



The Methane Impact of Food Loss and Waste in the United States

OCTOBER 2024

ReFED

Executive Summary

Global climate leaders have zeroed in on methane reduction as a key "emergency brake" in the fight against climate change. Methane is a powerful and short-acting greenhouse gas that only persists in the atmosphere for 12 years. Therefore, reducing methane emissions *now* has a cooling effect that will be felt in just a decade or two—which is crucial for limiting near-term warming.

Across the United States, surplus food is responsible for almost four million metric tons of methane, which is 14% of the country's total annual methane emissions and equivalent to what's generated by 75 million cars each year when converted to CO_2e on a 20-year time horizon—which more accurately captures the real warming potential of the gas. Methane comes both from the production of food—primarily beef and dairy—where the resources required and emissions produced are for naught when the food is not eaten, and the disposal of food, which accounts for the majority of landfill methane as well as significant release from sewers.

Reducing food loss and waste therefore presents an opportunity to rapidly and dramatically cut methane emissions and avoid its most harmful impacts to our communities and ecosystems.

Supported by the Global Methane Hub, new data from ReFED reveals the methane hotspots for surplus food in the United States and highlights corresponding solutions that can slash methane emissions and help meet national and international commitments to address climate change before 2050.

Total methane footprint of U.S. surplus food = 4 million $MTCH_4$

Three key solutions to achieving reduced methane emissions from food loss and waste are:

- Establishing organics diversion infrastructure, which could avoid an estimated 800,000 $MTCH_4$ from landfill and sewer
- Addressing consumer food waste, which could avoid an estimated 463,000 $MTCH_4$
- Incentivizing business adoption of food waste prevention solutions, which could avoid an estimated 400,000 $MTCH_4$

Background

Reducing food loss and waste (FLW) is a critical lever in the fight against climate change, with clear and tangible solutions that are ready to scale. The food system accounts for up to one-third of global greenhouse gas emissions (GHG) each year, with food loss and waste alone contributing 10%. These emissions include methane, a powerful greenhouse gas that is increasingly being targeted as an "emergency brake" to limit catastrophic warming.

While extremely potent in terms of its warming effect, methane breaks down in the atmosphere after about 12 years. Therefore, reducing methane emissions *now* has a cooling effect that will be felt in just a decade or two—which is crucial for limiting near-term warming. The latest IPCC report predicts our planet is on track to breach the target of 1.5°C of warming by 2050, so deep reductions in greenhouse gas emissions are urgently required to bend the trendlines and avoid the most harmful impacts to our communities and ecosystems. The global community has responded to this need by emphasizing methane as a key opportunity to rapidly slash atmospheric greenhouse gas concentrations.

Sectors that generate the most methane include those directly related to the food system: agriculture, mostly through enteric fermentation in the digestive systems of ruminant livestock like cattle, and waste, through anaerobic decomposition of organic materials such as food. Addressing these sources means methane can be reduced by limiting the amount of meat and dairy wasted, and keeping food out of landfills, sewers, and other anaerobic waste management systems.

Reducing food loss and waste represents an often overlooked but significant opportunity to cut methane emissions, along with other greenhouse gases, while also conserving water, protecting biodiversity, reducing food insecurity, and improving local air quality.

Reducing methane emissions now has a cooling effect that will be felt in just a decade or two—which is crucial for limiting near-term warming.

New Data from ReFED and the Global Methane Hub

Methane emissions from landfills and livestock are typically reported as totals, making it difficult to calculate emissions on a per-cow or per-ton-of-food-waste basis. With support from the Global Methane Hub, ReFED has addressed this gap by analyzing the latest science to better estimate the methane component of GHG emissions from food and its disposal, enabling users to set concrete methane reduction goals.

