THE NEW YORK TIMES BUILDING

620 EIGHTH AVENUE
NEW YORK, NEW YORK 10018

TECHNICAL REPORT ONE: BUILDING AND PLANT ENERGY ANALYSIS REPORT

AE 481-Comprehensive Senior Project I
Building Mechanical & Energy Systems Option
IPD / BIM Senior Thesis

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EXECUTIVE SUMMARY

The New York Times Building (NYTB) is located on the west-side of Midtown Manhattan in New York City, New York. This 52-story building is 1.6 million square feet and offers high end office space and ground level retail. The NYTB was modeled floor-by-floor in Autodesk Revit, however, in this report the analysis was performed on the eighth floor only. A building and plant analysis was performed using the energy simulation program Trane Trace 700. Information in the energy model was derived from the design documents. Information that was not provided by the design engineer was assumed based on select ASHRAE Standards and typical values provided by Trane Trace. When the peak and block loads were determined by the energy simulation, emissions data and economic factors were applied to find annual energy consumption and operating costs of the NYTB.

The built environment constitutes 41% of the total energy consumption in the United States (Energy Information Administration 2008). The combined effects of the current economic climate and concerns about environmental awareness have pushed the construction industry to place more emphasis on energy consumption in buildings. Energy simulation is a powerful tool for building designers to predict the load profiles, total energy consumption, and associated emissions of a building. It is important for mechanical designers to understand how to effectively use these programs so that they may identify critical factors affecting energy consumption by their systems in a building.

Another promising technology within the building industry is Building Information Modeling (BIM). It is a powerful tool that is intended to make the design process more collaborative and efficient. BIM allows design changes to be reflected in real-time to the entire design team so that all disciplines may make informed decisions. This Integrated Project Delivery (IPD) is a holistic approach to building design. For mechanical designers, IPD and BIM are primarily intended to optimize energy usage, facilitate trade coordination (clash detection) and to benchmark building performance for certification programs or energy initiatives including LEED, or in the case of the NYTB, plaNYC. Part of this analysis focused on the utilization of energy modeling programs as a part of IPD and BIM.

The use of a BIM platform for analysis of the NYTB produced a more efficient workflow and accurate analysis of energy consumption and plant operating conditions. The architectural model of the NYTB was built in Autodesk Revit Architecture 2010. The building geometry was originally used to create a gbXML export file-type which was then imported into Trane Trace 700 for energy simulation. The intent of this process was to improve the speed and accuracy of inputting the building geometries into Trane Trace. However, errors within the architectural model resulted in the inability of Trane Trace to run the energy analysis successfully. It was determined that, without recreating an architectural model in Revit, it was necessary to manually enter the geometries into Trane Trace to run the analysis with minimal errors. Despite the non-interoperability with Trane Trace, the Revit schedule feature was still utilized to ensure accuracy in take-offs and optimize time in creating the Trace model. This feature was used to determine material properties, wall areas, % glazing, and square footages, all from information that was embedded in the model.

The results of the load and energy analysis include peak cooling and heating load, total energy and water use, total associated emissions, and annual operating costs. These results are used to determine if the NYTB is operating efficiently compared to other similar buildings. The energy analysis was performed on the eighth floor alone, which is considered a simplified representation of the overall building load profile.

DESIGN LOAD ESTIMATION

The information used in the energy simulation model was derived from relevant design documents, ASHRAE Standards and typical schedules found in the Trane Trace energy simulation program, as well as assumptions made by the model user. The assumptions may have differed from those made by the design engineer of record resulting in differences in final energy consumption and load data.

ASSUMPTIONS

1. For this analysis, only the eighth floor of The New York Times Building was modeled. The data center, cogeneration plant, lobby, and remaining tower floors were neglected.
2. Supply Air Temperature
    a. Cooling Supply: 60-62 °F
    b. Heating Supply: 83-85 °F
3. Glazing Properties
    a. A shading coefficient of 0.75 was used for all exterior glazing.
4. Infiltration
    a. The infiltration rate for a neutrally pressurized building with tight construction was assumed to be 0.3 CFM/SF.
5. For modeling purposes, the weather data was taken from John F. Kennedy Airport.

