

EAN Emissions Reductions Pathways Model

August 3, 2021

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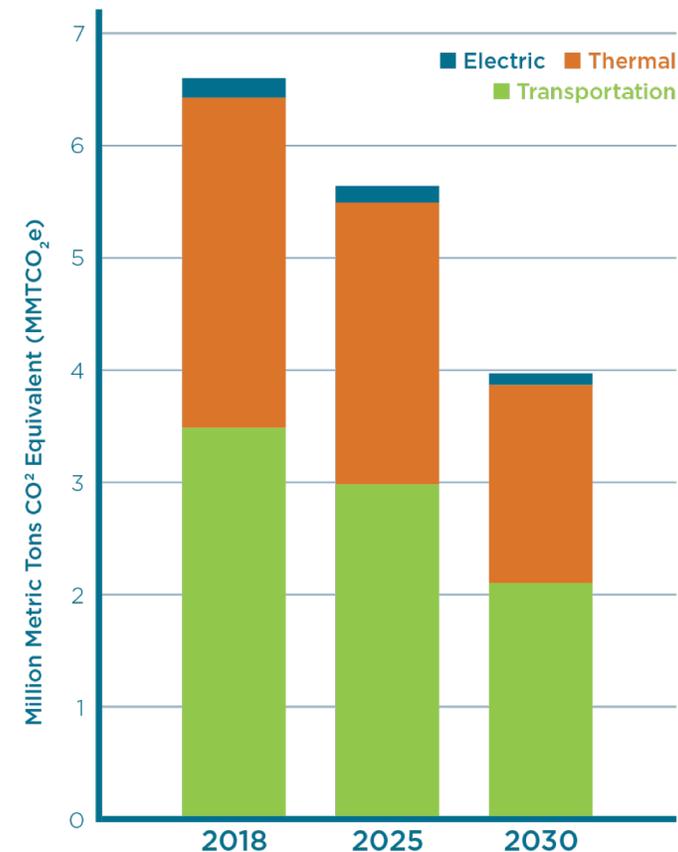
ENERGY ACTION NETWORK



Emissions Reductions Pathways - Introduction

- Developed to present pathway scenarios for VT to meet statutory GHG reduction requirements for 2025 and 2030
- Focused on the 76% of emissions that come from energy use
- Transportation and Thermal are the main focus
- Sectoral reductions need to be in proportion to the amount of emissions they are responsible for

