The

Gaige

Technology and Business Innovation Building

Penn State Berks, Reading PA

Technical Report Two

Building and Plant Energy Analysis

October 1st, 2013

Matthew Neal, Mechanical Option

Stephan Treado, Advisor

Table of Contents

Technical Report Two

Executive Summary

Technical Report Two for the Gaige Building identifies key characteristics of the building's mechanical system, the loads associated with the current design, the energy consumption on an annual basis, the monthly utility costs, and the emissions associated with the yearly operation. This report was created to help identify critical elements of the design, so that in future analysis of the building, limiting factors in the current mechanical design of the building can be identified and altered. This report is a first look at the previously mentioned aspects of the Gaige Building.

In order to predict these various quantities, a Trace 700 model of the building was created to predict the Gaige Building's load profile. In the first part of this report, the assumptions behind this model are given, as well as a summary of the resulting loads from the Trace 700 model. Overall, the building is heating dominated, but still has a significant cooling energy summary. As well, the loads predicted in Trace 700 are compared and contrasted with results from a Carrier HAP model of the same building from the mechanical engineers on the project at H.F. Lenz Company. The models were created using as much of the same assumptions as possible to help with the comparison between the two.

When comparing the two models, overall, the Trace 700 model under predicted the Carrier HAP model by only 10%, which is a fairly successful result for a first attempt at creating an energy model for the Gaige Building. Despite this success, it is noted that some under and over predictions lay hidden within this 10%. Most substantially, the heating load for the entire building was under estimated by close to 50%, and the cooling load for the building was overestimated by 100%. These are differences that need to be analyzed for further reporting and modeling of the Gaige Building as this senior thesis project continues.

The second half of the report is an analysis of the energy consumption, cost, and emissions of the Gaige Building. First, using the same Trace 700 model, the overall energy consumption of the Gaige Building was run, and using rates from the mechanical engineers on the project, monthly utility rates were calculated. As well, the annual building utility cost was compared with the annual cost reported from the Carrier HAP model from H.F. Lenz Company. When compared, again, only a 3.4% difference is found between the two models. It still should be noted that the underestimation of the heating system and the overestimation of the cooling system will cause this percentage to be slightly misleading. More work in analyzing the source of these issues will need to be determined as the project moves forward, so that changes to the building's current design can be contracted with an accurate model of the current building.

As well, charts are provided summarizing the monthly energy use and costs associated with the Gaige Building, broken down into the systems that consume the energy. These graphs help to identify the major contributors to the overall energy consumption of the Gaige Building, and whether or not some of these system have clear seasonal fluctuation. Finally, pollutant emissions are calculated for the Gaige Building using annual source energy rates, and the environmental impact of the operation of the Gaige Building can be seen. Overall, this report helps to provide a clear yet concise picture of the Gaige Building, and it will help to determine and guide proposed design alteration to improve the building as a whole.

Building Overview and Background

The Gaige Technology and Business Innovation Building is a 64,000 SF building located in Reading, PA, on the Berks commonwealth campus of Penn State University. The Gaige Building is a host of many functions, but primarily, it is used as classroom, office, and lab space for the college's engineering, business, and hotel and restaurant management programs.

The Gaige Building is three stories tall, and it was constructed between April 2010 and November 2011. It was operated on a design-bid-build project delivery method, and had a full range of consulting services, from cost-estimating to A-V consulting. Functionally, the first floor contains classroom and lab spaces primarily, with a large area for studying and relaxing called the Learning Loft. Once you move to the second floor, you see the same classroom and lab emphasis, but a corridor on the east-west wing of the building provides a large amount of conference and office space.

Once you move to the third floor, the east-west wing of the building is capped off at two stories, but the north-sound wing continues up to three stories to accommodate one more classroom space and ample office and conference space. The exterior of the building consists of weather-resistant terracotta panel, metal framed exterior glazing and curtain wall systems, and precast concrete panels. Together, all of these building elements provide an aesthetically pleasing, but sealed and energy efficient building façade and enclosure. More information on the architecture of the building can be found in the building statistics report performed on the Gaige Building through this same thesis project.

Mechanical System Overview

The Gaige Building has three main root top units (RTU-1, RTU-2, and RTU-3) that provide ventilation, conditioning, and exhaust for the majority of the spaces within the building's design. The units are sized to 20,500 CFM, 14,000 CFM, and 12,500 CFM respectively. Each of these units serve a variety of spaces within the first, second, and third floors of the building. Air is supplied from the roof top units at a supply temperature of 55 degrees, and it is ducted throughout the building.

At the individual spaces, variable air volume boxes are provided for each zone. The VAV box takes the 55 degree air, and varies the volume of air being supplied to the space to meet the cooling requirement of the space at the current time. The load is monitored by a thermostat located in each of the zones separately. CO2 and occupancy sensors also are coordinated with the VAV boxes to allow for a reduction in outside air required to be supplied to each space. A minimum set point prevents the VAV box from supplying air less than the minimum outside air requirement for the space. A reheat coil prevents from overcooling the space when providing minimum outside air at a time when cooling requirements are reduced.

Two 1300 MBH boilers provide the hot water service for the building and all mechanical heating requirements. Four split system air conditioners are required to provide individual space cooling for the telecom/data rooms in the building, and one computer room air conditioner is required for the IT storage and equipment room, also supplied with an air-cooled chiller. Unit heaters are provided throughout the building as needed in semi-heated spaces, such as the vestibules at the building entrances.

Finally, the heating loads for the building are met by radiant-heating panels and fin-tube heat exchangers placed at exterior walls of spaces that don't experience a year round cooling load. This allows for simultaneous heating and cooling throughout the building in spaces that contain these heating elements. Although it provides poor energy efficiency, the VAV boxes are equipped with reheat coils, so some heating in spaces without panes or fin-tubes could potentially have some heating capacity, but that is not the primary design intent.

Design Load Estimation

The first goal of technical assignment number two was to create a model that accurately estimated the design loads for the Gaige Building. For this report, Trace 700 was selected to perform the design load analysis. H.F. Lenz Company, the MEP firm that worked on the project, used Carrier HAP for the calculation of their design loads. Both programs have subtle differences in their calculation methods, but overall, they both produce accurate and reliable results. Below, the approach to the Trace 700 model will be outlined, as well as all of the assumptions that were used in making the model. These design assumptions outline what data inputs were used to create the model, like schedules, occupancies, ventilation rates, wall constructions, glazing performance, weather information, and lighting and electrical equipment rates. These assumptions will also describe from where the design assumptions were taken. The, with the design assumptions outlined, the two models' results will be compared to check the repeatability of the design results.

Model Design Approach

In Trace 700, the model designer is allowed to use various tools to help improve the accuracy and reliability of your results, and to help you decrease the amount of time required to create a reliable model. For the model used in this report, first, templates were created for each space type. The various spaces within the Gaige Building included classroom spaces, laboratory spaces, office spaces, lobby spaces, lounge spaces, one kitchen and dining space, and other basic building support spaces. Templates for each of these room types were made to be applied to individual rooms that controlled the lighting power wattage values, thermostat requirements, occupancy data, and much more.

Once these 'templates' were created, then each individual room was modeled in Trace 700. To do this, each room was created assigned a floor area. Then, all other parameters, outlined below, were added to each room specifically or to each room type from the assigned templates. Once all the rooms were defined, airside equipment was created using the create system function within trace. For the systems, the model for this report contained three roof top units that were assigned the system type "VAV with Baseboard Skin Heating", four air conditioning units assigned the system type "Fan Coil", and one computer room air conditioner assigned to the "Computer Room Unit" system type.

As well, all of the spaces that did not require strict temperature set points were assigned to a system entitled heating/ventilation only, known in Trace 700 as "Ventilation and Heating". Once all of the systems had been created, plants for the energy production were created. For heating, a plant was created with the two gas-fired boilers specified in the design documents. For cooling, each roof top unit was assigned to a separate unitary air side cooling plant, since the cooling equipment is contained in each roof top unit separately. For the four single zone air conditioning units and the computer room air conditioner, each system was assigned to a separate air-cooled chiller, each of which was found in the design documents as well. All cooling equipment was assigned to the electric utility and heating was assigned to the gas utility.

System Design Assumptions

The following sections outline how the building was modeled, what data was used for the system inputs as far as internal loads are concerned, and where the data was obtained from. Many of the design assumptions were pulled directly from the model created by H.F. Lenz, for this report aims to recreate accurately the actual model used to design the building. Despite the fact that values were pulled from the model, it was always ensured that the values used in this model accurately reflected the building's design, and it will be discussed where variations between what was designed and what was modeled in Carrier HAP were discovered, and how those variations were addressed.

Design Condition Assumptions

For the Gaige Building, standard values were used for space thermostat set points. All occupied spaces were set to values specified in table one below. This space type constitutes the majority of the building, but spaces that only require heating and ventilation were designed at differing thermostat set points. The set points for heating and ventilation only spaces is given below as well in table one.

Design Set Point for the Gaige Building			
Space Type	Temperature (°F)		Humidity
	Cooling	Heating	
Conditioned Spaces			
Set Point	75	70	50%
Drift Point	85	60	50%
Heating/Ventilation Spaces			
Set Point	110	70	50%
Drift Point	110	60	50%

Table 1: Design set points for the Gaige Building for differing spatial types

Occupancy Assumptions

For the Gaige Building, in order to recreate the best match between the model created by H.F. Lenz Company and the model created for this report, values were chosen based upon the design values found in both the design documentation of the Gaige Building and the model created by H.F. Lenz Company. Although values could be calculated on an occupancy per 1000 SF basis from ASHRAE recommendations, since design occupancies were available, they were used.

Ventilation Assumptions

For the ventilation rates in the model, rates were obtained from the design documents from H.F. Lenz Company. Although ventilation rates were calculated from the previous assignment, technical report one, it is the goal of this assignment to best recreate a model for the building, as designed. Because of this, the preloaded ASHRAE standards template values within Trace 700 were not used, and individual ventilation supply rates were input on a space by space basis.

Building Infiltration Assumptions

As per recommendation by the mechanical engineer from H.F. Lenz who worked on the project, 0.3 air changes per hour was used as the infiltration to all spaces within in the Gaige Building. This value was selected based upon the fact that the Gaige Building is designed to be positively pressurized, and it is of at least average construction quality. Since the building's façade has been given much thought, shown by its LEED Silver status, the building could probably be considered of a higher quality construction, and a lower value for infiltration could have been used. Since 0.3 air changes per hour was used in H.F. Lenz's model in Carrier HAP, that value was also adopted for the Trace 700 model created for this report.

Lighting and Equipment Assumptions

In the Trace 700 model, the constant value of 1.2 Watts/SF is used for the lighting load throughout the building. In the actual design of the building, this is not the value, but this value was the one assumed for the model created by H.F. Lenz in Carrier HAP. For consistency of results and for comparison's sake, 1.2 W/SF was used in the model, but for future assignments, and for comparison of benefits due to design changes, the building's model will be updated to the lower value determined from the previous technical report.

For the equipment loads in the Gaige Building, below, table two summarizes the assumed loads on a Watt/SF basis, varied by spatial type. These values are generally accepted values for each spatial type, and were used in the previous Carrier HAP model for the building. By using the same values, more consistency can be ensured in the comparison of the results between the Carrier HAP model and the Trace 700 model. As well, the model provided by H.F. Lenz contained various 'miscellaneous loads' for specific equipment used throughout the building. The type of loads and values for these loads are provided below in table three as well.

Electrical Equipment Loads	
Space Type	Load (W/SF)
Server Room	3
Telecom/Data Room	5
Mechanical Room	2
Laboratory	2.5
Shipping/Receiving	1
Office Space	2
Classroom	2
Electrical Room	2
Kitchen Area	500 W
Computer Lab	2.5

Table 2: Electrical equipment loads used in the model on a W/SF basis, with the exception of the kitchen area

Miscellaneous Building Loads		
Space Type	Load	Utility Type
Kitchen Hood Fan	44.8 kW	Electric
Kitchen Refrigeration	8 kW	Electric
Kitchen Hood Heating	515 MBH	Gas
Kitchen Equipment	534 MBH	Gas
Exterior Lighting	4 kW	Electric
Greywater Pumping	6.3 kW	Electric
Shop Compressor	11.6 kW	Electric
Domestic Hot Water	9.2 kW	Electric
Elevator	33 kW	Electric

Table 3: Miscellaneous Loads given throughout the building, provided by H.F. Lenz

Construction Type Assumptions

In the Trace 700 model for the Gaige Building for this report, and for the model created by H.F. Lenz in Carrier HAP, average construction values were used for each building element. For the wall construction, all walls are designed to a relatively similar total construction U-value, and an average value was assumed for the energy model. For window and skylight construction, one type of glazing was used throughout the entirety of the building, so the U-value and SHGC value are accurate, and used for all glazing in either model. For door construction, glass doors are assumed to have the same values as the window construction, and solid doors are provided with another design U-value and solar heat gain coefficient. Other door types with differing U-values, like the shipping/receiving garage door, are altered on an instance by instance basis. Finally, Floors that are slab-on-grade are modeled using an insulation value for perimeter type heat losses, and roofs are assumed to have a constant U-value throughout the Gaige Building's construction. Below, table four summarizes the values used for these various construction types in the model of the Gaige Building.

