

California Air Resources Board

**Greenhouse Gas Quantification Methodology for the
California Air Resources Board
Woodsmoke Reduction Program**

**Greenhouse Gas Reduction Fund
Fiscal Year 2016-17**



September 29, 2017

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Section A. Introduction

The goal of California Climate Investments (CCI) is to reduce greenhouse gas (GHG) emissions and further the purposes of the Global Warming Solutions Act of 2006, known as Assembly Bill (AB) 32. The California Air Resources Board (CARB) is responsible for providing the quantification methodology to estimate the GHG emission reductions and other benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). CARB develops these methodologies based on the project types eligible for funding by each administering agency as reflected in the program Expenditure Records available at:

<https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/expenditurerecords.htm>.

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified.

The Woodsmoke Reduction Program is administered by CARB in partnership with the California Air Pollution Control Officers Association (CAPCOA) and local air pollution control districts or air quality management districts (Districts). Participating Districts will help households replace uncertified wood stoves or inserts used as the primary source of heat with cleaner burning and more efficient home heating devices. For the purposes of the program, a project is defined as the set of change-outs funded by the program within a participating District.

For the CARB Woodsmoke Reduction Program, CARB staff developed this quantification methodology and Woodsmoke Reduction GHG Calculator Tool to provide methods for estimating GHG emission reductions of each project (Section B), provide instructions for documenting and supporting the estimate (Section C), and outline the process for tracking and reporting GHG and other benefits once a project is funded (Section D). This methodology uses calculations to estimate reductions in GHG, black carbon, and particulate emissions from uncertified wood stoves, wood inserts, and fireplaces used as primary sources of heat when replaced with cleaner, more efficient heating devices. Districts will report the total emission reductions estimated using this methodology as well as the total project GHG emission reductions per dollar of GGRF funds requested.

Woodsmoke Reduction Change-Out Types

The Woodsmoke Reduction Program Guidelinesⁱ identifies eligibility criteria including the types of old and new home heating devices that can be funded. This quantification methodology matches those eligibility criteria and quantifies benefits based on the quantity of each type of change-out performed by a District. The different change-out types are:

- Replacing fireplaces with certified non-catalytic wood stoves or wood inserts;
- Replacing uncertified wood stoves or wood inserts with certified non-catalytic wood stoves or wood inserts;

- Replacing fireplaces with certified catalytic wood stoves or wood inserts;
- Replacing uncertified wood stoves or wood inserts with certified catalytic wood stoves or wood inserts;
- Replacing fireplaces with electric home heating devices;
- Replacing uncertified wood stoves or wood inserts with electric home heating devices;
- Replacing fireplaces with propane home heating devices;
- Replacing uncertified wood stoves or wood inserts with propane home heating devices;
- Replacing fireplaces with natural gas home heating devices; and
- Replacing uncertified wood stoves or wood inserts with natural gas home heating devices.

This methodology estimates the benefits of a project based on the quantities of each type of change-out performed. Districts will therefore need to estimate emission reductions both when awarded and implemented.

1. Awarded Funds: Upon being awarded funds by CAPCOA, Districts will estimate the expected project outcomes using the methods described in Section B.
2. Implemented Projects: When change-outs are performed, Districts will revise earlier estimates, again using the methods described in Section B.

Methodology Development

CARB developed this quantification methodology consistent with the guiding implementation principles of CCI, including ensuring transparency and accountability.ⁱⁱ CARB developed this quantification methodology through a public process to be used to estimate the outcomes of awarded and implemented projects 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 Districts;
- Use existing and proven 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 woodsmoke reduction projects. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level. CARB released a draft FY 2016-17 quantification methodology for public comment in August 2017.

Tools

Districts must use this quantification methodology, in conjunction with the accompanying Woodsmoke Reduction GHG Calculator Tool, to estimate the reductions in GHG, black carbon, and particulate emissions of awarded and implemented projects. The Woodsmoke Reduction GHG Calculator Tool can be downloaded from: www.arb.ca.gov/cqi-quantification.

Program Assistance

Districts will calculate the emission reductions for woodsmoke reduction projects to estimate outcomes of awarded and implemented projects. Districts should use the following resources for additional questions and comments:

- Questions on this document should be sent to GGRFProgram@arb.ca.gov.
- For more information on CARB's efforts to support implementation of GGRF investments, see: <https://www.arb.ca.gov/auctionproceeds>.
- Questions pertaining to the Woodsmoke Reduction Program should be sent to WoodsmokeReduction@arb.ca.gov.

Section B. GHG Quantification Methodology

Overview

This quantification methodology accounts for avoided GHG emissions from uncertified wood stoves, wood inserts, and fireplaces used as primary sources of heat and GHG emissions associated with the use of cleaner, more efficient heating devices. In general, the GHG emission reductions are calculated using the following approach:

Table 1. General Approach to GHG Quantification

GHG Emission Reductions from Change-Out
<i>GHG Emission Reductions = GHG Emissions of Uncertified Wood Stove, Wood Insert, or Fireplace – GHG Emissions of New Heating Device</i>

Districts will follow the steps outlined in Figure 1 to estimate the GHG emission reductions from awarded and implemented projects. Detailed instructions for each step are provided on subsequent pages.

