Decarbonization Assessment Report

545 Main St

Falmouth, MA

Prepared by: enviENERGY Studio
Date: January 30th, 2025

enviENERGY

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EXECUTIVE SUMMARY

enviENERGY Studio is providing energy modeling services for 545 Main St to evaluate the site energy and emissions impact of this retrofit project. 545 Main St is an approximately 54,000 square foot vacant nursing home that was built in 1968 and will be transformed into affordable workforce housing units. Historical utility data of the nursing home have been analyzed and are included in this report. Due to the change of use from nursing home to a multifamily function, the results of an ASHRAE 90.1-2019 Baseline and 100-2024 EUI target have also been included in this report for comparison. The energy models were developed using eQuest (DOE-2.3) referencing provided Design Development package and ASHRAE 90.1-2019 Appendix G for the Baseline.

The results of this energy analysis demonstrate that the proposed retrofit design meets and exceeds the DOER Affordable Housing Decarbonization Grant Program through the following methods:

- **energy efficiency** through an upgraded opaque envelope, window replacements and air-source heat pump/variable refrigerant technology;
- **decarbonization** through the elimination of all combustion heating, hot water and cooking technologies;
- addition of **on-site renewables** through the installation of rooftop solar PV;

It is estimated that proposed design **will meet and *exceed* a 30% reduction in both site energy consumption and greenhouse gas emissions** from the Pre-Project and ASHRAE 90.1 Baselines.

Scenario	Total Electricity	Total Gas	Total Site Energy	Energy Savings		EUI
	kWh	*Therms*	*MBTU*	*Compared to ASHRAE Baseline*	*Compared to Pre-Project Baseline*	kBTU/SF
Pre-Project Baseline	580,548	49,132	6,895			**128**
90.1-2019 Baseline	389,085	10,410	2,369			**44**
Proposed Design (+ PV)	394,192	0	1,345	**43%**	**80%**	**25**

Scenario	Direct Emissions	Indirect Emissions	Total Emissions	Total Emissions Savings		CEI
	Gas (kg)	*Elec (kg)*	*kgCO2e*	*Compared to ASHRAE Baseline*	*Compared to Pre-Project Baseline*	kgCO2e/SF
Pre-Project Baseline	260,941	142,343	403,284			**7**
90.1-2019 Baseline	55,288	95,399	150,687			**3**
Proposed Design (+ PV)	0	96,651	96,651	**36%**	**76%**	**2**

Please note that the proposed estimated energy performance and cost are not predictions of actual energy consumption or costs for the proposed design after construction. The actual energy use will differ from these estimates due to the variations in occupancy patterns and schedules, weather conditions, and building operation and maintenance. Still, the energy modeling results should serve as an accurate comparison tool.

ENERGY MODELING APPROACH

Baseline Performance

Electric and natural gas bills from nursing home operation during years 2018 to early 2020 were analyzed and averaged to establish a Pre-Project aseline.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
kWh	51,206	45,708	43,232	42,638	41,106	45,528	59,400	62,408	51,866	45,088	47,690	44,678
Therm	6,585	6,137	6,058	3,006	3,452	2,863	1,109	1,185	1,781	3,782	6,020	7,156

	Total/Yr	kBtu/yr	EUI
kWh	580,548	1,980,830	128
Therm	49,132	4,913,217	

A nursing home is typically more energy intensive than a standard multifamily building type, therefore an ASHRAE 90.1-2019 model was developed with a Building Performance Factor (BPF) of 0.70 applied, as prescribed by Table 4.2.1.1 for Multifamily in Climate Zone 5A.

