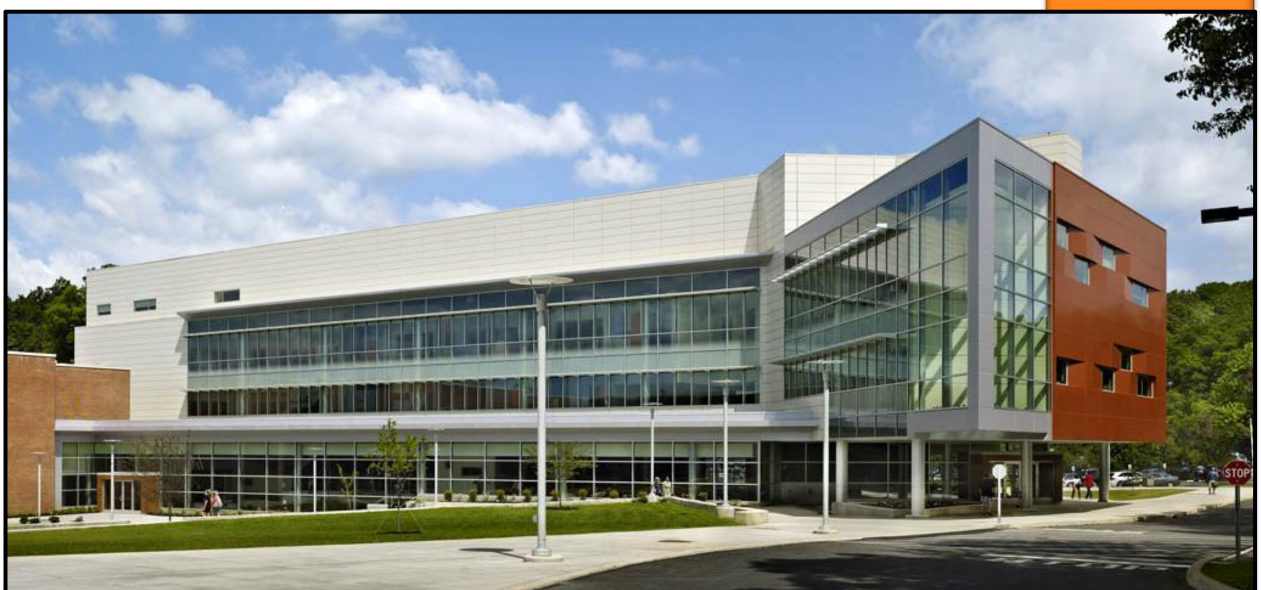
Technical Report 3

Mechanical Systems Existing Conditions Evaluation

Delaware County Community College

STEM Center

Media, PA



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Executive Summary

(Photos Provided by Burt Hill)

The Delaware County Community College Science, Technology, Engineering, and Mathematics (STEM) Center is a new addition to their Marple Campus, and is part of the two-building STEM Complex. At 105,000 square feet and four stories it is a focal point for the campus, and stands out with both architectural and sustainable features.

The purpose of this report is to complete a full-scale analysis of the mechanical system on a variety of different levels. Assessment of ASHRAE Standard 62.1 and 90.1 compliance and block load energy modeling has been completed and are further discussed in this report. An energy simulation was conducted with Trane TRACE™ 700 software, followed by analysis of ventilation, building loads, energy usage, and operating cost breakdown based on the known energy sources and rates for the STEM Center. These discussions are continuations of Technical Reports 1 and 2.

For this state-of-the-art educational facility, the total construction cost was roughly $28.725 Million, of which roughly 6% was for mechanical equipment. Partial use of existing systems of the campus's adjacent buildings helped alleviate this cost to a degree. The newly installed equipment for the system includes a 600 ton water-cooled chiller, (2) 89,500 cfm air handling units, (2) gas-fired boilers, and pumps in primary/secondary arrangement.

The loss of usable space was decreased with the consolidation of equipment to the roof and a few mechanical spaces. Altogether, the efficiency of design and quality of system achieves LEED Certification at the Silver level, including numerous credits awarded for energy and atmosphere and environmental quality. This achievement is something for the Delaware County Community College to be proud of as it continues its growth on the Marple Campus with the addition of the $49 million STEM Complex.

SECTION 1 – Mechanical Design Description

Design Objectives

The STEM Center is a part of new construction located adjacent to the existing buildings that make up the Delaware County Community College campus. It was decided early on that for the STEM Complex there was minimal capacity to utilize nearby existing systems, and that significant mechanical systems design were necessary for both the STEM Center and Technology Building. The considerations going into this all new mechanical design varied in degree but included low initial and/or operating costs, excellent air quality, adequate heating and cooling, and high energy efficiency. A goal for the project from the very beginning was to achieve LEED certification. This achievement of high building sustainability will be discussed further in Section 3 of this report.

Special considerations for this building, specifically, mainly stemmed from the occupancy and space types that were included in such a science-based building. Room types such as laboratories and preparation rooms, as well as other standard educational spaces, meant heightened requirements for air quality, ventilation, and exhaust. Laboratories for the building include physics, biology, anatomy/physiology, earth and space, CAD, and both organic and general chemistry.

Of course a major concern was placed on the operating cost of the mechanical system. For a college such as DCCC, the hope was to be capable of maintaining the building systems with ease and as little expense as possible. Considerations were taken to provide energy efficient equipment to potentially decrease utility bills.

Energy Sources and Rates

For the STEM Center, energy usage mainly consists of electricity and natural gas, which are primarily for cooling and heating, respectively. Although it is an educational facility on a main campus, neither the heating nor cooling are district systems, and are specific to this building. The rates for each energy source were a yearly average taken from the design documents provided by Burt Hill for electricity and gas. These values are shown below in Table 1.

Energy Source	Energy Rate
Electricity	\$0.089 /kWh
Natural Gas	\$1.347 /therm

Table 1: Energy Rates

For energy modeling, Trane TRACE™ 700 was used, and a full analysis for this block load simulation can be found in Technical Report 2. With TRACE™, a model was done based on several factors from airflow rates to space occupancies to the systems used and even the aforementioned energy rates. For load schedules, the TRACE™ template for typical College was used for Lighting Loads, Miscellaneous Loads, People Activity, Ventilation, and Infiltration. This was deemed suitable for a building such as the STEM Center that was primarily used for academic purposes on a daily basis with minimal after-hour activity. For this schedule, the highest rates occur between 8 AM and 5 PM, and a detailed look at the schedule can be found in Appendix A – Figure 10 of Technical Report 2.

(Photos Provided by Burt Hill)

Design Considerations

Overall, limiting factors on the STEM Center design were minimal. With the site being on the DCCC Marple Campus, in the greater Philadelphia area, it was obvious that there would be a slightly higher emphasis on heating than cooling, but a need for good balance and control altogether. The building design and architecture itself, containing a sizeable glass façade on south side at all four levels, suggested a concern for high amount of solar gain as well. The orientation of the building is suitable though, as the majority of the glazing won't receive the significant glare they might if facing east or west.

Figure 1: Site Plan Aerial View

Indoor and Outdoor Air Conditions

From the ASHRAE Handbook of Fundamentals 2009, and using weather data for Philadelphia, PA (within 10 miles of the campus), the indoor and outdoor air conditions were determined to be as shown below in Table 2.

