REDACTED

250 Freight Street Waterbury – SCOPING STUDY

Utility/Site Contacts

[redacted]
Supervisor, Facilities
Eversource Energy
[redacted]

Justin Marmaras
Principal
QGM Consulting
860-515-6331
m@qgmconsulting.com

Padraic Hagan
Senior Energy Advisor
QGM Consulting
860-634-6298
phagan@QGMconsulting.com

Austin Malik
Associate Energy Advisor
QGM Consulting
austin.malik@qgmconsulting.com

Executive Summary

QGM Consulting (Padraic Hagan, & Austin Malik) conducted an energy efficiency scoping study at an Eversource Connecticut building located at 250 Freight Street in Waterbury, CT on Wednesday, September 25th, 2024. QGM analyzed the site's electric and natural gas use as well as associated Greenhouse Gas emissions. Objectives were to identify and quantify potential Energy Efficiency Measures (EEMs) for site energy reduction and estimated Greenhouse Gas reductions for corporate initiatives or targets.

Included in this report is a list of potential EEMs with savings and implementation cost estimates. Please note that the values presented in this report are meant to provide an order of magnitude and are not final values or guarantees for the determination of the incentives. A measure summary is provided in the table below. These are the initial measures identified during the brief walk through, additional measures are possible with more time on site. Simple paybacks do not include potential incentives or any non-energy benefits that may include maintenance savings, labor savings, water savings, etc.

QGM - 250 Freight Street - Scoping Study Measure Summary								
EEM#	Energy Efficiency Measure (EEM)	Estimated Annual Cost Savings	Estimated Annual Energy and GHG Savings			Potential GHG Reduction	Estimated Project Cost	Simple Payback
#	Description	$	kWh	CCF	GHG (MT CO2e)	% Site GHG	$	years
1	Repair Compressed Air Leaks in Garage	$471	3,300		1.0	0.3%	$225	0.5
2	Additional Lighting Controls - Motion/Occ & Dimming	$2,142	15,000		4.4	1.3%	$50,000	23.3
3	BMS Upgrade - Scheduling and AOSS	$17,395	91,000	4,000	48.5	14.0%	$200,000	11.5
4	BMS Upgrade - Demand Control Ventilation	$877	4,600	200	2.4	0.7%	$10,000	
5	Occupancy Scheduling for Intermittent Use Areas	$1,615	9,000	300	4.3	1.2%	$5,000	3.1
6	Building Envelope	$3,627	15,000	1,350	11.8	3.4%	$30,000	8.3
7	Building Heating Electrification	n/a	(193,000)	16,000	32.0	9.2%	$1,500,000	n/a
TOTAL		**$26,127**	**137,900**	**5,850**	**72.4**	**21%**	**$295,225**	**11.3**

Note that Measure (7) – Building Heating Electrification is presented as a GHG emissions reduction measure, with minimal or no direct energy or cost savings associated.

REDACTED

General Facility Description

The site has approximately 118,000 square feet of total space in (1) main building and an adjacent shop. The facility includes offices/administration, garage/ repair areas, warehouse, and storage, and original construction date was 1907.

Approximately 25,000 SF of the building space is in current use, with 2nd Floor offices and other spaces shuttered. Space temperature and humidity are controlled even in the shuttered spaces to mitigate humidity issues.

The facility operates a regular schedule, with typical staff occupancy Monday – Friday 6:00 AM – 6:00 PM, and occasional weekend hours. Critical support areas were noted to have 24/7 staffing – this is understood to be minimal at this site. Annual hours are estimated at ~3,500 hours/year.

HVAC Systems Description
HVAC systems consist primarily of water source heat pumps (WSHPs) throughout conditioned spaces and (1) additional roof-mounted (MAU). Heat is rejected from the WSHP loop via a roof mounted cooling tower loop. Heat is provided via the basement boiler plant consisting of natural gas and electric boilers.

The Building Management System is no longer functioning. Replacement is planned.

Site Lighting Description
Site lighting has been replaced within the last few years with controls-integrated LED fixtures. Lighting serving occupied areas is not currently programmed for motion/occupancy, scheduling, or dimming, relying on manual controls.

Site Production and CAIR Equipment Description
Site garage and repair areas contain typical hoists, air and electric tools, and powered washing equipment.

Garage utilizes a 10hp Quincy reciprocating compressor. Compressed air is used for garage air tools, air pumping, and minor tank pressurization.

Monthly Billing Analysis

Historical electrical and natural gas use for the past three years is reviewed below. The site has (1) electric and (1) natural gas meter. Due to the type of site and use accounting, historical records for this site are annual use only. $0.1428/kWh was used as an electric rate based upon Eversource Facilities' third-party electric supply costs for similar type facilities.

An annual summary of the most recent year can be seen below:

REDACTED

Existing Building Baseline Most Recent 12 Month Total						
Energy Usage and Costs	Costs		Energy		Unit Cost ($/kWh, $/CCF)	CO2 Emitted (MT)
	Amount - $	% of Total	Amount - CCF, kWh	% of Total		
Natural Gas (CCF)	$ 17,546	12%	15,951	37%	$1.10	88
Electric Energy (kWh)	$ 127,365	88%	891,911	69%	$0.143	124
TOTAL	**$144,911**	**100%**		**106%**		

Natural gas is noted to be lower than would otherwise be expected for this building footprint and occupancy/operations at this site due to use of WSHPs for heating.