Electrical Equipment Loads	
Building Element	Thermal Value(s)
Exterior Wall	U-0.0714
Glazing	U-0.26, SHGC = 0.3
Opaque Door	U-0.167, SHGC = 0.4
Slab on Grade Floor	U-0.0714
Roof	U-0.041

Table 4: Thermal resistance values for the different construction types used in the Gaige Building

Weather Information Assumptions

For the model created in Trace 700, the weather data used in Trace was from Harrisburg, PA, for that is the location used in the Carrier HAP model of the building. The actual location provided by ASHRAE that is closest to the building site is for the Carl A. Spaatz Airfield, at the Reading Regional Airport. This data is available in the ASHRAE 2009 Handbook of Fundamentals, I-P Edition. After section 14.17 in the Handbook of Fundamentals, the Appendix containing design condition for selected locations contained weather data for this location. This data is clearly the best possible data available, for the airfield is less than two miles as the bird flies from the Gaige Building. Despite this data being available, since the data was not preloaded into Carrier HAP, Harrisburg, PA was used for the design of the building by H.F. Lenz. For my future models, the design overrides option in Trace 700 will be used to specify the design criterion used for the Gaige Building. The data used in the model and the data for the Spaatz Airfield are shown below in table five and table six.

Weather Inputs-Harrisburg, PA		
Heating	Cooling Data	
DB: 99.6%	DB: 0.4%	WB: 0.4%
8.7 °F	92.4 °F	73.8 °F

Table 5: Data used for the weather design conditions in the Trace 700 model, from the 2009 ASHRAE Handbook of Fundamentals

Weather Inputs-Reading, PA-Spaatz Field		
Heating	Cooling Data	
DB: 99.6%	DB: 0.4%	WB: 0.4%
9.4 °F	92.4 °F	74.1 °F

Table 6: Data used for the weather design conditions that will be used in future models for my thesis evaluation, despite not being used in the design of the building

Schedule Assumptions

When the original model of the Gaige Building was created by H.F. Lenz, various custom schedules were made for use in the Carrier HAP model. Schedules that were assigned are provided in Appendix B. The schedules given for nighttime, compressor, greywater pumping, and kitchen hoods are all used for the miscellaneous loads specified in the Carrier HAP model for the Gaige Building. These are utilization schedules that control the operation of the equipment. Other than that, the "All-Classroom" schedule is the main schedule used for the Gaige Building for the operation of all people, lighting, and ventilation, apart from a separate people and lighting schedule provided for the Office Spaces. As well, and Office miscellaneous load schedule is provided for office equipment operation. Again, all of these schedules can be seen in Appendix B of this report.

Comparison of Results: Calculated Loads versus Design Loads

After completing the Trace 700 model for the Gaige Building, the results need to be compared to that which was used for the design of the building by the MEP firm, H.F. Lenz. Since most of the assumptions and approximations used were based upon the design assumptions used by H.F. Lenz, the results should be fairly similar. Table seven below summarizes the loads that were calculated from the Trace 700 model created for this report.

Comparison of Calculated and Design Results					
Unit	Service Area (SF)	Cooling (CFM/ton)	Heating (BTU/hr-SF)	Total Supply (CFM/SF)	Ventilation Supply (CFM/SF)
Calculated					
RTU-1	20033	360	46.0	1.4	0.43
RTU-2	13670	361.34	33.7	1.0	0.37
RTU-3	12500	305	31.9	0.8	0.15
AHU-1	102	585.8	23.4	1.1	n/a
AHU-2	75	586	23.4	1.1	n/a
AHU-3	95	508	35.5	1.5	n/a
AHU-4	51	500	24.0	1.1	n/a
CRAC-1	325	523.6	31.6	1.4	n/a
Heat/Vent	4608	n/a	n/a	n/a	n/a
Total	**51459**				**0.30**

Table 7: A summary of the loads calculated for this report from Trace 700

The three roof top units from the above tables are the major components to the building's HVAC design, and they all can be seen to perform at an acceptable efficiency. All providing cooling at above 300 CFM/ton, this exceeds average recommendations for most common office/classroom building types, which recommend somewhere in the range of 250 to 350 CFM/ton. As well, one general recommendation, or average design value, is that there should be approximentaly 1.0 CFM/SF of total airflow for a building. All three air handling units are around this value, with some slightly above or below. Now that the load calculations have been presented, we should consider how they compare to the Carrier HAP model of the Gaige Building. Shown below in table eight is the comparison between the two models.

Comparison of Calculated and Design Results					
Unit	Service Area (SF)	Total Supply (CFM/SF)		Ventilation Supply (CFM/SF)	
		Design	Difference (CFM/SF)	Design	Difference (CFM/SF)
RTU-1	20033	1.1	0.3	0.46	-0.03
RTU-2	13670	0.9	0.1	0.38	-0.01
RTU-3	12500	0.8	0.0	0.28	-0.12
AHU-1	102	1.0	0.1	n/a	n/a
AHU-2	75	1.5	-0.4	n/a	n/a
AHU-3	95	1.5	0.0	n/a	n/a
AHU-4	51	1.9	-0.8	n/a	n/a
Total	**51459**			**0.35**	

Table 8: A comparison of the loads calculated from the Trace 700 model and the Carrier HAP model

As you can see in the table above, there seems to be fairly good agreement between the Trace and HAP models for the project. For the total supply, the three main building units, RTU-1, RTU-2, and RTU-3, all come in at a reasonable value in comparison to those provided by H.F. Lenz Company. The maximum difference is in RTU-1 with a difference in 0.3 CFM/SF, which is still a figure that is in the ballpark of the correct value. There is more variation in CFM/SF when it comes to the individual air conditioning units, but this is not unexpected. Since each of these units only serves one space, small changes in how each space was modeled, the system for which the design was based upon and other design assumptions could have a significant impact upon the results.

Finally, on a CFM/SF comparison for ventilation air, it is clear that the first two units, RTU-1 and RTU-2, have extremely good correlation between models. The third unit, RTU-3, has a fairly significant deviation, which should be analyzed. Since design values provided by the mechanical engineer were used for ventilation airflow rates, a deviation of this amount should not be seen. More investigation into future models should reveal if an incorrect input in the air system for RTU-3 has skewed the results, and this should be fixed and adjusted for future models. Finally, the ventilation calculations were not compared for any of the AHUs, for the individual zone AHUs only provide space conditioning and no outside air to the space. This is reflected in the model as well.

Also, heating and cooling checksums in table seven above from the trace model could not be replicated from the design documents, so they are not provided. Overall building comparison checks for heating and cooling can be found in the next section on system energy consumption. Overall there is good accuracy on load comparison, but some clear variations in RTU-3 need to be addressed in future versions of this energy model for the Gaige Building. More detained Trace outputs of the load calculations from the model are given in Appendix D.

Annual Energy Consumption and Cost

In the Trace 700 model, provisions were also made to model the energy consumption of the building for full year analysis. As well as energy consumption on a yearly basis, operating costs are calculated using provided energy rates, and monthly utility costs are reported. The following section will first compare the energy differences in the annual usage calculation in Trace 700 compared to Carrier HAP. Then, a comparison will be provided between the annual costs of utilities for each model. For more detailed information on the energy or cost outputs from the model, refer to Appendix D.

System Energy Consumption

In Trace 700, the building was also analyzed on an annual energy consumption basis. This data was then taken and compared to the values that were obtained in the energy analysis performed in Carrier HAP by the mechanical engineers on the Gaige Building. Since the outputs from Trace and HAP are not identical in format and categorization, they were adjusted for reasonable comparison. Below, the two energy models are compared, and then a note is provided commenting on the differences in site and source energy.

Energy Consumption Comparison

Below, in table nine, the outputs of the Trace 700 and the Carrier HAP models are provided. A designed load in Carrier HAP is presented, then a modeled load using Trace 700, and a percentage difference is given to contrast the two results.

Building Energy Usage Breakdown			
Type	Load (kBTU/yr)		% Difference
	Designed	Modeled	
Heating	1867073	1017367	-46%
Cooling	236739	465831	97%
Air System Fans	156909	229301	46%
Pumps	44954	28037	-38%
Lights	480901	519662	8%
Electrical Equipment/ Receptacles	1839097	1727367	-6%
Misc. Fuel	113292	272740	141%
Total:	**4738965**	**4260306**	**-10%**

Table 9: A comparison of the annual energy usage calculated from the Trace 700 model and the Carrier HAP model

As you can see, there are some categories where there is reliable comparison, and some where a significant difference is found. First, the lighting and electrical equipment and receptacle loads are fairly accurate in their correspondence to the design predictions. On the other hand, the other categories have some significant deviations. First, although the miscellaneous fuel, pumps, and air system fan categories have significant percentage deviations, these categories account for a small part of the overall energy, so these high percentages have less of an effect on the results of the overall model than the heating and cooling categories per say. Also, there are assumptions in how Trace 700 and Carrier HAP models the particular systems within your building, and differences in these assumptions inherent within the program will cause deviations in results. That being said, in future models, a more in depth look at how Trace 700 calculates specified systems should be determined to accurately predict annual energy estimates for the Gaige Building model.

As well, there are clear deviations in both the heating and cooling sections of the load calculations. Although no specific conclusions can be drawn as to where these deviations result from, the most likely source is in assumptions based upon the systems selection tool within Carrier HAP and Trace 700. For both models made, fairly common and generic system types were selected, and the small intricacies behind the system unique to the Gaige Building need to be analyzed to ensure the building can be properly modeled. Overall though, the building only underestimates the total annual load by ten percent, which is a fairly good first result for a preliminary energy model. As well, shown in figure one and figure two below, the overall energy distribution in both building simulations is fairly similar. The main issue that can be seen in the under prediction of the annual heating load in the Trace 700 model.

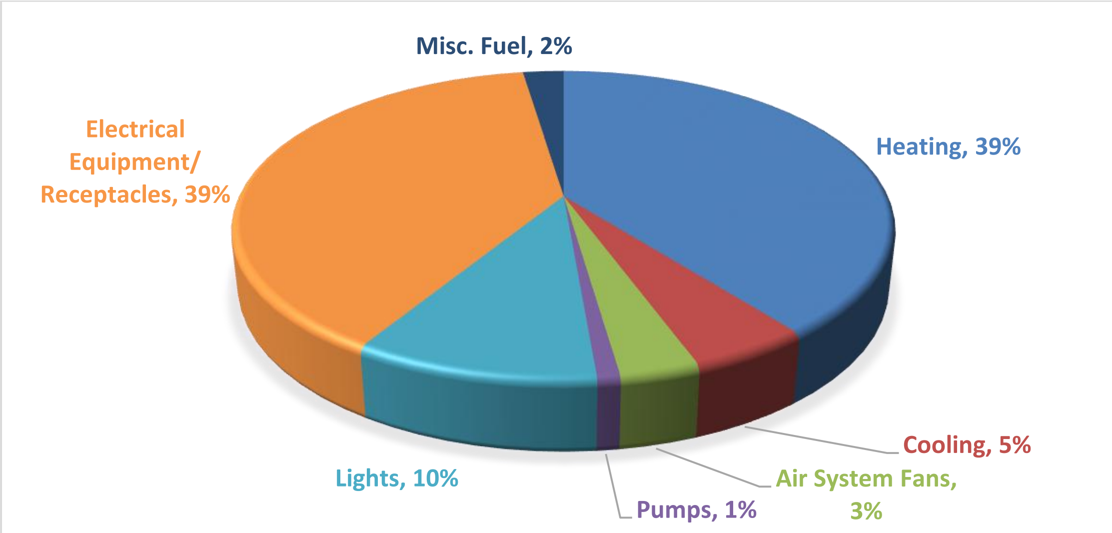


Figure 1: Annual energy distribution as calculated by the Carrier HAP model for the design of the building

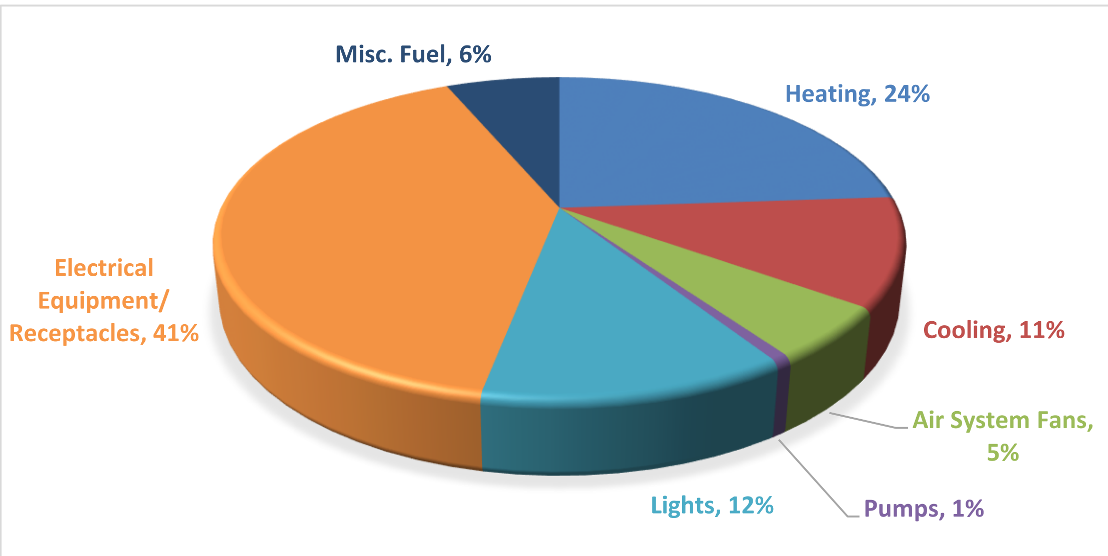


Figure 2: Annual energy distribution as calculated by the Trace 700 model used for the energy estimation for this report

Site versus Source Energy Comparison

Another issue that should be noted is the difference between site and source energy. Although the Gaige Building will use a certain amount of energy which is supplied to the building on an annual basis, the environmental impact of that energy usage is still not clear. Even though energy sources can be equated on a consumption basis, you must consider how much energy is lost in the processes of production and transportation of that energy to the building site. In the Gaige Building, although natural gas does not have significant losses associated with transportation to the site, electricity does have such losses. Much electricity is lost due to its transportation over many miles before it reaches the building. To account for this, from requirements given from the mechanical engineer on the project, a 28% factor was applied to account for the total amount of energy it took at the source of production to deliver the required site energy to the building.

