Town Of Henniker

Energy Analysis of Municipal Buildings

Prepared by: The Jordan Institute as part of the GSE2 Program

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1. Executive Summary

This is the first step in a two-step process initiated by the town of Henniker with The Jordan Institute (Jordan) to assist municipalities eager to find and implement ways to reduce energy use and costs in their buildings. This first step, the Level II audit, is a strategy document which provides you with a thorough understanding of all of your buildings’ current energy performances, the opportunities they present for improving their performance, and the costs associated with implementing the measures that take advantage of those opportunities. This is a project development guide which details the information you need to make an important financial investment decision about substantially reducing the energy cost portion of your operating budget and, thus, your bottom line. This document is a tool to help you support the business case for why becoming more energy efficient now is a sensible, even financially necessary, move for your town.

This report outlines the building envelope and the HVAC equipment for eleven town buildings in Henniker, NH. The purpose of this report is to describe the building energy systems, provide brief calculations of energy consumption and to recommend potential upgrades in order to reduce energy consumption. One of the main goals of this report was to evaluate each building’s current energy efficiency performance and to determine the most cost effective way to improve their performance. This evaluation was performed with an emphasis on the building envelope. Several site visits were conducted where Jordan met with the Town of Henniker representatives to investigate and evaluate the buildings. The performance of several of the building envelopes were tested through the use of blower door testing and infrared imaging. Jordan reviewed available architectural and mechanical drawings as well as the utility data for each building. Occupancy comfort issues and other areas of concern were noted at each building as well. Energy use data was analyzed and each building’s performance was benchmarked. All of this helped Jordan evaluate how energy is consumed by each of the building’s various end uses, discover sources of energy waste and inefficiency, and strategize about appropriate energy saving measures to be considered for future implementation.

In creating the energy plan, many Energy Efficiency Measures (EEMs) have been studied. The results of our analysis indicate numerous energy use and cost reductions which can be achieved.

The second step is to complete the implementation of an aggressive, cost-effective, energy saving project at your town. Jordan can provide professional project oversight to ensure that chosen measures are installed correctly so that estimated costs and savings levels are achieved. This can only be done with a comprehensive oversight program to ensure that all of the project components, from materials to installation practices to final commissioning, meet a high performance standard.

The purpose of this report is to evaluate each building’s performance and opportunities for energy improvement, but also to identify the lowest performing buildings and ways to approach retrofits in the most cost effective way. We will determine what building to address first and what measures to implement in each building. Please note that all pricing and savings numbers included in the financial modeling are estimates.

This report was written in a way that allows the reader to flip to any section or building and read a comprehensive analysis of that building. Therefore there may be some repeated text explaining certain building efficiency terminology.
2. Town Description

General Information

The town of Henniker is located in Merrimack County, New Hampshire and was incorporated in 1768. It currently has a population over 5,000 and is known for being the only “Henniker” on earth. It is approximately 45 square miles and includes several municipal buildings. The majority of the buildings in Henniker are 50 to 100 years old, their municipal buildings included. This report will focus on eleven buildings selected for energy audits. Each building that was studied has individual characteristics that determine and affect its performance. Jordan gathered square footage information from the “Building Inspection and Appraisal Reports” supplied to us by the town. The sizes of the buildings are listed by square foot (SF) below to illustrate the range of buildings we looked at and to later compare the sizes to their energy use.

<table>
<thead>
<tr>
<th>Municipal Building</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Community Center</td>
<td>2,244 SF</td>
</tr>
<tr>
<td>2 Fire Station</td>
<td>10,344 SF</td>
</tr>
<tr>
<td>3 Grange Hall</td>
<td>2,888 SF</td>
</tr>
<tr>
<td>4 Highway Department</td>
<td>5,632 SF</td>
</tr>
<tr>
<td>5 Historical Society Building</td>
<td>3,904 SF</td>
</tr>
<tr>
<td>6 Library</td>
<td>7,711 SF</td>
</tr>
<tr>
<td>7 Police Station</td>
<td>3,360 SF</td>
</tr>
<tr>
<td>8 Town Hall</td>
<td>6,098 SF</td>
</tr>
<tr>
<td>9 Transfer Station</td>
<td>1,800 SF</td>
</tr>
<tr>
<td>10 Waste Water Treatment Plant*</td>
<td>4,362 SF</td>
</tr>
<tr>
<td>11 Water Treatment Plant*</td>
<td>1,675 SF</td>
</tr>
</tbody>
</table>

*It is important to note that for the Waste Water Treatment Plant and the Water Treatment Plant Jordan did not evaluate the treatment processes, and evaluated the building envelope only.

As you can see the Fire Station is the largest of the buildings and the smallest is the Water Treatment Plant. The square footage plays a role in the cost of any envelope or mechanical measures as well.

Photo 1: Street view of the Fire Station  
Photo 2: Interior of Grange Hall  
Photo 3: Historical Society
3. Evaluation of the Buildings

Building Occupancies

The occupancy of the buildings was also studied. The frequency and schedule of the use of the buildings was taken into account when recommendations were determined for the buildings. The buildings with the most use are those that make more sense to invest money in improving. We listed the occupancy in hours per week for comparison.

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Occupancy (Hours per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Center</td>
<td>An estimated 20+</td>
</tr>
<tr>
<td>Fire Station</td>
<td>52+</td>
</tr>
<tr>
<td>Grange Hall</td>
<td>An estimated 30</td>
</tr>
<tr>
<td>Highway Department</td>
<td>40</td>
</tr>
<tr>
<td>Historical Society</td>
<td>4-7</td>
</tr>
<tr>
<td>Library</td>
<td>37</td>
</tr>
<tr>
<td>Police Station</td>
<td>168</td>
</tr>
<tr>
<td>Town Hall</td>
<td>35-37</td>
</tr>
<tr>
<td>Transfer station</td>
<td>26-29</td>
</tr>
<tr>
<td>Waste Water Treatment Plant</td>
<td>168</td>
</tr>
<tr>
<td>Water treatment Plant</td>
<td>168</td>
</tr>
</tbody>
</table>

The amount of time that a space is occupied greatly affects the amount of energy that it consumes. A building such as the Historical society looks to be very efficient judging by the amount of energy it uses. However, looking at the occupancy schedule of the building we learn that the low energy use is due to the low use of the building. The amount of hours occupied per week should be taken into consideration when deciding which buildings to upgrade. The more a building is occupied, the more energy it uses, and the larger the opportunity for actual savings. According to the data above the most used buildings are, in order: the Police Station, Fire Station, the Highway Department, the Library, and The Town Hall. This list excludes the Waste Water Treatment and Water Treatment plants, due to their high process energy usage which was out of the scope of this audit.
Building Energy Use Intensities (EUI)

The energy usage and cost figures for the selected Henniker town buildings have been analyzed to display the performance of the buildings. This process, known as “building benchmarking,” rates the building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)** (discussed in the following section). Both are recognized as standard values in the industry.

EUI is the annual energy use in BTUs (British Thermal Units, usually displayed as kBTUs to signify thousands of BTUs) per square foot of conditioned space in the building (kBTU/SF). EUI is often split into two numbers, one providing the annual BTUs used at the **site** for all purposes, and the other combining this site use figure with the additional BTUs required to generate and transmit electrical energy from its **source**. At The Jordan Institute, we are chiefly interested in the **source** number because it provides the most accurate accounting for the total greenhouse gas emissions associated with a building’s energy consumption.

Many factors driving a building’s CUI are linked to current fuel prices and market conditions and are therefore beyond the control of the building’s manager.

The building’s EUI, however, is a value which The Jordan Institute’s experienced staff can significantly help to reduce. The numbers provide the “benchmark” against which to measure those reductions. We have included each building’s EUI on the following page. These numbers will tell us which building is using the most energy per square foot.

The U.S. Department of Energy tracks the breakdown of energy usage in eighteen different building categories via their **Commercial Buildings Energy Consumption Survey** (CBECS). The survey is conducted every four years. This information is available on a regional basis and New England is listed within the data as a distinct region. It should be noted that the CBECS data used to create the graph below is based on 2003 responses to the survey because 2007 data is not yet published. These charts can be found in each building’s “Energy Use and Cost Analysis Section”.

For building benchmarking, and to help us compare building performance against other similar buildings, Jordan uses a statistically representative building model, created from the CBECS responses. In New England, the 2003 CBECS survey covered 252,000 buildings. Those buildings are separated into 18 different categories of use.

Using the responses from the survey, the percentiles below were created by the Department of Energy’s Oak Ridge National Laboratory for making building energy performance comparisons. For a more in-depth explanation of building benchmarking go to: [http://eber.ed.ornl.gov/benchmark/bldgtype.htm](http://eber.ed.ornl.gov/benchmark/bldgtype.htm)

By comparing each building to other similar facilities in the Northeast, they each fall into a percentile. This means that a certain percent of buildings are more efficient, and a certain percent are less efficient than the building being compared. For example, when comparing the Police Station building to other police station buildings in New England, the Henniker Police Station is in the 65th percentile, meaning that 35% of police station buildings are more energy efficient, and 65% are less energy efficient. However, because of the unique use of buildings it often happens that we are unable to find comparable energy use data. Therefore some of the Henniker buildings are not given percentiles.

The Architecture 2030 (Arch2030) EUI numbers, also on the following page, are EUI goals for building types set forth by the Arch2030 organization. Arch2030 is a non-profit, non-partisan and independent organization whose mission is to achieve a dramatic reduction in the climate change causing greenhouse gas (GHG) emissions of the building sector by changing the way buildings and developments are planned, designed and constructed. These EUI numbers represent energy efficiency and reduced carbon emissions that each building should be working towards.
### Henniker Buildings Energy Consumption

<table>
<thead>
<tr>
<th>Building</th>
<th>EUI (kbtu/sf/yr)</th>
<th>CBECs Percentile</th>
<th>Arch 2030 EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Water Treatment Plant</td>
<td>1396.2</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Water Treatment Plant</td>
<td>959.8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Transfer Station</td>
<td>182.12</td>
<td>10th</td>
<td>0.5</td>
</tr>
<tr>
<td>Community Center</td>
<td>170.9</td>
<td>N/A</td>
<td>26</td>
</tr>
<tr>
<td>Police Station</td>
<td>164.1</td>
<td>65th</td>
<td>39</td>
</tr>
<tr>
<td>Highway Department</td>
<td>87</td>
<td>25th</td>
<td>0.5</td>
</tr>
<tr>
<td>Town Hall</td>
<td>81.5</td>
<td>45th</td>
<td>26</td>
</tr>
<tr>
<td>Fire Station</td>
<td>75.3</td>
<td>65th</td>
<td>39</td>
</tr>
<tr>
<td>Library</td>
<td>65.4</td>
<td>85th</td>
<td>52</td>
</tr>
<tr>
<td>Grange Hall</td>
<td>59.67</td>
<td>N/A</td>
<td>26</td>
</tr>
<tr>
<td>Historical Society</td>
<td>9.8</td>
<td>N/A</td>
<td>23</td>
</tr>
</tbody>
</table>

The following is a chart of each building’s annual energy use in kBTU’s. The waste water treatment plant is on another scale (in red) due to its high energy use. These were calculated using three year averages.

The Energy Consumption chart above displays the energy use of the Henniker town buildings and shows which buildings use the most energy out of these eleven buildings. This does not to make a statement on their efficiency as a building, which can only be done by comparing the energy use to other similar building types or uses. Please see the “Building Benchmarking” sections to see building energy efficiency comparisons.

### Utility Costs
Many factors drive a building’s operating costs. Fuel prices and market conditions determine the cost of fuel and are therefore beyond the control of the building’s manager or occupants. The total yearly utility costs are also a chance to spot opportunities for savings. Higher operating costs are indicative of a building’s use, its size and its envelope. Below we have charted the yearly utility bill costs for each building, including both electric use and heating fuel, as well as the each building’s CUI. CUI is the Cost Use Intensity, which is the annual energy cost per square foot in the building ($/SF). It is clear from the chart below which buildings are costing the town the most money in utilities.

<table>
<thead>
<tr>
<th>Building</th>
<th>Utility cost per year</th>
<th>CUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Center</td>
<td>$6,699</td>
<td>$2.89</td>
</tr>
<tr>
<td>Fire Station</td>
<td>$14,000</td>
<td>$1.35</td>
</tr>
<tr>
<td>Grange Hall</td>
<td>$3,239</td>
<td>$1.12</td>
</tr>
<tr>
<td>Highway Department</td>
<td>$10,566</td>
<td>$1.87</td>
</tr>
<tr>
<td>Historical Society</td>
<td>$2,417</td>
<td>$0.62</td>
</tr>
<tr>
<td>Library</td>
<td>$8,800</td>
<td>$1.14</td>
</tr>
<tr>
<td>Police Station</td>
<td>$8,745</td>
<td>$2.60</td>
</tr>
<tr>
<td>Town Hall</td>
<td>$8,472</td>
<td>$1.39</td>
</tr>
<tr>
<td>Transfer Station</td>
<td>$2,410</td>
<td>$1.34</td>
</tr>
<tr>
<td>Waste Water Treatment</td>
<td>$60,932</td>
<td>$13.96</td>
</tr>
<tr>
<td>Water Treatment</td>
<td>$4,590</td>
<td>$2.74</td>
</tr>
</tbody>
</table>

Below is a chart showing the total yearly cost of utilities for each building. The Waste Water plant is on its own scale again (in red) due to the extreme difference in cost compared to the other buildings.

<table>
<thead>
<tr>
<th>Henniker Buildings Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
</tr>
<tr>
<td>Waste Water Treatment Plant</td>
</tr>
<tr>
<td>Transfer Station</td>
</tr>
<tr>
<td>Town Hall</td>
</tr>
<tr>
<td>Police Station</td>
</tr>
<tr>
<td>Library</td>
</tr>
<tr>
<td>Historical Society</td>
</tr>
<tr>
<td>Highway Department</td>
</tr>
<tr>
<td>Grange Hall</td>
</tr>
<tr>
<td>Fire Station</td>
</tr>
<tr>
<td>Water Treatment Plant</td>
</tr>
<tr>
<td>Community Center</td>
</tr>
</tbody>
</table>

Again we see that the costs for the Waste Water Treatment Plant and the Water Treatment Plant are very high due to the treatment process. The next most expensive buildings to operate are the Fire Station, Highway Department, Library, Police Station, and the Town Hall. Again, this is not a statement of efficiency but to show which town buildings are costing the most for the town to operate. The buildings with the highest costs generally have the most room for savings (excluding the treatment plants).
Envelope Performance

Air changes per Hour

A well-sealed and insulated envelope is an essential element in creating a high performance building. Investment in measures to achieve such an envelope will mean reduced costs in other areas of both building construction and operation. Heating systems can be smaller and less expensive, for instance, and the amount of fuel required to keep a well-sealed and insulated building comfortable is less than that required for a poorly constructed building.

According to results of a 1995 study titled Energy Impact of Air Leakage in US Office Buildings prepared by the Building and Fire Research Laboratory in Maryland, nationwide, infiltration is responsible for about 15% of the total annual heating load of the office building stock, but only 1% of the cooling load (and the principle is applicable to other building types as well). The heating and cooling percentages are different because of the different extent to which these loads depend on ΔT (temperature differential between interior and exterior temperatures). Heating loads arise from heat loss due to ventilation, conduction, and infiltration, all of which depend on ΔT. On the other hand, cooling loads have a substantial contribution from internal gains and solar gains, which do not depend on ΔT. Thus the portion of the total load that arises from ΔT-driven mechanisms, including infiltration, is smaller for cooling than for heating.

An effective building envelope is one which provides a barrier between outside and inside air and which is able to retain a high percentage of the energy used to condition the inside air (heating or cooling energy). This means that an effective envelope is well insulated and provides a continuous air infiltration barrier. The only way to properly investigate the current condition of a building envelope or shell is to perform a full blower door test. The blower door test quantifies the amount of uncontrolled outside air that is getting into the building through cracks, gaps and poorly sealed penetrations, etc. Shell shortcomings, such as lack of air sealing and lack of insulation, serve to compromise the temperature of the indoor air which the owner has paid to condition.

Blower door testing creates a measurable building pressure and airflow that allows us to evaluate a building’s air leakage. ACH50 is the number of Air Changes per Hour at -50 pascals (created by the fan). CFM50 is the cubic feet per minute of air being pulled into the building while it is depressurized to 50 pascals. Natural air changes per hour (ACHn) represents infiltration into the building under normal conditions and tells how many times the entire volume of air in the building is replaced (by infiltration through building imperfections) per hour. The goal of any successful building envelope improvement effort is to control this infiltration to a value of 0.25 - 0.33 ACHn by air sealing all cracks and penetrations identified in the blower door test. This number allows for comparison of the leakiness of different sized buildings.

Blower door tests were performed on five of the buildings that were eligible. Conditions such as the presence of asbestos or vermiculite, and certain mechanical and medical equipment prevented us from doing some blower door tests safely. The following are the blower door numbers of each of the buildings tested, in order of highest infiltration to lowest. The higher the ACHn number the leakier the building.

<table>
<thead>
<tr>
<th>Building</th>
<th>ACHn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Photo 4- Blower door testing at the Community Center
It is recommended that the ACHₙ numbers be close to 0.33. The Library is double this number and the Town Hall is almost four times that number. Therefore we know that all of these buildings could see potential savings from air sealing and other envelope upgrades.

**Henniker Buildings Air Infiltration Numbers**

![Bar chart showing the ACHₙ numbers for different buildings in Henniker.]

- Grange Hall: 0.76
- Community Center: 0.84
- Town Hall: 1.27
- Police Station: 1.70

**Green House Gas Emissions**

The largest amount of energy consumption in the U.S. is by buildings. Fossil fuels supply 76% of the building sector energy demands. The burning of fossil fuels to generate energy results in the production of carbon dioxide and other greenhouse gasses that cause climate change (See chart at right. Statistics derived from Architecture 2030 data, please see [http://architecture2030.org](http://architecture2030.org) for more information).

The energy that a building uses in gallons of oil, therms of gas or gallons of propane added to the kWh of electricity used can all be used to calculate the amount of greenhouse gases that a particular building releases into the atmosphere over a year. We have entered the yearly energy data of each building into the EPA Energy Star Portfolio Manager software to show the amount of Carbon Dioxide emissions (in million tons of CO₂) per building. The breakdown of the environmental impact per building is as follows:
<table>
<thead>
<tr>
<th>Building</th>
<th>MtCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Center</td>
<td>16.64</td>
</tr>
<tr>
<td>Fire Station</td>
<td>34.57</td>
</tr>
<tr>
<td>Grange Hall</td>
<td>7.72</td>
</tr>
<tr>
<td>Highway Department</td>
<td>26.51</td>
</tr>
<tr>
<td>Historical Society</td>
<td>1.18</td>
</tr>
<tr>
<td>Library</td>
<td>24.62</td>
</tr>
<tr>
<td>Police Station</td>
<td>26.39</td>
</tr>
<tr>
<td>Town Hall</td>
<td>27.9</td>
</tr>
<tr>
<td>Transfer Station</td>
<td>10.63</td>
</tr>
<tr>
<td>Waste Water Treatment Plant</td>
<td>182.43</td>
</tr>
<tr>
<td>Water Treatment</td>
<td>66.44</td>
</tr>
</tbody>
</table>

In our recommendations, it is suggested that many of the buildings switch to a wood fired heating system which would greatly decrease the carbon emissions for that building.

**Energy Supplier**

A no cost recommendation to save money on electricity is to switch energy suppliers. Since deregulation has come to New Hampshire, the PUC (Public Utility Commission) has approved eight energy suppliers. By working with an energy supplier your electric is still delivered through the transmission lines by the existing utility, but by working with a third party supplier you are purchasing the commodity from them at a lower rate. There is no cost to switch.

There are two types of contracts, month-to-month contracts and a fixed contract. It is recommended that with a fixed contract you use an RFP process to evaluate the energy supplier and ensure you are getting the best rate. For large electric consumers it is best to obtain a month-to-month contract to gain savings instantly while going through the RFP process. Some choose to stay with the month to month contracts. We suggest using one of the eight suppliers recommended by the NHPUC, which can be found on their website. For more information please see the PUC’s website at [http://www.puc.nh.gov/consumer/energysuppliers.htm](http://www.puc.nh.gov/consumer/energysuppliers.htm).

