



Capital Metro – Zero Emission Bus Project

Resource Management Commission

November 13, 2018

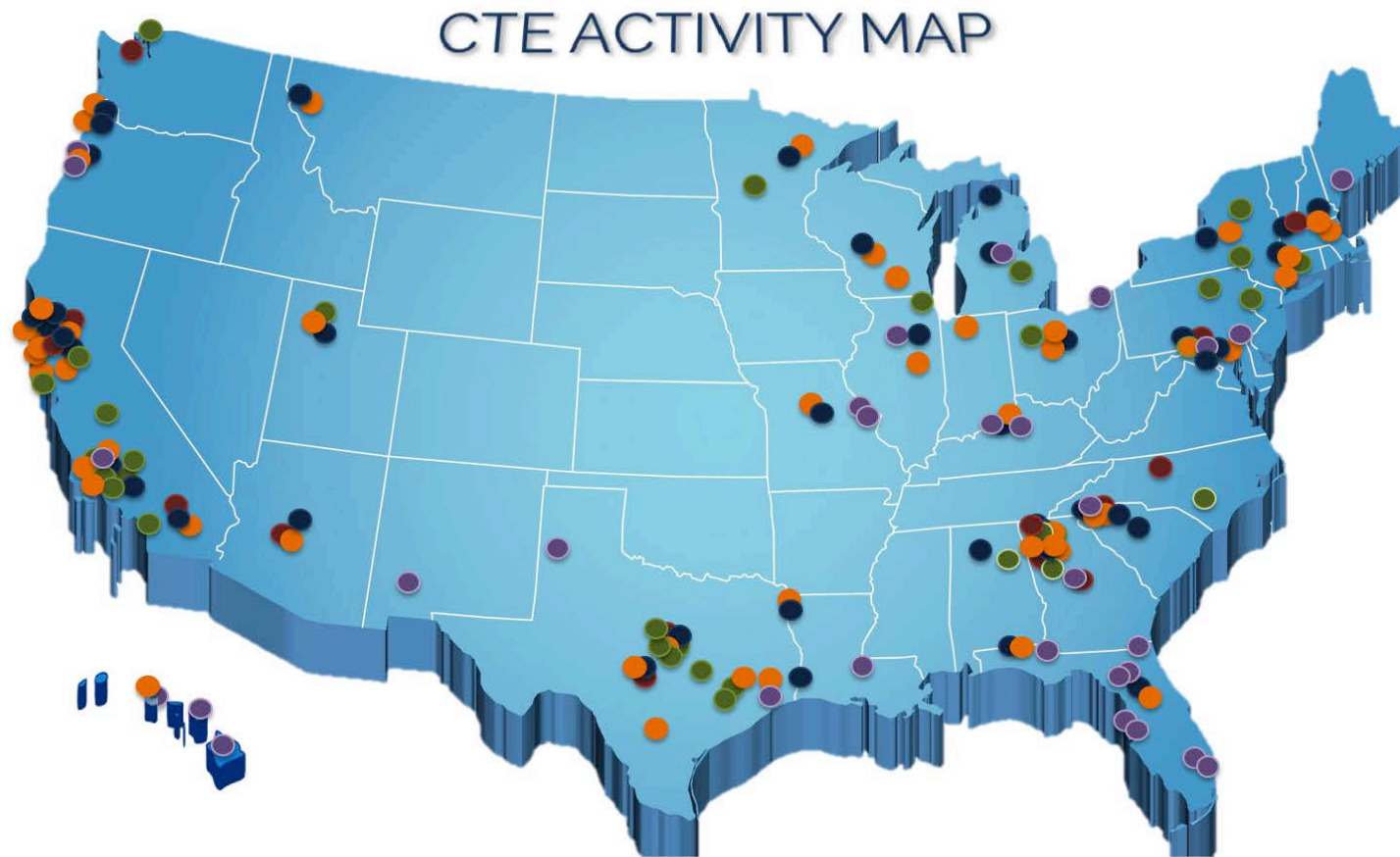


METRO

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

- Non-profit, membership-based - founded in 1993
- Portfolio - \$450+ million
 - Research, development, demonstration, and deployment
 - Alternative fuel and advanced vehicle technologies
- Project sponsorship
 - Federal Transit Administration (NFCBP, TIGGER, Clean Fuels, Low No, procurements)
 - Departments of Energy, Defense, Interior, NASA, and EPA
 - State of California – CEC, ARB, BAAQMD, SCAQMD

