Energy and Design Evaluation Report

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George W. Hays PK-8

Cincinnati Public School

Cincinnati, OH

Prepared For

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Mechanical Option

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Executive Summary

This report is to analyze the George W. Hays PK-8 public school with respect to energy consumption and green design. Two major national standards that deal with these issues are the standards developed by The Leadership in Energy and Environmental Design (LEED), and American Society of Heating Air Conditioning and Refrigeration Engineers (ASHRAE) Standard 90.1. Along with comparison of the building with National Standards, a complete yearly energy analysis of the structure was created.

The building was checked for LEED certification potential in applications to the mechanical sections. LEED checks for the environmentally and socially friendliness of the building. The George W. Hays did not accumulate a sufficient number of points to obtain any LEED Certification.

The building did not comply with ASHRAE Standard 90.1 due to an excess lighting density. However, for mechanical sections where sufficient information was known about the system, the school passed Standard 90.1 requirements.

To complete the energy analysis of the building, a complete building simulation was created using Carrier's Hourly Analysis Program. This program returned estimations for a yearly energy consumption of the building.

LEED-NC 2.2 Assessment

The Leadership in Energy and Environmental Design, LEED, is a national coalition with the goal of promoting environmentally conscious, energy effective, and healthy occupant conditions in building design. To help recognize green building design, members of the LEED consol define green building design numerically by relating aspects of green office design with points. These points are used to rate the building as one of five categories. The lowest category doe not receive any certification. Buildings that have accumulated fewer than 26 points fall into this category, and are not considered a green building. A LEED certified building has between 26 and 32 points. Next, is the Silver Certification of 33 through 38 points. Gold follows with 39 to 51 points. Finally, 52 to 69 points earns the building a platinum status. Since the George W. Hays PK-8 is a school and not an office building, the majority of the space does not apply to LEEDS. However, because of some of the similarities between office spaces and education facilities, assuming that the building were to pass all non-mechanical requirements, Figure A-1 from Appendix A shows LEED points that the Hays School may qualify for.

The LEED point criteria are broken into six different categories, Sustainable Site, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process. Sections not applicable to the Mechanical aspect of design and without sufficient knowledge to grant LEED credits were omitted. Of the three categories shown in Figure A-1 in Appendix A, only 10 points were acquired and two required prerequisites failed. In order for this building to obtain a LEED Certification, 16 points would need to be obtained in the three remaining categories and all failing prerequisites would have to be modified.

Mechanical System Lost Rentable Space

The entire facility building is for the owner, Cincinnati Public Schools. Therefore none of the building is rented. Because of this, the lost rentable space is not a major factor for the owner. If the owner desired more space, it would not be difficult to expand the building without increasing the height. However, the mechanical system does occupy a significant portion of the building. The three Air Handling Units, AHUs, are each in a separate space. Of those three, one is in a mechanical mezzanine, not a mechanical room. AHU-1 serves three stories and AHUs 2 & 3 only serve two stories. This results in minimal lost space due to vertical mechanical shafts. The remaining mechanical room is isolated from the rest of the spaces in such a way that it is an addition to the space that was not likely to be useable space otherwise. The four mechanical rooms take up a total area of 4303 ft^2, or 6.8% of the total building square footage.

ASHRAE 90.1 Compliance

ASHRAE 90.1 is a national standard of guidelines for designing energy-efficient buildings. This report will analyze the George W. Hays School to determine if it meets the requirements to be considered an energy-efficient building by ASHRAE 90.1. Because of limited resources, not all aspects of 90.1 were analyzed. Instead this section focuses on the mechanical compliance. The main components that will be analyzed are, Building Envelope, Lighting & Power, and sections of HVAC.

ASHRAE 90.1 Compliance - Building Envelope

The building envelope was analyzed using two different wall types. Wall type one is composed of monarch bricks, insulation, and concrete masonry units (CMU). Wall type two contains corrugated metal panel (CMP), insulation, and CMU. Different wall type areas and orientations were found on drawing documents and engineering reports. The R-Values of these materials were determined from the architectural drawings. To determine the corresponding U-value, Equation 2-1 was used.

$$U = \frac{1}{\sum R} \quad (2\text{-}1)$$

These values were then compared with the values in ASHRAE Standard 90.1 Table 5.5-4. Because the structure is on a flat site entirely above grade, both of these walls were analyzed as "Mass Walls, Above Grade." The conclusions of this analysis are found in Figure B-1 of Appendix B.

The facility has a total glass area of 2,389 ft^2, while the building has a surface area of 31,988 ft^2. The vertical glazing percentage, 2,389/31,988, comes to be 6.9% of the vertical walls. This low percentage places the building in the 0-10% Vertical Glazing category of ASHRAE 90.1 Table 5.5-4. These surfaces were checked for a maximum U value dependant on the component being either fixed or operable, and they were checked for a maximum SHGC value dependant on a North or Other orientation. The conclusions of this analysis are found in Figure B-2 of Appendix B.

The building passed all requirements to meet the Building Envelope portion of ASHRAE Standard 90.1.

ASHRAE 90.1 Compliance – Lighting & Power

ASHRAE 90.1 Power requirements demand no greater then a 2% voltage drop for feeders, and no more then a 3% voltage drop for branch circuits. This value is found by determining the resistance of the wire per length of wire. From this value the overall resistance in the entire branch or circuit of wire is the resistance per length times the length. The voltage drop across this length is:

$$V=I/R \quad (2\text{-}2)$$

Where the current is in Amps and the resistance is in Ohms. Keeping these values within the 2% and 3% voltage drops reduces lost energy due to heat from excessive resistance.

According to engineering reports, all feeder wires were designed for less than a 2% voltage drop, and all branch circuits were designed for no more then 3% voltage drop to comply with Standard 90.1.

ASHRAE 90.1 Section 9.2.2.3, Interior Lighting Power, calls for Section 9.5 to determine the maximum wattage per square foot. The only interior lighting fixtures in this building exempt from the analysis were exit signs; all other lights were accounted for.

The allowed wattage for the building was found using Table 9.5.1 from Standard 90.1. This table is shown in Figure B-4, of Appendix B. This Watt/sq ft value was then multiplied by the total building square footage,

$$1.2\ \text{Watt/ft}^2 \times 63259\ \text{ft}^2 = 75{,}911\ \text{Watt}$$

This value was then compared against the actual wattage of the building.

Light fixture quantities were found from the Architectural drawings. The lighting schedules were then used to determine the wattage per light fixture. This wattage was summed through the entire building, which showed a total interior lighting power of 85,921 Watts. The total building square footage was calculated to be 63,259 ft^2. Though this building fails ASHRAE 90.1 Section 5, the space-by-space method in Section 6, is also acceptable for compliance.

