

Zero-Emission Implementations

ZEB Technology, California ZEB Projects and the Future of ZEBs

Presented by David Warren, Director of Sustainable Transportation

® California Transit Association's 52nd Annual Fall Conference & Expo
November 9, 2017 in Riverside, CA

NEW FLYER OF AMERICA

Agenda

- New Flyer Introduction and ZEB Experience
- Xcelsior CHARGE™ Technology
- California ZEB Programs
- Where ZEB Technology is Heading

The New Flyer Group of Companies

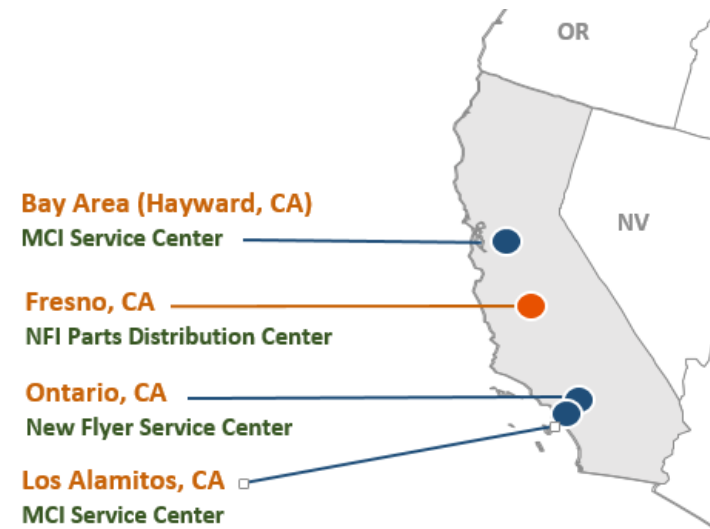
North America's Leading Bus & Coach Manufacturer

- **87 Years** of Experience
- **> 5,800** Employees
- **31 Locations** throughout North America
- Manufacture approximately **3,800** buses and coaches, annually*
 - Delivered **45%** of North American heavy-duty transit buses in 2016
 - Delivered **39%** of North American motor coaches in 2016
- Support **41%** of heavy duty transit buses in service
 - Supply **33%** heavy duty transit bus parts
 - Supply **40%** motor coach parts

* Equivalent Units



New Flyer California Operations



NEW FLYER OF AMERICA

New Flyer Has 50 Years of ZEB Experience

Our Zero Emission Technology 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

2002: Diesel–Electric Hybrid
delivered to Seattle

2010: Hydrogen Fuel Cell Buses
Delivered to BC Transit

2012: e-Accessories
Delivered to Minneapolis Metro

2014: Launch of the Xcelsior XE40 Electric Bus
Delivered to Chicago Transit Authority and also
delivered to Winnipeg Transit

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

2016: Launch of the Xcelsior XHE40 Fuel Cell
Bus (Hydrogenics and Ballard)

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

The Road Ahead:

- Increased Battery Energy Density
- Autonomous Driving Features
- Advanced Power Management
- Diagnostics & Prognostics



NEW FLYER OF AMERICA

New Flyer Low and No-Emission Propulsion

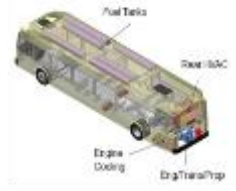
Transforming Communities with Sustainable, Clean Transit Technology

LOW EMISSIONS

Clean Diesel



Natural Gas



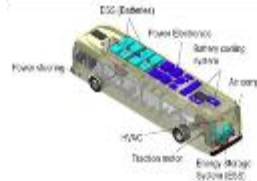
Hybrid-Electric



Electric-Trolley



xcelcior CHARGE



Hydrogen Fuel-Cell



ZERO EMISSIONS

Proven Heavy Duty Transit Bus Platform

- > 12,000 Xcelcior buses delivered and on-order
- Broadest Range of Propulsion Options
- Over 6,000 buses delivered with electric motors and batteries
- Only Platform with all 3 Types of ZEBs
- Built for Accessibility
- Designed for Maintainability
- Flexible Battery Pack Design – Evolves with Battery Technology

NEW FLYER OF AMERICA



Our Vision: To be America's leader in the exploration and advancement of bus and coach technology connecting people to places.

