The Town of Duxbury Energy Reduction Plan

Prepared by the Metropolitan Area Planning Council with support from the Town of Duxbury

In fulfillment of the
Massachusetts Green Communities Grant Program
Criterion 3

Adopted by Board of Selectmen October 16, 2017
Adopted by School Committee October 19, 2017

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A. Letters from Both General Government and School District Verifying Adoption of the ERP

Town of Duxbury, Massachusetts

OFFICE OF THE BOARD OF SELECTMEN AND TOWN MANAGER

October 17, 2017

Mr. Seth Pickering
Green Communities Regional Coordinator
Mass DOER C/O Mass DEP
20 Riverside Drive
Lakeville, MA 02346

Re: ***Green Community Application - Criterion 3*** *Energy Reduction Plan and* ***Criterion 4*** *Purchasing Policy for Fuel Efficient Vehicles*

Dear Mr. Pickering:

Duxbury's Board of Selectmen met on October 2 and October 16, 2017 and, as part of the agenda at these public meetings, reviewed and considered both the Energy Reduction Plan and the Fuel Efficient Vehicle Policy being proposed by the Town of Duxbury as part of our Green Community Application.

The Board of Selectmen endorsed and adopted this Energy Reduction Plan and this Fuel Efficient Vehicle Policy at the October 16, 2017 meeting and has authorized me to submit the plan and policy as part of Duxbury's Green Community Application.

We look forward to working with the Department of Energy Resources as we move forward with energy reduction plan implementation and other Green Community activities.

Sincerely,

René J. Read
Town Manager

cc: Megan Aki, MAPC, Energy Analyst | Clean Energy Department
Valerie Massard, Duxbury Planning Director
Scott Lambiase, Duxbury Director of Inspectional Services
John Antonucci, Duxbury Superintendent of Schools
Brian Cherry, Duxbury Facilities Director
Barbara Bartlett, Duxbury Energy/Special Projects Manager

878 Tremont Street, Duxbury, MA 02332 Telephone: 781-934-1100 x6016 Fax: 781-934-9011

DUXBURY
PUBLIC SCHOOLS

Duxbury Public Schools
93 Chandler Street, Duxbury, Massachusetts 02332
Tel: (781) 934-7600 • Fax: (781) 934-7644
District website • www.duxbury.k12.ma.us
Twitter: @duxbury_ps • Facebook: Duxbury Public Schools

October 19, 2017

MA Department of Energy Resources
Green Communities Division
100 Cambridge Street – Suite 1040
Boston, MA 02114

Dear MA Department of Energy Resources,

Please be advised that the Duxbury School Committee adopted the Energy Reduction Plan as part of the Town of Duxbury's Green Communities Application for Designation.

Sincerely,

John J. Antonucci
Superintendent of Schools

B. List of Contributors:

The collaborative efforts of the offices of Planning Director Valerie Massard, Energy/Special Projects Manager Barbara Bartlett, and Facilities Director Brian Cherry and MA Department of Energy Resource's Green Communities Regional Coordinator Seth Pickering were vital to produce this plan.

Much of the information in this plan was derived from energy audits performed by Energy Source, led by Dalton Ling and Jorge Soares. Additional technical assistance was provided by the Metropolitan Area Planning Council (MAPC), the author of this plan.

II. Executive Summary

A. Narrative Summary of the Town

The Town of Duxbury is a Plymouth County community situated around 35 miles southeast of Boston along the Atlantic Ocean. Duxbury was first settled in 1624, and was officially incorporated in 1637. With an area of 37.6 square miles, Duxbury has a population of 15,059 according to the 2010 Census. The Town is governed by a Town Manager and Board of Selectmen with an open Town meeting. Duxbury's school district is made up of Duxbury Middle-High School and two Elementary Schools.

In 2014, the Town consolidated energy management and maintenance services for both Town facilities and school buildings. All energy management and maintenance is supervised by the Town Facilities Director, Brian Cherry, with support from the Town's Energy/Special Projects Manager, Barbara Bartlett. Streamlining operations in this way ensures ease of communication between the Town facilities and the schools, and sets the Town well to successful implementation of their Green Communities Energy Reduction Plan. Additionally, the Town's clean energy efforts are supported by an active Alternative Energy Committee. The is an Ad-Hoc committee appointed by the Board of Selectmen to advise the Town Manager and Board of Selectmen in identifying ways to help control the costs of energy and reduce energy consumption in the Town of Duxbury.

The Town is committed to improving the energy efficiency of the existing buildings and also requiring that new construction meet high performance standards. The Duxbury Middle-High School opened in fall 2014 and is a Collaborative for High Performance Schools (CHPS) Verified Building. A CHPS Verified school meets the Massachusetts CHPS Criteria, a stringent green school building standard that includes requirements for LED lighting, high efficiency boilers and rooftop units, daylighting, and green building materials and requires a smaller footprint than the buildings replaced. The Town also uses SchoolDude, a web-based work request system, to allow staff to input work requests to manage operation and maintenance in real-time for their buildings.

In addition to these energy efficiency highlights, the Town is also committed to increasing use of renewable energy sources on their municipal buildings. In January 2017, rooftop solar photovoltaic arrays were installed on the Chandler Elementary School and Duxbury Middle-High School.

B. Summary of Municipal Energy Uses

Total Number of Municipal Buildings: 25

The municipal buildings add up to approximately 850,000 square feet, with 650,000 square feet making up Duxbury public schools. Municipal buildings are responsible for 70% of the Town's energy use baseline. The Duxbury Middle-High School, Alden Elementary School, and Chandler Elementary School account for nearly half of the Town's energy use baseline (46%).

Per approval from DOER, the Town has excluded the Duxbury Crematory from the FY16 baseline because the Crematory is used regionally by private residents of the Commonwealth, and the extremely high gas consumption is unlikely to change even with direct efficiency interventions from

the Town due to the nature of the building's function and services. The Duxbury Crematory was established the year of 1980 and was the first municipal crematory in the state. The Crematory started as a small crematory service in a modest building in 1980, and has since been transformed into a regional provider. The cremation services are performed in a modern, state-of-the-art facility that began operations in mid-2012. The Duxbury Crematory is not only the second largest energy user in Town, it also has the highest EUI in Town of 2,031 kBTU per square foot. By removing the crematory from the Baseline, the Town can set a Baseline and 20% reduction target that will be achieving through projects and interventions within the Town's control.

Building Additions and New Construction

The Town has planned an addition of approximately 2,500 square feet to the Senior Center during the summer of 2018. Additionally, in the next five years the Town is considering the construction of a new DPW facility. This facility would likely seek to consolidate some older buildings such as the Town Hall, Highway Department, and Water Department buildings.

Total Number of Municipal Vehicles: 87

The Town's municipal fleet is responsible for over 20% of the Town's energy use baseline. All of the Town's vehicles are fueled by either gasoline or diesel, but opportunities exist to integrate clean fuel vehicles into the municipal fleet in the next five years. Additionally, there are no electric vehicle charging stations in the Town of Duxbury that are available for public use.

Total Number of Street Lights and Traffic Lights: 333 streetlights, 18 field lights, and accounts for 8 traffic lights.

The most commonly occurring fixture is 60 watt high pressure sodium. Streetlights and traffic lights account for a small percentage of the Towns energy use baseline. Eversource owns a majority of the Town's streetlights.

Water and Sewer: 2 drinking water treatment plants, 11 drinking water pumping stations, 4 waste water pumping stations, and 1 waste water treatment plant.

Water and sewer treatment plans and pumping stations account for 6% of the Town's energy use baseline.

Table 1: Municipal Energy Use Summary

	Number	Ownership
Buildings	25	Muni
Natural Gas Heat	20	Muni
Electric or No heat	5	Muni
Vehicles	87	Muni
Gasoline or Diesel	87	Muni
Hybrid	-	-
Electric	-	-
Street Lights & Traffic Lights	359	
Street Lights	333	Utility (excluded)
Field Lights	18	Muni

Traffic Lights	8	Muni
Water and Sewer	19	Muni
Drinking Water Treatment Plant	3	Muni
Drinking Water Pumping Station	11	Muni
Wastewater Treatment Plant	1	Muni
Wastewater Pumping Station	4	Muni

C. Summary of Energy Use Baseline and Plans for Reduction

This Energy Reduction Plan commits Duxbury to reduce energy use in municipal facilities by at least 20% compared to Fiscal Year 2016 over five years. In the baseline year, the Town used 59,444 MMBTUs of energy.[1] Duxbury's 20% energy reduction goal will be measured against the non-weather normalized baseline of MMBTUs. This means the Town must reduce usage by at least 11,889 MMBTUs.

As shown in **Figure 1**, buildings made up over two thirds (70%) of the usage by facility type (i.e. building, vehicles, street/traffic light, water/sewer, and open space). As shown in **Figure 2**, the School Department made up 46% of the usage by department (i.e. School dept., DPW dept., Recreational dept., Water dept., Library, Fire dept., Police dept., and Misc.).

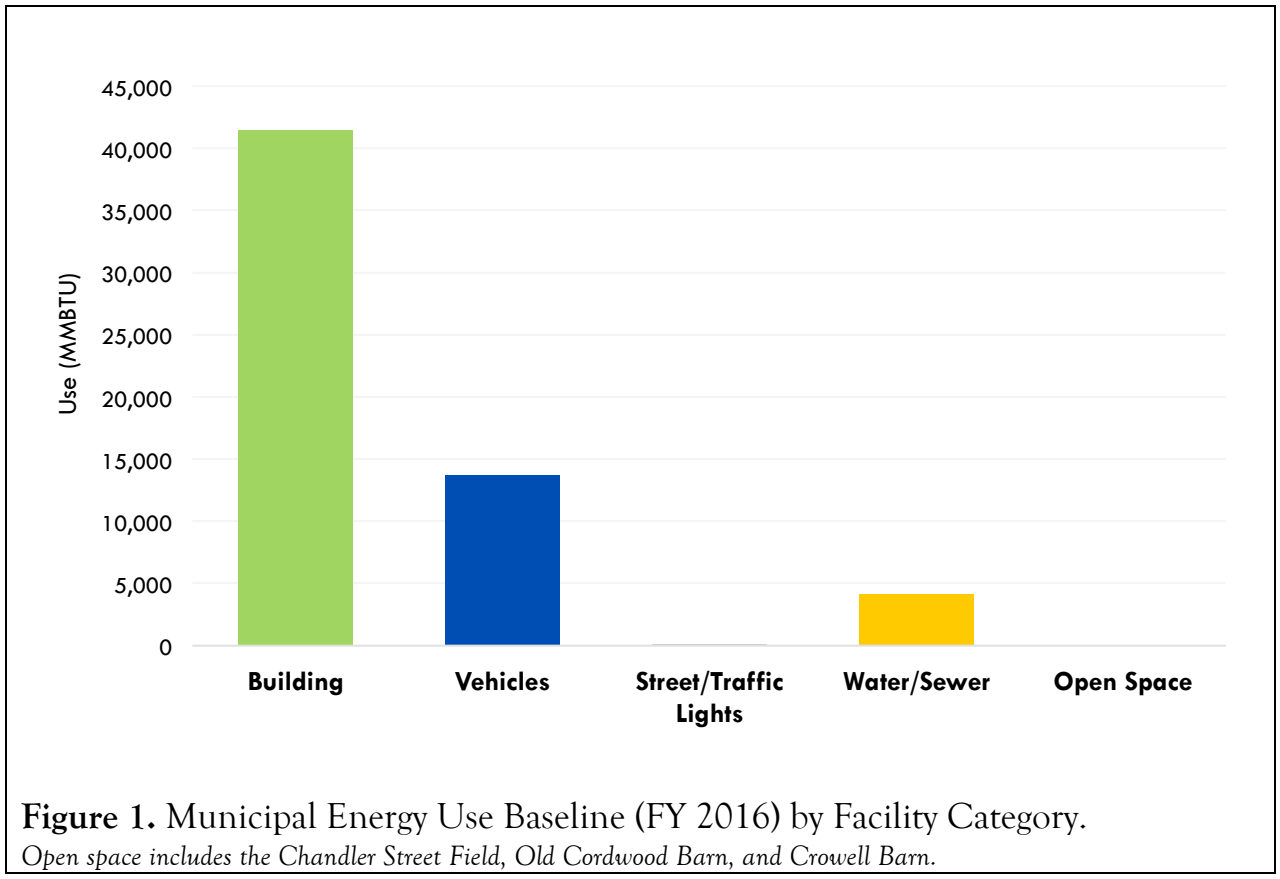


Figure 1. Municipal Energy Use Baseline (FY 2016) by Facility Category.
Open space includes the Chandler Street Field, Old Cordwood Barn, and Crowell Barn.

[1] Duxbury Crematory FY16 use of 9,116 MMBTUs is excluded from Town's baseline.

