California Air Resources Board

Quantification Methodology

California Department of Resources Recycling and Recovery
Food Waste Prevention and Rescue Program

California Climate Investments

FINAL
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Section A. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work facilitating greenhouse gas (GHG) emission reductions; strengthening the economy; improving public health and the environment; and providing benefits to residents of disadvantaged communities, low-income communities, and low-income households, collectively referred to as "priority populations." Where applicable and to the extent feasible, California Climate Investments must maximize economic, environmental, and public health co-benefits to the State.

The California Air Resources Board (CARB) is responsible for providing guidance on estimating the GHG emission reductions and co-benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefits calculator tools. CARB develops these methodologies and tools based on the project types eligible for funding by each administering agency, as reflected in the program expenditure records available at: www.arb.ca.gov/cci-expenditurerecords.

For the California Department of Resources Recycling and Recovery (CalRecycle) Food Waste Prevention and Rescue Program, CARB staff developed this Food Waste Prevention and Rescue Program Quantification Methodology and Food Waste Prevention and Rescue Program Benefits Calculator Tool to provide guidance for estimating the GHG emission reductions and select co-benefits of each proposed project type, provide instructions for documenting and supporting the estimate, and outline the process for tracking and reporting GHG and other benefits once a project is funded.

This methodology uses calculations to estimate reductions in GHG emissions associated with the diversion or prevention of food waste from landfills. These calculations are based on estimates of tonnage of diverted material and emission reduction factors from published sources. This GHG quantification methodology applies to additional material only (i.e., material that would otherwise be sent to a landfill). Projects will report the total project GHG emission reductions and select co-benefits estimated using this methodology as well as the total project GHG emission reductions per dollar of GGRF funds requested.

The Food Waste Prevention and Rescue Program Benefits Calculator Tool automates methods described in this document, provides a link to a step-by-step user guide with a project example, and outlines documentation requirements. Projects will report the total project GHG emission reductions and co-benefits estimated using the Food Waste Prevention and Rescue Program Benefits Calculator Tool as well as the total project GHG emission reductions per dollar of GGRF funds requested. The Food Waste Prevention and Rescue Program Benefits Calculator Tool is available for download at: http://www.arb.ca.gov/cci-resources.

Using largely the same inputs required to estimate GHG emission reductions, the Food Waste Prevention and Rescue Program Benefits Calculator Tool estimates the following co benefits and key variables from Food Waste Prevention and Rescue Program projects: select criteria and toxic air pollutants (in pounds (lbs))—including nitrogen oxide (NOx), reactive organic gases (ROG), diesel particulate matter (diesel PM), and fine particulate matter less than 2.5 micrometers (PM2.5); edible food rescued and donated (in tons); material diverted from landfill (in tons); reduction of vehicle miles traveled (in miles); and energy and fuel cost savings (in dollars). Additional co benefits for which CARB assessment methodologies were not incorporated into the Benefits Calculator Tool may also be applicable to the project. Applicants should consult the Food Waste Prevention and Rescue Program guidelines, solicitation materials, and agreements to ensure they are meeting Food Waste Prevention and Rescue Program requirements.All CARB co-benefit assessment methodologies are available at: www.arb.ca.gov/cci-cobenefits.

Methodology Development

CARB and CalRecycle developed this Quantification Methodology consistent with the guiding principles of California Climate Investments, including ensuring transparency and accountability.[1] CARB and CalRecycle developed this Food Waste Prevention and Rescue Program Quantification Methodology to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:
- Apply at the project-level;
- Provide uniform methods to be applied statewide, and be accessible by all applicants;
- Use existing and proven tools and methods;
- Use project-level data, where available and appropriate; and
- Result in GHG emission reduction estimates that are conservative and supported by empirical literature.

CARB assessed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for the Food Waste Prevention and Rescue Program project types. CARB also consulted with CalRecycle to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

In addition, the University of California, Berkeley, in collaboration with CARB, developed assessment methodologies for a variety of co-benefits such as providing cost savings, lessening the impacts and effects of climate change, and strengthening community engagement. Co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

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[1] California Air Resources Board. www.arb.ca.gov/cci-fundingguidelines

Tools

This Food Waste Prevention and Rescue Program Quantification Methodology and accompanying Food Waste Prevention and Rescue Program Benefits Calculator Tool adopted methods and emission factors from existing quantification methodologies and published studies that are publicly available, applicable statewide, and subject to regular updates to incorporate new information. The documents are free of charge, available online, and provide California specific methods for quantifying the impacts of waste diversion projects. These source materials are described below.

