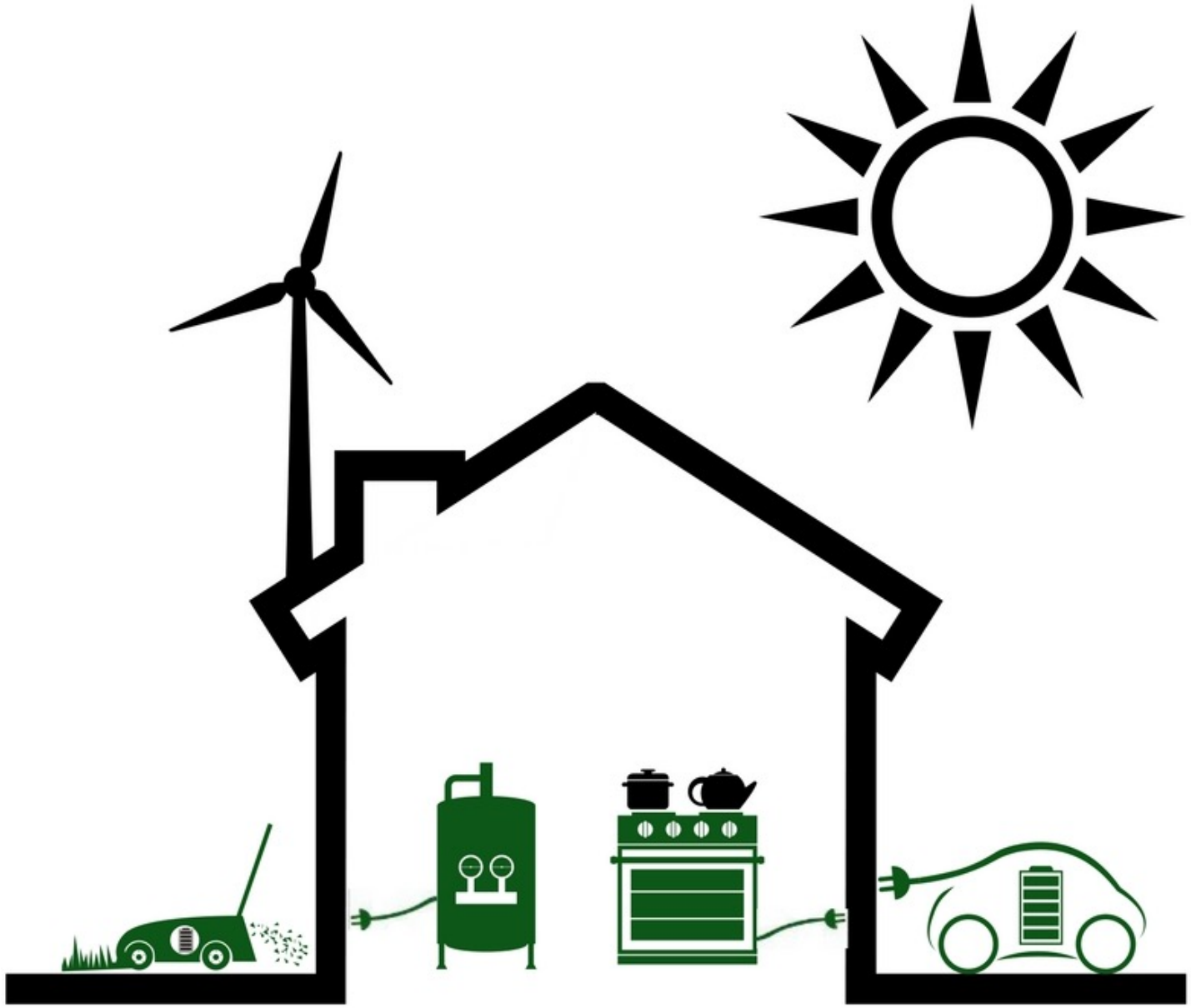

GHG EMISSION REDUCTIONS AND ASSOCIATED COST OF ELECTRIC HEAT PUMP CONVERSIONS VERSUS INCREASING BIOBLENDS

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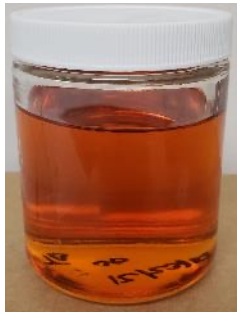
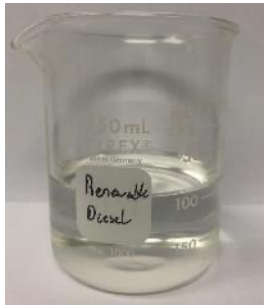
NATIONAL OILHEAT RESEARCH ALLIANCE RESEARCH

