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

Technical Supplement No. 8
On-Vehicle Electrification Infrastructure and Automatic Shutdown Devices

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TECHNICAL SUPPLEMENT NO. 8

ON-VEHICLE ELECTRIFICATION INFRASTRUCTURE AND AUTOMATIC SHUTDOWN DEVICES

Summary

Idle reduction technology allows the use of an alternative energy source in lieu of idling the vehicles or locomotives main engine thus reducing long duration engine idling. Some of these technologies are mobile and are attached to the vehicle or locomotive main engine as auxiliary power units (APUs) or idle shutdown devices. Other technologies involve using stationary equipment which can supply electricity to the vehicle or locomotive while parked. These idle reduction technologies are used to provide electricity for operating on-board equipment to supply heat, air conditioning, and other needs.

This supplement contains the calculations for engine idle reduction infrastructure and automatic shutdown devices. The emission reductions are estimated using the applicant=s information on the type of vehicles or equipment for which the infrastructure is to be installed. Use of these approaches reduces emissions by a vehicle or locomotive while operating within the eligible counties.

Use the worksheets provided at the end of this chapter to calculate emission reductions. Use IR-1 for on-road vehicle electrification, IR-2 for on-road APU, and IR-3 for locomotives.

Texas Low Emission Diesel Correction Factor

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

All of the counties eligible for TERP incentive funding, as listed in the *Guidelines*, except for El Paso County are required to meet TxLED standards for diesel fuel sales. The new requirements set a maximum aromatic hydrocarbon content standard of 10% 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, reduction factors of **5.7%** (0.057) for on-road use and **7.0%** (0.07) for non-road use have been accepted as a NO_x reduction estimate resulting from use of TxLED fuel. 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 (except for El Paso County), a correction factor of either **0.943** for on-road vehicles or **0.93** for non-road equipment should be applied when calculating the baseline and/or reduced emissions for diesel engines.

Calculating NO_x Emission Reductions for idling reduction infrastructure to allow acceptance of electricity for on-road heavy-duty vehicles

The NO_x emission reduction from use of idling reduction infrastructure is the amount of NO_x not produced by using off-vehicle electrical infrastructure in lieu of idling to power vehicle support systems such as engine heating and air conditioning.

To find the baseline NO_x emissions, multiply the vehicle=s NO_x emission factor by the estimated number of reduced long-duration idling hours per day. The result of this calculation expresses baseline emissions in grams per day.

Then convert the baseline NO_x emissions per day to tons of NO_x emissions per year by multiplying the daily baseline emissions by 365 to annualize and dividing the result by 907,200 to convert grams to tons.

For an example of the calculation, see Example 1 below.

Table 8.1 lists the emission factor for heavy-duty on-road vehicles, which is expressed in "*grams per idling hour*" (g/hr).

TABLE 8.1 EPA ON-ROAD IDLE EMISSION FACTORS IN G/HR

Year	Emission Factor (g/hr)
Up to 2020	135

Example 1: Calculation for determining NO_x emission reduction based on annual/daily hours of idling time

Activity: Installation of infrastructure that allows for electrical hook-up during idling time on a heavy-duty truck built in 2001.
Heavy-duty truck idle engine emission factor: 135 g/hr
Estimated hours per parking space: 8 hours
Estimated idle hours reduced by supplied electricity: 7 hours
TxLED Correction factor: 1 - 057 = 0.943

Idling Engine NO_x Emission Factor (g/day)
135 g/hr x 0.943 = 127.305 g/hr
127.305 g/hr x 7 hr/day = 891.135 g/day

NO_x Emission Reduction (tons/yr)
891.135 g/day x 365 day/yr = 325,264 g/yr
325,264 g/yr / 907,200 g/ton = 0.3585 tons/yr

Calculating NO_x Emission Reductions for APUs to generate and provide electricity on vehicles

Emission reductions are calculated as the difference in the NO_x emissions of the APU and the emissions that would have been produced by the idling of the vehicle=s main engine for the same amount of time (the baseline emissions). To compute the baseline emissions, multiply the vehicle=s NO_x emission factor by the number of reduced "long-duration idling hours" to find the NO_x emission factor in grams per day. To compute APU emissions, multiply the APU=s NO_x emission factor, load factor (default load factor for APUs is 0.43), and horsepower to derive the number of grams per hour of APU NO_x emissions.

