

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



California has made great strides in improving its air quality over many decades, but transportation remains the state's dominant source of air pollution. If California is to meet its air quality improvement and emissions reduction goals, the continued growth of zero emission electric bus deployment is essential.

Among the different electric bus options available today, fuel cell electric buses (FCEBs) offer a number of advantages.

### Emissions and GHG Reductions

FCEBs have zero tailpipe emissions and produce no nitrogen oxides, sulfur dioxides or particulate matter. Hydrogen 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 impacts of poor air quality in disadvantaged communities.

### Performance

Zero-emission FCEBs offer conventional full vehicle performance (e.g. gradeability, highway speeds, fueling times and range) over all types of transit routes. Expected 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 have successfully completed testing at the FTA's Altoona Bus Research and Testing Center.

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. FCEBs offer a 1:1 replacement to CNG & diesel buses without compromises. For example, 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. There are no route constraints due to limited range and fueling.

### Cost

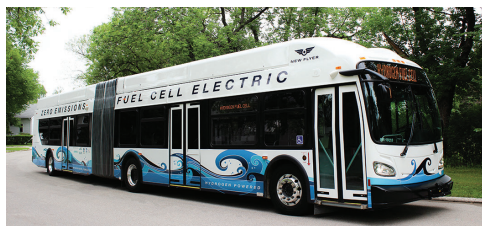
FCEB capital costs have decreased considerably as early volumes have grown. 2010 Winter Olympics fuel cell buses cost \$2m per bus for a fleet of 20. For the 25 New Flyer FCEBs currently being built for 3 California transit agencies, the cost per bus is \$1.235m. New Flyer estimates that a production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



In addition, fuel cell electric buses are eligible for a \$300,000 California HVIP incentive. The ultimate cost target is \$600,000 per bus. In a recent 2017 discussion paper of the European JIV 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%).”

## Hydrogen Fuel

Deployments around the world have proven fuel cell electric buses 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. Hydrogen fuel allows zero emission transit without requiring grid strengthening. Hydrogen fueling infrastructure is very similar to CNG infrastructure.



### 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 liquid fueling
- Lower weight than battery electric option (maximum passenger capacity)
- Low maintenance cost
- High fuel economy (high efficiency)
- Scalability

## Overview

	CURRENT STATUS	SOURCE
Power plant life time	25,000 – 30,000 hrs	NREL 2017 report
Bus availability	Up to 93%	NREL 2017 report
Refueling time	< 10 minutes (1/day)	NREL 2017 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	\$0.56/mile	NREL 2017 report
Fuel economy	7-8 miles/DGE	NREL 2017 report
Range	277-357 miles	NREL 2017 report

## #TheOtherElectricBus

### References

- Fuel Cell Buses in U.S. Transit Fleets: Current Status 2017, NREL (National Renewable Energy Laboratory), 2017, <https://www.nrel.gov/docs/fy18osti/70075.pdf>.
- Progress Report on the District's Study on ZEB Expansion and Facilities Assessment, Alameda-Contra Costa Transit District, [http://www.actransit.org/wp-content/uploads/board\\_memos/18-134%20ZEB%20Assessment.pdf](http://www.actransit.org/wp-content/uploads/board_memos/18-134%20ZEB%20Assessment.pdf), p6, 2018.
- Mission Statement on Mobility Hydrogen Technologies, the Missing Link to Decarbonising the European Transport and Mobility Sectors, Hydrogen Europe, <https://hydrogeneurope.eu/sites/default/files/2017-05/Transport.pdf>, p2, 2016. More at <https://www.fuelcellbuses.eu/projects/jive>.
- Electric Buses: Sustainable Zero-Emission Transit Innovation for the Long Run, New Flyer Industries, <https://cafc.org/sites/default/files/New-Flyer-Electric-Bus-2018-08-15-Rev-B.pdf>, 2018.
- Commercialisation of hydrogen fuel cell buses, [https://www.fuelcellbuses.eu/sites/default/files/documents/FC%20bus%20commercialisation%20-%20White%20Paper\\_October%202017.pdf](https://www.fuelcellbuses.eu/sites/default/files/documents/FC%20bus%20commercialisation%20-%20White%20Paper_October%202017.pdf), 2017.