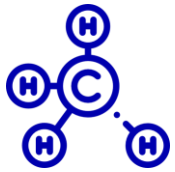


WTE In the Climate Policy Landscape

Reworld™

Waste Sector: Untapped Opportunity to Address Climate Change



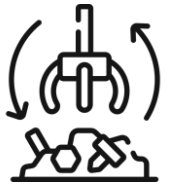
Reducing methane is a key priority of mitigating climate change

- Over 20 years, methane is over **80 times more potent** than CO2.
- According to the UNEP, “Cutting methane is the **strongest lever** we have to slow climate change over the next 25 years.”
- Methane is estimated to contribute **30%** of overall global warming
- The U.S. and EU led **Global Methane Pledge** calls for a 30% reduction in methane emissions by 2030.



Landfills are a major source of methane

- Landfills are a leading source of methane globally and in the U.S.
- Landfills only collect **50-60%** of gas generated over the lifetime of waste.
- Using the 20-year GWP and current data on measured emissions, landfills would represent **9% of total U.S. GHG inventory**.
- WTE is used extensively alongside source reduction, composting, and recycling in Europe for successful diversion.



Current policies have been ineffective at driving change in sector

- **Waste generation rates are up**; recycling is where it was 15 years ago
- Even in states with organics diversion laws and regulations, **few new diversion facilities have been built**
- CA’s attempts to aggressively reduce methane emissions at landfills have been largely ineffective: NASA research finds landfill “**super-emitters**” of methane



How we manage waste & materials critical for reaching net zero

- Management of materials from cradle to grave responsible for **40-45%** of U.S. GHG emissions.
- Industries as diverse as aluminum, steel, and cement need to increase recovery & recycling by 50% to 600% to reach their goals.
- Better management can reduce net GHG emissions by ~700 million metric tonnes of CO2e year by 2050, equivalent to removing 75% of gasoline vehicles from the road.

All Eyes on Methane: **The Policy**

The Biden-Harris Administration launches the U.S. Methane Emissions Reduction Action Plan.

Part of Global Methane Pledge to reduce global emissions by 30% below 2020 levels by 2030, with a focus on reducing landfill methane emissions.

UNEP Identifies landfill organics diversion & energy recovery treatment as a key mitigation measure.

"Cutting methane is the strongest lever we have to slow climate change over the next 25 years."

Inger Andersen
Executive Director of UNEP
Global Methane Assessment

Methane is a precursor to ground-level ozone, which poses respiratory health risks.

Ground-level ozone, produced by the atmospheric interaction of a mix of air pollutants (including CH4) poses health risks, raising rates of asthma and chronic respiratory illness.

Waste to Zero Initiative announced at COP 28, highlighting the role of waste sector in climate

For the first time at COP, global leaders strategized around the role of sustainable waste management in meeting climate targets

Source: U.S. Methane Emissions Reduction Action Plan (2021) UNEP Global Methane Assessment (2021) WHO – Health Risks COP28 Waste to Zero (2023)

Landfill GHG Emissions Systematically Underreported

Published paper:
Harvard & NASA
70 landfills
Emissions 0.5-2X greater than reported.

Published paper in **Science:**
EPA & NASA
100s of landfills
Emissions 1.4-2.7X greater than reported.

UNEP Report
9 studies cited
Emissions 2-3X greater than reported.

A review of recent published peer-reviewed data covering ~30 landfills is consistent with these ranges:

Study	Scope	LF-specific Reported Value (Gg CH_4/y)	Inventory Source	LF-specific Measured Value (Gg CH_4/y)	Difference Factor
Peischl et al. 2013*	SoCAB (L.A.)	17.84	EPA GHGRP	24.1 – 43.9	1.9x
Wecht et al. 2014**	California	312	CARB (2010)	840	2.7x
Cambaliza et al. 2015*	Indianapolis	13.93	EPA GHGRP	22.5	1.6x
Ren et al. 2018	Baltimore/DC	19.68	EPA-GHGRP	47.3	2.4x
Jeong et al. 2017	San Francisco Bay	61.5	BAAQMD	88.5 – 143.8	1.9x
Average					**2.0x**

