Fuel cell electric buses in 2022

Patrick Scully
General Manager – Global Bus Market
Ballard Fuel Systems

Fuel cell electric buses have evolved over the years...

A fuel cell electric bus is one of the most mature application for fuel cell technology

The advantages of fuel cells over battery electric vehicles

Only fuel cell vehicles can directly replace diesel, route for route for range.

All weather performance

Increased range

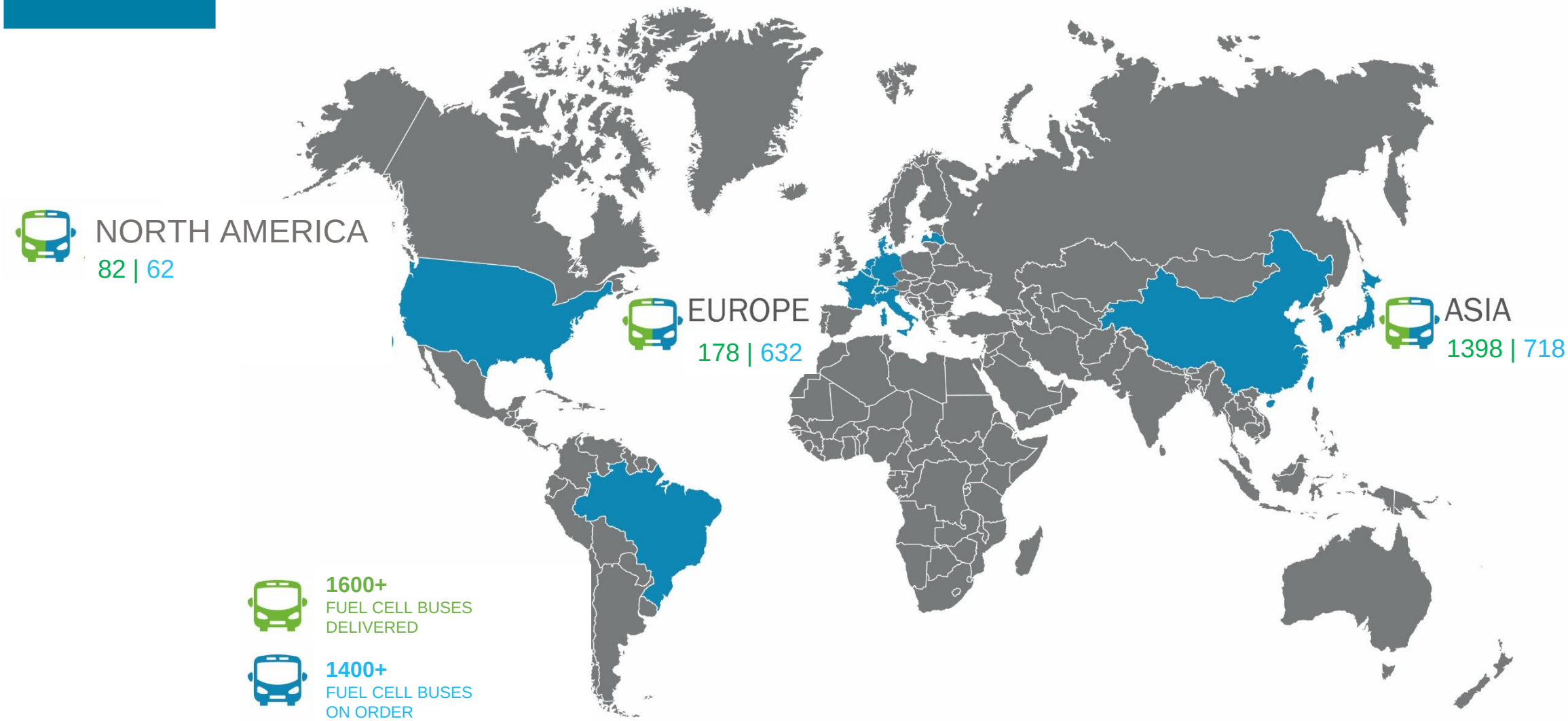
Rapid refueling

Fuel cell vehicles are more adaptable:

