Technical Report 3:

Mechanical Systems Existing Conditions Evaluation

Berks Classroom and Lab Building - Berks Campus Reading, PA

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1. Executive Summary

This report provides a clear, concise summary of Berks Classroom and Lab Building's mechanical systems. This includes design requirements, external influences on design, major hardware components, system configuration, and operation characteristics.

2. Introduction

Burks Classroom and Lab Building is located on Penn State's Burks Campus, located near Reading, Pennsylvania in Berks County. Penn State Burks sits among rolling hill and tree-lined pathways. The campus has a rich history, considering it was not always part of the Penn State system. The campus started as Wyomissing Polytechnic Institute (WPI) and became part of the Penn State System in 1958. In 1972 it moved to the Spring Township location and added residence halls in 1990. Even though there is rich history with the campus Penn State did not have to follow any historical requirements.

Burks Classroom and Lab Building is 62,188 square feet with all three levels above ground the occupancy for the building is designated as Group B - Business. The building was started in April 2010 and is scheduled to be completed in either August or September of 2011. The delivery method was design-bid-build. As with the new buildings at Penn State, Burks Classroom and Lab Building is designed using LEED certification and after completion is anticipated to achieve a LEED Silver rating under LEED 2.2.

The design team is as follows:

Owner: The Pennsylvania State University Berks Campus

General Contractor: Alvin H Butz, Inc.

Construction Cost Estimator: Becker & Frondorf

Building Architect: RMJM Hiller

Engineers:

Structural: Greenman-Pedersen, Inc.

MEP: H.F. Lenz Company

Civil: Gannett Fleming Engineers

Lighting Consultant: Illumination Arts, LLC

Acoustical Consultant: Shen Milsom Wilke, Inc.

They used multiple codes in the design of Burks Classroom and Lab Building; the codes are mostly 2006 with one exception being 2003. The code are as follows: International Building Code, International Mechanical Code, International Plumbing Code, International Energy Conservation Code, International Code Council Electrical Code, International Fire Code, and Accessibility Code ICC/ANSI 117.1 2003. There were some zoning requirements which included a Land Development Permit (LDP) from Springs Township and an NPDES permit was required from Burks County Conservation District (BCCD).

The building façade of the first floor is consists of two different types of façade, the first and closest to grade are Architectural precast concrete panels backed with an airspace rigid insulation air space and finally a masonry wall. The second part of the first floor façade has an aluminum curtain wall system in place of the architectural precast concrete panels, the two airspaces and rigid insulation. Above the first floor the façade changes again to have an exterior finish of terracotta rain screen backed by rigid insulation backed by cold formed metal framing (CMFM).

The roof system consists of metal decking covered by rigid composite insulation and a Kee membrane. KEE stands for ketone ethylene ester and is gaining popularity in Southern California because of its great waterproofing protection and lightweight design. The KEE membrane is a single-ply, lightweight vinyl and is extremely easy to install. The install for most types of the KEE membrane requires the contractors to use a simple hot air bonding technique; this creates a seamless molecular bond between each sheet of the membrane. This makes the membrane easy to repair and remains highly flexible with age, making it easy to uncover the substructure for repairs if needed.

Considering the Burks Classroom and Lab Building is designed to achieve a LEED Silver rating at completion. The building utilizes a gray water system; this system is designed to supply the restrooms within the building with water for their water closets and urinals. Other things considered for LEED rating was using materials that are made within a 500 mile radius from the site.

System Description

The building utilizes a VAV system that has an air side and hydronic side to it.

AIR SIDE:

On the air side there are three roof top air handling units (AHUs) that range from 26 tons to 70 tons.

HYDRONIC SIDE:

The water side consists of two gas fired boilers with a 6.2 gallon capacity and an output of 850 MBH. The building utilizes four Split system air conditioning units with rated capacities of either 1 or 1.5 tons. There are supplemental heaters located in two vestibules, two corridors and a stair well to help regulate the temperature of these spaces.

ZONE CONDITIONING:

The spaces are supplied air from Variable Air Volume Boxes (VAV Boxes). The server room is served by a computer room air conditioning unit (CRAC).

3. Design Objectives and Requirements

The objectives of the HAVC systems in this building are to properly ventilate the building and maintain comfortable temperatures and humidity levels for the occupancy and surrounding temperatures. There are three roof top units that distribute air to VAV boxes that serves most of the building. There is a CRAC unit that serves the server room. The system also includes two boilers and four split system air conditioning units, as well as several cabinet unit heaters.

