ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Town House

459 Main St. Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Heat Pump Water Heater	0	2,500	0	$475	$5,000	10.5	$1,000	8.4
2	High Efficiency Air Cooled Chiller Replacement	0	10,500	0	$3,000	$65,000	21.7	$0	21.7
3	Condensing Boiler	0	0	500	$650	$35,000	53.9	$3,200	48.9
	TOTAL	**0**	**13,000**	**500**	**$4,100**	**$105,000**	**25.6**	**$4,200**	**24.6**
			13%	15%					

The Town House building is an historic building built in 1900 and almost completely rebuilt after a fire in 1997. The rehabbed building was insulated at or above the code in place at the time. The EPA ENERGY STAR® rating of the building is 88 out of 100 (1-100) indicating that it qualifies to apply for the 2024 ENERGY STAR Award building certification label, as a top 12% energy efficient buildings.

Last year an additional quantity of cellulose insulation was blown into attic to enhance the shell insulation package. The mechanical system consists of numerous 2-pipe fan coil units (FCU's) terminal units and two (2) dedicated 100% outdoor air ventilation units. The building is heated by a Burnham natural gas fired cast iron boiler and Trane air cooled chiller with a 2HP dual temperature pump. Domestic Hot Water (DHW) is generated by an electric tank top heater installed in 2023. The building is controlled by a building management system manufactured by Automated Logic system.

The chiller is approaching the end of its useful service life. The replacement of the chiller with a high-performance chiller can reduce chiller energy consumption by 30% to 50% (9,000 to 12,000 kWh/Yr.) with current air-cooled chiller technology.

EMA was able to identify one potential ECM that will reduce energy consumption cost effectively, replacing the electric tank types DHW heater with a heat pump tank type water heater saving approximately 2,500 kWh. This $5,000 project qualifies for a $1,000 rebate and has an 8.4-year simple payback.

The renewable solar PV production potential is very limited due to shading of the Town House roof. If the trees are damaged and are cut down, we recommend that the Town House roof be replaced before a renewable project is started so that the system does not have to be disassembled at a future date.

Electrification of the building's natural gas heating system is limited by the size of the electric service. With current technology an electric resistance boiler will be required to meet the 180 °F heating hot water temperature requirement at design heating conditions. A detailed building heating load

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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calculation is required to determine if the electric service is adequate. Another process to determine the heating load is to data log the boiler burners motor operation during design heating (single digit outdoor temperature) conditions.

BUILDING DESCRIPTION

Architectural

The original Town House building was constructed in 1900. This 17,356 square foot brick façade building is three (3) story building with a fully occupied basement with a north facing basement entrance. The building has had two (2) fires that have gutted the interior. An attic was added to accommodate modern HVAC equipment. The building was last renovated in 1997 to its current configuration. The attic mechanical roof was added over the existing roof under the attic addition. Access to the equipment is very poor. Last year blown-in cellulose insulation was installed above the old roofing to bring the building up to energy code. The original walls have been furred out for additional insulation in the exterior walls. The windows were also replaced during the recent renovation with wood frame double hung window with double glazing to maintain original character. Not all the original windows were replaced.

TownHouse houses town offices in the basement and first floor. The second floor is occupied by the School Department.

Lighting

All lighting has been replaced with LED lighting fixtures or lamps. The building lacks occupancy sensors in some areas. The window area does not support lighting dimming systems. The ten (10) decorative pole lighting fixtures on the site with LED lamps.

Mechanical

The building is fully heated and cooled. Heating hot water is generated by a natural gas fired Burnham case iron model V905-5 boiler installed in 2006. The boiler has a power flame Model Bour15A-10 burner. The boiler rated input is 646 MBH. The boiler is controlled by a tekmar® model 252 two stage boiler & DHW outdoor air reset controller. Based on the quantity of natural gas consumed and the overall ENERGY STAR® rating, the controller is well programmed and operates correctly.

Chilled water is generated by a 1997 Trane air cooled 40-ton electric scroll compressor chiller Model CGAEC40GACA1FA chiller. The chiller has four 10-ton R-22 compressors. The HVAC system is a 2-pipe fan coil unit with two (2) dedicated outdoor air units. There are four (4) exhaust fans to balance

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ventilation supply. Exhaust fans 1 & 4 are associated with the DOAS units. The other exhaust fans are toilet exhaust.

The dual temperature system has a 2HP pump. The pump does not have a VSD because chiller requires constant water flow. This system must remain as constant flow to protect the chiller.

Building Management System

The BMS is made by Automated Logic Systems. The schedule for the School Administration Offices is 4AM to 6PM Monday through Friday and 9AM to 3PM Saturday and Sunday. The general schedule for the rest of the Town House offices is 6Am to 4PM Monday, Wednesday through Friday, 6AM to 7:30 PM Tuesdays, and off on Saturdays and Sundays. There is no evidence of holiday scheduling. The thermostat dead bands are set at 4 °F. Switching over from heating mode to cooling mode is manual by town facilities staff based on season of the year.

Domestic Hot Water (DHW

DHW is generated by an electric tank type water heater Rheem model # PROE50 installed in 2023. This 50-gallon tank has two (2) 3,360-watt 208-volt heating elements. Replacing it with a heat pump tank type water heater will reduce energy consumption by approximately 66%. Heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial). With no metering of the DHW consumption or electric heater electricity it is impossible to estimate savings. This type of office building traditionally uses very little DHW.

Electric Service

The building has an 800 AMP 120/208Y 3-phase electric service. This service can support an electrical demand of approximately 230 kW. Based on existing peak winter demand of 35 kW there is marginally enough power to convert the natural gas boiler to an electric resistance boiler and meet existing heating load. Electric resistance boiler is required because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology. This conversion will increase total utility bills but give the Town of Medfield Town House the ability to be carbon free with electric Mass Class1 RECs.

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160 Beech Street
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Fax: 508.533.7332

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UTILITIES

The building consumes electricity and natural gas. The building has averaged 39,000 BTU/SQFT over the last three (3) years. The EPA's ENERGY STAR® rating is 88 which places the building in the top 12% of the nation based on energy consumption.

The following tables are a summary of the electrical consumption over the last three years. For the year ending in June 2024, we only have eight (8) months of data. Electrical consumption appears to be trending up due to the reduction of work at home rules. So far in the latest year electric consumption almost equals the previous two years. At around 20,000 BTU/SQFT this is a good consumption number for a municipal office building. Electric consumption does increase during the summer representing air conditioning of the building.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
2/21/2022	3/21/2022	7,840	32	2/21/2023	3/21/2023	8,000	33
3/21/2022	4/21/2022	7,920	32	3/21/2023	4/21/2023	7,200	27
4/21/2022	5/21/2022	7,360	51	4/21/2023	5/21/2023	6,480	33
5/21/2022	6/21/2022	8,480	50	5/21/2023	6/21/2023	7,840	49
6/21/2022	7/21/2022	9,760	38	5/21/2023	7/21/2023	11,440	47
7/21/2022	8/21/2022	11,680	37	7/21/2023	8/21/2023	11,120	57
8/21/2022	9/21/2022	9,600	54	8/21/2023	9/21/2023	10,400	50
9/21/2022	10/21/2022	7,360	40	9/21/2023	10/21/2023	6,800	46
10/21/2022	11/21/2022	7,600	27	10/21/2023	11/21/2023	6,400	27
11/21/2022	12/21/2022	8,240	34	11/21/2023	12/21/2023	7,120	27
12/21/2022	1/21/2023	8,240	30	12/21/2023	1/21/2024	7,920	30
1/21/2023	2/21/2023	8,720	33	1/21/2024	2/21/2024	8,400	33
Total		**102,800**	**458**	**Total**		**99,120**	**459**

The following tables are a summary of the natural gas consumption for the last two (2) plus years. For a building of this size and age the overall usage indicates that the night setback function of the thermostat is being utilized. The zero-summer consumption indicates that the boiler is shut down manually properly by the BMS during the summer. The building has a two-pipe distribution system, so the building is either in heating or cooling mode.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
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Start Date	Read Date	Therms	Start Date	Read Date	Therms
3/4/2022	4/4/2022	507	3/7/2023	4/5/2023	472
4/4/2022	5/4/2022	230	4/5/2023	5/4/2023	102
5/4/2022	6/3/2022	5	5/4/2023	6/6/2023	9
6/3/2022	7/6/2022	0	6/6/2023	7/6/2023	0
7/6/2022	8/5/2022	0	7/6/2023	8/9/2023	0
8/5/2022	9/6/2022	0	8/9/2023	9/6/2023	0
9/6/2022	10/4/2022	0	9/6/2023	10/5/2023	0
10/4/2022	11/3/2022	117	10/5/2023	11/6/2023	159
11/3/2022	12/6/2022	469	11/6/2023	12/5/2023	508
12/6/2022	1/6/2023	694	12/5/2023	1/5/2024	633
1/6/2023	2/3/2023	616	1/5/2024	2/5/2024	759
2/3/2023	3/7/2023	772	2/5/2024	3/5/2024	614
Total		**3,410**	**Total**		**3,256**

ENERGY CONSERVATION MEASURES

ECM – 1 Heat Pump Water Heater

The DHW heater for the building is a tank type 50-gallon electric heater. Replacing it with a heat pump hybrid 50-gallon water heater will reduce electrical consumption for DHW production by approximately 70%. The estimated savings are 2,500 kWh per year ($475). The estimated project cost is $5,000 with a potential rebate of $1,000 resulting in a simple payback of 8.4 years.

ECM – 2 High Efficiency Air Cooled Chiller Replacement

The existing air-cooled chiller was installed in 1997. It is approaching the end of its useful service life. Pro-actively replacing with high efficiency replacement units will reduce electricity consumption between 30% and 50%. The new chiller maybe eligible for a prescriptive rebate based on the efficiency greater than LPLV or 16.59 EER. EMA estimates that the potential savings are of 9,000 kWh to 12,000 kWh per year resulting in annual savings of $3,000 per year. With a capital cost of over $65,000 the project will have over a 30-year simple payback. This improvement is not recommended.

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ECM – 3 Condensing Boiler

The existing boiler is a standard efficiency natural gas fired cast iron boiler. Replacing the boiler with a high efficiency condensing boiler such as a Lochinvar Kight XL model KBX0650N will reduce natural gas consumption to heat the building. A condensing boiler can operate above 95% efficiency at times while the existing boilers maximum efficiency is 82%. After this year replacement natural gas equipment will not qualify for utility incentives. The Mass Saves current prescriptive rebate is $3,200. The estimated savings are 500 therms ($650). The estimated project cost is $35,000 before rebate results in a 50-year simple payback. This improvement is not recommended.

RENEWABLE ENERGY POTENTIAL

Due to shading and of the southern exposure by tall trees the installation of renewable energy on the south sloped roof effectiveness will be heavily compromised. This building is not a good candidate for solar PV panels unless the trees must be removed for some other reason such as safety or damage. In general, the value of the additional PV production by actively removing trees does not offset the increase in cooling requirements due to the loss of shading.

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Prepared for

Town of Medfield – Thomas Blake Elementary School

24 Pound Street Medfield, MA 02052

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ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	BMS HVAC Equipment scheduling, tuning, programming	0	30,000	2,000	$7,800	$7,500	0.96	TBD	---
2	Retrofit heating hot water secondary pumps with VSDs	0	50,000	0	$8,500	$40,000	4.7	$6,400	4.0
3	Insulate Roof's Thermal Breaks	0	0	325	$425	$2,000	4.7	0	4.7
	TOTAL		**80,000**	**2,325**					
			14%	5%					

The Thomas Blake Middle School is a 121,564 square foot one story building originally constructed in 1960 with an addition in the 1990's. The building is heated and partially air conditioned. The ENERGY STAR® rating of the school is 56 out of 100 (1-100) just above average based on the age and condition of the building.

The roofing was replaced with white EPDM membrane and about 4 inches of rigid board insulation. The current condition of the membrane is poor and in need of replacing. Two sections were replaced last year due to leaks in the A and C sections of the building. The A section had new black EDPM with an additional 2 inches of rigid added. A 126.2 kW PV array has been installed on the new black EPDM section of roof. The building shell is the original uninsulated brick over block construction. The windows have been replaced with aluminum framed double glassed casement units similar to the original.

The lighting has been converted to LED.

The unit ventilators and heating & ventilation units are replacements for the original equipment. Two of the three boilers have been replaced with condensing high efficiency equipment. The Trane Tracer BMS system has all the bells and whistles for an efficient building operation including Demand Control Ventilation based on CO_2 concentrations. All the CO_2 sensors are out of calibration. The scheduling of HVAC equipment does not match the school schedule or activities. Examples the classrooms are maintained in occupied mode until midnight weekdays year-round with fan running, outdoor air damper open, and space heating. The heating system starts to heat the building at 3AM for a 7:40 AM school start time.

EMA has identified three Energy Conservation Measures that will significantly improve the energy efficiency of the school.

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ECM-1 BAS/EMS HVAC Equipment scheduling, tuning, programming - has the potential of reducing energy consumption by 30,000 kWh and 2,000 therms per year for a net savings of $7,800. The estimated project cost is $7,500 resulting in a 0.96-year simple payback. This ECM maybe eligible for the LCTM prescriptive program.

ECM-2 Retrofit heating hot water secondary pumps with VSDs (variable speed drives). The estimated annual savings are 50,000 kWh resulting in $8,500 in savings. The installed budget for this project is $40,000 minus the prescriptive rebate of $6,400 results in a 4.0-year simple payback.

ECM-3 Insulating the thermal breaks in the roofing insulation package will save approximately 325 therms per year or $425. The estimated project cost is $2,000 resulting in a simple payback of 4.7 years.

The existing electrical service is not large enough to electrify the building heating system. A portion of the natural gas used for building heating can be displaced by:

1. Air source ductless split low temperature heat pumps as replacements of the outdoor condensing unit serving the H & V units.
2. If cooling is added to each classroom with air source ductless low temperature heat pumps. This $1,250,000 project can save 10,000 to 15,000 therms of natural gas per year.

BUILDING DESCRIPTION

Architectural

The 121,564 square foot Thomas Blake Middle School was constructed in 1960 with additional building in the 1990's. This one-story brick building houses approximately 600 students grade 6 through 8. The schools' roof membrane and most of the HVAC equipment was replaced during the 1990's renovation. The 1990's renovation was white EPDM roofing. Most of the schools' roofs are a white EPD membrane with approximately 4 inches of rigid insulation. An addition in the late 1990's has a black EPM roof. Recently a portion of the white roof membrane was replaced above one classroom wing with a black EPDM roofing, additional 2 inches of rigid insulation, and a PV array. The walls are un-insulated except for the small new wing. The windows are replacement aluminum frame double glazed operable lower sash casement.

EMA noticed that many of the original exhaust fans were removed during the renovation. Below is a picture of the typical result. The openings were covered with galvanized sheet metal covers. Some have white EPDM membrane covering the sheet metal. The opening is hollow to the touch indicating significant thermal breaks in the roof insulation integrity. EMA identified approximately 10 such thermal breaks. This is a source of large heat losses.

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Franklin, MA 02038

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It should be noted that the white EPDM roofing membrane is in poor condition with many leaks and will require replacement soon.

The school's kitchen has a walk-in cooler and freezer.

Lighting

Most of the lighting has been converted to LED. The classrooms have occupancy sensors. The Tork pin time clock is set for 5:30PM to 7:30AM for the exterior lighting. The poles have photocells for dusk to dawn operation. The key question is the exterior lighting required after 11PM to 6AM.

Mechanical

The classrooms are conditioned by Unit Ventilators with perimeter hot water baseboard. The unit ventilators provide ventilation air which is exhausted by rooftop exhaust fans. Each classroom has two-way valves on the heating hot water system. Some classrooms and offices have window A/C units.

The two (2) primary boilers are high efficiency natural gas fired Weil McLain condensing model SVF Stainless Vertical Firetube 2500 rated at 2,500 MBH input. The condensing boilers are piped in a primary/secondary distribution configuration. The primary pumps are Grundfos VSD driven high efficiency pumps. One of the 2002 fifteen (15) section Model 28HE-W-15 natural gas fired Smith cast iron sectional boiler rated at 3,831 MBH input is a backup. The backup boiler has a Power Flame C-4-G burner. The secondary heating hot water pumps are a TACO Model FI501 25 HP, 650 GPH, and 95 Feet of head. The HHW pump motor ais Baldor Super-E invertor duty high efficiency motor.

There are ten (10) DX condensing units for the Heating and Ventilation units for various spaces such as offices, library, gym, administrative offices, etc. (see table below). The nameplates are in poor condition. The table below is a list of the DX condensing units serving these H & V units.

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Condenser unit	Manufacture	Model #	RLA Comp	HP Cond	kW	Tons
Carrier 1	Carrier	38AK-008	25	0.75	9.00	5
Carrier 2	Carrier	38AK-008	25	0.75	9.00	5
Carrier 3	Carrier	38AK-008	25	0.75	9.00	5
Ruud 1	Ruud	UAKA-037JAZ	16.5	0.2	5.94	4
Ruud 2	Ruud	UAKA-037JAZ	16.5	0.2	5.94	4
Sanyo1	Sanyo	No Nameplate				
Sanyo2	Sanyo	No Nameplate				
Mitsubishi1	Mitsubishi	MUZ-GS36NA	17.5	0.067	6.30	3
Mitsubishi2	Mitsubishi	MUY-GL24NA	12.9	0.93	4.64	2
Mitsubishi3	Mitsubishi	No Nameplate				

There is a small Trane RTU with DX cooling and a natural gas furnace. The nameplate is not readable.

There are two (2) rooftop H & V units with natural gas fired furnaces. The nameplates are not readable or missing.

There are 23 fractional and small HP exhaust fans. During our survey the ones serving the classrooms were off.

Most of the HVAC rooftop equipment has reached the end of their useful service life. This is an opportunity to reduce fossil fuel consumption with partial electrification of equipment with low temperature heat pump replacements. Since most of this equipment refrigerant is R-22. On January 1st, 2025, the refrigerant regulations change. The new proposed refrigerants are not compatible with existing piping used for R-22 equipment. Any upgrade will also require replacement of refrigerant piping.

Building Management System

The building management system is a Trane Tracer system. The following table lists all the schedules:

Weekday M - F Schedules			
Space	**Warm-up**	**Occupied**	**Unoccupied**
Classroom Schedule	3AM - 6AM	6AM - 12AM	12AM - 3AM
HV-1 Art Schedule	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV-10 Library	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV-11 Cafeteria	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV -12 Auditorium	None	6AM - 5PM	5PM - 6AM
HV - 13 and 14	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 2 Lecture Hall	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 3 Science	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 4 Admin	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 5 Computer	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 6 Boys Locker Room	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 7 Weight Rm	3AM - 6AM	6AM - 5PM	5PM - 3AM
HV - 8 Girls Locker Rm	None	6AM - 5PM	5PM - 6AM
HV - 9 Library	3AM - 6AM	6AM - 5PM	5PM - 3AM
RTU - 1 Instrumental	None	6AM - 5PM	5PM - 6AM

None of the schedules had the holiday schedule programmed. There is no summer schedule when the school is closed. The weekend schedule during our survey was un-occupied.

The classrooms and most other spaces have CO_2 sensors. None of them read more than 380 PPM indicating they are out of calibration. We found one schedule labeled Min Outdoor Air Setpoint OCCUPIED 2PM to 7AM. We do not understand what this schedule is since during un-occupied periods the outdoor air damper of UVs should be closed for freeze protection. We also found the overtime schedules for the Gym and Auditorium set to 24/7 occupied. Hopefully, this was a temporary override for graduation and end of the year activities. The following overtime schedules were set to un-occupied for:

- Band
- Cafeteria
- Chorus
- Guidance
- Library
- School Committee Area

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Fax: 508.533.7332

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Domestic Hot Water (DHW)

DHW is generated by four (4) Ruud tank type electric hybrid heat pumps. The Ruud hybrid heat pump water heaters Model PROPH80 T2 RH375-30 with 80 gallons of storage and two (2) 3.38 kW electric boost elements. The tanks are maintained at 140 °F. There is a State model SEF 80 199 NEI 2 natural gas atmospherically fired tank type backup water heater with a BMS control relay. The input capacity of the state water heater is 199,990 BTU/Hr. It is not clear if this unit is standby or in operation.

