

DOCKETED

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CALIFORNIA
ENERGY COMMISSION

Fuel Cell Electric Buses – Building Infrastructure

Workshop on Medium- and Heavy-Duty Zero-
Emission Vehicles and Infrastructure Deployment

CEC – Sacramento

October 25, 2019

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Center for Transportation
and the Environment



25th Anniversary
1993-2018

About CTE



Prototype Development & Demonstration

Support technology providers by finding funding for and managing technology research, development, and demonstration programs



Smart Deployment

Support early adopters by providing the best technical solutions for initial deployments

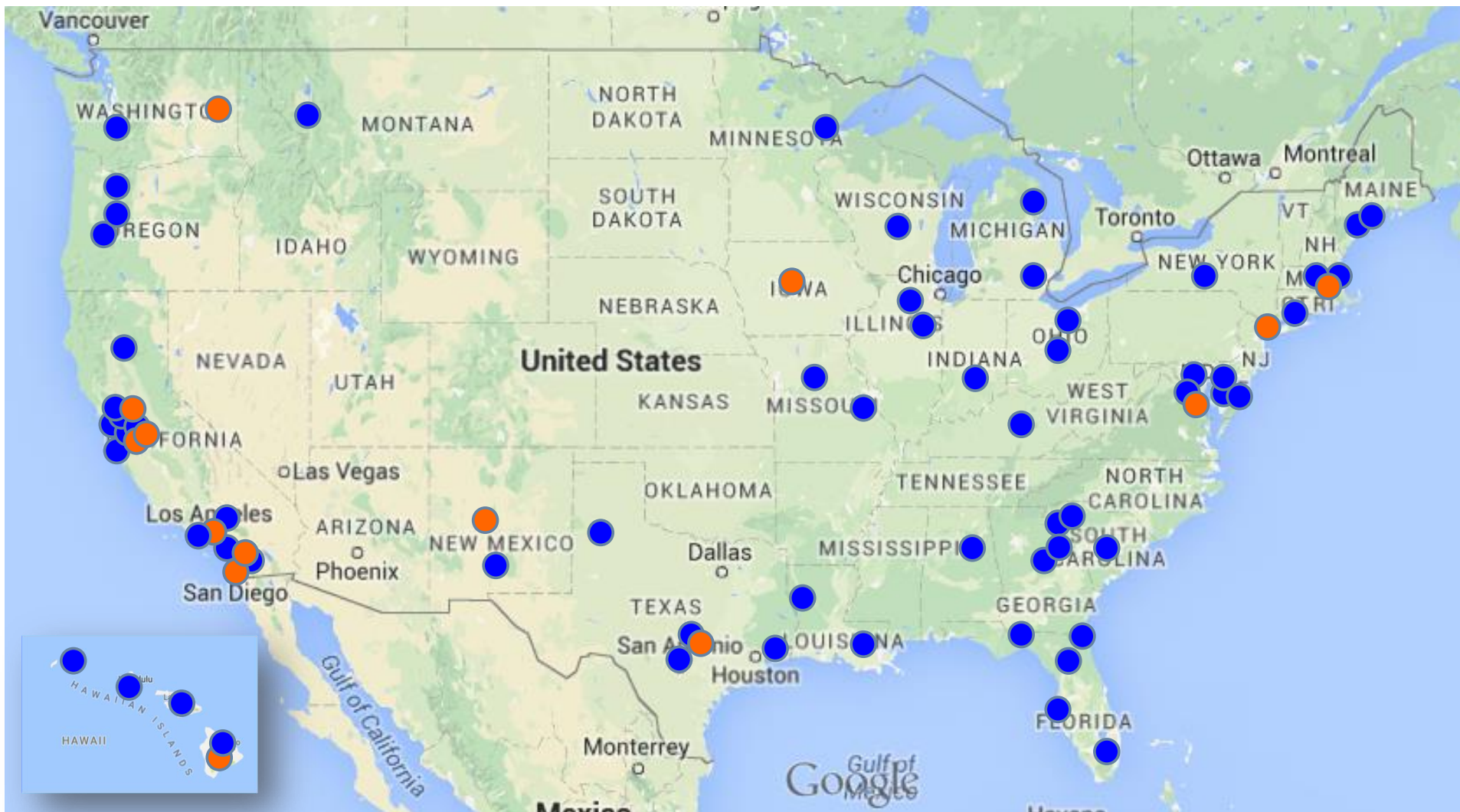


Fleet Transition

Help fleet operators plan for full electrification

- **Mission:** To advance clean, sustainable, innovative transportation and energy technologies
- **501(3)(c) non-profit** engineering and planning firm
- **Portfolio - >\$500 million**
 - Research, demonstration, transition planning, deployment
 - **86 Active Projects** Totaling over **\$300 million**
- Focused on **Zero-Emission** Technologies
- **National Presence**
 - Atlanta, Berkeley, Los Angeles, Minneapolis/St. Paul

Zero-Emission Projects



- ZEB Planning Projects**
- ZEB Deployment Projects**

Fuel Cell Electric and H₂ Projects

- Class 6 Trucks
- Class 8 Drayage Trucks
- Marine Cargo Top Loader
- 40' and 60' Transit Buses
- HD and LD H₂ Stations