Source: U.S. Methane Emissions Reduction Action Plan (2021) Quantifying Methane Emissions from US Landfills (2024) High Resolution US methane emissions inferred from an inversion of 2019 TROPOMI satellite data (2024) Landfill Gas Collection Efficiency: Categorization of data from existing in-situ measurements (2024)

*values are for a single landfill within respective scope
**values calculated from combined total for landfills/wastewater treatment

Inflation Reduction Act (IRA)

Statutory Language

To determine the GHG emissions rate for a facility using combustion or gasification ("C&G") to produce electricity, §45Y(b)(2)(B) of the Internal Revenue Code ("IRC") provides:

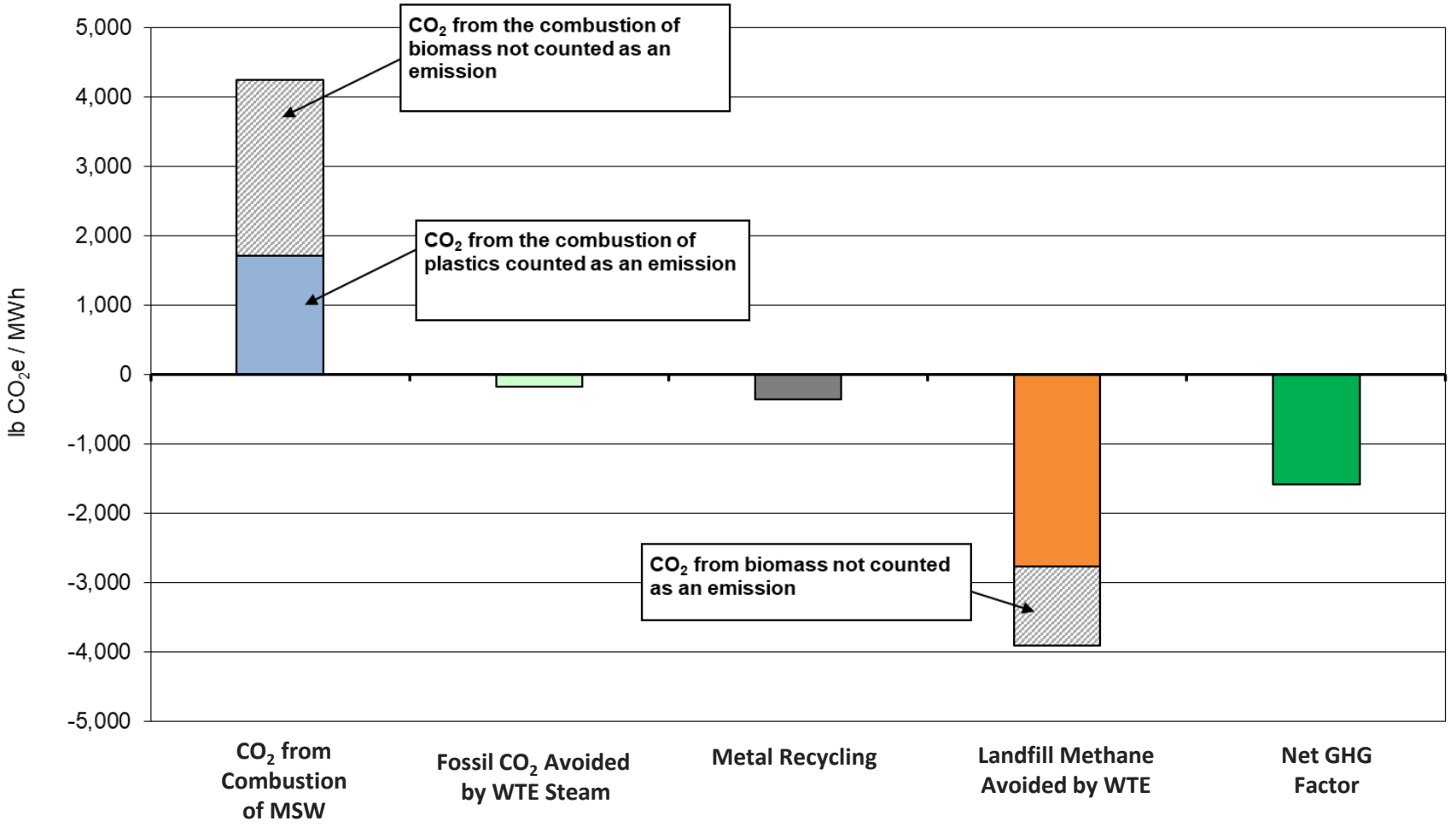
"(B) Fuel combustion and gasification

*In the case of a facility which produces electricity through combustion or gasification, the greenhouse gas emissions rate for such facility shall be equal to the net rate of greenhouse gases emitted into the atmosphere by such facility (**taking into account lifecycle greenhouse gas emissions**, as described in section 211(o)(1)(H) of the Clean Air Act (42 U.S.C. 7545(o)(1)(H))) in the production of electricity, expressed as grams of CO2e per KWh."*

In accordance with statute, it is appropriate to consider **avoided emissions** in the lifecycle analysis (LCA) for WTE facilities.

- Consistent with the calculation of net lifecycle GHG emissions in sec. 211(o)(1)(H) of the Clean Air Act
- Similar approach utilized in the EPA's Waste Reduction Model and its MSW Decision Support Tool

Lifecycle Net GHG Emissions from Waste to Energy



"[WTE] generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills."

U.S. EPA | Sustainable Materials Management: Energy Recovery

GREET Inputs / recommendations

Parameter	GREET "Mixed MSW" Waste Type	Proposed	Source
