ECONOMIC IMPACT ANALYSIS OF EPA’s PROPOSED GHG EMISSIONS STANDARDS FOR HEAVY-DUTY VEHICLES – PHASE 3

FEBRUARY 2024 UPDATE FINAL REPORT

PREPARED FOR:

TRUCK & ENGINE MANUFACTURERS ASSOCIATION

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In November 2023, ACT Research Company (ACTR), at the request of the Truck and Engine Manufacturers Association (EMA), developed an analysis of the potential economic and environmental impacts associated with U.S. EPA's Notice of Proposed Rulemaking (NPRM) for Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles—Phase 3, published on April 27, 2023. Subsequent to that analysis, EMA has retained ACTR to revisit and expand on that original analysis to include additional potential scenarios for the implied HD zero emission penetration rates mandated under the anticipated Phase 3 rule.

ACTR is a boutique research firm focused on surface transportation dynamics and commercial vehicle (CV) demand. ACTR's customers include leading medium-duty (MD) and heavy-duty (HD) vehicle manufacturers, the commercial vehicle industry's supply base, investors in transportation and machinery companies, transportation companies, and other groups of stakeholders that need to understand the impact of economic activity on trucking industry profitability, and by extension, demand for MD and HD on-highway vehicles.

ACTR has been and will continue to be a supporter of the EPA's efforts to improve air quality. We applaud the 99% and 98% reductions in particulates and NOx emissions standards, respectively, that have occurred over the past quarter-century plus. Our analysis is simply to help identify various impacts and potential pathways to achieving improved air quality.

Contents

Page(s)

Executive Summary

The Truck and Engine Manufacturers Association (EMA) retained ACT Research (ACTR) to conduct additional analysis of the potential economic impacts if the EPA adopts a final Phase 3 GHG rule that sets an indirect mandate for the sale of medium- and heavy-duty (MHD) zero-emission vehicles (ZEVs) at levels above the sales volumes of MHD ZEVs that can actually be supported by the MHD vehicle market and by the installed and available MHD ZEV infrastructure. With input from the EMA, ACTR has analyzed additional MHD ZEV penetration-rate scenarios which are similar to the analysis completed in 2023. This update assumes the target percentages of ZEVs in the EPA's final rule making (FRM) will revert to either the Aggressive Adoption Rates or to the EPA's Alternative Adoption Rates from the NPRM. There is a base case scenario, titled "Scenario 0 EMA Strawman Neutral Adoption Rates," that investigates alternative ZEV sales adoption rates.

There are five scenarios which are examined in this analysis, two from the EPA, and three alternatives presented by the EMA, identified in the following tables. Those scenarios include:

EPA

- The EPA's main NPRM proposal for MHD ZEV adoption rates
- The EPA's NPRM "Alternative" proposal for slightly lower MHD ZEV adoption rates

EMA proposals

- The Strawman proposal with reduced MHD neutral ZEV adoption rates
- A scenario that includes MHD ZEV adoption rates with more aggressive final-year targets than the original EPA NPRM proposed rates
- A scenario that assesses MHD ZEV adoption rates that fall between EMA's Strawman and EPA's Alternative proposals

In each scenario assessed by ACTR, the maximum number of MHD ZEV unit sales cannot exceed the number that occur in Scenario 0, based on the EMA's Strawman Neutral Adoption Rates. The number of assumed MHD ZEV unit sales considered achievable does not change even as the assumed EPA FRM ZEV adoption rates do in each scenario.

- **Scenario 0, EMA Strawman Neutral Adoption Rates**: The Strawman scenario includes indirectly mandated ZEV sales and associated stringencies in the final Phase 3 rule that attempt to match realistic targets.

  Table 1: EMA Strawman Adoption Rates 2027-2032

EMA Strawman Adoption Rates						
Subcategory	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
LHD	6%	9%	12%	20%	25%	35%
MHD	5%	7%	9%	15%	20%	30%
HHD	0%	0%	0%	5%	8%	15%
MHD & HHD Day Cab Tractors	0%	0%	2%	5%	9%	15%
Sleeper Cab Tractors	0%	0%	0%	0%	2%	3%

  This scenario results in no change to total vehicle sales relative to ACTR's base-case forecast expectations, no change to overall fleet size, and no regulatory-driven change to market freight rates.

- **Scenario 1, Aggressive Adoption Rates**: Indirectly mandated MHD ZEV adoption rates and associated stringencies in the Phase 3 FRM are the same as in the EPA's Aggressive Adoption Rates.

  Table 2: Aggressive Adoption Rates 2027-2032

Aggressive Adoption Rates						
Subcategory	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
LHD	16%	23%	27%	32%	46%	60%
MHD	13%	16%	19%	22%	31%	40%
HHD	0%	10%	13%	15%	22%	30%
MHD & HHD Day Cab Tractors	5%	8%	12%	16%	28%	40%
Sleeper Cab Tractors	0%	0%	0%	6%	12%	25%

  Actual ZEV sales in the market are approximately 52% less than the EPA's projections. This scenario utilizes the EMA's Strawman Adoption Rate scenario as the actual achievable penetration rates but assumes OEMs will be forced to sell fewer diesel-powered vehicles to remain compliant with the implicitly mandated ZEV sales percentages in the FRM. This scenario results in labor reductions due to suppressed vehicle manufacturing, higher freight rates due to a decreased overall fleet size relative to freight demand levels, and greater pollution levels as older trucks are kept in service beyond their useful lives.

- **Scenario 2, Alternative Adoption Rates**: Under this scenario, the indirectly mandated MHD ZEV adoption rates and associated stringencies in the Phase 3 FRM are the same as in EPA's Alternative Phase 3 proposal.

  Table 3: NPRM Alternative Adoption Rates 2027-2032

NPRM Alternative Adoption Rates						
Subcategory	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
LHD	15%	22%	28%	34%	40%	46%
MHD	13%	17%	20%	22%	25%	28%
HHD	11%	13%	15%	20%	25%	32%
MHD & HHD Day Cab Tractors	5%	8%	10%	15%	20%	25%
Sleeper Cab Tractors	0%	0%	0%	10%	15%	20%

  In this scenario, actual ZEV sales in the market are approximately 48% less than the EPA's projected sales. This scenario again utilizes the EMA's Strawman Adoption Rate scenario as achievable penetration rates. As a result, this scenario assumes OEMs will be forced to sell fewer diesel-powered vehicles to remain compliant with the implicitly mandated ZEV sales percentages in the FRM. This scenario results in labor reductions due to suppressed vehicle manufacturing, higher freight rates due to a decreased overall fleet size relative to freight demand levels, and greater pollution levels as older trucks are kept in service beyond their useful lives.

- **Scenario 3, Mid-Point Difference Adoption Rates:** Indirectly mandated MHD ZEV adoption rates and associated stringencies in the Phase 3 FRM are the same as the EMA's Mid-Point Difference Adoption Rates.

  Table 4: Mid-Point Difference Adoption Rates 2027-2032

Mid-Point Difference Adoption Rates						
Subcategory	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
LHD	11%	16%	20%	27%	33%	41%
MHD	9%	12%	15%	19%	23%	29%
HHD	6%	7%	8%	13%	17%	24%
MHD & HHD Day Cab Tractors	3%	4%	6%	10%	15%	20%
Sleeper Cab Tractors	0%	0%	0%	5%	9%	12%

  Actual ZEV sales are approximately 24% less than the EPA's projected ZEV sales target. This scenario again utilizes the EMA's Strawman Adoption Rate scenario as achievable penetration rates. The Mid-Point Difference Adoption Rates have been established as a "middle ground" between the EPA's NPRM Alternative Adoption Rates and the EMA's Strawman Adoption Rate scenario. This scenario assumes that OEMs will be forced to constrain diesel-powered vehicle sales to remain compliant with the implicitly mandated ZEV sales percentages in the FRM. This scenario results in labor reductions due to suppressed vehicle manufacturing, higher freight rates due to a decreased overall fleet size relative to freight demand levels, and greater pollution levels as older trucks are kept in service beyond their useful lives.

Methodology for Analysis

In this report, we look at the industry through three different lenses.

- First, the proposed Phase 3 GHG rule covers MHD and HHD vehicles, which correspond to vehicle Classes 4-8. As a result, our analysis of potentially reduced sales volumes under Scenarios 1, 2, and 3 covers all trucks in Classes 4-8, and so is a comprehensive analysis of those potential impacts of the Phase 3 rule.
- Second, due to limitations in the available data, our analysis of the potential negative employment impacts of the Phase 3 rule covers only Classes 6-8 vehicle production. As such, our estimates of manufacturing employment effects likely understate reality, because they do not include the employment impacts of reduced production volumes at Classes 4-5 CV manufacturers.
    - In addition, our employment estimates focus on the lost production in the Class 8 market alone. As a result, our calculations of lost jobs are further underestimated, as the job losses related to Classes 4-7 will likely be significantly above the estimates presented here.
- Third, in our economic cost analysis, we focus on the Class 8 tractor market specifically because, as the lifeblood of the US economy, it is a highly observable market and among the most challenging to decarbonize. Since our economic cost analysis focuses only on the HHD tractor market, which comprises only 37% of the total Classes 4-8 vehicle population, the actual costs to the US economy from the impacts of the Phase 3 rule (which again covers all Classes 4-8 vehicles, not just HHD tractors) *will likely be more than twice our estimates*.

In Scenarios 1, 2, and 3, ACTR utilized our long-term sales forecasts for US Classes 4-8 CVs, and from that baseline, calculated revised MHD sales volumes by decreasing ICE CV sales to align with mandated ZEV market share percentages in a ZEV-demand constrained market. The actual number of ZEVs that can be feasibly sold under Scenarios 1, 2, and 3 are aligned with the reduced percentages and resultant volumes reflected in the EMA's Strawman Adoption Rates. Those calculated reductions in MHD sales volumes relative to market-driven capacity demand are utilized in ACTR's calculations to determine the negative impact on employment and increases in freight rates. Consequentially, ACTR calculated the net impact of carbon dioxide (CO2) and nitrogen oxides (NOx) emissions due to fleet aging.

The focus of ACTR's analysis is to project the economic implications of a market in which new truck sales are constrained at an increasing rate over the life of the Phase 3 regulation. The resultant market impacts include:

- **Reduced Commercial Vehicle Sales/Production**: Unit sales/production volumes of conventionally fueled MHD vehicles will fall below economically derived levels due to the industry's inability to sell the required number of MHD ZEVs, thereby constraining overall sales volumes.
- **Lower Manufacturing Labor**: There will be a significant loss of manufacturing jobs as a result of the projected reduced sales/production volumes, including job

losses for OEMs, suppliers, and the secondary service sector due to lack of re-spending of lost wages from the reduced manufacturing labor force.

- **Higher Freight Transportation Costs**: If vehicle sales fall below economically derived levels, the capacity shortfall would be borne by US consumers in the form of higher freight rates. Increased freight costs would result not only from the higher cost of ZEV units, but also reductions in the number of new Class 8 HHD tractors added to the fleet each year. The failure of the market to add capacity to account for economic growth will impact freight market supply-demand dynamics.
- **Increased Emissions**: If new trucks are brought into the market at below economically derived levels, it will force freight to be hauled by older trucks. The subsequent rise in fleet age will result in a higher net change in both CO_2 and NOx emissions due to differences in fleet mix of new trucks, both diesel and ZEV, and the older trucks that will be required to remain in the fleet longer than under unconstrained market conditions.

As noted, the scenarios were developed to analyze the impacts likely to occur should the EPA adopt in its FRM:

a) the same implicit ZEV-sales mandates outlined in the Alternative Adoption Rates in the NPRM,
b) Aggressive Adoption Rates, or
c) the "Mid-Point Difference."

In each scenario, we assess the economic impacts if the actual sales of MHD ZEVs end up matching the reduced projections identified in the Strawman base-case scenario. The Strawman, Scenario 0 has been developed as the base case and assumes the EPA's final rule adopts alternative standards that would result in lower-than-implicitly-mandated MHD ZEV sales percentages. Those lower than implicitly mandated ZEV adoption rates are achievable if based on feasible payback criteria.

Scenario 0 assumes the EPA finalizes a regulation that projects a roughly 50% lower MHD ZEV adoption rate, matching the percentages of ZEVs that EMA member companies have identified as reasonably achievable. This scenario results in no change to total vehicle sales versus projected sales, no change to overall fleet size, no change to freight market rate expectations, and cleaner air. This scenario serves as the base case from which impacts for the other scenarios were derived.

EMA Scenarios 1, 2, and 3 decrease the level of ICE CV sales to volumes determined by ZEV sales. The regulation's prescribed ZEV adoption rates would determine ICE sales, rather than freight market supply and demand conditions. These ZEV share-driven scenarios result in lower truck sales/builds, the loss of primary manufacturing jobs and related jobs in OEM supplier support industries, and cascading job losses in other sectors due to lost income from the reduced manufacturing workforce. Sales constraints in turn would lead to materially higher freight rates with costs converted to consumer inflation.

In addition to these significant CV industry and macroeconomic impacts, there are associated significantly negative environmental impacts. Rather than the intended goal of reducing GHG/CO_2, the analysis shows there would be a net increase in CO_2 under Scenarios 1, 2, and 3, as well as increased levels of NOx. Truck fleets would be forced to extend the useful life of aging trucks that are inherently less efficient and have higher emissions of GHG/CO_2 as well as tail-pipe NOx emissions.

Table 5, shown on the following page summarizes the cumulative impact of Scenarios 1, 2, and 3, compared to the base-case Strawman Scenario 0. As noted, Scenario 0 would result in zero losses in either CV sales or employment, no increases in freight costs, and reduced emissions as new trucks replace older trucks in the fleet.

Table 5: EPA GHG Phase 3 NPRM Scenarios – Cumulative Impact Summary

ACT RESEARCH - EPA GHG PHASE 3 SCENARIOS - CUMULATIVE IMPACT SUMMARY	SCENARIO 0		SCENARIO 1		SCENARIO 2		SCENARIO 3	
VEHILCE FORECASTS	**Units**		**Units**		**Units**		**Units**	
Class 4-5	800,200		399,404		431,094		552,809	
Class 6-7	1,062,500		603,316		666,063		794,715	
Class 8	1,592,100		607,966		563,809		677,483	
TOTAL CLASSES 4-8 SALES	**3,454,800**		**1,610,686**		**1,660,966**		**2,025,007**	
CUMULATIVE UNIT SALES DECREASE	**Units from Base Case**	**Δ from Base Case**	**Units from Base Case**	**Δ from Base Case**	**Units from Base Case**	**Δ from Base Case**	**Units from Base Case**	**Δ from Base Case**
Class 4-5	0	--	(400,796)	-50%	(369,106)	-46%	(247,391)	-31%
Class 6-7	0	--	(459,184)	-43%	(396,437)	-37%	(267,785)	-25%
Class 8	0	--	(984,134)	-62%	(1,028,291)	-65%	(914,617)	-57%
TOTAL CLASSES 4-8 CUMULATIVE UNIT SALES DECREASE	0	--	**-1844114**	**-53%**	**-1793834**	**-52%**	**-1429793**	**-41%**
CUMULATIVE EMPLOYMENT IMPACT FROM BASE CASE	**Jobs**		**Jobs**		**Jobs**		**Jobs**	
EMPLOYMENT LEVELS	**640,000**		**455,000**		**470,000**		**510,000**	
	Jobs from Base Case	**Δ from Base Case**	**Jobs from Base Case**	**Δ from Base Case**	**Jobs from Base Case**	**Δ from Base Case**	**Jobs from Base Case**	**Δ from Base Case**
CUMULATIVE EMPLOYMENT DECREASE (Jobs)	**0**	--	**-185,000**	**-29%**	**-170,000**	**-27%**	**-130,000**	**-20%**
CUMULATIVE FREIGHT COST IMPACT FROM BASE CASE	**$ Billions**		**$ Billions**		**$ Billions**		**$ Billions**	
CUMULATIVE FREIGHT COST ($ Billions)	**$2,587**		**$2,886**		**$2,885**		**$2,860**	**thi**
	$(B) from Base Case	**Δ from Base Case**	**$(B) from Base Case**	**Δ from Base Case**	**$(B) from Base Case**	**Δ from Base Case**	**$(B) from Base Case**	**Δ from Base Case**
CUMULATIVE FREIGHT COST INCREASE ($ Billions)	**0**	--	**+$299 B**	**+12%**	**$+298 B**	**+12%**	**+$273 B**	**+11%**
CUMULATIVE CO2 EMISSIONS IMPACT FROM BASE CASE	**MMT**		**MMT**		**MMT**		**MMT**	
CUMULATIVE CO2 EMISSIONS (MMT)	**154.2**	--	**173.14**		**172.79**		**170.04**	
	CO2 from Base Case	**Δ from Base Case**	**CO2 from Base Case**	**Δ from Tot Population**	**CO2 from Base Case**	**Δ from Tot Population**	**CO2 from Base Case**	**Δ from Tot Population**
CUMULATIVE INCREASE IN CO2 EMISSIONS (MMT)	**0**	--	**+18.94**	**+6.2%**	**+18.59**	**+6%**	**+15.84**	**+5.1%**
percentage impact reflects total US truck population								
CUMULATIVE NOx EMISSIONS IMPACT FROM BASE CASE	**US tons**		**US tons**		**US tons**		**US tons**	
CUMULATIVE NOx EMISSIONS (US tons)	**330,000**		**131,441**		**129,032**		**114,129**	
	NOx from Base Case	**Δ from Base Case**	**NOx from Base Case**	**Δ from Tot Population**	**NOx from Base Case**	**Δ from Tot Population**	**NOx from Base Case**	**Δ from Tot Population**
CUMULATIVE INCREASE IN NOx EMISSIONS (US tons)	**0**	--	**+102,413**	**+31%**	**+100,004**	**+30%**	**+85,101**	**+26%**
percentage impact reflects total US truck population								

Source: ACT Research Co., Copyright 2024

As illustrated in the table on the previous page, the impacts across the 2027 through 2032 timeframe are significant.

