MUNICIPAL ENERGY RESILIENCE PROGRAM
LEVEL II ENERGY ASSESSMENT

prepared for

Town of Starksboro
2849 Rte 116
Starksboro, VT 05487

Jerusalem Schoolhouse
200 Jerusalem Rd
Starksboro, VT 05443

September 9, 2024

Mechanical, Electrical, Plumbing
6 Green Tree Dr.
S. Burlington, VT 05403

Building Enclosure
206 W. Newberry Rd.
Bloomfield, CT 06002

TABLE OF CONTENTS

1. Executive Summary

The purpose of this Level II Energy Assessment is to provide the building Owner (Town/City) and the State of Vermont - Building and General Services with specific recommendations for building Energy Conservation Measures (ECMs) and Renewable and Resilient Energy Measures (RREMs). These measures will reduce electric and fossil fuel consumption and associated costs, and potentially provide resilience against cost fluctuations and interruptions in the supply of purchased energy. The assessment includes a review of the building's historical energy consumption and costs, exterior enclosure, mechanical and plumbing systems, and lighting.

The costs and savings for each measure are calculated using industry standard engineering methods. ECMs with a payback period greater than the Expected Useful Life (EUL) of the equipment are not typically recommended, as the cost of the measure will not be recovered during the lifespan of the equipment. These ECMs may be recommended for implementation at the time of future system replacement, where it would be appropriate to evaluate based on the premium cost of installing energy efficient equipment rather than the full cost.

1.1. Building General Data

General Building Data			
Type	Story Quantity	Year Built / Renovated	Floor Area (sq. ft.)
Schoolhouse, Garage	1	1874 / 1970	2,200

Building Occupancy	
Building Area	Entire Building
Occupied Hours/Week	2
Occupied Weeks/Year	20
Occupant Quantity	2

Building Conditioning	
Conditioning Type	Percent of Floor Area
Heated	100%
Cooled	0%
Unconditioned	0%

Facility Contact		
Name	Title	Phone Number
Rebecca Elder	Town Administrator	(802) 578-0501

1.2. Basis of Assessment

This Assessment is completed based on information obtained from the following sources.

Building Information Sources				
Site Visit	Utility Data Summary from Owner	Utility Bills	Construction / As-Built Drawings	Other
✓ 03/08/2024	✓		✓	

1.3. Energy Conservation Measures

There are no recommended ECMs.

1.4. Renewable & Resilient Energy Measures

The following tables summarize the recommended RREMs in terms of investment cost and benefits provided.

Battery Electric Storage Summary	
Equipment Quantity / Capacity	1 / 13.5 kWh
Investment Cost After Incentives	$6,700

Note: Information on this measure is provided for informational purposes only; The Owner needs to consider if the value of backup power to the building, and the value of electric storage vs. a fuel-fired electric generator is worth the investment.

Solar Photovoltaic Summary	
Annual Electrical Energy Generated (kWh)	1,100 kWh
Annual Building Electrical Consumption Offset (%)	90%
Investment Cost After Incentives	$1,750
Annual Energy Cost Savings	$180
Simple Payback	9.7 Years

1.5. Occupant Health & Comfort Measures

Occupant Health & Comfort Summary	
Measure	Benefit
Add Domestic Water Heater	Improve occupant health / safety

2. Introduction

The purpose of this Energy Assessment is to provide the building Owner (Town/City) and the State of Vermont - Building and General Services (VT BGS) with a baseline of energy usage, the relative energy efficiency of the facility, and specific recommendations for Energy Conservation and Renewable and Resilient Energy Measures. Information obtained from these analyses may be used to support a future application for a Municipal Energy Resilience Implementation Grant, any other State or Federal Energy Conservation Program, as well as support performance contracting, justify a municipal bond-funded improvement program, or as a basis for replacement of equipment or systems.

The energy assessment consisted of an onsite visual assessment to determine current conditions, itemize the energy consuming equipment (mechanical, electrical, plumbing); The study also included interviews and consultation with operational and maintenance personnel. The following is a summary of the tasks and reporting that make up the Energy Assessment report.

Utilities

A review of the existing energy types supplied to the building, historical consumption, and associates costs and required on-site storage.

Building Enclosure

A survey and assessment of the characteristics and conditions of the building enclosure including walls, windows, doors, and roofs.

Whole building air leakage testing utilizing a blower door tool.

Energy Consuming Equipment & Systems

A survey of building spaces to document and assess utility-related equipment, including heating, cooling, ventilation, domestic hot water and lighting systems.

Measurement of illumination levels in each space and comparison to recommended levels.

Recommendations for Energy Savings Opportunities

Based on the information gathered during the on-site assessment, the utility rates, as well as recent consumption data and engineering analysis, identification of opportunities to save energy and associated probable construction costs, projected energy/utility savings and resulting simple payback analysis.

Clarifications

This Assessment has been completed in accordance with the State of Vermont ACT 172.

This report has been prepared for and is exclusively for the use and benefit of the Town / City and VT BGS (“Client”). The purpose for which this report shall be used shall be limited to the use as stated in the contract between the Client and Salas O’Brien’s / DuBois & King (“Assessor”). This report, or any of the information contained therein, is not for the use or benefit of, nor may it be relied upon by any other person or entity, for any purpose without the advance written consent of the Assessor. Any reuse or distribution without such consent shall be at the Client’s sole risk, without liability to the Assessor.

The Assessor has no control over the cost of labor, material, and equipment, or over competitive bidding or market conditions. Therefore, the accuracy of project construction cost estimates included in this Assessment as compared to actual contractor bids or the actual cost to the Client are not guaranteed. Construction costs estimates are understood to be an opinion of a probable budget for construction costs. If a more accurate budget is required, we recommend enlisting the services of a professional estimating agency. Financial incentives are additionally included in the assessment and are accurate at the time the report is completed, but can typically change at any time; the availability and value of incentives needs to be verified by the Owner before deciding on equipment to purchase.

This Assessment is not intended to be or should be construed as any type of design for construction which a licensed Architect or Engineer is required for.

3. Utilities

3.1. Historical Energy Consumption & Cost by Type

Energy can be calculated and reported in multiple different ways, each with their advantages and disadvantages. Generally, this report uses Site Energy and Energy Cost, but also reports on Emissions.