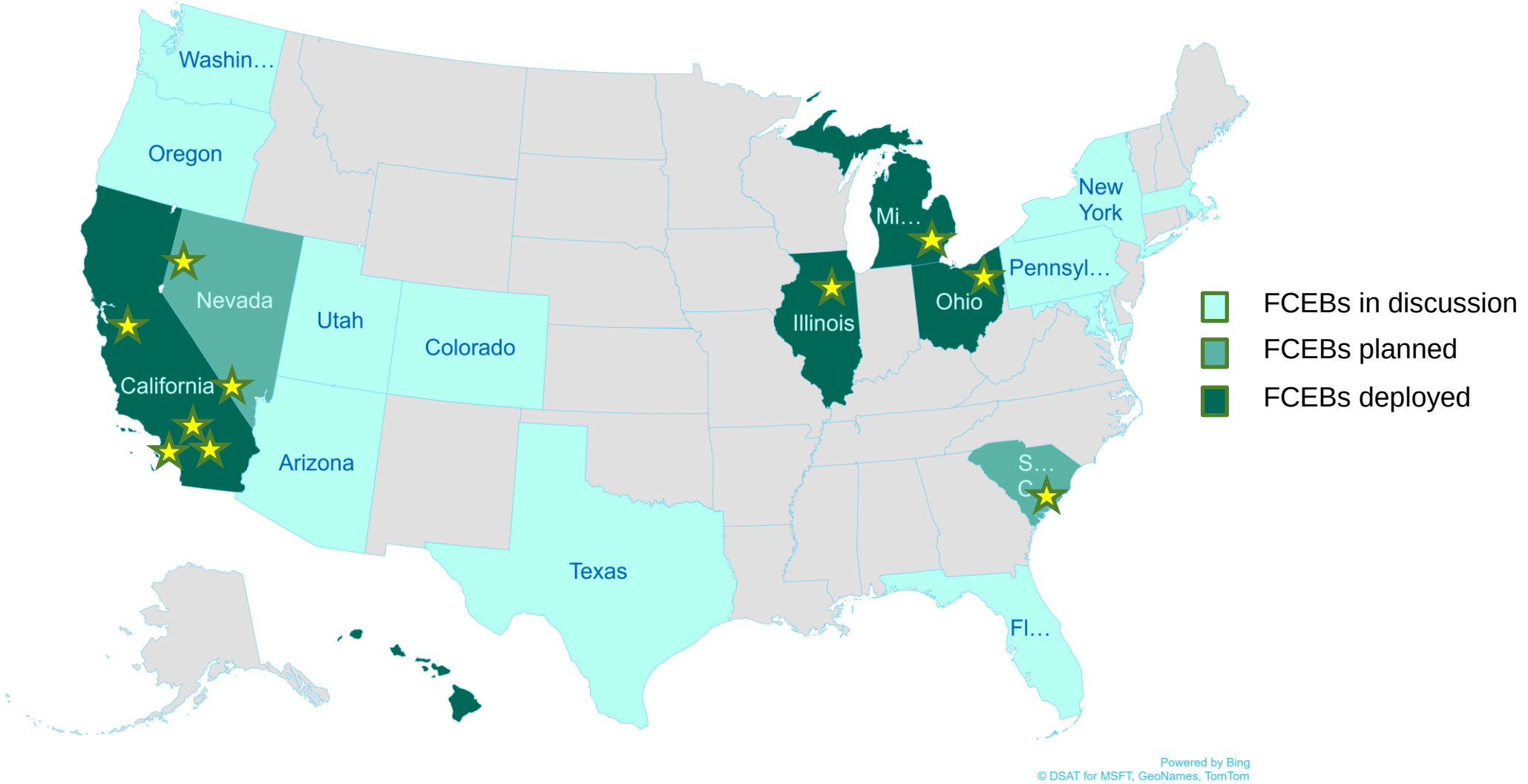
- Hybrid, scalable power system, optimized for vehicle performance
- Higher energy density enables longer routes, and heavier payloads and hotel loads
- **Scalable infrastructure enables rapid deployment and scaling of EV fleets**

Hydrogen fuel is widely available today. Expansion of renewable hydrogen, and advancements in hydrogen conversion are increasing renewable options.

