

APPENDIX C

METHODOLOGY FOR DETERMINING COST EFFECTIVENESS

This appendix is an excerpt from the Board approved
2008 Carl Moyer Program Guidelines Part IV Appendixes

The complete Carl Moyer Program Document including all appendices can be found at:

http://www.arb.ca.gov/msprog/moyer/2008guideline_updates.htm

TABLES FOR EMISSION REDUCTION AND COST-EFFECTIVENESS CALCULATIONS

This appendix presents tables summarizing the data and instructions needed to calculate the emissions reductions and cost-effectiveness of potential marine vessel demonstration projects, examples provided below are for reference only and do not constitute additional demonstration project types or categories nor do Carl Moyer funding amounts limit the amount of funding that may be available for demonstration projects.

Table B-1
Capital Recovery Factors (CRF) for Various Project Life
At Four Percent Discount Rate

Project Life	CRF
1*	1.040
2*	0.530
3	0.360
4	0.275
5	0.225
6	0.191
7	0.167
8	0.149
9	0.134
10	0.123
11	0.114
12	0.107
13	0.100
14	0.095
15	0.090
16	0.086
17	0.082
18	0.079
19	0.076
20	0.074

**Table B-13
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)**

Tier	Horsepower	NO_x	ROG	PM10
1	25 – 49	5.26	1.74	0.480
	50 – 119	6.54	1.19	0.552
	120 – 174	6.54	0.82	0.274
	175 +	5.93	0.38	0.108
2	25 – 49	4.63	0.29	0.280
	50 – 119	4.75	0.23	0.192
	120 – 174	4.17	0.19	0.128
	175 – 250	4.15	0.12	0.088
	251+	3.79	0.12	0.088
3	50 – 120	2.74	0.12	0.160
	121 – 750	2.32	0.12	0.112
4 Interim	25 – 49	4.55	0.12	0.128
	50 – 120	2.40	0.11	0.056
	121 – 174	2.15	0.11	0.008
	175 – 750	1.29	0.08	0.008
	>750	2.24	0.12	0.048
4 Final	25 – 49	2.75	0.12	0.008
	50 – 120	1.33	0.08	0.008
	121 – 750	0.26	0.06	0.008
	>750	2.24	0.06	0.016

Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table B-28.

**Table B-20a
Uncontrolled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)**

Horsepower	Model Year	ROG	NO _x	PM
25 - 50	all	1.32	7.57	0.52
51 - 120	pre-1997	1.04	14.27	0.575
	1997+	0.71	9.7	0.524
121 - 250	pre-1971	0.95	15.36	0.527
	1971 - 78	0.79	14.27	0.451
	1979 - 1983	0.72	13.17	0.376
	1984+	0.68	12.07	0.376
251+	pre-1971	0.91	15.36	0.506
	1971 - 78	0.76	14.27	0.431
	1979 - 83	0.68	13.17	0.363
	1984 - 94	0.65	12.07	0.363
251 - 750	1995+	0.49	8.97	0.26
751+	1995+	0.6	12.07	0.363

**Table B-20b
Controlled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)**

Tier	Horsepower	ROG	NO _x	PM
1	25 - 50	1.3	6.93	0.58
	51 - 120	0.71		0.524
	121+	0.49	8.97	0.29
2	25 - 50	1.3	5.04	0.24
	51 - 120	0.71		
	121 - 175	0.49	4.84	0.176
	176 - 750			0.12
	751+		5.24	0.16
3	25 - 50	1.3	5.04	0.176
	51 - 120	0.71		
	121 - 175	0.49	3.6	0.077
	176 - 1900		3.87	0.068
	1901+		4.14	0.085