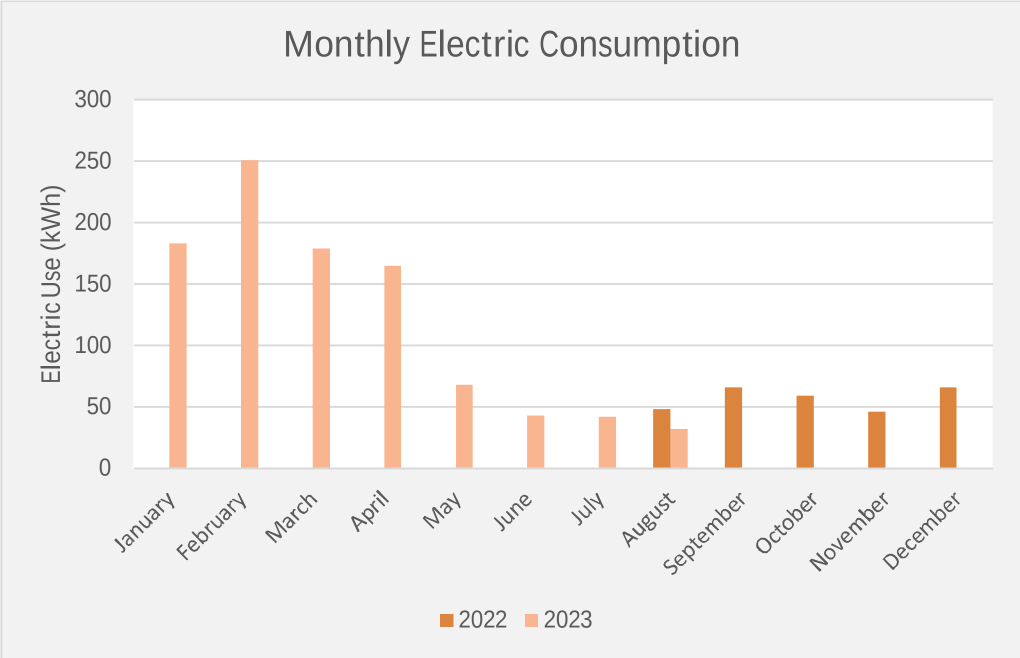
- **Site Energy** – Amount of energy consumed by a building as measured by site utility meters. Typically, electricity and one or multiple fuels.
- **Source Energy** – Accounts for the additional energy consumed in the extraction, processing, and transport of primary fuels such as coal, oil, gas, the energy losses in thermal combustion in power generation plants, and the energy losses in transmission and distribution to a building. Site/source conversions are typically national averages.
- **Energy Cost** – The monetary value for energy which serves a building.
- **Energy Emissions** – Amount of CO_{2e} source emissions. Rates are from regional grid annual averages for electric and national averages for fuel.

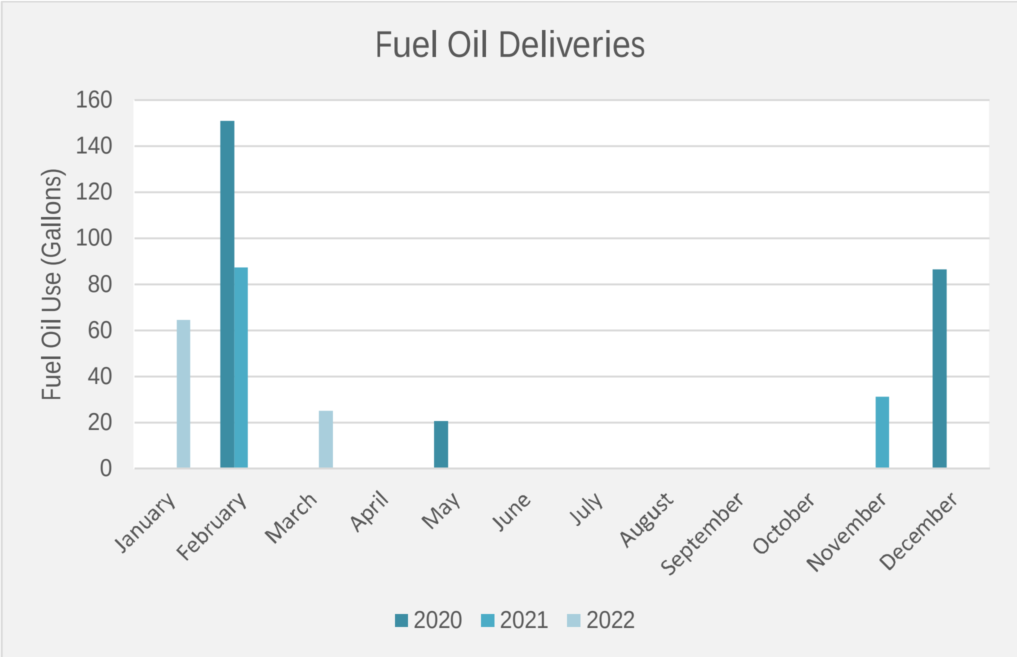
Energy Summary				
Energy Type	Energy Provider	Meter Quantity	Energy Uses	Usage Data Time Period
Electric	Green Mountain Power	1	Lighting, plug-in equipment, fans	08/2022 – 08/2023
No. 2 Oil	Jackman's Inc.	-	Space heating	02/2020 - 03/2023

Energy Analysis						
Energy Type	Annual Energy Use	Annual Energy Cost	Energy Cost Rate	Annual Site Energy Use (MBtu)	Annual Source Energy Use (MBtu)	Annual Energy Emissions (Mt CO_2e)
Electric	1,200 kWh	$240	$0.21/kWh	4	11	0.5
No. 2 Oil	190 Gal	$400	$2.15 /gal	26	31	2.5
TOTAL	-	$530	-	30	42	3.0

Assessment/Recommendations:

- Electric and fuel use are both strongly correlated with seasonal building space heating demand.
- Fuel use represents roughly 80% of total energy cost and 70% of total energy emissions vs. electric use.





The following utility rates were used for the purposes of savings analysis. The electrical savings rate is lower than the blended electrical rate ($0.21/kWh) as only variable usage costs are able to be offset; fixed costs are not.

Average Utility Rates			
Electricity	No.2 Oil	Propane	Wood Pellets
$0.190 /kWh	$3.00/Gal	$2.50/Gal	$300/Ton

3.2. Fuel Storage

Fuel Storage - Existing	
Type	No.2 Oil
Quantity / Capacity	2 / 275 Gal Each
Location	Interior and Above Grade Exterior

Figure 2 – Exterior Oil Storage Tank

Figure 1 - Exterior Oil Storage Tank

3.3. Electric Service

Electrical Service - Existing	
Capacity	200A, 120/240V, 1Ø, 60Hz

Assessment/Recommendations:

The existing electrical service capacity to support the addition of an electric vehicle charger was not assessed as it is not recommended. The existing electrical service does appear to have the capacity to support the addition of electric heat pumps (detailed later in report).

