BUILDINGENERGY BOSTON

Why We Stopped Doing Deep Energy Retrofits

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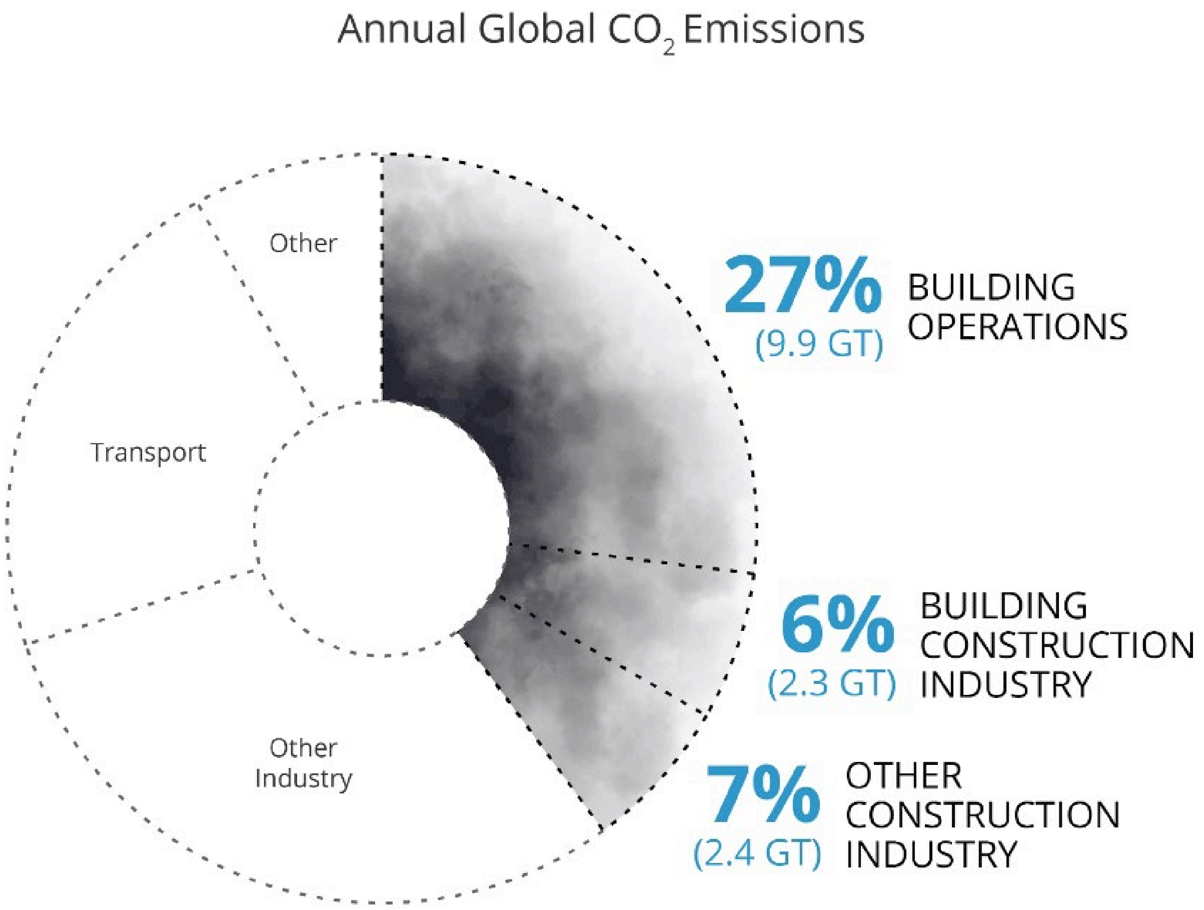
Northeast Sustainable Energy Association (NESEA)
March 29, 2023

We’re headed towards a climate crisis



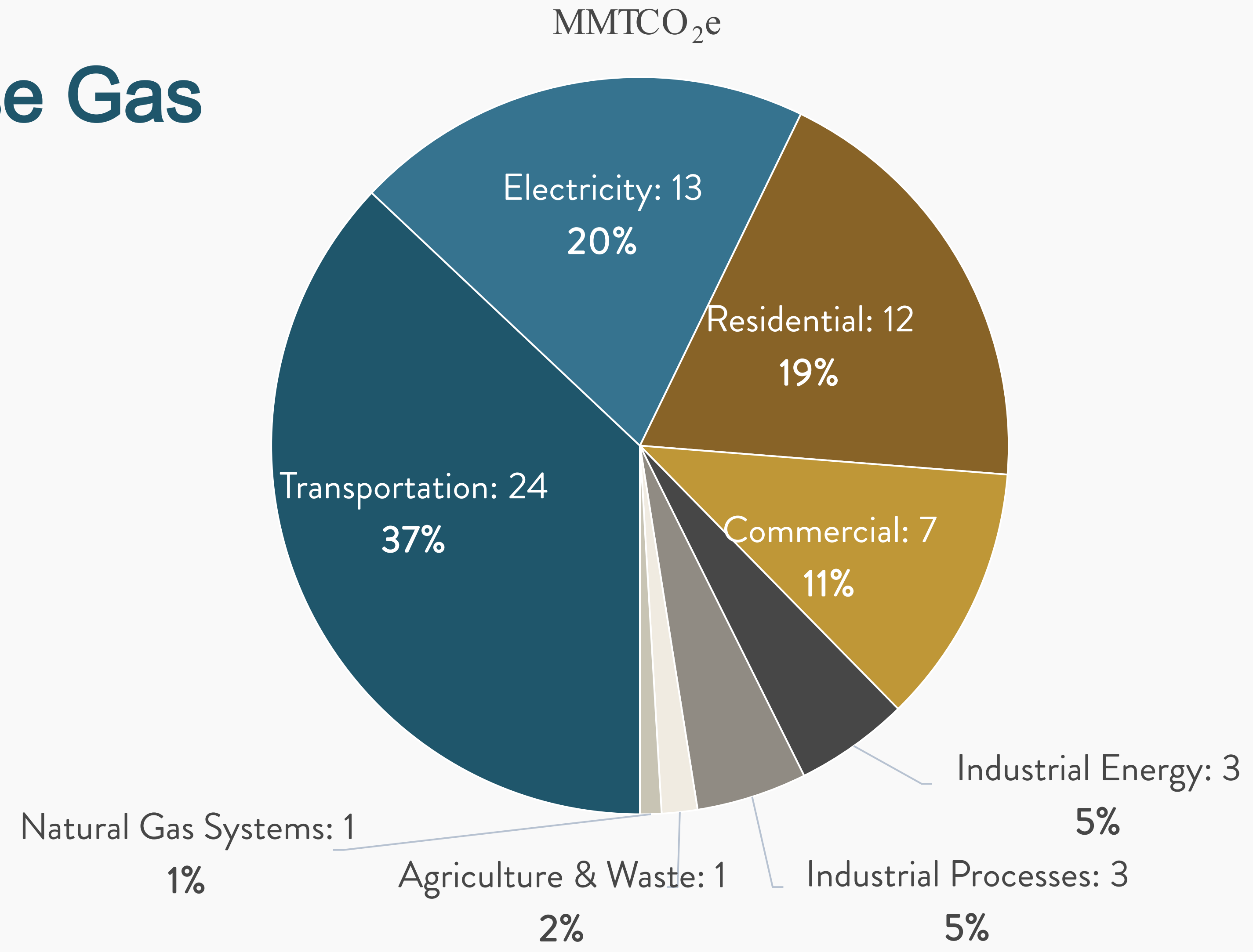
Credit: Architecture 2030

We can’t build our way to carbon neutrality

In 2040, **2/3 of the global building stock** will be buildings that exist today.
Without upgrades, they will still be emitting GHGs.

Data Source: IEA Energy Technology Perspectives 2020, February 2021 Revised Edition

2020 MA Greenhouse Gas Emissions by Sector



MA Clean Energy and Climate Plan for 2025 and 2030

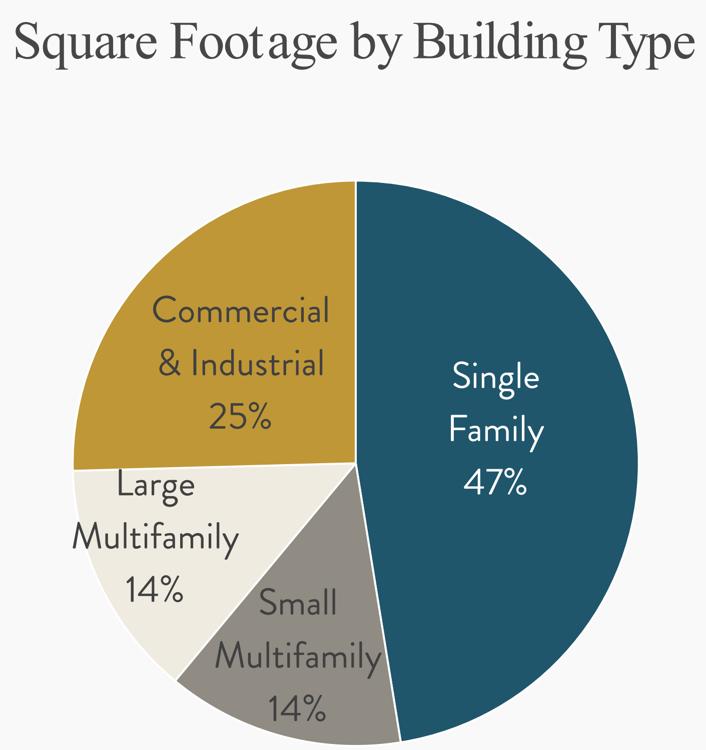
MA GHG Residential Emissions

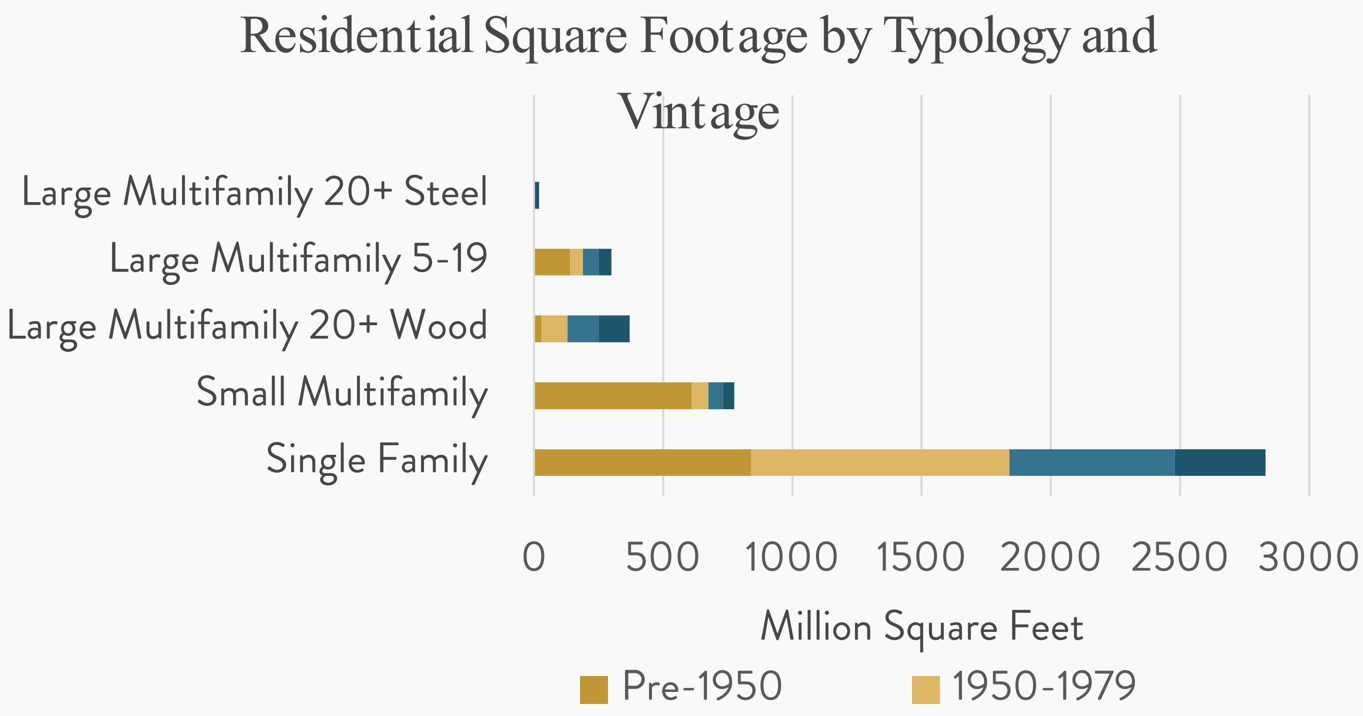
Residential Heating & Cooling	1990	2010	2015	2020	2025	2030
Gross Emissions ($MMTCO_2e$)	15.3	13.7	13.6	12.2	10.8	7.8
% Reduction (Increase) from 1990		10%	11%	20%	29%	49%

Note: GHG emissions in 2020 are based on preliminary estimates from MassDEP as of June 2022, while historical GHG emissions for years before 2020 are based on MassDEP's preliminary estimates in February 2022.