To develop these methane emissions factors, ReFED worked with Quantis, a life-cycle assessment consultancy, to improve an existing model that quantifies the climate benefits of reducing **surplus food**[1] in the United States, by differentiating between methane and other greenhouse gases. Quantis used a life-cycle approach to establish methane emissions factors for 48 product types (e.g., beef, tomato, etc.), across five supply chain stages (farm, manufacturing, retail, foodservice, and residential), and going to 10 destinations (e.g., donation, compost, landfill, etc.). The underlying assumptions are based on management practices seen across the country, with the intention that results represent a "U.S. average" scenario.[2]

The emissions factors were then applied through ReFED's Insights Engine models to generate estimates of total methane footprints for different products and sectors, as well as total methane avoided by implementing food waste solutions. Importantly, in addition to emissions factors that use a 100-year time frame, users can view methane emissions on a 20-year time frame, which more accurately conveys its near-term warming potential.

New methane emissions factors:

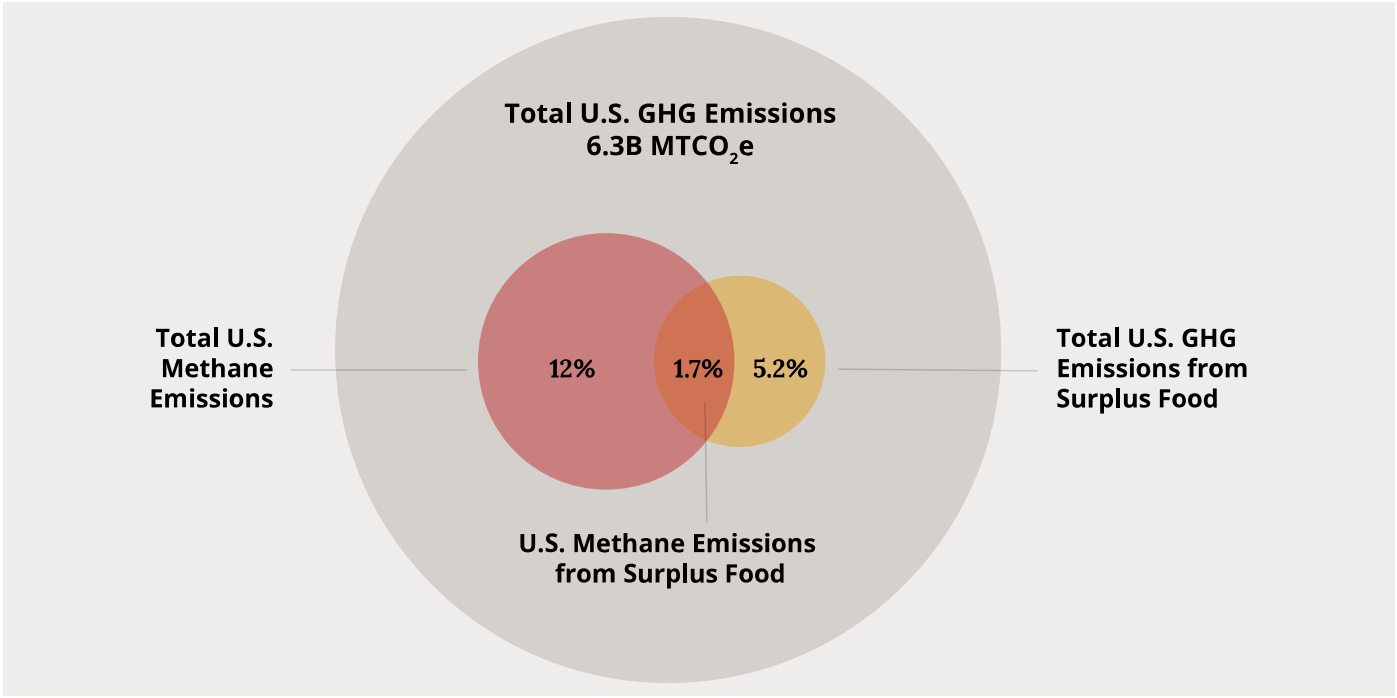
- *Covering 48 food product types*
- *Across 5 supply chain sectors*
- *Going to 10 destinations*

[1] Surplus Food = Food that goes unsold or unused by a business or that goes uneaten at home—including food and inedible parts (e.g., peels, pits, bones) that are donated, fed to animals, repurposed to produce other products, composted, anaerobically digested, or otherwise wasted. ReFED bases its analysis on surplus food instead of food loss and waste in order to capture food that goes to donation, animal feed, and industrial uses, as a more holistic view of the food system.