The failure of the trucking industry to meet ZEV targets in Scenarios 1, 2, and 3 raises the potential for onerous outcomes. Whether high prices, uncompetitive ownership economics, or failures in infrastructure follow through limiting adoption, the scenarios analyzed risk cumulative truck builds dropping for a loss of ~1.4M to ~1.8M truck sales (41% to 53% of the market) relative to economically projected volumes. Those lost unit sales would result in employment reductions of 130k to 185k jobs, impacting just under 30% of the CV market workforce. The decrease in new truck builds will result in cumulative freight cost increases of just under $300B across the six-year forecast horizon, representing a 12% increase in the nation’s freight bill above Scenario 0’s base-case expectations.

The impact on emissions due to the inability to retire aging trucks risks higher pollution levels than would otherwise have occurred. For CO2, the scenario projections range from a net increase of ~16MMT to ~19MMT of higher emissions, or between 5% and 6% in additional CO2 emissions relative to the base-case Scenario 0 projections. More striking is the impact on the additional NOx emissions, which would see increases ranging from ~85k to ~102k US tons. Those volumes represent increases of ~26% to 30% in higher NOx emissions above the Scenario 0 levels. This relatively large increase in NOx above the base case—nearly one-third—is significant.

Base-case Scenario 0 assumes less stringent GHG standards, with lower ZEV adoption rates through the forecast period, resulting in less onerous incremental impacts to the trucking industry and the broader economy.

When one considers the high probability of the significantly negative impacts of Scenarios 1, 2 and 3, the more pragmatic Scenario 0 is clearly the most favorable for adoption, as it avoids negative impacts to jobs and freight costs, while still achieving the goal of reduced GHG/CO2 emissions.

The remainder of this report presents the detailed analysis for the scenarios summarized above.

Unintended Consequences Analysis

Impact on Commercial Vehicle Sales/Builds

Table 6: Cumulative Impact on Vehicle Sales/Builds

ACT RESEARCH - EPA GHG PHASE 3 SCENARIOS - CUMULATIVE IMPACT SUMMARY								
	SCENARIO 0		SCENARIO 1		SCENARIO 2		SCENARIO 3	
VEHILCE FORECASTS	Units		Units		Units		Units	
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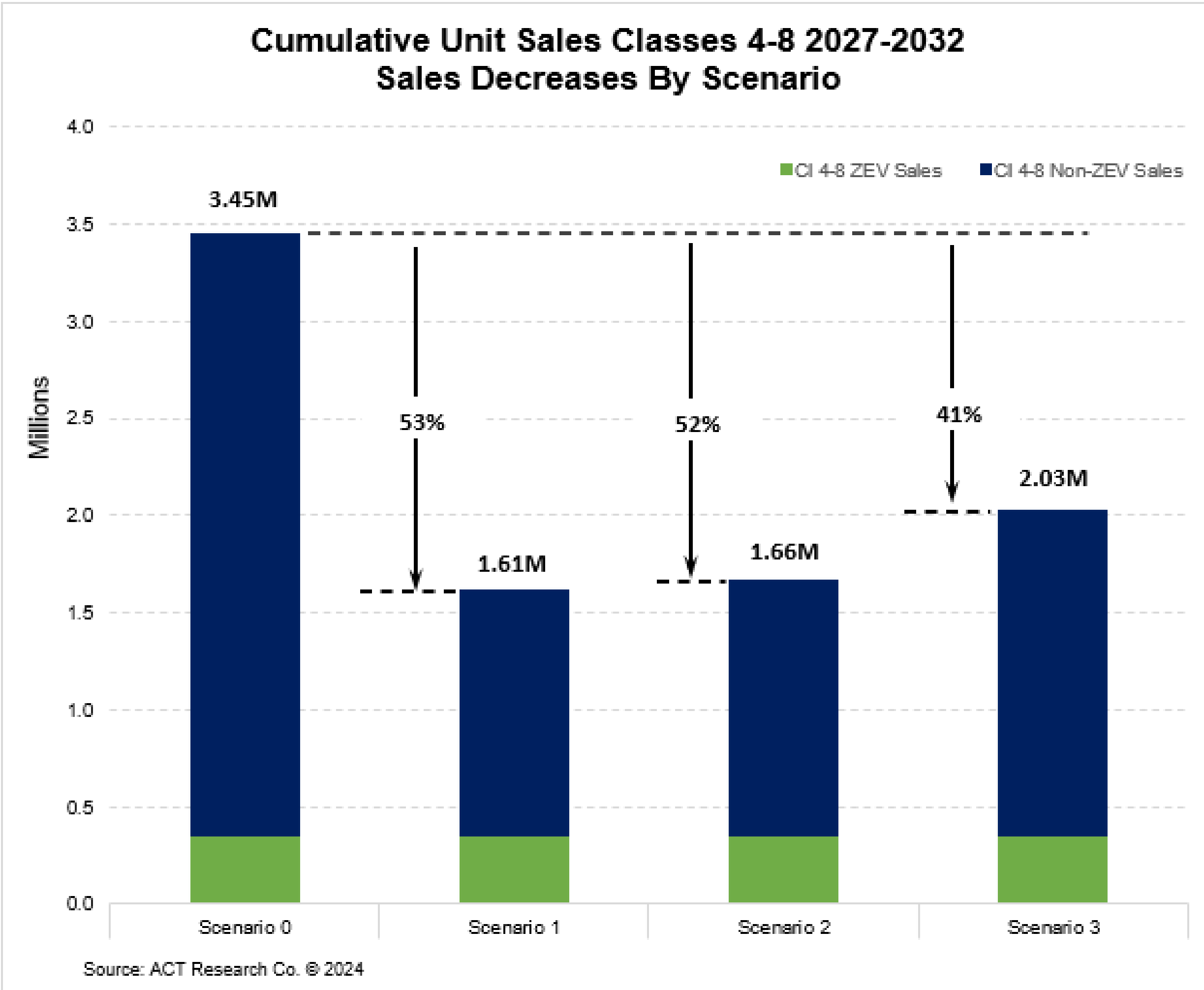
TOTAL CLASSES 4-8 CUMULATIVE UNIT SALES DECREASE	0	--	**-1844114**	**-53%**	**-1793834**	**-52%**	**-1429793**	**-41%**

Source: ACT Research Co., Copyright 2024

A major consequence of prematurely forcing the adoption of technologies that have materially higher total cost of ownerships (TCOs) relative to the incumbent fleet is weak demand for those products. In addition to non-competitive TCOs relative to the incumbent fleet, the mandates are dictating ZEV sales targets in a period in which infrastructure availability remains not only a formidable barrier to adoption but is also utility dependent. Barriers to easy adoption grow as GVW's increase, with publicly available charging infrastructure for HD vehicles essentially at zero today. As a chicken and egg problem, the infrastructure situation won't resolve itself without upstream support. Even with incentives like better fuel economy and increased engine durability, we are reminded that it took nearly 50 years for diesel to replace gasoline as the primary transportation fuel for commercial vehicles. The graph shown in Table 6 illustrates the total unit sales forecasted for the four scenarios described in this section. Scenario 0 reflects no decrease in total CV sales (Classes 4-8) from ACTR's economically derived base-case forecasts, while Scenarios 1, 2, and 3 result in significantly reduced CV sales.

The remainder of this section details CV sales under each of the scenarios.

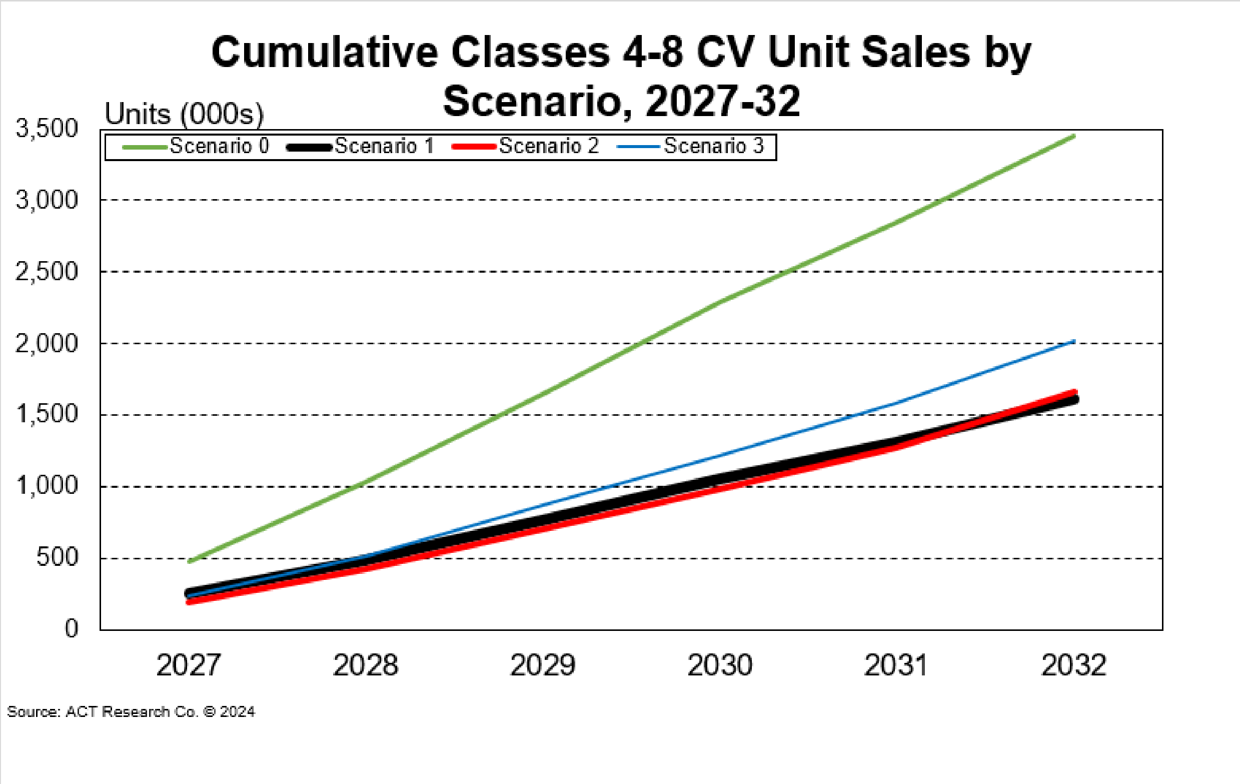
Graph 1: Total Cumulative Commercial Vehicle Unit Sales, Scenarios 0, 1, 2, and 3 2027-2032



The graph above illustrates the significant decrease in cumulative sales across the 2027-2032 timeframe that occurs in Scenarios 1, 2, and 3. Decreases in cumulative CV builds range from 41% to 53%, a staggering loss of vehicles over this six-year time frame. Graph 2, on the following page, illustrates the cumulative CV sales decrease on an annual basis.

Where Graph 1 depicts forecasted cumulative commercial vehicle sales/builds for the four scenarios analyzed in this report, Graph 2 tracks the annual path of sales over the course of the forecast.

Graph 2: Total Annual Cumulative Commercial Vehicle Unit Sales, Scenarios 0, 1, 2, and 3 2027-2032



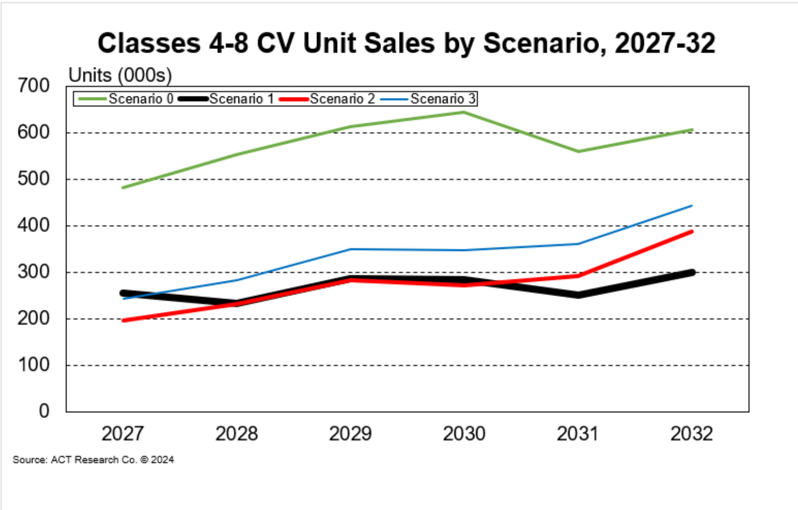
Scenario 0 depicts an industry that is not impacted by ZEV adoption rates, while the other scenarios result in decreased vehicle sales/builds.

Scenario 0 utilizes ACTR's long-term, top line forecast for US Classes 4-8 commercial vehicles and applies the implicitly mandated MHD ZEV sales adoption rates from the EMA's Strawman to determine ZEV volumes. As this is the EMA's attainable ZEV penetration scenario, the baseline scenario does not require any reduction in MHD sales/build volumes to achieve compliance, and therefore does not result in any lost jobs or increased freight rates as it assumes feasible MHD ZEV sales targets and adoption rates with costs that can be absorbed by the trucking industry.

For the increasingly difficult to achieve Scenarios 1, 2, and 3, ACTR utilized our long-term forecast for US Classes 4-8 commercial vehicles, from which the forecasted MHD sales volumes are revised lower as implicitly mandated, and higher ZEV sales percentages decrease ICE CV sales. The actual number of ZEVs that can be feasibly sold under Scenarios 1, 2, and 3 are aligned with the reduced percentages and resultant volumes the EMA detailed in its Strawman adoption rates. Those calculated reductions in MHD sales volumes are then utilized in ACTR's calculations to determine the impact on lost jobs and increased freight rates. In addition to those economic impacts, ACTR also calculated the net impact of an older CV fleet contributing to higher CO_2 and NOx emissions.

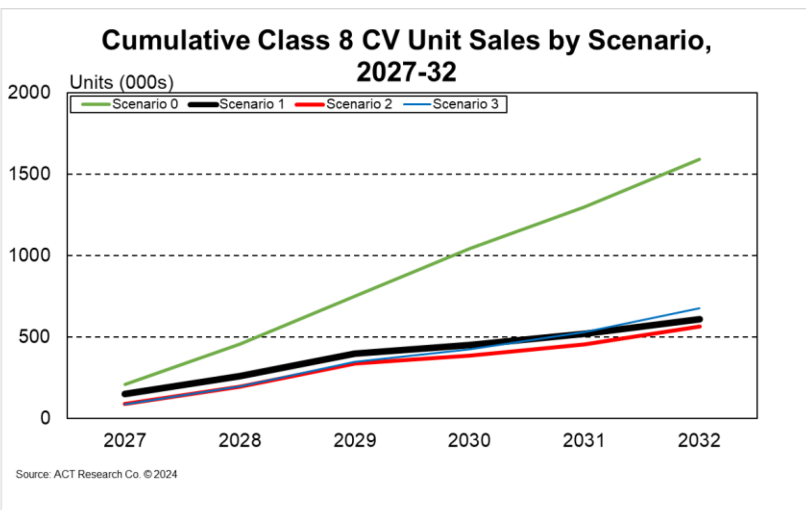
Graph 3 shows the yearly sales volumes Classes 4-8 for all four scenarios, and the significant decreases in annual vehicle volumes under Scenarios 1, 2, and 3.

Graph 3: Annual Unit Sales by Scenario, 2027-2032



The impact under Scenarios 1, 2, and 3 is most onerous when analyzing decreases in Class 8 sales, as shown in Graph 4 below.