FUEL CELL BUSES WORLDWIDE



Fuel Cell Electric Buses are Spreading Across US



The Rise of the FCEB

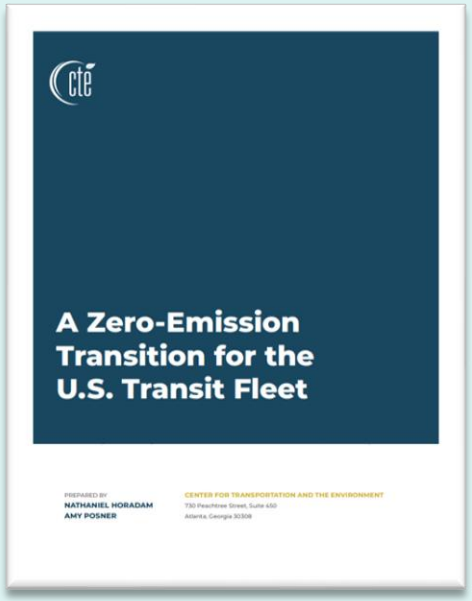
ZEB Transition Plans from California transit systems shows FCEB adoption growing rapidly!

When this year's buses retire in 12 years, there will be over 700 FCEB's on the road in California from these agencies alone!

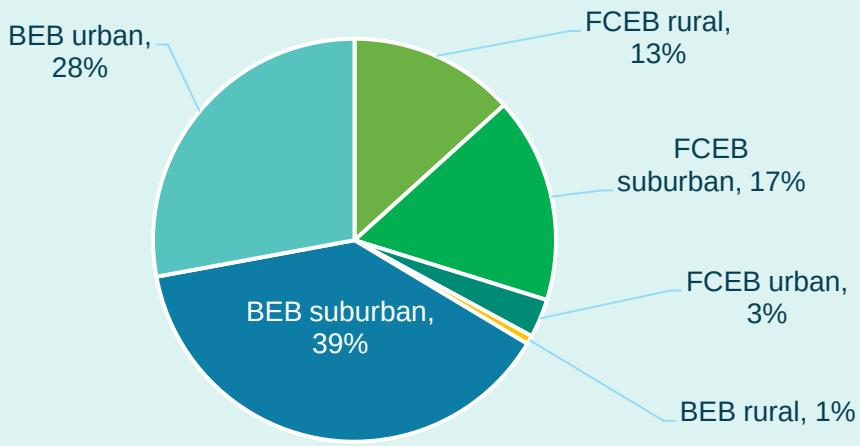
The Center for Transportation and the Environment, recognized as global experts in ZEB deployments, estimate that almost a third of all buses in the US are best suited as FCEB's for ZEB transitions.

