Edward G. Connolly Center

Comprehensive Building Assessment

Prepared by

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Comprehensive Building Assessment

TABLE OF CONTENTS

Contacts 3
- City of Everett 3
- National Grid 3
- B2Q Associates 3

Introduction 4

Executive Summary 5
- Energy Conservation Measures 7
- Recommended Next Steps 8

Facility Description 9

Utility Information 13

HVAC Electrification Options 17
- Electrification Feasibility Considerations 17
- Technologies Considered 18
- Option 1: Air-to-Air Heat Pumps 24
- Domestic Hot Water 27
- Electrical Infrastructure 29

Energy Conservation Measures 30
- ECM-1: Implement Unoccupied Temperature Setpoints on AHUs 30
- ECM-2: Optimize Boiler Operation 31
- ECM-3: EC Motor Retrofit on Existing Motors 33
- ECM-4: BAS & DDC Upgrade 34
- ECM-5: Weatherization 35
- ECM-6: Lighting Improvements 38
- FIM-1: Add Makeup Air Unit to Kitchen Ventilation System 39

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INTRODUCTION

B2Q was engaged by National Grid to complete a comprehensive building assessment at the Edward G. Connolly Center to evaluate the potential for electrifying the building's fossil fuel-fired heating systems and reducing existing loads and usage within the building.

The majority of existing mechanical equipment is original to the building's most recent renovation in 1999 and is nearing the end of its useful life. We understand the City is interested in gaining a better understanding of the options for phasing out fossil fuels in the facility in pursuit of their longer-term carbon reduction goals.

The objective of this study is to evaluate potential approaches to energy conservation and electrification and to perform a high-level evaluation to determine the technical advantages and disadvantages of several options, as well as the likely budget impacts. The options discussed are provided as a high-level view of the potential energy savings and costs and are not reflective of what would be produced by a detailed investment grade design and economic analysis. Energy savings were calculated using high-level estimates, past experience, and typical industry metrics. High level opinions of probable construction costs were estimated based on industry-standard cost estimating guides, as well as past experience and previous budget quotes from equipment vendors and contractors.

EXECUTIVE SUMMARY

ELECTRIFICATION

Table 1: Electrification Screening Executive Summary Table.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings	Estimated Annual Fossil Fuel Savings	Estimated Annual Energy Cost Savings	Opinion of Probable Cost	Estimated Potential Utility Incentive	Estimated Net Cost
	tons	*tons*	*kWh*	*therms*	*$*	*$*	*$*	*$*
Option 1: VRF Heat Pumps	52	46	-72,184	11,841	-$3,244	$928,669	$182,000	$746,669
Heat Pump Water Heater	--	--	-4,990	574	-$530	$49,800	$2,200	$47,600
Percent of Baseline Usage - Option 1			-55%	90%				
Percent of Baseline Usage - Heat Pump Water Heater			-4%	4%				

Table 2: Electrification Screening Summary of CO_2 Emissions Savings.

Proposed Electrification Option	$/lb CO_2 Emission Reduction	Estimated Annual CO_2 Emissions Savings w/ 2025 MA Emissions Factor		Estimated Annual CO_2 Emissions Savings w/ 2030 MA Emissions Factor		Projected Annual CO_2 Emissions Savings w/100% Carbon Free Electricity Grid	
	$	*lbs*	*%*	*lbs*	*%*	*lbs*	*%*
Option 1: VRF Heat Pumps	$5.61	133,033	52%	150,251	58%	170,573	66%
Heat Pump Water Heater	$8.38	5,678	2%	6,868	3%	8,273	3%

The tables above summarize the estimated annual energy, cost, and emissions savings for the electrification approaches considered. In reviewing the tables above, please note the following:

1. Cost savings are based upon assumed utility rates of $0.25/kWh for electricity and $1.25/therm for natural gas. Utility data provided to B2Q included delivery costs only hence the need for assumed rates. Utility rates can be updated upon request.
2. Potential utility incentives have been estimated for select options in the Executive Summary Tables above. Incentive estimates are based on published MassSave prescriptive incentive rates, as shown in Table 3 below**.** Systems which exceed the combined capacity limit shown in Table 3 will require a custom incentive application, but rebates may be similar to the prescriptive rate on a $/ton basis. All incentives will be subject to further analysis and rebate amounts are solely determined by the utilities. It should be noted that MassSave does not currently include air-to-water heat pumps in the prescriptive rebate table; therefore, it is unclear at this time what the available incentive may be for that option, but the approximate scale of incentive, if approved, could be comparable to other heat pump technologies on a $/ton basis. Accordingly, a custom incentive application is required for all air-to-water heat pump projects seeking utility assistance, and all incentives are subject to further analysis. Refer to the MassSave website for more information.

Table 3: Heat pump incentives

Heat Pump Technology	Prescriptive Incentive Rate	System Size
VRF Heat Pump	$3,500/ton	0-150 tons cooling
Non-VRF Air-to-Air Heat Pumps	$2,500/ton	0-150 tons cooling
Central Air-to-Water Heat Pump	N/A - Custom Application Required	
Ground-Source Heat Pump	$4,500/ton	0-150 tons cooling
Air Source DHW Heat Pump	$1,000/unit	80 gallons storage

3. The preliminary budgetary opinions of probable construction costs for electrification are based on past experience, previous vendor quotes, and industry metrics. The opinions of probable cost presented are a high-level view of the potential costs to screen the economic viability of the project and are not reflective of what would be produced by a detailed economic feasibility analysis. Refer to the cost sections within the descriptions of each option below for more specific information. ***Please note that there is some important and significant context about the budget cost information in the sections that follow. These notes weigh heavily on how the values in this report can be extrapolated to project future costs at the time of construction and should be considered carefully.***
4. CO_2 emissions reductions estimates presented in Table 2 are based on projected emissions factors for 2025 and 2030 presented in the Greenhouse Gas Emissions Reduction Goal for MassSave published on March 1, 2024, by the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs. Note that equivalent

CO_2 emissions savings will continue to improve over time if New England continues to make progress toward its goal of decreasing carbon intensity on the electric grid. Therefore, Table 2 also presents the potential CO_2 emissions reductions in the future if 100% carbon-free electricity is available in Massachusetts.

ENERGY CONSERVATION MEASURES

Table 4: Edward G. Connolly Center – ECM Executive Summary

Edward G. Connolly Center ECMs - Executive Summary						
ECM #	Measure Description	Estimated Electric Savings	Estimated Natural Gas Savings	Total Estimated Cost Savings	Project Cost Estimate	Simple Payback
		kWh	therms	$/yr	$	yrs
1	Implement Unoccupied Temperature Setpoints on AHUs	9,552	0	$2,388	$4,800	2.0
2	Optimize Boiler Operation	291	2,928	$3,733	$6,400	1.7
3	EC Motor Retrofit on Existing Motors	1,675	0	$419	$3,400	8.1
4	BAS & DDC Upgrade	8,255	456	$2,634	$107,000	40.6
5	Weatherization	--	--	--	--	--
6	Lighting Improvements	4,217	0	$1,054	$15,200	14.4
	Totals	**23,990**	**3,384**	**$10,227**	**$136,800**	**13.4**
	% of Baseline	*18%*	*26%*			

Table 5: Edward G. Connolly Center – ECM Emissions Summary

ECM #	Measure Description	Estimated Annual CO_2 Emissions Savings w/ 2025 MA Emissions Factor		Estimated Annual CO_2 Emissions Savings w/ 2030 MA Emissions Factor	
		lbs	%	lbs	%
1	Implement Unoccupied Temperature Setpoints on AHUs	4,968	2%	2,689	1%
2	Optimize Boiler Operation	42,329	16%	42,260	16%
3	EC Motor Retrofit on Existing Motors	871	0%	472	0%
4	BAS & DDC Upgrade	10,862	4%	8,893	3%
5	Weatherization	--	--	--	--
6	Lighting Improvements	2,193	1%	1,187	0%
	Totals	**61,223**		**55,500**	
	% of Baseline	*24%*		*22%*	

In reviewing the ECM summary table, please consider the following:

- ECM-1 and ECM-2 show significant potential for savings which can be addressed in the near term while the City works to formulate the best path forward for the HVAC system. Both measures relate to the staging and setpoints of the existing systems.
- ECM-3 and ECM-4 are longer term measures to evaluate if the City decides not to move forward with a new heat pump system. The City should be looking towards an upgrade of the BAS, regardless of what choice is made related to the HVAC system.

