RESILIENT BUILDINGS
GROUP
*Superior energy performance*

# Town of Gilmanton Department of Public Works

# 770 Stage Rd, Gilmanton

## Level II Energy Audit

August 23, 2021

Prepared by: *Resilient Buildings Group*, Inc.

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# Contents

# Executive Summary

Many buildings in New Hampshire, and throughout the country, use more energy than they need to be safe and comfortable. When energy costs are low, building owners focus on other priorities. However, as energy costs become more of a burden to budgets, building owners seek solutions to reduce costs and improve the comfort of their buildings. The first important step in this process is an energy audit, which recommends cost-effective and appropriate improvements called Energy Efficiency Measures (EEMs). These EEMs are recommended to reduce energy use, but may also have other benefits including improved comfort, indoor air quality, and resiliency. The Resilient Buildings Group (RBG) team assessed the Town of Gilmanton Dept. of Public Works building in Gilmanton, New Hampshire and has determined there are opportunities to increase the building's energy efficiency.

This Level II Energy Audit Report intends to document energy efficiency opportunities for the garage. It provides a thorough understanding of the building's current energy performance, the opportunities for improvement, and the costs associated with the implementation of each EEM. The report is also a tool to guide investment decisions that maximize energy reductions and minimize the building's operating costs, as well as improve overall occupant comfort.

RBG analyzed and benchmarked the energy usage of the building and compared it to buildings of similar function and type. During the site visit, RBG examined the existing conditions of the building, its shell, and all pertinent systems. This allowed RBG to understand how energy is consumed on site, to discover energy waste, and to recommend appropriate energy-saving measures to implement.

RBG selected the recommended measures to help the Town of Gilmanton Dept. of Public Works maximize the benefits and minimize the cost of the potential project. If the EEMs are implemented in a different order, the energy savings and the cost savings will differ from this report. Some of the recommended EEMs should be made in conjunction with others to either maximize benefits or for health/safety reasons. If the recommended EEMs are implemented with rebates, grants, or low-interest loans as outlined, this project could generate a higher return on investment and net present value. If the project receives rebates, grants, or loans lower than 5% interest and/or energy prices increase faster than 5% per year, these returns could improve.

# Existing Conditions at the Town of Gilmanton Dept. of Public Works

## Site

- **Size:** 3,620 ft²
- **Sewer:** Septic system
- **Water:** Private
- **Year built:** The building was originally constructed in 1996.
- **Building Type:** Garage

## Shell

- **Number of Levels:** One
- **Foundation and Insulation:** The foundation is poured concrete, slab-on-grade.
- **Exterior Wall Construction and Insulation:** The exterior walls are constructed of 2”x6” metal studs. The walls are insulated with R-19 fiberglass insulation.
- **Roof Type and Insulation:** The roof is metal frame with a metal roof. The roof is insulated with R-19 fiberglass batts.
- **Doors and Windows:**
    - **Windows:** The office windows are double-pane, casement windows with an estimated U-value of 0.28.
    - **Doors:** The door to the office is an insulated metal door with glass window.
    - **Overhead doors:** The overhead doors are uninsulated steel units.

## Heating, Plumbing, Ventilation, and Air Conditioning

- **Heating Fuel:** Waste oil
- **Heat Generation Equipment:** The garage is heated by a 235,000 Btuh oil-fired furnace.
- **Heating Controls:** The waste oil furnace is controlled by mercury, bi-metal thermostat.
- **Domestic Hot Water (DHW):** The DHW for the building is heated by a 40 gallon, electric storage tank.
- **Air-Conditioning Equipment:** None.
- **Air-Conditioning Controls:** N/A.
- **Ventilation Equipment**: The bathroom is equipped with an exhaust fan that is vented to the exterior.

