TECHNICAL REPORT 2

Building and Plant Energy Use Analysis

Ann & Richard Barshinger Life Science & Philosophy Building

Franklin & Marshall College
Lancaster, PA

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Table of Contents

Executive Summary 2

LEED 2.2 – NC Compliance 3

ASHRAE 90.1-2004 Compliance Analysis 5

Lost “Rentable” Space 9

Mechanical System First Cost 10

Annual Energy Consumption / Operating Costs 11

Appendix 1 13

Appendix 2 16

Appendix 3 17

Appendix 4 18

Appendix 5 . . . . . 19 – end

Executive Summary

The Barshinger Life Science & Philosophy Building (LS&P) at Franklin & Marshall College (F&M) in Lancaster, PA has been evaluated for compliance with ASHRAE Standard 90.1-2004 and LEED 2.2 for New Construction.

This building is F&M's new laboratory, office, and classroom facility for the Biology, Psychology, and Philosophy departments and their associated education spaces. It is a 3-story building plus basement. This steel braced-frame structure encompasses 104,000 square feet.

The LEED evaluation shows that the project, currently, could only obtain 15 of the 69 LEED points, still 11 short of certification. Because making the project LEED certified was not a primary concern early on, not very much attention was paid to environmental concerns; the building was just designed to code (for the most part). Since the building does not fully meet 90.1-2004, some required points were forfeited, and LEED certification would not be a possibility.

The ASHRAE 90.1 analysis showed that most of the building does meet code, including the wall assemblies, windows, doors, roof assemblies, and skylights. Motor efficiencies meet or exceed minimum requirements, and the HVAC system design does meet minimum standards. One very beneficial element is the addition of runaround coils for sensible heat recovery from the centralized exhaust air handling units to the outdoor intake section on the three main air handlers.

However, the building does not meet the lighting density section; the building has 62% too much power for lighting purposes, amounting to 63 kW of excess lighting power. The building's summer steam boiler also does not meet the minimum efficiency standards of 90.1. It is only 63% efficient, and 90.1 requires a minimum of 83% efficient equipment.

The building has a fairly efficient layout to minimize the space taken by mechanical and electrical equipment, only taking 6.3% of the total gross interior floor area. This is accomplished through limiting the size and number of mechanical/electrical/telecom rooms, and a direct limitation on shaft spaces, not through an efficient layout of rooms, equipment, or systems. Much of the equipment in the mechanical rooms (especially the basement rooms) was jammed into the spaces because little attention was paid to an efficient layout. However, they did keep the overall size use down.

Carrier's HAP 4.34 (Hourly Analysis Program) was used to perform an energy analysis on the building, but could not be validated with actual meter data or any other energy model, after numerous requests for the model that was apparently created by the building designers. The building, in total, should take roughly $194,000 per year to heat, cool, and light, and should consume about 2,500,000 kWh/year.

LEED 2.2 – NC Compliance

LEED is a certification program overseen by the U.S. Green Building Council (www.usgbc.org) used to evaluate the sustainability of the built environment. There are four certification levels: certified, silver, gold, and platinum. Each level is associated with a certain number of points, assigned based on six broad scopes of application. These are Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, and LEED Innovation. A brief summary below covers the most basic elements of the Barshinger Life Science & Philosophy Building's estimated certification; for a more detailed breakdown of points assignments, see Appendix 1.

Sustainable Sites (Y=3, N=11)

The building was constructed on a site that previously held tennis courts and pedestrian areas on campus, so not many Site points were available. These courts had been grass turf courts, so the impervious area actually increased after building construction was finished.

Water Efficiency (Y=1, N=4)

The Barshinger LS&P Building has not selected vegetation surrounding the building to minimize water use for irrigation. Most of the building has an automatic sprinkler system to water flowers, shrubs, and lawns at night to keep a "green" campus look. The building does include water-reducing fixtures, mostly automated. This does reduce the amount of potable water used within the building, but there is still a fairly large amount of water used for irrigation.

Energy & Atmosphere (Y=0, N=17)

The building does not include any plans for green energy, either bought from suppliers or generated locally. While the building was commissioned properly, extended measures were not taken to fully train building maintenance personnel to keep the building operating at peak performance. There are numerous refrigerant-containing systems in the building; most are still R-22 systems. Some of the smaller units (lab coolers, etc.) are 410A, but not enough to overcome the aquatic suites that run on R-22 environmental chambers. While the building does have sensible energy recovery for the extremely high amount of exhaust/makeup air used in the lab hoods, it does not reduce the energy consumption of the building enough to qualify for energy reduction credits. The building envelope was built to just meet code, so no additional savings can be realized there. The lighting power densities are above what is required by ASHRAE 90.1, so one of the required points here is not attained.

Materials & Resources (Y=1, N=12)

This building contains a great number of labs; some of which did not exist on campus before. However, most labs are just coming to a new home in a new building. This allowed the re-use of many pieces of lab equipment (burners, chemicals, glassware, coolers, etc.). This reduced the finished budget of the entire building by approximately 6.2%. This was the only materials re-use sought for the building. No other focus on materials was sought by the college or by the firms involved.

Indoor Environmental Quality (Y=10, N=5)

In this category, the Barshinger LS&P Building does do rather well. I am not sure whether this is because the designers pursued these points, or because these materials were the most readily available. Many of the interior finishing systems (paint, floorings, wall coverings, etc.) were low-VOC. All spaces have lighting and thermal control, many of which will operate even during power failures. Most spaces (82% by area) have access to windows, and have some daylight. During construction, many Indoor Air Quality controls were in place. Filters (while meant for construction) were changed monthly, and the site was kept clean, swept and clear at least.

LEED Innovation (Y=1, N=4)

The only point that could be claimed by this project is the LEED AP credit. A number of those involved in all stages of the project were Accredited Professionals, but no Innovation credits were sought.

In total, this gives the Life Science and Philosophy Building 15 of the 69 credits, still below the minimum 26 for certification.

ASHRAE 90.1-2004 Compliance Analysis

ASHRAE 90.1 is used as an energy consumption cap based on occupancy type, building size, and location (climate zone). Most local code authorities have adopted the use of this standard, and it is used very often as the "measuring stick" for energy-efficient building design.

Building Envelope

Franklin & Marshall College is located in Lancaster, Pennsylvania, placing this building in Climate Zone 5A, as defined by Appendix B of the standard.

The building has been evaluated using the Prescriptive Method since the fenestration makes up only 23% of the walls, and the skylight is only 0.1% of the roof. This allows the building to qualify for this compliance calculation method.