The Section 6 space-by-space method analysis was based off of values from ASHRAE 90.1, Table 9.6.1. The allowable Watts/ft^2 for each space was then multiplied by the area of each space. The sum of all spaces, shown in Figure, B-3 of Appendix B, resulted in a total allowable power of 74,787 Watts. This value is lower then the allowable wattage in Section 5. As a result the building does not pass the allowable Lighting Power portion of ASHRAE Standard 90.1.

In addition to interior lighting density, the standard also calls for a minimum exterior lighting density. This is based on Watt/sq ft of parking area, walkway area, and building façade area. Standard 90.1 allows for the total allowed wattages by summing up the determined allowed wattage for each component. This allows the building the opportunity to exceed wattages in one area, for example the parking lot, if the walkway wattage is under the requirement by at least the same amount.

The allowance for parking lots is 0.15 Watt/ft^2, for walkways it is 0.2 Watt/ft^2, and for the build façade it is 0.2 Watt/ft^2 all found in Table 9.4.5 of Standard 90.1. However, there is insufficient data as to whether this building passes this compliance or not.

ASHRAE 90.1 Compliance – HVAC Systems

For HVAC compliance the various components of the system were analyzed independently. These components include: ductwork insulation, pipe insulation, boiler efficiency, condensing unit efficiency, and chiller efficiency.

According to 90.1 Table 6.8.2A, no interior insulation on ductwork in Climate Zone 4 is required. The George W. Hays School has no exterior duct and therefore passes this section of ASHRAE standard 90.1.

Any pipes carrying water in the temperature range laid out in 90.1 Table 6.8.2A are required to have an appropriate amount of insulation. Engineering reports showed that all piping equipment was designed beyond these minimum standards.

The two natural gas boilers are required to meet the minimum parameters of a boiler efficiency of 80%. The building has two identical 1500 MBH Boilers. Mechanical Schedules show that both of these boilers pass the ASHRAE 90.1 requirement with an efficiency of 85%.

The buildings 170 nominal ton chiller is required by Standard 90.1 to have a minimum performance of a 2.80 Coefficient of Performance (COP), and a minimum Integrated Part Load Value (IPLV) of 3.05.

The maximum power of the chiller is 195.7 kW, or 55.7 tons. The actual capacity of the chiller at 100% capacity is 164 tons. The COP is equal to the useful energy absorbed divided by the total energy in, or

$$COP = Capacity / Powerin \quad (2\text{-}2)$$

Using Equation 2-2,

$$COP = 170 / 3.05 = 3.37 > 3.05$$

This value passes the minimum requirement of COP for Standard 90.1. However, as chillers reduce capacity to conditions other the full-load, performance per kilowatt is lost. To analyze the chillers energy use at part-load conditions the IPLV is found. This is done by creating variables equal to the COP of a chiller at various load percentages. The COP at 100%, 75%, 50%, and 25% are equal to A, B, C, and D, respectively. The IPLV is then defined by the equation,

$$IPLV = 0.01A + 0.42B + 0.45C + 0.12D \quad (2\text{-}3)$$

This equation estimates the amount of time that a chiller will be used at each load capacity to determine an estimated real running COP, not the design COP. This accounts for the energy that the chiller uses for the bulk of its performance which has been proven to generally be at low load capacities. For example, the variable corresponding to 100% capacity is multiplied by 1%, implying that 100% capacity is only achieved for 1% of the running time.

The variables for the IPLV equation corresponding to the George W. Hays building are outlined in Figure B-5 of Appendix B. All tons and kilowatts were found from design equipment cut sheets. The determined IPLV, 5.01, meets the 3.05 requirement of Standard 90.1

Mechanical System First Cost

HVAC and Plumbing first costs were found on bid documents. These two areas included the span of the mechanical system first cost, not including fire protection. The HVAC system was bid at $1,288,000 and the Plumbing system was bid at $628,049. The corresponding building area is 66,338 ft^2. These values show that the total mechanical system cost was $1,916,049, or $28.88/$ft^2$.

Design Load Estimation

Carrier's Hourly Analysis Program (HAP) was used to model George W. Hays facility to find a design load estimation. This estimation is based off of data taken from design documents and heating and cooling outdoor air conditions from the ASHRAE Handbook of Fundamentals, 2005. The summer design conditions are based off of the temperature that weather data has shown to exceed 0.4% of the time. Conditions beyond these values are not part of the summer design conditions because the building has a thermal mass that will be able to absorb energy as long as the OA conditions do not exceed the 0.4% range for an extended period of days. A dry bulb temperature of 93 degrees Fahrenheit and a wet bulb temperature of 74 degrees Fahrenheit are the conditions that meet the 0.4% condition. For cooling design the 99.6% condition of 4 degrees Fahrenheit was used, meaning that 99.6% of the days in Cincinnati, Ohio are shown to exceed 4 degrees. Assumptions regarding the loads of the building are shown in Figure C-1 of Appendix C. The exact values for lighting were used in all spaces by looking at the electrical schedules and drawings for each space. These values are also shown in Figure B-3. The space occupancies and square footages were determined from building drawing documents. All assumptions concerning schedules, air and equipment properties and performance characteristics are in Appendices D, E, & F.

The design simulation resulted in a total cooling load close to what the drawings suggested. AHU-1 was designed to be 78 tons according to the Mechanical Schedules. The HAP analysis found a value of 71.9 tons. For AHU-2, the Mechanical Schedule showed 64.6 tons, where the HAP program showed 66.5 tons. Finally, the design for AHU-3 was 45.6 tons and the program determined 31.3 tons. The scheduled chiller has a nominal capacity of 170 tons (165 actual tons according to design documents) and the HAP analysis called for a 169.7 ton chiller. There is a clear flaw in that the sum of the HAP analysis loads is less then the scheduled loads, where the HAP chiller is sized to be larger then what the schedule calls for. The reason for this discrepancy is being looked into, but has not yet been determined. Despite this problem these values fall within the error possible for different design assumptions such as Watt/sq ft for miscellaneous loads. Another discrepancy may be with the program used to do the analysis. According to the engineer, the design loads were determined using Trane TRACE. Discrepancies between the modeled systems and the way the two different programs interoperate the systems may be a reason for error. Prior to the start of this

report the Trane TRACE file was destroyed due to improper archiving. Therefore, these files cannot be compared to determine what assumptions may have been made differently.

