TEXAS EMISSIONS REDUCTION PLAN (TERP)
Emissions Reduction Incentive Grants Program

Technical Supplement No. 3
Marine Vessels

Revised: May 2018

Texas Commission on Environmental Quality (TCEQ)
Air Quality Division
Implementation Grants Section, MC-204
P.O. Box 13087
Austin, Texas 78711-3087
1-800-919-TERP (8377)

www.terpgrants.org

TECHNICAL SUPPLEMENT NO. 3
MARINE VESSELS

Summary

This supplement contains instructions and inputs to calculate nitrogen oxides (NO_X) reductions for qualifying activities under the Texas Commission on Environmental Quality (TCEQ) Texas Emissions Reduction Plan (TERP), Emissions Reduction Incentive Grants (ERIG) Program. The project categories may include new purchases and leases, replacement, repower, retrofit, and add-on activities.

Marine vessels and engines equal to or greater than 25 horsepower (hp) are eligible for grants under this program. Most of the activities eligible under this program will be powered by diesel-fueled compression-ignition engines. However, engines powered by other fuels may also be eligible, subject to decisions by the TCEQ for particular funding periods and geographic areas. If the activity being proposed involves a gasoline, liquified petroleum gas (LPG), liquefied natural gas (LNG) or compressed natural gas (CNG) powered marine vessel contact TCEQ for appropriate emission factors.

The United States Environmental Protection Agency's (EPA) marine engine emissions regulations are divided into three categories (1, 2, and 3) based on engine displacement per cylinder measured in liters (L). Most marine vessel activities that will be funded under the ERIG program include Category 1 and 2 engines, including both propulsion engines and auxiliary engines. For Category 3 engines (primarily ocean-going vessels) contact the TCEQ for eligibility.

There is a worksheet provided at the end of this supplement that may be used to calculate the NO_X emissions reductions and the cost-effectiveness of the activities proposed in your application. The TCEQ also provides an electronic calculator in Excel format that may be used for the calculations. The calculator and information about the grant application process will be available on the TERP website at <www.terpgrants.org>.

Before you begin the calculation steps, review the conversion information below to understand units of measure and engine categorties according to displacement.

Engine Measurement Unit Conversion

Marine vessel engine power can be measured in either horsepower (hp) or kilowatts (kW). For consistency purposes, calculations for NO_X reductions use horsepower.

To convert kW into horsepower, multiply the kW by 1.341.

1 kW = 1.341 hp
1 hp = 0.746 kW

Example: Convert to hp, the power rating of an engine that has a maximum continuous rated (MRC) power of 450 kW.

450 kW x 1.341 hp/kW = 603.5 hp

Engine emission standards may also be converted by using these factors:

1 g/kWh = 0.746 g/hp-hr

1 g/hp-hr = 1.341 g/kWh

Example: Convert the emissions standard of an engine listed as 10.5 g/kw-hr, to g/hp-hr.

10.5 g/kWh x 0.746 = 7.8 g/hp-hr

Engine Displacement Categories

Marine vessel engine categories are determined by cylinder displacement in Liters (L) per cylinder. To determine the baseline engine category; divide total engine displacement by the number of cylinders and reference Table 3.1 below. Marine emission standards apply to marine engines with output greater than or equal to (≥) 37kW (50hp). Marine engines with output less than 37kW must comply with the non-road emission standards.

Table 3.1 Engine Displacement Categories

Category	Engine Displacement (D) in Liters per Cylinder	
	Tier 1-2	**Tier 3-4**
1	D < 5.0L	D < 7.0L
2	5.0L ≤ D < 30.0L	7.0L ≤ D < 30.0L
3	D ≥ 30.0L	

Category 1 and 2 engines are generally used to power small to medium sized vessels and have an output that ranges up to approximately 11,000 hp. These engines are typically used for propulsion in commercial working vessels like tugboats, push boats, fishing boats, and dredges in and around harbors. Category 3 engines are for much larger ocean going vessels and have hp ranging from 11,000 hp up to 100,000 hp. Category 3 engines may be considered for a grant on a case by case basis. If you have a Category 3 engine, please contact the TERP program personnel directly for consideration.