OUTDOOR AIR VENTILATION & MECHANICAL EXHAUST RATES

The design OA Ventilation Rates and Mechanical Exhaust rates were not provided at time of analysis, therefore rates from ASHRAE Standard 62.1 (2004) were used. A value of 5 CFM/person and 0.06 CFM / SF was used for all space types. Table 1 summarizes exhaust rates modeled in the Trane Trace simulation.

Table 1 - Typical exhaust rates. Source: ASHRAE Standard 62.1 (2004)

Exhaust Rates	
Space Occupancy	Exhaust Rate (CFM/SF)
Copy Room	0.5
Electrical Rooms	0.5
Telecom	0.5
Space Occupancy	Exhaust Rate (CFM/fixture)
Toilets	70

DESIGN OCCUPANCY

The design occupancy values were not provided at time of analysis, therefore criteria for typical spaces were used from Trane Trace and are provided in Table 2.

Table 2 - Design occupancy Source: Trane Trace

Space Occupancy	SF / # People
Private Office	143
Open Office	143
Conference Room	20
Copy	-
Corridor	-
Mail	-
Mechanical	-
Electrical	-
Toilet	-
Pantry	-
Telecom	-

LIGHTING & EQUIPMENT LOADS

The lighting and equipment loads were not provided at time of analysis, therefore rates from Trane Trace were used and are provided in Table 3.

Table 3 - Cooling load intensity by space type Source: Trane Trace

Space Occupancy	Lighting Power Density (W/SF)	Equipment Load (W/SF)
Private Office	1.1	0.5
Open Office	1.1	0.5
Conference Room	1.1	-
Copy	1.1	400
Corridor	1.1	-
Mail	1.1	0.5
Mechanical	1.1	-
Electrical	1.1	-
Toilet	1.1	-
Pantry	1.1	900
Telecom	1.1	400

DESIGN INDOOR & OUTDOOR AIR CONDITIONS

Table 4 provides the ASHRAE indoor and outdoor design conditions used in the energy simulation.

Table 4 - Outdoor and indoor design conditions. Source: ASHRAE Fundamentals (2005)

<table>
<tr><th colspan="6">Outdoor Design Conditions (0.4% and 99.6%)</th></tr>
<tr><th>Season</th><th colspan="2">Dry Bulb (^{0}F)</th><th colspan="3">Wet Bulb (^{0}F)</th></tr>
<tr><td>Winter</td><td colspan="2">15</td><td colspan="3">-</td></tr>
<tr><td>Summer</td><td colspan="2">87</td><td colspan="3">72</td></tr>
<tr><th colspan="7">Indoor Design Conditions</th></tr>
<tr><th rowspan="2">Space Occupancy</th><th colspan="2">Temperature (^{0}F)</th><th rowspan="2">Humidity</th><th colspan="2">Drift points</th></tr>
<tr><th>Summer</th><th>Winter</th><th>Cooling</th><th>Heating</th></tr>
<tr><td>All Spaces</td><td>75</td><td>70</td><td>50 % RH</td><td>81</td><td>64</td></tr>
</table>

LOAD SOURCES & SCHEDULES

Typical load schedules for standard high-rise office buildings for people, lights and miscellaneous loads were taken from ASHRAE Standard 90.1 and are summarized in Table 5 and Table 6.

