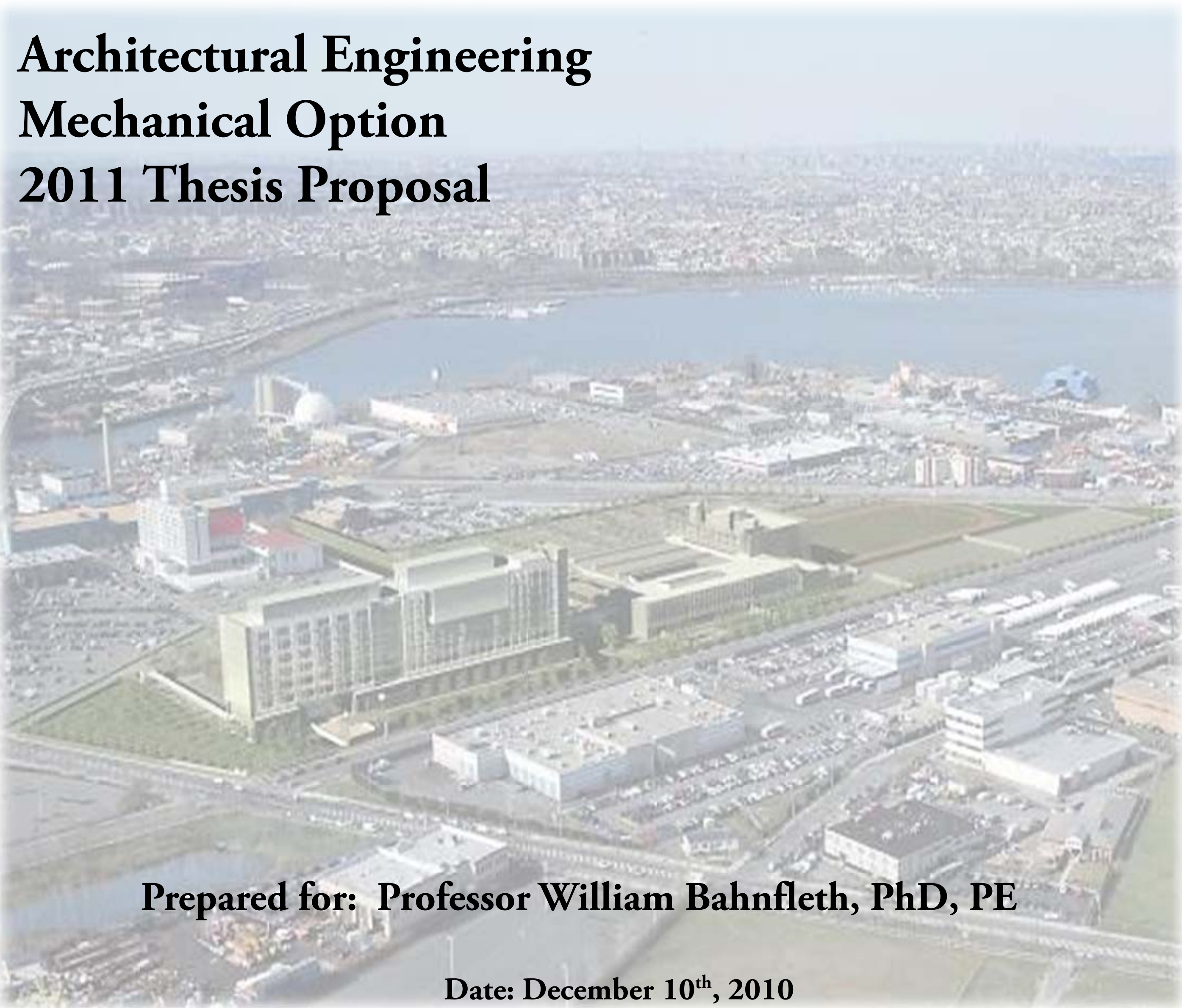
New York Police Academy

College Point, New York



Architectural Engineering
Mechanical Option
2011 Thesis Proposal

Prepared for: Professor William Bahnfleth, PhD, PE

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Mechanical Option
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John M. Scavelli

