot to equal almost \$400. In comparison, most libraries in the past have cost less than \$200 per square foot to build. High investments were made towards sustainability. Many features of the building collectively contribute to a LEED Silver certification. Please note that a fictitious name and location were used for this project for owner confidentiality.

MECHANICAL SYSTEMS OVERVIEW

The existing mechanical systems within Glen Library were designed to comply with the 2009 North Carolina State Building Code, applicable ASHRAE Standards, and LEED Certification requirements. Ventilation rates for all spaces within Glen Library were determined based on ASHRAE 62.1 and LEED IEQc2. Three air handling units, AHU-1, AHU-2, and AHU-3, serve as ventilation and perimeter cooling for the North Area, South Area, and Auditorium 1103. An air recirculation unit, ARU-1, serves as space heating, cooling and humidification for the Automated Storage and Retrieval System (ASRS). The Central Utility Plant delivers chilled water to Glen Library from the campus distribution system where it is sent to primary and secondary chilled water loops. The primary loop serves cooling coils in all air handling units and fan coil units. After passing through two plate and frame heat exchangers, secondary chilled water is distributed to active chilled beams and radiant cooling panels. High pressure steam is also delivered from the Central Utility Plant where it is reduced to a lower pressure when it reaches the building. Two shell and tube steam to water converters generate heating hot water. Once the hot water leaves the converters, it is distributed to air handling units, active chilled beams, radiant heating panels and fan coil units throughout the building. The active chilled beams and radiant panels maintain temperature setpoints. The radiant panels are located in perimeter zone spaces because of the large curtain wall areas.

LOAD AND ENERGY ANALYSIS

Trane TRACE 700 was used to calculate the building heating and cooling loads for Glen Library. The goal of using this load and energy simulation software is to determine estimated annual energy consumption required to meet the demands of this building. The first section of this report explains the design parameters that were entered into TRACE based on design documentation and references such as the ASHRAE Handbook of Fundamentals, ASHRAE Standard 90.1, and ASHRAE Standard 62.1. These design parameters include weather conditions, building orientation, exterior material properties, and internal heat generation through people, lighting, and equipment. After the template inputs are defined, zoning of spaces by similar interior environment and the system selections are explained. The results generated in TRACE are then reviewed and analyzed in comparison to the results obtained from the design engineer’s model.

Weather Conditions

The exact building location was not used for this report because of owner confidentiality purposes. Wilmington, NC was selected for Glen Library because it is in a similar region and receives electricity through the same utility company. However, this location proved to be in Climate Zone 3A according to the ASHRAE Climate Zone Map which is different than the original building location. Typical weather within Climate Zone 3A is described as warm and humid with an above average amount of sunny days. TRACE weather inputs were verified using ASHRAE Climatic Data for a typical reduced year. The summer and winter design conditions used are seen in Tables 1 and 2 below. Results were simulated using the “analysis” weather option to determine peak heating and cooling loads and total annual energy usage.

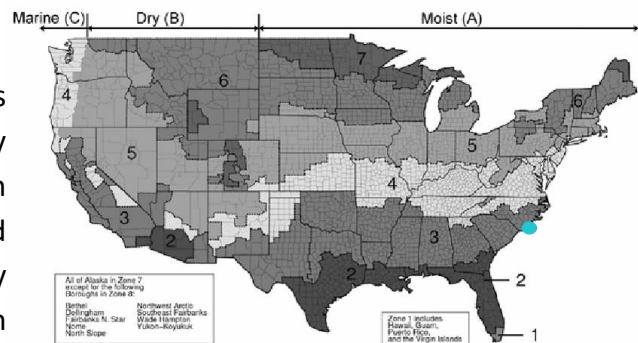


Figure 1: ASHRAE Climate Zone Map

WINTER DESIGN HEATING		
Dry Bulb Temperature (°F)	99.60%	23.2

Table 1: Winter Design Heating Conditions

SUMMER DESIGN COOLING		
Dry Bulb Temperature (°F)	0.40%	93.3
MC Wet Bulb Temperature (°F)	0.40%	78.5

Table 2: Summer Design Cooling Conditions

External Load Assumptions

After looking at weather and climatic conditions, the building orientation and envelope was analyzed because these parameters play a critical role in the amount of load a building will experience due to solar heat gain. The building orientation of Glen Library can be seen on the right in Figure 2. In TRACE, external walls were assigned directions starting with North at 0 degrees going clockwise to West at 270 degrees.

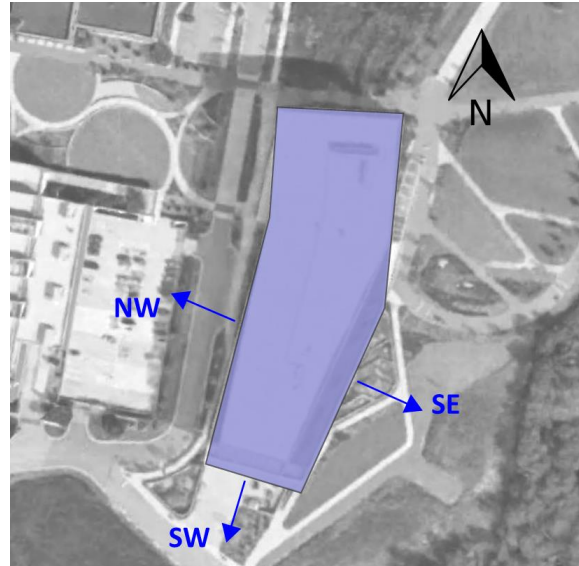


Figure 2: Site Plan with Building Orientation

The building envelope is composed primarily of glass curtain wall and metal panels. This is a concern for solar heat gain especially in large open areas such as the Learning Commons and Skyline Reading Room. However, a fritted low-emissivity glass material was used to allow daylight through without significant heat gain. Aside from the curtain wall, three additional wall materials were defined which include a brick assembly found at the ASRS, spandrel panels where glass is not used in the curtain wall system, and heavyweight CMUs at exterior stairs. Floor to floor heights are 16' on all five floors with a 5' plenum space except for at the ASRS where the ceiling is 59' tall. There are three different roof assemblies found throughout the building which include the main roof, roof terrace, and the green roof. It was assumed that all areas of the building had the insulation of the main roof to simplify inputs in TRACE. Finally, all floor slabs were assumed to have the insulation of 4" lightweight concrete. The U-Values for these materials are shown in Table 3 below.

Location	Material Assembly	U-Value (BTU/hr-sf-°F)
Wall at ASRS	3" Brick	0.054
Curtain Wall	Window Glass	0.38, SC = 0.30
Curtain Wall	Spandrel Panel	0.046
Wall at Stairs	4" HW CMU	0.48
Main Roof	Insulation on Metal Deck	0.047
Slab on Grade	4" LW Concrete	0.21

Table 3: Material Properties and U-Values

Internal Load Assumptions

Considerations for internal heat generation include people, lighting, and miscellaneous equipment. Schedules were created in TRACE based on the hours of operation of Glen Library which can be seen in Table 4 on the right. This allows for a more accurate approximation of when the building experiences demands. People activity levels were found through the ASHRAE Handbook of Fundamentals *Rates of Heat Gain from Occupants of Conditioned Spaces* for sensible and latent loads based on estimated activity level within the spaces. Lighting levels were then found through ASHRAE Standard 90.1 *Lighting Power Density Allowances by Using the Space-by-Space Method*. All light fixtures were assumed to be recessed fluorescent, vented with 80% of the load being transferred into the space. Finally, miscellaneous equipment loads were calculated by using ASHRAE Handbook of Fundamentals *Recommended Rates of Heat Gain* using the architectural drawings as reference for what equipment may be placed in the spaces. Electrical equipment found in spaces such as the Immersion Theater, the Visualization Lab, the machinery in the ASRS, and AV closets on every floor are large internal heat gain contributors because this library is so technologically advanced. The design team on this project also accounted for miscellaneous electrical loads including the parking lot lights, domestic hot water usage, hot water recirculation pumps, elevators, DOAS wheel motors, and ASRS machinery. These values were included in this TRACE model for higher accuracy.

