WEST COAST COLLABORATIVE
A public-private partnership to reduce diesel emissions

West Coast Partnership to Promote Alternative Fuel Corridors

Plug-In Electric & Hydrogen Fuel Cell Technologies & Infrastructure

Alternative Fuel Infrastructure Corridor Coalition (AFICC)

Washington, Oregon, and California

Webinar Session #4

Tuesday, November 6, 2018

10:30 a.m. – 12:00 p.m. PT

Overview

- Overview of Alternative Fuel Infrastructure Corridor Coalition (AFICC)
- AFICC Technical Webinar Objectives
- Discussion Leader Presentations: Plug-In Electric and Hydrogen Fuel Cell Technologies and Infrastructure
- Workgroup Discussion

West Coast MD/HD Alternative Fuel Corridors

Interstate collaboration is needed to develop west coast corridors for MD/HD AFV fueling similar the one shown here for LD ZEVs. This would help to address:

- Emission reductions
- Fuel supply diversity
- Sustainable freight, public works, refuse collection, transit & school bus
- Local job creation and economic development

MD/HD Alternative Fuel Infrastructure Corridor Coalition

1. Convene a stakeholder coalition focused on M/HD alternative fuel infrastructure deployment.
2. Conduct stakeholder workgroups & targeted outreach to identify desired/unfunded M/HD alternative fuel stations.
3. Synthesize stakeholder input into a plan document.
4. Use the plan to support project development, leverage existing funds, and seek joint applications to US DOT and other competitive funding programs.
5. Obtain federal funding assistance to help implement infrastructure in California, Oregon and Washington (i.e., natural gas, propane, electric vehicle charging and hydrogen for public and private M/HD fleets).

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AFICC Project Overview

Needs

- Prioritize Hot Spots (Areas of Congestion, Communities, Intermodal Freight Hubs)
- ID Alt. Fuel Infrastructure Gaps
- ID Best Techs/Fuels for Transportation Activities/Project Areas

Establish Framework

- Define Workgroup Discussion Objectives
- ID Key Stakeholders
- ID Coalition-Supporting Resources
- ID Direct Outcomes

Facilitate Workgroup Sessions [CA, OR & WA] Collect Feedback, Compile Info, & Research Q's

Develop AFV Stakeholder Synthesis

- Summarize Workgroup Feedback
- Respond to Questions
- Outline Critical Barriers & Challenges
- Evaluate Needs & Costs for AFV Infrastructure

Draft Implementation Plan

- Include Themes & Priorities
- Outline Strategy & Actions
- Provide Recommendations
- ID AFV Project Partnerships
- Estimate Project Costs & ID Funds

Present Outcomes to Partners

Opportunities

- ID partnerships with Freight Shippers, Carriers, BCOs, Ports, Railroads, Truck Associations (LMCs/IOOs) Truck Stops, Warehouses, EDCs, and Cities on Coordinated Alt. Fuel Corridor Projects

Today's Webinar Objectives

Learn from vehicle manufacturers, fuel suppliers and fleets about the benefits, application and business case for plug-in electric and hydrogen fuel cell vehicle technologies.

1)Latest emerging technologies and costs;

2)Operational suitability;

3)Infrastructure considerations;

4)Fleet best practices; and

5)Opportunities for alternative fuel corridors.

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Today's Discussion Leaders

Program Facilitators

- **Alycia Gilde,** Director, CALSTART
- **John Mikulin**, Environmental Protection Specialist, EPA Region 9

Presentations by:

- **Tim Weaver,** Vice President of Corporate Development, Chanje
- **Brendan Riley**, President, GreenPower Motor Company, Inc.
- **Rob Del Core**, Managing Director, Hydrogenics, USA, Inc.
- **Alan Mace**, Heavy-Duty Market Manager, Ballard Power System

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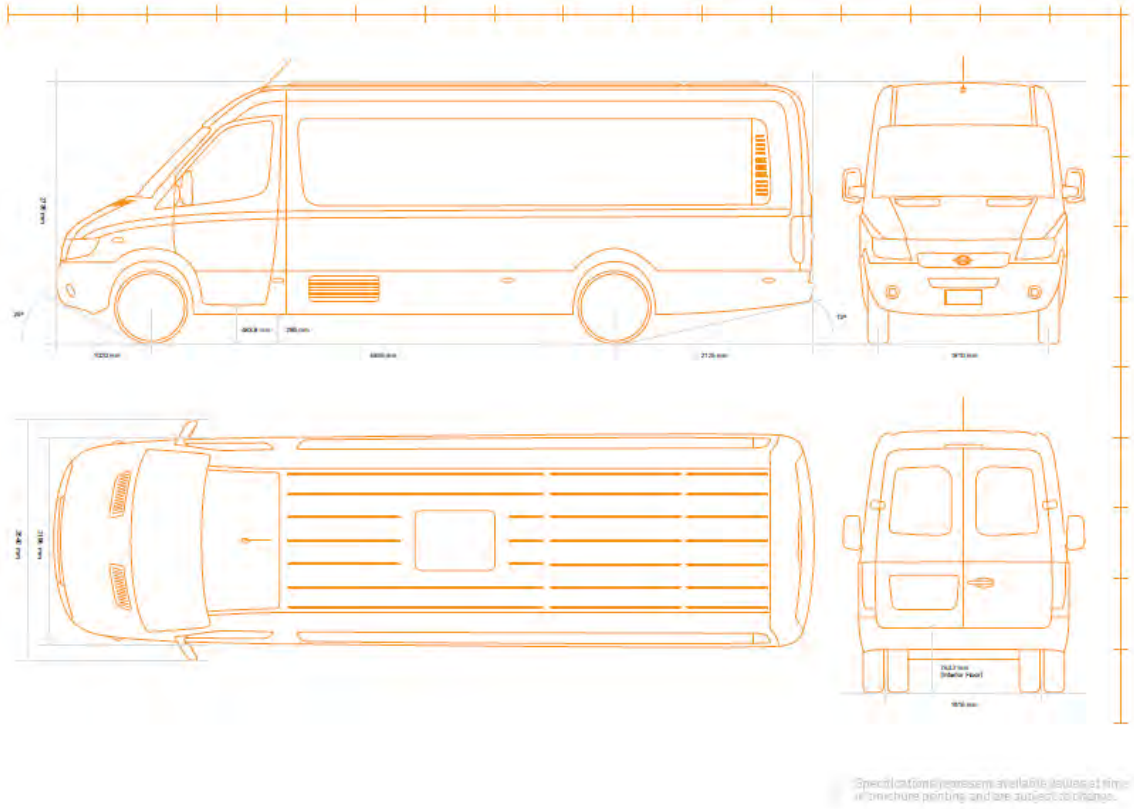
Tim Weaver, Vice President of Corporate Development

