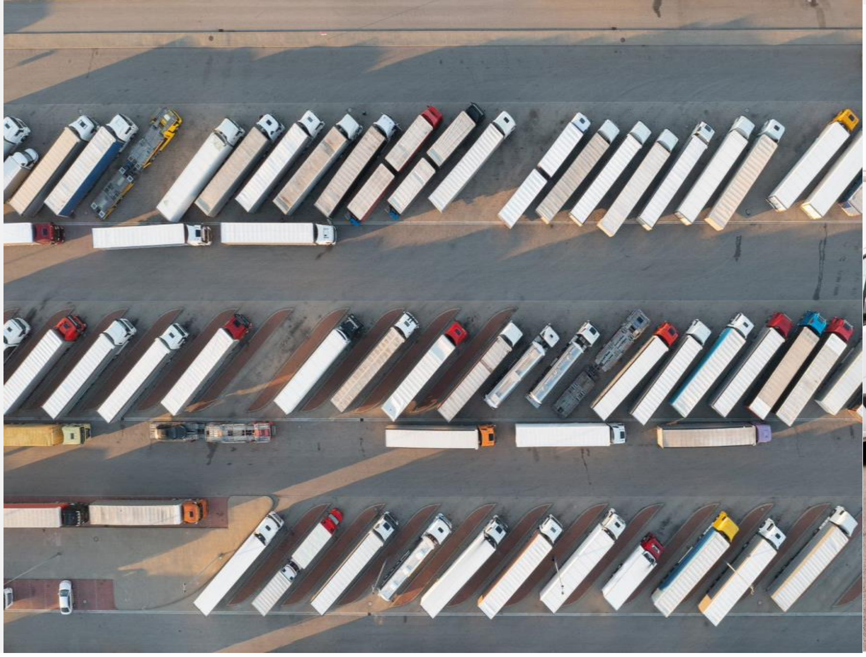


Union of Concerned Scientists

Maryland Clean Trucks Program

An Analysis of the Impacts of Zero-Emission Medium- and Heavy-Duty Trucks on the Environment, Public Health, Industry, and the Economy

August 2023

The business of sustainability

ERM

Acknowledgements

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INTRODUCTION

ERM was commissioned by the Natural Resources Defense Council and the Union of Concerned Scientists to evaluate the costs and benefits of state-level requirements for manufacturers that Maryland could adopt to increase sales of no- and low-emission medium- and heavy-duty (M/HD) trucks and buses. The analysis examines all on-road vehicles registered in Maryland with greater than 8,501 pounds gross vehicle weight, encompassing vehicle weight classes from Class 2b though Class 8. This is a diverse set of mostly commercial vehicles that includes heavy-duty pickups; school and shuttle buses; sanitation, construction, and other types of work trucks; and freight trucks ranging from local delivery vans to tractor-trailers that weigh up to 80,000 pounds when loaded.

Collectively the Maryland M/HD fleet includes 346,197 vehicles that annually travel more than nearly 5.5 billion miles and consume almost 615 million gallons of petroleum-based fuels.
In Maryland, M/HD vehicles are currently responsible for a disproportionate amount of pollution from on-road vehicles. Despite making up only 10 percent of the on-road fleet, ERM's analysis projects that M/HD vehicles emit an estimated 7.4 million metric tons (MMT) of greenhouse gas (GHG) emissions annually—approximately 24 percent of all GHGs from the on-road vehicle fleet.[1] In Maryland M/HD vehicles are also responsible for 51 percent of the nitrogen oxide (NOx) and 41 percent of the particulate matter (PM) emitted by on-road vehicles, both of which contribute to poor air quality and resulting negative health impacts in many urban areas, including low-income and communities of color that are often disproportionately affected by emissions from freight movement due to their proximity to transportation infrastructure.[2]

Prior work by ERM (2020) conducted in consultation with the New Jersey Environmental Justice Alliance and members of the Coalition for Healthy Ports NY NJ demonstrated that emissions from diesel trucks and buses produce higher levels of air pollution, which can lead to greater health concerns in populations exposed to diesel emissions.[3] Communities located adjacent to goods-movement infrastructure (e.g., warehouses, intermodal terminals, logistics centers, rail yards, etc.) experience higher levels of truck traffic, both from surrounding thruways and on local streets, which exacerbates health concerns. Since these emissions are local in their effects, policies to reduce transportation emissions from medium- and heavy-duty vehicles can improve the health and well-being of communities in urban areas or around transportation corridors, which are often home to people of color or low income or those who are otherwise vulnerable or disadvantaged. But to ensure reductions in those communities, program requirements on truck manufacturers, such as the Advanced Clean Truck Rule discussed below, would need to be accompanied by additional policies designed specifically with these communities in mind.

For the study of Maryland, ERM modeled two Clean Truck policy scenarios with increasing levels of ambition. Under the least aggressive scenario—adoption of California's Advanced Clean Truck (ACT) rule (allowable under the Clean Air Act)—estimated cumulative net societal benefits total $6.6 billion (in constant 2022$) through 2050, compared with the baseline scenario.[4] These net societal benefits include the monetized value of climate and public health benefits resulting from reduced GHG, NOx, and PM

[1] The remainder of emissions are from passenger cars and light trucks. This includes tailpipe emissions and "upstream" emissions from fuel production and transport.

[2] In this report all references to PM are particulate matter with mean aerodynamic diameter less than 2.5 microns ($PM_{2.5}$).

[3] Allen, Paul et al. *Newark Community Impacts of Mobile Source Emissions: A Community-Based Participatory Research Analysis*. *M.J. Bradley & Associates.* November 2020. http://www.njeja.org/wp-content/uploads/2021/04/NewarkCommunityImpacts_MJBA.pdf.

[4] All values cited in this report are in constant 2022$, unless otherwise stated.

emissions in the state, including up to 66 fewer premature deaths and 63 fewer hospital visits from breathing polluted air. Net societal benefits also include net cost savings to fleets from operating zero-emission trucks, and savings to all residential and commercial electricity customers due to lower electric rates made possible by the additional electricity sales for electric vehicle charging. Under the ACT scenario, by 2050 annual cost savings for Maryland fleets are estimated to be $498 million.[5]

The most aggressive policy scenario (100 x 40 ZEV + Clean Grid, discussed below) results in turnover of virtually the entire Maryland M/HD fleet to zero-emission vehicles (ZEVs) by 2050, together with a shift to cleaner electricity generation sources. Cumulative net societal benefits through 2050 increase to more than $11.6 billion under this scenario, and there will be an estimated 126 fewer premature deaths and 118 fewer hospital visits. In 2050 estimated annual fleet cost savings also increase to $819 million.

Implementation of the modeled scenarios will require significant changes to the national economy, as manufacturing of internal combustion engine vehicles is replaced by manufacturing of electric and fuel cell vehicles, and production and sale of petroleum fuels is replaced by increased production and sale of electricity and hydrogen. This analysis indicates that this transition will have positive macroeconomic effects, including increased net jobs and gross domestic product (GDP), as well as increased wages for the new jobs that will be added, relative to the jobs that will be replaced.

Compared with the baseline scenario, net national job gains under the most aggressive policy scenario total 2,934 in 2035. This will be accompanied by a $459 million increase in 2035 GDP. Average wages for the new jobs created under the ZEV transition are expected to be, on average, almost twice as high as average wages for the jobs that will be replaced.

POLICY SCENARIOS

This report summarizes the projected environmental and economic effects of Maryland adopting policies requiring manufacturers to sell a greater number of M/HDV no-emission vehicles over the next 30 years. Two specific Clean Truck policy scenarios, representing increasing levels of ambition, were evaluated.

- **ACT Rule:** Maryland adopts requirements analogous to those adopted by California under the Advanced Clean Trucks Rule, which requires an increasing percentage of new trucks purchased in the state to be ZEVs beginning in the 2027 model year.[6] The percentage of new vehicles that must be ZEV varies by vehicle type, but for all vehicle types the required ZEV percentage increases each model year between 2027 and 2035 (see Figure 1).

- **100 x 40 ZEV + Clean Grid:** In addition to adopting the ACT Rule, Maryland takes further actions to ensure more rapid and continued increases in new ZEV sales, such that virtually all new trucks are ZEV by 2040 (see Figure 1), with Class 2b–3 achieving 100 percent ZEV sales in 2038 and Class 4–8 (non-tractors) achieving 100 percent ZEV sales in 2035. In addition, an aggressive federal Clean Energy Standard is assumed to ensure that electricity generation in the state is carbon free and 100% renewable by 2040. State-specific, renewable portfolio standards that could increase the renewable electricity levels even more were not analyzed as part of this study.

