Energy Analysis and Mechanical Re-design of Little Souls Daycare

A project submitted for the 2016 ASHRAE Student Design Competition.

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The following report is a condensed version, and has been provided to ensure compliance with the 2016 Applied Engineering Challenge judging criteria. If you wish to review the extended document, please contact Brad Lulik at Brad.Lulik@uregina.ca

SOULS HARBOUR RESCUE MISSION

To The Applied Engineering Competition

RE: Souls Harbour Rescue Mission entry

Dated: May 31 2016

Our organization was approached last fall by a team of engineering students, (Brent Yeske, Eva Rennie, and Brad Lulik) to do an energy assessment of one of our buildings (1475 Athol St). We discussed a couple aspects that we would appreciate out of this process: one being some accurate floor plans that we could use for future renovations and an updated fire plan, along with a suggestive strategy in order to deal with the lack of any air circulation systems in this building.

Our organization was very impressed with the finished product, whereas the team completed a very thorough energy assessment of our building, allowing us to clearly see where there are major energy inefficiencies through a variety of deficiencies. In addition, they put together a strategic plan that takes into account our non-profit status and inability to suddenly produce hundreds of thousands of dollars for building repairs. This strategic plan analyzes the best approach to do strategic upgrades to our building to install a series of air ventilation systems, providing us with the best ROI over a ten year period.

It was this balance between the professional standards associated with engineering and the empathic understanding of our organization's challenges to implement these necessary changes that impressed us the most. Their help and contribution has provided us with a blueprint for success, allowing us to implement a plan to upgrade our building without it overwhelming us financially, over the next ten years.

Well done team!

Michael Towers

Director of Operations

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EXECUTIVE SUMMARY

The project team has entered into a partnership with Little Souls Daycare, an affiliate of Souls Harbour Rescue Mission, to provide an energy audit and mechanical system redesign for their facility. Construction of the building was completed in 1951, and originally housed St. Andrew's United Church. Following the closure of St. Andrews, Souls Harbour Rescue Mission purchased the facility and re-purposed it to include an administration area, youth center, and fully licensed childcare facility.

For more than 25 years, Souls Harbour Rescue Mission has been providing a variety of programs and services to the community of Regina, Saskatchewan. Men’s and Women’s shelters, a clothing store, meal programming, youth centres, a daycare facility, addiction programming, and affordable housing are where the organization focuses most of their effort.

In August of 2015, the project team was made aware of mechanical deficiencies at the Souls Harbour Rescue Mission facility. Due to the nature of these deficiencies, largely related to ventilation requirements, the physical health of the occupants was at risk. Souls Harbour Rescue Mission makes it their goal to provide a caring, warm, and safe environment for each child to play, explore, and learn; in doing so, special consideration is being applied by the project team to ensure a regulatory compliant mechanical system is proposed. The facility is a not-for-profit and relies solely on charitable donations from the general public; and as such, the management team at Souls Harbour works relentlessly to provide all necessary care for their stakeholders, while attempting to retain enough resources to maintain each of their facilities. Due to the fact that the majority of Souls Harbour’s funding is invested into the programs and services being offered, financial consideration has remained a large component of the project.

Literature review pertaining to regulatory compliance was an important aspect of the final project. Compliance with the National Building Code of Canada, with a specific focus on ASHRAE Ventilation requirements, was crucial to ensuring that any proposed solution addresses deficiencies with the stipulations laid out by government. Given that the current mechanical system at Little Souls Daycare lacks any form of cooling or ventilation, the health of the primary occupants -- children -- must be ensured. When discussing improvements to the efficiencies and quality of heating, ventilation, and air-conditioning, the building envelope becomes important. In the context of an energy audit and mechanical system redesign, an economical system coupled with an effective envelope creates an energy efficient building.

The project team worked closely with the Operations staff at Souls Harbour Rescue Mission to analyze various mechanical solutions within an HVAC simulation software. This exercise provides for optimization and proper sizing of the proposed heating, ventilation, and air-conditioning systems; and in doing so, the project team is able to ensure that the design is on the basis of energy utilization. A multitude of simulations were completed to further enhance the facilitation of the energy analysis, and confirmation of the simulation outputs was completed to verify that the results reflect an accurate measure of energy within the system. Further to the basic energy utilization for Little Souls Daycare, the project team utilized an energy modeling software, as well as past utility expenses, to explore the energy use for the building on a multitude of levels. There are many factors that have an influence on the heating and cooling loading for the facility, and with this in mind the project team explored several opportunities for improvement to the physical building that may lead to better resulting efficiencies. Component specifications were altered to reflect replacement with higher quality materials, and several mechanical solutions were simulated to determine if a more efficient system, at a greater capital expense, provides a more significant return-on-investment. Additionally, in order to provide a more qualitative analysis of the current and proposed facilities, ASHRAE’s Building Energy Quotient (BEQ) was utilized to characterize the various energy uses of the current and proposed systems. The BEQ provides an opportunity to

analyze a system on the merits of its energy efficiencies rather than compromising the indoor environment quality. As such, although the current system, with no means of ventilation, achieves a A- (Very Good) grading for its efficiencies, by creating a regulatory compliant facility, that ultimately uses more energy than the current system, the BEQ can still achieve a grading of B (efficient).

Infrared analysis of the existing facility was an important component for gaining further insight into problematic areas throughout the building. Infrared serves as a formidable tool for identifying areas of substantial heat loss. There is little purpose to implementing an improved mechanical system when the facility is experiencing excessive infiltration. The trouble areas that have been identified proved to be influential on the final recommendations.

Throughout the duration of the energy audit and mechanical re-design of Little Souls Daycare, various recommendations have been made in order to improve the efficiencies of the space and the regulatory compliances of the facility. Roof Top Units, often referred to as Air Handling Units, have been recommended as the most practical design solution. It is also recommended that Souls Harbour Rescue Mission utilize a phased implementation plan, which effectively utilizes any returns on investment.

The project team designed an energy model which was validated through the use of past utility expenses, infrared imaging, and ASHRAE's Building Energy Quotient. This process allowed for recommendations to improve the energy performance of Little Souls Daycare. Ensuring that recommendations are on the basis of both energy utilization and economic evaluation remained a priority for the project team. Following the project team's wrap-up meeting with the client, it is hoped that this plan will further assist with ensuring the health and safety of future generations of facility users.

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1.0 Introduction and Background

In partnership with Souls Harbour Rescue Mission, the project team has completed an energy audit and mechanical system redesign of Little Souls Daycare. Through extensive analysis of the Little Souls Daycare facility, the project team was able to thoroughly examine the impacts of external factors on both the heating and cooling loads of the building. The project team has worked to ensure that the energy audit and mechanical system redesign is on the basis of energy utilization and economic evaluation; in doing so, various engineering tools were used to facilitate the analysis of energy-use and the economic effects of the proposed mechanical solutions. Recommendations made through this report will assist Souls Harbour in improving the energy performance of Little Souls Daycare, and will include practical solutions for improving the regulatory compliance associated with operation.

2.0 Facility Description

The facility of interest is located at 1475 Athol Street, Regina, Saskatchewan, and was originally owned by the United Church. The chapel was located on the upper floor where the daycare facility is currently situated. The building was renovated and repurposed after its purchase by Souls Harbour. The purpose of the facility today is to provide children in lower income families the opportunity to partake in daycare activities,while under the supervision of Souls Harbour employees. The building now consists of a large daycare room with kitchen and washroom facilities on the main floor, along with administrative offices and a small boardroom. The lower level houses ample storage space, as well as a second kitchen area, a fully equipped computer room, and a rumpus area for kids to play. Furthermore, there is a gymnasium located on the East side of the building, which gives children and youth the opportunity to play sports and interact. Along the perimeter of the gymnasium, there are additional storage rooms on the main level, and office spaces on the upper balcony. (Towers, 2015)

3.0 Problem Statement

3.1 Client Concerns

The client had concerns regarding their building ventilation and the inherent safety of their occupants. More specifically, the client was fully aware that the facility has no current means of ventilation in summer months, which results in a stale and humid environment. This environment can reach temperatures upwards of 30 degrees Celsius during hot summer months, and poses a risk to occupants who are generally children under the age of 10. Furthermore, when the building was repurposed, the ventilating ductwork was closed off and made unusable. The deliverables for the client were made very clear; the organization wanted to improve inefficiencies at the lowest possible cost while improving the health and safety of the building and providing a habitable environment for its users. (Towers, 2015)

Given that the organization is not-for-profit, their budget is limited and is primarily directed towards providing quality services for the children they care for each day. Additional operating and maintenance costs for the facility create a burden for the organization, but must be budgeted for and justified in order to improve the indoor environment for occupants. Therefore, by helping Souls Harbour update their HVAC system, the project group can effectively accomplish the client's goal, preferably at a reasonable cost and with a phased approach. (Towers, 2015)

3.2 Constraints

The first constraint of the project was the cost of implementation of an HVAC solution. The company, as mentioned, is not-for-profit and thus has limited funds available for spending on additional capital costs.

Also, because the facility was constructed in the 1950's, the structural integrity of the building may be compromised and this could ultimately impact the type of alternatives allowable for HVAC in terms of weight and size. Furthermore, since the building is already constructed, there is limited access to walls, ceilings and other areas where insulation and plumbing exists. Therefore the group, working together with their industry partner and other qualified individuals, had to come up with assumptions regarding the building condition, including but not limited to: thermal insulation values and clearances for ductwork. Technologies such as infrared scanning, which will be discussed later, were utilized to help reveal building deficiencies undetected by the naked eye that require immediate or future attention.

4.0 Measurement

4.1 Infrared Photography

Infrared photos were taken of the facility in order to provide insight into the problematic areas related to heat loss during winter months, and potential heat gain during summer months. The photos, taken in January of 2016 in sub-zero temperatures, identify areas of the building where significant amounts of heat are being expelled to the outside atmosphere. Furthermore, photographs of the inside surfaces were also taken to compare the differentiation of temperatures between the inside environment and cool or drafty spots throughout the rooms. Analyzing the infrared photos reveals areas of particular concern, including: ground-level concrete foundations, single-pane windows, structural cracks, poorly sealed skylights, door cracks, ceiling cracks, and an uninsulated chimney cap.. Examples of these problematic areas can be seen in the below photographs. Note the outlined portions, and how they relate to heat loss for the facility. It is recommended that the operator mitigate the identified trouble areas before proceeding with the recommended mechanical upgrades to ensure maximum efficiency.

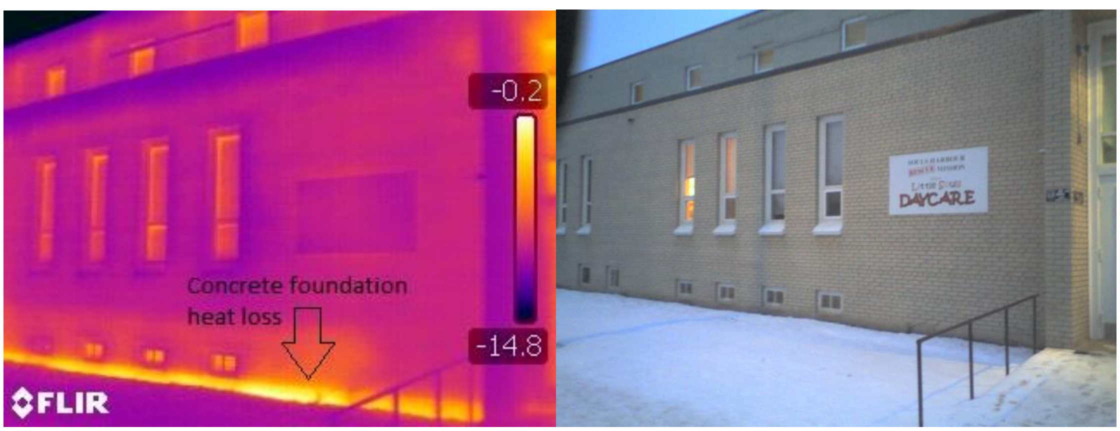

FIGURE 1: INFRARED PHOTO: CONCRETE FOUNDATION HEAT LOSSES

Figure 1 demonstrates the heat loss through the concrete foundation that was identified around the entire perimeter of the building. This type of heat loss is caused by inadequate insulating material between the facility wall and the outside air. The scale shown on the right side of the infrared photograph denotes an outside ambient temperature of -14.8 degrees Celsius. The concrete foundation exterior wall experiences temperatures upwards of -0.2 degrees Celsius, a differential temperature of 14.6 degrees Celsius.

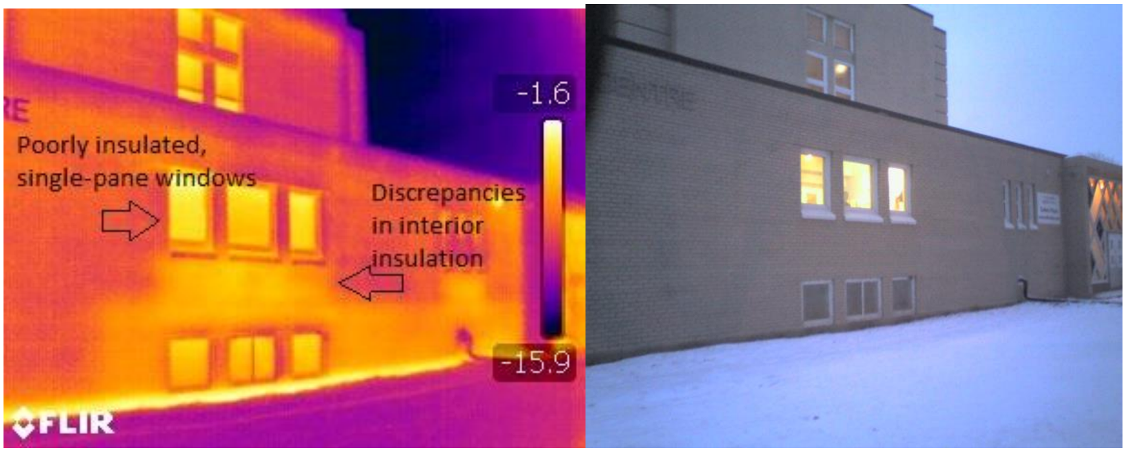

FIGURE 2: INFRARED PHOTO: SINGLE-PANE WINDOWS & WALL INSULATION DISCREPANCIES

Figure 2 shows a clear indication of the heat losses experienced when using single-pane windows. The temperature difference is 13.2 degrees Celsius. There are evident discrepancies in the exterior insulation, shown by "shadowed" lines. Furthermore, the upper level windows also appear to be single-pane, which was confirmed by inspection.

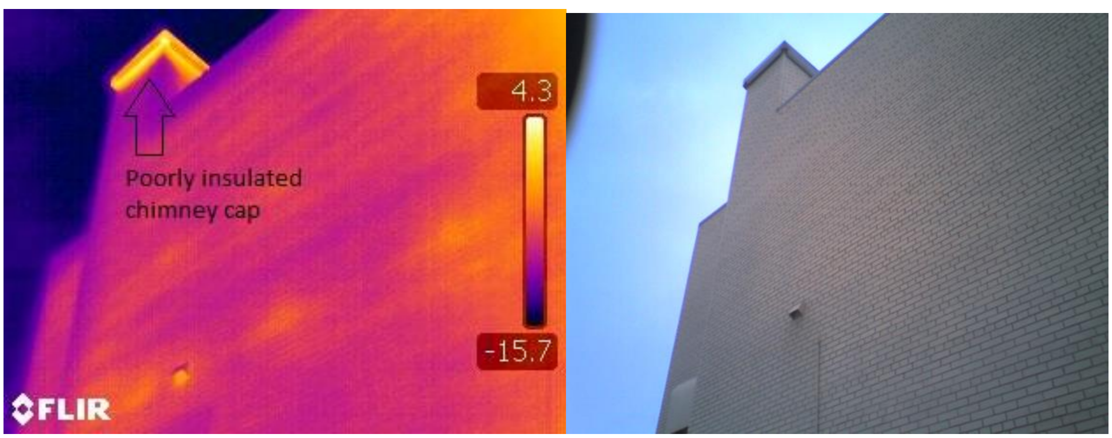

FIGURE 3: INFRARED PHOTO: POORLY INSULATED CHIMNEY CAP

Figure 3 shows the heat loss due to the poorly designed chimney cap, which is assumed to have been installed after the removal of the chimney exhaust when the boiler system was updated. A ground-level exhaust system for the boilers now exists, which adheres to current code. The temperature differential is 20.0 degrees Celsius. This area should be addressed by the client.

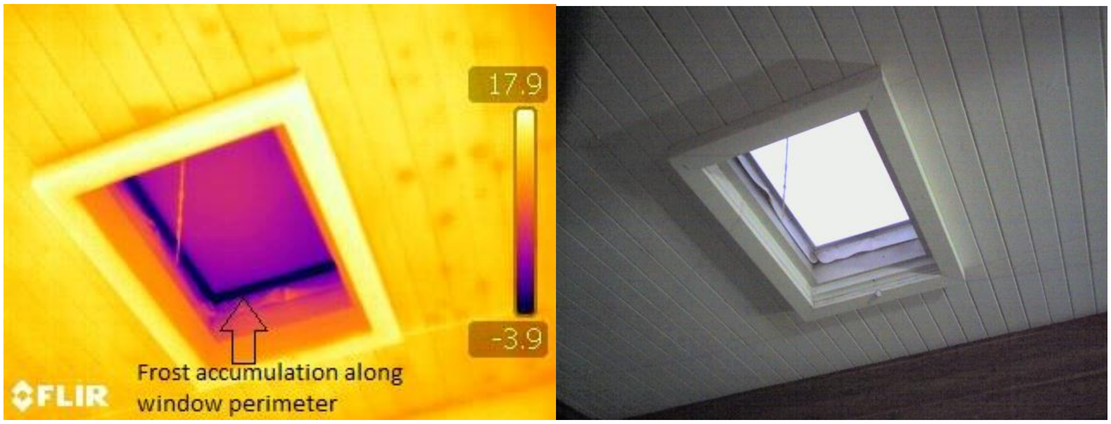

FIGURE 4: INFRARED PHOTO: FROST PENETRATION OF GYMNASIUM SKYLIGHTS

Figure 4 shows the appearance of frost along the perimeter of the gymnasium skylight windows. The existence of frost indicates that a significant amount of heat loss is occurring along these edges. Moreover, since the skylight is located on the roof of the building, and because heat inherently rises, there is an increased risk of significant heat loss through skylights and other poorly insulated roof-mounted fixtures. As seen in the infrared photograph, the differentiation in temperature is 21.8 degrees Celsius. This is another area of concern that should be addressed.

4.2 Simulation

4.2.1 System Model

TRACE700 is an engineering simulation tool designed to weight the energy and economic impacts of architectural features, HVAC systems, HVAC equipment, building utilization and financial options; and was the primary software program used for simulating the existing and proposed systems for the daycare facility. Values entered into the program were referenced from ASHRAE standards, as well as recommendations by our industry partner. It is important to have an understanding on the techniques used by the program to calculate output values, as such, the general formula for heat loss is described below: (ASHRAE, 2013)

$$H = U \cdot A \cdot (t_{out} - t_{in}) \qquad [1]$$

As seen from the above equation, the total change in enthalpy is proportional to the U-value of the shared barrier, the square footage of the barrier, and the temperature difference across the barrier. When discussing the daycare facility, it was determined that the R-value of the walls was 15, while the roof's R-value is 20. Below-grade walls were determined to have minimal insulation barrier, aside from the existing brick, as was supported through the aforementioned infrared photos. In Regina, Saskatchewan, most walls are constructed with either 4" to 6" insulation. For the Little Souls Day Care facility, insulation thickness was determined to be slightly less than 4". When discussing insulation, it is important to note that the U-Value represents the thermal conduction across the surface.

The first step to ensuring an accurate model was creating architectural drawings for the facility. Although Souls Harbour Rescue Mission had basic plans available, they were determined to be outdated and inaccurate for our purposes. Following the creation of these drawings, TRACE700 was used to perform the heating and cooling load calculations for the individual rooms throughout the facility. The relevant characteristics of the area -- such as dimensions, the number of people, the amount of heat gain due to lighting, as well as miscellaneous loads -- were defined for the consideration of internal loading of the facility. (TRANE, 2015)

In order to ensure that the proposed HVAC system is appropriate for the current operational needs, clear design temperatures for the facility must also be defined. In doing so, the cooling and heating dry bulb values were selected as 88 °F and -33°F, respectively. Although temperature considerations are important, due to the fact that Regina, Saskatchewan is a relatively dry climate, the humidity considerations must be accounted for to ensure an appropriate unit selection. Finally, moisture capacitance of any absorbing materials present within the facility will be considered throughout our facility model. (TRANE, 2015)

The interior loading of the facility is another crucial component when considering the facility model, as the occupants contribute towards substantive loading within the system. With this said, specifying the number of occupants must be completed to ensure that the proposed system is able to overcome the natural heat being displaced by the occupants. For the purposes of this facility, a sensible heat gain and latent heat gain of 250 Btu/person and 200 Btu/person, respectively, can be used for the office space and daycare, while a sensible heat gain and latent heat gain of 710 Btu/person and 1090 Btu/person, respectively, can be used for the Gymnasium. (TRANE, 2015)

Regarding lighting, recessed fluorescents are used for the majority of the facility, and approximately 80% of the heat load is rejected into the space, with the heat gain due to the lighting being determined to be 1 W/sqft. The heat gain due to the lighting was calculated by examining the wattage and size of each lighting unit. (TRANE, 2015)

The above listing has been provided to briefly outline a general summary of the information used to accurately model the proposed system.

4.2.2 System Model Confirmation

The system model serves as an important tool when proposing a mechanical system, but the data from the simulation outputs should be confirmed to ensure accuracy. For the Little Souls Daycare facility, the overall envelope performance was determined to be:

TABLE 1: ENVELOPE PERFORMANCE DATA

	U-Value
Overall Roof U-Value	0.056 Btu/h*ft^2*F
Overall Wall U-Value	0.067 Btu/h*ft^2*F
Overall Glass U-Value	0.962 Btu/h*ft^2*F
Overall Ceiling U-Value	0.317 Btu/h*ft^2*F

Further to this, the internal loads of Little Souls Daycare were determined to be:

TABLE 2: INTERNAL LOADS

Internal Load	
Occupancy Density	200 ft^2 per person
Lighting Power Density	1 W/ft^2 (max)
Plug-Loads	20% after-hours

Simulation data summaries can be viewed in Appendix C. Although TRACE700 provides a reasonable outline of internal loading, the data should be confirmed for accuracy. As such, the project team has committed to confirming the output data, and an example of these calculations have been provided for the administrative space in Appendix D.