Regular Library Hours	
Mon - Thurs	24 hours
Friday	closes at 10pm
Saturday	9am - 10pm
Sunday	9am - overnight
Summer Hours	
Mon - Thurs	7am - 11pm
Friday	7am - 6pm
Saturday	9am - 6pm
Sunday	9am - 11pm

Table 4: Glen Library Hours of Operation

Temperature setpoints and room airflow rates were assigned to spaces in TRACE. Temperature setpoints are defined in the design documents as 75°F during the summer and 70°F during the winter with a 2°F dead band. The relative humidity is specified as 50% during the summer and 35% during the winter. All of the spaces were assigned these setpoints except for the ASRS, mechanical and electrical, telecom, and unoccupied spaces. Rooms supplied by AHU-1 and AHU-2 were set at a continuous VAV minimum cooling airflow of 30% except in storage spaces where 0.4 cfm/sf was used.

Zone Assignments

Area takeoffs were used from Technical Report 2 for the rooms inputted into TRACE. Assumptions were made to simplify room inputs where repetition occurred. An average of 150-sf was used for all Group Study Rooms and 118-sf was used for all Offices. The rooms were grouped into nine zones, which include AHU-1 Chilled Beams, AHU-1 Radiant Panels, AHU-1

Other, AHU-2 ASRS, AHU-3 Auditorium, FCU Telecom, FCU MEP, FCU Stair, and FCU Server Room. These were decided based on similar environmental conditions and the perimeter or interior locations of the rooms. The design team on the project placed specific equipment types in these areas as reflected in the zone names. For example, radiant panels were most commonly placed in perimeter areas of the building. All interior areas with active chilled beams were placed under AHU-1. The names of the air handling units in the zones do not correspond to the air handling units on the equipment schedules. After the TRACE simulation, it was confirmed that the rooms under AHU-1 should be divided into two separate air handling units because of the large capacity that would be required. Figure 3 on the right shows zone assignments for Level 2. The complete area takeoffs and zone assignments can be found at the end of this report in Appendix VI.

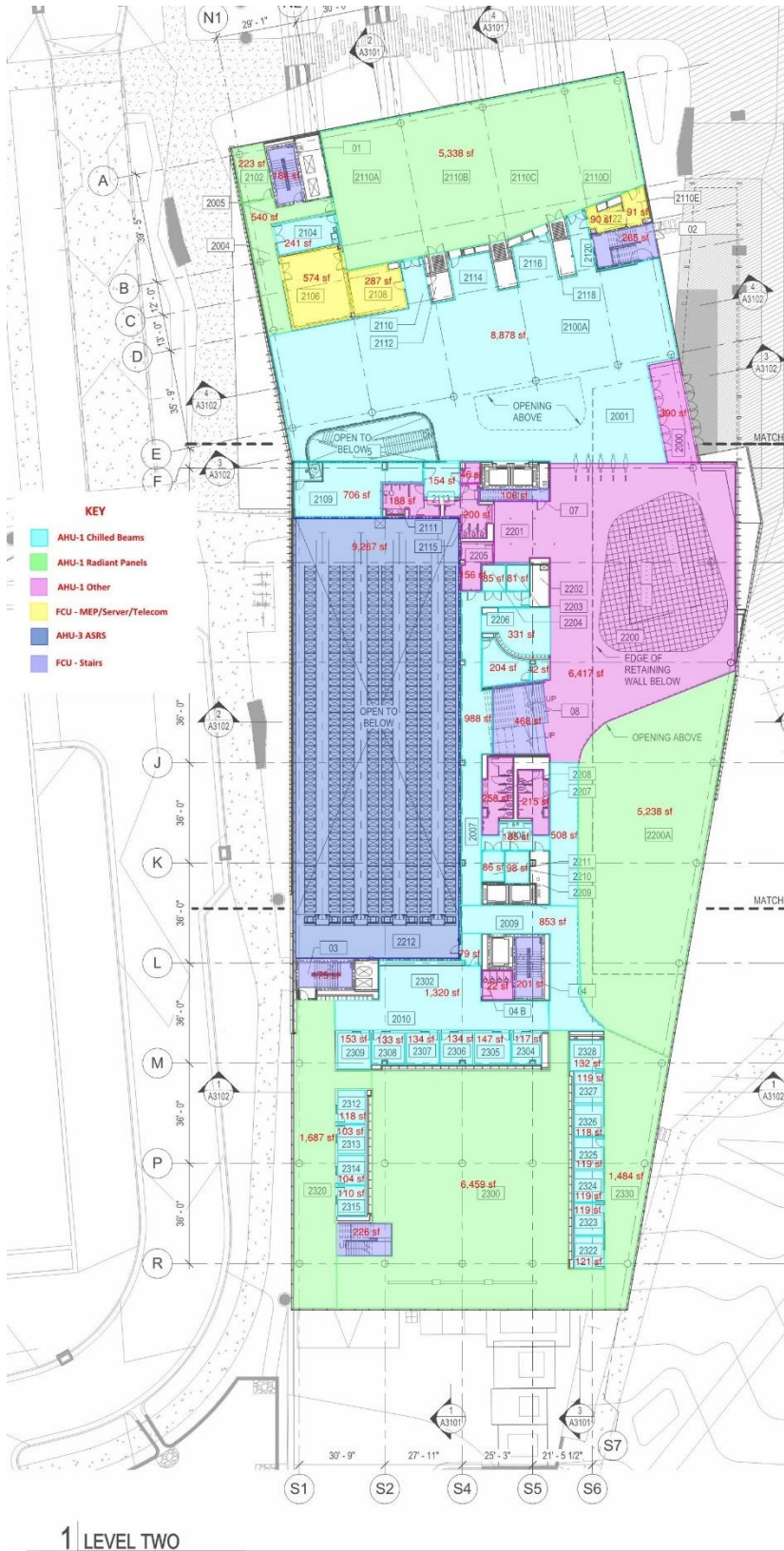


Figure 3: Zoning Diagram (Level 2)

System Selections

As stated previously, the names of the zones reflect equipment types placed in them. In TRACE, AHU-1 Chilled Beams was modeled as two pipe active chilled beams, AHU-1 Radiant Panels was modeled as a single zone, AHU-1 Other and AHU-2 Auditorium were modeled as variable volume reheat, AHU-3 ASRS was modeled as a computer room, and all FCU spaces were modeled as fan coil units. Glen Library is one of fifteen buildings on the Central Utility Plant distribution loop served by steam and chilled water. Because of this, the main, reheat, auxiliary, preheat, and frost protection heating coils were assigned to a steam boiler and the main and auxiliary cooling coils were assigned to a chiller in TRACE. The Central Utility Plant should be capable of handling the additional loads created by Glen Library. Figure 4 shows a site plan of Glen Library in relation to the Central Utility Plant.

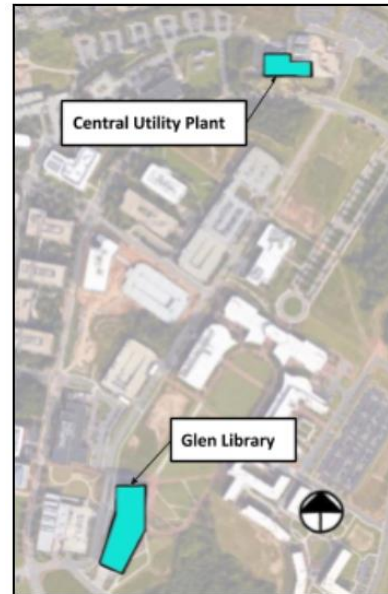


Figure 4: Site Plan with Central Utility Plant

Total Building and System Loads

The following results show the heating and cooling loads calculated by TRACE using the inputs defined above. In TRACE, “peak” loads are based on the sum of the peak airflows in each space while “block” loads are based on the peak time in which the building as a whole reaches its peak demand. The total block cooling load of Glen Library is 469.9 tons and the total block heating load is 4779 MBh. Zone AHU-1 Chilled Beams experiences the greatest amount of cooling and heating loads because it had the most spaces assigned to it. These interior spaces account for about 50% of the cooling total and 40% of the heating total. The perimeter zone, AHU-1 Radiant Panels, accounts for 20% of the cooling total and 26% of the heating total. All FCU areas except for the stairs require more cooling than heating because the equipment within them generates its own heat. The stairs receive no heating or cooling. In comparison, a block total of 469.9 tons of cooling is equivalent

TOTAL BLOCK LOADS		
Zone	Cooling Total (ton)	Heating Total (MBh)
AHU-1 - Chilled Beams	231.4	1943
AHU-1 - Radiant Panels	109	1253
AHU-1 - Other	82.4	1250
AHU-2 - Auditorium	25.4	248
AHU-3 - ASRS	0.6	31
FCU - MEP Space	3.4	45
FCU - Telecom	0.7	4
FCU - Stair	0	0
FCU - Server Room	17	6
Total:	469.9	4779.4

Table 5: Total Block Heating and Cooling Loads

to 5638.8 MBh. Therefore, Glen Library requires more cooling than heating. However, the difference is not significant because this is not an internally dominated building.

