IMPLEMENTATION GRANT APPLICATION TECHNICAL APPENDIX

This technical appendix details the calculations, methods, assumptions, and tools used to estimate greenhouse gas (GHG) emission reductions and, where available, changes in air co-pollutants for each measure and project included in the Virginia Department of Environmental Quality's (DEQ's) Climate Pollution Reduction Grant application entitled: "Comprehensive Emissions Reductions within Virginia's Transportation Systems."

Measure 1. Reduce GHG emissions from the on-road transportation sector through vehicle electrification and other zero- and low-carbon fuels.

Project 1: Electrification of VDOT's Light-Duty Fleet
To determine the emissions reductions from replacing a VDOT gasoline truck to an electric truck, the following methodology was used as adapted from the United States Department of Energy, Alternative Fuels Data Center: Data Sources and Assumptions for the Electricity Sources and Fuel-Cycle Emissions Tool, https://afdc.energy.gov/vehicles/electric_emissions_sources.html.

The CO_2 emissions for a vehicle in a given year of operation is calculated using the following equation.

$$\text{Average Annual VMT} \times \frac{1\ \text{kWh}}{\text{Q mi}} \times \frac{\text{Z lbs. } CO_{2e}}{1\ \text{kWh}}$$

Q = miles per kWh

Z = Average emissions from generated electricity

The Ford F-150 Lightning uses approximately 50 kWh to travel 100 miles, yielding a Q of 2 miles per kWh. Electricity emission factors and AR5 GWPs were used to derive from the AEO 2023 Ref Case used to capture impacts of IRA and existing power sector decarbonization policies (RPS, VCEA) in Virginia to better reflect the starting point, or reference projection. The average annual distance traveled by a truck in VDOT's fleet from the CalAmp data is 12,000 miles. The results of the above equation for each year, and assuming 50 trucks are put into place in 2025 are used to calculate the CPRG scenario emissions across a time series, and assuming a 10 year lifetime of trucks.

This can then be compared with the emission from an equivalent gasoline-powered vehicle. Emissions are calculated from both the tailpipe as well as the energy required to extract, refine, produce, and transport the fuel. Estimates including these upstream emissions is referred to as "well to wheels" and these estimates are used in these calculations. Gasoline production and usage emits 648 grams CO2e/mile.[1] Again assuming an annual miles traveled for each truck of 12,000 and 50 trucks, an annual reference case is calculated.

Annual emissions from each scenario are compared to calculate annual and cumulative GHG reductions. This calculation is provided in the *Electrification of DRPT's Public Transit Fleet* attachment *GHGcalcs_VADEQ.*

Project 2: Electrification of DRPT's Public Transit Fleet
To estimate the potential GHG reductions and other changes in other emissions from the conversion of existing buses to battery electric over the period from FY2026 to FY2030, EPA's MOtor Vehicle Emissions Simulator (MOVES) was used to determine appropriate emissions rates of the existing bus fleet and

[1] Argonne National Laboratory GREET model, GHG emissions for well to wheel for a pick up using AR5 GWPs.

determine GHG reductions. MOVES4 is the latest official version of EPA's software and is used to estimate mobile source emissions for various air pollutants. DEQ acknowledges that MOVES4 relies on AR4 global warming potential values (GWPs). DEQ conducted a post-processing variability analysis of the MOVES4 results to determine the effect moving from AR4 to AR5 GWPs would have on the GHG reduction results. This was done by assuming a range of proportions of each GHG (CO_2, CH_4, N_2O) in total CO_2e in the GHG reduction estimates and then applying the AR4/AR5 GWP ratios for CH_4 and N_2O. In looking at ranges of reductions assuming 85% to 95% CO_2 of total GHG reductions, it was determined that the different in GHG emissions relying on the AR4 and AR5 GWP values was negligible and presenting results directly from MOVES would produce the most accurate results given the detailed and robust nature of MOVES. If anything, GHG emission reductions are likely underestimated (mor conservative) given the increase in GWPs for Upon EPA request DEQ can conduct additional analyses to fully convert the MOVES4 results.

