APPENDIX 7 | CENTRAL UTILITY PLANT OPTIONS

Shippensburg University Campus Master Plan

Summary of Heating/Cooling Plant Options

Submitted by Entech Engineering, Inc.
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Shippensburg University
Central Utility Plant Options
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Heating Plant

The existing heating plant is 55 years old and is approaching the end of its useful life. The steam distribution system for the Campus is also at the end of its life and must be replaced. Since the steam pipes and condensate lines must also be replaced, there is flexibility where the heating plant can be located. It does not have to be located in the same location as the existing plant.

The following options for renovating or replacing the existing heating plant have been evaluated.

Option 1 Renovate the existing coal-fired heating plant.
Option 2 Construct a new gas/oil-fired heating plant in a new location.

Another heating plant option briefly considered was to construct a new coal plant: However, this option is not recommended for further investigation because it is significantly more costly to construct a new coal-fired plant rather than re-tubing the existing boilers and renovating the rest of the plant. There are also few, if any, vendors that sell new coal-fired boilers in this size range. The quality of what can be purchased today is most likely not as good as a reconditioned coal-fired boiler.

A brief description of the two boiler plant options considered is described below.

Option 1 Renovate the Existing Coal-Fired Heating Plant

The existing coal-fired heating plant is sized large enough to handle the future steam loads estimated for the Campus. However, the equipment and building are reaching the end of their expected useful lives. In 2005, Abacus prepared an assessment of the existing plant and equipment and listed the deferred maintenance projects that should be completed in order to maintain the heating plant. The total cost of the remaining renovation work identified in the report is $12 million (in 2008 dollars). This cost does not include air pollution control equipment which may be required in the coming years.

Some of the projects identified include the following:

- Roof Replacement
- Re-pointing and Repair of Brick
- Replace Windows
- Replace Motor Control Centers
- Replace Plant Branch Wiring
- Replace Boiler #4 Stoker
- DA Tank Replacement
- Structural Repairs
- Install Two Additional Hoppers
- Coal Pile and Yard Modifications
- New Emergency Generator
- Re-tube Boilers
- Install Emission Controls

Existing Heating Plant

Option 2 Construct a New Gas/Oil-Fired Heating Plant in a New Location

Construct a new heating plant in a new location north of the existing plant. Three new gas/oil-fired boilers can be installed, where two of the boilers can provide the expected peak steam load of 75,000 lb/hr. and the third boiler is used as a spare. The boiler fuel can be selected based upon price, but it is expected that the primary fuel will be natural gas, and the secondary fuel will be No. 2 fuel oil. B-Tane is a fuel generated from recycled vegetable oil which can also be used. This environmentally friendly fuel is presently priced less than No. 2 fuel oil. Another "green" fuel that could possibly be used includes landfill gas from a landfill located approximately 6 miles from the Campus.

Example of New Boiler Plant – Kutztown University

The new heating plant should be sized to include offices, locker facilities, a maintenance area, etc. for the utility maintenance staff. The building can also be sized to add central chilled water to the Campus, and space for other Campus maintenance functions.

Heat Distribution

The existing steam and condensate lines are generally in poor condition and have reached the point where they should be replaced. Because the underground pipe must be replaced in total, it allows more flexibility and options for its design. The following design features are recommended, where possible:

- The pipe should be designed in a looped arrangement, so buildings can be supplied with heat if a section of pipe is out of service for repair or replacement.
- The new distribution pipe should be located in a different location than the existing pipe in order to minimize utility outages as the new system is installed.

Option 1 Replace Steam Distribution Pipe

Install new steam and condensate pipe throughout the Campus. Most of the existing pipe is deteriorating due to moisture in the ground corroding the exterior of the underground pipe. Today there are better pipe materials that should be used. Welded pipe with a plastic HDPE shell will perform much better than the older steel jacketed piping used earlier. Proper welding specifications and inspections during pipe installation will prevent problems encountered with previous pipe installations on campus.

The attached exhibit shows a proposed piping layout that meets the criteria described above. Approximate pipe sizes are estimated for future heating loads based upon campus growth projections described in the master plan. There should also be capacity for continued campus growth further into the future. The proposed piping plan shows a ring around the interior of the Campus, so steam can be supplied from either direction. The distribution pipe then will have branches which feed outlying buildings.

The estimated cost to replace the steam pipe is $9.3 million.

Option 2 Replace Steam Distribution Pipe with Hot Water Distribution Pipe

Rather than installing new steam and condensate pipe, distribute heat on campus with a hot water distribution system. Pipe can be located similar to the steam option, but there will be a supply and return hot water pipe rather than steam and condensate pipes. The boiler plant can be designed with hot water boilers, simplifying the plant design. Variable flow circulating pumps must be added, but a deareator, condensate system, and other steam related equipment can be eliminated. The steam equipment in buildings can be removed, and the buildings that still use steam can be converted to hot water. Steam generators can be installed for buildings still requiring steam.

The benefits of a hot water heating system are that it is more energy efficient, easier to control, and has less maintenance. As the weather becomes milder, the hot water temperature can be reduced, which will reduce losses from underground pipe and from pipe and equipment in mechanical spaces. Variable speed drives can also reduce the pumping energy used on most days, and the hot water pipe will have much longer life than steam and condensate pipe. Such a system should also be much more efficient in the summer because the hot water temperature can be lowered, eliminating the need for a summer shutdown of the boiler plant.

The estimated cost to install hot water distribution, including some modifications to piping in some buildings is $7.5 million. It is assumed the existing steam pipe will be abandoned in place.

Other

Geothermal Heat Pumps for Residence Halls

A geothermal heat pump system utilizes the year round constant ground temperature to absorb or reject heat for the building conditioning systems. Fluid is circulated between the building and the ground loop piping buried in the ground. In the winter, heat is absorbed from the ground by the fluid and in the summer, heat is rejected to the ground by the fluid. Each individual heat pump compressor then utilizes this energy to heat or cool the space being served. A geothermal heat pump system eliminates outdoor equipment, minimizes fossil fuel heating, requires no supplemental heat, and provides a level seasonal electric demand. These systems have a 15 to 20 year life expectancy and the ground loop piping system is typically warranted for 50 years.

The future Campus housing is planned to be split into two quads, each with equivalent occupancy counts of approximately 1,400 students each. Therefore, there will be two separate geothermal heat pump systems, one for each quad that will be sized for approximately 1,200 tons of cooling and 450 HP of heating capacity. Each quad system will include the following:

<u>Geothermal Heat Pump</u>

- Well field consisting of approximately 460 closed-loop wells. Each well field will require a minimum of approximately 2 acres of land based on a well spacing of 15 feet minimum between all wells. The wells are not exposed to view and can be below a parking lot or playing fields. Each well will be 400-450 feet deep. Well spacing may have to be increased to prevent the ground from overheating.
- 10-12 wells will be looped together with reverse-return piping to a central piping header vault. Pipe material will be polyethylene.
- The header vault will manifold the well loops together and send water to the primary pumps.
- The primary distribution pumps should be variable flow and support a secondary pump in each quad building.
- System fluid will be a polypropylene glycol solution distributed to heat pumps located inside the buildings.
- A water-to-water heat pump will be used to produce domestic hot water. Each domestic water heater will also have backup/supplemental gas heat. Domestic water storage tanks will be required.

