TECHNICAL REPORT 2

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Mechanical Option

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The New Offices for RLPS Architects

Lancaster, PA

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Executive Summary

The objective of this report is to discuss the energy and load simulation analysis the New RLPS Architects' Office Building to determine its heating and cooling loads, as well as energy consumption, and projected operating costs.

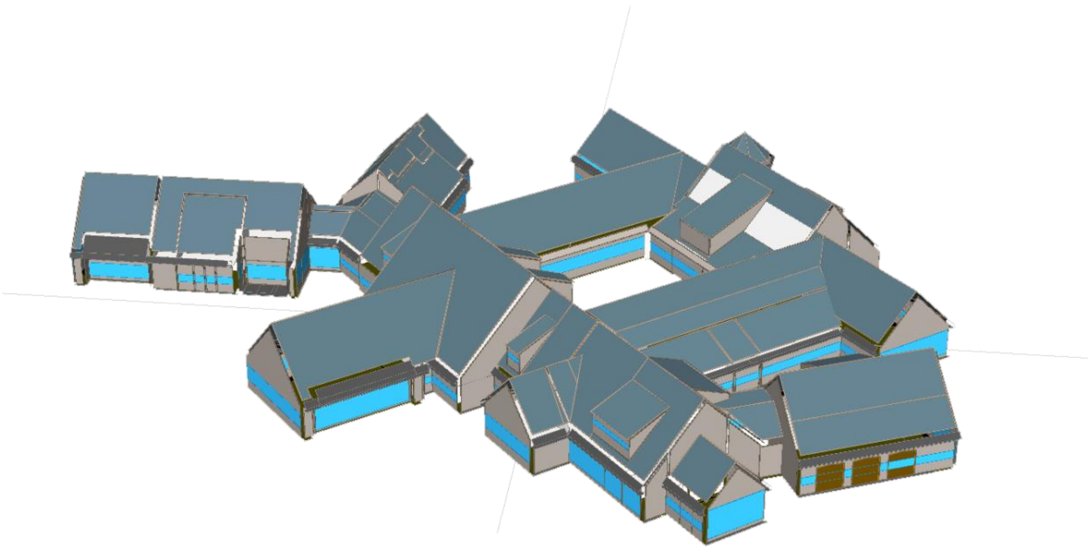
The calculations for the analysis were performed by Carrier Corporation's Hourly Analysis Program version 4.6. A model was constructed in HAP consisting of fifty four spaces that were combined into seven zones, each representing a wing or similar cluster of spaces. The results of these block calculations yielded a total annual heating load of 454 [MBtuh] and total annual cooling load of 564 [MBtuh]. The overall values of the model were found to vary greatly from the design engineers model.

Further analysis was done on the annual energy costs and energy consumption. It was found that the New RLPS Architects' Office Building consumes 1,105,491 [kWh] per annum at a cost of $31,931. Though there is no model data to compare to these estimates appear accurate. When compared to a Department of Energy study the consumption was on par with standard office buildings.

Finally, analysis of the emissions of specific pollutants were performed. The HAP v4.6 model yielded a CO_2e value of 507,102 [lb/year]. Further calculations using data from the National Renewable Energy Laboratory (NREL) yield 1.85×10^5 [lb/year] of CO_2. Discussion of other pollutants follow in this report.

Building Overview

Building Description



The New Office Building for RLPS Architects is a new construction office building located in Lancaster County, PA. It totals 22,500 square feet which is split between one full ground level and a small mezzanine area, to be used for storage. The use of this building is primarily office spaces, studio space, or group work areas. Some unique features to the building include a bistro area and adjoined living room space. Additionally, there is an interior courtyard complete with a water feature. Overall, the building is classified as Business with an occupancy capacity just short of 230 people. The expected completion date is January 2013.

Architecture

The site of the building is primarily independent, but is situated in a more residential area. The new office has some styles of a colonial home, but with a modern feel. One focus is an interior courtyard with water feature that is visible from all of the studio spaces.

Occupant and Project Team

Owner & Architects: RLPS Architects Ltd.

General Contractor: Warfel Construction

Mechanical & Electrical Engineers: Reese Engineering Inc.

Structural Engineers: Zug & Associates, Ltd. Structural Engineers.

Civil Engineers; Harbor Engineering

Surveyor: Herbert, Rowland, & Grubic, Inc.

Landscaping: RLPS Architects Ltd.

