



IF THIS FUEL CELL BUS COULD TALK:
THE TRUE STORY

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champaign-urbana mass transit district



APTA Sustainability Conference

Vancouver, BC Canada

July 31, 2018



Jaimie Levin, Sr. Management Consultant

CTE – NON-PROFIT

Mission: To advance clean, sustainable, innovative transportation and energy technologies

501(3)(c) non-profit

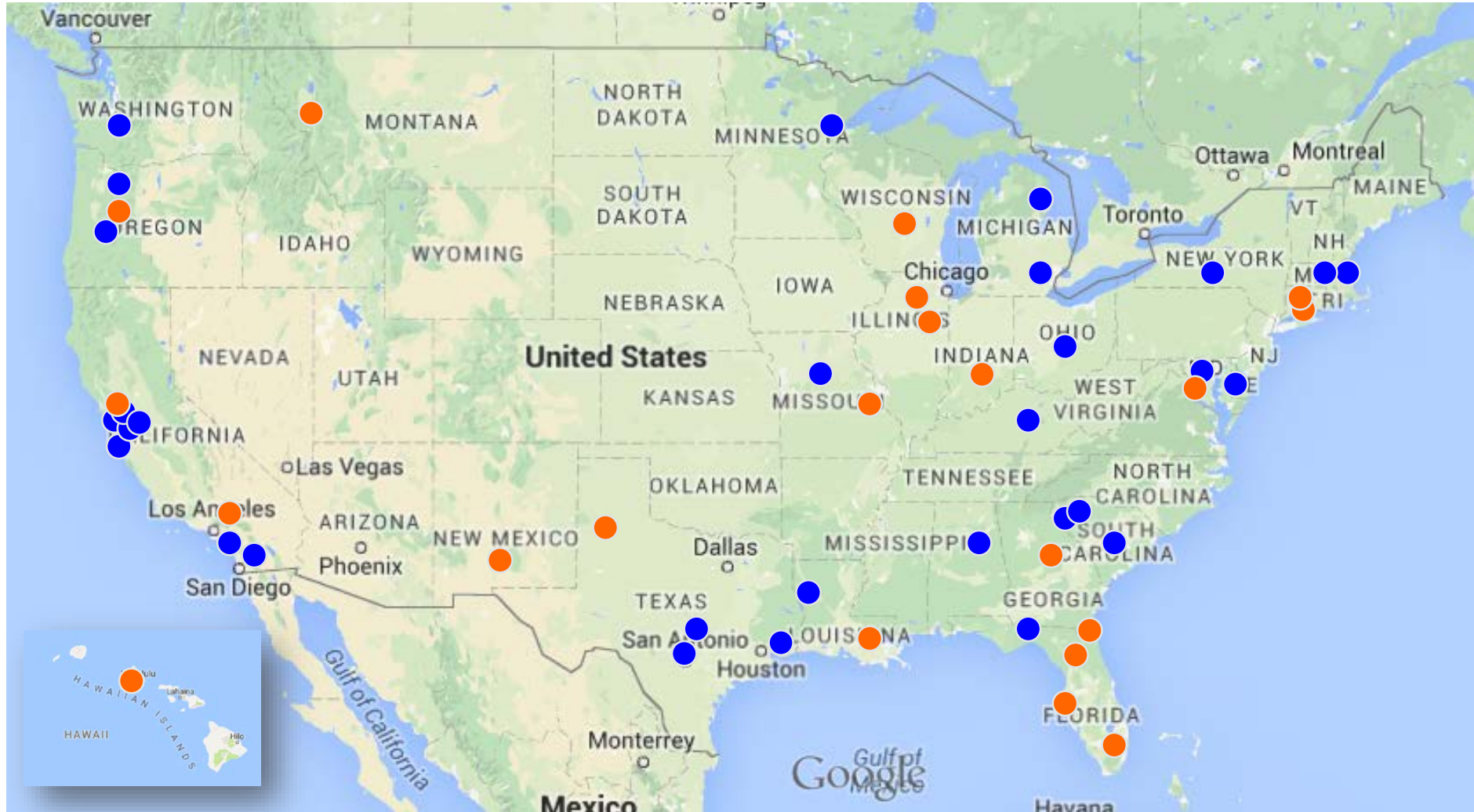
Portfolio - \$450+ million

- Research, demonstration, deployment
- Alt. fuel and advanced vehicle technologies

National Presence

Atlanta, Berkeley, Los Angeles, St. Paul

CTE ZEB PROJECTS



- Existing Zero Emission Bus (ZEB) Projects (more than 140 ZEB's with over 30 Transit Agencies)
- 2017 Low-No Awards with CTE (more than 50 ZEB's with 25 Agencies)

CLASS 8 FUEL CELL TRUCK

Specifications

- 85 kW Fuel Cell
- 100 kWh Battery
- 420 kW (560 HP) Motor
- 30 kg Hydrogen Storage
- Plug-in Capable