When the design simulation was run for heating loads a greater division arose between the HAP analysis and scheduled equipment. The Air Handling Unit schedule calls out for loads of 741 MBH, 603 MBH, and 1167 MBH for AHU-1, AHU-2, and AHU-3, respectively. However, engineering design documents showed that loads of 501.3 MBH, 410.1 MBH, and 387.3 MBH for AHU-1, AHU-2, and AHU-3, respectively. The same design documents found a total boiler load of 3286 MBH. The HAP analysis found values less then both of these. AHU-1 was just 253.1 MBH, AHU-2 was 193.3 MBH, and AHU-3 was 229.2 MBH, including other small unit heaters, the total boiler load was 696.9 MBH. Part of the reason for these discrepancies is because the boilers are designed for the HVAC equipment as well as the hot water supply to the building. Other reasons may include safety factors and allowances for future expansion. The HAP analysis will continue to be reviewed with design documents to find any differences in the model versus the drawings.

Annual Energy Consumption & Costs

The HAP program predicted the annual energy consumption of electricity and natural gas. The total power per year in the building is expected to be 1,023,685 kW. The building is also expected to consume 2,449 Therms of Natural Gas, which is approximately equal to 244,900 ft^3 of natural gas per year. The energy consumption break up by system component is shown on Figure C-2.

This relationship is further explored in the yearly cost analysis of the building. Figure C-3a and C-3b shows a majority of the utility costs being spent on the HVAC equipment. In addition, this figure emphasizes the large cooling load and small heating load. This is perhaps due to a small envelope load in comparison to the interior loads. The envelope has been shown to be strong in the 90.1 portion of this report, by having both walls with a good resistance to heat, and a small window area to wall area proportion.

The proportional costs of C-3a are shown in a more specific dollar value in Figure C-3b. The dollar value was determined using an estimated energy rate. Because the building does not exist and cannot yet have any utility bills, the utility rates were estimated. According to the Energy Information Administration (EIA), the average cost of natural gas for commercial customers is $1.62 dollars/ Therm. For electricity, the Average Commercial Rate is $.0837 in the state of Ohio.

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Appendix A- Leeds

Figure A-1

Credit Number	Category	Credits Received	Possible Credits
	Sustainable Sites		
Credit 1	Site Selection	1	1
Credit 2	Development Density & Community Connectivity	1	1
Credit 3	Brownfield Redevelopment	0	1
Credit 4.1	Public Transportation Access	0	1
Credit 4.2	Bicycle Storage & Changing Rooms	0	1
Credit 4.3	Low Emitting & Fuel Efficient Vehicles	0	1
Credit 4.4	Parking Capacity	0	1
Credit 5.1	Protect or Restore Habitat	0	1
Credit 5.2	Maximize Open Space	1	1
Credit 6.1	Stormwater Quantity Control	0	1
Credit 6.2	Stormwater Quality Control	0	1
Credit 7.2	Non-Roof Heat Island Effect	0	1
Credit 7.3	Roof Heat Island Effect	1	1
Credit 8	Light Pollution Reducion	0	1
	Energy & Atmosphere		
Prereq 1	Fundamental Commissioning of the Building Energy Systems		Required
Prereq 2	Minimum Energy Performance	Fail	Required
Prereq 3	Fundamental Refrigerant Management	Pass	Required
Credit 1	Optimize Energy Performance	0	1-10
Credit 2	On-Site Renewable Energy	0	1-3
Credit 3	Enhanceed Commissioning	1	1
Credit 4	Enhanced Refrigerant Management	0	1
Credit 5	Measurement & Verification	0	1
Credit 6	Green Power	0	1
	Indoor Environmental Quality		
Prereq 1	Minimum IAQ Performance	Fail	Required
Prereq 2	Environmental Tobacco Smoke Control	Pass	Required
Credit 1	Outdoor Air Delivery Monitoring	0	1
Credit 2	Increased Ventilation	0	1
Credit 3.1	Construction IAQ Management Plan Cons.	0	1
Credit 3.2	Construction IAQ Management Plan Occu.	0	1
Credit 4.1	Low Emitting Adhesives & Sealants	0	1
Credit 4.2	Low Emitting Paints & Coatings	0	1
Credit 4.3	Low Emitting Carpet Systems	0	1
Credit 4.4	Low Emitting Composite Wood & Agrifiber Products	0	1
Credit 5	Indoor Chemical & Pollutant Source Control	1	1
Credit 6.1	Controllability of Lighting Systems	1	1
Credit 6.2	Controllability of Thermal Comfort Systems	1	1
Credit 7.1	Thermal Comfort Design	1	1
Credit 7.2	Thermal Comfort Verification	0	1
Credit 8.1	Daylight 75% of Spaces	1	1
Credit 8.2	Views for 90% of Spaces	0	1

Appendix B- Standard 90.1

Figure B-1

NAME/ DESCRIPTION	COMPONENT	COMPONENT R-VALUE	GROSS AREA	U-FACTOR	ASHRAE 90.1 TABLE 5.5-4 MAXIMUM U VALUES	COMPLIANCE
NORTH						
Exterior Wall 1	Outside Air Film	0.17	5824	0.066	0.151	YES
	4" Masonry	0.44				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break		280	0.570	0.57	YES
Door 1	Clear Glass		42	0.570	0.67	YES
Exterior Wall 2	Outside Air Film	0.17	1332	0.068	0.151	YES
	Corrugated Metal Panel	0.05				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Door 2	Insulated Metal, Non-Swinging		42	1.450	1.45	YES
NAME/ DESCRIPTION	COMPONENT	COMPONENT R-VALUE	GROSS AREA	U-FACTOR	ASHRAE 90.1 TABLE 5.5-4 MAXIMUM U VALUES	COMPLIANCE
EAST						
Exterior Wall 1	Outside Air Film	0.17	7191	0.066	0.151	YES
	4" Masonry	0.44				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break		501	0.570	0.57	YES
Door 1	Clear Glass		84	0.570	0.67	YES
Exterior Wall 2	Outside Air Film	0.17	1332	0.068	0.151	YES
	Corrugated Metal Panel	0.05				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Door 2	Non-Swinging, Insulated Metal		96	1.450	1.45	YES
SOUTH						
Exterior Wall 1	Outside Air Film	0.17	4834	0.066	0.151	YES
	4" Masonry	0.44				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break		272	0.570	0.57	YES
Door 1	Clear Glass		42	0.570	0.67	YES
Exterior Wall 2	Outside Air Film	0.17	1332	0.068	0.151	YES
	Corrugated Metal Panel	0.05				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				

Figure B-1 (Cont'd)