**Table B-21a
Uncontrolled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)**

Horsepower	Model Year	ROG	NO _x	PM
25 - 50	All	1.58	6.42	0.46
51 - 120	pre-1997	1.23	12.09	0.508
	1997+	0.85	8.14	0.417
121 - 250	pre-1971	1.13	13.02	0.466
	1971 - 78	0.94	12.09	0.399
	1979 - 1983	0.86	11.16	0.333
	1984 - 95	0.82	10.23	0.333
	1996+	0.59	7.75	0.255
251 - 750	pre-1971	1.08	13.02	0.448
	1971 - 78	0.9	12.09	0.381
	1979 - 83	0.81	11.26	0.321
	1984 - 94	0.77	10.23	0.321
	1995+	0.58	7.6	0.23
751+	pre-1971	1.08	13.02	0.448
	1971 - 78	0.9	12.09	0.381
	1979 - 86	0.81	11.16	0.321
	1987 - 98	0.72	10.23	0.321
	1999+	0.58	7.75	0.255

**Table B-21b
Controlled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)**

Tier	Horsepower	ROG	NO _x	PM
1	25 - 50	1.54	6.54	0.511
	51 - 120	0.85	6.93	0.464
	121+	0.58		0.255
2	25 - 50	1.54	5.04	0.24
	51 - 120	0.85		
	121 - 175	0.58	4.84	0.176
	176 - 750			0.12
	751+		5.24	0.16
3	25 - 50	1.54	5.04	0.176
	51 - 120	0.85		
	121 - 175	0.58	3.6	0.077
	176 - 750		3.78	
	751 - 1900		3.87	0.068
	1901+		4.14	

**Table B-22
Harbor Craft Load Factors**

Vessel Type	Propulsion Engine	Auxiliary Engine
Commercial Fishing	0.27	0.43
Charter Fishing	0.52	
Ferry/Excursion	0.42	
Crew and Supply	0.45	
Pilot	0.51	
Tow	0.68	
Work	0.45	
Other	0.52	
Tug	0.5	0.31

REFERENCES

The information in these tables has already been incorporated into the preceding emission factor tables. These tables are included for informational purposes.

**Table B-26
Pollutant Fractions
NO_x+NMHC Standards**

Diesel Engines		Alternative Fuel Engines	
NO _x	NMHC	NO _x	NMHC
0.95	0.05	0.80	0.20

**Table B-28
Fuel Correction Factors
Off-Road Diesel Engines**

Model Year	NO _x	PM10
Pre-Tier 1	0.930	0.720
Tier 1+	0.948	0.800

Example cost effectiveness calculations are show below.

General Cost-Effectiveness Calculations

The cost-effectiveness of a project is determined by dividing the annual cost of the potential project by the annual weighted surplus emission reductions that will be achieved by the project as shown in formula C-1 below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions (\$/ton):

$$\frac{\text{Annualized Cost (\$/yr)}}{\text{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Descriptions on how to calculate annual emission reductions and annualized cost are provided in the following sections.

A. Calculating the Annual Weighted Surplus Emission Reductions

Annual weighted emission reductions are estimated by taking the sum of the project's annual surplus pollutant reductions following formula C-2 below. This will allow projects that reduce one, two, or all three of the covered pollutants to be evaluated for eligibility to receive Carl Moyer Program funding. While NO_x and ROG emissions are given equal weight; emissions of combustion PM10 (such as diesel exhaust PM10 emissions) have been identified as a toxic air contaminant and thus carry a greater weight in the calculation.

Formula C-2: Annual Weighted Surplus Emission Reductions:

$$\text{NO}_x \text{ reductions (tons/yr)} + \text{ROG reductions (tons/yr)} + [20 * (\text{PM10 reductions (tons/yr)})]$$

The result of formula C-2 is used to complete formula C-1 to determine the cost-effectiveness of surplus emission reductions.

In order to determine the annual surplus emission reductions by pollutant, formula C-3 below must be completed for each pollutant (NO_x, ROG, and PM10), for the baseline technology and the reduced technology, totaling up to 6 calculations:

1. Annual emissions of NO_x for the baseline technology
2. Annual emissions of NO_x for the reduced technology
3. Annual emissions of ROG for the baseline technology
4. Annual emissions of ROG for the reduced technology
5. Annual emissions of PM10 for the baseline technology
6. Annual emissions of PM10 for the reduced technology

These calculations are completed for each pollutant by multiplying the engine emission factor or converted emission standard (found in Appendix B) by the annual activity level and by other adjustment factors as specified for the calculation methodologies presented.