Our Mission:

- Explore and advance bus and coach technology through sustainable research and development, fresh innovation, progressive manufacturing, and bold thinking;
- Foster dialogue through discussion, education, and training on the latest zero-emission and autonomous driving vehicle technologies;
- Engage learning through current and interactive exhibits, simulation and hands-on experiences, and observations;
- Generate energy and commitment to clean air quality, safety, and economic benefits for people, communities, and business; and
- Harness the positive influence of collaboration, environmental stewardship, and social change to advance mobility solutions.

Features of the Center:

- Interactive Technology Exhibit Space
- Demonstrator Buses with Custom Transport Rig
- New Flyer Institute Manufacturing Lab
- Classroom Training
- Charging and Hands On Training Bay
- Engineering Testing Area
- Battery Assembly Area



NEW FLYER OF AMERICA

Agenda

- New Flyer Introduction and ZEB Experience
- Xcelsior CHARGE™ Technology

xcelSior CHARGE™



- Built on the proven XcelSior transit bus platform
- Extended range battery technology designed in America
- Industry-leading gradeability
- Interoperable
- Available in 35, 40, and 60-foot bus rapid transit articulated models.

New Flyer's Next Generation Battery-Electric Bus

NEW FLYER OF AMERICA

xcelSior CHARGE™



XE35/XE40

Long Range &
Rapid Charge



XE60

Long Range &
Rapid Charge

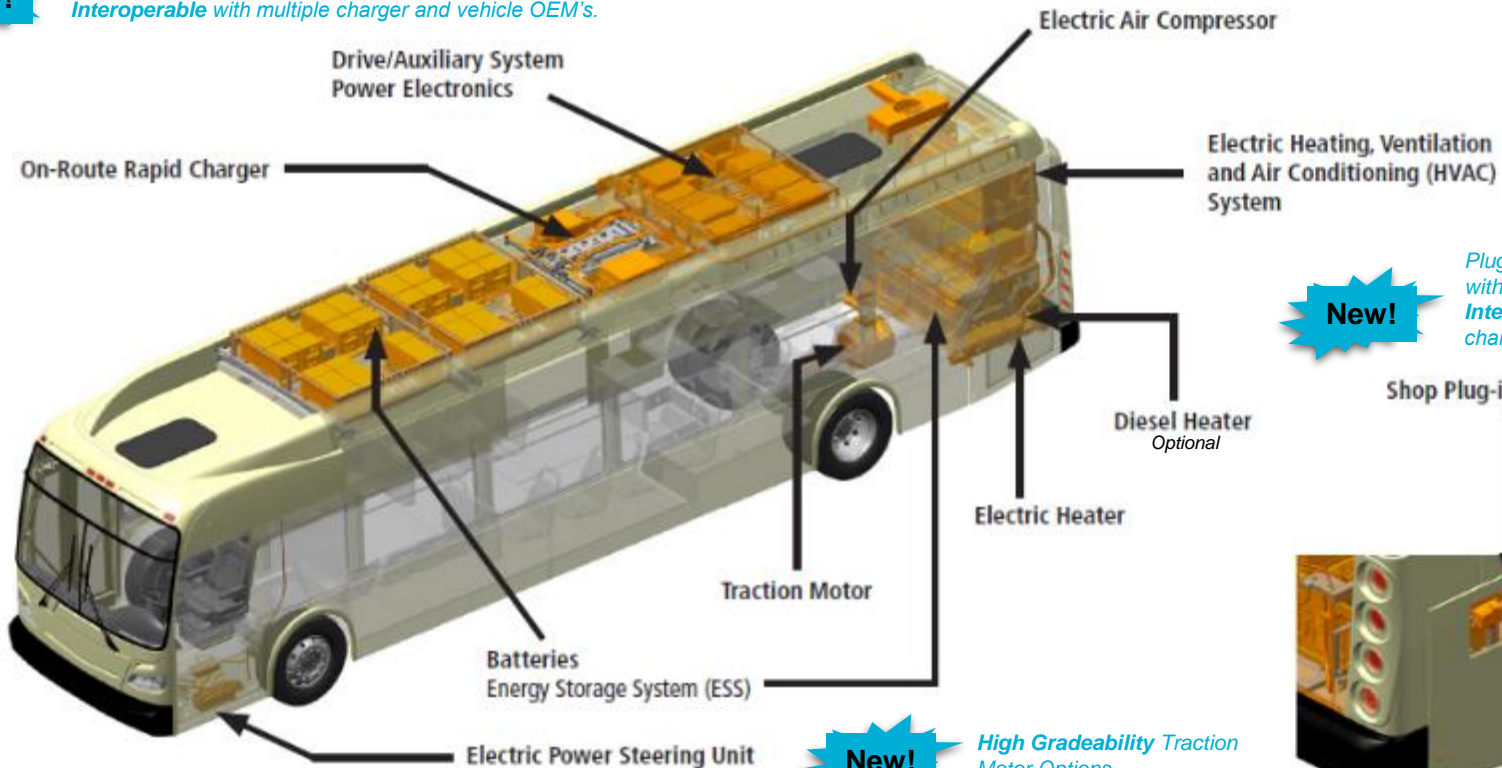
NEW FLYER OF AMERICA

xcelSior CHARGE™

New! Design Highlights

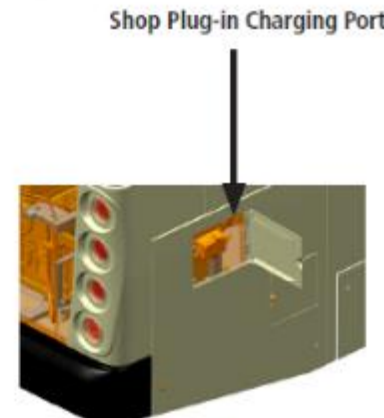
New!

*On-Route Charging Compliant with OppCharge
Interoperable with multiple charger and vehicle OEM's.*



New!

*Plug In Charging Compliant with SAE Standards
Interoperable with multiple charger and vehicle OEM's.*



New!

Extended Range and Rapid Charge Energy Storage Configurations

New!

High Gradeability Traction Motor Options

NEW FLYER OF AMERICA

- Siemens founded in 1847
- 170 years of innovation
- 10 operating divisions
 - Power Generation
 - Mobility
 - Process Industries & Drives
 - Energy Management
 - Building Technologies
 - Digital Factory

