Example 1 – Replacement: New Zero-emission heavy heavy-duty vehicle
(Example 1 calculation can be used for a new zero-emission school bus replacement using the same $500,000 cost-effectiveness limit)

A small fleet with 8 vehicles wants to replace a heavy heavy-duty (HHD) truck equipped with a 2009 model year engine with a new 2022 zero-emission truck. The replacement vehicle exceeds the regulatory requirement to meet 2010 emission standards (0.20 g/bhp-hr NOx) before January 1, 2023, where emission reductions from the 0.2 g/bhp-hr NOx standard to zero-emission standard surplus to regulatory requirements. The project is funding for emission reductions from the 0.2 g/bhp-hr NOx standard to zero-emission standard and is eligible for a maximum 7-year project life. Project life may change if the delivery date occurs later than the noted first year of operation. The fleet owner has provided conclusive documentation that for the last two years the truck operated a minimum of 30,000 miles per year and operated 100 percent of the time in California.

This project is eligible for the on-road optional zero-emission cost-effectiveness limit. Surplus reductions (cleaner than required) calculated will be based on the maximum project life and $500,000 CE limit.

Baseline Technology Information
- Baseline technology (application): EMY 2009 HHD diesel truck
- Emission factors (EF) and deterioration rates (DR) (Table D-2):

	NOx	ROG	PM
EF	1.76 g/mi	0.13 g/mi	0.004 g/mi
DR	0.068 g/mi-10,000 mi	0.002 g/mi-10,000 mi	0.0001 g/mi-10,000 mi

- Activity (application): 30,000 mi/yr
- Discount rate is 1% and project life is 7 years; CRF (Table D-24): 0.149
- Percentage operation in California (application): 100%

Reduced Technology Information
- Reduced technology (application): EMY 2022 HHD Zero-Emission truck
- Emission factors (EF) and deterioration rates (DR):

	NOx	ROG	PM
EF	0.0 g/mi	0.0 g/mi	0.0 g/mi
DR	0 g/mi-10,000 mi	0.0 g/mi-10,000 mi	0.0 g/mi-10,000 mi

- Cost of reduced technology: $500,000
- Maximum eligible amount for a truck replacement (Table 4-4): 80%
- Maximum funding cap for HHD ZEV (Table 4-6): $410,000
- Cost-effectiveness limit: $500,000 per weighted ton of emission reductions
- Expected first year of operation: 2022

(a) <u>Determine deterioration calculations for a 2009 to 2022 ZEV:</u>

Formula C-5: Estimated annual emissions based on mileage (tons/yr)
*Annual emissions by pollutant (tons/yr) = (emission factor (g/mi) + deterioration product(g/mi)) * annual activity (mi/yr) * percentage operation in California / 907,200 (g/ton)*

(1) Calculate deterioration life (baseline equipment) (yrs):
Deterioration life (baseline equipment) (yrs) =
expected first year of operation – baseline engine model year + (project life / 2)

Deterioration life (baseline equipment) = 2022 – 2009 + (7 / 2) = <u>16.5 yrs</u>

(2) Calculate deterioration life (reduced equipment) (yrs):
Deterioration life (reduced equipment) (yrs) = project life / 2

Deterioration life (reduced equipment) = 7 / 2 = <u>3.5 yrs</u>

(3) Calculate total equipment activity and cap the baseline equipment activity when applicable (mi):
*Total equipment activity (mi) = annual activity (mi/yr) * deterioration life (yrs)*

Total baseline equipment activity = 30,000 (mi/yr) * 16.5 (yrs) = <u>495,000 mi</u>

Total reduced equipment activity = 30,000 (mi/yr) * 3.5 (yrs) = <u>105,000 mi</u>

(4) Calculate mile-based deterioration product for baseline and reduced equipment, for each pollutant (g/mi):
Mile-based deterioration product (g/mi) =
*deterioration rate (g/mi-10,000 mi) * total equipment activity (mi)*