NAME/ DESCRIPTION	COMPONENT	COMPONENT R-VALUE	GROSS AREA	U-FACTOR	ASHRAE 90.1 TABLE 5.5-4 MAXIMUM U VALUES	COMPLIANCE
WEST						
Exterior Wall 1	Outside Air Film	0.17	8497	**0.066**	**0.151**	**YES**
	4" Masonry	0.44				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break		736	**0.570**	**0.57**	**YES**
Exterior Wall 2	Outside Air Film	0.17	1332	**0.068**	**0.151**	**YES**
	Corrugated Metal Panel	0.05				
	1-1/2" Air Space	0.68				
	2" Polystyrene Insulation	12.00				
	8" CMU	1.11				
	Inside Air Film	0.68				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break		432	**0.570**	**0.57**	**YES**
Door 2	Non-Swinging, Insulated Metal		176	**1.450**	**1.45**	**YES**

NON-VERTICAL						
Roof 1	Outside Air Film	0.17	35928	**0.063**	**0.063**	**YES**
	Membrane Roofing	-				
	3" Isocyanrate Insulation	15.00				
	1-1/2" Metal Deck	-				
	Inside Air Film	0.68				
Roof 2	Outside Air Film	0.17	1043	**0.061**	**0.063**	**YES**
	Membrane Roofing	-				
	3" Isocyanrate Insulation	15.00				
	Vapor Retarder	-				
	1/2" Fire Rated Gypsum Wallboard	0.45				
	1-1/2" Metal Deck	-				
	Inside Air Film	0.68				

Figure B-2

	COMPONENT	COMPONENT SHGC	ASHRAE 90.1 TABLE 5.5-4 MAXIMUM SHGC VALUES	COMPLIANCE
NORTH				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break	0.37	0.49	YES
Door 1	Clear Glass	0.37	0.49	YES
EAST				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break	0.37	0.39	YES
Door 1	Clear Glass	0.37	0.39	YES
SOUTH				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break	0.37	0.39	YES
Door 1	Clear Glass	0.37	0.39	YES
WEST				
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break	0.37	0.39	YES
Window 1	Double Pane, Low-E Clear, Fixed Metal Frame with Thermal Break	0.37	0.39	YES

Envelope Compliance Check

Figure B-3

Room Type	Room #	# Fixtures	Type	Watts	Total Watts	Area	90.1 W/ft2 for space type	Allowed Watts
Entry	101	7	F3	94	658	387.1	1.3	503.23
Vestibule	102	1	F1	47	47	included in 101		0
Corridor	103	10	A2N	64	640	887.8	0.5	443.9
Corridor	103	2	F1	47	94	887.8		0
Corridor	103	2	F2	36	72	887.8		0
Corridor	103	2	T3	50	100	887.8		0
Gymnasium	105	30	H1	336	10080	5935.8	1.4	8310.12
RR	108	5	F2	36	180	372.3	0.9	335.07
RR	109	5	F2	36	180	372.3	0.9	335.07
Stairwell	110	4	W2	86	344	362.7	0.6	217.62
Teachers Prep	111	5	A7	96	480	289.2	1.3	375.96
Storage	112	2	A2	64	128	81.6	0.8	65.28
Classroom	113	13	A7	96	1248	1226.4	1.4	1716.96
Classroom	113	2	A7N	96	192	1226.4		0
Classroom	114	12	A3	96	1152	900	1.4	1260
Classroom	115	13	A3	96	1248	901.4	1.4	1261.96
Classroom	116	13	A3	96	1248	901.4	1.4	1261.96
Classroom	117	12	A3	96	1152	900	1.4	1260
Corridor	118	1	A2N	64	64	104.7	0.5	52.35
Stairwell	119	2	W2	86	172	192.3	0.6	115.38
Classroom	120	13	A7	96	1248	1226.4	1.4	176.96
Classroom	120	2	A7N	96	192	1226.4		0
Classroom	121	10	A3	96	960	1082.4	1.4	1515.36
Classroom	121	2	A3N	96	192	1082.4		0
Classroom	122	15	A3	96	1440	1078.5	1.4	1509.9
Classroom	122	2	A3N	96	192	1078.5		0
Classroom	123	1	A1	96	96	1078.5	1.4	1509.9
Classroom	123	14	A3	96	1344	1078.5		0
Classroom	123	2	A3N	96	192	1078.5		0
Classroom	124	10	A3	96	960	1082.1	1.4	1514.94
Classroom	124	2	A3N	96	192	1082.1		0
Classroom	125	13	A3	96	1248	1082.6	1.4	1515.64
Classroom	125	2	A3N	96	192	1082.6		0
Community	126	6	A7	96	576	403	1.4	564.2
Student Dining	127	1	A3N	96	96	3001.1	0.9	2700.99
Student Dining	127	6	F5	150	900	3001.1		0
Student Dining	127	3	L1	1374	4122	3001.1		0
Student Dining	127	9	N1	96	864	3001.1		0
Student Dining	127	2	N1N	96	192	3001.1		0
Student Dining	127	9	T1	150	1350	3001.1		0
Student Dining	127	6	T2	150	900	3001.1		0
Platform	128	7	A5	128	896	896.5	0.9	806.85
Serving Area	129	6	A3	96	576	1780	0.9	1602
Corridor	130	1	A2	64	64	104	0.5	52
Corridor	130	1	A2N	64	64	104		0
Office	131	1	A3	96	96	96	1.1	105.6
Central Storage	132	2	A3	96	192	125.1	0.8	100.08
Workroom	133	5	A3	96	480	295.5	1.2	354.6
Workroom	133	1	A3N	96	96	295.5		0
Storage	134	4	A2	64	256	197.6	0.8	158.08
Storage	135	2	J1	96	192	171.6	0.8	137.28

Figure B-3 (Cont'd)