November 6, 2018

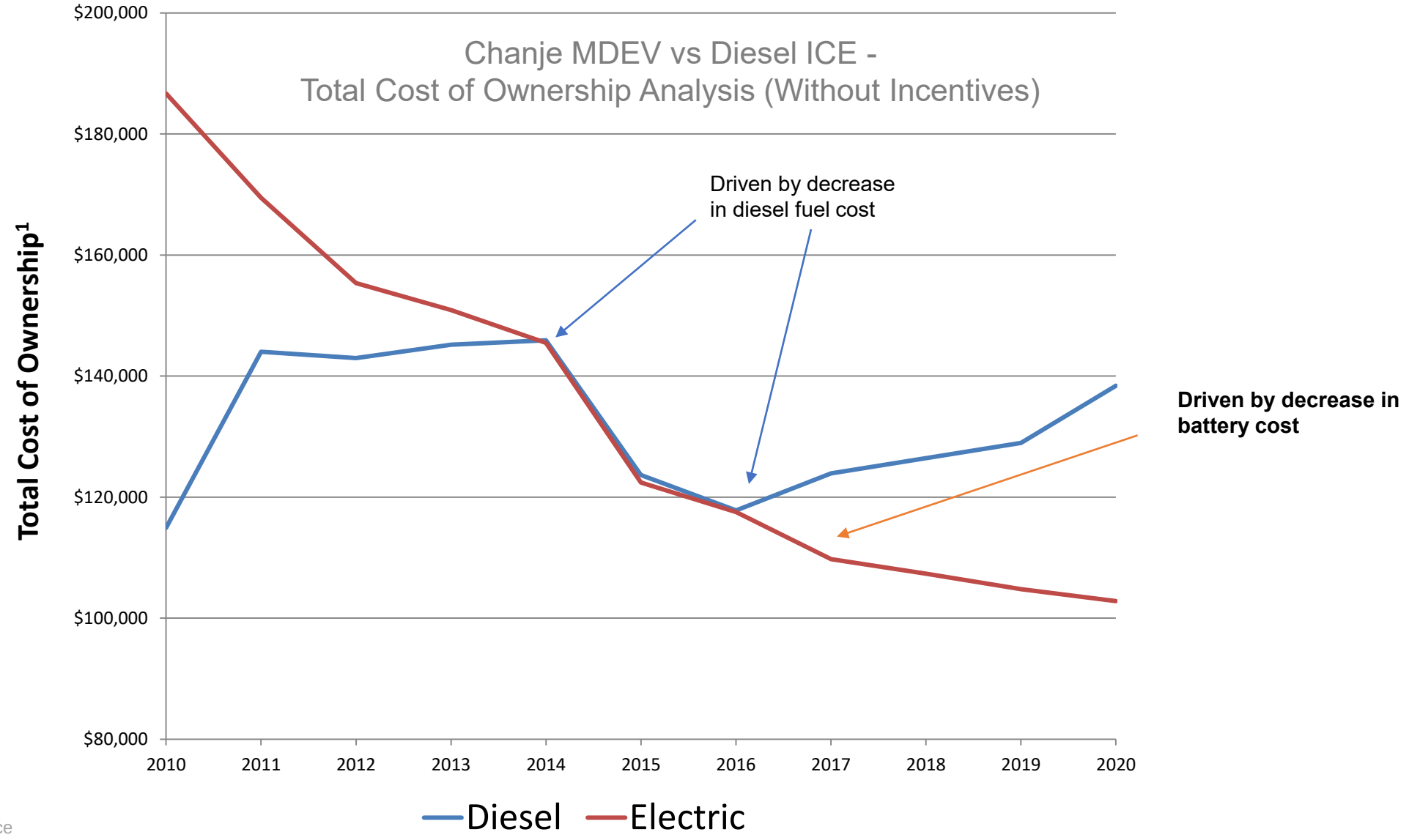

chanje
Zero Emissions
100% Electric
chanje.com
chanje

Specifications



Dimensions	Wheelbase (in/mm)	194.3 / 4,935
	Overall Length (in/mm)	318.1 / 8,080
	Overall Width Excluding Mirrors (in/mm)	86.4 / 2,195
	Overall Height (no roof rails) (in/mm)	109.4 / 2,780
	Curb Weight (lb/kg)	10,535 / 4,778
	Gross Vehicle Weight Rating (lb/kg)	16,535 / 7,500
	Total Payload (lb/kg)	6,000 / 2,722
	Cargo Volume (cu ft)	675
Mechanical	Drive Configuration	RWD
	Motor Type	Synchronous Permanent Magnet
	Number of Motors	Dual Motor System
	Motor Cooling Method	Liquid Cooling
	Battery Capacity	100 kWh
	Battery Chemistry	LiFePO4
	On-Board Charger	13.2 kW
	Charge Port	J1772 Level 2
		DC Fast Charge CCS
Performance	Total Peak Power (hp/kW)	198 / 148
	Total Peak Torque (lb-ft/Nm)	563 / 764
	Top Speed (mph/kmh)	81 / 130
	Max. Gradeability [%]	30%
	Turning Radius (ft)	26.6
	MPGe	50
Chassis	Body Construction	Unibody
	Front Suspension	Independent
	Rear Suspension	Leaf Spring
	Tire Size	215 / 75R17.5

Why Now?



[1] Includes fuel and maintenance
Source: United States Energy Information Administration

Value Proposition

MDEVs provide superior operating costs: ~70% less than ICE vehicles

Chanje all-in Total Cost of Ownership (including maintenance) no longer a barrier to entry for customers

- is at parity with other equivalent performance ICE vehicles now

Diesel and ICE vehicle costs continue to increase while battery costs continue to decrease

				GHG per 100k miles	
	$/Gallon	M-Duty MPG	$/Mile	Well-to-Wheel	Pump-to-Tail
Diesel	$3.00	11	**$0.27**	115.0k lbs	92.0k lbs
CNG	$2.00	9	$0.22	122.0k lbs	85.4k lbs
LPG	$3.00	9	$0.33	124.6K lbs	96.0k lbs
Electric	$.15/kWh	50+ MPGe	**$0.10**	60.0k lbs	0 lbs

Significant Operating Cost Benefits (Without Incentives)

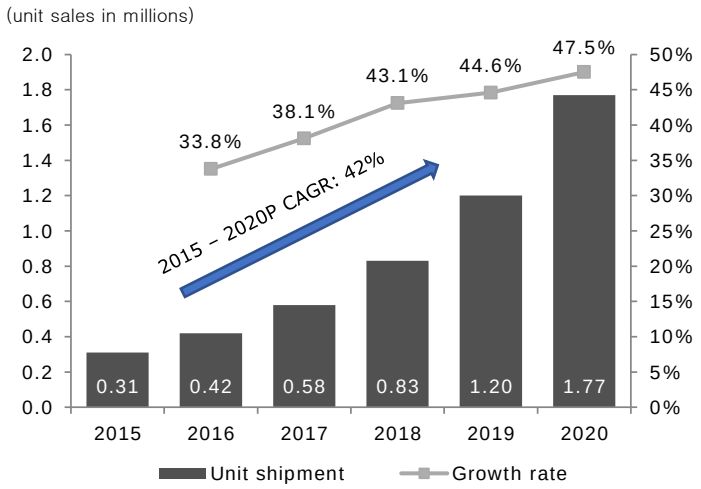
Source: GREET

Trends Leading to Market Expansion

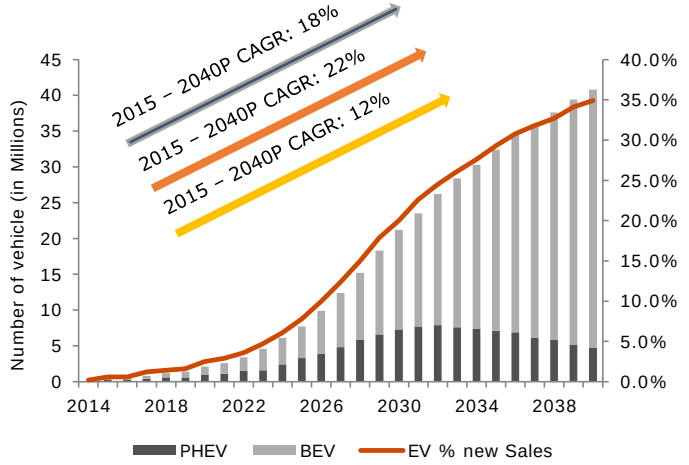
Trends Driving EV Adoption:

- Customer Demand
- Operational Cost Savings
- Fleet Standardization
- Corporate Sustainability
- Urban Access/Emissions Restrictions
- Polices at the federal and local level both encouraging and mandating zero-emission transport
- Growth in Telematics Solutions
- Ongoing Driver Shortage
- Driver Dissatisfaction
- Connected Trucks/Digital Driver Aids

