Technical Support Document

for

Advanced Clean Cars II, Advanced Clean Trucks, Low NOx Heavy-Duty Omnibus, and Phase 2 Greenhouse gas emission standards for trucks and trailers

Background

This document includes technical support and supplemental information for the Agency of Natural Resources proposed rules for Advanced Clean Cars II, Advanced Clean Trucks, the Low NOx Heavy-Duty (HD) Omnibus, and Phase 2 greenhouse Gas emission standards for trucks and trailers. Supplemental information as referenced and required in the Economic Impact Statement, the Environmental Impact Statement, and Scientific Information Statement in the Standardized Rule Forms required by the Vermont Administrative Procedure Act is included herein.

Economic Impact Statement Supplemental Information

1. Introduction
    a. Summary of the rules

Emissions from mobile sources are the greatest contributor to emissions of criteria pollutants[1] and greenhouse gases (GHG) in Vermont, accounting for about 51%[2] of non-biogenic ozone precursor emissions (including nitrogen oxides (NOx) and volatile organic compounds) and approximately 40% of statewide GHG emissions. In this rulemaking, the Agency of Natural Resources (ANR) proposes to adopt or amend key regulations that reduce greenhouse gas and criteria pollutant emissions from passenger cars, light-duty trucks, and medium- and heavy-duty vehicles that are delivered for sale or placed in service in Vermont. This suite of rules includes the adoption of California's Advanced Clean Trucks Rule, the Low NOx Heavy-Duty Omnibus Rule, and the Phase 2 Greenhouse Gas Rule, and amendments to California's Advanced Clean Cars program which was originally adopted by Vermont in 2012[3] and incorporates previously adopted rules to control criteria and GHG emissions. The Advanced Clean Trucks Rule (ACT) requires the sale of at least 30% zero-emission trucks by 2030 (depending on vehicle classification). The Low NOx Heavy-Duty Vehicle Omnibus Rule (HD Omnibus) requires a 90% reduction in NOx emissions for model year (MY) 2027 engines. The Phase 2 Greenhouse Gas Rule (Phase 2 GHG) sets greenhouse gas emission standards for heavy duty trucks and truck trailers. Advanced Clean Cars II (ACCII) requires that all passenger car and light-duty truck vehicles delivered for sale by 2035 meet the definition of zero-emission vehicle and will further reduce smog-forming and GHG emissions from new

[1] Criteria pollutants are those classified as such pursuant to the Clean Air Act: Oxides of nitrogen, Sulphur dioxide, Carbon monoxide, lead, ozone, and particulate matter.
[2] EPA - 2017 National Emissions Inventory: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data#dataq
[3] Prior to 2012, Vermont adopted California vehicle emissions standards that were later combined into California's Advanced Clean Cars program.

internal combustion engine vehicles (ICEVs). For a more detailed summary of each rule and adopting authority, see the Regulation Summary Document.

2. Background and analysis

The proposed regulations will result in reduced NOx, PM2.5 and GHG emissions. Each of these pollutants presents a distinct set of challenges and risks to public health and the environment.

NOx are a group of highly reactive compounds that pose direct human health impacts, such as irritation of the respiratory tract, and the worsening or triggering of asthma.[4] These gases are also precursor pollutants that undergo complex chemical reactions in the atmosphere to form other air pollutants of concern, such as PM2.5 and ground-level ozone (also known as smog). Breathing air with elevated concentrations of ozone is especially harmful to children, the elderly, and people of all ages who have asthma and other respiratory impairments. Breathing ozone can trigger a variety of health issues ranging from coughing to chest pain, to reduced lung function or damage.[5] NOx also contributes to the formation of acid rain[6] and visibility impairment (haze)[7] in Vermont.

PM2.5 is emitted directly from vehicle exhaust and formed through secondary reactions with NOx and other pollutants in the atmosphere. PM2.5 can be inhaled deeply into the lungs and transferred into the bloodstream resulting in significant health problems, such as reduced lung function, worsened asthma, non-fatal heart attacks, and premature death in individuals with heart or lung disease.[8]

GHGs contribute to climate change causing increased risks to public health and safety, food and water resources, infrastructure and ecosystems. Additional details on GHG emission impacts can be found in Environmental Impact Supplemental Information, below.

To complete a thorough and sophisticated analysis of the emissions and economic benefits and impacts of the suite of rules proposed, Vermont is collaborating with several other "Section 177 states" and the Northeast States for Coordinated Air Use Management (NESCAUM). This analysis uses models such as the MOtor Vehicle Emission Simulator (MOVES)[9], the CO-benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[10], and other tools to aid in understanding the how implementation of these rules will benefit Vermonters, and what economic impacts may result.

This Technical Support Document (TSD) also relies on the comprehensive analysis of costs and other impacts performed by the California Air Resources Board and is extrapolated here to apply to Vermont and the expected impacts from the adoption of this suite of rules locally.

