Energy Assessment Report

Whitemarsh Township Municipal Building

616 Germantown Pike, Lafayette Hill, PA 19444

Prepared For:

Whitemarsh Township

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practical energy solutions

practical energy solutions

101 e. evans street, suite 2, west chester, pa 19380

t.610.430.1382 f.610.430.1375 www.practicalenergy.net

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Executive Summary

Practical Energy Solutions (PES) performed an energy assessment of the Whitemarsh Township administration building on June 27, 2013. The goal was to identify cost-effective energy conservation measures (ECMs), both capital and operational, that will help reduce ongoing energy costs.

From July 2012 – June 2013, Whitemarsh Township spent $60,374 on energy for this facility. Approximately 96% ($58,121) was for electricity; 4% ($2,253) was for natural gas. The building has an energy use intensity (EUI) – a measure of whole-building energy performance – of **108** kBtu/sf, significantly higher than the median score of 76 for similar local buildings. This EUI indicates clear opportunities for saving energy in this building.

PES identified opportunities for total energy savings of more than $16,000 annually, or 27% of the facility's total energy costs, associated with the HVAC system, roofing, and interior lighting systems (Table 1). These energy savings will also reduce harmful CO_2 emissions by more than 215,000 pounds per year. Whitemarsh Township has begun to address the aging HVAC system and roofing, and this report provides guidance to ensure implementation of cost-effective high-efficiency solutions.

Table 1: Summary of Recommendations

#	Measure Description	Annual Energy Savings		Energy Cost Savings [$/yr]	Est. Premium Cost*	Premium Payback [yrs]*	% Energy Cost Savings	CO_2 Savings [lbs]	Savings Over Rated Life of System^
		kWh	ccf						
1	High Efficiency Water-Source Heat Pump System	96,110	46	$ 9,030	$ 31,968	3.5	15%	121,652	$ 103,848
2	Replace and Upgrade Roof Insulation	13,073	311	$ 1,578	$ 19,565	12.4	3%	20,233	$ 19,877
#	Measure Description	Annual Energy Savings		Energy Cost Savings [$/yr]	Est. Project Cost	Project Payback [yrs]	% Energy Cost Savings	CO_2 Savings [lbs]	Savings Over Rated Life of System^
		kWh	ccf						
3	High Efficiency Interior Lighting	58,735	-	$ 5,487	$ 20,151	3.7	9%	74,006	$ 45,538
	TOTALS	**167,918**	**357**	**$ 16,094**	**$ 71,683**	**4.5**	**27%**	**215,891**	**$ 169,264**

**The estimated premium cost for measure 1 is the incremental cost between new standard efficiency equipment and new high-efficiency equipment, not total project cost. Similarly, the estimated premium cost for measure 2 is the cost to purchase and install the roof insulation only, and is not the entire roof replacement project cost. Paybacks shown for these two measures are based on these premium costs only, to show how quickly this additional investment in high-efficiency equipment and materials will pay off.*

Savings are based on current energy prices and will increase as energy prices rise.

Building Description

The Whitemarsh Township municipal building (approx. 21,500 ft^2) comprises administrative offices, council meeting rooms, and a police department; a bank occupies the northeast corner of the facility and was not included in this assessment (see Figure 1 below). The brick masonry building is at least 80 years old and has undergone several renovations in its history. Whitemarsh Township moved into the building in the 1980s and performed extensive renovations including the current HVAC system.

The offices have normal business hours (45 hours per week), whereas the council and caucus chambers are typically vacant, with scheduled meetings once or twice per week. The police department may be occupied by one or more officers at any time and is considered a 24-hour use area, although many areas are typically vacant.

Figure 1: Whitemarsh Township Building, Aerial View *(© 2013 Google Earth)*

Energy Consumption & End-Uses

Utility Summary

Whitemarsh Township spent $60,374 on energy from July 2012 – June 2013. Approximately 96% ($58,121) of the energy cost was for electricity, and 4% ($2,253) was for natural gas (Table 2).

