Technical Analysis of End of Useful Life Scenarios

Staff modelled useful life scenarios that require trucks (or buses) older than 18 years of age or those with more than 800,000 miles and at least 13 years old to turn over to new zero emissions (ZE), new diesel combustion, and new methane combustion technology. The baseline included the impact of the following regulations: Advanced Clean Trucks (ACT), Heavy-Duty Omnibus (HD Omnibus), Heavy-Duty Inspection & Maintenance (HD I/M) with a 4x testing frequency, and Advanced Clean Fleets (ACF). Note that this baseline choice means that very substantial electrification is already assumed in this analysis; without these CARB policies favoring electric vehicles and cleaning up remaining internal combustion engines, the remaining pollution addressed in this analysis would be substantially greater and the need for electrification more acute. Of course, even with CARB policies operating to clean the fleet, turning over remaining trucks in later years is important, as this analysis shows.

This analysis considered heavy-duty Class 4-8 (Gross Vehicle Weight Rating > 14,000 lbs.) vehicles. All new California engine sales must meet the Omnibus standard beginning 2024. As such, new combustion methane and diesel vehicles are assumed to meet the Omnibus in-use standard, i.e. 0.03 g/bhp-hr (in-use threshold = 1.5). However, this assumption represents an ideal case. Preliminary results from the 200-vehicle study[1] indicate that real-world heavy-duty emission rates can be substantially larger than their certification standard. For example, 0.02-certified methane combustion vehicles have an average in-use emission rate of 0.07 g/bhp-hr. Emissions from new combustion vehicles will be managed somewhat by regulations (e.g. in-use testing improvements through HD Omnibus), but will be larger than the in-use standard due to various vehicle operational characteristics, such as duty cycle and idling time. The summary presented in this document represents a regional analysis and not a community level health impact analysis.

NOx and PM emissions benefits, cumulative cost, and the number of vehicles replaced in **South Coast Air Basin** are shown in the table below for each scenario.

- **The largest NOx emissions benefits (4.5 tpd in 2037) are achieved with zero emission vehicles (ZEVs)**. ZEVs have no exhaust emissions throughout their lifetime, and they also simultaneously reduce PM and GHG emissions. Starting in 2024, new combustion engines will have significantly lower NOx than 2010-certified engines due to the Heavy-duty Omnibus Regulation. However, these benefits are limited because combustion engines deteriorate as they age and when malfunctions occur. CNG engines certified to the optional NOx standard today are not expected to be any cleaner than new engines certified to the Omnibus emissions standards and enhanced durability requirements.

[1] California Air Resources Board, *In-Use Emission Performance of Heavy Duty Natural Gas Vehicles – Lessons Learned from 200 Vehicle Project*, (https://ww2.arb.ca.gov/sites/default/files/2021-04/Natural_Gas_HD_Engines_Fact_Sheet.pdf)

- **The largest PM2.5 emissions benefits (0.037 tpd in 2037) are achieved with ZEVs.** Also, it is notable that a recent International Council on Clean Transportation analysis[2] has shown that after factoring in upstream methane emissions, natural gas trucks are more harmful to the climate than diesel trucks.
- **Community emissions benefits of ZEVs are large, but not explicitly accounted for here.** This analysis focus on regional benefits, but exposure to heavy-duty vehicle pollution is also a community-level issue. ZEVs would reduce community exposure to acute PM pollution as well as having regional benefits.
- The incremental costs for ZEVs are declining rapidly, and **the total cost of ownership is lowest for ZEVs**, even when including infrastructure costs, due to fuel and maintenance cost savings. Methane combustion truck market expansion costs also include new fueling and maintenance infrastructure. The cost comparisons are shown below.
- Infrastructure for methane trucks is expensive and would become a stranded asset if use of those trucks continued to expand; EV infrastructure, in contrast, will be needed indefinitely.
- This analysis also does not include costs of repeated truck turnovers; however, methane combustion trucks would ultimately need to be funded to turnover to ZEVs, which would further add to their total costs.
- Fleets regularly exclude costs of renewable natural gas (RNG) when claiming it is cost competitive with ZEVs because they fail to include the substantially higher costs of producing RNG (the higher costs are paid by fuel providers due to the Low Carbon Fuel Standard or LCFS).
- Zero emission technology helps put California on track for meeting the goals of Executive Order N-79-20.
- Combustion engines purchased in 2031 or 2037 will stay in the fleet until the end of their useful life (15 years for semi-tractors and 18 years for all other trucks).
- The analysis does not address ultrafine particulate matter emissions and their near source health impacts on communities.
- Staff continue to be concerned about the performance of combustion trucks (including diesel and methane) in the field especially as they age and is looking into it further.

