RESILIENT BUILDINGS GROUP
Superior energy performance

Tamworth Town Office

Level II Energy Audit

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Executive Summary

Resilient Buildings Group (RBG) conducted a site visit of the Tamworth Town Office building in Tamworth, NH. The Community Development and Finance Authority helped fund the Audit. During the audit, RBG examined the building's shell and all other pertinent building systems. The assessment shows that the energy performance of the building can be improved. This report will provide an overview of the building's existing conditions and an initial outline of problem areas and recommendations for cost-effective ways to reduce energy use and costs.

Existing Conditions at the Tamworth Town Office Building

Site

- **Size:** 4,469 ft²
- **Sewer:** Municipal
- **Water:** Municipal
- **Year built:** 2003
- **Building Type:** Town Office

Shell

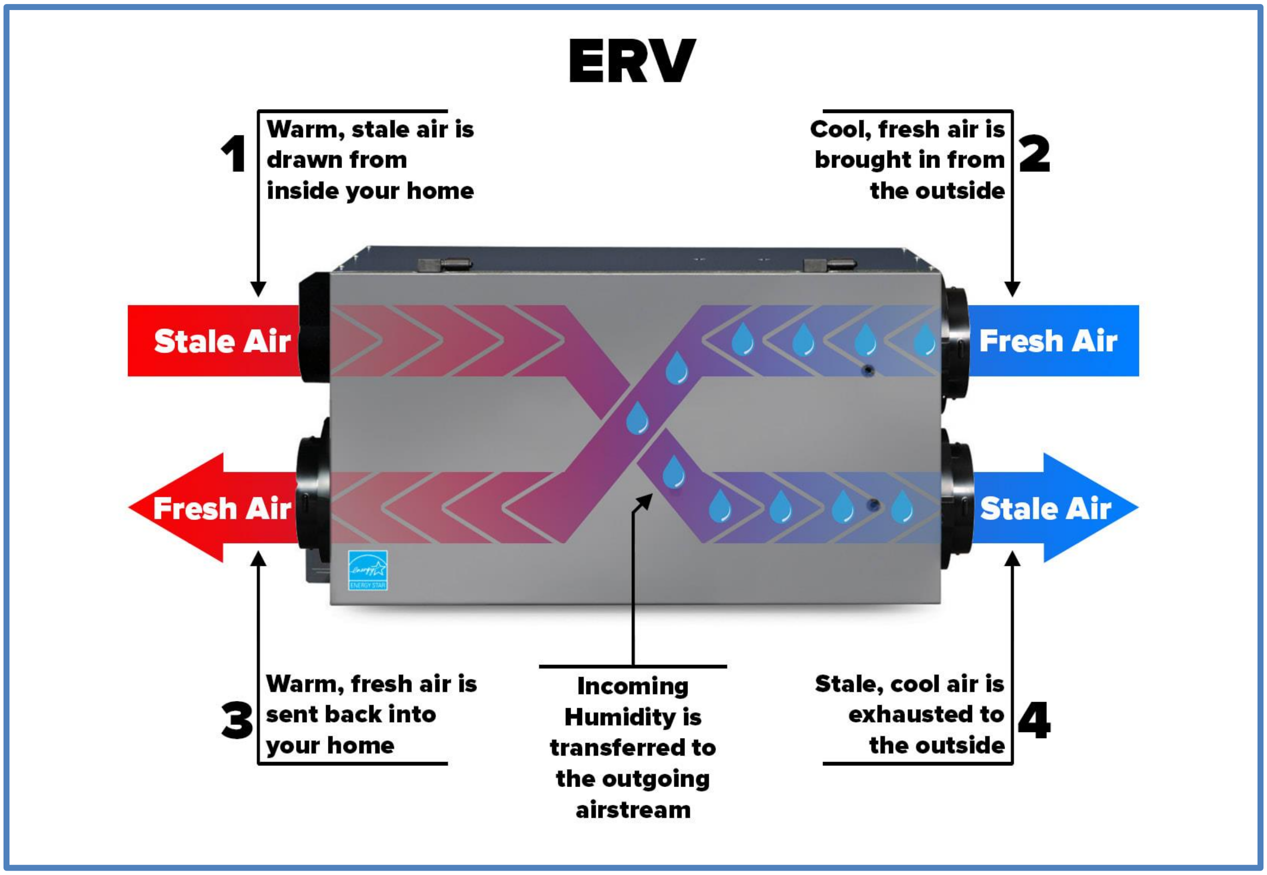
- **Number of Levels:** 1 level with a basement and a mechanical mezzanine in the attic
- **Slab (below grade and above grade):** 4" concrete slab, no insulation
- **Foundation Wall:** 8" concrete wall, 2" rigid insulation (estimated R-10)
- **Basement Wall:** 8" concrete wall, 2" rigid insulation (estimated R-10)
- **Exterior Wall Construction and Insulation:** 2"x6" wood stud, 16" on center, R-21 fiberglass batt
- **Roof Type and Insulation:** Pitched with vented attic (proper vents and ridge vent), wood truss, R-38 suspended fiberglass and acoustic ceiling tiles in attic floor
- **Doors and Windows:**
    - **Windows:** Double-hung, vinyl frame, double-pane
    - **Doors:** Aluminum with no insulation