Energy emissions goals by milestone year



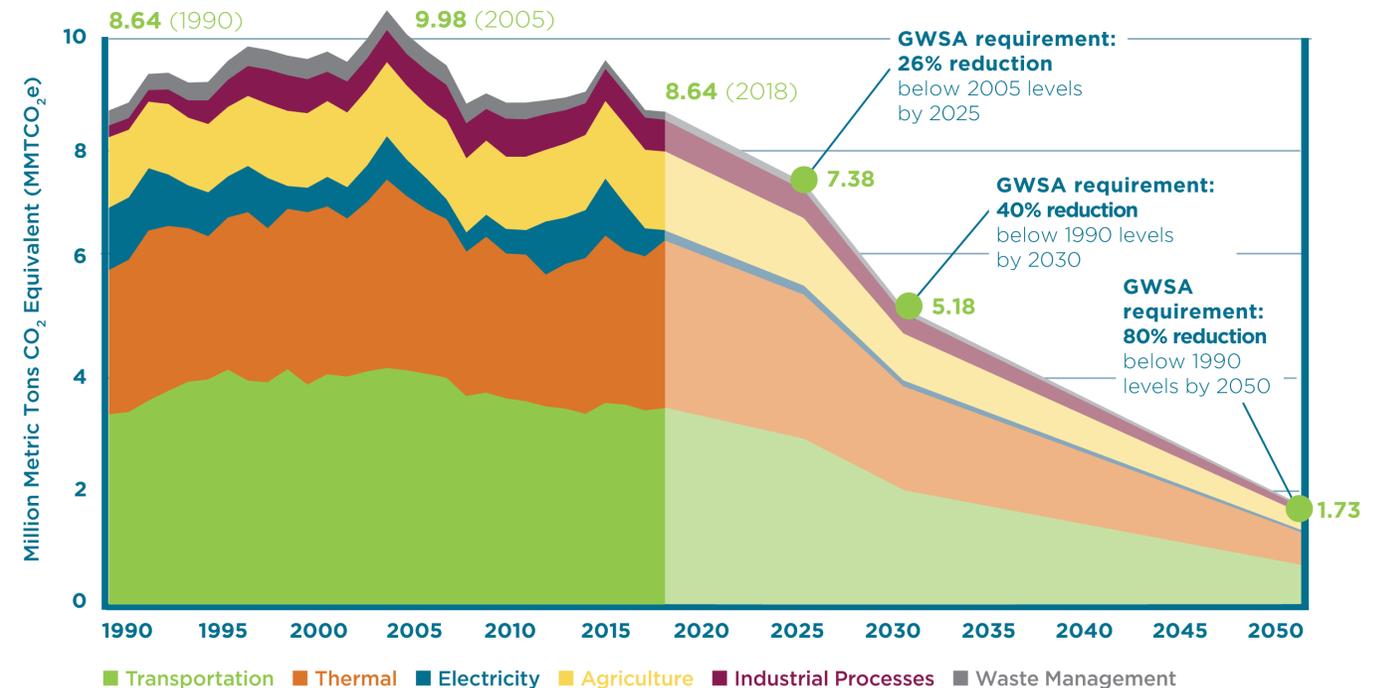
Source: EAN Emissions Reduction Pathways Model, 2021.



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Vermont's historical GHG emissions and future requirements



Source: Vermont Agency of Natural Resources, Vermont GHG Emissions Inventory and Forecast (1990-2017), 2021.





Pathways by Sector

Transportation Pathways

- Electrification
 - Electric Vehicles, Heavy Duty Electrification, Bus Electrification
- Transportation Mode Changes
 - Carpool/ Rideshare, Public Transportation, Bike/ Walk Commuters, Telecommute, Rail Transit, VMT Reductions
- Efficiency & Low-Carbon Fuels
 - Biofuels, Hybrids, ICE Efficiency Increases, Rail/ Aviation Biofuels

Thermal Pathways

- Electrification
 - Cold Climate Heat Pumps, Ground Source Heat Pumps, Heat Pump Water Heaters
- Weatherization & Efficiency
 - Weatherization, Commercial Efficiency, Industrial Processes Efficiency
- Wood & Biofuels
 - Advanced Wood Heat (Residential and Commercial), Renewable Natural Gas, Biofuels