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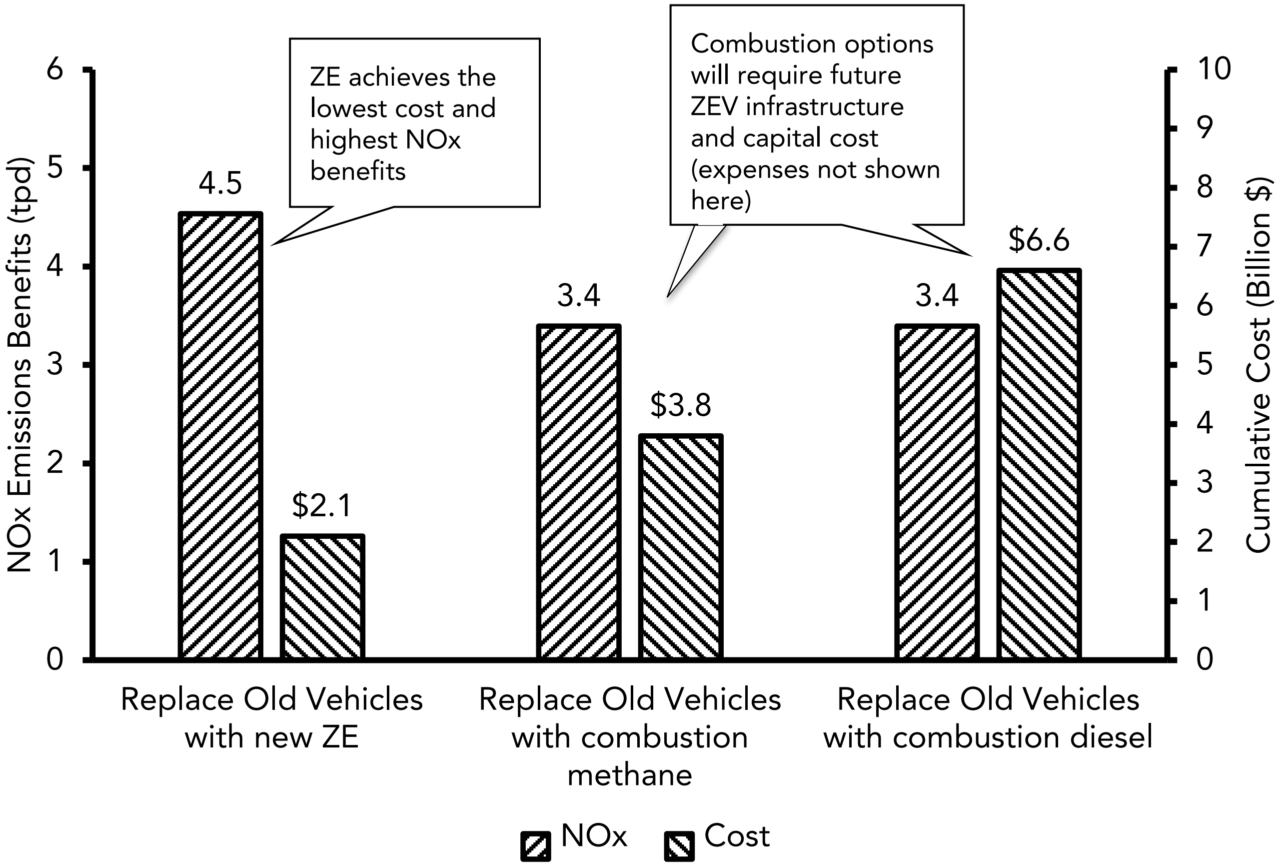
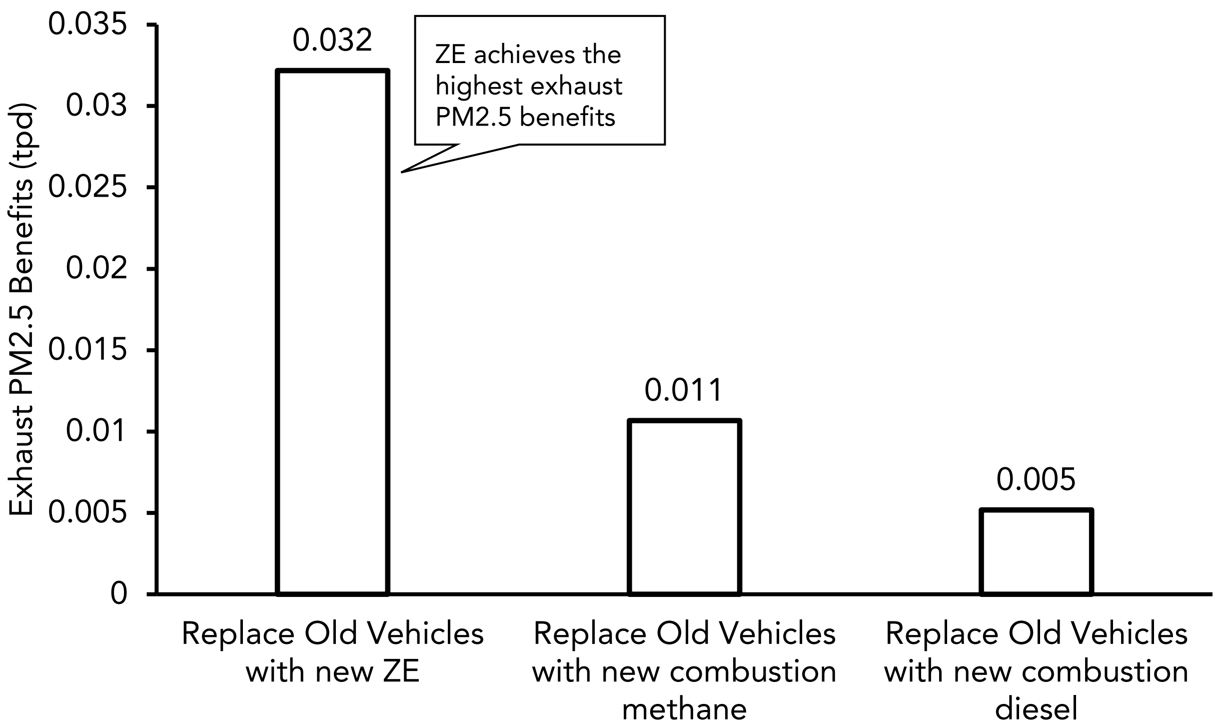
[2] International Council on Clean Transportation, *A comparison of nitrogen oxide (NOx) emissions from heavy-duty diesel, natural gas, and electric vehicles*, (https://theicct.org/sites/default/files/publications/low-nox-hdvs-compared-sept21.pdf)