Surface	Total Gross Area (SF)	Total Glazed Area (SF)	% glazed
Roof	25,200	28	0.11%
Walls	45,195	10,295	22.78%

The building's exterior walls are all typically the same, with very slight variations. Usually, 8" CMU backup with face brick veneer, and an interior metal stud cavity with 5/8" gyp. brd. This allows an open space to place outlets, plumbing, fixtures, and the like in the exterior walls without penetrating the CMU block wall. However, these cavities are left empty (no batt insulation) because the walls technically meet code without that "additional" insulation. Below is a table summarizing the R- and U-values for the typical opaque exterior wall.

Layer	**R-Value**
Inside air film	0.68
5/8" gyp. Brd.	0.56
3-1/2" airspace	1.01
6" (8") CMU (uninsulated)	1.3
2" EPS foam insulation board	10
1" airspace	1.25
4" face brick	0.56
Outside air film	0.17
Total Assembly R-value	**15.53**
Total Assembly U-value	**0.0644**

The above-grade walls are nominally R-15.5 for this building, and 90.1 only requires R-13, so the walls do meet code. Below grade, no insulation is required for this climate zone, but 2" of insulation (R-10) is provided anyway.

The roof (actual thermal envelope) is a flat roof, with insulation entirely above the concrete deck. 90.1 requires that there be a minimum of R-15 continuous insulation. This

building does comply with this, using 3" insulation, plus sloped insulation above that for drainage. This averages to R-17 over the entire roof surface, plus hung ceilings, air films, liners, etc. that provide some additional insulation.

The vertical windows used have an assembly U-value of 0.46, below the maximum limit of 0.57. Their SHGC is listed in the specifications as 0.37, also below the maximum allowed by table 5.5-5 of 0.39.

There is one single skylight used in the building, located in the Biology Lounge on the third floor. This skylight has an assembly U-value of 0.68, and an SHGC of 0.44, both below the maximum values specified in 90.1. The maximum allowed U-value is 1.17, and SHGC is 0.49.

HVAC Systems

The building has been evaluated using section 6 of 90.1, which focuses on heating and cooling systems for buildings. Because the Barshinger LS&P Building is more than 2 stories high and over 25,000 square feet, the building must meet the Mandatory Provisions (6.4) and Prescriptive Paths (6.5) sections.

All Outdoor Air streams and Exhaust Air streams contain one glycol-based runaround heat exchanger loop with 67% effectiveness (by specifications). These are provided to allow some sensible energy recovery from the enormous amounts of exhaust air being taken from the building through all the labs. Since these are centralized exhausts controlled by duct pressure sensors, energy recovery is made easier. Each of the three exhaust units is associated with the same floor areas of the building as one specific air handling unit, and the exhaust unit's recovered energy is taken to that air handler's makeup/ventilation airstream. This covers the energy recovery in section 6.5.6.1 for the 100% OA AHU-3, and is also used for AHU-1 and AHU-2 to provide some energy savings, since those air handlers serve many lab spaces laden with exhaust hoods/systems.

All lab exhaust hoods are controlled by a variable-volume damper with pressure-independent controls and a sash to limit airflow when the hood is not in use.

The building's air handlers also provide for use of an economizer (in AHU-1 and AHU-2), as required by 90.1 for buildings in climate zone 5A. An air bypass around the heat-recovery coils is provided, mostly for fan energy savings. The recovery loop pumps are shut down during economizer operation, adding small additional energy savings to the system.

All supply ductwork is insulated with R-6 insulation to prevent any drift in supply temperature, even though the insulation is not required for energy conservation purposes. All ductwork is located in the ceiling plenums, except for a few short segments of ductwork outdoors, for connection to the rooftop AHUs. These rooftop-mounted AHUs are in an enclosed insulated housing, within an accessible insulated enclosure, accessible from the roof surface.

All zone controls are set to minimize cool supply airflow before the reheat valves (where applicable) are allowed to open. This prevents a great deal of energy waste during "normal" occupation. However, during heavy use of laboratories, especially the exhaust systems, the full supply flow must be maintained to the room, and the reheat valve is allowed to open to keep the room somewhat close to design conditions. Some variation is allowed to save some energy on the reheat units, but they are still allowed to operate.

The boilers in the Central Utilities Plant (natural gas) operate during the winter to provide heating, water heating, and humidification for the building. During the summer, this central plant is shut down, and a summer steam boiler is provided on the roof of the LS&P Building for water heating, and reheat operation. This boiler lists as a gas burner input of 3392MBH, and a

net output of 2120MBH. This 63% efficient boiler is not up to the efficiency standards set forth in 90.1 for boilers. The central plant boilers are being refurbished and rebuilt due to their great age (one is original to the building/campus, from 1932), and efficiencies are not available at this time.

There are four chillers serving multiple loads on a "central chilled water loop" in parts of campus located in the Central Plant. One of these chillers is listed as serving the North Loop, but currently only serves the LS&P Building. Future extension is planned for the North Loop, but those extensions will wait for more building project funds. The chiller serving the new building has a rated capacity COP of 6.21, above the 5.86 required by 90.1.

All supply and return (where applicable) piping (Domestic Hot, Domestic Cold, Chilled Water, Heating Water, and Fuel Oil) is insulated with 1" minimum insulation, which covers all bases for minimum pipe insulation for 90.1. Some of the larger lines (heating water, chilled water) are insulated with 1-1/2" insulation because of temperature drift concerns. All Steam piping in the basement has R-6 insulation, above the R-4 required by 90.1.

Service Water Heating

The Barshinger LS&P Building has two steam-driven service water heaters. These heat a constantly circulating loop of water for the building. Water flows from these heating vessels to a 250 gallon storage tank (R-15 insulation), then throughout the DHWS piping in the building. Returns are then taken from the ends of hot water runs at the third floor back to the DCW inlet to the steam heating units.

Since the boiler data for the main Central Plant (CUP) boilers is not available, no determination can be made on their efficiency. During summer months, the system is in violation because of the low efficiency of the building's summer boiler. All piping and storage and heating vessels are insulated by the plumbing contractor to the standards set in 90.1.

Power

All feeders and branch circuits are designed with a maximum voltage drop of 2% and 3% respectively as specified in Section 8 of 90.1.

Lighting

Section 9 of 90.1 covers lighting systems within buildings. All of the LS&P Building has dual-use occupant sensors (for lighting control and security system motion detection) for all offices, labs, corridors, and other intermittent-use spaces, in addition to traditional switches and dimmers provided at doors. The Building Area Method was used to calculate the lighting density for the building, as summarized by the table below.

Building Lighting		
SF	W lights	W / SF
84,762	164,887	1.945

The building is a School/University building, limited to 1.2W/SF. The building is 62% over the maximum allowed power for lighting, which amounts to 63.1kW. The LS&P Building does not meet the lighting power density portion of 90.1-2004. For a detailed space-by-space breakdown, see Appendices 2, 3, and 4.

Other Equipment (Electric Motor Efficiency)

After looking at the detailed breakdowns of all electric motors used on all pumps, fans, and other equipment, every single one meets or exceeds the specifications in table 10.8 in Section 10 of Standard 90.1.