MA Clean Energy and Climate Plan for 2025 and 2030

MA Existing Building Stock as of 2016





MA Decarbonization Roadmap, Buildings Sector Report

We need to rapidly decarbonize single family homes to meet our climate goals. But how?

A Deep Energy Retrofit (DER) achieves performance on par with best-in-class new construction

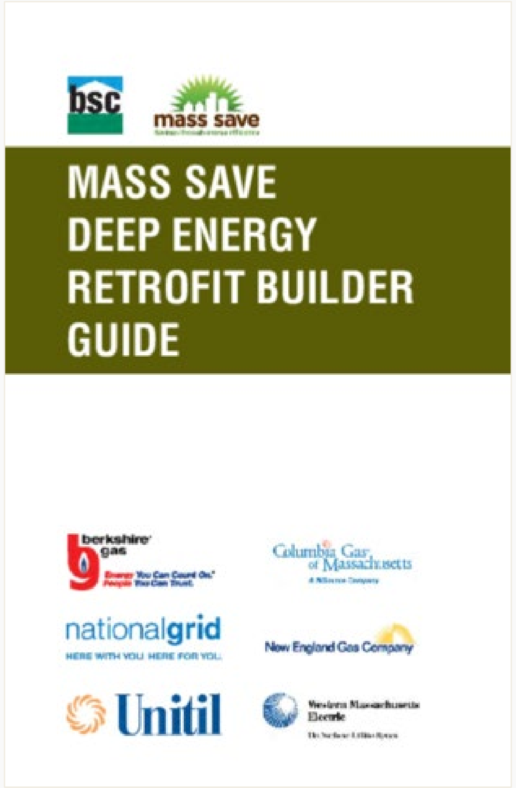
Prescriptive Standards

Enclosure

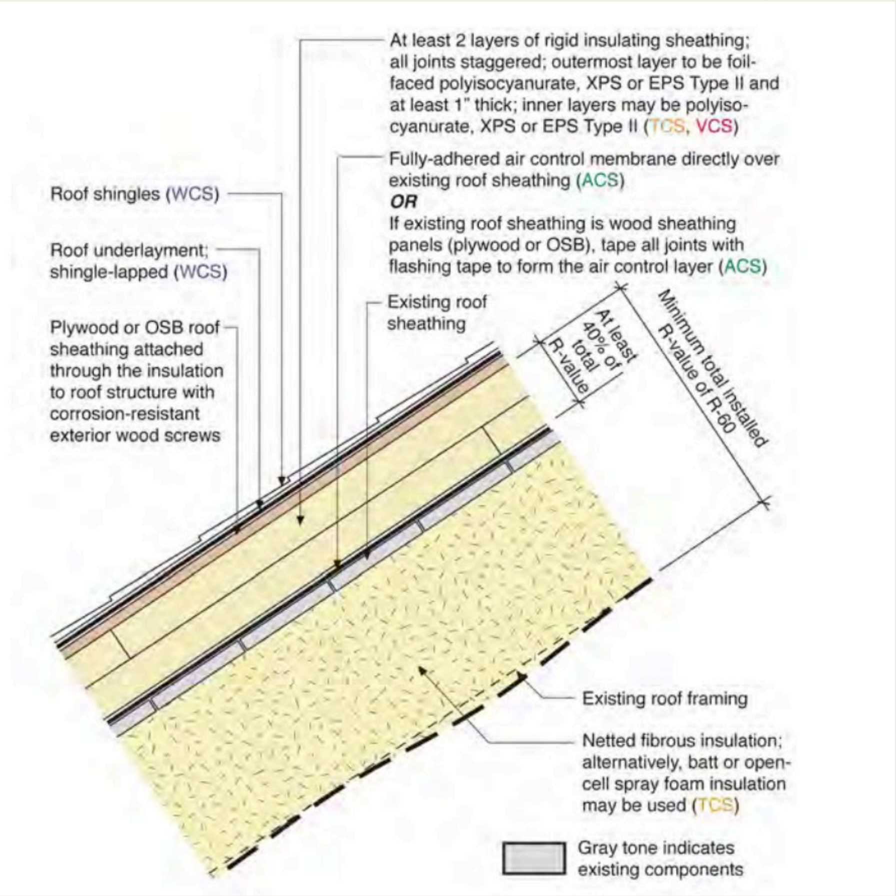
- R60 Attic/roof
- R40 Above grade walls
- R20 Foundation Walls
- R10 Slabs
- R5 Windows
- 1.5 ACH 50

HVAC

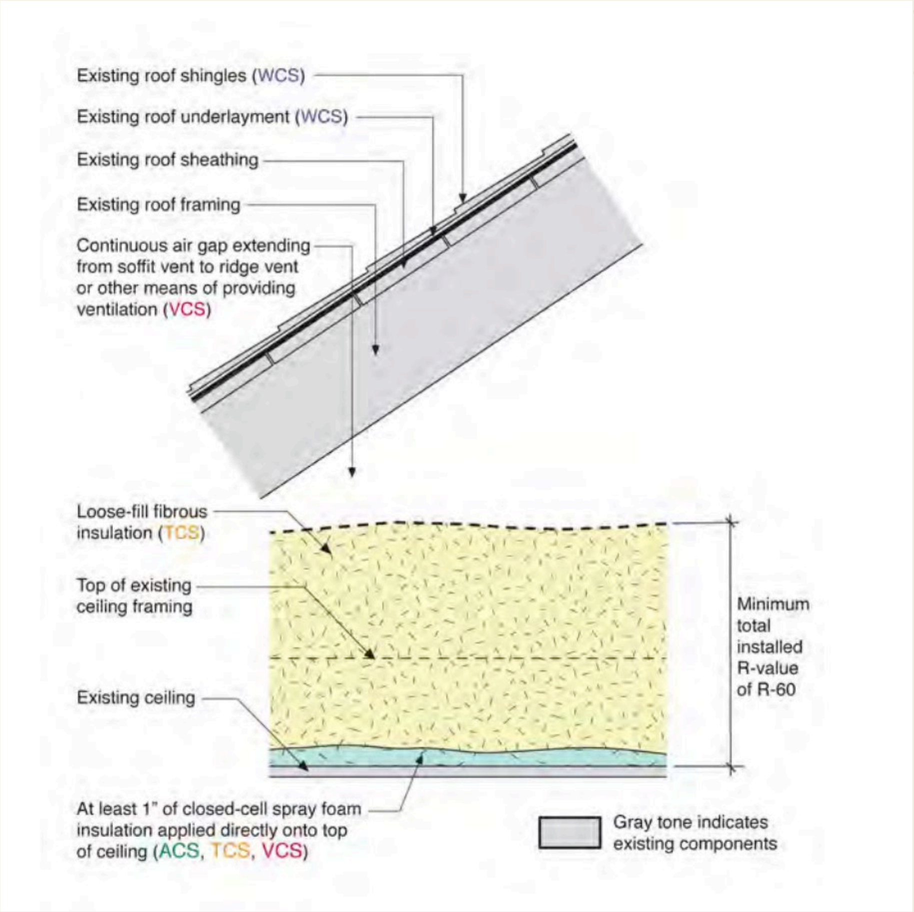
- High efficiency mechanicals
- Balanced ventilation