3.4. Electric Storage

The existing building/site has no battery electric storage.

Assessment/Recommendations:

An electric lithium battery storage system could be added to increase building resiliency. The value of this system is primarily the ability to continue to utilize the building in the case of a loss of electrical power from the utility, similar to that provided by a traditional fuel-fired electric generator. The benefit is it does not consume fuel or produce the associated on-site emissions. The battery system may provide additional utility cost savings; however, these are relatively minor or nonexistent based on current rates. The system proposed is selected to provide the capacity to power the building for approximately one average 24-hour period based on historical consumption data.

It's not clear the value of resiliency is high for this building, somewhat demonstrated by the fact that no back-up electric system currently exists (fossil fuel powered or battery).

Battery Electric Storage - Proposed	
Quantity / Capacity	1 / 13.5 kWh
Location	Interior Electrical Room
Space Served	Entire Building
Investment Cost	$15,000
Potential Incentives	$3,825 (GMP), $4,500 (Federal IRS)

3.5. Electric Generation

The existing building/site does not have a fuel fired generator or solar PV system.

Assessment/Recommendations:

The addition of a new solar PV system appears to be feasible on the existing roof. Only a small portion of the roof would be necessary to be utilized for a solar system sized to offset the majority of the building's annual electric consumption. The system is assumed to be a grid-tied, net metered account. A licensed structural engineer should be consulted on the capacity of the existing roof structure, and an electrical engineer on the system design.

Solar Photovoltaic System - Proposed	
Capacity	1 kW
Location	Roof
Annual Electrical Energy Generated (kWh)	1,100 kWh
Annual Building Electrical Consumption Offset (%)	90%
Investment Cost	$2,500
Potential Incentives, Tax Credits	$750 (Federal IRS)
Annual Energy Cost Savings	$180
Simple Payback	9.7 Years

Note: System is sized based on current facility electrical use. Implementing ECMs could reduce electric use and result in a smaller PV system being required. Implementing RREMs including EV chargers or heat pumps would increase electric use and result in a larger PV system being required. System costs and annual energy costs savings would be proportionally smaller or larger, but result in a similar payback.

3.6. Electric Vehicle Chargers

No EV chargers currently exist at the building/site.

Assessment/Recommendations:

The addition of new Level 1 or Level 2 chargers appear to be technically feasible for the building, however due to minimal building occupancy and the resulting minimal impact, EV chargers are not recommended.

4. Building Enclosure

The building envelope consists of the exterior shell, made up of the walls, windows, roof, and floor. The envelope provides building integrity and separates the exterior from the interior conditioned space.

Notes for Understanding the Building Envelope:

1. All building systems interrelate and occasionally improvements to one building system can create problems in another. This is particularly true of envelope and HVAC improvements. Measures to improve energy efficiency should be regarded in the context of the health and safety of occupants and in the long-term durability of the building. Careful consideration of the following and testing before and after efficiency improvements will help to prevent conditions that could have a negative impact on the building.
2. When viewing thermographs, lighter colors indicate higher surface temperatures than darker colors. What is considered “heat loss” is dependent upon the perspective from which it is viewed, inside or outside.
3. Some infrared images are taken under depressurization. Depressurization causes all outdoor air to flow inward and is not the normal operating state of the building. It is done to reveal conditions that would not normally be detected or to enhance thermographic images. Depressurization is also used to mimic the environment a building would be under in conditions of high wind or very cold temperatures. The building was depressurized to about –30 Pascals during the last part of the imaging.
4. Air leaks are detected by the infrared camera when cooler air “washes” across a surface. The pattern of air leakage is typically wispy lines emanating from the air leakage site.
5. One measure used to determine if an improvement is warranted is comparison to the current 2020 Vermont Commercial Building Energy Standards (CBES). Though code minimum might be considered a low bar it is important to understand that the code minimums have progressed significantly in recent years. They are far more stringent than they were even 20 years ago. Today, a code minimum envelope is quite robust from an energy perspective. In addition, the energy savings from increased insulation thickness (R-value) is not linear, it is geometric. So, the energy savings for doubling the insulation thickness is high for areas with low or missing insulation but low for areas with code minimum insulation. While the CBES is used as a reference, the requirements are applicable only to new buildings and to existing buildings when renovation occur; existing buildings which are not modified are not required to comply with the requirements.
6. Estimated costs include only the costs that relate to energy improvements. For example, if the recommendation is to add more insulation when the roof membrane is replaced, only the cost of the additional insulation is included in the simple payback calculation since the roof membrane replacement would have to be done regardless.
7. Building enclosure energy conservation measures are recommended based on a simple payback threshold of 30 years.

4.1. Summary

This building was reported to use only 200 gallons of heating oil per year. While on site, it was determined that the schoolhouse has not been regularly occupied for the last few years. This may be because of how leaky and uninsulated the building is; heating it through the winter would be costly. This leads us to believe only the fire department was partially heated, hence the low fuel usage, unless it was to prevent pipes from freezing in the bathroom. In terms of energy savings and lowering the towns spending, the best option is to continue to not use the schoolhouse in the winter when it needs to be heated. However, it is a building and with extensive repairs and renovation could be better utilized by the town and its people. Because the building is used so little, any recommendations would not be cost effective as there would be no savings in terms of lowering the current energy bill. The recommendations below only go over estimated costs and what should occur during renovation. A payback/estimated energy savings is not given because again the building is hardly used. If a decision was to be made considering energy savings alone, no ECM measures would be completed for the building. Because of how much is deficient in terms of air leakage, missing insulation, and crumbling foundation, the building should be fully renovated.

4.2. Foundation

Building Foundation	
Foundation (main)	Stone with concrete finish
Foundation (addition)	Concrete foundation walls
Crawl Space	Crawl space, dirt floor
Foundation Wall Insulation Type	None
Foundation Wall R-value	R-1

Assessment/Recommendations:

The foundation is in poor condition and performing below a code compliant (R-15 continuous insulation) foundation. A structural engineer should determine if the foundation can be saved. The fire department is reported to flood every winter/spring. The cheapest option, which is the one recommended, is to insulate the foundation around the perimeter of the building from the exterior:

1. From outside dig down into the soil around the foundation and expose 12 to 18" of the foundation wall. Wash off the soil and allow the walls to dry completely.
2. Glue at least 2" thickness of rigid extruded polystyrene (XPS) foam board to the wall by setting it in the bottom of the trench and going up to the top of the foundation. 3 or 4 inch thickness will save more but the largest payback will come from the first 2" of foam. Be cautious about the glue you select, get a construction adhesive that is formulated for XPS insulation, the other types will eat the foam.
3. Cover the above grade XPS insulation with metal sheeting (break metal), vinyl coil stock, or stucco. You can also get protective coated XPS that can be attached with masonry anchors for a higher price but a faster install.
4. Backfill the trenches in the soil.
5. Add flashing at the top of the insulation so that it can shed water away from the building.

