2012

Technical Report 2

American Art Museum

Building and Plant Energy Analysis

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Executive Summary

The objective of this technical report is to conduct a building energy model of American Art Museum (AAM) and analyze in the following criteria:

- Design load calculation
- Annual energy consumption break down
- Operating cost of major HVAC components
- Air pollution produced by the regional power plant

This energy calculation in this report is applied block load calculation and computer-based method. And, the software used in this report is Trace 700. Trace700 is one of the recommended software in this assignment. It provides both load calculations and energy simulation by enter the parameters of the building system, such as dimensions of zones, the thermal setting in each zones, and types of activities in each zone.

Since AAM is a building with a complex HVAC and building design, there are many simplifications and assumptions made in the calculation. For example, some of the secondary HVAC systems are neglected. And, all assumptions and simplifications are listed in the section, The Inputs and Assumptions of Block Load Calculation.

After conducting an energy building model, the resultant data is compared and ensured its accuracy in 2 ways:

- Outdoor air flow rate, heating and cooling load in design documents,
- Energy consumption and utility rate of a generic museum generated by conEdison.

Overall, the heating and cooling load of the Trace700 energy model match with the designed load, but the outdoor air flow rate doesn't match with the flow rate in the design documents. Also, in the second comparison, it found that the generic model of conEdison doesn't match with the Trace700 energy model, because of different characteristics of both HVAC systems and the significant difference of their natural gas utility rates.

In the last section of this report, it states the emission rate of regional power plant. It helps for selecting New York utility company(s) in further study of the senior thesis.

In conclusion, the load calculation of this energy model is accurate, but the utility rates and flow rates of this model require more adjustment.

Project Background

Name	American Art Museum
Location	New York, NY
Occupancy Type	Group A-3 Museum
Size	195000 sq. ft.
Function	Gallery, Classroom, Office, Auditorium, Restaurant
Floors	9 levels with cellar mezzanine and cellar level underground
Construction	Start in February 2012, End in later 2014
Main Architectural Feature(s)	1. Cantilevered entrance 2. The Biggest column-free gallery in New York 3. Ground floor restaurant and top floor café 4. Rooftops on Multiple levels for outdoor exhibition 5. Glazing system, pre-cast concrete, and stud wall as façade
Sustainability	Goal: LEED Gold Certification

Figure 1 Courtesy of the owner

Figure 2 Courtesy of the owner

Figure 3 Courtesy of the owner

Mechanical overview

Cooling System	2 branches of air conditioning system: 3 air conditioning systems as cooling systems • Located on the cellar Level (-1) • Handle 1/3 of the load • Manage the air in floors C through 7. Another AC system • Located in Level 8 • Manages the air condition in 8th floor. The main refrigeration plant • 3 electrically driven centrifugal refrigeration machines 5 cooling towers • On the roof • Hold 200 ton cross-flow or counter-flow typed cells Cold water fluiding roofing and greenroofs
Heating System	A hot water heating boiler plant • Located on cellar level • 5 condensing water fire-tubed boilers • Built-in water treatment • A combustion chamber with gas filters Finned tube convector along the exterior walls Unit heaters and fan coil type heaters • Provide heat on all mechanical rooms, exit and entrances. Fan coil units along the glass façade walls • Heat and cool the lobby area
Ventilation	Several main zones with different ventilation distribution: • Galleries with VAV system • Lobbies with VAV system • Restaurant with constant air volume (CAV) system • Auditorium with CAV system. Both branches of AC system • Fogged type humidifier systems. • Flirtation with 95% efficient filters
Control System	Direct Digital Control (DDC) Modes of setting: • Unoccupied Mode • "Summer" Occupied Mode • "Winter" Occupied Mode • "Auto" Mode

Design Load Estimation

The load estimation is conducted in Trace700. By providing the room structures, the cooling and heating plants, and the site location, Trace700 generates the analysis of building energy and economic impact. Since the building project of this report, American Art Museum consists of very complex HVAC system, the detail assumptions and inputs are recorded.

The Inputs and Assumptions of Block Load Calculation

Weather Data

The location of American Art Museum (AAM) is set as New York (LaGuardia), NY.

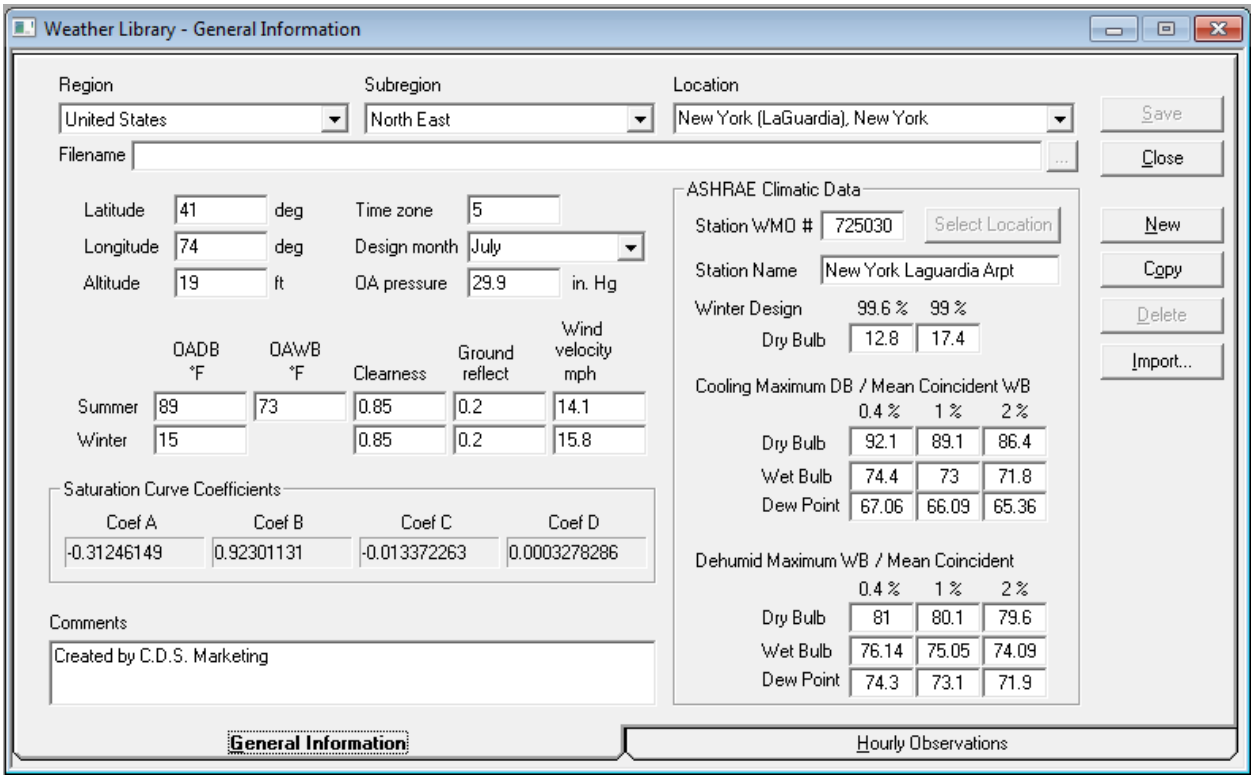


Figure 4 Weather Data of AAM

Room and Zone

In Trace700, the user(s) should input the rooms and group the rooms into the corresponding zones. However, because of the time limitation of this report, the divided zones are treated as a number of rooms, and the actual rooms of AAM are neglected. Moreover, the zones are divided by the occupant types and the orientation of rooms, which shows in Appendix A. The number of occupants in different zones is from the code analysis of AAM drawings.

Assumption

Some of the small rooms are grouped into an adjacent zone with different occupant types, due to the excessive varieties of rooms in American Art Museum. For example, the solar gain effect of reasonably small space, such as Stair A, is neglected, although it is west-orientated and has low-e glazing curtain.

Structure

Trace700 also requests the user(s) to input the basic structures of each room, such the material of walls, roofs, windows and floors, the orientation of each wall, and the sizes of windows and doors. In this calculation, the structure is simplified in order to shorter the calculation time.

Façade Assumption

In American Art Museum, there are 2 types of exterior walls and 8 curtain wall designs. The 2 exterior walls are pre-concrete wall and stud wall with steel plate. The u-values of exterior walls are set as default walls in Trace700, 4" light-weighted concrete wall with 2" insulation and metal plate.

According to the curtain walls, the u-values of 8 curtain wall designs are only considered as the insulating glass unit with 0.5 inch Argon, which also is a default window in Trace700. The calculation also assumes that the mullion design is the same overall.

Interior Wall Assumption

There are 14 types of general interior walls in American Art Museum. Each general interior wall type consists of different dimensions. In order to simplify the calculation, the average dimension of each interior wall is used. And, selecting wall types in Trace700 are based on the similarity of original wall thicknesses and u-values. Each u-value of Trace700 wall types is re-written as the calculated u-value in Appendix B.

Floor Assumption

Since the floor types are not clearly defined in the drawings, it assumes that the floor of cellar level is 12 inches concrete, and the rest are 4 inches light-weighted concrete with 2 inches insulation in this calculation.

Internal Load

The internal loads that generated by Trace700 are the sensible and latent load of people activity, lighting load and miscellaneous. And, the schedule is set as Office, because the Museum schedule is not provided in Trace700.

General Assumption

It assumes that the outdoor gallery activities in multiple terraces do not affect the internal load. For example, the doors are assumed to keep shut in terraces during the outdoor activities.

Miscellaneous Load

The miscellaneous load can be found in the panel board schedule of electrical drawings. After calculating the loads (Shown in Appendix C), the calculated miscellaneous load is significantly bigger than the load of a typical museum, 0.5 W/sf (Walter T. Grondzik, 2009). Therefore, the miscellaneous load on each floor is the following:

Table 1Miscellaneous Load on Each Floor

Miscellaneous Load on Each Floor	
Area	Load Density (W/sf)
Typical Museum	0.5
Cellar Level	3.383
Cellar Mezzanine Level	17.986
1st Level	4.875
2nd Level	4.903
3rd Level	5.808
4th Level	18.099
5th Level	3.909
6th Level	2.752
7th Level	3.6903
8th Level	13.215
9th Level	7.656

Air Flow

Ventilation Rate: Clg Ez, Htg Ez, and Er

In this calculation, it assumes that all cooling and heating supply air is from ceiling, the return air also goes through the ceiling return grilles and registers, and the air recirculates from ceiling plenums. It is because the specs of AAM indicate that most of the major zones consist of the ceiling return and supply systems.

VAV control

As it is mentioned in the Technical Report 1, the Variable Air Volume (VAV) control is used in galleries, offices, and restaurant.

Table 2 Ventilation System of Zones

	Ventilation System	
Types of Zone	Variable Air Volume(VAV)	Constant Air Volume
Gallery	x	
Lobby	x	
Restaurant		x
Auditorium		x
9th Floor	x	
Cellar and Back-of-House	x	
Kitchen		x

The ventilation rate of galleries is set as the given values in the mechanical VAV box schedule of AAM. And, the assumption of the zones with VAV controls, other than galleries, is that the minimal cooling VAV rate is 30% of cooling airflow and the maximal heating VAV is 100% of cooling airflow. 30% of max air flow rate is a reference value from ASHRAE Journal, Sizing VAV Boxes (Steven T. Taylor, 2004).

Selecting HVAC Systems

Mechanical System Overview mentions the system consists of two primary systems located on cellar level and 9th level. The general air distribution systems described in the mechanical specs and drawings of AAM is shown in Table.3.

Table 3 General Air Distribution System of Zones

General Air Distribution System of Zones		
Floor	**Zone**	**Air Distribution System**
All floors	Gallery	VAV
All floor (except 1st floor)	Lobby	CAV
All floor	Auditorium	VAV
Cellar, 2nd, 9th Level	Mechanical Room	Unit Heaters
1st Floor	Loading Deck	Unit Heater
1st Floor	Restaurant/Lobby	Fan Coil Unit

Therefore, VAV systems, CAV systems, Unit heaters, and fan coils are created in the function 'Create Systems'. Also, in another function 'Create Plants', two plants, heating and cooling are created.

VAV System

The mechanical spec mentions that the VAV boxes are fan powered. However, it doesn't indicate the fans are parallel or series powered. It assumes that the parallel powered fans are used, because parallel powered fans are most common (McQuiston, Parker, and Spitler, 2005).

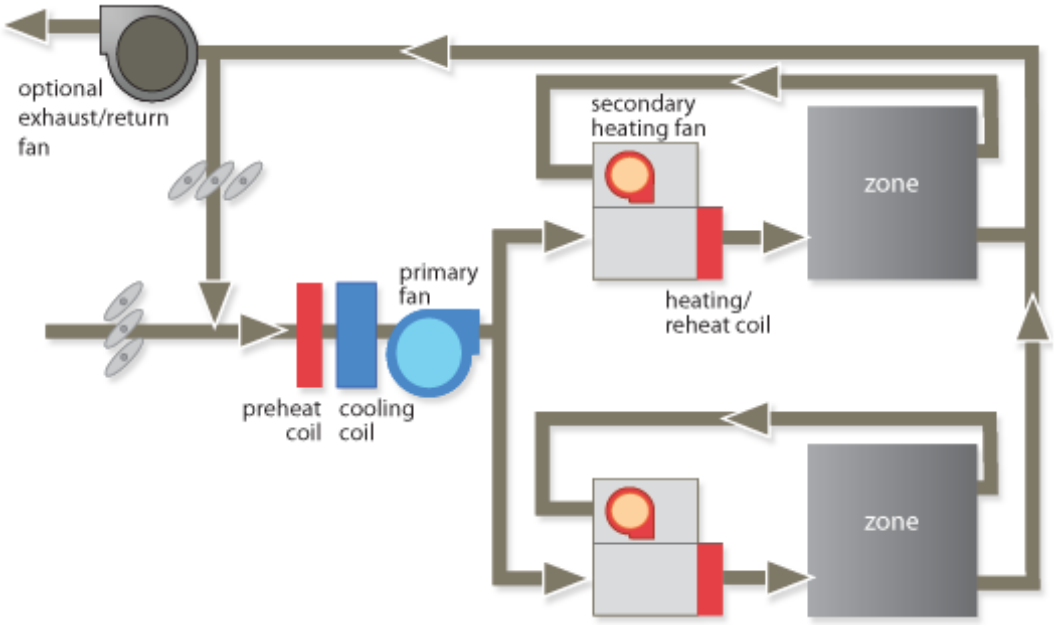


Figure 5 Paralleled Fan-Powered VAV Schematic

In addition, the evaporative cooling is set as none instead of indirect type, because the indirect efficiency is undefined.

CAV Systems

Since the mechanical specs and drawings do not show what CAV component is applied on the HVAC system, it assumes that the Terminal Air Blenders are used.

