

# Appendix C. Technical Appendix – GHG Emissions Reductions Calculations

## Approach

The proposed Project includes one primary GHG reduction measure, replacing (100) diesel transit buses with battery-electric buses and their complementary charging infrastructure at (3) bus depots.

A combination of a publicly available calculator from the Federal Transit Administration (FTA) and modeling are used to estimate GHG emissions reductions.

This analysis created a Reference Scenario against which to compare the Project Scenario. The scenarios are defined as follows, and GHG emission-producing activities in each scenario for which GHG emissions must be quantified to ensure this analysis is comprehensive are identified.

- **Reference Scenario** – 40-foot diesel transit buses are replaced with modern 40-foot diesel transit buses.
  - o GHG emission sources: on-board diesel engine produces direct GHG emissions during fuel combustion.
- **Project Scenario** – 40-foot diesel transit buses are replaced with modern 40-foot battery-electric buses.
  - o GHG emission sources: on-board battery consumes purchased grid electricity, which indirectly produces emissions from the generation of that electricity.

The lifetime of the measure is taken to be from 1/1/27 beyond 2050 (See **Assumptions** below).

Cumulative GHG reductions tally the annual difference in GHG emissions between the Project Scenario and Reference Scenario over the measure lifetime.

## Inputs/Activity Data

- Number of Buses Requested:
  - o Ulmer Park Depot: 30 buses
  - o Jamaica Depot: 60 buses
  - o Yukon Depot: 10 buses
- Average Annual Vehicle Miles Traveled (VMT) Per 40-foot Bus by Depot:
  - o Average VMT per bus per year were calculated for 2023 calendar year for Standard 40' buses, based on depot assignment, using odometer readings. Average VMT was calculated granularly by bus type and depot to ensure calculations were representative of specific activity levels of bus types operating out of different depots (and serving different routes).
    - Ulmer Park Depot: 21,215 miles/bus/year
    - Jamaica Depot: 21,560 miles/bus/year
    - Yukon Depot: 28,633 miles/bus/year
- Average Battery-Electric Bus Electrical Efficiency:

- Calculated from actual measurements of electricity consumed for charging MTA’s existing fleet of 10 battery-electric buses from May 2020 through June 2021, Standard buses averaged 3.22 kWh/mi.

## Methods/Tools

Calculation results are presented on the “FINAL\_Emissions Reduction Calcs” tab of the calculation spreadsheet.

### *Reference Scenario*

A tool published by the Federal Transit Administration (FTA), “[FTA's Low-No/Bus Competitive Emissions Reduction Calculator for at Least Twenty 40' Zero-Emission Buses](#)”, version updated 2/8/24, was used. The calculator uses a distance-based method to calculate average annual direct (combustion-related) GHG emissions for 40-foot transit buses with different propulsion types. An estimate of annual per-bus direct GHG emissions was calculated for diesel buses. Annual per-bus annual estimates of direct GHG emissions were combined with information on the timeline for bus delivery to calculate annual emissions in a **Reference Scenario** (i.e., 100 buses replaced with new diesel) over 2025-2050.

### *Project Scenario*

An estimate of electrical efficiency of modern 40-foot transit buses was combined with data on average annual VMT per bus to determine annual electricity consumption, which was converted to annual emissions using forecasted grid electricity emission factors through 2050. Annual per-bus estimates of electricity-related GHG emissions were combined with information on the timeline for bus delivery to calculate annual emissions in a **Project Scenario** (i.e., 100 buses replaced with new battery-electric) over 2025-2050.

## Emission Factors

The direct mobile fuel combustion emission factors in FTA’s calculator are expressed in MT CO<sub>2</sub>e per-vehicle mile traveled and include all relevant greenhouse gases – CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O – expressed as a single CO<sub>2</sub>e emission rate. Representatives at the FTA were not able to confirm whether AR5 or AR6 was used. The factors are unchanged from FTA’s latest calculator version, are visible in the calculation spreadsheet on “Emission Factors” tab, and are reproduced below.

**Table. All GHG emission factors for 40’ transit buses from FTA’s Low No Bus Emissions Reduction Calculator**

CURRENT FUEL-TYPE	DIRECT EMISSIONS per veh-mile per year	MTCO <sub>2</sub> e
DIESEL	0.001954	/veh-mile/yr
CNG	0.001920	/veh-mile/yr
HYBRID DIESEL	0.001615	/veh-mile/yr
GAS	0.001209	/veh-mile/yr
LNG	0.002000	/veh-mile/yr
ZERO-EMISSION	0.000000	/veh-mile/yr

The electricity-related emission factors used in the calculation spreadsheet are sourced from the NY-NJ MSA Priority Climate Action Plan (NY-NJ MSA PCAP) submitted to the EPA March 2024, 2022 eGrid Output Rates for subregion NYC-Westchester where all (3) bus depots will be located.

2022 eGrid factors for all relevant greenhouse gases – CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O – are published in lbs/GWh. Factors for 2023-2050 are estimated assuming existing New York State policy goals are achieved, i.e., 70% of statewide electricity consumed in 2030 comes from renewable generation, 100% zero-emission grid by 2040. Consistent with the NY-NJ MSA PCAP, the analysis assumes a straight-line decrease in generation from fossil fuel power plants in New York State from 2022 levels (sourced from NYISO data on 2022 production) to 2030 levels (14%, or what's remaining if we achieve 70% renewable generation goal + 16% of state load served by nuclear, as predicted by NYSERDA's Power Grid Study, i.e., 100% - (70% + 16%) = 14%). Annual CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O factors are converted to MT/mi using 2204.62 lbs/MT and historic activity data on battery-electric bus efficiency of 3.22 kWh/mi (see **Inputs** above), then expressed in MT CO<sub>2</sub>e per-vehicle mile traveled using 100-year Global Warming Potentials in the IPCC Fifth Assessment Report (AR5).

### Assumptions

- Average annual VMT by bus type and depot assignment (see **Inputs** above) remains same through 2050 as recorded in 2023 calendar year. In other words, this measure-specific activity data holds constant over analyzed timeframe. In addition, for periods less than calendar year, it is assumed that vehicle mileage is approximately full-year mileage times portion of year in days.
- Emission factors published in FTA's Low No Bus Emissions Reduction Calculator version 2/8/24, which are annual distance-based emission rates (MT CO<sub>2</sub>e/veh-mi/yr), will still be representative for the same equipment type in later model years 2026. It is MTA's understanding that FTA has assumed some typical fuel economy, appropriate for the 2024 calendar year, for 40-foot transit buses to convert fuel-based CO<sub>2</sub> emission factors to distance-based, for combination with CH<sub>4</sub> and N<sub>2</sub>O components in a composite CO<sub>2</sub>e factor in their calculator. We assume there will be no material change between this year and the 2026 calendar year in which new buses would be purchased under this Project; therefore, the emission factors embedded in the FTA Calculator can be used as Reference Scenario annual GHG emission rates.
- Reference Scenario annual GHG emission rates are constant over time through 2050 calendar year, no decline with bus age or in-kind replacement.
- The New York State Climate Leadership and Community Protection Act (CLCPA) goals for grid decarbonization – i.e., 70% renewables by 2030, 100% zero-emission by 2040 – are achieved. Regional grid average factors for each greenhouse gas decrease evenly and linearly from 2022 levels to achieve these 2030 and 2040 milestone states.
- Project Scenario electrical efficiency is constant over time through 2050 calendar year at measured levels of 3.22 kWh/mi, no decline with bus age or in-kind replacement.
- The proposed measure lifetime extends beyond 2050, since the proposed measure includes depot modifications that will continue to serve an all-electric fleet in perpetuity.
- Although some fossil fuel buses will be scrapped and replaced by battery-electric buses during 9/25/26-3/31/27 delivery period, meaning that the MTA will start to see GHG emissions savings over that interim period, for ease of calculation (and as conservative estimate, since the calculations do not take credit for savings over that interim period), the emission reduction

period is assumed to begin once all buses are delivered, starting 4/1/27. For the 2027 calendar year, the VMT is scaled down by 75% to reflect emission reductions begin on 4/1/27.

- Emission factors published in FTA's Low No Bus Emissions Reduction Calculator use 100-year GWPs in the IPCC Fifth Assessment Report (AR5).
- Carbon dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), and Nitrous oxide (N<sub>2</sub>O) are the only relevant GHGs for this analysis.

**Outputs** (provided separately in calculation spreadsheet for periods 2025-2030 and 2025-2050)

- **Reference Scenario Emissions** – cumulative emissions generated were the Project not to proceed and, rather, typical practice of replacing buses with modern diesel buses proceeded.
- **Project Scenario Emissions** – cumulative emissions generated were the Project to proceed.
- **Net GHG Emissions Reductions** – cumulative emissions change attributed to the Project.