SIEMENS

Ingenuity for life



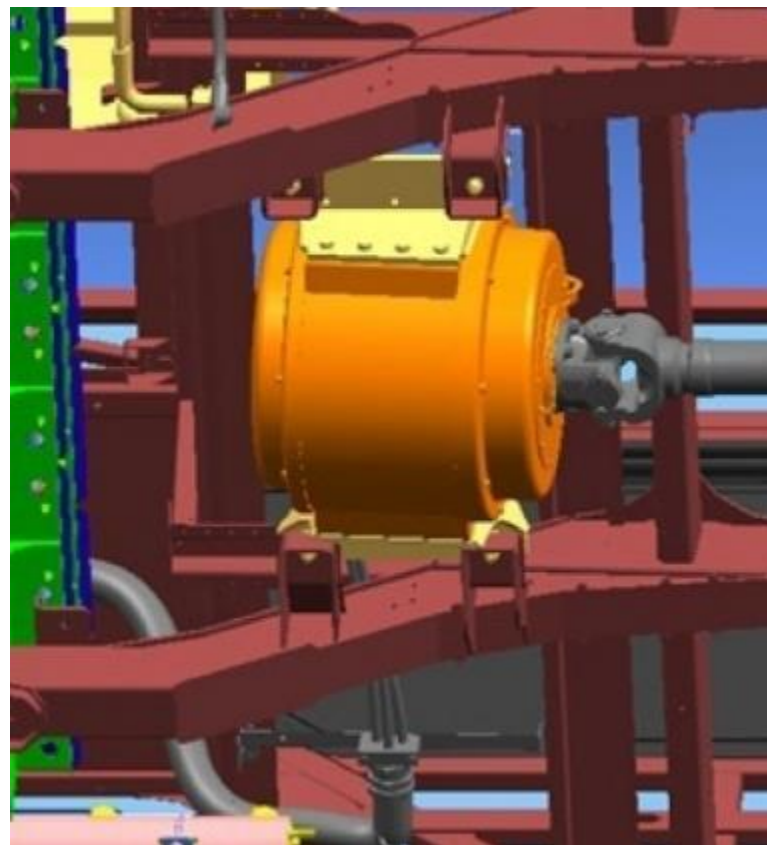
Siemens in the U.S.

-  **60+** manufacturing sites and **50,000** employees
-  Over **\$5 billion** in exports annually
-  **\$35 billion** invested in the U.S. in last 15 years
-  **\$50 million** job training programs annually
-  **\$1 billion** annual R&D investment



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| Electric Traction Motor | | |
|-------------------------|---------------------------------------|-------------------|
| OEM | Siemens | |
| Type | Permanent Electromagnetic Motor (PEM) | |
| Models | 1DB2016 | 1DB2022 |
| Motor Inverters | 1 | 2 |
| Rated Power | 160 kW | 210 kW |
| Rated Torque | 1,033 lb-ft | 1,475 lb-ft |
| Grades | Up to 12.5% at GVWR | Up to 19% at GVWR |





xcelsior **CHARGE**

Energy Storage Systems

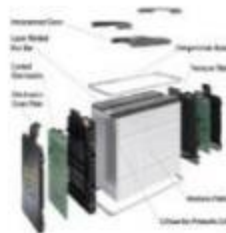
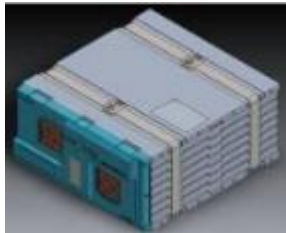
| | XE35 | XE40 | XE60 | XHE (fuel cell electric) |
|--------------|----------------------------------|----------------------------------|-----------------------------------|-----------------------------------|
| Long Range | XALT Energy NMC Batteries | XALT Energy NMC Batteries | A123 SYSTEMS NMC Batteries | A123 SYSTEMS NMC Batteries |
| Rapid Charge | XALT Energy NMC Batteries | XALT Energy NMC Batteries | XALT Energy NMC Batteries | |

NEW FLYER OF AMERICA

The Path to Energy Density & Range

Improve Cell Chemistry Using the Same Footprint & Weight

| Passengers | Xcelsior CHARGE | | Xcelsior CHARGE 2019 | |
|------------|-----------------|------------|----------------------|------------|
| | ESS (kWh) | Range (mi) | ESS (kWh) | Range (mi) |
| 67-76 | 200 | 87 | 300 | 142 |
| | 400 | 189 | 490 | 232 |
| | 480 | 227 | 590 | 280 |
| 116-119 | 250 | 80 | 375 | 125 |
| | 450 | 155 | 575 | 200 |
| | 600 | 200 | 760 | 260 |
| | | | 885 | 300 |



| Battery Supplier | | | New Flyer | |
|------------------|--|---|---|---|
| Cell | Bundle | Module / Pack | Bank / String | Bus |
| One Cell | Multiple cells pre-bundled, laser-welded bus bars, heat transfer plates between cells, pre-wired for temp and volt measurement | Cell Bundle plus CMU (cell monitoring unit) monitoring cell temp and voltage and transmitting data to BMS. Also balances cells within bundle. | Multiple Modules with BMS Battery Management System, cooling & environmentally sealed. Full System voltage, Fusing and Contactors | Multiple Strings for power and energy required. Master BMS consolidates messages from strings for Vehicle Controller and Charger. Additional System Fusing and Contactors |