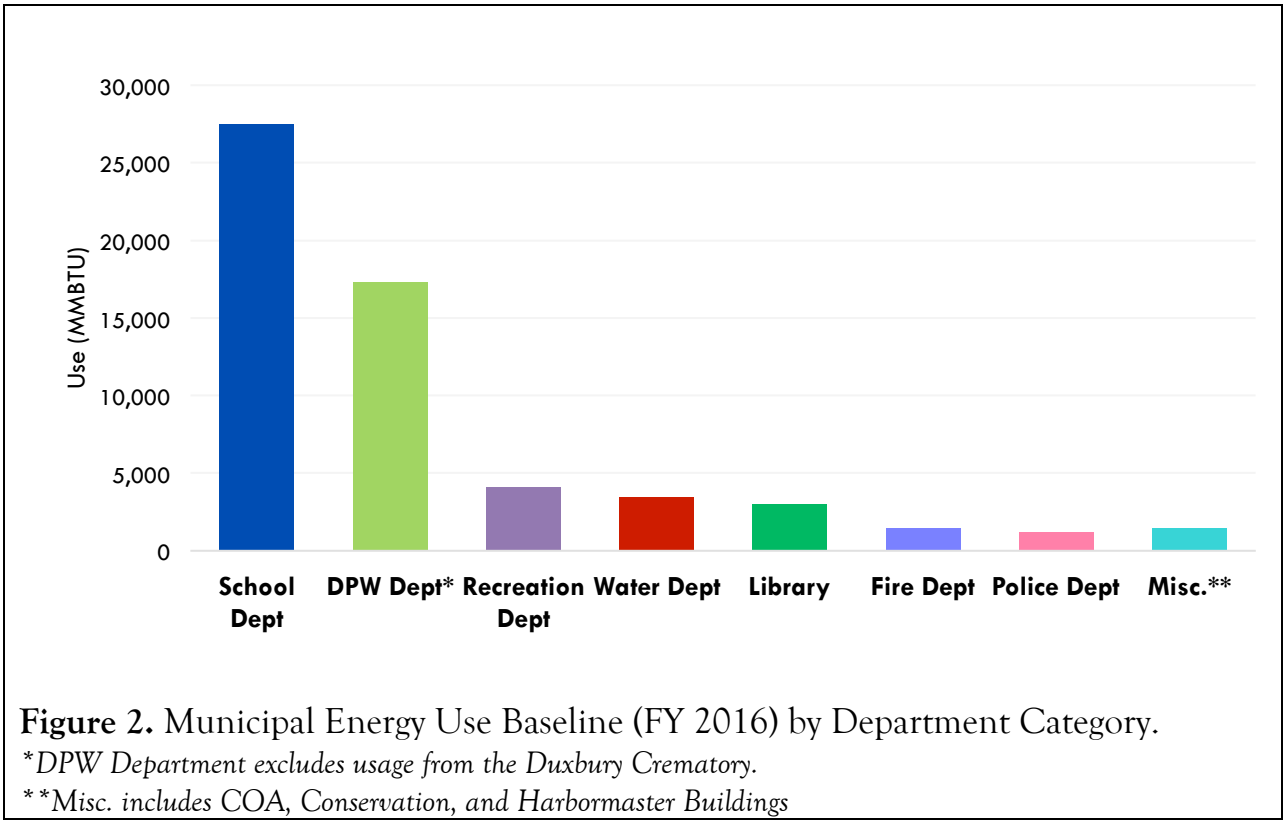


Figure 2. Municipal Energy Use Baseline (FY 2016) by Department Category.
**DPW Department excludes usage from the Duxbury Crematory.*
***Misc. includes COA, Conservation, and Harbormaster Buildings*

Duxbury has identified energy savings measures in each facility category to reduce energy use 20.9% based on the total **non-weather normalized** usage, as illustrated in **Table 2**.

Table 2: Summary of Municipal Energy Use & Reductions

Facility Category	MMBTU Used in Baseline Year	% of Total MMBTU Baseline Energy Consumption	Projected Planned MMBTU Savings	Savings as % of Total MMBTU Baseline Energy Consumption
Building	41,483	69.8%	10,177	17.1%
Vehicles	13,683	23.0%	2,142	3.6%
Street & Traffic Lights*	98	0.2%	0	0.0%
Water & Sewer	4,155	7.0%	129	0.2%
Open Space	22	0.0%	0	0.0%
Total Non-Weather Normalized	**59,444**	**100.0%**	**12,447**	**20.9%**

***Only municipally owned lighting is included in this category. A majority of the Town's streetlights are owned by Eversource.**

III. Energy Use Baseline Inventory

A. Identification of the Inventory Tool Used

The Town of Duxbury used the Department of Energy Resources' (DOER) MassEnergyInsight (MEI) web-based energy inventory and analysis tool. Energy use is measured in British thermal units (MMBTUs), which allow all fuel types (e.g. electricity, natural gas, diesel, etc.) to be converted to a common unit.

B. Identification of the Baseline Year

Fiscal Year (FY) 2016 will serve as the baseline year. FY 2016 ran from July 1, 2015 to June 30, 2016. This will give the Town until June 30, 2021 (FY 2016 – FY 2021) to reach its 20% energy reduction goal.

C. Municipal Energy Consumption for the Baseline Year (FY 2016)

Appendix A presents **Table 3** showing energy use for each municipal facility in native units and MMBTUs in the Baseline year. Note that Appendix A shows **non-weather normalized** data, because MEI only provides weather-normalized data for total town usage and fuel type. In the baseline year, the Town used 59,444 MMBTUs of energy.

As shown in **Figure 3**, consumption of electricity accounts for 42% of the Town's FY16 energy use baseline.

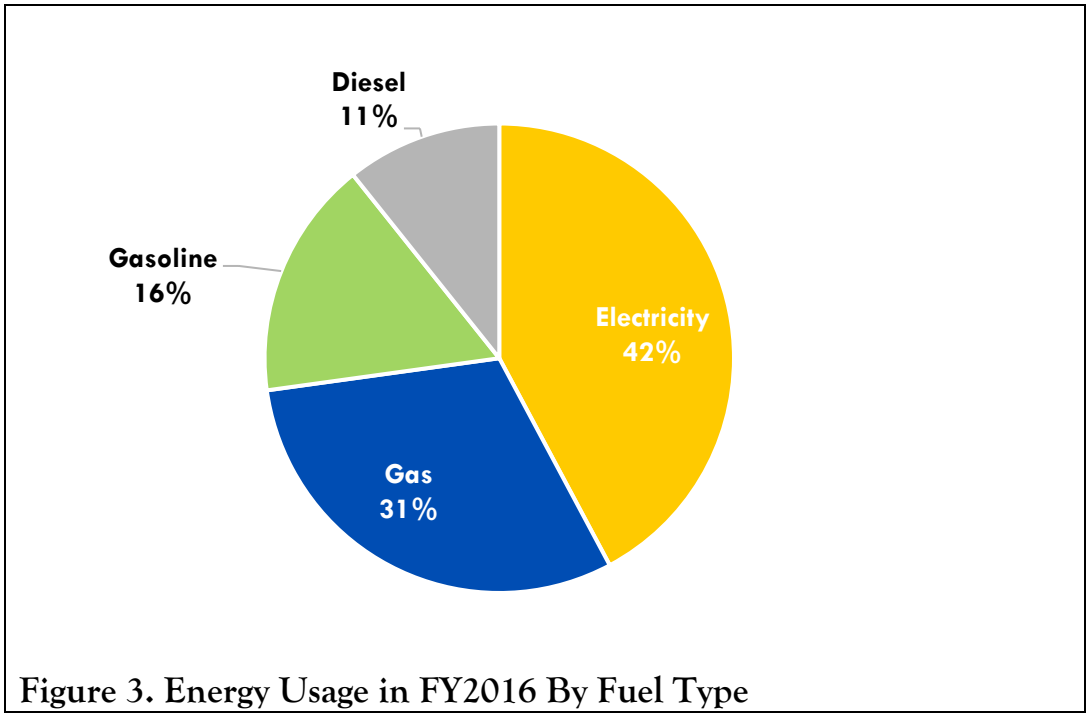


Figure 3. Energy Usage in FY2016 By Fuel Type

Table 3a shows that the top 10 largest energy users in town account for approximately 65% of all usage. The top three energy users are all Duxbury public school buildings.

Table 3a. Top 10 Energy Consuming Facilities in Duxbury

Facility	MMBTUs	Percent of FY2016 Baseline
#1 Duxbury Middle-High School	12,071	20%
#2 Alden Elementary School	7,907	13%
#3 Chandler Elementary School	5,124	9%
#4 Percy Walker Pool	3,967	7%
#5 Duxbury Free Library	2,982	5%
#6 Steele Athletic Building	1,685	3%
#7 Town Hall and Annex	1,548	3%
#8 Senior Center	1,378	2%
#9 New Police Headquarters	1,195	2%
#10 Central Fire Station	1,064	2%
Total FY 2016 Usage for Top Ten	**38,921**	**65%**
Total FY 2016 Usage Baseline	**59,444**	**100%**

Energy Use Intensity is a measure of the energy used per square foot, with lower EUIs indicating more efficient buildings. Buildings with a higher EUI generally have more opportunities for cost-effective energy efficiency upgrades.

The median EUI of all buildings in Duxbury is 68 kBTU per square foot. As shown in **Figure 4**, the largest user in town, Duxbury Middle-High School, has a EUI of 38. This low EUI is exemplary of the work the Town did during the design and construction of the building to achieve a CHPS Verified Building with a smaller footprint than the building it replaced.

Alden Elementary School and Chandler Elementary School are the third and fourth largest energy users in Town and both have low EUIs of 49 and 39 respectively. The remaining seven buildings in the top 10 largest users – Percy Walker Pool (#4), Duxbury Free Library (#5), Steele Athletic Building (#6), Town Hall and Annex (#7), Senior Center (#8), New Police Headquarters (#9), and Central Fire Station (#10) – all have an EUI either at or above the Town's median. While Duxbury would not expect to see significant savings from the Middle-High School or the two elementary schools that are operating at high efficiency levels, these six buildings should be able to provide some energy savings through measures to improve their overall efficiency.

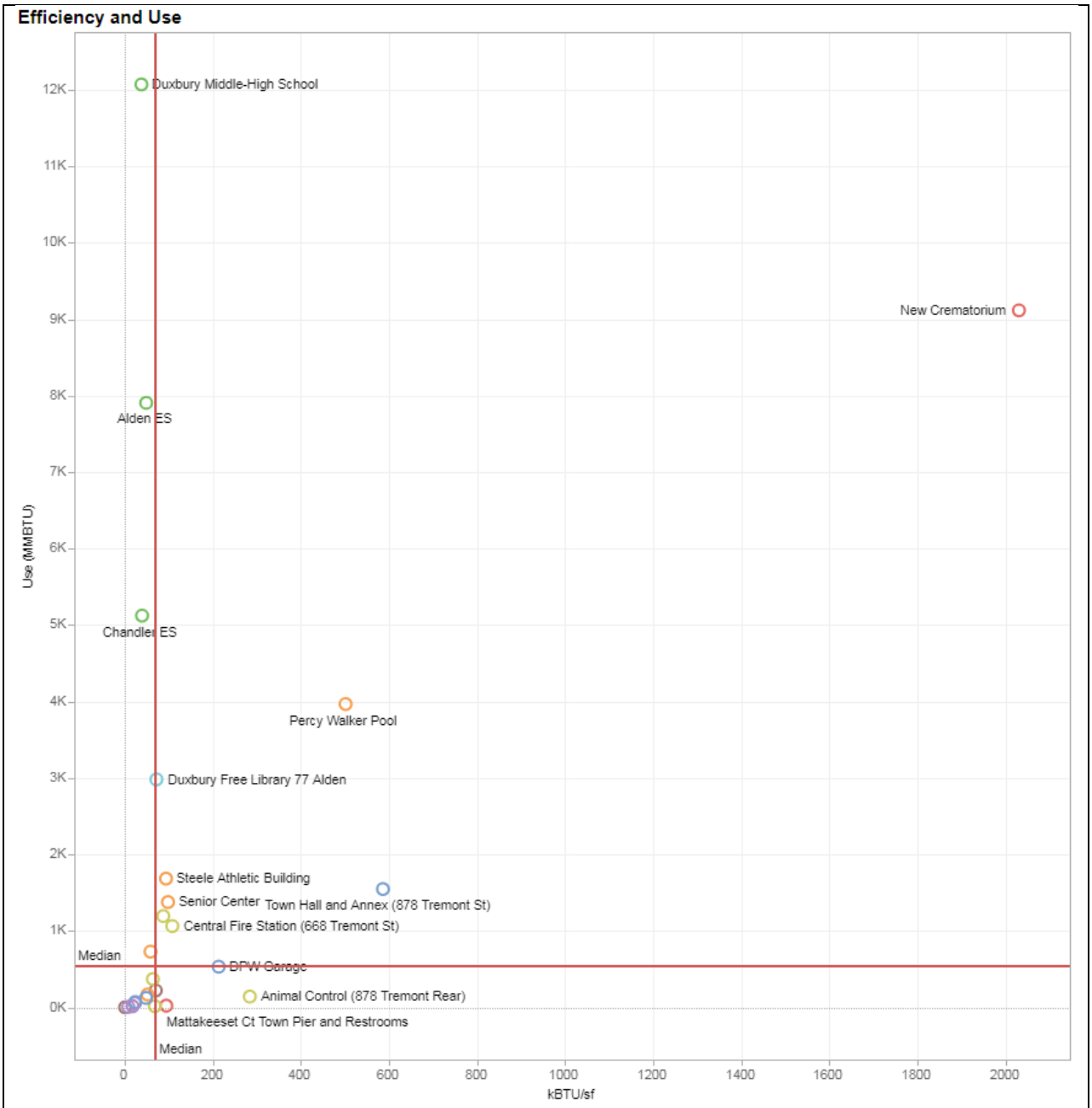


Figure 4. Energy Use Intensity (kBTU/sf) and Total Energy Use (MMBTU) for Buildings.

