California Air Resources Board

Quantification Methodology

California Department of Resources Recycling and Recovery Organics Programs

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) Organics Programs (Organics) which include the Organics Grant Program, Food Waste Prevention and Rescue Program, and the Community Compost Grant Program, CARB staff developed this Organics Quantification Methodology to provide guidance for estimating the GHG emission reductions and selected co-benefits of each proposed project type. This methodology uses calculations to estimate GHG emission reductions from avoided landfill methane emissions and GHG emissions associated with the implementation of Organics projects.

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

Using many of the same inputs required to estimate GHG emission reductions, the Organics Benefits Calculator Tool estimates the following co-benefits and key variables from Organics projects select criteria and toxic air pollutants (in pounds (lbs))—including nitrogen oxide (NO_x), reactive organic gases (ROG), diesel particulate matter (diesel PM), and fine particulate matter less than 2.5 micrometers ($PM_{2.5}$); edible food rescued and donated (in tons); material diverted from landfill (in tons); reduction of vehicle miles traveled (in miles); fossil fuel use reductions (in gallons and kWh); energy and fuel cost savings (in dollars); renewable fuel generation (in gallons and scf); renewable energy generation (in kWh); compost production (in dry tons); compost application area (in acres); trees planted (in number of trees); and water savings (in gallons). Key variables are project characteristics that contribute to a project's GHG emission reductions and signal an additional benefit (e.g., renewable fuel generation, compost production, etc.). Additional co-benefits for which CARB assessment methodologies were not incorporated into the Organics Benefits Calculator Tool may also be applicable to the project. Applicants should consult the program guidelines, solicitation materials, and agreements to ensure they are meeting 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 Organics 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 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 Organics 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.

CARB released the Draft Organics Quantification Methodology and Draft Organics Benefits Calculator Tool for public comment in February 2020. This Final Organics Quantification Methodology and accompanying Organics Benefits Calculator Tool have been updated to address public comments, where appropriate, and for consistency with updates to the Organics Guidelines.

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

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

community engagement. Co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

Tools

The Organics Benefits Calculator Tool relies on project-specific outputs from the following tools:

Compost Emission Reduction Factor (CERF)
The 2017 final draft *Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities*[i] 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)[ii] 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)*[iii]. 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*[iv] and the Department of Energy in the *Code of Federal Regulations: 10 CFR 431.66 - Energy conservation standards and their effective dates.*[v]

Transportation Emissions
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,[vi] CARB's Mobile Source Emission Factor Model (EMFAC 2014),[vii] California-modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET 2.0),[viii] and

U.S. Department of Transportation mileage assumptions.[ix] The WTW method accounts for the emissions associated with the production and distribution of different fuel types as well as any associated exhaust emissions.

Low Carbon Fuel Standard (LCFS) Regulation and Pathways

The LCFS pathways use a well-to-wheels (WTW) life-cycle approach to determine the emissions associated with 27 different transportation fuels taking into consideration the fuel production, transportation, distribution and use. This GHG quantification methodology uses the fuel production rates and GHG emissions from the *Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from High Solids Anaerobic Digestion (HSAD) of Organic (Food and Green) Wastes* (2014)[x] and *Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from the Mesophilic Anaerobic Digestion of Wastewater Sludge at Publicly-Owned Treatment Works (POTW)* (2014)[xi] to accurately and uniformly quantify GHG emission reductions attributable to the diversion of organic waste (i.e., food scraps, yard trimmings, branches, leaves, grass, and organic municipal waste) for the purpose of anaerobic digestion.

United States Forest Service i-Tree Planting Software

The United States Forest Service (USFS) i-Tree Planting web-based tool provides quantitative data for an individual or population of trees planted as part of the project, including the amount of carbon stored, the estimated effects of tree shade on building energy use, the dry weight of aboveground biomass, and rainfall interception based on project characteristics such as the climate zone, tree species, tree age, tree diameter at breast height (DBH), and tree location relative to a building. i-Tree Planting can be accessed at: https://planting.itreetools.org/. A description about the tool can be accessed at: https://planting.itreetools.org/help/.

The Organics Benefits Calculator Tool also includes water savings co-benefit calculations that require the use of the Department of Water Resources (DWR) Water Budget Calculator for New and Rehabilitated Residential/Non-Residential Landscapes[2] and the University of California Division of Agriculture and Natural Resources (UCANR) Water Use Classification of Landscape Species (WUCOLS) IV online database.[3] In order to estimate water savings resulting from the project activities, refer to CARB's Co-benefit Assessment Methodology for Water Savings, available at: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/final_water_am.pdf, which includes an urban landscaping project example in Appendix C.

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[2] Department of Water Resources (2017). *Water Budget Calculator for New and Rehabilitated Residential/Non-Residential Landscapes*. http://water.ca.gov/wateruseefficiency/landscapeordinance/docs/BetaWaterBudgetNonResidentialV130.xlsm

[3] University of California Division of Agriculture and Natural Resources. (2019). *Water Use Classification of Landscape Species (WUCOLS) IV online database*. http://ucanr.edu/sites/WUCOLS/Plant_Search/

In addition to the tools above, the Organics 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 Organics Benefits Calculator Tool to estimate the GHG emission reductions and co-benefits of the proposed project. The Organics 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 Organics Quantification Methodology from the previous version[4] to enhance the analysis and provide additional clarity. The changes include:

- Addition of community compost and tree planting options;
- Updates to the step-by-step user guide with a new project example for community composting and tree planting;
- Updates to the emission factors for GHG and air pollutant emission reductions.

