Building and Plant Energy Analysis Report

Photo rendering courtesy of Hooper Shiles Architects

Philadelphia School District Administration Headquarters 440 North Broad Street, Philadelphia, PA

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Executive Summary

A plant and energy analysis was done on the Philadelphia School District (PSD) Administration Headquarters in Philadelphia, PA. The building was evaluated against the LEED Certification requirements and also against the American Society of Heating, Refrigeration, and Air-Conditioning Engineers' Standard 90.1-2004. LEED design is based on sustainability of the whole building design and Standard 90.1 contains standards on building envelope and building lighting requirements. More calculations were done to analyze building energy usage and system operating characteristics. Lost rentable space and mechanical system first cost was also analyzed.

The PSD building was constructed in 1948 as a printing facility so the thought of LEED design wasn't "officially" present in the original design. As for the renovations, they weren't designed for LEED so the building did not receive many points in this analysis. For the building envelope compliance, the walls and windows complied but the roof did not. Also the window area is less than 50% which complies, but the skylight area for the atrium is not less than 5% which does not comply. Lost rentable space due to MEP systems in the building amounted to 5.68% and mechanical system first cost was $4,456,500.00.

Trane's Trace program was used to assess the building's energy usage and operating cost. The total kilowatt-hours used by the building was calculated to be 9,963,009 per year. The following chart gives the distribution of energy use by different components of the building.

Energy Consumption Breakdown	
primary heating	0.23%
primary cooling	31.06%
supply fans	5.25%
lighting	63.47%
Total	100.00%

Energy consumption was used to calculate the emissions per year by the mechanical system. A summary of the calculations is provided below. The most emissions by the system turned out to be CO_2 with 13,744,649 lbm.

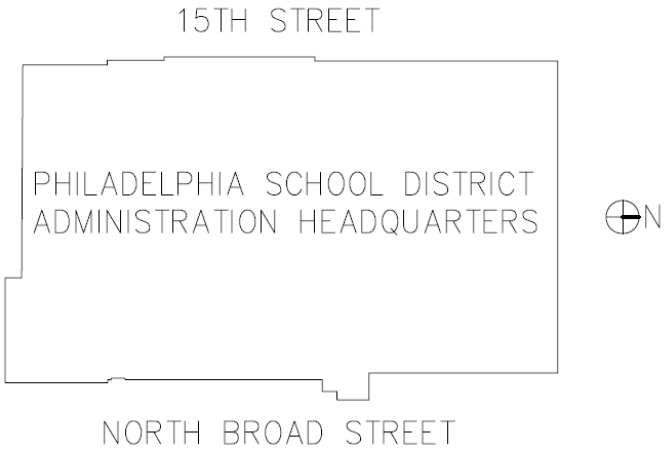
Pollutant	lbm
Particulates	6400
SO_2	75082
NO_x	44207
CO_2	13744649

The total energy cost for the year in the Administration building is $419,177.84. Mechanical system operating cost is $153,137.97 per year, about 36.53% of the total operating cost.

The loads within the building were analyzed using Trace. By trying to match what actually exists in the building after design, it was noticed that the air handling units were sized about 10% larger than estimated by the program, a common design practice.

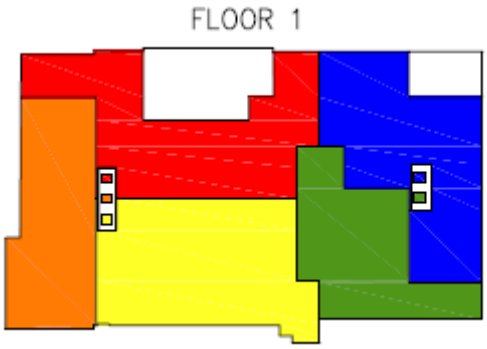
Building AHU Systems Overview

The Administration building has a total **footprint area** of **161,000 square feet** (SF) with a total **gross area** of **848,000 SF**.



The building has a parallel fan-powered VAV system and is supplied by 17 new air handling units (AHUs) with supply air totaling 529,000 cubic feet per minute (CFM). Individual units are contained in mechanical rooms on the floor it is supplying. An example of an AHU's schedule number is 1.4, where 1 is the floor number and 4 is the unit's number on that floor. The following is a color-coded schedule of the unit layout by floor:

Floors 1 through 3 are broken up by a north half and a south half, each with its own mechanical room. The **first floor** has 5 AHUs, two serving the south half, two serving the north half and one serving the south tenant space (a double height space). The later AHU rises through a shaft to serve the space from the second floor ceiling.

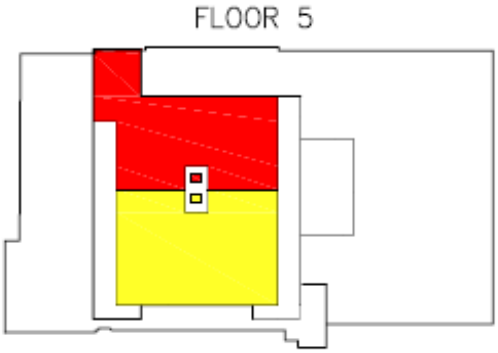


Four AHUs serve the **second floor**: two serving the south half and two serving the north half.

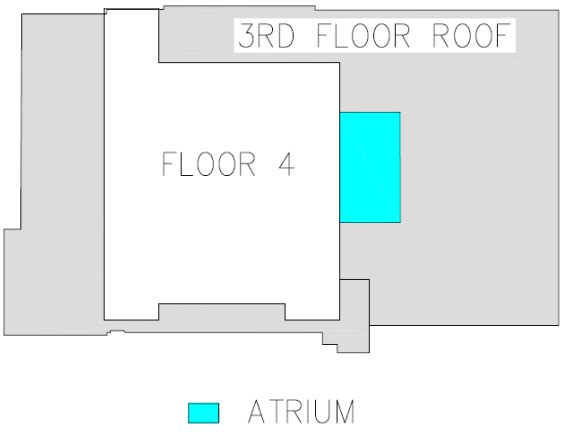
The **third floor** has 4 AHUs, two serving the south half, two serving the north half and one serving the south tenant space (above the tenant space on the first floor).

