Study of Energy Conservation Alternatives

Peaks Island Library and Community Center

For Peaks Energy Action Club

Portland, ME

Holbrook Engineering, LLC

December, 2015

1. INTRODUCTION

The Peaks Island Library and Community Center will be undergoing a renovation/expansion to better suit the needs of the community. The Peaks Energy Action Club (PEAC) is interested in ensuring the changes include cost effective energy conservation measures and has commissioned this Study to examine the financial impact of several construction alternatives.

Energy conservation efforts at the Library and Community Center are complicated by the fact that the Library and Community Center share a building and central heating system with the Portland Police and Fire Departments. The portion of the Building devoted to Public Safety is not directly part of this Study, but it does limit the number of energy conservation measures available at the Library and Community Center.

This Study uses computerized energy modeling and mechanical system cost estimating to compare various construction alternatives from a financial perspective.

2. METHOD

The existing building and its HVAC systems were examined in the field and further architectural and mechanical information was obtained through study of the Building design drawings. Occupancy schedules and thermostat settings were also obtained. This information was used to create a computerized Energy Model of the Building. The Model calculated the heating and cooling loads in the Building through out the year as well as the amount and type of energy necessary to compensate for those loads. The results for the existing Building were then compared to the actual energy usage to verify the accuracy of the Model.

The changes intended in the upcoming renovation/expansion were then added to the Model and the resulting energy usage was used as a Baseline to compare alternative energy conservation measures.

The construction costs for each of the energy conservation alternatives was estimated by determining required systems, equipment and capacities and then estimating their installation costs through use of Mean's Estimating Publications, budget quotations from vendors and costs incurred on previous construction projects.

Maintenance costs and equipment life expectancies were determined through use of industry and government publications.

Expected utility costs were used to calculate the energy costs for the Baseline and each Alternative. The expected energy cost savings, along with the construction and maintenance costs for each Alternative, are presented in numeric and graphical form for each Alternative considered. The expected utility costs are $0.05404/KWH and $2.48/gallon of Fuel Oil.

The reduction in CO2 emissions were also calculated and are presented in numerical form for each of the Alternatives considered. CO2 emissions by source are 0.588 lbs/KWH and 22.4 lbs/gallon of Fuel Oil.

3. CURRENT BUILDING ENVELOPE

The Building was constructed in two different stages:

Original Building

The Public Safety offices and living quarters were original constructed as a residence around 1880. This construction is brick walls with interior gypsum board supported by wood furring against the brick walls. There is a Basement, 1st Floor and 2nd floor with an attic. Insulation was added to the original building when the addition was constructed and consists of 1 ½" polystyrene in the walls and 12" of fiberglass batt in the attic. At some point, the attic insulation was removed from about 50% of the attic space and today there is only the gypsum board ceiling between the occupied space and attic.

The windows have been replaced and are typical vinyl double hung windows.

1979 Addition

The Garage, Community Center, Library and ancillary spaces are contained in the 1979 Addition. The addition is built on a slab and the walls are concrete block with brick siding. There is 2" of polystyrene insulation between the brick and block.

The roof/ceiling construction varies:

- In the Garage, there is 12" of fiberglass batt above an acoustic ceiling. Above the insulation, is a wood truss attic with a wood roof deck.
- The Library has a cathedral style ceiling with acoustic ceiling tiles hung on a parallel plane to the roof above. There is 12" of fiberglass batt on the sloped ceiling tiles. The roof is wood deck on wood rafter with steel posts and beams.
- The ancillary spaces and Community Center have horizontal acoustic ceilings with 12" of batt. There is attic space above the insulation with the wood rafter and wood roof deck above.

The windows have been replaced and are vinyl double hung style.

4. CURRENT HVAC SYSTEM

The Building heat is generated in a late model, cast iron, hot water boiler with a fuel oil burner. There are four circulating pumps for separate areas of the Building:

- Public Safety Department 1st Floor
- Public Safety Department 2nd Floor
- Garage
- Library, Community Center

The pump for the Library/Community Center can be energized through 3 different thermostats that will both start the pump and open a zone valve for the fin tube that serves the associated thermostat:

- Library
- Community Center
- Library Entry Foyer

An additional two thermostats located in the Library 2nd Floor Store Room and the Foyer Office will open their zone valves to allow heating when the Library/Community Center circulating pump is running.

Fin Tube is used throughout the Building to transfer heat to the spaces with the exception of the Public Safety stairway which uses a Convector, the Garage which uses two vertical throw Unit Heaters and the Library Entry Foyer which uses a Cabinet Unit Heater.

During the summer several residential window style air conditioners are used to provide cooling. These units are removed each winter.

