



Cross Pollination Knowledge
Share:
Zero Carbon Deep Energy Retrofits



Treehouse at Easthampton Village

Team: Beacon Communities, New Ecology, Inc.,
Davis Square Architects, Petersen Engineering, Waypoint KLA, Keith Construction

Location: Easthampton, MA Number of Apartments: 60
Year Built: 2006 Number of Stories: 1 and 2 stories
Status of Renovation: Predevelopment

Anticipated Energy Reduction: 50%
Energy Use Intensity (EUI) BEFORE: 71 kbtu/sf
Energy Use Intensity (EUI) AFTER: 35.6 kbtu/sf modeled

Roof: Before R-22, After R-40
Walls: Before R-15 , After R-22.5
Windows: Before U-0.40, SHGC-0.5, After U-0.25, SHGC-0.30
Target Air Tightness: 2 ACH; 0.10/0.14 CFM50
Solar: To Be Determined Due to Shading On Site
Passive House Certified: No



About Treehouse at Easthampton Meadows

Intentional Intergenerational Community

- Treehouse Foundation as partner
- Families who have adopted out of foster care system, and
- Seniors who agree to serve as mentors

60 Units in 23 Buildings, plus Community Building

- 48 1-bedroom senior units in 17 1-story buildings
- 12 3- 4- and 5-bedroom family units in 6 2- story townhouse buildings
- 55 Affordable Senior & Family Units, 5 market Family Units

Homes at Easthampton Meadows

- Subdivided part of the land for 33 Net Zero Ready Single-Family Homes

Overview Treehouse at Easthampton Meadows

Current Systems

- **Gas-fired** individual heat and hot water systems
- **Electric air** conditioning and cooking
- **Insulated wall assembly** but not a focus on air sealing

Low Income Housing Tax Credit Year 15- good time for capital reinvestment and refinancing

- **Capital needs list** -relatively small
- **Built with energy efficiency in mind** – theory that improvements for a Deep Energy Retrofit with Electrification would be cost effective for a resyndication

Integrated Design Process

Team

Beacon Communities, New Ecology, Inc. Davis Square Architects, Petersen Engineering, Waypoint KLA , Keith Construction

Process

- **Energy Audit-** including whole building blower door testing for 1 building/type
- **Goal Setting- 1)** Electrification, 2) envelope improvement, 3) maximize carbon emission and energy reduction 4) while keeping total hard cost no more than \$200,000/unit, 5) low embodied carbon/reuse materials.
- **Iterative Decision-Making Approach-** Compare Retrofit Packages for 1) Carbon Emissions Reduction, 2) Energy Use Reduction, 3) First Cost, and 4) Operational Costs. Chose final design package based on optimizing all.

Site Plan



TREEHOUSE AT EASTHAMPTON MEADOWS - SITE PLAN

Project RENOVATIONS TO TREEHOUSE AT EASTHAMPTON DEEP ENERGY RETROFIT	Title SITE PLAN
Designer PW	Date 6/2/2022
Checker RS	Drawing No. L-100
Scale 1"=100'	Project No. 2022019
Date 6/2/2022	Scale 1"=100'
Designer PW	Date 6/2/2022
Checker RS	Drawing No. L-100
Project No. 2022019	Project No. 2022019
Scale 1"=100'	Scale 1"=100'
Date 6/2/2022	Date 6/2/2022

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Existing Conditions

Building 6 (elderly units)

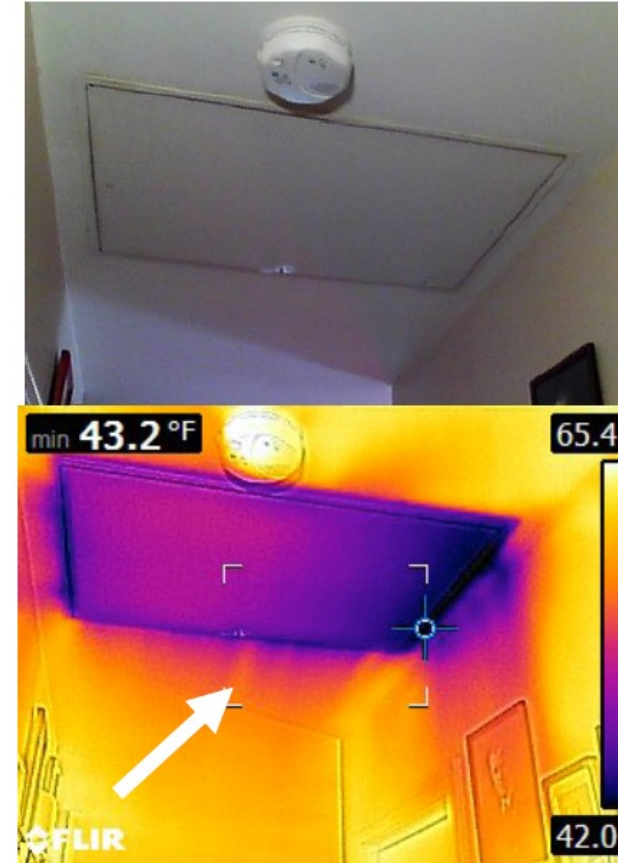
Building Volume: 17,816 CF

CFM @ 50 : 1,526 CFM

ACH @ 50 : 5 ACH



Thermal bridge and air leakage around windows



Attic Hatch without gasket

Retrofit Options: Early Stage Discussions

	Envelope As-Is			
	Building As Is	All-Electric	Package #1	Package #2
Roof/Attic			Roof 6" CCSF	Same
Wall			1.5" Polyiso (R-9)	2" XPS R-11 (updated in 3/15 narrative)
Foundation Wall			As-Is	2" Rigid to 12" below grade
Windows/Doors			U-0.25	U-0.17
Air Sealing	5 ACH50 (Tested)	5 ACH50 (Tested)	3 ACH50	2 ACH50
Heating/Cooling			ASHP (18 SEER, COP 3)	Same
Ventilation			OA Duct to Return	ERV
DHW			Electric Resistance	HPWH Individual per unit, CO2, COP 2.0

Narrowing Retrofit Options

Date: 3/28/2022

Project: **Treehouse Apartments - Development**

Baseline Annual Utility Usage

Water Usage	2,410,230	gallons
Electric Usage	368,275	kWh
Gas Usage	31,783	therms
Site Energy	4,435	MMBtu
Total Utility Cost	\$ 123,229	
EUI	77	kBtu/ft2
Carbon Emissions	1,964,908	kg CO2e

