Texas Commission on Environmental Quality (TCEQ)

Texas Emissions Reduction Plan (TERP)

Emission Reduction Incentive Grants (ERIG) Program

Technical Supplement for Marine Vessels

Revised - January 2023

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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 replacement, repower, retrofit, and add-on activities. Please refer to the current Request for Grant Applications (RFGA) for a definitive list of eligible project categories.

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. 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 an application. The TCEQ also provides a web-based calculator 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 beginning the calculation steps, review the conversion information below to understand units of measurement that will be used in this technical supplement.

Energy Measurement and 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 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 displacement in Liters (L) per cylinder. To determine the baseline engine category; divide the total engine displacement by the number of cylinders and reference Table 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 (See the Non-Road and Stationary Engine Technical Supplement).

Table 1 - Engine Displacement Categories

Engine Category	Tier 1-2 Engines[1]	Tier 3-4 Engines[1]
1	D[1] < 5.0L	D < 7.0L
2	5.0L ≤ 30.0L	7.0L ≤ 30.0L
3	D ≥ 30.0L	

[1]Engine tiers as defined in 40 CFR 1042 – Control of Emissions from New and In-Use Marine Compression-Ignition Engines and Vessels.
[2]D is engine displacement in liters per cylinder.

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. Applicants with a Category 3 engine should contact TERP prior to applying.

This technical supplement 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 NO_X Emission Reductions.

Step 3: Calculating the Cost Per Ton.

These steps are explained in the following instructions. Applicants may use the worksheet found at the end of this technical supplement to compute the emissions reductions and cost per ton for their application. Applicants may instead use the available web-based calculator available at www.terpgrants.org which will also refer to this technical supplement.

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

All activities must achieve at least a 25% reduction in NO_x emissions when compared to a baseline emission rate.

Baseline NO_X Emission Rate

To determine the default baseline NO_x emission rate for an engine, first determine the model year of the engine. If the engine is 2003 or older and does not comply with an International Maritime Organization (IMO) or Environmental Protection Agency (EPA) emission rate, use Tables 2 and 3 to determine the default uncontrolled emission rate for that engine.

Tier 1 NOx emission standards were voluntary under the EPA 1999 rule and are equivalent to the IMO MARPOL Annex VI requirements. If the engine is IMO compliant or is subject to the EPA Tier 1 standards starting with model year 2004 engines then Table 4 can be used to calculate the emission standard for that engine.

Tier 2, 3, and 4 NO_x emission standards are presented below in Table 5, based on the engine category (See Table 1) and power density of the engine. 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. Additional information about the engine will be needed to determine the emission standard for engines using Table 5. This information includes the following: displacement in liters per cylinder (L/cyl), the model year of the engine, and the power of the engine (hp or kW).

For Tier 2, 3 and 4 engines, the TCEQ will use the engine family code (EFC) of that engine to confirm the emission standard applicable to that engine. This is a 12-digit code that should be printed on the engine plate or be available via the engine manufacturer. Applicants may verify the emission standard of an engine by looking this code up on the EPA's website. Please be aware that some engines may have a Family Emission Limit (FEL) which may be different than the standard emission rate. If an engine has an FEL, the TCEQ will use that value as it is the emission standard applicable to that 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 auxiliary engines not certified as a marine engine, use the non-road engine emission standards in the Technical Supplement for Non-Road and Stationary Engines.

Table 2 – Default NO_x Emission Factors for Category 1 Uncontrolled Engines

Power Range (hp)	Emission Rate (g/kW-hr)	Emission Rate (g/bhp-hr)
50 – 1341+	13.4	10

Table 3 – Default NO_x Emission Factors for Category 2 Uncontrolled Engines (g/bhp-hr)

Age	2-Stroke	Turbo (2-Stroke)	4-Stroke	Turbo (4-Stroke)
Pre-1980	14.0	11.0	8.0	7.0
1980+	8.0	7.0	7.0	6.0

Table 4 – Category 1 & 2 Marine Vessel IMO NO_x Emission Standards (Tier 1 Standards)

Maximum In-Use Engine Speed in RPM (N)	NO_x (g/bhp-hr)
N < 130	12.7
130 < N < 2000	$(45 * N^{-0.2}) * 0.746$
N = 2000+	7.3

Note: The Tier 1 Standard for vessels with a rated power of 19 to 37 kW is 6.73 g/bhp-hr (9.5 g/kW-hr).