One AHU serves the entire **fourth floor**.

The **fifth floor** has 2 AHUs, one serving the east half and one serving the west half.



A new architectural feature in the building is the **three story atrium** between floors 1 and 3. This space is served by AHU 4 on each floor (1, 2, and 3). It receives 15,000 CFM in total from these three air handling units.



LEED Green Building Certification Assessment

Leadership in Energy and Environmental Design (LEED) Green Building ratings are meant to encourage sustainable design practices within the construction industry. Certification is based on a system where points are assigned on different "green" objectives. There are six categories in the assessment: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process.

Because the PSD Administration Headquarters was originally built as a printing facility in 1948, it did not pass on many of the aspects of LEED Certification. Due to limited documentation, this assessment was completed by assigning no points if there was an insufficient amount of information to prove certification. The Administration Headquarters received 6 LEED points in this assessment. See **Appendix A** for the complete LEED chart.

ASHRAE Standard 90.1 Assessment, Building Envelope and Building Lighting Compliance

The purpose of Standard 90.1 is to provide minimum requirements for the energy-efficient design of buildings with the exception of low-rise residential buildings. This applies to the building envelope and the following systems and equipment used in buildings: heating, ventilating, and air conditioning; service water heating; electric power distribution and metering provisions; electric motors and belt drives; and lighting. The focus of this assessment will be on the building envelope and on the building lighting.

Building Envelope Compliance

The building envelope consists of the walls, windows, and roof of a building that separates the outdoor environment from the indoor conditioned spaces. A building envelope analysis was performed using Standard 90.1 Section 5 as a guide to determine whether Philadelphia School District Administration Headquarters complies with this section of the ASHRAE Standard.

Method of Analysis

1. Determine the Heating Degree Days (HDD) and the Cooling Degree Days (CDD) for the location of the building. These values are provided in Table D-1 of ASHRAE Standard 90.1.
   * For Philadelphia, PA HDD is 4,954 and CDD is 3,623.

2. Determine the Climate Zone from Table B-1 or Figure B-1.
   * Philadelphia is climate 4A.

3. Determine Standard 90 compliance U-Values and Solar Heat Gain Coefficents from Tables 5.5-1 – 5.5-8.
   * For climate 4A, use Table 5.5-4

4. Compare Standard 90 requirements with design requirements.

Building Envelope Summary		
Element	Assessment	Complies?
Wall	U-Value	Yes
	R-Value	Yes
Roof	U-Value	No
	R-Value	No
Window	U-Value	Yes
Window	% Area	Yes
Skylight	% Area	No

For detailed results, reference **Appendix B**. The walls and windows complied with Standard 90 while the roof did not. The percentage of exterior wall that is window area is 17.76% which complies since it is less than 50%. The new atrium has 3 large skylights which total an area that is 29.94% of that portion of the roof. Since this is more than 5% it doesn't comply with Standard 90.

Building Lighting Compliance

Interior lighting power allowance for a building is determined using either the Building Area Method or the Space-by-Space Method. The Building Area Method uses the total building area to determine lighting power allowance. The Space-by-Space Method determines power allowance from individual spaces within the building.

A building lighting analysis was performed using Standard 90.1 Section 9 as a guide to determine whether Philadelphia School District Administration Headquarters complies with this section of the ASHRAE Standard.

Method of Analysis: Building Area Method

1. Determine building area type and allowed lighting power density.
   * For PSD Administration Headquarters, use Office building with 6 W/sf design power density.

2. Determine gross lighted floor area.

3. Multiply the allowed power density by the gross lighted floor area.

4. Sum the lighting power allowances for all building area types to obtain the interior lighting power allowance.

As can be seen in **Appendix C**, the Philadelphia School District Administration Headquarters did not comply with the lighting part of Standard 90. The assumed lighting power density was taken from the design load calculations provided by the engineer. This value was 6 watts per square foot which is really high. The actual lighting within the building most likely provides a lot less than 6 W/sf.

Lost Rentable Space

Mechanical, electrical, and plumbing systems require a percentage of a building's space. This reduces the amount of rentable space for the tenants who will occupy these spaces. Even though 440 North Broad is a very large building, Philadelphia School District loses out on a certain amount of office space. However, this hardly affects the school district. It can be seen from **Appendix D** that **the total lost rentable space amounts to 5.68%** with mechanical rooms amounting to 2.27% of the total building floor area. Total **unusable space is 27,916 square feet of 491,658 square** feet between floors 1 and 5.

Mechanical System First Cost

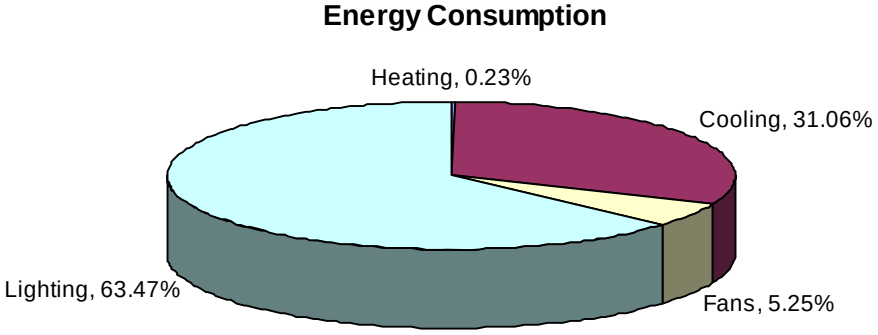
The mechanical system first cost is detailed in the following chart. Total first cost amounted to $4,456,500.00 through a Guaranteed Maximum Price bid.