Range of Biofuels

	Petroleum No. 2 Fuel Oil	Biodiesel	Renewable Diesel (HVO)	EL[1]
C (w%)	86.8	75.8	85.0	58.3
H (w%)	13.2	12.6	15.0	8.3
O (w%)	0	11.6	0	33.3
HHV[2] (Btu/gal)	138,300	125,300	132,800	95,508
Density (lb/gal)	7.09	7.34	6.51	8.47
Water Vapor Saturation[3] (F)	120	121	121	121





1. Ethyl Levulinate
2. Higher Heating Value
3. Saturation temperature of flue gas water vapor at 30% excess air

Research Study and Multi-Variant Calculator Development

This presentation presents results from a residential heating multivariant analysis tool converting oil heated homes through several carbon reduction pathways through 2050:

- Increasing biodiesel blends
- More efficient bioblend fueled boilers
- Bioblend fueled thermal heat pump
- Electrification with air-source electric heat pumps with electric backup heating

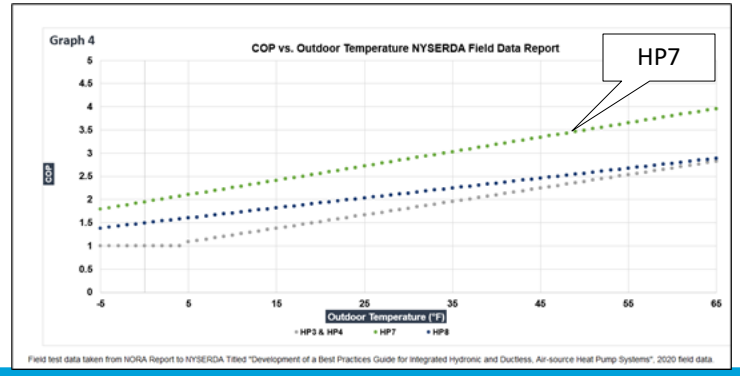
The Purpose of the model is to understand the cost and benefit of these pathways to the future.

Model Results Background

- Using Bangor, ME Weather Data
- Using current Maine oil heated homes as baseline (344,869 homes)
- All emissions data are from U.S. DOE Argon National Laboratory Argonne National Laboratory GREET Model Calculations, Using December 2020 Version
- All electric heat pump performance curves are from NYSERDA report titled “Development of a Best Practices Guide for Integrated Hydronic and Ductless, Air-source Heat Pump Systems” using 2020 field data.
- Electric heat pump conversion cost estimates are from current HVAC contractors consensus findings.
- This model does not include the impact of water heating

Main Variables

City:	Bangor, ME
Global Warming Atmospheric Lifetime:	20 Year Lifetime-AR5
Biodiesel Feedstock:	Average Bioblend of Feedstocks
Average Liquid Fueled Efficiency:	78%
Seasonal Liquid Fueled Non-Condensing Boiler Efficiency:	86%
Seasonal Liquid Fueled Condensing Boiler Efficiency:	95%
Liquid Fuel and Boiler Conversions Starting in 2023:	5%
Seasonal Liquid Fueled Thermal Heat Pump Efficiency:	125%
Liquid Fueled Thermal Heat Pump Conversions Starting in 2025:	5%
Electric Heat Pump (EHP) Performance Curve:	HP7
Annual Home Heating Load (MMBtu):	100
Total Number of Existing Oil Heated Homes to be Assessed:	344,869
Percentage of Existing Liquid Fueled Homes to be Converted Annually to Heat Pumps Starting in 2023:	5%
Annual Number of Annual Home Conversions to Electric Heat Pumps:	17,243