[4] Organics Programs Quantification Methodology released September 5, 2019

Section B. Methods

The following section provides details on the methods supporting emission reductions in the Organics Benefits Calculator Tool.

Project Type

CalRecycle developed multiple project types that meet the objectives of the Organics Programs and for which there are methods to quantify GHG emission reductions.[5] Other project features may be eligible for funding under the Organics Programs; however, each project requesting GGRF funding must include at least one of the following:

- Composting of organic material;
- Standalone anaerobic digestion (AD) of organics producing biofuels or bioenergy;
- Co-Digestion of organics at wastewater treatment plants producing biofuels or bioenergy;
- Edible food rescue and food waste prevention; and
- Tree Planting.

General Approach

Methods used in the Organics 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.

For projects with a composting, AD, or food rescue component, these methods account for methane emission reductions at landfills due to organics removed from the waste stream and used for compost, digestion, or rescued for consumption. Emission reductions can also be associated with the offset of fossil fuel in vehicle fuel, electricity production, or natural gas usage. Application of compost is outside of the boundary of the projects and is not included in the net GHG benefits for these project types. Emissions increases can occur from increased vehicles miles traveled for food delivery or pickup, fugitive emissions from waste processing, or refrigerant leakage and electricity consumption.

For projects with a tree planting component, these methods account for carbon storage in planted trees, energy savings from the benefits of tree shade, and the GHG emissions associated with the implementation of the tree planting projects.

[5] https://www.calrecycle.ca.gov/Climate/GrantsLoans/

In general, the GHG emission reductions are estimated in the Organics Benefits Calculator Tool using the approaches in Table 1. The Organics Benefits Calculator Tool also estimates air pollutant emissions and key variables using many of the same inputs used to estimate GHG emission reductions.

Using the same inputs for estimating GHG emission reductions, the Organics Benefits Calculator Tool also estimates criteria and toxic emission reductions. Because criteria and toxic emissions have a local impact compared to GHG emissions which have a global impact, criteria and toxic emissions are broken into two categories: local and remote. Local emissions are those that take place at the project location. This can include emissions from process emissions, emissions from a generator or boiler, or onsite fossil fuel usage, etc. Remote emissions are those that take place outside of the project location boundary and can include electricity generation emissions from the electrical grid, reduction in diesel usage due to new RNG vehicles, etc. The Organics Benefits Calculator Tool calculates these emissions separately in the Co-benefit Summary Tab and also provides the net benefit.

Table 1. General Approach to Quantification by Project Types

Composting of Organic Material
GHG Emission Reductions = Avoided Landfill Methane Emissions – Fugitive Emissions from Composting Process
Standalone Anaerobic Digestion of Organics Producing Biofuels or Bioenergy
GHG Emission Reductions = Avoided Landfill Methane Emissions + Avoided Emissions from Use of Biomethane in Vehicle Fuel, Electricity Production or Pipeline Injection – Fugitive Emissions from AD Process
Co-Digestion of Organics at Wastewater Treatment Plants Producing Biofuels or Bioenergy
GHG Emission Reductions = Avoided Landfill Methane Emissions + Avoided Emissions from Use of Biomethane in Vehicle Fuel, Electricity Production, or Pipeline Injection – Fugitive Emissions from AD Process
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)
Tree Planting
Net GHG benefit = carbon storage in planted trees – carbon in planted trees not assumed to survive[6] + GHG reductions from energy savings from shade[7] – GHG emissions from tree planting and maintenance

[6] This methodology applies a 3% annual tree mortality rate to the years after the period of establishment care (including replacement) provided by the project through year 10, at which time tree mortality is substantially reduced. This assumption is based on USFS publications and personal communication with John Melvin, State Urban Forester, CAL FIRE (April 19, 2016).

[7] Some tree planting sites may not provide shade to buildings and will therefore not result in building energy savings. If there are no trees that provide tree shade to conditioned buildings in the proposed project, this variable may be set to 0. If only a subset of trees will provide shade, see the step-by-step user guide for additional details about how to apply the third party tool, i-Tree Planting.

A. Emission Reduction Estimates 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 1-6. 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	$MTCO_2e$/ 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	CO_2e
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 Criteria and Toxic 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 recipients. These equations consider electricity consumption of the equipment and refrigerant leakage which have climate impacts due to the high Global Warming Potential (GWP) of many refrigerant gases.

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 consider 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

$$GHG_{FW} = (FR + FW) \times EF_{FW}$$

Where,

			Units
GHG_{FW}	=	GHG emissions reductions from diversion of food waste or source reduction	$MTCO_2e$
FR	=	Amount of food rescued	short tons
FW	=	Amount of food waste reduction	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

$$CT_{FW} = ((FR + FW) \times EF_{AFT}) + ((FR + FW) \times EF_{LF})$$

Where,

			Units
CT_{FW}	=	Criteria and toxic emissions reductions from avoided transportation and avoided landfill flare emissions	lbs
FR	=	Amount of food rescued	lbs
FW	=	Amount of food waste reduction	lbs
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

B. Emission Reduction Estimates from Composting Projects

Both the GHG emission reductions and air pollutant emission estimates from composting projects are estimated as the difference between the baseline of sending the organic materials to a landfill versus composting those materials using windrow or aerated static pile (ASP) composting processes. Equations 7 and 8 estimate the GHG reductions and Equations 9 and 10 estimate the criteria and toxics emissions.