Room Type	Room #	# Fixtures	Type	Watts	Total Watts	Area	90.1 W/ft2 for space type	Allowed Watts
Corridor	201	5	F3	94	470	297.1	0.5	148.55
Corridor	202	14	A2N	64	896	1389.4	0.5	694.7
Corridor	202	1	F2	36	36	1389.4		0
Corridor	202	5	F6	47	235	1389.4		0
Corridor	203	8	A2N	64	512	387.7	0.5	193.85
Computer Lab	204	1	A6	96	96	1000.5	1.4	1400.7
Computer Lab	204	13	A7	96	1248	1000.5		0
Computer Lab	204	1	A7N	96	96	1000.5		0
Reading Room	205	12	M1	94	1128	1204	1.2	1444.8
Reading Room	205	4	M2	94	376	1204		0
Stairwell	208	4	W2	86	344	362.7	0.6	217.62
Conference	209	2	A7	96	192	151.9	1.3	197.47
Storage	210	2	A2	64	128	81.6	0.8	65.28
Classroom	211	13	A7	96	1248	1226.4	1.4	1716.96
Classroom	211	2	A7N	96	192	1226.4		0
Classroom	212	12	A3	96	1152	900	1.4	1260
Classroom	213	13	A3	96	1248	901.4	1.4	1261.96
Classroom	214	13	A3	96	1248	901.4	1.4	1261.96
Classroom	215	12	A3	96	1152	900	1.4	1260
Corridor	216	1	A2N	64	64	104.7	0.5	52.35
Stairwell	217	2	W2	86	172	198	0.6	118.8
Classroom	218	13	A7	96	1248	1226.4	1.4	1716.96
Classroom	218	2	A7N	96	192	1226.4		0
Classroom	219	9	A3	96	864	905	1.4	1267
Classroom	220	12	A3	96	1152	901.4	1.4	1261.96
Classroom	220	1	A3N	96	96	901.4		0
Classroom	221	13	A3	96	1248	901.4	1.4	1261.96
Classroom	221	1	A3N	96	96	901.4		0
Classroom	222	12	A3	96	1152	900	1.4	1260
Science Room	223	11	A3	96	1056	898.6	1.4	1258.04
Science Room	223	1	A3N	96	96	898.6		0
Art Room	224	10	A3	96	960	902.6	1.4	1263.64
Art Room	224	1	A3N	96	96	902.6		0
Music Room	225	20	A3	96	1920	1353	1.4	1894.2
Music Room	225	2	A3N	96	192	1353		0
Mechanical	226	9	C1	64	576	1317.1	1.2	1580.52
Stairwell	227	2	C1	64	128	768.4	0.6	461.04
Mechanical	228	17	C1	64	1088	1484.2	1.2	1781.04
Corridor	104,104N	5	A7	96	480	189.9	0.5	94.95
Corridor	104,104N	2	A7N	96	192	189.9		0
Reception	104A	1	A7	96	96	298.9	1.3	388.57
Reception	104A	1	A7N	96	96	298.9		0
Secretarial	104B	4	A7	96	384	298.4	1.1	328.24
Health Clinic	104C	5	A3	96	480	391.1	1	391.1
Health Clinic	104C	1	A3N	96	96	391.1		0
Laundry	104D	1	A2	64	64	46.1	0.6	27.66
Office	104E	4	A7	96	384	148.3	1.1	163.13
Conference	104F	4	A6	96	384	248.3	1.3	322.79
Office	104G	2	A7	96	192	98.6	1.1	108.46
Mail/Copy	104H	4	A7	96	384	249.6	1.2	299.52
Storage	104K	2	A7	96	192	148.5	0.8	118.8
Storage	104M	1	J1	96	96	64.8	0.8	51.84
RR	104P	1	B2	65	65	44.3	0.9	39.87

Figure B-3 (Cont'd)

Room Type	Room #	# Fixtures	Type	Watts	Total Watts	Area	90.1 W/ft2 for space type	Allowed Watts
RR	104Q	1	B2	65	65	44.3	0.9	39.87
Classroom	104R	4	A1	96	384	249.4	1.4	349.16
Conference	104S	3	A7	96	288	205.8	1.3	267.54
RR	104T	1	B2	65	65	43.6	0.9	39.24
Storage	105A	4	J1	96	384	277.8	0.8	222.24
Locker Room	105B	4	J1	96	384	266.8	0.6	160.08
Locker Room	105B	1	J1N	96	96	266.8		0
RR	105C	2	J1	96	192	130.9	0.9	117.81
RR	105D	1	J1	96	96	130.9	0.9	117.81
RR	105D	1	J1N	96	96	130.9		0
Locker Room	105E	4	J1	96	384	266.8	0.6	160.08
Locker Room	105E	1	J1N	96	96	266.8		0
Office	105F	1	J1	96	96	75.6	1.1	83.16
Shower	105G	1	J1	96	96	64.4	0.6	38.64
Corridor	107	5	A2N	64	320	464.4	0.5	232.2
Elevator Equipment	111A	1	C1	64	64	52.4	1.2	62.88
RR	113A	1	B2	65	65	48.4	0.9	43.56
RR	113B	1	B2	65	65	48.4	0.9	43.56
RR	113C	1	B2	65	65	48.4	0.9	43.56
Janitor	118A	1	C1	64	64	27	0.8	21.6
RR	120A	1	B2	65	65	48.4	0.9	43.56
RR	120B	1	B2	65	65	48.4	0.9	43.56
RR	120C	1	B2	65	65	48.4	0.9	43.56
RR	121A	1	B3	65	65	51.7	0.9	46.53
RR	122A	1	B3	65	65	49.5	0.9	44.55
RR	123A	1	B3	65	65	49.5	0.9	44.55
RR	124A	1	B3	65	65	51.8	0.9	46.62
RR	125A	1	B3	65	65	51.8	0.9	46.62
Storage	127A	2	A2	64	128	233	0.8	186.4
Ware Washing	129A	2	A3	96	192	included in 129		
Locker Room	129B	2	A2	64	128	included in 129		
RR	129C	1	B2	65	65	included in 129		
Dietician Office	129D	1	A3	96	96	included in 129		
Dry Food Storage	129F	3	A2	64	192	included in 129		
Prep Area	129G	3	A3	96	288	included in 129		
Prep Area	129G	3	A3N	96	288	included in 129		0
Loading	130A	1	A2N	64	64	120	1.2	144
Mechanical	137A	3	A3N	96	288	288	1.2	345.6
Conference	205A	4	A6	96	384	200.4	1.3	260.52
Office	205B	2	A7	96	192	120.1	1.1	132.11
Storage	205C	2	A7	96	192	148.6	0.8	118.88
Tech Center	205D	5	A3	96	480	379.1	1.1	417.01
Tech Center	205D	1	A3N	96	96	379.1		0
Storage	205F	1	A2	64	64	98.4	0.8	78.72
RR	211A	1	B2	65	65	48.4	0.9	43.56
RR	211B	1	B2	65	65	48.4	0.9	43.56
RR	211C	1	B2	65	65	48.4	0.9	43.56

Figure B-3 (Cont'd)