The energy use intensity (EUI) shown below calculated in kbtu/sf is an indicator of building performance in terms of energy use per building square foot:

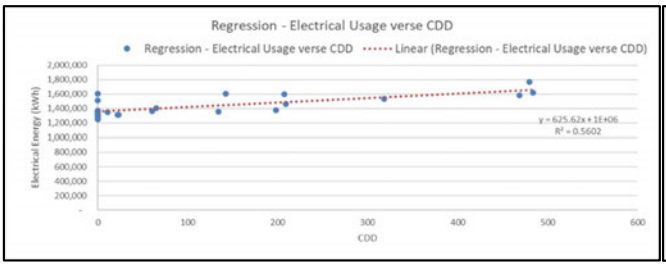
Building Energy Use Intensity (EUI)			
Utility	Site EUI	Source EUI	Unit
Natural Gas	14	15	kbtu/sf
Electricity	26	72	kbtu/sf
TOTAL	**40**	**87**	**kbtu/sf**

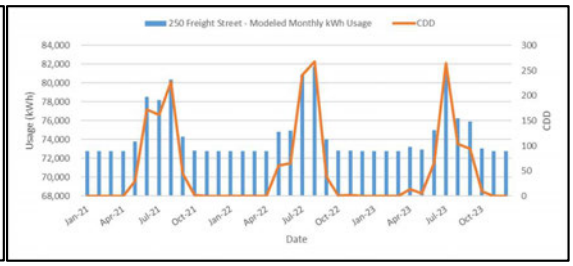
Source-site ratio per national average, source:
https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf

The EUI metric can be used to baseline existing energy use for future comparison or to compare to similar buildings, though it should be noted the EUI does not consider production levels.

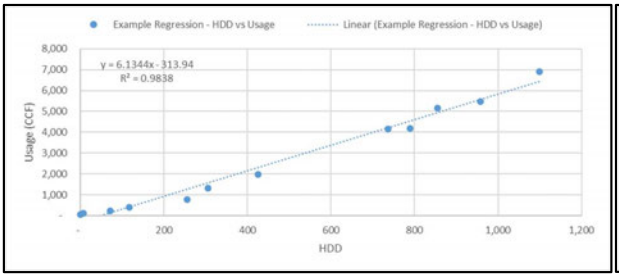
Lacking monthly use data, profiles for electricity and natural gas were modelled for this site using provided annual metered totals and linear regression models developed from similar sites. Regression models based on weather impact from similar buildings/operations were used to provide basic linear regression equations for heating and cooling, which were then scaled for total use and building footprint and used to estimate monthly use. A building was selected with some garage/process electrical use to reflect the garage/repair operation at the site, as well as a significant summer cooling load. Some variability would be expected in the non-cooling season baseline use due to production volume fluctuation as well as WSHP electrical heating – the flat result is due to the use of a cooling weather-impact regression equation to model use.

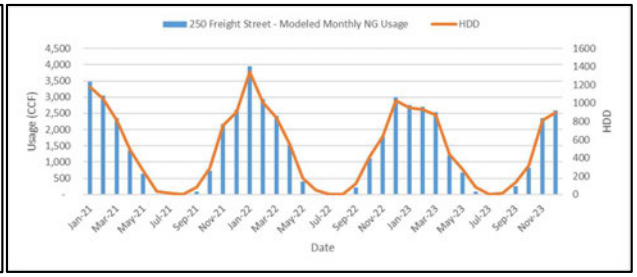
Below are graphs showing the example regression used and the resulting modeled monthly electrical use:





Similar analysis was performed for natural gas use, as seen below:





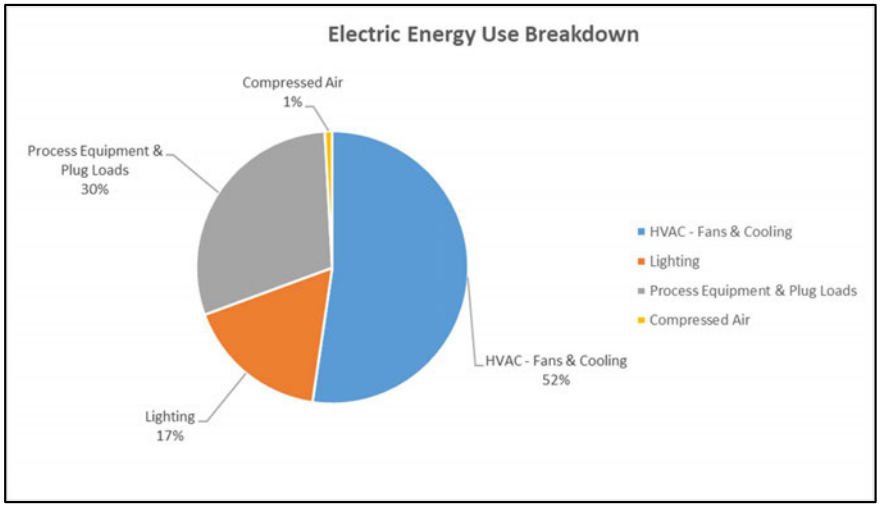
As above, modeled use would expect to show some variability. The use of a weather-impact regression equation creates a model with a close correlation.

Based on these models, estimated monthly use breakout is shown in the table below:

Monthly Utility Bill Summary									
Electric					Natural Gas				
Month	CDD (Balance Point 65 °F)	Billed Energy (kWh)	Total Electric Cost	Blended Rate ($/kWh)	Month	HDD (Balance Point 65°F)	Billed Usage (CCF)	Estimated Total Cost ($)	Average Blended Rate ($/CCF)
Jan-23	-	72,772	$ 10,392	$ 0.14	Jan-23	949	2,753	$ 3,028	$ 1.10
Feb-23	-	72,772	$ 10,392	$ 0.14	Feb-23	931	2,698	$ 2,968	$ 1.10
Mar-23	-	72,772	$ 10,392	$ 0.14	Mar-23	875	2,526	$ 2,779	$ 1.10
Apr-23	14	73,241	$ 10,459	$ 0.14	Apr-23	443	1,201	$ 1,322	$ 1.10
May-23	5	72,939	$ 10,416	$ 0.14	May-23	274	683	$ 752	$ 1.10
Jun-23	66	74,986	$ 10,708	$ 0.14	Jun-23	78	82	$ 90	$ 1.10
Jul-23	264	81,627	$ 11,656	$ 0.14	Jul-23	-	-	$ -	$ -
Aug-23	104	76,260	$ 10,890	$ 0.14	Aug-23	14	-	$ -	$ -
Sep-23	94	75,925	$ 10,842	$ 0.14	Sep-23	136	260	$ 286	$ 1.10
Oct-23	9	73,074	$ 10,435	$ 0.14	Oct-23	317	815	$ 897	$ 1.10
Nov-23	-	72,772	$ 10,392	$ 0.14	Nov-23	816	2,345	$ 2,580	$ 1.10
Dec-23	-	72,772	$ 10,392	$ 0.14	Dec-23	895	2,587	$ 2,846	$ 1.10
TOTAL		**891,911**	**$ 127,365**	**$ 0.14**	**TOTAL**		**15,951**	**$ 17,546**	**$ 1.10**

Mechanical System Energy Use Breakdown

Based on the initial walk-through, the following electric energy use breakdown was developed. These results are considered high level at this point by using motor nameplates, typical load factors and estimated operational hours. Actual data logging is required to confirm these assumptions.