	Heating Dry Bulb Temperature (F)	Cooling Dry Bulb Temperature (F)	Cooling Wet Bulb Temperature (F)
	99.6%	0.4%	0.4%
Philadelpha, PA	**11**	**93.1**	**75.7**

Table 2: Design Air Conditions

For the interior design, a value of 75°F was used for room temperature and 58°F for supply air temperature. Also, an assumption of 0.11 air changes per hour was made based on information provided in design documents. These air conditions were used for the TRACE™ simulation to adequately model the climate in Media, PA.

Ventilation Requirements

In Technical Report 1, an analysis of ASHRAE Standards 62.1 and 90.1 was conducted. Among the sections evaluated, the minimum outdoor air ventilation rate was determined for the building based on equations and requirements from ASHRAE Standard 62.1. These values were then compared to the design maximum for the two rooftop air handling units. As will be explained later in this report, nearly all of the building air handling is accomplished by two rooftop AHUs, and a very small percentage (for a few machine rooms) is handled by fan coil units. The two AHUs each are capable of a maximum airflow of 89,500 total cfm, including 66,000 cfm of outdoor air. The total outdoor air intake required according to the ASHRAE

Standard 62.1 for all four floors was just 43,748 cfm, as is tallied in Table 3. This comparison is shown below and points out overcompensation on the part of the air handlers for outdoor air requirements.

	Outdoor Air Intake Required (cfm)
First Floor	18,349
Second Floor	10,007
Third Floor	10,462
Fourth Floor	4,930
Total	**43,748**
Design Maximum Primary Air (cfm)	**132,000**
TRACE Simulation Design OA (cfm)	**56,309**

Table 3: Outdoor Air Requirements Comparison

Upon running the TRACE™ model, the simulated design outdoor air rate was shown to be above the amount required by ASHRAE Standard 62.1 by a difference of 12,561 cfm. This is more within the ballpark of the ASHRAE minimum, yet still fully capable of achieving that level. The percentage of outside air was calculated to be 42%, which is an adequate level for an educational facility.

Heating and Cooling Loads

As discussed in Technical Report 2, the TRACE™ simulation produced design heating and cooling loads for the building based on the information from design documentation. This simulation took into account the aforementioned indoor and outdoor air conditions, as well as many other factors, including mechanical equipment and various load sources. The results from TRACE™ were compared with the energy modeling results of the designer using IES (Integrated Environmental Solutions), a similar program. The outcomes of the separate models can be seen below in Table 4.

	Cooling (SF/ton)	Heating (BTUh/SF)	Total Supply (cfm/SF)	Ventilation Supply (cfm/SF)
Computed	201.220	40.510	1.328	0.557
Design Documented	197.310	40.696	1.282	0.559
% Difference	1.982	0.457	3.579	0.396

Table 4: Computed and Design Load Comparison

As can be seen in Table 4, the results by the designer using IES software were very near those from the simulation conducted for Technical Report 2 in TRACE™. The results for both cooling capacity in square feet per ton were within 2% of each other, and the two computed values for heating capacity were even closer in difference.

Energy Analysis

Annual energy use was also analyzed through the simulation conducted by TRACE™, and is also more completely discussed in Part 2 of Technical Report 2. For the STEM Center, as was mentioned before, electricity is the main energy usage for cooling and primarily natural gas is consumed for heating in the building. The rates for these two sources are noted in Table 1 on page 4 of this report.

By using TRACE™ for energy modeling, many different loads were taken into account, including lighting, solar, and occupancy loads. The plants selected in TRACE™ were a water-cooled chiller and a gas-fired boiler, which are described in greater detail in Tables 10 and 11 of Section 2 of this report. These two were designed at 700 tons, and 12,000 MBh, respectively.

Energy Results

Shown below in Table 5 are the results of the energy modeling conducted by TRACE™. As anticipated, the auxiliary loads from fans and pumps resulted in a significant percentage (48.6%) of the total building energy usage. This particular load category was greatly higher than that of the heating and cooling system and may be the result of an oversimplification somewhere along the way. Still, however, the amount of energy usage by each category is reasonable, and all add up to a total building energy usage of **7,991 mBtu/year**.

	Electric (kWh)	Gas (kBtu)	Water (1000 gal)	% of Total Building Energy	Total Building Energy (kBtu/yr)
Heating					
Primary Heating		1,132,702			1,192,318
Heating Accessories	37,888				387,969
Heating Subtotal	**37,888**	**1,132,702**	**0**	**15.8%**	**1,580,287**
Cooling					
Cooling Compressor	72,830				248,570
Tower/Cond Fans	109,988		530		375,389
Condenser Pump	339,682				1,159,335
Cooling Accessories	2,847				9,717
Cooling Subtotal	**525,348**	**0**	**530**	**22.4%**	**1,793,011**
Auxiliary					
Supply Fans	759,974				2,953,792
Pumps	377,136				1,287,166
Aux Subtotal	**1,137,110**	**0**	**0**	**48.6%**	**3,880,957**
Lighting	**282,857**	**0**	**0**	**12.1%**	**965,391**
Receptacles	**26,160**	**0**	**0**	**1.1%**	**89,284**
TOTAL	**2,009,362**	**1,132,702**	**530**	**100%**	**7,990,655**

Table 5: Energy Usage Breakdown

Energy Consumption Breakdown

A report for monthly energy use was also compiled and showed a general peak of electrical energy usage in the summer months and a peak of fuel energy usage in the winter months. Though these graphs are not as perfectly normally distributed as would be assumed, they still provide evidence of the general pattern of energy usage based on necessary heating and cooling loads throughout the year. The highest therm consumption occurs in January and February, and likewise the highest amount of kilowatt-hours is in August. The numerical breakdown of monthly energy consumption is shown in Table 6, and Figures 2 and 3 display the pattern of energy usage in kWh and therms, respectively.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Electric (kWh)	145,839	124,847	173,958	158,933	183,830	187,078	173,508	197,374	168,150	175,545	165,230	155,070	2,009,362
Gas (therms)	1,980	1,943	1,339	808	491	416	344	435	435	804	1,009	1,323	11327
Water (1000 gal)	7	5	17	25	61	83	105	101	60	31	22	12	587