Table 5 – Category 1 & 2 EPA Tier 2, 3, and 4 NO_x Emission Standards

Category 1 Vessels – Standard Power Density

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
19kW – 36kW 25hp – 49hp	<0.9	2004-2013	5.32	7.13	5.6	7.5
19kW – 36kW 25hp – 49hp	<0.9	2014+	3.33	4.465	3.51	4.7
37kW – 74kW 50hp – 99hp	<0.9	2005-2013	5.32	7.13	5.6	7.5
37kW – 74kW 50hp – 99hp	<0.9	2014+	3.33	4.465	3.51	4.7
75kW – 599kW 100hp – 804kW	<0.9	2005-2011	5.32	7.13	5.6	7.5
75kW – 599kW 100hp – 804kW	<0.9	2012+	3.83	5.13	4.03	5.4
75kW – 599kW 100hp – 804kW	0.9 ≤ D < 1.2	2004-2012	5.10	6.84	5.37	7.2
75kW – 599kW 100hp – 804kW	0.9 ≤ D < 1.2	2013+	3.83	5.13	4.03	5.4
75kW – 599kW 100hp – 804kW	1.2 ≤ D < 2.5	2004-2013	5.10	6.84	5.37	7.2
75kW – 599kW 100hp – 804kW	1.2 ≤ D < 2.5	2014+	3.97	5.32	4.18	5.6
75kW – 599kW 100hp – 804kW	2.5 ≤ D < 3.5	2007-2012	5.10	6.84	5.37	7.2
75kW – 599kW 100hp – 804kW	2.5 ≤ D < 3.5	2013+	3.97	5.32	4.18	5.6
75kW – 599kW 100hp – 804kW	3.5 ≤ D < 7.0	2007-2011	5.10 5.53	6.84 7.41	5.37 5.82	7.2 7.8 (D≥5)
75kW – 599kW 100hp – 804kW	3.5 ≤ D < 7.0	2012+	4.11	5.51	4.33	5.8
600kW – 1399kW 805hp – 1876hp	<0.9	2005-2011	5.32	7.13	5.6	7.5
600kW – 1399kW 805hp – 1876hp	<0.9	2012-2016	3.83	5.13	4.03	5.4

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
600kW – 1399kW 805hp – 1876hp	<0.9	2017+	1.28	1.71	1.34	1.8
600kW – 1399kW 805hp – 1876hp	0.9 ≤ D < 1.2	2004-2012	5.10	6.84	5.37	7.2
600kW – 1399kW 805hp – 1876hp	0.9 ≤ D < 1.2	2013-2016	3.83	5.13	4.03	5.4
600kW – 1399kW 805hp – 1876hp	0.9 ≤ D < 1.2	2017+	1.28	1.71	1.34	1.8
600kW – 1399kW 805hp – 1876hp	1.2 ≤ D < 2.5	2004-2013	5.10	6.84	5.37	7.2
600kW – 1399kW 805hp – 1876hp	1.2 ≤ D < 2.5	2014-2016	3.97	5.32	4.18	5.6
600kW – 1399kW 805hp – 1876hp	1.2 ≤ D < 2.5	2017+	1.28	1.71	1.34	1.8
600kW – 1399kW 805hp – 1876hp	2.5 ≤ D < 3.5	2007-2012	5.10	6.84	5.37	7.2
600kW – 1399kW 805hp – 1876hp	2.5 ≤ D < 3.5	2013-2016	3.97	5.32	4.18	5.6
600kW – 1399kW 805hp – 1876hp	2.5 ≤ D < 3.5	2017+	1.28	1.71	1.34	1.8
600kW – 1399kW 805hp – 1876hp	3.5 ≤ D < 7.0	2007-2011	5.10 5.53	6.84 7.41	5.37 5.82	7.2 7.8 (D≥5)
600kW – 1399kW 805hp – 1876hp	3.5 ≤ D < 7.0	2012-2016	4.11	5.51	4.33	5.8
600kW – 1399kW 805hp – 1876hp	3.5 ≤ D < 7.0	2017+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 2681hp	<0.9	2005-2011	5.32	7.13	5.6	7.5
1400kW – 1999kW 1877hp – 2681hp	<0.9	2012-2015	3.83	5.13	4.03	5.4
1400kW – 1999kW 1877hp – 2681hp	<0.9	2016+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 2681hp	0.9 ≤ D < 1.2	2004-2012	5.10	6.84	5.37	7.2