Energy and Load Calculation Procedure

1.1 Mechanical System Summary

The new office building will be utilizing a ground source well field consisting of eight closed loops. A large capacity pump will feed the twenty eight water source heat pump terminal units. These units were designed individually, with varying capacities, for each zone. Some units serve individual spaces and some serve multiple spaces. Ventilation will be provided by four large ventilation units.

The ground source system above ground facilities are situated in a mechanical space in the northeast of the building. This includes the pumps, heat exchanger, and other equipment like instantaneous water heaters in case the well field cannot meet the demand. The terminal and ventilation units are primarily housed in a mechanical mezzanine level that is above a large portion of the ground level.

2.0 Model Preparation

To create the HAP Model used for the calculations, a great deal of data was needed to accurately describe the spaces being considered and the mechanical systems that would be serving them. This input data was generally broken into two categories. The first category is Known Data, which includes data found in previous reports, information from the specifications or project engineer, and finally data that can be found or measured from the project drawings. The second category is Assumed Data, this includes information found from reputable sources and information gained from past experience.

2.1 Known Data

Architecture Features

2.1.1 Weather Data

Though Lancaster is a larger Pennsylvania city, it does not carry it sown weather data in the HAP v4.6 program. The city of York, PA was chosen from the HAP v4.6 library due to its proximity. For the energy simulation the Allentown, PA TM2 weather data was used as it was the closest recorded.

2.1.2 Space Geometry

The determination of the individual spaces floor area and average ceiling height were measured from the drawings. In cases of sloped ceilings the ceiling height was simplified to the height of the slope initialization and one third the height of the slope at its peak. Figure 1 below shows this calculation. H is the value used for average ceiling height, h1 is the height of the sloped ceiling, h2 is the height of initialization of the slope.

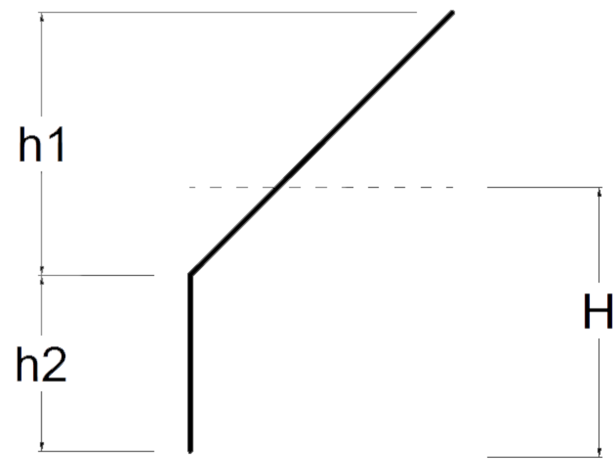


Figure 1

2.1.3 Construction Types

The construction types of each space were derived from the project drawings. The measurement of lineal feat in each of the eight cardinal directions of exterior wall was found. There were multiplied by the average ceiling height to find the wall area of each space in each direction. Additionally, the number of exterior windows and doors were confirmed with the drawings and place 'in' the appropriate walls. A total of sixteen window types and five door types were used. Over twenty exterior wall types were recorded in the drawings, but this was simplified to three types for the model as the differences were minute. The area of roof for each room was taken from a roof plan, approximations were made when considering borders between neighbor spaces and the same roof.

System Features

2.1.4 Internal Loads and Air Requirements

The values used for Lighting Power Density were found in an IESNA 2005 Publication. Additionally, HAP utilized ASHRAE 90.1-2007 Standard and ASHRAE 62.1-2007 Standard. Information was used from all of these publications in the determination of energy used and outdoor air requirements.

Figure 2 is a table showing the LPD values used in the new office building from the IES 90.1-2004 .

Space Description	LPD [W/sf]	Space Description	LPB [W/sf]
Corridor/Transition	0.46	Restrooms	0.86
Electrical/Mechanical	1.45	Lobby	1.32
Dining Area (Lounge)	1.4	Office (Open Plan)	1.06
Conference Meeting	1.25	Inactive Storage	0.31

Figure 2

2.1.5 System Selection

The system selection was derived from the project schedules and specifications. A generic ground source heat pump with terminal units was selected with minor changes to the zone components using information from the project schedule.

Figure 3, found in Appendix A, is a simplified version of the water source heat pump terminal unit schedule that was used as a basis for the model.

2.1.6 Economics

Finally, the information needed for the economic and energy analysis was found from PPL data. PPL has already installed a new transformer onsite and the have been confirmed as the utility manager. Let it be noted that a flat rate was used, neglecting demand rates as they vary per contract.

Figure 4 below shows the values used for the utility economics.