Performance

- 150-Mile Range
- 65 mph Top Speed
- Power: Maintains 30 MPH on 6% Grade
- Torque: Enough to Start on 20% Grade
- Port of Los Angeles – June 2018



<https://www.todaystrucking.com/focus-kenworth-zero-emissions-cargo-transport/>

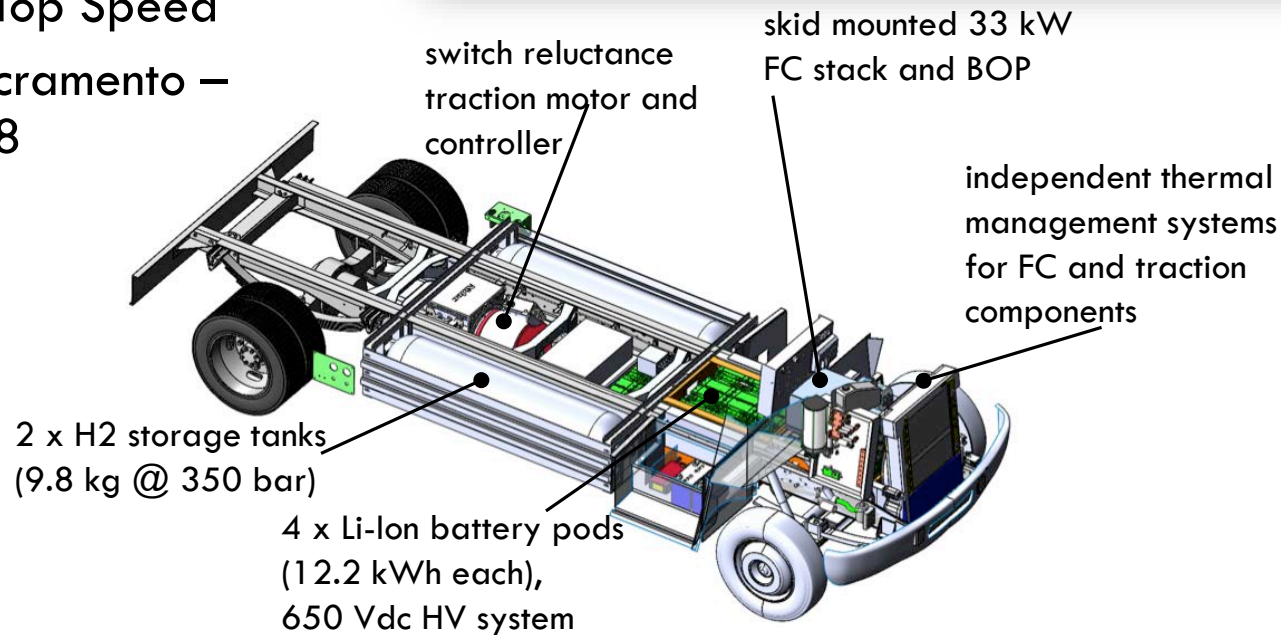
CLASS 6 STEP-VAN

Specifications

- 33 kW Fuel Cell
- 49 kWh Battery
- 9.8 kg Hydrogen Storage

Performance

- 125-Mile Range
- 65 mph Top Speed
- West Sacramento – Fall 2018



SHELL HYDROGEN

Largest Fuel Retailer in the World

4 Existing Light-duty Stations (southern CA)

2017 California Energy Commission Award
for **7 New Stations** (northern CA)

2018 California Energy Commission Award
for **Heavy-Duty Truck Fueling Station**
(1,000 kg/day) with **100% Renewable**
Hydrogen (Port of Long Beach)



FCE BUS PROJECTS

- National Fuel Cell Bus Program
- AC Transit Expanded Service (13 Buses)
- OCTA Demonstration (1 Eldorado Bus)
- Fuel Cell Electric Bus Commercialization Consortium (FCEBCC) (\$45m; 20 Buses; OCTA/AC Transit)



- **CUMTD Articulated Buses (2 Buses)**

- AC Transit ZEB Study (BEB/FCEB)
- San Diego ZEB Study (BEB/FCEB)
- LA Metro ZEB Roadmap (WSP/CTE)



- 100-Bus Initiative



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.

