

n-catt



**National Center
for Applied Transit
Technology**

Hydrogen as a Transportation Fuel in Rural Communities

August 18, 2020



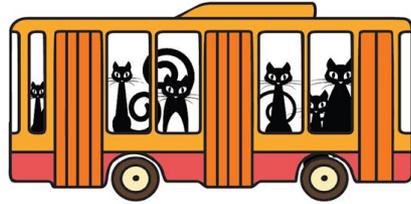
- National Technical Assistance Center
- Launched in late 2019
- Operated by Community Transportation Association of America
- Through a cooperative agreement with the Federal Transit Administration (FTA)



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.

n-catt



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<https://n-catt.org/>



Hydrogen as a Transportation Fuel in Rural Communities

N-CATT Webinar Series

August 18, 2020



Cory Shumaker
Engineering Consultant
Alison Smyth
Lead Engineering Consultant

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

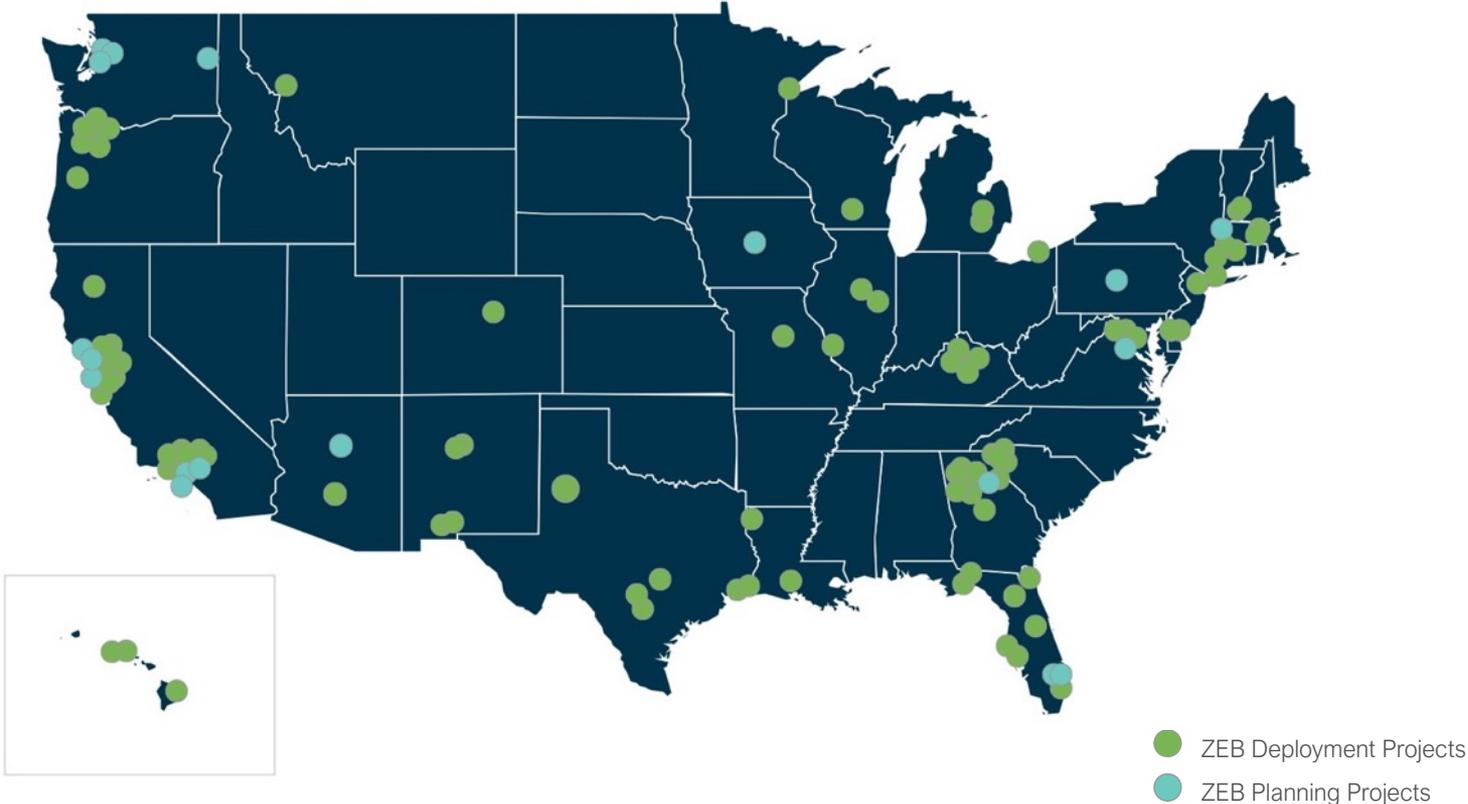
Zero-Emission Transportation Technologies



NATIONAL PRESENCE

Atlanta, Berkeley, Los Angeles, St. Paul

CTE Zero Emission Bus Projects



Introduction

What is Hydrogen?