Total Carbon Content			Data reporting to U.S. EPA through GHG Reporting Rule for municipal waste combustion, excluding carbon from auxiliary fuels.
(kg C/kg dry matter)	0.52	0.34	
(tons C / ton MSW, wet)	0.42	0.27	
Biogenic Carbon Content			
(kg C/kg dry matter)	0.42	0.21	
(tons C / ton MSW, wet)	0.34	0.17	
Fossil Carbon Content			
(kg C/kg dry matter)	0.10	0.13	
(tons C / ton MSW, wet)	0.08	0.10	
Lifetime Collection Efficiency			Updated LFG collection phases using phase length in MSW-DST
Flare (%)	51%	45%	
LFGTE (%)	59%	51%	
Methane Yield, L_0 (calculated) (kg CH_4, biogenic/dry tonne)	90	no change	U.S. EPA: AP-42, LandGEM, WARM, GHG Reporting Rule
Biogenic Carbon Sequestration (kg biogenic C /dry tonne)	80	0*	High uncertainty, lack of consensus on treatment
Oxidation (% of uncollected CH_4)	24%	10%	IPCC, update to conceptual model recognizing preferential pathways
CH_4 EF (MSW combustion) (g / MMBtu)	9.87	0.45	Direct measurements from Balentine et. al. (2010)
N_2O EF (MSW combustion) (g / MMBtu)	6.11	1.27	

Summary of Modeling Suggestions

- Correct calculation error: conversion from dry to wet tonne in WTE emissions calculation
- Use a predefined default “Mixed MSW” input, that reflects real world data, rather than conduct a bottom-up material composition.
- Model landfill emissions using landfill gas collection efficiencies based on most recent literature.
- Exclude carbon storage in landfills from calculation, given the lack of data, lack of consistency with its treatment, and vast uncertainty with regard to quantification.
- Update model assumptions related to soil oxidation in landfills.
- Update model assumptions for N_2O and CH_4 emissions from WTE facilities to ensure assumptions are defensible and well supported by actual measurements and data.
- The GHG benefits associated with the recovery of metals (e.g. steel, aluminum, copper) at WTE facilities should be included in the analysis.