Typical (for us) DER Roof

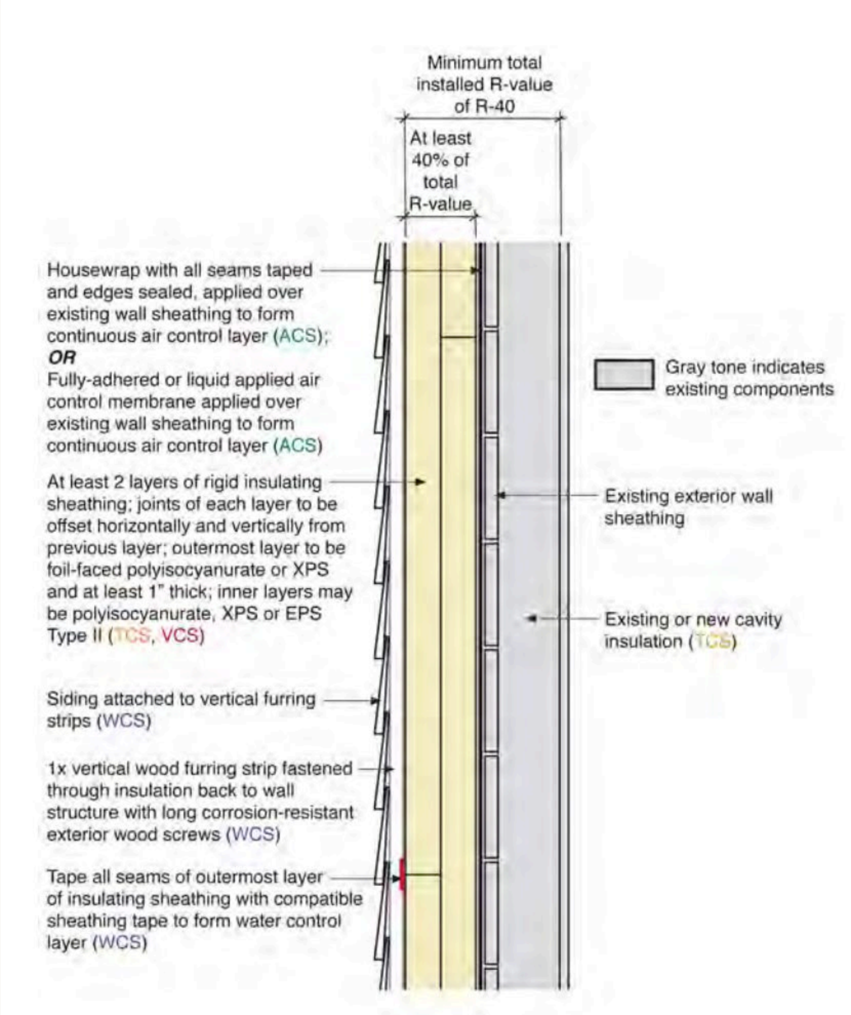


Unvented attic with exterior insulation

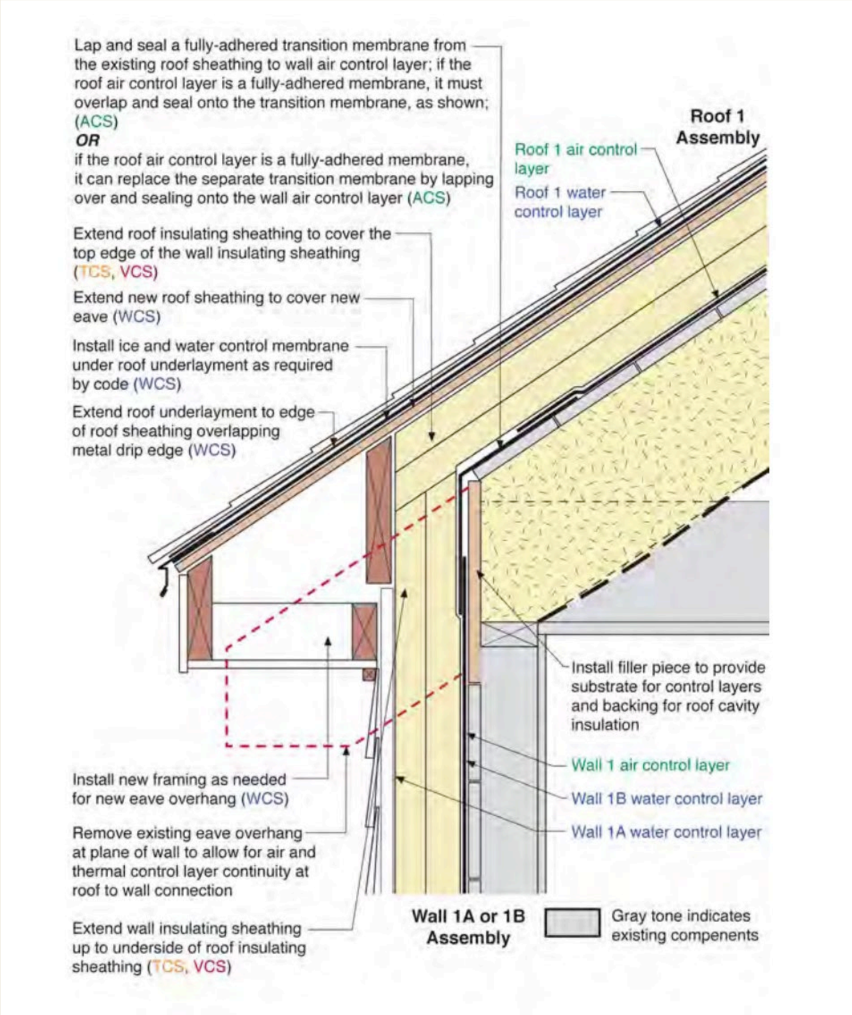


Vented attic with insulation at the floor

Typical DER Walls

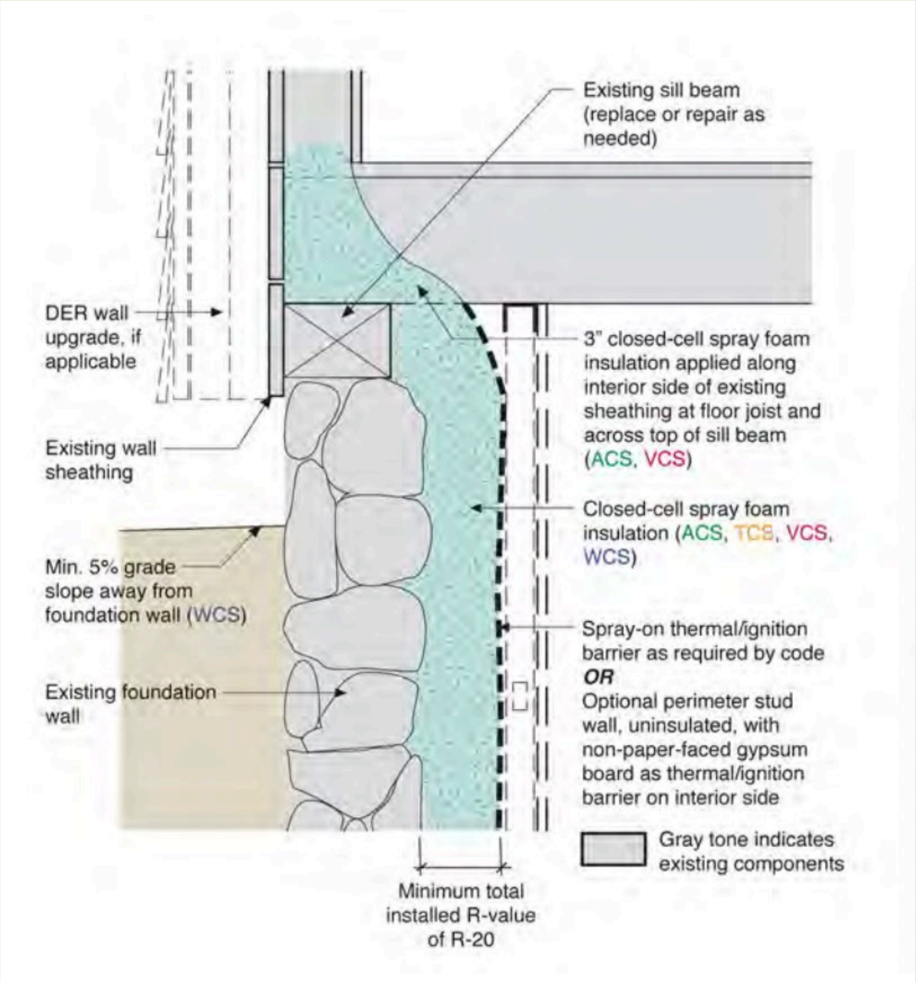


Cavity insulation and exterior insulation with seams taped

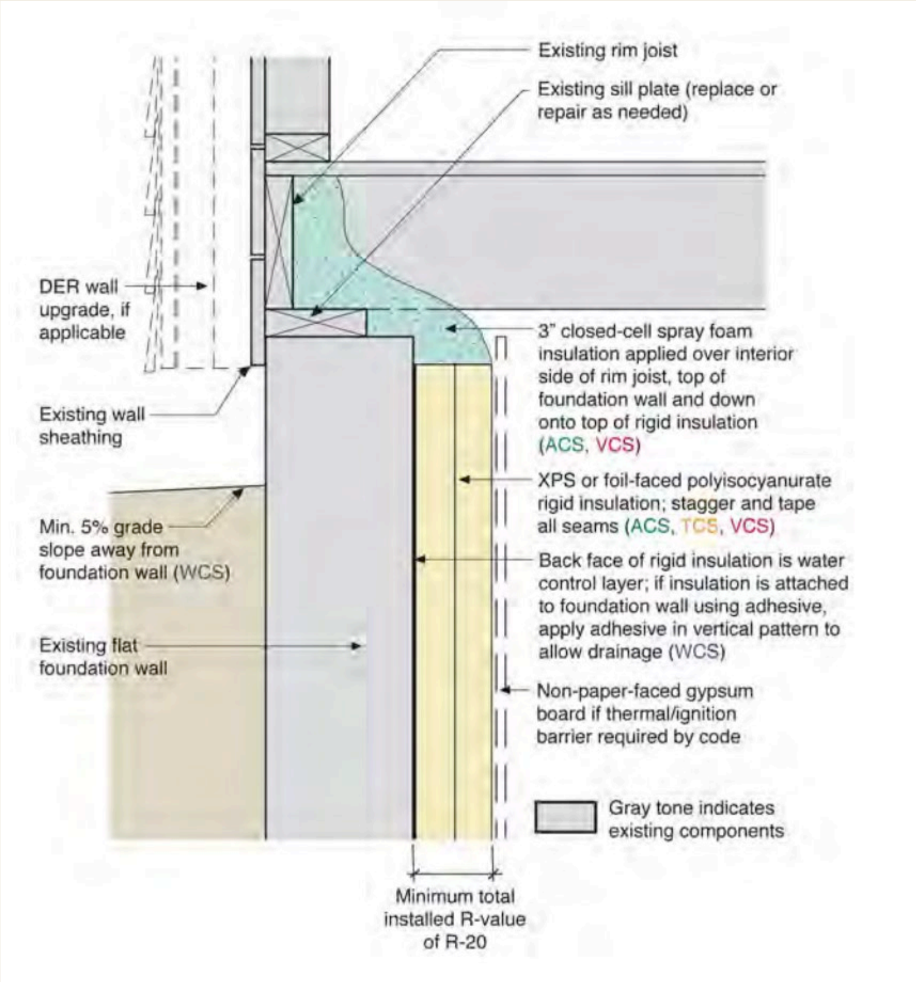


Wall to roof chainsaw eave

Typical DER Basement



Closed cell spray foam to interior



Rigid foam to interior

DER
Ramp Up

2008 ZNE Buildings Task Force

2009 DER Pilot Programs Launch

2010 Our first full DER

National Grid DER Program

- 2009-2016
- Incentive based on square footage of treated area
- $35k-$42k for whole home retrofit

2014 Net Energy Positive DER

Before

After

Net Positive DER Project Scope

Remodeling

- 1st floor kitchen and studio addition
- Kitchen and bath renovations
- Finish upgrades throughout the house

Envelope

- R60 new roof; R49 existing roof
- R40 new and existing walls
- R30 below grade walls
- R10 new slab; no insulation existing basement slab
- R5 windows everywhere except study and windows facing street (R3)

Mechanical & Solar

- 2 ducted and 1 ductless minisplit heat pumps
- Heat pump water heater
- Heat recovery ventilation.
- Woodstove
- 11 kw pv array

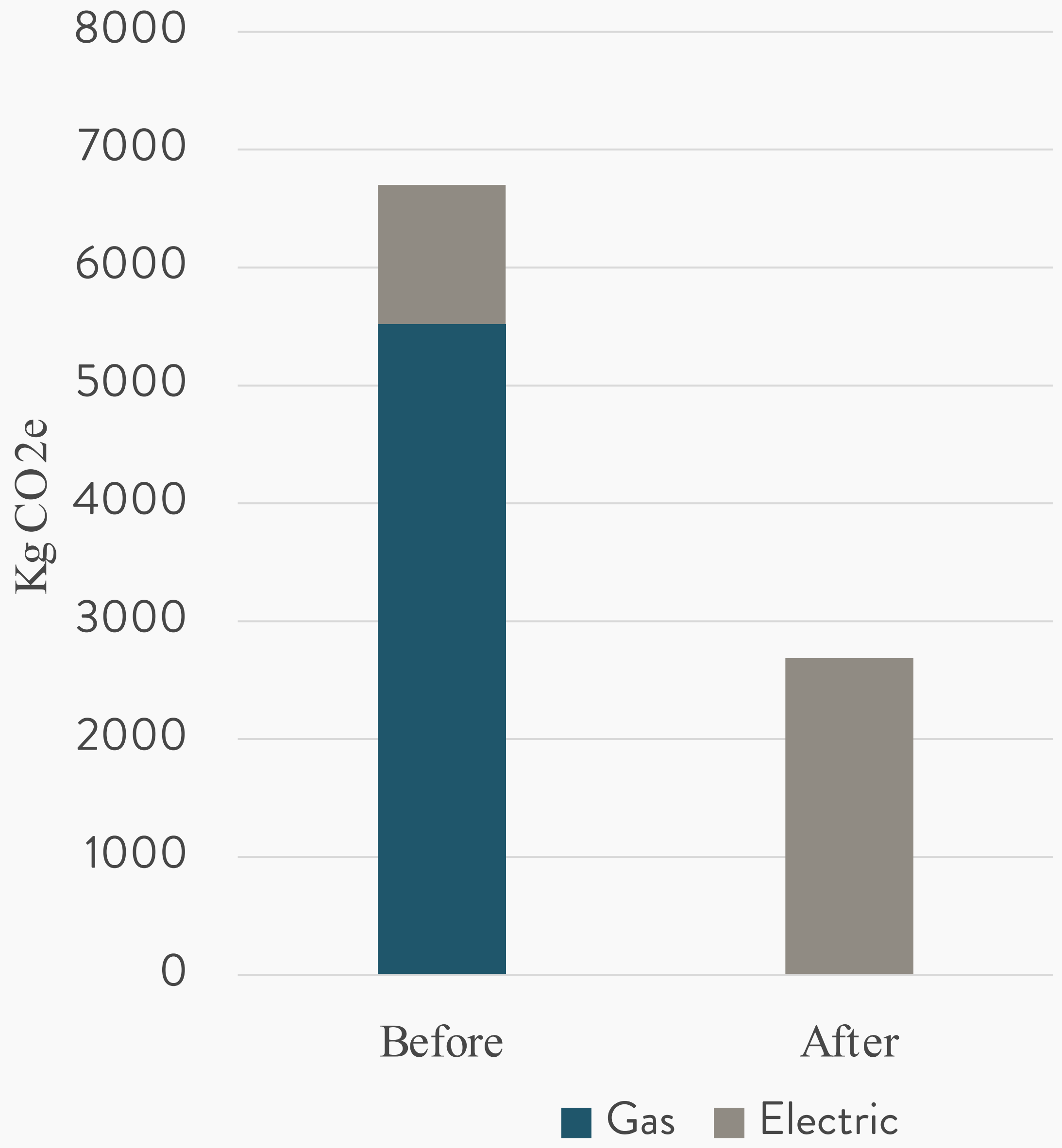

ATLAS
EnergyShield
ATLAS
EnergyShield


ATLAS

Net Positive DER Performance

	Before	After
Air Leakage	12 ACH50	1.1 ACH50
Heating Load	46 kbtu/hr	21 kbtu/hr
Annual Site Energy	118 MMBtu	29 MMBtu
Energy Use Intensity	38 kBtu/sf	6 kBtu/sf