Utility Rates

Water	\$0.0123	/gallon
Electric	\$0.1452	/kWh
Gas	\$1.2594	/therm

2021 Emission Factors

Source: Building Emissions Reduction and Disclosure (BERDO)

Natural Gas	5.31	kg CO2e /therm
Electricity	0.2832	kg CO2/kWh

Summary of Energy Conservation Measures by Component

ECM #	Description of Upgrade	Emission Reduction (kg CO2e)	Est. Annual Cost Savings (\$)	KCI		Simple Payback Time (years)	Emission Reduction per dollar (kgCO2e/\$)
				Upfront Cost	Variance		
1	New LED fixtures	346	\$ 2,051	\$ 77,400		38	0.004
2	New faucets aerators	5,526	\$ 7,469	\$ 5,320		1	1.039
3	New toilets (0.8 gpf)	-	\$ 3,457	\$ 42,000		12	0.000
4	Foundation - 2" XPS with low GWP (R-10)	3,369	\$ 806	\$ 516,928		641	0.007
5	Roof - Install 6" CCSF below existing Sheathing	17,223	\$ 4,317	\$ 913,633		212	0.019
6	Heating/Cooling - ASHP (18 SEER, 3 COP)	47,376	\$ 2,288	\$ 1,156,902		506	0.041
7	Wall - 1.5" XPS with low GWP (R-7.5)	13,899	\$ 3,368	\$ 1,058,096	\$ 115,106	314	0.0131
8	Wall - 2" XPS with low GWP (R-10)	15,618	\$ 3,779	\$ 1,173,202		310	0.0133
9	Windows - U-0.25, 0.3 SHGC	5,226	\$ 1,948	\$ 142,257	\$ 357,929	73	0.037
10	Windows - U-0.17, 0.25 SHGC	12,002	\$ 3,465	\$ 500,186		144	0.024
11	Air Sealing - 3 ACH50	10,925	\$ 2,699	\$ 87,118	\$ -	32	0.125
12	Air Sealing - 2 ACH50	15,905	\$ 3,931			22	0.183
13	DHW - Electric Resistance	(2,015)	\$ (22,329)	\$ 412,800	\$ 356,000	-	-
14	DHW - HPWH (2.0 COP)	38,025	\$ (1,799)	\$ 768,800		-	0.092
15	Ventilation - OA Duct to Return	(13,996)	\$ (3,578)	\$ 156,600	\$ 99,000	-	-
16	Ventilation - ERV	(6,679)	\$ (2,380)	\$ 255,600		-	-

Modeling Options, Then Mix and Match

Project: **Treehouse Apartments (Building 6)**

Baseline Annual Utility Usage

Water Usage	124,675	gallons
Electric Usage	12,819	kWh
Gas Usage	1,037	therms
Site Energy	147	MMBtu
Total Utility Cost	\$ 4,705	
EUI	66	kBtu/ft ²
Carbon Emissions	9,138	kg CO ₂ e

Utility Rates

Water	\$0.0123	/gallon
Electric	\$0.1452	/kWh
Gas	\$1.2594	/therm

2021 Emission Factors

Source: Building Emissions Reduction and Disclosure (BERDO)

Natural Gas	5.31	kg CO ₂ e /therm
Electricity	0.2832	kg CO ₂ /kWh

Summary of Energy Conservation Measures of Package 2

ECM #	Description of Upgrade	Total Electricity Savings (kWh)	Total Gas Savings (therms)	Residential Property Energy Savings (%)	Est. Annual Water Savings (Gallons)	% Water Savings (%)	Est. Annual Cost Savings (\$)	% Costs Savings (%)	Emission Reduction (kg CO ₂ e)	% Emission Reduction (%)
1	New LED fixtures	979	(50)	-1.1%	-	0.0%	\$ 79	2%	13.14	0%
2	New faucets aerators	-	33	2.3%	16,060	13%	\$ 240	5%	178	2%
3	New toilets	-	-	0.0%	9,344	7.5%	\$ 115	2%	-	-
4	Exterior foundation insulation (R-10)	4	28	1.9%	-	0.0%	\$ 35	1%	148	2%
5	Exterior wall insulation (R-10)	37	112	7.7%	-	0.0%	\$ 146	3%	605	7%
6	6" Spray foam insulation below roof sheathing	97	104	7.3%	-	0.0%	\$ 145	3%	579	6%
7	New windows and Glass Doors (U=0.17 , SHGC=0.25)	271	54	4.3%	-	0.0%	\$ 107	2%	364	4%
8	Air Sealing (2 ACH50)	28	39	2.7%	-	0.0%	\$ 53	1%	216	2%
9	New Heat pump water heater (2 COP)	(4,010)	421	19.3%	-	0.0%	\$ (52)	-1%	1,100	12%
10	New air source heat pump (18 SEER, 3 COP)	(2,520)	297	14.3%	-	0.0%	\$ 8	0%	863	9%
11	New ERV (88 % Heat recovery)	(800)	-	-1.9%	-	0.0%	\$ (116)	-2%	(226)	-2%
12	Solar PV	-	-	0.0%	-	0.0%	\$ -	-	-	-
	Total	(5,914)	1,038	57%	25,404	20%	\$ 762	16%	3,839	42%

Retrofit: Where We Landed

Proposed Model Annual Utility Usage

Water Usage	1,926,121	gallons
Electric Usage	649,476	kWh
Gas Usage	50	therms
Site Energy	2,222	MMBtu
Total Utility Cost	\$ 118,124	
EUI	35.59	kBtu/ft2
Carbon Emissions	184	MTCO2e
% Carbon Emission Reduction	33	%

Proposed Model Annual Utility Usage (with Gas DHW) (Not Selected)

Water Usage	1,926,121	gallons
Electric Usage	437,298	kWh
Gas Usage	11,077	therms
Site Energy	2,600	MMBtu
Total Utility Cost	\$ 101,203	
EUI	42	kBtu/ft2
Carbon Emissions	183	MTCO2e
% Carbon Emission Reduction	33	%

Proposed Model Annual Utility Usage (with Heat pump water heater) (Not Selected)