ASHRAE 90.1-2004 Baseline (Without BPF)

	Total/Yr	kBtu/yr	EUI
kWh	457,766	1,561,898	57
Therm	15,009	1,500,900	

ASHRAE 90.1-2019 Baseline (BPF 0.70)

	Total/Yr	kBtu/yr	EUI
kWh	389,085	1,327,558	44
Therm	10,410	1,041,000	

The Performance Cost Index as prescribed for compliance in 4.2 is minimal due to the high cost of electricity Massachusetts and the low cost of natural gas, which is the prescribed baseline heating fuel type. Performance Energy Index calculations per C407.2.2, however, indicate that the retrofit design without proposed renewable energy contribution complies by 28% and by 43% *with* the proposed renewable energy contribution from the 110,000-kWh solar PV array.

Building Envelope

The current opaque wall assembly, original to 1968 and 1972, consists of 8" CMU with 2" rigid insulation only at the 1972 addition. The proposed design will incorporate the air sealing of all penetrations, 1" of continuous R-6.5/inch closed-cell spray foam with 2.5" more inches of spray foam within the furred-out cavity. This will reduce the original wall assembly u-value to approximately U-0.058 with clear field derating. The existing windows will be replaced with high-performance windows with a U-value of 0.30 and SHGC of 0.29.

Occupancy

The building was modeled with a standard residential schedule, assuming a reduced occupancy during extended working hours throughout the year and more partial occupancy during weekends. The peak occupancy density is estimated to be one person per studio and two occupants per 1-bedroom unit (# BR+1). The residential HVAC system(s) will operate 24/7. The occupancy reflects the design team's understanding of the typical number of people that will be in the building and is identical in the baseline and proposed models.

Internal Gains

For interior lighting calculations, the spaces within the building are sorted into space types based on the space-by-space method. The lighting power densities are consistent with ASHRAE 90.1-2019, Table G3.7 for the ASHRAE Baseline. The proposed case design lighting power densities reflect the actual design.

End uses such as kitchen and miscellaneous equipment are included as equipment gains and are modeled as 0.37-0.41 W/Sf and 0.25 W/SF, respectively. These inputs reflect the design team's understanding of the anticipated equipment usage. A more efficient equipment load density was assumed for the proposed case based on proposed equipment specifications.

Building Energy Modeling Assumptions and Inputs

Envelope	Residential	
	ASHRAE 90.1-2019 Baseline	**Proposed Design**
Roof	*Appendix G, Table G3.4-5* Roofs - Insulation entirely above deck U-0.063	Insulation entirely above deck: R-31 continuous insulation U-0.032
Exterior Walls	Walls, Above-Grade - Steel-framed U-0.064	Mass Wall, 2.5" cavity and 1" c.i. R-6.5/in spray foam ~U-0.058
Window Properties	Vertical Glazing (all): U-0.57	New Punch Window: U-0.30
WWR	24%	24%
SHGC	SHGC-0.39	SHGC-0.29
Slab-on-Grade Floors	Unheated: F-0.730	Unheated: F-0.730
Below-grade wall	C-1.140	2.5" cavity and 1" c.i. R-6.5/in spray foam, ~C-0.09
Opaque Doors	Swinging: U-0.700	Swinging: U-0.37

Interior Loads	Residential	
	ASHRAE 90.1-2019 Baseline	**Proposed Design**
Occupancy	1 Occupant/Studio (x61) 2 Occupants/1-BR (x6) 25-Occupant Café	1 Occupant/Studio (x61) 2 Occupants/1-BR (x6) 25-Occupant Café
Interior Lighting	*ASHRAE Appendix G,* *Table G3.7 Space-by-Space Method*	*As Designed*
Plug Loads	W/ft^2	W/ft^2
Res Kitchen Appliances	0.41	0.37
Res Miscellaneous	0.25	0.25
Elevators	Typical Apartment Schedule	Typical Office Schedule
Power	11 kW/car	11 kW/car