With a geothermal heat pump system, the University will still require a central heating plant to heat the rest of the Campus. Auxiliary heat will also still be required for the residence halls. While the central heating plant capacity can be smaller if geothermal heat pumps are installed, the added construction cost for the heat pump system will exceed the construction cost savings from the heating plant. The estimated cost for the well fields and central components required for the residence halls is $6 million. There will be additional costs to install the heat pumps inside the buildings.

The limestone/Karst topography found at the University can dramatically impact the cost to install the wells. Before moving forward with a geothermal heat pump system for the Campus, a detailed geotechnical investigation should be performed to better select a location for the many wells required and determine if additional costs will be incurred with drilling the well field.

Central DHW System for Residence Halls and Dining Halls

If the University continues to distribute steam on campus, summer shutdown of the central heating system should be considered because of the energy savings and the opportunity to perform maintenance on the steam system. Problems with pipe corrosion (from the outside) should be prevented with a properly designed and installed system with a HDPE jacket.

With summer shutdown of the boiler plant, it may be beneficial to install a central domestic hot water system for each resident areas of the campus. A larger water heater and storage tanks can supply domestic hot water to the new residence halls. If a gas fired water heater is installed, this system can be used, even if the central heating system is shut down. The cost to install this option is probably similar to individual steam heat exchangers and storage tanks within each building.

Energy Selection

Projecting energy costs for the Campus for the life of a new or renovated heating plant is difficult because of the volatility of the energy markets. The energy market is dynamic and will continue to change. The typical energy options are as follows:

Electricity

Electricity is supplied to the Campus by First Energy. 56 percent of their generation portfolio is coal, and 28 percent is nuclear. On an environmental basis, it should be understood that if electricity is used for heating, more than half of the power supplied has associated emissions from a coal-fired power plant.

Presently, electricity is moderately priced compared to other regions in the United States. With electric power de-regulation in Pennsylvania, rate caps were put in place for a period of 10 years. These rate caps will expire in 2010, and the utilities are predicting rate increases of 30% to 40%. It is also expected that electric utilities will begin moving to charge on a "time of day" basis, where the electric rates will reflect the varying costs throughout the day. When electricity is purchased on a day of high electricity usage, the price charged may be very high. Periods of time when electric usage is low, the electric charges may be relatively low. Having the ability to shift electricity usage from one part of the day to another may become very cost beneficial for the University.

Shippensburg University is presently purchasing wind power and is contracted through 2008. The University purchases 868,970 kWh annually of wind power in the form of attributes (credits) from wind farms such as those along the PA Turnpike near Somerset. This wind power translates to 4% of the overall electricity consumed at Shippensburg.

The Campus participates in a state government mandate to purchase 10% of its total electricity requirements from green power sources. They also purchase hydro and small amounts from other green sources

Coal

Anthracite, a hard coal found in Pennsylvania, has long been the primary fuel used in the central heating plant at the University. The heating plant also uses natural gas, primarily when the Campus steam load is low and the coal boilers can not run efficiently at the low load.

The main benefit of coal is that it is less expensive than most other fuels and readily available in Pennsylvania. The 2007 National Institute of Standards & Technology (NIST) publishes its estimate of energy prices into the future. NIST escalation rates indicate moderate price escalation of a few percent per year for coal. The state also requires campus heating plants use coal unless an alternate fuel is used which is more cost effective.

Coal has some disadvantages that should also be considered:

- It takes twice the manpower to operate a coal plant.
- The capital cost to install a coal-fired plant is 3 to 4 times higher than the cost of a conventional plant.
- Coal is a significant contributor to emissions, which cause global warming.
- DEP continues to place more restrictions on air emissions. Even if the plant is "grandfathered" in the future, it is likely that more air pollution equipment will be required for the existing heating plant.

- Coal boilers are less efficient, especially at low firing rates.
- The building and site for a coal plant is significantly larger to house the equipment and coal supply.
- The coal pile can be unsightly if in a highly visible location.
- Trucks delivering coal and hauling ash should be located away from the Campus traffic and pedestrians.
- The anthracite industry has significantly declined in the past 50 years, for the reasons described above. Consequently, there are few, if any, suppliers of new stokers and boilers in the size range required by the University. It is possible to find a company who can manufacture replacement parts, but the cost is relatively high.
- While coal is plentiful in Pennsylvania, the decline in the industry has eliminated all but a few coal suppliers. Therefore, the reliability of the coal supply and competition is not as great as it may first appear.

Natural Gas

Natural gas use in the country has increased dramatically in past years because it is fairly easy to use, the price has been competitive, and it has less air emission issues. However, in recent years, the cost of natural gas has been volatile with changes in supply and demand. Demand has been higher as many switched to gas, including electric power producers. When Hurricane Katrina hit the gulf coast, the natural gas supply was impacted. The result was a spike in natural gas prices. Presently, gas pricing has moderated some, in part because suppliers prepared for hurricanes that did not materialize in the two past years. While there may be some periodic spikes and price decreases in gas costs, the NIST escalation rates for natural gas project slight decreases and then later, modest increases for the next ten years.

Fuel Oil

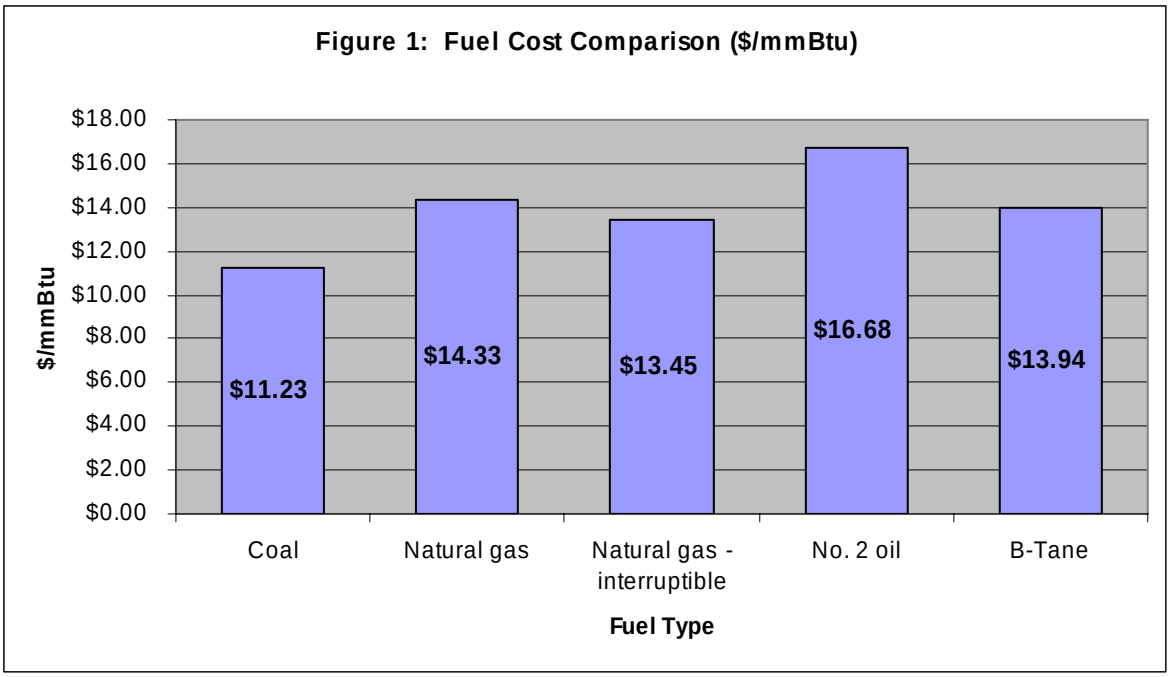
Fuel oil pricing is much more volatile because it is a global commodity. Presently, fuel oil is priced significantly higher than natural gas. There have been times when oil prices have been better than natural gas prices; however, most of the time natural gas is priced slightly less than fuel oil. In our opinion, fuel oil should only be used as a secondary fuel to back up natural gas.