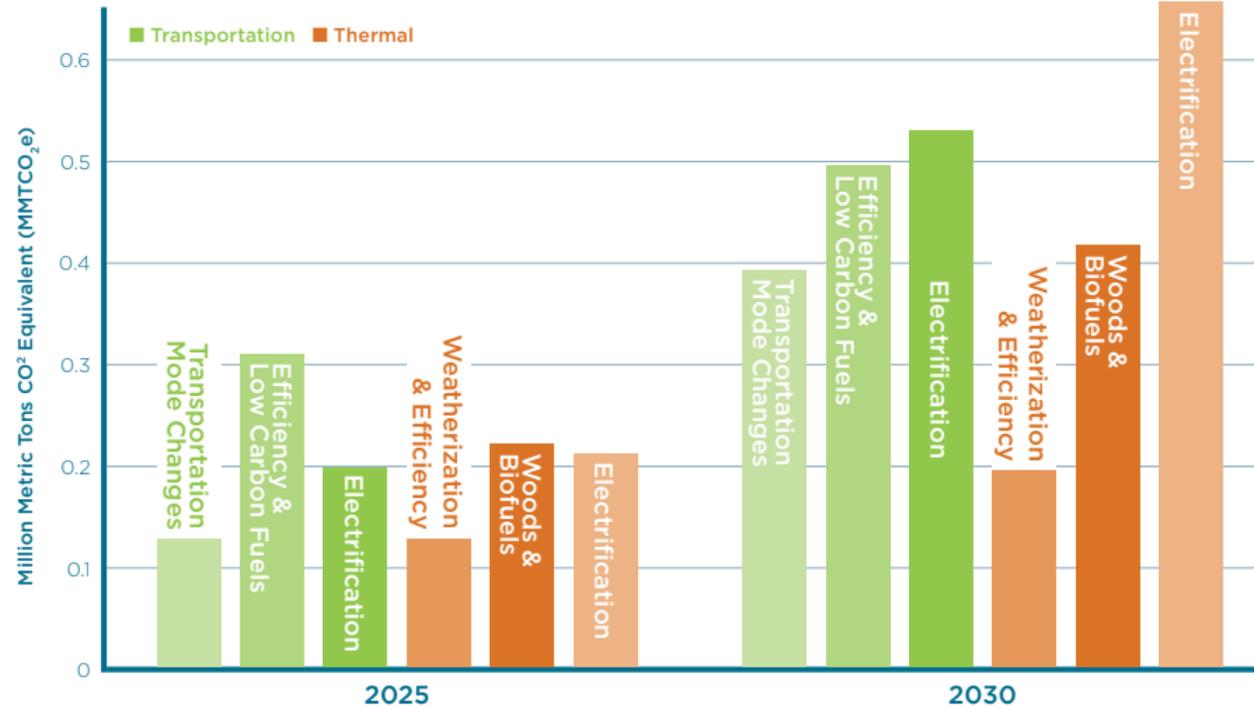


Pathways by Sector

Transportation Pathways

Thermal Pathways

Emissions reductions by pathways

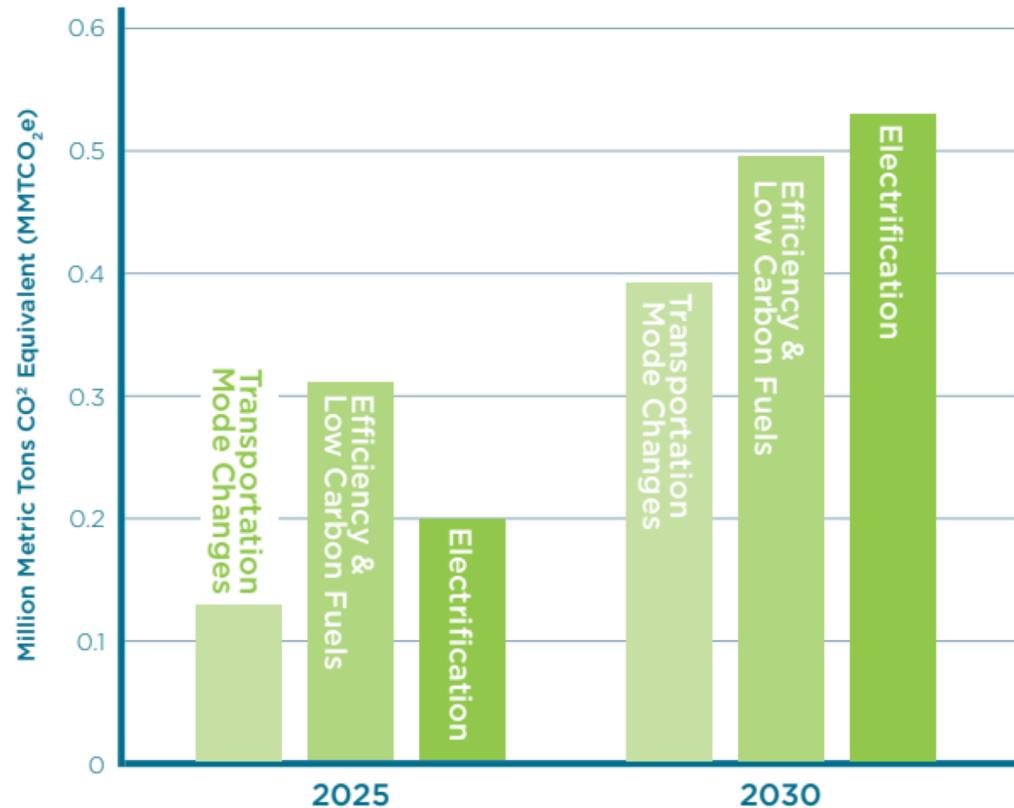


Source: EAN Emissions Reduction Pathways Model, 2021.