Global EV Sales 2015-20



Global EV Demand Through 2040



Source: Technavio, BNEF and Wall Street Research

chanje

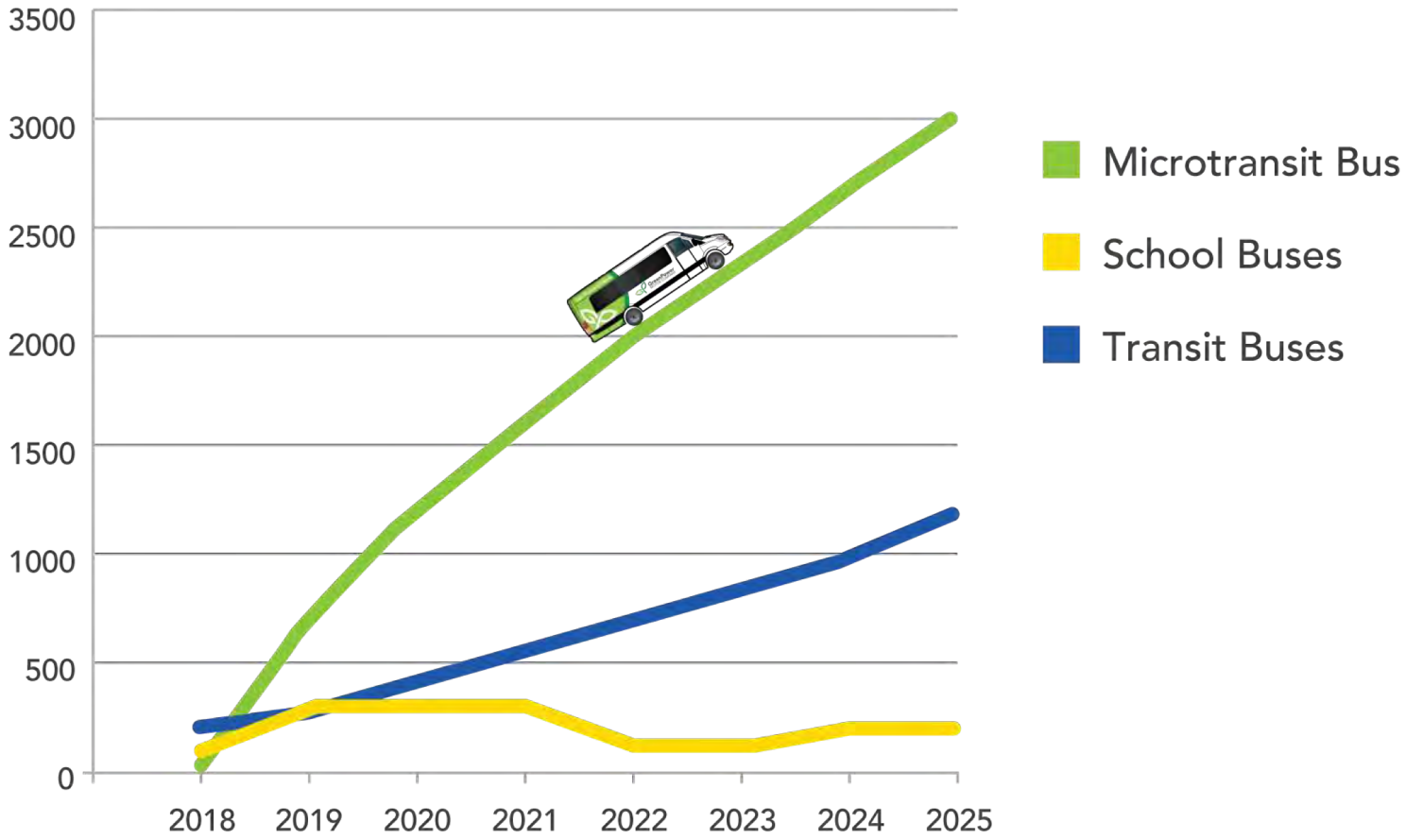
GreenPower MOTOR COMPANY

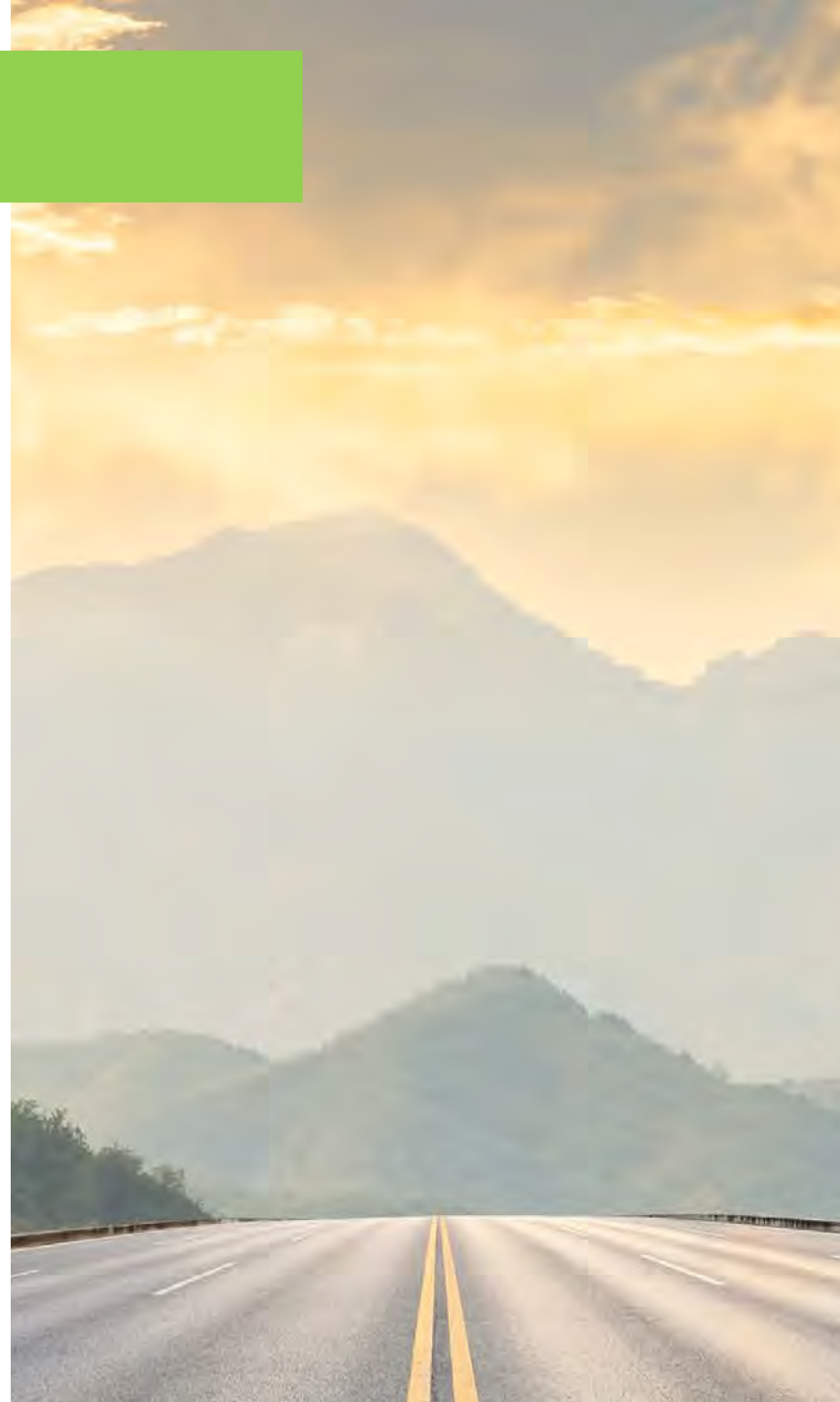
The EVolution of Transportation

TSXV: GPV OTCQX: GPVRF

Electric Bus Trends

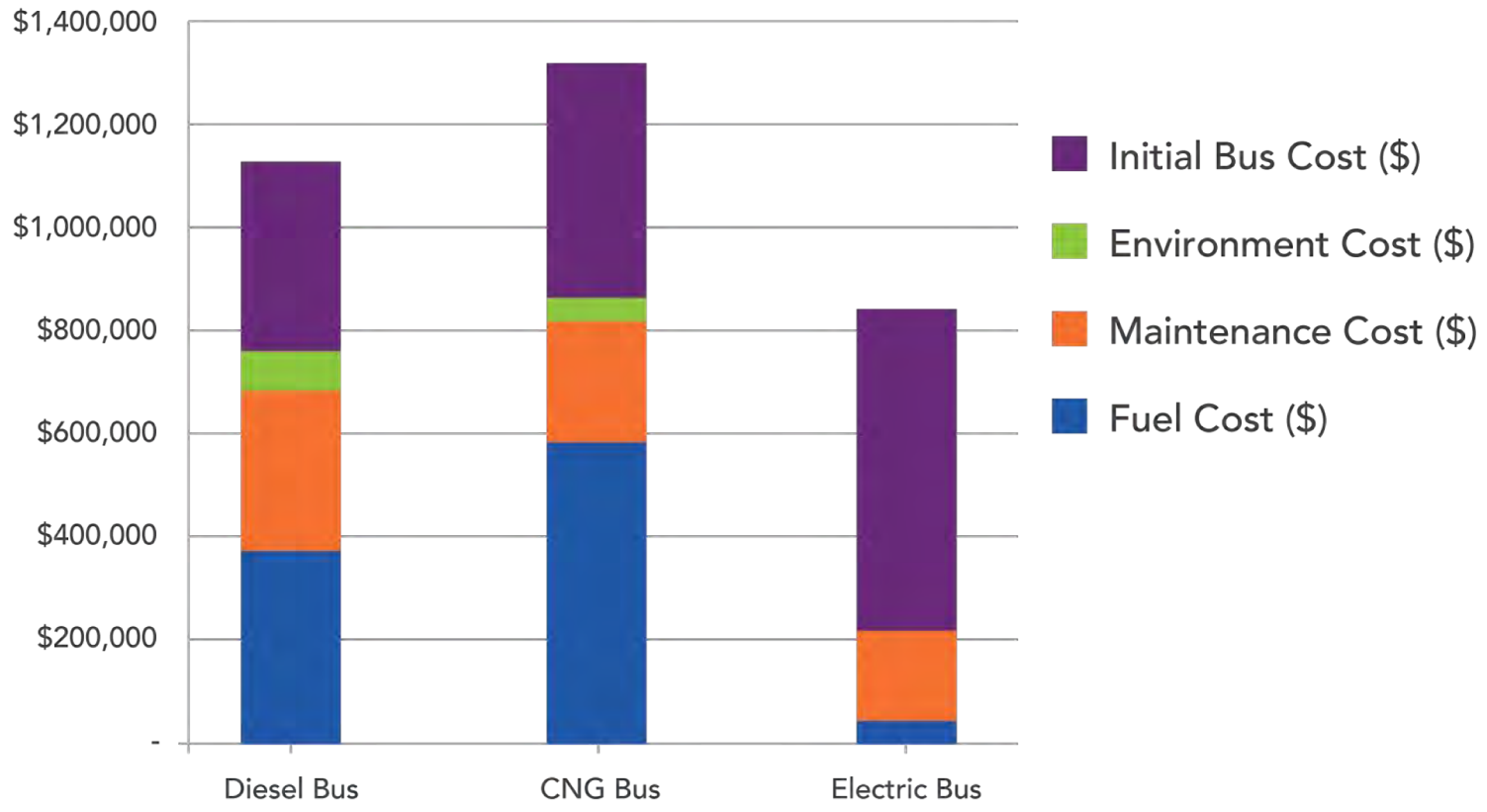
GreenPower projects massive uptick in new bus sales in the emerging micro-transit industry over the next decade