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
1400kW – 1999kW 1877hp – 2681hp	0.9 ≤ D < 1.2	2013-2016	3.83	5.13	4.03	5.4
1400kW – 1999kW 1877hp – 2681hp	0.9 ≤ D < 1.2	2017+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 2681hp	1.2 ≤ D < 2.5	2004-2013	5.10	6.84	5.37	7.2
1400kW – 1999kW 1877hp – 2681hp	1.2 ≤ D < 2.5	2014-2015	3.97	5.32	4.18	5.6
1400kW – 1999kW 1877hp – 2681hp	1.2 ≤ D < 2.5	2016+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 2681hp	2.5 ≤ D < 3.5	2007-2012	5.10	6.84	5.37	7.2
1400kW – 1999kW 1877hp – 2681hp	2.5 ≤ D < 3.5	2013-2015	3.97	5.32	4.18	5.6
1400kW – 1999kW 1877hp – 2681hp	2.5 ≤ D < 3.5	2016+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 2681hp	3.5 ≤ D < 7.0	2007-2011	5.10 5.53	6.84 7.41	5.37 5.82	7.2 7.8 (D≥5)
1400kW – 1999kW 1877hp – 2681hp	3.5 ≤ D < 7.0	2012-2015	4.11	5.51	4.33	5.8
1400kW – 1999kW 1877hp – 2681hp	3.5 ≤ D < 7.0	2016+	1.28	1.71	1.34	1.8
2000kW – 3699kW 2682hp – 4960hp	<0.9	2005-2011	5.32	7.13	5.6	7.5
2000kW – 3699kW 2682hp – 4960hp	<0.9	2012-2013	3.83	5.13	4.03	5.4
2000kW – 3699kW 2682hp – 4960hp	<0.9	2014+	1.28	1.71	1.34	1.8
2000kW – 3699kW 2682hp – 4960hp	0.9 ≤ D < 1.2	2004-2012	5.10	6.84	5.37	7.2
2000kW – 3699kW 2682hp – 4960hp	0.9 ≤ D < 1.2	2013	3.83	5.13	4.03	5.4
2000kW – 3699kW 2682hp – 4960hp	0.9 ≤ D < 1.2	2014+	1.28	1.71	1.34	1.8

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
2000kW – 3699kW 2682hp – 4960hp	1.2 ≤ D < 2.5	2004-2013	5.10	6.84	5.37	7.2
2000kW – 3699kW 2682hp – 4960hp	1.2 ≤ D < 2.5	2014+	1.28	1.71	1.34	1.8
2000kW – 3699kW 2682hp – 4960hp	2.5 ≤ D < 3.5	2007-2012	5.10	6.84	5.37	7.2
2000kW – 3699kW 2682hp – 4960hp	2.5 ≤ D < 3.5	2013	3.97	5.32	4.18	5.6
2000kW – 3699kW 2682hp – 4960hp	2.5 ≤ D < 3.5	2014+	1.28	1.71	1.34	1.8
2000kW – 3699kW 2682hp – 4960hp	3.5 ≤ D < 7.0	2007- 2011	5.10 5.53	6.84 7.41	5.37 5.82	7.2 7.8 (D≥5)
2000kW – 3699kW 2682hp – 4960hp	3.5 ≤ D < 7.0	2012-2013	4.11	5.51	4.33	5.8
2000kW – 3699kW 2682hp – 4960hp	3.5 ≤ D < 7.0	2014+	1.28	1.71	1.34	1.8

Category 1 Vessels – High Power Density

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
75kW – 599kW 100hp – 804hp	<0.9	2012+	4.11	5.51	4.33	5.8
75kW – 599kW 100hp – 804hp	0.9 ≤ D < 1.2	2013+	4.11	5.51	4.33	5.8
75kW – 599kW 100hp – 804hp	1.2 ≤ D < 2.5	2014+	4.11	5.51	4.33	5.8
75kW – 599kW 100hp – 804hp	2.5 ≤ D < 3.5	2013+	4.11	5.51	4.33	5.8
75kW – 599kW 100hp – 804hp	3.5 ≤ D < 7.0	2012+	4.11	5.51	4.33	5.8

Note: Use the Category 1 Vessels – Standard Power Density table for high power density engines not covered here.