The Pennsylvania State University

Master of Architectural Engineering
Bachelor of Architectural Engineering

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Executive Summary

The New York Police Academy (NYPA) will be built in College Point by the end of 2013. The academy will be built on a 2.4 million square foot site, with two main campuses (East and West Campus). The East Campus will consist of the academic and office spaces of the academy. The West Campus will be comprised of the athletic training facilities and central heating and cooling plant. The academy is also being designed for future expansions. Technical evaluation of the NYPA has been performed. Specifically, the technical evaluations have focused on the compliance with ASHRAE's ventilation and energy standards, an energy model of the academy, and description of the actual designed mechanical system.

The purpose of this report is to use the information gathered from previous technical reports to develop a proposal for a new design of the mechanical systems of the New York Police Academy. The major design proposal is to incorporate a ground source heat pump (GSHP) system to serve the East Campus building. The proposed design alternative will be compared to the actual designed systems in areas such as energy efficiency and emission reduction. Also an incorporation of several other mechanical systems will be proposed. A thermal ice storage system will be considered to help cut back on high New York City electricity costs. There is a storm water retention ditch located in between the East and West Campus and a stormwater reuse system will be evaluated to reduce the water consumption of the Academy.

Aside from the mechanical system, there will be other areas of research for the proposed design. In regards to the electrical system, a photovoltaic array located on the roof of the West Campus will be designed to evaluate the benefits of on-site electricity production. Also from a construction standpoint, the constructability of the vertical boreholes for the GSHP system will be evaluated as well as economic costs/reductions of the GSHP system.

Overall, this report is geared towards outlining the direction that will be taken for the mechanical re-design of the New York Police Academy. More importantly, it will provide a basis of research and education in regards to optimizing mechanical systems.

Building Information

Site

Currently, the New York Police Department's training facilities are scattered among New York City and the Academy will aim to consolidate these faculties into one campus. The New York Police Academy will be built in College Point, Queens New York. It will be in close proximity with the John F. Kennedy International Airport and Citi Field, home of the New York Mets. The design consists of approximately 2.4 million square feet, 1 million square feet will consist of the actual building. The building will house academic, training, office, and related support spaces. The other sections of the site will include such things as an outdoor track, field, parking, and waste water management stream.

Figure 1: Site Plan Courtesy of New York City Department of Design and Construction

Figure 2: New York Police Academy Aerial Rendering Courtesy of Perkins + Will

Mechanical System Overview

The New York Police Academy's mechanical system operates around a central heating and cooling plant located in the West Campus Building. Boilers, chillers, and cooling towers provide the necessary hot and cold water needs for the campus. The central plant operates on a primary-pumping system. The primary pumps are located in the central plant and they distribute hot/cold water to the air handling units (AHUs) throughout the campus.

There are five water tube boilers that are located in the central plant that will be responsible for introducing the hot water for the entire campus. Along with the boilers there will be six 1350 ton chillers that will supply all the cold water needs of the Academy. The central plant serves both the East and West Campus. The capacity of the central plant has been oversized both for redundancy and the intent for future expansion of the New York Police Academy.

The air conditioning needs of the building will be met by 63 AHUs. The capacity of the AHUs range from 3,000 CFM to 30,000 CFM. The 63 Air Handling Units will be housed in different sections of the campus. 18 AHUs will reside in the Central Plant, 26 AHUs will reside in the West Campus, the final 19 AHUs will be located in the East Campus. Each zone that the particular AHU serves is equipped with variable air volume boxes to distribute the proper amount of air to the particular room.

The central plant mechanical system provides a reliable system that can easily be expanded and should increase the efficiency of maintenance and operation.

Alternative Design Considered

"De-Centralizing" The Central Heating and Cooling Plant

The New York Police Academy has been designed with a central heating and cooling plant that serves both the East and West Campus buildings. The design centralizes all major heating and cooling equipment such as chillers, boilers, cooling towers, pumps etc. This is very helpful for maintenance and operation, however this increases the pumping energy necessary to serve all the air handling units located throughout the academy.