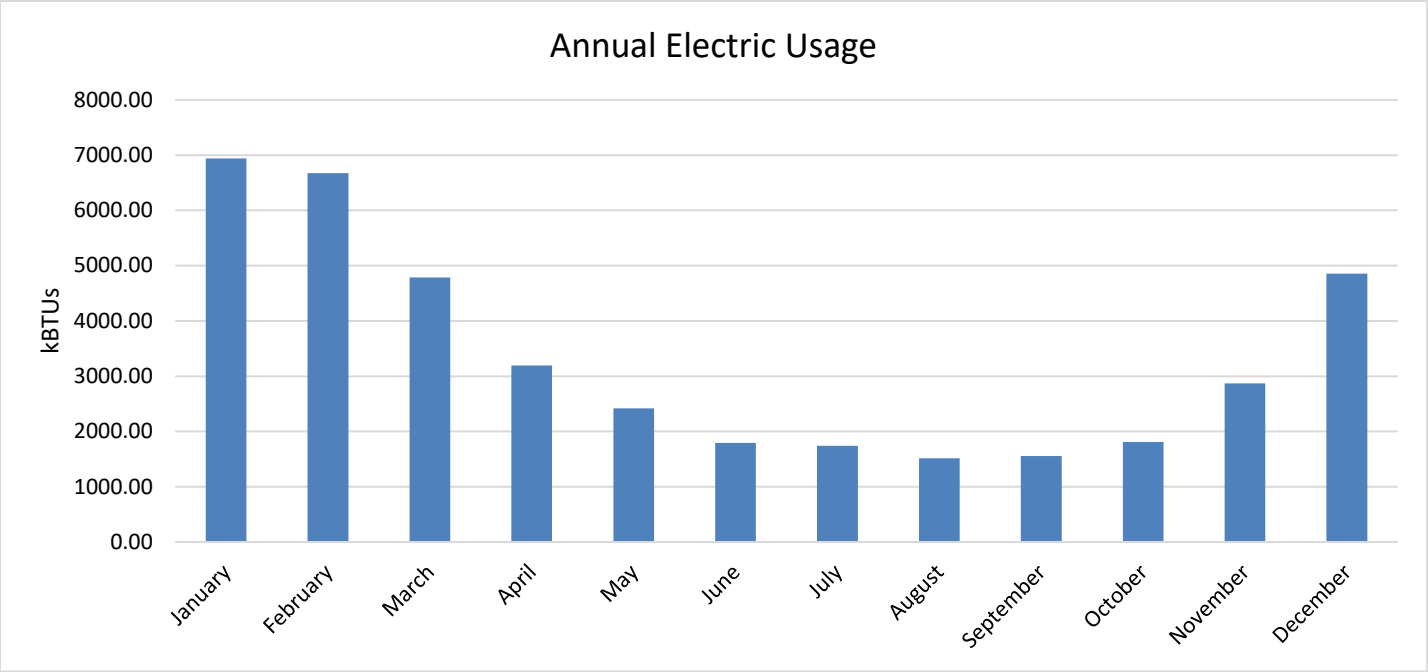
## Electrical

- **Common Area Lighting Type:** The building’s interior lighting is T8 fluorescent tube fixtures.
    - **Lighting Controls:** The interior lighting is controlled by toggle switches.