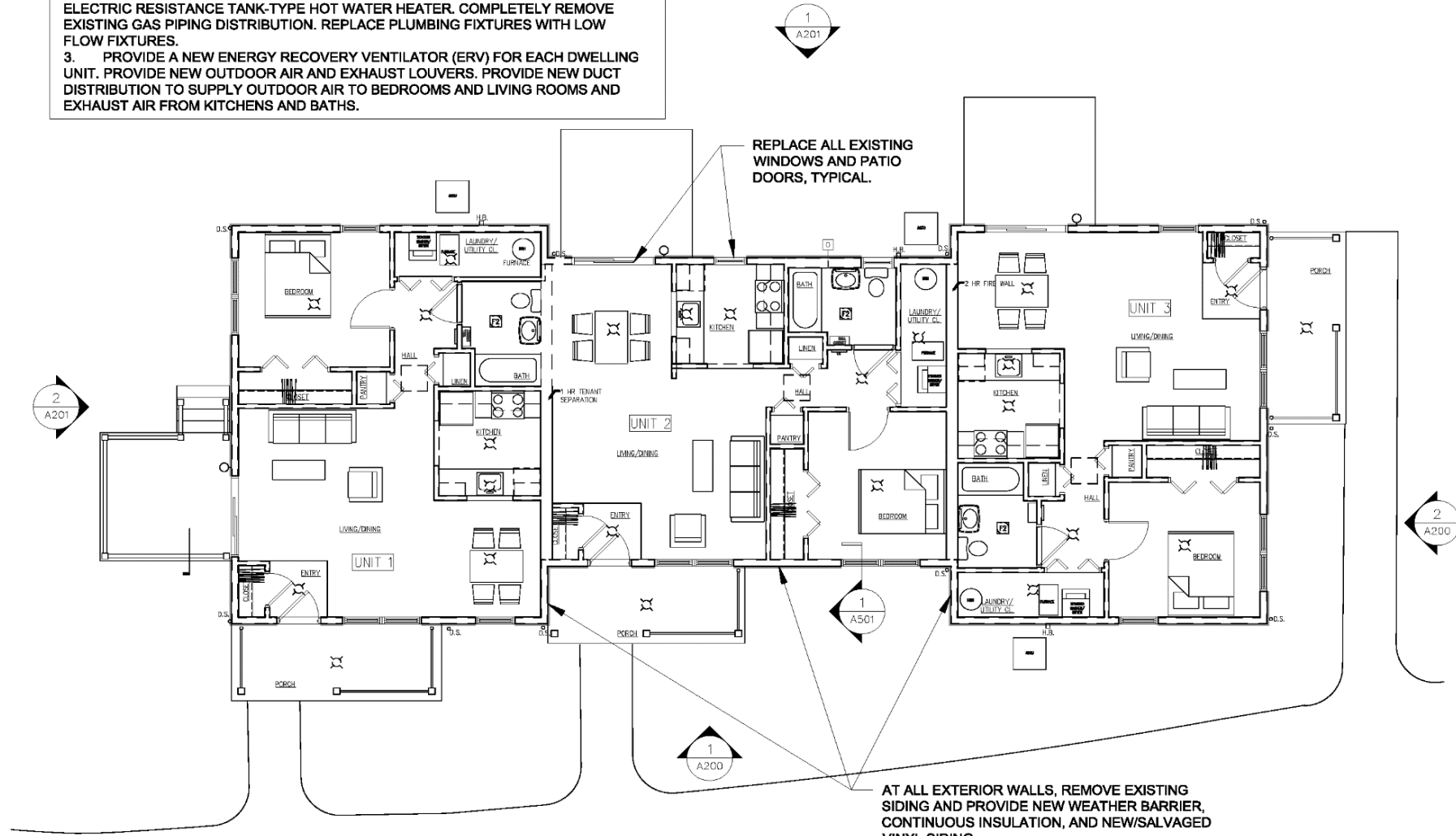
Water Usage	1,926,121	gallons
Electric Usage	543,387	kWh
Gas Usage	50	therms
Site Energy	1,860	MMBtu
Total Utility Cost	\$ 102,720	
EUI	30	kBtu/ft2
Carbon Emissions	154	MTCO2e
% Carbon Emission Reduction	44	%


Summary of Energy Conservation Measures of Proposed Model

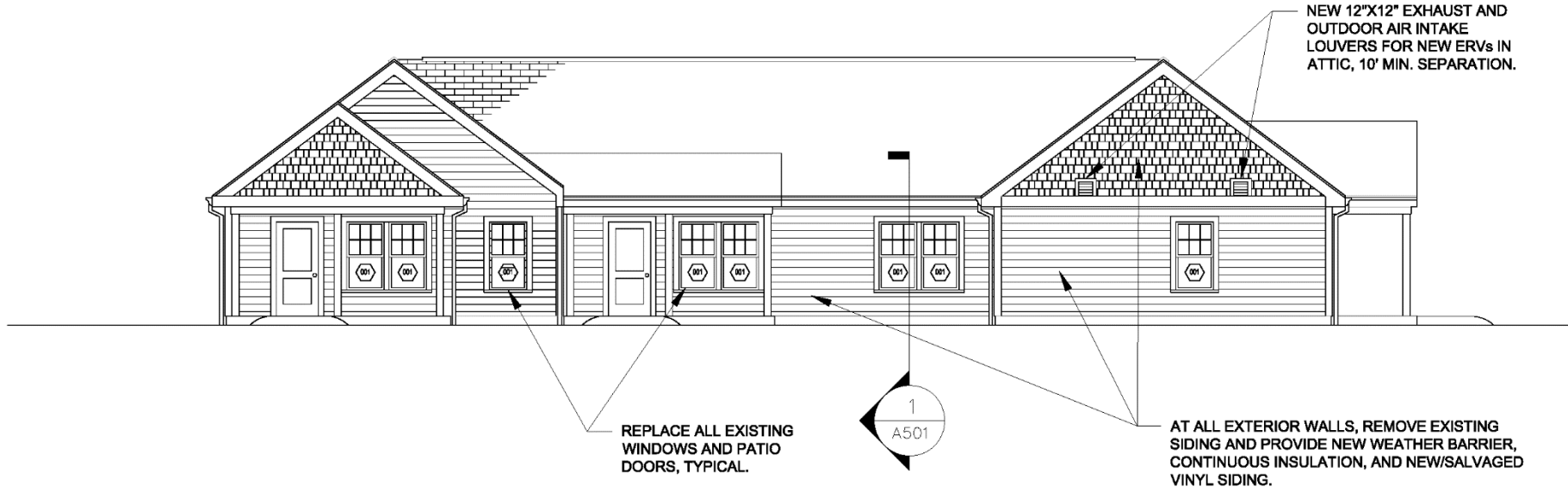
ECM #	Description of Upgrade	Total Electricity Savings (kWh)	Total Gas Savings (therms)	Residential Property Energy Savings (%)	Est. Annual Water Savings (Gallons)	% Water Savings (%)	Est. Annual Cost Savings (\$)	% Costs Savings (%)	Emission Reduction (MTCO2e)	% Emission Reduction (%)	Upfront Cost
1	New LED fixtures	27,740	(1,457)	-1%	-	0%	\$ 2,193	2%	0.12	0%	\$ 77,400
2	New faucets aerators	-	1,039	2%	334,888	14%	\$ 5,440	4%	5.52	2%	\$ 5,320
3	New toilets (0.8 gpf)	-	-	0%	189,070	8%	\$ 2,332	2%	-	-	\$ 42,000
4	Exterior wall insulation (R-7.5)	1,367	3,963	9%	-	0%	\$ 5,190	4%	21.44	8%	\$ 1,058,096
5	6" Spray foam insulation below roof sheathing	2,623	3,162	7%	-	0%	\$ 4,363	4%	17.54	6%	\$ 913,633
6	New windows and Glass Doors (U=0.25 , SHGC=0.30)	7,755	909	3%	-	0%	\$ 2,271	2%	7.02	3%	\$ 142,257
7	Air Sealing (2 ACH50)	1,030	1,587	4%	-	0%	\$ 2,148	2%	8.72	3%	\$ 87,118
8	New electric resistance water heater	(212,177)	11,026	9%	-	0%	\$ (16,922)	-14%	(1.53)	-1%	\$ 412,800
9	New air source heat pump (18 SEER, 3 COP)	(90,340)	11,499	19%	-	0%	\$ 1,364	1%	35.49	13%	\$ 1,156,902
10	New ERV (88 % Heat recovery)	(19,199)	4	-1%	-	0%	\$ (2,783)	-2%	(5.42)	-2%	\$ 255,600
11	Solar PV	-	-	0%	-	0%	\$ -	-	-	-	
	Total	(281,201)	31,733	50%	523,958	21%	\$ 5,596	5%	89	33%	\$ 4,151,126