This method is more durable, and it brings the mass of concrete inside the insulation which makes the energy performance of the wall a little better than if the concrete is trapped on the outside of the insulation. It is also easier to access the whole wall from outside and allows the slab edge to be covered. Unfortunately, this method costs more and makes the payback longer.

Figure 3 – Large crack in concrete foundation

Figure 4 – Concrete over existing stone foundation

4.3. Roof

Primary Roof - Existing			
Finish	Metal	Main Ventilation Source	Unvented
Type / Geometry	Gable	Roof Drains	Edge drainage to ground
Insulation	None	Roof / Attic Insulation	R-1

Assessment/Recommendations:

The roof is in fair condition, but the attic is in poor condition and performing below a code compliant (R-49) attic. The attic has no insulation, no well-defined air barrier, and no well-defined path between the front and back of the building. As such, an extensive renovation should occur that involves making the attic continuous from the front to the back of the building. For this to happen, the floorboards in the front attic should be removed along with all dirt so that the topside of the first floor wood ceiling is exposed within the attic. In the back of the building, a new ceiling will need to be installed. This can be done with sheetrock with its joints mudded and taped. Then, 1.5" of closed cell spray foam can be applied over the entire attic floor ceiling to the back of the perimeter walls sheathing. Finally blown in cellulose insulation can be applied until the total R-value from the spray foam and the cellulose equals R-49 or greater. This will reduce the buildings air leakage by over 50 percent and bring the attic R-value up to code.

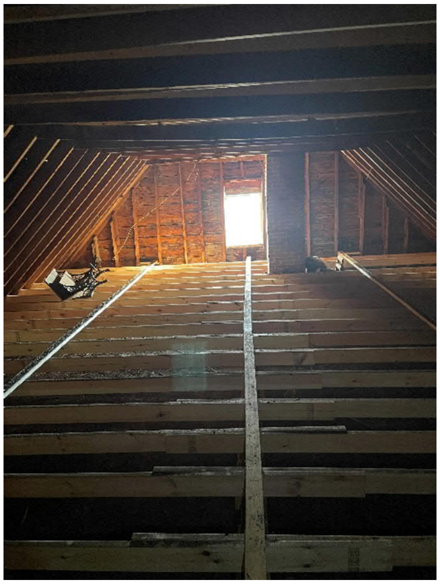


Figure 5 – Front attic

Figure 6 – Back attic with no defined air barrier

Figure 7 – Attic floorboards

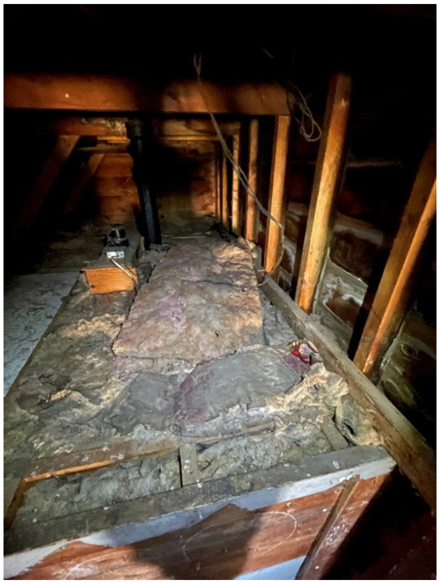


Figure 8 – Inadequate insulation over the bathroom

4.4. Walls

Exterior Walls - Existing	
Wall Primary Finish	Painted wood
Wall Framing Type	Wood framed
Wall Construction	Exterior painted wood siding, wood board sheathing, wood balloon framing, interior wood siding boards.
Wall Insulation Type	None
Wall R-value	R-2.5

Assessment/Recommendations:

The walls are in poor condition and performing below a code compliant (R-19+R-8ci 2x6) wood framed wall. The walls have no insulation, and are balloon framed which leads to large amounts of air leakage. To address this, the walls should be gutted so the wood framing and backside of the board sheathing is exposed. This involves removing all interior wood siding. Once done, 4" of closed cell spray foam should be applied to the exterior walls between the studs. The foam should seal to the floor and to the underside of the attic boundary. This will bring the R-value close to current code. Then, drywall can be installed over the spray foam. This is both for visual appearance and the drywall will act as a thermal barrier for the spray foam.

Figure 9 – Balloon framing visible from within the attic

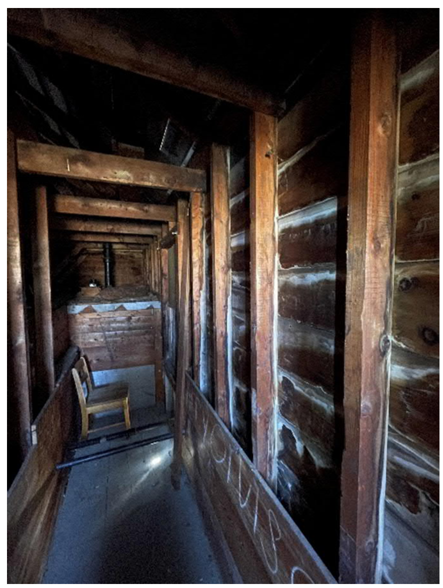


Figure 10 – The back of the building has the sheathing already exposed in some areas

4.5. Windows

Exterior Windows - Existing					
Location	Window Framing	Glazing	Storm Windows	Air tightness	R-Value
Building	Wood-framed, operable	Single glaze	None	Poor	R-0.9

Assessment/Recommendations:

The windows are in fair condition and performing below a code compliant (R-3) fixed window. Replacing the windows is recommended as they are low in R-value and high in air leakage.

When it is time to replace the windows with new windows keep the following considerations in mind:

1. Are there any oversized window areas that are no longer necessary? Most buildings that predate electricity had large windows for day lighting. Can parts of the window area be in filled with insulated wall? Walls always outperform even the best windows at a fraction of the cost. If aesthetics is a concern can part of the window area be in filled with translucent panels such as Kal wall?

2. If the new windows are inserts remove window weights and fill in the weight pockets with injected foam. Air seal the original window opening as much as possible before the window insert is installed.