3. Affected parties
    a. Costs and benefits to individuals

[4] EPA – Basic Information about NO2 webpage: https://www.epa.gov/no2-pollution/basic-information-about-no2
[5] EPA – Health Effects of Ozone Pollution webpage: https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
[6] EPA – Acid Rain webpage: https://www.epa.gov/acidrain
[7] EPA – Visibility and Regional Haze website: https://www.epa.gov/visibility
[8] EPA – Health and Environmental Effects of Particulate Matter (PM): https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
[9] https://www.epa.gov/moves
[10] https://www.epa.gov/cobra

i. ACCII

The proposed regulation will benefit Vermonters mainly from the reductions in NOx resulting in reduced ozone exposure and reduced PM exposure from the secondary formation of NOx and PM2.5, improving Vermont air quality and reducing adverse health impacts. The reduction of GHG emissions, while being a global pollutant, will also benefit Vermont residents monetarily by reducing the future social costs of carbon emissions as discussed below.

[Insert forthcoming monetized health benefits of ACCII as informed by COBRA modeling, SCC avoided estimates]

The proposed regulation will have an impact on individual vehicle owners in Vermont in the form of operation and ownership costs. These costs include the costs impacts of installing an electrical receptable for electric vehicles supply equipment (EVSE) for purchasers of ZEVs, fuel costs, difference in maintenance costs, registration costs, and insurance costs over a ten-year period. These costs are combined with the incremental vehicles prices to estimate the total cost of ownership (TCO) during the period of proposed regulation. An analysis[11] of the TCO for individual vehicle owners conducted by the California Air Resources Board concludes that operational savings will offset and incremental costs of the initial electric vehicle purchase. For example, a passenger car EV with a 300-mile range will have a payback period of seven years for the 2026 MY technology. For the 2035 MY technology, the payback is nearly immediate and cumulative savings over ten years exceeds $6,000. It is important to note that cost trends differ for fuel-cell EVs (FCEVs) and plug-in hybrid EVs (PHEVs). Neither the FCEV nor PHEV technologies will have a payback within a ten-year period.

[11] California Air Resources Board – Advanced Clean Cars II Initial Statement of Reasons, at Pg 144.

	BEV (300 mile range)		FCEV	PHEV
	With home charger	No home charger		With home charger
Incremental vehicle price	$ 4,936	$ 4,936	$ 8,679	$ 7,068
Home Level 2 circuit (not including the charger)	$ 680			$ 680
Finance costs & sales tax (for incr veh price and Level 2 circuit)	$ 1,185	$ 1,042	$ 1,832	$ 1,635
Incremental Fuel costs	$ (4,871)	$ (2,912)	$ 7,158	$ (7)
Incremental Maintenance costs	$ (4,540)	$ (4,540)	$ (1,249)	$ (1,249)
Incremental Insurance	$ 1,003	$ 1,003	$ 1,765	$ 1,437
Incremental Registration	$ 806	$ 806	$ 905	$ 863
Total (10 years)	**$ (1,732)**	**$ (484)**	**$ 17,649**	**$ 9,141**
Payback period	**6 years**	**8 years**	**Never**	**Never**

*Finance costs include a 5 year loan at 5% interest; Operation and ownership costs over 10 yrs (~150,000 miles) shown as net present value for 2026 at a discount rate of 10%.

Figure 1: Total cost of ownership over 10 years for individual ZEV and PHEV buyer compared to baseline ICEV, 2026 MY passenger car in a single-family home.

Increasing access to ZEVs and clean mobility in low-income and frontline communities is of utmost importance. The proposed ACC II regulations will reduce exposure to vehicle pollution in communities that are often disproportionately impacted by motor vehicle pollution, such as near-roadway communities, by reducing emissions from ICEVs and accelerating the transition to ZEVs. Further, the proposed ZEV assurance measures will ensure these emissions benefits are long lasting and support the development of a robust used ZEV market. In addition, the ZEV regulation incentivizes automakers to invest in community carshare programs, produce more affordable ZEVs, and ensure that more used ZEVs are available. While the proposed ACC II regulations will advance equity, a whole-of-government approach is needed to maximize access, ensure affordability, and direct benefits to low-income and frontline communities. Thus, other policies and programs beyond ACC II will be needed in California and the Section 177 states to ensure these communities benefit from and have direct access to ZEVs.

ii. ACT/Low NOx HD Omnibus/Phase 2

The proposed ACT regulation will reduce NOx, PM2.5, and GHG emissions, while the proposed HD Omnibus regulation will reduce NOx and secondary PM2.5 formation since NOx is a precursor to secondary PM2.5 formation. The proposed Phase 2 GHG regulations will require heavy duty trucks and trailers to reduce greenhouse gas emissions. Reductions in NOx and PM2.5 emissions result in health benefits for Vermonters, including reduced instances of premature deaths, hospitalizations for cardiovascular and respiratory illnesses, and emergency room visits.

Using U.S. EPA's COBRA screening model, NESCAUM assisted Vermont in calculating the estimated economic value of the health benefits associated with the adoption of the proposed rules. Utilizing the COBRA model is generally consistent with EPA practice for estimating avoided health impacts and monetized benefits. The COBRA model estimates impacts to PM air pollution concentrations, which are translated into health outcomes. Table 1 shows the estimated avoided premature deaths, hospitalizations for cardiovascular and respiratory illnesses, and emergency room visits due to the proposed ACT, HD Omnibus, and Phase 2 GHG regulations for 2025 through 2050 in Vermont, relative to the baseline.