[5] The modeling tools used for this analysis could not apportion these estimated benefits to individual communities within Maryland.

[6] If the ACT is adopted in Maryland in 2023, the first year of compliance will be model year 2027. The modeling assumes the first compliance year is 2027.

These two Maryland policy scenarios are compared with a baseline “business as usual” scenario in which all new trucks sold in the state continue to meet EPA’s latest NOx emission standards and ZEV sales increase only marginally, never reaching more than 1.2 percent of new vehicle sales each year.[7]

The analysis assumes that M/HD annual vehicle miles traveled (VMT) in Maryland will continue to grow by approximately 1.5 percent annually through 2050, as projected by the Energy Information Administration (EIA), as the economy and population continue to grow. The modeled policy scenarios do not include freight system enhancements or mode shifting to slow the growth of, or reduce, M/HD truck miles; this would be expected to provide additional emission reductions.

The analysis was conducted using ERM’s STate Emission Pathways (STEP) Tool. The climate and air quality impacts of each policy scenario were estimated on the basis of changes in M/HD fleet fuel use and include both tailpipe emissions and “upstream” emissions from production of the transportation fuels used in each scenario. These include petroleum fuels used by conventional internal combustion engine vehicles (gasoline, diesel, natural gas) and electricity and hydrogen used by ZEVs, which are assumed to include both battery electric (EV) and hydrogen fuel cell electric (FCV) vehicles.

To evaluate climate impacts, the analysis estimated changes in all combustion related GHGs, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). To evaluate air quality impacts, the analysis estimated changes in total nitrogen oxide (NOx) and particulate matter (PM) emissions and resulting changes in ambient air quality and health metrics such as premature deaths, hospital visits, and lost workdays.

The economic analysis estimated the change in annual M/HD fleet-wide spending on vehicle purchase, charging/fueling infrastructure to support ZEVs, vehicle fuel, and vehicle and infrastructure maintenance under each scenario. Currently ZEVs are more expensive to purchase than equivalent gasoline and diesel vehicles, but they have lower fuel and maintenance costs. Over time the incremental purchase cost of ZEVs is also projected to fall.

Based on estimated changes in fleet spending, the analysis estimated the macroeconomic effects of each scenario on national jobs, wages, and gross domestic product (GDP).

[7] The baseline ZEV sales assumptions are consistent with projections in the Energy Information Administration’s Annual Energy Outlook 2023.

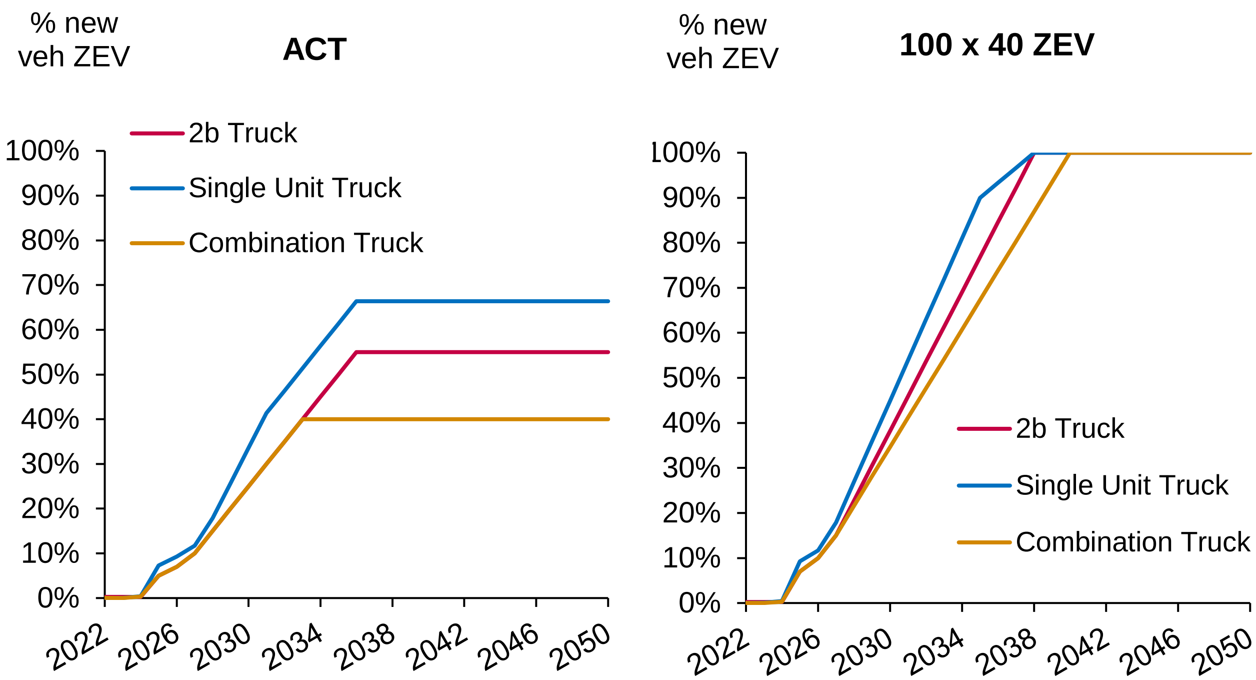


Figure 1: Annual Zero-Emission Vehicle Sales in Clean Truck Policy Scenarios

The analysis also estimated the impact of each scenario on Maryland's electric utilities, including the total state change in power demand (kW) and energy consumption (kWh) for M/HD EV charging, as well as the additional costs that would be placed on the state's electric utilities for providing this power. On the basis of projected utility net costs, the analysis estimates the potential effect on state electricity rates for residential and commercial customers.

In addition, the analysis estimated the total number of vehicle chargers that will be required to support the increase in M/HD EVs under each scenario—both depot-based chargers and shared public chargers—compared with the existing charging network in the state.

For a full description of the modeling approach and sources of assumptions used for this analysis, see the report: *Clean Trucks Analysis: Costs & Benefits of State-Level Policies to Require No- Emission Trucks, Technical Report—Methodologies and Assumptions*, Updated July 2023 *(*https://www.erm.com/clean-truck-regulations-analysis-nrdc-ucs/*).*

The Maryland electric grid mix and energy cost assumptions used can also be found in the Appendix to this report.

MARYLAND RESULTS

The sections below detail the results of the Maryland Clean Trucks analysis, beginning with a description of the current Maryland M/HDV fleet and the projected fleet under each modeled policy scenario. This is followed by a summary of the environmental and public health benefits of each scenario and the economic impacts of the modeled fleet transitions.

Maryland M/HD Vehicle Fleet

Table 1 summarizes the current M/HD fleet in Maryland, broken down by the four major vehicle types used to frame the Clean Trucks analysis.

Table 1: Current Maryland M/HD Fleet

Vehicle Type		No. of Vehicles	Annual VMT (billion miles)	Annual Fuel (million gallons)
Heavy-Duty Pickup and Van ***Class 2b***		132,303	1.35	69.3
Bus ***Class 3–8***		25,970	0.47	58.2
Single-Unit Work and Freight Truck **Class 3–8**		159,088	1.95	236.8
Combination Truck **Class 7–8**		28,836	1.73	250.4
TOTAL		346,197	5.500	614.7

Approximately 38 percent of the in-use M/HD fleet are Class 2b vehicles (8,500–10,000 in gross vehicle weight rating, GVWR), which are mostly heavy-duty pickup trucks and vans.[8] These vehicles account for

[8] A very small percentage of these vehicles are large SUVs.

25 percent of annual M/HD miles and 11 percent of annual fuel use. Approximately 8 percent of the fleet are buses, which account for 9 percent of annual VMT and 9 percent of annual fuel use. This includes relatively small shuttle buses (class 3–5) as well as school buses, transit buses, and intercity/charter coach buses.[9] Forty-six percent of the fleet are single-unit freight and work trucks, which account for 36 percent of annual VMT and 39 percent of annual fuel use. These vehicles come in a wide variety of sizes (Class 3–8) and have a wide variety of uses, from vans and box trucks used to deliver freight, to sanitation and construction trucks, to boom-equipped utility trucks. Only 8 percent of the fleet are combination truck-tractors, but these vehicles account for 31 percent of annual VMT and 41 percent of annual fuel use, since approximately two-thirds of these vehicles are used primarily for long-distance freight hauling and typically log many more daily and annual miles than other M/HD vehicles.

Today less than 1 percent of the national M/HD fleet is powered by electricity or alternative fuels (natural gas and propane). Approximately 64 percent of the fleet have diesel engines and 36 percent use gasoline.[10] The largest Class 7 and 8 vehicles are almost all diesel, while almost 50 percent of the smaller Class 2b–5 trucks have gasoline engines, with most of the remainder diesel.

