10/27

Virtua West Jersey Replacement Hospital

Voorhees NJ

TECHNICAL REPORT TWO

Energy Analysis

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Mechanical

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Executive Summary

The purpose of this document is to analyze and discuss the results from an energy simulation for a model of the Virtua West Jersey Replacement Hospital. This report includes the estimated overall loads of the building, annual cost, and emissions. While the model results cannot be compared to the actual energy model performed by the building design team (HGA Architects & Engineers), various rules of thumb and typical values were found through research and the use of the Department of Energy average values. Programs used in the analysis of the hospital were Revit Architecture and Trace 700.

While the calculated values cannot be compared to a professional energy model, comparing them to average values did yield realistic results. Energy usages between the systems in the hospital were compared to see if they did indeed make sense. While some calculated values initially seemed out of range, there was a reasonable cause for it. The overall energy breakdown for the hospital did compare well to that of the DOE (Department of Energy) average energy breakdown for a typical hospital. A specific breakdown of each system was conducted first, finally culminating into overall system loads. Following this was a utility cost breakdown to analyze the annual cost to operate the building.

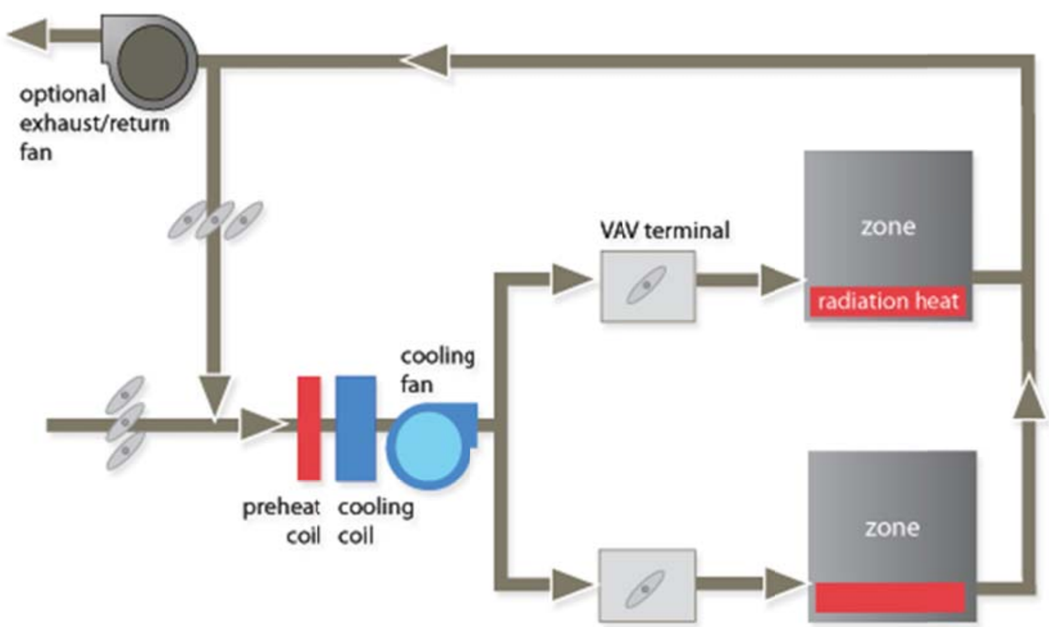
The overall calculated energy for electric and gas in the building was 397,124x10^6 BTU/Yr. 104,721.7x10^6 BTU/Yr is from electricity, while 292,402.1x10^6 BTU/Yr is from gas. This equates to a total of 397,124x10^6 BTU/Yr, with a total annual cost of $2,996,172. The electric rate was based on the actual rates from the Atlantic City Electricity Company; meanwhile the gas rate was an average from the DOE.

System Description

The hospital consists of three 1,000 ton centrifugal chillers located in the central utility plant behind the ancillary portion of the building. Located on the roof of the building are three 9,000 gpm high efficiency cooling towers.

The hospital utilizes a VAV (Variable Air Volume) with a baseboard reheat system throughout the building. There are three sets of AHU's located on the 7th floor. The first set consists of two AHU's at 50,000 cfm each. This will serve dietary areas and labs. The second set of AHU's also consists of two sets of 50,000 cfm AHU's. These will serve emergency and surgery rooms. The last set consists of six 75,000 cfm units that will serve the 8 story patient bedroom tower. For the computer room there are three computer room air conditioning units (CRAC).

For heating and humidifying the hospital has four steam boilers. Two of the boilers are 40 BHP, while the other two are 287 BHP. All four are located in the central utility plant. Coupled with the boilers are six shell and tube heat exchangers located in various areas around the building used for hot water heating.