Lost "Rentable" Space

Mechanical and Electrical equipment takes up space. Period. No architect or building owner/manager likes to give up this precious area that can earn them thousands of dollars in rent or fees. An efficient layout is needed to allow all necessary equipment to fit in the space allowed, but not to take up too much room. The Barshinger LS&P Building has two electrical rooms and two telecom rooms on each floor for electrical and teledata distribution, and many shaft spaces for plumbing and ductwork distribution networks. The table below summarizes this "lost" space.

Space Type	**Area (SF)**	**% of Total**
Gross Building (interior)	96,500	100.0%
Mech./Elec./Telecom Rooms	5,058	5.2%
Shaft Spaces (all)	1,065	1.1%
Total Lost Space	**6,123**	**6.3%**

Most of the lost space is from the rooms, not all the shaft penetrations. The vast majority of this area (3650 / 5058 – 72%) comes from the three main mechanical and electrical rooms located in the basement. Using the roof for summer boiler and AHU placement helps with keeping building interior impact low. Also, using the centrally-located chillers and boilers helps to reduce "lost" floor area to a minimal 6.3%.

Mechanical System First Cost

Holly Green from Turner Construction provided a detailed breakdown of the construction bid costs for the LS&P Building. The entire building's cost was originally estimated at $40M, and $7.7M was budgeted for piping/plumbing systems, sheet metal ductwork, chillers, cooling towers, the building automation system, and testing/balancing of the entire system. The whole (gross) building costs came to $384.62/SF for the 104,000 gross SF building, and $74.08 was spent per square foot for the mechanical system's first costs, making up about 19.26% of the total building cost.

Annual Energy Consumption / Operating Costs

No Energy Consumption data was available from F&M College since the LS&P Building is not metered separately from the rest of the campus. An energy analysis was apparently performed, but no results could be obtained from EYP after inquiry.

Design Outdoor conditions are listed on the Air Handler schedule. The summer design condition is 92°F DB / 78°F WB, and winter design condition is 0°F. This was used in the building energy model that was created in Carrier's Hourly Analysis Program (HAP 4.34). Because of the program's limitations, a calculated summary cannot be output when the actual occupancy and lighting schedule is put into the model. All the program will output is the amount of energy that the system will use to fulfill the loads scheduled.

All lighting was assumed to be on at an 80% level during occupied hours (6am-6pm), and the occupied/unoccupied comfort setpoints were also put into the program (72/85 for cooling, and 70/65 for heating). Laboratory spaces are to be maintained at setpoints 24/7, so their thermostat schedules indicated this. Lighting in the vivarium is kept to a minimum during the night, but certain fixtures remain on with red-colored lights. This is to keep the animals (used to moonlight) accustomed to some small level of nighttime lighting. Occupants were scheduled in the spaces from 6a-6p, with a reduced number from 6-9am and from 4-6pm, and based on the number of available seats, desks, and observed quantities of people. This is, I believe, an accurate representation of the loads seen in the spaces. After multiple site visits, the model is the best non-numerical-analysis method of computing the loads that can be created with limited software abilities.

The energy consumption of the building was estimated as follows.

	Annual Cost ($)	Annual Cost / SF ($/SF)
Electricity	$178,339	$1.71
Natural Gas	$15,583	$0.15
Total	$193,922	$1.86

This seems a bit high to me, and to some of the facilities staff at F&M. Unfortunately, since the building is not metered separately from the rest of campus, there is no way to check this data against how the building actually performs. Also, there isn't a second model check against the results of the EYP energy model.

The building receives power from Philadelphia Power & Light (PPL), as does the rest of the F&M Campus. The best estimate received from PPL on power rates is for schedule LP-4 (12.5 kV service). There is a minimum 25kW charge rate, with an approximate energy cost of $0.038 per kWh, and a demand charge of $4.107 per kW of all billing kW. The demand rate is constant for the 2007 year, and the energy cost is approximated as the center of the usage (200 kWh mark) band. Natural gas is provided through the campus' system, and no cost data is available on that. For use in the estimating software, a cost of $0.90 / Therm (100,000 Btu) was used.

Each Air Handler is listed below as it was input into HAP. HAP only calculated the amount of energy used and taken to complete these tasks; it was not set up to size each element.

	Total Airflow (cfm)	Ventilation Airflow (cfm)	Design discharge temp (°F)
AHU-1	51,400	26,400	51.2
AHU-2	52,100	27,800	51.2
AHU-3	13,800	13,800	51.5

The cooling only lists as $0.326/ SF*year in the summary sheets provided at the end of the HAP simulation. This seems unusually low, even with an efficient chiller and tower design. Also, the design simulation shows that the central heating coil is never needed at any point during the year. This seems absurd. I have visited the building in November, and saw that the main heating coil in the air handler was in use. That was on a day when it was only in the mid forties outside. The reheat coil loads seem extremely high, but would be much lower if the main coil was operational.

One difficult thing to model is the exhaust from all the lab hoods. We can assume that they're fully exhausting all the time, but that would be extremely inaccurate. An estimate was used that put them all exhausting half their full-flow rate for the entire "occupied" time of day. This is set up in the ventilation air rate at each of the two main air handlers. AHU/EAHU-3 is operational 24/7 to provide a continuous supply of fresh air for the animals in the vivarium. During actual operation, as more lab hoods are exhausting, the OA rate at the main AHU will increase, calling for more heating at the central coil. This was not a capability of HAP. For a full breakdown, please see the summary sheets attached at the end of the report.

Appendix 1

LEED for New Construction v2.2
Registered Project Checklist

Project Name: Ann & Richard Barshinger Life Science & Philosophy Building
Project Address: Franklin & Marshall College, Lancaster Pennsylvania

Yes	?	No			
3		**11**	**Sustainable Sites**		**14 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
1			Credit 1	**Site Selection**	1
		1	Credit 2	**Development Density & Community Connectivity**	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**, Low-Emitting & Fuel-Efficient Vehicles	1
1			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
		1	Credit 5.1	**Site Development,** Protect or Restore Habitat	1
		1	Credit 5.2	**Site Development,** Maximize Open Space	1
		1	Credit 6.1	**Stormwater Design,** Quantity Control	1
		1	Credit 6.2	**Stormwater Design,** Quality Control	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

Yes	?	No			
1		**4**	**Water Efficiency**		**5 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

		17	**Energy & Atmosphere**		**17 Points**
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y	**N**	**N**	Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

