Rural Transit Zero-Emission Vehicle Deployments: Collaborating with your Electric Utility

November 5, 2019, 2:00 PM ET
Presenters

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Overview

• About CTE
• Zero-Emission Transit Industry Overview
  – Vehicle technology
  – Fueling approaches
• Electricity usage for transit fleets
• Case Study – Roaring Fork Transit Authority and Holy Cross Energy
• Action Plan: Building relationships with utilities
Center for Transportation and the Environment

• Technical and project management support for zero-emission vehicle (ZEV) deployments

• Other areas of focus
  – Prototype Development
  – R&D support
  – Education & Outreach
  – Advocacy

• Offices in Atlanta, St. Paul, Berkeley, Los Angeles
POLLING QUESTION 1

Do you operate any electric vehicles? (Select all that apply)

- Yes, 35’ or 40’ buses
- Yes, cutaways
- Yes, light-duty vehicles
- No
Zero-Emission Transit Industry Overview
Zero Emission Vehicle Benefits

✓ Lower emissions
✓ More efficient
✓ Cleaner and quieter
✓ Lower operating costs

Source: Gallo, et al
ZEBs in the U.S.

- Almost 1,600 ZEBs sold or ordered in 44 U.S. states
  - Battery electric buses (BEBs)
  - Fuel cell electric buses (FCEBs)

- ZEB regulations and incentives
  - Federal grant programs available to support ZEB deployments
  - All transit agencies in CA must have 100% zero-emission bus fleets by 2040
Long-Range Battery Electric Buses

Example Bus Specifications
• 150 - 450 kWh batteries
• 150 mile range
• $750K - $1M

Example Charging Specifications
• 50 - 125 kW plug-in chargers
• Charge at the bus yard
• Overnight or mid-day charging
Fast-Charge Battery Electric Buses

Example Bus Specifications
• 150 - 200 kWh batteries
• “Unlimited” range
• $750K - $1M

Example Charging Specifications
• 150 - 450 kW chargers
  – Overhead charging
  – Inductive charging
• Charging for 5 - 15 min per hour
Plug-in Charger

Equipment
- Lower power
- 1 dispenser per vehicle
- Chargers next to bus or remote dispensers

Planning considerations
- Siting - space constraints
- Power upgrades
Overhead Charging

Equipment
• 1 charger for multiple buses
• Pantograph – moving parts on the bus
• Inverted pantograph – moving parts on the charger

Planning considerations
• Siting
  – Land rights, clearances
  – Electrical infrastructure
• Maintenance
Inductive Charging

**Equipment**
- Higher power
- 1 charger for multiple buses
- No moving parts

**Planning considerations**
- Siting
  - Land rights
  - Electrical infrastructure
- Poor alignment reduces efficiency

Source: CARTA
Where do the chargers go?
Vehicle Performance

Range is more variable with zero-emission buses.

- **Route characteristics**: speed, stops, grade
- **Ridership**
- **Heating and cooling**: (Heat is no longer “free.”)
- **Battery degradation**
- **Unusable battery energy**
- **Operator behavior**
The “Other” Electric Bus: Fuel Cell

Example Bus Specifications
• 85 kW fuel cell with 50 - 120 kWh batteries
• Over 200 mile range
• About $850K - $1.2M
• 35 - 50 kg H2 per day

Example Hydrogen Fueling Specifications
• Hydrogen delivery
• On-site hydrogen generation
Hydrogen Fueling Station

Equipment

- Higher energy requirements than a diesel gas station – new compression, storage, and distribution equipment
- 150 kW for 12 buses

Planning Considerations

- Siting
- Permitting
- Scales more easily than charging
- Shorter fueling times than charging
On-site Hydrogen Generation

Equipment
• Electrolysis
• Natural gas reformation

Planning Considerations
• Siting
• Electrical infrastructure – Energy requirements may be comparable to charging

An electrolyzer to fuel 12 buses per day might use 1 MW.