Table 6: Monthly Energy Consumption

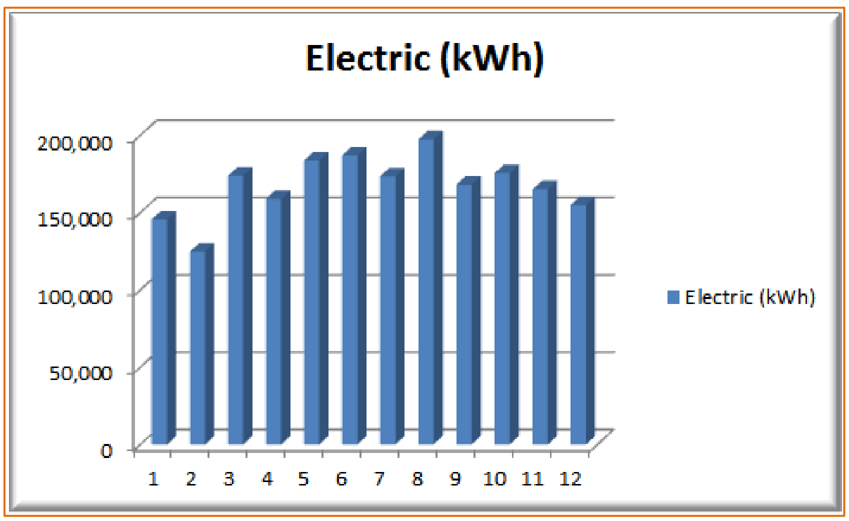

Figure 2: Electrical Energy Consumption

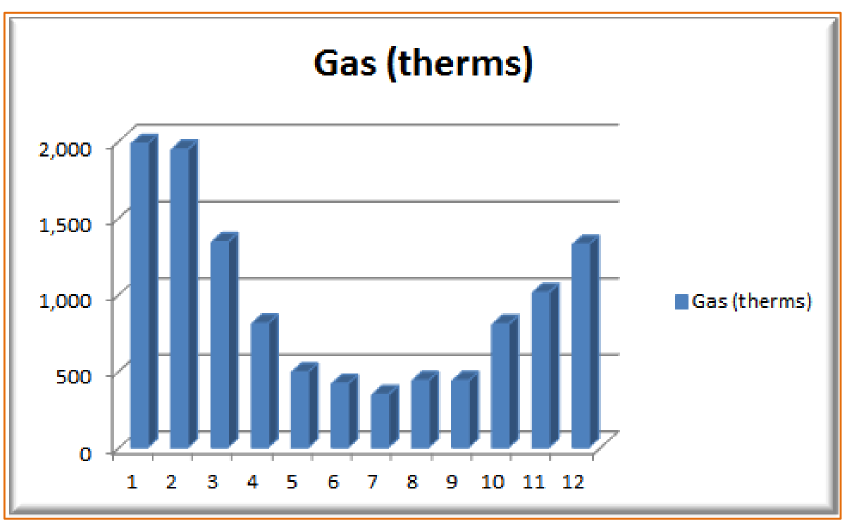

Figure 3: Gas Consumption

The electrical energy total was also broken down by usage, including cooling, heating, fans, lighting, and general equipment, as per the data outputs from TRACE™. This breakdown is represented graphically in Figure 4, and once again it can be seen that a substantial amount of energy is used for auxiliary purposes (41.5%), as well as for cooling systems (40.99%).

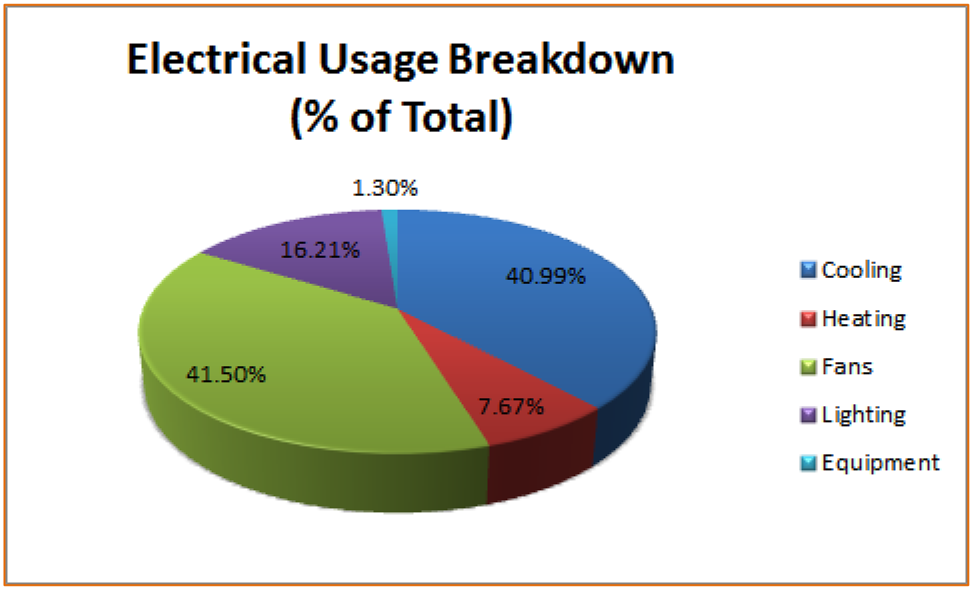

Figure 4: Electrical Usage Breakdown

<u>Results Comparison</u>

As was previously mentioned, the designer energy simulation was conducted using IES software. This program was selected largely due to its versatility in providing graphical features and overall ability to model the building loads, specifically those produced by the solar gain from the south side glass curtain wall that is present at all floors. The results for the IES simulation have been generously provided by Burt Hill, and it was seen that the TRACE™ model produced comparable data for energy usage. Shown in Table 7 is a comparison of the overall modeling results, showing the similarity of the values.

	TRACE	IES
Energy (kBtu/yr)	7,990,655	7,834,878
Utility Cost ($/yr)	177,826	164,139
Utility Cost ($/SF-yr)	1.70	1.57

Table 7: TRACE™ and IES Results Comparison

SECTION 2 – Mechanical System Overview

Description of System

Air Side Description

The two aforementioned air handling units that serve the entire building are roof mounted and have a capacity of 89,500 cfm apiece. Each of these units contains a heat recovery coil, pre-heat coil, and a chilled water coil, and a detailed drawing of AHU-4 is seen in Figure 5. Ductwork traveling down vertically through four different mechanical shafts lead to variable air volume (VAV) terminal units that are equipped with heating coils, with capacities ranging up to 4400 cfm. Fans for supply and return are all provided with variable frequency drives and full economizer capabilities. In terms of control, flow measuring stations are also used for outdoor air control.

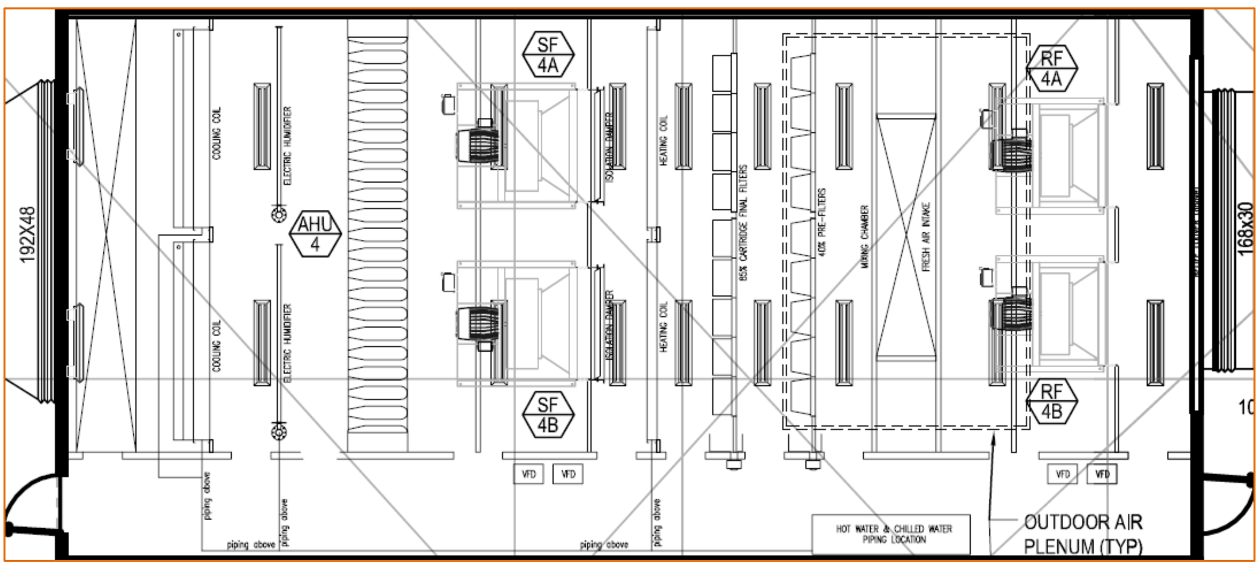

Figure 5: Air Handling Unit (AHU-4) Detail

While the supply and return paths for the air side mechanical system are relatively simple and straight forward, the exhaust system for the building is slightly more unique in order to cater to the laboratory and preparation spaces located on the top three floors. As was previously discussed, there are 13 science labs, most of which have dedicated preparation or storage rooms that require adequate exhaust of air. To comply, fume hoods are located in each lab and preparation room in the building. These are ducted vertically to the roof mounted exhaust fans, which are equipped with refrigerant coils for heat recovery systems. Pressure is controlled using a space pressurization monitoring system, and each exhaust fan is provided with a variable frequency drive.