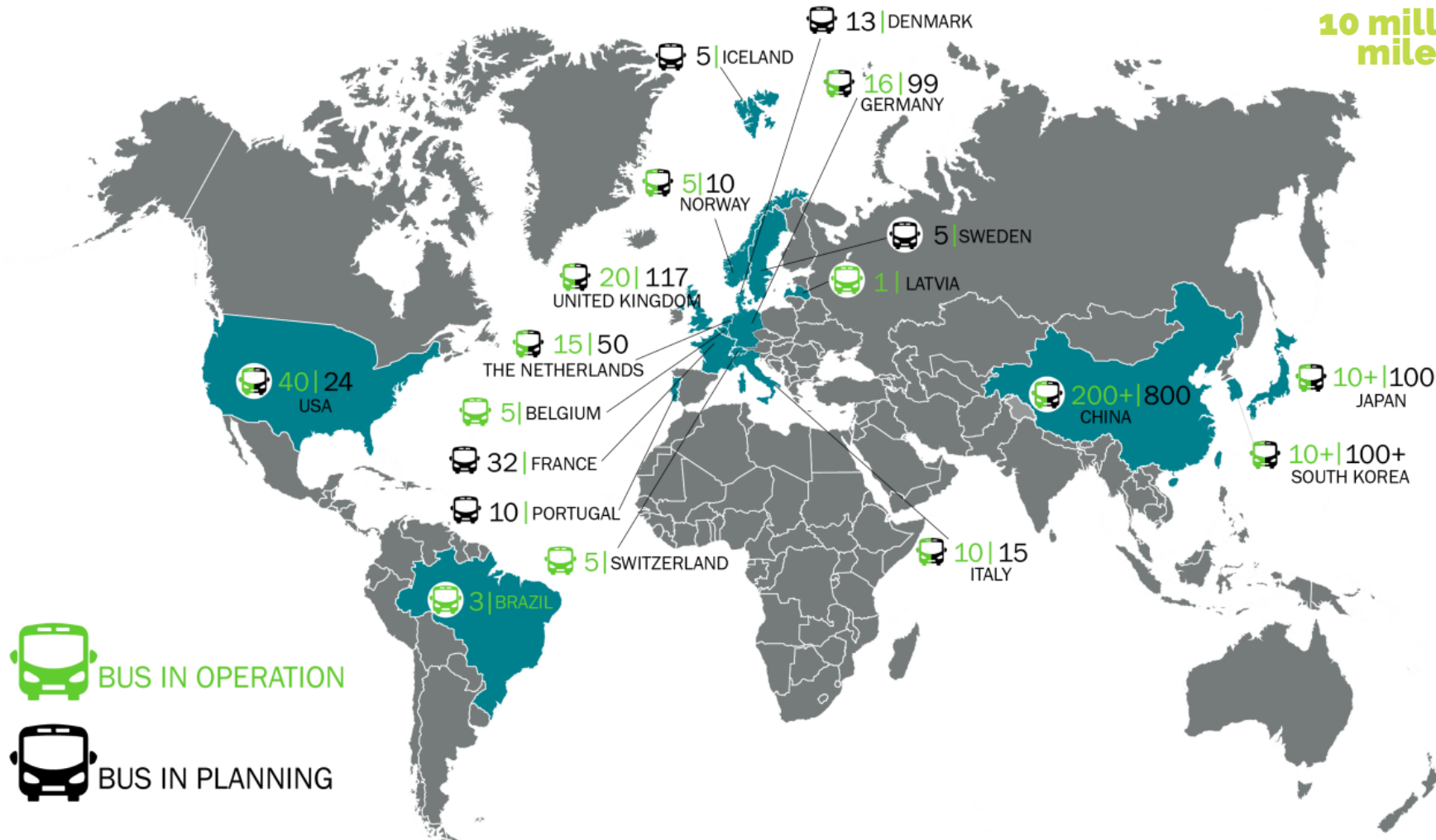
Worldwide Acceptance: 2,000 by 2020

FUEL CELL BUSES WORLDWIDE

 300+ | 2000+

10 million miles

Over 10 million miles of proven service worldwide; 3 million miles at AC Transit and over 1 million at SunLine Transit.



Operational Efficiency

THE KISS PRINCIPLE | **K**EEP
IT
SIMPLE,
STUPID

FCEB Advantages

**300-350
miles**

Proven
range



Significant
reduction in
vehicle weight

(carry more
passengers)



Rapid refueling
speeds

(6 to 10 minutes)



1:1
replacement of
conventional
vehicles

Durability: >32,000 Hours/2.98 Million Miles

AC Transit 9/17/2019		
Bus	Fuel Cell Hours Life to Date	Vehicle Miles Life to Date
FC4	25,950	244,893
FC5	26,090	247,302
FC6	26,689	218,522
FC7 ¹	11,258	229,171
FC8	25,043	180,648
FC9	25,840	223,868
FC10	28,506	258,762
FC11	29,066	255,762
FC12 ²	5,428	246,248
FC13	18,368	177,104
FC14	29,828	250,144
FC15	25,025	207,222
FC16	29,630	234,562
TOTALS	306,721	2,974,208
Average	25,592	228,785