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

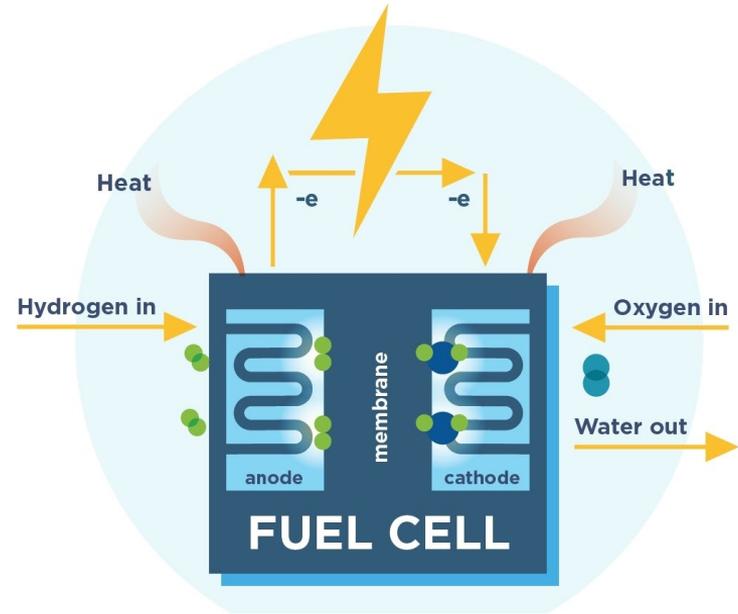


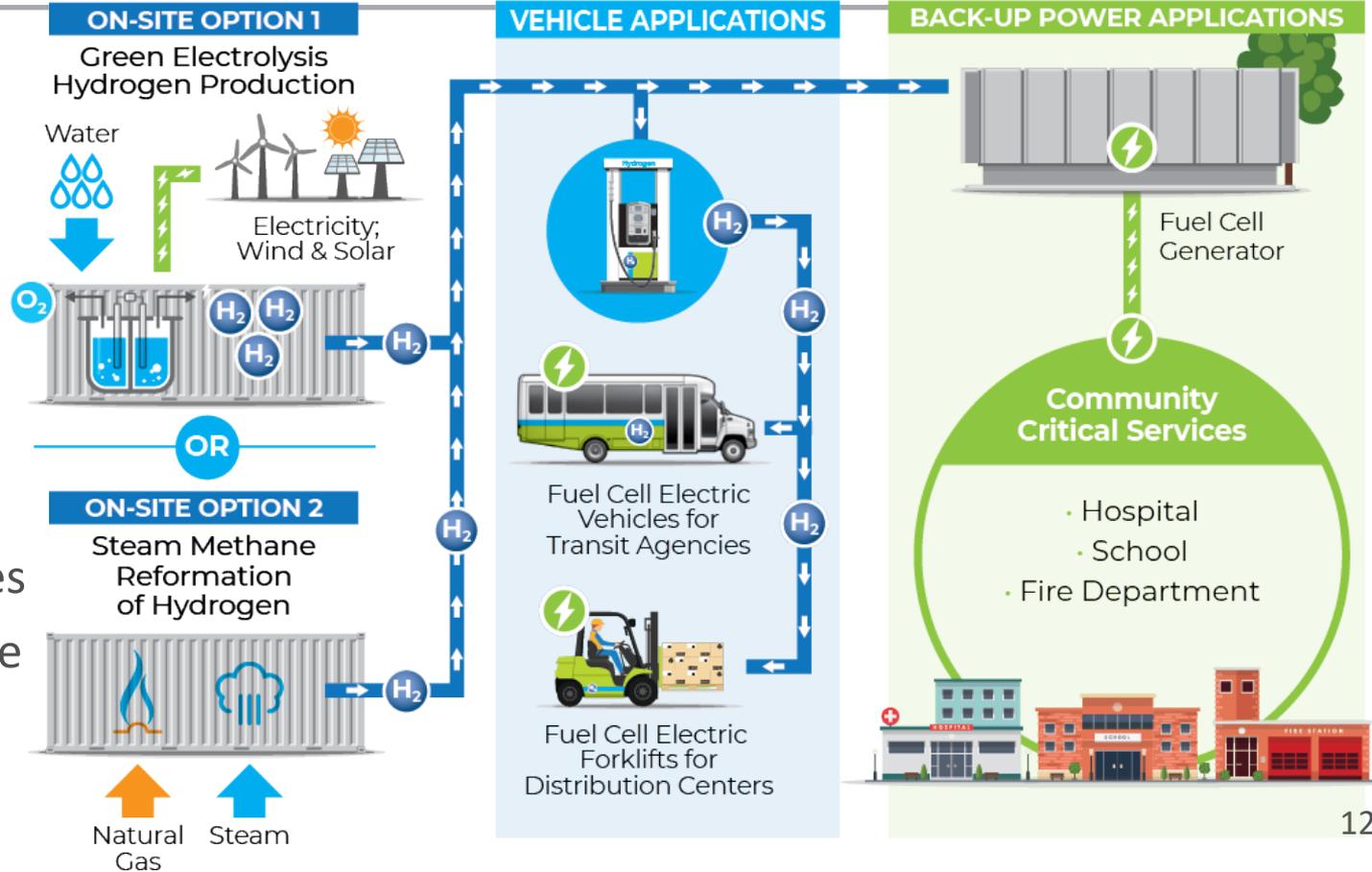
Diagram of basic hydrogen fuel cell operations

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)