Heating, Plumbing, Ventilation, and Air Conditioning

- **Heating Fuel:** Propane
- **Heat Generation Equipment:**
    - 3 condensing furnaces in mechanical mezzanine above nurses' office
        - Lennox EL195UH045XE24B-01, 95% efficiency
    - 1 condensing furnace in the basement under the town office
        - Carrier 58MXA040-F-1—08, 95% efficiency
- **Domestic Hot Water (DHW):** Electric, direct-heated tank, 28 gallons, Bradford White RE230LN6-1NCWW
- **Air-Conditioning Equipment:** 3 direct expansion (DX) cooling units, Carrier 38TKB0303000, SEER = 10
- **Temperature Controls:** Honeywell digital thermostats
- **Ventilation Equipment**: Bathroom exhaust only

Notable Issues

- **No mechanical ventilation**: Currently the building relies on operable windows for adequate ventilation. The windows are not open for most of the year and cannot control energy exchange with the outdoors. We recommend installing one or multiple energy recovery ventilators (ERV). These units will bring fresh air into the building and exhaust stale air while using a heat exchanger to keep heat in the building during the winter and keep heat out during the summer. These units typically operate at 70% efficiency, which means they can recover 70% of the heat traveling through the system.



ERV Diagram (credits: Build.com)

Blower Door Testing

Purpose of Blower Door Testing

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, 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. Natural air changes per hour (ACHn) represents infiltration into the building under normal conditions and tells how many times the entire volume of air in the building is replaced (by infiltration through building imperfections) per hour. These values allow for a comparison of the leakiness of different-sized buildings.

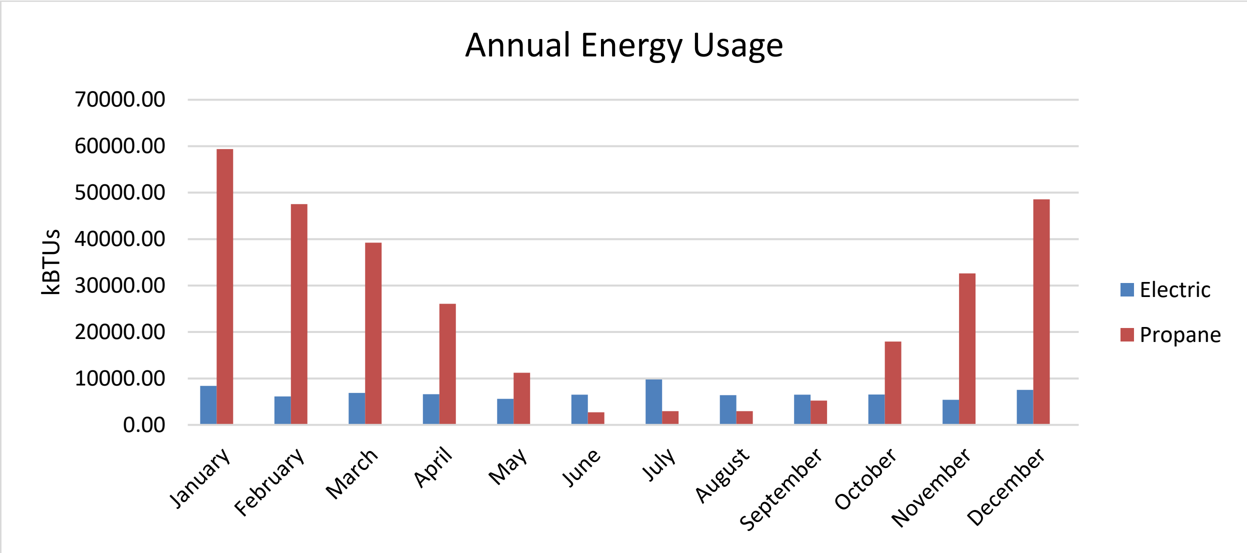
Testing Results

	Volume (Ft^3)	CFM @ -17.9 pascals	ACHn	ACH_{50}
Town Office	**45,080 ft^3**	**11,356 CFM**	**0.953**	**15.25**