		10	Credit 1	**Optimize Energy Performance**	1 to 10
				10.5% New Buildings or 3.5% Existing Building Renovations	1
				14% New Buildings or 7% Existing Building Renovations	2
				17.5% New Buildings or 10.5% Existing Building Renovations	3
				21% New Buildings or 14% Existing Building Renovations	4
				24.5% New Buildings or 17.5% Existing Building Renovations	5
				28% New Buildings or 21% Existing Building Renovations	6
				31.5% New Buildings or 24.5% Existing Building Renovations	7
				35% New Buildings or 28% Existing Building Renovations	8
				38.5% New Buildings or 31.5% Existing Building Renovations	9
				42% New Buildings or 35% Existing Building Renovations	10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
				2.5% Renewable Energy	1
				7.5% Renewable Energy	2
				12.5% Renewable Energy	3
		1	Credit 3	**Enhanced Commissioning**	1
		1	Credit 4	**Enhanced Refrigerant Management**	1
		1	Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

Yes	?	No			
1		12		**Materials & Resources**	13 Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
		1	Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
		1	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
1			Credit 3.1	**Materials Reuse**, 5%	1
		1	Credit 3.2	**Materials Reuse**,10%	1
		1	Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
		1	Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
		1	Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
		1	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
		1	Credit 6	**Rapidly Renewable Materials**	1
		1	Credit 7	**Certified Wood**	1

Yes	?	No			
10		5		**Indoor Environmental Quality**	15 Points
Y	N	N	Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
		1	Credit 1	**Outdoor Air Delivery Monitoring**	1
		1	Credit 2	**Increased Ventilation**	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 & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
		1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
		1	Credit 7.2	**Thermal Comfort**, Verification	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No			
	5		**Innovation & Design Process**		**5** Points
	1		Credit 1.1	**Innovation in Design**: Provide Specific Title	1
	1		Credit 1.2	**Innovation in Design**: Provide Specific Title	1
	1		Credit 1.3	**Innovation in Design**: Provide Specific Title	1
	1		Credit 1.4	**Innovation in Design**: Provide Specific Title	1
	1		Credit 2	**LEED® Accredited Professional**	1
Yes	?	No			
15	5	49	**Project Totals** (pre-certification estimates)		**69** Points

Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

Appendix 2

ROOM #	USE / NAME	Area	W lights	W / SF
395	Animal Housing	180	350	1.94
380, 386, 376	Potting & Storage Area	832	1519	1.83
371 suite	offices, student lounge	1070	1760	1.64
374, 372, 3C-8, 3C-7	offices, corridors	580	1248	2.15
370 suite	Plant Bio Teaching Lab	1200	2040	1.70
358, 360, 362	Bio Labs & Write-up	1700	3118	1.83
364	Biology Lounge	560	702	1.25
350	faculty office	150	192	1.28
357, 355, 353, 349	Bio Labs & Write-up	1800	3268	1.82
349, 341A	Cell/Molecular Bio Lab	1280	2482	1.94
341B	Equipment Room	155	192	1.24
3C-S, M352, M354	corridors, elec. Telecom	975	2714	2.78
281	Bio Seminar Room	570	862	1.51
282	Classroom	960	1622	1.69
286	Seminar Room	570	862	1.51
284	Study / Discussion	250	306	1.22
270	Psych Lab and Observ	800	1344	1.68
262 suite	Quant Psych Labs	850	1408	1.66
258 suite	Intro Psych Teaching Lab	1350	2432	1.80
266 suite	Breakout Session rooms	650	544	0.84
250	Bio Storage	150	192	1.28
280	Loeb Gallery	850	974	1.15
271 suite	offices, student lounge	1070	1632	1.53
257, 255, 253, 251	Bio Labs & Write-up	1800	4036	2.24
249	Salt Aquatics Suite	750	720	0.96
2C-S, M252, M254	corridors, elec. Telecom	1000	2726	2.73
191	Humanities Common Rm	1200	4215	3.51
172 suite	Faculty, Department Ofc.	2800	3683	1.32
170	Phil Dept Lounge	480	536	1.12
164 suite	Office and support	775	1152	1.49
166	Tech Office	100	196	1.96
162	Control Room	175	256	1.46
171 suite	interview/work offices	2300	4350	1.89
151 suite	testing area	850	1640	1.93
150	Café support	150	352	2.35
149	Lecture Hall	1175	3528	3.00
141	Advanced Statistics	375	860	2.29
100	Atrium - S	1150	8504	7.39
1C-S, M152/154, caterer prep, storage	corridors, elec. Telecom	1900	4332	2.28
M069	Bsmt Mech Room	1750	896	0.51
67	storage	330	256	0.78
063, 061	M/W restrooms	600	912	1.52
0C-S	corridors	1120	1224	1.09
M056	elevator Mech room	80	128	1.60
		39412	76265	1.94

Appendix 3

ROOM #	USE / NAME	Az	W lights	W / sf
302	micro/dev teaching lab	1070	1986	1.86
308	digital imaging lab	575	1512	2.63
312	discussion/study alcove	100	234	2.34
311 suite	offices, student lounge	1000	1726	1.73
328, 330, 322	Bio Labs, Write-up	1600	3032	1.90
306	media (glassware) prep	280	452	1.61
304	Chemical Storage	200	192	0.96
336	3rd floor restrooms	500	976	1.95
323, 325, 327	Bio Labs, Write-up	1600	2892	1.81
341	Bio/Chem Teaching Lab	1000	1994	1.99
3C-C	central 3rd fl. hall/stair	1100	1438	1.31
3C-N, M324, M326	corridors, elec. Telecom	1325	2632	1.99
202	Intro Bio Teaching Lab	1200	2116	1.76
206	Instrument & Prep	750	512	0.68
208	Intro Bio Teaching Lab	1150	2160	1.88
210	Anatomy Teaching Lab	1050	1312	1.25
236	2nd floor restrooms	500	976	1.95
212	discussion/study alcove	100	234	2.34
211 suite	offices, student lounge	900	1402	1.56
223, 225, 227	Bio Labs, Write-up	1900	3256	1.71
241	fresh aquatics suite	625	192	0.31
245	Neuro Teaching Lab	1150	1690	1.47
2C-C	central 2nd fl. hall/stair	1100	1564	1.42
2C-N, M234, M236	corridors, elec. Telecom	1220	2772	2.27
102 suite	Psych Dept Offices	2825	3764	1.33
104	Large Seminar Room	675	1502	2.23
106	Psych Dept Lounge	600	838	1.40
112	discussion/study alcove	100	234	2.34
111 suite	offices, student lounge	1000	1666	1.67
123	classroom - GP	725	1542	2.13
136	1st floor restrooms	500	976	1.95
127 suite	Psychophysics Lab	975	1522	1.56
145	Bio Dept. Offices	350	666	1.90
149	Lecture Hall	1175	3528	3.00
100	Atrium - N	1150	8504	7.39
1C-C	central 1st fl. Hall/stair	1200	1636	1.36
1C-N, M134, M136	corridors, elec. Telecom	1000	2370	2.37
141	Advanced Statistics	375	860	2.29
M004, M011	main elec rm, fire rm	1150	960	0.83
21	field work suite	400	576	1.44
27, 25	receiving/loading dock	620	576	0.93
23	autoclave	300	576	1.92
M001	Vivarium Mech. Room	750	640	0.85
0C-N	corridors	775	578	0.75
		38640	70766	1.83

