Town of Gilmanton Iron Works Fire Department

1824 NH 140, Gilmanton Iron Works

Level II Energy Audit

August 23, 2021

Prepared by: *Resilient Buildings Group*, Inc.

Town of Gilmanton Iron Works Fire Dept 1824 NH 140 Gilmanton Iron Works, NH 03837	**Resilient Buildings Group, Inc.** 6 Dixon Ave, Suite 200 Concord, NH 03301 (603) 226-1009

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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 Iron Works Fire Dept. 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 fire department. 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 Iron Works Fire Dept. 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 Iron Works Fire Dept.

Site

- **Size:** 8,100 ft²
- **Sewer:** Private
- **Water:** Private
- **Year built:** The front bays of the building were originally constructed in 1972. The rear of the building was added in 1992.
- **Building Type:** Fire station and dormitory

Shell

- **Number of Levels:** Two
- **Foundation and Insulation:** The foundation is poured concrete, slab-on-grade.
- **Exterior Wall Construction and Insulation:** The exterior walls are constructed of metal studs with metal siding. The exterior walls of the garage bays are insulated with 1" polystyrene rigid insulation. The exterior walls of the rear addition (offices and dormitory) are insulated with 2" fiberglass batt, vinyl wrapped insulation with a thermal resistance of r-19.
- **Roof Type and Insulation:** The roof over both sections of the building is metal frame with corrugated metal panels. The roof is insulated with 6" fiberglass batt, vinyl wrapped insulation.
- **Doors and Windows:**
  - **Windows:** The building's windows are double-pane, casement windows with an estimated U-value of 0.28.
  - **Doors:** Most of the doors are insulated, metal doors. There is an aluminum-framed, glass door to the public entrance/vestibule
  - **Garage overhead doors:** The overhead garage doors are insulated and in good condition.

Figure 1. Exteror insulation of garage

Figure 2. Roof insulation above dormitory

Heating, Plumbing, Ventilation, and Air Conditioning

- **Heating Fuel:** Oil and propane
- **Heat Generation Equipment:** The building is heated by a 305 MBH oil-fired boiler. Baseboard distributes the heat in the first-floor offices and second-floor dormitory. The hydro-air duct system supplies heat to the garage bays.
- **Heating Controls:** The heating zones for the building are controlled by digital thermostats.

- **Domestic Hot Water (DHW):** The DHW for the building is heated by a 40-gallon, propane-fired, atmospherically vented tank.
- **Air-Conditioning Equipment:** There are 7, portable, window air conditioning units in place.
- **Air-Conditioning Controls:** The air conditioning is controlled at each unit.
- **Ventilation Equipment**: The bathrooms are equipped with spot ventilation. The bathrooms do not appear to be vented to the exterior. The electric dryer is not vented to the exterior.

Electrical

- **Common Area Lighting Type:** The building's interior lighting primarily consists of T8, 2'x4' troffers.
  - **Lighting Controls:** The interior lighting is controlled by toggle switches. The exterior lights are controlled by a timer set for each season.

Notable Issues

- The window air conditioners appear to run at their maximum cooling capacity, whenever they are turned on.

- Protocol dictates the garage bays are maintained at 62 degrees throughout the winter.

- The bathroom exhaust fans are under performing and do not appear to be vented to the exterior. The dryer is not vented to the exterior.

- RBG believes that it is important to maintain a strong air barrier between the garage and office/dormitory spaces. Even though the town is installing a new point source exhaust system, we still recommend all penetrations through the wall between the offices and garage bay be sealed and the doors between those spaces weather-stripped.

Blower Door Information

An effective building envelope provides a barrier between the outside and inside air while retaining a high percentage of the energy used to condition the inside air (heating or cooling energy). This is achieved only when the envelope is well insulated and a continuous air barrier is implemented. The best 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 enters the building through cracks, gaps, and poorly sealed penetrations, etc. Shell shortcomings, such as a lack of air sealing and lack of insulation, further compromise the temperature of the indoor air which the owner has paid to condition (heat or cool).

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. These values allow for comparison of the leakiness of different sized buildings.

