EXAMPLE CALCULATIONS

This document provides sample calculations for determining the cost-effectiveness of surplus emission reductions for all Carl Moyer Program source categories using Appendices C, D, and G in the Carl Moyer Guidelines. The cost-effectiveness threshold and the CRF cited as outlined in Appendix G will be updated annually and provided via mailout. Check the Carl Moyer Program mailout website for the latest update. Sample calculations are provided for special circumstances such as comingling of funds, split project life, and two-for-one projects.

I. On-Road Heavy-Duty Vehicles

Example 1 – Diesel Heavy Heavy-Duty Truck Retrofit

A trucking company with 10 heavy-duty trucks proposes to retrofit a 2005 heavy heavy-duty diesel truck with a Level 3 retrofit that is verified for both PM and NOx reductions. This vehicle operates 80 percent of the time in California.

Baseline Technology Information:

- Baseline technology (application): 2005 heavy heavy-duty diesel truck
- Baseline diesel vehicle emission rates (Table D-4):
  11.63 g/mi NOx; 0.252 g/mi of PM10
- Activity (application): 100,000 mi/yr
- Percent operated in California (application): 80 percent

Reduced Technology Information:

- Retrofit verification emission levels (executive order):
  25 percent reduction of NOx and 85 percent reduction of PM10. ROG is not included since the retrofit device is not verified for ROG.
- Retrofit cost (quote provided with application):
  $18,000 + $600 annual filter maintenance (3 years)
- The maximum retrofit grant amount is:
  - $10,000 or the total retrofit cost, whichever is less, for the highest level retrofit verified to achieve Level 3 PM reductions of 85 percent, and NOx reductions if available for the specific engine;
  - $20,000 or the total retrofit cost, whichever is less, for retrofit devices verified to reduce NOx and PM emissions equivalent to 2007 engine standards of 1.20 g/bhp-hr NOx and 0.01 g/bhp-hr PM.

Emission Reduction Calculations:

Formula C-10: Estimated Annual Emissions Based on Mileage using Emission Factors

1. Annual NOx baseline technology emissions
   (11.63 g/mi * 100,000 mi/yr *0.80)/(ton/907,200 g) = 1.03 tons/yr NOx
2. Annual PM10 baseline technology emissions
   (0.252 g/mi * 100,000 mi/yr * 0.80)/(ton/907,200 g) = 0.022 tons/yr PM10

Formula C-14: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

1.03 * 0.25 = 0.26 tons/yr NOx
0.022 * 0.85 = 0.019 tons/yr PM10

Formula C-5: Annual Weighted Surplus Emission Reductions

0.26 + 20(0.019) =0.64 weighted tons/yr

Annualized Cost:

Project Life: 3 years

CRF (Table G-3): = 0.347

Formula C-3: Incremental Cost

[$18,000 + ($600*3)] * 100 percent = $19,800

Formula C-2: Annualized Cost

0.347 * 19,800 = $6,871/yr

Cost-Effectiveness:

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

($6,871/yr)/(0.64 weighted tons/yr) =
$10,736/ton of weighted surplus emissions reduced

The cost-effectiveness for the example is less than the cost-effective cap. This project qualifies for up to $10,000 of grant funds requested.

II. On-Road Heavy-Duty Fleet Modernization

Example 1 – Used Replacement of a Heavy-Heavy Duty Truck

An applicant with a fleet of seven trucks subject to the Truck and Bus Regulation wants to scrap a 1993 MY, heavy heavy-duty truck and replace it with a 2009 MY, used truck. The participant has provided conclusive documentation that for the last two years the old truck used an average 6,200 gallons a year and operated 100 percent of the time in California. The baseline truck is certified to a NOx level of 5.0 g/bhp-hr and PM level of 0.1 g/bhp-hr. The replacement truck engine has been certified to a NOx FEL level of 1.2 g/bhp-hr and PM level of 0.01 g/bhp-hr. Looking at the green charts for 2011, the maximum surplus life for fleets of 4-10 vehicles with a GVWR over 26,000 lbs. and a 1993 MY vehicle is three years. The project life is three years because the project is not a targeted vocation. Targeted vocation projects are eligible for a five year project life.

Baseline Technology Information

- Baseline technology (application): 1993 heavy heavy-duty diesel truck
- Converted Emission Standards (Table D-1a): 86.03 g/gal NOx, 4.44 g/gal ROG,1.33 g/gal PM10
- Activity (application): 6,200 gallons/year
- Percent operated in California (application): 100 percent

Reduced Technology Information

- Reduced technology (application): 2009 MY used, heavy heavy-duty diesel truck
- Converted Emission Standards (Table D-1a): 19.61 g/gal NOx, 1.01 g/gal ROG, 0.15 g/gal PM10
- Cost of replacement truck: $80,000
- Maximum eligible amount for a used HHD replacement truck certified to 1.20 g/bhp-hr NOx: $40,000

Emission Reduction Calculations:
Formula C-9: Estimated Annual Emissions based on Fuel using Emission Factors (tons/yr)

1. Annual NOx baseline technology emissions
   (86.03 g/gal)*(6,200 gal/yr)*(ton/ 907,200) = 0.59 tons/yr NOx
2. Annual NOx reduced technology emissions
   (19.61 g/gal)*(6,200 gal/yr)*(ton/ 907,200) = 0.13 tons/yr NOx
3. Annual ROG baseline technology emissions
   (4.44 g/gal)*(6,200 gal/yr)*(ton/ 907,200) = 0.03 tons/yr ROG
4. Annual ROG reduced technology emissions
   (1.01 g/gal)*(6,200 gal/yr)*(ton/ 907,200) = 0.01 tons/yr ROG
5. Annual PM10 baseline technology emissions
   (1.33 g/gal)*(6,200 gal/yr)*(ton/ 907,200) = 0.009 tons/yr PM10
6. Annual PM10 reduced technology emissions
   (0.15 g/gal)*(6,200 gal/yr)*(ton/ 907,200)
   = 0.001 tons/yr PM10

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

- NOx Emission Benefits = 0.59 tons/yr – 0.13 tons/yr = 0.46tons/yr NOx
- ROG Emission Benefits =0.03 tons/yr - 0.01 tons/yr = 0.02 tons/yr ROG
- PM10 Emission Benefits = 0.009 tons/yr - 0.001 tons/yr = 0.008 tons/yr PM10

Formula C-5: Annual Weighted Surplus Emission Reductions

0.46 tons/yr + 0.02 tons/yr + 20(0.008 tons/yr) = 0.64 weighted tons/yr

Annualized Cost
Project Life = 3 Years
CRF (Table G-3) = 0.347

Formula C-3: Incremental Cost
Maximum Percent Funding for Used Replacement Vehicle: $40,000

Formula C-2: Annualized Cost
$40,000 * 0.347 = $13,880/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions
= ($13,880/yr) / (0.64 weighted tons/yr)
= $21,688 /ton of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit
($16,640 * 0.64)/0.347 = **$30,690**

This project qualifies for up to **$30,690** in grant funds requested.

Example 2 – Used Replacement of a Medium-Heavy Duty Truck
An applicant with a fleet of two trucks subject to the Truck and Bus Regulation wants to scrap a 1995 MY, medium heavy-duty truck with a GVWR greater than 26,000 lbs. and replace it with a 2010 MY, used truck. The participant has provided conclusive documentation that for the last two years the old truck operated an average of 40,000 miles a year and operated 100 percent of the time in California. The project life is different for PM10 and NOx for this project. Looking at the green charts for 2011, the maximum surplus life for fleets of 1-3 vehicles with a GVWR over 26,000 lbs. and a 1995 MY vehicle is two years for PM10, and eight years for NOx. However, under the Fleet Modernization guidelines the maximum project life for small fleets is five years. Therefore, the project life used to determine cost effectiveness is two years for PM10 and five years for NOx. To accommodate the different project lives the PM10 benefit is spread over the five year contract period. Since ROG emissions are not subject to any in-use regulation, ROG is eligible for the five year maximum project life.

Baseline Technology Information

- Baseline technology (application): 1995 medium heavy-duty diesel truck
- Emission Factors (Table D-3): 10.70 g/mile NOx, 0.10 g/mile ROG, 0.216 g/mile PM10
- Activity (application): 40,000 miles/year
- Percent operated in California (application): 100 percent

Reduced Technology Information

- Reduced technology (application): 2010 MY used, medium heavy-duty diesel truck
- Emission Factors (Table D-3): 0.51 g/mile NOx, 0.02 g/mile ROG, 0.024 g/mile PM10
- Maximum eligible amount for a used MHD replacement truck certified to 0.20 g/bhp-hr NOx: $40,000

Emission Reduction Calculations:

Formula C-10: Estimated Annual Emissions Based on Mileage using Emission Factors

1. Annual NOx baseline technology emissions
   (10.70 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.47 tons/yr NOx

2. Annual NOx reduced technology emissions
   (0.51 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.02 tons/yr NOx

3. Annual ROG baseline technology emissions
   (0.10 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.00 tons/yr ROG

4. Annual ROG reduced technology emissions
   (0.02 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.00 tons/yr ROG

5. Annual PM10 baseline technology emissions
   (0.216 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.010 tons/yr PM10

6. Annual PM10 reduced technology emissions
   (0.024 g/mi * 40,000 mi/yr)/(ton/907,200 g) = 0.001 tons/yr PM10

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

Transaction 1

NOx Emission Benefits = 0.47 tons/yr – 0.02 tons/yr = 0.45tons/yr NOx
ROG Emission Benefits =0.00 tons/yr - 0.00 tons/yr = 0.00 tons/yr ROG

Transaction 2

PM10 Emission Benefits = 0.010 tons/yr - 0.001 tons/yr = 0.009 tons/yr PM10

Formula C-5: Annual Weighted Surplus Emission Reductions
Transaction 1
0.45tons/yr + 0.00 tons/yr = 0.45 weighted tons/yr

Transaction 2
20(0.009 tons/yr) = 0.18 weighted tons/yr

Formula C-12: Split Project Life
Only a fraction of each of the annual weighted surplus emission reductions from the two transactions is used to determine the total annual weighted surplus emission reductions for cost-effectiveness. This fraction is the project life associated with each transaction over the total project life.

