Metro Transit

Zero-Emission Bus Annual Report

2024

September 2025

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Zero-Emission Bus Program Overview

Over the past two decades, Metro Transit has been continuously pursuing different initiatives to aid in sustainable transit operations. As part of Metro Transit's long-standing efforts to move toward greener operations, Metro Transit established a battery electric bus (BEB) pilot program as part of its implementation of the METRO C Line, an arterial Bus Rapid Transit (BRT) route traveling from downtown Minneapolis to Brooklyn Center that launched in June 2019. This battery electric bus pilot was Metro Transit's first implementation of Zero Emission Buses (ZEB). The project was designed to compare the performance of electric and diesel buses on the same transit corridor, provide experience operating electric buses in Minnesota, and understand the performance of electric buses on an existing BRT route. The pilot program included the purchase of eight New Flyer 60-foot Xcelsior Charge battery electric buses with 466 kilowatt-hour (kWh) batteries in addition to two 300 kW on-route overhead conductive chargers installed at the Brooklyn Center Transit Center (BCTC), the route's northern terminus, and eight 150 kW plug-in garage chargers and other associated charging infrastructure installed at the Fred T. Heywood (Heywood) Garage.

As of 2024, Metro Transit's Zero-Emission technology inventory includes:

(8) 60-foot 2019 New Flyer Xcelsior Charge Battery Electric Buses (466 kWh),
(8) Siemens plug-in chargers (150 kW) located at the Heywood Garage.

Metro Transit's two one-route overhead conductive chargers (300 kW) located at BCTC were discontinued in 2023 due to poor reliability and safety concerns with the equipment.

Zero-Emission Bus Transition Plan

Under state statute, the Metropolitan Council is responsible for developing a Zero-Emission Bus and electric vehicle transition plan and revising the plan at least once every three years (Minnesota Session Laws 2024 Regular Session Chapter 127 – HF 5247 Article 3 Section 106).[1] The initial Metro Transit Zero-Emission Bus Transition Plan was submitted to the Legislature in February 2022. The plan was revised for the first time in February of 2025. The 2025 Transition Plan identifies short (2025-2030) and long (2030 and beyond) term opportunities, risks, and implementation strategies to transition Metro Transit's bus fleet towards zero-emission technology. Refer to Section 1 of Metro Transit's Zero-Emission Bus Transition Plan (February 2025) for further discussion of the Transition Plan's purpose and context.

Transition Progress

Key progress in 2024 towards Metro Transit's zero-emission transition include:

- Construction at the East Metro Garage to support 5 battery electric buses, 4 chargers, and charge management software to enter revenue service in 2025 as part of the Gold Line project.

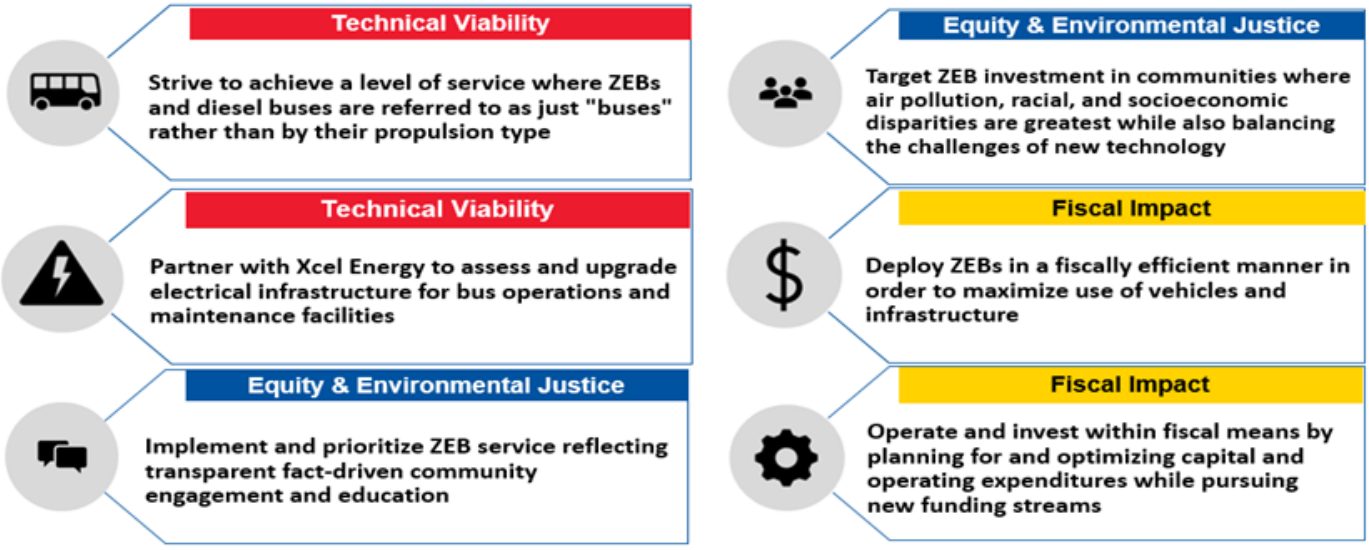
[1] When the ZEBTP was originally developed, state statute (Minn. Stat. 473.3927) required the Metropolitan Council to revise the plan at least once every five years. New state statute (posted 6/5/2024) requires plan revision at least once every three years.