Mechanical System First Cost	
Equipment	2,963,000.00
Equipment Premium	60,000.00
Sheetmetal/Air Distribution Systems	948,000.00
Testing Existing DX Units	5,000.00
ATC/BMS	250,000.00
Insurance	198,500.00
Hoisting	32,000.00
Total	4,456,500.00

Trace Energy Analysis

Yearly Energy Utilization Data

Because the Administration building was just opened for the current school year, actual energy data was not available. Energy utilization was estimated using Trane's Trace program. The Philadelphia School District Administration Headquarters building uses one source of energy, electric. The engineer used electric heat for maintenance and operational reasons that suited the School District better than alternatives like steam. Since it is an office building a schedule based on a 6:00am to 8:00pm work period was assumed. Total kilowatt-hours used for the building was calculated to be 9,963,009 per year. A summary of the consumption can be found in Appendix . Here is a simple pie chart to show exactly what is consuming energy in the building. Lighting is the largest with 63.47%.



The total energy consumption was used to calculate the emissions of the building. This was done on a lbm/kWh basis. Details from the Trace simulation can be found in **Appendix E**.

Cooling and Ventilation Load

Trane's Trace program was used to calculate the cooling and ventilation load in the Administration building. Once these values were found, they were compared to those on the Air Handler Unit schedules from the design documents. The following chart shows a summary of the calculations. By trying to match what actually exists in the building after design in Trace, it was noticed that the air handling units were sized using the load in ton per space. Calculated airflow rates for the supply and ventilation air were higher than those scheduled because lighting loads were assumed to be 6 W/sf and the amount of people used in the simulation was higher than what was used to calculate the outdoor air. Trace output files can be found in **Appendix F** and a more detailed spreadsheet can be found in **Appendix G**.

Energy Analysis Summary

		Load		Supply Air		Ventilation Air	
		Calculated	Scheduled	Calculated	Scheduled	Calculated	Scheduled
AHU	Space	ton	ton	cfm	cfm	cfm	cfm
1.1 & 1.2	1S	135.3	160	72755	56000	6713	5600
1.3 & 1.4	1N	144.2	160	79305	56000	6993	5600
1.5	1T	76.2	80	42083	28000	3846	2800
2.1 & 2.2	2S	161.4	180	86677	63000	8112	6300
2.3 & 2.4	2N	161.4	180	85981	63000	8112	6300
3.1 & 3.2	3S	166.9	200	89275	70000	8112	7000
3.3 & 3.4	3N	184.3	200	93138	70000	8112	7000
3.5	3T	85.1	90	43072	32000	3916	3200
4.1	4	147.1	100	78823	35000	6993	3500
5.1 & 5.2	5	124.9	160	63691	56000	5385	5600

Operating Cost

The energy utilization data provided above gives a breakdown of the energy used for different components of the building load. These energy consumption numbers are proportional to the operating cost of the system. The **total energy cost is $419,177.84 per year**. This is an estimate based on the Trace energy analysis. Taking lighting out of that estimate, **HVAC operating cost is $153,137.97** per year. This includes the cost to run the cooling compressor, supply fans, and condenser pump. The lighting cost includes lights and other electrical equipment. See the Economic Summary in **Appendix H** for more details.

Energy Cost Breakdown	
primary heating	$962.92
primary cooling	$130,188.09
supply fans	$21,986.96
lighting	$266,039.87
Total	$419,177.84

Emissions Estimate

Using the Yearly Energy Utilization Data, the emissions given off by the operating systems within the Administration building can be calculated. In the chart below it can be seen that this building gives off more emissions than the average taken from the 1995 database. A detailed chart of the calculation of the emissions by PSD Administration Headquarters can be found in **Appendix I**.

Emissions Comparison: PSD Admin HQ vs. 1995 Database

	Thousand BTU/sq.ft.-yr.				lbm Pollutant/ft.^{2}-yr			
	1995 Database	Total	50% e~	kWh e~	NOx	SOx	Particulates	CO2
All Buildings		90.5	45.25	13.26	6.54E-02	1.11E-01	9.47E-03	2.03E+01
Floorspace (sq. ft)	Over 500,000	96.8	48.4	14.19	6.99E-02	1.19E-01	1.01E-02	2.17E+01
Principal Building Activity	Office	97.2	48.6	14.24	7.02E-02	1.19E-01	1.02E-02	2.18E+01
Climatic Zone	Zone 4	79.9	39.95	11.71	5.77E-02	9.80E-02	8.36E-03	1.79E+01
PSD Administration Headquarters					4.42E+04	7.51E+04	6.40E+03	1.37E+07

Appendix A: LEED Assessment

Leed Assessment

Project Checklist

Y	N	Sustainable Sites		14 Possible Points
	1	Prereq 1	Erosion & Sedimentation Control	Required
	1	Credit 1	Site Selection	1
1		Credit 2	Urban Redevelopment	1
	1	Credit 3	Brownfield Redevelopment	1
1		Credit 4.1	Alternative Transportation, Public Transportation Access	1
	1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	1	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
1		Credit 4.4	Alternative Transportation, Parking Capacity	1
	1	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
	1	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
	1	Credit 6.1	Stormwater Management, Rate and Quantity	1
	1	Credit 6.2	Stormwater Management, Treatment	1
	1	Credit 7.1	Heat Island Effect, Non-Roof	1
	1	Credit 7.2	Heat Island Effect, Roof	1
	1	Credit 8	Light Pollution Reduction	1
3				