Points further to the right have a higher energy use per square foot (i.e. less energy efficient). Points higher up use more total energy. Duxbury Middle-High School, for example, uses the most energy of any building but has a relatively low usage per square foot. The New Crematorium is an outlier in relationship to other buildings in Town and has been excluded from the Town's Baseline for this Energy Reduction Plan.

Red lines show the medians for the Town's buildings.

D. **Energy Reduction Goal**

Duxbury's 20% energy reduction goal will be measured against the non-weather normalized baseline of 59,444 MMTBUs. Duxbury will need to reduce its non-weather normalized energy consumption by at least 11,889 MMBTUs.

IV. Energy Reduction Plan

A. Narrative Summary

As shown in Table 4, the Town has identified energy savings measures to reduce **non-weather normalized** usage from FY2016 by 12,447 MMBTUs or 20.9%. These measures are also summarized below:

A. Overview of Goals for Years 1-3:

- Expand the **energy management system** to include administrative offices at the Alden Elementary School office to refine and tighten building temperature controls. The proposed system will allow for remote control, monitoring, and alarming of mechanical equipment.
- Install Direct Digital Controlled **unit ventilators** and integrate into the existing energy management system at the Chandler Elementary School.
- Install **Variable Frequency Drives** (VFDs) at Percy Walker Pool, Alden Performing Arts Center, and Steele Athletic building.
- Install electronically commutated **circulator pumps** at the Percy Walker Pool, New Town Hall and Wright Building.
- Install EMME **comfort controls** in the Senior Center office space.

B. Overview of Goal for Years 4-5:

- Install **LED lighting and smart controls** where applicable in Alden Elementary School and Performing Arts Center, Chandler Elementary School, Duxbury Free library, Percy Walker Pool, Town Hall & Annex, Senior Center, Central Fire Station, Ashdod Fire Station, New Police Headquarters, Steele Athletic Building, Evergreen Chemical Treatment Plant, Waste Water Treatment Plant, and the Wright Building.
- Install **plug load controls** at Duxbury Middle-High School, Alden Elementary School and Performing Arts Center, Chandler Elementary School, Duxbury Free Library, Percy Walker Pool, Town Hall & Annex, Senior Center, Central Fire Station, Ashdod Fire Station, New Police Headquarters, Wright Building, and Tarklin Community Center.
- Install **demand control ventilation** at the Chandler Elementary School and Alden Elementary School. This measure will include equipping HVAC systems with field controls and installing CO_2 sensors on each air handing hunt and make-up air unit in the two buildings.
- Install **tank and valve insulation** at Chandler Elementary School.
- Install **kitchen hood controls** on the ventilation and exhaust fans in the kitchens at Alden Elementary School. This measure includes the installation of two VFDs and temperature sensors.
- Install **destratification fans** in the main lobby of the Alden Performing Arts Center.
- Install **high efficiency transformers** at the Alden Elementary School, Chandler School, Annex Building (Old Town Hall), Evergreen Chemical Treatment Plant, Waste Water Treatment Plant, and Damon Pump Station.
- Install **Variable Frequency Drives** (VFDs) at the Duxbury Free Library.

- Install **infrared heaters** in the Police Headquarters Garage.
- Install **rooftop unit controls** on the two rooftop units at Ashdod Fire Station to better control the building's temperature.
- Install **condensing boilers** at Chandler Elementary School, Duxbury Free Library, Percy Walker Pool, the New Town Hall, and the Wright Building.
- Implement **weatherization measures** to conserve energy at eight buildings as follows:
    - Air sealing and weather stripping at Alden Elementary School.
    - Air sealing, frame sealing, and weather stripping at Chandler Elementary School.
    - Weather stripping at Percy Walker Pool.
    - Weather stripping at Duxbury Free Library.
    - Air sealing at the New Town Hall.
    - Attic air barrier retrofit and weather stripping at the Annex Building (Old Town Hall).
    - Window weatherization and weather stripping at the Senior Center.
    - Weather stripping at the Waste Water Treatment Plant.
- Pilot **behavior-based energy savings programs** in Duxbury Public Schools (Alden Elementary School, Chandler Elementary School, and Duxbury Middle-High School).
    - Programs should include initial documentation of appropriate set points and a quarterly documentation that those set points are being followed.
- Achieve **Building Operator Certification** for Facilities Director and additional staffer.
- Implement the following vehicle policy and maintenance strategies:
    - Adopt a city-wide "No Idling" policy for all municipal vehicles.
    - Incorporate a switch to 100% synthetic oil for all municipal vehicles' oil replacement.
    - Closely monitor vehicle tire air pressure to maintain vehicle fuel efficiency.
- Build on pilot behavior-based energy reduction programs to create a permanent program in schools.

C. Energy Efficiency Identification Measures:

- The Town should continue to utilize MEI to review data and identify if year over year trends are occurring as expected. Unexpected increases or the failure of some categories to decrease despite known interventions/retrofits should prompt further inquiry.
- Use MEI's building "Buildings to Target" tab to identify underperforming and/or wasteful buildings based on Energy Use Intensity (see Figure 4 above).
- Conduct research and talk with experts such as energy auditors, DOER, MAPC, Massachusetts Clean Energy Center and others to find out if new technologies have come to market that could provide new savings in existing facilities. MAPC recommends exploring Massachusetts Clean Energy Center's Commercially Ready Technology's list. See http://www.masscec.com/.

B. Path to 20% Energy Use Reduction by the end of Fiscal Year 2020

A. Program Management Plan for Implementation, Monitoring, and Oversight

The Facilities Department, in collaboration with the Planning Department, will be responsible for oversight of the Energy Reduction Plan and for implementation of the energy conservation measures within the Town. The Planning Director, with support from the Facilities Director and Energy Manager, will be responsible for the annual reporting requirements to DOER to maintain designation and eligibility for annual competitive grant funding.

The Facilities Director, Town Planner, and Energy Manager plan to meet on a quarterly basis to ensure effective implementation of the Energy Reduction Plan and ongoing upkeep of the required data and information for annual reporting and competitive grant funding (e.g. maintenance and manual upload of data to MEI, energy conservation project updates and development, changes in vehicle inventory, and building permits under the Stretch Code).

The Energy Manager, or other designee of the Town Manager, should provide an annual update to the Board of Selectmen by the end of January following the submission of the Annual Report to DOER. The presentation should include:

- The trend for town-wide energy usage:
    - Should show the baseline, current year and any years in between
    - The Duxbury Crematory will remain excluded from all reporting to DOER and to Board of Selectmen
- The trend for energy usage in at least the top three energy using buildings – Duxbury Middle-High School, Alden Elementary School, and Chandler Elementary School – which together comprise approximately 42% of the town's energy use.
    - Should show the baseline, current year and any years in between
- A summary of the major efficiency measures implemented over the past year
- An explanation or hypothesis the cause of the trends town-wide and in at least each of the top 3 buildings
- Update on Green Communities competitive grant applications

B. Summary of Energy Audit(s) or Other Sources for Projected Energy Savings

Building audits were provided by Energy Source in 2017 and provide 14.7% energy savings (8,751 MMBTUs). The Energy Source Energy Audit Report is included in **Appendix B**.

Water and Sewer measures were also provided through an audit by Energy Source in 2017. The audit identifies 0.2% energy savings (129 MMBTUs). The full audit is available in **Appendix B**.

Vehicle policy and maintenance measures targeting overall vehicle usage will provide another 3.6% energy savings (2,142 MMBTUs). The supporting documentation for these policy and maintenance measures are available in **Appendix C**.

MAPC developed estimates for energy savings through building operator certification trainings and **behavior-based energy programs** in schools, based on published research from the report Powering Down from the US Green Building Council's Center for Green Schools. These supplementary measures identify 2.4% additional energy savings (1,426 MMBTUs). The supporting documentation is included in **Appendix D**.

C. Energy Conservation Measures

Table 4 lists recommended energy conservation measures. References for each measure is included in the table and these references are included as appendices to the Energy Reduction Plan. Projected annual MMBTU savings for each category (buildings, vehicles, water and sewer) are subtotaled to arrive at a municipal grand total of 12,447 MMBTUs.

Table 4: Estimated Energy Savings in Duxbury Municipal Facilities.

Table 4: Estimated Energy Savings in Duxbury Municipal Facilities.