- Details on the weatherization improvements are detailed in a separate study conducted by the City which they can provide upon request.

RECOMMENDED NEXT STEPS

In summary, further planning and detailed engineering review are necessary in preparation for the next phases of design and construction of electrification options and/or energy conservation measures. Here are the recommended next steps:

- Internal review to be completed by the City of Everett to determine interest in pursuing electrification at this building further. Please make B2Q aware of any errors or omissions that may have impacted our results or recommendations. We would be glad to issue an updated report that addresses any such concerns.
- Meet with B2Q and utility representatives to discuss any questions about the information contained in this report, including these Next Steps.
- Coordinate with utility representatives to obtain an estimate of potential utility incentives related to the proposed projects for the building.
- If this site is determined to be prioritized for implementation of any of the options identified herein, assess how to move forward with the option proposed in this report for further investigation. Note that, as discussed in the report, the factors that influence the choice of one option over another include a multitude of considerations, such as estimated construction cost, compatibility with the existing building and equipment, impact on annual energy/operating costs, reliability/resiliency, ability to operate and maintain the equipment, etc. so the Owner should consider its own goals and priorities in relation to these projects as part of the decision-making process. Note also that the optimal strategy for a given building may include a combination of technologies deployed for different applications to take advantage of the relative strengths and weaknesses of each option.
- Consider working with stakeholders to secure funding for a follow up effort to conduct a more detailed feasibility study and/or schematic design to better develop the scope of work for the multiple projects (electrification, ECMs, weatherization) which are currently being evaluated separately but on a similar timeline. It is also recommended that during this effort a third-party cost estimate be developed to better inform capital planning.
- Consider initiating temporary and/or expanded permanent electric sub-metering, per NEC requirements.

FACILITY DESCRIPTION

GENERAL

The Edward G. Connolly Center located at 90 Chelsea St in Everett, MA was built in 1902 by the City of Everett as an armory to provide a location for training of the local volunteer militia which was required by law at the time. The building was taken over by the state in 1910 and completely renovated for use by Company B, 8th Regiment Infantry, Massachusetts Volunteer Militia. The building was used for various military activities through to the 1960's but was also used for community functions including banquets, exhibitions and social events. Ownership of the building was transitioned back to the City from the National Guard in the 1970's and underwent an extensive renovation project in 1989. In 2006, the building was renamed the Edward G. Connolly Center in honor of longtime state representative and former mayor, Edward G. Connolly. The 34,000 ft^2 building currently houses the City's Council on Aging, Human Services, and Veteran's Affairs offices. The building is also used as a cooling center for the City during periods of excessive heat and is also used as an emergency shelter for displaced families. The first floor consists of offices and an assembly hall which spans two floors. A partial second floor contains additional offices. The building features a full basement which is currently unused.

The building underwent a major renovation around 1989 which included the installation of new hot water boilers and terminal devices as well as new cooling equipment.

MECHANICAL SYSTEMS

The mechanical systems descriptions below are primarily based on information obtained from the 1989 Renovation of Everett Armory drawing set, as well as observations and conversations with City staff during walkthroughs performed on July 26th and August 15th, 2024.

CENTRAL PLANT

Hot water for the building is provided by two (2) gas-fired Weil McLain H976 SW cast iron boilers equipped with PowerFlame JR30A-12 burners. The boilers have a rated output of 624 MBH, and the most recent combustion efficiency tests conducted in 2021 list their efficiencies as 82.2% and 80% respectively. There was no further information available on the boilers as the production of this model has been discontinued for over 30 years and the boilers are operating beyond their useful life.

Hot water is circulated throughout the building via three (3) inline pumps which each serve an individual zone. The hot water is provided to a mixture of fin-tube radiation, and convectors located in the main hall and back-office portion of that area. There are also cast-iron radiators, which originally received steam, on the first and second floors of the front office section of the building providing heating. Each of the 3 zones have a single thermostat which enables/disables the operation of the zone pump. Each of the zones had an occupied setpoint of 67°F as of the time of our site visit.

Figure 1

Tag	MFGR	Boiler Size	Fuel	Input Capacity	Output Capacity	Thermal Efficiency *
--	--	--	--	MBH	MBH	%
B-1	Weil McLain	H976 SW	Nat. Gas	794	624	82.2%
B-2	Weil McLain	H976 SW	Nat. Gas	794	624	80%

** Thermal efficiency for the boilers derived from 2021 combustion tests*

AIRSIDE SYSTEMS

The building has several split air conditioning systems and packaged units providing cooling and ventilation to the building. The front area of the main hall is conditioned by four (4) 7.5-ton MagicAire split systems located above ceiling on the first floor. The back area of the hall, including the office area is conditioned via a 2-ton Carrier unit and a 10-ton Trane unit. The Trane unit is designed for a gas connection to provide heating, but it appears that this connection was never made for the system. Select areas of the 1st floor front offices are equipped with cooling and ventilation. Mini split heat pumps have been added to the front entrance hallway as well as an adjoining office. A mini split heat pump was also added to the main hall, close to the stairwell, to provide additional cooling to the space.

While reviewing available trend data for the facility, B2Q noted that the AHUs only cycled on when there was a call for cooling from the space. This does not match the sequence of operation displayed on the BAS, whereby when the AHU is in occupied mode the supply fan shall run and the outside air damper shall open to its minimum scheduled airflow rate during the occupied mode. This means that for the majority of the year, ventilation is potentially inadequate for the building.

Details about each air handler can be found below.

Indoor Unit							Condenser Unit		
Tag	Service	MFGR	Model	Supply Airflow	Min Outside Airflow	Supply Fan Size	DX Coil Capacity	MFGR	Model
--	--	--	--	CFM	CFM	HP	Tons	--	--
AHU-1	Main Hall	Magic Aire	90-BHX-3-A	3,750	*500*	1	7.5	ICP	CA5090VHA3
AHU-2	Main Hall	Magic Aire	90-BHX-3-A	3,750	*500*	1	7.5	ICP	CA5090VHA4
AHU-3	Main Hall	Magic Aire	90-BHX-3-A	3,750	*500*	1	7.5	ICP	CA5090VHA5
AHU-4	Main Hall	Magic Aire	90-BHX-3-A	3,750	*500*	1	7.5	Goodman	GSC100903AC
AHU-5	First Floor Offices	York	-	-	-	-	2.5	Goodman	CK30-18
AHU-6	Main Hall	Trane	YSC120	4,000	-	2.75	10.0	Packaged	
AHU-7	Back Office/Main Hall	Carrier	-		-	-	2.0	Carrier	38TH024
AHU-8	Second Floor Offices	York	NC120C	3,750	-	3	10.0	Packaged	
-	1st Floor Office/Main Hall	Samsung	-	-	-	-	3.0	Samsung	AJ036BX

Building Automation Systems

The building has its primary HVAC systems controlled via a Building Automation System over BACnet MSTP communication protocol. The network and interface were created and operated by FMC Technologies, utilizing Trend Controls product.

The BAS is relatively limited in its configuration and utilizes basic control relay logic to operate features such as supply fans, cooling staging, boilers and pumps. The BAS allows for the building to operate on a schedule; however, it is currently set to 24/7 operation. Users can view the status of the AHUs and boilers and monitor space and supply temperatures as well as setpoints.

Building Envelope

The Edward G. Connolly Center is a brick building designed in the English Revival style and with crenellation round corner towers at the front of the building including narrow window openings. The center bay containing the main entrance to the building has a battered wall with brick quoining and is capped by a crenellated parapet. Extending behind the front office block is a single-story brick hall capped by an asphalt-shingled gable roof. Projecting brick piers with granite capstones order the side elevations of the hall into nine (9) equal bays. None of the windows in place at the building are original and all appear to be single pane glass.

The building has been evaluated by another firm and details of those findings as well as B2Q's findings from our walkthrough will be detailed later in the report.

Lighting

Lighting upgrades have been made throughout the occupied office spaces of the building converting from incandescent and fluorescent lighting to LED. The basement area of the building still contains incandescent lighting. No lighting controls were observed.

Cooking Facilities

There is a small kitchen located to the rear of the building at the main hall, which provides meals to senior citizens as part of their Council on Aging program. The kitchen contains gas-fired open-burner range, oven, and griddle as well refrigerators and freezers. There is a central kitchen exhaust hood which is wall switch-operated, however there is no specific makeup air unit for the kitchen which should be taken into consideration when redesigning the primary HVAC system for the main hall as the kitchen is open to the area.