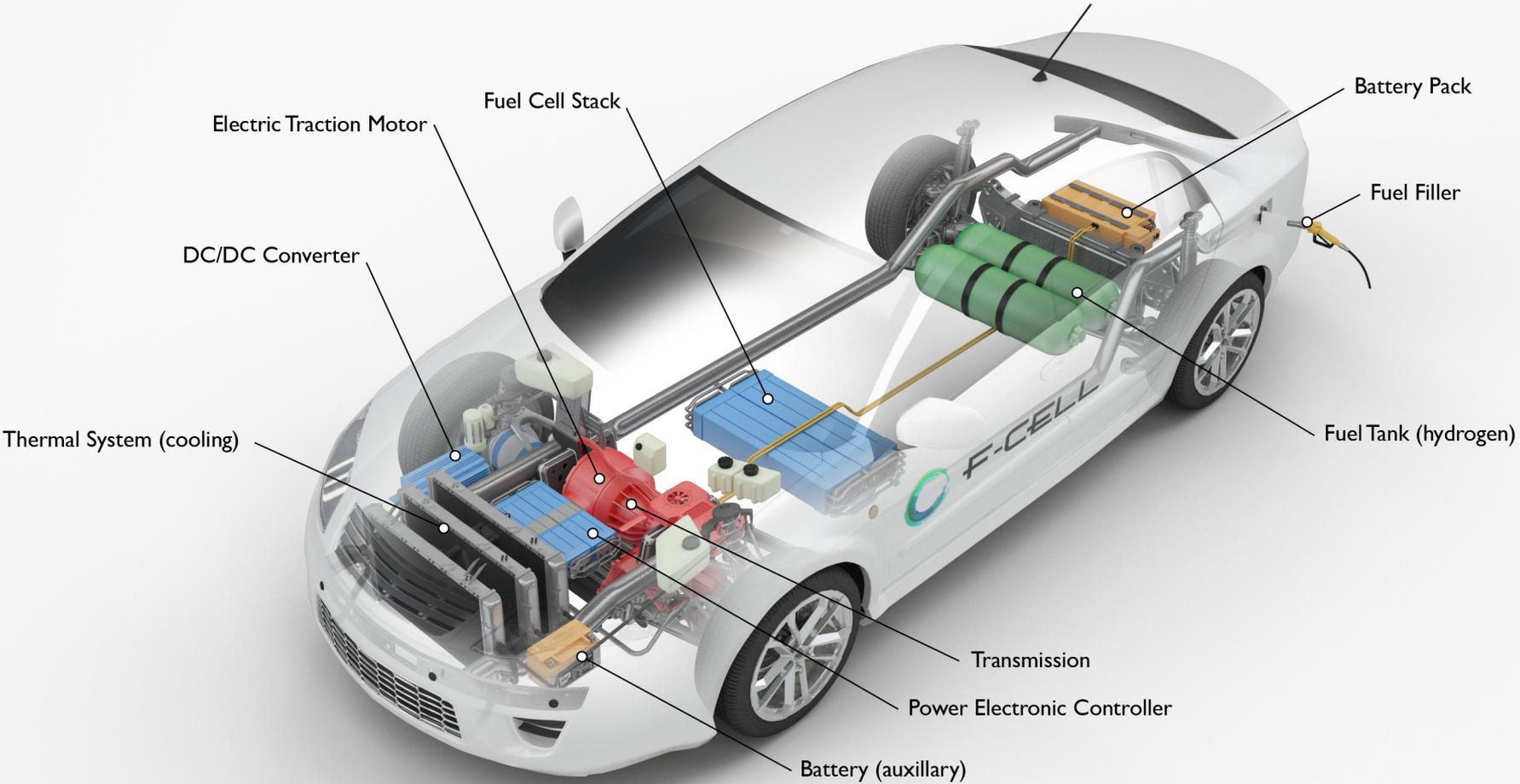
Benefits to Rural Communities

- Local production
- Energy storage
- Clean fuel
- Partner opportunities
- Vehicle range



Deploying a Hydrogen Powered Fleet

Hydrogen Fuel Cell Electric Vehicle



What FCEVs are Available Today?

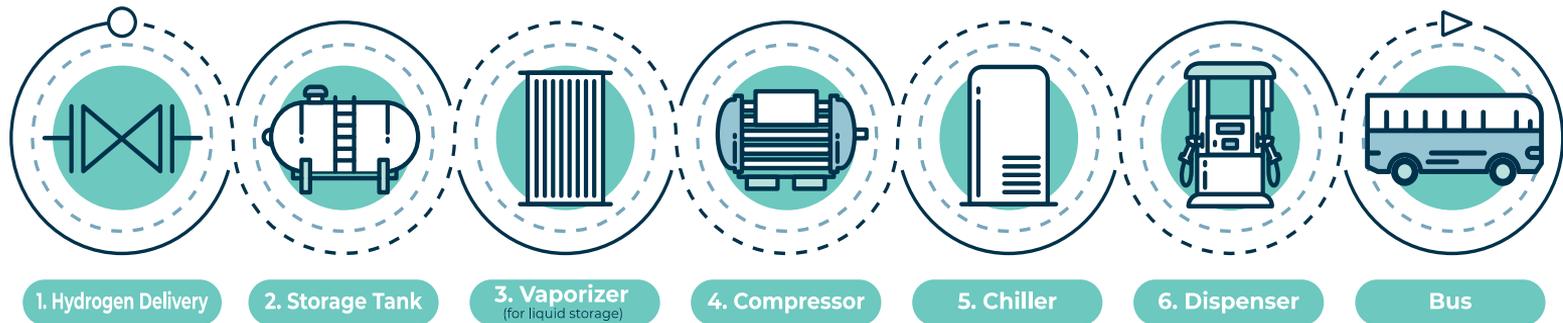
- 40 – 60 ft buses
 - OEMs: New Flyer, ENC
- Large format passenger vans and cutaways
 - Lightning Systems
- Light-duty vehicles
 - Toyota Mirai, Hyundai Nexo (SUV)



How to Fuel the Fleet?

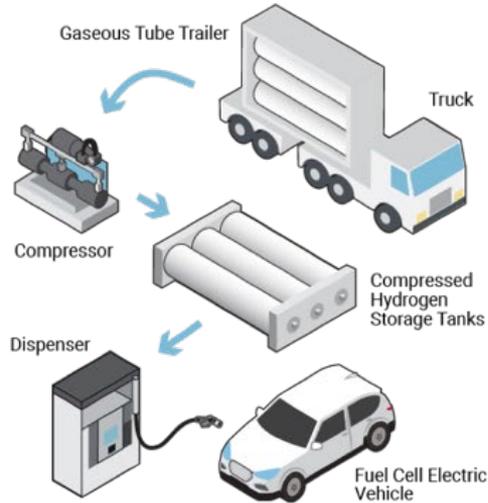
There is no “one-size-fits-all” solution. Many factors will influence the configuration of your local fueling station.