Figure 2 summarizes the modeled turnover of the Maryland in-use fleet to zero-emission trucks under the two Clean Truck policy scenarios. Fleet turnover to new trucks is based on historical average turnover rates and projected fleet growth rates, along with the new vehicle ZEV purchase percentages shown in Figure 1. Approximately 6.1 percent of existing Class 2b trucks and 4.7 percent of Class 3–8 trucks and buses are retired each year and replaced with new vehicles.[11] Both Clean Truck policy scenarios further assume that all new vehicles purchased in 2027 and later years that are not ZEV will have low-NOx engines compliant with EPA's latest Heavy-Duty NOx standards[12].

As shown, under the ACT Rule policy scenario, 34.8 percent of the in-use M/HD fleet will turn over to ZEV by 2040, and 59.4 percent are ZEV by 2050; all of these ZEVs are assumed to be electric vehicles. Under the 100 x 40 ZEV + Clean Grid policy scenario, 54.2 percent of the in-use fleet turns over to ZEV by 2040 and 93.3 percent do so by 2050. This scenario assumes that new ZEVs will include both EV and fuel cell vehicles powered by hydrogen. In 2050, 5.5 percent of in-use ZEVs are assumed to be FCV and 87.8 percent are EV.

[9] Note that the ACT Rule does not include ZEV requirements for transit buses, as these vehicles are covered by a separate Innovative Clean Transit regulation in California.

[10] These figures are based on state registration data collected by IHS Markit.

[11] This is a long-term average. Actual annual turnover is highly correlated to economic conditions and can vary widely from year to year.

[12] Environmental Protection Agency, "Control of Air Pollution From New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards", January 2023, https://www.govinfo.gov/content/pkg/FR-2023-01-24/pdf/2022-27957.pdf

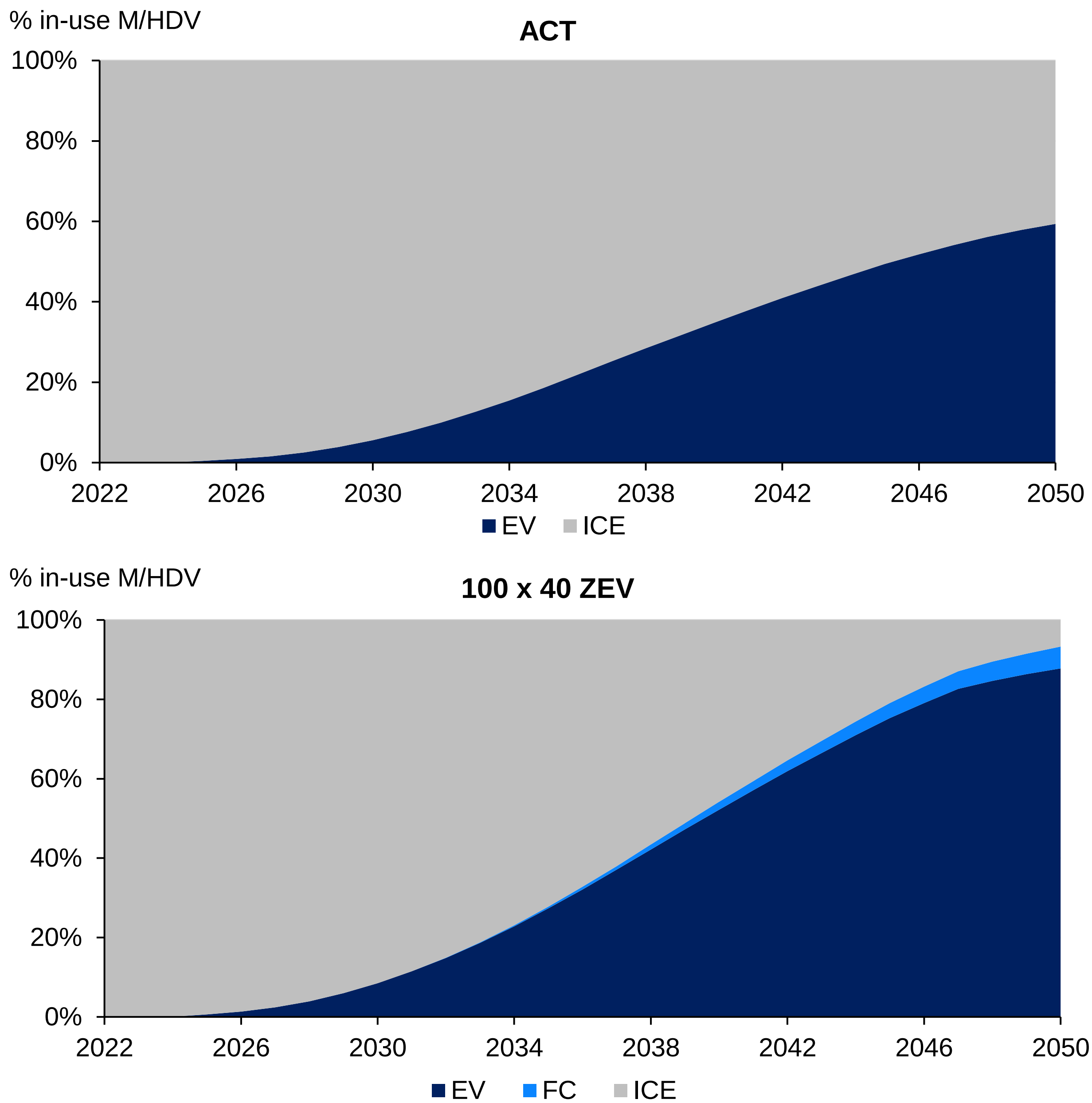


Figure 2: Fleet Turnover to Zero-Emission Vehicles in Clean Truck Policy Scenarios

Changes in Fleet Fuel Use

Under both modeled Clean Truck policy scenarios, a significant portion of the Maryland M/HD fleet is assumed to turn over to EV and FCV trucks and buses. This will result in replacement of petroleum fuels—primarily gasoline and diesel fuel—with electricity and hydrogen.[13]

Under the baseline scenario, total petroleum fuel use by the Maryland M/HD fleet in 2050 is projected to be 575.1 million gallons. Under the ACT Rule policy scenario, petroleum fuel use in 2050 falls to an

[13] A small number of M/HD trucks and buses in Maryland currently use natural gas.

estimated 307.4 million gallons (–47 percent), and cumulative reductions in diesel and gasoline use by the M/HD fleet total 3.2 billion gallons between 2022 and 2050. This petroleum fuel is replaced by 59.7 million megawatt-hours (MWh) of electricity between 2022 and 2050. Electricity use for M/HD EV charging in 2050 is estimated to be 5.4 million MWh, about an 8 percent increase to estimated baseline electricity use by Maryland residential and commercial customers that year (63.3 million MWh).

Under the 100 x 40 ZEV + Clean Grid scenario, estimated petroleum fuel use by the M/HD fleet in 2050 falls to 115.6 million gallons (–80 percent), and cumulative reductions in diesel and gasoline use by the M/HD fleet total 5.3 billion gallons between 2022 and 2050. This petroleum fuel is replaced by 87.9 million MWh of electricity and 0.6 billion kilograms of hydrogen between 2022 and 2050. Electricity use for M/HD EV charging in 2050 is estimated to be 7.9 million MWh, a 13 percent increase to estimated baseline electricity use by Maryland residential and commercial customers that year.

Public Health and the Environment

The modeled Clean Trucks policy scenarios produce significant reductions in NOx, PM, and GHG emissions from the M/HD fleet, even after accounting for the emissions from producing the electricity and hydrogen needed to power ZEVs. NOx and PM reductions will improve air quality resulting in public health benefits from reduced mortality and hospital visits.

Air Quality Impacts

Figures 3 and 4 show estimated annual M/HD fleet NOx and PM emissions, respectively, under the baseline scenario and the modeled Clean Truck policy scenarios. Under the baseline scenario, annual M/HD fleet NOx emissions are projected to fall by 67 percent and annual fleet PM emissions are projected to fall 72 percent through 2045, as the current fleet turns over to new gasoline and diesel trucks with cleaner engines that meet more stringent EPA new engine emissions standards. After 2045 baseline annual NOx and PM emissions are then projected to start rising again as annual fleet VMT continues to grow.