Appendix 4

ROOM #	USE / NAME	Az	W lights	W / sf
16	Animal Teaching Lab	700	1800	2.57
14	Jan. Closet, Storage	115	192	1.67
18	Cage Wash	475	384	0.81
28A, 28B	Animal Housing	190	384	2.02
28C, 28D	Animal Housing	190	384	2.02
28E, 28F	Animal Housing	190	384	2.02
044A	Animal Housing	230	480	2.09
44B	Animal Housing	250	3577	14.31
44C	Observation & Support	250	320	1.28
44D	Animal Housing	310	3577	11.54
44E	Animal Housing	320	672	2.10
54	Showers/Lockers	210	294	1.40
50	Kitchen	100	128	1.28
52	Medical/Procedure	190	384	2.02
46 suite	Animal Housing	360	768	2.13
36	Animal Housing	90	192	2.13
34	Wrire-up	100	128	1.28
32C	Animal Housing	190	288	1.52
32B	Animal Housing	190	288	1.52
32A	Animal Housing	200	288	1.44
30 suite	Animal Housing, halls	640	1408	2.20
24	Office	100	128	1.28
26	Feed/Bed Storage	110	128	1.16
22	Quarantine	110	192	1.75
0C-V	Vivarium Corridors	900	1088	1.21
		6710	17856	2.66

Appendix 5 – Carrier HAP 4.34 Summary Sheets

Monthly Simulation Results for AHU-1

Project Name: Franklin and Marshall LSandP
Prepared by: PSUAE

12/23/2007
07:06PM

Air System Simulation Results (Table 1) :

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Terminal Heating Coil Load (kBTU)	Humidifier Load (kBTU)	Supply Fan (kWh)	Return Fan (kWh)	Vent. Reclaim Device (kWh)
January	0	1666	55565	74830	10556	1267	0
February	0	7399	44732	69889	9665	1160	0
March	0	44035	34675	81458	11088	1331	0
April	0	111311	25856	38297	11206	1345	0
May	0	351033	22893	6399	12591	1511	0
June	0	582417	21062	35	13159	1579	0
July	0	722825	21286	0	14318	1718	0
August	0	705793	21503	0	13795	1655	0
September	0	511799	21758	109	12275	1473	0
October	0	217589	26919	9523	11474	1377	0
November	0	44030	39020	31755	10550	1266	0
December	0	0	57232	63378	10512	1261	0
Total	**0**	**3299898**	**392502**	**375673**	**141188**	**16943**	**0**

Air System Simulation Results (Table 2) :

Month	Lighting (kWh)	Electric Equipment (kWh)
January	52072	5803
February	47033	5242
March	52072	5803
April	50392	5616
May	52072	5803
June	50392	5616
July	52072	5803
August	52072	5803
September	50392	5616
October	52072	5803
November	50392	5616
December	52072	5803
Total	**613108**	**68328**

Monthly Simulation Results for AHU-2

Project Name: Franklin and Marshall LSandP
Prepared by: PSUAE

12/23/2007
07:09PM

Air System Simulation Results (Table 1) :

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Terminal Heating Coil Load (kBTU)	Humidifier Load (kBTU)	Supply Fan (kWh)	Return Fan (kWh)	Vent. Reclaim Device (kWh)
January	0	2707	36192	61939	11561	1387	0
February	0	8407	28873	58849	10629	1275	0
March	0	53044	21054	73331	12511	1501	0
April	0	127224	15068	32574	13053	1566	0
May	0	397412	9777	5201	14759	1771	0
June	0	647775	7097	10	15249	1830	0
July	0	800504	6245	0	16457	1975	0
August	0	785298	6623	0	16065	1928	0
September	0	578010	7873	55	14586	1750	0
October	0	256952	13537	7559	13454	1615	0
November	0	54741	22558	23356	11692	1403	0
December	0	0	38467	50381	11484	1378	0
Total	**0**	**3712074**	**213364**	**313256**	**161499**	**19380**	**0**

Air System Simulation Results (Table 2) :

Month	Lighting (kWh)	Electric Equipment (kWh)
January	59866	7440
February	54072	6720
March	59866	7440
April	57935	7200
May	59866	7440
June	57935	7200
July	59866	7440
August	59866	7440
September	57935	7200
October	59866	7440
November	57935	7200
December	59866	7440
Total	**704872**	**87600**

Monthly Simulation Results for AHU-3

Project Name: Franklin and Marshall LSandP
Prepared by: PSUAE

12/23/2007
07:09PM

Air System Simulation Results (Table 1) :

Month	Preheat Coil Load (kBTU)	Central Cooling Coil Load (kBTU)	Terminal Heating Coil Load (kBTU)	Humidifier Load (kBTU)	Supply Fan (kWh)	Vent. Reclaim Device (kWh)	Lighting (kWh)
January	0	183	3895	55321	2604	0	13285
February	0	877	3496	49302	2355	0	11999
March	0	5061	3717	42293	2631	0	13285
April	0	12890	3483	18725	2564	0	12856
May	0	53193	3433	2504	2678	0	13285
June	0	122528	3217	19	2609	0	12856
July	0	162623	3234	0	2712	0	13285
August	0	162720	3269	67	2708	0	13285
September	0	105571	3263	24	2604	0	12856
October	0	38354	3557	5501	2660	0	13285
November	0	4437	3615	21985	2544	0	12856
December	0	0	3905	50877	2602	0	13285
Total	**0**	**668436**	**42086**	**246619**	**31271**	**0**	**156420**

Air System Simulation Results (Table 2) :

Month	Electric Equipment (kWh)
January	74
February	67
March	74
April	72
May	74
June	72
July	74
August	74
September	72
October	74
November	72
December	74
Total	**876**

Annual Cost Summary

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:13PM

Table 1. Annual Costs

Component	LSand P ($)
Air System Fans	26,233
Cooling	28,014
Heating	15,630
Pumps	3,087
Cooling Tower Fans	5,383
HVAC Sub-Total	**78,348**
Lights	104,465
Electric Equipment	11,110
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	**115,574**
Grand Total	**193,922**

Table 2. Annual Cost per Unit Floor Area

Component	LSand P ($/ft²)
Air System Fans	0.305
Cooling	0.326
Heating	0.182
Pumps	0.036
Cooling Tower Fans	0.063
HVAC Sub-Total	**0.912**
Lights	1.216
Electric Equipment	0.129
Misc. Electric	0.000
Misc. Fuel Use	0.000
Non-HVAC Sub-Total	**1.345**
Grand Total	**2.258**
Gross Floor Area (ft²)	85902.0
Conditioned Floor Area (ft²)	85902.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 3. Component Cost as a Percentage of Total Cost