- Purchasing 20 40-foot battery electric buses, 22 chargers, and charge management software in support of local service routes. This includes procuring from multiple manufacturers following strategies outlined in the Transition Plan.
    - 8 buses funded in part by a successful 2021 Low Emissions or No Emissions grant from the Federal Transit Administration (FTA).
    - 12 buses and 15 chargers funded in part by a successful 2023 Low Emissions or No Emissions grant from the Federal Transit Administration (FTA).
    - Matching funds for 2023 Low Emissions or No Emissions grant provided by Minnesota Department of Transportation (MnDOT) Infrastructure Investment and Jobs Act (IIJA) match Program.
- Aligning capital plans with the 2025-2030 target for 20% of 40-foot bus replacement procurements to be electric buses.

Guiding Principles

Three guiding principles and six supporting actions were established as the framework for the Transition Plan and for use in defining what a successful transition towards ZEBs would look like (Figure 1). The guiding principles are: Technical Viability, Equity and Environmental Justice, and Fiscal Impact.

Figure 1: Zero-Emission Bus Transition Plan (2025) Guiding Principles and Supporting Actions



Key Performance Indicators (KPIs)

The Transition Plan established eight key performance indicators (KPIs) for annual reporting in alignment with the Transition Plan's guiding principles (Table 1). This 2024 Annual Report documents the performance of Metro Transit's Zero-Emission program from launch in 2019 through calendar year 2024. As of 2024, all of Metro Transit's ZEB's are battery electric buses. A summary of each KPI is presented in the following sections.

Table 1: Zero-Emission Bus Transition Plan Key Performance Indicators

Key Performance Indicators	Guiding Principles		
	Technical Viability	Equity & Environmental Justice	Fiscal Impact
Fleet Mileage	◆		◆
Bus Availability	◆		◆
Bus Reliability	◆	◆	◆
Infrastructure Availability	◆		◆
Infrastructure Reliability	◆	◆	◆
Environmental Impact		◆	
Equity & Environmental Justice		◆	
Energy Cost per Mile	◆		◆

2024 Factors Impacting Multiple KPIs

Performance across multiple battery electric bus KPIs declined in 2024. This was largely influenced by numerous bus high voltage battery pack replacements.

In 2024, a significant number of battery electric bus high voltage battery pack replacements were needed. Although battery pack replacement was completed by the manufacturer under warranty, these replacements led to extended out-of-service times reducing the number of battery electric bus miles driven and decreasing battery electric bus availability and reliability.

Metro Transit removed on-route chargers from service in June 2023 due to ongoing reliability and safety issues. After several months of investigation, use of these chargers was permanently discontinued. Service schedules were reduced to reflect a garage-only charging strategy in December 2023 as part of quarterly service changes.

In 2021, battery electric buses were out of service from March to November while plug-in chargers at the Heywood Garage were replaced under warranty. Therefore, 2021 data referenced throughout this report reflects data for the approximately 90 days the battery electric buses were in service.

Fleet Mileage

What is Being Measured?

- The total number of miles driven by battery electric buses each year.

How is it Being Measured?

- Total odometer miles for the battery electric buses.

Why is it Important?

- As Metro Transit makes progress towards transitioning its fleet to zero emission buses, including battery electric buses, the total number of fleet miles driven by zero emission buses will increase. Comparing annual vehicle mileage for battery electric buses using the **Fleet Mileage** metric will help depict how they perform in our service environment.

2024 Performance

In 2024, the battery electric bus fleet drove a total of approximately 64,000 miles (Table 2). The percentage of scheduled battery electric bus miles successfully driven by a battery electric bus declined significantly in 2024 compared to prior years (Figure 2). The 2024 results translate to 51% of the planned electric bus miles being driven by an electric bus. This decline was largely driven by the need for numerous bus high voltage battery pack replacements. Prior to the C Line Electric bus pilot, midlife battery replacements were planned for all battery electric buses. However, individual battery pack failures led to the need for reactive maintenance on the electric fleet. Overall, the average Metro Transit battery electric bus drove 85% fewer miles than its diesel counterpart (Figure 3).