Then multiply the APU emissions by the number of hours the APU will operate to find the APU NO_x emissions, stated in grams per day.

Subtract the APU=s NO_x emissions per day from the vehicle=s baseline NO_x emissions per day to arrive at the net NO_x emission reduction per day. Then multiply the result by 365 to annualize and divide by 907,200 to convert grams to tons of NO_x.

If the NO_x emission reduction technology is only used for a percentage of time in the eligible counties, multiply the percentage of time by the tons of NO_x per year to find the tons per year of NO_x reduction for the qualified counties.

Example 2 below illustrates these calculations.

Use Table 8.1 (page 3) for the NO_x emission factors of idling heavy-duty on-road vehicles.

Use Table 8.2 for APU/small engine NO_x emission factors.

TABLE 8.2 EPA NON-ROAD EMISSION STANDARDS FOR SMALL ENGINES

Engine Power (hp)	Tier	Model Year	NMHC+ NO_x (g/bhp-hr)	NO_x (g/bhp-hr)
<11	Tier 1	2000 - 2004	7.8	**7.41**
	Tier 2	2005-2007	5.6	**5.32**
	Tier 4	2008+	5.6	**5.32**
11#hp<25	Tier 1	2000 - 2004	7.1	**6.745**
	Tier 2	2005-2007	5.6	**5.32**
	Tier 4	2008+	5.6	**5.32**
25#hp<50	Tier 1	1999 - 2003	7.1	**6.745**
	Tier 2	2004-2012	5.6	**5.32**
	Tier 4	2013+	3.5	**3.325**

Example 2: Calculation for determining NO_x emission reduction based on annual hours of idling with an APU.

Activity: Installation of a 14.6-hp APU on a Heavy-duty truck.

Heavy-duty truck idle engine emission factor: 135 g/hr
APU engine emission standard: 5.32 g/bhp-hr
APU horse power: 14.6 hp
APU Load factor: 0.43
Total number of idling hours per year: 3,000 hr/yr
Percent time idling in affected counties: 75%
TxLED Correction factor: Propulsion engine: 1 - 0.057 = 0.943
APU engine: 1 - 0.07 = 0.93
Idling Engine NO_x Emission Factor (g/hr)
135 g/hr x 0.943 = 127.305 g/hr

APU NO_x Emission Factor (g/hr)
5.32 g/bhp-hr x 0.93 = 4.9476 g/bhp-hr
4.9476 g/bhp-hr x 14.6 hp x 0.43 load factor = 31.0610 g/hr

NO_x Emission Reduction (tons/yr)
127.3050 g/hr – 31.0610 g/hr = 96.2440 g/hr
96.2440 g/hr x 3,000 hr/yr x 75% = 216548.9262 g/yr
216548.9262 g/yr / 907,200 g/ton = 0.2387 tons/yr

Calculating NO_x Emission Reductions for APUs to generate and provide electricity on Switcher Locomotives

Emission reductions are calculated as the difference in the NO_x emissions of the APU and the locomotive engine during idling hours. For the baseline, multiply the locomotives' NO_x emission factor by the number of reduced long-duration idling hours to get a NO_x emission factor in grams per day. For the APU, multiply the APU=s NO_x emission factor, load factor (default load factor for APUs is 0.43), and horsepower to derive the number of grams per hour. Then multiply the number of grams per hour by the number of hours the APU will operate to find the APU NO_x emissions in grams per day. Subtract the APU=s NO_x emission from the locomotive=s NO_x baseline emission to arrive at the net NO_x emission reduction. Then multiply the result by 365 to annualize and divide by 907,200 to convert grams to tons of NO_x. If the NO_x emission reduction technology is only used for a percentage of time in the eligible counties, multiply the percentage of time by the tons of NO_x per year to find the tons per year of NO_x reduction for the qualified counties.

For an example of the calculation, see Example 3 below.

Table 8.2 contains the APU/small engine NO_x emission factors.

Use Table 8.3 for the NO_x emission factors for the idling switcher locomotive.

Use Table 8.4 for the EPA default idling factors.

TABLE 8.3 EPA SWITCHER LOCOMOTIVE IDLING EMISSION FACTORS

Model	NO_x g/hr
2 -Stroke	800
4 -Stroke	620

TABLE 8.4 EPA DEFAULT SWITCHER LOCOMOTIVE IDLING PERCENTAGE

Type	(%)	(hr)
Switcher	59.8	14.4

Example 3: Calculation for determining NO_x emission reduction based on annual hours of idling with an APU.