This worksheet is divided into three major steps.

Step 1: Determining that the activity meets the 25% NOx emissions reduction requirement using baseline (old) and reduced (new) emissions standards.

Step 2: Calculating the NOx Emission Reductions.

Step 3: Calculating the Cost Per Ton.

These steps are explained in the following instructions. You should refer to the worksheet and use the instructions to complete each step of the calculations. These steps generally follow the calculations used in the available Excel calculator. However, be sure to follow the instructions provided with that calculator.

Step 1: Determine if the activity meets the 25% NO_x emissions reduction requirement.

All new purchase or lease, replacement, repower, retrofit, and add-on activities must achieve at least a 25% reduction in NO_x emissions when compared to a baseline emission rate. Worksheet MA-1 may be used to determine if your activity meets the minimum emission reduction requirements.

Baseline NO_x Emission Rate

To determine the default baseline NO_x emission rate for your engine, use the certified manufacturer's emission rate if available. Using the engine information, look up the NO_x emissions factors in the following tables and include it in your worksheet. Baseline engine and emissions information required for your application should be found on the emissions label located on the engine.

For marine engines with uncontrolled emissions (engines with a model year 2003 or older) use the default emission factors presented in Tables 3.1 or 3.2.

Tier 1 NO_x emission standards were voluntary under the EPA 1999 rule and are equivalent to the International Maritime Organization (IMO) MARPOL Annex VI requirements. If the engine is IMO compliant, then the IMO emission standard can be calculated using the information presented in Table 3.3. If your engine was certified to EPA voluntaryTier 1 or IMO standards, please contact TCEQ for assistance in determining the appropriate baseline NO_X emission factor.

Tier 2, 3, and 4 NO_x emission standards are presented below in Table 3.4, based on the power density (standard or high power), displacement in liters per cylinder (L/cyl), and the effective date of the emission standard. Most engines will have a standard power density, considered less or equal to 35 kW/L (47 hp/L). High power density engines will have a power rating greater than 35 kW/L. Vessels with high power density engines are generally high speed vessels. Discuss with TCEQ staff if you are unsure of the power density of your engine(s), as that will make a difference in the emission standards you use. The TCEQ will use the engine family code to confirm the emission standard applicable to the engine.

Most newer auxiliary engines will be certified under the EPA marine engine emission standards, depending upon the extent to which the engine components and frame are integrally connected to the vessel. For those auxiliarly engines not certified as a marine engine, use the non-road engine emission standards in Technical Supplement No. 2.

Table 3.1 Default NOx Emission Factors for Category 1 Uncontrolled Engines

Power Range (hp)	NOx g/kW-hr	NOx g/bhp-hr
50 - 101	13.4	**10**
102 - 1340	13.4	**10**
1341 +	13.4	**10**

Table 3.2 Default NOx Emission Factors for Category 2 Uncontrolled Engines [g/bhp-hr (g/kW-hr)]

Age	2-Stroke	Turbo(2-S)	4-Stroke	Turbo(4-S)
Pre-1980	**14.0** (18.77)	**11.0** (14.75)	**8.0** (10.73)	**7.0** (9.39)
1980+	**8.0** (10.73)	**7.0** (9.39)	**7.0** (9.39)	**6.0** (8.05)

Table 3.3 Category 1 & 2 Marine Vessel IMO NOx Emission Standards

Engine Speed (N)	NOx (g/bhp-hr)
N < 130	12.7
130 < N < 2000	$(45 * N^{-0.2}) * 0.746$ = 12.7 at 130 rpm and 7.3 at 1999 rpm
N = 2000+	7.3

Example: engine with an engine speed of 1,500 rpm.
$45 \times 1{,}500^{-0.2} = 10.423$ g/kw-hr
10.423 g/kw-hr x 0.746 bhp/kw = ***7.776 g/bhp-hr***

Table 3.4 Marine Vessel EPA Tier 2, 3, and 4 NOx Emission Standards (starting with 2011)