Equation 7. GHG Emission Reductions from Windrow Composting

$$GHG_{COM,WIN} = \left((FS_{WIN} \times COM_{FOOD}) - RES_{WIN,FOOD}\right) \times ERF_{WIN,FOOD} + \left((FS_{WIN} \times COM_{GREEN}) - RES_{WIN,GREEN}\right) \times ERF_{WIN,GREEN}$$

Where,

			Units
$GHG_{COM,WIN}$	=	GHG emission reductions from windrow composting	MT CO_2e
FS_{WIN}	=	Amount of feedstock diverted to windrow composting	short tons
COM_{FOOD}	=	Percentage of feedstock that is food waste	%
$RES_{WIN,FOOD}$	=	Amount of food waste residual material that is screened out before composting	short tons
$ERF_{WIN,FOOD}$	=	Emission reduction factor for windrow composting of food waste	MT CO_2e/ short ton
FS_{WIN}	=	Amount of feedstock diverted to windrow composting	short tons
COM_{GREEN}	=	Percentage of feedstock that is green waste	%
$RES_{WIN,GREEN}$	=	Amount of green waste residual material that is screened out before composting	short tons
$ERF_{WIN,GREEN}$	=	Emission reduction factor for windrow composting of green waste	MTCO2e/ short ton

Equation 8. GHG Emission Reductions from ASP Composting

$$GHG_{COM,ASP} = \left((FS_{ASP} \times COM_{FOOD}) - RES_{ASP,FOOD}\right) \times ERF_{ASP,FOOD} + \left((FS_{ASP} \times COM_{GREEN}) - RES_{ASP,GREEN}\right) \times ERF_{ASP,GREEN}$$

Where,

			Units
$GHG_{COM,ASP}$	=	GHG emission reductions from ASP composting	MT CO_2e
FS_{ASP}	=	Amount of feedstock diverted to ASP composting	short tons
COM_{FOOD}	=	Percentage of feedstock that is food waste	%
$RES_{ASP,FOOD}$	=	Amount of food waste residual material that is screened out before composting	short tons
$ERF_{ASP,FOOD}$	=	Emission reduction factor for ASP composting of food waste	MT CO_2e/ short ton
FS_{ASP}	=	Amount of feedstock diverted to ASP composting	short tons
COM_{GREEN}	=	Percentage of feedstock that is green waste	%
$RES_{ASP,GREEN}$	=	Amount of green waste residual material that is screened out before composting	short tons
$ERF_{ASP,GREEN}$	=	Emission reduction factor for ASP composting of green waste	MTCO2e/ short ton

Equation 9. Criteria and Toxics Emission Reductions from Windrow Composting

$$CT_{COM,WIN} = \left((FS_{WIN} \times COM_{FOOD}) - RES_{WIN,FOOD}\right) \times ERF_{WIN,FOOD,CT} + \left((FS_{WIN} \times COM_{GREEN}) - RES_{WIN,GREEN}\right) \times ERF_{WIN,GREEN}$$

Where,

			Units
$CT_{COM,WIN}$	=	Criteria and toxics emissions reductions from windrow composting	lb pollutant
FS_{WIN}	=	Amount of feedstock diverted to windrow composting	short tons
COM_{FOOD}	=	Percentage of feedstock that is food waste	%
$RES_{WIN,FOOD}$	=	Amount of food waste residual material that is screened out before composting	short tons
$ERF_{WIN,FOOD,CT}$	=	Avoided landfill emission factor for windrow composting of food waste	lb pollutant/ short ton
FS_{WIN}	=	Amount of feedstock diverted to windrow composting	short tons
COM_{GREEN}	=	Percentage of feedstock that is green waste	%
$RES_{WIN,GREEN}$	=	Amount of green waste residual material that is screened out before composting	short tons
$ERF_{WIN,GREEN,CT}$	=	Avoided landfill emission factor for windrow composting of green waste	lb pollutant /short ton

Equation 10. Criteria and Toxics Emission Reductions from ASP Composting

$$CT_{COM,ASP} = \left((FS_{ASP} \times COM_{FOOD}) - RES_{ASP,FOOD}\right) \times ERF_{ASP,FOOD,CT} + \left((FS_{ASP} \times COM_{GREEN}) - RES_{ASP,GREEN}\right) \times ERF_{ASP,GREEN,CT}$$

Where,

			Units
$CT_{COM,ASP}$	=	Criteria and toxics emissions reductions from ASP composting	lb pollutant
FS_{ASP}	=	Amount of feedstock diverted to ASP composting	short tons
COM_{FOOD}	=	Percentage of feedstock that is food waste	%
$RES_{ASP,FOOD}$	=	Amount of food waste residual material that is screened out before composting	short tons
$ERF_{ASP,FOOD,CT}$	=	Avoided landfill emission factor for ASP composting of food waste	lb pollutant/ short ton
FS_{ASP}	=	Amount of feedstock diverted to ASP composting	short tons
COM_{GREEN}	=	Percentage of feedstock that is green waste	%
$RES_{AS\{,GREEN}$	=	Amount of green waste residual material that is screened out before composting	short tons
$ERF_{ASP,GREEN,CT}$	=	Avoided landfill emission factor for ASP composting of green waste	lb pollutant/ short ton

C. Emission Reduction Estimates from Standalone Anaerobic Digestion Projects

Both the GHG emission reductions and air pollutant emission estimates from Standalone AD projects are estimated as the difference between the baseline sending the organic materials to a landfill versus digesting those materials using a dedicated digester. Equation 11 estimates the GHG reductions and Equations 12 through 16 estimate the criteria and toxics emissions.