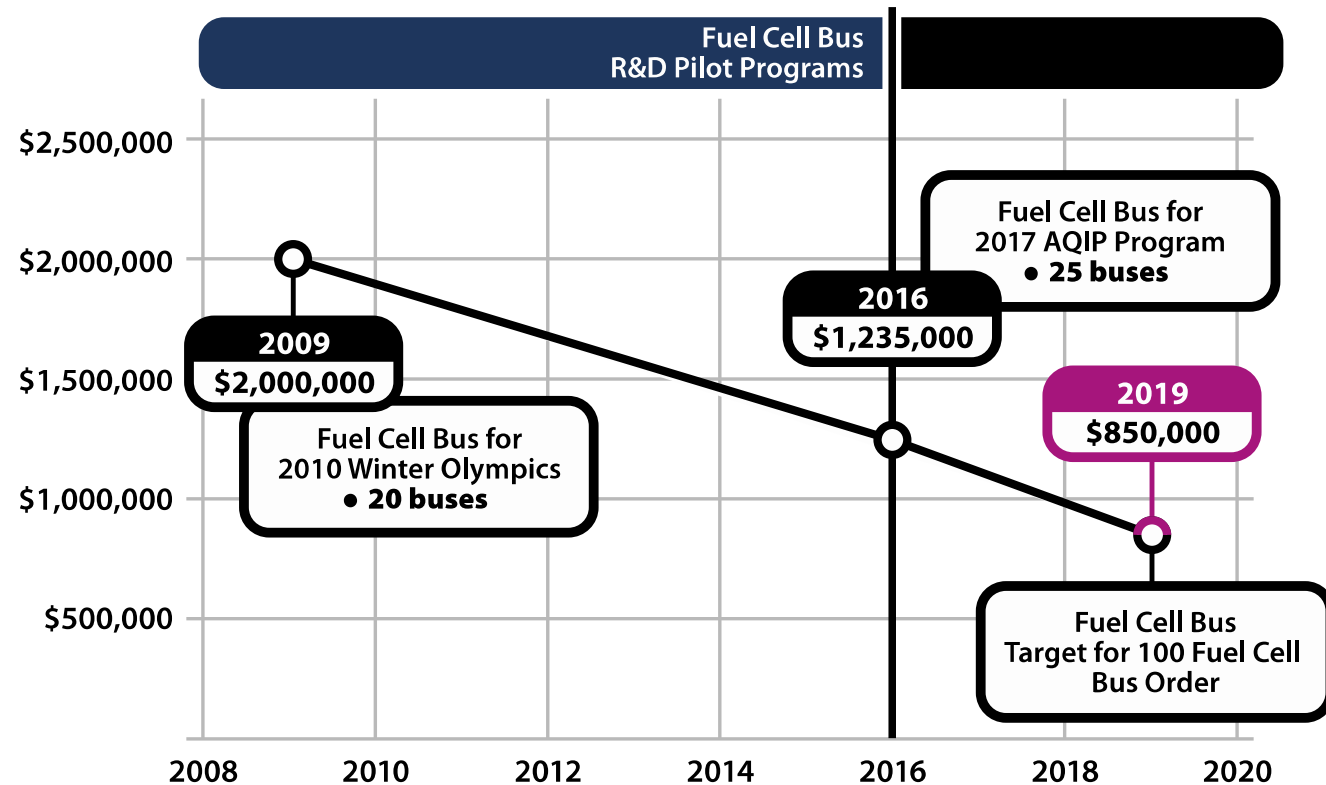
OBJECTIVE

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

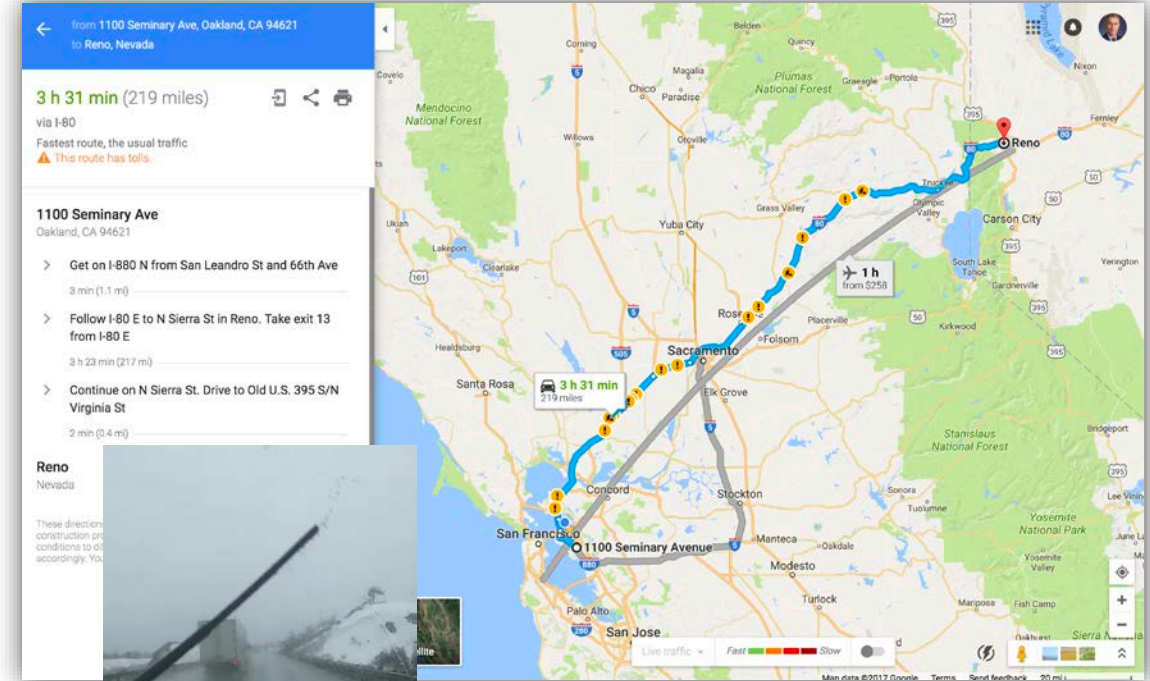
FCEB REAL-WORLD PERFORMANCE

AC Transit Fuel Cell Bus Performance - July 21, 2018			
Bus	FUEL CELL HOURS	June Miles @ 9 MPH	Vehicle Miles Life to Date
FC4	22,984	3,061	219,148
FC5	22,688	2,671	214,109
FC6	23,123	2,483	184,074
FC7	28,945	2,629	197,861
FC8	22,087	3,455	151,888
FC9	21,912	4,050	188,171
FC10	24,445	4,096	218,257
FC11	25,246	2,679	217,122
FC12	25,960	2,396	220,000
FC13	14,057	2,262	140,267
FC14	25,604	2,629	216,611
FC15	20,673	2,497	177,654
FC16	25,483	2,666	202,766
TOTALS	303,207	37,574	2,547,928
Average	23,324	2,890	195,994

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

Hydrogen Dispensed			
Yearly Totals	Buses		Cars
	Emeryville	Oakland	Light Duty
2014	22,383	31,862	1,743
2015	27,750	38,589	1,188
2016	26,070	59,537	583
2017	21,610	66,422	188
2018 JAN-MAY	10,624	29,178	39
TOTALS	108,437	225,588	3,742
Total to Date		337,767	>2011: ≈ 500k

Hydrogen Fill Transactions			
Yearly Totals	Buses		Cars
	Emeryville	Oakland	Light Duty
2014	1,129	1,749	931
