



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 vehicle's or locomotive's 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 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<sub>x</sub> emissions from diesel engines. Currently, reduction factors of **5.7 percent** (0.057) for on-road use and **7.0 percent** (0.07) for non-road use have been accepted as a NO<sub>x</sub> 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 NOx Emission Reductions for idling reduction infrastructure to allow acceptance of electricity for on-road heavy-duty vehicles

The NOx emission reduction from use of idling reduction infrastructure is the amount of NOx 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 NOx emissions, multiply the vehicle's NOx 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 NOx emissions per day to tons of NOx 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 NOx 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:**  $1 - 0.057 = 0.943$

#### Idling Engine NOx Emission Factor (g/day)

$135 \text{ g/hr} \times 0.943 = 127.305 \text{ g/hr}$

$127.305 \text{ g/hr} \times 7 \text{ hr} = \mathbf{891.135 \text{ g/day}}$

#### NOx Emission Reduction (tons/yr)

$891.135 \text{ g/day} \times 365 \text{ days} = 325,264 \text{ g/yr}$

$325,264 \div 907,200 \text{ g/ton} = 0.3585 \text{ tons/yr}$

## **Calculating NOx Emission Reductions for APUs to generate and provide electricity on vehicles**

Emission reductions are calculated as the difference in the NOx 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 NOx emission factor by the number of reduced "long duration idling hours" to find the NOx emission factor in grams per day. To compute APU emissions, multiply the APU's NOx emission factor, load factor (default load factor for APUs is 0.43), and horsepower to derive the number of grams per hour of APU NOx emissions.

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

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

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

Example 2 below illustrates these calculations.

Use Table 8.1 (page 3) for the NOx emission factors of idling heavy-duty on-road vehicles.  
Use Table 8.2 for APU/small engine NOx emission factors.

**Table 8.2 EPA Non-road Emission Standards for Small Engines**

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

**Example 2: Calculation for determining NOx 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 hours

**Percent time idling in affected counties:** 75%

**TxLED Correction factor:** Propulsion engine:  $1 - 0.057 = 0.943$

APU engine:  $1 - .07 = 0.93$

**Idling Engine NOx Emission Factor (g/hr)**

$135 \text{ g/hr} \times 0.943 = 127.305 \text{ g/hr}$

**APU NOx Emission Factor (g/hr)**

$5.32 \text{ g/bhp-hr} \times 0.93 = 4.9476 \text{ g/bhp-hr}$

$4.9476 \text{ g/bhp-hr} \times 14.6 \text{ hp} \times 0.43 \text{ load factor} = 31.0610 \text{ g/hr}$

**NOx Emission Reduction (tons/yr)**

$127.3050 \text{ g/hr} - 31.0610 \text{ g/hr} = 96.2440 \text{ g/hr}$

$96.2440 \text{ g/hr} \times 3,000 \text{ hours} \times 75\% = 216548.9262 \text{ g/yr}$

$216548.9262 \text{ g/yr} \div 907,200 \text{ g/ton} = 0.2387 \text{ tons/yr}$

## **Calculating NOx Emission Reductions for APUs to generate and provide electricity on Switcher Locomotives**

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

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

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

Use Table 8.3 for the NOx 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	NOx g/hr
2 -Stroke	800
4 -Stroke	620

**Table 8.4 EPA Default Switcher Locomotive Idling Percentage**

Type	(%)	Hrs
Switcher	59.8	14.4

**Example 3: Calculation for determining NOx 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 hours

**Estimated idling hours reduced by the APU:** 11 hours

**Percent time idling in affected counties:** 85%

**TxLED Correction factor:**  $1 - 0.07 = 0.93$

**Idling Engine NOx Emission Factor (g/day)**

$800 \text{ g/hr} \times 0.93 = 744 \text{ g/hr}$

$744 \text{ g/hr} \times 11 \text{ hr} = \mathbf{8184 \text{ g/day}}$

**APU NOx Emission Factor (g/day)**

$6.745 \text{ g/bhp-hr} \times 0.93 = 6.273 \text{ g/hr}$

$6.273 \text{ g/hr} \times 20 \text{ hp} \times 0.43 \text{ load factor} = 53.9465 \text{ hp}$

$53.9465 \text{ g/bhp-hr} \times 11 \text{ hr} = \mathbf{593.4116 \text{ g/day}}$

**NOx Emission Reduction (tons/yr)**

$8184 \text{ g/day} - 593.446 \text{ g/day} = 7590.59$

$7590.59 \text{ g/day} \times 365 \text{ days} = 2,770,564.8 \text{ g/yr}$

$2,770,564.8 \text{ g/yr} \div 907,200 \text{ g/ton} = 3.0539 \text{ tons/yr}$

$3.0539 \text{ tons/yr} \times 85\% = \mathbf{2.5958 \text{ tons/yr}}$

## Calculating NOx Emission Reductions for Automatic Shutdown Devices on Switcher Locomotives

The NOx 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 NOx emission factor by the number of reduced long duration idling hours to get a NOx 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 NOx.