Equation 11. GHG Emission Reductions from Standalone Anaerobic Digestion

$$GHG_{SAD} = (FS_{SAD} - RES_{SAD}) \times ERF_{SAD}$$

Where,			Units
GHG_{SAD}	=	Net GHG benefit from standalone AD	MT CO_2e
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
ERF_{SAD}	=	Emission reduction factor for standalone AD projects based on final use of biomethane (vehicle fuel, onsite electricity, or injection into natural gas pipeline).	MT CO_2e/ short ton

Equation 12. Criteria and Toxics Emission Reductions from Standalone Anaerobic Digestion Avoided Diesel Usage (Remote Benefit)

$$CT_{ADR,SAD} = DP_{SAD} \times (FS_{SAD} - RES_{SAD}) \times CE \times (TEF_{Diesel} - TEF_{AF}) \times FE \times \frac{1}{454}$$

Where,			Units
$CT_{ADR,SAD}$	=	Criteria and toxic emission reductions from replacement of diesel with renewable fuel (renewable natural gas (RNG), dimethyl ether (DME), or hydrogen)	lb pollutants
DP_{SAD}	=	Amount of biomethane available to offset diesel fuel usage (if applicable)	gallons of diesel eq./ short ton
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
CE	=	Conversion efficiency from RNG to DME or hydrogen	%
TEF_{Diesel}	=	Transportation emission factor of diesel	g/mile
TEF_{AF}	=	Transportation emission factor of alternative fueled vehicle	g/mile
FE	=	Fuel efficiency	miles/gallon
1/454	=	Conversion factor from g to lb	lb/g

Equation 13. Criteria and Toxics Emission Reductions from Standalone Anaerobic Digestion Usage of Grid Power (Remote Benefit)

$$CT_{Grid,SAD} = \left(EP_{SAD} \times (FS_{SAD} - RES_{SAD}) \times ERF_{grid}\right) - \left(EU_{grid} \times (FS_{SAD} - RES_{SAD}) \times ERF_{grid}\right)$$

Where,

			Units
$CT_{grid,SAD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste	lb pollutants
EP_{SAD}	=	Facility electricity production that is sent to the grid for electricity generation projects (if applicable)	kWh/short ton
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
ERF_{grid}	=	Grid criteria and toxic emission reduction factors	lb/kWh
EU_{grid}	=	Electricity consumption to process waste material	kWh/ short ton

Equation 14. Avoided Flare Criteria and Toxics Emissions from Standalone Anaerobic Digestion (Remote Benefit)

$$CT_{flare,SAD} = (FS_{SAD} - RES_{SAD}) \times ERF_{flare}$$

Where,

			Units
$CT_{flare,SAD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste	lb pollutants
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
ERF_{flare}	=	Flare criteria and toxic emission reduction factors	lb/short ton

Equation 15. Criteria and Toxics Emissions from Processing of Diverted Material for Standalone Anaerobic Digestion (Local Benefit)

$$CT_{proc,SAD} = \left((FS_{SAD} - RES_{SAD}) \times DU_{proc} \times EF_{equip}\right) + \left((FS_{SAD} - RES_{SAD}) \times RNGU_{proc} \times EF_{boiler}\right)$$

Where,

			Units
$CT_{proc,SAD}$	=	Criteria and toxic emissions from processing waste	lb pollutants
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
DU_{proc}	=	Diesel usage to manage waste at the digester	gallon/short ton
EF_{equip}	=	Off-road diesel equipment criteria and toxic emission factors	lb/gallon
$RNGU_{proc}$	=	RNG usage to generate heat in a boiler to manage waste at the digester	scf/short ton
EF_{boiler}	=	Boiler criteria and toxic emission factors	lb/scf

Equation 16. Criteria and Toxics Emissions from Electricity Generation at a Standalone Anaerobic Digestion Facility (Local Benefit)

$$CT_{elec,SAD} = (FS_{SAD} - RES_{SAD}) \times AF_{SAD} \times 0.00102 \times EF_{gen}$$

Where,

			Units
$CT_{elec,SAD}$	=	Criteria and toxic emissions from onsite production of electricity	lb pollutants
FS_{SAD}	=	Amount of feedstock diverted to standalone AD	short tons
RES_{SAD}	=	Amount of standalone AD residual material that is screened out before digestion	short tons
AF_{SAD}	=	Amount of fuel production per ton of waste	scf/short ton
0.00102	=	Conversion of scf to MMBtu	MMBTU/scf
EF_{gen}	=	Electricity generation device criteria and toxic emission factor	lb/MMBtu

D. Emission Reduction Estimates from Co-Digestion Anaerobic Digestion Projects

Both the GHG emission reductions and air pollutant emission estimates from Co-Digestion AD projects are estimated as the difference between the baseline sending the organic materials to a landfill versus digesting those materials using a co-digestion process. Equation 17 estimates the GHG reductions and Equations 18 through 22 estimate the criteria and toxics emissions.