Water Side Description

On the water side of the mechanical system, a 700 ton water cooled chiller accounts for the chilled water. This is arranged with (2) 25 hp primary chilled water pumps and (2) 125 hp secondary chilled water pumps to make a primary/secondary chilled water system as is shown in the in Figure 7: Chilled Water Schematic. In Figure 7, pumps P-7 and P-8 are primary chilled water pumps and pumps P-9 and P-10 are secondary chilled water pumps, and all primary/secondary pumps are equipped with variable frequency drives.

With the construction of the STEM Center, the intent in the mechanical design was to replace the existing cooling tower, and this was done with the addition of (4) 600 ton induced draft crossflow cooling towers (shown in Figure 6: Condenser Water Schematic). The new chiller and cooling towers are adequately served by the new 40 hp in-line condenser water pump, which is P-11 in Figure 6.

For the hot water system, (2) Bryan 250 BHP dual fuel heating hot water pumps account for the hot water heating using natural gas, as discussed in Section 1. For the heating hot water system, a primary/secondary arrangement is utilized as well, consisting of (2) 7.5 hp pumps (P-11 and P-12). Additionally for the hot water system, and also located in the boiler room, are two pumps for the heat exchanger, two for the reheat coils, two for the preheat coils, and also two in-line pumps for the fin-tube radiation heating that is utilized for the exterior glass façade on the south side of the building to prevent condensation.

Shown below in Figures 6 through 8 are the Condenser Water, Chilled Water, and Heating Hot Water Schematics drawn using Microsoft Visio software with reference to the design documents.