Pathways by Sector - Transportation

Transportation pathway reductions



Source: EAN Emissions Reduction Pathways Model, 2021.

- In the long run, Electrification will have the greatest impact
- Efficiency & Low Carbon Fuels initially sees the greatest reductions, but decreases over time as more of the fleet becomes electric
- While important, there are limits to the potential of Transportation Mode Changes

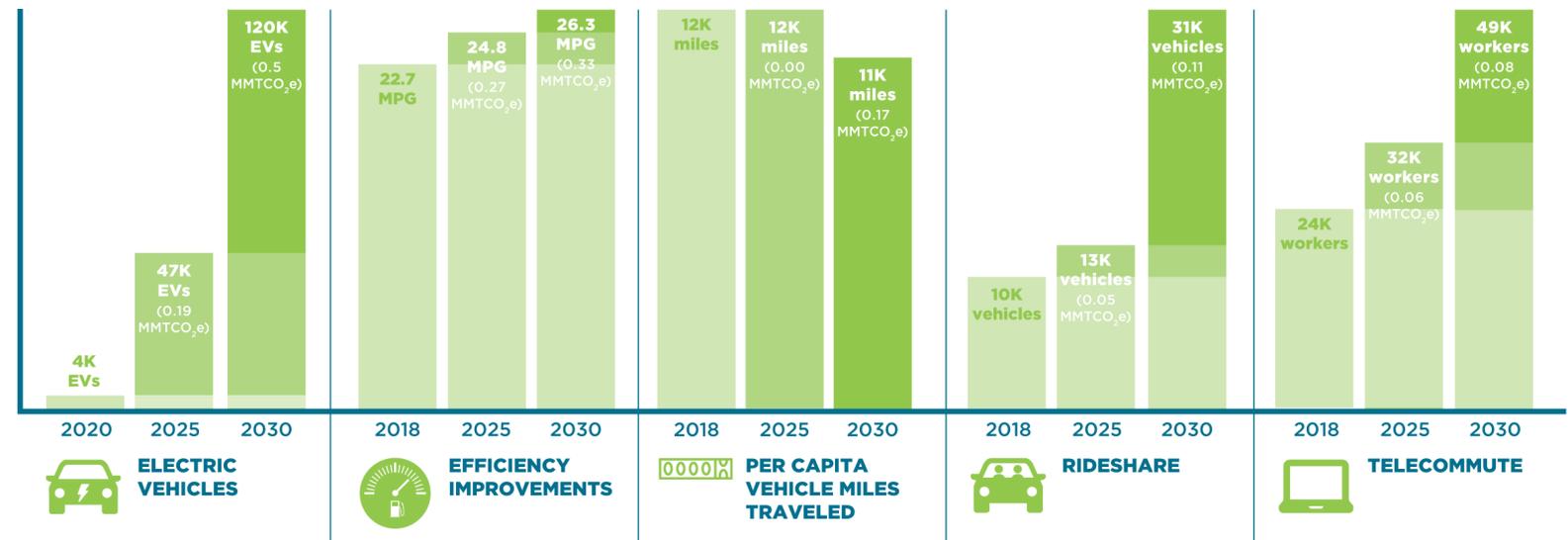


Pathways by Sector - Transportation

Transportation Measures

- Highest impact Measures across all Pathways
- Electrification is still the main focus, where we will see a very dramatic ramp-up rate
- Although Per Capita VMT, Rideshare, and Telecommute all belong in the Transportation Mode Changes Pathway, they are outweighed by large-impact Measures