Bio-Fuel

Bio-fuel has only recently been an option to consider. The industry is still developing. Bio-diesel is gaining use in Pennsylvania, with the state government actively promoting the technology. Entech has assisted Lehigh University implement a pilot project to use recycled vegetable oil from the restaurant industry. We expect research and development will continue to increase in this area and with it, these fuels will become more cost competitive. There may also be an opportunity to pipe methane from a landfill reported to be about 6 miles from the campus. This fuel source can be explored as a way to supplement natural gas usage.

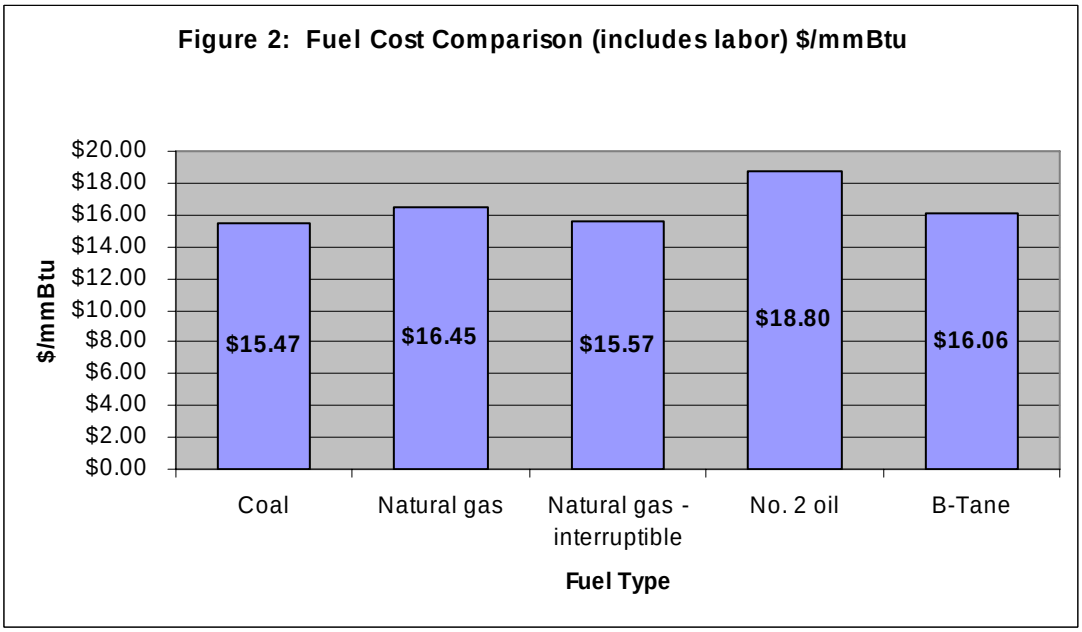
Fuel Cost Comparison

In Figure 1 below, the 2007 fuel costs for various fuels at the University are compared. It should be understood that energy rates will continue to fluctuate. For example, since these rates were recorded, natural gas pricing has decreased, and fuel oil increased. However, using these figures, it is evident that coal has a 17% price advantage over natural gas.



One reason the fuel costs are this close is the coal-fired boilers are less efficient.

Coal also requires twice as many operators (12 versus 6) than a conventional plant. In Figure 2 on the following page, the cost for the operators is included in the energy cost. Based on this analysis which includes operator's wages, the cost for coal and natural gas using an interruptible rate are about the same.



Geothermal Heat Pump

Geothermal heat pumps as described above are an efficient source of heating. Presently, the cost for heating with a geothermal heat pump is about half the cost to heat with natural gas. For cooling, the equipment is fairly efficient but not as efficient as a highly efficient system using variable flow chillers. In order to determine whether there is sufficient cost benefit to have the added capital expense to install a geothermal heat pump system, Table 3 below shows the energy cost comparison between a central heating plant using natural gas and a central chilled water plant versus a geothermal heat pump (for the residence halls only). From this analysis, the estimated annual energy cost for cooling and heating the residence halls is as follows:

Table 3
Annual Heating/Cooling Cost Comparison
for Residence Halls

	Heat Pump	Central Plant	Difference
Heating	$159,817	$403,500	$243,683
Cooling	$310,262	$166,212	($144,050)
Total	$470,079	$569,712	$ 99,633

From this analysis, the net energy savings with a geothermal heat pump system is approximately $100,000 per year. If the electric rates are increased by 40% to reflect the expected rate increase, then the heat pump option provides no savings and is actually $20,000 more costly to operate.

CO_2 Emissions

The CO_2 emissions for the geothermal heat pump and the central chilled water/central gas heating plant are basically the same; approximately 1750 metric tons of CO_2 per year. There is significant CO_2 emissions reduction by switching from coal to natural gas; approximately 9600 metric tons per year.

Solar Heating and Photovoltaic Panels

The University will have opportunities to install solar devices for heating and for power generation. Solar collectors can be installed to provide supplemental heating for year-round heating loads such as domestic hot water. Photovoltaic panels can be used to convert sunlight into electricity. The installed cost for such equipment continues to decline, but is not yet cost competitive with conventional energy and power costs. The equipment and weather are also not reliable enough to allow the campus utilities to be decreased in size as a result of installing solar collectors. However, in order to demonstrate environmentally positive technologies, there will be opportunities at both the proposed resident halls and the central utility plant to install solar technology to provide some of the campus energy needs.

