

Real Life Experiences with Fuel Cell Electric Buses

California Transit
Association



November 14, 2019

NEW FLYER®

Topics

- About New Flyer of America Inc.
- New Flyer's Road to Today's Fuel Cell Electric Bus (FCEB)
- Knowledge Gained Through Experience
- Xcelsior *CHARGE H2TM* Design and Performance
- Closing the Cost Gap with the Battery Electric Bus (BEB)
- Takeaways and Summary



ARBOC



nfi.parts

New Flyer Electric Bus Experience

- Over 50 years of experience manufacturing zero-emission buses
- New Flyer actively supports over 41,000 heavy-duty transit buses currently in service, of which 7,300 are powered by electric motors and battery propulsion and 1,600 are zero-emissions
- New Flyer offers all (4) types of electric, and all (3) types of zero-emission propulsion systems:
 - Diesel-electric hybrid (low-emission)
 - Battery Electric (zero-emission)
 - Trolley Electric (zero-emission)
 - Fuel Cell Electric (zero-emission)

New Flyer's Fuel Cell Bus Roadmap

Pre-1993:

Conventional Fossil Fuels (Diesel, Gas)
Early electric trolleys (1960s and 1970s)

1993: Electric Trolley

Delivered to San Francisco MUNI

1994: Compressed Natural Gas

Delivered to San Diego Transit Commission

1993: Hydrogen Fuel Cell Buses

Delivered to Vancouver and Chicago

2001: Diesel-Electric Hybrid

Delivered to Orange County

2009 - 2014: Whistler BC FCEB Demonstration (20 Buses)

2012: e-Accessories

Delivered to Minneapolis Metro

2014: Launch of the Xcelsior® XE40 Electric Bus

Delivered to Chicago Transit Authority

Delivered to Winnipeg Transit

2015: Start of the Xcelsior® XHE60 Fuel Cell Bus (Ballard)

2016: Start of the Xcelsior® XHE40 Fuel Cell Bus (Ballard & Hydrogenics)

2017: Xcelsior CHARGE™ Launch including Long -Range Batteries, High-Grade Package, Interoperable Depot and On-Route Charging

2017: Opened the Vehicle Innovation Center in Anniston, AL

2018: Launch of the Xcelsior® XE60, XHE60, and XHE40 Models



NEW FLYER®

Whistler BC Fuel Cell Electric Bus Project 2009-2014



- BC Transit initiated a project with California Air Resources Board (CARB) & the US Department of Energy's National Renewable Energy Laboratory (NREL) to test FCEBs in urban transit operation (1,880,000 miles of service)

NEW FLYER®

New Flyer Integrator to Innovator

- Knowledge Gained Through experience
 - New Flyer took ownership of systems controls
 - Serviceable components located in accessible areas
 - Ownership of fuel cell balance of plant needs to be with the manufacturer
- Development of Electrical Accessories
 - Component selections aligned with vehicle performance expectations
 - Technology with proven performance and reliability (Leverage the BEB design)
 - Improve the energy efficiency

Change Power & Energy Strategy

THEN:

- Large fuel cell / small battery
 - Ballard FCveloCity HD6-150 fuel cell (150 kW)
- Smaller Battery Energy Storage System
 - One battery string
 - Ability to take advantage of frequent regen events

NOW:

- Small fuel cell / large battery
 - Ballard FCveloCity HD85 fuel cell (85 kW)
- Larger Battery Energy Storage System
 - Two or Three String ESS (100-150 kWh)
 - Ability to take advantage of frequent regen events
 - Up to 235 kW peak power for acceleration, high-speed operation and hill climbs
 - Extends range when bus is out of fuel



NEW FLYER®

<https://www.youtube.com/watch?v=8HxWRWOvpyQ>

Fuel Cell Deployment Status (Nov 2019)

- (10) XHE40 FCEBs Delivered to AC Transit (Bay Area)
- (1) XHE60 FCEBs Delivered to AC Transit (Bay Area)
- (10) XHE40 FCEBs Delivered to OCTA (Orange County)
- (5) XHE40 FCEBs Delivered to SunLine (Thousand Palms)

*Funding and Sponsorship
Provided by Grants Through*



NEW FLYER®

xcelstor **CHARGE H2**™

	Bus Model	Fuel Cell	Readiness
Development	Xcelstor Charge H2 40-foot	Hydrogenics Celerity(+)	Evaluation
Production Builds	Xcelstor Charge H2 60-foot	Ballard HD85	Commercial Production
	Xcelstor Charge H2 40-foot	Ballard HD85	Commercial Production



Zero-Emission Options



xcelstor CHARGE™

- Battery Electric Bus (BEB)
- Eco Friendly
- Robust Design
- Up to 220 miles Range*
- Curb Weight Heavier than FCEB
- 4 Hour Overnight Charge
- One charger per 2-3 buses
- Diesel Aux heater recommended for cold climates

