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

Technical Supplement No. 3
Marine Vessels

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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 the calculations for activities involving Marine Vessels, including: new purchases and leases, replacement, repower, retrofit, and add-on activities.

Marine vessels and engine equal to or greater than 25 horsepower (hp) are eligible for grants under this program. Most of the engines 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 project being proposed involves a gasoline, LPG, or CNG powered marine vessel contact TCEQ for eligibility.** Most of the calculations will require input of a NO_x emission factor applicable to the engine.

Use the worksheet provided at the end of this supplement to calculate the emission reductions and the cost-effectiveness of the activities proposed for your activity. Most marine vessel activities that will be funded under this program include Category I and II vessels, including both propulsion engines and auxiliary engines. For Category III, ocean-going vessels, contact the TCEQ for eligibility.

This workbook is divided into three major steps.

a) Step 1: Determining that the activity meets the 25% NO_x emissions reduction requirement.

b) Step 2: Calculating the NO_x Emission Reductions.

c) 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.

Engine measurement units

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: an engine that has a maximum continuous rated (MRC) power of 450 kW.
450 kW x 1.341 hp/kW = 603.5 hp

Emissions 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: an engine that has an emission standard listed as 10.5 g/kw-hr.
10.5 g/kWh x 0.746 = 7.8 g/hp-hr

Engine Size Determination

Marine vessel engine categories are determined by cylinder displacement. To calculate, divide total displacement by number of cylinders.

Category I: means relating to a marine engine with specific engine displacement below 7.0 liters per cylinder.

Category II: means relating to a marine engine with a specific engine displacement at or above 7.0 liters per cylinder but less than 30.0 liters per cylinder.

Category III: means relating to a marine engine with a specific engine displacement at or above 30.0 liters per cylinder.

Step 1: Determining that 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. Use Worksheet

MA-1 to determine if your activity meets the minimum emission reduction requirements. Use the certified manufacturer's emission standards if available. If the engine is IMO compliant, then the IMO emission standard can be calculated using the information presented in Table 3.3. If the engine meets EPA Tier 2 emission standards, those standards are listed in Table 3.4. For all other engines use the default values presented in Tables 3.1 for Category 1 engines and Table 3.2 for Category 2 engines. For auxiliary engines use the Non-Road emission factors **except for those certified as a marine engine.**

Baseline NO_x Emission Rate

TABLE 3.1 DEFAULT NO_X EMISSION FACTORS FOR CATEGORY 1

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

TABLE 3.2 DEFAULT NO_X EMISSION FACTORS FOR CATEGORY 2 [G/BHP-HR (G/KWH)]