A hydrogen generation plant in CA that makes hydrogen to fuel 42 cars and 12 buses per day uses 2.4 MW.
## Other Vehicles

Infrastructure considerations may vary

<table>
<thead>
<tr>
<th>Battery Electric</th>
<th>Fuel Cell Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Charging connectors</td>
<td>• Tank pressures (350 vs 700 bar)</td>
</tr>
<tr>
<td>• Battery power limits</td>
<td>• Fueling receptacles</td>
</tr>
<tr>
<td></td>
<td>• Pre-cooling requirements</td>
</tr>
</tbody>
</table>
Cutaways

Example Specifications

• 100 – 120 kWh batteries
• Range up to 110 miles
• Seats 12 – 20 passengers
• Charges in 8 hours (0-100%)
Vans

- 40 – 100 kWh batteries
- Battery Electric with range up to 120 miles
- Charge time varies
Cars

Electric
• Tesla
• Chevy Bolt
• Nissan Leaf

Fuel Cell
• Toyota Mirai
Transit agencies with ZEB fleets may become major users of electricity.

Managing fuel costs is as important as ever, but it is a different exercise with electricity or hydrogen than it is with diesel or gas.
POLLING QUESTION 2

Have you met with your local utility to discuss EVs? (Select one)

• Yes
• No
• I don’t know
Relationship with Utilities

• **Manage demand and timing impacts** to grid, in order to reduce cost and stress on system

• **Operational and infrastructure improvements** from smart infrastructure planning to support long-term electrification goals

• **Partner engagement** to better communicate constraints and needs

• **Meeting carbon emission reduction goals**, especially in environmental justice or disadvantaged communities

• **Resilience is key**, and your utility can help with this
Know Your Needs vs Their needs

- Power may be more readily available or cheaper at certain times of day
  - Utility might be able to modify your pricing based on this

- Ask questions about:
  - Factors that will influence electricity bill
  - Short- and long-term infrastructure support
  - Service times
Simple Electric Grid

Generation → Transmission → Substation → Distribution → Consumption
Long Term Infrastructure

• Single Phase vs. Three Phase
Energy vs Demand
Limiting Demand

- Charge buses sequentially vs. simultaneously
- On-site storage
- Peak vs. off-peak charging
## Electricity and Charge Modeling

### Baseline Rate Cost Modeling

<table>
<thead>
<tr>
<th>Month</th>
<th>Miles</th>
<th>kWh Consumed</th>
<th>Demand kW</th>
<th>Demand Charge</th>
<th>Energy Charge</th>
<th>Customer Charge</th>
<th>Fuel Adjustment Charge</th>
<th>Energy Efficiency Program Charge</th>
<th>Energy Efficiency Investment Charge</th>
<th>Federal Tax</th>
<th>St. Louis City Municipal Charge - Service</th>
<th>Electricity Cost</th>
<th>Total Cost/Mile</th>
<th>Cumulative Electricity Costs</th>
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<tbody>
<tr>
<td>January</td>
<td>75,888</td>
<td>276,551</td>
<td>850</td>
<td>$1,700.00</td>
<td>$15,841.87</td>
<td>$44.51</td>
<td>$542.04</td>
<td>$55.31</td>
<td>$1,290.61</td>
<td>($1,277.67)</td>
<td>$2,021.83</td>
<td>$20,218.09</td>
<td>$0.27</td>
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<tr>
<td>February</td>
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<td>850</td>
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<td>267,630</td>
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<td>$524.55</td>
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<td>($1,236.45)</td>
<td>$1,870.86</td>
<td>$19,708.76</td>
<td>$0.27</td>
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<tr>
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<td>276,551</td>
<td>850</td>
<td>$1,700.00</td>
<td>$15,841.87</td>
<td>$44.51</td>
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<td>$2,021.83</td>
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</tr>
<tr>
<td>June</td>
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<tr>
<td>July</td>
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<td>August</td>
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<tr>
<td>September</td>
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<tr>
<td>Annual Total</td>
<td>883,520</td>
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<td>3,156</td>
<td>$31,960</td>
<td>$224,577</td>
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<td>$203,975</td>
<td>$203,975</td>
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</tr>
</tbody>
</table>