Highest impact transportation measures in EAN Pathways Model

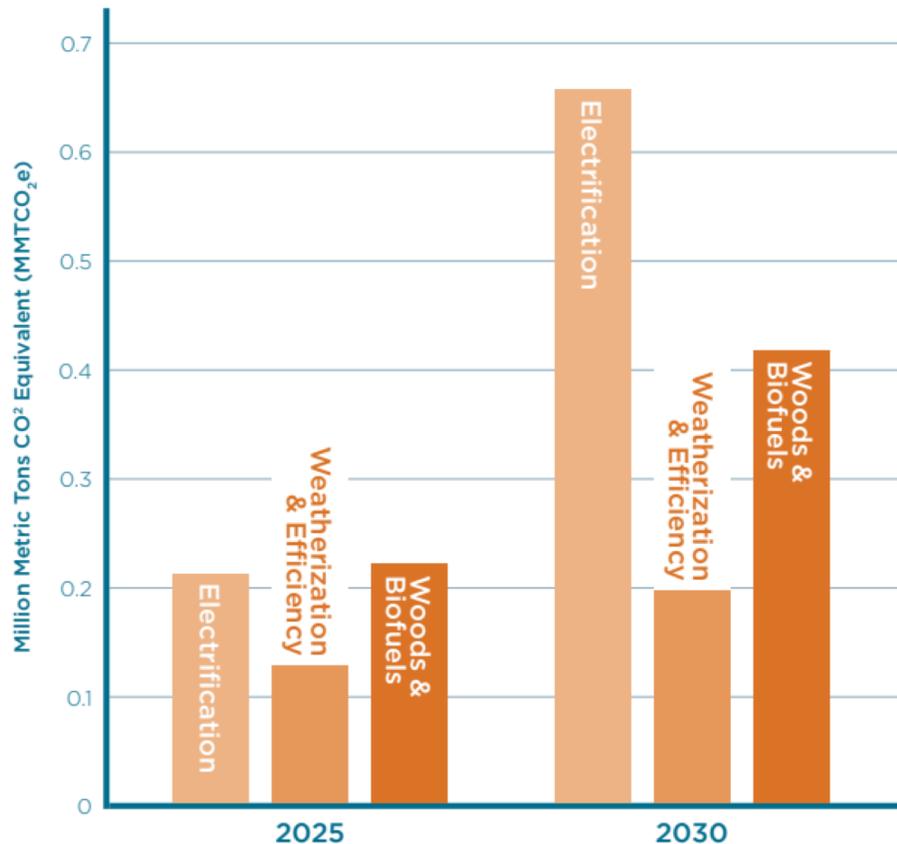


Source: EAN Emissions Reduction Pathways Model, 2021. Note: graph shows cumulative unit counts and is scaled based on unit count growth, not GHG reduction.



Pathways by Sector - Thermal

Thermal pathway reductions



Source: EAN Emissions Reduction Pathways Model, 2021.

- Again, in the long run, Electrification will have the greatest impact
- Efficient wood stoves and systems are initially a very important focus, but over time heat pumps become the greatest-impact measure
- Although Weatherization itself does not result in the most reductions, the effectiveness of other Thermal Pathways rely on it

