Town Of Truro – Public Library

Climate Leader Communities

Decarbonization Roadmap Report

7 Standish Way, Truro MA

Prepared on November 8th, 2024

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Executive Summary

Overview

Cape Light Compact has retained RISE to evaluate the energy consumption and a potential decarbonization pathway that includes standard efficiency, load reduction, and electrification measures for multiple buildings owned and operated by the Town of Truro, MA. The intent of this review is to summarize and benchmark the site's existing energy consumption with respect to the policies set forth by the Massachusetts Department of Energy Resources (DOER) and to create a Municipal Decarbonization Roadmap to meet 2030 and 2050 net-zero goals. These measures will help offset the site's reliance on fossil fuels, improve efficiency levels, and move toward the town's overall decarbonization goals. All costs, savings, and incentives[1] are representative of findings observed on site.

The efficiency measures listed within this report as energy conservation measures (ECMs) will decrease the site's energy consumption and support the decarbonization pathway. Further measures such as load reduction, renewables, and electrification, will also support the reduction of on-site fossil fuels and grid-based energy consumption. Incentives and tax credits may be available to help defer the cost of implementation. These tax credits and incentives are subject to change based on programs sponsored by the government, the utilities, or other parties involved in determining eligibility. The energy savings and project costs presented below are based on preliminary data and are subject to change pending confirmation of existing conditions and formal proposals being developed for the identified energy efficiency measures. The building management team is interested in pursuing electrification measures to reduce emissions and operating costs while maintaining or increasing occupant comfort within the space(s).

This report details potential decarbonization measures found at the Town Public Library in Truro, Massachusetts.

Summary of Findings

Year	EUI (kBtu/sf/yr)	CEI (MTCO2e/sf/yr)
2022	62.8	0.0026
Current (2023 Usage)	47.2	0.0018
2030 Target	47.1	0.0017
2030 Projected	19.9	0.0000

Table 1: EUI & CEI Summary (Target Values Based on a 25% EUI and 35% CEI Reduction from 2022 Consumption Values)

[1] Further site review may be necessary to develop final incentive approval.

Measure Type	Estimated Electric Savings (kWh)	Estimate Propane Savings (Gallons)	Savings ($)	Incentive ($)	Net Cost ($)
Lighting	1,020	-	$224	-	$1,125
ECM Pump Motors	553	-	$122	$400	$2,600
HP DHW	2,082	-	$458	$1,000	$5,000
Roof Insulation	-	321	$1,124	-	$51,051
Electrification – HVAC	(31,615)	4,742	$9,642	$51,250	$256,250
Solar	34,543	-	$7,599	$27,360	$63,840
TOTAL:	**6,583**	**5,063**	**$19,169**	**$80,010**	**$379,866**

Table 2: Measures, Savings, and Cost Summary

Cost Savings are based on the estimated cost $0.22/kWh for electricity and $3.50/Gallon for propane.

Efficiency Measures	Load Reduction Measures	Electrification Measures	Renewables

Facility Overview

General Facility Information

Building Use

The Truro Public Library building was constructed in 1998 according to tax assessor records. Based on the site assessment performed, there have been no major additions or renovations to the facility although some upgrades such as the implementation of ductless mini-split heat pumps and high efficiency condensing boilers. The core use of this building is devoted to the Truro community to be used as library and an additional senior center and community meeting place. The space is comprised of various areas which includes open areas with bookshelves, private meeting rooms, a technology space, and some administrative offices. The typical hours of use of this facility are as follows:

Wednesday, Friday, & Saturday: 10 AM – 4 PM

Tuesday & Thursday: 10 AM – 8 PM

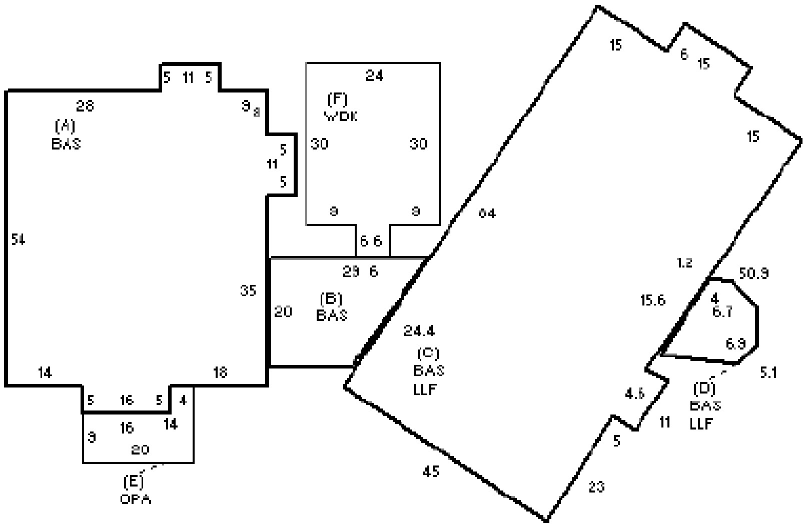
Gross Floor Area

Below is a summary of the building areas which notes the size of each floor and size of the space occupied:

Area Description	Floor Area
Full Building	11,364 Square Feet
1st Floor	7,293 Square Feet
Lower Level	4,071 Square Feet

Table 3: Floor Area & Square Footage

Building Overview



Year of Construction:	1998
Number of Stories:	2
Structure Material:	Wood Frame
Building Type:	Library
Conditioned Floor Area:	11,364 sq. ft.