HVAC Systems	Residential	
	ASHRAE 90.1-2019 Baseline	**Proposed Design**
System Type	Residential: Packaged Terminal AC (System 1) Common: Packaged VAV with Reheat (System 5) Café, Fitness: Packaged Rooftop AC (System 3) Heat Only: Warm air furnace, gas fired (System 9)	Residential: Air-Source Heat Pump with in-unit ERV Common: Heat Recovery VRF with Central DOAS Heat Only: Electric Unit Heaters
Heating Type	Gas-Fired Hot-Water Boilers	Electric *(all):* Air-Source Heat Pump (ASHP) Variable Refrigerant Flow (VRF) Electric Resistance (Stairwells)
Efficiency	80% E_c	COP 3.6-4.6 (ASHP) COP 3.5-3.8 (VRF)
Cooling Type	Direct Expansion	Electric *(all):* Air-Source Heat Pump (ASHP) Variable Refrigerant Flow (VRF)
Efficiency	System 1: 3.2 COP *nfcooling* Systems 3, 5: 3.0-3.5 COP *nfcooling*	Residential: 12.5-16.3 EER (3.7-4.8 COP) Common: 10.9-11.0 EER (3.2-3.5 COP)
Fan Control	Constant Speed	Cycling
Ventilation/ Energy Recovery	ASHRAE 62.1 Minimum Rates; Exhaust Air Energy Recovery Not Required per G3.1.2.10	In-unit ERV, 76% EFF; Common DOAS, 72% EFF
Studio		45 cfm/unit
1-BR		75 cfm/unit
Retail & Common Spaces		As Designed

Domestic Hot Water	Residential	
	ASHRAE 90.1-2019 Baseline	**Proposed Design**
Water Heater Type	Gas Storage Tank	Central CO2 Air-Souce Heat Pump
Modeled Flow	3 gpm Res, 0.16 gpm Kitchen	3 gpm Res, 0.16 gpm Kitchen
Efficiency	58% EF	3.83 COP