Baseline equipment:
NOx deterioration product= 0.068 (g/mi-10,000 mi) * 495,000 (mi)= <u>3.3660 g/mi</u>
ROG deterioration product= 0.002 (g/mi-10,000 mi) * 495,000 (mi)= <u>0.0990 g/mi</u>
PM deterioration product= 0.0001 (g/mi-10,000 mi) * 495,000 (mi)= <u>0.0050 g/mi</u>

Reduced equipment:
NOx deterioration product= 0.0 (g/mi-10,000 mi) * 105,000 (mi)= <u>0.0 g/mi</u>
ROG deterioration product= 0.0 (g/mi-10,000 mi) * 105,000 (mi)= <u>0.0 g/mi</u>
PM deterioration product= 0.0 (g/mi-10,000 mi) * 105,000 (mi)= <u>0.0 g/mi</u>

(b) Determine emission reductions calculations for a 2009 to 2022 ZEV:

(1) Calculate the estimated annual emissions for baseline and reduced equipment, for each pollutant (tons/yr):

Formula C-5: Estimated annual emissions based on mileage (tons/yr)
*Annual emissions by pollutant (tons/yr) = (emission factor (g/mi) + deterioration product (g/mi)) * annual activity (mi/yr) * percentage operation in California / 907,200(g/ton)*

Annual NOx **baseline** technology emissions (tons/yr)
(1.76 (g/mi) + 3.3660 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.1695 tons/yr
Annual NOx **reduced** technology emissions (tons/yr)
(0.0 (g/mi) + 0.0 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0 tons/yr
Annual ROG **baseline** technology emissions (tons/yr)
(0.13 (g/mi) + 0.0990 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0076 tons/yr
Annual ROG **reduced** technology emissions (tons/yr)
(0.0 (g/mi) + 0.0 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0 tons/yr
Annual PM **baseline** technology emissions (tons/yr)
(0.004 (g/mi) + 0.0050 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0003 tons/yr
Annual PM **reduced** technology emissions (tons/yr)
(0.0 (g/mi) + 0.0 (g/mi)) * 30,000 (mi/yr) * 100% /907,200(g/ton)
= 0.0 tons/yr

(2) Calculate annual surplus emission reductions for each pollutant (tons/yr):

Formula C-9: Annual surplus emission reductions (tons/yr)

Annual surplus emission reductions by pollutant (tons/yr) = annual emissions for the baseline technology (tons/yr) – annual emissions for the reduced technology (tons/yr)

Annual NOx surplus emission reductions (tons/yr)
= 0.1695 (tons/yr) - 0.0 (tons/yr) = 0.1695 tons/yr

Annual ROG surplus emission reductions (tons/yr)

=0.0076 (tons/yr) - 0.0 (tons/yr) = 0.0076 tons/yr

Annual PM surplus emission reductions (tons/yr)

=0.0003(tons/yr) - 0.0 (tons/yr) = 0.0003 tons/yr

(3) Calculate annual weighted surplus emission reductions (weighted tons/yr):

Formula C-3: Annual weighted surplus emission reductions (weighted tons/yr)

Weighted emission reductions (weighted tons/yr) = NOx reductions (tons/yr) + ROGreductions (tons/yr) + (20 * PM reductions (tons/yr))

Annual weighted surplus emission reductions (weighted tons/yr)
= 0.1695 (tons/yr NOx) + 0.0076 (tons/yr ROG) + 20 * (0.0003 (tons/yr PM))
= **0.1831 weighted tons/yr**

(c) Determine the maximum grant amount:

(1) Potential grant amount at the $500,000 cost-effectiveness limit ($):

Formula C-1: Potential grant amount at the cost-effectiveness limit ($)
Potential grant amount ($) = cost-effectiveness limit ($/ton) * estimated annual emission reductions (weighted tons/yr) / CRF

Potential grant amount = 500,000 ($/ton) * 0.1831 (tons/yr) / 0.149 = $614,430

(2) Potential grant amount based on maximum percentage of eligible cost ($):

Formula C-14: Potential grant amount based on maximum percentage of eligible cost($)
Potential grant amount ($) = cost of reduced technology ($) * maximum percentage of eligible cost

Potential grant amount = $500,000 * 80% = $400,000

(3) Potential grant amount at the funding cap when applicable:

On-road Zero Emission HHD Truck (Table 4-6)
Potential grant amount = $410,000

The lowest result of the three calculations above is the maximum grant amount:

Maximum grant amount: This project qualifies for up to **$400,000** in grant funds

Example 2 – Replacement: New HHD 0.02 g/bhp-hr NOx standard vehicle

(Example 2 calculation can be used for a new HHD school bus replacement meeting the 0.02 g/bhp-hr NOx standard using a $300,000 school bus cost-effectiveness limit)

A large fleet with 15 trucks wants to replace a heavy heavy-duty (HHD) truck equipped with a 2009 model year compressed natural gas (CNG) engine with a new 2022 truck certified to the 0.02 g/bhp-hr optional low NOx standard. The replacement vehicle exceeds the regulatory requirement to meet 2010 emission standards (0.20 g/bhp-hr NOx) before January 1, 2023, where emission reductions from the 0.2 g/bhp-hr NOx standard to 0.02 g/bhp-hr NOx standard surplus to regulatory requirements. The project is funding for emission reductions from the 0.2 g/bhp-hr NOx standard to 0.02 g/bhp-hr NOx standard and is eligible for a maximum 7-year project life. Project life may change if the delivery date occurs later than the noted first year of operation. The fleet owner has provided conclusive documentation that for the last two years the truck operated a minimum of 30,000 miles per year and operated 100 percent of the time in California.

This project is eligible for the on-road optional advanced technology cost-effectiveness limit. Surplus reductions (cleaner than required) calculated will be based on the maximum project life and $200,000 CE limit.

Baseline Technology Information
- Baseline technology (application): EMY 2009 HHD diesel truck
- Emission factors (EF) and deterioration rates (DR) (Table D-2):

	NOx	**ROG**
EF	1.76 g/mi	0.130 g/mi
DR	0.068 g/mi-10,000 mi	0.002 g/mi-10,000 mi

- Activity (application): 30,000 mi/yr
- Discount rate is 1% and project life is 7 years; CRF (Table D-24): 0.149
- Percentage operation in California (application): 100%

Reduced Technology Information
- Reduced technology (application): EMY 2022 HHD CNG truck
- Emission factors (EF) and deterioration rates (DR):

	NOx	**ROG**
EF	0.18 g/mi	0.130 g/mi
DR	0.004 g/mi-10,000 mi	0.001 g/mi-10,000 mi

- Cost of reduced technology: $250,000
- Maximum eligible amount for a truck replacement (Table 4-4): 50%
- Maximum funding cap for HHD CNG (Table 4-4): $160,000
- Cost-effectiveness limit: $200,000 per weighted ton of emission reductions
- Expected first year of operation: 2022

(a) <u>Determine deterioration calculations for a 2009 to 2022 CNG:</u>

Formula C-5: Estimated annual emissions based on mileage (tons/yr)
*Annual emissions by pollutant (tons/yr) = (emission factor (g/mi) + deterioration product(g/mi)) * annual activity (mi/yr) * percentage operation in California / 907,200 (g/ton)*

(1) Calculate deterioration life (baseline equipment) (yrs):
Deterioration life (baseline equipment) (yrs) = expected first year of operation – baseline engine model year + (project life / 2)

Deterioration life (baseline equipment) = 2022 – 2009 + (7 / 2) = <u>16.5 yrs</u>

(2) Calculate deterioration life (reduced equipment) (yrs):
Deterioration life (reduced equipment) (yrs) = project life / 2

Deterioration life (reduced equipment) = 7 / 2 = <u>3.5 yrs</u>

(3) Calculate total equipment activity and cap the baseline equipment activity when applicable (mi):
*Total equipment activity (mi) = annual activity (mi/yr) * deterioration life (yrs)*

Total baseline equipment activity = 30,000 (mi/yr) * 16.5 (yrs) = <u>495,000 mi</u>

Total reduced equipment activity = 30,000 (mi/yr) * 3.5 (yrs) = <u>105,000 mi</u>