General Conditions of Facility

This facility is in good condition and operates sufficiently for the type of occupancy. There have not been any significant upgrades to the structure although some upgrades have been implemented which include new LED lighting, condensing boilers, and mini-split heat pumps. There are still a few remaining fluorescents. The roof is shingled and in good condition. However, based on visual inspection and available records, it is unknown how old it is. There are no identified records showing whether the roof has been replaced since the building opened. The foundation is concrete. The flooring is a mix of carpet and tile. Based on the age of construction and documentation found on-site, the insulation is up to building code standards from the time of construction and sufficiently creates thermal barriers where intended. There are no renewables on-site. There is a buried propane tank serving the HVAC system.

System	Condition	Approximate Age	Useful Life (years)	Remaining Life (years)
HVAC – AHUs & Condensers	Fair	24	25	1
HVAC - Boilers	Okay	11	20	9
HVAC – HP Mini-Splits	Fair	Varies	18	-
DHW	Okay	14	13	0
Windows	Fair	26	20	0
Envelope	Good	26	-	-
Lighting Systems	Good	5	10	5
Renewable Energy Systems	N/A	-	-	-

Table 4: Facility and System Conditions

Site Summary

The Truro Public Library was built in 1998 and serves the Truro community. The site relies on electricity and propane to operate. However, to align with the local and state electrification goals there will be measures that will need to be implemented to net-zero carbon-based fuel emissions by the year 2050.

System	Description
Building Enclosure	The building is a wood framed building built in 1998. The wall and roof insulation are estimated to be original and meet the MA building code of that time. The roof is an open vaulted ceiling in most of the building. The windows are original double pane windows.
Electrical Infrastructure	The main distribution panel is rated for 400A. There are several sub-panels providing downstream service to HVAC equipment, lighting, and plug loads. A transfer switch located in the main electrical room provides the necessary operation to power the facility with the backup generator. Although the 400A service is sufficient for the current operation, it was noted that all breakers were in the on-position, implying that all breakers were loaded and that there is no additional space within the panels. When the site moves forward with the electrification of their HVAC systems, additional electric panels and/or service may be needed and so a further study into the capacity and loading constraints on the existing electrical infrastructure will be required.
Carbon-Based Fuel Sources	There is an underground propane tank fueling the gas-fired condensing boilers. There is a 50kW diesel backup generator on site. There is no other carbon-based fuel source used on-site.
Lighting Systems	The lighting fixtures within the space are primarily LED consisting of a mix of linear LED tubes in surface wraps, linear ambient fixtures, and troffers. There are minimal areas that have not been upgraded to LED which includes back of house areas like electrical, mechanical, and storage spaces which can be upgraded. Exterior parking lot pole lighting is all LED.
HVAC	The HVAC system at this facility is comprised of (3) AC split systems with hydronic coils that provide heat, cooling and ventilation. Two of AHUs are located in the basement and one in the mezzanine mechanical room. Additional heating is provided by a radiant floor system. The heating hydronic system that is provided by (2) 285 MBH Alpine condensing boilers and a two speed Grundfos pumps. The (2) AC split systems capacities are (1) 7.5-ton unit and (2) 5-Ton units. Supplemental heating and cooling are provided by (9) one-to-one 12 kbtu Mitsubishi heat pumps.
Domestic Hot Water	The domestic hot water load is provided by (1) 30-gallon electric water heater located in the mezzanine mechanical room. There is a smaller electric resistance instant hot water heater that was identified in the basement. Based on the age of the main water

	heater, it is recommended to upgrade to a Heat Pump Water heater upon failure.
Building Controls	There is no central BMS system, but all AHUs and hydronic zones are each controlled by Stadler standalone thermostats with night and day mode. The ductless heat pumps are controlled by basic remote control
Renewable Energy Systems	There are no existing renewable energy systems on-site. The facility has an irregular shape in which there are multiple sloped roof sections that are facing multiple different directions. There is a section, however, that may be suitable for solar.
EV-Charging	The town has plans to implement two EV-charging stations at this facility in the near future.

