

Appendix F - Emissions Inventory Analysis and Results

Emissions from heavy-duty trucks are major contributors to the NO_x and CO₂ inventory in California. Approximately a third of statewide NO_x emissions or 509 tons per day (CARB, 2016) come from heavy-duty trucks. Additionally, medium- and heavy-duty trucks account for one fifth of the GHG emissions from the transportation sector nationally, and are the fastest growing segment of the transportation sector in both the U.S. and worldwide (CARB, 2016a). Similar to their contribution on a national basis, medium- and heavy-duty trucks over 8,500 pounds in California emit about a fifth of the total transportation GHG emissions, which is about eight percent of the statewide total (CARB, 2016a).

Therefore, in addition to controlling criteria pollutant emissions to meet air quality goals in areas such as South Coast, CARB has also been taking initiatives to control GHG emissions from mobile sources to meet the ambitious targets set forth in AB 32 of 40 percent below 1990 levels by 2030, and 80 percent below 1990 levels by 2050. Key actions include the Advanced Clean Cars 2 regulation for light-duty vehicles, and implementation of the Phase 2 GHG regulation for heavy-duty trucks. These technology measures provide the majority of the reductions needed to meet the 2030 GHG reduction goal. The remaining reductions would be achieved through expansion of renewable fuel requirements and actions to reduce growth in VMT. The benefits of the technology measures will also continue to grow significantly through 2050 as the penetration of cleaner technologies increases over time.

CARB staff has worked jointly with U.S. EPA and NHTSA on the next phase of federal GHG emission standards for medium- and heavy-duty vehicles, called federal Phase 2 which was published in October 2016. The federal Phase 2 standards were built on the improvements in engine and vehicle efficiency required by the Phase 1 emission standards and represent a significant opportunity to achieve further GHG reductions for 2018 and later MY heavy-duty vehicles, including trailers.

This Appendix provides an overview covering the calculations of emissions benefits from Phase 1 and Phase 2 of the regulation.

Emissions Benefits: Alignment with Federal Phase-2 Heavy Duty Truck Standards

In 2013, CARB adopted the California Phase 1 regulations, aligning California's medium- and heavy-duty vehicle and engine regulations with the federal Phase 1

program. Also, in conjunction with the adoption of the California Phase 1 regulations, CARB amended its existing tractor-trailer GHG regulation making it consistent with the federal program. CARB's adoption of Phase 1 gave manufacturers the ability to certify in California and gave CARB the authority to enforce the regulatory requirements.

The Phase 1 rule was designed to get "off-the-shelf" GHG emission reduction technologies onto the 2014 through 2018 MY fleet. Phase 1 is expected to reduce CO₂ emissions in California by 12 percent in 2030.

On August 16, 2016, U.S. EPA and NHTSA released a pre-publication version of the Phase 2 standards. The final version of the Phase 2 rule was published on October 25, 2016. The Phase 2 standards are the second phase of federal heavy-duty GHG standards and build upon the Phase 1 standards. The Phase 2 standards are technology forcing, affordable, and flexible. On a national basis, Phase 2 will save over 82 billion gallons of fuel, and cut CO₂ by over 1 billion metric tons to help achieve our climate goals and save vehicle owners \$170 million in fuel costs (CARB, 2016a).

A. Overview of Regulation

- The federal Phase 2 requirements begin with MY 2018¹ for newly manufactured trailers and MY 2021 for newly manufactured engines and vehicles, and phase in through the 2027 MY. The rule organizes truck compliance into four groupings as shown below. Large pickups and vans (Class 2b and 3)
- Vocational vehicles (Class 4 through 8)
- Combination tractors (Class 7 and 8)
- Trailers pulled by combination tractors (introduced in Phase 2)

The federal Phase 2 program includes the first ever CO₂ emission standards for manufacturers of trailers used in combination with tractors. The standards get progressively more stringent for 2021, 2024, and 2027 and later MY vehicles. CARB is proposing to align California's Phase 2 GHG standards with the federal Phase 2 program.

Trucking operations and conditions in California differ substantially from those on a national scale. Favorable weather conditions and other factors allow trucks that are operated primarily in California to be retained longer by fleets than the national average. In addition, the California trucking market is segmented, with national, regional, and local fleets all competing in different segments of the goods movement economy. This

¹ In California, the Phase 2 trailer program begins with trailers manufactured on or after January 1, 2020.

leads to a different vehicle fleet mix, vehicle age, and VMT profiles compared to the national average. EMFAC2014 reflects these California-specific factors, and is used as the starting point for this analysis. Thus, this analysis focuses on the GHG emissions impact of the proposed rule as applied to heavy-duty vehicles operated in California.