Figure 1. Steps to Estimating GHG Emission Reductions

Step 1. Determine the Woodsmoke Reduction Program GHG Calculator Tool Inputs Needed



Step 2. Estimate the Emission Reductions for the Project using the Woodsmoke Reduction GHG Calculator Tool

Step 1: Determine the Woodsmoke Reduction GHG Calculator Tool Inputs Needed

Table 2 identifies the required data inputs needed to estimate the GHG emission reductions for awarded and implemented projects with the Woodsmoke Reduction GHG Calculator Tool.

Table 2. Required Woodsmoke Reduction GHG Calculator Tool Inputs

Read Me Worksheet
<ul style="list-style-type: none"> • Project Name; • Grant ID, if applicable; • Contact Name; • Contact Phone Number; • Contact Email; and • Date Completed.
Project Data Inputs Worksheet
<ul style="list-style-type: none"> • Quantity of fireplaces replaced with certified non-catalytic wood stoves or wood inserts; • Quantity of uncertified wood stoves or wood inserts replaced with certified non-catalytic wood stoves or wood inserts; • Quantity of fireplaces replaced with certified catalytic wood stoves or wood inserts; • Quantity of uncertified wood stoves or wood inserts replaced with certified catalytic wood stoves or wood inserts; • Quantity of fireplaces replaced with electric home heating devices; • Quantity of uncertified wood stoves or wood inserts replaced with electric home heating devices; • Quantity of fireplaces replaced with propane home heating devices; • Quantity of uncertified wood stoves or wood inserts replaced with propane home heating devices; • Quantity of fireplaces replaced with natural gas home heating devices; and • Quantity of uncertified wood stoves or wood inserts replaced with natural gas home heating devices.
Emissions Summary Worksheet
<ul style="list-style-type: none"> • Total amount of Woodsmoke Reduction GGRF funds requested to implement the project; and • Total amount of GGRF funds requested to implement the project.

Step 2: Estimate Emission Reductions for the Project Using the Woodsmoke Reduction GHG Calculator Tool

Districts will use the Woodsmoke Reduction GHG Calculator Tool to complete this step. The Calculator Tool can be downloaded from www.arb.ca.gov/cci-quantification.

Users should begin with the **Read Me** tab, which contains instructions and prompts users to enter project information. Key terms are defined in the **Definitions** tab. The **Project Data Inputs** tab identifies data inputs required by the user, generally requiring project-specific data or assumptions. Input and output fields are color coded:

- **Yellow** fields indicate a direct user input is required.
- **Gray** fields indicate output or calculation fields that are automatically populated based on user entries and the calculation methods.

Details of calculation methods are provided in Appendix B.

The **Emissions Summary** tab displays the total project GHG, black carbon, and particulate emission reductions as well as the estimated total project GHG emission reductions per Woodsmoke Reduction Program GGRF dollar requested and per total GGRF dollar requested, as described below.

- **Total Project GHG Emission Reductions** is equal to the sum total of each of the GHG emission reductions calculated in Section B and are automatically summed in the Woodsmoke Reduction GHG Calculator Tool in the **Emissions Summary** tab.
- **Total Project GHG Emission Reductions per Dollar of Woodsmoke Reduction Program GGRF Funds Requested** is calculated as:

$$\frac{\text{Total Project GHG Emission Reductions in Metric Tons of CO}_2\text{e}}{\text{Woodsmoke Reduction Program GGRF Funds Requested (\$)}}$$

Users should enter the Woodsmoke Reduction Program GGRF Funds Requested (\$) for all project features into the Woodsmoke Reduction GHG Calculator Tool. This amount is equal to the amount of GGRF dollars the District is requesting from the Woodsmoke Reduction Program. The Woodsmoke Reduction GHG Calculator Tool will provide the Total Project GHG Emission Reductions per Woodsmoke Reduction Program GGRF Dollar Requested.

- **Total Project GHG Emission Reductions per Dollar of GGRF** requested is calculated as:

$$\frac{\text{Total Project GHG Emission Reductions in Metric Tons of CO}_2\text{e}}{\text{Total GGRF Funds Requested (\$)}}$$

Users should enter the Total GGRF Funds Requested (\$) into the Woodsmoke Reduction GHG Calculator Tool for all project features. This amount is equal to the amount of GGRF dollars the District is requesting for the project from the

Woodsmoke Reduction Program plus all GGRF dollars from CARB or other agencies that have previously been awarded to the same project and any GGRF dollars from agencies other than CARB that the District has or plans to apply for. For a list of GGRF funded programs, go to: www.arb.ca.gov/cci-events. If no other GGRF funds are requested, this will be the same amount as the Woodsmoke Reduction Program GGRF Funds Requested. The Woodsmoke Reduction GHG Calculator Tool will provide the Total Project GHG Emission Reductions per GGRF Dollar Requested.