Equation 17. GHG Emission Reductions from Co-Digestion Anaerobic Digestion

$$GHG_{COD} = (FS_{COD} - RES_{COD}) \times ERF_{COD}$$

Where,			Units
GHG_{COD}	=	Net GHG benefit from co-digestion AD	MT CO_2e
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
ERF_{COD}	=	Emission reduction factor for co-digestion AD projects based on final use of biomethane (vehicle fuel, onsite electricity, or injection into natural gas pipeline).	MT CO_2e/ short ton

Equation 18. Criteria and Toxics Emission Reductions from Co-Digestion Anaerobic Digestion Avoided Diesel Usage (Remote Benefit)

$$CT_{ADR,COD} = DP_{SAD} \times (FS_{COD} - RES_{COD}) \times CE \times (TEF_{Diesel} - TEF_{AF}) \times FE \times \frac{1}{454}$$

Where,			Units
$CT_{ADR,COD}$	=	Criteria and toxic emission reductions from replacement of diesel with renewable fuel (RNG, DME, or hydrogen)	lb pollutants
DP_{COD}	=	Amount of biomethane available to offset diesel fuel usage (if applicable)	gallons of diesel eq./ short ton
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
CE	=	Conversion efficiency from RNG to DME or hydrogen	%
TEF_{Diesel}	=	Transportation emission factor of diesel	g/mile
TEF_{AF}	=	Transportation emission factor of alternative fueled vehicle	g/mile
FE	=	Fuel efficiency	miles/gallon
1/454	=	Conversion factor from g to lb	lb/g

Equation 19. Criteria and Toxics Emission Reductions from Co-Digestion Anaerobic Digestion Usage of Grid Power (Remote Benefit)

$$CT_{grid,COD} = \left(EP_{COD} \times (FS_{COD} - RES_{COD}) \times ERF_{grid}\right) - \left(EU_{grid} \times (FS_{COD} - RES_{COD}) \times ERF_{grid}\right)$$

Where,			Units
$CT_{grid,COD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste	lb pollutants
EP_{COD}	=	Facility electricity production that is sent to the grid for electricity generation projects (if applicable)	kWh/short ton
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
ERF_{grid}	=	Grid criteria and toxic emission reduction factors	lb/kWh
EU_{grid}	=	Electricity consumption to process waste material	kWh/ short ton

Equation 20. Avoided Flare Criteria and Toxics Emissions from Co-Digestion Anaerobic Digestion (Remote Benefit)

$$CT_{flare,COD} = (FS_{COD} - RES_{COD}) \times ERF_{flare}$$

Where,			Units
$CT_{flare,COD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste	lb pollutants
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
ERF_{flare}	=	Flare criteria and toxic emission reduction factors	lb/short ton

Equation 21. Criteria and Toxics Emissions from Processing of Diverted Material for Co-Digestion Anaerobic Digestion (Local Benefit)

$$CT_{proc,COD} = \left((FS_{COD} - RES_{COD}) \times DU_{proc} \times EF_{equip}\right) + \left((FS_{COD} - RES_{COD}) \times RNGU_{proc} \times EF_{boiler}\right)$$

Where,			Units
$CT_{proc,COD}$	=	Criteria and toxic emissions from processing waste	lb pollutants
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
DU_{proc}	=	Diesel usage to manage waste at the digester	gallon/short ton
EF_{equip}	=	Off-road diesel equipment criteria and toxic emission factors	lb/gallon
$RNGU_{proc}$	=	RNG usage to generate heat in a boiler to manage waste at the digester	scf/short ton
EF_{boiler}	=	Boiler criteria and toxic emission factors	lb/scf

Equation 22. Criteria and Toxics Emissions from Electricity Generation at a Co-Digestion Anaerobic Digestion Facility (Local Benefit)

$$CT_{elec,COD} = (FS_{COD} - RES_{COD}) \times AF_{COD} \times 0.00102 \times EF_{gen}$$

Where,

			Units
$CT_{elec,COD}$	=	Criteria and toxic emissions from onsite production of electricity	lb pollutants
FS_{COD}	=	Amount of feedstock diverted to co-digestion AD	short tons
RES_{COD}	=	Amount of co-digestion AD residual material that is screened out before digestion	short tons
AF_{COD}	=	Amount of fuel production per ton of waste	scf/short ton
0.00102	=	Conversion of scf to MMBtu	MMBTU/scf
EF_{gen}	=	Electricity generation device criteria and toxic emission factor	lb/MMBtu

E. GHG Benefit from Carbon Stored in Trees

The GHG benefit from carbon stored in trees planted by the project is calculated as the sum of carbon stored in individual trees 40 years after project start. A 3% annual tree mortality rate[8] is included for the years after the period of establishment care (including replacement) provided by the project through year 10.[9] Equation 23 determines the GHG benefit from carbon stored in live project trees at the end of the project based on i-Tree Planting outputs.