Table 2: Total Annual C Line Miles Driven by Propulsion Type (2019-2024)

	2019	2020	2021	2022	2023	2024
Annual C Line ZEB Miles*	66,400	162,700	37,800	175,300	117,400	64,000
Annual C Line Diesel Miles*	312,600	466,700	625,200	476,900	561,800	631,100

**Values rounded to nearest 100*

Figure 2: Percent of Electric Bus Miles Driven vs. Scheduled (2019-2024)

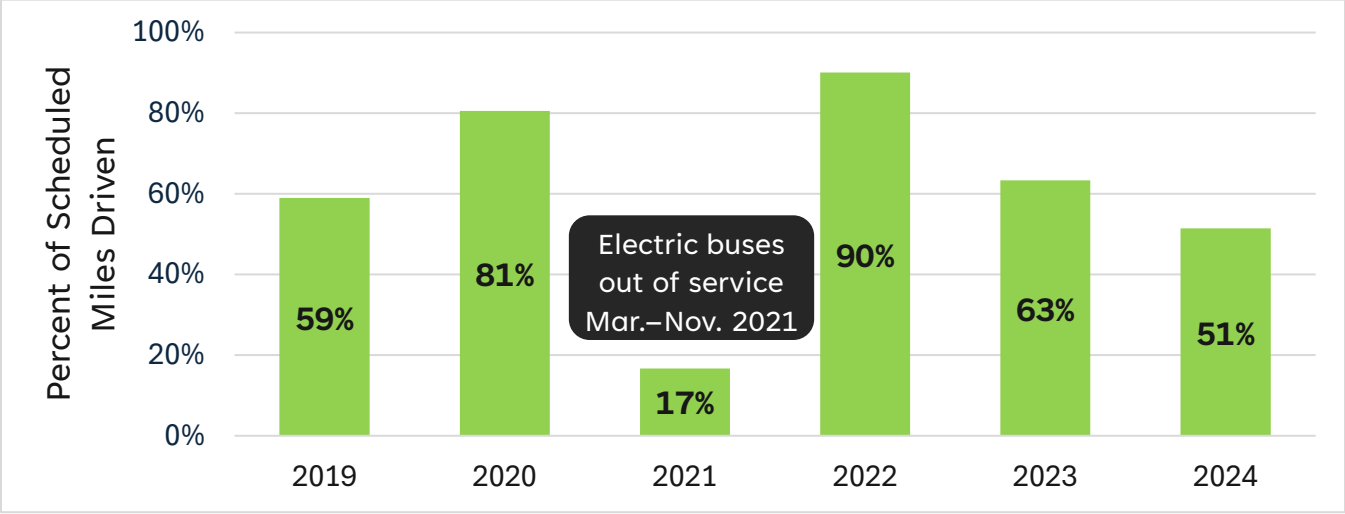
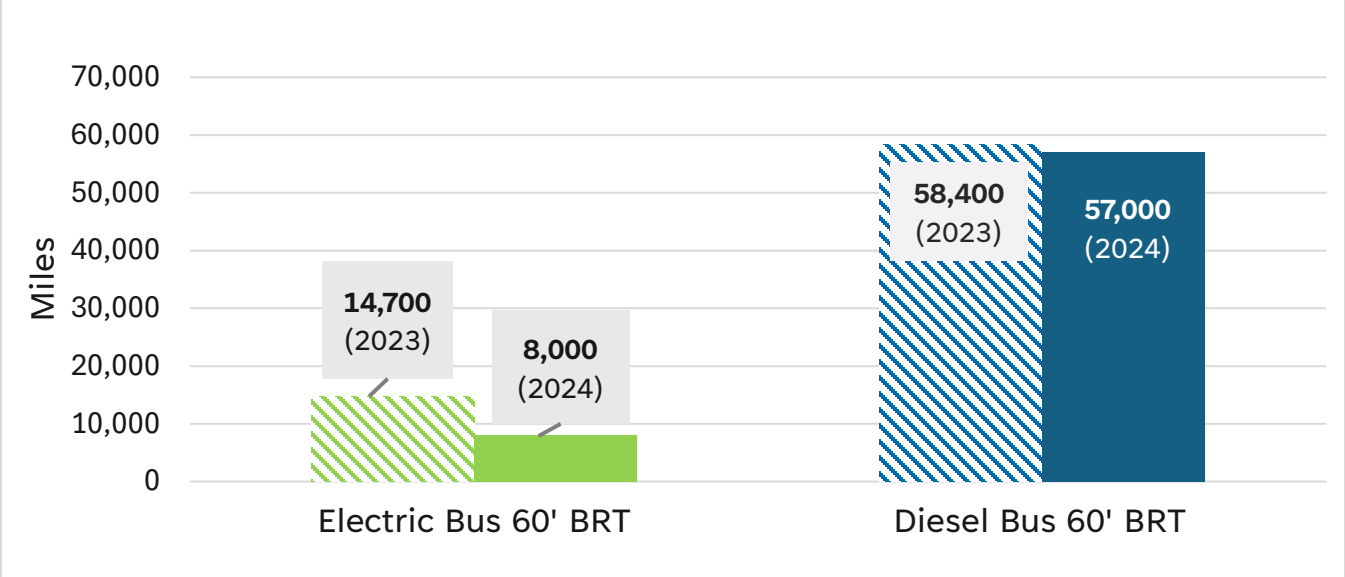


Figure 3: Annual Average Miles Per Bus by Propulsion Type



Bus Availability

What is Being Measured?

- The percent of battery electric buses available for use in service.

How is it Being Measured?

- The total number of days each bus is available for use in service divided by the total number of planned service days.