Section C. Documentation

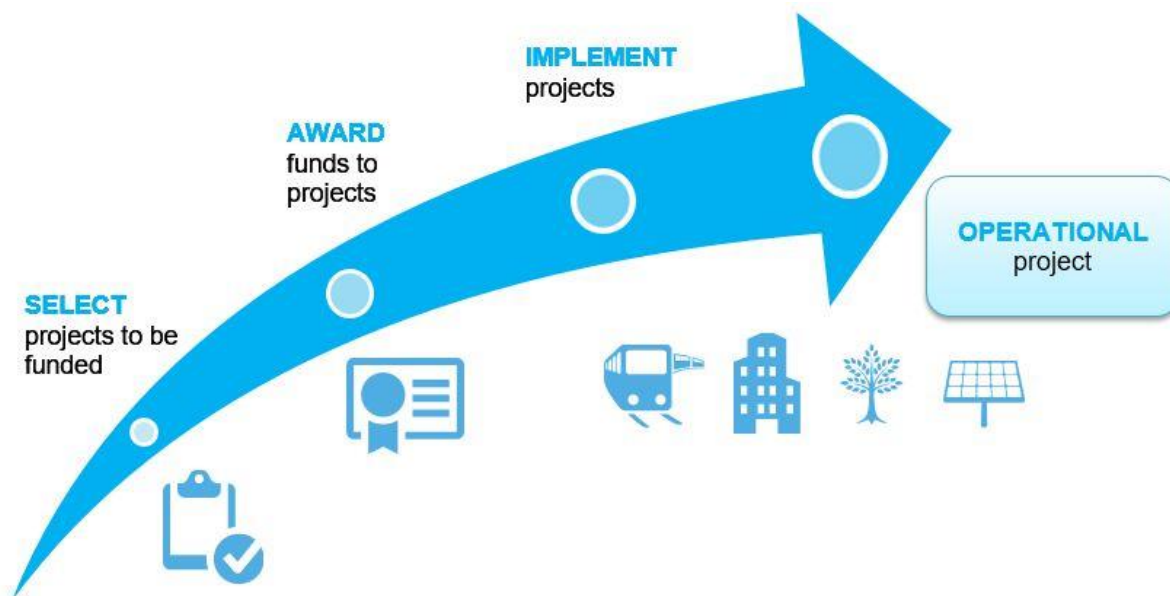
The final step to complete this quantification methodology is to document the estimated GHG emission reductions. Districts are required to provide electronic documentation that is complete and sufficient to allow the calculations to be reviewed and replicated. Paper copies of supporting materials must be available upon request by agency staff. The following checklist is provided as a guide; additional data and/or information may be necessary to support project-specific input assumptions.

	Documentation Description	Completed
1.	Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations	
2.	Project description, including project information necessary to complete the applicable portions of the quantification methodology	
3.	Populated Woodsmoke Reduction Program GHG Calculator Tool file (in .xlsx) with worksheets applicable to the project populated (ensure that the Total Project GHG Emission Reductions, Total Project GHG Emission Reductions/Woodsmoke Reduction Program GGRF Funds Requested, and Total Project GHG Emission Reductions/Total GGRF Funds Requested fields in the summary worksheet contain calculated values)	
4.	If the Total GGRF Funds Requested are different than the Woodsmoke Reduction Program GGRF Funds Requested, identify the other GGRF program(s) where funding is sought, including the fiscal year of the application(s)	
5.	Any other information as necessary and appropriate to substantiate inputs (e.g., how the quantity of each type of change-out was estimated)	

Section D. Reporting after Funding Award

Accountability and transparency are essential elements for all CCI. All administering agencies are required to track project implementation and report on the benefits of those investments. CARB develops tracking and reporting guidance for CCI. The reporting process and requirements are found in Volume 3 of the draft Funding Guidelines.¹ Draft Funding Guidelines Appendices 3.A and 3.B contain detailed reporting requirements that are specific to each project type or administering agency and cover all stages of reporting.

The administering agency will submit periodic reports to CARB. The specific data that need to be reported depend on the project type and the stage of project implementation at the time of reporting. Initially, administering agencies must report basic project information and expected benefits. As projects are implemented, administering agencies provide additional information on project status, benefits, and results. When projects are completed, administering agencies submit project closeout reports. A subset of projects, selected by the administering agency, will report on project outcomes upon reaching a specified milestone and being considered “operational.”



The administering agency is required to collect and compile project data from funding recipients, including the GHG emission reductions estimated using this Quantification Methodology, co-benefits, and information on benefits to AB 1550² Populations.