**4. What this data tells us**

From this data we can now make an informed decision as to which buildings to make energy upgrades to, and which ones to do first. From analyzing each building’s EUI, CUI, existing conditions, occupancy schedules, air infiltration numbers, and Green House gas emissions, Jordan has determined that the following buildings should be of top priority for energy efficiency measures:

1. Highway Department
2. Police Station
3. Transfer Station
4. Water Treatment Plant
5. Fire Station
The following sections of the report analyze the existing conditions and energy use of each of the buildings individually and recommends Energy Efficiency Measures (EEMs) for each building. The buildings are not presented in the order of which they should be addressed. They should be addressed in the following order:

1. Highway Department
2. Police Station
3. Transfer Station
4. Water Treatment Plant
5. Fire Station
6. Town Hall
7. Waste Water Treatment Plant
8. Library
9. Community Center
10. Historical Society
11. Grange Hall

### Building Assessment Summary

#### Rankings of Best Investment Potential for EEMs

<table>
<thead>
<tr>
<th>Rank</th>
<th>Building Name</th>
<th>Simple Payback* (years)</th>
<th>25 yr Internal Rate of Return** (%)</th>
<th>Projected Capital Costs*** ($)</th>
<th>Projected Annual Savings*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highway Department</td>
<td>5.2</td>
<td>23.85%</td>
<td>$ 58,710.97</td>
<td>$ 11,280.21</td>
</tr>
<tr>
<td>2</td>
<td>Police Station</td>
<td>6.9</td>
<td>18.66%</td>
<td>$ 56,293.17</td>
<td>$ 8,121.23</td>
</tr>
<tr>
<td>3</td>
<td>Transfer Station</td>
<td>7.0</td>
<td>18.57%</td>
<td>$ 34,565.20</td>
<td>$ 4,960.00</td>
</tr>
<tr>
<td>4</td>
<td>Water Treatment Plant</td>
<td>8.4</td>
<td>15.74%</td>
<td>$ 17,350.75</td>
<td>$ 2,062.74</td>
</tr>
<tr>
<td>5</td>
<td>Fire Station</td>
<td>9.0</td>
<td>14.86%</td>
<td>$ 70,900.30</td>
<td>$ 7,908.85</td>
</tr>
<tr>
<td>6</td>
<td>Town Hall</td>
<td>9.6</td>
<td>13.97%</td>
<td>$ 132,853.30</td>
<td>$ 13,850.44</td>
</tr>
<tr>
<td>7</td>
<td>Waste Water Treatment Plant</td>
<td>11.5</td>
<td>11.72%</td>
<td>$ 5,011.20</td>
<td>$ 435.00</td>
</tr>
<tr>
<td>8</td>
<td>Library</td>
<td>13.4</td>
<td>10.03%</td>
<td>$ 34,146.00</td>
<td>$ 2,544.68</td>
</tr>
<tr>
<td>9</td>
<td>Community Center</td>
<td>17.4</td>
<td>7.44%</td>
<td>$ 21,240.00</td>
<td>$ 1,222.88</td>
</tr>
<tr>
<td>10</td>
<td>Historical Society</td>
<td>20.4</td>
<td>5.99%</td>
<td>$ 22,584.15</td>
<td>$ 1,109.04</td>
</tr>
<tr>
<td>11</td>
<td>Grange Hall</td>
<td>23.4</td>
<td>4.80%</td>
<td>$ 17,341.38</td>
<td>$ 740.79</td>
</tr>
</tbody>
</table>

**Grand Total:** 8.7  $ 470,996.42  $ 54,235.86

*Simple payback and projected savings is each individual measure totaled for the building, in other words these numbers are not cascading.
**IRR assumes a 5% inflation rate and a 5% cost of capital
***Projected capital costs include every measure listed in the report for the specified building
5. Henniker Town Hall

General Information

A site visit was conducted where The Jordan Institute met Peter Flynn, the Town Administrator, to investigate and evaluate the building. At this site visit Jordan tested the performance of the building envelope through the use of blower door testing and infrared imaging.

The Town Hall is used as the Town offices and Town Hall for all of Henniker. The Town hall is approximately 6,098 square feet of conditioned space over two floors. All town offices are on level one, which houses about six rooms, two bathrooms, a waiting area and a break area with kitchenette. Level two is open gathering space that was used as a gymnasium and theatre. At this time it is used only for storage.

The Town Hall is home to many town departments and councils. The town clerk, tax collector, town administrator, planning board, assessing, building inspector, and registrar are all housed at the Town Hall. The Town hall has normal operation hours of Monday 8:00 am -5:30 pm, Tuesday and Wednesday from 8:00 am -4:30 pm, closed Thursday, and open Friday 8:00 am -4:30 pm. The Town Hall is also open every second and fourth Saturday from 10:00 am to 12:00 pm. This is a total of 35 to 37 hours a week that the building is occupied.

Existing Conditions

Building Envelope

Walls

The exterior walls are comprised of wood siding and the interior is lathe and plaster. The lathe was visible during infrared imaging in the interior walls revealing the wall construction. The walls of level one have had fiberglass insulation installed since the original construction.
There are a few different window types located throughout the building. Level one has had the windows replaced in the 1990’s with double hung, double pane, vinyl windows. There are decorative windows above the main entrance that are original. All other windows are single pane wood frame weight and pulley original windows with aluminum framed storms (on level two).

The main entry doors are double wood doors which do not form a tight seal. They are push latch doors from the interior and a great deal of infiltration occurs due to gaps between the doors. They open into the main entry way which is unconditioned. The doors to the conditioned space of the town offices is a double swinging door. Even larger gaps exist where these doors meet and at the base of the doors as well. Because these doors separate the unconditioned and conditioned they should be air tight insulated doors. The rear door off the break area is a newer wooden door that was found to be very leaky.

Roof

The attic above level two is narrow but accessible through a ceiling hatch, though it is not used. This attic has no insulation. Fiberglass insulation is above the dropped ceiling of level one to separate the conditioned space from the unconditioned space. However this insulation has a lowered effectiveness due to the poor installation and lack of an air seal. The exterior of the roof is asphalt shingles. There is one chimney that the boiler vents to, located in the rear of the building.
Foundation

The Town Hall sits on a granite and stone foundation that has been reinforced with concrete block. It is in good condition with no apparent moisture issues. The building sits above an unconditioned dirt floor crawl space and is insulated with fiberglass batts between the floor joists. The boiler and hot water heater are located in the crawl space and it is accessed from an exterior bulkhead.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The only conditioned space is level one where all the offices are located. Forced hot water is generated at the oil fired Smith Co. Boiler to baseboard radiators. The boiler is estimated to be at least 20 years old. A few offices utilize additional heat from electric space heaters to meet their comfort needs in winter.
Although the second floor is unconditioned there are two Janitrol fan unit heaters mounted from the ceiling. There are also two wall mounted unit heaters in the unconditioned main entryway that are not used.

Air conditioning is provided by window units on level one only and removed seasonally.

**HVAC Controls**

A Greentek thermostat control is located in the hallway of the main level to control indoor air comfort for level one. A broken thermostat is located in the unconditioned main entryway.

The thermostat for the main level baseboard radiators is located in the central hallway.

**Electrical, - Lighting and Appliances**

The Town Hall participated in a PSNH lighting retrofit done on most of the town’s buildings in 2008. The majority of the lighting on level one consists of fluorescent T-8 ceiling mounted fixtures and supplemental task lighting. Level two has several large single bulb fixtures mounted from the tall ceiling in protective cages.

The majority of level one has motion sensor lighting controls installed in individual offices by the on/off switches. These are programed to turn off after five minutes without motion detected. Several of the offices are over lit and occupants claim the areas are too bright and prefer not to replace burnt out bulbs. An installed and wired light fixture still uses electricity without a bulb at the ballast. The bathrooms and the councilmen room are not on motion sensors.

The kitchenette appliances include a standard refrigerator, a microwave, a toaster oven and a Keurig coffee maker.

**Plumbing and Domestic Hot Water**

Plumbing fixtures in the Town Hall are standard water use fixtures. The Town Hall has a very low demand for domestic hot water (DHW). DHW use is limited to hand washing in two bathrooms and the kitchenette. There are a total of three sinks located in the building where hot water is used. DHW is generated by a Vanguard electric hot water tank located beneath the building in the crawl space. It was noted that the hot water piping in the crawl space was not insulated.
Notable Problem Areas/Occupancy Comfort

- The insulation above the dropped ceiling was installed poorly and is strewn about creating inconsistencies in insulation levels and increased air movement up past the insulation.

- The insulation beneath the floor of level one is in poor condition and may still allow for conditioned air movement and cold transfer up into the space above.

- The main entry way doors have a gap between the doors which allows for a great deal of outside air to enter the building.

- The rear exit door was found to be very leaky.

- The doors into the conditioned space (the office area) is a swinging door with large gaps allowing unconditioned air from the entry way enter the office area. As the doors swing they push a large amount of the unconditioned air into the office spaces as well. They are not air tight or insulated.

- There is no hot water pipe insulation.

- The offices maybe over lit, using more energy than they need.
Energy Use and Cost Analysis

The Town Hall uses Fuel Oil #2 and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers and other office needs, cooling, appliances as well as domestic hot water heating. The fuel oil is attributed to space heating.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and oil use. The numbers shown are three year averages.

![Town Hall Energy Cost (3 Year Average)](image)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current State Wide Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$2,803</td>
<td>$0.16/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>$5,670</td>
<td>$2.80/gallon</td>
<td>$3.67</td>
</tr>
<tr>
<td><strong>Current Total Energy Cost</strong></td>
<td><strong>$8,473</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The current state wide average prices are according to the New Hampshire Office of Energy and Planning as of Sept 7, 2011.

Using current yearly oil use of 2,022 gallons a year and the current state wide average price per gallon of oil of $3.67, the Town Hall would be paying $7,420 a year for oil.
The Energy Consumption chart below, graphically analyzes the electric and oil consumption in kBTUs which allows for direct comparison of fuel consumption. The oil consumption is based off oil deliveries. **The numbers shown are also three year averages.**

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>59,077</td>
<td>17,314 kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>280,38</td>
<td>2,022 gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>339,462 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for Henniker Town Hall:

**Figure 1:** Energy Use Breakdown by Type  
<table>
<thead>
<tr>
<th>Town Hall</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>83% Oil</td>
<td>17% Electric</td>
<td>67% Oil</td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Examining the historical energy consumption of your building is known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use (for the 12 month period ending December 2010) for the Town Hall:

**EUI = 181.5 kBTU/SF/YR**  
**CUI = $2.93 /SF/YR**

By comparing the Town Hall to other offices across the United States they are in the 45th percentile. This means that 55% of libraries are more energy efficient and 45% are less energy efficient. **We did not include the square footage of the second floor in the calculation of the EUI and CUI because it is not conditioned.**
Envelope Testing

Blower door testing as well as Infrared imaging was performed on the building. (Please see Appendix B for the building’s IR report).

An air tight building will have infiltration rates of .25 -.33 AChn. These are the numbers we strive for in retrofits and new construction. The results of the blower door test are listed below.

Blower door test results:
CFM50=8775       ACHn=1.27  ACH50= 24.09

Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1a- Insulate first floor ceiling. Apply four inches of spray foam to the ceiling above the dropped ceiling of level one. This will separate the conditioned first floor from the unconditioned second floor with an air seal that will prevent heat loss to the space above, and make the existing insulation more effective.

B1b- Insulate second level floor. There is also the option to apply five inches of rigid board insulation to the floor of level two. This will also separate the conditioned first floor from the unconditioned second floor and can be finished with a top layer of plywood to protect the insulation and enable the space to still be used as it is now for storage. The joints of the rigid boards should be staggered and taped, and the perimeter should be air sealed.

B2- Insulate crawl space foundation. Insulate the foundation walls from the interior with 3 inches of spray foam from the rim joists down to the dirt. A vapor barrier should be applied along the dirt floor and up the walls to be secured to the wall by the spray foam. This will ensure no moisture enters the crawlspace and will prevent the current heat lost to through the floor making the first floor spaces more comfortable as well.

B3- Install insulated door at base of bulkhead to create a continuous thermal line along the foundation. The existing bulk head door does not insulate the entryway as is and in order to make the most of the foundation insulation recommended in B2, the high insulation level must be maintained across the whole foundation.

B4- Replace swinging doors to the office area with insulated doors. The thin swinging doors do nothing to separate the unconditioned space of the entryway from the conditioned office space. The new doors should be insulated and have appropriate weather stripping as well. This will prevent cold air from entering the space and save on heating.

B5- Weather strip exterior doors and adjust/repair main entry doors to close tighter. Weather stripping is a low cost repair that prevents the unconditioned air from entering the building and conditioned air from leaving the building. This saves on heating. The main entry doors should be repaired to close tightly or replaced with insulated doors that do so. This will prevent a tremendous amount of outdoor air from entering the space, and therefore save on heating.

B6- Close storm windows- no cost. The day of the site visit to the Town Hall, it was noted that several of the storm windows were open in winter. By closing these and making sure they are closed each fall will save energy throughout the winter. Because there is no cost associated with this measure it is not included in the financial model.
Recommended Mechanical Energy Efficiency Measures

**M1a- Upgrade the boiler to a high efficiency boiler.** A new and more efficient boiler can use less oil and save on heating costs. Because the current boiler is around 20 years old energy savings can be realized by upgrading the boiler. However this may be done as the current boiler reaches end of life.

**M1b- Replace boiler with a pellet boiler system.** There is also the option to replace the boiler with a pellet boiler which would end fuel oil use at the building, and greatly reduce the buildings greenhouse gas emissions as well. This option may require further engineering, but would result in energy cost savings due to the difference between oil and pellet fuel prices.

**M2- Insulate hot water piping.** By insulating the hot water piping it increases the efficiency of the distribution system and delivers heat more effectively saving on heating.

**M3- Install programmable thermostats.** Installing programmable thermostats and installing the proper setbacks allows for the heat to automatically be set back according to the building schedule. This will save money on heating as well.

**M4- If the need for air conditioning rises, consider installing a mini split system as a cooling system for level one.** A more efficient way to cool the office spaces would be to install an air conditioning system. A “Mr. Slim” or equivalent system would work well for level one.

**M5- Consider installing an energy recovery ventilator to supply fresh air while also recovering heat/cooling from the space.** We recommend installing an Energy Recovery Ventilator (ERV) to serve the office area. This will provide conditioned air while recovering heat and moisture from the outgoing air. ERV equipment is extremely efficient. It would provide automatically controlled mechanical air exchanges, capturing from 65% to 80% of the heat/cooling contained in the exhaust air. Stale indoor air is removed and replaced with fresh outside air, and as the stale air leaves the building it passes by the incoming fresh air in an air exchange device which uses the heat/or cooling from the exhaust air to temper the incoming fresh air so that it requires less from the building’s heating system before it is distributed to the occupied spaces.

![Photo 21: Image of how an ERV works](image)

Recommended Electrical Energy Efficiency Measures

**E1- Install occupancy sensors for lights in rooms without.** This will continue the energy savings by ensuring that lights are not left on when they are not in use.

**E2- Upgrade refrigerator in kitchenette to Energy Star Model.** Refrigerators have come so far in their efficiency that if your refrigerator is more than five years old there is energy saving potential from upgrading to the current Energy Star models. By replacing the older refrigerator, electric savings can be realized. When the refrigerator reaches end of life, replace with an Energy Star Model. This measure has not been priced or included in the financial model.
Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
### Projected Financial Analysis

**Baseline Energy Usage:**
- **Electricty:** 17,314 kwh
- **Oil:** 2,022 gallons
- **Total Energy:** 33,311 MBtu

**Baseline Annual Energy Cost:**
- **Electricity:** $2,803
- **Oil:** $8,088
- **Total:** $14,461

**Baseline Unit Cost:**
- **Electricity:** $0.16 ($/kWh)
- **Oil:** $4.00 ($/gal.)

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#### EEM

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>B1a Apply closed cell spray foam to the ceiling above the dropped ceiling, also apply fire barrier (2,720 SF)</td>
<td>$16,184</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$16,184</td>
<td>$2,669</td>
<td>6.1</td>
<td>21.2%</td>
<td>$57,214</td>
</tr>
<tr>
<td>B1b Install rigid insulation over existing 2nd level floor, tape seams and air seal perimeter, cover with plywood for protection</td>
<td>$18,604</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$18,604</td>
<td>$2,669</td>
<td>7.0</td>
<td>19.0%</td>
<td>$54,909</td>
</tr>
<tr>
<td>B2 Insulate inside of foundation walls with spray foam and vapor barrier, also insulate rim joints (3&quot; x 216 LF=648' x 3&quot; of spray foam, 42'x70'=2940 SF of vapor barrier)</td>
<td>$45,770</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$45,770</td>
<td>$1,779</td>
<td>25.7</td>
<td>5.7%</td>
<td>$4,828</td>
</tr>
<tr>
<td>B3 Install insulation on the door at the bottom of the bulk head stairs (the door will require framing a doorway and installing a door)</td>
<td>$750</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$750</td>
<td>$72</td>
<td>7.1</td>
<td>15.5%</td>
<td>$1,487</td>
</tr>
<tr>
<td>B4 Replace swinging doors to the office area with double insulated doors (standard size)</td>
<td>$1,046</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,046</td>
<td>$72</td>
<td>7.1</td>
<td>15.5%</td>
<td>$1,487</td>
</tr>
<tr>
<td>B5 Repair front double doors to close tightly and install weather stripping at front and rear exterior doors.</td>
<td>$750</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$750</td>
<td>$162</td>
<td>7.1</td>
<td>15.5%</td>
<td>$1,487</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$82,553</strong></td>
<td><strong>$82,553</strong></td>
<td><strong>$8,088</strong></td>
<td><strong>10.2</strong></td>
<td><strong>$8,088</strong></td>
<td><strong>10.2</strong></td>
<td><strong>$8,088</strong></td>
<td><strong>10.2</strong></td>
<td><strong>$8,088</strong></td>
</tr>
</tbody>
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#### Mechanical System Upgrades

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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M1a Upgrade boiler to a high efficiency boiler</td>
<td>$20,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$20,000</td>
<td>$8,088</td>
<td>24.7</td>
<td>6.0%</td>
<td>$2,961</td>
</tr>
<tr>
<td>M1b Fuel switch to pellet boiler system</td>
<td>$25,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$25,000</td>
<td>$4,518</td>
<td>42.0</td>
<td>22.9%</td>
<td>$99,129</td>
</tr>
<tr>
<td>M2 Insulate Hot water piping</td>
<td>$500</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$500</td>
<td>$81</td>
<td>7.1</td>
<td>20.9%</td>
<td>$1,725</td>
</tr>
<tr>
<td>M3 Install Programmable thermostats</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$162</td>
<td>7.1</td>
<td>20.9%</td>
<td>$1,725</td>
</tr>
<tr>
<td>M4 Consider installing mini split unit for cooling system</td>
<td>$2,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$2,000</td>
<td>$56</td>
<td>7.1</td>
<td>20.9%</td>
<td>$1,725</td>
</tr>
<tr>
<td>M5 Install ERV for fresh air supply (will require ducting)</td>
<td>$3,000.00</td>
<td>$0.00</td>
<td>$600.00</td>
<td>$600.00</td>
<td>$3,000.00</td>
<td>$109</td>
<td>3.4</td>
<td>22.0%</td>
<td>$678</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$50,700</strong></td>
<td><strong>$50,100</strong></td>
<td><strong>$8,088</strong></td>
<td><strong>10.2</strong></td>
<td><strong>$5,734</strong></td>
<td><strong>8.7</strong></td>
<td><strong>$5,734</strong></td>
<td><strong>8.7</strong></td>
<td><strong>$5,734</strong></td>
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#### Electrical System Upgrades

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>E1 Install motion sensors in rooms that do not have them</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$28</td>
<td>7.1</td>
<td>18.7%</td>
<td>$572</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included*
6. Henniker Police Station

General Information

A site visit was conducted where The Jordan Institute met secretary, Michelle McGir, to investigate and evaluate the building. At this site visit Jordan tested the performance of the building envelope through the use of blower door testing and infrared imaging as well. The Henniker Police Station is located at 64 Western Avenue in Henniker. The building is approximately 3,360 square feet of conditioned space on one floor and was originally built in 1962. The building utilizes public water and sewer. Located in the Police Station is a waiting room, an office, a kitchenette, a ladies locker room, men’s locker room, an interview room, the Chief’s office, evidence room (which is kept locked), one larger office area with cubicles for the officers on duty, two holding rooms, and a mechanical room. There is also an attached two bay garage.

The Police Station has business operation hours of Monday-Friday, 8:00 am -5:00 pm, however there are always police on duty in the building 24/7. This is a total of 120 hours a week that the building is occupied.

