California Air Resources Board

Quantification Methodology

California Department of Resources Recycling and Recovery
Reuse Grant 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 net GHG benefit 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) Reuse Grant Program (Reuse), CARB staff developed this Reuse Quantification Methodology to provide guidance for estimating the net GHG benefit and selected co-benefits of each proposed project type. This methodology uses calculations to estimate carbon sequestration from reusing wood products and avoided GHG emissions from manufacturing of new wood products.

The Reuse 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 benefit and co-benefits estimated using the Reuse Benefits Calculator Tool as well as the total project GHG benefit per dollar of GGRF funds requested. The Reuse Benefits Calculator Tool is available at: http://www.arb.ca.gov/cci-resources.

Using many of the same inputs required to estimate net GHG benefit, the Reuse Benefits Calculator Tool estimates the following co-benefits and key variables from Reuse 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 ($PM_{2.5}$); reduction of vehicle miles traveled (in miles); fossil fuel use reductions (in gallons and kWh); energy and fuel cost savings (in dollars), and total weight of wood reused (Short tons) . Key variables are project characteristics that contribute to a project's net GHG benefit and signal an additional benefit (e.g., reduction in VMT). Additional co-benefits for which CARB assessment methodologies were not incorporated into the Reuse Benefits Calculator Tool may also be applicable to the project. Applicants should consult the Reuse guidelines, solicitation materials, and agreements to ensure they are meeting Reuse

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 Reuse 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 methods;
- Use project-level data, where available and appropriate; and
- Result in net GHG benefit 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 Reuse 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 Reuse Quantification Methodology and Draft Reuse Benefits Calculator Tool for public comment in March 2020. This Final Reuse Quantification Methodology and accompanying Reuse Benefits Calculator Tool have been updated to address public comments, where appropriate, and for consistency with updates to the Reuse 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 community engagement. Co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

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

Tools

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

Waste Reduction Model (WARM)

The United States Environmental Protection Agency (US EPA) created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report greenhouse gas (GHG) emissions reductions, energy savings, and economic impacts from several different waste management practices. WARM calculates and totals these impacts from baseline and alternative waste management practices—source reduction, recycling, anaerobic digestion, combustion, composting and landfilling.[i] Emission reduction factors were derived from the Construction Materials Chapters based on wood flooring and wood products.

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,[ii] CARB's Mobile Source Emission Factor Model (EMFAC 2017),[iii] California-modified Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET 2.0),[iv] and U.S. Department of Transportation mileage assumptions.[v] 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 Reuse 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 Reuse Benefits Calculator Tool to estimate the net GHG benefit and co-benefits of the proposed project. The Reuse Benefits Calculator Tool can be downloaded from: http://www.arb.ca.gov/cci-resources.

Section B. Methods

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

Project Type

CalRecycle developed two project types that meet the objectives of the Reuse and for which there are methods to quantify a net GHG benefit.[2] Other project features may be eligible for funding under the Reuse Program; however, only the following project types will be quantified for GHG benefits:

- Reuse of construction materials including hardwood flooring, solid wood doors, cabinets, and softwood lumber; and
- Reuse of wood furniture.

General Approach

Methods used in the Reuse Benefits Calculator Tool for estimating the net GHG benefit 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.

These methods account for the emissions associated with manufacturing new virgin wood construction materials and wood furniture along with increased forest carbon storage due to decreased demand for new materials. In general, the net GHG benefit is estimated in the Reuse Benefits Calculator Tool using the approaches in Table 1. The Reuse Benefits Calculator Tool also estimates air pollutant emission co-benefits and key variables using many of the same inputs used to estimate the net GHG benefit.

Table 1. General Approach to Quantification by Project Type

Reuse of Wood Construction Materials
net GHG benefit = avoided raw material and manufacturing emissions + forest carbon storage x reuse efficiency
Reuse of Wood Furniture
net GHG benefit = avoided raw material and manufacturing emissions + forest carbon storage

[2] CalRecycle's Reuse Grant Program Website

A. GHG Benefit Emission Reductions from Reuse of Wood Construction Materials and Wood Furniture

The GHG benefit from reuse of construction materials is estimated as the net increase in forest carbon storage and the avoided emissions associated from manufacturing of virgin materials using Equation 1. Reuse of furniture is estimated in Equation 2. Equation 3 is the sum of Equations 1 and 2.

Equation 1: GHG Benefit from Reuse of Construction Materials

$$GHG_{CM} = \sum_i Q_i \times CF \times \frac{1}{2{,}000} \times ERF_{CM} \times EF$$

Where,			Units
GHG_{CM}	=	Carbon storage and project emission reductions in construction reuse project	MT CO_2e
Q	=	Net quantity of construction materials saved for reuse	variable unit
i	=	Type of construction materials reused (e.g., hardwood flooring, solid wood doors, etc.)	
CF	=	Conversion factor based on weight of type of material	lbs/unit
2,000	=	Conversion from pounds to short tons	short ton/lbs
ERF_{CM}	=	Emission reduction factor based on material type	$MTCO_2e$/ short ton
EF	=	Efficiency factor based on amount of material salvageable for reuse (only applicable to hardwood flooring)	%