ENERGY PERFORMANCE RESULTS

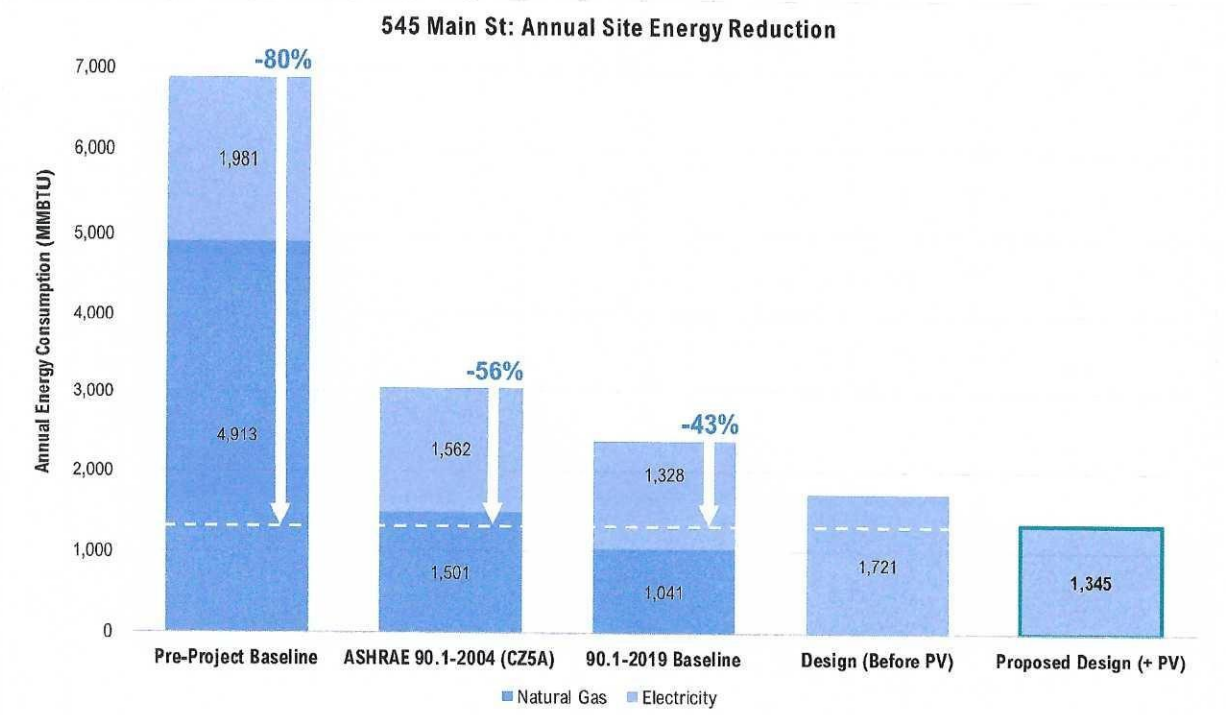


Figure 1. Annual Site Energy Reduction

Figure 1 illustrates the estimated annual site energy reduction of on-site fossil fuel (natural gas) and electricity of the proposed retrofit design compared to historical energy consumption (Pre-Project Baseline), the modeled ASHRAE 90.1-2004, which is analogous to ASHRAE 90.1-2019 Appendix G without the building performance factor applied, and the ASHRAE 90.1 Baseline (with the BPF applied).

It is estimated that the proposed design will use 80% less energy overall compared to historical utility consumption, and 43% less energy compared to the 90.1-2019 Baseline, with 100% reduction in natural gas compared to both cases. Annual electricity and natural gas consumption are graphed in units of MMBtu (million British thermal units).

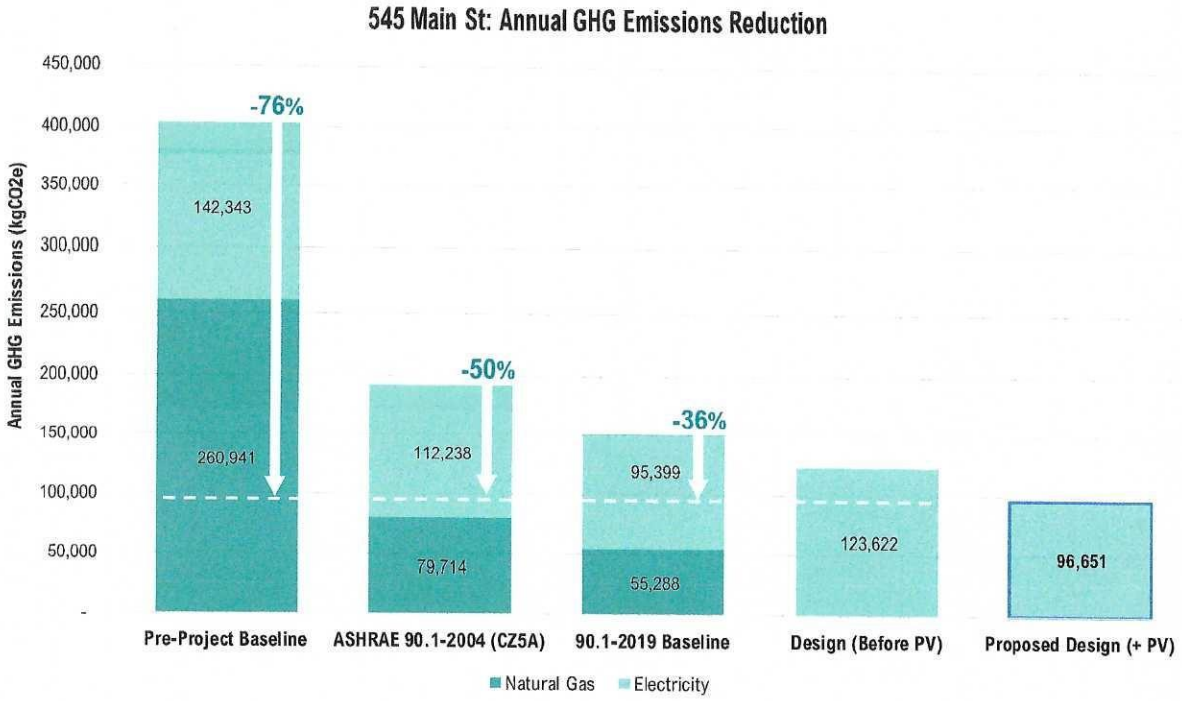


Figure 2. Annual Greenhouse Gas Reduction

Figure 2 illustrates the estimated annual greenhouse gas (GHG) reduction of the proposed design compared to historical energy consumption (Pre-Project Baseline), the modeled ASHRAE 90.1-2004 Baseline, which is analogous to ASHRAE 90.1-2019 Appendix G without the BPF applied, and the ASHRAE 90.1 Baseline (with BPF applied).