TOTAL 40', 60' FCEB'S ON THE ROAD IN CA

CALIFORNIA ICT ROLLOUT PLAN PROCUREMENTS



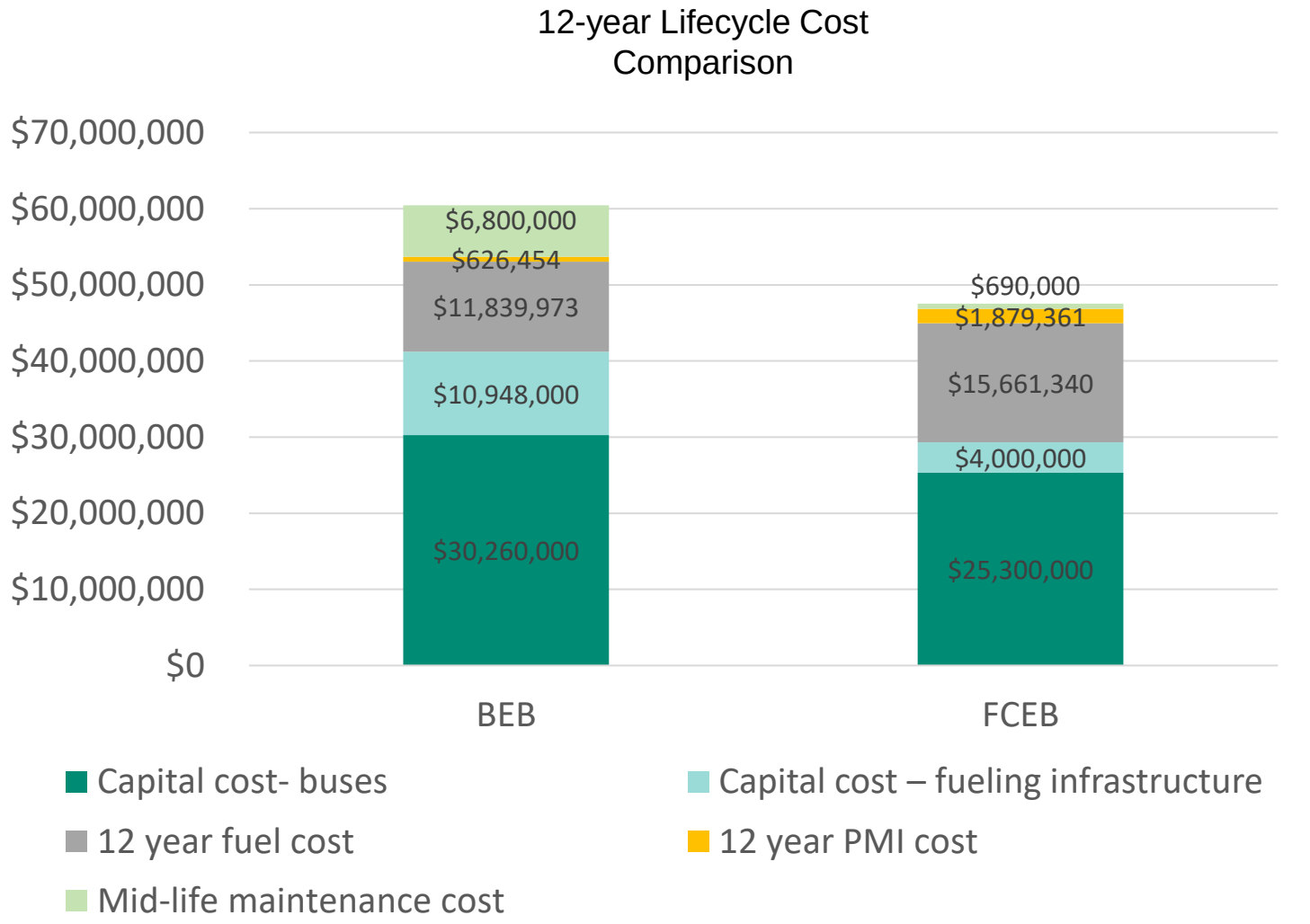
US Fleet ZEB Technologies
CTE's "A Zero-Emission Transition for the U.S. Transit Fleet" (2021)



Foothill Transit's (CA) study shows the total cost of ownership of FCEBs is lower than BEBs

Foothill Transit's study compares the cost of deploying 20 zero-emission buses on a 42-mile roundtrip route
(up to 263 mi per daily block)

Due to the range limitations of BEBs, it was determined the line will require 34 BEBs vs 23 FCEBs.