1. AHU Zones

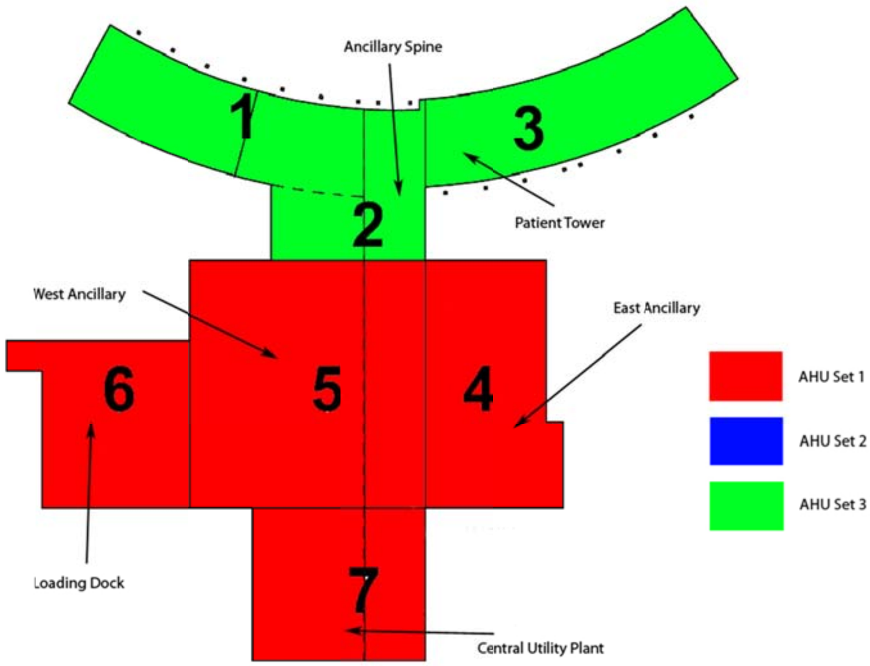


Figure 1.1 AHU Zones Floor Level 1

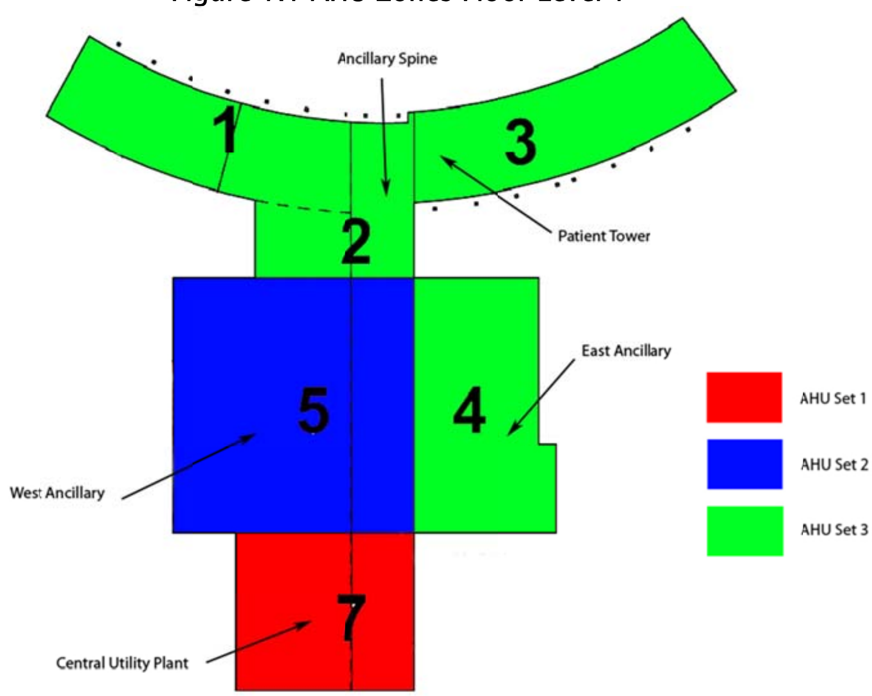


Figure 1.2 AHU Zones Floor Levels 2-6

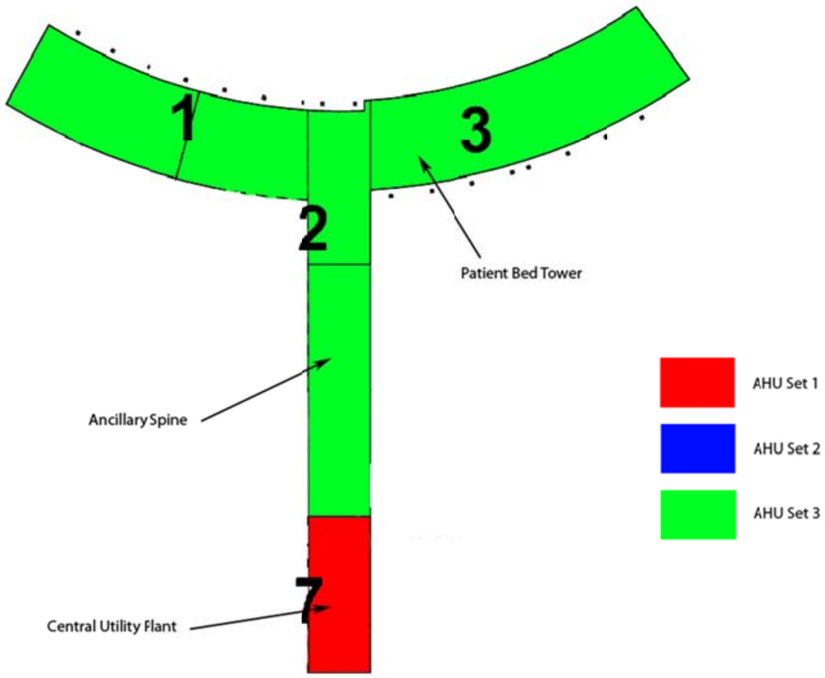


Figure 1.3 AHU Zones Floor Levels 7-8

Figures 1.1, 1.2, and 1.3 show the sections of the building that are being ventilated. AHU Set 1 serves almost all of the first floor lobbies and offices. This extends into the ancillary unit to serve the offices in this space. AHU Set 2 covers all of the west ancillary spaces for all the floors. These rooms consist of mainly operating, recovery, and other types of medical rooms. These are all grouped together under one AHU set since they all require a higher quality of indoor air. AHU Set 3 serves all of the patient rooms in the patient tower, as well as the offices in the east ancillary unit.

2. Design Load Estimation

Load Sources and Modeling Information

The main load sources in the hospital are the occupants, electrical and mechanical equipment, lighting, and the solar gain due to the large amount of glass that is being used.

Design Occupancy and Ventilation

The ventilation rates used for each space were taken from the design documents as well as the occupancy. These include the Max OA at Max SA, Max SA, Min SA, and Min OA at Min SA. Exhaust rates were also taken directly from the design documents.

Infiltration

The Virtua Hospital was assumed to have tight construction with positive pressure. This yielded .3 air changes per hour, which was used for all the spaces with an exterior wall.

Electrical Loads

All of the lighting loads were entered on a Watt/square foot basis. Lighting loads for different spaces varied greatly. Corridors for example, had a value of .9 Watts per square foot. Offices and other similar spaces had a higher value at around 1.2 Watts per square foot. This is because more light is needed in this space since work is being done. Operating rooms were given a particularly high value at 1.6 Watts per square foot since a lot of light is needed during the surgeries. Some of these spaces will not operate 100% of the time however, so the lighting load will not be as significant as if the lights were on 100% of the time. Patient rooms were given a 1 Watt per square foot value. There is less lighting in these rooms on purpose, since the idea for the patient rooms was to make it darker so patients could sleep during daylight hours. All of these values are estimated for each space.

