

**WASTE AND SCOPE 3 EMISSIONS:**  
ASSESSMENT OF VALUE CHAIN GREENHOUSE GAS EMISSIONS IN THE US SOLID  
WASTE AND RESOURCE RECOVERY INDUSTRY

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# ABSTRACT

## WASTE AND SCOPE 3 EMISSIONS: ASSESSMENT OF VALUE CHAIN GREENHOUSE GAS EMISSIONS IN THE US SOLID WASTE AND RESOURCE RECOVERY INDUSTRY

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In calendar year 2022, five of the 45 largest waste companies in the United States (“US”) contributed over 106 billion pounds of carbon dioxide equivalent greenhouse gas (“GHG”) emissions into the atmosphere. Meanwhile, as the global climate crisis nears irreversible tipping points, society at large must reduce anthropogenic, or human-caused, GHG emissions by 45 percent from 2010 levels by 2030 and reach a net-zero emission rate by 2050. Achieving these reductions requires standard measurement and reporting methodologies. As of 2023, most US solid waste and resource recovery companies accurately and transparently report Scope 1 (direct and controllable) and Scope 2 (indirect from purchased utilities) emissions. However, only five of the 45 largest waste companies in the US reported on Scope 3, or indirect value chain emissions, in the 2023 reporting cycle. This report presents a comprehensive analysis of 2023 waste industry reporting and identifies areas of (dis)consensus regarding material emission sources. As of said reporting, Scope 1 accounts for on average 87 percent of companies’ combined Scope 1, 2, and 3 emissions, while Scope 3 accounts on average for 12 percent. Thus, it is recommended that waste companies immediately prioritize Scope 1 emission reductions, while simultaneously implementing Scope 3 monitoring programs that focus on the industry’s material Scope 3 sources: purchased goods and assets, fuel-related lifecycle emissions, and third-party transportation services. By accounting for Scope 3 alongside Scope 1 and 2 emissions, companies will be poised to meet and exceed sustainability goals and explore new business development opportunities while maintaining resiliency against climate, financial, and legal risk. Deeper emissions literacy among sustainability professionals and leadership will be key to redesigning a more efficient global value chain. Ultimately, a collaborative business sector will play a major role in solving the 21st Century’s most pressing issue: the global climate crisis.

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## List of Abbreviations Used in This Report

CO<sub>2</sub>e: carbon dioxide equivalent

CY22: Calendar Year 2022

GHG: greenhouse gas

GRI: Global Reporting Initiative

ISO: International Organization for Standardization

kg: kilogram

LFGTE: landfill gas-to-energy

MRF: material recovery facility

MSW: municipal solid waste

MT: metric ton

SB: Senate Bill

SBTi: Science Based Targets Initiative

SEC: Securities and Exchange Commission

US: United States

waste industry: *used as an abbreviation for “solid waste and resource recovery industry”*

ZEV: zero-emission vehicle

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## Introduction: Climate and the Waste Industry

It is widely known and accepted that the major contributors to global warming are the world’s biggest GHG emitters: oil and gas, agriculture, and landfills among them. “Municipal solid waste (MSW) landfills are the third-largest source of human-related methane emissions in the US, accounting for approximately 14.3 percent of these emissions in 2021” (USEPA, 2023).

The US’ solid waste and resource recovery industry (“waste industry”) is made up of waste haulers, as well as owners and operators of landfills, material recovery facilities (“MRF”), commercial compost facilities, transfer stations, waste-to-energy facilities, and more. Despite being a major GHG emitter, the waste industry is making tremendous strides through commitments like reducing absolute Scope 1 and 2 GHG emissions 35 percent by 2030 (*Sustainability in Action: 2021 GRI Report, 2022*), 40 percent by 2030 (*Sustainability Progress Report, 2023*), and 42 percent by 2031 (*ESG Data Center, 2022*), and using 75 percent of collected landfill gas to generate renewable energy by 2028 (*Sustainability Report 2023, 2023*).

Still, there is more opportunity to make global impact.

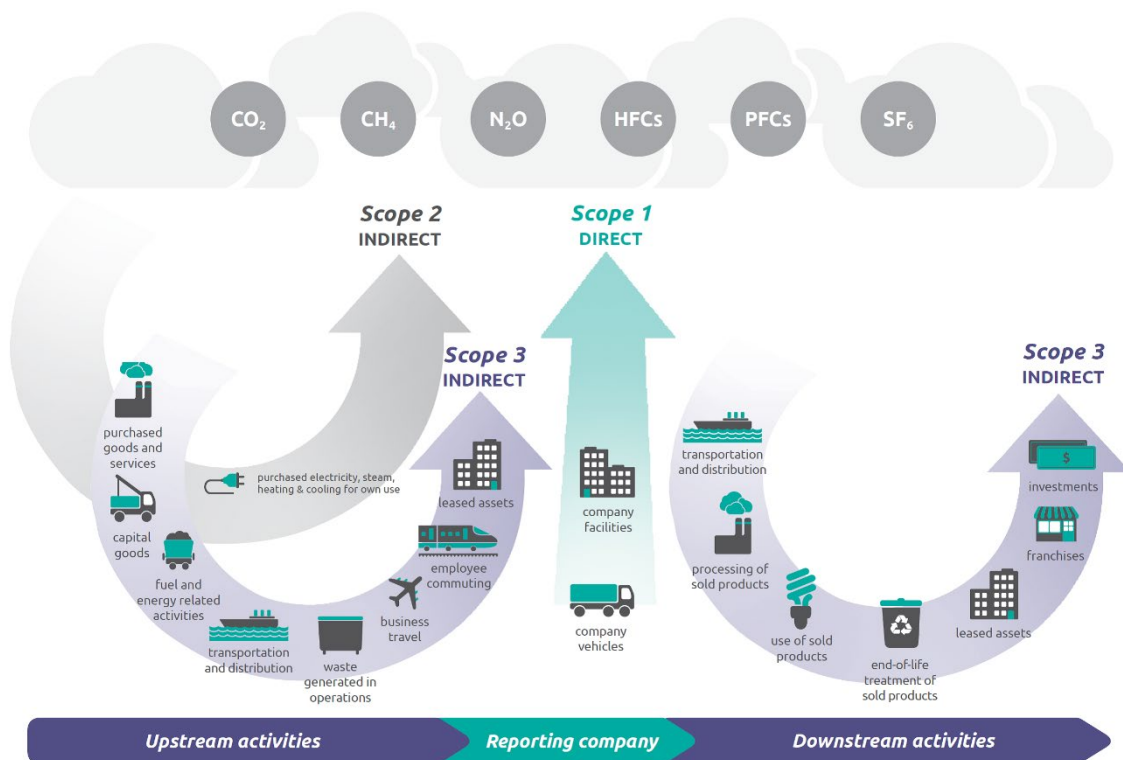


Figure 1: Overview of Scope 1, 2, and 3 GHG emissions across a reporting company's value chain. Source: Bhatia et al. (2011)

A company's entire carbon footprint is captured through a GHG emissions inventory. Figure 1 shows how emissions are distinguished between Scopes 1, 2, and 3. Today, most companies calculate and report Scope 1 emissions, those that result from direct sources such as company-owned vehicles and facilities, and Scope 2 emissions, indirect emissions from purchased electricity, steam, heating, and cooling for a company's own use. Less reported are Scope 3 emissions, or indirect emissions from a company's upstream and downstream value chain.

The waste industry's value chain – mapped graphically in Figure 2<sup>1</sup> – includes maritime transporters, contracted haulers, vehicle manufacturers, IT providers, business travel partners, and more. Working with these vendors, suppliers, and partners holds the key to unlocking well over five million metric tons (“MT”) of carbon dioxide equivalent (“CO<sub>2</sub>e”) GHG reductions each year across the waste industry's value chain.

A fully comprehensive emission inventory includes Scope 1, 2, and 3 emissions. As of the calendar year 2022 (“CY22”) reporting cycle, only five of the 45 largest US waste industry companies publicly disclosed Scope 3 emissions<sup>2</sup>. There is a need for guidance and industry-wide consensus on developing, maintaining, and improving comprehensive GHG inventories. Doing so will help companies meet and exceed sustainability goals and explore business development opportunities while maintaining resiliency against climate, financial, and legal risks.

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<sup>1</sup> Deeper explanation of Figure 2 can be found in the [Technical Guide: How to Build a Scope 3 Inventory](#).

<sup>2</sup> These companies are Covanta Energy, GFL Environmental, Republic Services, Waste Connections, and Waste Management, Inc. Stericycle also disclosed Scope 3 emissions in 2022, but is not included among the scope of “waste companies” because it is strictly a medical waste management company with no owned or operated landfills. Veolia Group similarly disclosed Scope 3 emissions in 2022, but because its primary service in the US is not traditional waste management, Veolia was not included in the analysis. See the full list of companies in the Appendix.

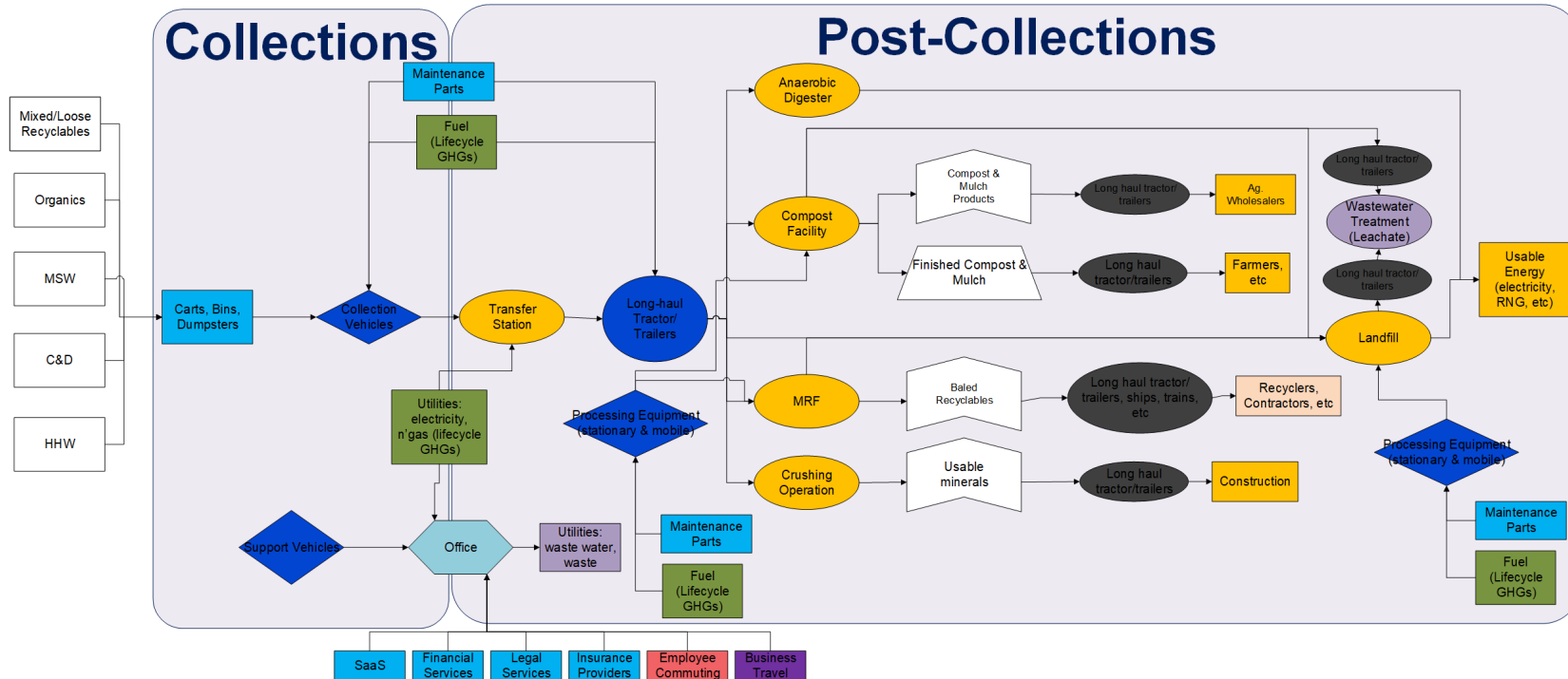
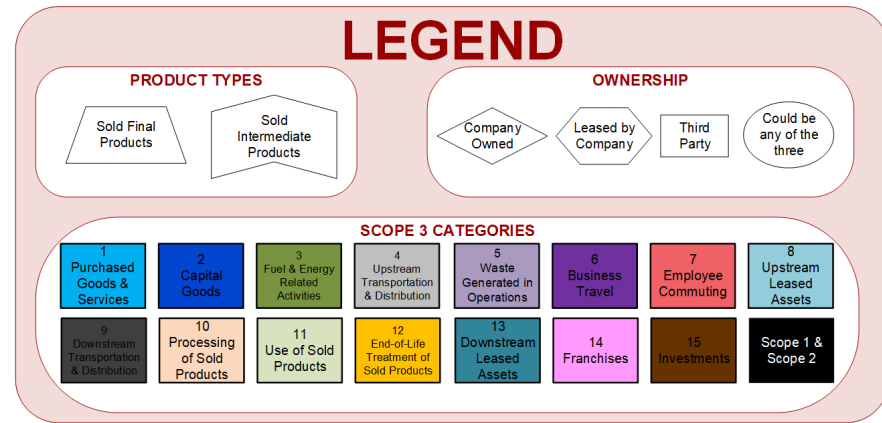


Figure 2: Value chain map for a typical waste company, developed by author with guidance from waste industry professionals.