Room Type	Room #	# Fixtures	Type	Watts	Total Watts	Area	90.1 W/ft2 for space type	Allowed Watts
Janitor	216A	1	C1	64	64	27	0.8	21.6
RR	218A	1	B2	65	65	48.4	0.9	43.56
RR	218B	1	B2	65	65	48.4	0.9	43.56
RR	218C	1	B2	65	65	48.4	0.9	43.56
Storage	224A	2	A2	64	128	122	0.8	97.6
Storage	224B	2	A2	64	128	103.3	0.8	82.64
Storage	225A	2	A3	96	192	196.9	0.8	157.52
Stairwell	301	4	W2	86	344	362.7	0.6	217.62
Corridor	302	7	A2N	64	448	579.4	0.5	289.7
Teacher Prep	303	6	A7	96	576	315.7	1.3	410.41
Conference	304	3	A7	96	288	155.4	1.3	202.02
Storage	305	2	A2	64	128	93.1	0.8	74.48
Classroom	306	13	A7	96	1248	1226.7	1.4	1717.38
Classroom	306	2	A7N	96	192	1226.7		0
Classroom	307	12	A3	96	1152	900	1.4	1260
Classroom	307	12	A3	96	1152	900		0
Classroom	308	13	A3	96	1248	901.4	1.4	1261.96
Classroom	309	13	A3	96	1248	901.4	1.4	1261.96
Classroom	310	12	A3	96	1152	900	1.4	1260
Stairwell	311	2	W2	86	172	198	0.6	118.8
Corridor	312	1	A2N	64	64	104.7	0.5	52.35
Janitor	312A	1	C1	64	64	27	0.8	21.6
Mechanical Mezzanine	313	11	C1	64	704	1213.5	1.2	1456.2
							TOTAL ALLOWED WATTS	**74786.51**

Interior Lighing Compliance Check

Figure B-4

TABLE 9.5.1 Lighting Power Densities Using the Building Area Method

Building Area Type[a]	Lighting Power Density (W/ft2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Religious Building	1.3
Retail	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

[a] In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

From ASHRAE Standard 90.1

Figure B-5

Variable	Load %	Tons	kW	COP	Multiplier
A	100%	164	195.7	2.941441	0.01
B	75%	123	103.1	4.187488	0.42
C	50%	82	50.7	5.676923	0.45
D	25%	41	25.8	5.577907	0.12
				IPLV	5.01

IPLV Calculation

Appendix C- Building Simulation

Figure C-1

Space Type	Lighting	Misc Load	People [Btu/hr*person]	
			Latent	Sensible
Kitchen Area	Exact Wattage	300000 Btu/hr	295	455
Office	Exact Wattage	1 Watt/sq ft	245	205
Computer	Exact Wattage	3 Watt/sq ft	245	205
Conference	Exact Wattage	0.5 Watt/sq ft	245	205
Classroom	Exact Wattage	0.0 Watt/sq ft	245	205
Gymnasium	Exact Wattage	0.0 Watt/sq ft	295	455
Other	Exact Wattage	0.0 Watt/sq ft	-	-

Load Assumptions

Figure C-2

Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	3,440,675	51.720
Heating Coil Loads	189,519	2.849
Grand Total	**3,630,194**	**54.568**

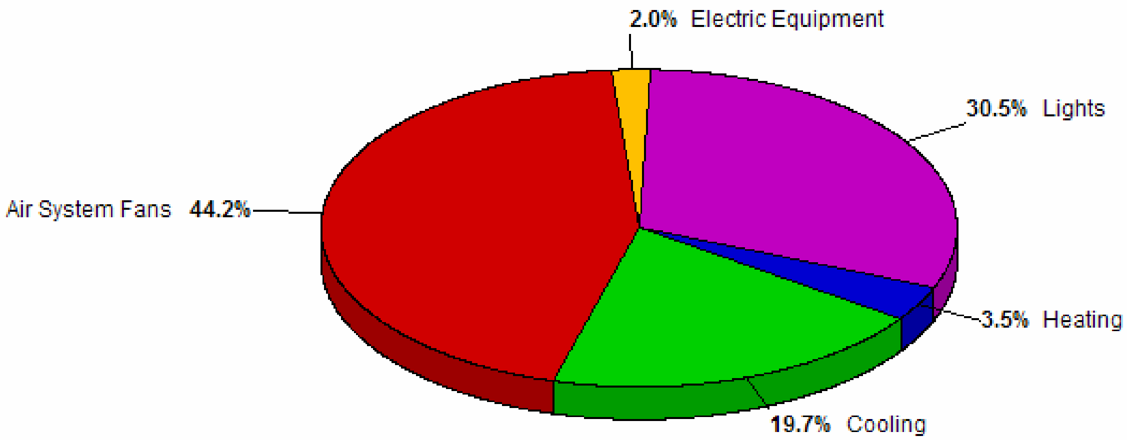
Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	1,601,236	24.070	5,718,702	85.962
Cooling	713,788	10.730	2,549,241	38.320
Heating	244,923	3.682	244,923	3.682
Pumps	0	0.000	0	0.000
Cooling Towers	0	0.000	0	0.000
HVAC Sub-Total	**2,559,947**	**38.481**	**8,512,866**	**127.964**
Lights	1,104,782	16.607	3,945,649	59.310
Electric Equipment	72,981	1.097	260,647	3.918
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**1,177,763**	**17.704**	**4,206,295**	**63.228**
Grand Total	**3,737,710**	**56.185**	**12,719,161**	**191.192**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area .... **66525.6** ft²
   Conditioned Floor Area .... **66525.6** ft²

Loads by Components

Figure C-3a



Annual Component Cost Percentage

Figure C-3b

Annual Energy Consumption

Component	George W. Hays PK-8
HVAC Components	
Electric (kWh)	678,504
Natural Gas (Therm)	2,449
Non-HVAC Components	
Electric (kWh)	345,182
Natural Gas (Therm)	0
Totals	
Electric (kWh)	1,023,685
Natural Gas (Therm)	2,449

Annual Costs

Component	George W. Hays PK-8 ($)
HVAC Components	
Electric	56,791
Natural Gas	3,103
HVAC Sub-Total	59,894
Non-HVAC Components	
Electric	28,892
Non-HVAC Sub-Total	28,892
Grand Total	88,786

Annual Energy Consumption and Annual Costs

Appendix D- Simulation Schedules

Cafiteria (Fractional)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	10	10	10	10	100	100	100	100	10	10	0	0	0	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	1	1	1	1	1	1	1
Tuesday	1	1	1	1	1	1	1	1	1	1	1	1
Wednesday	1	1	1	1	1	1	1	1	1	1	1	1
Thursday	1	1	1	1	1	1	1	1	1	1	1	1
Friday	1	1	1	1	1	1	1	1	1	1	1	1
Saturday	2	2	2	2	2	2	2	2	2	2	2	2
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

Cafe Lighting (Fractional)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	1	1	1	1	1	1	1
Tuesday	1	1	1	1	1	1	1	1	1	1	1	1
Wednesday	1	1	1	1	1	1	1	1	1	1	1	1
Thursday	1	1	1	1	1	1	1	1	1	1	1	1
Friday	1	1	1	1	1	1	1	1	1	1	1	1
Saturday	2	2	2	2	2	2	2	2	2	2	2	2
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