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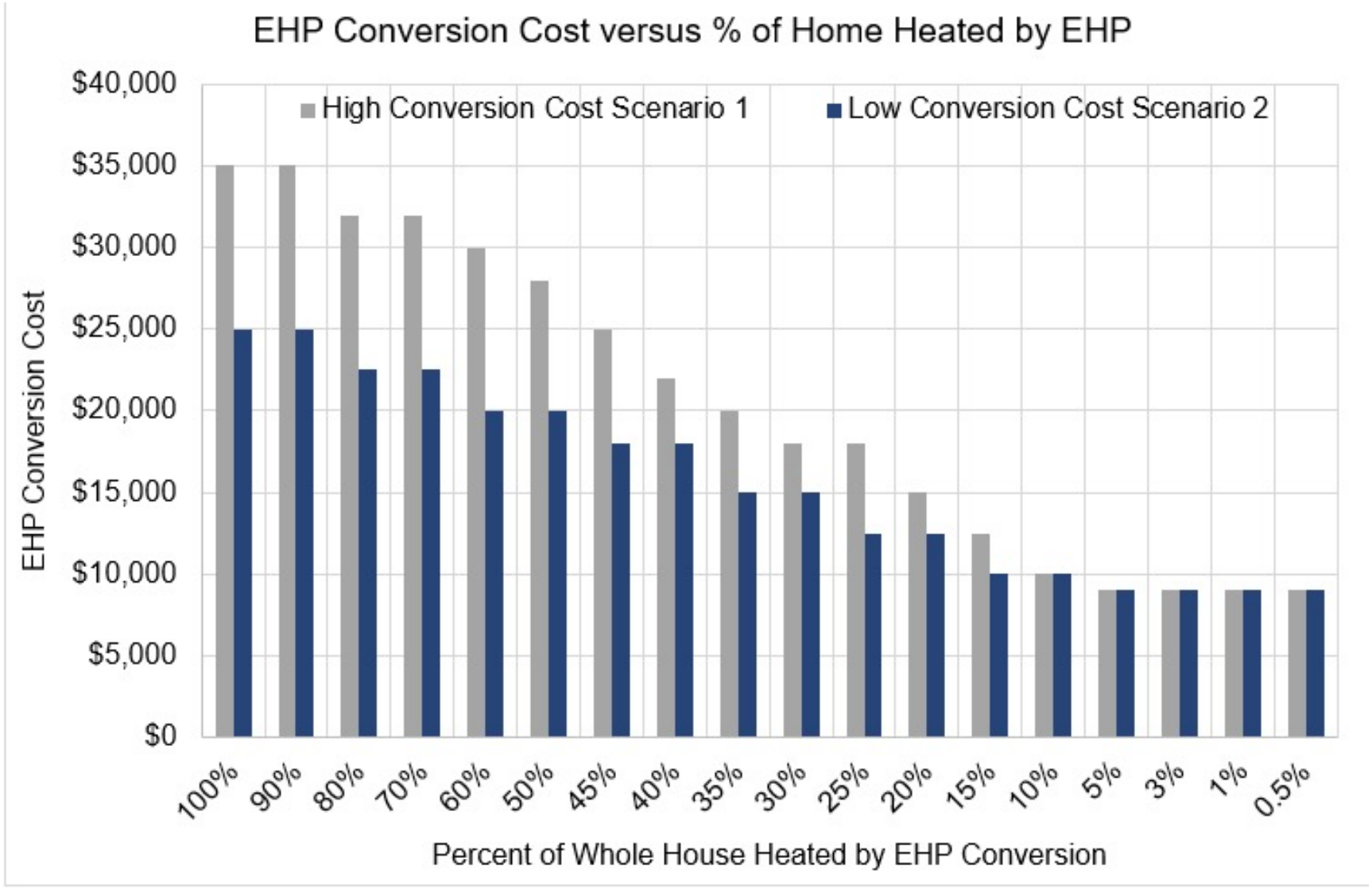
Assumed electricity decarbonization rate

15%@2025;
25% @ 2030;
50% @ 2040;
100% @ 2050.