Total Annual Weighed Surplus Emission Reductions =
(5/5 * 0.45) + (2/5 * 0.18) = 0.52 weighted tons/yr

Annualized Cost
Project Life = 5 Years
CRF (Table G-3) = 0.212

Formula C-3: Incremental Cost
Maximum Percent Funding for Used Replacement Vehicle: $40,000

Formula C-2: Annualized Cost
$40,000 * 0.212 = $8,480/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions
= ($8,480/yr) / (0.51 weighted tons/yr)
= **$16,627 /ton of weighted surplus emissions reduced**

The cost-effectiveness for the example is less than the cost-effective cap. This project qualifies for **$40,000** of grant funds requested.

III. Emergency Equipment (Fire Apparatus) On-Road Heavy-Duty Vehicle Replacement

Example 1 - Replacement of a Medium-Heavy Duty Truck (usage = gallons)
A participant wants to replace an old, medium heavy-duty pumper and replace it with a new 2009 pumper certified to a NOx FEL level of 1.2 g/bhp-hr engine. The applicant is proposing to use fuel usage to determine cost-effectiveness and operates 100 percent in California.

Baseline Technology Information

- Baseline technology (application): MY 1990 medium heavy-duty diesel truck
- Emission rates (Table D-9a): 103.23 g/gal NOx, 5.33 g/gal ROG, 7.992 g/gal PM
- Activity (application): 2,600 gallons/year

Reduced Technology Information

- Reduced technology (application): MY 2007 medium heavy-duty diesel truck
- Emission rates (Table D-9a): 19.61 g/gal NOx, 1.01 g/gal ROG, 0.148 g/gal PM
- Eligible cost: $185,000
- Maximum eligible amount for a truck replacement: 80 percent

Emission Reduction Calculations

Formula C-9: Estimated Annual Emissions Based on Fuel Using Emission Factors (tons/yr)

1. Annual NOx baseline technology emissions
   (103.23 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.30 tons/yr NOx
2. Annual NOx reduced technology emissions
   (19.61 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.06 tons/yr NOx
3. Annual ROG baseline technology emissions
   (5.33 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.02 tons/yr ROG
4. Annual ROG reduced technology emissions
   (1.01 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.003 tons/yr ROG
5. Annual PM baseline technology emissions
   (7.992 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.023 tons/yr PM
6. Annual PM reduced technology emissions
   (0.148 g/gal) (2,600 gallons) * 100% * (ton/ 907,200 g) = 0.000 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission Benefits	= 0.30 tons/yr - 0.06 tons/yr	= 0.24 tons/yr NOx
ROG Emission Benefits	= 0.02 tons/yr - 0.003 tons/yr	= 0.02 tons/yr ROG
PM Emission Benefits	= 0.023 tons/yr - 0.000 tons/yr	= 0.023 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.24 tons/yr + 0.02 tons/yr + 20(0.023 tons/yr) = 0.72 weighted tons/yr

Annualized Cost

Project Life = 14 Years
CRF (Table G-3) = 0.083

Formula C-3: Incremental Cost

Maximum Percent Funding for Replacement Vehicle:
$185,000 * 80 percent = $148,000

Formula C-2: Annualized Cost

$148,000 * 0.083 = $12,284/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($12,284/yr) / (0.72 weighted tons/yr) =

$17,061/ton of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 0.72 weighted tons/yr) / (0.083)

= **$144,347**

Example 2 - Replacement of a Heavy-Heavy Duty Vehicle (usage = miles)

A participant wants to replace a heavy heavy-duty ladder fire apparatus with a new 2010 certified to a NOx 0.2 g/bhp-hr engine. The applicant is proposing to use miles usage to determine cost-effectiveness and operates 100 percent in California.

Baseline Technology Information

- Baseline technology (application): 2000 heavy heavy-duty diesel truck
- Emission rates (Table D-9b): 10.79 g/mile NOx, 0.56 g/mile ROG, 0.130 g/mile PM
- Activity (application): 4,150 mi/yr

Reduced Technology Information

- Reduced technology (application): 2010 MY heavy heavy-duty diesel truck
- Emission rates (Table D-9b): 0.51 g/mile NOx, 0.03 g/mile ROG 0.014 g/mile PM
- Eligible cost: $210,000
- Maximum eligible amount for a truck replacement: 80 percent

Emission Reduction Calculations

Formula C-10: Estimated Annual Emissions Based on Mileage Using Emission Factors

1. Annual NOx baseline technology emissions
   (10.79 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.05 tons/yr NOx
2. Annual NOx reduced technology emissions
   (0.51 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.002 tons/yr NOx
3. Annual ROG baseline technology emissions
   (0.56 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.003 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.03 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.000 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.130 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.001 tons/yr PM
6. Annual PM reduced technology emissions
   (0.014 g/mi) (4,150 miles) * 100% * (ton/ 907,200 g) = 0.000 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission Benefits = 0.05 tons/yr - 0.002 tons/yr = 0.048 tons/yr NOx
ROG Emission Benefits = 0.003 tons/yr - 0.00 tons/yr = 0.003 tons/yr ROG
PM Emission Benefits = 0.001 tons/yr - 0.000 tons/yr = 0.001 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.048 tons/yr + 0.003 tons/yr + 20(0.001 tons/yr) = 0.071 weighted tons/yr

Annualized Cost

Project Life = 14 Years
CRF (Table G-3) = 0.083

Formula C-3: Incremental Cost

Maximum Percent Funding for Replacement Vehicle:
$210,000 * 80 percent = $168,000

Formula C-2: Annualized Cost

$168,000 * 0.083 = $13,944/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($13,944/yr) / (0.071 weighted tons/yr) =
$196,394/ton of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 0.071 weighted tons/yr) / (0.083)
= **$14,234**

IV. Off-Road Compression-Ignition Engines

Example 1 - Repower with a Tier 4 Alt NOx Engine and Level 3 Retrofit

A construction company meeting the definition of a large fleet in the Off-Road Regulation wants to repower a scraper with a Tier 4 Alt NOx engine. The baseline technology is a model year 1988, 300 hp uncontrolled engine that operates for 1,500 hours per year. The applicant is proposing to install a 300 hp Tier 4 Alt NOx engine that costs $80,000. This equipment operates 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. This project will be installed and in operation prior to January 1, 2012 thus the

applicant is potentially eligible for funding of up to 95.2 percent of the companion fleet horsepower. This engine is less than 95.2 percent of the hp of the fleet and thus is surplus to the Off-Road Regulation and can be given a project life of 3 years.

Baseline Technology Information

- Engine (application): MY 1988
- Engine Horsepower (application): 300 hp
- Annual Hours of operation (application): 1,500 hr/yr
- Load factor (Table D-10): 0.48
- Emission factors (Table D-11): 7.60 g/bhp-hr NOx, 0.82 g/bhp-hr ROG, 0.274 g/bhp-hr PM

Reduced Technology Information

- Engine: Tier 4 Alt NOx (ARB executive order)
- Engine Horsepower (application): 300 hp
- Hours of operation (application): 1,500 hr/yr
- Cost of new engine (quote provided with application): $80,000
- Tier 4 Alt NOx repowers are eligible for up to 85 percent of the cost of the repower
- Load factor (Table D-10): 0.48
- Emission factors (Table D-12): 1.29 g/bhp-hr NOx, 0.08 g/bhp-hr ROG,
- 0.008 g/bhp-hr PM
- Percent operating in California (application): 100 percent
- Retrofit: Level 3 verified reductions: 85 percent PM
- Cost of retrofit (quote provided with application): $25,000
- Retrofits are eligible for up to 100 percent of total retrofit costs

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (7.60 g/bhp-hr) (300 hp*0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 1.81 tons/yr NOx
2. Annual NOx reduced technology emissions
   (1.29 g/bhp-hr) (300 hp*0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 0.31 tons/yr NOx
3. Annual ROG baseline technology emissions
   (0.82 g/bhp-hr) (300 hp* 0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 0.20 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.08 g/bhp-hr) (300 hp*0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 0.02 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.274 g/bhp-hr) (300 hp*0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 0.065 tons/yr PM
6. Annual PM reduced technology emissions
   (0.008 g/bhp-hr) (300 hp*0.48) (1500 hr/yr) * 100% * (ton/907,200 g)
   = 0.002 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits	= 1.81 tons/yr - 0.31 tons/yr	= 1.50 tons/yr NOx
ROG Emission benefits	= 0.20 tons/yr - 0.02 tons/yr	= 0.18 tons/yr ROG
PM Emission benefits	= 0.065 tons/yr - 0.002 tons/yr	= 0.063 tons/yr PM

Formula C-14: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

0.002 tons/yr PM * 0.85 = 0.002 tons/yr PM

Total PM Emission Benefits

0.063 tons/yr + 0.002 tons/yr = 0.065 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

1.50 tons/yr + 0.18 tons/yr + 20(0.065 tons/yr) = 2.98 weighted tons/yr

Annualized Cost

Project Life: 3 years

CRF (Table G-3): = 0.347

Formula C-3: Incremental Cost

($80,000 * 85 percent) + ($25,000 * 100percent) = $93,000

Formula C-2: Annualized Cost

0.347 * $93,000 = $32,271

Cost-Effectiveness

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

($32,271/yr) / (2.98 weighted tons/yr) =

$10,829/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$93,000** of grant funds requested.

Example 2 - Retrofit of a Tier 1 Engine with a Level 3 DECS

A local municipality proposed to install Level 3 diesel particulate filter on a rubber tired loader with a Tier 1, 160 hp engine. The cost of the retrofit is $20,000 and is verified for 85 percent reductions of PM. The rubber tired loader operates 850 hours per year, 100 percent of the time in California. The local municipality meets the definition of a small fleet under the Off-Road Regulation. This project will be installed and in operation prior to January 1, 2012 and thus is eligible for the maximum project life of 5 years.