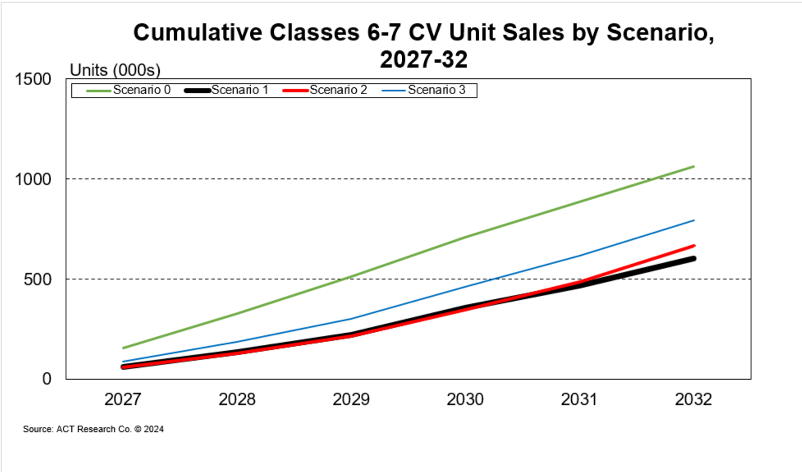
Graph 4: Cumulative Class 8 Unit Sales by Scenario, 2027-2032



During the six-year time frame of 2027-2032, a total of nearly one million Class 8 trucks would be eliminated from vehicle sales due to the OEMs inability to sell higher volumes of Class 8 ZEVs.

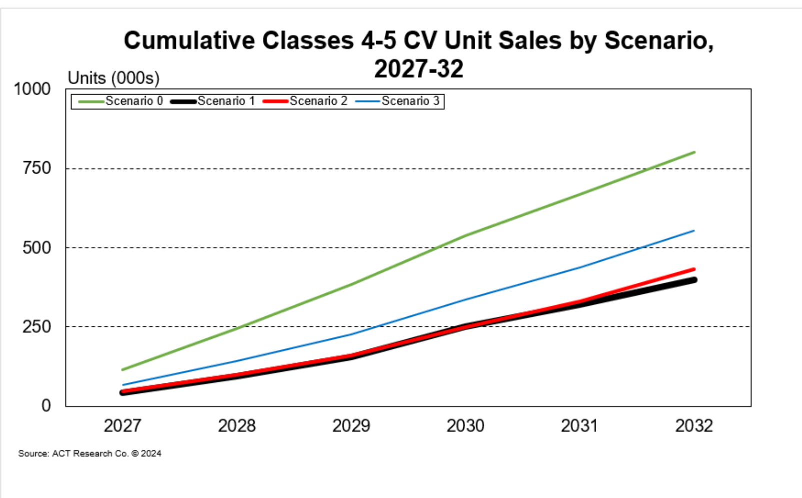
The impact under Scenarios 1, 2, and 3 is significant when analyzing lower GVW CVs, though less severe than the impact on Class 8, as shown in Graph 5 below.

Graph 5: Cumulative Classes 6-7 Unit Sales by Scenario, 2027-2032



During the six-year time frame of 2027-2032, a total of nearly 300k – 460k Classes 6-7 trucks would be eliminated from vehicle sales due to the OEMs inability to sell higher volumes of Classes 6-7 ZEVs.

Graph 6: Cumulative Classes 4-5 Unit Sales by Scenario



During the six-year time frame of 2027-2032, a total of nearly 250k – 400k Classes 4-5 trucks would be eliminated from vehicle sales due to the OEMs inability to sell higher volumes of Classes 4-5 ZEVs.

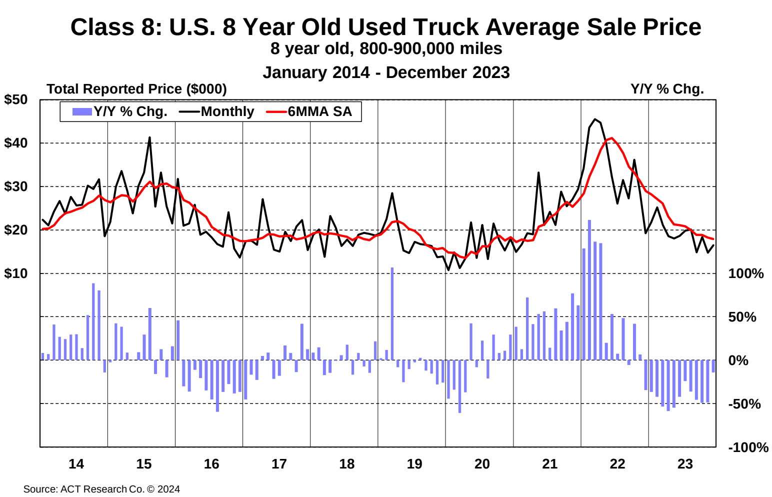
US Commercial Vehicle Fleet Aging/Retirements

As to whether older vehicles would be returned to frontline duty, we only must look to the most recent past for an answer. The exact situation—older Class 8 tractors being repurposed back into the general freight economy—occurred as recently as 2020-2021, as the supply-chain driven fleet capacity shortage during a period of upswinging freight volumes drove significant freight rate gains. In 2021-2022, there was an on-highway supply-demand imbalance ACTR estimates to be around 10% at its peak. During that period, DAT's spot load-to-equipment postings ratio rose from around 4:1 pre-pandemic, to a plateau of around 14:1, with spot freight rates, net fuel, rising from around $1.70 per mile to $2.70 mile.

Extrapolating those data points, and if 20,000 units is equivalent to roughly 1 percentage point (pp) of capacity, a 600,000-unit sales shortfall would be equivalent to a 30% capacity takeout by 2032, or 3x the 10% capacity shortfall experienced from late 2021 through mid-2022. Clearly, the implied $3/mile rate increase would help facilitate ZEV purchases, thereby reducing the capacity shortfall, if expensively.

Older trucks are typically retired when they are no longer economically viable (fuel economy, reliability/uptime, driver recruiting/retention, etc.), but viability is a relative concept. The out-of-balance supply-demand situation experienced in 2021-1H'2022 resulted in sharply higher freight rates causing past-prime aged equipment to again become economically viable. As the US economy does not work if goods are not moved, and companies who don't deliver their goods to market will find themselves out of business, many shippers are less concerned about who or what is delivering their freight if their freight is being delivered.

Graph 7: Class 8: U.S. 8-Year-Old Used Truck Average Sale Price



ACTR's collection of used truck data illustrates the phenomenon of older trucks returning to market. As illustrated in Graph 7, sales prices for eight-year-old, *800k-900k mile*, US Class 8 tractors generally ranged from $15k-$20k across the 2016-2020 period ($17.8k average). Starting in 2021, as freight demand and freight rates rose to unprecedented highs, the value of that very old equipment rose 150% from its long-run average to a $45k peak by early 2022. As freight volumes ebbed beginning in mid-2022 at the same time supply-constraints became less burdensome for manufacturers (allowing for increased new truck production and sales), truckers re-retired those super-old, 800k-900k mile used tractors. Prices for those units returned to the long-run average around Q2'23. This is a clear illustration of the shadow capacity that lingers in the market—not economically viable under normal market conditions, but easy to press into service at the drop of a hat when the supply-demand pendulum swings to favoring truckers.

Like freight market pricing, used vehicle valuations also directly reflect the supply-demand balance between the number of tractors available and the amount of freight to be hauled. Stronger new vehicle production beginning in 2022 and the moderation in consumer goods spending were triggers that allowed those older trucks to be reparked. Without the lever of stronger new vehicle availability, old vehicle demand would remain strong, and those older units would, by necessity, gain market share on US highways.

At ACTR, we believe the US economy would not operate anywhere near seamless without Class 8 vehicles. No substitute transportation mode exists that delivers freight to the end user, whenever and wherever, as efficiently as do heavy trucks. Freight creation is a fundamental output of a healthy economy and is essential to human survival. Any shortages of new vehicles entering the market will, by necessity, prolong the lives of existing vehicles. Reiterating, the freight must and will get delivered. Carrier profitability gains in a capacity-constrained market will determine to what extent and for how long older trucks are returned to the fold of economic viability, and by the same token, new technologies are made viable by the capacity shortfall that drives freight rates into the stratosphere.

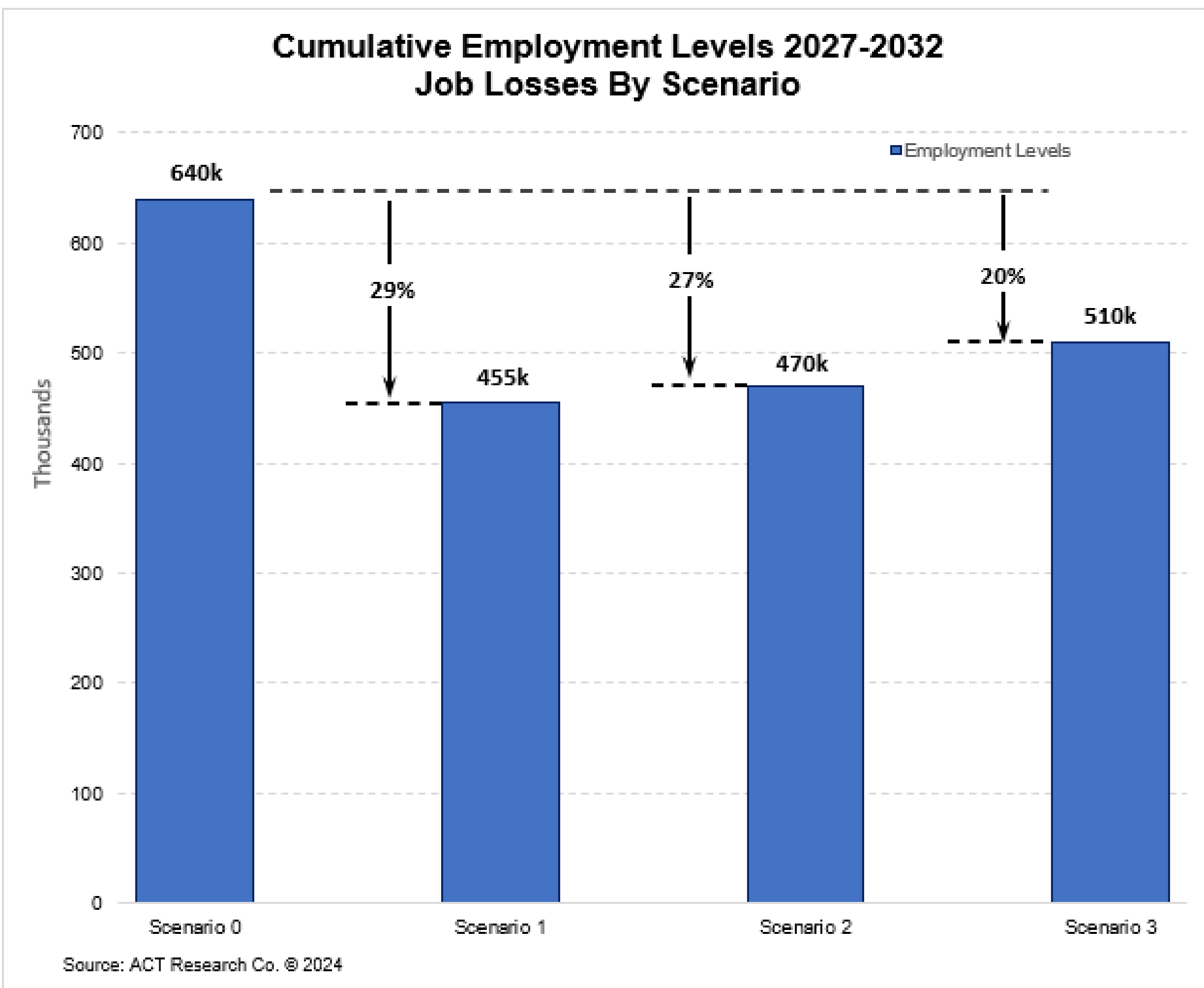
Impact on Labor

Table 7: Cumulative Impact on Employment Levels

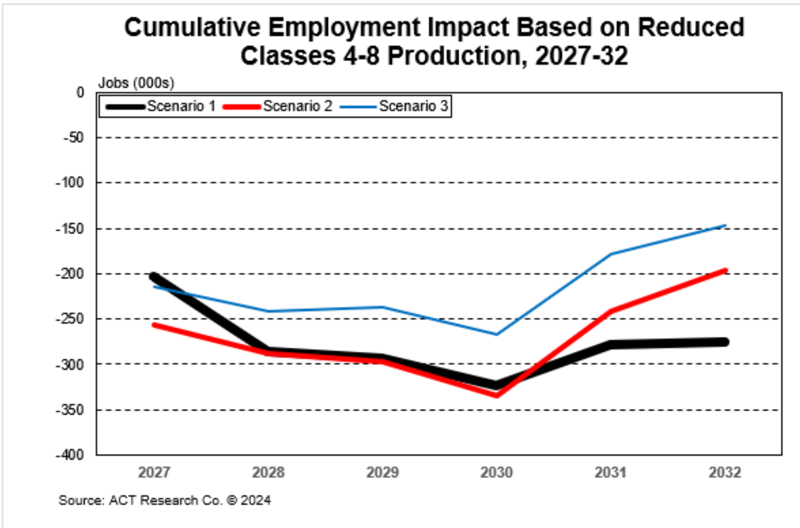
ACT RESEARCH - EPA GHG PHASE 3 SCENARIOS - CUMULATIVE IMPACT SUMMARY								
	SCENARIO 0		SCENARIO 1		SCENARIO 2		SCENARIO 3	
CUMULATIVE EMPLOYMENT IMPACT FROM BASE CASE	Jobs		Jobs		Jobs		Jobs	
EMPLOYMENT LEVELS	640,000		455,000		470,000		510,000	
	Jobs from Base Case	Δ from Base Case	Jobs from Base Case	Δ from Base Case	Jobs from Base Case	Δ from Base Case	Jobs from Base Case	Δ from Base Case
CUMULATIVE EMPLOYMENT DECREASE	0	--	-185,000	-29%	-170,000	-27%	-130,000	-20%

Source: ACT Research Co., Copyright 2024

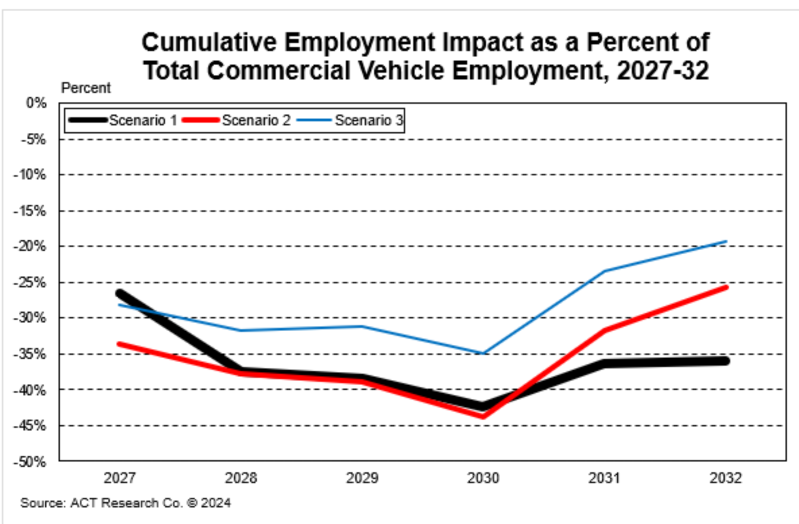
Graph 8: Cumulative Employment Levels 2027-2032, Job Losses by Scenario



Graph 9: Cumulative Employment Impact Based on Reduced Classes 4-8 Production, 2027-2032



Graph 10: Cumulative Employment Impact as a Percentage of Total Commercial Vehicle Employment, 2027-2032



Scenario 0: Scenario 0 will have no reductions in vehicle sales/builds, and as a result no impact on manufacturing labor. There is workforce under Scenario 0.

Scenario 1: ACTR's modeling projects a significant ~205,000-unit annual decline in Class 8 production by 2032. We estimate this lost production results in the loss of about 185,000 truck assembly and other related jobs over the 2027–2032 time frame, with the largest effect in 2030.

Table 8: Scenario 1 Production and Employment Impact, 2027-2032

Scenario 1: Employment Impact Based on Reduced Class 8 Production	2027	2028	2029	2030	2031	2032
Production impact (units)	(56,800)	(142,000)	(152,100)	(240,531)	(187,381)	(205,321)
Cumulative Employment impact	**(51,120)**	**(127,800)**	**(136,890)**	**(216,478)**	**(168,643)**	**(184,789)**

Source: ACT Research Co., Copyright 2024

Scenario 2: ACTR's modeling projects a ~186,000-unit annual decline in Class 8 production by 2032, resulting in the loss of about 167,000 truck assembly and other related jobs over the 2027–2032 time frame. These figures include some recovery from the largest effects in 2030.