2015	1,635	2,081	638
2016	1,954	4,047	490
2017	1,660	4,777	98
2018 JAN-MAY	771	2,215	14
TOTALS	7,149	14,869	2,171
Total to Date		24,189	



Oakland to Reno: 219 miles

- **2.547 million miles** (3.3 million since 2005)
- **28,945 hours** Fuel Cell (5,000-hour Design Life)
- **≈ 500,000 kilograms of H₂** (1 kg = 1 gallon gasoline)
- **24,189 safe fills**

WORLDWIDE ACCEPTANCE

► Performance

10 million miles

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

27,000 hours

Fuel cell durability — over 27,000 hours of service and counting. Exceeds the half-life of the bus.

► Global Expansion



There will be over 330 fuel cell electric buses in operation in Europe at more than 22 cities by the end of 2020 (FCH-JU JIVE and 3Emotion programs) and over 1,500 worldwide with large scale deployments in China.

1,500 FCEBS BY 2020

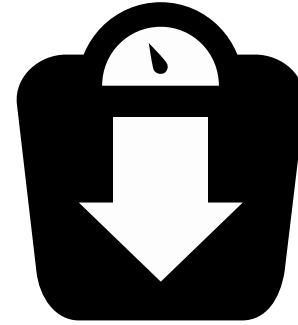
FUEL CELL BUSES WORLDWIDE



FCEB ADVANTAGES

**250-300
miles**

Proven
range



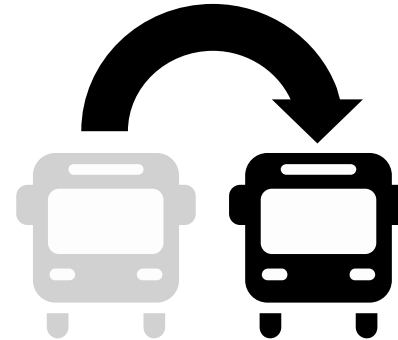
Significant
reduction in
vehicle weight

(carry more
passengers)



Rapid refueling
speeds

(6 to 10 minutes)



