

APTA Emerging Leaders Project

Resiliency for Battery **Electric Buses: Best Practices** & Future Strategies



APTA ELP Team Members









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Introduction

Many agencies pursuing
 Zero-Emission Bus (ZEB) goals

WIND-POWERED BY

RIGMEY

TRIGMET

- Battery electric buses are fundamentally different than other vehicle types
- Need to ensure resiliency of the fuel source – the local electricity grid
- Our team conducted interviews with transit agencies to summarize best practices

State of the Industry - Deployments

Top Fifteen Electric Bus Fleets

Transit Agency	City/State	Active Vehicles
Denver RTD	Denver, CO	36
Foothill Transit	West Covina, CA	33
King County	Seattle, WA	26
SEPTA	Philadelphia, PA	25
IndyGo	Indianapolis, IN	21
RTC Washoe	Reno, NV	21
StarMetro	Tallahassee, FL	19
San Joaquin RTD	Stockton, CA	17
GTA	Greensboro, NC	16
CARTA	Chattanooga, TN	15
TARC	Louisville, KY	15
DDOT	Washington DC	14
SB MTD	Santa Barbara, CA	14
CAT	Clemson, SC	10
LBT	Long Beach, CA	10
Total Battery Electric	437	



Source: APTA 2020 Public Transportation Vehicle Database, includes battery electric buses that have been deployed and reported to APTA

Benefits of Electric Buses

- Zero Tailpipe Emissions
- Potential for lower fuel cost depending on local electricity rates
- Quiet Operations
- Potential for lower maintenance costs due to the absence of an engine



食 Challenges with Electric Buses

- Higher Capital Costs
- Range Limitations
- Battery degradation leads to lower range over time
- Charging management needed
 to minimize electricity costs
- New resiliency strategies may be required



Plug-in Slow Depot Charging

- Charger Power: 40-125 kW
- Charge Time: 1-8+ Hours
- Pros:

Let's clear the air

Your all-elegtric bus

151610

-800-RIDE-INFO foothilltransit.org

- Lower Infrastructure Cost
- Lower Electricity Costs
- More chargers if one goes down there is less impact
- Cons:
 - If power goes out, buses will take several hours to charge once power returns

On-Route Fast Charging

- Charger Power: 125-500 kW
- Charge Time: 5-20+ Minutes
- Pros:
 - Enables electric buses to operate on longer routes
 - Smaller batteries on bus
 - Fewer chargers required
- Cons:
 - If power goes out, buses may not be able to continue operating until power is restored.







- Resiliency for electric buses may differ from other vehicle types in the fleet
- Each agency must assess their own risk of power outages
- Some solutions, like microgrids may offer additional benefits
- Sharing ideas with
 peer networks will be
 essential to move the
 industry forward

Reliability of Utilities and Electricity Grid

The North American electrical grid is currently reliable and remarkably structured and affective. However, clean energy technologies threaten to overwhelm the grid's reliability.

> How can the electrical power grid adapt?

Improve Grid Reliability

- Energy storage technologies that would allow electricity to be stored for use when demand peaks or increases rapidly
- Displace coal fired steam turbine generating plants with newer distributed technology, such as gas turbines or solar and wind power which are capable of generating electricity at over 60% efficiency.
- Consumers purchasing energy efficient appliances, constructing energy-efficient buildings, and installing solar panels or wind powered generation can all attribute to, overall, using less energy which would increase the reliability of the electrical grid.
- Combined Heat and Power systems (CHP) have the potential of increase efficiency to more than 80%; by using almost all waste heat for other purposes.





States with Most Power Outages

5) Michigan (Ann Arbor, Grand Rapids)
4) Ohio (COTA, RTA, TARTA)
3) New York (MTA, CDTA, NFTA)
2) Texas (CapMetro, DART, Houston Metro)
1) California (LA Metro, BART, Foothill)