Table 2: Annual Utility Consumption + Costs (7/2012 - 6/2013)

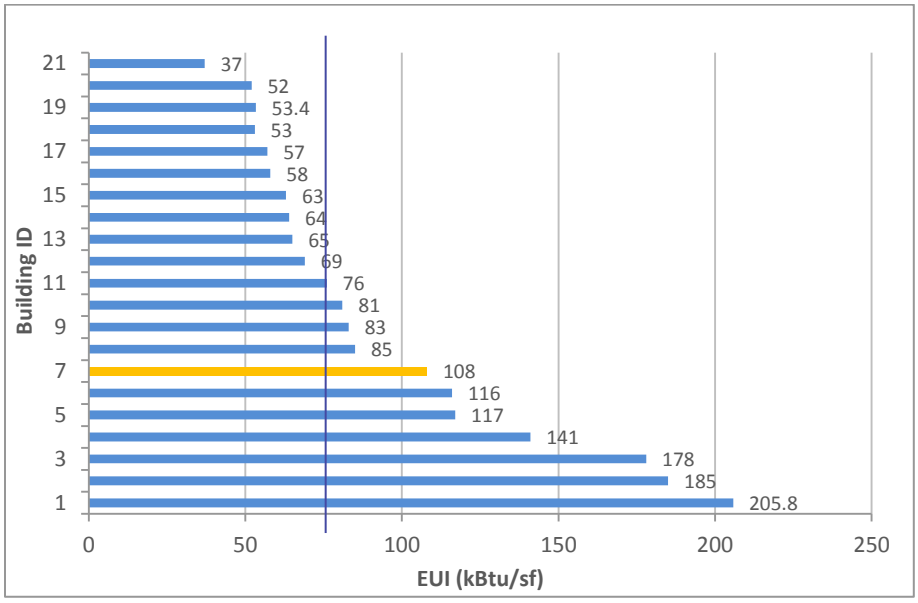
Utility	Units	Avg. Rate	Cost
Electricity	622,200 kWh	$ 0.093	$ 58,121
Natural Gas	1,965 ccf	$ 1.147	$ 2,253
		TOTAL	$ 60,374

Energy Use Intensity (EUI) Benchmark

The Energy Use Intensity (EUI) is the ratio of total energy consumed – including both electricity and natural gas – to gross floor area. The EUI provides a benchmark of whole-building energy performance that can be compared to similar facilities in the region.

This facility's EUI is 108 kBtu/ft^2 for the 12-month period shown above, approximately 42% higher than the median score of 76 for similar local municipal buildings with shared administration and police departments (Figure 2).

Figure 2: EUI Scores (kBtu/sf) for Shared Municipal Admin/Police Facilities in Philadelphia Suburbs