Y	N	Water Efficiency		5 Possible Points
	1	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
	1	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
	1	Credit 2	Innovative Wastewater Technologies	1
	1	Credit 3.1	Water Use Reduction, 20% Reduction	1
	1	Credit 3.2	Water Use Reduction, 30% Reduction	1
0				

Y	N	Energy & Atmosphere		17 Possible Points
	1	Prereq 1	Fundamental Building Systems Commissioning	Required
	1	Prereq 2	Minimum Energy Performance	Required
	1	Prereq 3	CFC Reduction in HVAC&R Equipment	Required
	1	Credit 1	Optimize Energy Performance	1–10
	1	Credit 2.1	Renewable Energy, 5%	1
	1	Credit 2.2	Renewable Energy, 10%	1
	1	Credit 2.3	Renewable Energy, 20%	1
	1	Credit 3	Additional Commissioning	1
	1	Credit 4	Ozone Depletion	1
	1	Credit 5	Measurement & Verification	1
	1	Credit 6	Green Power	1
0				

Y	N	Materials & Resources		13 Possible Points
	1	Prereq 1	Storage & Collection of Recyclables	Required
1		Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	1
	1	Credit 1.2	Building Reuse, Maintain 100% of Shell	1
	1	Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	1
	1	Credit 2.1	Construction Waste Management, Divert 50%	1
	1	Credit 2.2	Construction Waste Management, Divert 75%	1
	1	Credit 3.1	Resource Reuse, Specify 5%	1
	1	Credit 3.2	Resource Reuse, Specify 10%	1
	1	Credit 4.1	Recycled Content, Specify 5% (p.c. + 1/2 p.i.)	1
	1	Credit 4.2	Recycled Content, Specify 10% (p.c. + 1/2 p.i.)	1
	1	Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	1
	1	Credit 5.2	Local/Regional Materials, of 20% in MRc5.1, 50% Harvested Locally	1
	1	Credit 6	Rapidly Renewable Materials	1
	1	Credit 7	Certified Wood	1
1				

Appendix A

Y	N	Indoor Environmental Quality	15 Possible Points
	1	Prereq 1 Minimum IAQ Performance	Required
	1	Prereq 2 Environmental Tobacco Smoke (ETS) Control	Required
	1	Credit 1 Carbon Dioxide (CO2) Monitoring	1
	1	Credit 2 Ventilation Effectiveness	1
	1	Credit 3.1 Construction IAQ Management Plan, During Construction	1
	1	Credit 3.2 Construction IAQ Management Plan, Before Occupancy	1
	1	Credit 4.1 Low-Emitting Materials, Adhesives & Sealants	1
	1	Credit 4.2 Low-Emitting Materials, Paints	1
	1	Credit 4.3 Low-Emitting Materials, Carpet	1
	1	Credit 4.4 Low-Emitting Materials, Composite Wood	1
	1	Credit 5 Indoor Chemical & Pollutant Source Control	1
	1	Credit 6.1 Controllability of Systems, Perimeter	1
	1	Credit 6.2 Controllability of Systems, Non-Perimeter	1
	1	Credit 7.1 Thermal Comfort, Comply with ASHRAE 55-1992	1
	1	Credit 7.2 Thermal Comfort, Permanent Monitoring System	1
1		Credit 8.1 Daylight & Views, Daylight 75% of Spaces	1
1		Credit 8.2 Daylight & Views, Views for 90% of Spaces	1
2			

Y	N	Innovation & Design Process	5 Possible Points
	1	Credit 1.1 Innovation in Design	1
	1	Credit 1.2 Innovation in Design	1
	1	Credit 1.3 Innovation in Design	1
	1	Credit 1.4 Innovation in Design	1
	1	Credit 2 LEED™ Accredited Professional	1
0			

	Project Totals	69 Possible Points
	Certified	26-32 points
	Silver	33-38 points
	Gold	39-51 points
	Platinum	52-69 points

Appendix B: Building Envelope Compliance

U-Value Assessment					
Wall			Roof		
U-Value			U-Value		
Design	Standard 90	Complies?	Design	Standard 90	Complies?
0.148	0.151	**Yes**	0.150	0.063	**No**

R-Value Assessment					
Wall			Roof		
R-Value			R-Value		
Design	Standard 90	Complies?	Design	Standard 90	Complies?
6.757	5.700	**Yes**	6.667	15.000	**No**

U-Value Assessment		
Window		
U-Value		
Design	Standard 90	Complies?
0.500	0.570	**Yes**

Skylight Assessment		
Space		Area
Atrium	Skylight	1817.0
	Total	6068.5
% Skylight Area		29.94
Complies if % is less than 5		**No**

Appendix B (continued)