Category 1 <75kW Standard Power Density See note 3

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9 (<19kW)	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	7.5	7.125	5.6	5.32
	2015	7.5	7.125	5.6	5.32
	2016	7.5	7.125	5.6	5.32
	2017	7.5	7.125	5.6	5.32
	2018	7.5	7.125	5.6	5.32
	2019	7.5	7.125	5.6	5.32
<0.9 (19-<75kW) See note 2:	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	4.7	4.465	3.5	3.325
	2015	4.7	4.465	3.5	3.325
	2016	4.7	4.465	3.5	3.325
	2017	4.7	4.465	3.5	3.325
	2018	4.7	4.465	3.5	3.325
	2019	4.7	4.465	3.5	3.325

Category 1 75-600kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.4	5.13	4.0	3.8
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	5.4	5.13	4.0	3.8
	2017	5.4	5.13	4.0	3.8
	2018	5.4	5.13	4.0	3.8
	2019	5.4	5.13	4.0	3.8
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	5.4	5.13	4.0	3.8
	2017	5.4	5.13	4.0	3.8
	2018	5.4	5.13	4.0	3.8
	2019	5.4	5.13	4.0	3.8
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	5.6	5.32	4.2	3.99
	2017	5.6	5.32	4.2	3.99
	2018	5.6	5.32	4.2	3.99
	2019	5.6	5.32	4.2	3.99
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.6	5.32	4.2	3.99
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	5.6	5.32	4.2	3.99
	2017	5.6	5.32	4.2	3.99
	2018	5.6	5.32	4.2	3.99
	2019	5.6	5.32	4.2	3.99

Category 1 75-600kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	5.8	5.51	4.3	4.085
	2018	5.8	5.51	4.3	4.085
	2019	5.8	5.51	4.3	4.085

Category 1 600-<1400kW Standard Power Density See note 4:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.4	5.13	4.027	3.825
	2013	5.4	5.13	4.027	3.825
	2014	5.4	5.13	4.027	3.825
	2015	5.4	5.13	4.027	3.825
	2016	5.4	5.13	4.027	3.825
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	5.4	5.13	4.0	3.8
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	5.6	5.32	4.2	3.99
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 600-<1400kW Standard Power Density See note 4:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.6	5.32	4.2	3.99
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	5.6	5.32	4.2	3.99
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 1400-<2000kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.4	5.13	4.027	3.825
	2013	5.4	5.13	4.027	3.825
	2014	5.4	5.13	4.027	3.825
	2015	5.4	5.13	4.027	3.825
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 1400-<2000kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.6	5.32	4.2	3.99
	2014	5.6	5.32	4.2	3.99
	2015	5.6	5.32	4.2	3.99
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 2000-<3700kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 2000-<3700kW Standard Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2013	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 2 <3700kW Standard Power Density See note 5:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
7.0-<15.0	Tier 2 - 2011	7.8	7.41	5.8	5.51
	2012	7.8	7.41	5.8	5.51
	2013	6.2	5.89	4.6	4.37
	2014	6.2	5.89	4.6	4.37
	2015	6.2	5.89	4.6	4.37
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
15.0-<20.0 (<3300kW)	Tier 2 - 2011	8.7	8.265	6.5	6.175
	2012	8.7	8.265	6.5	6.175
	2013	8.7	8.265	6.5	6.175
	2014	7.0	6.65	5.2	4.94
	2015	7.0	6.65	5.2	4.94
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
15.0-<20.0 (≥3000kW)	Tier 2 - 2011	9.8	9.31	7.3	6.935
	2012	9.8	9.31	7.3	6.935
	2013	9.8	9.31	7.3	6.935
	2014	8.7	8.265	6.5	6.175
	2015	8.7	8.265	6.5	6.175
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
20.0-<25.0	Tier 2 - 2011	9.8	9.31	7.3	6.935
	2012	9.8	9.31	7.3	6.935
	2013	9.8	9.31	7.3	6.935
	2014	9.8	9.31	7.3	6.935
	2015	9.8	9.31	7.3	6.935
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 2 <3700kW Standard Power Density See note 5:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
25.0-<30.0	Tier 2 - 2011	11.0	10.45	8.2	7.79
	2012	11.0	10.45	8.2	7.79
	2013	11.0	10.45	8.2	7.79
	2014	11.0	10.45	8.2	7.79
	2015	11.0	10.45	8.2	7.79
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 2 ≥3700kW Standard Power Density See note 5:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<15.0	Tier 2 - 2011	7.8	7.41	5.8	5.51
	2012	7.8	7.41	5.8	5.51
	2013	7.8	7.41	5.8	5.51
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
≥15.0	Tier 2 - 2011	7.8	7.41	5.8	5.51
	2012	7.8	7.41	5.8	5.51
	2013	7.8	7.41	5.8	5.51
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 <75kW High Power Density See note 3:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9 (<19kW)	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	7.5	7.125	5.6	5.32
	2015	7.5	7.125	5.6	5.32
	2016	7.5	7.125	5.6	5.32
	2017	7.5	7.125	5.6	5.32
	2018	7.5	7.125	5.6	5.32
	2019	7.5	7.125	5.6	5.32

