



March 12, 2026

To: Transit Committee
From: Darrell E. Johnson, Chief Executive Officer
Subject: Zero-Emission Bus Program Update

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Overview

The Orange County Transportation Authority Board of Directors adopted the zero-emission rollout plan in 2020 and subsequently approved the purchase of zero-emission buses and infrastructure to gain necessary operational and technological experience in preparation for transitioning the Orange County Transportation Authority's bus fleet to zero-emission technologies as required by the State. This report provides an update on the zero-emission bus program 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. In June 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 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 allows 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 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 critical infrastructure elements required for operations, including a 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, located at the Santa Ana Bus Base, capable of fueling up to 50 buses per day. The FCEBs were placed into service on February 10, 2020.

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 partnered 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 station equipment.

On June 14, 2021, the Board approved the purchase of ten, 150-kilowatt (kW) BEB charging stations. The charging stations can supply power evenly or sequentially, which 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. However, the charging stations were not fully operational until December 2023, due to delays from SCE completing the infrastructure upgrades required to install the ten BEB charging stations and other equipment issues. In the interim, the BEBs were charged using onsite pay-per-use fast chargers.

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 arrived in December 2022. The delay in receiving the remaining eight BEBs was due to shortages to electronic components and other supply chain disruptions.

On June 24, 2024, the Board approved the purchase of ten battery-electric paratransit vans to replace ten gasoline OC ACCESS cutaway buses. OCTA applied for and was awarded funding through a competitive Federal Transportation Authority grant program. The ten battery-electric vans arrived in December 2025 and will be charged using temporary charging stations that were provided by the vehicle manufacturer at no additional cost. The permanent charging equipment is expected to be installed later this year.

On November 14, 2024, the Board approved the purchase of an additional 40 FCEBs, ten BEBs, and battery chargers to accelerate the operational and technological experience necessary to operate and maintain a ZEB fleet. The

50 ZEBs in this procurement will replace compressed natural gas buses that have met their useful life, moving OCTA closer to the required fleet conversion of OCTA’s current 464 buses to 100 percent zero-emission. The first of ten BEBs have been delivered and the first of 40 FCEBs is in production. The remaining BEBs are expected to arrive by the fourth quarter of this calendar year and the FCEBs by first quarter of 2027.

On January 9, 2025, the Board approved the short-listing of three design-build firms, the evaluation criteria and weightings, and the release of the request for proposals for the design and construction of a second hydrogen fueling station to be located at the Garden Grove Bus Base. Unfortunately, due to the low quantity of qualified bids, the procurement was cancelled. On September 22, 2025, the Board approved the second release of the request for qualifications and request for proposals. Staff anticipate returning to the Board later this year with a recommendation for award.

Discussion

The ten FCEBs have been in service for six years and the ten BEBs have been deployed consistently for three years. The performance data included in this report covers the period beginning February 2020 through December 2025. The performance of the ten FCEBs and ten BEBs is measured against the performance of ten CNG buses that were selected during 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	CNG Bus	FCEB	BEB
Number of Buses	10	10	10
Manufacturer/Model	New Flyer Xcelsior	New Flyer Xcelsior	New Flyer Xcelsior
Model Year	2016	2018	2020
Deployment Date	Aug-18	Feb-20	Dec-22
Bus Purchase Price	\$580,000	\$1.3M	\$1.1M
Length	40-foot	40-foot	40-foot
Curb Weight	30,000 pounds	33,560 pounds	33,500 pounds
Propulsion System	CNG Engine 280 hp (209 kW)	Electric Motor 210 kW, 85kW Fuel Cell	Electric Motor 210 kW
Energy Storage	Six Fuel Cylinders	Five Fuel Cylinders 100 kWh Lithium-ion Battery	Lithium-ion Batteries 440kW
Total Operating Range	400 miles	300 miles	200 miles
Usable Operating Range	350 miles	250 miles	150 miles

The key performance indicators for the pilot 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 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 not used. Buses unavailable for service may have had mechanical issues with the propulsion system (fuel-cell system, electric drive system, engine), regularly scheduled maintenance, or required unscheduled repairs.

The OCTA performance standard for bus availability is 80 percent. However, for new bus technology, availability can be challenging as the system issues are analyzed and buses are out of service for a longer period. For 2025, both the FCEBs and BEBs fell below the target at 65 percent and 44 percent respectively, while CNG buses achieved the goal at 85 percent.

The FCEBs did not achieve the availability goal primarily due to electrical issues and degradation of fuel-cell components, compounded by long wait times for replacement parts. It has become common to see FCEBs out of service for 60 to 100 days at a time waiting for parts. Despite these challenges, FCEB availability improved from 49 percent in 2024 to 65 percent in 2025.

The BEBs also did not meet the availability goal, with availability dropping from 58 percent in 2024 to 44 percent in 2025. Like the FCEBs, the BEBs faced persistent electrical issues and long lead times for replacement parts; a replacement battery pack currently requires approximately 135 days to procure. Additionally, a manufacturer's battery recall in late September 2025 resulted in a temporary removal of the BEBs from service. The buses were returned to service after the manufacturer-issued software update limited battery charging to 75 percent to reduce the risk of overheating; this temporary solution does affect the range, limiting it to 110 miles per charge. Full battery replacements will proceed once the manufacturer secures a new battery supplier.