Measure		Status	Energy Data				Financial Data						Reference	
			Projected Annual Energy Savings											
Category/Building	Energy Conservation Measure	Status (Completed with month/year or Planned Quarter/year)	Electricity Savings (kWh)	Natural Gas Savings (therms)	Vehicle Gasoline (gallons)	Diesel Savings (Gallons)	Projected Annual Cost Savings ($)	Estimated Total Project Cost ($)	Green Communities Grant* ($)	Estimated Utility Incentives ($)	Estimated Cost After Utility Incentives ($)	Estimated Payback After Incentives (years)	Funding Source	Source for Energy Savings
		NATIVE UNIT TOTALS:	**2,195,202**	**28,154**	**10,695**	**6,208**	**453,858**	**$ 3,559,388**		**$ 528,643**	**$ 3,030,745**	**6.7**		
Duxbury Middle-High School	Install Plug Load Controls	**Planned QT2 - FY21**	14,192	0			$2,058	$13,279		$2,838	$10,441	5.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Alden Elementary School	Install LED Lighting	**Planned QT2 - FY21**	258,186	0			$49,902	$371,442		$64,547	$306,895	6.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install High Efficiency Transformers	**Planned QT2 - FY20**	51,726	0			$7,500	$87,335		$15,518	$71,817	9.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Kitchen Hood Controls	**Planned QT2 - FY21**	3,630	2,298			$3,284	$19,240		$2,000	$17,240	5.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Energy Management System	**Planned QT2 - FY19**	4,351	468			$4,693	$57,120		$6,000	$51,120	10.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Demand Control Ventilation	**Planned QT2 - FY21**	32,340	2,819			$8,072	$37,700		$6,000	$31,700	3.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	8,918	0			$1,293	$7,499		$1,784	$5,715	4.4	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	2,425	1,326			$1,943	$14,884		$0	$14,884	7.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Chandler Elementary School	Install LED Lighting	**Planned QT2 - FY21**	417,036	0			$75,302	$505,286		$104,259	$401,027	5.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Condensing Boilers	**Planned QT2 - FY20**	0	3,428			$9,114	$177,005		$16,000	$161,005	17.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Unit Ventilators with Controls	**Planned QT2 - FY19**	90,205	2,482			$41,058	$540,726		$22,400	$518,326	12.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install High Efficiency Transformers	**Planned QT2 - FY20**	46,809	0			$6,787	$40,076		$14,043	$26,033	3.8	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Demand Control Ventilation	**Planned QT2 - FY21**	0	1,069			$1,283	$22,100		$6,000	$16,100	12.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	8,230	0			$1,193	$8,905		$1,646	$7,259	6.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	1,818	994			$1,456	$13,911		$0	$13,911	9.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Pipe Insulation	**Planned QT2 - FY21**	0	80			$96	$1,764		$0	$1,764	18.4	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Duxbury Free Library	Install LED Lighting	**Planned QT2 - FY21**	282,797	0			$49,214	$180,873		$70,699	$110,174	2.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Condensing Boilers	**Planned QT2 - FY21**	0	2,145			$6,324	$146,029		$12,000	$134,029	21.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	VFDs/Motors on Distribution Pumps	**Planned QT2 - FY21**	20,240	0			$2,935	$53,650		$6,000	$47,650	16.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	4,474	0			$649	$3,281		$895	$2,386	3.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	148	80			$118	$813		$0	$813	6.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Percy Walker Pool	Install LED Lighting	**Planned QT2 - FY21**	82,200	0			$13,242	$62,648		$20,550	$42,098	3.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Condensing Boilers	**Planned QT2 - FY21**	0	2,672			$7,206	$141,604		$8,000	$133,604	18.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	VFDs/Motors on Distribution Pumps	**Planned QT2 - FY19**	52,290	0			$7,582	$20,010		$2,250	$17,760	2.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Electronically Commutated Pumps	**Planned QT2 - FY19**	5,158	0			$748	$7,540		$1,350	$6,190	8.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	3,432	0			$498	$2,344		$686	$1,658	3.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	130	68			$100	$824		$0	$824	8.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
New Town Hall	Install LED Lighting	**Planned QT2 - FY21**	41,247	0			$8,960	$63,463		$10,312	$53,151	5.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Condensing Boilers	**Planned QT2 - FY21**	0	1,560			$4,422	$148,800		$8,000	$140,800	31.8	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Electronically Commutated Pumps	**Planned QT2 - FY19**	12,240	0			$1,775	$21,600		$3,750	$17,850	10.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	7,481	0			$1,085	$4,062		$1,496	$2,566	2.4	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	532	290			$426	$4,957		$0	$4,957	11.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Annex Building (Old Town Hall)	Install LED Lighting	**Planned QT2 - FY21**	4,155	0			$989	$7,695		$1,039	$6,656	6.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install High Efficiency Transformers	**Planned QT2 - FY20**	6,282	0			$911	$5,344		$1,885	$3,460	3.8	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	305	167			$244	$1,452		$0	$1,452	5.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	1,223	0			$177	$1,094		$245	$849	4.8	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Senior Center	Install LED Lighting	**Planned QT2 - FY21**	73,719	0			$15,180	$81,233		$18,430	$62,803	4.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Comfort Controls	**Planned QT2 - FY19**	72,558	0			$15,621	$114,400		$0	$114,400	7.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	1,575	0			$228	$1,562		$315	$1,247	5.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	576	316			$462	$4,272		$0	$4,272	9.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Alden Performance Art Center	Install LED Lighting	**Planned QT2 - FY21**	65,028	0			$12,768	$78,930		$16,257	$62,673	4.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	VFDs/Motors on Distribution Pumps	**Planned QT2 - FY19**	4,761	0			$690	$7,975		$2,500	$5,475	7.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Destratification Fans	**Planned QT2 - FY21**	0	2,480			$2,976	$26,400		$2,976	$23,424	7.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	4,826	0			$700	$3,281		$965	$2,316	3.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Central Fire Station	Install LED Lighting	**Planned QT2 - FY21**	51,898	0			$9,244	$46,064		$12,975	$33,089	3.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	4,428	0			$642	$2,812		$886	$1,926	3.0	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Ashdod Fire Station	Install LED Lighting	**Planned QT2 - FY21**	30,500	0			$4,999	$18,754		$7,625	$11,129	2.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Rooftop Unit Controls	**Planned QT2 - FY21**	18,779	144			$2,896	$21,324		$4,857	$16,467	5.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	3,715	0			$539	$1,875		$743	$1,132	2.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
New Police Headquarters	Install LED Lighting	**Planned QT2 - FY21**	31,253	0			$5,873	$40,456		$7,813	$32,643	5.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Infrared Heaters	**Planned QT2 - FY21**	0	1,320			$2,484	$62,400		$4,500	$57,900	23.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	10,232	0			$1,484	$3,749		$2,046	$1,703	1.1	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Steele Athletic Building	Install LED Lighting	**Planned QT2 - FY21**	23,994	0			$4,892	$31,179		$8,395	$22,784	4.7	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	VFDs/Motors on Distribution Pumps	**Planned QT2 - FY19**	85,928	1,153			$13,843	$27,550		$4,800	$22,750	1.6	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Wright Building	Install LED Lighting	**Planned QT2 - FY21**	33,458	0			$7,236	$54,254		$8,364	$45,890	6.3	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Condensing Boilers	**Planned QT2 - FY21**	0	699			$3,339	$102,700		$8,000	$94,700	28.4	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Electronically Commutated Pumps	**Planned QT2 - FY19**	9,423	0			$1,366	$12,801		$2,500	$10,301	7.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install Plug Load Controls	**Planned QT2 - FY21**	4,576	0			$664	$2,812		$915	$1,897	2.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Tarklin Community Center	Install Plug Load Controls	**Planned QT2 - FY21**	2,951	0			$428	$1,250		$590	$660	1.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Duxbury Middle-High School	Behavioral energy efficiency program	**Planned QT2 - FY21**	95,179	0			$13,325	$5,000		$0	$5,000	0.4	GC Grant and/or Capital Funds	MAPC Calculations and Powering Down Report, see Appendix E
Alden Elementary School	Behavioral energy efficiency program	**Planned QT2 - FY21**	36,943	0			$5,172	$5,000		$0	$5,000	1.0	GC Grant and/or Capital Funds	MAPC Calculations and Powering Down Report, see Appendix E
Chandler Elementary School	Behavioral energy efficiency program	**Planned QT2 - FY21**	29,777	-			$4,169	$5,000		$0	$5,000	1.2	GC Grant and/or Capital Funds	MAPC Calculations and Powering Down Report, see Appendix E
Buildings Subtotal		**MMBTU Saved:**	**10,177**	**2,160,276**	**28,058**	**-**	**-**	**$ 453,858**	**$ 3,559,388**	**$ -**	**$ 528,643**	**$ 3,030,745**	**6.68**		
Evergreen Chemical Treatment Plant	Install LED Lighting	**Planned QT2 - FY21**	15,872	0			$2,751	$22,872		$7,640	$15,232	5.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install High Efficiency Transformers	**Planned QT2 - FY20**	6,282	0			$911	$5,564		$1,885	$3,679	4.0	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Waste Water Treatment Plant	Install LED Lighting	**Planned QT2 - FY21**	4,315	0			$626	$7,696		$1,510	$6,186	9.9	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Install High Efficiency Transformers	**Planned QT2 - FY20**	4,892	0			$709	$5,564		$1,468	$4,096	5.8	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
	Building Weatherization	**Planned QT2 - FY21**	150	96			$138	$1,268		$0	$1,268	9.2	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Damon Pump Station	Install High Efficiency Transformers	**Planned QT2 - FY20**	3,415	0			$495	$5,212		$1,025	$4,188	8.5	GC Grant and/or Capital Funds	2017 Energy Source Audit Report, see Appendix B
Water & Sewer Subtotal		**MMBTU Saved:**	**129**	**34,926**	**96**	**-**	**-**	**5,630**	**48,176**	**-**	**13,527**	**34,649**	**6.15**		
Vehicle maintenance	Switch to 100% synthetic oil	**Planned FY21**			1,337	776							GC Grant and/or Capital Funds	MAPC Vehicle Measures Calculations, see Appendix D
Vehicle maintenance	Tire air pressure maintenance toolkit	**Planned FY21**			2,674	1,552							GC Grant and/or Capital Funds	MAPC Vehicle Measures Calculations, see Appendix D
Vehicle policy	City-wide "No Idling" policy for municipal vehicles	**Planned FY21**			6,685	3,880							GC Grant and/or Capital Funds	MAPC Vehicle Measures Calculations, see Appendix D
Vehicle Subtotal		**MMBTU Saved:**	**2,142**	**-**	**-**	**10,695**	**6,208**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**-**		
		Total MMBTU Saved	**12,447**	**7,490**	**2,815**	**1,289**	**853**							

C. Summary of Long-Term Energy Reduction Goals – Beyond 5 Years

A. Municipal Buildings (including schools)

To better strategize for the long-term maintenance and management of municipal buildings, Duxbury will work with internal schools and Town staff as well as outside consultants, when necessary, to assess and document the condition of major municipal buildings. In addition to exposing continuing opportunities for energy use reductions, this effort will provide the Town with a clear, long-term asset management strategy for the effective budgeting and maintenance of buildings.

B. Vehicles (including schools)

The Fuel-Efficient Vehicle policy will have become engrained within municipal purchasing practices after 5 years, and the Town will seek to explore even more efficient policies and tracking systems to enable more efficiency.

C. Street and Traffic Lighting

As the Town expects to have all streetlights retrofitted with LED bulbs within the 5 year period, the Town will next look to include wireless controls that can dim to drive further savings.

D. Perpetuating Energy Efficiency

An annual municipal audit by Town and Schools staff can tap into the knowledge of the employees who use and maintain the building every day. It can empower building staff to develop a detailed repair and management schedule and collect data on problems and inefficiencies that may be missed by traditional third party audits.

The Town of Duxbury will grow its capacity to retrofit and build more efficient facilities, purchase more efficient vehicles, and illuminate the Town through more efficient lighting throughout the 5-year period. These practices will become more engrained in the culture of the Town and will provide opportunities to instill the ethos into additional policies and programs for more dedicated long-term funding streams and strategies.

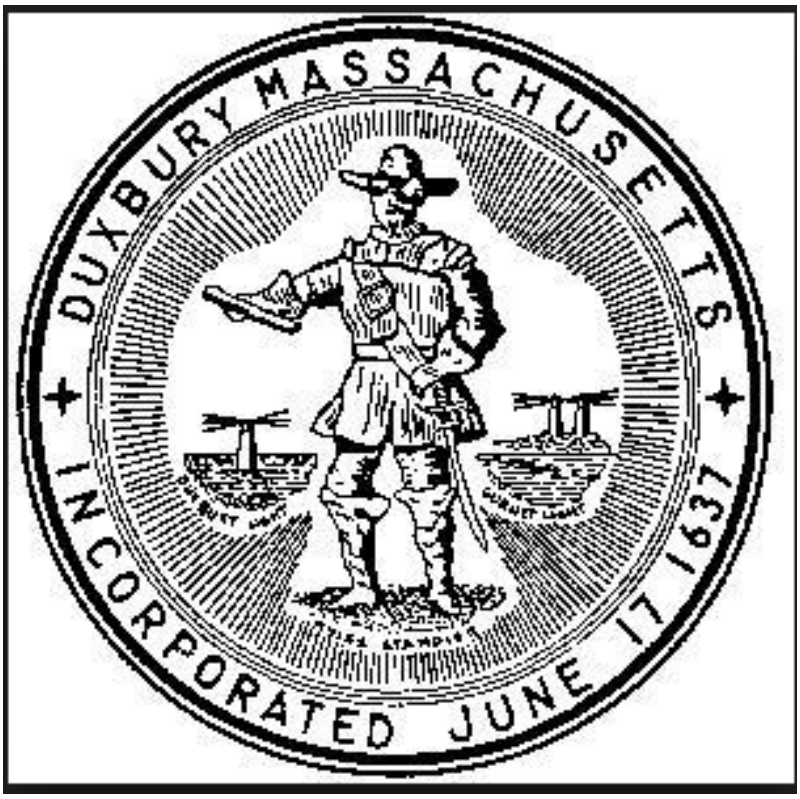
V. Appendix A: Table 3 - Municipal Energy Consumption for FY 2016

Table 3: Municipal Energy Use Baseline (FY2016)

Facility	Electric		Gas		Gasoline		Diesel		Total MMBTU
	kWh	MMBTU	therms	MMBTU	Gallons	MMBTU	Gallons	MMBTU	
Chandler Elementary School	595,500	2,032	30,918	3,092					5,124
Alden Elementary School & Performing Arts Center	738,912	2,521	53,860	5,386					7,907
Duxbury Middle-High School	1,903,560	6,495	55,762	5,576					12,071
Steele Athletic Building	376,680	1,285	3,993	399					1,685
Senior Center	146,560	500	8,780	878					1,378
Duxbury Free Library	366,720	1,251	17,310	1,731					2,982
Central Fire Station	207,014	706	3,574	357					1,064
Ashdod Fire Station	42,398	145	2,261	226					371
Central Fire Garage	1,957	7							7
Bluefish River Fire Station			160	16					16
New Police Headquarters	264,680	903	2,918	292					1,195
Transfer Station	64,766	221							221
DPW Garage	36,398	126	4,078	408					530
DPW Storage Garage	458	2							2
DPW Barn Emergency Generator			48	5					5
DPW Sand and Salt Shed	22,991	78							78
Town Hall and Annex	160,520	548	10,001	1,000					1,548
Wright Building (147 St George St)	97,920	334	3,952	395					729
Tarkiln Community Center	8,159	28	1,408	141					169
Girl Scout House	5,080	17	1,068	107					124
Animal Control (878 Tremont Rear)	8,871	30	1,117	112					142
Percy Walker Pool	301,520	1,029	29,386	2,939					3,967
Mattakeeset Ct Town Pier and Restrooms	6,899	24							24
Harbormaster's Office	4,798	16							16
Old Cemetery Admin (774 Tremont St)	2,029	7	636	64					71
Cemetery Maintenance Garage	3,003	10	471	47					57
Buildings Subtotal	**5,367,393**	**18,315**	**231,701**	**23,171**					**41,483**
Street Lights/Field Lights	26,206	90							**90**
Traffic Lights	2,535	8							**8**
Street Lights/Traffic Lights Subtotal	**28,741**	**98**							**98**