(4) Calculate mile-based deterioration product for baseline and reduced equipment, for each pollutant (g/mi):
*Mile-based deterioration product (g/mi) = deterioration rate (g/mi-10,000 mi) * total equipment activity (mi)*

Baseline equipment:
NOx deterioration product= 0.068 (g/mi-10,000 mi) * 495,000 (mi)= <u>3.3660 g/mi</u>
ROG deterioration product= 0.002 (g/mi-10,000 mi) * 495,000 (mi)= <u>0.0990 g/mi</u>

Reduced equipment:
NOx deterioration product= 0.004 (g/mi-10,000 mi) * 105,000 (mi)= <u>0.0420 g/mi</u>
ROG deterioration product= 0.001 (g/mi-10,000 mi) * 105,000 (mi)= <u>0.0105 g/mi</u>

(b) Determine emission reductions calculations for a 2009 to 2022 CNG:

(1) Calculate the estimated annual emissions for baseline and reduced equipment, for each pollutant (tons/yr):

Formula C-5: Estimated annual emissions based on mileage (tons/yr)
Annual emissions by pollutant (tons/yr) = (emission factor (g/mi) + deterioration product (g/mi)) * annual activity (mi/yr) * percentage operation in California / 907,200 (g/ton)

Annual NOx **baseline** technology emissions (tons/yr)
(1.76 (g/mi) + 3.3660 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.1695 tons/yr
Annual NOx **reduced** technology emissions (tons/yr)
(0.18 (g/mi) + 0.0420 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0073 tons/yr
Annual ROG **baseline** technology emissions (tons/yr)
(0.130 (g/mi) + 0.0990 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0076 tons/yr
Annual ROG **reduced** technology emissions (tons/yr)
(0.130 (g/mi) + 0.0105 (g/mi)) * 30,000 (mi/yr) * 100% / 907,200 (g/ton)
= 0.0046 tons/yr

(2) Calculate annual surplus emission reductions for each pollutant (tons/yr):

Formula C-9: Annual surplus emission reductions (tons/yr)
Annual surplus emission reductions by pollutant (tons/yr) = annual emissions for thebaseline technology (tons/yr) – annual emissions for the reduced technology (tons/yr)

Annual NOx surplus emission reductions (tons/yr)
= 0.1695 (tons/yr) - 0.0073 (tons/yr) = 0.1622 tons/yr

Annual ROG surplus emission reductions (tons/yr)
=0.0076 (tons/yr) - 0.0046 (tons/yr) = 0.0030 tons/yr

(3) Calculate annual weighted surplus emission reductions (weighted tons/yr):

Formula C-3: Annual weighted surplus emission reductions (weighted tons/yr)
Weighted emission reductions (weighted tons/yr) = NOx reductions (tons/yr) + ROGreductions (tons/yr) + (20 * PM reductions (tons/yr))

Annual weighted surplus emission reductions (weighted tons/yr)
= 0.1622 (tons/yr NOx) + 0.0030 (tons/yr ROG)
= **0.1652 weighted tons/yr**

(c) <u>Determine the maximum grant amount:</u>

(1) Potential grant amount at the $200,000 cost-effectiveness limit ($):

Formula C-1: Potential grant amount at the cost-effectiveness limit ($)
*Potential grant amount ($) = cost-effectiveness limit ($/ton) ***
estimated annualemission reductions (weighted tons/yr) / CRF

Potential grant amount = 200,000 ($/ton) * 0.1652 (tons/yr) / 0.149 = <u>$221,745</u>

(2) Potential grant amount based on maximum percentage of eligible cost ($):

Formula C-14: Potential grant amount based on maximum percentage of eligible cost($)
*Potential grant amount ($) = cost of reduced technology ($) * maximum percentageof eligible cost*

Potential grant amount = $250,000 * 50% = <u>$125,000</u>

(3) Potential grant amount at the funding cap when applicable:

On-road CNG HHD Truck (Table 4-6)
Potential grant amount = <u>$160,000</u>

The lowest result of the three calculations above is the maximum grant amount:

<u>**Maximum grant amount:**</u> This project qualifies for up to <u>**$125,000**</u> in grant funds