	Value from PPL Price to Compare	Value Accepted by HAP v4.6
Flat Price	10.346 [¢/kWh]	0.10346 [$/kWh]
Customer Charge	1.294 [¢/kWh]	0.01 $
Minimum Charge	9.081 [¢/kWh]	0.09 $
Tax Rate	5.9 [%]	5.90%

Figure 4

2.2 Assumed Data

Architecture Features

2.2.1 General Building Assumptions

Some data was assumed across the building and not for individual spaces. The building was generally assumed to be medium weight construction at 70 [PSF]. Additionally, schedules were developed based on the 8am to 5pm work day schedule. It was assumed to be empty at night and gradually increase to capacity in the morning and the opposite at night. Additionally, specific spaces that function as a meeting place or the bistro were scheduled with lower capacity throughout the day as they are not expected to be occupied regularly.

Figure 5 below displays the 'Office Schedule' used for most spaces in the new office building.

Figure 6 below displays the 'Meeting Schedule' used for spaces determined to have occupancies dependent on meeting schedules.

Hour	1	2	3	4	5	6	7	8	9	10	11	12
% of Max. Occupation	0	0	0	0	10	20	40	80	80	80	80	80
Hour	13	14	15	16	17	18	19	20	21	22	23	24
% of Max. Occupation	80	80	80	80	80	40	20	10	0	0	0	0

Figure 5

Hour	1	2	3	4	5	6	7	8	9	10	11	12
% of Max. Occupation	0	0	0	0	0	5	10	20	20	20	20	20
Hour	13	14	15	16	17	18	19	20	21	22	23	24
% of Max. Occupation	20	20	20	20	20	10	5	0	0	0	0	0

Figure 6

System Features

2.2.1 Internal Loads

The Electrical Power Densities for each space was assumed across the building. Most spaces were assumed to be 1.2 [W/ft^2], while a few spaces were assumed to be 1.5 [W/ft^2]. These values came from past experience from previous models as accurate with some diversity. The spaces with the higher density were designated as such due to their use. For example the space labeled 'Computers' is in actuality the home to the offices servers and will require an above average amount of power.

2.2.2 Space Properties

The occupancy for each space as classified by ASHRAE standards was assumed to the most fitting type. For example, architecture studio is not a standard ASHRAE classification, "Office Space' was assumed to be the best fit. An additional space property that was assumed was 0.5 Air Changes per Hour. This value was regularly used for baseline models in previous work in industry.

2.2.3 System Selection

As the systems were selected, most values provided by HAP were accepted as typical and assumed correct. Only in instances where the design documents explicitly change a system value, was it changed.

Energy and Load Calculation Results

Note: Several of the following section will include comparisons to an energy and load model created by the project engineer. The most up to date model was last edited in late 2009 and has different input data from the HAP v4.6 model used for this report. The project engineer's report was made in eQUEST, a program unfamiliar with the compiler of this report.

1.1 Design Load estimate

Figure 7 below shows a comparison between the results of the model done by the design engineer and the model created for this report. Let it be noted that the results vary greatly. The first discrepancy to notice is that both the heating and cooling loads of the new model appear to be a quarter to a third of the designed. Additionally, the design air flow and supply air per square foot are about twice the designed values. Differences of this magnitude would suggest a large difference in how the building was modeled and the accuracy of the data input. The idea that both the cooling and heating loads are lower is interesting. If only one were lower it would suggest that a major source for either load type was omitted. The fact both are lower would imply that the new model was designed as much more efficient than the previous and the construction is more resistant to thermal changes. Furthermore, it is believed that sources of both heat gain and heat loss were omitted as efficiency alone could not account for this great a difference.

The differences in design air, though not as great, are still off by a factor of two. It is assumed they differences are derived from different safety factors/redundancies, variation in infiltration, and the use of different schedules. It is unknown if infiltration was integrated into the design model. It is know that infiltration only occurred on the new model if 'the fan' was off, this setting would cause the model to calculate the fan as 'on' more often to prevent the infiltration. Finally, the schedule difference would play a difference in both supply air and heating/cooling loads. If the design schedule were more active than the new model schedules the loads would increase as occupancy increases. If the schedules were less active it would explain the lesser supply air required.