Check Figures

Engineering check figures are provided to ensure that the calculated heating and cooling loads are within a standard range as compared to other typical buildings of this type. Cooling load check figures were used from the ASHRAE Pocket Guide *Cooling Load Check Figures* under the classification of Educational Facilities and Libraries/Museums. Heating load check figures were used from the HVAC Equations, Data, and Rules of Thumb textbook under the classification of Libraries/Museums. The most notable difference in this case is the heating BTUh/sf, although the cooling CFM/sf and CFM/ton check figures were in a more reasonable range.

CHECK FIGURES				
	Cooling			Heating
	CFM/sf	CFM/ton	sf/ton	BTUh/sf
Modeled	1.43	181.97	127.38	18.9
Check Figures	1.2	250	185	34
Difference (%)	16.10%	27.20%	31%	44.40%

Table 6: Check Figures for Cooling and Heating Loads

Comparison with Design Documents

The TRACE model generated proved to have similar results to that of the design engineer where all values were within 10% aside from the block cooling load. All of the modeled results were greater than those calculated by the design engineer except for peak cooling load. This was expected because Glen Library is in a slightly different location with a more southern climate zone. Because of the discrepancies between what was modeled and what the design engineer modeled, the equipment selections are no longer in a safely sized range. In this case, the existing equipment would be undersized. This would be a concern because undersizing leads to equipment being unable to maintain temperature and satisfy occupants in the space. Existing equipment schedules are summarized in Appendix V.

Building Loads	COOLING		HEATING	SUPPLY AIR		
	Block Load (tons)	Peak Load (tons)	Peak Load (MBh)	OA (CFM)	Cooling (CFM)	Heating (CFM)
Modeled	469.9	676.7	4,779	94,886	112,172	108,907
Designer	367.9	752.6	4,394	91,290	103,047	100,992
Difference	27.70%	10.08%	8.06%	3.79%	8.13%	7.27%

Table 7: Modeled and Design Load and Airflow Comparison

ENERGY CONSUMPTION AND COST ANALYSIS

The total building energy consumption of Glen Library is about 15,653,000 kBTU/year, or 64,700 BTU/sf-yr. When resource utilization factors are accounted for during the energy production and delivery process, the total source energy consumption is 163,000 BTU/sf-yr. An electric efficiency of 33% was used due to account for plant production and grid transmission losses and a natural gas efficiency of 90% was used to account for incomplete fuel burning and heat transfer during distribution. A list of buildings on the Central Utility Plant has been acquired from the university, but request is still pending on actual measured thermal and electric demands of Glen Library.

Annual Totals by Energy Source and End Use

The following pie charts show total annual energy consumption divided into energy source and electricity end use. The data used for these charts was normalized so that all values presented are in kWh for an even comparison. The total amount of natural gas was 3,774,000 kBTU and the total amount of oil is 77,500 kBTU. Figure 5 illustrates that electricity accounts for almost 75% of the total energy consumed. Figure 6 breaks electricity consumption down further to show its end use. The end uses for electricity include lighting, receptacle, and auxiliary at Glen Library and cooling, auxiliary, and a small amount of heating at the Central Utility Plant.

Annual Energy Consumption

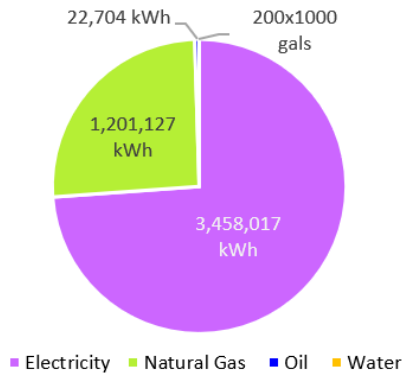


Figure 5: Annual Energy Consumption by Energy Source

Annual Electricity End Use

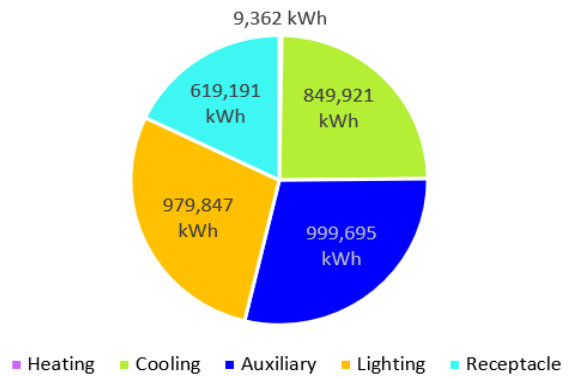


Figure 6: Annual Energy Consumption by End Use

Monthly Totals by Energy Source and End Use

The following graph shows energy consumption by energy source on a monthly basis. Natural gas is used the most during the winter months and the electricity is used the most during the summer months with August being its greatest. Electricity does not vary significantly. Even in February, a baseline of 117,000 kWh of electricity is required to meet lighting, receptacle, and auxiliary purposes as stated above. Small amounts of oil are also used at the Central Utility Plant.

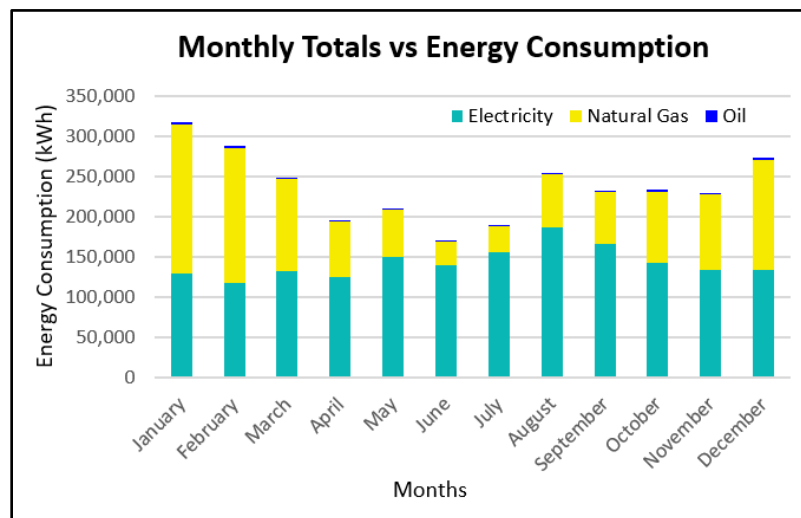


Figure 7: Monthly Energy Consumption by Energy Source

The graph below shows monthly energy consumption by end use of heating and cooling. In this case, tons of cooling was converted to kWh so that the totals amounts could be viewed equally. The amount of energy needed for cooling peaks at 2,100,000 kBTU in August and never falls

below a 140,000 kBTU baseline. On the other hand, heating stays relatively consistent with a light decrease during the earlier summer months. It should be noted that during December, January, and February, the energy consumed for heating is greater than that of cooling.