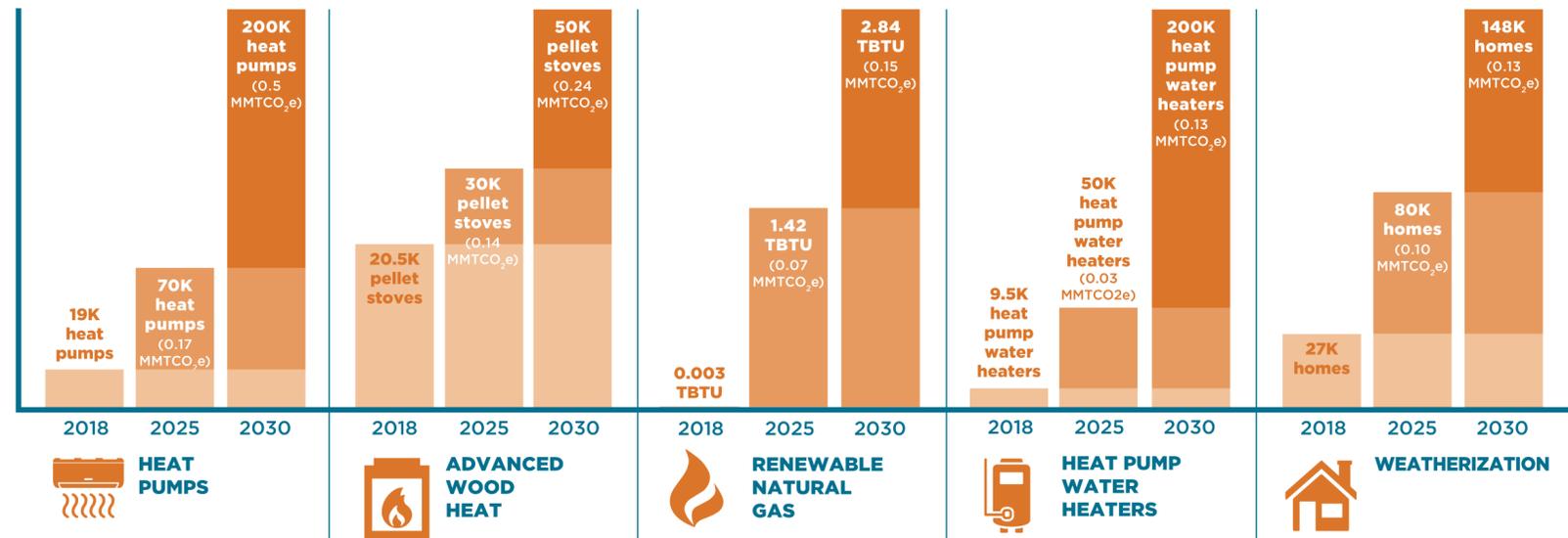


Pathways by Sector

Thermal Pathways

- Highest impact Measures across all Pathways
- Similar to Transportation - we will need a huge lift in Electrification
- RNG also has a significant ramp rate, although its emissions impact is uncertain

Highest impact thermal measures in EAN Pathways Model



Source: EAN Emissions Reduction Pathways Model, 2021. Note: graph shows cumulative unit counts and is scaled based on unit count growth, not GHG reduction.



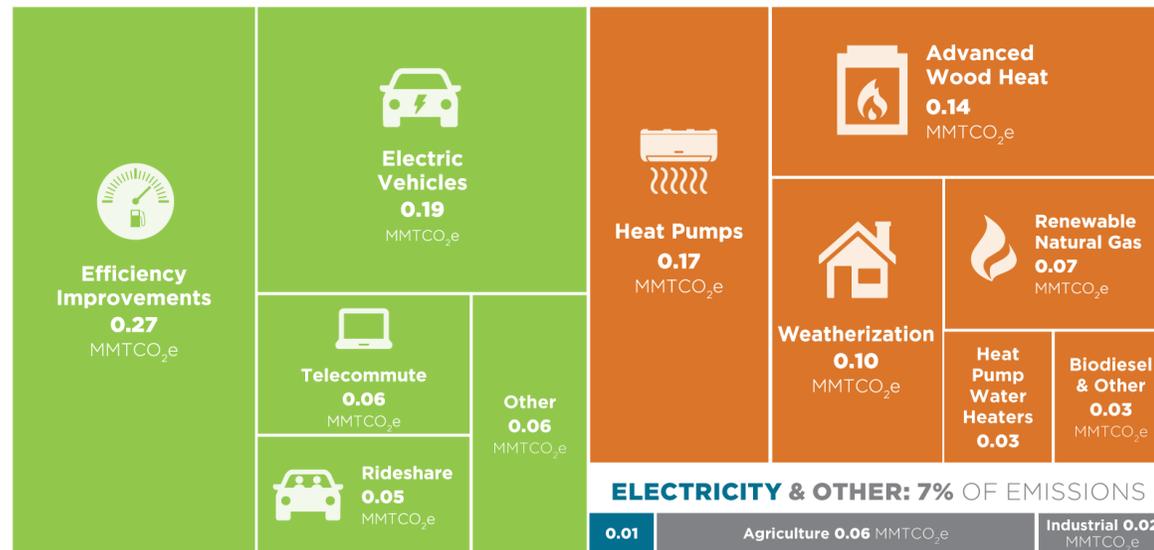
Pathways by Year

Modeled emission reductions for 2025

Total reductions of 1.26 MMTCO₂e to meet Vermont's statutory emissions reduction requirements