Table 5: Description of Systems

Energy Use Overview

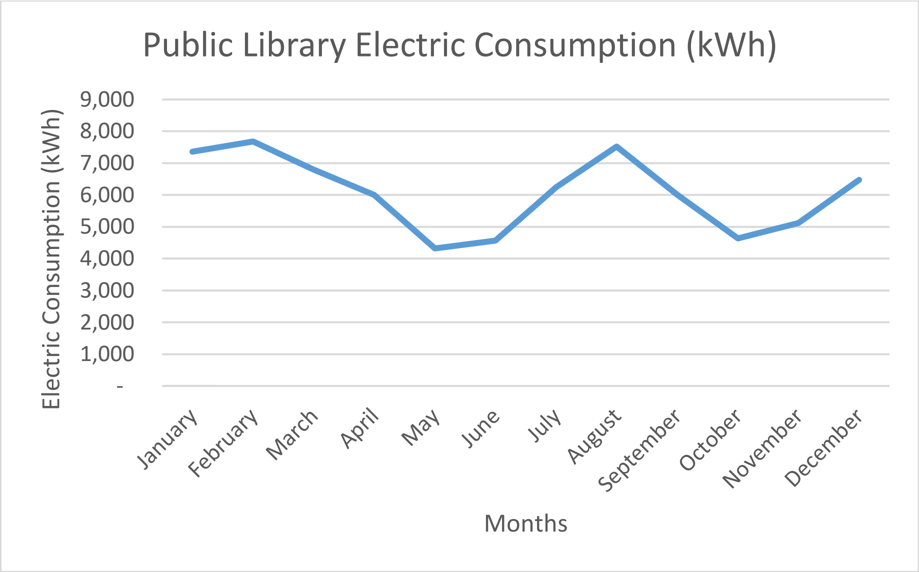
Electricity Consumption

The site has one electric account, Acct# 16462230018, that serves the entire facility. There is one electric meter (Meter# 5089846) feeding the 400A, 480/277V main distribution panel to energize the facilities sub-panels and downstream loads. Transformers are used to step-down the voltage for downstream 120/208V loads. The facility utilizes a gas-powered generator capable of providing 50kW to one transfer switch.

Normalized Electric Usage

Month	2022 Electricity Consumption (kWh)	2023 Electricity Consumption (kWh)	Normalized Electricity Consumption (kWh)
January	7,360	5,600	7,256
February	7,680	6,720	7,898
March	6,800	5,440	7,197
April	6,000	5,280	6,382
May	4,320	4,480	4,320
June	4,560	4,800	4,480
July	6,240	6,160	4,480
August	7,520	5,680	4,480
September	6,000	4,720	6,223
October	4,640	3,840	4,668
November	5,120	4,560	5,326
December	6,480	4,800	6,869
Totals:	**72,720**	**62,080**	**69,578**

Table 6: Electricity Usage (2022 Usage, 2023 Usage, & Weather Normalized to Represent an Average Year)



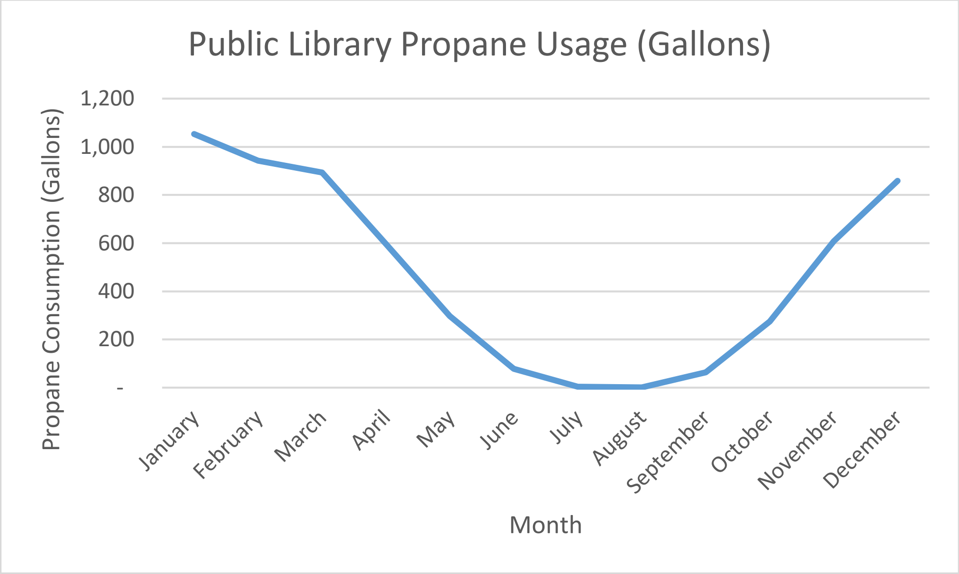
Deliverable Fuel Consumption (Propane & Diesel)

The site utilizes propane for the condensing hydronic boilers and for the kitchen equipment. The backup generator uses diesel fuel, but there is no available or reported diesel usage for this site.