Below, table ten summarizes the energy that was modeled in Trace 700 on an annual basis, and then, it divides the electrical energy by the factor of 28% to account for the amount of source energy required. A new total for the amount of source energy is given for the building's annual consumption, as well as a new graph, figure three, showing the cost distribution of the building. It is important to note that since most of the building's heating energy is from natural gas, it shows much less importance when looking at that demand from a source energy perspective. Where it accounted for 24% of the building's load on site, it is reduced to 9% of buildings load from the various sources. This is a strong consideration when considering the overall impact of you building, as opposed to simply the impact of your building from an annual cost perspective.

Building Energy Usage: Site vs. Source Energy			
Type	Site Energy (kBtu)		Source Energy (kBtu)
	Electricity	Natural Gas	
Heating	37892	979475	1114804
Cooling	465831	0	1663682
Air System Fans	229301	0	818932
Pumps	28037	0	100132
Lights	519662	0	1855936
Electrical Equipment/ Receptacles	1727367	0	6169168
Misc. Fuel	0	272740	272740
Total:	**3008090**	**4260306**	**11995394**

Table 10: Annual energy consumption from both a site energy perspective and a source energy perspective

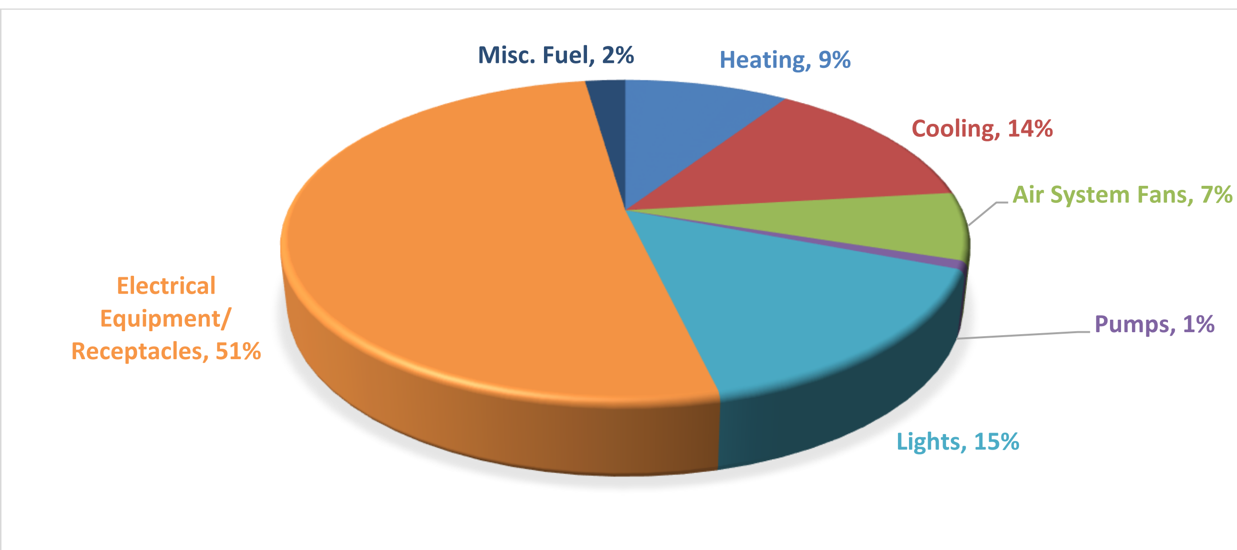


Figure 3: Annual energy consumption for the Gaige Building as modeled in Trace 700 from a source energy perspective

Annual Energy Costs

Along with energy consumption, a building's operation cost is an imperative consideration in the design process, especially to the owner, who will be paying for the building in the future. When a building is only analyzed in terms of energy consumption, it is not clear which option will be a more fiscally responsible choice. Cost rates per unit area found for a particular building's site must be determined and applied to the energy consumption as well. This will help identify not only which option consumes more energy, but what the overall cost of that energy will be.

Energy Rates Used

The energy rates used for the analysis run in Trace 700 were the numbers provided for the cost of electricity and natural gas from the mechanical engineer from H.F. Lenz Company. Below, table eleven provides the rates used for electricity and natural gas, on a dollar per kWh and a dollar per MCF basis. Both were assumed to be flat rate price values.

Energy Rates		
Energy Source	Rate	Units
Electricity	0.0964	$/kWh
Natural Gas	15	$/MCF

Table 11: Energy rates used for the cost analysis for the Gaige Building, used in both the Trace 700 and HAP models

The rates provided were taken from energy price estimates from 2009 into 2010, when the Building was designed. The rates were taken from documentation and rates put out by the US Energy Information Administration. The electricity rate is for commercial buildings in Pennsylvania, and the natural gas rate used is not straight from the document. It appears to be slightly higher than that provided from the EIA, but for comparison's sake of results, the rates were simply adopted from the previous model.

Annual Energy Costs: Comparison of Results

When these rates were used and applied to the annual energy consumption estimates previously stated, monthly and yearly energy costs could be estimated. Since only annual energy costs were provided from the mechanical engineer from their energy model, table twelve below summarizes a comparison between the Trace 700 model and the Carrier HAP model for annual energy consumption.

Annual Energy Cost Comparison			
Resource	Cost		
Designed			
Natural Gas	$ 28,822.00		
	$ 77,977.00		
Total	**$ 106,799.00**		
Modeled			**% Difference**
Natural Gas	$ 18,236.00		**-36.7%**
Electricity	$ 84,963.00		**9.0%**
Total	**$ 103,199.00**		**-3.4%**

Table 12: A comparison between the modeled and designed annual energy cost for the Gaige Building

As you can see, there is extremely good agreement between the modeled and designed values for the annual utility costs, with only a 3.4% deviation. Despite this extremely great agreement, it must be noted that when looking at each resource independently, electricity is overestimated, and natural gas is underestimated, so some of the error is covered up when solely looking at the total. The underestimate for natural gas is expected, due to the large underestimate previously seen for the heating load estimation for the building. As well, since the cooling load was overestimated, it is expected that the annual electricity costs would be overestimated as well.

The monthly utility costs are shown below in figure four as well, showing that the annual cost of the building is dominated by heating in the winter months as far as costs are concerned. After that, the building's energy consumption is broken down into monthly consumption, showing what different elements of the building's load compose each month's consumption. That is shown in figure five. It can be seen that the equipment and receptacle loads are dominant throughout the yearly operation of the building, and that the heating costs are the second most significant cost for the building, but they are effectively zero from May through September. Finally, graphs breaking down the building's monthly heating and cooling coil loads, showing only the buildings cooling consumption, and showing the monthly HVAC energy are provided in figure six, figure seven, and figure eight respectively. These graphs provide a clear idea of what loads are dominant in the building during the different times of year.

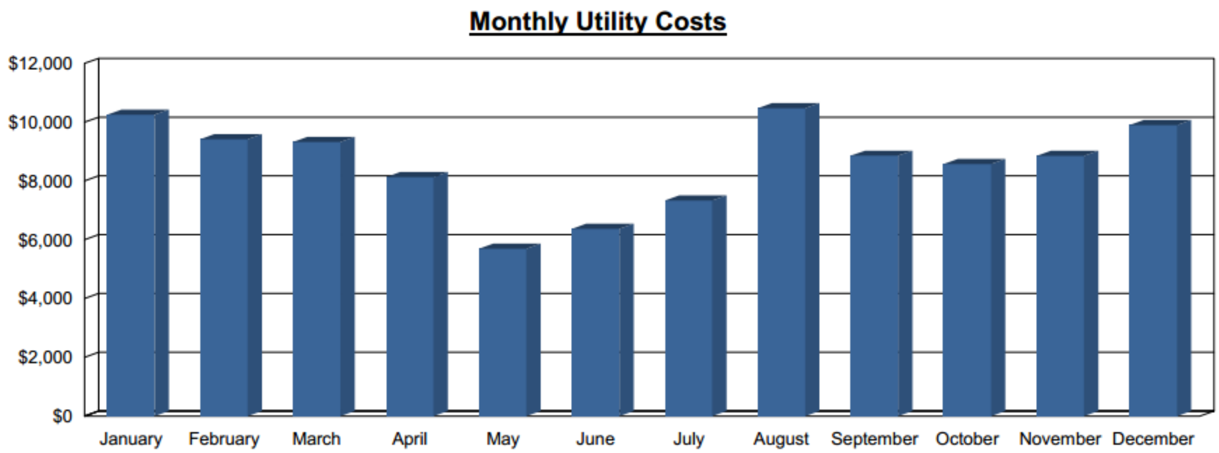


Figure 4: A graph showing a breakdown of the utility costs for the building on a monthly basis

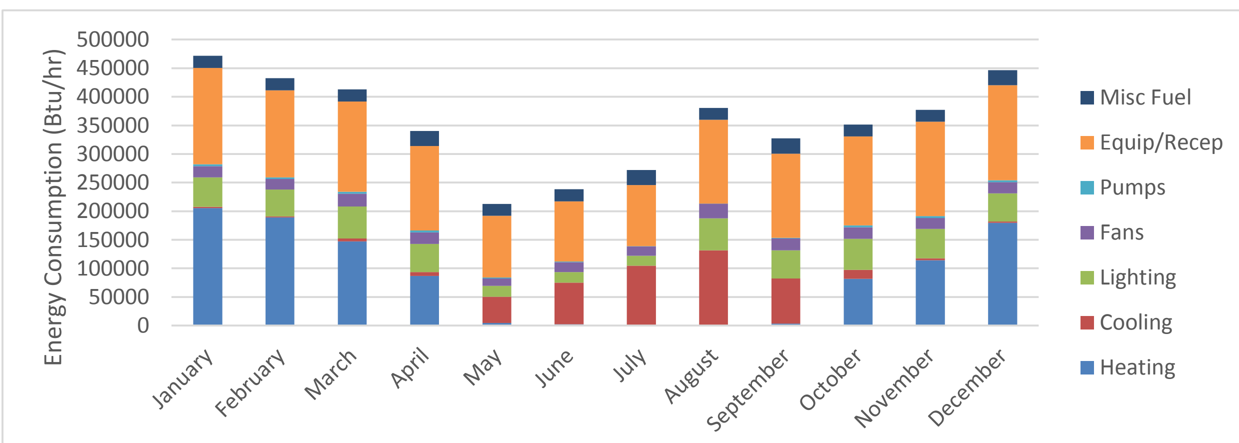


Figure 5: The monthly energy demand of the building broken down into sources

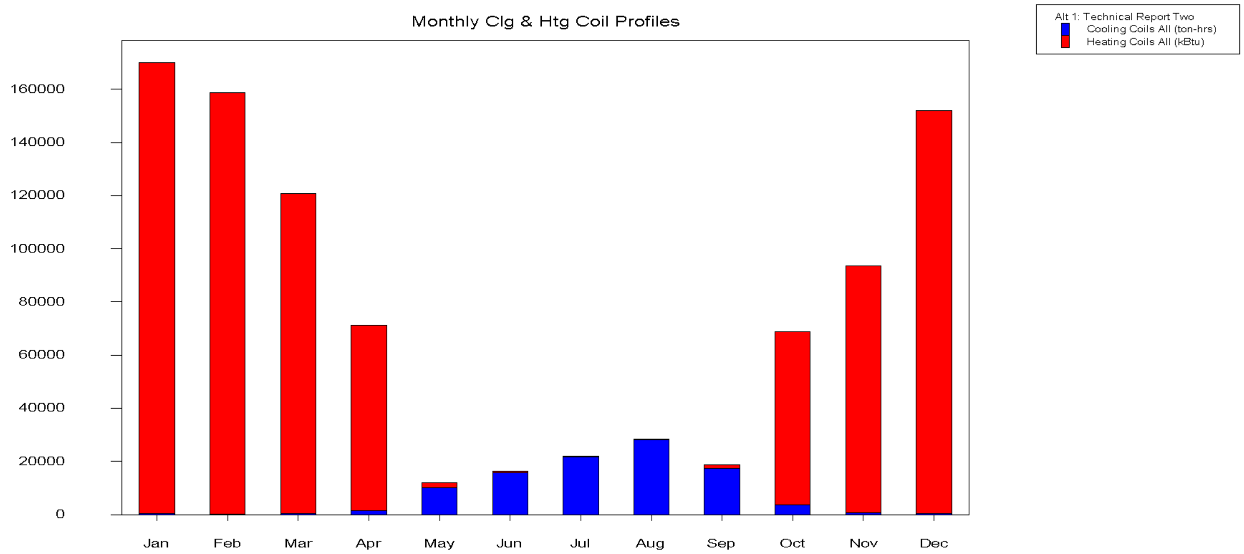


Figure 6: A graph breaking down the heating and cooling coil overall loads on a monthly basis