Category 2 Vessels – Standard Power Density - EPA Tier 2 Standards

Displacement (L/Cylinder)	Power	Start Year	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
5≤D<15	All	2007	5.53	7.41	5.82	7.8
15≤D<20	<3300kW <4425hp	2007	6.17	8.27	6.49	8.7
15≤D<20	≥3300kW ≥4425hp	2007	6.95	9.31	7.31	9.8
20≤D<25	All	2007	6.95	9.31	7.31	9.8
25≤D<30	All	2007	7.80	10.45	8.21	11.0

Category 2 Vessels – Standard Power Density - EPA Tier 3 Standards

Displacement (L/Cylinder)	Power	Start Year	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
7≤D<15	<2,000kW <2682hp	2013	4.39	5.89	4.63	6.2
7≤D<15	2000kW to 3699kW 2682hp to 4960hp	2013	5.53	7.41	5.82	7.8
15≤D<20	<2,000kW <2682hp	2014	4.96	6.65	5.22	7.0
20≤D<25	<2,000kW <2682hp	2014	6.95	9.31	7.31	9.8
25≤D<30	<2,000kW <2682hp	2014	7.80	10.45	8.21	11.0

Category 2 Vessels – Standard Power Density - EPA Tier 4 Standards

Power	Displacement (L/Cylinder)	Effective Year(s)	NO_x (g/bhp-hr)	NO_x (g/kW-hr)	NO_x + HC (g/bhp-hr)	NO_x + HC (g/kW-hr)
600kW – 1399kW 804hp – 1876hp	All	2017+	1.28	1.71	1.34	1.8
1400kW – 1999kW 1877hp – 268hp	All	2016+	1.28	1.71	1.34	1.8
2000kW – 3699kW 2681hp – 4960hp	All	2014+	1.28	1.71	1.34	1.8
≥3700kW 4961hp	All	2014+	1.28	1.71	1.34	1.8

Determine the Reduced NO_x Emission Standard

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

Replacement and Repower. Use the certified emission standard (g/bhp-hr) of the replacement engine. In most cases, an applicant should use the current NO_x emission standard for that model year and category of the vessel and engine. However, if the new engine is certain to be certified to a lower emissions standard (e.g., the engine will have an FEL), an applicant 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 certified or verified by the EPA or CARB, or otherwise accepted by the TCEQ.

Calculate the Percentage NO_x Emission Reductions

Utilizing the baseline NO_x emission standard and the reduced NO_x emission standard identified above, use the equation provided below to calculate the percentage reduction in NO_x emissions. Remember, this value must be 25% or greater.

[(Baseline NO_x emission standard - Reduced NO_x emission standard) / Baseline NO_x emission standard] x 100 = Percentage Reduction in NO_x Emissions

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: Convert the emission rates to grams per hour (g/mile) and apply the TxLED correction factor (where appropriate)

Part C: Calculate the NO_x emission reductions

Part A: Determine the TxLED Correction Factor

The TCEQ 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, except for El Paso, Howard, and Hutchinson Counties.

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, 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: Convert the emission rates to grams per hour (g/hr) and apply the TxLED correction factor (where appropriate)

The NO_X emissions standards of heavy-duty engines are certified in grams per brake horsepower-hour (g/bhp-hr) or grams per kilowatt-hour (g/kW-hr). For performing these calculations, all emission standards must be in g/bhp-hr. Use the conversion factors provided in the Summary section of this document to convert emission standards that are in g/kW-hr to g/bhp-hr.

To perform the emissions reduction calculations, the emissions standards in g/bhp-hr must be converted to grams per hour (g/hr). Multiply the emission standard of an engine by its power (in brake horsepower) to complete this conversion.

Next, if an engine is determined to have a TxLED factor in Part A, apply that factor to the converted emission standard.

For each engine, new and old, the following equation should be completed to ensure that an emission rate has been calculated for each of them.

Emission Rate (g/bhp-hr) * Engine Power (bhp) * TxLED factor = Emission Rate (g/hr)

Part C: Calculate the NO_X Emission Reductions

Calculating the NO_X emissions reductions requires some of the information that has been calculated or gathered in the previous steps plus some additional information. The following is needed to calculate the NO_X emissions reductions.

- The emissions factors calculated in Part B for the new and old engines in g/hr.
- The load factor for the engines (Table 6)
- The default annual hours for the old engines.
    - Use Table 7 to determine the default annual hours for an engine.
    - Applicants may elect to use non-standard hours for this equation; however, applicants should refer to the RFGA for details and requirements about using non-standard hours.
- The percentage of time in area that the applicant will commit to use the vessel and/or engines in the eligible areas (e.g., 75%, 90%).
    - This value must not be less than 55% and may be increased in increments of 10% up to a maximum of 95%. See the RFGA for more details regarding usage commitments.
- The length of the activity life of the project.
    - See Table 8 for available activity life options.
- A conversion factor to convert grams to tons which is 907,200 grams in a U.S. standard ton.