Our Projects



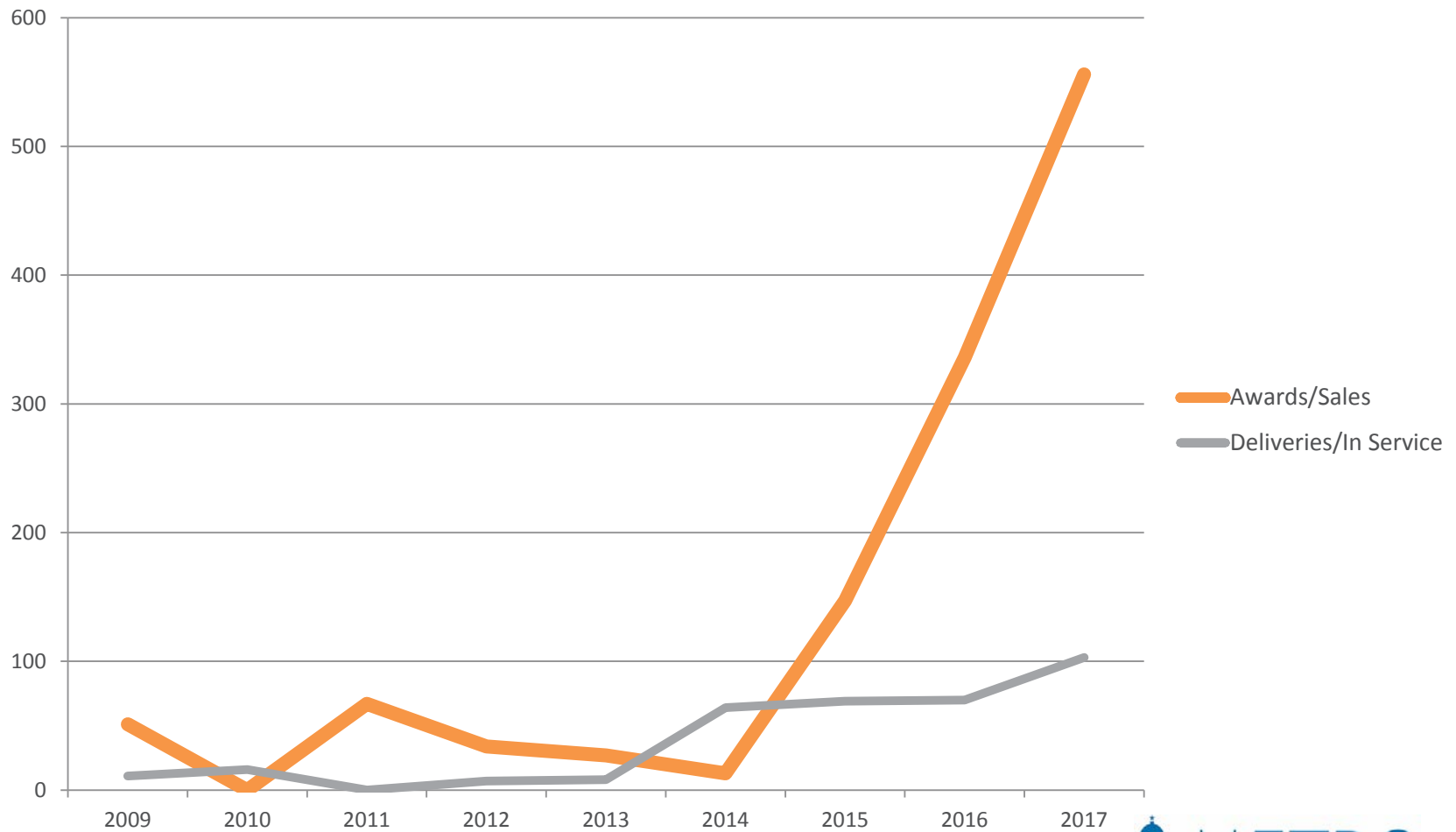
● CURRENT PROJECTS ● PENDING PROJECTS ● MEMBERS ● TRANSIT ● PAST PROJECTS

www.cte.tv

Pace of Change

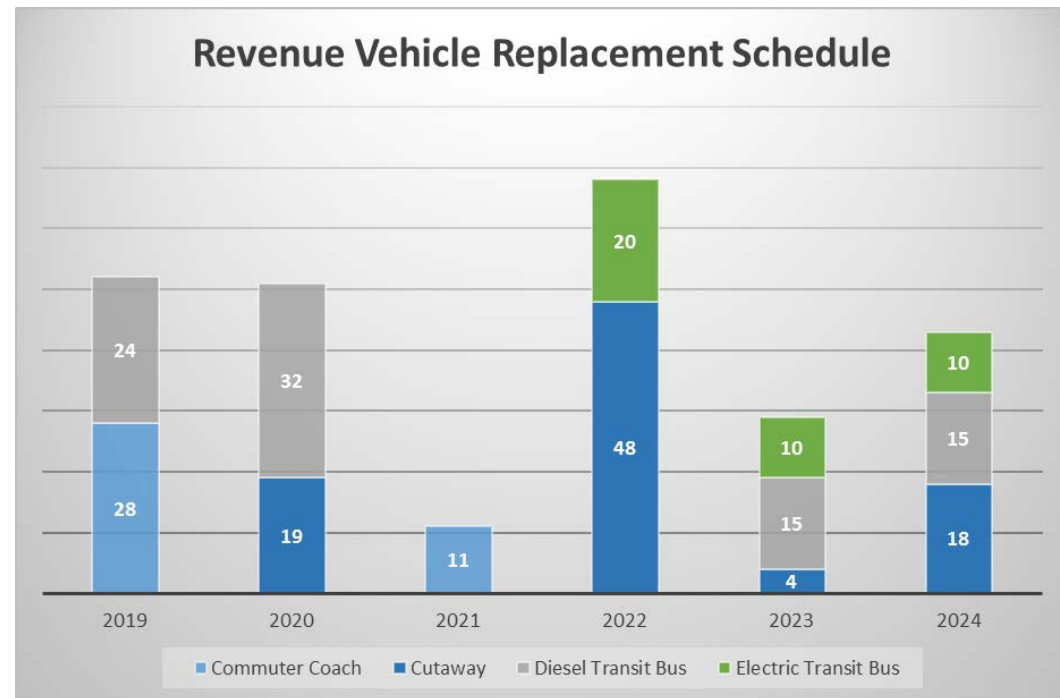


ZEB U.S. Annual Sales & Deliveries



Capital Metro ZEB Fleet Plans

- ZEBRA membership
- Vehicle demonstrations in August/September
- Phase One Implementation Planned
 - 40 buses over 3 year period (FY22 to FY24)
 - Infrastructure is greatest “unknown” at this point
 - Grant funding or other incentives assumed in financial plan



What is “success” for
Capital Metro’s 2024
zero emission
deployment?

Example Motivations

Opportunity
to lead

Reduced
GHG

Zero Local
Emissions

Lower
TCO

Better rider
experience

Motivations for Deploying ZEB



- Why transition to a zero emission fleet?
- Why now?
- What are the critical outcomes?
- What is not important?

Battery Electric Bus Recent History

Calendar Year		Awards & Sales
2009 - 2014		146
2015		136
2016		294
2017		556

Calendar Year	Base Price	Energy Storage
2010	\$1.2 mm	75 kWh
2018	\$750k	450+ kWh