Xcelsior **CHARGE™** Battery Strings are interchangeable with any battery supplier

- FACT: Lithium-ion batteries have significantly less energy (Wh/kg) compared to diesel or CNG fuel
 - Battery-Electric buses carry more weight to store the same amount of energy and cover the same mileage as a CNG and diesel bus
 - New Flyer's Xcelsior CHARGE™ **design biases the weight distribution of the battery packs to the rear of the bus where axle and tires are capable of higher legal rated loads**
 - Xcelsior CHARGE™ buses are capable of carrying the equivalent seated and standee passengers as our non-electric Xcelsior®



Industry Leading Carrying Capacity

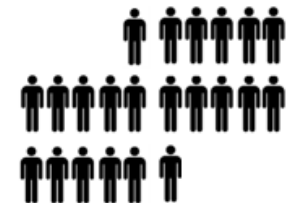
Xcelsior CHARGE

Competitor

On the Bus


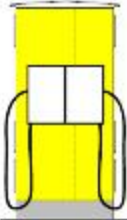



Left Waiting



NEW FLYER OF AMERICA

2 (a). Standalone CCS HPC 150/300kW for eBus

Single PCS enclosure
 1.000x1.000x2.000 (300kW)
 0.800x0.800x2.000 (150kW)
 High rated isolation transformer for LV grid 400/480VAC
 DCB connectors with liquid cooled busbar connectors (400A)

Optional separated front end
 300kW 400A 200-1000VDC
 150kW 200A 200-1000VDC
 Environmental operating range - 25 °C / 155 °F