Loads for the electrical equipment in each space were entered by Watts. This is because equipment plans were made available, which showed the exact equipment being used in each space. Using 2005 ASHRAE Handbook of Fundamentals, wattages were determined for each space. Using this method made for a more accurate energy model.

Weather Data

The outdoor and indoor air conditions for Philadelphia, PA were used. This is because there was no available data for the buildings location in Voorhees NJ. However, Philadelphia is very close, making the weather data an accurate representation for the weather in Voorhees. Values were taken from the 2005 ASHRAE Handbook of Fundamentals. Values used were the .4% and 99.6%. The OA Dry Bulb for the summer is 92.7° F, while the OA Wet Bulb is 75.6° F. The OA Dry Bulb for the winter is 11.6° F. The clearness number was .98 as well. The weather data information can be seen in Figure 2.1

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Design conditions for PHILADELPHIA, PA, USA

Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
1a	1b	1c	1d	1e	1f	1g	1h	1i
PHILADELPHIA	724080	39.87N	75.26W	30	14.680	-5.00	NAE	7201

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	11.6	15.8	-4.8	4.3	15.0	-0.7	5.3	18.8	28.5	35.2	26.2	34.1	11.9	280

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
7	17.1	92.7	76.6	90.1	74.5	87.6	73.0	78.3	88.4	77.0	86.1	75.7	83.6	10.9	240

Dehumidification DP/MCDB and HR									Enthalpy/MCDB					
0.4%			1%			2%			0.4%		1%		2%	
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
12a	12b	12c	12d	12e	12f	12g	12h	12i	13a	13b	13c	13d	13e	13f
76.5	133.5	83.0	74.3	128.2	81.7	73.1	123.0	80.4	34.0	89.0	32.6	86.0	31.3	83.7

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%	WB	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
14a	14b	14c	15	16a	16b	16c	16d	17a	17b	17c	17d	17e	17f	17g	17h
24.2	20.6	18.5	88.1	97.0	5.6	2.9	6.8	99.1	0.9	100.8	-3.0	102.4	-6.7	104.6	-11.6

Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18a	18b	18c	18d	18e	18f	18g	18h	18i	18j	18k	18l
0.4%	63.1	58.5	66.5	53.8	77.1	62.4	86.2	66.1	90.6	71.6	93.9	74.8
1%	60.1	56.5	61.8	54.0	72.9	60.2	81.2	65.2	87.9	70.2	92.1	74.6
2%	56.9	53.4	58.7	52.0	68.3	58.4	76.8	62.0	85.5	69.0	90.3	74.0

%	Jul		Aug		Sep		Oct		Nov		Dec	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18m	18n	18o	18p	18q	18r	18s	18t	18u	18v	18w	18x
0.4%	97.3	78.8	95.3	76.7	91.1	76.2	81.5	68.4	73.8	63.8	64.7	59.8
1%	95.2	76.7	93.2	76.3	88.5	73.2	79.2	67.7	70.7	62.5	62.4	57.8
2%	93.3	76.3	91.5	75.9	86.2	72.2	76.7	66.3	68.2	61.3	59.9	55.5

Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19a	19b	19c	19d	19e	19f	19g	19h	19i	19j	19k	19l
0.4%	60.2	62.4	58.7	62.2	64.3	74.3	68.1	81.4	74.6	86.5	78.1	89.0
1%	57.3	59.1	56.0	59.3	62.2	70.0	66.5	78.2	73.0	83.5	77.1	87.4
2%	54.1	56.4	53.4	56.8	59.5	66.5	64.8	74.5	71.4	81.8	76.2	86.1

%	Jul		Aug		Sep		Oct		Nov		Dec	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19m	19n	19o	19p	19q	19r	19s	19t	19u	19v	19w	19x
0.4%	80.5	92.2	80.0	90.4	77.4	86.2	71.9	78.3	66.6	70.5	61.3	63.7
1%	79.6	90.7	79.0	89.3	76.4	84.2	70.5	76.3	64.9	68.2	58.9	61.2
2%	78.8	89.1	78.0	87.3	75.4	82.3	69.0	74.0	63.4	66.9	56.4	59.4

Monthly Mean Daily Temperature Range

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20a	20b	20c	20d	20e	20f	20g	20h	20i	20j	20k	20l
14.0	15.3	17.1	19.0	18.8	18.1	17.1	16.8	16.8	17.7	15.9	14.0

WMO#	World Meteorological Organization number	Lat	Latitude, °	Long	Longitude, °
Elev	Elevation, ft	StdP	Standard pressure at station elevation, psi		
DB	Dry bulb temperature, °F	DP	Dew point temperature, °F	WB	Wet bulb temperature, °F
WS	Wind speed, mph	Enth	Enthalpy, Btu/lb	HR	Humidity ratio, grains of moisture per lb of dry air
MCDB	Mean coincident dry bulb temperature, °F	MCDP	Mean coincident dew point temperature, °F	MCWB	Mean coincident wet bulb temperature, °F
MCWS	Mean coincident wind speed, mph	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East		

Figure 2.1 ASHRAE Weather Data for Philadelphia, PA

3. Energy Model Foreword

The building model was first constructed in REVIT Architecture. This was done to accurately represent the square footages, volumes, and wall types for each of the spaces. The model was then imported into Trace 700 for energy analysis. Trace 700 was used due to the author's familiarity with the program, as well as its history of showing accurate results when used by the author.

While comparing the results to the actual building energy model results from the actual design engineers would be ideal in confirming an accurate energy analysis, HGA Architects and Engineers preferred not to make the information available. The results of the energy model will be compared to industry standards and rules of thumb. Comparing the different systems of the hospital will to each will also help determine if the results are indeed accurate.

4. Energy Model Results

The first section analyzed after the modeling was complete was the three main AHU sets. Tables 4.1, 4.2, and 4.3 show the basic analysis for each AHU set.