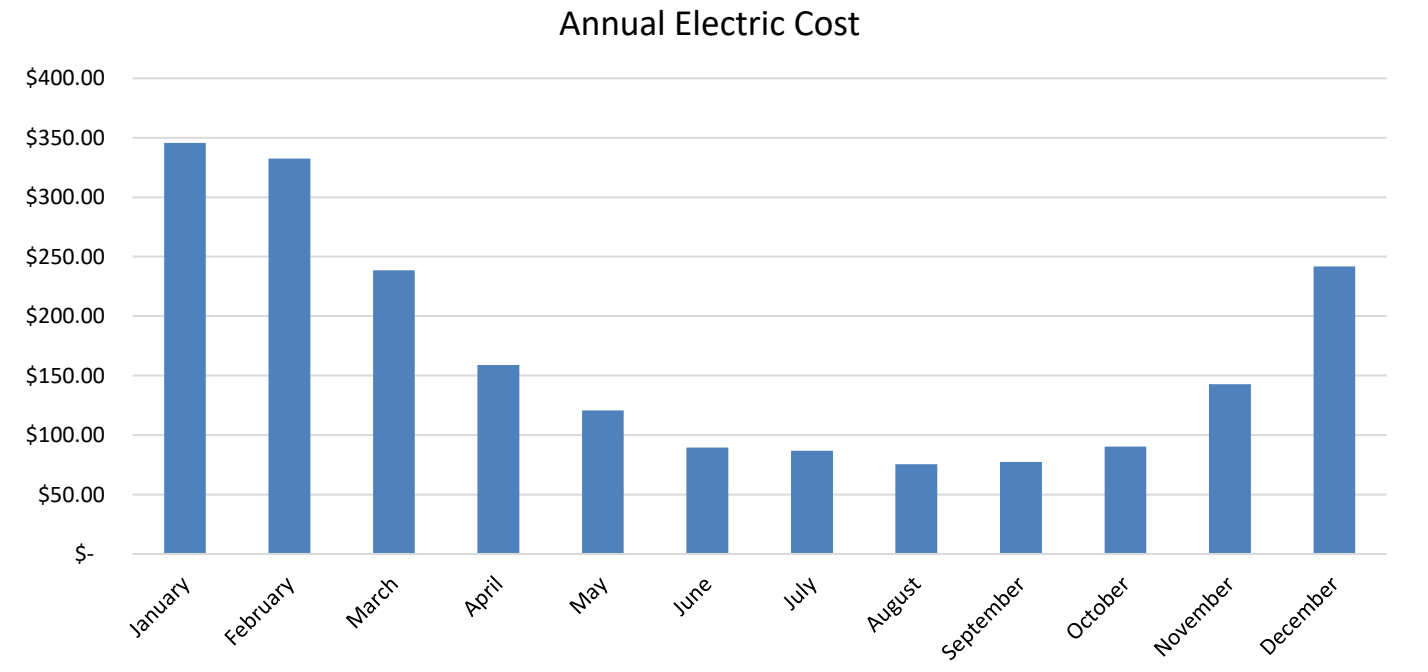
## Notable Issues

- The chimney serving the waste oil furnace appears to be filling up with creosote and should be cleaned.
- The lighting schedule is 40 -70 hours per week during the winter and 25 – 30 hours per week in the summer.

## Energy Usage and Cost Analysis




Using past utility bills for the garage, we calculated an average yearly consumption of 11,768 kWh of electricity, which translates to a total of 40,154 kBTU of energy consumed per year on average. RBG was not able to calculate the fuel consumption because the garage is heated with waste oil as it becomes available.*




The building's average energy costs are $2,000 per year for electricity. The waste oil does not cost the town any money. *

*Based off 2 years of electric bills. The analysis includes 1 building, with a total square footage of 7,488 ft².

## Preliminary Building Benchmarking

RBG analyzed the historical energy consumption of this building to calculate a Building Benchmarking rating. 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 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/YR). CUI displays the annual energy cost per square foot in the building ($/SF/YR).

EUI is often split into two numbers, one providing the annual BTUs used at the site for all purposes (as used in the previous energy tables), and the other combining the site use figure with the additional BTUs required to generate and transmit electrical energy from its source. At RBG, 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. RBG accounted for both Site and Source kBTUs in the EUI numbers given below.

