December 8, 2022

To: Transit Committee

From: Darrell E. Johnson, Chief Executive Officer

Subject: Zero-Emission Bus Pilot Update

Overview

On October 8, 2020, the Orange County Transportation Authority Board of Directors approved the purchase of ten hydrogen fuel-cell electric buses and ten plug-in battery-electric buses to gain necessary operational and technological experience in preparation for transitioning the Orange County Transportation Authority's bus fleet to zero-emission technologies. This report provides an update on the zero-emission bus pilot performance and deployment efforts.

Recommendation

Receive and file as an information item.

Background

In 2018, the California Air Resources Board (CARB) passed the Innovative Clean Transit (ICT) rule requiring all public transit agencies to transition their bus fleets to zero-emission technologies by the year 2040. Transit agencies were required to develop and submit a rollout plan that describes how the agency will transition to a zero-emission bus (ZEB) fleet by 2040, with purchasing requirements beginning in 2023. On June 22, 2020, the Orange County Transportation Authority (OCTA) Board of Directors (Board) approved the OCTA ZEB Rollout Plan, which included the deployment of a mix of hydrogen fuel-cell electric buses (FCEB) and plug-in battery-electric buses (BEB) to prepare for compliance with the ICT rule.

In anticipation of the ICT rule, OCTA developed a strategy to pilot both FCEB and BEB technologies using available grant funding. Piloting both technologies will allow OCTA to gain direct experience with operational effectiveness, maintenance, and cost. OCTA has initiated both pilots as outlined in this report. In 2017, OCTA entered into an agreement to utilize grants provided by CARB and the South Coast Air Quality Management District to purchase ten FCEBs in lieu

of compressed natural gas (CNG)-powered buses to replace buses that had reached their useful life. The grant also funded the required supporting infrastructure, such as the hydrogen fueling station and maintenance shop upgrades.

On February 9, 2020, OCTA initiated the FCEB pilot, which included ten, 40-foot FCEBs operating in OC Bus fixed-route service, and a hydrogen fueling station capable of fueling up to 50 buses per day.

On October 12, 2020, the Board approved the purchase of ten plug-in BEBs as a pilot for operation in OC Bus fixed-route service. To support the charging of these vehicles, OCTA is partnering with Southern California Edison (SCE) and the Charge Ready Transport Program to provide electrical infrastructure at the Garden Grove Bus Base. In addition to the equipment being provided by SCE, OCTA is required to provide the BEB charging stations.

On June 14, 2021, the Board approved the purchase of ten, 150-kilowatt (kW) BEB charging stations that will provide power to ten depot charging stations. The chargers can supply power evenly or sequentially to the charging stations. This allows buses to be intelligently charged in a manner tailored to the power and logistical needs of each bus. BEBs can be fully charged in less than four hours.

The first two BEBs arrived in December 2021. After acceptance testing and working through supply chain issues, the buses went into OC Bus fixed-route service in July 2022. The remaining eight buses are arriving between October and December 2022. Delays in receiving the remaining eight BEBs are related to electronic parts shortages and other supply chain issues. The performance of the two BEBs is provided below.

The BEB charging stations have arrived and will be installed following the completion of infrastructures upgrades being made by SCE. The charging stations are expected to be installed and operational by January 2023. In the interim, the BEBs are being charged using the pay-per-use level III charging stations installed at both directly-operated bus bases.

On August 16, 2022, the Federal Transit Administration (FTA) awarded OCTA $2.5 million in federal funding toward the purchase of ten battery-electric buses that will replace ten gasoline OC ACCESS buses. OCTA applied for and was awarded this funding through a competitive FTA grant program.

Discussion

The FCEBs have been in service for 33 months. The performance data included in this report will cover 32 months of operation from February 2020 through October 2022. The two BEBs have been in service for five months and their performance will be through October 2022. The BEB data is only informational and will not be comparative until all ten buses are fully deployed into service, which is expected to occur in January 2023. The performance of the ten FCEBs and two BEBs is measured against the performance of ten CNG buses that were selected at the onset of the pilot to provide comparative performance analytics. General vehicle information on all three bus types is provided in the following chart.