Electric Service

The building has a 1600 AMP 208/120 volt 3-phase 4-wire electric service. This service can support an electrical demand of approximately 575 kW. Based on existing peak winter demand of 155 kW there is not enough capacity to convert one boiler to electric resistance boilers to partially electrify the heating in the school. There is not enough capacity to offset one of the condensing boilers. Electric resistance boiler is required because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology.

UTILITIES

The school consumes electricity and natural gas. The school has averaged approximately 58,000 BTU/SQFT over the last two (2) years. The EPA Energy Star rating of the school is 56, just above average. This is to be expected based on the age and condition of the building.

The following tables are a summary of the electrical consumption over the last two (2) years. The summer monthly electrical energy consumption is only slightly less than winter electrical energy consumption. With the limited number of spaces having air conditioning this is an indication that equipment and lighting is not shut down during the summer.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/25/2022	5/24/2022	43,896	121	4/25/2023	5/24/2023	47,112	146
5/24/2022	6/23/2022	43,368	143	5/24/2023	6/23/2023	42,456	143
6/23/2022	7/26/2022	45,360	108	6/23/2023	7/26/2023	41,712	91
7/26/2022	8/24/2022	43,176	106	7/26/2023	8/24/2023	36,696	99
8/24/2022	9/23/2022	45,600	168	8/24/2023	9/25/2023	46,872	179
9/23/2022	10/25/2022	44,952	131	9/25/2023	10/25/2023	50,280	164
10/25/2022	11/23/2022	50,904	136	10/25/2023	11/24/2023	49,344	133
11/23/2022	12/23/2022	54,768	136	11/24/2023	12/22/2023	50,520	133
12/23/2022	1/25/2023	57,648	134	12/22/2023	1/25/2024	61,512	127
1/25/2023	2/23/2023	53,184	135	1/25/2024	2/23/2024	54,408	133
2/23/2023	3/24/2023	53,712	139	2/23/2024	3/25/2024	58,704	135
3/24/2023	4/25/2023	54,432	155	3/25/2024	4/24/2024	52,488	131
Total		**591,000**	**1612**	**Total**		**592,104**	**1614**

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160 Beech Street
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Fax: 508.533.7332

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The following tables is a summary of the natural gas consumption for the last two (2) years. The low summer consumption represents the monthly natural gas consumption to generate DHW for cleaning of the building. The slight annual reduction can also be contributed to the installation of heat pump DHW water heaters displacing natural gas water heaters.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
4/4/2022	5/4/2022	5,566	4/5/2023	5/4/2023	3,317
5/4/2022	6/3/2022	1,643	5/4/2023	6/6/2023	2,073
6/3/2022	7/6/2022	246	6/6/2023	7/6/2023	411
7/6/2022	8/5/2022	51	7/6/2023	8/9/2023	62
8/5/2022	9/6/2022	72	8/9/2023	9/6/2023	144
9/6/2022	10/4/2022	92	9/6/2023	10/5/2023	1,129
10/4/2022	11/3/2022	2,958	10/5/2023	11/6/2023	2,752
11/3/2022	12/6/2022	6,281	11/6/2023	12/5/2023	6,343
12/6/2022	1/6/2023	8,942	12/5/2023	1/5/2024	7,607
1/6/2023	2/3/2023	7,988	1/5/2024	2/5/2024	9,539
2/3/2023	3/7/2023	9,096	2/5/2024	3/5/2024	7,689
3/7/2023	4/5/2023	6,511	3/5/2024	4/4/2024	6,343
Total		**49,446**	**Total**		**47,409**

ENERGY CONSERVATION MEASURES

ECM -1 BAS/EMS HVAC Equipment scheduling, tuning, programming

EMA has identified several scheduling opportunities to reduce equipment run hours:

1. Turning off HVAC equipment such as Unit Ventilators and associated exhaust fans, H & V units, kitchen hoods and makeup air units during the summer when the school is underutilized. Only the spaces were active programs or administrative workspaces should run during the summer. Each schedule should be divided into a winter and summer schedule. Summer schedule would run from July 1st through the second or third week of August when new teacher orientation begins.
2. Morning Warmup – School starts at 7:40 AM. Morning warmup starts at 3AM. Recognizing that staff and students may start to arrive around 7AM the question is does it take 4 Hours to warmup the school? Typical school's warmup in an hour. Monday mornings after a cold weekend can be difficult and maybe a longer period is needed. We recommend reconsidering the morning startup time. Recommend starting it one hour prior to teachers' and staff arrivals.
3. Classroom General Schedule ends at midnight. This should be reexamined. Very few public schools have activities after 8 or 9 PM. The activities are usually limited to a small section of the school. Adding a schedule for location of these activities will mean that the whole school HVAC

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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is not running for a small, localized group of activities. There are four wings to the school, at minimum a schedule for each wing would help reduce runtimes of HVAC equipment.

4. Add a holiday schedule with the common reoccurring holidays that always fall on the same date or day of the month year to year such as Presidents Day (third Monday of February) or New Years Day January 1st. There is a minimum of ten of these dates on the calendar.
5. Scheduling heating hot water pumps for un-occupied freeze protection. The heating hot water pumps operate whenever the outdoor air temperature is below a programmed set point (55 to 60 °F). During un-occupied periods if the outdoor air temperature is above 35 °F there is no potential of freezing heating hot water piping, domestic water piping, or sprinkler piping. The school has no need for heating. Heating hot water pumps are required below 32 °F to prevent freezing of pipes. We recommend a set point of 36 °F ± 2 to account for sensor error and to prevent rapid starting and stopping of the HHW pumps.

The Scheduling ECM has the potential of saving 30,000 kWh and 2,000 therms per year for a cost savings of $7,800. The estimated project cost for a programming technician and engineering consultant is $7,500 for a simple payback of 0.96 years. The project may qualify for Mass Saves prescriptive Low-Cost Tuning Measure ESPO program. Note the rebate cannot exceed the cost of the project.

ECM-2 Retrofit heating hot water secondary pumps with Variable Speed Drives (VSDs)

The heating distribution system is a variable volume system with two-way valves at each unit ventilator and heating ventilation unit. Installing a VSD on each of the heating hot water pumps will reduce pumping energy since the flow is proportional to the heating load. The estimated savings are 50,000 kWh per year ($8,500). The estimated project cost is $40,000 and may qualify for a $6,400 Mass Saves prescriptive rebate resulting in a simple payback of 4.0-year simple payback.

ECM-3 Insulate Roof's Thermal Breaks

EMA has identified approximately ten (10) thermal breaks in the roof where exhaust fans have been removed and the opening covers with sheet metal. No insulation was applied to either side of the opening. The result is uninsulated sections of the roof now has thermal breaks. We recommend affixing 3 to 4 inches of rigid board insulation to the interior of the void. This improvement will reduce energy consumption by approximately 325 therms per year ($425). Project cost estimate is $2,000 for a simple payback of 4.7 years. This may be eligible for Mass Saves Rebates.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ELECTRIFICATION POTENTIAL

Electrifying more than 40% of the existing heating capacity cannot be supported by the existing electric service. When the old rooftop DX condensers are replaced, there is a potential to install low temperature air source heat pump for decarbonizing some of the heating. There is hydronic backup heat from the central plant.

If the classrooms are fitted for cooling with air source ductless split units installing low temperature heat pumps is a good strategy to supplement the heating with carbon free heating. This $1,250,000 project can save 10,000 to 15,000 therms of natural gas per year.

RENEWABLE ENERGY POTENTIAL

A 126.2 kW PV solar array has been installed over parts of A and C wings classrooms. The array has not been energized yet. It has the potential to offset approximately 20% of the electric consumption of the school. The reason this wing was selected is because it has a new black EPDM roof. There is more than adequate space on the roof to offset the rest of the school's electric consumption. If the entire roof is utilized a considerable amount of the energy consumed to heat the building with natural gas can also be offset. The school could be close to net zero energy rating.

The Inflation Reduction Act (IRA) maybe a way to finance this project. Municipalities are eligible for direct payment from the program. The roofing project may be included in the project cost.

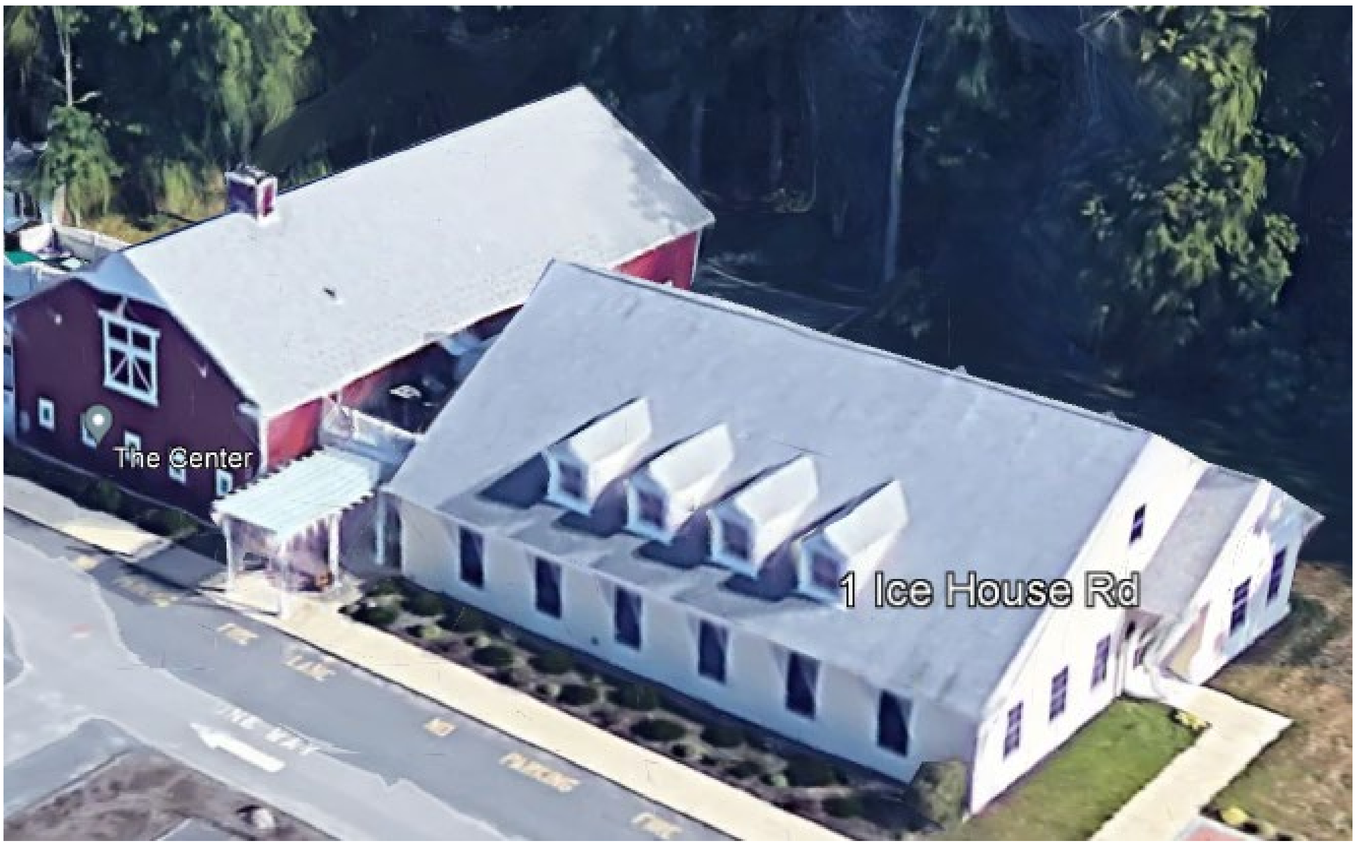
ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Council of Aging

1 Ice House Rd., Medfield, MA 02052



Prepared by

EMA - Energy Management Associates, Inc.
www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

The 7,810 square foot Council on Aging building was constructed in 2007 and met or exceeded the energy codes of the time. The building has a stick-built shell and fiberglass insulation. All the lighting has been upgraded to LED. All the Lennox HVAC equipment is 17-year-old and approaching the end of their useful lives. At an EUI of 58,000 BTU/SQFT current performance of the building is excellent considering the age of the occupants. Council on Aging building typically are heated more than typical building and that is reflected in the natural gas consumption. Air conditioning is minimal also reflected in the electric consumption.

EMA did not identify any Energy Conservation Measure for the building.

EMA examined the potential for electrification of natural gas heating systems. It is a good time to start planning and budgeting for this since the opportunity will present itself in the near future due to the age of the existing DHW and HVAC equipment.

The DHW water heater is in the Attic of the meeting room end of the facility. The only access is through a pull-down attic hatch. EMA has identified a heat pump tank type water heater that should fit through the opening (RUUD Ultra plug-in model PROUH40 with HydroBoost and LeakGuard). EMA believes one or two of these heat pumps will meet the DHW requirements of the facility since the commercial kitchen is not used often. The existing heater can be used as additional storage capacity. It is estimated that the project will displace 900 therms of natural gas with approximately 7,100 kWh of electricity for a negative cash flow of $200 per year. The estimated project cost for each heat pump water heater is $5,000.

On January 1st, 2025, the refrigerant for HVAC electrification will change to a low GWP refrigerant. Lennox has selected B454. At this point Lennox has not issued any performance data for the new equipment so we used the data for the R410A equipment currently manufactured by Lennox to estimate performance. The proposed Lennox replacement equipment will displace approximately 1,800 therms with 22,000 kWh of electricity for a net increase in utility bills of $1,500 per year. The estimated capital cost of the project is $400,000 and eligible rebate of $133,750.

The roof can support approximately 16 kW solar PV array that will displace approximately 50% of current electric consumption of the building. The roof has the original asphalt shingle roof. Until it must be replaced, we do not recommend proceeding with the project.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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BUILDING DESCRIPTION

Architectural

The Council on Aging building was constructed in 2007. The 7,810 square foot stick-built building is one (1) story building. The attic spaces house all mechanical equipment. The building was built to the energy codes of the early 2000's. All the windows are double glazed, and the walls are insulated with fiberglass insulation. The facility has a small commercial kitchen that has limited usage. The asphalt shingle roof is original and approaching the end of its useful life.

Lighting

All lighting has been replaced with LED lighting fixtures or lamps. The building lacks occupancy sensors in some areas. The window area does not support lighting dimming systems.

The exterior and parking lot lighting have two (2) pin type 24-hour time clocks. Currently they are set for 5PM to 1AM operation the time set on the clocks is an hour off due to daylight savings time. Photocells are used to turn on the lighting if the time clock is scheduled.

Mechanical

The building is fully heated and cooled by natural gas furnaces and DX cooling. The building has eight (8) Lennox condensing furnaces and two RTU's. The two RTU's serve the large cafeteria/meeting space. Eight (8) Lennox units serve the rest of the Senior Centers program spaces and offices. Seven out of the eight Lennox furnaces have a split DX coil. The eighth furnace is dedicated for the kitchen and seldom utilized. All the equipment is controlled by dedicated night setback thermostats. Based on the natural gas consumption it does not appear that the night setback programming is aggressively utilized.

All the HVAC equipment is original and 17 years old. It is approaching the end of useful life. This is a good opportunity for electrification. The Lennox equipment refrigerant is R-22. A simple upgrade to current code will reduce air conditioning energy consumption by approximately 25%. Since this is a senior center the air conditioning load is very low, and the savings will be minimal. Currently Lennox does not have 2025 refrigerant code compliant heat pump selections.

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Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Unit #	Manufacture	Model #	Comp # 1 RLA	Comp. # 2 RLA	Conden Fan 1 HP	Conden Fan 2 HP	SF Motor HP	Max BTU/HR	CFM	O.A. CFM	SEER/ EER	IPLV	Cooling MBH	Tons
RTU # 1	Trane	YHC120A3RHA00LY	17.3	12.4	1	1	5	250,000	4,000	1,200	10.7	11.2	116.73	9.73
RTU # 2	Trane	YCH210C3HOEA	31.5	20.8	1	1	5	350,000	6,000	1,800	9		208	17.33
	Total							**600,000**						**27.06**

	Manufacture	Model	CFM Exhaust	CFM Supply	HP	Max BTU/HR
KH-1	Greenheck	GHFV	2250	1575	1	
MA-1	Greenheck	DC-110-H10	N/A	1800	0.75	172,500

Unit #	Manufacture	Model #	CFM	O.A. CFM	Cooling MBH	Nominal Tons	Max MBTU/HR	SF Motor HP
AHU-1	Lennox	G51MP-48C-090	1410	350	49.6	4	88	0.5
AHU-2	Lennox	G51MP-24C-045	1015	40	31.5	3	44	0.2
AHU-3	Lennox	G51MP-48C-090	1660	415	50.2	4	88	0.5
AHU-4	Lennox	G51MP-48C-093	880	160	31	3	44	0.2
AHU-5	Lennox	G51MP-48C-094	2172	540	60.7	5	88	1
AHU-6	Lennox	G51MP-48C-095	1245	300	44.3	3.5	88	0.5
AHU-7	Lennox	G51MP-48C-096	880	210	31	3	44	0.2
GF-1	Lennox	G51MP-48C-097	755	160	0	0	44	0.2
	Total			**2175**		**25.5**	**528**	

Unit #	Manufacture	Model #	Service	Nominal tons	Voltage	Phase	Comp AMPS	Fan AMPS	SEER
CU-1	Lennox	HS26-048-4Y	AHU-1	4	208	3	13.5	1.7	12.5
CU-2	Lennox	HS26-030-4P	AHU-2	3	208	1	13.5	1.1	12.8
CU-3	Lennox	HS26-048-4Y	AHU-3	4	208	3	13.5	1.7	12.5
CU-4	Lennox	HS26-030-4P	AHU-4	3	208	1	13.5	1.1	12.7
CU-5	Lennox	HS26-060-1Y	AHU-5	5	208	3	17.4	1.7	12.2
CU-6	Lennox	HS26-042-1Y	AHU-6	3.5	208	3	12.5	1.1	11.1
CU-7	Lennox	HS26-030-4P	AHU-7	3	208	1	13.5	1.1	12.7

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Unit #	Manufacture	Model #	kW	Max MBTU/HR Gas	Fan Motor HP
CUH - 1	Q-Mark	CU935	3		
UH - 1	Sterling	QVF		45	0.033333

Unit #	Manufacture	Model #	CFM	Fan Motor HP
EF - 1	Greenheck	G-101-A	780	0.25
EF - 2	Greenheck	SP-8110	100	0.08
EF - 3	Greenheck	SWB-215-10	2,500	1
EF - 4	Greenheck	G-070-A	270	0.033
EF - 5	Greenheck	G-070-A	270	0.033

Domestic Hot Water (DHW)

DHW is generated by the original natural gas fired tank type water heater A.O. Smith model # BTR 251A 118. This 118-gallon tank is rated at 251,000 BTU/Hr. input and recovery capacity of 243.39 gallons per hour. Replacing it with a heat pump tank type water heater will reduce energy consumption by approximately 66%. Commercial heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial).

Electric Service

The building has an 800 AMP 208 volt 3-phase electric service. This service can support an electrical demand of approximately 230 kW. Based on existing peak demand of 17 kW there is enough power to convert the natural gas furnaces and unit heater to an electric resistance heating and meet the existing connected heating load. This conversion will increase total utility bills but give the Town of Medfield Town Hall the ability to be carbon free with electric Mass Class1 RECs.

UTILITIES

The building consumes electricity and natural gas. The building has averaged approximately 58,000 BTU/SQFT over the last two (2) years. This is high for this building type.