Table 3: Municipal Energy Use Baseline (FY2016) – cont'd.									
Facility	Electric		Gas		Gasoline		Diesel		Total MMBTU
	kWh	MMBTU	therms	MMBTU	Gallons	MMBTU	Gallons	MMBTU	
Wastewater Treatment Plant			6,973	697					697
Birch Street - Water Tank	24,505	84							84
Captain's Hill - Water Tank	6,200	21							21
Cedar Street Art Center - Pump Station	324	1							1
Damon Pump Station	181,696	620							620
Depot Street Pump and Chemical Buildings	3,523	12							12
Elm Street PRV	4,286	15							15
Evergreen Chemical Treatment Plant			3,430	343					343
Evergreen - 1 & 2 Pump Station	206,760	705							705
Harrison Street - Pump Station	6,844	23							23
Lake Shore Pump Shed	60,622	207							207
Mayflower Street - Well #1	72,697	248							248
Mayflower Street - Well #2	95,247	325							325
Millbrook Station - Pump #1 & #2	80,074	273							273
Millbrook Station Chemical Building & Garage	5,998	20							20
Old Colony Road - Pump Station	966	3							3
Partridge Road - Pump Station	34,989	119							119
Tremont I & II Pump Station	125,780	429							429
Washington Street - Bluefish Pump Station	766	3							3
West Street Pump	2,030	7							7
Water/Sewer Subtotal	**913,307**	**3,115**	**10,403**	**1,040**					**4,155**
Chandler Street Field	5,557	19							19
Crowell Barn	749	3							3
Old Cordwood Path Barn	21	0							0
Open Space Subtotal	**6,327**	**22**							**22**
Vehicles Subtotal					**66,845**	**8,289**	**38,803**	**5,394**	**13,683**
TOTAL ENERGY USE	**6,315,768**	**21,550**	**242,104**	**24,211**	**66,845**	**8,289**	**38,803**	**5,394**	**59,444**

VI. Appendix B: 2017 Energy Audit Report –Energy Source



Energy Efficiency Comprehensive Project

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September 21st, 2017

Dear Barbara Bartlett,

Energy Source is pleased to present you with this energy conservation analysis. We trust you will find this to be a cost-effective means to reduce your energy costs, and improve the comfort throughout your facilities by optimizing your lighting and HVAC systems. Other factors to consider as you evaluate this analysis are existing equipment related disruptions and maintenance costs are eliminated or minimized until the new equipment enters its end of life – typically several years.

In the attached analysis, you will find a detailed report recommending the following:

- LED lighting fixtures
- Condensing Boilers
- Unit Ventilators
- High Efficiency Transformers
- Comfort Controls
- Variable Frequency Drives (VFDs)/Motors
- Infrared Heaters
- Plug Load Controls
- Energy Managements System
- Building Weatherization
- Electronically Commutated Magnetic Pumps,
- Demand Controls Ventilation
- Destratification Fans
- RTU Controls
- Kitchen Hood Control System
- Pipe Insulation

Energy Source will secure incentives from the utility company which will substantially reduce the net cost of this project. The utility incentives reflected in this proposal are estimated and are subject to change until projects are reviewed by the utility company.

I hope you find this proposal informative. If you have any questions, please do not hesitate to contact me.

Sincerely,

Dalton Ling

Energy Source

Disclaimer

This report is not for general use and is the property of Energy Source.

All savings estimates and rebates must be considered estimated until reviewed and approved by the utility companies designated within this report.

For any questions regarding this report, please contact Dalton Ling, Energy Efficiency Consultant for Energy Source, Inc. at 401-490-7555. Any additional use of this report is prohibited unless permission is given in writing from Energy Source, Inc.

Executive Summary

Energy Source recently conducted an energy survey at the following Duxbury buildings:

- Alden School
- Chandler School
- Duxbury Library
- Duxbury Pool
- Duxbury Town Hall
- Duxbury Old Town Hall
- Duxbury Senior Center
- Performance Art Center
- Central Fire Station
- Ashdod Fire Station
- Duxbury Police Station
- Steele Athletic Building
- Evergreen Water Treatment Plant
- Wastewater Treatment Plant
- Wright Building
- Tarklin Community Center

Our recommendations are known as Energy Conservation Measures which are outlined in separate write-ups.

The expected energy savings were determined based on current operating hours of equipment surveyed. Poorly performing equipment will reduce the effectiveness of employing these ECMs, and the cost to repair or replace that equipment is not covered in this estimate.

Energy Conservation Measures	Total Project Cost	Estimated Incentives	Estimated Customer Cost	Electricity Savings		Heating Savings		O & M Savings	Total Cost Savings	Payback Period (years)
				kWh	Cost	Therms	Cost			
Install LED Lighting	$1,572,845	$360,415	$1,212,430	1,415,658	$205,270	0	$0	$55,908	$261,178	4.6
Install Condensing Boilers	$716,138	$52,000	$664,138	0	$0	10,504	$12,605	$17,800	$30,405	21.8
Install Unit Ventilators	$540,726	$22,400	$518,326	90,205	$13,080	2,482	$2,978	$25,000	$41,058	12.6
Install High Efficiency Transformers	$149,095	$35,822	$113,273	119,406	$17,314	0	$0	$0	$17,314	6.5
Install Comfort Controls	$114,400	$0	$114,400	72,558	$10,521	0	$0	$5,100	$15,621	7.3
VFDs/Motors on Distribution Pumps	$109,185	$15,550	$93,635	163,219	$23,667	1,153	$1,384	$0	$25,051	3.7
Install Infrared Heaters	$62,400	$4,500	$57,900	0	$0	1,320	$1,584	$900	$2,484	23.3
Install Plug Load Controls	$57,805	$16,050	$41,755	80,253	$11,637	0	$0	$0	$11,637	3.6
Install Energy Management System	$57,120	$6,000	$51,120	4,351	$631	468	$562	$3,500	$4,693	10.9
Building Weatherization	$42,381	$0	$42,381	6,083	$882	3,337	$4,005	$0	$4,887	8.7
Install Electronically Commutated Pumps	$41,941	$7,600	$34,341	26,821	$3,889	0	$0	$0	$3,889	8.8
Install Demand Control Ventilation	$59,800	$12,000	$47,800	32,340	$4,689	3,888	$4,666	$0	$9,355	5.1
Install Destratification Fans	$26,400	$2,976	$23,424	0	$0	2,480	$2,976	$0	$2,976	7.9
Install Rooftop Unit Controls	$21,324	$4,857	$16,467	18,779	$2,723	144	$173	$0	$2,896	5.7
Install Kitchen Hood Controls	$19,240	$2,000	$17,240	3,630	$526	2,298	$2,757	$0	$3,283	5.3
Pipe Insulation	$1,764	$0	$1,764	0	$0	80	$96	$0	$96	18.4
Total	**$3,592,564**	**$542,170**	**$3,050,394**	**2,033,303**	**$294,829**	**28,154**	**$33,785**	**$108,208**	**$436,822**	**7**

ECM #1- Install LED Lighting and Controls

Existing Conditions

This measure involves the installation of LED fixtures and integrated smart controls where applicable. Currently, twelve town/school buildings have 28 Watt or 32 Watt T-8 flourescent and compact flourescent fixtures.

Energy Conservation Measure Details

It is recommended that high efficiency LED light fixtures are installed to replace the flourescent fixtures. This measure will reduce the energy consumption based on the decrease in lighting power output and the use of adaptive control technology. The scope of this work includes the following:

- Supply and installing new LED lighting fixtures
- Remove and recycle existing fluorescent fixtures
- Warranty on new LED lighting fixtures of seven years

By implementing this measure, the following Annual Energy Savings can be obtained:

Building	Number of Fixtures	Electricity Savings		O & M Cost Savings	Total Cost Savings	Total Project Cost	Estimated Utility Incentives	Customer Cost	Payback Period (years)
		kWh	Cost						
Alden School	1,385	258,186	$37,437	$12,465	$49,902	$371,442	$64,547	$306,895	6.1
Chandler School	1,648	417,036	$60,470	$14,832	$75,302	$505,286	$104,259	$401,027	5.3
Duxbury Library	912	282,797	$41,006	$8,208	$49,214	$180,873	$70,699	$110,174	2.2
Percy Walker Pool	147	82,200	$11,919	$1,323	$13,242	$62,648	$20,550	$42,098	3.2
Duxbury Town Hall	331	41,247	$5,981	$2,979	$8,960	$63,463	$10,312	$53,151	5.9
Duxbury Old Town Hall	43	4,155	$602	$387	$989	$7,695	$1,039	$6,656	6.7
Duxbury Senior Center	499	73,719	$10,689	$4,491	$15,180	$81,233	$18,430	$62,803	4.1
Performance Art Center	371	65,028	$9,429	$3,339	$12,768	$78,930	$16,257	$62,673	4.9
Central Fire Station	191	51,898	$7,525	$1,719	$9,244	$46,064	$12,975	$33,089	3.6
Ashdod Fire Station	64	30,500	$4,423	$576	$4,999	$18,754	$7,625	$11,129	2.2
Duxbury Police Station	149	31,253	$4,532	$1,341	$5,873	$40,456	$7,813	$32,643	5.6
Steele Athletic Building	157	23,994	$3,479	$1,413	$4,892	$31,179	$8,395	$22,784	4.7
Evergreen Water Treatment Plant	49	15,872	$2,301	$450	$2,751	$22,872	$7,640	$15,232	5.5
Waste Water Treatment Plant	50	4,315	$626	$0	$626	$7,696	$1,510	$6,186	9.9
Wright Building	265	33,458	$4,851	$2,385	$7,236	$54,254	$8,364	$45,890	6.3
Total	**6,261**	**1,415,658**	**$205,270**	**$55,908**	**$261,178**	**$1,572,845**	**$360,415**	**$1,212,430**	**4.6**

Annual energy savings of 1,415,658 kWh can be realized from this measure which will lead to an annual total cost savings of $205,270. There is also an Operation and Maintenance Cost Savings of $55,908 resulting a total cost savings of $261,178.

Implementation

The implementation of this measure requires the purchase and installation LED fixtures to replace the flourescent fixtures. The total implementation cost is displayed on the table below:

Building	Total Project Cost	Estimated Utility Incentives	Customer Cost	Payback Period (years)
Alden School	$371,442	$64,547	$306,895	6.1
Chandler School	$505,286	$104,259	$401,027	5.3
Duxbury Library	$180,873	$70,699	$110,174	2.2
Percy Walker Pool	$62,648	$20,550	$42,098	3.2
Duxbury Town Hall	$63,463	$10,312	$53,151	5.9
Duxbury Old Town Hall	$7,695	$1,039	$6,656	6.7
Duxbury Senior Center	$81,233	$18,430	$62,803	4.1
Performance Art Center	$78,930	$16,257	$62,673	4.9
Central Fire Station	$46,064	$12,975	$33,089	3.6
Ashdod Fire Station	$18,754	$7,625	$11,129	2.2
Duxbury Police Station	$40,456	$7,813	$32,643	5.6
Steele Athletic Building	$31,179	$8,395	$22,784	4.7
Evergreen Water Treatment Plant	$22,872	$7,640	$15,232	5.5
Waste Water Treatment Plant	$7,696	$1,510	$6,186	9.9
Wright Building	$54,254	$8,364	$45,890	6.3
Total	**$1,572,845**	**$360,415**	**$1,212,430**	**4.6**

It was estimated approximately $360,415 can be obtained from the utility program; therefore, the adjusted customer cost is $1,212,430. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$1{,}212{,}430}{\$261{,}178} = 4.6\ years$$

ECM #2- Install Condensing Boilers

Existing Conditions

This measure involves the installation of new condensing boilers. Currently, the hot water at the buildings is being supplied from non-condensing boilers and delivered to baseboards, unit ventilators, and Air Handler Units (AHUs).