Normalized Propane Usage

Month	2022 Propane Consumption (Gallons)	2023 Propane Consumption (Gallons)	Normalized Propane Consumption (Gallons)
January	1,091	562	1,053
February	884	586	942
March	768	542	893
April	483	328	596
May	268	185	298
June	72	50	78
July	4	-	4
August	1	2	1
September	60	9	64
October	238	114	274
November	468	469	608
December	725	682	859
Totals:	**5,063**	**3,530**	**5,669**

Table 7: Propane Usage (2022 Usage, 2023 Usage, & Weather Normalized to Represent an Average Year)



Energy Usage & Carbon Emissions Benchmarking

Energy Usage Intensity (EUI)

Energy Usage Intensity measures how much energy a facility uses with respect to its size. Based on the noted square footage and the available utility consumption data, the Truro Public Library had an EUI of approximately 62.8 kBtu/Sqft/yr in 2022 which is below the national median reference value of 71.6 kBtu/Sqft/yr reported for "Public Services/Library" by Energy Star Portfolio Manager Data.

https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf

Carbon Emissions Index (CEI)

Benchmarking the carbon emissions of any facility begins with identifying the quantity and types of the fuels used to operate a facility. Organizations such as local, state, and federal governments continue to implement regulatory compliance policies requiring carbon emissions of buildings to be calculated and benchmarked against ordinance defined emission limits.

For Climate Leader Communities in the state of Massachusetts, the carbon emissions index is a measure of Metric Tons (MT) of CO2e/sf/yr which accounts for the different carbon emissions values of each unit of fuel type considered. Based on the noted square footage of the facility and the quantities used of each fuel type, this facility has a CEI of 0.0026 MTCO2e/sf/yr. The only on-site fossil fuel use reported at this site is propane. Although the generator requires diesel there is no available or reported usage. The target carbon emissions reduction percentage is based on the total emissions from on-site fossil fuels.

EUI & CEI Benchmarking

The Climate Leader Communities program in Massachusetts requires the use of a greenhouse gas emission baseline in Metric Tons of CO2. This report utilizes DOER's MassEnergyInsight (MEI) data provided by Cape Light Compact. As noted in the table below, the decarbonization road map required by Climate Leaders lists that both emissions from on-site fossil fuels in buildings and the energy usage intensity must be reduced by the noted percentages in the noted years.

Suggested Emission Reduction Timeline

Targets	2027	2030	2040	2050
Reduce emissions from onsite fossil fuels in buildings	-20%	-35%	-60%	-100%
Zero emission vehicles (ZEVs) in light-duty fleet adoption	5%	20%	75%	100%
Zero emission vehicles (ZEVs) in medium-/heavy-duty fleet adoption	0%	20%	50%	100%
Energy Use Intensity reduction *(deep energy retrofits/retro commissioning)*	-20%	-25%	-25%	-30%
Total Emissions Reduction Goals (% of 2022 emissions)	**>15%**	**>35%**	**>65%**	**>95%**

https://www.mass.gov/doc/climate-leader-communities-municipal-decarbonization-roadmap/download#:~:text=The%202021%20Climate%20Law%2C%20statewide,reduction%20by%20calendar%20year%202030.

Public Library - EUI				
Year	**Electricity Usage (kWh)**	**Propane Usage (Gal)**	**EUI (kBtu/sf/yr)**	**2030 EUI Compliance**
2022	72,720	5,063	62.8	-
2023	62,080	3,530	47.2	-
2030 (Projected)	66,137	-	19.9	Compliant

Table 8: EUI Benchmarking

Public Library - CEI					
Year	**Propane CO2e (MT/yr)**	**Total CO2e (MT/yr)**	**CEI (MT/sf/yr)**	**2030 CEI Target - 35% Reduction (MT/sf/yr)**	**Compliance**
2022	29.16	29.16	0.0026	0.0017	-
2023	20.33	20.33	0.0018		-
2030 (Projected)	-	-	-		Compliant

Table 9: CEI Benchmarking (2030 Projected Emissions are Based on the Implementation of the Proposed Measures)

Decarbonization Overview

The process of decarbonizing a building involves implementing measures to reduce or eliminate carbon dioxide (CO2) emissions associated with its operation. The goal is to make buildings more energy-efficient, use cleaner energy sources, and overall contribute to a lower carbon footprint. Here are key strategies for decarbonizing a building, which include Energy Efficiency (Foundational), Load Reduction, and Electrification measures:

The start to the decarbonization process takes a whole-building approach similar to the energy efficiency process; the site is subject to an energy audit. Opportunities to upgrade the building envelope are identified and implemented. Here, envelope insulation and fenestration deficiencies are rectified to reduce heating and cooling loads. At this point, the site considers installing energy efficient equipment including but not limited to lighting, HVAC systems, appliances and any equipment specific to building use. The transition from fossil fuel-based heating systems to electric heat pumps for space heating and cooling needs to be considered at this part of the process. In concert, smart building technologies like controls based on occupancy or other parameters can be implemented to further reduce energy load.