System Schematic

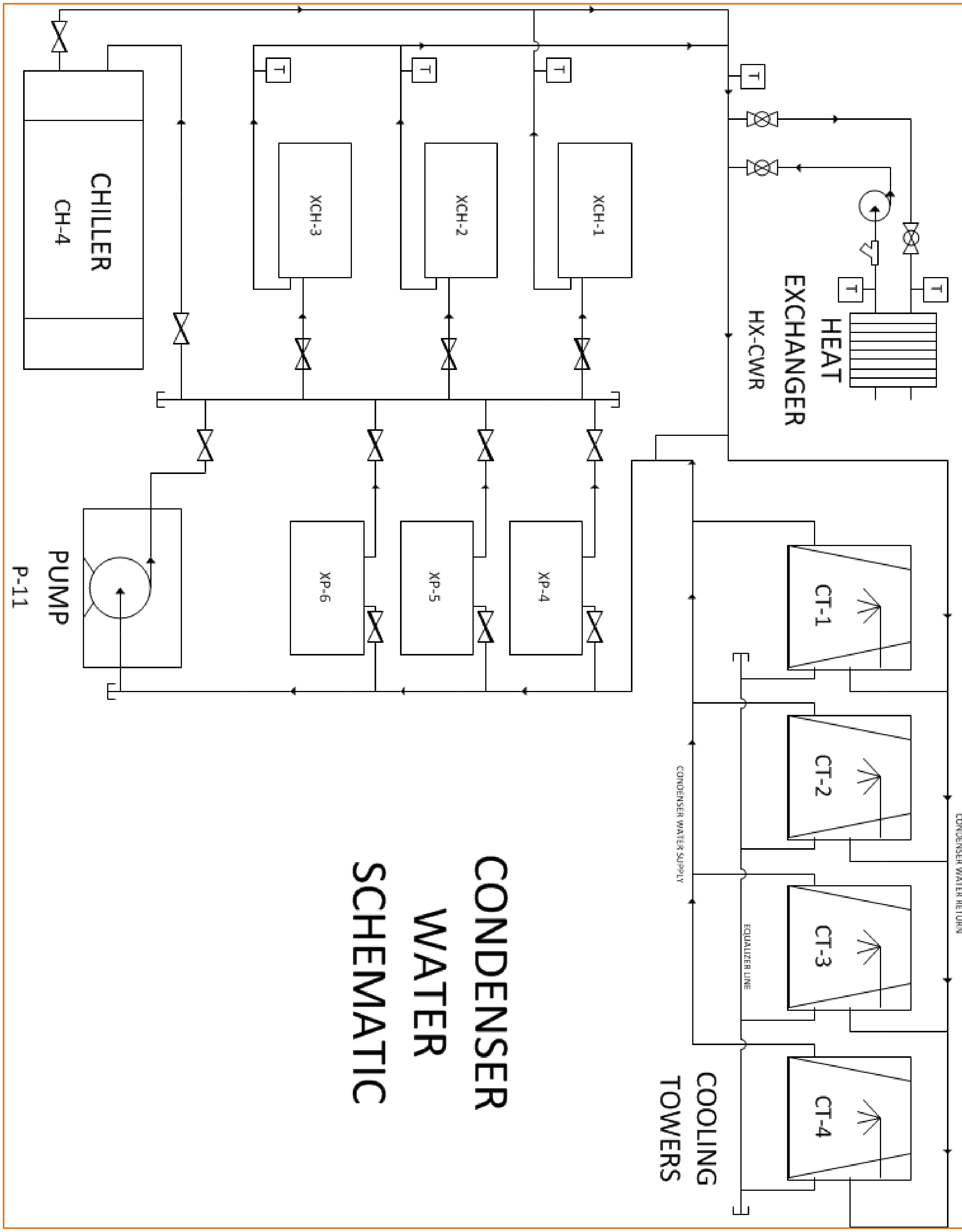

Figure 6: Condenser Water Schematic

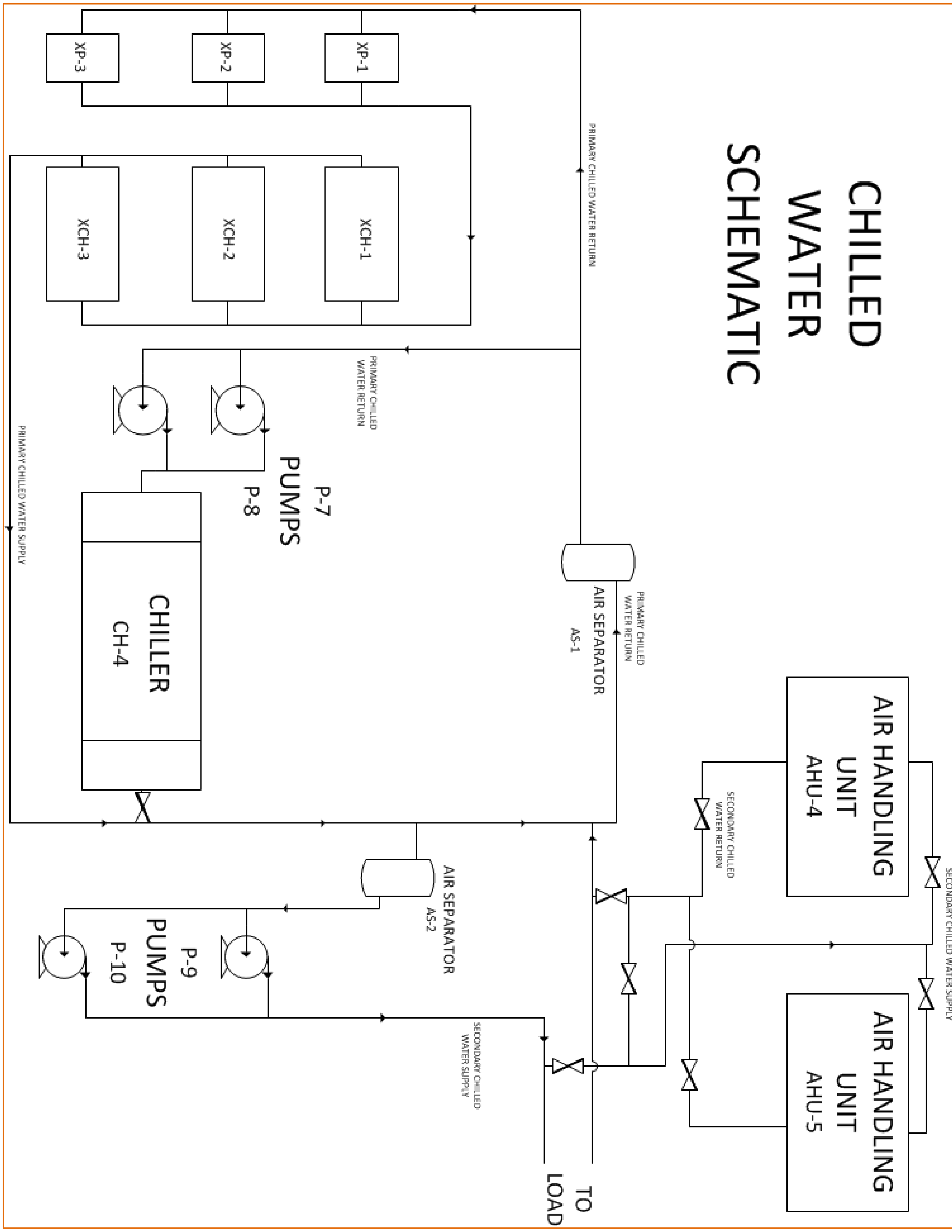

Figure 7: Chilled Water Schematic

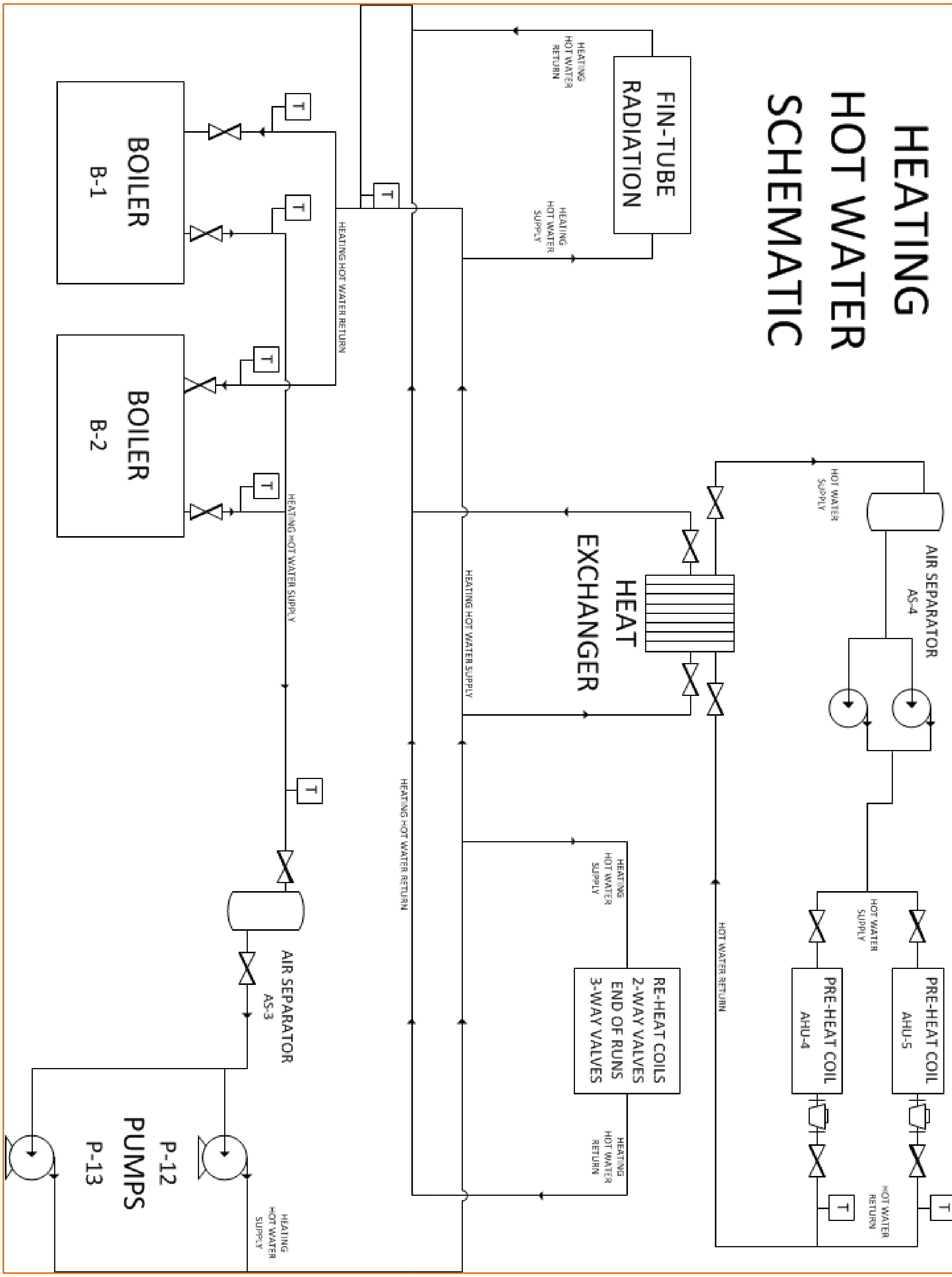

Figure 8: Heating Hot Water Schematic

Mechanical Equipment Breakdown

The mechanical system for the STEM Center can be described as fewer, yet larger, pieces of equipment. The air handling is taken care of by two AHUs designed at 89,500 cfm apiece, and there is one chiller and two boilers for the building. The information for these pieces of equipment is shown below in Tables 8 through 11.

Air Handling Units			
Name	**Airflow (CFM)**	**Min. OA (CFM)**	**Outside Air %**
AHU-4	89,500	66,000	74
AHU-5	89,500	66,000	74

Table 8: Air Handling Units

	Cooling Coil			Heating Coil		
Name	**Entering Air Temp. (F)**	**Leaving Air Temp. (F)**	**MBH**	**Entering Air Temp. (F)**	**Leaving Air Temp. (F)**	**MBH**
AHU-4	84.4	50.5	5,351	10	50	3,861
AHU-5	84.4	50.5	5,351	10	50	3,861

Table 9: Cooling and Heating Coils

Water Cooled Chiller		Evaporator		Condenser	
Capacity (tons)	**kW/ton**	**EWT (F)**	**LWT (F)**	**EWT (F)**	**LWT (F)**
700	0.58	56	45	85	97

Table 10: Water Cooled Chiller

Gas-Fired Boilers				
Mark	**MBH In**	**MBH Out**	**EWT (F)**	**LWT (F)**
B-1	6,000	5,040	160	190
B-2	6,000	5,040	160	190

Table 11: Gas-Fired Boilers

Additionally, there are four cooling towers for the building, rated at 604 tons each. The information for these as well as a breakdown of the 16 major pumps used in the mechanical system is shown below in Tables 12 and 13. As can be seen in Table 13, the majority of the pumps are equipped with variable frequency drives.