Table 5 - Typical occupancy loads. Source: ASHRAE Standard 90.1 (2007)

Occupancy Loads		
Space Type	Sensible (Btu/hr per person)	Latent (Btu/hr per person)
All Spaces	250	200

Table 1 - Miscellaneous equipment loads. Source: ASHRAE Standard 90.1 (2007)

Miscellaneous Loads		
Equipment	Load (W)	Location
Copier	400	Copy Rooms
Refrigerator	500	Pantry
Microwave	450	Pantry
Telecom Equipment	400	Telecom Room

ENERGY SIMULATION RESULTS

The results of the energy simulation performed by Trane Trace is provided by the following data based on the analysis of the eighth floor:

- Peak cooling load: 63.2 tons @ 36,240 CFM of SA
- Peak heating load: 517,000 Btu/hr @ 17,900 CFM of SA

DESIGN DOCUMENT VS. COMPUTED LOAD AND VENTILATION INDICES

Design load and ventilation requirements were not provided by design engineer, therefore a comparison with computed values was not performed for this analysis.

ANNUAL ENERGY CONSUMPTION

ANNUAL ENERGY CONSUMPTION ESTIMATION

The results of the energy simulation performed by Trane Trace is provided by the following data based on the analysis of the eighth floor:

- Annual energy intensity: 84,200 BTU/SF/yr
- Annual electric consumption: 274,761 kWh/yr
- Annual district steam consumption: 8,144 Therms/yr
- Annual domestic water consumption: 477,000 gallons/yr

MONTHLY BREAKDOWN OF ELECTRICITY, STEAM & WATER CONSUMPTION

Figure 1, Figure 2, and Figure 3 provide the monthly breakdown of electricity, steam, and water consumption respectively, based on outputs from the Trane Trace simulation.