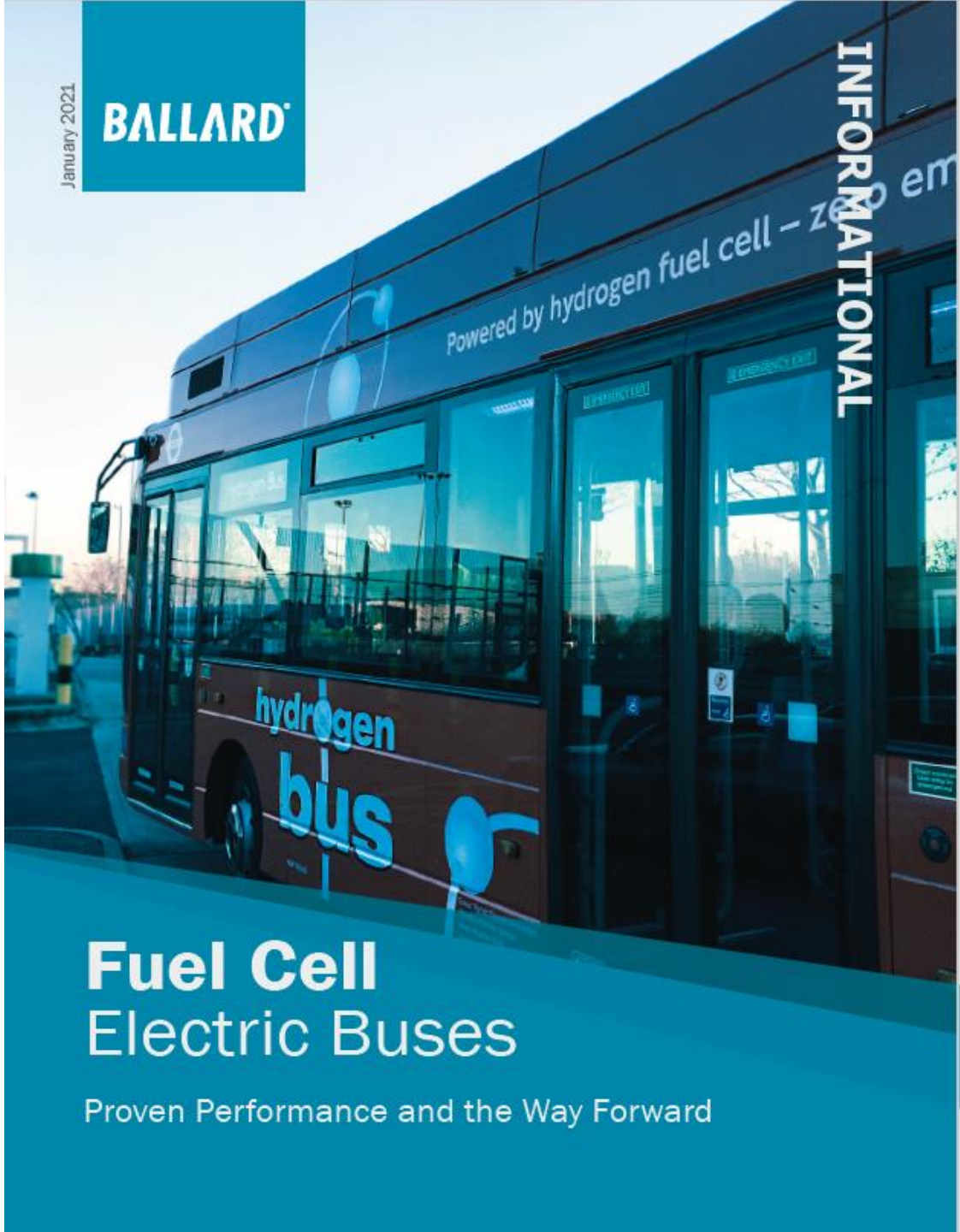


Cost Savings with FCEB: $12,943,726 (20%)

Foothill Transit Executive Board Meeting (July 24, 2020)

