Hydrogen as a Transportation Fuel in Rural Communities
• National Technical Assistance Center
• Launched in late 2019
• Operated by Community Transportation Association of America
• Through a cooperative agreement with the Federal Transit Administration (FTA)
N-CATT’s mission is to provide small-urban, rural, and tribal transit agencies with practical, replicable resources that help them apply technological solutions and innovations.

N-CATT is carrying out this mission by analyzing information, communicating it, helping transit systems plan, and encouraging implementation of cost-effective, value-adding technology.
https://n-catt.org/
Hydrogen as a Transportation Fuel in Rural Communities

N-CATT Webinar Series
August 18, 2020
Overview

• Introduction to Hydrogen and Fuel Cell Electric Vehicles
• Lightning Systems – Zero Emission Vehicle Manufacturer
• Plug Power – Fuel Cell Vehicle and Fueling Infrastructure Provider
• SARTA – Fuel Cell Electric Bus Operator
• Q&A
About CTE

WHO WE ARE
501(c)(3) nonprofit engineering and planning firm

OUR MISSION
Improve the health of our climate and communities by bringing people together to develop and commercialize clean, efficient, and sustainable transportation technologies

PORTFOLIO
$571 million
- Research, demonstration, deployment
- 90 Active Projects totaling over $316 million

OUR FOCUS
Zero-Emission Transportation Technologies

NATIONAL PRESENCE
Atlanta, Berkeley, Los Angeles, St. Paul
CTE Zero Emission Bus Projects

[Map showing locations of ZEB Deployment and Planning Projects across the United States]
Introduction
What is Hydrogen?

- Energy carrier
- Used in a fuel cell; takes oxygen from the air and produces electricity
- Only emission is water vapor

Diagram of basic hydrogen fuel cell operations
Is Hydrogen Safe?

- Hydrogen is non-toxic.
- Upon release, the lighter-than-air gas escapes vertically into the atmosphere.
- Several safety protocols and standards in place:
  - NASA
  - Center for Hydrogen Safety (H2tools.org)
  - National Fire Protection Association (NFPA 2)
Benefits to Rural Communities

- Local production
- Energy storage
- Clean fuel
- Partner opportunities
- Vehicle range
Deploying a Hydrogen Powered Fleet
What FCEVs are Available Today?

- 40 – 60 ft buses
  - OEMs: New Flyer, ENC
- Large format passenger vans and cutaways
  - Lightning Systems
- Light-duty vehicles
  - Toyota Mirai, Hyundai Nexo (SUV)
How to Fuel the Fleet?

There is no “one-size-fits-all” solution. Many factors will influence the configuration of your local fueling station.

The typical pathway for hydrogen fueling station is as follows:
Options for Hydrogen Sourcing

(Image source: California Fuel Cell Partnership)
How to Fund the Fleet?

Some examples of funding sources include

• Federal Programs: Low-No Emissions Program
• State Programs: VW funds

Partnerships within the Community

• Local utilities
• Other partners working with FCEVs
  – Warehouses
  – Truck stops (future)
Action Plan

1. Reach out to peer agencies to learn from their experiences with zero-emission technology.
2. Develop support within the agency for pursuing hydrogen fuel cell technology.
3. Perform a planning study to evaluate feasibility of deploying hydrogen FCEVs at the agency, including infrastructure.
4. Contact local partners and speak to local and state officials about your project proposal. Identify opportunities for collaboration and funding support.
5. Pursue and secure funding for the FCEV deployment and associated infrastructure (facilities and fueling) detailed in the study.
6. Create a project plan and execute the hydrogen fuel cell electric vehicle deployment project.
WELCOME TO ZERO

2020 INTERNATIONAL
ZERO EMISSION BUS CONFERENCE
ONLINE • SEPTEMBER 15TH - 17TH

REGISTER FOR FREE AT ZEBconference.com
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Hydrogen in Rural Transit
Plug Power is the Leader in Hydrogen and Fuel Cell Technology

Holds 90%+ of the Hydrogen Fuel Cell Market for Material Handling Equipment

Key Performance Characteristics

- 1st to create a market for HFC technology
- Strong patent portfolio and proprietary know-how
- 44 trademarks
- ~70% blue chip customer base
- 340MM+ operating hours (1.1Bn+ miles)
- 30 MM+ fuelings; 27 Tons liquid H₂ used daily
- Harsh operating conditions: 40G shock, airborne contaminants, -30F – +100F change within 30 seconds; rapid start/stops

Cumulative Hybrid Fuel Cell Units Installed

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</thead>
<tbody>
<tr>
<td>Units</td>
<td>4,400</td>
<td>6,700</td>
<td>10,600</td>
<td>14,800</td>
<td>20,000</td>
<td>24,800</td>
<td>30,000</td>
<td>34,000</td>
</tr>
</tbody>
</table>

38% CAGR, 2013-2019
How does a Fuel Cell work?