Electrical Infrastructure

As part of this study, B2Q performed a high-level preliminary review of the main electrical service and equipment at the Edward G. Connolly Center. The existing main switchboard is rated for 800A at 208V, 3-phase power. A more detailed look at the existing infrastructure and its suitability for future loads is detailed later in the report.

Renewables

There are currently no renewables on site, however, the City has engaged with a consultant to determine the feasibility of installing solar photovoltaics (PVs) along with battery storage at the site

UTILITY INFORMATION

UTILITIES

Electricity Delivery: National Grid

Natural Gas: National Grid

The graphs and discussion on the following pages are based on utility data provided by National Grid from January 2020 through June 2024.

MONTHLY ENERGY USE

A summary of the monthly electricity and natural gas consumption is shown in the graphs below. Natural gas and electricity data is normalized by multiplying the daily usage in a billing cycle by the days in the month of the billing cycle to improve comparison across years.

The historical electricity usage follows expected weather dependent patterns for a building with mechanical cooling. Monthly usage ranges from 6,000-12,000 kWh/month throughout the fall, winter, and spring, but increases to 14,000-18,000 kWh/month in August and September, when cooling equipment is likely active. Monthly energy usage is generally consistent from year to year, with the exception of February through June 2024, where usage is markedly higher than in previous years. An increase in peak demand is not observed in these months, which indicates the building may have been occupied or operating in occupied mode for a greater portion of the month than the typical office schedule.

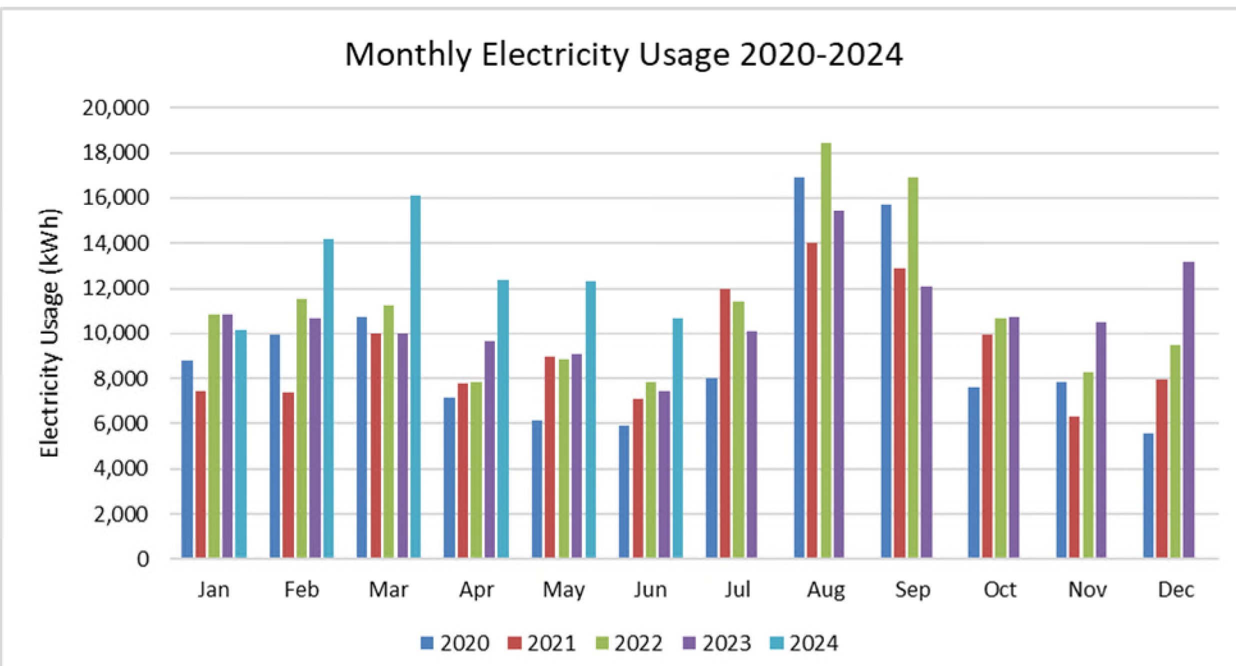

Figure 2: Monthly Electric Usage.

The monthly peak electric demand follows a similar pattern as the electricity usage, with peak demand consistently between 20 and 40 kW from November through June, and an increase to 45-70 kW in August and September. Electric demand is consistent from year to year, including February through June 2024, when total usage increased over previous years.

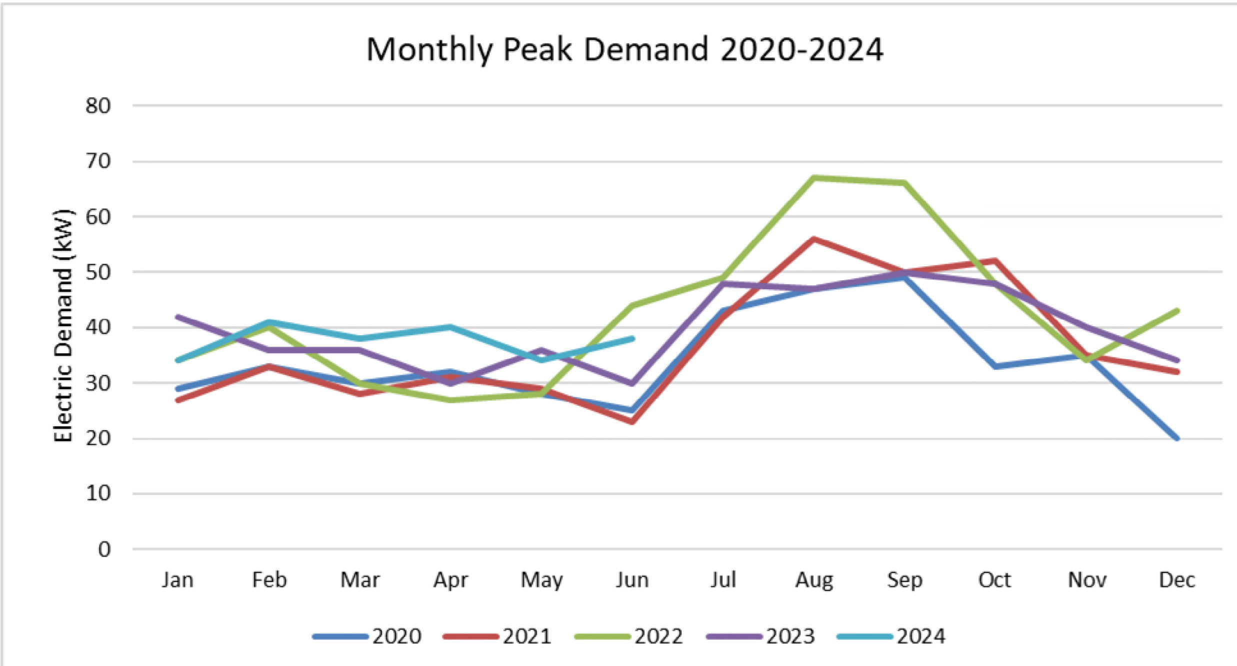

Figure 3: Monthly Peak Electric Demand.

Natural gas usage is highest from January through March of each year, when the heating system is heavily loaded. In these months, usage falls between 2,000 and 2,500 therms/month before falling to 10-200 therms/month throughout the summer. This is expected in a building with heating systems fueled by natural gas, which aren't typically operating in the summer. Summer usage can be attributed to the kitchen and domestic hot water heater.