Performance of fuel cell electric buses today

- Range: over 350 miles/500 kms
- Fuel consumption: < 8 kilograms/100km
- Fuel cell stack durability: > 30,000 hours (proven in service) and are refurbishable
- Over 97% availability for fuel cell system
- Fuel cell maintenance cost: <$0.10/km
- Fuel cell power systems operates from -40°C to +50°C ambient temperature
- Freeze start from -25°C



Based on fleet of FEB monitored by Ballard in 2018-2021

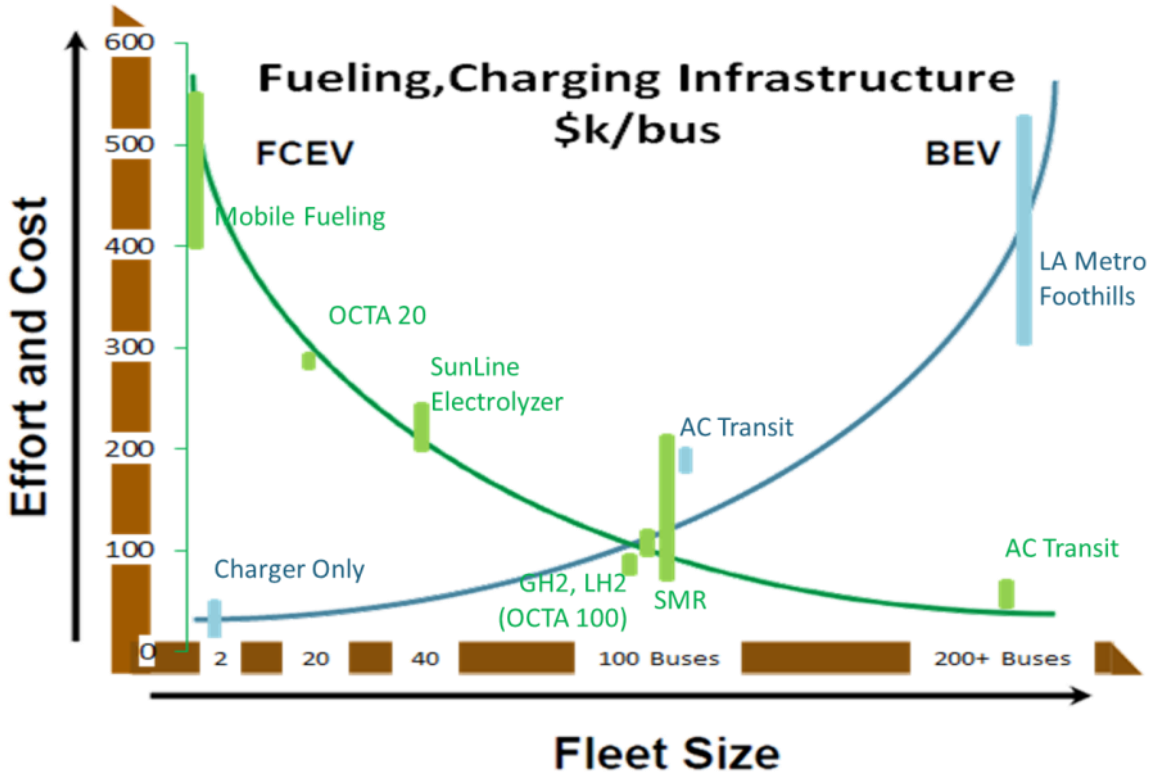
AC Transit (Oakland, CA)5x5 vehicle study