Vertical Fenestration Assessment				
		Area		% Window
Floor/AHU	Wall	Total	Window	Area
1N	E	3642.5	1115.0	
1S	E	4805.0	1391.0	
1T	E	2870.0	0.0	
Broad Lobby	E	1160.0	1102.0	
2N	E	3102.0	1010.0	
2S	E	2310.0	1198.0	
3N	E	4230.0	1000.0	
3S	E	3150	1198.0	
3T	E	1800.0	0.0	
4	E	3262.5	655.0	
5	E	2860	655.0	
East Wall Subtotal		**33192.0**	**9324.0**	**28.09**
1N	N	5115.0	654.0	
Broad Lobby	N	1015.0	1015.0	
2N	N	3960.0	655.0	
3N	N	5400.0	959.0	
4	N	4640	659.0	
5	N	4147	659.0	
North Wall Subtotal		**24277.0**	**4601.0**	**18.95**
1S	S	4805.0	0.0	
1T	S	7462.0	0.0	
Broad Lobby	S	783.0	783.0	
3T	S	1800.0	0.0	
4	S	4640	504.0	
5	S	4147	504.0	
South Wall Subtotal		**23637.0**	**1791.0**	**7.58**
1N	W	3642.5	453.0	
1S	W	4650.0	40.0	
1T	W	2870.0	0.0	
15 Lobby	W	2364.0	330.0	
2N	W	3102.0	453.0	
2S	W	2310.0	912.0	
3N	W	4230.0	993.0	
3S	W	3150	1096.0	
3T	W	5580.0	0.0	
4	W	3262.5	583.0	
5	W	2860	583.0	
West Wall Subtotal		**38021.0**	**5443.0**	**14.32**
Building Total		***119127.0***	***21159.0***	***17.76***
Complies if % is less than 50				**Yes**

Appendix C: Building Lighting Compliance

Lighting Assessment : Building Area Method							
		Design Conditions				Standard 90	
Space	Area	W/SF	W			W/SF	W
Atrium	7220	1.5	10830.00	retail	fluorescent hung below ceiling 100% load to space	1.5	10830.00
1S	50000	6.0	300000.00	office	fluorescent hung below ceiling 100% load to space	1.0	50000.00
1N	48000	6.0	288000.00	office	fluorescent hung below ceiling 100% load to space	1.0	48000.00
1T	27500	6.0	165000.00	office	fluorescent hung below ceiling 100% load to space	1.0	27500.00
2S	58000	6.0	348000.00	office	fluorescent hung below ceiling 100% load to space	1.0	58000.00
2N	58000	6.0	348000.00	office	fluorescent hung below ceiling 100% load to space	1.0	58000.00
3S	58000	6.0	348000.00	office	fluorescent hung below ceiling 100% load to space	1.0	58000.00
3N	58000	6.0	348000.00	office	fluorescent hung below ceiling 100% load to space	1.0	58000.00
3T	28000	6.0	168000.00	office	fluorescent hung below ceiling 100% load to space	1.0	28000.00
4	50000	6.0	300000.00	office	fluorescent hung below ceiling 100% load to space	1.0	50000.00
5	38500	6.0	231000.00	office	fluorescent hung below ceiling 100% load to space	1.0	38500.00
Broad Lob	4600	2.0	9200.00	retail	recessed fluorescent, non vented, 80% load to space	1.5	6900.00
15 Lobby	5838	2.0	11676.00	retail	recessed fluorescent, non vented, 80% load to space	1.5	8757.00
			2875706.00				500487.00
						Complies?	No

Appendix D: Lost Rentable Space

Lost Rentable Space by Floor (SF)						
Space	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Total**
mechanical rooms	4349	2508	3011	638	638	11144
elevator machine rooms	76	179	179	0	0	434
electric rooms	898	876	955	881	881	4491
elevators	1121	1184	1186	974	974	5439
vertical shafts	1251	1301	1311	626	286	4775
equipment	327	0	0	0	0	327
plumbing shafts	245	313	298	207	243	1306
lost rentable space	*8267*	*6361*	*6940*	*3326*	*3022*	*27916*
total floor area	143158	116000	144000	50000	38500	491658
% space lost	**5.8%**	**5.5%**	**4.8%**	**6.7%**	**7.8%**	**5.68%**

Lost Rentable Space by Space Type (SF)		
Space	**Area**	**% Total**
mechanical rooms	11144	2.27%
elevator machine rooms	434	0.09%
electric rooms	4491	0.91%
elevators	5439	1.11%
vertical shafts	4775	0.97%
equipment	327	0.07%
plumbing shafts	1306	0.27%

Appendix E: Energy Consumption Summary

ENERGY CONSUMPTION SUMMARY
By ae

	Elect Cons. (kWh)	Water Cons. (1000 gals)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Primary heating				
Primary heating	22,886.6		0.2 %	2,343.6
Primary cooling				
Cooling Compressor	1,205,562.1		12.1 %	123,449.9
Tower/Cond Fans	530,514.4	6,765.2	5.3 %	54,324.8
Condenser Pump	1,357,507.6		13.6 %	139,009.1
Other CLG Accessories	723.2		0.0 %	74.1
Cooling Subtotal....	3,094,307.3	6,765.2	31.1 %	316,857.8
Auxiliary				
Supply Fans	522,585.5		5.3 %	53,512.9
Circ Pumps			0.0 %	0.0
Base Utilities			0.0 %	0.0
Aux Subtotal....	522,585.5		5.3 %	53,512.9
Lighting				
Lighting	6,323,229.0		63.5 %	647,500.2
Receptacle				
Receptacles			0.0 %	0.0
Heating plant load				
Base Utilities			0.0 %	0.0
Cogeneration				
Cogeneration			0.0 %	0.0
Totals				
Totals**	9,963,009.0	6,765.2	100.0 %	1,020,214.5

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 6 utilities. If additional utilities are used, they will be included in the total.