AHU-1		
	Cooling	Heating
%OA	36.4	1.2
cfm/ft^2	0.61	9.27
cfm/ton	155.98	
ft^2/ton	257.5	
Occupancy	918	

Table4.1AHU Set 1 Analysis

AHU-2		
	Cooling	Heating
%OA	34.9	3.7
cfm/ft^2	0.73	2.86
cfm/ton	111.96	
ft^2/ton	152.83	
Occupancy	861	

Table 4.2 AHU Set 2 Analysis

AHU-3		
	Cooling	Heating
%OA	34.4	10.5
cfm/ft^2	0.89	1.7
cfm/ton	177.9	
ft^2/ton	199.5	
Occupancy	3516	

Table 4.3 AHU Set 3 Analysis

As seen in the tables the %OA for each AHU is around 35%. These all seem relatively high, however, when considering the design ventilation rates for the hospital they make sense. Many of the offices in the hospital have a very high %OA, as do the patient rooms. Many of these spaces are conditioned by AHU Set 3. The reason for AHU Set 2s high %OA is because this set conditions many of the medical rooms, including operating, radiation, recovery, and C-section rooms. AHU Set 1 has a high %OA because it also serves offices on the first floor, as well as the large kitchen areas which required a high percentage of outdoor air.

A rule of thumb for a standard building is 400 ft^2/ton. This is for a typical office building however. When looking at the individual AHU sets it is clear that much more energy is used. This makes sense due to the type of building being modeled. A hospital will naturally use much more energy than that of a standard commercial building. According to the DOE (Department of Energy) hospitals can use as much as 2.5 times the amount of energy compared to an office building. When comparing the ft^2/ton for the 3 sets of AHUs it is apparent that they are in the correct range.

Further comparing the ft2/ton for each set to each other also seems to yield accurate results. AHU Set 1 has the highest, at 257.5 ft^2/ton. This is due to the fact that mainly office, lounges, and waiting areas are on this set. It does condition the main kitchen, however, which most likely contributes to it using more energy. The other sets condition spaces that require much more energy. AHU Set 2 uses the most energy, 152 ft^2/ton, since it mainly conditions the operating rooms and medical rooms. AHU Set 3 is in the middle at 199.5 ft^2/ton. Once again, this seems accurate since this supplies most of the patient rooms, and some medical rooms, which require more ventilation than standard offices, such as the ones on AHU Set 1.

Design Cooling		
Plant	System	Main Coil (Tons)
Cooling	AHU-1	396.5
	AHU-2	703.5
	AHU-3	2350.4
Total		**3423.5**

Table 4.4 Peak Design Cooling

Design Heating		
Plant	System	Main Coil(MBH)
Heating	AHU-1	30915
	AHU-2	17520
	AHU-3	30704
Total		**79,139**

Table 4.5 Peak Design Heating

Tables 4.4 and 4.5 show the peak Design Cooling and Design Heating loads on the main coils, which occurs in May. Comparing the peak loads to each other helps confirm whether they are accurate. AHU Set 3 clearly has the highest peak load, which makes absolute sense since it conditions a significantly larger amount of spaces than the other two sets. AHU Set 2 once again is higher than AHU Set 1 due to the types of spaces it conditions. At first glance the Design Heating loads may seem a bit odd, but further analysis can help explain the peak loads. AHU Set 1 consists of many rooms on ground level, which consists of mainly exterior glazing. A large effort was made to allow as little direct solar gain through the glass. This in turn will decrease the solar gain that can enter into the building and help heat the spaces. These spaces will have infiltration that enters the rooms through any gaps in construction, which is why the heating load may be larger than one would think. The same can be said for the AHU Set 3, however this has a large load due to the large number of spaces served as well. AHU Set 2 has a smaller peak heating load due to its smaller size, and the fact that the spaces being served do not include any exterior glazing, as well as the fact that many of the spaces are not on the exterior of the building.

After analyzing the peak loads on the AHU Sets, an energy analysis was performed on the building mechanical plant. Much of the sizing and efficiencies were taken off of the actual design documents to provide accurate modeling of the mechanical equipment. Electrical rates were taken directly off of the Atlantic City Electric

Company's website. The breakdown of the rates can be seen in Appendix A. The average value used for the electric rate was $4.50/KW. The rate used for natural gas was $0.50/Therm.

In addition to entering the correct rates, the building schedule was also necessary to enter correctly. Since this is a hospital, many of the spaces will be operating at all hours of the day. All of the patient rooms are running 100% of the time, as well as the nurse and other spaces that serve the patient rooms. Many of the medical rooms, including surgery rooms are also assumed to be operational 100% of the time. The only spaces that are not operational at all times of the day are the many offices throughout the hospital. Many of the offices were given a schedule for operating times from 8 am to 8 pm. While this is a larger amount of time than a standard office schedule, given the type of occupancy for the building it was decided to increase the amount of time the offices were operational.

After entering the correct energy rates and schedules the energy analysis of the building was performed. Table 4.6 shows the overall breakdown for the energy consumption by the building annually. The primary heating for the building comprises of mostly natural gas, since the boilers are responsible for this and they run on natural gas. There are several heat exchangers that also operate throughout the building for additional heating that do use electricity, which mainly comprises the "Other" in Table 4.6 under primary heating. The Primary Cooling consists of the various parts of the chillers, and the cooling towers. As seen in the table all of the cooling equipment runs on electricity, with the chiller cooling compressors using the majority of the energy. It is important to note the amount of water used mainly in the cooling towers as well. The supply fans also use a significant amount of electricity as well. This is because they are powerful fans that must push large amounts of air through high MERV rating filters. This equates to a large pressure drop, making it necessary for large, powerful fans to be used.

When looking at the total percentages for the energy consumptions, it is clear that the primary heating load was a significant part of the overall energy consumption. To make sure that this value is indeed correct it was decided to compare it with the average energy consumption in a hospital. Figure 4.1 shows a breakdown for typical hospitals, provided by the DOE. This figure does show that primary heating for a hospital comprises a lot of the energy use (50%). However, the model for this hospital still had a higher than normal heating load. This could be explained once again by the fact that there is little solar heat gain that penetrates through the exterior glazing. Most likely the average hospital does not have glazing with such a low U-factor, which means that more heating will be required in the winter due to the fact that not as much solar heat will reach the spaces compared to a normal space. This does affect the cooling loads in a positive way. The building will not need to be cooled as much in the summer months since not as much solar heat will penetrate the glazing. This could be an important factor for why the cooling primary load is much lower than the heating primary load. An additional factor could be the large number of boilers and heat exchangers used in the building for heating and domestic hot waters as well.

Another difference to note between the model and the DOE averages is the lighting loads. The lighting loads for this building are much lower than the average. This can be explained by the purposeful attempt to greatly lower the lighting loads in the building. The building uses only fluorescents, and in the patient rooms (large portion of the building) the lighting is greatly reduced to keep it dark so patients can sleep during daylight hours.