NY Climate Law (CLCPA)

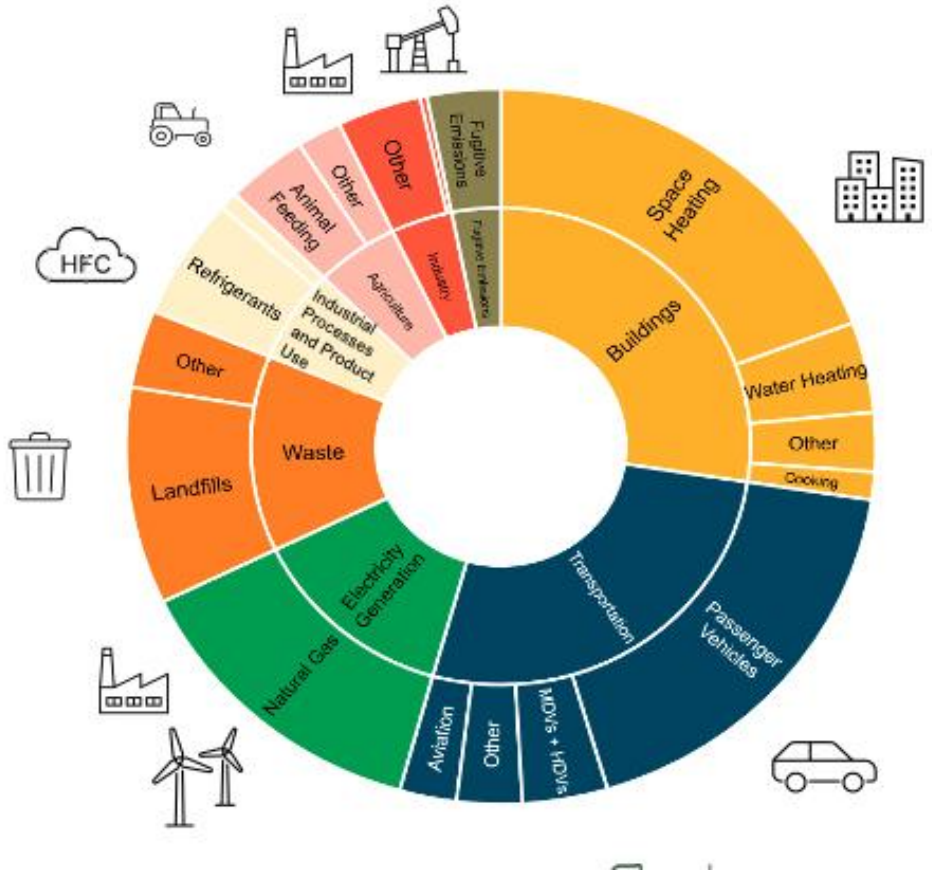
Climate Act Overview

Climate Leadership & Community Protection Act advancing a carbon-neutral economy, mandating at least:

- 40% reduction in emissions by 2030
- 85% reduction in emissions below 1990 levels by 2050
- Commitments to climate justice and just transition

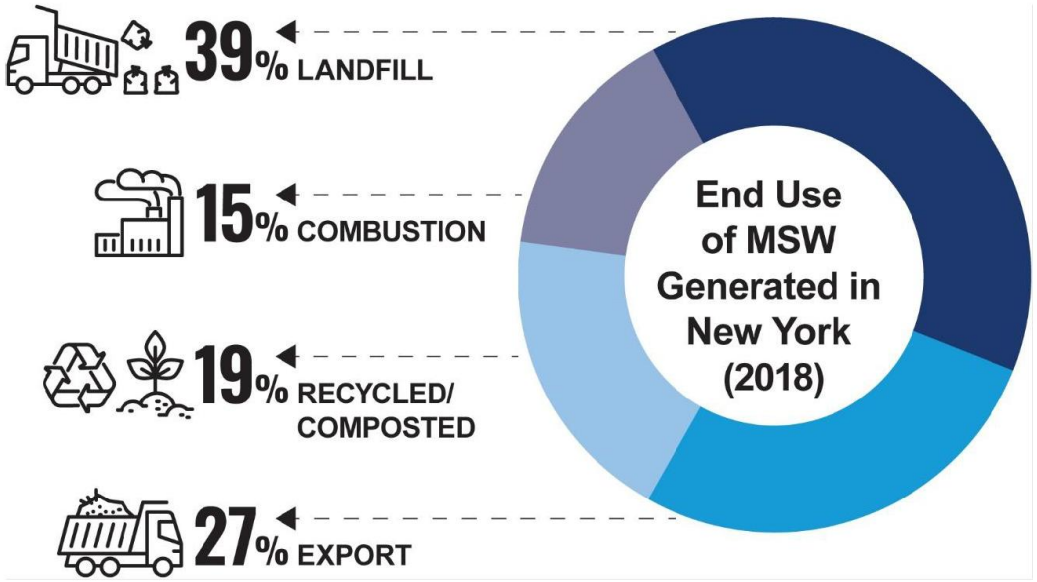
Draft Scoping Plan out for public comments and 10 public hearings (climate.ny.gov for details)