If the NOx 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 NOx per year to find the tons per year of NOx reduction for the qualified counties.

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

Use Table 8.3 for the NOx emission factors of the current model switcher locomotive.  
Use Table 8.4 for the EPA default idling factors.

### **Example 4: Calculation for determining NOx 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 hours

**Estimated idling hours reduced by the APU:** 11 hours

**Percent time idling in affected counties:** 85%

**TxLED Correction factor:**  $1 - 0.07 = 0.93$

**Idling Engine NOx Emission Factor (g/day)**

$800 \text{ g/hr} \times 0.93 = 744 \text{ g/hr}$

$744 \text{ g/hr} \times 11 \text{ hr} = \mathbf{8184 \text{ g/day}}$

**NOx Emission Reduction (tons/yr)**

$8184 \text{ g/day} \times 365 \text{ days} = 2,987,160 \text{ g/yr}$

$2,987,160 \text{ g/yr} \div 907,200 \text{ g/ton} = 3.2927 \text{ tons/yr}$

$3.2927 \text{ tons/yr} \times 85\% = \mathbf{2.7988 \text{ tons/yr}}$

## 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 NOx 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 NOx emission reductions for all of the activities included in that project.

$$\text{Grant Amount} \div \text{Total NOx Emission Reductions} = \text{Cost Per Ton of NOx Reduced}$$

## 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 <input type="checkbox"/> Electrification	
What is the activity life in years?	
Number of Parking Spaces (if applicable)	
Estimated idle hours (per parking, space if applicable)	
Estimated idle hours reduced by supplied electricity	

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

Model Year	
Vehicle Weight Class	
Fuel Type	

### Calculate the NOx emission reductions

#### Part A. Calculate the TxLED Correction Factor (all areas but El Paso County)

On Road TxLED Correction Factor (1 - 0.057)	<b>0.0943</b>
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#### Part B. Calculate the NOx Emission Reductions

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

### What is the activity cost per ton?

Grant activity amount (\$):	
÷ NOx 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 <input type="checkbox"/> 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 NOx emission reductions

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

TxLED Correction Factor <i>propulsion engine (1 - 0.057)</i> <i>APU engine (1 - 07)</i>	<b>0.943</b> <b>0.93</b>
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### Part B. Determine the NOx Emission Factor

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

### Part C. Calculate the NOx Emission Reduction Using Annual Hours of Idling Time

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 (%)	
= 907,200 grams per ton	
= estimated annual NOx emission reduction (tons/yr)	
x activity life (years)	
= estimated activity life NOx emission reduction (tons)	

## What is the activity cost per ton?

Grant activity amount (\$):	
÷ NOx 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 <input type="checkbox"/> APU <input type="checkbox"/> 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 NOx emission reductions

#### Part A. Calculate the TxLED Correction Factor (all areas but El Paso County)

Non Road TxLED Correction Factor $1 - 0.070$	<b>0.93</b>
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#### Part B. Determine the NOx Emission Factor

<b>Determine Baseline NOx Emission Factor (g/hour)</b>	
baseline engine NOx emission standard (g/hr)	
x TxLED correction factor (diesel engines only)	
x idling hours per day (hr)	
= baseline NOx emission factor (g/day)	

<b>Determine Reduced NOx Emission Factor (g/hour)</b>	
<b>Option A. If using automatic shutdown device(s) emissions:</b>	enter zero for NOx
<b>Option B. APU emissions factor (hr)</b>	certified NOx emissions (g/bhp-hr)
	x TxLED correction factor (diesel engines only)
	x APU horsepower
	x 0.43 load factor
	x idling hours per day (hr)
	=reduced NOx emission factor (g/day)

**Part C. Calculate the NOx Emission Reduction Using Annual Hours of Idling Time**

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

**What is the activity cost per ton?**

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