The new buses will be allocated to various transit agencies across Virginia as shown in Table 1 below. Additional information about replacement buses by year, average annual VMT per bus, age of buses being replaced, and existing bus fuel type is used in the final emission reductions calculations.

Table 1: Virginia Bus Replacements by Transit Agency

Agency	Total Buses
City of Alexandria (DASH)	24
Town of Blacksburg (Blacksburg Transit)	13
HRT	21
Fairfax County (Fairfax Connector)	4
Arlington County (ART)	26
Williamsburg Area Transit Authority	7
Bay Transit	8
Bristol Transit	5
Total	**108**

MOVES4 contains emissions rates for each combination of air pollutant, emissions process, source type, vehicle model year, and fuel/engine type. For this analysis emissions rates were collected for each applicable combination as described below.

To account for differences in environment and policy throughout Virginia, MOVES utilizes different emissions rates for each county and independent city. After running a baseline MOVES run for a few different counties/independent cities that include the Transit Agencies listed in Table 1, it was determined that the rates for transit buses were relatively similar, with the rates for Arlington County standing out as average for the group. Arlington County would also receive the largest allocation of replacement buses with 26. Therefore, emissions rates for Arlington County were chosen to be representative of counties/independent cities included in this analysis.

MOVES has three levels of analysis: default scale, county scale, and project scale. County and project scale require more in-depth local information and are used for more specific analyses like to determine emissions conformity. The default scale uses default state and local allocation factors to represent emissions and is the scale appropriate for this analysis. Default runs were completed for Arlington County for each of the analysis years from FY2026 to FY2030 (2026, 2027, 2028, 2029, and 2030).

To determine the estimated GHG and other emissions reductions for each analysis year, the emissions rates for both start and running exhaust for each of the possible combinations in pollutant, source type, model year, and fuel type were collected from each MOVES run. Emissions reductions were first calculated for each transit agency using the emissions rates for the model year of the existing buses, the average yearly VMT per bus, and the total number of buses being replaced. Then, total reductions for each year were added together, along with a continuation of reduction from previous years, to develop a cumulative estimated emissions reduction for both the Grant period from 2026-2030 and the extended period from 2026-2050.

Since DEQ and DRPT are seeking 68% of total project costs with CPRG funds, the GHG results for the CPRG application were proportioned accordingly.

DRPT received explicit interest from large- and small-urban agencies, as well as rural agencies to build out the proposed GHG reduction measure. Long-term GHG emissions reductions projections are conservative as we ran data for vehicles explicitly planned for replacement by using our agencies' five-year capital plans. DRPT and DEQ expects broader adoption and impact upon completion of the Modernizing Transit Fleets (MTF) project. MTF will produce a comprehensive planning toolkit geared towards rural and small-urban transit agencies interested in zero-emissions fleet transitions. The project includes the development of financial planning tools, a readiness checklist and an FTA-compliant transition plan template. Agencies will be required to complete a transition plan to be eligible to receive CPRG funds for ZE transit vehicles. Requiring a transition plan for eligibility will ensure the long-term sustainability of fleet transitions across the Commonwealth. Heavy-duty vehicles typically have a 12-year useful life, while light-duty vehicles have a 4-year useful life before being eligible for replacement.

Project 3. Fund Virginia's EV Rebate Program

To determine the emissions reductions for the EV rebate program, the following methodology was used as adapted from the United States Department of Energy, Alternative Fuels Data Center: Data Sources and Assumptions for the Electricity Sources and Fuel-Cycle Emissions Tool, https://afdc.energy.gov/vehicles/electric_emissions_sources.html.