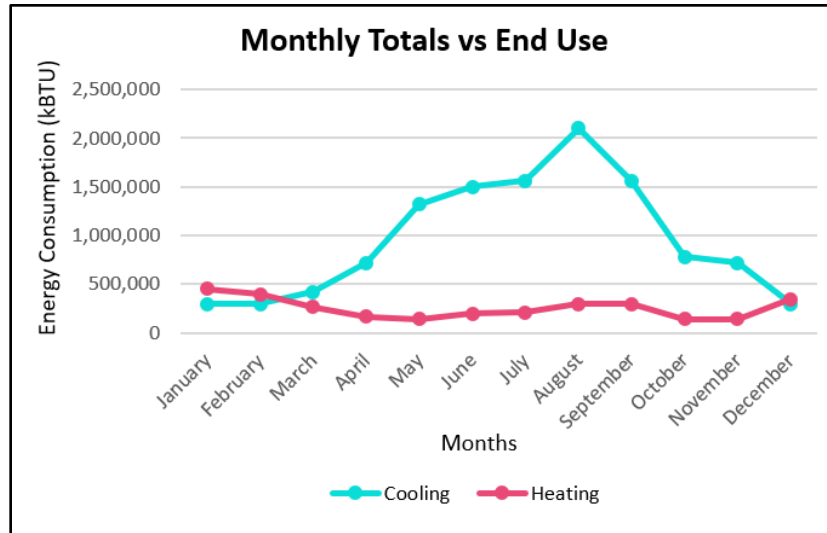


Figure 8: Monthly Energy Consumption by End Use

Utility Rates

According to the US Energy Information Administration (eia.gov), the average price of electricity for commercial buildings in North Carolina is \$0.0882 cents per kilowatt hour and the average price of natural gas is \$10.02 per thousand cubic feet. These rates were assumed to determine the annual energy cost of Glen Library. Electricity is generated and delivered by Duke Energy Progress, a regulated utility company, for Wilmington, NC. For the future, actual rates should be used for a more accurate analysis.



Figure 9: North Carolina Electric Utility Service Map

Annual Energy Cost

The total annual energy cost for Glen Library is about \$342,800 as shown in Table 8. The total cost of electricity contributes to almost 90% of the annual energy expenses for Glen Library. Electricity is a secondary energy source, which means it is highly inefficient because it requires primary energy sources to be consumed. The existing building is energy efficient in terms of how

primary energy sources to be consumed. The existing building is energy efficient in terms of how it uses it's the electricity delivered and is equipped with LED fixtures throughout. Further improvements could be made during the cooling production process at the Central Utility Plant.

ANNUAL ENERGY COSTS			
Utility Type	Energy Use	Utility Rate	Total Cost (\$)
Electricity (kWh)	3,458,017	\$0.0882 per kWh	304,997
Natural Gas (kBTU)	3,773,941	\$1.002 per therm	37,814
Total:			342,811

Table 8: Annual Energy Costs for Electricity and Natural Gas

Energy Use Intensity

The Building Energy Use Intensity, also known as EUI, was calculated to gain a better perspective of how the building is performing. EUI is measured in total energy consumed per square foot of building area per year. The EUI of Glen Library is 61.55 kBTU/sf-year as shown in the following calculations that include electricity and natural gas.

$$\text{Electricity: } 3458017 \text{ kWh} = 11799244 \text{ kBTU}$$

$$\text{Natural Gas: } 3773941 \text{ kBTU}$$

$$\text{Total: } 15,573,185 \text{ kBTU divided by } 253,000 \text{ sf} = \mathbf{61.55 \text{ kBTU/sf-year}}$$

CBECs Comparison

Data was collected through the 2012 Commercial Building Energy Consumption Survey (CBECS). According to the US Energy Information Administration "Consumption and Efficiency" Sector Tables E2 – Major Fuel Consumption Intensities and B6 – Building Size and Characteristics, the average total EUI for buildings within 200,001 to 500,000 sf is 96.3 kBTU/sf-yr. At 61.55 kBTU/sf-year, Glen Library is lower than average for most buildings in this size range. For a building occupancy classification of Education, an EUI of 68.8 kBTU/sf-yr is the average total EUI. Glen Library can be most closely compared to a building occupancy classification of Education. It has an EUI that is slightly lower than this which means it performs better than most buildings of this occupancy classification.

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APPENDIX II – REFERENCES

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APPENDIX III - ASHRAE DESIGN CONDITIONS

2005 ASHRAE Handbook - Fundamentals (IP)

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Design conditions for WILMINGTON INTERNATIONAL, NC, 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
WILMINGTON INTERNATIONAL	723013	34.27N	77.90W	30	14.680	-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%	99.6%		99%		0.4%		1%		MCWS	PCWD		
	3a	3b	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB			WS	MCDB
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	23.2	26.9	5.6	7.4	30.9	10.8	9.5	33.8	24.5	53.7	21.6	51.1	6.5	0

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%		MCWS	PCWD
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB		
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
7	15.8	93.3	78.5	91.2	77.7	89.1	77.0	80.4	89.2	79.5	87.8	78.4	85.9	10.0	240

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
78.2	146.7	84.5	77.2	141.8	83.4	76.3	137.5	82.6	43.9	89.6	42.9	87.8	41.9	86.4

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
1%	2.5%	5%		Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
Max	Min	Min		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
20.5	18.5	16.8	88.3	97.5	16.0	2.4	5.8	99.2	11.8	100.6	8.4	102.0	5.2	103.7	1.0

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%	74.4	65.5	76.3	64.1	82.1	65.8	87.8	68.6	91.1	73.6	95.0	77.7
1%	71.6	64.4	74.4	63.5	79.3	65.9	85.4	67.7	88.9	73.3	93.2	77.0
2%	69.4	63.0	72.2	62.1	77.0	64.7	82.8	67.3	87.0	72.7	91.4	76.8

%	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%	97.0	79.0	95.2	79.5	92.0	77.5	85.9	72.9	80.4	70.1	76.4	66.4
1%	95.4	79.3	93.5	79.2	90.3	76.9	83.8	72.3	78.5	68.8	74.2	66.0
2%	93.8	79.1	92.2	78.9	88.6	76.2	82.2	71.2	77.0	67.8	72.1	64.9

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%	68.2	71.4	68.0	73.0	70.1	76.0	73.0	80.6	77.3	86.8	80.3	90.4
1%	66.8	69.8	66.4	71.1	68.8	74.8	71.5	78.8	76.3	84.8	79.4	89.3
2%	65.4	68.4	65.1	69.5	67.7	73.5	70.4	77.8	75.2	82.8	78.5	87.6

%	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%	82.3	92.3	81.8	90.6	79.5	87.3	76.7	81.9	73.2	76.9	69.9	72.9
1%	81.4	91.3	81.0	89.4	78.5	85.7	75.6	80.4	72.0	75.6	68.1	71.3
2%	80.6	89.9	80.3	88.5	78.1	85.1	74.4	79.1	70.7	74.2	66.7	70.1

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
19.0	20.2	20.5	20.9	18.9	16.8	15.8	15.6	16.5	20.2	20.9	19.9

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	MCWB	Mean coincident wet bulb temperature, °F	MCWS	Mean coincident wind speed, mph
PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East				

APPENDIX IV - TRANE TRACE TEMPLATES

CONSTRUCTION TEMPLATES					
Construction Template Name	Floor to Floor Height (ft)	U-Value (BTU/hr-sf-°F)			
		Wall	Window	Slab	Roof
ASRS	59	0.054 - 3" Brick	0.38, SC=0.3	0.21	0.047
Default	16	0.046 - Spandrel	0.38, SC=0.3	0.21	0.047
Curtain Wall	16	0.046 - Spandrel	0.38, SC=0.25	0.21	0.047
Stairs	16	0.48 - 4" HW CMU	0.38, SC=0.3	0.21	0.047

Space Type	PEOPLE			LIGHTING	EQUIPMENT
	Density (sf/person)	Sensible (BTU/hr)	Latent (BTU/hr)	LPD (W/sf)	Miscellaneous Loads (W/sf)
Break	0	250	250	0.62	1250 W
Classroom	20	250	200	0.92	0.5
Computer Lab	50	250	200	1.33	3
Conference	20	245	155	1.07	0.75
Corridor	0	250	250	0.66	0
Default	0	250	200	0	0
Electrical Room	0	250	200	0.43	2
Kitchen	0	250	250	1.08	2
Library - Reading Area	50	245	155	1.2	0.25
Library - Stacks	100	245	155	0.82	0.25
Lobby	0	250	200	1	0.25
Mechanical Room	0	250	200	0.43	1
Office	143	250	200	0.93	0.75
Shop	0	250	250	1.14	1
Stair	0	250	250	0.6	0
Storage - Active	0	250	200	0.72	0
Telecom	0	250	200	0.43	5
Toilet	1 person	250	250	0.85	0
Vending	0	250	250	0.9	1050 W