Pumping energy can use a significant source of energy in a large scale hydronic system such as the New York Police Academy. An alternative considered would be to "de-centralize" the heating and cooling plant and to reallocate several smaller mechanical rooms throughout the East and West Campus. The smaller mechanical rooms would each have the necessary heating and cooling equipment to provide a smaller zone with the necessary hot and cold water. This would greatly reduce the pumping costs of the entire system and in turn reduce energy usage significantly. The volumetric flow rate of water supplied from these smaller mechanical rooms would be reduced, thus reducing pipe sizes. Smaller piping helps reduce material usage, installation cost, and material usage. The possible advantages of several smaller mechanical rooms could be a useful area for research.

Nonetheless, in theory reducing the central heating and cooling plant to several smaller mechanical rooms could provide significant energy savings. In reality, for this particular project it is not feasible. The reason it is not feasible is because of the plan for future expansion of the academy. Originally, the academy was designed to be larger than it already is, but lack of funding has reduced the size of the academy. One of the major benefits of having a central heating and cooling plant was the ability to house several extra chillers, boilers, cooling towers, and pumps that would be able to meet the demands of future expansions. It would be much harder to outfit several smaller mechanical rooms with added equipment than it is for one central plant. Thus, because of the plan for future expansion of the academy it would not make sense to consider "de-centralizing" the central plant to several smaller mechanical rooms.

Alternative Designs Proposed

Hybrid Central Plant & Ground Source Heat Pump System

The actual plan for the NYPA is to have a central plant located in the West Campus that will serve the entire academy as well as future buildings. The major alternative design that will be proposed for the New York Police Academy will be to incorporate a ground source heat pump system (GSHP) for the East Campus building of the NYPA. The GSHP is not intended to replace the central heating and cooling plant. The central plant will be necessary for the heating and cooling needs of the West Campus as well as for future buildings. The GSHP system will allow the central plant to be greatly reduced in size, and the cooling and heating will come from a more energy efficient source.

There are several reasons that make a GSHP system a feasible mechanical system for the NYPA. First and foremost is the energy savings and emissions reduction of the system. An analysis of both the electrical savings of the GSHP and the emissions reduction will be studied. Also the East Campus building will not be expanded, thus developing a mechanical system that is appropriately sized will be a much more efficient design than the current grossly oversized mechanical system serving the building. However, the central plant will remain in the West Campus. The plant will now only serve the west campus as well as future buildings.

Below are a few diagrams representing the intended design for the East Campus GSHP system. A vertical loop system will be designed to serve the building. The loops will provide hot/cold water to heat pumps located throughout the East Campus. The heat pump system will be integrated with a ventilation system to provide the thermal and ventilation needs for the entire building. The focus of study for this proposed design will be to establish the energy savings of the GSHP system compared to the actual central plant design.