TRANSPORTATION: 50%
OF EMISSIONS REDUCTIONS

THERMAL: 43%
OF EMISSIONS REDUCTIONS



Source: EAN Emissions Reduction Pathways Model, 2021



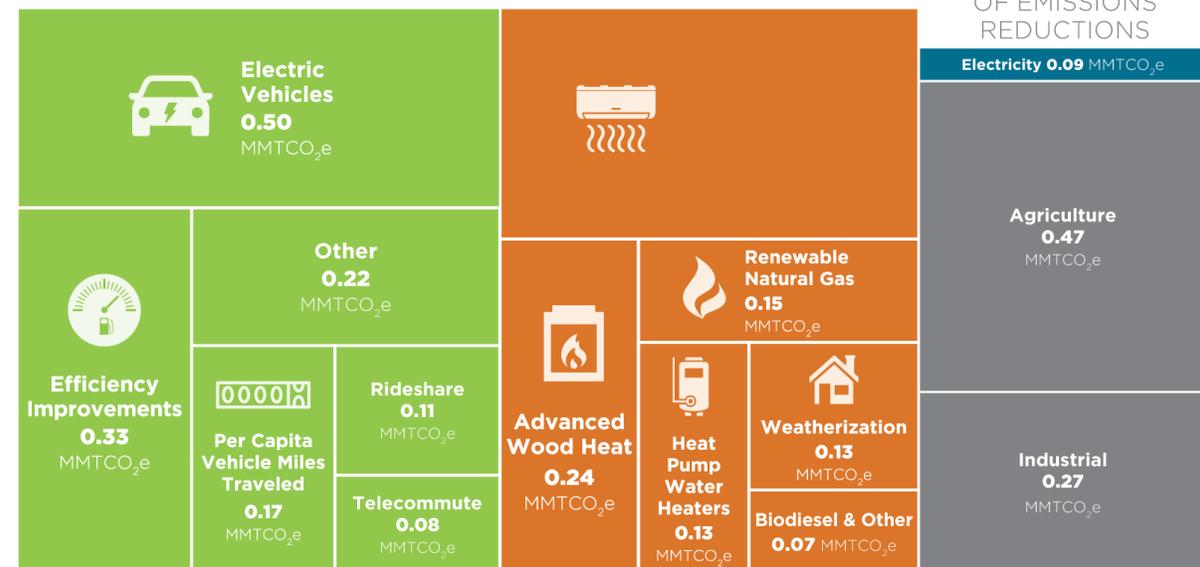
Modeled emission reductions for 2030

Total reductions of 3.46 MMTCO₂e to meet Vermont's statutory emissions reduction requirements

TRANSPORTATION: 41%
OF EMISSIONS REDUCTIONS

THERMAL: 35%
OF EMISSIONS REDUCTIONS

ELECTRICITY & OTHER: 24%
OF EMISSIONS REDUCTIONS



Source: EAN Emissions Reduction Pathways Model, 2021





Key Takeaways

1. Meeting our emissions reduction requirements is possible

- As shown, we have the technology and knowledge to do so using presently available measures

2. Equipment choices matter greatly

- Changing out fossil fuel-based vehicles and heating systems for low-carbon options is key





Key Takeaways

3. Clean vehicles and clean heating systems will need to be installed at a geometric rate

- This is due to the lock-in effect of choices having emissions impacts for decades, and because Vermont's emissions reduction requirements are not linear

4. Each Measure will have different impacts over differing periods

- We can see this from the changing focus of different Measures and Pathways over time