B. Emissions Inventory Methods: Emission Rates

The federal Phase 2 rule sets CO₂ emission standards for each vehicle category listed below:

- Vocational Vehicles
 - Heavy Heavy (Class 8)
 - Medium Heavy (Class 6 & 7 single-unit and buses)
 - Light Heavy (Class 4-5)
- Tractors
 - Class 7
 - Class 8
 - Sleeper cab
 - Day cab
- Pickups and Vans
 - Diesel (Class 2b-3)
 - Gasoline (Class 2b-3)
- Trailers

Since EMFAC2014 vehicle categories are different than the vehicle categories defined by the federal Phase 2 regulations, staff made necessary adjustments described below in order to estimate the emission reductions in terms of EMFAC2014 vehicle categories. These adjustments were derived from an analysis of VIUS (U.S. Census, 2002) data and EMFAC 2014 population/VMT data.

Staff calculated the population/VMT shares for relevant vehicle categories in EMFAC2014. Within each vehicle category, population and VMT are split among vehicles of various types as indicated by the percentages in parentheses:

- T7 trucks (33,001+ pounds GVWR)
 - Vocational (13 percent)
 - Day cabs tractor-trailer (41 percent)
 - Sleeper cab tractor-trailer (46 percent)
- T6 trucks (14,001 to 33,000 pounds GVWR)
 - Vocational class 4 and 5 (45 percent)

- Vocational class 6 and 7 (49 percent)
- Class 7 tractor-trailer (6 percent)
- LHDT(8,501 to 14,000 pounds GVWR)
 - Vocational (100 percent)
 - Tractor-trailer (0 percent)

Using these population/VMT shares, staff aggregated the emission rates obtained from the vehicle standards to obtain a composite CO₂ emission rate (g/mile) applicable to each EMFAC2014 vehicle category.

Staff applied these reductions to the EMFAC2014 CO₂ emissions output. For this analysis, school buses, urban transit buses, motor coaches, motor homes, and all other buses were assigned the same reduction level as medium heavy-duty vocational vehicles. The trailer reductions would be the result of implementing the Phase 2 regulation while keeping the CARB heavy-duty Tractor-Trailer GHG regulation in place. The basic assumption is that a Phase 2 compliant trailer complies with the Tractor-Trailer GHG regulation and therefore the Tractor-Trailer GHG regulation will not result in any additional benefit after the Phase 2 standards are implemented. The percentage reductions in CO₂ emission rates with respect to 2010 are shown in Tables F-1 through F-3.

Table F-1. Phase 1 and 2 CO₂ Remaining Emissions (Class 2b-3)²

MY	LHDT1/LHDT2 Reductions		Regulation
	Diesel	Gasoline	
2010	100.0%	100.0%	Phase 1
2014	97.7%	98.5%	
2015	97.0%	98.0%	
2016	94.0%	96.0%	
2017	91.0%	94.0%	
2018-2020	85.0%	90.0%	
2021	82.9%	87.8%	Phase 2
2022	80.8%	85.6%	
2023	78.8%	83.4%	
2024	76.8%	81.4%	
2025	74.9%	79.3%	
2026	73.0%	77.3%	

² The table shows remaining emission percentages; for example, 97.7 percent in the table for diesel MY 2014 would mean there is a 2.3 percent reduction in emissions due to the standards for that MY.

MY	LHDT1/LHDT2 Reductions		Regulation
	Diesel	Gasoline	
2027+	71.2%	75.4%	

Table F-2. Phase 1 and 2 CO₂ Remaining Emissions (T6, T7 and Buses)

MY	Composite Reduction		Buses	Regulation
	T6	T7		
2010	100.0%	100.0%	100.0%	Phase 1
2014	94.7%	87.0%	94.7%	
2015	94.7%	87.0%	94.7%	
2016	94.7%	87.0%	94.7%	
2017	91.1%	84.5%	91.1%	
2018-2020	91.1%	84.5%	91.1%	
2021-2023	82.4%	74.2%	82.4%	Phase 2
2024-2026	76.2%	68.6%	76.2%	
2027+	73.4%	65.5%	73.4%	