The typical pathway for hydrogen fueling station is as follows:

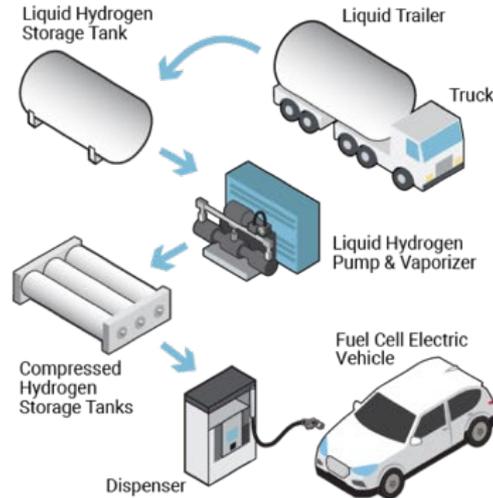


Options for Hydrogen Sourcing

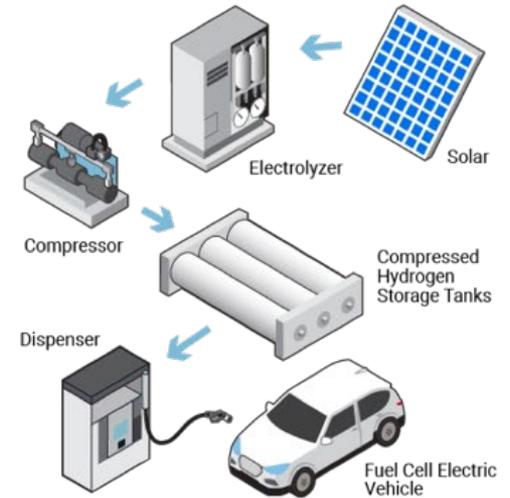
Gaseous Delivery



Liquid Delivery



On-Site Production



(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](https://www.zebconference.com)



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**Lead Engineering
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Hydrogen in Rural Transit

N-CATT 2020

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)



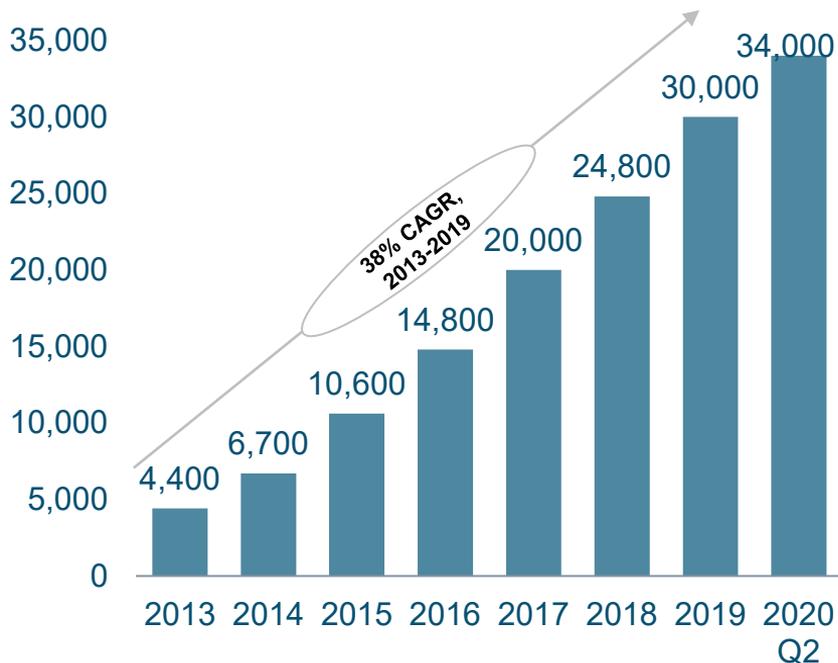
30 MM+ fuelings; 27 Tons liquid H₂ used daily



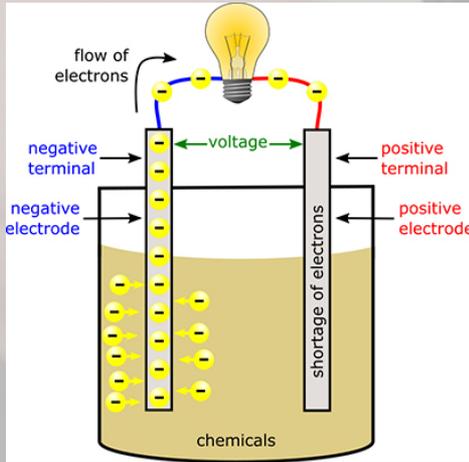
Harsh operating conditions; 40G shock, airborne contaminants, -30F – +100F change within 30 seconds; rapid start/stops