There is no mechanical ventilation system in any portion of the Building. The Restrooms and Utility Room in the Library Community Center have exhaust fans.

There are two electric water heaters in the Building. One serving the Public Safety Department and one serving the Library/Community Center.

Currently there is no means for Portland Buildings (maintainer of the Building) to remotely monitor HVAC set points, space temperatures or equipment function. Mechanical problems or unintended set points remain unresolved until discovered by the building occupants. Though difficult to quantify, this is an expensive process from the City of Portland perspective as it results in emergency maintenance calls as well as unnecessary heating and cooling.

The remote location of the Library makes it a good candidate for an HVAC control system with remote monitoring capability.

5. PLANNED RENOVATION/EXPANSION

The current plans for the Library expansion will add approximately 315 sf to the Library and another 175 sf by reconfiguring the internal layout.

The renovation will upgrade the thermal envelope of the existing Library and Community Center section of the Building. The new thermal values for both existing and new envelope components are projected to be:
R-50 Ceiling/Roof Assembly
R-30 Exterior Wall Assembly
R-29 (equivalent) Slab Assembly

In addition to improved thermal values, the envelope improvements will also decrease infiltration of outside air into the Building. "Tightening" the Building will result in a significant energy savings as less energy will be spent on conditioning the infiltrating air.

The improved Building envelope will result in a net decrease in the heat loss when compared to the current condition.

6. ASSUMED HVAC DESIGN FOR THE RENOVATION/EXPANSION

HVAC for the reconfigured Library and ancillary spaces has not been designed. However, many of the requirements and constraints for the new HVAC are known:

- The renovation/expansion has limited budget. The base HVAC budget should be kept at the minimum possible to meet Building Code and Owner requirements.
- Air Conditioning is required in the Library, Community Center, Entry Foyer and Library Offices.
- Mechanical Ventilation is required in the Library and Community Center
- The HVAC Control System will include remote monitoring capability

This Study is based on the following design criteria:

- The Library Occupancy schedule will remain at 20 hours per week.
- The Community Center is assumed to be Occupied 30 hours per week.

To meet these criteria, the following HVAC design is assumed for the Baseline energy usage case:

- Hydronic fin tube will be added to the Library to make up for the lost fin tube along the South wall.
- A Cabinet Unit Heater will be added to the Lobby
- Air Conditioning will be provided by using ductless split air conditioners with high wall fan coils.
- Air Conditioning Fan Coils will be located in the Library, Community Center, Foyer and both upstairs Library Offices
- Ventilation air will be provided by a fan coil using hydronic heat
- Programmable thermostats will be used to change heating and cooling set points when the spaces are Unoccupied. The thermostats will be connected to a local Building Controller that will have an internet link available to Portland Buildings.

7. MODELLED ALTERNATIVES

Four upgrades were modelled to determine their impact on energy usage at the Library/Community Center

A. Install Heat Pumps instead of Air Conditioners
B. Install a Heat Recovery Ventilator instead of a Ventilation Fan Coil
C. Install LED Lighting (as opposed to fluorescent)
D. Install High Efficiency Air Conditioning Units

8. RESULTS AND ANALYSIS

The improved insulation envelope is calculated to save 1,470 KWH of electricity and 300 gallons of oil per year for a total cost savings of $820 per year. This results in a net reduction in CO2 emissions of 7,500 lbs/year.

The effects of the alternative upgrades listed below are in relation to the renovated Library and Community Center. It is important to note that the savings resulting from each Alternative are in relation to this Baseline case. If two Alternatives were to be installed, the resulting savings would not be the sum of their individual savings.

Install Heat Pumps

Under this Alternative, the heat pumps are sized to handle the peak summer cooling load and are used to provide heat down to a temperature of 17°F. The Hydronic system would have to be engaged around 25°F to assist in warming the spaces.

This Alternative is expected to add $950 to the construction budget and $490 to the annual maintenance budget. This Alternative will save 375 gallons of Fuel Oil per year but will increase electrical usage by 4,600 KWH per year for an annual energy cost savings of $680. The total net annual savings including expected maintenance is $190.

Net reduction in CO2 emissions is calculated at 5,700 lbs/year.

Install Heat Recovery Ventilator

This Alternative uses a Heat Recovery Ventilator (HRV) instead of a Fan Coil to ventilate the Library and Community Center. This device allows the heat to be transferred between the exhaust air stream and the incoming air stream and is generally beneficial in both winter and summer.

The cost for an HRV is approximately equivalent to an exhaust fan and fan coil arrangement – there is no cost adder for this Alternative. An HRV is expected to save approximately 120 gallons of fuel per year and electrical usage does not change significantly, resulting in a total annual cost savings of about $290.