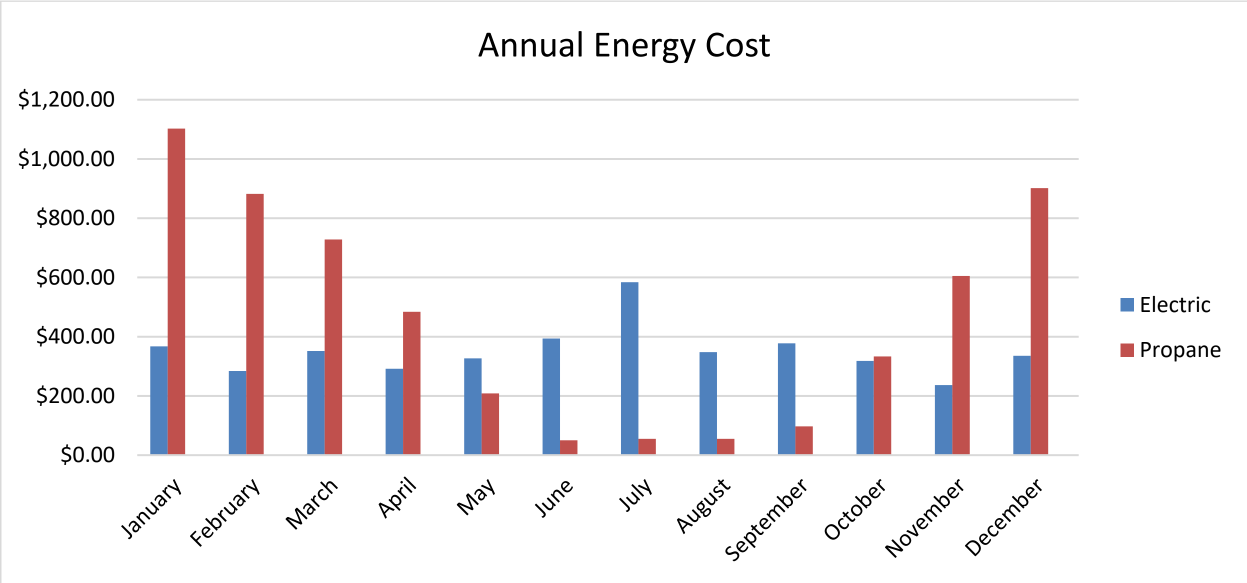
Goal ACH_{50}:	**3.0**

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. These results are much higher than what we would expect for a building of this type and age. The major issue is that there is no air barrier between the interior conditioned space and the vented attic space. See the section on Energy Efficiency Measures for recommendations on how to address this issue.

Energy Usage and Cost Analysis



Using past utility bills for the Tamworth Town Office building, we calculated an average yearly consumption of 3,252 gallons of oil and 24,130 kWh of electricity, which translates to a total of 379,324 kBtu of energy consumed per year on average.*



The building's average energy costs are $5,513 for fuel oil and $4,215 for electricity, which equates to a combined average of $9,727 per year.*

*Based on 2 years of oil and electricity bills (2020 & 2021). The analysis includes 1 building with a total square footage of 4469 ft². The costs are based on exact values from bills received from the building owner.

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 British Thermal Units (Btu), usually displayed as kBtu to signify thousands of Btu 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 Btu 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 Btu 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 kBtu in the EUI numbers given below.

Our source EUI and CUI are calculated using the 2 years of gas and electricity use and cost data (2020 & 2021).

Current EUI/CUI Data:	
Site EUI:	84.9 kBtu/ ft^2/Year
Source EUI:	121.7 kBtu/ ft^2/Year
CUI:	$2.18/ 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
Office	N/A	**116.4**	**52.9**	CBECS – Office & Bank/Financial

The national average Source EUI for a typical office is 116.4 kBtu/ft^2/Yr and the average Site EUI is 52.9 kBtu/ft^2/Yr. The Tamworth Town Office building Source and Site EUIs (121.7 kBtu/ft^2/Yr and 84.9 kBtu/ft^2/Yr respectively) are both higher than the national averages. This is likely due to the fact that the attic floor does not have a continuous air barrier, as mentioned in the previous section on blower door testing.