Baseline Technology Information

- Engine (application): Tier 1
- Engine Horsepower (application): 160 hp
- Annual hours of operation (application): 850 hr/yr
- Load factor (Table D-10): 0.36
- Emission factors (Table D-12): 0.274 g/bhp-hr PM

Reduced Technology Information

- Level 3 verified reductions: 85 percent PM
- Cost of retrofit (quote provided with application): $20,000

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

Annual PM baseline technology emissions
(0.274 g/bhp-hr) (160 hp*0.36) (850 hr/yr) * 100% * (ton/907,200 g)
= 0.015 tons/yr PM

Formula C-14: Annual Surplus Emission Reductions by Pollutant (tons/yr) for retrofits

0.015 tons/yr * 0.85 percent = 0.013 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

20(0.013 tons/yr) = 0.260 weighted tons/yr PM

Annualized Cost

Project Life: 5 years
CRF (Table G-3): = 0.212

Formula C-3: Incremental Cost

$20,000 * 100 percent = $20,000

Formula C-2: Annualized Cost

0.212 * $20,000 = $4,240

Cost-Effectiveness

F*ormula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)*

($4,240/yr) / (0.260 weighted tons/yr) =
$16,308/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$20,000** of grant funds requested.

Example 3 - Portable Equipment (Engine Repower)
An applicant proposes to replace an existing Tier 1, 150 hp engine in a pull-behind chipper with a new Tier 4 Alternate NOx, 150 hp engine in 2012. This portable equipment is owned by a rental company, is subject to the Portable Engine ATCM, and operates 100 percent in California. The applicant has provided weighted PM emission fleet information for all portable equipment they own that is < 175 hp and certified that the 2013 weighted PM emission fleet average of 0.3 g/bhp-hr PM has been met. This company's fleet average is between 0.18 and 0.3 g/bhp-hr PM requirement and therefore is eligible for a 4 year project life.

Engines subject to the Portable Engine ATCM will receive the minimum project life of three years and the applicant needs to prove fleet compliance to the in-use fleet compliance requirements in order to be eligible for Moyer grant funding. Note that portable agricultural equipment is regulated under the agricultural provisions of the Stationary Engine ATCM and may be eligible for funding under Chapter 10: Portable and Stationary Agricultural Sources.

Baseline Technology Information
- Current year: 2012
- Baseline technology (application): MY 2002 - Tier 1
- Engine horsepower (application): 150 hp
- Activity (application): 1,000 hr/yr
- Load factor Non-Mobile Agricultural, Other (Table D-10): 0.51
- Emission factors (Table D-12): 6.54 g/bhp-hr NOx, 0.82 g/bhp-hr ROG, 0.274 g/bhp-hr PM

Reduced Technology Information
- Reduced technology (application): MY 2012 - Tier 4 Alternate NOx
- Engine horsepower (application): 150 hp
- Activity (application): 1,000 hr/yr
- Load factor Non-Mobile Agricultural, Other (Table D-10): 0.51
- Emission factors (Table D-12): 2.15 g/bhp-hr NOx, 0.06 g/bhp-hr ROG, 0.008 g/bhp-hr PM
- New engine cost (quote provided with application): $30,000 (includes hour meter and labor to install new engine) and Tier 4 Alternate NOx engine repowers are eligible for up to 85 percent of repower cost.

Emission Reduction Calculations
Formula C-6: Estimated Annual Emissions Based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   (6.54 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.55 tons/yr NOx
2. Annual NOx reduced technology emissions
   (2.15 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.18 tons/yr NOx

3. Annual ROG baseline technology emissions
   (0.82 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.07 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.06 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.01 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.274 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.023 tons/yr PM
6. Annual PM reduced technology emissions
   (0.008 g/bhp-hr) (150 hp * 0.51) (1,000 hrs) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission benefits	= 0.55 tons/yr - 0.18 tons/yr	= 0.37 tons/yr NOx
ROG emission benefits	= 0.07 tons/yr - 0.01 tons/yr	= 0.06 tons/yr ROG
PM emission benefits	= 0.023 tons/yr - 0.001 tons/yr	= 0.022 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.37 tons/yr + 0.06 tons/yr + 20(0.022 tons/yr) = 0.87 weighted tons/yr

Annualized Cost

Project life: 4 years

CRF (Table G-3): = 0.263

Formula C-3: Incremental Cost

$30,000 * 85 percent = $25,500

Formula C-2: Annualized Cost

0.263 * $25,500 = $6,707/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($6,707/yr) / (0.87 weighted tons/yr) =

$7,709/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$25,500** of grant funds requested.

V. Large Spark-Ignition Off-Road Equipment

Example 1 - New Electric Purchase

A lumber company applied for a Carl Moyer grant to purchase a new counter balanced sit down rider electric forklift (Class I, lift code 6) costing $30,000 (including one battery pack). The owner has decided to purchase a new electric forklift instead of purchasing a 55 horsepower 2011 model year propane fueled forklift certified to the 0.6 g/bhp-hr NOx + HC. The company is a small fleet and thus exempt from the off-road LSI in-use fleet emission requirements. The equipment will operate 1900 hours annually and 100 percent of the time in California. This equipment is eligible for a project life of 10 years.

Baseline Technology Information

- Engine (application): 2011 model year
- Engine Horsepower (application): 55 hp
- Load factor (Table D-13): 0.30
- Activity (from application): 1,900 hr/yr
  Emission factors (Table D-14): 0.32 g/bhp-hr NOx, 0.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Reduced Technology Information

- Technology (application): Electric forklift
- Forklift cost: $30,000
- Electric equipment is eligible for up to 30 percent of the total cost
- Percent operated in California (application): 100 percent
- Emission factors: Electric equipment are zero emission
  0 g/bhp-hr NOx, 0 g/bhp-hr ROG, 0 g/bhp-hr PM

Emission Reduction Calculation

Formula C-6: Estimated Annual Emissions based on hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (0.32 g/bhp-hr) (55 hp * 0.30) (1,900 hr/yr) * 100% * (ton/907,200 g)
   = 0.01 ton/yr NOx
2. Annual NOx reduced technology emissions = 0 ton/yr NOx

3. Annual ROG baseline technology emissions
   (0.02 g/bhp-hr) (55 hp * 0.30) (1,900 hr/yr) * 100% * (ton/907,200 g)
   = 0.00 ton/yr ROG
4. Annual ROG reduced technology emissions = 0 ton/yr ROG

5. Annual PM baseline technology emissions
   (0.060 g/bhp-hr) (55 hp * 0.30) (1,900 hr/yr) * 100% * (ton/907,200 g)
   = 0.002 ton/yr PM
6. Annual PM reduced technology emissions = 0 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission benefits	= 0.01 tons/yr - 0 tons/yr	= 0.01 tons/yr NOx
ROG emission benefits	= 0.00 tons/yr - 0 tons/yr	= 0.00 tons/yr ROG
PM emission benefits	= 0.002 tons/yr - 0 tons/yr	= 0.002 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.01 tons/yr + 0.00 tons/yr + 20(0.002 tons/yr) = 0.05 weighted tons/yr

Annualized Cost

Project Life: 10 years (from application)

CRF (Table G-3): = 0.111

Formula C-3: Incremental Cost

$30,000 * 30 percent = $9,000

Formula C-2: Annualized Cost

0.111 * $9,000 = $999/yr

Cost-Effectiveness

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

($999/yr / (0.05 weighted tons/yr) =

$19,980/ton of weighted surplus emissions

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 0.05 weighted tons/yr) / (0.111)

= **$7,495**

Example 2 - LSI Engine Retrofit

A forklift owner proposes to retrofit an existing forklift. The existing forklift is an uncontrolled 55 horsepower propane fueled MY 1998. A level 3a retrofit has been verified for use on this engine. The cost of the retrofit is $3,300. The company is a large fleet, and provided the required fleet data to show that it is already compliant with the final fleet average emission level applicable on January 1, 2013 of 1.1 g/bhp-hr HC + NOx. The applicant operates the equipment 600 hours per year and will operate 100 percent of the time in California. This equipment is eligible for the maximum project life of 5 years.

Baseline Technology Information

- Engine (application): MY 1998
- Engine Horsepower (application): 55 hp
- Load factor (Table D-13): 0.30
- Annual hours (application): 600 hr/yr
- Emission factors (Table D-14): 10.51 g/bhp-hr NOx, 1.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Reduced Technology Information

- Technology (application): Level 3a LSI retrofit verified to an absolute emission value of 1.0 g/bhp-hr
- Engine Horsepower (application): 55 hp
- Load factor (Table D-13): 0.30
- Annual hours (application): 600 hr/yr
- Cost of retrofit (quote provided with application): $3,300
- Retrofit emission factors from (Table D-15): 0.53 g/bhp-hr NOx, 0.03 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operations (tons/yr)

1. Annual NOx baseline technology emissions
   (10.51 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.11 ton/yr NOx
2. Annual NOx reduced technology emissions
   (0.53 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.01 ton/yr NOx
3. Annual ROG baseline technology emissions
   (1.02 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.01 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.03 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.00 ton/yr ROG
5. Annual PM baseline technology emissions
   (0.060 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 ton/yr PM
6. Annual PM reduced technology emissions
   (0.060 g/bhp-hr) (55 hp * 0.30) (600 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits	= 0.11 tons/yr - 0.01 tons/yr	= 0.10 tons/yr NOx
ROG Emission benefits	= 0.01 tons/yr - 0.00 tons/yr	= 0.01 tons/yr ROG
PM Emission benefits	= 0.001 tons/yr - 0.001 tons/yr	= 0.00 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.10 tons/yr + 0.01 tons/yr + 20(0.00 tons/yr) = 0.11 weighted tons/yr

Annualized Cost
Project Life: 5 years
CRF (Table G-3): = 0.212

Formula C-3: Incremental Cost
$3,300 * 100 percent = $3,300

Formula C-2: Annualized Cost
0.212 * $3,300 = $700/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($700/yr) / (0.11 tons/yr) =
$6,364/ton of surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$3,300** of grant funds requested.

VI. Off-Road Equipment Replacement

Example 1 - Replacement of a 1985 agricultural tractor and Level 3 Retrofit
A farmer proposes to replace an uncontrolled MY 1985, 170 hp agricultural tractor with a new 170 hp Tier 3 agricultural tractor. The new equipment will cost $100,000. This equipment operates 1,000 hours annually, 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. The applicant is eligible for up to 80 percent of the new equipment cost. This equipment is eligible for a project life of 10 years.

