

# Evaluation of Projected and Inventoried Vermont Greenhouse Gas Emissions

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# Synapse Energy Economics

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- Founded in 1996 by Bruce Biewald and Jean Ann Ramey
- Leader for public interest and government clients in providing rigorous analysis of the energy sector and associated environmental and economic impacts
- Staff of 40+ includes experts in energy, economic, and environmental topics
  
- About me:
  - Senior VP for Consulting @ Synapse
  - Director of Energy Policy and Planning at Vermont Dept of Public Service 2011-2016

# Summary

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- Synapse prepared a report for CLF that reviewed Vermont's analysis of expected greenhouse gas (GHG) emissions in 2024 and previous years
- The purpose of our analysis was to compare the Pathways 3.27 Model the State relied upon with the State's GHG Inventory, with focus on how well aligned the Model is to the Inventory from 2015-2020
  - Pathways 3.27 Model was developed by Energy Futures Group for a thermal policy analysis report
- This calibration comparison is necessary because the State relied on the Model to make projections about the Inventory for 2024
  - The Inventory is backward-looking only, whereas the Model builds from past years to project forwards
- For each sector of the economy, we compared historical Model and Inventory emissions from 2015-2020, and identified potential implications for the accuracy of the Model's projection of 2024 emissions
- In some cases, the model and Inventory are well aligned; in other cases, they are not
- We found numerous cases in which the Inventory and Model consistently differ (both under- and over-estimates), which call into question the accuracy of the 2024 projected emissions

# Sectoral and Cumulative Approximate Corrections to Model Estimates

Sector	Pathways 3.27 2024 Estimate (kMT)	Approx. Correction to 2024 Emissions Estimate
Thermal/RCI	2,287	+80
Transportation	2,954	net 0
Electricity	120	-40 to -120
Fossil Fuel T&D	21	~0
Industrial Process	565	+50
Waste	125	+30
Agriculture	1,190	+200
<b>TOTAL</b>	<b>7,262</b>	<b>+240 to +320</b>
<b>Relative to 1/1/25 limit</b>	<b>(-13 below limit of 7,275)</b>	<b>(+230 to +310 over limit)</b>

- The middle column breaks out expected 2024 emissions by sector as detailed in the Model.
- The right column approximately corrects for each sector’s emissions if the Model had been correctly calibrated to account for Inventoried sectoral-emissions.
- Synapse analysis concludes that Model likely undercounts state-wide emissions for 2024 by an estimated 240,000 to 320,000 metric tons, due to calibration or configuration errors in the Model.

# Thermal (Residential, Commercial, Industrial) Emissions

Residential, commercial, and industrial (RCI) sector emissions comparison (kMT CO<sub>2</sub>e)

		2015	2016	2017	2018	2019	2020	Avg Dif.
Residential	Inventory	1528	1418	1480	1570	1650	1500	79
	Model	1458	1330	1402	1499	1569	1417	
Commercial	Inventory	1007	870	780	920	890	880	(3)
	Model	1009	874	786	927	903	867	
Industrial	Inventory	407	415	440	440	450	480	2
	Model	401	408	445	445	447	474	

- RCI emissions in the Model for the residential sector are, on average, lower than the Inventory by around 79 kMT/year between 2015-2020.
- RCI emissions in the Model for Commercial and Industrial Sectors are better calibrated, with the Model overestimating emissions by 1 kMT/year.
- Wood emissions have the largest difference, although other fuels also show notable difference
  - The Model could be improved by more completely accounting for CH<sub>4</sub> and N<sub>2</sub>O emissions from wood combustion, primarily in the residential sectors.
  - It is not clear whether the Model is counting CO<sub>2</sub> emissions (contrary to the Inventory treatment of biogenic CO<sub>2</sub>) or otherwise miscounting CH<sub>4</sub> and N<sub>2</sub>O emissions.