Table 9: Scenario 2 Production and Employment Impact, 2027-2032

Scenario 2: Employment Impact Based on Reduced Class 8 Production	2027	2028	2029	2030	2031	2032
Production impact (units)	(119,900)	(142,000)	(149,420)	(246,033)	(185,154)	(185,784)
Cumulative Employment impact	**(107,910)**	**(127,800)**	**(134,478)**	**(221,430)**	**(166,639)**	**(167,205)**

Source: ACT Research Co., Copyright 2024

Scenario 3: ACTR's modeling projects a ~145,000-unit annual decline in Class 8 production by 2032, resulting in the loss of about 130,000 truck assembly and other related jobs over 2027–2032. While the job losses are 29% and 22% smaller than Scenarios 1 and 2 at the end of the forecast period, the peak decline in 2030 in Scenario 3 is just 9% and 11% smaller than those in Scenarios 1 and 2.

Table 10: Scenario 3 Production and Employment Impact, 2027-2032

Scenario 3: Employment Impact Based on Reduced Class 8 Production	2027	2028	2029	2030	2031	2032
Production impact (units)	(119,900)	(142,000)	(138,700)	(219,490)	(149,540)	(144,987)
Cumulative Employment impact	**(107,910)**	**(127,800)**	**(124,830)**	**(197,541)**	**(134,586)**	**(130,488)**

Source: ACT Research Co., Copyright 2024

Labor Effects of GHG Scenarios

The employment data shown on the following pages (Tables 11 & 12) reflect some estimates but incorporate a largely complete historical picture from prior EMA-sponsored studies that utilized direct inputs from the major truck manufacturers. These figures should approximate employment at the assembly level very closely.

To estimate total jobs tied to commercial vehicle manufacturing, we applied the standard employment multiplier for the Motor Vehicle Manufacturing sector in the multiplier tables published by the Economic Policy Institute of 14.28 consistently in each year of the analysis. To focus on blue-collar workers, we specifically exclude manufacturing executives, sales, and R&D people. Since our multipliers are based off OEM assembly employment, they should prove a reasonable proxy of blue-collar workers at the supplier level as well.

The multiplier is a critical assumption. In our view, while 14.28 is one of the highest multiples in the economy, and we are including both the 9.36 supplier jobs for every assembly job and 4.92 induced jobs related to re-spending of the income generated from these activities, we see valid arguments for both higher and lower figures.

On the lower side, the broader durable goods sector multiple of 7.44 is plausible, but this includes a broad range of industries and is thus relatively blunt for our purposes. On the higher side, since the average commercial vehicle costs considerably more than the average light vehicle, a multiplier above the average could also be justified. Additionally, the multiplier does not include the millions of transportation jobs tied to the production of those vehicles.

Using this framework, we estimate the range of US commercial vehicle manufacturing jobs between 425k – 710k over the past two decades, with a peak in 2006 yet to be eclipsed. The prebuy ahead of the EPA'07 standard, which we estimate at 147,200 units between 2005 and 2006, precipitated a loss of about 9,300 truck assembly jobs in 2007, or about 19% of the OEM's blue-collar labor force. This compares to a decline in US Classes 6–8-unit production of 48% in 2007 and in this context, the 19% estimate seems reasonable, if perhaps conservative.

Applied to our total industry employment estimate, about 132,900 jobs were lost in 2007, a sensitivity of 0.90. The sensitivity of 0.90 is the best example we have, but still is just a single data point, as we really only have one such major event on record. The decline of 20,400 commercial vehicle manufacturing jobs in 2003 could be attributed to the roughly 30,000-unit "hidden prebuy" of 2002, but as this prebuy lasted less than a year and preceded rules which were being pulled forward from 2004, confidence in the 0.68 sensitivity of this example is even lower. Determining the correct sensitivity is critical. We apply it to our scenario analysis to estimate how many jobs would be impacted under various scenarios. We estimate the long-term average is 2.2 jobs per truck built, and our 0.9 estimate seems conservative in this context.

Table 11: US Commercial Vehicle Employment Before and After EPA'07 Emissions Regulations

Commercial Vehicle Manufacturing Employment Estimates	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total Active Employment, assembly	**41,756**	**36,558**	**41,904**	**41,818**	**37,887**	**36,644**	**44,805**	**42,337**	**37,384**	**40,682**	**44,537**
y/y change	(4,322)	(5,199)	5,347	(86)	(3,932)	(1,243)	8,161	(2,468)	(4,953)	3,299	3,854
y/y change %	-9%	-12%	15%	0%	-9%	-3%	22%	-6%	-12%	9%	9%
Estimated Total Employment, US Classes 6-8 vehicle manufacturing	**596,267**	**522,029**	**598,380**	**597,150**	**541,009**	**523,263**	**639,799**	**604,553**	**533,829**	**580,931**	**635,968**
y/y change	(61,711)	(74,238)	76,351	(1,230)	(56,141)	(17,747)	116,537	(35,246)	(70,724)	47,102	55,037
y/y change %	-9%	-12%	15%	0%	-9%	-3%	22%	-6%	-12%	9%	9%

Table 11 shows our estimates of US Classes 6-8 employment from 2012 through 2022, to provide additional historical context. Taken together, the data set confirms the inherent cyclicality of the industry and shows the impact on labor from the EPA'07 regulations has been eclipsed only once this century, by the Great Recession of 2009. To emphasize: The only year this century that featured a larger job loss in US commercial vehicle manufacturing than 2007 was the worst economic year in over 70 years, 2009. The pandemic did not have nearly the impact on blue-collar manufacturing jobs as the EPA'07 regulations.

Table 12: US Commercial Vehicle Employment Estimates, 2012 - 2022

US Commercial Vehicle Manufacturing Employment Estimates	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Active Employment, assembly	**34,626**	**33,197**	**41,647**	**46,078**	**49,682**	**40,375**	**42,875**	**29,724**	**38,064**
y/y change		(1,429)	8,450	4,432	3,604	(9,307)	2,500	(13,151)	8,341
y/y change %		-4%	25%	11%	8%	-19%	6%	-31%	28%
Estimated Total Employment, US Classes 6-8 vehicle manufacturing	**494,453**	**474,041**	**594,700**	**657,982**	**709,448**	**576,543**	**612,236**	**424,446**	**543,546**
y/y change		(20,412)	120,659	63,282	51,466	**(132,905)**	35,693	(187,790)	119,100
y/y change %		-4%	25%	11%	8%	-19%	6%	-31%	28%

Employment Impact Estimates

The following tables show alternative employment impact estimates. Anticipating the employment effects of prospective major reductions in commercial vehicle production is no easy task. Our main approach did not attempt to account for the likely lost Classes 4-7 production jobs because the historical precedent of regulation-related job losses has heretofore been mainly a HHD vehicle event. In adding lower vehicle classes to the analysis, we prefer to understate the job loss impact rather than the alternative as we have less visibility on labor sensitivity in the smaller vehicle classes. In addition, and as previously discussed, there is a fair debate about the right job impact multiplier.

We reiterate that the economic uses of trucks are not included in the 14.2x multiplier we use in calculating our primary employment estimates, leaving likely considerable upside to our decision to use the Economic Policy Institute's vehicle manufacturing multiplier. However, if one chose to use the Economic Policy Institute's durable manufacturing jobs multiplier of 7.4x, then the estimate of total industry employment becomes not much larger than the losses in Scenario 3, illustrated below.

Table 13: Commercial Vehicle Manufacturing Employment Estimates

Commercial Vehicle Manufacturing Employment Estimates	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total Active Employment, assembly	**41,756**	**36,558**	**41,904**	**41,818**	**37,887**	**36,644**	**44,805**	**42,337**	**37,384**	**40,682**	**44,537**
y/y change	(4,322)	(5,199)	5,347	(86)	(3,932)	(1,243)	8,161	(2,468)	(4,953)	3,299	3,854
y/y change %	-9%	-12%	15%	0%	-9%	-3%	22%	-6%	-12%	9%	9%
Estimated Total Employment, US Classes 4-8 vehicle manufacturing	**372,827**	**326,408**	**374,148**	**373,379**	**338,276**	**327,179**	**400,046**	**378,008**	**333,786**	**363,238**	**397,651**
y/y change	(38,586)	(46,419)	47,740	(769)	(35,103)	(11,096)	72,867	(22,038)	(44,222)	29,451	34,413
y/y change %	-9%	-12%	15%	0%	-9%	-3%	22%	-6%	-12%	9%	9%

The estimated employment table shows our estimates of industry employment using the Classes 6-8 baseline figures in our primary analysis, adjusting from the 14.2x assembly multiplier to 7.4x, and adding about 20% to account for Classes 4-5 vehicle production. This is slightly below the 22%-23% Classes 4-5 share of Classes 4-8 production because of the lower vehicle values.

In the following analysis, we present an alternative, similarly plausible set of job losses to our base case, albeit riskier due to data constraints. We return to our base case of a 14.2x jobs multiplier, and we include a similar 20% for Classes 4-5. We do not include Classes 4-5 in our primary estimate because we have very precise data for Classes 6-8 OEM manufacturing employment, but little industry input in regard to Classes 4-5. With this assumption, we estimate about 763k US manufacturing jobs related to Classes 4-8 in 2022.

Table 14: Commercial Vehicle Manufacturing Employment Estimates, Alternative

Commercial Vehicle Manufacturing Employment Estimates	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Estimated Total Employment, US Classes 4-8 vehicle manufacturing	**715,521**	**626,435**	**718,056**	**716,581**	**649,211**	**627,915**	**767,759**	**725,464**	**640,595**	**697,117**	**763,162**
y/y change	(74,053)	(89,086)	91,622	(1,476)	(67,370)	(21,296)	139,844	(42,295)	(84,869)	56,522	66,045
y/y change %	-9%	-12%	15%	0%	-9%	-3%	22%	-6%	-12%	9%	9%

We lower our key sensitivity assumption of 0.9 jobs per vehicle, which as discussed earlier focuses on the highly customized Class 8 production process, to 0.75 in order to incorporate Classes 4-7, where there is significantly greater commonality in the light vehicle production processes. We have less conviction in this sensitivity factor, however, as there is not the same historical precedent as there is with Class 8. We believe our discounted estimate is fair, as the Economic Policy Institute's 14.2x vehicle manufacturing multiplier is heavily weighted by lower value and more highly automated passenger vehicle production.

The primary reason for detailing this alternative is to reiterate that our primary estimates are conservative and understated. In Scenarios 2 and 4, our employment estimates based on the larger Classes 4-8 market are respectively about 43% and 24% higher than our estimates under our primary approach. The result in Scenarios 3 and 5 with very similar Classes 4-8 estimates as shown above for Class 8 suggests our sensitivity assumption may be too low, and reality could be worse than projected.

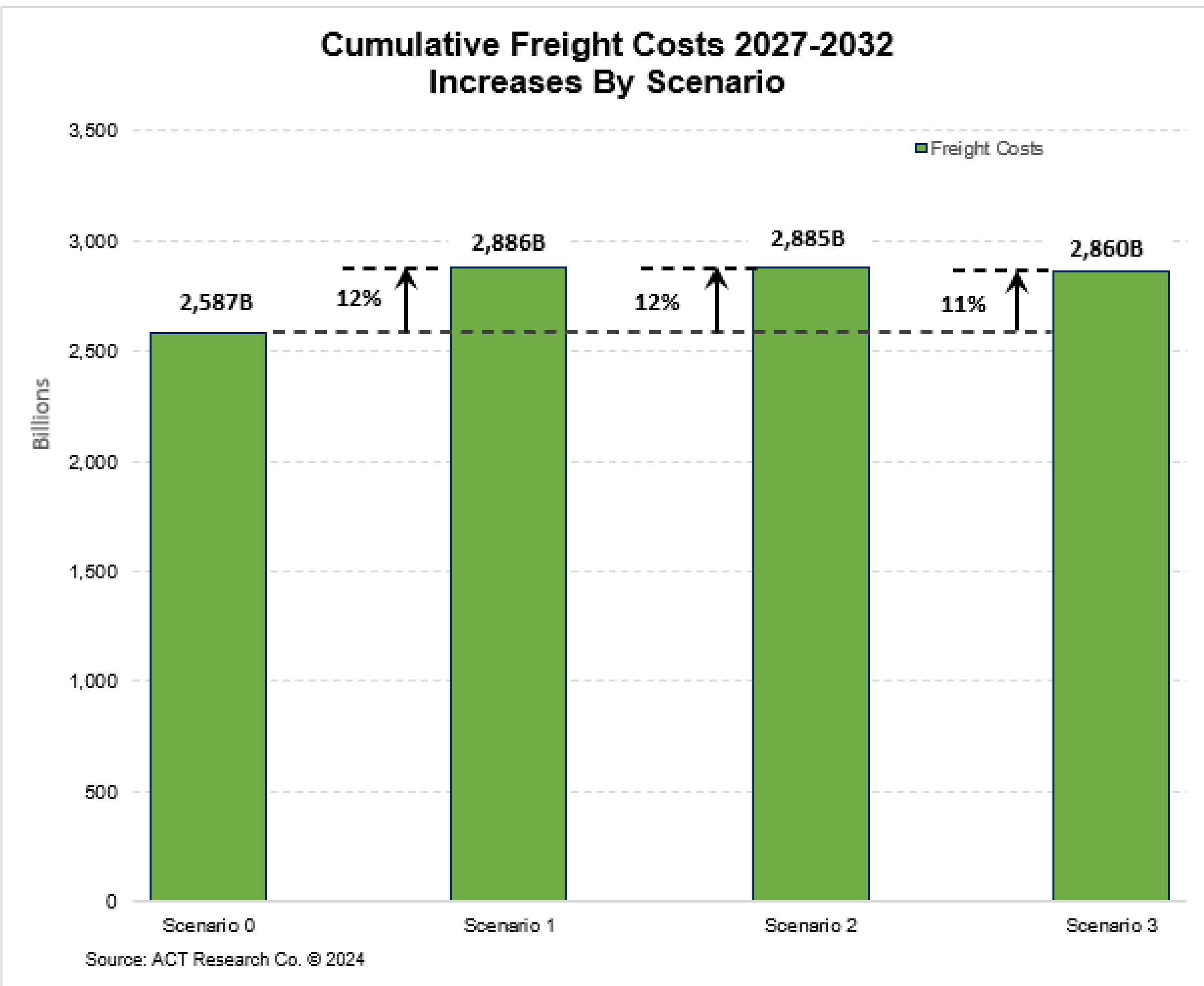
Impact on Freight Transportation Costs

Table 15: Cumulative Impact on Freight Costs

ACT RESEARCH - EPA GHG PHASE 3 SCENARIOS - CUMULATIVE IMPACT SUMMARY								
	SCENARIO 0		SCENARIO 1		SCENARIO 2		SCENARIO 3	
CUMULATIVE FREIGHT COST IMPACT FROM BASE CASE	$ Billions		$ Billions		$ Billions		$ Billions	
CUMULATIVE FREIGHT COST ($ Billions)	$2,587		$2,886		$2,885		$2,860	
	$(B) from Base Case	Δ from Base Case	$(B) from Base Case	Δ from Base Case	$(B) from Base Case	Δ from Base Case	$(B) from Base Case	Δ from Base Case
CUMULATIVE FREIGHT COST INCREASE ($ Billions)	0	--	+$299 B	+12%	$+298 B	+12%	+$273 B	+11%

Source: ACT Research Co., Copyright 2024

Graph 11: Cumulative Freight Costs 2027, Increases by Scenario



Scenario 0: Scenario 0 will not impact freight costs, as there will be no reduction in the overall Class 8 tractor fleet in our base case analysis. By contrast, Scenarios 1, 2, and 3, driven by anticipated transportation capacity shortfalls are projected to have significant effects on the freight industry, which is critical to the efficient functioning of the broader economy.

Scenario 1: In Scenario 1, a large reduction in HHD tractor sales is projected. For 2027 to 2029, we assume no vehicle-type shifting, though with no restrictions until 2030, sleepers could be substituted for day cabs. However, since even this switch would likely put upward pressure on freight rates, the lost day cab sales in 2027–2029 are included in this analysis, and these assumptions are consistent for each scenario.

In 2027, the 56,800 units of lost Class 8 tractor sales would reduce the HHD tractor fleet, which we estimate at 2.31 million units in 2027, by 2.4%. Applying our -79% sensitivity, we estimate this reduction in supply will result in a 1.9% increase in US freight cost per mile in 2027. In a $390 billion for-hire truckload market, this results in an $8 billion cost increase that shippers will pass to US consumers. As the new vehicle capacity deficit widens, transportation cost increase rises to $28 billion in 2029 and $110 billion by 2032 as the regulations tighten. For context, the US economy is projected at $38.0 trillion in 2032 in nominal dollars, or $26.4 trillion in 2017 dollars. As our freight market forecasts are in nominal dollars, we use a consistent dollar basis for comparison.