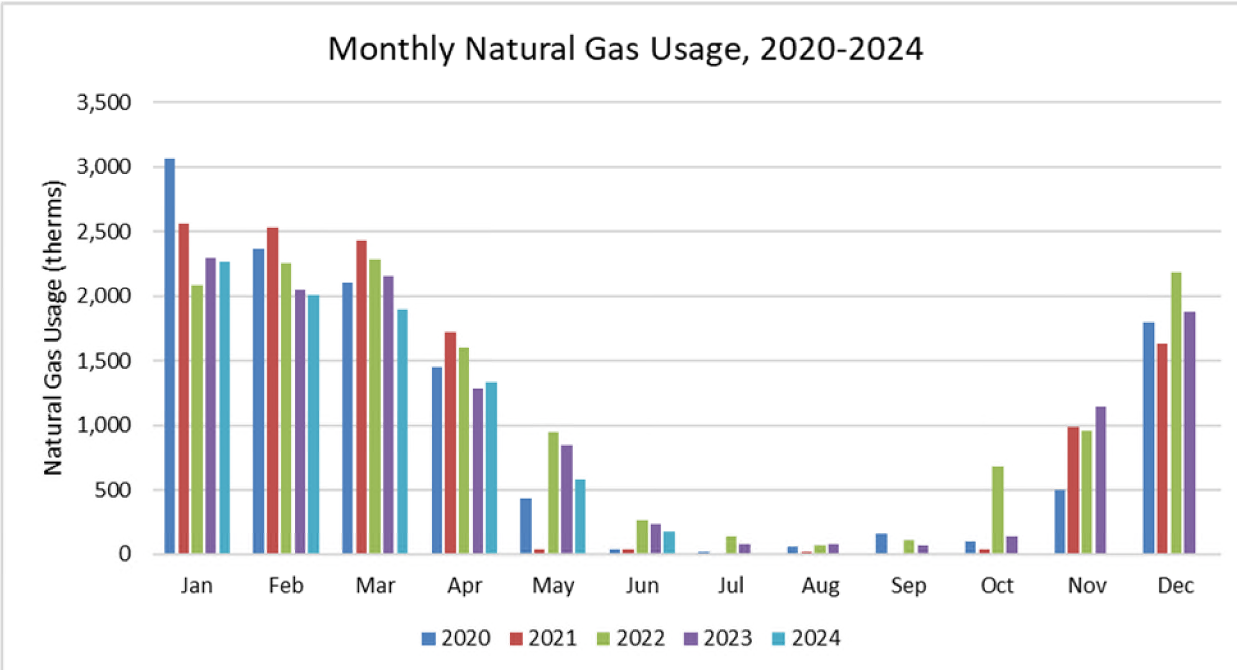

Figure 4: Monthly Natural Gas Usage.

Annual Energy Benchmarking

The table below summarizes the annual energy use and energy use intensity (EUI) for the building from 2020 through 2023. According to the 2018 Commercial Buildings Energy Consumption Survey (CBECS) conducted by the US Energy Information Administration, the average building EUI in New England is 73.9 kBtu/ft^2. The average EUI for buildings 25,000-50,000 ft^2 and public assembly buildings is 79.2 kBtu/ft^2 and 71.6 kBtu/ft^2, respectively.

The Connolly Center had an average EUI of 89.9 kBtu/ft^2 from 2020 through 2023, which is higher than similar buildings in New England. New England buildings operating 40 to 48 hours per week have an average EUI of 49.9 kBtu/ft^2. The EUI for this building is being driven by the gas usage for the building. It should also be noted that the building is used as a cooling center and emergency shelter so its usage can be irregular and extend far beyond a 40 to 48 hour week.

Table 6: Annual energy usage and energy use intensity (EUI).

Building Information		Energy Usage		Performance			
Floor Area	Fiscal Year	Electric Usage	Natural Gas Usage	Electric Intensity	Electric EUI	Natural Gas EUI	Total EUI
ft^2	--	kWh	therms	kWh/ft^2	kBtu/ft^2	kBtu/ft^2	kBtu/ft^2
18,700	2020	110,280	12,540	5.9	20.1	67.1	87.2
	2021	110,520	12,006	5.9	20.2	64.2	84.4
	2022	133,840	13,903	7.2	24.4	74.3	98.8
	2023	129,360	12,293	6.9	23.6	65.7	89.3
* Note that the floor area used relates to just the conditioned area of the building rather than the total square footage							

HVAC Electrification Options

The potential electrification options evaluated during this scoping study are described on the following pages. The options discussed are provided as a high-level view of the potential energy savings and costs and are not reflective of what would be produced by a detailed investment grade conceptual design and economic feasibility analysis. Emissions, energy, and cost savings were calculated using high-level estimates based on existing equipment capacities, actual electric and natural gas usage, past experience, published heat pump performance, and typical industry metrics. High level opinions of probable construction costs were estimated based on industry-standard cost estimating guides, as well as past experience and previous budget quotes from equipment vendors and contractors.

Electrification Feasibility Considerations

Determining the feasibility of an electrification option is a complex effort that should account for multiple interactive factors. As shown in the figure below, these factors include the solution availability, technical requirements, site specific conditions, implementation costs, and societal pressures. This study consists of a high-level review of heat pump feasibility, with a focus on technical factors and site-specific conditions. Further evaluation of feasibility based on societal factors, project cost, and the long-term goals of the Owner, in conjunction with the findings in this report, is recommended.

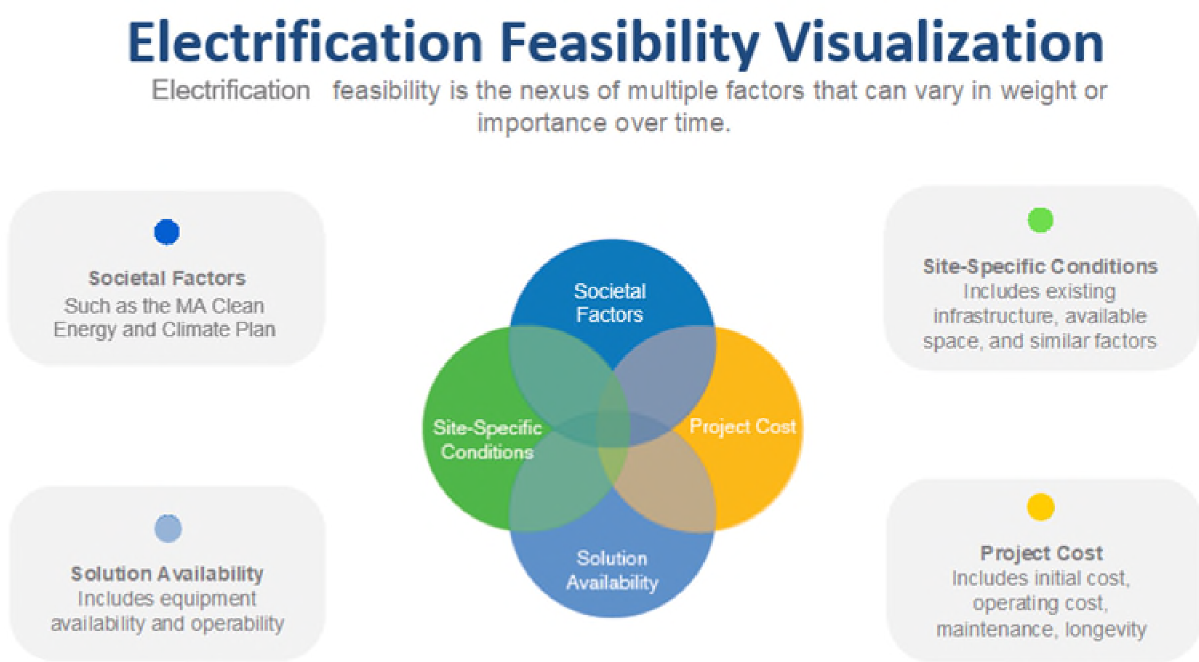

Figure 5: Visualization of prominent electrification feasibility considerations

Technologies Considered

The following section provides a brief description of each heat pump technology considered in this study. The table below summarizes the general advantages and disadvantages of each technology.

Table 7: Heat Pump option advantages and disadvantages

Option	Advantages	Disadvantages
Air-to-Air Heat Pump Packaged Air Handling Units	• Single piece of equipment could provide heating/ cooling and ventilation, rather than requiring separate ERV • Potential to reuse existing ductwork to provide better air distribution relative to wall-mounted fan coil style VRF units. • Relative better efficiency than air-to-water options at lower ambient conditions because of reduced compressor lift • No new equipment in visible occupied areas	• May require installation of an electrical or hot water preheat coil to ensure entering-coil temperature is within a permissible range • Potential need for supplementary baseboard heating in areas to maintain occupant comfort given high ceilings/overhead distribution and relatively large envelope loads in Main Hall • No heat recovery ability for ventilation
Air-to-Air VRF Heat Pumps	• Limited need for supplementary boiler operation (may still be needed for backup during power outage) • Potential for full electrification of space heating • Independent of existing infrastructure and terminal equipment, which is approaching end of life in some cases • Potential for heat recovery and simultaneous heating and cooling	• Requires replacement or abandonment of existing terminal devices throughout the building • Increased points of failure/pieces of equipment to maintain from small, distributed equipment • Potentially safety/maintenance concern of refrigerant in occupied spaces • Requires installation of energy recovery ventilators (ERVs) or a dedicated outdoor air system (DOAS) to provide required ventilation separate from heat pumps

		• Potential for exposed equipment and piping, which may impact building aesthetics • Potential need for supplementary electric resistance baseboard heating in areas with existing hot water baseboard radiation to maintain occupant comfort
Central Air-to-Water Heat Pump	• Existing boilers can remain tied into HW system for supplementary heating or backup • Singular piece of equipment providing hot or chilled water, potentially leading to maintenance cost savings •	• New terminal equipment would still be required with this setup. • Invasive and costly pipework renovations required • Limited low-temperature operation (i.e., <0°F ambient); backup boiler use still required on coldest days • Efficiency and heating capacity decreases significantly as outside air temperature decreases, even as compared with other heat pump technologies • Heating capacity decreases as outside air temperature decreases more significantly than compared to VRF options

Air-to-Air Heat Pumps

Air-to-Air Heat Pumps, also known as air-source heat pumps, directly transfer heat to and from outside air to the spaces served. Heat pumps can operate during both the summer to provide cooling and the winter to provide electrically-sourced heating.