4.2.3 EQUEST

EQuest is a free software available from the Government of Canada. It allows users to predict changes in energy usage for a building based on a variety of different factors, including but not limited to: window efficiency, heating and cooling efficiency, mechanical system parameters, insulation ratings, miscellaneous plug loads, area lighting, hours of operation, and occupancy. From this software, the project team was able to compare the results of many different simulation runs to determine the ultimate impact each change would have on the overall building energy consumption. (EQUEST, 2016)

4.2.3.1 Baseline System

The baseline system, or existing system, is best described as having no ventilation or cooling capability, coupled with baseboard (boiler supplied) heating. Insulation values were estimated to be R-20 for the roof, R-15 for the walls, and zero insulation for any below grade walls (foundation). This is a conservative estimate, as no access was available to the existing insulating material. However, through the use of infrared scanning technology, it was evident that insulation quality was poor on all below grade surfaces, as earlier discussed. Furthermore, the baseline system assumed a lighting power density of one Watt per square foot in heavy traffic areas. These areas included the daycare and offices, where the majority of day-to-day operations and activities take place. Lighting in the gymnasium, storage areas, kitchen and corridors was assumed to be zero, as these areas are infrequently used and are not lit when unoccupied. Plug loads were assumed to be low, approximately 20% during hours of no occupancy, and 60% during hours of occupancy. However, plug loads were only accounted for in areas of high traffic or where administrative duties typically take place. Other areas, including the kitchen and storage rooms were assumed to have plug loads of 20% during occupancy, since there were not many appliances identified in these areas during field visits. Windows for the baseline system were all assumed to be single pane. This assumption holds true for the majority of the building, with exception to a select few areas where renovations have taken place in recent years. However, for the purpose of the simulations, single pane was assumed for all windows. Infiltration rates were assumed to be 0.45 CFM/ft^2 at the perimeter and 0.225 CFM/ft^2 in the core area. From the baseline system, a variety of simulations could be performed by manipulating the system characteristics, and results could be compared to the baseline system from the exported data. (EQUEST, 2015)

4.2.3.2 Mid-Efficiency System

The first option provided for improvement over the baseline system consisted of mid-efficiency ventilation, cooling and heating units located on the roof of the facility. These units are capable of providing air-conditioned air to the building during summer months. Ventilation is provided by circulating fans within the unit, with return air and exhaust ports. Heating is provided via forced air heating, which can be used in combination with the existing boiler system, as a stand-alone solution, or not at all. The mid-efficiency system does not include the ability to vary the speed of the output fan motor, which limits its abilities to a simple on/off operation. This is typical of most furnace and air conditioning units; however, variable frequency drives (VFDs) and variable air volume (VAV) control are becoming more popular in industry because of their ability to operate at speeds between zero (off) and 100% (maximum). VAV units can provide additional cost savings. The mid-efficiency system described assumes that no other upgrades have been made to the building aside from the heating, cooling and ventilation system. Therefore, windows, insulation, skylights, doors and other sources of heat gain/loss have been left unchanged. (EQUEST, 2015)

The eQuest report, as shown in Appendix A, indicates that the mid-efficiency system coupled with no other building improvements would result in annual energy savings of (-$26,176) over the baseline system. The reasoning for this loss of operating costs is due to the fact that the baseline system, as described in section 4.2.3.1 above, does not currently provide any means of ventilation or air conditioning to the building. Therefore, by introducing both ventilation and air conditioning, additional operating costs must also be incurred as a result of more energy consumption during hot summer months, as well as increased electricity usage as a result of ventilation fans. The benefits of the mid-efficiency system are that it brings the current building up to Code with respect to ventilation requirements, and also provides improved health benefits for its occupants. (EQUEST, 2015)

4.2.3.3 High-Efficiency System

The high-efficiency system is an upgrade over the mid-efficiency system, mainly due to its ability to provide variable fan speeds through the use of VAV's. The system utilizes the most up-to-date mechanical features and provides heating, cooling and ventilation to the building through the most efficient means available.

Referring to the eQuest report in Appendix A, comparison of the high-efficiency system to the baseline system shows that the total annual savings of implementing this option, coupled with no other building upgrades, equates to ($-12,631). As previously mentioned, the high-efficiency system, similar to the mid-efficiency system, will require more energy than the baseline system mainly because it provides ventilation and cooling capabilities not currently available. However, in comparison to the mid-efficiency system, the high-efficiency option can save the organization approximately $13,500 annually due to its energy saving features.

4.2.3.4 Mid-Efficiency System with Building Upgrades

As previously discussed, the mid-efficiency system, if implemented alone, will result in additional operating expenses of approximately $26,000 annually. However, if further improvements are made to the building infrastructure, these additional costs can be reduced. A brief description of the predicted annual savings is given below.

A simulation was performed to observe the effect of the mid-efficiency system coupled with all suggested improvements (windows, skylights and insulation). The insulation values for the walls were increased from R-15 to R-21, and the roof was increased from R-20 to R-30. Furthermore, the windows were upgraded from single pane to triple pane low-e alternatives. Lastly, the skylights in the gymnasium were removed from the simulation and assumed to be a part of the roof with an insulation value of R-30. The results of these changes, as shown in Appendix A, conclude that the overall savings (in comparison to the existing baseline system) would be (-$17,979) annually. However, when compared to the mid-efficiency system described in section 4.2.3.2, the annual savings are approximately $8,000.

4.2.3.5 High-Efficiency System with Building Upgrades

As previously discussed, the high-efficiency system, if implemented alone, will result in additional operating costs of approximately $12,600 annually. However, if further improvements are made to the building, these additional operating costs can be reduced. A brief description of the predicted annual savings is given below.

A simulation was run to observe the effect of the high-efficiency system coupled with all recommended building upgrades, including windows, skylights and insulation improvements. Similar to the system in section 4.2.3.4, the insulation value for the walls was increased from R-15 to R-21, and the roof was increased from R-20 to R-30. The windows were upgraded from single pane to triple pane low-e. Furthermore, the skylights in the gymnasium were removed and replaced with insulation with a value of R-30. The results, as shown in Appendix A, conclude that the overall savings (in comparison to the baseline system) would be ($-7,414) annually. However, in comparison to the system described in section 4.2.3.3, the annual savings are $5,200.

4.3 Regulatory Compliance

4.3.1 ASHRAE Standard 55: Thermal Comfort

ASHRAE Standard 55 does not provide specific guidance for the design of mechanical systems, as stated in section 6.1 of the standard (ASHRAE, 2004). However, it is recommended that at least one of the several methodologies provided within the standard be used to help design an effective and comfortable environment. The method presented in section 7.6.2.1 of the standard recommends surveying the occupants to ensure 80% (minimum) of the people feel comfortable in their environment. This type of survey could easily be completed by the building operator, providing valuable feedback to the design engineer. Furthermore, it would be beneficial moving forward to perform a complete analysis of the existing temperature conditions including but not limited to: floor surface temperature, vertical temperature difference, and radiant temperature asymmetry. Furthermore, after the proposed HVAC system has been installed, it is recommended that a survey and full analysis be completed to ensure the set-points and system variance remain consistent, and provide 80% satisfaction (minimum) for all frequent occupants. The steady state of the system shall remain consistent (if possible) without cycling, as defined in ASHRAE 55 section 7.6.2.2 (ASHRAE, 2004).

4.3.2 ASHRAE Standard 62: Ventilation for Acceptable Indoor Quality

The National Building Code of Canada requires that ASHRAE Standard 62 be followed. ASHRAE Standard 62 provides guidelines for minimum ventilation rates and other requirements of ventilation systems. It covers new buildings, as well as additions, renovations, and change of use to existing buildings. The standard applies to all buildings intended for human occupancy with the exception of houses of three stories above grade or less, vehicles, and aircrafts. ASHRAE 62, similar to the national building code, provides guidelines for minimum air intake separation distances, as well as regulations for resistance to erosion, resistance to mold growth, and snow and rain entrainment. Additional measures need to be taken if the outdoor air is contaminated, for smoking areas, and areas requiring additional ventilation such as hospital operating rooms, laboratories, and industrial facilities. (ASHRAE, 2013)

All units manufactured in Canada or the United States will comply with this standard. The most important section of the standard describes the procedures for the calculation of minimum ventilation rates. It states that "either the ventilation rate or the IAQ procedure shall be used to design each ventilation system in a building". The ventilation rate procedure determines the outdoor intake rate based on the type of space, the area of the space, and the occupancy level of the space, whereas the IAQ procedure takes into account the contaminant sources, contaminant concentration targets, and perceived acceptability targets. For the purposes of this project, TRACE700 was used for the calculation of the minimum ventilation rate. (ASHRAE, 2013)

The standard also provides guidelines for construction and system start-up which would need to be used during the construction and commissioning phases of the project. Section 8 contains regulations on operations and maintenance of ventilation systems including information on the maintenance of the various components of the system, including the filters, air dampers, and sensors. The standard also provides guidelines for minimum activity and frequency of maintenance of the components. (ASHRAE, 2013)

5.0 Analysis

5.1 System Analysis

The building envelope is defined as the enclosure that "provides physical separation between the indoor and outdoor environments" (ASHRAE, 2013) . Within the envelope there are numerous components, including all mechanical, structural, electrical, plumbing, and miscellaneous equipment, which is often referred to as the “system” for the building. Therefore, by upgrading the “system”, one is essentially upgrading the overall condition, performance, and efficiency of such system, depending on the changes made to the system. Together, an economical system coupled with an effective envelope create an energy efficient building.

Some of the structural components included in a building system are insulation values for the roof, walls, ceiling and windows, as well as the window characteristics, and the material from which the building itself was constructed. All of these components play a significant role in the effectiveness of the overall building efficiency in terms of retaining heat in winter months, and stopping the permission of heat into the building during summer months. The importance of adequate insulation in a building is evident from the basic equation for heat transfer through a body, given as H=U·A(to-ti), where H represents the heat transfer, U is the U-value of the given medium, A is the surface area, and t values represent inside and outside temperatures.

Similarly, windows have different thermal resistivity values, depending on their quality, thickness, and insulating medium. As an example, a double paned window with ½ inch of air space between panes has an effective U-value of 0.35 ft^2·h·F/BTU, whereas the same double pane window containing ½ inch of argon space between panes has an improved U-value of 0.30 ft^2·h·F/BTU, as described in the ASHRAE Fundamentals Handbook.

Taking into account the effect of window insulating mediums and thickness, it was observed at the daycare facility that many of the existing windows were either single or double paned, depending on the location and age of the window. The offices along the West and East sides of the building appeared to have newer double pane windows installed, while the remainder of the windows were primarily single paned. Single pane windows, when compared to double pane or triple pane windows, have a significant impact on the heat loss and heat gain of the building. For example, referring again to Table 4 in Chapter 15 of the ASHRAE Fundamentals Handbook, a single pane, ¼ inch acrylic window has an effective U-value of 0.88 ft^2·h·F/BTU, while a double pane ¼ inch air spaced window has an effective U-value of 0.55 ft^2·h·F/BTU and a triple pane ¼ air spaced window has a U-value of 0.38 ft^2·h·F/BTU. As was discussed earlier in this section, a lower U-value results in a significantly lower amount of heat transfer through an insulating body, and therefore by reducing the U-value of the windows throughout the facility, the heat transfer can be reduced to in turn save energy and operating costs.

Skylights, as confirmed by Chapter 15 of the ASHRAE Fundamentals Handbook, can be treated similar to windows in terms of insulation quality and U-values. Five important aspects that are often considered for skylights include: “(1) transmittance and absorptance of the skylight unit, (2) transmitted solar flux that reaches the aperture of the light well, (3) whether that aperture is covered by a diffuser, (4) transmitted solar flux that strikes the walls of the light well, and (5) reflectance of the walls of the light well”. (ASHRAE, 2013) Skylights are especially important in terms of insulation quality, mainly due to the fact that they are located on the roof of the facility, and since heat rises, the temperature of air on the interior side of the skylight is often warmer than it would be near a window in the same room. As seen from the daycare facility, the skylights were heavily frosted around the perimeter edges, and infrared scanning revealed even more information regarding the poor insulation capability of these skylights. Therefore, by simply removing the skylights and replacing them with an appropriate insulating medium, or improving the skylight quality with another better insulated skylight, one could significantly reduce the amount of heat loss during winter months and heat gain during summer months.

5.2 Equipment Alternatives Analysis

The client has not specified preference for mechanical equipment to be used within the Little Souls Daycare facility, and as such the project team has tasked themselves with determining the most appropriate system selection.

5.2.1 Roof Top Units

The project team proposes that Roof-top units (RTUs) be installed for the purposes of this project. All proposed units have electrical specifications of 208-230V/60Hz, with single phase for the 5 ton unit, and three-phase for the 7 and 10 ton units. All proposed units incorporate electromechanical controls rather than microprocessor controls, and due to our local climate, an economizer with barometric relief for all units has been specified. As mentioned, the project teams continued goal is to ensure that the expenses associated with the upgrades remains modest. In doing so, seven RTUs are to be analyzed.

The first unit to be discussed is the 5 ton 4YCC, which serves as a single packaged convertible gas and/or electric unit. These particular units are versatile and will provide operators with simplicity of maintenance. Although the project team is proposing that all RTUs be installed on the roof, this unit also has the ability to be installed on ground level should the client see fit. The additional benefit of this particular unit is the fact that the components used within are common, and therefore less expensive than most other alternatives. The second proposed unit to be discussed is the 4YCZ, and also serves as a single packaged convertible gas and/or electric unit. Both of the aforementioned units are designed to provide energy efficient operation with minimal maintenance. Further information regarding product data can be found in Appendix B.

The following five units to be discussed are similar in style, with several alternative features. The benefit of the following units are certainly their performance standards, as well as their reasonable price points. The 5 ton YSC060 includes DX Cooling as well as gas heat. This unit has been specified with standard efficiency rather than high efficiency to provide a lower cost option for the facility operator. Microchannel condenser coils have been specified as they help reduce the space requirements of conventional coils, while providing the same cooling capacities and using less refrigerant. For the YSC060 unit, high heat has been specified, which is largely due to the climatic considerations in Regina, Saskatchewan. Due to our extreme temperatures, it is necessary to ensure that the units are designed for both extreme cold and hot. The fourth unit to be discussed is the 7 ton YSC090 unit, which is very similar to the YSC060 with exception to the cooling and heating capacities. The final YSC unit to be discussed is the YSC120. The primary characteristics of this unit are very similar to the previous YSC's, with exception to the larger cooling and heating capacities. Further information regarding product data can be found in Appendix B.

Finally, there are a variety of YHC air handling units available for use within the facility. Similar to the YSC units, these are packaged rooftop air conditioners with both cooling and heating capabilities. To assist with the additional static requirements, the YHC units offer a variable speed direct drive motor. The YHC090 provides both DX Cooling and gas heat capabilities, but is rated as a high efficiency unit to assist with providing the client with an environmentally friendly solution to their current concerns. This particular unit has a 7 ton cooling capacity with a single compressor. Similar to the previously discussed units, microchannel type condensing coils have been specified to further reduce space considerations within the unit itself. Finally, a high heat capacity has been specified to help combat the extreme weather conditions of Saskatchewan. The YHC120 holds close resemblance to the YHC090, with exception to the fact that the 120 is capable of 10 tons of cooling capacity. Further information regarding product data can be found in Appendix XX.

5.3 Energy Analysis

5.3.1 TRACE 700

Simulation calculations use techniques described by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, and a selection of the commonly used TRACE700 reports have been provided in Appendix C. These reports serve as an example of the air-distribution capabilities of the software. After the load-design is complete, the subsequent calculations simulate the mechanical systems over the extension of a year. These simulations explicitly describe the climatic data, the structural attributes of the building, the operational characteristics of the facility, the operational characteristics of the HVAC system, and the heat generated within the facility. (TRANE, 2015)

Within the facility, there are four primary spaces: the administration area, daycare, gymnasium, and basement. Additionally, there are several subsidiary spaces such as the infant sleep-room, and computer room. Due to the sensitive nature of the sleep-room, and the substantial internal loading of the computer room, there is special consideration being applied to these spaces.

The system checksum report, which can be found in Appendix C, is more commonly used for high-level overview. For example, the airflow section of the system checksums is easily used to confirm that there is indeed sufficient available airflow for energy recovery. The system checksum report will characterize the various envelope loads being produced in the space, and the internal loads such as lights, occupants, and computers. (TRANE, 2015)

The room checksum report, also found in Appendix C, focusses on the loading of individual spaces within the system. This serves as a formidable tool when designing a system that will provide adequate ventilation to all spaces. (TRANE, 2015)

5.3.1.1 TRACE700 Report Overview

Total capacities of both the heating and cooling coils for the TRACE700 simulations have been provided below. It will be noted that simulations were completed for varying qualities of paned windows.

TABLE 3: TOTAL CAPACITY OF HEATING COIL

	Heating Coil: Total Capacity (Ton)		
	Single Pane Windows	**Double Pane Windows**	**Triple Pane Windows**
Daycare	267.6	255.4	243.8
North East Exit	13.1	13.1	13.1
Basement	39.4	38.9	38.4
North West Exit	21.4	21.1	20.7
South Entrance	48.2	39.4	30.2
South West Entrance	47.9	41.9	35.8
Gymnasium	194.4	183.7	173.2
Office	42.9	40.2	37.5

TABLE 4: TOTAL CAPACITY OF COOLING COIL

	Cooling Coil: Total Capacity (Ton)		
	Single Pane Windows	**Double Pane Windows**	**Triple Pane Windows**
Daycare	11.9	11.6	10.9
North East Exit	0.3	0.3	0.3
Basement	6	6	5.9
North West Exit	0.5	0.6	0.6
South Entrance	3.4	3.1	2.5
South West Entrance	2.8	2.6	2.2
Gymnasium	14.3	13.9	13.2
Office	2.3	2.2	2

It becomes clear that the heating and cooling capacities are affected by insulation values of windows. When analyzing the data, it appears easy to realize the benefits of enhancing the insulation of the windows and walls. This claim is discussed more thoroughly in the following section.

5.3.2 eQuest

As discussed in section 4.2.3, eQuest software had an important role in the project, allowing the group to effectively measure the efficiency of the existing mechanical system and interpret this data both numerically and graphically. It was observed from the output data that any manipulation to the existing system had a noticeable effect on the energy consumption and overall operating costs of the facility. The full data report, including graphs and analysis is shown in Appendix A; however, this section will provide an overview of the analysis done using eQuest and the results inferred therein.

Using the utility bills provided by Souls Harbour for the 2015 calendar year, the actual energy consumption and cost was imported into Excel for further comparison. These values were also used to establish the baseline energy model in eQuest, as discussed in section 4.2.3.1. It should be noted that the utility bills for the facility had some data that did not align well with the remainder of the bills, and was treated as outlier data for that purpose. The eQuest model provides a relatively stable, realistic energy consumption curve based on real-world weather data from Regina, Saskatchewan. A comparison of the utility bills and the eQuest baseline model energy consumption is shown in the figures below. It is evident from the graphical representation of the actual data that there are outliers within the data, and these outliers can be assumed to be caused by either:

a) Improper meter reading of gas/power consumption
b) Credit/back-charge applied to the gas/power bills, resulting in increased/decreased billing amounts
c) Irregular utility usage for that month, or
d) System malfunction (mechanical/electrical) resulting in higher/lower utility usage

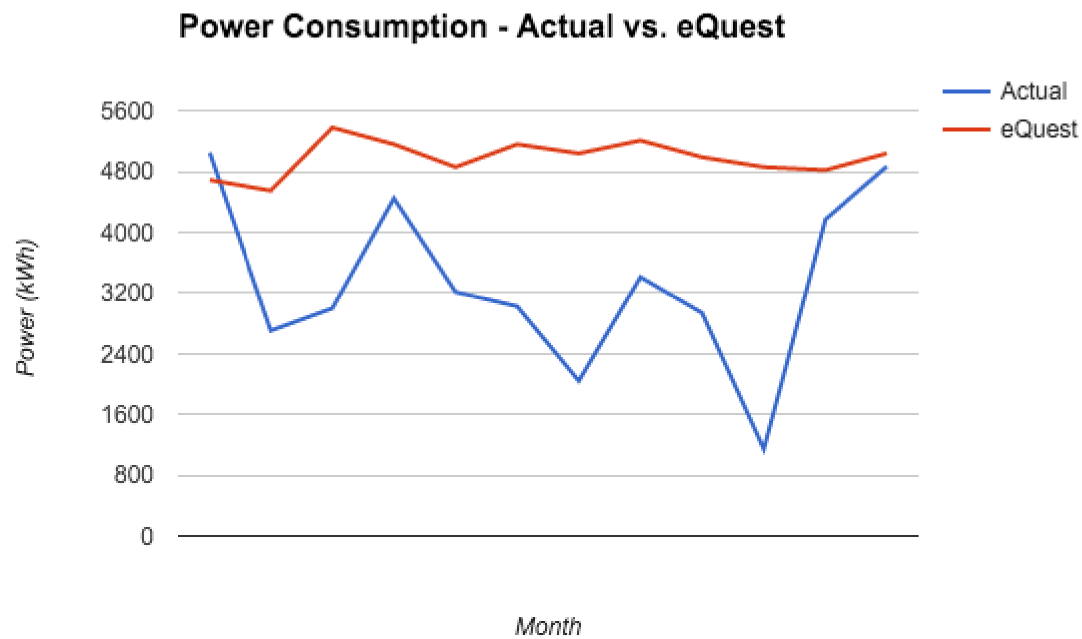

FIGURE 5: POWER CONSUMPTION COMPARISON (ACTUAL VS EQUEST)

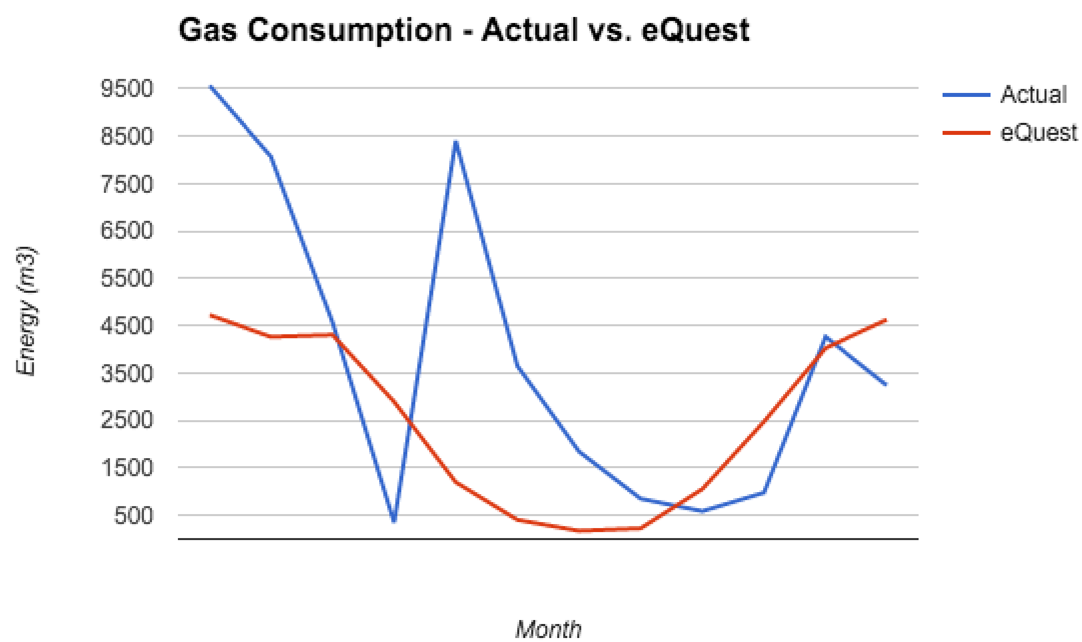

FIGURE 6: GAS CONSUMPTION COMPARISON (ACTUAL VS EQUEST)

For the baseline system, the summation of the total costs for power and gas consumption, as provided from the utility bills, equates to:

a) Power consumption = $4,534.45/year (2015)
b) Gas consumption = $11,798.37/year (2015)

The eQuest software, using the same baseline model, calculated annual power and gas consumption costs of approximately:

a) Power consumption = $6,773.80/year (2015)
b) Gas consumption = $7,724.40/year (2015)

It can be seen from this comparison that the eQuest software is relatively close in terms of utility costs for both power and gas consumption. The total annual cost comparison between the actual and eQuest data is as follows:

a) Actual cost/year = $16,332.82
b) eQuest cost/year = $14,498.20
c) DIFFERENCE (cost/year) = $1,834.62

The eQuest software was manipulated extensively in order to reach a value that would accurately reflect the actual energy consumption of the building for the baseline system. This includes, but is not limited to, manipulating lighting power densities, plug loads, occupancy levels, infiltration, etc. As mentioned earlier, the difference in the data stems primarily from the discrepancy in data for the actual utility bills for certain months of the year. The eQuest model follows a relatively predictable pattern, and this can be seen in the figures above. The power and gas consumption for the eQuest baseline system can be seen graphically in the figures shown below as well.