Estimated GHG Emissions by Sector



NY State Waste Management Under the CLCPA

Where we Are

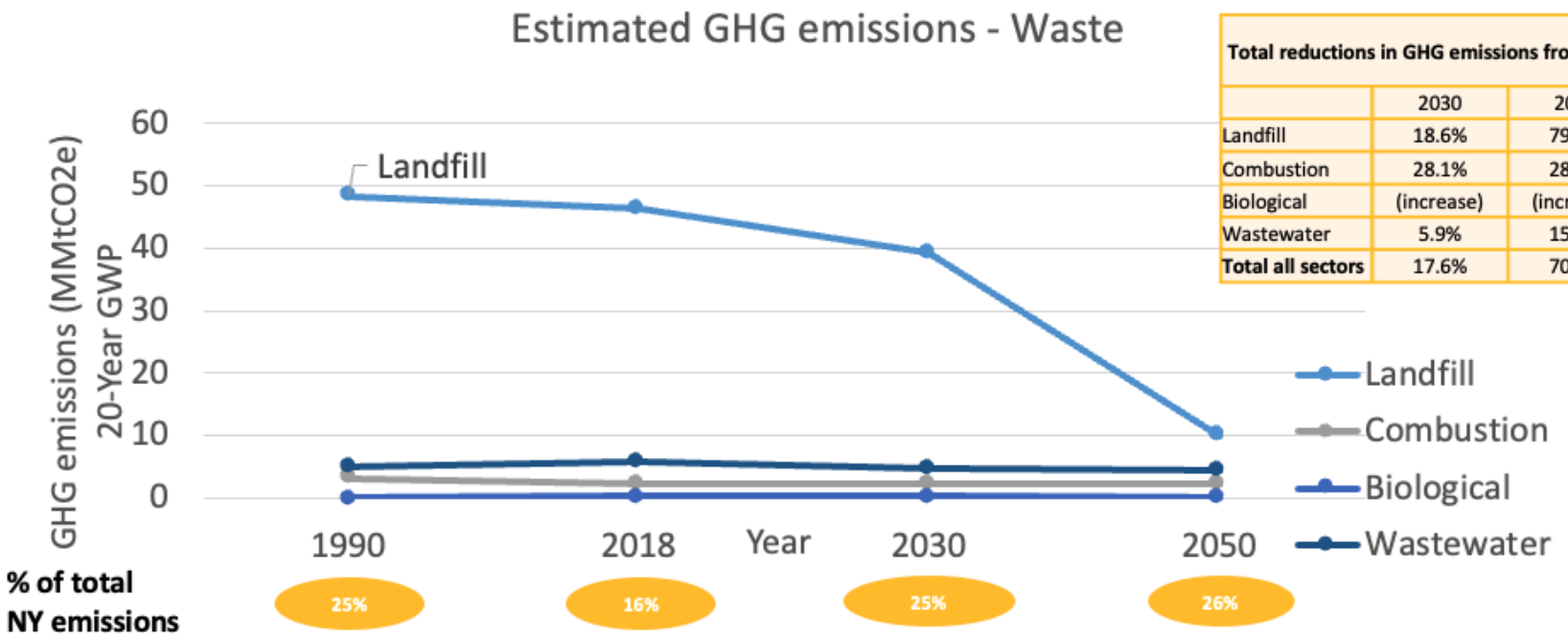


Source: DEC Solid Waste Annual Report.