Category 1 <75kW High Power Density See note 3:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9 (19-<75kW) See note 2:	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	4.7	4.465	3.5	3.325
	2015	4.7	4.465	3.5	3.325
	2016	4.7	4.465	3.5	3.325
	2017	4.7	4.465	3.5	3.325
	2018	4.7	4.465	3.5	3.325
	2019	4.7	4.465	3.5	3.325

Category 1 75-600kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	5.8	5.51	4.3	4.085
	2018	5.8	5.51	4.3	4.085
	2019	5.8	5.51	4.3	4.085
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	5.8	5.51	4.3	4.085
	2018	5.8	5.51	4.3	4.085
	2019	5.8	5.51	4.3	4.085
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	5.8	5.51	4.3	4.085
	2018	5.8	5.51	4.3	4.085
	2019	5.8	5.51	4.3	4.085

Category 1 75-600kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	5.8	5.51	4.3	4.085
	2018	5.8	5.51	4.3	4.085
	2019	5.8	5.51	4.3	4.085
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.4	5.13	4.0	3.8
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	5.4	5.13	4.0	3.8
	2017	5.4	5.13	4.0	3.8
	2018	5.4	5.13	4.0	3.8
	2019	5.4	5.13	4.0	3.8

Category 1 600-<1400kW High Power Density See note 4:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 600-<1400kW High Power Density See note 4:

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	5.8	5.51	4.3	4.085
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.4	5.13	4.0	3.8
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	5.4	5.13	4.0	3.8
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 1400-<2000kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	5.8	5.51	4.3	4.085
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 1400-<2000kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	5.8	5.51	4.3	4.085
	2014	5.8	5.51	4.3	4.085
	2015	5.8	5.51	4.3	4.085
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	5.4	5.13	4.0	3.8
	2013	5.4	5.13	4.0	3.8
	2014	5.4	5.13	4.0	3.8
	2015	5.4	5.13	4.0	3.8
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 2000-<3700kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
<0.9	Tier 2 - 2011	7.5	7.125	5.6	5.32
	2012	7.5	7.125	5.6	5.32
	2013	7.5	7.125	5.6	5.32
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
0.9-<1.2	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
1.2-<2.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235
2.5-<3.5	Tier 2 - 2011	7.2	6.84	5.4	5.13
	2012	7.2	6.84	5.4	5.13
	2013	7.2	6.84	5.4	5.13
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Category 1 2000-<3700kW High Power Density

Displacement L/cyl	Effective date	NOx + HC (g/kW-hr)	NOx (g/kW-hr)	NOx + HC (g/bhp-hr)	NOx (g/bhp-hr) See note 1:
3.5-<7.0	Tier 2 - 2011	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2012	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2013	7.2/7.8	6.84/7.41	5.4/5.8	5.13/5.51
	2014	1.8	1.71	1.3	1.235
	2015	1.8	1.71	1.3	1.235
	2016	1.8	1.71	1.3	1.235
	2017	1.8	1.71	1.3	1.235
	2018	1.8	1.71	1.3	1.235
	2019	1.8	1.71	1.3	1.235

Notes:
1) ***Use NOx g/bhp-hr column for calculations.*** *Other columns are for reference only.*
2) Option for 19-75 kW starting in 2004. 5.8 g/kW-hr and 4.3 g/hp-hr for NOx+HC.
3) Any <75kW engine with a displacement above 0.9L/cyl are subject to corresponding 75-600kW standards.
4) Manufacturers may delay compliance within indicated 2017 compliances model years to 10/1/2017 for 600-1000 kW
5) Option for C2: Tier 3 7.8 g/kW-hr and 5.8 g/hp-hr in 2012 and Tier 4 in 2015.