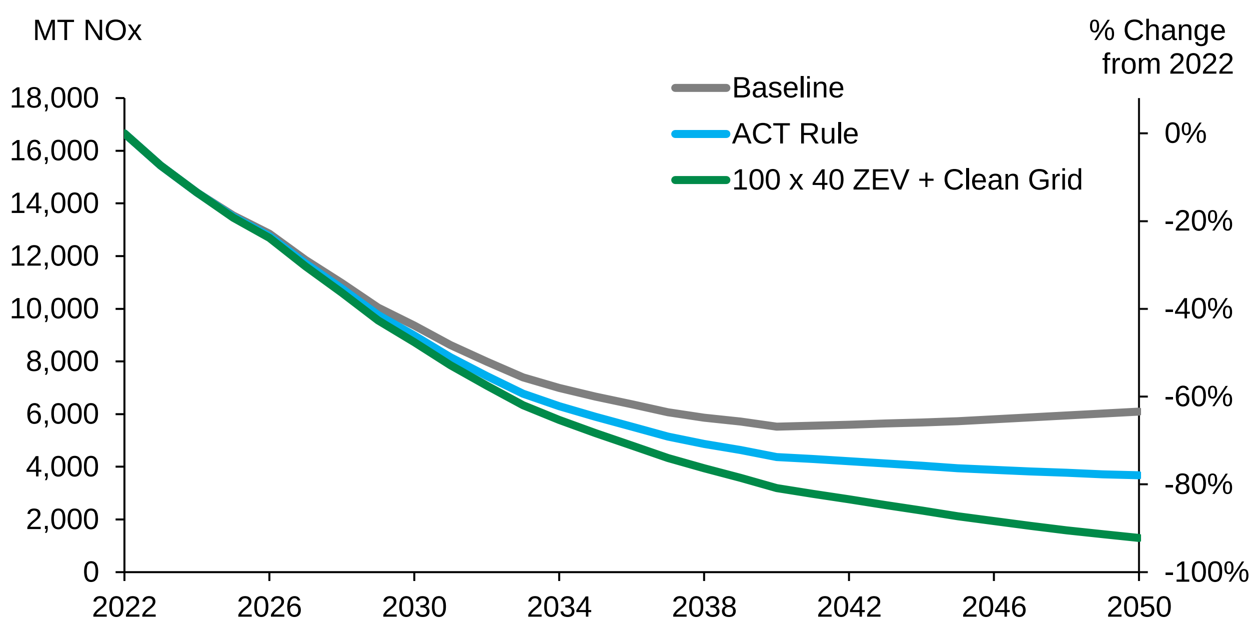


Figure 3: Projected M/HD Fleet NOx Emissions

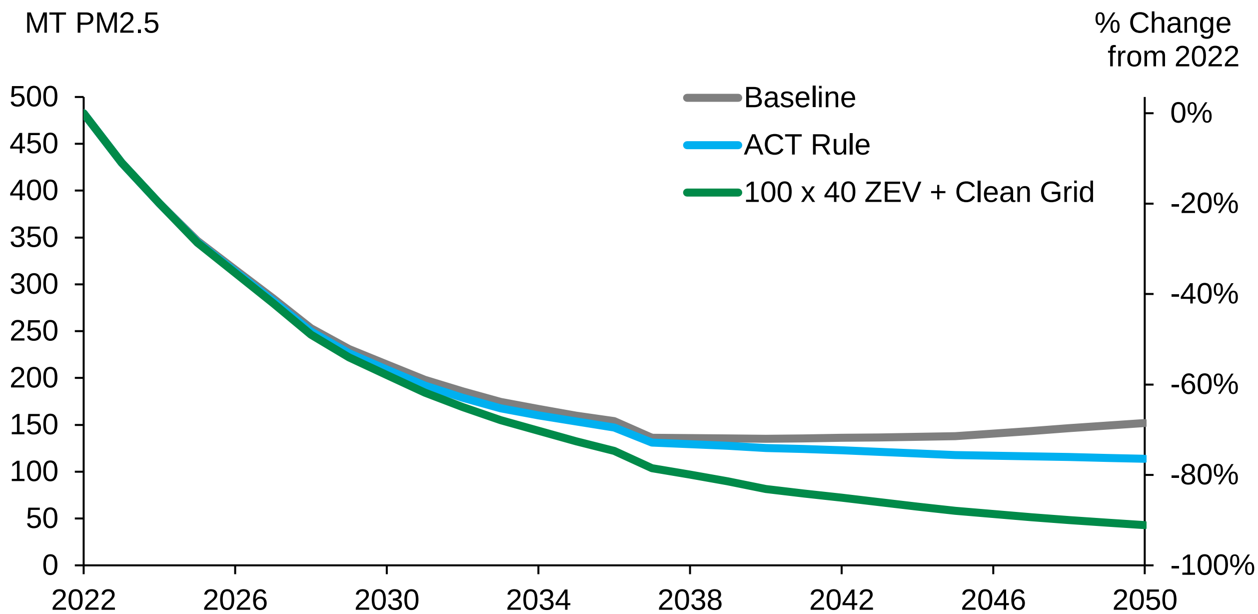


Figure 4: Projected M/HD Fleet PM Emissions

Compared with the baseline, by 2050 the ACT rule is estimated to reduce annual fleet NOx and PM emissions by 40 percent and 25 percent, respectively, as diesel and gasoline trucks are replaced with electric vehicles.

As shown in Figures 3 and 4, the 2050 emission levels are dramatically lower for both scenarios compared to today's (2022) levels. The 100 x 40 ZEV + Clean Grid scenario has the lowest fleet emissions due to replacement of virtually all gasoline and diesel trucks and buses with EVs and FCVs by 2050, when annual NOx and PM emissions are estimated to be 79 percent and 72 percent lower, respectively, than baseline emissions.

Through 2050, cumulative NOx and PM emission reductions from the ACT Rule (compared with the baseline scenario) total 27,524 metric tons (MT) and 307 MT, respectively. Additional cumulative NOx and PM emission reductions from the 100 x 40 ZEV + Clean Grid scenario (compared with the baseline) are projected to total 54,456 MT and 1,200 MT, respectively.

Public Health Benefits

The reduced annual NOx and PM emissions under the Clean Truck policy scenarios will reduce ambient particulate levels in the air, which will reduce the negative health effects on Maryland residents breathing in these airborne particles.[14] Estimated public health impacts include reductions in premature mortality and fewer hospital admissions and emergency room visits for asthma. There will also be reduced cases of acute bronchitis, exacerbated asthma, and other respiratory symptoms, and fewer restricted activity days and lost workdays. Cumulative estimated reductions in these health outcomes in Maryland under the modeled Clean Truck policy scenarios are shown in Table 2; these benefits were estimated using the

[14] PM is directly emitted to the atmosphere from combustion sources as solid particles. NOx is emitted from combustion sources as a gas but contributes to the formation of secondary particles via chemical reactions in the atmosphere. Both direct and secondary particles have negative health effects when taken into the lungs.

U.S. Environmental Protection Agency's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.

Table 2: Cumulative Public Health Benefits of Clean Truck Policy Scenarios, 2022–2050

Health Metric	ACT Rule	100 x 40 ZEV + Clean Grid
Avoided Premature Deaths	66	126
Avoided Hospital Visits[a]	63	118
Avoided Minor Cases[b]	38,427	73,462
Monetized Value, 2022$ (millions)	$876	$1,661

[a] Includes hospital admissions and emergency room visits.

[b] Includes reduced cases of acute bronchitis, exacerbated asthma, and other respiratory symptoms, and reduced restricted activity days and lost workdays.

The monetized value of cumulative public health benefits from the ACT Rule through 2050 totals more than $875 million. For the 100 x 40 ZEV + Clean Grid policy scenario, the monetized total amounts to over $1.6 billion through 2050.

Climate Benefits

Figure 5 illustrates estimated annual M/HD fleet GHG emissions under the baseline scenario and the modeled Clean Truck policy scenarios. As shown, under the baseline scenario annual M/HD fleet GHG emissions are projected to fall by 5 percent through 2050 as the current fleet turns over to new, more efficient gasoline and diesel trucks that meet more stringent EPA new engine and vehicle emission standards.

Compared with the baseline, by 2050 the ACT rule is estimated to further reduce annual fleet GHG emissions by 37 percent, as diesel and gasoline trucks are replaced with electric vehicles. The 100 x 40 ZEV + Clean Grid scenario has the lowest fleet emissions due to replacement of virtually all gasoline and diesel trucks and buses with EV and FCV by 2050, when annual fleet GHG emissions are estimated to be 79 percent lower than baseline emissions.

