Electric Vehicle Buses

Webinar Date: May 30, 2019
Hosted by: American Climate Cities Challenge, the Electrification Coalition, Natural Resources Defense Council, Proterra, and BYD North America
The Electrification Coalition (EC) is a nonpartisan, not-for-profit group of business leaders committed to promoting policies and actions that facilitate the deployment of electric vehicles on a mass scale in order to combat economic, environmental, and national security dangers caused by our dependence on oil.
Electrification Coalition Programs

- Technical Lead: Climate Mayors EV Purchasing Collaborative
- Electrification Advisor: American Climate Cities Challenge
- Electrification Partner: Smart Columbus
- Electrification Advisor: City of Atlanta Partnership
- Project Lead: Drive Electric Northern Colorado
- Project Lead: Rochester EV Accelerator
The Case for Bus Electrification
Current Global Bus Market

- More than 70,000 buses on the road in the US.
- The average bus uses more than 9,000 gal of Diesel equivalent per year.
- Worldwide demand for buses is expected to rise 4.9% each year through 2021, reaching 623,000 units.
Comparative Analysis - MPG
EV vs Diesel Buses (By Region)

American Cities Climate Challenge
Electrification Coalition

Note: The MPG (miles per gallon, diesel) value listed is the fuel efficiency a diesel bus would need to have the same life cycle global warming emissions as a battery electric bus in each region. Regional global warming emissions ratings are based on 2016 power plant data in the EPA’s eGRID database (the most recent version). Argonne National Laboratory’s GREET 2017 model was used to estimate emissions from diesel and electricity fuel production.
Comparative Analysis - Emissions
EV vs Diesel Buses (US Average)

Life cycle global warming emissions from different types of transit buses

<table>
<thead>
<tr>
<th>Type</th>
<th>CO₂e (g/mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>2,680</td>
</tr>
<tr>
<td>Natural gas</td>
<td>2,364</td>
</tr>
<tr>
<td>Diesel-hybrid</td>
<td>2,212</td>
</tr>
<tr>
<td>Battery electric</td>
<td>1,078</td>
</tr>
</tbody>
</table>

(American Cities Climate Challenge)
Global e-bus sales increased 80x between 2011 and 2017, according to Bloomberg NEF.

- **2025**: 50% the world’s municipal bus fleet will be electric.
- **2030**: 84% of new municipal buses sold will be electric.
- **2040**: 80% of the world’s city bus fleet will be electric, along with 33 percent of the world’s cars.
## E-Bus Fleets Around the World

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Europe</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Largest producer and user of electric vehicles</td>
<td>U.K has the largest e-bus fleet</td>
<td>There are ~360 electric buses in the US, representing less than 0.1% of the global fleet.</td>
</tr>
<tr>
<td></td>
<td>99% of the E-buses sold globally in 2017 were in China</td>
<td>E-buses made up 1.6% of all municipal buses in Europe in 2017</td>
<td>E-buses contribute about 0.5% of the total municipal fleet of 70,000 buses</td>
</tr>
<tr>
<td></td>
<td>E-buses make up about 17% of the total Chinese bus fleet</td>
<td></td>
<td>California is the first state to require E-buses, starting in 2029</td>
</tr>
<tr>
<td></td>
<td>Cities like Shanghai and Shenzhen have halted purchases of ICE buses</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>in favor of e-buses</td>
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</table>
US E-Bus Fleet

- The US E-Bus market was worth $45 M in 2018, and will reach $1.9 B by 2024 – a compound annual growth rate of 18.5%.
- At the end of 2017, 9% of US transit agencies had E-Buses ordered or on the road.
- Only a few hundred of the 480,000 US school buses are electric.
## Available E-Bus Models

<table>
<thead>
<tr>
<th>BYD K7</th>
<th>BYD K9S</th>
<th>GreenPower EV250-400 All-Electric Transit Bus</th>
<th>GreenPower Synapse 72 All-Electric School Bus</th>
<th>Motiv Electric EPIC 6 series Chassis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lion Electric LionA Electric Mini School Bus</td>
<td>Lion Electric LionC Electric School Bus</td>
<td>Lion Electric LionM Electric Transit Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lion Electric LionM Electric Transit Bus</td>
<td>Proterra Catalyst Bus</td>
<td>Thomas Built Saf-T-Liner C2 Jouley</td>
</tr>
</tbody>
</table>