VRF Heat Pumps

Air-to-air heat pump indoor units and outdoor condensing units can be connected 1-to-1 or configured to use one outdoor condensing unit for multiple indoor units. There are also variable refrigerant flow (VRF) systems where one outdoor condensing unit could be connected to as many as 50 indoor units, depending on the equipment. Indoor units can range from wall-mounted units, ducted and non-ducted ceiling cassettes or fan coil units, or floor-mounted units. Condensing units can also be integrated with heat pump coils in air handling units via linear expansion valve (LEV) kits. Condensing units for VRF systems can be capable of operating at low ambient temperatures, depending on the equipment, and therefore VRF heat pumps could be designed to meet most or all a building's space heating needs, as compared with other technologies described below. On the other hand, it is often advisable to maintain a non-electric backup heating source in the event of extreme cold (e.g., less than -10°F) or power outage.

Packaged Heat Pump RTUs

Packaged air-source heat pump rooftop units can be installed in place of traditional rooftop units. Packaged heat pump RTUs are typically offered with a secondary source of heat for supplementary heating during low-temperature operation or backup in the event of equipment malfunction. Secondary heat sources typically come in the form of an electric resistance heating element or a natural gas-fired furnace. Dual fuel heat pump RTUs typically have smaller electrical requirements than heat pump RTUs with electric resistance backup, often leading to no or limited cost to upsize the electrical circuit breaker and feeders to the unit. Existing traditional RTUs can often be swapped out with package heat pump RTUs with minimal roof, structural, or duct modifications, though careful engineering is required to verify such details during the design process.

Central Air-to-Water Heat Pumps

Central air-to-water heat pumps transfer heat from outside air to a water loop. Where air-to-air systems are comparable to DX cooling, air-to-water systems are comparable to an air-cooled chiller, where a refrigerant cycle is used to transfer heat from the air to a water loop, and then the water is distributed throughout the building to heat or cool supply air at air handling units and terminal devices. Typically, this option is attractive for buildings with existing hot water, chilled water, or dual temperature infrastructure, due to the potential ability to reuse existing infrastructure and retain boilers for supplementary heating.

As with air-to-air heat pumps, air-to-water heat pumps typically have reduced capacities and lower efficiencies as the ambient temperature decreases, but the effect is more pronounced for air-to-water heat pumps compared to air-to-air. Similarly, capacity and efficiency decrease significantly as the hot water supply temperature increases. Air-to-water heat pumps are typically able to provide 120 – 140°F hot water or lower, whereas existing hot water infrastructure and equipment is typically selected based on 180 – 200°F hot water. Also, air-to-water heat pumps typically cannot operate below 0°F ambient temperature, based on equipment currently available on the market. As a result, fossil fuel-fired boilers, or electric resistance boilers, typically must be in place to supplement heating in the coldest weather, limiting the potential for full heating system electrification.

Geothermal Heat Pumps

The discussions in this report use several acronyms related to "geothermal systems":

- Geoexchange refers to the process of harvesting heat energy from the Earth and using that energy to heat a building and discharge the heat energy to the Earth to support cooling a building.
- GSHP stands for Ground Source Heat Pump, which is collectively the geothermal heating, ventilation, and air conditioning (HVAC) equipment within a building.
- GSHP System means the entirety of the installation, including the ground heat exchanger, ground source heat pumps, and distribution system (i.e., piping, ductwork).
- GHEX is the Ground Heat Exchanger which is the underground portion of the GSHP System.

GSHP Systems rely on the GHEX as a source or sink for heat energy. GHEXs come in a variety of configurations. The major categories of GHEXs are 'Open Loop' and 'Closed Loop'. Open Loop systems utilize groundwater as the GHEX fluid and move groundwater to/from one or more Standing Column Wells. Closed Loop GHEXs are either configured as horizontal or vertical piping configurations. Vertical Closed Loop installations are generally the most commonly installed GHEXs in Massachusetts. Conceptually, a traditionally configured vertical closed loop GHEX consists of an array of vertically drilled borings. Borings are typically hundreds of feet deep and arrays of borings are arranged in a parallel flow configuration with many circuits. Warmed water from the GHEX is then used as a source for GSHPs that produce hot water for separate heating coils or hot air supplied directly to spaces. Because of the consistently warm ground temperatures, when compared with much colder outside air temperatures, during peak heating periods, geothermal heat pump systems are generally the most efficient heat pump option, but at a higher first cost compared to air-source heat pump systems.

Water Source Heat Pumps

Water source heat pumps often refer to geothermal heat pump systems, which rely on a Ground Heat Exchanger (GHEX) as a source or sink for heat energy. However, water source heat pumps are capable of working with many different water sources including lakes, streams, aquifers, and the sea.

Central Water-Source Heat Pumps

Central water-source heat pumps (WSHPs) transfer heat from water in the source loop to the building hot/chilled water loop. Contrasted to the central air-to-water heat pump, the central WSHP is expected to have a less severe capacity and efficiency derate with outside air temperature due to the consistency of the raw water temperature. However, the operating hours of the WSHP would be limited to the hours when there is sufficient active raw water flow, which is reported to decline in the winter months. A central water-source heat pump could provide heating and cooling to the space(s) served. However, this would require the installation of a new dual temperature hydronic loop and associated end devices.

Distributed Water-Source Heat Pumps

Another WSHP option is a distributed WSHP system, which utilizes water-to-air heat pumps. As with the central water-source heat pump, a new distribution loop could circulate water to the space(s) served. Instead of installing new hot/chilled water hydronic coils in each space/end device to make sure of the conditioned water from the central heat pump, the distributed heat pumps would utilize more neutral source water (on the other side of a heat exchanger to isolate and protect the raw water) to directly make warm or cool air to supply to each space. Distributed water-to-air heat pumps are typically more efficient than central water-to-water heat pumps as there is one fewer heat transfer step (water-to-refrigerant-to-air vs water-to-refrigerant-to-water-to-air), the heat pump output can be limited to only what is needed in each space as opposed to having to provide warm/cool enough water for the worst case zone from a centralized system, and because distributed systems have the potential for heat recovery when some spaces are in heating while others are in cooling. This reduces the lift on the compressor and results in less energy use to achieve the same space temperature.

Options Proposed

Given the constraints of the existing building, the electrification option likely most suited for this site is the implementation of air-to-air heat pumps. Air-to-air heat pumps offer the best individual temperature control out of the options listed above while also being the least disruptive installation. Geothermal heat pump options were excluded from the scope of this study prior to commencing work because of the lack of available outdoor space on the property and the major upfront capital cost relative to small size and capacity of the building. B2Q did evaluate the potential of an air-to-water heat pump, however there were many factors which were not well aligned with the building infrastructure that limit this technology's effectiveness:

- The existing piping infrastructure would likely not be suitable for reuse with an air-to-water heat pump. The existing heating infrastructure such as the radiators and convectors were designed for 200°F HWST, which is significantly above the typical temperature supply range for an air-to-water heat pump and are not suitable for low temperature hot water.
- There is no existing chilled water infrastructure in the building which would require the installation of CHW piping as well as new air handling units to house the coils the new piping would serve.
- An air-to-water heat pump would require fossil fueled boilers to remain in place as a backup source when the ambient conditions are too low for the heat pump to operate (i.e., < 0°F). The existing boilers for the building have exceeded their useful life and would require replacement as part of an air-to-water heat pump installation adding additional upfront costs to the project.