Project Name: 440 N. BOARD STREET
Dataset Name: C:\Documents and Settings\jla250\Desktop\Copy of Energy 11 Zones.TRC

TRACE® 700 v4.1 calculated at 09:11 PM on 10/30/2005
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Appendix F: Trace Energy Analysis

Load / Airflow Summary

By ae

Description **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg	ASHRAE 62-89 OA fraction
FL-1 north	Rm/Zn Tot	50,000	349.7	1,486,382	1,731,268	79,317	7.61	0	0	0	8.8		
FL-1 NORTH	Sys Tot/Ave	50,000	349.7	1,486,382	1,731,268	79,317			0	0	8.8		
FL-1 NORTH	Sys Block	50,000	349.7	1,486,382	1,731,269	79,317			0	0	8.8		
FL-1 south	Rm/Zn Tot	48,000	335.7	1,388,268	1,623,499	72,787	7.28	0	0	0	9.2		
FL-1 SOUTH	Sys Tot/Ave	48,000	335.7	1,388,268	1,623,499	72,787			0	0	9.2		
FL-1 SOUTH	Sys Block	48,000	335.7	1,388,268	1,623,499	72,787			0	0	9.2		
FL-2 north	Rm/Zn Tot	58,000	405.6	1,654,524	1,938,535	86,613	7.17	0	0	0	9.4		
FL-2 NORTH	Sys Tot/Ave	58,000	405.6	1,654,524	1,938,535	86,613			0	0	9.4		
FL-2 NORTH	Sys Block	58,000	405.6	1,654,524	1,938,535	86,613			0	0	9.4		
FL-2 south	Rm/Zn Tot	58,000	405.6	1,655,716	1,939,938	86,812	7.18	0	0	0	9.3		
FL-2 SOUTH	Sys Tot/Ave	58,000	405.6	1,655,716	1,939,938	86,812			0	0	9.3		
FL-2 SOUTH	Sys Block	58,000	405.6	1,655,716	1,939,938	86,812			0	0	9.3		
FL-3 north	Rm/Zn Tot	58,000	405.6	1,938,663	2,210,844	93,260	7.72	0	0	0	8.7		
FL-3 NORTH	Sys Tot/Ave	58,000	405.6	1,938,663	2,210,844	93,260			0	0	8.7		
FL-3 NORTH	Sys Block	58,000	405.6	1,938,663	2,210,844	93,260			0	0	8.7		
FL-3 south	Rm/Zn Tot	58,000	405.6	1,730,733	2,002,881	89,318	7.39	0	0	0	9.1		
FL-3 SOUTH	Sys Tot/Ave	58,000	405.6	1,730,733	2,002,881	89,318			0	0	9.1		
FL-3 SOUTH	Sys Block	58,000	405.6	1,730,733	2,002,881	89,318			0	0	9.1		
FL-4	Rm/Zn Tot	50,000	349.7	1,530,480	1,765,111	78,987	10.53	0	0	0	8.9		
FL-4	Sys Tot/Ave	50,000	349.7	1,530,480	1,765,111	78,987			0	0	8.9		
FL-4	Sys Block	50,000	349.7	1,530,480	1,765,111	78,987			0	0	8.9		
FL-5	Rm/Zn Tot	38,500	269.2	1,318,426	1,499,119	63,814	11.05	0	0	0	8.4		
FL-5	Sys Tot/Ave	38,500	269.2	1,318,426	1,499,119	63,814			0	0	8.4		
FL-5	Sys Block	38,500	269.2	1,318,426	1,499,119	63,814			0	0	8.4		
tenant-fl1	Rm/Zn Tot	27,500	192.3	778,757	913,447	42,081	3.57	0	0	0	9.1		
TENANT FL-1	Sys Tot/Ave	27,500	192.3	778,757	913,447	42,081			0	0	9.1		
TENANT FL-1	Sys Block	27,500	192.3	778,757	913,447	42,081			0	0	9.1		
tenant-fl3	Rm/Zn Tot	28,000	195.8	889,943	1,021,424	43,081	3.59	0	0	0	9.1		
TENANT FL-3	Sys Tot/Ave	28,000	195.8	889,943	1,021,424	43,081			0	0	9.1		
TENANT FL-3	Sys Block	28,000	195.8	889,943	1,021,424	43,081			0	0	9.1		
Atrium	Rm/Zn Tot	7,220	216.8	416,063	567,951	16,379	2.90	0	-369,431	6,024	26.5	0.0	

** This report does not display heating only systems.

Project Name: 440 N. BOARD STREET
Dataset Name: C:\Documents and Settings\jla250\Desktop\Energy.TRC

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Alternative - 1 Load/Airflow Summary report page 1

Load / Airflow Summary

By ae

Description **		Floor Area ft²	People #	Coil Cooling Sensible Btu/h	Coil Cooling Total Btu/h	Space Design Max SA cfm	Air Changes ach/hr	VAV Minimum SA cfm	Main Coil Heating Sensible Btu/h	Heating Fan Max SA cfm	Percent OA Clg	Percent OA Htg	ASHRAE 62-89 OA fraction
Atrium	Sys Tot/Ave	7,220	216.8	416,063	567,951	16,379			-369,431	6,024	26.5	0.0	
Atrium	Sys Block	7,220	216.8	416,063	567,951	16,379			-369,431	6,024	26.5	0.0	
Broad St lobby	Rm/Zn Tot	4,600	138.1	209,295	260,575	9,053	9.45	0	-169,477	9,053	15.2	0.0	
BROAD ST LOBBY	Sys Tot/Ave	4,600	138.1	209,295	260,575	9,053			-169,477	9,053	15.2	0.0	
BROAD ST LOBBY	Sys Block	4,600	138.1	209,295	260,575	9,053			-169,477	9,053	15.2	0.0	
15 ST LOBBY	Rm/Zn Tot	5,838	83.4	138,248	194,429	5,164	4.25	0	-94,700	5,164	32.3	0.0	
15 ST LOBBY	Sys Tot/Ave	5,838	83.4	138,248	194,429	5,164			-94,700	5,164	32.3	0.0	
15 ST LOBBY	Sys Block	5,838	83.4	138,248	194,429	5,164			-94,700	5,164	32.3	0.0	

** This report does not display heating only systems.

Project Name: 440 N. BOARD STREET
Dataset Name: C:\Documents and Settings\jla250\Desktop\Energy.TRC