Why is it Important?

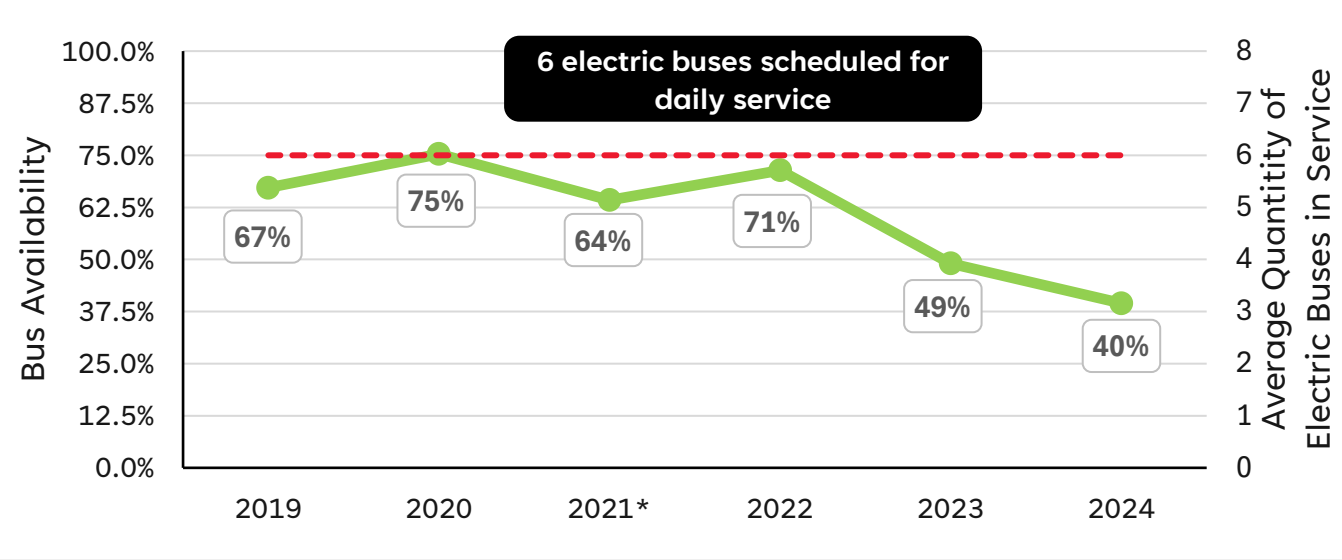
- The **Bus Availability** metric quantifies bus readiness and helps Metro Transit assess product availability to consistently provide reliable service.

2024 Performance

Battery electric bus availability declined in 2024 (Figure 4). This decline was largely influenced by battery failures and the time needed for the manufacturer to complete these repairs under warranty, which led to extended time out of service.

As of 2024, Metro Transit owns eight battery electric buses. On a typical day, six electric buses are planned to be used in service while the remaining two buses are spares to allow for non-revenue needs such as maintenance and training. In 2024, an average of just above three battery electric buses were available per day. When an electric bus was not available, a diesel bus was used in its place to ensure reliable service to customers.

Figure 4: Average Annual ZEB Availability (2019-2024)



**2021 metrics measured for the 90 days electric buses were used in revenue service*

Bus Reliability

What is Being Measured?

- The mean (average) distance between chargeable roadcalls. Chargeable roadcalls are defined as instances when a bus requires unplanned maintenance attention while in service.

How is it Being Measured?

- The number of miles traveled divided by the number of chargeable roadcalls.

Why is it Important?

- The **Bus Reliability** metric will help Metro Transit evaluate how often a bus breaks down while in service to assess the impact battery electric buses have on service reliability and customer experience.