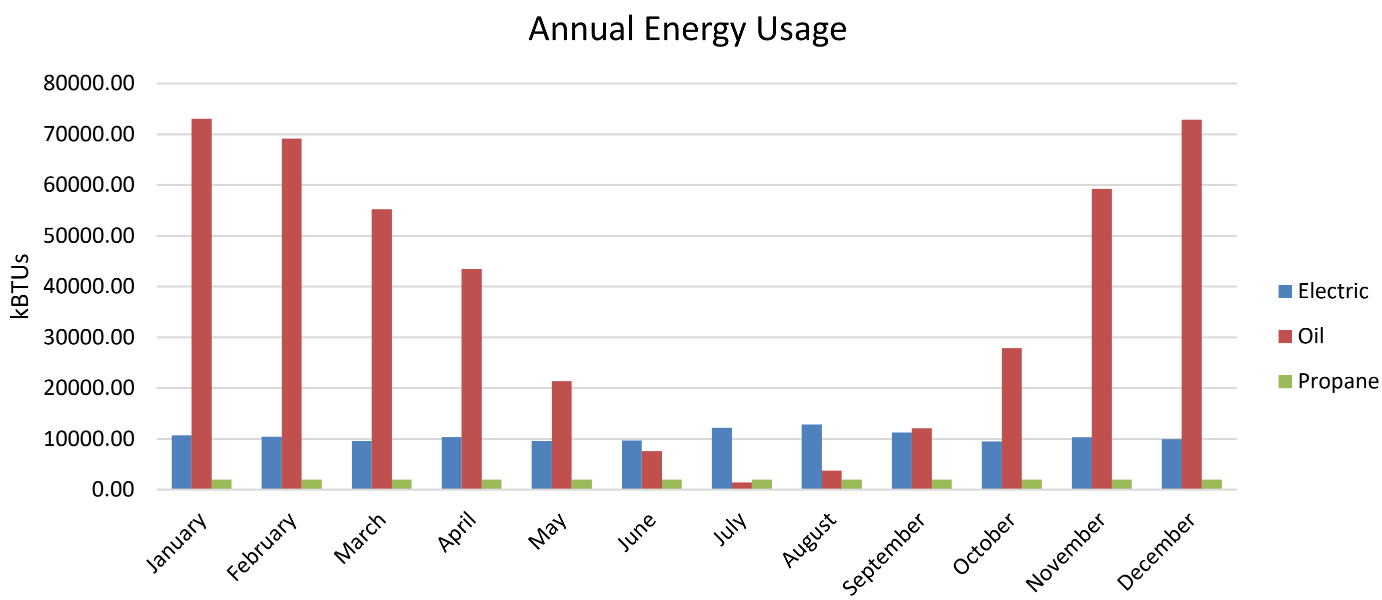
Blower Door Testing

Volume Ft^3	CFM @ -20 pascals	ACH_{50}
108,000 ft^3	12,029 CFM	6.7

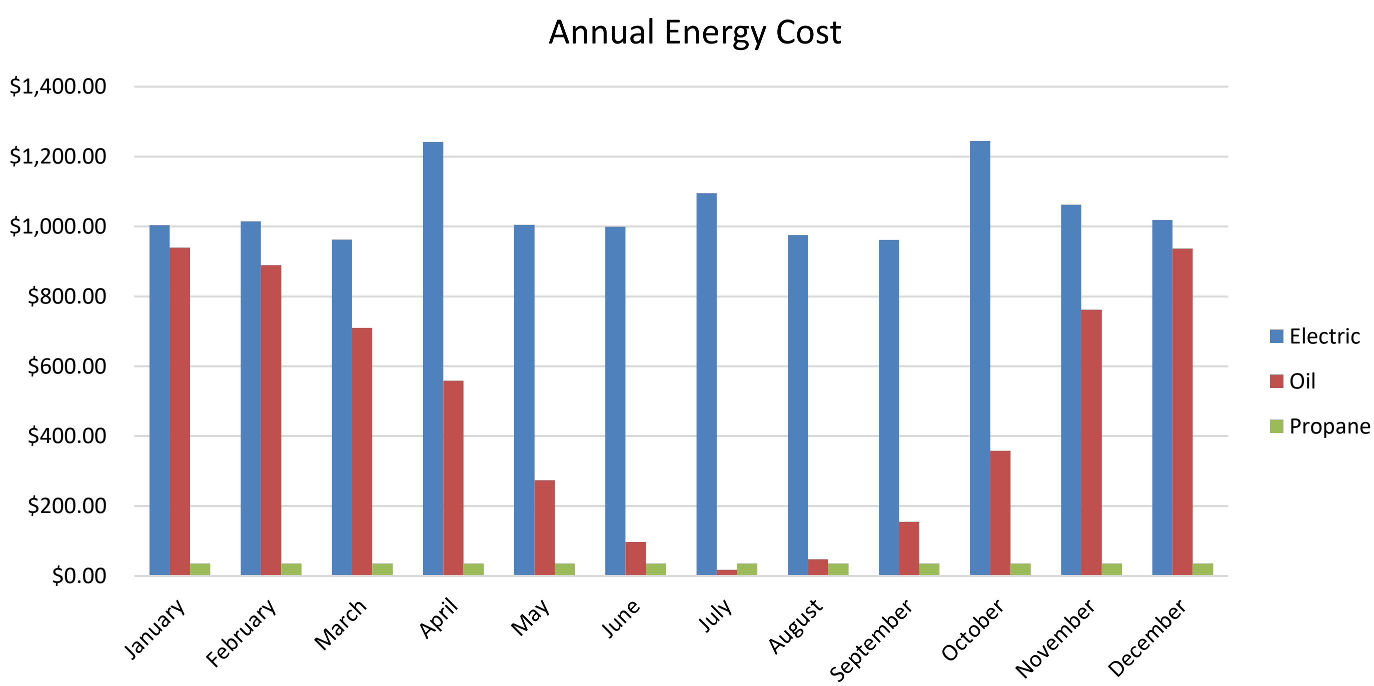
Goal:	**3.0**

RBG conducted a Blower Door Test on the Iron Works Fire Department. The findings of the blower door test suggest that there is ample room to air seal the building and reduce the amount of air infiltration through the envelope. The main source of air leakage through the space is cause by the lack of an air barrier in the attic space.

Energy Usage and Cost Analysis



Using past utility bills for the garage, we calculated an average yearly consumption of 3,222 gallons of heating oil, 258 gallons of propane for domestic hot water and 37,015 kWh of electricity, which translates to a total of 596,878 kBTUs of energy consumed per year on average.*



The building's average energy costs are $5,747 for oil, $430 for propane and $12,585 for electricity, which equates to a combined average of $18,762 per year. *

*Based off 2 years of electric, oil and propane bills.

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, oil, and propane use and cost data with the stated conditioned floor area of 8,100 ft^2.

Current EUI/CUI Data:	
Site EUI:	73.6 kBTU/ ft^2/Year
Source EUI:	104.8 kBTU/ ft^2/Year
CUI:	$ 2.31 / ft^2/Year

ENERGY STAR® PortfolioManager® Technical Reference

Primary Function	Further Breakdown (where needed)	Source EUI ($kBtu/ft^2$)	Site EUI ($kBtu/ft^2$)	Reference Data Source - Peer Group Comparison
Fire Station		**124.9**	**63.5**	CBECS – Fire Station/Police Station