### Monthly Average Cost/Mile

<table>
<thead>
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<th>Month</th>
<th>Non-Electric</th>
<th>Elec</th>
<th>Total Fleet</th>
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</thead>
<tbody>
<tr>
<td>Sep-13</td>
<td>$1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov-13</td>
<td>$0.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan-14</td>
<td>$0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar-14</td>
<td>$0.70</td>
<td></td>
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</tr>
<tr>
<td>May-14</td>
<td>$0.60</td>
<td></td>
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</tr>
<tr>
<td>Jul-14</td>
<td>$0.50</td>
<td></td>
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<tr>
<td>Sep-15</td>
<td>$0.40</td>
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<tr>
<td>Nov-15</td>
<td>$0.30</td>
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<tr>
<td>Jan-16</td>
<td>$0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar-16</td>
<td>$0.10</td>
<td></td>
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</tr>
</tbody>
</table>

### Charging Simulation

- **0 charge s**: Bus SOC 2:24 AM 4:48 AM 7:12 AM 9:36 AM 12:00 PM 2:24 PM 4:48 PM 7:12 PM 9:36 PM 12:00 AM
- **40% 2 charge s**: Bus SOC 2:24 AM 4:48 AM 7:12 AM 9:36 AM 12:00 PM 2:24 PM 4:48 PM 7:12 PM 9:36 PM 12:00 AM
- **33% 2 charge s**: Bus SOC 2:24 AM 4:48 AM 7:12 AM 9:36 AM 12:00 PM 2:24 PM 4:48 PM 7:12 PM 9:36 PM 12:00 AM
- **20% 2 charge s**: Bus SOC 2:24 AM 4:48 AM 7:12 AM 9:36 AM 12:00 PM 2:24 PM 4:48 PM 7:12 PM 9:36 PM 12:00 AM
Cost Competitiveness with Diesel

Monthly Average Cost/Mile

- Non-Electric
- Elec
- Total Fleet

- Sep-13
- Nov-13
- Jan-14
- Mar-14
- May-14
- Jul-14
- Sep-14
- Nov-14
- Jan-15
- Mar-15
- May-15
- Jul-15
- Sep-15
- Nov-15
- Jan-16
- Mar-16
- May-16
Roaring Fork Transit Authority and Holy Cross Energy
Rural Transit Zero-Emission Vehicle Deployments: Collaborating with your Electric Utility

Tuesday November 5, 2019

RFTA & Holy Cross Energy
BATTERY ELECTRIC BUS PILOT PROJECT

Jason White
Multimodal Transit Planner

Chris Bilby
Research & Programs Engineer
Roaring Fork Transportation Authority (RFTA) Service Region
Holy Cross Energy

Member-Owner
Not-for-Profit
Electrical Cooperative

$120 million revenue
160 employees
260 MW winter peak
60,000 meters
3,000 miles of distribution
120 miles of transmission
RFTA by the Numbers

- Regional transit authority, 8 members
- 2nd largest transit agency in Colorado
- Largest rural transit agency in the nation
- First rural BRT System, opened in 2013
- 70-mile service region from Aspen to Rifle
- Spans 4 rural utilities
- 5.16 million passengers
- 5.15 million miles of service
- 380 employees during peak winter season
- 34-mile Rio Grande Rail Corridor and Trail
- $44.7 million budget
- 90 revenue service vehicles
  - 34 compressed natural gas (CNG)
  - 8 new battery electric buses (BEBs)
  - 22 vans
- 34-mile Rio Grande Rail Corridor and Trail
- Over 70,000 annual WE-cycle public bike trips
RFTA-City of Aspen
BATTERY ELECTRIC BUS PILOT PROJECT

• Jan. 2017 scoping workshop with bus vendors
• New Flyer chosen via competitive RFP process
• (8) XE40 New Flyer CHARGE Excelsior buses
• (4) ABB 150 kW depot chargers; on-route in future
• $9.2 m project ($4.2 m grants, $5.0 m local)
• Challenging Operational Conditions
  • 5,761’ to 9,580’ elevation range
  • Snow, ice and steep grades
  • -10 to 90 degrees F fluctuation
  • High customer expectations
• Shared sustainability goals with Holy Cross Electric
• Innovative time-of-use tariff for bus charging
• RMI Mobility Lab for relationship building
• Exploring renewable energy offset options
• Flexible fleet replacement plan based on realities

One of the valley’s new battery-powered, electric buses is on display Monday. Roaring Fork Transportation Authority plans to put eight of the buses into service around Thanksgiving. RFTA courtesy photo.
Seventy70Thirty

Our path to a clean energy future

Clean power. Lower emissions. By 2030.