Baseline Technology Information
- Engine (application): MY 1985
- Engine Horsepower (application): 170 hp
- Hours of operation (application): 1,000 hr/yr
- Load factor (Table D-10): 0.70
- Emission factors (Table D-11): 10.23 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.396 g/bhp-hr PM

Reduced Technology Information
- Engine: Tier 3 (ARB executive order)
- Engine Horsepower (application): 170 hp
- Hours of operation (application): 1000 hr/yr
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Cost of new equipment (quote provided with application): $100,000
- Load factor (D-10): 0.70
- Emission factors (D-12): 2.32 g/bhp-hr NOx, 0.12 g/bhp-hr ROG, 0.112 g/bhp-hr PM

- Retrofit: Level 3 verified reductions- 85 percent PM
- Retrofits are eligible for up to 100 percent of total cost.
- Cost of retrofit (quote provided with application): $25,000

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (10.23 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 1.34 tons/yr NOx
2. Annual NOx reduced technology emissions
   (2.32 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 0.30 tons/yr NOx
3. Annual ROG baseline technology emissions
   (1.06 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 0.14 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.12 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 0.02 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.396 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 0.052 tons/yr PM
6. Annual PM reduced technology emissions
   (0.112 g/bhp-hr) (170 hp*0.70) (1,000 hr) * 100% * (ton/907,200 g)
   = 0.015 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits	= 1.34 tons/yr - 0.30 tons/yr	= 1.04 tons/yr NOx
ROG Emission benefits	= 0.14 tons/yr - 0.02 tons/yr	= 0.12 tons/yr ROG
PM Emission benefits	= 0.052 tons/yr - 0.015 tons/yr	= 0.037 tons/yr PM

Formula C-14: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

0.015 tons/yr PM * 0.85 = 0.013 tons/yr PM

Total PM Emission Benefits

0.037 tons/yr + 0.013 tons/yr = 0.050 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

1.04 tons/yr + 0.12 tons/yr + 20(0.050 tons/yr) = 2.16 weighted tons/yr

Annualized Cost

Project Life: 10 years
CRF (Table G-3): = 0.111

Formula C-3: Incremental Cost

($100,000 * 80 percent) + ($25,000 * 100 percent) **=** $105,000

Formula C-2: Annualized Cost

0.111 * $105,000 = $11,655

Cost-Effectiveness

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

($11,655/yr) / (2.16 weighted tons/yr) =

$5,396/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$105,000** of grant funds requested.

Example 2 - Replacement of two rubber tired loaders and Level 3 Retrofit

A construction company meeting the definition of a medium fleet in the Off-Road Regulation wants to replace two uncontrolled rubber tired loaders with one Tier 4 phase-in rubber tired loader. The baseline technologies are: 1) a model year 1987, 240 hp uncontrolled engine that operates for 750 hours per year and 2) a model year 1978, 180 hp uncontrolled engine that operates for 350 hours per year. The horsepower rating for the replacement equipment must not be greater than 125 percent of the lowest hp of the baseline engine (i.e., 180 hp). Therefore, the applicant will not be allowed to purchase an equipment replacement greater than 225 hp rating.

The applicant is proposing to purchase a 210 hp Tier 3 rubber tired loader. The new equipment costs $275,000. This equipment operates 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. The applicant is eligible for up to 80 percent of the new equipment cost. This project will be in operation prior to January 1, 2012, thus the applicant is potentially eligible for funding up to 100 percent of the companies fleet horsepower. This equipment is surplus to the Off-Road Regulation and can be given a maximum project life of 5 years.

Baseline Technology Information, Equipment 1

- Engine (application): MY 1987
- Engine Horsepower (application): 240 hp
- Annual Hours of operation (application): 750 hr/yr
- Load factor (Table D-10): 0.36
  Emission factors (Table D-11): 10.23 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.396 g/bhp-hr PM

Baseline Technology Information, Equipment 2

- Engine (application): MY 1978
- Engine Horsepower (application): 180 hp
- Annual Hours of operation (application): 350 hr/yr
- Load factor (Table D-10): 0.36
- Emission factors (Table D-11): 11.16 g/bhp-hr NOx, 1.20 g/bhp-hr ROG, 0.396 g/bhp-hr PM

Reduced Technology Information

- Engine: Tier 4 Phase-in (ARB executive order)
- Engine Horsepower (application): 210 hp
- Hours of operation (application): 1,100 hr/yr
- Cost of new equipment (quote provided with application): $275,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table D-10): 0.36
- Emission factors (Table D-12): 1.29 g/bhp-hr NOx, 0.08 g/bhp-hr ROG, 0.008 g/bhp-hr PM
- Retrofit: Level 3 verified reductions- 85 percent PM
- Cost of retrofit (quote provided with application): $25,000
- Retrofits are eligible for up to 100 percent of total retrofit costs

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions, equipment 1
   (10.23 g/bhp-hr) (240 hp*0.36) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.73 tons/yr NOx
2. Annual NOx baseline technology emissions, equipment 2
   (11.16 g/bhp-hr) (180 hp*0.36) (350 hr/yr) * 100% * (ton/907,200 g)
   = 0.28 tons/yr NOx
3. Annual NOx reduced technology emissions
   (1.29 g/bhp-hr) (210 hp*0.36) (1,100 hr/yr) * 100% * (ton/907,200 g)
   = 0.12 tons/yr NOx
4. Annual ROG baseline technology emissions, equipment 1
   (1.06 g/bhp-hr) (240 hp*0.36) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.08 tons/yr ROG
5. Annual ROG baseline technology emissions, equipment 2
   (1.20 g/bhp-hr) (180 hp*0.36) (350 hr/yr) * 100% * (ton/907,200 g)
   = 0.03 tons/yr ROG
6. Annual ROG reduced technology emissions
   (0.08 g/bhp-hr) (210 hp*0.36) (1,100 hr/yr) * 100% * (ton/907,200 g)
   = 0.01 tons/yr ROG
7. Annual PM baseline technology emissions, equipment 1
   (0.396 g/bhp-hr) (240 hp*0.36) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.028 tons/yr PM
8. Annual PM baseline technology emissions, equipment 2
   (0.396 g/bhp-hr) (180 hp*0.36) (350 hr/yr) * 100% * (ton/907,200 g)
   = 0.010 tons/yr PM
9. Annual PM reduced technology emissions
   (0.008 g/bhp-hr) (210 hp*0.36) (1,100 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits = (0.73 ton/yr + 0.28 tons/yr) - 0.12 tons/yr
= 0.89 tons/yr NOx

ROG Emission benefits = (0.08 ton/yr + 0.03 tons/yr) - 0.01 tons/yr
= 0.10 tons/yr ROG

PM Emission benefits = (0.028 tons/yr + 0.010 tons/yr) - 0.001 tons/yr
= 0.037 tons/yr PM

Formula C-14: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

0.001 tons/yr PM * 0.85 = 0.001 tons/yr PM

Total Emission Benefits

0.037 tons/yr + 0.001 tons/yr = 0.038 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.89 tons/yr + 0.10 tons/yr + 20(0.038 tons/yr) = 1.75 weighted tons/yr

Annualized Cost:

Project Life: 5 years

CRF (Table G-3): = 0.212

Formula C-3: Incremental Cost

($275,000 * 80 percent) + ($25,000 * 100 percent) = $245,000

Formula C-2: Annualized Cost

0.212 * $245,000 = $51,940

Cost-Effectiveness

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

($51,940/yr) / (1.75 weighted tons/yr) =

$29,680/tons of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 1.75 weighted tons/yr) / (0.212)

= **$137,358**

Example 3 - Replacement of a 1993 LSI forklift with a new LSI forklift
An applicant proposes to replace a 1993 70 hp LPG forklift with a new Model Year 2011 70 hp LPG forklift. The new equipment will cost $22,000. This equipment operates 750 hours per year, 100 percent of the time in California. This equipment belongs to a small fleet and is exempt from the off-road LSI in-use fleet emission requirements, and thus is eligible for a project life of 3 years.

Baseline Technology Information
- Engine (application): Model Year 1993
- Engine Horsepower (application): 70 hp
- Hours of operation (application): 750 hr/yr
- Load factor (Table D-13): 0.30
- Emission factors (Table D-14): 10.51 g/bhp-hr NOx, 1.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Reduced Technology Information
- Engine: Model Year 2011
- Engine Horsepower (application): 70 hp
- Hours of operation (application): 750 hr/yr
- Cost of new equipment (quote provided with application): $22,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table D-13): 0.30
- Emission factors (Table D-14): 0.32 g/bhp-hr NOx, 0.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Emission Reduction Calculations
Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   (10.51 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.18 tons/yr NOx
2. Annual NOx reduced technology emissions
   (0.32 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g) = 0.01 tons/yr NOx
3. Annual ROG baseline technology emissions
   (1.02 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g) = 0.02 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.02 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.0003 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.060 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM
6. Annual PM reduced technology emissions
   (0.060 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits = 0.18 tons/yr - 0.01 tons/yr = 0.17 tons/yr NOx
ROG Emission benefits = 0.02 tons/yr - 0.0003 tons/yr = 0.020 tons/yr ROG
PM Emission benefits = 0.001 tons/yr - 0.001 tons/yr = 0.0 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.17 tons/yr + 0.020 tons/yr + 20(0.0 tons/yr) = 0.19 weighted tons/yr

Annualized Cost

Project Life: 3 years
CRF (Table G-3): = 0.347

Formula C-3: Incremental Cost

$22,000 * 80 percent = $17,600

Formula C-2: Annualized Cost

0.347 * $17,600 = $6,107

Cost-Effectiveness

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

($6,107/yr) / (0.19 weighted tons/yr) =
$32,142/tons of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 0.19 weighted tons/yr) / (0.347)
= **$9,111**

Example 4 - Replacement of a 1993 LSI forklift with a new electric forklift

An applicant proposes to replace a 1993 70 hp LPG forklift with a new electric 70 hp (52 KW) forklift in 2011. The new equipment will cost $34,000. This equipment operates 750 hours per year, 100 percent of the time in California.

When calculating emission benefits for replacement with electric equipment, SB 467 requires that calculations are done from two transactions:

- Transaction 1: Existing equipment to be scrapped to zero emission (maximum of 3 year project life attributed to this transaction)
- Transaction 2: New piece of equipment that would be purchased in 3 years, or the time of normal attrition, to zero emission (maximum of 7 year project life attributed to this transaction)

This equipment belongs to a small fleet and is exempt from the off-road LSI in-use fleet emission requirements, and thus eligible for a maximum total project life of 10 years.