NOTE: FC7 and FC12 fuel cells were manufactured by UTC in 2003, 14 years ago with an expected EOL of 5,000 hours. The other 11 fuel cells were manufactured by UTC in 2008 and 2009.

* LDV Station converted to Messer commercial station as of September 2018. AC Transit stopped recording fuel dispensed as of May 2018.

- 1) Fuel Cell on FC7 retired on 5/14/18 with 32,134 hrs.
- 2) Fuel Cell on FC12 retired 11/21/18 with 25,969 hrs.



New Flyer XHE40 Performance

AC Transit 54 Line Service											
Date	Run	Time Out	Time In	Odometer	Run Time	Miles Run	Total Fuel (kg)*	Miles per kg	Miles per DGE (1.13)	Projected Range Based on 36 kg of Useable H ₂	Approximate Battery-Only Range
4/10/19	54-0002	7:04 AM	10:42 PM	1697.4							
4/11/19	54-0002	7:04 AM	10:42 PM	1896.3	15:46 hrs	198.9	23.8	8.36	9.44	300.9	10 to 20
4/12/19	54-2002	7:04 AM	10:42 PM	2098.3	15:46 hrs	202	22.4	9.02	10.19	324.6	10 to 20
4/13/19	54-2002	7:04 AM	10:42 PM	2298.5	15:46 hrs	200.2	20.9	9.58	10.82	344.8	10 to 20