The national average Source EUI for a typical fire station is 124.9 $kBtu/ft^2$/Yr and the average Site EUI is 63.5 $kBtu/ft^2$/Yr. The Town of Gilmanton Iron Works Fire Dept.'s Source EUI is less and its Site EUI is higher than the national average. What stands out the most in these metrics is the CUI. RBG considers any CUI above $1 as high. At $2.31, the fire station has an astronomically high operating cost. We are confident that investments made to improve the building's efficiency will dramatically lower its annual operating costs.

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 penetrations through the roof above the dormitory and the between the dormitory attic storage space and the roof system of the front bays should be sealed. We recommend continued weather-stripping maintenance to all exterior doors and windows, along with other shell penetrations to prevent infiltration. This should be recognized as an annual maintenance task, as continual maintenance of weather stripping is needed on high-use doors.

- **B2: Spray foam attic and garage roof.** The storage attic roof and garage roof is insulated with R19 fiberglass batt insulation. RBG recommends installing 3” of closed cell spray foam on the underside of garage roof and apply intumescent paint. This will increase the total R-value to R-40.

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: Mechanical Ventilation.** RBG recommends replacing the bathroom exhaust fans and venting them to the exterior. RBG recommends occupancy sensors or time delay switches that are tied to the operation of the bathroom lights. The sensors and delay switches trigger the bathroom exhaust fans to run while the spaces are occupied and for a set period (typically 10-20 minutes) after the fan is turned off or the bathroom is unoccupied. The exhaust fans and dryer should be hard piped to the exterior through the roof or wall. These measures are important to maintain healthy indoor air quality by exhausting warm, moist air to the exterior. High humidity can potentially lead to mold growth and respiratory irritants.