The **baseline technology** is the technology applied under normal business practices, such as, an engine certified by ARB to the current emission standards for new purchases; or the existing engine in a vehicle or equipment for repowers and retrofits.

The **reduced technology** is the newer technology used by the applicant to obtain surplus emission reductions. The newer technology may be one of the following:

- For a new purchase it would be the engine certified by ARB to reduce NO_x emissions by at least 30 percent less than the current NO_x emission standard, or certified by ARB to the optional NO_x or NO_x+NMHC emission standard. Locomotive and marine vessel new purchases have slightly different criteria. Please see the specific source category cost-effectiveness criteria for more information.
- For a repower it would be the replacement engine certified by ARB (for locomotives and marine vessels it would be EPA verified) to a minimum of 15 percent less than the NO_x emissions from the baseline technology (existing engine).
- For a NO_x retrofit it would be an ARB-verified retrofit technology that will reduce NO_x emissions by a minimum of 15 percent from the NO_x emissions of the baseline technology.
- For a PM retrofit it would be the ARB-verified diesel emission control strategy (DECS) that reduces PM emissions as level 1 (25 percent reduction), level 2 (50 percent reduction), or level 3 (85 percent reduction).

Since the emission factor or converted standard is given in units of grams, a conversion from grams to tons is also required, as described in formula C-3 below.

Formula C-3: Estimated Annual Emissions by Pollutant (tons/yr):

$$\text{Emission Factor or Converted Emission Standard (g/bhp-hr)} * \text{Annual Activity} * \\ \text{Adjustment Factor(s)} * \text{Percent Operation in CA} * \text{ton}/907,200\text{g}$$

The Carl Moyer Program allows the emissions reductions from a project to be calculated using the following activity factors on an annual basis:

- Hours of operation,
- Fuel consumption, or
- Miles traveled.

1. Calculating Annual Emissions Based on Fuel Consumption

When annual fuel consumption is used for determining emission reductions, the equipment activity level must be based on annual fuel usage within California provided by the applicant. Fuel records must be maintained by the engine owner as described in the relative source category chapter for additional information on this topic.

An energy consumption factor (ECF) must be used to convert emissions given in g/bhp-hr to units of grams of emissions per gallon of fuel used (g/gal). The ECF is a number that combines the effects of engine efficiency and the energy content of the fuel used in that engine into an approximation of the amount of work output by an engine for

each unit of fuel consumed. The ECF is found in Table B-25 in Appendix B. Formula C-6 below is the formula for calculating annual emissions based on annual fuel consumed.

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

$$\text{Emission Factor or Converted Emission Standard (g/bhp-hr)} * \text{ECF (hp-hr/gal)} * \text{Activity (gal/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

For on-road projects, if the emission factor is in g/mile, a unit conversion factor (bhp-hr/mile) found in Table B-8 in Appendix B must be used to convert from g/mile to g/bhp-hr. This is completed by dividing the emission factor (g/mile) by the conversion factor (bhp-hr/mile) resulting in (g/bhp-hr). Formula C-7 below is used to calculate annual emissions for fuel based on-road calculations.

Formula C-7: Estimated Annual Emissions based on Fuel Consumed using On-Road Emission Factors (tons/yr):

$$[\text{On-Road Emission Factor (g/mile)/Unit Conversion Factor (bhp-hr/mile)}] * \text{ECF (hp-hr/gal)} * \text{Activity (gal/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

2. Calculating Annual Emissions Based on Annual Miles Traveled

Calculations based on annual miles traveled are only used for on-road projects. Mileage records must be maintained by the engine owner as described in Part 1, Chapter 3: On-road Heavy-Duty Vehicles.