Appendix A: Assumptions

General Assumptions

- Model's assumptions reflect current best practices and options, which have peer-reviewed literature and measured characteristics
- As much as possible, Vermont-specific assumptions were used as it sometimes has very specific characteristics that cannot be accurately represented by national-level assumptions
- Each technology measure uses assumptions regarding annual rates of change that were applied to meet specific targets and market penetration



Appendix A: Assumptions

Emissions Factors

- This is one of the most important assumption categories as the emissions impact of each Pathway and Measure depends on it
- The majority of emissions factors came from either the EPA or the EIA. These sources were chosen due to their rigorous methodologies and widespread usage
- Deviations from this are for Electricity and Wood, which use the Vermont Agency of Natural Resource's (ANR) methodology to align with current state GHG accounting
- ANR currently does not characterize biofuels at all in its methodology, so future updates to it could have implications on the Model's assumptions, with unknown impacts - this would apply towards RNG, biofuel oil, ethanol, and biodiesel



Appendix B: Thermal Measures

	Pathway	Measures	Baseline Unit Count (2018)	2025 Unit Count	2025 Percent Increase	2030 Unit Count	2030 Percent Increase
THERMAL	Electrification	Cold Climate Heat Pumps	13,770	70,000	408%	200,000	1352%
	Electrification	Ground Source Heat Pumps	198	1,063	437%	5,023	2437%
	Electrification	Heat Pump Water Heater	9,510	50,000	426%	200,000	2003%
	Weatherization & Efficiency	Residential	27,186	80,000	9%	148,102	16%
	Wood and Biofuels	Advanced Wood Heat - Commercial	231	1,586	587%	3,205	1287%
	Wood and Biofuels	Advanced Wood Heat - Residential	20,490	30,000	46%	50,000	144%
	Wood and Biofuels	RNG	2,650	1,417,038	53373%	2,839,221	107040%
	Wood and Biofuels	Biofuels	280,424	280,424	9%	1,020,640	16%
	Weatherization & Efficiency	Commercial	15,767,000	15,223,364	-3%	14,846,567	-6%
	Weatherization & Efficiency	Industrial Process	6,788,000	6,632,741	-2%	6,524,021	-4%



Appendix B: Transportation Measures

TRANSPORTATION	Transportation Mode Changes	Bike / Walk	22,055	30,305	37%	33,000	50%
	Transportation Mode Changes	Carpool	10,052	12,518	25%	30,558	204%
	Transportation Mode Changes	Public Transportation	2,800	4,516	61%	6,353	127%
	Transportation Mode Changes	Rail Transit	94,249	115,914	23%	134,377	43%
	Transportation Mode Changes	Telecommute	24,206	32,434	34%	48,651	101%
	Efficiency and Low Carbon Fuels	HDF Biofuel	6,970,965	9,529,154	37%	12,574,529	112%
	Efficiency and Low Carbon Fuels	LVF Biofuel	21,970,533	18,369,819	-16%	13,892,470	-25%
	Efficiency and Low Carbon Fuels	Hybrids	12,027	24,000	100%	42,536	254%
	Electrification	Electric Bus	-	48	4676%	213	21219%
	Electrification	Electric HDF	1	86	8465%	1,095	109402%
	Transportation Mode Changes	VMT Reductions	12,497	12,497		11,000	
	Efficiency and Low Carbon Fuels	HDF Efficiency	7	7		8	
	Efficiency and Low Carbon Fuels	ICE Efficiency	23	25		26	
	Electrification	EVs	2,985	46,000	1441%	120,000	3920%



Appendix C: Future Updates

Future updates to the Model that EAN is considering

- Incorporate long-term population and housing stock growth into annual projections
- Include a more nuanced view of EV types
- Add in a simple cost-effectiveness analysis or financial modeling component
- Think further about interactive effects to avoid misstating any of the Measures' impacts. This applies to cases such as:
 - The interaction of wood heat, heat pumps, and biodiesel in the Thermal sector
 - The interaction of biofuels with EVs



Questions?

Thank you!

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