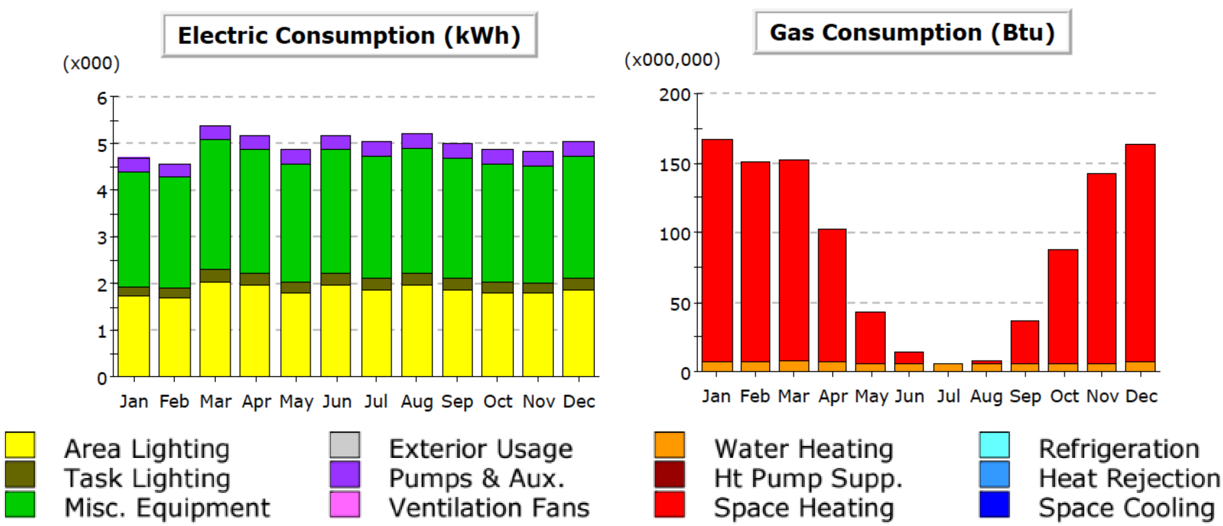

FIGURE 7: POWER CONSUMPTION OF BASELINE SYSTEM (LEFT)
FIGURE 8: GAS CONSUMPTION OF BASELINE SYSTEM (RIGHT)

After the baseline system was established, further comparisons were done with respect to heating, cooling and ventilation upgrades, and the effect each upgrade would have on the energy model. For reference, the baseline system energy usage, in terms of quantity per year, as established in the eQuest baseline model was:

a) Power consumption = 59,770 kWh/year
b) Gas consumption = 1,071,500,000 BTU/year = 30,354.10765 m^3/year

As provided on the utility bills from SaskPower and SaskEnergy, the energy multipliers were as follows:

a) Power multiplier = $0.11335/kWh
b) Gas multiplier = $0.2545/$m^3$ (includes delivery & supply costs)

These multipliers were useful in determining the annual savings or costs of implementing a different mechanical system into the facility. Each utility will include a standard monthly fee, regardless of the amount of energy consumed during the monthly period. These fees were held constant, and ignored during the comparison.

The first system analyzed after the baseline system was completed was the mid-efficiency system. As mentioned earlier, this system includes the implementation of several roof-top units on the facility, each capable of providing cooling, ventilating and heating to the building. The mid-efficiency units assumed air volume inputs could not be adjusted (Variable Air Volume) and the motor efficiency within the units was 80%, as given by industry standards. The mid-efficiency system was first modeled, assuming no other upgrades were done to the building. Energy usage of this system was as follows:

a) Power consumption = 169,800 kWh/year
b) Gas consumption = 2,972,300,000 BTU/year = 84,201.13314 m^3/year

Comparing these values to the above baseline system, it is evident that both the gas and power consumption for the facility increases substantially. There are several reasons for the increase in consumption. First of all, the mid-efficiency system introduces two components that did not exist in the baseline system: ventilation and cooling. Therefore, since neither of these components were available with the baseline system, it is expected that power consumption will increase as a result. Cooling requires substantial energy during summer months to provide a comfortable interior temperature, and ventilation requires energy consumption year-round in order to provide adequate air changes to the facility. It should be noted that although ventilation alone will not provide heating/cooling for the facility, it still requires that external air being drawn into the roof-top unit be pre-heated or pre-cooled before entering the system in order to refrain from disturbing the room temperature established by the heating or cooling system. Thus, ventilation alone requires an increased amount of energy usage, which can be illustrated by the graph shown in the figure below.

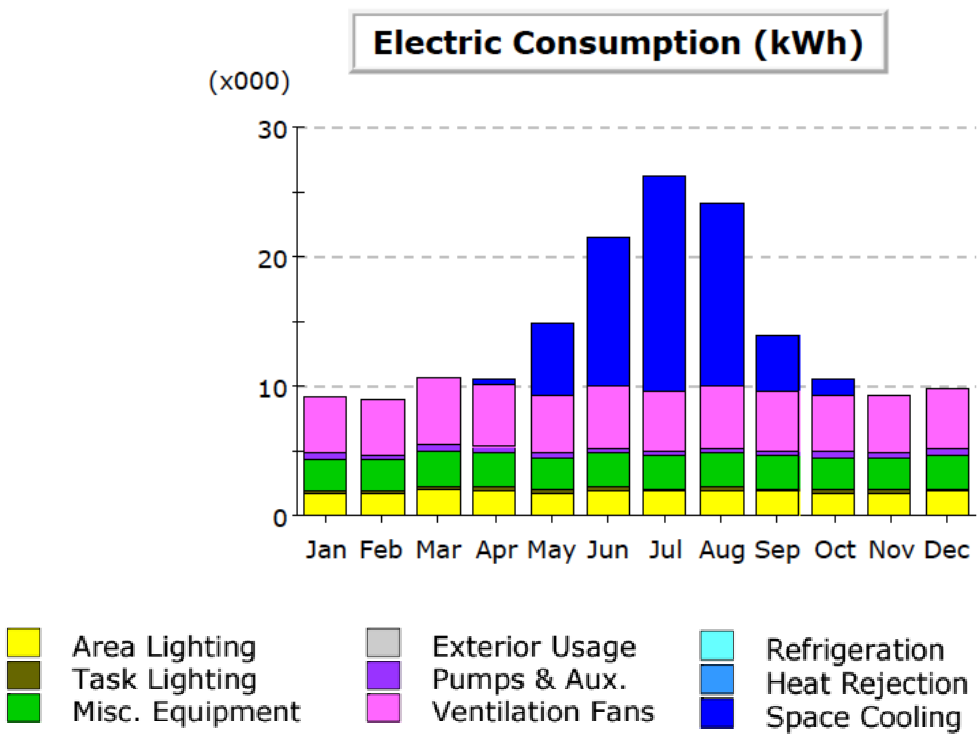

FIGURE 9: POWER CONSUMPTION OF MID-EFFICIENCY SYSTEM

Furthermore, the increase in gas consumption can best be explained by the difference between the roof-top units versus the boiler system that currently exists in the building. The boiler system was implemented in the building seven years ago, and includes three higher efficiency boilers that pump hot water through baseboard heaters throughout the facility. Boiler systems are traditionally cheaper to run than forced air systems, mainly because they require less energy to start/stop frequently. Also, the boiler system is typically located inside the facility, resulting in less heat loss to the surrounding environment in comparison to roof-top units, which must heat outside air (potentially at -40 degrees Celsius) to room temperature. Boiler system piping is typically insulated to prevent heat loss during transportation through the piping system. Forced air furnaces require ductwork, which can result in heat losses to the plenum area before exiting into the appropriate zone. All of these factors result in efficiency differences between boiler heaters and forced air furnaces. The increase in gas requirements for the mid-efficiency roof-top units is illustrated in the figure below:

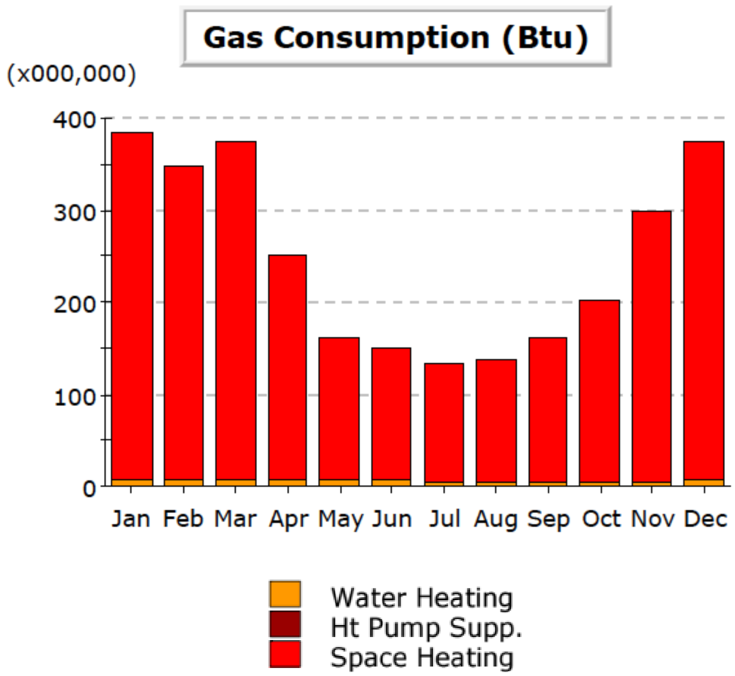

FIGURE 10: GAS CONSUMPTION OF MID-EFFICIENCY SYSTEM

The second system analyzed using eQuest was the high-efficiency system. As mentioned earlier, this system is similar in characteristic to the mid-efficiency system, but includes higher efficiency heating, cooling and ventilation components, coupled with improved motor efficiency and variable air volume capabilities. The energy usage of this system was modeled, and the energy consumption was analyzed to determine any cost differentiation from the other two systems. The energy consumption for the high-efficiency system was as follows:

a) Power consumption = 99,650 kWh/year
b) Gas consumption = 2,196,500,000 BTU/year = 62,223.79603 m^3/year

As can be seen, these energy consumption values are significantly lower than was described for the mid-efficiency system. This is expected, since the general layout of the mechanical ductwork, as well as the number of roof-top units for the high-efficiency system remains the same as the mid-efficiency system. However, it is still evident that the high-efficiency system, even though it accommodates improved efficiencies and industry-leading mechanical components, still uses more energy in comparison to the baseline system. Again, this can be explained by the fact that the baseline system does not incorporate ventilation or cooling capability, whereas the premium system provides this option. The additional utility usage can be seen in the two figures below, both in terms of power and gas consumption:

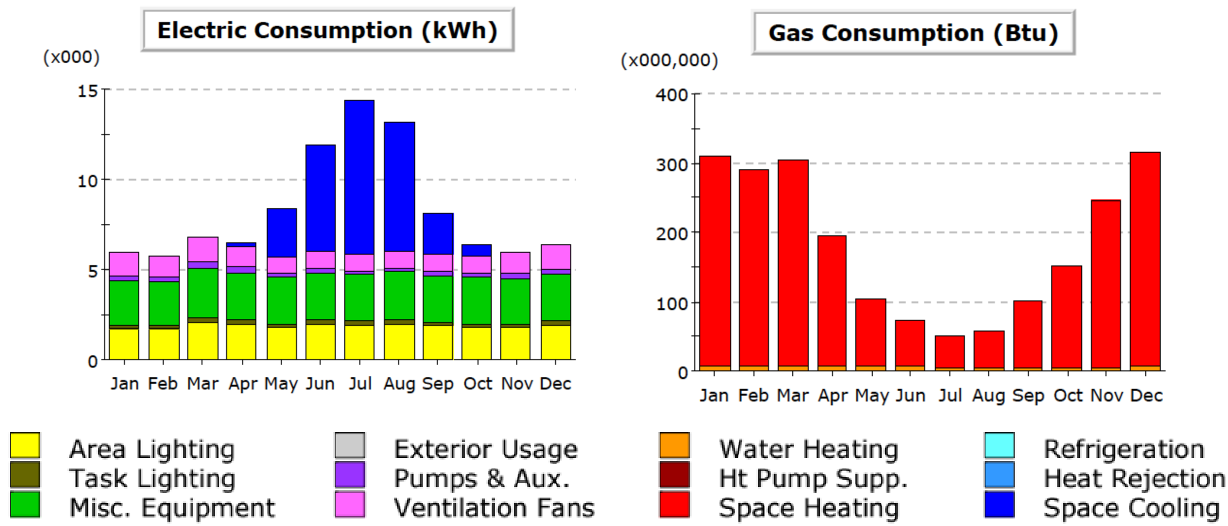

FIGURE 11: POWER CONSUMPTION OF HIGH-EFFICIENCY SYSTEM (LEFT)
FIGURE 12: GAS CONSUMPTION OF HIGH-EFFICIENCY SYSTEM (RIGHT)

The figures help illustrate the primary consumers of power and gas within the facility, and help draw conclusions regarding the additional operating costs that must be incurred if the building operator chooses to implement the high-efficiency system.

As mentioned in section 4.2.3, energy models were created for the baseline, mid-, and high-efficiency systems. Windows, insulation and skylights were manipulated. Building upgrades, whether completed individually or together, affected the performance of the building envelope. By upgrading the mechanical system and improving the building envelope, a more comfortable and healthier environment can be created for occupants.

5.3.3 Building Energy Quotient

As was discussed in the previous section, the utility expenses associated with Little Souls Daycare are significant, but can be mitigated to ensure that the majority of their resources remain directed towards programming. ASHRAE`s BEQ as-designed worksheet has been used to assist with characterizing the energy uses of the building, and determining how the facility is designed to perform, how it actually performs, and the best methods that can be employed to improve future performance.

The BEQ program focuses on the energy efficiencies of the facility without compromising the indoor environment quality. In essence, the program is built to provide information for improving energy performance. The table below has been provided to summarize the various mechanical systems discussed above and their respective BuildingEQ Rating.

TABLE 5: BUILDINGEQ RATINGS

	BuildingEQ Rating No Facility Upgrades	BuildingEQ Rating With Facility Upgrades
Baseline System	A- (Very Good)	A- (Very Good)
Mid-Efficiency System	C (Average)	B (Efficient)
High-Efficiency System	C (Average)	B (Efficient)

As described in section 5.3.2, the Baseline system does not employ any form of ventilation or cooling. The Baseline System BEQ rating should only be used as a reference point due to the fact that it is not compliant with ASHRAE ventilation standards. As mentioned above, the BEQ labeling program focuses solely on the energy performance of the facility and not the regulatory compliances, and with this in mind the above results confirm that enhancing the facility envelope will reflect positively on the energy efficiency of the space.

6.0 System Improvements

Through the project team's analysis and energy audit of Little Souls Daycare, various recommendations have been made in order to improve the efficiencies of the space and the regulatory compliances of the facility. These recommendations serve as the initial stage for major renovations.

6.1 Mechanical System Selection

The project team has concluded that the aforementioned Roof Top Units (RTUs) are the most practical design solution for Little Souls Daycare facility. There were various units described in section 5.2.1 of the report. Additionally, a thorough cost analysis of the proposed system has been included to better capture the size of the re-design project and in order to evaluate the feasibility of the various system options. The cost analysis has also been included in the proceeding section.

6.1.1 Sizing and Placement of Equipment

In order to effectively size the air-handling units to be used within the facility, the TRACE700 load outputs have been used. Table 6 below outlines the cooling and heating capacities for the facility.

TABLE 6: COOLING AND HEATING CAPACITIES

	Cooling Coil (ton)	Heating Coil (MBh)
Office	2.3	42.9
Daycare/Infant	11.9	267.6
Basement/Computer	6	39.4
Gymnasium	14.3	194.4

Units that meet, and more-often exceed, the above capacities have been specified for this project. This is to assist in ensuring that appropriate safety-factors and ventilation loading is encapsulated within this project. The project team spoke with a local structural engineering firm to discuss implications of installing roof top units on Little Souls Daycare. The first consideration discussed with the engineer was to ensure that snow drifts are accounted for in the placement of this unit. ASHRAE standards should be further analyzed prior to installation, but a 15 foot range from vertical walls should be an appropriate factor. The weight from snow drifts can be substantial in Saskatchewan, and as such, must be a consideration. In addition to the weight from snow, it is essential to ensure that the rooftop is able to support the physical weight of the unit over an extended period of time. In the case that there are concerns with the weight of the units on the roof-top, steel beams or steel plates can be bolted to the wood joist to assist in supporting the unit, and distributed the load evenly throughout. In doing this, the curb that the roof top unit will be positioned on must be supported around the entirety of the perimeter. (Gallagher, 2016)

When selecting units for use within Little Souls Daycare, it was recommended by the structural engineer that the project team select smaller units, rather than one larger units (where possible). This is often more economical in terms of structural considerations, as the weight loads can be distributed over a larger area. If a larger unit is to be used, there would need to be a thorough analysis of the foundational support to ensure that the facility is able to have a significant point load without any catastrophic impacts. In addition to spacing out the units on the rooftop, the project team should also locate the units over the beams and columns rather than joists. This will lead to a more economical solution. (Gallagher, 2016) Consultation should be carried out with a structural engineer prior to installation of any units.

6.1.2 Cost Analysis

Quotes were obtained for the equipment required for the ventilation system and for the building upgrades. Estimates of labour costs were made for the installation of the ductwork and for the covering of the skylights. Note that costs associated with structural reinforcements of the roof were not included in this analysis A summary of the costs for the mid-efficient and high-efficiency system, as well as each of these two systems with the building upgrades are shown in Table 7 below. The annual operating cost of each system is also shown using data estimated by eQuest.

TABLE 7: BREAKDOWN OF COSTS FOR EACH ALTERNATIVE

	Mid-Efficiency System	High-Efficiency System	Mid-Efficiency w/ Upgrades	High-Efficiency w/ Upgrades
Crane	$18,900.00	$18,900.00	$18,900.00	$18,900.00
Electrical	$35,000.00	$35,000.00	$35,000.00	$35,000.00
Gas lines	$10,000.00	$10,000.00	$10,000.00	$10,000.00
Ductwork	$7,000.00	$7,000.00	$7,000.00	$7,000.00
Labour for Ductwork	$21,000.00	$21,000.00	$21,000.00	$21,000.00
Supply Diffusers	$20,740.00	$20,740.00	$20,740.00	$20,740.00
Return Grilles	$3,900.00	$3,900.00	$3,900.00	$3,900.00
Fire Dampers	$600.00	$600.00	$600.00	$600.00
5 Ton RTUs - Mid	$55,575.00	-	$55,575.00	-
5 Ton RTUs - High	-	$77,220.00	-	$77,220.00
10 Ton RTUs - Mid	$46,085.00	-	$46,085.00	-
10 Ton RTUs - High	-	$58,300.00	-	$58,300.00
Window Upgrades	-	-	$34,400.00	$34,400.00
Insulation Upgrades	-	-	$15,900.00	$15,900.00
Skylight Covering	-	-	$500.00	$500.00
Total Cost	$218,800.00	$252,660.00	$269,600.00	$303,460.00
Annual Operating Costs	$40,676.00	$27,131.00	$32,479.00	$21,915.00
Present Value (i=5%, n=20)	$725,712.00	$590,776.00	$674,358.00	$576,563.00

Since a ventilation system is required for the building to meet the National Building Code, operating costs will increase whether the mid-efficiency or the high-efficiency system is implemented. The minimum required investment by Souls Harbour is therefore $218,800 which corresponds to the Mid-Efficiency ventilation system without the recommended building upgrades. Souls Harbour can however save on annual operating costs if one of the other three systems is implemented instead. From these savings, the payback period of the required additional investment can be calculated using the following formula:

$$Payback\ Period\ = \frac{Capital\ Cost}{Annual\ Savings} \quad [2]$$

The net present value of the additional investment and the corresponding savings was also calculated using a discount rate (i) of 5% and an analysis period (n) of 20 years using the following formula:

$$NPV\ = -Additional\ Investment\ + (Annual\ Savings) \times (\frac{(1+i)^n - 1}{i(1+i)^n}) \quad [3]$$

The additional investment, the annual savings, the payback period, and the net present value over 20 years are shown in Table 8 below for each of the incremental options as compared to the base option of the mid-efficiency system without upgrades.

TABLE 8: NPV AND PAYBACK PERIOD FOR INCREMENTAL OPTIONS

	Additional Investment	Annual Savings	NVP (i=5%, n=20)	Payback Period
Mid-Efficiency w/ Upgrades	$50,800.00	$8,196.00	$51,340.28	6.20
High-Efficiency w/o Upgrades	$33,860.00	$13,545.00	$134,940.64	2.50
High-Efficiency w/ Upgrades	$84,660.00	$18,761.00	$149,143.53	4.51

The above results show that the high-efficiency system with the upgrades provides the highest net present value over 20 years as compared to the mid-efficiency system without upgrades. This means that it is the most cost effective option if the equipment is expected to be use for at least 20 years.

The net present value of a project is a useful way of evaluating project alternatives over the lifetime of the project. Since there are no revenues or savings associated with the overall alternatives of this project, a present value of cost (PVC) analysis was conducted. The present value of cost of each option for an analysis period of 20 years is shown in Table 8 above. A discount rate of 5% was again used. The lowest value of this analysis corresponds to the most cost effective option. The following formula was used for the analysis of each system.

$$PVC\ = Capital\ Cost\ + (Annual\ Operating\ Costs) \times (\frac{(1+i)^n - 1}{i(1+i)^n}) \quad [4]$$

The number of analysis periods (n) of a project is crucial to the conclusion drawn from the net present value analysis. For this reason, the present value of each project was plotted versus the number of periods (see Figure 13 below). The graph shows that if the system is used for only three years, the mid-efficiency system is the most cost effective, since the capital costs of the system are the lowest; however, since the annual operating costs of the mid-efficiency system are the highest of the four options, as the analysis period expands beyond ten years, the high-efficiency system with upgrades proves to be the most cost effective option. The graph also shows the points for the mid-efficiency and high-efficiency systems where the corresponding systems with the upgrades become more cost effective than the system without upgrades.

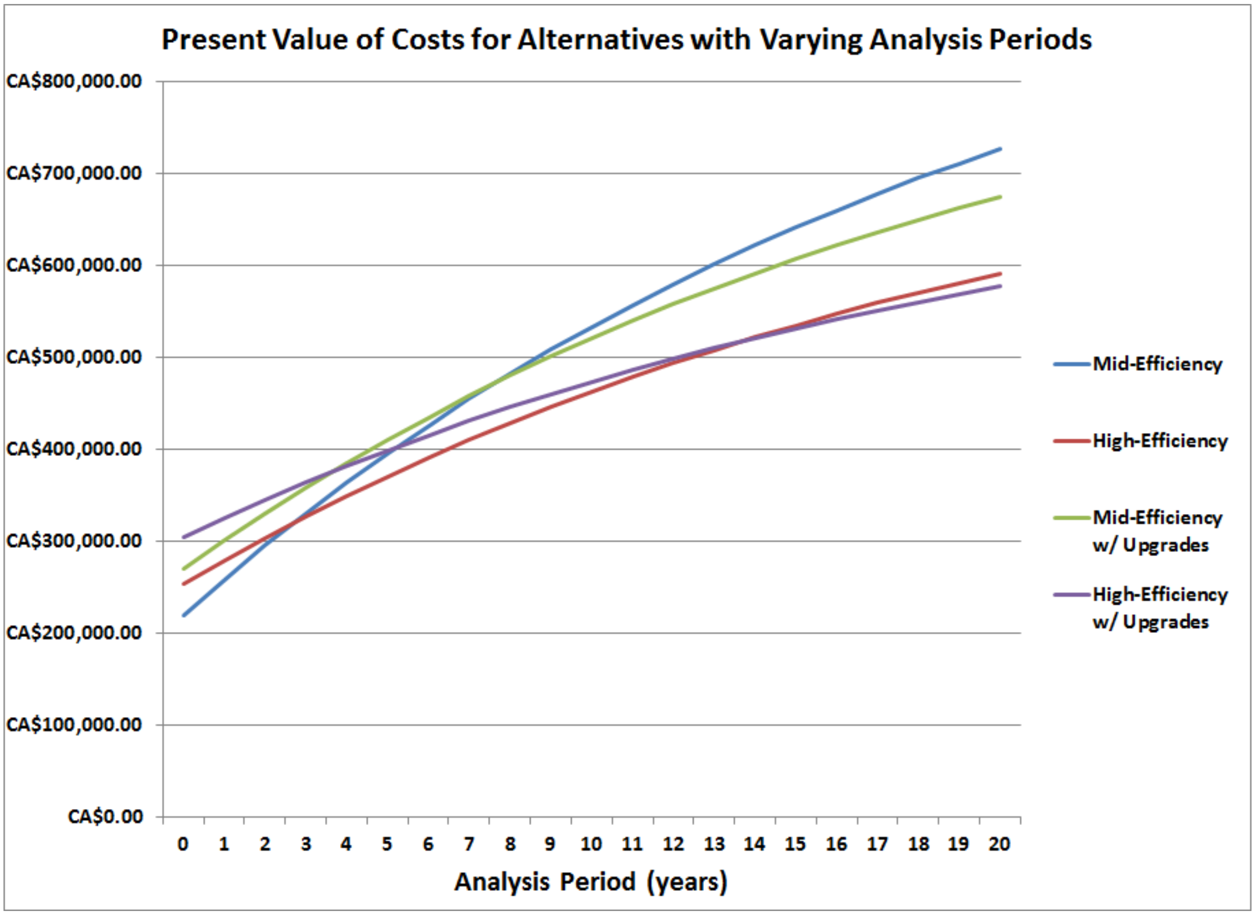

FIGURE 13: PRESENT VALUE OF COST FOR VARYING ANALYSIS PERIODS

Since the implementation of this project will likely be done in several phases, a cost analysis of the various zones of the ventilation system was completed. There are six main zones of the ventilation system: the gymnasium, the offices, the daycare, the nursery, the basement, and the computer room.