Energy Conservation Measure Details

It is recommended new condensing boilers are installed at five buildings in Duxbury. Condensing boilers (average efficiency 92%) can obtain a much higher efficiency than the standard non-condensing boiler (average efficiency 80%). The scope of this work includes the following:

- Supply and install Lochinvar condensing boilers
- Removal and disposal of existing boilers and all necessary piping and components of the old system no longer required
- Installation of direct venting system for combustion air and exhaust air
- Install outside air controls for maximum efficiency
- Commissioning and startup of new boiler systems

The annual energy cost savings summary and the proposed conditions are shown below,

Building	Heat Savings		Total O & M Savings	Total Cost Savings
	Therms	Cost		
Chandler School	3,428	$4,114	$5,000	$9,114
Duxbury Library	2,145	$2,574	$3,750	$6,324
Percy Walker Pool	2,672	$3,206	$4,000	$7,206
Duxbury Town Hall	1,560	$1,872	$2,550	$4,422
Wright Building	699	$839	$2,500	$3,339
Total	**10,504**	**$12,605**	**$17,800**	**$30,405**

Implementation

The implementation of this measure requires the purchase and installation of condensing boilers. The total material and installation cost breakdown along with incentives are shown on the table below,

Building	Make	Model #	Quantity	Total Project Cost	Estimated Utility Incentives	Customer Cost	Payback Period (years)
Chandler School	Lochinvar	FTX850	4	$177,005	$16,000	$161,005	17.7
Duxbury Library	Lochinvar	FTX500	3	$146,029	$12,000	$134,029	21.2
Percy Walker Pool	Lochinvar	FTX850	2	$141,604	$8,000	$133,604	18.5
Duxbury Town Hall	Lochinvar	FTX725	2	$148,800	$8,000	$140,800	31.8
Wright Building	Lochinvar	FTX500	2	$102,700	$8,000	$94,700	28.4
Total			**13**	**$716,138**	**$52,000**	**$664,138**	**21.8**

Approximately $52,000 can be obtained from utility rebates; therefore, the adjusted Customer Cost is $664,138. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$664{,}138}{\$30{,}405} = 21.8\ years$$

ECM #3- Install Unit Ventilators at the Chandler School

Existing Conditions

This measure involves the installation of fourty-four Direct Digital Controlled (DDC) unit ventilators at Chandler School. Currently, the Chandler School has fourty-four pneumatic controlled unit ventilators that are equipped with hot water coils and Permanent Split Capacitor (PSC) fans. Many of the pneumatic dampers and controls have failed leading to many maintenance issues and resulting to a excess amount of energy being wasted. The specifications of the unit ventilators are shown below:

Type of Unit	Fan Flow (cfm)	# of Units	Fans #/ Unit
Horizontal	750	4	2
Horizontal	1,250	11	4
Horizontal	2,000	7	5
Vertical	1,250	22	4
Total		**44**	

Energy Conservation Measure Details

It is recommended that fourty-four Magic Aire unit ventilators equipped with Electronically Commutated Magenetic (ECM) motors are installed to replace the fourty-four pneumatic controls unit ventilators equpped with PSC motors at Chandler Schools. ECM motors have a better motor efficiency (78%) compared to PSC motors (30%) resulting in reduction in electrical consumption. Energy savings will also occur from the new furnished controls to tighten and refine building temperature conditions. In conjunction with the local controllers and their energy savings features, it will also allow for remote control, monitoring and alarming of the mechanical equipment. The full scope of work is shown below:

Unit Ventilators

- Disconnect and remove existing unit ventilator chassis
- Furnish and install (44) Magic Aire Unit Ventilators as follows:
    - (11) 1250 cfm Horizontal Unit Ventilator supplied OA damper, EC motors and DDC ready unit
    - (4) 750 cfm Horizontal Unit Ventilator supplied OA damper, EC motors and DDC ready unit
    - (7) 2000 cfm Horizontal Unit Ventilator supplied OA damper, EC motors and DDC ready unit

    - (20) 1250 cfm Vertical Unit Ventilator supplied OA damper, EC motors & DDC ready unit
    - (2) 3 ton vertical self-contained unit ventilators supplied with EC motors & OA damper (for areas 420 and 207)
- Connect hot water piping to the supply and return connections of the unit ventilators

Energy Management System

- Furnish, install and wire controls for (44) classroom unit ventilators.
- Furnish and install control valves
- Remove and discard the existing Global Control Module
- Furnish, install and wire one SmartStruxure Automation Server complete with new power supplies and new enclosures
- Program one Automation Servers with existing sequence of operation from the GCMs
- Furnish and install new Desktop with Microsoft 7 Software
- Furnish and install new Enterprise Server Software
- Load and set-up software onto new Server
- Furnish new graphic screens to replace all existing Screen
- All new graphics will be as per building standards
- Recreate existing database points
- Furnish programming and mapping of customer over-ride points for each screen (one for one)
- Field commissioning, graphical interface and checkout.
- Field Training and O&M Manuals and documentation.
- Classroom training
- Integrate into existing building Energy Management System

Annual energy savings of 90,205 kWh and 2,482 Therms can be realized from this measure which will lead to an annual total cost savings of $14,961. There is also Operation and Maintenance Cost Savings of $25,000 resulting a total cost savings of $41,058.

Implementation

The implementation of this measure requires the purchase and installation of forty-four Magic Aire Unit Ventilators equipped with Electronically Commutated Motors and Direct Digital Controls. The cost of this measure is approximately $540,726 and it was estimated approximately $22,400 can be obtained from the utility program; therefore, the adjusted customer cost is $518,326. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$518{,}326}{\$41{,}058} = 12.6\ years$$

ECM #4- Install High Efficiency Transformers

Existing Condition

Six Duxbury buildings use low voltage transformers to step voltage up or down. Transformer process is not 100% efficient; therefore, there are two different types of losses associated with the process; core losses and winding losses. Transformer efficiency has improved over time and transformers are have a higher efficiency.

Energy Conservation Measure Details

It is recommended that eighteen standard efficiency transformers at six Duxbury buildings are replaced with Rex High Efficiency Transformers. By implementing this measure, the overall energy consumption of the transformers will decrease which will lead to annual energy cost savings. The scope of work includes the following:

- Furnish and install twenty-one Rex High Efficiency Transformers
- Removal of existing Transformers

By implementing this measure, the following Annual Energy Savings can be obtained:

Building	Quantity	Capacity (kVA)	Electricity Savings	
			kWh	Cost
Alden School	12	698	51,726	$7,500
Chandler School	5	335	46,809	$6,787
Duxbury Old Town Hall	1	30	6,282	$911
Evergreen Treatment Plant	1	30	6,282	$911
Wastewater Treatment Plant	1	30	4,892	$709
Damon Well Treatment Plant	1	20	3,415	$495
Total	**21**	**1,143**	**119,406**	**$17,314**

Annual energy savings of 119,406 kWh can be realized from this measure; therefore, total cost savings of $17,314 can be obtained.

Implementation

The implementation of this measure requires the purchase and the installation of twent-one Rex Transformers. The total material and installation cost of the transformers for this measure is approximately $149,905. Utility incentives of $35,822 are estimated to be obtained

as well; therefore, the adjusted customer cost is $113,273. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$113{,}273}{\$17{,}314} = 6.5\ years$$

ECM#5- Install Comfort Controls at Senior Center

Existing Conditions

This measure requires the installation of EMME comfort controls at the Senior Center office space. Currently, eight Air Handler Units (AHUs) (and only eight thermostats) are used to heat/cool the senior center. There are approximately 34 zones; therefore, having this many zones leads to a temperature imbalance issue.

Energy Conservation Measure Details

It is recommended that the EMME comfort controls are installed in order to provide a zone in every office room. Majority of the savings are related to maintenance and operating savings, but savings can be obtained from "Twinning" the Air Handler Units together. Therefore, when the temperature permits (when minimal amount of cooling/heating is needed), the Air Handler Units are sequenced optimally to make sure all of the AHUs do not need to be on. Each zone will get its own thermostat allowing for a tighter HVAC control. The full scope of work is shown below:

- Provide and install four EMME controllers
- Remove existing thermostat and standalone AHU controls
- Thirty-Four EMME thermostats will be installed in each zone
- All new graphics will be as per building standards
- Furnish programming and mapping of customer over-ride points for each screen
- Selectable alerts
    - Temperatures outside of desired ranges
    - Changes to temperature settings
    - Filter Change reminder
    - Battery low in a specific wireless temperature sensor
- Field commissioning, graphical interface and checkout.
- Field Training and O&M Manuals and documentation.
- Classroom training
- Provide all necessary controls, programming and graphics to provide a fully functional control system.

Annual Energy Savings of 72,558 kWh and Annual Cost Savings of $10,521 can be obtained. There are also Operation and Maintenance Cost Savings of $5,100 resulting a total cost savings of $15,621.

Implementation

The implementation of this measure requires the purchase and the installation of the necessary sensors, controllers. Programming and training is also included in this scope of work. The total material and installation cost of the control system for this measure is approximately $114,400. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$114{,}400}{\$15{,}621} = 7.3\ years$$

ECM #6- Install VFDs/Motors

Existing Conditions

This measure involves the installation of nine Variable Frequency Drives at four Duxbury buildings. The hot water is being supplied from boilers to provide hot water to supply fans throughout the Duxbury Library and the Performance Arts Center. At the Duxbury Library, a chiller is being used to provide chilled water to their supply fans. These buildings use a differential pressure sensor to control the water flow to allow sufficient amount of water to be supplied throughout the entire building. When adequate flow is met, the remaining water runs through a bypass loop which recirculates the water; therefore, the circulating pumps operate at a constant speed regardless of the load conditions needed for each hot/chilled water coil. For the Steele Athletic Building, the ERV fans turn on/off based on occupancy.

Energy Conservation Measure Details

It is recommended Variable Frequency Drives (VFDs) and high efficiency motors (if applicable) are installed on each pump/fan and controlled via differential pressure, temperature, or CO_2 allowing for electrical savings. The specifications for each pump/fan system is shown below:

Building	VFD Application	Quantity	Size (hp)	Controlling Parameter	Install New Motor?	Install New Pump/Fan?
Duxbury Library	Hot Water Pumps	2	2	Diff. Pressure	Yes	Yes
	Chilled Water Pumps	2	7.5	Diff. Pressure	Yes	Yes
Duxbury Pool	Pool Pump	1	10	Manual	Yes	No
Performance Arts Center	Hot Water Pumps	2	1	Diff. Temp.	No	No
Steele Athletic Building	Supply Air Fan	1	20	CO_2	No	No
	Exhaust Fan	1	15	CO_2	No	No
Total		**9**				

The scope of this work includes the following:

- Supply and install nine Variable Frequency Drives (VFDs) in place of the existing motor starters
- Remove and replace five existing motors with new NEMA premium motors
- Remove and replace four existing pump with newer pumps (applicable for the Duxbury Library building)

- Start-up and testing of the new VFDs, motors, and pumps
- Integrate into Energy Management System
- Warranty for one year

The table below shows the annual energy cost savings for each building:

Building	VFD Application	Quantity	Size (hp)	Controlling Parameter	Electricity Savings		Gas Savings		Total Cost Savings
					kWh	Cost	Therms	Cost	
Duxbury Library	Hot Water Pumps	2	2	Diff. Pressure	9,434	$1,368	0	$0	$1,368
	Chilled Water Pumps	2	7.5	Diff. Pressure	10,806	$1,567	0	$0	$1,567
Percy Walker Pool	Pool Pump	1	10	Manual	52,290	$7,582	0	$0	$7,582
Performance Arts Center	Hot Water Pumps	2	1	Diff. Temp.	4,761	$690	0	$0	$690
Steele Athletic Building	Supply Air Fan	1	20	CO_2	49,079	$7,116	1,153	$1,384	$8,500
	Exhaust Fan	1	15	CO_2	36,849	$5,343	0	$0	$5,343
Total		**9**			**163,219**	**$23,667**	**1,153**	**$1,384**	**$25,050**

Annual energy savings of 163,219 kWh and 1,153 Therms can be realized from this measure; therefore, total annual cost savings of $25,050 can be obtained.

Implementation

The implementation of this measure requires the purchase and installation of nine VFDs and motors controlled by differential pressures or temperature. The implementation also requires a controller, pressure/temperature/CO_2 sensors and electrical wiring. The total material and installation cost of the drives and control system for this measure is $109,185. Approximately $15,550 can be obtained from rebates by the utility company; therefore the adjusted customer cost is $93,635. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$93{,}635}{\$25{,}050} = 3.7\ years$$

ECM #7- Install Infrared Heaters in Police Station Garages

Existing Conditions

This measure involves the installation of six gas fired infrared heaters in the police station garages. Currently, the facility has six forced air heaters that are used for space heating.

Energy Conservation Measure Details

It is recommended six forced air heaters are replaced with six infrared heaters. The radiant system transfers energy to objects, similar to the sun, depending on the material; therefore, less energy is needed than using the current forced air system which has heat losses that are taken into account. The savings from this measure will come from using less fuel to generate the same heat loss.

By implementing this measure, approximately 1,320 Therms can be realized, resulting in an annual energy cost savings of $1,584. Operations and Maintenance Savings of $900 can also be obtained. Therefore, total cost savings of $2,484 can be obtained.

Implementation

The implementation of this measure requires the purchase and installation of six infrared heaters. The project cost is $62,400 for this measure. Approximately $4,500 can be obtained from utility rebates; therefore, the adjusted Customer Cost is $57,900. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$57{,}900}{\$2{,}484} = 23.3\ years$$

ECM #8- Install Plug Load Controls

Existing Conditions

This measure involves the installation of plug load controls at fourteen Duxbury Buildings. Currently, many of the buildings has plug load equipment that stays on and idles during unoccupied hours.