Energy Consumption Summary						
System		Elec (KWH)	Gas (KBTU)	Water (1000 gal)	Total (KBTU/Yr)	% Total
Primary Heating	Primary Heating	-	292,402,592	-		
	Other	17,721	-	1	292,463	73.70%
Primary Cooling	Cooling Comp.	12,924,327	-	-		
	Tower/Cond Fans	1,859,147	-	88,409		12.70%
	Condenser Pumps	-	-	-	50,455,997	
Auxiliary	Supply Fans	8,851,427	-	-	30,209,902	7.60%
Lighting	Lighting	6,512,327	-	-	22,226,570	6%
Total		**30164949**	**292,402,592**	**88410**	**103,184,932**	**100%**

Table 4.6 Energy Consumption Summary

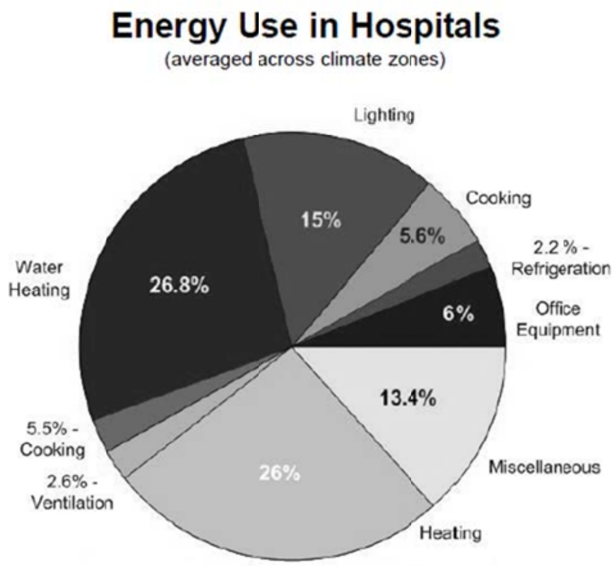

Figure 4.1 Typical Energy Breakdowns in Hospitals

After looking at the overall energy consumption breakdowns, an analysis was done on the main mechanical components for the peak loads. Table 4.7 shows the peak electrical loads demands for the three main chillers and four main steam boilers. As expected, the chillers make up a large percentage of the electrical load during its peak. The boilers use almost no electricity since they run on natural gas. The lighting also makes up a large portion of the electrical load on the building, as well as the three AHU Sets. Once again, AHU Set 3 clearly uses more energy due to its much larger size compared to the other AHU Sets.

Electrical Peak			
System		Elec Demand (KW)	% Total
Cooling	Chiller 1	687	17.7
	Chiller 2	687	17.7
	Chiller 3	687	17.7
Heating	Boiler 1	0.5	0.01
	Boiler 2	0.5	0.01
	Boiler 3	0.51	0.01
	Boiler 4	0.51	0.01
Fan Equip	AHU-1	374.95	9.6
	AHU-2	152.78	3.9
	AHU-3	481.5	12.4
Miscellaneous	Misc.	59.16	1.5

	Equip		
	Lighting	743.42	19.2
Total		**3874.83**	**100%**

Table 4.7 Electrical Peak Loads

Appendix B shows the monthly energy consumption for the entire hospital. This includes the on peak consumption as well as the on peak demand for electric, gas, and water. The overall building consumption is 591,271 BTU/ft^2-year. This equates to a total building consumption of 3.9x10$^{\wedge 10}$ BTU/Yr.

Appendix C also shows a more specific monthly breakdown for each piece of equipment used in the central plant. It includes both the average energy use as well as the peak for each component.

Once the energy usage of the building was known, the annual cost of running the hospital could be calculated. Table 4.8 shows the breakdown of the annual cost for both the electric and gas. As seen in the table they both end up costing roughly the same annually, with a total operational cost for utilities being $2,996,172. The annual operating cost can also be seen in the graph in Figure 4.2.

Annual Utility Breakdown Cost		
Source	Energy (10^6 BTU/yr)	Cost ($)
Electricity	104,721.70	1,534,159
Gas	292,402.60	1,462,013
Total	**397,124.30**	**2,996,172**

Table 4.8 Annual Utility Costs

Figure 4.3 shows the monthly breakdown for utility cost. As seen in the graph the monthly cost does not fluctuate greatly. This could be due to the electrical and gas costs being roughly similar.