End Use Breakdown - Electricity	
Electric End Use	**Energy Use (kWh)**
HVAC - Fans & Cooling	466,309
Lighting	152,000
Process Equipment & Plug Loads	265,000
Compressed Air	7,833
TOTAL	**891,142**

HVAC Equipment:

To calculate the breakout of energy use described above, the following equipment data was used to estimate equipment loads and use (capacities estimated for units with worn nameplates):

250 Freight Street HVAC Equipment List										
Site ID #	**Type**	**Manufacturer**	**Model**	**Serial #**	**Fan hp**	**Fan CFM**	**Cooling capacity (Tons)**	**Heating Capacity (MBH)**	**VFD (1,0)**	**Notes**
Mult.	WSHPs				1	2,000	2	24	1	Throughout offices
MAU	MAU	Econaire	EARTU1-150-6T-ERV		3	1,700	5.8	121	1	Rooftop
CT	Cooling Tower	BAC		N230737902-01-01	7.5				1	CHWPs on VFDs
B-1	Boiler	Bradford White	BNTH750NJN3	G23563932				724	1	HWPs on VFDs
B-2	Boiler	Bradford White	BNTH750NJN3	G23589854				724	1	HWPs on VFDs
B-3	Boiler	Indeeco	7U-150U-GHJV1					512		Electric
EUH-1	EUH	Chromalox			0.25			3.5		Shop, Electric
EUH-2	EUH	Chromalox			1.25			3.5		Shop, Electric
EUH-3	EUH	Chromalox			2.25			3.5		Shop, Electric
EUH-4	EUH	Chromalox			3.25			3.5		Shop, Electric
EUH-5	EUH	Chromalox			4.25			3.5		Shop, Electric
EUH-6	EUH	Chromalox			5.25			3.5		Shop, Electric
EUH-7	EUH	Chromalox			6.25			3.5		Shop, Electric
EUH-8	EUH	Chromalox			7.25			3.5		Shop, Electric
EUH-9	EUH	Chromalox			8.25			3.5		Shop, Electric
EUH-10	EUH	Chromalox			9.25			3.5		Shop, Electric

Lighting Equipment:

Lighting was noted to be LED, primarily modern controls-integrated fixtures. Fixtures have integrated controls, which are not currently in use for occupied areas.

Compressed Air Plant:

Site current operates (1) 10hp Quincy reciprocating air compressor with an estimated max capacity of 43 SCFM at 100 psig. Unit was observed to be lightly loaded.

Best Practices

Site was observed during the assessment walkthrough to be observing the following energy Best Practices:

- LED lighting in most/all areas
- Condensing boilers in hot water applications
- ERV makeup air unit

REDACTED

Recent Energy Efficiency Projects Overview

The site has completed several energy efficiency projects in recent years. Listed below are some of the various energy projects:

- Upgrade to LED Lighting
- Installation of WSHPs for space heating and cooling
- Upgrades to energy-savings equipment on replacement

With the Best Practices and projects described above, the identification of additional energy efficiency measures (EEMs) and sustainability projects during the time of the survey was challenging. Some potential recommendations are outlined below that may require some additional analysis and monitoring.

Site Energy Efficiency Measures/Recommendations

EEM - 01 – Compressed Air Leak Repair

The site currently operates a 10hp Quincy reciprocating air compressor with a max capacity of ~45 SCFM at 100 psig, which appears to satisfy the plant air demand most/all of the time. Pictures below show detail:



Garage/shop air compressor



Air end-use in garage/shop

Compressed air end uses at this site include equipment pressurization, CNC/machine tool use, bench tools, and air guns.

The most likely sources of non-value-add (NVA) compressed air use for this site are unplanned leaks. (3) unplanned leaks were identified via audible leak noise and ultrasonic tool and quantified by hand during the course of the assessment, as noted in the pictures below:

REDACTED



Compressed air leak at elbow on connector at base of compressor



Compressed air leak at connector for hose leading to air pump



Compressed air leak at seal on top of air pump

Table below estimates cost and savings from this measure:

Repair Compressed Air Leaks			
Description	Value	Unit	Note
Volume of air leaks identified	1.5	cfm	
kWh savings per year	3,300	kWh	
Annual cost savings per year	$ 471	$	
Estimated annual GHG savings	1.0	MT CO2e	@ 0.0055 MT/CCF & 0.000291 MT/kWh
Cost to repair air leaks (assume $150/cfm)	$ 225	$	
Simple Payback (no incentives)	**0.5**	**yrs**	
Estimated $/ Lifetime MT CO2e	**$ 47**	**$**	**Estimated 5 year measure life**

QGM CONSULTING

Data logging is often recommended to confirm compressor loading assumptions and leak rate. However, the size of the CAIR plant (10 – 15hp total) suggests that additional study is not economical. Site is encouraged to repair all identified leaks, either through a local compressed air vendor, or internally.