Baseline Technology Information-Transaction 1

- Engine (application): Model Year 1993
- Engine Horsepower (application): 70 hp
- Hours of operation (application): 750 hr/yr
- Load factor (Table D-13): 0.30
- Emission factors(Table D-14):10.51 g/bhp-hr NOx,1.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Baseline Technology Information-Transaction 2

- Engine (application): Model Year 2014
- Engine Horsepower (application): 70 hp
- Hours of operation (application): 750 hr/yr
- Load factor (Table D-13): 0.30
- Emission factors (Table D-14): 0.32 g/bhp-hr NOx, 0.02 g/bhp-hr ROG, 0.060 g/bhp-hr PM

Reduced Technology Information

- Engine: electric
- Engine Horsepower (application): 70 hp
- Hours of operation (application): 750 hr/yr
- Cost of new equipment (quote provided with application): $34,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table D-13): 0.30
- Emission factors : 0 g/bhp-hr NOx, 0 g/bhp-hr ROG, 0 g/bhp-hr PM

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions- Transaction 1
   (10.51 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.18 tons/yr NOx
2. Annual NOx baseline technology emissions- Transaction 2
   (0.32 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.01 tons/yr NOx
3. Annual NOx reduced technology emissions
   (0 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g) = 0.0 tons/yr NOx
4. Annual ROG baseline technology emissions- Transaction 1
   (1.02 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.02 tons/yr ROG
5. Annual ROG baseline technology emissions- Transaction 2
   (0.02 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.00 tons/yr ROG
6. Annual ROG reduced technology emissions
   (0.0 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g) = 0.0 tons/yr ROG
7. Annual PM baseline technology emissions- Transaction 1
   (0.060 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM

8. Annual PM baseline technology emissions- Transaction 2
   (0.060 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM
9. Annual PM reduced technology emissions
   (0 g/bhp-hr) (70 hp*0.30) (750 hr/yr) * 100% * (ton/907,200 g) = 0.0 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

Transaction 1

NOx Emission benefits	= 0.18 tons/yr - 0.0 tons/yr	= 0.18 tons/yr NOx
ROG Emission benefits	= 0.02 tons/yr - 0.0 tons/yr	= 0.02 tons/yr ROG
PM Emission benefits	= 0.001 tons/yr - 0.0 tons/yr	= 0.001 tons/yr PM

Transaction 2

NOx Emission benefits	= 0.01 tons/yr - 0.0 tons/yr	= 0.01 tons/yr NOx
ROG Emission benefits	= 0.00 tons/yr - 0.0 tons/yr	= 0.00 tons/yr ROG
PM Emission benefits	= 0.001 tons/yr - 0.0 tons/yr	= 0.001 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

Transaction 1

0.18 tons/yr + 0.02 tons/yr + 20(0.001 tons/yr) = 0.22 weighted tons/yr

Transaction 2

0.01 tons/yr + 0.00 tons/yr + 20(0.001 tons/yr) = 0.03 weighted tons/yr

Formula C-12: Split Project Life

Only a fraction of each of the annual weighted surplus emission reductions from the two transactions is used to determine the total annual weighted surplus emission reductions for cost-effectiveness. This fraction is the project life associated with each transaction over the total project life.

Total Annual Weighed Surplus Emission Reductions =
(3/10 * 0.22) + (7/10 * 0.03) = 0.087 weighted tons/yr

<u>Annualized Cost</u>

Project Life: 10 years
CRF (Table G-3): = 0.111

Formula C-3: Incremental Cost

$34,000 * 80 percent = $27,200

Formula C-2: Annualized Cost

0.111 * $27,200 = $3,019

<u>Cost-Effectiveness</u>

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

($3,019/yr) / (0.087 weighted tons/yr) =
$34, 701/tons of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit
($16,640 * 0.087 weighted tons/yr) / (0.111)
= **$13,042**

VII. Agricultural Sources

Example 1 - New Purchase (Electric Motor)
Note that only engines regulated under the Agricultural Provisions of the Stationary Engine ATCM should receive a 1-year project life. Engines exempt to the Stationary Engine ATCM (e.g. remotely-located agricultural engines) must use a minimum three year project life.

An applicant proposes to purchase a new 175 hp electric motor to be installed in a new, irrigation well in spring of 2012 to operate in California. This new irrigation system is not replacing an existing system. The Stationary Diesel Engine ATCM for this 175 hp engine size requires a diesel Tier 4 or engine meeting the 0.01 g/bhp-hr PM requirements by December 31, 2014.

The project applicant has selected a 5-year project life instead of the maximum 10 year project life available for this project. The emission reductions will be determined from the current cleanest available engine, which in spring of 2012 is a Tier 4 Alternate NOx, sometimes called an interim Tier 4 engine.

<u>Baseline Technology Information</u>
- Current year: 2012
- Baseline technology (application): 2012 MY (Tier 4 Alternate NOx)
- Engine horsepower (application): 175 hp
- Activity (application): 500 hr/yr
- Load factor (Table D-10): 0.65
- Emission factors (Table D-12): 1.29 g/bhp-hr NOx, 0.08 g/bhp-hr ROG, 0.008 g/bhp-hr PM

<u>Reduced Technology Information</u>
- Reduced technology (application): New electric motor
- Engine horsepower (application): 175 hp
- Activity (application): 500 hr/yr
- Load factor (Table D-10): 0.65
- Emission factors: 0 g/bhp-hr NOx, 0 g/bhp-hr ROG, 0 g/bhp-hr PM
- New motor cost (quote provided with application): $40,000 (includes hour meter & peripheral equipment). New motor purchase is eligible for up to 20 percent of new motor cost and peripheral equipment associated with the installation.

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions Based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (1.29 g/bhp-hr) (175 hp * 0.65) (500 hrs) * 100% * (ton/907,200 g)
   = 0.08 tons/yr NOx
2. Annual NOx reduced technology emissions = 0 tons/yr NOx
3. Annual ROG baseline technology emissions
   (0.08 g/bhp-hr) (175 hp * 0.65) (500 hrs) * 100% * (ton/907,200 g)
   = 0.01 tons/yr ROG
4. Annual ROG reduced technology emissions = 0 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.008 g/bhp-hr) (175 hp * 0.65) (500 hrs) * 100% * (ton/907,200 g)
   = 0.001 tons/yr PM
6. Annual PM reduced technology emissions = 0 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission benefits	= 0.08 tons/yr - 0 tons/yr	= 0.08 tons/yr NOx
ROG emission benefits	= 0.01 tons/yr - 0 tons/yr	= 0.01 tons/yr ROG
PM emission benefits	= 0.001 tons/yr - 0 tons/yr	= 0.001 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.11 tons/yr + 0.01 tons/yr + 20(0.001 tons/yr) = 0.14 weighted tons/yr

Annualized Cost

Project life: 5 years
CRF (Table G-3): = 0.212

Formula C-3: Incremental Cost

$40,000 * 20 percent = $8,000

Formula C-2: Annualized Cost

0.212 * $8,000 = $1,696/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($1,696/yr) / (0.14 weighted tons/yr) =
$12,114/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$8,000** of grant funds requested.

Example 2 - Repower (portable agricultural equipment diesel to diesel)

An applicant proposes to replace an existing Tier 1, 503 hp engine in a pull-behind chipper with a new Tier 4 (final), 500 hp engine in 2013. This portable equipment is operated exclusively at an agricultural source in California and is subject to the agricultural provisions of the Stationary Engine ATCM. This equipment is also subject to SBx2 3 and may be eligible for funding up to the compliance date of an applicable in-use rule. In order to be eligible, portable farm equipment projects must be under fully executed contract, and must be installed in the equipment and in operation prior to the applicable compliance date.

The district offered the applicant a 10-year project life for this portable farm equipment; however, the applicant requested a five year project life.

Baseline Technology Information

- Current year: 2013
- Baseline technology (application): MY 2002 (Tier 1)
- Engine horsepower (application): 503 hp
- Activity (application): 700 hr/yr
- Load factor Non-Mobile Agricultural, Other (Table D-10): 0.51
- Emission factors (Table D-12): 5.93 g/bhp-hr NOx, 0.38 g/bhp-hr ROG, 0.108 g/bhp-hr PM

Reduced Technology Information

- Reduced technology (application): MY 2013 (Tier 4 (final))
- Engine horsepower (application): 500 hp
- Activity (application): 700 hr/yr
- Load factor Non-Mobile Agricultural, Other (Table D-10): 0.51
- Emission factors (Table D-12): 0.26 g/bhp-hr NOx, 0.06 g/bhp-hr ROG,
- 0.008 g/bhp-hr PM
- New engine cost (quote provided with application): $92,000 (includes hour meter and labor to install new engine)
- Tier 4 engine repowers are eligible for up to 85 percent of repower cost.

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions Based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (5.93 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 1.17 tons/yr NOx
2. Annual NOx reduced technology emissions
   (0.26 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 0.05 tons/yr NOx
3. Annual ROG baseline technology emissions
   (0.38 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 0.08 tons/yr ROG

4. Annual ROG reduced technology emissions
   (0.06 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 0.01 tons/yr ROG
5. Annual PM baseline technology emissions
   (0.108 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 0.021 tons/yr PM
6. Annual PM reduced technology emissions
   (0.008 g/bhp-hr) (503 hp * 0.51) (700 hrs) * 100% * (ton/907,200 g)
   = 0.002 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission benefits	= 1.17 tons/yr - 0.05 tons/yr	= 1.12 tons/yr NOx
ROG emission benefits	= 0.08 tons/yr - 0.01 tons/yr	= 0.07 tons/yr ROG
PM emission benefits	= 0.021 tons/yr - 0.002 tons/yr	= 0.019 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

1.12 tons/yr + 0.07 tons/yr + 20(0.019 tons/yr) = 1.57 weighted tons/yr

Annualized Cost

Project life: 5 years

CRF (Table G-3): =0.212

Formula C-3: Incremental Cost

$92,000 * 85 percent = $78,200

Formula C-2: Annualized Cost

0.212 * $78,200 = $16,578/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($16,578/yr) / (1.57 weighted tons/yr) =

$10,559/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$78,200** of grant funds requested. When entering this project into CARL include on the equipment page, comment box “Project subject to SBx2 3”.