Calculations Using Emission Factors: There is no conversion since the emission factors for on-road projects provided are given in units of g/mile. Formula C-8 describes the method for calculating pollutant emissions based on emission factors and miles traveled.

Formula C-8: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr):

$$\text{Emission Factor (g/mile)} * \text{Activity (miles/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

Calculating Annual Emissions Based on Converted Standards: The unit conversion factor found in Table B-8 in Appendix B is used to convert the units of the converted emission standard (g/bhp-hr) to g/mile. Formula C-9 describes the method for calculating pollutant emissions using converted emission standards.

Formula C-9: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr):

*Converted Emission Standard (g/bhp-hr) * Unit Conversion (bhp-hr/mile) * Activity (miles/yr)
* Percent Operation in CA * ton/907,200g*

3. Calculating Annual Surplus Emission Reductions by Pollutant

The final step in this portion of the calculations is to determine the annual surplus emission reductions by pollutant. For new purchases and repower projects, subtract the annual emissions for the reduced technology from the annual emissions for the baseline technology following formula C-10 below.

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

*Annual Emissions for the Baseline Technology –
Annual Emissions for the Reduced Technology*

For retrofits, multiply the baseline technology pollutant emissions by the percent of emission reductions that the ARB-verified reduced technology is verified to following formula C-11 below.

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits:

*Annual Emissions for the Baseline Technology *
Reduced Technology Verification Percent*

Calculations must be done for each pollutant, NO_x, PM₁₀, and ROG, giving a total of three calculations.

For fleet modernization projects the baseline will be the newer vehicle emissions.

The annual surplus emission reductions by pollutant would be used in Formula C-2 to calculate the annual surplus emission reductions.

Determining the Annualized Cost

Annualized cost is the amortization of the one-time incentive grant amount for the life of the project to yield an estimated annual cost. The annualized cost is calculated by multiplying the incremental cost by the capital recovery factor (CRF). The resulting annualized cost is used to complete formula C-12 to determine the cost-effectiveness of surplus emission reductions.

Formula C-12: Annualized Cost (\$):

$$CRF * \text{incremental cost } (\$)$$

1. Calculating the CRF

The CRF is the level of earnings reasonably expected by investing state funds in various financial instruments over the length of a Carl Moyer Program project. The CRF uses an interest rate and project life to determine the rate at which earnings could reasonably be expected if the same funds were invested over a length of time equaling the project life. The CRF is calculated following formula C-13 below.

Formula C-13: Capitol Recovery Factor (CRF):

$$[(1 + i)^n (i)] / [(1 + i)^n - 1]$$

Where

i = discount rate (4 percent)

n = project life (at least 3 years see specific project criteria for default maximums)

The discount rate of 4 percent reflects the prevailing earning potential for state funds that could reasonably be expected by investing state funds in various financial instruments over the length of the minimum project life of Carl Moyer Program projects.

Table B-1 in Appendix B lists the CRF for various project lives using a discount rate of 4 percent. Use the result from formula C-13 to complete formula C-12 to determine the annualized cost of a project.

2. Calculating the Incremental Cost

In previous guidelines, incremental cost was determined by calculating the difference in cost between the new reduced technology and the baseline technology, making it necessary for the applicant to receive quotes for both the reduced and the baseline technologies. ARB staff decided to streamline this process by applying maximum eligible percent funding amounts to define incremental cost, eliminating the need to receive quotes for the baseline technology. An applicant would only need to provide an estimate of the cost of the reduced technology. Therefore, the incremental cost is determined by multiplying the cost of the reduced technology by the maximum eligible percent funding amount (from applicable chapter), as described in formula C-14 below.

Formula C-14: Incremental Cost (\$):

$$\text{Cost of Reduced Technology } (\$) * \text{Maximum Eligible Percent Funding Amount}$$

Generally the cost of the baseline vehicle for a new purchase is assumed to be a certain percentage of the cost of a new vehicle meeting reduced emissions from the standard. The cost of the baseline technology for a repower is assumed to be a percentage of the

new engine. For retrofits, there is no baseline technology cost; hence the entire cost of the retrofit may be eligible for funding.