Net Positive DER Annual Carbon

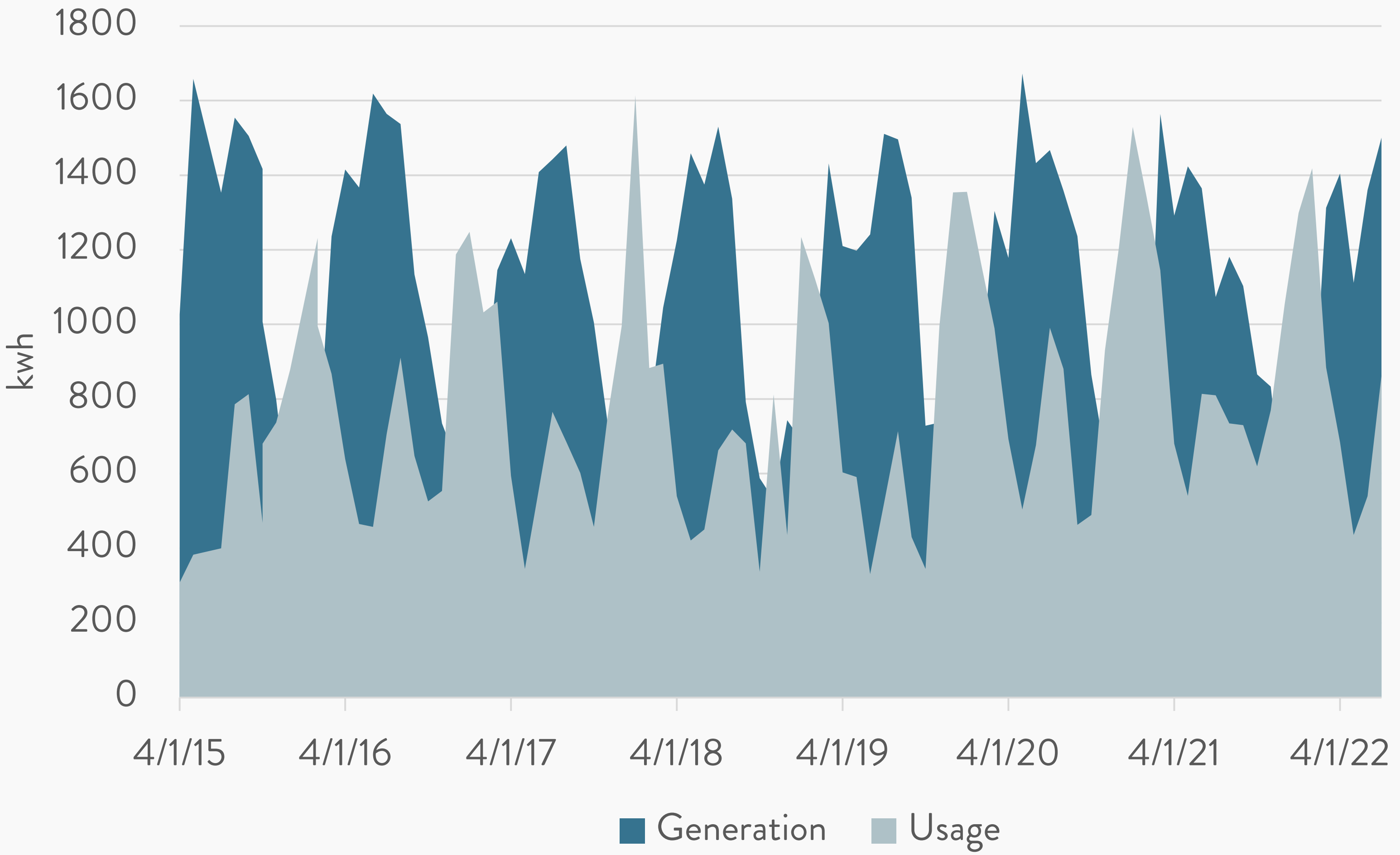


60% less carbon emitted annually

DER Net Positive Energy

39% more energy generated than consumed

Credit of ~$5k with utility



DER Wind Down

2016 National Grid DER Program ends

2017 Our last DER (full or partial)

2017 Our first all-electric moderate retrofit

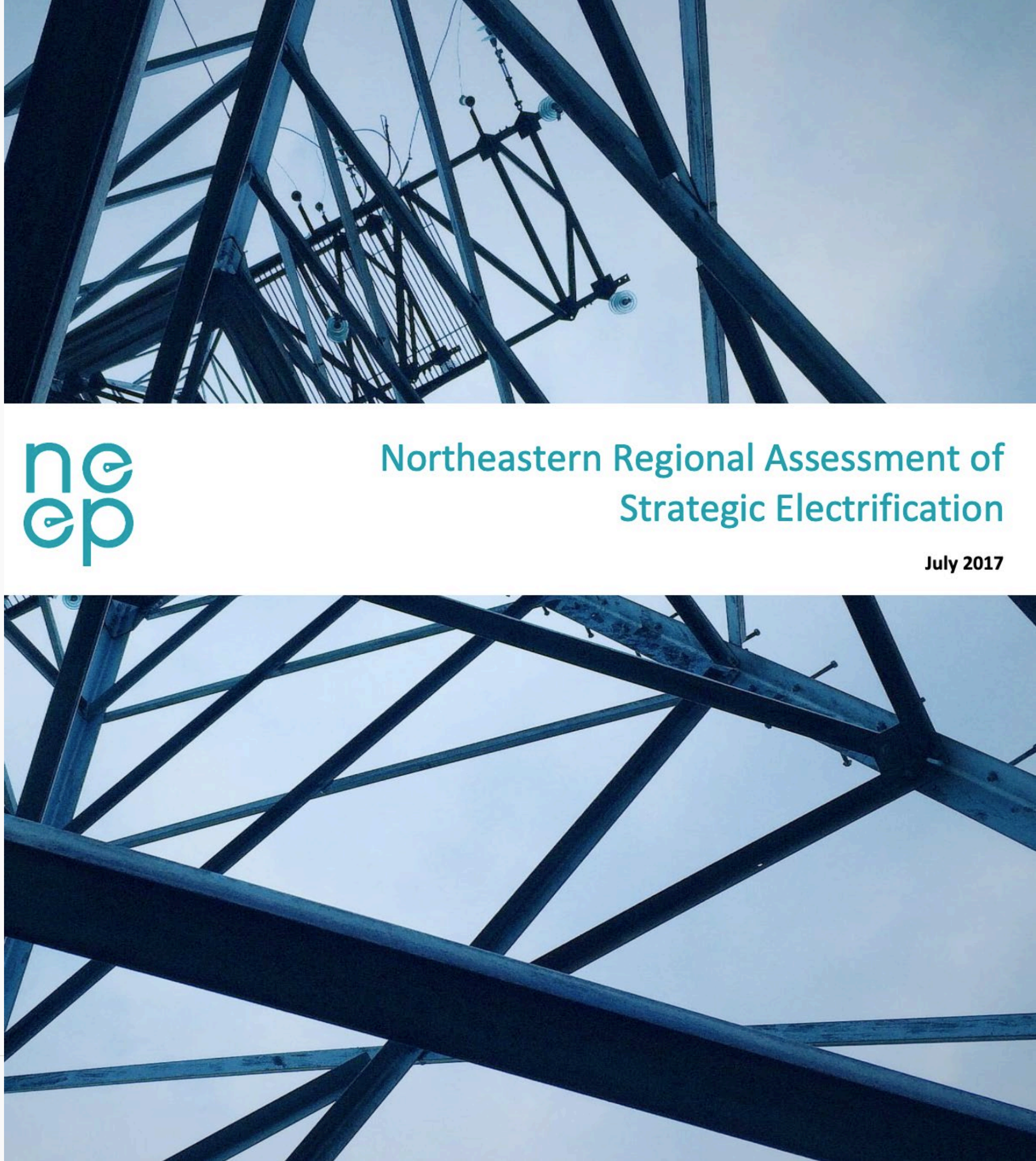
High Cost and Waste

- Roof outsulation ~ 1.5-2x the cost of insulation (not including new roof)
- Wall outsulation ~ 3-4x the cost of insulation (not including new siding)
- Discarding material with years, sometimes decades, of usable life

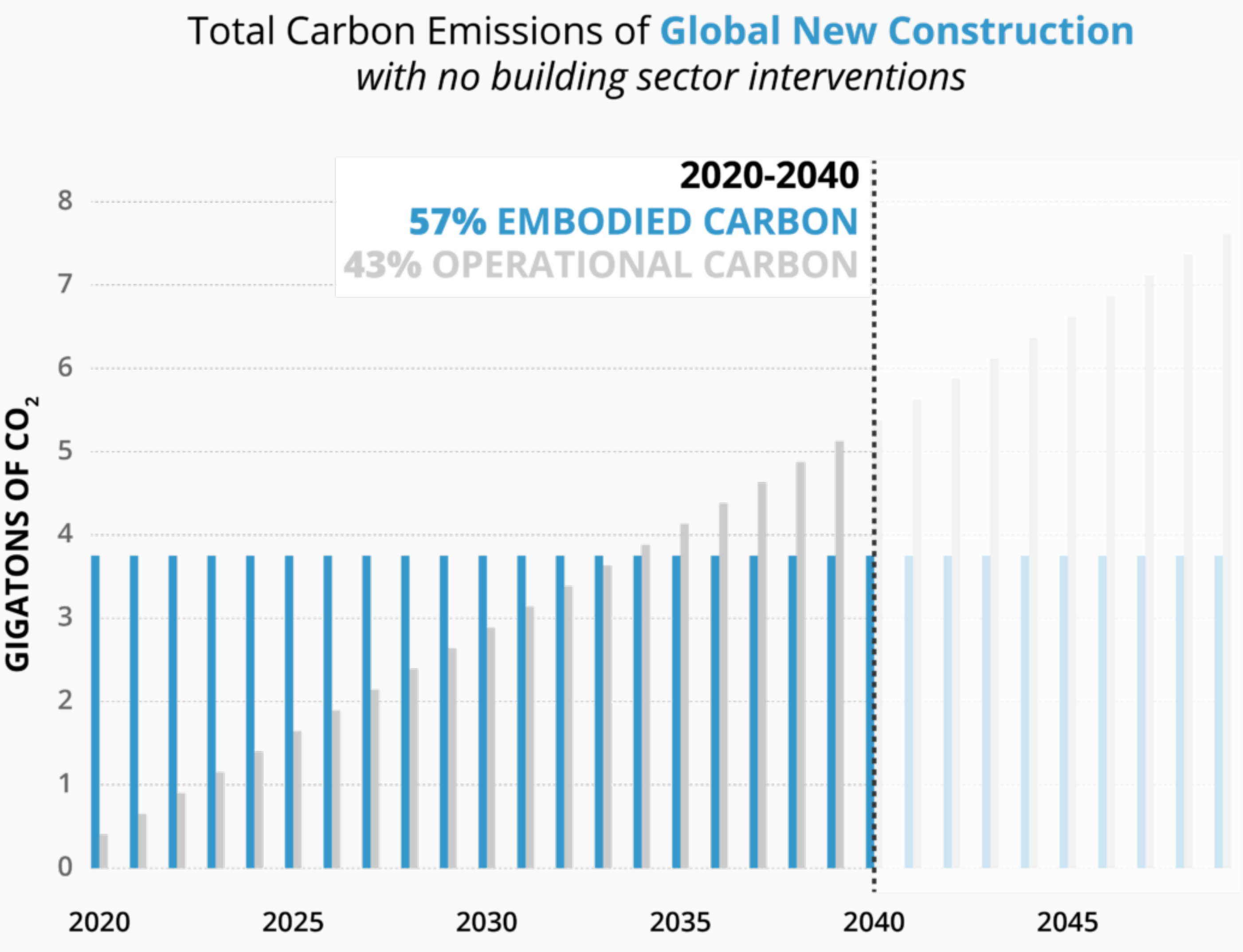
Electrification priority

To date, state and market actions that reduce GHG emissions have focused on the electric supply sector and on increasing energy efficiency….