TRACE® 700 v4.1 calculated at 03:48 PM on 10/25/2005
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Appendix F (continued)

ENGINEERING CHECKS
By ae

Description	Type	COOLING % OA	COOLING cfm/ft²	COOLING cfm/ton	COOLING ft²/ton	COOLING Btu/hr·ft²	HEATING % OA	HEATING cfm/ft²	HEATING Btu/hr·ft²	Floor Area ft²
FL-1 north	Zone	8.82	1.59	540.8	346.6	34.63		0.00	-7.10	50,000
FL-1 NORTH	System - Parallel Fan-Powered VAV	8.82	1.59	540.8	346.6	34.63		0.00	-4.64	50,000
FL-1 south	Zone	9.22	1.52	538.0	354.8	33.82		0.00	-7.08	48,000
FL-1 SOUTH	System - Parallel Fan-Powered VAV	9.22	1.52	538.0	354.8	33.82		0.00	0.00	48,000
FL-2 north	Zone	9.37	1.49	536.2	359.0	33.42		0.00	-7.08	58,000
FL-2 NORTH	System - Parallel Fan-Powered VAV	9.37	1.49	536.2	359.0	33.42		0.00	0.00	58,000
FL-2 south	Zone	9.34	1.50	537.0	358.8	33.45		0.00	-7.07	58,000
FL-2 SOUTH	System - Parallel Fan-Powered VAV	9.34	1.50	537.0	358.8	33.45		0.00	0.00	58,000
FL-3 north	Zone	8.70	1.61	506.2	314.8	38.12		0.00	-19.19	58,000
FL-3 NORTH	System - Parallel Fan-Powered VAV	8.70	1.61	506.2	314.8	38.12		0.00	0.00	58,000
FL-3 south	Zone	9.08	1.54	535.1	347.5	34.53		0.00	-7.09	58,000
FL-3 SOUTH	System - Parallel Fan-Powered VAV	9.08	1.54	535.1	347.5	34.53		0.00	0.00	58,000
FL-4	Zone	8.85	1.58	537.0	339.9	35.30		0.00	-7.10	50,000
FL-4	System - Parallel Fan-Powered VAV	8.85	1.58	537.0	339.9	35.30		0.00	0.00	50,000
FL-5	Zone	8.44	1.66	510.8	308.2	38.94		0.00	-19.69	38,500
FL-5	System - Parallel Fan-Powered VAV	8.44	1.66	510.8	308.2	38.94		0.00	0.00	38,500
tenant-fl1	Zone	9.14	1.53	552.8	361.3	33.22		0.00	-7.10	27,500
TENANT FL-1	System - Parallel Fan-Powered VAV	9.14	1.53	552.8	361.3	33.22		0.00	0.00	27,500
tenant-fl3	Zone	9.09	1.54	506.1	329.0	36.48		0.00	-18.31	28,000
TENANT FL-3	System - Parallel Fan-Powered VAV	9.09	1.54	506.1	329.0	36.48		0.00	0.00	28,000
Atrium	Zone	26.48	2.27	346.1	152.5	78.66	0.00	0.83	-79.49	7,220
Atrium	System - Parallel Fan-Powered VAV	26.48	2.27	346.1	152.5	78.66	0.00	0.83	-32.15	7,220
Broad St lobby	Zone	15.24	1.97	416.9	211.8	56.65	0.00	1.97	-36.84	4,600
BROAD ST LOBBY	System - Packaged Terminal Air Conditioner	15.24	1.97	416.9	211.8	56.65	0.00	1.97	0.00	4,600
15 ST LOBBY	Zone	32.30	0.88	318.7	360.3	33.30	0.00	0.88	-16.22	5,838
15 ST LOBBY	System - Packaged Terminal Air Conditioner	32.30	0.88	318.7	360.3	33.30	0.00	0.88	0.00	5,838
15 ST LOBYY HEAT	Zone	0.00	0.00	0.0	0.0	0.00	0.00	4.59	-281.21	200
15ST LOBBY HEAT	System - Unit Heaters	0.00	0.00	0.0	0.0	0.00	0.00	4.59	-281.21	200
BROAD ST LOBBY HEAT	Zone	0.00	0.00	0.0	0.0	0.00	0.00	2.99	-183.34	300
BROAD ST LOBBY HEAT	System - Unit Heaters	0.00	0.00	0.0	0.0	0.00	0.00	2.99	-183.34	300

Project Name: 440 N. BOARD STREET
Dataset Name: C:\Documents and Settings\jla250\Desktop\Energy.TRC

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SYSTEM SUMMARY
DESIGN AIRFLOW QUANTITIES
By ae