Existing Conditions

Building Envelope

Walls

There are two exterior wall construction types in the building. The south wall and part of the east and west walls are concrete block, the front of the building (the east side) has a brick veneer over concrete block. The area of the east and south walls that make up the garage are not insulated. The rear of the south wall and the west wall are insulated with fiberglass from the interior in the finished spaces. The other side of the building, the north side and parts of the east and west side, is wood framed with fiberglass batts between the studs. The exterior finish here is vinyl siding.

The infrared (IR) imaging found the batt insulation within the walls to be in poor condition. Many batts were settling in corners and tops of bays which decreases the effectiveness of the insulation.
There are approximately eight double hung wood framed windows located on the east, north, and west sides of the building that have aluminum framed storms. The south side of the building has a few smaller wooden framed awning type windows located higher up on the wall. Most of the double hung windows showed signs of cold infiltration at the corners of the window trim with the IR camera.

The main entry door is a wood door with a glass window, while the two rear exit doors are metal doors. The doors to the building seemed to be in fairly good condition, with the exception of the weather stripping. Many of the doors’ weather stripping showed to be inadequate during the blower door testing.
Two large garage doors are located on the east wall. These were found to be letting in large amounts of cold unconditioned air, even without the use of the blower door testing because they do not close tightly to the floor. Because the garage is an unconditioned space for the majority of the time (there are two modine heaters that sometimes get used), cold air is able to enter the building beneath the doors that connect the office and holding spaces to the garage. There are two doors that connect these spaces. Another concern is that if cold air is able to move so easily into the interior spaces, carbon monoxide from the cars in the garage is also able to do so. No carbon monoxide (CO) detectors are present. Special attention should be paid to sealing these two spaces off from each other as best as possible to avoid any carbon monoxide health risks to the occupants, which also enhances the need for CO detectors.

**Roof**

The roof is a large wood framed gabled roof with asphalt shingles. It was estimated by a town employee that the roof is around twenty years old. There is soffit venting that follows the overhang on the north and south sides of the building. The insulation line runs along the ceiling plane above the dropped ceiling. Fiberglass batts are suspended above the mechanical and electrical equipment with no air barrier. The batts are approximately 6-9 inches thick. It is important to note that without an air barrier present the effectiveness of the insulation drops drastically.
Foundation

The Police Station was built entirely on a slab on grade. There is no foundation insulation evident and heat loss was obvious in the IR imaging.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The building is heated via forced hot air. One Weil McLain oil fired boiler (original to the construction of the building) is located in the rear mechanical room of the building. This has a hot water coil that runs to an air handler in the adjoining closet area. This air handler is three years old. Another air handler is located above the dropped ceiling in the hallway. It was installed in the 1990’s and also has a hot water coil off the main boiler.

The heating distribution system is forced hot air ducts to ceiling diffusers. The ducts are located above the dropped ceiling and below the insulation to be included in the conditioned space. They are sealed with duct tape rather than an appropriate mastic duct sealant. It was found that no hot water piping running to the air handlers is insulated. Several of the supply and return diffusers were very close together. This is not efficient as the incoming conditioned air is immediately sucked into the return. This was found mostly in the bathrooms. Many of the diffusers
were found to be very dirty- a sign that the ducts may be dirty as well and that the filters are not changed often enough. There is no fresh air supply introduced to the forced air system.

The garage is heated by two forced hot air modines with hot water coils running to them off the boiler. These are only used when the space is especially cold.

Air conditioning is supplied via the same air handlers as the heating. Two American Standard condensers are located out behind the Police Station and have coolant coils running to the air handlers.

HVAC Controls

There are two thermostats serving the building. One is a programmable thermostat located in the officer workspace and the other is a non-programmable knob thermostat located in the hallway.

The workers do not to alter the thermostat settings.
Electrical, Lighting and Appliances

The interior lighting of the police station consists of mostly T-8 flourecent tube lighting. T-8’s were found to be in the garage, hallway, offices and kitchenette.

Lighting controls for the station include motion d ectors in most rooms. The garage, kitchenette, hallway, holding area, officer work space, booking room, and bathrooms all have motion sensors. The offices do not.

The plug load evaluation for the Henniker Police Station is an overall high electric plug load due to the office equipment in the secretary’s office and the officer work space. The kitchenette has a microwave and toaster oven, but also has an energy star model refrigerator.

A back up generator is located behind the building and runs off propane. There is very little use of this generator and it is estimated that it was only used 4 to 6 times last year due to weather related power outages.

Plumbing and Domestic Hot Water

Plumbing fixtures in the Police Station are standard water use fixtures. The station has a fair demand for domestic hot water (DHW). DHW use is used for hand washing and showering in two bathrooms and the sink in the kitchenette. There are a total of three sinks located in the building where hot water is used.

Notable Problem Areas/Occupancy Comfort

- During our site visit, one of the holding cells was being supplied with heat the entire time, while the rest of the building was not calling for heat.
- The exhaust and supplies are located very close to one another on the ceilings.
- Cold air is able to move down into the bays from the attic due to an unsealed top plate.
- The south wall is an un-insulated concrete block wall.
- Ice damming was present along the eaves indicating that there is heat loss into the attic at the tops of the walls at the eaves.
- Hot water piping was un-insulated.
- Corners of windows showed missing insulation behind window trim.
Energy Use and Cost Analysis

The Police Station uses Fuel Oil #2 and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers and other office needs, cooling, and appliances. The fuel oil is attributed to space heating. Propane use was not included as it is rarely used for the backup generator.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and oil use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current State Wide Average Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$4,379</td>
<td>$0.14/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>$4,366</td>
<td>$2.89/gallon*</td>
<td>$3.67</td>
</tr>
<tr>
<td>Current Total Energy Cost</td>
<td>$8,745</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The current state wide average price per gallon of oil is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly oil use of 1,509 gallons a year and the current state wide average price per gallon of oil of $3.67, the Police Station would be paying $5,538 a year for oil.
The Energy Consumption chart below graphically analyzes the electric and oil consumption in kBTUs which allows for direct comparison of fuel consumption. The oil consumption is based off oil deliveries. The numbers shown are also three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>108,292</td>
<td>31,739 kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>209,330</td>
<td>1,509 gallons</td>
</tr>
<tr>
<td>Total Energy Use</td>
<td>317,623 kBTU</td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for Henniker Police Station:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Station</td>
<td><img src="image" alt="Energy Use Breakdown" /></td>
<td><img src="image" alt="Energy Cost Breakdown" /></td>
</tr>
</tbody>
</table>

The following graphs show energy use and cost breakdowns by fuel type for Henniker Police Station:

Building Benchmarking

Examining the historical energy consumption of your building is known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Police Station:

**EUI = 94.5 kBTU/SF/YR**

**CUI = $2.60 /SF/YR**

By comparing the Police Station to other police and fire stations across the United States they are in the 65th percentile. This means that 35% of police and fire stations are more energy efficient and 65% are less energy efficient.
Envelope Testing

Blower door testing as well as Infrared imaging was performed on the building. (Please see Appendix B for the building’s IR report).

An air tight building will have infiltration rates of \(0.25 - 0.33 \text{ ACH}_n\). These are the numbers we strive for in retrofits and new construction. The results of the blower door test are listed below.

**Blower door test results:**

\[
\text{CFM}_{50} = 10134.25 \quad \text{ACH}_n = 1.7 \quad \text{ACH}_{50} = 32.4
\]

Recommended Energy Efficiency Measures

**Recommended Building Envelope Energy Efficiency Measures**

**B1-Install an air barrier in the attic.** There is no air barrier in the attic above the fiberglass insulation. Without an air barrier heating and cooling (conditioned air) are able to move up past the batts and into the attic space. In order to prevent this, we suggest installing an air tight layer of one to two inches of rigid foam board atop the rafters that the fiberglass batts are in-between. Boards should be spray foamed at the edges to create an air tight seal between boards. A blower door test can then be conducted to test the air barrier and an IR camera can verify and check for leaks as well. After it is confirmed that the rigid foam air barrier is air tight, 16-18 inches of blown in cellulose should be installed on top of the rigid to add R-value to achieve the recommended R-60 for a roof. This will create an air tight barrier and also add R-value to the attic.

**B2- Air seal behind window trim.** Because all the double hung windows were showing cold air the corners with the IR camera, we suggest removing the trim and spray foaming around the window. This will prevent cold from entering around the window (and also stop heat in the summer), therefore saving on heating and cooling costs. It will also improve the comfort around these windows.

**B3- Weather strip exterior doors and garage doors.** All doors to the exterior, and the doors to the garage should be outfitted with commercial grade weather stripping to prevent the unconditioned air from entering the building and the conditioned air from escaping the building. This will save on heating, and also acts as a safety measure to prevent any carbon monoxide from the vehicle exhaust in the garage from getting into the building. The garage doors can be done as well, but it will be more effective to do the exterior doors first.

**B4- When it is time to replace the garage doors, replace them with insulated garage doors.**

**B5- Air seal all garage to wood frame connections to ensure that cold and CO are not leaking in from the garage.**
B6- **Insulate the foundation from the exterior.** This can be done by digging out around the exterior of the foundation and installing 3-4” of rigid foam board four feet down on the exterior of the foundation and also going out three feet to prevent colder temperatures from reaching the foundation.

**Recommended Mechanical Energy Efficiency Measures**

M1- **Because the existing oil boiler is almost 50 years old, we recommend replacing the boiler.** Due to the age and heavy use of the older boiler energy savings can be realized by upgrading the boiler to a high efficiency boiler. You may also consider the option of a wood pellet boiler (this option may require more upkeep but would get the building off fossil fuels and save a great deal of money on heating costs).

M2- **For health and safety reasons we recommend installing automatic exhaust fans in the garage and carbon monoxide detectors in all spaces adjacent to the garage.** The exhaust fans will turn on and expel any car exhaust fumes from the garage for a set amount of time each time the garage doors are operated. This will keep the toxic fumes out of the garage and prevent any fumes from leaking into the building space. The CO monitors will warn if any high levels of carbon monoxide do make their way into the building and will ensure the safety of the occupants at all times.

M3- **Replace the knob thermostat in the hallway with a programmable thermostat and ensure that both thermostats are set to the proper setbacks.** Simple upgrade such as programmable thermostats can save a lot of money ensuring the temperatures are set back in the heating and cooling months when the building is not occupied.

M4- **Install an energy recovery ventilator to supply fresh air to the building while recovering any heat or cooling from the building.** More information on ERV’s is mentioned in the Recommended Mechanical Energy Efficiency Measures section for the Town Hall building. This will be an easy addition to the existing mechanical system since it is a forced air system.

**Recommended Electrical Energy Efficiency Measures**

E1- **Consider upgrading computer monitors to energy star monitors to save electricity.** Also ensure that any electronic devices that may be shut down are shut down after hours.

**Recommended Renewable Energy Efficiency Measures**

There are no renewable measures recommended at this time.

**Financial Modeling**

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
### Financial Analysis

#### Assumptions (2-Year Average)

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Average Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>31,739 kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>1,509 gal</td>
</tr>
<tr>
<td>Total Energy</td>
<td>316,556 MBtu</td>
</tr>
</tbody>
</table>

Baseline Unit Cost:
- Electricity: $0.14/kWh
- Fuel Oil: $4.00/gal

#### Baseline Energy Usage

- **Baseline Energy Usage:** 31,739 kWh, 1,509 gal, 316,535 kBTU
- **Baseline Annual Energy Cost:** $4,379, $6,036, $12,955
- **Energy Cost ($/kWh):** $0.14, $4.00

#### Building Envelope Upgrades

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Install air barrier in the attic above the fiberglass with 1” of air sealed rigid foam to sit on the ceiling joists and install 16-18” of blown in cellulose on top of the rigid (3267 SF)</td>
<td>$9,604</td>
<td>$0</td>
<td>$0</td>
<td>$9,604</td>
<td>$2,354</td>
<td>4.1</td>
<td>29.0%</td>
<td>$54,909</td>
</tr>
<tr>
<td>B2 Air seal behind window trim (remove trim, foam, reinstall ~8 windows, 128 LF of 2” of spray foam)</td>
<td>$1,480</td>
<td>$0</td>
<td>$0</td>
<td>$1,480</td>
<td>$181</td>
<td>0.2</td>
<td>16.7%</td>
<td>$3,518</td>
</tr>
<tr>
<td>B3 Weatherstrip exterior doors and garage doors</td>
<td>$740</td>
<td>$0</td>
<td>$0</td>
<td>$740</td>
<td>$74</td>
<td>0.9</td>
<td>119.2%</td>
<td>$3,178</td>
</tr>
<tr>
<td>B4 When time to replace garage doors, replace with insulated.</td>
<td>$4,530</td>
<td>$0</td>
<td>$0</td>
<td>$4,530</td>
<td>$643</td>
<td>9.4</td>
<td>15.0%</td>
<td>$8,255</td>
</tr>
<tr>
<td>B5 Air seal all garage wall to interior space connections (72 LF)</td>
<td>$112</td>
<td>$0</td>
<td>$0</td>
<td>$112</td>
<td>$121</td>
<td>4.2</td>
<td>82.8%</td>
<td>$3,178</td>
</tr>
<tr>
<td>B6 Insulate the foundation from the exterior with rigid down 4’ and out 3’ (building footprint 61’ x 54’)</td>
<td>$7,577</td>
<td>$0</td>
<td>$0</td>
<td>$7,577</td>
<td>$132</td>
<td>25.1</td>
<td>5.9%</td>
<td>$996</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$24,043</td>
<td>$24,043</td>
<td>$4,286</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Mechanical System Upgrades

<table>
<thead>
<tr>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 When time to replace the boiler consider a pellet boiler or choose high efficiency boiler (don't have size)</td>
<td>$25,000</td>
<td>$0</td>
<td>$0</td>
<td>$25,000</td>
<td>$2,980</td>
<td>7.2</td>
<td>18.6%</td>
<td>$71,320</td>
</tr>
<tr>
<td>M2 Install exhaust fans in the garage to exhaust fumes from the garage automatically triggered by garage doors opening. Also install CO detectors in rooms adjacent to the garage.</td>
<td>$400</td>
<td>$0</td>
<td>$0</td>
<td>$400</td>
<td>$NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>M3 Replace the knob thermostat in the hallway with a programmable thermostat</td>
<td>$100</td>
<td>$0</td>
<td>$0</td>
<td>$100</td>
<td>$31.96</td>
<td>1.0</td>
<td>109.1%</td>
<td>$2,739</td>
</tr>
<tr>
<td>M4 Install an ERV to the duct system to supply fresh air to the building</td>
<td>$6,000</td>
<td>$0</td>
<td>$0</td>
<td>$6,000</td>
<td>$31.96</td>
<td>57.6</td>
<td>0.8%</td>
<td>($2,880)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$31,500</td>
<td>$31,100</td>
<td>$3,704</td>
<td>8.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Electrical System Upgrades

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Upgrade the computer monitors (5)</td>
<td>$750</td>
<td>$0</td>
<td>$0</td>
<td>$750</td>
<td>$131</td>
<td>5.7</td>
<td>22.2%</td>
<td>$2,860</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*

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7. Tucker Free Library

General Information

Two site visits were conducted for the Library, where Jordan met Lynn Piotrowicz, the Director at the library, to investigate and evaluate The Tucker Free Library. At another site visit Jordan tested the performance of the building envelope through the use of blower door testing and infrared imaging.

The Tucker Free Library was built in 1903 and has maintained much of its originality and historical features through the years. In the early 1990’s a handicap accessible stairwell addition was completed on the south west corner of the building. The library installed blown in cellulose insulation between the main floor ceiling and the floor of the attic in 2008. The library has approximately 7,711 square feet of conditioned space over two floors. The building contains an attic, a main level, a lower level, and a sub-basement. The attic is unfinished, unconditioned space and is used as storage. There is a small portion of finished space in the attic, however this space is not used and there are no plans to use the space for anything other than storage. The main level houses a large collection of books, audiobooks, and videos/DVDs. Located on the first floor are the New Hampshire Room, Non-Fiction Room, and Fiction Room. Several library staff also have offices on the main floor. The lower level is home to the children’s and juvenile’s collection as well as the kitchen/meeting area, archives and furnace room. The sub-basement or Kindergarten Room was at one time used, but now serves as a storage space. It is heated to 58 degrees in the winter and an ERV runs in the space to maintain low levels of relative humidity and control odor.

The library has a small staff of six and is run by a five member board of trustees. The Tucker Free Library’s hours of operation are Tuesdays and Wednesdays 10am to 8pm, Thursdays and Fridays 10am to 5pm, Saturdays 10am to 1pm, and Sundays and Mondays the library is closed.

Existing Conditions

Building Envelope

Walls

The walls of The Tucker Free Library have not been altered since the original construction in 1903. The exterior is brick and the interior is lathe and plaster. The lathe and plaster construction was confirmed by the infrared imaging.

The exterior walls in the 1990s stairwell addition are composed of drywall, metal studs with fiberglass batts and a brick exterior. The stairwell was chosen not to be conditioned although there are ducts running through the space if heating or cooling were needed.
There are several different window types located throughout the building.

- There are eleven 4’x8’8’’ large windows on the main level. Each window is composed of two sections. The lower portion of the window measures 4’x6’ and the upper portion of the window is an awning. The awnings are lead glass, and very fragile. Library staff would like the windows to be more functional, but due to their age and fragility they are rarely used. All of these windows are located on the main floor. Four are on the front (north) façade of the building and an additional three are on the east and west elevations of the building and one on the south eastern façade of the New Hampshire Room. These windows also have exterior storms installed.

- Nine refurbished windows, measuring 2’4”x 6’6” are located on the southern façade of the building, in the main floor fiction/stacks room. A retrofit of the windows was completed in 2010 by Jon Routon and included removal of the windows, scraping and painting of the exterior sides, installation of weather stripping, and replacement of deteriorating ropes with brass fixtures. These windows also have aluminum exterior storms.

- Another nine 2’4”x 5’ windows are located on the lower level in the Children’s Room. These are also on the south façade of the building, and are newer wood frame windows. Storms are also on these windows.

- Seven hopper windows measuring 4’x 3’ are located along the front façade on the lower level of the building, extending around to the east and west façade. These are often opened in the juvenile room in the summer for ventilation.

- Two small windows measuring 3’x 1’8” are on the lower level. Both are located in the kitchen/meeting area.

- Two small windows measuring 3’x 2’ are blocked off for use with the ERV in the sub-basement.

**Roof**

The attic of the library has blown in cellulose insulation that was added in 2008 along the main floor ceiling plane beneath the floor boards of the attic. According to Lynn Piotrowicz, Library Director, some portions of the attic had up to four feet of cellulose added during installation. During one site visit with Building Energy Technologies, an attic floorboard was removed and it was discovered that portions of the attic held as few as 4-6 inches of cellulose. The varying levels of
insulation were apparent with the infrared imaging as well. The attic is vented with two small fans located on opposite ends of the roof and a vented window on the front façade.

There are two chimneys, one from the chimney located in the New Hampshire room that is not used, and one from the chimney exhausting off the furnace. The unused chimney and fireplace in the New Hampshire room is not sealed off.

Severe ice damming was present near the front of the building at the eaves due to insufficient amounts of attic insulation and air sealing. Ice dams are areas of ice and icicles created by snow and ice melting further up the roof and re-freezing lower on the roof, usually along the eave. A “dam” is created by a ridge of ice along the eaves that traps even more melt water and can result in water melt leaking under and through the roofing. This leakage can cause damage to the sheathing, the roof structure, or the ceiling and walls below. Large icicles and the ice ridge along the eaves are also a danger to people below if they fall.

Foundation

The Tucker Free Library sits on a granite and stone foundation with poured concrete floors. There is no insulation. It is in good condition with no moisture issues (aside from possibilities in the Kindergarten sub-basement room, please see the section ahead titled “Notable Problem Areas” for more details).

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The library is heated by two systems. The main floor has a forced air distribution system while the lower level uses forced hot water to radiators to meet its heating needs. The main floor has the option of using air conditioning in the summer, which was added in 2005, but the high cost of providing air conditioning to the space has limited its use to only a handful of days a year.

The furnace servicing the main floor is a York. It was installed in 2005 and is rated at 80% efficiency with an hourly output range of 168,000-188,000 BTU. There is also an air handler with a hot water coil off the boiler. It is also a York and was installed in 2007. The boiler servicing the lower level is a Weil-McLain, model number P-268-W, with an 82.25%
efficiency. The boiler is estimated to have been installed around 1994. Both the boiler and the furnace use fuel oil. During the last heating system evaluation, performed September 21, 2010, the boiler was rated in excellent condition and the furnace was rated in good condition.