It is estimated that the proposed design will emit 76% less GHG emissions overall compared to historical consumption, and 36% less GHG emissions compared to the 90.1-2019 Baseline, with a 100% reduction in direct emissions from natural gas compared to both cases. Until the electric grid becomes greener, RECs can be pursued to offset indirect emissions associated with electric usage, resulting in a Net Zero design.

The CO_{2eq} emissions factors used for these calculations are 53.11 kg/MMBtu for natural gas and 71.84 kg/MMBtu (0.245 kg/kWh) for electricity. These values are sourced from EnergyStar's Portfolio Manager Technical Reference for Greenhouse Gas Emissions published in August of 2024.[1] Indirect GHG emissions from electricity are specific to the New England (NEWE) eGRID Region.

[1] Greenhouse Gas Inventory and Tracking in Portfolio Manager

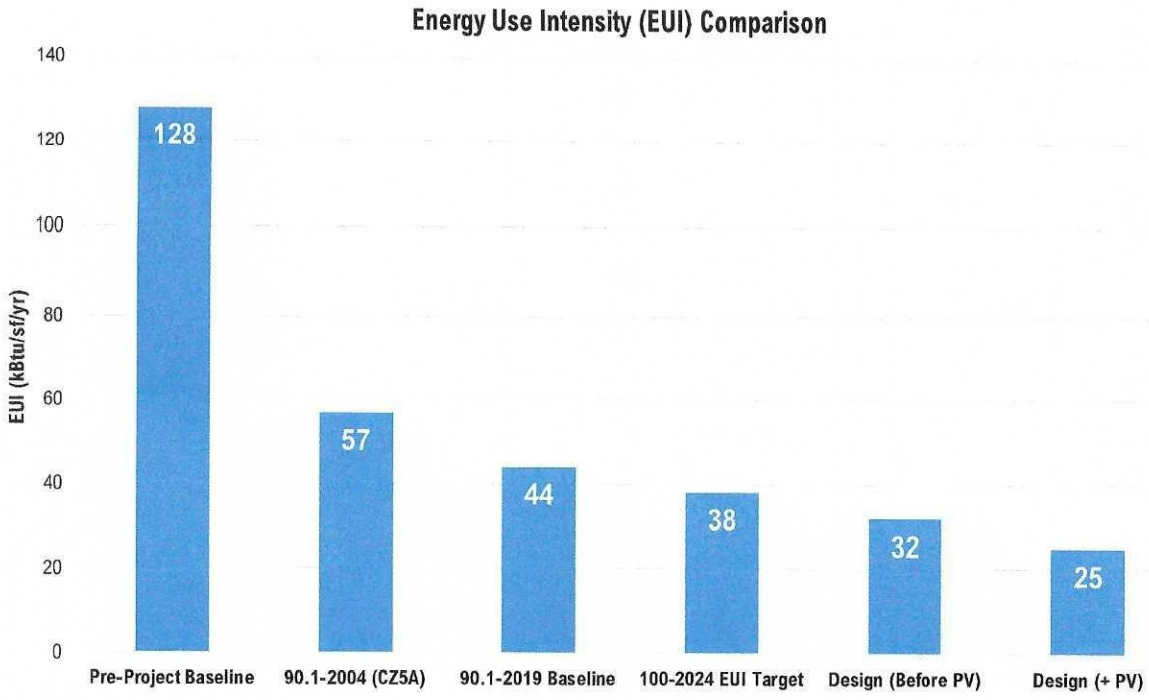


Figure 3. Annual Energy Use Intensity (EUI) Comparison

Figure 3 provides a normalized energy comparison in kBtu per square foot per year (kBtu/sf/yr) of the proposed design against historical energy consumption (Pre-Project Baseline), the modeled ASHRAE 90.1-2004 (analogous to ASHRAE 90.1-2019 Appendix G without BPF applied), and the ASHRAE 90.1 Baseline. Added to this graph is the Site Energy Use Intensity Target for Apartments (in 5+ unit building) in Climate Zone 5A from ASHAE Standard 100-2024, *Energy and Emissions Building Performance Standard for Existing Buildings* (p. 23, Table 7-2a). The EUI target for this type of existing building is 38 kBtu/sf/yr, from which the proposed retrofit design is 34% more efficient.

Home Energy Rating Certificate

Projected Report
Based on Plans

Rating Date: 11/21/2024
Registry ID:
Ekotrope ID: L7aebPev

SUSTAINABLE ENERGY ANALYTICS

HERS® Index Score:

43

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$1,262

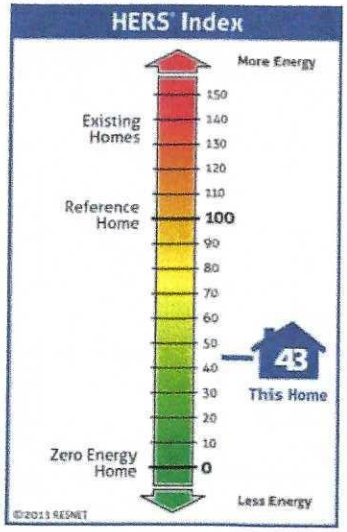
*Relative to HERS Reference Home

Home:
545 Main St Unit S12
Falmouth, MA 02540

Builder:
PCA Architecture Interiors + Planning

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	2.1	$198
Cooling	0.2	$19
Hot Water	1.3	$121
Lights/Appliances	9.1	$863
Service Charges		$102
Generation (e.g. Solar)	0.0	$0
Total:	**12.6**	**$1,303**



Home Feature Summary:

Home Type:	Apartment, end unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	449 ft²
Number of Bedrooms:	1
Primary Heating System:	Air Source Heat Pump • Electric • 8.8 HSPF2
Primary Cooling System:	Air Source Heat Pump • Electric • 19 SEER2
Primary Water Heating:	Residential Water Heater • Electric • 3.45 UEF
House Tightness:	3 ACH50 (Adjusted Infiltration: 0.48 ACH50)
Ventilation:	30 CFM • 13 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-21
Ceiling:	Adiabatic, R-30
Window Type:	U-Value: 0.3, SHGC: 0.29
Foundation Walls:	N/A
Framed Floor:	R-30

This home meets or exceeds the criteria of the following:

Massachusetts Stretch Code
2021 International Energy Conservation Code

Rating Completed by:

Energy Rater: Chris Zimmel
RESNET ID: 7630921

Rating Company: Sustainable Energy Analytics
440 Totten Pond Rd Ste 201, Waltham, MA 02451
781-790-5718

Rating Provider: Performance Systems Development
950 Danby Rd, Ste 201P, Ithaca NY 14850
607-277-6240

Chris Zimmel, Certified Energy Rater
Digitally signed: 11/21/24 at 10:23 PM

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Energy savings calculated without modifications to the energy model. (As Modeled)

Ekotrope RATER - Version:4.0.2.3523
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.
This report does not constitute any warranty or guarantee.