Scenario 1 includes a set of volume inputs which eliminated nearly all HHD tractor sleeper sales starting in 2030. The consequences of this scenario are larger in terms of costs. Though day cabs would pick up some slack, they too would be constrained.

In Scenario 1, the percentage of the fleet constraint grows cumulatively to 29% in 2032, with a large step-change in 2030 when tractor sleeper ZEV targets begin under this scenario. The step-change in economic costs jumps to $56 billion in 2030 from $28 billion in 2029, and rises to $110 billion, about 35bps of economic growth as the regulations tighten further in 2032. Cumulatively, we estimate a $299 billion cost to the US economy over the six-year time horizon from 2027 to 2032. That cumulative added cost would be equal to around 0.8pps of ACTR's 2032 US GDP forecast, contributing about 0.3pps to inflation in 2032 alone.

Table 16: Scenario 1 Economic Impacts Due to Equipment Supply Shortages

	2027	2028	2029	2030	2031	2032
Cumulative unit sales reduction	**56,800**	**124,800**	**191,800**	**374,731**	**514,894**	**677,515**
% of HHD Tractor Fleet	-2.5%	-5.4%	-8.3%	-16.2%	-22.3%	-29.4%
Freight cost / mile impact	1.9%	4.3%	6.6%	12.8%	17.6%	23.2%
($ in billions)	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
For-hire TL market	**390**	**406**	**422**	**439**	**456**	**474**
Added Freight Cost	**8**	**17**	**28**	**56**	**80**	**110**
Cumulative Added Cost	**8**	**25**	**53**	**109**	**189**	**299**

These additional costs to shippers (and ultimately to consumers) should provide earnings growth for fleets to invest in compliant ZEV equipment, thereby offsetting some of the cost pressures in this analysis. But because of the market's competitive nature, these costs will likely be borne by fleets in the first few years, as most of the fleet will be competing with materially lower per-mile operating costs, so this may overstate the impact on inflation at the outset.

As previously noted above, this analysis is specific to the for-hire TL market, which focuses on 37% of the US commercial vehicle population. The HHD tractor market performs considerably more economic activity than its 37% of the roughly 6 million-unit US MHD and HHD vehicle population, but this analysis still significantly underestimates the total cost to the US economy, likely by a factor of about 2x.

Our analysis stops short of addressing the broader effects on US inflation. With the inflation situation still quite fluid, much is likely to change between now and the start of these regulations, and secondary effects will vary materially according to the state of the economy. For example, in a more inflationary environment, spillover effects would be larger, and could even impact US monetary policy, as logistics cost inflation has done in the past few years.

Scenario 2: In Scenario 2, the second-largest reduction in HHD tractor sales is projected. In 2027, the 56,800 units of lost Class 8 tractor sales would reduce the HHD tractor fleet, which we estimate at 2.31 million units in 2027, by 2.7%. Applying our -79% sensitivity, we estimate this reduction in supply will result in a 2.1% increase in US freight cost per mile in 2027.

In a $390 billion for-hire truckload market, this results in an $8 billion cost increase that shippers would ultimately pass to US consumers in 2027, rising to $29 billion in 2029 and $105 billion in 2032 as the regulations tighten. Scenario 2 eliminates nearly all HHD tractor sleeper sales starting in 2030, with significant inflationary consequences.

Table 17: Scenario 2 Economic Impacts Due to Equipment Supply Shortages

	2027	2028	2029	2030	2031	2032
Cumulative unit sales reduction	**56,800**	**124,800**	**189,120**	**370,353**	**505,052**	**645,467**
% of HHD Tractor Fleet	-2.7%	-5.8%	-8.8%	-16.8%	-21.9%	-28.0%
Freight cost / mile impact	2.1%	4.6%	6.9%	13.3%	17.3%	22.1%
($ in billions)	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
For-hire TL market	**390**	**406**	**422**	**439**	**456**	**474**
Added Freight Cost	**8**	**19**	**29**	**58**	**79**	**105**
Cumulative Added Cost	**8**	**27**	**56**	**114**	**193**	**298**

In Scenario 2, the percentage of the fleet constrained grows cumulatively to 28% in 2032, with a large step-change in 2030 when sleeper constraints begin under this scenario. The step-change in economic costs jumps to $58 billion in 2030 from $29 billion in 2029 and rises to $105 billion as the regulations tighten further in 2032.

Cumulatively, we estimate a $298 billion cost to the US economy over the six-year time horizon from 2027 to 2032. That cumulative added cost would be equal to around 0.8pps of ACTR's 2032 US GDP forecast, contributing about 0.3pps to inflation in 2032 alone.

Scenario 3: In Scenario 3, the third-largest reduction in HHD tractor sales is projected, with projections unchanged from Scenario 2 in 2027 and 2028, and modestly smaller in the subsequent years on lower hurdle-rate ZEV targets.

The inflation effects similarly start out small at 0.03% and 0.06% in 2027 and 2028, respectively, but grow to a 0.24% annual impact in 2032. We estimate the cumulative impact on US inflation would be 0.72% for the 2027-to-2032 period, which compares to 0.79% for both Scenarios 1 and 2.

In Scenario 3, the percentage of the fleet constrained grows cumulatively to 25% in 2032, which compares to 28% and 30% in Scenarios 1 and 2. The step-change in economic costs jumps to $54 billion in 2030 from $28 billion in 2029 and rises to $93 billion as the regulations tighten further in 2032.

Cumulatively, we estimate a $273 billion cost to the US economy over the six-year time horizon from 2027 to 2032 in Scenario 3, which compares to $299 billion and $298 billion in Scenarios 1 and 2.

Table 18: Scenario 3 Economic Impacts Due to Equipment Supply Shortages

	2027	2028	2029	2030	2031	2032
Cumulative unit sales reduction	**56,800**	**124,800**	**178,400**	**346,050**	**457,366**	**571,464**
% of HHD Tractor Fleet	-2.7%	-5.8%	-8.3%	-15.7%	-19.9%	-24.8%
Freight cost / mile impact	2.1%	4.6%	6.5%	12.4%	15.7%	19.6%
($ in billions)	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
For-hire TL market	**390**	**406**	**422**	**439**	**456**	**474**
Added Freight Cost	**8**	**19**	**28**	**54**	**72**	**93**
Cumulative Added Cost	**8**	**27**	**54**	**109**	**180**	**273**

Economic Costs of Freight Transportation Effects of GHG Scenarios

Summary

Given the considerable risks associated with future ZEV demand, meeting EPA's proposed GHG Phase 3 carbon emissions standards may well require curtailment of diesel vehicle sales. As Americans experienced during the recent pandemic, supply chain breakdowns can be a major driver of inflation nationally. In 2021 and 2022, freight rates as measured by the Cass Freight Index® rose 23% and 22% respectively, playing a major part in unleashing the largest wave of macroeconomic inflation since the early 1980s.

Freight Transportation Market Size

Using US Census Bureau data, we estimate the US freight transportation services market generated $1.24 trillion in sales in 2022. We estimate an extraordinary 18% growth rate in 2022, but the industry is in the midst of a sharp cyclical downturn that brought 2023 freight transportation revenues back down close to 2021 levels. In the US freight market pie chart (following), the segments served with HHD tractors include for-hire and private truckload (TL), less-than-truckload (LTL), and intermodal, which collectively encompass nearly 75% of US freight transportation.

The GHG regulation scenarios will affect numerous commercial vehicle and freight transportation markets. In addition to those noted above, couriers also rely heavily on commercial trucks, including HHD tractors for linehaul operations. On a US$ derived basis, more than 80% of US freight transportation is reliant upon HHD tractors.

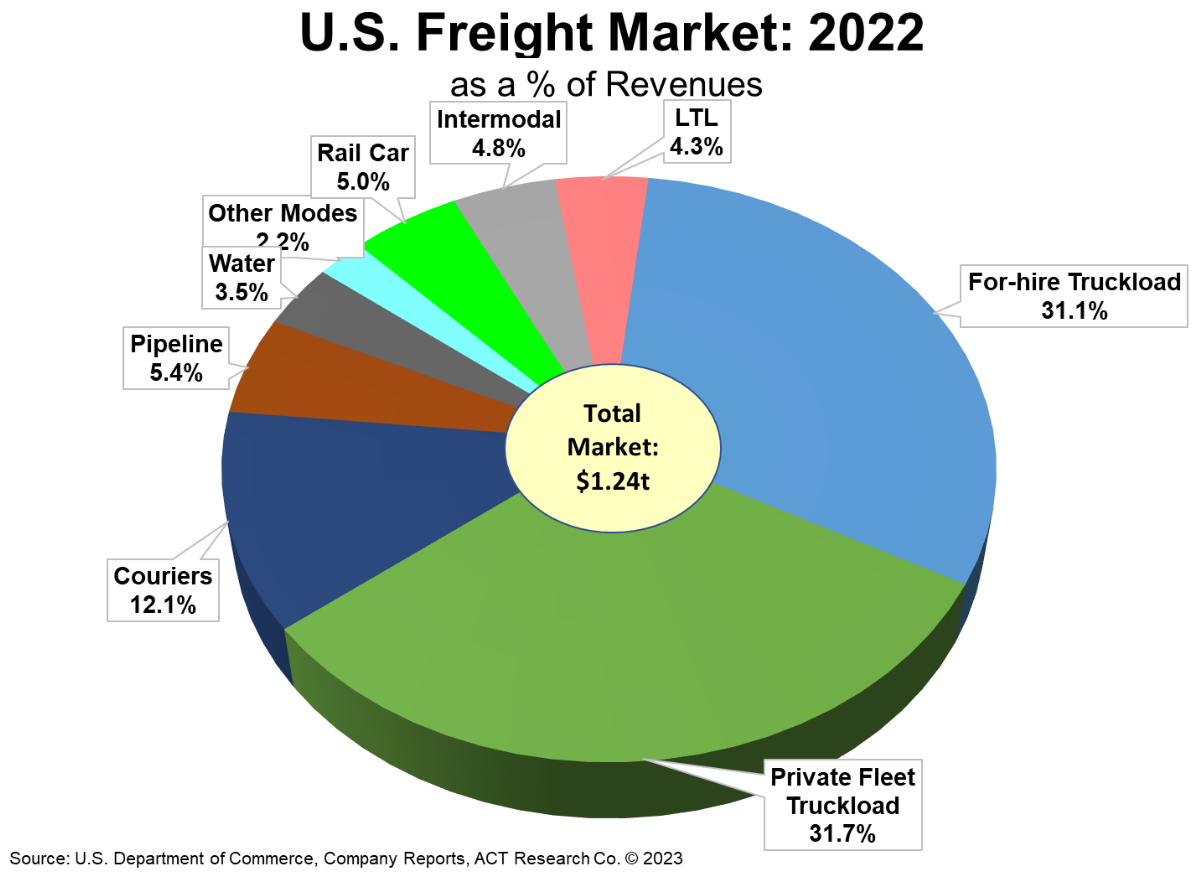
For this analysis, we narrow our focus to the for-hire truckload market because it is publicly observable, crucial to the functioning of the economy, one of the modes entirely reliant upon HHD tractors, and the most economically challenging vehicle type to decarbonize.

According to the US Census Bureau's Quarterly Services Survey, general freight trucking generated about $320 billion in industry revenue (NAICS code: 484, Truck Transportation) in 2021, 30% of industry revenue. Thus, the actual economic costs of supply shortages relating to production shortfalls in these cost scenarios will likely be two to three times larger than our estimates for the for-hire truckload market, if they remain linear. If they cause inflation more broadly, the costs rise yet higher.

As noted, we focus on the for-hire truckload market because it is the domain of the most economically challenging vehicle type to decarbonize, Class 8 tractor sleepers, and because it is a widely observable public market.

Using the 10-year average annual industry growth rate of 5% to extrapolate to 2027, the HHD freight service industry will generate about $390 billion of revenue if the long-term trend persists.

Chart 1: US Freight Market Size



Our freight pricing models indicate that the sensitivity of truckload contract pricing to changes in the HHD tractor fleet size is roughly -79%, relative to capacity additions when modeled econometrically with demand and exogenous factors included. In other words, every 1% decline in the fleet size has the effect of pushing industry pricing up 0.79%.

Impact on CO_2 & NOx Emissions

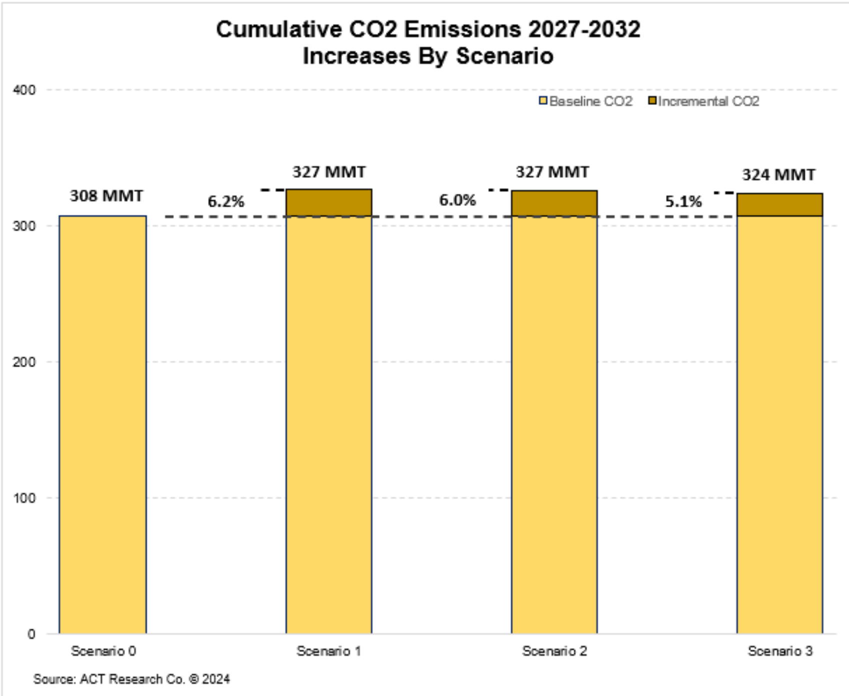
Table 19: Cumulative Impact on Emissions Levels

ACT RESEARCH - EPA GHG PHASE 3 SCENARIOS - CUMULATIVE IMPACT SUMMARY								
	SCENARIO 0		SCENARIO 1		SCENARIO 2		SCENARIO 3	
CUMULATIVE CO2 EMISSIONS IMPACT FROM BASE CASE	MMT		MMT		MMT		MMT	
CUMULATIVE CO2 EMISSIONS (MMT)	154.2	--	173.14		172.79		170.04	
	CO2 from Base Case	Δ from Base Case	CO2 from Base Case	Δ from Tot Population	CO2 from Base Case	Δ from Tot Population	CO2 from Base Case	Δ from Tot Population
CUMULATIVE INCREASE IN CO2 EMISSIONS (MMT)	0	--	+18.94	+6.2%	+18.59	+6%	+15.84	+5.1%
percentage impact reflects total US truck population								
CUMULATIVE NOx EMISSIONS IMPACT FROM BASE CASE	US tons		US tons		US tons		US tons	
CUMULATIVE NOx EMISSIONS (US tons)	330,000		131,441		129,032		114,129	
	NOx from Base Case	Δ from Base Case	NOx from Base Case	Δ from Tot Population	NOx from Base Case	Δ from Tot Population	NOx from Base Case	Δ from Tot Population
CUMULATIVE INCREASE IN NOx EMISSIONS (US tons)	0	--	+102,413	+31%	+100,004	+30%	+85,101	+26%
percentage impact reflects total US truck population								

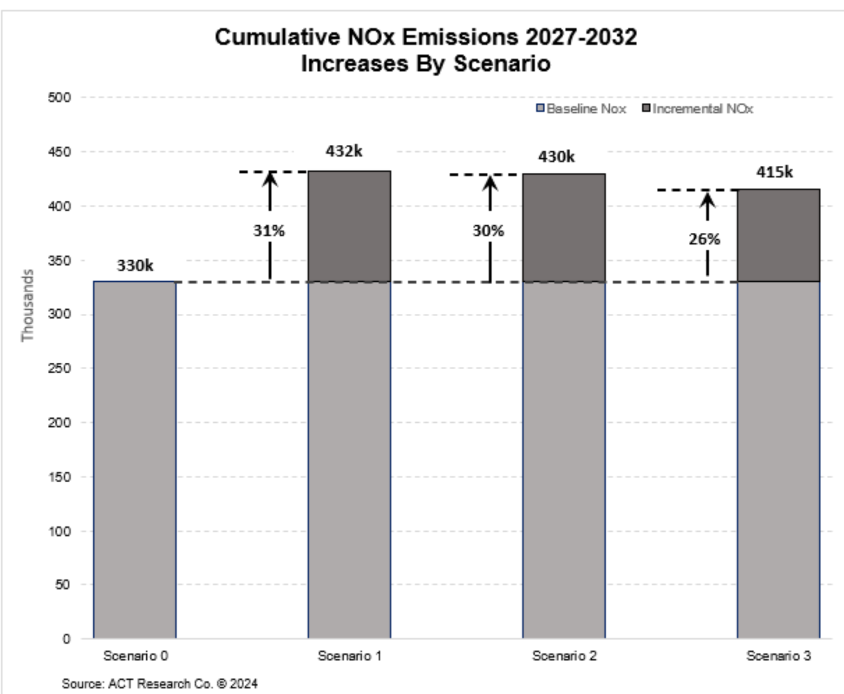
Source: ACT Research Co., Copyright 2024

If carriers defer purchases due to significantly higher operating costs and/or a lack of access to charging infrastructure, older trucks will be required to linger in the fleet longer than they otherwise would. The higher TCO costs of new, more expensive ZEV units will materially outweigh the cost of paid-for older diesel-powered units.