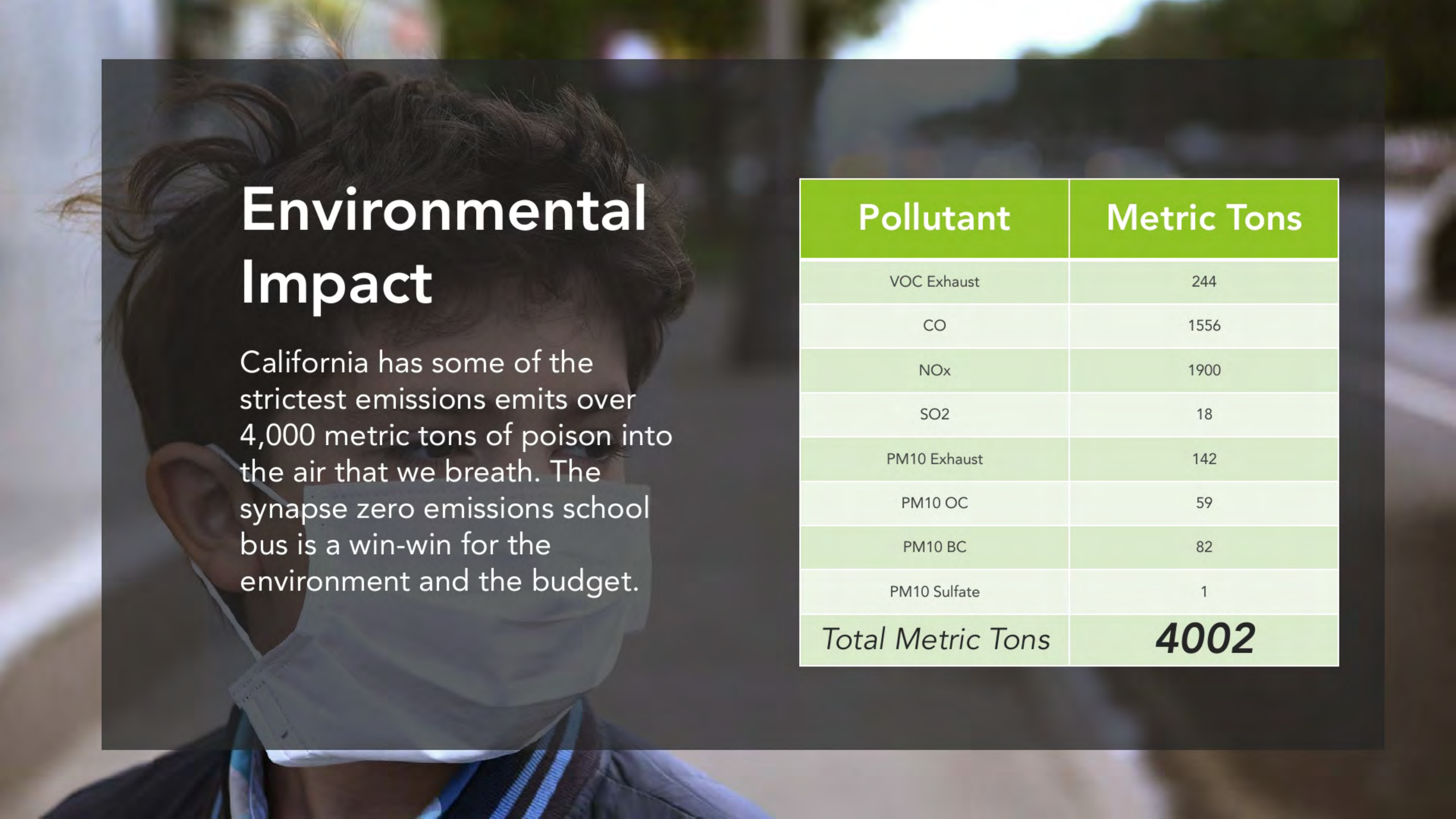




Capital & Operational Cost

GreenPower buses are more cost effective. The following table compares a forty foot Diesel, CNG and GreenPower electric bus over a lifespan of 12 years or 500,000 miles





Environmental Impact

California has some of the strictest emissions emits over 4,000 metric tons of poison into the air that we breath. The synapse zero emissions school bus is a win-win for the environment and the budget.