[2] A full description of the methodology and assumptions can be found on the ReFED Insights Engine.

Key Findings

Figure 1: Total Annual U.S. Emissions vs. Emissions from U.S. Surplus Food



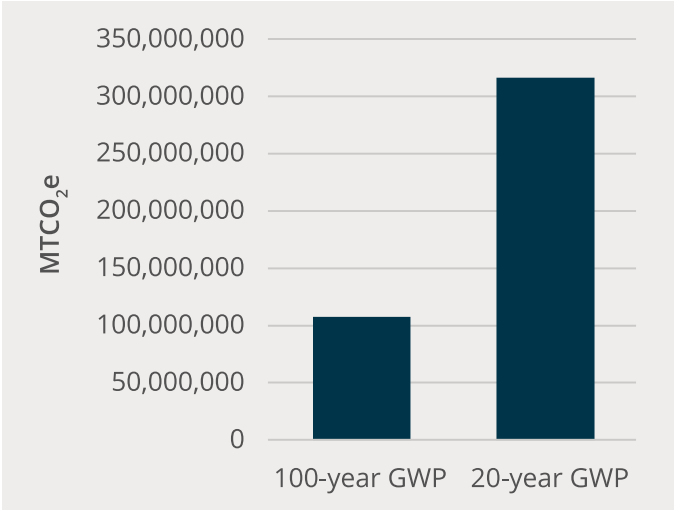
Surplus food is a significant contributor to U.S. methane.

In 2022, methane emissions from surplus food in the United States reached nearly four million metric tons, representing 14% of total U.S. methane emissions. A significant portion (2.5 million $MTCH_4$[3]) comes from "upstream" production and supply chain activities; the rest (1.5 million $MTCH_4$) comes from "downstream" management and disposal activities, such as landfill and sewer. Translated to carbon dioxide equivalent (CO_2e) over a 100-year time horizon, which allows us to see methane in the context of all greenhouse gas emissions in the United States, this totals 107 million $MTCO_2e$—comparable to the emissions from 26 million cars in a year.

[3] MT = metric ton = 1000 kg

However, using a 20-year time horizon, which more accurately reflects methane's shorter atmospheric lifespan, the impact jumps to 316 million $MTCO_2e$—or the equivalent of 75 million cars (over one quarter of the registered passenger fleet in the U.S.). This stark difference highlights the importance of addressing methane emissions in the near term to mitigate global warming (Figure 2).