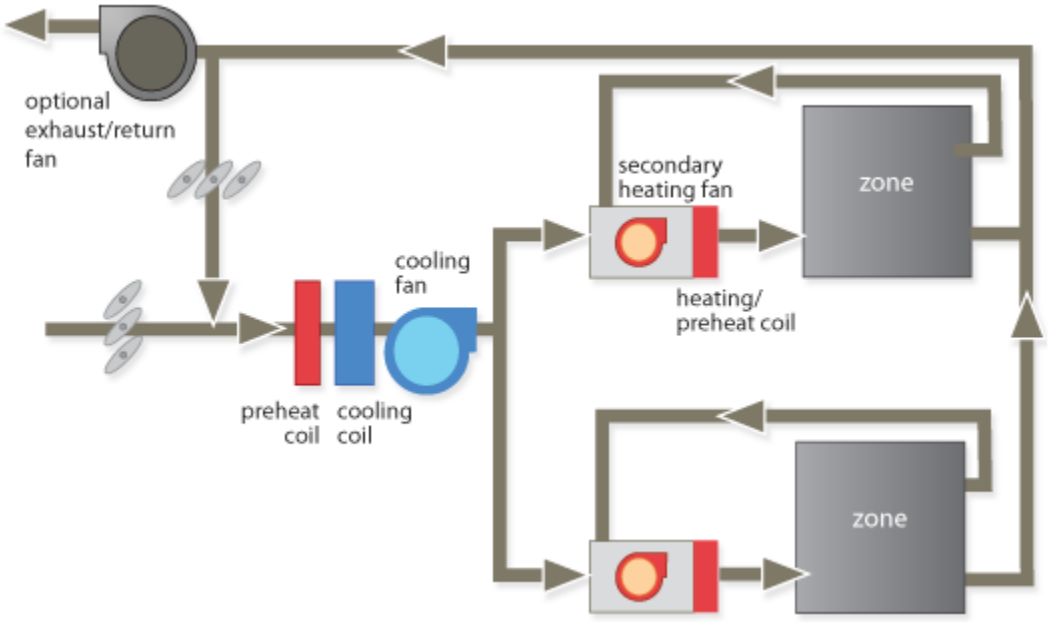


Figure 6 Terminal Air Blender Schematic

Unit Heaters

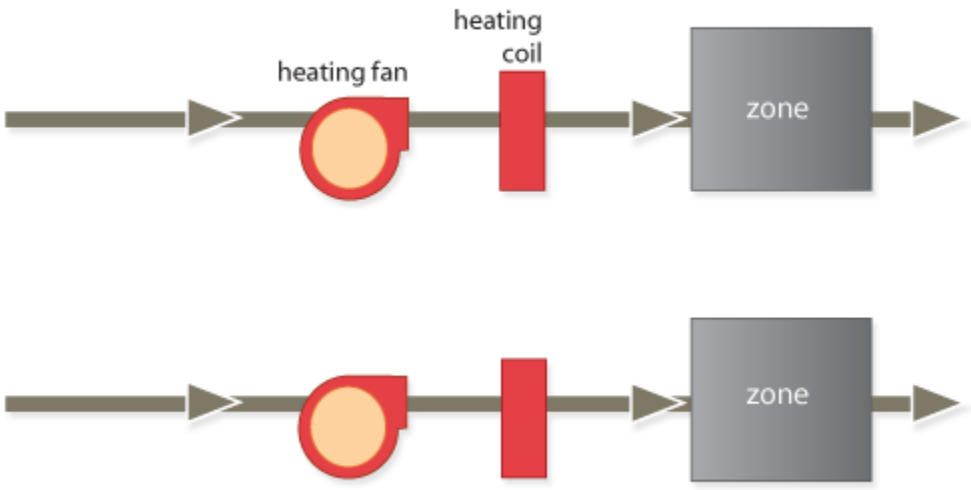


Figure 7 Unit Heater Schematic

Fan Coils

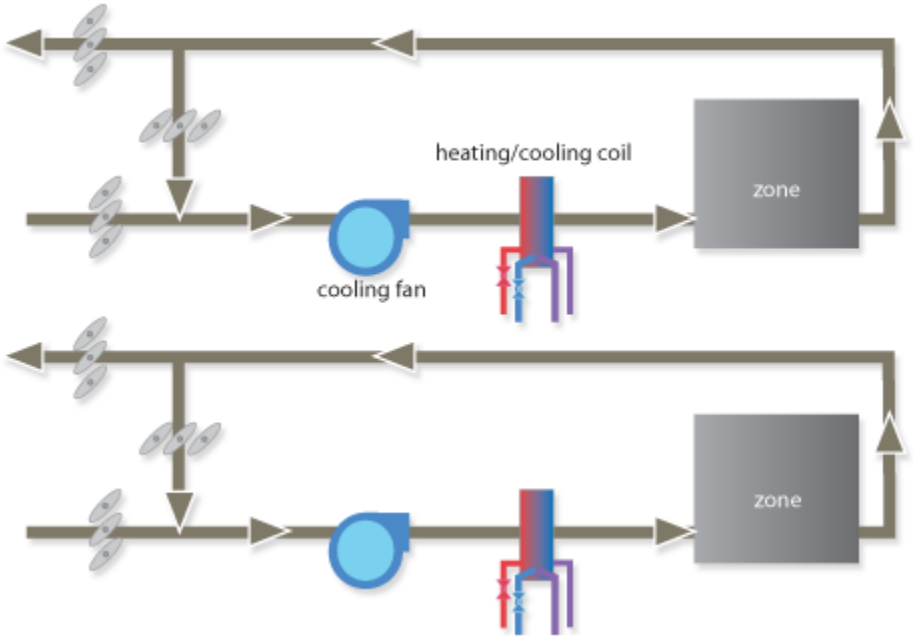


Figure 8 Fan Coil Schematic

Heating and Cooling Plants

Trace700 has a unique logic, so the following configuration is generated.

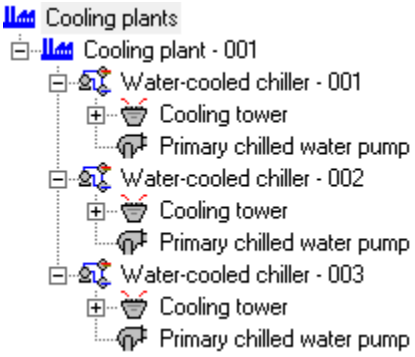


Figure 10 Cooling Plant

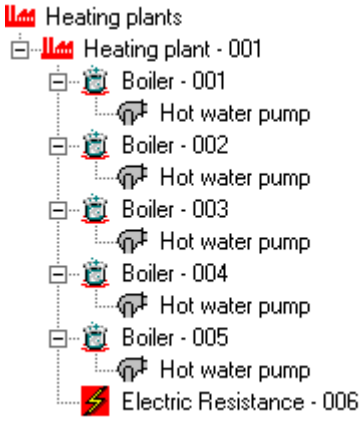


Figure 9 Heating plants

Utility Rate

The energy source of AAM is natural gas and electric, because the boilers in AAM are natural gas fired condensing boilers, and the chillers are powered by electricity. According to the researched information from three articles and one website,

- Average Energy Price in New York-Northern New Jersey-2012 ,
- NYSERDA DG/CHP Integrated Database System, Utility Rate Database Documentation,
- Con Edison - Commercial Energy Calculator website ,
- Water and Wastewater Rate Schedule - NYC.gov,

3 options of electric and natural gas utility rates and one water utility rate are found in these four sources. However, NYSERDA DG/CHP Integrated Database System is a database of district energy system, which is not applied on AAM. Therefore, two types of utility rates are used in this report, which are a local utility company, Con Edison, and overall New York City utility companies.

In this Trace700 calculation, the electricity and gas rate is set as the utility rate of overall supplier companies:

- Assumed electricity rate = $0.203 / kWh
- Assumed utility (piped) gas = $1.124 / therm
- Assumed water rate = $3.17 /cf =$4.938 / 1000 gal

Table A. Average prices for energy products, United States and the New York area, June 2011 and June 2012

	June 2011			June 2012		
Energy product	United States	New York area	Percent difference	United States	New York area	Percent difference
Electricity (per KWH)	$0.134	$0.204	52.2	$0.135	$0.203	50.4
Utility (piped) gas (per therm)	1.077	1.296	20.3	0.927	1.124	21.3
Gasoline (per gallon)	3.753	3.952	5.3	3.602	3.706	2.9

NOTE: A positive percent difference measures how much the price in the New York area is above the national price, while a negative difference reflects a lower price in the New York area.

Figure 11 Assumed Utility Rates of AAM (Bureau of Labor Statistics, 2012)

	FY2012 Average	FY2013 Average	Change
Metered Customers, Rates per 100 Cubic Feet			
Water	$3.17	$3.39	$0.22
Wastewater	$5.04	$5.39	$0.35
Combined	$8.21	$8.78	$0.57

Figure 12 Assumed Utility rates of AAM (New York City Water Board, 2012)

Comparison between Design Document and Computed Load

In this section, a comparison between the Trace700 building energy model and the design model is conducted to ensure the accuracy of the energy model. Since the HVAC system of AAM has many sub-systems, such as fan coil heating the lobby façade and fin-tubed convectors along exterior walls, the comparison is conducted on the loads of main heating and cooling plants.

Table 4 Cooling and Heating Capacity: Calculated vs. Designed

Heating plant: Building Peak Load				
Calculated	17068.2	Mbh	75.962	Btuh/ft^2
Designed	13500	Mbh	60.081	Btuh/ft^2
			Difference :	-20.91%

Heating plant: Building Peak Load				
Calculated	811.8	ton	276.786	ft^2/ton
Designed	900	ton	249.661	ft^2/ton
			Difference :	11%

Table 5 Ventilation Rate: Calculated vs. Designed

Ventilation Rate						
System Outdoor Air Flow						
Calculated	37857	cfm	0.168482	cfm/ft^2		
Designed	60800	cfm	0.270589	cfm/ft^2	Difference :	-61%
Tech 1 calculated	53464	cfm	0.237941	cfm/ft^2	Difference:	-41%

The calculated loads are matched with the designed values, but only the calculated ventilation rate is not matched with the designed rate. Therefore, the VAV assumption is very different with the true value.

Annual Energy Consumption

Utility Rates

In this section, it shows two estimations. Con Edison - Commercial Energy Calculator website is used as an area-estimation, and Average Energy Price in New York-Northern New Jersey is used as detail estimation. By comparing the two estimations, it defines the accuracy of the calculated model and the different characteristics between AAM and a typical museum.

Area Estimate

After inputting the basic information of AAM, the annual energy and fuel cost and usage are generated. The electric and fuel analysis is an analysis that the building has two separated energy suppliers, and the combined fuel analysis assumes that the building has only one utility supplier. The two electric difference and fuel difference analysis show the energy difference depended on the local weather from last month (September 2012) and last year (2011).

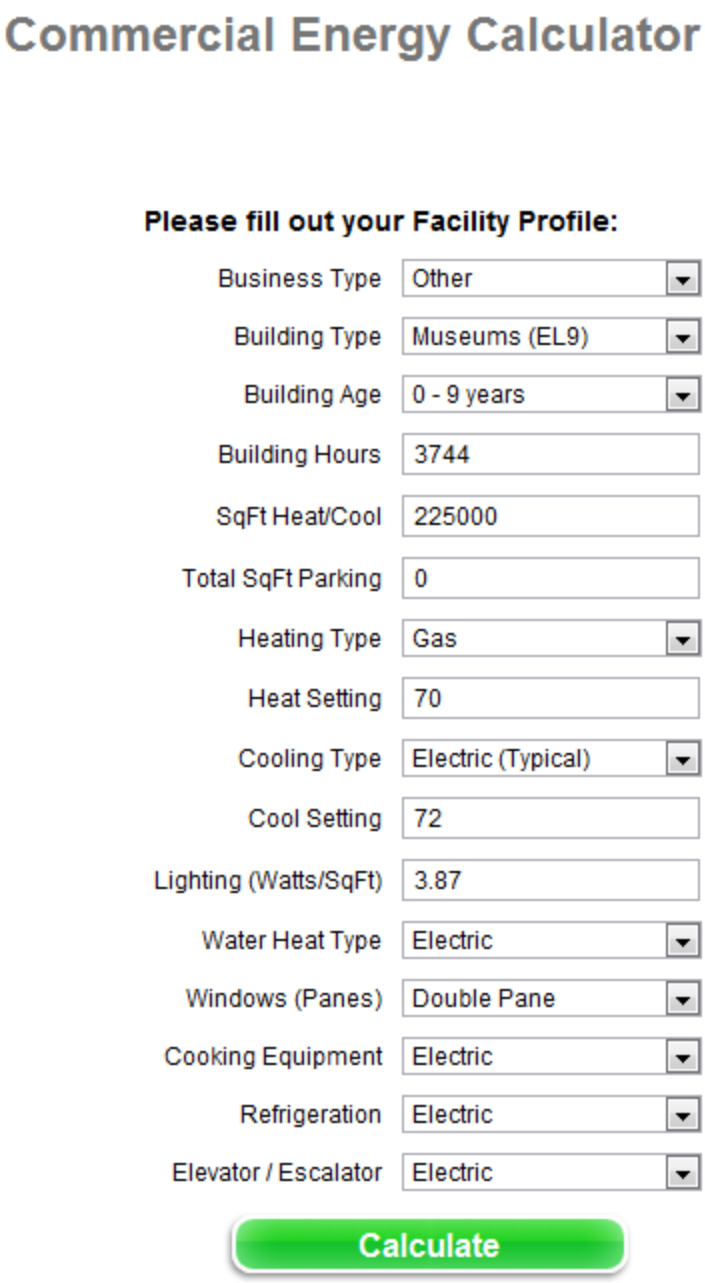


Figure 13 Input Data of Area Estimate

Annual Electric Cost

	Base Facility
	Average Efficiency
Indoor Lighting	$125,293
Outdoor Lighting	$0
Cooling	$236,607
Refrigeration	$7,503
Heating	$17,716
Cooking	$15,005
Water Heating	$12,504
Miscellaneous	$53,240
Annual Total	**$467,869**
Average Electric Cost	**$0.2217**
Average Load Factor	**37.2%**

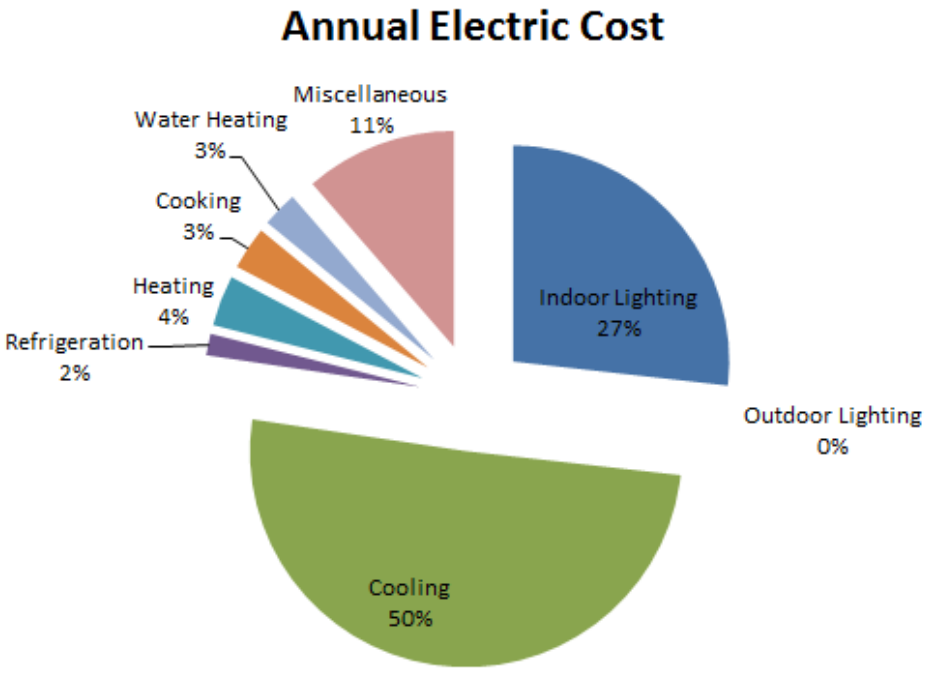


Figure 14 Annual Electric Cost Comparison of Area Estimation

Annual Fuel Cost

	Base Facility		
	Natural Gas	**Propane**	**Oil**
Heating	$38,783	N/A	N/A
Cooking	N/A	N/A	N/A
Water Heating	N/A	N/A	N/A
Annual Total	**$38,783**	**N/A**	**N/A**

Figure 15 Annual Fuel Cost Comparison of Area Estimation

Annual Combined Energy Cost

	Base Facility
	Average Efficiency
Indoor Lighting	$124,950
Outdoor Lighting	$0
Cooling	$236,607
Refrigeration	$7,482
Heating	$56,500
Cooking	$14,964
Water Heating	$12,470
Miscellaneous	$53,095
Annual Total	**$506,069**

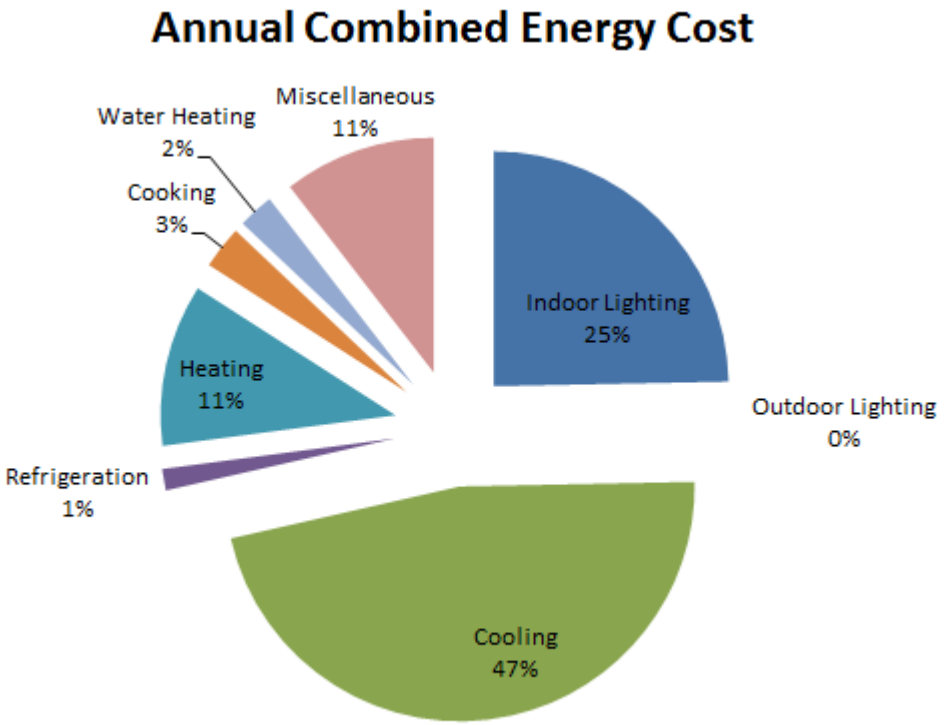


Figure 16 Annual Combined Energy Cost Comparison of Area Estimation

Annual Electric Usage

	Base Facility
	Average Efficiency
Indoor Lighting	565,171
Outdoor Lighting	0
Cooling	1,067,289
Refrigeration	33,842
Heating	79,915
Cooking	67,685
Water Heating	56,404
Miscellaneous	240,157
Annual Total kWh	**2,110,464**

Figure 17 Annual Electric Usage of Area Estimation

Annual Fuel Usage

	Base Facility		
	Natural Gas (Therms)	**Propane (gal)**	**Oil (gal)**
Heating	24,392	N/A	N/A
Cooking	N/A	N/A	N/A
Water Heating	N/A	N/A	N/A
Annual Total	**24,392**	**N/A**	**N/A**

Figure 18 Annual Fuel Usage of Area Estimation

For additional information, select a question

Why are my energy costs different from last month or last year? | Start Over

Electric | Fuel

Electric Difference From Last Month

kWh Summary:

The September 2012 usage was about 127,115 kWh lower than the August 2012 period.