Equation 2: GHG Benefit from Reuse of Furniture

$$GHG_{FR} = \sum_i Q_i \times CF \times \frac{1}{2{,}000} \times ERF_{FR}$$

Where,			Units
GHG_{FR}	=	On-site carbon storage in reforestation baseline scenario	MT CO_2e
Q	=	Quantity of furniture items saved for reuse	
i	=	Type of furniture reused (e.g., desk, dresser, table, etc.)	
CF	=	Conversion factor based on weight of type of furniture piece	lbs/ furniture item
2,000	=	Conversion from pounds to short tons	short ton/lbs
ERF_{FR}	=	Emission reduction factor based on material type	$MTCO_2e$/ short ton

Equation 3: Net GHG Benefits from Reuse of Wood Construction Materials and Wood Furniture

$$GHG = GHG_{CM} + GHG_{FR}$$

			Units
Where,			
GHG	=	Net GHG Benefit of Reuse Project	MT CO_2e
GHG_{CM}	=	Carbon storage and project emissions in construction reuse project	MT CO_2e
GHG_{FR}	=	On-site carbon storage in reforestation baseline scenario	MT CO_2e

B. Criteria and Toxic Emissions from Reuse of Construction Materials and Furniture

The criteria and toxic emission reductions are estimated based on the avoided transportation emissions and avoided electricity emissions from the production of virgin materials. Equation 4 estimates the benefits from construction materials and Equation 5 estimates benefits from furniture reuse. Equation 6 is the sum of Equations 4 and 5.

Equation 4: Criteria and Toxic Emission Benefits from Reuse of Construction Materials

$$CT_{CM} = \left(W_{CM} \times TE \times \frac{1}{0.137381} \times \frac{1}{FE_{HHD}} \times EF_{Diesel} \times \frac{1}{454}\right) + (W_{CM} \times PE \times 293 \times EF_{Grid})$$

Where,			Units
CT_{CM}	=	Criteria and toxic emission benefits from reuse of construction materials	lbs
W_{CM}	=	Weight of construction materials reused	Short tons
TE	=	Transportation energy savings per short ton of material	Million BTU/ short ton
0.137381	=	Conversion factor from Million BTU to diesel gallon equivalent	DGE/ Million BTU
FE_{HHD}	=	Fuel Economy of heavy heavy duty diesel trucks	miles/ gallon
EF_{Diesel}	=	Emission factor of heavy heavy duty diesel trucks	g/mile
454	=	Conversion factor from grams to pounds	g/lbs
PE	=	Process energy savings per ton of material	Million BTU/ short ton
293	=	Conversion factor from Million BTU to kWh	kWh/ Million BTU
EF_{Grid}	=	Emission factor of California's electrical grid	lbs/kWh

Equation 5: Criteria and Toxic Emission Benefits from Reuse of Furniture

$$CT_{FR} = \left(W_{FR} \times TE \times \frac{1}{0.137381} \times \frac{1}{FE_{HHD}} \times EF_{Diesel} \times \frac{1}{454}\right) + (W_{FR} \times PE \times 293 \times EF_{Grid})$$

Where,			Units
CT_{FR}	=	Criteria and toxic emission benefits from reuse of furniture	lbs
W_{FR}	=	Weight of furniture reused	Short tons
TE	=	Transportation energy savings per short ton of material	Million BTU/ short ton
0.137381	=	Conversion factor from Million BTU to diesel gallon equivalent	DGE/ Million BTU
FE_{HHD}	=	Fuel Economy of heavy heavy duty diesel trucks	miles/ gallon
EF_{Diesel}	=	Emission factor of heavy heavy duty diesel trucks	g/mile
454	=	Conversion factor from grams to pounds	g/lbs
PE	=	Process energy savings per ton of material	Million BTU/ short ton
293	=	Conversion factor from Million BTU to kWh	kWh/ Million BTU
EF_{Grid}	=	Emission factor of California's electrical grid	lbs/kWh

Equation 6: Net Criteria and Toxic Benefits from Reuse of Wood Construction Materials and Wood Furniture

$$CT = CT_{CON} + CT_{FR}$$

Where,			Units
CT	=	Criteria and toxic emission benefits from reuse project	lbs
CT_{CON}	=	Criteria and toxic emission benefits from reuse of construction materials	lbs
CT_{FR}	=	Criteria and toxic emission benefits from reuse of furniture	lbs

Section C. References

The following references were used in the development of this Quantification Methodology and the Reuse Benefits Calculator Tool.

California Air Resources Board. (2015). CA-GREET 2.0.
https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm

California Air Resources Board EMFAC 2017 Web Database
https://www.arb.ca.gov/emfac/2017

California Air Resources Board Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard (2014)
http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf

Furniture Re-use Network. *Set of average weights for furniture, appliances and other items.*
https://democracy.york.gov.uk/documents/s2116/Annex%20C%20REcycling%20Report%20frnweights2005.pdf

United States Environmental Protection Agency. (2019). *Waste Reduction Model 15 (WARM*). https://www.epa.gov/warm

United States Environmental Protection Agency. *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model - Construction Materials Chapters.* (May 2019). https://www.epa.gov/sites/production/files/2019-06/documents/warm_v15_construction_materials.pdf

[i] US EPA WARM Model available at https://www.epa.gov/warm

[ii] Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard, December 2014 available at:
http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf

[iii] https://www.arb.ca.gov/emfac/2017

[iv] Direct values (without energy efficiency ratio adjustments). Source: California Air Resources Board, CA-GREET 1.8b versus 2.0 CI Comparison Table, April 1, 2015 available at:
http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_pathway_ci_comparison.pdf

[v] http://www.fhwa.dot.gov/policyinformation/statistics/2014/vm1.cfm