AIRFLOW		
Airflow Template Name	Type	Cooling and Heating Ventilation
Break	General Office Space	20 cfm/person
Classroom	Classroom	7.5 cfm/person
Computer Lab	General Office Space	20 cfm/person
Conference	Classroom	15 cfm/person
Corridor	Corridor	0.05 cfm/sf
Default	None	20 cfm/person
Electrical Room	None	90 cfm
Elevator Machine Room	None	0 cfm/person
Exhibit	Auditorium	15 cfm/person
Libraries	Library	15 cfm/person
Lobby	Cafeteria	20 cfm/person
Mechanical Room	None	0 cfm/person
Office	General Office Space	40 cfm
Stair	None	0 cfm/person
Storage	None	20 cfm
Wood-Metal Shop	General Office Space	20 cfm/person

THERMOSTAT			
Thermostat Template Name	Cooling Dry Bulb (°F)	Heating Dry Bulb (°F)	Relative Humidity (%)
Default	75	70	50
ASRS	68	68	45
MEP	85	60	50
Telecom	72	72	50
Unoccupied	80	65	50

APPENDIX V - EXISTING EQUIPMENT SCHEDULES (SUMMARIZED)

Equipment Tag	Location	Supply Air (CFM)	Outside Air (%)	Cooling Coil		Heating Coil
				Total Capacity (MBH)	Sensible Capacity (MBH)	Total Capacity (MBH)
AHU-1	North	42175	100	2026.2	1170.3	1438.9
AHU-2	South	42175	100	2026.2	1170.3	1438.9
AHU-3	Auditorium	6500	50	335.5	211.6	137.5
ARU-1	ASRS	4000	0	105	95	86.8

Equipment Tag	Location	Supply Air (CFM)	Cooling Coil	
			Total Capacity (MBH)	Sensible Capacity (MBH)
FCU-1 and 2	Main Electrical	370	10.9	8.8
FCU-3 and 4	Emergency Switchgear	490	15.6	11.7
FCU-5	Main Telecom	640	19.9	15.2
FCU-6	Mechanical Room	1100	26.5	20.3
FCU-7 and 8	AV Server	1440	38.3	29.7

APPENDIX VI – AREA TAKEOFFS AND ZONE ASSIGNMENTS

Level	General Area	Room Number	Room Name	Az - Floor Area	Air Handling Unit	Equipment	Space Type
1	N	1000	Vestibule	296	AHU-1	Other	Lobby - Library
1	N	1001	Lobby	4352	AHU-1	Radiant Panels	Lobby - Library
1	N	1004	Corridor	375	AHU-1	Other	Corridor
1	S	1011	Corridor	1376	AHU-1	Other	Corridor
1	N	1101	Vestibule	162	AHU-1	Other	Corridor
1	N	1103	Auditorium	5152	AHU-3	None	Auditorium Seating
1	N	1104	Cafe	950	AHU-1	Radiant Panels	Cafe
1	N	1105	Control Room	187	None	FCU - MEP	Electrical Room
1	N	1106	Corridor	252	AHU-1	Other	Corridor
1	N	1108	Mechanical Room	4537	None	FCU - MEP	Mechanical Room
1	N	1112	BAS/FACP	131	AHU-1	Other	Control Room
1	N	1119	Corridor	445	AHU-1	Chilled Beams	Corridor
1	N	1201	Wheelchair Storage	163	AHU-1	Other	Storage - Active
1	N	1203	Nursing Mothers	175	AHU-1	Other	Storage - Active
1	N	1205	Women's Toilet	296	AHU-1	Other	Toilet
1	N	1207	Men's Toilet	295	AHU-1	Other	Toilet
1	N	1209	IDF	89	AHU-1	Chilled Beams	Telecom Room
1	N	1211	Electrical	67	AHU-1	Chilled Beams	Electrical Room
1	N	1213	Janitor	104	AHU-1	Other	Toilet
1	N	1215	Furniture Storage	772	AHU-1	Other	Storage - Active
1	S	1219	IT Workroom	1120	AHU-1	Chilled Beams	Office
1	S	1221	Supply Storage	557	AHU-1	Other	Storage - Active
1	S	1223	IDF	93	AHU-1	Chilled Beams	Telecom Room
1	S	1225	Electrical	124	AHU-1	Chilled Beams	Electrical Room
1	S	1228	Shipping/ Receiving	937	None	FCU - MEP	Storage - Active
1	S	1230	Sprinkler	299	None	FCU - MEP	Storage - Active
1	S	1231	Workshop	1060	AHU-1	Chilled Beams	Shop
1	S	1235	Custodial Office	118	AHU-1	Other	Office
1	S	1236	Mail - Library	65	AHU-1	Other	Office
1	S	1237	Janitor	132	AHU-1	Other	Toilet
1	S	1238	Security Control	106	AHU-1	Other	Office
1	S	1239	Archive Storage	183	AHU-1	Other	Storage - Active
1	S	1240	Mail IEI	43	AHU-1	Other	Storage - Active
1	S	1241	Facilities Storage	896	AHU-1	Other	Storage - Active
1	S	1242	Mail CS	41	AHU-1	Other	Storage - Active
1	S	1243	Main Electrical	907	None	FCU - MEP	Electrical Room
1	S	1244	Men's Toilet	77	AHU-1	Other	Toilet
1	S	1245	Mechanical Room	2287	None	FCU - MEP	Mechanical Room
1	S	1246	Women's Toilet	77	AHU-1	Other	Toilet
1	S	1248	Main Telecom	150	None	FCU - Telecom	Telecom Room
1	S	1250	Emer Switchgear	423	None	FCU - MEP	Electrical Room
2	S	1270	Open Group Work	1270	AHU-1	Chilled Beams	Office
2	N	2000	Vestibule	399	AHU-1	Other	Corridor
2	N	2000A	Gallery A	4249	AHU-1	Radiant Panels	Exhibit
2	N	2000B	Gallery B	4157	AHU-1	Radiant Panels	Exhibit
2	N	2004	Corridor	328	AHU-1	Radiant Panels	Corridor
2	N	2007	Corridor	997	AHU-1	Chilled Beams	Corridor
2	N	2102	Gallery Office	222	AHU-1	Radiant Panels	Office
2	N	2104	Catering Storage	242	AHU-1	Chilled Beams	Storage - Active
2	N	2106	Multi-Purpose Furniture	581	AHU-1	Other	Storage - Active
2	N	2108	Gallery AV Closet	291	AHU-1	Other	Equipment Room
2	N	2109	Gallery Storage	701	AHU-1	Chilled Beams	Storage - Active

2	N	2110A	Multipurpose A	1650	AHU-1	Radiant Panels	Conference - Low Density
2	N	2110B	Multipurpose B	1168	AHU-1	Radiant Panels	Conference - Low Density
2	N	2110C	Multipurpose C	1086	AHU-1	Radiant Panels	Conference - Low Density
2	N	2110D	Multipurpose D	1449	AHU-1	Radiant Panels	Conference - Low Density
2	N	2111	Men's Toilet	185	AHU-1	Other	Toilet
2	N	2112	Exhibit Storage	75	AHU-1	Chilled Beams	Exhibit
2	N	2113	Janitor	45	AHU-1	Other	Toilet
2	N	2114	Work Group Meeting	223	AHU-1	Chilled Beams	Conference - Low Density
2	N	2115	Women's Toilet	199	AHU-1	Other	Toilet
2	N	2116	Work Group Meeting	219	AHU-1	Other	Conference - Low Density
2	N	2000A	Learning Commons Main	7276	AHU-1	Other	Conference - Low Density
2	N	2200B	Learning Commons Open	5244	AHU-1	Radiant Panels	Learning Commons
2	N	2201	Service Desk	433	AHU-1	Chilled Beams	Lobby - Office
2	N	2203	Electrical	75	AHU-1	Chilled Beams	Electrical Room
2	N	2204	AV Closet	77	AHU-1	Chilled Beams	Equipment Room
2	N	2205	Device Storage	155	AHU-1	Other	Storage - Active
2	N	2206	Immersion Theater	322	AHU-1	Chilled Beams	Conference - Low Density
2	N	2207	Men's Toilet	209	AHU-1	Other	Toilet
2	N	2208	Women's Toilet	251	AHU-1	Other	Toilet
2	S	2210	Electrical	98	AHU-1	Chilled Beams	Electrical Room
2	N	2211	AV Closet	87	AHU-1	Chilled Beams	Equipment Room
2	S	2212	Collections Processing	690	AHU-1	Chilled Beams	Storage - Active
2	S	2300	Reading Room	7055	AHU-1	Radiant Panels	Library - Reading Area
2	S	2304	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2305	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2306	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2307	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2308	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2309	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2312	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2313	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2314	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2315	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2320	Open Seating	1537	AHU-1	Radiant Panels	Library - Reading Area
2	S	2322	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2323	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2324	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2325	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2326	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2327	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2328	Group Study	150	AHU-1	Chilled Beams	Group Study
2	S	2330	Open Seating	1275	AHU-1	Radiant Panels	Library - Reading Area
2M	S	3002	Corridor	490	AHU-1	Chilled Beams	Corridor
2M	S	3003	Corridor	833	AHU-1	Chilled Beams	Corridor
2M	N	3032	Corridor	477	AHU-1	Chilled Beams	Corridor
2M	S	3200	Commons	9529	AHU-1	Chilled Beams	Learning Commons
2M	N	3201	Gaming	603	AHU-1	Chilled Beams	Conference - High Density
2M	N	3205	IDF	70	AHU-1	Chilled Beams	Telecom Room
2M	N	3206	Electrical	67	AHU-1	Chilled Beams	Electrical Room
2M	N	3207	Janitor	94	AHU-1	Other	Toilet
2M	N	3208	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3209	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3211	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3212	Group Study	150	AHU-1	Chilled Beams	Group Study