Classroom (Fractional)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	20	100	100	100	100	100	100	100	100	100	20	0	0	0	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3:Profile Three

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	3	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	3	3	3	1	1	1	1
Tuesday	1	1	1	1	1	3	3	3	1	1	1	1
Wednesday	1	1	1	1	1	3	3	3	1	1	1	1
Thursday	1	1	1	1	1	3	3	3	1	1	1	1
Friday	1	1	1	1	1	3	3	3	1	1	1	1
Saturday	2	2	2	2	2	2	2	2	2	2	2	2
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

Food Prep (Fractional)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	20	80	100	100	100	100	50	0	0	0	0	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

3:Profile Three

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

4:Profile Four

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	2	2	2	2	2	2	2	2	2	2	2	2
Tuesday	2	2	2	2	2	2	2	2	2	2	2	2
Wednesday	2	2	2	2	2	2	2	2	2	2	2	2
Thursday	2	2	2	2	2	2	2	2	2	2	2	2
Friday	2	2	2	2	2	2	2	2	2	2	2	2
Saturday	3	3	3	3	3	3	3	3	3	3	3	3
Sunday	4	4	4	4	4	4	4	4	4	4	4	4
Holiday	4	4	4	4	4	4	4	4	4	4	4	4

Gym (Fractional)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	10	30	61	100	100	30	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	10	10	10	0	0	0	0

3:Profile Three

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	2	2	2	2	2	2	2	2	2	2	2	2
Tuesday	2	2	2	2	2	2	2	2	2	2	2	2
Wednesday	2	2	2	2	2	2	2	2	2	2	2	2
Thursday	2	2	2	2	2	2	2	2	2	2	2	2
Friday	1	1	1	1	1	1	1	1	1	1	1	1
Saturday	3	3	3	3	3	3	3	3	3	3	3	3
Sunday	3	3	3	3	3	3	3	3	3	3	3	3
Holiday	3	3	3	3	3	3	3	3	3	3	3	3

Gym Lighting (Fractional)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3:Profile Three

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

4:Profile Four

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	2	2	2	2	2	2	2	2	2	2	2	2
Tuesday	2	2	2	2	2	2	2	2	2	2	2	2
Wednesday	2	2	2	2	2	2	2	2	2	2	2	2
Thursday	2	2	2	2	2	2	2	2	2	2	2	2
Friday	2	2	2	2	2	2	2	2	2	2	2	2
Saturday	3	3	3	3	3	3	3	3	3	3	3	3
Sunday	4	4	4	4	4	4	4	4	4	4	4	4
Holiday	4	4	4	4	4	4	4	4	4	4	4	4

Lighting (Fractional)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	1	1	1	1	1	1	1
Tuesday	1	1	1	1	1	1	1	1	1	1	1	1
Wednesday	1	1	1	1	1	1	1	1	1	1	1	1
Thursday	1	1	1	1	1	1	1	1	1	1	1	1
Friday	1	1	1	1	1	1	1	1	1	1	1	1
Saturday	2	2	2	2	2	2	2	2	2	2	2	2
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

Office (Fractional)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	30	100	100	100	100	100	100	100	100	100	90	71	21	0	0	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3:Profile Three

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	5	20	30	30	30	30	30	30	30	30	30	20	5	0	0	0	0

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	3	3	3	1	1	1	1
Tuesday	1	1	1	1	1	3	3	3	1	1	1	1
Wednesday	1	1	1	1	1	3	3	3	1	1	1	1
Thursday	1	1	1	1	1	3	3	3	1	1	1	1
Friday	1	1	1	1	1	3	3	3	1	1	1	1
Saturday	2	2	2	2	2	2	2	2	2	2	2	2
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

T-STAT (Fan / Thermostat)

Hourly Profiles:
1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	U	U	U	U	U	U	O	O	O	O	O	O	O	O	O	O	O	O	O	O	U	U	U	U

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U

O = Occupied; U = Unoccupied

Assignments:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Design	1	1	1	1	1	1	1	1	1	1	1	1
Monday	1	1	1	1	1	1	1	1	1	1	1	1
Tuesday	1	1	1	1	1	1	1	1	1	1	1	1
Wednesday	1	1	1	1	1	1	1	1	1	1	1	1
Thursday	1	1	1	1	1	1	1	1	1	1	1	1
Friday	1	1	1	1	1	1	1	1	1	1	1	1
Saturday	1	1	1	1	1	1	1	1	1	1	1	1
Sunday	2	2	2	2	2	2	2	2	2	2	2	2
Holiday	2	2	2	2	2	2	2	2	2	2	2	2

Appendix E- Plant Inputs

Boiler Inputs

Note: The drawings called for two boilers in parallel for the same system. It was assumed that the boiler efficiency does not vary significantly under part load conditions and only one boiler was put into HAP because of HAP modeling restrictions.

1. General Details:

Plant Name **Boiler1**
Plant Type .... **Hot Water Boiler Plant**

2. Air Systems served by Plant:

Air System Name	Mult.
AHU1	1
AHU2	1
AHU3	1
CUH-1	1
CUH-2	1
CUH-4	1
UH-1	1
UH-2	1
UH-3	1

3: Configuration

Boiler Name .... **Boiler 1**
Est. Max Load .... **696.9** MBH
Full Load Capacity .... **2550.0** MBH
Hot Water Flow Rate .... **260.0** gpm

5: Distribution

Distribution System

Type .... **Primary Only, Constant Speed**
Coil Delta-T at Design .... **28.3** °F
Pipe Heat Loss Factor .... **0.0** %

Fluid Properties

Name .... **Ethylene Glycol - 25% Solution**
Density .... **62.4** lb/ft^3
Specific Heat .... **0.95** BTU / (lb - °F)

Primary Loop

Pump for	Flow (gpm)	Head (ft wg)	Mechanical Efficiency (%)	Electrical Efficiency (%)
B-1	260.0	0.0	80.0	94.0

Chiller Inputs

1. General Details:

Plant Name .... **Chilled Water**
Plant Type .... **Chiller Plant**

2. Air Systems served by Plant:

Air System Name	Mult.
AHU1	1
AHU2	1
AHU3	1

3: Configuration

Number of Chillers **1**
Plant Control .... **Equal Unloading**
Design LCHWT .... **44.0** °F
Maximum LCHWT .... **44.0** °F
Cooling Tower Configuration .... **One tower for each W/C chiller**

4: Schedule of Equipment

Sequence	Chiller Name	Full Load Capacity (Tons)	Cooler Flow Rate (gpm)	Condenser Flow Rate (gpm)	Cooling Tower Name	Tower Flow Rate (gpm)
CH-1	Chiller 1	170.0	300.0	0.0	<none>	0.0
	Totals:	170.0	300.0	0.0	Totals:	0.0