Heating Options Summary

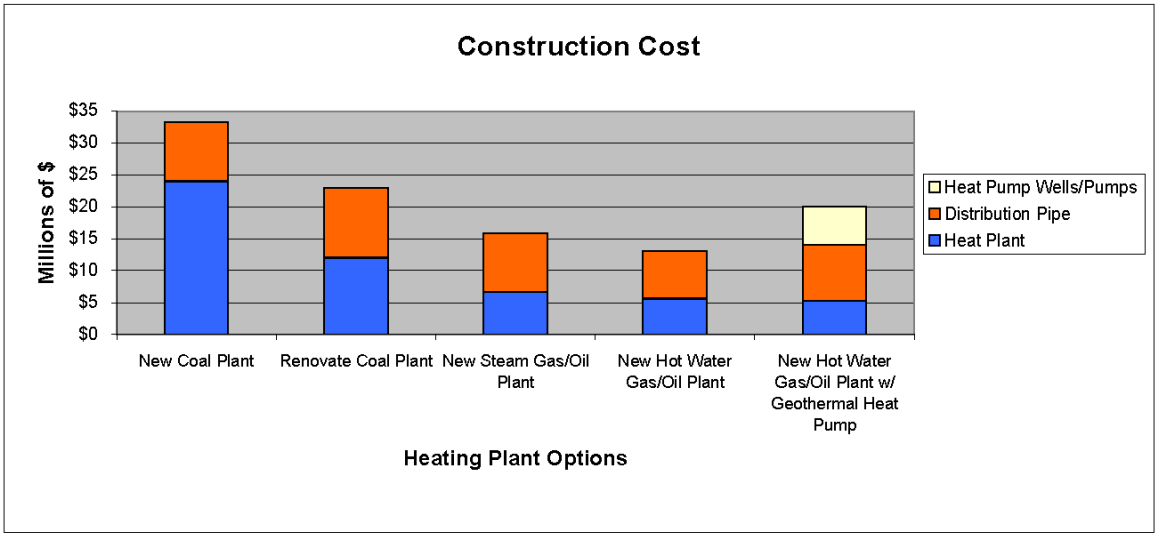
Figure 4 on the following page summarizes the heating options for the campus, including the option for geothermal heat pumps to serve the proposed residence halls. The added cost for installing heat pumps inside the buildings is not included. The lowest cost option is a new gas/oil hot water plant with hot water distribution pipe.

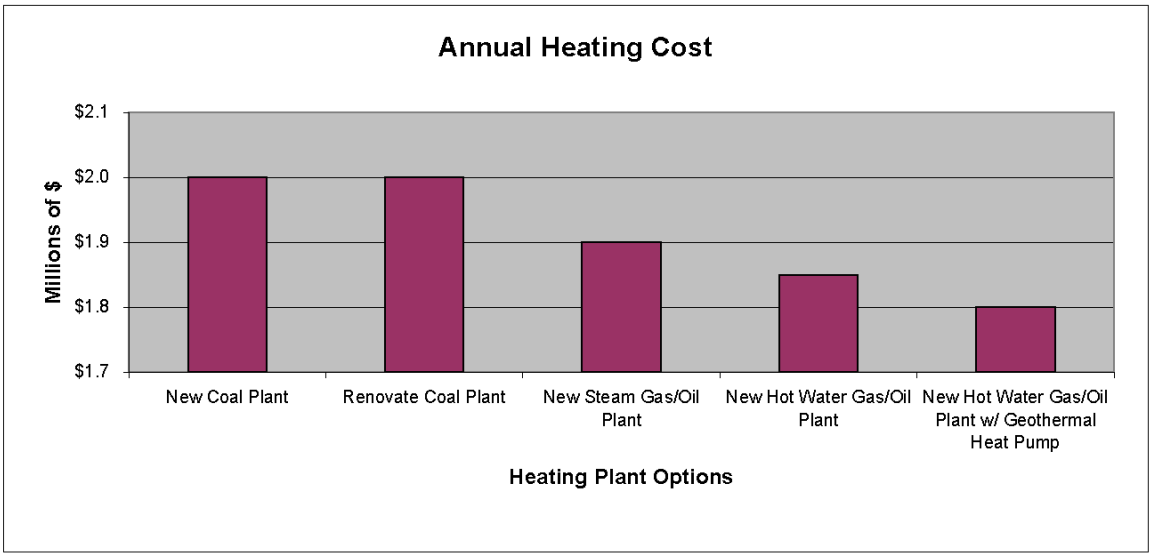
The annual energy cost for heating is also shown in Figure 4. The option to construct a new hot water gas/oil plant with geothermal heat pumps for the residence halls has the lowest heating cost for all the options, saving approximately $50,000 to $100,000 per year in annual energy costs. It should be noted that the expected electricity rate increases will impact this projected cost savings.

Shippensburg University
Campus Master Plan
Utility Options
Figure 4

	New Coal Plant	Renovate Coal Plant	New Steam Gas/Oil Plant	New Hot Water Gas/Oil Plant	New Hot Water Gas/Oil Plant w/ Geothermal Heat Pump
Heat Plant	~ $24.0 million	$12.0 million	$6.6 million	$5.6 million	$5.2 million
Distribution Pipe	$9.3 million	$11.0 million	$9.3 million	$7.5 million	$8.8 million
Heat Pump Wells/Pumps	$ - million	$ - million	$ - million	$ - million	$6.0 million
TOTAL	$33.3 million	$23.0 million	$15.9 million	$13.1 million	$20.0 million
Annual Heating Cost	$2.0 million	$2.0 million	$1.9 million	$1.85 million*	$1.8 million*

* Assumes $50,000 savings using hot water distribution with campus heating.





Cooling

Presently, about half of the Campus building spaces are air conditioned. It is anticipated that most of the buildings will be air conditioned in the future.

There is approximately 3,000 tons of chiller capacity installed in the buildings that have chilled water cooling. The total future cooling load for the Campus is estimated to be approximately 5,000 to 6,000 tons. The University has several cooling options to consider.

Option 1 Distributed Cooling

With distributed cooling, the University will continue to install chillers or direct expansion cooling for each building as it is constructed or renovated. Cooling equipment will be replaced in buildings as the equipment reaches the end of its operating life.

There are a number of buildings on campus where the air conditioning equipment will be reaching the end of its life and should be replaced. There are additional buildings without air conditioning that will need cooling equipment. There are also new buildings proposed in this campus master plan. It is estimated that in the next 5 to 10 years 6,000 to 7,000 tons of cooling capacity will be required. If this equipment is installed for each building, the estimated cost is $18.6 million. Approximately $2.5 million of this cost is for the additional building cost to add mechanical space for chillers and towers in new buildings.

There are approximately 6 buildings that have chillers that were recently installed, or are being installed in the next year. This cooling equipment, approximately 2,400 tons, should not have to be replaced for at least 20 years. The current cost to replace this equipment is estimated to be approximately $5 million.

Option 2 Central Chilled Water

With this option, a centralized chilled water plant is constructed on campus. Large, highly efficient chillers will produce chilled water which is then distributed on campus through underground pipes. The pipe can be looped similar to the heating system piping. It may be possible to connect some of the chillers presently installed at some of the buildings to provide cooling to the cooling loop which can lower construction costs or add cooling capacity. The plant and piping should be designed to allow the system to expand as buildings are connected to the system.

The benefits of a central chilled water system include the following:

- Better reliability.
- Because of system “diversity,” less cooling capacity can be installed.
- Equipment noise from the chillers and towers can be removed from the buildings.
- Very efficient equipment and controls can be installed, reducing energy costs.
- Reduces the requirements for mechanical rooms within buildings.
- Replacement of aging cooling equipment in existing buildings or adding air conditioning to buildings will be less costly
- It will be possible to add thermal storage to shift electrical usage to off-peak periods, lowering operating costs.

While there will be a central chiller plant, most of the buildings with recently installed chillers can be connected to the chilled water loop. On days with high air conditioning load, these chillers can contribute to campus cooling requirements.

