1.0 BUILDING OVERVIEW

1.1 SITE, ARCHITECTURE AND CONSTRUCTION

In 2000, when The Art Institute of Pittsburgh (AIP) moved across town to its current location on 420 Boulevard of the Allies, a considerable distance was created between the college and its sponsored housing at the Allegheny Center Apartment complex. Therefore, as can be seen in Figure 1.1-b the location of the Try Street Terminal Building at 620 Second Avenue provides a housing solution that is much closer to the AIP college campus.

Figure 1.1-a AIP Campus to Allegheny Center

Figure 1.1-b AIP Campus to Try Street Terminal

In addition to the distance created by the Art Institute of Pittsburgh's move in 2000, six years ago the college changed their degree program from a 2-year associate degree to a 4-year bachelor's degree program. This resulted in a greater need to house the increased number of students in the program. Consequently, the Art Institute became far more involved in residential construction. The Try Street Terminal Building has

since become 1 of 3 Downtown building renovations that the college is involved in. The restoring of these old building is not only meeting the needs of the Art Institute, but the city as well. These renovations are helping to bring younger people back to the city.

The building at 620 Second Avenue was originally constructed in 1910 as a nine-story concrete warehouse structure. With the disappearance of the railroad the use of the building has changed throughout the years. The building also known as, The Keystone Grocery Building, was also a former site of American Thermoplastics.

Figure 1.1-c The Try Street Terminal Building on left

Renovations, including the addition of a mezzanine level between floors 1 and 2, have transformed this 230,000 square foot building into a 10-story apartment complex which can accommodate 650 residents. Although the main function is to provide apartments for the Art Institute of Pittsburgh, other features include: a two-story atrium, sports

court and recreation space, 11,000 square foot activities lounge, and 9,000 square feet of retail space reserved for a convenience store and casual dining restaurant.

Because the project does include renovations to an industrial building that was constructed in 1910, special considerations were taken in order to preserve the appearance of the building's façade. In fact, according to a news article found on The Art Institute's website, the building is in the process of being designated a historic landmark. A lightwell in the core of the building was also added in order to satisfy a natural lighting requirement for the interior apartments set forth by the IBC 2003. The building footprint is approximately 24,600 square feet. On the 2nd through 9th floors, a 30 foot by 50 foot lightwell was cut in the core of the building. A driveway approximately equal to 3,700 square feet reduces the area on floors 1, 1A and the basement. Also equal to 3,700 square feet, a building setback decreases the area of the 8th and 9th floors. The primary focus of this project will be the apartment units on floors one through nine.

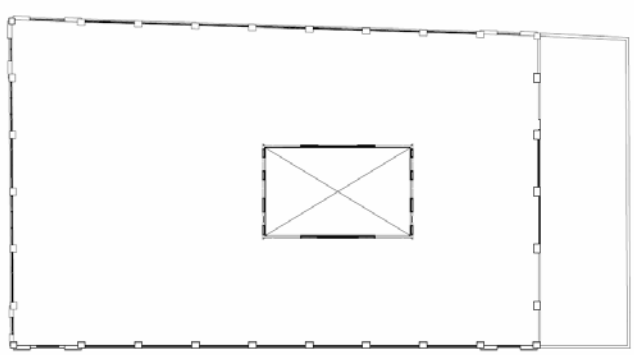


Figure 1.1-d Building Footprint - also shows location of lightwell and setback

Construction began on the existing structure in October 2005. The project team includes: **TKA Architects** as the architect, **Massaro Corporation** as the general

contractor, **The Kachelle Group** as structural engineer, **McKamish** as mechanical engineer, **Sauer, Inc.** as plumbing engineer, **Ruthrauff, Inc.** for fire protection and **Star Electric Company** as the electric engineer. The Try Street Terminal Building is still currently under construction and is expected to be complete in June 2007.