Year	2031			2037		
Vehicle Type	**ZE**	**Methane Combustion***	**Diesel Combustion**	**ZE**	**Methane Combustion***	**Diesel Combustion**
Vehicles Replaced	39,300	39,300	39,300	48,000	48,000	48,000
NOx Benefits (tpd)	5.1	3.6	3.6	4.5	3.4	3.4
Cumulative Cost (Billion $)	$2.2	$3.1 ($3.3)	$3.6	$2.1	$3.8 ($4.7)	$6.6
PM Benefits (tpd)	0.037	0.012	0.006	0.032	0.011	0.005

* Costs with methane infrastructure are included in the parentheses.

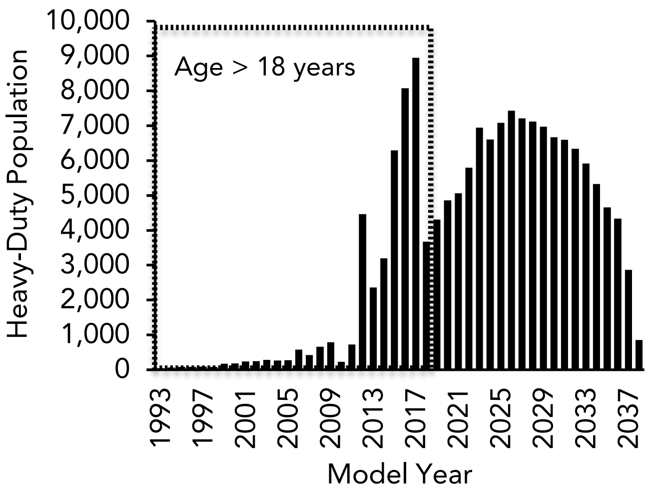
The figures below show scenario results in **calendar year 2037**.