Reducing emissions to 80% will require adding a third strategy: Move end uses to electricity.



Upfront Carbon



Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

To hold true to our commitment to address climate change, we would need to reconsider our approach.

Moderate Energy Retrofit 2019

Moderate Retrofit Project Scope

Remodeling

- Kitchen, dining room and living room renovation
- Replacement of powder room with full bathroom
- Deck addition

Envelope

- R49 roof
- R13 or 20 above grade walls
- R13 foundation walls
- No slab insulation
- 40% of windows replaced

Mechanical & Solar

- 2:1 ducted minisplit heat pumps
- Heat pump water heater
- Continuous exhaust ventilation
- No solar PV

After

Before

Before

After

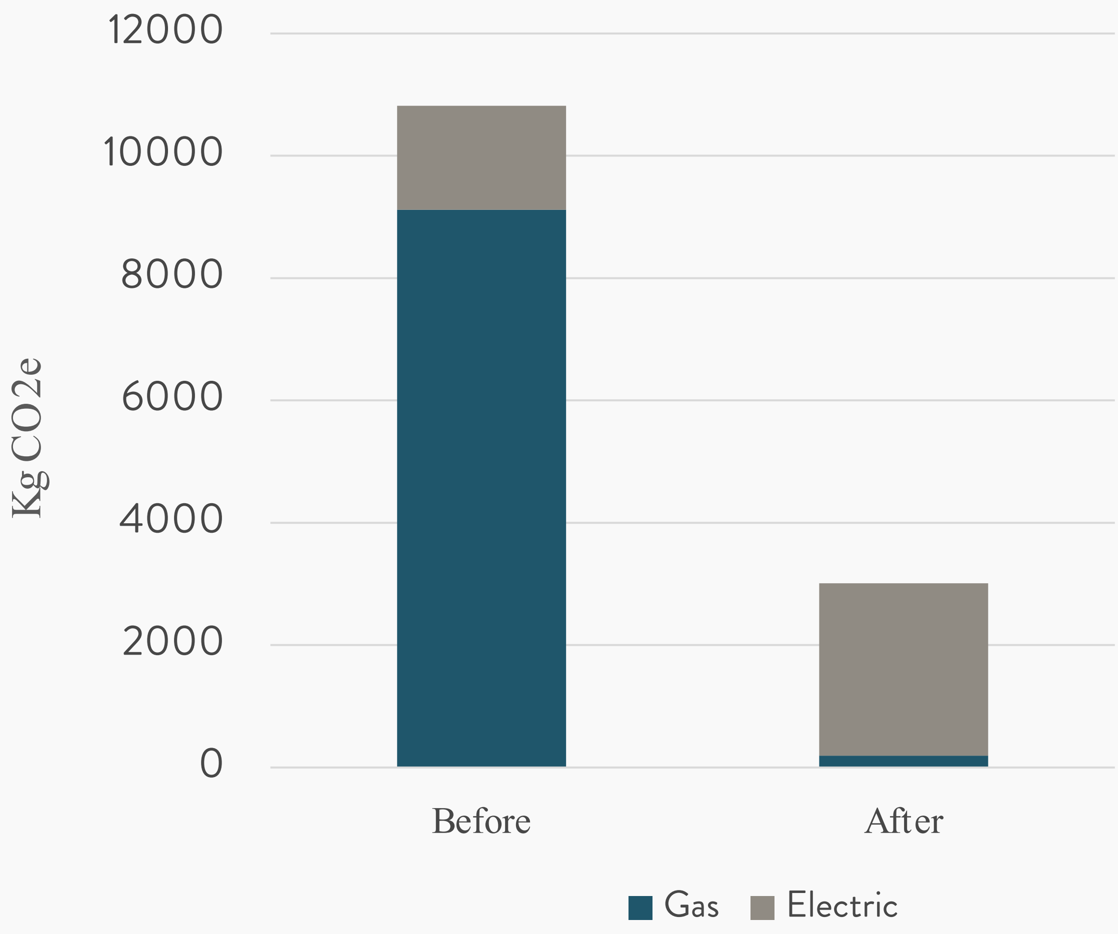
Before

After

Moderate Retrofit Performance

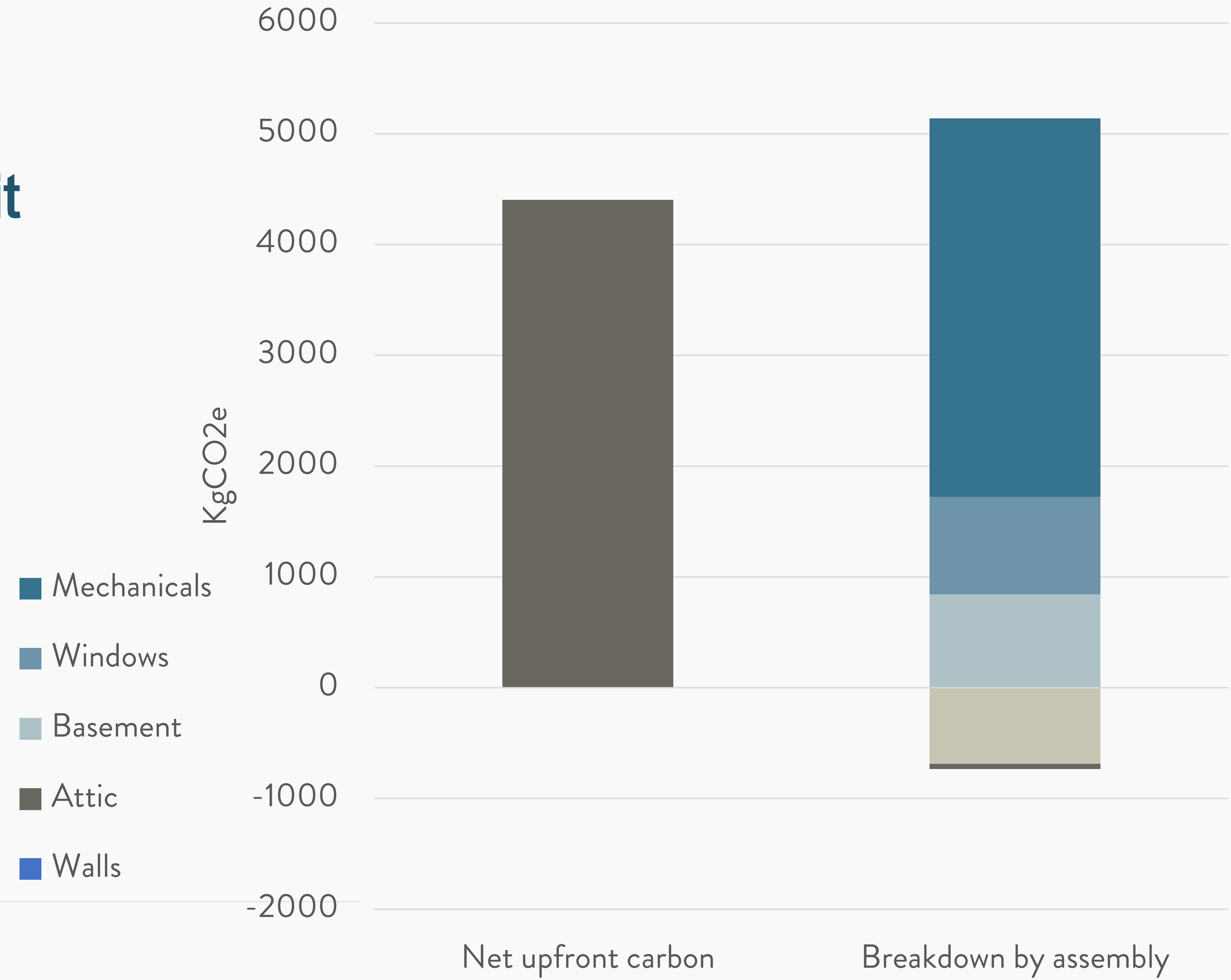
	Before	After
Air Leakage	13.5 ACH50	4.9 ACH50
Heating Load	67 kbtu/hr	32 kbtu/hr
Annual Site Energy	195 Mbtu	42 Mbtu
Energy Use Intensity	85 kBtu/sf	18 kBtu/sf