EEM – 02 – Lighting Controls

The site was observed to have recently installed modern LED lighting. Existing lighting controls include motion control and dimming but are reported to be currently manually controlled in occupied areas. Site is recommended to pursue the following for more efficient, better controlled lighting:

- Programming and/or commissioning of controls to enable scheduling, full occupancy control, task-tuning, and dimming

Existing and proposed site lighting use were estimated via lighting density estimates and burn hours. The table below details estimated savings and costs from this measure:

Consider Motion/Occupancy and Dimming Controls for Fixtures			
Description	**Value**	**Unit**	**Notes**
Estimated Average Lighting Demand	13	kW	
Annual Burn Hours	3,000	hours	
Estimated Annual Lighting Energy Usage	38,000	kWh	
Proposed Average Lighting Demand, with Controls	8	kW	Motion and dimming
Annual Burn Hours	3,000	hours	
Proposed Annual Lighting Energy Usage, with Controls	23,000	kWh	
Estimated Annual Lighting Energy Savings	15,000	kWh	
Estimated Annual Cost Savings	**$ 2,142**	**$**	**@ $0..1428/kWh**
Estimated Annual GHG Savings	4.4	MT CO2e	@ 0.0055 MT/CCF & 0.000291 MT/kWh
Estimated Installation Cost	$ 50,000	$	Programming/Commissioning
Simple Payback (with incentive)	**23.3**	**$**	
Estimated $/Lifetime MT CO2e	**$ 1,145**	**$**	**estimated 10 yr measure lifetime**

Next steps for this measure are to discuss retrofit and/or programming of new controls strategies with a local lighting vendor.

EEM – 03 – Building Management System – Scheduling and AOSS

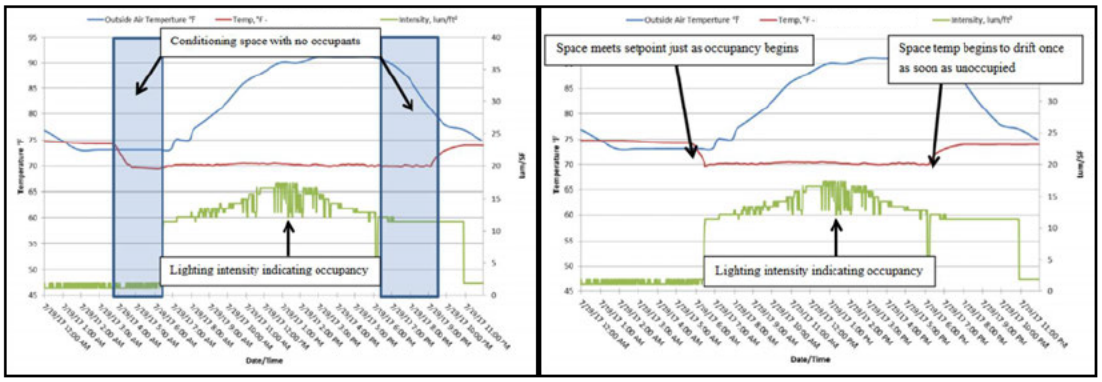
The site currently uses an aged INet Building Management System (BMS) for all HVAC controls. The system is understood to be failing, with limited to no capability and functionality. The site is strongly recommended to move forward with plans to replace the failing system with a new DDC, remote-access capable BMS with ability to:

- Handle detailed scheduling by area/unit – with temporary overrides and ability to revert back
- Adaptive Optimal Start-Stop (AOSS) – help building with heating/cooling schedules

Adaptive/Optimal Start/Stop (AOSS) is a control sequence available within modern Building Management Systems. AOSS allows the control system to iteratively “learn” the most optimal times to start up heating or

cooling equipment so that the space is conditioned just as it becomes occupied. The example below is historical data from an example building, with the blue curve representing outdoor air temperature, the red curve, space temperature, and the green series lighting intensity (indicating occupancy).

The blue rectangles highlight the unnecessary long equipment ramp up and cool down periods in the "before" graph, while in the "after" graph with AOSS enabled, the equipment enables precisely and only when needed to meet setpoint once occupancy begins:



New BMS savings estimates below assume site would be able to:

- effectively schedule setback or equipment shutdown hours
- Optimize scheduling and startups via AOSS

Table below shows estimated cost and savings from the installation of a new BMS:

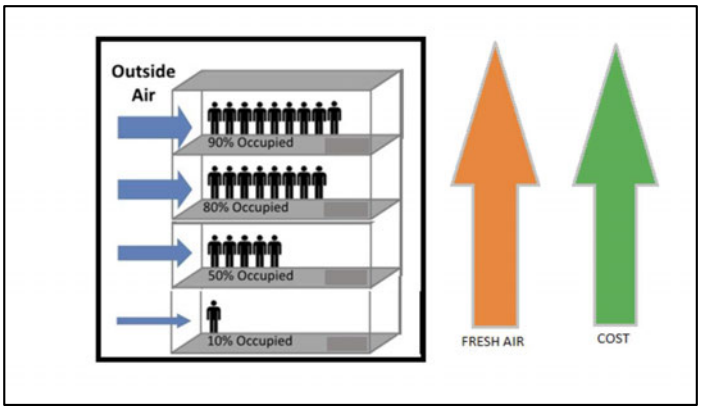
REDACTED

BMS Upgrade - Scheduling & Adaptive Optimal Start Stop			
Description	**Number**	**Unit**	**Notes**
Building footprint, SF	25,000	SF	Occupied areas only
Average Ceiling Ht, Ft	10	LF	Average
Estimated office volume, CF	250,000	CF	
Typical Air Change per Hour (ACH)	2	ACH	
Estimated Average Outdoor Air Intake, CFM	8,333	CFM	
Estimated Existing Operation			
Estimated Annual Cooling Energy	58,000	kWh	
Estimated Annual Natural Gas Heating Energy	7,000	CCF	
Estimated Annual Electric Heating Energy	162,000	kWh	WSHPs
Proposed Operation			
Proposed Annual Cooling Energy	48,000	kWh	
Proposed Annual Natural Gas Heating Energy	3,000	CCF	
Proposed Annual Electric Heating Energy	81,000	kWh	
Estimated New Control Strategy Savings			
Estimated Annual Electrical Savings	91,000	kWh	
Estimated Annual Natural Gas Savings	4,000	CCF	
Estimated Annual Cost Savings	**$ 17,395**	**$**	**@$0.1428/kWh and $1.10/CCF**
Change Cost - Upgrade BMS	**$ 200,000**	**$**	
Simple Payback - no incentives	**11.5**	**yrs**	
Estimated Annual GHG Reduction	**49**	**MT CO2e**	
$/Lifetime GHG Reduction	**$ 412.19**	**$/MT CO2e**	**10 year measure life**

Recommended next steps for this project involve working with a local vendor to develop a controls scope of work and cost quotation and move forward with the installation.