Vehicle Information	FCEB	BEB	CNG Bus
Number of Buses	10	10	10
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**	**350 miles**

The key performance indicators include bus availability, miles between road calls (MBRC), fuel economy, and cost per mile (CPM).

Bus availability, which is a measure of reliability, is the percentage of days the buses are actually available compared to the total number of days that the buses are planned for revenue service. Buses available for service may be used in revenue service, training, special events, or they may be available but just not used. Buses unavailable for service may have had mechanical issues with the propulsion system (fuel-cell system, electric drive system, engine), regular scheduled maintenance, or required unscheduled repairs.

The OCTA performance standard for bus availability is 80 percent; however, for new bus technology, especially during the onset of a pilot, availability can be challenging as the system issues are analyzed and buses are out of service for a longer period. Both the ten FCEBs and the ten CNG buses fell below the target.

Bus availability can fluctuate for a variety of reasons and lengths of time due to the nature of repairs or scheduled service, eventually averaging out to meet the goal. However, due to the coronavirus pandemic, the drop in ridership, and subsequent drop in bus usage led to holding operational buses from service in order to rotate fleet usage. As a result, the availability for CNG buses was skewed. The CNG buses selected for this comparison achieved a 77 percent availability. Had the CNG buses not been held artificially, the goal would have been met.

Unlike the CNG buses, the FCEBs did not achieve the goal for a variety of mechanical and electrical issues. The FCEBs dropped slightly from 59 percent availability in 2021 to 57 percent availability in 2022. Considering this is new technology and buses may be placed out of service for longer periods of time as issues are analyzed and often require factory support, the expectation is that availability will improve as experience with the technology grows. Another contributing factor to availability was supply chain issues. In one example, two FCEBs were out of service for more than two months waiting for parts.

The two BEBs achieved 76 percent availability within five months of operation.

MBRC is a measurement of bus reliability. A road call is defined as a revenue vehicle mechanical or system failure that causes the bus to be replaced on a route or causes a significant delay in the route schedule.

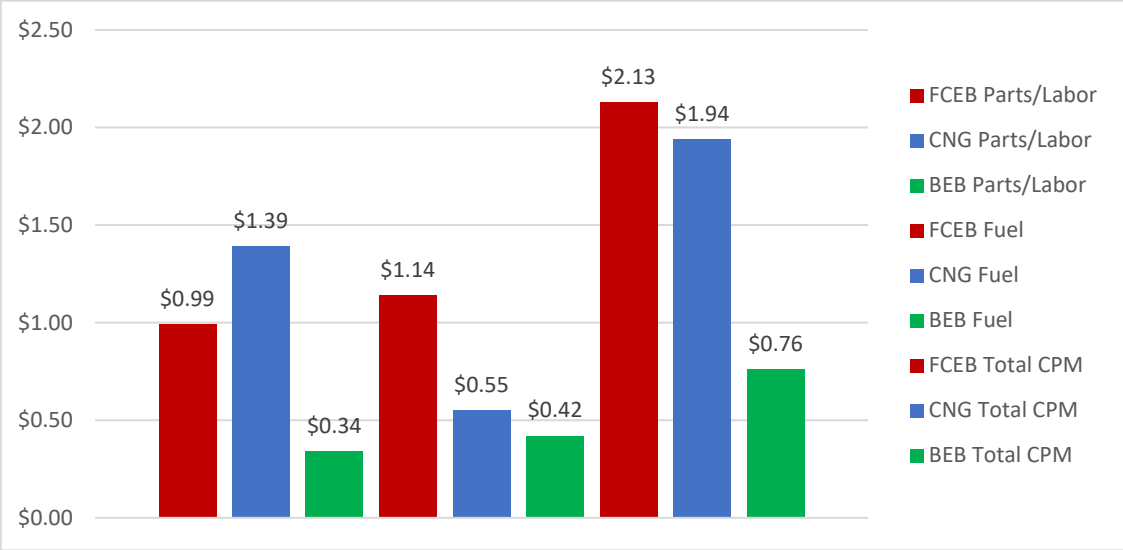
The OCTA performance standard for MBRC is 14,000 miles. The CNG buses regularly exceeded the standard achieving a total of 29,316 MBRC over the last 32 months.