¹ CARB released updated draft Funding Guidelines in August 2017. These draft Funding Guidelines are subject to change based on public input and Board direction. While the draft provides an indication of what is currently required, administering agencies must incorporate all provisions reflected in the draft Funding Guidelines and subsequent Board approved Funding Guidelines.

² AB 1550, Gomez, Chapter 369, Statutes of 2016; amending Health and Safety Code Section 39713. Detailed information on AB 1550 requirements is provided in Volume 2 of the draft Funding Guidelines.

Reported information will be used to demonstrate how the Administration is achieving or exceeding the statutory objectives for CCI. GHG, black carbon, and particulate emission estimates are highlighted in the Emissions Summary tab of the Woodsmoke Reduction Calculator Tool. Funding recipients have the obligation to provide, or provide access to, data and information on project outcomes to CARB. Applicants should familiarize themselves with the requirements within the Woodsmoke Reduction Program Guidelines, solicitation materials, and grant agreement, as well as the CARB Funding Guidelines.

Section E. References

The following references were used in the development of this quantification methodology and the accompanying Woodsmoke Reduction GHG Calculator Tool.

California Air Resources Board (2016). *California Greenhouse Gas Inventory for 2000-2014 by Sector and Activity*. Retrieved from:
<https://www.arb.ca.gov/cc/inventory/data/data.htm>

California Air Resources Board (2016). *California's Black Carbon Emission Inventory Technical Support Document*. Retrieved from:
https://www.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf

California Air Resources Board (2016). *Global Warming Potentials*. Retrieved from:
<https://www.arb.ca.gov/cc/inventory/background/gwp.htm>

California Air Resources Board (2017). *Short-Lived Climate Pollutant Reduction Strategy*. Retrieved from:
https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf

California Energy Commission (2016). *California Electrical Energy Generation*. Retrieved from:
http://www.energy.ca.gov/almanac/electricity_data/electricity_generation.html

Houck, J.E. and Tiegs, P.E. (1998). *Review of Fireplace Use and Technology*. Retrieved from: <http://www.omni-test.com/publications/firepl.pdf>

National Association of Home Builders Economics Department. *Life Expectancy of Housing Components*. Retrieved from:
http://www.metrohome.us/information_kit_files/life.pdf

U.S. Census Bureau (2015). *2015 American Community Survey 1-Year Estimates, California House Heating Fuel*. Retrieved from:
https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_15_1YR_B25040&prodType=table

U.S. Department of Energy. *Electric Resistance Heating*. Retrieved from:
<https://energy.gov/energysaver/electric-resistance-heating>

U.S. Energy Information Administration (2013). *2009 Residential Energy Consumption Survey, Consumption and Expenditure Table CE3.5 End-use consumption Totals and averages, West homes*. Retrieved from:
<https://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption#end-use>

U.S. Energy Information Administration (2014). *Heating Fuel Comparison Calculator*. Retrieved from: <https://ag.purdue.edu/extension/renewable-energy/Documents/ON-Farm/heatcalc.xls>

U.S. Environmental Protection Agency (1996). *AP-42: Compilation of Air Emission Factors, Fifth Edition, Residential Wood Stoves*. Retrieved from: <https://www3.epa.gov/ttn/chief/ap42/ch01/index.html>

U.S. Environmental Protection Agency (2009) *Burn Wise Emission Calculator*. Retrieved from: https://www.epa.gov/sites/production/files/2015-11/emissioncalculator_2.xlsx

U.S. Environmental Protection Agency (2015). *Emission Factors for Greenhouse Gas Inventories*. Retrieved from: https://www.epa.gov/sites/production/files/2015-12/documents/emission-factors_nov_2015.pdf

U.S. Environmental Protection Agency (2015). Regulatory Impact Analysis (RIA) for Residential Wood Heaters NSPS Revision. Retrieved from: https://www3.epa.gov/ttnecas1/docs/ria/wood-heaters_ria_final-nsps-revision_2015-02.pdf

ⁱ FY 2016-17 CARB Woodsmoke Reduction Program Guidelines available at: http://www.arb.ca.gov/planning/sip/woodsmoke/reduction_program.htm

ⁱⁱ As described in Volume 1 of the California Air Resources Board. Draft Funding Guidelines for Agencies Administering California Climate Investments (August 4, 2017) (Funding Guidelines). www.arb.ca.gov/ccifundingguidelines.

Appendix A. Example Project

Introduction

The following is a hypothetical project³ to demonstrate how the FY 2016-17 Woodsmoke Reduction Program Quantification Methodology would be applied. This example does not provide examples of the supporting documentation that is required.

Overview of the proposed project

The District is requesting \$400,000 to offer incentives toward the replacement of existing uncertified residential wood stoves, uncertified wood inserts, or fireplaces used as primary sources of heat. The District expects to perform a total of 123 change-outs replacing uncertified wood stoves, uncertified wood inserts, or fireplaces with certified catalytic or non-catalytic wood stoves or wood inserts and electric, propane, and natural gas home heating devices. Replacement devices will be installed by appropriately licensed installers participating in the program and removed devices will be rendered permanently inoperable and recycled.