Determine Reduced NO_x Emission Rate

The reduced NO_x emission rate will normally be the certified or verified emissions of the new reduced-emission vehicle or engine.

New Purchase or Lease. Use the certified emission rate (g/bhp-hr) of the new marine vessel. Certified means certified by the EPA or CARB, or otherwise accepted by the TCEQ.

Replacement. Use the certified emission rate (g/bhp-hr) of the replacement vessel and engine. In most cases, you should use the federal NOx emission standard for that model year and category of the vessel and engine. However, if the engine is certified to a lower emissions level, you may use that rate, subject to approval by the TCEQ. Certified means certified by the EPA or CARB, or otherwise accepted by the TCEQ.

Repower. Use the certified emission rate (g/bhp-hr) of the engine to be installed on the vessel. In most cases, you should use the federal NOx emission standard for that model year and category of the vessel and the replacement engine. However, if the engine is certified to a lower emissions level, you may use that rate, subject to approval by the TCEQ. Certified means certified by the EPA or CARB, or otherwise accepted by the TCEQ.

Retrofit/Add-on. Use the verified or certified emission rate (g/bhp-hr) or emission reduction percentage for the retrofit or add-on device. The emission reductions must be verified or certified by the EPA or CARB, or otherwise accepted by the TCEQ.

Calculate NO_x Emission Reductions

Use the baseline NOx emission standard from tables for the appropriate year of the baseline emission engine year and the reduced emission engine, and input them into the NOx emission

reduction equation below to determine the percent reduction of emissions from the baseline emission engine.

[(Baseline Engine - Reduced Engine) / Baseline Engine]
x 100 = Baseline Emission Rate Reduction Percentage

Step 2: Calculate the NO_x Emission Reductions

This step is divided into three main parts:

Part A: Determine the TxLED Correction Factor

Part B: Determine the NO_x emission factors

Part C: Calculate the NO_x emission reductions

Points to remember when performing Emission Reduction Calculations

- Emission reduction represents the difference in the emission level of a baseline (old) engine and a (new) reduced-emission engine.
- The emission level is calculated by multiplying an emission factor, an activity level, and a conversion factor, if necessary.
- In situations where the model year of the vessel/equipment/chassis and the model year of the existing engine are different, the engine model year shall be used to determine the baseline emissions for grant calculations.
- Because conversion factors and the activity levels may be expressed in different units for the existing and replacement engines, the emission levels for the baseline and reduced-emission engines should be calculated separately and then differences taken to determine emission reductions.
- For marine applications, the activity level should be established by the annual hours of engine operation.
- If the equipment operates in a county or counties that is in the TxLED region the TxLED conversion factor must be applied.

Part A: Determine the TxLED Correction Factor

The TCEQ has adopted rules (30 TAC '114.312 - '114.319) requiring that beginning on October 1, 2005, diesel fuel produced for use in compression-ignition engines in certain counties in Texas must meet new low emission diesel (TxLED) standards.

The counties affected by the new TxLED requirements currently include all of the counties eligible for TERP incentive funding, as listed in the *Guidelines*, except for El Paso County.

The TxLED requirements set a maximum aromatic hydrocarbon content standard of 10 percent by volume per gallon. The requirements also set a minimum cetane number for TxLED of 48.

The TxLED requirements are intended to result in reductions in NO_x emissions from diesel engines. Currently, a reduction factor **of 5.7%** (0.057) for on-road use and **7.0%** (0.07) for non-road use and has been accepted as an estimate for use of TxLED. However, this reduction estimate is subject to change, based on the standards accepted by the EPA for use in the Texas State Implementation Plan (SIP).

For activities in the applicable counties (does not include El Paso County), a correction factor of **0.93** will need to be applied when calculating the baseline and/or reduced emissions for diesel engines, regardless of when the grant-funded equipment began or will begin operation.

