Zero-Emission Bus Pilot Update

Background

- December 2018, the California Air Resources Board passed the Innovative Clean Transit (ICT) rule
  - Requires transitioning to zero-emission bus fleet by 2040
  - Purchasing requirements begin in 2023
- June 2020, the OCTA Board of Directors (Board) approved the OCTA Zero-Emission Bus (ZEB) Rollout Plan
  - Includes a mix of zero emission technologies
- February 2020, OCTA initiated the Fuel Cell Electric Bus (FCEB) Pilot
  - Ten 40-foot FCEBs, a hydrogen fueling station, maintenance shop upgrades
  - Grant funded $13.2M - California Air Resources Board and South Coast Air Quality Management District
- July 2022, OCTA initiated the Battery Electric Bus (BEB) Pilot
  - Started with two BEBs, eight more arrived in December 2022
  - Grant funded $10.3M - California Transportation Commission Solutions for Congested Corridors Program (SCCP) under SB 1 (Chapter 5, Statutes of 2017) and the Low Carbon Transit Operations Program (LCTOP)
- August 2022, Battery Electric Paratransit Bus Pilot
  - FTA awarded $2.5M for ten battery-electric paratransit buses and infrastructure
  - Grant funded $2.5M - FTA's Buses and Bus Facilities, and Low and No Emission Vehicle programs

ZEB Pilot Buses

Vehicle Information	FCEB	BEB	CNG
Number of Buses	Ten	Ten	Ten
Manufacturer/Model	New Flyer Xcelsior	New Flyer Xcelsior	New Flyer Xcelsior
Model Year	2018	2020	2016
Bus Cost Each	$1.3M	$1.1M	$580,000
Length	40 feet	40 feet	40 feet
Curb Weight	33,560 pounds	33,500 pounds	30,000 pounds
Propulsion System	Ballard Fuel Cell 85 kW	Siemens Electric Motor 210 kW	Cummins CNG Engine 280 hp
	Siemens Electric Motor 210 kW		Allison Transmission
Energy Storage	Five Composite Fuel Cylinders		Six Composite Fuel Cylinders
	Lithium-Ion Batteries 100 kW	Lithium-Ion Batteries 440kW	
Operating Range	300 miles	200 miles	400 miles

*FCEB – Fuel Cell Electric Buses
*BEB – Battery Electric Buses
*CNG – Compressed Natural Gas

FCEB

- Deployed in February 2020
- Same standard equipment as the OCTA CNG Bus
- Fuel cell acts as an onboard battery charger
- Operated 1,037,910 miles
- Usable operating range 250 miles
- Operates on 80% of OCTA routes
- Refuel in six to ten minutes, similar to CNG

BEB

- Deployed in December 2022
- Same standard equipment as the OCTA CNG bus
- 100% battery electric
- Operated 145,618 miles
- Usable operating range 150 miles
- Operates on 20% of OCTA routes
- Recharge in four hours

Key Performance Indicators

Bus Availability

- Percentage of days the buses are available compared to the total number of days that the buses are planned for revenue service

Miles Between Road Calls

- A road call is defined as a revenue vehicle mechanical or system failure that causes the bus to be replaced in route or causes a significant delay in the bus schedule