Step 1: Determine the Woodsmoke Reduction GHG Calculator Tool Inputs Needed

Utilizing Table 2 in the quantification methodology, the District estimates installers will perform the following change-outs:

- 5 fireplaces replaced with certified non-catalytic wood stoves or wood inserts;
- 75 uncertified wood stoves or wood inserts replaced with certified non-catalytic wood stoves or wood inserts;
- 15 uncertified wood stoves or wood inserts replaced with certified catalytic wood stoves or wood inserts;
- 9 uncertified wood stoves or wood inserts replaced with electric home heating devices; and
- 9 uncertified wood stoves or wood inserts replaced with propane home heating devices;
- 15 uncertified wood stoves or wood inserts replaced with natural gas home heating devices.

The District is not seeking GGRF funding from sources other than the CARB Woodsmoke Reduction Program.

³ The hypothetical project has not undergone verification of any Woodsmoke Reduction Program requirements; all assumptions about project features are for quantification methodology demonstration purposes only.

Step 2: Estimate Emission Reductions for the Proposed Project Using the Woodsmoke Reduction GHG Calculator Tool

Districts use the Woodsmoke Reduction GHG Calculator Tool to estimate reductions in GHG, black carbon, and particulate emissions from the project. To begin, enter project identification information in the **Read Me** tab of the tool as shown in Figure A-1.

Figure A-1

Project Name:	Air Quality Management District Program
Grant ID, if applicable:	12345
Contact Name:	John Doe
Contact Phone Number:	916-555-5555
Contact Email:	John.Doe@domain.com
Date Completed:	7/1/2017

Next, enter the quantity of each type of change-out that the District will perform into the yellow cells in the **Project Data Input** tab as shown in Figure A-2.

Figure A-2

California Air Resources Board



Greenhouse Gas Calculator Tool
Woodsmoke Reduction Program
Greenhouse Gas Reduction Fund
Fiscal Year 2016-2017

Project Name:	Air Quality Management District Program
Grant ID, if applicable:	12345

Project Data Inputs Worksheet

If using at the Awarded stage: Enter the quantity of each type of change-out expected to be completed as part of the project.

If using at the Implemented stage: Enter the quantity of each type of change-out completed as part of the project.

Old Heating Device	New Heating Device	Quantity of Replacements
Fireplace	Certified non-catalytic wood stove or wood insert	5
Uncertified wood stove or insert	Certified non-catalytic wood stove or wood insert	75
Fireplace	Certified catalytic wood stove or wood insert	0
Uncertified wood stove or insert	Certified catalytic wood stove or wood insert	15
Fireplace	Electric home heating device	0
Uncertified wood stove or insert	Electric home heating device	9
Fireplace	Propane home heating device	0
Uncertified wood stove or insert	Propane home heating device	9
Fireplace	Natural gas home heating device	0
Uncertified wood stove or insert	Natural gas home heating device	15

Next, proceed to the **Emissions Summary** tab where the total GHG, black carbon, and particulate emission reductions will be displayed. Enter the Woodsmoke Reduction Program GGRF Funds Requested (\$) and Total GGRF Funds Requested (\$) into the yellow cells. The Woodsmoke Reduction Program funds requested may equal the Total GGRF funds requested if the District has not and does not plan to request funds for the same project from other GGRF programs. In this case, the user will enter the same dollar amount into both fields. The GHG benefit per Woodsmoke Reduction GGRF Funds Requested and the GHG benefit per GGRF Funds Requested will then be displayed as shown in Figure A-3.

Figure A-3



California Air Resources Board
 Greenhouse Gas Calculator Tool
 Woodsmoke Reduction Program
 Greenhouse Gas Reduction Fund
 Fiscal Year 2016-2017

Project Name:	Air Quality Management District Program
Grant ID, if applicable:	12345

Emissions Summary Worksheet

Old Heating Device	New Heating Device	GHGs (MTCO ₂ e)	PM _{2.5} (lbs)	Black Carbon (lbs)
Fireplace	Certified non-catalytic wood stove or wood insert	999	14,265	1,783
Uncertified wood stove or insert	Certified non-catalytic wood stove or wood insert	448	23,857	2,982
Fireplace	Certified catalytic wood stove or wood insert	0	0	0
Uncertified wood stove or insert	Certified catalytic wood stove or wood insert	90	3,615	452
Fireplace	Electric home heating device	0	0	0
Uncertified wood stove or insert	Electric home heating device	89	2,996	375
Fireplace	Propane home heating device	0	0	0
Uncertified wood stove or insert	Propane home heating device	90	2,996	375
Fireplace	Natural gas home heating device	0	0	0
Uncertified wood stove or insert	Natural gas home heating device	168	4,933	624

Net Benefits	1,884	52,722	6,590
Woodsmoke Reduction GGRF \$ Requested (\$)	\$400,000		
Total GGRF \$ Requested (\$)	\$400,000		
Net GHG Benefit/Woodsmoke Reduction GGRF Funds Requested (MT CO ₂ e/\$)	0.0047		
Net GHG Benefit/GGRF \$ Requested	0.0047		

Information for Documentation

When all inputs are entered, the user saves the file. Districts must submit the completed calculator along with other required documentation to CAPCOA. Refer to Section D of this quantification methodology and the grant agreement for additional requirements.