Table 1: 2025-2050 Statewide Estimated Cumulative Health Impacts

Proposed Regulations	Item	Avoided Premature Deaths	Avoided Hospitalizations for Cardiovascular Illness	Avoided Hospitalizations for Respiratory Illness	Avoided ER Visits	Total Costs Avoided
ACT, HD Omnibus, Phase 2 GHG	# of Incidents	0.9 - 2.0	0.1	0.1	0.3	-
	Valuation (million $2018)	$11 - $24M	$0.01	$0.01	$0.000	**$11 - $24M**

Notes:

1. COBRA version 4.0.
2. Emissions baseline year, Phase II Source-Receptor (S-R) Matrix and adjustment factors, and incidence and health effect functions for 2023.
3. Vermont population projection for 2025-2050 utilized the 2017 U.S. Census Bureau National Population Projections as a baseline, which was adjusted at the state and county levels using the COBRA population inventory database.
4. Valuation functions were projected for 2025-2050 using a linear model based on the COBRA valuation inventory database.
5. Discount rate of 3%.

The proposed ACT and Phase 2 GHG regulations account for GHG benefits in terms of carbon dioxide (CO_2) emissions avoided. The social cost of carbon (SC-CO_2) is an estimate of the monetized value of long-term impacts (economic, health and environmental) from climate change as a result of a single metric ton increase in CO_2 emissions in a given year. [12]

This analysis utilizes the Vermont Climate Council recommended SC-CO_2 values and discount rates, which is a method of placing a present value on costs or benefits that will occur at a future date, identified in the *Initial Vermont Climate Action Plan.*[13] Because the SC-CO_2 is highly sensitive to the discount rates applied, the range of discount rates from 1% to 3% is used to illustrate the varying

[12] The National Academy of Sciences defines the Social Cost of Carbon as "an estimate, in dollars, of the present discounted value of the future damage caused by a metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year or, equivalently, the benefits of reducing CO_2 emissions by the same amount in that year."

[13] Vermont Climate Council, *Initial Vermont Climate Action Plan*, December 2021. https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2021-12/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf

magnitude of possible economic outcomes. Table 2 shows the cumulative GHG emissions reductions with estimated benefits from the proposed ACT regulation 2026 through 2050.

Table 2: 2026-2050 Statewide Estimated Avoided Social Cost of CO2 from Medium- and Heavy-duty vehicle rules

Year	3% Average Discount Rate		2% Average Discount Rate		1% Average Discount Rate	
	Value (2020$/metric ton CO2)	Cost Avoided	Value (2020$/metric ton CO2)	Cost Avoided	Value (2020$/metric ton CO2)	Cost Avoided
2025	56	$0	129	$0	418	$0
2026	57	$71,779	131	$164,965	421	$530,156
2027	59	$148,595	132	$332,449	423	$1,065,349
2028	60	$226,670	134	$506,229	426	$1,609,356
2029	61	$307,264	136	$685,047	428	$2,155,883
2030	62	$390,376	137	$862,605	430	$2,707,446
2031	63	$747,123	139	$1,648,415	433	$5,134,990
2032	64	$1,114,996	141	$2,456,475	435	$7,578,488
2033	65	$1,493,994	142	$3,263,802	437	$10,044,237
2034	66	$1,884,118	144	$4,110,802	440	$12,560,784
2035	67	$2,285,367	146	$4,980,053	442	$15,076,597
2036	69	$2,824,536	147	$6,017,490	444	$18,175,275
2037	70	$3,343,246	149	$7,116,338	446	$21,301,253
2038	71	$3,875,607	151	$8,242,488	449	$24,509,120
2039	72	$4,421,618	152	$9,334,528	451	$27,696,527
2040	73	$4,981,281	154	$10,508,455	453	$30,911,235
2041	74	$5,500,425	156	$11,595,491	456	$33,894,513
2042	75	$6,031,757	158	$12,706,901	459	$36,914,351
2043	77	$6,661,791	160	$13,842,684	461	$39,884,232
2044	78	$7,223,590	162	$15,002,840	464	$42,971,097
2045	79	$7,797,574	164	$16,187,370	467	$46,094,522
2046	80	$8,304,704	166	$17,232,260	469	$48,686,326
2047	81	$8,822,044	167	$18,188,658	471	$51,298,551
2048	82	$9,349,594	169	$19,269,286	472	$53,817,178
2049	84	$10,006,481	170	$20,251,211	474	$56,465,141
2050	85	$10,559,558	172	$21,367,576	476	$59,133,524
TOTAL		**$108,374,086**		**$225,874,418**		**$650,216,129**

The ACT and HD Omnibus regulations impose requirements on vehicle manufacturers to produce and sell vehicles with higher upfront costs and these costs are expected to be passed on to Vermont vehicle fleets and individuals who purchase these vehicles. The Phase 2 GHG regulation imposes requirements on medium- and heavy-duty engines, vehicles, and trailer manufacturers, which results in increased compliance costs that are also expected to be passed on to Vermont vehicle fleets and individuals who purchase these vehicles and trailers. There are no direct costs onto individuals as a result of these regulations.