Cumulative Hybrid Fuel Cell Units Installed



Battery

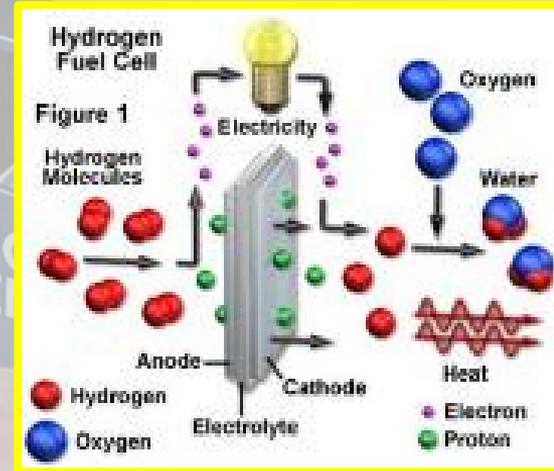


Electricity in – Electricity out

Acts as both storage tank and engine

Long recharge time

Fuel Cell



Hydrogen & Air in – Electricity out

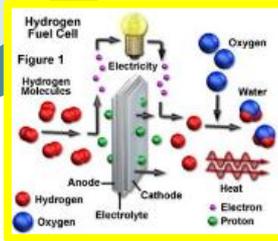
Separate hydrogen tank and engine

Fast refuel times

Fuel Cells operate just like diesel engines without emissions

Drop-in Hydrogen Fuel Cell Solution – Direct Replacement for a Battery

Inputs:
hydrogen &
air
Outputs:
electricity &
water



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

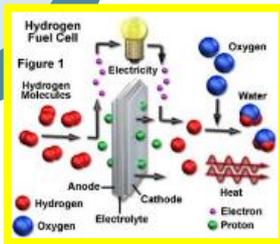


Drop-in
replacement
for
conventional
batteries

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

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 \$

- 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

Operational Criteria	ICE	Battery	
Refuel/Recharge Time	X	---	
Vehicle Cycle Performance	X	---	X 
Work Force Productivity	X	---	
Asset & Space Utilization	X	---	
Emissions	---	X	X 
All Weather Operation	X	---	
<p>Applies to ALL Commercial Vehicles operating in high capacity and high daily utilization</p>			