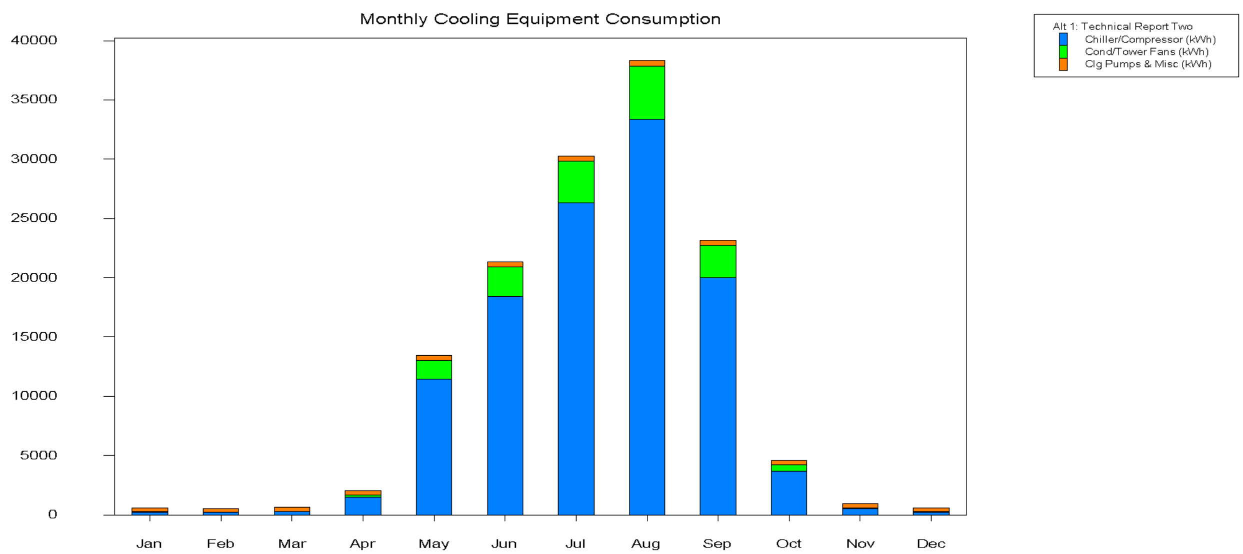


Figure 7: A graph showing cooling equipment's energy consumption on a monthly basis

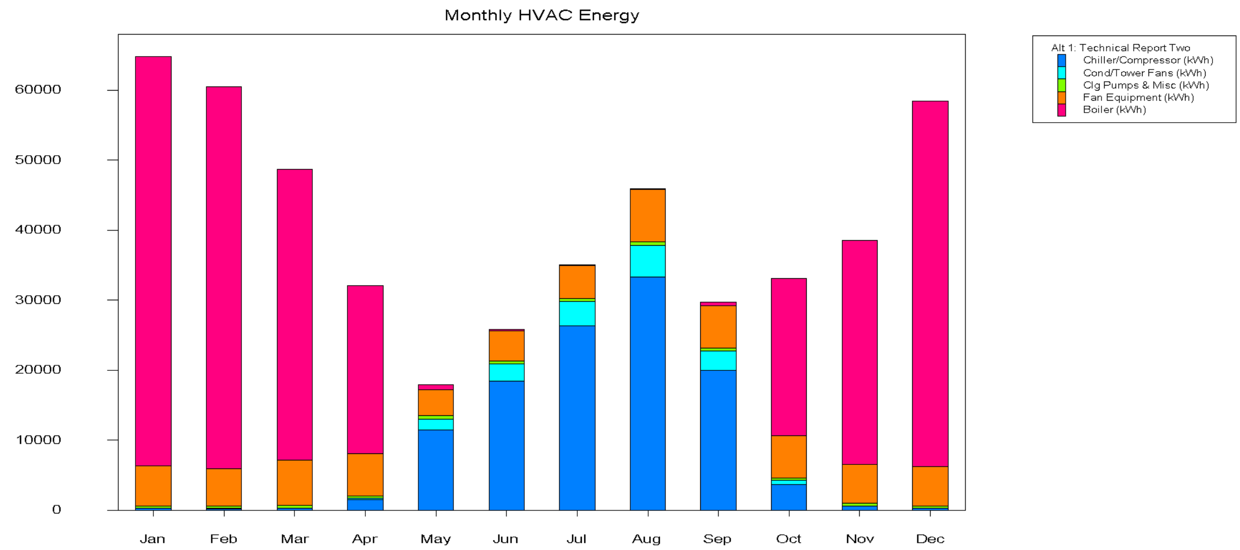


Figure 8: A graph showing the buildings HVAC energy consumption, broken down into heating and cooling equipment

Total Annual Emission Rates

The annual emissions that are associated with the Gaige Building from its daily operation and energy use are shown in the table below. By factoring out the electrical consumption and the natural gas consumption of the Gaige Building on an annual basis, and multiplying by a factor of emissions per unit of energy consumed (source), the total emission of the Gaige Building can be estimated. Factors were taken from the *Source Energy and Emission Factors for Energy Use in Buildings* report from the National Renewable Energy Laboratory. The tables from which the factors were taken can be found in Appendix C, which shows tables three and eight from the report put out by the NREL, revised in 2007. Below table thirteen summarizes the amount of pollutants put out annually by the Gaige Building. As well, figure nine shows a breakdown of the pollutants produced by the Gaige Building on an annual basis.

Annual Emmisions Summary					
Pollutant	Electricity Rate (lb/kWh)	Natural Gas Rate (lb/MCF)	Source Electricity (kWh/yr)	Natural Gas (MCF/yr)	Total Emissions (lb/yr)
CO_{2e}	1.74E+00	1.23E+02	3148515	4136	5987170.8
CO_2	1.64E+00	1.22E+02	3148515	4136	5668183.1
CH_4	3.59E-03	2.50E-03	3148515	4136	11313.5
N_2O	3.87E-05	2.50E-03	3148515	4136	132.2
NO_x	3.00E-03	1.11E-01	3148515	4136	9904.7
SO_x	8.57E-03	6.32E-04	3148515	4136	26985.4
CO	8.54E-04	9.33E-02	3148515	4136	3074.7
TNMOC	7.26E-05	6.13E-03	3148515	4136	253.9
Lead	1.39E-07	5.00E-07	3148515	4136	0.4
Mercury	3.36E-08	2.60E-07	3148515	4136	0.1
PM10	9.26E-05	8.40E-03	3148515	4136	326.3
Solid Waste	2.05E-01	0.00E+00	3148515	4136	645445.5

Table 13: A summary of the annual pollutants produced by the Gaige Building estimated using source energy

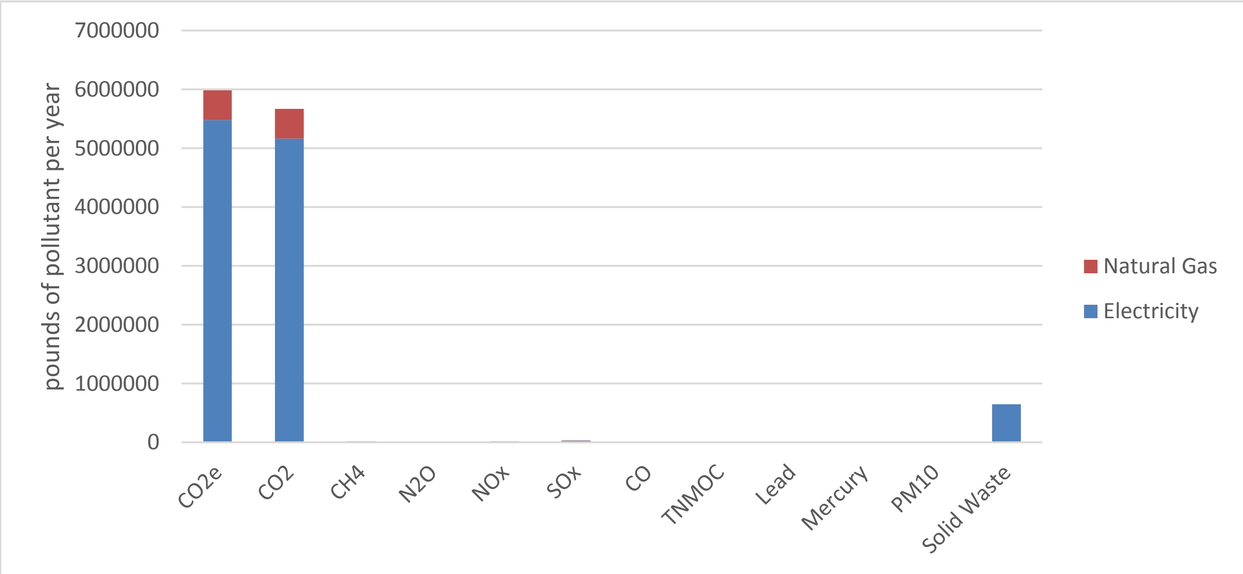


Figure 9: A graph of emissions by the Gaige Building for all pollutants, on an annual basis

Conclusion

Overall, this assignment has helped to identify exactly what the characteristic loads of the Gaige Building are and how they interact with the building's mechanical system as a whole. As well, energy consumption, cost, and emissions have been considered and analyzed, which provide significant insight into how this building will continue to impact the environment once it is in use. As well, these figures help to identify the differences in consumption of the building's different fuel sources and their cost differences versus energy outputs. Finally, the Trace 700 model created for this report provided a substantially accurate first attempt at modeling the loads and energy consumption of the Gaige Building. The problems and fixes that have been identified in this report will be analyzed and addressed as the analysis of the Gaige Building continues, and potential solutions to improve the Gaige Building's design should emerge with further work on this model.

References

ANSI/ASHRAE. (2010). Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE. (2010). Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE. (2009). Handbook of Fundamentals. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

EIA. (2012). Pennslyvania Energy Fact Sheet. Washington, DC: United States Energy Information Administration

Deru, M. and Torcellini, P. (2007). Technical Report NREL/TP-550-38617, Source Energy and Emission Factors for Energy Use in Buildings. Golden, CO: Nation Renewable Energy Laboratory

H. F. Lenz Company, LLP. Electrical, Mechanical, and Plumbing Construction Documents. H. F. Lenz Company, Johnstown, PA

H. F. Lenz Company, LLP. Electrical, Mechanical, and Plumbing Construction Specifications. H. F. Lenz Company, Johnstown, PA

RMJM Hillier Architects. Architectural Construction Documents. RMJM/Hillier Architecture, New York,

Appendix A: Room Information

Room Information Inputs								
Room Name	Area	Wall Name	Opening	Length	Height	Wall Area	Opening Area	Roof Area (SF)
Learning Loft Q206	1773	West	(2/3)A37	14.2	24	360.8	353.76	2657
		South	A27	158	6	948	911	
Resource Q205	205	North	A25	12.4	10	124	224	205
Classroom 244	902	South	none	14	10	140	0	902
		West	A35	31.3	10	313	213	
		North	A5	30.4	10	304	42.3	
			A6				83	
Classroom 245	856	South	A15	27.1	10	271	83	856
			A15				83	
			A15				83	
			(1/5)A16				31.4	
		West	(4/5)A16	32.7	10	327	125.6	
Classroom 246	1269	South	A15	42	10	420	83	1269
			A15				83	
			A15				83	
			A15				83	
			A15				83	
Classroom 247	1010	South	A15	33.6	10	336	83	1010
			A15				83	
			A15				83	
			A15				83	
Classroom 248	764	South	A15	25.2	10	252	83	764
			A15				83	
			A15				83	
Classroom 249	789	South	A15	24.3	10	243	83	789
			A15				83	
		East	none	5.7	10	57	0	
Learning Loft Q102	2884	West	(1/3)A37	14.6	13	189.8	174.24	0
Corridor Q103	478	None						0
Classroom 120	805	South	A9	25.2	10	252	96	0
		West	A19	32.5	10	325	121.5	
Classroom 121	1587	South	A9	50.3	10	503	96	0
			A9				96	
		West	all glass	4.3	10	43	43	
Seminar Classroom 122	406	South	(1/5)A10	17.1	10	171	156	0
Bits & Bytes Café 123	740	South	(4/5)A10	62.6	10	626	624	0

HRIM Lab Kitchen 123A	492	None						0
Retail 123B	191	None						0
Lobby F102	635	West	A28			355.7	355.7	635
		South	A29			527	527	
Electrical Lab 116	804	North	(1/3)A2	25	10	250	44.55	0
			A3			-		
Super/Assistant 115	169	None						0
Equipment Storage 115A	307	North	(2/3)A2	16.5	12	198	90.45	0
Engineering Automation 114	1007	North	A2	33.7	10	337	135	0
			(1/3)A2			-	44.55	
Electronics Lab 113	750	North	(2/3)A2	25	10	250	90.45	0
			(1/3)A2			-	44.55	
Learning Resource Center 111	394	North	A1	23.2	10	232	219	0
Lounge 111A	315	None						0
Seminar Classroom 112	501	North	(2/3)A2	17.3	10	173	90.45	0
						-		
Open Source Computer Lab 209	712	East	A5	24.8	10	248	42.3	0
			A6				83	
Lobby F201	444	None						0
Department Resource Q207	288	None						0
Lobby F204	87	None						0
Networking Computer Lab 208	701	East	A5	24.8	10	248	42.3	0
			A6				83	
Server Room 207/IT Storage 207A	325	East	A6	11.6	12	139.2	83	0
IT Storage 203	376	West	A15	13.3	12	159.6	83	0
General Purpose Computer Lab 204	1024	West	A15	32.8	10	328	83	0
			A15				83	
			A15				83	
			A15				83	
		South	(1/2)A31	4.8	10		48.5	
Emerging Technology Lab 206	696	East	A5	23.2	10	232	42.3	0
			A6				83	
Corridor Q201	980	South	A13	8	10	80	81.7	0
General Purpose Computer Lab 205	856	East	(1/2)A34	29.1	10	291	20.25	0
			(3/8)A14				274	
		South	(5/8)A14	30.8	10	308	274	