Installing on-site renewable energy systems such as solar panels or wind turbines to generate clean, renewable electricity needs to be a part of the plan with the goals of electrification and decarbonization in mind. When the site's electric loads are reduced through energy efficiency and optimization, renewable energy systems like solar panels can be properly sized. Energy storage solutions to store excess energy generated by renewable sources, such as batteries, are part and parcel and will improve overall energy resilience.

Decarbonizing a building requires a holistic approach that considers both operational and embodied carbon, as well as the entire lifecycle of the structure. It often involves a combination of technological innovations, design considerations, and policy support to achieve meaningful reductions in carbon emissions.

Proposed Measures

Type	Measure Description	Implementation Difficulty	Cost Implication ($/$$/$$$)
Efficiency Measure 1	LED Lighting	Low	$
Efficiency 2	ECM Pump Motors	Medium	$
Efficiency 3	HP DHW	Medium	$$
Load Reduction Measure 1	Roof Insulation	Medium	$$
Electrification 1	Air-to-Water HP Hydronic Boiler Replacement	High	$$$
Electrification 2	Ducted AHU HP Units	High	$$$
Renewable Energy Generation	Solar	High	$$$

Table 10: Proposed Emissions Reduction Measures

Efficiency Measures	Load Reduction Measures	Electrification Measures	Renewables

Efficiency & Load Reduction Measures:

The noted efficiency and load reduction strategies shown in the table above provide an overview of measures that can be explored before electrification options to immediately reduce the facility's consumption. Although some measures are more difficult to implement than others, any of these measures will either reduce the consumption to operate (i.e. Lighting) or will support the HVAC system by reducing envelope losses (i.e. Insulation) and in turn, reduce the load on the HVAC system that is required to meet desired temperature setpoints.

LED Lighting:

It is recommended to convert the remaining fluorescent lighting equipment to LED. This facility has very few remaining fluorescent fixtures but converting them will provide energy savings that will reduce the energy usage index and support the facility with reaching reduction goals.

Incentives: No available incentives (at this time) as Mass Save lighting program to undergo significant changes in 2025.

ECM Pump Motors:

The existing pump motors serving the hydronic heating system and the domestic hot water system are not variable speed controlled and can be replaced with Electronically Commutated Motors (ECM) to reduce the energy required to circulate hot water. Using ECMs will reduce the speed of the motor based on the demand for hot water to terminal units and in turn reduce the electricity consumed to do so.

Incentives: Mass Save prescriptive incentives based on type and motor horsepower.

Heat Pump Domestic Hot Water Heater:

The existing domestic hot water heater is an electric resistance unit that can be replaced with a Heat Pump water heater to improve DHW efficiency. Heat pump water heaters move heat rather than creating it and can provide efficiencies roughly three times higher than that of standard electric resistance units throughout the facility.

Incentives: Mass Save prescriptive incentives based on size of the unit (HP Water Heaters under 80 gallons may qualify for an incentive of $1,000/unit).

Roof Insulation:

Based on the history of the facility, the roof is reaching the end of its useful life. In conjunction with the need for a new roof, this site will also need to reduce its overall heat load by reducing thermal envelope losses for decarbonization benchmarking requirements. Additionally, for this site to reach its CEI and EUI goals, implementing solar will be a supportive component moving forward. To do so, however, a new roof will need to be installed. When assessing the needs for this site to reach energy and carbon emissions reduction targets, it is recommended to provide additional insulation in the roof at the same time as the roof replacement. Even if solar is not implemented, the roof will need to be replaced, and additional insulation should be added to reach an approximate resistance value of R-49.

Incentives: Mass Save custom incentives are available for roof and attic insulation and are determined by the program administrators upon review.

Electrification Measures:

Replacing the gas-fired equipment via electrification with Heat Pump technology will reduce the carbon footprint of the facility. Although there may be challenges with implementation due to the nature of retrofitting new equipment to an existing system, the electrification pathway coupled with the previously noted load reduction strategies will not only support the movement away from fossil fuel, but it will also support decarbonization.

There are a variety of opportunities at this facility to electrify the heating system as well as improve the efficiency of the cooling system. It is recommended to replace the existing condensing boilers with an Air-to-Water heat pump system serving the radiant floor heating and the (3) AHUs so that they utilize heat pump technology. The (3) condenser units outside provide the cooling capabilities to these AHUs and can be converted to Heat Pump condenser units.