Equation 23: GHG Benefit of Carbon Stored in Live Project Trees

$$GHG_{CSC} = \frac{\sum_i C_{ITP,i} \times (1-0.03)^{10-YC}}{2,204.62}$$

Where,			Units
GHG_{CSC}	=	GHG benefit of carbon stored in live project trees estimated using i-Tree Planting	MT CO_2e
$C_{ITP,i}$	=	Carbon stored in each group of project trees (i), over the 40 year quantification period (from i-Tree Planting)	lb CO_2e
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
i	=	Project tree species planted	
2,204.62	=	Conversion factor from lb to MT	lb/MT

[8] Roman, Lara. (2014). How many trees are enough? Tree death and the urban canopy. *Scenario Journal*. http://www.fs.fed.us/nrs/pubs/jrnl/2014/nrs_2014_roman_001.pdf
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[9] Establishment and replacement care reduces the risk of mortality of trees planted by the project. Because this methodology applies an increased mortality rate in the first ten years after planting when trees are most at risk, the maximum value for years of establishment care in Equations 1-4 is 9 years to limit the tree mortality rate to 3%.

F. GHG Benefit from Energy Savings as a Result of Strategically Planting Trees to Shade Buildings

The GHG benefit from energy savings is calculated as the total annual energy savings from individual trees planted strategically to shade buildings (i.e., planted within 60 feet) during the 40 year quantification period, accounting for tree mortality. Equation 24 determines the GHG emission reductions from energy savings throughout the quantification period of the project based on i-Tree Planting outputs.

Equation 24: GHG Benefit from Energy Savings

$$GHG_{ESC} = (\frac{\sum_i ER_{ITP,i}}{1{,}000} \times EF_{ELEC} + \sum_i NG_{ITP,i} \times 10 \times EF_{NG}) \times (1 - 0.03)^{10-YC}$$

Where,

			Units
GHG_{ESC}	=	GHG benefit from energy savings estimated using i-Tree Planting	MT CO_2e
$ER_{ITP,i}$	=	Total electricity reductions from each group of project trees over the 40 year quantification period (from i-Tree Planting)	kWh
EF_{ELEC}	=	GHG emission factor for electricity	MT CO_2e/ MWh
1,000	=	Conversion factor from kWh to MWh	kWh/MWh
$NG_{ITP,i}$	=	Total annual natural gas reductions from each group of project trees over the 40 year quantification period (from i-Tree Planting)	MMBtu
10	=	Conversion factor from MMBtu to therms	therm/ MMBtu
EF_{NG}	=	GHG emission factor for natural gas	MT CO_2e/ therm
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
i	=	Group of project trees planted	

G. GHG Emissions from Project Implementation

Tree planting projects must account for GHG emissions from tree planting, maintenance, and other tree-related activities. The GHG emissions from implementation of tree planting projects are calculated by deducting 5%.[10] of the annual reductions obtained through carbon storage and avoided emissions from energy savings. Equation 25 is used to determine the GHG emissions from implementation of tree planting projects.

Equation 25: GHG Emissions from Tree Planting Project Implementation

$$GHG_{PI} = (GHG_{CSC} + GHG_{ESC}) \times EF_{IMP}$$

Where,			Units
GHG_{PI}	=	GHG emissions from tree planting	MT CO_2e
GHG_{CSC}	=	GHG benefit from carbon stored in live project trees estimated using i-Tree Planting	MT CO_2e
GHG_{ESC}	=	GHG benefit from energy savings estimated using i-Tree Planting	MT CO_2e
EF_{IMP}	=	Emission factor for project emissions	

The process and transportation emissions associated with tree removal in an urban wood and biomass utilization project are excluded from this quantification methodology because the trees to be utilized are trees that would be removed and transported to a landfill without the project. Process emissions at a mill or biomass facility are factored into the emission reduction factor for these activities.

[10] U.S. Department of Agriculture Forest Service, Tree Guides (multiple publications). https://www.fs.fed.us/psw/topics/urban_forestry/products/tree_guides.shtml

H. Air Pollutant Co-Benefit from Trees Planted by the Project

The air pollutant emissions co-benefit from trees planted by the project is calculated as the sum of air pollutant emissions removed from the atmosphere by individual trees during the 40 year quantification period, accounting for a 3% annual tree mortality rate for the years after the period of establishment care (including replacement) provided by the project through year 10. Equations 26 and 27 are used to determine the air pollutant emission co-benefits from live project trees at the end of the project based on i-Tree Planting outputs.

Equation 26: $PM_{2.5}$ Emissions Co-benefit from Tree Absorption (Local Benefit)

$$PM_{2.5,TA} = \left((ER_{PM,ITP} \times 0.28\right) \times (1 - 0.03)^{10-YC}$$

Where,			Units
$PM_{2.5,TA}$	=	$PM_{2.5}$ benefit of tree planting in live project trees estimated using i-Tree Planting	lb
$ER_{PM,ITP}$	=	Total $PM_{2.5}$ savings over the 40 year quantification period calculated from i-Tree Planting	lb
0.28	=	Conversion from PM_{10} to $PM_{2.5}$	$PM_{2.5}/PM_{10}$
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project	years

Equation 27: NO_x Emissions Co-benefit from Tree Absorption (Local Benefit)

$$NO_{x,TA} = \left(ER_{NOx,ITP}\right) \times (1 - 0.03)^{10-YC}$$

Where,			Units
$NO_{x,TA}$	=	NO_x benefit of tree planting in live project trees estimated using i-Tree Planting	lb
$ER_{NOx,ITP}$	=	Total NO_x savings over the 40 year quantification period calculated from i-Tree Planting	lb
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project	years

I. Air Pollutant Co-benefit from Energy Savings as a Result of Strategically Planting Trees to Shade Buildings

Equations 28 through 30 are used to determine the air pollutant emission co-benefits from energy savings throughout the quantification period of the project based on i-Tree Planting outputs.