Main Battery Electric Bus Manufacturers



BYD

- 35' – 60' transit buses, 23' – 45' motor coaches available
- On-route charging and depot charging available



Main Battery Electric Bus Manufacturers



Gillig

- 40' transit buses available
- Depot charging available



Main Battery Electric Bus Manufacturers



New Flyer

- 35', 40' and 60' buses available
- On-route charging and depot charging available



Main Battery Electric Bus Manufacturers



Proterra

- 35' and 40' buses available
- On-route charging and depot charging available



Additional Electric Bus Manufacturers



- CCW
- Novabus
- Ebus
- Greenpower
- MCI (New Flyer)
- Van Hool
- El Dorado

Battery Electric Bus Advantages



- Available today
- Fully zero emissions
- Fuel available everywhere
- Batteries will continue to get better
- Simplest zero emission vehicle architecture
- Capital and fuel cost can be similar to conventional buses



Bus Charging Systems



Depot charging

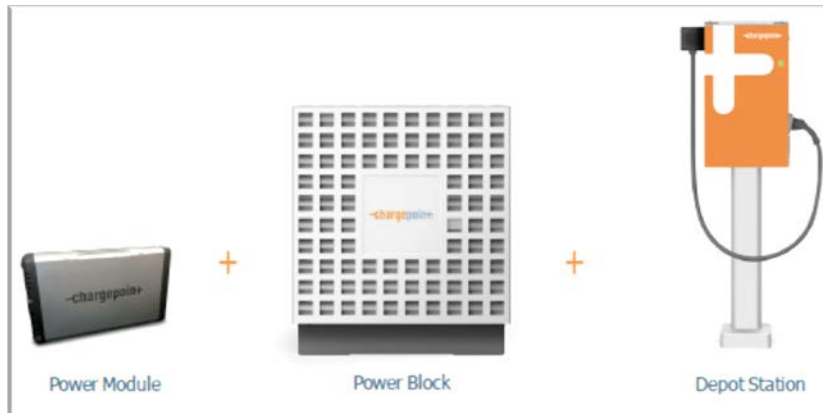
- Standard largely agreed by major OEMs - SAE J1772
- CCS 1 plug most common