![Available E-Bus Models](image-url)
City Leadership

• The majority of buses operate in cities.
• Momentum for bus electrification is centered in metropolitan areas.
• Bus electrification helps cities meet internal, state-wide, and international fuel and emissions reduction goals.
• In the C40 Fossil-Fuel-Free Streets Declaration, 13 cities committed to procure only zero-emissions buses.
Communities Leading the Way on Bus Electrification

- Antelope Valley, CA
- Philadelphia, PA
- White Plains, NY
- Illinois
- Indiana
- Indianapolis, IN
- Columbus, OH
- Nevada
- Greensboro, NC
- Charlotte, NC
- Washington, DC
- Orlando, FL

American Cities Climate Challenge
Electrification Coalition
E-Bus Savings

- Lower fuel costs
- Lower maintenance costs
- World Resource Institute created a Costs and Emissions Appraisal Tool for Transit Buses to help transit agencies evaluate E-Bus cost savings
Barriers and Considerations

- Higher upfront costs
- Associated infrastructure
- Misconceptions of technology readiness
- Customer uncertainty with electricity as a fuel
- Standardization and scalability
- Underdeveloped supply chains
- Long procurement and sales cycles
E-Bus Infrastructure

- E-Bus charging can range from 60 – 500 kW and utilize J1772-CCS and/or overhead charging connections.

- Overhead charging is meant to be done on route, to limit vehicle down time.

- Plug-in charging best suited for depot charging, such as overnight, during service or shift changes.
Incentives for Bus Electrification

- Volkswagen Settlement Funding
- EPA Grants (Federal and State)
- FTA Low-No Funding
- FTA Bus and Bus Facility Funding
Funding Opportunities

**VW Settlement**
- $2.9 billion nationwide in Trust to invest in technologies that reduce harmful emissions
- Each state has a disbursement plan
- Funds could used as local match

**Additional USDOT Funding Opportunities**
- FY19 Bus and Bus Facilities
- Over $427 million for FY19
- 12 electric bus projects selected in FY18 program (approximately 10% of projects)
- Notice of Funding likely released in Spring/Summer 2019

**FY19 BUILD (formally known as TIGER)**
- 900 million available for FY19
- 50% Urban/50% Rural Split
- Notice of Funding Opportunity likely to be released Spring/Summer 2019
Low or No Emission FY 2019
Notice of Funding

Overview of Notice of Funding:

• $85 million total funding available from The Federal Transit Administration (FTA) for FY 2019.

• Provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities. Under the FAST Act, $55 million per year is available until fiscal year 2020.

• Support national transit fleet transition to the lowest polluting and most energy efficient transit vehicles

https://www.transit.dot.gov/funding/grants/lowno
Timeline

• **Notice of Funding Opportunity Posted:** 3/18/2019

• **Registration Details Announced:** 2-3:30 PM Eastern Time, 4/11/2019 via webinar

• **Proposals Due:** 11:59 PM Eastern Time by 5/14/2019 via electronic submission to [www.grants.gov](http://www.grants.gov)
Eligibility

Eligible Applicants

- Public transit agencies
- State transportation departments
- Tribes
- Direct recipients of FTA grants under the Section 5307 Urbanized Area Formula program

Eligible Projects

- Purchasing or leasing low- or no-emission buses
- Acquiring low- or no-emission buses with a leased power source
- Construct or lease related facilities and equipment (including intelligent technology and software)
- Rehab or improving existing public transportation facilities to accommodate low- or no-emission buses
- Construct new public transportation facilities for low- or no-emission buses
Grants for Buses and Bus Facilities
Program:
(49 U.S.C. Section 5339 / FAST Act Section 3017)

Overview:

• $423.3 total funding available from the Federal Transit Administration (FTA) for FY 2019.
• Award Ceiling (per project) = $42,335,024