Cost Summary:

The September 2012 costs were about $28,180 lower than the August 2012 period.

Days:

The September 2012 bill period was 1 day shorter than the August 2012 bill period.

Weather:

The average temperature for September 2012 was 8.1 degrees colder than August 2012.

Based upon the way you described your facility, these weather differences would decrease your kWh use by 124,638 kWh and decrease your estimated monthly costs by about $27,631.

Electric Difference From Last Year

kWh Summary:

The September 2012 usage was about 20,639 kWh lower than the September 2011 period.

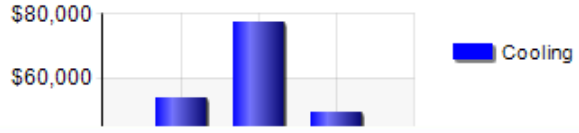
Cost Summary:

The September 2012 costs were about $4,576 lower than the September 2011 period.

Weather:

The average temperature for September 2012 was 1.5 degrees colder than September 2011.

Based upon the way you described your facility, these weather differences would decrease your kWh use by 20,639 kWh and decrease your estimated monthly costs by about $4,576.



Month	Sep 2011	Aug 2012	Sep 2012
Avg. Temp	69.3°F	75.9°F	67.9°F
Cost	$53,741	$77,346	$49,165

Figure 19 Electric Difference of Area Estimation

For additional information, select a question

Why are my energy costs different from last month or last year? | Start Over

Electric | Fuel

Fuel Difference From Last Month

Fuel Summary:

The September 2012 usage was about 10.2 gallons/Therms higher than the August 2012 period.

Days Summary:

The September 2012 bill period was 1 day shorter than the August 2012 bill period.

Price Impact:

The average price in August 2012 changed from Infinity per gallons/Therm to $1.5900 per gallons/Therm in September 2012.

Weather:

The average temperature for September 2012 was 8.1 degrees colder than August 2012.

Based upon the way you described your facility, these weather differences would increase your fuel use by 10 gallons/Therms and increase your estimated monthly costs by about $16.

Fuel Difference From Last Year

Fuel Summary:

The September 2012 usage was about 10.2 gallons/Therms higher than the September 2011 period.

Price Impact:

The average price in September 2011 changed from Infinity per gallons/Therm to $1.5900 per gallons/Therm in September 2012.

Weather:

The average temperature for September 2012 was 1.5 degrees colder than September 2011.

Based upon the way you described your facility, these weather differences would increase your fuel use by 10 gallons/Therms and increase your estimated monthly costs by about $16.

Month	Sep 2011	Aug 2012	Sep 2012
Avg. Temp	69.3°F	75.9°F	67.9°F
Cost	$0	$0	$16

Figure 20 Fuel Difference of Area Estimation

Detail Estimation

The detail estimation is based on the utility rate of Average Energy Price in New York-Northern New Jersey-2012 and Water and Wastewater Rate Schedule - NYC.gov. The energy of AAM is dominated by the heating cost, because the cost of natural gas is very high. In the HVAC system of AAM, only 5 boilers are fired by natural gas. However, in this calculation, the cogeneration system and some heating devices in AAM are not included. Therefore, the utility cost of natural gas should be lowered.

Cost Break-down between Electricity, Natural gas, Water

(The detail breakdown of AAM annual utility cost is shown in Appendix D.)

Table 6 Electricity vs. Month

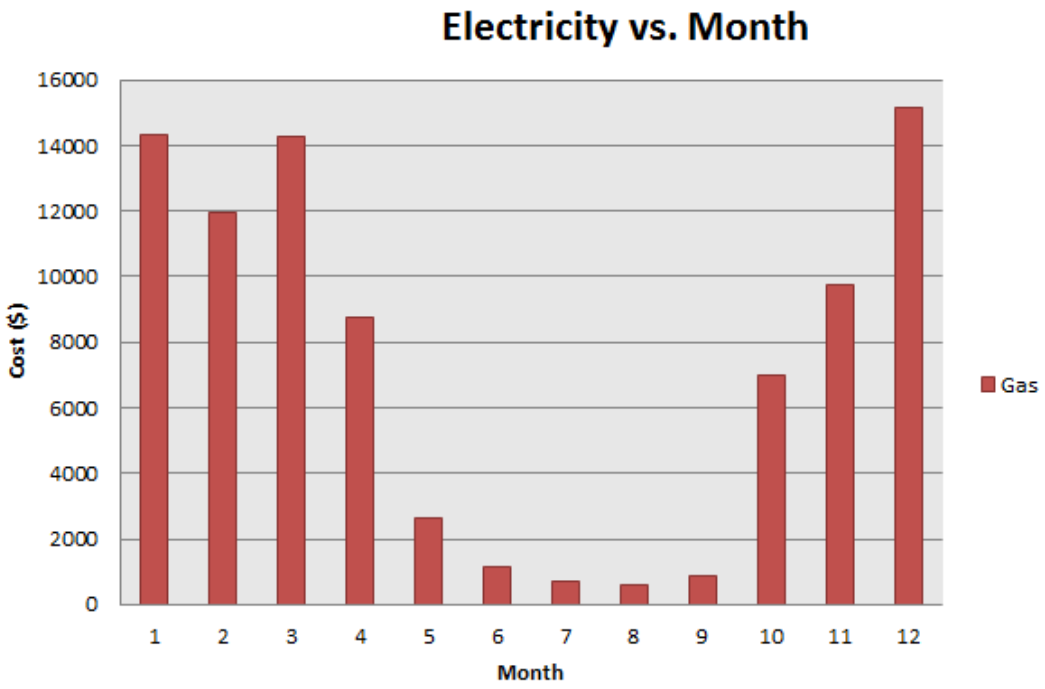


Table 7 Water vs. Month

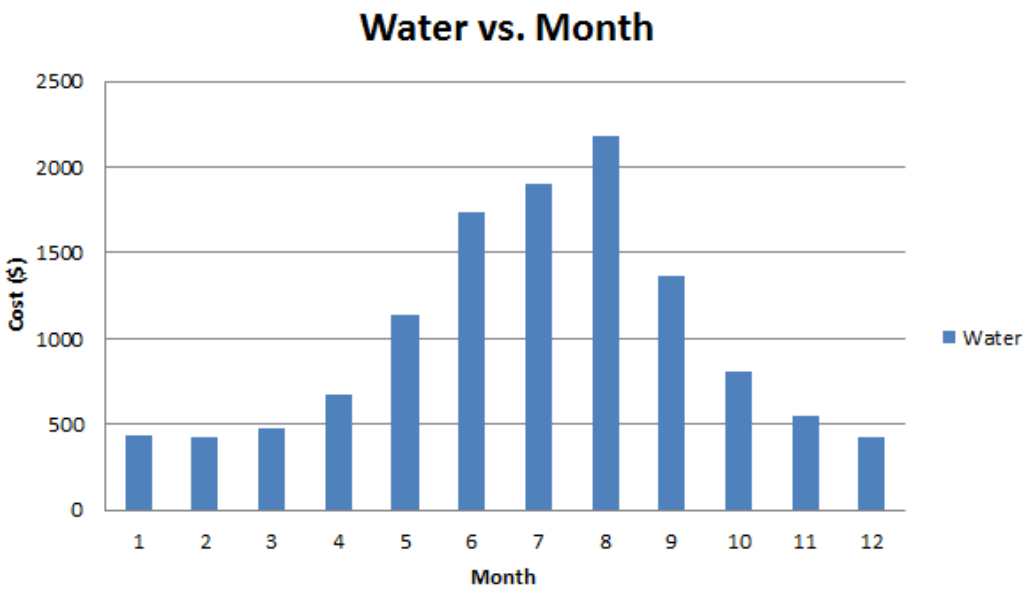
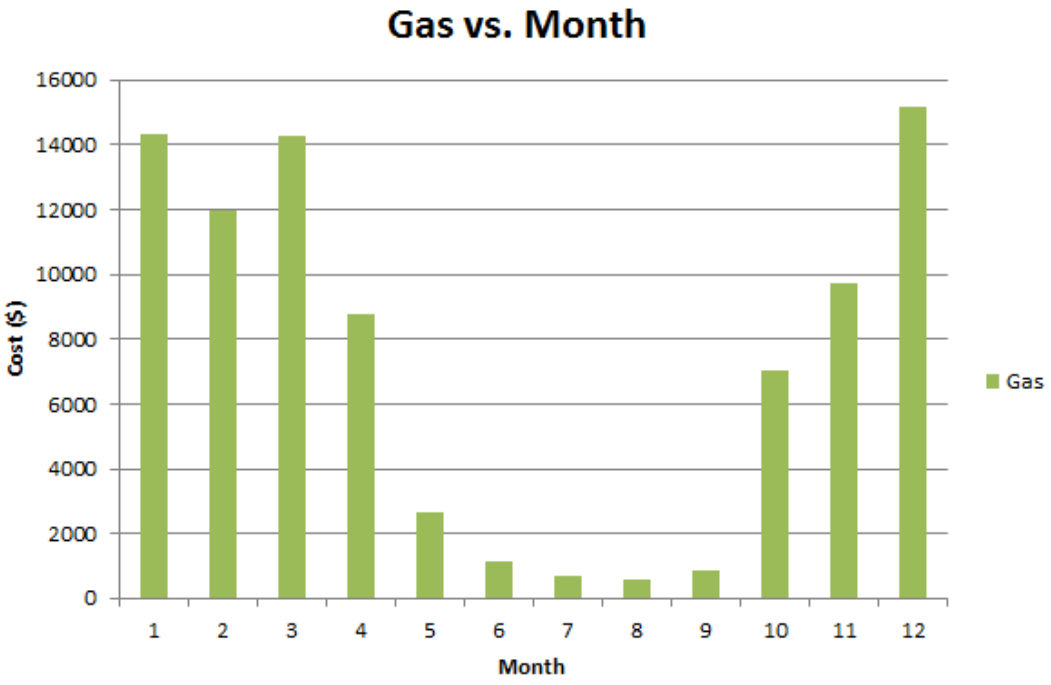


Table 8 Gas vs. Month



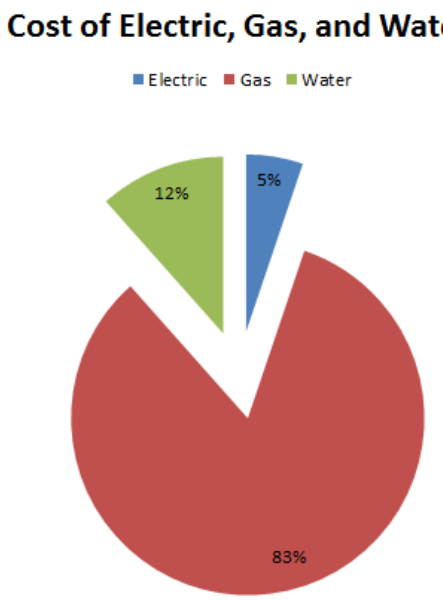


Figure 21 Cost of Electric, Gas, and Water

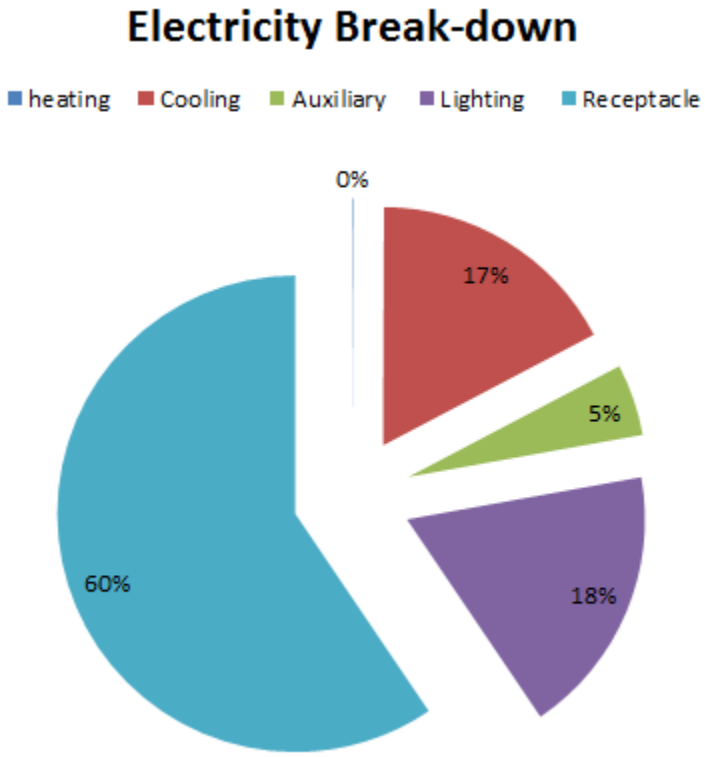


Figure 22 Electric energy fraction of various building subsystems

Equipment-Utility	Cost ($)	Cost/Area ($/sf)	%
Lighting	999.82	0.004	1.08
Misc. Ld	3237.82	0.014	3.49
Chiller	446.71	0.002	0.48
Cooling Tower	143.93	0.0006	0.16
Chilled Water Pump	607.18	0.003	0.66
Ctrl panel & interlock (cooling)	7.41	~0	0.01
Boiler	87215.00	0.388	94.12
Make-up Water	0.62	~0	0.00
Ctrl panel & interlock (heating)	3.51	~0	0.00

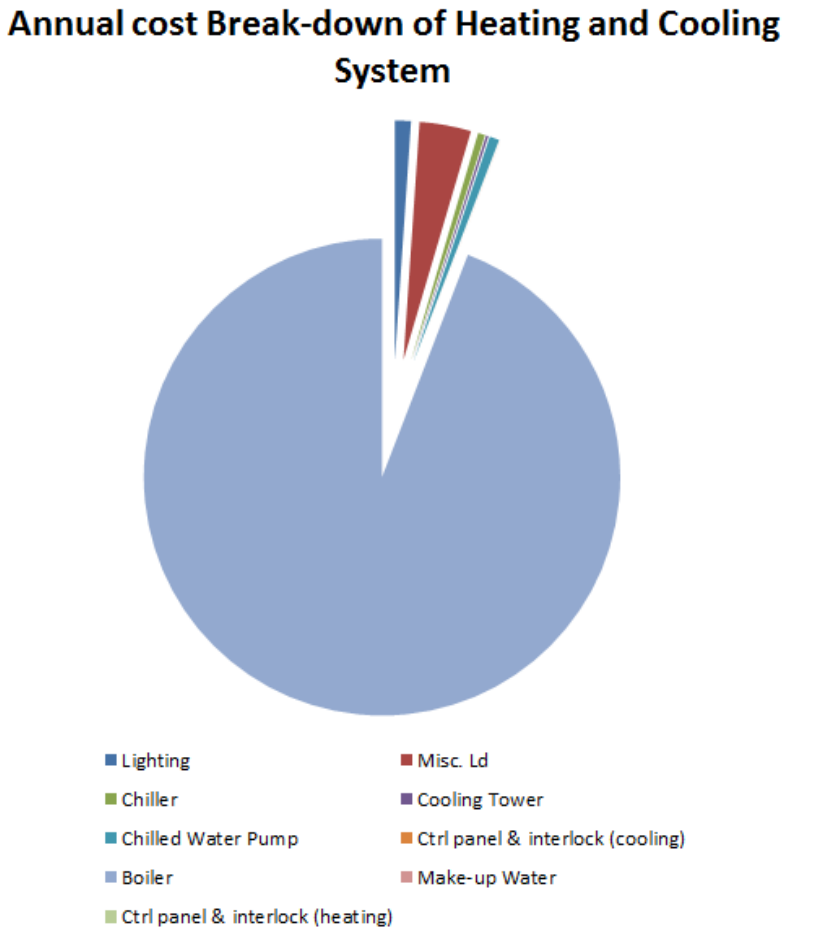


Figure 23 Annual cost Break-down of Heating and Cooling System

Conclusion of Area and Detail Estimation

The area estimation is based on statistical data of overall museums in New York State, and the detail estimation focuses on AAM with typical utility rates, which show in Table 9 Utility Rate. This comparison shows the uniqueness of AAM with energy usage concern and the similarity/difference(s) of average and particular utility rate. The annual utility cost of a typical museum is $506,652/yr, and the annual utility cost of AAM is significantly lower, which is $92,662/yr. The reasons why both of the annual utility costs are very different are:

- AAM is a very energy-efficient building, and it will gain 19 LEED points on Optimize Energy Performance.
- The utility rates provided by two sources are different. The different of two electric rate falls in an acceptable range, but the natural gas rates have ~40% difference.
- The detail estimation doesn't include the electric powered heating equipment.