Pollutant	Metric Tons
VOC Exhaust	244
CO	1556
NOx	1900
SO2	18
PM10 Exhaust	142
PM10 OC	59
PM10 BC	82
PM10 Sulfate	1
Total Metric Tons	***4002***

CALIFORNIA INCENTIVES

MODEL	2018 Voucher [1]
EV550 Double Decker	$175,000
EV350 Forty Foot	$150,000
EV250 Thirty Foot	$120,000
Synapse 72 School Bus	$220,000
Synapse Shuttle	$120,000
EV STAR	$90,000

[1] CARB approved $180 million in funding for the HVIP in 2018

CALIFORNIA HVIP + CEC INCENTIVES

- Presently there are over 70 school districts in California actively looking for 550 all-electric school buses
- California Vouchers $220,000 + $15,000
- Many states have prioritized their allocation from the $2.9 billion VW Mitigation Trust fund to purchase all-electric school buses
- Level 2, 20kW charging ($1500 per EVSE) or DC Fast charge
- Seatbelts standard
- Multiple range configurations

Infrastructure

Infrastructure = Adoption

EV Star: Leverage Existing Charge

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HYDROGENICS

SHIFT POWER | ENERGIZE YOUR WORLD

Coast Collaborative, Alternative Fuel Infrastructure Corridor Coalition (WCC-AFICC)

Webinar: Plug-In Electric and Hydrogen Fuel Cell Technologies & Infrastructure

November 6, 2018

Rob Del Core

Managing Director
Hydrogenics USA

Version: 02.17

Shifting Power Across Industries Around the World

HYDROGEN GENERATION

Electrolyzers
Industrial Hydrogen Supply

POWER SYSTEMS

Fuel cells
Stand-by Power
Mobile Power Modules
MW Power Plants

RENEWABLE HYDROGEN

Energy Storage
Hydrogen Refueling Station
Power-to-X
Grid Balancing Services

Why Hydrogen Fuel Cell Transportation

Positive feedback from Operators for adopting hydrogen-powered vehicles:

- Zero emission
- No range anxiety
- Fast fuelling
- Offer flexibility in operation
- Using electrolyzer to produce hydrogen fuel onsite, operators enjoy energy independence => more cost and operation control
- Integration ready with renewable energy source – onsite with fleets or offsite co-located with solar and wind farms

Zero Emission Goods Movement & Transportation in California

Fuel Cell Transit Bus and Port Truck, California

- Funded by CEC, to develop New Flyer fuel cell bus and Freightliner fuel cell trucks, Hydrogenics' Celerity bundled with Siemens ELFA drive

Fuel Cell Range Extend Drayage Truck, California

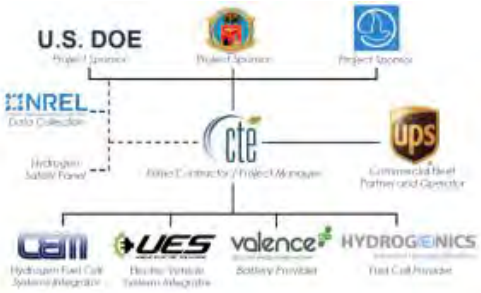
•Powered by Hydrogenics fuel cell

Fuel Cell Port Truck, California

•Funded by DOE ZECT, SCAQMD to develop hydrogen fuel cell Daimler class 8 freight tuck using Hydrogenics' Celerity fuel cell power system for zero emission cargo transportation

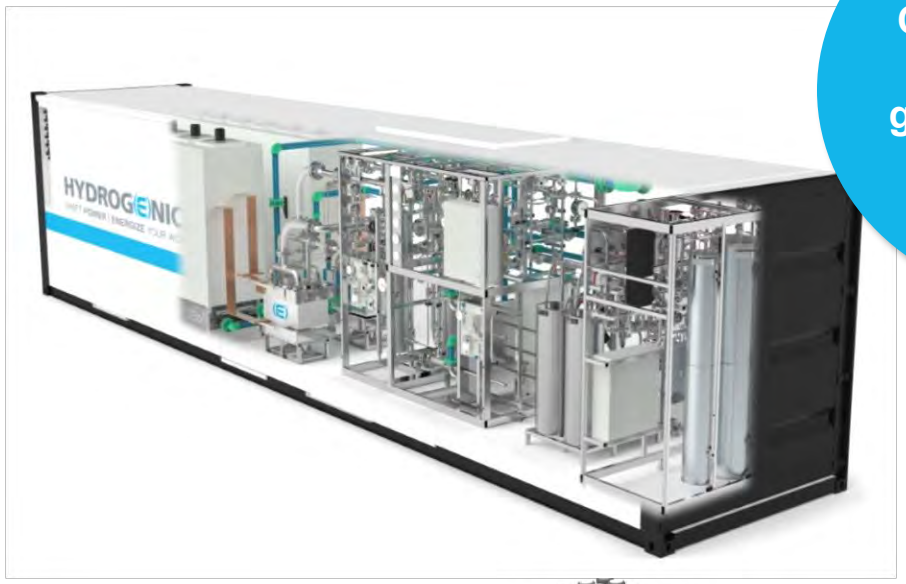
Fuel Cell Range Extend UPS Medium Duty Delivery Van, California

•17 UPS fuel cell delivery van powered by Hydrogenics fuel cell



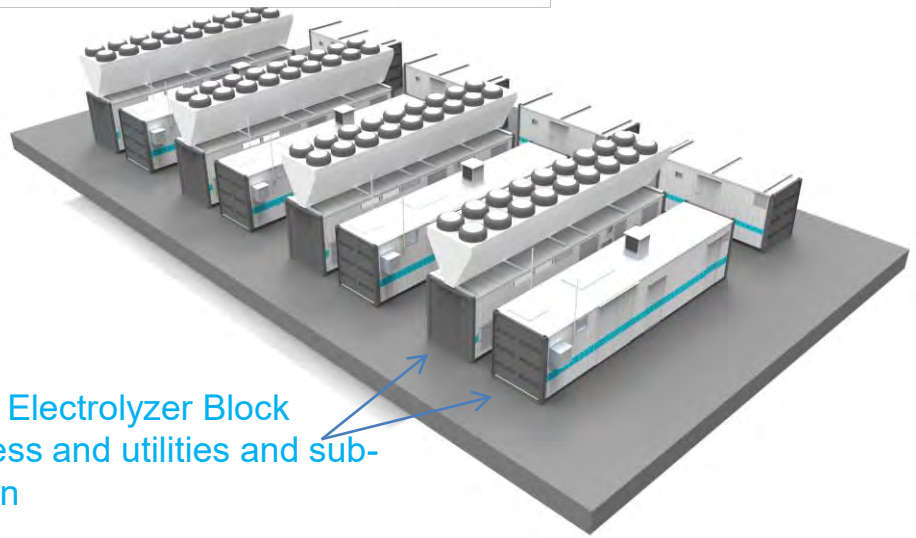
Onsite Hydrogen Refueling Infrastructure with Electrolyzers