	Designed (eQUEST)	Modeled (HAP v4.6)
Cooling [tons]	140	47.0
Cooling [sf/ton]	179	460
Cooling [cfm/ton]	132	N/A
Cooling [Btuh/sf]	67.1	26.1
Heating [Btuh/sf]	78.0	21.0
Design air Flow [cfm]	18522	29336
Supply [cfm/sf]	0.74	1.36

Figure 7

1.2 Annual Cost Analysis

The new HAP v4.6 model was also used. The total annual cost was found to be $31,931. This value is considered to be very low for the building type. However, given the new model was found to have such low heating and cooling loads compared to the design model it can be expected that HVAC costs were also be down substantially. Below Figure 8 shows the cost per annum, cost per area, and percentage of total cost for each category. Though the total cost may be considered low, when compared to the national average for office buildings provided by the Department of Energy the percent of total cost is consistent with the exception of heating and electrical equipment. Furthermore, the Department of Energy reports an average cost of $1.51 per square foot. The $1.48 per square foot calculated is consistent with DOE estimates.

HVAC Components	Cost [$/yr]	Cost per area [$/sf]	Percent of Total Cost [%]	National Avg. for Office Buildings [%]
Air System Fan	2,274	0.105	7.1	5
Cooling	3,829	0.177	12.0	9
Heating	3,585	0.166	11.2	25
Pumps	3,765	0.174	11.8	N/A
Non-HVAC Components				
Lights	8,679	0.402	27.2	29
Electrical Equipment	9,803	0.454	30.7	16
Total	31,931	1.477	100	

Figure 8

1.3 Annual Energy Consumption Analysis

The annual energy consumed by the New RLPS Office Building was calculated for the Cooling Load, Heating Load, WSHP Loop water Pump, Lighting, and Electrical Equipment. Figure 9 shows the break down by category with energy used per annum, energy used per area, and percentage of total energy used. As expected a majority of the energy used was consumed by the heating and cooling coils. Applicable averages could not be found to compare with.

Figure 10 in Appendix A is a graphical representation of Figure 9 and Figure 11 is a graphical representation of the national average.

Components	Energy Used[kWh]	[kWh/sf]	[%]
Cooling Coil	549756	25.43	49.7
Heating Coil	352673	16.32	31.9
Loop Pump	34359	1.59	3.1
Lighting	79217	3.66	7.2
Elec. Equipment	89476	4.13	8.1
Total	1105491	18.5 weighted	100

Figure 9

1.4 Emissions Analysis

Hourly Analysis Program v4.6 does not fully support emissions calculations so the annual NOx, SOx, CO_2, and particulate matter emission could not be computed. However, the CO_2e could be calculated. The equivalent carbon dioxide was found to be 507,102 [lb/year]. Also, let it be noted that there is a large fireplace in the meeting space near the bistro. This fireplace would add to the total emissions, but it unlikely to be used regularly and could be considered negligible in an annual analysis.

Calculations of the emissions could be completed by using pound of pollutant values per kWh from the National Renewable Energy Laboratory. Figure 10 displays the pollutant, the value of pounds of pollutant per kWh, and the total value of pounds per year of each pollutant. To determine these values the NREL "Source Energy and Emission Factors for Energy Use in Buildings" was used. It was determined that the new office building is in the Eastern Interconnection for which all subsequent data was selected from. When the annual CO_2 emissions are considered per area (8.4 [lb/sf]) it is found to be substantially less than the 24 [lb/sf] for a standard office building in the mid-Atlantic as measured by Energy Star. Other pollutant data was considered negligible for these purposes.

Figure 13 in Appendix A displays the map from NREL used to determine that the new office building is located in the 'eastern' region.

Figure 14 in Appendix A displays a table of values used to find the pound of pollutant per kWh numbers.

Pollutant	[lb of pollutant per kWh]	[lb pollutant/year]
CO2	1.64	1.81×10^{5}
NOx	3.0×10^{-3}	3316
SOx	8.57×10^{-3}	9474
Particulate Matter	9.26×10^{-5}	102

Figure 12

Summary

An energy and load analysis was performed for the New RLPS Architects' Office Building. The goal was to calculate and analyze the building heating and cooling loads, energy consumption, energy costs, and emissions. The analysis included the discussion of input data including both known and assumed, the process for the calculations, and comparisons to the project engineers load model. A great deal of discrepancy occurred between the two models in terms of heating, loads, cooling loads, and required airflow. The discrepancies were not a matter of being different by a common factor which leads to the belief that the model created for this report is missing consideration made the design model or used different assumptions in enough data inputs to change the value significantly.

The energy cost analysis yielded and annual cost of $31,931. The breakdown of this value into cost per square foot and cost per consumption category is consistent with DOE reports. Though, one could expect the new office building to be more efficient than the average office building due to its use of ground source well and other energy conscious measures taken by the owner and design team. The model for this report is not able to utilize tools like occupancy sensors or advanced BAS controls. That would drive the expected energy consumption down into the expected range for a building designed to as efficient the new office building. Actual metered energy consumption data should be available shortly after January of 2013 when the building is complete.