For fleet modernization projects, the incremental cost is determined by adjusting the value given to the vehicle by the National Automotive Dealership Association (N.A.D.A.), as described in formula C-15 below.

Formula C-15: Incremental Cost for Fleet Modernization Projects (\$):

When the replacement vehicle is not new:

N.A.D.A value

where the N.A.D.A value is the retail value of the used vehicle * 50 percent.

When the replacement vehicle is new:

*Invoice of the New Vehicle * 50 percent*

Use the results from formula C-14 or C-15 to complete formula C-12 to determine the annualized cost of a project.

List of Formulas

For an easy reference, the necessary formulas to calculate the cost-effectiveness of surplus emission reductions for a project funded through the Carl Moyer Program are provided below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions (\$/ton):

$$\frac{\text{Annualized Cost (\$/yr)}}{\text{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Formula C-2: Annual Weighted Surplus Emission Reductions:

NO_x reductions (tons/yr) + ROG reductions (tons/yr) + [20 * PM10 reductions (tons/yr)]

Formula C-3: Estimated Annual Emissions by Pollutant (tons/yr):

Emission Factor or Converted Emission Standard (g/bhp-hr) * Annual Activity *
Adjustment Factor(s) * Percent Operation in CA * (ton/907,200g)

Formula C-4: Estimated Annual Emissions based on hours of Operation (tons/yr):

Emission Factor or Converted Emission Standard (g/bhp-hr) * Horsepower *
Load Factor * Activity (hrs/yr) * Percent Operation in CA * ton/907,200g

Formula C-5: Replacement Load Factor:

$$\text{Load Factor}_{\text{baseline}} * \text{hp}_{\text{baseline}} / \text{hp}_{\text{reduced}}$$

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

$$\text{Emission Factor or Converted Emission Standard (g/bhp-hr)} * \text{ECF (hp-hr/gal)} * \text{Activity (gal/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

Formula C-7: Estimated Annual Emissions based on Fuel Consumed using On-Road Emission Factors (tons/yr):

$$[\text{On-Road Emission Factor (g/mile)/Unit Conversion Factor (bhp-hr/mile)}] * \text{ECF (hp-hr/gal)} * \text{Activity (gal/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

Formula C-8: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr):

$$\text{Emission Factor (g/mile)} * \text{Activity (miles/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

Formula C-9: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr):

$$\text{Converted Emission Standard (g/bhp-hr)} * \text{Unit Conversion Factor (bhp-hr/mile)} * \text{Activity (miles/yr)} * \text{Percent Operation in CA} * \text{ton/907,200g}$$

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

$$\text{Annual Emissions for the Baseline Technology} - \text{Annual Emissions for the Reduced Technology}$$

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits:

$$\text{Annual Emissions for the Baseline Technology} * \text{Reduced Technology Verification Percent}$$

Formula C-12: Annualized Cost (\$):

$$\text{CRF} * \text{incremental cost (\$)}$$

Formula C-13: Capitol Recovery Factor (CRF):

$$[(1 + i)^n (i)] / [(1 + i)^n - 1]$$

Where i = discount rate (4 percent) and n = project life (at least 3 years see specific project criteria for default maximums)

Formula C-14: Incremental Cost (\$):

Cost of Reduced Technology (\$) * Maximum Eligible Percent Funding Amount

The above excerpt from the 2008 Carl Moyer Program Guidelines does not contain all the information that is found in the complete 2008 guidelines.

The complete Carl Moyer Program Guidelines can be found at :
http://www.arb.ca.gov/msprog/moyer/2008guideline_updates.htm

Example Marine Vessel Calculation

This section provides an example of the calculations for estimating cost-effectiveness of surplus emission reductions for marine vessel projects. Example calculations are provided as an illustration only of the methodology for performing different types of marine vessel cost effectiveness calculations. Specific projects that are used as an example below do not constitute an additional project type that AQIP demonstration project funds will be allocated toward, the examples below are provided as a reference only.