The following tables are a summary of the electrical consumption over the last two (2) years. Electrical consumption appears to be stable for the study period. So far in the latest year electric consumption almost equals the previous two years. At around 15,250 BTU/SQFT this is a good consumption number for a senior center. Electric consumption does increase during the summer representing air conditioning

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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of the building. Senior centers are not cooled to the level of other municipal buildings due to the occupants.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	2,480	11	4/21/2023	5/21/2023	2,480	11
5/21/2022	6/21/2022	2,320	11	5/21/2023	6/21/2023	2,160	9
6/21/2022	7/21/2022	3,040	10	6/21/2023	7/21/2023	3,440	11
7/21/2022	8/21/2022	4,000	9	7/21/2023	8/21/2023	3,520	10
8/21/2022	9/21/2022	2,800	12	8/21/2023	9/21/2023	3,600	9
9/21/2022	10/21/2022	2,160	11	9/21/2023	10/21/2023	2,240	10
10/21/2022	11/21/2022	2,560	14	10/21/2023	11/21/2023	2,560	14
11/21/2022	12/21/2022	2,560	17	11/21/2023	12/21/2023	2,960	17
12/21/2022	1/21/2023	2,640	15	12/21/2023	1/21/2024	2,960	16
1/21/2023	2/21/2023	4,640	16	1/21/2024	2/21/2024	4,640	16
2/21/2023	3/21/2023	6,160	16	2/21/2024	3/21/2024	2,080	15
3/21/2023	4/21/2023	3,600	14	3/21/2024	4/21/2024	2,800	14
Total		**34,160**	**156**	**Total**		**35,440**	**152**

The following tables are a summary of the natural gas consumption for the last two (2) plus years. For a building of this size and age the overall usage indicates that the night setback function of the thermostat is not being utilized. The low summer consumption represents the monthly natural gas consumption to generate DHW.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
3/4/2022	**4/4/2022**	438	3/7/2023	**4/5/2023**	387
4/4/2022	**5/4/2022**	259	4/5/2023	**5/4/2023**	237
5/4/2022	**6/3/2022**	94	5/4/2023	**6/6/2023**	141
6/3/2022	**7/6/2022**	74	6/6/2023	**7/6/2023**	63
7/6/2022	**8/5/2022**	52	7/6/2023	**8/9/2023**	56
8/5/2022	**9/6/2022**	60	8/9/2023	**9/6/2023**	44
9/6/2022	**10/4/2022**	90	9/6/2023	**10/5/2023**	69
10/4/2022	**11/3/2022**	183	10/5/2023	**11/6/2023**	176
11/3/2022	**12/6/2022**	412	11/6/2023	**12/5/2023**	397
12/6/2022	**1/6/2023**	572	12/5/2023	**1/5/2024**	523
1/6/2023	**2/3/2023**	514	1/5/2024	**2/5/2024**	688
2/3/2023	**3/7/2023**	620	2/5/2024	**3/5/2024**	560
Total		**3,368**	**Total**		**3,341**

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ELECTRIFICATION

Electrification-1 Electrification of Natural Gas DHW Heat Pump Water Heater w/ Air Source Heat Pump

Install one 40-gallon 120-volt hybrid electric heat pump water heaters as the primary source of DHW. The Ruud Ultra plug-in model PROUH40 with HydroBoost and LeakGuard are 20 inch in diameter and 157 pounds. The small size of the plug in water heater may alleviate the rigging issues associated with the standard 208/240-volt heat pump tank type heaters. The heater should be piped in series with the existing natural gas 118-gallon tank type heater for extra capacity if needed by the kitchen. Utilizing a 15-amp 120-volt power supply will also reduce electrical costs associated with the installation. The estimated project cost is $5,000. EMA believes this project will only qualify for the residential rebate of $700. The project will displace 900 therms of natural gas with approximately 7,100 kWh of electricity for a negative cash flow of $200 per year.

Electrification-2 Electrification of Natural Gas Heating System

The original split DX Lennox furnace with A-coils for A/C are approaching the end of their useful service life and are over 17 years old. The two rooftop units are also original and appear to be in good working order. Replacing the split DX A-coils with low temperature heat pump outdoor condensers and compatible DX A-coil can electrify the heating of the spaces served by the equipment. It should be noted that all the R-22 refrigerant piping will also have to be replaced to accommodate the new refrigerant. Replacing the RTU's with low temperature heat pump rooftop units of the same size or smaller will also electrify the heating for the cafeteria/ meeting room. The existing equipment appears to be oversized, and we recommend detail heating and cooling load calculations prior to proceeding. For the incremental cost of the heat pump replacement vs standard DX cooling equipment 75% or more of the building can be electrified. The activity spaces served by the Lennox furnaces should have backup natural gas heat. This type of upgrade is eligible for Mass Saves rebates of $2,500 per ton. The total connected tons are 53.5 tons. Potential rebate under the current Mass Saves program is up to $133,750. The Mass Save program will be revised January 1st, 2025. Based on the current project at the library the capital cost of this project is estimated at $400,000.

It should be noted that Lennox does not have literature on the new B454 refrigerant equipment required by law in January 2025. There is no pricing available for the equipment. Performance curves have not been published. Any estimate of performance is based on the discontinued R410A equipment. Lennox low outdoor air temperature performance is way below industry standard.
The estimated therms displaced are 1,800 with 22,000 kWh of electricity for a net increase in utility bills of $1,500 per year. Electrification should be considered at the end of useful service life of the HVAC equipment or the next round in 20 years.

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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There is a natural gas fired unit heater and the kitchen hood makeup air unit that also are natural gas fired. The unit heater can be replaced with electric resistance unit heater. At this time the technology does not exist to replace the 100% outdoor air natural gas fired kitchen hood makeup air unit. The kitchen hood makeup air unit is not used more than a couple of times a year.

RENEWABLE ENERGY POTENTIAL

The building has enough open roof space to install solar PV to offset approximately 50% of the annual electrical consumption with a 16-kW system. A $60,000 system will have a simple payback of 12 years without IRA incentives. The project is not recommended until the roof is replaced. The IRA act may provide direct payments of 30% to municipalities for solar PV installation if prevailing wages labor is used. If the project is financed by tax exempt bond the direct payment is reduced 15%.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Dale Street School

45 Adams Street, Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Attic Insulation	0	0	5,000	$6,500	$35,000	5.4	TBD	---
2	Heat-Timer Steam Boiler Controller	0	0	TBD	TBD	$7,500	TBD	TBD	---
	TOTAL		**0**	**5,000**	**$6,500**				
			0%	12%					

The Dale School was constructed in three stages beginning in 1942 as the Town of Midfields High School. The building has a large gymnasium/ auditorium. The original building is uninsulated and the two additions poorly insulated. The only architectural improvements to the school are new vinyl double glazed double hung windows in the classrooms. The lighting has been retrofitted or replaced with LED. The building is steam heated with a limited number of window air conditioners. The school has reached the end of its useful life and the town developing a plan to replace it. The new school will not be online for 7 to 10 years. Despite all these handicaps the EPA ENERGY STAR® rating of the school is 61 out of 100 (1-100) which is above average.

EMA has identified two potential energy conservation measures that may fit into the remaining useful life span of the school:

1. Attic insulation with blown in cellulose over the existing plaster metal lath ceiling. The thickness that the contractor may be comfortable with may not comply with Mass Saves program or building code but too much weight may collapse the ceiling. We estimate that 5,000 thems per year ($6,500) can be saved. Based on a project cost of $35,000 the simple payback is 5.3 years. Consideration should be given to the improved comfort and freeze protection that will be achieved with this installation.
2. Heat-Timer or equal boiler heating controls. It is unclear if the automated system will outperform the manual operation based on the $7,500 estimated project cost.

While there is roof area suitable for solar PV installation the condition of the roofs disqualifies consideration until the roofs are replaced.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

BUILDING DESCRIPTION

Architectural

The 67,249 square foot Dale Street School was constructed in 1942 as the towns High School. This two-story brick building houses approximately 400 grades 4 and 5 Students. The original building has a full basement/ bomb shelter. In the 1960's an addition was built with library, general purpose room, classrooms, and offices. In the 1980's two modular classrooms with dedicated RTU's were installed. The original building is an uninsulated brick building with no attic insulation. One wing of the original school is a large gymnasium/auditorium.

The original wood framed windows have been replaced with double hung double glazed vinyl framed windows in the classroom. Most of the other windows are original.

Lighting

Most of the lighting has been converted to LED. There are scattered CFL's in high hats and fluorescent lamps.

Mechanical

The classrooms are conditioned by Unit Ventilators and steam radiators. The UVs are pneumatically controlled. The functional steam radiators have Danfoss steam control valves to help control space temperature. The building is very difficult to balance space temperature between classrooms. The UVs are much newer than the building. It is not known if the original building had UVs or at some point the school added them for active ventilation. The main building has a central ventilation exhaust fan (5 HP) and toilet exhaust fan (3 HP).

The boilers are natural gas fired cast iron sectional Weil-McLain model 588 rated at 1064 MBH input with Power Flame model WJSOA - 15 burner. The boilers were installed in July 2006. The boilers have no controller. The school staff manually turn the boilers on/off based on an as need basis. Based on the natural gas consumption and the poorly insulated building shell the staff is doing a good job.

The modular classrooms have a DX RTU with electric heating for space conditioning.

The gymnasium/auditorium also has steam radiators for heating. The gymnasium/auditorium has two (2) H&V units with steam heating coils for ventilation. It is unclear if they are functionable. There was no access to the fan motors.

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Domestic Hot Water (DHW)

DHW is generated by a natural gas fired State model SUF100250NEA 200 high efficiency Tank Type DHW heater rated at 250,000 BTU/HR input and a Ruud® commercial model EGL 120-12-G tank type heater. The electric heater is a 120-gallon unit with a 12-kW electric element. The State® heater also has 120-gallons of storage.

Electric Service

The building has an 800 AMP 120/208 volt 3-phase four (4) wire electric service. The service can support approximately 230 kW demand. The existing peak demand is 56 kW. This service cannot support the electrification of the school.

UTILITIES

The school consumes electricity and natural gas. The school has averaged approximately 70,000 BTU/SQFT over the last two (2) years. The EPA Energy Star rating of the school is 61 on a scale of 1 to 100 indicating the school operates above average from and energy consumption prospective. The major contributor to this good rating is the low electric consumption per square foot. Electric consumption is low due to steam heat (there aren't any heating hot water electric pumps) and limited other HVAC fans or pumps.

The following tables are a summary of the electrical consumption for the last two (2) years. The electrical consumption is well below average for a school.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	13,280	50	4/21/2023	5/21/2023	12,240	45
5/21/2022	6/21/2022	13,280	53	5/21/2023	6/21/2023	11,920	49
5/21/2022	7/21/2022	7,440	38	6/21/2023	7/21/2023	8,480	25
7/21/2022	8/21/2022	8,480	30	7/21/2023	8/21/2023	8,080	32
8/21/2022	9/21/2022	12,720	54	8/21/2023	9/21/2023	13,440	56
9/21/2022	10/21/2022	12,000	42	9/21/2023	10/21/2023	12,240	45
10/21/2022	11/21/2022	12,720	47	10/21/2023	11/21/2023	13,040	45
11/21/2022	12/21/2022	13,760	49	11/21/2023	12/21/2023	13,520	43
12/21/2022	1/21/2023	12,800	41	12/21/2023	1/21/2024	13,360	46
1/21/2023	2/21/2023	14,160	42	1/21/2024	2/21/2024	15,640	46
2/21/2023	3/21/2023	12,320	46	2/21/2024	3/21/2024	13,120	46
3/21/2023	4/21/2023	12,720	47	3/21/2024	4/21/2024	12,640	47
Total		**145,680**	**539**	**Total**		**147,720**	**525**

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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The following tables are a summary of the electrical consumption for April 2022 through March 2023. The MEI data for the next year is identical to this data. The modulars are all electric with cooling. The modulars consume approximately 43,500 BTU/Yr., which is good for school spaces. This indicated that the HVAC is well controlled.

Start Date	Read Date	kWh
4/25/2022	5/24/2022	1,723
5/24/2022	6/23/2022	1,559
6/23/2022	7/26/2022	1,669
7/26/2022	8/24/2022	1,862
8/24/2022	9/23/2022	2,050
9/23/2022	10/25/2022	2,378
10/25/2022	11/23/2022	2,529
11/23/2022	12/23/2022	2,730
12/23/2022	1/25/2023	2,663
1/25/2023	2/23/2023	2,226
2/23/2023	3/24/2023	2,207
3/24/2023	4/25/2023	1,880
Total		**25,476**

The following tables are a summary of the natural gas consumption for the last two (2) plus years. The consumption is almost the same from year to year, indicating no change in the operation of the school. The low summer consumption represents the monthly natural gas consumption to generate DHW for cleaning.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
4/4/2022	5/4/2022	2,865	4/5/2023	5/4/2023	2,865
5/4/2022	6/3/2022	411	5/4/2023	6/6/2023	410
6/3/2022	7/6/2022	123	6/6/2023	7/6/2023	123
7/6/2022	8/5/2022	82	7/6/2023	8/9/2023	102
8/5/2022	9/6/2022	103	8/9/2023	9/6/2023	103
9/6/2022	10/4/2022	123	9/6/2023	10/5/2023	133
10/4/2022	11/3/2022	1,161	10/5/2023	11/6/2023	1,530
11/3/2022	12/6/2022	6,096	11/6/2023	12/5/2023	5,839
12/6/2022	1/6/2023	8,623	12/5/2023	1/5/2024	7,463
1/6/2023	2/3/2023	8,101	1/5/2024	2/5/2024	9,539
2/3/2023	3/7/2023	8,861	2/5/2024	3/5/2024	8,121
3/7/2023	4/5/2023	4,293	3/5/2024	4/4/2024	6,487
Total		**40,842**	**Total**		**42,715**

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY CONSUMPTION MEASURES

ECM # 1 – Roof Insulation

The existing attic in the Dale Street school above the classrooms is not insulated. The ceiling of the attic has acoustical tile finish below the original metal lath plaster ceiling. We recommend installing blown in cellulose insulation above the plaster ceiling. The existing holes in the plaster ceiling need to be covered to maintain a continuous cellulose insulation layer for best performance. The thickness of the cellulose insulation should be controlled to account for the load bearing capacity of the metal lath plaster ceiling. This thickness may not comply with Mass Saves rebate program. This improvement will decrease comfort issues and reduce energy consumption to heat the building. It also will reduce overheating of the classrooms during the cooling season. The estimated savings are 5,000 therms per year ($6,500). The estimated project cost is $35,000 and results in 5.3 years.

ECM # 2 – Heat-Timer Steam Boiler Controller

To automate the steam heating a Heat-Timer MPCP (or equal) steam boiler controller based on outdoor air temperature or a selected space can be installed to achieve the goal. The controller has 7-day programming capacity with up to four (4) occupied/unoccupied time settings. The It is not clear that the controller will perform better than the staff's manual control. The one area of potential improvement would be un-occupied heating control when no staff is on site. The programmer can control un-occupied heat as the temperature varies. The staff must decide before the weekend which holidays to keep the boilers on for freeze protection. The Heat-Timer does this function automatically. The indictive project cost of this project is $7,500. How long the school will function in its current configuration should be accounted for this investment.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ELECTRIFICATION POTENTIAL

Replacing the electric domestic hot water heaters with electric heat pump tank-type water heaters will reduce energy consumption by approximately 66%. Commercial heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial). The mechanical room has limited space for installation of four or more heat pump water heaters. Project economics requires further study.

RENEWABLE ENERGY POTENTIAL

The building has good solar exposure. Unfortunately, the roofing material of the building is in poor condition disqualifying the site from consideration until the roofs are repaired. There is significant area to generate almost all the electricity consumed on site.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – DPW Building

55 North Meadows Rd. Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	JCI BMS Retro/Up commissioning	0	19,000	3,500	$8,000	$13,500	1.7	0	1.7
2	Garage lighting upgrade to LED	7.5	15,000	0	$3,600	$12,000	3.3	$9,000	0.8
	TOTAL	**7.5**	**34,000**	**3,500**	**$11,600**	**$25,500**	**2.2**	**$9,000**	**1.4**
			23%	17%					

The Medfield Department of Public Works building was opened in 2014. The building has two vehicle high bay storage garages, high bay vehicle maintenance garage, and DPW offices. Overall, it was built to the high energy and sustainability standards of the time. Many advanced Technologies were incorporated into the design including (below); however, this does not always translate to energy savings if not operated optimally. This building uses approximately 52 kBTU per SF for heating, which is high.

- Heat recovery vehicle storage and maintenance ventilation
- Roof insulation beyond code of the time
- CO_2 demand-controlled ventilation
- Infrared heating of vehicle storage
- Fan and pump motor VSDs –

In 2017 a 216.48 kWdc solar array was installed that generates more electricity than the building consumes. The lighting fixtures in the DPW offices have been retrofitted with LED lamps. The garage lighting is original T-5 fluorescent with what appears to be original lamps.

Overall, the building consumes more energy than anticipated for level of enhanced design. In large part this is due to a rather unnecessarily high heating setpoint in the vehicle storage and maintenance garages, 60 °F all winter. Often these type garages do not need to be heated beyond the minimum required for freeze protection when not in use, 40 °F. The garages are active approximately 50 hours a week, DPW emergencies, and snow removal duties. Currently the DPW offices have a manual override switch in the mechanical room that enables 24 hours of office occupied operation. Unfortunately, the garages were not incorporated into this switch. The garages have single setting manual thermostats.

EMA has identified two Energy Conservation Measures for the building:

1. Retro/Up commissioning of the Johnson Controls Building Management System. This project includes implementing night setback in the garages with the installation of BMS integrated thermostats. The rest of the project includes updating the set points and control algorithms incompliance to the latest ASHRAE standards. This project is estimated to save 19,000 kWh and

3,500 therms per year for a total of $8,000. The estimated project cost is $13,500 for a simple payback of 1.7 years. Most of the thermal savings are related to night setback of the garage.

2. Replace the fluorescent T-5 4-lamp garage lamps with LED compatible lamps. The projected savings are 15,000 kWh/year and 7.5 kW demand per month or $3,600 per year. EMA estimates material cost for the lamps is $9,000, plus $3,000 for a lift rental. Since the fixtures are in high bays over 20 feet tall, we are not able to estimate labor. DPW or facilities could replace them with town personnel by renting a lift. The project is eligible for prescriptive Mass Saves rebates. The program pays $15 per lamp or about 100% of the material cost. The program ends December 31, 2024. It will not be renewed in 2025. This project should have a simple payback of less than a year. It should be noted that the lamps will have to be replaced soon since they are failing in service.

There is one electrification project that can be implemented soon. Installing a Heat Pump water heating system with large storage capacity. To complicate the project the mechanical room is not large enough to locate the equipment. Without July through Aug 2023 natural gas data from MEI it is impossible to calculate electrification potential.

BUILDING DESCRIPTION

Architectural

The Medfield Department of Public Works building was opened in 2014. The building is 38,873 square feet with three distinct sections. The center section is the office space for DPW. The office area is approximately 6,500 square feet. There are two (2) high bay garage wings for the maintenance and storage of DPW vehicles. The east wing has nine (9) drive through bays and the west wing has eleven (11) drive through bays. The vehicle maintenance space is in the west wing occupies four garage bays. The garage doors are insulated and in good condition.

The roof of the garages is white EPDM with 4inches of rigid board insulation. The walls of the garage and office are 4" ground face CMU, 2" cavity, 2 inches of rigid insulation, and 12 in CMU blocks. The office space has 5/8" interior dry wall on ½" metal studs. The roofing of the office has asphalt shingles. The attic insulation is located between the roof joist and is approximately 8 to 12-inches of fiberglass insulation.

The roofs of the two (2) garage sections have a 216.48 DCKW solar PV system installed. The town has leased the roof to Select Energy and purchases the generated electricity on a Power Purchase Agreement (PPA).

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Lighting

The lighting in the office section of the building is LED with some occupancy sensors. The predominate lighting system for the high bay garages is four (4) lamp T-5 industrial fixtures with occupancy sensors. The are approximately 160 fixtures. Many of the lamps maybe original since the ends blackened.

The exterior lighting is LED controlled by an INTERMATIC model ET1705C time clock. Each fixture has a photocell.

Mechanical

The office section of the building is heated and cooled by a standard VAV system with reheat and/or perimeter radiation for each zone. There are nine VAV zones. All spaces have CO2 sensors for DCV control. The office section has one 6,000 nominal CFM Trane AHU with hot water heating and DX cooling. The supply fan is 1.5 HP Baldor Super E invertor duty motor with a VSD. The heating hot water pump is a 1.5 HP Taco model kV 1507 rated at 50 GPM at 10 feet of head.