Activity: Installation of a 20 hp APU on EMD 16-645

Locomotive Idling engine emission factor: 800 g/hr
APU engine emission standard: 6.745 g/bhp-hr
APU horse power: 20 hp
APU load factor 0.43
Idling hours per day: 14.4 hr/day
Estimated idling hours reduced by the APU: 11 hr/day
Percent time idling in affected counties: 85%
TxLED Correction factor: 1 - 0.07 = 0.93

Idling Engine NO_x Emission Factor (g/day)
800 g/hr x 0.93 = 744 g/hr
744 g/hr x 11 hr/day **= 8184 g/day**

APU NO_x Emission Factor (g/day)
6.745 g/bhp-hr x 0.93 = 6.273 g/bhp-hr
6.273 g/bhp-hr x 20 hp x 0.43 load factor = 53.9478 g/hr
53.9478 g/hr x 11 hr/day **= 593.4258 g/day**

NO_x Emission Reduction (tons/yr)
8184 g/day - 593.446 g/day = 7590.57 g/day
7590.57 g/day x 365day/yr = 2,770,558.1 g/yr
2,770,558.1 g/yr / 907,200 g/ton = 3.0540 ton/yr
3.0540 tons/yr x 85% **= 2.5959 ton/yr**

Calculating NO_x Emission Reductions for Automatic Shutdown Devices on Switcher Locomotives

The NO_x emission reduction for an automatic shutdown device on a switcher locomotive is the amount of emissions avoided by shutting the propulsion engine(s) down when they would have otherwise been left to run at idle.

Multiply the switcher locomotive=s NO_x emission factor by the number of reduced long duration idling hours to get a NO_x emission factor in grams per day.

Then multiply the result by 365 to annualize and divide by 907,200 to convert grams to tons of NO_x.

If the NO_x emission reduction technology is only used for a percentage of time in the eligible counties, multiply the percentage of time per county by the tons of NO_x per year to find the tons per year of NO_x reduction for the qualified counties.

For an example of the calculation, see Example 4 below.

Use Table 8.3 for the NO_x emission factors of the current model switcher locomotive.

Use Table 8.4 for the EPA default idling factors.

Example 4: Calculation for determining NO_x emission reduction based using an automatic shutdown device on a locomotive.

Activity: Installation of an automatic shutdown device on a EMD 16-645F3.

Locomotive Idling engine emission factor: 800 g/hr
Idling hours per day: 14.4 hr/day
Estimated idling hours reduced by the APU: 11 hr/day
Percent time idling in affected counties: 85%
TxLED Correction factor: 1 - 0.07 = 0.93

Idling Engine NO_x Emission Factor (g/day)
800 g/hr x 0.93 = 744 g/hr
744 g/hr x 11 hr/day **= 8184 g/day**

NO_x Emission Reduction (tons/yr)
8184 g/day x 365day/yr = 2,987,160 g/yr
2,987,160 g/yr / 907,200 g/ton = 3.2927 tons/yr
3.2927 ton/yr x 85% **= 2.7988 ton/yr**

Calculate the Cost Per Ton

The cost per ton for an activity is then determined by dividing the 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 grant amount for the entire project by the total NO_x emission reductions for all of the activities included in that project.

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

Activity Worksheet IR-1

Annual Hours of Vehicle Idle Reduction

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

Activity / Baseline Information

Type of activity ☐ Electrification

What is the activity life in years?	
Number of Parking Spaces (if applicable)	
Estimated idle hours (per parking, space if applicable) (hr/day)	
Estimated idle hours reduced by supplied electricity (hr/day)	

Baseline Engine Information (if calculation is for a single vehicle)

Model Year	
Vehicle Weight Class	
Fuel Type	

Calculate the NO_x emission reductions

PART A. CALCULATE THE TXLED CORRECTION FACTOR (ALL AREAS BUT EL PASO)

On Road TxLED Correction Factor *(1 - 0.057)*	0.0943

PART B. CALCULATE THE NO_X EMISSION REDUCTIONS

baseline engine NO_x emission standard (g/hr)	135
x TxLED correction factor (diesel engines only)	
x idling hours per day (hr/day) (per space, if applicable)	
= baseline NO_x emission factor (g/day)	
x 365 (day/yr)	
= grams per year (grams/yr)	
x parking spaces, if applicable	
/ 907,200 (g/ton)	
= estimated annual NO_x emission reduction (tons/yr)	
x activity life (years)	
= estimated activity life NO_x emission reduction (tons)	

WHAT IS THE ACTIVITY COST PER TON?