Figure 1 - Monthly electricity consumption

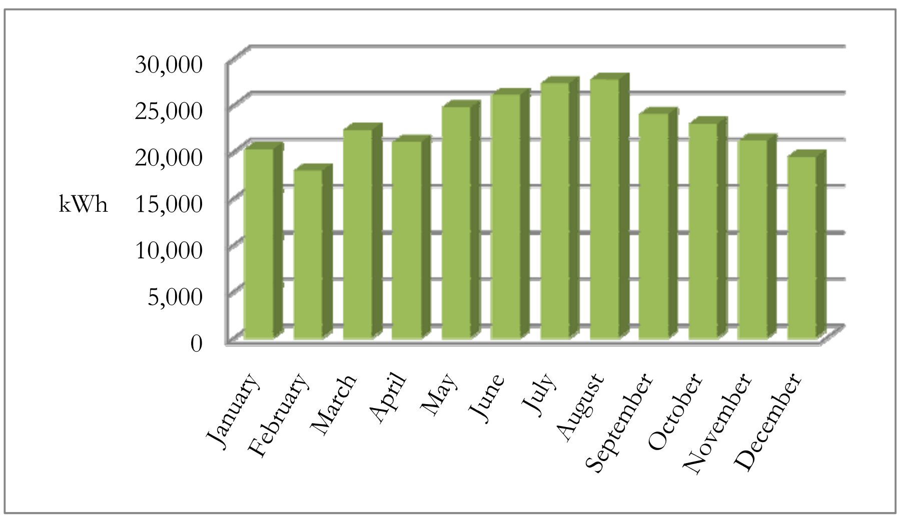


Figure 2 - Monthly purchased steam consumption

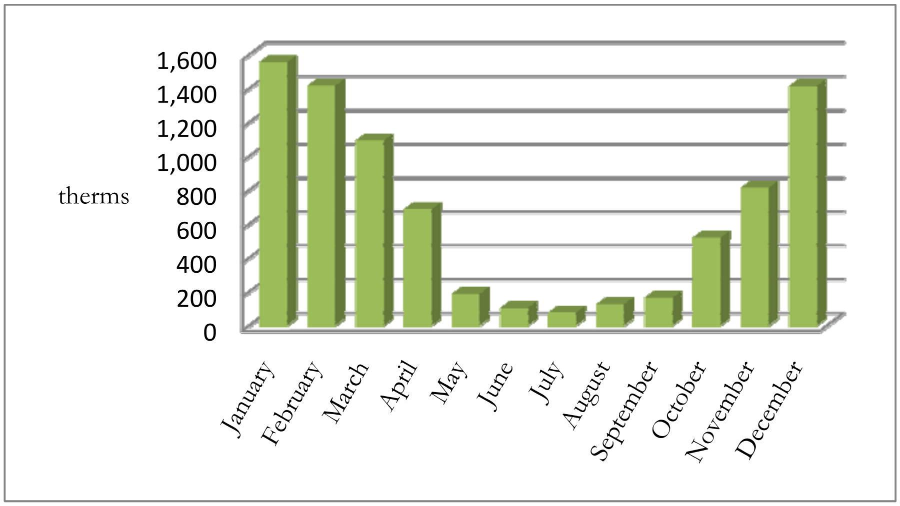
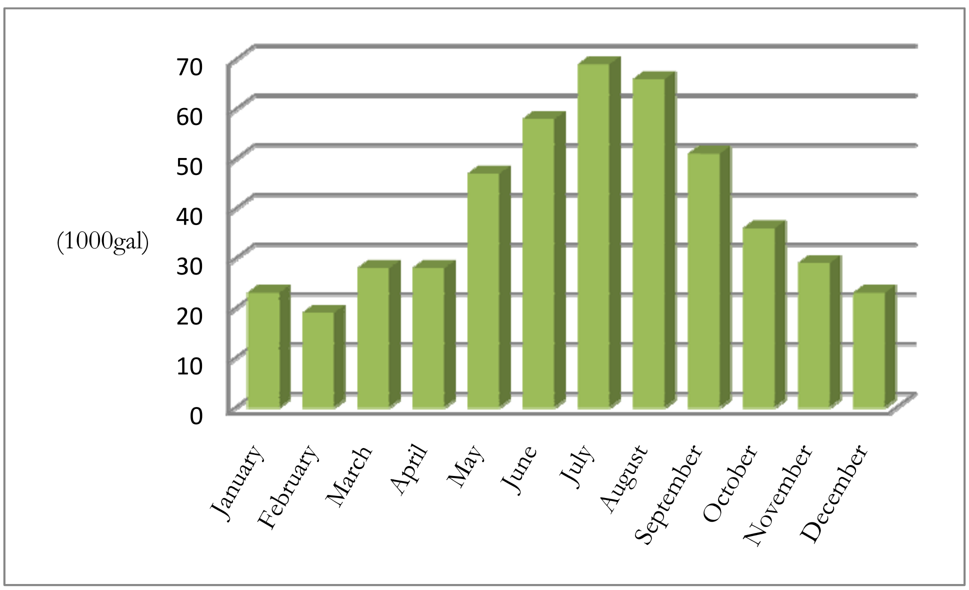