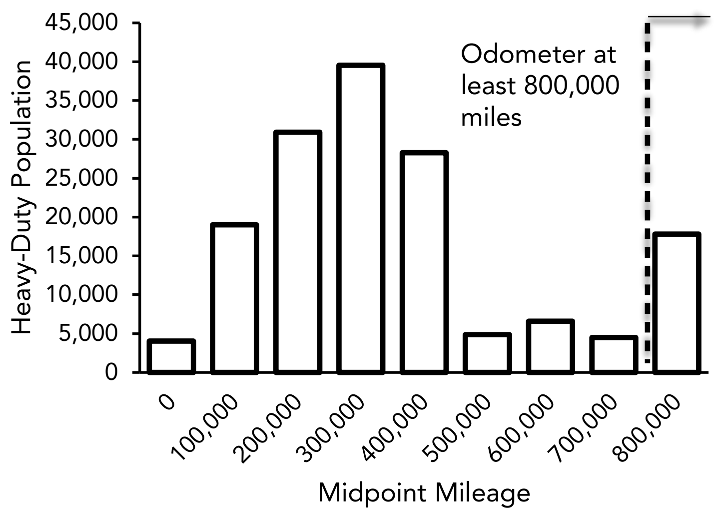


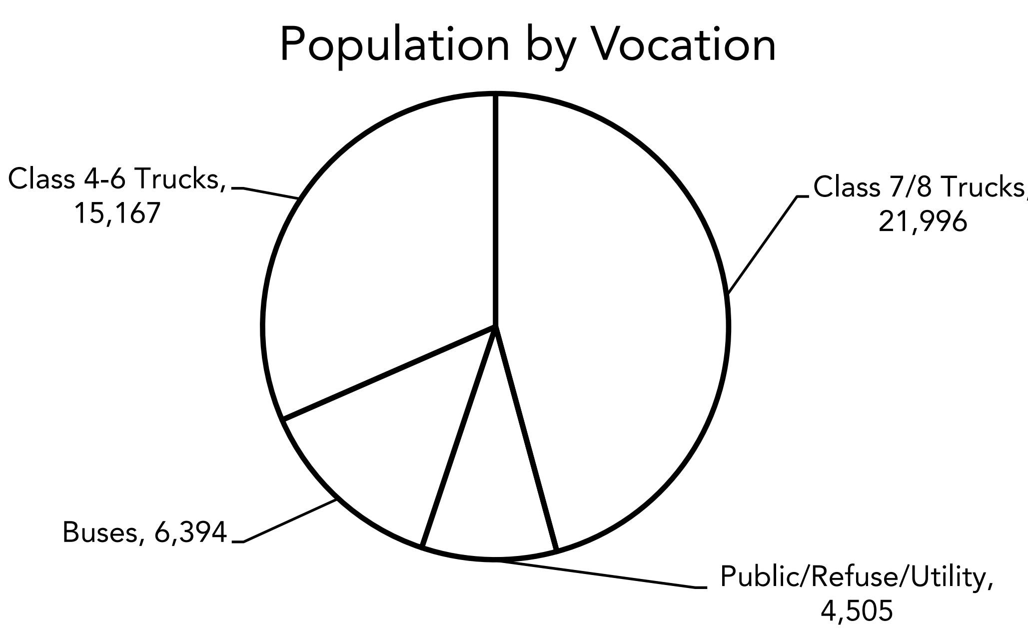


I. Characteristics of Replaced Vehicles in 2037 South Coast Air Basin

Shown below are model year and odometer mileage distributions of the remaining heavy-duty combustion fleet after ACT and ACF. Here, the portion of vehicles meeting the useful life criteria are highlighted. In addition, the turned over or replaced vehicles are broken down by vehicle vocation. As noted above, this analysis assumes extensive zero emission deployment from these policies.