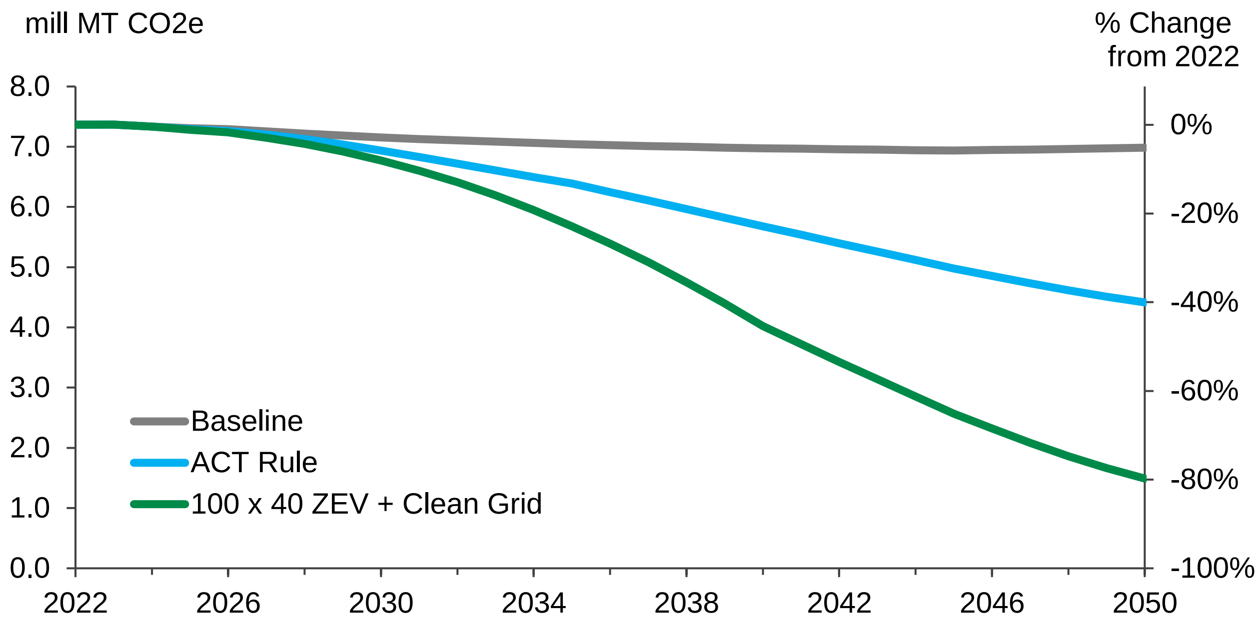


Figure 5: Projected M/HD Fleet GHG Emissions

Through 2050, cumulative GHG emission reductions from the ACT Rule (compared with the baseline scenario) total nearly 28.3 million MT. Cumulative GHG emission reductions from the 100 x 40 ZEV + Clean Grid scenario (compared with the baseline) are projected to total 61.4 million MT. These estimates of GHG reductions from each policy scenario account for reductions in petroleum fuel use (gasoline, diesel fuel) by the M/HD fleet, the decreased upstream emissions from gasoline and diesel production, as well as increased emissions from electricity and hydrogen production to fuel the EVs and FCVs that will replace gasoline and diesel trucks and buses.

Using the social cost of greenhouse gases as estimated by the federal government's Interagency Working Group, these estimated cumulative GHG reductions have a monetized value of over $2.5 billion for the ACT Rule policy scenario and $5.5 billion for the 100 x 40 ZEV + Clean Grid policy scenario.[15] The social value of GHG reductions represents potential societal cost savings from avoiding the negative effects of climate change, if GHG emissions are reduced enough to keep long-term warming below 2 degrees Celsius from preindustrial levels.[16]

The assumed grid mix for electricity production each year is shown in the Appendix for Maryland. For the baseline and ACT Rule, this analysis conservatively uses a business-as-usual (BAU) grid mix, while the 100 x 40 ZEV + Clean Grid scenario assumes a "decarbonized" grid mix. In 2022, the BAU grid mix is 17.5 percent coal-fired generation, 45.7 percent natural gas-fired generation, and 36.7 percent "zero-emitting" generation source. By 2050 the zero-emitting portion of the BAU grid mix increases to 75.1 percent while the coal portion decreases to 1.6 percent and natural gas decreases to 23.2 percent.

[15] For the social cost values used, see MJB&A, *Clean Trucks Analysis: Costs & Benefits of State-Level Policies to Require No- and Low-Emission Trucks, Technical Report—Methodologies & Assumptions*, May 2021, https://mjbradley.com/clean-trucks-analysis.

[16] The Interagency Working Group developed GHG social cost estimates using a range of discount rates. These values are based on the average 3 percent discount rate, which is in the middle of the range of estimated values. The monetized value of cumulative GHG reductions under each policy scenario would be 72 percent lower if using the lowest published social cost values, and three times greater if using the highest published values.

Under the 100 x 40 ZEV + Clean Grid scenario, zero-emitting generation increases to 67.7 percent in 2030, and 100 percent in 2040 and beyond. It is noted that additional state policies, such as Renewable Portfolio Standards, could potentially accelerate the decline of fossil sources faster than projected, but these were not considered in this analysis.

Economic Impacts

This section summarizes projected economic impacts of the modeled Clean Truck policy scenarios, including changes in annual operating costs for Maryland fleets; impacts to Maryland electric utilities and their customers; net societal benefits; and macroeconomic effects on jobs, wages, and gross domestic product from the transition to zero-emission trucks and buses. This section also estimates the required public and private investment in electric vehicle charging infrastructure to support the electric M/HD fleet under each scenario.

Costs and Benefits to Fleets

For all the modeled Clean Truck policy scenarios, this analysis estimated annual incremental costs associated with purchase and use of M/HD ZEVs compared with baseline conventional vehicles with combustion engines that operate on petroleum fuels (gasoline, diesel). These costs include the incremental purchase cost of the new ZEVs added each year (instead of new combustion vehicles), the cost of installing the charging and hydrogen fueling infrastructure required by these new ZEVs, and net fuel and maintenance costs for all ZEVs in the fleet, both those newly purchased each year and those purchased in prior years and still in use.

Net fuel costs include reductions in purchases of diesel fuel and gasoline (due to fewer combustion vehicles), offset by the increased purchase of electricity and hydrogen to power ZEVs. Net maintenance costs include net savings in annual vehicle maintenance for the ZEVs in the fleet compared with combustion vehicles, offset by annual costs to maintain the charging and hydrogen fueling infrastructure needed to support in-use ZEVs.

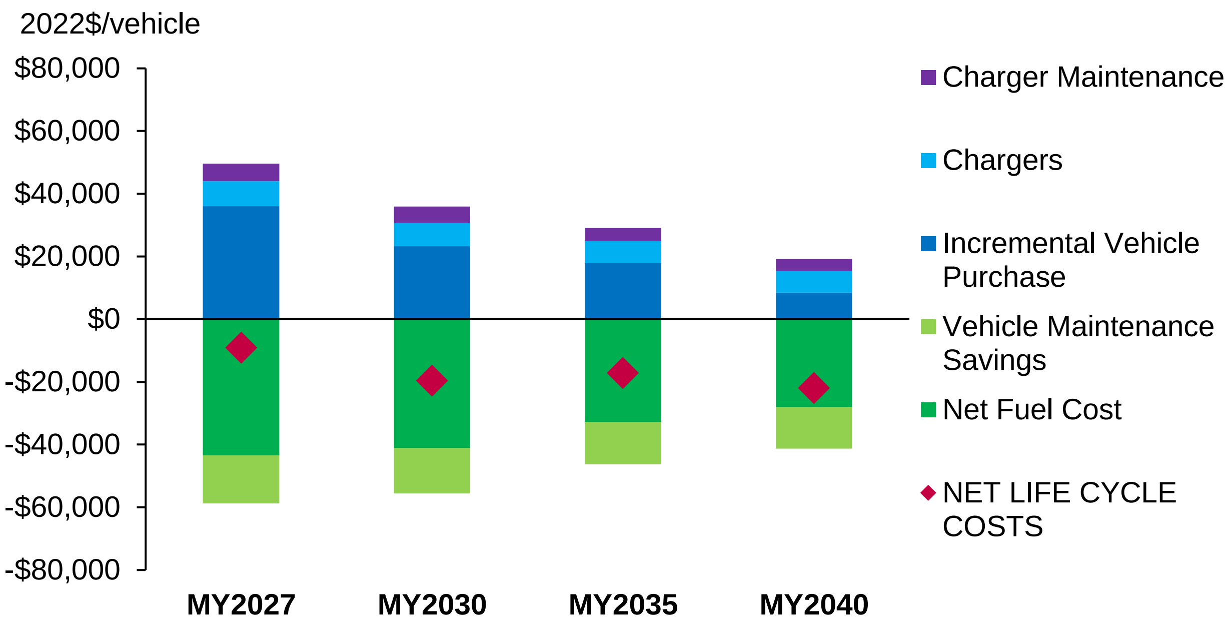


Figure 6: Projected Lifetime Incremental Costs for Maryland ZEVs Compared with Combustion Vehicles

Figure 6 shows projected average lifetime incremental costs for new ZEVs purchased in Maryland compared with lifetime costs for combustion vehicles purchased in the same model year; the bars show fleet average values for all Class 2b–8 ZEVs purchased each year under the 100 x 40 ZEV scenario. Incremental fuel and maintenance costs are discounted lifetime costs, assuming 21-year vehicle life, and 6 percent annual discount rate. Vehicle financing, which is often used by fleets when purchasing vehicles, was not considered in this analysis.