www.hpc.xcelco.com

Depot Plug-in Charging
100 - 150 kW



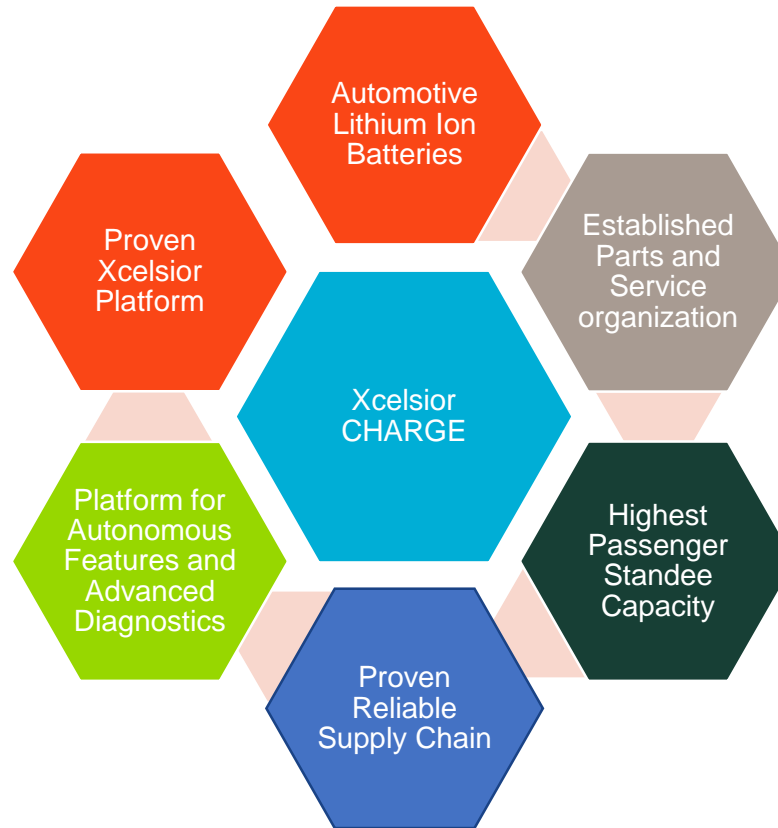
Overhead On-Route Charging
300 - 450 kW

- XcelSior CHARGE™ is Interoperable, conforming to emerging industry standards
 - **SAE J3068 and SAE J1772 compliant** depot charging equipment can be used to charge buses, coaches, trucks and cars from other manufacturers
 - Opportunity charging accomplished with **OppCharge compliant fast** charging equipment. Efforts to align with the forthcoming **SAE J3105** (Overhead Fast Charge – Standard under development)
- New Flyer charging equipment available from globally recognized suppliers





The Complete Solution.



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- Xcelsior CHARGE Electric Bus Features Technology
- California ZEB Programs

Trolley Electric ZEBs

New Flyer XT60 Articulated Bus



*“San Francisco Municipal
Transportation Agency (SFMTA)
Expands Zero-Emission Footprint
with an Order for 185 Trolley-
Electric Buses”*

- July 2017



NEW FLYER OF AMERICA

California Fuel Cell Electric Bus Programs

New Flyer Active Fuel Cell Bus Commercialization Programs in California



FTA National Fuel Cell Bus Program

- Active Program for (1) XHE60 Battery-Electric Bus with a Ballard Fuel Cell, stainless steel structure, and enter driven axle technology for traction challenged applications. (Service for AC Transit in 2018)

California Energy Commission (CEC)

- Design and Manufacture (1) XHE40 battery-electric bus with a Hydrogenics fuel cell (SunLine Transit Agency)

California Climate Investment (Air Resources Board AQIP Program)

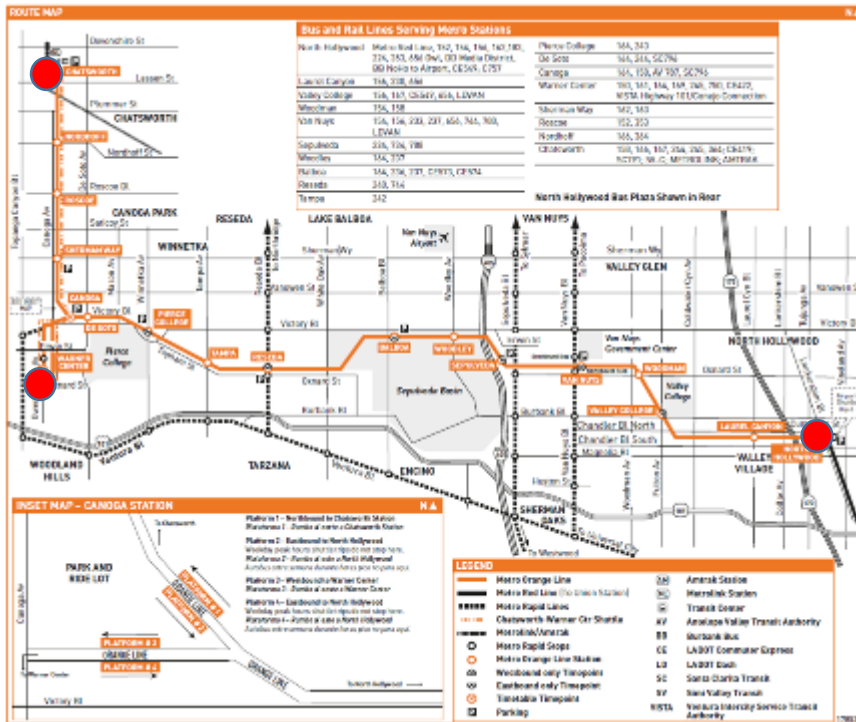
- 10 XHE40 Fuel Cell Buses for AC Transit
- 10 XHE40 Fuel Cell Buses for OCTA
- 5 XHE40 Fuel Cell Buses for SunLine