On a high note the emission of pollutants for the new office building were found to be much better than a standard office building. The CO_2 emissions were found to be nearly a third of a standard office building of similar location.

References

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Appendix A

Figure 3

A copy of the water source heat pump schedule from the project engineer. Some values from this table were used to better define the terminal units in the HAP v4.6 model.

WATER SOURCE HEAT PUMP SCHEDULE

PLAN CODE	AREA SERVED	SUPPLY FAN CFM TOTAL AIR	SUPPLY FAN CFM OUTSIDE AIR	SUPPLY FAN EXT. S.P. (IN WG @ S.L.)	SUPPLY FAN FAN HP	CONDENSER WATER GPM	CONDENSER WATER SIZE (INCHES)	CONDENSER WATER MAX. WATER PD (FT. W.G.)	COOLING TOTAL CAP. (MBH)	COOLING SENS. CAP. (MBH)	COOLING EAT DB (%%127F)	COOLING EAT WB (%%127F)	COOLING HEAT REJ. (MBH)	COOLING EWT (%%127F)	COOLING LWT (%%127F)	COOLING CERT. PERFORM. DATA (EER)	HEATING TOTAL CAP. (MBH)	HEATING HEAT ABS. (MBH)	HEATING EAT DB (%%127F)	HEATING LAT DB (%%127F)	HEATING EWT (%%127F)	HEATING LWT (%%127F)	ELECTRICAL VOLTAGE/ %%129/HZ	ELECTRICAL MCA	ELECTRICAL MFS (AMPS)	SIZE (INCHES) L	SIZE (INCHES) W	SIZE (INCHES) H	OPERATING WEIGHT (LBS)	MANUFACTURER & MODEL NUMBER	NOTES
HP-1	LARGE CONFERENCE	1,200	350	0.5	0.5	7.5	1	6.5	35.7	26.0	75	63	44.7	70.2	81.4	14.2	31.7	22.0	70	94.5	45.1	38.8	208/1/60	22.4	35	26	21.5	43.25	253	FHP EC036-1VTC-FLT	1, 2, 3, 4
HP-2	SMALL CONFERENCE	330	150	0.5	0.1	2.5	3/4	7.9	10.8	8.1	75	63	13.4	70.2	80.4	14.1	9.7	6.8	70	97.2	45.1	39.3	208/1/60	6.0	15	19	19	24.25	129	FHP EC012-1VTC-FLT	1, 2, 3, 4
HP-3	EATERY/LOBBY	1,200	140	0.5	0.5	7.5	1	6.5	35.7	26.0	75	63	44.7	70.2	81.4	14.2	31.7	22.0	70	94.5	45.1	38.8	208/1/60	22.4	35	26	21.5	43.25	253	FHP EC036-1VTC-FLT	1, 2, 3, 4
HP-4	MIKE'S OFFICE	300	30	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-5	GREGG'S OFFICE	300	30	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FLT	1, 2, 3, 4
HP-6	DAVE'S OFFICE	210	25	0.6	0.1	2.0	3/4	5.9	6.1	4.6	75	63	7.7	70.2	77.8	14.1	5.2	3.6	70	92.9	45.1	41.1	208/1/60	4.8	15	19	19	24.25	118	FHP EC007-1VTC-FLT	1, 2, 3, 4
HP-7	ADMINISTRATIVE	300	70	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-8	ACCOUNTING	300	60	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-9	MEETING ROOM	300	25	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-10	ADD. PARTNER OFFICE	300	30	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-11	OFFICE 116/COPIER	350	65	0.5	0.1	2.5	3/4	7.9	10.8	8.1	75	63	13.4	70.2	80.4	14.1	9.7	6.8	70	95.6	45.1	39.3	208/1/60	6.0	15	19	19	24.25	129	FHP EC012-1VTC-FRT	1, 2, 3, 4
HP-12	EAST LIVING RM.	1,825	N/A	0.5	0.75	12.5	1-1/4	7.8	62.4	46.0	75	63	74.0	70	81.9	18.5	54.6	5.0	70	95.1	45	37.7	208/1/60	41.0	60	26	33.25	66.25	390	FHP AP061-1VTC-FLT	1, 2, 3, 4, 5