Table 9 below shows a summary of the total cost of each of the main zones of the ventilation system.

TABLE 9: COST BREAKDOWN FOR INDIVIDUAL HVAC ZONES

Zone	System	Total Cost
Gymnasium	Mid- Efficiency	$68,914.00
	High-Efficiency	$79,352.00
Offices	Mid- Efficiency	$25,552.00
	High-Efficiency	$29,881.00
Daycare	Mid- Efficiency	$41,318.00
	High-Efficiency	$47,427.00
Nursery	Mid- Efficiency	$22,755.00
	High-Efficiency	$27,084.00
Basement	Mid- Efficiency	$35,584.00

Computer Room	High-Efficiency	$39,913.00
	Mid- Efficiency	$26,340.00
	High-Efficiency	$30,669.00

7.0 Implementation Plan

A phased implementation approach is recommended, and is outlined for the client in the sections below.

7.1 List of Alternatives

The complete list of alternatives for the client is given in the Appendix E**.**

7.2 Priority List

To provide the client with further flexibility in terms of implementation, the project team also developed a priority list which provides further recommendations related to a "phased" implementation plan. The client requested that a phased approach be taken, mostly due to the fact that Souls Harbour has limited available funds, and the implementation of the entire HVAC system with (or without) upgrades is beyond feasible. Therefore, the below priority list was created, which provides insight into the cost and benefits of a phased approach, allowing the client to pick-and-choose which HVAC systems are implemented first, and any other associated upgrades.

TABLE 10: PRIORITY LIST FOR PROJECT IMPLEMENTATION

Priority	Timeline	Justification	Total (Approx.) Cost
1) Daycare HVAC System (High Efficiency)	Immediately	Biggest concern for client; provides stable temperature for children during summer months	$47,427.00
2) Skylights & Insulation Throughout Entire Facility; Remove Stained-Glass Front Window	1-2 years after implementation of Daycare HVAC system	Costs are relatively low; payback period is <10 years; helps improve entire facility without installing new HVAC system for every zone; less cost if installed all at once	$16,400.00 + cost to board up & insulate stained-glass front window
3) Administrative Offices HVAC (High Efficiency)	< 5 years	High occupancy area; ducting already in place for HVAC unit	$29,881.00
4) Gymnasium Area HVAC System (High Efficiency)	5-10 years	Next highest occupancy area; high cost (due to capacity) but relatively large area	$79,352.28
5) Windows Throughout Facility	< 10 years	Costs are relatively low; helps improve performance of entire facility; current window performance is hard to simulate, but infrared	$34,400.00

	revealed high heat loss	
TOTAL INVESTMENT OVER 10 YEARS		**$207,460.28**

Caution should be taken when implementing each zone in a phased approached. Pressurization of adjacent rooms can cause issues, and can be mitigated by installing appropriate controls such as door grating. Efficiencies will also be reduced if adjacent zones are unconditioned; however, this is something the client has been made aware of.

8.0 Recommendations

After analyzing the supporting data, and reviewing the costs and payback periods, the project group was able to provide the client with a short list of recommendations moving forward. It is recommended that the client follow as closely as feasible the priority list from section 7.2 related to the phased implementation of HVAC improvements and structural upgrades. Furthermore, the full list of administrative and engineering controls should be closely reviewed and implemented as deemed necessary by the facility operator. Administrative controls can easily be implemented through instructional training of employees and general employee awareness. Engineering controls such as occupancy light sensors should be compared cost-wise to the proposed annual savings, and installed if deemed feasible.

Further recommendations include consultation with a structural engineer prior to purchasing and installing roof-top units to be used at the facility. As mentioned previously, a structural engineer was briefly consulted by the project group, and general direction was provided regarding the installation of the roof-top units; however, a full structural analysis should be completed to further support the recommendations provided in this report. Moreover, the project team, though under the direction of a Professional Engineer throughout the entirety of the project, does not maintain the capacity to make any formal recommendations to the client without a full review and signing off of the herein technical report.

9.0 Conclusion

Throughout the duration of the energy audit and mechanical system redesign, the project team was able to outline several recommendations for improving the energy performance of Little Souls Daycare. These recommendations were fashioned on the basis of both energy utilization and economic evaluation, and will assist Souls Harbour Rescue Mission with mitigating any concerns pertaining to regulatory compliance. It remained a focus for the project team to establish an implementation plan that allows for a phased installation with returns on investment throughout the duration of the proposed plan. This plan will assist Little Souls Daycare with further providing a caring, warm, and safe environment for each child to play, explore, and learn.

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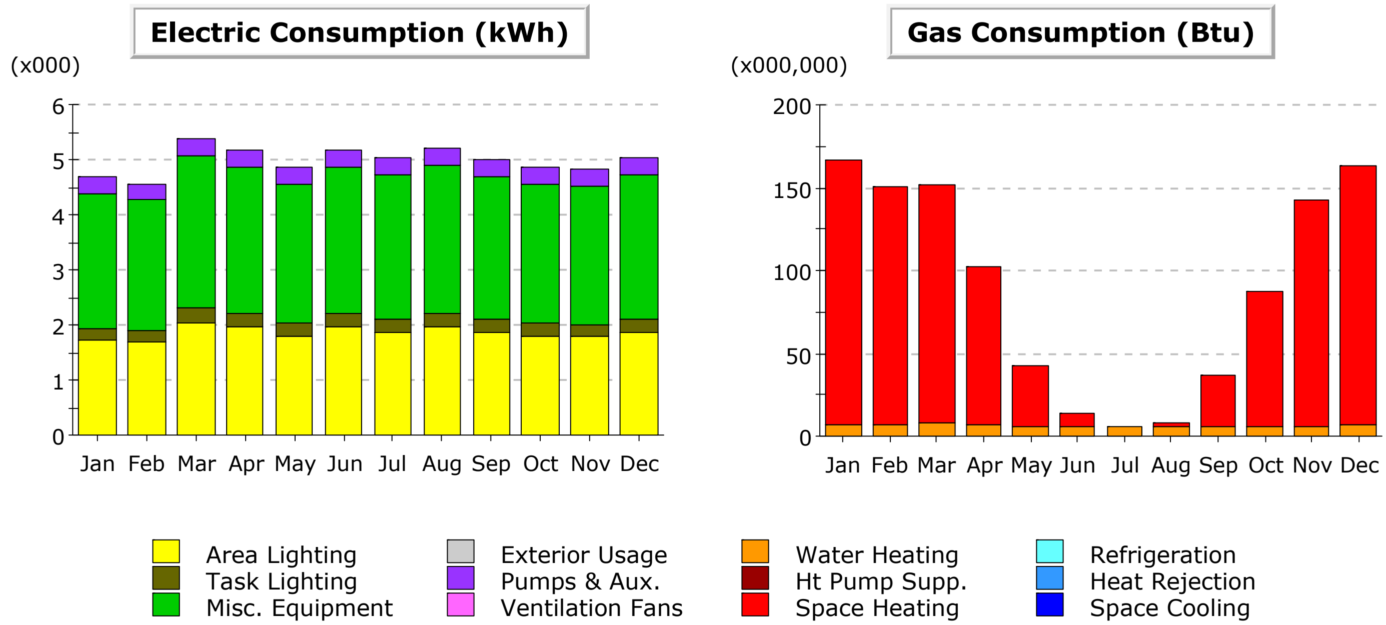
APPENDIX A – EQUEST DATA

Existing System



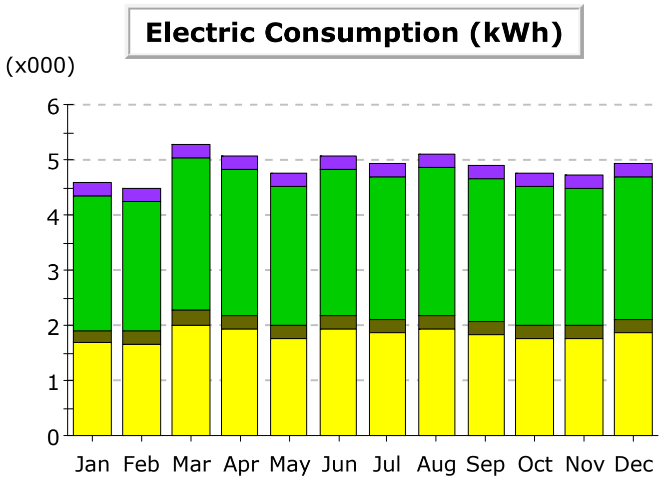
Electric Consumption (kWh x000)

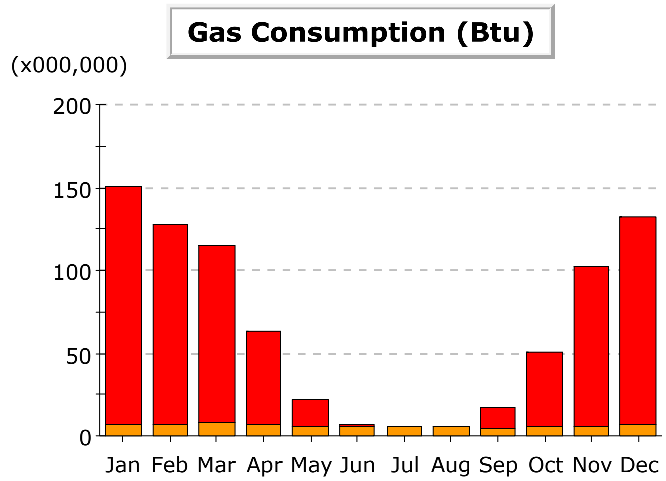
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.31	0.28	0.31	0.30	0.31	0.30	0.31	0.31	0.30	0.31	0.30	0.31	3.66
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.71	1.69	2.04	1.95	1.79	1.95	1.87	1.96	1.87	1.79	1.79	1.87	22.28
Total	4.69	4.55	5.38	5.16	4.86	5.16	5.04	5.21	4.99	4.86	4.82	5.04	59.77

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	160.1	143.8	143.9	94.7	36.0	8.1	0.6	2.6	32.0	82.1	136.4	156.7	996.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.5	6.7	8.0	7.5	6.3	6.3	5.5	5.4	5.2	5.2	5.7	6.5	74.7
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	166.6	150.4	151.9	102.1	42.3	14.3	6.1	8.0	37.2	87.3	142.0	163.2	1,071.5

Existing System with Upgrades





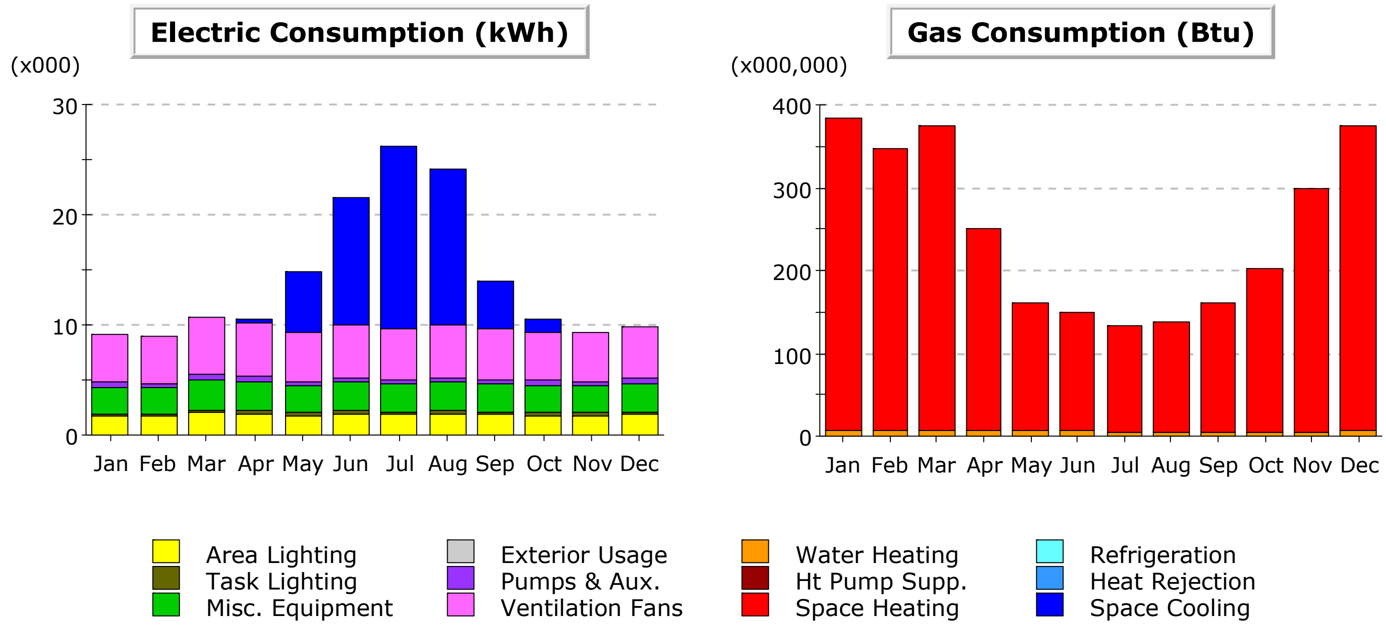
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.25	0.22	0.25	0.24	0.25	0.24	0.25	0.25	0.24	0.25	0.24	0.25	2.90
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.68	1.67	2.01	1.92	1.76	1.92	1.85	1.93	1.84	1.76	1.76	1.85	21.96
Total	4.60	4.47	5.29	5.07	4.77	5.07	4.94	5.12	4.90	4.77	4.73	4.94	58.69

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	143.98	121.12	106.46	55.72	16.05	1.21	-	0.04	12.13	44.80	96.46	125.67	723.63
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.40	6.59	7.95	7.44	6.26	6.23	5.45	5.39	5.16	5.21	5.66	6.49	74.24
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	150.38	127.72	114.42	63.16	22.31	7.43	5.45	5.43	17.29	50.01	102.12	132.16	797.88

Mid-Efficiency System



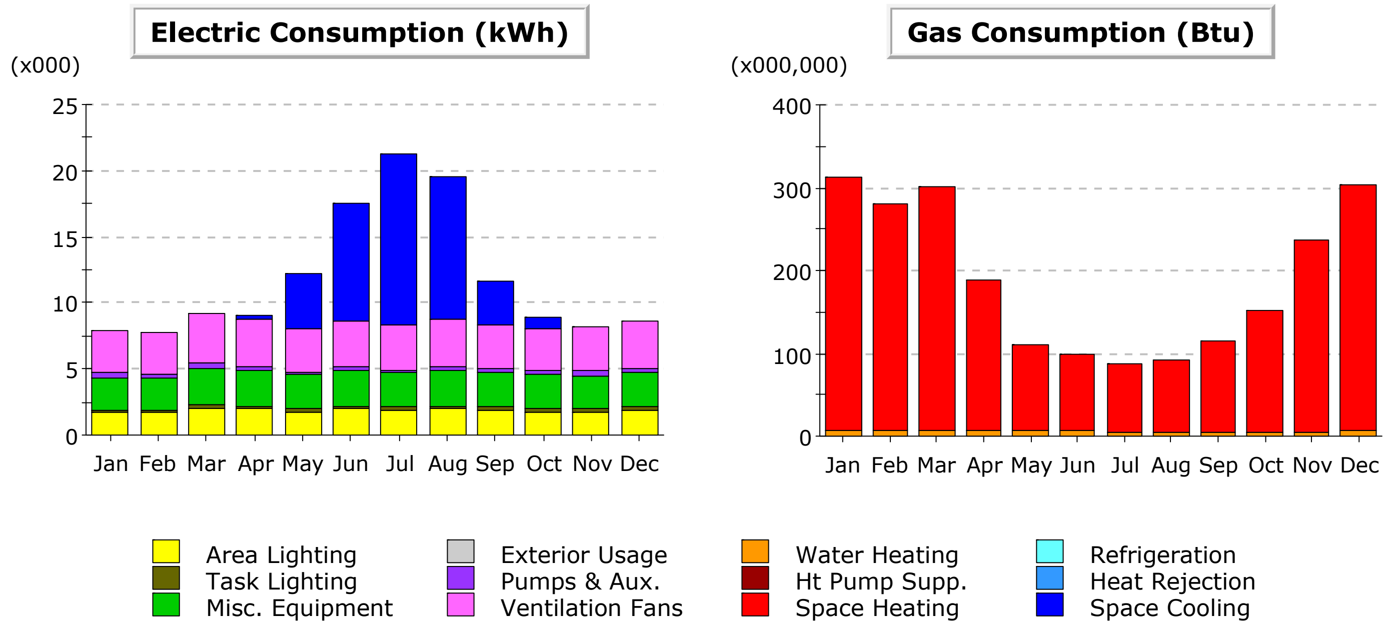
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.41	5.56	11.46	16.60	14.09	4.38	1.12	-	-	53.64
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	4.35	4.30	5.17	4.86	4.41	4.85	4.63	4.85	4.63	4.41	4.46	4.74	55.64
Pumps & Aux.	0.38	0.37	0.44	0.41	0.33	0.33	0.30	0.33	0.35	0.38	0.39	0.41	4.41
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.71	1.69	2.04	1.95	1.79	1.95	1.87	1.96	1.87	1.79	1.79	1.87	22.28
Total	9.11	8.94	10.68	10.55	14.85	21.50	26.26	24.16	14.05	10.46	9.37	9.87	169.80

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	376.4	340.6	367.8	242.0	154.7	142.0	127.6	133.2	156.2	196.0	293.6	367.6	2,897.6
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.4	6.6	8.0	7.5	6.3	6.3	5.5	5.5	5.2	5.2	5.7	6.5	74.7
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	382.8	347.2	375.8	249.5	161.0	148.3	133.1	138.6	161.4	201.2	299.3	374.1	2,972.3

Mid-Efficiency System with Upgrades



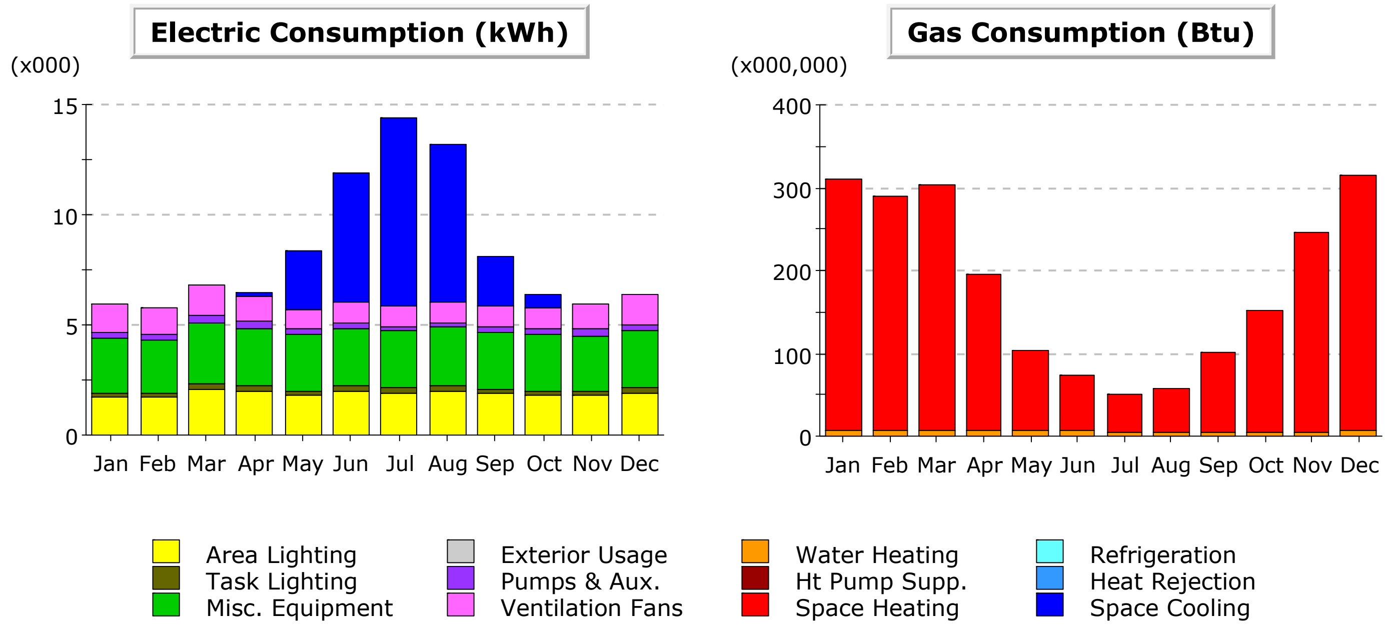
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.30	4.18	8.82	12.91	10.85	3.31	0.83	-	-	41.17
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	3.24	3.19	3.83	3.58	3.24	3.56	3.40	3.56	3.40	3.25	3.30	3.52	41.08
Pumps & Aux.	0.31	0.30	0.35	0.32	0.25	0.24	0.22	0.24	0.27	0.30	0.31	0.33	3.44
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.71	1.69	2.04	1.95	1.79	1.95	1.87	1.96	1.87	1.79	1.79	1.87	22.28
Total	7.92	7.76	9.25	9.06	12.22	17.48	21.26	19.55	11.67	8.92	8.13	8.57	141.81

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	305.6	274.7	292.3	180.1	104.1	91.5	82.4	86.9	110.1	145.7	231.5	296.0	2,200.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.4	6.6	8.0	7.4	6.3	6.3	5.5	5.4	5.2	5.2	5.7	6.5	74.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	312.0	281.3	300.3	187.5	110.3	97.7	88.0	92.3	115.3	150.9	237.2	302.6	2,275.4

High-Efficiency System



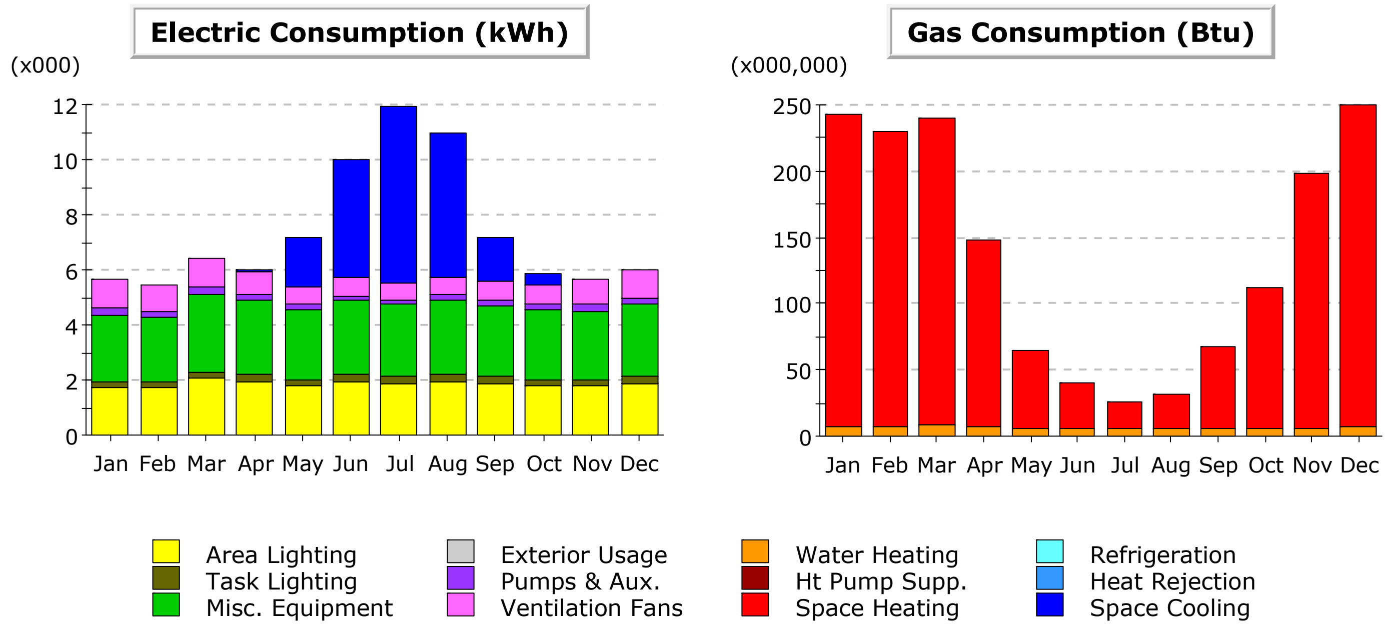
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.17	2.67	5.87	8.59	7.14	2.21	0.57	-	-	27.22
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	1.32	1.24	1.38	1.10	0.89	0.95	0.90	0.94	0.92	0.94	1.15	1.35	13.08
Pumps & Aux.	0.29	0.28	0.33	0.31	0.24	0.22	0.21	0.22	0.25	0.28	0.30	0.31	3.25
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.71	1.69	2.04	1.95	1.79	1.95	1.87	1.96	1.87	1.79	1.79	1.87	22.28
Total	5.99	5.80	6.78	6.43	8.35	11.91	14.43	13.21	8.07	6.34	5.96	6.39	99.65