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 I & II MARINE VESSEL. CURRENT IMO NO_X EMISSION STANDARDS IN 2004

Engine Speed (N)	NO_x (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/kWh

10.423 g/kWh x 0.746 bhp/kW = **7.776 g/bhp-hr**

TABLE 3.4 MARINE VESSEL EPA TIER 2, 3, AND 4 NO_X EMISSION STANDARDS

Category 1. Engine Power < 19kW ; Displacement < 0.9 L/cyl See note 3				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx** See note 1 **(g/bhp-hr)**
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. 19kW < Engine Power < 75kW ; Displacement < 0.9 L/cyl 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. 600kW< Engine Power < 1400kW ; Displacement < 0.9 L/cyl See note 4				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx See note 1 (g/bhp-hr)**
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
Category 1. 600kW< Engine Power < 1400kW; 0.9 < Displacement < 1.2 L/cyl See note 4				
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
Category 1. 600kW< Engine Power < 1400kW ; 1.2 L/cyl < Displacement < 2.5 L/cyl				
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
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. 600kW< Engine Power < 1400kW ; 2.5 L/cyl < Displacement < 3.5 L/cyl				
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
Category 1. 600kW< Engine Power < 1400kW ; 3.5 L/cyl < Displacement < 7.0L/cyl				
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. 1400kW < Engine Power-<2000kW; Displacement < 0.9L/cyl				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx** See note 1 **(g/bhp-hr)**
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
Category 1. 1400kW < Engine Power-<2000kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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. 1400kW < Engine Power-<2000kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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
Category 1. 1400kW < Engine Power-<2000kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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
Category 1. 1400kW < Engine Power-<2000kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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. 2000kW < Engine Power < 3700kW; Displacement < 0.9L/cyl				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx** See note 1 **(g/bhp-hr)**
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. 2000kW < Engine Power < 3700kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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. 2000kW < Engine Power < 3700kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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. 2000kW < Engine Power < 3700kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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. 2000kW < Engine Power < 3700kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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. Engine Power <3700kW; 7.0 < Displacement > 15.0L/cyl See note 5:				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx See note 1 (g/bhp-hr)**
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
Category 2. Engine Power < 3300kW; 15.0L/cyl < Displacement > 20.0L/cyl				
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
Category 2. Engine Power less than or equal to 3700kW; 15.0 < Displacement > 20.0L/cyl				
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
Category 2. Engine Power less than or equal to 3700kW; 20.0 < Displacement > 25.0L/cyl				
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. Engine Power less than or equal to 3700kW; 25.0 < Displacement > 30.0L/cyl				
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. Engine power less than or equal to 3700kW; Displacement < 15.0L/cyl See note 5				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx See note 1 (g/bhp-hr)**
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 2. Engine power less than or equal to ≥ 3700kW; Displacement greater than or equal to 15.0L/cyl				
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. Engine power < 19kW; Displacement < 0.9L/cyl See note 3				
Starting date	**NOx + HC (g/kWh)**	**NOx (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx See note 1 (g/bhp-hr)**
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. 19kW < Engine power < 75kW; Displacement < 0.9L/cyl See note 3				
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

Starting date	NOx + HC (g/kWh)	NOx (g/kWh)	NOx + HC (g/bhp-hr)	NOx See note 1 (g/bhp-hr)
Category 1. 75kW < Engine power <600kW; Displacement < 0.9L/cyl				
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
Category 1. 75kW < Engine power <600kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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
Category 1. 75kW < Engine power <600kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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. 75kW < Engine power <600kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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
Category 1. 75kW < Engine power <600kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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. 600kW < Engine Power < 1400kW; Displacement < 0.9L/cyl See note 4:				
Starting date	**NOx + HC (g/kWh)**	**Nox (g/kWh)**	**NOx + HC (g/bhp-hr)**	**NOx See note 1 (g/bhp-hr)**
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
Category 1. 600kW < Engine Power < 1400kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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. 600kW < Engine Power < 1400kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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
Category 1. 600kW < Engine Power < 1400kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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. 600kW < Engine Power < 1400kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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

Starting date	NOx + HC (g/kWh)	NOx (g/kWh)	NOx + HC (g/bhp-hr)	NOx See note 1 (g/bhp-hr)
Category 1. 1400kW < Engine power < 2000kW; Displacement < 0.9L/cyl				
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. 1400kW < Engine power < 2000kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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
Category 1. 1400kW < Engine power < 2000kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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
Category 1. 1400kW < Engine power < 2000kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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
Category 1. 1400kW < Engine power < 2000kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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

Starting date	NOx + HC (g/kWh)	NOx (g/kWh)	NOx + HC (g/bhp-hr)	NOx See note 1 (g/bhp-hr)
Category 1. 2000kW < Engine power < 3700kW; Displacement < 0.9L/cyl				
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. 2000kW < Engine power < 3700kW; 0.9L/cyl < Displacement < 1.2L/cyl				
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. 2000kW < Engine power < 3700kW; 1.2L/cyl < Displacement < 2.5L/cyl				
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. 2000kW < Engine power < 3700kW; 2.5L/cyl < Displacement < 3.5L/cyl				
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. 2000kW < Engine power < 3700kW; 3.5L/cyl < Displacement < 7.0L/cyl				
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:

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

Reduced NO_x Emission Rate

The reduced NO_x emission rate will normally be the certified or verified emissions of the 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 installed on the replacement 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.

