December 9, 2021

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 in order 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 (H2Bs) and plug-in battery-electric buses (BEBs) to prepare for compliance with the ICT rule.

Discussion

In anticipation of the ICT rule, OCTA developed a strategy to pilot both H2B 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 H2Bs 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 fueling station. A provision of the grant was a commitment to deploy the buses in regular service within disadvantaged communities.

On February 9, 2020, OCTA initiated the H2B pilot, which included ten, 40-foot H2Bs running in OC Bus fixed-route service, and a hydrogen fueling station capable of fueling up to 50 buses per day. The performance of the H2Bs to date is provided below.

On October 12, 2020, the Board approved the purchase of ten, plug-in BEBs as a pilot for operation of 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 Base. In addition to the equipment being provided by SCE, OCTA is required to provide the BEB chargers.

On June 14, 2021, the Board approved the purchase of ten 150 kilowatt (kW) BEB chargers 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.

Plug-in Battery-Electric Bus Update

The first two BEBs and the BEB chargers are expected to arrive in December 2021. The OCTA Maintenance Department will complete the necessary inspection and testing of these buses in revenue service before issuing the notice to proceed for the remaining eight buses. The remaining eight buses are expected to begin arriving in mid-May 2022. The battery chargers will be installed in conjunction with the SCE infrastructure upgrades, which are currently in the design stage.

Hydrogen Fuel-Cell Electric Bus Update

The H2Bs have been in service 22 months. The performance data included in this report will cover the first 20 months of operation from February 2020 through September 2021. The performance of the ten H2Bs is being measured against the performance of ten CNG-powered buses that were selected at the onset of

the pilot in order to provide consistent performance analytics. General vehicle information on both bus types is provided below.

Vehicle Information	**H2 Bus** 	**CNG Bus** 
Number of Buses	10	10
Manufacturer/Model	New Flyer/Xcelsior	New Flyer/Xcelsior
Model Year	2018	2016
Bus Purchase Cost	$1.3 million	$580,000
Length	40 foot	40 foot
Curb Weight	33,560 pounds	30,000 pounds
Propulsion System	Ballard FCvelocity-HD85, 85 kW Siemens Electric Motor, 210 kW	Cummins ISL-G 280 hp Allison B400 Transmission
Energy Storage	Five Composite Fuel Cylinders (Compressed Hydrogen) Lithium-ion Batteries (100 kW)	Six Composite Fuel Cylinders (CNG)
Operating Range	300 miles	350 miles

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

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 issues with the propulsion system (fuel-cell system, electric drive system), required regular scheduled maintenance, or required other 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 failures are analyzed and buses are out of service for a longer period of time. Both the ten H2Bs and the ten CNG-powered 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-powered buses was skewed. The CNG-powered buses selected for this comparison achieved a 73 percent availability.

Unlike the CNG-powered buses, the H2Bs did not achieve the goal for a variety of mechanical issues. The H2Bs dropped from 62 percent availability in the first six months to 59 percent availability in the last 20 months. Considering this is new technology and buses may be placed out of service for longer periods of time as failures are analyzed and often require factory support, the expectation was that performance would improve in the second year of service. The most recent failures on the H2Bs have been related to fuel control and fuel-cell failures.

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 route or causes a significant delay in the route schedule.

The performance standard for MBRC is 14,000 miles. The CNG-powered buses consistently exceeded the standard achieving a total of 35,461 MBRC over the last 20 months.

The H2Bs met the MBRC standard in only three of the 20 months. Overall, the H2Bs are not meeting the standard achieving only 8,655 MBRC. Peak performance for a conventional transit bus is typically realized in the second year of operation or approximately 100,000 miles in service without introducing new technology. Currently, each H2B has only averaged 58,500 miles in service. Taking into consideration that this is new technology, peak performance may be delayed compared to a conventional transit bus. In the early months there were a variety of issues related to electrical components and software calibration issues, but as of late, the majority of the road calls are related to fuel control and fuel-cell failures.

Fuel economy is a measurement of how efficiently the fuel is being used by the propulsion system. Because CNG is measured in therms and hydrogen is measured in kilograms, both fuels are converted to a common measurement. In this case, both are measured in miles per diesel gallon equivalent (mpdge). CNG-powered buses have consistently averaged 4.22 mpdge, while H2Bs have more than doubled that with an average of 9.73 mpdge. H2B fuel economy is 2.3 times that of a CNG-powered bus. The higher mpdge helps offset the higher cost of hydrogen fuel. The current cost per mile for hydrogen fuel is $0.97 compared to the CNG fuel at $0.42.

OCTA calculates total cost per mile, scheduled maintenance cost per mile, and unscheduled maintenance cost per mile. This includes parts and labor. Maintenance cost is categorized by system to provide insight into which systems have the most costs for each technology.

The cost per mile for H2Bs is lower than CNG-powered buses by approximately 17 percent. The cost per mile for H2Bs is $0.62, compared to $0.75 for CNG-powered buses. Combined with the cost per mile of fuel, the H2B's total cost per mile is $1.60, compared to the CNG-powered buses at $1.18. The cost per mile for both CNG-powered buses and H2Bs have remained consistent over the last 20 months.

Hydrogen Fueling Station Update

In the early months, the hydrogen fueling station experienced a variety of issues resulting in the station shutting down during operation. These issues have been resolved with software updates while issues required engineering reconfigurations. The overall availability of the fueling station has improved over the last 20 months, matching that of the CNG fueling station. Monthly meetings with the fuel station provider have resulted in prompt resolutions and improved performance.

Summary

At the 20-month mark of the ZEB pilot, the performance of the H2B is below the standard primarily due to fuel control and fuel-cell failures. The H2B builder and fuel-cell system provider have been very responsive in resolving the issues as they occur, and staff is encouraged that the level of effort will result in performance improvements. New conventional transit buses typically reach peak performance in their second year of service without the challenge of new technology. As a result, working through the new technology issues will likely result in a delay in reaching peak performance. Staff will continue to monitor

performance between the H2Bs and CNG-powered buses and will soon incorporate the plug-in BEBs.

Attachment

None.

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