**Our source EUI and CUI are calculated using the 2-year average of electric with the stated conditioned floor area of 3,620 ft².**

| Current EUI/CUI Data: | |
|---|---|
| **Site EUI:** | 11.0 kBTU/ ft²/Year |
| **Source EUI:** | 33.2 kBTU/ ft²/Year |
| **CUI:** | $ 0.55 / ft²/Year |


Technical Reference

| Primary Function | Further Breakdown (where needed) | Source EUI (kBtu/ft²) | Site EUI (kBtu/ft²) | Reference Data Source - Peer Group Comparison |
|---|---|---|---|---|
| Other | Other Public Services | **89.3** | **40.1** | CBECS - Other |

The national average Source EUI for a typical public service building is 89.3 kBtu/ft²/Yr and the average Site EUI is 40.1 kBtu/ft²/Yr. Town of Gilmanton Dept. of Public Works' Source and Site EUIs is significantly lower because it does not include the heating oil consumption. However, we still believe the building's energy performance can be improved.

# Energy Efficiency Measures

## Building Envelope

*Infiltration and Insulation*

A well-sealed and insulated building envelope is an essential element to create a high-performance building and can make a tremendous difference in comfort. Investment in measures to achieve such an envelope will reduce costs in building construction and operation. In a well-sealed and insulated building, heat systems can be smaller and therefore less expensive and less fuel intensive.

The *Energy Impact of Air Leakage in US Office Buildings* study prepared by the Building and Fire Research Laboratory in Maryland, analyzed nationwide infiltration levels. They found that infiltration - when outdoor air leaks into and out of buildings - is responsible for about 15% of the total annual heating load of the typical building. Heating loads rise from heat loss due to ventilation, conduction, and infiltration; all of which depend on Delta T (ΔT). Delta T is the difference between the indoor and outdoor temperatures. However, cooling loads are also heavily impacted by internal heat gains and solar gains, which do not always depend on ΔT between indoor and outdoor temperatures.

## Building Envelope Recommendations:

- **B1: Air Sealing.** The exterior door to the office should be weatherized. The weather-stripping around the overhead doors is deteriorated and should be replaced with heavy duty brush seals.

- **B2: Insulate Roof and Walls.** The existing insulation appears to be typical 6" vinyl backed fiberglass. RBG recommends increasing the insulation level to fill the space between the existing insulation and the perlins.

  Consider using a product like the Simple Saver warehouse insulation system. For price quotes, contact Thermal Design.

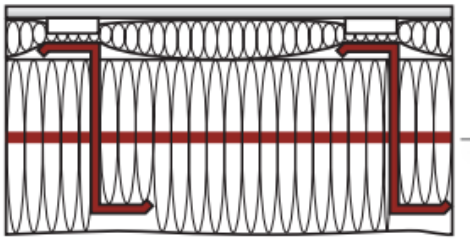


**Figure 1: Example Insulation retrofit**
(Thermal Design, Inc, 2018)

## Mechanical System

Once the building envelope is improved, the next step is to address the necessary mechanical improvements. High-efficiency heating, cooling, and ventilating systems, especially when reduced to a size appropriate to the needs of the improved building, can make an immediate difference in expenditures for heating and electricity. Improved piping and ducting systems for distributing heated and cooled air, fresh air, and water throughout the building ensures energy is delivered to the end-use areas with less waste and less cost. Tighter buildings have less infiltration of unconditioned outside air and may need high-performance ventilation systems to provide fresh air

to occupants. While this may be an addition to the mechanical systems of some buildings and may add a small amount of electrical use, modern-day ventilators recover up to 80% of the replaced air's heat, thus creating a thermal savings. The result is a more comfortable and productive building; something well worth the additional cost.

The mechanical systems in any building – heating, cooling, ventilating, and plumbing – are the biggest users of fuels and electricity. For the building owner to save energy and money, it is essential that the building's need for all those services be reduced as much as possible. That means making the building envelope as resistant to the loss of conditioned (heated or cooled) air and the gain of excess outside air as is economically feasible.

## Mechanical Recommendations:

- **M1: Electric Baseboard.** The office is heated with a portable electric space heater. We recommend installing baseboard electric heat tied to a programable thermostat. This will heat the space more evenly and accurately, as well as allow for setbacks during unoccupied hours.