Figure 2: Annual Methane Emissions from Surplus Food, 20-yr vs. 100-yr GWP



Using the 20-year time horizon to talk about methane

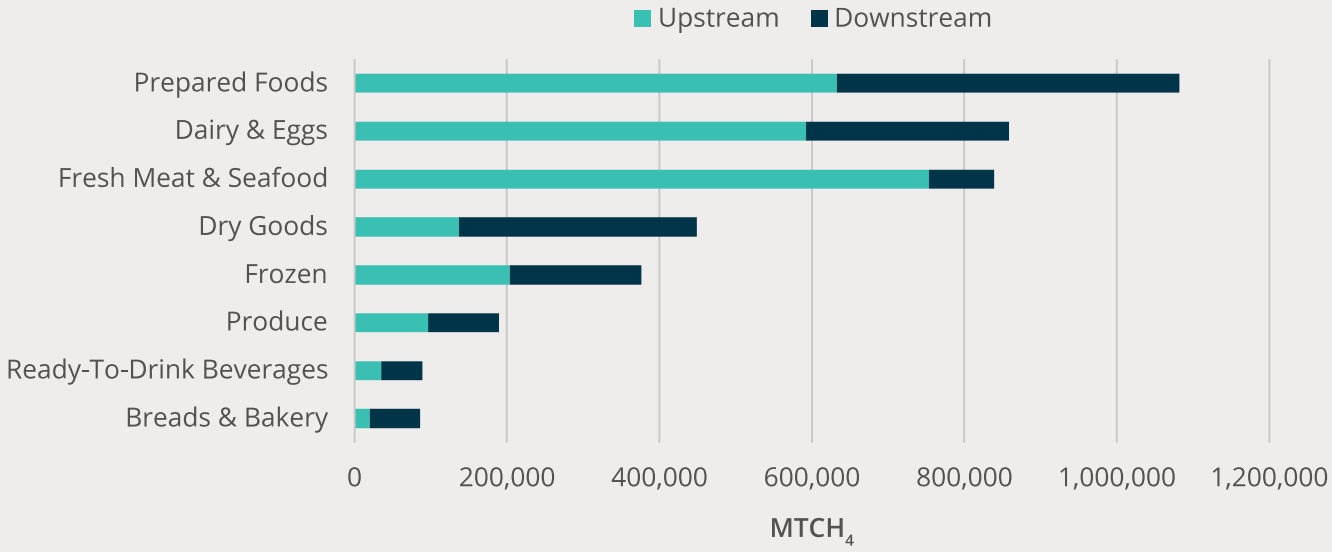
Emissions are often reported as "carbon dioxide equivalent" (CO_2e), which combines multiple greenhouse gases into a single standard metric. Greenhouse gases have different potencies, or warming effects, and are converted to CO_2e using the gas's Global Warming Potential (GWP)—a measure of how much warming a gas will induce relative to one unit of carbon dioxide over a given period of time. Most commonly, GWPs are calculated over a 100-year time horizon.

However, in reality, methane exists in the atmosphere for only 12 years, and on this time horizon is about 80 times more powerful than carbon dioxide. Using a 100-year time horizon obscures its true impact, making methane seem less potent than it actually is. As a result, we believe that using the 20-year GWP for methane more accurately conveys the urgency of addressing these emissions in the near term.

Preventing surplus food is more impactful than managing downstream emissions.

While methane accounting systems often separate livestock emissions from landfill emissions, surplus food actually contributes to both (e.g., throwing away a hamburger wastes the methane emissions from production *and* produces methane in a landfill). In fact, the methane emissions from producing food that is ultimately not eaten outweigh those coming from disposal (62% vs. 38%). This makes it critical to *prevent* food from going to waste—which ultimately reduces demand and the need for overproduction—in addition to diverting food scraps from landfills, which only addresses the downstream emissions.