The central chilled water system can be constructed in phases. In the first phase, approximately 5,000 tons of cooling will be required, which is less than the decentralized cooling option because the system takes advantage of the cooling load diversity from the connected buildings. The peak cooling load arrives at different times for each building. The central chiller plant can be constructed with approximately 3,500 ton cooling capacity, and buildings with chillers can be connected to provide the remaining cooling required. The building and piping system should be built to allow future expansion.

The central chiller plant should be designed to use highly efficient chillers, cooling towers and pumps, all using variable frequency drives. The central plant should be able to use the cooling towers to provide "free cooling" when the outdoor air temperature drops below a certain level. The system and building should be sized to add capacity for the chillers that will be retired in the future, approximately 1,700 tons.

For the first phase, it is estimated the cost for the chilled water plant will be approximately $8 million and the distribution pipe will be $8.8 million. There will also be reduced construction costs for new buildings because they will not require space for chillers, pumps, and towers. These building costs were included in the decentralized option described above.

With the central chilled water, the annual energy cost for air conditioning should be approximately $400,000 to $500,000 less than the decentralized cooling option where each building has its own cooling system. Additional savings may be available if the utility offers curtailment incentives where the Campus electric load is voluntarily reduced for a few hours during periods of high electric usage. Because there will be less equipment, operation and maintenance costs should be less with central chilled water. Equipment noise from chillers and towers will be concentrated at the utility plant and away from the Campus buildings.

Option 3 Two Cooling Plants to Serve Residence Halls

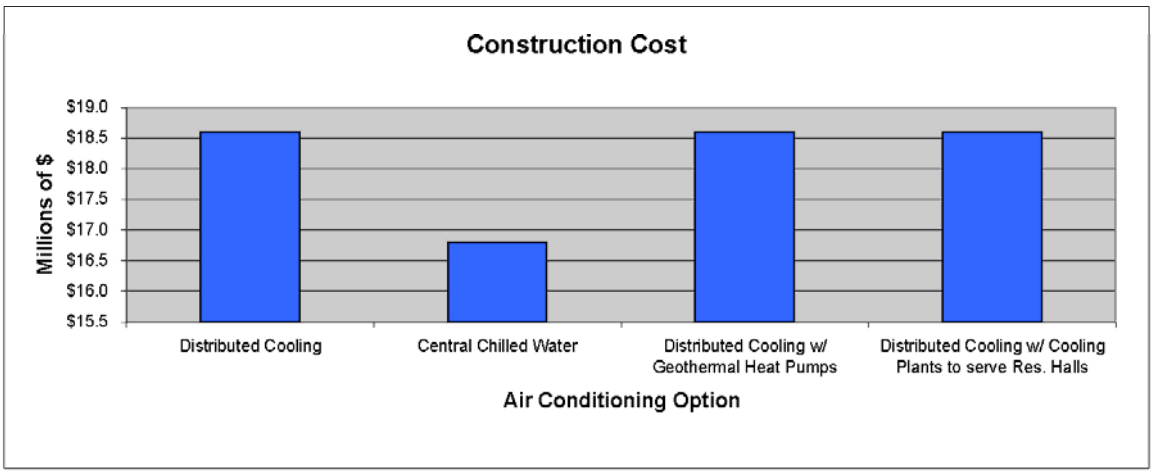
Install a chiller plant to serve the new residence halls. Two 1,500 ton chiller plants can be constructed with the new residence halls; one for each area. Dining facilities could also be connected to the systems, but the cost is presently not included. The rest of the Campus would continue to operate with distributed cooling. This option will be less expensive to construct than a total central chilled water system, but many of the benefits are not realized. The cost to install the two satellite plants is approximately $5 million.

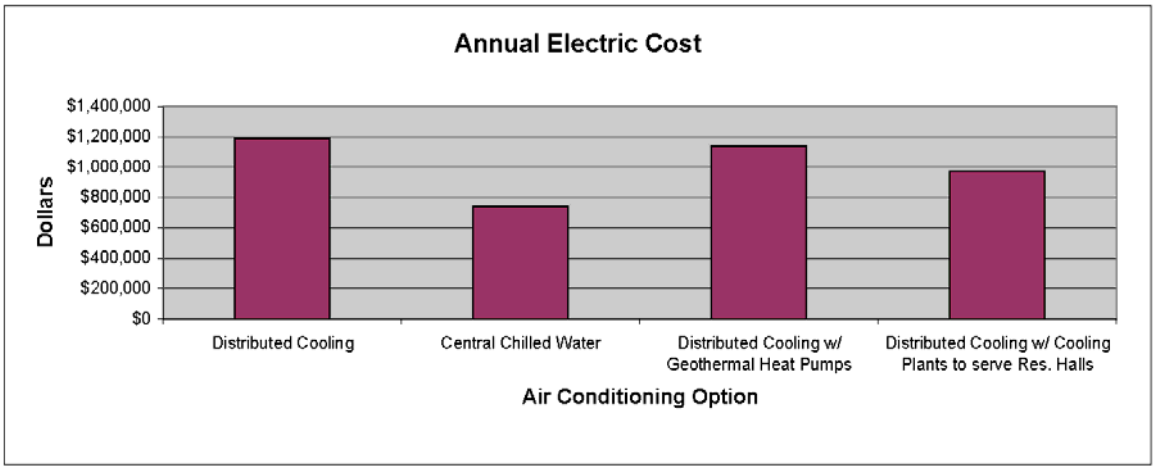
Cooling Options Summary

Figure 5 on the follow page summarizes the cooling options evaluated for the campus, including geothermal heat pumps for the proposed residence halls. The cost for the wells required for the geothermal heat pump systems are included in the heating option.

Shippensburg University
Campus Master Plan
Utility Options
Figure 5

	Distributed Cooling	Central Chilled Water	Distributed Cooling w/ Geothermal Heat Pumps	Distributed Cooling w/ Cooling Plants to serve Res. Halls
Construction Cost	$18.6 million	$16.8 million	$18.6 million	$18.6 million
Annual Electric Cost (assumes average $0.095/kWh)	$1,190,000	$740,000	$1,140,000	$970,000





Combined Heating and Cooling Options

Because the geothermal heat pump option covers both heating and cooling, selecting a utility strategy should evaluate heating and cooling together.

Table 6 and Figure 7 on the following pages summarize the heating options for the total campus, including the proposed residence halls. The operating cost for both heating and cooling are also shown.

From this summary, the option that has the lowest estimated capital cost is:

- New gas/oil hot water plant with central chilled water.

The option with the lowest annual operating cost is the option with new gas/oil hot water plant with central chilled water.