*40-foot on APTA transit duty cycle



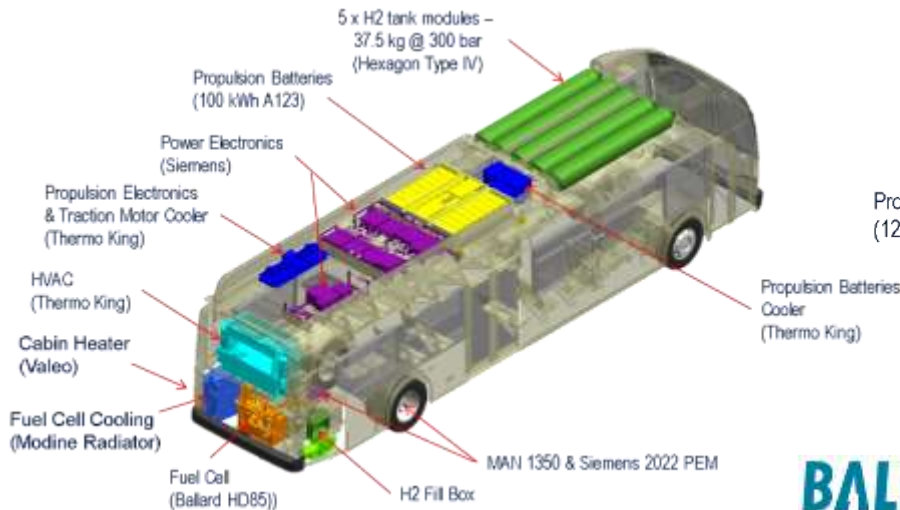
xcelstor CHARGE H2™

- Fuel Cell Electric Bus (FCEB)
- Eco Friendly
- Robust Design
- Up to 350 miles Range*
- Curb Weight Lighter than a BEB
- 6-20 minutes fill time
- Fill station scalable by fleet size
- No secondary Aux heater required for cold climates

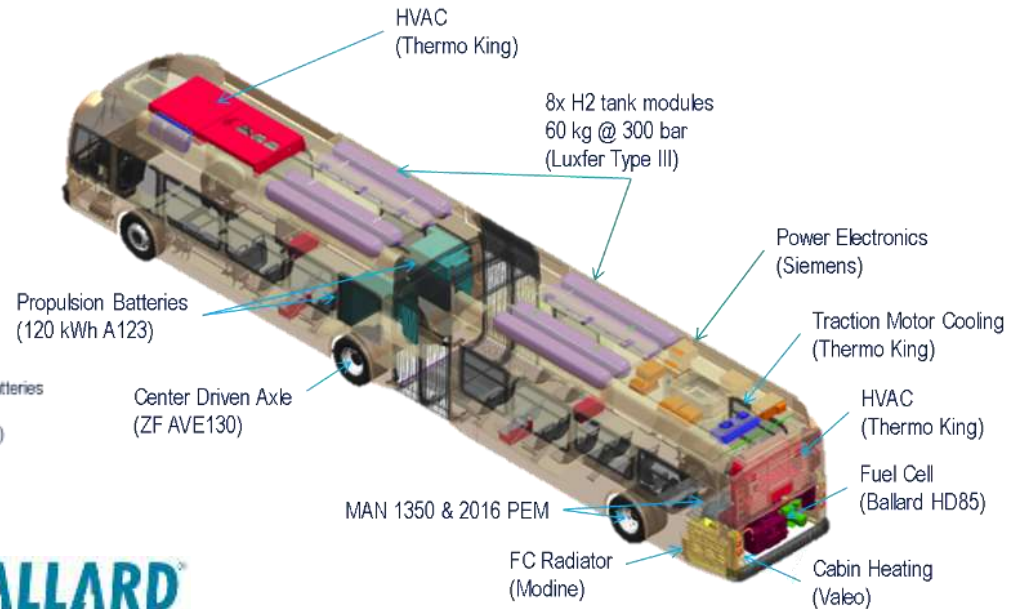
NEW FLYER®

xcelstor **CHARGE H2**™

XHE40



XHE60



NEW FLYER®

xcelstor **CHARGE H2™**

XHE40 (40 Ft. FCEB)

Altoona Range @ Seated Load Weight

	Manhattan	OCBC	UDDS	Average
Power Consumption[kWh/mile]	8.57	1.83	0.94	3.78
Fuel Consumption [miles/kg]	5.32	6.91	8.33	6.86
Fuel Cell Range [miles]	192	249	300	247
Battery Range [miles]	7	33	64	16
Total Range [miles]	199	282	364	263

- **> 300 miles** on a single fill validated during testing in Orange County
 - 9.16 miles/kg
 - 330 miles on fuel only
 - 20 miles battery range