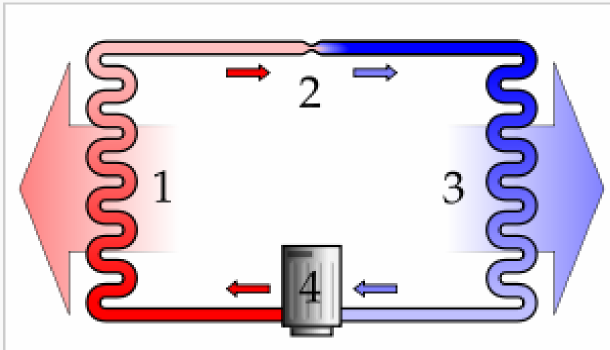
1.2 EXISTING MECHANICAL SYSTEM

The existing mechanical system consists of water source heat pumps (WSHPs) fed by 2 boilers and a fluid cooler on the roof. The 1st through 9th floor apartments are served by this system. Four self contained air handling units serve the unassigned basement and first floor spaces.

1.2.1 HEAT PUMP OPERATION

Heat pumps are devices that operate on a cycle known as vapor compression refrigeration. This cycle consists of four basic components which include the condenser coil, expansion valve, evaporator coil and compressor.

The condenser coil acts as a heat exchanger through which high temperature refrigerant flows and transfers its heat to a heat sink. During this process, the vapor condenses to a liquid which remain at a high temperature and high pressure. This liquid refrigerant then flows through an expansion valve where the temperature and pressure of the fluid are reduced. The liquid then flows through an evaporator which absorbs heat from the heat source. The heat source is the medium to be cooled. Therefore, as the source is cooled the refrigerant is heated causing it to evaporate within the coil back to a low pressure, low temperature vapor. Finally, this vapor then enters the compressor where its pressure and temperature are raised to a value in which it can condense back into a liquid in the following condenser step.



A diagram of a simple heat pump's vapor-compression refrigeration cycle: 1) condenser, 2) expansion valve, 3) evaporator, 4) compressor.

Figure 1.2-a Vapor Compression Refrigeration Cycle

Heat pumps also include an additional component called a reversing valve which reverses the direction of the refrigerant flow. Reversing the flow provides the heat pump with the capability of providing heating or cooling to the building. When the valve is switched the condenser functions as the evaporator and the evaporator functions as the condenser.

Conventional or geothermal exchange may be used by the heat pump system in order to absorb heat or reject heat to the environment. Geothermal exchange will be studied later in this report.

1.2.2 WATER SOURCE HEAT PUMPS

The conventional WSHP system in the Try Street Terminal Building is a heating and cooling system which places a Whalen Series VI heat pump in each individual zone. A piping system that connects this conventional system circulates water between 60F and 90F to and from the heat pumps. The advantage of this arrangement is that the heat pumps are capable of simultaneously heat and cooling. When this occurs the water loop generally maintains its 60-90F range because heat removed from one space is rejected to the loop and then used to heat a space that is in heating mode.

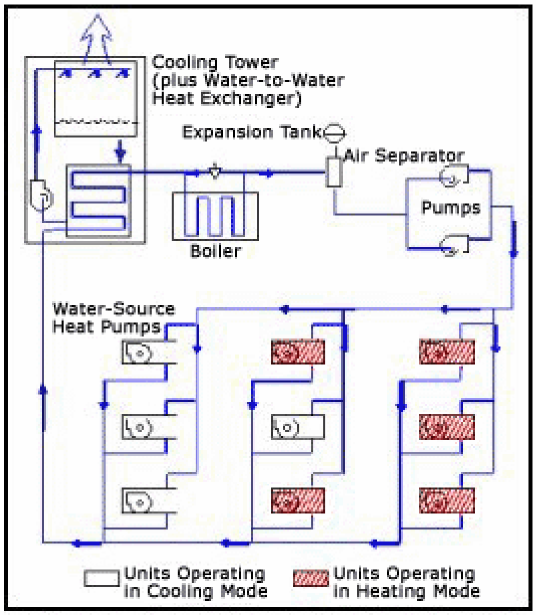


Figure 1.2-b WSHP System - can simultaneously heat and cool

When the majority of the units are in the heating mode, the loop temperature may fall below the lower range limit of 60F. In that case, heat will be added to the loop by the two Raypak gas fired boilers. This hot refrigerant flows through the air coil then warms the air to be supplied to the conditioned space. Heat added to the room is removed from the water through the water coil and through the rejected compressor heat.

In cooling mode, the loop temperature may exceed the upper limit of 90F. Therefore, a Baltimore Aircoil Company, FXV closed circuit cooling tower provides the necessary condenser water to the heat pumps. This cold refrigerant flows through the coil which then cools the conditioned supply air. Heat removed from the air is transferred to the water flowing through the water coil.