System Description	System Type	MAIN SYSTEM Outside Airflow cfm	MAIN SYSTEM Cooling Airflow cfm	MAIN SYSTEM Heating Airflow cfm	MAIN SYSTEM Return Airflow cfm	MAIN SYSTEM Exhaust Airflow cfm	Auxiliary System Supply Airflow cfm	Room Exhaust Airflow cfm
FL-1 NORTH	Parallel Fan-Powered VAV	6,993	79,317	0	79,317	6,993	0	0
FL-1 SOUTH	Parallel Fan-Powered VAV	6,713	72,787	0	72,787	6,713	0	0
FL-2 NORTH	Parallel Fan-Powered VAV	8,112	86,613	0	86,613	8,112	0	0
FL-2 SOUTH	Parallel Fan-Powered VAV	8,112	86,812	0	86,812	8,112	0	0
FL-3 NORTH	Parallel Fan-Powered VAV	8,112	93,260	0	93,260	8,112	0	0
FL-3 SOUTH	Parallel Fan-Powered VAV	8,112	89,318	0	89,318	8,112	0	0
FL-4	Parallel Fan-Powered VAV	6,993	78,987	0	78,987	6,993	0	0
FL-5	Parallel Fan-Powered VAV	5,386	63,814	0	63,814	5,386	0	0
TENANT FL-1	Parallel Fan-Powered VAV	3,846	42,081	0	42,081	3,846	0	0
TENANT FL-3	Parallel Fan-Powered VAV	3,916	43,081	0	43,081	3,916	0	0
Atrium	Parallel Fan-Powered VAV	4,336	16,379	6,024	16,379	4,336	0	0
BROAD ST LOBBY	Packaged Terminal Air Conditioner	1,380	9,053	9,053	9,053	1,380	0	0
15 ST LOBBY	Packaged Terminal Air Conditioner	1,668	5,164	5,164	5,164	1,668	0	0
15ST LOBBY HEAT	Unit Heaters	0	0	917	0	25	0	0
BROAD ST LOBBY HEAT	Unit Heaters	0	0	897	0	19	0	0
Totals		73,678	766,665	22,054	766,665	73,722	0	0

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

Project Name: 440 N. BOARD STREET
Dataset Name: C:\Documents and Settings\jla250\Desktop\Energy.TRC

TRACE® 700 v4.1 calculated at 03:48 PM on 10/25/2005
Alternative - 1 Design Airflow Quantities report page 1

Appendix G: Energy Analysis Summary

Energy Analysis													
		Load				Supply Air				Ventilation Air			
		Calculated		Scheduled		Calculated		Scheduled		Calculated		Scheduled	
Space	Area	ton	sf/ton	ton	sf/ton	cfm	cfm/sf	cfm	cfm/sf	cfm	cfm/sf	cfm	cfm/sf
1S	50000	135.3	369.5	160	312.5	72755	1.46	56000	1.12	6713	0.13	5600	0.11
1N	48000	144.2	332.9	160	300.0	79305	1.65	56000	1.17	6993	0.15	5600	0.12
1T	27500	76.2	360.9	80	343.8	42083	1.53	28000	1.02	3846	0.14	2800	0.10
2S	58000	161.4	359.4	180	322.2	86677	1.49	63000	1.09	8112	0.14	6300	0.11
2N	58000	161.4	359.4	180	322.2	85981	1.48	63000	1.09	8112	0.14	6300	0.11
3S	58000	166.9	347.5	200	290.0	89275	1.54	70000	1.21	8112	0.14	7000	0.12
3N	58000	184.3	314.7	200	290.0	93138	1.61	70000	1.21	8112	0.14	7000	0.12
3T	28000	85.1	329.0	90	311.1	43072	1.54	32000	1.14	3916	0.14	3200	0.11
4	50000	147.1	339.9	100	500.0	78823	1.58	35000	0.70	6993	0.14	3500	0.07
5	38500	124.9	308.2	160	240.6	63691	1.65	56000	1.45	5385	0.14	5600	0.15

Appendix H: Economic Summary

TRACE® 700 Economic Summary

By ae

Project Information

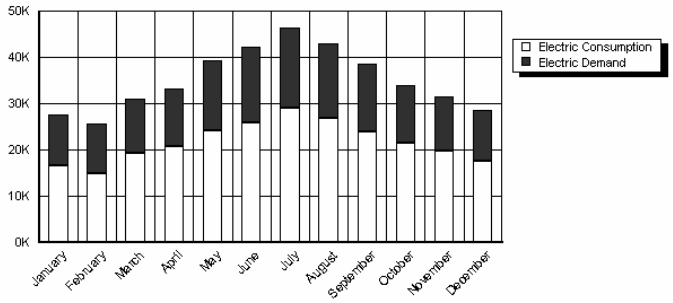
Weather file	Philadelphia, Pennsylvania	Alternative 1 - - Electric Heating
Project Name	440 N. BOARD STREET	
Location	PHILADELPHIA SCHOOL DISTRICT	
Building Owner		
User		
Company		
Comments		

Economic Summary

Alternative Number	Installed Cost	First Year Util. Cost	Final Year Util. Cost	First Year Maint. Cost	Final Year Maint. Cost	Life Cycle Cost
1	0.00	419,177.84	419,177.84	0.00	0.00	3,568,697.43

Monthly Utility Costs per Utility

(1 alternative)



Appendix I: Emissions Estimate

Estimating Emissions Associated with On-Site Electricity Use											
U.S. Power Generation Mix											
				lbm Pollutant$_i$ /kWh							
Fuel	kWh(1999)	% Total	kWh	Particulates	lbm Particulates	SO_2/kWh	lbm SO_2	NO_x/kWh	lbm Nox	CO_2/kWh	lbm CO_2
Coal	1.77E+12	55.7	5545258.2	1.10E-03	10959.31	1.28E-02	127321.97	7.41E-03	73800.53	2.15E+00	21421022.54
Oil	8.69E+10	2.7	272698.7	1.10E-03	10959.31	1.54E-02	153578.58	2.83E-03	28194.28	2.11E+00	21031783.75
Nat. Gas	2.96E+11	9.3	929755.4	0.00E+00	0.00	1.35E-05	134.46	2.54E-03	25278.89	1.34E+00	13355792.39
Nuclear	7.25E+11	22.8	2274458.1	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00
Hydro/Wind	3.00E+11	9.4	940838.6	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00	0.00E+00	0.00
Totals	3.18E+12	100.0	9963009.0	6.42E-04	6400.24	7.54E-03	75081.62	4.44E-03	44207.00	1.38E+00	13744648.98

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ASHRAE Standard 90.1-2004

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Past Penn State AE Thesis Technical Reports