RCI emissions comparison by fuel (kMT CO<sub>2</sub>e)

		2015	2016	2017	2018	2019	2020	Avg Dif.
Coal	Inventory	-	-	-	-	-	-	
	Model	-	-	-	-	-	-	
Natural Gas	Inventory	645	652	649	748	756	708	3
	Model	638	645	647	749	756	703	
Oil, Propane, and Other Petroleum	Inventory	2202	1956	1957	2097	2147	2076	25
	Model	2189	1925	1944	2083	2126	2017	
Wood	Inventory	94	96	97	99	99	88	58
	Model	38	39	39	38	36	36	

Overall: Model understates expected emissions by about 80,000 MT

# Transportation Sector Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
On & Off Road Gasoline	Inventory	2553	2516	2498	2525	2501	2088	14
	Model	2571	2565	2554	2352	2497	2057	
On & Off Road Diesel	Inventory	793	813	765	749	709	648	(9)
	Model	801	823	775	755	714	660	
Jet Fuel	Inventory	81	88	64	69	69	62	(42)
	Model	113	128	104	114	114	114	
All Mobile (CH <sub>4</sub> /N <sub>2</sub> O)	Inventory	21	20	18	16	16	13	17
	Model	-	-	-	-	-	-	
Non-energy: Lubricants	Inventory	51	50	47	42	41	36	35
	Model	12	11	10	9	8	8	
Other Fuels	Inventory	-	-	-	-	-	-	(7)
	Model	11	13	7	3	3	3	

- The Model and Inventory gas and diesel emissions are relatively well aligned, including accounting for the decrease in emissions during the 2020 Covid pandemic.
- The Model consistently underestimates emissions from the lubricants sector by about 35 kMT, but overestimates jet fuel emissions by a similar 40 kMT
- We are unsure whether CH<sub>4</sub>/N<sub>2</sub>O emissions (called out separately in the Inventory) are captured by fuel in the Model, and where the Model's "other fuels" are captured in the Inventory

Overall: Model nets out close to expected emissions (net 0)

# Electric Sector Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
<b>Coal</b>	Inventory	-	-	-	-	-	-	-
	Model	-	-	-	-	-	-	
<b>Natural Gas</b>	Inventory	16	5	7	0	0	0	(9)
	Model	0	0	0	0	0	81	
<b>Oil</b>	Inventory	7	4	4	0	0	0	(18)
	Model	18	20	20	19	24	21	
<b>Wood and Waste</b>	Inventory	15	15	14	14	12	12	(46)
	Model	57	56	55	57	59	74	
<b>Residual System Mix</b>	Inventory	960	898	598	301	240	164	381
	Model	191	181	174	168	162	0	

- Model is not well calibrated to the state’s electric sector GHG emissions Inventory
- The Model does not appear to account for dominant change driving electric emissions: the state RES enacted in 2015, with compliance beginning in 2017, and voluntary utility actions
- Also: the Model is likely overstating emissions from wood and waste combustion by counting biogenic CO<sub>2</sub>, which the Inventory does not

# Electric Sector Emissions

- How accurate/inaccurate could the 2024 Model projected emissions be?
- If wood/waste emissions are overstated due to biogenic CO2, then overestimate could be about 40 kMT
- If VT utilities maintain almost zero-carbon portfolios through 2024, then electric sector emissions could be almost zero, or a 120 kMT overstatement

Model projections for 2024:

Source	2024 Emissions
ISONE Landfill Gas	0.77
ISONE Natural Gas Fired Combined Cycle	60.94
ISONE Petroleum Liquids	10.99
ISONE Wood_ Wood Waste Biomass	13.39
Vermont Landfill Gas	0.01
Vermont Petroleum Liquids	0.95
Vermont Wood_ Wood Waste Biomass	33.09
<b>Total</b>	<b>120.14</b>