Where we Need to Go

"The Climate Act requires a more dramatic decrease in GHG emissions by 2050, achieving at least an 85% reduction (compared with 1990 levels). For solid waste and WRRFs, this necessitates **a dramatic shift in the way waste is managed**, to the point that landfills and combustors are only used sparingly for specific waste streams, and reduction and recycling are robust and ubiquitous.."

Aggregate GHG Emissions Impact of Waste Panel Recommendations



Total reductions in GHG emissions from 1990		
	2030	2050
Landfill	18.6%	79.3%
Combustion	28.1%	28.1%
Biological	(increase)	(increase)
Wastewater	5.9%	15.7%
Total all sectors	17.6%	70.5%

NEW YORK STATE | Department of Environmental Conservation

2018 emissions data are preliminary draft

The CLCPA's structure provides

...Opportunities

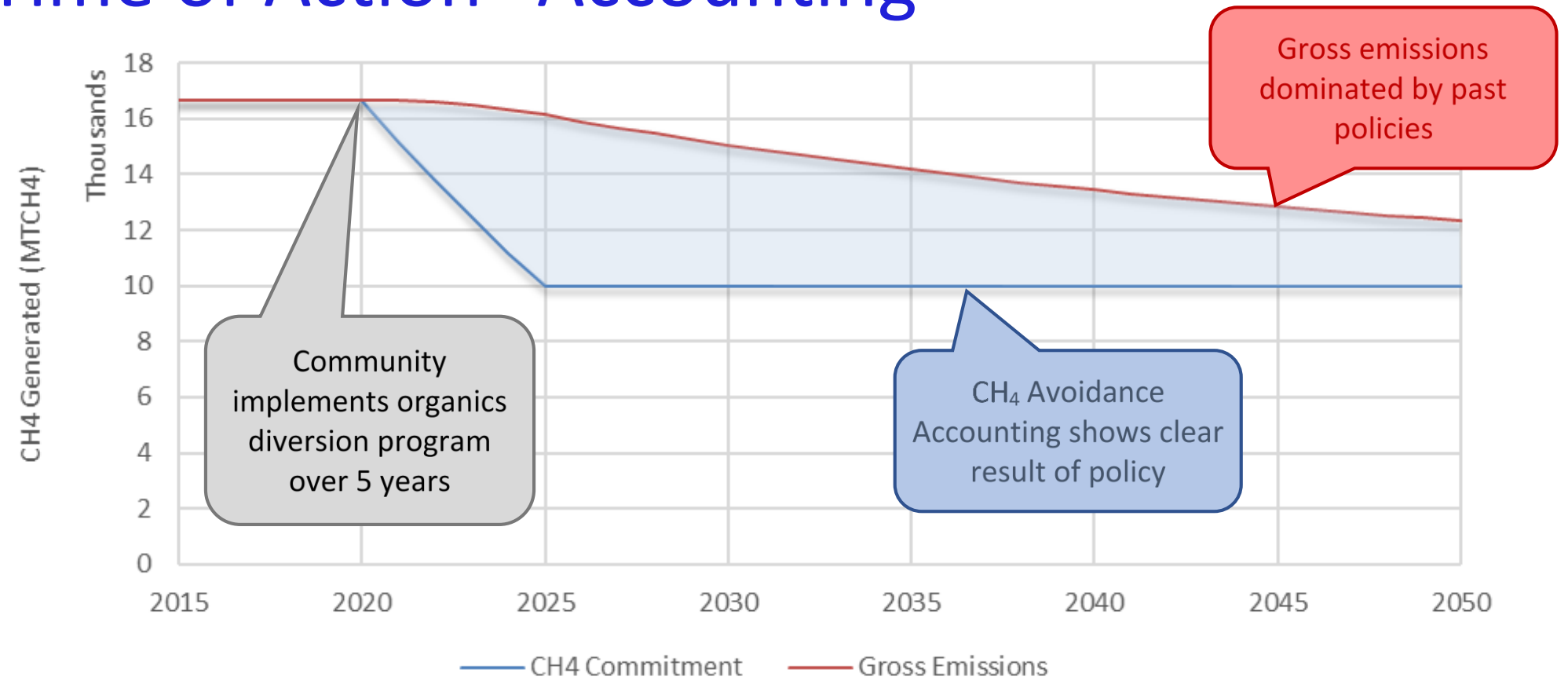
- 20-year methane GWP of 84
- Recognizes methane's role as a short-lived climate pollutant (SLCP) where reductions in methane emissions can have a large positive impact
- Recognizes impacts of waste shipped out of state