Liquid H₂ supplied by trailer



On site Steam Reforming

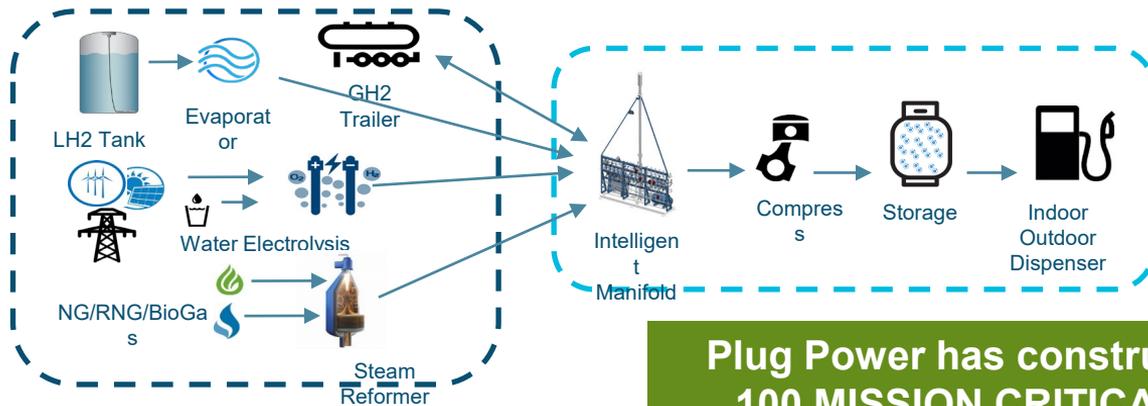


On site Electrolysis

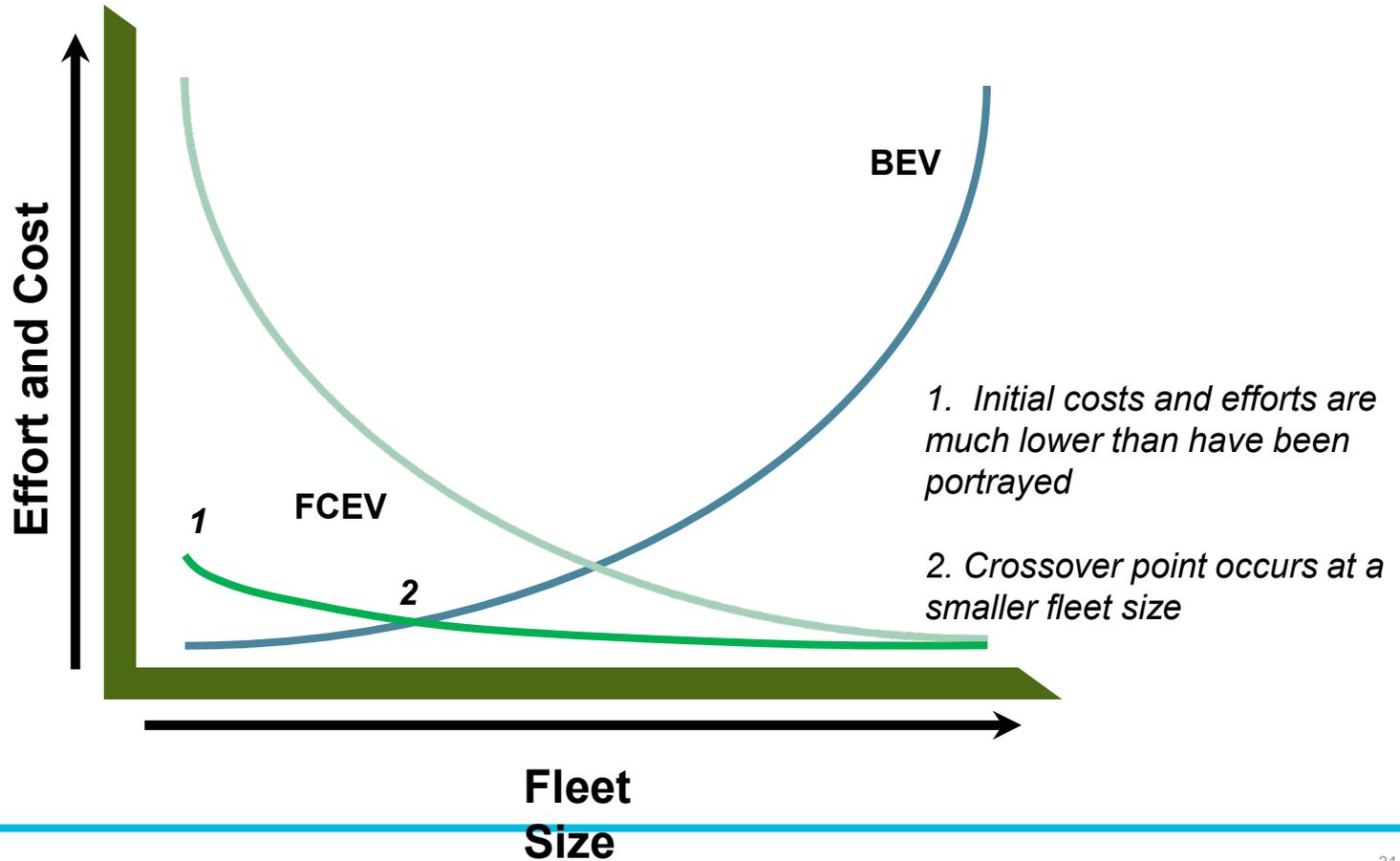


Hydrogen Solutions - Flexible, Forging, Scalable

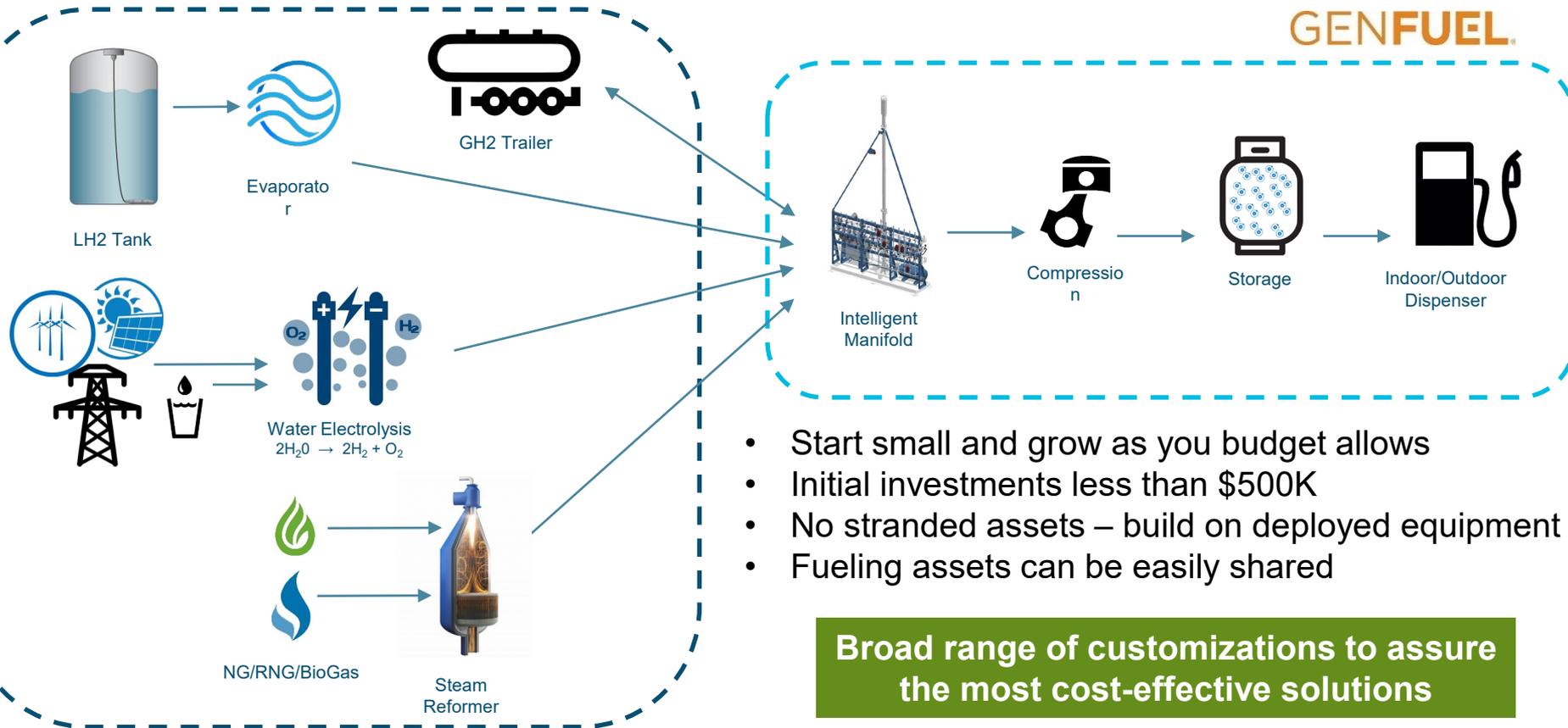
- All forms of Hydrogen can be renewable, and/or carbon free, and/or sustainable
- Hydrogen can be delivered or generated on-site
 - Liquid or Gas, truck or pipeline
 - Reformer or Electrolyzer
- H2 Tanker just like diesel tanker



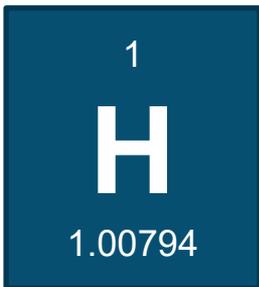
Plug Power has constructed and operates over 100 MISSION CRITICAL Hydrogen Refueling Stations



Hybrid Solutions – Scalable, Flexible, and Forging



GENFUEL®



Molecule



Infrastructure
- Large Outdoor H₂ Pad
- Small Outdoor H₂ pad



Indoor & Outdoor
Dispensers

Cost effective hydrogen is the critical enabler to be the full service provider – power, infrastructure, molecule & service



