2024 Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program Guidelines: Appendix A

Approved: October 24, 2024

Appendix A: Quantification Methodology

(a) Introduction

This appendix provides guidance for calculating the estimated criteria pollutant and toxic air contaminant emission reductions for projects eligible under the FARMER Program Guidelines.

(b) Criteria Pollutant and Toxic Air Contaminant Emission Reductions

In the FARMER Program, the criteria pollutant and toxic air contaminant emission reductions are calculated for each project for the following pollutants: oxides of nitrogen (NOx), reactive organic gases (ROG), and particulate matter (PM). These calculations require multiple steps as described in more detail below, and the approach differs by project category.

(1) Efficiency Factor

Some off-road replacement projects may include replacement equipment that can perform additional work per hour, which can be verified through physical characteristics, such as harvesters that can operate across more rows per pass or a sprayer with a wider applicator. For these projects, an efficiency factor may be applied to the baseline annual activity to calculate the adjusted annual activity for the replacement equipment, as described in Formula 1 and Formula 2 below. For projects that do not provide an efficiency improvement, the efficiency factor is one and the replacement annual activity is the same as the baseline annual activity.

Formula 1: Efficiency Factor

$$Efficiency\ Factor = \frac{replacement\ characteristic}{baseline\ characteristic}$$

Formula 2: Adjusted Annual Activity for the Replacement

$$Adjusted\ Annual\ Activity\ (replacement) = \frac{baseline\ annual\ activity}{efficiency\ factor}$$

For example, a baseline harvester that operates 600 hours per year and picks 4 rows of a commodity per pass is replaced with a new harvester that picks 6 rows per pass. This project would have an efficiency factor of 1.5 and the adjusted annual activity for the replacement would be 400 hours per year. Another example is a sprayer with a total boom width of 90 feet and operates 800 hours per year that is replaced with a sprayer with a total boom width of 120 feet. This project would have an efficiency factor of 1.33 and the adjusted annual activity for the replacement would be 600 hours per year.

(2) Emission Rates

The emission rate for a given vehicle, equipment, or engine is calculated by summing the zero-mile or zero-hour emission factor and the emissions associated with the deterioration of the engine.

Engine deterioration is based on total activity, up to the limits specified in the following table. Total activity can be calculated using Formula 3, Formula 4, and Formula 5 below. Annual activity is in miles (mi) for on-road vehicles and hours (hr) for off-road equipment and engines.

Table A-1: Total Activity

Engine Category	Model Year	Total Activity Limit
On-Road Diesel (LHD, MHD, and HHD)	All model years	800,000 miles
Off-Road Diesel	All model years	12,000 hours
Off-Road Large Spark-Ignition (greater than or equal to 25 hp)	2007 and newer	5,000 hours
	2006 and older	3,500 hours
Off-Road Spark-Ignition (<25 hp)	All	1,000 hours
UTVs	All	N/A

Formula 3: Total Activity for the Baseline

$$Total\ Activity\ (baseline) = \left(first\ year\ of\ operation - engine\ model\ year + \left(\frac{project\ life}{2}\right)\right) * annual\ activity$$

Formula 4: Total Activity for the New Replacement

$$Total\ Activity\ (new\ replacement) = \left(\frac{project\ life}{2}\right) * adjusted\ annual\ activity$$

Formula 5: Total Activity for the Used Replacement

$$Total\ Activity\ (used\ replacement) = \left(\left(\frac{project\ life}{2}\right) * adjusted\ annual\ activity\right) + hour\ or\ odomoter\ reading$$

Once the total activity has been calculated, the emissions associated with the deterioration of the engine (the deterioration product) may be calculated using Formula 6 and Formula 7 below. Deterioration rates are included in Appendix B and are in units of grams per mile per 10,000 miles (g/mi-10,000 mi) for on-road vehicles and in grams per brake horsepower-hour per hour (g/bhp-hr-hr) for off-road equipment and engines.

Formula 6: On-Road Deterioration Product

$$Deterioration\ Product\ (on\text{-}road) = Deterioration\ Rate\ (g/mi\text{-}10{,}000\ mi) * \frac{Total\ Activity\ (mi)}{10{,}000}$$

Formula 7: Off-Road Deterioration Product

$$Deterioration\ Product\ (off\text{-}road) = Deterioration\ Rate\ (g/bhp\text{-}hr\text{-}hr) * Total\ Activity\ (hr)$$

The emission rate for the baseline or replacement vehicle, equipment, or engine is then calculated by summing the zero-mile or zero-hour emission factor and the deterioration product, as shown in Formula 8. For on-road vehicles, emission rates are in units of grams per mile (g/mi) and for off-road equipment and engines, emission rates are in grams per brake horsepower-hour (g/bhp-hr). NOx emission rates are provided in Appendix B for 2013 model year or newer on-road vehicles based on the total activity calculated for the vehicle. Emission factors and deterioration rates for all other eligible vehicles, equipment, and engines are included in Appendix B.