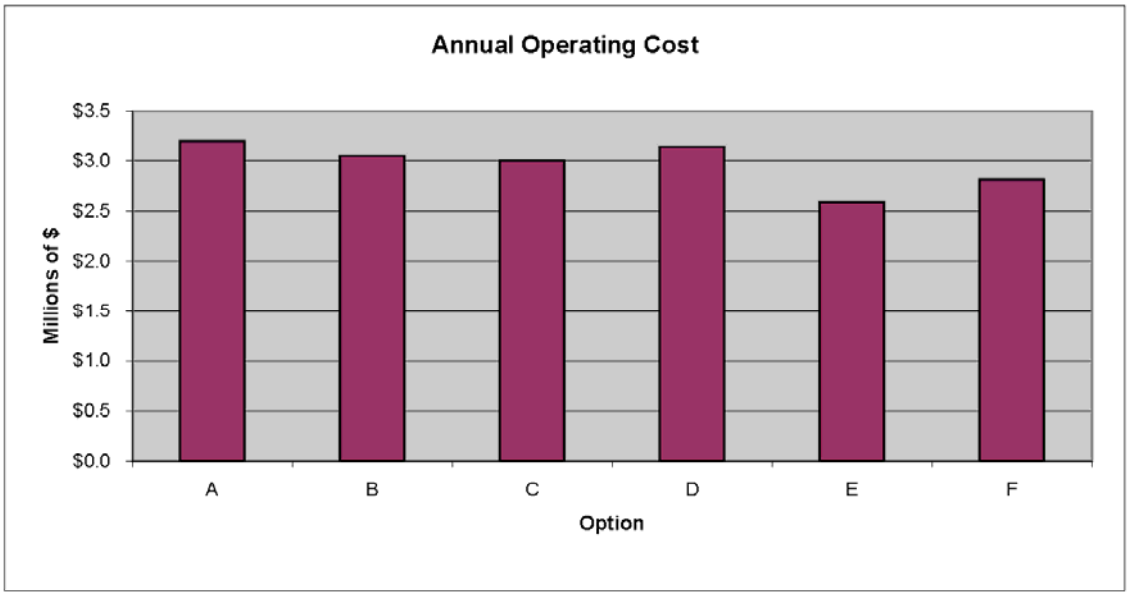
A more detailed feasibility will be required to better define the scope and cost of the selected option.

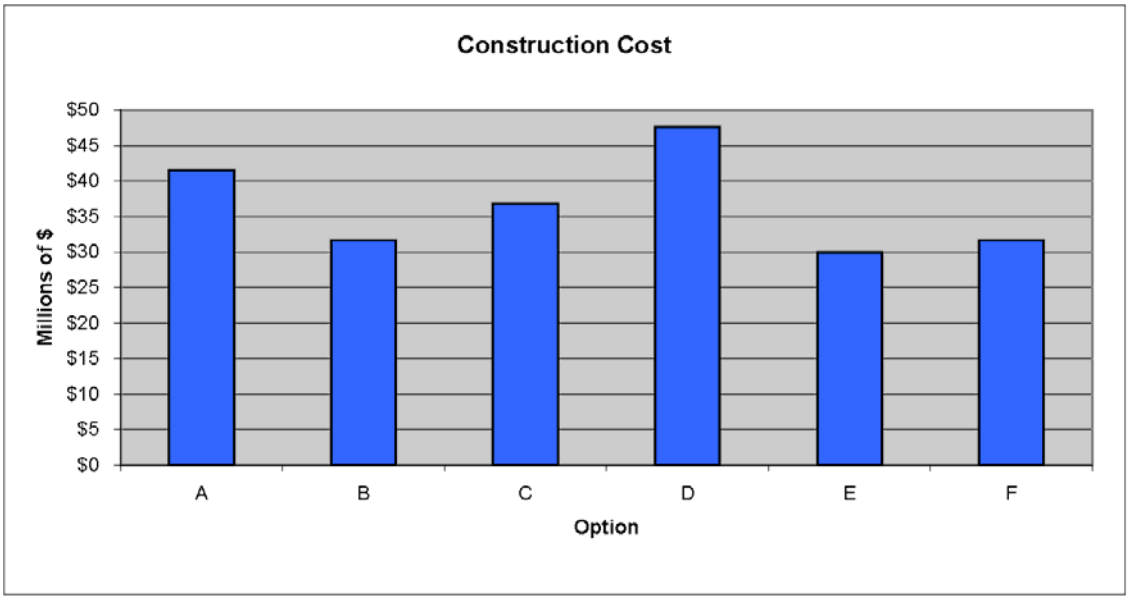
Shippensburg University
Campus Master Plan
Utility Options
Table 6

Option	Description		Construction Cost	Annual Operating Cost
A	Renovate Coal Plant		$23.0 million	$2.0 million
	with Dist. Cooling		$18.6 million	$1.2 million
		TOTAL	$41.6 million	$3.2 million
B	New Gas/Oil HW Plant		$13.1 million	$1.85 million
	with Dist. Cooling		$18.6 million	$1.2 million
		TOTAL	$31.7 million	$3.05 million
C	New Gas/Oil HW Plant with Dist.		$20.0 million	$1.80 million
	Cooling & Geothermal Heat Pump		$16.8 million	$1.2 million
		TOTAL	$36.8 million	$3.00 million
D	Renovate Coal Plant with Dist.		$23.0 million	$2.0 million
	Cooling & Geothermal Heat Pump		$24.6 million	$1.14 million
		TOTAL	$47.6 million	$3.14 million
E	New Gas/Oil HW Plant		$13.1 million	$1.85 million
	with Central Chilled Water		$16.8 million	$0.74 million
		TOTAL	$29.9 million	$2.59 million
F	New Gas/Oil HW Plant		$13.1 million	$1.85 million
	with Dist. Cooling & Central Clng		$18.6 million	$0.97 million
	for Residence Halls			
		TOTAL	$31.7 million	$2.82 million

Note: Options with geothermal heat pump have $6 million for wells included in heating construction cost

Shippensburg University
Campus Master Plan
Utility Options
Figure 7





Phasing

It is anticipated that some of the new residence halls will be operational prior to the completion of a new heating and central cooling plant. Temporary means will therefore be required to supply heat and cooling to these new buildings until the new utility plant is constructed. This could be accomplished several different ways. For example, the existing steam line could easily be extended to the new buildings until a new system is in place. For cooling, temporary chillers could be rented, a used chiller temporarily installed, or a chiller could be installed which could then be moved over to the central plant and used as the permanent chiller for the central cooling plant.

CO_2 Emissions

The University has stated that green house gas emissions is one of the factors that should be used to determine how the campus is heated and cooled. The CO_2 emissions have been estimated for two heating/cooling options investigated for the proposed residence halls. The calculations are based upon the "Clean Air – Cool Planet Campus Carbon Calculator" which is the recommended calculator of the American College and University's Presidents Climate Commitment.

CO_2 Emissions
Residence Halls ONLY

Option	CO_2 Emissions
• Central Natural Gas Heating Plant Central Chilled Water 30,000 mm Btu Natural Gas 277,900 kWh Electricity	1,754 metric tons
• Geothermal Heat Pump 3,181,612 kWh Electricity	1,738 metric tons

From this comparison, it appears both options have nearly equivalent CO_2 emissions. One reason they are so close is because over 60% of Penn Electric's electricity is generated from coal-fired plants.

It should also be noted that with the central chilled water option, the CO_2 emissions will decrease further because the efficient central plant will replace the less energy efficient distributed cooling system currently in place. Perhaps, the most important thing to recognize is the nearly 10,000 metric ton reduction in CO_2 emissions that will result from switching from coal to natural gas.

Recommended Heating and Cooling

Based on the current information reviewed above, we recommend the following strategies for heating and cooling the campus:

- Construct a new gas/oil fired heating plant with hot water boilers.
- Replace the aging steam distribution piping with hot water heat distribution.
- Install a central chilled water plant adjacent to the new heating plant.
- Install central chilled water piping distribution piping system.