Drawings

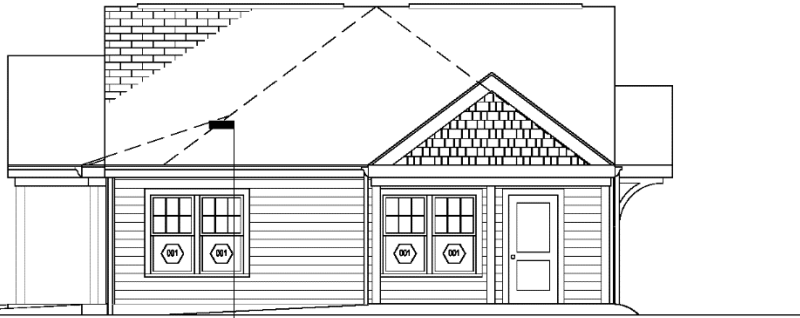
- MEP SCOPE, TYP. FOR EACH DWELLING UNIT:
1. REMOVE EXISTING GAS FURNACE AND CONDENSING UNIT AND REPLACE WITH A DUCTED AIR SOURCE HEAT PUMP. CLEAN AND AEROSEAL AND RE-INSULATE ALL EXISTING DUCTWORK TO REMAIN. PROVIDE NEW PROGRAMMABLE WALL-MOUNTED THERMOSTATS.
 2. REMOVE EXISTING GAS-FIRED HOT WATER HEATER AND REPLACE WITH AN ELECTRIC RESISTANCE TANK-TYPE HOT WATER HEATER. COMPLETELY REMOVE EXISTING GAS PIPING DISTRIBUTION. REPLACE PLUMBING FIXTURES WITH LOW FLOW FIXTURES.
 3. PROVIDE A NEW ENERGY RECOVERY VENTILATOR (ERV) FOR EACH DWELLING UNIT. PROVIDE NEW OUTDOOR AIR AND EXHAUST LOUVERS. PROVIDE NEW DUCT DISTRIBUTION TO SUPPLY OUTDOOR AIR TO BEDROOMS AND LIVING ROOMS AND EXHAUST AIR FROM KITCHENS AND BATHS.




Project RENOVATIONS TO TREEHOUSE AT EASTHAMPTON DEEP ENERGY RETROFIT	Title BUILDING 6 FLOOR PLAN	 DAVIS SQUARE ARCHITECTS 240A Elm St., Somerville, MA 02144 617.628.5700 www.davisquarearchitects.com	Designed PW
			Checked RS
Project No. 2022019		Scale 1/8"=1'-0"	
Date 6/2/2022		Drawing No. A100	



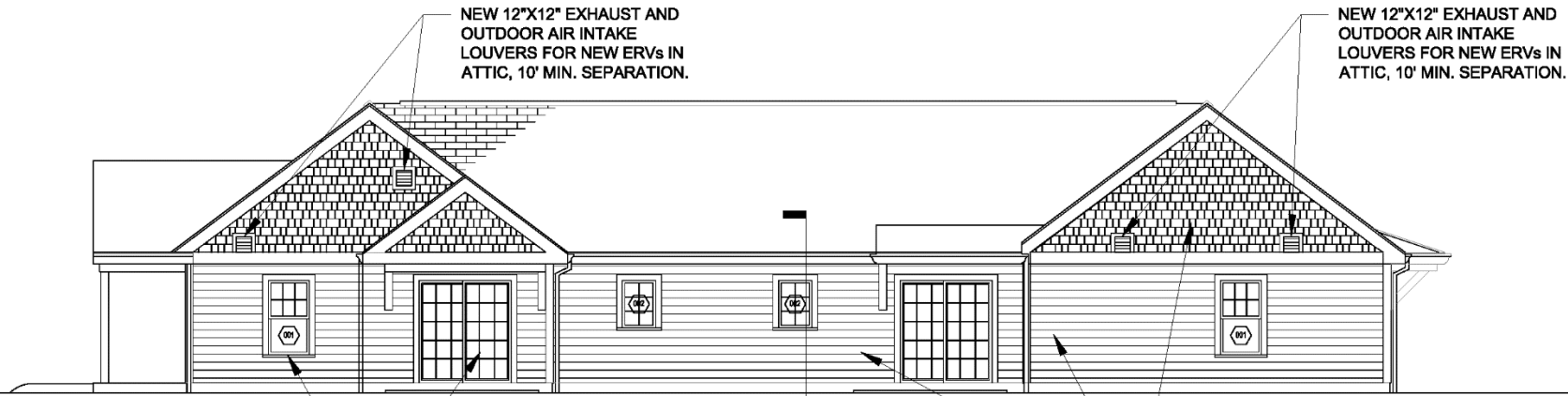
1 BUILDING 6 SOUTH ELEVATION
1/8"=1'-0"



2 BUILDING 6 EAST ELEVATION
1/8"=1'-0"

Project RENOVATIONS TO TREEHOUSE AT EASTHAMPTON DEEP ENERGY RETROFIT		Title BUILDING 6 ELEVATIONS - SOUTH AND EAST	
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Designed PW	Checked RS	Project No. 2022019	Scale 1/8"=1'-0"
Drawing No. A200		Date 6/2/2022	© Copyright 2022 Davis Square Architects, Inc.