Footnotes

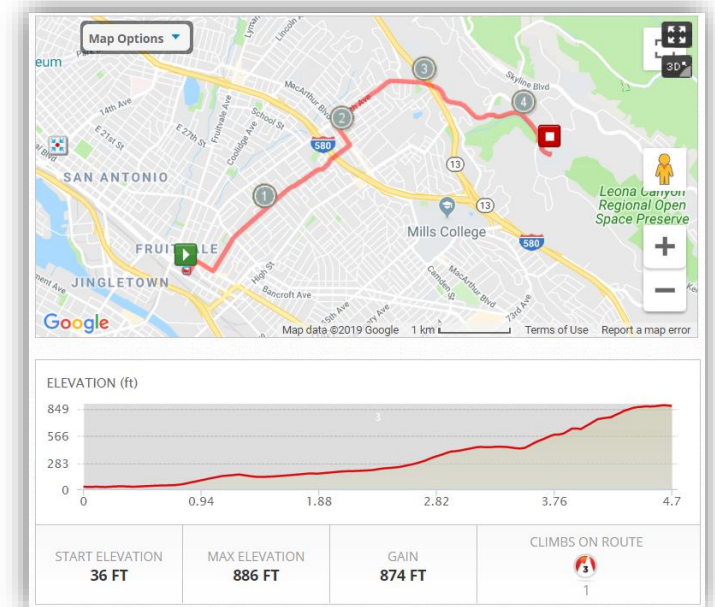
* Three different drivers. Variation in fuel consumption based on how different drivers drive and ambient temperature.

AC Transit

- Load = 17 Average; 34 Max
- 300 to 344 miles on H₂
- 20 miles on battery

OCTA

- Seated Load (40)
- 330 miles on H₂
- 20 miles on battery



100-Bus Initiative



NEED

Transit agencies will need **both** Battery-Electric and Fuel Cell Electric Buses (FCEBs) to meet the California Air Resources Board goal of 100% zero emission buses by 2040.