Our reasons for making these recommendations include the following:

- The new heating plant can be highly controlled to free up operators to maintain other equipment on campus.
- The old plant can be removed or re-used for other functions.
- The Campus utility operations can be removed from the highly visible “front door” to the Campus and remove the truck traffic from the front of campus.
- The new utility plant can be designed to optimize the operations of the heating and chilled water plant rather than having compromises that will occur with trying to renovate the existing plant.
- With a new plant, it may be possible to switch to bio-fuels in the future. It is unlikely that a coal plant can be converted to other fuels.
- With new gas-fired boilers with state-of-the-art air pollution control, there will be much less, if any, concern with increased air emission regulations.
- With hot water distribution versus steam distribution, construction costs are less with the hot water distribution, the system will be more energy efficient, there will be less overheated mechanical spaces, and the piping should last longer.
- With hot water distribution, the temperature and the pump speed can be reduced in the summer to efficiently supply heat to the summer heating loads. Summer shutdown of the boiler plant is not necessary and the summer boilers can be eliminated.
- With central chilled water, cooling will be much more efficient than individual cooling equipment at each building. Very efficient chillers, variable flow towers, and pumping should be used.
- It will be much easier to replace existing chillers and add chilled water cooling to buildings when the central chilled water system is in place.
- The noise and disturbance of cooling towers will be moved off campus to the central chilled water plant.
- With the combined central heating and cooling, it will be much easier to add cogeneration in the future, if it is found to be cost effective.
- As time of day electric charges evolve, thermal storage is an opportunity that can be easily implemented at the central plant.
- The normal equipment operating life of geothermal heat pumps is about 15 years, where chillers and boilers have an operating life of 30 years.

Rarely is there a good opportunity to install central utilities in a coordinated and efficient manner, but the University has that opportunity today. First, both the heating plant and the steam distribution pipe must be replaced at the same time. Therefore, the University can make both the plant and the piping hot water, which is more efficient and less costly to install and maintain. Second, the chilled water plant and pipe can be coordinated with the construction of the heating system. Third, there will be a large number of buildings coming online very soon that can take advantage of the central systems, decreasing the building costs and decreasing the mechanical space required within the buildings.

Building Heating and Cooling

The new buildings should be designed with energy efficient HVAC systems, and should target efficiency levels to meet LEED certification criteria. With hot water and chilled water supplied from a highly efficient central utility plant, it will be easier to attain the efficiency levels required. The HVAC systems in the residence halls should use chilled water and hot water with temperature reset. The systems should have individual space control. There should be an ability to curtail electric load to reduce electric demand on peak days. Heat recovery should be

considered for exhaust, and each building should have individual electric, heat, and cooling meters so energy use can be monitored and controlled.

Natural Gas

The piping system for natural gas is relatively new and in good condition. The only improvements required will be to install a new supply line to the new heating plant and to extend lines to new buildings. Because it has a lower energy cost, gas appliances such as dryers, cooking equipment, etc. should be used, rather than electric appliances.

Electrical Distribution Recommendations

Addition of a Standby Line for Redundant Service

The University's customer focus has increased the need to provide more reliable electrical service throughout the Campus. This can be accomplished by bringing a second separate power feed from Penelec to the Campus. There are three options to be considered.

First, a new feeder from the Carlisle Pike substation could be extended along Adams Drive and stepped-down to 13.2kV and terminated in switchgear at the proposed new heating plant. From there, a new feeder could be routed across campus to tie into the existing Campus substation along Lancaster Drive. The opinion of probable construction cost for this option is $1,650,000.

Second, in addition to the existing line feeding the Campus from the Shippensburg substation that is routed along Newburg Road, there is another line from the Carlisle Pike substation routed from the opposite direction. A second feeder from this line could be routing overhead across Newburg Road and terminated in the existing main switch. Including Penelec charges, the opinion of probable construction cost is $385,000.

Lastly, since lines from both the Shippensburg substation and the Carlisle Pike substation are routed overhead along Newburg Road, Penelec could install radio controlled switches on the poles to allow either line to feed the Campus. For this option, Penelec charges will be the only costs associated with installation. These will be approximately $65,000.

The first two options would require switching and maintenance of equipment by the University, whereas under the third option, Penelec maintains the switches and automatically transfers the load from dispatch in less than 60 seconds after a loss of the primary line to the Campus. Based on this and the fact that the costs for Options 1 and 2 will most likely be higher than the third, the third option is recommended.

Upgrade of Main Campus Transformers

Since the proposed new housing and other Campus buildings are to be cooled as part of the Master Plan, the overall Campus load will increase. The projected increase is around 3,000kVA. Currently, the peak load is 5,200kVA at about 95% power factor. The total projected load will be around 8,200kVA.

The two existing Campus transformers are rated at 5,600kVA each, with cooling. Once the total Campus load exceeds 5,600kVA, one transformer will no longer be able to carry the Campus without shedding load. Therefore, upgrade of both Campus main transformers to 7,500/9,975kVA is recommended. This is the next standard size transformer and, with cooling, will allow operation of the Campus on one transformer up to almost 10,000kVA. This should support the needs of the Campus beyond this Master Plan. The construction cost opinion to replace both main transformers is $1,500,000. It is recommended that both transformers are upgraded simultaneously because the initial added HVAC load will not come from the heat/chiller plant but distributed throughout the new housing buildings. This load will need to be distributed over multiple feeders along with other building loads. If the heat/chiller plant were to be completed prior to construction of the new dorms, the plant could be serviced by two feeders only and the replacement of the main transformers could be phased.

Relocate and Upgrade Campus Distribution Feeder Ductbanks

For both housing options, ductbanks will need to be relocated and extended to allow construction of the proposed housing and other Campus buildings. As these ductbanks are being relocated, the existing feeder cables throughout the Campus should be replaced. New manholes should be provided with multi-point junctions and load break elbows to facilitate replacement of cabling. In addition to upgrade of the cabling, sectionalizing equipment should be installed to allow switching of critical loads upon loss of a feeder and to facilitate future system maintenance. As the new buildings are added to the system, care should be taken to balance the load among feeders and ensure proper selective coordination of overcurrent protective devices. The construction cost opinion and phasing for upgrade of all Campus feeder cabling and relocation of ductbanks and feeders to facilitate new buildings is as follows:

1. Relocate, extend, and upgrade Feeders 1201 and 1202 for Phase 1 housing and the heat/chiller plant - $1.8 million.
2. Extend and upgrade Feeder 1204 for Phase 2 housing - $80,000.
3. Relocate and upgrade Feeders 1202, 1203, and 1204 for Phase 3 housing – $270,000.
4. Upgrade remaining portions of 1203 and 1204 beyond new housing construction - $1,200,000.

Item # 1 above is required to support the additional point load of the proposed chiller/heat plant. This would involve installation of a new ductbank from the north corner of the Ceddia Union Building along Loop Road and new feeder cabling for Feeder 1201 and 1202 from the substation to the plant. In addition to providing service for the new chiller/heat plant, it will also facilitate construction of Phase 1A and Phase 2 housing. If the new chiller/heat plant option is not constructed and individual chillers are located within the each of the new housing buildings, the loading can be distributed over all four campus feeders. In this case, the existing feeders should be able to handle the increased distributed load and the feeder upgrades can be postponed until after housing is complete. Item #2 above allows for extension of existing Feeder 1204 to Phase 2 housing by utilizing existing feeders and ductbanks. For Phase 3 buildings, ductbanks and Feeders 1202, 1203, and 1204 will need to be relocated along Delaware Drive and Lancaster Drive. Item #4 is associated with upgrading all remaining portions of the existing feeders not required for the new housing construction.