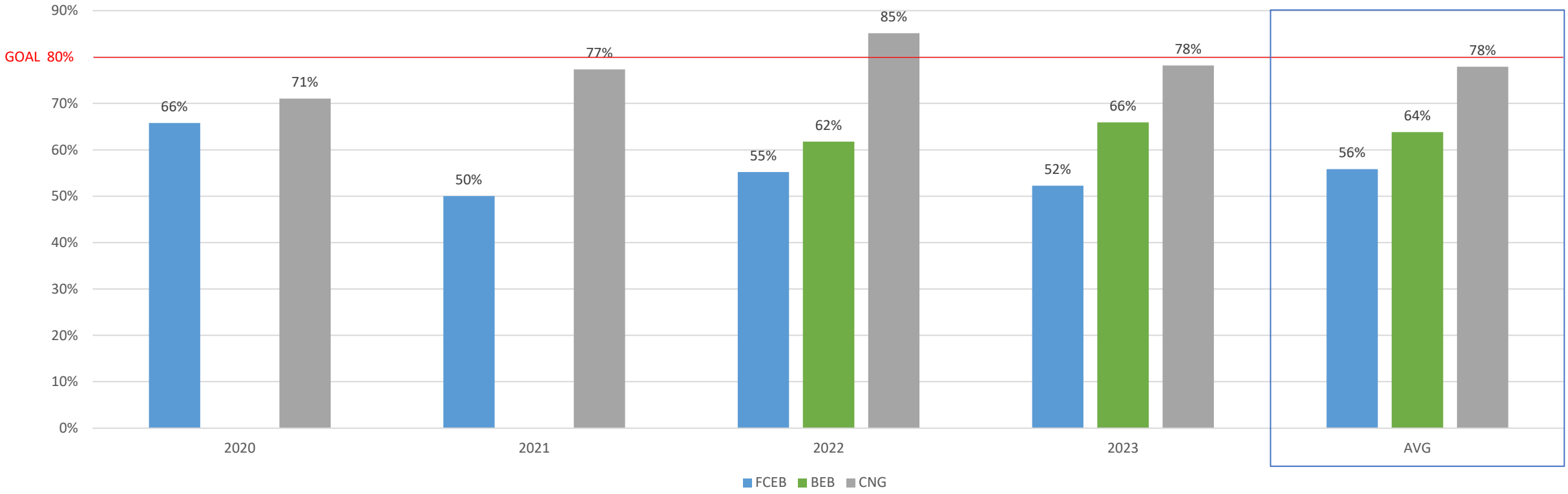
Fuel Economy

- Fuel economy is a measurement of how efficiently the fuel is being used by the propulsion system

Cost Per Mile (CPM)

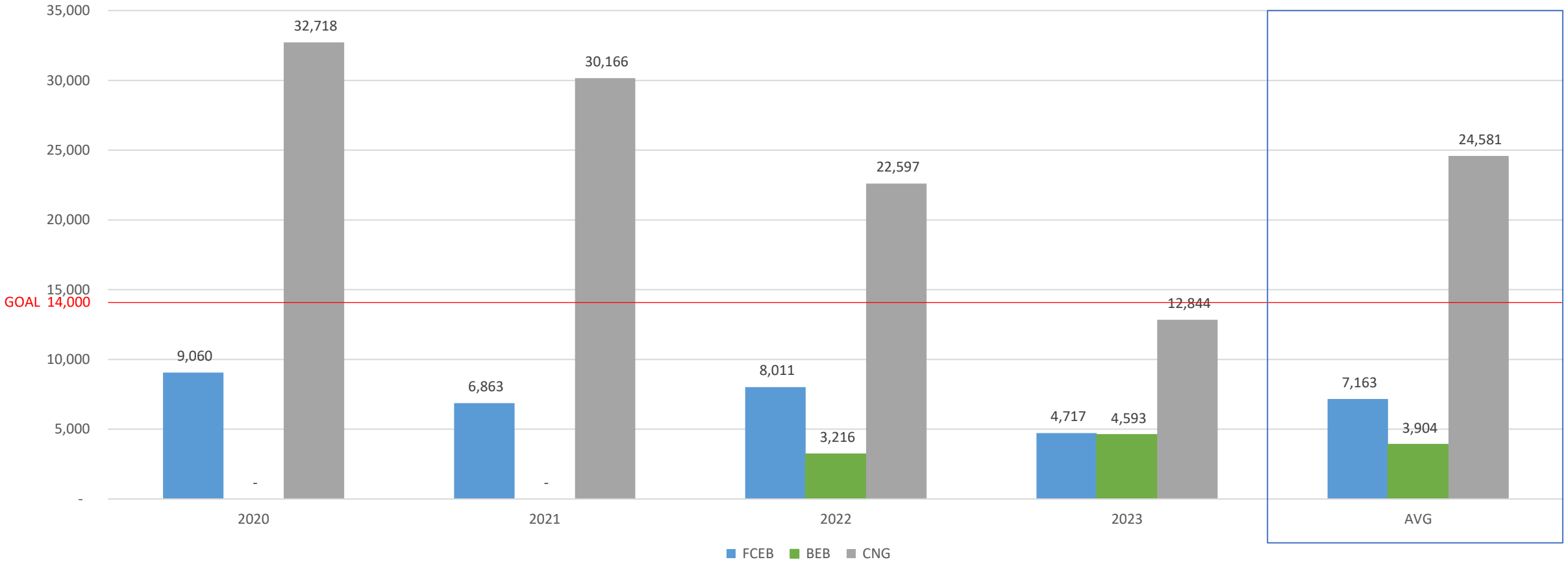
- OCTA calculates total CPM for each technology by tracking parts and labor cost and fuel cost
- CPM is the lowest common denominator between the three technologies