Moderate Retrofit Annual Carbon

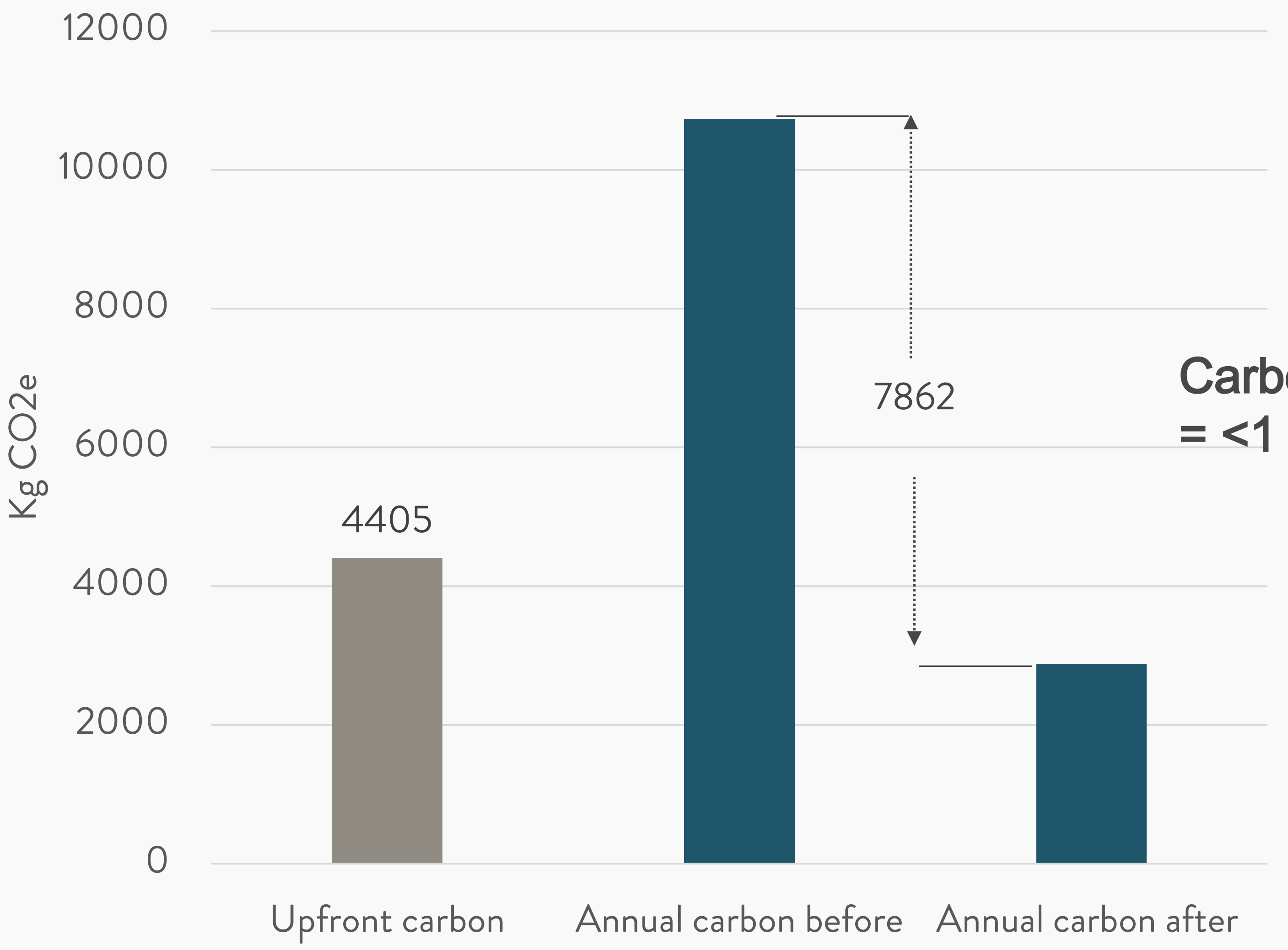


74% less carbon emitted annually

Moderate Retrofit Upfront Carbon

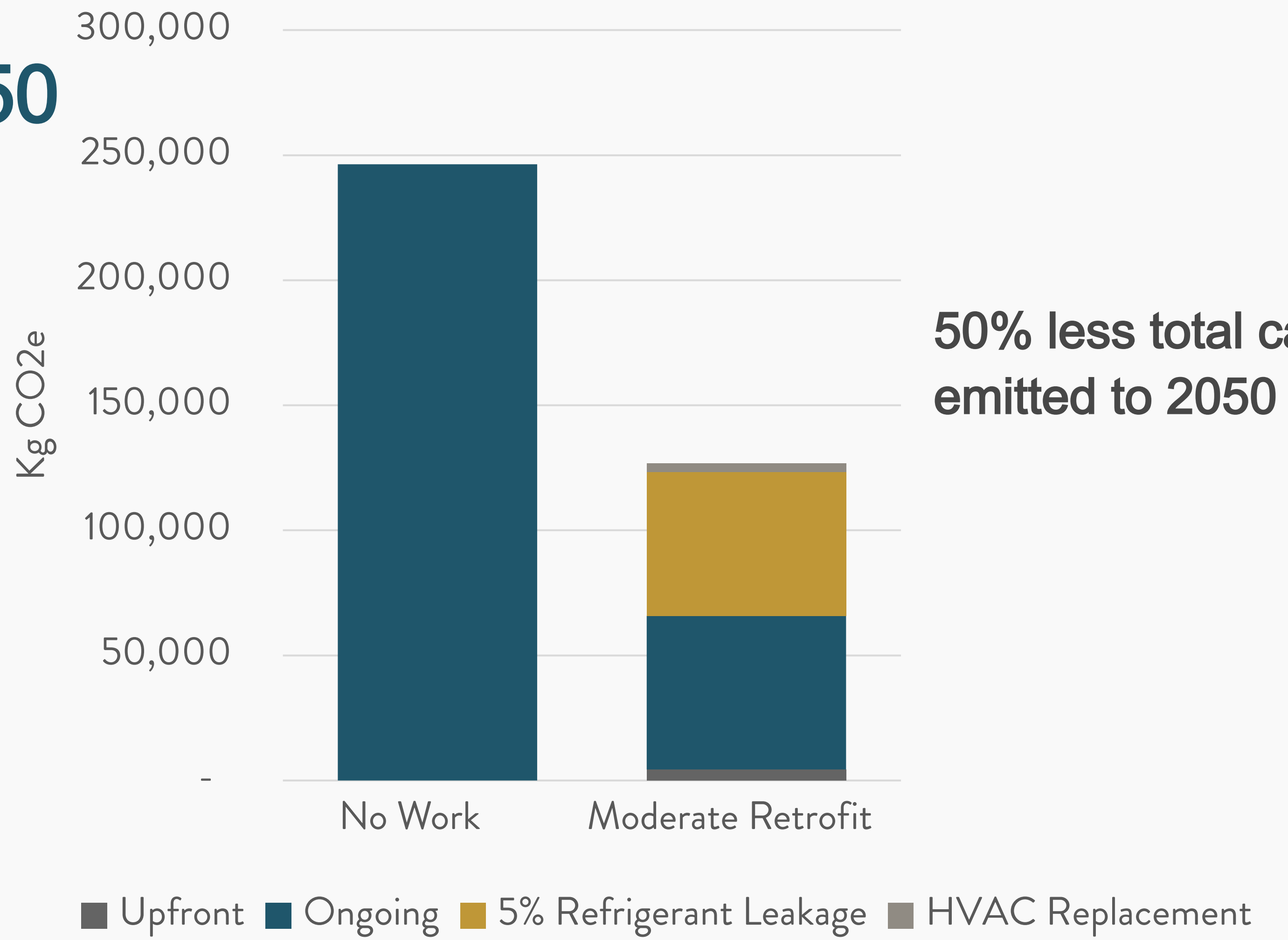


Moderate Retrofit Carbon Payback



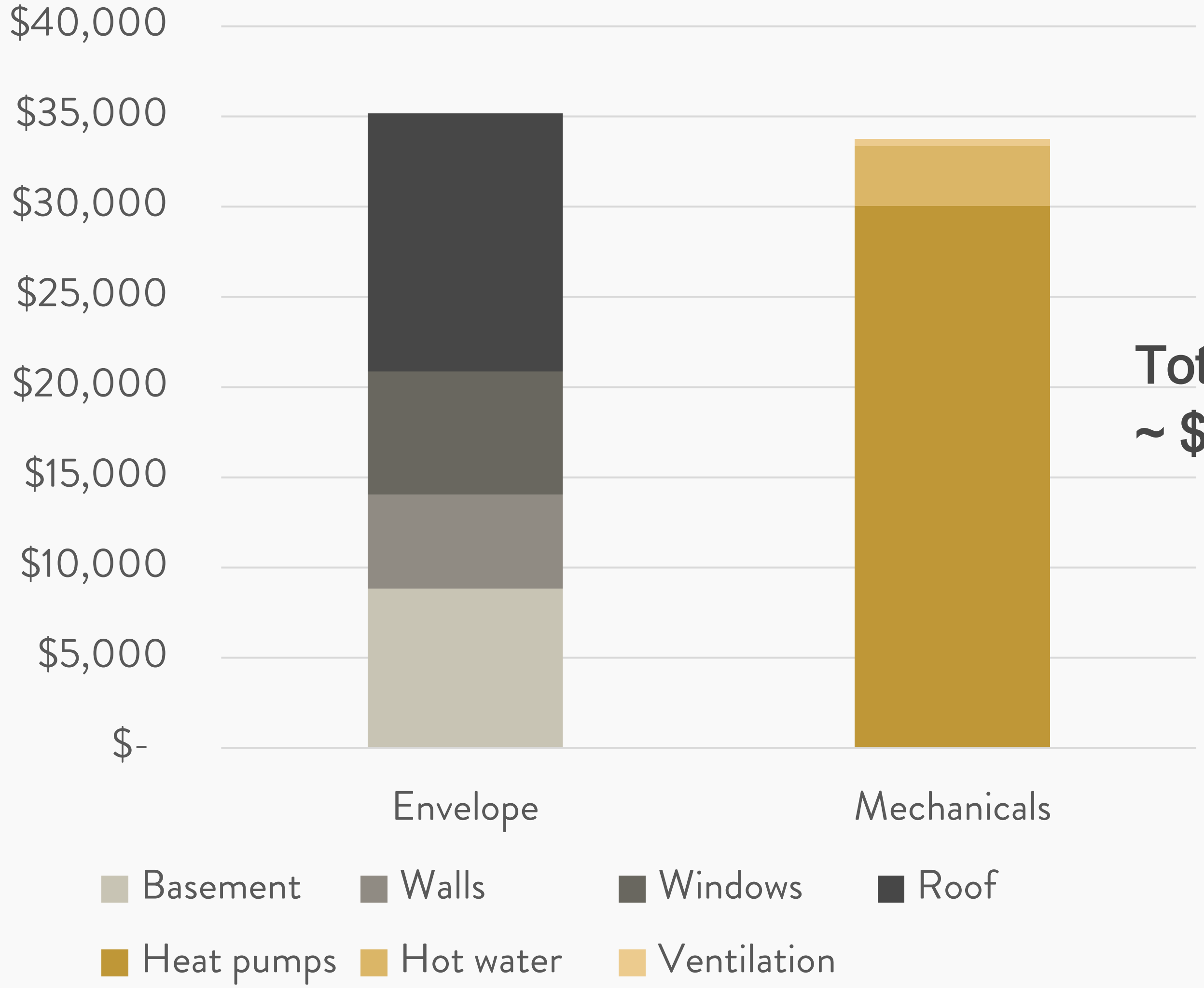
Carbon payback = <1 year

Moderate Retrofit Total Carbon Emissions to 2050



50% less total carbon emitted to 2050

Moderate Retrofit Direct Cost Breakdown



Total direct cost ~ $69,0000

Home MVP Pilot Program

Based on the current list of recommendations, this project **may qualify** for an estimated incentive of

$ 24,535.00

	NOW	GOAL	SAVED	SAVED %
Whole House MMBTU (excluding new PV)	226	60	166	73

	MMBTU SAVED BY TIER	$/MMBTU	TOTAL
1st Tier - % Savings of Base (5% - 20%)	45	125	$ 5,625.00
2nd Tier - % Savings of Base (20% - 40%)	45	150	$ 6,750.00
3rd Tier - % Savings of Base (>40%)	76	160	$ 12,160.00
New Solar PV Install	0	15	$ 0
		Grand Total Incentive	**$ 24,535.00**

DER Scenarios Compared to Moderate Retrofit

DER Scenarios

High Upfront Carbon

- 3” spray foam on basement walls (R20)
- Cellulose in wall cavities + 4” polyisocyanurate (R40)
- Triple paned windows
- Cellulose in 10” roof cavities (built-down) + 4” polyiso (R60)
- 2:1 ducted heat pump & ERV