Energy Efficiency Measures

Three major areas of activity were examined for energy-saving opportunities: building envelope, mechanical systems, and electrical systems. The proposed energy efficiency recommendations could qualify for the energy efficiency incentives offered by NHSaves.

Building Envelope

Infiltration and Insulation

A well-sealed and insulated building envelope is an essential element of 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. This section will provide strategies to improve the Center's building's envelope.

Building Envelope Recommendations:

- **B1. EEM: Air-seal and Insulate Attic Floor.** During our inspection of the attic space and review of the drawings, we discovered the building does not exhibit any sort of air barrier across the attic floor. This allows for a large amount of air communication between the interior building space and the attic, which is connected directly to the outdoors via attic venting. Our blower door test results were also quite high, further confirming that this lack of air barrier is a major source of air leakage in the building. Without an air barrier at the attic floor, the building will lose much of its heat in the winter and gain heat during the summer. We recommend installing a smart vapor retarder membrane on the underside of the attic floor (see images to the right). In addition, the attic is currently only insulated with R-38 fiberglass batts. We typically recommend R-60 in the attic for high-performing buildings. To achieve this, we recommend adding 6" of loose-blown cellulose to the attic floor.
- **B2. EEM: Add Continuous Wall Insulation with Vinyl Siding Replacement.** The wall is currently only insulted with 5.5" inches of fiberglass batt insulation in the 16" stud bays. This equates to an insulation R-value of about R-15, but we typically recommend R-40 for exterior walls.

Attic floor with no air barrier between acoustic ceiling and attic space

Smart vapor retarder membrane stapled to attic floor joists (photo credit: Fine Homebuilding)

In the future, when the vinyl siding is replaced, we recommend adding 2.5” of foil-faced polyisocyanurate insulation.

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.

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. EEM: Install an Air Source Heat Pump (ASHP) System.** To convert the building to an all-electric building and improve the efficiency of the entire heating and cooling systems, we recommend installing an ASHP system. The furnaces currently run at 95% efficiency, while a heat pump system would run at about 350% efficiency. Such a system could also provide cooling and would likely have a higher efficiency rating than 10 SEER, which is the rated efficiency of the units currently in place. If the owner decides to remove the furnaces currently in place, this EEM would also eliminate the need for the mechanical mezzanine above the nurse's office, which would alleviate maintenance needs and eliminate the need for exhausting the attic with an exhaust fan.
- **M2. EEM: Replace Electric Water Heater with Heat Pump Water Heater.** The electric water heater could be replaced with a heat pump water heater, which will be approximately three times as efficient.
- **M3. EEM: Add Ductwork Insulation.** If the ductwork is maintained for any reason, the insulation should be repaired and improved. Currently, the ductwork is insulated with a thin layer of foil-faced insulation that has several missing and damaged segments. This ductwork comes in direct contact with the air in the attic space, which is connected directly to the outdoors via attic venting. To inhibit heat transfer between the ductwork and the attic air, we recommend adding a layer of 2” thick foil and fiberglass duct insulation around all ductwork in the attic.

Inadequate insulation on ductwork

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 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.

Renewable Recommendations:

- **R1. EEM: Install a 4.8 kW Solar Electric System.** During the interview with the building representative, we learned that the project team is interested in installing solar where possible. Based on our review of the site, we believe the west-facing roof is optimal for roof-mounted solar. We used the PVWatts calculator to estimate that there is enough space for a 4.8 kW system that is capable of producing about 4,760 kWh annually. This would cover about 20% of the building's electricity use. It should be noted that switching the building to heat pumps (M1 EEM) will increase the building's electricity usage, so installing solar would be a good complementary measure that would reduce the added annual operating cost of using heat pumps.

No Cost/Low-Cost Energy Savings Opportunities

There are Energy Efficiency Measures (EEMs) that will cost little or no money to implement at the workshop. It is important to encourage employees to slightly change their behavior. This is not easy, but such efforts will produce energy savings without any other investment. For this reason, RBG provided these initiatives as part of this analysis. By encouraging the building's occupants to alter routines, energy can be saved regardless of energy-saving investments. These No-Cost /Low-Cost Initiatives are:

❶ **Refrigerator replacement:** We recommend replacing refrigerators more than 15 years old with Energy Star-rated refrigerators.