As shown, the average M/HD ZEV in Maryland is projected to produce about $50,500 in discounted fuel and maintenance cost savings over its lifetime. For ZEVs purchased in the very near term, this savings may not be enough to offset the projected incremental cost of vehicle purchase and fueling infrastructure for some ZEVs, resulting in net increased lifetime costs compared with those of combustion vehicles. However, incremental ZEV purchase costs are projected to fall over time, such that the average ZEV will reach lifetime cost parity with combustion vehicles, when discounted lifetime fuel and maintenance savings are considered. For all years shown, the average ZEV purchased that year is projected to produce between $9,000 to $22,000 in discounted lifetime net savings (2022$) compared with the costs of an equivalent combustion vehicle.

It is important to reiterate that the values in Figure 6 are fleet average values, which mask a significant amount of variability across vehicle types and among different fleets of the same vehicle type.

M/HD ZEVs in some fleets will likely achieve lifetime cost parity with combustion vehicles much earlier, while others may lag. In addition, this analysis, and the values shown in Figure 6, assume no government incentives for vehicle purchase or development of fueling infrastructure. If existing and potential incentives are considered, or policies such as improved electricity rates for fleets, then actual net costs to fleets will be lower, resulting in cost parity sooner.

Electric Utility Impacts

Current annual electricity sales to residential and commercial customers in Maryland total 55.6 million MWh and are projected to grow to 63.3 million MWh in 2050.[17]

Under the ACT Rule policy scenario, additional annual electricity sales for M/HD EV charging are estimated to total 0.43 million MWh in 2030, rising to 5.4 million MWh in 2050. This incremental load represents 0.8 percent and 9.3 percent of the total electricity demand in 2030 and 2050, respectively. Incremental monthly peak charging demand under this scenario is estimated at 119 MW in 2030, rising to 1,717 MW in 2050.

Under the 100 x 40 ZEV policy scenario, incremental peak charging demand is estimated at 181 MW in 2030, rising to 2,473 MW in 2050, and annual incremental electricity sales are estimated to be 0.68 million MWh in 2030, rising to 7.9 million MWh in 2050 (1.1 percent and 12.5 percent of the total electricity demand, respectively).

This analysis estimated the revenue that Maryland electric utilities would receive from these incremental electricity sales, the marginal generation and transmission costs of providing this power, and the net revenue that utilities would realize (net revenue = revenue – marginal cost). The estimated marginal cost includes costs associated with procuring the necessary additional peak generation and transmission capacity to serve the load ($/MW) as well as marginal generation and transmission energy costs ($/MWh).

Figure 7 summarizes the estimated annual utility net revenue from M/HD EV charging under the modeled Clean Truck policy scenarios. In all modeled years, the net utility revenue for MHD EV is positive with annual revenues of $141.4 million, and $213.8 million in 2050 for the ACT Rule and 100 x 40 ZEV scenarios respectively as shown in Figure 7. It is important to note that these values are calculated based on currently available utility tariff information and are likely to change over time as tariffs are adjusted to a more electrified economy. One reason for the negative net utility revenue is the relatively high assumed capacity prices[18] in Maryland compared to the electricity price. Although not considered in this modeling, additional measures could help to mitigate the impact of the high demand chargers which contribute to the increased capacity requirements from charging MHDVs. For example, battery storage installed at the charger location could lower the amount of current the charger pulls from the grid while still enabling the vehicle to charge quickly. As charging, battery, and other electric grid management technology continue to evolve, more solutions will likely emerge to mitigate the impact to the grid.

[17] This growth assumption is from the EIA 2023 Annual Energy Outlook. It does not include sales to large industrial customers.

[18] Commercial demand prices for the major utilities in the state are used as a proxy for capacity prices.

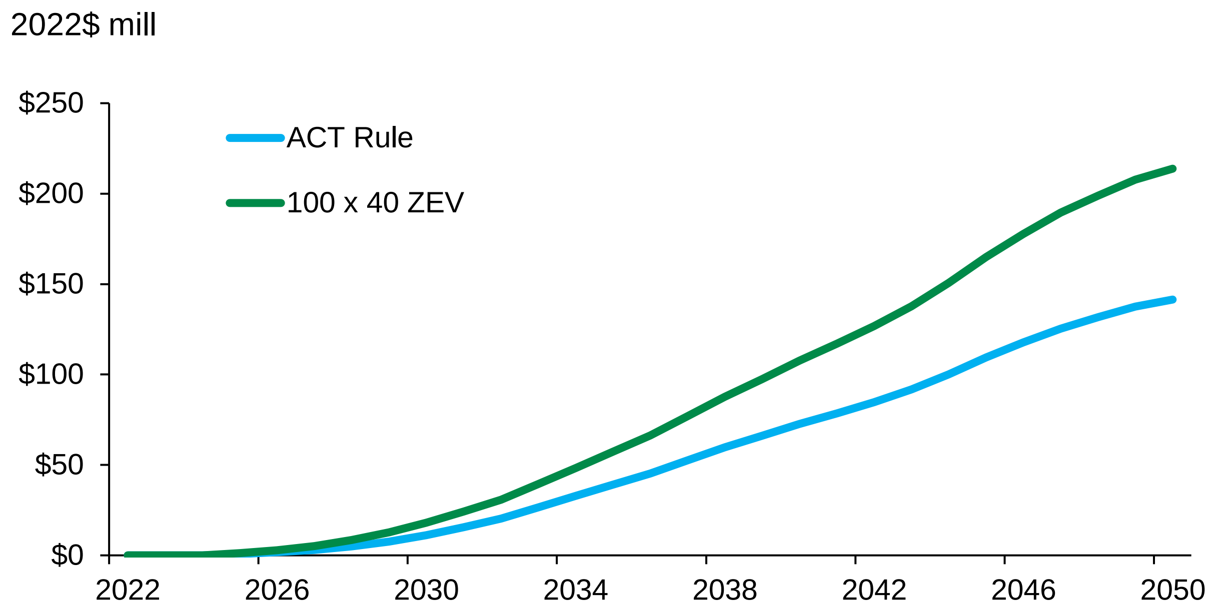


Figure 7: Projected Annual Utility Net Revenue From M/HD EV Charging

In general, a utility's costs to maintain its distribution infrastructure increase each year with inflation, and these costs are passed on to utility customers in accordance with rules established by the Maryland Public Service Commission via periodic increases in residential and commercial electric rates. Due to the daytime charging demand required for Maryland ZEVs and their high cost of providing electricity, this analysis indicates that under the 100 x 40 ZEV scenario, by 2050 incremental utility net revenue from M/HD EV charging could potentially decrease average residential and commercial electricity rates in Maryland by as much as 3.68% percent ($0.0066/kWh in 2022$). This decrease could save the average Maryland household $77.71 per year and the average commercial customer $278.10 per year on their electricity bills (2022$).[19] This further demonstrates the importance of utility planning to effectively integrate M/HD EV charging into the grid and the value of implementing other measures, such as the ones mentioned above, in order to reduce the potential burden on residential and commercial electricity customers.

Jobs, Wages, and GDP

The transition from gasoline and diesel M/HD vehicles to ZEVs will have significant impacts on the U.S. economy, with substantial job gains in many industries (e.g., battery and electric component manufacturing, charging infrastructure construction, electricity generation), accompanied by fewer jobs in other industries (e.g., engine manufacturing, oil exploration and refining, gas stations, auto repair shops).[20]

This analysis used the IMPLAN model to estimate these macroeconomic effects of the modeled Maryland Clean Truck policy scenarios based on estimated changes in spending in various industries (relative to

[19] Figures are based on average annual electricity use of 11,780 kWh per housing unit and 42,161 kWh per commercial customer in Maryland.

[20] For example, in-state charging infrastructure is estimated to increase by 344 jobs in 2045 under the most aggressive scenario.

the baseline scenario). These estimates of spending changes by industry were developed from the fleet cost analysis. For example, under the modeled Clean Truck policy scenarios, more money will be spent to manufacture batteries and electric drive components for ZEVs, but less will be spent to manufacture gasoline and diesel engines, and transmissions. Similarly, less money will be spent by fleets to purchase petroleum fuels, but more will be spent to purchase electricity and hydrogen.