Compost Emission Reduction Factor (CERF)

The 2017 draft Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities document (CERF) calculates the net avoided emissions from diverting organic waste from landfills to composting facilities. It includes California-specific emission factors for avoided landfill emissions attributable to the diversion of organic waste (i.e., food scraps, yard trimmings, branches, leaves, grass, and organic municipal waste). These emission reduction factors are used consistently across all organic waste diversion projects included in the Quantification Methodology and Benefits Calculator Tool. The methods used, assumptions, and results are detailed in the draft CERF.

Food Rescue Emission Reduction Factor

The GHG emission reduction factor for food rescue is calculated based on lifecycle GHG emissions from avoidable U.S. food waste as reported in The Climate Change and Economic Impacts of Food Waste in the United States (2012) and published in the International Journal on Food System Dynamics. These factors are also used by institutions such as the U.S. Department of Agriculture (USDA) and Organisation for Economic Co-operation and Development (OECD) to estimate emissions from food waste.

Refrigeration and Freezer Equipment Emissions

The emissions associated with refrigerant leakage from equipment used for food rescue was developed using the inventory from CARB's Refrigerant Management Program as described in California's High Global Warming Potential Gases Emission Inventory (2015) . The emissions associated with energy consumption of the refrigeration equipment is calculated based on the energy use requirements set by the California Energy Commission in 2015 Appliance Efficiency Regulations and the Department of Energy in the Code of Federal Regulations: 10 CFR 431.66 - Energy conservation standards and their effective dates.

<u>Transportation Emissions</u>

Transportation related emissions in this GHG quantification methodology are calculated based on a well-to-wheel (WTW) emission factor derived from carbon intensity data, fuel energy density values, and fuel efficiency values. The emission factor was developed using CARB's Low Carbon Fuel Standard, ARB's Mobile Source Emission Factor Model (EMFAC 2014), California-modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET 2.0), and U.S. Department of Transportation mileage assumptions. The WTW method accounts for the emissions associated with the production and distribution of different fuel types as well as any associated exhaust emissions.

In addition to the tools above, the Food Waste Prevention and Rescue Program Benefits Calculator Tool relies on CARB-developed emission factors. CARB has established a single repository for emission factors used in CARB benefits calculator tools, referred to as the California Climate Investments Quantification Methodology Emission Factor Database (Database), available at: http://www.arb.ca.gov/cci-resources. The Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

Applicants must use the Food Waste Prevention and Rescue Program Benefits Calculator Tool to estimate the GHG emission reductions and co-benefits of the proposed project. The Food Waste Prevention and Rescue Program Benefits Calculator Tool can be downloaded from: http://www.arb.ca.gov/cci-resources.

Updates

CARB staff periodically review each quantification methodology and benefits calculator tool to evaluate their effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the Food Waste Prevention and Rescue Program Quantification Methodology from the previous version[2] to enhance the analysis and provide additional clarity. The changes include:

- Creation of a standalone Food Waste Prevention and Rescue Benefits Calculator Tool;
- The addition of new vehicle types and the option to select multiple vehicles;
- The option to select multiple refrigeration systems;
- Additional definitions and clarity in the Benefits Calculator Tool; and
- Addition of new output tab in the Benefits Calculator Tool that summarizes select co-benefits and key variables using largely the same inputs used to estimate GHG emission reductions.

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[2] "Quantification Methodology for the Food Waste Prevention and Rescue Program," California Air Resources Board, July 20, 2018. E-mail GGRFProgram@arb.ca.gov to request a copy.

Section B. Methods

The following section provides details on the methods supporting emission reductions in the Food Waste Prevention and Rescue Program Benefits Calculator Tool.

Project Type

CalRecycle developed two project types that meet the objectives of the Food Waste Prevention and Rescue Program and for which there are methods to quantify GHG emission reductions.[3] Other project features may be eligible for funding under the Food Waste Prevention and Rescue Program; however, each project requesting GGRF funding must include at least one of the following:

- Food Waste Prevention; and
- Edible Food Waste Rescue

General Approach

Methods used in the Food Waste Prevention and Rescue Program Benefits Calculator Tool for estimating the GHG emission reductions and air pollutant emission co-benefits by activity type are provided in this section. The Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

Food waste prevention, also known as source reduction of food waste, is the elimination of food waste before it is created. Food waste prevention activities include but are not limited to: use of food waste prevention technology/software, conducting food waste assessments to identify where and why food waste is occurring and then purchasing less or preparing less food based on waste assessment results, implementing trayless dining, creating food waste prevention training programs, and food waste prevention education and outreach. All prevention activities must be quantifiable. If multiple food waste prevention strategies will be used, the applicant must provide clear calculations to quantify the impact of each strategy. Food waste prevention does not include food rescue, diverting food waste to compost or anaerobic digestion, or any activity that manages food waste once the waste has already been created.

Edible food rescue is the act of collecting edible food that would otherwise be landfilled for distribution to feed people.