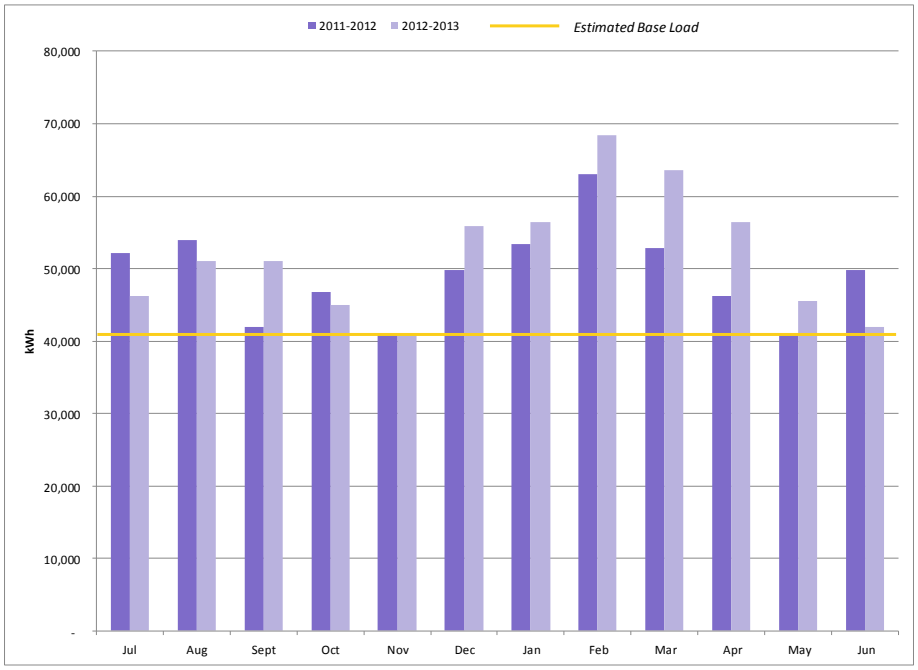


Electricity Consumption

Figure 3 shows monthly electricity use for the 24 months spanning July 2011 - June 2013. The usage pattern shows elevated consumption during both the winter heating season and summer cooling season due to the facility's electric water-source heat pump system. However, the winter peak is significantly higher than the summer peak and may be due in part to personal electric space heaters.

This facility's electric "base load" – which typically includes all non-HVAC energy consumption such as lights, office equipment, fans, and pumps – is approximately 79% of the annual electricity consumption. A high baseload is typical of 24-hour use areas where lights are left on and rooms are conditioned at occupied setpoints for 24/7 use. Finding ways to reduce energy consumption in vacant 24-hour use areas will significantly reduce energy consumption and reduce the EUI score.

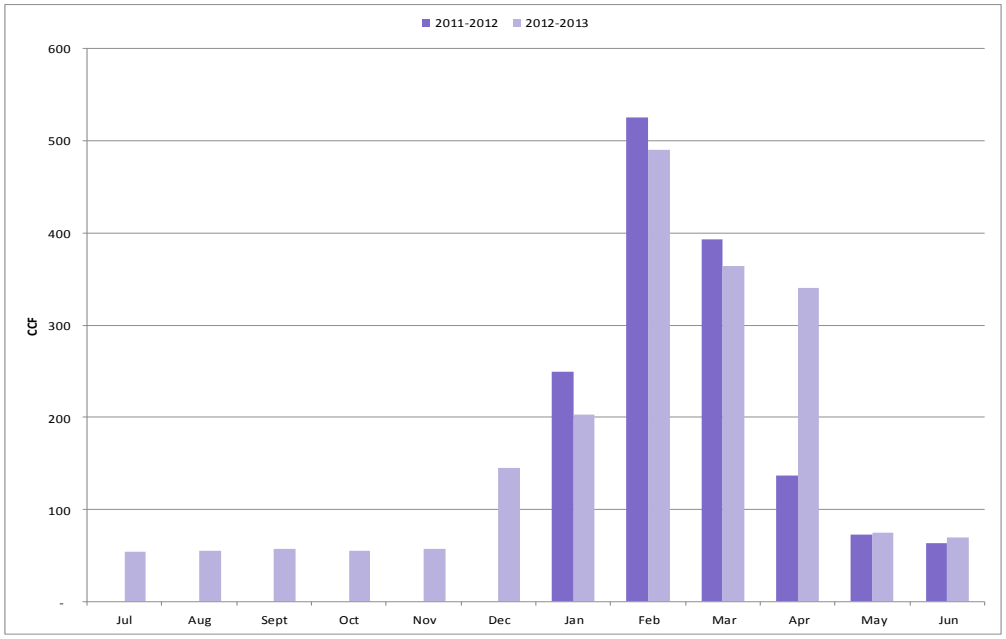
Figure 3: Monthly Electricity Consumption (kWh), 24 Months (7/2012 - 6/2013)



Natural Gas Consumption

The monthly natural gas consumption trend (Figure 4) is typical of space heating, with a small amount of summertime use for domestic water heating.

Figure 4: Monthly Natural Gas Consumption (ccf), 24 Months (7/2012 - 6/2013)



Energy End Uses

To determine the best opportunities for energy savings, it is important to understand how the various building systems consume energy. PES developed a breakdown of energy "end-uses" (i.e., lighting, HVAC, etc.) based on historical utility consumption and our site walkthrough. Figure 5 and Figure 6 show the percentage of total utility consumption for the major electric and natural gas end uses.