HP-13	WEST LIVING RM.	1,620	580	0.6	0.75	9.5	1-1/4	6.7	48.5	35.9	75	63	60.0	70.2	82.6	15.4	41.2	29.4	70	93.5	45.1	38.2	208/1/60	31.7	45	24	32.50	45.25	326	FHP EC048-1CFC-FRB	1, 2, 3, 4
HP-14	OCTAGON CONF.	600	100	0.4	0.25	3.5	3/4	10.8	18.6	13.9	75	63	23.0	70.2	82.3	14.1	15.1	10.6	70	93.3	45.1	38.9	208/1/60	12.3	20	21.5	21.50	32.25	205	FHP EC018-1VTC-FLT	1, 2, 3, 4
HP-15	SOUTHWEST STUDIO	1,620	265	0.6	0.75	9.5	1-1/4	6.7	48.5	35.9	75	63	60.0	70.2	82.6	15.4	41.2	29.4	70	93.5	45.1	38.2	208/1/60	31.7	45	24	32.50	45.35	326	FHP EC048-1VTC-FRT	1, 2, 3, 4
HP-16	WEST OFFICES	600	100	0.4	0.25	3.5	3/4	10.8	18.6	13.9	75	63	23.0	70.2	82.3	14.1	15.1	10.6	70	93.3	45.1	38.9	208/1/60	12.3	20	21.5	21.50	32.25	205	FHP EC018-1VTC-FLT	1, 2, 3, 4
HP-17	SOUTH STUDIO	1,800	245	0.5	0.75	9.5	1-1/4	6.7	48.5	35.9	75	63	60.0	70.2	82.6	15.4	41.2	29.4	70	91.2	45.1	38.2	208/1/60	31.7	45	24	32.50	45.35	326	FHP-EC048-1VTC-FRT	1, 2, 3, 4
HP-18	NORTH STUDIO	1,800	245	0.6	0.75	9.5	1-1/4	6.7	48.5	35.9	75	63	60.0	70.2	82.6	15.4	41.2	29.4	70	91.2	45.1	38.2	208/1/60	31.7	45	24	32.50	45.35	326	FHP EC048-1VTC-FLT	1, 2, 3, 4
HP-19	NORTHWEST STUDIO	1,620	255	0.6	0.75	9.5	1-1/4	6.7	48.5	35.9	75	63	60.0	70.2	82.6	15.4	41.2	29.4	70	93.5	45.1	38.2	208/1/60	31.7	45	24	32.50	45.35	326	FHP EC048-1VTC-FRT	1, 2, 3, 4
HP-20	MARKETING	330	45	0.5	0.1	2.5	3/4	7.9	10.8	8.1	75	63	13.4	70.2	80.4	14.1	9.7	6.8	70	97.2	45.1	39.3	208/1/60	6.0	15	19	19	24.25	129	FHP EC012-1VRC-FLT	1, 2, 3, 4
HP-21	PRINTING	1,300	200	0.4	0.5	8.5	1-1/4	8.2	39.9	29.7	75	63	50.0	70.2	81.3	14.1	35.9	25.2	70	95.6	45.1	38.8	208/1/60	26.4	40	21.5	26	43.25	275	FHP-EC042-1VTC-FLT	1, 2, 3, 4
HP-22	I.T. OFFICE	300	20	0.4	0.1	2.0	3/4	4.9	7.5	5.7	75	63	9.6	70.2	79.3	14.1	7.2	5.0	70	92.2	45.1	39.7	208/1/60	6.0	15	19	19	24.25	120	FHP EC009-1VTC-FRT	1, 2, 3, 4
HP-23	SERVER	700	20	0.5	0.3	5.0	1	8.9	24.7	18.5	75	63	30.0	70.2	81.5	15.2	20.0	14.2	70	96.5	45.1	39.0	208/1/60	13.1	20	21.5	21.50	36.25	205	FHP EC024-1VTC-FRT	1, 2, 3, 4
HP-24	CORRIDOR A158	720	95	0.5	0.3	5.0	1	8.9	24.7	18.5	75	63	30.0	70.2	81.5	15.2	20.0	14.2	70	95.7	45.1	39.0	208/1/60	13.1	20	21.5	21.50	36.25	205	FHP EC024-1VTC-FRT	1, 2, 3, 4
HP-25	ELEC./MECH.	700	0	0.5	0.3	5.0	1	8.9	24.7	18.5	75	63	30.0	70.2	81.5	15.2	20.0	14.2	70	96.5	45.1	39.0	208/1/60	13.1	20	41.5	43	19	205	FHP EC024-1HZC-FRE	1, 2, 3, 4
HP-26	SMALL CONFERENCE	330	85	0.5	0.1	2.5	3/4	7.9	10.8	8.1	75	63	13.4	70.2	80.4	14.1	9.7	6.8	70	97.2	45.1	39.3	208/1/60	6.0	15	19	19	24.25	129	FHP EC012-1VTC-FLT	1, 2, 3, 4
HP-27	WORK ROOM	950	360	0.5	0.3	6.0	1	10.3	28.8	21.5	75	63	35.5	70.2	81.4	14.4	23.7	16.5	70	93.1	45.1	39.0	208/1/60	15.5	25	22	45	19	230	FHP-EC030--1HZC-FRE	1, 2, 3, 4
HP-28	STORAGE	760	265	0.4	0.25	5.0	1	8.9	24.7	18.5	75	63	30.0	70.2	81.5	15.2	20.0	14.2	70	94.4	45.1	39.0	208/1/60	13.1	20	21.5	21.50	36.25	205	FHP EC024-1VTC-FRT	1, 2, 3, 4