Est. Max Load .... **169.7** Tons

5: Distribution

Distribution System

Type .... **Primary Only, Constant Speed**
Coil Delta-T at Design .... **10.0** °F
Pipe Heat Gain Factor .... **0.0** %

Fluid Properties

Name .... **Fresh Water**
Density .... **62.4** lb/ft³
Specific Heat .... **1.00** BTU / (lb - °F)

Primary Loop

Pump for	Flow (gpm)	Head (ft wg)	Mechanical Efficiency (%)	Electrical Efficiency (%)
CH-1	300.0	0.0	80.0	94.0

Appendix F- AHU Inputs

AHU-1

Note: Because AHU-1,2,&3 are similar inputs for AHU-1 only are given

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1. General Details:

Air System Name **AHU1**
Equipment Class .... **Chilled Water AHU**
Air System Type .... **VAV**
Number of zones **54**

2. System Components:
Ventilation Air Data:

Airflow Control .... **Proportional**
Ventilation Sizing Method .... **Sum of Space OA Airflows**
Minimum Airflow .... **0** %
Unocc. Damper Position .... **Closed**
Damper Leak Rate .... **0** %
Outdoor Air CO2 Level .... **400** ppm

Economizer Data:

Control .... **Integrated enthalpy control**
Upper Cutoff .... **88.0** °F
Lower Cutoff .... **0.0** °F

Preheat Coil Data:

Setpoint .... **50.0** °F
Heating Source .... **Hot Water**
Schedule .... **JFMAMJJASOND**
Coil position .... **Downstream of Mixing Point**

Central Cooling Data:

Supply Air Temperature .... **54.0** °F
Coil Bypass Factor **0.100**
Cooling Source .... **Chilled Water**
Schedule .... **JFMAMJJASOND**
Capacity Control .... **Constant Temperature - Fan On**

Supply Fan Data:

Fan Type .... **Forward Curved**
Configuration .... **Draw-thru**
Fan Performance .... **6.00** in wg
Overall Efficiency .... **54** %

% Airflow	100	90	80	70	60	50
% kW	100	91	81	72	61	54

% Airflow	40	30	20	10	0
% kW	46	40	33	27	21

Duct System Data:
Supply Duct Data:

Duct Heat Gain .... **0** %
Duct Leakage .... **0** %

Return Duct or Plenum Data:

Return Air Via .... **Ducted Return**

Return Fan Data:

Fan Type .... **Forward Curved**
Fan Performance .... **3.00** in wg
Overall Efficiency .... **54** %

% Airflow	100	90	80	70	60	50
% kW	100	91	81	72	61	54

% Airflow	40	30	20	10	0
% kW	46	40	33	27	21

Thermostats and Zone Data:

Zone .... **All**
Cooling T-stat: Occ. .... **75.0** °F
Cooling T-stat: Unocc. .... **85.0** °F
Heating T-stat: Occ. .... **70.0** °F
Heating T-stat: Unocc. .... **60.0** °F
T-stat Throttling Range .... **3.00** °F
Diversity Factor .... **100** %
Direct Exhaust Airflow .... **0.0** CFM
Direct Exhaust Fan kW .... **0.0** kW

Thermostat Schedule .... **T-STAT**
Unoccupied Cooling is .... **Available**

Supply Terminals Data:

Zone .... **All**
Terminal Type .... **VAV box with RH**
Minimum Airflow .... **40** % of supply air

Reheat Coil Source .... **Hot Water**
Reheat Coil Schedule .... **JFMAM* * * SOND**

Zone Heating Units:

Zone .... **All**
Zone Heating Unit Type .... **None**

Zone Unit Heat Source .... **Hot Water**
Zone Heating Unit Schedule .... **JFMAMJJASOND**

3. Sizing Data (User-Modified):
System Sizing Data:

Cooling Supply Temperature .... **54.0** °F
Supply Fan Airflow .... **22000.0** CFM
Ventilation Fan Airflow .... **11066.0** CFM

Hydronic Sizing Specifications:

Chilled Water Delta-T .... **14.0** °F
Hot Water Delta-T .... **28.3** °F

Safety Factors:

Cooling Sensible .... **0** %
Cooling Latent .... **0** %
Heating .... **0** %

Zone Sizing Data:

Zone Airflow Sizing Method .... **Peak zone sensible load**

Space Airflow Sizing Method .... **Individual peak space loads**

4. Equipment Data
No Equipment Data required for this system.

CUH-1

Note: CUH-1 is the only Unit Heater with inputs shown, however six similar Unit Heaters exist in the building

1. General Details:
Air System Name **CUH-1**
Equipment Class .... **Terminal Units**
Air System Type .... **2-Pipe Fan Coil**
Number of zones **1**
Ventilation .... **Direct Ventilation**

2. Ventilation System Components:
(Common Ventilation System not used: no inputs)

3. Zone Components:
Space Assignments:

Zone 1: Zone 1	
119	x1

Thermostats and Zone Data:
Zone .... **All**
Cooling T-stat: Occ. .... **75.0** °F
Cooling T-stat: Unocc. .... **85.0** °F
Heating T-stat: Occ. .... **70.0** °F
Heating T-stat: Unocc. .... **60.0** °F
T-stat Throttling Range .... **3.00** °F

Thermostat Schedule .... **T-STAT**
Unoccupied Cooling is .... **Available**

Common Terminal Unit Data:
Heating Coil:
Design Supply Temperature .... **124.0** °F
Heating Source .... **Hot Water**
Schedule .... **JFMAM* * * SOND**

Fan Control .... **Fan On**
Ventilation Sizing Method .... **Sum of Space OA Airflows**

Terminal Units Data:
Zone .... **All**
Terminal Type .... **Fan Coil**
Minimum Airflow .... **230.0** CFM
Fan Performance .... **12.50** in wg
Fan Overall Efficiency .... **50** %

4. Sizing Data (Computer-Generated):
System Sizing Data:

Heating Supply Temperature .... **124.0** °F

Hydronic Sizing Specifications:
Chilled Water Delta-T .... **2.0** °F
Hot Water Delta-T .... **18.0** °F

Safety Factors:
Cooling Sensible .... **0** %
Cooling Latent .... **0** %
Heating .... **0** %

Zone Sizing Data:
Zone Airflow Sizing Method .... **Sum of space airflow rates**
Space Airflow Sizing Method .... **Individual peak space loads**

Zone	Supply Airflow (CFM)	Zone Htg Unit (MBH)	Reheat Coil (MBH)	Ventilation (CFM)
1	230.0	-	-	0.0

5. Equipment Data
No Equipment Data required for this system.