Battery

- Electricity in – Electricity out
- Acts as both storage tank and engine
- Long recharge time

Fuel Cell

- Hydrogen & Air in – Electricity out
- Separate hydrogen tank and engine
- Fast refuel times

Fuel Cells operate just like diesel engines without emissions
Drop-in Hydrogen Fuel Cell Solution – Direct Replacement for a Battery

Our customers willingly replace ZE batteries with ZE fuel cells! >34,000 times!! Why is that?

Inputs: hydrogen & air
Outputs: electricity & water

Fuel cell, small battery, tank, control systems, ballast

Drop-in replacement for conventional batteries

Inputs: hydrogen & air
Outputs: electricity & water
Drop-in Hydrogen Fuel Cell Solution – Direct Replacement for a Battery

Inputs:
- hydrogen & air

Outputs:
- electricity & water

Fuel cell, small battery, tank, control systems, ballast

Drop in replacement for conventional batteries

$ Compelling Economic Value $
Operations Excel with GenDrive

- Battery changes/Long recharge times
- Special handling equipment
- Non-productive space
- Operator downtime
- Duplicate Assets
- Performance drop-off throughout shift
- Performance drop-off with Temperature
- Grid charging
- Demand charges
- Vehicle availability
- Capacity loss with age/environment
- Toxic chemicals and handling
- Personnel hazards
- Emissions

Labor and asset productivity/utilization increase anywhere from 15% - 25+% This is real money!
### Commercial Motive Power

<table>
<thead>
<tr>
<th>Operational Criteria</th>
<th>ICE</th>
<th>Battery</th>
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<tbody>
<tr>
<td>Refuel/Recharge Time</td>
<td>X</td>
<td>---</td>
</tr>
<tr>
<td>Vehicle Cycle Performance</td>
<td>X</td>
<td>---</td>
</tr>
<tr>
<td>Work Force Productivity</td>
<td>X</td>
<td>---</td>
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<tr>
<td>Asset &amp; Space Utilization</td>
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<td>---</td>
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<tr>
<td>Emissions</td>
<td>---</td>
<td>X</td>
</tr>
<tr>
<td>All Weather Operation</td>
<td>X</td>
<td>---</td>
</tr>
</tbody>
</table>

Applies to ALL Commercial Vehicles operating in high capacity and high daily utilization.
Hydrogen Supply Options

- **Liquid H2 supplied by trailer**
- **On site Steam Reforming**
- **On site Electrolysis**
Hydrogen Solutions - Flexible, Forgiving, Scalable

- All forms of Hydrogen can be renewable, and/or carbon free, and/or sustainable
- Hydrogen can be delivered or generated on-site
  - Liquid or Gas, truck or pipeline
  - Reformer or Electrolyzer
- **H2 Tanker** just like diesel tanker

Plug Power has constructed and operates over 100 MISSION CRITICAL Hydrogen Refueling Stations
1. Initial costs and efforts are much lower than have been portrayed
2. Crossover point occurs at a smaller fleet size
Hybrid Solutions – Scalable, Flexible, and Forgiving

- Start small and grow as you budget allows
- Initial investments less than $500K
- No stranded assets – build on deployed equipment
- Fueling assets can be easily shared

Broad range of customizations to assure the most cost-effective solutions
Cost effective hydrogen is the critical enabler to be the full service provider – power, infrastructure, molecule & service.
Fuel Cell Electric Vehicles

Keith Lehmeier
Director, New Product Development

lightningsystems.com
Our Facility

142,000 sqft Manufacturing Facility located in Loveland, Colorado
TRANSFORMING ESTABLISHED OEM TRUCKS AND BUSES INTO PREMIUM COMMERCIAL BATTERY ELECTRIC AND FUEL CELL ELECTRIC VEHICLES

Focus on the Heart and Brain of Electrification

**POWERTRAIN**
High quality, integrated system that’s easy for upfitters to install

**SOFTWARE**
Advanced algorithms, controls, and integration

**ANALYTICS**
Actionable fleet intelligence

Engineered with custom and off-the-shelf components
Proprietary deep integration with OEM vehicle
Critical to fleet range and ROI
## ELECTRIC POWERTRAINs FOR CLASS 3-8 VEHICLES