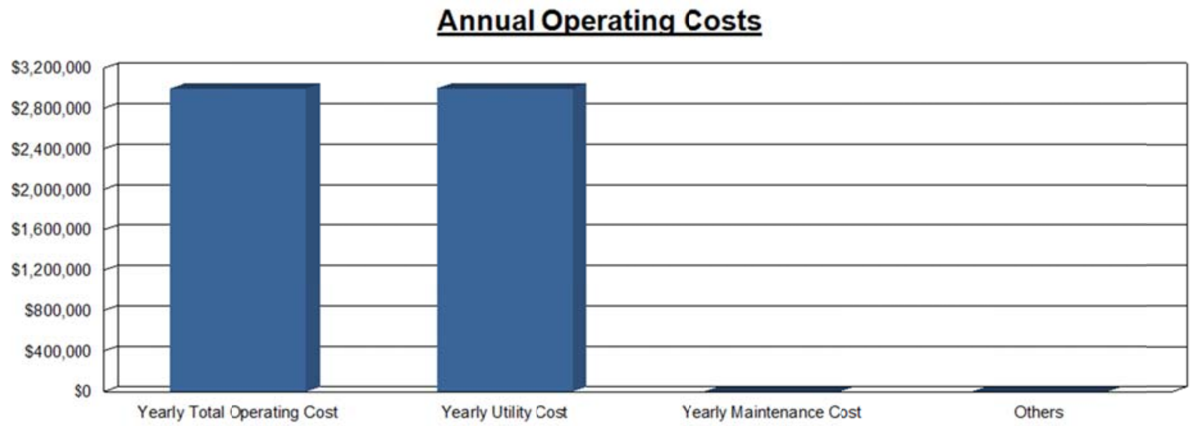

Figure 4.2 Annual Utility Cost

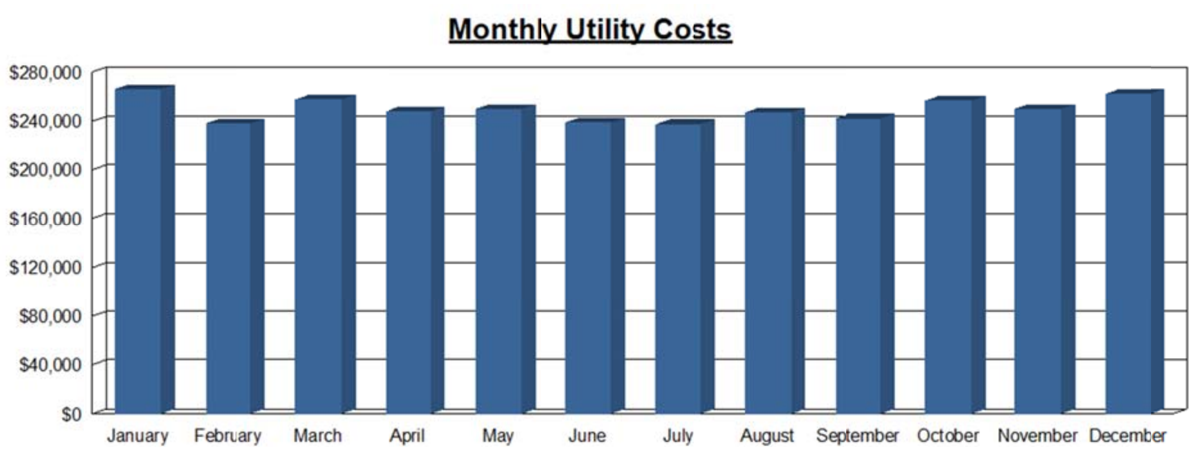

Figure 4.3 Monthly Utility Cost

Tables 4.9 and 4.10 below show the estimated emission factors for the hospital. The data was taken from the total emission factors for delivered electricity for New Jersey. The value given in Table 4.9 was multiplied by KWH to obtain the total emissions. This is just the emissions for the electricity. Table 4.10 shows the emission factors for the gasoline used to run the steam boilers. The cubic feet of gasoline were taken directly from the design documents for each boiler.

Annual Emmission Factors		
Pollutant	lb/KWH in NJ	Building lb/Year
CO2e	9.31E-01	2.81E+07
CO2	8.61E-01	2.60E+07
CH4	2.79E-03	8.42E+04
N20	1.76E-05	5.31E+02
Nox	1.32E-03	3.98E+04
Sox	6.34E-03	1.91E+05
CO	6.69E-04	2.02E+04
TNMOC	6.92E-05	2.09E+03
Lead	4.27E-08	1.29E+00
Mercury	1.44E-08	4.34E-01
PM10	5.14E-05	1.55E+03
Solid Waste	6.23E-02	1.88E+06

Table 4.9 Emission Factors for Electricity

Annual Emmission Factors		
Pollutant	lb/cf	lb/Year
CO2e	1.37E+02	4.13E+09
CO2	1.16E+02	3.50E+09
CH4	8.38E-01	2.53E+07
N20	3.41E-03	1.03E+05
Nox	3.56E+00	1.07E+08
Sox	6.32E-04	1.91E+04
CO	2.29E+00	6.91E+07
VOC	2.06E-03	6.21E+04
Lead	5.00E-07	1.51E+01
Mercury	2.60E-07	7.84E+00
PM10	1.66E-02	5.01E+05

Table 4.10 Emission Factors for Natural Gas

References

ASHRAE Standard 62.1 2004

ASHRAE Standard 90.1 2004

ASHRAE Handbook of Fundamentals 2005

Stephen Treado

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Appendix A

MONTHLY RATE

Delivery Service Charges:	**SUMMER** June Through September	**WINTER** October Through May
Customer Charge	$93.33	$93.33
Distribution Demand Charge ($/kW)		
Including 25 kW	$4.50	$4.50
Per kW for the next 875 kW	$4.50	$4.50
Per kW for the next 9100 kW	$4.47	$4.47
Per kW for each additional kW	$4.86	$4.86
Winter Excess Demand*	N/A	$2.50
Reactive Demand (for each kvar over one-third of kW demand)	$0.40	$0.40
Distribution Rates ($/kWh)		
Step 1. For each of the first 82,500 kWh after determining Step 3	$0.000843	$0.000843
Step 2. For each additional kWh, except	$0.000803	$0.000803
Step 3. For each kWh over 330 kWh per kW demand	$0.000803	$0.000803

Appendix B

Monthly Energy Consumption

Utility		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Electric	On-Pk Cons. (kWh)	2,361,259	2,126,070	2,462,549	2,500,389	2,749,188	2,705,880	2,838,993	2,802,993	2,679,621	2,602,391	2,444,051	2,410,376	30,683,760
	On-Pk Demand (kWh)	3,424	3,403	3,635	3,670	3,795	3,831	3,875	3,851	3,831	3,677	3,656	3,520	3,875
Gas	On-Pk Cons. (therms)	296,651	264,002	269,447	245,765	225,444	206,989	191,277	214,104	216,514	253,662	255,945	284,226	2,924,026
	On-Pk Demand (therms/hr)	600	437	438	432	332	314	299	317	325	430	434	453	600
Water	Cons. (1000 gal)	6,379	5,735	6,900	7,264	8,230	8,033	8,340	8,308	8,009	7,593	6,983	6,637	88,411