1:1
replacement of
conventional
vehicles

H₂ AND BEB STATION 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

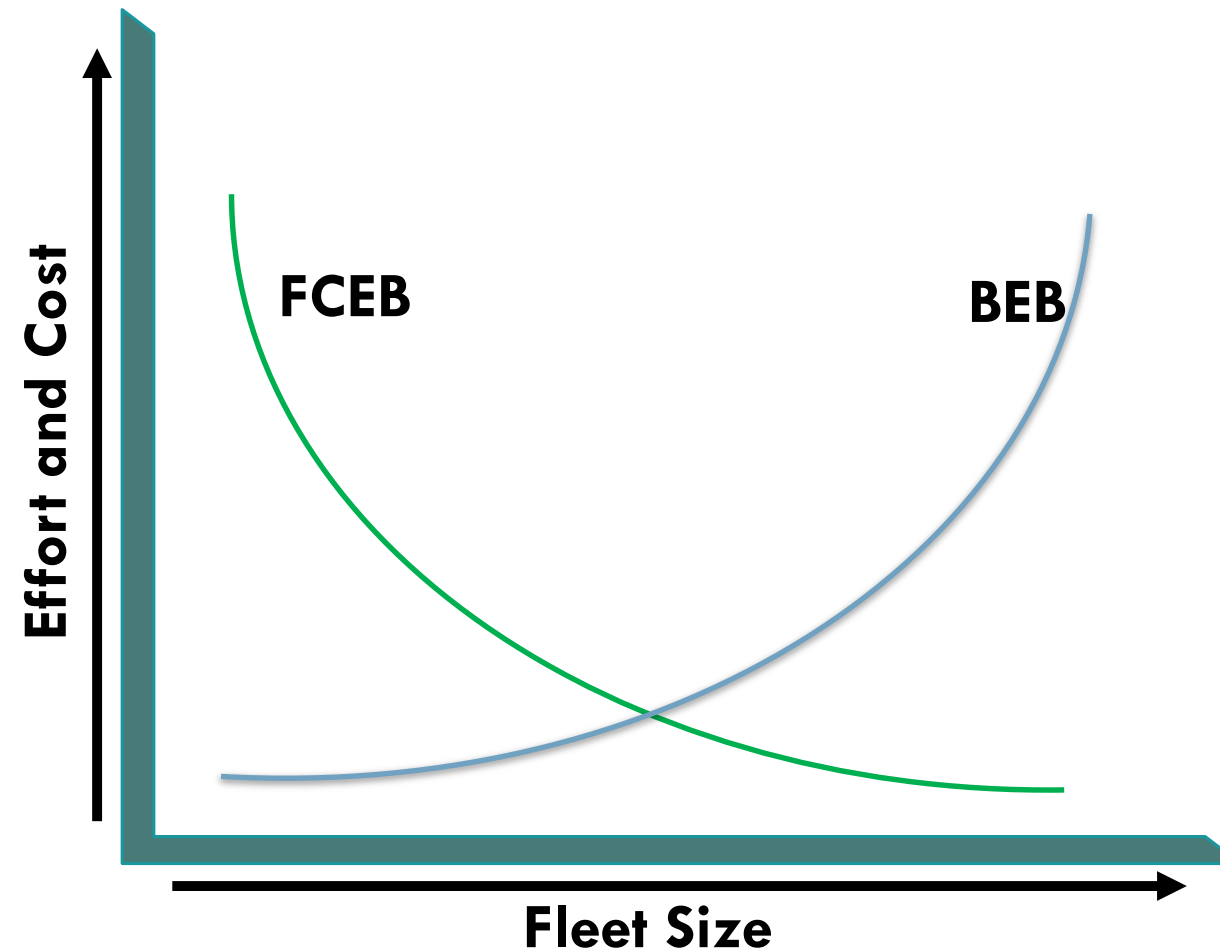
Speed of refueling in the normal five- to seven-hour night window;
Also **Scalability** for future expansion.

E

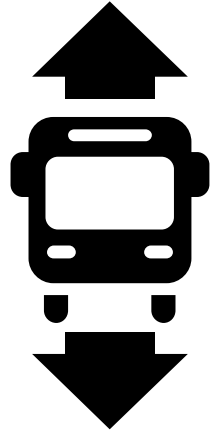
Equity, or CapEX, needed to build at a reasonable price utilizing
baseline components for future scale up.

SCALABILITY

The Challenge for 100% ZEB Deployment: Infrastructure and Scalability



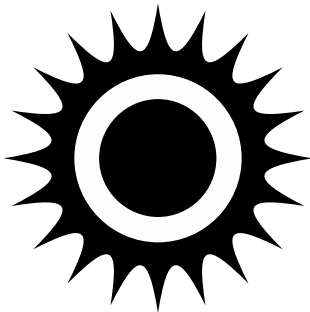
H2 STATION CAPABILITIES



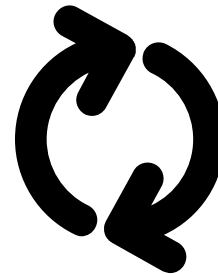
Scalable
to support
hundreds of
buses



Small footprint



Renewable
sources
(wind, solar, biogas)



Redundancy
and backup
(enable operators
to respond to
natural disasters)