The following table is the design VAV box schedule. The current ASHRAE 90.1 guidelines recommend a 5:1 turn down ratio of the cooling air flow. Most of the existing VAV box turn down ratios are 2:1 resulting in cold spaces.

		Existing			Proposed		
Item #	**Location**	**Max cooling**	**Min cooling**	**Min Heating**	**Max cooling**	**Min cooling**	**Min Heating**
VAV-1	School Dept. 114	350	105	105	350	85	105
VAV-2	Cong./Operations 112	560	280	280	560	110	280
VAV-3	Facilities Dept. 111/Entrance 110	450	225	225	450	85	225
VAV-4	Hwy Dept. 124	450	105	105	450	85	105
VAV-5	Back Ent. 118/Hallway	405	205	205	405	75	205
VAV-6	Locker Rooms	580	290	N/A	580	120	N/A
VAV-7	Crew Room 120	1020	510	510	1020	200	510
VAV-8	Plan Room/ HWY Dept. 123	320	160	160	320	80	160
VAV-9	Electric Room	450	100	N/A	400	50	N/A
	Total	**4,585**	**1,980**	**1,590**	**4,535**	**890**	**1,590**

The garages are heated by natural gas fired infrared heaters and radiant underfloor systems. The zone thermostats are single setting type set at 60 °F. The underfloor heating system is controlled by a tekmar® model mixing control 360. The tekmar® controller has no schedule programmed.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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The DPW building boiler is a natural gas fired condensing boiler HTP model MOD CON 500 rated input of 500,000 BTU/Hr. The outdoor air reset schedule is 180°F at 0°F OAT and 120°F at 60°F. The potential for high efficiency condensing operation is limited by the reset schedule.

The garage is ventilated by five (5) Greenheck ERVs (see table below). Ventilation is only required during occupied periods. During our survey ERV-2 electric pre-heater was running on a 70 °F Day. The heat recovery wheel for the ERV-3 is destroyed due to the oils from the vehicle maintenance garage. ERVs 1 & 3 are not communicating with the BMS. ERV – 5 has been turned off due to overnight noise complaints by neighbors. ERV – 5 is not scheduled by the BMS.

Unit #	Make	**Model #**	**Location Served**	**Pre Heat kW Electric Heat**	**Supply Fan Hp**	**Exhaust Fan HP**	**CFM**	**Natural Gas Furnace Heating MBH**	**Control**
ERV-1	Greenheck	ERCH-90-30L-1G-01	West Garage Vehicle Exhaust	20	5	5	9,000		CO and NO2 Sensor
ERV-2	Greenheck	ERCH-20-15H-1G-01	West Garage Min. Ventilation	5	0.5	0.5	2,000	350	Continuous
ERV-3	Greenheck	ERCH-45-30L-1G-01	Vehicle Maintenance	10	2	2	4,500		Manual
ERV-4	Greenheck	ERCH-90-30L-1G-01	West Garage Vehicle Exhaust	20	7.5	7.5	9,000		CO and NO2 Sensor
ERV-5	Greenheck	ERCH-20-15H-1G-01	West Garage Min. Ventilation	5	0.5	0.5	2,000	350	Continuous

Building Management System (BMS)

The BMS is a legacy proprietary Johnson Controls Metasys system. Most of the components are no longer supported by Johnson controls. The system controls the office building HVAC and the building boiler. It monitors the radiant floor system status. The control of the ERV's appears to be split between the Greenheck unit controls and the BMS. The electric pre-heat is controlled by the Greenheck unit controls.

The occupied schedule of the BMS is:

- Monday 4AM to 7:30 PM
- Tuesday through Friday 4AM to 5PM
- Saturday and Sunday Off

The holiday schedule has not been activated. The schedule does not control the ERVs.

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160 Beech Street
Franklin, MA 02038
Tel: 508.533.1128
Fax: 508.533.7332
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The BMS performs the garage indoor air quality function monitoring the space CO and motion for the ERVs 1 and 4. It is unclear if it is monitoring the NO2 sensor. The CO and NO2 readings are not mapped to the graphics. The garage motion sensor status is also not mapped to the graphics.

AHU-1 is programmed with a constant discharge air temperature control at 55°F, economizer free cooling cycle, demand control ventilation based on highest zone CO2 reading. Heating control is with a face and by-pass damper and the heating coil valve continually open. We noticed that most of the room CO2 sensors are out of calibration. The AHU runs during un-occupied periods for unoccupied heating. Each room except the Crew Room 120 (VAV-7) has perimeter baseboard radiation for un-occupied heating. The VAV boxes turn down ratios are 2:1 not consistent with current ASHRAE guidelines of 5:1. During our site survey the building was over cooled because reheat is not available during cooling season. Based on conversation with the building staff it is cold during the winter. This may be an indication that the low DAT setpoint cannot be offset by heat from the reheat coils and perimeter radiation.

Domestic Hot Water (DHW)

DHW is generated by an indirect TurboMax model 65A. The indirect DHW heater tank size has 72-gallon storage capacity. The boiler supply water temperature in DHW mode is 160 °F. The minimum rating of the TurboMax is 200,000 BTU/Hr. with 200 °F boiler water. Replacing it with heat pump tank type water heater will reduce energy consumption by approximately 66%. Commercial heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial).

Electric Service

The building has a 600 AMP 460 volt 3-phase electric service. This service can support an electrical demand of approximately 380 kW. Based on existing peak winter demand of 48 kW there is enough power to convert the natural gas fired heating boiler to an electric boiler. Electric resistance boiler is required because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology. Further study is required to determine if the natural gas infrared heaters can be replaced with electric infrared heaters. Another alternative to the natural gas fired infrared heaters is replacing them with low temperature ductless split heat pumps. This conversion will increase total utility bills but give the Town of Medfield Town Hall the ability to be carbon free with electric Mass Class1 REC’s.

The site has a 350-kW diesel emergency generator.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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UTILITIES

The building consumes electricity and natural gas. The utility bill data is incomplete so we cannot benchmark the building annual energy consumption.

The following table summarizes typical years electrical consumption and typical year PV production of the building. This is the best data from the MEI database and the Select Energy tabulation software. Based on the data the PV system generates more electricity than the facility consumes.

Annual Electric Consumption			PV Generation	
Start Date	**Read Date**	**kWh**	**Month**	**kWh**
6/23/2022	7/26/2022	11,088	June-23	21,088.7
7/26/2022	8/24/2022	10,572	May-23	30,099.5
8/24/2022	9/23/2022	9,512	April-23	26,576.4
9/23/2022	10/25/2022	10,160	March-23	20,013.5
10/25/2022	11/23/2022	9,568	February-23	16,634.9
11/23/2022	12/23/2022	9,636	January-23	11,864.2
12/23/2022	1/25/2023	14,384	December-22	7,540.4
1/25/2023	2/23/2023	14,460	November-22	4,900.5
2/23/2023	3/24/2023	15,072	October-22	14,914.6
3/24/2023	4/25/2023	14,476	September-22	19,745.5
4/25/2023	5/24/2023	12,276	August-22	23,946.9
5/24/2023	6/23/2023	14,648	July-22	28,778.3
Total		**145,852**	**Total**	**226,103.4**

The following table is a summary of the natural gas consumption in the MEI data base form two years we have data from MEI. At 52,000 BTU/SQFT the heating energy consumed by this building is high considering the high-performance shell and mechanical installed such as heat recovery ventilation of garages, demand control ventilation, underfloor radiant heating, etc. The high consumption indicates that un-occupied temperature set back is not being fully utilized. The low summer consumption represents the monthly natural gas consumption to generate DHW. The July 2022 through August 2023 data is missing from MEI

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Start Date	Read Date	Therms
7/6/2021	8/4/2021	134
8/4/2021	9/3/2021	134
9/3/2021	10/5/2021	175
10/5/2021	11/3/2021	863
11/3/2021	12/3/2021	2,457
12/3/2021	1/4/2022	3,464
1/4/2022	2/3/2022	5,196
2/3/2022	3/4/2022	3,571
3/4/2022	4/4/2022	2,498
4/4/2022	5/4/2022	709
5/4/2022	6/3/2022	698
6/3/2022	7/6/2022	709
Total		**20,608**
7/6/2023	8/9/2023	0
8/9/2023	9/6/2023	62
9/6/2023	10/5/2023	246
10/5/2023	11/6/2023	1,202
11/6/2023	12/5/2023	3,588
12/5/2023	1/5/2024	4,318
1/5/2024	2/5/2024	5,351
2/5/2024	3/5/2024	3,824
3/5/2024	4/5/2024	
3/6/2024	5/6/2024	1,491
Total		**20,082**

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY CONSERVATION MEASURES

ECM-1 Retro/Up commissioning of BMS - integrate Garage Thermostats and Underfloor radiant system into the BMS for un-occupied temperature night setback of garage heat.

The thermostats for the infrared heaters and hot water unit heaters are single setting manual thermostats typically set at 60 °F. The underfloor control system is a stand-alone tekmar® model 360 mixing control. The thermostats do not have un-occupied set back capacity. The tekmar® controller is not programmed for un-occupied operation. We recommend that the thermostat and underfloor heating control be programmed into the BMS for un-occupied control and freeze protection. They can be tied into the manual override switch in the boiler room that overrides the BMS schedule. Retro-commissioning recommendations begin with the replacement of the office building space CO2 sensors with Kele GMW wall sensors compatible with the BMS.

- The DCV programming and set points should be reviewed.
- The cooling min flow setpoints should be reduced to 20% of the cooling maximum setpoint.
- The AHU and VAV box un-occupied heat programming should be reviewed so that the perimeter hot water radiation is the first stage of unoccupied heating.
- Follow ASHRAE 90.1 recommendation for thermostat deadband for all VAV boxes of 5°F.
- Check if occupancy sensors are used for temporary space temperature set points override.
- Implement unoccupied heating hot water pump freeze protection control. Turn off the heating hot water pumps during unoccupied period above 35 °F.
- Implement morning startup programming with outdoor and exhaust air dampers close.
- Review the economizer free cooling cycle set points
- Implement discharge air reset based on outdoor air temperature (65°F DAT (adjustable) at 70° OAT. or below and 55 °F (adjustable) at 95 °F or above)
- Implement night setback control of the infrared heaters. Replace the manual thermostats with BMS temperature sensors.
- Repair the ERVs
- Replace ERV – 3 heat recovery media with a cleanable medium compatible with vehicle maintenance garage.

These improvements will optimize the operation of the building while reducing energy consumption and improving comfort.

ECM – 2 Garage Lighting Upgrade to LED

The garage lighting is T-5 fluorescent 4-lamp lamps. There are approximately 160 4-lamp fixtures in the garage. They appear to be original since most of the ends are blackened or the lamp has failed in service. It should be noted that even though a lamp is not lighting up the ballast continues to consume

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

rated input watts. It is recommended replacing the existing lamps with T-5 LED replacements of the same lumen output that are compatible with the existing ballast. The DPW staff can replace the lamps.

ECM -3 Heat Pump Water Heater and Storage Tank

DHW is generated by an indirect 120-gallon tank type water heater. EMA was unable to estimate potential electrification potential since there is no Natural Gas Data in MEI for the months of July 2022 through August 2023. To further complicate the issue there is not significant space in the mechanical room to install heat pump water heaters. EMA is not able to account for the vehicle washing to estimated natural gas consumption or develop a schematic design for project cost estimating. A system with the capacity to meet DHW demand will require a large DHW storage tank (500 to 1,000 gallons) due to the slow generating capacity of heat pump water heaters. The largest demand maybe during the winter after snow removal activities to wash off salt.

RENEWABLE ENERGY POTENTIAL

The main building has a 216.48 kWdc solar array. It was put into operation on June 6th, 2023. The production from the array is purchased by the town through a PPA. On the site is a road salt storage building with a large roof. Further study is required to evaluate the potential for additional PV installation. The building sloped roofs and orientation do not make the storage building the best candidate for PV production efficiency. Also to be considered is the very small electric service to the building from the main building. Extensive wiring may be required to export the electricity.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Pfaff Parks & Recreation Building

124 North St. Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

The Pfaff Center operates very efficiently consuming less than 20,000 BTU/SQFT of total energy per year. This matches the goal of any Net Zero Energy annual building design. The building is 100% heated but only partially cooled by window A/C units. Several architectural upgrades including (see bulleted item) have contributed to the excellent performance:

- New insulated roof
- Replacement of the original windows with double hung double glazed windows.

The occupants are manually controlling energy usage that contributes to achieving performance. The lighting switches are being well utilized. The manual thermostat control along with the night set back thermostat setting have resulted in low thermal energy consumption for heating.

The building electrical service is very limited at 200 AMP 120/208-volt three phase. Electrification of the building will require an upgraded electric service.

The flat roof can accommodate enough solar PV to easily offset all the electricity consumed by the building with a 3-4 kW system. There is enough roof space to make the building Net-Zero Energy annually.

EMA recommends keeping up the good job. ***No Energy Reduction Measures are recommended***.

BUILDING DESCRIPTION

Architectural

The Medfield Pfaff Center is 12,033 square foot brick building with half un-conditioned basement located at 124 North St. Medfield, MA 02052. The building was built in 1930. It is currently in the Park & Recreation Department headquarters. The windows are replacement double hung double glazed windows. The interior walls plaster over brick. The roofing is new white EPDM membrane over ridged insulation. The basement has concrete walls.

Lighting

Most of the lighting is LED.

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Mechanical

The HVAC system is a simple one pipe steam system for heating with window A/C units for cooling. The steam boiler is an atmospherically fired natural gas cast iron boiler. Burnham model 5010 with a rated 702,000 BTU/Hr. input and 561,600 BTU/Hr. output. Some of the steam piping and fittings in the basement are not insulated. The boiler is controlled by a night setback programmable thermostat.

EMA does not recommend insulating the piping in the basement since it is the only source of heating in the basement. This is the only source of freeze protection of the building water service. Any heat from these pipes rises and helps heat the building.

Domestic Hot Water

Domestic Hot Water is generated by two (2) electric tank type hot water heaters, one each located in the men's and women's bathroom. Each tank is 5 to 10 gallons in size.

Electric Service

The building is served by a 200 AMP 120/208 three phase. The service is not adequately sized to support heating electrification.

UTILITIES

The building consumes electricity and natural gas. The overall energy consumption is very low and similar to a net zero energy building defined as 20,000 to 25,000 BTU/SQFT. The building has averaged 19,500 BTU/SQFT over the last three (3) years.

The following table is a summary of the electrical consumption over the last three years. Consumption goes up in summer reflecting use of the window A/C's. Overall, the consumption is well below average for a building this size reflecting the low overall occupancy and the very low plug loads. It indicates that the staff uses the manual lighting switching effectively.

Start Date	Read Date	kWh	Start Date	Read Date	kWh	Start Date	Read Date	kWh
6/23/2021	7/23/2021	1,663	5/24/2022	7/25/2022	1,980	5/23/2023	7/23/2023	1,830
7/23/2021	8/24/2021	1,765	7/25/2022	8/23/2022	1,746	7/23/2023	8/24/2023	1,529
8/24/2021	9/23/2021	960	8/23/2022	9/23/2022	863	8/24/2023	9/22/2023	871
9/23/2021	10/22/2021	806	9/23/2022	10/25/2022	799	9/22/2023	10/25/2023	789
10/22/2021	11/24/2021	1,234	10/25/2022	11/23/2022	838	10/25/2023	11/22/2023	850
11/24/2021	12/23/2021	1,225	11/23/2022	12/22/2022	922	11/22/2023	12/22/2023	1,001
12/23/2021	1/25/2022	1,318	12/22/2022	1/25/2023	1,022	12/22/2023	1/24/2024	997

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1/25/2022	2/23/2022	1,029	1/25/2023	2/23/2023	954	1/24/2024	2/22/2024	1,075
2/23/2022	3/24/2022	1,146	2/23/2023	3/24/2023	961	2/22/2024	3/22/2024	945
3/24/2022	4/26/2022	973	3/24/2023	4/24/2024	884	3/22/2024	4/23/2024	967
4/26/2022	5/24/2022	708	4/24/2024	5/23/2023	783			
5/24/2022	6/22/2022	695	5/23/2023	6/22/2023	721			
Total		**13,522**	**Total**		**12,473**	**Total**		**10,854**

The following table is a summary of the natural gas consumption for the last two (2) years. For a building of this size and age the overall usage is below average indicating that the night setback function of the thermostat is being utilized. The small summer consumption indicates that the boiler could be shut down manually some of the time.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
3/4/2022	4/4/2022	1,028	3/7/2023	4/5/2023	939
4/4/2022	5/4/2022	707	4/5/2023	5/4/2023	531
5/4/2022	6/3/2022	150	5/4/2023	6/6/2023	262
6/3/2022	7/6/2022	0	6/6/2023	7/6/2023	58
7/6/2022	8/5/2022	3	7/6/2023	8/9/2023	0
8/5/2022	9/6/2022	0	8/9/2023	9/6/2023	2
9/6/2022	10/4/2022	42	9/6/2023	10/5/2023	203
10/4/2022	11/3/2022	565	10/5/2023	11/6/2023	592
11/3/2022	12/6/2022	1,003	11/6/2023	12/5/2023	1,000
12/6/2022	1/6/2023	1,275	12/5/2023	1/5/2024	1,134
1/6/2023	2/3/2023	1,138	1/5/2024	2/5/2024	1,345
2/3/2023	3/7/2023	1,292	2/5/2024	3/5/2024	1,088
Total		**7,203**	**Total**		**7,154**

ENERGY CONSERVATION MEASURES

There are no recommendations.

RENEWABLE ENERGY POTENTIAL

The new flat roof is an excellent candidate for solar PV. A small residential array of 3-4 kW will offset all the electricity consumed. A $15,000 system will have a simple payback of 6 years. The IRA act provides direct payments of 30% to municipalities for solar PV installation if prevailing wages labor is used. If the project is financed by tax exempt bond the direct payment is reduced 15%.

The roof area is significant enough to install a solar PV system that will offset all the natural gas emissions to achieve Net Zero emission annual.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Transfer Station

135 North Meadows Rd. Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Office conversion to Air Source Heat Pump	0	7,750	0	$1,500	$10,000	4.9	$2,625	4.9
	TOTAL	**0**	**7,750**	**0**	**$1,500**	**$10,000**	**4.9**	**$2,625**	**4.9**
			25%						

The transfer station is a very small electric energy consumer. No fossil fuels are consumed on site for HVAC. We recommend one ECM (energy conservation measure); there is a small office onsite that is space conditioned. Replacing the electric baseboard heat and the window A/C with an air source heat pump of ½ to ¾ ton will reduce energy consumption of the office with night setback thermostat. The $10,000 project will qualify for Mass Saves rebate of $3,500 per ton. This project will save approximately $1,500 per year (7,750 kWh) with simple payback of 4.9 years with incentive.

To generate all the current electricity consumed on site a 30-35 kW PV array is required. If the heat pump is installed for space heating and cooling a 22.5-27.5 kW PV array is required.

BUILDING DESCRIPTION

Architectural

The transfer station's main building includes an office and an attached large garage. Both buildings have corrugated metal walls and roof over a steel frame; they are not insulated. The transfer station is open for the residences:

Month	Wed	Fri	Sat	Sun
All Months	9-4	9-4	9-4	
April and November	9-4	9-4	9-4	9-4
May, June, and September	9-4	7:30-4	9-4	
July and August	9-7	7:30-4	9-4	

The office is used for other activities during the week on an ad hoc basis.

The site also has two (2) hydraulic compactors for trash. And a small shack at the site entrance.

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Lighting

All lighting is LED. The outdoor lights have photocells. The garage bay light switching is unknown.

Mechanical

The office shed has electric baseboard heat and a small window A/C unit is used for cooling. There is no HVAC in the garage. The office must be heated all winter since there is a bathroom. The A/C is used on an as needed basis since the unit was off during our site visit.

Domestic Hot Water (DHW)

A small 6-gallon tank type electric heater generates DHW.

Electric Service

The electric service is 225 AMP at 460/277 volt. This is more than enough to power the existing all electric resistance heating requirements of the site.