Home Energy Rating Certificate

Projected Report
Based on Plans

Rating Date: 11/21/2024
Registry ID:
Ekotrope ID: 25YRWPp2

SUSTAINABLE ENERGY ANALYTICS

HERS® Index Score:

44

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$1,383

*Relative to HERS Reference Home

Home:
545 Main St Unit 1BR-1
Falmouth, MA 02540

Builder:
PCA Architecture Interiors + Planning

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	2.5	$240
Cooling	0.2	$21
Hot Water	1.3	$128
Lights/Appliances	11.1	$1,056
Service Charges		$102
Generation (e.g. Solar)	0.0	$0
Total:	**15.2**	**$1,547**

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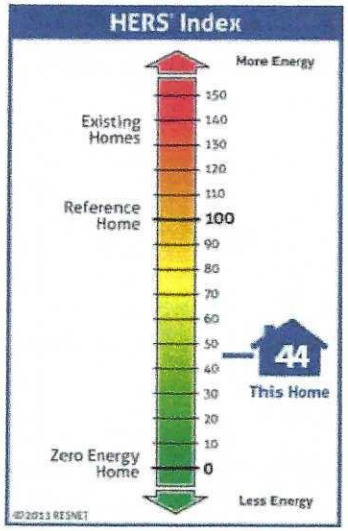
2021 International Energy Conservation Code



Home Feature Summary:

Home Type:	Apartment, end unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	681 ft²
Number of Bedrooms:	1
Primary Heating System:	Air Source Heat Pump • Electric • 8.8 HSPF2
Primary Cooling System:	Air Source Heat Pump • Electric • 19 SEER2
Primary Water Heating:	Residential Water Heater • Electric • 3.45 UEF
House Tightness:	3 ACH50 (Adjusted Infiltration: 0.46 ACH50)
Ventilation:	40 CFM • 19 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-21
Ceiling:	Adiabatic, R-30
Window Type:	U-Value: 0.3, SHGC: 0.29
Foundation Walls:	N/A
Framed Floor:	R-30

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RESNET ID: 7630921

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781-790-5718

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950 Danby Rd, Ste 201P, Ithaca NY 14850
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Chris Zimmel, Certified Energy Rater
Digitally signed: 11/21/24 at 10:28 PM

ekotrope

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Ekotrope RATER - Version:4.0.2.3523
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Home Energy Rating Certificate

Projected Report
Based on Plans

Rating Date: 11/21/2024
Registry ID:
Ekotrope ID: dNBzR5qd

SUSTAINABLE ENERGY ANALYTICS

HERS® Index Score:

45

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$1,189

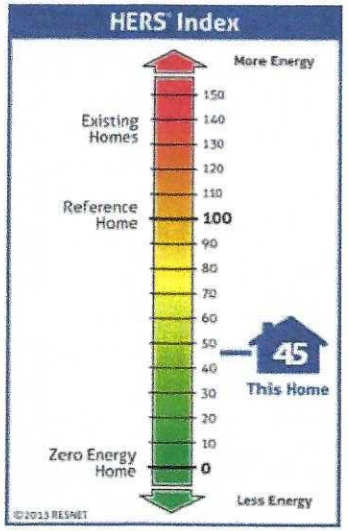
*Relative to HERS Reference Home

Home:
545 Main St Unit S03
Falmouth, MA 02540

Builder:
PCA Architecture Interiors + Planning

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	2.4	$230
Cooling	0.3	$32
Hot Water	1.2	$117
Lights/Appliances	8.9	$844
Service Charges		$102
Generation (e.g. Solar)	0.0	$0
Total:	**12.8**	**$1,324**



Home Feature Summary:

Home Type:	Apartment, end unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	396 ft²
Number of Bedrooms:	1
Primary Heating System:	Air Source Heat Pump • Electric • 8.8 HSPF2
Primary Cooling System:	Air Source Heat Pump • Electric • 19 SEER2
Primary Water Heating:	Residential Water Heater • Electric • 3.45 UEF
House Tightness:	3 ACH50 (Adjusted Infiltration: 0.63 ACH50)
Ventilation:	30 CFM • 13 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-21
Ceiling:	Adiabatic, R-30
Window Type:	U-Value: 0.3, SHGC: 0.29
Foundation Walls:	N/A
Framed Floor:	R-30

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