Corridor Q101	900	South	A11	8.8	10	88	76	0
Corridor Q104	310	North	(1/2)A24	12.5	10	125	71	
			Door-glass			-	42	
Super/Assist Office 107	102	None			10			0
Lobby F103	465	None			10			0
Lobby F104	105	None			10			0
Lobby F105	106	None			10			0
Prototype Lab 108	1534	East	(1/3)A2	58.8	10	588	44.55	0
			A2			-	135	
			A2			-	135	
Receiving 109/Storage 109A	425	North	(1/4)A24	18.5	12	222	71	0
			A23			-	75	
			Door-ship			-	113	
		East	A17	15.9	12	190.8	89.5	
Design Lab 103	785	West tilt	(2/3)A21	28.1	10	281	123.95	0
			A22			-	58	
Projects Lab 106	956	East	(2/3)A2	32.9	10	329	90.45	0
			(2/3)A2			-	90.45	
Research Lab 104	518	West tilt	(3/4)A20-horz	19	10	190	59.475	0
			(1/3)A21			-	61.05	
Measurement Lab 105	975	East	(1/3)A2	33.2	10	332	44.55	0
			A18			-	225.5	
		South	A12	28	10	280	244	
Faculty Office 336 & Q304	509	West	Door-solid	17.5	10	175	21	509
		North	(1/2)A6	9	10	90	41.5	
		East	(1/4)A8	7.4	10	74	50.25	
Department Resource 328	116	None						
Faculty Office 333, 334 & 335	277	North	(1/2)A6	25.3	10	253	41.5	277
			A5				42.3	
			(1/2)A6				41.5	
Faculty Office 330, 331 & 332	273	North	(1/2)A6	25	10	250	41.5	273
			A5				42.3	
			(1/2)A6				41.5	
Faculty Office 329	123	North	(1/2)A6	12	10	120	41.5	123
			(1/4)A8				50.25	
		East	(1/2)A8	10.4			100.5	
Conference 325	154	None						154

Faculty Office 324, 326 & 327	294	East	A5	23.6	10	236	42.3	294
			A6				83	
Corridor Q303	621	None						621
Lobby F301	456	None						456
Lobby F304	97	None						97
Corridor Q305	99	None						99
Copy/Fax/Printer 322	95	None						95
Faculty Office 319	131	None						131
Corridor Q301	800	South	A13	8	10	80	81.7	800
Corridor Q302	82	None						82
Corridor Q306	48	None						48
Corridor Q307A	95	None						95
Faculty Office 320, 321, & 323	299	East	A5	23.3	10	233	42.3	299
			A6				83	
Faculty Office 304	114	West	A5	5	10	50	42.3	114
Faculty Office 305 & 306	221	West	A15	16.3	10	163	83	221
			A15				83	
Conference 317	150	None						150
PT Faculty Office 313	133	None						133
Faculty Office 303 & 303A	244	None						244
Conference 311A	150	None						150
Admin. Assistant 307A	133	West	A15	8.9	10	89	83	133
Chancellors Office 307B	321	South	(1/2)A31	5	10	50	48.5	321
		West	A15	19	10	190	83	
			A15				83	
Reception 307	476	None						476
Conference 311	205	None						205
Faculty Offices 315, 316, 318	295	East	A5	23.3	10	233	42.3	295
			A6				83	
Faculty Office 310, 312 & 314	285	East	A5	23.8	10	238	42.3	285
			A6				83	
Corridor Q202	894	None						0
Support 234	212	None						0
Q203	201	None						0
Faculty Office 309	115	East	(1/2)A34	9.2	10	92	20.25	115
			(1/6)A14				91.516	
Seminar Classroom 308	634	East	(1/3)A14	20	10	200	180.84	634
		South	(1/2)A14	32.6	10	326	274	

Storage 209A	100	None						0
Storage 210A	180	East	A5	9.9	12	118.8	42.3	0
Admin. Assistant 210B	182	East	(1/8)A4	7.4	10	74	30.375	0
Directors Office 210	201	North	A5	20.1	10	201	42.3	0
			(3/8)A4				91.125	
		East	(1/2)A4	10.8	10	108	121.5	
Faculty Office 211, 212 & 213	260	North	A6	24.2	10	242	83	0
			A5				42.3	
Faculty Office 214, 215, & 216	263	North	A6	24	10	240	83	0
			A5				42.3	
Faculty Office 219, 218 & 217	261	North	A7	23.7	10	237	304	261
Faculty Office 221, 223 & 224	264	North	A6	23.7	10	237	83	264
			A5				42.3	
Faculty Office 220	95	None						95
Mail Support 222	130	None						130
Faculty Office 226, 228 & 225	277	North	A6	23.2	10	232	83	277
			A5				42.3	
PT Faculty Lounge 229	292	None						292
Faculty Office 232, 233 & 230	271	North	A6	23.7	10	237	83	271
			A5				42.3	
Conference 231	155	None						155
Faculty Office 236, 238, & 235	262	North	A6	23.7	10	237	83	262
			A5				42.3	
Faculty Office 237, 239, & 241	360	None						360
Faculty Office 242 & 240	172	North	A6	15.9	10	159	83	172
M118	642	North	Door-ship	33	12	396	72	0
		West	none	28	12	336	0	
		South	none	12.5	12	150	0	
F105	68	North	door/glass	12.6	10	126	124	0
P110	423	North	(3/4)A24	30	12	360	106.5	0
			Door-glass				35	
			(1/4)A24				35.5	
T110	95	North	(1/4)A24	8.3	12	99.6	35.5	0
Z102	360	None						0
R101	231	None						0

R102	231	None						0
R101A	48	None						0
R102A	43	None						0
J101	39	None						0
P102	54	None						0
F101	161	South	all	16.2	10	162	161	0
		West	all	10	10	100	100	
		North	all	3.7	10	37	37	
Z101	325	South	A33	25	14	350	33	0
		West tilt	A38	13.4	14	187.6	18.7	
			(1/4)A20-horz				79.3	
			(1/3)A20-vert				138.4	
Z202	323	None						0
R201	247	None						0
R202	234	West	none	7.9	11	86.9	0	0
R202A	38	None						0
R201A	58	None						0
J201	46	None						0
P202	54	None						0
ELV201	102	None						0
Z201	309	South	(1/2)A32	22	14	308	197.5	0
		West tilt	(1/3)A20-vert	18.6	14		138.4	0
Z301	299	South	(1/2)A32	24.9	14	348.6	197.5	299
		West tilt	(1/3)A20-vert	14	14		138.4	
Z302	332	West	none	10.9	14	152.6	0	332
R301	194	None						194
R302	183	None						183
R301A	55	None						55
J302	40	None						40
P303	51	None						51
R302A	40	None						40
T301	88	None						88
337 (Roof Access)	44	None						44
307E	82	None						82

Appendix B: Trace 700 Schedules

Below are the schedules used for the model in this technical report. Note that when holiday values are given, these are not used, for Trace 700 does not have the capacity to incorporate holidays into a model. This data is from a Carrier HAP output, in which holidays can be accounted for due differences in the design of that program. As well, when some values are only given on specific weekdays, schedules had to be slightly adjusted to produce the same results, for Trace 700 only allows you to specify a generic weekday instead of specific days of the week.

Classroom Schedule

Hourly Profiles:

1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	20	0

2:M-F Fall & Spring

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	20	80	100	100	100	100	100	100	100	81	80	80	80	80	50	0	0

3:Summer

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20	60	60	60	60	0	0	0

4:Weekend

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20	0	0	0	0	0	0	0	0	0

5:Holiday

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Compressor Schedule (for all times and days)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	20	20	20	20	20	20	20	20	20	50	20	20	50	20	20	50	20	20	20	20	20	20	20	20

Greywater Pumps Schedule (for all times and days)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	11	11	11	11	11	11	11	30	30	30	30	30	30	30	30	30	30	30	30	11	11	11	11	11

Kitchen Hoods Schedule (profile one for all days, except profile two for Thursdays)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	0	0	0

2:Profile Two

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Mechanical Schedule (for all times and days)

Hourly Profiles:

1:Profile One

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	50	50	50

Nighttime Schedule

Hourly Profiles:

1:Winter

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100

2:Spring/Fall

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100

3:Summer

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	100	100	100	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100

Office Electrical Schedule

Hourly Profiles:

1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	25	25	25	25	25	25	25	100	100	100	100	100	100	100	100	100	100	100	100	25	25	25	25	25

2:M-F Fall & Spring

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	25	25	25	25	25	25	25	50	50	90	90	90	50	90	90	90	50	50	25	25	25	25	25	25

3:Weekend or Summer

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	25	50	50	50	50	50	50	50	50	25	0	0	0	0	0	0	0

4:Holiday

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Office People and Lighting Schedule

Hourly Profiles:

1:Design Day

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	70	100	100	100	100	70	100	100	100	100	40	20	0	0	0	0	0

2:M-F Fall & Spring

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	20	50	80	80	80	50	80	80	80	50	20	5	0	0	0	0	0

3:Weekend or Summer

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	0	0	0	0	0	0	0

4:Holiday

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C: Emissions Factors

Table 8 Emission Factors for On-Site Combustion in a Commercial Boiler (lb of pollutant per unit of fuel)

Pollutant (lb)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 lb	1000 lb	1000 ft^3 ***	1000 gal	1000 gal	1000 gal
CO_{2e}	2.74E+03	2.30E+03	1.23E+02	2.56E+04	2.28E+04	1.35E+04
CO_2	2.63E+03	2.30E+03	1.22E+02	2.55E+04	2.28E+04	1.32E+04
CH_4	1.15E-01	2.00E-02	2.50E-03	2.31E-01	2.32E-01	2.17E-01
N_2O	3.68E-01	ND †	2.50E-03	1.18E-01	1.19E-01	9.77E-01
NO_X	5.75E+00	5.97E+00	1.11E-01	6.41E+00	2.15E+01	1.57E+01
SO_X	1.66E+00	1.29E+01	6.32E-04	4.00E+01	3.41E+01	0.00E+00
CO	2.89E+00	4.05E-03	9.33E-02	5.34E+00	5.41E+00	2.17E+00
VOC	ND †	ND †	6.13E-03	3.63E-01	2.17E-01	3.80E-01
Lead	1.79E-03	6.86E-02	5.00E-07	1.51E-06	ND †	ND †
Mercury	6.54E-04	6.54E-04	2.60E-07	1.13E-07	ND †	ND †
PM10	2.00E+00	ND †	8.40E-03	4.64E+00	1.88E+00	4.89E-01

* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 60°F and 14.70 psia.
† no data available

Table 3 Total Emission Factors for Delivered Electricity (lb of pollutant per kWh of electricity)

Pollutant (lb)	National	Eastern	Western	ERCOT	Alaska	Hawaii
CO_{2e}	1.67E+00	1.74E+00	1.31E+00	1.84E+00	1.71E+00	1.91E+00
CO_2	1.57E+00	1.64E+00	1.22E+00	1.71E+00	1.55E+00	1.83E+00
CH_4	3.71E-03	3.59E-03	3.51E-03	5.30E-03	6.28E-03	2.96E-03
N_2O	3.73E-05	3.87E-05	2.97E-05	4.02E-05	3.05E-05	2.00E-05
NO_X	2.76E-03	3.00E-03	1.95E-03	2.20E-03	1.95E-03	4.32E-03
SO_X	8.36E-03	8.57E-03	6.82E-03	9.70E-03	1.12E-02	8.36E-03
CO	8.05E-04	8.54E-04	5.46E-04	9.07E-04	2.05E-03	7.43E-03
TNMOC	7.13E-05	7.26E-05	6.45E-05	7.44E-05	8.40E-05	1.15E-04
Lead	1.31E-07	1.39E-07	8.95E-08	1.42E-07	6.30E-08	1.32E-07
Mercury	3.05E-08	3.36E-08	1.86E-08	2.79E-08	3.80E-08	1.72E-07
PM10	9.16E-05	9.26E-05	6.99E-05	1.30E-04	1.09E-04	1.79E-04
Solid Waste	1.90E-01	2.05E-01	1.39E-01	1.66E-01	7.89E-02	7.44E-02

Appendix D: Trace 700 Outputs

Below and attached are the significant output reports from the Trace 700 model created for this report.