Component	LSand P (%)
Air System Fans	13.5
Cooling	14.4
Heating	8.1
Pumps	1.6
Cooling Tower Fans	2.8
HVAC Sub-Total	**40.4**
Lights	53.9
Electric Equipment	5.7
Misc. Electric	0.0
Misc. Fuel Use	0.0
Non-HVAC Sub-Total	**59.6**
Grand Total	**100.0**

Annual Energy and Emissions Summary

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:13PM

Table 1. Annual Costs

Component	LSand P ($)
HVAC Components	
Electric	62,765
Natural Gas	15,583
Fuel Oil	0
Propane	0
Remote HW	0
Remote Steam	0
Remote CW	0
HVAC Sub-Total	**78,348**
Non-HVAC Components	
Electric	115,574
Natural Gas	0
Fuel Oil	0
Propane	0
Remote HW	0
Remote Steam	0
Non-HVAC Sub-Total	**115,574**
Grand Total	**193,923**

Table 2. Annual Energy Consumption

Component	LSand P
HVAC Components	
Electric (kWh)	886,096
Natural Gas (Therm)	14,969
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	647,951
Remote Steam (na)	0
Remote CW (na)	0
Non-HVAC Components	
Electric (kWh)	1,631,240
Natural Gas (Therm)	0
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	0
Remote Steam (na)	0
Totals	
Electric (kWh)	2,517,336
Natural Gas (Therm)	14,969
Fuel Oil (na)	0
Propane (na)	0
Remote HW ()	647,951
Remote Steam (na)	0
Remote CW (na)	0

Table 3. Annual Emissions

Component	LSand P
CO2 (lb)	3,373,185
SO2 (kg)	0
NOx (kg)	0

Table 4. Annual Cost per Unit Floor Area

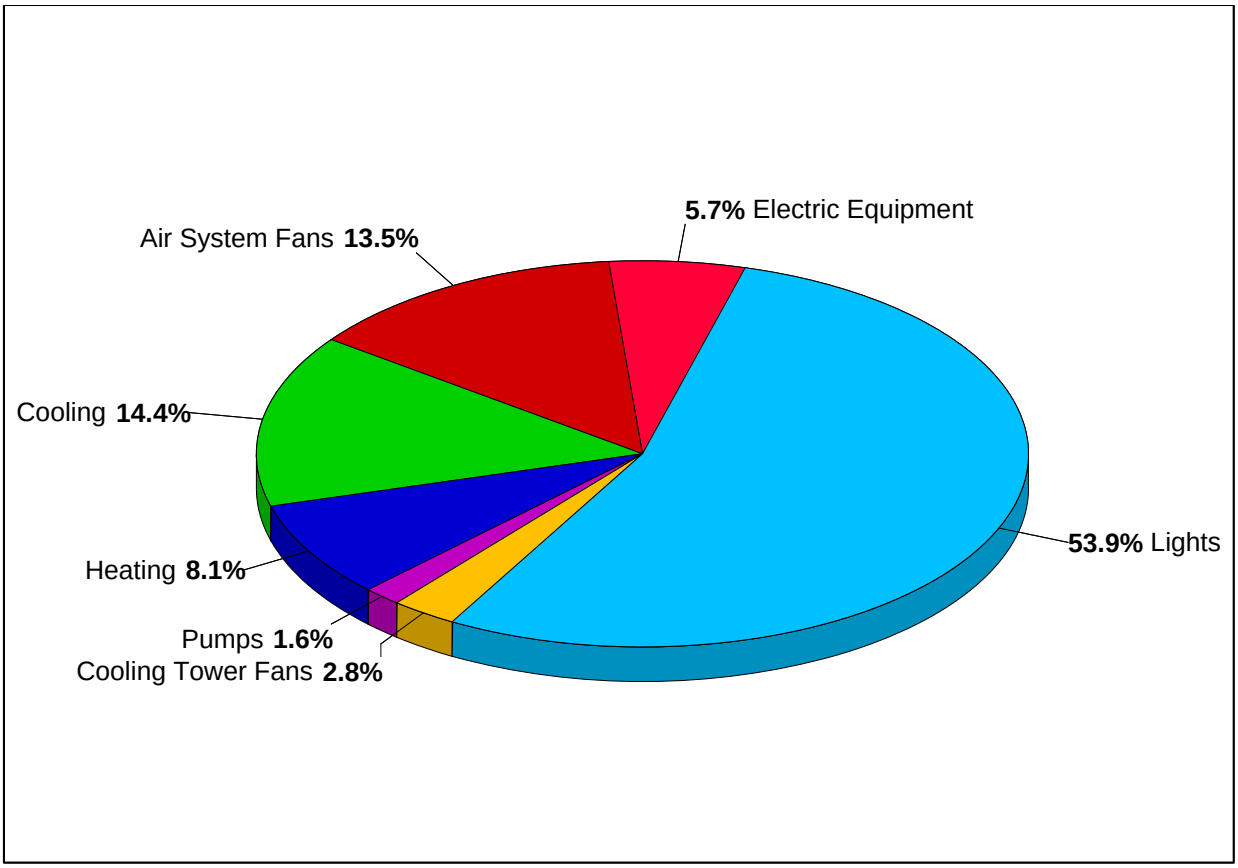
Component	LSand P ($/ft²)
HVAC Components	
Electric	0.731
Natural Gas	0.181
Fuel Oil	0.000
Propane	0.000
Remote HW	0.000
Remote Steam	0.000
Remote CW	0.000
HVAC Sub-Total	**0.912**
Non-HVAC Components	
Electric	1.345
Natural Gas	0.000
Fuel Oil	0.000
Propane	0.000
Remote HW	0.000
Remote Steam	0.000
Non-HVAC Sub-Total	**1.345**
Grand Total	**2.258**
Gross Floor Area (ft²)	85902.0
Conditioned Floor Area (ft²)	85902.0

Note: Values in this table are calculated using the Gross Floor Area.