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	305.0	282.5	295.9	187.2	97.0	66.6	45.2	51.9	95.1	145.6	241.2	308.4	2,121.7
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.5	6.7	8.0	7.5	6.3	6.3	5.5	5.4	5.2	5.2	5.7	6.6	74.8
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	311.5	289.2	304.0	194.6	103.3	72.9	50.7	57.4	100.3	150.8	246.9	314.9	2,196.5

High-Efficiency System with Upgrades



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.10	1.82	4.30	6.39	5.23	1.59	0.40	-	-	19.83
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	1.00	0.95	1.03	0.79	0.63	0.67	0.64	0.67	0.65	0.68	0.87	1.04	9.63
Pumps & Aux.	0.25	0.24	0.28	0.26	0.20	0.18	0.16	0.18	0.21	0.24	0.26	0.27	2.74
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	2.45	2.36	2.77	2.66	2.53	2.66	2.61	2.69	2.58	2.53	2.50	2.61	30.95
Task Lights	0.22	0.22	0.27	0.25	0.23	0.25	0.24	0.25	0.24	0.23	0.23	0.24	2.88
Area Lights	1.71	1.69	2.04	1.95	1.79	1.95	1.87	1.96	1.87	1.79	1.79	1.87	22.28
Total	5.63	5.47	6.39	6.02	7.19	10.02	11.92	10.98	7.15	5.87	5.65	6.03	88.31

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	236.8	222.6	232.0	141.3	59.0	34.0	21.0	26.3	61.9	106.2	192.2	243.4	1,576.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.5	6.6	8.0	7.4	6.3	6.3	5.5	5.4	5.2	5.2	5.7	6.5	74.7
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	243.3	229.2	240.0	148.7	65.3	40.3	26.5	31.7	67.1	111.4	197.9	250.0	1,651.2

APPENDIX B – ROOF TOP UNIT DATA

YCC30603R41096A

General Data

MODEL	4YCC3048A4096B	4YCC3048A4120B	4YCC3060A1096B	4YCC3060A1120B	4YCC3060A3096B
RATED Volts/PH/Hz	460/3/60	460/3/60	208-230/1/60	208-230/1/60	208-230/3/60
Performance Cooling BTUH ①	46500	46500	58000	58000	58000
Indoor Airflow (CFM)	1600	1600	1800	1800	1800
Power Input (KW)	4.252	4.252	5.478	5.478	5.478
EER/SEER (BTU/Watt-Hr.)	11.0 / 13.0	11.0 / 13.0	10.95 / 13.0	10.95 / 13.0	10.95 / 13.0
Sound Power Rating [dB(A)] ⑦	80	80	79	79	79
Performance Heating ②					
Input BTUH (Natural Gas) ③	96000	120000	96000	120000	96000
AFUE	80.0	80.0	80.0	80.0	80.0
Temp. Rise — Min/Max (°F)	30 / 60	40 / 70	25 / 55	30 / 60	25 / 55
Orifice Qty / Drill Size (Natural Gas)	3 / #37	3 / #32	3 / #37	3 / #32	3 / #37
POWER CONN.—V/PH/HZ	460/3/60	460/3/60	208-230/1/60	208-230/1/60	208-230/3/60
Min. Brch. Cir. Ampacity	10.7	10.7	41.9	41.9	28.6
Fuse Size — Max. (amps)	15	15	60	60	40
Fuse Size — Recmd. (amps)	15	15	60	60	40
COMPRESSOR	SCROLL	SCROLL	SCROLL	SCROLL	SCROLL
Volts/Ph/Hz	460/3/60	460/3/60	208-230/1/60	208-230/1/60	208-230/3/60
R.L. Amps — L.R. Amps	6.2 / 41	6.2 / 41	26.3 / 134	26.3 / 134	15.6 / 110
OUTDOOR COIL — TYPE	SPINE-FIN	SPINE-FIN	SPINE-FIN	SPINE-FIN	SPINE-FIN
Rows/F.P.I.	2 / 24	2 / 24	2 / 24	2 / 24	2 / 24
Face Area (sq.ft.)	18.01	18.01	20.54	20.54	20.54
Tube Size (in.)	3/8	3/8	3/8	3/8	3/8
INDOOR COIL — TYPE	PLATE FIN	PLATE FIN	PLATE FIN	PLATE FIN	PLATE FIN
Rows/F.P.I.	3 / 15	3 / 15	4 / 15	4 / 15	4 / 15
Face Area (sq.ft.)	5	5	5	5	5
Tube Size (in.)	3/8	3/8	3/8	3/8	3/8
Refrigerant Control	EXPANSION VALVE	EXPANSION VALVE	EXPANSION VALVE	EXPANSION VALVE	EXPANSION VALVE
Drain Conn. Size (in.)	3/4 FEMALE NPT	3/4 FEMALE NPT	3/4 FEMALE NPT	3/4 FEMALE NPT	3/4 FEMALE NPT
OUTDOOR FAN — TYPE	PROPELLER	PROPELLER	PROPELLER	PROPELLER	PROPELLER
Dia. (in.)	27.6	27.6	27.6	27.6	27.6
Drive/No. Speeds	DIRECT / 1	DIRECT / 1	DIRECT / 1	DIRECT / 1	DIRECT / 1
CFM @ 0.0 in. w.g. ⑧	4390	4390	4390	4390	4390
Motor — HP/R.P.M.	1/4 / 825	1/4 / 825	1/4 / 825	1/4 / 825	1/4 / 825
Volts/Ph/Hz	460/1/60	460/1/60	208-230/1/60	208-230/1/60	208-230/1/60
F.L. Amps/L.R. Amps	0.74 / 1.6	0.74 / 1.6	1.4 / 3.5	1.4 / 3.5	1.4 / 3.5
INDOOR FAN — TYPE	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL
Dia x Width (in.)	10 X 10	10 X 10	11 X 10	11 X 10	11 X 10
Drive/No. Speeds	DIRECT / 2	DIRECT / 2	DIRECT / 3	DIRECT / 3	DIRECT / 3
CFM @ 0.0 in. w.g. ⑤	SEE FAN PERF TABLE	SEE FAN PERF TABLE	SEE FAN PERF TABLE	SEE FAN PERF TABLE	SEE FAN PERF TABLE
Motor — HP/R.P.M.	3/4 / 1080	3/4 / 1080	1 / 1075	1 / 1075	1 / 1075
Volts/Ph/Hz	460/1/60	460/1/60	208-230/1/60	208-230/1/60	208-230/1/60
F.L. Amps/L.R. Amps	2.2 / 4.36	2.2 / 4.36	7.6 / 7.4	7.6 / 7.4	7.6 / 7.4
COMBUSTION FAN — TYPE	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL
Drive/No. Speeds	DIRECT / 1	DIRECT / 1	DIRECT / 1	DIRECT / 1	DIRECT / 1
Motor — HP/R.P.M.	1/35 / 3480	1/35 / 3480	1/35 / 3480	1/35 / 3480	1/35 / 3480
Volts/Ph/Hz	460/1/60	460/1/60	208-230/1/60	208-230/1/60	208-230/1/60
FLA	0.25	0.25	0.26	0.26	0.26
FILTER / FURNISHED	NO	NO	NO	NO	NO
Type Recommended	THROWAWAY	THROWAWAY	THROWAWAY	THROWAWAY	THROWAWAY
Recmd. Face Area (sq. ft.) ⑥	5.3	5.3	5.3	5.3	5.3
REFRIGERANT	R410A	R410A	R410A	R410A	R410A
Charge (lbs.) ④	8.50	8.50	10.30	10.30	10.30
GAS PIPE SIZE (in.)	1/2	1/2	1/2	1/2	1/2
DIMENSIONS	H X W X L	H X W X L	H X W X L	H X W X L	H X W X L
Crated (in.)	47.86 / 47.4 / 61.75	47.86 / 47.4 / 61.75	49.86 / 47.4 / 61.75	49.86 / 47.4 / 61.75	49.86 / 47.4 / 61.75
WEIGHT					
Shipping (lbs.) / Net (lbs.)	653 / 525	659 / 531	678 / 550	684 / 556	678 / 550

YSC060G3E3H3AD3

Table 2. General data - 3 to 5 tons - standard efficiency

	3 Tons	4 Tons	5 Tons
	T/YSC036G3,4,W	T/YSC048G3,4,W	T/YSC060G3,4,W
Cooling Performance[a]			
Gross Cooling Capacity	37,000	49,000	60,000
EER/SEER[b]	12.0/14.0	12.0/14.0	12.0/14.0
Nominal cfm/AHRI Rated cfm	1,200/1,200	1,600/1,600	2,000/2,000
AHRI Net Cooling Capacity	36,000	48,000	58,500
System Power (kW)	3.00	4.00	4.88
Compressor			
Number/Type	1/Scroll	1/Scroll	1/Scroll
Sound			
Outdoor Sound Rating (dB)[c]	79	80	81
Outdoor Coil - Type	Microchannel	Microchannel	Microchannel
Configuration	Full Face	Full Face	Full Face
Tube Size (in.)	0.63	0.63	1
Face Area (sq. ft.)	10.50	10.50	11.90
Rows/FPI	1/23	1/23	1/23
Indoor Coil - Type	Microchannel	Microchannel	Microchannel
Configuration	Full Face	Full Face	Full Face
Tube Size (in.)	0.63	0.63	0.81
Face Area (sq. ft.)	6.98	6.98	8.15
Rows/FPI	2/16	2/16	2/16
Refrigerant Control	Thermal Expansion Valve	Thermal Expansion Valve	Thermal Expansion Valve
Drain Connection Number/Size (in.)	1¾ NPT	1¾ NPT	1¾ NPT
Outdoor Fan - Type	Propeller	Propeller	Propeller
Number Used/Diameter (in.)	1/22	1/22	1/22
Drive Type/No. Speeds	Direct/1	Direct/1	Direct/1
cfm	3600	4050	3950
Motor hp	0.25	0.33	0.4
Motor rpm	1100	1100	1100
Indoor Fan - Type (Standard)	FC Centrifugal	FC Centrifugal	FC Centrifugal
Number Used/Diameter (in.)/Width (in.)	1	1	1
Drive Type/No. Speeds/RPM	11x11	11x11	11x11
Number Motors	Direct/5[d]	Direct/5[d]	Direct/5[d]
Motor hp	0.75/—	1.0/—	1.0/—
Motor Frame Size	48/—	48/—	48/—
Filters[e]			
Type Furnished	Throwaway	Throwaway	Throwaway
Number Size Recommended	(2) 20x35x2	(2) 20x35x2	(2) 20x35x2
Refrigerant Charge[f]			
Pounds of R-410A	3.2	3.5	4.8

continued on next page

YSC060G3E3H3AD3 – cont'd

Table 2. General data - 3 to 5 tons - standard efficiency (continued)

	3 Tons	4 Tons	5 Tons
	T/YSC036G3,4,W	T/YSC048G3,4,W	T/YSC060G3,4,W
Heating Performance[g]			
(Gas/Electric Only)			
Heating Input			
Low Heat Input (Btu)	60,000	60,000	60,000
Mid Heat Input (Btu)	80,000	80,000	80,000
High Heat Input (Btu)	120,000	120,000	130,000
Heating Output			
Low Heat Output (Btu)	49,200	49,200	49,200
Mid Heat Output (Btu)	65,600	65,600	65,600
High Heat Output (Btu)	98,400	98,400	106,600
AFUE%[h]			
Low Heat Input (Btu)	–	–	–
Mid Heat Input (Btu)	–	–	–
High Heat Input (Btu)	–	–	–
Steady State Efficiency%			
Low Heat Input (Btu)	82%	82%	82%
Mid Heat Input (Btu)	82%	82%	82%
High Heat Input (Btu)	82%	82%	82%
No. Burners			
Low Heat Input (Btu)	2	2	2
Mid Heat Input (Btu)	2	2	2
High Heat Input (Btu)	3	3	3
No. Stages			
Low Heat Input (Btu)	1	1	1
Mid Heat Input (Btu)	1	1	1
High Heat Input (Btu)	1	1	1
Gas Supply Line Pressure			
Natural (minimum/maximum)	4.5/14.0	4.5/14.0	4.5/14.0
LP (minimum/maximum)	11.0/14.0	11.0/14.0	11.0/14.0
Gas Connection Pipe Size (in)			
Low Heat	1/2	1/2	1/2
Mid Heat	1/2	1/2	1/2
High Heat	1/2	1/2	1/2

(a) Cooling performance is rated at 95°F ambient, 80°F entering dry bulb, 67°F entering wet bulb. Gross capacity does not include the effect of fan motor heat. AHRI capacity is net and includes the effect of fan motor heat. Units are suitable for operation to ±20% of nominal cfm. Units are certified in accordance with the Unitary Air-Conditioner Equipment certification program, which is based on AHRI Standard 210/240.
(b) EER and/or SEER are rated at AHRI conditions and in accordance with DOE test procedures.
(c) Outdoor Sound Rating shown is tested in accordance with AHRI Standard 270. For additional information refer to Table 126, p. 171.
(d) For multispeed direct drive rpm TSC values, reference Table 34, p. 83. For multispeed direct drive rpm YSC (low & medium gas heat) values reference Table 35, p. 84. For multispeed direct drive rpm YSC (high gas heat) values reference Table 36, p. 85.
(e) Optional 2" MERV 8 and MERV 13 filters also available.
(f) Refrigerant charge is an approximate value. For a more precise value, see unit nameplate and service instructions.
(g) Heating performance limit settings and rating data were established and approved under laboratory test conditions using American National Standards Institute standards. Ratings shown are for elevations up to 2000 feet. For elevations above 2000 feet, ratings should be reduced at the rate of 4% for each 1000 feet above sea level. Applicable to Gas/Electric units only.
(h) AFUE is rated in accordance with DOE test procedures.

4YZC60601R410115AD3

General Data

MODEL	4YCZ6060A1120C	4YCZ6060A3120C	4YCZ6060A4120D
RATED Volts/PH/Hz	208-230/1/60	208-230/3/60	460/3/60
Performance Cooling BTUH④			
BTUH (High)	57500	57500	57500
Indoor Airflow (CFM) (High)	1950	1950	1950
Power Input (KW)	5.0	5.0	5.0
BTUH (Low)	40500	40500	40500
Indoor Airflow (CFM) (Low)	1325	1325	1325
Power Input (KW)	3.2	3.2	3.2
EER - HI / LOW / SEER	11.4 / 12.65 / 15.10	11.4 / 12.65 / 15.10	11.4 / 12.65 / 15.10
Sound Power Rating [dB(A)]⑦	73	73	73
Performance Heating②			
Input BTUH - 1st Stage (Natural Gas)	90000	90000	90000
Input BTUH - 2nd Stage (Natural Gas)	120000	120000	120000
AFUE	80.0	80.0	80.0
Temp. Rise — Min/Max (°F)	30 / 60	30 / 60	30 / 60
Orifice Qty / Drill Size (Natural Gas)③	3 / #32	3 / #32	3 / #32
POWER CONN.—V/PH/HZ	208-230/1/60	208-230/3/60	460/3/60
Min. Brch. Cir. Ampacity④	44.4	28.6	17.2
Fuse Size — Max./Recmd. (amps)	60 / 60	40 / 40	20 / 20
COMPRESSOR	2-STAGE SCROLL	2-STAGE SCROLL	2-STAGE SCROLL
Volts/Ph/Hz	208-230/1/60	208-230/3/60	460/3/60
R.L. Amps — L.R. Amps	28.8 / 152.9	17.6 / 123.0	7.6 / 52.0
OUTDOOR COIL — TYPE	SPINE-FIN	Spine-Fin	SPINE-FIN
Rows/F.P.I.	2 / 24	2 / 24	2 / 24
Face Area (sq.ft.)	23.57	23.57	23.57
Tube Size (in.)	3/8	3/8	3/8
INDOOR COIL — TYPE	PLATE FIN	PLATE FIN	PLATE FIN
Rows/F.P.I.	4 / 15	4 / 15	4 / 15
Face Area (sq.ft.)	5.0	5.0	5.0
Tube Size (in.)	3/8	3/8	3/8
Refrigerant Control	EXPANSION VALVE	EXPANSION VALVE	EXPANSION VALVE
Drain Conn. Size (in.)	3/4 FEMALE NPT	3/4 FEMALE NPT	3/4 FEMALE NPT
OUTDOOR FAN — TYPE	PROPELLER	PROPELLER	PROPELLER
Dia. (in.)	28.2	28.2	28.2
Drive/No. Speeds	DIRECT / 1	DIRECT / 1	DIRECT / 1
CFM @ 0.0 in. w.g. ⑥	4700	4700	4700
Motor — HP/R.P.M.	1/4 / 830	1/4 / 830	1/4 / 830
Volts/Ph/Hz	208-230/1/60	208-230/1/60	460/1/60
F.L. Amps/L.R. Amps	1.4 / 3.37	1.4 / 3.37	0.7 / 1.68
INDOOR FAN — TYPE	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL
Dia x Width (in.)	11 X 10	11 X 10	11 X 10
Drive/No. Speeds	DIRECT / VARIABLE	DIRECT / VARIABLE	DIRECT / VARIABLE
CFM @ 0.0 in. w.g.⑤	SEE FAN PERFORMANCE TABLE	SEE FAN PERFORMANCE TABLE	SEE FAN PERFORMANCE TABLE
Motor — HP/R.P.M.	1 / VARIABLE	1 / VARIABLE	1 / VARIABLE
Volts/Ph/Hz	208-230/1/60	208-230/1/60	208-230/1/60
F.L. Amps/L.R. Amps	6.9 / 6.9	6.9 / 6.9	6.9 / 6.9
COMBUSTION FAN — TYPE	CENTRIFUGAL	CENTRIFUGAL	CENTRIFUGAL
Drive/No. Speeds	DIRECT / 2	DIRECT / 2	DIRECT / 2
Motor — HP/R.P.M.	1/45 / 2800/1500	1/45 / 2800/1500	1/45 / 3460/3412
Volts/Ph/Hz	208-230/1/60	208-230/1/60	208-230/1/60
FLA	0.34	0.34	0.34
FILTER / FURNISHED	NO	NO	NO
Type Recommended	THROWAWAY	THROWAWAY	THROWAWAY
Recmd. Face Area (sq. ft.)⑥	5.3	5.3	5.3
REFRIGERANT — Charge (lbs.)④	R410A / 9.30	R410A / 9.30	R410A / 9.30
GAS PIPE SIZE (in.)	1/2	1/2	1/2
DIMENSIONS	H X W X L	H X W X L	H X W X L
Crated (in.)	52.00 / 47.0 / 62.0	52.00 / 47.0 / 62.0	52.00 / 47.0 / 62.0
WEIGHT— Shipping (lbs.) / Net (lbs.)	676 / 548	676 / 548	676 / 548

YSC090F3E3H3AD3

Table 3. General data - 6 to 7½ tons - standard efficiency

	6 Tons	7½ Tons	7½ Tons
	T/YSC072F3,4,W	T/YSC090F3,4,W	T/YSC092F3,4,W
Cooling Performance[a]			
Gross Cooling Capacity	75,000	89,000	94,000
EER[b]	11.2	11.2	11.2
Nominal cfm/AHRI Rated cfm	2,400/2,100	3,000/2,400	3,000/2,625
AHRI Net Cooling Capacity	71,000	83,000	89,000
IEER[c]	13.0	12.2	13.0
System Power (kW)	6.36	7.48	7.97
Compressor			
Number/Type	1/Scroll	1/Scroll	2/Scroll
Sound			
Outdoor Sound Rating (dB)[d]	89	89	91
Outdoor Coil - Type	Microchannel	Microchannel	Microchannel
Configuration	Full Face	Full Face	Face-Split
Tube Size (in.)	0.71	0.71	0.71
Face Area (sq. ft.)	16.91	16.91	17.31
Rows/FPI	1/23	1/23	1/23
Indoor Coil - Type	Lanced	Lanced	Lanced
Configuration	Full Face	Full Face	Face-Split
Tube Size (in.)	0.3125	0.3125	0.3125
Face Area (sq. ft.)	9.89	9.89	12.36
Rows/FPI	3/16	4/16	3/16
Refrigerant Control	Thermal Expansion Valve	Thermal Expansion Valve	Thermal Expansion Valve
Drain Connection Number/Size (in.)	1¾ NPT	1¾ NPT	1¾ NPT
Outdoor Fan - Type	Propeller	Propeller	Propeller
Number Used/Diameter (in.)	1/26	1/26	1/26
Drive Type/No. Speeds	Direct/1	Direct/1	Direct/1
cfm	6,037	6,037	6,610
Motor hp	0.7	0.7	0.75
Motor rpm	1,100	1,100	1,100
Indoor Fan - Type	FC Centrifugal	FC Centrifugal	FC Centrifugal
Number Used/Diameter (in.)/Width (in.)	1/12x12	1/12x12	1/15x15
Drive Type/No. Speeds/rpm	Belt/Variable/1,750	Belt/Variable/1,750	Belt/Variable/1,750
Motor hp (Standard/Oversized)	1.0/2.0	1.0/3.0	1.0/3.0
Motor Frame Size (Standard/Oversized)	56/56	56/56	56/56
Filters[e]			
Type Furnished	Throwaway	Throwaway	Throwaway
Number Size Recommended	(4) 16x25x2	(4) 16x25x2	(4) 20x25x2
Refrigerant Charge[f]			
Pounds of R-410A	5.5	5.9	3.9/3.6

continued on next page

YSC090F3E3H3AD3 – cont'd

Table 3. General data - 6 to 7½ tons - standard efficiency (continued)

	6 Tons	7½ Tons	7½ Tons
	T/YSC072F3,4,W	T/YSC090F3,4,W	T/YSC092F3,4,W
Heating Performance(g)			
(Gas/Electric Only)			
Heating Input			
Low Heat Input (Btu)	80,000	120,000	120,000
Mid Heat Input (Btu)	120,000	150,000/105,000	150,000/105,000
High Heat Input (Btu)	150,000/105,000	200,000/140,000	200,000/140,000
Heating Output			
Low Heat Output (Btu)	64,000	96,000	96,200
Mid Heat Output (Btu)	96,000	120,000/84,000	120,000/84,000
High Heat Output (Btu)	120,000/84,000	160,000/112,000	160,000/112,000
AFUE%(h)			
Low Heat Input (Btu)	–	–	–
Mid Heat Input (Btu)	–	–	–
High Heat Input (Btu)	–	–	–
Steady State Efficiency%			
Low Heat Input (Btu)	80	80	80
Mid Heat Input (Btu)	80	80	80
High Heat Input (Btu)	80	80	80
No. Burners			
Low Heat Input (Btu)	2	3	3
Mid Heat Input (Btu)	3	3	3
High Heat Input (Btu)	3	4	4
No. Stages			
Low Heat Input (Btu)	1	1	1
Mid Heat Input (Btu)	1	2	2
High Heat Input (Btu)	2	2	2
Gas Supply Line Pressure			
Natural (minimum/maximum)	4.5/14.0	4.5/14.0	4.5/14.0
LP (minimum/maximum)	11.0/14.0	11.0/14.0	11.0/14.0
Gas Connection Pipe Size (in)			
Low Heat	1/2	1/2	1/2
Mid Heat	1/2	3/4	3/4
High Heat	3/4	3/4	3/4

(a) Cooling performance is rated at 95°F ambient, 80°F entering dry bulb, 67°F entering wet bulb. Gross capacity does not include the effect of fan motor heat. AHRI capacity is net and includes the effect of fan motor heat. Units are suitable for operation to ±20% of nominal cfm. Units are certified in accordance with the Unitary Air-Conditioner Equipment certification program, which is based on AHRI Standard 340/360.
(b) EER is rated at AHRI conditions and in accordance with DOE test procedures.
(c) Integrated Efficiency Ratio (IEER) is rated in accordance with AHRI Standard 340/360. The IEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% load (net capacity) at the specified in AHRI Standard.
(d) Outdoor Sound Rating shown is tested in accordance with AHRI Standard 270. For additional information refer to Table 126, p. 171.
(e) Optional 2" MERV 8 and MERV 13 filters also available.
(f) Refrigerant charge is an approximate value. For a more precise value, see unit nameplate and service instructions.
(g) Heating performance limit settings and rating data were established and approved under laboratory test conditions using American National Standards Institute standards. Ratings shown are for elevations up to 2000 feet. For elevations above 2000 feet, ratings should be reduced at the rate of 4% for each 1000 feet above sea level. Applicable to Gas/Electric units only.
(h) AFUE is rated in accordance with DOE test procedures.