1.2.3 LAYOUT OF AIR HANDLING UNITS

The existing mechanical system in the Try Street Terminal Building consists of 8 new air handling units. Four Carrier indoor self contained, air-cooled vertical package units supply constant volume cooling of 47 tons to the basement and first floor unassigned spaces. For each of these units, approximately 30% of the supply air is fresh outdoor air. The units are also equipped with electric open coil duct heaters which provide the necessary heating. The other four units are Aaon rooftop make-up air units (MAUs). These MAUs are 100% outdoor air units that provide 122 tons of cooling. They supply the required ventilation to all the apartments and corridors on floors 1-9. The lobby is also served by these units. Since the Carrier air handling units serve unassigned spaces in the basement and first floor, these areas were not a focus of the project. The focus of this project is primarily on the apartment spaces on floors 1-9. The general distribution of the outdoor air supplied by the MAUs to floors 1-9 is shown below.

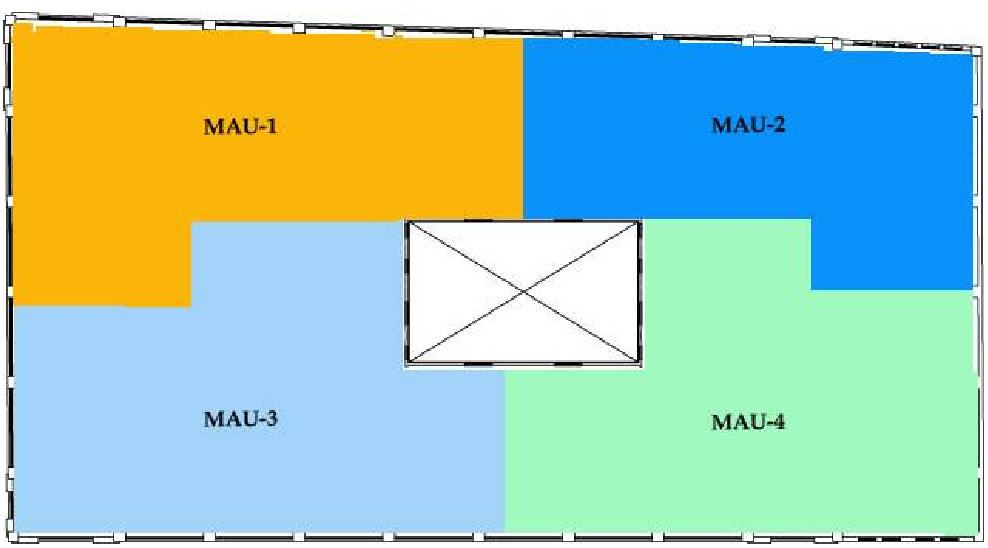


Figure 1.2-c Floors 1-9 General existing MAU layout

In addition to the units discussed above, a 10 ton fan coil unit was designed to supply the required outdoor air to the exercise room located on the first floor.

1.2.4 VENTILATION ANALYSIS: STANDARD 62.1

The main purpose of ASHRAE Standard 62.1-2004 is to specify the minimum ventilation requirements and consequent indoor air quality that will be considered acceptable to human occupants. For new buildings and renovations to existing buildings, the standard is intended to be used as a way to regulate the indoor air quality by prescription. Acceptable indoor air quality is defined as air having no harmful concentrations of contaminants. Using the Ventilation Rate Procedure it was shown that the make up air units, air handling units and fan coil unit were sized more than adequately in order to achieve an acceptable indoor air quality level.

SUMMARY OF UNITS			
UNIT NAME	V_{ot} (cfm)	OA SUPPLIED (cfm)	COMPLIES WITH STANDARD 62.1?
MAU-1	3,461	5,625	YES
MAU-2	1,988	4,820	YES
MAU-3	3,049	7,550	YES
MAU-4	2,896	5,830	YES
AHU-1	2,193	2,490	YES
AHU-2	907	1,300	YES
AHU-3	2,085	2,220	YES
AHU-4	752	960	YES
FCU-6	2,365	4,000	YES
*Note: V_{ot} is the required outdoor air intake flow			

Figure 1.2-d Ventilation air comparison

1.2.5 LEED ASSESSMENT

The Leadership in Energy and Environmental Design (LEED) rating systems were developed by the U.S. Green Building Council (USGBC) committees and meant to encourage sustainable design. The rating system is applicable to new commercial construction, as well as major renovation project. The 6 major categories that make up the rating system are: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process. Although the Try Street Terminal Building was a major renovation project, only a few points were earned in this assessment. Therefore, no certification was earned. LEED design was not considered in the original plans for the building nor was it considered in the alternative designs.