EEM – 04 – Building Management System – Demand Controlled Ventilation

The site is not currently able to control the introduction of outside air with existing (failing) HVAC controls. For additional HVAC control and energy optimization, site is recommended to consider Demand Controlled Ventilation (DCV) on the DOAS makeup air unit. DCV works by modulating the outdoor air intake to only what is needed to satisfy the space occupancy. As the graphic below illustrates, a higher occupant load requires more outdoor air and higher HVAC costs, while lower (or no) occupant load requires less (or even no) outdoor air:



Demand Control Ventilation (DCV) uses CO2 sensors in the space and/or return airstream to monitor the level of CO2 in the space and modulate RTU outdoor air dampers to introduce only as much outdoor air as needed. Sites are commonly found to be introducing significant excess outdoor air, well beyond any occupant requirements – outdoor air dampers often come from the factory set at 20 – 50% without any ability to modulate.

Table below shows estimated cost and savings from the installation of DCV controls on (4) RTUs:

Consider Switching Makup Air Unit to Demand Control Ventilation			
Description	**Value**	**Unit**	**Notes**
Existing Electric Load - Cooling and Heating	7,400	kWh	WSHPs
Existing Natural Gas Heating Load	300	CCF	w/ ERV
Proposed Demand Controlled Electric Load	2,800	kWh	w/ ERV
Proposed Demand Controlled Heating Load	100	CCF	w/ ERV
Estimated Demand Control Savings (Electric)	4,600	kWh	w/ ERV
Estimated Demand Control Savings (Natural Gas)	200	CCF	w/ ERV
Estimated Annual Cost Savings	**$ 877**	**$**	**@$0.1428/kWh and $1.10/CCF**
Estimated Annual GHG Reduction	2.4	MT CO2e	@ 0.0055 MT/CCF & 0.000291 MT/kWh
Estimated Cost to Upgrade	$ 10,000	$	Programming, RTU dampers/actuators
Simple Payback	**11.4**	**$**	
Estimated $/Lifetime MT CO2e	**$ 410**	**$**	**estimated 10 yr measure lifetime**

Recommended next steps for this project involve working with a local vendor to develop a controls scope of work and cost quotation, moving to implement this measure as a facet of the planned BMS upgrade/installation.

EEM - 03 – Control Intermittently Occupied Spaces Heating and Cooling via Occupancy

An innovative control strategy noted in use at the Berlin Eversource campus is the control of site main Auditorium HVAC equipment based on an occupancy schedule. This space sees highly variable occupancy, particularly post-COVID. Setting other similar spaces to unoccupied setpoints for significant periods of non-use (much as many sites do with lighting) reduces the associated energy expenditure, while allowing a quick recovery for event use.

REDACTED

It was noted during the assessment that the site Auditorium could likely utilize this type of scheduling, with possibilities in conference rooms and other areas.

The example below summarizes a potential before and after schedule – assuming average consistent use in the 10 AM – 2 PM period of weekdays. This model is likely conservative; many of these spaces are experiencing virtually no use and could remain in unoccupied mode for the majority of the operating schedule.

Intermittent Spaces HVAC Operation - Existing and Proposed with Occupancy Control															
Existing - Typcial Schedule								Proposed - Occupancy Control							
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday		Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
12:00 AM								12:00 AM							
1:00 AM								1:00 AM							
2:00 AM								2:00 AM							
3:00 AM								3:00 AM							
4:00 AM								4:00 AM							
5:00 AM								5:00 AM							
6:00 AM		X	X	X	X	X		6:00 AM							
7:00 AM		X	X	X	X	X		7:00 AM							
8:00 AM		X	X	X	X	X		8:00 AM							
9:00 AM		X	X	X	X	X		9:00 AM							
10:00 AM		X	X	X	X	X		10:00 AM		X	X	X	X	X	
11:00 AM		X	X	X	X	X		11:00 AM		X	X	X	X	X	
12:00 PM		X	X	X	X	X		12:00 PM		X	X	X	X	X	
1:00 PM		X	X	X	X	X		1:00 PM		X	X	X	X	X	
2:00 PM		X	X	X	X	X		2:00 PM		X	X	X	X	X	
3:00 PM		X	X	X	X	X		3:00 PM							
4:00 PM		X	X	X	X	X		4:00 PM							
5:00 PM		X	X	X	X	X		5:00 PM							
6:00 PM		X	X	X	X	X		6:00 PM							
7:00 PM								7:00 PM							
8:00 PM								8:00 PM							
9:00 PM								9:00 PM							
10:00 PM								10:00 PM							
11:00 PM								11:00 PM							
Occ Hrs	0	13	13	13	13	13	0	Occ Hrs	0	5	5	5	5	5	0
UnOcc Hrs	24	11	11	11	11	11	24	UnOcc Hrs	24	19	19	19	19	19	24

Implementation of this strategy should be possible via programming within the proposed BMS and the addition of occupancy sensors. Table below shows estimated cost and savings from the implementation of this type of control:

QGM CONSULTING

Occupancy Control of Intermittent Use Spaces			
Description	**Number**	**Unit**	**Notes**
Building footprint, SF	5,000	SF	Estimated area affected
Average Ceiling Ht, Ft	10	LF	Average
Estimated office volume, CF	50,000	CF	
Typical Air Change per Hour (ACH)	1.75	ACH	
Estimated Average Outdoor Air Intake, CFM	1,458	CFM	
Estimated Existing Operation			
Estimated Annual Cooling Energy	8,000	kWh	
Estimated Annual Natural Gas Heating Energy	500	CCF	
Estimated Annual Electric Heating Energy	13,000	kWh	WSHPs
Proposed Operation			
Proposed Annual Cooling Energy	7,000	kWh	
Proposed Annual Natural Gas Heating Energy	200	CCF	
Proposed Annual Electric Heating Energy	5,000	kWh	
Estimated New Control Strategy Savings			
Estimated Annual Electrical Savings	9,000	kWh	
Estimated Annual Natural Gas Savings	300	CCF	
Estimated Annual Cost Savings	**$ 1,615**	**$**	**@$0.1428/kWh and $1.10/CCF**
Change Cost - Programming	**$ 5,000**	**$**	
Simple Payback - no incentives	**3.1**	**yrs**	
Estimated Annual GHG Reduction	**4**	**MT CO2e**	
$/Lifetime GHG Reduction	**$117.04**	**$/MT CO2e**	**10 year measure life**