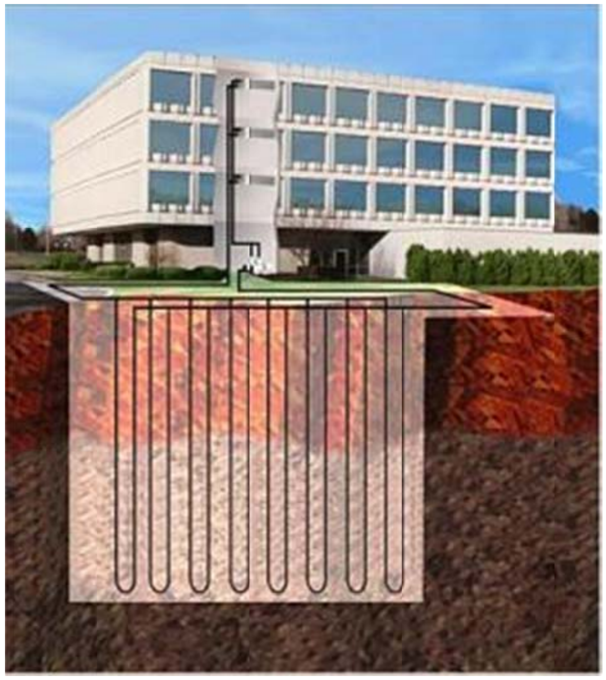
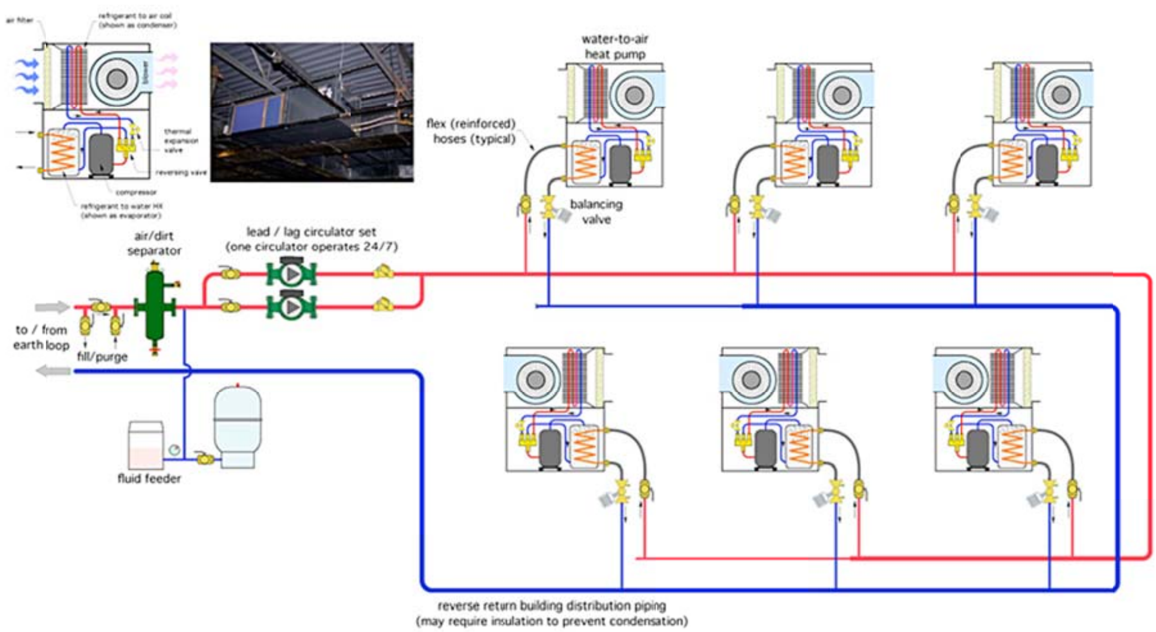


Figure 3: Vertical Borehole Schematic



www.pmengineer.com

Figure 4: Ground Source Heat Pump Distribution Schematic

Integrating Storm Water Stream for Domestic Water Use

The New York Police Academy will be built on the site of the current New York City tow pound. This site has a large drainage ditch that cuts through the entire site. Perkins + Will the architects of the New York Police Academy decided to keep this large drainage ditch and to build the new Academy around it. In the design the drainage ditch offers a pleasant aesthetic effect, the ditch appears like a moat surrounding a castle. Not only does the drainage ditch offer a nice visual effect but it can act as a useful tool that provides a symbiotic relationship with the building. The drainage ditch collects the run-off storm water from the NYPA site. Due to the magnitude of the NYPA, there will be a significant amount of storm water that accumulates in this ditch. Instead of simply discharging this water into the public sewer system, a proposed water storage system will be implemented to provide water needs for the academy.

Thermal Ice Storage System

New York is on top of the list for most expensive states for electricity prices in the country. New York falls short only to Connecticut and Hawaii based on data from the United States Energy Information Administration reports of 2009. The cooling needs of the New York Police Academy are to be me with electric chillers. The electricity cost for cooling the academy is a significant portion of the total operational costs. A proposed thermal ice storage system would allow the electric chillers to produce ice during off-peak hours. The electricity rates will be lower during off-peak hours. The ice storage can then be processed to be used when electricity rates are higher. This system should help reduce the cost of electricity and overall operational costs of the NYPA.