Figure 3 - Monthly domestic water consumption



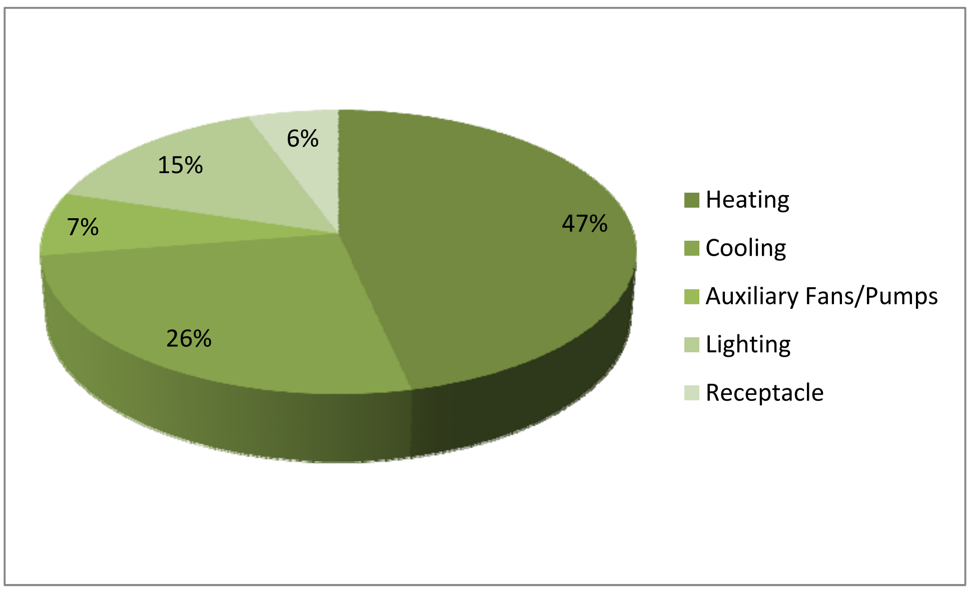
ENERGY FRACTIONS OF BUILDING SUBSYSTEMS

Table 7 and Figure 4 show the relationship between individual building subsystems and their impact on the total building energy consumption.

Table 2 - Energy use of systems as a percentage of total energy use

System	Load (kBtu/yr)	% of total load
Heating	814,986	47%
Cooling	455,743	26%
Auxiliary Fans/Pumps	126,680	7%
Lighting	256,644	15%
Receptacle	98,009	6%
Total	1,752,062	-

Figure 4 - Energy fractions of subsystems as a percentage of total energy use



NYTB ENERGY VS. TYPICAL OFFICE

The energy analysis, performed by the mechanical design engineers, and the existing document utility bills for The New York Times Building, are not available for review due to confidentiality requests of the owner. A comparison between the NYTB energy intensity and that of a base case helped estimate accuracy of the simulation. According to the Energy Information Administration (2008), a typical building over 500,000 SF has an energy intensity of 118,200 Btu/SF/yr. The EIA also reports that typical office buildings have an energy intensity of 92,900 Btu/SF/yr. Averaging these two values gives a reasonable assumption for a building similar to the NYTB. The typical office baseline energy intensity is 105,600 Btu/SF/yr. As reported in the previous section "Annual Energy Consumption Estimation", the energy simulation suggests that the NYTB has an annual energy intensity of 84,200 BTU/SF/yr. This value significantly lower than that of the baseline for the typical office building.

EMISSIONS DATA

The emissions associated with the operation of the NYTB was calculated based on the annual energy consumption. To perform this analysis, several assumptions were made:

1. Emissions data was taken from the Eastern United States region.
2. Source energy factor (for electricity) = 3.443 KWh of source energy / KWh of delivered electricity
3. Total annual emissions are calculated based on electricity production alone. The power plants producing this electricity are cogeneration sites which also produce district steam. For this reason, it is assumed that the emissions related to steam delivered to the site are accounted for in the electricity production.

Table 8 - Pollutants associated with off-site electricity. Source: National Renewable Energy Laboratory.

Energy consumed on-site (kWh/yr)	Source energy consumed (kWh/yr)	lb of pollutant per kWh of delivered electricity					
		$CO^{2}e$	CO^{2}	$N^{2}O$	NO^{X}	SO^{X}	CO
274761	946002	1.74E+00	1.64E+00	3.87E-05	3.00E-03	8.57E-03	8.54E-04
	Total Pollutants (lbs/yr)	1,646,044	1,551,444	37	2,838	8,107	808

COST ANALYSIS

An analysis was performed to estimate the cost of operating the heating and cooling plants, air distribution fans, secondary equipment, the lighting system, and miscellaneous equipment. An annual cost per square foot to operate the eighth floor was determined to be $3.90/SF. The following assumptions were made in the cost analysis.

ASSUMPTIONS

1. Natural Gas
    a. Rates for gas were based on a monthly gas bill from a typical commercial or industrial customer.
2. Electricity
    a. Typical monthly utility bills from Consolidated Edison were used from January and July.
    b. Calculated rate reflects an annual rate from the average of the monthly rates.
    c. The NYTB falls in the large electric consumer bracket (over 250 KW).
    d. The monthly rate was based on the average of the total electric charge per KWh used for the large consumer bracket.
    e. Flat rates are used. There are no on/off-peak conditions because no occupancy schedule was provided.
3. Steam
    a. Rates were based on Consolidated Edison's published steam utility rates.
    b. The NYTB will be billed with the Service Classification 2 under Rate 2.
    c. Rate is given as an average of the seasonal billing period rates.