System Checksums

By ACADEMIC

ACU-1 — **Fan Coil**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak		
Peaked at Time:	Mo/Hr:	7 / 15
Outside Air:	OADB/WB/HR:	91 / 74 / 101

CLG Space Peak	
Mo/Hr:	Sum of
OADB:	Peaks

	Space Sens. + Lat. (Btu/h)	Plenum Sens. + Lat (Btu/h)	Net Total (Btu/h)	Percent Of Total (%)	CLG Space Peak: Space Sensible (Btu/h)	CLG Space Peak: Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	231		231	10	90	4
Sub Total ==>	231	0	231	10	90	4
Internal Loads						
Lights	334	84	418	18	334	15
People	0	0	0	0	0	0
Misc	1,741	0	1,741	73	1,741	80
Sub Total ==>	2,075	84	2,158	90	2,075	95
Ceiling Load	16	-16	0	0	16	1
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-3	-3	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	2,322	64	2,387	100.00	2,181	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design

OADB: 11

	Space Peak Space Sens (Btu/h)	Coil Peak Tot Sens (Btu/h)	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-331	-331	0.00
Sub Total ==>	-331	-331	0.00
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	1,741	1,741	0.00
Sub Total ==>	1,741	1,741	0.00
Ceiling Load	0	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-1,409	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	1,409	0	100.00

TEMPERATURES

	Cooling	Heating
SADB	58.0	70.0
Ra Plenum	75.5	70.0
Return	75.5	70.0
Ret/OA	75.5	70.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	117	117
Terminal	117	117
Main Fan	117	117
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	5	5
MinStop/Rh	0	0
Return	122	122
Exhaust	5	5
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.14	1.14
cfm/ton	585.84	
ft²/ton	512.87	
Btu/hr·ft²	23.40	0.00
No. People	0	

COOLING COIL SELECTION

	Total Capacity (ton)	Total Capacity (MBh)	Sens Cap. (MBh)	Coil Airflow (cfm)	Enter DB (°F)	Enter WB (°F)	Enter HR (gr/lb)	Leave DB (°F)	Leave WB (°F)	Leave HR (gr/lb)
Main Clg	0.2	2.4	2.3	117	75.5	61.6	60.8	58.0	54.6	59.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	2.4								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	102		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	0	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity (MBh)	Coil Airflow (cfm)	Ent (°F)	Lvg (°F)
Main Htg	0.0	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	0.0			

System Checksums
By ACADEMIC

ACU-2 — **Fan Coil**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 91 / 74 / 101

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	170		170	10	66	4
Sub Total ==>	170	0	170	10	66	4
Internal Loads						
Lights	246	61	307	18	246	15
People	0	0	0	0	0	0
Misc	1,280	0	1,280	73	1,280	80
Sub Total ==>	1,526	61	1,587	90	1,526	95
Ceiling Load	12	-12	0	0	12	1
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-2	-2	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	1,707	47	1,755	100.00	1,604	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-244	-244	0.00
Sub Total ==>	-244	-244	0.00
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	1,280	1,280	0.00
Sub Total ==>	1,280	1,280	0.00
Ceiling Load	0	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-1,036	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	1,036	0	100.00

TEMPERATURES

	Cooling	Heating
SADB	58.0	70.0
Ra Plenum	75.5	70.0
Return	75.5	70.0
Ret/OA	75.5	70.0
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	86	86
Terminal	86	86
Main Fan	86	86
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	4	4
MinStop/Rh	0	0
Return	89	89
Exhaust	4	4
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.14	1.14
cfm/ton	585.84	
ft²/ton	512.87	
Btu/hr·ft²	23.40	0.00
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	0.2	1.8	1.7	86	75.5	61.6	60.8	58.0	54.6	59.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	1.8								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	75		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	0	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	0.0			

System Checksums

By ACADEMIC

ACU-3 | **Fan Coil**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 9; Outside Air: OADB/WB/HR: 78 / 69 / 92

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	1,125	0	1,125	33	1,204	38
Glass/Door Cond	22	0	22	1	-24	-1
Wall Cond	65	51	116	3	62	2
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	149		149	4	-9	0
Sub Total ==>	1,361	51	1,412	42	1,233	39
Internal Loads						
Lights	272	68	340	10	272	9
People	0	0	0	0	0	0
Misc	1,621	0	1,621	48	1,621	52
Sub Total ==>	1,894	68	1,962	58	1,894	60
Ceiling Load	19	-19	0	0	18	1
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-3	-3	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	3,273	97	3,370	100.00	3,145	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-550	-550	961.41
Wall Cond	-88	-158	276.87
Partition/Door	0	0	0.00
Floor	-35	-35	61.11
Adjacent Floor	0	0	0
Infiltration	-309	-309	539.38
Sub Total ==>	-982	-1,052	1,838.77
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	1,621	1,621	2,833.74
Sub Total ==>	1,621	1,621	2,833.74
Ceiling Load	-11	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		2	-3.32
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-628	,098.29
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	628	-57	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	70.0
Ra Plenum	75.6	69.6
Return	75.6	69.6
Ret/OA	75.6	69.6
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	143	143
Terminal	143	143
Main Fan	143	143
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	5	5
MinStop/Rh	0	0
Return	148	148
Exhaust	5	5
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.50	1.50
cfm/ton	508.47	
ft²/ton	338.27	
Btu/hr·ft²	35.47	-0.60
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Enter °F	Enter gr/lb	Leave DB/WB/HR °F	Leave °F	Leave gr/lb
Main Clg	0.3	3.4	3.2	143	75.6	59.6	51.4	55.0	51.0	50.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	3.4								

AREAS

	Gross Total	Glass ft²	(%)
Floor	95		
Part	0		
Int Door	0		
ExFlr	8		
Roof	0	0	0
Wall	100	36	36
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-0.1	143	69.6	70.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-0.1			

System Checksums

By ACADEMIC

ACU-4 — **Fan Coil**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 91 / 74 / 101

Clg Space Peak — Mo/Hr: Sum of; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	47	47	4	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	115		115	9	45	4
Sub Total ==>	115	47	162	13	45	4
Internal Loads						
Lights	155	39	194	16	155	14
People	0	0	0	0	0	0
Misc	870	0	870	71	870	80
Sub Total ==>	1,026	39	1,065	87	1,026	94
Ceiling Load	17	-17	0	0	17	2
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-3	-3	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	1,158	66	1,224	100.00	1,087	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-120	129.75
Glass Solar	0	0	0.00
Glass/Door Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-166	-166	178.63
Sub Total ==>	-166	-286	308.38
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	870	870	-938.45
Sub Total ==>	870	870	-938.45
Ceiling Load	-23	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		4	-4.39
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-681	734.46
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	681	-93	100.00

TEMPERATURES

	Cooling	Heating
SADB	58.0	70.0
Ra Plenum	76.0	68.6
Return	76.0	68.6
Ret/OA	76.0	68.6
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	58	58
Terminal	58	58
Main Fan	58	58
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	3	3
MinStop/Rh	0	0
Return	61	61
Exhaust	3	3
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.14	1.14
cfm/ton	569.49	
ft²/ton	499.98	
Btu/hr·ft²	24.00	-1.82
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	0.1	1.2	1.2	58	76.0	61.8	60.8	58.0	54.6	59.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	1.2								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	51		
Part	0		
Int Door	0		
ExFlr	0		
Roof	51	0	0
Wall	0	0	0
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-0.1	58	68.6	70.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-0.1			

System Checksums

By ACADEMIC

CRAC-1 — **Computer Room Unit**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 9 / 10; Outside Air: OADB/WB/HR: 71 / 59 / 57

Clg Space Peak — Mo/Hr: Sum of Peaks; OADB: Peaks

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	5,554	0	5,554	54	5,554	56
Glass/Door Cond	-115	0	-115	-1	-115	-1
Wall Cond	48	115	163	2	48	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	18		18	0	-77	-1
Sub Total ==>	5,505	115	5,620	55	5,410	55
Internal Loads						
Lights	1,065	266	1,331	13	1,065	11
People	0	0	0	0	0	0
Misc	3,328	0	3,328	32	3,328	34
Sub Total ==>	4,393	266	4,659	45	4,393	45
Ceiling Load	64	-64	0	0	64	1
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-11	-11	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	9,961	306	10,267	100.00	9,866	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-1,286	-1,286	17.38
Wall Cond	-41	-140	1.89
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-1,056	-1,056	14.27
Sub Total ==>	-2,382	-2,481	33.53
Internal Loads			
Lights	1,065	1,331	-17.99
People	0	0	0.00
Misc	3,328	3,328	-44.97
Sub Total ==>	4,393	4,659	-62.96
Ceiling Load	28	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		-5	0.07
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-2,038	27.55
Additional Reheat		-7,534	101.82
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	2,038	-7,400	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	75.0
Ra Plenum	75.6	70.3
Return	75.6	70.3
Ret/OA	75.6	70.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	448	448
Terminal	448	448
Main Fan	448	448
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	16	16
MinStop/Rh	448	448
Return	464	464
Exhaust	16	16
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	1.38	1.38
cfm/ton	523.62	
ft²/ton	379.85	
Btu/hr·ft²	31.59	-30.36
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	0.9	10.3	10.2	448	75.6	58.8	48.2	55.0	50.4	47.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.9	10.3								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	325		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	139	83	60
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-9.9	448	55.0	75.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-9.9	448	55.0	75.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-9.9			

System Checksums

By ACADEMIC

Heat/Vent — **Ventilation and Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 0 / 0; Outside Air: OADB/WB/HR: 0 / 0 / 0

Clg Space Peak — Mo/Hr: 0 / 0; OADB: 0

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	0	0	0	0	0	0
Wall Cond	0	0	0	0	0	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	0		0	0	0	0
Sub Total ==>	0	0	0	0	0	0
Internal Loads						
Lights	0	0	0	0	0	0
People	0	0	0	0	0	0
Misc	0	0	0	0	0	0
Sub Total ==>	0	0	0	0	0	0
Ceiling Load	0	0	0	0	0	0
Ventilation Load	0	0	0	0	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		0	0	0		
Sup. Fan Heat			0	0		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	0	0	0	100.00	0	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	-2,417	9.35
Roof Cond	0	-2,156	8.34
Glass Solar	0	0	0.00
Glass/Door Cond	-22,839	-22,839	88.32
Wall Cond	-2,163	-4,040	15.62
Partition/Door	0	0	0.00
Floor	-732	-732	2.83
Adjacent Floor	0	0	0
Infiltration	-14,968	-14,968	57.88
Sub Total ==>	-40,701	-47,151	182.34
Internal Loads			
Lights	10,386	12,983	-50.21
People	0	0	0.00
Misc	39,652	39,652	-153.34
Sub Total ==>	50,039	52,635	-203.55
Ceiling Load	-2,680	0	0.00
Ventilation Load	0	0	0.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	-31,682	-31,682	122.52
Exhaust Heat		339	-1.31
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-25,024	-25,859	100.00

TEMPERATURES

	Cooling	Heating
SADB	0.0	125.0
Ra Plenum	0.0	68.2
Return	0.0	68.2
Ret/OA	0.0	68.2
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	0	413
Terminal	0	413
Main Fan	0	413
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	0	230
MinStop/Rh	0	0
Return	0	581
Exhaust	0	168
Rm Exh	0	63
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	0.0	0.0
cfm/ft²	0.00	0.09
cfm/ton	0.00	
ft²/ton	0.00	
Btu/hr·ft²	0.00	-5.61
No. People	0	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Enter °F	Enter gr/lb	Leave DB/WB/HR °F	Leave °F	Leave gr/lb
Main Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	4,608		
Part	0		
Int Door	0		
ExFlr	174		
Roof	1,081	161	15
Wall	3,083	1,428	46
Ext Door	72	72	100

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-25.9	413	68.2	125.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-25.9			

System Checksums

By ACADEMIC

RTU-1 — **VAV w/Baseboard Skin Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 91 / 73 / 96

Clg Space Peak — Mo/Hr: 9 / 16; OADB: 83

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	11,935	11,935	1	0	0
Glass Solar	178,184	0	178,184	19	247,918	39
Glass/Door Cond	22,422	0	22,422	2	10,016	2
Wall Cond	1,642	2,358	4,000	0	1,552	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	37,205		37,205	4	7,556	1
Sub Total ==>	239,452	14,292	253,745	28	267,043	43
Internal Loads						
Lights	63,315	15,829	79,143	9	63,315	10
People	324,900	0	324,900	35	162,450	26
Misc	131,870	0	131,870	14	131,870	21
Sub Total ==>	520,085	15,829	535,914	58	357,635	57
Ceiling Load	5,352	-5,352	0	0	3,448	1
Ventilation Load	0	0	133,052	14	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-17,200	-17,200	-2		
Sup. Fan Heat			15,125	2		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	764,889	7,569	920,634	100.00	628,127	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-27,611	41.04
Glass Solar	0	0	0.00
Glass/Door Cond	-98,826	-98,826	146.88
Wall Cond	-2,099	-5,091	7.57
Partition/Door	0	0	0.00
Floor	-1,484	-1,484	2.21
Adjacent Floor	0	0	0
Infiltration	-65,072	-65,072	96.71
Sub Total ==>	-167,481	-198,084	294.39
Internal Loads			
Lights	63,315	79,143	-117.62
People	127,000	127,000	-188.75
Misc	69,738	69,738	-103.65
Sub Total ==>	260,053	275,881	-410.02
Ceiling Load	-4,508	0	0.00
Ventilation Load	0	-155,430	231.00
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		10,348	-15.38
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	88,064	-67,285	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	0.0
Ra Plenum	77.1	0.0
Return	77.1	0.0
Ret/OA	78.4	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.4	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	27,621	7,785
Terminal	27,621	7,785
Main Fan	27,621	7,785
Sec Fan	0	0
Nom Vent	8,588	7,569
AHU Vent	8,588	7,569
Infil	1,002	1,002
MinStop/Rh	7,785	7,785
Return	28,622	8,786
Exhaust	9,590	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	31.1	97.2
cfm/ft²	1.38	0.39
cfm/ton	360.02	
ft²/ton	261.12	
Btu/hr·ft²	45.96	-8.02
No. People	650	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	76.7	920.6	658.1	25,523	78.4	65.2	73.1	54.5	53.2	59.3
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	76.7	920.6								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	20,033		
Part	0		
Int Door	0		
ExFlr	352		
Roof	11,885	0	0
Wall	8,459	6,379	75
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	-172.0	0	0.0	0.0
Preheat	-27.5	8,588	51.6	54.5
Reheat	-133.2	7,785	54.5	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-332.6			

System Checksums

By ACADEMIC

RTU-2 — **VAV w/Baseboard Skin Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 91 / 73 / 96