The IMPLAN analysis also includes the effects of induced economic activity due to consumers having more money to spend, thanks to return of utility net revenue in the form of lower electric rates, and net fleet cost savings returned as lower shipping costs for goods, resulting in lower consumer prices for those goods.

The IMPLAN analysis was run at the national level, but assuming only the industry spending changes (from application of the policy scenarios) occurring due to M/HD vehicle purchase and use in Maryland. Estimated national effects would be significantly greater if the modeled policy scenarios were applied to the entire U.S. M/HD fleet.

Table 3 offers a summary of estimated macroeconomic effects of the modeled Clean Truck scenarios on jobs, GDP, and wages.

Compared with the baseline scenario, adoption of the ACT policy and 100 x 40 ZEV + Clean Grid scenarios will increase national net jobs through 2035. The loss in 2045 is largely due to the reductions in spending on diesel fuel and decreases in the costs of M/HDV ZEVs over time, resulting in decreased spending and investments in the out years. In both scenarios, annual GDP decreases through 2045. For both scenarios in all years, the average wages for new jobs added to the economy are almost twice the average wages for jobs that are replaced. This is because the largest number of added jobs are in electrical component manufacturing and in construction of charging infrastructure, requiring many well-paid electricians and electrical engineers, while the largest job losses are in vehicle repair—due to lower maintenance required by ZEVs—as well as relatively low-paid retail workers at gas stations.

Table 3: Macroeconomic Effects of Maryland Clean Truck Policy Scenarios

Metric		ACT		100 x 40 ZEV + Clean Grid	
		2035	2045	2035	2045
Net Change in Jobs		1,933	436	2,934	1,059
Net Change in GDP 2022$ (millions)		$298	$181	$459	$338
Average Annual Compensation	Added Jobs	$103,564	$101,708	$103,709	$102,610
	Replaced Jobs	$54,508	$55,696	$54,266	$55,250

Today many components used in electric and fuel cell vehicles—most notably batteries, but also many electric drivetrain components—are manufactured outside the United States and imported for final vehicle assembly. The percentage of imported content is higher for ZEV drivetrains today than for conventional drivetrains (gasoline and diesel engines, and transmissions). The scale of U.S. macroeconomic effects from the modeled Clean Truck policy scenarios will depend on how the nascent M/HD ZEV industry develops; for this analysis, ERM assumed that all incremental spending on ZEV batteries and electric drivetrain components would be in the United States, with no imported content. As such, the results summarized in Table 3 represent a higher-end estimate of what is possible from the ZEV transition, with the right federal and state policy supports in place to incentivize development of U.S.-based ZEV component manufacturing. If vehicle manufacturers continue to rely primarily on imported batteries and electric drivetrain components, the net job and GDP gains will be lower than those summarized here.

This macroeconomic analysis only includes direct, indirect, and induced impacts from changes in M/HD vehicle manufacturing and use, and from consumer re-spending of net utility revenue and fleet cost savings returned as lower prices for electricity and shipped goods. It does not include any effects on freight industry growth and investment due to lower operating costs, or any macroeconomic effects associated with the estimated climate and air quality (health) benefits of the modeled Clean Truck policy scenarios. These effects may increase economic and job numbers compared to those presented here.

Required Public and Private Investments

Using a detailed charging model that considers typical daily usage patterns for different vehicle types, this analysis assumes that most M/HD ZEVs in Maryland will use overnight charging at their place of business, though about 10 percent will need to rely on a publicly accessible network of higher-power chargers.[21] The exception are combination trucks, 70 percent of which are assumed to require high-power public chargers since they are used primarily for long-haul freight operations.

Table 4 summarizes estimated charging infrastructure required to support M/HD electric trucks and buses under the Clean Truck policy scenarios.

Table 4: Projected Charging Infrastructure Required for Clean Truck Policy Scenarios

Metric		ACT Rule			100 x 40 ZEV		
		2035	2045	2050	2035	2045	2050
Cumulative Charge Ports	Depot	38,588	121,931	162,753	57,387	186,194	249,617
	Public 150 kW	629	2,001	2,677	918	3,000	4,036
	Public 500 kW	333	852	1,049	493	1,707	2,269
Cumulative Investment, 2022$ (millions)	Depot	$347	$1,041	$1,428	$529	$1,680	$2,332
	Public	$188	$503	$671	$276	$898	$1,242

Depot chargers will need to be 10–50 kW per port depending on vehicle type. The smaller 150 kW public chargers are needed primarily to support single-unit freight trucks, while the higher-capacity 500 kW public chargers are needed mostly for combination trucks.

As of July 2023, there were 1,373 publicly accessible charging stations in Maryland with a total of 764 direct current fast-charging (DCFC) ports (>50 kW).[22] 56 percent of these DCFC ports are Tesla superchargers that currently can be used only by Tesla owners.[23] In Maryland, there are only 333 DCFC ports fully available to any vehicle.

[21] See the methodology report for a detailed discussion of M/HD EV charging needs.

[22] These numbers are from the U.S. Department of Energy's Alternative Fuel Data Center public charger database.

[23] Hamilton Asher, Isobel. "Tesla has started selling chargers for non-Tesla cars, just as it begins to open up its Supercharger network to other vehicles." Business Insider. November 2, 2021.https://www.businessinsider.com/tesla-elon-musk-chargers-supercharger-network-2021-11.

Under the ACT Rule policy scenario, Maryland's fleet owners will have to invest an average of $62.1 million per year (2022$) between 2027 and 2050 to purchase and install depot-based charging infrastructure. The government and private investors will need to invest an average of $29.2 million per year over the same time period to build out a publicly accessible charging network across the region to serve the EV M/HD truck fleet.

Under the 100 x 40 ZEV scenario, fleet investments in depot charging infrastructure from 2025 to 2050 will need to increase to an average of $101.4 million per year, and public and private investments in the public charging network will need to rise to an average of $54.0 million per year.

Net Societal Benefits

The net societal benefits from the modeled Maryland Clean Truck policy scenarios include the monetized value of public health and climate benefits, net cost savings for fleets, and net utility costs from increased electricity demand for EV charging.

Figure 8 shows projected annual net societal benefits under the ACT Rule and 100 x 40 ZEV + Clean Grid scenarios. Under both Clean Truck policy scenarios, near-term fleet costs are higher than fleet costs under the baseline.[24] However, after approximately 2030 the policy scenarios show annual net societal benefits, despite net fleet costs and growing utility net costs, due to growing public health and climate benefits. After approximately 2035 there is an annual net savings in fleet costs from operating ZEVs instead of diesel and gasoline trucks, and net societal benefits grow quickly.[25]

[24] If an individual truck owner finances a vehicle, it would better equalize payments for increased vehicle price and fuel savings, resulting in a better balancing of cash flow. On a net fleet-wide basis, however, the cost of financing reduces total net fleet savings.

[25] Note that fleet-wide annual net savings under the Clean Truck policy scenarios lag average ZEV life-cycle cost parity to combustion vehicles by about 5 years. This is because even after life-cycle cost parity is achieved, most ZEVs will still have higher up-front purchase costs (vehicle plus charger) than combustion vehicles; these higher costs are then paid back over the next few years via fuel and maintenance cost savings.