3. Consider installing single hung units so the top sash is sealed in place. This reduces air leakage overall and makes them easier to close and latch.

4. Consider installing fixed or casement windows, which have the lowest overall air leakage. Casement windows should have cam latches as part of the hardware.

5. Specify that new windows are to be foam sealed into the rough opening or to the original frame to make an airtight connection to the wall.

6. Buy windows with low conduction frames like fiberglass and warm edge spacers between the glazing.

7. Get as high an R-value and as low a U-value as possible. New windows with suspended films can perform on par with triple pane windows at a much lower weight. Target R-4 (U-0.25) or better.

8. If installing aluminum framed windows get windows with thermally broken frames to separate the interior aluminum from the exterior aluminum.

9.Finally, identify any windows that are no longer in use and infill them with insulated wall panels.

Figure 11 – Windows have poor thermal resistance

Figure 12 – Visible light image

4.6. Doors

Exterior Doors - Existing			
Building Doors		R-Value	Weather-stripping
Main Entrance Doors	Solid core wood	R-3	None or ineffective

Assessment/Recommendations:

The doors are in fair condition and performing below a code compliant (R-4.75) insulated door. They were found to have no weather stripping. Improving the doors is recommended as they were found to leak heavily at their perimeter due to the missing weather stripping. All exterior doors should have weather stripping added. The most effective way to do this would be to use commercial-grade weather stripping (www.draftseal.com). On doors that are still in good shape the most cost-effective measure is to check the thresholds, sweeps, and weather-stripping of all the exterior doors once a year and replace as needed. Even old doors can serve very well if the weather stripping and sweeps are in good shape. When installed, make the weather-stripping and sweeps as tight as possible on the doors. At the head and jambs commercial grade neoprene or rubber bulb gasketing is preferred over brush weather-stripping. To ensure that the weather stripping and sweeps are installed properly, you should not be able to see daylight at the weather-stripping when the doors are closed.

Figure 13 – Side entrance

4.7. Air Tightness

Blower Door Test Results			
Indoor Temperature (ºF)	50	CFM/sf at 75 Pa.	1.41
Outside Temperature (ºF)	45	Test Notes	This does not include the attached fire department as it has a separate entrance.
Total Surface Area (s.f.)*	5,800		
CFM at 75 Pa.	8,185		

*Six-sided surface area of the envelope bounding conditioned space, includes above and below grade surfaces.

Building Air Tightness Comparison	
Type	CFM/sf at 75 Pa.
This Building	1.41
Leaky Construction	> 0.50
Average Construction	0.21 to 0.50
High Performance Construction	< 0.20
Ultra Tight Construction	< 0.08
Overall Assessment	The building is extremely leaky

Assessment/Recommendations:

The building air tightness is performing way leakier than a code compliant (0.30 CFM/sf at 75 Pascals) building. Improving the air tightness is recommended through the measures described above.

Dedicated combustion air systems are recommended for fuel-fired appliances; an HVAC engineer should be consulted to review the mechanical ventilation when planning improvements that will improve the air tightness of the building.

Building Envelope – ECMs					
Type	Foundation	Attic	Walls	Windows	Doors
Investment Cost*	$10,000	$35,000	$40,000	$20,000	$1,000

**The cost is provided for these recommendations in case the town wants to use the building more often in the future. Since the building is currently used little, the payback period is both high, and difficult to accurately calculate. If the building is used more, the efficiency measures may be cost effective.*

5. Building Heating, Ventilating, and Air-Conditioning (HVAC)

The schoolhouse portion of the building is heated with a hot air system consisting of an oil-fired furnace and associated ductwork. The garage portion of the building is heated with an oil-fired wall furnace. The garage also has a gas-fired unit heater which has been abandoned and is no longer in use. The building has no mechanical cooling or ventilation.

HVAC Terminal Equipment - Existing		
Type	Oil-Fired Hot Air Wall Furnace, Non-Condensing, Single Stage Burner	Propane-Fired Hot Air Unit Heater, Non Condensing, Single Stage Burner
Venting	Vented Through Wall, No Combustion Air Provision	Vented Through Wall, No Combustion Air Provision
Quantity	1	1
Make / Model	Miller / CMF80PO	Modine / PA105
Capacity	Heating – 60 MBh	Heating – 84 MBh (est.)
Rated Efficiency	Heating – 75% AFUE	Heating – 80% AFUE (est.)
Electrical Power	115V, 1Ø, 60Hz, 1/3hp	120V, 1Ø, 60Hz
Year Installed / Age	2002 / 27 Years est.	Unable to Verify
Location / Spaces Served	Garage	Garage
Control	Non-Programmable Thermostat Occupied Period Setpoint: 60°F Unoccupied Period Setpoint: 54°F	Unable to Verify

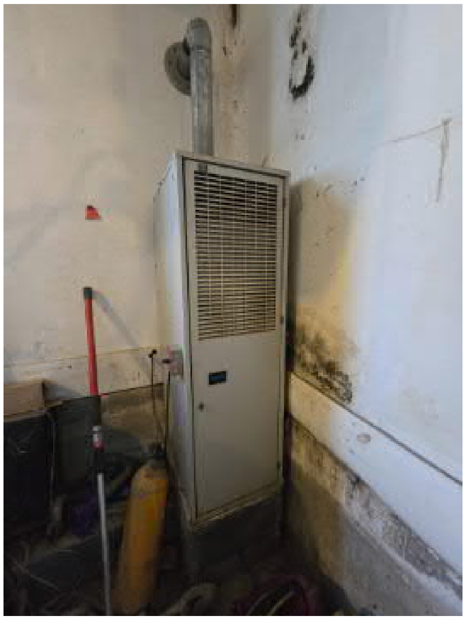


Figure 14 – Existing Wall Furnace

Figure 15 - Existing Unit Heater

HVAC Central Equipment - Existing	
Type	Oil-Fired Hot Air Furnace, Non-Condensing, Single Stage Burner
Venting	Vented Through Chimney, No Combustion Air Provision
Quantity	1
Make / Model	Select-Aire / OF150
Capacity	Heating – 166 MBh
Rated Efficiency	Heating – 80% AFUE (est.)
Electrical Power	120V, 1Ø, 60Hz, 1.0 hp (est.)
Year Installed / Age	2002 / 27 Years est.
Location / Spaces Served	Mechanical Room / Schoolhouse
Control	Non-Programmable Thermostat Occupied Period Setpoint: 60°F, Unoccupied Period Setpoint: 54°F

Figure 16 – Existing Ducted Furnace

HVAC Insulation - Existing	
Duct Insulation	There is no insulation on the existing system ductwork, typical and appropriate for a single-zone system with no cooling capability.