Graph 12: Cumulative CO2 Emissions 2027-2032, Increases by Scenario



Graph 13: Cumulative NOx Emissions 2027-2032, Increases by Scenario



Scenario 0: In Scenario 0, there are no decreases in overall sales. In this scenario, the final GHG Phase 3 standards match the EMA's Strawman analysis and resultant assumed ZEV adoption rates, and those rates are met. This means that no older, less efficient ICE trucks will be required to stay in the population to meet freight demand levels. The following tables show the annual and cumulative truck CO2 emissions for Scenario 0, which are less (and so more beneficial) than the cumulative emissions forecasted for Scenarios 1, 2, and 3.

Table 20: Scenario 0 Annual CO2 Emissions (MMT)

Scenario 0: Annual CO2 Emissions (MMT)							Cumulative
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Class 4-5 Truck	2.47	2.70	2.80	2.77	2.17	1.92	**14.83**
Class 6-7 Truck	2.95	3.35	3.54	3.61	2.82	2.52	**18.80**
Class 8 Truck & Tractor	16.20	19.45	22.71	22.70	18.73	20.79	**120.57**
							154.20

In this scenario, the increase in annual and cumulative NOx emissions for Classes 4-8 trucks through the forecast period are:

Table 21: Scenario 0 Annual NOx Emissions (US Tons)

Scenario 0: Annual NOx Emissions (US Tons)							Cumulative
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Class 4-5 Truck	465	509	527	522	408	362	**2,792**
Class 6-7 Truck	555	630	667	680	532	475	**3,538**
Class 8 Truck & Tractor	3,049	3,662	4,276	4,272	3,525	3,913	**22,697**
							29,028

Scenario 1: The overall sales decrease for Classes 4-8 trucks under Scenario 1 is illustrated in Table 22.

Table 22: Scenario 1 Truck Sales Decrease, 2027-2032

Scenario 1: Overall Truck Sales Decrease						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Class 4-5 Truck	69,188	76,148	74,444	54,750	56,974	53,292
Class 6-7 Truck	61,723	65,419	66,211	43,750	41,303	29,700
Class 8 Truck & Tractor	56,800	131,600	141,500	233,331	181,909	200,321

As this number of new units would not be added to the active U-11 tractor and U-15 truck populations, it is assumed that minimally the same number of older vehicles would be required to remain in the active population longer than they would otherwise. ACTR's modeling also assumes there is no spec shifting between day cabs and sleepers in the 2027–2029 period when tractor sleepers are not yet impacted by ZEV mandates.

Overall, the cumulative risk to CO2 emissions in Scenario 1 for Classes 4-8 trucks is a ~6% increase over the 2027–2032 timeframe. Cumulative additional CO2 emissions in Scenario 1 will make up ~7% of Classes 4-5 truck population emissions, ~3% of Classes 6-7 truck population emissions, and nearly 7% of Class 8 truck population emissions by 2032. The impact of additional CO2 emissions on total population emissions is shown in Table 23.

Scenario 1 will result in a cumulative increase in CO2 emissions of 18.94 MMT over 2027–2032. The annual and cumulative increased CO2 emissions in Scenario 1 compared to Scenario 0—those CO2 emissions that are additive because older ICE trucks remain in the active population—are shown in Table 23.

In addition to higher CO2 emissions, Scenario 1 will also result in a cumulative increase in NOx emissions of 102,413 tons over 2027–2032. The annual difference in NOx emissions in Scenario 1—the NOx emissions that are additional because older ICE trucks are remaining in the active population—are shown in Table 23.

Overall, the cumulative increase in NOx emissions in Scenario 1 is nearly 31% across the total truck population through the forecast horizon. For Classes 4-5, projected NOx emissions will rise by around 32% above Scenario 0's baseline projection—an 18% increase for Classes 6-7 truck population NOx emissions, and an increase in Class 8 fleet emissions of 34% by 2032. This relatively large percentage increase, over 30%, is primarily as a result of pre-2027 trucks with higher NOx levels remaining in the vehicle population when they otherwise would have been retired. The impact of additional NOx emissions on total population emissions is shown in Table 23.

Table 23: Scenario 1 Annual Difference in CO2 & NOx Emissions Compared to Scenario 0, 2027-2032 and Cumulative Additional CO2 & NOx Emissions as a % of Population CO2 & NOx Emissions, 2027-2032

Scenario 1: Cumulative Additional CO2 Emissions as Percent of Population CO2 Emissions						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cl. 4-5	1.1%	2.3%	3.5%	4.7%	5.8%	6.9%
Cl. 6-7	0.6%	1.2%	1.8%	2.4%	2.8%	3.1%
Cl. 8	0.5%	1.2%	2.0%	3.9%	5.4%	6.7%
Total	**0.6%**	**1.4%**	**2.1%**	**3.7%**	**5.0%**	**6.2%**

Scenario 1: Annual Difference in CO2 Emissions Compared to Scenario 0 (MMT)							**Cumulative**
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Cl. 4-5	0.37	0.41	0.40	0.29	0.34	0.29	**2.10**
Cl. 6-7	0.32	0.34	0.35	0.23	0.24	0.16	**1.65**
Cl. 8	1.11	1.72	1.79	4.08	3.51	2.99	**15.20**
							18.94

Scenario 1: Cumulative Additional NOx Emissions as Percent of Population NOx Emissions						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cl. 4-5	5.2%	10.9%	16.2%	21.8%	26.7%	31.7%
Cl. 6-7	3.6%	7.2%	10.7%	13.8%	16.2%	18.0%
Cl. 8	2.3%	6.0%	9.9%	19.3%	26.3%	33.8%
Total	**2.8%**	**6.7%**	**10.7%**	**18.6%**	**24.6%**	**30.9%**

Scenario 1: Annual Difference in NOx Emissions Compared to Scenario 0 (US Tons)							**Cumulative**
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Cl. 4-5	1,856	2,043	1,997	1,469	1,535	1,402	**10,301**
Cl. 6-7	2,043	2,165	2,192	1,448	1,372	969	**10,189**
Cl. 8	5,551	9,167	9,531	22,185	17,091	18,397	**81,923**
							102,413

Scenario 2: Reiterating, the overall sales decrease for Classes 4-8 trucks under Scenario 2 is illustrated in Table 24.

Table 24: Scenario 2 Commercial Vehicle Sales Decrease, 2027-2032

Scenario 2: Overall Truck Sales Decrease						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Class 4-5 Truck	66,420	73,923	76,571	60,118	46,800	30,585
Class 6-7 Truck	61,723	68,412	69,190	43,750	23,280	0
Class 8 Truck & Tractor	109,700	131,600	138,820	237,933	179,306	180,471

As this number of new units would not be added to the active U-11 tractor and U-15 truck populations, we assume the same number of older vehicles would be required to remain in the active populations longer than they would otherwise. We also assume there is no spec shifting between day cabs and sleepers in the 2027–2029 period when tractor sleepers are not yet impacted.

Overall, Scenario 2 will result in cumulative increase in CO2 emissions of 18.6 MMT over the 2027–2032 period. The annual and cumulative increased CO2 emissions in Scenario 2 compared to Scenario 0—those CO2 emissions that are additive because older ICE trucks remain in the active population—are shown in Table 25.

The cumulative increase in CO2 emissions in Scenario 2 for the Classes 4-8 CV fleet is a 6% increase across the total population over the 2027–2032 period. For Classes 4-5, projected additional CO2 emissions above the Strawman baseline will rise by over 6%, Classes 6-7 will see an almost 3% emissions increase, and Class 8 will see a nearly 7% increase in CO2 emissions by 2032. The impact of additional CO2 emissions on total population emissions is shown in Table 25.

Scenario 2 will result in a cumulative increase in NOx emissions of 100,004 US tons over the 2027–2032 period. The annual difference in NOx emissions in Scenario 2—the NOx emissions that are additional because older ICE trucks are required by demand to remain in the active population—are illustrated in Table 25.

Overall, the cumulative incremental NOx emissions in Scenario 2 for Classes 4-8 trucks is over 30% above the Strawman scenario across 2027–2032. NOx emissions for Classes 4-5 will rise by around 30% above the baseline by 2032, a more than 15% increase for the Classes 6-7 truck population, and nearly 34% for the population of the Class 8 fleet by 2032. This relatively large percentage increase—just over 30%—is primarily the result of pre-2027 trucks remaining in the vehicle population with higher NOx levels, when they would have otherwise been retired. The impact of additional NOx emissions on total population emissions is shown in Table 25.

Table 25: Scenario 2 Annual Difference in CO2 & NOx Emissions Compared to Scenario 0, 2027-2032 and Cumulative Additional CO2 & NOx Emissions as a % of Population CO2 & NOx Emissions, 2027-2032

Scenario 2: Cumulative Additional CO2 Emissions as Percent of Population CO2 Emissions

Type	2027	2028	2029	2030	2031	2032
Cl. 4-5	1.1%	2.3%	3.4%	4.7%	5.7%	6.4%
Cl. 6-7	0.6%	1.3%	1.9%	2.4%	2.7%	2.7%
Cl. 8	0.7%	1.4%	2.2%	4.1%	5.6%	6.8%
Total	**0.7%**	**1.5%**	**2.3%**	**3.9%**	**5.1%**	**6.0%**

Scenario 2: Annual Difference in CO2 Emissions Compared to Scenario 0 (MMT)

Type	2027	2028	2029	2030	2031	2032	Cumulative
Cl. 4-5	0.36	0.40	0.41	0.32	0.28	0.16	**1.93**
Cl. 6-7	0.32	0.36	0.36	0.23	0.14	0.00	**1.41**
Cl. 8	1.55	1.72	1.75	4.11	3.45	2.68	**15.25**
							18.59

Scenario 2: Cumulative Additional NOx Emissions as Percent of Population NOx Emissions

Type	2027	2028	2029	2030	2031	2032
Cl. 4-5	5.0%	10.5%	16.0%	22.0%	26.1%	29.2%
Cl. 6-7	3.6%	7.4%	11.1%	14.1%	15.5%	15.6%
Cl. 8	3.2%	6.9%	10.7%	20.1%	27.0%	33.7%
Total	**3.4%**	**7.4%**	**11.3%**	**19.3%**	**24.9%**	**30.2%**

Scenario 2: Annual Difference in NOx Emissions Compared to Scenario 0 (US Tons)

Type	2027	2028	2029	2030	2031	2032	Cumulative
Cl. 4-5	1,782	1,983	2,054	1,613	1,261	805	**9,497**
Cl. 6-7	2,043	2,264	2,290	1,448	773	0	**8,819**
Cl. 8	7,778	9,167	9,275	22,288	16,764	16,416	**81,688**
							100,004

Scenario 3: Reiterating, the overall sales decrease for Classes 4-8 trucks under Scenario 3 is illustrated in Table 26.

Table 26: Scenario 3 Commercial Vehicle Sales Decrease, 2027-2032

Scenario 3: Overall CV Sales Decrease						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Class 4-5 Truck	47,443	52,461	53,600	37,852	28,800	17,369
Class 6-7 Truck	44,578	48,458	47,717	26,014	12,933	0
Class 8 Truck & Tractor	109,700	131,600	128,100	213,010	145,110	141,370

As this number of new units would not be added to the active U-11 tractor and U-15 truck populations, we assume the same number of older vehicles would be required to remain in the active populations longer than they would otherwise. We also assume there is no spec shifting between day cabs and sleepers in the 2027–2029 period when tractor sleepers are not yet impacted.

Overall, Scenario 3 will result in a cumulative increase in CO2 emissions of 15.84 MMT over 2027–2032. The annual and cumulative increased CO2 emissions in Scenario 3 compared to Scenario 0—those CO2 emissions that are additive because older ICE trucks remain in the active population—are shown in Table 27.

The cumulative increase in CO2 emissions in Scenario 3 for the Classes 4-8 truck fleet is 5.1% across the total truck population over the 2027–2032 period. For Classes 4-5, projected additional CO2 emissions above the Strawman baseline will rise by over 4%, Classes 6-7 will see an almost 2% emissions increase, and Class 8 will see a 6% increase in CO2 emissions by 2032. The impact of additional CO2 emissions on total population emissions is shown in Table 27.

Scenario 3 will result in a cumulative increase in NOx emissions of 85,101 US tons over 2027–2032. The annual difference in NOx emissions in Scenario 3—the NOx emissions that are additional because older ICE trucks are required by freight demand to remain in the active population—is shown in Table 27.

Overall, the cumulative incremental NOx emissions in Scenario 3 for Classes 4-8 trucks is ~25% above the Strawman scenario over the 2027–2032 period. NOx emissions for the Classes 4-5 fleet will rise by around 20% above the baseline by 2032, a more than 10% increase for the Classes 6-7 truck population, and 30% for the Class 8 vehicle fleet by 2032. This relatively large percentage increase, 30%, is primarily a result of pre-2027 trucks remaining in the vehicle population with higher NOx levels, when they would have otherwise been retired. The impact of additional NOx emissions on total population emissions is shown in Table 27.

Table 27: Scenario 3 Annual Difference in CO_2 & NO_x Emissions Compared to Scenario 0, 2027-2032 and Cumulative Additional CO_2 & NO_x Emissions as a % of Population CO_2 & NO_x Emissions, 2027-2032

Scenario 3: Cumulative Additional CO2 Emissions as Percent of Population CO2 Emissions						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cl. 4-5	0.8%	1.6%	2.4%	3.3%	3.9%	4.3%
Cl. 6-7	0.4%	0.9%	1.3%	1.7%	1.8%	1.8%
Cl. 8	0.7%	1.4%	2.1%	3.8%	5.1%	6.0%
Total	**0.7%**	**1.4%**	**2.0%**	**3.4%**	**4.4%**	**5.1%**

Scenario 3: Annual Difference in CO2 Emissions Compared to Scenario 0 (MMT)							Cumulative
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Cl. 4-5	0.25	0.28	0.29	0.20	0.17	0.09	**1.29**
Cl. 6-7	0.23	0.25	0.25	0.14	0.08	0.00	**0.95**
Cl. 8	1.55	1.72	1.56	3.77	2.84	2.15	**13.60**
							15.84

Scenario 3: Cumulative Additional NOx Emissions as Percent of Population NOx Emissions						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cl. 4-5	3.6%	7.5%	11.3%	15.2%	17.7%	19.6%
Cl. 6-7	2.6%	5.3%	7.8%	9.7%	10.5%	10.5%
Cl. 8	3.2%	6.9%	10.3%	19.0%	24.6%	30.0%
Total	**3.1%**	**6.7%**	**9.9%**	**17.0%**	**21.5%**	**25.7%**

Scenario 3: Annual Difference in NOx Emissions Compared to Scenario 0 (US Tons)							Cumulative
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	
Cl. 4-5	1,273	1,407	1,438	1,015	776	457	**6,366**
Cl. 6-7	1,476	1,604	1,579	861	430	0	**5,950**
Cl. 8	7,778	9,167	8,251	20,514	13,835	13,241	**72,785**
							85,101

In calculating CO_2 and NOx emissions for each scenario, we assume that for each ICE tractor unable to be sold, one tractor in the existing active tractor population will have to continue to operate to keep up with demand. ACTR uses U-11 (11-years old and under) tractor and U-15 (15-years old and younger) truck population and replacement models for determining the most active portion of the US MHD population. ACTR's collection of used truck data indicates that by their eleventh year, Class 8 tractors are no longer in either first- or second-tier operations. While they do not go away, those units typically shift from on-highway freight hauling applications to less intensive localized applications. Old Class 8 tractors are most often found in applications like farming, lower mileage local/regional routes like drayage, are exported, or even scrapped/retired. If new truck sales are constrained, the result is that rather than having enough new ICE trucks joining the active U-11 and U-15 combined population—that are required to meet the most current emissions standards—older, less-efficient ICE trucks will be required to remain active, with higher freight rates supporting older trucks returning to the marketplace. As was learned during the pandemic-induced supply chain crisis, when the CV manufacturers are unable to satisfy new vehicle demand, there is a considerable population of marginally profitable equipment that can be brought to bear when the freight rates rise.