NEW FLYER OF AMERICA

BRT Line with High-Power On-Route Chargers

New Flyer XE60 Articulated Buses – LA Metro Orange Line



Up to 40 Buses Operating Continuously with (8) 450 kW High-Power Siemens Chargers



● Locations of High-Power Chargers



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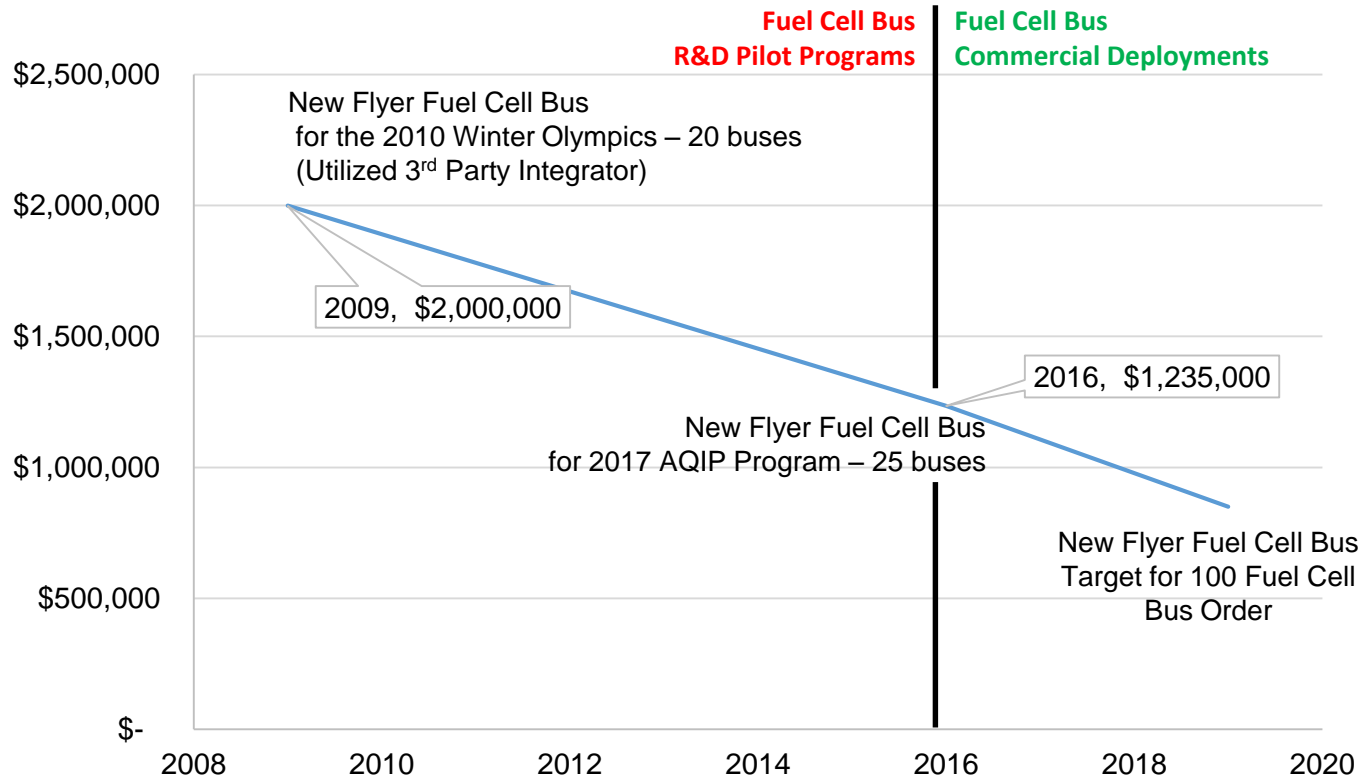
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Fuel Cell Electric Bus (FCEB) – Future