Figure 3: Total Annual Methane Emissions, by Food Type

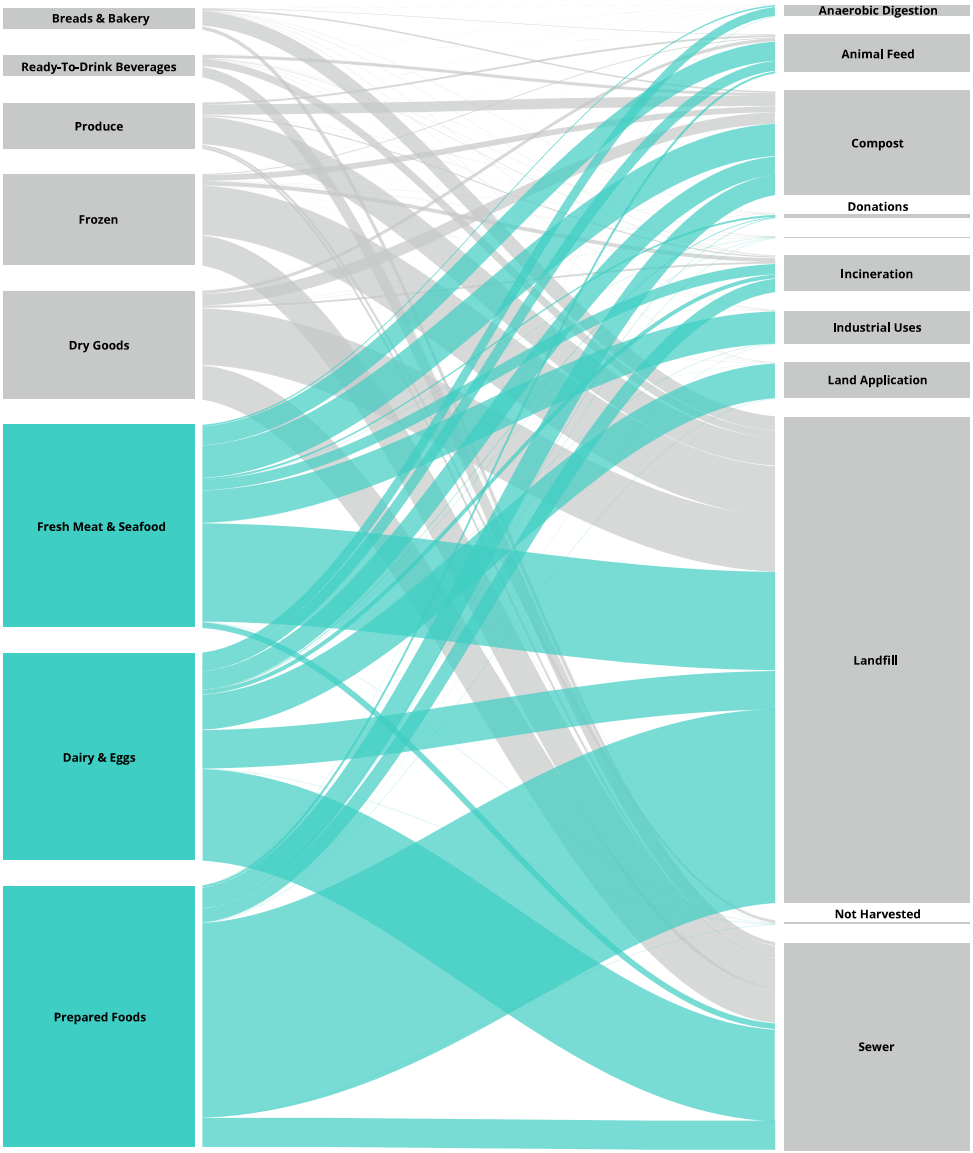


The types of food that generate the most methane in the United States are beef and dairy products, since cows are the primary livestock animal producing methane through their digestive systems. Consequently, the greatest upstream methane emissions come from the Fresh Meat & Seafood category, with high values also in Dairy & Eggs and Prepared Foods (which contain food items with beef and dairy content)—despite the relatively low volume of Fresh Meat & Seafood surplus compared with other food types (Figure 3).

However, downstream emissions still make up a significant portion of methane emissions, and food that goes uneaten ultimately needs to be managed. In the United States, landfills and sewers[4] together receive nearly 45% of all surplus food but contribute almost the entirety (98%) of downstream methane emissions. Both landfills and sewers create anaerobic environments where methane-producing microbes break down the organic materials—and downstream methane emissions from surplus food could essentially be eliminated by diverting material from these destinations.

Considering upstream and downstream emissions together (Figure 4), total methane emissions from two categories—Meat & Seafood and Dairy & Eggs—represent 43% of the total attributed to surplus food. However, given the high volume of surplus from the Prepared Foods category—and that 70% of that surplus goes to landfill—this category accounts for the highest overall methane emissions.