YHC090F3E3H3A

Table 7. General data - 6 to 7½ tons - high efficiency

	6 Tons	6 Tons	7½ Tons
	T/YHC072E/F3,4W[a]	T/YHC074F3,4	T/YHC092F3,4W[a]
Cooling Performance[b]			
Gross Cooling Capacity	72,000	73,000	92,000
EER[c]	12.6	13.1	12.6
Nominal cfm/AHRI Rated cfm	2,400/2,100	2,400/2,100	3,000/2,625
AHRI Net Cooling Capacity	68,000	71,000	89,000
IEER[d],[e],[f]	14.5	15.5	14.5
System Power (kW)	5.37	5.42	7.06
Compressor			
Number/Type	1/Scroll	2/Scroll	2/Scroll
Sound			
Outdoor Sound Rating (dB)[g]	89	89	88
Outdoor Coil - Type	Microchannel	Microchannel	Microchannel
Configuration	Full Face	Face-Split	Face-Split
Tube Size (in.)	0.71	1	1
Face Area (sq. ft.)	20.77	20.77	20.77
Rows/FPI	1/23	1/20	1/20
Indoor Coil - Type	Lanced	Lanced	Lanced
Configuration	Full Face	Intertwined	Intertwined
Tube Size (in.)	0.3125	0.3125	0.3125
Face Area (sq. ft.)	12.36	12.36	12.36
Rows/FPI	4/16	4/16	4/16
Refrigerant Control	Thermal Expansion Valve	Thermal Expansion Valve	Thermal Expansion Valve
Drain Connection Number/Size (in.)	1¾ NPT	1¾ NPT	1¾ NPT
Outdoor Fan - Type	Propeller	Propeller	Propeller
Number Used/Diameter (in.)	1/26	1/26	1/26
Drive Type/No. Speeds	Direct/1	Direct/1	Direct/1
cfm	5,900	5,750	6,800
Motor hp	0.7	0.7	0.75
Motor rpm	1,100	1,100	1,100
Indoor Fan - Type	FC Centrifugal	BC Plenum	BC Plenum
Number Used/Diameter (in.)/Width (in.)	1/15x15	1/19.7x15	1/19.7x15
Drive Type/No. Speeds/rpm	Belt/Variable/1,750	Direct/Variable[h]	Direct/Variable[h]
Motor hp (Standard/Oversized)	1.0/2.0	3.75/—	3.75/—
Motor Frame Size (Standard/Oversized)	56/56	—/—	—/—
Filters[i]			
Type Furnished	Throwaway	Throwaway	Throwaway
Number Size Recommended	(4) 20x25x2	(4) 20x25x2	(4) 20x25x2
Optional Hot Gas Reheat Coil - Type			
Tube Size (in.) OD	—	—	0.3125
Face Area (sq. ft.)	—	—	8.652
Rows/FPI	—	—	1/16
Refrigerant Charge (Lbs. of R-410A)[j]			
Standard	7.7	5.8/4.1	5.5/4.2
Optional Hot Gas Reheat Coil	—	—	6.2/4.3

continued on next page

YHC090F3E3H3A – cont'd

Table 7. General data - 6 to 7½ tons - high efficiency (continued)

	6 Tons	6 Tons	7½ Tons
	T/YHC072E/F3,4W[a]	T/YHC074F3,4	T/YHC092F3,4W[a]
Heating Performance[k]			
(Gas/Electric Only)			
Heating Input			
Low Heat Input (Btu)	80,000	80,000	120,000
Mid Heat Input (Btu)	120,000	120,000	150,000/105,000
High Heat Input (Btu)	150,000/105,000	150,000/105,000	200,000/140,000
Heating Output			
Low Heat Output (Btu)	64,000	64,800	96,000
Mid Heat Output (Btu)	96,000	97,200	120,000/84,000
High Heat Output (Btu)	120,000/84,000	121,500/85,050	160,000/112,000
AFUE%[l]			
Low Heat Input (Btu)	–	–	–
Mid Heat Input (Btu)	–	–	–
High Heat Input (Btu)	–	–	–
Steady State Efficiency%			
Low Heat Input (Btu)	80	81	80
Mid Heat Input (Btu)	80	81	80
High Heat Input (Btu)	80	81	80
No. Burners			
Low Heat Input (Btu)	3	3	3
Mid Heat Input (Btu)	3	3	3
High Heat Input (Btu)	4	4	4
No. Stages			
Low Heat Input (Btu)	1	1	1
Mid Heat Input (Btu)	1	1	2
High Heat Input (Btu)	2	2	2
Gas Supply Line Pressure			
Natural (minimum/maximum)	4.5/14.0	4.5/14.0	4.5/14.0
LP (minimum/maximum)	11.0/14.0	11.0/14.0	11.0/14.0
Gas Connection Pipe Size (in)			
Low Heat	1/2	1/2	1/2
Mid Heat	1/2	1/2	3/4
High Heat	3/4	3/4	3/4

(a) 575V (W voltage) is only available as YHC. No THC models available with 575V (W voltage).
(b) Cooling performance is rated at 95°F ambient, 80°F entering dry bulb, 67°F entering wet bulb. Gross capacity does not include the effect of fan motor heat. AHRI capacity is net and includes the effect of fan motor heat. Units are suitable for operation to ±20% of nominal cfm. Units are certified in accordance with the Unitary Air-Conditioner Equipment certification program, which is based on AHRI Standard 340/360.
(c) EER is rated at AHRI conditions and in accordance with DOE test procedures.
(d) Integrated Efficiency Ratio (IEER) is rated in accordance with AHRI Standard 340/360. The IEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% load (net capacity) at the specified in AHRI Standard.
(e) 15.0 IEER for Multi Speed, SZVAV, and MZVAV.
(f) 16.0 IEER for Multi Speed, SZVAV, and MZVAV.
(g) Outdoor Sound Rating shown is tested in accordance with AHRI Standard 270. For additional information refer to Table 126, p. 171.
(h) For multispeed direct drive rpm THC/YHC values, reference Table 125, p. 170.
(i) Optional 2" MERV 8 and MERV 13 filters also available.
(j) Refrigerant charge is an approximate value. For a more precise value, see unit nameplate and service instructions.
(k) Heating performance limit settings and rating data were established and approved under laboratory test conditions using American National Standards Institute standards. Ratings shown are for elevations up to 2000 feet. For elevations above 2000 feet, ratings should be reduced at the rate of 4% for each 1000 feet above sea level. Applicable to Gas/Electric units only.
(l) AFUE is rated in accordance with DOE test procedures.

YSC120F3E3H3AD3

Table 4. General data - 8½ to 10 tons - standard efficiency

	8½ Tons	10 Tons
	T/YSC102F3,4,W	T/YSC120F3,4,W
Cooling Performance[a]		
Gross Cooling Capacity	102,000	119,000
EER[b]	11.2	11.3
Nominal cfm/AHRI Rated cfm	3,400/2,720	4,000/3,500
AHRI Net Cooling Capacity	96,600	113,000
IEER[c]	13.0	13.0
System Power (kW)	8.62	10.0
Compressor		
Number/Type	2/Scroll	2/Scroll
Sound		
Outdoor Sound Rating (dB)[d]	88	88
Outdoor Coil - Type	Microchannel	Microchannel
Configuration	Face-Split	Face Split
Tube Size (in.)	1	1
Face Area (sq. ft.)	20.77	20.77
Rows/FPI	1/20	1/20
Indoor Coil - Type	Lanced	Lanced
Configuration	Face-Split	Intertwined
Tube Size (in.)	0.3125	0.3125
Face Area (sq. ft.)	12.36	12.36
Rows/FPI	3/16	4/16
Refrigerant Control	Thermal Expansion Valve	Thermal Expansion Valve
Drain Connection Number/Size (in.)	1¾ NPT	1¾ NPT
Outdoor Fan - Type	Propeller	Propeller
Number Used/Diameter (in.)	1/26	1/26
Drive Type/No. Speeds	Direct/1	Direct/1
cfm	6,610	6,800
Motor hp	0.75	0.75
Motor rpm	1,100	1,100
Indoor Fan - Type	FC Centrifugal	BC Plenum
Number Used/Diameter (in.)/Width (in.)	1/15x15	1/19.7x15
Drive Type/No. Speeds/rpm	Belt/Variable/1,750	Direct/Variable[e]
Motor hp (Standard/Oversized)	2.0/3.0	3.75/—
Motor Frame Size (Standard/Oversized)	56/56	—/—
Filters[f]		
Type Furnished	Throwaway	Throwaway
Number Size Recommended	(4) 20x25x2	(4) 20x25x2
Refrigerant Charge [g]		
Pounds of R-410A	4.7/3.9	5.5/4.2

continued on next page

YSC120F3E3H3AD3 – cont'd

Table 4. General data - 8½ to 10 tons - standard efficiency (continued)

	8½ Tons	10 Tons
	T/YSC102F3,4,W	T/YSC120F3,4,W
Heating Performance(h)		
(Gas/Electric Only)		
Heating Input		
Low Heat Input (Btu)	120,000	150,000/105,000
Mid Heat Input (Btu)	150,000/105,000	200,000/140,000
High Heat Input (Btu)	200,000/140,000	250,000/175,000
Heating Output		
Low Heat Output (Bu)	96,000	120,000/84,000
Mid Heat Output (Btu)	120,000/84,000	160,000/112,000
High Heat Output (Btu)	160,000/112,000	200,000/140,000
AFUE%(i)		
Low Heat Input (Btu)	—	—
Mid Heat Input (Btu)	—	—
High Heat Input (Btu)	—	—
Steady State Efficiency%		
Low Heat Input (Btu)	80	80
Mid Heat Input (Btu)	80	80
High Heat Input (Btu)	80	80
No. Burners		
Low Heat Input (Btu)	3	3
Mid Heat Input (Btu)	3	4
High Heat Input (Btu)	4	5
No. Stages		
Low Heat Input (Btu)	1	2
Mid Heat Input (Btu)	2	2
High Heat Input (Btu)	2	2
Gas Supply Line Pressure		
Natural (minimum/maximum)	4.5/14.0	4.5/14.0
LP (minimum/maximum)	11.0/14.0	11.0/14.0
Gas Connection Pipe Size (in)		
Low Heat	1/2	3/4
Mid Heat	3/4	3/4
High Heat	3/4	3/4

(a) Cooling performance is rated at 95°F ambient, 80°F entering dry bulb, 67°F entering wet bulb. Gross capacity does not include the effect of fan motor heat. AHRI capacity is net and includes the effect of fan motor heat. Units are suitable for operation to ±20% of nominal cfm. Units are certified in accordance with the Unitary Air-Conditioner Equipment certification program, which is based on AHRI Standard 340/360.
(b) EER is rated at AHRI conditions and in accordance with DOE test procedures.
(c) Integrated Efficiency Ratio (IEER) is rated in accordance with AHRI Standard 340/360. The IEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% load (net capacity) at the specified in AHRI Standard.
(d) Outdoor Sound Rating shown is tested in accordance with AHRI Standard 270. For additional information refer to Table 126, p. 171.
(e) For multispeed direct drive rpm T/YSC values, reference Table 125, p. 170.
(f) Optional 2" MERV 8 and MERV 13 filters also available.
(g) Refrigerant charge is an approximate value. For a more precise value, see unit nameplate and service instructions.
(h) Heating performance limit settings and rating data were established and approved under laboratory test conditions using American National Standards Institute standards. Ratings shown are for elevations up to 2000 feet. For elevations above 2000 feet, ratings should be reduced at the rate of 4% for each 1000 feet above sea level. Applicable to Gas/Electric units only.
(i) AFUE is rated in accordance with DOE test procedures.

YHC120F3E3H3A

Table 8. General data - 8½ to 10 tons - high efficiency

	8½ Tons	10 Tons
	T/YHC102F3,4W[a]	T/YHC120F3,4,W[a]
Cooling Performance[b]		
Gross Cooling Capacity	104,000	116,000
EER[c]	12.5[e]	12.4
Nominal cfm/AHRI Rated cfm	3,400/2,720	4,000/3,350
AHRI Net Cooling Capacity	99,000	113,000
IEER[d]	14.7[f][g]	14.7[h]
System Power (kW)	7.92	9.11
Compressor		
Number/Type	2/Scroll	2/Scroll
Sound		
Outdoor Sound Rating (dB)[i]	89	87
Outdoor Coil - Type	Microchannel	Microchannel
Configuration	Face Split	Face Split
Tube Size (in.)	1	1
Face Area (sq. ft.)	20.77	26.77
Rows/FPI	1/20	1/23
Indoor Coil - Type	Lanced	Lanced
Configuration	Intertwined	Intertwined
Tube Size (in.)	0.3125	0.3125
Face Area (sq. ft.)	12.36	16.65
Rows/FPI	5/16	4/16
Refrigerant Control	Thermal Expansion Valve	Thermal Expansion Valve
Drain Connection Number/Size (in.)	1¾ NPT	1¾ NPT
Outdoor Fan - Type	Propeller	Propeller
Number Used/Diameter (in.)	1/26	1/30
Drive Type/No. Speeds	Direct/1	Direct/1
cfm	6,800	7,540
Motor hp	0.75	0.75
Motor rpm	1,100	1,100
Indoor Fan - Type	BC Plenum	BC Plenum
Number Used/Diameter (in.)/Width (in.)	1/19.7x15	1/19.7x15
Drive Type/No. Speeds/rpm	Direct/Variable[j]	Direct/Variable[j]
Motor hp (Standard/Oversized)	3.75/—	3.75/—
Motor Frame Size (Standard/Oversized)	—/—	—/—
Filters[k]		
Type Furnished	Throwaway	Throwaway
Number Size Recommended	(4) 20x25x2	(3) 20x25x2 (2) 20x30x2
Optional Hot Gas Reheat Coil - Type		
Tube Size (in.) OD	0.3125	0.3125
Face Area (sq. ft.)	8.652	15.225
Rows/FPI	1/16	1/16
Refrigerant Charge (Lbs. of R-410A)[l]		
Standard	6.3/4.9	7.1/5.0
Optional Hot Gas Reheat Coil	6.6/4.7	8.0/5.0

continued on next page

YHC120F3E3H3A – cont'd

Table 8. General data - 8½ to 10 tons - high efficiency (continued)

	8½ Tons	10 Tons
	T/YHC102F3,4W[a]	T/YHC120F3,4,W[a]
Heating Performance[m]		
(Gas/Electric Only)		
Heating Input		
Low Heat Input (Btu)	120,000	150,000/105.000
Mid Heat Input (Btu)	150,000/105,000	200,000/140,000
High Heat Input (Btu)	200,000/140,000	250,000/175,000
Heating Output		
Low Heat Output (Btu)	96,000	120,000/84,000
Mid Heat Output (Btu)	120,000/84,000	160,000/112,000
High Heat Output (Btu)	160,000/112,000	200,000/140,000
AFUE%[n]		
Low Heat Input (Btu)	—	—
Mid Heat Input (Btu)	—	—
High Heat Input (Btu)	—	—
Steady State Efficiency%		
Low Heat Input (Btu)	80	80
Mid Heat Input (Btu)	80	80
High Heat Input (Btu)	80	80
No. Burners		
Low Heat Input (Btu)	3	3
Mid Heat Input (Btu)	3	4
High Heat Input (Btu)	4	5
No. Stages		
Low Heat Input (Btu)	1	2
Mid Heat Input (Btu)	2	2
High Heat Input (Btu)	2	2
Gas Supply Line Pressure		
Natural (minimum/maximum)	4.5/14.0	4.5/14.0
LP (minimum/maximum)	11.0/14.0	11.0/14.0
Gas Connection Pipe Size (in)		
Low Heat	1/2	3/4
Mid Heat	3/4	3/4
High Heat	3/4	3/4

(a) 575V (W voltage) is only available as YHC. No THC models available with 575V (W voltage).
(b) Cooling performance is rated at 95°F ambient, 80°F entering dry bulb, 67°F entering wet bulb. Gross capacity does not include the effect of fan motor heat. AHRI capacity is net and includes the effect of fan motor heat. Units are suitable for operation to ±20% of nominal cfm. Units are certified in accordance with the Unitary Air-Conditioner Equipment certification program, which is based on AHRI Standard 340/360.
(c) EER is rated at AHRI conditions and in accordance with DOE test procedures.
(d) Integrated Efficiency Ratio (IEER) is rated in accordance with AHRI Standard 340/360. The IEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% load (net capacity) at the specified in AHRI Standard.
(e) YHC102FW: EER = 12.4
(f) 15.5 IEER for SZVAV.
(g) YHC102FW IEER = 14.5
(h) 15.2 IEER for SZVAV.
(i) Outdoor Sound Rating shown is tested in accordance with AHRI Standard 270. For additional information refer to Table 126, p. 171.
(j) For multispeed direct drive rpm THC/YHC values, reference Table 125, p. 170.
(k) Optional 2" MERV 8 and MERV 13 filters also available.
(l) Refrigerant charge is an approximate value. For a more precise value, see unit nameplate and service instructions.
(m) Heating performance limit settings and rating data were established and approved under laboratory test conditions using American National Standards Institute standards. Ratings shown are for elevations up to 2000 feet. For elevations above 2000 feet, ratings should be reduced at the rate of 4% for each 1000 feet above sea level. Applicable to Gas/Electric units only.
(n) AFUE is rated in accordance with DOE test procedures.

APPENDIX C – TRACE700 DATA

System Checksums

System Checksums

VAV - DAYCARE | **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 88 / 68 / 78

Clg Space Peak — Mo/Hr: 7 / 16; OADB: 87

	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	13,494	13,494	9	0	0
Glass Solar	22,495	0	22,495	16	24,013	22
Glass/Door Cond	2,745	0	2,745	2	2,749	2
Wall Cond	9,001	2,265	11,266	8	9,528	9
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	31,467		31,467	22	20,719	19
Sub Total ==>	65,709	15,759	81,467	57	57,009	51
Internal Loads						
Lights	31,978	7,995	39,973	28	31,978	29
People	14,640	0	14,640	10	7,320	7
Misc	9,993	0	9,993	7	9,993	9
Sub Total ==>	56,612	7,995	64,606	45	49,292	44
Ceiling Load	4,168	-4,168	0	0	4,505	4
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		-3,818	-3,818	-3		
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 ==>	126,488	15,768	142,256	100.00	110,805	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-25,304	9.46
Glass Solar	0	0	0.00
Glass/Door Cond	-31,448	-31,448	11.75
Wall Cond	-27,843	-34,933	13.05
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-175,064	-175,064	65.42
Sub Total ==>	-234,355	-266,749	99.68
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-10,569	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		9,681	-3.62
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-10,535	3.94
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-244,924	-267,603	100.00

TEMPERATURES

	Cooling	Heating
SADB	59.4	70.0
Ra Plenum	77.3	64.3
Return	77.3	64.3
Ret/OA	77.3	64.3
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	6,835	2,057
Terminal	6,835	2,057
Main Fan	6,835	2,057
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	1,640	1,640
MinStop/Rh	2,057	2,057
Return	8,475	3,696
Exhaust	1,640	1,640
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	1.17	0.35
cfm/ton	576.58	
ft²/ton	493.98	
Btu/hr·ft²	24.29	-45.70
No. People	29	

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	11.9	142.3	125.6	6,773	77.3	62.9	69.6	59.4	55.8	65.9
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	11.9	142.3								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	5,856		
Part	0		
Int Door	0		
ExFlr	0		
Roof	5,201	0	0
Wall	5,465	317	6
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-267.6	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-22.7	2,057	59.4	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-267.6			

System Checksums

VAV - BACK EXIT (NE) — **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 14; Outside Air: OADB/WB/HR: 87 / 68 / 81

Clg Space Peak — Mo/Hr: 7 / 15; OADB: 88

	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	214	214	6	0	0
Glass Solar	0	0	0	0	0	0
Glass/Door Cond	35	0	35	1	39	2
Wall Cond	304	76	379	11	326	13
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	1,937		1,937	55	1,302	51
Sub Total ==>	2,276	290	2,565	73	1,667	65
Internal Loads						
Lights	546	137	683	19	546	21
People	250	0	250	7	125	5
Misc	171	0	171	5	171	7
Sub Total ==>	967	137	1,103	31	842	33
Ceiling Load	53	-53	0	0	58	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		-166	-166	-5		
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 ==>	3,295	208	3,502	100.00	2,567	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-488	3.72
Glass Solar	0	0	0.00
Glass/Door Cond	-434	-434	3.31
Wall Cond	-1,625	-2,044	15.59
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-10,315	-10,315	78.65
Sub Total ==>	-12,373	-13,281	101.26
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-168	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		532	-4.05
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-366	2.79
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-12,541	-13,115	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.4	70.0
Ra Plenum	76.7	64.7
Return	76.7	64.7
Ret/OA	76.7	64.7
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	126	38
Terminal	126	38
Main Fan	126	38
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	97	97
MinStop/Rh	38	38
Return	223	134
Exhaust	97	97
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	1.26	0.38
cfm/ton	432.05	
ft²/ton	342.62	
Btu/hr·ft²	35.02	-131.15
No. People	1	

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	0.3	3.5	2.7	121	76.7	62.8	69.8	55.4	52.6	59.2
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	3.5								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	100		
Part	0		
Int Door	0		
ExFlr	0		
Roof	100	0	0
Wall	301	0	0
Ext Door	21	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-13.1	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-0.6	38	55.4	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-13.1			

System Checksums

VAV - BASEMENT | **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 88 / 68 / 78

Clg Space Peak — Mo/Hr: 7 / 17; OADB: 85

	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	595	0	595	1	1,251	2
Glass/Door Cond	141	0	141	0	129	0
Wall Cond	770	190	960	1	1,183	2
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	3,882		3,882	5	2,159	4
Sub Total ==>	5,388	190	5,578	8	4,723	8
Internal Loads						
Lights	32,852	8,213	41,065	57	32,852	56
People	15,040	0	15,040	21	7,520	13
Misc	10,266	0	10,266	14	10,266	18
Sub Total ==>	58,158	8,213	66,372	93	50,638	87
Ceiling Load	2,811	-2,811	0	0	2,832	5
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		-309	-309	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 ==>	66,357	5,283	71,641	100.00	58,193	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-1,555	-1,555	3.95
Wall Cond	-3,500	-4,423	11.24
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-21,591	-21,591	54.86
Sub Total ==>	-26,645	-27,569	70.05
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-548	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		60	-0.15
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-11,845	30.10
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-27,193	-39,353	100.00