For the ACT rule, individuals may see health benefits due to ZEVs displacing ICE vehicles and providing statewide, regional, and local emission benefits. Individuals are also likely to benefit from cost savings as a result of reduced fuel consumption and fuel costs. Cost savings are also likely due to the enhanced warranty requirements of ACT and the HD Omnibus Rules. These warranty provisions should result in longer useful life of the subject vehicles, and broader coverage of warranty-repairs within the subject vehicle's warranty period.

b. Costs and benefits to businesses, including small businesses
    i. ACCII

Businesses that will be directly affected by the proposed regulation include light- and medium-duty vehicle manufacturers because they are entities directly regulated and required to comply. ZEV-only manufacturers are likely to directly benefit from the regulation because they do not manufacture ICEV and will be able to over comply and sell surplus credits to other manufacturers. Auto manufacturing is currently not occurring in Vermont. Businesses that may be indirectly affected, and likely exist in Vermont, are suppliers of Tier 1 components supplied directly to auto manufacturers, electric vehicle service providers, electric utilities, electric charging and hydrogen infrastructure providers.

Suppliers of Tier 1 components would benefit from increased opportunities created by the need to develop, sell, and support technology to decrease emissions from ICEVs. Many of these companies are also changing their business models to include components for vehicle electrification, as demand for conventional vehicle components declines.

The proposed regulation will increase the total amount of electric vehicle miles traveled in the state, and the charging of those electric vehicles will increase Vermont's overall electric load. Electric infrastructure needed to charge BEVs and PHEVs represents a significant area of expected increased load for electric utility companies, as traditional areas of growth have slowed due to energy conservation and energy efficiency efforts. Understanding the grid impacts of the additional load expected from electrification of the transportation system is an important consideration. The Vermont-wide transmission operator (VELCO) releases a Long-Range Transmission Plan every three years that incorporates various scenarios of building and transportation electrification with a requirement of the plan to meet mandatory reliability standards. This plan will help to better understand and implement any necessary grid modifications related to this increase in number of electric vehicles[14].

In addition to the electric utilities that will supply additional electricity to power BEVs and PHEVs under the proposed regulation, ZEV infrastructure businesses will benefit as well. This includes companies that manufacturer, install, operate, and maintain EV charging stations and hydrogen dispensing equipment. Electric Vehicle Supply Equipment (EVSE) providers, and hydrogen station operators will all benefit from increased demand for their equipment with home and public fueling stations. The Proposed Regulation will increase the total amount of electric vehicle miles travelled in the state, which in turn will likely increase utilization of charging and hydrogen stations across the state and lead to increased revenue for these businesses, making the business model for their investment more stable and predictable. This allows investor capital and venture capital funds to be accessed for increased deployment rates of ZEV infrastructure. Increased use of public charging stations may also have benefits to retail businesses

[14] Vermont Comprehensive Energy Plan, Pg. 65, available at https://publicservice.vermont.gov/sites/dps/files/documents/2022VermontComprehensiveEnergyPlan_0.pdf

operating or close to charging stations. Many charging stations are located in areas with available shopping, food, or other services such as dry cleaning. Additionally, Vermont businesses that are contracted to install stations will benefit from the rapidly growing network.

Typical passenger car rental businesses could see increasing incremental purchase costs for vehicles over the course of the regulation as stringency increases. At the same time, rental firms would benefit from operational savings due to the reduction in repair and maintenance costs. There may also be an increased cost for electricity depending on whether the rental business or the driver ends up bearing the costs of vehicle charging, though reduced gasoline usage leads to net fuel savings in nearly all cases.

ZEVs inherently have far fewer propulsion-related parts especially mechanical moving parts as electric motors and power electronics dominate the electric drive propulsion system instead of mechanical internal combustion engines and automatic transmissions comprised of mechanical components like valves, springs, and gears. As a result, it is expected that individual ZEVs will likely need fewer propulsion-related repairs than gasoline vehicles. While this will be a benefit to individual vehicle owners, the vehicle repair and maintenance service industry is estimated to see negative impacts, including dealerships that have service departments, as ZEVs become a greater portion of the fleet. This trend would suggest that the number of businesses providing the services may decrease along with the reduced demand.

The proposed regulation would provide operational savings to small businesses and small fleet owners, although the proposed regulation could increase initial vehicle prices and incremental costs on small fleet owners in the early years of the regulation. The proposed ZEV assurance measures would help owners of small fleets by eliminating or greatly limiting subsequent out-of-pocket costs for vehicle repairs during the time the vehicle is under warranty. In addition, the enhanced useful life and warranty reporting and battery warranty provisions would encourage manufacturers to produce more durable components, resulting in fewer failures and less downtime for the small fleet owner. Small businesses would also benefit from the operational and fuel savings discussed above in (3)(a)(i). In an example analysis conducted by CARB[15], a cost example for a small business that purchases a typical full-size light truck for business use is considered and the total cost of ownership analyzed over time. This result shows that the business owner breaks even at year six as annual savings accumulate sufficient to compensate for expenses. By the tenth year, the owner has saved nearly $5,500 in total ownership costs.

