



# Capital Metro – Zero Emission Bus Project

Resource Management Commission

September 18, 2018

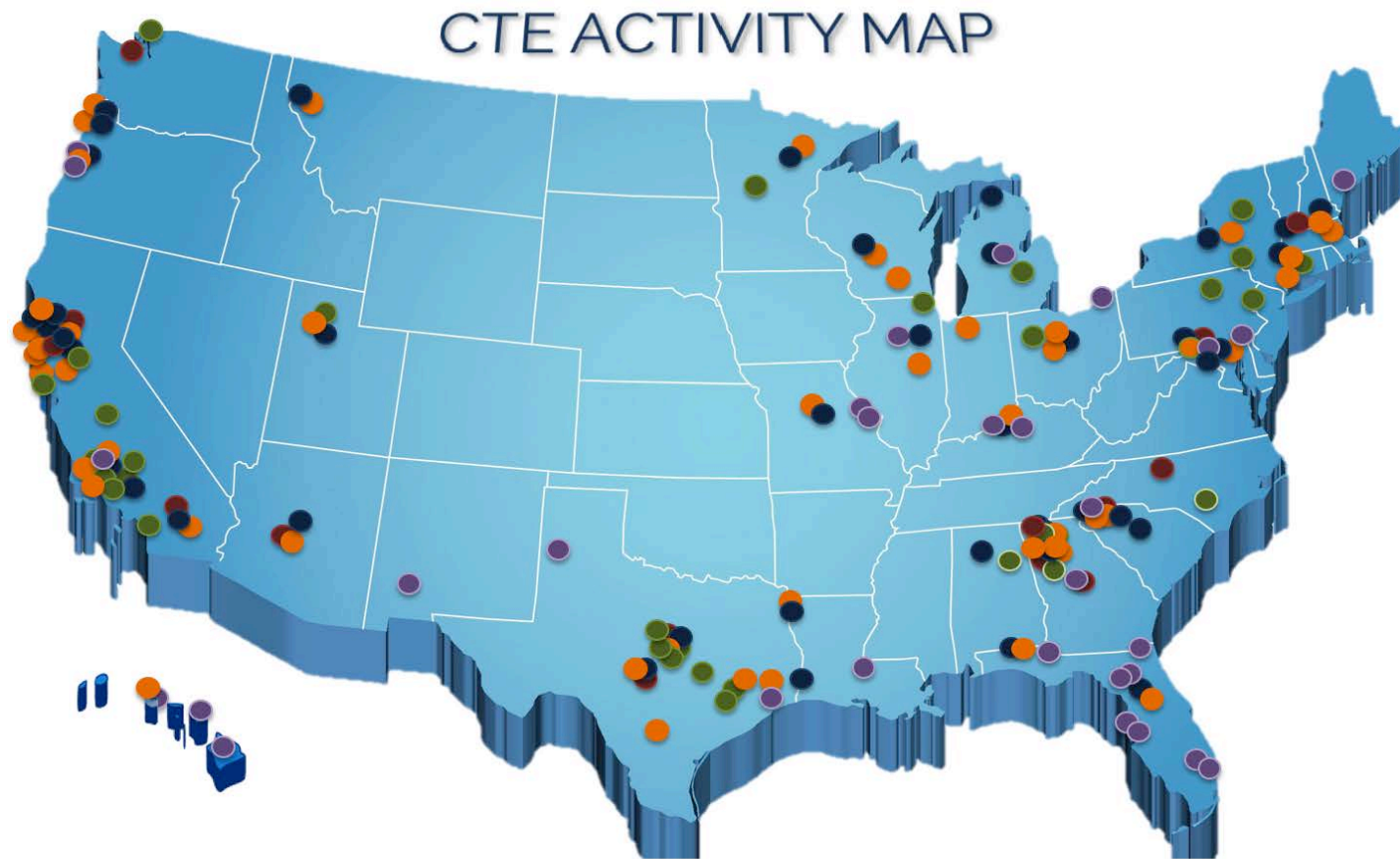


**METRO**

**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