Table 9 Annual Cost of Utility

Annual Cost of Utility		
	Area Estimation	Detail Estimation
Electricity	$467,869	$5,447
Natural Gas Fuel	$38,783	$87,215
Water	--	$104,787
Combined Fuel	$506,069	--

Table 10 Utility Rate

Utility Rate			
	Area Estimation	Detail Estimation	Differences
Electricity	$ 0. 2217/kWh	$0. 203/kWh	9.21%
Natural Gas Fuel	$1.590/therms	$1.124/therms	41.56%
Water	--	$3.17/100cf.	--

Table 11 Electric Consumption of Different Equipment Ratio

Peak Electric Consumption of Different Equipment		
	Area Estimation (kWh)	Detail Estimation (kW)
Cooling Equipment	1890.7	646.43
Heating Equipment	137.2	0
Misc Equipment	625.4	1485.85
Lighting	970.4	354.34

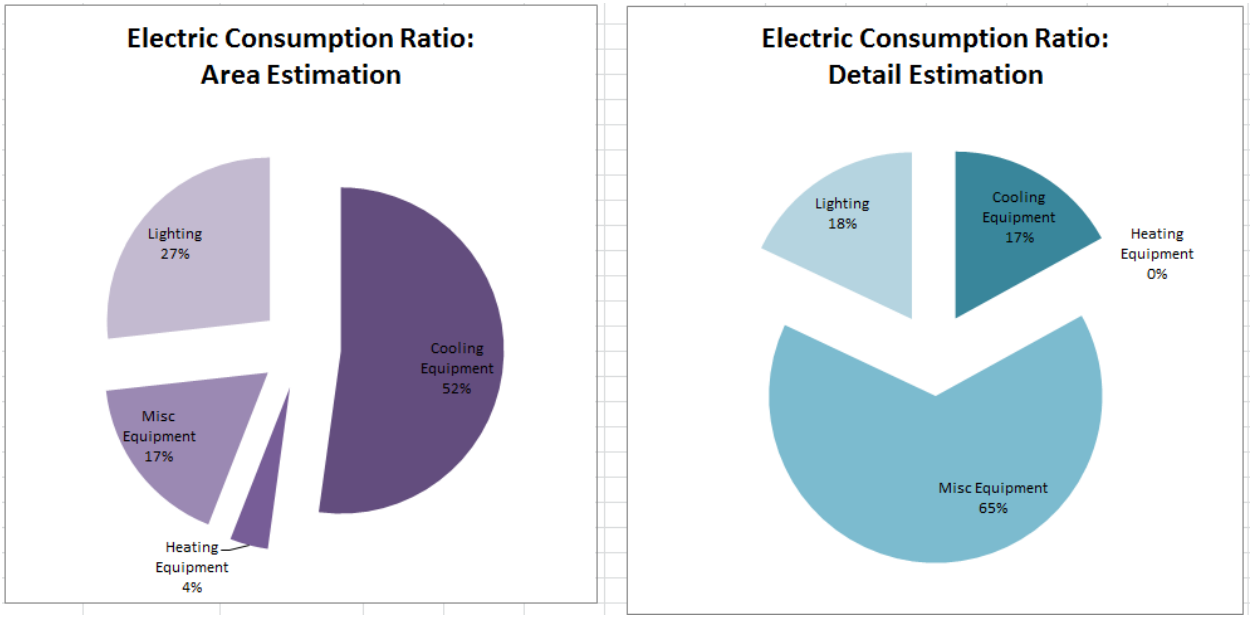


Figure 24 Electric Consumption of Different Equipment Ratio

Maintenance Cost

The maintenance costs are only for the major components of the system. Since the construction of AAM is not completed, the following maintenance cost is founded in RS Means Mechanical Cost:

Table 12 Maintenance Cost of AAM

Maintenance Cost of AAM				
The Component of System	Quantity	Repair/ Replace	Frequency (yr)	In-house costs ($) [1]
Cooling plant				
Electric drive centrifugal chiller	3	Repair	10	100,095.5
		Replace	20	248,050
Central Air AHU (~5,400 cfm)	8	Repair	10	--
		Replace	15	19,875
Central Air AHU (~8,000 cfm)	2	Repair	10	782
		Replace	15	30,675
Central Air AHU (~16,000 cfm)	2	Repair	10	1,101
		Replace	15	59,150
Heating plant				
Hot Water Boiler (~2700 MBH)	5	Repair	30	4,764.05
		Replace	30	30,925
Cooling Tower (~200 tons)	5	Repair	10	6,412.5
		Replace	15	38,650

Table 13 installation Cost of AAM

Installation Cost of AAM		
The Component of System	Quantity	Costs ($) incl O&P
Gas fired boiler (2700 MBH)	5	7,875
Centrifugal type water chiller (300 tons)	3	164,500
Cooling Tower (300 tons)	5	62,000

[1] In house cost: the building provides its own maintenances to lower the profit.

Emissions

After conducting a building energy model of AAM, it is important to analyze the environmental impact of regional power plants. Understanding the pollution emission of power plant, it helps to select the environmental friendly power plant in the later HVAC design of the thesis.

AAM is located in New York, which falls in NPCC, Eastern interconnection. It shows the plants in the Eastern region:

- Generate electricity by using coals.
- Produce more PM10 and SOx.
- Produce high rate of mercury during pre-combustion.
- Produce most CO2e in all pollutants.

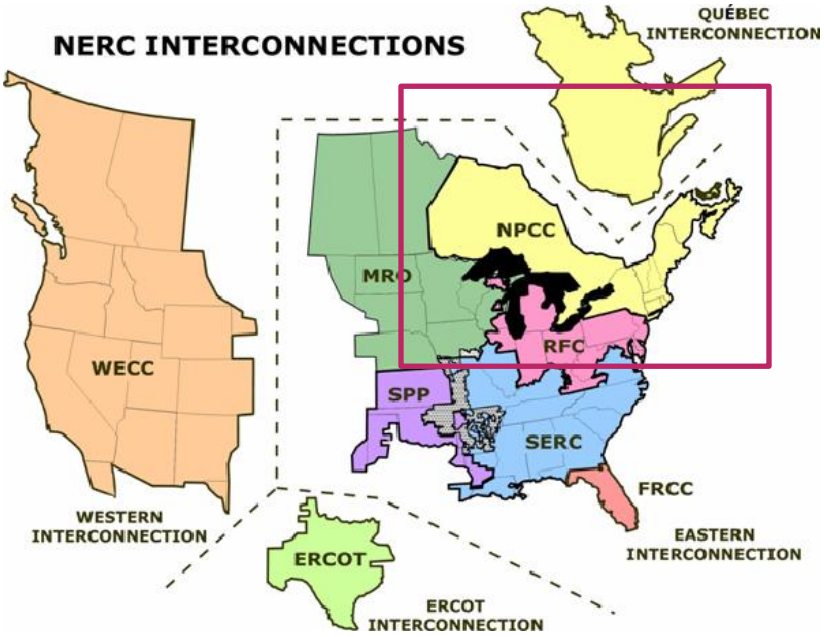


Figure 25 Nerc Interconnections

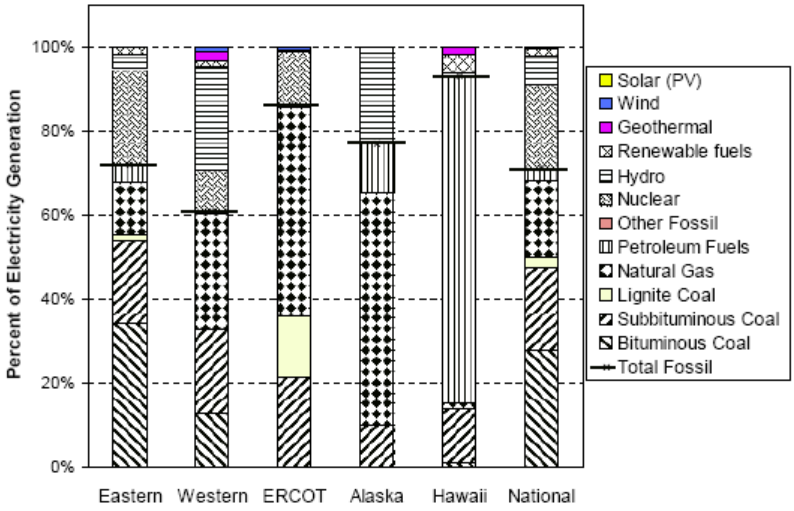


Figure 2 Electricity generation fuel mix for the continental United States (national), three interconnections, Alaska, and Hawaii for 2004 (EIA 2006a)

Figure 26 Electric generation fuel

Table B-3 Combustion Emission Factors for Generated Electricity
(lb of pollutant per kWh of electricity)

Emission (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.37E+00	1.43E+00	1.07E+00	1.38E+00	1.26E+00	1.48E+00
CO_2	1.36E+00	1.42E+00	1.06E+00	1.37E+00	1.25E+00	1.47E+00
CH_4	1.45E-05	1.43E-05	1.26E-05	2.01E-05	2.01E-05	1.87E-05
N_2O	3.25E-05	3.39E-05	2.62E-05	3.27E-05	2.46E-05	1.44E-05
NO_x	2.03E-03	2.21E-03	1.45E-03	1.53E-03	1.24E-03	2.29E-03
SO_x	5.25E-03	5.98E-03	3.27E-03	2.78E-03	1.77E-03	6.03E-03
CO	2.82E-04	2.59E-04	2.95E-04	4.69E-04	6.24E-04	3.22E-04
TNMOC	4.71E-05	4.64E-05	4.37E-05	6.11E-05	7.21E-05	5.62E-05
Lead	1.14E-07	1.23E-07	8.00E-08	1.12E-07	5.21E-08	1.12E-07
Mercury	2.70E-08	2.98E-08	1.65E-08	2.32E-08	3.28E-08	1.56E-07
PM10	6.96E-05	6.98E-05	5.42E-05	1.00E-04	8.13E-05	1.21E-04
Solid Waste	5.20E-02	5.40E-02	3.43E-02	7.07E-02	1.55E-02	1.28E-02

Figure 27 Combustion Emission Factors for Generated Electricity

Table B-5 Precombustion Emission Factors for Generated Electricity
(lb of pollutant per kWh of electricity)

Emission (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.54E-01	1.52E-01	1.38E-01	2.09E-01	2.50E-01	2.77E-01
CO_2	7.63E-02	7.63E-02	6.32E-02	1.04E-01	1.22E-01	2.14E-01
CH_4	3.36E-03	3.26E-03	3.23E-03	4.55E-03	5.54E-03	2.70E-03
N_2O	1.46E-06	1.47E-06	1.25E-06	1.90E-06	2.40E-06	3.94E-06
NO_X	4.80E-04	5.24E-04	3.45E-04	3.68E-04	4.81E-04	1.68E-03
SO_X	2.36E-03	1.85E-03	3.02E-03	5.57E-03	8.17E-03	2.27E-03
CO	4.50E-04	5.20E-04	2.09E-04	3.12E-04	1.19E-03	6.50E-03
TNMOC	1.78E-05	1.98E-05	1.58E-05	2.97E-06	2.25E-06	4.92E-05
Lead	4.44E-09	4.22E-09	2.54E-09	1.04E-08	3.74E-09	8.93E-09
Mercury	8.13E-10	8.50E-10	6.16E-10	8.96E-10	7.86E-10	1.53E-09
PM10	1.37E-05	1.47E-05	1.03E-05	1.19E-05	1.51E-05	4.33E-05
Solid Waste	1.21E-01	1.33E-01	9.37E-02	7.26E-02	5.44E-02	5.55E-02

Figure 28 Pre-combustion Emission Factors for Generated Electricity

Table B-10 (page 2) Total Emission Factors for Delivered Electricity by State (lb of pollutant per kWh of electricity)

Pollutant (lb)	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA
CO_{2e}	1.99E+00	1.47E+00	2.68E+00	1.81E+00	8.60E-01	9.31E-01	2.43E+00	1.88E+00	1.03E+00	2.20E+00	2.08E+00	4.85E-01	1.55E+00
CO_2	1.87E+00	1.41E+00	2.61E+00	1.71E+00	8.05E-01	8.61E-01	2.29E+00	1.76E+00	9.61E-01	2.10E+00	1.93E+00	4.40E-01	1.48E+00
CH_4	4.17E-03	2.37E-03	2.41E-03	3.70E-03	2.19E-03	2.79E-03	5.38E-03	4.81E-03	2.59E-03	3.71E-03	5.67E-03	1.83E-03	2.70E-03
N_2O	5.29E-05	3.11E-05	5.92E-05	4.94E-05	1.53E-05	1.76E-05	6.50E-05	3.75E-05	1.68E-05	4.73E-05	5.09E-05	1.04E-05	3.22E-05
NO_X	3.33E-03	2.83E-03	3.71E-03	3.09E-03	1.44E-03	1.32E-03	4.00E-03	2.89E-03	1.72E-03	4.14E-03	3.02E-03	5.21E-04	2.91E-03
SO_X	5.88E-03	8.26E-03	1.00E-02	4.79E-03	5.47E-03	6.34E-03	7.30E-03	1.21E-02	6.23E-03	1.19E-02	8.88E-03	3.03E-03	8.88E-03
CO	7.40E-04	4.31E-04	1.07E-03	6.09E-04	1.13E-03	6.69E-04	8.66E-04	7.39E-04	1.75E-03	6.38E-04	8.67E-04	2.72E-04	6.01E-04
TNMOC	6.02E-05	5.25E-05	5.34E-05	5.23E-05	8.62E-05	6.92E-05	7.27E-05	6.23E-05	6.38E-05	5.41E-05	8.01E-05	3.90E-05	5.46E-05
Lead	1.99E-07	1.16E-07	4.23E-07	1.87E-07	4.57E-08	4.27E-08	2.37E-07	1.09E-07	5.59E-08	1.76E-07	1.61E-07	2.05E-08	1.17E-07
Mercury	4.08E-08	2.40E-08	7.52E-08	3.73E-08	2.60E-08	1.44E-08	4.75E-08	2.27E-08	3.99E-08	3.59E-08	3.27E-08	4.59E-09	2.70E-08
PM10	1.14E-04	6.55E-05	3.03E-04	1.01E-04	5.47E-05	5.14E-05	1.36E-04	8.97E-05	6.87E-05	8.87E-05	1.16E-04	2.87E-05	7.14E-05
Solid Waste	3.01E-01	1.78E-01	3.33E-01	2.88E-01	5.65E-02	6.23E-02	3.65E-01	1.68E-01	6.18E-02	2.71E-01	2.49E-01	3.25E-02	1.78E-01

Figure 29 Total Emission Factors for Delivered Electricity by State

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Appendix A

Zone Division

Cellar Level

Table 14 Occupant Number

Zone	Number of Occupants
Mechanical Room	88
Kitchen	8
Lobby (Left)	0
Office	3
Lobby (Right)	0