[15] Standardized Regulatory Impact Assessment for Advanced Clean Cars II, CARB, at page 102. Available at: https://dof.ca.gov/wp-content/uploads/Forecasting/Economics/Documents/ACCII-SRIA.pdf

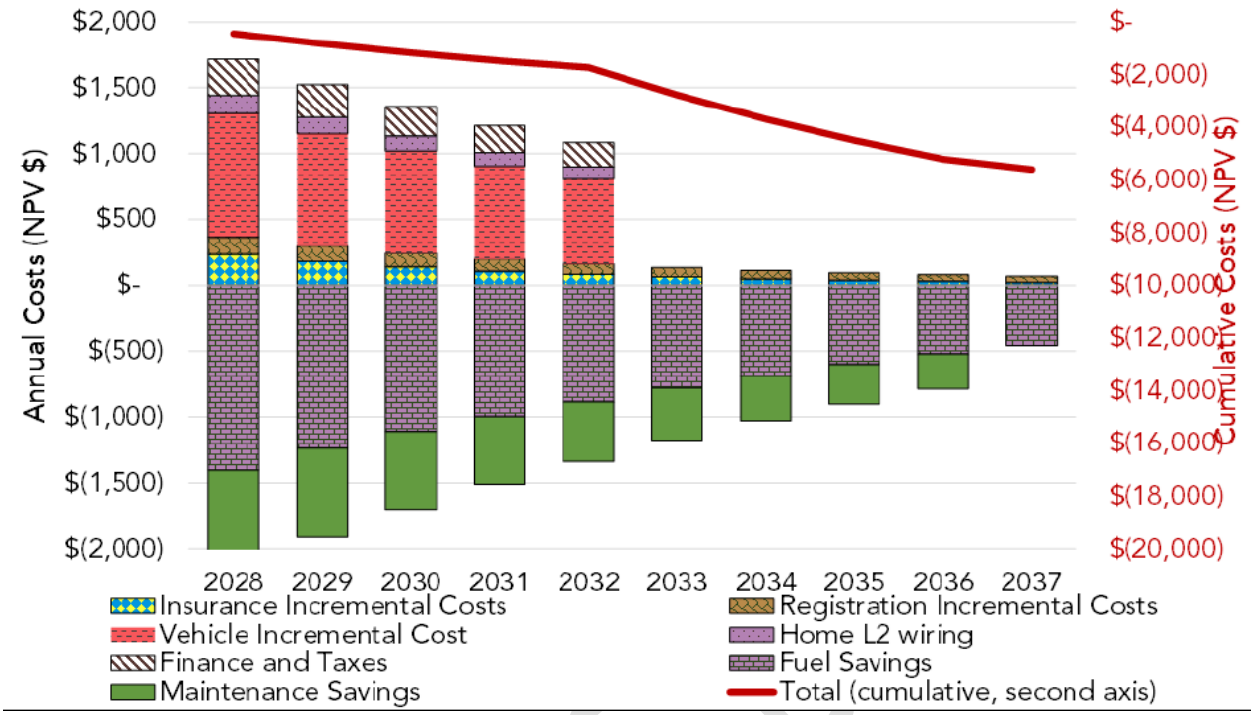

Figure 2: Small business light-duty fleet purchase cost example.

ii. ACT/Low NOx HD Omnibus/Phase 2

1. Advanced Clean Trucks

Manufacturers sell trucks to trucking fleets who operate the vehicles and incur costs following the point of sale including taxes, fueling, maintenance, midlife costs, and registration fees. Adding electric trucks to their fleet will also cause fleets to incur costs relating to EVSE, infrastructure, maintenance bay upgrades, workforce training, and other transitional costs.

The ACT Regulation is likely to increase the supply of ZEVs and will provide another vehicle option for fleets to consider in meeting their needs. Individual businesses that have operations that are well suited for using ZEVs will likely be able to lower their total cost of ownership by taking advantage of the operational cost savings of battery-electric vehicles. Reduced costs to the overall state's trucking fleet are forecast as the operational cost savings of the ZEVs likely outweigh the potential infrastructure and vehicle prices. Amortizing the vehicle and infrastructure investments will help with these companies' cash-flow to realize positive cash-flow shortly after purchase.

Figure 3 illustrates an example where a reference fleet purchases 20 Class 4-5 trucks in 2024 for usage in last mile delivery applications over twelve years.[16] The costs for 20 diesel vehicles, 20 battery-electric vehicles and the difference between them is shown. The costs over the twelve-year period are lower for the battery-electric fleet as compared to the diesel fleet; however, the upfront capital expenses are significantly higher for the BEV fleet. Access to capital or financing will be critical for fleets to take advantage of the overall savings of BEVs.

[16] California Air Resources Board – Advanced Clean Trucks Initial Statement of Reasons, at Pg IX-33.