## Methods: A Comprehensive Analysis

This report begins with a brief policy analysis to examine the risks and opportunities associated with reporting Scope 3 inventories in the waste industry. It then presents a comprehensive study of CY22 Scope 3 inventories in the waste industry to identify areas of consensus regarding material Scope 3 categories and methods for creating Scope 3 inventories. This study was informed by GHG accounting guidelines from The GHG Protocol, The Climate Registry's General Reporting Protocol, and the International Organization for Standardization ("ISO"), as well as conversations with industry professionals.

Conversations with industry professionals and research on the industry informed the creation of a waste industry value chain map, which should generally match that of most waste companies but can be modified to fit reporting companies' unique business models.

Finally, the learnings from the industry Scope 3 reporting analysis and value chain mapping exercise supported the development of a playbook-style guide for waste companies to develop Scope 3 inventories. This guide focuses on the industry's material Scope 3 categories and offers suggested data sources, emission factors, and calculation methodologies for different levels of Scope 3 accounting maturity levels.

## Results and Discussion

### Policy Analysis: An Evolving Scope 3 Reporting Landscape

The need for Scope 3 emissions disclosures has never been greater than it is today. The existential climate crisis necessitates action immediately to preserve the planet for future generations. A new wave of environmentally conscious customers is creating a social contract that requires businesses to govern and market themselves from a sustainability-focused foundation. Meanwhile, regulations on GHG emissions disclosures and reductions are propagating at local, state, federal, and international scales that, if not adhered to, could jeopardize businesses' financial health and profitability. The need is fundamental to the planet, to strategic business play, and to mitigating regulatory risk for corporations.

The global climate crisis is nearing irreversible tipping points. To avoid surpassing the 1.5-degree Celsius warming threshold by 2040, humans must decrease anthropogenic GHG emissions by 45 percent from 2010 levels by 2030 and reach net-zero carbon emissions by 2050. That which cannot be measured cannot be managed. It is thus imperative to achieve standard global measurement and disclosure practices to achieve these goals.

The 2020's are seeing a global workforce and customer-base dominated by Millennials and Generation Z, as opposed to Baby Boomers and Generation X. The younger generations are keen on social justice and environmental consciousness and expect businesses to function and act in line with those values. The workforce is no longer content with wages alone, nor are consumers content with products alone. Both demand that companies are both profitable and serve the greater good. Companies who put environmental sustainability at the front of branding efforts, measure and reduce carbon footprints, and work with suppliers to cascade these values into the value chain are more likely to attract and retain top talent and loyal customers.

In pursuit of these business development strategies, companies are voluntarily taking environmental sustainability action, such as reporting climate data to CDP<sup>3</sup> and the Global Reporting Initiative ("GRI"), setting GHG reduction targets with the Science Based Target Initiative ("SBTi"), and disclosing GHG inventories in alignment with methodologies such as the ISO 14000 series, The Greenhouse Gas Protocol, and The Climate Registry's General Reporting Protocol. Most companies report Scope 3 emissions, among other climate data, through CDP in response to customer requests.

In the waste industry, Republic Services and Waste Management are the only companies to have received approval on GHG reduction targets through SBTi. However, as shown in Table 1, these targets do not yet include any Scope 3 reductions. This is because SBTi only requires Scope 3 reductions if a company's Scope 3 inventory makes up 40% or more of its combined Scope 1, 2, and 3 inventory (*Target Validation Protocol for Near-term Targets*, 2023). This is uncommon to achieve in the waste industry because of landfills' and heavy-duty vehicle fleets' high GHG emissions. As companies take both voluntary and mandated steps to decarbonize those two emission sources, said companies may approach the 40% threshold for Scope 3 emissions more quickly than expected. This is especially relevant in states with food scrap diversion policies meant to reduce landfill fugitive methane emissions – Scope 1 emission sources for waste companies – which result from anaerobic decomposition of organic waste in landfill cells. It is also relevant in states with zero-emission vehicle ("ZEV") policies meant to decarbonize the transportation sector – also Scope 1 emission sources for waste companies – by reducing or altogether eliminating tailpipe emissions from on-road

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<sup>3</sup> Previously named the "Carbon Disclosure Project," CDP is a not-for-profit charity that runs global disclosure systems. The organization rebranded to CDP in 2013 to encompass additional environmental disclosure topics such as forests and water. CDP's Climate Change reports – which include Scope 1, 2, and 3 disclosure requests – are due in July of each year.

vehicles. Table 2 shows states with such policies. Waste companies operating in these states should monitor Scope 3 emissions more carefully, as the chances of reaching the 40% threshold are more likely in the nearer future than for waste companies operating in less progressively regulated states.

Beyond voluntary disclosures, policymakers are no longer encouraging, but instead mandating, action across the board on GHG emissions reporting. On October 7<sup>th</sup>, 2023, California Governor Gavin Newsom signed several climate-related bills into law<sup>4</sup>, including Senate Bill 253 (“SB 253”), the Climate Corporate Data Accountability Act. SB 253 requires all public and private companies doing business in California with over one billion dollars in annual global revenue to report annual GHG emissions to the state. These reports will begin in 2026 with Scope 1 and 2 emissions disclosures. Scope 3 disclosure requirements begin in 2027. This regulation will impact all major US waste companies as well as many smaller waste companies.

Additionally, similar rulings have been proposed and adopted by the US Securities and Exchange Commission (“SEC”) and the US federal government for US public companies and federal contractors, respectively. On March 6<sup>th</sup>, 2024, the SEC voted to mandate disclosure of climate risk information from all publicly traded companies. This regulation includes Scope 1 and 2 emissions and additional climate risk disclosures. Though included in earlier drafts of the proposal, the regulation adopted lacks mandatory Scope 3 disclosures<sup>5</sup>. Meanwhile, a proposed amendment to the Federal Acquisition Regulation would require certain federal contractors to disclose their Scope 1, 2, and 3 emissions, climate-related financial risk, and science-based reduction targets.

These regulations are likely the first waves of an approaching tsunami of climate regulations. GHG accounting is shifting from a carrot to a stick approach, no longer leaning on goodwill-based voluntary disclosures, but instead requiring action through regulation. Eccles and Mulliken (2021) beg the question, “what is your carbon liability?” specifically of financial, legal, and compliance leaders. Regulations like SB 253 and the SEC mandate are likely to be steppingstones toward a regulatory landscape that is focused on reductions rather than measurement and disclosures alone. In other words, there exist two types of risk: physical and

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<sup>4</sup> As of March 2024, California’s \$38 billion budget deficit is leaving SB 253 and all newly signed laws from 2023 without funding. This will likely delay implementation timelines.

<sup>5</sup> Additionally, the ruling is facing litigation as of March 2024 and could be revoked entirely should the US presidency change hands in 2024.

Table 1: Scope 3 Disclosure and Action by US Waste Companies (2023 Sustainability Report, 2023; Covanta Energy Corporation - Climate Change 2023, 2023; GFL Environmental Inc - Climate Change 2023, 2023; Republic Services, Inc. - Climate Change 2023, 2023; Stericycle Inc. - Climate Change 2022, 2022; Veolia Environnement SA - Climate Change 2022, 2022; Waste Management, Inc. - Climate Change 2023, 2023)

Waste Company	Scope 3 Disclosures	Scope 3 Target
Covanta Energy	CDP	n/a
GFL Environmental	CDP	n/a
Republic Services	CDP	SBTi (S3 n/a)
Stericycle	CDP	n/a
Veolia Environmental USA	CDP	n/a
Waste Connections	GRI	n/a
Waste Management, Inc.	CDP	SBTi (S3 n/a)

Table 2: US states with food scrap diversion and zero-emission vehicle (“ZEV”) mandates as of 2023 (Fletcher, 2024; Organics Bans and Mandates, 2023)

State	Food Scrap Policy	ZEV Policy
California	•	•
Colorado		•
Connecticut	•	•
Delaware		•
Illinois		•
Maine		•
Maryland		•
Massachusetts	•	•
Michigan		•
Minnesota		•
Nevada		•
New Hampshire	•	
New Jersey	•	•
New Mexico		•
New York	•	•
North Carolina		•
Oregon	•	•
Rhode Island		•
South Carolina		•
Vermont	•	•
Virginia		•
Washington	•	•

transition risk. Climate change bears physical risk. That is, with climate change comes extreme weather events – hurricanes, wildfires, drought, etc. – with the potential to damage and destroy physical assets – buildings, trucks, and processing equipment – and put waste companies out of business. But climate change also bears high transition risk, or the potential for regulation meant to decarbonize the economy to increase the cost of doing business by orders of magnitude. Carbon taxes are yet to come. The larger a company’s GHG footprint, the larger its carbon liability and risk of massive regulatory-based operating expenditures. Regulations like California’s Advanced Clean Fleets act, which requires fleets to transition to ZEVs, are already bringing these transition risks to form in the waste industry.

### Industry Analysis: A Need for Consistency in GHG Reporting

Scope 3 emissions are quickly becoming one of the most significant accounting challenges and emission reduction opportunities of corporate sustainability professionals’ work. CDP notes that as of 2021 response data, “Scope 3 emissions account on average for 75% of total Scope 1+2+3 emissions.” This can range as high as 100% for the financial services sector and as low as 16% for the cement industry, as shown in Figure 3. The transport services sector, which typically encompasses the waste industry, sees Scope 3 emissions accounting on average for about 33% of total Scope 1+2+3 emissions (*CDP Technical Note: Relevance of Scope 3 Categories by Sector, 2022*).

