

Technical Report 2: Building and Plant Energy Analysis

Berks Classroom and Lab Building - Berks Campus Reading, PA

Authored by Julia Broskey - Mechanical Option

Prepared for Dr. William P. Bahnfleth PE

Contents

- 1. EXECUTIVE SUMMARY 3
- 2. INTRODUCTION 3
- 3. LOAD ESTIMATION 5
 - 3.1. Program Selection 5
 - 3.2. Assumptions 5
 - 3.3. Design Conditions 5
 - 3.4. Load Schedule 7
 - 3.5. Load Comparison 7
- 4. ANNUAL ENERGY CONSUMPTION AND OPERATING COSTS 7
 - 4.1. Annual Energy Consumption 7
 - 4.2. Cost Information 9
 - 4.3. Emission Information 10
- 5. CONCLUSION 10
- 6. BIBLIOGRAPHY 11

List of Tables

Table 1: Summer Design Conditions..... 6

Table 2: Winter Conditions 6

Table 3: Optional Direct Humidification Weather 6

Table 4: Seasonal Values..... 6

Table 5: Annual Energy Consumption..... 8

Table 6: Energy Rates 9

Table 7: Annual Energy Cost..... 9

1. EXECUTIVE SUMMARY

This report contains a design load estimation and annual energy consumption and operating costs for the Berks Classroom and Lab Building. The numbers in this report are just estimates and not actual cost which I was unable to obtain.

To obtain the estimates some assumptions were made which include which energy suppliers that are used, and since this is a classroom building for the campus the schedule for the lighting to follow was between the hours of 0800 and 2100 hours. To create these estimates Trane Trace was used. Since the drawings are in PDF format some of the scaled measurements taken from the documents did not match up to the dimensioned measurements. The scale of the drawings used was 1/8" = 1' all scaled measurements were taken with the PDF viewed at 100% and the assumption that this would be original document size therefore the measurements should be correct.

The building uses 8,620,166 kWh/year and 903,312 kBtu/year respectively of electricity and natural gas which is a total cost of \$877,971.81. This translates to approximately \$14.12/square foot in operational costs.

The building is assumed to produce the equivalent of pollutants each year, 49,732,158 lbm CO₂, 90,972 lbm NO_x and 265,445 lbm SO_x

2. INTRODUCTION

Berks Classroom and Lab Building is located on Penn State's Berks Campus, located near Reading, Pennsylvania in Berks County. Penn State Berks 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.

Berks 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, Berks Classroom and Lab Building is designed for 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.

The design team consulted multiple codes in for the design of the Berks 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 Berks 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 Berks 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. (RMJM Miller, 2009)

3. LOAD ESTIMATION

3.1. PROGRAM SELECTION

The design load estimation was to be a block load analysis of the building spaces based on information taken from the design documents, issued for bid on 17 July 2009. This analysis was done using Trane Trace program. The program was chosen due to the familiarity I have with it, from class and internship.

3.2. ASSUMPTIONS

In order to get a best guess analysis some assumptions were made. These include the energy providers, measurements taken from the documents, and lighting schedules. The energy providers were assumed to be PPL Electric Utilities for electric and UGI for natural gas. The measurements were taken from the PDF design documents when the PDF was view full screen at 100% zoom, even with this view some of the measurements read from the scale did not completely match up with the dimensions listed on the document. To be consistent for the energy analysis all dimensions are the scaled dimensions. Since this is a classroom building the lighting schedule is assumed to be 0800 to 2100 hours, the HVAC equipment is assumed to start at 0700 and shut off at 2200 hours.

3.3. DESIGN CONDITIONS

The design conditions for the building were approximated for Allentown, PA which is about 35 miles North East of Reading, PA. This was chosen because it was the closest location within Trane Trace. The summer conditions were taken from ASHRAE 0.4% dry and wet bulb and the winter conditions were the 99.6% for the dry bulb, the clearness number and ground reflectance were kept at the default values. See Tables 1 - 4 for a summary of the design values used by Trane Trace. (Trane, 2011)

TABLE 1: SUMMER DESIGN CONDITIONS

Condition	Temperature in °F
Dry Bulb (0.4%)	90.7
Wet Bulb (0.4%)	73.4

TABLE 2: WINTER CONDITIONS

Condition	Temperature in °F
Dry Bulb (99.6%)	6.6

TABLE 3: OPTIONAL DIRECT HUMIDIFICATION WEATHER

Condition	Temperature in °F
Dry Bulb (0.4%)	81
Wet Bulb (0.4%)	75.4
Dew Point (0.4%)	73.4

TABLE 4: SEASONAL VALUES

	Summer	Winter
Clearness Number	1	1
Ground Reflectance	0.2	0.2

3.4. LOAD SCHEDULE

Since the building is a classroom building the lighting schedule is assumed to be 0800 to 2100 hours Monday through Friday, this was arrived at by knowledge of Penn State class schedules. Classes do not start before 0800 and the last class of the day end at 2100. It is assumed that the building is not accessible on the weekends. The HVAC system is assumed to be constant to provide the necessary ventilation for a new building to keep the concentrations of VOC emitted by the construction and finish materials in compliance with indoor air quality recommendations.

3.5. LOAD COMPARISON

There will be no load comparison due to the inability to get the information from designers for the building.

4. 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.

4.1. 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.

4.2. 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 respectively. This was arrived at by researching electricity and natural gas suppliers in the Reading, PA area. The rates are listed below in Table 6 and these were used as well as the values in Table 5 to calculate the values in Table 7.

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	25,507.11	-	25,507.11

Fans			
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 7 we can estimate the annual cost per square foot to operate the Berks Classroom and Lab Building at \$14.12.

4.3. EMISSION INFORMATION

The Berks Classroom and Lab Building has two boilers that are natural gas fired and the some kitchen equipment that uses natural gas. The information was calculated using Table 5 in the document Source Energy and Emission Factors for Energy Use in Buildings provided by the mechanical faculty of the Architectural Engineering department of Penn State.

- 49,732,158 lbm CO₂/year
- 90,972 lbm NO_x/year
- 265,445 lbm SO_x/year

5. CONCLUSION

The Berks Classroom and Lab Building requires energy in order for the activities to take place, it uses a mixture of natural gas and electricity. The building uses a total of 8,620,166 kWh and 903,312 kBtu of electricity and natural gas respectively. From assumptions above are charged \$ 0.10185 / kWh and \$ 0.75793 / ccf which results in a total cost per year of \$877,971.81. Since the building is approximately 62,188 square feet it results in an operational cost of \$14.12 per square foot.

With all this energy use the building would produce the equivalent of pollutants each year, 49,732,158 lbm CO₂, 90,972 lbm NO_x, 265,445 lbm SO_x.

6. BIBLIOGRAPHY

RMJM Miller. (2009, July 17). Working Drawings for Berks Classroom and Lab Building. *Bid Documents*. Princeton, New Jersey, USA.

Torcellini, M. D. (2007). *Source Energy and Emission Factors for Energy Use in Buildings*.

Trane. (2011, October 8). Trace.