The reduction in CO2 emissions is calculated at $2,700 lbs/year.

An HRV will add a maintenance item to the Building. The amount of expected maintenance will depend on the model selected. At a minimum, the heat exchanger will need at an annual scheduled inspection to ensure proper operation.

Install LED Lighting

This Alternative uses LED light bulbs instead of fluorescent bulbs. LED is approximately 40% more energy efficient in delivering the same amount of usable light, however the cost for the bulbs is about 3 times as much as fluorescent bulbs. One of the most attractive aspects of LEDs is their life expectancy is 60% longer than fluorescent bulbs – resulting in less maintenance and improved lighting.

This Alternative is expected to add $1100 to the construction budget and would save approximately 1375 KWH. An additional 20 gallons of fuel oil will need to be used to make up for the heat generated by the fluorescent bulbs. The expected net annual energy savings is $45.

Net CO2 emissions reduction is calculated at 360 lbs/year.

Install High Efficiency Air Conditioners

This Alternative uses air conditioners with a 20 SEER energy efficiency ratio instead of the 13 SEER required by Energy Conservation Code. This is expected to add $300 to the construction cost and will save approximately $65 per year in energy costs.

Net CO2 emissions reduction is calculated at 700 lbs/year

9. DISCLAIMER

It is important to note that the calculated costs and savings are based on field observations, estimates and data available from a building that is between 35 and 125 years old. There is no implied guarantee of any costs or savings indicated in this Study.

Attachments:
Block Representation of Various Alternatives
Graphical Representation of Estimated Savings over Planned Expansion/Renovation

PROVIDE HEAT PUMPS INSTEAD OF AIR CONDITIONERS

THIS ALTERNATIVE WOULD PROVIDE HEAT PUMPS INSTEAD OF AIR CONDITIONERS IN THE LIBRARY AND COMMUNITY CENTER. AIR CONDITIONING IS CURRENTLY PLANNED FOR THESE SPACES, SO THE INCREMENTAL COST FOR PROVIDING HEAT PUMPS IS RELATIVELY SMALL. THE SIZE OF THE UNITS IS BASED ON THE COOLING REQUIREMENTS, THEREFORE THEY WILL NOT BE ABLE TO PROVIDE SUFFICIENT HEAT TO THE SPACES WHEN OUTDOOR TEMPERATURES FALL BELOW 25°F +/- AND HYDRONIC HEAT WILL HAVE BE ACTIVATED.

POSITIVES:

- LOW INSTALLATION COST ADDER
- BACK-UP TO HYDRONIC SYSTEM
- REDUCE FUEL OIL CONSUMPTION
- SIGNIFICANT REDUCTION OF C02 EMISSIONS

NEGATIVES:

- INCREASED MAINTENANCE COSTS

PROVIDE HEAT RECOVER VENTILATOR INSTEAD OF OUTDOOR AIR FAN COIL

THIS ALTERNATIVE WOULD INSTALL A PACKAGED AIR TO AIR HEAT EXCHANGER AND HYDRONIC DUCT COIL INSTEAD OF A FAN COIL UNIT. THE INSTALLATION COST BETWEEN THE TWO APPROACHES IS ESSENTIALLY EQUIVALENT AS THE FAN COIL SYSTEM WOULD REQUIRE A SEPARATE EXHAUST FAN SYSTEM WHILE THE HRV COMBINES BOTH VENTILATION AIR AND EXHAUST IN ONE UNIT.

POSITIVES:

- NEGLIGIBLE INCREASE IN INSTALLATION COST
- IMPROVED AIR QUALITY
- MINOR REDUCTION IN UTILITY COSTS
- SIGNIFICANT REDUCTION IS CO2 EMISSIONS

NEGATIVES:

- ADDS A MAINTENANCE ITEM

LED LIGHTING

THIS ALTERNATIVE ADDS LED LIGHTING TO THE PROJECT IN PLACE OF FLUORESCENT BULB LIGHTING.