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 in route or causes a significant delay in the bus schedule.

The OCTA performance standard for MBRC is 14,000 miles. The ten designated CNG buses exceeded the goal in 2025, achieving 20,629 MBRC. This improvement over 2024 is primarily due to completing a scheduled mid-life overhaul, which included replacing the engine and transmission.

The FCEBs did not meet the MBRC standard in 2025, achieving 7,116 MBRC, a decline from 8,399 MBRC in 2024. While battery-related failures and fuel-cell

degradation remain the primary contributors to poor performance, a significant factor this year was the reduced operating mileage due to the hydrogen fueling station at the Santa Ana Bus Base being out of service, which is discussed further later in this report. With the station being unavailable for fueling, the FCEBs accumulated only 14,232 miles in 2025 compared to 270,462 miles in 2024. With such a low mileage denominator, just two road calls were sufficient to reduce MBRC below the standard. OCTA staff continues to apply lessons learned from these challenges to improve infrastructure resilience, supplier coordination, and overall fleet performance as the ZEB program evolves.

The BEBs also did not meet the MBRC standard in 2025, achieving 10,474 MBRC; however, this represents a significant improvement over 2024, when MBRC was 4,923. The BEBs experienced a range of issues during the year, primarily electrical in nature, including battery failures and electrical management system failures.

Fuel economy measures how efficiently a vehicle uses fuel to travel. Because the buses in OCTA's fleet run on different types of propulsion systems, CNG, hydrogen, and electricity, each fuel is measured differently: CNG in therms, hydrogen in kilograms, and battery power in kW. To fairly compare fuel efficiency across these technologies, the fuel types are converted to a common measurement, miles per diesel gallon equivalent (mpdge). This unit shows how far each bus can travel using the same amount of energy found in one gallon of diesel fuel, regardless of the fuel type used.

CNG buses are averaging 3.74 mpdge, which falls within the normal operating range. FCEBs are averaging and estimated 6.81 mpdge, representing an 11 percent decrease from 7.57 mpdge in 2024. The mpdge was estimated due to using an offsite commercial retail hydrogen fueling station. The reduction is attributed to fuel-cell degradation, which requires the fuel-cell system to consume more fuel to meet the electrical demands of the batteries. BEBs continue to achieve the highest efficiency, averaging 16.87 mpdge, an eight percent decrease from 18.14 mpdge in 2024.

OCTA calculates total CPM for each technology by tracking fuel, parts, and labor costs. CPM is used because it serves as the lowest common denominator across all bus technologies. Assigning daily, weekly, or monthly cost values can be misleading, as buses are deployed on different routes with varying mileage.

Fuel costs for the FCEBs increased in 2025 due to the unavailability of the on-site hydrogen fueling station, which required buses to be refueled at a commercial retail station. In 2025, the CPM was \$2.02, up from \$1.23 in 2024. For BEBs, electricity-related CPM rose to \$0.66, compared to \$0.32 in 2024. This increase is primarily due to rising electricity rates. It is important to note that

electricity cost is based on kW usage, and under the current rate structure, the cost per kW as total usage rises directly impacting overall CPM. CNG CPM increased from \$0.37 to \$0.40 in 2025, also due to price increases in renewable natural gas and electricity rates.

Parts and labor CPM for FCEBs increased significantly year over year, rising to \$3.67 from \$1.30 in 2024. The primary driver of this increase is reduced vehicle operation, resulting in a low mileage denominator that inflates CPM. Costs are expected to decrease once the vehicles return to normal operating mileage levels.

BEB parts and labor CPM decreased to \$1.13 from \$1.26 in 2024. This reduction is largely due to the buses reaching the end of their break-in period, with most early life failures now covered under warranty.

CNG bus parts and labor CPM increased to \$1.17 from \$0.99 in 2024. This increase is attributed to expanded use of the contingency fleet, which consists of 2008 model year CNG buses. The reliance on the contingency fleet is driven by pending deliveries of new bus orders and reduced FCEB availability.

Total CPM includes combining parts, labor, and fuel costs. The total CPM for FCEBs increased to \$5.69 from \$2.53 in 2024 due to cost increases in all areas. The total CPM for BEBs increased to \$1.79 from \$1.58 in 2024 primarily due to cost increases in fuel. Finally, the total CPM for CNG buses increased to \$1.57 from \$1.36 in 2024 primarily due to increased use of contingency buses. A summary of the CPM trends for the three technologies is provided in the table below:

Cost Per Mile (CPM)	FCEB			BEB			CNG		
Year-Over-Year Comparison	2025	2024	Trend	2025	2024	Trend	2025	2024	Trend
CPM - Fuel Costs	\$2.02	\$1.23	▲64%	\$0.66	\$0.32	▲106%	\$0.40	\$0.37	▲8%
CPM - Parts and Labor	\$3.67	\$1.30	▲182%	\$1.13	\$1.26	▼-10%	\$1.17	\$0.99	▲18%
CPM Total	\$5.69	\$2.53	▲125%	\$1.79	\$1.58	▲13%	\$1.57	\$1.36	▲15%

Infrastructure Update

On November 13, 2017, the Board approved an agreement with Trillium for the construction, operation, and maintenance of a hydrogen fueling station located at the Santa Ana Bus Base. This agreement also included hydrogen fuel supply, for a three-year term with a two-year option term. On February 9, 2020, when OCTA initiated the fuel cell electric bus pilot program, the hydrogen fueling station became operational. Trillium subcontracted the fueling station design, equipment, operation and maintenance, and fuel supply to Air Products and

Chemicals, Inc. (Air Products). Most of the fueling station equipment is owned by OCTA, except for the 18,000-gallon liquid hydrogen storage tank and associated vaporizers, which were leased from Air Products.

To ensure the continued operation of the hydrogen fueling station, OCTA staff began negotiations with Trillium and Air Products one year prior to the contract expiration on December 31, 2024. In parallel, staff initiated a separate solicitation for a mobile hydrogen fueling station and hydrogen fuel supply. Air Products ultimately refused to sell or lease the existing equipment and indicated its intent to remove the leased equipment, which would render the station inoperable.

As a result, on February 24, 2025, the Board approved a sole source agreement with Air Products to continue the operation, maintenance, and hydrogen fuel supply for the station until a more suitable solution could be implemented. After Board approval, Air Products proposed significant changes to the terms and conditions of the agreement. Despite months of negotiations, an agreement could not be reached. On January 22, 2026, Air Products removed the leased equipment from the Santa Ana Bus Base location.

During this interim period, OCTA has been utilizing a commercial hydrogen fueling station operated by Shell USA, Inc. near the City of Long Beach to maintain the FCEBs in a reliable state of operation. In addition, staff is in the process of procuring a temporary mobile hydrogen fueling station while the existing station is being rebuilt. As noted in the Background section of this staff report, OCTA is also procuring a second hydrogen fueling station, which will provide the redundancies necessary to support consistent and reliable FCEB operations.

The battery charging stations located at the Garden Grove Bus Base are fully operational. Overall, the chargers operate reliably, maintaining an average availability of 80 percent. Because each charger can serve multiple buses per night, there have been no incidents in which a bus could not be deployed due to insufficient or unavailable charging infrastructure.

On November 14, 2024, the Board approved the purchase of additional depot battery charging stations to be installed at the Santa Ana Bus Base in support of additional BEBs on order. Installing charging infrastructure at both directly operated bases provides redundancy in the event of a power outage and enhances operational flexibility to deploy BEBs throughout Orange County.

Key Takeaways

- Higher Upfront Costs: Although the cost gap is narrowing, ZEBs currently cost 50 to 100 percent more than comparable CNG buses.
- Reduced Operating Range: ZEBs have 30 to 55 percent less operating range than CNG buses, requiring more frequent fueling/charging and more complex route planning.
- Performance: Performance has been consistent but remains below established operational standards. Availability remains a challenge, mainly due to supply chain issues.
- Maintenance: ZEBs have required more maintenance than initially anticipated, though overall maintenance costs are generally comparable to CNG buses.
- Hydrogen Challenges: Hydrogen fuel remains expensive, but supporting infrastructure is still developing and evolving.
- Electricity Constraints: Electrical capacity can be limited, and charging infrastructure deployment is often complex and resource intensive.

Summary

After six years of operating FCEBs and more than three years of operating BEBs, OCTA has gained substantial knowledge and experience with ZEB technologies and supporting infrastructure. While ZEB performance has not matched that of CNG buses, OCTA has developed a deeper understanding of the differences between technologies, the components requiring improvement to enhance reliability, and the elements necessary to build a sustainable fueling and charging infrastructure.

Additionally, an improved understanding of the costs associated with operating and maintaining ZEBs has strengthened financial planning efforts and enhanced advocacy for additional funding and cost-reduction strategies. These strategies include the need to reduce hydrogen fuel costs and address the capital and utility expenses associated with expanding electrical infrastructure.

The next steps in OCTA's ZEB Program include taking delivery of 40 additional FCEBs and ten additional BEBs currently on order.

From an infrastructure perspective, planned actions include restoring the Santa Ana hydrogen fueling station to operational status, completing procurement and installation of a second hydrogen fueling station at the Garden Grove Bus Base, and completing the installation of additional battery charging stations at the Santa Ana Bus Base, which is currently underway.

In addition, a planned acquisition for seven 60-foot FCEBs is currently on hold as grant funding awarded under the SB 125 (Chapter 54, Statutes of 2023) Transit Program is at risk of not being appropriated as planned.

Staff will continue to provide the Board with regular updates on the OCTA ZEB Program, including vehicle deployment, infrastructure progress, and regulatory developments.

Attachment

None.

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