Table 5. Component Cost as a Percentage of Total Cost

Component	LSand P (%)
HVAC Components	
Electric	32.4
Natural Gas	8.0
Fuel Oil	0.0
Propane	0.0
Remote HW	0.0
Remote Steam	0.0
Remote CW	0.0
HVAC Sub-Total	**40.4**
Non-HVAC Components	
Electric	59.6
Natural Gas	0.0
Fuel Oil	0.0
Propane	0.0
Remote HW	0.0
Remote Steam	0.0
Non-HVAC Sub-Total	**59.6**
Grand Total	**100.0**

Annual Component Costs - LSand P



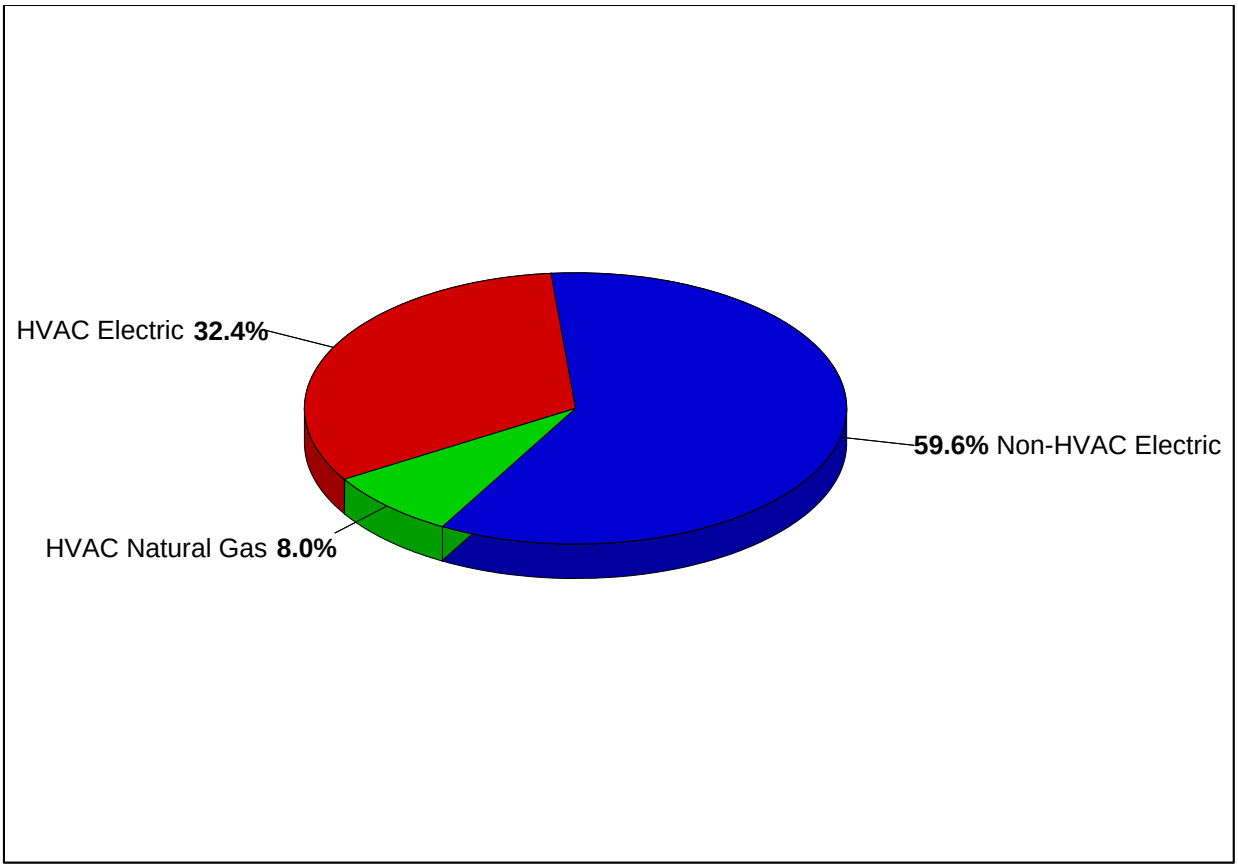
1. Annual Costs

Component	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	26,233	0.305	13.5
Cooling	28,014	0.326	14.4
Heating	15,630	0.182	8.1
Pumps	3,087	0.036	1.6
Cooling Tower Fans	5,383	0.063	2.8
HVAC Sub-Total	**78,348**	**0.912**	**40.4**
Lights	104,465	1.216	53.9
Electric Equipment	11,110	0.129	5.7
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	**115,574**	**1.345**	**59.6**
Grand Total	**193,922**	**2.258**	**100.0**

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area ..... **85902.0** ft²
Conditioned Floor Area ..... **85902.0** ft²