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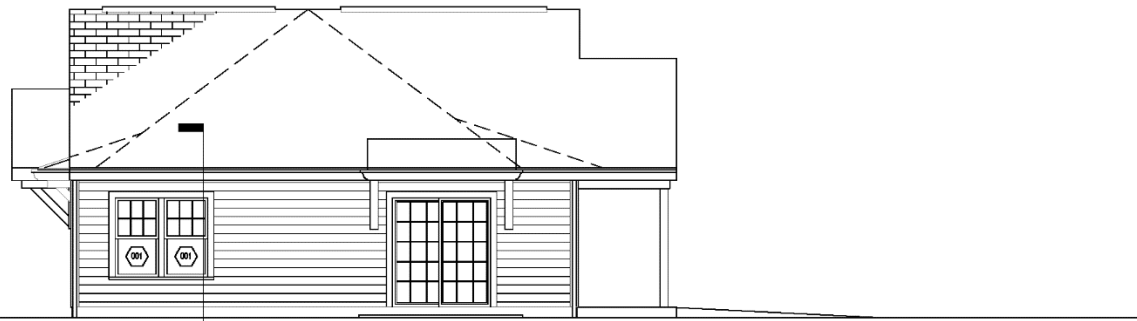


REPLACE ALL EXISTING
WINDOWS AND PATIO
DOORS, TYPICAL.



AT ALL EXTERIOR WALLS, REMOVE EXISTING
SIDING AND PROVIDE NEW WEATHER BARRIER,
CONTINUOUS INSULATION, AND NEW/SALVAGED
VINYL SIDING.

1 BUILDING 6 NORTH ELEVATION
1/8"=1'-0"



2 BUILDING 6 WEST ELEVATION
1/8"=1'-0"

Project
RENOVATIONS TO
TREEHOUSE AT EASTHAMPTON
DEEP ENERGY RETROFIT

Title
BUILDING 6
ELEVATIONS - NORTH AND WEST



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PW

Checked
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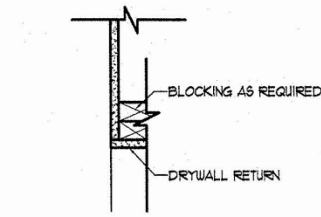
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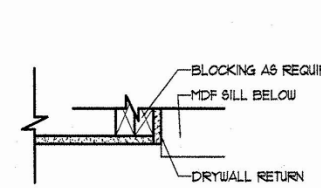
Date
6/2/2022

Drawing No.
A201

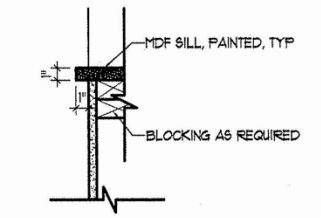
NOTE: THE WINDOW DETAILS FROM THE ORIGINAL CONSTRUCTION DRAWINGS (BELOW) DO NOT INCLUDE AIR/MOISTURE SEALING PROVISIONS, ONLY FINISH CONDITIONS.



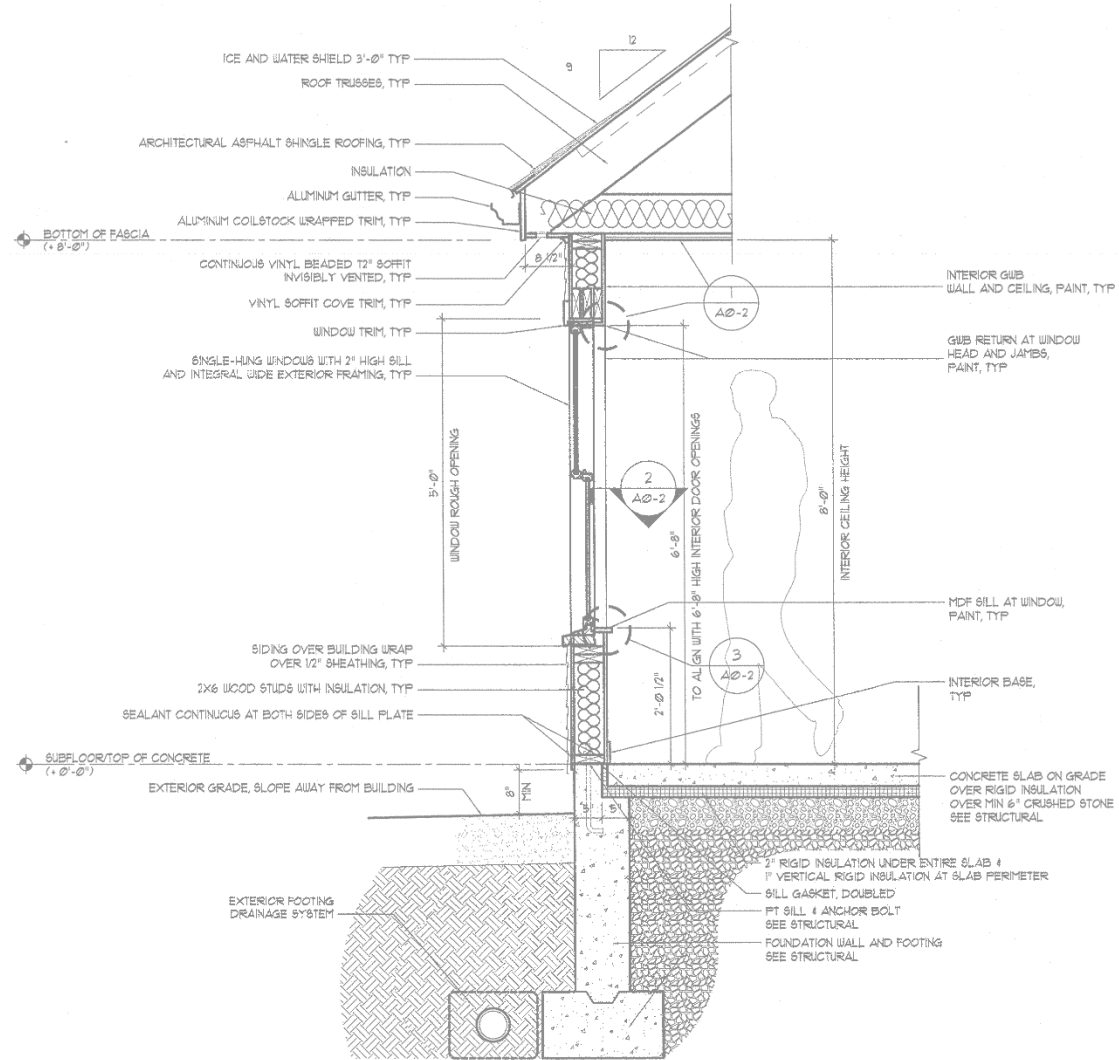
1 TYPICAL WINDOW HEAD
A0-1 1/12"=1'-0"