Figure 5: Electricity End-Uses[1]

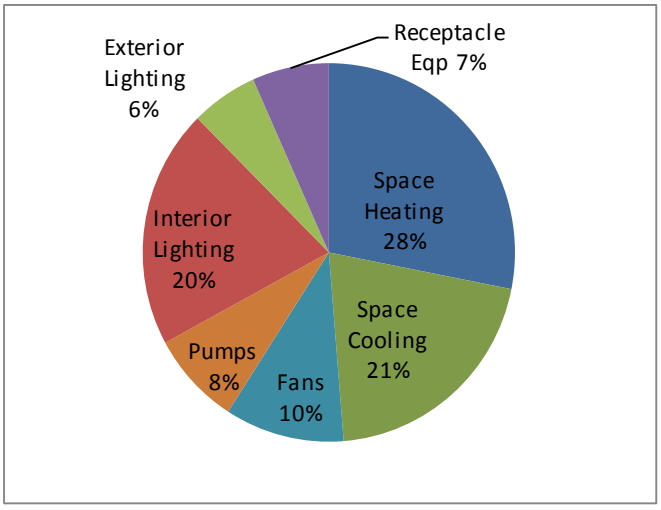
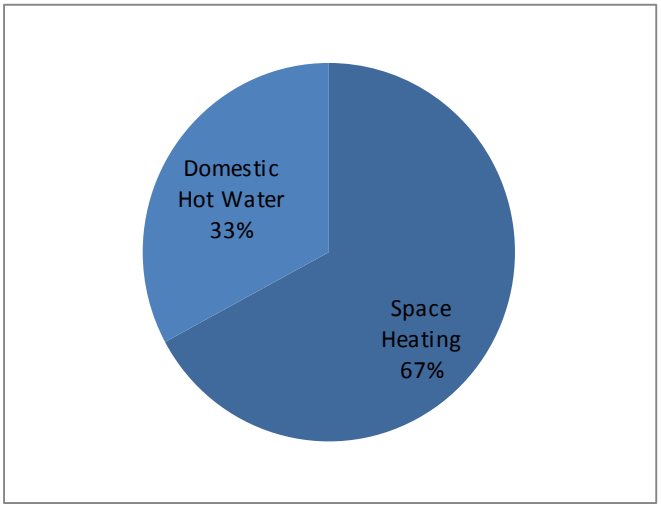


Figure 6: Natural Gas End-Uses



[1]Receptacle equipment includes office equipment such as computers and printers and any non-hardwired "plug" loads.

Existing Conditions

HVAC

A water-source heat pump system provides heating and cooling to the majority of the building. The system comprises approximately 35 *ClimateMaster HS* series water-to-air heat pumps ranging in capacity from 12 MBH to 60 MBH, a *Lochinvar PBN1000* hot water boiler (880 MBH output, rated 88% E_T[2]), and an *Evapco LSWA-41B* cooling tower. Appendix A contains an HVAC inventory.

Many of the HVAC components have exceeded their typical service lives,[3] and Whitemarsh Township has issued and awarded a bid for a one-to-one replacement of the existing HVAC system – including the cooling tower, natural gas boiler, condenser water pumps, water-source heat pumps, air handlers, and exhaust fans. This project offers an opportunity to ensure that the upgrades are properly sized, well controlled, and offer high operating efficiency. Proper sizing and control will help ensure occupant comfort, and high efficiency will reduce the township's energy costs over time due to lower energy consumption. This is important, since HVAC systems have a long service life of 15 years or more and are expensive to operate.

Currently, temperature setpoints during occupied hours appear to be controlled via digital, nonprogrammable thermostats throughout the facility. According to the HVC contractor, a central control enables uniform, facility-wide setbacks at night and on weekends.

Lighting

Interior lighting is primarily recessed fluorescent troffers in 2'x2' U-bent and 2'x4' linear configurations, and most fluorescent lamps are energy-efficient T-8s. Compact fluorescent lamps (CFLs) are installed in recessed high-hat cans and wall sconces, and incandescent bulbs remain in the lobby chandelier, high-hat cans in the police department, and a number of wall sconces. Exterior lighting consists of parking lot and walkway pole lights (250W mercury vapor) and wall packs (150W high pressure sodium).

Building Envelope

The building envelope (exterior walls, roofs, windows, and doors) plays a significant role in the heating and cooling performance of any conditioned building. Any opportunities to improve insulation, increase air-tightness, or reduce unwanted solar heat gain through windows will result in energy savings.