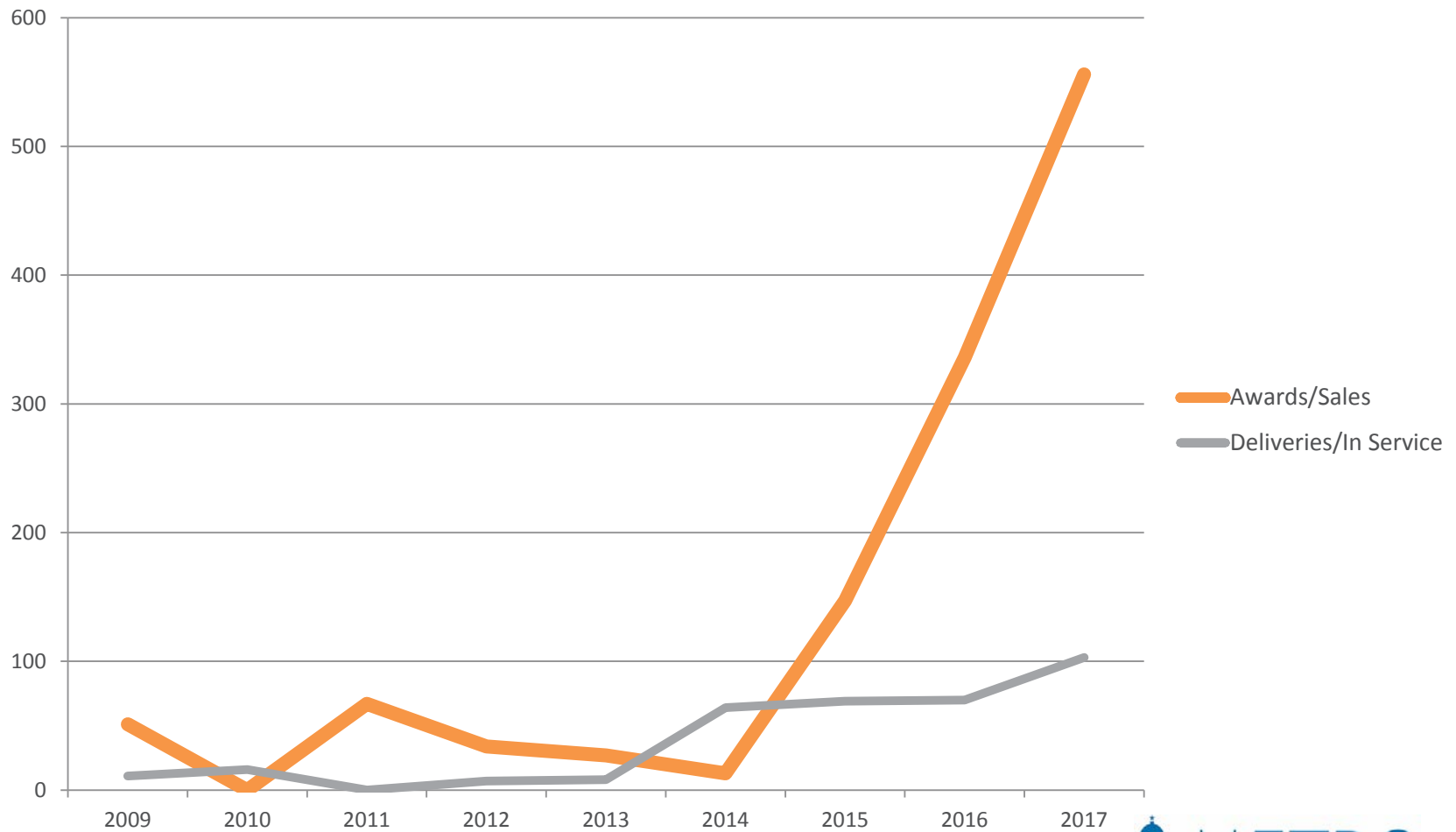
● CURRENT PROJECTS    ● PENDING PROJECTS    ● MEMBERS    ● TRANSIT    ● PAST PROJECTS

[www.cte.tv](http://www.cte.tv)