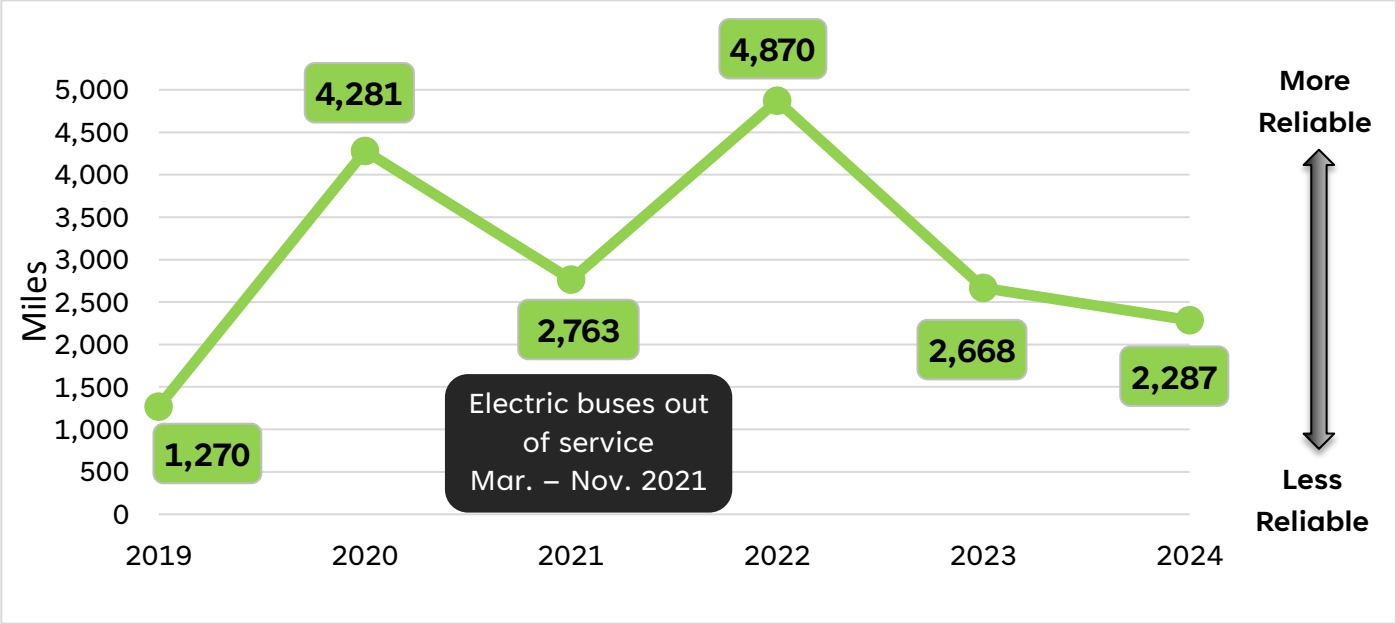
2024 Performance

In 2024, the mean distance between chargeable roadcalls for the battery electric bus fleet was approximately 2,290 miles compared to approximately 8,210 miles for comparable 60' diesel BRT buses (Table 3). Battery electric bus reliability declined slightly in 2024, driven by the significant number of battery pack replacements and reduced battery electric bus fleet mileage (Figure 5). Diesel buses were able to drive an average of nearly four times more miles between unplanned maintenance needs compared to the electric buses.

Table 3: Mean Distance Between Chargeable Roadcalls by Propulsion Type (2019-2024)

Mean Distance Between Chargeable Roadcalls	2019	2020	2021	2022	2023	2024
60' Electric BRT Buses	1,270	4,281	2,763	4,870	2,668	2,287
60' Diesel BRT Buses	8,247	8,656	5,201	8,862	7,700	8,214

Figure 5: Annual Mean Distance Between Chargeable Roadcalls (2019-2024)



Infrastructure Availability

What is Being Measured?

- Percent of chargers available to charge a bus for revenue service.

How is it Being Measured?

- Total number of days each charger is available to support deploying buses in revenue service divided by the total number of planned service days.

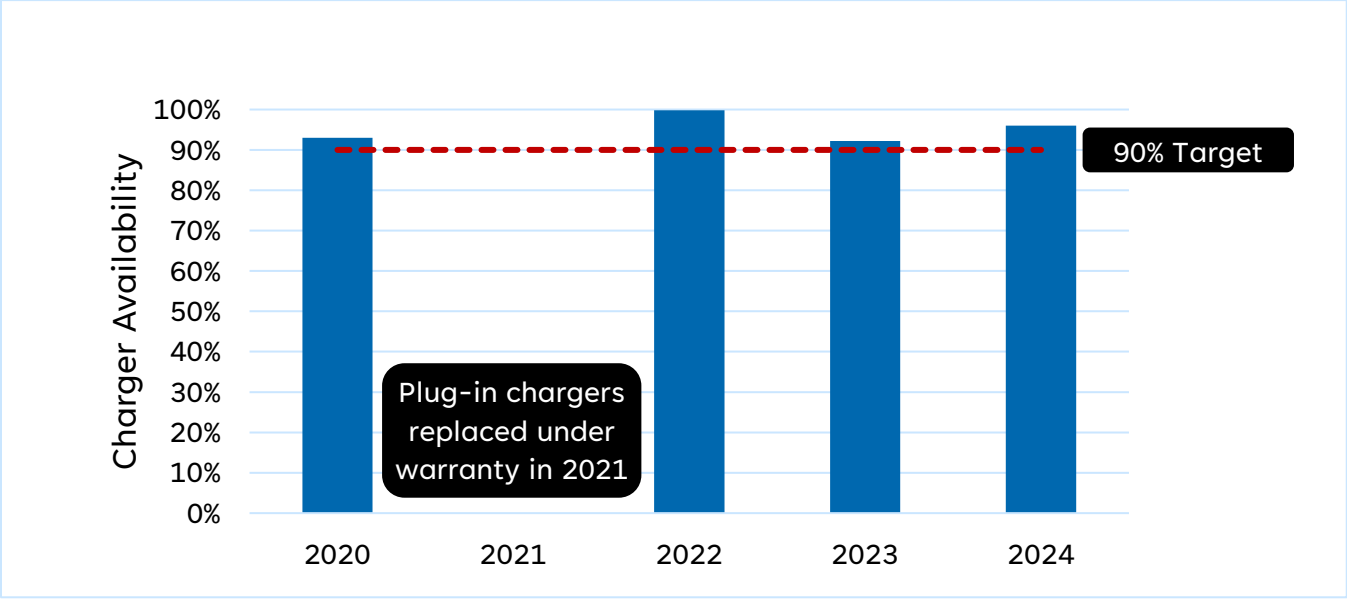
Why is it Important?