We recommend approaching HVAC electrification in two phases. Phase 1 is converting AHU 1, 2, and 3 to heat pump since they're two of them are at the end of their useful life. The units can be replaced with new ducted heat pump system coupled with Energy Recovery Ventilator (ERV) with CO2 sensors. The ERV will allow the system to provide building code required ventilation while reducing energy and; heating and cooling peak loads. The new heat pump ducted systems will act as the primary source of heat.

Phase 2 will involve replacing the boiler with an air-to-water heat pump when it reaches the end of its useful life. The hydronic system will act as a supplemental source of heat to the Phase 1 ducted heat pumps. The proposed air-to-water system will need careful engineering design by an engineering professional where the existing hydronic infrastructure and distribution will be assessed for conversion. Additionally, it is recommended that the electrical infrastructure and loads are checked by a professional electrical engineer.

Code Triggers:

OA Ventilation:

Replacing the existing systems with electrification measures will trigger the requirement for outdoor air ventilation. This can be performed by the addition of an Energy Recovery Ventilator (ERV). Not only do ERVs ensure that the proper ventilation rates are met by supplying the proper amount of fresh air to occupied spaces, but they also utilize a heat exchanger allowing for enthalpy (heat energy) within the air exhausted from the space to be re-used. Doing so enables the HVAC system to operate at higher efficiencies while meeting code requirements. An ERV in conjunction with interior CO2 sensors will allow for the system to provide the required code ventilation rate based on demand and will improve ventilation while recovering heat within the return air flow before it is exhausted improving the overall efficiency of the system.

Renewables

Solar Photovoltaic (PV) Array

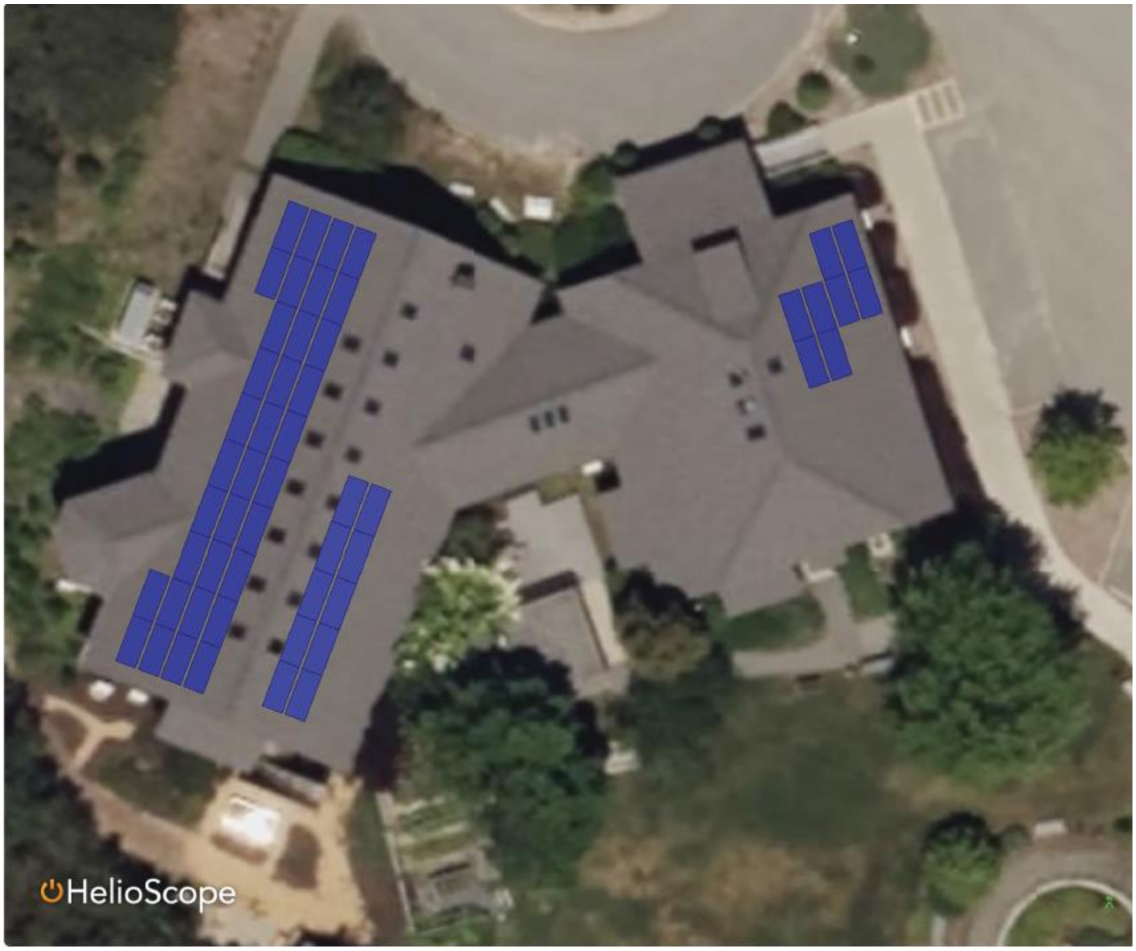
Solar Photovoltaic (PV) systems harness sunlight to generate electricity, where semiconductor materials convert sunlight into direct current (DC) electricity. These systems consist of solar panels made up of interconnected solar cells, inverters to convert DC electricity into usable alternating current (AC), mounting structures, and often include energy storage solutions such as batteries for storing excess energy. Ideally in the northern hemisphere, solar panels are south facing to receive the most direct sunlight.