UTILITIES

The site is all (100%) electric. The following table is the tabulation of the last two years electric consumption.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	1,893	11	4/21/2023	5/21/2023	2,151	11
5/21/2022	6/21/2022	1,560	11	5/21/2023	6/21/2023	1,545	9
6/21/2022	7/21/2022	1,535	10	6/21/2023	7/21/2023	1,478	11
7/21/2022	8/21/2022	2,020	9	7/21/2023	8/21/2023	1,606	10
8/21/2022	9/21/2022	1,153	12	8/21/2023	9/21/2023	1,521	9
9/21/2022	10/21/2022	1,512	11	9/21/2023	10/21/2023	1,617	10
10/21/2022	11/21/2022	2,693	14	10/21/2023	11/21/2023	2,542	14
11/21/2022	12/21/2022	3,481	17	11/21/2023	12/21/2023	3,356	17
12/21/2022	1/21/2023	4,153	15	12/21/2023	1/21/2024	4,691	16
1/21/2023	2/21/2023	4,121	16	1/21/2024	2/21/2024	4,982	16
2/21/2023	3/21/2023	3,406	16	2/21/2024	3/21/2024	3,889	15
3/21/2023	4/21/2023	2,591	14	3/21/2024	4/21/2024	3,442	14
Total		**30,118**	**156**	**Total**		**32,820**	**152**

160 Beech Street
Franklin, MA 02038

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Fax: 508.533.7332

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Electrical consumption varies within an acceptable range for facilities like this. The energy consumption appears to be high for such a small, occupied office. Without submetering it is difficult to estimate process electric loads for the compactors and related equipment. The data does support that HVAC equipment is not scheduled for night setback.

ENERGY CONSERVATION MEASURES

ECM-1 Office conversion to ductless Split Air Source Heat Pump

Replace the window A/C and electric baseboard with a Mitsubishi Hi (hyper heat) or equal low temperature heat pump of ¾ ton or smaller. Leave the existing electric baseboard as backup heat. The recommended thermostat should have night setback capacity. This $10,000 project will qualify for a $2,625 rebate from Mass Saves. The estimated savings are 7,750 kWh per year ($1,500) in heating and cooling consumption. The simple payback after rebate is approximately 4.9 years.

RENEWABLE ENERGY POTENTIAL

The site is an excellent candidate for solar PV. A small 30 kW array will offset the entire transfer stations energy consumption.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – High School

88R South Street Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	BMS HVAC Equipment Scheduling	0	115,000	3,600	$24,500	$10,000	0.4	TBD	---
2	Install thermal insulation at Roof hatches & at other roof thermal breaks	0	0	450	$600	$4,000	3.7	0	6.7
3	Install condensing high efficiency boiler	0	0	6,500	$8,500	$100,000	11.8	TBD	---
	TOTAL	**0**	**115,000**	**10,550**	**$33,600**	**$114,000**	**3.4**	**TBD**	**---**
			9%	15%					

The Medfield High School is a 187,487 square foot two-story building originally constructed in 1967 with an addition in 2003. The addition approximately doubled the size of the school. The building is heated and partially air conditioned. The ENERGY STAR® rating of the school is 54 out of 100 (1-100) just above average consistent with the age and condition of this design of a high school.

The original school's roofing was replaced with rolled asphalt membrane and about 4 inches of rigid board insulation. The current condition of the asphalt membrane is poor and in need of replacing. The additions have black EPDM roofing above 4 inches of rigid board insulation. The new roof is in good condition. The original high school building shell is uninsulated brick over block construction. The windows have been replaced with aluminum framed double glassed casement units similar to the original. The additions are constructed to the standard of the early 2000's.

The lighting has been converted to LED.

The unit ventilators and heating/ventilation units and associated exhaust fans are replacements for the original equipment. The three natural gas-fired H.B. cast iron boilers and 23 RTUs and 10 AHUs were replaced or installed during the renovation and building addition. Twelve (12) of these units have air-cooled air conditioning capacity. The heating systems are scheduled from 3AM warmup for a school schedule of 7:40AM to 3:30PM.

EMA has identified three Energy Conservation Measures that will significantly improve the energy efficiency of the school.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ECM-1 BMS HVAC Equipment Scheduling – Reviewing the scheduling of the school has the potential of reducing energy consumption by 115,000 kWh and 3,600 therms per year for a net savings of $24,500. The estimated project cost is $10,000 for programming and energy consultant resulting in a 0.4-year simple payback.

ECM-2 Insulating the three (3) roof hatches over the auditorium and miscellaneous other roof thermal breaks. The project will save approximately 450 therms per year or $600. The estimated project cost is $4,000 resulting in a simple payback of 6.7 years. This project may be eligible for Mass Saves rebate financing.

ECM-3 Install high efficiency natural gas condensing boiler as the lead heating boiler. This improvement will save approximately 6,500 therms per year ($8,500). The estimated project cost is $100,000 yielding a 12-year simple payback. EMA recommends exploring this ECM at the end of the useful lives of the existing boilers.

The existing electrical service is not large enough to electrify the building hydronic and RTU furnace system. It is large enough to replace two (2) of the existing boilers with electric resistance boilers and 100% of the natural gas consumed by the hot water heating boilers. Additional electrification savings can be accomplished if one of these two projects listed below are implemented:

1. The existing Air-Cooled DX RTU can be replaced with heat pump AHUs with natural gas furnaces to offset more of the heating. This is an end of useful life project.
2. If cooling is added to each classroom with air source ductless low temperature heat pumps. This $1,500,000 project can save 12,000 to 17,000 therms of natural gas per year.

BUILDING DESCRIPTION

Architectural

The 186,487 square foot Medfield High School was constructed in 1967 and doubled in size in 2003. This two and ½ - story brick school with approximately 800 students grade 9 through 12. The school has a full auditorium, two (2) basketball court gymnasium, library, cafeteria, daycare center for school staff, and kitchen. The schools' roofing was replaced with asphalt rollout roof membrane with 4 inches rigid insulation and most of the HVAC equipment was replaced during the 2003 renovation. While the new construction has EPDM membrane roof with 4.5 inches of rigid insulation. The windows are replacement aluminum frame double glazed operable lower sash casement. Most of the HVAC equipment is on the roof.

The school has a kitchen for the cafeteria has a walk-in cooler and freezer.

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160 Beech Street
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Fax: 508.533.7332

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Lighting

Most of the lighting has been converted to LED. The classrooms have occupancy sensors. The poles have photocells for dusk to dawn operation. The key question is the exterior lighting required after 11PM to 6AM.

Mechanical

The classrooms are conditioned by Unit Ventilators with perimeter hot water baseboard. The unit ventilators provide heating and ventilation which is exhausted by rooftop exhaust fans. Each classroom has two-way valves on the heating how water system. Some classrooms and offices have window A/C units.

The three (3) primary boilers are natural gas fired HB Smith Model 28A-W-14 rated input of 4,180,000 BTU/Hr were installed in 2008. The boilers are piped in a primary/secondary distribution configuration. The primary pumps are Taco model KO3007 centrifugal pumps with 1 HP. The secondary heating hot water pumps are a TACO Model FI501 with 25 HP motors rated at 640 GPH, and 100 Feet of head. The HHW pump motors are Baldor Super-E invertor duty high efficiency motor. The secondary pumps have VSD's.

There are 23 Trane RTUs and nine (9) of the RTU's have air conditioning capacity serving the various large spaces throughout the school. The auditorium has a remote air-cooled DX chiller. One of the DX RTU's has been replaced in 2021. All the A/C equipment is standard efficiency equipment available at the time of construction. See the table in Appendix "A" for a summary of rooftop equipment.

There are 48 exhaust fans. During our survey the ones serving the classrooms were off. The rest of exhaust fans were on. The survey was performed after the end of the school year.

See Appendix A for mechanical equipment list. The BMS equipment and the RTU numbering do not always match. Detailed schedules of equipment are lacking.

Building Management System

The building management system is a Trane Tracer system. The following table lists all the HVAC equipment schedules:

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Tel: 508.533.1128
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Schedule Monday through Friday			
Schedule Description	**Warm Up**	**Occupied**	**Un-Occupied**
General Schedule	3AM to 5AM	5AM to 3:30PM	3:30PM to 3AM
Overtime Auditorium	N/A	All Day 7Day/Week	N/A
Overtime Gymnasium	N/A	All Day 7Day/Week	N/A
Minimum Outside Air Set Point	N/A	3PM to 7AM	7AM to 2PM
Overtime Band Area	N/A	N/A	All Day
Overtime Cafeteria Area	N/A	N/A	All Day
Overtime Chorus Area	N/A	N/A	All Day
Overtime Guidance Area	N/A	N/A	All Day
Overtime Library Area	N/A	N/A	All Day
Overtime School Committee Area	N/A	N/A	All Day

None of the schedules appear to have a holiday schedule programmed. There is no summer schedule when the school is closed. The weekend schedule during our survey was un-occupied except auditorium and gymnasium.

We also found the Overtime schedules for the Gym and Auditorium set to 24/7 occupied. Hopefully this was a temporary override for graduation and end of the year activities. The following overtime schedules set to un-occupied:

- Band
- Cafeteria
- Chorus
- Guidance
- Library
- School Committee Area

Domestic Hot Water (DHW)

DHW is generated by two new (2) State model SUF-119-400-NEA 300 high efficiency natural gas fired tank type heaters. The heaters are rated at 399,900 BTU/Hr. input with 119 gallons of storage. The tanks are maintained at 120 °F.

ELECTRIC SERVICE

The building has a 3000 AMP 480/277 volt 3-phase 4-wire electric service. This service can support an electrical demand of approximately 2,375 kW. Based on existing peak winter demand of 312 kW there is enough electric capacity to replace two (2) of the natural gas boilers with electric resistance boilers with power to spare. Assuming that the plant is designed with N+1 capacity the electric service is adequate to electrify 100% of the boiler heating capacity of the school. Electric resistance boiler is required

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because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology. There is not enough capacity to replace all the RTU natural gas fired RTU furnace capacity with electric resistance heating coils.

UTILITIES

The school consumes electricity and natural gas. The school has averaged approximately 62,500 BTU/SQFT over the last two (2) years. The EPA Energy Star rating of the school is 54, just above average. This is to be expected based on the age, HVAC equipment condition, and design of the school building.

The following tables are a summary of the electrical consumption over the last two (2) years. The summer monthly electrical energy consumption is less than winter electrical energy consumption. With the limited number of spaces having air conditioning this is an indication that some of the HVAC equipment and lighting is not being shut down during the summer. From year to year the annual consumption is approximately 100,000 kWh less than the year before. Most of the kWh savings occurred during the summer.

Start Date	Read Date	kWh	kW Demand	Start Date	Read Date	kWh	kW Demand
4/24/2022	5/24/2022	99,000	313	4/25/2023	5/24/2023	103,530	329
5/24/2022	6/23/2022	102,210	340	5/24/2023	6/23/2023	96,900	333
6/23/2022	7/26/2022	105,810	289	6/23/2023	7/26/2023	87,360	
7/26/2022	8/24/2022	94,920	294	7/26/2023	8/24/2023	81,060	
8/24/2022	9/23/2022	110,130	375	8/24/2023	9/25/2023	99,570	
9/23/2022	10/25/2022	114,090	357	9/25/2023	10/25/2023	97,410	
10/25/2022	11/23/2022	100,860	310	10/25/2023	11/24/2023	106,770	
11/23/2022	12/23/2022	110,880	306	11/24/2023	12/22/2023	104,880	
12/23/2022	1/25/2023	116,700	309	12/22/2023	1/25/2024	116,100	
1/25/2023	2/23/2023	111,900	311	1/25/2024	2/23/2024	98,640	
2/23/2023	3/24/2023	108,180	312	2/23/2024	3/25/2024	104,250	
3/24/2023	4/25/2023	112,320	310	3/25/2024	4/24/2024	101,010	
Total		**1,287,000**	**3,826**	**Total**		**1,197,480**	

The following tables are a summary of the natural gas consumption for the last two (2) plus years. The low summer consumption represents the monthly natural gas consumption to generate DHW for school cleaning.

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160 Beech Street
Franklin, MA 02038

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Start Date	Read Date	Therms	Start Date	Read Date	Therms
4/4/2022	5/4/2022	6,450	4/5/2023	5/4/2023	4,755
5/4/2022	6/3/2022	1,171	5/4/2023	6/6/2023	1,960
6/3/2022	7/6/2022	503	6/6/2023	7/6/2023	689
7/6/2022	8/5/2022	227	7/6/2023	8/9/2023	462
8/5/2022	9/6/2022	370	8/9/2023	9/6/2023	555
9/6/2022	10/4/2022	965	9/6/2023	10/5/2023	1,077
10/4/2022	11/3/2022	3,482	10/5/2023	11/6/2023	4,467
11/3/2022	12/6/2022	9,560	11/6/2023	12/5/2023	10,342
12/6/2022	1/6/2023	13,614	12/5/2023	1/5/2024	12,655
1/6/2023	2/3/2023	12,819	1/5/2024	2/5/2024	14,437
2/3/2023	3/7/2023	14,556	2/5/2024	3/5/2024	11,627
3/7/2023	4/5/2023	9,551	3/5/2024	4/4/2024	8,584
Total		**73,268**	**Total**		**71,610**

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160 Beech Street
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Fax: 508.533.7332

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ENERGY CONSERVATION MEASURES

ECM-1 BMS HVAC Equipment Scheduling

EMA has identified several scheduling opportunities to reduce equipment run hours:

1. Turning off HVAC equipment such as Unit Ventilators and associated exhaust fans, RTUs, kitchen hoods and makeup air units during the summer when the school is underutilized. Only the spaces where active programs or administrative work is happening should run during the summer. Each schedule should be divided into a winter and summer schedule. Summer schedule would run from July 1st through the second or third week of August when the school has few students or occupants.
2. Morning Warmup – School starts at 7:40 AM. Morning warmup starts at 3AM. Recognizing that staff and students may start to arrive around 7AM the question is does it take 4 Hours to warmup the school. Typical school's warmup in an hour. Monday mornings after a cold weekend can be difficult and maybe a longer period is needed. We recommend reconsidering adjustments on the morning startup time. Recommend starting it one hour prior to teachers and staff arriving.
3. Add a holiday schedule with the common reoccurring holidays that always fall on the same date or day of the month year to year such as Presidents Day (third Monday of February) or New Years Day January 1st. There is a minimum of ten of these dates on the calendar.
4. Scheduling heating hot water pumps for un-occupied freeze protection. The heating hot water pumps operate whenever the outdoor air temperature is below a programmed set point (55 to 60 °F). During un-occupied periods if the outdoor air temperature is above 35 °F there is no potential of freezing heating hot water piping, domestic water piping, or sprinkler piping. The school has no need for heating. Heating hot water pumps are required below 32 °F to prevent freezing of pipes. We recommend a set point of 36 °F ± 2 to account for sensor error and to prevent rapid starting and stopping of the HHW pumps.

The Scheduling ECM has the potential of saving 115,000kWh and 3,600 therms per year for a cost savings of $24,500. The estimated project cost for a programming technician and engineering consultant is $10,000 for a simple payback of 0.4 years. This may be eligible for Mass Saves under the prescriptive Low-Cost Tuning Measure ESPO program. It should be noted that the rebates cannot exceed the cost of the project.

ECM-2 Install thermal insulation at Roof hatches, and other roof thermal breaks

Insulating the three (3) roof hatches over the auditorium and miscellaneous other roof thermal breaks. The project will save approximately 450 therms per year or $600. The estimated project cost is $4,000 resulting in a simple payback of 6.7 years. This project may be eligible for Mass Saves rebate financing. The project will reduce any condensation on the hatches during the winter and related issues with

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Tel: 508.533.1128
Fax: 508.533.7332

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dripping water. We recommend 3-inch weather resistant insulation board on the exterior and down the sides. The insulation board should be installed so the hatches can be open.

ECM-3 Condensing Boiler

Replace one of standard efficiency natural gas fired cast iron boilers with a condensing boiler. A Benchmark model 4000 output is about equivalent to an existing cast iron boiler. The new boiler will be the lead boiler during the heating season. The potential savings are 6,500 therms per year savings $8,500. With an estimated project cost of $100,000 the simple payback is 12, years. After January 1st, 2025, this type of improvement will not be eligible for Mass Saves rebates. Currently the installation may be eligible for custom rebates.

ELECTRIFICATION POTENTIAL

The school's electric service is large enough to completely electrify the heating natural gas boilers and some of the RTU units natural gas furnaces. The electric supply to the seven (7) RTUs with DX cooling makes them eligible for replacement with hybrid heat pump RTU with natural gas backup furnaces. These proposed improvements can displace 50 to 75% of the natural gas consumption of the school.

If the classrooms are fitted for cooling with air source ductless split units installing low temperature heat pumps is a good strategy to supplement the heating with carbon free heating. This $1,750,000 project can save 10,000 to 15,000 therms of natural gas per year. This project will only reduce heating natural gas if the electric resistance heating boiler is not installed.

RENEWABLE ENERGY POTENTIAL

The school has enough roof space to install a solar PV array. The array would offset a significant portion of the school's annual electric consumption. Unfortunately, the roof over the original portion of the school is in fair condition. The roofing over the addition is in better condition but still 20 years old. Until these roofing membranes are repaired or replaced, EMA does not recommend installing a PV array. If solar PV is installed now, the future roofs members replacements will result in the solar array will have to be disassembled and reassembled. All the savings will be lost to the extra costs of the roofing project.

The Inflation Reduction Act (IRA) may be a way to finance this project. Municipalities are eligible for direct payment from the program. The roofing project may be included in the project cost.