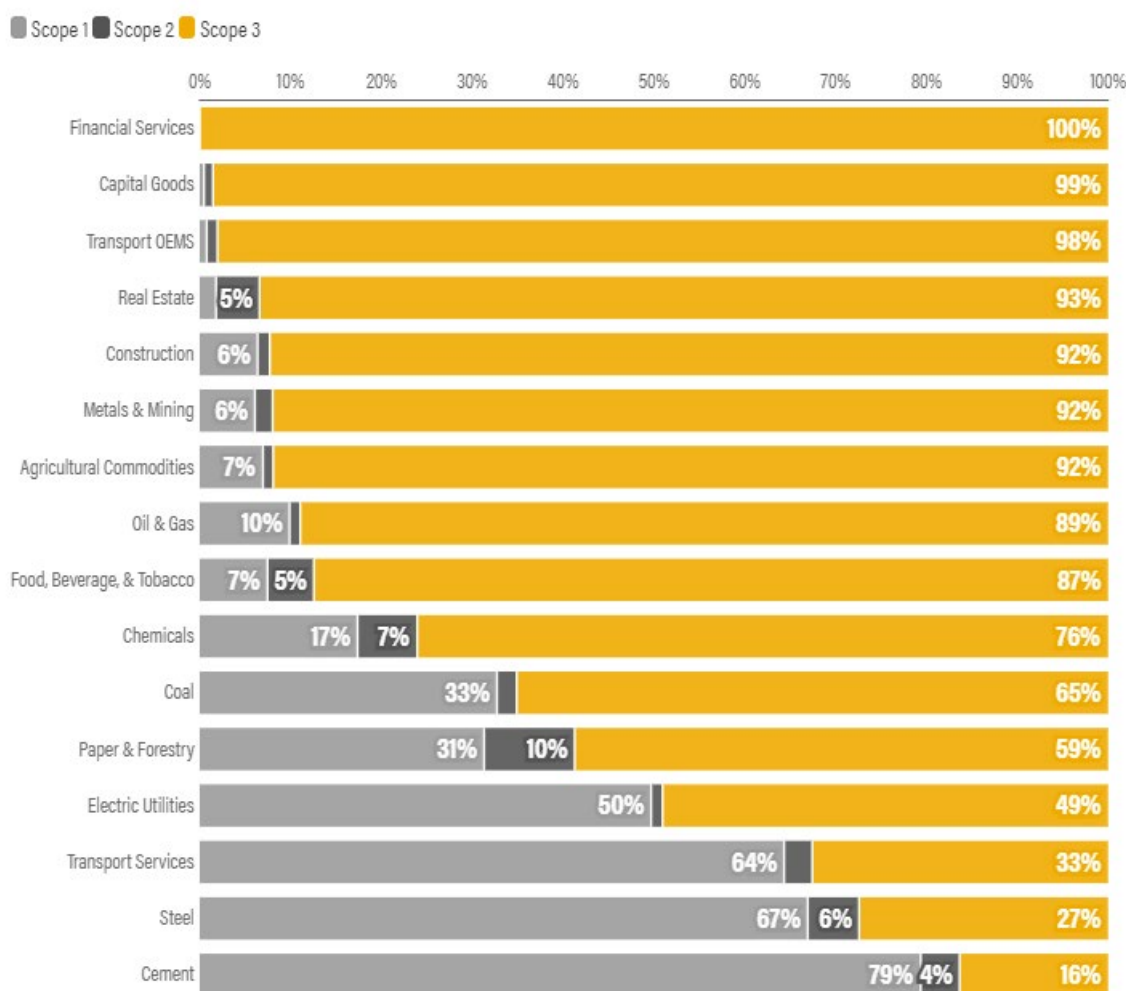
Despite the well-respected and recognized Scope 3 Standard, which outlines the 15 key Scope 3 emission source categories and exists to provide a global framework for GHG emissions accounting and reporting for corporations (Bhatia et al., 2011), there can be significant discrepancies in methodologies, data sources, and completeness of Scope 3 emission inventories, particularly within the waste industry. For example, in CY22, Waste Management, Inc. reported an impressive 10 of the 15 total Scope 3 categories outlined in the GHG Protocol, but admitted that changing methodologies, limited knowledge of the supply chain, and data availability results in the inclusion and omission of such categories, as well as the sources within these categories, changing year to year (*ESG Data Center, 2022*).

Studies of other sectors, including Danish wastewater treatment plants, a mix of Australian corporations, as well as global food and beverage companies have found similar challenges with Scope 3 reporting, including,

- 1) a wide range of internal emission factors to choose from, published by both private and public entities at local, regional, and global levels,

- 2) significant variety in number of emission sources reported,
- 3) inconsistent use of various methodologies to determine material Scope 3 emission categories,
- 4) lack of national and industry-specific regulatory rigor in emissions accounting guidance and requirements, and
- 5) general underreporting for various other reasons, including data availability, a corporations' commitment to sustainability, or lack of internal human resources available to support reporting (Downie & Stubbs, 2013; Faragò et al., 2022; Hansen et al., 2022).

### Share of Scope 3 Emissions to Total Emissions, by Sector



Source: Data is from CDP. Research and analysis of the data was conducted by Concordia University.

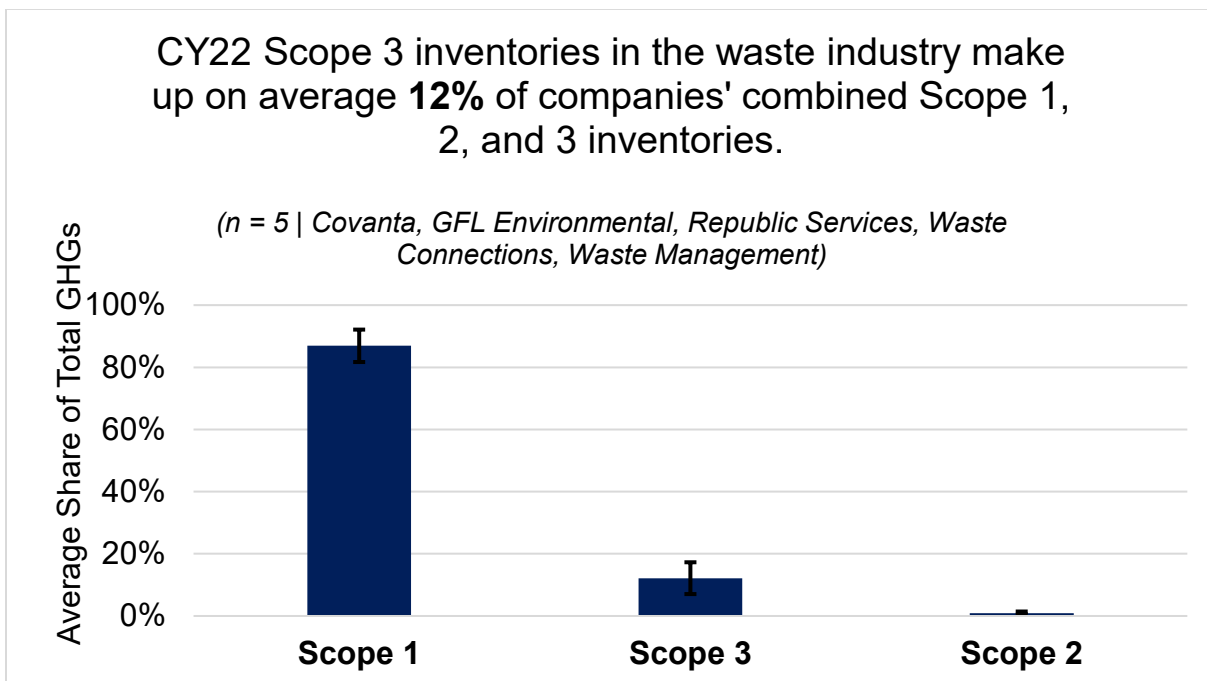


Figure 3: Total GHG Inventories by Sector (Hadziosmanovic et al., 2022)

These challenges can result in significant Scope 3 reporting variances, in one instance as large as 1500% (Faragò et al., 2022). Though total Scope 3 inventory discrepancies have not yet been thoroughly researched, this instance alone shows the impact emission factor variances can have on total GHG inventories.

Further review of waste industry Scope 3 emissions methodologies and data, available for the year ended December 31, 2022 from Covanta, GFL Environmental, Republic Services, Waste Connections, and Waste Management, reveals trends and discrepancies in Scope 3 category contribution, methodologies, data sources, and inventory completeness.

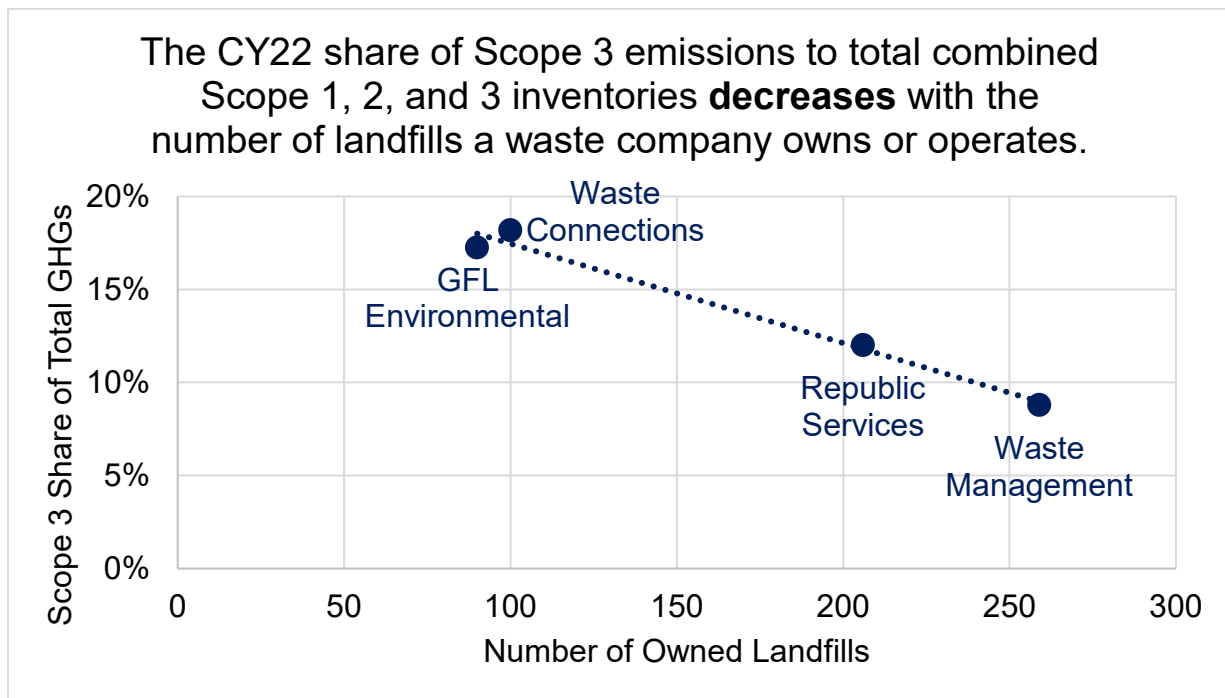
Figure 4 shows that, as of CY22 publicly reported values (which, as previously stated, carry some uncertainty), Scope 1 emissions account for on average 87% (5% standard deviation) of waste companies' combined Scope 1, 2, and 3 emissions, while Scope 3 emissions account on average for 12% (5% standard deviation) of waste companies' total emissions. It is evident that the primary near-term priority for emission reductions by waste companies must be on Scope 1 emissions. Meanwhile, Scope 3 emissions must be monitored and, as they grow in share of combined GHG inventories, reduced.



*Figure 4: An analysis of the average share of Scope 3 emissions compared to waste companies' Scope 1 and 2 emission inventories (2023 Sustainability Report, 2023; Covanta Energy Corporation - Climate Change 2023, 2023; GFL Environmental Inc - Climate Change 2023, 2023; Republic Services, Inc. - Climate Change 2023, 2023; Waste Management, Inc. - Climate Change 2023, 2023)*

The large contribution of Scope 1 emissions to waste companies' total GHG inventories can be largely attributed to landfill ownership and management. In fact, the USEPA (2023) states, "landfills are the third-largest source of human-related methane emissions in the United States, accounting for approximately 14.3% of these emissions in 2021." Figure 4 shows this enormity of landfill methane emissions – the primary source of Scope 1 emissions for the waste industry – compared to indirect Scope 2 and 3 emissions.

Looking more deeply at the impact of landfill emissions on waste companies' GHG inventories, Figure 5 shows the direct correlation between the number of landfills a company has and its share of Scope 3 emissions. The more landfills a waste company owns or operates, the less impact Scope 3 has on its overall GHG inventory. Thus, there is a stronger need for waste companies with minimal landfill ownership business models to prioritize Scope 3 emission reporting and reduction efforts compared to waste companies with heavy landfill ownership.