Part B. Determine the NO_x Emission Factors

To complete the calculation of the NO_x emission reductions for the activity, you must convert the NO_x emission rates (g/bhp-hr) to a NO_x emission factor. For most types of equipment, the NO_x emission reduction factors should be based on annual hours of operation.

You should consult with the TCEQ to determine the factors to use for non-diesel engines, or if you wish to use a different conversion factor.

Most commercial marine vessels have two propulsion engines. For projects that involve a new purchase/lease or replacement, both propulsion engines emission reductions need to be determined. There is a column in the worksheet for engine 1 and engine 2. For other projects that involved only one engine, complete only one column.

For calculation based on annual hours of operation, the engine NO_X emission standard in g/bhp-hr is converted to a NO_X emission factor expressed in g/hr by multiplying it by the engine horsepower (hp). The default load factor, provided in Table 3.8, must also be included in the calculation to account for the fraction of the maximum available engine's power actually used. This conversion must be applied to the NO_X emission standard for the baseline engine and for the reduced emission engine.

Table 3.8 Default Load Factors for Category 1 & 2 Marine Engines

Power Range (hp)	Load Factors	
	Propulsion	Auxiliary
All	0.43	0.65

Part C. Calculate the NO_x Emission Reductions

Use the factors determined in Part B to calculate the NO_x emission reductions for the activity. To complete the calculations, you will need to determine the estimated annual hours of operation.

The TCEQ provides the default usage rates for some types of projects in lieu of determining the usage specific to each particular vehicle or piece of equipment. Refer to the Request for Grant Applications (RFGA) for instructions and requirements on the default usage options.

Where a default usage rate option is used, the applicable default usage rates should be used for the emissions reduction calculations. Refer to the instructions in the RFGA for determining the usage rate to enter in the application where a default usage rate is not used.

The default usage rates for marine vessels are listed in Table 3.9 below. Please note that the marine vessel must be powered by engines of at least 25 horsepower (hp). Also, vessels used primarily for competition or recreation are not eligible for funding.

The TCEQ will make a final decision regarding the type of vessel, based on its primary use. In particular, a vessel configured as a tug or towboat, but not used exclusively for towing or pushing barges and other vessels, may be considered a general work board and assigned the lower default usage rate of 1,000 hours per year. In other cases, the TCEQ may assign a usage rate between the rates listed to account for vessels that may be used in multiple capacities.

Table 3.9 Default Usage Rates for Marine Vessels

Vessel Type	Main Engine (annual hours)	Auxiliary Engine (annual hours)
Assist Tug	3,000	3,000
Towboat	3,000	3,000
Pilot Boat	3,000	3,000
Dredge	2,000	2,000
General Work Boat, Fishing, Excursion, Government and other Commercial Vessels	1,000	1,000

You must also enter the percentage of annual usage that will occur within the eligible counties. For marine vessels, eligible operation must occur within the coastal county lines, approximately 3 leagues (10.35 miles) offshore. At least 75% of the annual usage must be projected to occur within those counties. A primary area will need to be identified in the project application form, this will normally be where the vessel is moored when not in use. Activities to be operated in different primary areas will need to be submitted in separate applications.

Finally, to complete the calculations, you will need to designate an activity life. This will be the number of years used to calculate the emission reductions. If awarded the grant, you must commit to operating the equipment within the eligible counties for this time period, and to track and report on that use.

Activity life may not exceed the life of the marine vessel or the maximum useful life. Table 3.10 list the maximum grant activity life for marine vessels. For example a Category 1 engine that is purchased new and has documentation that the Category 1 engine has a useful life of 20 years, is only eligible for a 16 year activity life. The applicant must also commit to using the marine vessel in the eligible counties during the TERP activity life of the marine vessel. Requests for longer activity life will require documentation justifying request, such as ships logs. An example calculation is provided below.