- Historically fuel pump availability was not a concern, however early charger deployments have had lower availability. The **Infrastructure Availability** metric will help Metro Transit assess technology ability to consistently provide reliable service.

2024 Performance

In 2024, plug-in charger availability met operational needs. Since the replacement of first-generation equipment under warranty in 2021, average annual garage (plug-in) charger availability has exceeded 90 percent and was 96% in 2024 (Figure 6).

Figure 6: Average Annual Plug-in Charger Availability (2020-2024)



Note: Metrics not reported for 2019 while commissioning was ongoing

Infrastructure Reliability

What is Being Measured?

- The quantity of incidents that take a charger out of service.

How is it Being Measured?

- Number of incidents that take a charger out of service.

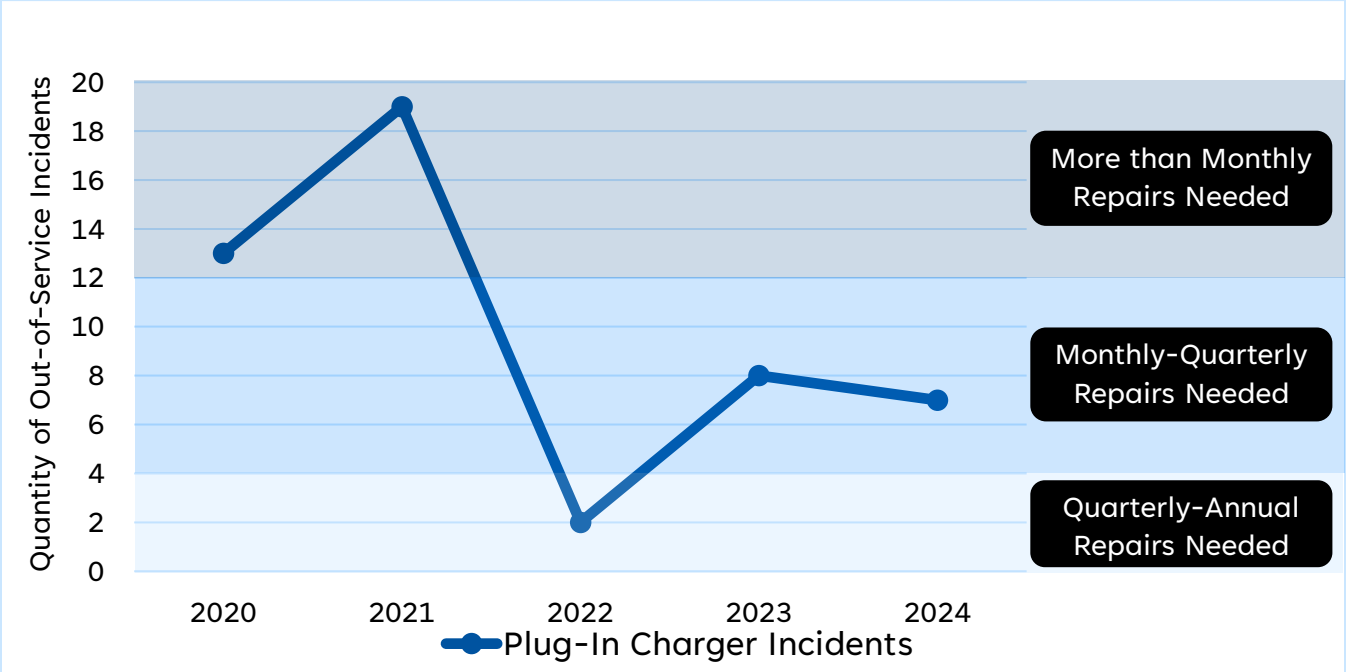
Why is it Important?

- The **Infrastructure Reliability** metric will help Metro Transit understand how often chargers must be temporarily removed from service for unplanned maintenance. This will help Metro Transit assess technology ability to consistently provide reliable service.

2024 Performance

In 2024, there were a total of 7 out-of-service incidents across the eight garage (plug-in) chargers (Figure 7). Power outage event tracking began in 2023 as chargers are impacted by changes to the incoming power. In 2023 and 2024 respectively, there was one power outage lasting two hours or less. There were two momentary power disruptions in 2023 and none in 2024.

Figure 7: Annual Out-of-Service Incident Frequency (2020-2024)



Note: Metrics not reported for 2019 while commissioning was ongoing.

Environmental Impact

What is Being Measured?

- Greenhouse gas (GHG) emission reductions compared to a baseline diesel fleet.

How is it Being Measured?