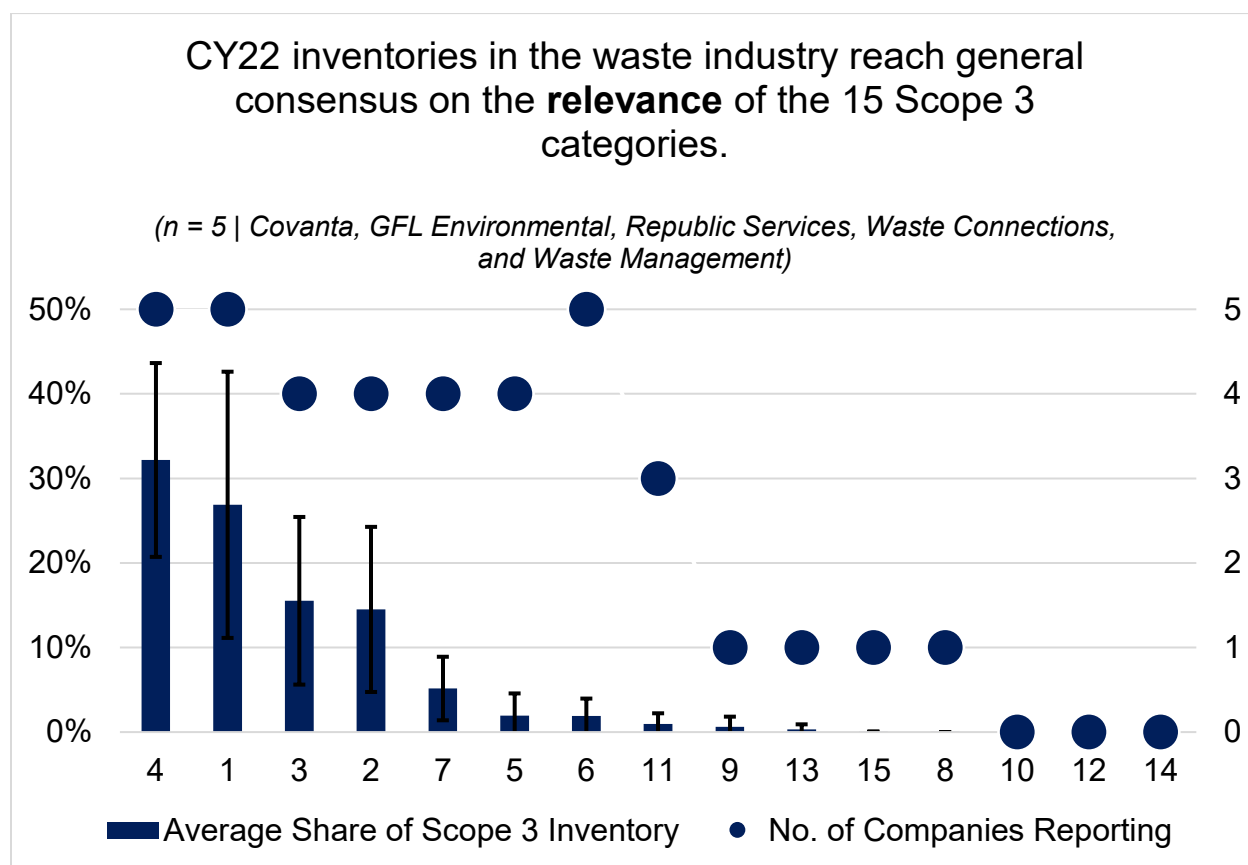


*Figure 5: An analysis of Scope 3 emissions compared to landfill ownership (2022 ESG Data Summary Table, 2022; 2023 Sustainability Report, 2023; Form 10-K: Republic Services, Inc., 2023; Form 10-K: Waste Management, Inc., 2023; GFL Environmental Inc - Climate Change 2023, 2023; Republic Services, Inc. - Climate Change 2023, 2023; Waste Management, Inc. - Climate Change 2023, 2023)*

Finally, existing CY22 Scope 3 reports from the waste industry highlight some consensus on the materiality, or relevancy, of the 15 recognized Scope 3 categories to the industry overall. Figure 6 summarizes the findings, highlighting a clear consensus that



categories 1 (Purchased Goods and Services), 2 (Capital Goods), 3 (Fuel and Energy Related Activities), and 4 (Upstream Transportation and Distribution) are key categories to capture quantitatively, as they account for most Scope 3 emissions in the waste industry as of CY22 reporting. Category 5 (Waste Generated in Operations) is increasingly becoming relevant as better data becomes available, particularly on leachate from waste operations, but also from MSW generated during operations. Categories 6 (Business Travel) and 7 (Employee Commuting) are also highly reported, often noted as relevant because of their potential positive effect on employee engagement with regards to emission reduction efforts.



*Figure 6: An analysis of the average contribution of each Scope 3 category to the overall Scope 3 GHG inventory (2023 Sustainability Report, 2023; Covanta Energy Corporation - Climate Change 2023, 2023; GFL Environmental Inc - Climate Change 2023, 2023; Republic Services, Inc. - Climate Change 2023, 2023; Waste Management, Inc. - Climate Change 2023, 2023)*

Clearly, Scope 1 emission reductions must be critical priorities for the waste industry. However, as internal environmental sustainability efforts mature, companies should consider accurately and completely calculating and reporting Scope 3 inventories, as well.

## Recommendations: A Journey Towards GHG Accounting Maturity

An organization's Scope 3 reporting journey is just that: a journey. A company should expect to improve its GHG accounting maturity over time by evolving from spend-based methodologies, to average data, to hybrid data, and finally to supplier-specific data methods, as described in detail in Figure 7.

Each improvement in methodology and source both requires additional resources and yields more insightful, actionable data. For example, if a company purchases a brand-new waste collection vehicle, the Scope 3 emissions from said purchase will look different based on the data methodology applied. With the spend-based methodology, the company only needs to know how much the procurement team spent on said vehicle: \$1,000,000.00. An analyst would then apply a spend-based emission factor to estimate the associated Scope 3 emissions: 0.307 kilograms ("kg") of CO<sub>2</sub>e per US dollar (Ingwersen, 2023). This would result in an equivalent carbon footprint for the purchase: 307 MT-CO<sub>2</sub>e. This is helpful for estimating and reporting the company's Scope 3 emissions, but not helpful for making progress towards absolute emission reductions. Instead, should the waste company seek to make meaningful Scope 3 reductions, it must first partner with its supply chain to understand the emissions more granularly. The average data method will make use of an emission factor that is not by spend – which might be significantly dependent on taxes (or tax subsidies), unique dealers' business models, etc. – but instead by the asset itself: kg-CO<sub>2</sub>e per heavy-duty vehicle. The final level of emissions maturity is asking the vendor for its unique carbon intensity: e.g., kg-CO<sub>2</sub>e per Heil® automated side loader vehicle. In doing so, the waste company can compare offerings of unique assets between two or more vendors to optimize its purchasing choice not only on performance and cost, but also on embodied GHG emissions. A company should aim for the right level of data maturity based on its GHG reduction strategy, which is heavily influenced by its Scope 3 maturity and risk appetite, as discussed in Figure 7.

Emission monitoring, reporting, and reduction approaches take time, effort, thoughtfulness, and resources. Dedicated personnel, modern data management technologies, and well-designed, continuously refined, climate justice-centered supplier engagement strategies must be implemented to achieve an organization's goals. As a company matures in its journey, additional thought and resources should be dedicated to efforts to improve the accuracy of GHG data and develop and execute the supplier engagement strategy.

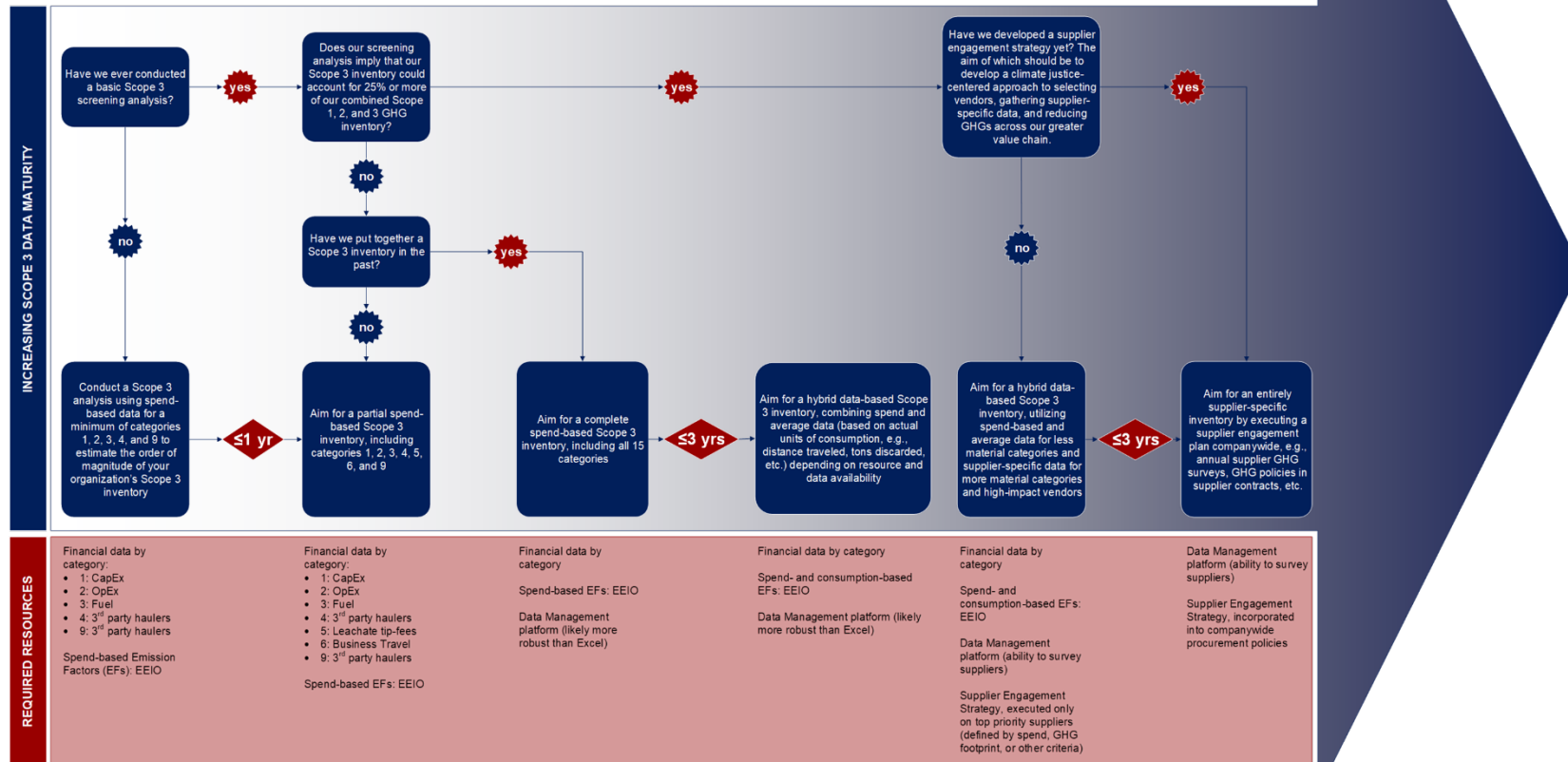


Figure 7: Decision-making tree for selecting a reporting company's targeted level of Scope 3 inventory maturity, based on relative size of Scope 3 inventory compared to Scope 1 and 2 emissions, history of Scope 3 inventory development, and readiness to engage with suppliers.

## Conclusion: Meaningful Reporting for a Sustainable Future

The Earth is set to pass the 1.5-degree Celsius warming threshold by 2040. The global climate crisis requires decreasing anthropogenic GHG emissions by 45 percent from 2010 levels by 2030 and reaching net-zero carbon emissions by 2050 (Pörtner et al., 2022). Progress towards these emission reduction targets requires proper measurement, accounting, and reporting methodologies. While emissions accountants worldwide are becoming more comfortable with Scope 1 (direct and controllable) and Scope 2 (indirect from purchased utilities) emissions, Scope 3 emissions accounting is still uncharted territory for many organizations across sectors and disciplines.