Walls

The exterior walls are brick masonry construction and appear to be in good condition.

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[2] E_T = Thermal Efficiency

[3] Heat pump = 15 years (PA PUC Technical Reference Manual). Gas boiler = 25 years (PGW TRM)

Roof

The roof has both flat and pitched sections. The flat sections of the existing roof (approx. 19,371 ft^2) are in poor condition and in need of replacement. The existing roof likely has no more than 1/2" of rigid insulation above the roof deck, and interior foil-faced batt insulation adhered to the ceiling appears to have significant water damage in many areas (Figure 7). Moisture can compress the batt insulation and inhibit insulation performance; this can also promote mold growth on neighboring surfaces. Whitemarsh Township has already issued a bid specification for replacing the flat roof sections, and this is critical to prevent further leaks.

Figure 7: Ceiling Leak in Lobby of Police Area

Windows

Windows in the office and police areas are double-paned, wood-framed units with internal metal shades; many of the frames are in poor condition or have been patched recently (Figure 8). These windows should be considered for replacement due to their age, poor frame condition, and poor thermal performance.

Figure 8: Window with Frame Damage

The large windows in the council meeting and conference rooms are also double-paned, wood-framed units, and they appear to be in relatively good condition. Whitemarsh Township should consider installing insulated shades on these windows to reduce solar heat gain and improve comfort during the cooling season; however, this is not likely to be cost-effective based on energy savings alone.

Window replacements and insulated shade installation are both unlikely to be cost-effective from an energy savings perspective, and are therefore not discussed further in this report. However, these measures can improve occupant comfort and, when replacements are necessary due to age or condition, energy-efficiency should be part of the selection criteria.

Domestic Hot Water (DHW)

The domestic hot water system is composed of an *A.O. Smith HW-120M* natural gas water heater (120 MBH, 116 gph recovery) and a *Lochinvar RJA120* hot water storage tank (119 gallons). A small recirculation pump ensures that hot water is available on demand throughout the building, and a second small circulator conveys hot water from the DHW generator to the storage tank.

Energy Conservation Measures (ECMs)

ECM-01: Renovate HVAC System with Focus on Efficiency

To maximize energy efficiency, PES recommends that the new water-source heat pump system include the following features:

1. *High efficiency or ultra-high efficiency heat pumps* rather than standard efficiency units.[4]
2. *High efficiency modulating boiler* capable of low-temperature operation equal to or better than the existing *Lochinvar Power-Fin* boiler (87% E_T or better). Importantly, the existing boiler has a relatively high efficiency. Replacing it with a new standard-efficiency boiler (80% E_T) would reduce energy efficiency and increase energy consumption.
3. *Variable frequency or variable speed drives* for the condenser water pumps and cooling tower fan so this equipment can precisely match power output to load conditions.

Temperature setbacks during nights and weekends in police offices, which are frequently vacant during these hours (to be implemented on a trial basis).

Table 3 shows the estimated energy savings and premium cost differences between the existing equipment, new equipment with the current contractor-specified efficiencies, and a new high-efficiency system with the components specified above. Table 3 also shows that, while the high-efficiency system will cost approximately $32,000 more to install, it will save an additional $9,000 per year in energy costs. Over the 15-year life of the system, the high-efficiency option will save

[4] "Standard Efficiency" = 12.0 EER/4.2 COP as per ASHRAE 90.1-2007; "High Efficiency" = ~16.5 EER/~5.5 COP based on ClimateMaster TS series (weighted average efficiencies)

Whitemarsh more than $100,000 in operational costs vs. the current contractor-specified efficiencies.

Table 3: Energy Savings and Cost of Specified and High Efficiency WSHP Systems vs. Existing WSHP System

System	Efficiency	Energy Savings vs. Existing		Cost Savings vs. Existing	Est. Project Cost
		kWh	ccf		
Existing WSHP System	10.2 EER 3.6 COP	-	-	$ -	$ -
Bid-Spec WSHP System	12.8 EER 4.2 COP	59,121	88	$ 5,623	$ 171,824
High Efficiency WSHP System	16.5 EER 5.5 COP	155,231	134	$ 14,654	$ 203,792
HIGH-EFFICIENCY INCREMENTAL SAVINGS		96,110	46	$ 9,030	$ 31,968

Savings reflect current energy prices and will increase as energy prices rise.
Calculations based on current boiler and cooling tower sizing; a load sizing study is strongly recommended for proper comfort and operation.