- **M2: Infrared Heaters.** There is no economic reason to invest in a new heating system for the building if the waste oil burner works, and the town can secure free waste oil. However, if the town does source most of its electric consumption from solar PV, an electric based heating system should be considered for the building.

  If solar PV is installed, RBG recommends installing electric infrared heaters in the garage to heat the space. Infrared heaters are more efficient in garages than air systems because they heat surfaces, not air space. This means that garage doors can be opened and closed without losing excess heat.

## Electrical System

Improving electrical systems includes analyzing the electrical demands, or the loads, in a building – lighting, appliances, computers, the electrical portion of the operation of mechanical equipment, etc. – and devising ways to reduce their requirements for energy and make them more efficient. Installation of all demand reduction techniques should be implemented first.

After envelope and mechanical improvements, installing high-performance, efficient electricity using devices, remains as a high priority in any building retrofit. The cheapest kilowatt hour is the one you do not need to buy.

## Electrical Recommendations:

- **E1: LED Lights**. RBG recommends replacing the T8 lights with LED fixtures. When possible, the light fixtures should be operated by multiple switches to customize task lighting specific areas of the garage. This will further reduce the building's electric load.

Figure 1: Example LED Fixture.

## Renewable Energy

The use of renewable energy to meet buildings' thermal and electrical needs is expanding rapidly. Incentives are now in place at the federal, state, and even some local government levels. Any building upgrade project under consideration today should take advantage of the opportunities presented by renewable energy technologies including: stabilizing energy supply costs, reducing the environmental impact of the greenhouse gas emissions from buildings, and cost savings.

A key goal for RBG in building upgrade projects is to recommend and help implement measures that will dramatically reduce a building's reliance on fossil fuels. Renewable resources can help building owners achieve independence from fossil fuels.

- **R1: Photovoltaic Array.** Install a roof-mounted 23 kW PV array on the building's roof. This array is projected to generate 30,431kWh/year assuming the installation of high-efficiency panels. The garage building consumes an average of 11,768 kWh per year, which means the proposed PV system would generate approximately 258% of the building's existing average annual electric usage. This PV array would supply enough electricity to power the building if its fuel source was switched to electricity.

Figure 2. Proposed PV array

The cost and output of the PV Array is estimated using NREL's PVWatts calculator and project costs that RBG has been involved in. These numbers are strictly estimates.

## Financial Modeling Results

The following table identifies each EEM's projected cost, **estimated** annual energy savings and costs savings, simple payback, internal rate of return, and net present value.

The building's energy use was modeled using the EQUEST energy modeling program to estimate energy use, which include breakdowns and energy savings from the recommended EEMs. Cost estimates were derived from several sources: RS Means construction estimating tools, actual contractor estimates, and RBG staff with field knowledge of installed work.

## Energy Efficiency Measures With Estimated Oil Usage and Cost*

| Assumptions : | Electric | | Oil | | Total Energy per Year | |
|---|---|---|---|---|---|---|
| Baseline Energy Usage: | 11,768 | kWH | 1,396 | Gallons | 233,723 | kBTU |
| Baseline Energy Cost: | $2,001 | Cost | $2,792 | Cost | $4,792 | Cost |
| Baseline Unit Cost: | $0.17 | ($/kWh) | $2.00 | ($/Gallon) | | |

| EEM # | Building Envelope Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **B1** | Air Sealing | $1,200 | $295 | 15,558 | 4.1 | 29.6% | $6,896 |
| **B2** | Simple Saver System | $8,600 | $481 | 31,407 | 17.9 | 8.5% | $4,907 |

| EEM # | Mechanical System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **M1** | Electric Baseboard Heater | $800 | $223 | 4,481 | 3.6 | 32.9% | $5,313 |
| **M2** | Infrared Heaters | $6,000 | -$2,931 | -58,821 | N/A | N/A | ($85,461) |