Cooling Towers						
Mark	Capacity (tons)	EWT (F)	LWT (F)	CFM	GPM	Motor HP
CT-1	604	97	85	136,170	1524	30
CT-2	604	97	85	136,170	1524	30
CT-3	604	97	85	136,170	1524	30
CT-4	604	97	85	136,170	1524	30

Table 12: Cooling Towers

Pumps					
Mark	GPM	Min. Efficiency (%)	RPM	VFD? (Y/N)	HP
P/7	1527	80	1160	No	25
P/8	1527	80	1160	No	25
P/9	3327	90	1760	Yes	125
P/10	3327	90	1760	Yes	125
P/11	1623	82	1760	No	40
P/12	392	70	1760	No	7.5
P/13	392	70	1760	No	7.5
P/14	20	40	1760	No	0.5
P/15	20	40	1760	No	0.5
P/16	320	74	1760	Yes	10
P/17	320	74	1760	Yes	10
P/18	200	67	1760	Yes	7.5
P/19	200	67	1760	Yes	7.5
P/20	320	69	1760	Yes	15
P/21	320	69	1760	Yes	15
P/CW	75	69	1160	Yes	1

Table 13: Pumps

System First Cost Analysis

First cost for the mechanical system and associated equipment was decreased slightly due to the partial use of existing systems adjacent to the STEM Center site on campus. For the installation of the new 600 ton chiller, the estimated cost was $959,050, and for the four new cooling towers, it was another $587,850. Those values, as well as the estimated cost of the two new boilers and two new air handling units and all the additional necessary costs, totaled the mechanical system first cost to $2,875,029, or roughly $27.38/SF. This number is slightly lower than may be anticipated; however, with the partial utilization of existing equipment and construction, and the consolidation of air handlers, first cost savings were foreseeable.

Lost Usable Space

Although there is no basement in the STEM Center, usable floor area is occupied by mechanical space on all four floors. At the ground floor, a sizeable mechanical room is located in the western portion of the building with a total floor area of 1,852 square feet. For floors 2 through 4, there are four mechanical shafts that run vertically through the building. Two of the shafts (Shaft 3 and Shaft 4) run through the middle of the building where science labs are located on the 2nd and 3rd floor. These two are not a factor on the fourth floor, which is roof space in the middle portion of the building. The other two (Shaft 1 and Shaft 2) occupy all of the top three floors and are at each end of the building and smaller in size. Additionally found on the outdoor roof portion of the 4th floor is 3,687.45 square feet occupied by mechanical equipment. A complete breakdown of the lost usable space due to mechanical systems is shown below in Table 14, and totals 6,651.43 square feet of floor area.

Floor	Space	Area (SF)
1	Mech. Room	1,851.79
2	Shaft 1	80.50
2	Shaft 2	91.24
2	Shaft 3	106.29
2	Shaft 4	192.18
3	Shaft 1	80.50
3	Shaft 2	91.24
3	Shaft 3	106.29
3	Shaft 4	192.18
4	Shaft 1	80.50
4	Shaft 2	91.24
4/R	Mech. Space	94.79
4/R	Mech. Space	145.94
4/R	Mech. Space	3,172.08
4/R	Mech. Space	28.00
4/R	Mech. Space	246.67
ALL	TOTAL	6,651.43

Table 14: Lost Usable Space

SECTION 3 – LEED Analysis

A goal for the project from the very beginning was to achieve LEED certification according the requirements and point system outlined by the USGBC (U.S. Green Building Council). The USGBC has existed since 1993 and has been rating building green performance since LEED Version 1.0 debuted in August of 1998. Since then it has developed into a highly respected and pursued standard for excellence in green building, and continues to progress and improve just as the building industry and need for sustainability also advances.

The LEED rating for New Construction and Major Renovations takes into account 7 different topics: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Environmental Quality (EQ), Innovation in Design (ID), and Regional Priority (RP). It was the aim for the project team to achieve a LEED Silver design, which they decided would be possible without significantly increasing the project budget.

The rating scale used for the building design was version 2.2 and a copy of the LEED Review including the anticipated scoring based on design objectives can be found in Appendix A (Figure 9). For version 2.2, there are 69 total points possible, and this report will discuss in detail several of the points from the EA and EQ sections, which are pertinent to the mechanical system design. The building design anticipated scoring 8 points from the Sustainable Sites category, 2 points for Water Efficiency, 4 points from the Materials and Resources category, and 2 points for Innovation in Design. Among those points includes selecting an appropriate site, using high reflectivity non-roof materials, diverting 50% of construction and demolition waste, using 10% recycled materials, and having LEED accredited designers on the project team. The following is discussion of the points anticipated by the design team in regards to the mechanical system:

ENERGY AND ATMOSPHERE

EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems (Required)

Intent – Verify that the building’s energy related systems are installed, calibrated and perform according to the owner’s project requirements, basis of design, and construction documents.

Execution – Section 23 Mechanical specifications from the design documentation states a requirement for commissioning by a proper commissioning agent. This commissioning plan was developed and implemented by the project team with the help of Bala Consulting Engineers.

EA Prerequisite 2: Minimum Energy Performance (Required)

Intent – Establish the minimum level of energy efficiency for the proposed building and systems.

Execution – ASHRAE/IESNA Standard 90.1-2004 (Sections 5.5, 6.5, 7.5, and 9.5) is met as discussed in full in Part 3 of Technical Report 1. Also, based on the IES simulation, building yearly energy use is projected to be greater than the minimum 10% energy improvement from the baseline building as outlined by ASHRAE Standard 90.1 Appendix G.

EA Prerequisite 3: Fundamental Refrigerants Management (Required)

Intent – Reduce ozone depletion.

Execution – The mechanical system for the STEM Center does not use any CFC-based refrigerants.

EA Credit 1: Optimize Energy Performance (3 Points)

Intent – Achieve increasing levels of energy performance above the baseline in the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

Execution – The baseline building has a calculated yearly utility cost of $368,268, while the proposed building projects a cost of $299,950. This totals to $68,318 in savings, equal to 18.55%, worth 3 points according to the 1-10 point scale for new buildings.

EA Credit 2: On-Site Renewable Energy (0 Points)

Intent – Encourage and recognize increasing levels of on-site renewable energy self-supply in order to reduce environmental and economic impacts associated with fossil fuel energy use.

Execution – Based on the goal to not substantially increase project cost, the design team did not pursue the use of on-site renewable energy sources. This does not earn any of the 3 possible points for this category.

EA Credit 3: Enhanced Commissioning (1 Point)

Intent – Begin the commissioning process early during the design process and execute additional activities after systems performance verification is completed.

Execution – The third party commissioning agent, Bala Consulting Engineers, was involved in the commissioning process prior to the construction document phase and continued after the construction completion.

EA Credit 4: Enhanced Refrigerant Management (1 Point)

Intent – Reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to global warning.

Execution – Documented analysis of HVAC equipment shows a LCGWP (Lifecycle Direct Global Warming Potential) lower than 100, which meets the maximum threshold for refrigerant impact in order to achieve this LEED credit.

EA Credit 5: Measurement & Verification (1 Point)

Intent – Provide for the ongoing accountability of building energy consumption over time.

Execution – Control and monitoring systems have been installed consistent with the *International Performance Measurement & Verification Protocol (IPMVP): 2003 Edition*.