Clg Space Peak — Mo/Hr: 9 / 11; OADB: 75

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	76,975	0	76,975	17	115,603	38
Glass/Door Cond	13,094	0	13,094	3	-1,263	0
Wall Cond	511	1,390	1,901	0	955	0
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	27,453		27,453	6	-233	0
Sub Total ==>	118,033	1,390	119,423	26	115,061	38
Internal Loads						
Lights	44,789	11,197	55,987	12	44,789	15
People	134,000	0	134,000	29	67,000	22
Misc	75,415	0	75,415	16	75,415	25
Sub Total ==>	254,205	11,197	265,402	58	187,205	61
Ceiling Load	2,782	-2,782	0	0	2,799	1
Ventilation Load	0	0	71,422	16	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-4,065	-4,065	-1		
Sup. Fan Heat			7,864	2		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	375,020	5,740	460,046	100.00	305,065	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass/Door Cond	-50,438	-50,438	-263.74
Wall Cond	-926	-3,228	-16.88
Partition/Door	0	0	0.00
Floor	-1,063	-1,063	-5.56
Adjacent Floor	0	0	0
Infiltration	-44,403	-44,403	-232.18
Sub Total ==>	-96,830	-99,132	-518.36
Internal Loads			
Lights	44,789	55,987	292.75
People	67,000	67,000	350.34
Misc	75,415	75,415	394.34
Sub Total ==>	187,205	198,402	1,037.43
Ceiling Load	4,777	0	0.00
Ventilation Load	0	-76,029	-397.55
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		-4,117	-21.53
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	95,152	19,124	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	0.0
Ra Plenum	75.6	0.0
Return	75.6	0.0
Ret/OA	77.3	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.4	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	13,853	4,020
Terminal	13,853	4,020
Main Fan	13,853	4,020
Sec Fan	0	0
Nom Vent	5,065	4,019
AHU Vent	5,065	4,019
Infil	684	684
MinStop/Rh	4,020	4,020
Return	14,536	4,704
Exhaust	5,749	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	36.6	100.0
cfm/ft²	1.01	0.29
cfm/ton	361.34	
ft²/ton	356.57	
Btu/hr·ft²	33.65	-6.77
No. People	268	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	38.3	460.1	334.3	13,270	77.3	64.0	69.2	54.5	52.3	55.6
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	38.3	460.1								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	13,670		
Part	0		
Int Door	0		
ExFlr	252		
Roof	0	0	0
Wall	4,508	3,217	71
Ext Door	60	60	100

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	-92.1	0	0.0	0.0
Preheat	-23.7	5,065	50.2	54.5
Reheat	-68.8	4,020	54.5	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-184.5			

System Checksums

By ACADEMIC

RTU-3 | **VAV w/Baseboard Skin Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 12; Outside Air: OADB/WB/HR: 87 / 73 / 101

Clg Space Peak — Mo/Hr: 7 / 12; OADB: 87

	Cooling Coil Peak: Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Clg Space Peak: Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	6,938	6,938	2	0	0
Glass Solar	77,891	0	77,891	25	77,891	35
Glass/Door Cond	7,268	0	7,268	2	7,268	3
Wall Cond	1,260	1,798	3,058	1	1,260	1
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	24,567		24,567	8	8,121	4
Sub Total ==>	110,986	8,736	119,723	39	94,540	43
Internal Loads						
Lights	39,469	9,867	49,337	16	39,469	18
People	51,517	0	51,517	17	25,017	11
Misc	58,478	0	58,478	19	58,478	26
Sub Total ==>	149,464	9,867	159,331	52	122,964	55
Ceiling Load	4,680	-4,680	0	0	4,680	2
Ventilation Load	0	0	27,233	9	0	0
Adj Air Trans Heat	0		0	0	0	0
Dehumid. Ov Sizing			0	0		
Ov/Undr Sizing	0		0	0	0	0
Exhaust Heat		-3,319	-3,319	-1		
Sup. Fan Heat			5,979	2		
Ret. Fan Heat		0	0	0		
Duct Heat Pkup		0	0	0		
Underflr Sup Ht Pkup			0	0		
Supply Air Leakage		0	0	0		
Grand Total ==>	265,130	10,605	308,947	100.00	222,184	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: 11

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-22,581	198.28
Glass Solar	0	0	0.00
Glass/Door Cond	-49,634	-49,634	435.83
Wall Cond	-2,055	-4,892	42.96
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-40,603	-40,603	356.53
Sub Total ==>	-92,291	-117,710	1,033.60
Internal Loads			
Lights	40,956	51,195	-449.54
People	26,500	26,500	-232.69
Misc	54,478	54,478	-478.37
Sub Total ==>	121,934	132,173	1,160.60
Ceiling Load	-9,190	0	0.00
Ventilation Load	0	-31,410	275.81
Adj Air Trans Heat	0	0	0
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		5,559	-48.81
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	20,453	-11,388	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	0.0
Ra Plenum	76.2	0.0
Return	76.2	0.0
Ret/OA	76.8	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.1	0.0
Fn Frict	0.4	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	10,089	1,590
Terminal	10,089	1,590
Main Fan	10,089	1,590
Sec Fan	0	0
Nom Vent	1,926	1,440
AHU Vent	1,926	1,440
Infil	625	625
MinStop/Rh	1,590	1,590
Return	10,714	2,215
Exhaust	2,551	0
Rm Exh	0	0
Auxiliary	0	0
Leakage Dwn	0	0
Leakage Ups	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	19.1	90.6
cfm/ft²	0.81	0.13
cfm/ton	391.88	
ft²/ton	485.52	
Btu/hr·ft²	24.72	-2.93
No. People	106	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	25.8	309.0	248.0	10,089	76.8	63.5	67.8	54.5	53.2	59.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	25.8	309.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	12,500		
Part	0		
Int Door	0		
ExFlr	0		
Roof	9,891	0	0
Wall	5,233	3,204	61
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	0.0	0	0.0	0.0
Aux Htg	-101.5	0	0.0	0.0
Preheat	-9.4	1,926	50.1	54.5
Reheat	-27.2	1,590	54.5	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-138.1			

ENERGY CONSUMPTION SUMMARY

By ACADEMIC

	Elect Cons. (kWh)	Gas Cons. (kBtu)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1					
Primary heating					
Primary heating		979,475	23.0 %	979,475	1,031,026
Other Htg Accessories	11,102		0.9 %	37,892	113,689
Heating Subtotal	**11,102**	**979,475**	**23.9** %	**1,017,367**	**1,144,715**
Primary cooling					
Cooling Compressor	116,135		9.3 %	396,367	1,189,220
Tower/Cond Fans	15,744		1.3 %	53,734	161,218
Condenser Pump			0.0 %	0	0
Other Clg Accessories	4,609		0.4 %	15,730	47,194
Cooling Subtotal....	**136,487**		**10.9** %	**465,831**	**1,397,632**
Auxiliary					
Supply Fans	67,185		5.4 %	229,301	687,972
Pumps	8,215		0.7 %	28,037	84,120
Stand-alone Base Utilities			0.0 %	0	0
Aux Subtotal....	75,399		6.0 %	257,338	772,092
Lighting					
Lighting	152,260		12.2 %	519,662	1,559,142
Receptacle					
Receptacles	506,114	272,740	47.0 %	2,000,107	5,469,715
Cogeneration					
Cogeneration			0.0 %	0	0
Totals					
Totals**	**881,363**	**1,252,215**	**100.0** %	**4,260,306**	**10,343,297**

* Note: Resource Utilization factors are included in the Total Source Energy value .
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

MONTHLY ENERGY CONSUMPTION

By ACADEMIC

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Technical Report Two**												
Electric													
On-Pk Cons. (kWh)	73,061	66,375	72,147	68,012	55,606	62,830	72,072	105,447	87,670	74,177	72,158	71,808	881,363
On-Pk Demand (kW)	181	194	196	241	348	376	406	390	367	264	225	190	406
Gas													
On-Pk Cons. (therms)	2,206	2,073	1,628	1,082	233	216	265	213	280	978	1,302	2,046	12,522
On-Pk Demand (therms/hr)	13	13	12	11	10	10	10	10	10	11	11	12	13

Energy Consumption

Building	82,790	Btu/(ft2-year)
Source	201,001	Btu/(ft2-year)
Floor Area	51,459	ft2

Environmental Impact Analysis

CO_2	1,064,704 lbm/year
SO_2	8,284 gm/year
NOX	1,592 gm/year

EQUIPMENT ENERGY CONSUMPTION
By ACADEMIC

Alternative: 1 Technical Report Two

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Lights													
Electric (kWh)	15,141.9	13,697.1	16,413.4	14,448.4	5,576.9	5,519.1	5,232.8	16,413.4	14,448.4	15,777.7	15,084.2	14,506.2	152,259.6
Peak (kW)	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6
Misc. Ld													
Electric (kWh)	49,290.7	44,632.3	46,250.4	43,264.0	31,538.8	30,760.9	31,169.4	42,809.4	43,264.0	45,476.6	48,253.8	48,740.9	505,451.2
Peak (kW)	112.7	112.7	96.9	96.9	96.3	96.3	96.3	96.3	96.9	96.9	112.7	112.7	112.7
Misc. Ld													
Gas (therms)	209.8	209.8	209.8	262.3	209.8	209.8	262.3	209.8	262.3	209.8	209.8	262.3	2,727.4
Peak (therms/Hr)	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Energy Recovery Parasitics													
Electric (kWh)	0.0	4.6	0.0	0.0	77.2	150.3	205.9	170.2	54.7	0.0	0.0	0.0	663.0
Peak (kW)	0.3	0.3	0.0	0.0	0.9	0.9	0.9	0.9	0.9	0.0	0.0	0.0	0.9
Cooling Coil Condensate													
Recoverable Water (1000gal)	0.0	0.0	0.0	0.0	0.7	4.7	8.1	9.8	3.3	0.1	0.0	0.0	26.7
Peak (1000gal/Hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Cpl 1: CU-2 [Sum of dsn coil capacities=0.15 tons]													
CU-2 [Clg Nominal Capacity/F.L.Rate=0.15 tons / 0.16 kW] (Cooling Equipment)													
Electric (kWh)	45.7	40.4	46.6	45.9	52.3	54.5	61.1	57.0	51.0	48.6	46.3	46.2	595.3
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2
MZ packaged rooftop cond fan [Design Heat Rejection/F.L.Rate=0.19 tons / 0.02 kW]													
Electric (kWh)	6.2	5.5	6.3	6.2	6.7	6.8	7.3	7.1	6.5	6.6	6.2	6.2	77.4
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	876.0
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 2: CU-1 [Sum of dsn coil capacities=0.20 tons]													
CU-1 [Clg Nominal Capacity/F.L.Rate=0.20 tons / 0.22 kW] (Cooling Equipment)													
Electric (kWh)	62.2	54.9	63.3	62.4	71.1	74.1	83.0	77.5	69.4	66.1	62.9	62.8	809.6
Peak (kW)	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2

EQUIPMENT ENERGY CONSUMPTION

By ACADEMIC

Alternative: 1 Technical Report Two

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Cpl 2: CU-1 [Sum of dsn coil capacities=0.20 tons]													
MZ packaged rooftop cond fan [Design Heat Rejection/F.L.Rate=0.26 tons / 0.02 kW]													
Electric (kWh)	8.4	7.4	8.5	8.4	9.1	9.2	9.9	9.6	8.9	8.9	8.5	8.5	105.2
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	876.0
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 3: CU-3 [Sum of dsn coil capacities=0.28 tons]													
CU-3 [Clg Nominal Capacity/F.L.Rate=0.28 tons / 0.31 kW] (Cooling Equipment)													
Electric (kWh)	32.9	28.8	41.2	49.2	70.5	79.7	90.1	78.9	64.8	49.0	41.9	34.7	661.7
Peak (kW)	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.3
MZ packaged rooftop cond fan [Design Heat Rejection/F.L.Rate=0.37 tons / 0.03 kW]													
Electric (kWh)	4.7	4.1	5.8	6.8	9.1	9.9	10.7	9.7	8.2	6.8	5.9	5.0	86.7
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	876.0
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 4: CU-4 [Sum of dsn coil capacities=0.10 tons]													
CU-4 [Clg Nominal Capacity/F.L.Rate=0.10 tons / 0.11 kW] (Cooling Equipment)													
Electric (kWh)	27.1	24.0	28.9	29.7	35.7	38.0	42.9	39.4	34.4	31.0	28.7	27.6	387.3
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
MZ packaged rooftop cond fan [Design Heat Rejection/F.L.Rate=0.13 tons / 0.01 kW]													
Electric (kWh)	3.6	3.2	3.9	4.0	4.6	4.7	5.1	4.9	4.4	4.2	3.9	3.7	50.2
Peak (kW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	876.0
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 5: CU-5 [Sum of dsn coil capacities=0.86 tons]													