TEMPERATURES

	Cooling	Heating
SADB	58.9	70.0
Ra Plenum	76.5	69.7
Return	76.5	69.7
Ret/OA	76.5	69.7
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	3,486	1,057
Terminal	3,486	1,057
Main Fan	3,486	1,057
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	202	202
MinStop/Rh	1,057	1,057
Return	3,689	1,259
Exhaust	202	202
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	0.58	0.18
cfm/ton	583.98	
ft²/ton	1,007.70	
Btu/hr·ft²	11.91	-6.54
No. People	30	

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	6.0	71.6	63.0	3,456	76.5	62.7	69.6	58.9	55.6	65.8
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	6.0	71.6								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	6,016		
Part	0		
Int Door	0		
ExFlr	0		
Roof	0	0	0
Wall	656	12	2
Ext Door	18	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-39.4	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-12.2	1,057	58.9	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-39.4			

System Checksums

VAV - ENTRANCE (NW) — **VAV w/Baseboard Heating**

	COOLING COIL PEAK				CLG SPACE PEAK	
Peaked at Time:	Mo/Hr: 7 / 15				Mo/Hr: 7 / 15	
Outside Air:	OADB/WB/HR: 88 / 68 / 78				OADB: 88	
	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	669	669	10	0	0
Glass Solar	264	0	264	4	264	5
Glass/Door Cond	125	0	125	2	125	2
Wall Cond	500	121	622	9	500	10
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	2,842		2,842	40	2,001	38
Sub Total ==>	3,732	790	4,522	64	2,891	55
Internal Loads						
Lights	1,409	352	1,761	25	1,409	27
People	645	0	645	9	323	6
Misc	440	0	440	6	440	8
Sub Total ==>	2,494	352	2,846	41	2,172	41
Ceiling Load	181	-181	0	0	181	3
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		-340	-340	-5		
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 ==>	6,407	621	7,028	100.00	5,243	100.00

	HEATING COIL PEAK		
	Mo/Hr: Heating Design		
	OADB: -33		
	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	-1,252	5.85
Glass Solar	0	0	0.00
Glass/Door Cond	-1,425	-1,425	6.65
Wall Cond	-2,506	-3,147	14.69
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-15,857	-15,857	74.02
Sub Total ==>	-19,788	-21,681	101.20
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-484	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		911	-4.25
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-653	3.05
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-20,272	-21,423	100.00

TEMPERATURES

	Cooling	Heating
SADB	56.4	70.0
Ra Plenum	77.2	64.1
Return	77.2	64.1
Ret/OA	77.2	64.1
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	271	81
Terminal	271	81
Main Fan	271	81
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	149	149
MinStop/Rh	81	81
Return	420	230
Exhaust	149	149
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	1.05	0.32
cfm/ton	462.95	
ft²/ton	440.52	
Btu/hr·ft²	27.24	-83.04
No. People	1	

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	0.6	7.0	5.9	271	77.2	63.0	69.7	56.4	54.0	63.2
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	0.6	7.0								

AREAS

	Gross Total	Glass ft²	(%)
Floor	258		
Part	0		
Int Door	0		
ExFlr	0		
Roof	258	0	0
Wall	474	10	2
Ext Door	21	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-21.4	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-1.2	81	56.4	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-21.4			

System Checksums

VAV - FRONT ENTRANCE (S) | **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 8 / 15; Outside Air: OADB/WB/HR: 78 / 65 / 81

Clg Space Peak — Mo/Hr: 10 / 15; OADB: 57

	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	534	534	1	0	0
Glass Solar	26,703	0	26,703	66	34,763	105
Glass/Door Cond	96	0	96	0	-4,366	-13
Wall Cond	598	205	803	2	502	2
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	5,904		5,904	15	-2,789	-8
Sub Total ==>	33,301	739	34,040	85	28,110	85
Internal Loads						
Lights	3,107	777	3,884	10	3,107	9
People	1,423	0	1,423	4	711	2
Misc	971	0	971	2	971	3
Sub Total ==>	5,501	777	6,278	16	4,789	15
Ceiling Load	139	-139	0	0	80	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		-117	-117	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 ==>	38,940	1,260	40,200	100.00	32,980	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-1,388	2.88
Glass Solar	0	0	0.00
Glass/Door Cond	-23,099	-23,099	47.89
Wall Cond	-1,154	-1,547	3.21
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-15,696	-15,696	32.54
Sub Total ==>	-39,949	-41,731	86.51
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-373	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		316	-0.65
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-6,822	14.14
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-40,322	-48,237	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	70.0
Ra Plenum	75.8	67.9
Return	75.8	67.9
Ret/OA	75.8	67.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	1,591	509
Terminal	1,591	509
Main Fan	1,591	509
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	147	147
MinStop/Rh	509	509
Return	1,738	656
Exhaust	147	147
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	2.80	0.89
cfm/ton	474.82	
ft²/ton	169.85	
Btu/hr·ft²	70.65	-84.77
No. People	3	

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	3.4	40.2	34.0	1,581	75.8	52.0	24.4	55.0	40.8	18.0
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	3.4	40.2								

AREAS

	Gross Total	Glass ft²	(%)
Floor	569		
Part	0		
Int Door	0		
ExFlr	0		
Roof	275	0	0
Wall	452	225	50
Ext Door	39	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-48.2	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-7.9	509	55.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-48.2			

System Checksums

VAV - FRONT ENTRANCE (SW) — **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 18; Outside Air: OADB/WB/HR: 82 / 63 / 60

Clg Space Peak — Mo/Hr: 7 / 19; OADB: 79

	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	784	784	2	0	0
Glass Solar	16,943	0	16,943	50	18,363	62
Glass/Door Cond	1,022	0	1,022	3	661	2
Wall Cond	925	373	1,298	4	693	2
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	2,623		2,623	8	824	3
Sub Total ==>	21,513	1,157	22,670	67	20,541	69
Internal Loads						
Lights	5,723	1,431	7,154	21	5,723	19
People	2,620	0	2,620	8	1,310	4
Misc	1,788	0	1,788	5	1,788	6
Sub Total ==>	10,131	1,431	11,562	34	8,821	30
Ceiling Load	423	-423	0	0	401	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		-270	-270	-1		
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 ==>	32,068	1,895	33,963	100.00	29,763	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-1,211	2.53
Glass Solar	0	0	0.00
Glass/Door Cond	-16,302	-16,302	34.03
Wall Cond	-2,242	-3,156	6.59
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-21,767	-21,767	45.43
Sub Total ==>	-40,310	-42,435	88.57
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-703	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		448	-0.93
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-5,923	12.36
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-41,014	-47,910	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	70.0
Ra Plenum	76.3	67.9
Return	76.3	67.9
Ret/OA	76.3	67.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	1,436	443
Terminal	1,436	443
Main Fan	1,436	443
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	204	204
MinStop/Rh	443	443
Return	1,639	647
Exhaust	204	204
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	1.37	0.42
cfm/ton	507.20	
ft²/ton	370.29	
Btu/hr·ft²	32.41	-45.72
No. People	5	

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	2.8	34.0	31.6	1,432	76.3	58.8	51.5	55.0	49.8	48.9
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	2.8	34.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,048		
Part	0		
Int Door	0		
ExFlr	0		
Roof	240	0	0
Wall	613	151	25
Ext Door	67	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-47.9	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-6.9	443	55.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-47.9			

System Checksums

VAV - GYMNASIUM | **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 88 / 68 / 78
Clg Space Peak — Mo/Hr: 7 / 15; OADB: 88

	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	16,107	0	16,107	9	16,107	12
Skylite Cond	0	604	604	0	0	0
Roof Cond	0	17,602	17,602	10	0	0
Glass Solar	14,404	0	14,404	8	14,404	11
Glass/Door Cond	2,067	0	2,067	1	2,067	2
Wall Cond	5,625	1,429	7,054	4	5,625	4
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	19,003		19,003	11	13,342	10
Sub Total ==>	57,206	19,635	76,841	45	51,545	39
Internal Loads						
Lights	48,246	12,062	60,308	35	48,246	36
People	22,088	0	22,088	13	11,044	8
Misc	15,077	0	15,077	9	15,077	11
Sub Total ==>	85,411	12,062	97,472	57	74,367	56
Ceiling Load	7,324	-7,324	0	0	7,324	5
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		-2,685	-2,685	-2		
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 ==>	149,941	21,687	171,628	100.00	133,236	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-8,857	4.56
Roof Cond	0	-32,661	16.80
Glass Solar	0	0	0.00
Glass/Door Cond	-23,539	-23,539	12.11
Wall Cond	-16,498	-20,716	10.66
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-105,711	-105,711	54.39
Sub Total ==>	-145,747	-191,483	98.51
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-19,975	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		7,323	-3.77
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-10,213	5.25
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-165,723	-194,373	100.00

TEMPERATURES

	Cooling	Heating
SADB	58.9	70.0
Ra Plenum	77.6	62.9
Return	77.6	62.9
Ret/OA	77.6	62.9
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	7,989	2,492
Terminal	7,989	2,492
Main Fan	7,989	2,492
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	990	990
MinStop/Rh	2,492	2,492
Return	8,979	3,482
Exhaust	990	990
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	0.90	0.28
cfm/ton	558.55	
ft²/ton	617.73	
Btu/hr·ft²	19.43	-22.00
No. People	44	

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	14.3	171.6	154.9	7,989	77.6	63.1	69.6	58.9	55.8	66.4
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	14.3	171.6								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	8,835		
Part	0		
Int Door	0		
ExFlr	0		
Roof	6,910	96	1
Wall	3,300	237	7
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-194.4	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-28.7	2,492	58.9	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-194.4			

System Checksums

VAV-OFFICE — **VAV w/Baseboard Heating**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 17; Outside Air: OADB/WB/HR: 85 / 65 / 68

Clg Space Peak — Mo/Hr: 7 / 18; OADB: 82

	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	3,095	3,095	11	0	0
Glass Solar	6,556	0	6,556	24	7,980	37
Glass/Door Cond	537	0	537	2	426	2
Wall Cond	1,956	516	2,472	9	2,321	11
Partition/Door	0		0	0	0	0
Floor	0		0	0	0	0
Adjacent Floor	0	0	0	0	0	0
Infiltration	4,379		4,379	16	1,818	8
Sub Total ==>	13,429	3,611	17,040	63	12,545	58
Internal Loads						
Lights	5,352	1,338	6,689	25	5,352	25
People	2,450	0	2,450	9	1,225	6
Misc	1,672	0	1,672	6	1,672	8
Sub Total ==>	9,474	1,338	10,812	40	8,249	38
Ceiling Load	963	-963	0	0	960	4
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		-762	-762	-3		
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 ==>	23,865	3,224	27,090	100.00	21,754	100.00

HEATING COIL PEAK

Mo/Hr: Heating Design; OADB: -33

	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	-4,728	11.03
Glass Solar	0	0	0.00
Glass/Door Cond	-6,772	-6,772	15.80
Wall Cond	-3,871	-4,887	11.40
Partition/Door	0	0	0.00
Floor	0	0	0.00
Adjacent Floor	0	0	0
Infiltration	-25,307	-25,307	59.04
Sub Total ==>	-35,949	-41,693	97.26
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-2,021	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		1,599	-3.73
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-2,773	6.47
Additional Reheat		0	0.00
Underflr Sup Ht Pkup		0	0.00
Supply Air Leakage		0	0.00
Grand Total ==>	-37,970	-42,867	100.00

TEMPERATURES

	Cooling	Heating
SADB	55.0	70.0
Ra Plenum	78.1	63.5
Return	78.1	63.5
Ret/OA	78.1	63.5
Fn MtrTD	0.0	0.0
Fn BldTD	0.0	0.0
Fn Frict	0.0	0.0

AIRFLOWS

	Cooling	Heating
Diffuser	1,049	315
Terminal	1,049	315
Main Fan	1,049	315
Sec Fan	0	0
Nom Vent	0	0
AHU Vent	0	0
Infil	237	237
MinStop/Rh	315	315
Return	1,286	552
Exhaust	237	237
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	1.07	0.32
cfm/ton	464.78	
ft²/ton	434.12	
Btu/hr·ft²	27.64	-43.74
No. People	5	

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	2.3	27.1	24.0	1,003	78.1	60.4	55.9	55.0	50.4	51.2
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	2.3	27.1								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	980		
Part	0		
Int Door	0		
ExFlr	0		
Roof	980	0	0
Wall	790	68	9
Ext Door	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-42.9	0	0.0	0.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Reheat	-4.9	315	55.0	70.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-42.9			

Building U-Values

BUILDING U-FACTORS

Description	Partition	Internal Door	Exposed Floor	Summer Skylight	Winter Skylight	Roof	Summer Window	Winter Window	External Door	Wall	Ceiling	Room Mass lb/ft^2	Room Capacitance Btu/lb·°F
	ROOM U-FACTORS Btu/h·ft^2·°F												
Alternative 1													
FIRST - Reception - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	39.5	8.8
FIRST - Staff Room - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	51.2	11.1
FIRST - Office #1 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	42.6	9.4
FIRST - Office #2 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	43.3	9.6
FIRST - Office #3 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	43.2	9.5
FIRST - Office W/C - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	42.5	9.4
VAV-OFFICE - System	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	42.9	9.5
FIRST - Boys W/C - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	28.2	5.6
FIRST - Handicap W/C - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	34.6	6.9
FIRST - Girls W/C - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
FIRST - Day Care Hallway - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
FIRST - Office/Storage - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	31.5	6.3
FIRST - Day Care - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	45.5	10.0
FIRST - Nursery W/C - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	38.0	7.6
FIRST - Nursery - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	48.3	10.6
FIRST - Day Care Entrance - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	42.1	9.3
VAV - DAYCARE - System	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	43.1	9.4
BASEMENT - Stage - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	41.8	9.3
BASEMENT - Gymnasium - Zone	0.000	0.000	0.000	0.950	0.962	0.050	0.000	0.000	0.000	0.000	0.317	30.8	7.0
BASEMENT - Office #2 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	44.5	9.8
BASEMENT - Office #3 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	40.8	9.1
BASEMENT - Office #4 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	45.0	9.9
BASEMENT - Office #5 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	43.2	9.5
BASEMENT - Office #6 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	44.8	9.9
BASEMENT - Office #7 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.000	0.067	0.317	45.3	10.0
BASEMENT - Storage #4 - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.067	0.317	46.0	10.1
BASEMENT - Spare Room - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.067	0.317	52.4	11.4
BASEMENT - Spare Room #2 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	26.8	5.4
BASEMENT - Office #8 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.7	3.5
BASEMENT - Office #9 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.3	3.5
BASEMENT - Office #10 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.5	3.5

BUILDING U-FACTORS

Description	Partition	Internal Door	Exposed Floor	Summer Skylight	Winter Skylight	Roof	Summer Window	Winter Window	External Door	Wall	Ceiling	Room Mass lb/ft²	Room Capacitance Btu/lb·°F
	ROOM U-FACTORS Btu/h·ft²·°F												
BASEMENT - Office #11 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.0	3.4
BASEMENT - Mens Changroom - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	16.9	3.4
BASEMENT - Womens Changroom - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.5	3.5
BASEMENT - Shower - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	17.9	3.6
BASEMENT - Office #12 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	37.2	7.4
BASEMENT - Office #13 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	25.5	5.1
BASEMENT - Canteen - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	17.4	3.5
VAV - GYMNASIUM - System	0.000	0.000	0.000	0.950	0.962	0.050	0.950	0.962	0.000	0.067	0.317	32.6	7.2
FIRST - Front Entrance - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	48.6	10.6
BASEMENT - Hallway - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	17.3	3.5
VAV - FRONT ENTRANCE (SW) - System	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	24.4	5.1
FIRST - Back Fire Exit - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	59.8	12.9
VAV - ENTRANCE (NW) - System	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	59.8	12.9
BASEMENT - Fire Exit - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.200	0.067	0.317	79.1	16.7
VAV - BACK EXIT (NE) - System	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.200	0.067	0.317	79.1	16.7
BASEMENT - MAIN ENTRANCE - Zone	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	32.1	7.3
BASEMENT - Entrance - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	24.7	4.9
VAV - FRONT ENTRANCE (S) - System	0.000	0.000	0.000	0.000	0.000	0.050	0.950	0.962	0.200	0.067	0.317	28.3	6.1
BASEMENT - Office #1 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	16.2	3.2
BASEMENT - Kitchen - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	16.3	3.3
BASEMENT - Mens W/C #1 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	16.0	3.2
BASEMENT - Womens W/C #1 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.000	0.067	0.317	16.2	3.2
BASEMENT - Storage #1 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	22.4	4.5
BASEMENT - Hallway #2 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.317	19.5	3.9
BASEMENT - Boiler Room - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.067	0.317	18.8	3.8
BASEMENT - Computer Room - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
BASEMENT - Storage #2 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
BASEMENT - Multi Purpose - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
BASEMENT - Storage #3 - Zone	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.7
VAV - BASEMENT - System	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.962	0.200	0.067	0.317	15.0	3.0

BUILDING U-FACTORS

Description	ROOM U-FACTORS Btu/h·ft²·°F Partition	Internal Door	Exposed Floor	Summer Skylight	Winter Skylight	Roof	Summer Window	Winter Window	External Door	Wall	Ceiling	Room Mass lb/ft²	Room Capacitance Btu/lb·°F

Overall U-Factors

Roof	0.056	Btu/h·ft²·°F
Wall	0.142	Btu/h·ft²·°F
Building	0.096	Btu/h·ft²·°F

Overall Thermal Transfer Values

Roof (OTTVr)	3.52	Btu/hr·ft²
Wall (OTTVw)	12.93	Btu/hr·ft²

Peak Cooling Load

PEAK COOLING LOADS

MAIN SYSTEM

System Zone Room		Floor Area ft²	SPACE Peak Time Mo/Hr	SPACE OA Condition DB °F	SPACE OA Condition WB °F	SPACE Room Dry Bulb °F	SPACE Supply Dry Bulb °F	SPACE Space Air Flow cfm	SPACE Space Sensible Load Btu/h	SPACE Space Latent Load Btu/h	COIL Peak Time Mo/Hr	COIL OA Condition DB °F	COIL OA Condition WB °F	COIL Supply Dry Bulb °F	COIL Coil Airflow cfm	COIL Coil Sensible Load Btu/h	COIL Coil Latent Load Btu/h
Alternative 1																	
FIRST - Boys W/C	Peak	120	7 /16	87	67	75.0	59.4	103	1,676	250	7 /14	87	68	59.4	100	1,651	403
FIRST - Day Care	Peak	4,522	7 /16	87	67	75.0	59.4	5,426	87,966	9,536	7 /15	88	68	59.4	5,347	100,045	13,107
FIRST - Day Care Entrance	Peak	369	7 /15	88	68	75.0	59.4	487	7,889	941	7 /15	88	68	59.4	487	9,086	941
FIRST - Day Care Hallway	Peak	133	6 /19	66	53	75.0	59.4	76	1,239	166	7 /14	87	68	59.4	74	1,301	166
FIRST - Girls W/C	Peak	95	6 /19	66	53	75.0	59.4	55	885	119	7 /14	87	68	59.4	53	929	119
FIRST - Handicap W/C	Peak	66	7 /15	88	68	75.0	59.4	65	1,050	233	7 /14	87	68	59.4	62	1,019	282
FIRST - Nursery	Peak	310	7 /15	88	68	75.0	59.4	408	6,610	988	7 /15	88	68	59.4	408	7,578	988
FIRST - Nursery W/C	Peak	31	7 /14	87	68	75.0	59.4	35	567	147	7 /14	87	68	59.4	35	583	147
FIRST - Office/Storage	Peak	210	7 /15	88	68	75.0	59.4	201	3,252	674	7 /14	87	68	59.4	199	3,317	806
VAV - DAYCARE	**Peak**	**5,856**		**87**	**67**	**75.0**	**59.4**	**6,855**	**111,133**	**13,056**		**88**	**68**	**59.4**	**6,764**	**125,509**	**16,959**
VAV - DAYCARE	**Block**	**5,856**	**7 /16**	**87**	**67**	**75.0**	**59.4**	**6,835**	**110,805**	**12,203**	**7 /15**	**88**	**68**	**59.4**	**6,773**	**125,564**	**16,692**
BASEMENT - Fire Exit	Peak	100	7 /15	88	68	75.0	55.4	126	2,567	665	7 /14	87	68	55.4	121	2,661	841
VAV - BACK EXIT (NE)	**Peak**	**100**		**88**	**68**	**75.0**	**55.4**	**126**	**2,567**	**665**		**87**	**68**	**55.4**	**121**	**2,661**	**841**
VAV - BACK EXIT (NE)	**Block**	**100**	**7 /15**	**88**	**68**	**75.0**	**55.4**	**126**	**2,567**	**665**	**7 /14**	**87**	**68**	**55.4**	**121**	**2,661**	**841**
BASEMENT - Boiler Room	Peak	808	7 /15	88	68	75.0	58.9	521	8,696	1,518	7 /14	87	68	58.9	514	9,226	1,680
BASEMENT - Computer Room	Peak	597	2 /19	13	12	75.0	58.9	320	5,336	746	7 /14	87	68	58.9	318	5,840	746
BASEMENT - Hallway #2	Peak	100	7 /15	88	68	75.0	58.9	65	1,087	192	7 /14	87	68	58.9	64	1,151	213
BASEMENT - Kitchen	Peak	413	7 /18	82	63	75.0	58.9	275	4,582	356	7 /17	85	65	58.9	272	4,929	489
BASEMENT - Mens W/C #1	Peak	221	7 /18	82	63	75.0	58.9	144	2,411	199	7 /17	85	65	58.9	143	2,597	263
BASEMENT - Multi Purpose	Peak	2,744	2 /19	13	12	75.0	58.9	1,469	24,528	3,430	7 /14	87	68	58.9	1,461	26,843	3,430
BASEMENT - Office #1	Peak	606	7 /18	82	63	75.0	58.9	399	6,662	532	7 /17	85	65	58.9	396	7,173	719
BASEMENT - Storage #1	Peak	110	7 /16	87	67	75.0	58.9	78	1,305	194	7 /15	88	68	58.9	78	1,391	246
BASEMENT - Storage #2	Peak	110	2 /19	13	12	75.0	58.9	59	983	138	7 /14	87	68	58.9	59	1,076	138
BASEMENT - Storage #3	Peak	86	2 /19	13	12	75.0	58.9	46	769	108	7 /14	87	68	58.9	46	841	108
BASEMENT - Womens W/C #1	Peak	221	7 /18	82	63	75.0	58.9	145	2,428	193	7 /17	85	65	58.9	144	2,616	262
VAV - BASEMENT	**Peak**	**6,016**		**85**	**65**	**75.0**	**58.9**	**3,522**	**58,788**	**7,606**		**88**	**68**	**58.9**	**3,494**	**63,684**	**8,295**
VAV - BASEMENT	**Block**	**6,016**	**7 /17**	**85**	**65**	**75.0**	**58.9**	**3,486**	**58,193**	**7,295**	**7 /15**	**88**	**68**	**58.9**	**3,456**	**62,963**	**8,677**
FIRST - Back Fire Exit	Peak	258	7 /15	88	68	75.0	56.3	271	5,243	1,163	7 /15	88	68	56.3	271	5,865	1,163
VAV - ENTRANCE (NW)	**Peak**	**258**		**88**	**68**	**75.0**	**56.3**	**271**	**5,243**	**1,163**		**88**	**68**	**56.3**	**271**	**5,865**	**1,163**
VAV - ENTRANCE (NW)	**Block**	**258**	**7 /15**	**88**	**68**	**75.0**	**56.3**	**271**	**5,243**	**1,163**	**7 /15**	**88**	**68**	**56.3**	**271**	**5,865**	**1,163**
BASEMENT - Entrance	Peak	294	7 /15	88	68	75.0	55.0	194	4,017	2,587	7 /15	88	68	55.0	194	4,425	2,587
BASEMENT - MAIN ENTRANCE	Peak	275	10 /15	57	47	75.0	55.0	1,503	31,157	926	8 /15	78	65	55.0	1,420	30,275	3,456
VAV - FRONT ENTRANCE (S)	**Peak**	**569**		**57**	**47**	**75.0**	**55.0**	**1,696**	**35,174**	**3,514**		**78**	**65**	**55.0**	**1,614**	**34,700**	**6,043**
VAV - FRONT ENTRANCE (S)	**Block**	**569**	**10 /15**	**57**	**47**	**75.0**	**55.0**	**1,591**	**32,980**	**1,731**	**8 /15**	**78**	**65**	**55.0**	**1,581**	**34,042**	**6,158**