Currently, the contractor is performing a thermal load study to ensure proper equipment sizing, and PES strongly supports this. Our broad calculations suggest that the boiler may be oversized by as much as 25%. The energy and cost savings shown in Table 3 will be greater with a smaller boiler, and this will benefit Whitemarsh in lower capital costs and lower operational costs over time.

ECM-02: Replace + Increase Roof Insulation

The bid specification issued for the roof replacement includes a new EPDM membrane roof and 1/2" of polyisocyanurate (polyiso) above-deck rigid insulation (R-2.5), with an option to increase the insulation thickness to 3" (R-19). PES strongly urges that the approved project include at least 3" of above-deck polyiso insulation to meet the minimum energy code.[5] This will likely increase the project cost by approximately $20,000 and pay back in approximately 12 years due to increased energy savings (Table 5). Table shows the estimated relative energy savings and cost premium between the bid-specified 1/2" polyiso and the recommended 3" polyiso, as well as a high-efficiency option of 3-1/2" polyiso, which would further increase the roof insulation performance to approximately R-25.[6]

[5] R-20 c.i. as per ASHRAE Standard 90.1-2007
[6] R-25 c.i. as per ASHRAE Standard 189.1-2011

Table 4: Energy Savings and Cost of Roof Insulation vs. ½" Polyiso Base Bid

Insulation Depth/ R-Value	Energy Savings		Cost Savings	Premium Cost	Premium Payback [yrs]
	kWh	ccf			
3" (R-19)	13,073	311	$ 1,578	$ 19,565	12.4
3-1/2" (R-25)	15,119	359	$ 1,824	$ 35,062	19.2

Premium cost = Difference in cost compared with the bid-specified ½" polyiso.

R value = The capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power.

We also recommend removal of the existing ceiling-adhered batt insulation. With 3" of polyiso insulation, the batt insulation will no longer be needed. In addition, the insulating value of the batt is likely already compromised due to moisture, and mold/deterioration issues could occur if this wet insulation is left in place.

ECM-03: High Efficiency Interior Lighting

Interior lighting accounts for approximately 20% of this facility's electricity consumption. The majority of fixtures have already been converted to high-efficiency compact fluorescent bulbs or T-8 fluorescent tubes, but a number of opportunities for maximizing lighting energy efficiency and energy savings remain.

Specifically, Whitemarsh Township should consider implementing the following measures to improve interior lighting energy efficiency:

1. *Replace all remaining incandescent bulbs* with low-wattage-equivalent compact fluorescent or LED lamps (approx. 20 fixtures). Incandescents were found in the police department, the chandelier in the lobby near the council meeting room, and a few of the wall sconces.
2. *Install lamp-reducing retrofit kits on all 4-lamp linear fluorescent fixtures*, reducing them to two lamps per fixture (approx. 76 fixtures). Select a retrofit kit that incorporates a high-efficiency reflector, pre-wired electronic ballast and sockets, and new lenses into the existing fixture housing. Lamps in these fixtures should be replaced with low-wattage 28W T-8 lamps as they burn out. This will reduce fixture energy consumption by up to 60% while maintaining or improving light output.
3. *Install retrofit kits on all 2'x2' U-bent fluorescent fixtures*, converting them to 2-lamp 24" linear fluorescent fixtures (approx. 128 fixtures). This will reduce fixture energy consumption by up to 45% while maintaining or improving light levels.
4. *As they burn out, replace 48" T-8 lamps with low-wattage 28W T-8s*. These are typically the same price as standard 32W lamps and provide the same light output while consuming 13% less energy.
5. *Install occupancy sensors* to automatically turn off lights when rooms are vacant. These are likely to be particularly effective in bathrooms, locker rooms, and 24-hour use areas that are frequently unoccupied.

Table 5 summarizes the potential energy and cost savings, estimated project costs, and simple payback of these measures.