2M	N	3213	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3214	Presentation	193	AHU-1	Chilled Beams	Conference - High Density
2M	N	3215	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3217	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3218	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3219	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	N	3220	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3230	Mezzanine	664	AHU-1	Chilled Beams	Corridor
2M	S	3232	IDF	90	AHU-1	Chilled Beams	Telecom Room
2M	S	3233	Electrical	96	AHU-1	Chilled Beams	Electrical Room
2M	S	3241	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3242	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3243	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3304	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3305	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3306	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3307	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3309	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3312	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3313	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3314	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3315	Group Study	150	AHU-1	Chilled Beams	Group Study
2M	S	3316	Group Study	150	AHU-1	Chilled Beams	Group Study
3	N	4011	Men's Toilet	207	AHU-1	Other	Toilet
3	N	4013	Women's Toilet	208	AHU-1	Other	Toilet
3	S	4040	Toilet Vestibule	164	AHU-1	Other	Corridor
3	S	4060	Corridor	741	AHU-1	Other	Corridor
3	N	4100	Corridor	3535	AHU-1	Other	Corridor
3	N	4101	Large Group Workroom	820	AHU-1	Chilled Beams	Conference - Low Density
3	N	4103	Executive Conference	893	AHU-1	Chilled Beams	Conference - Low Density
3	N	4104	Project Team	714	AHU-1	Chilled Beams	Conference - High Density
3	N	4105	Large Group Meeting	729	AHU-1	Chilled Beams	Conference - Low Density
3	N	4106	Meeting Room	1529	AHU-1	Chilled Beams	Conference - Low Density
3	N	4107	Large Group Meeting	780	AHU-1	Chilled Beams	Conference - Low Density
3	N	4108	Janitor	57	AHU-1	Other	Toilet
3	N	4109	H Office	255	AHU-1	Chilled Beams	Office
3	N	4110	Control/ IT	54	AHU-1	Chilled Beams	Equipment Room
3	N	4120	Open Meeting	141	AHU-1	Chilled Beams	Conference - Low Density
3	N	4121	Resource	413	AHU-1	Chilled Beams	Storage - Active
3	N	4122	Media Production	225	AHU-1	Chilled Beams	Equipment Room
3	N	4123	Assistant Director	141	AHU-1	Chilled Beams	Office
3	N	4124	Assistant Director	145	AHU-1	Chilled Beams	Office
3	N	4125	Focus Booth	50	AHU-1	Chilled Beams	Office
3	N	4126	Focus Booth	50	AHU-1	Chilled Beams	Office
3	N	4127	Assistant Director	143	AHU-1	Chilled Beams	Office
3	N	4128	Assistant Director	145	AHU-1	Chilled Beams	Office
3	N	4129	Director	257	AHU-1	Chilled Beams	Office
3	N	4130	Meeting	275	AHU-1	Chilled Beams	Conference - Low Density
3	N	4131	Library	693	AHU-1	Chilled Beams	Storage - Active
3	N	4140	IEI Commons	4498	AHU-1	Chilled Beams	Work Stations
3	N	4160	Director	243	AHU-1	Chilled Beams	Office
3	N	4200	Flexible Collection	5265	AHU-1	Chilled Beams	Work Stations
3	N	4201	Conference	850	AHU-1	Chilled Beams	Conference - Low Density
3	N	4202	Janitor	78	AHU-1	Other	Toilet

3	N	4203	Electrical	79	AHU-1	Chilled Beams	Electrical Room
3	N	4204	IDF	130	AHU-1	Chilled Beams	Telecom Room
3	N	4210	Group Study	150	AHU-1	Chilled Beams	Office
3	N	4211	Music	85	AHU-1	Chilled Beams	Music Room
3	S	4212	Music	80	AHU-1	Chilled Beams	Music Room
3	S	4213	Music	82	AHU-1	Chilled Beams	Music Room
3	S	4214	Music	82	AHU-1	Chilled Beams	Music Room
3	S	4215	Media/ Presentation	194	AHU-1	Chilled Beams	Group Study
3	S	4216	Lockers	404	AHU-1	Other	Corridor
3	S	4217	Media/ Presentation	196	AHU-1	Chilled Beams	Group Study
3	S	4221	Men's Toilet	173	AHU-1	Other	Toilet
3	S	4222	Women's Toilet	189	AHU-1	Other	Toilet
3	S	4224	Electrical	100	AHU-1	Chilled Beams	Electrical Room
3	S	4225	IDF	139	AHU-1	Chilled Beams	Telecom Room
4	N	4293	Work Stations	5801	AHU-1	Chilled Beams	Work Stations
3	N	4300	Graduate Commons	4639	AHU-1	Chilled Beams	Conference - Low Density
3	N	4302	Group Study	150	AHU-1	Chilled Beams	Office
3	N	4304	AV Closet	128	AHU-1	Chilled Beams	Equipment Room
3	N	4311	Group Study	150	AHU-1	Chilled Beams	Group Study
3	N	4312	Group Study	150	AHU-1	Chilled Beams	Group Study
3	N	4313	Group Study	150	AHU-1	Chilled Beams	Group Study
3	N	4314	Group Study	150	AHU-1	Chilled Beams	Group Study
3	N	4315	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4321	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4322	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4400	User Seating	2748	AHU-1	Chilled Beams	Lobby - Library
3	S	4401	Seminar	387	AHU-1	Chilled Beams	Classroom
3	S	4403	Creativity Lab	1845	AHU-1	Chilled Beams	Conference - High Density
3	S	4411	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4412	Printer	155	AHU-1	Chilled Beams	Printer
3	S	4500	Flexible Collection	2311	AHU-1	Chilled Beams	Learning Commons
3	S	4502	Fishbowl	466	AHU-1	Chilled Beams	Classroom
3	S	4505	Teaching + Viz Lab	1467	AHU-1	Chilled Beams	Classroom
3	S	4510	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4511	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4512	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4513	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4514	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4515	Group Study	150	AHU-1	Chilled Beams	Group Study
3	S	4520	User Seating	7703	AHU-1	Chilled Beams	Lobby - Library
4	N	5000	Elevator Lobby	413	AHU-1	Chilled Beams	Lobby - Library
4	S	5001	Toilet Vestibule	218	AHU-1	Chilled Beams	Corridor
4	S	5003	Elevator Lobby	308	AHU-1	Chilled Beams	Lobby - Library
4	N	5004	Corridor	785	AHU-1	Chilled Beams	Corridor
4	N	5100	Reception	356	AHU-1	Chilled Beams	Lobby - Library
4	N	5102	Corridor	299	AHU-1	Chilled Beams	Corridor
4	N	5103	Office	118	AHU-1	Chilled Beams	Office
4	N	5104	Office	118	AHU-1	Chilled Beams	Office
4	N	5105	Office	118	AHU-1	Chilled Beams	Office
4	N	5106	Office	118	AHU-1	Chilled Beams	Office
4	N	5107	Head Office	225	AHU-1	Chilled Beams	Office
4	N	5109	Office	118	AHU-1	Chilled Beams	Office
4	N	5111	Open Meeting	164	AHU-1	Chilled Beams	Conference - Low Density
4	N	5112	Office	118	AHU-1	Chilled Beams	Office