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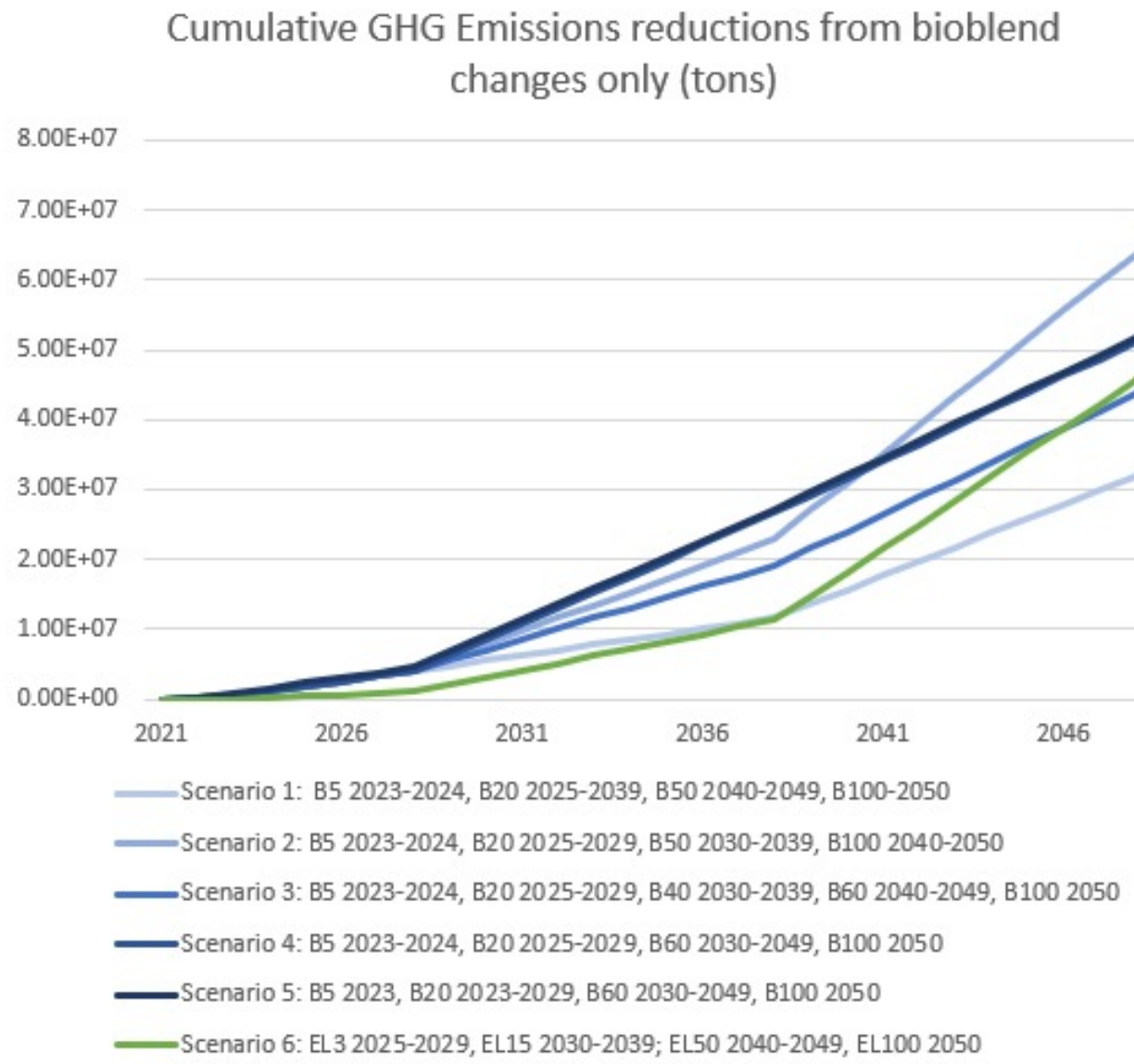