Figure 4: Methane Emissions from Surplus Food by Food Type and Destination

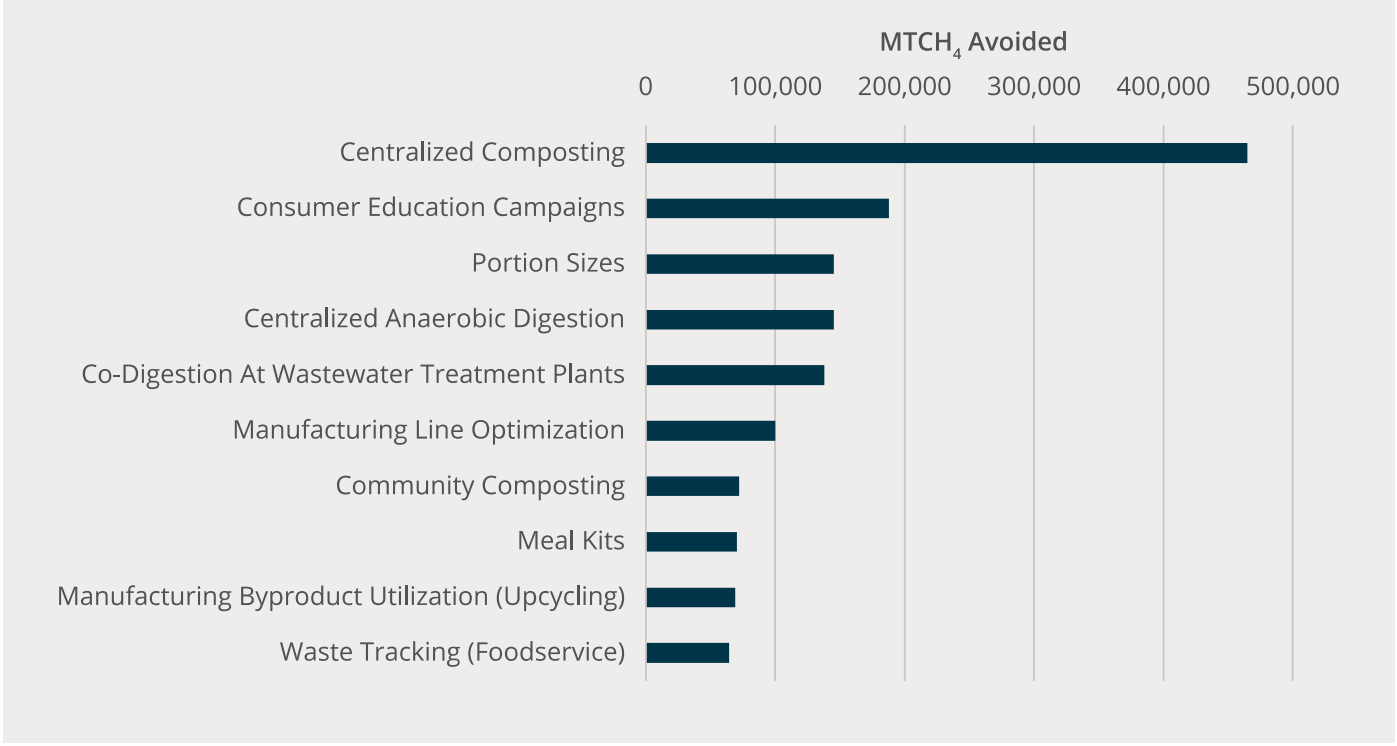


[4] As noted in EPA's Field to Bin report, the impact of food sent down the drain is an area of emerging research. While these estimates provide an initial understanding, further research is needed to refine the model for emissions from sewers.

Solutions in three main categories can meaningfully reduce methane emissions and therefore warrant investment.

Because so much food currently ends up in landfills and sewers, the most methane can be avoided by diverting scraps from landfills and other anaerobic environments. However, preventing food from being wasted in the first place not only keeps surplus food out of methane-generating destinations, it also reduces upstream emissions from production and supply chain activities. While diversion solutions address the largest *volume* of material (Figure 5), prevention solutions offer the highest methane reduction *per ton* of food material diverted (Table 1).