Example 3 - Repower (diesel engine to electric motor)

An applicant based in California wants to replace an existing Tier 1,120 hp diesel stationary irrigation pump engine with a new 100 hp (75 kW) electric motor. The existing engine is subject to the Stationary Diesel ATCM and must be replaced with an engine meeting Tier 4 emission standards by 12/31/15. The project may use up to a 10 year project life for this project; the applicant and district choose to use a 5 year project life. The emission reductions provided by this project are calculated in two transactions

following the "Stationary Diesel Engine ATCM Carl Moyer Program Implementation Chart" (http://www.arb.ca.gov/msprog/moyer/guidelines/supplemental-docs.htm):

- Transaction 1: 3 years of emission reductions are calculated for the existing engine being replaced with the electric motor.
- Transaction 2: 2 years of emission reductions are calculated for a Tier 4 Alternate NOx diesel engine being replaced with an electric motor.

Baseline Technology Information- Transaction 1

- Current Year: 2012
- Project life: 3 years (2013 - 2015)
- Engine (application): MY 1991 (uncontrolled)
- Engine horsepower (application): 120 hp
- Load factor (Table D-10): 0.65
- Activity (application): 2,000 hours per year
- Emission factors (Tables D-12): 6.54 g/bhp-hr NOx, 0.82 g/bhp-hr ROG, 0.274 g/bhp-hr PM

Baseline Technology Information- Transaction 2

- Project life: 2 years (2016 -2017)
- Engine (application): MY 2012 (Tier 4 Alt. NOx)
- Engine horsepower (application): 120 hp
- Load factor (Table D-10): 0.65
- Activity (application): 2,000 hours per year
  Emission factors (Tables D-12): 2.15 g/bhp-hr NOx, 0.06 g/bhp-hr ROG, 0.008 g/bhp-hr PM

Reduced Technology Information

- Motor (application): New electric motor
- Motor horsepower (application): 100 hp (75 kW)
- Activity (application): 2,000 hours per year
- Cost of new motor and necessary peripheral equipment (itemized quote provided with application): $35,000
- Project eligible for up to 85 percent of cost
- Emissions: 0 g/bhp-hr NOx, 0 g/bhp-hr ROG, 0 g/bhp-hr PM

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions Based on Hours of Operation

1. Annual NOx baseline technology emissions- Transaction 1
   (6.54 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g)
   = 1.12 tons/yr NOx
2. Annual NOx baseline technology emissions- Transaction 2
   (2.15 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g)
   = 0.37 tons/yr NOx
3. Annual NOx reduced technology emissions = 0 tons/yr NOx

4. Annual ROG baseline technology emissions- Transaction 1
   (0.82 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g)
   = 0.14 tons/yr ROG
5. Annual ROG baseline technology emissions- Transaction 2
   (0.06 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g)
   = 0.01 tons/yr ROG
6. Annual ROG reduced technology emissions = 0 tons/yr ROG
7. Annual PM baseline technology emissions- Transaction 1
   (0.274 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g)
   = 0.047 tons/yr PM
8. Annual PM baseline technology emissions- Transaction 2
   (0.008 g/bhp-hr) (120 hp * 0.65) (2,000 hrs) * 100% * (ton/907,200 g) =.001 tons/yr PM
9. Annual PM reduced technology emissions = 0 tons/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

Transaction 1

NOx Emission benefits	= 1.12 tons/yr - 0 tons/yr	= 1.12 tons/yr NOx
ROG Emission benefits	= 0.14 tons/yr - 0 tons/yr	= 0.14 tons/yr ROG
PM Emission benefits	= 0.047 tons/yr - 0 tons/yr	= 0.047 tons/yr PM

Transaction 2

NOx Emission benefits	= 0.37 tons/yr - 0 tons/yr	= 0.37 tons/yr NOx
ROG Emission benefits	= 0.01 tons/yr - 0 tons/yr	= 0.01 tons/yr ROG
PM Emission benefits	= 0.001 tons/yr - 0 tons/yr	= 0.001 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

Transaction 1

1.12 tons/yr + 0.14 tons/yr + 20(0.047) tons/yr = 2.20 weighted tons/yr

Transaction 2

0.37 tons/yr + 0.01 tons/yr + 20(0.001) tons/yr = 0.40 weighted tons/yr

Only a fraction of each of the annual weighted surplus emission reductions from the two transactions is used to determine the total annual weighted surplus emission reductions for project cost-effectiveness. This fraction is the project life associated with each transaction over the total project life.

Formula C-12: Split Project Life

(3/5 * 2.20 tons/yr) + (2/5 * 0.40 tons/yr) = 1.48 tons/yr

<u>Annualized Cost</u>

Project Life: 5 years

CRF (Table G-3) = 0.212

Formula C-3: Incremental Cost
$35,000 * 85 percent = $29,750

Formula C-2: Annualized Cost
$29,750 * 0.212 = $6,307/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/weighted ton)
($6,307yr) / (1.48 weighted ton/yr) =
$4,261/weighted ton of surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$29,750** of grant funds requested.

VIII. Locomotives

Example 1 - Switch Locomotive Engine Remanufacture Kit (Class 3 Railroad)
A Class 3 railroad operator opts to remanufacture an existing 1971 model year switch locomotive engine with a U.S. EPA-certified Tier 0+ Engine Remanufacture Kit. The existing locomotive consumes 40,000 gallons of fuel per year, with 100 percent operation in California. The cost of the remanufacture kit plus installation of the kit costs $400,000. The cost to purchase and install an automatic engine start-stop ILD is $11,000. The railroad company will commit to a 10 year project life.

Baseline Technology Information
- Locomotive model year (application): 1971
- Locomotive emission rate (Table D-17a): 16.36 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM
- Activity (application): 40,000 gal/yr
- Fuel Consumption Rate (Table D-24): 15.2 bhp-hr/gal

Reduced Technology Information
- Emission Factors (Table D-17b): 11.09 g/bhp-hr NOx, 2.21g/bhp-hr ROG, 0.224 g/bhp-hr PM
- Activity (application): 40,000 gal/yr
- Fuel Consumption Rate (Table D-24): 15.2 bhp-hr/gal
- ILD emission reduction factor (Table D-18): 0.90
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 85 percent of the remanufacture kit cost and 50 percent of ILD cost

Emission Reduction Calculations

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NOx baseline technology emissions
   (16.36 g/bhp-hr * 15.2 bhp-hr/gal) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 10.96 ton/yr NOx
2. Annual NOx reduced technology emissions
   (11.09 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 6.69 ton/yr NOx
3. Annual ROG baseline technology emissions
   (1.06 g/bhp-hr * 15.2 bhp-hr/gal) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 0.71 ton/yr ROG
4. Annual ROG reduced technology emissions
   (2.21 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 1.33 ton/yr ROG
5. Annual combustion PM baseline technology
   (0.378 g/bhp-hr * 15.2 bhp-hr/gal) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 0.253 ton/yr PM
6. Annual combustion PM reduced technology emissions
   (0.224 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (40,000 gal/yr) * 100% * (ton/907,200 g)
   = 0.135 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission benefits	= 10.96 tons/yr - 6.69 tons/yr	= 4.27 tons/yr NOx
ROG emission benefits	= 0.71 tons/yr - 1.33 tons/yr	= -0.62 tons/yr ROG
PM emission benefits	= 0.253 tons/yr - 0.135 tons/yr	= 0.118 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

4.27 tons/yr - 0.62 tons/yr + 20(0.118 tons/yr) = 6.01 weighted tons/yr

Annualized Cost

Project Life: 10 years

CRF (Table G-3): = 0.111

Formula C-3: Incremental Cost

($400,000 * 85 percent) + ($11,000 * 50 percent) = 345,500

Formula C-2: Annualized Cost

0.111 * $345,500 = $38,351/yr

Cost-Effectiveness

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

($38,351/yr)/(6.01 weighted tons/yr) =

$6,381/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$345,000** of grant funds requested.

Example 2 - Multiple Engine Switcher Purchase (Class 1 Railroad)
A Class 1 railroad operator has the opportunity to purchase an alternative technology switch locomotive. Because this is a multiple engine switcher (Engine Family Number ANREG0060LOC-004) with new electronics, a new battery, and other components, the project is evaluated as a new locomotive purchase. Fuel receipts indicate other switch locomotives with the same activity in the rail yard consume 45,000 gallons of fuel per year with 100 percent operation in California. The cost of the new alternative technology switcher is $1.3 million. The project life is 10 years.

Baseline Technology Information

- Locomotive model year: none
- Locomotive emission factor (Tier 0, Table D-17a): 13.16 g/bhp-hr NOx, 2.21 g/bhp-hr ROG, 0.619 g/bhp-hr PM
- Activity (application): 45,000 gal/year
- Fuel Consumption Rate (Table D-24): 15.2 bhp-hr/gal

Reduced Technology Information

- Engine model year: 2010
- Emission factors (Engine Family ANREG0060LOC-004, FEL certified =use MY 2010 Tier 2+ emission factors): 7.61 g/bhp-hr NOx, 0.630 g/bhp-hr ROG, 0.112 g/bhp-hr PM
- Activity: must use baseline 45,000 gal/yr
- The product of Activity and Fuel Consumption Rate Factor in Formula C-8 must be the same for the baseline and reduced engines - see end of example for estimate of new locomotive fuel consumption.
- Fuel Consumption Rate: must use baseline 15.2 bhp-hr/gal
- The product of Activity and Fuel Consumption Rate Factor in Formula C-8 must be the same for the baseline and reduced engines.
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 50 percent of Class 1 railroad alternative switcher locomotive purchase cost.