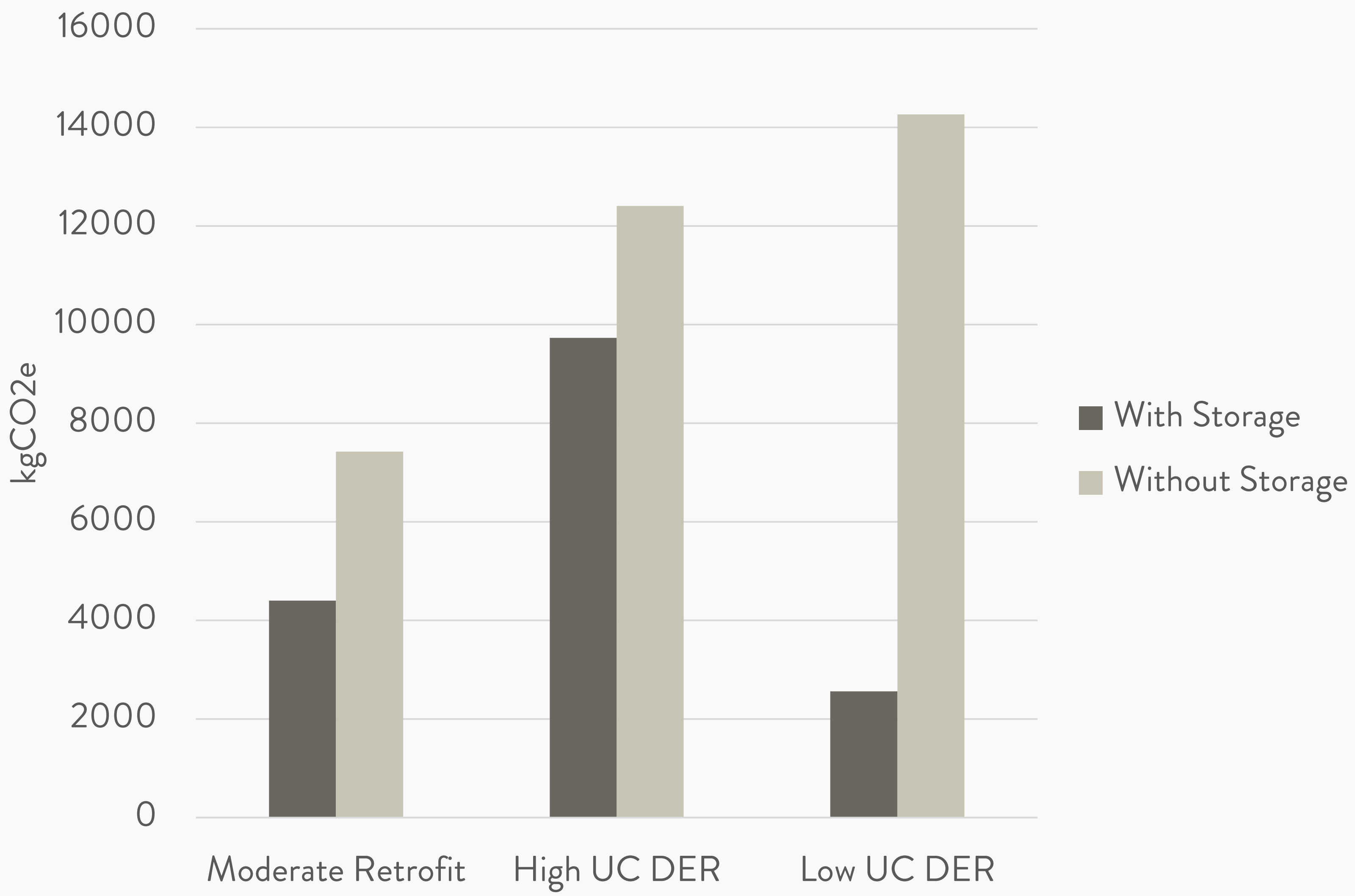
Low Upfront Carbon

- 3” spray foam on basement walls (R20)
- Cellulose in wall cavities + 7” wood fiberboard (R40)
- Triple paned windows
- Cellulose in 10” roof cavities (built-down) + 7” wood fiber board (R60)
- 2:1 ducted heat pump & ERV

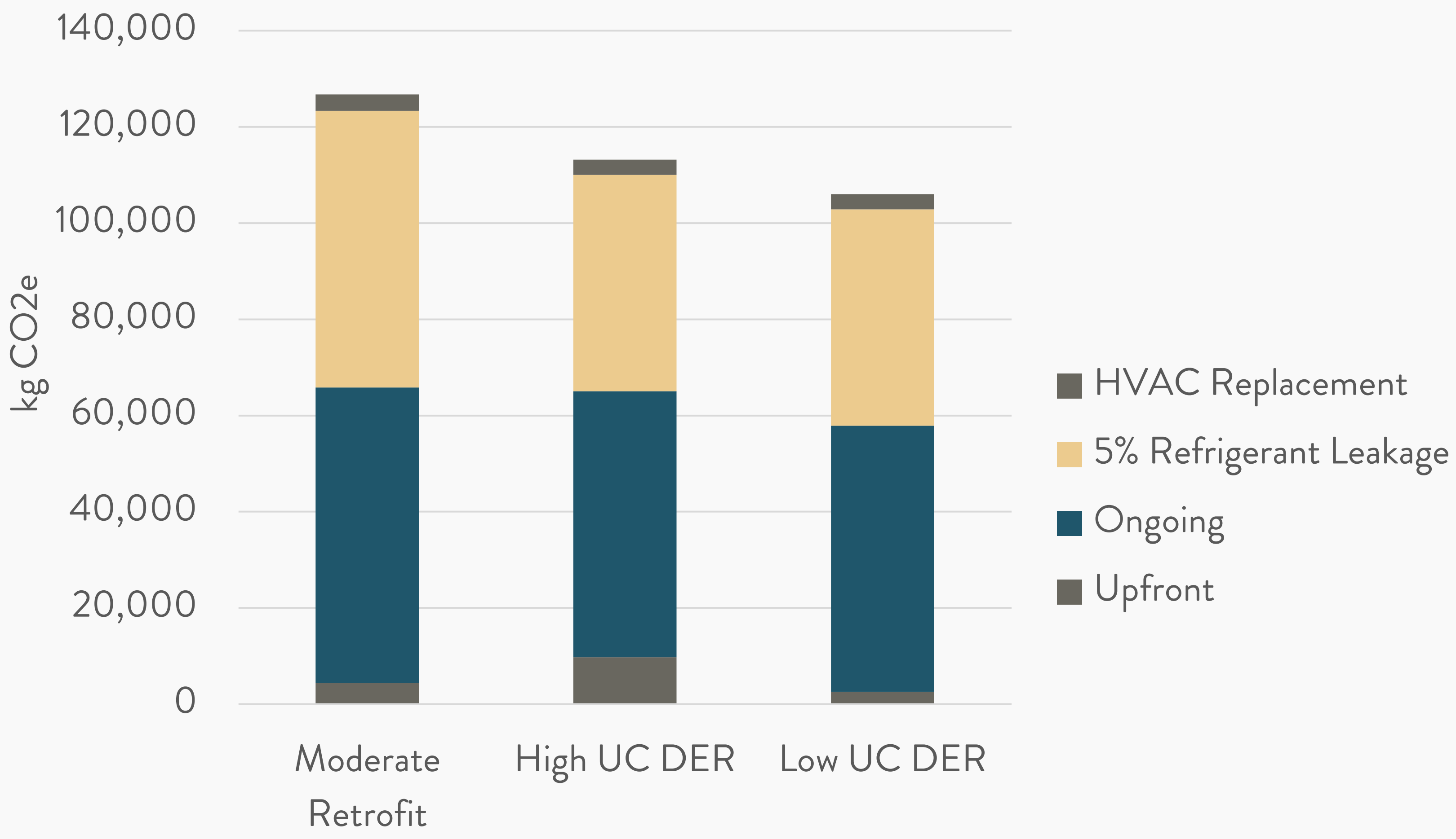
Performance of Retrofit Scenarios

	No Work	Moderate Retrofit	Hypothetical DER (High or Low EC)
Air Leakage	13.5 ACH50	4.9 ACH50	1.0 ACH50
Heating Load	67 kbtu/hr	32 kbtu/hr	13 kbtu/hr
Annual Site Energy	195 Mbtu	42 Mbtu	36 Mbtu
Energy Use Intensity	85 kBtu/sf	18 kBtu/sf	16 kBtu/sf