Overhead/On-Route Charging

- Working Group standard - J3105
- Several competing solutions



Depot Charger Options



On-Route Charging



Battery Electric Bus Challenges



- Not a drop in replacement today for diesel buses in large numbers
- Deployments are more complicated than diesel
 - Fuel costs can change based on utility rate schedules
 - Bus range can vary route-to-route and season-to-season
 - User can only access ~75 percent of battery capacity
 - Battery capacity decreases over time
 - Drivers can have a large influence on performance

Deployment decisions will need careful planning

Large Battery Electric Bus Charging



- Few large-scale infrastructure plans implemented so far
 - 20 buses charging = 1 - 3 MW grid requirement
 - 200 buses charging = 10 - 30 MW grid requirement

Hydrogen Fuel Cell Buses

Advantages

- Vehicle fueling is similar to CNG
- Sufficient range for most transit service
- FC system can be support cabin heat
- Hydrogen weighs less than batteries
- Simpler redundancy with delivered LH₂



Challenges

- High fuel costs
- Fueling infrastructure is expensive for small deployments
- Capital Costs are high
- Limited OEMs at this point
- Lower production volumes



Hydrogen Refueling Station



- SARTA station shown below – completed late 2016
- About 40'x40' area, capable of fueling around 20-40 buses daily in about 10 minutes



Unknowns and Potential Challenges



Infrastructure for 100's of buses



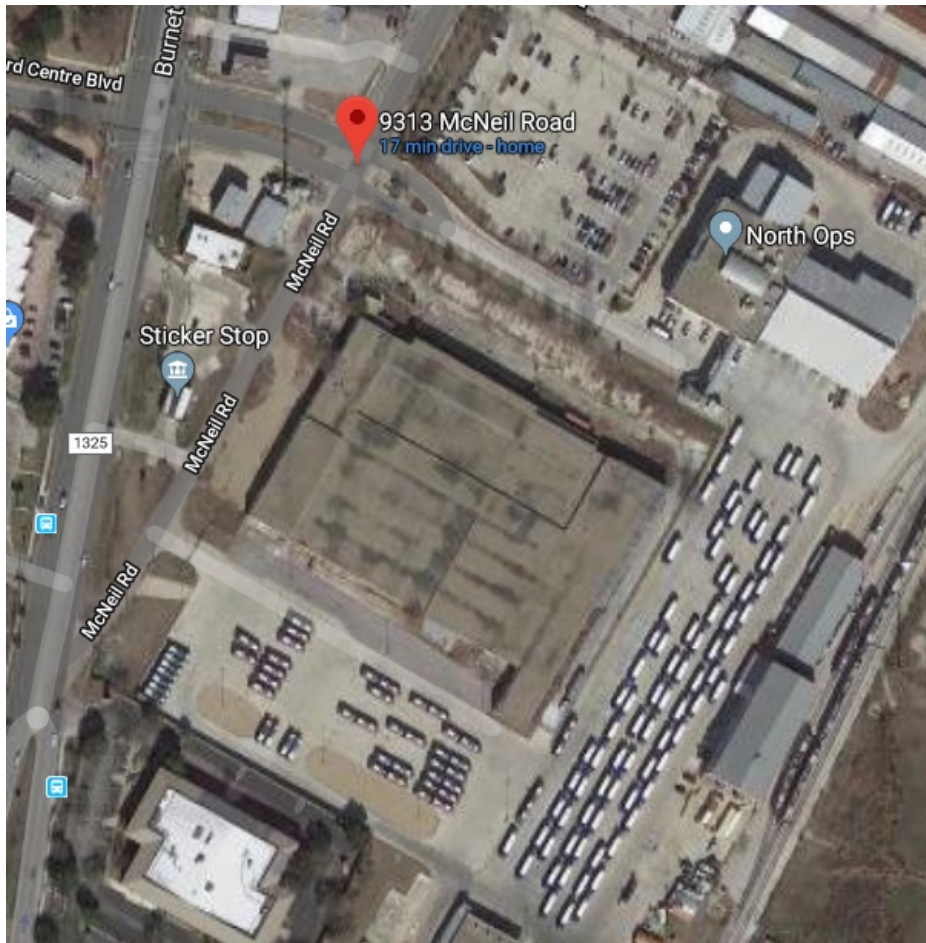
Source: Proterra.com



Unknowns and Potential Challenges



Long term ZEB fleet size requirements



- ZEB impacts
- planned growth

Unknowns and Potential Challenges



Long term maintenance costs



Unknowns and Potential Challenges



Technology obsolescence / fast progress



Unknowns and Potential Challenges



Capital and lifecycle cost – Buses and facilities



Unknowns and Potential Challenges



Training / Human Resources



Next Steps



- Funding and total cost
- Research, peer assistance with ZEB
- Technology decisions
- Analysis needed