UTILITY DATA

Table 9 - Utility rates

Utility	Yearly $/Unit	Reference
Natural Gas	$1.392/Ccf	New York State Public Service Commission
Electric	$0.249/kWh	New York State Public Service Commission
Steam	$18.36/Mlb	Consolodated Edison
Water	$2.31/per(748gals)	New York City Water Board

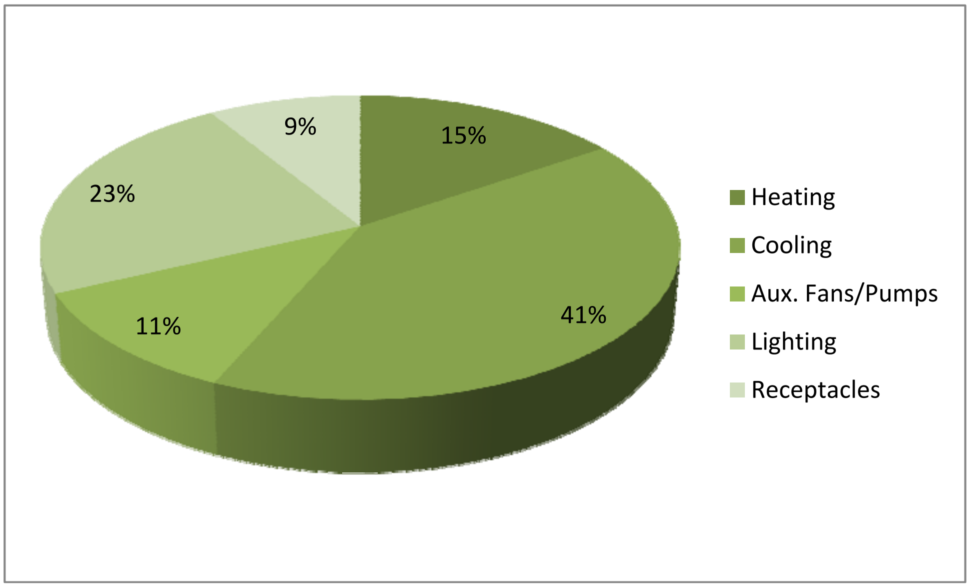
ANNUAL OPERATING COST

Annual operating costs for major end uses including heating, cooling, lighting, receptacle loads were found using the Trane Trace model. These costs are represented in Table 10 and Figure 5.