2 TYPICAL WINDOW JAMB
A0-1 1/12"=1'-0"

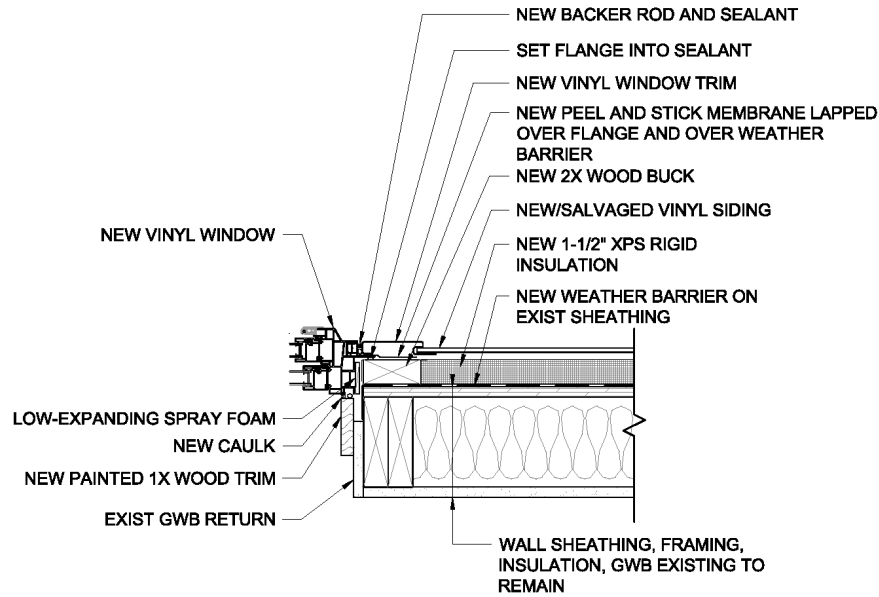


3 TYPICAL WINDOW SILL
A0-1 1/12"=1'-0"

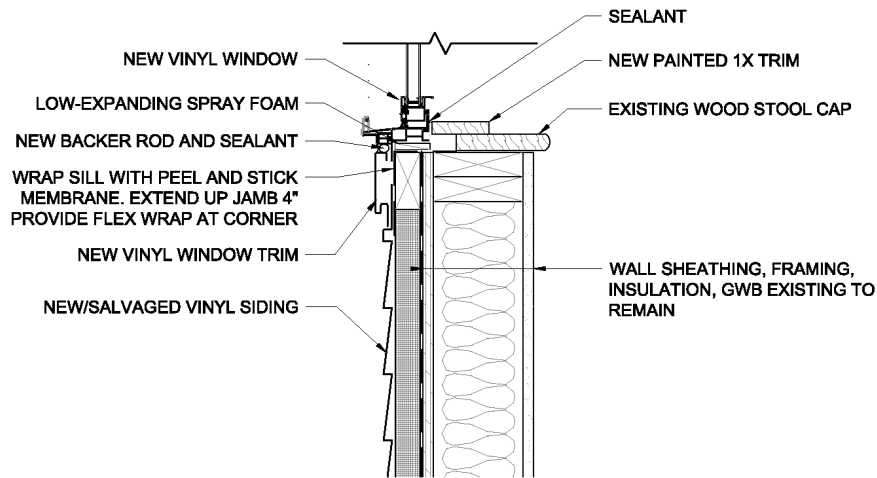


TYPICAL EXISTING WALL SECTION - FROM ORIGINAL 2003 CONSTRUCTION DRAWINGS

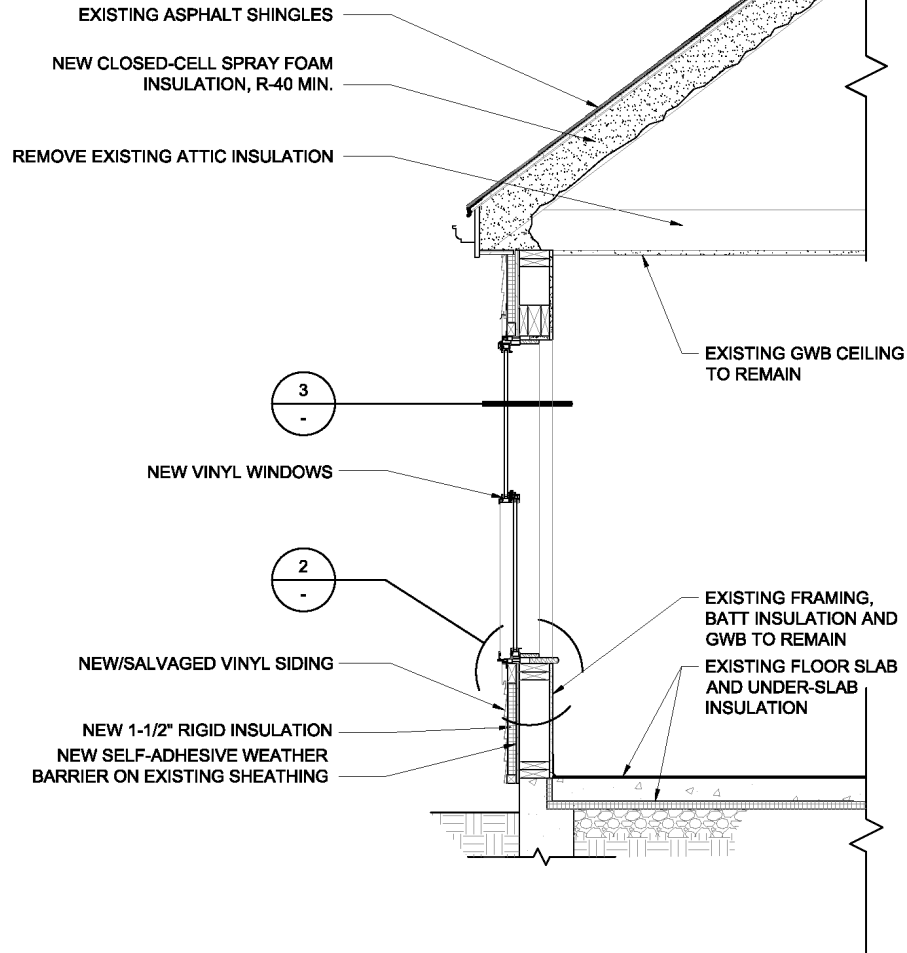
Project RENOVATIONS TO TREEHOUSE AT EASTHAMPTON DEEP ENERGY RETROFIT		Title EXISTING WALL SECTION	
 DAVIS SQUARE ARCHITECTS		240A Elm St, Somerville, MA 02144 617.628.5700 www.davisquarearchitects.com	
Designed Checked Project No. 2022019 Scale NTS Date 6/2/2022	Drawing No. <h1>A500</h1>		