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*“While it is critical to immediately begin monitoring Scope 3 emissions, today’s resources should primarily be allocated toward Scope 1 emission reductions.”*

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The GHG reduction potential and transition risk liability for a company depends on its distribution of Scope 1, 2, and 3 emissions, and the sources within each. As previously discussed, the SBTi sets a materiality threshold of 40% for Scope 3 emissions; that is, if Scope 3 emissions make up 40% or more of an organization’s combined Scope 1, 2, and 3

emissions, SBTi believes it is imperative for said organization to establish and make progress towards a Scope 3 emission reduction target. Scope 3 emissions account for, on average, 12% of waste companies’ combined GHG inventories. Thus, while it is critical to immediately begin monitoring Scope 3 emissions, today’s resources should primarily be allocated toward Scope 1 emission reductions, namely fugitive landfill emissions and mobile fleet emissions. Because waste companies with minimal landfill ownership or operations in states with organics diversion and/or ZEV mandates are likely to have lower or more quickly mitigate Scope 1 emissions, said companies will approach the 40% threshold more quickly. Thus, said companies should pay immediate attention towards monitoring, reporting, and working with suppliers to reduce Scope 3 emissions.

The waste industry has traditionally been seen as an antagonist, aiding in the man-made mountains of once-valuable materials that now generate billions of metric tons of methane annually, contributing to the climate crisis. But today’s waste industry – characterized by recycling, composting, and rediscovering the value in discarded materials – is well-positioned to

lead a sustainable future. Embedding integrous emissions accounting programs in waste companies is a foundational step in this journey.

With commonly accepted and practiced GHG emissions accounting practices, companies can build complete and accurate emission inventories, which become tools to drive business development decisions and maintain resiliency against climate, financial, and legal risk. When professionals understand complete emission inventories, including emissions from Scope 1, 2, and 3 sources, a common language can be used to redesign a less polluting, more efficient, and more just value chain across sectors and industries. This collaboration from the business sector is vital to solving the global climate crisis.

## Appendix

### Detail on the Analysis of Waste Industry GHG Reporting

More detail on the conducted Scope 3 inventory analysis of the waste industry, as referenced through Figures 4, 5, and 6, can be found in Tables 3 and 4. Table 3 shows further detail on CY22 reports for Covanta, GFL Environmental, Republic Services, Waste Connections<sup>6</sup>, and Waste Management. Table 4 presents most US waste companies, sorted by annual revenue, and whether each has publicly shared Scope 3 data.

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<sup>6</sup> Waste Connections only reports quantitative Scope 3 emissions through its GRI report. Waste Connections' data methodologies for Scope 3 are not publicly available.

Table 3: Full CY22 analysis of waste companies' GHG inventories. Blue text denotes raw data. Black text denotes calculated data. Gray cells denote non-reported categories (2022 ESG Data Summary Table, 2022; 2023 Sustainability Report, 2023; Covanta Energy Corporation - Climate Change 2023, 2023; Form 10-K: Republic Services, Inc., 2023; Form 10-K: Waste Management, Inc., 2023; GFL Environmental Inc - Climate Change 2023, 2023; Republic Services, Inc. - Climate Change 2023, 2023; Waste Management, Inc. - Climate Change 2023, 2023)

	Purchased Goods & Services	Capital Goods	Fuel & Energy Related Activities	Transportation & Distribution	Waste Generated in Operations	Business Travel	Employee Commuting	Leased Assets	Transportation & Distribution	Processing of Solid Products	Use of Solid Products	End-of-life Treatment of Solid Products	Leased Assets	Franchises	Investments							
	Upstream Activities								Downstream Activities							Scope 3 Total	Scope 1	Scope 2 Location	Scope 2 Market	Biogenic	S1 + S2m + S3	
CDP Climate Change 2023 Reports	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Scope 3 Total	Scope 1	Scope 2 Location	Scope 2 Market	Biogenic	S1 + S2m + S3	
Covanta	% of S3	50%	0%	13%	30%	0%	2%	3%	0%	3%	0%	0%	0%	0%	0%							
	MTCO2e	106,077	0	27,569	63,895	0	3,584	6,634	0	6,516	0	0	0	0	0	214,275	4,417,301	19,279	19,279	5,980,106	4,650,855	
	Data Method	Avg Data	Not Relevant	Avg Data	Avg Data Distance-based	Not Relevant	Supplier-specific	Distance-based	Not Relevant	Avg Data Distance-based	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant						Not Applicable
% of S1 + S2m + S3	2%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	95%		0%			
GFL Environmental	% of S3	29%	17%	13%	36%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%							
	MTCO2e	251,791	145,107	112,210	310,456	1,242	3,184	34,356	0	0	0	12,010	0	0	0	670,358	4,142,262	30,802	30,802	531,767	5,043,422	
	Data Method	Spend-based	Spend-based	Fuel-based	Spend-based	Hybrid	Distance-based	Avg Data	Not Relevant	Not Relevant	Not Relevant	Fuel-based	Not Relevant	Not Relevant	Not Relevant							Not Applicable
% of S1 + S2m + S3	5%	3%	2%	6%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	17%	82%		1%				
Republic Services	% of S3	34%	11%	29%	16%	1%	0%	8%	0%	0%	0%	0%	0%	0%	0%							
	MTCO2e	656,385	203,995	554,664	313,376	17,989	7,211	155,334	186	0	0	0	0	0	0	1,909,140	13,688,116	300,782	304,496	6,692,685	15,901,752	
	Data Method	Spend-based	Spend-based	Supplier-specific	Supplier-specific	Waste-type-specific	Supplier-specific	Distance-based	Spend-based	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant	Not Relevant							
% of S1 + S2m + S3	4%	1%	3%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	12%	86%		2%				
Waste Connections (GRI; CDP is not public)	% of S3	2%	30%	0%	51%	7%	6%	0%	0%	0%	3%	0%	0%	0%	0%							
	MTCO2e	23,405	326,464		555,459	76,217	63,637									1,080,550	4,812,957	49,805	49,805	Not reported	5,943,312	
	Data Method	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available							
% of S1 + S2m + S3	0%	5%	0%	9%	1%	1%	0%	0%	0%	0%	1%	0%	0%	0%	18%	81%		1%				
Waste Management	% of S3	19%	15%	23%	28%	2%	1%	11%	0%	0%	0%	0%	2%	0%	0%							
	MTCO2e	288,762	222,620	339,725	410,615	24,397	16,544	157,395	0	0	0	1,175	0	22,731	0	2,130	1,488,094	15,321,737	301,883	138,743	15,144,779	16,948,574
	Data Method	Spend-based	Spend-based	Avg Data	Distance-based	Waste-type-specific	Distance-based	Avg Data	Not Relevant	Not Relevant	Not Relevant	Fuel-based	Not Relevant	Avg Data	Not Relevant	Avg Data						
% of S1 + S2m + S3	2%	1%	2%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	9%	90%		1%				
Industry Totals (MT-CO2e)																5,562,417	42,382,373	702,551	543,125	28,349,327	48,487,915	
[lbs-CO2e]																12.26B	93.44B	1.55B	1.20B	62.50B	106.90B	
Average % of S3	27%	15%	16%	32%	2%	2%	5%	0%	1%	0%	1%	0%	0%	0%	0%							
Std. Deviation	16%	10%	10%	11%	3%	2%	4%	0%	1%	0%	1%	0%	1%	0%	0%							
No. of Companies Reporting	5	4	4	5	4	5	4	1	1	0	3	0	1	0	1							
Avg % of S1+S2+S3	3%	2%	2%	4%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	12%	87%		1%			
Std. Dev.	2%	2%	1%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	5%		1%			

Table 4: Seven of the top 46 US waste companies disclosed Scope 3 emissions as of September 2023. Each company researched individually. List adapted from Cottom (2019) with insight from industry professionals. 2018 revenues captured from Cottom (2019). Revenues from companies with asterisks captured from ZoomInfo (About: Alameda County Industries, 2024; About: Edco, 2024; About: GreenWaste Recovery, 2024; About: Mid Valley Disposal, 2024; About: Mt Diablo Resource Recovery, 2024; About: Solid Waste of Willits, 2024)

Waste Company	2018 Revenue	Scope 3 Disclosures (as of Sep 2023)
WM	\$14,910.0M	✓
Republic Services	\$10,040.9M	✓
Waste Connections	\$4,923.0M	✓
Stericycle	\$3,485.9M	✓
Clean Harbors	\$3,300.3M	✗
GFL Environmental	\$2,052.0M	✓
Covanta Energy	\$1,868.0M	✓
Recology	\$1,200.0M	✗
Waste Pro	\$694.0M	✗
Casella Waste Systems	\$660.7M	✗
Rumpke Waste & Recycling	\$643.3M	✗
US Ecology	\$565.9M	✗
Veolia Environmental USA	\$425.0M	✓
Heritage-Crystal Clean	\$410.2M	✗
WCA Waste Corporation	\$357.0M	✗
Action Environmental Group (Interstate Waste Services)	\$300.0M	✗
USA Hauling and Recycling	\$300.0M	✗
Solid Waste Services dba J.P. Mascaro & Sons	\$225.0M	✗
Nuverra Environmental Solutions	\$197.5M	✗
Lakeshore Recycling Systems	\$184.0M	✗
Heritage Environmental Services LLC	\$150.0M	✗
Sprint Waste Services	\$133.1M	✗
California Waste Solutions	\$125.0M	✗
Santek Waste Services	\$125.0M	✗
Texas Disposal	\$125.0M	✗
KRD Trucking	\$95.8M	✗
E.L. Harvey & Sons	\$95.0M	✗
GreenWaste*	\$90.9M	✗
ACTenviro	\$82.9M	✗
Aspen Waste Systems Inc.	\$75.0M	✗
County Waste	\$75.0M	✗
Winter Brothers	\$75.0M	✗
American Waste Control	\$67.7M	✗
Mt. Diablo Resource Recovery*	\$66.0M	✗
Orion Waste Solutions	\$65.0M	✗
Ross Environmental Services Inc	\$60.0M	✗
Mid Valley Disposal*	\$59.0M	✗
Wall Recycling LLC	\$52.0M	✗
Perma-Fix Environmental Services	\$49.5M	✗
Ware Disposal	\$42.5M	✗
Green City USA, LLC	\$30.0M	✗
EDCO*	\$29.8M	✗
Pellitteri Waste Systems	\$27.5M	✗
Filco Carting Corp.	\$27.0M	✗
Solid Waste of Willits*	\$21.8M	✗
Pelligrini Group (ACI, Peninsula Services, etc)*	\$19.3M	✗



## Technical Guide: How to Build a Scope 3 Inventory

All GHG inventories should begin by establishing the boundaries for an organization's GHG responsibility. Most companies choose to use the operational control approach, though reporting boundary decision-making is beyond the scope of this report. Refer to the Greenhouse Gas Protocol for further guidance.

A complete Scope 3 inventory should include upstream and downstream emissions for all entities included in the waste company's Scope 1 reporting boundary, as well as the direct emissions of any entities for which a company has financial or equity-share control over, as noted in Figure 8.