- Well-to-Wheel GHG reductions calculated using the Argonne National Laboratory's 2024 Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) model.[2] Well-to-wheel GHG estimates include the GHGs produced during fuel production and delivery (Well-To-Pump) in addition to GHGs produced during vehicle operation (Pump-To-Wheel).

Why is it Important?

- The **Environmental Impact** metric quantifies the impact transitioning towards zero-emission buses has on reducing transit vehicle emissions and demonstrates the community benefits that battery electric buses deliver to the region.

2024 Performance

In 2024, battery electric bus deployments reduced Metro Transit's well-to-wheel GHG emissions by approximately 32 metric tons of CO_2 equivalent. Over the five and a half years of operating the C Line, the electric bus fleet has resulted in a cumulative reduction in emissions of 458 metric tons of CO_2 equivalent (Figure 8). The electric bus fleet leads to a 17.4% reduction in emissions on a per mile basis.

Figure 8: Well-to-Wheel GHG Emission Reduction Equivalencies (2019-2024)

GHG emissions from 107 gasoline-powered passenger vehicles driven for one year

CO_2 emissions from 44,990 gallons of diesel consumed

CO_2 emissions from 95.4 homes' electricity use for one year

[2] Historically, Argonne National Laboratory's AFLEET model has been updated every 2-3 years to add additional features and reflect updated vehicle emissions factors. The 2024 Annual Report uses the most recent 2024 AFLEET model and MROW eGRID 2023 Table 2 resource mixes.

Equity and Environmental Justice

What is Being Measured?

- The percent of battery electric bus deployments on “High Priority” EEJ service blocks as defined in Section 7.5 of Metro Transit’s Zero-Emission Bus Transition Plan (February 2025). High priority service blocks have the greatest portion of bus mileage in High Priority (pink) EEJ Areas (Figure 9). EEJ priority areas were identified based on community input and ranking of seven different factors from the Metropolitan Council’s Equity Considerations for Place-Based Advocacy and Decisions dataset. Community input coalesced around cancer risk (a proxy for air quality), population density, and the percent of census tract population that identified as Black, Indigenous, and People of Color (BIPOC) as the top three factors when calculating census tract equity tiers.

How is it Being Measured?

- The number of battery electric bus deployments on “High Priority” EEJ service blocks divided by the total number of battery electric bus deployments.

Why is it Important?

- The **Equity and Environmental Justice** metric will help Metro Transit understand the impact battery electric bus deployment prioritization is having in the community based on environmental, racial, and socioeconomic considerations.

2024 Performance

As of 2024, Metro Transit’s battery electric bus pilot program includes one route, the METRO C Line. This route was selected to be the first route in the region to pilot electric bus service in part, due to an emphasis on targeting the investment in a heavily utilized transit corridor serving historically underinvested communities with historically higher rates of asthma in downtown Minneapolis, North Minneapolis, and Brooklyn Center. As a result of this prioritization, in 2024, 100% of battery electric bus deployments were on “High Priority” EEJ blocks (Figure 9).

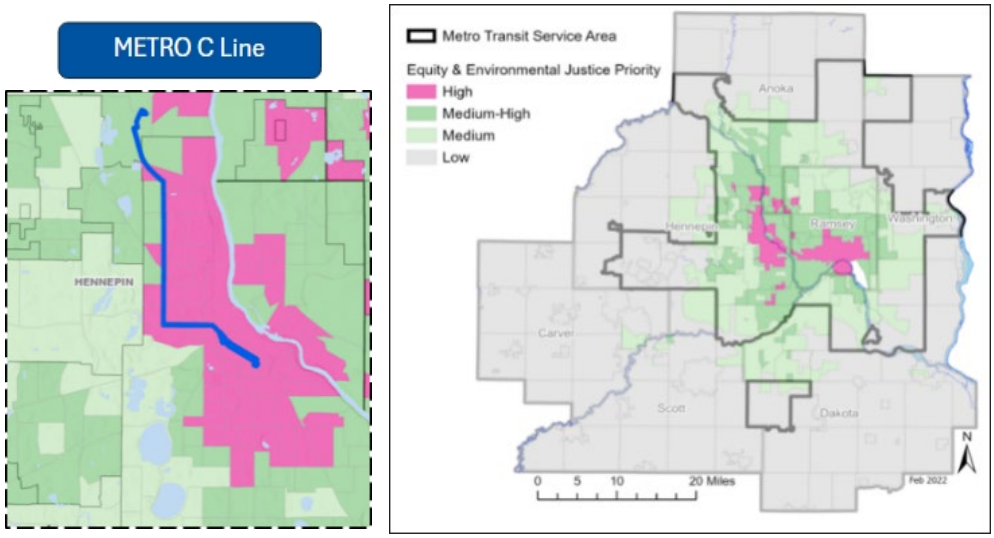


Figure 9: Equity and Environmental Justice Priority Areas and 2024 Battery Electric Bus Deployments

Energy Cost/Mile

What is Being Measured?