1. PROVIDE FACTORY INSTALLED INTERNALLY MOUNTED CONDENSATE DRAIN TRAP.
2. PROVIDE CONDENSATE OVERFLOW SWITCH CONFORMING WITH UL508.
3. ARI/ASHRAE/ISO 13256-1 CERTIFIED.
4. PROVIDE HEAT PUMP WITH LOW TEMPERATURE PACKAGE INCLUDING FREEZE-STAT DEDICATED FOR UNIT SHUT-DOWN.
5. ALL REQUIRED ZONE OUTSIDE AIR SUPPLIED THROUGH WEST LIVING ROOM HEAT PUMP (HP-13).

Figure 10

A graphical representation of energy consumption by category. This pie chart was created in HAP v4.6.

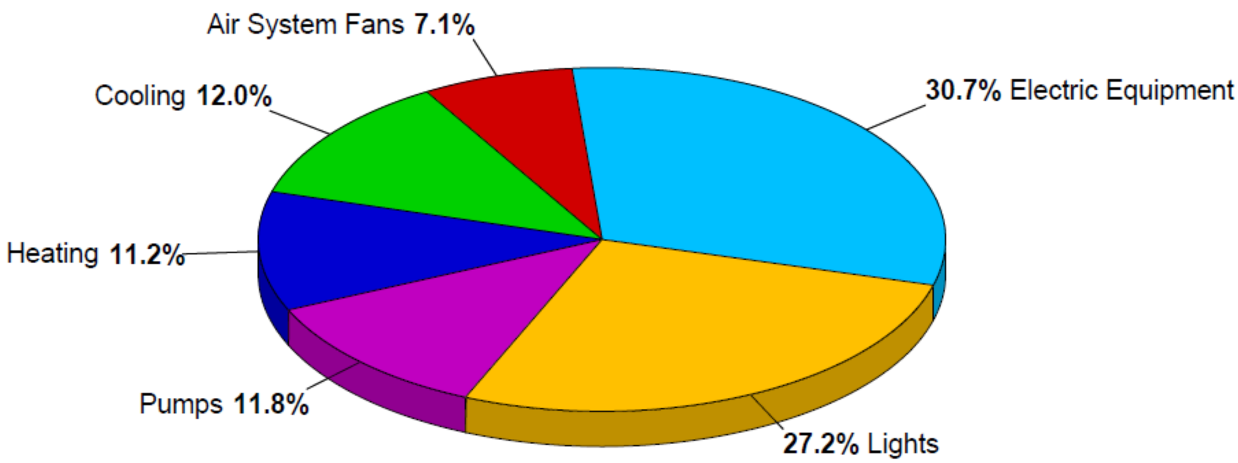

Figure 11

This graph shows the energy consumption per category as calculated by the Department of Energy.