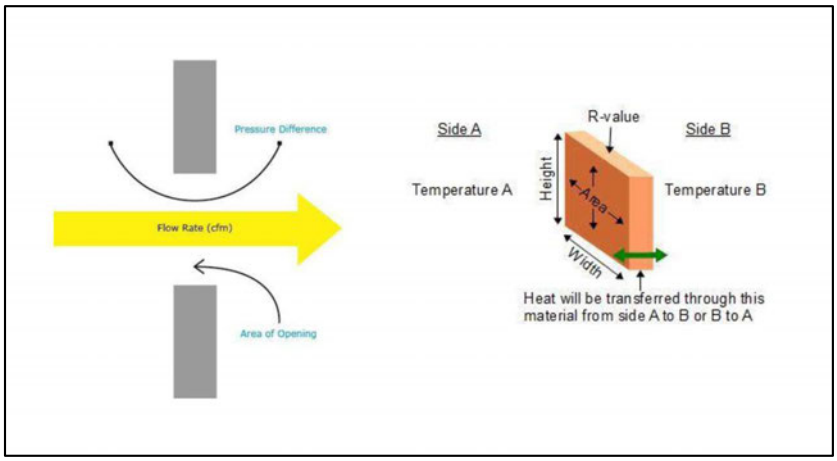
Recommended next steps for this project involve working with controls vendor to develop a scope of work and cost quotation, then working to implement as a facet of BMS installation/upgrade.

EEM – 06 – Building Envelope

Age of the building was noted during site walkthrough. Relatively low heating energy use indicates the structure is sound and retains heat well, and staff is active in reducing unneeded air infiltration and movement via sealing ducts and openings not in use.

Aged doors, garage area bay doors, windows, and building plane transitions (e.g., roof/wall joint) likely have deteriorated seals simply due to building age.

Diagram below summarizes the possible heat transfers due to infiltration and thermal envelope deficiencies:



Site is recommended to engage with a vendor to perform a full building shell assessment of the site and to follow the recommendations regarding thermal envelope and air infiltration. The table below shows a high-level estimate of potential cost and savings from this measure:

Building Shell Savings Calculation			
Description	**Value**	**Unit**	**Notes**
Existing Electric Heating and Cooling Load	102,000	kWh	
Existing Natural Gas Heating Load	7,250	CCF	
Proposed Electric Heating Cooling Load	87,000	kWh	
Proposed Natural Gas Heating Load	5,900	CCF	
Estimated Building Shell Remediation Savings (Electric)	15,000	kWh	
Estimated Building Shell Remediation Savings (Natural Gas)	1,350	CCF	
Annual Cost Savings	**$ 3,627**	**$**	**@ $0.1428/kWh & $1.10/CCF**
Estimated Annual GHG Reduction	11.8	MT CO2e	@ 0.0055 MT/CCF & 0.000291 MT/kWh
Estimated Install Cost	$ 30,000	$	Including survey cost
Simple Payback	**8.3**	**$**	
Estimated $/Lifetime MT CO2e	**$ 170**	**$**	**estimated 15 yr measure lifetime**

Next steps involve working with a local vendor to obtain a building shell assessment and recommendations, determining path forward with regard to performing remediations, then working with a local vendor to remediate gaps and cracks.

EEM – 07 – Building Heating Electrification

Existing heating and cooling are primarily via WSHPs, served for heating by basement boiler plant. This system is both efficient and has shifted a portion of the building heating load to electricity. Backup boiler is additionally electric – the 150 kW boiler is reported to be able to meet WSHP loop heating needs for some portions of the year. This site has made great strides towards electrification of heating loads.

Full heating electrification could potentially be achieved with the installation of larger (heat pump) electric boilers to replace the primary natural gas fired boilers. Note that existing boilers are condensing (high efficiency)

REDACTED

and recent installation, and such and addition to the building electric load would require additional electrical service to the building at significant cost.

Heat pump boiler technology is available. However, boilers at the size required to meet the WSHP loop demand are likely not on the market yet, or at significant cost if available. Site would need to stage multiple boilers with associated plumbing to meet heating loop needs. In addition to the equipment cost and additional electrical service, there would likely be significant engineering and design costs, with an undetermined path forward to implementation.

Energy and GHG emissions savings would be realized via:

- Associated site Greenhouse Gas emissions reduction the switch from natural gas to lower GHG emissions grid electricity

Additionally, this would require a switch to electricity as a heating fuel, with possible higher energy costs to achieve site heating than existing natural gas (increased heating efficiency/COP but also higher $/btu cost fuel).

Table below estimates costs and associated GHG reduction from electrification of all existing natural gas heating applications:

Convert Natural Gas Building Heating Systems to Electric			
Description	**Value**	**Unit**	**Notes**
Estimated Annual Natural Gas Heating Usage	16,000	CCF	
Estimated Annual Natural Heating Gas Cost	$ 17,600	$	
Annual Associated GHG Emissions	90	MT CO2e	
Electric Boiler Efficiency	2	#	Average ASHP boiler efficiency
Proposed Annual Heating Energy	193,000	kWh	
Proposed Area Heating Cost	$ 27,600	$	
Proposed Associated GHG Emissions	60.0	MT CO2e	
Estimated Annual Natural Gas Savings	16,000	CCF	
Estimated Annual Electric Savings	(193,000)	kWh	
Estimated Annual Cost Savings	$ (10,000)	$	
Estimated Change Cost - Add't'l Electric Boilers	$ 1,500,000	$	New service into building needed
Simple Payback - no incentives	**n/a**	**yrs**	
GHG Emissions Reduction	**30**	**MT CO2e**	
Lifetime Cost per MT CO2e	**$ 2,500**	**$/MT**	**20 year measure life**

QGM can recommend installation vendors if desired for a more precise cost and scope of work, and site is encouraged to work with utility representatives to determine incentive/rebate eligibility and potential cost offsets.