Available to states and direct recipients to:

• Replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities including technological changes or innovations to modify low or no emission vehicles or facilities.
Grants for Buses and Bus Facilities
Program:
FY 2018 - Previous Selections

Key Highlights: (FY 2018)

- $366.2 million - 107 projects in 50 states
- Total # of EV Bus Projects Receiving Funds = 17 out of 107 (~16%)
- Total Funds Received for EV Bus Projects (FY 2018) = $61,709,507 (~17%)

Expected FY 2019: (Based on FY 2018 %)

- ~20 EV Bus projects
- Total funding amount ~$72 million
Timeline

• Notice of Funding Opportunity Posted: 5/15/2019

• Proposal Due: 11:59 PM Eastern Time by June 21, 2109 via electronic submission to https://www.grants.gov/web/grants/view-opportunity.html?oppId=316003
Discussion
Questions and Answers

American Cities
Climate Challenge

Electrification Coalition
The Electrification Coalition
Revolutionizing Transportation and Achieving Energy Security

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www.electrificationcoalition.org

Contact:
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Lead for ACCC
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Ben Prochazka
Vice President
BProchazka@electrificationcoalition.org
ABOUT PROTERRA

Proterra’s Mission
Advancing electric vehicle technology to deliver the world’s best-performing heavy-duty vehicles

• Offices and manufacturing in CA and SC
• 500+ employees, with strong transportation expertise
• >90 customers; >700 vehicles sold
• >265 vehicles delivered; >7,000,000 service miles
• >39,000,000 pounds of CO2 emissions avoided

Strong Transportation Expertise

World-Class Financial Partners
HIGH-QUALITY, ADVANCED MANUFACTURING FOR RAPID EV ADOPTION AT SCALE

Burlingame, California
Battery Manufacturing Company HQ

Los Angeles, California
Bus Manufacturing West Coast Operation

Greenville, South Carolina
Bus Manufacturing East Coast Operation
OUR CUSTOMERS

>700 buses sold to >90 customers across 41 states/provinces
ACCC PROTERRA CUSTOMERS

- **Hawaii**
  - JTB Hawaii Honolulu

- **Texas**
  - VIA San Antonio
  - Capital Metro Austin

- **Washington**
  - King County Metro Seattle

- **Washington, D.C.**
  - DC Circulator Washington

- **Illinois**
  - JLL Chicago

- **California**
  - LADOT Transit Los Angeles
  - San Jose International Airport
  - VTA San Jose

- **Pennsylvania**
  - SEPTA Philadelphia
THE TRANSIT MARKET IS RAPIDLY SHIFTING TO EV

- Moving toward widespread industry adoption

- **Purchase barriers eliminated** due to:
  - Improved range
  - Charging standardization
  - Sharp decline in battery costs
  - Service-proven performance
  - Increased total cost of ownership
  - Environmental stewardship
  - Rising health costs associated with fossil fuels
  - Government programs (e.g., grants)
  - Urbanization

Source: CTE Center for Transportation and the Environment
EV Transit Bus adoption continues to increase

Major cities adopting EV technology for transit buses

- **New York**: 100% EV by 2040, 4,700 buses
- **Chicago**: Piloting since 2014, 2,100 buses
- **Washington D.C.**: 100% EV by 2045, 1,900 buses
- **Seattle**: 100% EV by 2034, 1,500 buses
- **Philadelphia**: Piloting since 2017, 1,500 buses
- **Miami**: 50% EV by 2035, 800 buses

California mandates 100% electric transit buses by 2040

- **New purchase mandates**
  - 25% by 2023
  - 50% by 2026
  - 100% by 2029

12,000 buses across California (17% of nationwide fleet)

Source: Frost & Sullivan Heavy Duty Transit Bus North America Powertrain Adoption Forecast

Source: National Transit Database; agency websites; 2017 American Public Transportation Association Fact Book
Battery-electric vehicles have the lowest operational lifecycle cost:
- High EV energy efficiency, low electricity rates, and high annual vehicle mileage combine to create significant fuel savings
- 30% fewer parts dramatically reduce maintenance and operating costs
- Electricity prices far more stable and predictable than volatile fossil fuel prices

12-yr Operational Savings per Bus
$462k vs. Diesel
$467k vs. CNG
$479k vs. Hybrid
Advanced battery technology cost has declined to the point of replacing fossil fuels in the transit market.