<table>
<thead>
<tr>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
<th>Class 6</th>
<th>Class 7/8</th>
<th>Class 8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRUCKS</strong></td>
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<tr>
<td>Ford Transit 350HD</td>
<td>Ford E-450</td>
<td>Ford F-59</td>
<td>GM 6500XD</td>
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</tr>
</tbody>
</table>

| **BUSES** | | | | | |
| Ford Transit 350HD | Ford E-450 | Ford F-550 | Transit Bus Repower | Motor Coach | |

CARB Certified | Enabled and supported by [GM](https://www.gm.com) [Ford](https://www.ford.com) [QVM](https://www.qvm.com) and their dealer networks

[lightningsystems.com](http://lightningsystems.com)
Class-3 and Class-6 Fuel Cell Concepts

**Ford T350HD**
- 10,360 GVWR
- 32kWh battery capacity
- 1x 30kW fuel cell engines
- 7.2 kg of storage
- Plug-In FCEV
- 135 mile range (depending on storage)

**Class-6 GM6500 XD**
- 25,950lb GVWR
- 64kWh battery capacity
- 3x 30kW fuel cell engines
- 20-40 kg of storage
- 200-400 mile range (depending on storage)
BEV vs FCEV

Vehicle Operating Range

Vehicle Operating Weight

High Payload: FCEV
Low Payload: BEV

High Payload: FCEV
Low Payload: FCEV
• Repower existing fleet vehicles with Lightning’s cutting-edge ZEV powertrain
• Keep the bus you & your mechanics are familiar with
• Refurbish vehicles to upgrade to current safety & cosmetic standards
• Creates new ZEV vehicles that meet looming mandates
• Less expensive than a new bus
• Quick lead time (new ZEV vehicles have 18-24 month waiting list)
Fleets Powered by Lightning
Funding Your Projects
• Tier II • 34 fixed routes
• County wide Proline (Paratransit) services.
• Service area is 576.2 miles

• 1 Administrative/Maintenance Facility/Bus Garage
• 4 Transit Stations

• 42 Fixed Route Buses - 14 Diesel, 12 CNG, 13 Hydrogen, and 3 Hybrid

• 55 Proline (Paratransit) Buses - 25 Diesel, 30 CNG, (end of 2020) 5 hydrogen

• 16 Support Vehicles

• 1 Diesel Fueling Station
• 2 CNG Fueling Stations (1 Public and 1 SARTA)
• 1 Hydrogen Fueling Station
Funding Streams Grant Opportunities

- US EPA/ State EPA
- US Department of Energy
- State funding - *Ohio has State funding - SGR and Ohio Transportation Preservation*
- 5310
- 5311 - Rural
- 5339 Formula, LoNo and Bus & Bus Facilities
- 5307 Formula – *Talk with a transit nearby to become a partner or subgrantee.*
- CMAQ
- Check Grants.gov [https://www.grants.gov/web/grants/applicants/applicant-resources.html](https://www.grants.gov/web/grants/applicants/applicant-resources.html)
- Local Utilities or Merchants
BENEFITS OF USING A STATEWIDE CONTRACT

• Eliminates the procurement process
• Drives down prices for everyone
  • – Agencies
  • – OEMs
• Creates greater price transparency for agencies
Funding Streams 8 40’ Hydrogen Buses

- LoNo - $7,139,040  100% Federal funding (TDC Credits $1,070,856)
- DERG - $1,000,000  80% Federal funding
- OTPPP - $1,261,680  100% Federal funding (CMAQ $189,252)
- LoNo - $3,415,174  100% Federal funding (TDC Credits $512,276)
- DERG - $375,000  80% Federal funding

- Project Total $13,972,994
- Federal - $13,279,894  Local Match – $693,100
Funding Streams 5 <30’ Hydrogen Buses

- FY17 OTP3 - $517,022  100% State funding
- FY18 OTP3 - $610,022  80% State funding
- FY18 EPA DERA - $217,000  43% Federal funding ($125,000 Vendor match)

Project Total $1,772,732
Federal – $1,337,044  Local Match – $435,688
($125,000 Vendor match; $310,688 SARTA)
Funding Streams Hydrogen Station & Upgrades

Original Station, including safety infrastructure completed September 2016

- LoNo- $300,000  100% Federal funding
- 5307 - $54,990  80% Federal funding
- OTPPP - $450,000  90% State flexed to Federal funding
- CMAQ – $1,185,735  100% State flexed to Federal funding

Project Total $2,054,648
Federal – $1,990,725  Local Match – $63,923

2020 Additional pumps and equipment being added

- CMAQ – 1,240,000  90% State flexed to Federal funding

Project Total $1,377,778
Federal – $1,240,000  Local Match – $137,778
5 year lease of hydrogen storage equipment from Air Products
O&M monthly costs for maintaining equipment
Thank you!

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