Overall: Model overstates expected emissions by between 40,000 and 120,000 MT



# Fossil Fuel Transmission & Distribution Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
<b>Distribution</b>	Inventory	3.9	4.0	4.1	4.2	4.3	4.3	4
	Model	-	-	-	-	-	-	
<b>Transmission</b>	Inventory	14.7	18.8	23.4	23.4	23.4	23.4	1
	Model	10	20	20	23	23	22	

- Reflects natural gas system transmission and distribution (T&D) leaks and other fugitive emissions
- The Model attributes all T&D emissions from the state’s natural gas system to the transmission system – It is not clear if it includes distribution at all

Overall: Model is close to expected emissions

# Industrial Process Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
<b>ODS Substitutes</b>	Inventory	315	326	337	345	359	367	20
	Model	323	323	321	321	321	323	
<b>Electric Utilities</b>	Inventory	6	6	6	6	6	6	0
	Model	6	6	6	6	6	6	
<b>Semiconductor Manufacturing</b>	Inventory	256	239	228	220	231	245	33
	Model	210	210	206	201	197	197	
<b>Limestone &amp; Dolomite Use</b>	Inventory	33	29	23	15	29	29	1
	Model	33	25	24	23	23	23	
<b>Soda Ash Use</b>	Inventory	4	4	4	4	4	4	0
	Model	4	4	4	4	4	4	
<b>Urea Consumption</b>	Inventory	1	2	2	2	3	3	0
	Model	1	2	2	2	2	2	

- Industrial sector emissions remain relatively constant over the years with little variability in subsector emissions
- The Model is not well aligned with the Inventory, consistently underestimating emissions by roughly 20 kMT in the ODS substitute sector and roughly 30 kMT from the semiconductor manufacturing sector
- Modeled 2024 emissions are comparable to Model in 2020, and show no indication of further calibration

Overall: Model understates expected emissions by about 50,000 MT

# Waste Management Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
Solid Waste	Inventory	96	78	72	82	81	77	26
	Model	54	55	55	55	55	55	
Composting	Inventory	8	11	12	12	13	14	12
	Model	-	-	-	-	-	-	
Wastewater	Inventory	63	63	64	64	64	65	(5)
	Model	69	69	69	69	69	69	

- The Model is not well calibrated to actual historical state waste emissions. Together, the Model underestimates Inventoried sector emissions by an average of 33 kMT.
- Inventory only includes CH<sub>4</sub> and N<sub>2</sub>O from solid municipal waste, wastewater treatment facilities within the state, and composting, and does not include biogenic sources.
- Model does not include compost emissions

Overall: Model understates expected emissions by about 30,000 MT

# Agricultural Sector Emissions

		2015	2016	2017	2018	2019	2020	Avg Dif.
Enteric Fermentation	Inventory	635	643	645	643	630	614	6
	Model	634	643	645	643	643	638	
Manure Management	Inventory	341	357	348	355	347	334	162
	Model	180	189	186	191	191	171	
Agricultural Soils	Inventory	400	366	354	359	367	287	45
	Model	312	314	312	309	309	307	
Liming and Urea Fertilization	Inventory	48	47	52	38	38	25	(6)
	Model	48	47	47	47	47	47	

- The Model consistently underestimates total agricultural sector emission by around 200 kMT CO<sub>2</sub>e through 2020
- Manure management shows a difference between the Inventory and the Model of almost a factor of two
- Year to year variation in the Inventory is not captured in the Model

Overall: Model understates expected emissions by about 200,000 MT

# Conclusion: State Model Underestimates Actual Emissions and does not project 2025 Emissions Accurately

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- Vermont’s Pathways 3.27 Model has not been calibrated to correct for consistent differences between the Model and the Inventory
- There is no evidence in the Model that its consistent differences from the Inventory change between 2020 and 2024
- Synapse expects that the Pathways 3.27 Model estimate of 2024 emissions retains these differences and therefore understates the inventoried 2024 emissions by a comparable amount
- Based on this analysis, if the Secretary had used a calibrated Model, her review would have reached a different conclusion regarding meeting the Jan. 1, 2025 milestone

# Questions?

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