POSITIVES:

- REDUCES ELECTRICITY CONSUMPTION AND ANNUAL ENERGY COST
- LED BULBS ARE NON SHATTERING
- LED BULBS WORK WELL WITH DIMMER SWITCHES
- LED BULBS HAVE LONGER LIFE EXPECTANCY THAN FLUORESCENT BULBS

NEGATIVES:

- ADDS TO PROJECT COST
- LOW ELECTRICAL RATE RESULTS IN LONG FINANCIAL PAYBACK

HIGH EFFICIENCY AIR CONDITIONERS

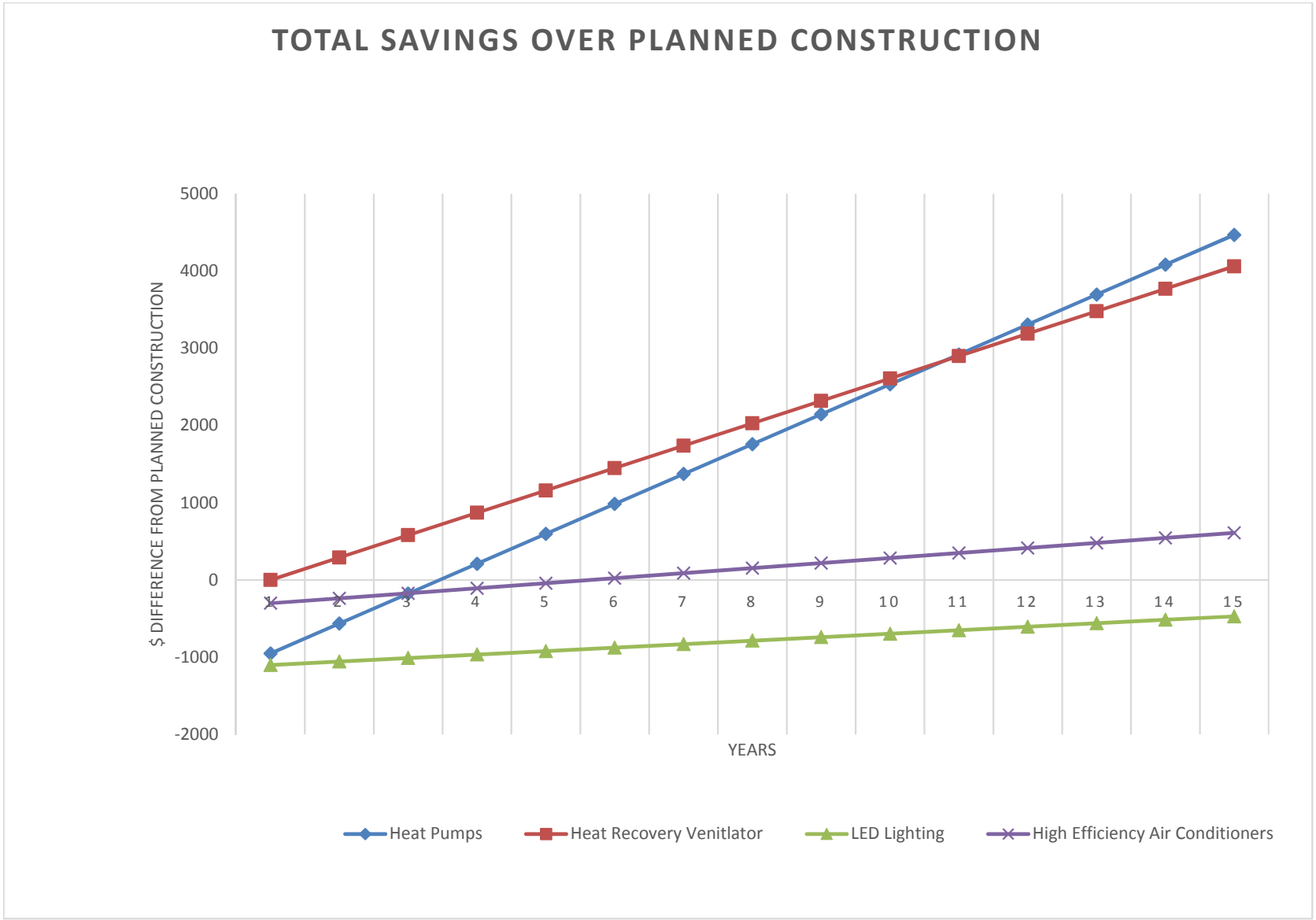
THIS ALTERNATIVE ADDS HIGH EFFICIENCY AIR CONDITIONERS TO THE PROJECT

POSITIVES:

- REDUCES ELECTRICAL CONSUMPTION AND ANNUAL ENERGY COST
- HIGH EFFICIENCY AIR CONDITIONERS PROVIDE FOR MORE CONSTANT SPACE TEMPERATURES AND QUIETER OPERATION – OCCUPIED SPACE IS MORE COMFORTABLE.

NEGATIVES:

- ADDS MINOR AMOUNT TO PROJECT COST


TOTAL SAVINGS OVER PLANNED CONSTRUCTION
$ DIFFERENCE FROM PLANNED CONSTRUCTION
5000
4000
3000
2000
1000
0
-1000
-2000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
YEARS
Heat Pumps
Heat Recovery Venitlator
LED Lighting
High Efficiency Air Conditioners