Corporate Headquarters

968 Albany Shaker Road, Latham, NY 12110

West Coast

15913 E. Euclid Avenue, Spokane, WA 99216

plugpower.com



Lightning
Systems

Fuel Cell Electric Vehicles

Keith Lehmeier

Director, New Product Development

lightningsystems.com



Our Facility



142,000 sqft Manufacturing Facility located in Loveland, Colorado

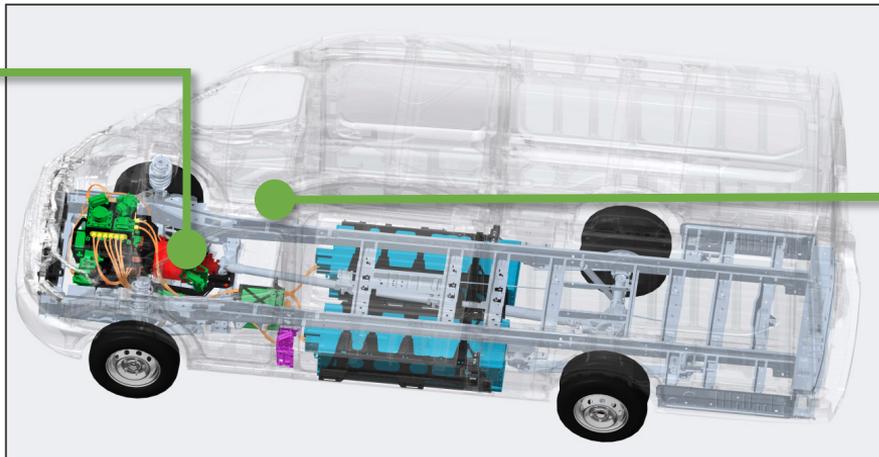
TRANSFORMING ESTABLISHED OEM TRUCKS AND BUSES INTO PREMIUM COMMERCIAL BATTERY ELECTRIC AND FUEL CELL ELECTRIC VEHICLES



POWERTRAIN

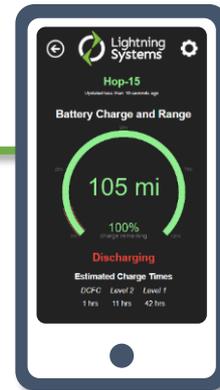
High quality, integrated system that's easy for upfitters to install

Focus on the Heart and Brain of Electrification



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

	Convert NEW Vehicles			Repower EXISTING Vehicles		
	Class 3	Class 4	Class 5	Class 6	Class 7/8	Class 8
TRUCKS	Ford Transit 350HD 	Ford E-450 	Ford F-59  Ford F-550 	GM 6500XD 		
BUSES	Ford Transit 350HD 	Ford E-450 	Ford F-550 		Transit Bus Repower 	Motor Coach 



CARB Certified

Enabled and supported by



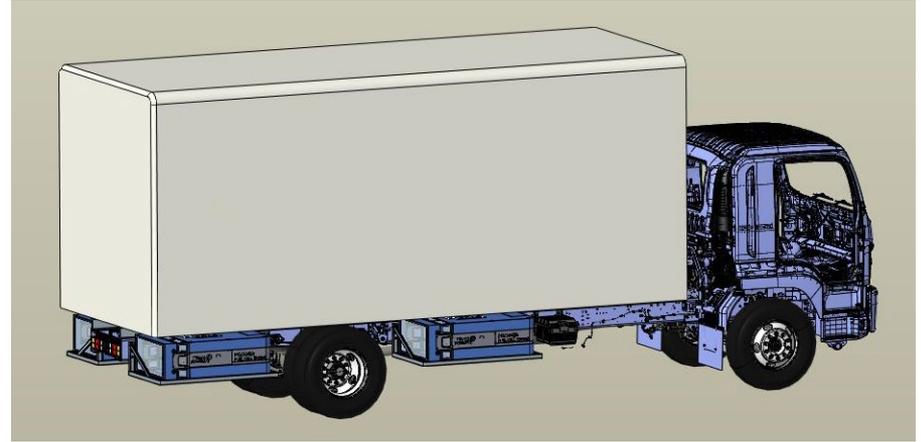
and their dealer networks

Class-3 and Class-6 Fuel Cell Concepts



Ford T350HD

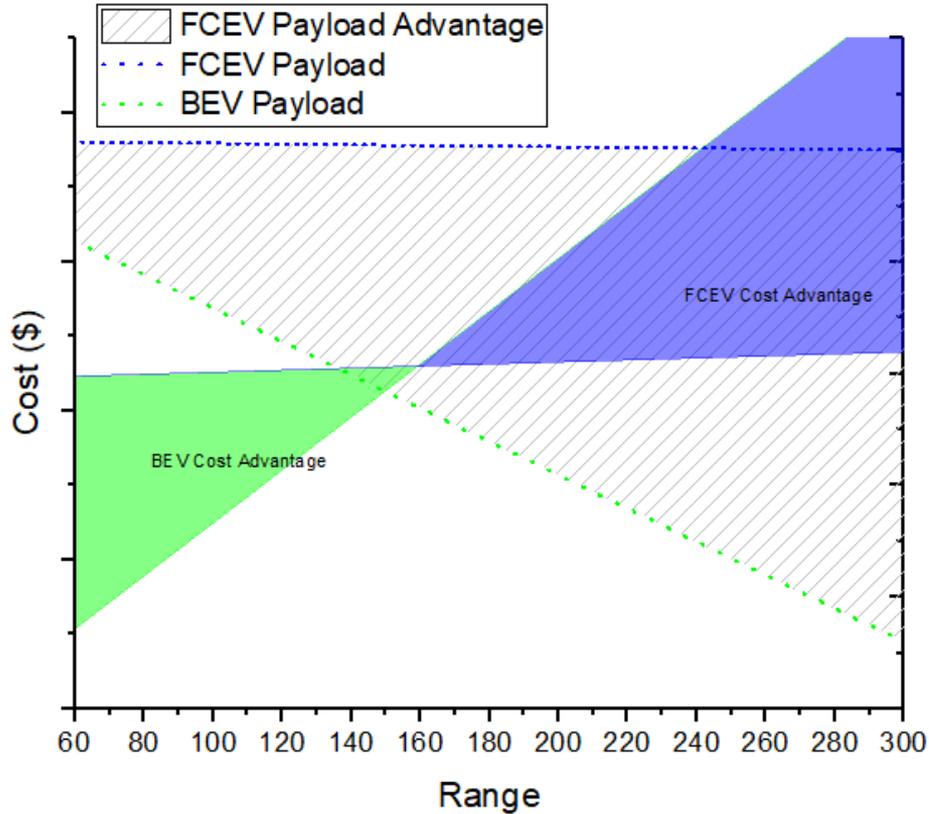
- 10,360 GVWR
- 32kWh battery capacity
- 1x 30kW fuel cell engines
- 7.2 kg of storage
- Plug-In FCEV
- 135 mile range (depending on storage)