Clean renewable hydrogen generation onsite and on-demand



Ontario Hydrogen Station

CalState LA Hydrogen Station



5MW Electrolyzer Block
Process and utilities and sub-station

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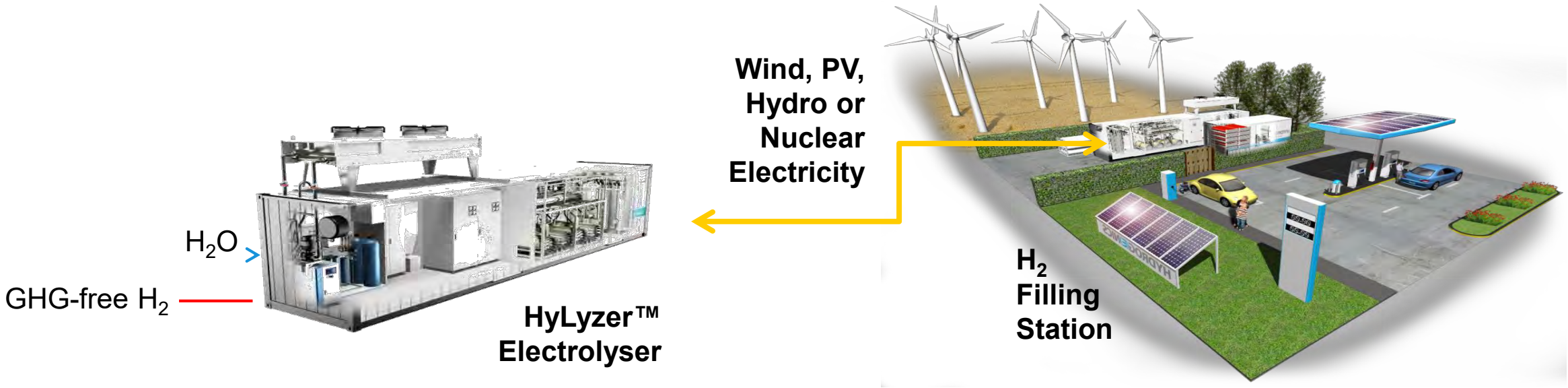
Offsite/Remote Renewable Hydrogen Fuel Production Plants Co-located with Wind and Solar Farms



- ✓ Multiple MW Electrolyzers integrated with remote renewable energy farms along regional freeways
- ✓ Perfect for refueling long haul freight trucks crossing states
- ✓ Perfect for delivering renewable hydrogen fuel to refueling stations in nearby cities
- ✓ Hydrogenics is currently partnering with Stratos Fuel to develop a renewable hydrogen production facility using wind energy in California

Scale Consumption Matches Scale Supply:

Multiple Heavy Duty Port Applications Coupled with Remote 100% Renewable Hydrogen Production to **Bring Down TCO**

Let's do some math:

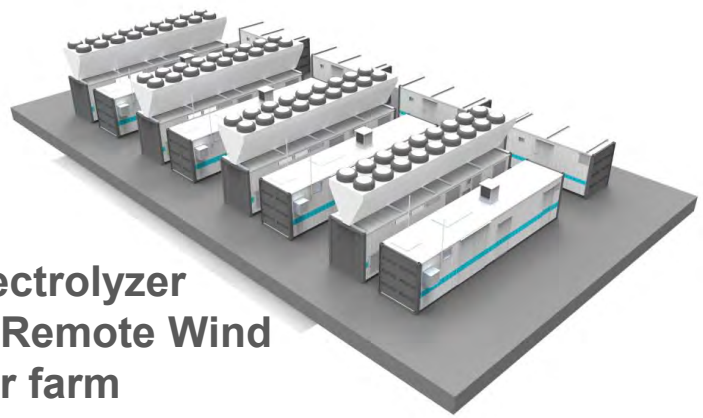
5 X 

100 X 

1 X 

1 X 

can easily consume ~4,000 kg of hydrogen per day, and supply of this scale of hydrogen can come from

2 X 

5 MW Electrolyzer Block in Remote Wind and Solar farm

Multiple Dispensers in and close to ports 

This Scale Bundled Hydrogen Solution can Multiply to Substantially Bring Down the Cost Through Planned and Committed Projects

Thank you for your attention

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Hydrogen Fuel Cell Vehicles

Alan Mace

November 6, 2018

Hydrogen and Fuel Cells for Range, Power, Payload & Utilization




"Fuel cell vehicles provide drivers with the same driving experience they have today with the internal combustion engine: a driving range of 300 – 400 miles, a refueling time of three to five minutes, and normal performance in both hot and cold weather." (Fuel Cell & Hydrogen Energy Association)

BALLARD®

The future of clean transit will be electric .

There are different options to re-charge an electric bus

TROLLEY E-BUS

- Electric drive
- Direct electric
- Powered directly by grid
- Overhead power lines

OPPORTUNITY E–BUS

- Electric Drive
- Small battery
- Grid charging along the road
- Charging stations

OVERNIGHT E–BUS

- Electric drive
- Large battery
- Grid charging at depot
- No route infrastructure

FUEL CELL E-BUS

- Electric drive
- Small battery & fuel cell engine
- Hydrogen refilling at depot
- No route infrastructure

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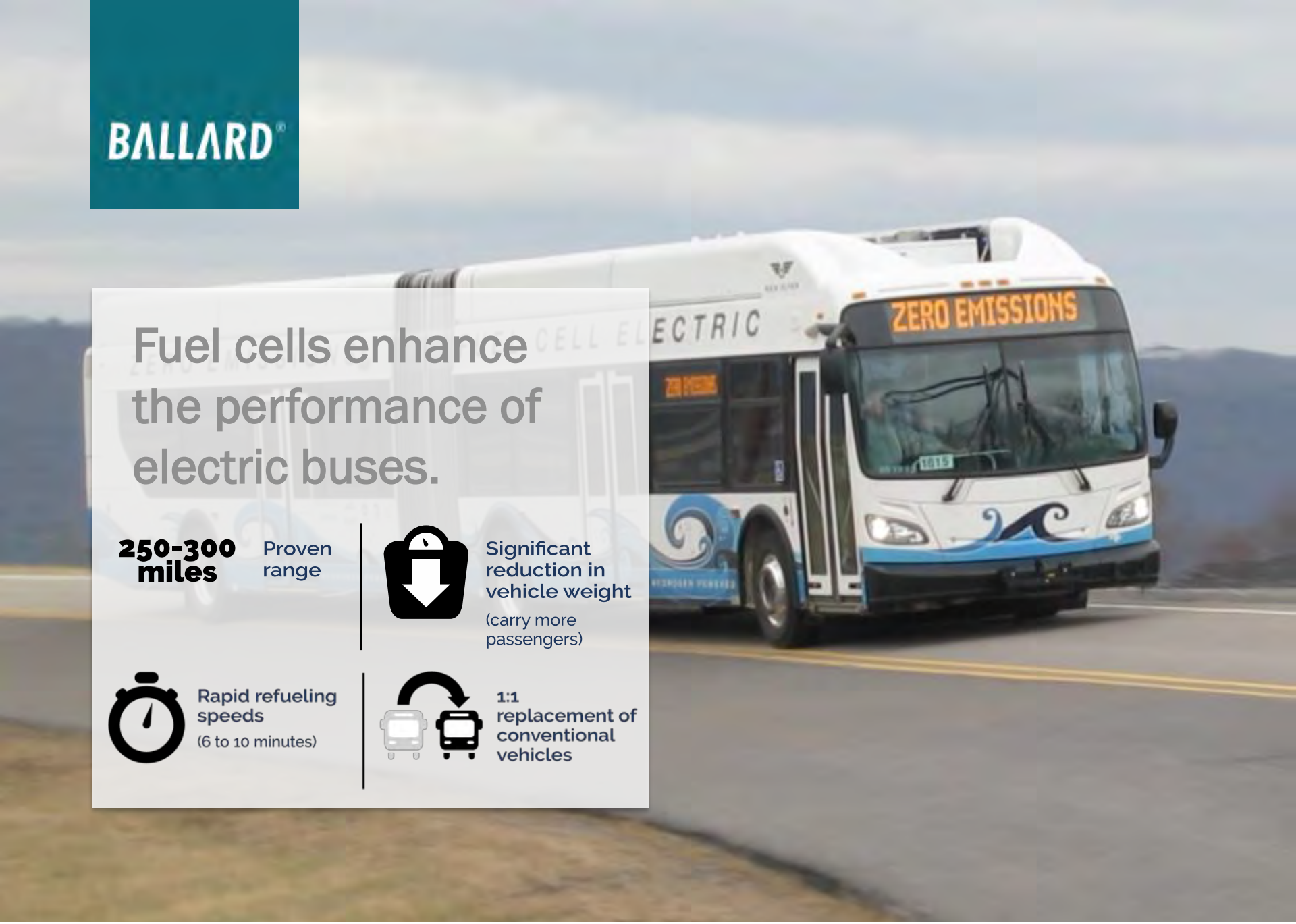