Emergency Power Recommendations

Emergency generation should be provided for key buildings and loads. The proposed new heating plant should be 100% backed by emergency power so heat can be provided to the Campus in the event of an extended power outage. Other key buildings and loads include:

1. Dormitories: Egress lighting, fire alarm, security, and heating loads.
2. Central Mustering Point: Lighting, fire alarm, security, heating loads, and food storage and preparation loads.
3. The Reed Annex Building (telecommunications hub).
4. The data center in the MCT Center (data hub).
5. The proposed operations and security building.

The emergency power for new student housing buildings and the proposed operation and security building should be included with the construction cost for each building. The central mustering point is a building or buildings where students can be brought in the event of an emergency throughout Campus that will have light, heat, communications, and possibly cold food. The central mustering point has not been determined at this time, but would most likely be the dining halls or a combination of the gymnasium building and dining hall. Although these areas have not been determined, an allowance of $1.25 million should be allotted to provide adequate emergency power. The opinion of probable construction cost to provide emergency power for the MCT Center and the Reed Annex, respectively, are $750,000 and $350,000. The emergency services for the Reed Annex and the MCT Center should be provided within a 0-5 year window, while the emergency power for the mustering point(s) can probably be provided within a 5-15 year window. The total cost opinion for emergency power in today's dollars is approximately $2.35 million.

Site Lighting Recommendations

As new buildings are added and the Campus site is modified, site lighting should be provided along pathways and in parking areas in accordance with University and IESNA standards. The opinion of probable cost to provide new site lighting throughout the Campus is $950,000. Based on construction costs of existing site lighting installation to the University's standards, this cost breaks down as follows:

1. The cost to add site lighting along pathways between the Phase 1A and Phase 2 buildings and central campus buildings is approximately $240,000.
2. The cost to add site lighting along pathways between the Phase 1B and Phase 3 buildings and central campus building is also about $240,000.
3. The approximate cost to upgrade lighting throughout the remainder of Campus is $470,000.

Telecommunications Distribution Recommendations

Telecommunications pathways will need to be extended and relocated to support the construction of the proposed housing and campus buildings. As the pathways are being relocated, additional pathways should be included within the ductbanks to allow routing of future cabling around Campus. Currently, the following services come into the Campus from State Route 696 through the pathway within the Reed operations Center to the Reed Annex Building:

1. Embarq - 600 pair telephone local telephone trunk lines and 24 strand fiber optic data cabling.
2. Level 3 – 24 strand fiber optic cabling for data network and long distance telephone trunk lines.
3. Comcast – 12 strand fiber optic and ¾" hard line cable TV service.
4. Verizon Wireless – 25 pair T1 cabling.

Within the Reed Annex building, there is a University owned Nortel Private Branch Exchange (PBX), which feeds the entire Campus telephone system. From the PBX, large count copper telephone cables are routed to the Reed Operations Center through the same pathway as incoming services. These large count cables are spliced in the Reed Operation Center and from there are distributed to Campus as follows:

1. 1800 pair routed to the north end of Campus along Delaware and Lancaster Drive past McCune Hall.
2. 1500 pair routed to the south end of Campus toward Old Main.
3. 1800 pair routed to the East side of Campus toward the Dauphin Humanities Center.

In Addition, part of the fiber optic network is distributed out of the Reed Annex and serves multiple buildings through the Reed Operations Center. A Hybrid 24/24 fiber optic cable passes through the Reed Operations Center and terminates in McCune Hall. From McCune, cabling is routed to Harley Hall, Reisner House, and the Robb Field Complex. To allow demolition of the Reed Operations Center, pathways will need to be rerouted and new cabling will need to be extended from the Reed Annex to redistribute service to Campus.

For service to new Housing Buildings 1A, 2A, and 2B, the existing pathways and telephone cabling can be used and extended. These costs should be included with the building costs. A new fiber cable will need to be routed from MCT to Housing Buildings 2A and 2B through existing pathways.

New cabling and pathways for Housing Buildings 1B, 3A, and 3B should be extended from MCT and the Reed Annex to central point (manhole in quad area or a telecom closet in Building 1B). From that central point it can be distributed to all three new housing buildings.

Some of the existing buildings on Campus are fed from adjacent buildings. These situations are as follows:

1. Mowrey Hall serves the Seavers Apartments and the Student Recreation Pavilion.
2. Naugle Hall serves Mclean Hall and the Spiritual Center.

Operations of existing buildings supported from buildings to be demolished must be considered as the new housing construction progresses. New cabling will need to be extended as required. If a central chilled water/heat plant is constructed, new cabling and ductbank will need to be extended to it.

The fiber optic pathway and cabling between MCT and Grove Hall will need to be relocated to allow construction of the future academic building proposed for that location. Installation of additional pathways and cabling should be considered beyond the new housing improvements to create system redundancy and flexibility.

The opinion of probable construction cost for Campus telecommunications upgrades is approximately $1,800,000. This cost opinion breaks down as follows:

1. Relocate duct banks, incoming services, and distribution cabling to allow demolition of the Reed Operations Center - $600,000.
2. New fiber optic cable from MCT for Phase 1A, 2A, and 2B housing - $50,000.
3. Extend cabling and ductbank from Reed Annex and MCT to Phase 1B, 3A, 3B housing - $180,000.
4. Maintain service to existing building fed from buildings to be demolished - $60,000.
5. Relocate fiber optic pathway between MCT and Grove Hall and replace cabling routed through it - $ 230,000.
6. Extend cabling and ductbanks to new heat/chiller plant - $120,000.
7. Future system upgrades (ductbank along loop road and from the CUB north along Cumberland Drive) - $520,000.

Fire Alarm and Security System Recommendations

Fire alarm and security panels should be provided within each new building. Fire alarm systems within each building shall be designed in accordance with applicable codes. The security system for each building should include card access with smart card technology and cameras as required. The fire alarm and security panels should be connected to separate head-end servers in Campus security post within the proposed operations building through fiber optic lines. The systems should be fully addressable with graphic interfaces utilizing maps and building backgrounds to indicate alarms. The cost for fire alarm and building security should be included with the cost of each new building and the cost to relocate and upgrade the head-end for each system should be included with the proposed operation and security building.

Energy Management System Recommendations

The existing energy management system should be expanded as new buildings are built. This will allow monitoring and control of energy usage throughout the Campus. An ideal location for the head-end server or workstation for this system would be the proposed heating plant. The head-end would be connected to remote building panel via fiber optic lines. Cost for energy management equipment within new buildings should be included in the construction cost for each building.

CATV Recommendations

CATV cabling should be brought onto Campus and distributed to buildings as required using the Telecommunications pathway system. Once inside a building, it should be distributed as required. Within the dormitories, the cabling should be terminated in a patch box to facilitate service and distribution. Again, installation costs should be included with each building.