3 TYPICAL NEW WINDOW JAMB DETAIL (HEAD SIM)
1-1/2"=1'-0"



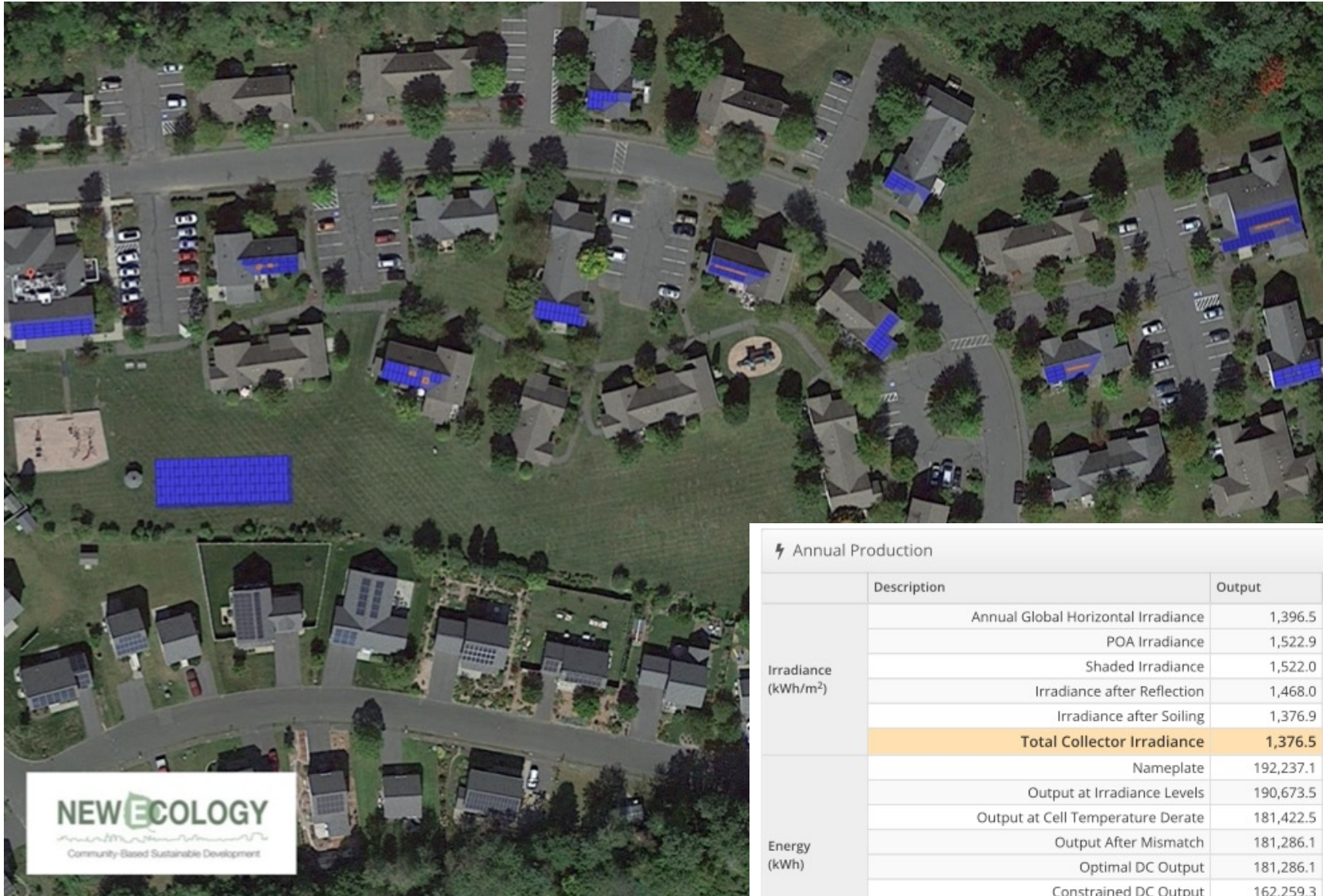
2 TYPICAL NEW WINDOW SILL DETAIL
1-1/2"=1'-0"



1 TYPICAL NEW WALL SECTION
1/2"=1'-0"

Project RENOVATIONS TO TREEHOUSE AT EASTHAMPTON DEEP ENERGY RETROFIT		Title PROPOSED WALL SECTIONS PROPOSED WINDOW DETAILS	
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Designed PW	Checked RS	Project No. 2022019	Scale AS NOTED
Drawing No. A501		Date 6/2/2022	Date 6/2/2022