System Zone Room		Floor Area ft²	SPACE Peak Time Mo/Hr	SPACE OA Condition DB °F	SPACE OA Condition WB °F	SPACE Room Dry Bulb °F	SPACE Supply Dry Bulb °F	SPACE Space Air Flow cfm	SPACE Space Sensible Load Btu/h	SPACE Space Latent Load Btu/h	COIL Peak Time Mo/Hr	COIL OA Condition DB °F	COIL OA Condition WB °F	COIL Supply Dry Bulb °F	COIL Coil Airflow cfm	COIL Coil Sensible Load Btu/h	COIL Coil Latent Load Btu/h
BASEMENT - Hallway	Peak	808	7 /15	88	68	75.0	55.0	414	8,583	2,058	7 /15	88	68	55.0	414	9,336	2,058
FIRST - Front Entrance	Peak	240	7 /19	79	60	75.0	55.0	1,064	22,068	457	7 /18	82	63	55.0	1,044	22,739	1,048
VAV - FRONT ENTRANCE (SW)	**Peak**	**1,048**		**79**	**60**	**75.0**	**55.0**	**1,478**	**30,651**	**2,515**		**82**	**63**	**55.0**	**1,458**	**32,075**	**3,106**
VAV - FRONT ENTRANCE (SW)	**Block**	**1,048**	**7 /19**	**79**	**60**	**75.0**	**55.0**	**1,436**	**29,763**	**1,532**	**7 /18**	**82**	**63**	**55.0**	**1,432**	**31,594**	**2,369**
BASEMENT - Canteen	Peak	123	7 /15	88	68	75.0	58.9	108	1,795	214	7 /15	88	68	58.9	108	1,857	214
BASEMENT - Gymnasium	Peak	4,447	6 /16	73	60	75.0	58.9	3,491	58,227	5,559	7 /17	85	65	58.9	3,440	73,561	5,559
BASEMENT - Mens Changroom	Peak	129	7 /12	82	66	75.0	58.9	122	2,030	202	7 /12	82	66	58.9	122	2,143	202
BASEMENT - Office #10	Peak	150	7 /12	82	66	75.0	58.9	136	2,271	241	7 /12	82	66	58.9	136	2,402	241
BASEMENT - Office #11	Peak	172	7 /12	82	66	75.0	58.9	148	2,468	268	7 /12	82	66	58.9	148	2,617	268
BASEMENT - Office #12	Peak	245	7 /15	88	68	75.0	58.9	278	4,637	938	7 /14	87	68	58.9	271	4,615	1,139
BASEMENT - Office #13	Peak	196	7 /14	87	68	75.0	58.9	161	2,689	583	7 /14	87	68	58.9	161	2,779	583
BASEMENT - Office #2	Peak	257	7 /12	82	66	75.0	58.9	462	7,702	617	7 /12	82	66	58.9	462	8,180	617
BASEMENT - Office #3	Peak	172	7 /12	82	66	75.0	58.9	517	8,628	403	7 /12	82	66	58.9	517	8,947	403
BASEMENT - Office #4	Peak	150	7 /12	82	66	75.0	58.9	249	4,151	362	7 /13	85	67	58.9	242	4,364	465
BASEMENT - Office #5	Peak	172	7 /12	82	66	75.0	58.9	261	4,359	390	7 /13	85	67	58.9	254	4,618	492
BASEMENT - Office #6	Peak	129	7 /13	85	67	75.0	58.9	135	2,248	374	7 /14	87	68	58.9	134	2,562	422
BASEMENT - Office #7	Peak	150	7 /13	85	67	75.0	58.9	154	2,569	443	7 /14	87	68	58.9	154	2,941	500
BASEMENT - Office #8	Peak	257	7 /12	82	66	75.0	58.9	203	3,385	411	7 /12	82	66	58.9	203	3,611	411
BASEMENT - Office #9	Peak	172	7 /12	82	66	75.0	58.9	149	2,485	272	7 /12	82	66	58.9	149	2,635	272
BASEMENT - Shower	Peak	86	7 /15	88	68	75.0	58.9	56	939	150	7 /14	87	68	58.9	56	983	163
BASEMENT - Spare Room	Peak	318	7 /15	88	68	75.0	58.9	342	5,700	1,127	7 /15	88	68	58.9	342	6,588	1,127
BASEMENT - Spare Room #2	Peak	245	7 /15	88	68	75.0	58.9	222	3,702	661	7 /14	87	68	58.9	214	3,695	775
BASEMENT - Stage	Peak	1,029	7 /15	88	68	75.0	58.9	924	15,410	2,573	7 /15	88	68	58.9	924	18,173	2,573
BASEMENT - Storage #4	Peak	86	7 /14	87	68	75.0	58.9	76	1,265	290	7 /14	87	68	58.9	76	1,479	290
BASEMENT - Womens Changroom	Peak	150	7 /12	82	66	75.0	58.9	114	1,902	237	7 /13	85	67	58.9	114	2,009	265
VAV - GYMNASIUM	**Peak**	**8,835**		**88**	**68**	**75.0**	**58.9**	**8,308**	**138,564**	**16,316**		**88**	**68**	**58.9**	**8,227**	**160,761**	**16,981**
VAV - GYMNASIUM	**Block**	**8,835**	**7 /15**	**88**	**68**	**75.0**	**58.9**	**7,989**	**133,236**	**16,705**	**7 /15**	**88**	**68**	**58.9**	**7,989**	**154,923**	**16,705**
FIRST - Office #1	Peak	270	7 /19	79	60	75.0	55.0	329	6,823	220	7 /18	82	63	55.0	329	7,739	491
FIRST - Office #2	Peak	149	7 /18	82	63	75.0	55.0	134	2,785	270	7 /17	85	65	55.0	131	3,210	467
FIRST - Office #3	Peak	135	7 /18	82	63	75.0	55.0	134	2,772	245	7 /17	85	65	55.0	129	3,119	426
FIRST - Office W/C	Peak	68	7 /18	82	63	75.0	55.0	53	1,101	120	7 /17	85	65	55.0	53	1,317	202
FIRST - Reception	Peak	258	7 /18	82	63	75.0	55.0	239	4,948	427	7 /17	85	65	55.0	229	5,612	673
FIRST - Staff Room	Peak	100	7 /18	82	63	75.0	55.0	161	3,337	222	7 /17	85	65	55.0	151	3,449	452
VAV-OFFICE	**Peak**	**980**		**82**	**63**	**75.0**	**55.0**	**1,050**	**21,766**	**1,504**		**85**	**65**	**55.0**	**1,022**	**24,446**	**2,712**
VAV-OFFICE	**Block**	**980**	**7 /18**	**82**	**63**	**75.0**	**55.0**	**1,049**	**21,754**	**1,775**	**7 /17**	**85**	**65**	**55.0**	**1,003**	**24,017**	**3,073**

Peak Heating Load

PEAK HEATING LOADS

MAIN SYSTEM

	OA Condition DB °F	OA Condition WB °F
Peak Time		
Htg Design	-33	-34

System Zone Room	Block or Peak	Floor Area ft²	SPACE Room Dry Bulb °F	SPACE Supply Dry Bulb °F	SPACE Space Air Flow cfm	SPACE Space Sensible Load Btu/h	COIL Supply Dry Bulb °F	COIL Coil Air Flow cfm	COIL Coil Sensible Load Btu/h
Alternative 1									
FIRST - Boys W/C	Peak	120	70.0	70.0	31	-4,420	70.0	0	-4,762
FIRST - Day Care	Peak	4,522	70.0	70.0	1,628	-196,755	70.0	0	-214,707
FIRST - Day Care Entrance	Peak	369	70.0	70.0	146	-13,569	70.0	0	-15,179
FIRST - Day Care Hallway	Peak	133	70.0	70.0	23	-240	70.0	0	-493
FIRST - Girls W/C	Peak	95	70.0	70.0	16	-172	70.0	0	-352
FIRST - Handicap W/C	Peak	66	70.0	70.0	19	-3,421	70.0	0	-3,636
FIRST - Nursery	Peak	310	70.0	70.0	122	-15,104	70.0	0	-16,453
FIRST - Nursery W/C	Peak	31	70.0	70.0	10	-1,857	70.0	0	-1,973
FIRST - Office/Storage	Peak	210	70.0	70.0	60	-9,385	70.0	0	-10,049
VAV - DAYCARE	**Peak**	**5,856**	**70.0**	**70.0**	**2,057**	**-244,924**	**70.0**	**0**	**-267,604**
VAV - DAYCARE	**Block**	**5,856**	**70.0**	**70.0**	**2,057**	**-244,924**	**70.0**	**0**	**-267,604**
BASEMENT - Fire Exit	Peak	100	70.0	70.0	38	-12,541	70.0	0	-13,115
VAV - BACK EXIT (NE)	**Peak**	**100**	**70.0**	**70.0**	**38**	**-12,541**	**70.0**	**0**	**-13,115**
VAV - BACK EXIT (NE)	**Block**	**100**	**70.0**	**70.0**	**38**	**-12,541**	**70.0**	**0**	**-13,115**
BASEMENT - Boiler Room	Peak	808	70.0	70.0	156	-11,423	70.0	0	-13,222
BASEMENT - Computer Room	Peak	597	70.0	70.0	96	-54	70.0	0	-1,158
BASEMENT - Hallway #2	Peak	100	70.0	70.0	20	-1,473	70.0	0	-1,697
BASEMENT - Kitchen	Peak	413	70.0	70.0	82	-3,405	70.0	0	-4,353
BASEMENT - Mens W/C #1	Peak	221	70.0	70.0	43	-1,647	70.0	0	-2,146
BASEMENT - Multi Purpose	Peak	2,744	70.0	70.0	441	-250	70.0	0	-5,323
BASEMENT - Office #1	Peak	606	70.0	70.0	120	-4,789	70.0	0	-6,167
BASEMENT - Storage #1	Peak	110	70.0	70.0	23	-2,374	70.0	0	-2,644
BASEMENT - Storage #2	Peak	110	70.0	70.0	18	-10	70.0	0	-214
BASEMENT - Storage #3	Peak	86	70.0	70.0	14	-8	70.0	0	-167
BASEMENT - Womens W/C #1	Peak	221	70.0	70.0	44	-1,760	70.0	0	-2,262
VAV - BASEMENT	**Peak**	**6,016**	**70.0**	**70.0**	**1,057**	**-27,194**	**70.0**	**0**	**-39,353**
VAV - BASEMENT	**Block**	**6,016**	**70.0**	**70.0**	**1,057**	**-27,193**	**70.0**	**0**	**-39,353**
FIRST - Back Fire Exit	Peak	258	70.0	70.0	81	-20,272	70.0	0	-21,423
VAV - ENTRANCE (NW)	**Peak**	**258**	**70.0**	**70.0**	**81**	**-20,272**	**70.0**	**0**	**-21,423**
VAV - ENTRANCE (NW)	**Block**	**258**	**70.0**	**70.0**	**81**	**-20,272**	**70.0**	**0**	**-21,423**
BASEMENT - Entrance	Peak	294	70.0	70.0	58	-8,074	70.0	0	-8,977
BASEMENT - MAIN ENTRANCE	Peak	275	70.0	70.0	451	-32,249	70.0	0	-39,259
VAV - FRONT ENTRANCE (S)	**Peak**	**569**	**70.0**	**70.0**	**509**	**-40,322**	**70.0**	**0**	**-48,237**

	OA Condition DB °F	OA Condition WB °F
Peak Time		
Htg Design	-33	-34

System Zone Room	Block or Peak	Floor Area ft²	SPACE Room Dry Bulb °F	SPACE Supply Dry Bulb °F	SPACE Space Air Flow cfm	SPACE Space Sensible Load Btu/h	COIL Supply Dry Bulb °F	COIL Coil Air Flow cfm	COIL Coil Sensible Load Btu/h
VAV - FRONT ENTRANCE (S)	**Block**	**569**	**70.0**	**70.0**	**509**	**-40,322**	**70.0**	**0**	**-48,237**
BASEMENT - Hallway	Peak	808	70.0	70.0	124	-8,029	70.0	0	-9,960
FIRST - Front Entrance	Peak	240	70.0	70.0	319	-32,985	70.0	0	-37,950
VAV - FRONT ENTRANCE (SW)	**Peak**	**1,048**	**70.0**	**70.0**	**443**	**-41,014**	**70.0**	**0**	**-47,910**
VAV - FRONT ENTRANCE (SW)	**Block**	**1,048**	**70.0**	**70.0**	**443**	**-41,014**	**70.0**	**0**	**-47,910**
BASEMENT - Canteen	Peak	123	70.0	70.0	32	-1,956	70.0	0	-2,327
BASEMENT - Gymnasium	Peak	4,447	70.0	70.0	1,047	-10,055	70.0	0	-22,094
BASEMENT - Mens Changroom	Peak	129	70.0	70.0	37	-2,165	70.0	0	-2,585
BASEMENT - Office #10	Peak	150	70.0	70.0	41	-2,606	70.0	0	-3,076
BASEMENT - Office #11	Peak	172	70.0	70.0	44	-2,656	70.0	0	-3,166
BASEMENT - Office #12	Peak	245	70.0	70.0	83	-14,364	70.0	0	-15,323
BASEMENT - Office #13	Peak	196	70.0	70.0	48	-6,053	70.0	0	-6,609
BASEMENT - Office #2	Peak	257	70.0	70.0	139	-13,540	70.0	0	-15,132
BASEMENT - Office #3	Peak	172	70.0	70.0	155	-11,628	70.0	0	-13,412
BASEMENT - Office #4	Peak	150	70.0	70.0	75	-7,682	70.0	0	-8,540
BASEMENT - Office #5	Peak	172	70.0	70.0	78	-7,731	70.0	0	-8,633
BASEMENT - Office #6	Peak	129	70.0	70.0	40	-5,009	70.0	0	-5,474
BASEMENT - Office #7	Peak	150	70.0	70.0	46	-5,919	70.0	0	-6,451
BASEMENT - Office #8	Peak	257	70.0	70.0	61	-4,030	70.0	0	-4,730
BASEMENT - Office #9	Peak	172	70.0	70.0	45	-2,787	70.0	0	-3,301
BASEMENT - Shower	Peak	86	70.0	70.0	17	-1,114	70.0	0	-1,308
BASEMENT - Spare Room	Peak	318	70.0	70.0	103	-16,687	70.0	0	-17,865
BASEMENT - Spare Room #2	Peak	245	70.0	70.0	67	-8,322	70.0	0	-9,087
BASEMENT - Stage	Peak	1,029	70.0	70.0	277	-36,007	70.0	0	-39,194
BASEMENT - Storage #4	Peak	86	70.0	70.0	23	-3,215	70.0	0	-3,477
BASEMENT - Womens Changroom	Peak	150	70.0	70.0	34	-2,195	70.0	0	-2,589
VAV - GYMNASIUM	**Peak**	**8,835**	**70.0**	**70.0**	**2,492**	**-165,723**	**70.0**	**0**	**-194,373**
VAV - GYMNASIUM	**Block**	**8,835**	**70.0**	**70.0**	**2,492**	**-165,723**	**70.0**	**0**	**-194,373**
FIRST - Office #1	Peak	270	70.0	70.0	99	-11,162	70.0	0	-12,697
FIRST - Office #2	Peak	149	70.0	70.0	40	-5,363	70.0	0	-5,989
FIRST - Office #3	Peak	135	70.0	70.0	40	-5,094	70.0	0	-5,718
FIRST - Office W/C	Peak	68	70.0	70.0	16	-2,157	70.0	0	-2,404
FIRST - Reception	Peak	258	70.0	70.0	72	-7,448	70.0	0	-8,561
FIRST - Staff Room	Peak	100	70.0	70.0	48	-6,747	70.0	0	-7,497
VAV-OFFICE	**Peak**	**980**	**70.0**	**70.0**	**315**	**-37,970**	**70.0**	**0**	**-42,867**
VAV-OFFICE	**Block**	**980**	**70.0**	**70.0**	**315**	**-37,970**	**70.0**	**0**	**-42,867**

APPENDIX D - TRACE700 CALCULATIONS

The first step to confirming the TRACE 700 simulation outputs is calculating the measure of energy within the system. This measurement will include the internal energy, and the amount of energy that the facility requires to make room for the incoming energy through the displacement of its environment. To begin, the total heat leakage equation, along with the specific enthalpy equations for windows, doors, walls, and the roof can be found below: (ASHRAE, 2013)

Total Heat Leakage (Enthalpy, $\frac{BTU}{hr}$):

Windows & Doors: $H = U \cdot A(t_o - t_i) + A \cdot SC \cdot SHGF$ [1]

Walls & Roof: $H = U \cdot A(t_o - t_i)$ [2]

The below sensible heat calculation can be used to verify that the simulated data is reasonable to use throughout the energy analysis of Little Souls Daycare. The below data has been taken from the single pane office glass and doors found in Appendix C.

$$H\frac{BTU}{hr} = 0.962 \cdot (68ft^2) \cdot (70 - (-33)) + 68ft^2 \cdot SC \cdot SHGF$$

Since there are windows on the West side, choose worst $SHGF = 41\frac{BTU}{hr \cdot ft^2}$

Assume no shading: $SC = 1.00$

$$H\frac{BTU}{hr} = 0.962 \cdot (68ft^2) \cdot (103) + 68ft^2 \cdot 1.00 \cdot 41$$

$$H\frac{BTU}{hr} = 9525.85$$

It should be noted that the program simulation does not account for SC or SHGF, which is a reasonable assumption. As such, the program simulation outputs a value of $H\frac{BTU}{hr} = 6772$. When repeating the previous sensible heat calculation without accounting for SC or SHGF, the value is:

$$H\frac{BTU}{hr} = 0.962 \cdot (68ft^2) \cdot (103)$$

$$H\frac{BTU}{hr} = 6737.85$$

This value is within 0.006% of the simulated value, and therefore the simulated data can be used as a reasonable representation of the physical system.

The below sensible heat calculation can be used to verify that the simulated data is reasonable to use throughout the energy analysis of Little Souls Daycare.

$$H\frac{BTU}{hr} = 0.605 \cdot (68ft^2) \cdot (70 - (-33)) + 68ft^2 \cdot SC \cdot SHGF$$

Since there are windows on the West side, choose worst $SHGF = 41\frac{BTU}{hr \cdot ft^2}$

Assume no shading: $SC = 1.00$

$$H\frac{BTU}{hr} = 0.605 \cdot (68ft^2) \cdot (103) + 68ft^2 \cdot 1.00 \cdot 41$$

$$H\frac{BTU}{hr} = 7025.42$$

It should be noted that the program simulation does not account for SC or SHGF, which is a reasonable assumption. As such, the program simulation outputs a value of $H\frac{BTU}{hr} = 4256$. When repeating the previous sensible heat calculation without accounting for SC or SHGF, the value is:

$$H\frac{BTU}{hr} = 0.605 \cdot (68ft^2) \cdot (103)$$

$$H\frac{BTU}{hr} = 4237.42$$

This value is within 0.437% of the simulated value, and therefore the simulated data can be used as a reasonable representation of the physical system.

The below sensible heat calculation can be used to verify that the simulated data is reasonable to use throughout the energy analysis of Little Souls Daycare.

$$H\frac{BTU}{hr} = 0.281 \cdot (68ft^2) \cdot (70 - (-33)) + 68ft^2 \cdot SC \cdot SHGF$$

Since there are windows on the West side, choose worst $SHGF = 41\frac{BTU}{hr \cdot ft^2}$

Assume no shading: $SC = 1.00$

$$H\frac{BTU}{hr} = 0.281 \cdot (68ft^2) \cdot (103) + 68ft^2 \cdot 1.00 \cdot 41$$

$$H\frac{BTU}{hr} = 4756.12$$

It should be noted that the program simulation does not account for SC or SHGF, which is a reasonable assumption. As such, the program simulation outputs a value of $H\frac{BTU}{hr} = 1978$. When repeating the previous sensible heat calculation without accounting for SC or SHGF, the value is:

$$H\frac{BTU}{hr} = 0.281 \cdot (68ft^2) \cdot (103)$$

$$H\frac{BTU}{hr} = 1968.12$$

This value is within 0.499% of the simulated value, and therefore the simulated data can be used as a reasonable representation of the physical system.

The above calculation verifications prove that the outputs generated by the TRACE 700 software system are accurate and coincide with the values calculated using equations found in textbooks (Harris, 1983). The enthalpy values, given in BTU/hr (British Thermal Units per hour), were calculated using the basic equation provided by the textbook. Total enthalpy, in terms of air conditioning or heating an indoor space, is given by the total sensible heat summed with the total latent heat. Sensible heat, as defined by Harris, is "heat which, when supplied to or removed from a substance, produces temperature which is measurable by a thermometer" (Harris, 1983). In other words, sensible heat is heat that can be physically measured and felt by human touch. In contrast, latent heat as defined by Harris, is “heat which, when supplied to or removed from a substance, produces a change of state without any change in temperature” (Harris, 1983). Therefore, latent heat can be described as the heat required to change the state of water from liquid to gas, or solid to liquid. This occurrence can be seen through experimental means.

APPENDIX E - LIST OF ALTERNATIVES

The complete list of alternatives is provided below. These alternatives include the implementation of the suggested HVAC system for the entire building system (not broken into zones). However, the cost of implementing a HVAC system for each individual 'zone' is given above in the cost analysis portion of the report. A priority list for implementation is presented in section 7.2 of the report, and provides a recommended plan of action for Souls Harbour, Dean Smith Youth Center.

Alternative	Options Included	Approximate Total Cost
1. Mid-Efficiency HVAC system	Mid-efficiency roof-top units; includes all necessary ductwork, materials, labor and installation; less structural improvements to roof supports (if required)	$218,798.34
2. Mid-Efficiency HVAC system with Window Upgrades	Same as alternative (1); includes upgrades to all single-pane windows to triple-pane low-e windows	$253,198.34
3. Mid-Efficiency HVAC system with Insulation Upgrades	Same as alternative (1); includes upgrades to insulation along grade wall and other areas identified by infrared scanning	$234,698.34
4. Mid-Efficiency HVAC system with Skylight Upgrades	Same as alternative (1); includes sealing, insulating and covering of skylights in gymnasium area	$219,298.34
5. Mid-Efficiency HVAC system with Window and Insulation Upgrades	Alternative (2) and (3) combined	$269,098.34
6. Mid-Efficiency HVAC System with Window and Skylight Upgrades	Alternative (2) and (4) combined	$253,698.34
7. Mid-Efficiency HVAC System with Insulation and Skylight Upgrades	Alternative (3) and (4) combined	$235,198.34

8. Mid-Efficiency HVAC System with All Upgrades	Alternative (2), (3) and (4) combined	$269,598.34
9. High-Efficiency HVAC system	Mid-efficiency roof-top units; includes all necessary ductwork, materials, labor and installation; less structural improvements to roof supports (if required)	$252,660.12
10. High-Efficiency HVAC system with Window Upgrades	Same as alternative (9); includes upgrades to all single-pane windows to triple-pane low-e windows	$287,060.12
11. High-Efficiency HVAC system with Insulation Upgrades	Same as alternative (9); includes upgrades to insulation along grade wall and other areas identified by infrared scanning	$268,560.12
12. High-Efficiency HVAC system with Skylight Upgrades	Same as alternative (9); includes sealing, insulating and covering of skylights in gymnasium area	$253,160.12
13. High-Efficiency HVAC system with Window and Insulation Upgrades	Alternative (10) and (11) combined	$302,960.12
14. High-Efficiency HVAC System with Window and Skylight Upgrades	Alternative (10) and (12) combined	$287,560.12
15. High-Efficiency HVAC System with Insulation and Skylight Upgrades	Alternative (11) and (12) combined	$269,060.12
16. High-Efficiency HVAC System with All Upgrades	Alternative (10), (11) and (12) combined	$303,460.12

This list of alternatives provided gives the client an overview of the options available for implementation, and the associated cost of implementation. For a full breakdown of the cost structure, please refer to section 6.2.2 of the report.