Table 5: Energy Savings and Cost of Interior Lighting Upgrades

Item	Existing Fixture	Proposed Fixture	Energy Savings [kWh]	Cost Savings	Project Cost	Payback [yrs]
1	Incandescent	Compact Fluorescent (CFL)	7,147	$ 668	$ 363	0.5
2	2'x4' Linear Fluor., 4-Lamp	2'x4' Linear Fluor., 2-Lamp	32,167	$ 3,005	$ 7,372	2.5
3	2'x2' U-Bent Fluor.	2'x2' Linear Fluor.	15,635	$ 1,460	$ 12,416	8.5
4	2'x4' Linear Fluor., 32W Lamps	2'x4' Linear Fluor., 28W Lamps	3,786	$ 354	$ -	-
5	Wall Switches	Occupancy Sensors	23,002	$ 2,149	$ 11,025	5.1
		TOTAL	**58,735**	**$ 5,487**	**$ 20,151**	**3.7**

Additional Recommendation

Once the new HVAC system is installed, good control of temperature setpoints is essential to ensuring efficiency and employee comfort. Temperature setpoints for the new system should be uniformly set according to a facility-wide energy management policy.

The new thermostatic controls should also be set up to ensure that all units (with the exception of the *occupied police areas*) can be set back during unoccupied times (i.e., at night and on weekends) by +/- 10° F (down in winter; up in summer).

Upon installation of the new system, PES also recommends eliminating space heaters. Heat from these portable units can prevent thermostats from engaging the heat pumps. This causes nearby spaces (without space heaters) to become cold, further worsens employee discomfort and leads to more frequent and widespread use of space heaters. This practice is costly, as it causes electricity consumption to rise.

To ensure that control is established, PES recommends performing a follow-up temperature logging study upon installation of the new units. The loggers will measure actual supply air temperatures over a 3-week period and the results will help diagnose areas of insufficient control. PES can provide a price quotation for this service.

APPENDIX A

HVAC Inventory

Desig.	Description	Make/Model	Year	Qty	Cooling				Heating			
					Capacity		Efficiency		Capacity		Efficiency	
AHU	OA AHU w/ HW			5	3.0	HP	74.4	%				
CT	CT Fan	Evapco LSWA-41B	1996?	1	15.0	HP	77.4	%				
CT-P	CT Pump	WEG 00158EP3E145JM-W22	1996?	1	1.5	HP	71.4	%				
P	CW Pumps	Baldor M3311T (motors)	1980s	2	7.5	HP	72.7	%				
B	Boiler	Lochinvar PBN1000	1996	1					880,000	Btu/h	81%	Et
WSHP-12	WSHP	ClimateMaster HS012E	1980s	1	12,000	Btu/h	9.5	EER	12,000	Btu/h	3.6	COP
WSHP-15	WSHP	ClimateMaster HS015E	1980s	5	15,000	Btu/h	9.5	EER	15,000	Btu/h	3.6	COP
WSHP-19	WSHP	ClimateMaster HS019E	1980s	7	19,000	Btu/h	10.2	EER	19,000	Btu/h	3.6	COP
WSHP-24	WSHP	ClimateMaster HS024E	1980s	7	24,000	Btu/h	10.2	EER	24,000	Btu/h	3.6	COP
WSHP-30	WSHP	ClimateMaster HS030F	1980s	5	30,000	Btu/h	10.2	EER	30,000	Btu/h	3.6	COP
WSHP-36	WSHP	ClimateMaster HS036F	1980s	2	36,000	Btu/h	10.2	EER	36,000	Btu/h	3.6	COP
WSHP-42	WSHP	ClimateMaster HS042F	1980s	3	42,000	Btu/h	10.2	EER	42,000	Btu/h	3.6	COP
WSHP-48	WSHP	ClimateMaster HS048F	1980s	3	48,000	Btu/h	10.2	EER	48,000	Btu/h	3.6	COP
WSHP-60	WSHP	ClimateMaster HS060F	1980s	2	60,000	Btu/h	10.2	EER	60,000	Btu/h	3.6	COP
EH	Personal Space Heaters	various		10					1,500	W	100 %	%