Interviews with Transit Agencies

Agency	City/State	Region	Agency Size	Bus Fleet Size	BEB's in Operation
RTD	Denver, CO	Mountain West	Large	1,085	36
Foothill Transit	West Covina, CA	West	Medium	373	33
SEPTA	Philadelphia, PA	Northeast	Large	1,513	25
RTC	Reno, NV	Southwest	Small	74	21
IndyGo	Indianapolis, IN	Midwest	Small	184	21
TARC	Louisville, KY	South	Small	221	15
DDOT	Washington DC	South	Small	72	14
King County	Seattle, WA	Northwest	Large	1,653	10
RFTA	Aspen, CO	Mountain West	Small	170	8
SD MTS	San Diego, CA	West	Medium	599	6
TriMet	Portland, OR	Northwest	Medium	698	5
MBTA	Boston, MA	Northeast	Large	1,019	5
Cap Metro	Austin, TX	Midwest	Medium	458	4
Metro Transit	Minneapolis, MN	North	Medium	886	1
WMATA	Washington DC	South	Large	1,772	1
NFTA	Buffalo, NY	Northeast	Medium	343	0
DART	Dallas, TX	Midwest	Medium	528	0
LA Metro	Los Angeles, CA	West	Large	2,359	0

Our team spent several months reaching out to transit agencies of different sizes, in all parts of the country, in various stages of electric bus adoption.

Fleet Mix: Backup Diesel/CNG Buses

- A quarter of the agencies interviewed were relying on having a diversified fleet to handle resiliency.
- This allows for buses of other fuel types to cover runs that use BEBs.
- What if an agency has a fully electric fleet - Possibility of FTA regulated contingency fleets of diesel or CNG buses.

RFTA Case Study: Fleet by Fuel Type



RFTA Case Study: Resiliency Strategies by Fuel Types

Diesel/Hybrid

- Two strategies for keeping diesel buses running: diversified sources for acquiring fuel and diesel generators at fueling locations in case power is lost.
- Fuel can be acquired from three locations: Denver, Grand Junction, & Salt Lake City.
- As long as fuel can be acquired the diesel generators at the fueling sites can continue to keep buses running.
- 9% of the 70% of the fleet that is diesel are hybrid buses. No appreciable difference in fuel economy.

Compressed Natural Gas

- Diesel generator on site can run the CNG compressor. At initial power failure the generator runs the compressor at 1/3 power. After being checked it can run at full power.
- Storage capacity in tanks is twice the size necessary, initial thoughts were that the cold weather would cause more issues than it did. That being the case, if necessary, we're able to run about
 2 days before refueling would be necessary. Not an ideal resilience strategy.

Battery Electric Bus

- Initial plan is to have a diversified fleet. The percentage of BEBs for the fleet will be brought up to 30%.
- Diesel Generators on site are not capable of producing enough energy to recharge BEBs.
- Only have plug in charging on-site, possible plans to have on-route charging (conductive charging) eventually.

Low Risk of Power Outages

- Half of all agencies interviewed felt that they were at low risk for power outages or had never had any significant power outages.
- Worst case scenario if buses are not able to be charged: Service levels are reduced (not mentioned by any agencies).
- Depending on the ratio of BEBs to the entire fleet, a combination of a diversified fleet and service reductions could be enacted.





Backup Generator (Diesel, CNG, etc)

- Many transit agencies have diesel or natural gas generators as a backup power source for their facilities.
 - Several agencies that we interviewed mentioned using their current generator or purchasing a new generator.

Multiple Connections to the Grid

- Many of the agencies interviewed have worked with their utilities to establish multiple connections to the grid
- This will allow the bus chargers to have power if there is an outage in part of the grid



Battery Storage/ Microgrid

- Several agencies had projects or plans for battery storage
- This would allow the bus chargers to draw energy from the battery storage in case of a power outage

ENERGY STORAGE

 This system could also be used to lower demand charges

Other Solutions

- "Off-the-shelf" hardware
- Existing infrastructure
- "Green clause"
- Tools to assess reliability



WIEL CEL

CA354N

Hydrogen Fuel Cell

- Similar fueling process to traditional fuels
 - Similar resiliency strategies to Diesel/CNG vehicles



Existing Resiliency Funding

- Reactive, not proactive
- FTA Grants for Hurricane Sandy Recovery and Resiliency
- FEMA Relief for non-FTA funded efforts

Related Funding

Funding for Electric Buses & Infrastructure

- FTA Low or No Emissions Vehicle Program
- FTA Bus & Bus Facilities Program

Focus on state of good repair, service reliability



Future Federal Funding and Regulatory Opportunities

- Still early in the implementation of electric fleets
- Explicitly include resilience in project evaluation
- Transportation reauthorization?



Q & A with Presenters









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