... and Challenges

- Biogenic CO_2 accounting
  - Emissions from a given biogenic material are "path dependent" – composting and landfill "pass through" excluded
- Aligning emissions signal with timing of & responsibility for waste management decisions
  - Inherent "lag" in emissions signal due to timing of landfill methane generation
  - Out of state waste management
  - Real GHG benefits realized elsewhere (e.g. recycling)

Shifting how waste is managed upstream of landfill disposal provides the greatest opportunity to reduce GHG emissions

“Time of Action” Accounting



Notes: Assumes 1st order decay rate constant of 0.04 / yr, 250ktons of MSW to landfill a year decreasing to 200ktons in 2025 at end of diversion program. Methane generation potential of 100 m^3 CH_4 / Mg MSW which declines to 75 m^3 CH_4 / Mg at the end of the organics diversion program. For clarity and to eliminate additional variables, methane generation prior to collection and oxidation is depicted.

Addressing the Waste Sector in NYCI

- All entities in the waste sector with CO_2 emissions greater than 25,000 metric tons must be obligated under the cap, regardless of the technology or source of the emissions, including all sources of biogenic CO_2.
- The economic signal must coincide with when the decision is made on how to manage the waste.
- Emissions accounting must be accurate and based on the latest science. Where accuracy cannot be assured, the emissions accounting should be conservative.
- The State's program must recognize the importance of waste management as a public service.
- For Long Island, including WTE facilities in the NY Cap and Invest (NYCI) program would in essence penalize Long Island towns and residents because there are no other disposal options somewhere between $21 million in 2025 to $138 Million in 2027.

Adherence to DAR-21

"When issuing permits, Section 7(2) of CLCPA requires all state agencies to consider 'whether such decisions are inconsistent with, or will interfere with, the attainment of **the statewide GHG emission limits** established in Article 75 of the environmental conservation law.' " *[emphasis added]*

- The purpose of DAR-21 is to evaluate attainment of statewide GHG emission limits, not ensure that all projects have no increase in emissions. WTE facilities divert waste from landfills, resulting in statewide emission reductions. This is a similar issue with other projects that reduce GHG emissions that invariably increase direct emissions from the project, including recycling (purchased energy, direct process emissions), wind turbines, and solar farms (upstream manufacturing emissions)

"In addition, the project scope includes any upstream, downstream, and indirect emissions known to be attributable to the project"

- DAR-21 sets the precedent for consideration of GHG emissions that occur outside of the fenceline of the project, including upstream, downstream, and indirect emissions.

"Any mitigation option must result in measurable GHG emissions reduction or sequestration that is in addition to actions already required by law or regulation."

- Diversion of post-recycled waste from landfills is not required by law or regulation.

"mitigation efforts must be real, quantifiable, permanent, verifiable, and enforceable."

- Emission reductions from increases in WTE throughput have been demonstrated in carbon offset markets and verified lifecycle assessments (LCAs). Reductions are quantifiable, real, permanent, and verifiable. There is no need to enforce the mitigation, as it occurs as a direct result of the project activity.

"mitigation should result in a reduction in GHG emissions that is at least equivalent to the increases in potential GHG emissions from the project."

- Diversion of post-recycled MSW from landfills to WTE results in a net GHG reduction

"mitigation must be undertaken at the project site or in the surrounding community whenever possible."

- Landfilling of post-recycled MSW is not allowed on Long Island, therefore, all reductions achieved by diversion must be realized outside of the community.

Thank You

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