# Pace of Change

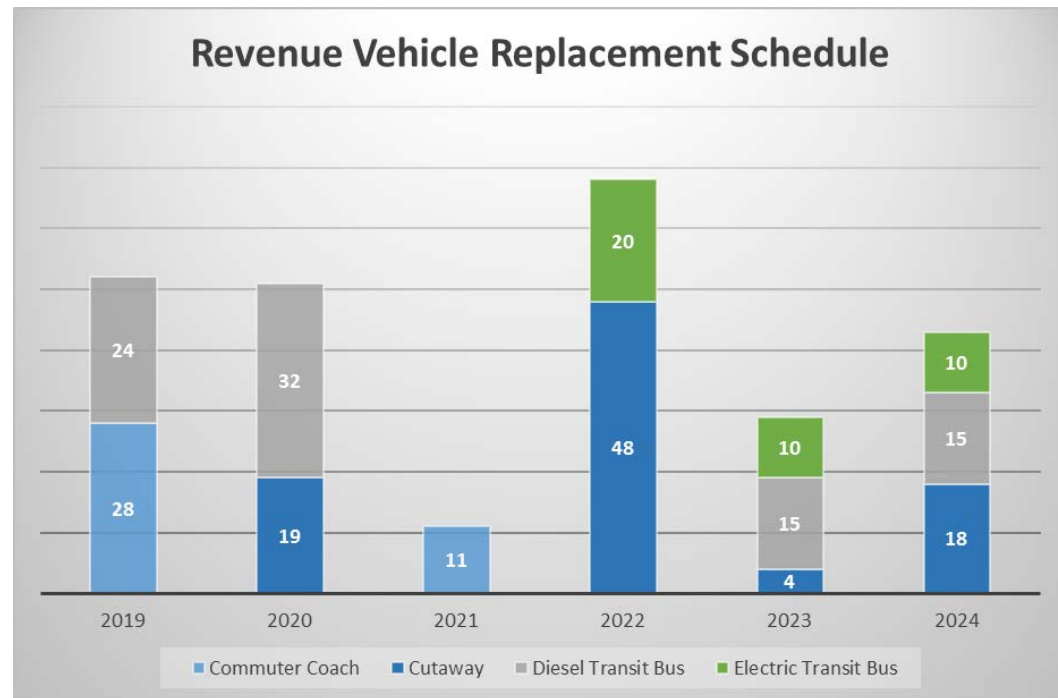


## ZEB U.S. Annual Sales & Deliveries



# 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

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Opportunity  
to lead

Reduced  
GHG

Zero Local  
Emissions

Lower  
TCO

Better rider  
experience

# Motivations for Deploying ZEB

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- 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

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- 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

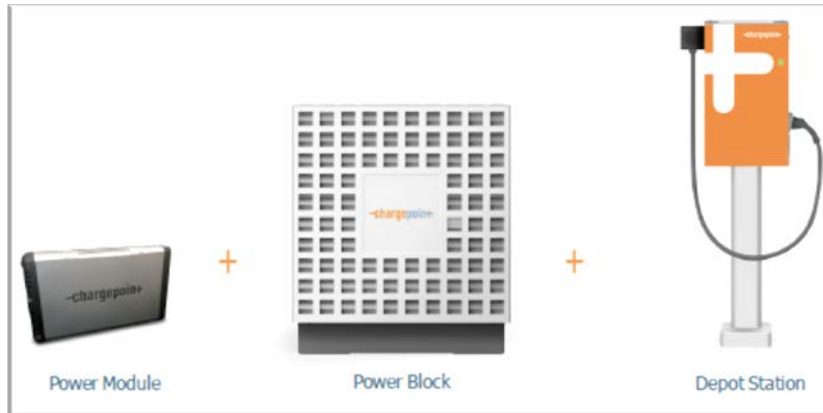
## Overhead/On-Route Charging

- 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 LH<sub>2</sub>



## 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*



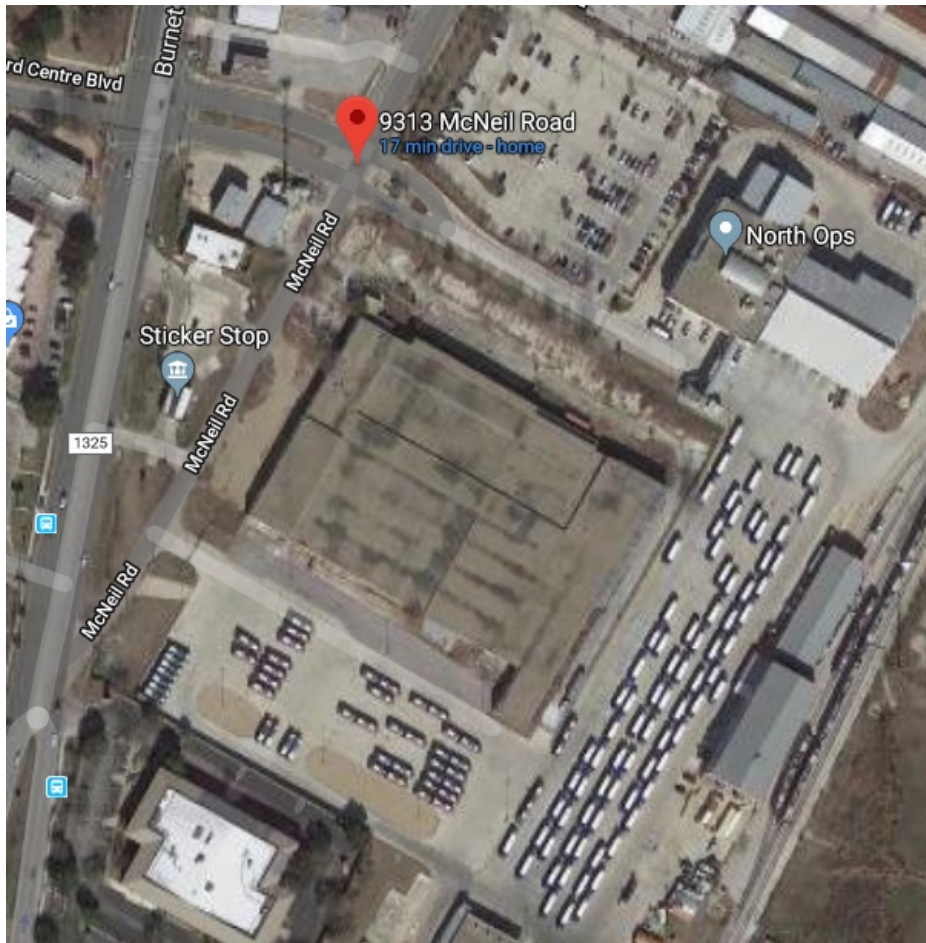
Source: Proterra.com



# 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