Additional Opportunities

Zero loss drains for compressor plant

REDACTED

Timed drains utilize compressed air from the plant to purge moisture; site is recommended to investigate replacement with zero-loss drains which use no air to purge moisture, thereby eliminating a source of air consumption from the plant.

Site may want to consider replacement of exiting timed drain with zero loss.

Ensure proper functioning of Economizers

Estimates indicate that only about one in four economizers works properly, with the remaining three providing sub-par performance or wasting energy. A 1995 survey of commercial buildings in the U.S. shows that about 461,000 buildings have economizers assisting HVAC systems that condition more than 16 billion square feet of building space. Proper economizer operation enhances energy efficiency, reduces costs, and extends equipment life. See the following online resources for more information:

https://www.energytocare.org/system/files/media/file/2020/11/17_Perform_Economizer_Maintenance.pdf

https://www.cedengineering.com/userfiles/M02-014%20-%20Economizers%20in%20Air%20Handling%20Systems%20-%20US.pdf

Sustainability Considerations

Background

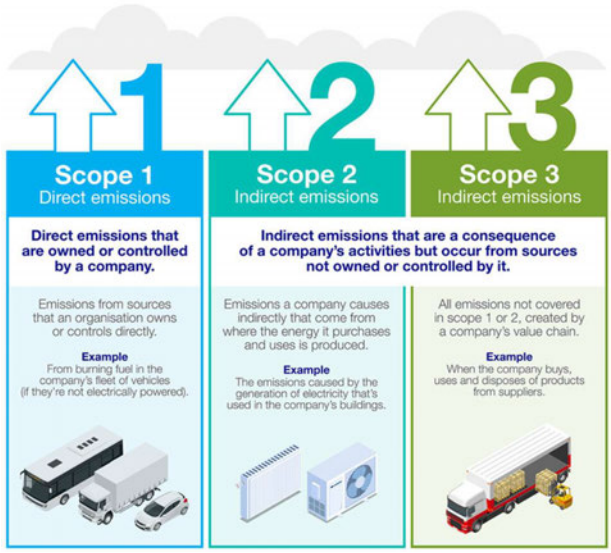
Site and portfolio sustainability is best guided by the framework and methodology set forth in ASHRAE Standard 228-2023 *Standard Method of Evaluating Zero Net Energy and Zero Net Carbon Building Performance* (available for purchase here: https://www.ashrae.org/technical-resources/bookstore/ansi-ashrae-standard-228-standard-method-of-evaluating-zero-net-energy-and-zero-net-carbon-building-performance). The site is not known to have a present net-zero strategy; however, the ASHRAE standard presents a strong method to:

- Assess current building energy use and carbon emissions
- Establish a baseline
- Develop milestones
- Develop a plan to reach milestones

The data and information shown below is intended to help develop an understanding of where current portfolio sustainability goal aligns with current position.

Emissions Scopes

Emissions reporting is generally addressed across three Emissions Scopes, as seen below:



An important aspect of developing a sustainability plan is the determination of which emissions scopes will be targeted for reduction. The majority of sustainability planning at the time of this report is focused on Scopes 1 and 2, although large corporations with significant supply and delivery chains have begun to address Scope 3 as well. The focus of the sustainability plan in this report is on Scope 1 and 2 emissions.

ASHRAE Standard 228-2023 *Standard Method of Evaluating Zero Net Energy and Zero Net Carbon Building Performance*

ASHRAE 228-2023 includes the following diagram illustrating energy flows into, from, and out of a site:

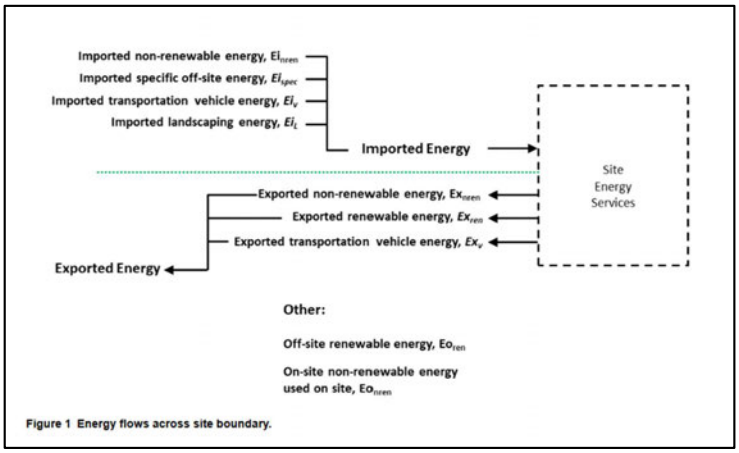


Figure 1 Energy flows across site boundary.

REDACTED

The difference between energy flow into a site, and energy flow out, is site net energy. The primary goal of sustainability is to reduce this net energy, and therefore, net carbon emissions associated with the site and its operation.

ASHRAE 228-2023 – examples of data gathering and forms

ASHRAE 228-2023 recommends site conduct an all-energy and associated carbon emissions accounting as seen in the tables shown below. Known values are filled in as a beginning of the process:

Form 1
General Building and Site Description

ID:	250 Freight St	Measurement Start Date:	9/25/2024
Address:	250 Freight St		
City, State, Country, ZIP Code:	Waterbury, CT 06072		
Primary Year of Construction:	c. 1920	Secondary:	

Gross Floor Area (GFA):	117,810
Physical site area, SF:	
Non-green-roof building footprint area:	
Other Physical site area not requiring landscape care:	
Landscape area (LA):	

On-site renewable energy system type:		On-site renewable energy system design max output, kW:	

Compliance Type

Portion of building:	~25,000 SF
Building:	(2)
Part of a Commnuity? If "Yes," Community Name?	