Table 10 - Annual cost of operation for building subsystems

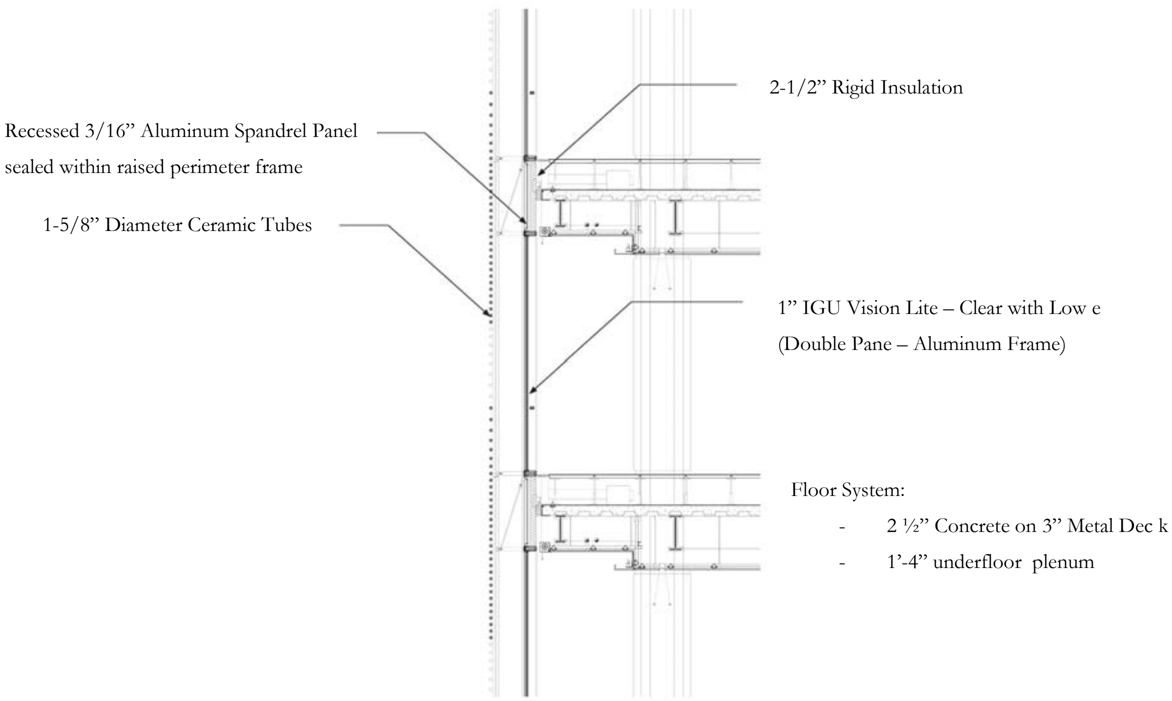
Function	Utility	kBtu	kWh	$/kWh	Mlb	$/Mlb	Cost ($)
Heating	Steam	814300			681.9933	$18.36	12,521.40
Cooling	Electricity		133533	0.249			33,249.72
Aux. Fans/Pumps	Electricity		37117	0.249			9,242.13
Lighting	Electricity		75196	0.249			18,723.80
Receptacles	Electricity		28716	0.249			7,150.28
						Total	$80,887.33

Figure 5 - Annual cost of operation for building subsystems



APPENDIX 1: MATERIAL PROPERTIES

TYPICAL CURTAIN WALL SECTION



U-value for wall: 0.08 Btu/ft^2-^{0}F-hr

U-value for glazing: 0.625 Btu/ft^2-^{0}F-hr

WORKS CITED

1. ANSI/ASHRAE. (2004). *ASHRAE Standard 62.1.* Atlanta: ASHRAE.
2. ANSI/ASHRAE/IESNA. (2004). *ASHRAE Standard 90.1.* Atlanta: ASHRAE.
3. ASHRAE. (1993). *ASHRAE Fundamentals.* Atlanta: ASHRAE.
4. ASHRAE. (2005). *ASHRAE Fundamentals.* Atlanta: ASHRAE.
5. Consolodated Edison. (2009, January 1). *Con Edison: Rates and Tariffs - Schedule for Steam Service.* Retrieved October 1, 2009, from conEdison: http://www.coned.com/rates/steam-sched.asp
6. Energy Information Administration. (2008). *2003 Commercial Buildings Energy Consumption Survey.* Washington DC: Department of Energy.
7. Energy Information Administration. (2008). *Energy Consumption by Sector.* Washington DC: Department of Energy.
8. New York City Water Board. (2009). *Rate Schedule.* Retrieved October 1, 2009, from New York City Water Board: http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml
9. New York State Public Service Commission. (2009, September 14). *Typical Customer Bill Information.* Retrieved October 1, 2009, from New York State Public Service Commission: http://www.dps.state.ny.us/TypicalBills.htm
10. Saint-Gobain Glass. (2008). *SGG Vision-Lite Manufacturer Catalog.* Retrieved September 28, 2009, from Saint-Gobain Glass: http://uk.saint-gobain-glass.com/b2b/default.asp?nav1=pr&nav2=details&nav3=Vision&nav4=8088
11. Torcellini, M. D. (2007). *Source Energy and Emission Factors for Energy Use in Buildings.* Golden: National Renewable Energy Laboratory.