Table 3.10 Maximum Activity Life Marine Vessel Activities

Engine Category	Minimum Activity Life	Maximum Activity Life
New Purchase, Lease, Repower, or Retrofit/Add-On Activity		
Category 1 Engines	5 years (including lease)	10 years
Category 2 Engines	5 years (including lease)	10 years
Auxiliary Engines (Categories 1 & 2)	5 years (including lease)	10 years
Replacement Activity (all engine categories)	5 years	10 years

Step 3. Calculate Cost Per Ton

The cost per ton for an activity is then determined by dividing the requested grant amount for that activity by the total NO_x emission reductions for that activity.

For multi-activity projects, the cost per ton of the complete project is determined by dividing the requested grant amount for the entire project by the total NO_x emission reductions for all of the activities included in that project.

Requested Grant Amount / Total NO_x Emission Reductions = Cost Per Ton of NO_x Reduced

MR-1 Marine Vessels -- Hours of Operation

Please fill in the following information. This information will help you with your calculations

Base Information

Type of project ☐ New Purchase/Lease ☐ Repower ☐ Replacement ☐ Retrofit/Add-on

What is the activity life of the project in years?	
What are/how many hours of Default Usage for this marine vessel?	
What is the percent time the equipment is in the eligible counties?	
What is the requested grant amount for the activity?	

Baseline Engine Information

Model Year	
Fuel Type	
Marine Engine Category *(Table 3.1)*	
Horsepower (hp)	
Emission Standard (g/bhp-hr)	
Load Factor (propulsion .43, auxiliary .65)	

New Engine Information

Model Year	
Fuel Type	
Marine Engine Category *(Table 3.1)*	
Horsepower (hp)	
Emission Standard (g/bhp-hr)	
Load Factor (propulsion .43, auxiliary .65)	
If the activity is a retrofit/add-on, is there a verified percentage NO_x emission reduction?	%

Step 1: Does this project meet the 25% NO_x baseline emission rate reduction requirements?

Baseline Engine Emission Standard (g/bhp-hr)	
- New Engine Emission Standard (g/bhp-hr)	
= Difference (g/bhp-hr)	
/ Baseline Engine Emission Standard (g/bhp-hr)	
x	100
= Emission Rate Reduction	

Step 2: What are your NO_x emission reductions?

Part A. Calculate the TxLED Correction Factor (all areas except for El Paso County)

Marine TxLED Correction Factor 1 - (0.07)	0.93

Part B. Determine the NO_x Emission Factor

Determine Baseline NO_x Emission Factor (g/hour)	**Engine 1**	**Engine 2**
baseline engine NO_x emission standard (g/bhp-hr)		
x TxLED correction factor (diesel engines only)		
= corrected NO_x emission factor (g/bhp-hr)		
x load factor		
x horsepower (hp)		
= baseline NO_x emission factor (g/hr)		
Determine Reduced NO_x Emission Factor (g/hour)		
OPTION A. REDUCED-EMISSION ENGINE CERTIFIED TO A SPECIFIC EMISSIONS STANDARD (G/BHP-HR)		
reduced engine NO_x emission standard (g/bhp-hr)		
x TxLED correction factor (diesel engines only)		
= corrected NO_x emission factor (g/bhp-hr)		
x load factor		
x horse power (hp)		
=reduced NO_x emission factor (g/hr)		

OPTION B. REDUCED-EMISSION TECHNOLOGY CERTIFIED/VERIFIED TO ACHIEVE A PERCENTAGE REDUCTION FROM THE BASELINE.		
Baseline NO_x emission factor (g/hr)		
x certified/verified percentage reduction from baseline		
= reduced NO_x emission factor (g/hr)		

Part C. Calculate the NOx Emission Reduction Using Annual Hours of Operation

baseline NO_x emission factor(g/hr)		
- reduced NO_x emission factor (g/hr)		
= grams per hour reduced (g/hr)		
x annual hours of operation (hr/yr)		
x percent within affected counties (%)		
= grams per year reduced (g/yr)		
/ 907,200 (g/ton)		
= estimated annual NO_x emission reduction (tons/yr)		

Engine 1 + Engine 2 annual NO_x emission reduction (ton/yr)	
x activity life (yr)	
= estimated activity life NO_x emission reduction (tons)	

Step 3: What is the activity cost per ton?

Requested activity amount ($):	
/ NO_x emission reductions (tons):	
= cost per ton ($/ton)	