Breadth Topics

Construction Management

The feasibility of the GSHP system will be evaluated from a constructability standpoint. The construction and placement of the vertical boreholes will be evaluated. The position and construction techniques needed to install this system will be considered. The NYPA is in the infancy stages of construction. Obviously, it will be assumed that a GSHP system would have been implemented as an original system in the project. A GSHP for this size of building would not be feasible if the building has already been constructed. Therefore, the construction of GSHP will be treated as if the building has not yet been constructed. Also the reduction in equipment needed for the central plant will be evaluated against the cost of the system.

Electrical

The New York Police Academy is a very large facility, which offers a tremendous amount of rooftop space. Much of the roof top of the New York Police Academy is not being used, and it offers a unique opportunity to explore a large photovoltaic array. The proposed area for the photovoltaic array would be on the West Campus above the Athletic Facilities (see figures below). There are also several long sky-lights that run the length of the roof that could potentially offer valuable space for an array, a schematic section view is shown below. These sky lights offer a tilted axis as well as direct southern exposure, which both would benefit the electrical output of the photovoltaic array.

An electrical analysis will be done to calculate the amount of electricity produced by such a system. Also an economic feasibility analysis will be done to determine if this system could potentially produce enough electricity to have a payback period that is worthwhile.

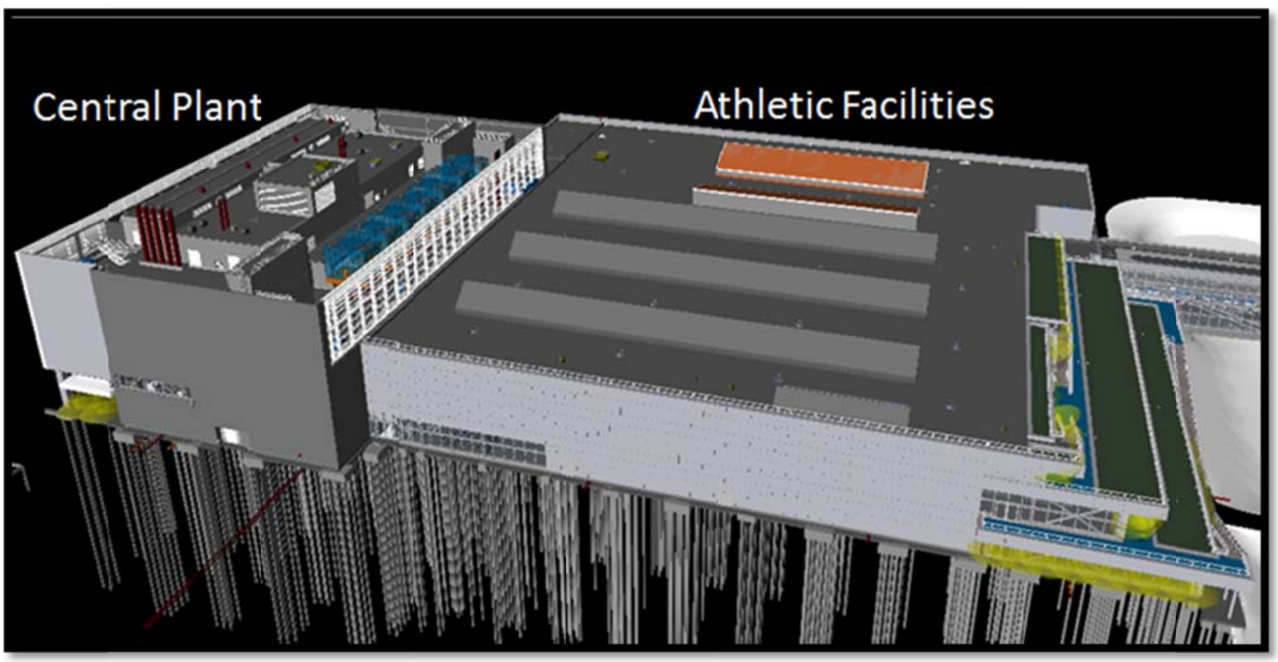


Figure 5: West Campus Roof Top

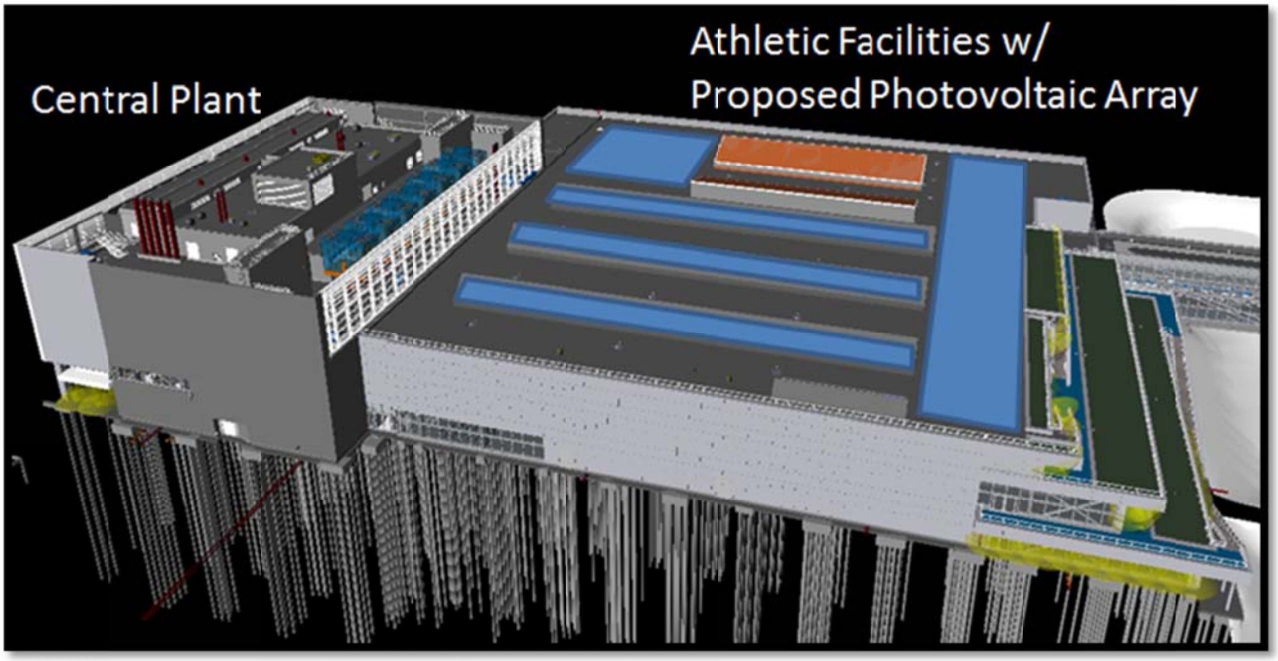


Figure 6: West Campus Roof Top with Proposed Photovoltaic Panels

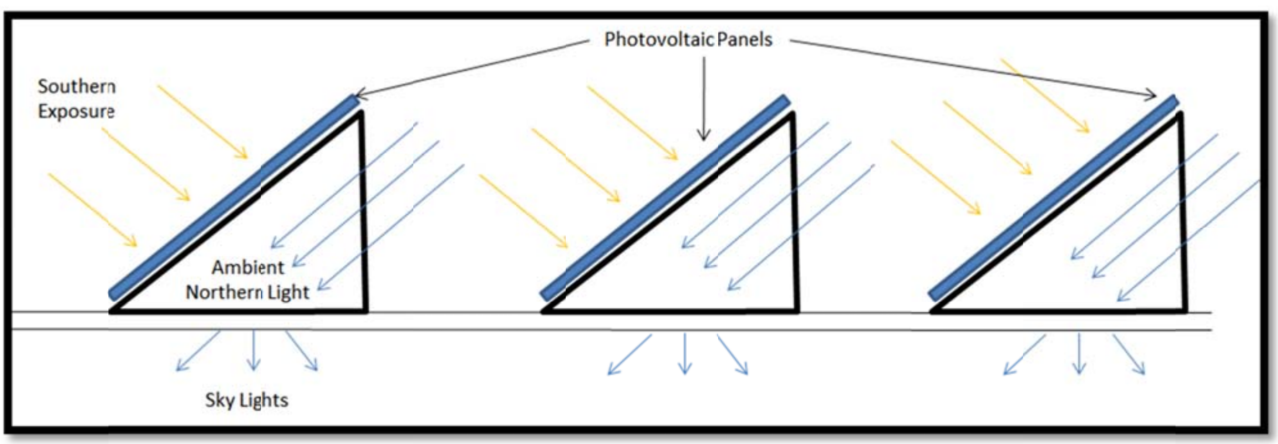


Figure 7: Section View of Proposed Photovoltaic Panels Mounted to Sky Lights

Justification of Proposed Re-Design