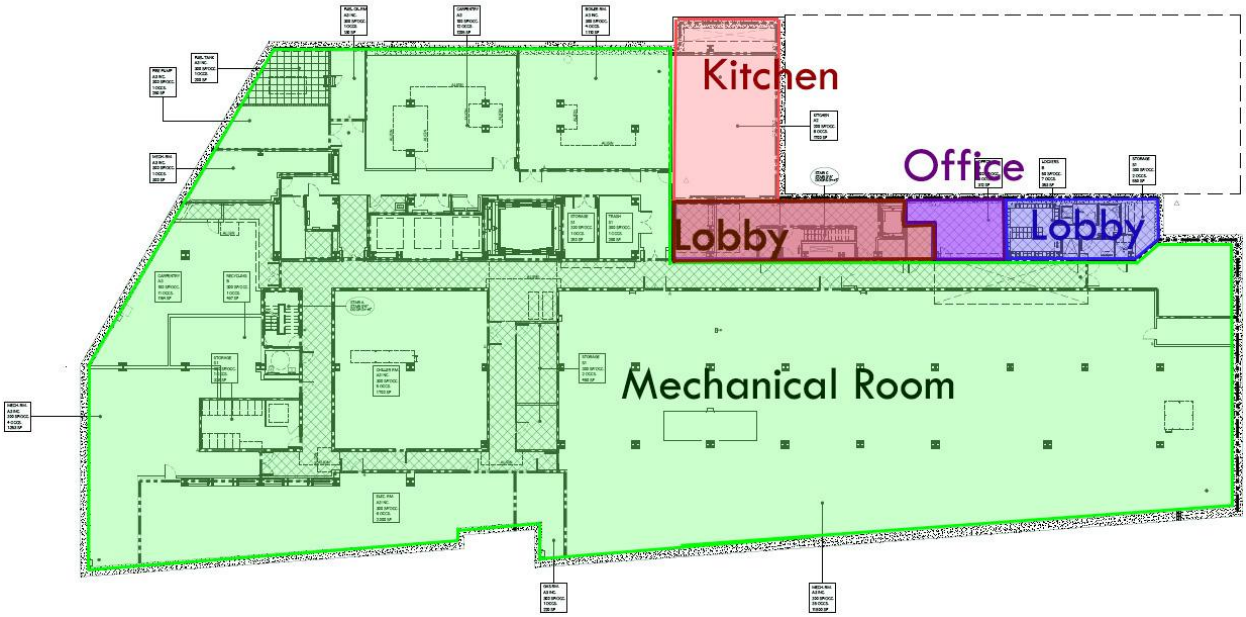

Figure 30 Zones in Cellar Level

Cellar Mezzanine Level

Table 15 Occupant Number

Zone	Number of Occupants
Storage	17
Restroom	0
Lobby (Left)	5
Lobby (Right)	0

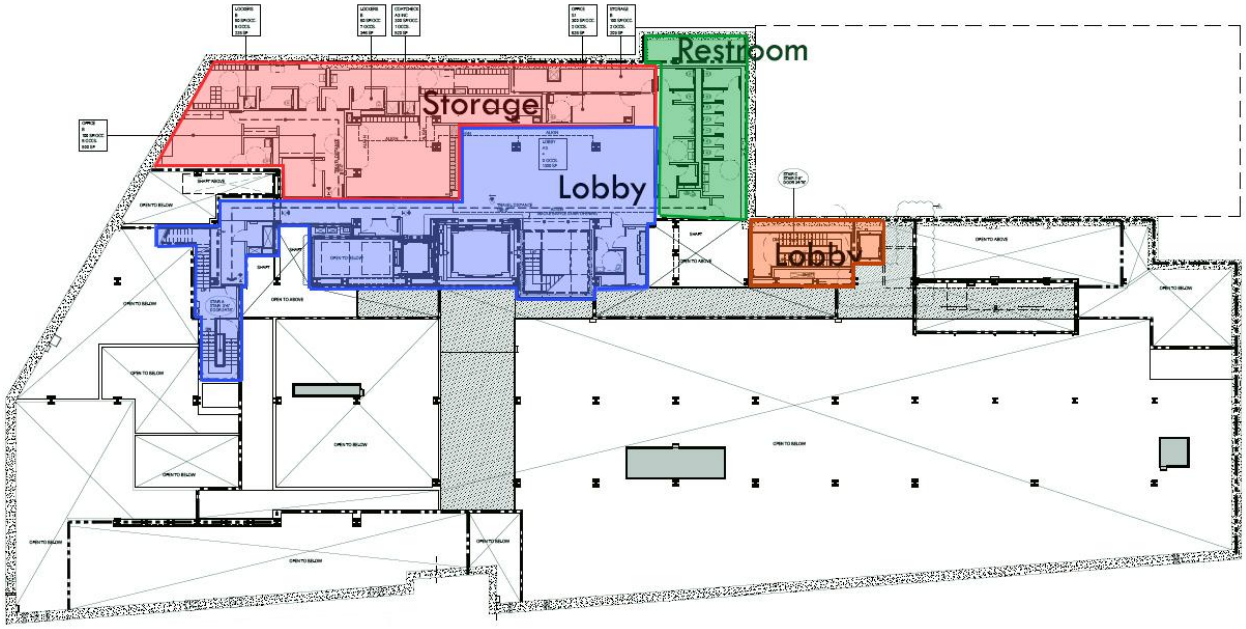

Figure 31 Zones in Cellar Mezzanine Level

1st Floor

Table 16 Occupant Number

Zone	Number of Occupants
Loading Area	10
Lobby	0
Gallery	37
Restaurant	166

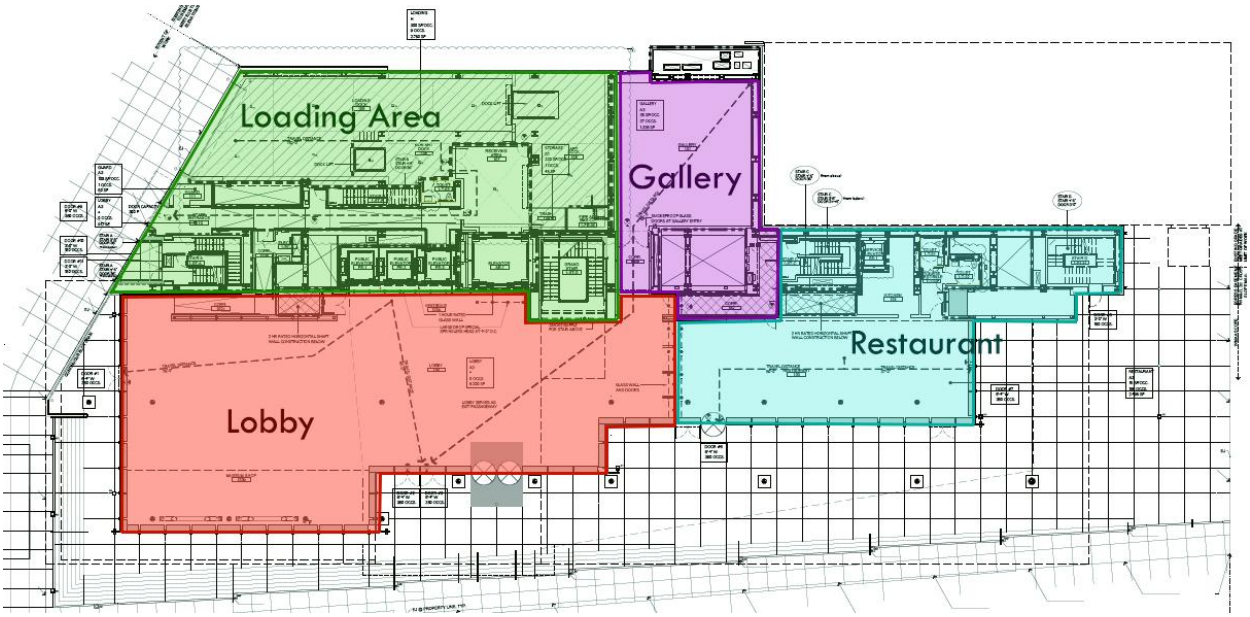

Figure 32 Zones in 1st Floor

2nd Floor

Table 17 Occupant Number

Zone	Number of Occupants
Loading Area	10

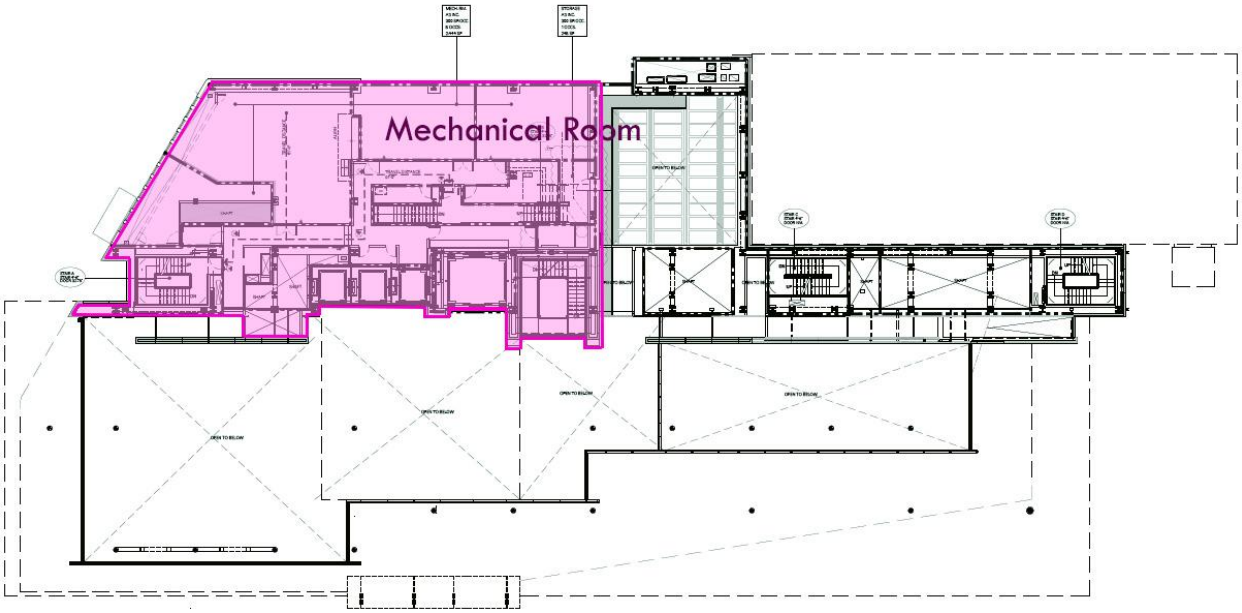

Figure 33 Zone in 2nd Floor

3rd Floor

Zone	Number of Occupants
Office (Top)	7
Restroom (Top)	0
Lobby (Left)	5
Lobby (Right)	0
Classroom	39
Theater	204
Restroom (Bottom)	0
Office (Bottom)	57

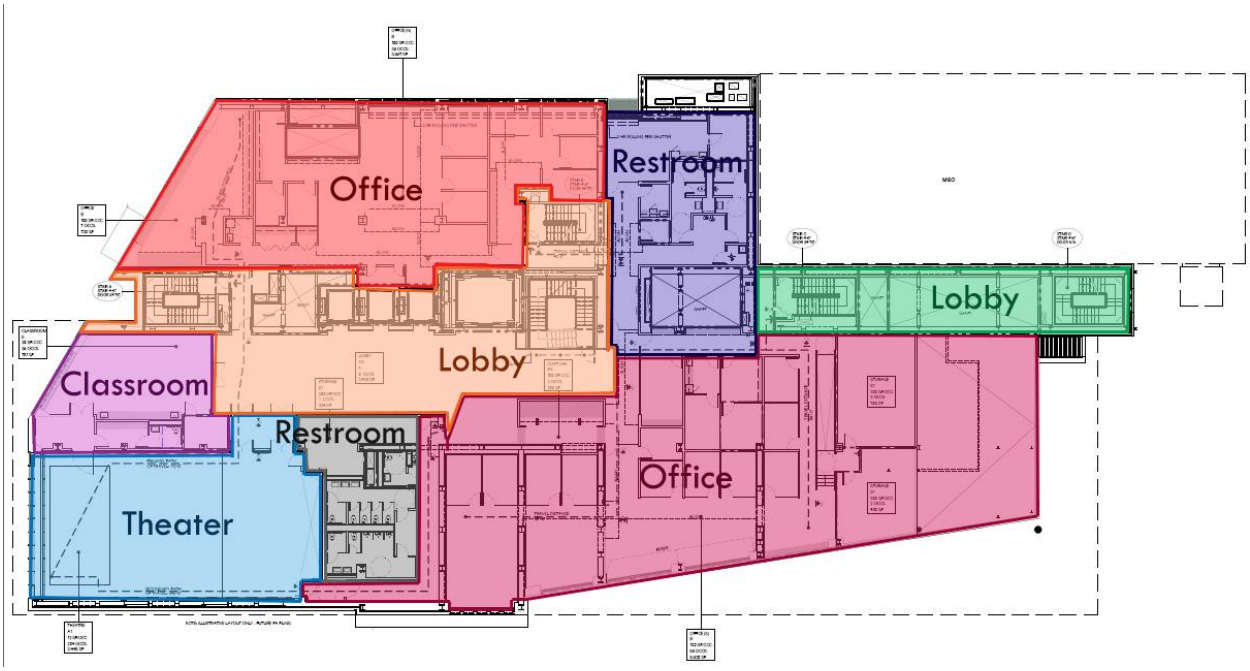

Figure 34 Zones in 3rd Floor

4th Floor

Table 18 Occupant Number

Zone	Number of Occupants
Office (Top)	55
Office (Bottom)	186
Lobby (Left)	0
Lobby (Right)	0

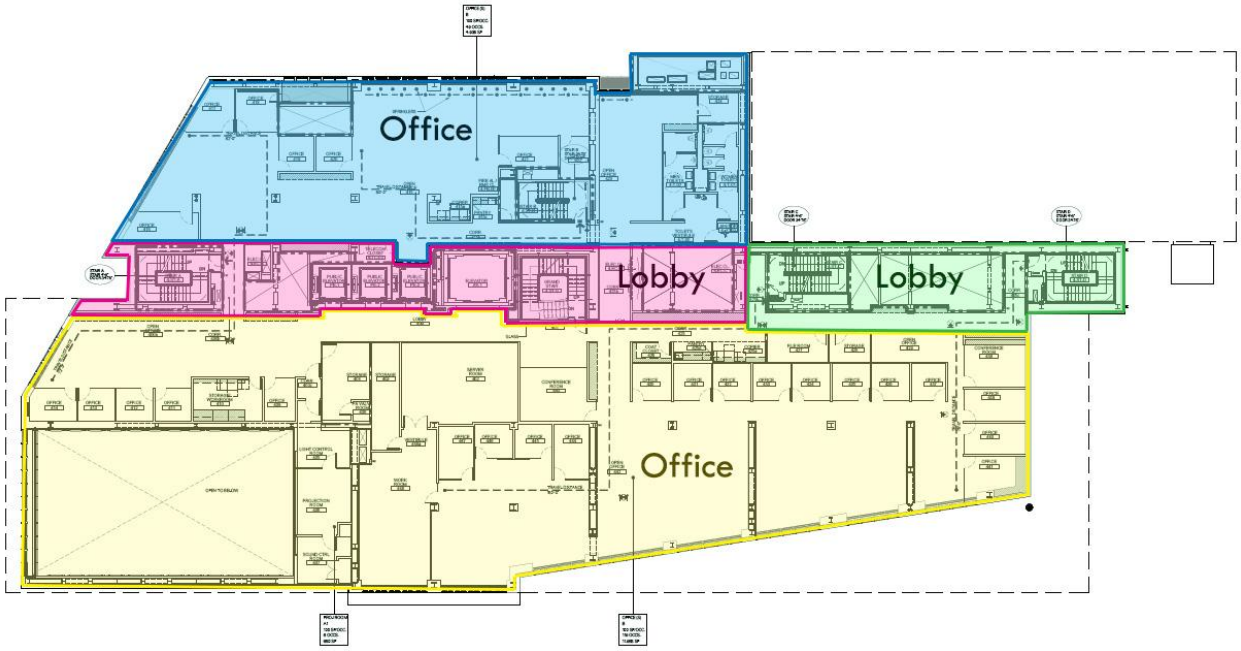

Figure 35 Zones in 4th Floor

5th Floor

Table 19 Occupant Number

Zone	Number of Occupants
Art Storage	31
Projecting Room	73
Lobby (Left)	0
Lobby (Right)	0
Gallery	513

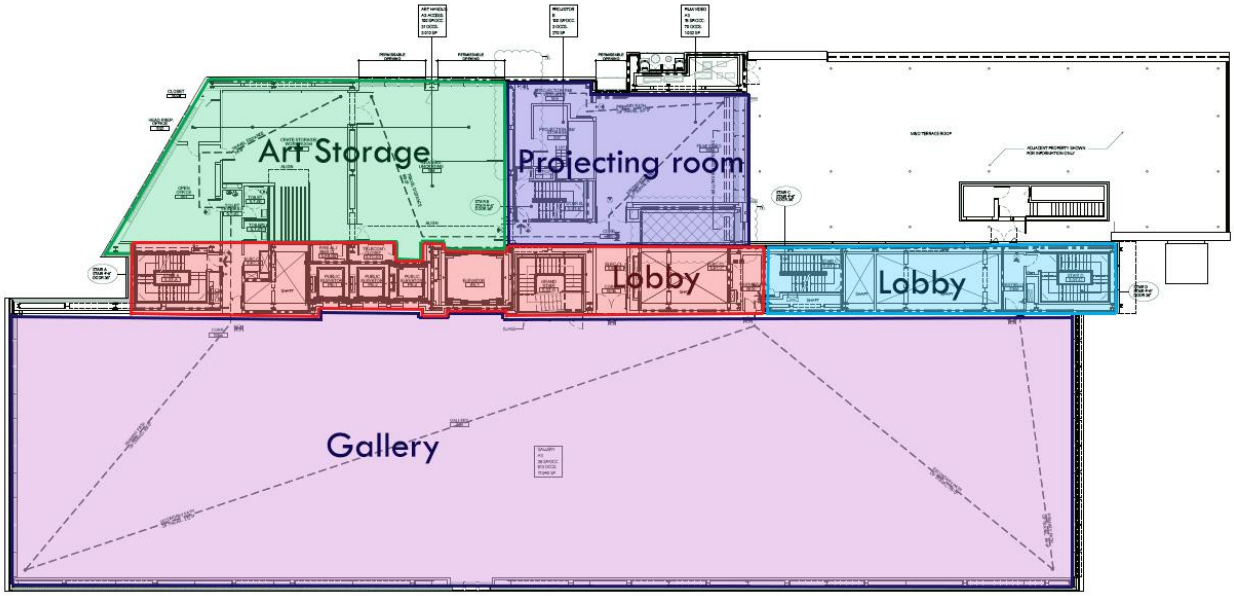

Figure 36 Zones in 5th Floor

6th Floor

Table 20 Occupant Number

Zone	Number of Occupants
Office	4
Conservatory	26
Lobby	0
Study Center	15
Gallery	325