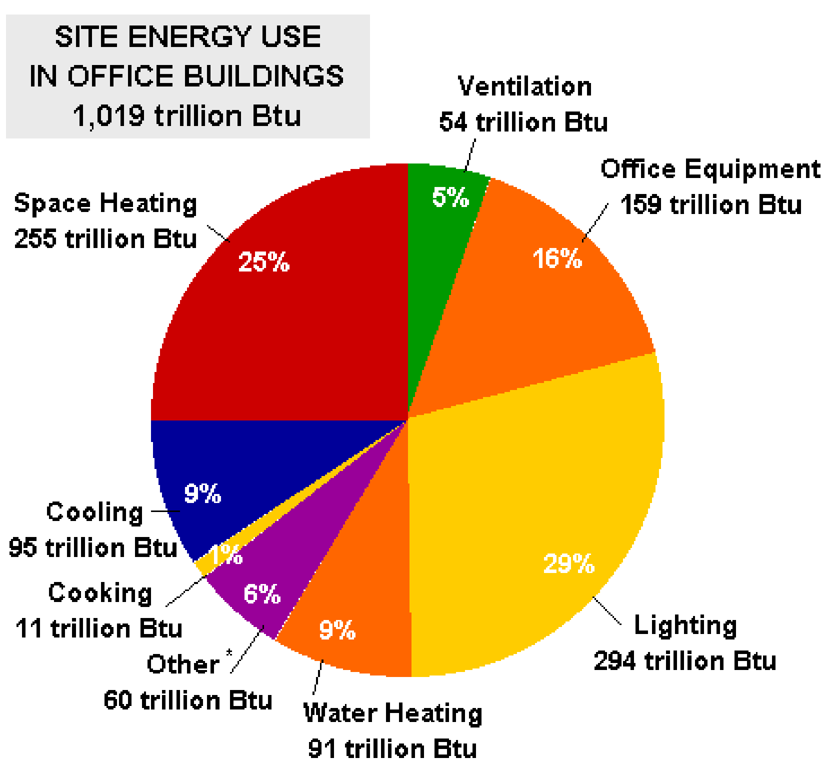

Figure 13

This map and surrounding text from its source the NREL, "Source Energy and Emission Factors for Energy Use in Buildings" were used to determine that the new office building was in the Eastern Interconnection for electrical utilites.

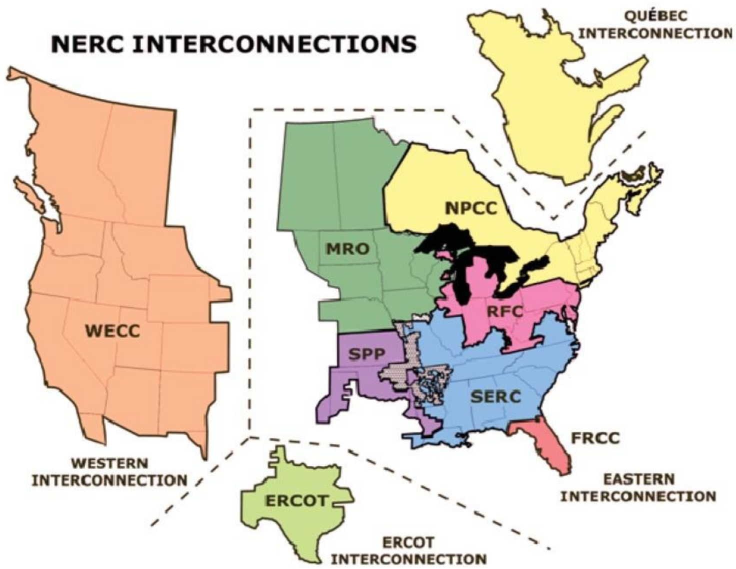

Figure 14

Table 4 from NREL "Source Energy and Emission Factors for Energy Use in Buildings". It displays the pounds of pollutant per kWh for different regions. These values are for a delivered electricity as a fuel source.

Pollutant (kg)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	7.58E-01	7.88E-01	5.94E-01	8.34E-01	7.74E-01	8.65E-01
CO_2	7.14E-01	7.45E-01	5.54E-01	7.74E-01	7.05E-01	8.32E-01
CH_4	1.68E-03	1.63E-03	1.59E-03	2.40E-03	2.85E-03	1.34E-03
N_2O	1.69E-05	1.76E-05	1.35E-05	1.82E-05	1.38E-05	9.06E-06
NO_X	1.25E-03	1.36E-03	8.84E-04	9.98E-04	8.83E-04	1.96E-03
SO_X	3.79E-03	3.89E-03	3.09E-03	4.40E-03	5.09E-03	4.10E-03
CO	3.65E-04	3.87E-04	2.48E-04	4.12E-04	9.31E-04	3.37E-03
TNMOC	3.24E-05	3.29E-05	2.93E-05	3.38E-05	3.81E-05	5.20E-05
Lead	5.92E-08	6.30E-08	4.06E-08	6.44E-08	2.86E-08	5.99E-08
Mercury	1.39E-08	1.52E-08	8.42E-09	1.27E-08	1.72E-08	7.79E-08
PM10	4.16E-05	4.20E-05	3.17E-05	5.92E-05	4.94E-05	8.12E-05
Solid Waste	8.63E-02	9.28E-02	6.29E-02	7.55E-02	3.58E-02	3.37E-02