# New Science & Technology Center

# The Chestnut Hill Academy

Philadelphia, PA


## Technical Report :

## Mechanical Project Proposal

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# Executive Summary

The New Science and Technology Center was already designed with energy efficiency and occupant comfort in mind.  Some of the implementations however still have the possibility to be improved.  While the current VAV air distribution system can be very effective when used properly, problems occur as occupants manually operate the controls.  Given the building has mainly labs and workshops air quality in the return system may also be in question.  By switching the supply air to strictly outdoor air and replacing the terminal units with active chilled beams any problem with return air quality will be minimize to the individual zone.  With the addition of a thermal storage system the space will require less energy for heating and cooling, which may result from the active chilled beam system.  The thermal storage system will be either a passive solar design taking advantage of available sunlight or an active system with a nearby storage tank.

In coordination with the main re-design a daylight study will show if the building is receiving enough quality daylight to justify the incurred expense of a daylight harvesting system.  Also, given the space is an educational facility, acoustics are very important.  A space by space analysis will provide enough information to properly coordinate materials and space layout to provide the necessary reverberation times.

# Building Summary

The New Science and Technology Center at the Chestnut Hill Academy is a two level building with a footprint area of 9,200 square feet and an aggregate area of 18,400 square feet on the two levels. The cost of construction is $9.6 million. The first and second levels are both occupied by classrooms and laboratories with the second level also containing a faculty office suite. The labs will be equipped to teach physics, biology, and chemistry classes, with a separate lab for robotics that will include a workshop area. The building will include a photovoltaic roof array and a wind turbine to harvest solar and wind energy. Both will be owner installed and operated. The adjacent parking lot and sidewalks will be paved with porous asphalt covering an uncompacted subgrade, providing better absorption back into the earth. It is the intent of the owner to achieve a LEED certified level once the construction of the building is completed in November of 2008. Floor plans are provided at the end of Appendix B

# Mechanical System Summary

The New Science and Technology Center is planned to act as an addition to the already existing MEP infrastructure on campus. Power and water (domestic, heated, and fire suppression) will all be supplied from the central plant. A 480/277 V feeder will be run from the neighboring Inn building for the power supply. The first and second levels will both be supplied by separate AHU's, AHU-1 and AHU-2, respectively. AHU-1 has a 6,300 CFM capacity and AHU-2 a 8,000 CFM capacity. Both are VAV units with an economizer and energy recovery in the form of a variable speed heat recovery wheel. The initial supply air setpoint from each AHU is 55$^oF$. Once the zones are satisfied, the setpoint will be gradually adjusted to reduce energy use from heating and cooling. The air is supplied to the different zones using a single duct VAV system. The system is run on a user defined schedule with both occupied and unoccupied modes. During the occupied mode, the cooling setpoint is 74$^oF$ and the heating setpoint is 70$^oF$. During the unoccupied mode, the cooling setpoint is raised to 85$^oF$ and the heating setpoint is dropped to 65$^oF$. The system is also equipped to monitor zone $CO_2$ levels and override the damper controls to maintain a level of 500 PPM. Several exhaust fans are located in the labs to provide extra ventilation, if needed.

# Mechanical Proposal

The current mechanical system at the New Science building is a VAV system with terminal reheat.  Each of the labs are equipped with exhaust fans and call for a higher rate of outdoor air to maintain a proper level of indoor air quality.  The current system includes mixing return air and outdoor air as well as an enthalpy enable wheel to minimize energy loss.  One concern with this system is the introduction of return air from the labs into the mixed air.  While the lab exhausts are designed to avoid this situation by exhausting directly to the exterior when needed, it could still be a problem.  One method of solving this problem would be to move the mixing of return air and supply air to each individual zone instead of on a system level.  An active chilled beam system would be a good system for this application.  Active chilled beams bring outdoor air into a space and uses induction to draw room air through a heating/cooling coil before it is mixed and re-introduced into the space.  With this design the current ductwork layout could still be utilized.  The major difference would be in removing the mixing section between the return air and supply air.  An air-to-air heat exchanger could still be used between the exhaust air and outdoor air to help offset cooling/heating energy.  The water coils for the active chilled beams could be incorporated into the grey water system to reduce water usage as well.