ZEB CONFERENCE – FALL 2018



2018 AMERICAN ZERO EMISSION BUS CONFERENCE

Los Angeles • September 10 & 11th



Hosted by LA Metro



Transit Agency Perspective

Champaign-Urbana Mass Transit District

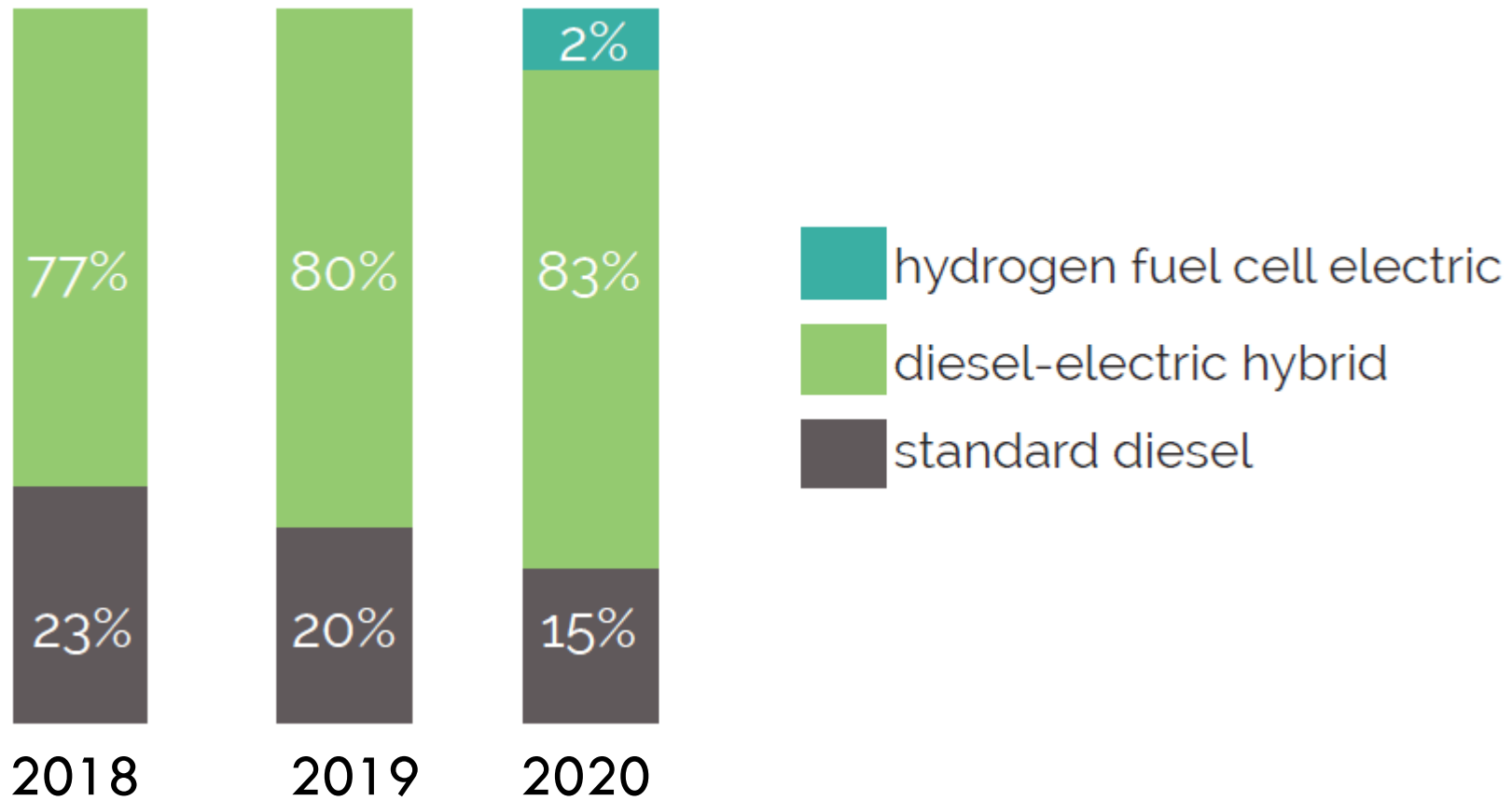


Jane Sullivan,
Grant Manager/Sustainability Planner

CHAMPAIGN-URBANA, ILLINOIS



MTD FLEET





GOAL: RENEWABLE HYDROGEN



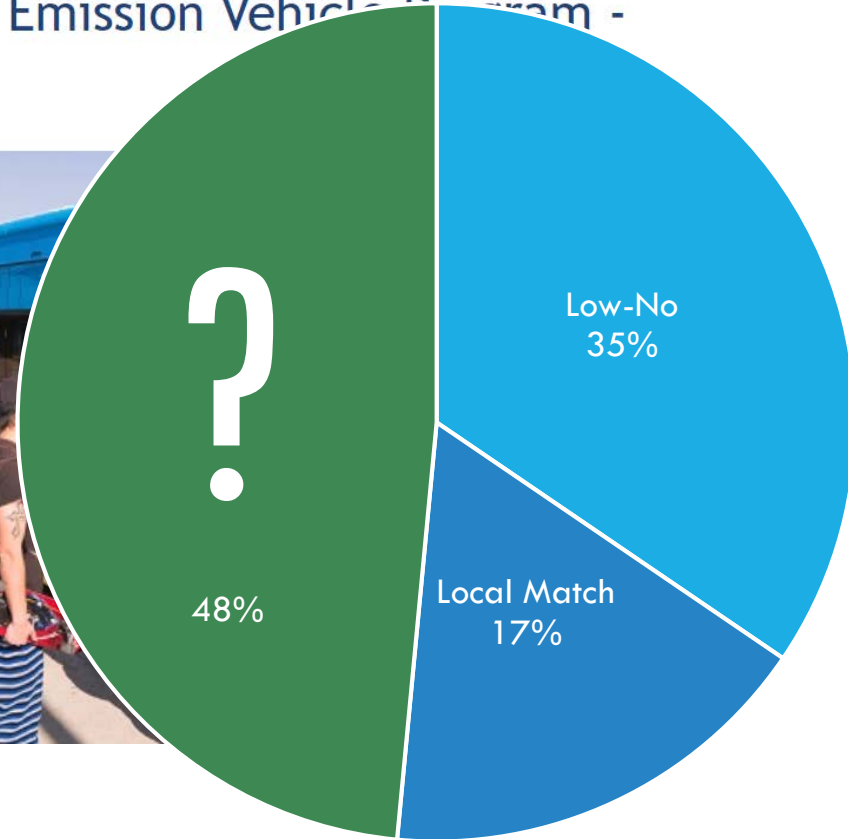
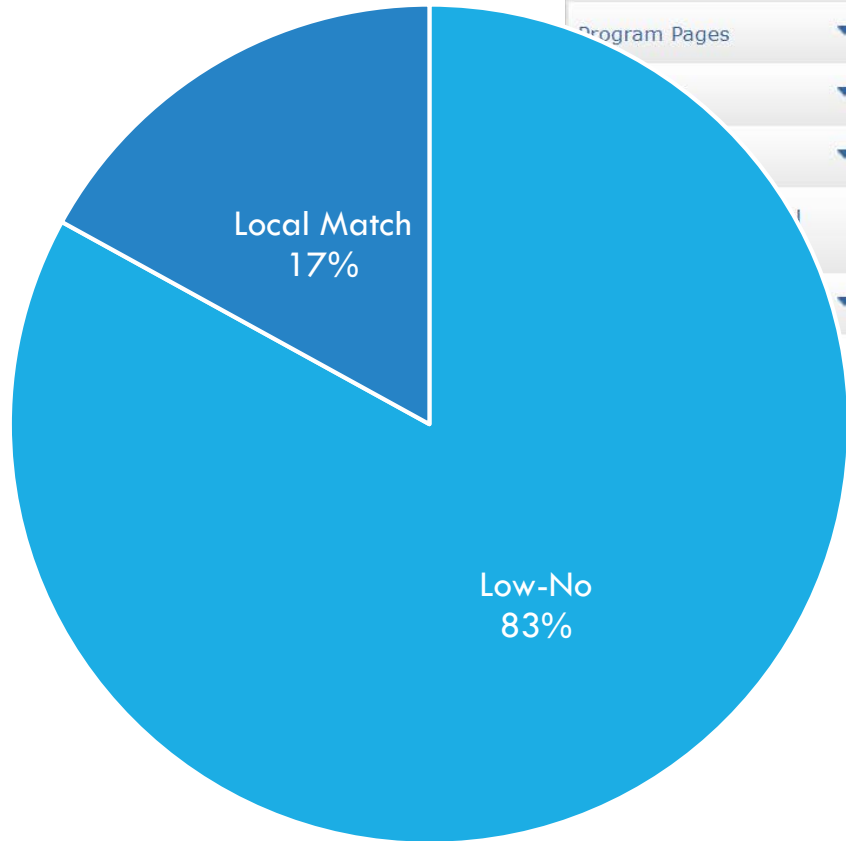
296 kW Solar
→ 230-260 MWh/year
→ 4,000 kg/year
→ Support one bus 21,000
miles/year
(assuming 5.25 mi/kg)

REQUEST:

REALITY:

- Home
- Grant Programs
- Program Pages

Low or No Emission Vehicle Program - 5339(c)



LOCAL INTEREST



But, I thought you were transitioning to hybrid buses?