The CO_2 emissions for a vehicle in a given year of operation is calculated using the following equation.

$$\text{Average Annual VMT} \times \frac{1\text{ kWh}}{\text{Q mi}} \times \frac{\text{Z lbs. } CO_{2e}}{1\text{ kWh}}$$

Q = miles per kWh

Z = Average emissions from generated electricity

A Q value of 0.25 kwh/mile is assumed. Electricity emission factors and AR5 GWPs were used to derive from the AEO 2023 Ref Case used to capture impacts of IRA and existing power sector decarbonization policies (RPS, VCEA) in Virginia to better reflect the starting point, or reference projection. The average annual distance traveled by a car as adopted from the AFLEET model is 12,400. The results of the above equation for each year, and assuming 2,830 rebates are used in the second half of 2025 and 2,830 are used in 2026 trucks, are used to calculate the CPRG scenario emissions across a time series, and assuming a 10 year lifetime of EVs.

This can then be compared with the emission from an equivalent gasoline-powered vehicle. Emissions are calculated from both the tailpipe as well as the energy required to extract, refine, produce, and transport the fuel. Estimates including these upstream emissions is referred to as "well to wheels" and these estimates are used in these calculations. Gasoline production and usage emits 0.9 lbs of CO2e/mile.[2] Again, assuming an annual miles traveled for each car of 12,400 miles and replacement of 5,660 combustion cars with EVs, an annual reference case is calculated. To account for the different years in which the EV rebates come into play for 2035 in the reference scenario an assumed half of the EV purchased with CPRG funded rebates are in use in 2035 (rebates from 2026 assuming 10 yr lifetime) and the other half of EV purchased with CPRG rebates from 2025 are replaced with EVs in 2035, hence the baseline emissions are reduced by half.

Annual emissions from each scenario are compared to calculate annual and cumulative GHG reductions. Because the rebates will not cover the full cost of EVs, and other funding sources such as federal tax credits can be leveraged, these reductions were proportioned compared to a total project cost of $226,400,000 (assuming a $40,000 cost for an EV and 5,660 vehicles) as compared to a CPRG requested funding value of a little over $21 million.

This calculation is provided in the attachment *GHGcalcs_VADEQ.*

Measure 2. Reduce GHG emissions from the off-road transportation sector, including ports and airports.

Project 4: Electrification of VPA Operations.
DEQ and VPA used the EPA's Diesel Emissions Quantifier tool to estimate the emissions associated with replacing the port's current fleet of diesel equipment with new electric equipment. The CO2 and N2O values from the tool were used to calculate GHG as CO2e (using AR5 GWPs) based on anticipated equipment lifespans and internal usage and fuel consumption numbers.

To calculate the emissions reductions for the Truck Reservation System, DEQ and VPA established an estimated reduction percentage of facility transaction turn time based on facility size and results through our previous implementations of the system at VIG and NIT. Reduced idling minutes were then converted to idling hours and the port utilized an idling emissions factor created from combined factors from the EPA's GHG Emissions Factors Hub (2024). The hours saved were then multiplied by the emissions factor and converted the information from grams to metric tons.

The EPA's Diesel Emissions Quantifier tool was used to calculate the emissions reduction values for the re-power of the Mobile Harbor Crane at Richmond Marine Terminal. The CO2 and N2O values from the tool were used to calculate GHG as CO2e (using AR5 GWPs).

In order to calculate the emissions reductions for the battery systems, DEQ and VPA used the SRVC combined CO2e emission factor for non-baseload generation (adjusted for AR5 GWPs and from EPA's eGRID, as what would be targeted to be reduced via peak shaving) as well as the port utility provider's, Dominion Energy, publicly stated net-zero commitments for generation and requirements for a clean grid within the Virginia Clean Economy Act. To account for this, DEQ and VPA discounted the SVRC rate by 20% from 2025-2030, a further 40% discount from 2030-2040, a 50% discount from 2040-2045, and a 70% discount from 2045-2050.

[2] Argonne National Laboratory GREET model, GHG emissions for well to wheel for a car using AR5 GWPs.

Further notes on these GHG calculations and more details on the assumptions are provided in the attachment *GHGcalcs_VADEQ.*