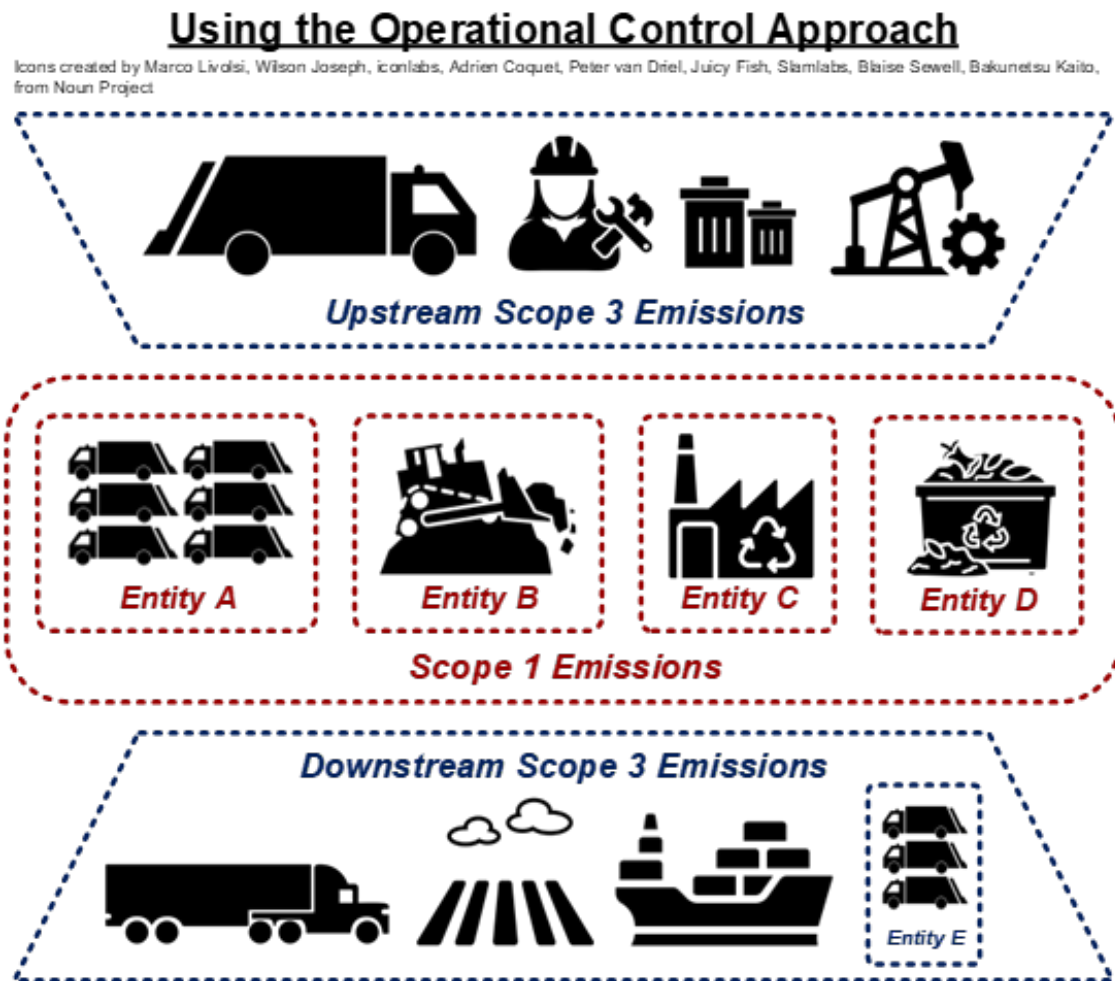


Figure 8: An example of how the consolidation approach affects the Scope 3 inventory, where the reporting company has equity share in Entities (often referred to as “operating companies” in the waste industry) A, B, C, D, and E, and operational control over Entities A, B, C, and D. Adapted from Bhatia et al. (2011).

To assist with establishing a comprehensive list of Scope 3 sources, a company should map its unique value chain. Figure 2 demonstrates a typical waste company’s value chain, from multi-stream collection operations, to transfer stations, to processing operations such as anaerobic digesters, composting facilities, MRFs, crushing operations, and landfills. Importantly, each company should adapt this map to match its unique value chain makeup based on its specific lines of business. For example, some companies might not engage in any anaerobic digestion or crushing operations, in which case the company can remove those parts of the map entirely. Additionally, a company may only lease its collection vehicles, in which case said company should reformat the representative blocks from Category Two to Category Eight coloring. Furthermore, the contents of this map should be made more specific, listing internal coding, vendor names, and more, as a company matures in its Scope 3 reporting journey. In doing so, a company can identify sources of GHG emissions and partners for GHG reductions throughout the value chain, in alignment with the 15 recognized Scope 3 categories.

As discussed alongside Figure 6, Categories 1, 2, 3, 4, 6, and 7 are the most material for the waste industry, so these categories will be explored in greater detail.

### Category 1: Purchased Goods and Services

Category 1 is a catch-all category for upstream vendor management. The emissions accounted for in this category should include those related to operational expenses by the reporting company, including but not limited to professional services, equipment and vehicle maintenance parts, and waste collections equipment.

Figure 9 depicts a decision tree to determine the calculation method for each purchased good or service, adapted from The GHG Protocol. The most typical path for waste companies in the early stages of developing Scope 3 inventories is highlighted for convenience, and suggests the use of spend-based methods.

Equation 1 can be used to calculate total Category 1 emissions. For each purchased good or service type – vehicle parts, software as a service, insurance providers, collection carts, etc. – a company can apply specific emission factors to spend data captured from internal accounts payable systems. While several emission factor libraries exist, the most commonly used and accepted is the *US Environmentally-Extended Input-Output (USEEIO) Models* (2023).

$$\text{Equation 1: } \textit{Category 1 Emissions} [lb CO_2e] = \sum_g \textit{OpEx}_g [\$] \times EF_g \left[ \frac{lb CO_2e}{\$} \right]$$

for all purchased goods and services of type  $g$ , each of whose total spend is noted by  $OpEx_g$ , with spend-based emission factors  $EF_g$

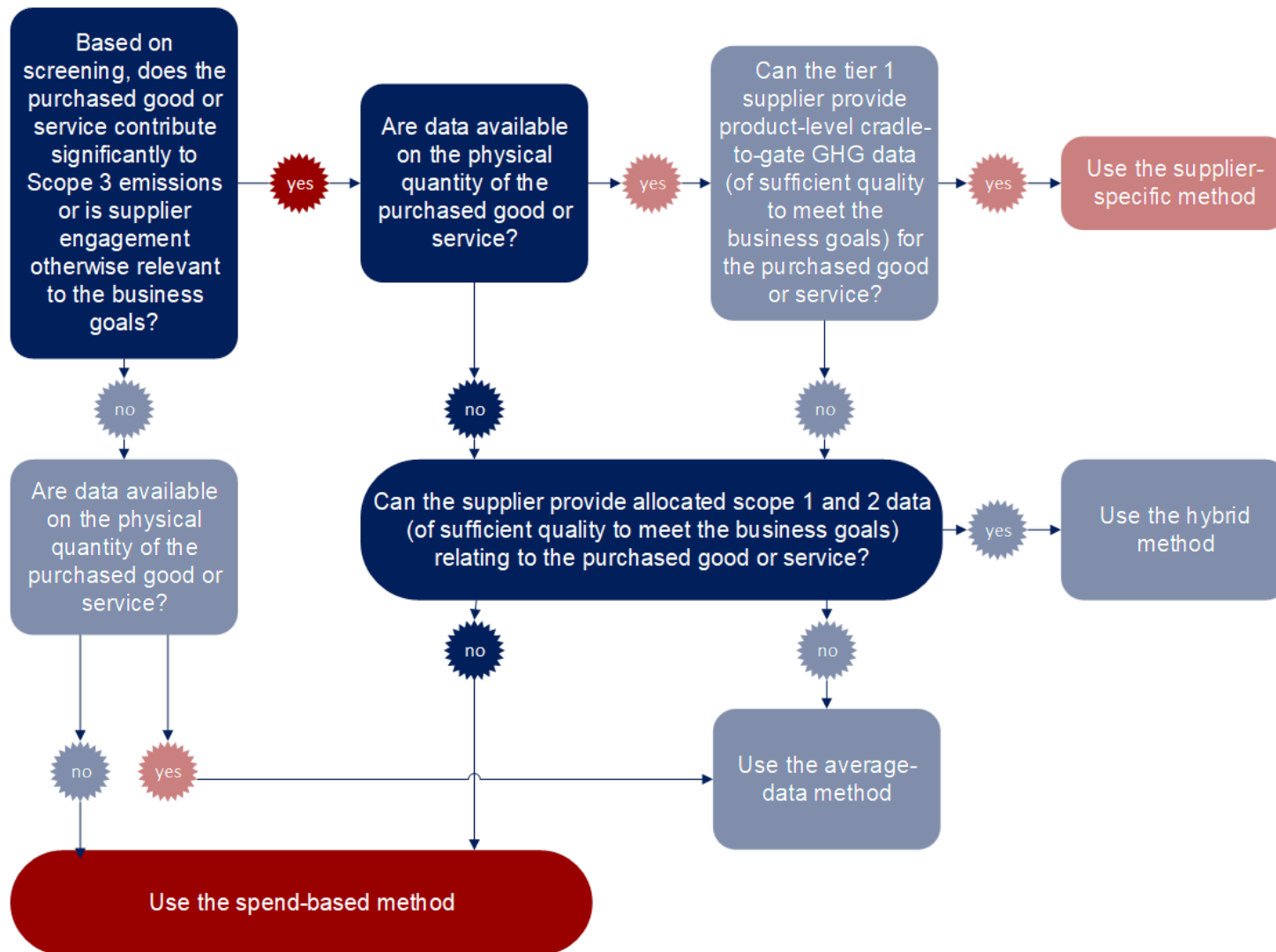


Figure 9: Decision tree for selecting a calculation method for emissions from purchased goods and services. The most typical path for waste companies in the early stages of the Scope 3 journey is highlighted for convenience and suggests the use of spend-based methods. Adapted from Barrow et al. (2013)

## Category 2: Capital Goods

Category 2 is a catch-all category for all capital expenditures, namely vehicles and large post-collections equipment for waste companies. The process for addressing Category 2 should match that of Category 1, but, if using a spend-based data approach, utilize capital expenditure reports rather than operating expenditure reports.

## Category 3: Fuel & Energy Related Activities

Category 3 is a significant category for waste companies because of high fuel usage for owned vehicles and processing equipment. Unlike Scope 1 tailpipe emissions from mobile and stationary combustion, Category 3 accounts for the rest of the fuel's lifecycle emissions: extraction and production. Because renewable fuels come from biomass rather than fossil fuels, their use can greatly reduce Scope 3 emissions. Additionally, as vehicles and equipment become electrified, tailpipe emissions will be reduced to zero. While vehicle fleet emissions will be passed from Scope 1 to Scope 2 with electrification, those emissions are likely to decrease overall as the grid itself decarbonizes. As this occurs, Category 3 emissions will also reduce.

Category 3 also accounts for transportation and distribution losses, extraction, and production from associated Scope 2 purchased electricity for facilities. This is not nearly as significant for waste companies' as fleet and equipment fuel, as Scope 2 inventories account on average for just one percent of waste companies' combined GHG inventories.

## Category 4: Upstream Transportation & Distribution

Category 4 reflects the tailpipe emissions of upstream transportation and distribution. For waste companies, the largest portion of Category 4 will likely come from transportation and distribution of purchased goods, such as emissions related to trucking or shipping new MRF equipment or new collections vehicles, or delivering any other purchased goods – office supplies, equipment maintenance parts, etc. – to a facility. This category also includes emissions from third-party contracted haulers moving equipment on behalf of the reporting company. For instance, a company may pay a third-party to transport a collection vehicle to a different franchise or to send heavy machinery to a manufacturer for repair. These emissions must align with financial payments by the reporting company. In other words, this category shall not include the emissions from independent haulers that pay a tipping fee to bring waste to a reporting company's facility, whether a landfill, compost facility, transfer station, or MRF.

For ease of data gathering and reporting, many waste companies currently choose to combine Category 4 emissions with Category 9 (Downstream Transportation and Distribution).

As a result, the CY22 analysis shows Category 4 looking more material than it likely is. To generate a Scope 3 inventory that is accurate and transparent, reporting companies must report upstream transportation and distribution related emissions separately from downstream.

As a company begins its Scope 3 reporting, internal financial accounting systems may make it difficult to segregate Category 4 from Category 9 emissions. In fact, this is likely the reason for the frequency of combined categories in the CY22 analysis. In such a case, the reporting company may opt to use an allocation methodology to distinguish between emissions for each of the two categories. For example, a reporting company could allocate Categories 4 and 9 based on the size of its collections and post-collections business units, respectively, by revenue or headcount, in line with carbon intensity denominators accepted by the SBTi. Any allocation methodology must be clearly and transparently stated in the company's report.