XHE60 (60 Ft. FCEB)

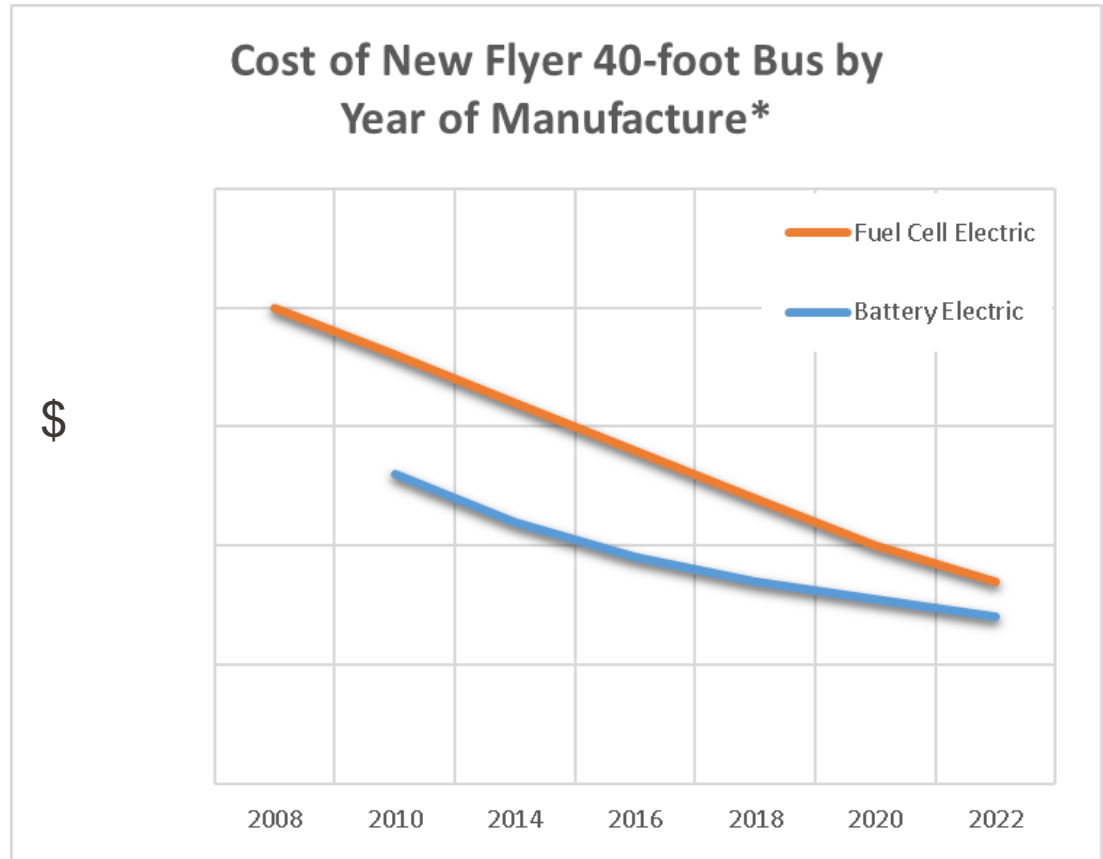
Altoona Range @ SLW

	CBD	ART	COM	Average
Power Consumption [kWh/mile]	3.25	3.68	2.10	3.04
Fuel Consumption [miles/kg]	4.74	3.91	7.42	5.36
Fuel Cell Range [miles]	277	227	432	294
Battery Range [miles]	22	19	34	24
Total Range [miles]	299	246	466	318

- Altoona Tested
- Bus delivered to AC Transit for a 2-Year demonstration

Fuel Cell Electric Bus Price Trends

- Manufacturing volumes will reduce cost
- Standardization between BEB and FCEB
- Decrease in Fuel Cell cost
- Decrease in Battery cost
- Improved Design for Manufacturability and Assembly
- Expanded Supply Chain with increased competition



*Cost varies by customer configuration and options

Key Takeaways and Summary

- Today's New Flyer BEBs and FCEBs share common technology, components and systems
- FCEBs are now Altoona tested and available from multiple OEMs
- Range, refueling time and weight are advantages of FCEBs
- The cost gap between a long-range BEB and FCEB is closing
- New Flyer is committed to supporting a highly successful deployments at AC Transit, OCTA and SunLine
 - o Strong field service and technical support team in place
 - o Proven supply base
 - o Reliability and ready-for-service metrics will be visible and shared
 - o Success is essential for all California Transit Agencies

Thank You

Contact Information:

David Warren
New Flyer of America Inc.
Director of Sustainable Transportation
david_warren@newflyer.com
320-203-4979 (office)
256-473-3246 (Mobile)



NEW FLYER®



NEW FLYER®

Built to **RELY ON.**