EA Credit 6: Green Power (0 Points)

Intent – Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

Execution – The STEM Center does not obtain the required 35% electricity from renewable sources.

ENVIRONMENTAL QUALITY

EQ Prerequisite 1: Minimum IAQ Performance (Required)

Intent – Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

Execution – The project has been designed to meet the minimum requirements of ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality, using the previously-discussed Ventilation Rate Procedure. More details on this procedure can be found in Part 2 of Technical Report 1.

EQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control (Required)

Intent – Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to Environmental Tobacco Smoke (ETS).

Execution – The STEM Center does not permit smoking inside the building and any designated smoking areas on the DCCC campus are at least 25 feet away from any building openings.

EQ Credit 1: Outdoor Air Delivery Monitoring (1 Point)

Intent – Provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being.

Execution – There is permanent CO_2 monitoring with operation adjustments installed for the building, fulfilling the necessary requirements for this LEED credit.

EQ Credit 2: Increased Ventilation (1 Point)

Intent – Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort, well-being and productivity.

Execution – As previously mentioned in Section 1 of this report, the rooftop air handling units contain the capacity for 132,000 cfm of primary air, and 48,000 cfm of outdoor air, which exceeds the requirements set forth by ASHRAE Standard 62.1.

EQ Credit 3.1: Construction Indoor Air Quality Management Plan During Construction (1 Point)

Intent – Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Execution – The construction methods fully complied with SMACNA (Sheet Metal and Air Conditioning National Contractors Association) standards for indoor air quality. Filters with a minimum rating of MERV 8 were used during construction to maintain air quality as well.

EQ Credit 3.2: Construction IAQ Management Plan Before Occupancy (1 Point)

Intent – Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants.

Execution – To achieve this management plan, a Building Flush-Out With Early Occupancy was conducted. For the square footage of the building, the flush-out was to occur such that 1.47 billion cubic feet of outdoor air was provided to the building, based on the need for a total of 14,000 cubic feet/square feet of floor area (14,000 CF/SF * 105,000 SF = 1,470,000,000 CF). The actual amount was 1.496 billion cubic feet, fully satisfying the flush-out requirements.

EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants (1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – All adhesives and sealants used in the construction process were of sufficiently low VOC (Volatile Organic Compounds) limits, thus earning the 1 point for this LEED credit.

EQ Credit 4.2: Low-Emitting Materials: Paints & Coatings (1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – Paints, primers, anti-rust paints, anti-corrosives, sealers, and stains used in the construction process were of sufficiently low VOC limits, thus earning the 1 point for this LEED credit.

EQ Credit 4.3: Low-Emitting Materials: Carpet Systems (1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – CRI (Carpet and Rug Institute) Green Label Plus carpet and Green Label cushions were installed for the STEM Center using low VOC adhesives, thus earning the 1 point for this LEED credit.

EQ Credit 4.4: Low-Emitting Materials: Composite Wood & Agrifiber Products (1 Point)

Intent – Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Execution – All composite wood and agrifiber products used in the construction process contained no added urea-formaldehyde resins.

EQ Credit 5: Indoor Chemical & Pollutant Source Control (1 Point)

Intent – Minimize exposure of building occupants to potentially hazardous particulates and chemical pollutants.

Execution – Entryway systems employed are of at least six feet in length in order to prevent dirt and particulates from entering the building. Also, due to the use of mechanical ventilation in the STEM Center, air filters are of MERV 13 rating or higher.

EQ Credit 6.1: Controllability of Systems: Lighting (1 Point)

Intent – Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces (i.e. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Execution – Installed for the building are individual lighting controls for at least 90% of the occupants, thereby earning the 1 point for this credit.

EQ Credit 6.2: Controllability of Systems: Thermal Comfort (1 Point)

Intent – Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces (i.e. classrooms or conference areas) to promote the productivity, comfort and well-being of building occupants.

Execution – Each multi-occupant space, including laboratories and classrooms, is provided with its own individual VAV box(es) and space controls. Likewise, all single occupant spaces, though less common in this building, are also provided with VAV box and controls.

EQ Credit 7.1: Thermal Comfort: Design (1 Point)

Intent – Provide a comfortable thermal environment that supports the productivity and well-being of building occupants.

Execution – Main air handling units in the building distribute 55° F supply air and VAV terminal units with hot water reheat coils are capable to provide supply air as high as 85° F, maintaining adequate thermal comfort. For spaces with high heat gain such as tele-data and elevator machine rooms, split cooling fan coil units are provided, and unit heaters are utilized for entry vestibules. Additionally, perimeter fintube radiation is used for the southern glazing to offset heat loss through the glass. Altogether, the building envelope and HVAC design meets ASHRAE Standard 55 and earns this 1 point credit.

EQ Credit 7.2: Thermal Comfort: Verification (1 Point)

Intent – Provide for the assessment of building thermal comfort over time.

Execution – A survey will be administered using IBM Lotus Notes QuickPlace every six to twelve months, assuring adequate assessment of building thermal comfort as time goes forward.

EQ Credit 8.1: Daylighting & Views: Daylight 75% of Spaces (0 Point)

Intent – Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Execution – For the windows on the exterior of the building, there is at least a 2% daylighting factor in only 18% of regularly occupied spaces. Therefore, this 1 point credit is not awarded.

EQ Credit 8.2: Daylighting & Views: Views for 90% of Spaces (1 Point)

Intent – Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Execution – Of the total regularly occupied space area (55,553 SF), 50,368 SF has access to views. This is a total of 90.67%, which meets the 90% requirement.

Overall System Evaluation

The mechanical system designed for the STEM Center is effective and appropriate for the needs outlined prior to design. The first cost for the mechanical system was able to be decreased with the partial use of existing plants and equipment alongside the addition of larger, consolidated equipment. The total estimated mechanical first cost was $2,875,029, or roughly $27.38/SF. There is potential to decrease the initial cost should the equipment become less centralized and ductwork distance decreased.

Operating cost analysis was conducted with the help of TRACE™ and a yearly cost of $177,286 was calculated. This value cannot be compared with current system reports for the building, as the STEM Center is currently only 6 months beyond the grand opening. The use of heat recovery, variable frequency drives, and economizers aids the operating cost to a degree, and further investigation will be taken to determine where the yearly totals can be decreased even more.

Altogether, the centralization of the equipment to the roof and the adjacent building help to alleviate the loss of usable floor space, and also contributes to the easier maintainability of the building as a whole. Obviously a great deal of mechanical shaft space is needed to ensure proper ventilation and exhaustion of air for various science-related rooms, and this usage is largely unavoidable.

As is summarized in Section 3 with discussion of the LEED credits awarded, great steps have been taken by the design team to ensure high quality of air and environmental control. The pursuit of LEED Silver certification accurately summarizes the sustainability and excellence of the building systems as a whole. There is potential, still, for improvement and a higher level of achievement on the LEED scale.