Appendix B. Equations Supporting the Woodsmoke Reduction GHG Calculator Tool

Methods used in the Woodsmoke Reduction GHG Calculator Tool for estimating the GHG, black carbon, and particulate emission reductions are provided in this appendix. The emission reduction estimates from the project is quantified within the Woodsmoke Reduction GHG Calculator Tool using the equations below. Additional information about the emission factors used is available in the GHG Calculator Tool.

A. GHG Emission Reductions from Project

The GHG emission reductions from the project are calculated as the difference between the baseline and project scenarios using Equation 1.

Equation 1: GHG Emission Reductions from Change-Outs

$$GHG = Q_{FNC} \times 199.86 + Q_{UNC} \times 5.97 + Q_{FC} \times 199.86 + Q_{UC} \times 5.98 + Q_{FE} \times 135.88 + Q_{UE} \times 9.86 + Q_{FP} \times 136.05 + Q_{UP} \times 10.03 + Q_{FNG} \times 137.24 + Q_{UNG} \times 11.22$$

Where,		Units
<i>GHG</i>	= GHG benefit from all project change-outs	MTCO ₂ e
<i>Q_{FNC}</i>	= Quantity of fireplaces replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
<i>Q_{UNC}</i>	= Quantity of uncertified wood stoves or wood inserts replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
<i>Q_{FC}</i>	= Quantity of fireplaces replaced with certified catalytic wood stoves or wood inserts	Change-outs
<i>Q_{UC}</i>	= Quantity of uncertified wood stoves or wood inserts replaced with certified catalytic wood stoves or wood inserts	Change-outs
<i>Q_{FE}</i>	= Quantity of fireplaces replaced with electric home heating devices	Change-outs
<i>Q_{UE}</i>	= Quantity of uncertified wood stoves or inserts replaced with electric home heating devices	Change-outs
<i>Q_{FP}</i>	= Quantity of fireplaces replaced with propane home heating devices	Change-outs
<i>Q_{UP}</i>	= Quantity of uncertified wood stoves or inserts replaced with propane home heating devices	Change-outs
<i>Q_{FNG}</i>	= Quantity of fireplaces replaced with natural gas home heating devices	Change-outs
<i>Q_{UNG}</i>	= Quantity of uncertified wood stoves or inserts replaced with natural gas home heating devices	Change-outs
199.86	= GHG emission reduction from replacing a fireplace with a certified non-catalytic wood stove or wood insert	MTCO ₂ e/ change-out
5.97	= GHG emission reduction from replacing an uncertified wood stove or wood insert with a certified non-catalytic wood stove or wood insert	MTCO ₂ e/ change-out
199.86	= GHG emission reduction from replacing a fireplace with a certified catalytic wood stove or wood insert	MTCO ₂ e/ change-out
5.98	= GHG emission reduction from replacing an uncertified wood stove or wood insert with a certified catalytic wood stove or wood insert	MTCO ₂ e/ change-out
135.88	= GHG emission reduction from replacing a fireplace with an electric home heating device	MTCO ₂ e/ change-out
9.86	= GHG emission reduction from replacing an uncertified wood stove or wood insert with an electric home heating device	MTCO ₂ e/ change-out
136.05	= GHG emission reduction from replacing a fireplace with a propane home heating device	MTCO ₂ e/ change-out
10.03	= GHG emission reduction from replacing an uncertified wood stove or wood insert with a propane home heating device	MTCO ₂ e/ change-out
137.24	= GHG emission reduction from replacing a fireplace with a natural gas home heating device	MTCO ₂ e/ change-out
11.22	= GHG emission reduction from replacing an uncertified wood stove or wood insert with a natural gas home heating device	MTCO ₂ e/ change-out

B. PM_{2.5} Emission Reductions from Project

The PM_{2.5} emission reductions from the project are calculated as the difference between the baseline and project scenarios using Equation 2.