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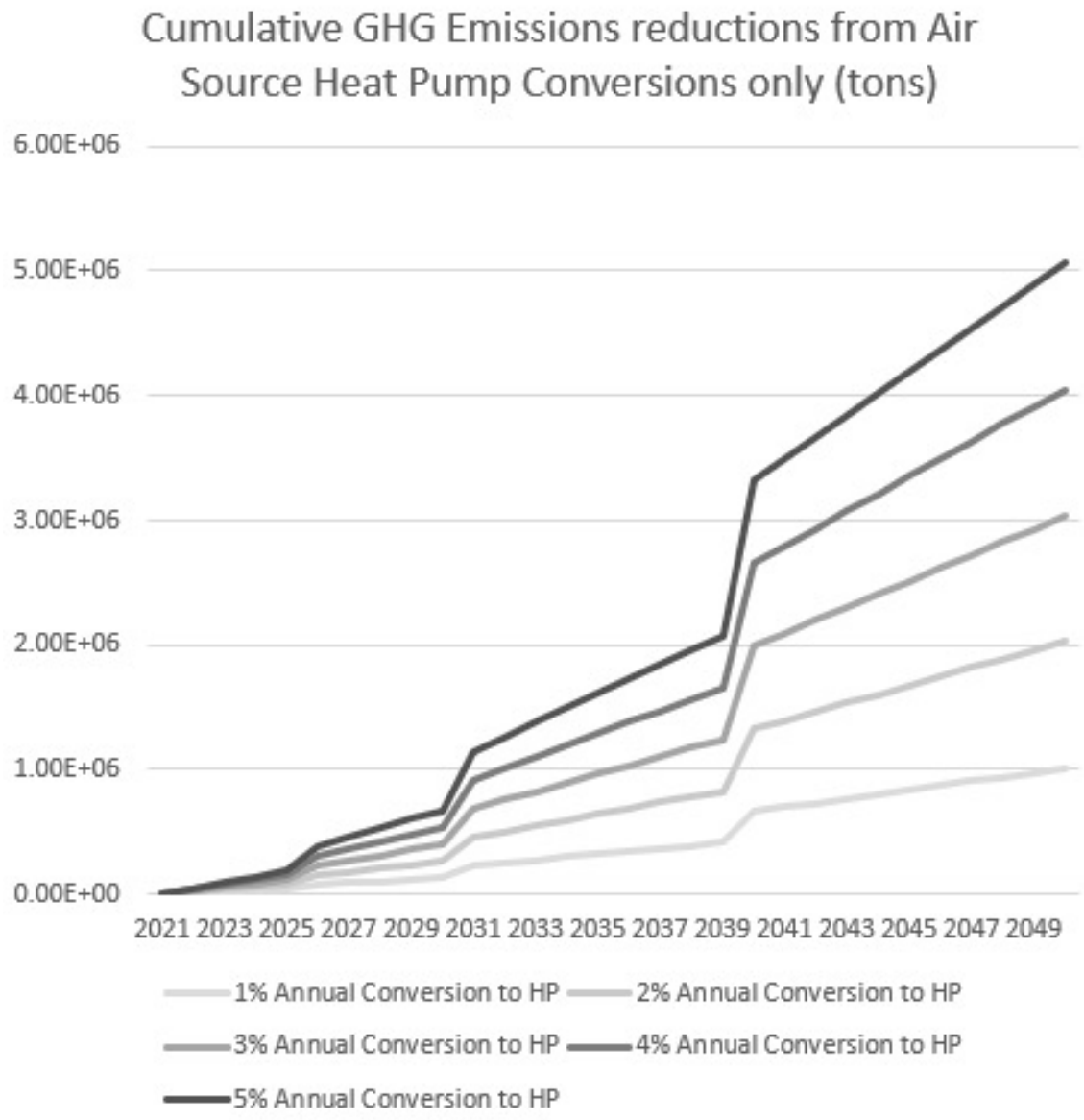