Equation 28: $PM_{2.5}$ Emissions Co-benefit from Energy Savings (Remote Benefit)

$$PM_{2.5,ES} = \left((ER_{ITP}) \times PM_{ELEC} + (NG_{ITP}) \times PM_{NG}\right) \times (1 - 0.03)^{10-YC}$$

Where,			Units
$PM_{2.5,ES}$	=	$PM_{2.5}$ benefit from energy savings estimated using i-Tree Planting	lb
ER_{ITP}	=	Total energy savings over the 40 year quantification period calculated from i-Tree Planting	kWh
PM_{ELEC}	=	$PM_{2.5}$ emission factor for electricity	lb/kWh
NG_{ITP}	=	Total natural gas savings over the 40 year quantification period calculated from i-Tree Planting	MMBtu
PM_{NG}	=	$PM_{2.5}$ emission factor for natural gas	lb/MMBtu
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project	years

Equation 29: NO_x Emissions Co-benefit from Energy Savings (Remote Benefit)

$$NO_{x,ES} = \left((ER_{ITP}) \times NOX_{ELEC} + (NG_{ITP}) \times NOX_{NG}\right) \times (1 - 0.03)^{10-YC}$$

Where,			Units
$NO_{x,ES}$	=	NO_x benefit from energy savings estimated using i-Tree Planting	lb
ER_{ITP}	=	Total energy savings over the 40 year quantification period calculated from i-Tree Planting	kWh
NOX_{ELEC}	=	NO_x emission factor for electricity	lb/kWh
NG_{ITP}	=	Total natural gas savings over the 40 year quantification period calculated from i-Tree Planting	MMBtu
NOX_{NG}	=	NO_x emission factor for natural gas	lb/MMBtu
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project	years

Equation 30: ROG Emissions Co-benefit from Energy Savings

$$ROG_{ES} = \left((ER_{ITP}) \times ROG_{ELEC} + (NG_{ITP}) \times ROG_{NG}\right) \times (1 - 0.03)^{10-YC}$$

Where,

			Units
ROG_{ES}	=	ROG benefit from energy savings estimated using i-Tree Planting	lb
ER_{ITP}	=	Total energy savings over the 40 year quantification period calculated from i-Tree Planting	kWh
ROG_{ELEC}	=	ROG emission factor for electricity	lb/kWh
NG_{ITP}	=	Total natural gas savings over the 40 year quantification period calculated from i-Tree Planting	MMBtu
ROG_{NG}	=	ROG emission factor for natural gas	lb/MMBtu
0.03	=	Mortality rate (3% annual)	
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years

J. Emission Reduction Estimates from Community Composting Projects

Both the GHG emission reductions and air pollutant emission estimates from community composting projects are estimated as the difference between the baseline of sending the organic materials to a landfill versus composting those materials using windrow composting processes. Equation 31 estimates the GHG reductions and Equation 32 estimates the criteria and toxics emissions.

Equation 31: Emission Reductions Estimates from Avoided Methane Emissions from Community Composting Projects

$$GHG_{CC} = (CP \div 1.4 \div 0.58) \times \left(COM_{FW} \times ERF_{FW,GHG} + COM_{GW} \times ERF_{GW,GHG}\right)$$

Where,

			Units
GHG_{CC}	=	GHG emission reduction estimates from community composting projects	$MTCO_2e$
CP	=	Annual compost production	Cubic yards
1.4	=	Conversion factor from cubic yards to short tons	Short ton/cubic yard
0.58	=	Conversion factor from short tons of compost to short tons of feedstock	short ton of feedstock/ short ton of compost
COM_{FW}	=	Composition of food waste in feedstock	%
$ERF_{FW,GHG}$	=	Avoided methane emissions from food waste feedstock	MTCO2e/ short ton
COM_{GW}	=	Composition of green waste in feedstock	%
$ERF_{GW,GHG}$	=	Avoided methane emissions from green waste feedstock	MTCO2e/ short ton

Equation 32: Emission Reductions Estimates from Avoided Flare Emissions from Community Composting Projects (Remote Benefit)

$$CT_{CC} = (CP \div 1.4 \div 0.58) \times \left(COM_{FW} \times ERF_{FW,CT} + COM_{GW} \times ERF_{GW,CT}\right)$$

Where,			Units
CT_{CC}	=	Criteria and toxic emission reduction estimates from community composting projects	lbs
CP	=	Annual compost production	Cubic yards
1.4	=	Conversion factor from cubic yards to short tons	Short ton/cubic yard
0.58	=	Conversion factor from short tons of compost to short tons of feedstock	short ton of feedstock/ short ton of compost
COM_{FW}	=	Composition of food waste in feedstock	%
ERF_{FW}	=	Avoided flare emissions from food waste feedstock	lbs/ short ton
COM_{GW}	=	Composition of green waste in feedstock	%
ERF_{GW}	=	Avoided flare emissions from green waste feedstock	lbs/ short ton

K. Total Emission Reduction Estimates from Organics Projects

Equations 33 through 36 estimate the net benefits for GHG and co-pollutants associated with all organics project types.