The Kindergarten Room, located in the sub-basement, has both electric baseboard heat and forced hot water baseboard radiators. The two electric baseboard heaters are used for back up heat only, while the two forced hot water radiators are used to heat the space to the required 58 degrees for operation of the ERV. The Kindergarten Room utilizes a RenewAire ERV (EV70@ 69cfm) to maintain a low relative humidity in the space. The ERV was installed in 2007 upon recommendation by a local engineer as a means to control an odor emanating from this room. According to the product information sheet supplied by the library director, the ERV should run at 69 cfm 51% of the day, and be off for the other 49% of the day. Jordan believes that the ERV is diluting the smell with fresh air, but has not solved the odor problem which may be mold or moisture related. Please see section 3 for more information on the Kindergarten Room.

**HVAC Controls System**

The main floor of the library is controlled by one LUX programmable thermostat located near the staff offices. During the heating season the temperature is kept around 68 degrees. It is set back to 55 degrees a half hour before the library closes and is set to turn to 68 degrees a half hour before the library opens.

The lower level is split into three zones, the Juvenile Room, the Children’s Room, and staff break room. Each have their own thermostat. The thermostats used are the same LUX programmable models as used on the main floor.

The Kindergarten Room has a round non-programmable thermostat to control the forced hot water radiators, and the electric back up radiators have controls on the units.
Electrical, - Lighting and Appliances

The Tucker Free Library also participated in the PSNH lighting retrofit done on most of the town’s buildings in 2008. On the main floor the entry way, New Hampshire room and Non-fiction room were outfitted with 2’x2’ high efficiency fluorescent fixtures. Each fixture has two T-8 bulbs. The fixtures blend well with the historical details of the ceilings in these rooms.

The Stacks room has single bulb T-8 fixtures mounted onto the book shelves. Due to the stack room’s location on the south side of the library it receives ample natural lighting during the day.

Occupancy sensors and day lighting controls were not installed as part of the lighting retrofit. Occupancy sensors would unlikely work in this type of building use, but day lighting controls could be explored as a way to conserve electricity. The main floor of the building has large windows that allow for great natural lighting.

On the lower level of the library recessed T-8 fixtures are present in the Children’s Room and in the Juvenile Room double bulb T-8 fixtures are in use.

Plumbing and Domestic Hot Water

The Tucker Free Library has a very low demand for domestic hot water (DHW). There are three sinks located in the building where hot water is used. They have an appropriately sized, 10 gallon electric hot water heater located in the furnace room.
Notable Problem Areas/Occupancy Comfort

- The library is cold in the winter and hot in the summer. In an effort to save energy and money, the staff maintains winter temperatures around 68 degrees, and limits the use of the air conditioning to days when it is very hot. Currently, meeting the thermal comfort needs of the staff and occupants would cost too much money and energy.

- Natural ventilation in the summer is difficult due to many fragile and inoperable windows in the New Hampshire Room and Non-Fiction Room.

- The large single pane windows contribute to a great deal of heat loss in the building.

- The attic’s blown in cellulose is uneven and lack of air sealing between the main floor and the attic have prevented full effectiveness of the insulation added in 2008. If this were fixed it would require less energy to heat the main floor space in the winter and increase occupant comfort.

- Old refrigerator in the upstairs kitchen uses a lot more energy than modern models.

- Fire place is never used, but is not sealed off allowing warm heated air to escape out throughout the chimney.

- Un-insulated ducts and pipes were seen through the library, decreasing the effectiveness of the heating and cooling distribution systems.

- There is a very Low R-value of the walls, only an R- 4.43 when the recommended R-value for a wall is R-40. However it would be destructive to the character of the building to address this at this time.

- The odor in the Kindergarten Room could be caused by an underlying mold problem. Additionally the ERV is using electricity to maintain the humidity in a space that is unoccupied. The Room must also be heated to 58 degrees in the winter, using more energy. The drain in the Kindergarten Room could be another cause of the smell in the space (please see EEM M3 for more details).
Energy Use and Cost Analysis

The Tucker Free Library uses Fuel Oil #2 and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers and other office needs, cooling, the ERV, back up baseboard heating in the Kindergarten Room, as well as domestic hot water heating. The fuel oil is attributed to space heating.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and oil use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$4,660</td>
<td>$0.17/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>$4,140</td>
<td>$3.01/gallon</td>
<td>$3.67/gallon</td>
</tr>
<tr>
<td><strong>Current Total Energy Cost</strong></td>
<td><strong>$8,800</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The current state wide average price per gallon of oil is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly oil use of 1,376 gallons a year and the current state wide average price per gallon of oil of $3.67, the Library would be paying $5,050 a year for oil.
The Energy Consumption chart graphically analyzes the electric and oil consumption in kBTUs which allows for direct comparison of fuel consumption. The numbers shown are also three year averages.

<table>
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<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>92,743</td>
<td>27,181 kWh</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>190,792</td>
<td>1,376 gallons</td>
</tr>
<tr>
<td>Total Energy Use</td>
<td>283,535 kBTU</td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Library:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tucker Free Library</td>
<td><img src="image1" alt="Energy Use Breakdown" /></td>
<td><img src="image2" alt="Energy Cost Breakdown" /></td>
</tr>
<tr>
<td>33% Electric</td>
<td>67% Oil</td>
<td>53% Electric</td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use (for the 12 month period ending December 2010) for The Tucker Free Library:

**EUI = 71.6 kBTU/SF/YR**  
**CUI = $1.20 /SF/YR**

By comparing The Tucker Free Library to other Libraries across the United States they are in the 85th percentile. This means that 15% of libraries are more energy efficient and 85% are less energy efficient. However, we know this to be because of the low temperatures the building is heated to, the low use of air conditioning in the summer, very low hot water use, and low electrical use due to the diligence of the library staff. If the library were to use energy as a typical library does, there would be a large increase in the EUI and CUI numbers. Therefore these numbers and comparison do not accurately represent the efficiency of the building’s actual performance, but rather the behavior of the library staff.
Envelope Testing

Blower door testing as well as Infrared imaging was performed on the building. (Please see Appendix B for the building’s IR report).

An air tight building will have infiltration rates of .25 -.33 ACHn. These are the numbers we strive for in retrofits and new construction. The results of the blower door test are listed below.

Blower door test results:

\[
\text{CFM50} = 10,609 \quad \text{ACHn} = 0.60 \quad \text{ACH50} = 10.04
\]

Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

**B1-Air seal and insulate the attic.** Although the attic has already been insulated, it was not air sealed at the time of installation. Air sealing is very important to the performance of insulation. Without air sealing air is able to move up through the insulation diminishing the effective R-value of the insulation. If the warm air is still able to leave the space below and enter the attic, the insulation is not effective. We also found by lifting up a few floor boards and by using our IR camera that the insulation is not level throughout. We suggest having the floor taken up and the current insulation vacuumed out by an insulation contractor. The floor plane can then be air sealed with an inch to two inches of spray foam to prevent any air (and therefore heat) from moving up into the attic. The perimeter of the attic floor and around the chimney’s should also be air sealed at this time. Next the cellulose insulation can be returned to the joist cavities. We also recommend adding additional cellulose to gain a higher R-value.

It is also recommended to build an insulated wall and attic entrance doorway at top of the stairs to the attic. This will move the thermal barrier in line with the attic floor and prevent the need for insulating the stair well to the attic.

**B2- Install insulated door in basement between archives and meeting room.** Currently a tarp separates the conditioned meeting area from the unconditioned archive space. This should be replaced with a permanent insulated door to prevent heat loss to the archive room and cold air infiltration into the conditioned meeting area. (From ongoing conversations with the Library Director we were informed that this measure has already been installed.) Also consider insulating the walls of the archive room and the mechanical room from the rest of the conditioned basement area. This will prevent heat loss to the unconditioned spaces, but should remain low priority for energy upgrades.
B3- **Install gaskets on seven hopper windows in the basement juvenile room.** These windows were found to be very leaky during the blower door testing. We found that it was because they do not close tightly. Installing gasketing around the edge of the windows will ensure the windows close tightly with no air infiltration. This will reduce heating loads in the winter and any cooling loads in the summer.

*Photo 57: Hopper window in the Juvenile room showing a lot of air infiltration during the blower door test*

B4- **In the juvenile room, we recommend replacing the exterior door with an insulated door and insulating and air sealing around the frame.** This will make this door operable and a safe fire exit, as well as save energy. With the IR camera we found this door to be very leaky.

*Photo 58: Exterior door in the Juvenile room with cold air infiltration into conditioned space around the edges of the door*

B5- **Install a fireplace balloon to seal off the fireplace on the main floor in the New Hampshire room.** The fireplace is never used in the building, and at our site visit we found that the damper on the fireplace was closed but no other measures had been taken to seal off the chimney to prevent cold air from entering the building. We suggest a fireplace balloon to be installed above the damper to seal off any cold air that may enter through the chimney. This will also make the room feel less drafty and more comfortable.

*Photo 59: Awning on the main floor showing cold around the edges*

B6- **On the main level, repair and install new gaskets on the awning windows.** The Director has expressed that they would like to be able to use the awning windows above the main windows in the New Hampshire room and the non-fiction room for ventilation in the summer, however most are broken and inoperable. In order to keep the original windows, we suggest having them repaired and installing gaskets so that they close properly and tightly saving on heating and cooling.
B7- Doors to the unconditioned stairwell should have weather stripping installed. This is an easy and inexpensive way to prevent the cold air from the unconditioned stairwell from entering the conditioned space of the library, saving energy on heating.

B8- Cap and seal all old supply/return vents from old heating system. There are vents located low on the walls of the New Hampshire room, the nonfiction room and the south facing stack room (the fiction room) on the main floor. Sealing the vents can be done in a way that will still maintain the character and keep the vents in place if wanted. A board stained to match the wooden trim can be placed behind the metal vent air sealed around the edges before the vent is replaced. This will prevent unwanted air movement in the building.

B9-Remove the header trim and insulate the cavity above the pocket door on the main floor. This is an option if air sealing of the attic is not done. It will eliminate the draft at the pocket door and make the area feel more comfortable, while not having to pay to condition the cold air coming in from the attic, or heated air entering the attic.
B10- Insulate the mechanical and storage room from the rest of the conditioned space in the basement level. This will prevent any heat loss to the unconditioned spaces, but it should be left for one of the last energy improvements made, as other measures will save more energy.

Future recommendation- In the future should any opportunity for an in depth renovation arise insulating the walls should be a priority. It is not suggested for the immediate future as it would be destructive to the original construction of the building, and very costly.

Recommended Mechanical Energy Efficiency Measures

M1- Install insulation on all hot water piping. On our site visit we noted there was no hot water pipe insulation in the building, aside from exposed hot water pipe in the juvenile room. This is another inexpensive and easy way to save energy. This will save electricity from the hot water heater and oil from the forced hot water heating.

M2- Repair and add insulation to exposed ductwork. Some ductwork at the library was insulated, but it was in poor condition. We recommend insulating all ductwork that is not already insulated and repairing the existing insulation. Although most duct work is running within the thermal envelope of the building the warm air has to travel up stairs to the main floor, from the lower level where the furnace is located. Heat is being lost along the way due to the great differences in supply air and room air temperatures. Insulating these ducts would make the distribution system more efficient.

M3- Testing and balancing of the ductwork is also an option that measures air flow at the ducts to see how the ducts are currently working and exactly where any repairs need to be made.

M4- Investigate the mold/mildew/odor in Kindergarten room. Further examination of the Kindergarten room was done to investigate the mold/mildew smells coming from the room. During a follow-up site visit the bags of books were removed and a drain was found in the Kindergarten room. This may be the cause of the odors, as it may be backing up or clogged at the other end of the drain. Further investigation is required by a plumber to determine if this is in fact the cause of the odors. If this is found to be the issue, the drain should be sealed off, and the ERV may be removed saving electricity, or it may be installed to serve the main floor instead.

We also recommend investigating possible mold behind kindergarten room walls. If mold is found it should be removed appropriately by a specialist. After proper removal and remediation of the mold and moisture source, reinsulate the walls with spray foam and install paperless drywall. Spray foam and paperless drywall do not permit the growth of mold. After the issue is addressed and found to be solved, the ERV can be disconnected as mentioned above. Air seal
and insulate the ERV penetrations through the exterior wall as well if removed. These measures have not been priced as further investigation is required.

Appendix C includes the data collected by our monitoring equipment over a two week span from the Kindergarten Room. Temperature and relative humidity (RH) in the air were monitored to determine if conditions were right for mold growth. The air was chosen to be monitored to avoid any damage that would be required to monitor within the exterior wall. We did not find that the conditions within the air would permit the growth of mold, however the walls should still be inspected because there may be higher levels of humidity within the walls that the monitoring equipment did not pick up on.

Recommended Electrical Energy Efficiency Measures

E1- Add day lighting controls. Several areas of the Library could benefit from day lighting controls, especially the more open concept of the main floor. Day lighting controls will call for lighting only when the natural day lighting falls under a certain lumen level in the room. They can also dim lighting to add slightly to the day lighting. This will save electricity by only having as much lighting on as needed.

E2- Upgrade refrigerators to Energy Star Models. Refrigerators have come so far in their efficiency that if your refrigerator is more than five years old there is energy saving potential from upgrading to the current Energy Star models. By replacing either of the older refrigerators, electric savings can be realized. We recommend doing this when the refrigerator reaches end of life. This has not been priced or included in the financial model for this reason.

Recommended Renewable Energy Efficiency Measures

R1-Solar power retrofit of the historical antique lamp posts (2). The Library director expressed interest in rehabbing the old lamp posts that used to be outside the entrance of the library to run off solar power. We have quoted the project of purchasing two bulbs, two batteries, two charge controllers, two night sensors, and two photovoltaic panels and installation. Our pricing does not include the glass globe and the necessary cable/wiring. This will save the library from paying for the added electricity of bringing these lights back, while also returning the Library to its old charm with a sustainable twist!
Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
### Projected Financial Analysis

#### Library

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS (kBTU)</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Air seal and insulate attic; build wall and attic door at top of stairs</td>
<td>$18,354</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$18,354</td>
<td>$495</td>
<td>17,338</td>
<td>37.1</td>
<td>3.3%</td>
</tr>
<tr>
<td>B2 Install insulated door between meeting area and archive room</td>
<td>Done</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>N/A</td>
<td>$0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B3 Repair worn gaskets on 7 hopper windows in juvenile room</td>
<td>$350</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$350</td>
<td>$220</td>
<td>7,706</td>
<td>1.6</td>
<td>67.9%</td>
</tr>
<tr>
<td>B4 Replace door with insulated door; insulate and air seal around new frame, Juvenile room</td>
<td>$1,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,000</td>
<td>$110</td>
<td>3,653</td>
<td>9.1</td>
<td>15.4%</td>
</tr>
<tr>
<td>B5 Install fireplace balloon</td>
<td>$90</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$90</td>
<td>$275</td>
<td>9,632</td>
<td>0.3</td>
<td>310.8%</td>
</tr>
<tr>
<td>B6 Repair (they currently do not all open/close) and install gaskets on 8 hopper windows (windows are 4' x 2 1/2&quot;)</td>
<td>$800</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$800</td>
<td>$275</td>
<td>9,632</td>
<td>2.9</td>
<td>39.4%</td>
</tr>
<tr>
<td>B7 Add weather stripping to doors to the stairwell</td>
<td>$120</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$120</td>
<td>$275</td>
<td>9,632</td>
<td>0.5</td>
<td>188.5%</td>
</tr>
<tr>
<td>B8 Cap and insulate unused return/supply ducting</td>
<td>$450</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$450</td>
<td>$220</td>
<td>7,706</td>
<td>2.0</td>
<td>53.9%</td>
</tr>
<tr>
<td>B9 Remove header/trim and air seal and insulate cavity above pocket door</td>
<td>$250</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$250</td>
<td>$220</td>
<td>7,706</td>
<td>1.1</td>
<td>93.1%</td>
</tr>
<tr>
<td>B10 Insulate the walls of the mechanical and archive room (342 SF)</td>
<td>$1,532</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,532</td>
<td>$165</td>
<td>5,779</td>
<td>9.3</td>
<td>15.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$22,946</td>
<td>$22,946</td>
<td>$2,202</td>
<td>10.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

#### MECHANICAL SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>MECHANICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS (kBTU)</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Insulate all hot water piping</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$55</td>
<td>1,926</td>
<td>3.6</td>
<td>32.0%</td>
</tr>
<tr>
<td>M2 Repair and add insulation to exposed duct work</td>
<td>$500</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$500</td>
<td>$55</td>
<td>1,926</td>
<td>9.1</td>
<td>15.4%</td>
</tr>
<tr>
<td>M3 Testing and balancing of ducts</td>
<td>$1,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$1,700</td>
<td>$1,700</td>
<td>$110</td>
<td>15.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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</table>

#### ELECTRICAL SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>ELECTRICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS (kBTU)</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Add day lighting controls to the main level</td>
<td>$6,200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$6,200</td>
<td>$233</td>
<td>4,637</td>
<td>35.2</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

#### RENEWABLE ENERGY SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>RENEWABLE ENERGY SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS (kBTU)</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 Install solar powered retrofit to old lamp posts</td>
<td>$1,300</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,300</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 3% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*
8. Fire Station

General Information

The Fire Station is located at 216 Maple Street in Henniker. The building is approximately 10,344 square feet of conditioned space on two levels. The Fire Station was built in 1994.

The Fire Station has open to the public business hours of Monday through Friday 7 am-5 pm. Weekends the building is not occupied.

Existing Conditions

Building Envelope

Walls

The exterior walls of the garage building consist of 2” x 8” wood framing with vinyl exterior siding. Some areas of the vinyl siding are in poor condition and is chipping or peeling. The walls are insulated with R-28 fiberglass batt insulation between bays and there is a 6 mil poly vapor barrier and 5/8” drywall and plaster interior finish. There are two louvers located in the wall of the back of the building. There is a fire wall between the garage and the rest of the building. There is a window however that connects the radio space to the garage where cold air often makes its way into the conditioned space.

Windows and doors

The windows of the Fire Station are double pane, framed double hung windows original to the construction of the building. Some are wood framed, some are vinyl framed. There are a total of six garage doors. Four are located on the front of the building and two are located on the back. Two are in line to be replaced. Each had weatherstripping in poor condition.

The entrance door beside the four garage doors could also benefit from weather stripping.
Roof

The roof is a large asphalt shingle, pre-manufactured truss framed roof. It has two gabled roofs that meet. There is soffit venting as well as gable end vent louvers and ridge vents. A cupola is located where the two roofs meet and supplies extra venting. The cupola may also be causing unbalanced venting and/or enhancing the stack effect in the building. Stack effect, according to the Building Science Corporation, is the air movement caused by warmer air rising and cold air falling. Air pressures are created in direct relation to the temperature difference between inside and outside and the height of the building. The greater the temperature difference (or ΔT) the greater the pressure and the taller the building the greater the pressure. The resulting pressure differences between the warm and cold air can lead to air leakage up and out the top of the building (the attic) and a pull of cold air in at the base of the building. This generates unwanted air flows within buildings that can result in heat loss.

The attic is insulated along the second floor ceiling plane. The building drawings indicated R-38 fiberglass insulation and vapor barrier, though site visit notes identified the insulation as blown in cellulose. This should be further determined. There is an attic hatch access to the attic. Severe ice damming occurs at the connection of the two roofs on the back of the building. There are two penetrations in the roof that are plumbing vents.

Foundation

The Fire Station was built on a poured concrete foundation and slab. The plans call for 2” of rigid insulation on the interior of the footing and 2’ in beneath the slab. However, at the site visit we saw an area of exposed foundation insulation on the exterior, so it seems that it had been installed on the outside.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The garage section of the building is heated via two propane fired Reznor ceiling mounted unit heaters. The temperature in the garage is kept at around 65 degrees in the winter. The garage areas is also served by seven airmation air cleaners to rid the space of vehicle exhaust fumes. They are activated by the garage doors opening and run for 16 minutes after being called on.

The rest of the building is heated by a Rheem Classic 90 Plus propane fired furnace. Pre-insulated forced hot air ducts supply heating and cooling to the space. The insulation level is very low on the ducts. The vents in the meeting room have been closed off to move more volume of air to the other spaces. The Rheem furnace is 6-7 years old.
Air conditioning is supplied to the space via two Goodman Manufacturing Corp condensors located outside behind the building. They utilize the same ducting supply as the heating system. They are original to construction in 1994.

**HVAC Controls**

There are two thermostats in the garage, one for each of the Reznor unit heaters. They are Honeywell knob thermostats.