As stated above under the discussion of the GSHP system, the academy has been designed with a grossly oversized central plant. Establishing a GSHP system to a section of the academy that will be not be expanded, allows for the central plant to be reduced in size and it allows for a chance to optimize the mechanical system for the East Campus building. Designing an optimum mechanical system for a building that will not have any future expansion is more feasible than designing a mechanical system for potential growth. The idea of a hybrid central plant and GSHP system allows for both expansion and optimization. The East Campus building can be optimized with a GSHP system. The East Campus is nearly 400,000 square feet. The opportunity to optimize the mechanical system of such a large building should greatly reduce the central plant size, but it will still leave the ability for future expansion.

Also the ability to incorporate systems such as photovoltaics, thermal storage, and stormwater reuse should provide significant energy and environmental savings for the academy. Optimization of systems is the basis of justification for the re-design of the mechanical system of the New York Police Academy.

Table 1: Original vs. Proposed Mechanical Systems Service

Original Mechanical Design		Proposed Mechanical Design	
Central Plant Service		Central Plant Service	GSHP Service
East Campus		---------->	East Campus
West Campus		West Campus	
Future Expansions		Future Expansion	

Preliminary Research

A majority of the preliminary research for the New York Police academy can be found in previous technical reports. However, initial investigation has been taken in the feasibility and usage of a GSHP system. Also the integration of photovoltaics and stormwater collection has all been considered as useful technology for optimizing the mechanical systems of the Academy.

Master of Architectural Engineering Course Related Study