Berks Classroom and Lab Building has several different types of spaces within the building, requiring different ventilation rates. The types of spaces that are most prevalent are office space, computer lab, and classroom space.

The building also utilizes a grey water system within the building. The grey water system supplies water for use in the rest rooms of the building primarily the toilets and urinals.

4. Energy Sources

The Berks Classroom and Lab Building uses both electricity and natural gas, most likely provided PPL Electric Utilities and UGI respectively. I have been unsuccessful in obtaining the providers and actual rates therefore the companies are the most prevalent in the area and the rates may be approximated and actual prices may vary. The following table provides the approximated rates.

TABLE 1: UTILITY RATES

Utility	Assumed Rate
Electricity	$0.10185 / kWh
Natural Gas	$0.75793 / ccf

5. Design Conditions

The weather data in Table 2 is the data from Trane Trace used in the development of the model run for technical report two.

TABLE 2: DESIGN CONDITIONS

Season	Indoor Design(°F)	Outdoor DB (°F)	Outdoor WB(°F)
Summer (0.4%)	72	90.7	73.4
Winter (99.6%)	68	6.6	

6. Equipment Summary

The equipment for the Berks Classroom and Lab Building include three AHU's(RTU), eight additional heaters(UHT&CUH), a computer room air conditioning unit(CRAC), four split system air condition units(ACU), five hot water pumps(HWP) and two boilers(BLR). The roof top units are variable air volume systems and for this summary the VAV boxes will not be included but will be summarized with the AHUs. (RMJM Miller, 2009). Tables 3 through 6 provide a summary of heating and cooling capacity and system supply and in the case of the boilers gpm and the pumps horse power (hp).

TABLE 3: ROOF TOP UNITS SUMMARY

Unit	System Supply (CFM)	% OA Min	Coil Capacities (MBH)	
			Heating	Cooling
RTU-1	20,500	16.6	414.8	799.6
RTU-2	14,000	39.4	366.8	471.4
RTU-3	10,725	29	324.4	318,4
ACU-1	-	-	-	12
ACU-2	-	-	-	18
ACU-3	-	-	-	18
ACU-4	-	-	-	18
CRAC-1	885/800	-	-	32.8

TABLE 4: BOILER SUMMARY

Boiler	Input MBH	Output MBH	Water Content GPM
BLR-1	1,000	850	6.2
BLR-2	1,000	850	6.2

TABLE 4: HEATER SUMMARY

Unit	System Supply	Heating Capacity (MBH)
UHTM118	460	18.2
UHT109	460	18.2
UHTP110	460	18.2
CUHF105	430	24.9
CUHQ104	335	19.5
CUHF101	430	24.9
CUHZ101	630	40.5
CUHQ304	230	12.9

TABLE 4: HOT WATER PUMP SUMMARY

Pump	Operation	Motor (HP)	GPM
HWP-1	Duty	1	85
HWP-2	Standby	1	85
HWP-3	Duty	1	85
HWP-4	Duty	.5	170
HWP-5	Standby	.5	170

7. Design Factors

I was unable to get information from the designers for major design consideration for this report. However, there are a few design conditions that are relevant for the HVAC System. The location of the building is in Reading, PA, which is about the same latitude as Pittsburgh, PA and historically requires more heating days than cooling days for the year. The spaces inside the building required consideration for design loads there are multiple computer labs as well as classroom spaces, since the building is located on a Penn State campus it is a good assumption that students would take computers to class to take notes. Since the building is owned by Penn State, sticking to the budget would be a big concern.

8. Annual Energy Consumption and Operating Costs

The annual energy consumption and operating costs were calculated using the information from the Trane Trace model and the assumptions listed above in 3.2. The building primarily uses electricity with natural gas used to provide fuel to the boilers and some kitchen equipment located in the HRIM Kitchen that provides food for the Bits and Bytes Café on the first floor.

8.1. Annual Energy Consumption

The annual energy consumption has been broken in to different categories and is show below in Table 5. The values in the table below were computed by using the energy model and equipment listed in the design documents. For the classrooms the default std school equipment was selected to account for projectors and

computers that could be located in the rooms. In the Faculty Offices the assumption was made for a computer per faculty member, which is assumed to be half of the occupants.