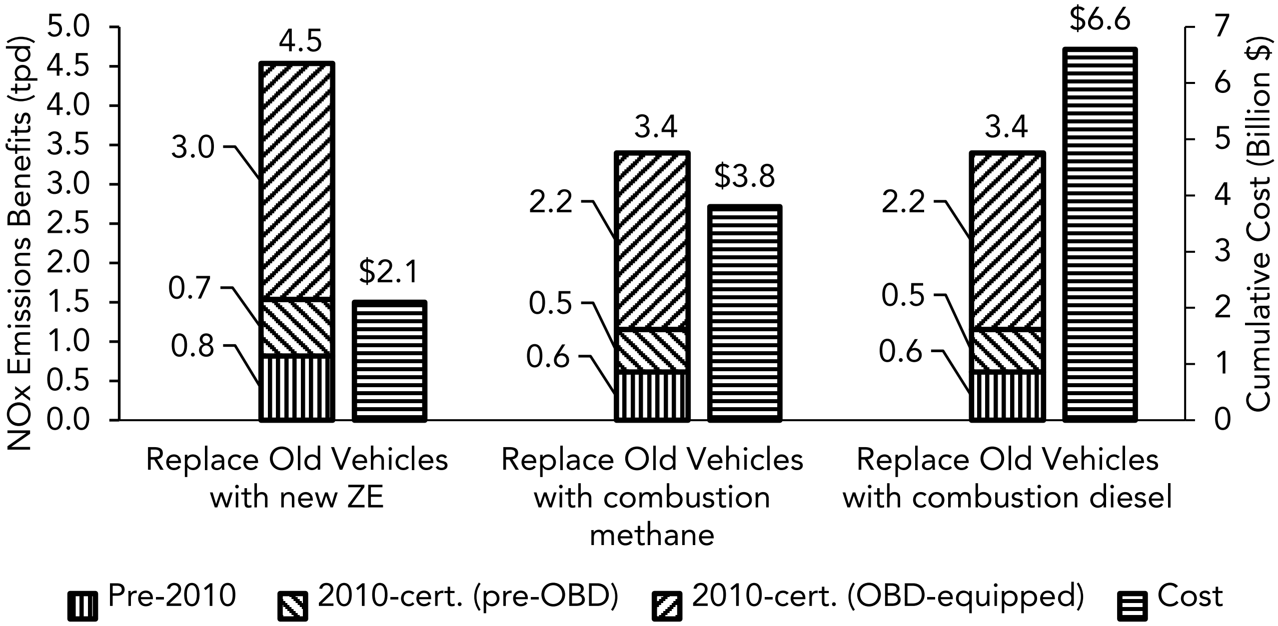


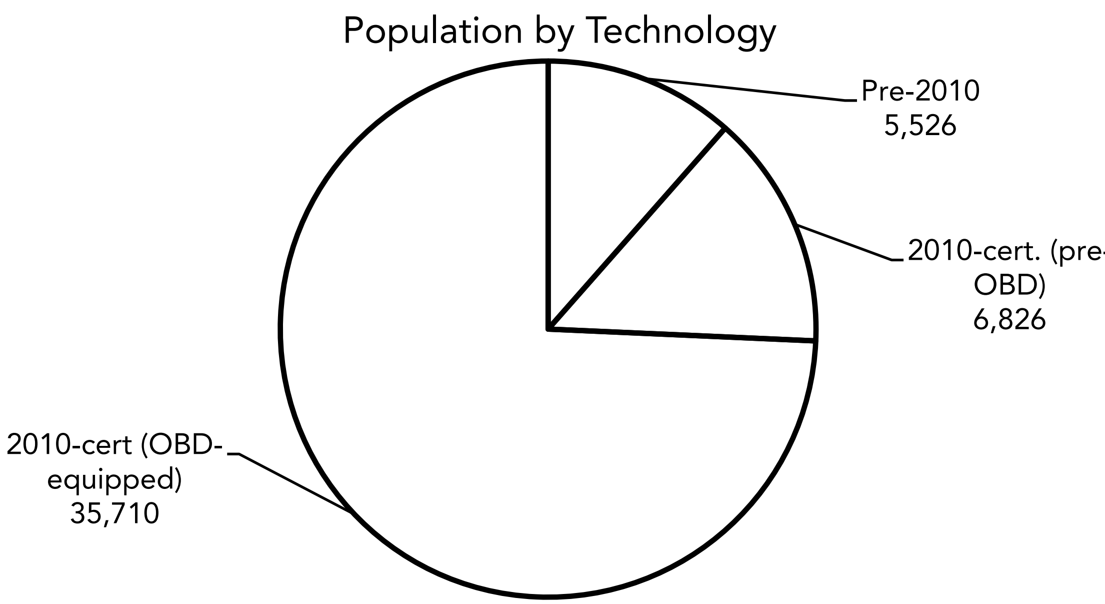




II. NOx Emissions Benefits by Technology in 2037 South Coast Air Basin

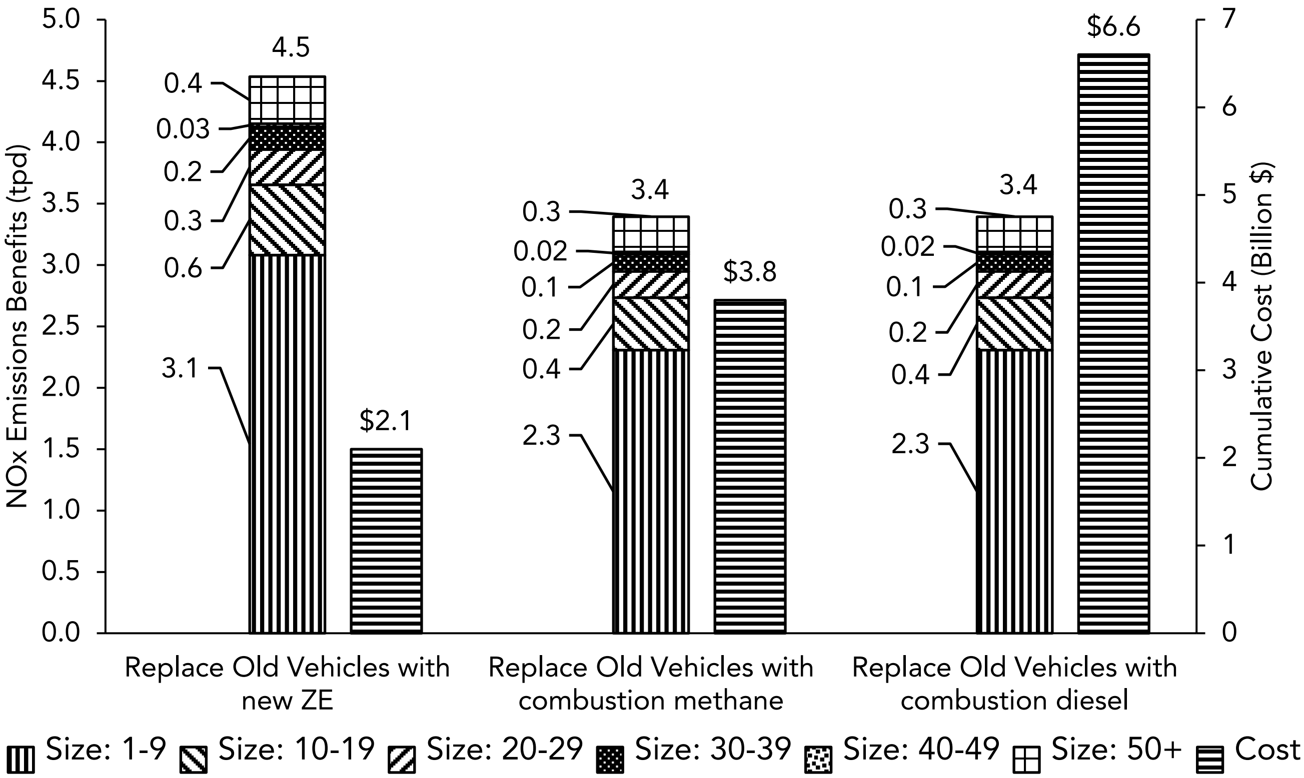
The majority of vehicles turned over are 2010-certified and OBD-equipped, i.e. engine model year 2013 and newer. A smaller fraction of the fleet are 2010-certified pre-OBD vehicles with engine model years 2010-2012. The remaining vehicles are Pre-2010 trucks that were not subject to the Truck and Bus regulation or have limited exemptions under Truck and Bus rule.