**Electrical - Lighting and Appliances**

The interior lighting of the Fire Station was updated last year when the town completed a lighting upgrade through PSNH. All rooms have motion sensor controls. There are 25 metal halide lighting fixtures in the garage as well as T-8 fluorescent bulb fixtures. The metal halide fixtures are very rarely needed. T-8’s are also common throughout the rest of the space. There are also sodium lights for outdoor lighting above the garage doors.

There is a back up generator behind the building that runs off propane.

The fire trucks need to be plugged in when not in use, and are a very large draw of electricity for the building. This is also a electric load very specific to this building, that can not be avoided.

The kitchen is used daily and contains a frigidaire freezer, an older 1980’s microwave and an old kenmore stove. There is also a washer and dryer present in the facility that also uses electricity.

The plug load evaluation for the Fire Station is very high due to the need for the fire engines to be plugged in and the air filtration exhaust system in the garage.

**Plumbing and Domestic Hot Water**

The bathrooms have standard flush toilets. There are low flow shower heads and aerators on the faucets.

There is an electric hot water tank that supplies the building's domestic hot water. The hot water pipes are not insulated.

**Notable Problem Areas/Occupancy Comfort**

- Ice damming is occurring at the eaves of the roof and the valley at the rear if the building due to heat loss through the roof. Insufficient insulation and lack of air sealing are usually the cause of ice damming.
- Electrical energy use very high due to the fire trucks and the air filtration system.
- Weather stripping on garage doors is in poor condition.
- Louvers on the back of the building are a source of heat loss because they are a penetration in the wall.
- Ducting has a low level of insulation and it is therefore not effective.
- Some areas of the vinyl siding are in poor condition and may allow moisture behind the siding.
- Older appliances in the kitchen are using more electric than newer appliances would.
Energy Use and Cost Analysis

The Fire Station uses propane and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers, appliances and the fire trucks. The propane use is attributed to space heating of the garage and the building.

The energy cost chart, below, graphically analyzes the electric and propane costs. The numbers shown are three year averages.

---

**Fire Station Energy Costs (3 Year Average)**

![Bar chart showing energy costs for electric and propane over a 3 year average.]

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$6,683</td>
<td>$0.16/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>$7,324</td>
<td>$1.98/Gallon*</td>
<td>$3.15/Gallon</td>
</tr>
</tbody>
</table>

*The current statewide average price is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly oil use of 3,689 gallons a year and the current state wide average price per gallon of propane of $3.67, the Fire Station would be paying $11,620 a year for propane.
The Energy Consumption chart below graphically analyzes the electric and propane consumption in kBTUs. *The numbers shown are also three year averages.*

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>138,721</td>
<td>40,656 kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>338,088</td>
<td>3,689 Gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>476,809 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Fire Station:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Station</td>
<td><img src="image1" alt="Energy Use Breakdown" /></td>
<td><img src="image2" alt="Energy Cost Breakdown" /></td>
</tr>
</tbody>
</table>

### Building Benchmarking

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Fire Station:

**EUI = 75.3kBTU/SF/YR**

**CUI = $1.35 /SF/YR**

By comparing the Fire Station to other buildings of similar use across the United States they are in the 65\(^{th}\) percentile. This means that 35% of similar fire station buildings are more energy efficient and 65% are less energy efficient.
Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

**B1- Air seal and add insulation to the attic.** Air sealing is a very important aspect of preventing heat loss in an attic. The integrity of the vapor barrier in the attic should be further examined to determine the condition. If it is found to be compromised by penetrations or tears, the existing blown in cellulose insulation should be removed, and surgical air sealing with spray foam should be applied around all penetrations. The cellulose can then be put back and more cellulose should be added to total 18” and an R-60. Also consider further investigation to determine if there is unbalanced venting in the attic.

**B2a- Replace garage doors with insulated garage doors.** The garage can save energy and see a cost savings benefit from installing insulated garage doors. Also make sure that the doors planned for replacement are insulated and have a thermal break in the frame. This may be something that is done as the garage doors reach their end of life.

**B2b- Weather strip garage doors and exterior doors.** This will prevent air leakage at the doors and save energy on heating.

Recommended Mechanical Energy Efficiency Measures

**M1- Re-insulate and seal the ducting.** The ducting has a very low and ineffective level of insulation that should be replaced with a higher level of insulation and the ducts should also be sealed. After removing the existing insulation on the ducts, the ducts should be sealed with mastic to prevent any leaks and improve the efficiency of the distribution system. Next the ducts should be insulated to an R-8, also improving the efficiency of the distribution.

**M2- Install CO detectors in rooms adjacent to the garage for health and safety.** This will warn if any high levels of carbon monoxide make their way into the building and will ensure the safety of the occupants at all times.

**M3- Install programmable thermostats.** This will ensure that temperature setbacks go into effect each day/weekend as occupants leave the building and will result in propane savings in the heating season and electrical savings in the cooling season.

Recommended Electrical Energy Efficiency Measures

**E1- Replace refrigerators with Energy Star models when the appliances reach end of life.** This should only be done once the refrigerators need to be replaced, and therefore has not been priced at this time. Significant electric savings can be seen by upgrading refrigerators. We recommend doing this only once the refrigerator reaches end of life. This item was not priced or included in the financial model.
Recommended Renewable Energy Efficiency Measures

R1-Consider installing photovoltaic panels to offset the electric use of the fire engines. Photovoltaic Panels, or PV panels, use the sun to create electricity that can offset the current use. Further study would be required to ensure the site has proper sun exposure before moving forward.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value.
### Projected Financial Analysis

#### Fire Station

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 In the attic, surgically air seal, air seal top plate add 10&quot; of blown in cellulose. (attic=10,344SF)</td>
<td>$11,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$11,000</td>
<td>$2,440</td>
<td>71,271</td>
<td>4.5</td>
<td>27.1%</td>
</tr>
<tr>
<td>B2a Replace garage doors with insulated doors (4) 12' x 14'</td>
<td>$12,957</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$12,957</td>
<td>$2,208</td>
<td>64,484</td>
<td>5.9</td>
<td>21.8%</td>
</tr>
<tr>
<td>B2b Replace weather stripping on (6) 12' x 14' garage doors</td>
<td>$1,500</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,500</td>
<td>$1,046</td>
<td>30,545</td>
<td>1.4</td>
<td>74.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$25,457</strong></td>
<td><strong>$25,457</strong></td>
<td><strong>$5,694</strong></td>
<td><strong>4.5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MECHANICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Re-insulate and seal the ducting (~50')</td>
<td>$244</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$244</td>
<td>$291</td>
<td>8,485</td>
<td>0.8</td>
<td>124.3%</td>
</tr>
<tr>
<td>M2 Install CO detectors in rooms adjacent to the garage</td>
<td>$280</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$280</td>
<td>$0</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>M3 Install programmable thermostats</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$116</td>
<td>3,394</td>
<td>1.7</td>
<td>63.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$724</strong></td>
<td><strong>$444</strong></td>
<td><strong>$407</strong></td>
<td><strong>1.1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RENEWABLE ENERGY SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 Install PV panels to offset electrical load</td>
<td>$45,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$45,000</td>
<td>$1,808</td>
<td>37,532</td>
<td>24.9</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*
9. Highway Department

General Information

The Highway Department is located at 209 Ramsdell Road in Henniker. The building is approximately 6,048 square feet of conditioned space on one floor and was built in 1972. The building is comprised of two sections, an office section in a mobile home structure and a garage section. There is also an addition to the garage that includes a single garage bay with a shed roof. The office space is approximately 1,344 square feet and the garage is approximately 4,704 square feet.

The Highway Department has normal weekday business hours and the garage may be used for additional hours in the case of poor road conditions. This is a total of around 40 hours a week that the building is used.

Existing Conditions

Building Envelope

Walls

The exterior walls of the garage building consist of a combination of metal and wood framing with metal exterior siding. There has recently been rigid and fiberglass insulation installed surrounding the garage doors. The majority of the exterior walls are un-insulated with no interior finish.
The office space is located in an attached mobile home structure. It houses an office and two bathrooms, storage area and a lounge area with a kitchenette. The wall assembly of the office structure consists of exterior vinyl siding, wood framing, fiberglass batt insulation and drywall interior finish. There is a through wall AC unit installed that is a fairly large penetration in the wall.

Windows and doors

There are no windows in the garage building, except for those in the garage doors. There are a total of six garage doors on the main building. A seventh garage door is located in the single bay unconditioned garage addition on the end of the main garage. All of the garage doors are not insulated doors. Weather stripping was present on the garage doors but in very poor condition. Some of the garage doors were in line to receive repairs as of the time of the site visit. The office section has single pane vinyl slider windows. All four exterior doors to the office section are properly weather stripped.

Roof

The roof is a large metal framed gabled roof with aluminum metal roofing. The single bay addition has a low pitched shed roof that is also aluminum. The attic is vented by gable end vents. The ceiling plane of the garage is corrugated metal. To our knowledge of the building there is no insulation above this corrugated metal or any insulation along the roof line. This is an extreme source of heat loss due to the lack of insulation.
Foundation

The garage was built on a slab on grade with a four foot concrete wall extending up the perimeter of the garage. The Office section is on a concrete slab but is supported above the slab by steel I-beam supports as most mobile homes are. There is additional support of concrete masonry unit blocks beneath the office as well. There is no known insulation beneath the floor of the office section and therefore a large amount of heat may be being lost to the space below the office.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The Highway Department garage is heated by an aged oil fired furnace. The garage section of the building’s temperature is kept low at around 60 degrees. There is no ducting to evenly disperse the conditioned air through the space, the hot air simply exits the furnace and is supplied right to the ceiling level (see photo 80 to the right). The Highway Department is looking to replace this furnace within the year. The occupants are very good about turning heat off if the garage doors are open.

The office space is also heated via a oil fired hot air furnace. This furnace is two years old and has an AFUE of 81. The air filters to the furnace were found to be very dirty at the time of the site visit and are most likely hindering the system’s efficiency and the indoor air quality. The heating distribution system is via metal ducting. The ducts are un-insulated.
HVAC Controls

The garage has one thermostat, though the space is kept at 60 degrees. The office space has a thermostat located in one of the two bathrooms that is not used.

Electrical - Lighting and Appliances

The interior lighting of the garage and the office space is upgraded T-5 flourescent tube lighting. There is also an electical exhaust vent in the garage area but it is not frequently turned on.

The plug load evaluation for the Highway Department is average compared to buildings of similar use. The garage electric demand are attributed to a compressor that runs all the time, lighting and miscellaneous plug loads. The office space’s electrical demand is the kitchenette area with two older microwaves, a refrigerator, stove, a grittle and toaster oven, as well as the office equipment.

Plumbing and Domestic Hot Water

There are two bathrooms located in the office section of the building. They each have American standard 1.6 gallon flush toilets, which are considered standard flow fixtures, as well as aerators on the faucets. A shower is located in each of the bathrooms, but they see very little use. The showers, bathroom sinks and the kitchen sink are the only draws of domestic hot water in the building.

Notable Problem Areas/Occupancy Comfort

- No insulation in ceiling of garage
- No insulation in wall of garage
- Poor weather stripping
- No insulation on the ducting
- No basement or under floor insulation to the office space
- Through wall penetrations in the office building (AC)
- Garage doors are un-insulated
Energy Use and Cost Analysis

The Highway Department uses oil and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers and appliances in the office area and the air compressor and tools in the garage. The oil is attributed to space heating via the two forced hot air furnaces.

The Energy Cost chart, shown on the following page, graphically analyzes the cost of your electric and oil use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$3,657</td>
<td>$0.16/kWh</td>
<td>$0.14/ kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>$6,909</td>
<td>$2.82/gallon*</td>
<td>$3.67/ gallon</td>
</tr>
</tbody>
</table>

*The statewide average price is according to the New Hampshire Office of Energy and Planning as of July 6, 2011.

Using current yearly oil use of 2,448 gallons a year and the current statewide average price per gallon of oil of $3.67, the Town Hall would be paying $8,984 a year for oil.
The Energy Consumption chart below graphically analyzes the electric and oil consumption in kBTUs which allows for
direct comparison of fuel consumption. The numbers shown are also three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>76,063</td>
<td>22,293 kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>339,514</td>
<td>2,448 gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>415,577 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Highway Department:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway Department</td>
<td><img src="image" alt="Energy Use Breakdown" /></td>
<td><img src="image" alt="Energy Cost Breakdown" /></td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI) and Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Highway Department:

- **EUI = 87 kBTU/SF/YR**
- **CUI = $1.42 /SF/YR**

By comparing the Highway Department to other buildings of similar use across the United States they are in the 25th percentile. This means that 75% of similar warehouse buildings are more energy efficient and 25% are less energy efficient.
Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1- Insulate the roof of the garage. A flash coat (one to two inches) of spray foam should be applied to the area above the ceiling along the flat plane. This will air seal and create a vapor barrier for the new attic plane. Next 15 to 16 inches of blown in cellulose should be installed atop the flash coat of spray foam to total an R-60 roof assembly. The roof is already properly vented for this.

B2- Insulate beneath the floor of the office section with 4” of spray foam to air seal and insulate to an R-20. Spray foam is recommended here due to the difficult access of the space and also because the spray foam can go over and around the framing and support structure beneath the office. Spray foam also is water tight and does not permit the growth of mold.

B3- Air seal around and seasonally seal the through wall AC unit in the office. This wall penetration is the source of a great deal of heat loss, especially when not in use in the winter when it is a direct connection to the outside. By properly closing off the AC unit seasonally, preventing the infiltration and heat loss will save on heating.

Recommended Mechanical Energy Efficiency Measures

M1- There are several options for upgrading the heating system in the garage. The following are a few options that will save energy compared to the current system.

M1a: Replace the oil fired furnace with a wood burning boiler. Moving to a boiler from a furnace will also require the cost of installing radiant heat and/or air handlers with hot water coils. This will save dramatically on heating costs, but likely will incur a larger up front cost to convert the distribution to hot water. This is the more simple of the options and has been priced in the financial model.

M1b: Install a new oil fired boiler as back up to solar thermal heating system to modines or radiant panels. With this system there is potential for free heating. Solar thermal hot water heating system heats or preheats the hot water that then goes to a fan coil modine, or a hot water radiant panel. This would also drastically lower your monthly heating bills, but would have the largest upfront costs. This option has not been priced or included in the financial and may require further engineering.

M2- Install programmable thermostats for the office and the garage. This will ensure that temperature setbacks go into effect each day/weekend as occupants leave the building and will result in propane savings in the heating season and electrical savings in the cooling season.

Recommended Electrical Energy Efficiency Measures

E1- Install motion sensors lighting controls in the bathrooms. This will ensure that lighting is not left on and wasting electricity.

Recommended Renewable Energy Efficiency Measures

Option M1b in Mechanical Energy Efficiency Measures is a renewable measure.
Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
## Highways Department

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MMBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Flash coat of spray foam along floor plane of “attic” Blow in 18” (to total R60) of cellulose insulation above the metal ceiling (4033 SF)</td>
<td>$13,926</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$13,926</td>
<td>$4,113</td>
<td>143,942</td>
<td>3.4</td>
<td>34.0</td>
<td>$98,846</td>
</tr>
<tr>
<td>B2 Insulate beneath the floor of the office from the underside of the trailer with 4” of spray foam (1344 SF)</td>
<td>$4,220</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$4,220</td>
<td>$881</td>
<td>30,845</td>
<td>4.8</td>
<td>25.5</td>
<td>$19,961</td>
</tr>
<tr>
<td>B3 Seal through wall AC unit in offices seasonally</td>
<td>$265</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$265</td>
<td>$245</td>
<td>8,568</td>
<td>1.1</td>
<td>97.4</td>
<td>$6,409</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$18,411</td>
<td></td>
<td></td>
<td></td>
<td>$18,411</td>
<td>$5,239</td>
<td>3.5</td>
<td></td>
<td></td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>MECHANICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MMBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1a Replace oil furnace with wood fired boiler - install all new distribution system hot water to modines</td>
<td>$40,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$40,000</td>
<td>$5,907</td>
<td>39,320</td>
<td>6.8</td>
<td>19.5</td>
<td>$122,639</td>
</tr>
<tr>
<td>M2 Install programmable thermostat in office</td>
<td>$100</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$100</td>
<td>$98</td>
<td>3,427</td>
<td>1.0</td>
<td>102.9</td>
<td>$2,569</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$40,100</td>
<td></td>
<td></td>
<td></td>
<td>$40,100</td>
<td>$6,005</td>
<td>6.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELECTRICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MMBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Motion sensors in bathrooms</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$37</td>
<td>761</td>
<td>5.5</td>
<td>23.1</td>
<td>$805</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.
10. Henniker Community Center

General Information

A site visit was conducted where Jordan investigated and evaluated the building. At this site visit Jordan tested the performance of the building envelope through the use of blower door testing and infrared imaging.

The Community Center is located at 17 Main Street in Henniker. The building is approximately 4,488 square feet of conditioned space on two floors and was originally built in the mid 1800’s. The building was originally constructed as a church and has also served as a Masonic Temple. The building utilizes public water and sewer. Located in bottom floor of the Community Center is a teen center and kitchen area. There is also a storage area with access to a crawl space on the bottom floor. The floor above is a large meeting space used to town functions and meetings.

The Community Center has operation hours of Monday- Friday, 8:00 am -5:00 pm, however it is only used as needed and is often unoccupied.

Photo 84: Main entrance to the Community Center

Photo 85: The Kitchen located in the lower level in the Teen Center has many old appliances that remain plugged in though are not used often.
Existing Conditions

Building Envelope

Walls

The exterior walls of the building consist of brick and lathe and plaster (original to the construction of the building) on the upper level. The lathe and plaster construction was visible through the IR imaging and concluded the lack of insulation in the upper level walls. The lower level has been reframed from the interior to include fiberglass batt insulation in the teen center walls. The infrared (IR) imaging of the lower level found the batt insulation within the walls to be in poor condition. Many batts were settling in corners and tops of bays which decreases the effectiveness of the insulation. Other bays showed that the batts were pushed away from the walls allowing cold air to move within the bay.

There are beautiful stained glass, single pane, double hung, wood framed windows with aluminum framed storms located on the upper level of the building. Each of these windows has a wooden decorative arch above them which proved to be a source of heat loss by the infrared imaging. The lower level of the building has smaller square, single pane wooden framed double hung windows located in the teen center.
The main entry door is a solid wood double door, whose doors did not meet. This was found to be a large source of air infiltration. The rear exit door of the upper level is a metal door that seemed to be in fair condition. The doors to the lower level of the building seemed to be in fairly good condition, with the exception of the weather stripping.

![Photo 91: IR image of the heat loss at the teen center entry door](image1)

![Photo 92: Main entry doors with light visible between the doors](image2)

### Roof

The roof is a large wood framed gabled roof with asphalt shingles. The insulation line runs along the ceiling plane above the arched tin ceiling. The IR imaging showed that the insulation does not run down the sides of the arch, leaving spaces of the ceiling un-insulated. Approximately 6 inches of blown in fiberglass is present above the tin ceiling. This totals an R-15. The recommended R-value for a roof assembly is an R-60.

![Photo 93: Photo taken above the tin ceiling showing the blown in fiberglass insulation.](image3)

![Photo 94: IR image of the arched tin ceiling showing missing areas of insulation](image4)
Foundation

The Community Center was built on a granite block foundation. There is no foundation insulation evident. The teen center is a finished space in the lower level of the building, there is also an unconditioned portion of the lower level that is a dirt floor crawl space. There is no insulation whatsoever that separates this space from the walls of the teen center or the floor of the conditioned upper level. Several floor vents also directly connect the two spaces. This is a large source of heat loss for the building.

Photo 95: the granite foundation from the exterior

Photo 96: IT image taken in the crawl space showing heat loss from the floor above

Photo 97: One of the floor vents that connects directly to the unconditioned crawl space below

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The building is heated two ways. The lower level (teen center) is heated by a propane fired Mitsubishi Mr. Slim/split heat pump system and has back up electric baseboard heating with individual thermostats on each radiator. A condensor is also hookedup to the mitsubishi mr slim and provides cooling to the lower level as well. The upper level is heated by two propane fired furnaces. The furnaces are York Diamond 90 models with an efficiency rating of 93. It was found that that air filters to the furnaces very very dirty and should be replaced more often.

The heating distribution system is forced hot air. Hot air is introduced to the spaces directly from the furnaces at two high spots on the upper level and directly form the mitsubishi Mr slim indoor unit in the lower level. The lower level also has the back up radiators.

Photo 98: The Mitsubishi split system heat pump exterior unit
Two dehumidifiers were also present in the teen center for moisture mitigation in the basement lower level.