In general, the GHG emission reductions are estimated in the Food Waste Prevention and Rescue Program Benefits Calculator Tool using the approaches in Table 1. The Food Waste Prevention and Rescue Program Benefits Calculator Tool also estimates

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[3] Link to CalRecycle's Food Waste Prevention and Rescue Grant Program

air pollutant emission co-benefits and key variables using many of the same inputs used to estimate GHG emission reductions.

Table 1. General Approach to Quantification by Project Type

Edible Food Rescue and Food Waste Prevention
GHG emission reductions = Avoided Food Production due to Food Waste Rescue or Prevention – Increased vehicle miles traveled (if applicable) – New Refrigeration Electricity Use and Refrigerant Leakage (if applicable)

A. Emission Reductions from Food Waste Rescue and Prevention

Both the GHG emission reductions and air pollutant emission estimates from food waste rescue and prevention are estimated as the difference between the baseline and project scenarios using Equations 1-8. Equations 1 and 2 estimate the annual emissions of new transportation vehicles associated with the pickup and delivery of rescued food.

Equation 1: GHG Emissions from Transportation Vehicles

$$GHG_{TR} = \sum_i \left[\left(\frac{VEF_{GHG} \times M}{1,000,000} \right) + \frac{(R_{Leak} \times R_{charge} \times R_{GWP})}{2,204.62} \right]$$

Where,			Units
GHG_{TR}	=	GHG emissions from transportation vehicle	MTCO₂e/year
i	=	Number of identical vehicles	
VEF_{GHG}	=	Vehicle GHG Emission Factor	g/mile
M	=	Average Miles per Year for a Delivery Truck	miles/year
1,000,000	=	Conversion from g to MT	g/MT
R_{Leak}	=	The leak rate of the TRU, if necessary	%
R_{charge}	=	TRU refrigerant charge size, if necessary	lbs
R_{GWP}	=	GWP of the refrigerant. All TRUs are assumed to use R-134A	CO₂e
2,204.62	=	Conversion from lbs to MT	lbs/MT

Equation 2: Criteria and Toxics Emissions from Transportation Vehicles

$$CT_{TR} = \sum_i \left(\frac{VEF_{CT} \times M}{454} \right)$$

Where,			Units
CT_{TR}	=	Criteria and Toxics emissions from transportation vehicle	lbs/year
i	=	Number of identical vehicles	
VEF_{CT}	=	Vehicle ROG, NOx, PM2.5, Diesel PM Emission Factors	g/mile
M	=	Average Miles per Year for a Delivery Truck	miles/year
454	=	Conversion from g to lbs	g/MT

Equations 3 and 4 estimate the annual emissions of new refrigeration equipment that is necessary to store the rescued food until it can be consumed or delivered to people. These equations take into account electricity consumption of the equipment and also refrigerant leakage which has a climate impact due to the high Global Warming Potential of many refrigerants.

Equation 3: GHG Emissions from Refrigeration Equipment

$$GHG_{RF} = \sum_i \left[((V \times EC + E_{Constant}) \times EF_{E,GHG}) + \frac{(R_{Leak} \times R_{charge} \times R_{GWP})}{2,204.62} \right]$$

Where,

			Units
GHG_{RF}	=	GHG emissions from refrigeration equipment	$MTCO_2e$/year
i	=	Number of identical units	
V	=	Volume of refrigeration compartment	ft^3
EC	=	Electricity consumption of refrigeration unit	kWh/year-ft^3
$E_{Constant}$	=	Electricity consumption of refrigeration unit constant factor	kWh/year
$EF_{E,GHG}$	=	Grid GHG electricity emission factor	$MTCO_2e$/kWh
R_{Leak}	=	The leak rate of the refrigeration unit	%
R_{charge}	=	Refrigerant charge size	lbs
R_{GWP}	=	GWP of the refrigerant	CO_2e
2,204.62	=	Conversion from lbs to MT	lbs/MT

Equation 4: Criteria and Toxic Emissions from Refrigeration Equipment

$$CT_{RF} = \sum_i ((V \times EC + E_{Constant}) \times EF_{E,CT})$$

Where,

			Units
CT_{RF}	=	Criteria and toxic emissions from refrigeration equipment	lbs/year
i	=	Number of identical units	
V	=	Volume of refrigeration compartment	ft^3
EC	=	Electricity consumption of refrigeration unit	kwh/year-ft^3
$E_{Constant}$	=	Electricity consumption of refrigeration unit constant factor	kWh/year
$EF_{E,CT}$	=	Grid criteria and toxic electricity emission factor	lbs/kWh

Equations 5 and 6 estimate the annual emissions reductions associated with the rescue of food waste for human consumption and food waste prevention. These equations are based on factors that take into account both upstream avoided food production emissions, avoided transportation emissions, and avoided emissions from disposal of food waste.

