Technical Appendix

The greenhouse gas (GHG) estimates for transitioning municipal fleets from fossil fuels to electric vehicles (EVs) were primarily calculated using assumptions and methodologies from [ARC’s CMAQ tool](https://atlantaregional.org/what-we-do/climate-resiliency/air-quality/#:~:text=CMAQ%20Calculator%20Download). This tool was custom-made for the ARC as an adaptation of FHWA’s own version to better reflect local projects and emissions rates. The emission rates embedded in the tool are derived from EPA’s MOVES model.

**Initial Data Cleaning**

The coalition governments have 445 vehicles of various models, years, builds, and fuel types to transition. This data was packaged together and clean first to begin the analysis. Table 1 shows an example of how these data were organized. Full data is in the spreadsheet attachment.

*Table 1: Example of Data Provided by Coalition Governments*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **City/County** | **Vehicle Type** | **Model Year** | **Fuel Type** | **Average Miles Driven Per Year** | **Number of Vehicles** |
| COBB | Transit Bus | 2005 | DIESEL | 6200 | 1 |
| COBB | Transit Bus | 2006 | DIESEL | 8250 | 1 |
| COBB | Heavy Duty Truck | 2016 | DIESEL | 8000 | 1 |
| COBB | Car | 2003-2017 | Gasoline | 14500 | 25 |
| COBB | Passenger Truck | 1998-2017 | Gasoline | 14000 | 12 |
| COBB | Passenger Truck | 2001-2016 | Gasoline | 14000 | 12 |
| COBB | Medium Duty Truck | 2005-2013 | Gasoline | 9500 | 10 |
| COBB | Passenger Truck | 2012-2016 | Gasoline | 12500 | 12 |
| COBB | Passenger Truck | 2002-2017 | Gasoline | 9100 | 5 |
| CLAYTON | Passenger Truck | 2009-2016 Ford Explorer | Gasoline | 3000 | 25 |
| CLAYTON | Passenger Truck | 2009-2016 Ford Expedition | Gasoline | 3000 | 20 |
| CLAYTON | Passenger Truck | 2016 Ford Escape | Gasoline | 3000 | 30 |
| CLAYTON | Car | 2009 Ford Crown Victoria | Gasoline | 14000 | 5 |
| CLAYTON | Car | 2009 Chevy Impala | Gasoline | 5000 | 5 |
| CLAYTON | Car | 2008 Ford Taurus | Gasoline | 5000 | 5 |
| CLAYTON | Car | 2012 Ford Fusion | Gasoline | 5000 | 5 |
| CLAYTON | Car | 2014 Dodge Charger | Gasoline | 12000 | 8 |

These data were then cleaned and supplemented with additional columns to ensure they could be matched to the emissions data. The emissions data pulled from the ARC CMAQ Calculator was formatted with vehicle types in this structure “Gas\_Passenger\_Car”, “Diesel\_Passenger\_Car”, “Gas\_Passenger\_Truck”, etc. This needed to be translated for the data provided by the coalition governments. Additionally, some of the model years needed to be cleaned by removing extra information such as “2009 Ford Crown Victoria” to simply “2009”. For entries where a range of years was given such as “2009-2016 Ford Explorer”, the mid-point year was chosen for the analysis. Table 2 shows how the data in Table 1 were cleaned. It should be noted that the full spreadsheet includes all the data columns from before and after the cleaning.

*Table 2: Cleaned and Processed Data*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **City/County** | **Year\_Clean** | **Combined Vehicle Type** | **Average Miles Driven Per Year** | **Number of Vehicles** |
| COBB | 2005 | **Diesel\_Transit\_Bus** | 6200 | 1 |
| COBB | 2006 | **Diesel\_Transit\_Bus** | 8250 | 1 |
| COBB | 2016 | **Diesel\_SUSH\_Truck** | 8000 | 1 |
| COBB | 2010 | **Gas\_Passenger\_Car** | 14500 | 25 |
| COBB | 2009 | **Gas\_Medium\_Truck** | 12500 | 12 |
| COBB | 2008 | **Gas\_Passenger\_Truck** | 14000 | 12 |
| COBB | 2009 | **Gas\_Passenger\_Truck** | 14000 | 10 |
| COBB | 2009 | **Gas\_Medium\_Truck** | 9500 | 12 |
| COBB | 2014 | **Gas\_Passenger\_Truck** | 12500 | 5 |
| CLAYTON | 2010 | **Gas\_Passenger\_Truck** | 9100 | 25 |
| CLAYTON | 2013 | **Gas\_Passenger\_Truck** | 3000 | 20 |
| CLAYTON | 2013 | **Gas\_Passenger\_Truck** | 3000 | 30 |
| CLAYTON | 2016 | **Gas\_Passenger\_Truck** | 3000 | 5 |
| CLAYTON | 2009 | **Gas\_Passenger\_Car** | 14000 | 5 |
| CLAYTON | 2009 | **Gas\_Passenger\_Car** | 5000 | 5 |
| CLAYTON | 2008 | **Gas\_Passenger\_Car** | 5000 | 5 |
| CLAYTON | 2012 | **Gas\_Passenger\_Car** | 5000 | 8 |

**Interim Calculations**

The emission factors for these to be matched with required an assumption of average vehicle speed. 45 mph was chosen for this exercise to ease calculations and adhere to an average highway speed. The emissions factors in g/vehicle/mile units, and Equation 1 was used to translate into MT CO2e.

*Equation 1*

***([Emission Factor (g/veh/mil)] X [Number of Vehicles] X [Average Miles Driven Per Year])/ 1000000 =***

***MT CO2e/year***

Other criteria pollutants VOCs, NOx, and PM2.5 were also included using Equation 2

*Equation 2*

***([Emission Factor (g/veh/mil)] X [Number of Vehicles] X [Average Miles Driven Per Year])/ 1000 =***

***kg/year***

This calculation was done for every vehicle entry, and then combined by jurisdiction to get annual tailpipe emissions from operating these fossil fuel vehicles. Table 3 shows the annual emissions for each jurisdiction. (Green signifies the “Trailblazer” Localities that will start the transition first, and blue signifies the “Newcomer” Localities who will transition after and with more support from the technical consultant).

*Table 3: Sum of CO2 Emissions per Year by Jurisdiction*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Jurisdiction** | **CO2 Emissions per Year (MT)** | **VOC Emissions per Year (kg)** | **NOx Emissions per Year (kg)** | **PM2.5 Emissions per Year (kg)** |
| City of South Fulton | 186.04 | 53.45 | 145.26 | 4.05 |
| COBB | 459.46 | 72.95 | 557.32 | 20.11 |
| CLAYTON | 150.85 | 10.75 | 29.40 | 2.09 |
| Forest Park City | 342.48 | 154.18 | 655.05 | 27.47 |
| Jonesboro/Clayton | 415.11 | 108.53 | 505.66 | 22.11 |
| LOVEJOY/CLAYTON | 0.18 | 0.01 | 0.03 | 0.00 |
| Douglasville | 42.54 | 14.01 | 38.20 | 0.76 |
| East Point/Fulton | 50.00 | 4.19 | 27.17 | 0.75 |
| Union City | 122.38 | 60.15 | 156.88 | 4.17 |
| Total | 1769.03 | 478.22 | 2114.96 | 81.51 |

It was assumed that these emissions would stay steady in a Business As Usual case where the vehicles were not replaced with EVs for both the 2025-2030 and the 2025-2030 scenarios, and that EV tailpipe emissions for all emissions would be completely eliminated.

**Final Tailpipe Emissions Calculations**

The replacement schedule assumed for the jurisdictions is as follows:

|  |  |
| --- | --- |
| **Jurisdiction** | **Year** |
| City of South Fulton | Early 2025 |
| COBB | Early 2025 |
| CLAYTON | Mid-Late 2025 |
| Forest Park City | Mid-Late 2025 |
| Jonesboro/Clayton | Mid-Late 2025 |
| LOVEJOY/CLAYTON | Mid-Late 2025 |
| Douglasville | Mid-Late 2025 |
| East Point/Fulton | Mid-Late 2025 |
| Union City | Mid-Late 2025 |

These assumptions led to eliminating emissions from City of South Fulton and Cobb County beginning in 2025, and the rest of the jurisdictions by 2026. Table 4 shows the 2025-2030 tailpipe emissions calculations for what will be emitted.

*Table 4: 2025-2030 Tailpipe Emissions Estimates*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** |
| GHG Emissions per Year (MT) | 1123.53 | 0 | 0 | 0 | 0 | 0 |
| VOC Emissions per Year (kg) | 351.81 | 0 | 0 | 0 | 0 | 0 |
| NOx Emissions per Year (kg) | 1412.38 | 0 | 0 | 0 | 0 | 0 |
| PM2.5 Emissions per Year (kg) | 57.35 | 0 | 0 | 0 | 0 | 0 |

The annual reductions in tailpipe emissions are the differences of the totals in the Business As Usual case and the annual totals after transitioning vehicles to EVs. Table 5 shows the progression for all emissions.

*Table 5: Reduced Tailpipe Emissions Per Year*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Reduced Emissions** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** |
| GHG Emissions (MT) | 645.50 | 1769.03 | 1769.03 | 1769.03 | 1769.03 | 1769.03 |
| VOC Emissions (kg) | 126.40 | 478.22 | 478.22 | 478.22 | 478.22 | 478.22 |
| NOx Emissions (kg) | 702.58 | 2114.96 | 2114.96 | 2114.96 | 2114.96 | 2114.96 |
| PM2.5 Emissions (kg) | 24.16 | 81.51 | 81.51 | 81.51 | 81.51 | 81.51 |

The emissions reductions beginning in 2026 are continued until 2050.

The cumulative tailpipe emissions reductions for the 2025-2030 and 2025-2050 periods are in Table 6.

*Table 6: Total Reduced Tailpipe Emissions*

|  |  |  |
| --- | --- | --- |
|  | **2025-2030 Reductions** | **2025-2050 Reductions** |
| **GHG Emissions per Year (MT)** | 9,491 | 44,871 |
| **VOC Emissions per Year (kg)** | 2,869 | 12,434 |
| **NOx Emissions per Year (kg)** | 12,690 | 54,989 |
| **PM2.5 Emissions per Year (kg)** | 489 | 2,119 |

**Solar Charger Emission Reductions**

Clayton County, Cobb County, and City of South Fulton are planning to purchase solar charging stations with battery storage to charge their vehicles, which would offset some amount of carbon emissions from the fossil fuel-based local grid. Taking these upstream calculations into account was aided by the [Oakridge National Laboratory’s Fuel Economy Calculator](https://www.fueleconomy.gov/feg/Find.do?year=2024&vehicleId=47487&zipCode=30236&action=bt3). Representative vehicles were used to estimate the upstream emissions for each vehicle type, and the Clayton County area code 30236 was chosen for the tool to pull from.

Figure 1 shows a representative truck used for the calculations. Based on the Calculator’s estimates, there would be 227 g CO2e/mile avoided by using a solar charging system. Table 7 shows all the upstream emissions for each vehicle type the three jurisdictions are replacing.

Graphical user interface

Description automatically generated

*Table 7: Upstream Emission Rates for EV Vehicles*

|  |  |
| --- | --- |
| **Vehicle Type** | **Upstream Emissions (g CO2e/mile)** |
| Passenger Car | 153 |
| Medium Truck | 285 |
| Passenger Truck | 227 |
| Heavy Duty Truck | 300 |
| Transit Bus | 679 |

Equation 3 was used to calculate the maximum annual emissions reductions by vehicle type groupings.

*Equation 3*

***(Upstream Emission Rate X Average Miles Driven Per Year X Number of Vehicles)/ 1000000 =***

***MT CO2e/year***

Each jurisdiction is purchasing a different amount of solar chargers, and that was taken into account when considering what the percent of vehicle they could charge off-grid. Table 8 has these assumptions, and the total annual offset value is 169.15 MT CO2e.

*Table 8: Emissions Offset by Using Solar Charging Stations*

|  |  |  |  |
| --- | --- | --- | --- |
| **Jurisdiction** | **Solar %** | **Maximum Solar Offset (MT CO2e)** | **Actual Solar Offset (MT CO2e)** |
| City of South Fulton | 50% | 104.57 | 52.29 |
| CLAYTON | 100% | 87.95 | 87.95 |
| COBB | 10% | 252.54 | 25.25 |
| **Total** | | | 165.49 |

It is assumed that that these solar charging stations would be installed in time to charge the EVs from the beginning of their use.

**Total Emissions Reductions**

The avoided tailpipe emissions and the solar charging offsets were added together for the annual reduced GHG emissions. Table 9 shows the 2025-2030 results.

*Table 9: Reduced Tailpipe and Solar Charging Emissions for 2025-2030*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** |
| Reduced Tailpipe Emissions (MT CO2e) | 645.50 | 1769.03 | 1769.03 | 1769.03 | 1769.03 | 1769.03 |
| Reduced Upstream Emissions (MT CO2e) | 165.49 | 165.49 | 165.49 | 165.49 | 165.49 | 165.49 |
| Total (MT CO2e) | 805.20 | 1,937.85 | 1,937.85 | 1,937.85 | 1,937.85 | 1,937.85 |

The emissions reductions beginning in 2026 are continued until 2050.

Table 10 shows the total emissions reductions for the 2025-2030 and the 2025-2050 periods.

*Table 10: Total Emissions Reductions*

|  |  |  |
| --- | --- | --- |
|  | **2025-2030 Reductions** | **2025-2050 Reductions** |
| **GHG Emissions per Year (MT)** | 10,484 | 49,174 |
| **VOC Emissions per Year (kg)** | 2,517 | 12,082 |
| **NOx Emissions per Year (kg)** | 11,277 | 53,577 |
| **PM2.5 Emissions per Year (kg)** | 432 | 2,062 |

Additional insight can be gained in the spreadsheet attachment.