Table 6 – Default Load Factors for Category 1 & 2 Marine Engines

Power Range	Propulsion Engines	Auxiliary Engines
All	0.43	0.65

Table 7 – Default Usage Rates for Marine Vessels

Vessel Type	Main Engine (annual hours)	Auxiliary Engine (annual hours)
Assist Tug	3,000	3,000
Tow Boat	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

Table 8 – Activity Life for Marine Vessels

Minimum Activity Life	Maximum Activity Life
5 years	10 years

NO_X emissions reductions are calculated in tons and should be rounded to 4 decimal places at the end of the calculation, should rounding be needed. The formula for the NO_X emissions reduction calculation is shown below.

ERIG is a competitive grant round and one of the factors utilized in the grant selection process is total NO_X emissions reductions. The higher the NO_X emissions reductions of the project, the more competitive the grant application may be.

(Old engine emissions factor (g/hr) * load factor) – (new engine emissions factor (g/hr) * load factor) = reduced emissions factor (g/hr)

Reduced emissions factor (g/hr) * default annual hours (hr) = emissions per year (g/yr)

Emissions per year (g/yr) * usage in area (%) = area emissions per year (g/yr)

Area emissions per year (g/yr) ÷ grams to tons factor (g/ton) = area emissions (tons/yr)

Area emissions (tons/yr) * activity life (yr) = Total NO_X emissions reductions (tons)

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 (tons)

= Cost Per Ton of NO_X Reduced ($/tons)

Marine Vessels Calculation Worksheet

This worksheet is provided to assist applicants in estimating the NO_X emissions reductions and cost per ton of NO_X reduced for each activity. See the Project Cost Per Ton and NO_X Emissions Reductions Worksheet to calculate these values for the entire project.

Activity Information

What is the default fuel usage for the old marine vessel (Appendix B)?	
What is the default fuel usage for the new marine vessel (Appendix B)?	
What is the percent of usage in the eligible counties (Part C)?	
What is the incremental cost of the activity?	
What is the requested grant amount for the activity?	
Old Engine Information	
Model Year:	
Engine Power (hp):	
Emission Rate (g/bhp · hr) (Step 1):	
TxLED Factor (Part A): Note: Only if applicable	
Load Factor (Table 6):	
New Engine Information	
Model Year:	
Engine Power (hp):	
Emission Rate (g/bhp · hr) (Step 1):	
TxLED Factor (Part A): Note: Only if applicable	
Load Factor (Table 6):	
Check the Emissions Rate Reduction	
Old Engine Emission Standard (g/bhp · hr):	
- New Engine Emission Standard (g/bhp · hr):	
= Difference (g/bhp · hr):	
÷ Old Engine Emission Standard (g/bhp · hr):	
x:	100
= Emission Rate Reduction (%): Note: Must be 25% or more	

Determine Old Engine NO_x Emission Rate (g/mile)	
Old Engine NO_x Emission Rate (g/bhp · hr):	
x TxLED Correction Factor:	
x Load Factor:	
= Corrected NO_x Emission Rate (g/bhp · hr):	
x Engine Power (hp):	
= Converted Old Engine NO_x Emission Rate (g/hr):	
Determine New Engine NO_x Emission Rate (g/mile)	
New Engine NO_x Emission Rate (g/bhp · hr):	
x TxLED Correction Factor:	
x Load Factor:	
= Corrected NO_x Emission Rate (g/bhp · hr):	
x Engine Power (hp):	
= Converted New Engine NO_x Emission Factor (g/hr):	
Calculate the NO_x Emissions Reductions	
Converted Old Engine NO_x Emission Factor (g/hr):	
- Converted New Engine NO_x Emission Factor (g/hr):	
= Grams per Hour Reduced (g/hr):	
x Default Annual Hours (hr):	
x Percent within Eligible Counties (%):	
= Grams per Year Reduced (g/yr):	
÷ 907,200 Grams per Ton	907200
= Estimated Annual NO_x Emission Reduction (tons/yr):	
x Activity Life (years):	
= Estimated Activity Life NO_x Emission Reductions (tons):	
Requested Grant Amount ($) ÷ NO_x Emission Reductions (tons) = Cost Per Ton ($):	
Eligibility Checks	
Is the requested grant amount less than or equal to 80% of the incremental cost?	
Does the new engine reduce emissions by at least 25%?	

Project Cost Per Ton and NO_X Emissions Reductions Worksheet

This worksheet is provided to assist applicants in calculating their project NO_X emissions reductions and cost per ton.

Activity	NO_x Reductions	Requested Grant Amount
Activity 1		
Activity 2		
Activity 3		
Activity 4		
Activity 5		
Activity 6		
Activity 7		
Activity 8		
Activity 9		
Activity 10		
Total		

Total Requested Grant Amount	Math Function	Total NO_x Reductions	Math Function	Project Cost Per Ton
	÷		=	