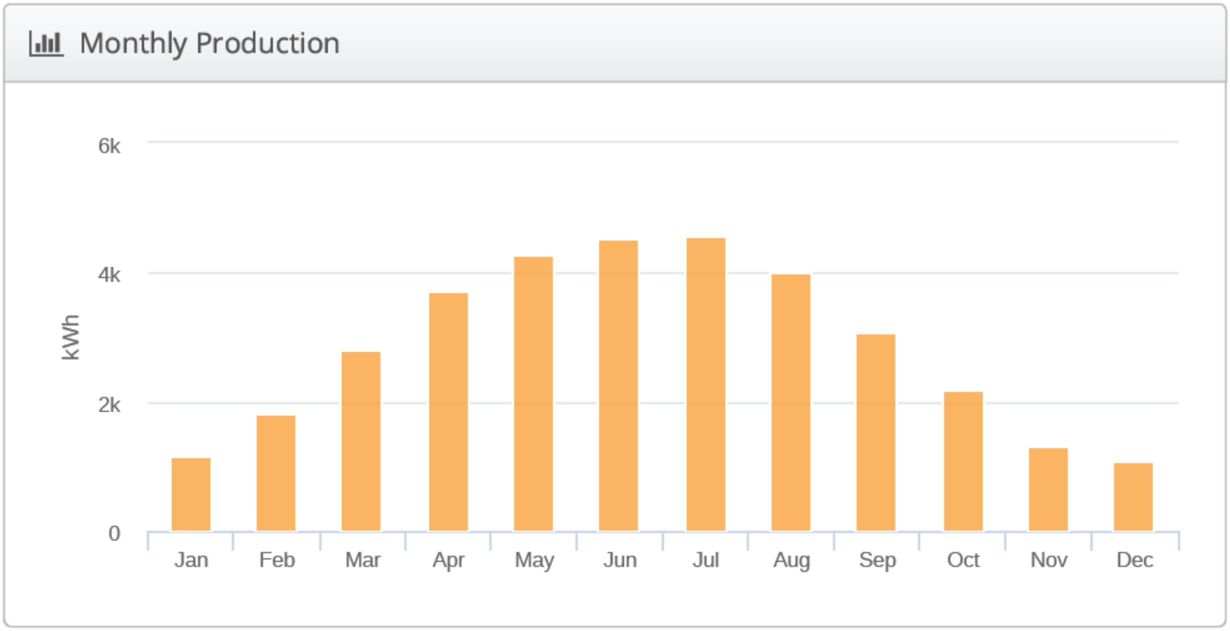
The main structure's roof has multiple sloped roof surfaces facing in different directions. An original review of the roof space revealed that there were no viable roof surfaces that could be used for solar that face south, west, or southwest. However, multiple roof sections were modeled to estimate the potential energy generation that could be provided by a solar system and to determine if the performance ratio was high enough to yield beneficial economic results. Solar PV modules in the north-east United States are most effective and receive the most solar irradiance when facing south-west which leads to a high performance ratio. Modeling the roof spaces at the Public Library that were not directly facing south or west still yielded a performance ratio of over 80 percent. Additional solar modules were modeled but shading from adjacent roof structures and trees created enough clipping and shading losses to be worthwhile.

The usable roof space would not be sufficient to provide the building with all of its electrical needs but could generate a significant portion of the annual electric consumption and most importantly, reduce grid-based energy consumption. As electrification measures are implemented and propane use is reduced/eliminated, the site will consume additional electricity to meet the required heating load. In this case, solar generation would significantly support the required reduction of the sites EUI and CEI. Nevertheless, the system was modeled, and a summary of results can be found below.