Figure 5: Top 10 Solutions* for Addressing Methane from Surplus Food



** of the 42 solutions to food loss and waste that ReFED analyzes*

While prevention solutions reduce the most methane per ton, ReFED's solutions modeling indicates that the following groups of solutions across prevention and recycling categories can achieve the greatest methane reduction:

1 RECYCLING INFRASTRUCTURE THAT DIVERTS ORGANIC MATERIAL FROM LANDFILL AND SEWER

Centralized and community recycling solutions such as composting and anaerobic digestion divert food scraps from landfill and present the greatest overall opportunity for reducing total methane emissions—680,000 metric tons per year. This would require a little over $5 billion to scale up infrastructure but would add 24,000 jobs over a 10-year period.[5]

When food waste is put through a garbage disposal and sent down the drain, it ends up in the sewer system and actually emits more methane per ton of food waste than material going to landfill. Food currently sent to the sewer system can be diverted from the treatment plant and into dedicated co-digesters that effectively capture and repurpose the methane generated. ReFED's solutions modeling indicates that co-digestion can avoid 138,000 metric tons of methane per year and create 5,000 jobs at a cost of $1.1 billion.

2 CONSUMER-FACING EDUCATION AND INTERVENTION

Households generate the most surplus food and account for 63% of the entire methane footprint of surplus food. Therefore, it's critical to implement consumer-facing solutions—and interventions that target consumer-level surplus (both in and out of the home) that are high in beef or dairy content are the most effective. Together, consumer education campaigns, smaller portion sizes, meal kits, and standardization of date labels would avoid 463,000 metric tons of methane per year, nearly a quarter of all methane avoided by the full suite of ReFED's modeled solutions. These solutions also tend to be more cost-effective, requiring $870 million to fully implement but saving consumers $34 billion.

3 FOOD BUSINESS EFFICIENCY AND UTILIZATION

Waste prevention strategies implemented by manufacturing, retail, and foodservice businesses can ensure that food moving through the food system is ordered, distributed, and stored effectively, and that every possible part of the food is utilized. These solutions are particularly important for beef and dairy products that carry a high methane production footprint. Together, a range of practices including line optimization and byproduct utilization in manufacturing, and markdown alert applications, decreased transit time, and waste tracking in retail and foodservice can avoid over 400,000 metric tons of methane emissions per year, at a cost of $6.8 billion to put into practice but saving businesses $16.5 billion collectively. ReFED's work with food business signatories of the Pacific Coast Food Waste Commitment and the U.S. Food Waste Pact shows that successful implementation of these solutions often requires invested leadership, meaningful employee engagement, and collaboration across the value chain.

[5] These calculations reflect a conservative model assumption of ~30% diversion rate for composting and ~15% diversion rate for anaerobic digestion. We believe the amount of material diverted through these solutions would be even higher with increased public and private investment.

New data from ReFED reveals the methane hotspots for surplus food in the U.S., and highlights corresponding solutions that can slash methane emissions by nearly 2 million $MTCH_4$—the equivalent of taking 36 million cars off the road.

A Call to Action—Empowered by New Data

It is estimated that at least 25% of today's warming is attributable to methane emissions from human activity. With 2030 climate goals looming, now is the time to take on the methane opportunity, reducing atmospheric GHG concentrations with effects that will be felt in just a decade or two. Food loss and waste is a significant methane contributor with clear sources that can be addressed with solutions that are at our fingertips.

By isolating the methane contribution to emissions from surplus food, the tools in the ReFED Insights Engine allow users to see the significant role methane plays in the food system's overall greenhouse gas footprint, as well as the potential benefits of implementing targeted waste-cutting solutions. These estimates are available at both the operational level through tools like the Insights Engine's Impact Calculator and custom business solutions, as well as at the national level through the Food Waste Monitor and Solutions Database. We hope that by clearly quantifying the link between surplus food and methane emissions, food businesses, policymakers, advocates, and funders will be equipped and empowered to take decisive action and drive meaningful progress in reducing emissions and mitigating climate change.

Table 1: Avoided Methane and Cost of Implementing Food Waste Solutions

Learn more about these solutions in the Solutions Database in ReFED's Insights Engine.