I did my own research, and...

This will cost a fortune.

This will use a lot of electricity.

Why not battery electric?



MTD has no experience in this technology.

WHY FUEL CELL?

Range

300 mi

Fuel cell-electric buses can drive up to 300 miles on a single refueling. Battery electric buses have a documented range up to 204 miles.

Refuel Time

10 min

Fuel cell-electric buses have the ability to refuel continuously in 6-10 minutes. As a comparison, recharging large battery packs take as much as 4-5 hours.

Weight

1/3

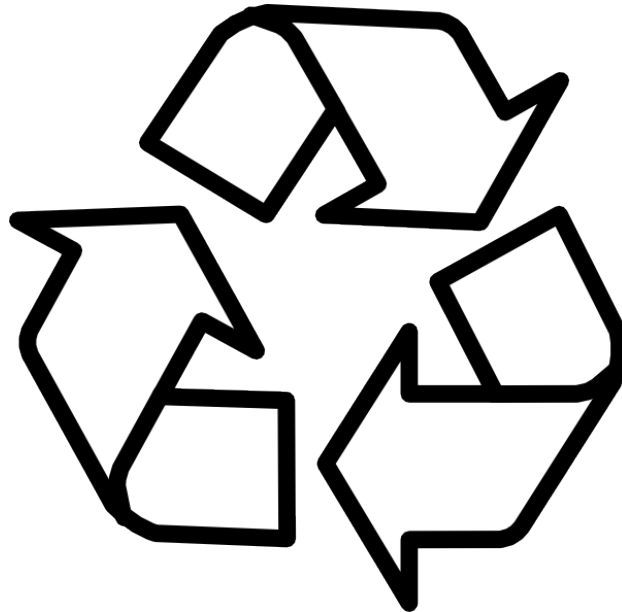
Fuel cells are achieving high power densities, are more compact, and lighter in weight. The fuel cell units are approximately one third of the weight of batteries.