Sources: Navigant Research, green.autoblog.com, Electric Drive Transportation Association. xEV = PHEV, HEV, EREV and BEV.
WAYS TO LOWER UPFRONT COSTS

1. $749,000 Electric Bus vs. $500,000 Fossil Fuel Bus
2. Local vouchers reduces electric bus price
3. Incremental cost required over Fossil Fuel Bus
4. Max Low-No Award Reduces Bus Cost
5. Battery Lease - Electric Bus Cost Fossil Fuel Bus
6. $0 Out of Pocket Cost for Bus/Charger Capital Lease
Combining Funding Sources

Grant “applicants may choose to combine formula and Low-No funding” – FTA

Low-No FAQ

1. Use formula funds budgeted for replacement fossil fuel bus for electric bus
2. Reduce up-front capital cost by leasing battery
3. Leverage small Low-No Award to purchase many electric buses

** VW settlement dollars are also now available to use

Case Study: Jackson, Wyoming
- 8 buses with 2018 Low-No Award of $2,290,000

JACKSON, WY 2018 low-no sources of funds
THE PROTERRA CATALYST’S RANGE

PROTERRA CATALYST® E2 MAX SETS WORLD RECORD AND DRIVES 1,101.2 MILES ON A SINGLE CHARGE

*Depending on model. Nominal range = total energy/ projected Altoona efficiency. Actual range will vary with route conditions, battery configuration and driver behavior.
**Advanced Composite Body**
Lightweight and durable carbon-fiber-reinforced composite

**High Efficiency Drivetrain**
2x horsepower
5x efficiency of diesel

**Heavy Duty Battery Pack**
High energy density, ruggedized battery packs purpose built for commercial vehicles

**Universal Charging**
Industry standard plug-in and overhead high power Level 3 charging

THE PROTERRA CATALYST
PURPOSE-BUILT EV TECHNOLOGY
FOR MASS TRANSIT
THE DUOPOWER™ DRIVETRAIN

By combining the DuoPower drivetrain with Proterra’s battery technology and lightweight composite bus body, the Catalyst delivers up to 29 MPGe—over 5X more fuel efficient than a diesel bus.

Enables the longest range
• Operating range up to 390 miles
• Tested at the Navistar Proving Grounds, achieving a world record range for an EV, traveling 1,101.2 miles on a single charge

Designed for best performance
• Propels a bus up a 26% grade, making it an ideal option for transit agencies with steep hills
• Enhances performance in extreme weather

2X The Horsepower, 2X The Acceleration, 5X More Efficient Than a Diesel Bus
The Proterra APEX™ connected vehicle intelligence system is a cloud-based data platform, offering historical and real-time performance information about your battery electric vehicle fleet, to optimize bus and charging operations and reduce costs.

**PROTERRA APEX CONNECTED VEHICLE INTELLIGENCE SYSTEM**

- **VEHICLE MONITORING**
  - Real-time information and historical charts on vehicle performance.

- **REMOTE DIAGNOSTICS**
  - Reduce on-site visits and solve problems remotely with alerts for vehicles and chargers.

- **PREVENTATIVE MAINTENANCE**
  - Notifications and recommendations for preventative maintenance.