Equation 2: PM_{2.5} Emission Reductions from Change-Outs

$$PM_{2.5} = Q_{FNC} \times 2,852.97 + Q_{UNC} \times 318.09 + Q_{FC} \times 2,775.88 + Q_{UC} \times 241.01 + (Q_{FE} + Q_{FP} + Q_{FNG}) \times 1,980.56 + (Q_{UE} + Q_{UP} + Q_{UNG}) \times 332.89$$

Where,		Units
$PM_{2.5}$	= PM _{2.5} emission reductions from all project change-outs	lbs
Q_{FNC}	= Quantity of fireplaces replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
Q_{UNC}	= Quantity of uncertified wood stoves or wood inserts replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
Q_{FC}	= Quantity of fireplaces replaced with certified catalytic wood stoves or wood inserts	Change-outs
Q_{UC}	= Quantity of uncertified wood stoves or wood inserts replaced with certified catalytic wood stoves or wood inserts	Change-outs
Q_{FE}	= Quantity of fireplaces replaced with electric home heating devices	Change-outs
Q_{UE}	= Quantity of uncertified wood stoves or inserts replaced with electric home heating devices	Change-outs
Q_{FP}	= Quantity of fireplaces replaced with propane home heating devices	Change-outs
Q_{UP}	= Quantity of uncertified wood stoves or inserts replaced with propane home heating devices	Change-outs
Q_{FNG}	= Quantity of fireplaces replaced with natural gas home heating devices	Change-outs
Q_{UNG}	= Quantity of uncertified wood stoves or inserts replaced with natural gas home heating devices	Change-outs
2,852.97	= PM _{2.5} emission reduction from replacing a fireplace with a certified non-catalytic wood stove or wood insert	lbs/change-out
318.09	= PM _{2.5} emission reduction from replacing an uncertified wood stove or insert with a certified non-catalytic wood stove or wood insert	lbs/change-out
2,775.88	= PM _{2.5} emission reduction from replacing a fireplace with a certified catalytic wood stove or wood insert	lbs/change-out
241.01	= PM _{2.5} emission reduction from replacing an uncertified wood stove or insert with a certified catalytic wood stove or wood insert	lbs/change-out
1,980.56	= PM _{2.5} emission reduction from replacing a fireplace with an electric, propane, or natural gas home heating device	lbs/change-out
332.89	= PM _{2.5} emission reduction from replacing an uncertified wood stove or insert with an electric, propane, or natural gas home heating device	lbs/change-out

C. Black Carbon Emission Reductions from Project

The black carbon emission reductions from the project are calculated as the difference between the baseline and project scenarios using Equation 3.

Equation 3: Black Carbon Emission Reductions from Change-Outs

$$BC = Q_{FNC} \times 35662 + Q_{UNC} \times 39.76 + Q_{FC} \times 34699 + Q_{UC} \times 30.13 + (Q_{FE} + Q_{FP} + Q_{FNG}) \times 247.57 + (Q_{UE} + Q_{UP} + Q_{UNG}) \times 41.61$$

<i>Where,</i>		<u>Units</u>
<i>BC</i>	= Black carbon emission reductions from all project change-outs	lbs
<i>Q_{FNC}</i>	= Quantity of fireplaces replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
<i>Q_{UNC}</i>	= Quantity of uncertified wood stoves or wood inserts replaced with certified non-catalytic wood stoves or wood inserts	Change-outs
<i>Q_{FC}</i>	= Quantity of fireplaces replaced with certified catalytic wood stoves or wood inserts	Change-outs
<i>Q_{UC}</i>	= Quantity of uncertified wood stoves or wood inserts replaced with certified catalytic wood stoves or wood inserts	Change-outs
<i>Q_{FE}</i>	= Quantity of fireplaces replaced with electric home heating devices	Change-outs
<i>Q_{UE}</i>	= Quantity of uncertified wood stoves or inserts replaced with electric home heating devices	Change-outs
<i>Q_{FP}</i>	= Quantity of fireplaces replaced with propane home heating devices	Change-outs
<i>Q_{UP}</i>	= Quantity of uncertified wood stoves or inserts replaced with propane home heating devices	Change-outs
<i>Q_{FNG}</i>	= Quantity of fireplaces replaced with natural gas home heating devices	Change-outs
<i>Q_{UNG}</i>	= Quantity of uncertified wood stoves or inserts replaced with natural gas home heating devices	Change-outs
356.62	= Black carbon emission reduction from replacing a fireplace with a certified non-catalytic wood stove or wood insert	lbs/change-out
39.76	= Black carbon emission reduction from replacing an uncertified wood stove or insert with a certified non-catalytic wood stove or wood insert	lbs/change-out
346.99	= Black carbon emission reduction from replacing a fireplace with a certified catalytic wood stove or wood insert	lbs/change-out
30.13	= Black carbon emission reduction from replacing an uncertified wood stove or insert with a certified catalytic wood stove or wood insert	lbs/change-out
247.57	= Black carbon emission reduction from replacing a fireplace with an electric, propane, or natural gas home heating device	lbs/change-out
41.61	= Black carbon emission reduction from replacing an uncertified wood stove or insert with an electric, propane, or natural gas home heating device	lbs/change-out