1.2.6 ASHRAE STANDARD 90.1 ASSESSMENT

The purpose of ASHRAE Standard 90.1 is to provide minimum requirements for the energy-efficient design of buildings with the exception of low-rise residential buildings. This standard applies to the building envelope, as well as the following systems and equipment used in buildings:

- heating, ventilation and air conditioning
- service water heating
- electric power distribution and metering provisions
- electric motors and belt drives
- lighting

The main focus of the Try Street Terminal assessment was on the building envelope and lighting compliance.

1.2.6.1 BUILDING ENVELOPE COMPLIANCE

The building envelope refers to the walls, windows, and roof that separate a building's indoor conditioned spaces from the outdoor environment. Carrier's Hourly Analysis Program (HAP) was used to determine the wall, roof and window U-values which all complied with the standard. The vertical and skylight fenestration areas also complied.

1.2.6.2 LIGHTING COMPLIANCE

The interior power lighting allowance is determined to minimize energy usage. When calculating the lighting compliance it was found that only half the spaces complied with Standard 90.1.

1.2.7 LOST RENTABLE SPACE

The mechanical system lost rentable space can be best described as the space occupied by mechanical equipment, rooms and shafts. Because these mechanical spaces reduce the amount of space rentable by the tenants, the space is considered to be a lost profit by the owner. For the Try Street Terminal Building, the lost rentable space appears to be minimized with only a 2.8% total impact on the basement through ninth floors. It is likely that this impact is minimized because of the mechanical penthouse and equipment, such as exhaust fans and make-up air units, being located on the roof.

1.2.8 MECHANICAL FIRST COST

The total HVAC cost for the Try Street Terminal Building amounted to $2,014,000.00 for floors 1-9. Therefore, the approximate cost per square foot is $9.17/ft^2. A more detailed breakdown of the mechanical cost was requested. However, this information was not available.

1.2.9 ENERGY ANALYSIS

Because the Try Street Terminal Building is currently under construction actual energy data was not available. Also, an energy analysis from the designer was not available for comparison because one was not performed. An analysis was not completed because first cost was the primary concern of the project. However, an energy analysis was conducted using Carrier's HAP for comparison to thesis depth work discussed later in this report.

Since the building's primary function is apartments, a 24 hour fully occupied schedule was assumed. The only exception to this schedule was made was for an assumed first floor retail space. In that case, the schedule was estimated from 8:00am to 9:00pm. The following tables and figures depict the existing building's annual energy consumption, as well as, the associated component and energy costs. It should also be noted that many assumptions were made in order to simplify the calculation process. Therefore, these assumptions may be the source of any inaccuracies.

Also, the source of energy for the Try Street Terminal Building is both electric and natural gas sources. Based on rates from respective energy provider websites, the energy rates assumed for this analysis were $0.087 per kWh and $1.594 per therm.