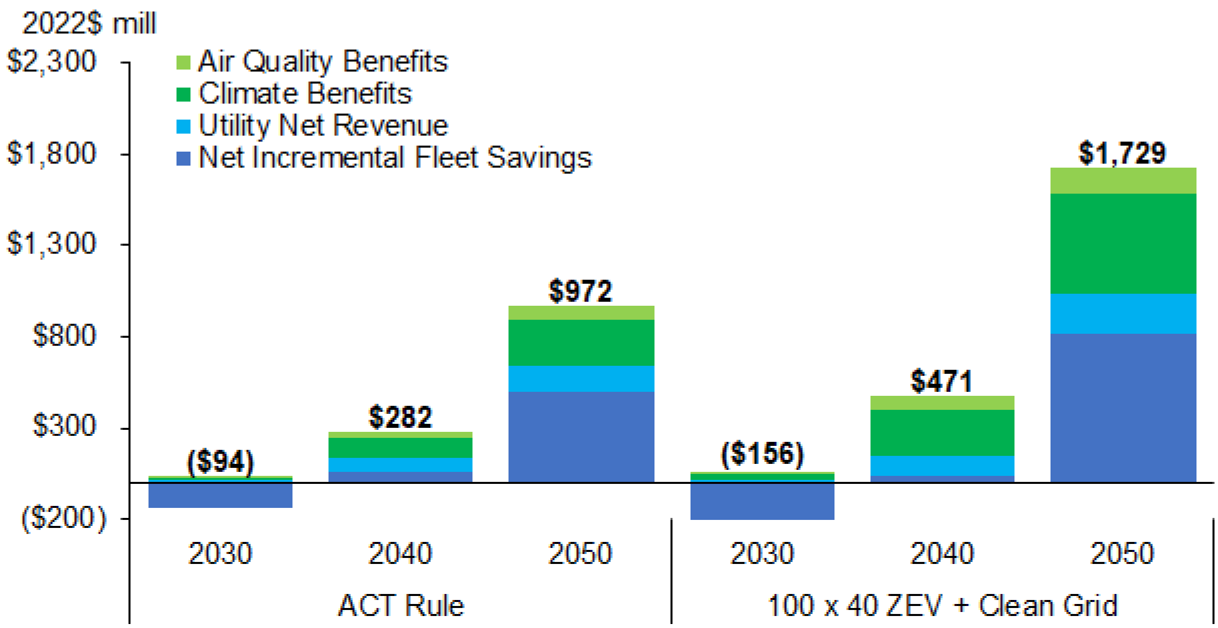


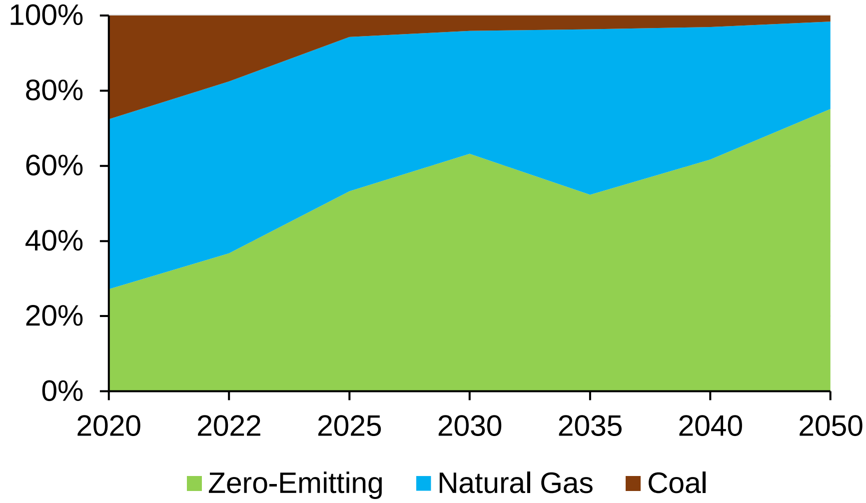
Figure 8: Projected Annual Net Societal Benefits from Clean Truck Policy Scenarios

Under the ACT Rule scenario, by 2050 annual net societal benefits are estimated to be $972 million, including $498 million in net fleet savings. Cumulative estimated societal net benefits under this scenario total about $6.6 billion between 2022 and 2050.

Under the 100 x 40 ZEV + Clean Grid scenario, by 2050 annual net societal benefits are estimated to be over $1.7 billion, including $819 million in net fleet savings. Cumulative estimated societal net benefits under this scenario total over $11.6 billion between 2022 and 2050.

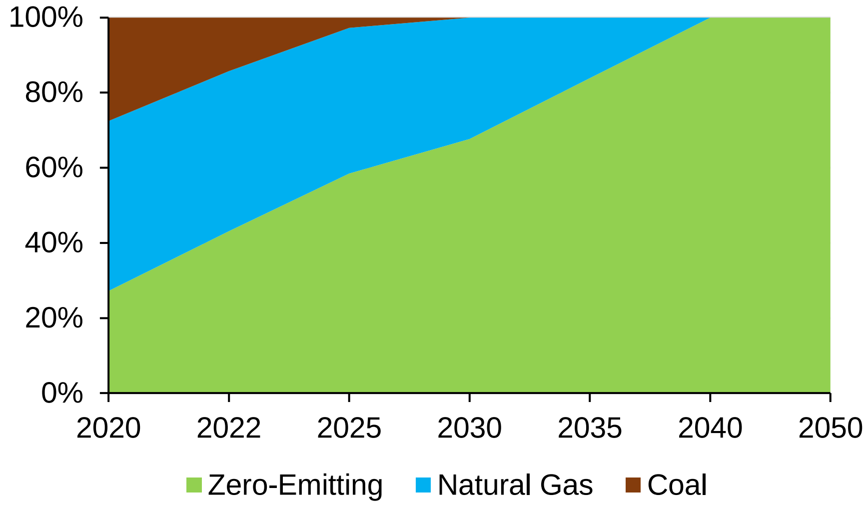
APPENDIX A MARYLAND ENERGY COST ASSUMPTIONS AND SUPPLEMENTAL MATERIAL

Figure A1: Maryland Business as Usual Grid Mix Assumptions



These business-as-usual grid mix assumptions were applied to the baseline and ACT Rule policy scenario.

Figure A2: Maryland Decarbonized Grid Mix Assumptions



These Decarbonized grid mix assumptions were applied to the 100 x 40 ZEV + Clean Grid policy scenario.

Table A1 M/HDV In-Use ZEVs Population

M/HDV In-Use ZEVs	2025	2030	2035	2040	2045	2050
Baseline	180	437	748	1,179	1,770	2,451
ACT	3,722	20,725	57,374	107,258	161,594	212,173
100x40 ZEV + Clean Grid	4,791	28,609	81,110	157,826	244,119	324,061
Total M/HDV Fleet (ZEV + ICE)	364,931	392,263	421,981	454,314	489,509	527,843

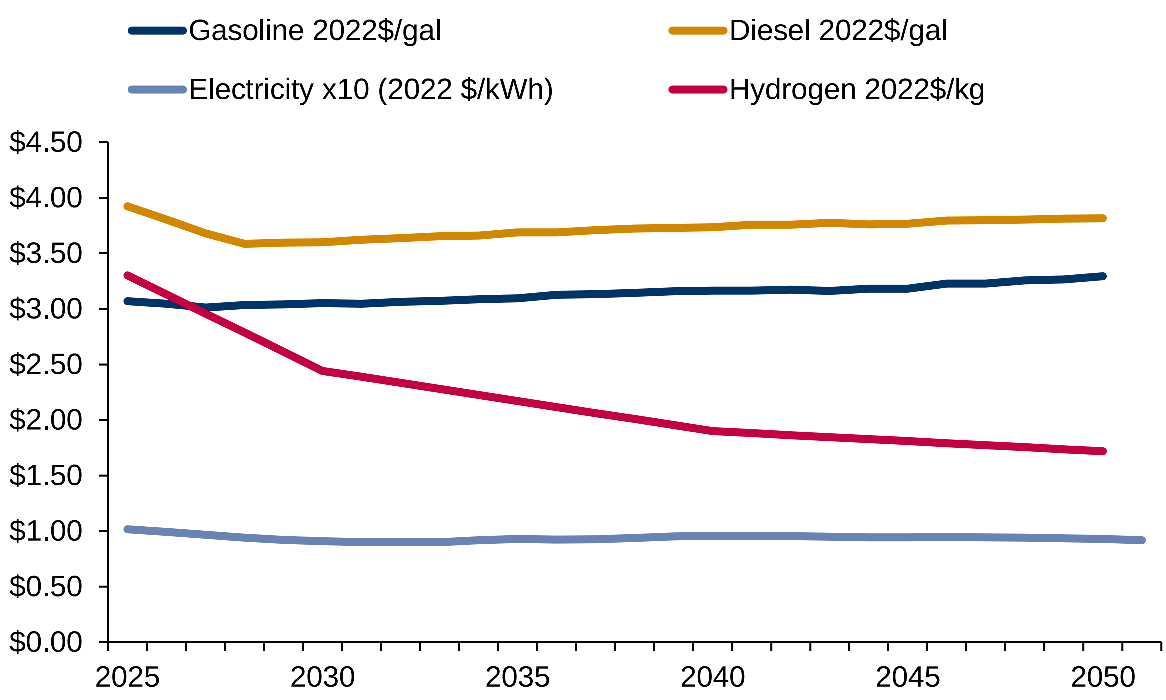
Table A2: Net Incremental Fleet Benefits

2022$ (millions)	2025	2030	2035	2040	2045	2050
ACT	($47)	($132)	($157)	$64	$281	$498
100x40 ZEV + Clean Grid	($92)	($221)	($266)	$41	$432	$819

Table A3: Average Maryland Household and Commercial Customer Electric Bill Savings in 2050

2022$	Household	Commercial Customer
ACT	($51.41)	($183.97)
100x40 ZEV + Clean Grid	($77.71)	($278.10)

Figure A3: Maryland Average Fuel Costs



Source: EIA AEO 2023, ERM Analysis