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 Weight ↑

High Payload: **FCEV**
Low Payload: **BEV**

High Payload: **FCEV**
Low Payload: **FCEV**

High Payload: **FCEV**
Low Payload: **BEV**

High Payload: **FCEV**
Low Payload: **BEV**

Vehicle Operating Range →

REPOWER: AN ALTERNATIVE TO BUYING NEW

- 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)





Lightning Systems

Fleets Powered by Lightning



Funding Your Projects



Stark Area Regional Transit Authority, Canton, OH - SARTA

- 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



HI
CE

EN
CE

A Key Initiative of the Renewable Hydrogen Fuel Cell Collaborative

● 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>
- Local Utilities or Merchants

● Funding Streams Contracts

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

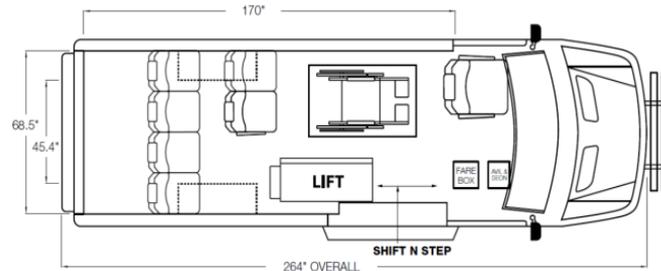
● Funding Streams 5 <30' Hydrogen Buses

- 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

● Funding Streams Hydrogen Station

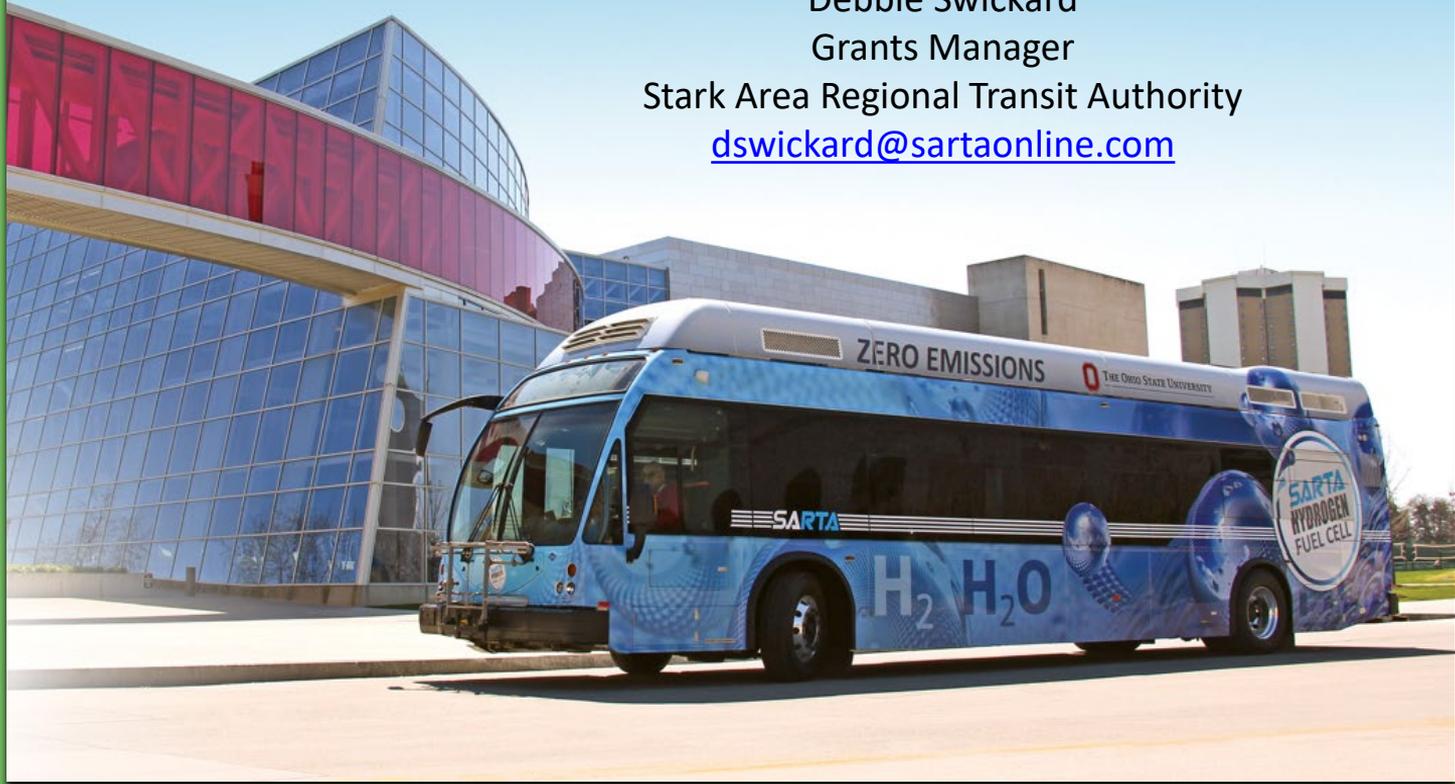


5 year lease of hydrogen storage equipment from Air Products
O&M monthly costs for maintaining equipment

Thank you!

Debbie Swickard
Grants Manager

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