PV System Summary	
Module DC Nameplate	30.4 kW
Total Estimated Annual Production	34,453 kWh
Performance Ratio	84.8%
Total Estimated Cost (Est. $3/Watt Installed)	$91,200
Total Tax Credits (Est. 30% Credit, 179d)	$27,360
Total Cost Savings (Est. $0.22/kWh)	$7,599
Payback (After Tax Credits)	8.4 yrs

Table 11: Proposed PV System Summary


HelioScope


Monthly Production
6k
4k
2k
0
kWh
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Resiliency

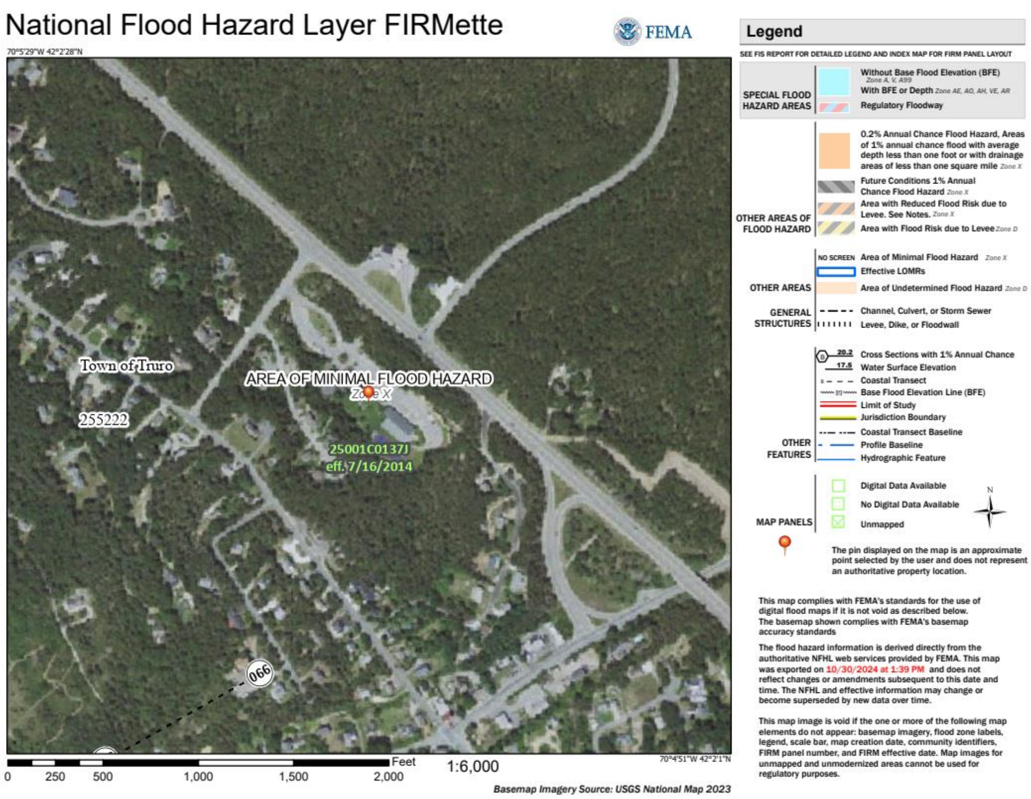
Backup Generator

A 50kW diesel backup generator is currently utilized by the facility. This generator is a crucial component to enhance and maintain reliability, resilience, and energy availability. In the event of a power outage or service disruption, the backup generator can quickly and automatically kick in, allowing the facility to operate in brief outage periods. This ensures a continuous and reliable power supply to critical loads, even during emergencies or natural disasters.

The backup generator seems to be in good condition and sufficiently sized for the site. This existing backup generator, while helpful, is still a fossil-fuel consuming piece of equipment. Further studies and development of a Solar PV system in conjunction with a battery storage system would support the facility with phasing out of fossil fuel use.

Coastal Flooding

The following depicts the National Flood Hazard FIRMette for the site location. The image below shows localized flood hazard data derived from the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs), which can help stakeholders identify flood risk and facilitate informed decision-making to mitigate potential risks. Based on this data, the building is in an area of minimal flood hazard. This indicates a low risk of flooding, with less than 0.2*% annual chance of flood events (500-year flood zone). Properties within this zone generally have a low probability of flood damage, and flood insurance is not typically required but may still be recommended for added protection. Incorporating flood-resistant designs and infrastructure ultimately safeguards lives and property and can reduce design costs when done in conjunction with designing for emission reduction measures.



Next Steps

It is recommended that you consider moving forward with the sustainable measures identified in this report. These measures represent a valuable opportunity to decarbonize the building while reducing energy usage and costs while leveraging available efficiency and sustainability incentives to decrease the overall implementation costs.

THREE EASY STEPS TO PARTICIPATE

- **Step #1:** Review your report with your Engineer and elect which measures to move forward with.
- **Step #2:** Sign proposal and schedule the installation of energy efficiency and microgrid improvements to ensure immediate meaningful energy savings and resiliency.
- **Step #3:** Recognize sustainable energy savings on a monthly basis!

Please be sure to contact Hossam Mahmoud, Sr. Energy Engineer at RISE engineering to take advantage of these opportunities today. I can be reached at hmahmoud@therisegroupinc.com or (774)-994-7269.