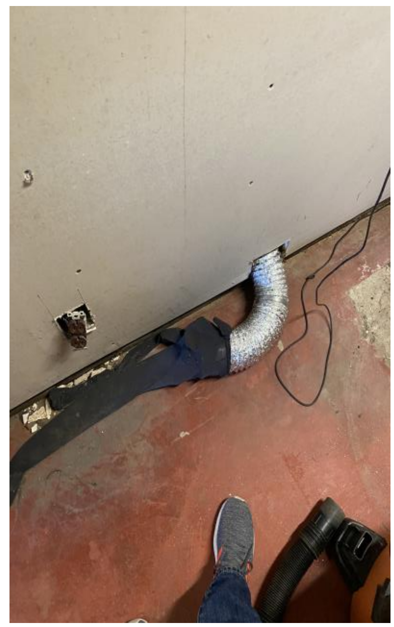


Figure 3. Dryer not vented to exterior

- **M2: Air Source Heat Pump System.**
    - **Option A: Cooling Only Heat Pumps.** The presence of multiple window air conditioners presents an opportunity to replace them with high-efficiency heat pumps. Ductless heat pumps will improve the air-tightness of the building envelope, while significantly reducing the amount of energy needed to cool the building.
    - **Option B: Heating and Cooling Heat Pump System.** Leave the existing hydro-air system in place as a backup and install a ductless heat pump system to heat and cool the office, gym, and dormitory spaces. This option would effectively electrify the rear of the building, which can be an economically sound decision if the electricity is sourced from a renewable system.

Furthermore, RBG recommends that the garage space continue to be heated with the fossil fuel based hydro air system or an infrared radiators rather than a heat pump system. This is because it is too leaky by nature for a heat pump system to effectively heat it.

- **M3: New Propane Boiler.** If the town prefers to keep a fossil fuel-based heating system than the fuel source oil to propane because it burns more efficiently than oil. If so, at the end of the existing boiler's service life, replace it with a new condensing propane unit. Be sure that the new unit has a minimum AFUE rating of at least 96.

  If the boiler is replaced to a high-efficiency unit, remove the propane fired domestic hot water heater and replace it with an indirect fired storage tank. This is a cost-effective way to improve the efficiency of the domestic hot water heater.

- **M4: Infrared Heaters in Garage.** When the existing boiler reaches the end of its service life and the Town wishes to electrify the building, install electric infrared heaters in the garage space. These are more efficient than air based systems in garages because they heat up surfaces rather than air. This ensures that the heat stays within the space even when the garage doors are opened.

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: Replace Refrigerators.** The refrigerator in the break room appears to be 24 years old. The refrigerator in the dormitory kitchen appears to be 26 years old. Replacing both refrigerators with new Energy Star appliances would result in significant energy savings.

- **E2: LED Lighting.** RBG recommends replacing the T8 fluorescent fixtures with LED fixtures. We recommend LED fixtures because they will have a longer lifetime, as opposed to swapping out just the bulbs.

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.

Figure 4. Proposed PV array

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 35 kW PV array on the building's roof. This array is projected to generate 45,080 kWh/year assuming the installation of high-efficiency panels. The building consumes an average of 37,015 kWh per year, which means the proposed PV system would generate approximately 120% of the building's average annual electric usage.

  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

Assumptions :	Electric		Oil		Propane		Total Energy per Year	
Baseline Energy Usage:	37,015	kWH	3,222	Gallons	258	Gallons	596,801	kBTU
Baseline Energy Cost:	$6,292	Cost	$5,747	Cost	$430	Cost	$12,469	Cost
Baseline Unit Cost:	$0.17	($/kWh)	$1.78	($/Gallon)	$1.67	($/Gallon)		

EEM #	Building Envelope Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback	IRR	NPV
B1	Insulate Roof	$25,600	$982	61,795	18.8	1.8%	($9,862)
B2	Air Sealing	$1,200	$972	93,393	9.8	26.8%	$6,006

EEM #	Mechanical System Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback	IRR	NPV
M2A	Heat Pump System (Cooling Only)	$10,000	$900	18,073	11.1	13.0%	$14,976
M2B	Heat Pump System (Heating and Cooling)	$13,000	$1,411	212,699	9.2	15.2%	$26,006
M3	New Propane Boiler	$15,000	-$395	71,451	N/A	N/A	($25,034)
M4	Infrared Heaters in Garage	$7,200	-$236	45,254	N/A	N/A	($13,267)

EEM #	Electrical System Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback	IRR	NPV
E1	LED Lighting	$7,600	$1,378	27,651	5.5	23.0%	$30,247
E2	Replace Refrigerators	$1,300	$220	4,424	5.9	21.8%	$4,760

EEM #	Renewable System Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback	IRR	NPV
R1	35 KW PV System	$87,502	$8,050	151,554	10.9	13.2%	$135,723

	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback	IRR	NPV
RBG Recommended Project – (B1,B2, M2B, E1 & E2)	**$48,700**	**$3,805**	**$289,997**	**12.80**	**11.5%**	**$57,157**
RBG Recommended Project With Renewables	**$136,202**	**$11,855**	**$441,551**	**11.49**	**12.6%**	**$192,880**

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 Iron Works Fire Dept., 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 Iron Works Fire Dept. in obtaining rebates through the NHSaves program.

RESILIENT BUILDINGS
— GROUP —
Superior energy performance

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