Example – Marine Vessel Propulsion Engine Replacement

A marine vessel operator opts to replace an existing 1971 model year, 1,200 horsepower ferry propulsion engine with a U.S. EPA-certified Marine Tier 2 Engine. The existing vessel consumes 40,000 gallons of fuel per year, with 100 percent operation in California. The cost of the replacement engine, including installation, costs \$400,000. The load factor for ferry engines is 0.42. The ferry company will commit to a 10 year project life. Emission reductions are calculated as follows:

Baseline Technology Information:

- Propulsion engine model year (application): 1971
- Propulsion engine emission rates (Table B-20a): 12.07 g/bhp-hr NO_x, 0.6 g/bhp-hr ROG, 0.363 g/bhp-hr PM10
- Activity (application): 40,000 gal/year
- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)

Reduced Technology Information:

- Emission Factors (Table B-18a): 3.87 g/bhp-hr NO_x, 0.49 g/bhp-hr ROG, 0.068 g/bhp-hr PM10¹
- Activity (application): 40,000 gal/year

¹ For information regarding how to calculate reduced engine emission factors, refer to the Supplemental Documents webpage at: www.arb.ca.gov/msprog/moyer/guidelines/supplemental-docs.htm

- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)
- Engine load factor = 0.42

Emission Reduction Calculations:

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NO_x baseline technology emissions
 $(12.07 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal}) * (\text{ton}/907,200\text{g}) = 11.10 \text{ ton/yr NO}_x$
2. Annual NO_x reduced technology emissions
 $(3.87 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal} * 0.90) * (\text{ton}/907,200\text{g}) = 3.55 \text{ ton/yr NO}_x$
3. Annual ROG baseline technology emissions
 $(0.6 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal}) * (\text{ton}/907,200\text{g}) = 0.55 \text{ ton/yr ROG}$
4. Annual ROG reduced technology emissions
 $(0.49 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal} * 0.90) * (\text{ton}/907,200\text{g}) = 0.45 \text{ ton/yr ROG}$
5. Annual combustion PM10 baseline technology
 $(0.363 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal}) * (\text{ton}/907,200\text{g}) = 0.33 \text{ ton/yr PM10}$
6. Annual combustion PM10 reduced technology emissions
 $(0.068 \text{ g/bhp-hr} * 40,000 \text{ gal/yr} * 20.8 \text{ bhp-hr/gal} * 0.90) * (\text{ton}/907,200\text{g}) = 0.06 \text{ ton/yr PM10}$

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- NO_x emission benefits = 11.1 tons/yr – 3.55 tons/yr = 7.55 tons/yr NO_x
- ROG emission benefits = 0.55 tons/yr - 0.45 tons/yr = 0.10 tons/yr ROG
- PM10 emission benefits = 0.33 tons/yr - 0.06 tons/yr = 0.27 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

$$7.55 \text{ tons/yr} + 0.10 \text{ tons/yr} + 20(0.27 \text{ tons/yr}) = 13.05 \text{ weighted tons/yr}$$

Annualized Cost:

Project Life: 10 years

$$\text{CRF (Table B-1):} = 0.123$$

Formula C-14: Incremental Cost

$$(\$400,000 * 85 \text{ percent}) + (\$11,000 * 50 \text{ percent}) = 345,500$$

Formula C-12: Annualized Cost

$$0.123 * \$345,500 = \$42,497/\text{yr}$$

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions (\$/ton)

$$(\$42,497/\text{yr}) / (13.05 \text{ weighted tons/yr})$$

$$= \mathbf{\$3,256/\text{ton of weighted surplus emissions reduced}}$$

The project cost-effectiveness is below \$16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for \$345,500 in Carl Moyer Program funding.