Cost line items	Diesel	Battery-Electric	Difference
Amortized Vehicle Price	$ 1,270,361.00	$ 1,747,840.00	$ 477,479.00
Sales Tax	$ 93,280.00	$ 135,896.00	$ 42,616.00
Amotized EVSE Cost	$ -	$ 104,315.00	$ 104,315.00
Amotized Infrastructure Upgrades	$ -	$ 417,261.00	$ 417,261.00
Charger Maintenance	$ -	$ 120,000.00	$ 120,000.00
Fuel Costs	$ 2,220,329.00	$ 947,961.00	$ (1,272,368.00)
Maintenance costs	$ 1,914,913.00	$ 1,436,185.00	$ (478,728.00)
Midlife Costs	$ -	$ 259,200.00	$ 259,200.00
Maintenance Bay Upgrades	$ -	$ 20,000.00	$ 20,000.00
Transitional Costs and Workforce development	$ -	$ 12,564.00	$ 12,564.00
Registration Fees	$ 245,823.00	$ 232,840.00	$ (12,983.00)
Total	**$ 5,744,706.00**	**$ 5,434,062.00**	**$ (310,644.00)**

Figure 3: Advanced Clean Trucks Fleet Cost Example.

The proposed ACT Regulation will increase the number of ZEVs deployed, which will in turn increase the amount of electricity supplied by utility providers. Increased electricity usage from ZEVs provides an opportunity for a number of benefits to the utilities, their customers, and the overall grid itself. Electric vehicles are capable of shifting load to off-peak periods, stabilizing voltage frequency, and potentially reducing the use of temporary frequency regulation through emergency generators, while also increasing overall demand, creating a more efficient, highly utilized grid with storage potential. Studies have found that light-duty ZEVs provide a benefit to all utility customers as their electricity utilization drives down rates for all other ratepayers[17].

There is no expected direct cost on small businesses, defined as businesses having 3 or fewer medium- and heavy-duty vehicles, under the ACT Regulation. No manufacturers or fleets who are regulated under this rule are considered to be small businesses. Small businesses who operate trucks will not be required to purchase zero-emission trucks but may independently decide to do so. This may enable cost savings for small businesses due to electric trucks' lower cost of operation.

2. HD Omnibus/Phase 2

Medium- and heavy-duty engine/vehicle manufacturers are the regulated entities under the HD Omnibus Rule. Because these manufacturers are located outside of Vermont, ANR assumes those manufacturers would pass the direct compliance costs onto the Vermont vehicle fleets that purchase the California-certified vehicles and engines that are subject to the HD Omnibus Rule. Typical businesses are defined here to be Vermont fleets with four or more medium- and heavy-duty vehicles (GVWR >10,000 pounds). The actual cost impact on fleets would depend on the number of new California-certified heavy-duty vehicles that fleets would purchase during the lifetime of this cost analysis. A lifetime analysis including initial purchase price increase, lifetime Diesel Exhaust Fluid (DEF)

[17] M.J. Bradley and Associates, MJB&A Analyzes State-Wide Costs and Benefits of Plug-in Vehicles in Five Northeast and Mid-Atlantic States, 2017. (https://www.mjbradley.com/reports/mjba-analyzes-state-wide-costs-and-benefits-plug-vehicles-five-northeast-and-mid-atlantic).

consumption for NOx control, lifetime savings from warranty, net lifetime cost impact, and percent increase in lifetime cost from the assumed purchase price is presented in Figure 4[18].

Engine MY	Lifetime Net Cost Per Vehicle	Lifetime Net Cost of 20 Vehicles
2024	$2,839	$56,780
2027	$5,317	$106,340
2031	$5,814	$116,280

Figure 4: Lifetime Cost Analysis of 20 Medium Heavy-Duty Diesel Trucks

Similar to typical fleets, the actual cost impact on smaller businesses and their fleets would depend on the number of new California-certified heavy-duty vehicles that fleets would purchase during the lifetime of this cost analysis. As shown in Figure 4 above, for a small fleet that would buy one new medium heavy-duty diesel (MHDD) vehicle with a 2024, 2027, or 2031 MY engine, the net lifetime vehicle cost due to the HD Omnibus is estimated to be $2,839, $5,317, or $5,814, respectively.

c. Costs and benefits to schools and school districts

i. ACCII

ACCII does not provide for the direct regulation of schools or school districts. To the extent schools or school districts have passenger cars and light duty trucks as part of their school transportation fleet, these entities should experience the same net benefit as described above when considering the total cost of ownership of a BEV when replacing and ICEV.

ii. ACT/Low NOx HD Omnibus/Phase 2

ACT, the HD Omnibus, and the Phase 2 rules do not provide for the direct regulation of schools and school districts. As most school districts have heavy-duty buses in their fleet, these entities are likely to experience the same cost savings and net lifetime vehicle cost as explained above in the discussion on the impact of these rules on medium- and heavy-duty fleets. Early adoption of school bus electrification has been identified as critical in reduction of children's exposure to criteria pollutants emitted by traditional fossil-fueled school buses. Several state and federal incentive programs for school bus replacement are currently available and are likely to be expanded in the future. Vermont has been a leader in investigating the feasibility of electric school buses in operation in a cold climate and rural setting via our on-going Electric School and Transit Bus Pilot project.