4	N	5113	Office	118	AHU-1	Chilled Beams	Office
4	N	5115	Office	118	AHU-1	Chilled Beams	Office
4	N	5116	Office	118	AHU-1	Chilled Beams	Office
4	N	5117	Open Meeting	126	AHU-1	Chilled Beams	Conference - Low Density
4	N	5118	Office	118	AHU-1	Chilled Beams	Office
4	N	5119	Office	118	AHU-1	Chilled Beams	Office
4	N	5121	Office	118	AHU-1	Chilled Beams	Office
4	N	5123	Head Office	268	AHU-1	Chilled Beams	Office
4	N	5125	Office	118	AHU-1	Chilled Beams	Office
4	N	5127	Break	109	AHU-1	Chilled Beams	Break Room
4	N	5128	Open Collab	513	AHU-1	Chilled Beams	Conference - Low Density
4	N	5131	Resource	112	AHU-1	Chilled Beams	Office
4	N	5132	Office	118	AHU-1	Chilled Beams	Office
4	N	5133	Office	118	AHU-1	Chilled Beams	Office
4	N	5134	Office	118	AHU-1	Chilled Beams	Office
4	N	5135	Office	118	AHU-1	Chilled Beams	Office
4	N	5136	Office	118	AHU-1	Chilled Beams	Office
4	N	5137	Office	118	AHU-1	Chilled Beams	Office
4	N	5139	Head Office	299	AHU-1	Chilled Beams	Office
4	N	5141	Office	118	AHU-1	Chilled Beams	Office
4	N	5142	Janitor	112	AHU-1	Chilled Beams	Toilet
4	N	5143	Office	118	AHU-1	Chilled Beams	Office
4	N	5144	Office	118	AHU-1	Chilled Beams	Office
4	N	5145	Office	118	AHU-1	Chilled Beams	Office
4	N	5146	Office	118	AHU-1	Chilled Beams	Office
4	N	5147	Head Office	233	AHU-1	Chilled Beams	Office
4	N	5148	Office	118	AHU-1	Chilled Beams	Office
4	N	5149	Office	118	AHU-1	Chilled Beams	Office
4	N	5151	Office	118	AHU-1	Chilled Beams	Office
4	N	5152	Office	118	AHU-1	Chilled Beams	Office
4	N	5153	Office	118	AHU-1	Chilled Beams	Office
4	N	5154	Office	118	AHU-1	Chilled Beams	Office
4	N	5155	Office	118	AHU-1	Chilled Beams	Office
4	N	5156	Office	118	AHU-1	Chilled Beams	Office
4	N	5157	Office	118	AHU-1	Chilled Beams	Office
4	N	5158	Office	118	AHU-1	Chilled Beams	Office
4	N	5159	Office	118	AHU-1	Chilled Beams	Office
4	N	5161	Office	121	AHU-1	Chilled Beams	Office
4	N	5172	Men's Toilet	144	AHU-1	Other	Toilet
4	N	5173	Women's Toilet	122	AHU-1	Other	Toilet
4	N	5174	Toilet Vestibule	150	AHU-1	Other	Corridor
4	N	5200	Research Commons	2230	AHU-1	Chilled Beams	Work Stations
4	S	5210	Focus Booth	58	AHU-1	Chilled Beams	Office
4	S	5211	Focus Booth	53	AHU-1	Chilled Beams	Office
4	N	5222	Focus Booth	63	AHU-1	Chilled Beams	Office
4	N	5223	Focus Booth	94	AHU-1	Chilled Beams	Office
4	N	5224	Focus Booth	64	AHU-1	Chilled Beams	Office
4	N	5231	Bookable Work	168	AHU-1	Chilled Beams	Conference - High Density
4	N	5232	Bookable Work	145	AHU-1	Chilled Beams	Conference - High Density
4	N	5233	Bookable Work	143	AHU-1	Chilled Beams	Conference - High Density
4	N	5234	Meeting	234	AHU-1	Chilled Beams	Conference - Low Density
4	N	5235	Copy	102	AHU-1	Chilled Beams	Equipment Room
4	N	5241	Bookable Work	112	AHU-1	Chilled Beams	Conference - High Density
4	N	5242	Bookable Work	116	AHU-1	Chilled Beams	Conference - High Density

4	S	5243	Bookable Work	117	AHU-1	Chilled Beams	Conference - High Density
4	S	5244	Bookable Work	117	AHU-1	Chilled Beams	Conference - High Density
4	S	5245	Bookable Work	119	AHU-1	Chilled Beams	Conference - High Density
4	S	5246	Kitchenette	61	AHU-1	Chilled Beams	Break Room
4	S	5300	Skyline Reading	4213	AHU-1	Other	Conference - Low Density
4	S	5302	Vending/ Recycling	142	AHU-1	Chilled Beams	Toilet
4	S	5303	Skyline Area B	1572	AHU-1	Other	Conference - Low Density
4	S	5311	Men's Toilet	175	AHU-1	Other	Toilet
4	S	5312	Women's Toilet	175	AHU-1	Other	Toilet
4	S	5314	Electrical	101	AHU-1	Chilled Beams	Electrical Room
4	S	5315	IDF	92	AHU-1	Chilled Beams	Telecom Room
4	S	5401	Work Stations	3457	AHU-1	Chilled Beams	Work Stations
4	S	5402	Catering	399	AHU-1	Chilled Beams	Break Room
4	S	5404	Resource	101	AHU-1	Chilled Beams	Conference - Low Density
4	S	5405	Elevator Controls	87	None	FCU - MEP	Equipment Room
4	S	5503	Resource Center	132	AHU-1	Chilled Beams	Conference - Low Density
4	S	5511	Administration	110	AHU-1	Chilled Beams	Office
4	S	5512	Associate Director	112	AHU-1	Chilled Beams	Office
4	S	5513	Library Director	225	AHU-1	Chilled Beams	Office
4	S	5514	Vice Provost	226	AHU-1	Chilled Beams	Office
4	S	5515	Associate Director	117	AHU-1	Chilled Beams	Office
4	S	5516	Administration	116	AHU-1	Chilled Beams	Office
4	S	5601	Work Stations	1573	AHU-1	Chilled Beams	Work Stations
4	S	5610	Focus Booth	89	AHU-1	Chilled Beams	Office
4	S	5611	Toilet	63	AHU-1	Other	Toilet
4	S	5612	Toilet	64	AHU-1	Other	Toilet
4	S	5613	Storage	62	AHU-1	Other	Storage - Active
4	S	5621	Manager Office	118	AHU-1	Chilled Beams	Office
4	S	5622	Manager Office	118	AHU-1	Chilled Beams	Office
4	S	5623	Manager Office	118	AHU-1	Chilled Beams	Office
4	N	5701	Collaboration Hub	1940	AHU-1	Chilled Beams	Learning Commons
4	S	5702	Meeting	250	AHU-1	Chilled Beams	Conference - Low Density
4	S	5703	Project Team	319	AHU-1	Chilled Beams	Office
4	S	5704	Meeting	145	AHU-1	Chilled Beams	Conference - Low Density
4	S	5705	Kitchen	103	AHU-1	Chilled Beams	Break Room
4	N	5706	Meeting	152	AHU-1	Chilled Beams	Mechanical Room
4	N	5707	Meeting	283	AHU-1	Chilled Beams	Mechanical Room
4	S	5712	Tech Services	493	AHU-1	Chilled Beams	Work Stations
4	S	5713	Large Meeting	633	AHU-1	Chilled Beams	Conference - Low Density
4	N	5714	Resource	148	AHU-1	Chilled Beams	Conference - Low Density
4	N	5715	AV Closet	86	AHU-1	Chilled Beams	Equipment Room
4	N	5720	Corridor	213	AHU-1	Chilled Beams	Corridor
4	N	5721	Meeting Room	323	AHU-1	Chilled Beams	Conference - Low Density
4	N	5723	Electrical	80	AHU-1	Chilled Beams	Electrical Room
4	N	5724	IDF	88	AHU-1	Chilled Beams	Telecom Room
4	N	5725	Janitor	92	AHU-1	Other	Toilet
4	N	5726	Storage	182	AHU-1	Chilled Beams	Storage - Active
4	N	5812	Men's Toilet	331	AHU-1	Other	Toilet
4	N	5816	Women's Toilet	341	AHU-1	Other	Toilet
4	N	5819	Elevator Controls	72	None	FCU - MEP	Mechanical Room
4	N	5821	Manager Office	118	AHU-1	Chilled Beams	Office
4	N	5822	Manager Office	118	AHU-1	Chilled Beams	Office
4	N	5823	Manager Office	118	AHU-1	Chilled Beams	Office
4	N	5824	Manager Office	118	AHU-1	Chilled Beams	Office