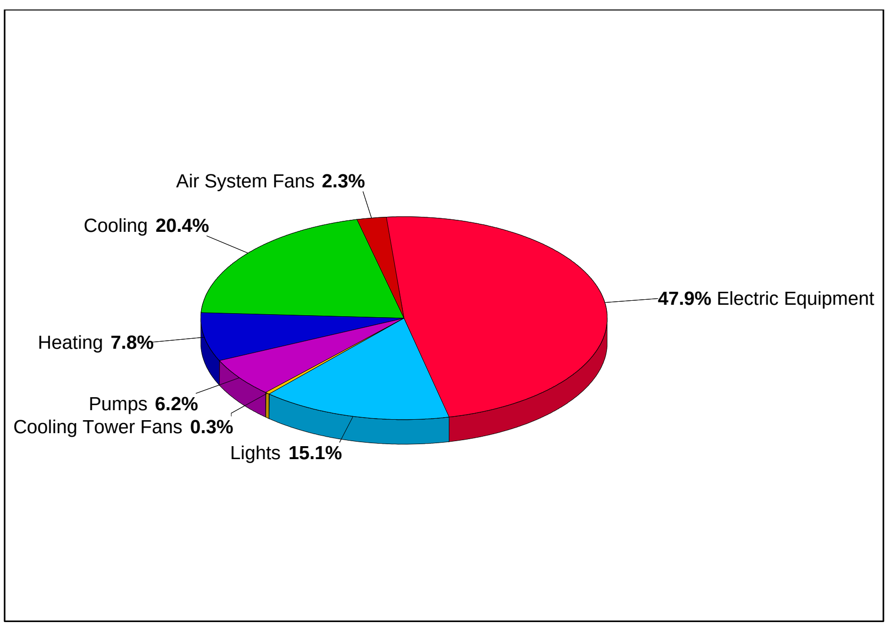


Figure 1.2-e Annual Component Costs - Existing Building

Component	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	21,335	0.127	2.3
Cooling	187,220	1.115	20.4
Heating	71,185	0.424	7.8
Pumps	56,924	0.339	6.2
Cooling Tower Fans	3,201	0.019	0.3
HVAC Sub-Total	**339,865**	**2.024**	**37.1**
Lights	138,214	0.823	15.1
Electric Equipment	439,187	2.615	47.9
Non-HVAC Sub-Total	**577,402**	**3.439**	**62.9**
Grand Total	**917,266**	**5.463**	**100**

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area **167920.4** ft²

Conditioned Floor Area **167920.4** ft²

Table 1.2-a Annual Component Costs - Existing Building

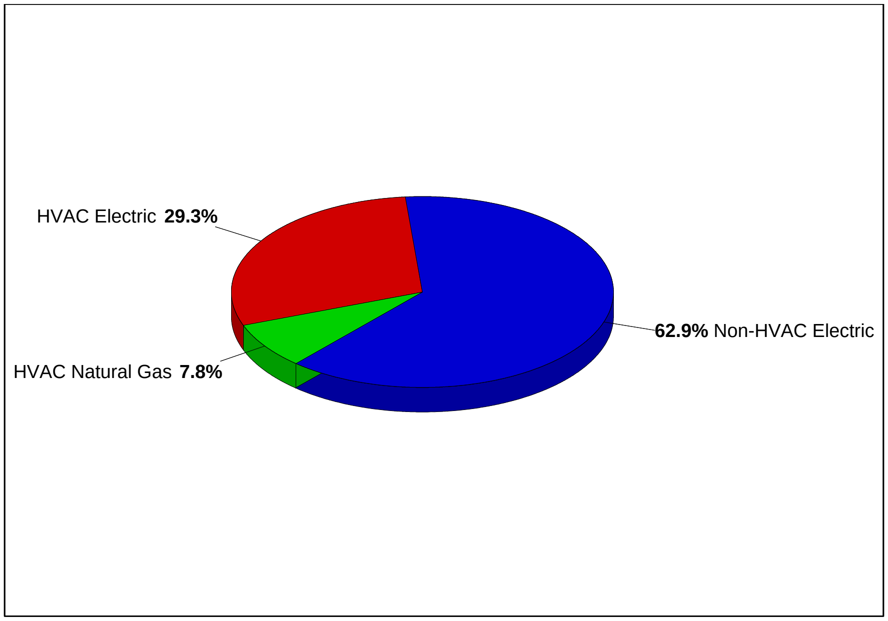


Figure 1.2-f Annual Energy Costs - Existing Building

Component	Annual Cost ($/yr)	($/ft²)	Percent of Total (%)
HVAC Components			
Electric	268,765	1.601	29.3
Natural Gas	71,097	0.423	7.8
HVAC Sub-Total	**339,863**	**2.024**	**37.1**
Non-HVAC Components			
Electric	577,381	3.438	62.9
Natural Gas	0	0	0
Non-HVAC Sub-Total	**577,381**	**3.438**	**62.9**
Grand Total	**917,243**	**5.462**	**100**

Note: Cost per unit floor area is based on the gross building floor area.

Gross Floor Area	**167920.4**	ft²
Conditioned Floor Area	**167920.4**	ft²

Table 1.2-b Annual Energy Costs - Existing Building

It should also be noted that this model for the existing building differs from the model presented in last semester's technical reports. In the previous model a pumping component and energy cost was nearly fifty percent of the cost. Therefore, further review of the model was completed and a new model was generated. The results of this energy model as seen above seems to depict numbers that correspond more to my building application.