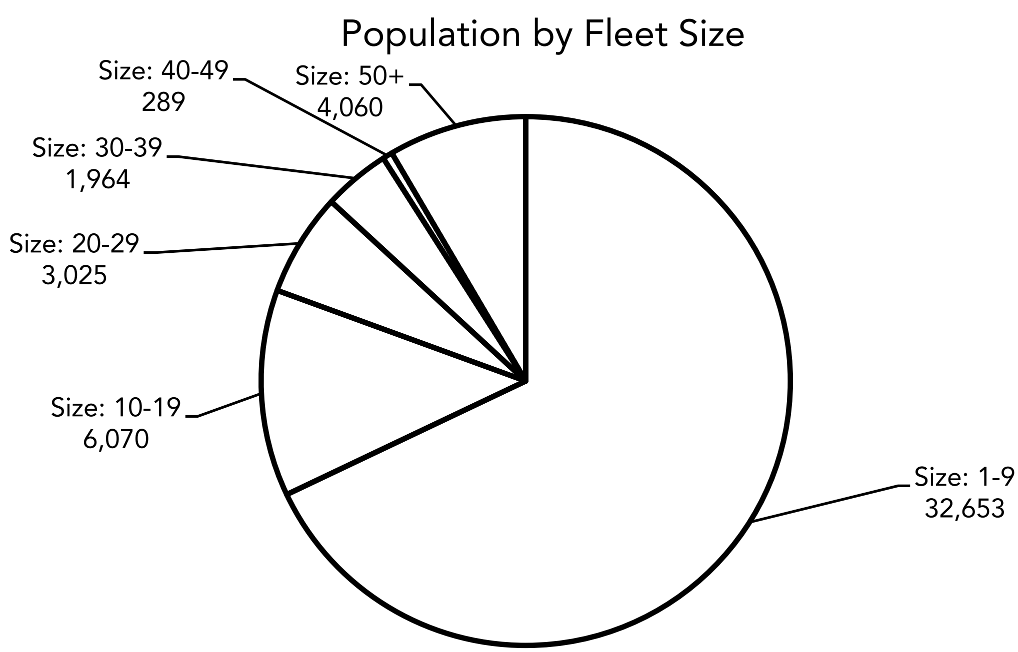




III. NOx Emissions Benefits by Fleet Size in 2037 South Coast Air Basin

Fleet size distribution was determined from staff's analysis of DMV data. The majority of heavy-duty vehicles are in smaller fleets (1-19 vehicles).





IV. NOx Emissions Benefits from Various Truck Measures in 2037 South Coast Air Basin

To put these results into context, the emissions benefits for key adopted and proposed heavy-duty regulations are shown below, including ACT, HD Omnibus, HD I/M, and ACF. The scenario emissions benefits are somewhat lower after ACF is included in the baseline. When ACF is included, some of the older vehicles meeting useful life criteria are turned over to zero emission through this regulation. This does not mean that ZEV trucks become less important – it is simply that more of them enter the baseline population already if ACF is finalized, meaning there are fewer remaining trucks to turnover.