Energy Consumption	
Building	591,271 BTU/ft2-year
Source	926,067 BTU/ft2-year

Appendix C

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

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Lights													
Electric (kWh)	553,101.6	499,576.7	553,101.3	535,260.1	553,101.8	535,259.1	553,102.0	553,101.3	535,260.3	553,101.8	535,259.6	553,102.0	6,512,326.5
Peak (kW)	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4	743.4
Misc. Ld													
Electric (kWh)	44,015.1	39,755.6	44015.1	42,595.3	44,015.1	42,595.3	44,015.1	44,015.1	42,595.3	44,015.1	42,595.3	44,015.1	518,242.2
Peak (kW)	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2	59.2
Cooling Coil Condensate													
Recoverable Water (1000gal)	0.9	0.1	20.8	90.0	231.1	357.4	495.7	422.4	289.5	105.0	58.0	16.0	2,086.7
Peak (1000gal/Hr)	0.2	0.0	0.1	0.2	0.4	0.7	0.8	0.6	0.6	0.2	0.2	0.1	0.8
Cpl 1: Cooling plant - 001 [Sum of dsn coil capacities=3,423 tons]													
Water-cooled chiller - 001 [Clg Nominal Capacity/F.L.Rate=1,000 tons / 610 kW] (Cooling Equipment)													
Electric (kWh)	295,747.3	265,906.9	320,785.5	343,306.6	408,600.4	410,681.8	438,594.4	426,731.3	401,852.9	360,803.0	327,616.5	307,482.6	4,308,109.0
Peak (kW)	465.9	462.9	529.1	540.9	582.7	594.7	609.6	601.8	595.1	543.5	536.4	491.0	609.6
Cooling tower for Cent. Chillers [Design Heat Rejection/F.L.Rate=1,173 tons / 77.45 kW]													
Electric (kWh)	41,025.6	36,036.7	49819.4	54,555.3	57,623.2	55,764.3	57,623.3	57,623.1	55,764.5	56,619.6	51,472.9	45,787.9	619,715.7
Peak (kW)	704	66.4	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5
Cooling tower for Cent. Chillers													
Make Up Water (1000gal)	2,128.5	1,911.6	2,299.9	2,421.2	2,743.4	2,677.8	2,780.0	2,769.2	2,669.6	2,530.9	2,327.5	2,212.2	29,469.7
Peak (1000gal/Hr)	3.3	3.3	3.7	3.7	3.7	3.7	3.8	3.8	3.7	3.7	3.7	3.5	3.8
Water-cooled chiller - 002 [Clg Nominal Capacity/F.L.Rate=1,000 tons / 610 kW] (Cooling Equipment)													
Electric (kWh)	295,747.3	265,906.9	320,785.5	343,306.6	408,600.4	410,681.8	438,594.4	426,731.3	401,852.9	360,803.0	327,616.5	307,482.6	4,308,109.0
Peak (kW)	465.9	462.9	529.1	540.9	582.7	594.7	609.6	601.8	595.1	543.5	536.4	491.0	609.6
Cooling tower for Cent. Chillers [Design Heat Rejection/F.L.Rate=1,173 tons / 77.45 kW]													
Electric (kWh)	41,025.6	36,036.7	49819.4	54,555.3	57,623.2	55,764.3	57,623.3	57,623.1	55,764.5	56,619.6	51,472.9	45,787.9	619,715.7
Peak (kW)	704	66.4	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5
Cooling tower for Cent. Chillers													
Make Up Water (1000gal)	2,128.5	1,911.6	2,299.9	2,421.2	2,743.4	2,677.8	2,780.0	2,769.2	2,669.6	2,530.9	2,327.5	2,212.2	29,469.7
Peak (1000gal/Hr)	3.3	3.3	3.7	3.7	3.7	3.7	3.8	3.8	3.7	3.7	3.7	3.5	3.8

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

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Cpl 1: Cooling plant - 001 [Sum of dsn coil capacities=3,423 tons]													
Water-cooled chiller - 003 [Clg Nominal Capacity/F.L.Rate=1,000 tons / 610 kW] (Cooling Equipment)													
Electric (kWh)	295,747.3	265,906.9	320,785.5	343,306.5	408,600.4	410,681.8	438,594.4	426,731.3	401,852.9	360,803.0	327,616.5	307,482.6	4,308,109.0
Peak (kW)	465.9	462.9	529.1	540.9	582.7	594.7	609.6	601.8	595.1	543.5	536.4	491.0	609.6
Cooling tower for Cent. Chillers [Design Heat Rejection/F.L.Rate=1,173 tons / 77.45 kW]													
Electric (kWh)	41,025.6	36,036.7	49,819.4	54,555.3	57,623.2	55,764.3	57,623.3	57,623.1	55,764.5	56,619.6	51,472.9	45,787.9	619,715.7
Peak (kW)	70.4	66.4	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5
Cooling tower for Cent. Chillers													
Make Up Water (1000gal)	2,126.5	1,911.6	2,299.9	2,421.2	2,743.4	2,677.8	2,780.0	2,769.2	2,669.6	2,530.9	2,327.5	2,212.2	29,469.7
Peak (1000gal/Hr)	3.3	3.3	3.7	3.7	3.7	3.7	3.8	3.8	3.7	3.7	3.7	3.5	3.8
Hpl 1: Heating plant - 002 [Sum of dsn coil capacities=85,205 mbh]													
Boiler - 001 [Nominal Capacity/F.L.Rate=1.34 mbh / 0.02 Therms] (Heating Equipment)													
Gas (therms)	12.5	11.3	12.5	12.1	12.5	12.1	12.5	12.5	12.1	12.5	12.1	12.5	146.7
Peak (therms/Hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	11.7
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	4,380.0
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
Condensate return - 4.7e-008 kW/Btu (Misc Accessory Equipment)													
Recoverable Water (1000gal)	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Make-up water - 5.18e-006 gal/btu (Misc Accessory Equipment)													
Make Up Water (1000gal)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Boiler - 002 [Nominal Capacity/F.L.Rate=1.34 mbh / 0.02 Therms] (Heating Equipment)													
Gas (therms)	12.5	11.3	12.5	12.1	12.5	12.1	12.5	12.5	12.1	12.5	12.1	12.5	146.7
Peak (therms/Hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	11.7