- **CHARGER MANAGEMENT**
  - Monitor charger status, control charging remotely, and receive real-time updates.
THE SOLUTION: REVOLUTIONARY APPROACH TO TRANSPORT

THE ONLY TRANSIT PLATFORM DESIGNED SPECIFICALLY FOR EV PERFORMANCE

- 100+% Less Tailpipe Emissions
- 78+% Lower Lifetime Fuel Cost
- 400+% More Fuel Efficiency
- 25+ Quieter
- % Land Scalable

THE ONLY TRANSIT PLATFORM DESIGNED SPECIFICALLY FOR EV PERFORMANCE
## THE HEALTH COSTS OF FOSSIL FUELS

### Annual Diesel Health Impacts in the US
(Number of cases in 2010)

<table>
<thead>
<tr>
<th>Health Impact</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature Deaths</td>
<td>21,000</td>
</tr>
<tr>
<td>Lung Cancer Deaths</td>
<td>3,000</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>15,000</td>
</tr>
<tr>
<td>Emergency Room Visits for Asthma</td>
<td>15,000</td>
</tr>
<tr>
<td>Non-fatal Heart Attacks</td>
<td>27,000</td>
</tr>
<tr>
<td>Asthma Attacks</td>
<td>410,000</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>12,000</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td>2,400,000</td>
</tr>
<tr>
<td>Restricted Activity Days</td>
<td>14,000,000</td>
</tr>
</tbody>
</table>
TRANSIT ELECTRIFICATION POLICY DEVELOPMENTS

- LA Metro Board passed resolution to convert its entire bus fleet to all-electric by 2030; LA DOT also moving to 100% zero emission by 2030; December 2018 passage of Innovative Clean Transit Reg
- Colorado now funds up to $35k per vehicle for Class 8 vehicles
- Stockton, CA announced the nation’s first all-electric bus rapid transit (BRT) route
- Georgia now offers EV public transit buses on master state contract; CA will soon follow
- Chicago’s Drive Clean Truck Voucher Program offers $150k per Proterra bus
- King County announced the purchase of 120 electric buses by 2020; 100% EV by 2034
- New York’s Truck Voucher Incentive Program offers $150k per Proterra bus
- FAST Act: $55M annually for LowNo Program; introduction of innovative procurement methods and leasing options
- Maryland Freedom Fleet Voucher program offers $20k per heavy duty vehicle; BG&E used to purchase 2 Proterra buses
- New York’s Truck Voucher Incentive Program offers $150k per Proterra bus
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SMARTER CHARGING

**SMARTER CHARGING**

**60KW**
For fleets with longer available charge times.
Catalyst E2 charge time: ~6 hours, w/ J1772-CCS plug-in

**125KW**
For fleets with high uptime requirements
Catalyst E2 charge time: ~3 hours, w/ J1772-CCS plug-in

**500KW**
For fleets with extended operating hours and high mileage requirements
Catalyst FC+ charge time: ~38 miles per 10 minutes, w/ J3105 overhead

**INTELLIGENT**
Automated and rules-based vehicle charging

**UNIVERSAL**
Standards-based, OCPP 1.6 open communications protocol-compatible

**REMOTE**
Can be located up to 492 feet from dispenser

**SCALEABLE**
Can be installed side-to-side and back-to-back for high-density charger banks

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**COMPATIBLE CONNECTIONS**
- Pantograph
- Inverted pantograph
- Universal plug-in
Proterra works closely with customer to recommend the **appropriate charging solution** for fleets and facilities planning for scale as the demand for charging increases.

Proterra technologies enable:
- Efficient charge speed
- Dynamic power sharing
- Driver-friendly stations
- Cost-effective operations
- Universal compatibility
- Serviceability
- Low maintenance costs
- High availability

Our experts provide counsel on:
- Site layout
- Energy management
- Real-time energy monitoring
- Site configurations
PROTERRA ENERGY™
FLEET SOLUTIONS

PROTERRA ENERGY DELIVERY SYSTEM
INTRODUCING PROTERRA ENERGY FLEET SOLUTIONS

TURNKEY ENERGY DELIVERY FOR ELECTRIC FLEETS

By providing a full suite of Proterra products and services in-house, we offer a comprehensive solution to help you meet your electrification goals.