Fuel cells enhance the performance of electric buses.

250-300 miles Proven range

Significant reduction in vehicle weight (carry more passengers)

Rapid refueling speeds (6 to 10 minutes)

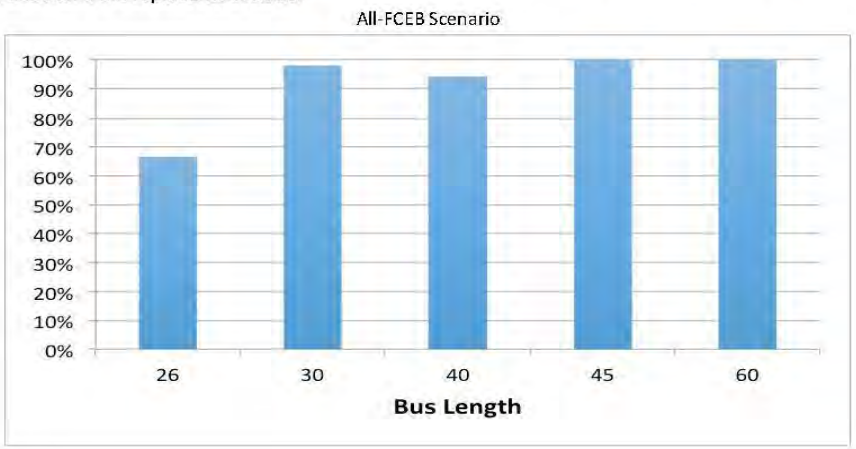
1:1 replacement of conventional vehicles

BALLARD®

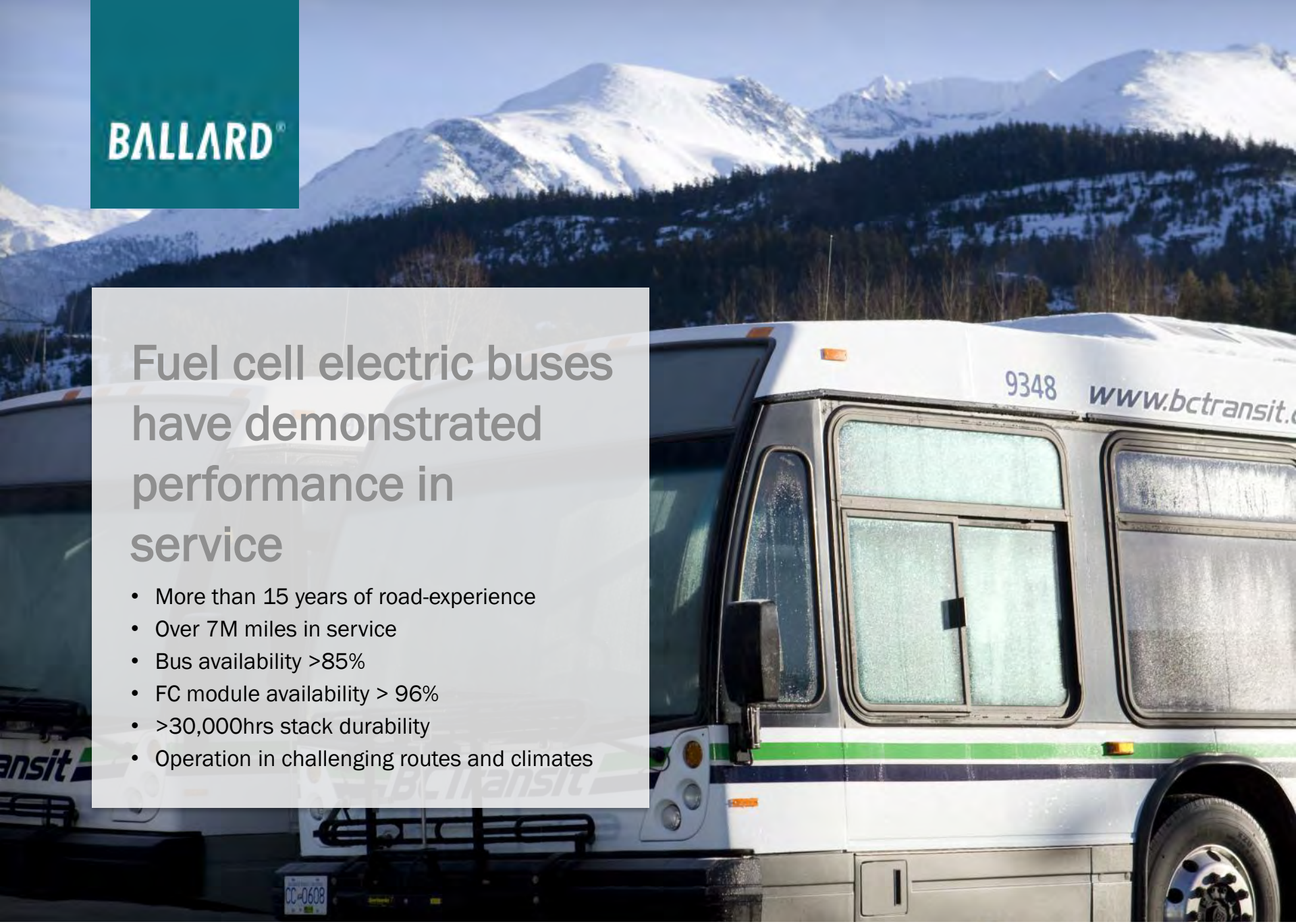
Fuel cell electric buses can replace diesel buses without significant changes to operation and service.

- No need to adapt routes and schedule
- No roadside infrastructure
- 1:1 replacement of conventional buses

FCEBs do not have the same range constraints as BEBs. 95% of all blocks can be served by FCEBs on a 1:1 replacement basis.