Assessment:

1. **Ventilation** – Based on current minimal building occupancy, the benefit of adding a mechanical ventilation system would be minimal. If the building occupancy is increased, the addition of a new mechanical ventilation system would increase heating demand and energy use, but would be valuable to maintain healthy indoor air quality for occupants. This is especially the case if the building envelope air leakage is reduced. An energy recovery ventilation unit could be used to minimize the impact on heating demand / energy use.
2. **Thermostats** - When the entire building or individual spaces within the building are unoccupied, thermostat temperature setpoints should be reset, and set to the same temperatures to minimize energy use. The building is minimally heated during the winter and when occupied, thermostat setpoints are adjusted by occupants as necessary. It does not appear that replacing the existing thermostats with programmable ones would be valuable.
3. **Motor Efficiency** - The PSC-type fan motors for both the ducted furnace and wall furnace are relatively inefficient versus modern EC-type motors.
4. **Air Filters**
    a. **Ducted Furnace** – The existing ducted furnace air filter could not be verified but is assumed to be a low-efficiency 1" thick type. This provides minimal protection to the equipment heat exchanger, and minimal benefit to indoor air quality. Utilizing a MERV-13 rated filter instead would provide the best benefit to indoor air quality, however based on current minimal building occupancy, the benefit of a higher effectiveness air filter would be minimal.
    b. **Wall Furnace** – The existing furnace air filter is a low-effectiveness type. This provides minimal protection to the equipment heat exchanger, and minimal benefit to indoor air quality, however this type of equipment is not capable of utilizing more effective air filters, so no opportunity for improvement exists.
5. **Heating System Capacity vs. Building Demand**
    a. **Ducted Furnace** – The existing furnace capacity appears to be more than <u>50% greater</u> than required for the maximum building heating demand based on its size and construction. If recommended building envelope insulation and air sealing ECMs were implemented, the furnace system capacity would be more than <u>four times</u> the maximum building heating demand.
    b. **Wall Furnace** – The existing furnace capacity appears to be approximately as much as required for the maximum building heating demand based on its size and construction. If recommended building envelope insulation and air sealing ECMs were implemented, the furnace system capacity would be nearly <u>three times</u> the maximum building heating demand.

    Oversized equipment results in more frequent on/off cycling leading to reduced operational eff. and equipment life.
6. **Heating System**
    a. **Ducted Furnace** – The existing mid-efficiency furnace appears to be in fair condition and past the end of its EUL. Replacing the existing oil-fired furnace with a new high efficiency gas-fired furnace, or replacing it with a hybrid mid effciciency gas fired furnace / electric heat pump are possible options. Due to a limited quantity of manufactures and limited available capacities, a wood pellet-fired furnace is not considered.
        - **Option 1 - High Efficiency Gas-Fired Furnace:** A new high efficiency, condensing, direct-vent, gas-fired furnace with a modulating output burner, stainless steel heat exchanger, EC fan motor, and an efficiency rating of 95%+ could be installed to completely replace the existing oil-fired furnace. A new above-grade or –ideally-buried exterior storage tank would be required.
        - **Option 2 – Electric Heat Pump:** A new heat pump system could be installed and utilized in conjunction with a new mid-efficiency gas-fired furnace. The heat pump system would consist of an exterior unit and a single interior ducted coil attached to the furnace with refrigerant piping in between. Heat pump controls would be integrated with the furnace. The indoor unit would require condensate drain piping to allow for cooling/dehumidification in addition to heating if that fuctionality was desired. The heat pump could heat the building for the majority of the year while the gas-fired furnace would operate only on the coldest days. The

relatively low indoor air temperature setpoint during unoccupied periods – 54F - is close to the minimum air temperature rating of different heat pumps – usually either 50F or 59F. Technical specifications of a specific heat pump would need to be confirmed before purchasing.

b. **Wall Furnace** – The existing mid-efficiency furnace appears to be in fair condition and past the end of its EUL. Replacing the existing oil-fired furnace with a new gas-fired model, or using it in conjunction with an electric heat pump are possible options. A high-efficiency wall furnace does not exist, only mid-efficiency. Due to a limited quantity of manufactures and limited available capacities, a wood pellet-fired furnace is not considered.

- **Option 1 - Mid Efficiency Gas-Fired Furnace:** A new mid efficiency, direct-vent, gas-fired furnace with a modulating output burner, and an efficiency rating of 80%+ could be installed to completely replace the existing oil-fired furnace. A new above-grade or –ideally- buried exterior storage tank would be required.
- **Option 2 – Electric Heat Pump:** A new heat pump system could be installed and utilized in conjunction with the existing oil-fired furnace. The heat pump system would consist of an exterior unit and a single wall, floor, or ceiling-mounted ductless or ducted interior unit with refrigerant piping in between. Heat pump controls would require some work to be integrated with the existing furnace. The indoor unit would require condensate drain piping to allow for cooling/dehumidification in addition to heating if that fuctionality was desired.The heat pump could heat the building for the majority of the year while the oil-fired furnace would operate only on the coldest days. The relatively low indoor air temperature setpoint during unoccupied periods – 54F - is close to the minimum air temperature rating of different heat pumps – usually either 50F or 59F. Technical specifications of a specific heat pump would need to be confirmed before purchasing.

The following should be considered when evaluating new systems:

- **Building Envelope Improvements** – This analysis assumes that building envelope ECMs recommended in this assessment report are pursued and the maximum building heating demand is reduced due to their impact. If these ECMs were not pursued, the heating system costs and energy savings would be greater.
- **Replacement Cost** – The existing furnaces are beyond the end of their EULs and will require an investment in a replacement units in the near future. The cost difference between similar new furnaces and a new high efficiency / renewable energy systems may be less than the full cost depending on the type of system.
- **Energy Cost Volatility** – Fossil fuel prices typically vary over time by +/- 50%, depending on a variety of factors. Wood and electricity costs are relatively stable over time.
- **Energy Source –** Fossil fuels originate from outside the local geographical region whereas electricity is sourced locally and regionally. Purchasing electricity contributes somewhat to the local economy whereas purchasing fossil fuels has relatively low benefit to the local economy. Propane is widely available through bulk delivery from many local distributors. Electric power already exists and is used at the building. It appears the existing electrical service does have the capacity to support a new heat pump system with few to no modifications, but an electrical engineer should be consulted to confirm.
- **Environmental Impact** – The oil use of the existing furnaces represents the majority of the building's environmental impact (vs. electricity use). Annual CO_2e emissions after recommended building enclosure ECMs have been implemented can be reduced further by different amounts depending on the option, from 20% up to 60%.
- **Equipment Life -** For the primary heating equipment, the expected useful life is 20 years for high efficiency gas-fired furnaces, 25 years for mid-efficiency gas and oil furnaces, 15 years for heat pumps.