### Category 5: Waste Generated in Operations

Category 5 reflects waste generated in operations, which, for waste companies, will likely be dominated by emissions associated with downstream third-party wastewater treatment plants that are treating leachate from waste companies' post-collections operations. Additionally, Category 5 includes solid waste generated by day-to-day business operations.

### Category 6: Business Travel

Category 6 is noted as significant for waste companies not because of its relative size compared to the other categories, but because of its potential for high reductions and improved employee experience through employee engagement and education. By creating internal policies to limit business travel and/or reduce the carbon footprint of necessary travel – such as incentivizing rail over air travel, or economy class over business class travel – a company can educate its workforce on and make progress toward lower impact travel options. Additionally, many of these policies can also save valuable operating expenses for a reporting company.

### Category 7: Employee Commuting

Like Category 6, Category 7 is also significant for its educational potential on a company's workforce and the resulting employee sentiment improvements when employees see active engagement in climate action from their employer. Again, internal company policies and rewards programs for employees striving to commute to work on a low carbon budget should be implemented to actively reduce the emissions from this category. For example, companies can incentivize rail transit by subsidizing annual rail passes and allowing employees to begin their workdays from public transit if and where possible.

While other industries have engaged in many methodologies for accounting for emissions from hybrid and/or remote workers' setups, the portion of those employees in the waste industry is small compared to in-person workers, so policies should be focused more on the in-person workforce. As a company reaches greater levels of maturity in its data monitoring and reporting, it can begin to account for hybrid and remote workers by using guidance from The GHG Protocol's Corporate Accounting and Reporting Standard.

### Category 8: Upstream Leased Assets

Though not decidedly a material Scope 3 category, a waste company's emissions from upstream leased assets could be attributed to rentals of office space, vehicles, or equipment.

### Category 9: Downstream Transportation & Distribution

Category 9 reflects the tailpipe emissions of downstream transportation and distribution. For waste companies, these will be attributed to third-party contracted haulers (e.g., trucking, rail, or marine freight services) moving material outbound from a company's facilities, so long as the waste company itself, not a downstream buyer, is paying for said hauler. These emissions should align with financial payments by the reporting company. In other words, if a waste company pays a third-party contractor to truck baled commodities from its MRF to a shipping port, those emissions should be accounted for. However, if a waste company sells finished compost to a farmer and the farmer pays for the trucking services from the composting facility to the farm, those emissions should not be included.

As previously discussed, for ease of data gathering and reporting, many waste companies currently choose to combine Category 9 with Category 4. As a result, the CY22 analysis resulted in Category 9 being left off the list of material Scope 3 categories for the waste industry. To generate a Scope 3 inventory that is accurate and transparent, reporting companies must report downstream transportation and distribution related emissions separately from upstream.

As a company begins its Scope 3 reporting, internal financial accounting systems may make it difficult to segregate Category 9 from Category 4 emissions. As previously recommended, in such a case, the reporting company may opt to use an allocation methodology to distinguish between emissions for each of the two categories. For example, a reporting company could allocate Categories 4 and 9 based on the size of its collections and post-collections business units, respectively, by revenue or headcount, in line with carbon

intensity denominators accepted by the SBTi. Any allocation methodology must be clearly and transparently communicated in the company's final report.

### Category 10: Processing of Sold Products

Category 10 is generally immaterial to the waste industry because the waste industry is categorized as a transportation and logistics service industry, rather than a product development industry. The waste industry's role in recycling<sup>7</sup> commodities is the service of sorting, not producing new products. Processing of organic materials through composting or anaerobic digestion does significantly change the state of inbound material, so finished compost or digestate could be considered a product, but is unlikely to be further processed downstream.

### Category 11: Use of Sold Products

The waste industry does not produce any products that will consume energy downstream, so Category 11 is irrelevant.

### Category 12: End-of-Life Treatment of Sold Products

Though not decidedly a material Scope 3 category, a waste company's emissions from end-of-life treatment of sold products may arise. For instance, emissions might arise from buyers of finished compost, digestate, or landfill gas products, such as agricultural wholesalers, farmers, construction projects, and/or landfill gas to energy ("LFGTE") generators. With the designation of landfill gas as a renewable fuel in the US and the associated influx of funding for LFGTE projects, these may prove to be a large source of Scope 3, Category 12 emissions in the near future for waste companies engaged with LFGTE partners.

### Category 13: Downstream Leased Assets

Notwithstanding unique cases, the waste industry generally does not lease assets.

### Category 14: Franchises

Notwithstanding unique cases, the waste industry generally does not own franchises. Subsidiaries are generally included in enterprise-wide reporting efforts.

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<sup>7</sup> A growing body of research exists quantifying and documenting avoided emissions associated with diverting materials from landfills, namely recycling and composting. While it is important to educate society-at-large about the positive impacts of avoiding emissions through these activities, extreme caution should be used if attempting to associate carbon offsets with said activities. While reporting companies may include mention of avoided emissions in the discussion section of Scope 3 reporting efforts (see *Republic Services, Inc. – Climate Change 2023 (2023)* for an example), quantitative Scope 3 inventories should always be disclosed as gross, never net (e.g., gross emissions minus offsets), emissions totals.



## Category 15: Investments

Though not decidedly a material Scope 3 category, a waste company's emissions associated with its financial investment decisions – including but not limited to 401k and other employee retirement options – should be considered as the company matures in its Scope 3 journey. Spend-based and supplier-specific emission factors can be used for this category.

## Resource Library: Recommended Emission Factors for the Waste Industry

Table 5 suggests recommended spend-based emission factors, organized by Scope 3 category, that relate to material emission sources for the waste industry. These recommendations align with emission sources and color-coding from Figure 2.

*Table 5: Relevant spend-based emission factors for the waste industry (US Environmentally-Extended Input-Output (USEEIO) Models, 2023)*

Category	Emission Source	Emission Factor	Unit of Measurement	Reference
1	Waste Collection Carts	0.403	kg CO2e/2021 USD, purchaser price	2017 NAICS 326199; USEEIO 326190
1	Waste Collection Bins	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 332439; USEEIO 332430
1	Waste Collection Dumpsters	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 332439; USEEIO 332430
1	Vehicle Parts	0.395	kg CO2e/2021 USD, purchaser price	2017 NAICS 336390; USEEIO 336390
1	Industrial Equipment Parts	0.395	kg CO2e/2021 USD, purchaser price	2017 NAICS 336390; USEEIO 336390
1	Software as a Service Providers	0.148	kg CO2e/2021 USD, purchaser price	2017 NAICS 518210; USEEIO 518200
1	Financial Services Providers	0.048	kg CO2e/2021 USD, purchaser price	2017 NAICS 522110; USEEIO 52A000
1	Legal Services Providers	0.054	kg CO2e/2021 USD, purchaser price	2017 NAICS 541199; USEEIO 541100
1	Insurance Providers	0.034	kg CO2e/2021 USD, purchaser price	2017 NAICS 524210; USEEIO 524200
2	Heavy Duty Vehicles	0.307	kg CO2e/2021 USD, purchaser price	2017 NAICS 336120; USEEIO 336120
2	Light Duty Support Vehicles	0.322	kg CO2e/2021 USD, purchaser price	2017 NAICS 336112; USEEIO 336112



2	Transport Trailers	0.262	kg CO2e/2021 USD, purchaser price	2017 NAICS 336212; USEEIO 336212
2	Post-Collections Industrial Equipment	0.21	kg CO2e/2021 USD, purchaser price	2017 NAICS 333249; USEEIO 33329A
3	Diesel Fuel (Lifecycle GHGs)	1.689	kg CO2e/2021 USD, purchaser price	2017 NAICS 211120+324110; USEEIO 211000+324110
3	Renewable Diesel Fuel (Lifecycle GHGs)	2.416	kg CO2e/2021 USD, purchaser price	2017 NAICS 111110+311224; USEEIO 1111A0+311224
3	Natural Gas (Lifecycle GHGs)	1.457	kg CO2e/2021 USD, purchaser price	2017 NAICS 211130+221210; USEEIO 211000+221200
3	Renewable Natural Gas (Lifecycle GHGs)	0.627	kg CO2e/2021 USD, purchaser price	2017 NAICS 221210; USEEIO 221200
3	Electricity (Lifecycle GHGs)	0.28	kg CO2e/2021 USD, purchaser price	2017 NAICS 335311; USEEIO 335311
4	Trucking Services	1.115	kg CO2e/2021 USD, purchaser price	2017 NAICS 484110; USEEIO 484000
5	Wastewater Treatment	0.652	kg CO2e/2021 USD, purchaser price	2017 NAICS 221320; USEEIO 221300
5	Solid Waste Collection	0.197	kg CO2e/2021 USD, purchaser price	2017 NAICS 562111; USEEIO 562111
5	Hazardous Waste Collection	1.777	kg CO2e/2021 USD, purchaser price	2017 NAICS 562112; USEEIO 562HAZ
5	Other Waste Collection	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 562119; USEEIO 562OTH
5	Solid Waste Landfill	10.989	kg CO2e/2021 USD, purchaser price	2017 NAICS 562212; USEEIO 562212
5	Materials Recovery Facilities	0.158	kg CO2e/2021 USD, purchaser price	2017 NAICS 562920; USEEIO 562920
5	Leachate Treatment	0.652	kg CO2e/2021 USD, purchaser price	2017 NAICS 221320; USEEIO 221300
6	Passenger Air Travel	0.976	kg CO2e/2021 USD, purchaser price	2017 NAICS 481111; USEEIO 481000
6	Passenger Rail Travel	0.499	kg CO2e/2021 USD, purchaser price	2017 NAICS 485112; USEEIO 485000
6	Taxis	0.499	kg CO2e/2021 USD, purchaser price	2017 NAICS 485310; USEEIO 485000

6	Passenger Car Rental	0.143	kg CO2e/2021 USD, purchaser price	2017 NAICS 532111; USEEIO 532100
6	Hotels	0.183	kg CO2e/2021 USD, purchaser price	2017 NAICS 721110; USEEIO 721000
7	Commuter Rail	0.499	kg CO2e/2021 USD, purchaser price	2017 NAICS 485112; USEEIO 485000
7	Commuter Vehicles	0.322	kg CO2e/2021 USD, purchaser price	2017 NAICS 336112; USEEIO 336112
8	Office Space Rentals	0.13	kg CO2e/2021 USD, purchaser price	2017 NAICS 551114; USEEIO 550000
8	Leased Support Vehicles	0.143	kg CO2e/2021 USD, purchaser price	2017 NAICS 532112; USEEIO 532100
8	Leased Trucks	0.143	kg CO2e/2021 USD, purchaser price	2017 NAICS 532120; USEEIO 532100
8	Leased Equipment	0.14	kg CO2e/2021 USD, purchaser price	2017 NAICS 532490; USEEIO 532400
9	Trucking Services	1.115	kg CO2e/2021 USD, purchaser price	2017 NAICS 484121; USEEIO 484000
9	Marine Freight Services	0.618	kg CO2e/2021 USD, purchaser price	2017 NAICS 483111; USEEIO 483000
9	Rail Freight Services	0.558	kg CO2e/2021 USD, purchaser price	2017 NAICS 482111; USEEIO 482000
10	Recycling/Re-manufacturing Facilities	0.463	kg CO2e/2021 USD, purchaser price	2017 NAICS 322299; USEEIO 322299
12	Solid Waste Landfill	10.989	kg CO2e/2021 USD, purchaser price	2017 NAICS 562212; USEEIO 562212
12	Transfer Station	0.568	kg CO2e/2021 USD, purchaser price	2017 NAICS 493190; USEEIO 493000
12	Anaerobic Digester	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 562998; USEEIO 562OTH
12	Compost Facility	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 562998; USEEIO 562OTH
12	Materials Recovery Facilities	0.158	kg CO2e/2021 USD, purchaser price	2017 NAICS 562920; USEEIO 562920
12	Crushing Operation	0.632	kg CO2e/2021 USD, purchaser price	2017 NAICS 562219; USEEIO 562OTH

12	Agricultural Wholesalers	0.117	kg CO2e/2021 USD, purchaser price	2017 NAICS 423820; USEEIO 423800
12	Farmers	1.32	kg CO2e/2021 USD, purchaser price	2017 NAICS 111998; USEEIO 111900
12	Construction	0.256	kg CO2e/2021 USD, purchaser price	2017 NAICS 236220; USEEIO 230301,233262,233210,2332A0
12	Generators (LFGTE)	0.229	kg CO2e/2021 USD, purchaser price	2017 NAICS 335312; USEEIO 335312
15	Investment Portfolio Management	0.062	kg CO2e/2021 USD, purchaser price	2017 NAICS 523920; USEEIO 523900

Reporting Template: CDP Climate Change Questionnaire (Abbreviated<sup>8</sup>)

(C6.5) Account for your organization’s gross global Scope 3 emissions, disclosing and explaining any exclusions.