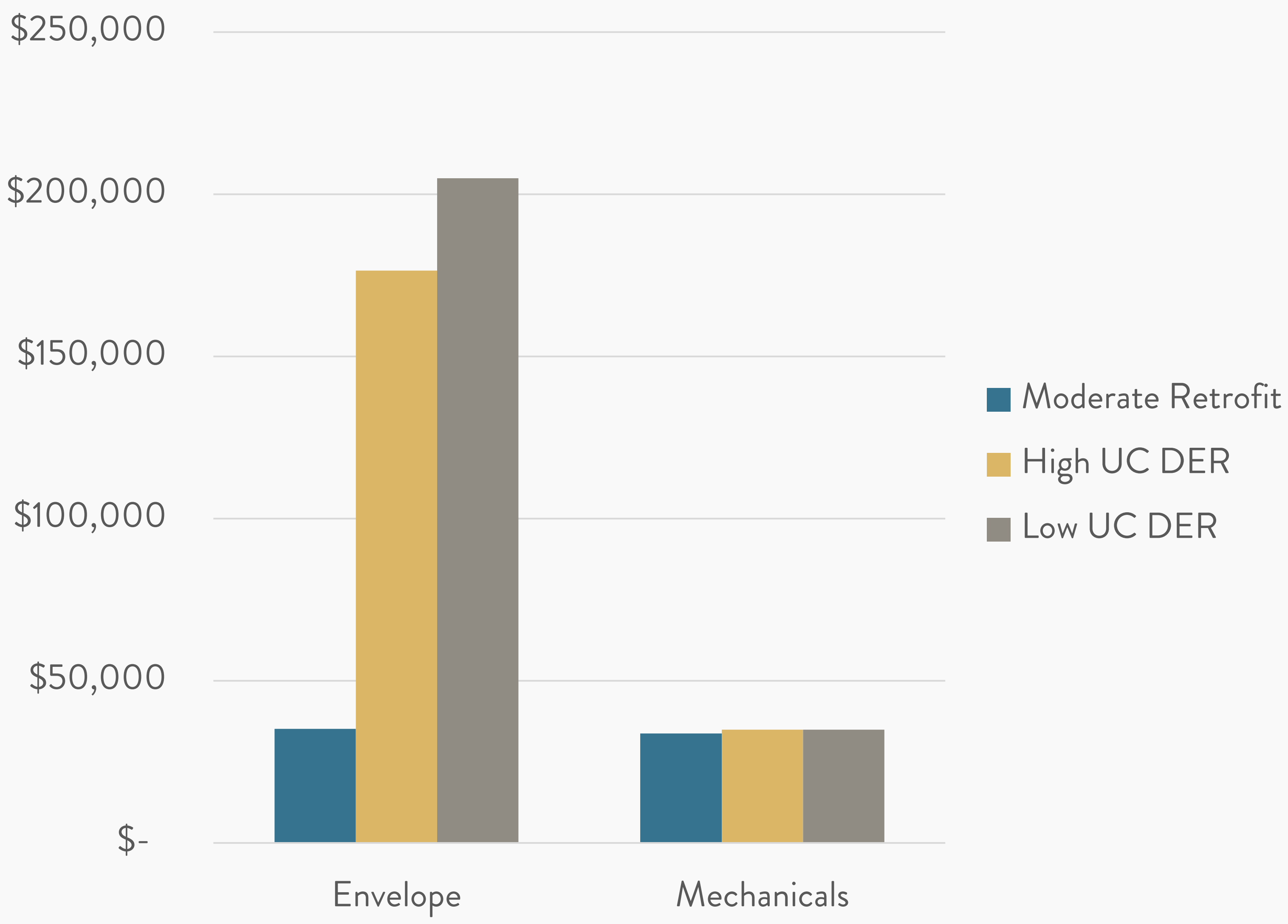
Upfront Carbon



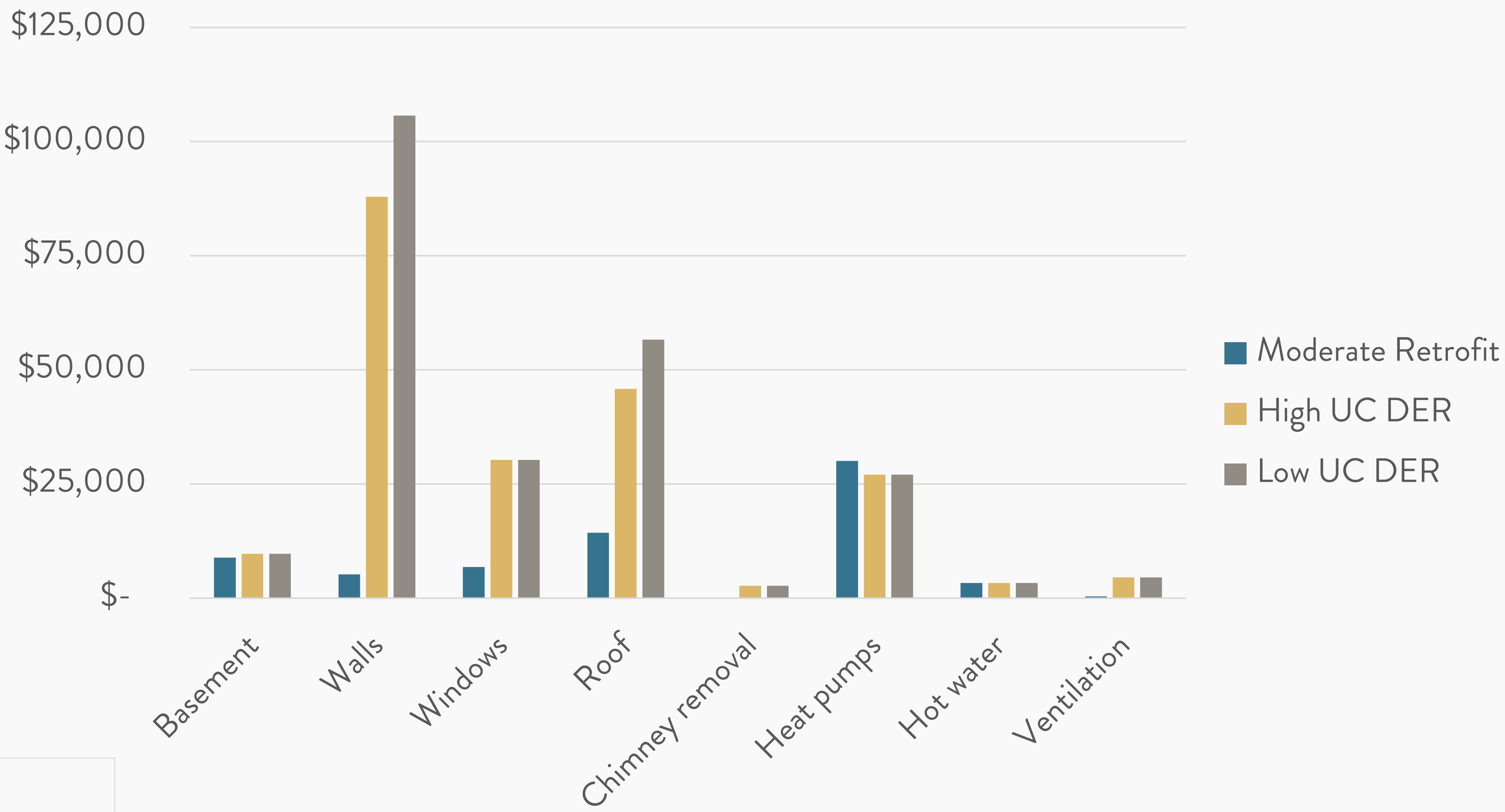
Total Carbon Emissions to 2050



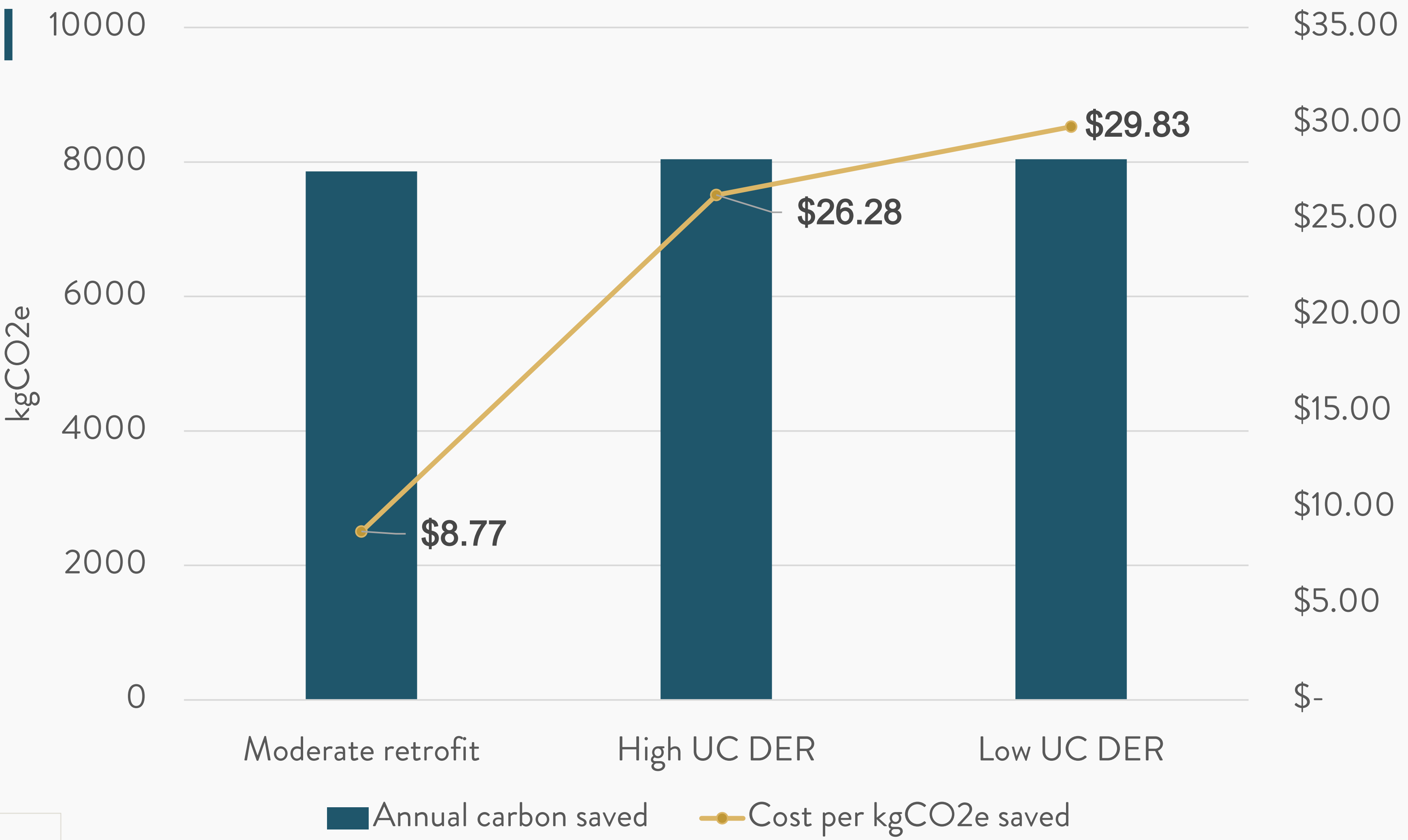
Hard Costs


$250,000
$200,000
$150,000
$100,000
$50,000
$-
Envelope
Mechanicals
Moderate Retrofit
High UC DER
Low UC DER

Hard Costs Breakdown

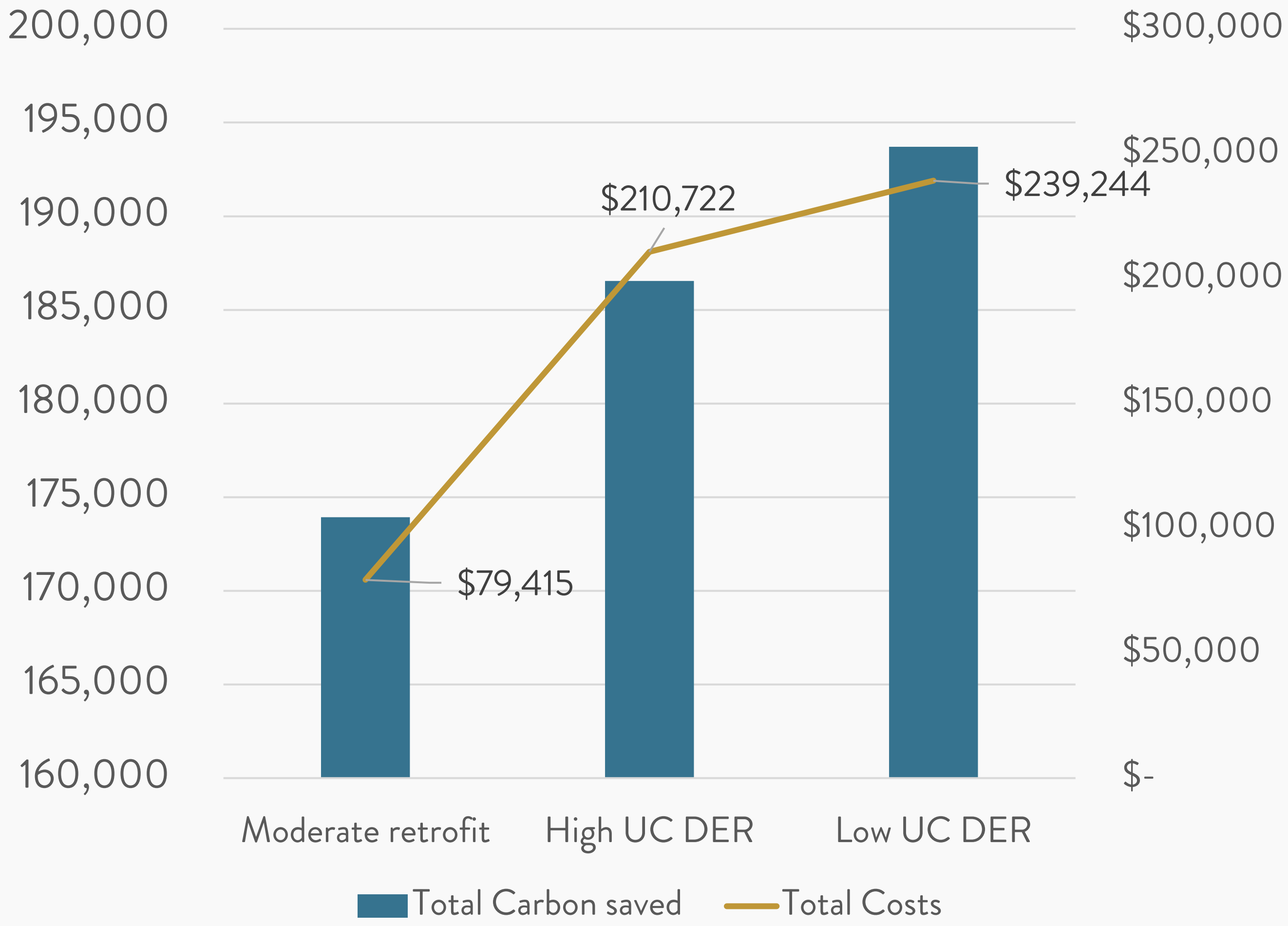


Cost of annual carbon saved (year one)



Total Costs Compared to Total Carbon Saved to 2050

	Cost per kgCO2e saved
Moderate Retrofit	$.46
High UC DER	$1.13
Low UC DER	$1.24



Deep energy retrofits are not (currently) a cost-effective carbon emissions reduction strategy for single family homes.

Key Takeaways

- Fixing existing single-family homes is not a sideshow. What we do, how we do it and how quickly has a big impact on whether we meet our climate goals.

- We are skeptical of any program that would prioritize exterior insulation of existing homes over electrification or would make exterior insulation a precondition of electrification.

- For now, we think all-electric moderate retrofits are where Byggmeister can have the most impact, but if experience or data indicate otherwise, we stand ready to pivot (again).

Things that keep us up at night

- Refrigerant leaks have the potential to turn building electrification from a winning climate strategy into a losing climate strategy (ask us how we know..)
- Will the grid decarbonize and modernize quickly enough to meet the increased demand?
- Is it even feasible to scale “moderate” retrofits given how expensive they still are?
- More broadly, is there *any* practical and scalable solution for existing homes that can be deployed quickly enough to meet our emissions reduction goals?

Interested in continuing the conversation?
Please join us an open discussion in Marina 3-4 at 4:00

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Sources and credits

Upfront Carbon

- BEAM Estimator, Builders for Climate Action
- Operational & Embodied Carbon Emissions Estimator (BETA), Skylar Swinford, Energy Systems Consultants

Operational Carbon

- Long Run Marginal Emissions Rates for Electricity – Workbooks for 2022 Cambium Data, NREL
- Emissions & Generation Resource Integrated Database (eGRID), EPA

Energy savings

- Measured savings: Normalized annual consumption spreadsheet (in-house tool), developed by Bruce Harley, Bruce Harley Energy Consulting
- Modeled savings: Snuggpro

Construction costs

- Cost estimation spreadsheet (in-house tool), developed by Byggmeister Founder Paul Eldrenkamp and Byggmeister Estimator Cador Pricejones