Equation 33. Net GHG Benefit

$$GHG = GHG_{FW} - (GHG_{TR} + GHG_{RF}) + GHG_{COM,WIN} + GHG_{COM,ASP} + GHG_{SAD} + GHG_{COD} + GHG_{CSC} + GHG_{ESC} + GHG_{CC} - GHG_{PI}$$

Where,

			Units
GHG	=	Net GHG benefit from the project	MT CO_2e
GHG_{FW}	=	GHG benefit of food waste diversion and source reduction	MT CO_2e
GHG_{TR}	=	GHG emissions from delivery vehicles	MT CO_2e
GHG_{RF}	=	GHG emissions from refrigeration unit	MT CO_2e
$GHG_{COM,WIN}$	=	GHG emission reductions from windrow composting	MT CO_2e
$GHG_{COM,ASP}$	=	GHG emission reductions from ASP composting	MT CO_2e
GHG_{SAD}	=	Net GHG benefit from standalone AD	MT CO_2e
GHG_{COD}	=	Net GHG benefit from co-digestion AD	MT CO_2e
GHG_{CSC}	=	GHG benefit of carbon stored in live project trees estimated using i-Tree Planting	MT CO_2e
GHG_{ESC}	=	GHG benefit from energy savings estimated using i-Tree Planting	MT CO_2e
GHG_{CC}	=	GHG emission reduction estimates from community composting projects	MTCO_2e
GHG_{PI}	=	GHG emissions from tree planting	MT CO_2e

Equation 34. Net Criteria and Toxics Benefit (Local Benefit)

$$CT_{Local} = -CT_{proc,SAD} - CT_{elec,SAD} - CT_{proc,COD} - CT_{elec,COD} + CT_{TA}$$

Where,

			Units
CT_{Local}	=	Net criteria and toxics local benefit from the project	lb pollutant
$CT_{proc,SAD}$	=	Criteria and toxic emissions from processing waste in standalone AD projects	lb pollutant
$CT_{elec,SAD}$	=	Criteria and toxic emissions from onsite production of electricity waste in standalone AD projects	lb pollutant
$CT_{proc,COD}$	=	Criteria and toxic emissions from processing waste in co-digestion AD projects	lb pollutant
$CT_{elec,COD}$	=	Criteria and toxic emissions from onsite production of electricity in co-digestion AD projects	lb pollutant
CT_{TA}	=	Criteria and toxic emission benefit of tree planting in live project trees estimated using i-Tree Planting	lb pollutant

Equation 35. Net Criteria and Toxics Benefit (Remote Benefit)

$$CT_{Remote} = CT_{FW} - (CT_{TR} + CT_{RF}) + CT_{COM,WIN} + CT_{COM,ASP} + CT_{ADR,SAD} + CT_{grid,SAD} + CT_{flare,SAD} + CT_{ADR,COD} + CT_{grid,COD} + CT_{flare,COD} + CT_{ES} + CT_{CC}$$

Where,

			Units
CT_{Remote}	=	Net criteria and toxics remote benefit from the project	lb pollutant
CT_{FW}	=	Criteria and toxics benefit of food waste diversion and source reduction	lb pollutant
CT_{TR}	=	Criteria and toxics emissions from delivery vehicles	lb pollutant
CT_{RF}	=	Criteria and toxics emissions from refrigeration unit	lb pollutant
$CT_{COM,WIN}$	=	Criteria and toxics emissions reductions from windrow composting	lb pollutant
$CT_{COM,ASP}$	=	Criteria and toxics emissions reductions from ASP composting	lb pollutant
$CT_{ADR,SAD}$	=	Criteria and toxic emission reductions from replacement of diesel with renewable fuel (RNG, DME, or hydrogen)	lb pollutant
$CT_{grid,SAD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste	lb pollutant
$CT_{flare,SAD}$	=	Criteria and toxic emission reductions from avoided landfill flare	lb pollutant
$CT_{ADR,COD}$	=	Criteria and toxic emission reductions from replacement of diesel with renewable fuel (RNG, DME, or hydrogen) in co-digestion AD projects	lb pollutant
$CT_{grid,COD}$	=	Criteria and toxic emission reductions from avoided grid electricity and electrical demand from processing waste in co-digestion AD projects	lb pollutant
$CT_{flare,COD}$	=	Criteria and toxic emission reductions from avoided landfill flare	lb pollutant
CT_{ES}	=	Criteria and toxic benefit from energy savings estimated using i-Tree Planting	lb pollutant
CT_{CC}	=	Criteria and toxic emission reduction estimates from community composting projects	lb pollutant

Equation 36. Net Criteria and Toxics Benefit

$$CT = CT_{Local} + CT_{Remote}$$

Where,

			Units
CT_{Local}	=	Net criteria and toxics local benefit from the project	lb pollutant
CT_{Local}	=	Net criteria and toxics local benefit from the project	lb pollutant
CT_{Remote}	=	Net criteria and toxics remote benefit from the project	lb pollutant

Section C. References

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