4. Alternatives to rule as proposed

As discussed above, the only alternative that ANR considered is to not amend Advanced Clean Cars or adopt Advanced Clean Trucks, the Low NOx HD Omnibus, or the Phase 2 Greenhouse Gas rules.

[18] California Air Resources Board – HD Omnibus Initial Statement of Reasons, at Pg. IX-52.

Pursuant to Section 177 of the Clean Air Act, Vermont's adoption of California's motor vehicle emission standards must be identical to California's rules. If Vermont does not adopt or amend these rules, this will result in a reversion to the federal motor vehicle emission standards, which are less stringent and would represent significant backsliding in the progress Vermont has so far made in reducing criteria pollutant emissions and greenhouse gas emissions as a result of implementation of these rules.

Environmental Impact Statement Supplemental Information

1. Climate change

The initial Vermont Climate Action Plan released in December 2021 includes a section devoted to understanding climate and climate change in Vermont. The key messages from the Climate Action Plan include the following:

- Across Vermont, the 11-year period of 2010-2020 was the warmest since records began in 1895, with the warmest winter and summer seasons occurring in the 2000-2020 period.
- Vermont's average annual temperature has increased over 2.5°F from the 1970s [1960s] to 2010s and over 3°F from the end of the last century.
- The rate of warming has increased through the last 120 years and is currently around +0.5°F a decade.
- Warming is having a number of notable effects, such as the lengthening of the growing season, less reliable winter snow cover, and shifting peak energy usage to the summertime.
- Seasonal temperature trends show the winter season warming nearly twice as fast [over 1.5 times faster] as the annual average, increasing over 4°F from the 1960s to the 2010s.
- Other observed seasonal shifts include an expanding warm season causing longer falls and winter to have more false starts, and more temperature fluctuation within seasons.
- Backward or false springs (during which snow and freezing rain can occur in April-June after the normal progression of warming temperatures) continue to be observed, even with the observation that freeze-free seasons are longer.
- As Vermont's climate warms there has been an observable shift in temperature extremes. Heat waves are becoming more likely while cold waves are decreasing. Evidence for this from Burlington shows a steady decline in cold waves peaking around nearly 6 per year in the 1970s to less than 2 per year in the 2010s. Heat waves have generally increased from around 3 to 4 per year in the 1960s/1970s to over 7 per year in the 2010s.
- Since the mid-2000s, a below average number of very cold nights (defined as nighttime temperatures of 0°F or less) has also been observed in winter, with a near to above average annual number of warm nights in the 2000-2020 period.
- As Vermont's climate warms, the overall amount of precipitation is also increasing. Warmer temperatures produce increased evaporation of water vapor from nearby bodies of water, resulting in a greater potential for weather systems to produce higher amounts of precipitation. In general, increases in annual precipitation changes are relatively small, on the order of +0.5" to +1.0" a decade, with the greatest increases in precipitation occurring during the winter season.
- Extreme precipitation (defined as greater than 2" over 24 hours) has also trended above the long-term average since 1995. These trends are reflected in the increases in stormflow between 1950-2006 as well as the increasing magnitudes of the 1% (100-year return interval) storms across timescales from 1 hour to 1 day.
- The Vermont Department of Health has documented the combined influence of warmer winters and longer warm seasons as contributing to both a more hospitable environment for blacklegged ticks, as well as their hosts, white-footed mice. There has been an exponential increase in probable Lyme disease cases between 1990 and 2016, with Vermont

and Maine being the states with the highest increases in actual reported case rates since 1991

a. Cause

The Intergovernmental Panel on Climate Change (IPCC) released "AR6 Climate Change 2021: The Physical Basis" [19] as part of the Sixth Assessment Report (AR6) process. This report states that human influence on the climate system is now an established fact. "It is unequivocal that the increase of CO_2, methane (CH_4) and nitrous oxide (N_2O) in the atmosphere over the industrial era is the result of human activities and that human influence is the principal driver of many changes observed across the atmosphere, ocean, cryosphere and biosphere."

2. Greenhouse gas emissions from motor vehicles in Vermont
    a. Light and medium-duty vehicle emissions

Motor vehicles and other mobile sources in Vermont are the largest source of a number of air pollutants in the state. These pollutants include, but are not limited to, nitrogen oxides (NOx) and volatile organic compounds (VOCs), which are precursors to ground level ozone formation (smog), carbon monoxide (CO), particulate matter (specifically $PM_{2.5}$), and greenhouse gases (GHGs). For information on the impacts of criteria pollutant emissions in Vermont, please refer to the discussion above in the Economic Impact Statement Supplemental Information Impacts of greenhouse gas emissions are explained above. Greenhouse gas emissions from mobile sources make up approximately 40% of Vermont's total GHG emissions profile, or 3.43 million metric tons of CO_2 equivalent (CO_2e) in 2018, with light-duty vehicles accounting for over 70% of that total and the heavy-duty fleet contributing approximately 12%[20].