EQUIPMENT ENERGY CONSUMPTION
By ACADEMIC

Alternative: 1 Technical Report Two

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Cpl 5: CU-5 [Sum of dsn coil capacities=0.86 tons]													
CU-5 [Clg Nominal Capacity/F.L.Rate=0.86 tons / 0.95 kW] (Cooling Equipment)													
Electric (kWh)	59.7	54.4	78.7	79.2	58.4	68.8	83.2	140.7	109.7	84.4	72.5	58.3	947.9
Peak (kW)	0.5	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.7	0.6	0.6	0.5	0.8
MZ packaged rooftop cond fan [Design Heat Rejection/F.L.Rate=1.13 tons / 0.09 kW]													
Electric (kWh)	8.1	7.4	10.7	10.8	7.5	8.5	9.7	17.2	13.8	11.4	9.8	7.9	122.8
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	29.3	26.9	32.3	32.5	33.1	32.6	31.5	38.5	33.0	34.4	30.0	28.2	382.3
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 6: RTU-1 [Sum of dsn coil capacities=76.72 tons]													
RTU-1 [Clg Nominal Capacity/F.L.Rate=76.72 tons / 105.9 kW] [**Orig F.L.Rate=105.9 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	0.0	701.2	6,787.7	10,731.6	15,139.2	18,545.1	11,116.0	1,974.9	155.4	0.0	65,151.0
Peak (kW)	0.0	0.0	2.2	23.4	76.8	89.6	101.7	96.9	87.6	36.0	18.7	0.0	101.7
Condenser fan for Heat Pump [Design Heat Rejection/F.L.Rate=103.4 tons / 12.41 kW]													
Electric (kWh)	0.0	0.0	0.0	103.9	935.7	1,451.9	2,004.8	2,501.8	1,524.3	288.9	23.2	0.0	8,834.4
Peak (kW)	0.0	0.0	0.3	3.4	10.0	11.4	12.4	12.3	11.4	5.1	2.7	0.0	12.4
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	0.0	16.0	38.4	40.2	64.3	45.3	39.0	22.0	8.4	0.0	273.6
Peak (kW)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Cpl 7: RTU-2 [Sum of dsn coil capacities=38.34 tons]													
RTU-2 [Clg Nominal Capacity/F.L.Rate=38.34 tons / 52.91 kW] [**Orig F.L.Rate=52.91 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	0.0	342.0	2,825.6	4,440.3	6,174.3	9,466.9	5,917.8	972.5	72.8	0.0	30,212.2
Peak (kW)	0.0	0.0	1.1	11.7	36.4	43.8	50.4	45.6	38.6	16.4	8.3	0.0	50.4
Condenser fan for Heat Pump [Design Heat Rejection/F.L.Rate=49.97 tons / 6.00 kW]													
Electric (kWh)	0.0	0.0	0.0	50.7	390.2	602.3	817.6	1,281.0	813.5	142.3	10.9	0.0	4,108.5
Peak (kW)	0.0	0.0	0.2	1.7	4.8	5.6	6.0	5.8	5.2	2.3	1.2	0.0	6.0
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	0.0	16.0	33.1	35.0	35.9	40.9	33.0	21.6	8.4	0.0	223.9
Peak (kW)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1

EQUIPMENT ENERGY CONSUMPTION

By ACADEMIC

Alternative: 1 Technical Report Two

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Cpl 8: RTU-3 [Sum of dsn coil capacities=25.75 tons]													
RTU-3 [Clg Nominal Capacity/F.L.Rate=25.75 tons / 35.53 kW] [**Orig F.L.Rate=35.53 kW] (Cooling Equipment)													
Electric (kWh)	0.0	0.0	0.0	165.6	1,549.9	2,927.0	4,655.4	4,942.4	2,639.5	452.2	37.4	0.0	17,369.4
Peak (kW)	0.0	0.0	0.7	7.6	22.3	28.2	34.1	29.5	24.8	10.3	5.2	0.0	34.1
Condenser fan for Heat Pump [Design Heat Rejection/F.L.Rate=32.44 tons / 3.89 kW]													
Electric (kWh)	0.0	0.0	0.0	24.5	214.8	402.2	611.5	672.5	361.6	66.1	5.6	0.0	2,358.8
Peak (kW)	0.0	0.0	0.1	1.1	3.0	3.6	3.9	3.9	3.3	1.5	0.8	0.0	3.9
Cntl panel & interlocks - 0.1 KW (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	0.0	13.0	36.7	35.8	35.9	41.7	37.0	17.7	7.2	0.0	225.0
Peak (kW)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Hpl 1: Heating plant - 002 [Sum of dsn coil capacities=701.0 mbh]													
BLR-1 [Nominal Capacity/F.L.Rate=1,300 mbh / 15.29 Therms] (Heating Equipment)													
Gas (therms)	1,996.2	1,863.2	1,418.0	819.4	22.9	5.8	2.7	3.6	18.0	768.6	1,092.6	1,783.9	9,794.8
Peak (therms/Hr)	5.7	4.3	3.6	2.7	0.2	0.1	0.1	0.1	0.4	2.8	3.3	3.9	5.7
Heating water circ pump (Misc Accessory Equipment)													
Electric (kWh)	990.9	895.0	990.9	958.9	506.1	341.0	203.8	89.2	310.3	978.9	958.9	990.9	8,214.8
Peak (kW)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	967.2	873.6	967.2	936.0	494.0	332.8	198.9	87.1	302.9	955.5	936.0	967.2	8,018.4
Peak (kW)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Cntl panel & interlocks - 0.5 KW (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	190.0	128.0	76.5	33.5	116.5	367.5	360.0	372.0	3,084.0
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sys 1: RTU-1													
BI Centrifugal var spd mtr [DsnAirflow/F.L.Rate=27,620 cfm / 12.01 kW] (Main Clg Fan)													
Electric (kWh)	1,626.6	1,486.9	1,762.8	1,590.5	1,149.9	1,194.6	1,313.1	1,936.9	1,642.5	1,675.2	1,581.3	1,576.0	18,536.1
Peak (kW)	7.0	11.0	10.7	9.4	9.4	9.3	10.1	11.0	12.0	11.1	10.5	9.8	12.0
BI Centrifugal var spd mtr [DsnAirflow/F.L.Rate=28,622 cfm / 4.92 kW] (Main Return Fan)													
Electric (kWh)	682.9	630.1	739.2	666.7	509.9	516.8	559.4	809.6	695.6	688.9	656.3	656.9	7,812.5
Peak (kW)	2.8	4.5	4.4	3.9	3.9	3.8	4.2	4.5	4.9	4.5	4.3	4.0	4.9

EQUIPMENT ENERGY CONSUMPTION

By ACADEMIC

Alternative: 1 Technical Report Two

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	-------				Monthly Consumption			-------					
Sys 4: RTU-2													
BI Centrifugal var spd mtr [DsnAirflow/F.L.Rate=13,852 cfm / 12.01 kW] (Main Clg Fan)													
Electric (kWh)	1,763.0	1,620.6	1,962.4	1,754.7	845.0	909.6	964.7	2,109.4	1,730.9	1,802.9	1,689.8	1,687.2	18,840.1
Peak (kW)	10.1	11.7	11.0	10.1	10.0	10.8	12.0	11.5	12.0	11.8	11.3	11.0	12.0
BI Centrifugal var spd mtr [DsnAirflow/F.L.Rate=14,536 cfm / 4.92 kW] (Main Return Fan)													
Electric (kWh)	739.9	688.5	820.4	733.0	402.4	413.9	430.4	880.6	738.0	736.1	698.9	700.8	7,982.8
Peak (kW)	4.2	4.8	4.5	4.2	4.1	4.5	4.9	4.7	4.9	4.8	4.7	4.5	4.9
Sys 5: RTU-3													
BI Centrifugal var spd mtr [DsnAirflow/F.L.Rate=10,089 cfm / 12.01 kW] (Main Clg Fan)													
Electric (kWh)	900.6	984.2	1,244.4	1,243.6	848.5	1,221.8	1,446.6	1,792.1	1,192.9	1,110.1	1,004.9	1,023.3	14,013.2
Peak (kW)	4.1	7.5	8.4	9.0	10.3	12.0	12.0	12.0	10.9	8.0	6.8	6.2	12.0
Sys 6: ACU-1													
Sys 7: ACU-2													
Sys 8: ACU-3													
Sys 9: ACU-4													

Economic Summary

Project Information

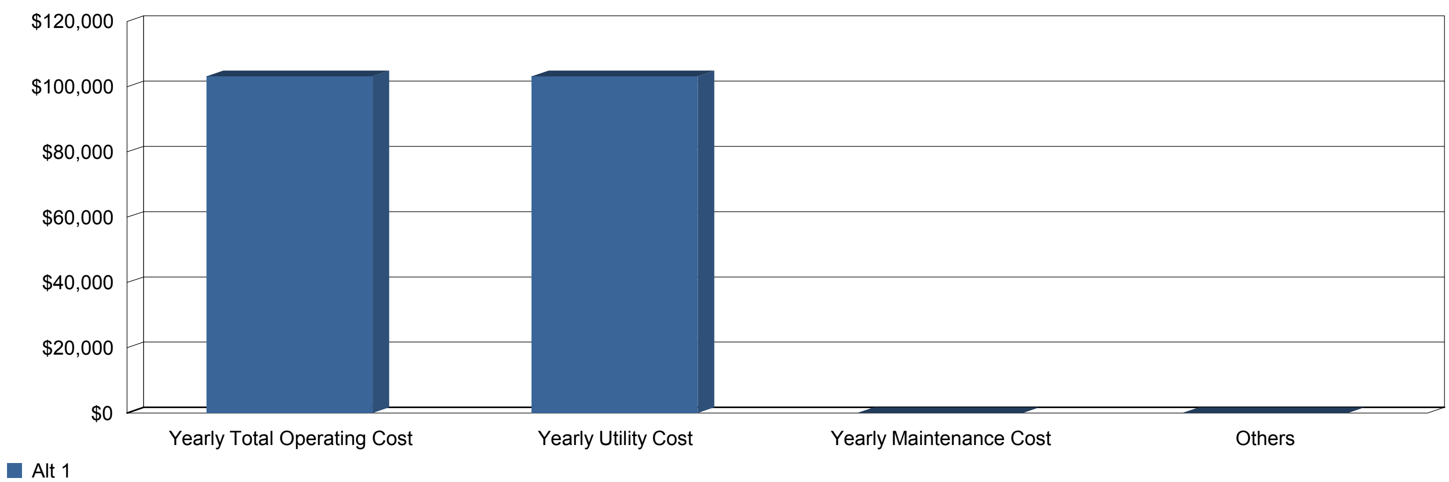
Location	Reading, PA
Project Name	The Gaige Builidng
User	Matthew Neal
Company	Penn State AE Senior Thesis
Comments	

Study Life:	20 years
Cost of Capital:	10 %
Alternative 1:	Technical Report Two

Economic Comparison of Alternatives

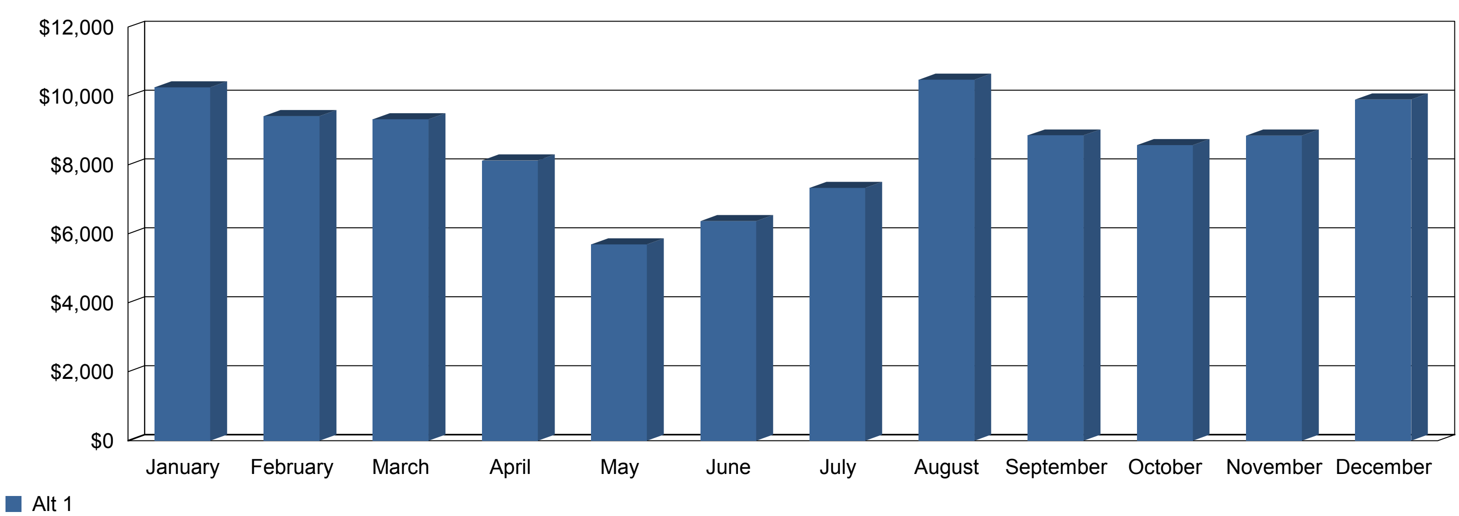
Yearly Savings ($)	First Cost Difference ($)	Cumulative Cash Flow Difference ($)	Simple Payback (yrs.)	Net Present Value ($)	Life Cycle Payback (yrs.)	Internal Rate of Return (%)	Life Cycle Cost

Annual Operating Costs



Yearly Total Operating Cost ($)	Yearly Utility Cost ($)	Yearly Maintenance Cost ($)	Plant kWh/ton-hr

Monthly Utility Costs



MONTHLY UTILITY COSTS

By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Alternative 1													
Electric													
On-Pk Cons. ($)	7,043	6,399	6,955	6,556	5,360	6,057	6,948	10,165	8,451	7,151	6,956	6,922	84,963
Gas													
On-Pk Cons. ($)	3,213	3,019	2,371	1,575	339	314	386	311	408	1,425	1,897	2,980	18,236
Monthly Total ($):	10,256	9,417	9,326	8,132	5,699	6,371	7,334	10,476	8,860	8,575	8,853	9,902	103,200

Building Area = 62,188 ft²

Utility Cost Per Area = 1.66 $/ft²