| EEM # | Electric System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **E1** | LED Lights | $3,600 | $822 | 16,503 | 4.4 | 27.8% | $18,945 |

| EEM # | Renewable System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **R1** | 23 KW PV System | $57,500 | $5,161 | 103,593 | 11.1 | 13.0% | $85,686 |

| | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|
| **RBG Recommended Package (B1, B2, M1, E1)** | **$14,200** | **$1,822** | **67,948** | **7.79** | **17.4%** | **$36,061** |
| **RBG Package with Renewable System** | **$71,700** | **$6,984** | **171,541** | **10.27** | **13.9%** | **$121,747** |

***Usage based off an eQuest Energy Model and the cost is based off an assumption of $2/gallon of waste oil**

**IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Many of these EEMs could qualify for Utility Rebates & Tax Credits.**

## Energy Efficiency Measures with Free Waste Oil Heat*

| Assumptions : | Electric | | Oil | | Total Energy per Year | |
|---|---|---|---|---|---|---|
| Baseline Energy Usage: | 11,768 | kWH | 1,396 | Gallons | 233,723 | kBTU |
| Baseline Energy Cost: | $2,001 | Cost | $0 | Cost | $2,001 | Cost |
| Baseline Unit Cost: | $0.17 | ($/kWh) | $2.00 | ($/Gallon) | | |

| EEM # | Building Envelope Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **B1** | Air Sealing | $1,200 | $100 | 15,558 | 12.0 | 12.2% | $1,579 |
| **B2** | Simple Saver System | $8,600 | $40 | 31,407 | 214.9 | -5.5% | ($7,102) |

| EEM # | Mechanical System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **M1** | Electric Baseboard Heater | $800 | $223 | 4,481 | 3.6 | 32.9% | $5,313 |
| **M2** | Infrared Heaters | $6,000 | -$2,931 | -58,821 | N/A | N/A | ($85,461) |

| EEM # | Electric System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **E1** | LED Lights | $3,600 | $822 | 16,503 | 4.4 | 27.8% | $18,945 |

| EEM # | Renewable System Upgrades | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|---|
| **R1** | 23 KW PV System | $57,500 | $5,161 | 103,593 | 11.1 | 13.0% | $85,686 |

| | Capital Investment | Annual Energy Cost Savings | Annual kBTU Savings | Simple Payback | IRR | NPV |
|---|---|---|---|---|---|---|
| **RBG Recommended Package (B1, B2, M1, E1)** | **$14,200** | **$1,186** | **67,948** | **11.98** | **12.2%** | **$18,736** |
| **RBG Package with Renewable System** | **$71,700** | **$6,347** | **171,541** | **11.30** | **12.8%** | **$104,421** |

*** Usage based off an eQuest Energy Model and the cost is based off an assumption of $0/gallon of waste oil**

**IRR and NPV assume a 5% inflation rate and a 5% Cost of Capital. Many of these EEMs could qualify for Utility Rebates & Tax Credits.**

## Next Steps

With the completion of this detailed Level II Energy Audit of the Town of Gilmanton Dept. of Public Works, the building managers should consider potential next steps to take advantage of the energy saving and comfort improving opportunities presented in this report. This Level II Report provides direction and guidance as you design and implement the renovation plans.

To achieve the projected energy savings, the managers must pay careful attention to the proper design and installation of the selected EEMs.

It should be noted that the estimated project costs shown in this report are limited to hard construction costs. The owners should be aware of project design fees and a contingency for unforeseen conditions are not included in the presented estimates but may be required to successfully complete the implementation of the EEMs.

The building examined in this report is an important physical asset and the energy use has significant economic and environmental implications. Proceeding to implement EEMs presents opportunities to reduce costs, improve comfort, and reduce environmental impacts. Please let RBG know if you have any questions about moving forward. RBG would also be able to assist the Town of Gilmanton Dept. of Public Works in obtaining rebates through the NHSaves program.

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