In calculating CO_2 and NOx emissions under each scenario, we have conservatively assumed that each tractor remaining in the population will be 11-years old, each truck remaining in the population will be 15-years old, and that there has not been any degradation in fuel efficiency over time. For example, in 2027, for a tractor that must remain in the "active" population (instead of a new tractor entering), the tractor is assumed to be a 2016 (CY) tractor (11-years old) and will have the same average fuel efficiency throughout its use. In real life, some degradation in a vehicle's fuel efficiency would be expected, but for the purposes of our analysis and to remain conservative, we have not factored this into the calculations.

Using ACTR's weighted average mileage and fuel efficiency for the following trucks by class, ACTR has determined the estimated additional CO_2 and NOx emissions caused in each scenario.

- Class 8: day cabs (regional, local, LTL linehaul, and drayage applications), sleepers (regional and long-haul applications), and straight trucks (construction, refuse, and local applications)
- Classes 6-7: conventional and low cab forward trucks (local, beverage, reefer, work truck, aerial lift, and LTL pickup and delivery applications) and step vans
- Classes 4-5: conventional and low cab forward trucks (short- and long-range parcel delivery, work truck, and reefer applications) and step vans

If either the NPRM Alternative, Aggressive, or Mid-Point adoption rates are adopted as the FRM rates, and the emissions standards set forth are unable to be met (as under Scenarios 1, 2, and 3), we will see higher CO_2 and NOx emissions due to older, less efficient trucks staying in the active population longer than they might otherwise, supported by higher freight rates due to capacity constraints. Additional NOx emissions under Scenarios 1, 2, and 3 are particularly daunting due to the EPA's MY

2027 NOx rule, “Control of Air Pollution From New Motor Vehicles: Heavy-Duty Engine Standards,” coming into effect the same year as the proposed GHG Phase 3 rule. The EPA’s NOx standards for HD trucks will increase in stringency from 0.2 g/bhp-hr pre-2027 to .035 g/bhp-hr in 2027.

Appendix A

Discussion of NPRM Proposed, Alternative, and Aggressive Adoption Rates

NPRM Proposed Adoption Rates

Projected MHD ZEV sales and associated stringencies in EPA's Phase 3 FRM are the same as those in EPA's main Phase 3 proposal, and the actual MHD ZEV sales in the market match those implicitly mandated sales percentages. This scenario results in higher operating costs the US trucking industry would be forced to pass on to shippers, who in turn would pass on to consumers.

We present this scenario for comparative purposes, but we believe its flaws and economic implications, macro and micro, make it inherently unrealistic. As detailed below, the assumption that the industry will immediately be able to pass these increased costs on to consumers fails to appreciate the fact that the US trucking industry is one of the most competitive businesses in the economy.

For example, trucking fleets would no doubt have liked to increase their rates in 2023 to cover inflationary cost increases. In contrast to those wishes, the for-hire truckload market, the trucking industry's largest sector, saw contract rates decline 13% in 2023. In other words, by and large, the market does not function in the way these adoption rates envision, but rather, pricing is dictated by the law of supply and demand. Logically, we believe these adoption rates break down into Scenarios 1, 2, and 3. Table 28 on the following page depicts the additional (unrealistic) ZEV sales compared to Scenario 0, EMA's strawman ZEV sales.

Appendix A

Table 28: Additional ZEV Sales to Meet EPA's Proposed Adoption Rates Compared to Scenario 0

Additional ZEV Sales Required to Meet EPA NPRM Proposed ZEV Adoption Rates Compared to Scenario 0							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	1,248	1,558	1,892	1,710	1,700	2,024	10,132
Conventional	13,008	17,898	22,352	21,280	18,460	20,570	113,568
Low Cab Forward	3,456	4,313	5,236	4,750	4,800	5,544	28,099
RV	832	988	1,166	1,045	1,020	1,188	6,239
Class 4-5	**18,544**	**24,757**	**30,646**	**28,785**	**25,980**	**29,326**	**158,038**
Step Van	742	784	885	744	600	315	4,070
Conventional	12,992	15,176	17,625	15,456	10,810	5,495	77,554
Low Cab Forward	308	322	360	300	230	130	1,650
School Bus	5,656	5,698	6,195	5,208	4,130	2,095	28,982
RV	2,198	2,212	2,430	1,980	1,690	865	11,375
Class 6-7	**21,896**	**24,192**	**27,495**	**23,688**	**17,460**	**8,900**	**123,631**
Yard Spotter	656	756	817	1,100	875	1,000	5,204
Transit Bus	976	1,116	1,197	1,600	1,275	1,500	7,664
Straight	8,464	11,448	14,155	18,900	16,400	18,850	88,217
Day Cab	5,680	8,160	10,452	12,225	14,931	15,542	66,990
Sleeper	0	0	0	12,690	19,854	27,874	60,418
Class 8	**15,776**	**21,480**	**26,621**	**46,515**	**53,335**	**64,766**	**228,493**

ACTR utilized our long-term forecasts for US Classes 4-8 commercial vehicles and applied the implicitly mandated sales percentages from EPA's main Aggressive Phase 3 proposal to determine MHD ZEV sales. This scenario results in higher ZEV sales when compared to the reduced percentages of ZEV sales that EMA detailed and calculated in its comments on the Phase 3 NPRM. ACTR has calculated the resulting higher MHD ZEV sales volumes and has applied the associated higher acquisition costs of those units. The associated higher costs are comprised of the retail price equivalent (RPE) differential cost, plus state sales tax and FET, and less the IRA vehicle tax credits.

The overall costs that will be incurred by the industry with these adoption rates make any "as planned" adoption inherently unrealistic as those costs could not be absorbed by the trucking industry, as discussed in previous paragraphs. The primary source of this impact is derived from the increased number of ZEVs comprising Class 8 sales required to meet the EPA's aggressive implicitly mandated percentage-based ZEV sales targets in the FRM.

ACTR believes it is important to have a strong grounding in basic freight market fundamentals and policy transmission mechanisms to understand why the higher costs from these aggressive adoption rates could not feasibly be absorbed by the marketplace in the time allotted.

The US freight transportation market is one of the most competitive businesses in the world, with over 750,000 fleets (FMCSA) competing for freight. Market rates are set based on the balance of supply and demand across millions of trucks and hundreds of millions of loads. Industry profit margins have historically been razor-thin, and after record years for volumes and rates in 2021 and 2022 that were driven on the supply-side by supply-chain constraints that limited CV capacity, the industry boom gave way to bust again in 2023. In a full tallying, 2023 represents the largest year-over-year decline in fleet profitability on record, with profitability pressures continuing in early 2024.

The mandated adoption of MHD ZEVs brings considerable costs and risks for industry participants who have not historically been held accountable for their operations' environmental costs. At ACT Research, we spend a lot of time talking with industry participants, and we believe that changing this fundamental aspect of the capitalist system, an admirable goal, will unsurprisingly meet significant resistance from the trucking industry, the viability of which depends upon minimizing cost and risk.

Fundamentally, shippers choose fleets to haul their freight primarily based on service and cost. The USPS is a prime example of the competitive nature of freight bids. Based on the network infrastructure of post offices already in place, the USPS is an ideal candidate for early electrification in HHD. But cost-based approaches are prevalent across the government. Even with government purchasing, which is significant in the freight sector, there are still insufficient financial mechanisms such as a GHG surcharge even within government contracts to support broad ZEV adoption. As well, we find it very hard to believe shippers would, or could, broadly implement GHG surcharges on their own. Thus, these costs will largely be borne by the transportation industry initially, which it will most likely only do willingly in the HHD sector after capacity shortages have pressed freight rates meaningfully higher.

As a result of market forces, the rapid adoption of ZEVs under NPRM Proposed Adoption Rates appears unlikely. Accordingly, this is a scenario that ACT Research believes to be implausible, as the market would be unable to absorb those costs initially without some form of significant incentives and subsidies.

Aggressive Adoption Rates

Projected MHD ZEV sales and associated stringencies in EPA's Phase 3 FRM are above EPA's proposed Alternative Adoption Rates, and the actual MHD ZEV sales in the market match those implicitly mandated sales percentages. This scenario results in higher costs the US trucking industry would be able to bear, leading to deferred purchases and ICE equipment kept in the market for an extended period. Higher vehicle costs and capacity constraint-driven price hikes would be passed on to shippers, who in turn would pass to consumers.

We present the following scenario for comparative purposes, but we believe its economic implications, macro and micro, make it inherently unrealistic. As detailed further below, the assumption that the industry will immediately be able to pass these costs on to consumers fails to appreciate the fact that the US trucking industry is one of the most competitive businesses in the economy.

Appendix A

For example, trucking fleets would no doubt have liked to increase their rates in 2023 to cover inflationary cost increases. In the for-hire truckload market, the largest sector, contract rates fell 13% from 2022 levels. In other words, by and large, the market does not function in the way this Scenario envisions. Logically, we believe implementing Aggressive Adoption Rates breaks down into Scenarios 1, 2, and 3.

Table 29 depicts the additional ZEV sales compared to Scenario 0, EMA's strawman ZEV sales.

(The discussion of basic freight market fundamentals and policy transmission mechanisms described under header "NPRM Proposed Adoption Rates" apply to Aggressive Adoption Rates as well.)

Table 29: Additional ZEV Sales to Meet Aggressive Adoption Rates Compared to Scenario 0

Additional ZEV Sales Required to Meet Aggressive ZEV Adoption Rates Compared to Scenario 0							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	780	1,148	1,290	1,080	1,785	2,300	8,383
Conventional	8,130	13,188	15,240	13,440	19,383	23,375	92,756
Low Cab Forward	2,160	3,178	3,570	3,000	5,040	6,300	23,248
RV	520	728	795	660	1,071	1,350	5,124
Class 4-5	**11,590**	**18,242**	**20,895**	**18,180**	**27,279**	**33,325**	**129,511**
Step Van	424	504	590	434	660	630	3,242
Conventional	7,424	9,756	11,750	9,016	11,891	10,990	60,827
Low Cab Forward	176	207	240	175	253	260	1,311
School Bus	3,232	3,663	4,130	3,038	4,543	4,190	22,796
RV	1,256	1,422	1,620	1,155	1,859	1,730	9,042
Class 6-7	**12,512**	**15,552**	**18,330**	**13,818**	**19,206**	**17,800**	**97,218**
Yard Spotter	0	420	559	440	490	600	2,509
Transit Bus	0	620	819	640	714	900	3,693
Straight	0	6,360	9,685	7,560	9,184	11,310	44,099
Day Cab	2,840	5,440	8,040	8,965	13,509	20,450	59,244
Sleeper	0	0	0	7,614	11,030	27,874	46,518
Class 8	**2,840**	**12,840**	**19,103**	**25,219**	**34,927**	**61,134**	**156,063**

ACTR utilized our long-term forecasts of US Classes 4-8 commercial vehicle production and retail sales and applied sales percentages in line with the EPA's Alternative Adoption Rates to arrive at a mandate-implied level of MHD ZEV sales. The implied ZEV sales volumes in this analysis are much higher than the reduced percentages of ZEV sales derived from the EMA strawman scenario analysis that was used as a basis of attempt to arrive at a realistic ZEV market in the supply chain- and infrastructure-constrained early-adoption period for new technologies.

Appendix A

In calculating the resulting higher MHD ZEV sales volumes, ACTR has applied the associated higher acquisition costs of those vehicles. Those higher costs are comprised of the retail price equivalent differential cost, plus state sales tax and FET, and less the IRA vehicle tax credits.

The overall costs that will be incurred by the industry in this slightly less aggressive alternative EPA scenario bring us to the same "inherently unrealistic" conclusion. The costs are material and could not be absorbed by the trucking industry, as discussed in previous paragraphs, which leads to older ICE trucks staying in the fleet longer. The primary source of this cost impact is derived from the increased number of ZEVs comprising Class 8 sales required to meet the EPA's aggressive implicitly mandated percentage-based ZEV sales targets in the FRM.

NPRM Alternative Adoption Rates

Projected MHD ZEV sales and associated stringencies in EPA's Phase 3 FRM are the same as those in EPA's proposal Alternative Adoption Rates, and the actual MHD ZEV sales in the market match those implicitly mandated sales percentages. This scenario results in higher costs the US trucking industry would be forced to pass on to shippers, who in turn would pass to consumers.

We present the following scenario for comparative purposes, but we believe its economic implications, macro and micro, make it inherently unrealistic as well. As detailed below, the assumption that the industry will immediately be able to pass these costs on to consumers fails to appreciate the fact that the US trucking industry is one of the most competitive businesses in the economy. The market doesn't function in the way the EPA's proposed adoption plan envisions. Logically, we believe those proposals break down into Scenarios 1, 2, and 3.

Table 30 on the following page depicts the additional ZEV sales compared to the Scenario 0 base case, EMA's strawman ZEV sales.

(The discussion of basic freight market fundamentals and policy transmission mechanisms described under NPRM Proposed Adoption Rates apply to Alternative Adoption Rates as well.)

Appendix A

Table 30: Additional ZEV Sales to Meet EPA NPRM Alternative Adoption Rates Compared to Scenario 0

Additional ZEV Sales Required to Meet EPA NPRM Alternative ZEV Adoption Rates Compared to Scenario 0							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	702	1,066	1,376	1,260	1,275	1,012	6,691
Conventional	7,317	12,246	16,256	15,680	13,845	10,285	75,629
Low Cab Forward	1,944	2,951	3,808	3,500	3,600	2,772	18,575
RV	468	676	848	770	765	594	4,121
Class 4-5	**10,431**	**16,939**	**22,288**	**21,210**	**19,485**	**14,663**	**105,016**
Step Van	424	560	649	434	300	0	2,367
Conventional	7,424	10,840	12,925	9,016	5,405	0	45,610
Low Cab Forward	176	230	264	175	115	0	960
School Bus	3,232	4,070	4,543	3,038	2,065	0	16,948
RV	1,256	1,580	1,782	1,155	845	0	6,618
Class 6-7	**12,512**	**17,280**	**20,163**	**13,818**	**8,730**	**0**	**72,503**
Yard Spotter	451	546	645	660	595	680	3,577
Transit Bus	671	806	945	960	867	1,020	5,269
Straight	5,819	8,268	11,175	11,340	11,152	12,818	60,572
Day Cab	2,840	5,440	6,432	8,150	7,821	8,180	38,863
Sleeper	0	0	0	12,690	14,339	21,539	48,568
Class 8	**9,781**	**15,060**	**19,197**	**33,800**	**34,774**	**44,237**	**156,849**
Total Class 4-8	**32,724**	**49,279**	**61,648**	**68,828**	**62,989**	**58,900**	**334,368**

ACTR utilized our long-term forecasts for US Classes 4-8 commercial vehicle retail sales and applied the adoption percentages from EPA's NPRM Alternative Adoption Rates to determine implied MHD ZEV sales levels. Using the EPA's adoption mandates results in higher ZEV sales when compared to the reduced percentages of ZEV sales from either the Mid-Point Difference adoption rates or the EMA strawman adoption rates, which are utilized under Scenarios 1, 2, and 3. After calculating the resulting higher MHD ZEV sales volumes, ACTR applied the associated higher acquisition costs of ZEVs relative to ICE units. Those higher costs are comprised of the RPE differential cost, plus state sales tax and FET, and less the IRA vehicle tax credits.

The overall costs that will be incurred by the industry, at least initially, if Alternative Adoption Rates were implemented, make it inherently unrealistic as those costs could not be absorbed by the trucking industry, as discussed previously. The primary source of this impact is derived from the increased number of higher priced ZEVs comprising Class 8 sales required to meet the EPA's alternative implicitly mandated percentage-based ZEV sales targets in the FRM. More likely, however, would be the shortfall of capacity brought about by constrained capacity due to cost- and infrastructure-driven reticence by truckers to adopt ZEVs at prescribed rates, thereby limiting ICE vehicle sales.

Appendix B

Projected ZEV Sales, Total Unit Sales, & Unit Sales Decreases

The following tables are included to show the projected ZEV sales (with the relative percent ZEV adoption rates), total unit sales, and unit sales decreases for each of the four scenarios.