Appendix C. Emission Factors

Type	Emission Rate	Units
Electricity	0.08887	MTCO _{2e} per mmBtu
Natural Gas	0.05314	MTCO _{2e} per mmBtu
Propane	0.06149	MTCO _{2e} per mmBtu
Wood	0.09505	MTCO _{2e} per mmBtu

A. Household Heating Needs and Device-Specific Consumption Rates

The Woodsmoke Reduction Program funds the replacement of uncertified, inefficient wood burning devices with cleaner-burning and more efficient residential heating devices. For the purposes of estimating emission reductions, this quantification methodology assumes that households will require the same amount of useful heat in the baseline and project scenario. Benefits accrue as a result of the difference in the efficiency of existing and replacement devices and relative improvement in emission rates of GHGs, PM_{2.5}, and black carbon. This appendix discusses the steps taken to derive the household heating needs as demonstrated in the “MMBtu” and “ERFs” tabs of the Calculator Tool.

1. Determine the California average annual household heating energy consumption from the U.S. EIA 2009 Residential Energy Consumption Survey.
2. Determine the California average efficiency of household heating using:
 - a. California rates of use of different residential heating devices from the U.S. Census 2015 American Community Survey 1-Year Estimates, California House Heating Fuel
 - b. Residential heating device efficiencies from the U.S. Energy Information Administration Heating Fuel Comparison Calculator for utility natural gas, electricity, and bottled, tank or LPG gas
 - c. Residential wood stove efficiencies from U.S. EPA AP-42
3. Determine the California average household heating energy need if devices were 100% efficient by multiplying the average annual household heating energy consumption derived in Step 1 by the average efficiency of household heating derived in Step 2.
4. Determine the average MMBtu demand of each device type by dividing the California average household heating energy need if devices were 100% efficient determined in Step 3 by the efficiencies of eligible existing and replacement devices using:
 - a. Efficiencies from Houk, J. and Tiegs, P. for fireplaces and propane or natural gas heating devices.

- b. Efficiency from the U.S. Department of Energy Electric Resistance Heating for electric heating devices.
 - c. Efficiencies from U.S. EPA AP-42 for residential wood stoves.
Efficiencies may vary from those used in Step 2 due to the broader device categories used in the census compared to the specific existing and replacement devices eligible under the Program.
5. For wood burning devices, determine the annual wood use for each type of wood burning device by dividing the average MMBtu demand for each device type determined in Step 4 by the heating value of wood.
 6. Calculate device specific emissions using the MMBtu demands and wood use from Steps 5 and 6 and the fuel specific emission factors described in sections B and C below.

B. Electricity GHG Emission Factor

For the purposes of CCI quantification methodologies, CARB developed a California grid average electricity emission factor based on total in-state and imported electricity emissions (in MTCO_{2e}) divided by total consumption (in kWh) as calculated in Equation 4.

Statewide electricity emissions data were obtained from the most recent edition of CARB’s GHG Emission Inventory.⁴ The total in-state electricity generation is combined with the total imported electricity to determine the total emissions for grid electricity. The total electricity consumption data was derived by summing electricity generation and net imports obtained from California Energy Commission’s (CEC) California Energy Almanac.⁵

Equation 4: California Grid Average Electricity Emission Factor

$$EF = \frac{\textit{Electricity Emissions}}{\textit{Electricity Consumption}}$$

<i>Where,</i>		
<i>Electricity Emissions</i>	=	Total in-state electricity and imported electricity emissions
		<u>Units</u> MTCO _{2e}
<i>Electricity Consumption</i>	=	Total California electricity generation and net imports
		kWh

⁴ CARB California Greenhouse Gas Emissions Inventory – 2017 Edition

<https://www.arb.ca.gov/cc/inventory/data/data.htm>

⁵ CEC California Energy Almanac

http://www.energy.ca.gov/almanac/electricity_data/electricity_generation.html

C. Heating Fuel GHG Emission Factors

Heating fuels for Woodsmoke Reduction projects are wood, natural gas, and propane. The heating fuel emission factors are derived from the United States Environmental Protection Agency’s (U.S. EPA) Emission Factors for Greenhouse Gas Inventories and is located at: https://www.epa.gov/sites/production/files/2015-12/documents/emission-factors_nov_2015.pdf.

In the absence of a mechanism to verify that the wood burned in an applicant’s primary heating device is waste material harvested pursuant to an approved timber management plan prepared in accordance with the Z’berg-Nejedly Forest Practice Act of 1973 or other locally or nationally approved plan and harvested for the purpose of forest fire fuel reduction or forest stand improvement, biogenic CO₂ is included in the calculation of GHG benefits for these devices.

The Emission Factors for Greenhouse Gas Inventories uses the global warming potentials (GWP) from the IPCC Fourth Assessment Report. Gases are converted to MTCO_{2e} by multiplying by their GWP and converting the units appropriately.

Gas	Units	100-year GWP
CO ₂	kg/mmBtu	1
CH ₄	kg/mmBtu	25
N ₂ O	kg/mmBtu	298