September 10, 2020

To: Transit Committee

From: Darrell E. Johnson, Chief Executive Officer

Subject: Hydrogen Fuel-Cell Electric Bus Pilot Update

Overview

On February 9, 2020, ten hydrogen fuel-cell electric buses began operating in revenue service on routes that run through disadvantaged communities and the hydrogen fueling station was readied for full production use. This report provides a six-month update on the buses and fueling station performance.

Recommendation

Receive and file as an information item.

Discussion

Background

In 2018, the California Air Resources Board (CARB) passed the Innovative Clean Transit rule (ICT) requiring all public transit agencies to transition their bus fleets to zero-emission technologies by 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 Zero-Emission Bus Rollout Plan, which included the deployment of a mix of hydrogen fuel-cell electric buses and plug-in battery-electric buses to prepare for compliance with the ICT rule.

In anticipation of the ICT rule, OCTA developed a strategy to pilot both hydrogen fuel-cell and battery-electric bus technologies using available grants. Piloting both technologies will allow OCTA to gain direct experience with operational effectiveness, maintenance, and cost. In 2017, OCTA entered into an agreement to utilize grants provided by CARB and South Coast Air Quality Management District to purchase ten hydrogen fuel-cell electric buses instead of compressed

natural gas buses that had completed their useful life cycle. The grant also funded the supporting infrastructure. A provision of the agreement was a commitment to deploy the buses in regular service within disadvantaged communities.

On February 9, 2020, OCTA launched the Hydrogen Fuel-Cell Electric Bus Pilot, which included ten, 40-foot hydrogen fuel-cell (H2) electric buses and a hydrogen fueling station capable of fueling up to 50 buses per day.

The performance of the ten H2 buses will be measured against the performance of ten compressed natural gas (CNG)-powered buses. General vehicle information on both bus types is provided below.

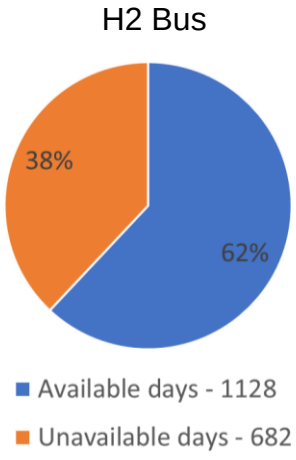
Vehicle Information	**H2 Bus** 	**CNG bus** 
Number of Buses	10	10
Manufacturer/Model	New Flyer/Xcelsior	New Flyer/Xcelsior
Model Year	2018	2016
Bus Purchase Cost	$1.3M	$580k
Length	40 foot	40 foot
Curb Weight	33,560 lbs.	30,000 lbs.
Propulsion System	Ballard FCvelocity-HD85, 85 kW Siemens Electric Motor, 210 kW	Cummins ISL-G 280 hp Allison B400 Transmission
Energy Storage	Five Composite Fuel Cylinders (CH2) Lithium-ion Batteries (100 kWh)	Six Composite Fuel Cylinders (CNG)
Operating Range	300 miles	350 miles

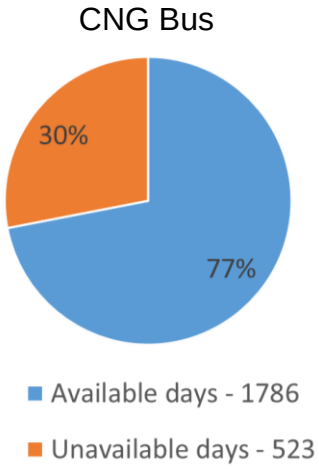
Performance Review

The performance data for a six-month period from February through July 2020 is included in this report. The key performance indicators will 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 have been used in revenue service, training, special events, or they may have been 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 H2 buses 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. Although the CNG-powered buses only achieved a 77 percent availability, when combined with the rest of the CNG-powered fleet, more than 80 percent availability was achieved. For this small sample of ten buses reviewed in a six-month period, any major maintenance on one bus can pull the average down below 80 percent. In terms of the H2 buses, 62 percent availability is low but understandable 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. Performance generally improves as systems are fine-tuned.





MBRC are road calls in response to a revenue vehicle mechanical or system failure that causes the bus to be replaced on route or causes a significant delay in schedule. Components, such as radios, fareboxes, and destination signs are not included in the MRBC calculation.

The performance standard for MBRC is 14,000 miles. Based on the chart below, the CNG-powered buses clearly and consistently met the standard, while the H2 buses attained the standard in two of the months, but overall, showed inconsistency in performance for MBRC for the period under review. The majority of the road calls for the H2 buses were electrical in nature and were resolved with software updates. This is not unusual performance for a new bus with advanced technologies. Peak performance for a transit bus is typically realized in the second year of operation. In terms of the fuel-cell system performance, the H2 buses achieved more than 76,000 MBRC, which is very encouraging.

Month	H2 (MBRC)	CNG (MBRC)
February	11,333	20,758
March	1,550	62,423
April	8,188	20,539
May	32,379	23,627
June	13,401	27,836
July	30,228	22,686
Six-Month MBRC	6,843	25,345

Fuel economy is a measurement of how efficiently the fuel is being used by the propulsion system. Because CNG is measured in therms and H2 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 4.24 mpdge, while H2 buses have more than doubled that with an average of 9.78 mpdge. H2 bus fuel economy is 2.31 times that of a CNG-powered bus. The higher mpdge helps offset the higher cost of H2 fuel. The current cost per mile for H2 fuel is $0.91 compared to the CNG fuel at $0.23.

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 H2 buses is lower than CNG-powered buses by approximately 25 percent. The cost per mile for H2 buses is $0.54 compared to $0.72 for CNG-powered buses. Combined with the cost per mile of fuel, the H2 buses' total cost per mile is $1.44 compared to the CNG-powered buses at $0.95.

Fueling Station

The hydrogen fueling station has experienced a variety of issues resulting in the station shutting down during operation. Many of these issues have been resolved with software updates while others have required engineering reconfigurations. The overall availability of the fueling station has improved over the last six months, and staff anticipates continued improvements as additional reconfigurations take place.

Summary

After monitoring the first six months of this pilot, the H2 buses have performed in a similar manner compared with other new vehicles. Staff is encouraged that performance will continue to improve as systems are fine-tuned. It is typical for new buses to reach peak performance in their second year of service. The performance of the H2 fueling station is also showing incremental improvements as fine-tuning efforts continue. Staff will continue to monitor performance between the H2 and CNG-powered buses and will incorporate the plug-in battery electric buses when they arrive.

Attachment

None.

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