Emission Reduction Calculations
Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NOx baseline technology emissions
   (13.16 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   = 9.92 ton/yr NOx
2. Annual NOx reduced technology emissions
   (7.61 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   = 5.74 ton/yr NOx

3. Annual ROG baseline technology emissions
   (2.21 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   = 1.67 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.630 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   = 0.48 ton/yr ROG
5. Annual combustion PM baseline technology
   (0.619 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   =0.467 ton/yr PM
6. Annual combustion PM reduced technology emissions
   (0.112 g/bhp-hr * 15.2 bhp-hr/gal) (45,000 gal/yr) * 100% * (ton/907,200g)
   =0.084 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits = 9.92 tons/yr - 5.74 tons/yr = 4.18 tons/yr NOx
ROG Emission benefits = 1.67 tons/yr - 0.48 tons/yr = 1.19 tons/yr ROG
PM Emission benefits = 0.467 tons/yr - 0.084 tons/yr = 0.382 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

4.18 tons/yr +1.19 tons/yr + 20(0.382 tons/yr) = 13.02 weighted tons/yr

Annualized Cost

Project Life: 10 years
CRF (Table G-3): = 0.111

Formula C-3: Incremental Cost

$1,300,000 * 50 percent = $650,000

Formula C-2: Annualized Cost

0.111 * $650,000 = $72,150/yr

Cost-Effectiveness

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

($71,150/yr)/(13.02 weighted tons/yr) =
$5,541/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$650,000** of grant funds requested.

Estimate of Fuel Consumption for New Locomotive
see guidelines chapter 11, section D(2)E for more information

- (Baseline Activity) * (Baseline Fuel Consumption Rate) / (Reduced Fuel Consumption Rate) = Estimate of Fuel Consumption

  (45,000 gal/yr) * (15.2 bhp-hr/gal) / (20 bhp-hr/gal) = 34,200 gal/yr

Example 3 - Idle-Limiting Device Installation (Class 3 Railroad)
A Class 3 railroad wants to purchase and install an AESS ILD on one of its 1970 uncontrolled switch locomotives. Fuel receipts indicate other switch locomotives with the same activity in the rail yard consume 25,000 gallons of fuel per year with 100 percent operation in California. The cost to purchase and install the AESS is $14,000. The project life is 3 years.

Baseline Technology Information
- Locomotive model year: 1970
- Locomotive emission rate (uncontrolled, Table D-17a): 16.36 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM
- Activity (application): 25,000 gal/year
- Fuel Consumption Rate: 15.2 bhp-hr/gal (Table D-24)
- ILD emission reduction factor (Table D-18): 0.90
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 50 percent of ILD cost

Emission Reduction Calculations
Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NOx baseline technology reductions
   (16.36 g/bhp-hr * 15.2 bhp-hr/gal) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 6.85 ton/yr NOx
2. Annual NOx reduced technology reductions
   (16.36 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 6.17 ton/yr NOx
3. Annual ROG baseline technology emissions
   (1.06 g/bhp-hr * 15.2 bhp-hr/gal) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 0.44 ton/yr ROG
4. Annual ROG reduced technology emissions
   (1.06 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 0.40 ton/yr ROG
5. Annual combustion PM baseline technology
   (0.378 g/bhp-hr * 15.2 bhp-hr/gal) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 0.158 ton/yr PM
6. Annual combustion PM reduced technology
   (0.378 g/bhp-hr * 15.2 bhp-hr/gal * 0.90) (25,000 gal/yr) * 100% * (ton/907,200g)
   = 0.143 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx Emission benefits = 6.85 tons/yr - 6.17 = 0.68 tons/yr NOx
ROG Emission benefits = 0.44 tons/yr - 0.40 = 0.04 tons/yr ROG
PM Emission benefits = 0.158 tons/yr - 0.143 = 0.015 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.68 tons/yr +0.04 tons/yr + 20(0.015 tons/yr) = 1.02 weighted tons/yr

Annualized Cost

Project Life: 3 years
CRF (Table G-3): = 0.347

Formula C-3: Incremental Cost

$14,000 * 0.50 = $7,000

Formula C-2: Annualized Cost

0.347 * $7,000 = $2,429/yr

Cost-Effectiveness

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

($2,429/yr)/(1.02 weighted tons/yr) =
$2,275/tons of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$7,000** of grant funds requested.

IX. Marine Vessels

Example 1 - Tow Boat Auxiliary Engine Repower

A tow boat owner in San Diego wishes to repower a 125 horsepower 2002 auxiliary engine with a new Tier 2 200 horsepower marine engine. The vessel owner has documented that the vessel auxiliary engine operates for 900 hours annually in California waters. The cost to repower the existing engine is $50,000. Since the vessel is subject to the Commercial Harbor Craft Diesel Engine Regulation, the repower must be completed by December 31, 2014, and the project life may not extend beyond December 31, 2017 (See supplemental documents for details). Since the repower shall be completed by December 31, 2012, the operator opts to commit to the maximum five year project life (i.e. the time between project completion and the rule implementation deadline).

Scenario 1

Baseline Technology Information

- Baseline technology (application): 2002
- Engine horsepower (application): 125 hp
  Engine emission rate (Table D-20a): 7.75 g/bhp-hr NOx, 0.59 g/bhp-hr ROG, 0.255 g/bhp-hr PM
- Activity (application): 900 hr/yr
- Engine load factor (Table D-21): 0.43

Reduced Technology Information

- Reduced technology (application): Tier 2 marine engine
- Engine horsepower (application) = 200 hp
- Emission rate (Table D-20b): 4.84 g/bhp-hr NOx, 0.58 g/bhp-hr ROG, 0.120 g/bhp-hr PM
- Activity (application): 900 hr/yr
- Load factor adjustment - see extended discussion on the effects of higher horsepower engine below

  Formula C-7: Replacement Load Factor:
  0.43 * (125 hp / 200 hp) = 0.27

- Marine vessel project criteria allow for the Carl Moyer Program to pay for up to 50 percent of the repower cost for this type of vessel

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (7.75 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.41 ton/yr NOx
2. Annual NOx reduced technology emissions
   (4.84 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.26 ton/yr NOx
3. Annual ROG baseline technology emissions
   (0.59 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.03 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.58 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.03 ton/yr ROG
5. Annual PM baseline technology emissions
   (0.255 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.014 ton/yr PM
6. Annual PM reduced technology emissions
   (0.120 g/bhp-hr) (125 hp * 0.43) (900 hr/yr) * 100% * (ton/907,200 g)
   = 0.006 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission reductions	= 0.41 tons/yr - 0.26 tons/yr	= 0.15 tons/yr NOx
ROG emission reductions	= 0.03 tons/yr - 0.03 tons/yr	= 0.00 tons/yr ROG
PM emission reductions	= 0.014 tons/yr - 0.006 tons/yr	= 0.007 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

0.15 tons/yr + 0.00 tons/yr + 20(0.007 tons/yr) = 0.29 weighted tons/yr

Annualized Cost

Project life = 5 years

CRF (Table G-3) = 0.212

Formula C-3: Incremental Cost

$50,000 * 50 percent = $25,000

Formula C-2: Annualized Cost

($25,000 * 0.212) = $5,300/yr

Cost-Effectiveness

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

($5,300/year) / (0.29 weighted tons/yr) =

$18,286/ton of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 0.29 weighted tons/yr) / (0.212)

= **$22,762**

Scenario 2

Discussion of Increased Horsepower Engine and Cost-Effectiveness:

District staff should exercise caution when funding a reduced engine with more horsepower than the baseline engine. The calculations above reflect the assumption that the applicant does not intend to actually use the extra capacity for work that is available with the higher horsepower reduced engine. Such an assumption is appropriate when the larger engine is selected because there is no other option available. However, it is more likely that the applicant wants a larger engine in order to use the additional power. For example, the auxiliary engine runs an electric generator and the applicant wants to operate more electrical equipment on the vessel, and therefore needs a larger capacity engine. The calculation below assumes that the applicant is intentionally requesting the larger engine with the intent to use the additional

power. Note that the emission benefits and cost-effectiveness are substantially less in this case.

Baseline Technology Information

- Baseline technology (application): 2002
- Engine horsepower (application): 125 hp
  Engine emission rate (Table D-20a): 7.75 g/bhp-hr NOx, 0.59 g/bhp-hr ROG, 0.255 g/bhp-hr PM
- Activity (application): 900 hr/yr
- Engine load factor (Table D-21): 0.43

Reduced Technology Information

- Reduced technology (application): Tier 2 marine engine
- Engine horsepower (application) = 200 hp
- Emission rate (Table D-20b): 4.84 g/bhp-hr NOx, 0.58 g/bhp-hr ROG, 0.120 g/bhp-hr PM
- Activity (application): 900 hr/yr
- Load factor (Table D-21, this calculation assumes the applicant is intentionally requesting an engine with higher output and plans to use the additional power, thus there is no derating adjustment to the load factor): 0.43
- Marine vessel project criteria allow for the Carl Moyer Program to pay for up to 50 percent of the repower cost for this type of vessel

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions
   (7.75 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.41 ton/yr NOx
2. Annual NOx reduced technology emissions
   (4.84 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.41 ton/yr NOx
3. Annual ROG baseline technology emissions
   (0.59 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.03 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.58 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.05 ton/yr ROG
5. Annual PM baseline technology emissions
   (0.255 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.014 ton/yr PM
6. Annual PM reduced technology emissions
   (0.120 g/bhp-hr) (200 hp * 0.43) (900 hrs/yr) * 100% * (ton/907,200 g)
   = 0.010 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

NOx emission reductions	= 0.41 tons/yr - 0.41 tons/yr	= 0.00 tons/yr NOx
ROG emission reductions	= 0.03 tons/yr - 0.05 tons/yr	= -0.02 tons/yr ROG
PM emission reductions	= 0.014 tons/yr - 0.010 tons/yr	= 0.004 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions
0.00 tons/yr - 0.02 tons/yr + 20(0.004 tons/yr) = 0.06 weighted tons/yr

Annualized Cost
Project life = 5 years
CRF (Table B-1) = 0.212

Formula C-3: Incremental Cost
$50,000 * 50 percent = $25,000

Formula C-2: Annualized Cost
$25,000 * 0.212 = $5,300/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($5,300/yr) / (0.06 weighted tons/yr) =
$88,333/ton of weighted surplus emissions reduced

Note that the larger reduced engine operating at a higher power output than the baseline engine yields no NOx emission reductions and a ROG emission increase, even though it is a newer, lower emission engine and there is a small PM emission reduction.