Equation 5: GHG Emission Reductions from Diversion of Food Waste or Source Reduction

$$GHG_{FW} = \frac{(FR + FW)}{2,000} \times EF_{FW}$$

Where,			Units
GHG_{FW}	=	GHG emissions reductions from diversion of food waste or source reduction	$MTCO_2e$
FR	=	Amount of food rescued	lbs
FW	=	Amount of food waste reduction	lbs
2,000	=	Conversion from lbs to short tons	lbs/short tons
EF_{FW}	=	Food Waste Prevention and Rescue Emission Reduction Factor	$MTCO_2e$/short ton of food waste

Equation 6: Criteria and Toxics Emission Reductions from Diversion of Food Waste or Source Reduction

$$CT_{FW} = \left(\frac{(FR + FW)}{2,000} \times EF_{AFT}\right) + \left(\frac{(FR + FW)}{2,000} \times EF_{LF}\right)$$

Where,			Units
CT_{FW}	=	Criteria and toxic emissions from refrigeration equipment	lbs
FR	=	Amount of food rescued	lbs
FW	=	Amount of food waste reduction	lbs
2,000	=	Conversion from lbs to short tons	lbs/short tons
EF_{AFT}	=	Avoided transportation for food waste emission reduction factor	lbs/short ton of food waste
EF_{LF}	=	Avoided landfill flare emission reduction factor	lbs/short ton of food waste

Equations 7 and 8 estimate the net benefits for GHG and co-pollutants associated with a food rescue or food waste prevention project.

Equation 7: Net GHG Benefit

$$GHG = GHG_{FW} - (GHG_{TR} + GHG_{RF})$$

Where,			Units
GHG	=	Net GHG benefit from the project	MT CO$_2$e
GHG$_{FW}$	=	GHG benefit of food waste diversion and source reduction (from Equation 5)	MT CO$_2$e
GHG$_{TR}$	=	GHG emissions from delivery vehicles (from Equation 1)	MT CO$_2$e
GHG$_{RF}$	=	GHG emissions from refrigeration unit (from Equation 3)	MT CO$_2$e

Equation 8: Net Criteria and Toxics Benefit

$$CT = CT_{FW} - (CT_{TR} + CT_{RF})$$

Where,			Units
CT	=	Net criteria and toxics benefit from the project	lbs
CT$_{FW}$	=	Criteria and toxics benefit of food waste diversion and source reduction (from Equation 6)	lbs
CT$_{TR}$	=	Criteria and toxics emissions from delivery vehicles (from Equation 2)	lbs
CT$_{RF}$	=	Criteria and toxics emissions from refrigeration unit (from Equation 4)	lbs

Section C. References

The following references were used in the development of this Quantification Methodology and the accompanying Food Waste Prevention and Rescue Program Benefits Calculator Tool.

10 CFR 431.66 - Energy conservation standards and their effective dates
http://www.ecfr.gov/cgi-bin/text-idx?SID=ea9937006535237ca30dfd3e03ebaff2&mc=true&node=se10.3.431_166&rgn=div8

CARB's California's High Global Warming Potential Gases Emission Inventory Emission Inventory Methodology and Technical Support Document (2016)
http://www.arb.ca.gov/cc/inventory/slcp/doc/hfc_inventory_tsd_20160411.pdf

CARB Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities (2017)
http://www.arb.ca.gov/cc/waste/cerffinal.pdf

CARB Refrigerant Management Program
http://www.arb.ca.gov/cc/rmp/rmprefrigerants.htm

CARB EMFAC 2014 Web Database
http://www.arb.ca.gov/emfac/2014/

The Climate Change and Economic Impacts of Food Waste in the United States (2012)
http://www.cleanmetrics.com/pages/ClimateChangeImpactofUSFoodWaste.pdf

San Joaquin Valley Air Pollution Control District, Greenwaste Compost Site Emissions Reductions from Solar-powered Aeration and Biofilter Layer (2013)
http://www.valleyair.org/Grant_Programs/TAP/documents/C-15636-ACP/C-15636_ACP_FinalReport.pdf

U.S. EPA Emission Factors for Greenhouse Gas Inventories (2015)
https://www.epa.gov/sites/production/files/2015-12/documents/emission-factors_nov_2015.pdf

U.S. EPA Advancing Sustainable Materials Management: Facts and Figures 2013 Assessing Trends in Material Generation, Recycling and Disposal in the United States (June 2015)
https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_rpt.pdf

U.S EPA AP-42, Compilation of Air Emission Factors, 2.4, Municipal Solid Waste Landfills, https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf

US Department of Transportation: Table VM-1 Annual Vehicle Distance Traveled in Miles and Related Data - 2014 by Highway Category and Vehicle Type
http://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm