



Environmental Protection Agency (EPA)
Climate Pollution Reduction Grants (CPRG) Program:

Carbon-Free Shared Mobility

Technical Appendix

April 1, 2024



TECHNICAL APPENDIX

Measure Description

RTC intends to expand the hydrogen fuel fleet by 5 buses and provide a hydrogen fueling skid that allows use of liquid hydrogen. The Project implements the RTC's Zero Emission Vehicle Plan, which establishes a strategy to reduce GHG emissions from the transit bus fleet. Additionally, RTC Bike Share is the Las Vegas region's first and only public bike share system. To continue Bike Share's success in getting people out of cars and onto bikes, expansion is planned on the Maryland Parkway corridor and the University of Nevada Las Vegas (UNLV).

GHG Emissions Reductions: Hydrogen Fleet

Methods and Assumptions

The Project will transition compressed natural gas (CNG) buses to hydrogen fuel cell, which will decrease tailpipe emissions. The following calculations were completed to determine the annual emissions reduction. The average block length (miles) of transit routes, provided by RTC, were multiplied by the number of buses intended to be replaced to estimate the daily miles of service. To determine annual miles of service, weekday daily miles of service estimates were multiplied by 260 working days while Saturday and Sunday estimates were multiplied by 52 days. Table 1 shows the greenhouse gas (GHG) emissions factors for CNG transit buses, which were obtained from Clark County Air Quality Department, and the emission factor for hydrogen bus, which was obtained from the Federal Transit Administration (FTA) Transit Bus Electrification Tool. The emission factors were applied to the estimated annual miles of service to evaluate the annual GHG emissions reductions, summarized in Table 2.

Table 1. Greenhouse Gas Emissions Factors

| Vehicle Type | VOC (g/mile) | NOx (g/mile) | CO (g/mile) | CO ₂ e (g/mile) |
|------------------------------|--------------|--------------|-------------|----------------------------|
| CNG Transit Bus ¹ | 0.682 | 2.788 | 20.296 | 1,908.7 |
| Hydrogen Bus ² | | | | 0.001354 |

**This can be found in the "Emission Factor" worksheet of the GHG emission reduction calculations spreadsheet.*

Table 2. Annual Emissions Based on Average Block Length and Number of Buses to Upgrade

| | Transit Bus | Block Length (mile) | Number of Buses Replaced | GHG Emissions (MTCO ₂ e) | | |
|--------------|-------------|---------------------|--------------------------|-------------------------------------|---------------|---------------|
| | | | | CNG 40' | Hydrogen | Savings |
| Weekday | CNG 40' | 223 | 5 | 609.94 | 392.52 | 217.42 |
| Saturday | CNG 40' | 230 | 5 | 125.82 | 80.97 | 44.85 |
| Sunday | CNG 40' | 230 | 5 | 125.82 | 80.97 | 44.85 |
| Total | | | | 861.58 | 554.46 | 307.12 |

**This can be found in the "CNG&Hydrogen" worksheet of the GHG emission reduction calculations spreadsheet.*

Results

Transitioning five CNG 40-foot transit buses to hydrogen is estimated to reduce GHG emissions by 307.12 metric tons of carbon dioxide equivalent (MTCO₂e) per year. The operation of hydrogen buses from July 2027 to September 2029 (2.25 years) is estimated to result in a 691.01 MTCO₂e reduction by 2030.

¹ Obtained from Clark County Department of Air Quality & Environmental Management

² FTA Transit Bus Electrification Tool

GHG Emissions Reductions: Bicycle Share System

Methods and Assumptions

Bike share systems can have a positive impact on air quality by providing an alternative mode of transportation to automobiles. Mode shift from automobiles to bike share can reduce emissions and correlates with other community benefits, such as improved mobility and health. The Project increases mobility choice for the public, which encourages mode shift, decreases vehicle miles traveled (VMT), and reduces criteria pollutants emissions. Quantifying the level of emissions reductions requires a two-step process; 1) quantifying the number of automobile VMT reduced, and 2) assigning emissions factors to the VMT reduced to determine the annual reduction in GHG emissions.

Automobile Vehicle Miles Traveled Reduction

Automobile vehicle miles traveled reduction (AVMTR) was calculated through the following equation based on findings from the Colorado Department of Transportation³:

$$AVMTR = PSOV * Nd * D$$

The assumptions are summarized in Table 3 and further details for the assumptions are described in the subsequent sections.

Table 3. Bike Share VMT Reduction Calculation Assumptions

| Variable | Description | Assumption |
|----------|---|---|
| PSOV | Proportion of users that formerly commuted by single occupant vehicle | 6.75% |
| Nd | Number of benefit days per year | 365 days |
| D | Average daily number of miles traveled on shared bicycles | 2.228 daily miles traveled on shared bicycles in 2026 |

Proportion of Users that Formerly Commuted by Single Occupant Vehicle (PSOV)

There is limited data available to determine the percentage of mode shift from automobiles to bikes when a bike share system is introduced. Bike share data from Barcelona, Lyon, Montreal, and Paris suggests that there is an impact on reducing car use (

Table 4). The percentage of automobile trips replaced by bike sharing in these cities ranges from 2% to 10%. This analysis assumes an average of the percentage of mode shift from automobile to bike sharing to apply to the Las Vegas region, which is 6.75%.

³ Colorado Department of Transportation (2010). Congestion Mitigation & Air Quality Program 2007-2008 Report. Retrieved from: https://www.codot.gov/programs/innovativemobility/assets/commuterchoices/documents/CMAQ_2007_2008_AnnualReport.pdf

Table 4. Trip Type Replaced by Bicycle-Sharing in Selected Cities⁴

| Type of Trip Replaced | Bicing Barcelona | BIXI Montreal | Vélib' Parus | Vélo'v Lyon |
|-----------------------|------------------|---------------|--------------|-------------|
| Bus or Metro | 51% | 33% | 65% | 50% |
| Car or motorcycle | 10% | 2% | 8% | 7% |
| Taxi | | 8% | 5% | |
| Walk | 26% | 25% | 20% | 37% |
| Bicycle | 6% | 28% | | 4% |
| New Trip | | 4% | | 2% |

Annual Benefit Days (Nd)

Favorable weather conditions enable bike share operations throughout the year. The assumed benefit days per year is 365.

Average Daily Miles Traveled on Shared Bicycles (D)

E-bikes in the current Bike Share system in downtown Las Vegas average three trips per day, thus the proposed expansion of 275 bicycles at project opening in 2026 will result in approximately 825 daily bike share trips. According to RTC's 2023 Household Travel Survey, the average bicycle trip length is 2.7 miles. Based on these assumptions, the proposed system expansion will produce approximately 2,228 daily miles traveled and reduce 54,892 VMT annually on shared bicycles in 2026.

Results

The emission factors detailed in Table 5 were applied to the annual VMT reduction to estimate annual emissions reductions. The expansion of bike share stations and related e-bikes is expected to result in a GHG emissions reduction of 19.3 MTCO₂e annually, or a 77.2 MTCO₂e reduction by 2030.

Table 5. Mobile Combustion Emission Factors⁵

| Pollutant | Emission Factor (g/mile) | Annual Emissions Reductions (metric tons) |
|-------------------|--------------------------|---|
| VOC | 0.254 | 0.0139 |
| NO _x | 0.121 | 0.0066 |
| CO | 4.338 | 0.2381 |
| CO ₂ e | 351.5 | 19.2946 |

**This can be found in the "Bike Share Emissions Reduction" worksheet of the GHG emission reduction calculations spreadsheet.*

⁴ Midgley, Peter (2011). Bicycle-Sharing Schemes: Enhancing Sustainable Mobility in Urban Areas. Retrieved from: https://www.un.org/esa/dsd/resources/res_pdfs/csd-19/Background-Paper8-P.Midgley-Bicycle.pdf

⁵ Obtained from Clark County Department of Air Quality & Environmental Management