HVAC Controls

There are two thermostats serving the upper level, one for each furnace. They are clearly marked that no one is to alter them and are in a locked box. Both are non-programmable. Individual thermostats are located on each back up electric radiator in the lower level and thermostat settings are also located on the Mr Slim unit.

Electrical - Lighting and Appliances

The interior lighting of the Community Center consists of mostly T-8 fluorescent tube lighting in the lower level. The lesser efficient T-12’s were found to be in upper level wall lighting. Lighting controls for the building were all manual switches.

The plug load evaluation for the Henniker Community Center is higher than most similar buildings electric plug load due to the electronic media in the teen center and the kitchen. Several televisions, game consoles and other games that require electricity were present (an air hockey table for example). The kitchen sees very little use, however all appliances are kept plugged in. They are also all older model appliances.

Plumbing and Domestic Hot Water
The two bathrooms in the Community Center have aerators on the faucets and Sloan flush mate “high tech” toilet pumps. There are two bathroom sinks and a kitchen sink that hot water is used at. The hot water heater is provided by a “hot point” hot water heater.

Notable Problem Areas/Occupancy Comfort

- The un-insulated crawl space is a major source of heat loss to the building. The floor vents to this space are also greatly increasing the heat loss here.

- The level of insulation in the attic is fairly low and allowing for heat loss through the attic in the winter and heat gain in the summer.

- There are several old appliances that are rarely used in the teen center kitchen that could be unplugged to save energy when not in use.

- The performance of the fiberglass batt insulation in the Teen Center walls is very poor.

- There is a large gap between the front entry doors that is adding greatly to the heat loss of the building.

- The lighting of the upper level is outdated and uses more energy than needed.
Energy Use and Cost Analysis

The Community Center uses propane and electricity to meet its energy needs. Electric consumption is attributed to lighting, gaming consoles and games in the Teen Center, cooling, the electric baseboard backup heating and kitchen appliances. The propane is attributed to space heating via the Mr. Slim heat pump and the two furnaces.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and propane use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$6,834</td>
<td>$0.15/kWh</td>
<td>$0.14/ kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>$6,565</td>
<td>$1.97/gallon</td>
<td>$3.15/ Gallon</td>
</tr>
<tr>
<td>Current Total Energy Cost</td>
<td>$6,699</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The current state wide average price per gallon of propane is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly propane use of 1,666 gallons a year and the current sate wide average price per gallon of propane of $3.15, the Community Center would be paying $5,248 a year for propane.
The Energy Consumption chart below graphically analyzes the electric and propane consumption in kBTUs which allows for direct comparison of fuel consumption. The numbers shown are also three year averages.

### Community Center Energy Consumption (3 Year Average)

<table>
<thead>
<tr>
<th></th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>76,202</td>
<td>22,334 kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>152,685</td>
<td>1,666 gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>228,887 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for Henniker Community Center:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Center</td>
<td><img src="image1" alt="Energy Use Breakdown" /></td>
<td><img src="image2" alt="Energy Cost Breakdown" /></td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Community Center:

**EUI = 170.9 kBTU/SF/YR**

**CUI = $2.92 /SF/YR**

Due to the ambiguity of the building, the closest match in energy use would be an office building. By comparing the Community Center to other office buildings across the United States they are in the 45th percentile. This means that 55% of similar buildings are more energy efficient and 45% are less energy efficient.

![Energy Performance of Offices – New England](image3)

*Provided by Oak Ridge National Lab (www.eber.ed.oml.gov)*
Envelope Testing

Blower door testing as well as Infrared imaging was performed on the building. (Please see Appendix B for the building’s IR report).

An air tight building will have infiltration rates of .25-.33 ACHn . These are the numbers we strive for in retrofits and new construction. The results of the blower door test are listed below.

Blower door test results:  
CFM50=9271       ACHn=0.84  ACH50= 13.06

Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1- Add insulation and air seal the attic. Install a one inch layer of rigid foam board insulation along the tops of the rafters, leaving the existing blown in fiberglass in place, and air seal the connections. This adds an R-5 to the assembly while also air sealing attic without having to remove the existing insulation, or harming the tin ceiling. Also install an additional 13” of blown in cellulose on top of the foam to reach the recommended R-60 roof assembly. This will dramatically decrease heat loss to the attic space above and save energy on heating.

B2- Replace attic hatch with an insulated hatch with gasket. The current attic hatch was found to not be air tight and therefore is allowing cold air to move from the attic into the conditioned space. A new insulated attic hatch will keep the thermal barrier continuous with the rest of the attic and the gasket will create an air tight seal that prevents any air movement from or to the attic, saving on heating costs.

B3-Insulate ceiling and walls of the crawl space. There is a tremendous amount of heat being lost to the crawl space below the main level. The IR imaging showed heat from the main level is conducting through the floor to the unconditioned crawl space. This space should remain out of the thermal barrier that is the conditioned space. This requires that you insulate the ceiling and three interior walls of the crawl space. This may most easily be done with rigid foam insulation (also air seal the joints/connections) or spray foam to total at least an R-20.

B4-Close off and insulate un-used floor vents. The floor vents on the main floor allow for the two levels to communicate directly and are therefore also a source for heat loss for the space. These should be removed and floored over. Prior to the insulating of the crawl space.

B5- Replace door to crawl space with an insulated door with weather-stripping. The door to the crawl space is a thin wood door that is not air tight. A new door that is insulated should be installed in its place, and weather stripped to create an air tight seal around the door.

B6-Seal crack in brick. The IR imaging showed the crack above the exterior door to the Teen Center to be a source of heat loss to the outside. This should be sealed with mortar and this will no longer be an issue.

B7- Replace front main entry double doors with insulated and weather stripped doors. The front entry doors were found to be very leaky due to the fact that they did not sit flush to the floor and light was visible beneath the door and between the doors.
B8-Remove trim around eight large windows and spray foam behind trim to air seal and insulate. This will prevent heat loss at the window frames and also make the space feel more comfortable.

B9-At rear entrance door, remove trim and air seal and insulate with spray foam. Weather-stripping should also be installed around the door for an air tight seal.

Recommended Mechanical Energy Efficiency Measures

**M1- Install an HRV for the Teen Center area.** Explore the need for fresh air ventilation and heat recovery in the ten center. An HRV is an Heat Recovery Ventilator. This will provide fresh air while recovering heat from the conditioned air. ERV equipment is extremely efficient. It would provide automatically controlled mechanical air exchanges, capturing from 65% to 80% of the heat/cooling contained in the exhaust air. Stale indoor air is removed and replaced with fresh outside air, and as the stale air leaves the building it passes by the incoming fresh air in an air exchange device which uses the heat/or cooling from the exhaust air to temper the incoming fresh air so that it requires less from the building’s heating system before it is ready for distribution to the occupied spaces. With a well performing envelope in a masonry building this becomes a very important aspect. The need for fresh air can then becomes energy efficient and while improving the indoor air quality and addressing humidity and dryness.

**M2- Install programmable thermostats.** This will ensure that, with nightly setbacks, that the energy use goes down and saves money on heating costs. They also work during the AC season to save money on electricity.

Recommended Electrical Energy Efficiency Measures

**E1-Unplug seasonally used appliances.** This will save energy and lower the electric bill and does not harm any appliances. This is no cost to implement and therefore has not been included in the financial model.

**E2- Upgrade main level lighting to T-8’s.** The current T-12 lighting is not efficient and electric savings can be realized by replacing the bulbs with T-8’s on the main level.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.
Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value.
## Community Center

<table>
<thead>
<tr>
<th>ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Install 1” layer of rigid across joists in attic; air seal seams and add 13” (to total R60) of blown in cellulose to the attic (attic is 4.7 x 49 or 2419 SF)</td>
<td>$9,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$9,000</td>
<td>$262</td>
<td>7.64</td>
<td>34.3</td>
<td>3.9%</td>
<td>N/A</td>
</tr>
<tr>
<td>B2 Repair/replace attic hatch with insulated hatch and install a gasket</td>
<td>$265</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$265</td>
<td>$52</td>
<td>1.53</td>
<td>5.0</td>
<td>24.7%</td>
<td>$1,176</td>
</tr>
<tr>
<td>B3 Insulate the ceiling and the three interior walls of the crawl space (486 sf) with rigid foam - no finish necessary</td>
<td>$1,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,000</td>
<td>$315</td>
<td>9.18</td>
<td>1.6%</td>
<td>36.5%</td>
<td>$7,616</td>
</tr>
<tr>
<td>B4 Remove, cap and insulate the floor vents on the main floor (18.6” x 18’ vents)</td>
<td>$795</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$795</td>
<td>$105</td>
<td>3.06</td>
<td>7.6</td>
<td>17.8%</td>
<td>$2,099</td>
</tr>
<tr>
<td>B5 Replace door to crawl space with insulated door.</td>
<td>$400</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$400</td>
<td>$315</td>
<td>9.18</td>
<td>3.8%</td>
<td>36.5%</td>
<td>$7,616</td>
</tr>
<tr>
<td>B6 Seal crack in exterior brick by replacing the mortar</td>
<td>$150</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$150</td>
<td>$52</td>
<td>1.53</td>
<td>2.9</td>
<td>40.0%</td>
<td>$1,285</td>
</tr>
<tr>
<td>B7 Replace the front doors with tightly closing insulated double doors</td>
<td>$1,500</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,500</td>
<td>$315</td>
<td>9.18</td>
<td>4.2%</td>
<td>36.5%</td>
<td>$7,616</td>
</tr>
<tr>
<td>B8 Remove trim around 8 windows, spray foam in cavities and replace trim and touch up.</td>
<td>$2,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$2,000</td>
<td>$105</td>
<td>3.06</td>
<td>19.1</td>
<td>8.0%</td>
<td>$951</td>
</tr>
<tr>
<td>B9 At the rear entrance door remove trim around door, air seal/insulate with spray foam, replace and touch up. Also install new weather stripping.</td>
<td>$360</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$360</td>
<td>$52</td>
<td>1.53</td>
<td>6.9</td>
<td>19.3%</td>
<td>$1,085</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$15,470</strong></td>
<td><strong>$15,470</strong></td>
<td><strong>$1,102</strong></td>
<td><strong>14.0</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### MECHANICAL SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>MECHANICAL UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Install HRV in the teen center to introduce fresh air to the space (one HRV and ducting)</td>
<td>$5,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$5,000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>M2 Install programmable thermostats</td>
<td>$300</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$300</td>
<td>$52</td>
<td>1.53</td>
<td>5.7</td>
<td>22.3%</td>
<td>$1,142</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$5,300</strong></td>
<td><strong>$5,300</strong></td>
<td><strong>$52</strong></td>
<td><strong>101.0</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>ELECTRICAL UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2 Upgrade main level lighting from T-12 to T-8 lighting</td>
<td>$470</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$470</td>
<td>$68</td>
<td>1.54</td>
<td>6.9</td>
<td>19.2%</td>
<td>$1,412</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% cost of Capital. Utility rebates and tax credits are not included
11. Grange Hall

General Information

A site visit was conducted where Jordan investigated and evaluated the building. At this site visit Jordan tested the performance of the building envelope through the use of blower door testing and infrared imaging.

Grange Hall is located at 7 Western Avenue in Henniker. The building is approximately 2,888 square feet of conditioned space on two floors and was originally built in 1910 as a church. The building was originally located elsewhere in the town and was moved to its current location in the 1990’s. The building is now used as a meeting space for several different gatherings in the town as well as the town food pantry. The building utilizes public water and sewer. The basement is used as sports equipment storage and the food pantry. The main level is used as the gathering space and a partially finished third floor also serves as sporting equipment storage for the town youth sports. Grange Hall has varying operation hours depending on the season and what groups need the space. It is used every day during the school year, as well as many weekends and almost every Sunday.
Existing Conditions

Building Envelope

Walls

The exterior walls of the building consist of lathe and plaster (original to the construction of the building) and wood siding. The lathe and plaster construction was visible through the IR imaging and concluded that there is no insulation in any of the walls.

There are beautiful tall stained glass, single pane, double hung, wood framed windows with aluminum framed storms located on the main level of the building. Many have the original rope weight and pulley mechanisms still intact. There are very few windows that are operable due to the movement of the framing from the moving of the building. This also left some windows unable to close tightly, adding to the heat loss of the windows.

The front entry door is a newer metal insulated door with a push latch. The weather stripping was found to be poor here. The rear exit door is a metal door. Cold air infiltration around the rear door was present as well during IR imaging.
Roof

The roof is a large wood framed gabled roof with asphalt shingles. There is also an attached bell tower. The insulation line runs along the ceiling plane above main gathering space. Approximately 8-10 inches of fiberglass batts are present. There is a mix of kraft faced and non-kraft faced batts. This totals an R-27. The recommended R-value for a roof assembly is an R-60. The batts are laid out unevenly with gaps between them and no air barrier is present, decreasing the effectiveness of the insulation. The framing members were also found to be conducting heat from the conditioned space below up into the cold attic. The thermal line is not continuous, as the insulation stops at the storage room. The attic is vented at the rear with a gable end vent and at the bell tower in the front of the building.
Foundation

Since Grange Hall originally was located on a different site, a new foundation was built when it was moved in the 1990’s. A concrete foundation was dug and poured on the new site for the building to be placed on top of. A full basement is beneath the entire building. There are a few cracks in the foundation wall, but the basement is dry. There is no foundation insulation evident and areas for basement windows have been sealed off with concrete.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

Grange Hall is heated by a Lennox Elite Series propane fired furnace. It has a 92.3 efficiency rating and is located in the basement mechanical room. The filter was found to be very dirty and could be hindering the systems efficiency and the quality of the air introduced to the space. The conditioned spaces are the food pantry and the main level.

The heating distribution system is forced hot air through metal ducting. The ducts run through the unconditioned basement are not insulated. They are unintentionally conditioning the storage space via heatloss from the ducts. The forced hot air is delivered to floor vents on the main floor only.

Photo 115: IR image of the attic floor

Photo 116: The new poured concrete foundation with basement window blocked off and crack

Photo 117: One of the forced hot air floor supply vents

Photo 118: the Lennox propane fired furnace
HVAC Controls

There is one thermostat serving the main level of the Grange Building. Like the other buildings, it is clearly marked that no one is to alter them and it is in a locked box. The thermostat is programmable, and is programmed with nightly setbacks starting at 10 pm to 50-55 degrees in the winter.

Electrical - Lighting and Appliances

The interior lighting of Grange Hall consists of mostly T-8 flourecent tube lighting on the main level and the basement.

The plug load evaluation for Grange Hall is very low due to the lack of electric demand. Coffee makers and lighting are the only electric draw on the first floor, while several refrigerators belonging to the food pantry are the draw in the basement. There are three refrigerators/freezers. Two are Kenmore heavy duty chest freezers in two sizes and a third is an upright. These are on constantly to keep frozen goods for the food pantry.
Plumbing and Domestic Hot Water

There is one bathroom located on the main floor of the building. It has standard plumbing fixtures only. This and a sink in the food pantry are the only draws of domestic hot water in the building. The hot water tank is an electric 19.9 gallon, 120 volt tank appropriately sized for the use.

Notable Problem Areas/Occupancy Comfort

- The windows are leaky and most are not operable.
- Poor weather stripping on the exterior doors allows for exterior unconditioned air to infiltrate the building.
- Uneven attic insulation and no air barrier greatly decrease the effectiveness of the insulation in the attic.
- Insulation is not present beneath the third floor storage area and creates a non-continuous thermal line in attic, which concentrates and heightens the heat loss in that area.
- No insulation in the walls results in a high amount of heat loss and high heating costs.
- No insulation on the ducting lowers the efficiency of the heating distribution system.
- Because a portion of the basement is conditioned, but there is no basement insulation there is heat loss occurring via the basement walls.
Energy Use and Cost Analysis

Grange Hall uses propane and electricity to meet its energy needs. Electric consumption is attributed to lighting and appliances. The propane is attributed to space heating via the Lennox forced hot air furnace.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and propane use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$891</td>
<td>$0.19/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>$2,348</td>
<td>$1.94/gallon*</td>
<td>$3.15/gallon</td>
</tr>
<tr>
<td>Current Total Energy Cost</td>
<td>$3,239</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The current state wide average price per gallon of propane is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly propane use of 1,206 gallons a year and the current state wide average price per gallon of propane of $3.15, the Community Center would be paying $3,799 a year for propane.
The Energy Consumption chart below graphically analyzes the electric and propane consumption in kBTUs which allows for direct comparison of fuel consumption. The numbers shown are also three year averages.
The following graphs show energy use and cost breakdowns by fuel type for Grange Hall:

![Energy Use Breakdown by Type](image1)

![Energy Cost Breakdown by Type](image2)

### Building Benchmarking

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Grange Hall:

**EUI = 59.67 kBTU/SF/YR**

**CUI = $1.12 /SF/YR**

By comparing Grange Hall to other buildings of similar use across the United States they are in the 90th percentile. This means that 10% of similar recreational buildings are more energy efficient and 90% are less energy efficient. However, we feel that this is not an accurate representation of the building’s performance, due to the low use of the building that results in low energy use. Thus this is not an accurate representation of the envelope efficiency or the systems efficiencies.
Envelope Testing

The goal of any successful building envelope improvement effort is to control this infiltration to a value of $0.25 - 0.33 \text{ACH}_{50}$ by air sealing all cracks and penetrations identified in the test.

Blower door test results:

CFM50 = 3880       ACHn = 0.76       ACH50 = 14.41

Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

**B1- Weather strip doors.** The basement, attic and exterior doors should all be properly weather stripped to ensure an air tight close to prevent unwanted unconditioned air from entering the conditioned space.

**B2- Re-insulate the attic floor.** Remove and dispose of fiberglass batt insulation in the attic and spray 1-2” of spray foam along the attic floor plane to air seal the attic. This will air seal the attic and prevent additional heat loss from the space below. Install 15-18” of blown in cellulose insulation on top of spray foam for added R-value. The area of insulation should be extended to go beneath the floor of the third floor storage room (see B3). This will prevent heat loss to the attic during heating season and heat gain from the sun in the cooling season.

**B3- Insulate the floor of the attic storage area.** The floor boards of the attic storage area should be taken up and the area air sealed. Next 18” of blown in cellulose should be installed. This will require installing another string of floor joists to raise the floor up high enough to get a depth of 18” for the cellulose. The floor boards can then be reinstalled. The wall that joins the attic and the storage area also needs to be insulated to the same R-value of 60 as the other two spaces to create a continuous thermal barrier. Without a continuous thermal barrier heat loss is amplified at the areas of missing or low insulation.

**B4- Insulate the basement walls from the interior with 2” of rigid foam board insulation.** This will prevent heat loss in the basement which is very important since the basement is conditioned. The rim joists should also be insulated at this time with spray foam. This will also require a drywall finish for fire rating protection since the space is used.

**B5- Repair the windows to a state of which they are operational.** Similar repair that the windows at the Library underwent may be appropriate for the windows here. They can be shimmed and sanded to open and close tightly and the weight and pulley’s can also be addressed.

**B6- Insulate hatch to bell tower,** ensure it has a gasket for tight closure. This will prevent heat loss into the bell tower which has an added stack effect that is pulling heat up and out of the conditioned space.

**For future recommendation,** if the building is ever to undergo an intensive retrofit, the walls should be addressed by adding insulation to prevent heat loss. The walls make up a large square footage of the building and have a low r value, though it would be an intensive and destructive process to install insulation at this time. We recommend addressing the attic for the time being and if the opportunity arises to address the walls, we recommend insulating to an R-40.
Recommended Mechanical Energy Efficiency Measures

**M1- Insulate all forced hot air ductwork.** The forced hot air ducts travel though a portion of the basement that is not heated and should be insulated to improve the efficiency of the distribution system and save on heating.