Energy Conservation Measure Details

It is recommended that plug load controls are installed to turn off idling equipment during unoccupied hours. Equipment such as projectors, printers, computers, TV's and vending misers will remain on and consume energy even when not in use. Therefore, savings will be obtained from turning off completely the receptacle power during unoccupied hours. The estimated plug load controllers needed for each building is shown below,

Location	Estimated Plug Load Controls	Annual Energy Savings	
		kWh	Cost
Duxbury High School/ Middle School	85	14,192	$2,058
Alden School	48	8,918	$1,293
Chandler School	57	8,230	$1,193
Duxbury Library	21	4,474	$649
Percy Walker Pool	15	3,432	$498
Duxbury Town Hall	26	7,481	$1,085
Duxbury Old Town Hall	7	1,223	$177
Duxbury Senior Center	10	1,575	$228
Performance Art Center	21	4,826	$700
Central Fire Station	18	4,428	$642
Ashdod Fire Station	12	3,715	$539
Duxbury Police Station	24	10,232	$1,484
Wright Building	18	4,576	$664
Tarklin Community Center	8	2,951	$428
Total	**370**	**80,253**	**$11,637**

By implementing this measure, approximately 80,253 kWh can be realized, resulting in an annual energy cost savings of $11,637.

Implementation

The implementation of this measure requires the purchase and installation of six infrared heaters. The project cost is $57,805 for this measure. Approximately $16,050 can be obtained from utility rebates; therefore, the adjusted Customer Cost is $41,755. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$41{,}755}{\$11{,}637} = 3.6\ years$$

ECM#9- Install Energy Management System at the Alden School

Existing Conditions

This measure includes installing an Energy Management Systems at the Alden School main office to refine and tighten the buildings temperature controls. Currently, the main office area uses manual thermostats and it remain on even during unoccupied hours.

Energy Conservation Measure Details

It is recommended that the Alden School main offices is integrated into the Energy Management System. Energy Savings will also occur from the new furnished controls to tighten and refine building temperature conditions. In conjunction with the local controllers and their energy savings features, it will also allow for remote control, monitoring and alarming of the mechanical equipment. The full scope of work is shown below:

- Provide and install seven new controllers for seven existing fan coil units (FCUs).
- Remove and discard the existing Global Control Module
- Furnish, install and wire one SmartStruxure Automation Server complete with new power supplies and new enclosures
- Program one Automation Servers with existing sequence of operation from the GCMs
- Furnish and install new Desktop with Microsoft 7 Software
- Furnish and install new Enterprise Server Software
- Load and set-up software onto new Server
- Furnish new graphic screens to replace all existing Screen
- All new graphics will be as per building standards
- Recreate existing database points
- Furnish programming and mapping of customer over-ride points for each screen (one for one)
- Field commissioning, graphical interface and checkout.
- Field Training and O&M Manuals and documentation.
- Classroom training
- Provide all necessary controls, programming and graphics to provide a fully functional control system.

The savings from this measure will result in the following control strategies:

Fan Coil Units

- Temperature Setback which will reduce the facility temperature during unoccupied hour

There are also Operation and Maintenance Cost Savings of $3,500 resulting a total cost savings of $4,693.

Implementation

The implementation of this measure requires the purchase and the installation of the necessary sensors, actuators, valves, and controllers. Programming and training is also included in this scope of work. The total material and installation cost of the control system for this measure is approximately $57,120. It is estimated $6,000 can be obtained in incentives; therefore, the customer cost for this measure is $51,120. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$51{,}120}{\$4{,}693} = 10.9\ years$$

ECM #10- Building Weatherization

Existing Condition

This measure involves weatherizing each municipal building. Below is a description of each weatherization measure that is being proposed,

- **Roof-Wall Intersection Air Sealing** – the roof-wall intersection is regularly an area that allows unwanted air leakage through the building shell. Exterior flashing and finish details at this area are not constructed to stop air leakage (exterior flashings are for water control, not air control); unsealed exterior flashing details combine with interior gaps in the framing between the roof and wall assembly to allow infiltration/ exfiltration.
- **Overhang Air Sealing** – overhangs are roofs, floor systems or areas above entryways that extend beyond the plane of the exterior wall system. These areas of construction are often misunderstood by builders and the cavity that extends beyond the plane of the exterior wall system is often incorrectly "connected" to the interior heated spaces of the building. Overhangs that are not properly sealed at the plane of the surface that should separate the conditioned space from the outdoors lead to excessive air leakage and heat loss at these vulnerable areas in the building envelope.
- **Buck Frame Sealing –** doors and windows are installed in rough openings in the shell of the building. Installers often do not properly seal the perimeter of the assembly into the rough opening after shimming it in place; this is especially true above drop ceilings in Chandler Elementary School where no finish trim is installed. The gap at the buck frame allows air infiltration/exfiltration to flow around the door or window by flowing through the gap between the door or window and the wall.
- **Attic Air Barrier Retrofit –** there are gaps in the air barrier between the conditioned space and the vented attic area. Oversized gaps are allowing unwanted air leakage past the ceiling surface and out of the conditioned space of the building.
- **Double Hung Window Weatherization –** window systems in the Town Hall Old are prone to air leakage due to the gaps at the sashes allowing infiltration/exfiltration to conditioned space of the building.
- **Door Weather Stripping –** deteriorated weather stripping materials, ineffective weather stripping installation and daylight showing at the perimeter of door systems create direct pathways for unwanted infiltration/exfiltration.

Roof-Wall Intersection Air Sealing – the exterior flashing and finishes at the roof-wall intersection are not constructed to stop air leakage (Alden ES).

Roof-Wall Intersection Air Sealing – gaps between the roof deck and the wall framing are pathways for unwanted infiltration/ exfiltration (Alden ES).

Buck Frame Sealing – the rough opening gap at the window between the wall and the window frame was not sealed above the drop ceiling; this gap is allowing air leakage around the window system (Chandler ES).

Attic Air Barrier Retrofit – there are gaps in the existing air barrier in place separating the unconditioned attic space from the conditioned office spaces. This allows for unwanted air leakage (Town Hall New).

Double Hung Window Weatherization – the upper and lower sash of the window is partially painted shut; the gaps and cracks in the paint at the joints of the window and the casing are pathways for unwanted air leakage (Town Hall Old).

Door Weather Stripping – the existing weather stripping is damaged and is no longer stopping air infiltration/ exfiltration at the perimeter of the door system (Alden ES).

Energy Conservation Measure Details

By implementing this measure, the reduction is heat loss/heat gain will occur which will lead to energy savings. The scope of work includes the following:

- Roof-Wall Intersection Air Sealing
- Overhang Air Sealing
- Buck Frame Sealing
- Attic Air Barrier Retrofit
- Double Hung Window Weatherization
- Door Weather Stripping

An overall work summary is shown below,

Weatherization Measure	Alden School	Chandler School	Percy Walker Pool	Duxbury Library	Duxbury Town Hall	Duxbury Old Town Hall	Duxbury Senior Center	Wastewater Treatment Plant	Total Quantity	
Roof-Wall Intersection Air Sealing	660	100							760	LF
Roof-Wall Intersection Air Sealing		59							59	LF
Overhang Air Sealing					212				212	SF
Buck Frame Sealing		123							123	SF
Attic Air Barrier Retrofit						308			308	SF
Double Hung Window Weatherization							8		8	Units
Single Door Weather Stripping	14	21	1	4		1	2	1	44	Units
Double Door Weather Stripping	1	10	1			1		1	14	Units

Building	Electricity Savings		Heating Savings		Total Cost Savings
	kWh	Cost	Therms	Cost	
Alden School	2,425	$352	1,326	$1,591	$1,943
Chandler School	1,818	$264	994	$1,192	$1,456
Percy Walker Pool	130	$19	68	$82	$100
Duxbury Library	148	$21	80	$96	$118
Duxbury Town Hall	532	$77	290	$348	$426
Duxbury Old Town Hall	305	$44	167	$200	$244
Duxbury Senior Center	576	$84	316	$379	$462
Wastewater Treatment Plant	150	$22	96	$116	$138
Total	**6,083**	**$882**	**3,337**	**$4,005**	**$4,887**

By implementing this measure approximately 6,083 kWh and 3,337 Therms can be realized; therefore, a total annual cost savings of $4,887 was estimated.

Implementation

The total material and installation cost for weatherizing each town building is shown below,

Building	Project Cost	Payback Period (years)
Alden School	$14,884	7.7
Chandler School	$13,911	9.6
Percy Walker Pool	$824	8.2
Duxbury Library	$813	6.9
Duxbury Town Hall	$4,957	11.6
Duxbury Old Town Hall	$1,452	5.9
Duxbury Senior Center	$4,272	9.2
Wastewater Treatment Plant	$1,268	9.2
Total	**$42,381**	**8.7**

The estimated customer cost is $42,381. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$42{,}381}{\$4{,}887} = 8.7\ years$$

ECM #11- Install Electronically Commutated Pumps

Existing Conditions

This measure involves the installation of seven Electronically Commutated Circulator Pumps at the three Duxbury buildings. Currently, the hot water is being supplied from a boiler and delivered to the hot radiators, and Air Handler Units (AHUs). The systems are constant volume which signifies that the system continuously runs to satisfy the building load. The specifications for each pump system is shown below:

Building	Quantity	Size (hp)
Duxbury Town Hall	3	1.5
Wright Building	2	2
Percy Walker Pool	1	1.5
	1	0.33

Energy Conservation Measure Details

It is recommended seven Electronically Commutated Circulator Pumps and control valves are installed in the crawl space to allow the pumps to modulate its speed based on differential pressure. The scope of this work includes the following:

- Supply and install seven Electronically Commutated Circulator Pumps in place of the existing pumps
- Start-up and testing of the new pumps

Annual energy savings of 26,821 kWh and annual cost savings of $3,889 can be realized.

Implementation

The implementation of this measure requires the purchase and installation of seven EC pumps controlled by differential pressure/temperature. The implementation also requires a controller, pressure/temperature sensors and electrical wiring. The total material and installation cost of the drives and control system for this measure is approximately $41,941. Approximately $7,600 can be

obtained from rebates by the utility company; therefore, estimated customer cost is $34,341. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$34{,}341}{\$3{,}889} = 8.8\ years$$

ECM #13- Install Demand Control Ventilation

Existing Conditions

This measure includes the installation of Demand Control Ventilation at two Duxbury school to refine and tighten the buildings temperature controls. Each of the schools have several Air Handler Units and Make-up Air Units that deliver fresh air into the larger common spaces. Currently, these areas use a standard thermostat to regulate room temperature and the outside air damper is fixed at a certain position. The unit fans will run on full load when the space is occupied. The specifications for the common area heating/cooling capacities is shown below:

Building	Common Space Name	Heating Capacity Output (MBH)	Cooling Capacity Output (MBH)
Alden Schools	Gym	1,000	-
	Auditorium	1,500	1,209
	Cafeteria	632	403
Chandler Schools	Gym	750	-
Total		**3,882**	**1,612**

Energy Conservation Measure Details

It is recommended that the current Energy Management System at these current schools are expanded or an Energy Management System is installed to include Demand Control Ventilation. This will also include furnishing and installing duct CO^2 sensors for any Air Handler Units and Make-Up Air Units. The scope of work includes the following:

- Each HVAC equipment will include a field controller (if applicable)
- Furnish and Install a CO^2 Sensor for each Air Handling Units and Make-Up Air Units

Building	Common Space Name	Total Project Cost	Rebate Cost	Customer Cost	Electricity Savings		Heating Savings		Total Cost Savings	Payback Period (years)
					kWh	Cost	Therms	Cost		
Alden Schools	Gym Auditorium Cafeteria	$37,700	$6,000	$31,700	32,340	$4,689	2,819	$3,383	$8,072	3.9
Chandler Schools	Gym	$22,100	$6,000	$16,100	0	$0	1,069	$1,283	$1,283	12.6
Total		**$59,800**	**$12,000**	**$47,800**	**32,340**	**$4,689**	**3,888**	**$4,666**	**$9,355**	**5.1**

Annual energy savings of 32,340 kWh and 3,888 Therms can be realized from this measure; therefore, total cost savings of $9,355 are estimated.

Implementation

The implementation of this measure requires the purchase and the installation of the necessary sensors, and controllers. Programming and training is also included in this scope of work. The total material and installation cost of the control system for this measure is approximately $59,800. Utility incentives of $12,000 are estimated to be obtained as well; therefore, the adjusted customer cost is $47,800. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$47{,}800}{\$9{,}355} = 5.1\ years$$

ECM #13- Install Destratification Fans in PAC Main Lobby

Existing Conditions

This measure involves the installation three Destratification fans similar to the high school fans. Currently, the lobby has a major issue with hot air rising to the roof due to its less dense air. It was assumed that there is a 20ºF difference between the floor level and the roof.