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Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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APPENDIX A

Mechanical Schedules

Unit #	Manufacture	Model #	Firing rate BTU/Hr	Air Flow CFM	SF Motor HP	Electric	RLA Comp # 1	RLA Comp # 2	QTY Cond. Fans	HP Cond. Fans	Notes
RTU 23	Trane	GRCA30PFJF	300,000	2,400 to 3,800	3	460/3/60					
RTU 20	Trane	GRCA#)PFJF	300,000	2,400 to 3,800	3	460/3/60					
RTU 20	Trane	YCD150DAHAAA	250,000		3	460/3/60	10	10	2	0.5	
RTU 18	Trane					460/3/60					No name Tag NO A/C
RTU 3	Trane	YCD180B4HAGA	350,000		3	460/3/60	14.6	10	2	0.5	
RTU 4	Trane	YSCD92A4RHAOZC1	200,000		3	460/3/60	7.6	5	1	0.7	
RTU 8	Trane					460/3/60					No name Tag NO A/C
RTU 5	Trane				30	460/3/60					No name Tag NO A/C
RTU 7	Trane				20	460/3/60					No name Tag NO A/C
RTU 6	Trane				5	460/3/60					No name Tag NO A/C
RTU 12	Trane	GRCA15PFJF0N8CK	150,000	1,200 to 1,300	1	460/3/60					
RTU 10	Trane	YCD180B4HAGA	350,000		3	460/3/60	14.6	10	2	0.5	
RTU 2	Trane	GRCA35P	350,000		?	460/3/60					
RTU 21	Trane					460/3/60					RTU DX, Gas Fired, No name Tag
RTU 11	Trane	YSCC48A	120,000		1	460/3/60	7.9			0.3	
???	Trane	YSD150G4RCH16	250,000		3	460/3/60	12.2	6.2	2	0.5	New 2021
RTU 9	Trane	YSCD92A4RHAOZC1	200,000		3	460/3/60	7.6	5	1	0.7	
RTU 15	Trane		Yes			460/3/60					No name Tag NO A/C
RTU 14	Trane		Yes			460/3/60					No name Tag NO A/C
RTU 13	Trane		Yes			460/3/60					No name Tag NO A/C
???	Trane		Yes			460/3/60					No name Tag NO A/C
RTU 1	Trane		Yes			460/3/60					No name Tag NO A/C
RTU 16	Trane		Yes			460/3/60					No name Tag NO A/C

Condenser Units								
Unit #	Manufacture	Model #	Tons	Total Amps	Electric	QTY Comp.	Amps Ea.	Cond Fans HP
Sanyo 1	Sanyo	CL2432A	2	11.6	203/1/60			
Sanyo 2	Sanyo	CL2432A	2	11.6	203/1/60			
Sanyo 3	Sanyo	CL2432A	2	11.6	203/1/60			
Auditorium	Trane	RAUCC604BX	60	105.2	460/3/60	4	26.3	1

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Unit #	BMS Listed Area Served	Type
AHU-10	Chem prep and Corridors	Heat Hot Water and No A/C
AHU-09	Nurse's Area	Heat Hot Water and No A/C
AHU-08	Resource and Work	Heat Hot Water and No A/C
AHU-07	Computer Labs D Wing	Heat Hot Water and A/C
AHU-06	DEP Office and Corridors	Heat Hot Water and No A/C
AHU-05	Child Foods and Corridors	Heat Hot Water and No A/C
AHU-04	Drama Area	Heat Hot Water and No A/C
AHU-03	Girls Locker Room	Heat Hot Water and No A/C
AHU-02	Boys Locker Room	Heat Hot Water and No A/C
AHU-01	Fitness Area and Training	Heat Hot Water and No A/C
RTU-22	Main Office	Heat and A/C
RTU-21	Language Lab	Heat and A/C
RTU-18	Outreach Program	Heat and A/C
RTU-11	Individual Comp Study Lab	Heat and A/C
RTU-10	Library	Heat and A/C
RTU-09	Library	Heat and A/C
RTU-04	TV Studio (old)	Heat and A/C
RTU-03	Guidance/Career Offices	Heat and A/C
RTU-20	Science/Math/Bio Science	Heat and No A/C
RTU-19	Math and Corridors	Heat and No A/C
MAU-12	C Wing Corridors	Heat and No A/C
RTU-07	Band Area	Heat and No A/C
RTU-02	Corridor/Restrooms/Genreral	Heat and No A/C
RTU-16	Cafeteria	Heat and No A/C
RTU-13	D Wing, Athletic Area	Heat and No A/C
RTU-08	Chorus Room	Heat and No A/C
RTU-06	B Wing, Auditorium/Restroom/Lobby	Heat and No A/C
RTU-01	D Wing, Wellness and Maintenance Area Basement	Heat and No A/C
RTU-15	Gym	Heat Cool Heat Recovery Wheel, DCV
RTU-14	Gym	Heat Cool Heat Recovery Wheel, DCV
RTU-05	Auditorium	Heat Cool Heat Recovery Wheel, DCV

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Public Library

468 Main Street - Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.

www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Air Source Heat Pump Water Heater	0	2,500	0	$475	$5,000	10.5	$1000	8.4
2	Electrification of Lennox Roof top units (RTU) Heating		(21,500)	2,200	($1,300)	NA	NA	Future $130,000	NA
	TOTAL	**0**	**(19,000)**	**2,200**	**($825)**	**NA**	**NA**	**$1,000**	
			(25%)	45%					

The Medfield Town Library is operated very efficiently. Its Energy Usage Index (EUI) is approximately 20,000 BTU/SQFT. This is the goal of new net zero energy construction of similar building types. The library staff should be recognized for its efforts for manually maintaining both occupied and un-occupied space temperatures. Several investments into the building also contribute including:

- Blown in attic insulation.
- Condensing natural gas fired boiler replacement.
- Installing LED lighting and a few lightings controls.
- Storm windows installed over the historic original wood frame windows.

EMA was able to Identify one potential ECM that will reduce energy consumption. Replacing the electric tank types DHW heater with a HP tank type water heater. This $5,000 project qualifies for a $1,000 rebate and has an 8.4-year simple payback.

The Town has an electrification project contracted to replace six (6) of eight (8) Lennox RTU with Lennox Heat Pump RTU with natural gas backup. This will electrify approximately 2,200 Therms of existing natural gas consumption and replace it with an additional 21,500 kWh per year. Operating cost for heating will increase by approximately $1,300 per year. A minor reduction in cooling cost will accrue since the efficiency of the heat pump in the cooling mode is better than the replaced DX units.

The replacement of the two (2) brand new Lennex standard natural gas fired DX RTU for further electrification is not recommended currently. By the time they reach the end of their useful life EMA anticipates that more efficient equipment will become available that can 100% electrify the heating.

The building has no potential for renewable energy production since it is significantly shaded by existing trees. EMA does not recommend cutting trees down to generate electricity as the trees' leaves provide invaluable shading during the summer months, and the net increase in cooling needs due to the loss of shading will negate much of the solar PV generation.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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BUILDING DESCRIPTION

Architectural

The original Medfield Public Library building was constructed in 1917 with an addition of approximately equal size was constructed in 1998. The 22,192 square foot building includes a full below grade ground floor, a full 1st floor and a half 2nd floor. The first-floor original sections are home to a beautiful and spacious reference and periodical rooms. These rooms have 25-foot ceilings; the remainder of the first floor was built in 1998 and houses PCs, browsing stacks, offices and a reading area. The 2nd floor houses the Children's section. The lower level contains a community meeting room, browsing stacks, a teen/young adult space and staff areas.

The original building is brick construction with original plaster walls. The attic was recently insulated with 6 to 10 inches of cellulose insulation. The original wood frame single glazed windows have been protected by exterior storm windows.

The new building has a brick-faced exterior over wood frame walls with insulation. The windows are double hung double glazed units. The attic and walls are insulated to the code of 1998.

Lighting

Most of the lighting has been replaced with LED lighting fixtures or lamps. The building lacks occupancy sensors in some areas. The window area does not support lighting dimming systems.

The outdoor lighting is controlled by a single day pin time clock scheduled from 6PM to 10PM. There are 11 pole fixtures with large screw-in LED retrofit lamps. Some of the lamps have been unscrewed. One of the fixture's glass covers is broken, and the fixture has shorted out. The pole for the lighting fixtures is in disrepair.

Mechanical

The building is heated eight (8) Lennox RTUs and perimeter baseboard hot water. Each RTU has DX cooling and a natural gas furnace for heating. Two of the eight units have been replaced in the last two years. Currently the town has contracted for the remaining six (6) RTUs to be replaced by heat pump RTU with natural gas backup furnaces resulting in partial electrification.

The perimeter heating hot water system is supplied by a condensing Hot Water Boilers. The boiler is a Lochinvar model Knight model KXL – 399 rated at 399,000 BTU/HR input. The heating hot water pump is a Wilo Type Stratos 1.5x3-40 with a built in VSD. The motor is rated 25 to 470 Watts. The system primary pump is Grundfos model UPS43-100F 3-speed motor rated from 265 to 370 Watts. The boiler has an internal hot water reset controller. The reset setting is 140 to 170°F. The boiler never functions in

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Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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condensing mode. We recommend adjusting the reset schedule to 100°F at 60°F OAT to 170°F at 10°F. this will allow the boiler to operate in high efficiency condensing mode most of the heating season. Air cooled heat pump technology currently does not exist that can generate 170°F heating hot water in this size range, thus the only technology to replace a gas boiler at this time is an electric resistance boiler.

Unit #	Service	Manufacture	Model #	Cooling BTU/Hr	Tons	MBH Heating	SF HP	Outdoor Fan HP	QTY Outdoor Fans	Comp. RLA	QTY Comp	EER
RTU-1	North Side	Lennox	KGB090S4BH2Y	88,000	7.33	150	2	0.5	1	26.9	1	11
RTU-2	South Side	Lennox	kGA090S4BH2Y	90,000	7.50	150	2	0.33	1	25	1	11
RTU-3	Copier Area	Lennox	TGA090S2BM1Y	90,000	7.50	180	2	2	2	12.8	2	10.1
RTU-4	South Side	Lennox	TGA06032DH1Y	59,000	4.92	150	0.75	0.33	1	15.4	1	11
RTU-5	Circ & Offices	Lennox	KGA090S4BH2Y	90,000	7.50	150	2	0.33	1	25	1	11
RTU-6	North Side	Lennox	KGA048S4DH2Y	48,000	4.00	150	0.5	0.25	1	13.7	1	11
RTU-7	Multi-Purpose Room	Lennox	HGA060S4DH3Y	59,000	4.92	150	0.75	0.33	1	13.5	1	11.2
RTU-8	Ref. & Periodicals	Lennox	KGB090S4BH2Y	88,000	7.33	150	2	0.5	1	26.9	1	11
	Total				**51.00**	**1230**	**12**	**4.57**				

Domestic Hot Water (DHW)

DHW is generated by an electric tank type water heater Bradford White model # M250S6DS. This 50-gallon tank has two 4,500/3,500-watt electric elements. Since the building has a 208-volt service the total electric heating capacity is 7,000 watts or 23,884 BTU/HR. Replacing it with a heat pump tank type water heater will reduce energy consumption by approximately 66%. Commercial heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial).

Electric Service

The building has an 800 AMP 120/208 volt 3-phase 4 wire electric service. This service can support an electrical demand of approximately 230 kW. The summer peak demand is 58 kW and winter peak are 21 kW. Based on existing winter peak demand of 21 kW there is enough power to convert the natural gas Lennox RTUs with natural gas furnaces and boiler to electric heating. Electric resistance boiler is required because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology. The new Lennox RTU's will require electric reheat coils because the Lennox heat pumps do not have adequate cold weather capacity to heat the building. This conversion will increase total utility bills but give the Town of Medfield Town Hall the ability to be carbon free with electric Mass Class1 RECs.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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UTILITIES

The building consumes electricity and natural gas. The building has averaged approximately 20,000 BTU/SQFT over the last two and half (2-1/2) years. This is extremely low for this building type. Based on EPA Portfolio Manager the current score exceeds 90. This building energy consumption for all intents and purposes at the "net zero" energy level.

The following tables are a summary of the electrical consumption over the last two (2) years. EMA attributes some of the performance to the heavy foliage around the building shading it and reducing air conditioning requirements compared to average buildings. The low electric usage indicates that the lighting is well controlled, and the HVAC is well scheduled for night temperature setback.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	5,440	33	4/21/2023	5/21/2023	5,200	24
5/21/2022	6/21/2022	6,800	37	5/21/2023	6/21/2023	5,120	34
6/21/2022	7/21/2022	8,320	46	6/21/2023	7/21/2023	8,400	44
7/21/2022	8/21/2022	10,160	46	7/21/2023	8/21/2023	9,920	53
8/21/2022	9/21/2022	7,040	38	8/21/2023	9/21/2023	6,960	45
9/21/2022	10/21/2022	5,120	23	9/21/2023	10/21/2023	4,960	24
10/21/2022	11/21/2022	5,280	26	10/21/2023	11/21/2023	5,440	19
11/21/2022	12/21/2022	5,680	21	11/21/2023	12/21/2023	5,680	19
12/21/2022	1/21/2023	5,840	21	12/21/2023	1/21/2024	6,160	20
1/21/2023	2/21/2023	6,400	22	1/21/2024	2/21/2024	6,320	21
2/21/2023	3/21/2023	5,600	22	2/21/2024	3/21/2024	5,680	21
3/21/2023	4/21/2023	5,440	38	3/21/2024	4/21/2024	5,680	20
Total		**77,120**	**373**	**Total**		**75,520**	**344**

The following tables are a summary of the natural gas consumption for the two (2) years ending September 2023. For a building of this size and age the overall usage is indicating that the building's heating is well controlled. The low summer consumption represents that the DHW is electric, and the heat is off. The year-to-year reduction represents the change in weather. MEI does not have accurate data after September 2023. Most months are recorded at 0 therms even during the winter.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Start Date	Read Date	Therms	Start Date	Read Date	Therms
9/3/2021	10/5/2021	7	9/6/2022	10/4/2022	14
10/5/2021	11/3/2021	143	10/4/2022	11/3/2022	211
11/3/2021	12/3/2021	666	11/3/2022	12/6/2022	607
12/3/2021	1/4/2022	932	12/6/2022	1/6/2023	965
1/4/2022	2/3/2022	1,423	1/6/2023	2/3/2023	876
2/3/2022	3/4/2022	1,027	2/3/2023	3/7/2023	1,028
3/4/2022	4/4/2022	632	3/7/2023	4/5/2023	602
4/4/2022	5/4/2022	304	4/5/2023	5/4/2023	203
5/4/2022	6/3/2022	60	5/4/2023	6/6/2023	50
6/3/2022	7/6/2022	2	6/6/2023	7/6/2023	2
7/6/2022	8/5/2022	0	7/6/2023	8/9/2023	0
8/5/2022	9/6/2022	0	8/9/2023	9/6/2023	0
Total		**5,196**	**Total**		**4,558**

ENERGY CONSERVATION MEASURES

ECM-1 Air Source Heat Pump Water Heater

The DHW heater for the building is a tank type 50-gallon electric heater. Replacing it with a heat pump hybrid 50-gallon water heater will reduce electrical consumption for DHW production by approximately 70%. The estimated savings are 2,500 kWh per year ($475). The estimated project cost is $5,000 with a potential rebate of $1,000 resulting in a simple payback of 8.4 years.

ECM-2 Electrification of Lennox RTUs Heating (under contract)

The original eight (8) Lennox rooftop units reached the end of their useful service lives and must be replaced. Replacing the RTU's with low temperature heat pump rooftop units of the same size or smaller will also electrify the heating for the cafeteria/ meeting room with natural gas furnaces will decarbonize most of the heating. The cooling efficiency of the new heat pumps will exceed the existing equipment's. For the incremental cost of the heat pump replacement vs standard DX cooling equipment 95% or more of the building can be electrified. The activity spaces served by the Lennox furnaces will have backup natural gas heat. This type of upgrade is eligible for Mass Saves rebates of $2,500 per ton. The total connected tons are 51 tons. Potential rebate under the current Mass Saves program is up to $130,000. The Mass Saves program changes January 1st, 2025.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Currently six (6) Lennox units are under contract for replacement with new Heat Pump units with natural gas furnaces as backup heat. Two (2) Lennox units were recently replaced with new Lennox RTU with DX cooling and natural gas furnaces.

There is a natural gas fired unit heater and the kitchen hood makeup air unit is also natural gas fired. The unit heater can be replaced with electric resistance unit heater. At this time the technology does not exist to replace the natural gas fired kitchen hood makeup air unit. The kitchen hood makeup air unit is not used often.

RENEWABLE ENERGY POTENTIAL

The building has small potential for solar PV due to the heavy foliage that shades the roof from the sun.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Memorial School

59 Adams St. Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.
www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

EMA recommends the following four ECM measures (see table below).

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Programming Heating Hot Water Pumps for Freeze Protection	0	10,000	1,950	$3,850	$1,000	0.3	TBD	0.3
2	Add Schedules to the BMS	0	13,000	2,500	$5,750	$7,000	1.2	TBD	1.2
3	Retro-Commissioning of select BAS/EMS programming	0	5,000	500	$1,650	$4,000	2.4	TBD	2.4
4	Variable Speed Drives for Heating Hot Water Pumps	0	13,000	0	$1,250	$9,000	7.2	$2,280	5.4
	TOTAL[A]	**0**	**41,000**	**4,950**	**$12,500**	**$21,000**	**1.7**	**$2,280**	**1.5**
			11%	19%					

A – there will be some ECM interaction, with regard to savings.

Medfield Memorial School was originally constructed in 1950 and a major expansion and gut rehab of the building was completed in 2003. The 54,387 square foot school was essentially rebuilt to 2003 construction and energy code standards. The roof and wall of the building were insulated, and all the windows replaced with high performance aluminum frame 1 inch double glazed casement windows, typical of that generation of schools. The HVAC system was completely replaced with that generation's state of the art unit ventilators, natural gas cast iron boilers, RTU's, and primitive BMS controls. As typical for that generation of school the classrooms were not air conditioned. Air conditioning was installed for the Media Center and main offices. The building EPA's ENERGY STAR® score is a 49 out of 100 (1-100) confirming that the school is an average energy performer.

In the drive for electrification of heating the most significant improvement to the school was the electric service size, increased to 1200 AMPs at 460 volts, sufficient to eventually support an all-electric school. In the short term this will also allow the school to add air conditioning to each classroom with ductless split heat pumps and partially electrify heating in the short term. The pre-K classrooms have ductless split A/C.

The BMS control system has one schedule for all HVAC equipment, 5AM to 6PM, Monday through Friday year-round. This represents the biggest potential opportunity for improvement in the energy consumption of the building. Adding schedules for individual equipment such as office RTU, Gym (afterschool program), and classroom seasonal (winter/summer) operation will reduce overall equipment run hours. Also utilizing the "Holiday" scheduling feature are recommended for additional savings. Typical holidays such as New Years Day can be scheduled years in advance, so that building staff

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
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does not have to do reprogram in advance of the Holiday. We would also recommend that the main office be outfitted with a manual 4-hour override switch for special events.

BUILDING DESCRIPTION

Architectural

The Medfield Memorial School was originally constructed in 1950. This one-story building houses Pre-K through 1st grades housing approximately 400 students. In 2003 it was expanded to its current 54,387 square foot footprint. In 2003 the HVAC systems of the school were completely updated and replaced, new windows installed, and the roofing replaced. The new windows are aluminum frame 1 inch double glazed casements with an operable lower sash. The roofing is a ballasted asphalt roll on membrane over 4.5 inches of additional rigid insulation. The roofing membrane is in poor condition with many patches. The exterior walls of the new building are the typical curtain wall system with 1-inch-thick insulating panels. The older building has drywall interior finish.

The school has 22 classrooms and an art room. There is a media center, gymnasium, kitchen and cafeteria. The school kitchen has a walk-in cooler and freezer.

Lighting

Most of the lighting has been converted to LED. There are scattered CFL's in high hats and fluorescent lamps in back of the house spaces. The exterior pole lighting is new. Each fixture has a photocell. Some of the photocells are not working since a minimum of two pole lights were "on" during our survey. The front entrance exterior high hats have LED lamps but do not turn off. There are two Intelligent Lighting Controls that control exterior lighting. They do not appear to function.

Mechanical

The classrooms' space temperatures are conditioned by Unit Ventilators with perimeter hot water baseboard. The head office, media center, gymnasium, and cafeteria are conditioned by RTU's. The main office, and media center have A/C. The gym and cafeteria units have heat recovery wheels. The gym heat recovery wheel has not rotated for a long time and is completely caked-up so that no air can pass through. The cafeteria DX coil has significant caking-up of material that limits air flow. Neither the gym nor cafeteria units were operating during our site survey. They must operate during the winter since there is no other source of heat in these spaces.

The unit ventilators provide outdoor (ventilation) air which is exhausted by rooftop exhaust fans. The Pre-K classroom A101 & A105 have DX air conditioning. The controls packages are quite limiting because

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they do not support advanced control strategies such as demand-controlled ventilation (DCV) but do report to the BMS. Each unit ventilator has a two-way heating hot water valve.

The boilers are natural gas fired cast iron sectional Smith model 28A-W-9 rated at 67BHP (2,718 MBH input) with power flame burner. The heating hot water pumps are 7.5 HP TACO model FI3009E2FAJILOA. The design is 300 GPM at 58 feet of head. The heating hot water pumps do not have VSDs.

The following table presents a detailed list of other HVAC equipment.