Sola

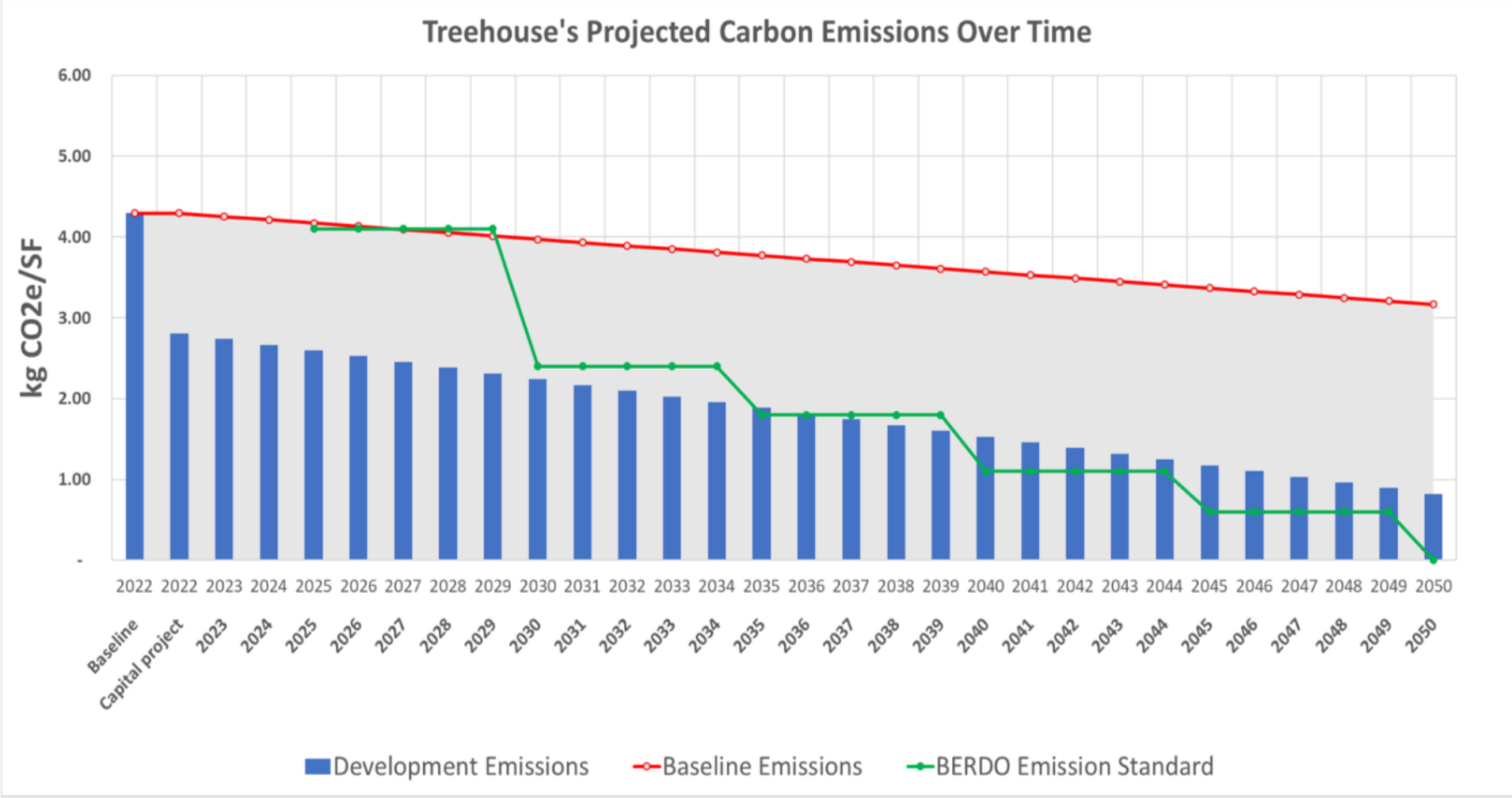


⚡ Annual Production			
	Description	Output	% Delta
Irradiance (kWh/m ²)	Annual Global Horizontal Irradiance	1,396.5	
	POA Irradiance	1,522.9	9.0%
	Shaded Irradiance	1,522.0	-0.1%
	Irradiance after Reflection	1,468.0	-3.6%
	Irradiance after Soiling	1,376.9	-6.2%
	Total Collector Irradiance	1,376.5	0.0%
Energy (kWh)	Nameplate	192,237.1	
	Output at Irradiance Levels	190,673.5	-0.8%
	Output at Cell Temperature Derate	181,422.5	-4.9%
	Output After Mismatch	181,286.1	-0.1%
	Optimal DC Output	181,286.1	0.0%
	Constrained DC Output	162,259.3	-10.5%
	Inverter Output	155,610.0	-4.0%
	Energy to Grid	147,211.1	-5.4%

Final Conservation Results

Description of Upgrade	Est. Annual Water Savings (gallons)	Property Water Savings (%)	Est. Annual Electricity Savings (kWh)	Est. Annual Natural Gas / Steam Savings (Therms)	Property Energy Savings (%)	Property Carbon Savings (%)
ENERGY AND WATER CONSERVATION MEASURES						
New faucets aerators	334,888	14%	0	1,039	2.3%	2.0%
Air Sealing (2 ACH50)	0	0%	1,030	1,587	3.7%	3.2%
New toilets	189,070	8%	0	0	0.0%	-
New LED fixtures	0	0%	27,740	(1,457)	-1.1%	-
New windows and Glass Doors (U=0.25, SHGC=0.30)	0	0%	7,755	909	2.6%	2.6%
Exterior wall insulation (R-7.5)	0	0%	1,367	3,963	9.0%	7.8%
6" Spray foam insulation below the roof sheathing	0	0%	2,623	3,162	7%	6.4%
New air-source heat pump (18 SEER, 3 COP)	0	0%	(90,340)	11,499	19%	13.0%
New ERV (88 % Heat recovery)	0	0%	(19,199)	4	-1%	-2.0%
New electric resistance water heater	0	0%	(212,177)	11,026	9%	-0.6%
TOTAL SAVINGS	523,958	21%	(281,201)	31,733	50%	33%
<i>Water savings percentages are against total property water consumption. Electricity and Gas savings percentages are against total property energy consumption. Projected savings account for the interactivity of some measures.</i>						

Decarbonization: BERDO Standard



Costs & Funding

TDC \$23.5 million

Hard Costs- \$10.2 million Total (\$169,500/unit)

- DER and Electrification Portion- \$3.5 million (\$58,000/unit)
- Other Improvements -\$6.7 million (\$111,500/unit)

Funding

- **LISC Climate Ready Housing Program-** applied for \$750,000 (\$12,500/unit)
- **MassSave LEAN Electrification-** estimating \$600,000 (\$10,000/unit)
- **MA DHCD** -4% LIHTC, State LIHTC, Soft Debt
- **Resubordinated Debt**

Trade-Offs & Open Questions

- **DHW-** Air Source Heat Pumps vs Electric Resistance
- **Utilities-** Resident vs Landlord Paid
- **Embodied Carbon & Materials Not at the End of Useful Life-** Siding, Windows, Roofs