- As is noted in the electrification option sections later in the report, there is very limited space available surrounding the building at grade where an air-to-water heat pump could be placed and the roof was expected to not be a good candidate to add such a large new load without significant reinforcement.

OPTION 1: AIR-TO-AIR HEAT PUMPS

ECONOMICS SUMMARY

Table 8: Option 1 Economic Summary

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings	Estimated Annual Fossil Fuel Savings	Estimated Annual Energy Cost Savings	Opinion of Probable Cost
	tons	*tons*	*kWh*	*therms*	*$*	*$*
Option 1: VRF Heat Pumps	52	46	-72,184	11,841	-$3,244	$928,669
Percent of Baseline Usage - Option 1			-55%	90%		

PROPOSED OPTION

This option proposes to install a new VRF heat pump system retrofit comprised of ceiling-mounted or wall-mounted indoor units in each room to serve as the primary source of heating and cooling. While VRF systems can often have exposed refrigerant and condensate piping, which could disrupt the aesthetic of a building, but the drop ceiling observed in these areas favor the use of ceiling cassettes, meaning the piping could be routed in ceiling plenums and result in minimal exposed equipment. The ceiling cassettes are typically installed flush with the ceiling, offering a clean and unobtrusive appearance. The VRF system would allow each space individual temperature control rather than a single supply temperature being supplied to multiple different spaces.

For the main hall, it is recommended that high throw ducted ceiling cassettes (similar to "mini-AHUs) be utilized in this area. These units are designed to deliver air across greater distances, for more even temperature distribution in large or open spaces.

In addition to the VRF system, an ERV and its associated ductwork will be required as part of the system to provide the necessary ventilation to each space. ERVs are generally the most efficient option for providing ventilation, as they utilize dedicated supply and exhaust fans to provide code minimum ventilation airflow in tandem with a fixed polymer "core" heat exchanger that uses exhaust air to pre-heat fresh air in the winter and pre-cool it in the summer. The ERV for this area could be located above the existing suspended ceilings where AHUs 1 through 4 are currently located or on the front area roof and ducted throughout the area to distribute ventilation.

An alternative option for this area would be the installation of a packaged air-to-air heat pump to condition the area. These units would provide all the necessary heating, cooling, and ventilation for the space served. However, the lack of available space around the building for it to be placed or for it to be supported by the existing roof makes this a more complex option in comparison to the VRF system. Also, the VRF system will offer better temperature control of individual offices/spaces compared to the packaged unit. Due to the building being used as an emergency shelter, the City could consider fitting the package units with gas-fired heaters as a backup heating source. The gas-fired backup is recommended because this configuration, as compared with a 100% electric RTU, is generally smaller, lighter, and requires a comparable electrical circuit capacity to the existing cooling units, though with the drawback of not achieving 100% displacement of natural gas.

For the front office section of the building, we also recommend the installation of a VRF heat pump system. Like the configuration proposed above, ceiling cassettes and/or wall mounted indoor units would be installed across both office floors. For ventilation of the space, the most efficient option would be to utilize energy recovery ventilators (ERVs) as described above. The ERV for this area could be placed on the flat roof of the front section of the building along with the condensing units for the VRF system. For the condensing units, they could be part of the modular system serving the main hall, however this should be determined in the next phase of evaluating this project.

Opinion of Probable Construction Cost

Table 9: Option 1 Opinion of Probable Construction Budget Cost

Category	Estimated Budget
Demolition	$43,600
HVAC Equipment	$117,000
HVAC Piping, Ductwork, Other Materials	$97,500
HVAC Installation	$161,769
Electrical Branch Circuit Materials and Labor	$42,400
Electrical Service Upgrade	$0
Startup, Commissioning, TAB, Closeout	$61,800
Controls	$68,000
Engineering	$75,100
Envelope Penetrations, Patching, Firestopping	$51,200
Contractor General Conditions & PM Labor	$82,000
Contractor Overhead & Profit	$55,200
Contingency	$73,100
Grand Total	**$928,669**

[1] Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs

The cost estimate above is meant to provide a high-level opinion of probable cost, and is based on the following assumptions:

- Construction would begin within the next year (given the need to reference currently available pricing estimates) and follow a standard design-bid-build procurement path, such as MGL Chapter 149. Based on recent market trends, construction costs continue to show steady escalation and customers should consider budgeting an additional 5 – 15% per year for construction starting later than this year. Additionally, alternative procurement methods, such as construction manager (CM) at risk, may increase the required budget.

- The HW portion of the existing system would remain in place as a backup or abandoned in place.
- The ceiling cassettes used in the main hall will be 'High Throw' cassettes. Standard velocity ceiling cassettes/wall mounted units would be used in all office spaces.
- New VRF system and ERVs can be installed with minimal structural and architectural work.
- Includes no "elective" scope for sub-projects that customer may wish to add to improve the overall building functionality and comfort, but that are not explicitly called out in this report as necessary to enable the heat pump retrofit.
- VRF condensing units would be placed at grade or on the front section roof. For mounting of ceiling cassettes as well as ERV ductwork in main hall, a review by a licensed structural engineer would be required to assess the condition of the roof and its ability to accept new loads.
- Excludes the cost to upgrade the building's electrical service and primary electrical infrastructure, as it appears it could be possible to incorporate the new electrification loads within the existing service capacity; however, this is a high-level assessment, and it is recommended that a licensed professional electrical engineer more thoroughly evaluate the existing infrastructure in preparing for any future phases of design and construction of new heat pump systems.
- Excludes weatherization and other building envelope improvements.
- No corrections of existing code violations, structural insufficiencies, or hazardous materials.

Given the volatile nature of construction costs in the current market, we recommend that the above estimates be considered preliminary budgets for purposes of vetting whether this building is a good candidate to proceed to the next phase of the process. In general, projects with a full set of design drawings and specifications are expected to have actual contractor bids within +/- 10 – 15% of a third-party cost estimator's projection. In this case, where the proposed system has not been designed, actual costs could vary by a much wider margin and the final design scope is likely to change and be refined as further investigation and coordination are completed in subsequent design phases.

DOMESTIC HOT WATER

As part of this effort, B2Q also reviewed the potential to replace the existing water heating equipment with domestic hot water heat pumps.

ECONOMICS SUMMARY

Table 10: DHW Heat Pump Economic Summary.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings	Estimated Annual Fossil Fuel Savings	Estimated Annual Energy Cost Savings	Opinion of Probable Cost
	tons	*tons*	*kWh*	*therms*	*$*	*$*
Heat Pump Water Heater	--	--	-4,990	574	-$530	$49,800
Percent of Baseline Usage - Heat Pump Water Heater			-4%	4%		

OVERVIEW

Domestic hot water (DHW) is provided to the building by (1) 40 MBH Bradford White RG250T6N natural gas fired water heater. This is a residential style water heater with a capacity of 50 gallons. The DHW heater appears to be relatively new and in good condition. Hot water from this system is used at handwashing sinks throughout the building and also in the kitchen area.

If the City is interested in decarbonizing the DHW system at this time, there is an option to replace the existing gas-fired DHW heaters and tanks with air-source heat pump water heaters with integral or separate storage tanks. These types of water heaters work most efficiently when installed in a relatively warm room, such as a boiler room, because they absorb heat from the ambient air. Installing them in colder storage rooms could cause them to run less efficiently. The existing location is beside the existing boilers for the building but in an area open to surrounding unconditioned basement areas. The suitability of the space would need to be determined in the next phase of project development.

We recommend considering an air-to-water heat pump water heater as a replacement when the existing equipment reaches its end of useful life, or if the DHW load in the building increases beyond the capacity of the existing equipment.

OPINION OF PROBABLE CONSTRUCTION COST

Table 11: DHW Heat Pump Opinion of Probable Construction Budget Cost.

Category	Estimated Budget
HVAC Equipment	$7,500
HVAC Piping, Ductwork, Other Materials	$6,500
HVAC Installation	$2,800
Electrical Branch Circuit Materials and Labor[1]	$7,100
Startup, Commissioning, TAB, Closeout	$2,800
Controls	$0
Engineering	$4,900
Contractor General Conditions & PM Labor	$12,200
Contractor Overhead & Profit	$2,600
Contingency	$3,400
Grand Total	**$49,800**

[1] Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs

Given the volatile nature of construction costs in the current market, we recommend that the above estimates be considered preliminary budgets for purposes of vetting whether this building is a good candidate to proceed to the next phase of the process. In general, projects with a full set of design drawings and specifications are expected to have actual contractor bids within +/- 10 – 15% of a third-party cost estimator's projection. In this case, where the proposed system has not been designed, actual costs could vary by a much wider margin and the final design scope is likely to change and be refined as further investigation and coordination are completed in subsequent design phases.