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

EXAMPLE CALCULATION

Example calculation for determining 25% baseline emission rate reduction for new purchase/lease

Activity: Purchase of a new category 1 marine vessel with a displacement of 2.0 liters

Engine emission standard for current year model: 5.13 g/bhp-hr
New engine certified NO_x emissions: 4.0 g/bhp-hr

Calculation of baseline emission rate reduction:
[(5.13 g/bhp-hr - 4.0 g/bhp-hr) / 5.13 g/bhp-hr] x 100 = 22.03% baseline emission rate reduction

Note: This project does not meet the 25% base emission rate reduction requirement.

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 engine and a 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 equipment chassis and the model year of the existing engine are different, the model year of the engine shall be used to determine the baseline emissions for benefit 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 operation.
- Emission reduction calculations should be consistent with the type of records maintained over the life of each activity.
- If the equipment operates in a county or counties that is in the TexLED region the TexLED 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 new 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 3.5, 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 as illustrated in the calculation example below.

TABLE 3.5 DEFAULT LOAD FACTORS FOR CATEGORY 1 & 2 MARINE

Power Range (hp)	**Load Factors**	
	Commercial	Auxiliary
All	0.43	0.65

Example calculation for determining NO_x emission rates based on annual hours of operation

Activity: Repowering of a 1966 diesel 700hp marine category 1 vessel with a new 2008 diesel engine.

Baseline engine horsepower: 700 hp
Reduced engine horsepower: 700 hp
Baseline NO_x emission factor: 10.0 g/bhp-hr
Reduced NO_x emission factor: 5.13 g/bhp-hr
Default load factor: 0.43
Annual hours of operation: 700 hr/yr
Percent time in affected counties: 100%
TXLed Correction factor: 0.93

Baseline NO_x Emission Factor (g/hr)
10.0 g/bhp-hr x 0.93 = 9.3 g/bhp-hr
9.3 g/bhp-hr x 0.43 = 3.999 g/bhp-hr
3.999 g/bhp-hr x 700hp = **2,799 g/hr**

Reduced NO_x Emission Factor (g/hr)
5.13 g/bhp-hr x 0.93 = 4.7709 g/bhp-hr
4.7709 g/bhp-hr x 0.43 = 2.0514 g/bhp-hr
2.0514 g/bhp-hr x 700hp = **1,436 g/hr**

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 may provide the option of using 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. Where a default usage rate is not used, refer to the instructions in the RFGA for determining the usage rate to enter in the application and use for the emissions reduction calculations.

You must also enter the percentage of annual usage that will occur within the eligible counties. 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. 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 3.6 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.

TABLE 3.6 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)	16 years
Category 2 Engines	5 years (including lease)	23 years
Auxiliary Engines (Categories 1 & 2)	5 years (including lease)	17 years
Replacement Activity (all engine categories)	5 years	10 years*

* If an applicant feels that a longer activity life is warranted, they should contact the TCEQ to discuss. Any request to use a longer activity life will need to be submitted in writing, and should include complete documentation and records of the historical use of similar equipment by the applicant.

Example calculation for determining NO_x emission rate reduction based on annual hours of operation

Activity: Repowering a category 1 marine vessel with a new engine. An emission factor of 10.0 was determined for the baseline engine.

Equipment horsepower: 700 hp
Baseline NO_x emission factor: 2,799 g/hr
Reduced NO_x emission factor: 1,436 g/hr
Annual hours of operation: 700 hr/yr
Percent time in affected counties: 100%

2,799 g/hr -1,436 g/hr = 1,363 g/hr
1,363 g/hr x 700 hours = 954,100 g/yr
954,100 g/yr x 1.00 = 954,100 g/yr
954,100 g/yr / 907,200 g/tons = **1.0517 ton/yr**

Step 3. 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 annual operation 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 Vessel Category	
Horsepower (hp)	
Emission Standard (g/bhp-hr)	
Load Factor	

Reduced Emission Engine Information

Model Year	
Fuel Type	
Marine Vessel Category	
Horsepower (hp)	
Emission Standard (g/bhp-hr)	
Load Factor	
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)	
- Reduced 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)	