Annual Energy Costs - LSand P



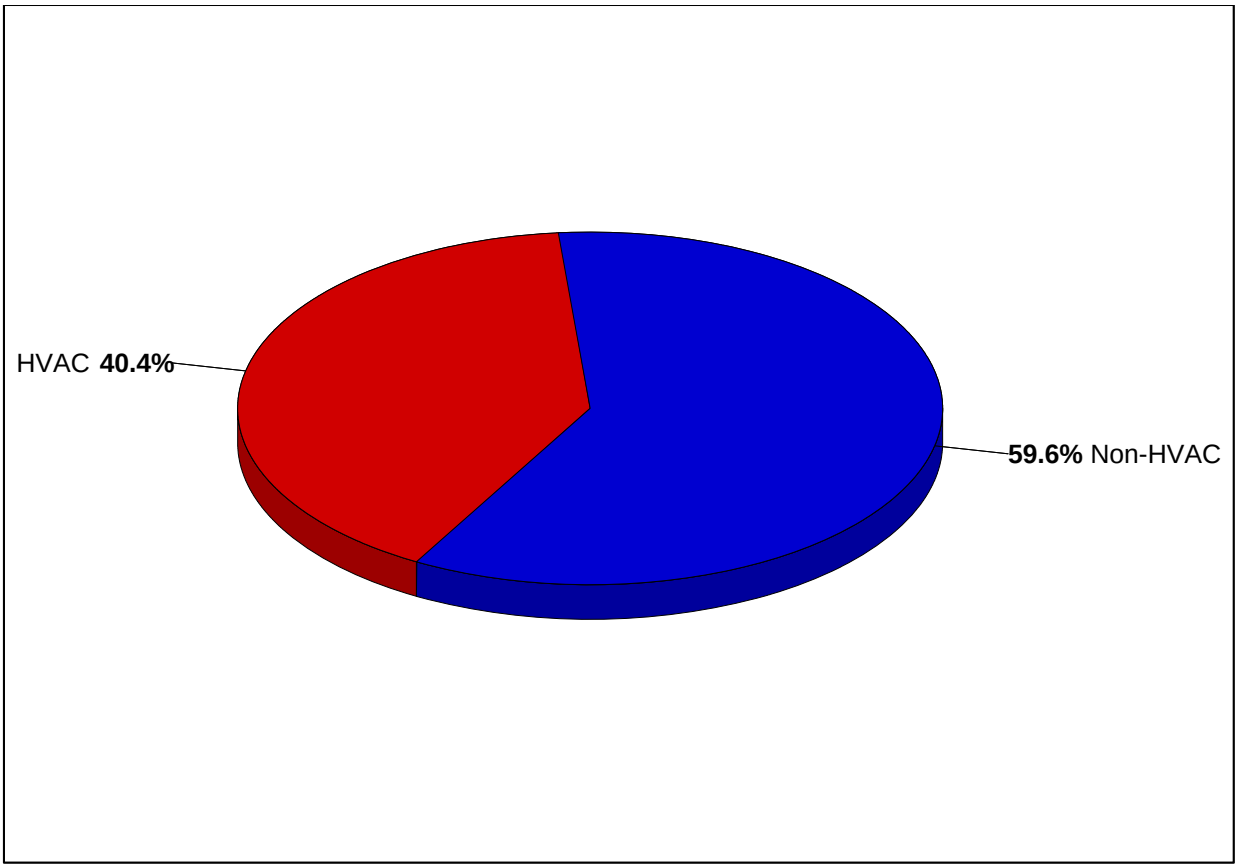
1. Annual Costs

Component	Annual Cost ($/yr)	($/ft²)	Percent of Total (%)
HVAC Components			
Electric	62,765	0.731	32.4
Natural Gas	15,583	0.181	8.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Remote Chilled Water	0	0.000	0.0
HVAC Sub-Total	**78,348**	**0.912**	**40.4**
Non-HVAC Components			
Electric	115,574	1.345	59.6
Natural Gas	0	0.000	0.0
Fuel Oil	0	0.000	0.0
Propane	0	0.000	0.0
Remote Hot Water	0	0.000	0.0
Remote Steam	0	0.000	0.0
Non-HVAC Sub-Total	**115,574**	**1.345**	**59.6**
Grand Total	**193,923**	**2.258**	**100.0**

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area ..... **85902.0** ft²
Conditioned Floor Area ..... **85902.0** ft²

Annual HVAC & Non-HVAC Cost Totals - LSand P



1. Annual Costs

Component	Annual Cost ($/yr)	($/ft²)	Percent of Total (%)
HVAC	78,348	0.912	40.4
Non-HVAC	115,574	1.345	59.6
Grand Total	**193,922**	**2.258**	**100.0**

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area ..... **85902.0** ft²
Conditioned Floor Area ..... **85902.0** ft²

Energy Budget by System Component - LSand P

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:13PM

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	7,680,407	89.409
Heating Coil Loads	1,583,499	18.434
Grand Total	**9,263,906**	**107.843**

2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	1,263,399	14.707	3,715,880	43.257
Cooling	1,349,616	15.711	3,969,459	46.209
Heating	2,147,087	24.995	2,151,471	25.046
Pumps	148,729	1.731	437,440	5.092
Cooling Towers	259,348	3.019	762,788	8.880
HVAC Sub-Total	**5,168,180**	**60.164**	**11,037,038**	**128.484**
Lights	5,030,769	58.564	14,796,381	172.247
Electric Equipment	535,012	6.228	1,573,566	18.318
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**5,565,781**	**64.792**	**16,369,947**	**190.565**
Grand Total	**10,733,960**	**124.956**	**27,406,984**	**319.049**

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 (34.0%).
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 ..... **85902.0** ft²
   Conditioned Floor Area ..... **85902.0** ft²

Energy Budget by Energy Source - LSand P

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:13PM

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	7,680,407	89.409
Heating Coil Loads	1,583,499	18.434
Grand Total	**9,263,906**	**107.843**

2. Energy Consumption by Energy Source

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
HVAC Components				
Electric	3,023,360	35.196	8,892,236	103.516
Natural Gas	1,496,878	17.425	1,496,878	17.425
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	647,951	7.543	647,951	7.543
Remote Steam	0	0.000	0	0.000
Remote Chilled Water	0	0.000	0	0.000
HVAC Sub-Total	**5,168,189**	**60.164**	**11,037,065**	**128.484**
Non-HVAC Components				
Electric	5,565,789	64.792	16,369,966	190.566
Natural Gas	0	0.000	0	0.000
Fuel Oil	0	0.000	0	0.000
Propane	0	0.000	0	0.000
Remote Hot Water	0	0.000	0	0.000
Remote Steam	0	0.000	0	0.000
Non-HVAC Sub-Total	**5,565,789**	**64.792**	**16,369,966**	**190.566**
Grand Total	**10,733,978**	**124.956**	**27,407,031**	**319.050**

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 (34.0%).
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 ..... **85902.0** ft²
   Conditioned Floor Area ..... **85902.0** ft²

Monthly Simulation Results for LSandP

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:11PM

Plant Simulation Results (Table 1) :

Month	Cooling Coil Load (kBTU)	Plant Load (kBTU)	Chiller Output (kBTU)	Chiller Input (kWh)	Primary Chilled Water Pump (kWh)	Secondary Chilled Water Pump (kWh)	Condenser Water Pump (kWh)
January	4556	4556	4556	340	0	0	48
February	16683	16683	16683	1122	0	0	155
March	102140	102140	102140	6868	0	0	939
April	251425	251425	251425	16709	0	0	2288
May	801638	801638	801638	46951	0	0	6063
June	1352719	1352719	1352719	66685	0	0	7119
July	1685952	1685952	1685952	79159	0	0	7682
August	1653810	1653810	1653810	78599	0	0	7604
September	1195381	1195381	1195381	61959	0	0	6970
October	512894	512894	512894	30134	0	0	3751
November	103208	103208	103208	7022	0	0	972
December	0	0	0	0	0	0	0
Total	**7680406**	**7680406**	**7680406**	**395550**	**0**	**0**	**43590**

Plant Simulation Results (Table 2) :

Month	Cooling Tower Fan (kWh)
January	17
February	169
March	724
April	1721
May	8211
June	14155
July	16918
August	15653
September	12619
October	4834
November	989
December	0
Total	**76011**

Monthly Simulation Results for LSandP heat

Franklin and Marshall LSandP
PSUAE

12/23/2007
07:12PM

Plant Simulation Results (Table 1) :

Month	Heating Coil Load (kBTU)	Plant Load (kBTU)	Boiler Output (kBTU)	Boiler Input (kBTU)	Boiler Misc. Electric (kWh)
January	192090	192090	192090	307344	136
February	178040	178040	178040	284865	126
March	197083	197083	197083	315332	139
April	89596	89596	89596	143353	63
May	14105	14105	14105	22568	10
June	65	65	65	104	0
July	0	0	0	0	0
August	67	67	67	107	0
September	188	188	188	300	0
October	22583	22583	22583	36133	16
November	77096	77096	77096	123353	55
December	164636	164636	164636	263418	116
Total	**935548**	**935548**	**935548**	**1496878**	**662**

Monthly Simulation Results for Sample Plant

Plant Simulation Results (Table 1) :

Month	Heating Coil Load (kBTU)	Remote Hot Water Load (kBTU)	Secondary Hot Water Pump (kWh)
January	95652	95652	0
February	77100	77100	0
March	59446	59446	0
April	44407	44407	0
May	36103	36103	0
June	31377	31377	0
July	30766	30766	0
August	31396	31396	0
September	32894	32894	0
October	44012	44012	0
November	65193	65193	0
December	99603	99603	0
Total	**647951**	**647951**	**0**