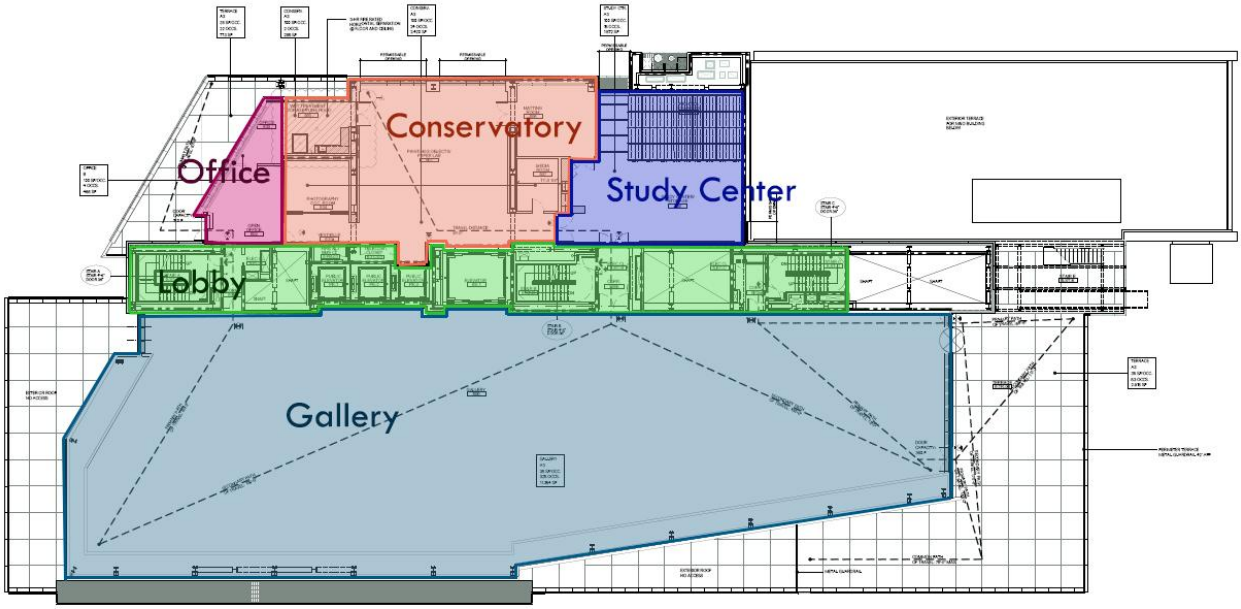

Figure 37 Zones in 6th Floor

7th Floor

Table 21 Occupant Number

Zone	Number of Occupants
Library	29
Office	31
Lobby	0
Gallery	260

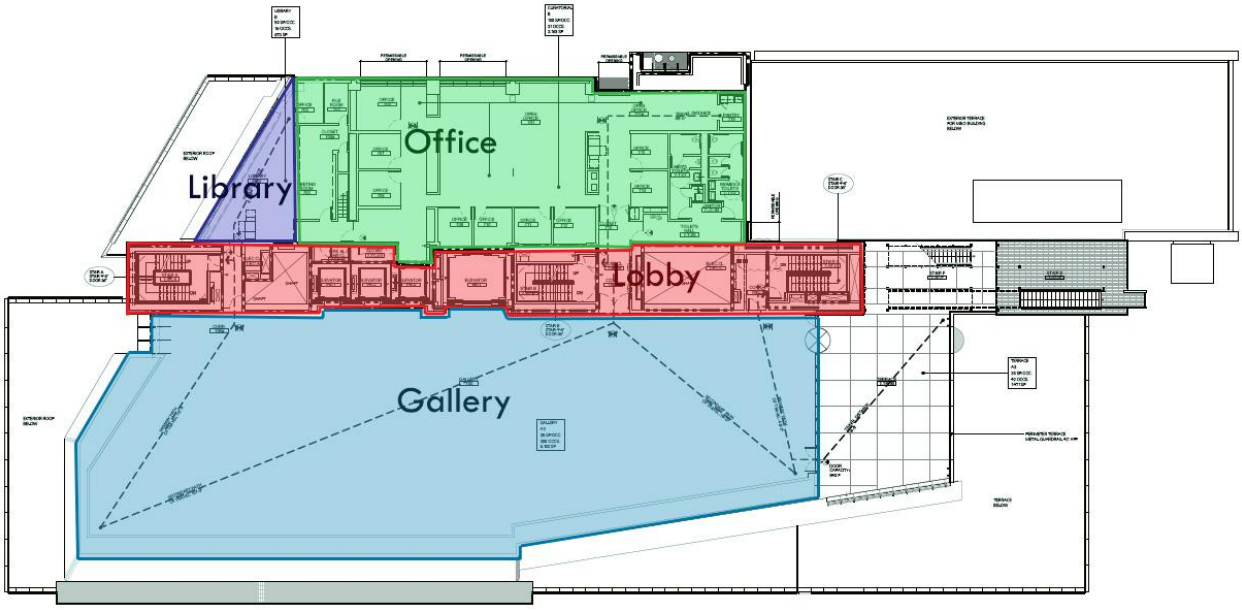

Figure 38 Zones in 7th Floor

8th Floor

Table 22 Occupant Number

Zone	Number of Occupants
Office (Right)	9
Conference	81
Office (Left)	0
Kitchen	4
Restroom	0
Lobby	0
Gallery	224

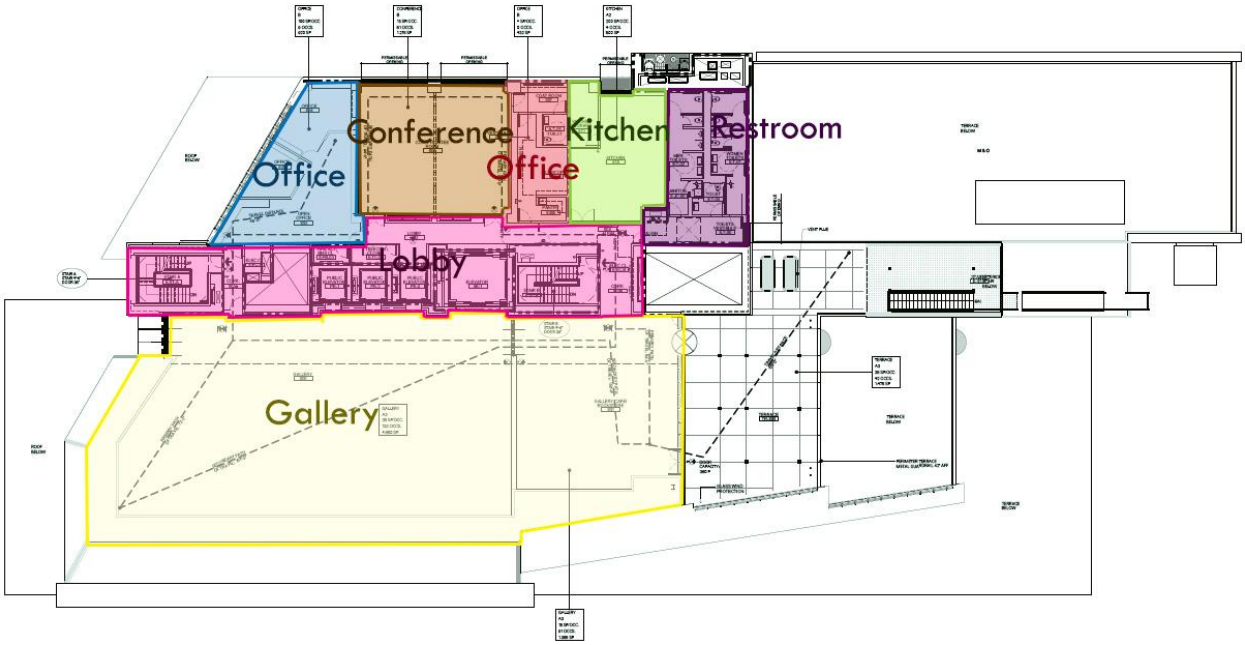

Figure 39 Zones in 8th Floor

9th Floor

Table 23 Occupant Number

Zone	Number of Occupants
Mechanical Room	18
Lobby	0

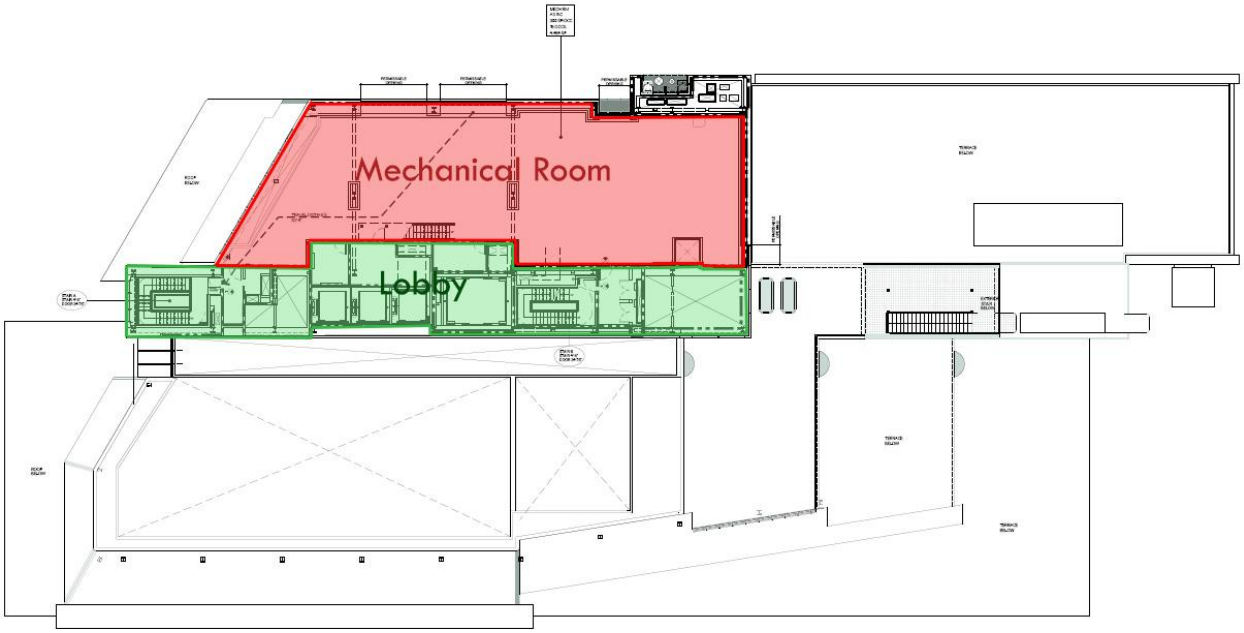

Figure 40 Zones in 9th Floor

Appendix B

U-value of Different Wall Types					
Type	insulation	thickness (in)	total r-factor	Density	Specific Heat
			(hr-F-ft^2/BTU)	lbm/ft^3	(BTU/lb-F)
A	gypsum board	0.625	1.136	40	0.270
	insulation (fiberglass)	4	13.333	0.7	0.200
		5.25	0.069	10.057	0.217
		total thickness	total u-value	avg density	avg specific heat
B	gypsum board	0.625	2.273	40	0.270
	insulation (fiberglass)	4	13.333	0.7	0.200
		6.5	0.064	15.815	0.227
		total thickness	total u-value	avg density	avg specific heat
C	gypsum board	0.625	1.136	40	0.270
	insulation (fiberglass)	2.5	16.667	0.7	0.200
		6.25	0.056	8.560	0.214
		total thickness	total u-value	avg density	avg specific heat
D	gypsum board	0.625	2.273	40	0.270
	insulation (fiberglass)	2.5	8.333	0.7	0.200
	Air		0.333		
		5	0.091	20.350	0.235
		total thickness	total u-value	avg density	avg specific heat
E	gypsum board	0.625	1.136	40	0.270
	insulation (fiberglass)	3	3.333	0.7	0.200
	Air		0.333		
		4.25	0.208	12.259	0.221
		total thickness	total u-value	avg density	avg specific heat
F-1 to 2	gypsum board	0.625	0.568	40	0.270
	insulation (fiberglass)	3	10.000	0.7	0.200
	Air		0.000		
		3.625	0.095	7.476	0.212
		total thickness	total u-value	avg density	avg specific heat
F-3 to 11	gypsum board	0.625	0.568	40	0.270
	insulation (fiberglass)	4	13.333	0.7	0.200
	Air		0.000		
		4.625	0.072	6.011	0.209
		total thickness	total u-value	avg density	avg specific heat
F-12 to 14	gypsum board	0.625	1.136	40	0.270
	insulation (fiberglass)	4	13.333	0.7	0.200
	Air		0.000		
		5.25	0.069	10.057	0.217
		total thickness	total u-value	avg density	avg specific heat
F-16 to 20	Plywood	0.75	1.080	28	0.45
	gypsum	0.625	0.568	40	0.270
		1.375	0.607	33.455	0.368
		total thickness	total u-value	avg density	avg specific heat
G-1 to 3, 7,	Steel plate	0.3125	0.012	489	0.120
	Plywood	0.75	1.080	28	0.45
	gypsum	0.625	0.568	40	0.270
		1.6875	0.602	117.815	0.322
		total thickness	total u-value	avg density	avg specific heat
G-4&5	gypsum board	0.625	1.136	40	0.270
	acoustics tile	5	11.905	21	0.000
	gypsum board	1	0.909	40	0.270
		7.25	0.072	26.897	0.270
		total thickness	total u-value	avg density	avg specific heat
H	gypsum board	0.625	1.136	40	0.270
	acoustics tile	3	7.143	21	0.000
	gypsum board	1	0.909	40	0.270
		5.25	0.102	29.143	0.270
		total thickness	total u-value	avg density	avg specific heat
M	masonary	4	1.110	100	0.21
		4	0.901	100.000	0.210
		total thickness	total u-value	avg density	avg specific heat

U-value of Roof			
	R-value	thickness [in]	total u value
E-1 Sidewalk & plaza (over Tempered) & conditioned below-grade space)			
4" reinforced concrete wearing surface	0.1	4	0.4
Filter fabric	0	0	0
Rigid insulation (polystyrene)	0.2	6	1.2
Composite Drainage Panel	0	0	0
Protection board	0	0	0
Waterproofing membrane	0	0	0
Sloped structural concrete slab or fill	0.1	4	0.4
		total u value	0.5
R-1 Terrace Roofs			
4" reinforced concrete wearing surface	0.1	4	0.4
Filter fabric	0	0	0
Rigid insulation (polystyrene)	0.2	6	1.2
Composite Drainage Panel	0	0	0
Protection board	0	0	0
Leak detection mat	0	0	0
Waterproofing membrane	0	0	0
Sloped structural concrete slab or fill	0.1	4	0.4
		total u value	0.5
R-2 Clerestory Gutters+(Over Conservation Spaces)			
Galvanized (Or stainless steel) Grating			
Counter flashing at skylight			
snow melting cables TBD	Not Used		
Primary flexible PVC Membrane			
Steel Substrate			
R-3 M&O building roof terrace (Over Substrate By Others)			
Pre-cast Concrete Pavers on Adjustable Pedestals	0.1	2.25	0.225
Roofing Substrate By M&O			0.333
		total u value	1.791
R-4A South Roof Perimeter (Over Conservation Spaces)			
Metal Grating	0	0	0
snow melting cables (5ft in width or less)	0	0	0
Gravel	0	0.5	0
Rigid Insulation (Polystrene)	0.2	3.6	0.72
Composite Drainage Panel	0	0	0
Protection Board	0	0	0
Waterproofing membrane P.M.M.A.	0	0	0
Slope structural Concrete Slb or Fill or Steel Structure	0.1	4	0.4
		total u value	0.893
R-4B South Roof Perimeter			
4" reinforced concrete wearing surface	0.1	4	0.4
Filter fabric	0	0	0
Rigid insulation (polystyrene)	0.2	4.2	0.84
Composite Drainage Panel	0	0	0
Protection board	0	0	0
Waterproofing membrane	0	0	0
Sloped structural concrete slab or fill	0.1	4	0.4
		total u value	0.610
R-5 North Roof (Over Mechanical Space)			
Integrally Footed Pre-cast Concrete Pavers	0.1	2.25	0.225
Rigid insulation (Polystrene)	0.2	7.75	1.55
Composite Drainage Panel	0	0	0
Protection Board	0	0	0
Waterproofing membrance H.R.A.	0	0	0
Sloped structural concrete slab or fill	0.1	4	0.4
		total u value	0.460
R-6 Loading Dock (Upper Deck Area)			
4" reinforced concrete wearing surface	0.1	4	0.4
Rigid insulation (polystyrene)	0.2	7.75	1.55
Composite Drainage Panel	0	0	0
Self adhering rubberized Asphalt	0.333	1	0.333
Structural Concrete Slab	0.1	4	0.4
		total u value	0.373
R-7 Truck Loading Dock			
4" reinforced concrete wearing surface	0.1	4	0.4
30 # felt in Hot Asphalt	0.3333	6	1.9998
Foamglas insulation in hot asphalt	3	1	3
Composite Drainage Panel	0	0	0
Waterproofing membrane	0	0	0
Sloped structural concrete slab or fill	0.1	4	0.4
		total u value	0.172
R-8 Exterior Plenum			
Waterproofing Membrane (Elastatex)	0		0
Sloped structural concrete slab or fill	0.1	4	0.4
4-1/2" Spray-applied ployurethane insulation	3	4.5	13.5
		total u value	0.072
R-9 Smoke Plenum (Level 7 - Stair D)			
Waterproofing Membrane (Elastatex)	0	0	0
Densdeck	0.67	0.625	0.419
Tapered Rigid insulation (Polystyrene)	0.15	5.04	0.756
Structural Concrete slab	0.1	4	0.4
		total u value	0.635
GR-1 Greenroof			
extensive growing medium (Soil) 4' min	0.083	4	0.333
Filter Fabric	0	0	0
Drainage Tray	0	0	0
Moisture Retention Mat	0.2	2	0.4
Rigid Insulation (Polystyrene)	0.2	4	0.8
Root Barrier	0	0	0
Waterproofing Membrane H.R.A.	0	0	0
Structural Concrete Slab	0.1	4	0.4
		total u value	0.517
R-10 North Flue roof			
Metal Grating			
Gravel			
Polyester mat			
PMMA waterproofing membrane	Not Used		
5/8" Densdeck			
Tapered rigid insulation			
5/8 " Densdeck			
Corrugated metal deck			

BUILDING U-FACTORS

By ACADEMIC

Description	ROOM U-FACTORS Btu/h·ft²·°F											Room Mass lb/ft²	Room Capacitance Btu/lb·°F
	Partition	Internal Door	Exposed Floor	Summer Skylight	Winter Skylight	Roof	Summer Window	Winter Window	External Door	Wall	Ceiling		

Overall U-Factors			Overall Thermal Transfer Values	
Roof	0.116	Btu/h·ft²·°F	**Roof (OTTVr)**	11.44 Btu/hr·ft²
Wall	0.179	Btu/h·ft²·°F	**Wall (OTTVw)**	18.42 Btu/hr·ft²
Building	0.167	Btu/h·ft²·°F		