- Energy cost a bus uses to travel one mile inclusive of propulsion energy (diesel or electricity) and diesel fuel for bus auxiliary heat.[3]

How is it Being Measured?

- The total energy cost by vehicle group divided by the total miles traveled by that group.

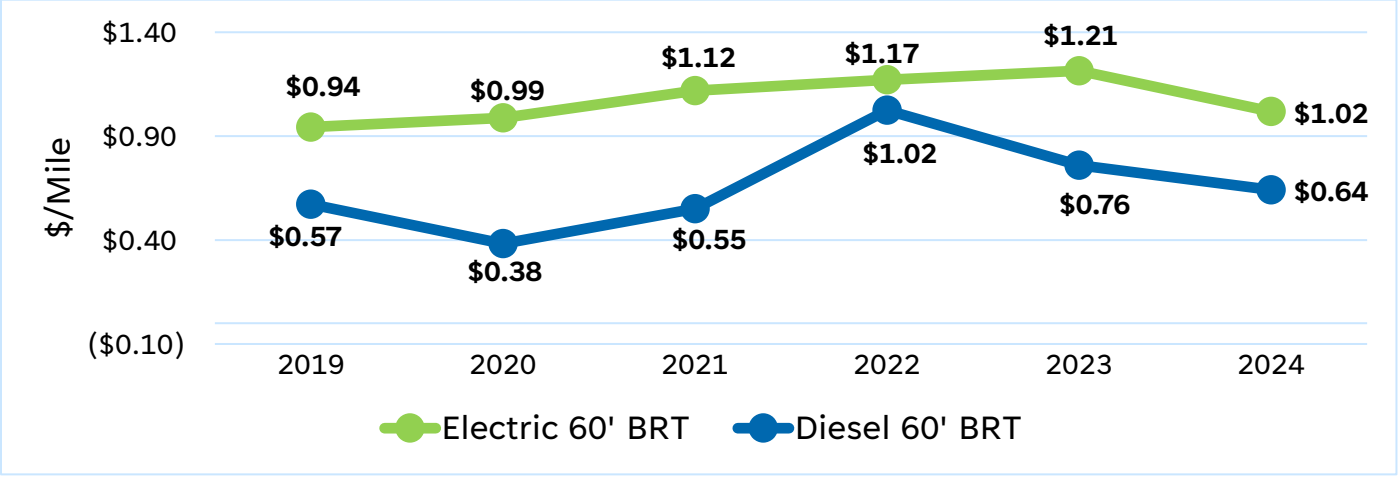
Why is it Important?

- The **Energy Cost/Mile** metric will help Metro Transit understand the ongoing energy costs and necessary budget to operate battery electric buses.

2024 Performance

In 2024, energy costs for battery electric buses were approximately $1.02 per mile. Throughout the years, battery electric bus energy costs per mile in Metro Transit's experience have been more expensive than diesel buses (Figure 10). The improvement in energy cost per mile between 2023 to 2024 is in part due to shifting charging times to overnight garage charging when electricity costs are more economical. The discontinuation of on route charging during the most expensive times of the day aided in shifting more charging to overnight. Refer to Section 11.9.3 of Metro Transit's Zero-Emission Bus Transition Plan (February 2025) for further discussion of electricity costs.

Figure 10: Average Annual Energy Cost per Mile by Propulsion Type (2019-2024)



[3] All Metro Transit buses regardless of propulsion type include auxiliary diesel heaters for passenger comfort.

Conclusion (2024 Performance)

Annual KPI performance for calendar year 2024 is summarized in Table 4 compared to calendar year 2023. Key takeaways from 2024 include:

- Fleet KPIs (mileage, bus availability, bus reliability) declined from 2023 to 2024 largely due to a continued need to replace failed battery packs under warranty.
- Energy cost per mile for battery electric buses remains higher than diesel buses though battery electric bus energy cost per mile improved in part due to the discontinuation of on route charging during peak times of day.
- Plug-in chargers are working as planned following replacement under warranty in 2021.
- 100% of 2024 battery electric bus deployments were on "High Priority" EEJ blocks.

Table 4: 2024 Annual KPI Summary

KPI	Electric Bus 2023	Electric Bus 2024
Fleet Mileage*	117,400	64,000
Bus Availability *(% of electric buses Available for Use in Revenue Service)*	49%	40%
Bus Reliability *(Mean Distance Between Chargeable Road Calls)*	2,668	2,287
Infrastructure Availability *(Avg. Full Days Available to Charge a Bus for Use in Revenue Service)*	Garage: 92%	Garage: 96%
Infrastructure Reliability *(Total incidents that take chargers out of service)*	Garage: 8	Garage: 7
Environmental Impact *(GHG [CO_2e] Reduction in Metric Tons)*	60	32
Equity and Environmental Justice (EEJ) *(% of electric buses Deployments on "High Priority" EEJ Blocks)*	100%	100%
Energy Cost/Mile	$1.21 *($0.76 for diesel bus)*	$1.02 *($0.64 for diesel bus)*

** Rounded to the nearest 100 miles*