REDACTED

Form 2
Annual Site Energy Conversion Calculation

		Energy Use Numercial Value	Units	Conversion Factor to kWh	Annual site Energy, kWh/yr
1a	Imported grid electricity	891,911	kWh	1	891,911
1b	Imported specific electricity				
2a	Imported grid natural gas	15,951	CCF	30.2	481,061
2b	Imported renewable natural gas				
3	Imported steam				
4	Imported hot water				
5	Imported chilled water				
6a	Imported grid fuel oil				
6b	Imported renewable fuel oil				
7a	Imported grid propane				
7b	Imported renewable propane				
8	Imported coal or other				
9	Imported biomass				
10	On-site nonrenewable energy				
11	Imported transportation vehicle energy				
12	Imported landscape energy				
13	Exported nonrenewable electricity				
14	Exported renewable electricity				
15	Exported steam				
16	Exported hot water				
17	Exported chilled water				
18	Exported other				
19	Exported transportation vehicle energy				

REDACTED

Form 3
Annual Site Energy Conversion Calculation

	Energy Form	Energy Use Numercial Value	Source Energy Conversion Factor	Annual Source Energy, kWh/yr
1a	Imported grid electricity	891,911		891,911
1b	Imported specific electricity			
2a	Imported grid natural gas	481,061		481,061
2b	Imported renewable natural gas			
3	Imported steam			
4	Imported hot water			
5	Imported chilled water			
6a	Imported grid fuel oil			
6b	Imported renewable fuel oil			
7a	Imported grid propane			
7b	Imported renewable propane			
8	Imported coal or other			
9	Imported biomass			
10	On-site nonrenewable energy			
11	Imported transportation vehicle energy			
12	Imported landscape energy			
13	Exported nonrenewable electricity			
14	Exported renewable electricity			
15	Exported steam			
16	Exported hot water			
17	Exported chilled water			
18	Exported other			
19	Exported transportation vehicle energy			
20	Qualified off-site renewable energy			

**Source energy factors typically available from local utilities*

REDACTED

Form 4
Annual Greenhouse Gas Emissions (GHG) Net Calculation

	Energy Form	Annual Site Energy, kWh/yr	GHG Emissions Factor, kg CO2e/kWh	Annual GHG Emissions, kg CO2e/yr
1a	Imported grid electricity	891,911	0.291	259,546
1b	Imported specific electricity			
2a	Imported grid natural gas	481,061	0.183	88,034
2b	Imported renewable natural gas			
3	Imported steam			
4	Imported hot water			
5	Imported chilled water			
6a	Imported grid fuel oil			
6b	Imported renewable fuel oil			
7a	Imported grid propane			
7b	Imported renewable propane			
8	Imported coal or other			
9	Imported biomass			
10	On-site nonrenewable energy			
11	Imported transportation vehicle energy			
12	Imported landscape energy			
13	Exported nonrenewable electricity			
14	Exported renewable electricity			
15	Exported steam			
16	Exported hot water			
17	Exported chilled water			
18	Exported other			
19	Exported transportation vehicle energy			
20	Qualified off-site renewable energy			
21	Refrigeration Loss (Form 4A)			

Annual GHG Net Emissions	347,580	**Annual GHG Net Emissions, kg CO2e**	347,580
Previous Measurement Period	none	**Previous GHG Net Emissions, kg CO2e**	none
Sum, Two-Year GHG Net Emissions	347,580	**Sum, Two-Year GHG Net Emissions kg CO2e**	347,580

**Refrigerant loss form not included as not relevant at site.*

QGM CONSULTING

Site sustainability team or personnel are encouraged to determine and enter applicable values. As seen above, these tables and final conversions result in an annual carbon baseline for the site.

The next step is the determination of the carbon reduction goal and the timeframe to reach it. Carbon emissions are suggested to be tracked monthly and annually along with energy use to assess the impact of reduction efforts.

Sustainability Plan

With a carbon baseline established and a goal and timeframe put in place, the next step is to develop a sustainability plan to reduce site net energy and carbon. A four-step plan, as outlined in an article from CBRE (Decarbonizing Commercial Real Estate | CBRE) and shown in the chart below, is recommended:



The table below details the four-step plan with narrative descriptions and progress to date for the target site. Note that the process is by nature to be repeated for continuous improvement and consideration of new technologies:

250 Freight Street Potential Sustainability Plan			
Step	Description	Progress	Notes
1	Efficiency/Conservation	50%	In process, identifying and determining measures
2	Electrify Remaining Loads	75%	Identify and electrify remaining energy loads
3	Renewable Energy Offset	50%	Onsite or purchased renewable electricity
4	Offset Remaining Loads	0%	Purchase RECs on open market, consider portfolio offsets

Step 1: Efficiency and Conservation

Identify possible efficiency and conservation measures at the target site to reduce energy use and associated carbon. This step is in progress at this site – this study has identified several possible measures for the reduction of energy use. These measures should be considered for implementation.

Step 2: Electrify Remaining Loads

Site net energy loads not able to be reduced should be considered for electrification. Site has made strong progress towards with goal with use of electric unit heaters, WSHPs, and an electric boiler able to meet WSHP loop heating demand for portions of the year.

Step 3: Renewable Energy Offset

Offset of site electrical energy use via renewable energy: either generated onsite or through purchasing of renewable energy from sources such as community solar or solar farms as well as energy brokerage.

Step 4: Offset Remaining Loads

Lastly, the site may consider RECs and/or purchased carbon offsets to meet the remaining site net carbon. ASHRAE 228-2023 rigorously defines each of these categories and is strongly recommended as a guideline for these efforts and associated accounting.

Repeat: Steps 1 – 4

A sustainability plan should be viewed as a process of continuous improvement. The site is encouraged to consider additional opportunities and technologies as they become available and more economical.

Next Steps:

- Site to review suggestions in report (and calculation assumptions) and discuss internally if any interest to move forward with any of the recommended opportunities. BMS replacement was noted to be planned for near-term future implementation.
- QGM and Eversource would like to have a virtual report out to discuss this report. The goal of the meeting is to determine which, if any, of the suggested ECMs are to be acted upon in the near to intermediate future.
- For those ECMs that require input from designers, site is suggested to initiate the process sooner than later. Site is encouraged to get contractors/vendors to site to review and provide budgetary costs.