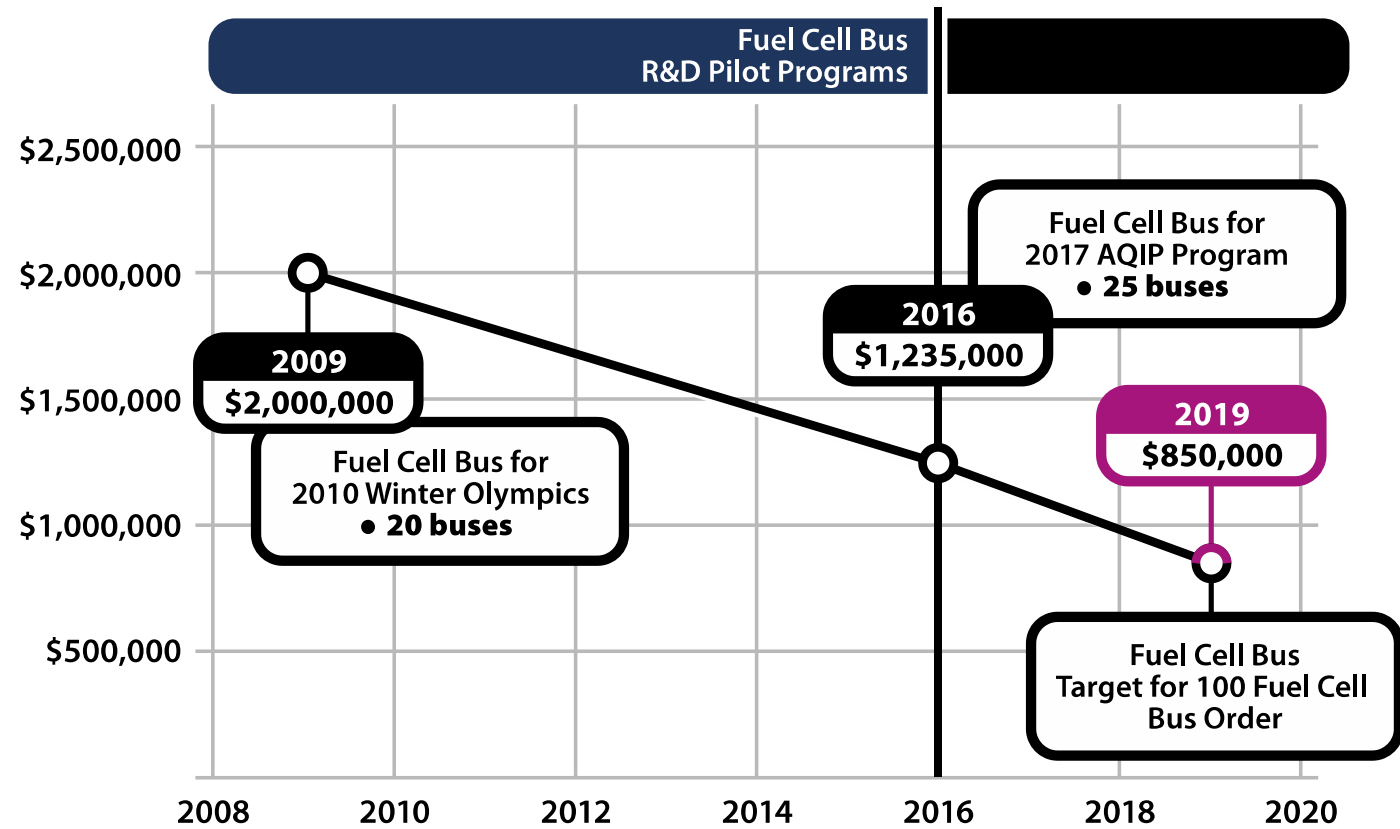
OBJECTIVE

Drive down the capital cost of North American FCEBs to the point where they are **commercially viable** for transit properties seeking zero-emission solutions — **\$850,000/bus**.

ACTION

Four or more transit agencies in northern and southern California, **purchasing up to 25 FCEBs** each, and installing hydrogen fueling stations and facility upgrades where needed.

Driving Price Down



Source: New Flyer Industries

100-Bus Initiative: Timeline



100-Bus Initiative Timeline																																															
Task	Task Summary	Responsibility	2019				2020				2021				2022																																
			1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q																													
			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
1	GGRF FY 19-20 Budget Adoption	CARB/CEC	I.D. Grant Funds																																												
2	Setup Consortium Partners	CTE/Transit			Transit Agencies																																										
3	Secure CARB and CEC Grant Funding	CTE/CARB/CEC					CARB/CEC Funding																																								
4	Select Bus OEM(s) and Fuel Suppliers	Consortium							Select Vendors																																						
5	Bus Build and Station Construction	OEMs/Suppliers									Manufacturing/Construction/Commissioning																																				
6	Station Openings and Facility Upgrades	Suppliers												Station Openings and Facility Upgrades																																	
7	Bus Deliveries	OEM (s)												Bus Deliveries																																	

Infrastructure Challenges

PARSE

P

Price and delivery of H₂ on parity with conventional fuels. Also equipment maintenance cost reduction.

A

Area of fueling footprint to refuel 50, 100, or 200 buses.

R

Renewables for hydrogen production; **Resiliency** - Natural Disasters; Also **Redundancy** to ensure near 100% service reliability.