TABLE 5: ANNUAL ENERGY CONSUMPTION

Load	Electrical Consumption (kWh)	Gas Consumption (kBtu)	Total Building Energy (kBtu/yr)	% of Total Building Energy
Heating				
Primary Heating		903,312	903,312	3
Other Accessories	18,118	-	61,836	0.2
Cooling				
Compressor	1,920,466	-	6,554,551	21.6
Condenser Fans	250,438	-	854,711	2.8
Cooling Accessories	876	-	2,990	0.0
Lighting	3,924,145	-	13,393,105	44.2
Receptacle	2,506,134	-	8,553,434	28.2
Totals	8,620,166	903,312	30,323,938	

From the table above the largest load is from the light equipment with in the building, followed by the receptacle loads. This is largely due to the computer loads in the building.

8.2. COST INFORMATION

Since actual cost information was unobtainable the operation rates for electricity and natural gas are assumed to be from PPL Electric Utilities and UGI respectfully. This was arrived at by researching electricity and natural gas suppliers in the Reading, PA area. The rates are listed below in Table 8 and these were used as well as the values in Table 7 to calculate the values in Table 9.

TABLE 6: ENERGY RATES

Energy Type	Rate see Energy type for units
Electricity	$ 0.10185 / kWh
Natural Gas	$ 0.75793 / ccf

TABLE 7: ANNUAL ENERGY COST

Load	Electrical Consumption ($)	Gas Consumption ($)	Total Building Energy ($/yr)
Heating			
Primary Heating		6.77	6.77
Other Accessories	1,845.32	-	1,845.32

Cooling			
Compressor	195,599.46	-	195,599.46
Condenser Fans	25,507.11	-	25,507.11
Cooling Accessories	89.23	-	89.23
Lighting	399,674.17	-	399,674.17
Receptacle	255,249.75	-	255,249.75
Totals	877,965.04	6.77	877,971.81

From Table 9 we can estimate the annual cost per square foot to operate the Berks Classroom and Lab Building at $14.12.

9. LEED Evaluation

The following LEED Evaluation is based on LEED 3.0 documentation provided by the mechanical faculity of the AE Department at Penn State. The Berks Classroom and Lab Building is designed to be a LEED silver building. Not all points will be recognized in this section only the ones those are associated with the mechanical systems of the building.

9.1. Energy & Atmosphere

There are three prerequisite points for this section and those are Fundamental Commissioning of Building Energy Systems, Minimum Energy Performance, and Fundamental Refrigerant Management. It as a safe assumption that these are met since the building is designed to be a LEED certified building. Upon reading the point description for the points in the category it is unknown which points were achieved.

9.2. Indoor Environmental Quality

There are two prerequisites that are met for this section for any points to be considered. They are Minimum Indoor Air Quality Performance and Environmental Tobacco Smoke (ETS) Control. The second of the prerequisites is met for all Penn State Buildings. The building's mechanical systems met the Increased Ventilation point, Controllability of Systems - Lighting, Controllability of Systems - Thermal Comfort and Thermal Comfort - Design. These points are met in some by occupancy sensors located within the rooms.

10. Description of System

The building utilizes a VAV system that has an air side and hydronic side to it.

AIR SIDE:

On the air side there are three roof top air handling units (AHUs) that range from 26 tons to 70 tons.

HYDRONIC SIDE:

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ZONE CONDITIONING:

The spaces are supplied air from Variable Air Volume Boxes (VAV Boxes). The server room is served by a computer room air conditioning unit (CRAC).

There are two boilers that supply hot water to the heating coils and the domestic hot water for the building.

11. Mechanical Space

There is one main mechanical room that houses the two boilers and the five hot water pumps that is located on the first floor in the North-West corner of the building. In addition to the mechanical room there are a few electrical rooms and tele-data closets located through-out the building. There are also a few vertical shafts for duct work to run in between the floors.

12. Evaluation of the System

Considering that Penn State is one of the Universities that have an accredited AE program, it is reflected in the building of new buildings on their campuses. It was no surprise that this building was scheduled to be a LEED certified building upon completion.

The cost to operate the building was higher than expected at $14.12 / sq. ft. I was expecting the cost to be lower considering the building is only used Monday through Friday.

Overall the designed system is the best solution for the budget given to the designers.

13. BIBLIOGRAPHY

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