Figure 1: 5x5 Vehicle Matrix

FLEET	DIESEL (BASELINE)	DIESEL HYBRID	FUEL CELL ELECTRIC (FCEB)	BATTERY ELECTRIC (BEB)	LEGACY FUEL CELL
Series Grouping	1600	1550	7000	8000	FC
Technology Type	Diesel	Hybrid	Fuel Cell	Battery	Fuel Cell
Bus Qty	5	5	5	5	5
Manufacturer	Gillig	Gillig	New Flyer	New Flyer	Van Hool
Year	2018	2016	2019	2019	2010
Length	40′	40′	40′	40′	40′
Data Summary (January - June 2021)					
Fleet Mileage	120,749	98,189	88,389	54,275	70,859
Cost/Mile	$1.41	$1.80	$1.97	$2.02	$4.07
Cost/Mile (w/ credits)	$1.37	$1.78	$0.58	$0.69	$4.07
Emissions (CO_2 Metric Tons)	298	182	0	0	0
Fleet Availability	96%	75%	69%	47%	68%
Reliability (MBCRC)	12,075	4,091	6,314	3,618	2,531

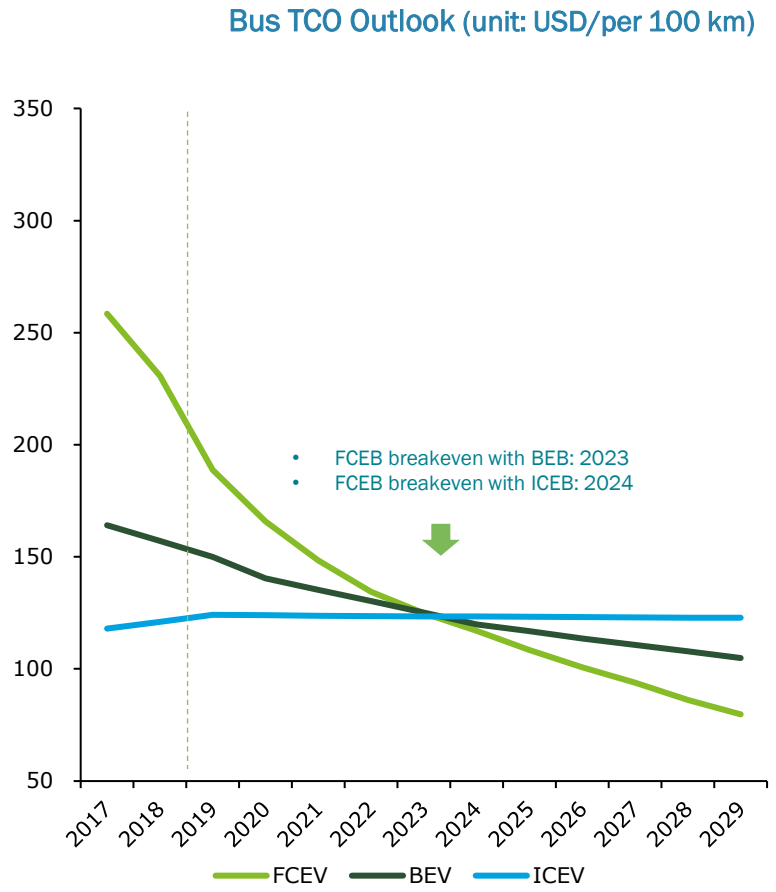
At scale, hydrogen infrastructure offers a flexible and cost attractive option

- Hydrogen fueling stations are fully scalable and cost per vehicle goes down as fleet increases – becoming cheaper than electric charging infrastructure for fleets above 40-50 vehicles
- No road-side infrastructure needed resulting in maximum route flexibility
- Low-carbon hydrogen can be produced using local resources: hydro, wind at same or better GHG impact as electricity
- Existing supply chain with competitive infrastructure & fuel suppliers



Challenge: improve TCO of fuel cell electric bus

- Reduce total life cycle cost of fuel cell power module
- Improve fuel cell bus efficiency
  - Fuel cell battery hybrid powertrain, DC/DC and thermal management optimization
- **Access to affordable low carbon hydrogen through competitive fuelling service offering**



Source: Deloitte-Ballard white paper "Fueling the Future of Mobility: Hydrogen and fuel cell solutions for transportation", January 2020

Thank you

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