A thermal energy storage system could be an additional way to save energy at the Science and Technology Building.  Thermal storage can be an effective method in lowering electric costs by offsetting peak demand prices.  A thermal storage tank could also take advantage of a grey water collection system in the building.  A passive solar energy storage system might also be applicable to this design.  If the daylighting conditions are correct a passive system could be the most efficient in heating and cooling the space.  A thermal storage system would also serve with educational value for a science and technology building.  Two references discussing the benefits and implementations of thermal storage are cited as references.

An alternative design that was considered was radiant heating with an under floor air distribution system.  This was quickly ruled out due to the lack of space in the floor slabs.  Redesigning the roof as a green roof was also considered in an attempt to reduce the heat island effect and decrease the lost energy, but given the surrounding environment architecturally the building would not blend well into the campus.

# Breadth Topics

In order to create a smooth flowing presentation, only breadth topics that would flow well with the overall project were considered. Two topics stood out from the rest: daylighting and acoustics.

## Daylighting

Daylighting was the original breadth topic considered. Several different aspects would be considered in a daylight study. Currently the building has daylight harvesting sensors and programmed dimmers in order to minimize the electric light usage. However, the quality and quantity of available daylight is questionable. From studies in AE 565 (daylighting) the use of daylight in a space is very specific. There must be a minimum level at the task plane, there cannot be direct sunlight in the space, too much daylight could also have an impact on the HVAC equipment. Modeling the building and running daylight simulation would be an appropriate breadth topic. This would provide the necessary information regarding whether there is enough available daylight given the site location and building orientation to justify the additional expenses of daylight sensors and dimming systems. Possible redesigns might include modifying the existing system by rewiring luminaires, removing some sensors in locations were dimming is not an option, incorporating shades/louvers, or even changing the glazing type/layout to increase the efficiency/quality of daylight entering the space. Two references, one regarding daylight quality and lighting techniques and the other discussing the effect daylight has on HVAC systems are included in the references.

## Acoustics

Acoustics are an important part of any design, especially in a school. For a second breadth topic an evaluation of the individual classrooms and labs from an acoustical perspective would be appropriate. This would include evaluating the reverberation times, checking the NC ratings for the HVAC equipment, and checking the transmission loss through the walls to adjacent spaces. Possible redesigns could include changing the materials in the rooms, changing the room layout, or changing the wall constructions.

### MAE/BAE Qualification

In order to qualify for the integrated program the proposal must include design objects learned in master level classes. In the proposal two such design objectives have been included: daylighting and thermal storage.

# Tools

Several simulation programs will be needed to complete the proposal's objectives. To start a 3D CAD model will be needed to model the space for analysis in AGI. AGI will be used to calculated the daylight levels in the space. A 3D revit model will also be useful in showing any subsequent changes in the architecture relating from the redesign. Trace or HAP will also be useful in calculating the energy consumption for comparison with the current design. EASE will be utilized for acoustical analysis. In addition to computer programs several design guidelines and manufactors's technical data will be necessary.

# References


•"A Green Building On Campus." Mark Rosenbaum. ASHRAE Journal, January 2002.

•"Daylighting." Gregg D. Ander, FAIA. National Institute of Building Sciences. November 5th, 2008. http://www.wbdg.org/resources/daylighting.php

•"Thermal Energy Storage Myths." Mark M. MacCracken, P.E. ASHREA Journal, September 2003.

•"Cool Thermal Storage: Is It Still Cool?" William P. Bahnfleth, PhD, PE. HPAC Engineering, April 2002. Volume 54.

# Work Schedule

## January

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| Notes: | | | | 1 | 2 | [redacted] |
| 4 | 5 | 6 | 7 | 8 | 9 | [redacted] |
| 11 | 12 | 13 | 14 | 15 | 16 | [redacted] |
| 18 | 19 | 20 | 21 | 22 | 23 | [redacted] |
| 25 | 26 | 27 | 28 | 29 | 30 | [redacted] |

## February

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | [redacted] |
| 8 | 9 | 10 | 11 | 12 | 13 | [redacted] |
| 15 | 16 | 17 | 18 | 19 | 20 | [redacted] |
| 22 | 23 | 24 | 25 | 26 | 27 | [redacted] |
| Notes: | | | | | | |

# Work Schedule

March

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | [redacted] |
| 8 | 9 | 10 | 11 | 12 | 13 | [redacted] |
| 15 | 16 | 17 | 18 | 19 | 20 | [redacted] |
| 22 | 23 | 24 | 25 | 26 | 27 | [redacted] |
| 29 | 30 | 31 | Notes: | | | |

April

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
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| Notes: | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
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