As part of the integrated Master of Architectural Engineering and Bachelor of Architectural Engineering program information from graduate level classes must be integrated into the thesis analysis. AE 557 Central Cooling Systems and AE 558 Central Heating Systems are classes that provide information directly related to central heating and cooling plants. The NYPA is equipped with a central plant and information from AE 557 and AE 558 were integral in understanding the central plant system. More specifically, a thermal storage system is being proposed as a design alternative and this specific topic directly relates to AE 557, where thermal storage techniques were covered. Also the storm water- domestic water system that is being proposed is relevant to AE 557 and AE 558. These courses provides information regarding equipment used for water distribution and filtration which will directly affect the storm water-domestic water system.

Tools for Analysis

Energy Modeling

Energy modeling is an extremely powerful tool for analyzing the characteristics of particular building systems. Energy modeling will be heavily used in the analysis of proposed systems for New York Police Academy. Determining cooling loads, heating loads, and electricity usage will come directly from energy analysis software. Particularly, Trane TRACE 700 will be used. A major part of the thesis proposal will be to evaluate the benefits or possible down falls of particular proposed systems. The energy analysis software will help to quantify and clarify the final analysis.

Specifically, for the GSHP system alternative energy modeling will be extremely useful in comparing the alternative system. Electricity consumption and utility costs will all be easily cross referenced to help develop a quantitative comparison between the alternative mechanical design and the actual mechanical design.

Engineering Equation Solver (EES) & Microsoft Excel

Engineering Equation Solver is a powerful program that can be used to evaluate solutions to systems of simultaneous equations (linear and non-linear). This program may be helpful when analyzing different proposed systems. Also the parametric tables and graphing capabilities can make EES a useful tool for presentation of material. Microsoft Excel will also be very useful for presenting graphical information. The ability to manipulate different visual graphs and diagrams will help when consolidating and analyzing the information.

Proposed Schedule