Recommended Electrical Energy Efficiency Measures

**E1- Replace two 18 cu freezers and refrigerator with Energy Star models.** Electric savings can be realized by upgrading to Energy Star Models. According to John Straube, an expert in the field of residential energy efficiency, the efficiency in refrigerators has come so far that if your refrigerator is more than five years old you can see energy savings from upgrading to a newer Energy Star model. We recommend replacing the units only once they have reached close to end of life. This measure was not included in financial modeling.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value.
### Projected Financial Analysis

**Baseline Energy Usage:**
- 4,503 kWh
- 1,206 gallon
- 126,316 kBTU

**Baseline Annual Energy Cost:**
- $891
- $3,799
- $4,690

**EEM**

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Capital Investment</th>
<th>End-of-Life</th>
<th>Rebates</th>
<th>EOL &amp; Rebates</th>
<th>Energy Investment</th>
<th>Annual Energy Cost Savings</th>
<th>Annual Energy Savings kBTU</th>
<th>Simple Payback</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Weather strip doors to basement, attic, and two exterior doors</td>
<td>$240</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$240</td>
<td>$38</td>
<td>1,110</td>
<td>6.3</td>
<td>20.6%</td>
<td>$895</td>
</tr>
<tr>
<td>B2 Remove and dispose of fiberglass batt insulation in attic. Spray 1'-2' of spray</td>
<td>$5,714</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$5,714</td>
<td>$228</td>
<td>6,657</td>
<td>25.1</td>
<td>5.9%</td>
<td>$760</td>
</tr>
<tr>
<td>foam over attic plane, install 18'-0&quot; of blown in cellulose (ATSC=4-6' x 20' or 1274 SF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B3 Take up floor boards in attic storage area and air seal and install 18&quot; of blown in cellulose. (This will require raising the floor up 8&quot; additional joists required)</td>
<td>$4,139</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$4,139</td>
<td>$114</td>
<td>3,329</td>
<td>36.3</td>
<td>3.4%</td>
<td>N/A</td>
</tr>
<tr>
<td>B4 Insulate the foundation walls from the interior with 2&quot; of rigid foam board and paperless drywall. Also insulate the rim joists using spray foam (1204 SF of wall, 106 LF of rim joists) 2115SF spray foam needed for rim joists.)</td>
<td>$5,783</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$5,783</td>
<td>$152</td>
<td>4,438</td>
<td>38.1</td>
<td>3.2%</td>
<td>N/A</td>
</tr>
<tr>
<td>B5 Repair windows</td>
<td>$1,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,000</td>
<td>$114</td>
<td>3,329</td>
<td>8.8</td>
<td>15.8%</td>
<td>$2,149</td>
</tr>
<tr>
<td>B6 Insulate the hatch to the bell tower</td>
<td>$265</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$265</td>
<td>$57</td>
<td>1,064</td>
<td>4.7</td>
<td>26.4%</td>
<td>$1,298</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$17,141</td>
<td>$17,141</td>
<td>$703</td>
<td>$703</td>
<td></td>
<td></td>
<td></td>
<td>24.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### MECHANICAL SYSTEM UPGRADES

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Capital Investment</th>
<th>End-of-Life</th>
<th>Rebates</th>
<th>EOL &amp; Rebates</th>
<th>Energy Investment</th>
<th>Annual Energy Cost Savings</th>
<th>Annual Energy Savings kBTU</th>
<th>Simple Payback</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Insulate the duct work</td>
<td>$200</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200</td>
<td>$38</td>
<td>1,110</td>
<td>5.3</td>
<td>2.39%</td>
<td>$843</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$200</td>
<td>$200</td>
<td>$38</td>
<td>$38</td>
<td></td>
<td></td>
<td></td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*

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The Town of Henniker Energy Analysis of Municipal Buildings

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12. Transfer Station

General Information

The Transfer Station is located at 1393 Weare Road in Henniker. The Recycling building is approximately 1,800 square feet of conditioned space on one floor and was built in 1990. The building is 60’ by 30’. There is also an office building in a mobile home structure and a garage section.

The Transfer Station is open in the Fall, Winter, and Spring on Tuesdays from 12-5 pm and Thursdays from 12-5 pm and also on Saturdays and Sundays from 9-5 pm. In the summer they have extended hours on Tuesdays, and they are open 12-8 pm. They are open Thursdays from 12-5 pm and Saturdays and Sundays from 9-5 pm as they are for the other seasons. This is a total of between 26 and 29 hours a week that the building is used.

Existing Conditions

Building Envelope

Walls

The exterior walls of the garage building consist of metal framing with metal exterior siding. A concrete foundation wall extends 4 feet up the wall before the metal siding begins. The exterior walls are insulated, but it was not clear how much insulation was present. There is no interior finish. The walls are 14 feet high and include only one story.

Windows and doors

There is one large garage door on the recycling building for truck access, and another smaller garage door beside it. Four openings exist along the side of the building are for different recycling drop offs.

The office space has two non-operable single plane wood framed windows, and three double pane windows, with only one having a storm window installed.
Roof

The roof is a large metal framed low pitched (2:12 to 6:12 pitch) gabled roof with steel metal roofing. The ceiling plane of the garage is corrugated metal. To our knowledge of the building there is no insulation above this corrugated metal or any insulation that runs along the roof line. This is an extreme source of heat loss due to the lack of insulation here.

Foundation

The recycling building was built on a slab on grade with a four foot foundation wall extending up the wall.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The recycling building space is not typically heated, although it has a Reznor oil fired furnace located in the shed. The furnace runs off used oil from the highway department in town. Along with the furnace the oil tank that holds the used oil is also in the shed. The distribution system is suspended unit heaters. The air filters to the furnace are changed often and get very dirty. It was estimated that the filters get changed only once a year.

The office space is heated via electric baseboard heating.

Electrical - Lighting and Appliances

The interior lighting of the recycling building was updated last year to T-5 florescent tube lighting. This an efficient lighting type for the space. There are five compactors in the recycling building that run off electricity as well. The shed utilizes older technology of the less efficient T-12 bulbs. Two ceiling fans are also located in the recycling building. Electric heat tape is installed on the gutter system of the recycling building to prevent damage to the gutter system. This is turned on only when necessary in attempts to save energy.
The office space utilizes T-12’s in two fixtures, but we were told that they are rarely on. There is also a ceiling fan and two personal computers located in the office space. The only lighting control is for a motion sensor in Bill’s office. There are also a few appliances in the break area that include two mini fridges, a microwave and a toaster oven.

The plug load evaluation for the Transfer Station is average compared to buildings of similar use. We believe that the majority of the electric use is due to the process and not excessive electric use.

**Plumbing and Domestic Hot Water**

There is a on demand electric hot water heater that supplies the building's domestic hot water.

**Notable Problem Areas/Occupancy Comfort**

- No insulation in ceiling of garage
- Poor weather stripping
- Garage doors are un-insulated
Energy Use and Cost Analysis

The Transfer Station consumes used oil from the highway department and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers, appliances and the compactors. The oil is attributed to space heating of the recycling building via the forced hot air furnace but this data is not included in the charts due to the fact that they do not pay for the oil and do not keep track of the amount of oil used, or how much per month. We recommend that in the future the amount of oil used be measured to evaluate the building and the system further and to better calculate savings.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric use. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$2,410</td>
<td>$0.16/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Used Oil</td>
<td>$0</td>
<td>$0</td>
<td>$3.67/gal</td>
</tr>
<tr>
<td>Current Total Energy Cost</td>
<td>$2,410</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The current state wide average price per kWh is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

** An average use of 2,000 gallons of oil a year was estimated by Bill the day of the site visit. We used this number to project the cost savings from using used oil. If the oil used at the Transfer Station was to be paid for the cost would be $7,340 a year (using the current NH state wide average oil price of $3.67/gal).
The Energy Consumption chart below graphically analyzes the electric consumption in kBTUs. The numbers shown are also three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>50,440</td>
<td>14,783 kWh</td>
</tr>
<tr>
<td>Used Oil</td>
<td>277,381</td>
<td>2,000 gal</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>327,821 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>

*The table above has included the estimated oil consumption of 2,000 gallons a year for reference, but it is only an estimate.*
The following graphs show energy use and cost breakdowns by fuel type for the Transfer Station:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer Station</strong></td>
<td><img src="image" alt="Energy Use Breakdown" /></td>
<td><img src="image" alt="Energy Cost Breakdown" /></td>
</tr>
<tr>
<td>85% Oil</td>
<td>15% Electric</td>
<td>100% Electric</td>
</tr>
</tbody>
</table>

*An average use of 2,000 gallons of oil a year was estimated by Bill the day of the site visit. We used this number to project the cost savings from using used oil. As you can see, 85% of the energy use of the building is free and $7,340 a year is saved by using used oil.

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Transfer Station:

**EUI = 182.12kBTU/SF/YR**

**CUI = $1.34 /SF/YR**

By comparing the Transfer Station to other buildings of similar use across the United States they are in the 10th percentile. This means that 90% of similar warehouse buildings are more energy efficient and 10% are less energy efficient.
Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1- Add insulation to the roof. Install 8-9” of rigid from the interior along the slope of the roof and air seal the seams (the roof to wall connection). An interior finish such as drywall will be required for fire rating purposes. This will create an R-60 roof assembly and prevent heat loss through the roof.

B2- Add 6” of rigid insulation to the walls from the interior, air sealing the seams. This will prevent heat loss through the walls of the building and save on heating.

B3- Replace garage doors with insulated garage doors. Because the garage doors here are so large, replacing the existing garage doors with insulated doors may prove to have energy savings.

B4-Weather strip garage doors and exterior doors. After new garage doors are installed ensure that they are properly weather stripped. All exterior doors should also have a commercial grade weather stripping installed to prevent heat loss as well.

Recommended Mechanical Energy Efficiency Measures

M1-Install measuring device to measure the amount of waste oil burned to better evaluate the heating system efficiency and the envelope system. This recommendation will not save energy itself and therefore has not been priced or included in the financial modeling.

Recommended Electrical Energy Efficiency Measures

E1-Replace two mini fridges with energy star model full size fridge. As previously stated for other buildings, the efficiency of refrigerators has come so far that if you have a five year old refrigerator it is worth replacing it with an Energy Star model, as you will see energy savings. Mini refrigerators are particularly in-efficient and a full size Energy Star model will actually use less energy. We recommend replacing the mini fridges only once they are near end of life, and therefore have not included this measure in the financial modeling.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
## Transfer Station

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>END-OF-LIFE</th>
<th>REBATES</th>
<th>EOL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS BTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Add insulation to the roof by applying 8'-9&quot; (R-60) of rigid from the interior and air seal seams. Need interior finish (30' x 60' = 1800 SF)</td>
<td>$13,320</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$13,320</td>
<td>$117,690</td>
<td>4.0</td>
<td>30.2%</td>
<td>$78,743</td>
<td></td>
</tr>
<tr>
<td>B2 Add 6&quot; (R-40) of rigid insulation to the walls from the interior and install drywall. (walls are 14' high = 2520 SF)</td>
<td>$14,083</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$14,083</td>
<td>$36,400</td>
<td>13.5</td>
<td>11.0%</td>
<td>$14,887</td>
<td></td>
</tr>
<tr>
<td>B3 Replace garage doors with insulated garage doors (2 garage doors, one ~10'x 19', one ~9’ x 10’)</td>
<td>$6,232</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$6,232</td>
<td>$14,000</td>
<td>15.6</td>
<td>9.7%</td>
<td>$4,949</td>
<td></td>
</tr>
<tr>
<td>B4 Weather strip all garage doors and exterior doors</td>
<td>$930</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$930</td>
<td>$5,600</td>
<td>5.8</td>
<td>22.0%</td>
<td>$3,468</td>
<td></td>
</tr>
</tbody>
</table>

Total: $34,565 $34,565 $4,949 7.0

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital, Utility rebates and tax credits are not included
13. Waste Water Treatment Plant

General Information

The Waste Water Treatment Plant is located at 199 Ramsdell Road in Henniker. The building is approximately 4,362 square feet of conditioned space on one floor and was built in 1976.

The Waste Water Treatment Plant has normal weekly business hours for a total of 40 hours a week.

Existing Conditions

Building Envelope

Walls

The exterior walls of the building are concrete block with a brick façade. The one level is approximately 14 feet high.

Windows and doors

The windows here are single pane aluminum awning windows. They are very poor windows.

Roof

The roof is a flat rubber membrane and tar and gravel roof. There are R-13 batts in the ceiling.
Foundation

The Waste Water Treatment Plant building was built on a concrete slab on grade.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The most of the space is heated by a 36 year old Weil Mclain oil fired boiler (model number WRL6.2-0-05). There is an electric Mr. Slim split system in the front office that provides heating and cooling to the office space. It was previously on an auto switch, but has since gone back to manual.

The distribution is hot water pipes to coils in air handlers. Other spaces are heated by Reznor unit heaters /modines that have hot water coils off the boiler as well.

Electrical - Lighting and Appliances

Most of the interior lighting of the building was updated last year through the PSNH lighting audit. Less used spaces still have older T-12 lighting. Ceiling fans are also present in some rooms. Ultraviolet disinfectant lamps are also a large draw of electricity. There is a GE “No Frost” fridge in the building that is not an energy star model. Most motors used in the building get switched out to more efficient ones as they die and efficient VFD’s (variable frequency drives) are used whenever possible.

Due to the process of waste water treatment, the electric load is extremely high.

Notable Problem Areas/Occupancy Comfort

- Extremely high electric load due to the process
- Boiler is old and inefficient
- Low insulation levels
- Leaky aluminum framed awning windows
Energy Use and Cost Analysis

The Waste Water Treatment Plant uses oil and electricity to meet its energy needs. Electric consumption is attributed to lighting, computers, appliances and the waste water treatment process. The oil is attributed to space heating.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and oil use. This graph includes the Waste Water Treatment facility and its pump stations. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$56,512</td>
<td>$0.13/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>$10,334</td>
<td>$2.85/Gallon</td>
<td>$3.67/gallon</td>
</tr>
<tr>
<td>Current Total Energy Cost</td>
<td>$66,847</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The current statewide average pricing is according to the New Hampshire Office of Energy and Planning as of September 7, 2011.

Using current yearly oil use of 3,625 gallons a year and the current sate wide average price per gallon of oil of $3.67, the Waste Water Treatment Plant would be paying $13,304 a year for oil.
The Energy Consumption chart below graphically analyzes the oil and electric consumption in kBTUs. This graph includes the Waste Water Treatment facility and its pump stations. The numbers shown are also three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>1,460,397</td>
<td>428,018 kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>502,799</td>
<td>3,625 Gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>1,963,196 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Waste Water Treatment Plant:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Water Treatment Plant</td>
<td><img src="image" alt="Energy Use Breakdown" /></td>
<td><img src="image" alt="Energy Cost Breakdown" /></td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Waste Water Treatment Plant:

**EUI = 1,396.2kBTU/SF/YR**

**CUI = $13.96 /SF/YR**

There is no category of building type that the Waste Water Treatment Plant accurately falls under for the available CBECs data, therefore we have no comparison EUI’s or chart.

**Recommended Energy Efficiency Measures**

**Recommended Building Envelope Energy Efficiency Measures**

**B1-Consider adding insulation to the walls that surround the office areas only.** This will move the thermal boundary to a smaller portion of the building, making it easier to heat. It also insulates the area and allows the space to retain heating and cool better as well.
Recommended Mechanical Energy Efficiency Measures

The following measures are not included in the financial modeling because the head to the Waste Water Treatment Plant is collecting actual quotes for the following:

**M1- At the main building, replace the existing boiler with a high efficiency boiler.** Due to the age of the existing boiler we recommend that the boiler be replaced with a new high efficiency boiler to increase the efficiency of the heating system and save energy in heating and lower heating costs.

**M2- Upgrade all motors to VFD (variable frequency drives).** A VFD is a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor. Variable-frequency motors save energy by allowing the motor to match the system demand.

Recommended Electrical Energy Efficiency Measures

**E1-Upgrade lighting in the less used spaces from T-12 to T-8.** Significant electric energy savings can be realized by upgrading from T-12 to T-8 bulbs, as they have a very small electrical draw even when not turned on. This is a fairly inexpensive and easy upgrade, though it can be placed low on the list of priorities.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
## Wastewater Treatment Plant

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Insulate around the office area only. Rigid foam, air seal, install drywall. (EST&gt; 480 SF of wall, 200 SF of ceiling)</td>
<td>$5,011</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$5,011</td>
<td>$435</td>
<td>15.225</td>
<td>11.5</td>
<td>12.6%</td>
<td>$7,994</td>
</tr>
</tbody>
</table>

Total: $5,011

$5,011 $435 11.5

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital, Utility rebates and tax credits are not included*
14. Water Treatment Plant

General Information

The Waste Water Treatment Plant, also called Cogwell Springs, is located at 146 Davison Road in Henniker. There are 3 buildings on the property. The office building with garage is 1,675 square feet. Together the total buildings square footage is approximately 5,632 Square feet of space. The office building with its garage was built in 1996 and the pump houses were built in the 1960’s.

The Water Treatment Plant has hours of Monday- Friday 7-3 and they often come in between 6 and 7 at night as well.

Existing Conditions

Building Envelope

Walls

The exterior walls of the building office building are 2”x6” wood frame construction with 5 1/2” of fiberglass batts between the studs. The garage is also insulated. The exterior finish is vinyl siding.

Pump Station One is concrete block. There was no evidence of insulation in the walls.

Pump Station Two has an original section that is concrete block with vermiculite in the block and an addition that is 2” x 6” wood framed, with fiberglass batts between studs.
Windows and doors

The windows of the office building are double hung, double pane, low-e, vinyl framed windows.

Pump station one has awning windows that are wood framed and thermal pane. Pump station two has wood frame, single pane, double and single windows that are original to the 60’s.

There is one garage door on the office building. The weather stripping on the garage door was poor. The entry doors seemed to be in good condition.

There is also a garage door on the pump station one that has poor weather-stripping.

Roof

The roof is a low pitched, wood framed, gable roof with asphalt shingles. Blown in fiberglass insulation is along the ceiling plane of the attic. Soffit vents are present. There is one roof penetration that is the plumbing vent.

There is no insulation in the pump station two roof. There is a great deal of ice buildup on this pump station roof. The roof of pump station one has fiberglass batt insulation above the ceiling and soffit venting.

Foundation

The Water Treatment Plant office building was built on a concrete foundation and slab. There is 4” of fiberglass batts between floor joists in the ceiling of the basement. There is also fiberglass batts along the band joists in the basement. The basement is currently unused, but there are plans to use it in the future for storage and calibrating water meters.

The pump stations are built on a concrete slabs on grade.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The office space is heated with a propane fired induced draft Mini-Therm ViTeledyne Laars hydronic boiler. The boiler is inspected once a year by Hilltop, a local mechanical company.

Pump station one is heated with a propane fired empire space heater and is kept at around 50 degrees. Pump station two is heated with a propane fired boiler and radiators, but is also only heated to around 50 degrees. There is also electric heat in pump station two, though it is not used.

The distribution is forced hot water to fin tube radiators in the office space. There is no hot water pipe insulation in the building.

The garage space off the office is heated via a modine. They keep the garage heated to a low temperature only.

Electrical - Lighting and Appliances

The Water Treatment Plant was not included in the PSNH lighting retrofit that most of the other buildings underwent. They have mostly T-12 lighting throughout. There are incandescent bulbs in the basement of the office building, and the garage has T-12’s. Pump station one also has T-12 lighting. Pump station two has incandescent lighting.
Due to the process of water treatment, the electric load is extremely high. The pump stations have 15 horse power upgraded motors, though they are not variable speed and the plant is not interested in getting variable speed drive motors. The pumps run 9-11 hours a day.

There are backup propane generators for the plant located in pump station two.

Plumbing and Domestic Hot Water

There is a 40 gallon hot water tank for the office building.

Notable Problem Areas/Occupancy Comfort

- Pump station two has no insulation in the walls or roof to keep heat in during the winter and excess heat out during the summer.
- No hot water pipe insulation.
- Windows of the pumps station two are in poor condition.
- Garage doors were leaky due to condition of the weather stripping.
- Older T-12 and incandescent lighting is inefficient, and easily upgraded.
Energy Use and Cost Analysis

The Water Treatment Plant (including pump houses) uses propane and electricity to meet its energy needs. Electric consumption is attributed to lighting, pumps, and the water treatment process. The propane use is attributed to space heating.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric and propane use. This graph includes the Water Treatment facility and its pump stations. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$20,163</td>
<td>$0.15/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>$3,946</td>
<td>$1.99/Gallon*</td>
<td>$3.15/gallon</td>
</tr>
<tr>
<td><strong>Current Total Energy Cost</strong></td>
<td><strong>$24,109</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The current state wide average pricing is according to the New Hampshire Office of Energy and Planning, as of September 7, 2011.

Using current yearly propane use of 1,988 gallons a year and the current state wide average price per gallon of propane of $3.15, the Water Treatment Plant would be paying $6,262 a year for propane.
The Energy Consumption chart below graphically analyzes the propane and electric consumption in kBTUs. This graph includes the Water Treatment facility and its pump stations. The numbers shown are also three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>472,894</td>
<td>138,597 kWh</td>
</tr>
<tr>
<td>Propane</td>
<td>182,165</td>
<td>1,988 Gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>655,059 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Water Treatment Plant:

<table>
<thead>
<tr>
<th>Water Treatment Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Use Breakdown by Type</strong></td>
</tr>
<tr>
<td>Electric: 72%</td>
</tr>
<tr>
<td>Propane: 28%</td>
</tr>
</tbody>
</table>

| **Energy Cost Breakdown by Type** |
| Propane: 17% |
| Electric: 83% |

Building Benchmarking

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

The total energy use included the pump stations, however we did not have the square footage of the pump houses to accurately calculate the EUI for the water treatment plant.