- New Flyer approaches the FCEB as a Battery Electric Bus (BEB) using hydrogen and the Fuel Cell as the on-board “battery charger”
- Fuel cell-electric buses offer advantages over BEBs for re-fueling time and range – operationally a near “one-for-one” replacement for a diesel or CNG bus
- Long-range BEBs have “closed” the gap on range to FCEBs. With additional batteries needed for BEBs, FCEBs have weight advantages over long-range BEBs
- FCEB Workshop sponsored by CTE was widely attended in Canton, OH on Nov 2-3, 2017
 - New Investments in FCEB technology by GM, Toyota, Ballard and others
 - Hydrogen supply and infrastructure providers are creating and expanding hydrogen energy solutions and options
- The California Climate Investments Programs through CARB and the FTA are supporting Fuel Cell-electric bus deployments with ZEB incentives
- Acquisition costs have declined and will continue to decline due to economies of scale and technology improvements

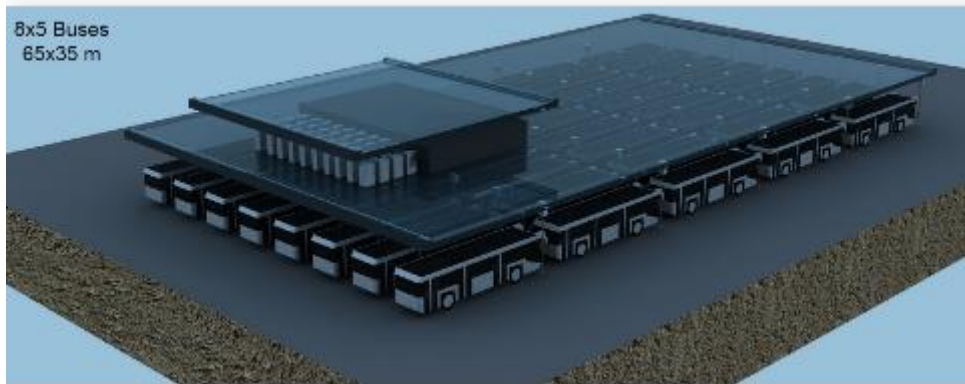
FCEB – Cost Trend and Target

Economies of Scale / Technology Improvements



Advanced “Smart Charging” and Creative Land Use Designs for Depot Charging

- New Flyer firmly supports interoperable chargers from multiple providers that can intelligently charge a large fleet of electric buses of different makes (leaving no stranded assets)
- Short-Term: New Flyer will assist transit agencies by providing buses with interoperable charging systems to support successful ZEB deployments
- Long-Term: New Flyer expects future RFPs will separate charging equipment from bus procurement
- Ultra-Fast DC Plug-In Chargers are emerging (Funded in part by \$2B VW EV Infrastructure Investment)
- Engineering and infrastructure firms (Black and Veatch, Burns and McDonald, WSP and others) will have significant roles in innovating solutions with eMobility companies, utility and energy providers, Charging Supply Equipment Manufacturers, and Bus OEMs --- creating highly innovative charging solutions for large fleet deployments, that will evolve into industry best practices



40 BEBs Consume ~12 MWh Daily

The energy equivalent of powering ~12,000 residential homes for 1 hour

Future (Early Stages Now)

Smart Charging will help even-out grid demand and reduce Infrastructure CapEx

Transit depots will be reconfigured or designed ground-up to accommodate innovative charging solutions

It's **bright** ahead.

Innovation to **RELY ON.**

Technology that Works

Transforming Your Community with Sustainable Clean Technology

Investment in Our Communities

Leading Transit with Investment in American Jobs

Progressive, but Prudent Innovation

Supporting Smart Cities with Technology, Training and Collaborative R&D

For More Information:

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Built to **RELY ON.**