For each of the categories (in **bold**) below, disclose:

- Evaluation status
- Emissions in reporting year (metric tons (CO2e))
- Emissions calculation methodology
- Percentage of emissions calculated using data obtained from suppliers or value chain partners
- Please explain

**Purchased goods and services**

**Capital goods**

**Fuel-and-energy-related activities (not included in Scope 1 or 2)**

**Upstream transportation and distribution**

**Waste generated in operations**

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<sup>8</sup> This template is abbreviated, but not otherwise adapted from the CDP Climate Change questionnaire. The CDP questionnaire does not make use of the Scope 3 category numbers defined by The GHG Protocol, nor does it use a tabular format for reporting. This template is meant to provide an example of an already established and widely accepted reporting format a company might use for its Scope 3 inventory. It is not the only approach a company can take to do so.

**Business travel**

**Employee commuting**

**Upstream leased assets**

**Downstream transportation and distribution**

**Processing of sold products**

**Use of sold products**

**End of life treatment of sold products**

**Downstream leased assets**

**Franchises**

**Investments**

**Other (upstream)**

**Other (downstream)**

(C6.7) Are carbon dioxide emissions from biogenic carbon relevant to your organization?

(C6.7a) Provide the emissions from biogenic carbon relevant to your organization in metric tons CO<sub>2</sub>.

	<b>CO<sub>2</sub> emissions from biogenic carbon (metric tons CO<sub>2</sub>)</b>	<b>Comment</b>
Row 1		
Row 2		

## Works Cited

- 2022 ESG Data Summary Table. (2022). G. Environmental.  
<https://s24.g4cdn.com/409248530/files/Sustainability/GFL-2022-ESG-Data-Summary.pdf>
- 2023 Sustainability Report. (2023). W. Connections.  
[https://cdn.wasteconnections.com/resources/documents/sustainability/2023/WasteConnections\\_2023\\_Sustainability+Report.pdf](https://cdn.wasteconnections.com/resources/documents/sustainability/2023/WasteConnections_2023_Sustainability+Report.pdf)
- About: Alameda County Industries. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/alameda-county-industries/3082805>
- About: Edco. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/edco-products-inc/31459910>
- About: GreenWaste Recovery. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/greenwaste-recovery-inc/51120176>
- About: Mid Valley Disposal. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/mid-valley-disposal/105103926>
- About: Mt Diablo Resource Recovery. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/mt-diablo-resource-recovery/352764473>
- About: Solid Waste of Willits. (2024). ZoomInfo Technologies LLC. Retrieved March 23, 2024 from <https://www.zoominfo.com/c/solid-waste-of-willits-inc/345156206>
- Barrow, M., Buckley, B., Caldicott, T., Cumberlege, T., Hsu, J., Kaufman, S., Ramm, K., Rich, D., Temple-Smith, W., Cummis, C., Draucker, L. C., Khan, S., Ranganathan, J., & Sotos, M. (2013). *Technical Guidance for Calculating Scope 3 Emissions* (Greenhouse Gas Protocol, Issue. W. R. Institute & W. B. C. f. S. Development.  
[https://ghgprotocol.org/sites/default/files/standards/Scope3\\_Calculation\\_Guidance\\_0.pdf](https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf)
- Bhatia, P., Cummis, C., Brown, A., Rich, D., Draucker, L. C., & Lahd, H. (2011). *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*. W. R. Institute & W. B. C. f. S. Development. [https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard\\_041613\\_2.pdf](https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard_041613_2.pdf)
- CDP Technical Note: Relevance of Scope 3 Categories by Sector. (2022).  
[https://cdn.cdp.net/cdp-production/cms/guidance\\_docs/pdfs/000/003/504/original/CDP-technical-note-scope-3-relevance-by-sector.pdf?1649687608](https://cdn.cdp.net/cdp-production/cms/guidance_docs/pdfs/000/003/504/original/CDP-technical-note-scope-3-relevance-by-sector.pdf?1649687608)
- Cottom, T. (2019). Top 40 haulers in North America. Retrieved January 29, 2024, from <https://www.wastetodaymagazine.com/article/top-40--haulers-in-north--america/>
- Covanta Energy Corporation - Climate Change 2023. (2023). CDP.  
[https://www.cdp.net/en/responses/3989/Covanta-Energy-Corporation?back\\_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Dcovanta&queries%5Bname%5D=covanta](https://www.cdp.net/en/responses/3989/Covanta-Energy-Corporation?back_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Dcovanta&queries%5Bname%5D=covanta)
- Downie, J., & Stubbs, W. (2013). Evaluation of Australian companies' scope 3 greenhouse gas emissions assessments [Article]. *Journal of Cleaner Production*, 56, 156-163.  
<https://doi.org/10.1016/j.jclepro.2011.09.010>
- Eccles, R., & Mulliken, J. (2021). Carbon Might Be Your Company's Biggest Financial Liability. *Harvard Business Review, Government Policy And Regulation*.  
<https://hbr.org/2021/10/carbon-might-be-your-companys-biggest-financial-liability>
- ESG Data Center. (2022). Waste Management, Inc. Retrieved 2/18/2023 from <https://sustainability.wm.com/esg-data-center/>
- Faragò, M., Damgaard, A., Rebsdorf, M., Nielsen, P. H., & Rygaard, M. (2022). Challenges in carbon footprint evaluations of state-of-the-art municipal wastewater resource recovery facilities [Article]. *Journal of Environmental Management*, 320, Article 115715.  
<https://doi.org/10.1016/j.jenvman.2022.115715>
- Fletcher, L. (2024, February 1, 2024). *Which States Have Zero-Emission Vehicle Mandates?* WorkTruck. Retrieved March 20, 2024 from

- <https://www.worktruckonline.com/10214784/which-states-have-zero-emission-vehicle-mandates>
- Form 10-K: Republic Services, Inc.* (2023). U. S. S. a. E. Commission.  
<https://investor.republicservices.com/static-files/adae82ee-ca67-45d8-8e85-a7014d1bd022>
- Form 10-K: Waste Management, Inc.* (2023). U. S. S. a. E. Commission.  
<https://investors.wm.com/static-files/9c4a4e7a-674b-482e-90c9-7718aee3a56a>
- GFL Environmental Inc - Climate Change 2023.* (2023). CDP.  
[https://www.cdp.net/en/responses/849367/GFL-ENVIRONMENTAL-INC?back\\_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Dgfl&queries%5Bname%5D=gfl](https://www.cdp.net/en/responses/849367/GFL-ENVIRONMENTAL-INC?back_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Dgfl&queries%5Bname%5D=gfl)
- Hadziosmanovic, M., Rahimi, K., & Bhatia, P. (2022). Trends Show Companies Are Ready for Scope 3 Reporting with US Climate Disclosure Rule. Retrieved September 17, 2023, from <https://www.wri.org/update/trends-show-companies-are-ready-scope-3-reporting-us-climate-disclosure-rule>
- Hansen, A. D., Kuramochi, T., & Wicke, B. (2022). The status of corporate greenhouse gas emissions reporting in the food sector: An evaluation of food and beverage manufacturers [Article]. *Journal of Cleaner Production*, 361, Article 132279.  
<https://doi.org/10.1016/j.jclepro.2022.132279>
- Ingwersen, W. (2023). *Supply Chain Greenhouse Gas Emission Factors v1.2 by NAICS-6*. Washington, DC
- Organics Bans and Mandates.* (2023). US Composting Council. Retrieved March 20, 2024 from <https://www.compostingcouncil.org/page/organicsbans>
- Republic Services, Inc. - Climate Change 2023.* (2023). CDP.  
[https://www.cdp.net/en/responses/15670/Republic-Services-Inc?back\\_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Drepublic%2Bservices&queries%5Bname%5D=republic+services](https://www.cdp.net/en/responses/15670/Republic-Services-Inc?back_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fqueries%255Bname%255D%3Drepublic%2Bservices&queries%5Bname%5D=republic+services)
- Stericycle Inc. - Climate Change 2022.* (2022). CDP.  
[https://www.cdp.net/en/formatted\\_responses/responses?campaign\\_id=79520704&discloser\\_id=984946&locale=en&organization\\_name=Stericycle+Inc.&organization\\_number=17809&program=Investor&project\\_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F195406&survey\\_id=78646008](https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=984946&locale=en&organization_name=Stericycle+Inc.&organization_number=17809&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F195406&survey_id=78646008)
- Sustainability in Action: 2021 GRI Report.* (2022). R. Services.  
[https://www.republicservices.com/cms/documents/sustainability\\_reports/2021-Republic-Services-GRI-Report.pdf](https://www.republicservices.com/cms/documents/sustainability_reports/2021-Republic-Services-GRI-Report.pdf)
- Sustainability Progress Report.* (2023). Casella.  
[https://sustainability.casella.com/sites/default/files/2023-08/Casella-REPORT-Sustainability-2023-Update\\_0.pdf](https://sustainability.casella.com/sites/default/files/2023-08/Casella-REPORT-Sustainability-2023-Update_0.pdf)
- Sustainability Report 2023.* (2023). R. Inc. <https://www.recology.com/pdfviewer/2023-sustainability-report/>
- Target Validation Protocol for Near-term Targets.* (2023). (SBTi Target Validation Protocol, Issue. <https://sciencebasedtargets.org/resources/files/Target-Validation-Protocol.pdf>
- US Environmentally-Extended Input-Output (USEEIO) Models.* (2023, October 31, 2023). United States Environmental Protection Agency. Retrieved January 29, 2024 from <https://www.epa.gov/land-research/us-environmentally-extended-input-output-useeio-models>
- USEPA. (2023, August 3, 2023). *Basic Information about Landfill Gas.* United States Environmental Protection Agency. Retrieved September 17 from <https://www.epa.gov/lmop/basic-information-about-landfill-gas>
- Veolia Environnement SA - Climate Change 2022.* (2022). CDP.  
[https://www.cdp.net/en/formatted\\_responses/responses?campaign\\_id=79520704&disclo](https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&disclo)

[ser\\_id=976867&locale=en&organization\\_name=Veolia+Environnement+SA&organization\\_number=20102&program=Investor&project\\_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F204311&survey\\_id=78646008](https://www.cdp.net/en/responses/20515/Waste-Management-Inc?back_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fper_page%3D10%26queries%255Bname%255D%3Dwaste%2Bmanagement%26sort_by%3Dproject_year%26sort_dir%3Ddesc&queries%5Bname%5D=waste+management)

*Waste Management, Inc. - Climate Change 2023.* (2023). CDP.

[https://www.cdp.net/en/responses/20515/Waste-Management-Inc?back\\_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fper\\_page%3D10%26queries%255Bname%255D%3Dwaste%2Bmanagement%26sort\\_by%3Dproject\\_year%26sort\\_dir%3Ddesc&queries%5Bname%5D=waste+management](https://www.cdp.net/en/responses/20515/Waste-Management-Inc?back_to=https%3A%2F%2Fwww.cdp.net%2Fen%2Fresponses%3Fper_page%3D10%26queries%255Bname%255D%3Dwaste%2Bmanagement%26sort_by%3Dproject_year%26sort_dir%3Ddesc&queries%5Bname%5D=waste+management)