❷ **Thermostat Setback (3°F+/-):** To reduce demands on the heating source, thermostat settings can be cut back by 3°F when outside temperature allows. Studies have shown that when the average outside temperature is above 38°F, a slight adjustment of interior temperature settings does not influence comfort. Over an eight-hour workday, this practice can produce a noticeable energy use reduction. It is suggested that the maintenance staff perform a test to see if comfort levels are affected. Resource:
https://www.energystar.gov/products/heating_cooling/programmable_thermostats

❸ **Task Lighting:** To reduce electrical demands from lighting, task lighting should be encouraged where appropriate. A task lighting initiative would encourage building occupants to shut off the ceiling-mounted lighting and utilize task lighting (portable desk lamps, workstation under-shelf lighting, etc.) to provide the illumination they need, whenever possible. Providing task lighting devices for spaces appropriate to their use may entail a small expense if task lights do not presently exist. Furthermore, we recommend replacing existing single-bulb incandescent or CFL fixtures (such as the task lighting mentioned above, or ceiling-mounted lighting) with appropriate LEDs.

❹ **Computer Settings:** An easy way to reduce plug load and electricity use is to turn off all computers at night and when not in use for extended periods. Ensure that the staff's computer towers and monitors are shut off when not in use and at the end of each day.
❺ **Low-flow Aerators and Showerheads:** Reducing the volume of water through fixtures, while maintaining comfortable pressure will reduce the water heating demand and could result in noticeable savings across the whole building. When installing new aerators, ensure they are low-flow. Consider installing low-flow showerheads throughout the building.

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.

We used the NHSaves Technical Reference Manual published by the New Hampshire utilities to estimate 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.

Assumptions :	Electric		Propane		Total Energy per Year	
Baseline Energy Usage:	24,130	kWh	3,252	Gallons	379,324	kBTU
Baseline Energy Cost:	$4,214.55	Cost	$5,512.83	Cost	$9,727	Cost
Baseline Unit Cost:	$0.17	($/kWh)	$1.70	($/Gallon)		

EEM #	Building Envelope Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback (Years)	IRR	NPV
B1	Air-seal and Insulate Attic Floor.	$25,439	$2,867	154,980	8.9	15.65%	$53,777
B2	Add Continuous Wall Insulation with Vinyl Siding Replacement.	$38,851	$772	41,725	50.3	1.51%	($16,000)

EEM #	Mechanical System Upgrades	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback (Years)	IRR	NPV
M1	Install an Air Source Heat Pump (ASHP) System.	$84,000	$3,996	268,399	21.0	7.21%	$28,724
M2	Replace Electric Water Heater with Heat Pump Water Heater.	$1,753	$253	4,940	6.9	19.10%	$5,211
M3	Add Ductwork Insulation	$2,780	$221	11,922	12.6	11.69%	$3,354

	Capital Investment	Annual Energy Cost Savings	Annual kBTU Savings	Simple Payback (Years)	IRR	NPV
Package 1: Attic EEM and all Mechanical EEMs (B1, M1, M2, M3)	**$158,952**	**$9,852**	**573,154.88**	**16.1**	**9.38%**	**$116,708**

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

Next Steps

With the completion of this Level II Energy Assessment, the Tamworth Town Office should consider potential next steps to take advantage of the recommended energy-saving and comfort-improving opportunities. Both the NHSaves program and the USDA provide grants and incentives that will reduce the implementation cost of many of the proposed energy efficiency measures in this report.

Disclaimer: This report is delivered without any warranties, expressed or implied. This report contains information about the Tamworth Town Office building only – and is based upon our observations and analysis and upon information which we received from employees. RBG has used care, its best professional judgment, and the services of qualified vendors and sub-contractors to research and prepare this report. We believe we are presenting an accurate and complete assessment of your building and the opportunities present for energy improvements. Please note that no project pricing displayed within this report includes the cost of the design, plans, or specifications for construction.

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

Rebates, grants, and low-interest loans often affect the financial results of energy-related improvements. As these opportunities often change, we have not included these advantages in our financial results. Efforts to define their availability should be made when the decision to implement the recommended energy measures is made.

Confidentiality Restrictions: This report contains data and information submitted to fulfill an Agreement between RBG and the Tamworth Town Office and is provided in full confidence. The recipient shall have a limited right as outlined in the Agreement to disclose the data herein.