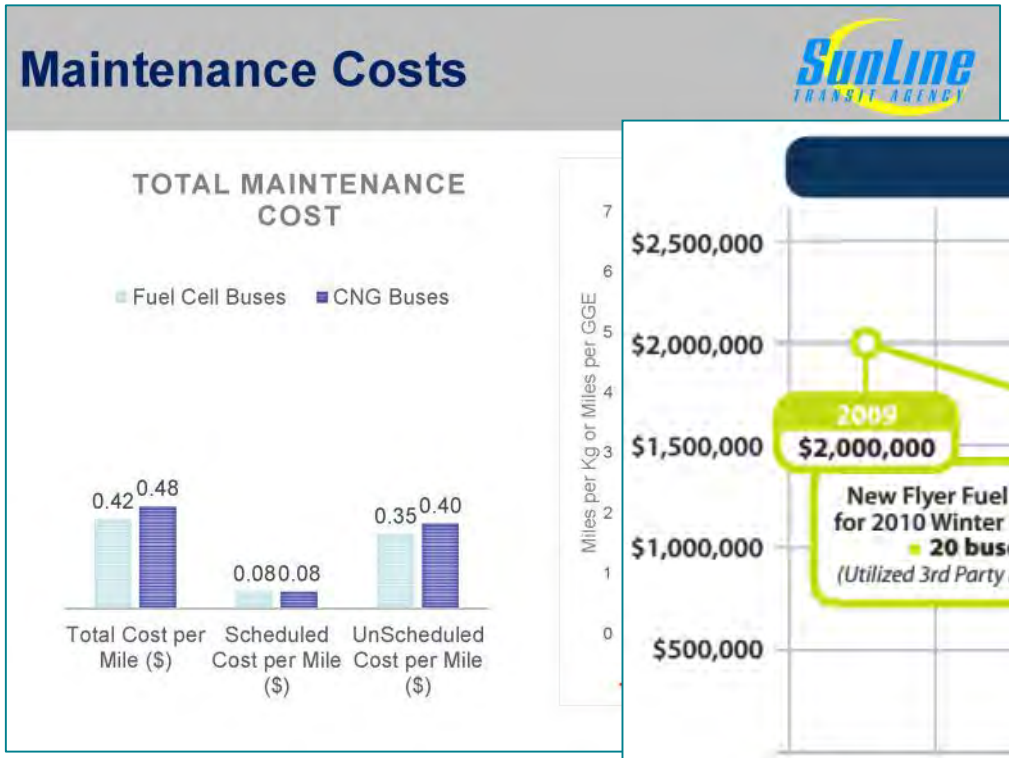
AC Transit Staff Report, 27 June 2018
CTE Assessment

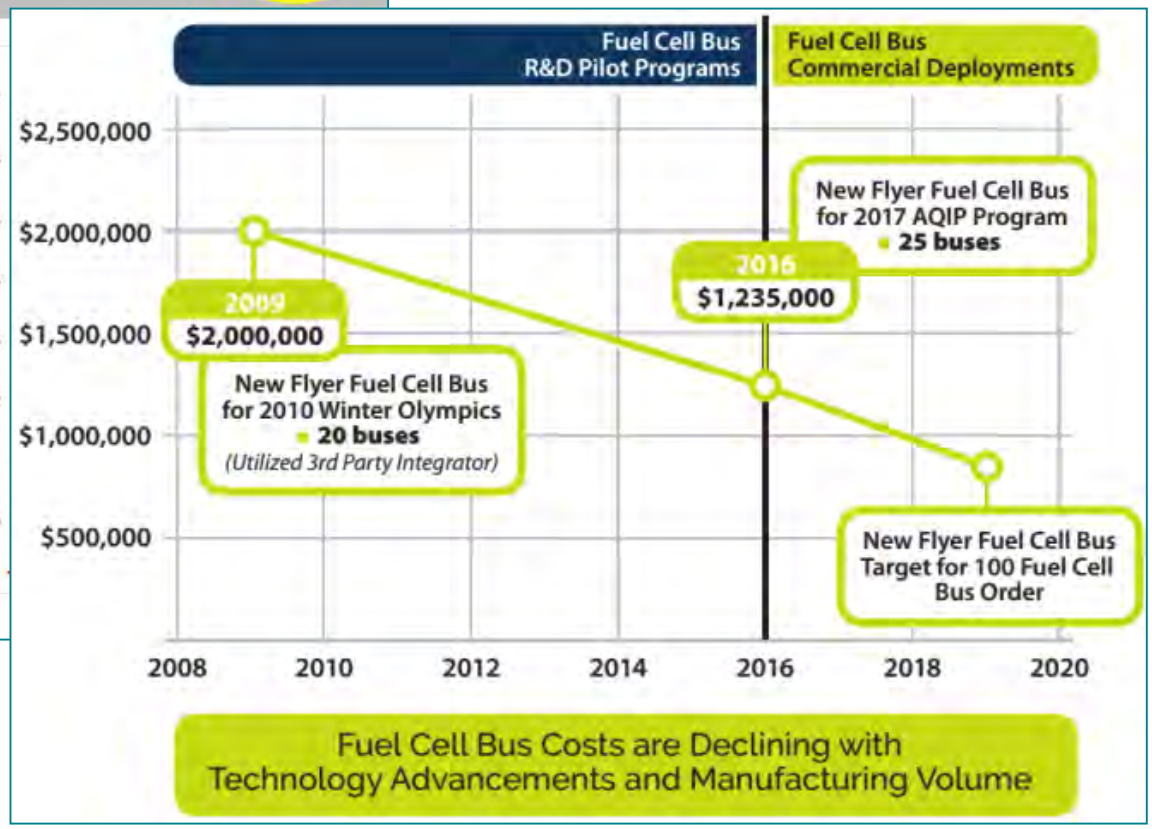


Fuel cell electric buses have demonstrated performance in service

- More than 15 years of road-experience
- Over 7M miles in service
- Bus availability >85%
- FC module availability > 96%
- >30,000hrs stack durability
- Operation in challenging routes and climates

Fuel cell bus cost is declining with technology advancements and manufacturing volume





"I see this increase in demand making the FCEBs' purchasing costs on par with diesel buses in the near future."

Kirt Conrad, CEO Stark Area Regional Transit Authority

Courtesy New Flyer

BALLARD®

4,300ft^2 footprint for a 75 bus station with 2x 4.5t storage of liquid H2

Hydrogen provides flexibility to transit fleets

- Scalable to support hundreds of buses
- Small footprint
- Renewable sources (wind, solar, biogas)
- Redundancy and backup (enable operators to respond to natural disasters)

Hydrogen fueling stations: flexible solutions for each depot

OCTA Station ~ 60’ x 30’ (up to 40 buses)
Liquid hydrogen delivery

AC Transit – Emeryville
On site H2 production (Electrolyser)

20 bus depot (Europe): Hydrogen storage & dispensing area, Compressed H2 delivery (55”x45” – 20 buses)

“Once you are used to using a gas, like CNG, the transition to hydrogen is really easy.”

Kirt Conrad, CEO Stark Area Regional Transit Authority

BALLARD

Committed to sustainable mobility, and clean air for everyone.

Alan Mace

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Discussion

Please raise hand to speak or submit a comment via GoToWebinar.

1. What infrastructure considerations should a fleet be aware of to successfully deploy an electric or hydrogen fuel cell fleet (small vs. large)?
2. Where do we see important infrastructure development opportunities to support alternative fuel corridors for electric/hydrogen fuel cell technologies?
3. What incentives are available for electric and hydrogen fuel cell vehicles and infrastructure?
4. How can multi-state planning lead to more infrastructure deployment assistance resources?
5. Are any webinar participants interested in developing electric charging and/or hydrogen fueling infrastructure for medium and/or heavy-duty equipment operating in California, Oregon, or Washington?

Save the Date for Our Next Webinars

Alternative Fuel Infrastructure Needs: Expanding Our Clean Corridors for MD/HD Vehicles

WASHINGTON

Monday, December 10th

1:00 p.m. – 2:30 p.m.

OREGON

Thursday, December 13th

1:00 p.m. – 2:30 p.m.

Partners will provide input on critical gaps & infrastructure needs along key corridors & evaluate actions and funding opportunities to support partnership, coordination & project implementation.

Contact Us

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