Appendix A: LEED Credits Breakdown

Delaware County Community College
Science, Technology, Engineering, and Mathematics (STEM) Center
Media, PA

LEED™ EVALUATION - VERSION 2.2

Category	Credit	LEED™ Credit Description	Possible Credits	Anticipated Score	Possible Additions	Not Possible	Cost	Comments
Sustainable Sites	SSp 1	Erosion and Sedimentation Control		R				Must meet conform with 2003 EPA Construction General Permit
	SS 1	Site Selection - Avoid Inappropriate Sites	1	1				site must meet criteria
	SS 2	Development Density and Community Connectivity	1			1		60,000 s.f. per acre density requirements or 10 Basic Services w/i 1/2 m.
	SS 3	Brownfield Development	1			1		Documented as a brownfield by Phase II ESA and effectively remediated
	SS 4.1	Alternative Transportation- Public Access	1		1	1		1/4 mile from two or more bus lines?
	SS 4.2	Alternative Transportation- Bicycles	1			1		bicycle storage plus showers and changing rooms.
	SS 4.3	Alternative Transportation- Fuel-efficient vehicles	1			1		vehicles + preferred parking for 3% of occupants
	SS 4.4	Alternative Transportation- Parking	1	1				size parking to meet but not exceed zoning requirements, include carpool
	SS 5.1	Reduced Site Disturbance- Habitat	1	1				restore vegetation of 50% of remaining open area
	SS 5.2	Reduced Site Disturbance- Development	1	1				dedicate open space- near the creek
	SS 6.1	Storm Water Management- Rate & Quantity	1	1				No net increase in runoff or reduce by 25%, need to evaluate existing
	SS 6.2	Storm Water Management- Quality	1		1			Implement EPA's BMP's for Nonpoint Pollution
	SS 7.1	Reduce Heat Island- Non-roof	1	1			$	high reflectivity site materials
	SS 7.2	Reduce Heat Island- Roof	1	1				75% Energy Star roof and high emissivity or 50% vegetated roof
	SS 8	Light Pollution Reduction	1	1				IESNA limits, cutoff fixtures, and no light trespass from building or site
Water	WE 1.1	Water Efficient Landscaping- 50% reduction	1	1				high efficiency irrigation or captured rainwater, drought tolerant plantings
	WE 1.2	Water Efficient Landscaping- No potable	1	1				No use of potable water for irrigation or no permanent irrigation system
	WE 2	Innovative Wastewater Technologies	1			1	$$	50% reduction in potable water for waste conveyance or 100% treatment
	WE 3.1	Water Use Reduction	1	1				20% reduction in potable water use over EPAct
	WE 3.2	Water Use Reduction	1			1		30% reduction in potable water use over EPAct
Energy and Atmosphere	EAp 1	Fundamental Commissioning		R				Must develop and implement a commissioning plan
	EAp 2	Minimum Energy Performance		R				Must meet ASHRAE/IESNA 90.1 2004
	EAp 3	CFC Reduction in HVAC&R Equipment		R				Zero use of CFC-based refrigerants
	EA 1	Optimize Energy Performance (10.5% - 42%)	10	3	2	5		10.5 - 42% improvement above ASHRAE/IESNA 90.1-2004
	EA 2.1	Renewable Energy- 2.5%	1			1	$	2.5% of total energy use from on-site renewables
	EA 2.2	Renewable Energy- 7.5%	1			1	$$	7.5% of total energy use from on-site renewables
	EA 2.3	Renewable Energy- 12.5%	1			1	$$$	12.5% of total energy use from on-site renewables
	EA 3	Enhanced Commissioning	1	1				3rd party Cx Agent, engaged prior to Construction Document phase
	EA 4	Enhanced Refrigerant Management	1	1				No refrigerants or demonstrate reduction in ozone depleting compounds
	EA 5	Measurement & Verification	1	1				install control and monitoring system consistent w/ IPMVP 2003
	EA 6	Green Power	1			1		35% of electricity purchased from grid source renewable technology
Conserving Materials & Resources	MRp 1	Storage and Collection of Recyclables		R				Design must accommodate collection of recyclables
	MR 1.1	Building Reuse- 75% Shell	1			1		75% of walls, floors, and roof retained
	MR 1.2	Building Reuse- 95% Shell	1			1		95% of shell retained
	MR 1.3	Building Reuse- 50% nonshell	1			1		50% of interior non-shell areas retained
	MR 2.1	Construction Waste- 50%	1	1				divert 50% of construction and demolition waste
	MR 2.2	Construction Waste- 75%	1		1			divert 75% of construction and demolition waste
	MR 3.1	Resource Reuse- 5%	1			1		5% of materials salvaged, refurbished, or reused
	MR 3.2	Resource Reuse- 10%	1			1		10% of materials salvaged, refurbished, or reused
	MR 4.1	Recycled Content- 10%	1	1				10% of materials w/ recycled content
	MR 4.2	Recycled Content- 20%	1		1			Additional 10% of materials
	MR 5.1	Regional Materials- 10%	1	1				10% materials extracted, processed and manufactured w/i 500 miles
	MR 5.2	Regional Materials- 20%	1		1			20% materials extracted, processed and manufactured w/i 500 miles
	MR 6	Rapidly Renewable Materials	1			1		2.5% of materials from rapidly renewable resources
	MR 7	Certified Wood	1	1				50% of wood based materials from FSC certified sources
Enhance Indoor Environmental Quality	EQp 1	Minimum IAQ Performance		R				Must meet ASHRAE 62-2004
	EQp 2	Environmental Tobacco Smoke Control		R				Prohibit smoking in the building
	EQ 1	Outdoor Air Delivery Monitoring	1	1				Permanent CO2 monitoring w/ operation adjustments
	EQ 2	Increased Ventilation	1	1			$	Outdoor Air delivery 30% over ASHRAE 62-2004
	EQ 3.1	Construction IAQ- During Construction	1	1				comply with SMACNA standards, MERV 8 filters during construction
	EQ 3.2	Construction IAQ- Before Occupancy	1	1				employ building flush out or do indoor air quality testing
	EQ 4.1	Low-Emitting Materials- Adhesives/Sealants	1	1				Low VOC adhesives and sealants
	EQ 4.2	Low-Emitting Materials- Paints and Coatings	1	1				Low VOC paints, primers, anti-rust paints, anti-corrosives, sealers, stains
	EQ 4.3	Low-Emitting Materials- Carpet	1	1				CRI Green Labeled Plus carpet, Green Labeled cushion, low VOC adhesi
	EQ 4.4	Low-Emitting Materials- Composite wood/agrifiber	1	1				No-added-urea-formaldehyde composite wood or agrifiber products only
	EQ 5	Indoor Chemical Pollution Source Control	1	1				entryway systems, isolation of chemical pollutants, and MERV 13 filters
	EQ 6.1	Controllability of Systems- Lighting	1	1				Individual lighting controls for 90% of occupants
	EQ 6.2	Controllability of Systems- Thermal Comfort	1	1				Thermal controls as per ASHRAE 55-2004 for 50% of occupants
	EQ 7.1	Thermal Comfort- Design	1	1				HVAC and envelope design must meet ASHRAE 55-2004
	EQ 7.2	Thermal Comfort- Verification	1	1				Agreement for post-occupancy survey and remediation
	EQ 8.1	Daylighting	1	1				minimum 2% daylighting factor in 75% of regularly occupied spaces
	EQ 8.2	Views	1	1				views from 90% of regularly occupied spaces
		TOTAL CORE POINTS	64	36	7	22		
Innovation in Design	ID 1.1	Innovation Credit	1	1				Green Building tour/ educational program
	ID 1.2	Innovation Credit	1		1			Exeplary performance on a credit???
	ID 1.3	Innovation Credit	1		1			
	ID 1.4	Innovation Credit	1		1			
	ID 2	LEED accredited Designer	1	1				LEED AP's on design team
		TOTAL POINTS	69	38	10	22		

LEED Certified	26 - 32 Points	Summary:	The project is likely to achieve a LEED Certified Rating. A Silver Rating is achievable. A Gold or Platinum rating is possible but is likely to increase the project budget.
Silver	33 - 38 Points		
Gold	39 - 51 Points		
Platinum	52 or more Points		

Figure 9: LEED Credits Breakdown