4	N	5831	Focus Booth	60	AHU-1	Chilled Beams	Office
4	N	5832	Focus Booth	51	AHU-1	Chilled Beams	Office
4	N	5903	Open Meeting	7670	AHU-1	Chilled Beams	Conference - Low Density
ALL	ARU-1	0001	ASRS	8168	ARU-1	None	Storage - Active
1	N	1104B	Service Area	430	AHU-1	Other	Break Room
1	N	1105B	Upper Control Room	319	AHU-1	Chilled Beams	Electrical Room
1	S	1219A	Server Room	900	None	FCU - Server Room	Storage - Active
2	N	2110E	AV Control	91	AHU-1	Chilled Beams	Equipment Room
2	S	2206A	Equipment Room	206	AHU-1	Chilled Beams	Equipment Room
2	N	2206B	AV Room	43	None	FCU - Telecom	Equipment Room
3	N	4106A	Resource Storage	125	AHU-1	Chilled Beams	Storage - Active

SYSTEM SUMMARY
DESIGN COOLING CAPACITIES
 By ACADEMIC

Alternative 1

Building Airside Systems and Plant Capacities

Plant	System	Peak Plant Loads							Block Plant Loads									
		Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1	Stg 2	Base Utility ton	Peak Total ton	Time	Main Coil ton	Aux Coil ton	Opt Vent Coil ton	Misc Load ton	Stg 1	Stg 2	Base Utility ton	Block Total ton
						Desic Cond ton	Desic Cond ton			Of Peak mo/hr					Desic Cond ton	Desic Cond ton		
CUP - Chilled Water		463.0	213.7	0.0	0.0	0.0	0.0	0.0	676.7	8/16	410.5	59.4	0.0	0.0	0.0	0.0	0.0	469.9
	AHU-1 - Chilled Beams	211.5	176.9	0.0	0.0	0.0	0.0	0.0	388.4	8/16	183.6	47.8	0.0	0.0	0.0	0.0	0.0	231.4
	FCU - Telecom	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	8/16	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	AHU-2 - Auditorium	26.6	0.0	0.0	0.0	0.0	0.0	0.0	26.6	8/16	25.4	0.0	0.0	0.0	0.0	0.0	0.0	25.4
	AHU-3 - ARS	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	8/16	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.6
	FCU - MEP space	9.4	0.0	0.0	0.0	0.0	0.0	0.0	9.4	8/16	3.4	0.0	0.0	0.0	0.0	0.0	0.0	3.4
	FCU - Stair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8/16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	AHU-1 - Other	85.8	0.0	0.0	0.0	0.0	0.0	0.0	85.8	8/16	82.4	0.0	0.0	0.0	0.0	0.0	0.0	82.4
	AHU-1 - Radiant	110.3	36.8	0.0	0.0	0.0	0.0	0.0	147.1	8/16	97.4	11.6	0.0	0.0	0.0	0.0	0.0	109.0
	FCU - Server Room	17.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	8/16	17.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0
Building totals		463.0	213.7	0.0	0.0	0.0	0.0	0.0	676.7		410.5	59.4	0.0	0.0	0.0	0.0	0.0	469.9

Building peak load is 676.7 tons.

Building maximum block load of 469.9 tons occurs in August at hour 16 based on system simulation.

SYSTEM SUMMARY
DESIGN HEATING CAPACITIES
 By ACADEMIC

Alternative 1

System Coil Capacities

System Description	System Type	Main	Aux	Preheat	Reheat	Humid.	Optional	Stg 1	Stg 2	Stg 1	Stg 2	Heating Totals Btu/h
		System Btu/h	System Btu/h	Btu/h	Btu/h	Btu/h	Vent Btu/h	Desic Regen Btu/h	Desic Regen Btu/h	Frost Prevention Btu/h	Frost Prevention Btu/h	
AHU-1 - Chilled Beams	Active Chilled Beams	-1,284,818	-279,631	-378,362	-1,284,818	0	0	0	0	0	0	-1,942,811
FCU - Telecom	Fan Coil	-4,328	0	0	0	0	0	0	0	0	0	-4,328
AHU-2 - Auditorium	Variable Volume Reheat (30% Min Flow Default)	-131,449	0	-116,584	-45,087	0	0	0	0	0	0	-248,033
AHU-3 - ARS	Computer Room Unit	-30,996	0	0	-18,562	0	0	0	0	0	0	-30,996
FCU - MEP space	Fan Coil	-45,109	0	0	0	0	0	0	0	0	0	-45,109
FCU - Stair	Fan Coil	0	0	0	0	0	0	0	0	0	0	0
AHU-1 - Other	Variable Volume Reheat (30% Min Flow Default)	-929,923	0	-320,135	-309,759	0	0	0	0	0	0	-1,250,058
AHU-1 - Radiant	Single Zone	-615,508	-316,718	-319,559	-615,508	0	0	0	0	0	0	-1,251,786
FCU - Server Room	Fan Coil	-6,247	0	0	0	0	0	0	0	0	0	-6,247
Totals		-3,048,379	-596,349	-1,134,640	-2,273,734	0	0	0	0	0	0	-4,779,368

Building Plant Capacities

Plant	System	Peak Loads												
		Main Coil MBh	Preheat Coil MBh	Reheat Coil MBh	Humid. Coil MBh	Aux Coil MBh	Opt Vent Coil MBh	Misc Load MBh	Stg 1 Desic. Regen. MBh	Stg 2 Desic. Regen. MBh	Stg 1 Frost Prev. MBh	Stg 2 Frost Prev. MBh	Base Utility MBh	Absorption Load MBh
CUP - Steam Boiler		3,048	1,135	0	0	596	0	0	0	0	0	0	0	0
AHU-1 - Chilled Beams		1,285	378	0	0	280	0	0	0	0	0	0	0	0
FCU - Telecom		4	0	0	0	0	0	0	0	0	0	0	0	0
AHU-2 - Auditorium		131	117	0	0	0	0	0	0	0	0	0	0	0
AHU-3 - ARS		31	0	0	0	0	0	0	0	0	0	0	0	0
FCU - MEP space		45	0	0	0	0	0	0	0	0	0	0	0	0
AHU-1 - Other		930	320	0	0	0	0	0	0	0	0	0	0	0
AHU-1 - Radiant		616	320	0	0	317	0	0	0	0	0	0	0	0
FCU - Server Room		6	0	0	0	0	0	0	0	0	0	0	0	0

Building peak load is 4,779.4 MBh.

MONTHLY ENERGY CONSUMPTION

By ACADEMIC

----- Monthly Energy Consumption -----

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1 Proposed													
Electric													
On-Pk Cons. (kWh)	110,882	100,535	123,967	136,223	178,302	188,452	173,406	214,456	173,449	125,843	118,002	106,045	1,749,563
Off-Pk Cons. (kWh)	128,871	117,772	131,489	125,349	149,359	139,148	155,694	186,118	166,388	142,038	133,198	133,031	1,708,455
On-Pk Demand (kW)	626	625	628	761	877	960	966	986	929	678	661	628	986
Off-Pk Demand (kW)	614	624	665	636	741	871	936	900	813	727	712	642	936
Gas													
On-Pk Cons. (therms)	6,314	5,705	3,913	2,350	2,008	1,019	1,079	2,271	2,165	3,036	3,202	4,680	37,739
On-Pk Demand (therms/hr)	19	19	12	9	8	4	5	6	7	9	11	14	19
Oil													
Cons. (therms)	130	118	80	48	41	21	22	46	44	62	66	96	775
Water													
Cons. (1000gal)	18	17	18	18	16	13	13	17	15	18	18	18	200

Energy Consumption

Building 64,735 Btu/(ft2-year)
 Source 163,204 Btu/(ft2-year)

Floor Area 241,809 ft2

Environmental Impact Analysis

CO2 4,270,549 lbm/year
 SO2 20,937 gm/year
 NOX 3,658 gm/year

ONLY