Formula 8: Baseline or Replacement Emission Rate

$$Emission\ Rate\ (g/bhp\text{-}hr\ \ or\ g/mi) = emission\ factor + deterioration\ product$$

(3) Annual Emissions

Once the emission rate has been calculated, the annual emissions in tons per year (tpy) for both the baseline and replacement vehicle, equipment, or engine may be calculated using Formula 9 and Formula 10 below. Load factors for off-road equipment are included in Appendix B.

Formula 9: Annual Emissions for On-Road Vehicles

$$Annual\ Emissions\ (tpy) = emission\ rate\ (g/mi) * annual\ activity\ (mi/year) * percentage\ operation\ in\ California * \left(\frac{1\ ton}{907{,}200\ g}\right)$$

Formula 10: Annual Emissions for Off-Road Equipment and Engines

$$Annual\ Emissions\ (tpy) = emission\ rate\ (g/bhp\text{-}hr) * max\ horsepower\ (hp) * load\ factor * annual\ or\ adjusted\ annual\ activity\ (hr/year) * percentage\ operation\ in\ California * \left(\frac{1\ ton}{907{,}200\ g}\right)$$

(4) Annual Emission Reductions

Once the annual emissions of the baseline and replacement vehicle, equipment, or engine has been calculated, annual emission reductions for each pollutant may be calculated using Formula 11 below.

Formula 11: Annual Emission Reductions

$$Annual\ Emission\ Reductions\ (tpy) = baseline\ annual\ emissions - replacement\ annual\ emissions$$

For projects that include multiple baseline vehicles, equipment, or engines, the annual emissions for the baselines are calculated individually following the steps outlined above and then summed together for the baseline annual emissions in Formula 11 above.

When calculating cost-effectiveness and potential grant amounts, annual emission reductions should be rounded to five decimal places for each pollutant.

(5) Lifetime Emission Reductions

To calculate the emission reductions over the life of the project, the annual emission reductions for the project are multiplied by the project life, as shown in Formula 12 below.

Formula 12: Lifetime Emission Reductions

$$Lifetime\ Emission\ Reductions\ (tons) = annual\ emission\ reductions * project\ life$$

(c) Cost-Effectiveness Calculations

The quantification methodology described below must be applied to ensure final grant amounts meet the cost-effectiveness limit requirement and do not exceed the maximum funding percentage or any other funding caps. The maximum grant amount for any project is the lowest of the three following calculations:

- The potential grant amount based on the maximum percentage of eligible costs;
- The potential grant amount at the cost-effectiveness limit (if applicable); and
- The potential grant amount based on the maximum dollar amount specified in the associated project category criteria.

The calculations for the first two options are described in more detail below.

(1) Calculating the Potential Grant Amount Based on the Maximum Percentage of Eligible Costs

Some project categories include a funding cap based on the maximum percentage of the eligible costs. To calculate the potential grant amount for these projects, the project's total eligible costs are multiplied by the maximum percentage of eligible cost, as shown in Formula 13 below.

Formula 13: Potential Grant Amount at Maximum Percentage of Eligible Costs

$$Potential\ Grant\ Amount\ (\$) = eligible\ costs\ (\$) * max\ percentage\ of\ eligible\ cost$$

(2) Calculating the Potential Grant Amount at the Cost-Effectiveness Limit

There are also some project categories that are subject to cost-effectiveness limits, which identifies the maximum amount of funding that can be provided for each weighted ton of emission reductions achieved by the project. To calculate the potential grant amount for these projects based on a cost-effectiveness limit, a capital recovery factor (CRF) must be applied. CRFs are based on a discount rate, which may vary from year to year. An interest rate and project life are used to determine the rate at which earnings could be reasonably expected to accrue if the same funds were invested over that length of time. CRF values can be calculated using Formula 14 below or referenced in Table B-13 in Appendix B, which lists CRF values at various project lives and discount rates.

Formula 14: Capital Recovery Factor (CRF)

$$CRF = \frac{(1 + discount\ rate)^{project\ life} * discount\ rate}{(1 + discount\ rate)^{project\ life} - 1}$$

Once the CRF is known, the potential grant amount can be calculated by multiplying the cost-effectiveness limit by the estimated annual emission reductions (in weighted tons per year), and then dividing it by the CRF value. These calculations are described in Formula 15 and Formula 16 below.

Formula 15: Weighted Annual Emission Reductions

$$\begin{aligned} &Weighted\ Annual\ Emission\ Reductions\ (weighted\ tons\ per\ year) \\ &= NOx\ (tpy) + ROG\ (tpy) + (20 * PM(tpy)) \end{aligned}$$

Formula 16: Potential Grant Amount at the Cost-Effectiveness Limit

$$\begin{aligned} &Potential\ Grant\ Amount\ (\$) \\ &= \frac{cost\text{-}effectiveness\ limit\ * weighted\ annual\ emission\ reductions}{CRF} \end{aligned}$$

A project's cost-effectiveness in dollars per weighted ton may also be calculated by multiplying the potential grant amount by the CRF value and dividing by the weighted annual emission reductions.

Formula 17: Project Cost-Effectiveness

$$Cost\text{-}Effectiveness\ (\$/weighted\ ton) = \frac{potential\ grant\ amount * CRF}{weighted\ annual\ emission\ reductions}$$