• SOPHISTICATED PLANNING
• TURNKEY INFRASTRUCTURE INSTALLATION
• SMART ENERGY MANAGEMENT
• ADVANCED ENERGY STORAGE
• PAY-AS-YOU-GO

Proterra has helped more than 45 fleet operators throughout North America install high-power charging systems.
Electrifying Transportation: Local Utility Engagement

**What Can Utilities Do?**

- Customers are confused and unsure about large scale charging solutions; easing the customer experience through utility support can facilitate vehicle adoption
- Establish a transportation electrification group
- Support electrification efforts with lower TOU rates for charging and addressing demand charges
- Rate basing infrastructure build-out
- Utilities can identify steps in interconnection and local permitting processes that can be streamlined and made more uniform

**Why Beneficial?**

- Potential to drive down average rates through infrastructure investment in high utilization projects
- Opportunity to strengthen utility service through a smarter grid
- Optimize the load profile on the grid through smart charging and using vehicles as distributed storage devices
- More load on the grid will potentially lead to lower electricity rates or the stabilization of such rates. EVs lead to increased throughput on utility distribution assets and more balanced loads in the generation market.
- Utilities can demonstrate their support for improving air quality and local health benefits, particularly in disadvantaged communities
SAF-T-LINER EC2 SCHOOL BUS
POWERED BY PROTERRA

ZERO EMISSIONS
• 100% battery-electric with no tailpipe emissions

FAST CHARGING
• DC charging enables a full charge in ~ 3 hours using Proterra’s 60 kW PCS

HIGH PERFORMANCE
• Efficient, smart, safe drivetrain technology for optimal performance in any climate

PROVEN TECHNOLOGY
• Proterra batteries and drivetrains proven in more than 7,000,000 service miles on transit buses
Proterra Gives Fleet Operators More Reasons To Go Electric With New Line Of Charging Stations

Emphasizing Connectivity at Scale, Proterra Introduces the APEX™ Vehicle Intelligence System for Heavy-Duty Transit Fleets

Daimler invests in electric bus company Proterra; exploring electrification of Daimler’s Thomas Built school buses

Proterra launches energy ecosystem

Proterra and Michelin Collaborate to Develop New Low Rolling Resistance Tire Optimized for Battery-Electric Buses

Proterra and Mitsui & Co., Ltd. Create $200 million Credit Facility to Scale Proterra Battery Leasing Program
AMERICAN CITIES CLIMATE CHALLENGE
| Opportunities for Bus Electrification |
May 30, 2019
A pioneer in providing a new energy ecosystem: from **Power Generation** to **Storage** to **Electrified Transportation**
Company Overview

- Over **240,000** employees and **33** industrial parks worldwide
- 2018 Group revenue: **US $19 billion**
- **20,000 Engineers**, with over 15,000 Patents
- Over **23 years** developing advanced battery technologies
- World-leading **Solar & Energy Storage Manufacturer**
- Delivered over **50,000** Electric Buses
- Delivered over **2,000** Electric Trucks
GLOBAL REACH

6 Continents, 48 Countries & Regions, 200+ Cities
BYD Buses Across the U.S.
From Sea to Shining Sea

Buses made by BYD in Lancaster, Calif. are at work in communities across the nation. Many more are on order.
U.S. BASED MANUFACTURING

550,000 Square-Foot EV Manufacturing Space

Lancaster, CA
More than 775 manufacturing jobs
900+ U.S. employees
4 Reasons to Electrify Your Bus Fleet

1. It makes financial sense to electrify
   • Fuel Savings
   • Maintenance Savings
   • Total Cost of Ownership
   • Innovative Financing

2. Environmental Benefits
   • Air Quality
   • Climate Change

3. Quality of Life
   • Quiet & Smooth Transit Experience

4. Support Disadvantaged Communities
4 Challenges to Fleet Electrification (and lessons learned)

1. Higher upfront costs
   - State/federal funding for incremental costs are available
   - Innovative financing

2. Infrastructure
   - Engage early with utility and public utility commission
   - FTA & state funding available
   - Create an electrification plan

3. Rate Design
   - Again, utility engagement & planning will save time & money
   - Think about how best to charge your buses from both operational & financial perspectives

4. Incumbency Bias
   - Get buy in from mgmt, ops, & maintenance
ELECTRIFICATION OPPORTUNITIES IN OUR COMMUNITIES
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