The FCEBs are not meeting the standard, achieving only 5,254 MBRC. The FCEBs only met the MBRC standard in five of the 32 months. Taking into consideration that this is new technology and only 30 FCEBs were built by this manufacturer at the time of delivery, peak performance may be delayed compared to a conventional transit bus. In the early months there were a variety of issues including software and calibration issues, but more recently most of the road calls are related to electrical components. In terms of the fuel cell performance, it is performing at parity with the CNG engine.

Fuel economy is a measurement of how efficiently the fuel is being used by the propulsion system. Because CNG is measured in Therms, hydrogen is measured in kilograms, and battery power in kW, fuel types are converted to a common measurement. In this case, all three technologies are measured in miles per diesel gallon equivalent (mpdge). CNG buses have consistently averaged 4.14 mpdge, while FCEBs have more than doubled that with an average of 9.63 mpdge. FCEB fuel economy is 2.3 times greater than a CNG bus. The higher fuel economy on the FCEB helps offset the higher cost of hydrogen fuel. The current CPM for hydrogen fuel is $1.14 compared to the CNG fuel at $0.55. The two BEBs in service have measured at $0.42 CPM. However, it is important to note that with electricity, cost is based on kW usage and due to current rate structures, as that usage increases the cost per kW also increases, which will increase the CPM.. The BEB fuel CPM is expected to increase when all ten buses are in service.

OCTA calculates total CPM for each technology by tracking parts and labor cost and fuel cost. Maintenance cost is categorized by each bus system to understand which components are the highest cost drivers.

As illustrated in the following chart, the parts and labor CPM for FCEBs is lower than CNG buses by approximately 28 percent. The parts and labor CPM for FCEBs is currently $0.99, compared to $1.39 for CNG buses. Adding fuel cost to parts and labor costs results in the FCEB total CPM exceeding the CNG bus total cost per mile by nine percent. The FCEB total CPM is $2.13, compared to the CNG buses at $1.93. Fuel cost is the highest cost driver for the FCEB. Preliminary CPM calculations show the BEB parts and labor cost at $.34 and fuel cost at $.042, for a total of $.076. Since BEBs share many of the same components with the FCEBs and as noted above electricity rates increase with usage and will therefore increase costs, the BEB CPM is expected to increase.



Hydrogen Fueling Station Update

In the first months of operation, the hydrogen fueling station experienced a variety of issues resulting in the station shutting down during operation. These issues were resolved with software updates while some issues required engineering reconfiguration. For the last year, the hydrogen fueling station has performed consistently well, matching the performance of the CNG fueling station. Monthly meetings with the fuel station provider are held to ensure incidents are discussed and resolved immediately. Although the hydrogen fueling station is performing well, there are times when the station is out of service resulting in buses not being fueled and not deployed into service. The CNG fueling station also goes down at times; however, fueling can be accomplished by sending buses to another base. Currently there is no backup fueling infrastructure, public or private, available for hydrogen.

Summary

After 33 months, much has been gained in terms of knowledge and experience from the ZEB pilot program. Although the performance of the FCEB is not yet meeting the OCTA standards in availability and MBRC, there is a greater understanding of the differences between the technologies, what components need improvement to improve reliability, and where training can be developed to help mitigate issues. Understanding the various costs to operate and maintain ZEBs helps drive financial planning and advocacy for funding and lowering costs, such as the need to find solutions to lower the cost of hydrogen fuel. As the ZEB pilot program continues with the addition of ten BEBs and ten battery-electric cutaway buses for paratransit services, OCTA will continue to gain necessary

operational and technological experience for each ZEB type available to shape and define the fleet mix required to meet the service demands of Orange County when utilizing ZEBs. Staff will keep the Board apprised of any changes in the ZEB Program and provide performance updates annually.

Attachment

None.

Prepared by:

Cliff Thorne
Director, Maintenance
(714) 560-5975

Approved by:

Johnny Dunning, Jr
Chief Operating Officer
(714) 560-5710