Although Vermont is a relatively small state it has one of the highest rates of GHG emissions per capita in the Northeast driven by high per capita vehicle miles traveled[21]. In order to meet the mandatory GHG reductions set forth in the Vermont Global Warming Solutions Act of 2020 dramatic emissions reductions from the transportation sector, and especially from light and medium duty on-road vehicles, will be required. Reductions from the sector can be achieved through multiple strategies but reducing criteria pollutant and greenhouse gas emissions via electrification of the vehicle fleet plays a critical role due to the general rural nature and non-centralized development patterns in the state.

3. GHG and Criteria pollutant emission reductions
    a. ACCII

[19] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

[20] Vermont DEC, 2021: Vermont Greenhouse Gas Emissions Inventory and Forecast 1990 – 2017: https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

[21] Energy Action Network (EAN), 2020: 2019 Annual Progress Report for Vermont: https://www.eanvt.org/wp-content/uploads/2020/03/EAN-report-2020-final.pdf

[Insert forthcoming analysis on GHG and criteria pollutant emissions reduced in Vermont]

b. ACT/ Low NOx HD Omnibus / Phase 2

To understand the impact these regulations could have on medium- and heavy-duty vehicle emissions in in Vermont, Vermont partnered with NESCAUM and the International Council on Clean Transportation (ICCT) who commissioned Sonoma Technology, Inc. (STI) to estimate the cumulative avoided nitrogen oxides (NOx), fine particulate matter (PM2.5) and well-to-wheel carbon dioxide equivalent (WTW CO2e) emission reductions beginning in 2025 from Advanced Clean Trucks, the HD Omnibus Rule, and the Phase 2 GHG Rule.

Table 3[22], below, estimates the emission reduction benefits of the zero-emission vehicles first sold in Vermont, whether or not the vehicle remains registered in Vermont through the end of its life. All sales that comply with ACT requirements are credited to the ACT, regardless of whether those zero-emission vehicles would have been sold without such regulation.

Table 3: Avoided Emissions of GHG, NOx and PM from ACT, HD Omnibus, and Phase 2 GHG Rules

Avoided Medium- and Heavy-Duty Emissions, 2020-2040			
	NOx (short tons)	PM2.5 (short tons)	WTW CO2e (million metric tonnes)
ACT	(1,820)	(16)	(1.04)
HD Omnibus[23]	(1,710)	-	-
Phase 2 GHG Stds	-	-	(0.26)
Full Harmonization	(3,010)	(16)	(1.31)
Avoided Medium- and Heavy-Duty Emissions, 2020-2050			
	NOx (short tons)	PM2.5 (short tons)	WTW CO2e (million metric tonnes)
ACT	(5,590)	(44)	(3.26)
HD Omnibus	(4,330)	-	-
Phase 2 GHG Stds	-	-	(0.50)
Full Harmonization	**(8,190)**	**(44)**	**(3.70)**

[Insert discussion and final quantification of emission reductions expected from adoption of the full suite of rules]

[22] The ICCT and STI - Benefits of adopting California medium- and heavy-duty vehicle regulations under Clean Air Act Section 177 (https://theicct.org/publication/state-level-hdv-emissions-reg-fs-dec21/)

[23] Only NOx emissions benefits were quantified for this program. This is because technologies that reduce NOx (e.g., an improved selective catalytic reduction [SCR] catalyst) are expected to have minimal impact on particulate matter (PM) and greenhouse gas (GHG) emissions.

Scientific Information Statement Supplemental Information

1. List of material incorporated by reference (IBR)
    a. ACCII
        i. Proposed Rule Record, available at: https://ww2.arb.ca.gov/rulemaking/2022/advanced-clean-cars-ii
    b. ACT/Low NOx/Phase 2 GHG
        i. Title 13 California Code of Regulations available at: https://govt.westlaw.com/calregs/Index?transitionType=Default&contextData=%28sc.Default%29
        ii. Title 17 California Code of Regulations available at: https://govt.westlaw.com/calregs/Index?transitionType=Default&contextData=%28sc.Default%29
2. Summary of record and documentation developed by CARB
    a. Initial Statements of Reason and Standardized Regulatory Impact Assessments:
        i. Advanced Clean Cars II, available at: https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/accii/isor.pdf
        ii. Advanced Clean Trucks, available at: https://ww3.arb.ca.gov/regact/2019/act2019/isor.pdf
        iii. Low NOx HD Omnibus, available at: https://ww3.arb.ca.gov/regact/2020/hdomnibuslownox/isor.pdf
        iv. Phase 2 GHG Rules, available at: https://www.arb.ca.gov/regact/2018/phase2/isor.pdf
3. Other materials cited in Supporting Documents
    a. The ICCT and STI - Benefits of adopting California medium- and heavy-duty vehicle regulations under Clean Air Act Section 177, available at https://theicct.org/publication/state-level-hdv-emissions-reg-fs-dec21/
    b. [Insert Source documents for Benefits of adopting ACCII under CAA Section 177]