TEXAS EMISSIONS REDUCTION PLAN (TERP)

Emissions Reduction Incentive Grants Program
Technical Supplement No. 3

Marine Vessels

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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 NOx 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.

Step 1: Determining that the activity meets the 25% NOx emissions reduction requirement.
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.

Engine measurement units

Marine vessel engine power can be measured in either horsepower (HP) or kilowatts (kW). For consistency purposes calculations for NOx 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 1.341hp/kW = 603.5 hp

Emission measurements may also be made by reversing the kW and HP factors.

- 1 g/kW-hr = 0.746 g/hp-hr
- 1 g/hp-hr = 1.341 g/kW-hr

Example: an engine that has an emission standard listed as 10.5 g/kw-hr.

- 10.5 g/kW-hr 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% NOx emissions reduction requirement.

All new purchase or lease, replacement, repower, retrofit, and add-on activities must achieve at least a 25 percent reduction in NOx 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 NOx Emission Rate

Table 3.1 Default NOx Emission Factors for Category 1

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 [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 I & II Marine Vessel
Current IMO NOx Emission Standards in 2004

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
10.423g/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

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

Displacement L/cyl	Starting 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	Starting 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
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	Starting 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
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	Starting 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
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	Starting 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
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	Starting 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
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	Starting 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	Starting 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 High Power Density

Displacement L/cyl	Starting 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
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	Starting 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
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	Starting 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
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	Starting 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
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) Manufactures 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.

Reduced NOx Emission Rate

The reduced NOx 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 NOx emissions: 4.0 g/bhp-hr

Calculation of baseline emission rate reduction:
(5.13 g/bhp-hr - 4.0 g/bhp-hr) divided by 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 NOx Emission Reductions

This step is divided into three main parts:

Part A: Determine the TxLED Correction Factor
Part B: Determine the NOx emission factors
Part C: Calculate the NOx 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 NOx emissions from diesel engines. Currently, a reduction factor of **5.7 percent** (0.057) for on-road use and **7.0 percent** (0.07) for non-road use an 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 NOx Emission Factors

To complete the calculation of the NOx emission reductions for the activity, you must convert the NOx emission rates (g/bhp-hr) to a NOx emission factor. For most types of equipment, the NOx 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 calculations based on annual hours of operation, a load factor is provided to convert the NOx emission standard (g/bhp-hr) to g/hr. The horsepower of the engine must also be included in the calculation. This conversion factor must be applied to the NOx emission standard (g/bhp-hr) for the baseline engine and for the reduced emission engine.

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

Baseline NOx 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 NOx 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 NOx Emission Reductions

Use the factors determined in Part B to calculate the NOx emission reductions for the activity. To complete the calculations, you will need to determine the estimated annual hours of operation, if needed. Use historical records and other information, where possible. Note that the usage estimates entered onto the application and used to calculate the emission reductions, will be entered into the grant contract.

You must also enter the percentage of annual usage that will occur within the eligible counties. At least 75 percent 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 NOx 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 NOx emission factor: 2,799 g/hr
Reduced NOx emission factor: 1,436 g/hr
Annual hours of operation: 700
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 NOx 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 NOx emission reductions for all of the activities included in that project.

Requested Grant Amount ÷ Total NOx Emission Reductions = Cost Per Ton of NOx 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	
Emission Standard (g/bhp-hr)	
Load Factor	

Reduced Emission Engine Information

Model Year	
Fuel Type	
Marine Vessel Category	
Horsepower	
Emission Standard (g/bhp-hr)	
Load Factor	
If the activity is a retrofit/add-on, is there a verified percentage NOx emission reduction?	**%**

Step 1: Does this project meet the 25% NOx 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 NOx 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 NOx Emission Factor

Determine Baseline NOx Emission Factor (g/hour)	**Engine 1**	**Engine 2**
baseline engine NOx emission standard (g/bhp-hr)		
x TxLED correction factor (diesel engines only)		
= corrected NOx emission factor (g/bhp-hr)		
x load factor		
x horse power		
= baseline NOx emission factor (g/hr)		
Determine Reduced NOx Emission Factor (g/hour)		
Option A. Reduced-emission engine certified to a specific emissions standard (g/bhp-hr)		
reduced engine NOx emission standard (g/bhp-hr)		
x TxLED correction factor (diesel engines only)		
= corrected NOx emission factor (g/bhp-hr)		
x load factor		
x horse power		
=reduced NOx emission factor (g/hr)		
Option B. Reduced-emission technology certified/verified to achieve a percentage reduction from the baseline.		
Baseline NOx emission factor (g/hr)		
x certified/verified percentage reduction from baseline		
= reduced NOx emission factor (g/hr)		

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

baseline NOx emission factor(g/hr)	
- reduced NOx emission factor (g/hr)	
= grams per hour reduced (g/hr)	
x annual hours of operation	
x percent within affected counties (%)	
= grams per year reduced (g/yr)	
÷907,200 grams per ton	
= estimated annual NOx emission reduction (tons/yr)	
Engine 1 + Engine 2 annual NOx emission reduction (tons/yr)	
x activity life (years)	

= estimated activity life NOx emission reduction (tons)	

Step 3: What is the activity cost per ton?

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