Heating System ECM and RREM Options - Schoolhouse			
Type	Mid Eff. Oil-Fired Furnace (Ref. Only)	High Eff. Gas-Fired Furnace	Heat Pump, Air-to-Air / Gas Hybrid
Estimated Heating Capacity (MBh)	50	40	Heat Pump: 20 Furnace: 40
Annual CO_2e Emissions Eliminated (%)	0	35%	65%
Investment Cost	$6,000	$6,000	$10,000
Potential Incentives	$0	$0	$1,000 (Efficiency VT)
Annual Energy Cost Savings*	0	5%	30%

Heating System ECM and RREM Options - Garage			
Type	Mid Eff. Oil-Fired Wall Furnace (Ref. Only)	Mid Eff. Gas-Fired Wall Furnace	Heat Pump, Air-to-Air / Oil Hybrid
Estimated Heating Capacity (MBh)	60	20	Heat Pump: 10 Furnace: 60
Annual CO_2e Emissions Eliminated (%)	0	20%	65%
Investment Cost	$5,000	$5,000	$5,000
Potential Incentives	$0	$0	$350 (Efficiency VT)
Annual Energy Cost Savings*	$0	-10%	30%

**Due to current minimal space heating, measures are far from being cost effective. Percent savings are provided rather than values for reference if building heating is increased in future.*

Recommendations:

1. **Motor Efficiency** – When a new, replacement furnace is purchased/installed, it should include an EC-type fan motor.
2. **Heating Capacity vs. Demand** - New heating equipment should be selected with a capacity to match the actual maximum building heating demand, or only a portion of it for hybrid systems. A licensed mechanical engineer should be consulted to determine this.
3. **Heating System** – Due to the minimal heating and resulting minimal fuel use of the building, no alternative is cost-effective at the present time. When the existing equipment requires replacement, alternatives may be attractive, particularly if considering other advantages including reduced energy cost volatility, positive local impact, and reduced environmental impact, and especially if the building is heated to a greater extent.

Figure 18 - Example York Brand
High Efficiency Gas-Fired Furnace

Figure 17 – Example Mitsubishi Brand Air-to-Air Ducted
Heat Pump, For Use With Gas-Fired Furnace

6. Building Lighting

Lighting - Existing		
Interior Illumination	Room	Measurement (foot-candles)
	Kitchen, School	Not Measured
Interior Light Fixtures	Room	Fixture/Technology
	Kitchen School	Ceiling mounted wrap fixture with T8 fluorescent bulbs Surface mounted screw base fixture with incandescent bulb
Interior Lighting Controls	Manual wall mounted switches	
Exterior Light Fixtures	Area	Fixture/Technology
	None	None
Exterior Lighting Controls	None	

Figure 20 - Existing Interior Light Fixture with Incandescent Bulb

Figure 19 - Existing Interior Light Fixture with T8 Bulbs

Assessment/Recommendations:

1. Interior light fixtures appear to provide illuminance at levels which are similar to what is recommended for the activities which take place in each space; no modifications are recommended.
2. All interior and exterior light fixtures operate few hours per year and replacing with more efficient fixtures would result in minimal energy savings and not be cost effective.
3. While many interior and exterior lighting controls are manual rather than automatic, building occupants appear to use lights only when needed; the use of automated controls is possible but would result in minimal energy savings and not be cost effective.

7. Building Domestic Hot Water

Plumbing Fixtures - Existing				
Type	Quantity	Location	Flow Rate	Age
Lavatory Faucet	1	Bathroom	2.2 GPM	10+
Kitchen Faucet	1	Kitchen	2.5 GPM	10+

Figure 22 – Existing Kitchen Sink

Figure 21 – Existing Lavatory Sink

Assessment/Recommendations:

The existing fixtures appear to be in moderately good condition. They are relatively efficient, but could be replaced with more efficient models. However due to their low usage, the resulting energy savings would be insignificant, and this is not recommended.

A water tank exists, but it does not appear to be a water heater, or at least appears not to be properly connected and not in use.

Figure 23 - Existing Water Tank

Assessment/Recommendations:

The addition of a hot water system would improve building occupant health at a minimum, and may be a violation of Vermont OSHA requirements. A relatively small electric storage water heater would likely be sufficient to serve the building.