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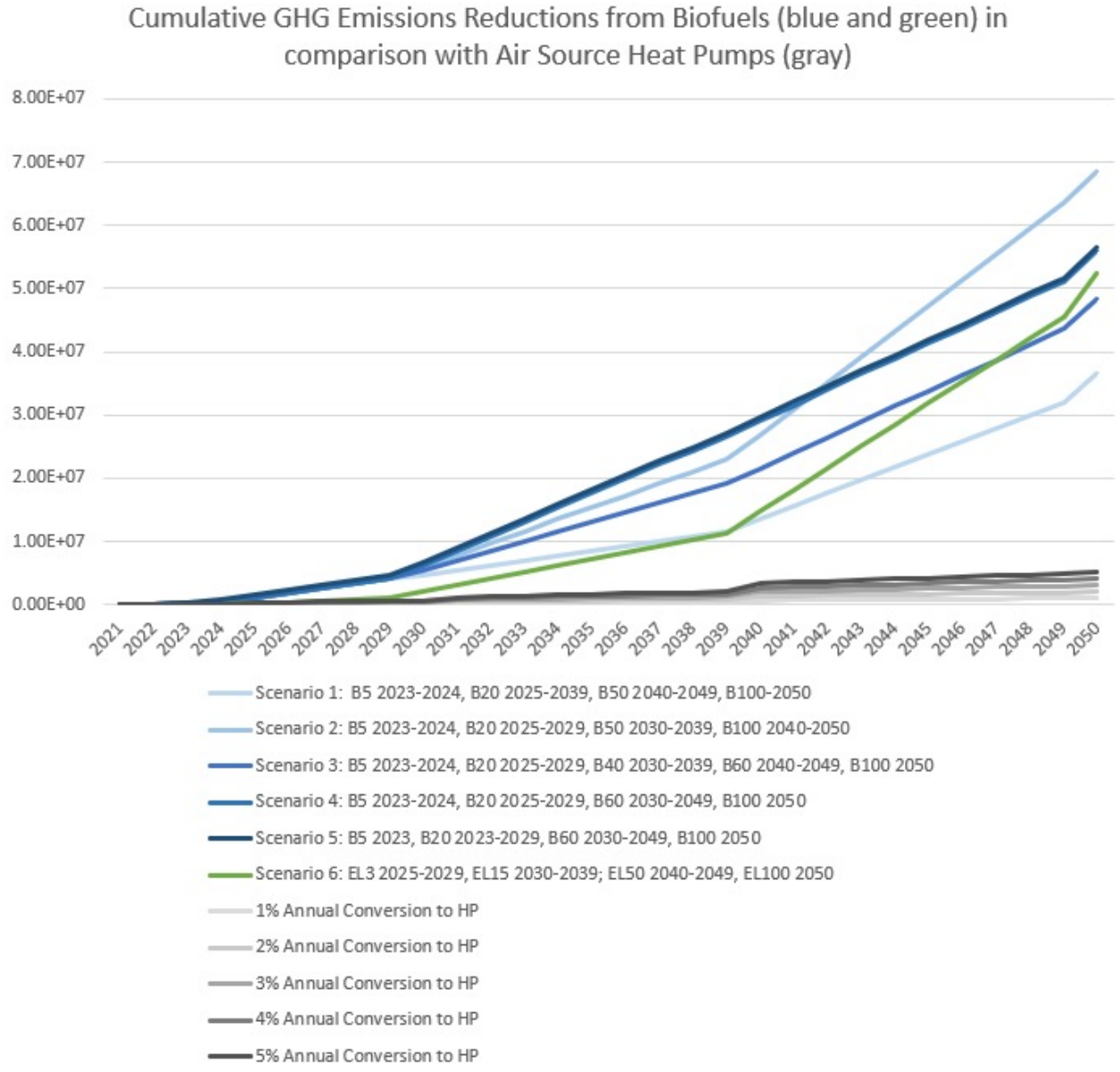

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Capital Cost

Capital cost per ton of GHG reduction:

Biofuels	$0.
Air-Source Heat Pumps	$2,963.

Conclusions

- Electric heat pump conversions are costly for homeowners
- Electric heat pump conversions substantially have higher cost per ton of GHG (CO_{2e}) than current market prices (RGGI = March 3, 2021, resulted in a clearing price of $7.60 per ton of CO_2 and on February 26, 2021 the Biden administration announced an initial estimate of $51 per ton of carbon).
- Adopting biofuels can achieve greater GHG impact in the near term

Followup?

The model this work is based on is still in a draft form. If you would like to discuss or get a full copy for review contact:

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