

## FUEL CELL ELECTRIC BUSES for Zero-Emission Public Transit



California has a proud history of leadership in developing and nurturing zero-emission transit options, especially fuel cell electric buses (FCEB). For 20 years, California transit agencies have operated FCEBs, with 14 years of federally collected data, 4 million miles of operational service, and in-state FCEB manufacturing. Among the different electric bus options available today, fuel cell electric buses offer a number of advantages.

### A Zero Emissions, Zero Compromise Bus

FCEBs have emerged as a one-for-one replacement (e.g. gradeability, highway speeds, fueling time and range) for conventional diesel and CNG buses over all types of transit routes, but with zero tailpipe emissions. Hydrogen produced from renewable sources like solar, wind and biogas ensures full carbon neutrality from a well-to-wheels perspective and significantly reduces carbon dioxide (CO<sub>2</sub>) emissions. As a result, FCEBs can make the biggest impact on the health-related effects of poor air quality in disadvantaged communities.

Fuel cell efficiency improvements will continue to increase the fuel economy of FCEBs, which is already 1.7 to 1.9 times higher than conventional buses. In addition, ElDorado National and New Flyer FCEBs successfully completed testing at the FTA's Altoona Bus Research and Testing Center for 40-ft. and 60-ft. buses.

With more than 10 million miles in revenue service and more than 15 years on the road in different environments and transit bus duty cycles, FCEBs have proven to meet operational requirements of transit agency operators. An AC Transit progress report on zero-emission bus expansion found that "95% of all routes can be served by FCEBs on a 1:1 replacement basis."



### Scalability

The use of a compressed gas like hydrogen fuel for transit buses is a scalable solution for up to hundreds of buses per depot without stressing electrical infrastructures.

### Fueling

Rapid fueling, like CNG & diesel fueling, can take place at any bus fueling depot designed with the addition of delivered hydrogen or onsite hydrogen production.

### Cost

FCEB capital costs have decreased considerably as early volumes have grown. 2010 Winter Olympics fuel cell buses cost \$2m per bus for a fleet of 20. For the 25 New Flyer FCEBs being built for 3 California transit agencies, the cost per bus is \$1.235m. New Flyer estimates that a production run of 100 buses will reduce the cost to \$850,000 per bus. Industry's 2029 cost target is \$600,000 per bus.

In addition, fuel cell electric buses are eligible for California HVIP incentives. In a 2017 discussion paper of the European JIVE program, the authors noted, "This is a profound conclusion – fuel cell buses can provide zero emission public transport at ownership costs competitive with battery electric buses and with relatively modest premiums relative to incumbent diesel vehicles (c.15–20%)."

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## Hydrogen Fuel

Deployments around the world have proven FCEBs can be fueled safely and efficiently in the depot. A range of standard solutions exists today to deliver or produce, store and dispense hydrogen at transit bus depots utilizing fueling infrastructure that is very similar to CNG infrastructure. For commercial sustainability, industry targets \$5 per kilogram for parity with present diesel costs (per mile).



## Key Features

- Zero tailpipe criteria pollutant and GHG emissions
- Operational flexibility (single depot fueling)
- Range and performance comparable to diesel and CNG buses (allows 1-to-1 replacement)
- High asset utilization, refueling time similar to conventional fuels
- Lower weight ensures maximum passenger capacity
- Low maintenance cost
- High fuel economy
- Scalability

## Overview

	CURRENT STATUS	SOURCE
Power plant life time	29,000 hours	NREL 2018 report
Bus availability	Up to 88%	NREL 2018 report
Refueling time	< 10 minutes (1/day)	NREL 2018 report
Bus cost (25 units, 2016)	\$1,235,000	New Flyer
Bus cost (100 units)	\$850,000 projected	New Flyer
Scheduled and unscheduled maintenance cost	\$0.22 - 0.73/mile	NREL 2018 report
Fuel economy	Up to 7.82 miles/DGE	NREL 2018 report
Range	199 - 348 miles	NREL 2018 report

## References

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