Bus Availability



Downtime Reasons	FCEB	BEB	CNG	Description
Propulsion System	5.8%	2.5%	2.3%	Engine, Trans, Batteries, Fuel Cell
Unscheduled Maintenance	25.6%	33.4%	16.3%	General Repairs
Scheduled Maintenance	11.7%	1.0%	3.3%	Preventive Maintenance, Training, Special Events

Miles Between Road Calls



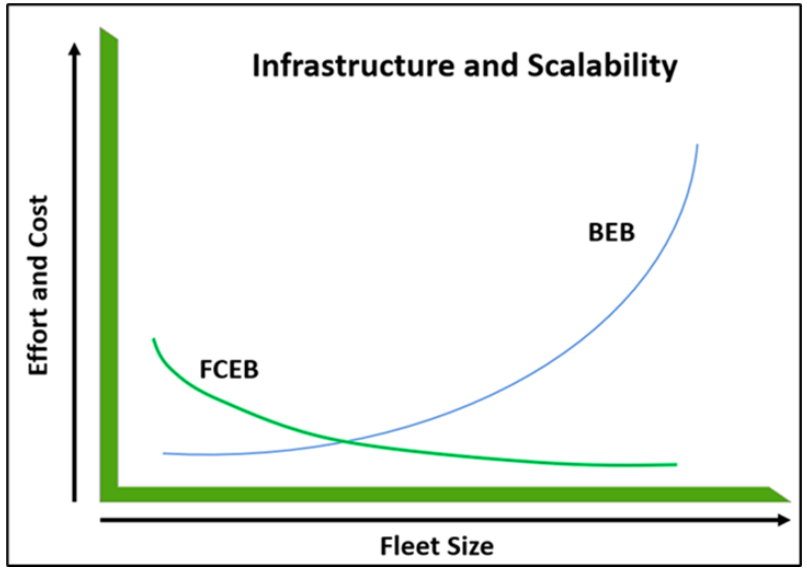
Fuel Economy

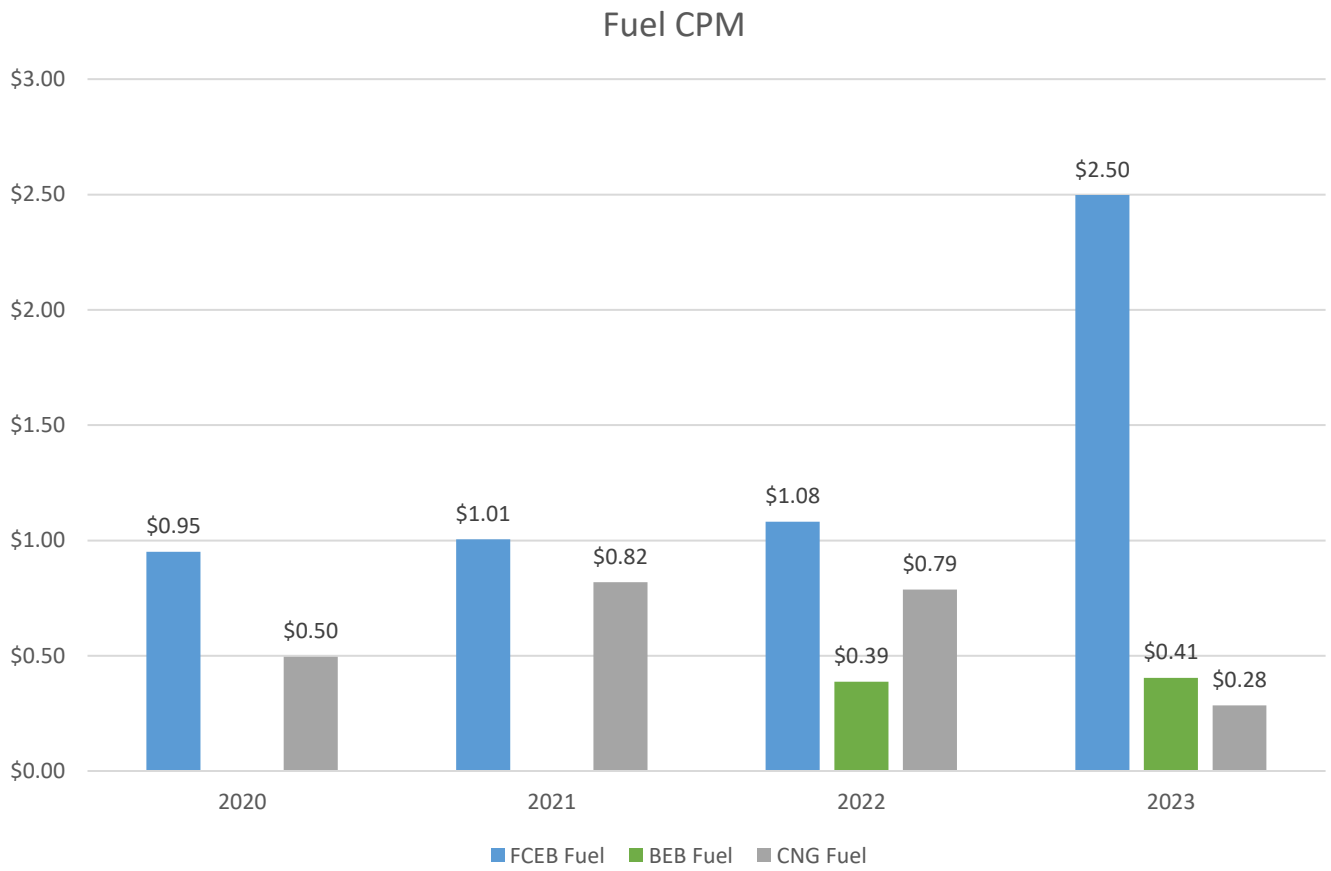
Measurement	FCEB	BEB	CNG
Miles per diesel gallon equivalent	8.92	17.05	3.91
Miles per kilogram equivalent	7.9	13.63	3.57
Miles per kilowatt	0.24	0.46	0.11

Fuel Cost	FCEB	BEB	CNG
Per kg, kW, Therm, respectively	$22.25	$0.17	$1.08

Cost per Mile

- FCEB fuel cost increased 131% due to O&M agreement
- CNG fuel cost decreased 64% due to lower renewable natural gas prices
- BEB electricity cost remained neutral, but will increase when bus chargers are activated