Solution Group	Solution Name	Methane Avoided ($MTCH_4$)	Cost (USD)	$MTCH_4$ Per Ton Surplus Food
Recycling	Centralized Composting	464,664	$3,290,283,426	0.029
Prevention	Consumer Education Campaigns	188,037	$197,385,372	0.060
Prevention	Portion Sizes	145,519	$44,557,778	0.060
Recycling	Centralized Anaerobic Digestion	145,157	$1,309,840,629	0.027
Recycling	Co-Digestion At Wastewater Treatment Plants	137,904	$1,109,261,286	0.027
Prevention	Manufacturing Line Optimization	100,129	$587,111,852	0.036
Recycling	Community Composting	72,199	$560,967,332	0.034
Prevention	Meal Kits	70,460	$616,430,267	0.058
Prevention	Manufacturing Byproduct Utilization (Upcycling)	69,331	$1,963,622,929	0.036
Prevention	Waste Tracking (Foodservice)	64,613	$1,182,492,888	0.062
Prevention	Standardized Date Labels	58,672	$10,759,936	0.076
Prevention	Active & Intelligent Packaging	50,808	$728,689,572	0.074
Prevention	Markdown Alert Applications	46,338	$935,391,982	0.046
Recycling	Home Composting	45,774	$296,682,748	0.029
Prevention	Decreased Transit Time	29,559	$354,155,153	0.049
Prevention	Intelligent Routing	25,485	$440,633,991	0.042
Prevention	Package Design	25,127	$58,424,519	0.077
Recycling	Livestock Feed	17,622	$469,567,478	0.007
Prevention	First Expired First Out	16,112	$315,404,476	0.046
Rescue	Donation Education	15,533	$520,247,325	0.013
Prevention	Dynamic Pricing	14,145	$548,020,548	0.040
Rescue	Donation Transportation	14,139	$464,683,810	0.021
Prevention	Temperature Monitoring (Pallet Transport)	13,518	$120,914,874	0.045
Prevention	Enhanced Demand Planning	10,692	$108,743,726	0.041
Prevention	Assisted Distressed Sales	9,953	$5,212,255	0.033
Rescue	Donation Coordination & Matching	6,652	$67,417,545	0.047
Prevention	Trayless	5,952	$20,550,025	0.060
Prevention	Decreased Minimum Order Quantity	5,352	$62,738,050	0.045
Rescue	Donation Storage Handling & Capacity	4,605	$332,294,493	0.016
Prevention	K-12 Lunch Improvements	3,619	$8,583,958	0.060
Prevention	Buyer Specification Expansion	3,028	$5,771,050	0.005
Prevention	Buffet Signage	2,821	$64,677	0.060
Prevention	Minimized On Hand Inventory	2,559	$16,911,321	0.042
Prevention	Increased Delivery Frequency	2,475	$41,609,993	0.050
Prevention	Partial Order Acceptance	1,726	$93,699,441	0.034
Prevention	Imperfect & Surplus Produce Channels	1,282	$1,438,657,385	0.001
Prevention	K-12 Education Campaigns	963	$2,506,590	0.060
Prevention	Reduced Warehouse Handling	509	$8,145,516	0.038
Prevention	Small Plates	338	$2,146,219	0.059
Rescue	Donation Value-Added Processing	142	$20,272,182	0.001
Prevention	Temperature Monitoring (Foodservice)	63	$36,479	0.084
Prevention	Gleaning	2	$5,538,223	0.001

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Acknowledgements

ReFED would like to thank Global Methane Hub for their instrumental support in enabling the research and analysis.

We would also like to thank Quantis for their detailed research and modeling, as well as the following partners for their contributions through review, feedback, and thought leadership:

- Kai Robertson/KOR Consulting
- U.S. Environmental Protection Agency
- Industrious Labs
- RMI
- GAIA
- Global Foodbanking Network
- ERG
- RRS
- Juniata Analytics

About ReFED

ReFED is a U.S.-based nonprofit that catalyzes the food system toward evidence-based action to stop wasting food. We work to increase adoption of food waste solutions across the supply chain by cultivating and convening the food community, delivering actionable evidence and insights, and seeding and accelerating promising initiatives. Our vision is a sustainable, resilient, and inclusive food system that makes the best use of the food we grow. To learn more about solutions to reduce food waste, please visit www.refed.org.

Learn more about what ReFED is doing to address end food loss and waste in the United States by following our work.

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