Appendix C

Cellar Level--Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load (W)
Cellar level	convenience recept	20	36	120	1	86400.000
	HWH	20	1	120	1	2400.000
	CLG MTD CORD REEL	20	3	120	1	7200.000
	DT-C-1, DT-C-2	20	1	120	1	2400.000
	FCU-IDF-C	20	1	120	1	2400.000
	UV STERILIZER	20	2	120	1	4800.000
	UH-C1	20	3	120	1	7200.000
	Desk recept	20	2	120	1	4800.000
	Fork Lift	20	1	120	3	4156.922
	Atuo Flush	20	2	120	1	4800.000
	Auto Sink	20	2	120	1	4800.000
	Hang Dryer	20	2	120	1	4800.000
	DT-C-3, DT-C-4	20	1	120	1	2400.000
	LTG	20	20	120	1	48000.000
	Elec ss RM/GAS	20	1	120	1	2400.000
	CUTING RM/STORAGE	20	1	120	1	2400.000
	Conv Quad	20	1	120	1	2400.000
	Tree PIT Recept	20	4	120	1	9600.000
	OUTDOOR FLOOR BOX	20	4	120	1	9600.000
	HVAC SNOW MELT	30	1	120	1	3600.000
	DRYER	30	1	120	3	6235.383
	WASHER RECEPTACLE	20	1	120	1	2400.000
	CORD REEL	20	5	120	1	12000.000
	Table saw	20	1	120	3	4156.922
	Chop saw	20	1	120	1	2400.000
	Drill Press	20	1	120	1	2400.000
	Band Saw	20	1	120	1	2400.000
	Dust collector	30	1	120	3	6235.383
	Radial Arm Saw	30	1	120	3	6235.383
	Joiner	30	1	120	1	3600.000
	Guillotine Frame Cutter	20	1	120	3	4156.922
	FE-C1-6	20	1	120	3	4156.922
	Self Contained Refr Ex	20	1	120	1	2400.000
	Counter recept	20	3	120	1	7200.000
	Air compressor	60	1	120	3	12470.766
	AC-C1-1	60	1	120	3	12470.766
	Vertical panel saw	30	1	120	1	3600.000
	Kettle, Tilting Gas	20	1	120	1	2400.000
	Tilt skillet	20	1	120	1	2400.000
	Electic Drop Cord	20	2	120	1	4800.000
	convection oven	20	1	120	1	2400.000
	Planting counter	50	1	120	1	6000.000
	double combi	20	1	120	1	2400.000
	Heat Lamp	20	1	120	1	2400.000
	40 QT Mixer	20	1	120	3	4156.922
	Heat Lamp	20	2	120	1	4800.000
	Walk in cooler	20	2	120	1	4800.000
	Dry pipe compressor	20	1	120	1	2400.000
	Cellar IDF security	20	1	120	1	2400.000
	Elect CL/NW MEP Room	20	1	120	1	2400.000
	BMS	20	5	120	1	12000.000
	Exit Sign	20	2	120	1	4800.000

total	371632.290	W
AREA	25802.000	SF
Load density	14.403	W/SF

	General Pupose	total VA	Demand factor	Load
4th Level	HVAC	68698.454	0.7	48088.9175
	Lighting	60000.000	1	60000
	Other Equipment	116376.915	0.75	87282.6859
	elevator	4156.922	0.8	3325.53755
	Receptacle	122400.000		94300

Overall Load Density	11.3555981	w/sf
Miscellaneous load Density	3.38278761	w/sf

Cellar Mezzanine--Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
Lower Level	convenience recept	20	7	120	1	16800
	FCU-LL-1	30	1	120	1	3600
	control RM refrigerator	20	1	120	1	2400
	control rm microwave	20	1	120	1	2400
	Control rm printer	20	1	120	1	2400
	open office quad	20	2	120	1	4800
	printer	20	1	120	1	2400
	auto flush	20	6	120	1	14400
	hand dryer	30	8	120	1	28800
	mire mold	20	1	120	1	2400
	EF-LL-1	20	1	120	1	2400
	FCU-IDF-LL	20	1	120	1	2400
	DT-LL-1	20	1	120	1	2400
	Coat rack motor	30	4	120	1	14400
	refrigrator	20	1	120	1	2400
	drinking fountain	20	1	120	1	2400
	auto sink	20	2	120	1	4800
	EF-LL-2	20	1	120	1	2400
	LTG	20	7	120	1	16800
	Exit Sign	20	4	120	1	9600
	Lower level Exit Sign	20	1	120	1	2400
	BMS	20	5	120	1	12000

total	154800	W
AREA	3803	SF
Load density	40.70470681	W/SF

	General Pupose	total VA	Demand factor	Load
3rd Level	HVAC	13200	0.7	9240
	Lighting	28800	1	28800
	Other Equipment	91200	0.75	68400
	elevator	0	0.8	0
	Receptacle	21600		18700

Overall Load Density	32.9056008	w/sf
Miscellaneous load Density	17.9858007	w/sf

1st Floor--Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
1st Level	convenience recept	20	5	120	1	12000
	dock leveler	40	1	120	3	8313.843876
	dock leveler	30	1	120	3	6235.382907
	loading dock door	20	1	120	3	4156.921938
	loading dock door	20	1	120	1	2400
	fire door	20	1	120	1	2400
	UH-1-3	20	1	120	1	2400
	UH-1-5	20	1	120	1	2400
	UH-1-6	20	1	120	1	2400
	UH-1-1	20	1	120	1	2400
	UH-1-2	20	1	120	1	2400
	Fork Lift	30	1	120	3	6235.382907
	recept	20	4	120	1	9600
	EH-1-2	20	1	120	1	2400
	FCU-S-C	20	1	120	1	2400
	EF-1-1	20	1	120	1	2400
	Auto flush	20	1	120	1	2400
	Hand dryer	30	3	120	1	10800
	Floor box	20	20	120	1	48000
	J-box	20	6	120	1	14400
	EH-1-2	20	1	120	1	2400
	Floor Warming	20	1	120	1	2400
	AV Projection Motor	20	2	120	1	4800
	motorized shades	20	1	120	1	2400
	Auto sink	20	1	120	1	2400
	UH-1-4	20	1	120	1	2400
	EH-1-1	20	1	120	1	2400
	FCU-S-A	20	1	120	1	2400
	workstation	20	2	120	1	4800
	IDF Rack J-box	30	10	120	1	36000
	Actuator	20	2	120	1	4800
	Wiremold	20	5	120	1	12000
	Display	20	1	120	1	2400
	Rack	20	1	120	1	2400

total	230141.5316	w
area	17094.1	sf
Load density	13.4632143	w/sf

	General Pupose	total VA	Demand factor	Load
3rd Level	HVAC	28800	0.7	20160
	Lighting	0	1	0
	Other Equipment	111106.15	0.75	83329.6115
	elevator	6235.3829	0.8	4988.30633
	Receptacle	69600		54700

Overall Load Density	9.5458619	w/sf
Miscellaneous load Density	4.87475863	w/sf

2nd Level --Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
2nd Level	EF-2-1	30	1	120	3	6235.382907
	EF-2-3	20	1	120	3	4156.921938
	SF-2-1	20	1	120	3	4156.921938
	FF-2-2	20	1	120	3	4156.921938
	SF-2-2	30	1	120	3	6235.382907
	FCU-S-A	20	1	120	1	2400
	UH-1M-1	20	1	120	1	2400
	UH-1M-2	20	1	120	1	2400
	UH-1M-3	20	1	120	1	2400
	UH-1M-4	20	1	120	1	2400
	FCU-S-C	20	1	120	1	2400
	FCU-S-D	20	1	120	1	2400
	EF-2-4	20	1	120	3	4156.921938
	CONV DUPL	20	5	120	1	12000
	LTG	20	8	120	1	19200
	PC QUAD	20	1	120	1	2400
	DT-2-1	20	1	120	1	2400
	FCU-IDF-2	20	1	120	1	2400
	receptable	20	2	120	1	4800
	Air compressor	20	1	120	1	2400
	IDF Security	20	1	120	1	2400
	exit sign	20	2	120	1	4800
	BMS	20	5	120	1	12000
	Battery charger	20	2	120	1	4800
	Battery control CAB	20	1	120	1	2400
	ess heater	20	1	120	1	2400
	motor starter	20	2	120	1	4800
	jacket heater	20	1	120	1	2400
	space water heater	20	1	120	1	2400
	Gutter pipe heat trace	30	4	120	1	14400

total	144298.4536	w
area	4038	sf
Load density	35.73512966	w/sf

	General Pupose	total VA	Demand factor	Load
3rd Level	HVAC	74698.454	0.7	52288.9175
	Lighting	24000	1	24000
	Other Equipment	26400	0.75	19800
	elevator	0	0.8	0
	Receptacle	19200		16900

Overall Load Density	27.981406	w/sf
Miscellaneous load Density	4.90341753	w/sf

3rd Level--Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
3nd Level	convenience recept	20	9	120	1	21600
	Floor box	20	8	120	1	19200
	open office quad	20	26	120	1	62400
	seminar recept	20	2	120	1	4800
	copier	20	2	120	1	4800
	laptop cart	20	2	120	1	4800
	convenience dupl	20	5	120	1	12000
	drinking fountain	20	1	120	1	2400
	refrigerator	20	4	120	1	9600
	Printer	20	3	120	1	7200
	FCU-S-A	20	1	120	1	2400
	Fan Power Boxes	20	9	120	1	21600
	Fire Door	20	6	120	1	14400
	SCP-3	20	1	120	1	2400
	AV Projector motor	20	2	120	1	4800
	AV project	20	4	120	1	9600
	AV project lift	20	2	120	1	4800
	Power strip	20	4	120	1	9600
	3 phase fan power box	30	3	120	3	18706.14872
	drinking fountain	20	1	120	1	2400
	copier	20	1	120	1	2400
	microwave	20	4	120	1	9600
	receptacles	20	1	120	1	2400
	open office recept	20	1	120	1	2400
	refrigerator	20	1	120	1	2400
	breakroom recept	20	1	120	1	2400
	auto flush	20	6	120	1	14400
	hand dryer	30	8	120	1	28800
	auto sink	20	3	120	1	7200
	shade controller	20	5	120	1	12000
	convenience	20	1	120	1	2400
	duplex recept	20	1	120	1	2400
	coat check quad	20	1	120	1	2400
	quan recept	20	2	120	1	4800
	convenience quad	20	1	120	1	2400
	FCU-S-D	20	1	120	1	2400
	FCU-S-C	20	1	120	1	2400
	LTG	20	7	120	1	16800
	exit sign	20	2	120	1	4800
	BMS	20	5	120	1	12000
	IDF security	20	1	120	1	2400

total	378706.1487	w
area	19833.7	sf
Load density	19.09407467	w/sf

	General Pupose	total VA	Demand factor	Load
3rd Level	HVAC	49906.149	0.7	34934.3041
	Lighting	21600	1	21600
	Other Equipment	153600	0.75	115200
	elevator	4800	0.8	3840
	Receptacle	139200		106900

Overall Load Density	14.2421386	w/sf
Miscellaneous load Density	5.80829598	w/sf

4th Floor --Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
4th Level	convenience recept	20	12	120	1	28800
	office quad	20	16	120	1	38400
	open office quad	20	39	120	1	93600
	FCU-S-A	20	1	120	1	2400
	DT-4-1	20	1	120	1	2400
	Fan Power Box	20	5	120	1	12000
	Copier	20	5	120	1	12000
	FCU-4-3	20	1	120	1	2400
	Microwave	20	2	120	1	4800
	Shade controlers	20	2	120	1	4800
	FCU-4-2	20	1	120	1	2400
	refrigrator	20	5	120	1	12000
	printer	20	11	120	1	26400
	office receptacle	20	2	120	1	4800
	color booth	20	1	120	1	2400
	FCU-4-1	20	1	120	1	2400
	FCU-4-A	20	1	120	1	2400
	SCP-4	20	1	120	1	2400
	FCU-IDF-4	20	1	120	1	2400
	Floor box	20	3	120	1	7200
	conv duplex	20	2	120	1	4800
	work room quad	20	3	120	1	7200
	fan power box	20	6	120	1	14400
	drinking fountain	20	1	120	1	2400
	FCU-S-C	20	1	120	1	2400
	3 phase fan power box	20	2	120	3	8313.843876
	FCU-S-D	20	1	120	1	2400
	auto flush	20	2	120	1	4800
	auto sink	20	1	120	1	2400
	hand dryer	30	4	120	1	14400
	theater quad	20	14	120	1	33600
	a/v camera	20	2	120	1	4800
	A/v rack	20	14	120	1	33600
	a/v projection screen	20	2	120	1	4800
	a/v projector lift	20	4	120	1	9600
	Theater E3	20	41	120	1	98400
	LCR quad	20	3	120	1	7200
	LCR TVSS	20	2	120	1	4800
	a/v rewind table	20	1	120	1	2400
	a/v audio mix table	20	1	120	1	2400
	a/v edit desk	20	1	120	1	2400
	a/v projector	45	1	120	1	5400
	a/v projector (30)	30	2	120	1	7200
	theater receptacle	20	1	120	1	2400
	theater duplex	20	4	120	1	9600
	do 5 disconnect	60	1	120	3	12470.76581
	a/v broadcast panel	20	1	120	1	2400
	theater e4	20	8	120	1	19200
	pin & sleeve connector	100	1	120	3	20784.60969
	rool drop control point	20	1	120	3	4156.921938
	LTG	20	8	120	1	19200
	FP-4-1	20	1	120	3	4156.921938
	compressor	20	1	120	1	2400
	exit sign	20	3	120	1	7200
	graphic annunciator	20	1	120	1	2400
	it room security	20	1	120	1	2400
	IDF sec	20	1	120	1	2400
	BMS	20	5	120	1	12000
	Carrier cabinet	30	4	120	1	14400
	security cbinet	30	2	120	1	7200
	network core (20)	20	4	120	1	9600
	sever core (30)	20	4	120	1	9600
	san cabinet	30	2	120	1	7200
	film/video storage cabinet	30	5	120	1	18000
	network core (30)	30	4	120	1	14400
	sever core (20)	20	4	120	1	9600
	sever cabinet	30	12	120	1	43200
	wiremold	20	2	120	1	4800
	film/video	20	1	120	1	2400

TOTAL	810083.0633	W
area	19427.3	sf
Load density	41.69818056	w/sf

	General Pupose	total VA	Demand factor	Load
4th Level	HVAC	67670.766	0.7	47369.5361
	Lighting	21600	1	21600
	Other Equipment	468812.3	0.75	351609.223
	elevator	9600	0.8	7680
	Receptacle	237600		180700

Overall Load Density	31.3455168	w/sf
Miscellaneous load Density	18.0987179	w/sf

5th Floor --Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
5th Level	convenience recept	20	3	120	1	7200
	ceiling power track	60	5	120	3	62353.82907
	printer	20	1	120	1	2400
	office desk quad	20	2	120	1	4800
	open office recept	20	2	120	1	4800
	conv duplex	20	3	120	1	7200
	SCP-5-A	20	1	120	1	2400
	SCP-5-B	20	1	120	1	2400
	conv quad	20	2	120	1	4800
	conv quad duplex	20	1	120	1	2400
	fan power box	20	2	120	1	4800
	fan power box (30)	20	2	120	3	8313.843876
	floor box	20	9	120	1	21600
	theater quad	20	10	120	1	24000
	theater e2	20	12	120	1	28800
	a/v project lift	20	2	120	1	4800
	a/v rewind table	20	1	120	1	2400
	a/v projector	30	3	120	1	10800
	a/v projection screen	20	2	120	1	4800
	a/v rack	20	2	120	1	4800
	LTG	20	12	120	1	28800
	Stairways FLRS	20	2	120	1	4800
	IDF SEC	20	1	120	1	2400
	Exit sign	20	1	120	1	2400
	BMS	20	5	120	1	12000
	fork lift	30	1	120	3	6235.382907
	hand dryer	30	3	120	1	10800
	auto flush	20	1	120	1	2400
	auto sink	20	1	120	1	2400
	drinking fountain	20	1	120	1	2400
	FCU-5-1	20	1	120	1	2400
	FCU-5-2	20	1	120	1	2400
	FCU-IDF-5	20	1	120	1	2400
	FCU-5-AB	20	1	120	1	2400
	conv duplex	20	1	120	1	2400
	indoor duplex	20	13	120	1	31200
	shade controllers	20	14	120	1	33600
	terrace recept	20	1	120	1	2400
	recept dupl terrace	20	3	120	1	7200
	fire door	20	2	120	1	4800
	duplex	20	1	120	1	2400
	FCU-S-C	20	1	120	1	2400
	CH-5-1	30	1	120	3	6235.382907

TOTAL	392738.4388	W
area	24408.2	SF
Load density	16.09043021	W/SF

	General Pupose	total VA	Demand factor	Load
5th Level	HVAC	110503.06	0.7	77352.1391
	Lighting	36000	1	36000
	Other Equipment	127200	0.75	95400
	elevator	11035.383	0.8	8828.30633
	Receptacle	112800		87100