There is also no category of building type that the Water Treatment Plant accurately falls under for the available CBECs data, therefore we also do not have comparison EUI’s from other water treatment plants.
Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1- Weather strip garage doors. By weather stripping the garage doors on the office building and the pump station one, it will prevent any unconditioned air from infiltrating the building. This measure will save on heating by keeping more heat in the garages and requiring less from the heating systems.

B2- Insulate basement walls of main building. In order to make the basement a conditioned space and a comfortable space, the walls of the basement should be properly insulated. This can be done from the interior by installing a metal stud wall with 2” space between the studs and the concrete foundation wall. Next spray foam the foundation wall with 4” thick spray foam for an R-24 insulation value. The insulation should continue up to the rim joists as well. A paperless drywall can then be installed over the studs and the walls can be finished to complete the space. This will prevent heat loss through the foundation walls and save on heating the new space as well as the space above.

B3-Surgically air seal the attic of the office building and air seal the top plate. This will prevent heat loss up through the attic and also prevent ice dams.

B4-At pump station two, replace two windows. Due to the condition of the two windows, replacing them will save energy.

B5- At pump station two, install an insulated and sealed attic hatch. This will create an air tight seal around the hatch preventing the two spaces from communicating with each other. The insulation will also prevent heat loss at this area, savings energy on heating.

B6- At pump station two, insulate the walls from the interior and the ceiling with rigid foam insulation. Insulating the pump house will keep all heat in the pump house in winter, and keep excess heat out in the summer, both benefiting the structure.

Recommended Mechanical Energy Efficiency Measures

M1- Insulate the hot water pipes to improve the efficiency of the hot water distribution system.

Recommended Electrical Energy Efficiency Measures

E1-Upgrade lighting in the office area from T-12 to T-8. Significant electric energy savings can be realized by upgrading from T-12 to T-8 bulbs.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.

Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value.
### Projected Financial Analysis

#### Baseline Energy Usage:
- **Electricity:** 120,597 kwh
- **Propane:** 1,988 gallons
- **Total Energy Use:** 650,750 BTU

#### Baseline Annual Energy Cost:
- **Electricity:** $20,163
- **Propane:** $6,262
- **Total:** $26,425

#### EEM Breakdown:

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</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Weather strip 4 garage doors</td>
<td>$500</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$500</td>
<td>$125</td>
<td>3,658</td>
<td>4.0</td>
<td>30.0%</td>
<td>$2,932</td>
</tr>
<tr>
<td>B2</td>
<td>Spray foam band joints, install 2&quot; rigid on basement walls and drywall 960 SF wall, 3.20 SF of rim joint</td>
<td>$3,408</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$3,408</td>
<td>$259</td>
<td>7,316</td>
<td>1.66</td>
<td>9.5%</td>
<td>$3,570</td>
</tr>
<tr>
<td>B3</td>
<td>Surgically air seal the attic, and air seal the top plate (190 LF of spray foam)</td>
<td>$190</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$190</td>
<td>$125</td>
<td>3,658</td>
<td>1.47</td>
<td>79.5%</td>
<td>$3,227</td>
</tr>
<tr>
<td>B4</td>
<td>Replace two windows in Pump station 2</td>
<td>$800</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$800</td>
<td>$188</td>
<td>5,487</td>
<td>2.88</td>
<td>11.2%</td>
<td>$4,250</td>
</tr>
<tr>
<td>B5</td>
<td>Install sealed and insulated attic hatch in pump station 2</td>
<td>$300</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$300</td>
<td>$188</td>
<td>5,487</td>
<td>1.82</td>
<td>67.9%</td>
<td>$4,026</td>
</tr>
<tr>
<td>B6</td>
<td>Insulate walls from the interior (and the ceiling) with rigid 3&quot; on the ceiling = 3,905 SF, 4&quot; on the walls= 600 SF At pump station 2</td>
<td>$11,008</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$11,008</td>
<td>$689</td>
<td>20,119</td>
<td>1.63</td>
<td>9.5%</td>
<td>$3,260</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>$16,206</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$16,206</td>
<td>$1,566</td>
<td>10.4</td>
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</tr>
</tbody>
</table>

#### MECHANICAL SYSTEM UPGRADES:

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</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Install hot water pipe insulation ~50ft</td>
<td>$245</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$245</td>
<td>$94</td>
<td>2,743</td>
<td>2.6</td>
<td>43.2%</td>
<td>$2,323</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>$245</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$245</td>
<td>$94</td>
<td>2,743</td>
<td>2.6</td>
<td>43.2%</td>
<td>$2,323</td>
</tr>
</tbody>
</table>

#### ELECTRICAL SYSTEM UPGRADES:

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Lighting upgrade to T-8's</td>
<td>$900</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$900</td>
<td>$403</td>
<td>9,459</td>
<td>2.2</td>
<td>49.8%</td>
<td>$1,016</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*
15. Historical Society/Academy Building

General Information

The Historical Society is housed in the Academy Building owned by the town and is located at 51 Maple Street in Henniker. It was originally built as a school house in 1836, making it 175 years old. It has undergone a cupola restoration by Fifield Building Restoration. It has also served as a community center around WWII and a college owned building in the 1950’s. The space includes a large open space that is now used as the town’s history museum.

The Historical Society has a light amount of hours that the building is open and used. Their hours are: Thursday from 10am-2pm and the 1st and 3rd Saturdays of the month from 10am-1pm. This is a total of just 4 to 7 hours a week that the building is occupied.

Existing Conditions

Building Envelope

Walls

The exterior walls of the Academy building are rough sawn nominal 2”x 4” wood frame construction with wood siding exterior and lathe and horse hair plaster interior. There is no insulation in the walls. The walls have not been altered since the original construction. The story height is about 11’.
Windows and doors

The windows of the building are double hung, single pane, wood framed windows with exterior aluminum storms. The windows are also original to construction.

Basement windows are mostly blocked off with plywood.

Doors are wood and some have single pane glass windows. There is no weather stripping on doors and they are not insulated.

Roof

The roof is a rough sawn wood framed, gable roof with asphalt shingles. Blown in fiberglass insulation is along the ceiling plane of the attic. The insulation is uneven and ranges from one inch to ten inches. The fiberglass is also dirty which is a sign of air movement (and therefore heat loss) up through the insulation. No air sealing or air barrier is present. Gable end vents and the cupola serve as venting for the attic. The chimney is the only roof penetration.
Foundation

The Academy Building was built on a granite block foundation and has a mostly dirt floor. There were also sections of brick in the foundation. The mechanical room in the basement that houses the furnace has areas of poured concrete and areas of rock with a vapor barrier beneath. There is no basement insulation, or insulation separating the space above.

HVAC Systems

Heating, Ventilating and Air Conditioning Equipment

The building has an oil fired Century furnace that generates forced hot air to the building.

At this time heating is only provided to the main office space on the first floor. This is only 10% or less of the building, leaving the heating system grossly oversized. When a system is oversized it causes the furnace to cycle very frequently, this uses more oil and is not efficient.

The distribution system is via metal forced hot air ducting. Because they no longer heat the entire building several ducts are blocked off. None of the ducting is insulated.

HVAC Controls

The office space has a programmable thermostat that controls the heat to the space. The office area is heated 24 hours a day during heating season with no set backs.

Electrical - Lighting and Appliances

The Historical Society was not included in the PSNH lighting retrofit that most of the other buildings underwent. They have T-12 fluorescent lighting throughout the building and single bulb incandescent lighting in the basement.
Plumbing and Domestic Hot Water

No hot water pipes were insulated, though they have no had pipe freezing issues. There is a very low domestic hot water (DHW) demand at the building. There is one bathroom in the building, and hot water is used for hand washing only.

Notable Problem Areas/Occupancy Comfort

- The heating system is oversized for the space that it is heating.
- The areas with blocked of heating vents are still receiving heat. This become inefficient as heat is still traveling to the areas and is not being re-routed to the heated area.

![Image of a blocked off vent on the second floor, still emitting heat]

- There is no insulation in the walls, allowing heat in the building to be lost to the outside via conduction through the walls. This is also an issue in the summer that can make for very high indoor temperatures. Also, the space that is heated (the office on the main floor) is not insulated and is losing heat to the surrounding spaces.
- The windows are very poor and also lead to a great deal of heat loss. They have a very low R-value and are also very leaky.
- The doors are very leaky and have a low R-value as well.
- The T-12 lighting could be upgraded to gain efficiency and save electricity.
Energy Use and Cost Analysis

The Historical Society uses oil and electricity to meet its energy needs. Electric consumption is attributed to lighting and the oil use is attributed to space heating.

The Energy Cost chart, shown below, graphically analyzes the cost of your electric use. Oil use was provided in yearly totals (noted in the table below) and with the low use of the building we were not able to estimate the oil use via heating degree days. Please keep in mind the low use of the building when analyzing the numbers. The numbers shown are three year averages.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Cost For One Year</th>
<th>Cost Per Unit</th>
<th>Current Statewide Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$804</td>
<td>$0.20/kWh</td>
<td>$0.14/kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>$1,613</td>
<td>$2.60/Gallon*</td>
<td>$3.67/gallon</td>
</tr>
<tr>
<td><strong>Current Total Energy Cost</strong></td>
<td><strong>$2,417</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The current state wide average pricing is according to the New Hampshire Office of Energy and Planning, as of September 7, 2011.

Using current yearly oil use of 621 gallons a year and the current state wide average price per gallon of oil of $3.67, the Historical Society would be paying $2,297 a year for propane.

Because we know how often the Historical Society is open each week we were able to calculate a per hour use for oil consumption to better show the actual inefficiency of the building. The building is open for 264 hours a year, or 22 hours a month. Using the 2010 data we know they used 512 gallons of oil that year, and that there are roughly seven months of the heating season in the northeast per year. This makes the per hour use 3.32
gallons of oil per hour, and $7.97 per hour of operation. This surely shows the inefficiency of the building versus its low yearly use compared to fully occupied buildings.

The Energy Consumption chart below graphically analyzes the electric consumption in kBTUs. Both electric and oil are included in the table below the chart. The numbers shown are also three year averages.

![Historical Society Energy Consumption (3 Year Average)](image)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kBTU Used for One Year</th>
<th>Unit Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>13,856</td>
<td>4,061 kWh</td>
</tr>
<tr>
<td>Oil</td>
<td>86,085</td>
<td>621 Gallons</td>
</tr>
<tr>
<td><strong>Total Energy Use</strong></td>
<td><strong>99,941 kBTU</strong></td>
<td></td>
</tr>
</tbody>
</table>
The following graphs show energy use and cost breakdowns by fuel type for the Historical Society:

<table>
<thead>
<tr>
<th>Figure 1:</th>
<th>Energy Use Breakdown by Type</th>
<th>Energy Cost Breakdown by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical Society</td>
<td><img src="image" alt="Energy Use Breakdown" /></td>
<td><img src="image" alt="Energy Cost Breakdown" /></td>
</tr>
<tr>
<td>- 35% Electric</td>
<td>- 65% Oil</td>
<td>- 33% Electric</td>
</tr>
</tbody>
</table>

**Building Benchmarking**

Jordan began by examining the historical energy consumption of your building, known as Building Benchmarking. Building Benchmarking rates your building’s performance on two metrics: **Energy Use Intensity (EUI)** and **Cost Use Intensity (CUI)**.

EUI is the annual energy use per square foot in BTUs, this is displayed as kBTUs to signify thousands of BTUs (British Thermal Units) per square foot of conditioned space in the building (kBTU/SF). CUI displays the annual energy cost per square foot in the building per year ($/SF/YR).

Our calculated energy use for the Historical Society:

**EUI = 36.79kBTU/SF/YR**

**CUI = $0.67/SF/YR**

There is no category of building type that the Historical Society Building falls under that would accurately project the true performance of the building due to the low use. Therefore we do not have EUI comparisons for the Historical Society building.
Recommended Energy Efficiency Measures

Recommended Building Envelope Energy Efficiency Measures

B1- The office space that is heated should be air sealed and insulated on all six sides. By insulating and air sealing the room it separates the conditioned space from the unconditioned space. This will keep heat in the office and less heat will be required to keep the office comfortable because heat will not be being lost to the surrounding spaces. This can be done from the interior with blown in cellulose in the walls with little demolition of the interior finish. The ceiling can be done by installing blown in cellulose beneath the floor joists of the room above and the floor can be insulated from the basement below. This should be considered if the current occupancy and heating situation will remain for a long time. If the building use may change in the near future, the insulation schedule should be revisited. Other insulating options were not chosen at this time due to most of the space not being used or heated.

B2- If measure B1 is not opted for, consider air sealing and insulating the attic. If the entire building would like to be kept in use as conditioned space, the attic should be re-addressed. The existing blown in fiberglass insulation should be removed to allow for a 1-2” layer of spray foam to be applied to the attic floor for air sealing. On top of the spray foam 16” of blown in cellulose should be installed to reach R-60 in combination with the spray foam. This will significantly reduce the heat lost to through the attic and prevent solar heat gain in the summer.

Recommended Mechanical Energy Efficiency Measures

M1- If B1 is chosen, an electric space heater may be used to heat the insulated one room office space. This removes the building from oil entirely for the season, but the heating system may stay in place for future use should the use of the building change. This has not been included in the financial modeling because the cost will be very low.

M2- If B1 is not chosen, replace the oversized furnace with a smaller sized high efficiency furnace. By having the heating system appropriately sized there can be large energy savings in heating, and therefore heating costs. With the price of oil rising this should be a priority. Zoning of the spaces should also be installed at this time to allow for heat to be turned off or lowered in the spaces that are not used. This will require further engineering and has therefore not been included in the financial modeling.

M3- Insulate hot water piping. The efficiency of the hot water distribution system will be greatly improved and save energy while also preventing the risk of pipes freezing.

Recommended Electrical Energy Efficiency Measures

E1-Upgrade lighting in the office area from T-12 to T-8. Significant electric energy savings can be realized by upgrading from T-12 to T-8 bulbs.

Recommended Renewable Energy Efficiency Measures

There are no renewable measures recommended at this time.
Financial Modeling

The following tables identify each energy efficiency measure’s cost, available rebates, annual energy savings and costs savings, simple payback, internal rate of return and net present value. For the financial model we have used the projected future cost of $4.00/gal for oil, this is very likely for the near future.
### Historical Society

<table>
<thead>
<tr>
<th>BUILDING ENVELOPE UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>B&amp;D-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Insulate around all six sides of the office area (include bathroom) with 6” of rigid/spray foam and finish with drywall (540 SF wall, 989 SF ceiling, 989 SF floor)</td>
<td>$12,441</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$12,441</td>
<td>$497</td>
<td>17,388</td>
<td>25.0</td>
<td>5.9%</td>
<td>$1,670</td>
</tr>
<tr>
<td>B2 Remove blown in fiberglass insulation, in attic space, apply 1/2” or spray foam, install 18” of blown in cellulose (1012 SF attic space)</td>
<td>$9,123</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$9,123</td>
<td>$571</td>
<td>19,996</td>
<td>16.0</td>
<td>9.5%</td>
<td>$6,857</td>
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<tr>
<td><strong>Total</strong></td>
<td>$21,564</td>
<td>$2,154</td>
<td>$1,068</td>
<td>20.2</td>
<td></td>
<td></td>
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<table>
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<tr>
<th>MECHANICAL SYSTEM UPGRADES</th>
<th>CAPITAL INVESTMENT</th>
<th>B&amp;D-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 Insulate hot water piping</td>
<td>$300</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$300</td>
<td>$25</td>
<td>899</td>
<td>12.1</td>
<td>12.1%</td>
<td>$39.0</td>
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<th>ELECTRICAL SYSTEM UPGRADES</th>
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<th>B&amp;D-OF-LIFE</th>
<th>REBATES</th>
<th>EDL &amp; REBATES</th>
<th>ENERGY INVESTMENT</th>
<th>ANNUAL ENERGY COST SAVINGS</th>
<th>ANNUAL ENERGY SAVINGS MBTU</th>
<th>SIMPLE PAYBACK</th>
<th>IRR</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Upgrade lighting to T-8 throughout</td>
<td>$720</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$720</td>
<td>$16</td>
<td>277</td>
<td>44.9</td>
<td>2.2%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Utility rebates and tax credits are not included.*
Disclaimer: This report is delivered without any warranties, expressed or implied. This report contains information about the Town of Henniker Municipal buildings, in Henniker, NH only – and is based upon our observations and analysis and upon information which we received from the Town of Henniker. The Jordan Institute has used care, its best professional judgment, and the services of qualified vendors and sub-contractors to research and prepare this report, and we believe we are presenting an accurate and complete assessment of your building and the opportunities present for energy improvements. Please note that no project pricing displayed within this report includes the cost of the design, plans or specifications for construction.

Furthermore, The Jordan Institute shall not be liable for any inaccuracies in this report, for any damages that may result from the implementation of measures recommended in this report, or discrepancies between the avoided energy cost estimates listed in this report and those which the building actually realizes from the implementation of the outlined plan.

Rebates, grants and low interest loans often impact the financial results of energy related improvements. As these opportunities are in constant change, we have not included these advantages in our financial results. Efforts to define their availability should be made when the decision to implement the recommended energy measures is made. Confidentiality Restrictions: This report contains data and information submitted to fulfill an Agreement between The Jordan Institute and the Town of Henniker and is provided in full confidence. The recipient shall have a limited right as set forth in the Agreement to disclose the data herein.
Appendix A – Infrared Image see separately binded report
Appendix B – Library Moisture Monitoring
The Kindergarten Room

There is a noticeable odor emanating from the sub-basement, or Kindergarten Room, of the Tucker Free Library. A few years ago, an ERV was installed in the Kindergarten Room upon recommendation from a local engineer. The ERV is set to turn on at set levels of relative humidity, keeping the relative humidity in the space low. The odor was more noticeable during blower door testing, and the smell was noticeable in other rooms of the library during the testing.

Before the installation of the ERV, the odor traveled to other areas of the Library. Currently the smell is controlled by the ERV but we our concern is that there is an underlying mold problem. If there is mold it needs to be addressed and properly remediated. We strongly encourage that a mold expert re-examine the space and test for mold.

Upon a later visit to the Library a drain was discovered in the sub-basement. It had previously been covered by trash bags filled with Library books. This could be the source of the odor and will need further investigation by a plumber to determine if it is draining properly.

Kindergarten Room and Data Logging Equipment

In order to test the effectiveness of the ERV and determine if conditions were suitable for mold growth, temperature and relative humidity were monitored in the Kindergarten room of the Tucker Free Library for approximately two weeks. Two data loggers, each measuring temperature and relative humidity, were placed on two exterior walls within the room and took readings at 20 minute intervals, yielding around 1000 data points. Given the temperature and relative humidity the dew point was calculated. The dew point is the temperature at which water vapor in the air will condense to water. When the temperature and dew point are equal at a give level of relative humidity, water vapor in the air will condense to water, and once there is moisture, mold is not far behind.

During the monitoring period the peak relative humidity recorded was 48% and the minimum recorded was 27%. When relative humidity peaked at 48% the corresponding temperature was 56 degrees Fahrenheit. This gives a dew point of 37.3 degrees Fahrenheit. Meaning if the warm air from the room were to be cooled to 37.3 degrees, possibly by coming into contact with a glass pane on a door or into contact with the interior of the masonry block, it would condense to form water on that cooler surface. Over the course of the monitoring period the temperature and the dew point remained a minimum of 20 degrees apart.

It is important to note that during the heating season mold growth is not typically a concern in basements. In the winter season mold growth is more likely in an attic space, while basements are more susceptible to mold growth in the summer months.

Our findings suggest that the Energy Recovery Ventilator is maintaining a relative humidity below 50%. Lynn said the Kindergarten room is kept around 58 degrees, our results indicate that the room temperature was closer to 56 degrees during the monitoring period.
From this chart we can determine that at the time of the testing, the conditions were not at humidity levels that would permit the growth of mold in the space. However, we recommend further testing within the walls to ensure that no mold problems exist inside the walls.

Appendix 7

Library Kindergarten Room Moisture Monitoring
Appendix C – Funding and Financing options for Municipalities