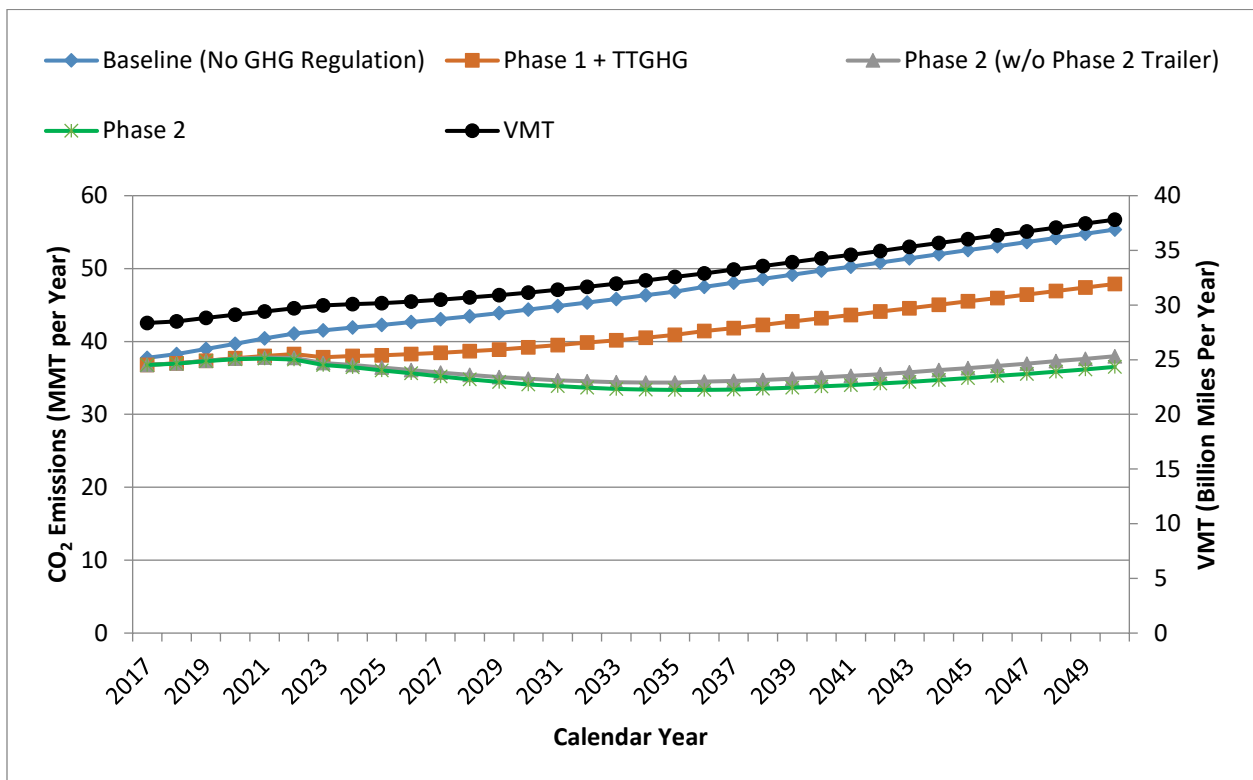
Table F-3. Phase 2 CO₂ Reduction Percentage due to Trailer Improvements

Phase 2 Trailer Reduction		Reductions			
Trailer Type	Assumed Distribution from MOVES	2018-2020	2021-2023	2024-2026	2027+
53'+ Dry Van	55.50%	6.7%	9.0%	10.5%	11.8%
<53' Dry Van	12.30%	2.9%	4.2%	5.1%	5.6%
53'+ Reefer	18.20%	5.8%	8.3%	10.0%	11.6%
<53' Reefer	5.20%	2.7%	3.8%	5.2%	5.9%
Container Chassis	0.20%	2.0%	3.0%	3.0%	3.0%
Flatbed	6.90%	2.0%	3.0%	3.0%	3.0%
Tank	0.40%	2.0%	3.0%	3.0%	3.0%
Other On-Highway	1.20%	0.0%	0.0%	0.0%	0.0%
Other Off-Highway	0.00%	0.0%	0.0%	0.0%	0.0%
Weighted Average	Combination Tractor-Trailer (except drayage trucks)	5%	7%	9%	10%
	Drayage trucks pulling container chassis only	2%	3%	3%	3%

C. Emissions Inventory Results

Figure F-1 shows the impact of the Phase 1 and Phase 2 regulation on GHG emissions from affected vehicles³. As shown, although the Phase 1 GHG standards are projected to reduce emissions below the baseline of what they would be without the standards, they are not enough to offset the projected growth in heavy-duty truck VMT. From around 2023 forward, without standards stricter than Phase 1, emissions would increase (see the orange line in Figure F-1). The Phase 2 GHG standards are needed to offset that projected VMT growth and keep heavy-duty truck CO₂ emissions declining through the mid-2030s (as shown in the green line in the Figure F-1). The results show that from 2019 to 2050, the California Phase 2 regulation achieves additional 207.6 MMT CO₂ reductions beyond those achieved by Phase 1.

Figure F-1. Statewide On-Road GHG Emissions from Phase 1 and Phase 2 Regulated Vehicles (TTGHG=Tractor-Trailer GHG regulation)



³ The affected EMFAC vehicle categories by Phase 1 and 2 regulations are heavy-duty trucks and buses exceeding 8,500 pounds GVWR.

Table F-2 shows the emission benefits in California from the California Phase 2 Program.

Table F- 2: California Phase 2 CO₂ Benefits

CO₂ Emissions from Affected Vehicles (in MMT per year)					
Calendar Year	Baseline CO₂ Emissions	CO₂ Emissions with Phase1 + Tractor-Trailer GHG	CO₂ Emissions with Phase 2	Phase 2 CO₂ Reductions	
				From Baseline	From Phase 1+Tractor-Trailer GHG Regulation
2030	44.4	39.2	34.1	23%	13%
2050	55.3	47.9	36.5	34%	24%