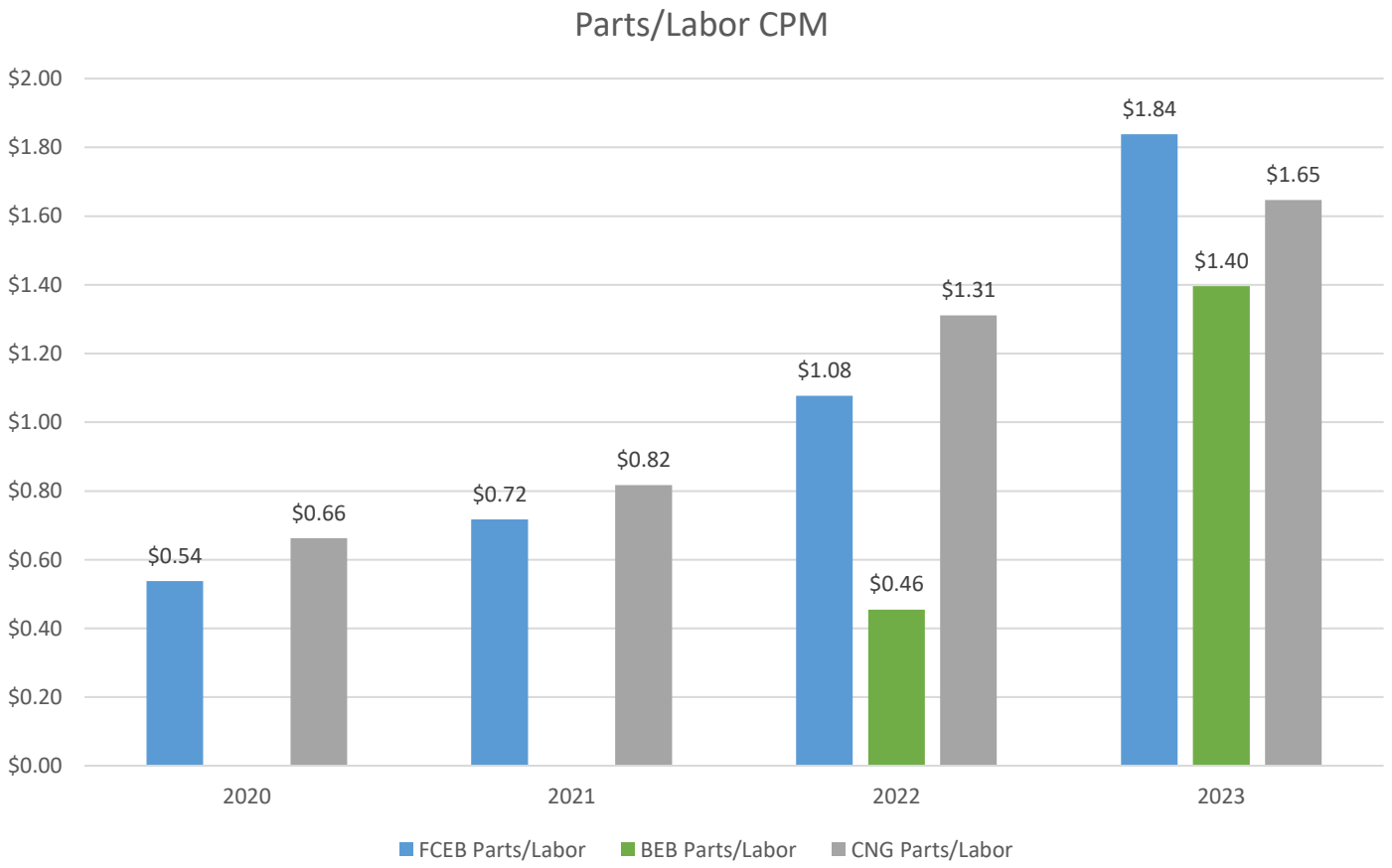




*O&M – Operations and Maintenance

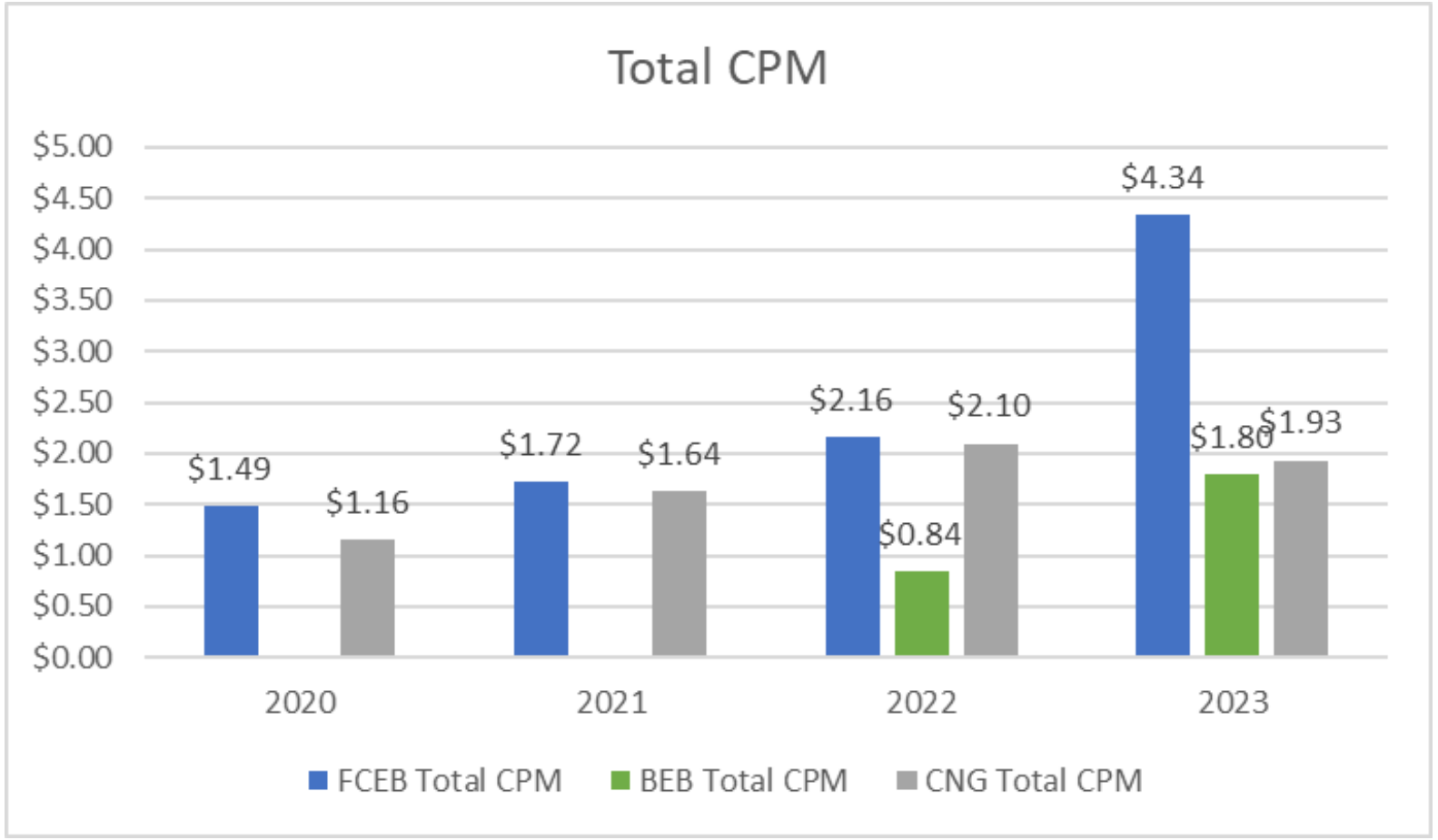
Cost per Mile (Cont.)

- CNG normal increases due to age
- FCEB increased due to increases in parts
- BEB increased due to failures outside the warranty



Cost per Mile (Cont.)

- Total CPM includes
  - Fuel CPM
  - Parts and Labor CPM
- FCEB four-year average
  - $2.43, 42% > CNG
- BEB two-year average
  - $1.32, 23% < CNG



Infrastructure

BEB Charging Stations

- Located at the Garden Grove Base
- Ten charging stations
- 50-150kW each
- Fully operational in February 2024

Hydrogen Fueling Station

- Located at the Santa Ana Base
- Two dispensers
- 50 buses per day
- Fully operational since 2020

Next Steps

- Expand ZEB Pilot
  - 40 additional 40ft FCEBs
  - Ten additional 40ft BEBs
  - Ten battery electric paratransit buses/vans
- Add Infrastructure
  - Second H2 Fueling Station at Garden Grove Base
  - Ten additional BEB Charging Stations at Santa Ana Base
  - Battery Charging Stations for battery electric paratransit buses/vans

ZERO EMISSION
FOR A HEALTHY
COMMUNITY