ELECTRICAL INFRASTRUCTURE

Table 12: Electrical Infrastructure Review Summary

Existing Conditions			Calculated Additional Peak Load	
Rated Capacity	Estimated Peak Demand	Available Spare Capacity	Air-to-Air Heat Pumps	DHW Heat Pump
A	A	A	A	A
800	258	542	299	67

As part of this study, B2Q performed a high-level preliminary review of the main electrical service and equipment at the Edward G. Connolly Center. The existing main switchboard is rated for 800A at 208V, 3-phase power. Peak demand data from utility bills indicate that the building's peak demand between 2021 and 2024 is 67 kW, which equates to approximately 258A, which includes an additional 25% of the metered peak demand in alignment with National Electric Code (NEC) requirements specified in section 220.87.

With approximately 542A of spare capacity, the electrical infrastructure appears to be able to support the heat pump option without a service upgrade. High-level calculations estimate additional loads of 299A for the air-to-air heat pumps and 67A from a DHW heat pump. Note that this electrical load review does not include the reduction in demand from removing the existing DX cooling equipment. Modifications may be necessary downstream of the main incoming service, though a more detailed study or design is required to enumerate and quantify the impact of the scope.

This review should be considered very preliminary given the limited, high-level scope of this study. Temporary metering should be included in the scope of a follow-on feasibility/design effort per the requirements of the NEC, as it will ultimately be required for any electrification option. This should involve a licensed professional electrical engineer to more thoroughly evaluate the available capacity and ability of the existing systems to accommodate the increased electrical loads.

Energy Conservation Measures

ECM-1: Implement Unoccupied Temperature Setpoints on AHUs

Table 13: ECM-1 Economic Summary

ECM-1: Implement Unoccupied Temperature Setpoints on AHUs				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
9,552	0	$2,388	$4,800	2.0

Base Case

Reviewing the BAS, B2Q identified that the units are currently set to operate 24/7. This means that the AHUs throughout the building are operating to maintain a constant temperature of 72°F during the cooling season in the main hall. As a result, these units are cycling on frequently, even during periods when the building is unoccupied, such as at night, on weekends, and during holidays. This continuous operation leads to unnecessary energy consumption, higher operational costs, and increased wear on the equipment.

All units serving the main hall and associated offices were also noted to have a 1°F deadband, which is causing the units to cycle on and off more than necessary during occupied periods.

Proposed Case

The proposed case proposes implementing an occupancy schedule for the building and implementing an unoccupied cooling setpoint of 78°F. During unoccupied periods, the AHUs will be programmed to allow the temperature in the space to rise to the unoccupied setpoint before they cycle on, significantly reducing the frequency of their operation. This adjustment is designed to reduce energy consumption while still ensuring that the building does not become excessively warm, making it easier to bring back to the occupied setpoint when necessary. Control strategies such as optimal start, as described in the BAS Upgrade ECM, can also help prepare the space in advance of the occupied period, utilizing predictive control algorithms that adjust the start time based on various factors, such as building occupancy, outdoor conditions, and how quickly the space can recover to occupied setpoint.

It is recommended to increase the occupied deadband to 4°F in order to allow less frequent cycling of the AHU equipment while still working to maintain a comfortable space temperature.

ECM-2: Optimize Boiler Operation

Table 14: ECM-2 Economic Summary

ECM-2: Optimize Boiler Operation				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
291	2,928	$3,733	$6,400	1.7

Base Case

As noted in the facility description, the building utilizes (2) Weil McLain Cast Iron Boilers, each with a rated output of 624 MBH, to provide hot water for heating throughout the building. These boilers are controlled through the BAS via relays and are enabled based on a call for heating.

B2Q reviewed the system's trend data and observed that, in most cases, both boilers were turning on within 1-2 minutes of each other, instead of allowing the lead boiler to activate first and assess whether one boiler could handle the load alone before the second boiler was needed. As can be seen in the trend below showing a two-week period in May 2024, both boilers appear to be cycling frequently and in operation together. This is occurring during relatively mild ambient conditions. Short cycling of boilers causes several issues such as:

- When a boiler frequently turns on and off, it's not operating long enough to reach an efficient operating level. Boilers consume more energy during startup, so frequent cycling increases energy usage and reduces overall system efficiency.
- Constantly turning the boiler on and off puts stress on its components, leading to faster wear and tear.
- Short cycling can cause uneven heating in a building because the system may not stay on long enough to distribute heat effectively. This leads to poor temperature control of the system.
- Boiler periodically perform blowdowns to remove accumulated impurities, such as dissolved solids, from the water. Frequent short cycling causes more frequent blowdowns, as each startup of the boiler involves some level of purging. This increases water losses as well as increased energy usage to heat the replacement water.

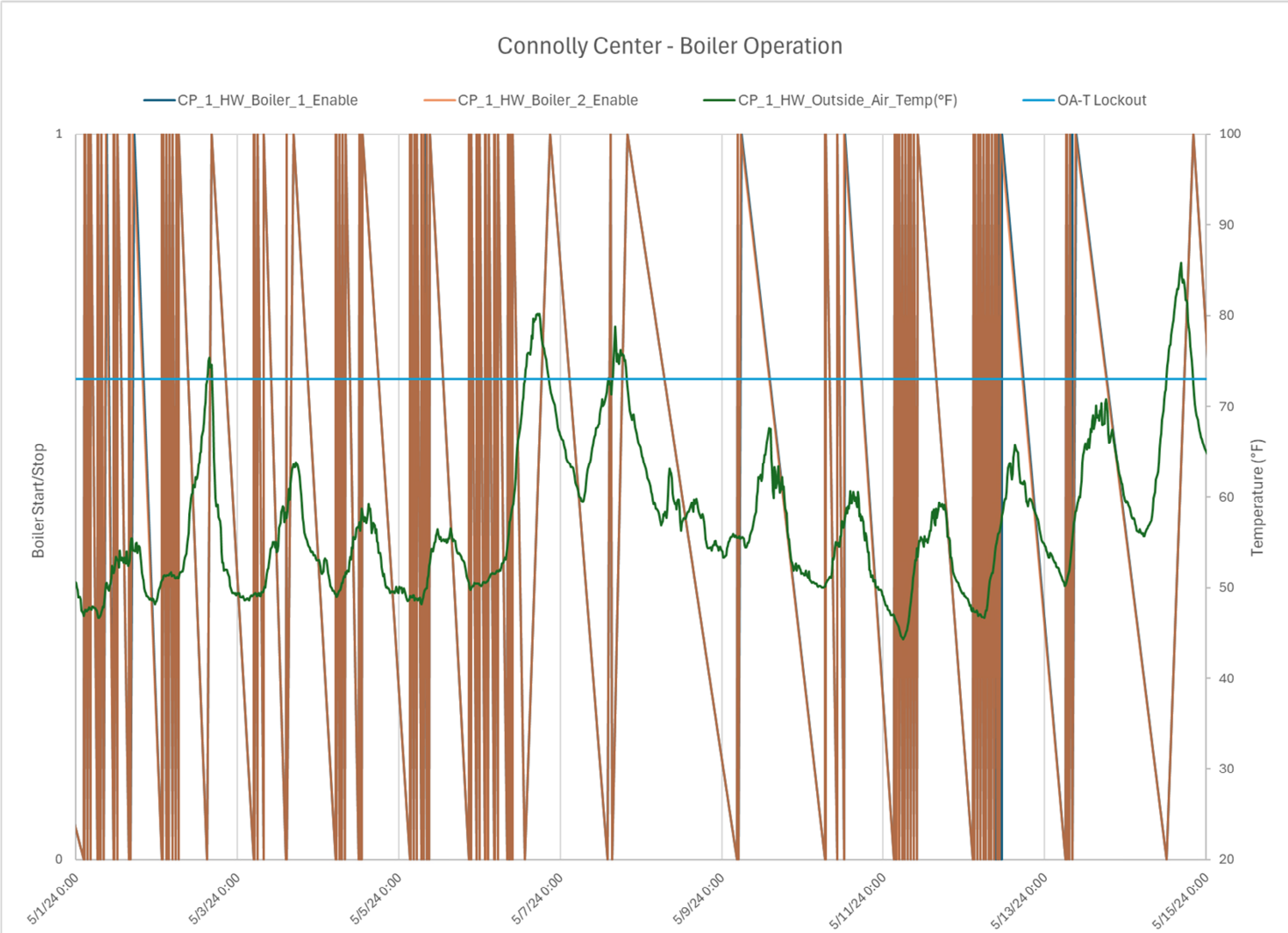

Figure 6: Trend from May 2024 showing both boilers being enabled together continuously. B-1 trend is under B-2 trend throughout the trend period shown.