Energy Conservation Measure Details

It is recommended three Destratification fans are installed in order to help the stratification issue in the main lobby. Excess amount of natural gas is being consumed in order to satisfy the roof as opposed to the floor level. The scope of this work includes the following:

- Supply and install three Destratification fans
- Electrically wire the fans
- Start-up and testing of the new fans

For implementing this measure, Annual energy savings of 2,480 Therms and annual cost savings of $2,976 can be realized.

Implementation

The implementation of this measure requires the purchase and installation of three destratification fans. The total material and installation cost of the fans for this measure is approximately $26,400. Approximately $2,976 can be obtained from rebates by the utility company; therefore, estimated customer cost is $23,424. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$23{,}424}{\$2{,}976} = 7.9\ years$$

ECM#14- Install Rooftop Unit Controls

Existing Conditions

This measure includes installing the installation of the Catalyst Rooftop Unit (RTU) controller on two Rooftop Units at Ashdod Fire Station to refine and tighten the buildings temperature controls. Currently, the station uses standard thermostats to operate the RTUs.

Energy Conservation Measure Details

It is recommended that the Catalyst RTUs controls are installed on two RTUs (5 ton and 3 ton). Each RTU controller will also include a Variable Frequency Drive and following strategies will be implemented.

- **Opti-Run" Fan Control –** Produces average fan energy savings of approximately 70%, while operating the unit within the manufacturer's rated design parameters. The CATALYST monitors key system variables and adjusts the fan speed as needed to ensure proper equipment operation. These combined capabilities go beyond the abilities of a typical variable frequency drive (VFD) installation.
- **Integrated Economizer –** Controls the economizer to allow for the simultaneous use of mechanical cooling and "free" outside air to satisfy a space. Most economizers operate on an "either/or" basis, leaving considerable energy savings unrealized.
- **Advanced Economizer Logic –** The CATALYST is an Advanced Digital Economizer that is coupled with fan speed control to maximize the use of outside air for free cooling beyond traditional economizer control. It introduces the ability to sense and compare outside air and return air based on dry bulb temperature or dew point depending upon the climate. New patent-pending techniques proactively cool the interior commercial space before there is an actual call for cooling provides even greater savings.
- **Demand Control Ventilation** – Demand Control Ventilation (DCV) uses a self-calibrating CO_2 sensor to reduce excessive ventilation commonly found on commercial spaces. The CATALYST establishes occupancy levels and matches the amount of ventilation air delivered to the true needs of the space. This eliminates the cost required to heat and cool excess outside air. This strategy is documented in ANSI/ASHRAE Standard 62. The CATALYST goes beyond typical DCV control with an improved sequence that produces additional savings

By implementing these control strategies approximately 18,779 kWh and 144 Therms can be realized, resulting in an annual energy cost savings of $2,896.

Implementation

The implementation of this measure requires the purchase and the installation of two RTU controllers. Programming and training is also included in this scope of work. The total material and installation cost of the control system for this measure is approximately $21,324. It is estimated $4,857 can be obtained in incentives; therefore, the customer cost for this measure is $16,467. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$16{,}647}{\$2{,}896} = 5.7\ years$$

ECM #15- Install Kitchen Hood Controls

Existing Conditions

This measure involves the install of kitchen hood systems to automatically control the kitchen ventilation and exhaust at Alden schools. Currently, the kitchen exhaust and the make-up air units stay on for 3,600 annual hours.

Energy Conservation Measure Details

It is recommended a kitchen hood control system is installed on the ventilation and exhaust fans and controlled based on temperature. When the kitchen ovens and grills are turned on and the kitchen is active; the exhaust temperature will increase and this will allow the Variable Frequency Drives to turn on to satisfy exhaust conditions. When the kitchen equipment gets turned off, the VFDs will ramp down which will reduce the schools' energy consumption. The scope of this work includes the following:

- Supply and install two Variable Frequency Drives (VFDs) in place of the existing motor starters for kitchen exhaust and ventilation fans
- Install temperature sensors in the kitchen exhaust ductwork
- Start-up and testing of the new VFDs
- Warranty for one year

Annual energy savings of 3,630 kWh and 2,298 Therms can be realized from this measure; therefore, the total cost savings is $3,283.

Implementation

The implementation of this measure requires the purchase and installation of three VFDs controlled by differential temperature. The implementation also requires a controller, temperature sensors and electrical wiring. The VFDs will also need to be programmed. The total material and installation cost of the drives and control system for this measure is $19,240. Approximately $2,000 can be obtained from rebates by the utility company; therefore, the adjusted customer cost is $17,240. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$17{,}240}{\$3{,}283} = 5.3\ years$$

ECM #16- Tank and Valve Insulation

This measure involves the insulation of a tank and strainer valve at Chandler School. Below is a description of each insulation measure that is being proposed,

- **Valve & Fitting Insulation –** valves and fittings are difficult components of a mechanical system to insulate and are frequently left un-insulated. These un-insulated or poorly insulated components have the same temperature fluids passing through them as the pipes that are more likely to be insulated; un-insulated components of the distribution system lead to unnecessary distribution losses and wasted energy.
- **Tank Insulation –** tanks are difficult components of a mechanical system to insulate and are frequently left un-insulated. Un-insulated, or poorly insulated tanks or equipment have the same temperature fluids passing through them as the pipes that are more likely to be insulated; un-insulated components of the distribution system lead to unnecessary distribution losses and wasted energy.

Tank Insulation – the air separator is not insulated which is leading to unnecessary distribution losses (Chandler ES).

Valve & Fitting Insulation – the strainer is not insulated which is leading to unnecessary distribution losses (Chandler ES).

Energy Conservation Measure Details

It is recommended that the bare tank, and valve is insulated with cellular insulation. By implementing this measure, the reduction is heat loss will accrue, which will lead to energy savings. The scope of work includes the following:

- Insulation a strainer valve and an air separator to meet the insulation requirements of the fluid temperature in the pipe
- Utilize/install pipe covering/jacket to protect the insulation material as required in the work area.

By implementing this measure approximately 80 Therms can be realized and annual total cost savings of $96.

Implementation

The implementation of this measure requires the insulation of a strainer valve and an air separator. The total material and labor cost of this measure is $1,764. The simple payback is calculated as follows:

$$Payback\ Period = \frac{Customer\ Cost}{Cost\ Savings} = \frac{\$1{,}764}{\$96} = 18.4\ years$$

Installation and Warranty Information

If you decide to proceed with this proposal, Energy Source will be responsible for the following tasks:

- Develop final equipment specifications and equipment layout
- Processing and filing application for utility incentives
- Material ordering and receiving
- Dismantling and removing existing systems from premises
- Construction
- Final walk-through with you
- Development and delivery of comprehensive project completion manual.

Installation

All installation staff will agree to submit to a CORI check before proceeding with project.

The removal and disposal of asbestos and toxic materials if present are the owner's responsibility and should be determined before proceeding with the project.

Warranty

Included with your project is a one-year warranty on all labor and materials provided by Energy Source. At the end of the first-year materials remain covered by standard warranties provided by their manufacturers. Warranty periods begin when the installation is completed. The owner has a one-month period following the completion of the installation to accept or reject work performed by Energy Source, after which time we will assume that the work has been accepted.

Due to the fluctuation in commodities this proposal is valid for a period of 30 days from the date shown at the top of this proposal, after which time we will be happy to provide an adjusted quote if necessary.

VII. Appendix C: MAPC Vehicle Calculations

Table 5: Policies that Affect Fleet Gas and Diesel Usage		
Anti-Idling Policy		
All FY 2016 Gas Usage (Gallons)	66,845	
All FY 2016 Diesel Usage (Gallons)	38,803	
Percent Savings	10%	Idling vehicles contribute significantly to air pollution and waste fuel, increasing fleet management costs. Municipalities across the commonwealth and the nation have seen significant cost and greenhouse gas emission reductions since implementing Town-wide "no idling" policies for municipal vehicles.*
Gallons Gasoline Saved per Year	6,685	
Gallons Diesel Saved per Year	3,880	
	1,339	
Closely Monitor Tire Air Pressure and Use Fuel Efficient Tires		
All FY 2016 Gasoline Usage (Gallons)	66,845	
All FY 2016 Diesel Usage (Gallons)	38,803	
Percent Savings	4%	Maintaining appropriate air pressure in vehicle tires can decrease that vehicles fuel consumption by as much as 4%.*
Gallons Gasoline Saved per Year	2,674	
Gallons Diesel Saved per Year	1,552	
MMBTUs Saved per Year	**535**	
Use 100% Synthetic Oil		
All FY 2016 Gasoline Usage (Gallons)	66,845	
All FY 2016 Diesel Usage (Gallons)	38,803	
Percent Savings	2%	The use of 100% synthetic oils reduces fuel consumption, the number of annual oil change and labor costs.*
Gallons Gasoline Saved per Year	1,337	
Gallons Diesel Saved per Year	776	
MMBTUs Saved per Year	**268**	
Total MMBTUs	**2,142**	
*http://www.fueleconomy.gov/feg/pdfs/OwnerRelatedFuelEconomyImprovements.pdf		

VIII. Appendix D: MAPC Behavior-Based Energy Savings

A School Behavior-Based Energy Use Reduction Program will allow Duxbury communities to not only better understand the inefficiencies in their school building operations, but will also help them implement programs that will work synergistically with their existing investments in energy infrastructure in school buildings. Further, this program can support or expand school curriculum by using "buildings as a teaching tool" for students.

While behavior-based energy reduction strategies have been difficult to measure or evaluate in the past, this is no longer the case. The Acton-Boxborough School District has been recognized by both DOER and the U.S. Department of Education as a national leader in implementing behavior-based energy programs that result in significant and measured energy savings. Moreover, schools with established behavior-based energy programs have reduced their energy use by 20 to 37% as a direct result to the behavior-based initiatives.

More information can be found in the Powering Down report the US Green Building Council's Center for Green Schools at http://centerforgreenschools.org/sites/default/files/resource-files/Behavior-based-Efficiency.pdf.

In 2016, four MAPC communities (Hamilton, Wenham, Salem and Swampscott), hired a consultant to oversee the implementation of a behavior-based energy reduction program in one school in each school district. The programs used a faculty lead to work with students that developed programs to ensure everyday energy savings – such as lights being turned off – as well as larger weekly savings, such as powering down all applicable electronics by end of day Friday. The programs also connected students to the facilities staff. In this way, students became an extension of the facilities staff to help monitor issues and check up on set points, etc.

Hiring a consultant is not necessary, but is highly recommended for the first year of implementation. Based on MAPC's program with the four schools, MAPC would recommend budgeting about $15,000 to $20,000 for a consultant. Also, each school would want to set aside about $500 to $1000 per year to pay for materials the students may need to implement their behavioral awareness programs.

For Duxbury, MAPC assumed a conservative 5% savings per year for electricity in three schools.

Table 7: School Behavior-Based Savings Program

School	MMBTU Electricity FY 2016	Reduction from Program	MMBTU Saved Electricity (Annual)	kWh Saved Electricity (Annual)	Cost Savings Electricity (Annual)
Chandler Elementary School	2,032	5%	101.6	29,777	$4,169
Alden Elementary School	2,521	5%	126.1	36,943	$5,172
Duxbury Middle-High School	6,495	5%	324.8	95,179	$13,325
Total	**11,048**		**552**	**161,899**	**22,666**

Building Operator Certification

The Building Operator Certification suggests that based on evaluated programs, the certification will have an average savings of:

- 215,000 kWh per year
- 1,400 therms per year

This translates to 874 MMBTUs per year.

Source: http://www.theboc.info/wp-content/uploads/2017/02/BOC-Energy-Savings-FAQ-2.0-web.pdf

IX. Appendix E: MMBTU Conversion Chart – DOER

MMBTU Conversion Chart[2]

Fuel Energy Content of Common Fossil Fuels per DOE/EIA

BTU Content of Common Energy Units – (1 million BTU equals 1 MMBTU)

1 kilowatt hour of electricity = 0.003412 MMBTU

1 therm = 0.1 MMBTU

1 ccf (100 cubic foot) of natural gas = 0.1028 MMBTU (based on U.S. consumption, 2007)

1 gallon of heating oil = 0.139 MMBTU

1 gallon of propane = 0.091 MMBTU

1 cord of wood = 20 MMBTU

1 gallon of gasoline = 0.124 MMBTU (based on U.S. consumption, 2007)

1 gallon of E100 ethanol = 0.084 MMBTU

1 gallon of E85 ethanol = 0.095 MMBTU

1 gallon of diesel fuel = 0.139 MMBTU

1 gallon of B100 biodiesel = 0.129 MMBTU

1 gallon of B20 biodiesel = 0.136 MMBTU[3]

1 gallon of B10 biodiesel = 0.137 MMBTU[7]

1 gallon of B5 biodiesel = 0.138 MMBTU[7]

1 barrel of residual fuel oil = 6.287 MMBTU

[2] If a conversion factor for a fuel you use is not provided, please contact DOER.
[3] Calculated Values from those of diesel and B100 biodiesel