FLEXIBILITY



REUSE & RECYCLE

The expected life of a fuel cell on a 60-foot bus is more than 12 years. Fuel cells have no hazardous materials and can be reused three or four times.



ENERGY SAVINGS



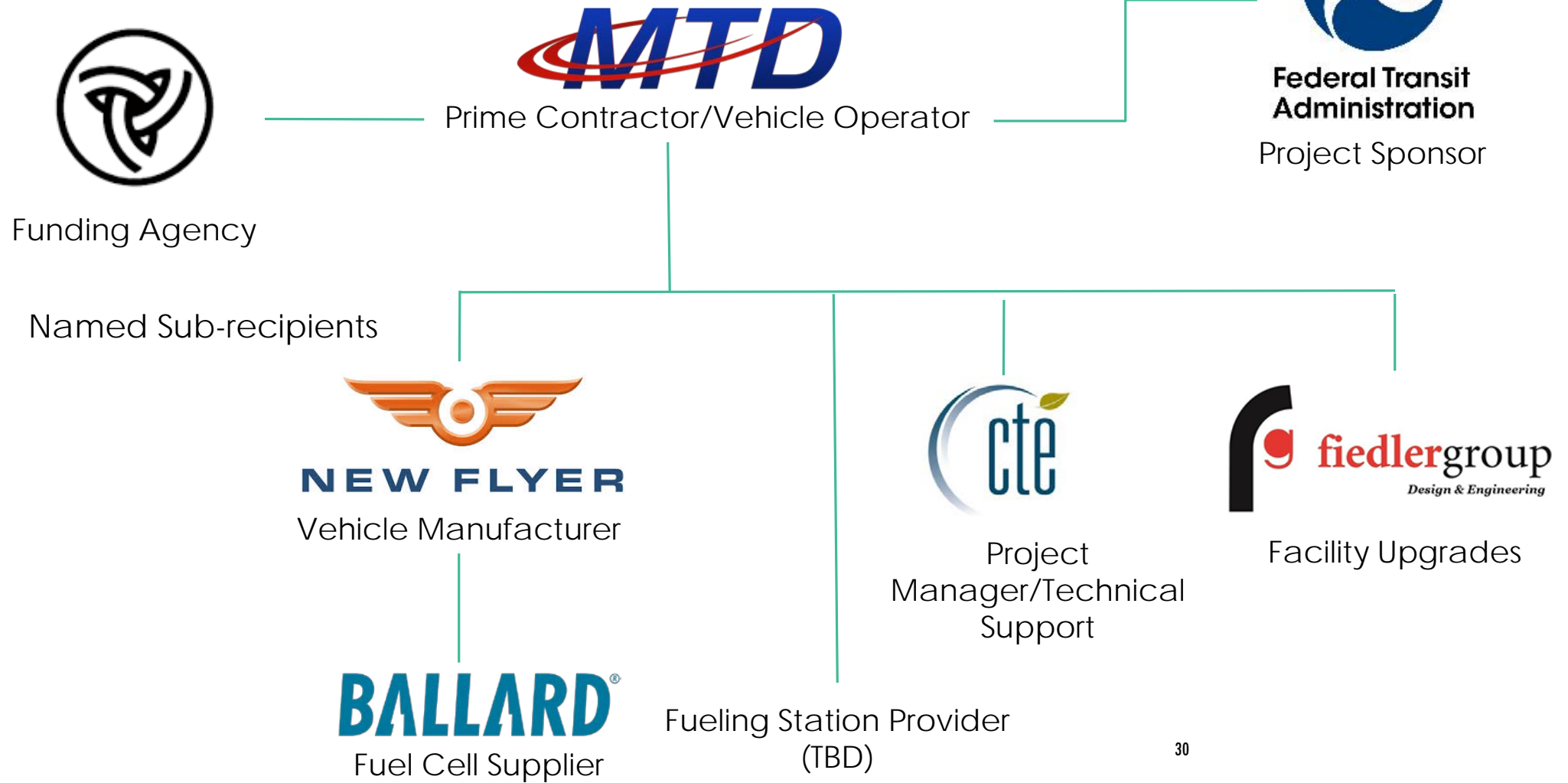
SAFETY

When used in accordance with proper guidelines, hydrogen fuel is safe.

Buses are equipped with hydrogen detectors to immediately detect if a leak has occurred.



PROJECT PARTNERS



LOOKING AHEAD



Thank you!



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