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit
($16,640 * 0.06 weighted tons/yr) / (0.212)
= **$4,709**

Example 2 - Fishing Vessel Propulsion Engine Repower (Wet Exhaust System)

A commercial fishing vessel owner wishes to repower a Model year 1973 250 horsepower propulsion engine with a new Tier 2 250 horsepower marine engine. The vessel has a wet exhaust system. The vessel owner has documented that the vessel propulsion engine operates 1,200 hours per year in California waters. The cost to purchase and install a new engine is $51,300. The applicant will commit to a 5 year project life.

Baseline Technology Information
- Baseline technology (application): 1973
- Engine horsepower (application): 250 hp

Engine emission rate (Table D-19a): 14.27 g/bhp-hr NOx, 0.79 g/bhp-hr ROG, 0.451 g/bhp-hr PM

- Activity (application): 1,200 hr/yr
- Engine load factor (Table D-21): 0.27
- Wet exhaust emission factor (from marine repower project criteria): 0.80

Reduced-Emission Technology Information

- Reduced technology (application): Tier 2 marine engine
- Engine horsepower (application): 250 hp
- Emission rate (Table D-19b): 4.84 g/bhp-hr NOx, 0.49 g/bhp-hr ROG, 0.120 g/bhp-hr PM
- Activity (application): 1,200 hr/yr
- Engine load factor (Table D-21): 0.27
- Wet exhaust emission factor (from marine repower project criteria): 0.80
- Marine vessel project criteria allow for the Carl Moyer Program to pay for up to 50 percent of the repower cost for this type of vessel

Emission Reduction Calculations

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

1. Annual NOx baseline technology emissions
   (14.27 g/bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 1.02 ton/yr NOx
2. Annual NOx reduced technology emissions
   (4.84 g/bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 0.35 ton/yr NOx
3. Annual ROG baseline technology emissions
   (0.79 g/bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 0.06 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.49 g.bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 0.04 ton/yr ROG
5. Annual PM baseline technology emissions
   (0.451 g/bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 0.032 ton/yr PM
6. Annual PM reduced technology emissions
   (0.120 g/bhp-hr) (250 hp * 0.27) (0.80) (1,200 hr/yr) * 100% * (ton/907,200 g)
   = 0.009 ton/yr PM

Formula C-13: Annual Surplus Emission Reductions by Pollutant for Repowers and New Purchases

NOx Emission Reductions	= 1.02 tons/yr - 0.35 tons/yr	= 0.67 tons/yr NOx
ROG Emission Reductions	= 0.06 tons/yr - 0.04 tons/yr	= 0.02 tons/yr ROG
PM Emission Reductions	= 0.032 tons/yr - 0.009 tons/yr	= 0.023 tons/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions
0.67 + 0.02 +20(0.023) = 1.15 weighted tons/yr

Annualized Cost
Project life = 5 years
CRF (Table G-3) = 0.212

Formula C-3: Incremental Cost
$51,300 * 50 percent = $25,650

Formula C-2: Annualized Cost
$25,650 * 0.212 = $5,438/yr

Cost-Effectiveness
Formula C-1: Cost-Effectiveness of Surplus Emission Reductions
($5,438/year) / (1.15 weighted tons/yr) =
$4,729 ton of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$25,650** of grant funds requested.

Example 3 - Container Vessel (Ship Side) Shore Power
A shipping company wants to install ship side shore power on three of its vessels. The project costs $1.5 million per vessel ($500,000 of which is transformer cost), and will be installed by December 30, 2011. The fleet's strategy for compliance with the shore power regulation uses other vessels to satisfy the required fraction of visits using shore power at all future milestones, so the three vessels in this project are therefore surplus to the requirement. In addition to Moyer funding, this project also uses $600,000 in district funds. The vessels typically use marine gas oil (MGO) with a sulfur content of less that 0.10 percent.

Project Information
- Type of Shore Power Berth: container vessel
  Vessel emission rate (Table D-22): 13.9 g/kW-hr NOx, 0.49 g/kW-hr ROG, 0.25 g/kW-hr PM
- Average Berthing Time: 24 hr/visit
- Number of Visits: 3 ships x 5 visits per ship per year = 15 visits/yr
- Ship Power Requirement (weighted average for vessels as provided by applicant): 1,500 kW
- Control Factor(Chapter 12, Section 6 (J)): 0.10

Emission Reduction Calculations

Formula C-6 (note: the product of hr/visit *and* visit/yr *yields the activity in hr/yr*)

1. Annual NOx emission reductions
   (13.9 g/kW-hr * 1,500 kW) (0.9 * 24 hr/visit * 15 visit/yr) * 100% * (ton/907,200g)
   = 7.45 ton/yr NOx

2. Annual ROG emission reductions
   (0.49 g/kW-hr * 1,500 kW) (0.9 * 24 hr/visit * 15 visit/yr) * 100% * (ton/907,200g)
   = 0.26 ton/yr ROG

3. Annual PM emission reductions
   (0.25 g/kW-hr * 1,500 kW) (0.9 * 24 hr/visit * 15 visit/yr) * 100% * (ton/907,200g)
   = 0.134 ton/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions

7.45 + 0.26 +20(0.134) = 10.39 weighted tons/yr

Eligible Incremental Cost

Formula C-3 (Incremental cost):

$4,500,000 - 50 percent (3 * $500,000 transformer cost) = $3,750,000

Annualized Cost

Project life = 9 years

CRF (Table G-3) = 0.123

Formula C-2: Annualized Cost

(NOTE: all state and district funds must be included in the cost-effectiveness calculations)

$3,750,000 * 0.123 = $461,250/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($461,250/yr) / (10.39 weighted tons/yr) =

$44,404/ ton of weighted surplus emissions reduced

Since the cost-effectiveness exceeds the cost-effectiveness threshold of $16,640 in Appendix G of the Carl Moyer Program Guidelines, this project would only qualify for a fraction of the incremental cost.

Formula C-18: Maximum Grant Amount for projects exceeding Cost Effectiveness Limit

($16,640 * 10.39 weighted tons/yr) / (0.123)

= **$1,405,606**

Example 4 - Port (shore Side) Shore Power

A port wants to install port side shore power on two of its berths. The project costs $2.5 million per berth ($500,000 of which is transformer cost, and $400,000 is components and labor between the transformer and the ship), and will be installed by December 30, 2011. The terminal operator has identified two vessels that will use the new facilities and the number of annual visits that will not be counted towards compliance with the shore power regulation in their respective fleets. In addition to Moyer funding, $1,000,000 of federal Incentive funds will also be used to fund part of this project. The vessels typically use marine gas oil (MGO) with a sulfur content of less that 0.10 percent.

Project Information

- Type of Shore Power Berth: container vessel
  Vessel emission rate (Table D-22): 13.9 g/kW-hr NOx, 0.49 g/kW-hr ROG, 0.25 g/kW-hr PM
- Average Berthing Time: 8 hours per visit
- Number of Visits: 2 berths x 15 visits per berth per year = 30 visits per year
- Ship Power Requirement (weighted average for vessels as provided by applicant): 7,400 kW
- Control Factor (Chapter 12, Section 6 (J)): 0.10

Emission Reduction Calculations

Formula C-6: Estimated Annual Emissions based on hours of Operation
(note: the product of hr/visit *and* visit/yr *yields the activity in hr/yr*)

1. Annual NOx emission reductions
   (13.9 g/kW-hr * 7,400 kW) (0.9 * 8 hr/visit * 30 visits/yr) * 100% * (ton/907,200g)
   = 24.49 ton/yr NOx
2. Annual ROG emission reductions
   (0.49 g/kW-hr * 7,400 kW) (0.9 * 8 hr/visit * 30 visits/yr) * 100% * (ton/907,200g)
   = 0.86 ton/yr ROG
3. Annual PM emission reductions
   (0.25 g/kW-hr * 7,400 kW) (0.9 * 8 hr/visit * 30 visits/yr) * 100% * (ton/907,200g)
   = 0.440 ton/yr PM

Formula C-5: Annual Weighted Surplus Emission Reductions
24.49 + 0.86 +20(0.440) = 34.15 weighted tons/yr

Annualized Cost

Project life = 4 years
CRF (Table G-3) = 0.263

Eligible Incremental Cost

Formula C-3: Incremental cost
$1,800,000 - 50 percent (2 * $500,000 transformer cost) = $1,300,000

Formula C-16: Moyer Grant for Grantees receiving other Public Financial Incentive Funds:

$1,300,000 - $1,000,000 = $300,000

Formula C-2: Annualized Cost

$300,000 * 0.263 = $78,900/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Surplus Emission Reductions

($78,900/year) / (34.15 weighted tons/yr) =

$2,310/ ton of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$300,000** of grant funds requested.

X. Light-Duty Vehicles

Example - Conventional VAVR Project

A district pays $1,000 to an enterprise operator to retire a 1985 light-duty vehicle in 2011. Added district costs including vehicle identification and testing are $125 for a total cost of $1,125.

Emissions Reduction

Default emission reductions over a 3-year project life in pounds for 2011 (Table 13-1): 94.4 lbs ROG_{Total}, 91.2 lbs NOX, 1.39 lbs PM

Converted to tons per year:

ROG_{Total}	= (94.4 lbs)/[(3 yrs)*(2,000 lb/ton)]	= 0.0157 tons/yr ROG
NOx,	= (91.2 lbs)/[(3 yrs)*(2,000 lb/ton)]	= 0.0152 tons/yr NOx
PM	= (1.39 lbs)/[(3 yrs)*(2,000 lb/ton)]	= 0.000232 tons/yr PM

Total Annual Weighted Surplus Emission Reductions

Formula C-5 Annual Weighted Surplus Emission Reductions:

0.0157 + 0.0152 + 20*(0.000232) = 0.0355 weighted tons/yr

Annualized Cost

Project Life = 3 Years

CRF (Table G-3) = 0.347

Total Cost: $1,125

Formula C-2: Annualized Cost

0.347 * $1,125 = $390/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions
($390/yr)/ (0.0355 weighted ton/yr) =
$10,986/ton of weighted surplus emissions reduced

Since the cost-effectiveness is below the cost-effective threshold in Appendix G of the Carl Moyer Program Guidelines, this project qualifies for up to **$1,125** grant funds requested.