Scenario 0 - EMA Strawman Neutral Adoption Rates

Table 31: Scenario 0 Projected ZEV Unit Sales & Adoption Rates, 2027-2032 and Total Commercial Vehicle Unit Sales, 2027-2032

Scenario 0: Projected ZEV Unit Sales and Adoption Rates 2027-32							Scenario 0: Total Commercial Vehicle Unit Sales					
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	468	738	1,032	1,800	2,125	3,220	7,800	8,200	8,600	9,000	8,500	9,200
Conventional	4,878	8,478	12,192	22,400	23,075	32,725	81,300	94,200	101,600	112,000	92,300	93,500
Low Cab Forward	1,296	2,043	2,856	5,000	6,000	8,820	21,600	22,700	23,800	25,000	24,000	25,200
RV	312	468	636	1,100	1,275	1,890	5,200	5,200	5,300	5,500	5,100	5,400
Class 4-5	**6,954**	**11,727**	**16,716**	**30,300**	**32,475**	**46,655**	**115,900**	**130,300**	**139,300**	**151,500**	**129,900**	**133,300**
Adoption Rate	***6%***	***9%***	***12%***	***20%***	***25%***	***35%***						
Step Van	265	392	531	930	1,200	1,890	5,300	5,600	5,900	6,200	6,000	6,300
Conventional	4,640	7,588	10,575	19,320	21,620	32,970	92,800	108,400	117,500	128,800	108,100	109,900
Low Cab Forward	110	161	216	375	460	780	2,200	2,300	2,400	2,500	2,300	2,600
School Bus	2,020	2,849	3,717	6,510	8,260	12,570	40,400	40,700	41,300	43,400	41,300	41,900
RV	785	1,106	1,458	2,475	3,380	5,190	15,700	15,800	16,200	16,500	16,900	17,300
Class 6-7	**7,820**	**12,096**	**16,497**	**29,610**	**34,920**	**53,400**	**156,400**	**172,800**	**183,300**	**197,400**	**174,600**	**178,000**
Adoption Rate	***5%***	***7%***	***9%***	***15%***	***20%***	***30%***						
Yard Spotter	0	0	0	220	280	600	4,100	4,200	4,300	4,400	3,500	4,000
Transit Bus	0	0	0	320	408	900	6,100	6,200	6,300	6,400	5,100	6,000
Straight	0	0	0	3,780	5,248	11,310	52,900	63,600	74,500	75,600	65,600	75,400
Day Cab	0	0	1,608	4,075	6,399	12,270	56,800	68,000	80,400	81,500	71,100	81,800
Sleeper	0	0	0	0	2,206	3,801	88,700	106,700	125,000	126,900	110,300	126,700
Class 8	**0**	**0**	**1,608**	**8,395**	**14,541**	**28,881**	**208,600**	**248,700**	**290,500**	**294,800**	**255,600**	**293,900**
Adoption Rate	***0%***	***0%***	***1%***	***3%***	***6%***	***10%***						

There is no decrease in unit sales in the baseline Scenario 0.

Appendix B

Scenario 1 - Aggressive Adoption Rates

Table 32: Scenario 1 Projected ZEV Unit Sales & Adoption Rates, 2027-2032 and Total Commercial Vehicle Unit Sales and Overall CV Sales Decrease, 2027-2032

Scenario 1: Projected ZEV Unit Sales and Adoption Rates 2027-32						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	468	738	1,032	1,800	2,125	3,220
Conventional	4,878	8,478	12,192	22,400	23,075	32,725
Low Cab Forward	1,296	2,043	2,856	5,000	6,000	8,820
RV	312	468	636	1,100	1,275	1,890
Class 4-5	**6,954**	**11,727**	**16,716**	**30,300**	**32,475**	**46,655**
Adoption Rate	***16%***	***23%***	***27%***	***32%***	***46%***	***60%***
Step Van	265	392	531	930	1,200	1,890
Conventional	4,640	7,588	10,575	19,320	21,620	32,970
Low Cab Forward	110	161	216	375	460	780
School Bus	2,020	2,849	3,717	6,510	8,260	12,570
RV	785	1,106	1,458	2,475	3,380	5,190
Class 6-7	**7,820**	**12,096**	**16,497**	**29,610**	**34,920**	**53,400**
Adoption Rate	***13%***	***16%***	***19%***	***22%***	***31%***	***40%***
Yard Spotter	0	0	0	220	280	600
Transit Bus	0	0	0	320	408	900
Straight	0	0	0	3,780	5,248	11,310
Day Cab	0	0	1,608	4,075	6,399	12,270
Sleeper	0	0	0	0	2,206	3,801
Class 8	**0**	**0**	**1,608**	**8,395**	**14,541**	**28,881**
Adoption Rate	***0%***	***0%***	***1%***	***15%***	***21%***	***33%***

Scenario 1: Total Commercial Vehicle Sales						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	2,925	3,209	3,822	5,625	4,620	5,367
Conventional	30,488	36,861	45,156	70,000	50,163	54,542
Low Cab Forward	8,100	8,883	10,578	15,625	13,043	14,700
RV	1,950	2,035	2,356	3,438	2,772	3,150
Class 4-5	**43,463**	**50,987**	**61,911**	**94,688**	**70,598**	**77,758**
Step Van	2,038	2,450	2,795	4,227	3,871	4,725
Conventional	35,692	47,425	55,658	87,818	69,742	82,425
Low Cab Forward	846	1,006	1,137	1,705	1,484	1,950
School Bus	15,538	17,806	19,563	29,591	26,645	31,425
RV	6,038	6,913	7,674	11,250	10,903	12,975
Class 6-7	**60,154**	**75,600**	**86,826**	**134,591**	**112,645**	**133,500**
Yard Spotter	4,100	0	0	1,467	1,273	2,000
Transit Bus	6,100	0	0	2,133	1,855	3,000
Straight	52,900	0	0	25,200	23,855	37,700
Day Cab	0	0	13,400	25,469	22,854	30,675
Sleeper	88,700	106,700	125,000	0	18,383	15,204
Class 8	**151,800**	**106,700**	**138,400**	**54,269**	**68,219**	**88,579**

Scenario 1: Overall CV Sales Decrease							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	4,875	4,991	4,778	3,375	3,880	3,833	25,733
Conventional	50,813	57,339	56,444	42,000	42,137	38,958	287,691
Low Cab Forward	13,500	13,817	13,222	9,375	10,957	10,500	71,371
RV	3,250	3,165	2,944	2,063	2,328	2,250	16,000
Class 4-5	**72,438**	**79,313**	**77,389**	**56,813**	**59,302**	**55,542**	**400,796**
Step Van	3,262	3,150	3,105	1,973	2,129	1,575	15,194
Conventional	57,108	60,975	61,842	40,982	38,358	27,475	286,740
Low Cab Forward	1,354	1,294	1,263	795	816	650	6,172
School Bus	24,862	22,894	21,737	13,809	14,655	10,475	108,431
RV	9,662	8,888	8,526	5,250	5,997	4,325	42,647
Class 6-7	**96,246**	**97,200**	**96,474**	**62,809**	**61,955**	**44,500**	**459,184**
Yard Spotter	0	4,200	4,300	2,933	2,227	2,000	15,661
Transit Bus	0	6,200	6,300	4,267	3,245	3,000	23,012
Straight	0	63,600	74,500	50,400	41,745	37,700	267,945
Day Cab	56,800	68,000	67,000	56,031	48,246	51,125	347,203
Sleeper	0	0	0	126,900	91,917	111,496	330,313
Class 8	**56,800**	**142,000**	**152,100**	**240,531**	**187,381**	**205,321**	**984,134**
Total	**225,484**	**318,513**	**325,963**	**360,153**	**308,638**	**305,363**	**1,844,113**

Appendix B

Scenario 2 - Alternative Adoption Rates

Table 33: Scenario 2 Projected ZEV Unit Sales & Adoption Rates, 2027-2032 and Total Commercial Vehicle Unit Sales and Overall CV Sales Decrease, 2027-2032

Scenario 2: Projected ZEV Unit Sales and Adoption Rates 2027-32						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	468	738	1,032	1,800	2,125	3,220
Conventional	4,878	8,478	12,192	22,400	23,075	32,725
Low Cab Forward	1,296	2,043	2,856	5,000	6,000	8,820
RV	312	468	636	1,100	1,275	1,890
Class 4-5	**6,954**	**11,727**	**16,716**	**30,300**	**32,475**	**46,655**
Adoption Rate	***15%***	***22%***	***28%***	***34%***	***40%***	***46%***
Step Van	265	392	531	930	1,200	1,890
Conventional	4,640	7,588	10,575	19,320	21,620	32,970
Low Cab Forward	110	161	216	375	460	780
School Bus	2,020	2,849	3,717	6,510	8,260	12,570
RV	785	1,106	1,458	2,475	3,380	5,190
Class 6-7	**7,820**	**12,096**	**16,497**	**29,610**	**34,920**	**53,400**
Adoption Rate	***13%***	***17%***	***20%***	***22%***	***25%***	***30%***
Yard Spotter	0	0	0	220	280	600
Transit Bus	0	0	0	320	408	900
Straight	0	0	0	3,780	5,248	11,310
Day Cab	0	0	1,608	4,075	6,399	12,270
Sleeper	0	0	0	0	2,206	3,801
Class 8	**0**	**0**	**1,608**	**8,395**	**14,541**	**28,881**
Adoption Rate	***0%***	***0%***	***1%***	***17%***	***21%***	***27%***

Scenario 2: Total Commercial Vehicle Sales						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	3,120	3,355	3,686	5,294	5,313	7,000
Conventional	32,520	38,536	43,543	65,882	57,688	71,141
Low Cab Forward	8,640	9,286	10,200	14,706	15,000	19,174
RV	2,080	2,127	2,271	3,235	3,188	4,109
Class 4-5	**46,360**	**53,305**	**59,700**	**89,118**	**81,188**	**101,424**
Step Van	2,038	2,306	2,655	4,227	4,800	6,300
Conventional	35,692	44,635	52,875	87,818	86,480	109,900
Low Cab Forward	846	947	1,080	1,705	1,840	2,600
School Bus	15,538	16,759	18,585	29,591	33,040	41,900
RV	6,038	6,506	7,290	11,250	13,520	17,300
Class 6-7	**60,154**	**71,153**	**82,485**	**134,591**	**139,680**	**178,000**
Yard Spotter	0	0	0	1,100	1,120	1,875
Transit Bus	0	0	0	1,600	1,632	2,813
Straight	0	0	0	18,900	20,992	35,344
Day Cab	0	0	16,080	27,167	31,995	49,080
Sleeper	88,700	106,700	125,000	0	14,707	19,005
Class 8	**88,700**	**106,700**	**141,080**	**48,767**	**70,446**	**108,116**

Scenario 2: Overall CV Sales Decrease							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	4,680	4,845	4,914	3,706	3,188	2,200	23,533
Conventional	48,780	55,664	58,057	46,118	34,613	22,359	265,590
Low Cab Forward	12,960	13,414	13,600	10,294	9,000	6,026	65,294
RV	3,120	3,073	3,029	2,265	1,913	1,291	14,690
Class 4-5	**69,540**	**76,995**	**79,600**	**62,382**	**48,713**	**31,876**	**369,106**
Step Van	3,262	3,294	3,245	1,973	1,200	0	12,973
Conventional	57,108	63,765	64,625	40,982	21,620	0	248,099
Low Cab Forward	1,354	1,353	1,320	795	460	0	5,282
School Bus	24,862	23,941	22,715	13,809	8,260	0	93,587
RV	9,662	9,294	8,910	5,250	3,380	0	36,496
Class 6-7	**96,246**	**101,647**	**100,815**	**62,809**	**34,920**	**0**	**396,437**
Yard Spotter	4,100	4,200	4,300	3,300	2,380	2,125	20,405
Transit Bus	6,100	6,200	6,300	4,800	3,468	3,188	30,056
Straight	52,900	63,600	74,500	56,700	44,608	40,056	332,364
Day Cab	56,800	68,000	64,320	54,333	39,105	32,720	315,278
Sleeper	0	0	0	126,900	95,593	107,695	330,188
Class 8	**119,900**	**142,000**	**149,420**	**246,033**	**185,154**	**185,784**	**1,028,291**
Total	**285,686**	**320,643**	**329,835**	**371,225**	**268,787**	**217,660**	**1,793,835**

Appendix B

Scenario 3 - Mid-Point Difference Adoption Rates

Table 34: Scenario 3 Projected ZEV Unit Sales & Adoption Rates, 2027-2032 and Total Commercial Vehicle Unit Sales and Overall CV Sales Decrease, 2027-2032

Scenario 3: Projected ZEV Unit Sales and Adoption Rates 2027-32						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	468	738	1,032	1,800	2,125	3,220
Conventional	4,878	8,478	12,192	22,400	23,075	32,725
Low Cab Forward	1,296	2,043	2,856	5,000	6,000	8,820
RV	312	468	636	1,100	1,275	1,890
Class 4-5	**6,954**	**11,727**	**16,716**	**30,300**	**32,475**	**46,655**
Adoption Rate	***11%***	***16%***	***20%***	***27%***	***33%***	***41%***
Step Van	265	392	531	930	1,200	1,890
Conventional	4,640	7,588	10,575	19,320	21,620	32,970
Low Cab Forward	110	161	216	375	460	780
School Bus	2,020	2,849	3,717	6,510	8,260	12,570
RV	785	1,106	1,458	2,475	3,380	5,190
Class 6-7	**7,820**	**12,096**	**16,497**	**29,610**	**34,920**	**53,400**
Adoption Rate	***9%***	***12%***	***15%***	***19%***	***23%***	***30%***
Yard Spotter	0	0	0	220	280	600
Transit Bus	0	0	0	320	408	900
Straight	0	0	0	3,780	5,248	11,310
Day Cab	0	0	1,608	4,075	6,399	12,270
Sleeper	0	0	0	0	2,206	3,801
Class 8	**0**	**0**	**1,608**	**8,395**	**14,541**	**28,881**
Adoption Rate	***0%***	***0%***	***1%***	***11%***	***14%***	***19%***

Scenario 3: Total Commercial Vehicle Sales						
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Step Van	4,457	4,761	5,160	6,667	6,538	7,951
Conventional	46,457	54,697	60,960	82,963	71,000	80,802
Low Cab Forward	12,343	13,181	14,280	18,519	18,462	21,778
RV	2,971	3,019	3,180	4,074	3,923	4,667
Class 4-5	**66,229**	**75,658**	**83,580**	**112,222**	**99,923**	**115,198**
Step Van	2,944	3,267	3,662	5,027	5,333	6,300
Conventional	51,556	63,233	72,931	104,432	96,089	109,900
Low Cab Forward	1,222	1,342	1,490	2,027	2,044	2,600
School Bus	22,444	23,742	25,634	35,189	36,711	41,900
RV	8,722	9,217	10,055	13,378	15,022	17,300
Class 6-7	**86,889**	**100,800**	**113,772**	**160,054**	**155,200**	**178,000**
Yard Spotter	0	0	0	1,760	1,697	2,553
Transit Bus	0	0	0	2,560	2,473	3,830
Straight	0	0	0	30,240	31,806	48,128
Day Cab	0	0	26,800	40,750	44,131	61,350
Sleeper	88,700	106,700	125,000	0	25,953	33,052
Class 8	**88,700**	**106,700**	**151,800**	**75,310**	**106,060**	**148,913**

Scenario 3: Overall CV Sales Decrease							
Type	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**Cumulative**
Step Van	3,343	3,439	3,440	2,333	1,962	1,249	15,766
Conventional	34,843	39,503	40,640	29,037	21,300	12,698	178,021
Low Cab Forward	9,257	9,519	9,520	6,481	5,538	3,422	43,739
RV	2,229	2,181	2,120	1,426	1,177	733	9,865
Class 4-5	**49,671**	**54,642**	**55,720**	**39,278**	**29,977**	**18,102**	**247,391**
Step Van	2,356	2,333	2,238	1,173	667	0	8,766
Conventional	41,244	45,167	44,569	24,368	12,011	0	167,359
Low Cab Forward	978	958	910	473	256	0	3,575
School Bus	17,956	16,958	15,666	8,211	4,589	0	63,379
RV	6,978	6,583	6,145	3,122	1,878	0	24,705
Class 6-7	**69,511**	**72,000**	**69,528**	**37,346**	**19,400**	**0**	**267,785**
Yard Spotter	4,100	4,200	4,300	2,640	1,803	1,447	18,490
Transit Bus	6,100	6,200	6,300	3,840	2,627	2,170	27,237
Straight	52,900	63,600	74,500	45,360	33,794	27,272	297,426
Day Cab	56,800	68,000	53,600	40,750	26,969	20,450	266,569
Sleeper	0	0	0	126,900	84,347	93,648	304,895
Class 8	**119,900**	**142,000**	**138,700**	**219,490**	**149,540**	**144,987**	**914,617**
Total	**239,083**	**268,642**	**263,948**	**296,114**	**198,917**	**163,090**	**1,429,793**