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

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Hpl 1: Heating plant - 002 [Sum of dsn coil capacities=85,205 mbh]													
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	4,380.0
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
Condensate return - 4.7e-008 kW/Btu (Misc Accessory Equipment)													
Recoverable Water (1000gal)	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6
Make-up water - 5.18e-006 gal/btu (Misc Accessory Equipment)													
Make Up Water (1000gal)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Boiler - 003 [Nominal Capacity/F.L.Rate=9.60 mbh / 0.12 Therms] (Heating Equipment)													
Gas (therms)	89.3	80.6	89.3	86.4	89.3	86.4	89.3	89.3	86.4	89.3	86.4	89.3	1,051.2
Peak (therms/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
Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	7.1	6.5	7.1	6.9	7.1	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	4,380.0
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
Condensate return - 4.7e-008 kW/Btu (Misc Accessory Equipment)													
Recoverable Water (1000gal)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	4.0
Make-up water - 5.18e-006 gal/btu (Misc Accessory Equipment)													
Make Up Water (1000gal)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Boiler - 004 [Nominal Capacity/F.L.Rate=9.60 mbh / 0.12 Therms] (Heating Equipment)													
Gas (therms)	89.3	80.6	89.3	86.4	89.3	86.4	89.3	89.3	86.4	89.3	86.4	89.3	1,051.2
Peak (therms/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
Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	7.1	6.5	7.1	6.9	7.1	6.9	7.1	7.1	6.9	7.1	6.9	7.1	84.1
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	372.0	360.0	372.0	372.0	360.0	372.0	360.0	372.0	4,380.0
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

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

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Hpl 1: Heating plant - 002 [Sum of dsn coil capacities=85,205 mbh]													
Condensate return - 4.7e-008 kW/Btu (Misc Accessory Equipment)													
Recoverable Water (1000gal)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	4.0
Make-up water - 5.18e-006 gal/btu (Misc Accessory Equipment)													
Make Up Water (1000gal)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Gas-fired heat exchanger - 005 [Nominal Capacity/F.L.Rate=7,200 mbh / 93.51 Therms] (Heating Equipment)													
Gas (therms)	69,568.9	62,836.4	69,568.9	67,324.6	69,568.8	67,324.8	69,568.8	69,568.9	67,324.6	69,568.8	67,324.7	69,568.8	819,116.9
Peak (therms/Hr)	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5
Gas-fired heat exchanger - 006 [Nominal Capacity/F.L.Rate=7,200 mbh / 93.51 Therms] (Heating Equipment)													
Gas (therms)	69,568.9	62,836.4	69,568.9	67,324.6	69,568.8	67,324.8	69,568.8	69,568.9	67,324.6	69,568.8	67,324.7	69,568.8	819,116.9
Peak (therms/Hr)	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5
Gas-fired heat exchanger - 007 [Nominal Capacity/F.L.Rate=2,512 mbh / 32.62 Therms] (Heating Equipment)													
Gas (therms)	24,271.8	21,922.9	24,271.8	23,488.9	24,271.8	23,488.9	24,271.8	24,271.8	23,488.9	24,271.8	23,488.9	24,271.8	285,781.0
Peak (therms/Hr)	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
Gas-fired heat exchanger - 008 [Nominal Capacity/F.L.Rate=7,850 mbh / 101.9 Therms] (Heating Equipment)													
Gas (therms)	75,843.0	68,433.2	72,682.1	69,680.4	61,178.7	48,653.7	27,663.9	50,490.8	58,128.6	72,767.2	70,659.0	75,222.9	751,403.5
Peak (therms/Hr)	102.0	102.0	102.0	102.0	102.0	94.3	79.4	97.5	102.0	102.0	102.0	102.0	102.0
Gas-fired heat exchanger - 009 [Nominal Capacity/F.L.Rate=10,041 mbh / 130.4 Therms] (Heating Equipment)													
Gas (therms)	57,195.1	47,789.7	33,152.4	17,749.4	652.0	0.0	0.0	0.0	49.9	17,282.1	26,950.8	45,374.4	246,195.6
Peak (therms/Hr)	130.4	115.1	116.5	109.7	10.1	0.0	0.0	0.0	2.8	107.8	112.0	130.4	130.4
Gas-fired heat exchanger - 010 [Nominal Capacity/F.L.Rate=10,041 mbh / 130.4 Therms] (Heating Equipment)													
Gas (therms)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	16.0
Peak (therms/Hr)	130.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	130.4
Gas-fired heat exchanger - 011 [Nominal Capacity/F.L.Rate=10,041 mbh / 130.4 Therms] (Heating Equipment)													
Peak (therms/Hr)	17.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.4
Sys 1: AHU-1													
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=882,325 cfm / 352.9 kW] (Main Clg Fan)													
Electric (kWh)	262,579.9	237,169.3	262,579.9	254,110.0	262,580.1	254,109.6	262,580.2	262,579.9	254,110.1	262,580.3	254,109.8	262,580.3	3,091,669.5
Peak (kW)	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9	352.9

					------ Monthly Consumption -------								
Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Sys 1: AHU-1													
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=883,690 cfm / 353.5 kW] (Main Return Fan)													
Electric (kWh)	16,217.4	14,658.4	16,210.6	15,661.6	16,285.7	15,717.9	16,233.3	16,226.4	15,748.0	16,147.8	15,633.6	16,155.0	190,905.6
Peak (kW)	22.1	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.1
Sys 2: AHU-2													
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=307,899 cfm / 123.2 kW] (Main Clg Fan)													
Electric (kWh)	91,631.0	82,763.3	91,631.0	88,675.1	91,630.9	88,675.1	91,630.9	91,631.0	88,675.0	91,630.8	88,675.1	91,630.9	1,078,880.0
Peak (kW)	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=308,856 cfm / 123.5 kW] (Main Return Fan)													
Electric (kWh)	22,190.7	20,033.8	22,086.7	21,274.8	21,979.5	21,240.9	21,942.2	21,938.3	21,259.0	21,959.7	21,333.5	22,132.0	259,371.0
Peak (kW)	29.9	29.9	29.9	29.8	29.7	29.6	29.6	29.6	29.6	29.7	29.8	29.9	29.9
Sys 3: AHU-3													
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=795,441 cfm / 318.2 kW] (Main Clg Fan)													
Electric (kWh)	236,723.3	213,814.9	236,723.2	229,087.6	236,723.5	229,087.0	236,723.8	236,723.2	229,087.6	236,723.7	229,087.2	236,723.7	2,787,228.3
Peak (kW)	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2	318.2
Parallel Fan Powered VAV [DsnAirflow/F.L.Rate=801,002 cfm / 320.4 kW] (Main Return Fan)													
Electric (kWh)	122,976.3	111,109.0	122,880.6	118,684.4	122,694.2	118,399.3	122,035.4	122,208.5	118,578.9	122,460.0	118,632.5	122,712.5	1,443,371.5
Peak (kW)	166.3	166.2	166.2	166.2	165.9	165.6	165.5	165.4	165.7	166.0	166.2	166.2	166.3