8. Building Equipment

Kitchen Equipment - Existing		
Type	Refrigerator	Oven
Location	Kitchen	

Figure 24 – Existing Oven

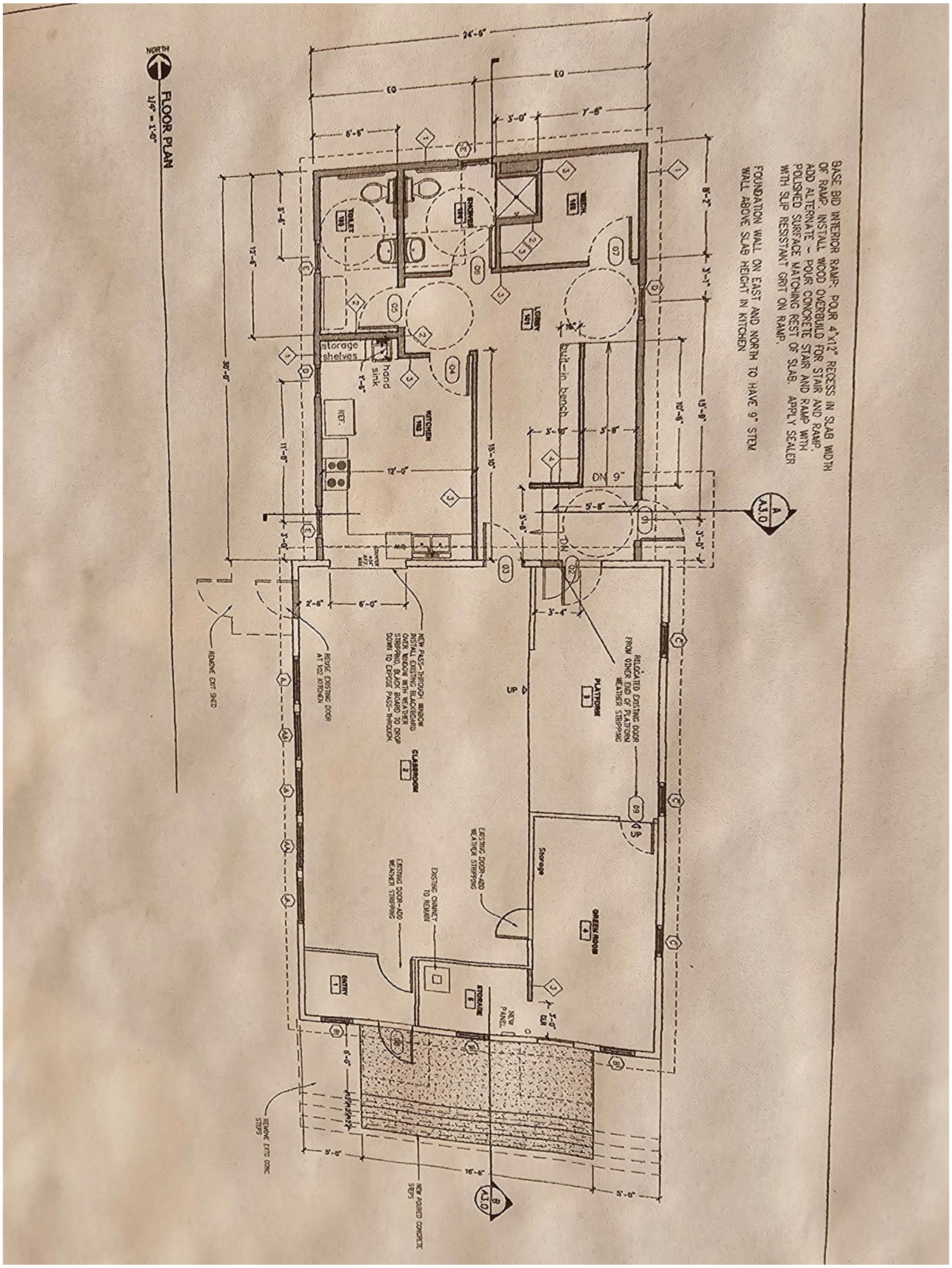
Figure 25 – Existing Refrigerator

Assessment/Recommendations:

The existing refrigerator is relatively energy inefficient but does not appear to be in use. If it is used in the future, replacing it with a high efficiency Energy Star labeled model would reduce energy use, be cost-effective, and is recommended.

9. Appendices

9.1. Appendix A – Building Architectural Floor Plan



10. Glossary of Terms and Acronyms

AFUE – Annual Fuel Utilization Efficiency; a measurement of a heating appliance's efficiency, calculated as the ratio of the heat output to the fuel consumed.

ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers; the governing society responsible for developing building design and efficiency standards and guidelines.

BTU – British Thermal Units, a measurement of the heat content of fuels or energy sources. One BTU is the quantity of heat required to raise the temperature of one pound of water by 1°F at the temperature which water has its greatest density – approximately 39°F

CFM – Cubic Feet per Minute; a measurement of air movement.

COP – Coefficient of Performance; a measurement of efficiency. Calculated as the ratio of useful heating or cooling provided to the work (energy require).

CO_2e – Carbon Dioxide Equivalent; A measurement of global warming impact for different greenhouse gases using a single unit (CO_2).

DHW – Domestic Hot Water; typically used in a building for cleaning and bathing.

DX – Direct Expansion; a cooling system utilizing refrigerant where the indoor cool is directly in the airstream.

ECM – Energy Conservation Measures; changes recommended to reduce energy consumption. These can be No/Low cost items implemented as part of routine maintenance or Capital Cost items to be implemented as a capital improvement project.

EC – Electronically Commutated; a type of high efficiency electric motor.

EER – Energy Efficiency Ratio; a measurement of equipment efficiency, calculated as the ratio of cooling energy output (measured in BTUs) to electrical energy consumed (measured in watt-hours).

EUI – Energy Use Intensity; The sum of the total site energy use per unit of gross building area.

EUL – Expected Useful Life; the estimated lifespan of a typical piece of equipment based on industry accepted standards.

F – Fahrenheit; the scale of temperature on which water freezes at 32° and boils at 212° under standard conditions.

GPM – Gallons Per Minute; a measurement of water or glycol/water mixture movement.

HP – Horsepower; a unit of measurement of power, or the rate at which work is done, usually in reference to the output of motors.

HSPF – Heating Seasonal Performance Factor; a measurement of equipment efficiency, calculated as the ratio of heating energy output (measured in BTUs) during the annual heating season to electrical energy consumed (measured in watt-hours) over the same period.

HVAC – Heating, Ventilating, and Air-Conditioning

GHG - Greenhouse Gases; Gases which trap heat in the atmosphere. Primarily consisting of carbon dioxide (CO_2), methane (CH_4), Nitrous Oxide (N_2O) and fluorinated gases. Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

LED – Light Emitting Diode; a device which emits light when current is applied to it in a relatively energy efficient manner.

LCC - Life Cycle Cost; The sum of the present values of (a) **I**nvestment costs, less salvage values at the end of the study period; (b) Non-fuel operation and maintenance costs: (c) Replacement costs less salvage costs of replaced building systems; and (d) Energy and/or water costs.

PSC – Permanent Split Capacitor; a type of standard efficiency electric motor.

PV – Photovoltaic; a device which converts light into electricity.

RUL – Remaining Useful Life; the EUL minus the effective age of the equipment and reflects the estimated number of operating years remaining for the item.

SEER – Seasonal Energy Efficiency Ratio; a measurement of equipment efficiency, calculated as the ratio of cooling energy output during the annual cooling season (measured in BTUs) to electrical energy consumed over the same period (measured in watt-hours).

Simple Payback – The number of years required for the cumulative value of energy cost savings less future non-fuel costs to equal the investment costs of the building energy system, without consideration of discount rates.

$$Simple\ Payback = \frac{Initial\ Cost}{Annual\ Savings}$$

SIR – Savings-to-Investment Ratio; the ratio of the present value savings to the present value costs of an energy conservation measure. The numerator of the ratio is the present value of net savings in energy and non-fuel operation and maintenance costs attributable to the proposed energy conservation measure. The denominator of the ratio is the present value of the net increase in investment and replacement costs less salvage value attributable to the proposed conservation measure. It is recommended that energy-efficiency recommendations be based on a calculated SIR, with larger SIRs receiving a higher priority. A project typically is recommended only if the SIR is greater than or equal to 1.0, unless other factors outweigh the financial benefit.

W – Watts; a unit of measurement of power, or the rate at which work is done, usually in reference to the output of motors.

XPS – Extruded Polystyrene; a type of foam insulation, typically in board form.