• Use clean and renewable resources to supply at least 70% of the power we provide.

• Reduce greenhouse gas emissions associated with our power by 70%.

• Accomplish both with no additional increase in Power Supply costs.
Clean Up The Supply

HCE’s Power Supply

2005 Energy by Fuel

2018 Energy by Fuel

2024 Projected Energy by Fuel
HCE’s Plan
2. Community Charging
3. Transit
4. HCE’s Fleet

http://www.holycross.com/charge-at-home-charge-at-work
• As our *Seventy70Thirty* plan is implemented, HCE will likely have excess wind generation overnight.

• Low cost, clean energy is perfect for utilization by transit fleets (ECO, RFTA) and school districts.

• HCE has collaborated on infrastructure analysis, rate design including TOU with *no demand charge*, on-site solar PV and green pricing.

<table>
<thead>
<tr>
<th>Rate</th>
<th>Consumer Charge</th>
<th>Demand Charge</th>
<th>Energy Charge</th>
<th>ECA</th>
<th>Minimum</th>
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</thead>
<tbody>
<tr>
<td>TOU</td>
<td>$12.00</td>
<td>$0.00</td>
<td>0.06¢ (off peak) 0.24¢ (on peak)</td>
<td>$0.00</td>
<td>$12.00</td>
</tr>
</tbody>
</table>

*on peak defined as 4pm-9pm 7 days a week
Example Support
Importance of Partnership

• **One size does not fit all** – Utilities, especially coops and municipals might be able to customize a rate schedule

• **Buses have 12 year service life**, electricity rates probably won’t

• **Balance of capital/operating funds** may be available
POLLING QUESTION 3

Does your utility have an EV rate structure or pilot program? (Select one)

• Yes
• No
• I don’t know
Sample infrastructure support

- **Austin Energy**
  - Providing design support for a 4 – 10 MW bus fueling center
- **Portland General Electric**
  - Pay for charging infrastructure
  - Own and operate charging equipment
- **Burlington Electric**
  - Built a temporary charging station for use during an electric bus demonstration
  - Supported transit agency Low-No application
Sample rate support

• PG&E proposal
  – Pay per kW of charging capacity instead of traditional demand charges
  – TOU energy charges

• SCE five year program
  – No demand charges (though these would return after five years)
  – TOU energy charges
  – SCE recovering costs through energy charges
Sample rate support

• Hawaiian Electric Company
  – Energy discounts and no demand charges during mid-day charging
  – Energy premium and incremental demand charge during peak hour charging

• MN Power
  – Peak and off-peak demand charges
  – Limiting demand to 30% of the total bill

• Xcel Energy
  – Energy charge credit per month per kWh
Building Partnerships
Building Partnerships

• Set up a kick-off meeting with your local electric utility

• Coordinate with other transit agencies throughout their ZEB deployments
Communicate your agency’s goals

• **Goals for ZEB deployments**
  – Short-term: Pilot technology, or small deployment?
  – Long-term: Eventually transition entire fleet?

• **Timeline for each planned deployment**

• **Vehicle fueling and operation**
  – Charging them at the bus depot?
  – On-route charging?
  – Hydrogen fueling?
Ask utilities about their constraints

• **Load profiles**
  – Ask about TOU rates and how they apply to you

• **Capital investments**
  – What can and can’t they help with? Why?

• **Energy production**
  – How renewable is the grid?
  – How might that change in the future and impact rates?
Would you be interested in learning more about this topic during a half- or full-day workshop? (Select one)

- Yes
- No
- I don’t know
POLLING QUESTION 5

Would you be interested in a workshop with your electric utility? (Select one)

• Yes
• No
• I don’t know