Unit #	Location Served	Manufacturer	Model #	Total CFM	O.A. CFM	SF HP	Comp # 1 RLA	Comp # 2 RLA	Tonnage	Heating	Notes
AHU - 1	Media Center	Trane	TCD180B40AGA	4,500	1,600	5	14.6	10	15	HHW Coil	
AHU - 2	Gymnasium	Trane	No Nametag	14,000	7,000	15				HHW Coil	Heat Recovery Wheel
AHU - 3	Main Office	Trane	No Nametag	3,000	440	3			10	HHW Coil	
AHU - 4	Cafeteria	Trane	No Nametag	8,000	4,000	7.5				HHW Coil	
	Total			**29,500**	**13,040**	**30.5**					

Unit #	Location Served	Manufacture	Model #	Total CFM	MBH/Hr	SF HP
MUA-1	Boiler Room	Greenheck	IGX-109-12-DB /PVF150	1,550	150	0.75
MUA-2	Kitchen	Greenheck	???/ PVF300	2,700	300	0.75

Unit #	Location Served	Manufacture	Model #	QTY	Total CFM	O.A. CFM	SF HP	Cooling MBH	Tonnage
UV-1	Pre-K A101 & A105	American Air Filter AFF	UAVDS15	2	1,500	420	0.25	52	4.3
UV-2	Classrooms	American Air Filter AFF	UAVDS13	18	1,250	420	0.25	N/A	N/A
UV-3	Reading B115 OT/PT B112	American Air Filter AFF	UAVDS07	1	750	225	0.25	N/A	N/A
UV-4	Art Room A144	American Air Filter AFF	UAVDS13	1	1,250	420	0.5	N/A	N/A

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Unit #	Location Served	Manufacture	CFM	HP
EF-1	A101 & A105	Greenheck	560	0.25
EF-2	Toilet A109, A103, A107, A112	Greenheck	300	0.25
EF-3	A108, A114, A111, A118	Greenheck	1,120	0.25
EF-4	Toilet, A 122, A116, A120, A123	Greenheck	300	0.25
EF-5	A124 & A121	Greenheck	560	0.25
EF-6	Toilet, A135, A137, A138, A139	Greenheck	750	0.25
EF-7	A144, A148, A140, A141	Greenheck	750	0.25
EF-8	A153, A154, A140, A141	Greenheck	450	0.25
EF-9	B131 & B 148	Greenheck	450	0.25
EF-10	B101 & B148	Greenheck	600	0.25
EF-11	B106, B110, B108, B113	Greenheck	1,200	0.25
EF-12	B115 & B122	Greenheck	250	0.25
EF-13	Toilet, B126, B128, B129, B130	Greenheck	1,000	0.25
EF-14	Toilet B146	Greenheck	100	0.07
EF-15	Kitchen Exhaust B150	Greenheck	250	1.5
EF-16	B176, B173, B178, B175	Greenheck	1,200	0.25
EF-17	B167, B169, B156	Greenheck	675	0.25
EF-18	Toilet B164, B162	Greenheck	850	0.25
EF-19	Toilets B161, B160	Greenheck	200	0.25
EF-20	Toilet B154	Greenheck	100	0.07
EF-21	Existing Dishwasher	Greenheck	800	0.25
EF-22	IDF B124	Greenheck	100	0.07
EF-23	IDF B165	Greenheck	100	0.07
EF-24	Gymnasium A155	Greenheck	7,000	1.5
EF-25	Cafeteria B155	Greenheck	4,000	1
EF-26	Emerg. Elect. A151	Greenheck	320	0.161
	Total		**23,985**	**8.941**

Building Management System

The building has a Proprietary Johnson Metasys BMS system. It is being upgraded to the open protocol Johnson FX supervisory controller. The programmed of the BMS appear to be very basic to scheduling, night setback, and maintain space temperature set points. The BMS has a few UV's that are not communicating and sensors that are out of calibration.

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The BMS has one schedule for all HVAC equipment of 5AM-6PM Monday through Friday every week of the year. The holiday schedule is not being utilized. After careful review of the electric billing data, it appears many HVAC devices and some lighting is not being turning off. The billing data indicates that on average 50% of all electric equipment is on all the time. The schedule equipment run time is 27% of the time.

Domestic Hot Water (DHW)

DHW is generated by two (2) new natural gas fired ARNOR model AWN 201PM high efficiency DHW heater rated at 201,000 BTU/HR input. The two DHW heaters feed two (2) insulated 120-Gallon storage tanks. Replacing it with a heat pump tank type water heater will reduce energy consumption by approximately 66%. Commercial heat pump water heaters are eligible for prescriptive rebated from Eversource. The current program incentive is $1,000 for a heater with less than 80-gallons of storage (residential/light commercial) or $2,200 for one over 80-gallons (commercial).

Electric Service

The building has a 1200 AMP 460 volt 3-phase electric service. This service can support an electrical demand of approximately 765 kW. Based on existing peak winter demand of 100 kW there may be enough capacity to convert the boilers to electric resistance boilers and meet the existing connected heating load. Electric resistance boiler is required because the heating system is designed for 180 °F heating hot water distribution system not available with existing air-source heat pump technology. This conversion will increase total utility bills but give the Town of Medfield Town Hall the ability to be carbon free with electric Mass Class1 REC's.

UTILITIES

The school consumes electricity and natural gas. The school has averaged approximately 70,000 BTU/SQFT over the last two (2) years. The EPA Energy Star rating of the school is 49, just below average. This is to be expected based on the age and condition of the building.

The following tables are a summary of the electrical consumption over the last two (2) years. Electrical consumption has been reduced by approximately 14%. EMA suspects some of the reduction is related to the GYM and cafeteria unit failing in service. The summer monthly electrical energy consumption is only slightly less than winter electrical energy consumption. With only a few spaces being air conditioned this indicates that the HVAC equipment is not being shut down during the summer.

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Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	34,920	95	4/21/2023	5/21/2023	25,560	80
5/21/2022	6/21/2022	33,120	95	5/21/2023	6/21/2023	22,440	74
6/21/2022	7/21/2022	26,160	78	6/21/2023	7/21/2023	20,040	71
7/21/2022	8/21/2022	26,880	74	7/21/2023	8/21/2023	21,240	67
8/21/2022	9/21/2022	30,120	91	8/21/2023	9/21/2023	28,680	95
9/21/2022	10/21/2022	27,600	84	9/21/2023	10/21/2023	29,040	85
10/21/2022	11/21/2022	33,480	88	10/21/2023	11/21/2023	32,280	84
11/21/2022	12/21/2022	37,800	92	11/21/2023	12/21/2023	32,640	84
12/21/2022	1/21/2023	36,120	96	12/21/2023	1/21/2024	31,920	85
1/21/2023	2/21/2023	37,440	91	1/21/2024	2/21/2024	33,000	84
2/21/2023	3/21/2023	32,400	85	2/21/2024	3/21/2024	30,120	82
3/21/2023	4/21/2023	33,000	85	3/21/2024	4/21/2024	30,480	83
Total		**389,040**	**1,054**	**Total**		**337,440**	**974**

The following tables are a summary of the natural gas consumption for the last two (2) plus years. The low summer consumption represents the monthly natural gas consumption to generate DHW for cleaning.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
3/4/2022	4/4/2022	4,019	3/7/2023	4/5/2023	3,492
4/4/2022	5/4/2022	2,362	4/5/2023	5/4/2023	811
5/4/2022	6/3/2022	626	5/4/2023	6/6/2023	236
6/3/2022	7/6/2022	144	6/6/2023	7/6/2023	123
7/6/2022	8/5/2022	82	7/6/2023	8/9/2023	113
8/5/2022	9/6/2022	103	8/9/2023	9/6/2023	113
9/6/2022	10/4/2022	134	9/6/2023	10/5/2023	226
10/4/2022	11/3/2022	1,520	10/5/2023	11/6/2023	2,105
11/3/2022	12/6/2022	3,362	11/6/2023	12/5/2023	3,670
12/6/2022	1/6/2023	4,795	12/5/2023	1/5/2024	4,359
1/6/2023	2/3/2023	4,420	1/5/2024	2/5/2024	5,351
2/3/2023	3/7/2023	5,027	2/5/2024	3/5/2024	4,338
Total		**26,594**	**Total**		**24,937**

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Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY CONSERVATION MEASURES

ECM-1 – Programming Heating Hot Water Pumps for Freeze Protection

One (1) heating hot water (HHW) pump operates all year unless manually turned off by building staff. While a HHW pump is required during all winter operating hours below 55 to 60 °F during occupied hours, its primary function during un-occupied hours is freeze protection. Heat is required to protect the hot water coils in the unit ventilators, perimeter baseboard, and AHU's them from freezing. Heat is also required to maintain night setback heating temperatures and freeze protection of the sprinkler systems. We recommend implementing the following un-occupied sequence of operation:

- Shut down the HHW pumps during un-occupied periods when the outdoor air temperature is above 35 ° ± 2 °F.

This will reduce pump operating hours by approximately 2,000 hours per year.

The O.A.T. sensor shall be located to determine if it is influenced by the sun or building exhaust. If this situation exists it shall be relocated to a north wall away from any radiant heat influences. We recommend replacing the sensor to confirm that it is calibrated.

We estimate savings of 10,000 kWh/Yr. ($1,900) and 1,500 therms ($1,950) with a project cost of $1,000 (4 hours at $250/hr. for programming of the BMS). The simple payback is under a quarter of a year.

ECM-2 – Add Schedules to the BMS

The building has one schedule for all HVAC equipment. The schedule starts at 5AM for the early drop off and ends at 6PM for the afterschool program (Monday through Friday). The programs utilize the gymnasium and maybe the cafeteria. School start time is about 8:30 in the morning and ends at 3PM. The main office operates on its own schedule. We recommend setting up three schedules for the school:

- Pre and after school program starting at 5AM and ending at 6PM
- Main Office 6AM to 4PM
- Rest of the school 6:30AM to 3:30PM.

Add and override button to the main BMS screen for special events. The override can be programmed for a 4-hour override so that the HVAC systems go back into un-occupied mode automatically.

The special event (holiday schedule) has not been programmed. The common holidays fall on the same day every year and can be programmed in perpetuity. These holidays include:

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- New Years Day – January 1st
- Martin Luther King Day – 3rd Monday of January
- Memorial Day – 4th Monday of May
- July 4th
- Labor Day – 1st Monday of September
- Columbus Day – 2nd Monday of October
- Thanksgiving – 4th Thursday and Friday of November
- Christmas – December 25th

This will result in an additional 10 days of un-occupied operation every year.

The classrooms can also be programmed for summer break July 1st to August 24th. The UVs and the exhaust fans will shut down when there are no students. The occupied period can be programmed to the custodial staff's schedule.

Add the exterior lighting light control to BMS.

We estimate savings of 13,000 kWh/Yr. ($2,500) and 2,500 therms ($3,250) with a project cost of $7,000 (12 hours at $250/hr. for programming of the BMS and $2,000 per existing lighting controllers). The simple payback is just over a year.

ECM-3 – Retro-commissioning of Select BAS Programming

The control drawing indicates that sophisticated control sequences were specified. These control strategies include:

- Warm-up cycles with ventilation closed.
- Economizer free cooling
- Heat recovery with heat wheels for the gym.

During our site survey we could not identify the above programs were implemented. We recommend a quick retro-commissioning project to confirm the existence of these control algorithms.

We estimate savings of 5,000 kWh/Yr. ($1,000) and 500 therms ($650) with a project cost of $4,000 (16 hours at $250/hr. for programming of the BMS). The simple payback is 2.4 years.

ECM-4 – Variable Speed Drives for Heating Hot Water Pumps

Heating hot water distribution system has two-way valve control. The heating hot water pumps have 7.5 HP motors. Installing VSDs with static pressure sensors 2/3 down the longest pipe run will turn distribution system into a variable flow system. The estimated savings are 13,000 kWh/Yr. ($1,250). This project qualifies for a Mass Saves rebate of $1,400 each. The estimated project cost is $9,000 for a simple payback of 5 years.

ECM-5 – Replace Boiler with Condensing Natural Gas Boiler (Not Recommended at this time)

The existing boilers are standard efficiency natural gas fired boilers rated at 80% combustion efficiency and operate at an annual seasonal efficiency below 75%. The boiler plant has N+1 capacity. Each boiler may be oversized for building heating load. EMA has reviewed replacing the existing boilers with three (3) Lochinvar model KBN1000 condensing boilers. The boilers will be sequenced based on heating load. This design should supply N+1 capacity. The estimated savings are 4,250 therms ($5,700). This $200,000 project cost is not recommended due to extended simple payback. The boilers are new, so this is an end-of-life project, therefore not recommended at this time.

ELECTRIFICATION

The electric service has the capacity to replace one boiler of the building's boilers and provide almost all the annual heat for the building with an electric resistance boiler. The electric boiler can generate the 180 °F heating hot water that the building HVAC equipment is designed for. State mandated minimum renewable content of electricity has a lower emissions factor compared to the equivalent natural gas emissions factor. Purchasing 100% renewable electricity will result in an almost carbon free building.

If the school district is considering adding air conditioning to the Memorial School, there is an option to partially electrify the building heating. We recommend installing low temperature ductless heat pumps or hyper heat units of approximately 2 tons each. This can reduce annual fossil fuel consumption by approximately 50%. The Mass saves rebate is $2,500 per ton or $5,000 per classroom. The estimated cost per classroom is $20,000 to $25,000.

The new DHW system can be replaced with heat pump water heaters utilizing the existing storage capacity.

RENEWABLE ENERGY POTENTIAL

The flat roof has significant space to install a large PV system of 150 to 200 kW. The current condition of the roof disqualifies the school from installation. It is not recommended that a PV system be installed since the system will have to be removed to replace the existing roofing membrane.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Public Safety Building

112 North Street Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.
www.EMA-Boston.com

June 2024

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Retro/up Commissioning of BMS	0	23,000	1,500	$6,250	$10,000	1.6	TBD	---
	TOTAL		**23,000**	**1,500**	**$6,250**	**$10,000**			
			6%	2%					

Also, the building has the potential to add 20 to 30 kW of additional solar PV to the police flat roof and the office main roof.

The Medfield Public Safety building was opened in 2015. The building has six high bay fire equipment garages, police vehicle maintenance garage, department offices, community conference room, and fire fighter dorms. offices. Overall, it was built to the high energy and sustainability standards of the time.

- Energy recovery outdoor air wheel and reheat wheel.
- Roof insulation beyond code of the time.
- The main AHU – 1 has CO2 demand control ventilation control.
- Fan and pump motor VSDs.
- Induction/ active chilled beams.

Many advanced Technologies were incorporated into the design including but not being used correctly resulting in a humid cold building. The police department complained during our survey. An uncomfortable building normally is a high energy consumer.

In 2017 a 64.1 kW solar array was installed that generates approximately 15% of electricity than the building consumes. All the lighting is LED with many occupancy sensors.

Overall, the building consumes more energy than anticipated for this much design detail related energy performance. EMA attributes the high energy consumption to the BMS.

EMA has identified one recommended Energy Conservation Measure for the building. Retro/Up commissioning of the Johnson Building Management System. AHU – 1 has many probe temperature sensors or short averaging sensors resulting in inaccurate inputs to the BMS. There are other sensors that may be out of calibration. Many of the set points illustrate a lack of understanding of how chilled beam system is supposed to function for energy efficiency and comfort. It is unclear at this point if the control sequence programming is corrupted. Since trend logging is lacking it is difficult to determine the cause. EMA estimates 10% (1,500 therms) natural gas savings and 5% (23,000 kWh) electric savings achieving $6,250 in utility cost savings. Project cost is estimated to be $10,000, and includes tasks such as setting up trend logs, review and replacement of sensors, and the BMS programming.

EMA has identified one Electrification project. Heat Pump Water heater and storage tank will reduce fossil fuel consumption of the building. Unfortunately, space to install the heat pump water heater and storage does not exist in the ground floor mechanical room. The heat pump water heater will displace (via electrification) approximately 1,900 therms per year while increasing electric usage 14,400 kWh with a net increase in utility cost of $300 per year. (Not Recommended)

BUILDING DESCRIPTION

Architectural

The 40,690 square foot Medfield Public Safety Building was opened in 2015 and houses the town's police and central fire station. The building includes approximately 12,610 square feet of one-story equipment garage. The rest of the 28,080 square footage two-story brick faced building is office space, holding cells, dorms, and meeting/training space. The stick-built brick façade facility is built to the energy code of the time with double glazed tinted double hung windows and fiberglass insulation. The garage doors are insulated metal panel rollup units with good weatherstripping. Since the building is new air infiltration is minimal except when the large garage doors are opened.

The fire department has six large drive through bays. The police department has a vehicle maintenance garage and sallyport for prisoners with garage doors.

Lighting

All Lighting is LED. Many of the spaces have occupancy sensors. Dimming control will have to be evaluated for some spaces with larger side by side windows. Exterior lighting has photocells and time clock control.

Mechanical

The HVAC system is a four-pipe distribution system. The HVAC system includes VAV boxes with hot water reheat coils and 4-pipe active chilled beams called Induction Units. The chilled beams do not have enough condensate collection and pumping capacity resulting in spell over. The office building HVAC system is supplied by AHU-1. Heating hot water is generated by two (2) Lochinvar natural gas fired condensing boilers. Chilled water is generated by a Trane 60-ton air cooled DX chiller located in the rear parking lot.

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Fax: 508.533.7332

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The building has forty-seven (47) induction / active chilled beams, and five (5) VAV boxes, twenty-seven (27) hydronic unit heaters, three (3) Radiant Floor Manifolds, sixteen (16) hot water convectors, two (2) 4-pipe fan coil units, etc.

AHU – 1 is a HAAKON INDUSTRIES Model# AIRPAK custom built up unit with a 20 HP supply fan and 15 HP return fan. Each fan has a VSD. There are two heat recovery wheels with ½ HP motor each. The motors are Baldor-Reliance SuperE premium efficiency invertor duty motor. The unit is designed capacity is 13,000 CFM. Most of the temperature sensors in the unit are probe type. Some of the averaging sensors are shorter than industry standard. The result is the temperature data transmitted to the BMS is inaccurate. The result is the data transmitted to the BMS is conflicting resulting in an inability to properly follow control algorithms. One heat wheel is an energy recovery wheel (sensible and latent heat recovery) for outdoor air pre-conditioning. The second wheel is a heat recovery wheel (sensible heat recovery) used for reheating discharge air from the AHU required for the chilled beams.

The two (2) boilers are natural gas fired Lochinvar Crest Model # FBN1251 condensing boilers. The rated input capacity of the boiler is 1,250,000 BTU/Hr. The heating hot water pumps are vertical pumps entangled in the pipe work and the access nameplate was impossible. The pumps have VSD's.

The electric air-cooled chiller is a Trane model CGAM060A2M02 60-ton unit. Each of the four (4) compressors RLA is 74. The chiller has four (4) 1.27 HP (6.2 FLA) condenser fans. The chilled water pumps are vertical pumps entangled in the pipe work and the access nameplate was impossible. The pumps have VSD's.

The fire station garage has underfloor hydronic heating supplemented with unit heaters. Underfloor heating can be electrified with existing air source heat pump technology because it uses low temperature heating hot water (80 to 110 °F).

Since the building is a public safety building occupied 24/7 there is no active schedule for any of the mechanical equipment.

Building Management System

The BMS system is legacy Johnson Metasys. Many of the controllers are no longer supported by Johnson controls. Some of the sensors are out of calibration such as the outdoor humidity, some air flow sensor for VAV boxes, and CO2 sensors based on the small sample observed. Some of the control sequences need review. The result is a humid building with an average space temperature of 68°F.

The BMS boiler reset programming is 180°F HHW at 0°F OAT and 120°F at 65°F.

AHU # 1 and chiller sequence of operation is suspect. The AHU must supply dry air to the induction units above 57°F for humidity control during the summer. Unfortunately, the chilled water temperature set

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Tel: 508.533.1128
Fax: 508.533.7332

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point is 53°F on the BMS and the chiller set point is manually set at 57 ° F. The DAT is 60°F and 90% RH. To achieve low humidity DAT the chilled water supply should be about 45 °F. This results in the induction units trying to perform all the dehumidification work. The economizer free cooling sequence or the building DCV control sequence is opening the OA dampers on a 73°F Day. The result is a humid building.

The VAV box turn down ratios are 3:1 while current ASHRAE 90.1 code recommends 5:1 so that the spaces do not over cool and reheat is required.

Many of the spaces deadband between heating and cooling set points are 2 to 3 °F. ASHRAE 90.1 recommends 5 °F.

The OAT trend log is recording in °C. The trend logs appear to be programmed for only recording 672 records, equivalent to about 7 days of data at 15-minute intervals; unfortunately, this is not enough data to trouble shoot the sequences of operations.

Domestic Hot Water (DHW)

DHW is generated by one (1) natural gas fired Lochinvar Armor model # AWN400PM with a separate 120-gallon insulated storage tank. The heater is rated input is 339,000 BTU/Hr.

Electric Service

The DPW building electrical service is 1200 amp. 208/120-volt 3 phase 4-wire. The building has a 61.4 kW electric PV array that is net metered for the building. The utility service can support approximately 350 kW of electrical demand. There is not enough power to replace the output of one heating boiler and run all the other equipment in the building with the existing electric service. This building can only be partially electrified with the existing electric service.