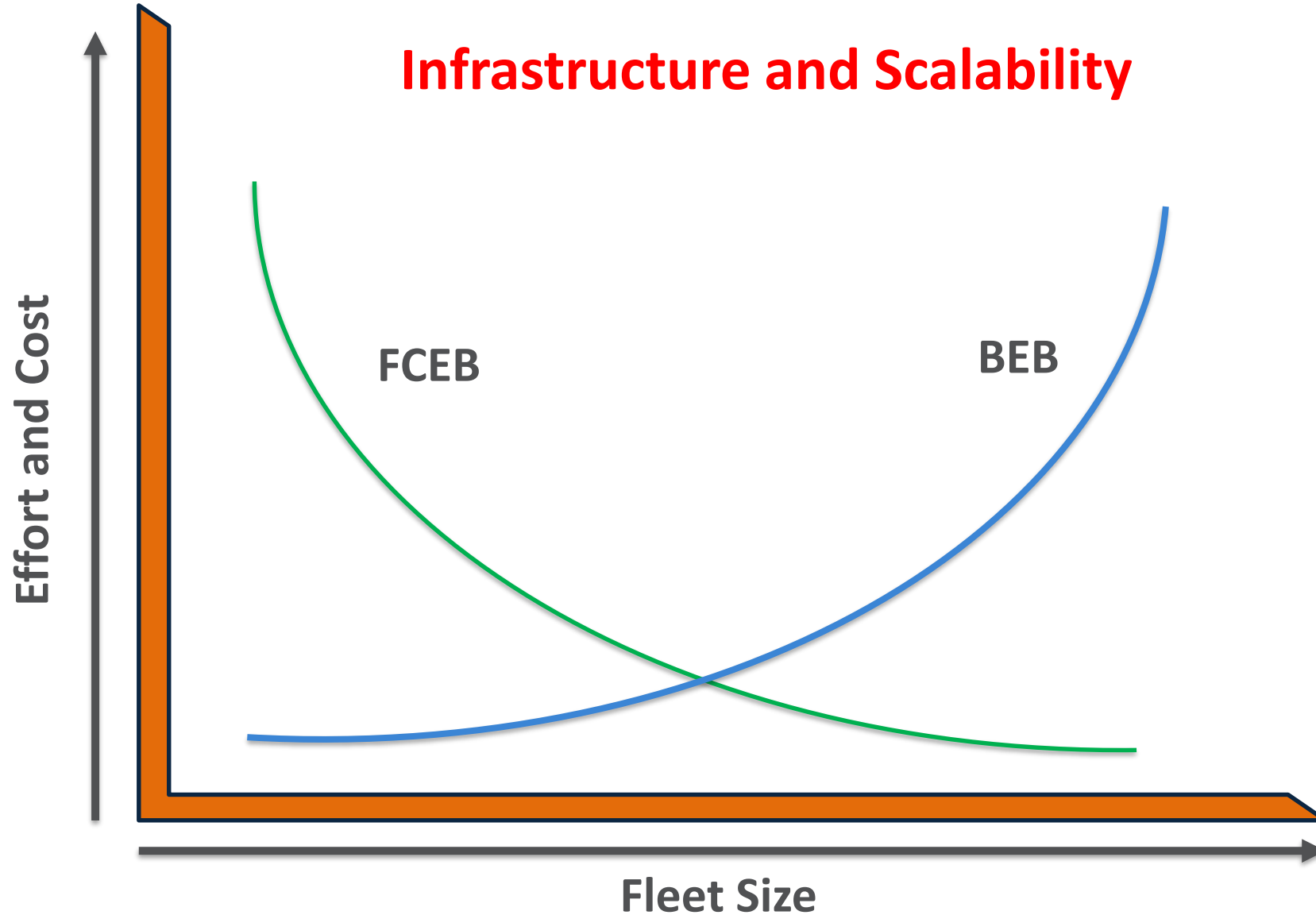
S

Speed of refueling in the normal 8- to 10-hour night window; Also **Scalability** for future expansion.

E

Entry-Level Startup and Equity (CapEX) needed to build at an affordable price, utilizing baseline components for future scale up.

The Challenge for 100% ZEB Deployment



Fueling Station Evolution