Reviewing the space temperature setpoints for the system, it was noted that two of the three zones served by the boiler system have an occupied deadband of 1°F. This can lead to the boiler frequently cycling on and off in order to maintain that deadband from the occupied setpoint.

PROPOSED CASE

B2Q recommends revising the boiler staging programming to ensure the lag boiler is only being staged on as needed to maintain the temperature setpoints in the building. Further review may be required to determine if automated isolation valves are required to close off flow to the boiler which is currently not in operation.

B2Q also recommends revising the existing deadband setpoints for the heating system and adding time delays between stages in order to prevent frequent cycling of the boilers.

ECM-3: EC Motor Retrofit on Existing Motors

Table 15: ECM-3 Economic Summary

ECM-3: EC Motor Retrofit on Existing Motors				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
1,675	0	$419	$3,400	8.1

Base Case

As identified through drawings provided by the City and onsite assessments, we believe the all motors serving the AHUs, exhaust fans, and pumping systems are permanent split capacitor (PSC) AC motors. PSC motors operate at a fixed speed (unless retrofitted with a VFD), and their efficiency typically ranges from 50% to 65%. The efficiency loss is mainly due to the design of the motor, which relies on a capacitor to create a phase shift for starting torque.

Proposed Case

The proposed case for this measure would be to retrofit all existing PSC motors with electronically commutated (EC) motors. EC motors are more efficient than standard AC motors for many reasons including generally higher power factors, lower heat production reducing energy losses, fewer mechanical parts making them more reliable and requiring less maintenance over time, and can modulate speed without the need for a variable frequency drive (VFD). For the purposes of this measure, the savings shown represent the marginal efficiency improvement vs. the base case motor and do not include additional savings or additional cost associated with varying the motor speed. It is assumed that the motors can be directly replaced without modifications to any of the existing assemblies.

It is recommended that a full evaluation be performed to assess the number of motors within the building which would benefit from an upgrade to EC motors before proceeding further with this measure. The economics for this measure are based on upgrades of (2) exhaust fan motors and (2) AC unit motors.

ECM-4: BAS & DDC Upgrade

Table 16: ECM-4 Economic Summary

ECM-4: BAS & DDC Upgrade				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
8,255	456	$2,634	$107,000	40.6

Base Case

The current Building Automation System (BAS) at the facility is a basic, legacy system primarily focused on starting and stopping equipment and adjusting temperature setpoints. The system controls HVAC equipment via relay switches and has limited monitoring and control capabilities. The only temperature parameters currently monitored are the RTU discharge air temperatures and various space temperatures, with no control over dampers or other HVAC components. The current BAS offers minimal energy efficiency functionalities due to its limited control and monitoring capabilities. The lack of damper control and additional temperature sensors results in a system that operates on a basic level, without the ability to optimize energy use based on real-time data.

Proposed Case

B2Q recommends enhancing the existing controls by taking control of components such as outside air dampers, return air dampers, with direct digital control (DDC) devices as well as adding additional sensors to the system including return air temperature, return air humidity, mixed air temperature. This upgrade should also include upgrading the existing infrastructure of the BAS, which would include the installation of a new supervisory controller to which the new field equipment controllers will be tied back. The upgraded BAS allows for more precise control, faster communication, improved monitoring and remote capabilities via the user interface, more reliable hardware, easier integration with third party devices, and advanced energy saving sequence of operations such as optimal start/stop, economizer, demand-controlled ventilation and supply air temperature resets.

ECM-5: Weatherization

Table 17: ECM-5 Economic Summary

ECM-5: Weatherization				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
--	--	--	--	--

** Please reference previous weatherization investigation completed by weatherization contractor on the City of Everett's behalf for project economics*

Base Case

A building weatherization audit was completed at the Connolly Center by a weatherization contractor in September 2023. Their report was made available to B2Q, and identified many areas of infiltration, primarily around doors, windows, and ceiling-wall junctions.

B2Q identified additional areas which warrant attention including sealing of windows above the drop ceiling, no thermal barrier between the unconditioned basement and the conditioned first floor, and damage to the exterior envelope of the building.

Figure 7: Window found with opening above ceiling tile grid allowing infiltration of outside air

Figure 8: Damage to exterior wall of main hall exposing existing insulation

Figure 9: Unconditioned basement area with opening to conditioned first floor area

Proposed Case

The City of Everett's weatherization contractor proposed the following weatherization improvements to the building to address the above issues:

- Weatherstrip around (10) exterior doors
- Air-seal perimeters of windows and ceiling-wall junctions
- Install additional insulation in the attics

To complete the proposed work to the main hall, the ceiling grid will need to be removed with all furniture either to be moved or covered. If the City's intention is to replace the existing roof in the near term as well as upgrade the HVAC system, B2Q recommends that these efforts be looked at in parallel rather than as standalone projects to minimize the number of lengthy disruptions to the building. Utilizing spray foam insulation on the existing roof can be a cost-effective way to improve thermal performance but if the roof needs replacement, then installing a new roof with integrated insulation could be a better long-term solution. It also will allow for any structural issues to be identified and remedied which may be required as part of any solar PV and heat pump upgrade project.

ECM-6: Lighting Improvements

Table 18: ECM-6 Economics Summary

ECM-6: Lighting Improvements				
Electric Use Savings	Gas Use Savings	Annual Cost Savings	Measure Cost	Simple Payback
kWh	therms	$/yr	$	yrs
4,217	0	$1,054	$15,200	14.4

Base Case

During our site walkthrough, B2Q noted that the basement area still utilizes incandescent lighting fixtures. Although this is not an occupied space, it is often accessed for storage purposes or to monitor the boiler operation and the lights appear to be left on in some cases.

The remainder of the building appears to have had its lighting fixtures upgraded to LED. The office areas in the front portion of the building were noted to have ample window area and sun exposure, however, there didn't appear to be any daylight dimming controls in place.

Proposed Case

In the proposed case, B2Q recommends implementing an LED retrofit for all non-LED fixtures within the building.

B2Q also recommends further evaluating the implementation of and occupancy sensors where possible for the offices located in the front section of the building. Daylight dimming controls are designed to optimize energy efficiency by adjusting artificial lighting levels based on the amount of natural daylight available. The controls automatically dim or brighten the artificial lights to maintain a consistent lighting level. Occupancy sensors automatically turn lights on or off based on the presence or absence of people in the space. These controls can also be integrated into a Building Automation System (BAS) if desired. Depending on the age of the existing fixtures, it may be easier and more cost effective to replace the whole fixture with a new on that includes factory-mounted sensors to simplify the controls and avoid a potentially troublesome interconnection between fixture power and the separate sensor.

As a next step for this measure, the City of Everett should engage with National Grid to have a lighting audit performed by an approved contractor for the building to provide a full scope and costs.

FIM-1: Add Makeup Air Unit to Kitchen Ventilation System

Base Case

During the site walkthrough, B2Q noted that there was no makeup air unit (MAU) serving the kitchen area. Ventilation systems for kitchens typically include exhaust fans that remove heat, smoke, grease, and cooking odors. However, if the kitchen operates with an exhaust-only system, it can create negative air pressure, which can lead to several issues. Without a MAU it can cause a significant imbalance with airflow and pressure in the space.

In the absence of makeup air, conditioned air is drawn from the hall area or infiltration from outdoors to replace the exhausted air. This results in increased energy consumption as the HVAC system requires a higher percentage of outside air for minimum ventilation and therefore uses more energy.

Proposed Case

B2Q recommends adding a MAU to the current kitchen ventilation system. Installing a MAU will introduce fresh, tempered air into the kitchen to offset the amount of air being exhausted. This can help balance air pressure, improve ventilation efficiency, enhance indoor air quality, and increase energy efficiency.

This measure has been listed as a Facility Improvement Measure (FIM) as the base case is using less energy by not having a MAU which is causing poor occupancy comfort and temperature control as a result. The addition of the MAU in the proposed case offsets the improvements made with the ventilation system to improve overall operating efficiency.