Overall Load Density	12.4827085	w/sf
Miscellaneous load Density	3.90852255	w/sf

6th Floor --Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
6th Level	convenience recept	20	1	120	1	2400
	ceiling power track	60	4	120	3	49883.06326
	receptacles	20	1	120	1	2400
	furniture recept	20	1	120	1	2400
	open office recept	20	2	120	1	4800
	j-box wet treat storage	20	3	120	1	7200
	photo room recept	20	2	120	1	4800
	pc duplex	20	1	120	1	2400
	FCU-IDF-6	20	1	120	1	2400
	LGT	20	10	120	1	24000
	printer	20	1	120	1	2400
	FCU-S-A	20	1	120	1	2400
	SCP-6	20	1	120	1	2400
	Conv quad dupl	20	2	120	1	4800
	LGT - 3 phase	20	1	120	3	4156.921938
	microwave	20	1	120	1	2400
	refrigerator	20	1	120	1	2400
	exit sign	20	3	120	1	7200
	IDF REC	20	1	120	1	2400
	BMS	20	5	120	1	12000
	ELCP-6	60	1	120	3	12470.76581
	indoor duplex	20	10	120	1	24000
	fan power box	20	1	120	1	2400
	pc quad duplex	20	1	120	1	2400
	shade controller	20	7	120	1	16800
	FCU-6-4	20	1	120	1	2400
	fork lift	30	1	120	3	6235.382907
	Conv quad	20	4	120	1	9600
	P+S	60	2	120	3	24941.53163
	pc quad	20	1	120	1	2400
	conv duplex	20	12	120	1	28800
	rack	20	2	120	1	4800
	CH-6-1	30	1	120	3	6235.382907
	projection screen	20	1	120	1	2400
	projector	20	1	120	1	2400
	projector lift	20	1	120	1	2400
	FCU-S-D	20	1	120	1	2400
	conv quad terrace	20	2	120	1	4800

total	303123.0485	w
area	15695.7	sf
Load density	19.31248995	w/sf

	General Pupose	total VA	Demand factor	Load
6th Level	HVAC	110330.7436	0.7	77231.52053
	Lighting	35356.92194	1	35356.92194
	Other Equipment	57600	0.75	43200
	elevator	8635.382907	0.8	6908.306326
	Receptacle	91200		70900

Overall Load Density	14.88285	w/sf
Miscellaneous load Density	2.752346184	w/sf

7th Floor --Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circ	Voltage (V)	Phase	Load
7th Level	convenience recept	20	2	120	1	4800
	ceiling power track	60	3	120	3	37412.3
	open office quad	20	14	120	1	33600
	office quad	20	2	120	1	4800
	printer	20	4	120	1	9600
	copier	20	2	120	1	4800
	flat panel display	20	1	120	1	2400
	library wiremold	20	2	120	1	4800
	SCP-7	20	1	120	1	2400
	FCU-S-A	20	1	120	1	2400
	Shade Controller	20	4	120	1	9600
	desk receptacle	20	1	120	1	2400
	conv quad duplex	20	2	120	1	4800
	library stor recept	20	1	120	1	2400
	LTG	20	4	120	1	9600
	IDF REC	20	1	120	1	2400
	exit sign	20	2	120	1	4800
	BMS	20	5	120	1	12000
	ELCP-7	60	1	120	3	12470.77
	refrigerator	20	1	120	1	2400
	microwave	20	1	120	1	2400
	office	20	1	120	1	2400
	fork lift	30	1	120	3	6235.383
	fan power box	20	3	120	1	7200
	indoor duplex	20	9	120	1	21600
	conv duplex	20	1	120	1	2400
	FCU-IDF-7	20	2	120	1	4800
	P+S	60	2	120	3	24941.53
	drinking fountain	20	1	120	1	2400
	Fan Power box	20	1	120	1	2400
	CH-7-1	30	1	120	3	6235.383
	hand dryer	30	3	120	1	10800
	auto sink	20	1	120	1	2400
	auto flush	20	2	120	1	4800

TOTAL	270895.4	W
area	14737	SF
Load densi	18.38199	W/SF

	General Pupose	total VA	Demand fa	Load
7th Level	HVAC	102660	0.7	71861.98
	Lighting	14400	1	14400
	Other Equipment	70800	0.75	53100
	elevator	6235.383	0.8	4988.306
	Receptacle	76800		60100

Overall Load Density	13.87326	w/sf
Miscellaneous load Density	3.603176	w/sf

8th Floor--Electrical Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
8th Level	convenience recept	20	2	120	1	4800
	printer	20	2	120	1	4800
	open office quad	20	4	120	1	9600
	EF-8-1	20	1	120	1	2400
	Flat panel display	20	2	120	1	4800
	conv duplex	20	2	120	1	4800
	floor box	20	3	120	1	7200
	FCU-S-A	20	1	120	1	2400
	Fan PWR Box with heat	20	2	120	1	4800
	SCP-CS-A	20	1	120	1	2400
	SCP-CS-B	20	1	120	1	2400
	fork lift	30	1	120	3	6235.382907
	SCP-8	20	1	120	1	2400
	LTG	20	13	120	1	31200
	Exit sign	20	3	120	1	7200
	IDF-REC	20	1	120	1	2400
	BMS	20	5	120	1	12000
	ELCP-8	60	1	120	3	12470.76581
	recept toilet	20	2	120	1	4800
	recept	20	5	120	1	12000
	indoor duplex	20	6	120	1	14400
	conv quad dupl	20	1	120	1	2400
	copier	20	1	120	1	2400
	dishwasher	20	2	120	1	4800
	large refrigerator	20	1	120	1	2400
	microwave	20	2	120	1	4800
	auto sink	20	1	120	1	2400
	auto flush	20	4	120	1	9600
	coffee maker	20	1	120	1	2400
	hand dryer	30	4	120	1	14400
	P+S	60	2	120	3	24941.53163
	refrigerator	20	2	120	1	4800
	FCU-8-A	20	1	120	1	2400
	shade controller	20	17	120	1	40800
	FCU-IDF-8	20	1	120	1	2400
	drinking fountain	20	1	120	1	2400
	coat room	20	1	120	1	2400
	fire suppress sys	20	1	120	1	2400
	air cooled cond	20	1	120	3	4156.921938
	dishwasher (3phase)	70	1	120	3	14549.22678
	cooking oven	50	2	120	1	12000
	heat lamp	50	2	120	1	12000
	coffee brewer (3 phase)	50	1	120	3	10392.30485
	coffee brewer	50	1	120	1	6000
	UP-8-K	150	1	120	3	31176.91454
	Planting converter	50	1	120	1	6000
	remote cond	20	2	120	1	4800
	walk in freezer	20	1	120	1	2400
	food water	30	1	120	3	6235.382907
	freezer	20	1	120	1	2400
	combi oven	20	1	120	1	2400
	exhaust hood	20	1	120	1	2400
	evaporator coil	20	1	120	1	2400

total	402958.4314	W
area	10041.7	sf
Load density	40.12850726	w/sf

	General Pupose	total VA	Demand factor	Load
8th Level	HVAC	94989.212	0.7	66492.4484
	Lighting	50400	1	50400
	Other Equipment	176933.84	0.75	132700.377
	elevator	6235.3829	0.8	4988.30633
	Receptacle	176933.84		135200.377

Overall Load Density	38.816287	w/sf
Miscellaneous load Density	13.2149315	w/sf

9th Floor--Electric Load

Miscellaneous load

	Purpose	current (A)	No. of circuit	Voltage (V)	Phase	Load
9th Level	convenience recept	20	2	120	1	4800
	LTG	20	11	120	1	26400
	receptacles	20	7	120	1	16800
	closet receptacle	20	1	120	1	2400
	unit heater	20	2	120	1	4800
	FCU-S-A	20	1	120	1	2400
	DT-9-1	20	1	120	1	2400
	Gutter snow melting	30	6	120	1	21600
	pavement snow melting	30	14	120	1	50400
	FCU-9-1	20	1	120	1	2400
	FCU-9-2	20	1	120	1	2400
	EXIT SIGN	20	4	120	1	9600
	BMS	20	5	120	1	12000
	COOLING TOWER PIPING HEAT TRACING	30	9	120	1	32400
	ww RECEPTACLE	30	8	120	3	49883.06326

TOTAL	240683.0633	w
area	8229	sf
Load density	29.24815449	w/sf

	General Pupose	total VA	Demand factor	Load
9th Level	HVAC	66000	0.7	46200
	Lighting	36000	1	36000
	Other Equipment	84000	0.75	63000
	Receptacle	73883.063		57912.2974
			load density	24.6825006 w/sf
			Miscellaneous load Density	7.65585126

Appendix D

SYSTEM SUMMARY

DESIGN AIRFLOW QUANTITIES

By ACADEMIC

System Description	System Type	MAIN SYSTEM Outside Airflow cfm	Cooling Airflow cfm	Heating Airflow cfm	Return Airflow cfm	Exhaust Airflow cfm	Auxiliary System Supply Airflow cfm	Room Exhaust Airflow cfm
Alternative 1								
VAV system_C	Parallel Fan-Powered VAV	20,183	226,376	150,535	226,696	226,376	0	6,101
CAV with outside_C	Terminal Air Blender	4,150	68,243	68,243	68,243	4,150	0	4,340
fan coil_C	Fan Coil	2,785	21,874	21,874	21,874	2,785	0	0
unit heater	Unit Heaters	5,034	0	7,724	0	5,034	0	0
unit heat -9	Unit Heaters	534	0	3,460	0	534	0	0
VAV-9	Parallel Fan-Powered VAV	4,061	85,174	38,005	85,174	4,061	0	0
CAV-9	Terminal Air Blender	1,110	31,970	31,970	32,196	1,337	0	4,685
Totals		**37,857**	**433,636**	**321,811**	**434,183**	**244,276**	**0**	**15,126**

Note: Airflows on this report are not additive because they are each taken at the time of their respective peaks. To view the balanced system design airflows, see the appropriate Checksums report (Airflows section).

ENERGY CONSUMPTION SUMMARY

By ACADEMIC

	Elect Cons. (kWh)	Gas Cons. (kBtu)	Water Cons. (1000 gals)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1						
Primary heating						
Primary heating		7,759,335		30.5 %	7,759,335	8,167,721
Other Htg Accessories	3,345		591	0.0 %	11,416	34,253
Heating Subtotal	**3,345**	**7,759,335**	**591**	**30.5 %**	**7,770,751**	**8,201,974**
Primary cooling						
Cooling Compressor	425,224			5.7 %	1,451,291	4,354,307
Tower/Cond Fans	135,147		1,864	1.8 %	461,258	1,383,913
Condenser Pump	326,188			4.4 %	1,113,280	3,340,174
Other Clg Accessories	7,049			0.1 %	24,058	72,182
Cooling Subtotal....	**893,609**		**1,864**	**12.0 %**	**3,049,887**	**9,150,575**
Auxiliary						
Supply Fans				0.0 %	0	0
Pumps	251,795			3.4 %	859,375	2,578,383
Stand-alone Base Utilities				0.0 %	0	0
Aux Subtotal....	251,795			3.4 %	859,375	2,578,383
Lighting						
Lighting	951,735			12.8 %	3,248,272	9,745,790
Receptacle						
Receptacles	3,082,105			41.3 %	10,519,224	31,560,828
Cogeneration						
Cogeneration				0.0 %	0	0
Totals						
Totals**	**5,182,589**	**7,759,335**	**2,455**	**100.0 %**	**25,447,509**	**61,237,548**

* Note: Resource Utilization factors are included in the Total Source Energy value .

** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

Energy Cost Budget / PRM Summary

By ACADEMIC

Project Name: American Art Museum	Date: October 14, 2012
City: Downtown Manhattan, NY	Weather Data: New York (LaGuardia), New York

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 for the ECB study.

		* Alt-1 Orig load cal American A		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	3,248.3	13	1,209
Space Heating	Electricity	11.4	0	2
	Gas	7,759.3	30	5,394
Space Cooling	Electricity	1,475.3	6	1,718
Pumps	Electricity	1,972.7	8	280
Heat Rejection	Electricity	461.3	2	208
Receptacles - Conditioned	Electricity	10,519.2	41	5,071
Total Building Consumption		**25,447.5**		

		* Alt-1 Orig load cal American A
Total	**Number of hours heating load not met**	1,223
	Number of hours cooling load not met	0

	* Alt-1 Orig load cal American A	
	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	17,688.2	5,447
Gas	7,759.3	87,215
Total	**25,448**	**92,662**

EQUIPMENT ENERGY CONSUMPTION

By ACADEMIC

Alternative: 1 Orig load cal American Art Museum

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Lights													
Electric (kWh)	79,403.8	71,814.1	85,262.1	75,897.5	82,333.0	81,755.9	76,474.7	85,262.1	75,897.6	82,333.0	78,826.7	76,474.7	951,735.2
Peak (kW)	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3	354.3
Misc. Ld													
Electric (kWh)	257,572.0	232,923.1	274,780.0	246,487.6	266,176.0	263,695.8	248,967.8	274,780.0	246,487.6	266,175.8	255,091.7	248,967.8	3,082,105.3
Peak (kW)	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9	1,485.9
Cooling Coil Condensate													
Recoverable Water (1000gal)	0.1	0.2	0.2	0.5	2.7	13.3	20.6	28.6	15.3	0.5	0.4	0.1	82.3
Peak (1000gal/Hr)	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.2
Cpl 1: Cooling plant - 001 [Sum of dsn coil capacities=811.8 tons]													
Water-cooled chiller - 001 [Clg Nominal Capacity/F.L.Rate=811.8 tons / 514.4 kW] (Cooling Equipment)													
Electric (kWh)	6,224.8	7,424.3	8,092.8	21,123.7	44,031.0	70,282.3	77,438.9	88,802.8	54,602.1	28,403.6	13,108.8	5,689.2	425,224.3
Peak (kW)	135.5	135.5	135.5	218.4	342.3	431.0	473.2	502.4	395.7	257.2	167.6	135.5	502.4
90.1 Min Cooling Tower [Design Heat Rejection/F.L.Rate=958.1 tons / 61.03 kW]													
Electric (kWh)	4,366.7	4,041.2	4,325.3	4,018.5	8,960.4	20,536.1	27,675.1	31,475.9	16,414.1	5,210.1	3,835.5	4,288.7	135,147.5
Peak (kW)	7.1	7.5	7.3	28.3	61.0	61.0	61.0	61.0	61.0	42.9	15.4	7.1	61.0
90.1 Min Cooling Tower													
Make Up Water (1000gal)	23.1	27.5	30.0	78.3	187.9	323.1	356.8	411.8	248.0	107.7	48.6	21.1	1,863.9
Peak (1000gal/Hr)	0.3	0.4	0.4	1.1	1.8	2.1	2.3	2.3	2.0	1.4	0.7	0.3	2.3
90.1 Min CV Chilled Water pump (Misc Accessory Equipment)													
Electric (kWh)	23,182.7	21,325.2	22,968.4	18,574.7	21,039.5	19,932.1	21,539.5	21,575.3	19,824.9	20,396.5	18,646.2	22,789.8	251,794.6
Peak (kW)	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
90.1 Min CV Cond Water Pump (Misc Accessory Equipment)													
Electric (kWh)	30,032.1	27,625.8	29,754.5	24,062.7	27,255.6	25,821.1	27,903.4	27,949.7	25,682.3	26,422.7	24,155.2	29,523.0	326,188.1
Peak (kW)	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3
Cntl panel & interlocks - 1 KW (Misc Accessory Equipment)													
Electric (kWh)	649.0	597.0	643.0	520.0	589.0	558.0	603.0	604.0	555.0	571.0	522.0	638.0	7,049.0
Peak (kW)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Hpl 1: Heating plant - 001 [Sum of dsn coil capacities=17,068 mbh]													

EQUIPMENT ENERGY CONSUMPTION

By ACADEMIC

Alternative: 1 Orig load cal American Art Museum

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Hpl 1: Heating plant - 001 [Sum of dsn coil capacities=17,068 mbh]													
Boiler - 001 [Nominal Capacity/F.L.Rate=17,068 mbh / 213.4 Therms] (Heating Equipment)													
Gas (therms)	12,752.3	10,651.5	12,703.4	7,799.8	2,368.5	1,025.7	625.0	532.2	753.9	6,231.7	8,665.7	13,483.7	77,593.3
Peak (therms/Hr)	53.9	51.1	51.4	44.4	22.3	6.1	5.0	4.7	5.5	39.9	47.3	52.1	53.9
Make-up water - 5.18e-006 gal/btu (Misc Accessory Equipment)													
Make Up Water (1000gal)	65.8	59.4	65.8	58.5	43.0	28.8	28.4	30.3	28.3	55.3	62.2	65.8	591.5
Peak (1000gal/Hr)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	331.0	243.0	163.0	160.5	171.5	160.0	312.5	351.5	372.0	3,345.0
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

ELECTRICAL PEAK CHECKSUMS

By ACADEMIC

Alternative 1 **Orig load cal American Art Mus**

Yearly Time of Peak: 15(Hr) 8(Month)

Equipment Description		Electrical Demand (kw)	Percent of Total (%)
Cooling Equipment			
Water-cooled chiller - 001		646.43	26.00
	Sub total	646.43	26.00
Miscellaneous			
Misc Equipment		1,485.85	59.75
Base Utilities		0.00	0.00
Lights		354.34	14.25
	Sub total	1,840.19	74.00
	Total	2,486.62	100

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 Demand ($)	419	420	420	441	472	490	499	505	483	451	428	419	5,447
Gas													
On-Pk Cons. ($)	14,334	11,972	14,279	8,767	2,662	1,153	703	598	847	7,004	9,740	15,156	87,215
Water													
On-Pk Cons. ($)	439	429	473	676	1,140	1,738	1,902	2,183	1,365	805	547	429	12,125
Monthly Total ($):	15,192	12,821	15,171	9,883	4,275	3,381	3,104	3,286	2,695	8,261	10,715	16,004	104,787

Building Area = 224,695 ft²

Utility Cost Per Area = 0.47 $/ft²