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

Activity Worksheet IR-2

Annual Hours of Vehicle Idle Reduction

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

Activity Information

Type of activity ☐ APU

What is the activity life in years?	
What is the requested grant amount for the activity?	
Total number of hours you will operate the infrastructure per year?	
What is the percent time the vehicle will travel in the eligible counties?	

Baseline Engine Information

Model Year	
Gross Vehicle Weight Rating (GVWR)	
Fuel Type	

APU Emission Information

Model Year	
Horsepower of APU	
Fuel Type	
Emissions Standard (g/bhp-hr) (see Table 8.2)	

Calculate the NO_x emission reductions

PART A. CALCULATE THE TXLED CORRECTION FACTOR (ALL AREAS EXCEPT EL PASO)

propulsion engine (1 - 0.057)	0.943
APU engine (1 - 07)	0.93

PART B. DETERMINE THE NO_X EMISSION FACTOR

Determine Baseline NOx Emission Factor (g/hr)	
baseline engine NO_x emission standard (g/hr)	135
= baseline NO_x emission factor (g/hr)	
Determine APU Reduced NOx Emission Factor (g/hr)	
certified NO_x emissions standard (g/bhp-hr)	
x TxLED correction factor (diesel engines only)	
= corrected NO_x emission factor (g/bhp-hr)	
x APU horsepower (hp)	
x 0.43 load factor	
=reduced NO_x emission factor (g/hr)	

PART C. CALCULATE THE NO_X EMISSION REDUCTION USING ANNUAL HOURS OF IDLING TIME

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 (%)	
/ 907,200 (g/ton)	907200
= estimated annual NO_x emission reduction (ton/yr)	
x activity life (yr)	
= estimated activity life NO_x emission reduction (ton)	

WHAT IS THE ACTIVITY COST PER TON?

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

Activity Worksheet IR-3

Annual Hours of Locomotive Idle Reduction

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

Activity Information

Type of activity ☐ APU ☐ Automatic Shutdown Device

What is the activity life in years?	
What is the average number of hours that the locomotive idles per day?	
What is the percent time the equipment is in the eligible counties?	

Baseline Engine Information

Model Year	
Type of Locomotive	
Fuel Type	
Emission Standard (g/hr) (see Table 8.3)	

Reduced Emission Engine Information

Model Year	
Equipment Type	
Fuel Type	
Emissions Standard (g/hr) (see Table 8.2)	
Estimated Idling Hours Reduced by the APU	

Calculate the NO_x emission reductions

PART A. CALCULATE THE TXLED CORRECTION FACTOR (ALL AREAS BUT EL PASO)

Non Road TxLED Correction Factor *1 - 0.070)*	0.93

PART B. DETERMINE THE NO_X EMISSION FACTOR

Determine Baseline NO_x Emission Factor (g/hour)	
baseline engine NO_x emission standard (g/hr)	
x TxLED correction factor (diesel engines only)	
x idling hours per day (hr/day)	
= baseline NO_x emission factor (g/day)	
Determine Reduced NO_x Emission Factor (g/hour)	
OPTION A. IF USING AUTOMATIC SHUTDOWN DEVICE(S) ENTER ZERO FOR NO_X EMISSIONS.	
OPTION B. APU EMISSIONS FACTOR CERTIFIED NO_X EMISSIONS (G/BHP-HR)	
x TxLED correction factor (diesel engines only)	
x APU horsepower (hp)	
x 0.43 load factor	0.43
x idling hours per day (hr/day)	
=reduced NO_x emission factor (g/day)	

PART C. CALCULATE THE NO_X EMISSION REDUCTION USING ANNUAL HOURS OF IDLING TIME

baseline engine NO_x emission standard (g/hr) (g/day)	
- reduced NO_x emission factor (g/day)	
= grams per day reduced (g/day)	
x 365 (day/yr)	365
= grams per year (g/yr)	
/ 907,200 (g/ton)	907200
= tons per year (tons/yr)	
x percent within affective counties %	
= estimated annual NO_x emission reduction (ton/yr)	
x activity life (yr)	
= estimated activity life NO_x emission reduction (ton)	

WHAT IS THE ACTIVITY COST PER TON?

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