UTILITIES

The building consumes electricity and natural gas, and has much room for improvement. The building has an average site energy consumption of approximately 75,750 BTU/SQFT over the past two (2) years that includes the 61.4 kW solar PV arrays net metered electricity. While this building's usage-type is not supported by EPA ENERGY STAR® Portfolio Manager and a 1-100 score in not attainable, it is EMA's experience the energy consumption is very high especially given the age of construction, and newer energy codes adhered to during the design phase.

The following tables are a summary of the electrical consumption over the last two (2) years. Electrical consumption appears to be stable for the study period. So far in the latest year electric consumption

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Fax: 508.533.7332

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almost equals the previous two years. The electric consumption does increase during the summer representing air conditioning of the building.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	28,080	71	4/21/2023	5/21/2023	29,760	67
5/21/2022	6/21/2022	31,440	72	5/21/2023	6/21/2023	32,040	90
6/21/2022	7/21/2022	32,160	83	6/21/2023	7/21/2023	36,720	77
7/21/2022	8/21/2022	29,840	95	7/21/2023	8/21/2023	36,240	76
8/21/2022	9/21/2022	38,760	86	8/21/2023	9/21/2023	37,080	73
9/21/2022	10/21/2022	30,960	72	9/21/2023	10/21/2023	33,840	67
10/21/2022	11/21/2022	33,720	72	10/21/2023	11/21/2023	33,240	66
11/21/2022	12/21/2022	31,800	60	11/21/2023	12/21/2023	32,280	68
12/21/2022	1/21/2023	33,480	73	12/21/2023	1/21/2024	35,760	64
1/21/2023	2/21/2023	32,400	61	1/21/2024	2/21/2024	33,600	64
2/21/2023	3/21/2023	29,400	64	2/21/2024	3/21/2024	28,800	58
3/21/2023	4/21/2023	30,360	68	3/21/2024	4/21/2024	30,000	62
Total		**382,400**	**877**	**Total**		**399,360**	**832**

The following table is the summary of PV generation by the solar PV array for fiscal years 2022 and 2023. The average annual generation is approximately 68,000 kwh per year. The array generates approximately 15% of the building's electric consumption.

Start Date	Read Date	kWh
7/1/2021	6/29/2022	65,515
Total		**65,515**
6/29/2022	7/31/2022	9,649
7/31/2022	8/31/2022	8,199
8/31/2022	9/30/2022	6,357
9/30/2022	10/31/2022	4,947
10/31/2022	11/30/2022	3,638
11/30/2022	12/31/2022	2,597
12/31/2022	1/31/2023	1,896
1/31/2023	2/28/2023	3,261
2/28/2023	3/31/2023	5,753
3/31/2023	4/30/2023	7,036
4/30/2023	5/31/2023	9,859
5/31/2023	6/30/2023	7,323
Total		**70,515**

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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The following tables are a summary of the natural gas consumption for the last two (2) plus years. The low summer consumption represents the monthly natural gas consumption to generate DHW.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
4/4/2022	5/4/2022	1,407	4/5/2023	5/4/2023	1,232
5/4/2022	6/3/2022	483	5/4/2023	6/6/2023	800
6/3/2022	7/6/2022	185	6/6/2023	7/6/2023	236
7/6/2022	8/5/2022	113	7/6/2023	8/9/2023	82
8/5/2022	9/6/2022	123	8/9/2023	9/6/2023	103
9/6/2022	10/4/2022	534	9/6/2023	10/5/2023	564
10/4/2022	11/3/2022	1,212	10/5/2023	11/6/2023	1,089
11/3/2022	12/6/2022	2,056	11/6/2023	12/5/2023	1,737
12/6/2022	1/6/2023	2,645	12/5/2023	1/5/2024	2,087
1/6/2023	2/3/2023	2,210	1/5/2024	2/5/2024	2,706
2/3/2023	3/7/2023	2,858	2/5/2024	3/5/2024	2,210
3/7/2023	4/5/2023	1,859	3/5/2024	4/4/2024	1,645
Total		**15,685**	**Total**		**14,491**

ENERGY CONSERVATION MEASURES

ECM-1 Retro/up commissioning of BMS

We recommend retro/up commissioning of the BMS. Up commissioning is updating the existing set points and control algorithms to the latest ASHRAE 90.1 recommendation for high efficiency building design. The project should include increasing the trend logging capacity so that a minimum of two years of data can be stored for future analysis. This may require adding a small server to the BMS system. Replace the point temperature sensors with averaging sensor in AHU 1. Recalibrate the humidity sensors. Retro-commissioning will reduce energy consumption and improve comfort.

Adding door sensors to the garage doors to turn off heating when open if they do not exist.

ECM-2 Heat Pump Water heater and storage tank.

The existing DHW system can be replaced with a heat pump water heater system with significant storage capacity to meet the demand of cleaning the fire trucks and showers after a fire. A large storage tank is required due to the slow generation rate of heat pump water heaters. The ground floor mechanical room where the DHW heater is very small and there is not space to locate the equipment. The mechanical room housing AHU – 1 is big. Finding a location for the equipment will be a challenge. EMA

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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has estimated that replacing the natural gas system with a heat pump system will displace 1,900 therms and consume an additional 14,400 kWh resulting in a negative $300 per year cash flow.

ELECTRIFICATION

The Medfield Public safety building will be difficult to electrify. The electric service is large enough to partially electrify the facility. There are two areas where fossil fuels can be replaced with current air source heat pump technologies:

1. The underfloor heating systems uses a low temperature heating hot water to heat the garage floors. Generally, underfloor heating systems use heating hot water under 120 °F. Air source heat pump equipment exists to generate heating hot water with an annual COP of 2 to 3. One drawback is insignificant room for additional mechanical equipment in the ground floor mechanical room.
2. DHW can be converted to Heat Pump water heaters. Unfortunately, the mechanical room does not have the space to accommodate the equipment.

The heating boilers are only nine (9) years old and have an additional 10 years of useful service life left. When the boilers have reached their useful service life hopefully technology may evolve to meet the requirements of the building. The technologies to look at include air or geothermal heat pumps. A geothermal system will also allow the town to install a water-cooled chiller that would be approximately twice as efficient compared to the existing. Existing technologies can generate 140 °F heating hot water. I would be worth experimenting with operating the existing equipment with 140 °F.

RENEWABLE ENERGY POTENTIAL

The building has a 61.4 kW solar PV array over the fire department garage. It is owned by the Town of Medfield and net metered by Eversource. Select Energy Services monitors and provide the accounting for the PV array. The array has been generating since 2017. There is some flat roofing over the police garage and sallyport and sloped roof over the main building to install more PV. The asphalt shingles are original and may not qualify for PV installation due to the age of the shingles. Another 20 to 30 kW of panels can be installed.

ASHRAE LEVEL 1

ENERGY AUDIT REPORT

Prepared for

Town of Medfield – Wheelock School

17 Elm St., Medfield, MA 02052

Prepared by

EMA - Energy Management Associates, Inc.
www.EMA-Boston.com

June 2024

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

EMA-Boston.com

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ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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EXECUTIVE SUMMARY

ECM #	ECM Description	Elec. kW Demand Saved	Elec. kWh Energy Saved	Gas Therms Energy Saved	Total Energy Saved	Project Estimated Cost	Simple Payback (Years)	Est. Mass Save Incentive	Simple Payback (Years)
1	Programming Heating Hot Water Pumps for Freeze Protection		13,000	2,500	$3,500	$1,000	0.3	0	0.3
2	Tighten up BMS equipment schedule programming; currently too broad.		TBD	TBD	TBD	$1,000	TBD		
3	Commissioning of temperature controls		TBD	TBD	TBD	$1,550	TBD		
	TOTALS		**13,000**	**2,500**	**$3,500**	**$,1550**			
			7%	10%					

EMA has identified three (3) ECM's we typically identify in similar school buildings:

ECM-1 – P**rogramming Heating Hot Water Pumps for Freeze Protection** – The potential savings are 13,000 kWh per year and 2,500 Therms for a savings of $3,500 per year. With an estimated project cost of $1,000 this ECM has a simple payback of 0.3 years.

ECM-2 – **Tighten up BMS equipment schedule programming; currently too broad**. Schedules should match school activities and include Holiday programming. Review schedules (programming) to confirm that HVAC equipment is not operating when not being utilized for education programming. Savings unknown for the $1,000 programming review. Add holiday programming.

ECM-3 – **Commissioning of temperature controls** – Confirm that the building is operating in an efficient manner after completion of the controls upgrade. Make sure that common modern control algorithms are programmed. Four hours of programming and commissioning agent time is adequate to confirm control sequences of operation and setup trend data for future trouble shooting ($1,550).

The 65,190 square foot Medfield Wheelock School was constructed in 1969 and houses approximately 400 students. The school Was constructed to the standards of the time. There have been only four (4) significant upgrades to the school:

- The roofing was replaced in the early 2000's with roll out asphalt membrane over 4.5 inches of additional rigid insulation.
- At the same time all the HVAC equipment was replace in-kind with a simple BMS system
- In 2016 the heating plant was replaced with condensing natural gas boilers and variable volume heating hot water pumping
- Last year the domestic hot water (DHW) was replaced with four (4) heat pump tank type heaters.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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The rest of the building shell including walls and windows are unchanged since original construction. The supervisory controller has failed in service and the actual control set points, schedules, and algorithms cannot be adjusted or reviewed. Replacement Tridium Jace equipment is out to bid currently.

Despite all these handy caps the buildings EUI is 50,000 BTU/SQFT as rated by EPAs ENERGY STAR® program is in the top 20% of all schools in the program.

The existing electrical service size is questionable as to whether it can handle the electric load of complete electrification of the heating. The school's electric load will support approximately 50% partial electrification with ductless split heat pumps located in each classroom. This will also provide air conditioning.

The roof is large enough to install a solar PV array that will offset possibly all the electricity consumed by the school. One identifiable problem is the existing roof membrane is failing in service and must be replaced before consideration of solar PV.

BUILDING DESCRIPTION

Architectural

The Medfield Wheelock School was originally constructed in 1969. The 65,190 square feet two-story school is occupied by approximately 400 the 2nd and 3rd graders. The original HVAC equipment has been replaced in many phases over the life of the building. The windows are original steel frame single glazed casement units. The lower sash is operable. The roofing is a ballasted asphalt roll on membrane over 4.5 inches of additional rigid insulation. The roofing membrane is in poor condition with many patches. The exterior walls brick faced over concrete block with no evidence of insulation.

The school has classrooms, library, two (2) gymnasiums, kitchen and cafeteria. The school has a walk-in cooler and freezer. The kitchen has a walk-in cooler and freezer.

Lighting

Most of the lighting has been converted to LED. There are scattered CFL's in high hats and fluorescent lamps. Most of the exterior lighting is new LED. Each new fixture has a photocell. A few fixtures are original and on during our site survey.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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Mechanical

The classrooms are conditioned (climate controlled) by Unit Ventilators with perimeter hot water baseboard and two-way heating hot water valves. The classrooms are exhausted by rooftop fans. EMA counted 22 small HP rooftop exhaust fans and a kitchen hood exhaust fan. There is no kitchen supply H&V unit. There a few window A/C units scattered around the building for the main offices and miscellaneous spaces. One of the gyms has two (2) H & V units for heating and ventilation.

The two (2) boilers are natural gas fired Lochinvar model FBN condensing boilers rated at 3,500,000 BTU/Hr. input installed in 2016. The heating hot water pumps are 10 HP Bell & Gossett model 1510 with VSDs rated at 265 GPM and 80 feet of head. The boilers are piped in a primary/secondary configuration. The primary pumps are 1.5 HP Bell & Gossett Model e-80 pump rated 167 GPM and 20 feet of head.

Building Management System

The building BMS systems supervisory controller has failed in service. EMA was not able to access the BMS to evaluate. Based on the excellent EUI the default programming is functioning well. It is EMA's understanding that an RFP has been issued to replace the supervisory controller and downstream controller and sensors as needed with a Tridium Jace. The boilers, heating hot water pumps, and VSDs are controlled by an independent Tridium Jace.

Domestic Hot Water (DHW)

DHW is generated by four (4) high efficiency hybrid electric heat pump Rheem tank type water heaters. The 80-gallon hybrid heat pump water heaters are model PROPH80 T2 RH375-30. The heater has two 3.38 kW 208-volt backup heating elements. The heaters are maintained at 140 °F.

Electric Service

The building has a 1200 AMP 120/208 volt 3-phase 4-wire electric service. This service can support an electrical demand of approximately 350 kW. The electric service is not big enough to replace one of the heating boilers. It only has the capacity to replace 1/3 of a boiler. It should be noted that the two boilers located at The Dale School total heating capacity is less than ½ of each new boiler in Wheelock Schools. A heating load calculation is recommended to confirm if the building electric can meet the heating requirements of the school.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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UTILITIES

The school consumes electricity and natural gas. The school has averaged approximately 50,000 BTU/SQFT over the last two (2) years. The EPA Energy Star rating of the school is 80. This rating qualifies the school for EPA Energy Star and confirms the school operates in the top 80% of all schools.

The following tables are a summary of the electrical consumption over the last two (2) years. EMA is surprised that the summer electric consumption does decrease more. The slight year to year increase is related to the hybrid heat pump DHW heaters installed last year. The low level of electrical usage is related to the limited quantity of HVAC equipment, limited air conditioning, and the new LED lighting system.

Start Date	Read Date	kWh	Demand kW	Start Date	Read Date	kWh	Demand kW
4/21/2022	5/21/2022	15,000	54	4/21/2023	5/21/2023	15,120	54
5/21/2022	6/21/2022	14,640	55	5/21/2023	6/21/2023	13,800	65
6/21/2022	7/21/2022	10,560	42	6/21/2023	7/21/2023	9,720	34
7/21/2022	8/21/2022	11,160	38	7/21/2023	8/21/2023	9,600	34
8/21/2022	9/21/2022	17,280	71	8/21/2023	9/21/2023	16,920	71
9/21/2022	10/21/2022	14,640	50	9/21/2023	10/21/2023	14,520	55
10/21/2022	11/21/2022	16,560	55	10/21/2023	11/21/2023	15,960	54
11/21/2022	12/21/2022	17,640	59	11/21/2023	12/21/2023	17,520	58
12/21/2022	1/21/2023	16,560	59	12/21/2023	1/21/2024	17,040	64
1/21/2023	2/21/2023	17,400	59	1/21/2024	2/21/2024	22,200	64
2/21/2023	3/21/2023	14,760	60	2/21/2024	3/21/2024	19,920	64
3/21/2023	4/21/2023	15,240	55	3/21/2024	4/21/2024	19,680	60
Total		**181,440**	**657**	**Total**		**192,000**	**677**

The following table is a summary of the natural gas for the last two (2) years. The reduction in natural gas consumption can be attributed to the new electric DHW heaters.

Start Date	Read Date	Therms	Start Date	Read Date	Therms
5/4/2022	6/3/2022	565	5/4/2023	6/6/2023	257
6/3/2022	7/6/2022	92	6/6/2023	7/6/2023	0
7/6/2022	8/5/2022	51	7/6/2023	8/9/2023	0
8/5/2022	9/6/2022	62	8/9/2023	9/6/2023	0
9/6/2022	10/4/2022	216	9/6/2023	10/5/2023	41
10/4/2022	11/3/2022	1,869	10/5/2023	11/6/2023	1,766
11/3/2022	12/6/2022	4,071	11/6/2023	12/5/2023	3,331
12/6/2022	1/6/2023	5,536	12/5/2023	1/5/2024	4,225
1/6/2023	2/3/2023	4,348	1/5/2024	2/5/2024	5,022
2/3/2023	3/7/2023	5,017	2/5/2024	3/5/2024	4,071
3/7/2023	4/5/2023	3,636	3/5/2024	4/4/2024	3,444
4/5/2023	5/4/2023	2,157	4/4/2024	5/6/2024	2,426
Total		**27,620**	**Total**		**24,583**

ENERGY MANAGEMENT ASSOCIATES, INC.

160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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ENERGY CONSERVATION MEASURES

ECM-1 – Programming Heating Hot Water Pumps for Freeze Protection

One (1) heating hot water (HHW) pump operates all year unless manually turned off by building staff. While a HHW pump is required during all winter operating hours below 55 to 60 °F during occupied hours its primary function during unoccupied hours is freeze protection. Heat is required to protect the hot water coils in the unit ventilators, perimeter baseboard, and AHU's them from freezing. They are also required to maintain night setback heating temperatures and freeze protection of the sprinkler systems. We recommend implementing the following un-occupied sequence of operation:

- Shut down the HHW pumps during un-occupied periods when the outdoor air temperature is above 35 ° ± 2 °F.

This will reduce pump operating hours by approximately 2,000 hours per year.

The O.A.T. sensor shall be shielded from sun and/or building exhaust or relocated to a north wall away from any influences. We recommend replacing the sensor to confirm that it is calibrated.

Potential savings are 13,000 kWh per year and 2,500 therms per year for a total of $3,500 of savings. This project can be completed with a few hours of programming for no more than $1,000.

ECM-2 – Tighten up BMS Equipment schedules; currently too broad. Add Holiday Schedules.

The building has one schedule for all HVAC equipment. Typical schools open at 7AM for the early drop off and end at 6PM for the afterschool program (Monday through Friday). The programs generally utilize the gymnasium and maybe the cafeteria. School start time is about 8:30 in the morning and ends at 3PM. The main office operates on its own schedule. We recommend setting up three schedules for the school:

- Pre and after school program starting at 5AM and ending at 6PM
- Main Office 6AM to 4PM
- Rest of the school 6:30AM to 3:30PM.

Add and override button to the main BMS screen for special events. The override can be programmed for a 4-hour override so that the HVAC systems go back into un-occupied mode automatically.

The special event (holiday schedule) frequently is not programmed. The common holidays fall on the same day every year and can be programmed in perpetuity. These holidays include:

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Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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- New Years Day – January 1st
- Martin Luther King Day – 3rd Monday of January
- Memorial Day – 4th Monday of May
- July 4th
- Labor Day – 1st Monday of September
- Columbus Day – 2nd Monday of October
- Thanksgiving – 4th Thursday and Friday of November
- Christmas – December 25th

This will result in an additional 10 days of un-occupied operation every year.

The classrooms can also be programmed for summer break July 1st to August 24th. The UVs and the exhaust fans will shut down or operating times reduced when there are no students. The occupied period can be programmed to the custodial staff's schedule. Four hours of programming time is adequate to any additional scheduling programming ($1,000).

ECM-3 – Commissioning of temperature controls

Generally, control upgrades similar to the ones currently out to bid include the direct transfer of the existing control sequences. These control strategies include:

- Warm-up cycles with ventilation closed.
- Demand-Controlled Ventilation for gymnasium (may have to add a CO_2 sensor).
- Economizer (free cooling).

Trend logs are critical for future trouble shoot of changes in operation.

During our site survey we could not identify whether this programming was implemented. We recommend a quick retro-commissioning project to confirm the existence of these control algorithms or programming of them. Four hours of programming and commissioning agent time is adequate to confirm control sequences of operation and setup trend data for future trouble shooting ($1,550).

ELECTRIFICATION

The electric service has the capacity to replace just one of the boilers with an electric resistance boiler that provides almost all the annual heat for the building. The electric boiler can generate the 180 °F heating hot water that the building HVAC equipment is designed for. State mandated minimum renewable content of electricity has a lower emissions factor compared to the equivalent natural gas emissions factor. Purchasing 100% renewable electricity will result in an almost carbon free building.

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160 Beech Street
Franklin, MA 02038

Tel: 508.533.1128
Fax: 508.533.7332

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If the school district is considering adding air conditioning to the Memorial School, there is an option to partially electrify the building heating. We recommend installing low temperature ductless heat pumps or hyper heat units of approximately 2 tons each. This can reduce annual fossil fuel consumption by approximately 50%. The estimated displaced 12,250 therms with 118,000kWh per year resulting a negative cash flow of $10,000 per year.

RENEWABLE ENERGY POTENTIAL

The flat roof has significant space to install a large PV system of 150 to 200 kW and possibly offset all the electricity consumed by the building. The current condition of the roof disqualifies the school from installation. Installation of a solar PV system is not recommended until the existing roofing membrane is replaced.